# 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

**Prepared By:**

S&ME
422 Codell Drive
Lexington, Kentucky 40509

**September 8, 2011**

September 8, 2011

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.
Geotechnical Professional

Craig Lee, P.E
Senior Geotechnical Engineer

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

Attachments: Geotechnical Data Report

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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.

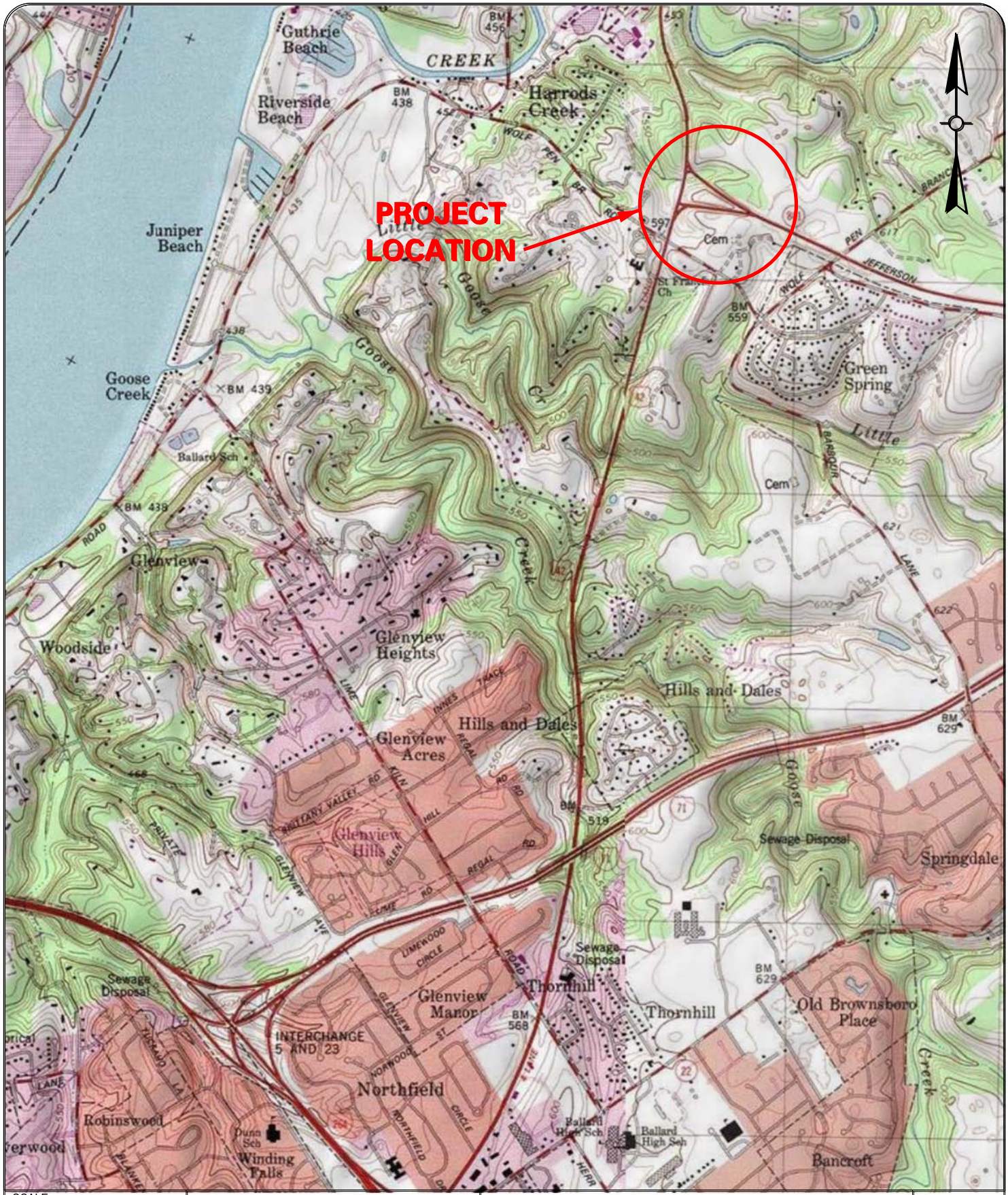
The permeability test results were reported as Lugeon values. The Lugeon unit is commonly used in grouting practice for measuring the permeability and the grout take potential of bedrock. Reporting the permeability test results using this method allows for the evaluation of the permeability characteristics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

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

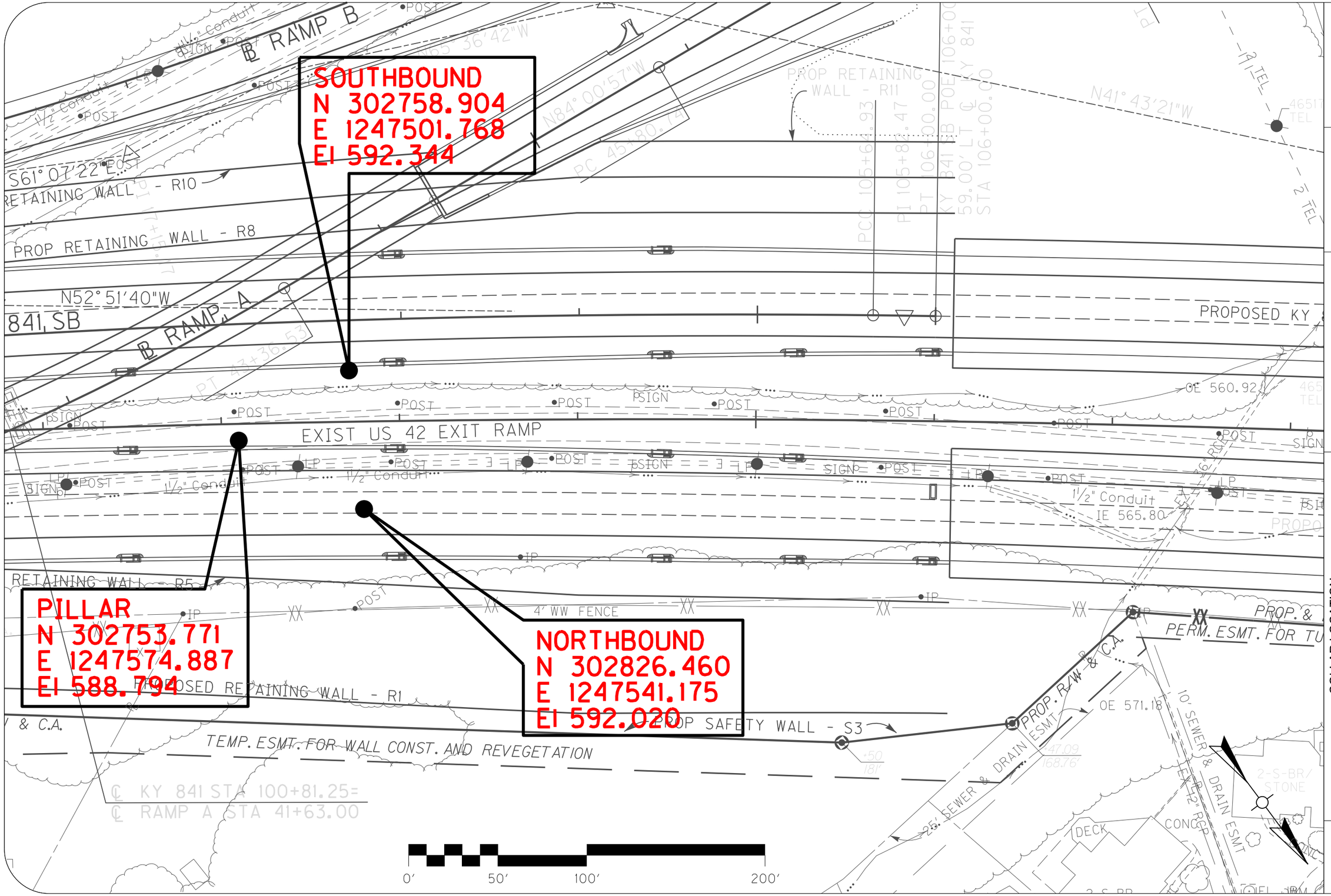
The packer system used in the North Bound Boring was provided by Tam International. A packer system consisting of two inflatable packers 2 foot in length and 2 inches in diameter were set 22 feet apart. Solid steel centralizers were placed above each packer to protect them during the placement and retrieval 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).




| | | | |
|---|---|---|---|
| SCALE: 1" = 2000' | S&ME<br>WWW.SMEINC.COM<br>422 CODELL DRIVE, LEXINGTON, KY 40509<br>PHONE: 859.293.5518 | COLLAR LOCATION<br>HORIZONTAL DIRECTIONAL BORING<br>GEOTECHNICAL DATA REPORT<br>LOUISVILLE SOUTHERN INDIANA<br>OHIO RIVER BRIDGES PROJECT<br>KENTUCKY EAST END APPROACH TUNNEL | FIGURE NO.<br>1 |
| DATE: 8/26/11 | | | |
| DRAWN BY: CAC | | | |
| PROJECT NO: 24305629 | | | |

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| DRAWN BY: | CAC |
| CHECKED BY: | |
| SCALE: | 1" = 50' |
| PROJECT NUMBER: | 24305629 |
| DRAWING NUMBER: | |

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

COLLAR LOCATION
HORIZONTAL DIRECTIONAL BORING
GEOTECHNICAL DATA REPORT

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

FIGURE NO.
2

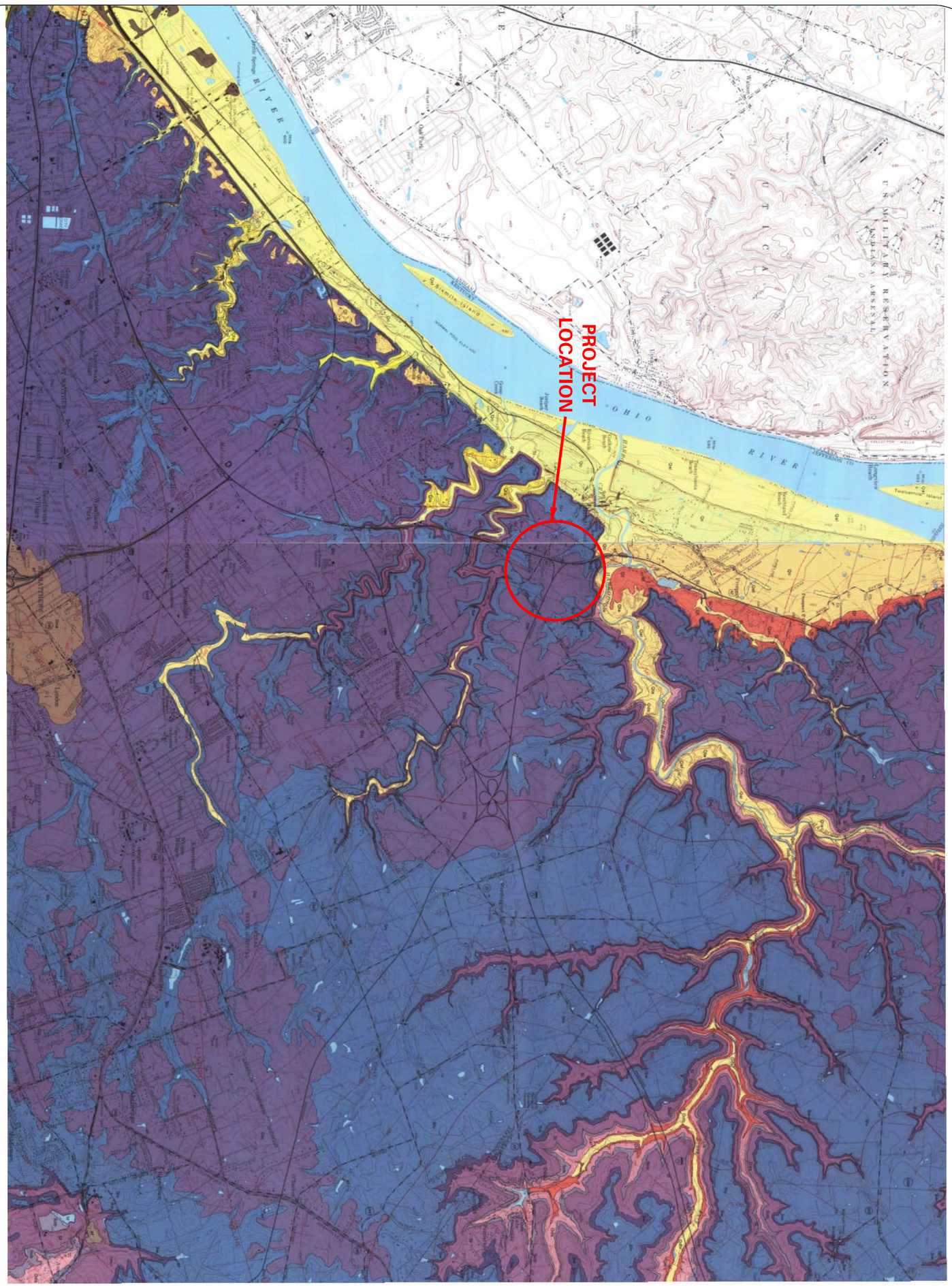


FIGURE NO. 3

PROJECT AREA GEOLOGIC MAP
HORIZONTAL DIRECTIONAL BORING
GEOTECHNICAL DATA REPORT

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

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

| | |
|---|---|
| SCALE: 1' = 50' | DATE: 8/25/11 |
| PROJECT NUMBER: 24305629 | DRAWN BY: CAC |
| DRAWING NUMBER: | CHECKED BY: |

# APPENDIX A

# BORING LOGS

# ROCK CORE PHOTOGRAPHS

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 1 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°  AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR / % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | GROUND SURFACE | | | | | | | | | | | | | | |
| | 5/22/2011 HQ Core | **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 | | **3.8 ft to 8.9 ft (Run No. 2) LIMESTONE** - Same as previous run. All breaks mechanical. | | 3.8<br>590.6 | 2 | | | | | | | | | | | |
| 10 | | **8.9 ft to 13.9 ft (Run No. 3) LIMESTONE** - Same as previous run; Joints at 11.8 and 12.2 feet. | | 8.9<br>589.8 | 3 | | | 590 | | | | | | J, R<br>J, R | | |
| 15 | 5/23/2011 HQ Core | **13.9 ft to 19.0 ft (Run No. 4) LIMESTONE** - Same as previous run; Joint at 17.2 feet. | | 13.9<br>588.9 | 4 | | | | | | | | | J, R | | |
| 20 | | **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). | | 19.0<br>588.1 | 5 | | | | | | | | | J, R<br>J, R, FE<br>J, R, FE | | |
| 25 | | **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<br>587.3 | 6 | | | | | | | | | | | |
| 30 | | **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<br>Inclination: -9.36 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring



LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| | HQ Core | **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. | | 586.5 | 7 | | | | | | | | | | | |
| 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'. | | 34.0 / 585.7 | 8 | | | | | | | | | J, R | | |
| 40 | | **34.0 ft to 44.0 ft (Run No. 9)** **LIMESTONE** - Same as previous run; Joint at 40.0'. | | 39.0 / 584.9 | 9 | | | 585 | | | | | | J, R | | |
| 45 | | **44.0 ft to 49.0 ft (Run No. 10)** **LIMESTONE** - Same as previous run. | | 44.0 / 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. | | 49.0 / 583.2 | 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. | | 54.0 / 582.4 | 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 | 13 | | | | | | | | | Azimuth: 305.02 Inclination: -9.97 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear

DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP

CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 3 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| | | | | 581.6 | 13 | | | | | | | | | | | |
| 65 | HQ Core | **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 | HQ Core | **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. | | 69.0 / 580.0 | 15 | | | 580 | | | | | | | | |
| 75 | HQ Core | **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 / 579.2 | 16 | | | | | | | | | | | |
| 80 | HQ Core | **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 / 578.4 | 17 | | | | | | | | | | | |
| 85 | HQ Core | **84.0 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. | | 84.0 / 577.5 | 18 | | | | | | | | | | | |
| 90 | HQ Core | **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 | | | | | | | | | | | |
| | | | | 93.2 | 20 | | | | | | | | | Azimuth: 304.58 Inclination: -10.29 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear

DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP

CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 4 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°  AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 95 | HQ Core | **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 | | | | | | | | | | | |
| 100 | | **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 | | | | | | | | | | | |
| 105 | | **103.4 ft to 108.6 ft (Run No. 22)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 103.4 / 574.4 | 22 | | | 575 | | | | | | | | |
| 110 | | **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 / 573.5 | 23 | | | | | | | | | | | |
| 115 | | **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 / 572.7 | 24 | | | | | | | | | | | |
| 120 | | **118.8 ft to 123.9 ft (Run No. 25)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 118.8 / 571.9 | 25 | | | | | | | | | | | |
| 125 | | **123.9 ft to 129.0 ft (Run No. 26)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 123.9 | 26 | | | | | | | | | Azimuth: 304.64 Inclination: -10.81 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 5 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| | HQ Core | **123.9 ft to 129.0 ft (Run No. 26)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 571.0 | 26 | | | | | | | | | | | |
| 130 | | **129.0 ft to 134.0 ft (Run No. 27)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 129.0 / 570.2 | 27 | | | | | | | | | | | |
| 135 | | **134.0 ft to 139.2 ft (Run No. 28)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 134.0 / 569.4 | 28 | | | 570 | | | | | | | | |
| 140 | | **139.2 ft to 144.2 ft (Run No. 29)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 139.2 / 568.6 | 29 | | | | | | | | | | | |
| 145 | | **144.2 ft to 149.2 ft (Run No. 30)** **LIMESTONE** - Light gray; very slight weathering; hard; crystalline; with pressure solution features; all breaks mechanical. | | 144.2 / 567.8 | 30 | | | | | | | | | | | |
| 150 | | **149.2 ft to 154.2 ft (Run No. 31)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 149.2 / 566.9 | 31 | | | | | | | | | | | |
| 155 | | **154.2 ft to 159.2 ft (Run No. 32)** **LIMESTONE** - Same as previous run; all breaks mechanical. Note: Terminate HQ core at 159.2 feet and begin NQ core to open boring for directional barrel. | | 154.2 | 32 | | | | | | | | | Azimuth: 304.39 Inclination: -11.11 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 6 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| | 5/25/2011 HQ Core | | | 566.1 | 32 | | | | | | | | | | | |
| 160 | 5/31/2011 NQ Core | **159.2 ft to 163.6 ft (Run No. 33)** **LIMESTONE** - Same as previous run; all breaks mechanical.<br><br>Note: Terminate NQ core at 163.6 feet and begin AQ directional core. | | 159.2 | 33 | | | | | | | | | | | |
| | | | | 565.4 | | | | | | | | | | | | |
| 165 | AQ Core | **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 | | | | | | | | |
| | | | | 563.9 | | | | | | | | | | | | |
| 170 | | | | 172.6 | | | | | | | | | | | | |
| 175 | | **172.6 ft to 182.6 ft (Run No. 35)** **LIMESTONE** - Light gray; slightly weathered; sound; hard; crystalline; with pressure solution features throughout; all breaks mechanical. | | | 35 | | | | | | | | | | | |
| 180 | | | | 562.3 | | | | | | | | | | | | |
| | | | | 182.6 | | | | | | | | | | | | |
| 185 | | **182.6 ft 192.6 ft (Run No. 36)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | | 36 | | | | | | | | | Azimuth: 304.39<br>Inclination: -11.11 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 7 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 190 | AQ Core | **182.6 ft 192.6 ft (Run No. 36)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 560.7 | 36 | | | | | | | | | | | |
| 195 | | **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 | | |
| 200 | | | | 559.1 | | | | | | | | | | J, R<br>J, R<br>J, R | | |
| 205 | | **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. | | 202.6 | 38 | | | | | | | | | | | |
| 210 | | | | 557.4 | | | | | | | | | | | | |
| 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<br>Inclination: -11.11 | | |
| 220 | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 8 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| | AQ Core | **212.6 ft to 222.6 ft (Run No. 39)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 555.8 | 39 | | | | | | | | | | | |
| 225 | | **222.6 ft to 232.6 ft (Run No. 40)** **LIMESTONE** - Same as previous; all breaks mechanical. | | 222.6 | 40 | | | 555 | | | | | | | | |
| 230 | | | | 554.2 | | | | | | | | | | | | |
| 235 | | **232.6 ft to 242.6 ft (Run No. 41)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 232.6 | 41 | | | | | | | | | | | |
| 240 | | | | 552.5 | | | | | | | | | | | | |
| 245 | | **242.7 ft to 252.8 ft (Run No. 42)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 242.7 | 42 | | | | | | | | | | | |
| 250 | | | | | | | | | | | | | | Azimuth: 308.50<br>Inclination: -9.38 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 9 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| | | | | 550.9 | 42 | | | | | | | | | | | |
| | | | | 252.8 | | | | | | | | | | | | |
| 255 | | **252.8 ft to 262.7 ft (Run No. 43)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | | 43 | | | 550 | | | | | | | | |
| 260 | | | | | | | | | | | | | | Azimuth: 308.50 Inclination: -9.38 | | |
| | | | | 549.3 | | | | | | | | | | | | |
| | | | | 262.7 | | | | | | | | | | | | |
| 265 | | **262.7 ft to 272.8 ft (Run No. 44)** **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 solution features throughout. | | | 44 | | | | | | | | | | | |
| 270 | AQ Core | | | | | | | | | | | | | J, R | | |
| | | | | 547.7 | | | | | | | | | | | | |
| | | | | 272.8 | | | | | | | | | | J, R<br>J, R<br>J, R<br>J, R<br>J, R<br>J, R<br>J, R | | |
| 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 | | | | | | | | | | | |
| 280 | | | | | | | | | | | | | | J, R | | |
| | | | | 546.0 | | | | | | | | | | J, R | | |
| | | | | 282.9 | 46 | | | | | | | | | | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 10 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 285 | AQ Core | **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 | | | | | 90 | J, R<br>J, R<br>J, R | | |
| 290 | | | | | | | | | | | | | 90 | J, R<br>J, R<br>J, R<br>J, R<br>J, R<br>J, R<br>J, R | | |
| 295 | | **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 | | | | | | | | | | | |
| 300 | | | | 542.8 | | | | | | | | | | | | |
| 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. | | 302.9 | 48 | | | | | | | | | | | |
| 310 | | | | 541.1 | | | | | | | | | | Azimuth: 310.47<br>Inclination: -6.98 | | |
| 315 | | **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'. | | 312.9 | 49 | | | | | | | | | | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 11 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 315 | AQ Core | **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'. | | 539.5 | 49 | | | 540 | | | | | | | | |
| 320 | | | | 322.9 | | | | | | | | | | | | |
| 325 | | **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 | | | | | | | | | | | |
| 330 | | | | 537.9 | | | | | | | | | | | | |
| 335 | | **332.9 ft to 342.9 ft (Run No. 51)** **LIMESTONE** - Same as previous run; sound; all breaks mechanical. | | 332.9 | 51 | | | | | | | | | | | 12927 |
| 340 | | | | 536.3 | | | | | | | | | | | | |
| 345 | | **342.9 ft 352.9 ft (Run No. 52)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 342.9 | 52 | | | | | | | | | Azimuth: 310.41 Inclination: -5.34 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 12 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 350 | AQ Core | **342.9 ft 352.9 ft (Run No. 52)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 534.6 | 52 | | | 535 | | | | | | | | |
| 355 | AQ Core | **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 / 533.1 | 53 | | | | | | | | | | | |
| 360 | AQ Core | | | 362.2 | | | | | | | | | | | | |
| 365 | AQ Core | **362.2 ft to 371.6 ft (Run No. 54)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 531.6 | 54 | | | | | | | | | | | |
| 370 | AQ Core | | | 371.6 | | | | | | | | | | | | |
| 375 | AQ Core | **371.6 ft to 381.6 ft (Run No. 55)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | | 55 | | | | | | | | | Azimuth: 309.10 Inclination: -3.64 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 13 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR / % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 380 | AQ Core | **371.6 ft to 381.6 ft (Run No. 55)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 530.0 | 55 | | | 530 | | | | | | | | |
| 385 | AQ Core | **381.6 ft to 390.1 ft (Run No. 56)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 381.6 / 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 / 526.9 | 57 | | | | | | | | | | | 18927 |
| 400 | AQ Core | **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 / 525.7 | 58 | | | | | | | | | | | |
| 405 | AQ Core | **407.6 ft to 412.6 ft (Run No. 59)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 407.6 | 59 | | | | | | | | | Azimuth: 309.10 Inclination: -3.64 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear

DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP

CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 14 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 410 | AQ Core | **407.6 ft to 412.6 ft (Run No. 59)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 524.9 | 59 | | | 525 | | | | | | | | |
| | | | | 412.6 | | | | | | | | | | | | |
| 415 | | **412.6 ft to 422.6 ft (Run No. 60)** **LIMESTONE** - Same as previous run; crystalline; all breaks mechanical. | | | 60 | | | | | | | | | | | |
| 420 | | | | 523.3 | | | | | | | | | | | | |
| | | | | 422.6 | | | | | | | | | | | | |
| 425 | | **422.6 ft to 432.6 ft (Run No. 61)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | | 61 | | | | | | | | | | | |
| 430 | | | | 521.7 | | | | | | | | | | | | |
| | | | | 432.6 | | | | | | | | | | | | |
| 435 | | **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. | | | 62 | | | | | | | | | Azimuth: 307.45 Inclination: -1.85 | | |
| 440 | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 15 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| | | | | 520.0 | 62 | | | | | | | | | | | |
| | | | | 442.6 | | | | 520 | | | | | | | | |
| 445 | AQ Core | **442.6 ft to 452.6 ft (Run No. 63)** **LIMESTONE** - Same as previous run; all breaks mechanical. Note: Terminate AQ directional core at 452.6 feet and begin standard NQ core. | | | 63 | | | | | | | | | | | |
| | 6/1/2011 | | | 518.4 | | | | | | | | | | | | |
| | | | | 452.6 | | | | | | | | | | | | 7028 |
| 455 | | **452.6 ft to 458.6 ft (Run No. 64)** **LIMESTONE** - Gray; very slight weathering; sound; hard; crystalline; with stylolitic features throughout. | | | 64 | | | | | | | | | | | |
| | | | | 517.4 | | | | | | | | | | | | |
| | | | | 458.6 | | | | | | | | | | | | |
| 460 | NQ Core | **458.6 ft to 468.6 ft (Run No. 65)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | | 65 | | | | | | | | | | | |
| 465 | | | | 515.8 | | | | | | | | | | | | |
| | | | | 468.6 | | | | | | | | | | | | |
| 470 | | **468.6 ft to 478.6 ft (Run No. 66)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | | 66 | | | | | | | | | Azimuth: 308.58 Inclination: -0.36 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 16 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | FLUSH | COLOR / % RETURN | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | | |
| | | | | | | | | | 515 | | | | | | | | |
| 475 | NQ Core | **468.6 ft to 478.6 ft (Run No. 66)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 514.2 | 66 | | | | | | | | | | | | |
| | | | | 478.6 | | | | | | | | | | | | | |
| 480 | | **478.6 ft to 488.6 ft (Run No. 67)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | | 67 | | | | | | | | | | | | |
| 485 | | | | 512.6 | | | | | | | | | | | | | |
| | | | | 488.6 | | | | | | | | | | | | | |
| 490 | | **488.6 ft to 498.6 ft (Run No. 68)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | | 68 | | | | | | | | | | | | |
| 495 | | | | 510.9 | | | | | | | | | | | | | |
| | | | | 498.6 | | | | | | | | | | | | | |
| 500 | | **498.6 ft to 508.6 ft (Run No. 69)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | | 69 | | | | | | | | | | Azimuth: 308.62 Inclination: -0.29 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 17 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | 510 | | | | | | | | |
| 505 | NQ Core | **498.6 ft to 508.6 ft (Run No. 69)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 509.3 | 69 | | | | | | | | | | | |
| 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 / 507.7 | 70 | | | | | | | | | | | 8294 |
| 515 | | | | | | | | | | | | | | | | |
| 520 | | **518.6 ft to 528.6 ft (Run No. 71)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 518.6 / 506.0 | 71 | | | | | | | | | | | |
| 525 | | | | | | | | | | | | | | | | |
| 530 | | **528.6 ft to 538.6 ft (Run No. 72)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 528.6 | 72 | | | | | | | | | Azimuth: 307.93 Inclination: -0.28 | | |
| 535 | | *--- CONTINUED NEXT PAGE ---* | | | | | | 505 | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 18 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| | NQ Core | **528.6 ft to 538.6 ft (Run No. 72)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 504.4 | 72 | | | | | | | | | | | |
| 540 | 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. | | 538.6 | 73 | | | | | | | | | | | |
| 545 | | | | 502.8 | | | | | | | | | | | | |
| 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 | | | | | | | | | | | |
| 555 | | | | 501.2 | | | | | | | | | | | | |
| 560 | | | | 558.6 | | | | | | | | | | | | 25343 |
| 565 | | **558.6 ft to 568.6 ft (Run No. 75)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | | 75 | | | 500 | | | | | | Azimuth: 307.93 Inclination: -0.28 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 19 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| | NQ Core | **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. | | 568.6 | 76 | | | | | | | | | | | |
| 575 | | | | 497.9 | | | | | | | | | | | | |
| 580 | | **578.6 ft to 588.6 ft (Run No. 77)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 578.6 | 77 | | | | | | | | | | | |
| 585 | | | | 496.3 | | | | | | | | | | | | |
| 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. | | 588.6 | 78 | | | 495 | | | | | | Azimuth: 308.68 Inclination: -0.34 | | |
| 595 | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 20 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 600 | 6/2/2011 | **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. | | 598.6 | 79 | | | | | | | | | | | |
| 605 | | | | 493.2 | | | | | | | | | | | | |
| 610 | AQ Core | **607.6 ft to 617.6 ft (Run No. 80)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 607.6 | 80 | | | | | | | | | | | |
| 615 | | | | 491.6 | | | | | | | | | | | | |
| 620 | | **617.6 ft to 627.6 ft (Run No. 81)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 617.6 | 81 | | | | | | | | | | | 18053 |
| 625 | 6/3/2011 | | | 489.9 | | | | 490 | | | | | | Azimuth: 309.00 Inclination: -1.6 | | |
| | AQ Core | | | 627.6 | 82 | | | | | | | | | | | |
| 630 | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 21 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | FLUSH | COLOR % RETURN | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | | |
| 630 | 6/3/2011 AQ Core | **627.6 ft to 637.6 ft (Run No. 82)** **LIMESTONE** - Gray; very slight weathering; sound; hard; crystalline; with white calcite veins and pressure solution features throughout; fracture at 635.6' to 635.9' along thin shale parting.<br><br>Note: Terminate AQ directional core at 637.6 feet and begin NQ core. | | 488.3 | 82 | | | | | | | | | | | | |
| 635 | | | | 637.6 | | | | | | | | | | | | | |
| 640 | | **637.6 ft to 643.6 ft (Run No. 83)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 487.3 | 83 | | | | | | | | | | | | |
| 645 | NQ Core | **643.6 ft to 653.6 ft (Run No. 84)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 643.6 | 84 | | | | | | | | | | | | |
| 650 | | | | 485.7 | | | | | | | | | | | | | |
| 655 | | **653.6 ft to 663.6 ft (Run No. 85)** **LIMESTONE** - Gray; very slight weathering; sound; hard; crystalline; all breaks mechanical. | | 653.6 | 85 | | | | 485 | | | | | | Azimuth: 308.42<br>Inclination: -2.53 | | |
| 660 | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring



LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR / % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| | NQ Core | **653.6 ft to 663.6 ft (Run No. 85)** **LIMESTONE** - Gray; very slight weathering; sound; hard; crystalline; all breaks mechanical. | | 484.1 / 663.6 | 85 | | | | | | | | | | | |
| 665 | NQ Core | **663.6 ft to 673.6 ft (Run No. 86)** **LIMESTONE** - Gray; very slight weathering; sound; hard; crystalline; all breaks mechanical. | | 482.5 / 673.6 | 86 | | | | | | | | | | | |
| 670 | NQ Core | **673.6 ft to 683.6 ft (Run No. 87)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 480.8 / 683.6 | 87 | | | | | | | | | | | 20262 |
| 675 | NQ Core | **683.6 ft to 693.6 ft (Run No. 88)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | | 88 | | | 480 | | | | | | Azimuth: 308.42 Inclination: -2.53 | | |
| 680 | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |
| 685 | | | | | | | | | | | | | | | | |
| 690 | | | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 23 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°  AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| | 6/4/2011 | | | 479.2 | 88 | | | | | | | | | | | |
| | | | | 693.6 | | | | | | | | | | | | |
| 695 | | **693.6 ft to 703.6 ft (Run No. 89)** **LIMESTONE** - Gray; very slight weathering; sound; hard; crystalline; all breaks mechanical. | | | 89 | | | | | | | | | | | |
| 700 | | | | | | | | | | | | | | | | |
| | | | | 477.6 | | | | | | | | | | | | |
| | | | | 703.6 | | | | | | | | | | | | |
| 705 | | | | | | | | | | | | | | J, R | | |
| | NQ Core | 703.6 ft to 713.6 ft (Run No. 90) LIMESTONE - Same as previous run; Joint at 707.0' | | | 90 | | | | | | | | | | | |
| 710 | | | | | | | | | | | | | | | | |
| | | | | 476.0 | | | | | | | | | | | | |
| | | | | 713.6 | | | | | | | | | | | | |
| 715 | | **703.6 ft to 723.6 ft (Run No. 91)** **LIMESTONE** - Gray; very slight weathering; sound; hard; crystalline; occasional pressure solution features. | | | 91 | | | 475 | | | | | | Azimuth: 308.42 Inclination: -2.53 | | |
| 720 | | | | | | | | | | | | | | | | |
| | | | | 474.3 | | | | | | | | | | | | |
| | | | | 723.6 | 92 | | | | | | | | | | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 24 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 725 | NQ Core | **723.6 ft to 733.6 ft (Run No. 92)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | | 92 | | | | | | | | | | | |
| | | | | 472.7 | | | | | | | | | | | | |
| 730 | NQ Core | **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 directional core at 743.6 feet. | | 733.6 | 93 | | | | | | | | | | | |
| 735 | 6/4/2011 | | | 471.1 | | | | | | | | | | | | |
| 740 | AQ Core | **743.6 ft to 752.6 ft (Run No. 94)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 743.6 | 94 | | | | | | | | | | | 4399 |
| 745 | 6/5/2011 | | | 469.6 | | | | | | | | | | | | |
| 750 | AQ Core | **752.6 ft to 762.6 ft (Run No. 95)** **LIMESTONE** - Same as previous run; Joint at 761.7'. | | 752.6 | 95 | | | 470 | | | | | | Azimuth: 308.07 Inclination: -2.59 | | |
| 755 | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 25 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR / % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 760 | AQ Core | **752.6 ft to 762.6 ft (Run No. 95)** **LIMESTONE** - Same as previous run; Joint at 761.7'. | | 468.0 | 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 / 466.4 | 96 | | | | | | | | | | | |
| 770 | AQ Core | **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. | | 772.6 / 464.9 | 97 | | | 465 | | | | | | | | |
| 775 | AQ Core | **781.9 ft to 792.0 ft (Run No. 98)** **LIMESTONE** - Gray; very slight weathering; hard; crystalline; sound. | | 781.9 | 98 | | | | | | | | | Azimuth: 309.74 Inclination: -2.7 | | |
| 780 | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |
| 785 | | | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 26 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 790 | AQ Core | **781.9 ft to 792.0 ft (Run No. 98)** **LIMESTONE** - Gray; very slight weathering; hard; crystalline; sound. | | 463.2 | 98 | | | | | | | | | | | |
| 795 | AQ Core | **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. | | 792.0 | 99 | | | | | | | | | | | |
| 800 | AQ Core | | | 461.6 | | | | | | | | | | | | |
| 805 | AQ Core | **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. | | 802.0 | 100 | | | | | | | | | | | 12451 |
| 810 | 6/6/2011 | | | 460.0 | | | | 460 | | | | | | | | |
| 815 | AQ Core | **812.0 ft to 822.0 ft (Run No. 101)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 812.0 | 101 | | | | | | | | | Azimuth: 311.1 Inclination: -3.2 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 27 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 820 | AQ Core | **812.0 ft to 822.0 ft (Run No. 101)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 458.3 | 101 | | | | | | | | | | | |
| 825 | | **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 | | |
| 830 | | | | | | | | | | | | | | | | |
| 835 | | **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 | | | | | | | | | J, R<br>J, R<br>J, R | | |
| 840 | | | | | | | | | | | | | | | | |
| 845 | | **842.0 ft to 852.0 ft (Run No. 104)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 842.0 | 104 | | | 455 | | | | | | Azimuth: 311.27<br>Inclination: -3.1 | | |
| 850 | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 28 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| | 6/7/2011 AQ Core | **842.0 ft to 852.0 ft (Run No. 104)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 453.5 | 104 | | | | | | | | | | | |
| 855 | NQ 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. | | 852.0 / 452.0 | 105 | | | | | | | | | | | |
| 860 | | | | | | | | | | | | | | | | |
| 865 | 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. | | 861.0 / 450.7 | 106 | | | | | | | | | | | 22408 |
| 870 | 6/8/2011 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. | | 869.0 / 449.2 | 107 | | | 450 | | | | | | | | |
| 875 | | | | | | | | | | | | | | | | |
| 880 | AQ 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 ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 29 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 885 | AQ Core | **878.0 ft to 888.0 ft (Run No. 108)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 447.6 | 108 | | | | | | | | | | | |
| 890 | AQ Core | **888.0 ft to 898.0 ft (Run No. 109)** **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', 895.2', 895.3'. Calcite vugs at 888.8' and 895.4'; occasional pressure solution features and white calcite veins; hard; crystalline. | | 888.0 | 109 | | | | | | | | | Calcite vug<br>J, R<br>J, R<br>J, R<br>J, R<br>J, R<br>J, R<br>J, R<br>J, R<br>J, R<br>Calcite vug | | |
| 895 | AQ Core | | | 446.0 | | | | | | | | | | | | |
| 900 | AQ Core | **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 | | | | | | | | |
| 905 | AQ Core | | | 444.3 | | | | | | | | | | | | |
| 910 | AQ Core | **908.0 ft to 918.0 ft (Run No. 111)** **LIMESTONE** - Same as previous run; with wide joint spacing and calcite crystals. | | 908.0 | 111 | | | | | | | | | Azimuth: 312.45<br>Inclination: -3.3 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 30 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 915 | | **908.0 ft to 918.0 ft (Run No. 111)** **LIMESTONE** - Same as previous run; with wide joint spacing and calcite crystals. | | 442.7 | 111 | | | | | | | | | | | 19538 |
| 920 | AQ Core | **918.0 ft to 928.0 ft (Run No. 112)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 441.1 | 112 | | | | | | | | | | | |
| 925 | 6/9/2011 | | | | | | | | | | | | | | | |
| 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 | | | | | | | | |
| 935 | | | | | | | | | | | | | | | | |
| 940 | | **938.0 ft to 948.0 ft (Run No. 114)** **LIMESTONE** - Same as previous run; trace fossils; all breaks mechanical. | | 938.0 | 114 | | | | | | | | | Azimuth: 313.8 Inclination: -1.7 | | |
| 945 | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 31 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR / % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 945 | | **938.0 ft to 948.0 ft (Run No. 114)** **LIMESTONE** - Same as previous run; trace fossils; all breaks mechanical. | | 437.8 | 114 | | | | | | | | | | | |
| 950 | | **948.0 ft to 958.0 ft (Run No. 115)** **LIMESTONE** - Same as previous run; with dark gray pressure solution features. | | 948.0 / 436.2 | 115 | | | | | | | | | | | |
| 955 | AQ Core | | | | | | | | | | | | | | | |
| 960 | | **958.0 ft to 968.0 ft (Run No. 116)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 958.0 / 434.6 | 116 | | | 435 | | | | | | | | |
| 965 | 6/10/2011 | | | | | | | | | | | | | | | |
| 970 | 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. | | 968.0 | 117 | | | | | | | | | Azimuth: 313.8 Inclination: -1.7 | | 9161 |
| 975 | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 32 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| | | | | 433.0 | 117 | | | | | | | | | | | |
| | | | | 978.0 | | | | | | | | | | J, R<br>J, R<br>J, R<br>J, R | | |
| 980 | | **978.0 ft to 988.0 ft (Run No. 118)**<br>**LIMESTONE** - Gray; very slight weathering; slightly fractured; close joint spacing with joints at 978.2', 978.4', 978.9', 979.2'; hard; crystalline; with pressure solution features throughtout. | | | 118 | | | | | | | | | | | |
| 985 | AQ Core | | | | | | | | | | | | | | | |
| | | | | 431.3 | | | | | | | | | | | | |
| | | | | 988.0 | | | | | | | | | | | | |
| 990 | | | | | | | | | | | | | | | | |
| | | **978.0 ft to 998.0 ft (Run No. 119)**<br>**LIMESTONE** - Same as previous run; all breaks mechanical.<br><br>Note: Terminate AQ directional core at 998.0 feet and begin NQ core. | | | 119 | | | | | | | | | | | |
| 995 | | | | | | | | | | | | | | | | |
| | 6/11/2011 | | | | | | | 430 | | | | | | | | |
| | | | | 429.7 | | | | | | | | | | | | |
| | | | | 998.0 | | | | | | | | | | | | |
| 1000 | | | | | | | | | | | | | | | | |
| | NQ Core | **998.0 ft to 1009.0 ft (Run No. 120)**<br>**LIMESTONE** - Same as previous run; fracture at 1000.7', 1001.3', 1002.0', 1004.5'. | | | 120 | | | | | | | | | Azimuth: 313.97<br>Inclination: -0.28 | | |
| 1005 | | | | | | | | | | | | | | | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 33 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| | | | | 427.9 | 120 | | | | | | | | | | | |
| | | | | 1009.0 | | | | | | | | | | | | |
| 1010 | | | | | | | | | | | | | | | | |
| 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 | | | | | | | | 16391 |
| 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 | | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear

DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP

CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 34 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1040 | NQ Core 6/12/2011 | | | 422.7 | 123 | | | | | | | | | | | |
| | | **1041.0 ft to 1051.0 ft (Run No. 124)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 1041.0 | 124 | | | | | | | | | | | |
| 1050 | | | | 421.1 | | | | | | | | | | | | |
| | | **1051.0 ft to 1061.0 ft (Run No. 125)** **LIMESTONE** - Same as previous run; fracture at 1052.0' to 1059.0' with clay. | | 1051.0 | 125 | | | 420 | | | | | | | | |
| 1060 | | | | 419.5 | | | | | | | | | | | | |
| | NQ Core | **1061.0 ft to 1071.0 ft (Run No. 126)** **LIMESTONE** - Light gray; very slight weathering; moderately hard; sound; fine grained; all breaks mechanical. | | 1061.0 | 126 | | | | | | | | | Azimuth: 313.86 Inclination: 0.25 | | |
| 1070 | | | | 417.8 | | | | | | | | | | | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 35 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1075 | NQ Core | **1071.0 ft to 1081.0 ft (Run No. 127)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 1071.0 / 416.2 | 127 | | | 415 | | | | | | | | |
| 1080 | | | | | | | | | | | | | | | | |
| 1085 | | **1081.0 ft to 1091.0 ft (Run No. 128)** **LIMESTONE** - Gray; very slight weathering; moderately hard; sound; fine grained. | | 1081.0 / 414.6 | 128 | | | | | | | | | | | |
| 1090 | | | | | | | | | | | | | | | | 19322 |
| 1095 | | **1091.0 ft to 1101.0 ft (Run No. 129)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 1091.0 / 413.0 | 129 | | | | | | | | | Azimuth: 314.32 Inclination: 0.04 | | |
| 1100 | | **1101.0 ft to 1111.0 ft (Run No. 130)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 1101.0 | 130 | | | | | | | | | | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 36 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1105 | NQ Core | **1101.0 ft to 1111.0 ft (Run No. 130)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | | 130 | | | | | | | | | | | |
| 1110 | | | | 411.3 | | | | | | | | | | | | |
| 1115 | | **1111.0 ft to 1121.0 ft (Run No. 131)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 1111.0 | 131 | | | 410 | | | | | | | | |
| 1120 | | | | 409.7 | | | | | | | | | | | | |
| 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 grained; | | 1121.0 | 132 | | | | | | | | | J, R | | |
| 1130 | | | | 408.1 | | | | | | | | | | | | |
| | | **1131.0 ft to 1141.0 ft (Run No. 133)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | 1131.0 | 133 | | | | | | | | | Azimuth: 314.77 Inclination: 0.02 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 37 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1135 | NQ Core | **1131.0 ft to 1141.0 ft (Run No. 133)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | | 133 | | | | | | | | | | | |
| 1140 | | | | 406.5 / 1141.0 | | | | | | | | | | | | |
| 1145 | | **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. | | | 134 | | | | | | | | | | | 24908 |
| 1150 | 6/13/2011 | | | 404.8 / 1151.0 | | | | 405 | | | | | | | | |
| 1155 | NQ Core | **1151.0 ft to 1161.0 ft (Run No. 135)** **LIMESTONE** - Same as previous run; all breaks mechanical. | | | 135 | | | | | | | | | | | |
| 1160 | | | | 403.2 / 1161.0 | | | | | | | | | | | | |
| 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. | | | 136 | | | | | | | | | Azimuth: 314.77 Inclination: 0.02 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring



LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR / % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1170 | NQ Core | **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. | | 401.6 / 1171.0 | 136 | | | | | | | | | | | |
| 1175 | | **1171.0 ft to 1181.0 ft (Run No. 137)** **LIMESTONE** - Same as previous run; fracture at 1173.4'. | | 399.9 / 1181.0 | 137 | | | 400 | | | | | | | | |
| 1180 | | | | | | | | | | | | | | | | |
| 1185 | | **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'. | | 398.3 / 1191.0 | 138 | | | | | | | | | | | |
| 1190 | | | | | | | | | | | | | | | | |
| 1195 | | **1191.0 ft to 1201.0 ft (Run No. 139)** **LIMESTONE** - Gray green; very slight weathering; sound; hard; crystalline; with pressure solution features throughout. | | | 139 | | | | | | | | | Azimuth: 314.77 Inclination: -0.10 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 39 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR / % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1200 | NQ Core 6/16/2011 | **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 | | | | | | | | | | | |
| 1205 | NQ Core 6/19/2011 | **1201.0 ft to 1211.0 ft (Run No. 140) LIMESTONE** - Same as previous run; all breaks mechanical.<br><br>Note: Terminate NQ core at 1211.0 feet and begin AQ directional core. | | 1201.0 | 140 | | | | | | | | | | | |
| 1210 | | | | 395.1 | | | | | | | | | | | | 21884 |
| 1215 | AQ Core 6/20/2011 | **1211.0 ft to 1219.0 ft (Run No. 141) LIMESTONE** - Light gray; very slight weathering; sound; hard; crystalline.<br><br>Note: Breaks in core caused by directional core barrel. | | 1211.0 | 141 | | | 395 | | | | | | | | |
| 1220 | | | | 393.8 | | | | | | | | | | | | |
| 1225 | 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.<br><br>Note: **Waldron Shale encountered at 1220.0 feet.** | | 1219.0 | 142 | | | | | | | | | Azimuth: 314.84<br>Inclination: -0.14 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 40 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| | | | | 392.1 | 142 | | | | | | | | | | | |
| | | | | 1229.0 | | | | | | | | | | | | |
| 1230 | | **1229.0 ft to 1239.0 ft (Run No. 143)** **SHALE** - Gray; very slight weathering; sound; hard; calcareous; with calcite vugs; pyritic. | | | 143 | | | | | | | | | | | |
| 1235 | | | | 390.5 | | | | | | | | | | | | |
| | | | | 1239.0 | | | | 390 | | | | | | | | |
| 1240 | | **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 | | | | | | | | | | | |
| 1245 | AQ Core | | | | | | | | | | | | | | | |
| | | | | 388.9 | | | | | | | | | | | | |
| | | | | 1249.0 | | | | | | | | | | | | |
| 1250 | | **1249.0 ft to 1259.0 ft (Run No. 145)** **SHALE** - Light gray to dark gray; very slight weathering; sound; hard; fine grained; calcareous; trace fossils; occasional calcite vugs. | | | 145 | | | | | | | | | Azimuth: 314.11 Inclination: -0.55 | | |
| 1255 | | | | | | | | | | | | | | | | |
| | 6/21/2011 | | | 387.3 | | | | | | | | | | | | |
| | | | | 1259.0 | 146 | | | | | | | | | | | |
| 1260 | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 41 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1260 | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| | AQ Core | **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 | | | | | | | | | | | |
| 1265 | | | | 1269.0 | | | | | | | | | | | | |
| 1270 | | **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. | | | 147 | | | 385 | | | | | | | | 22972 |
| 1275 | | | | 384.0 | | | | | | | | | | | | |
| 1280 | | **1279.0 ft to 1289.0 ft (Run No. 148)** **SHALE** - Same as previous run; all breaks mechanical. | | 1279.0 | 148 | | | | | | | | | | | |
| 1285 | | | | 382.4 | | | | | | | | | | | | |
| 1290 | | | | 1289.0 | 149 | | | | | | | | | Azimuth: 311.43 Inclination: -1.87 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring



LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1295 | 6/22/2011 AQ Core | **1289.0 ft to 1299.0 ft (Run No. 149)** **SHALE** - Dark gray; very slight weathering; sound; moderately hard; fine grained; calcareous.<br><br>Note: Terminate AQ directional core at 1299.0 feet and begin NQ core.<br><br>**1289.0 ft to 1299.0 ft (Run No. 149)** **SHALE** - Dark gray; very slight weathering; sound; moderately hard; fine grained; calcareous.<br><br>Note: Terminate AQ directional core at 1299.0 feet and begin NQ core. | | 380.8 | 149 | | | | | | | | | | | |
| 1300 | NQ Core | **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. | | 1299.0<br>379.5 | 150 | | | 380 | | | | | | | | |
| 1310 | | **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. | | 1307.0<br>377.8 | 151 | | | | | | | | | | | |
| 1315 | | | | | | | | | | | | | | | | |
| 1320 | | **1317.0 ft to 1327.0 ft (Run No. 152)** **SHALE** - Same as previous run; all breaks mechanical. | | 1317.0 | 152 | | | | | | | | | Azimuth: 311.77<br>Inclination: -2.29 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 43 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1325 | NQ Core | **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 / 374.6 | 153 | | | 375 | | | | | | | | 8226 |
| 1340 | | **1337.0 ft to 1347.0 ft (Run No. 154)** **SHALE** - Same as previous run; all breaks mechanical. | | 1337.0 / 372.9 | 154 | | | | | | | | | | | |
| 1345 | | | | | | | | | | | | | | | | |
| 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 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 44 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1355 | NQ Core | **1347.0 ft to 1357.0 ft (Run No. 155)** **SHALE** - Same as previous run; all breaks mechanical. | | 371.3 | 155 | | | | | | | | | | | |
| 1360 | NQ Core | **1357.0 ft to 1367.0 ft (Run No. 156)** **SHALE** - Dark gray; very slight weathering; sound; moderately hard; fine grained; calcareous. | | 1357.0 / 369.7 | 156 | | | 370 | | | | | | | | |
| 1365 | 6/23/2011 | | | | | | | | | | | | | | | |
| 1370 | NQ Core | **1367.0 ft to 1377.0 ft (Run No. 157)** **SHALE** - Same as previous run; all breaks mechanical. | | 1367.0 / 368.1 | 157 | | | | | | | | | | | |
| 1375 | NQ Core | | | 1377.0 | | | | | | | | | | | | |
| 1380 | | **1377.0 ft to 1387.0 ft (Run No. 158)** **SHALE** - Same as previous run; all breaks mechanical. | | | 158 | | | | | | | | | Azimuth: 311.92 Inclination: -2.14 | | |
| 1385 | | | | | | | | | | | | | | | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring



LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR / % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| | | | | 366.4 | 158 | | | | | | | | | | | |
| | | **1387.0 ft to 1397.0 ft (Run No. 159)** **SHALE** - Same as previous run; all breaks mechanical. | | 1387.0 / 364.8 | 159 | | | 365 | | | | | | | | 7008 |
| | NQ Core | **1397.0 ft to 1407.0 ft (Run No. 160)** **SHALE** - Dark gray; very slight weathering; sound; moderately hard; fine grained; calcareous. | | 1397.0 / 363.2 | 160 | | | | | | | | | | | |
| | | **1407.0 ft to 1417.0 ft (Run No. 161)** **SHALE** - Gray; very slight weathering; sound; moderately hard; fine grained; with dark gray, soft, thin shale partings; calcareous; occasional pyrite. | | 1407.0 / 361.6 | 161 | | | | | | | | | Azimuth: 311.92 Inclination: -2.14 | | |
| | | | | 1417.0 | 162 | | | | | | | | | | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

1390 1395 1400 1405 1410 1415

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring



LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1420 | NQ Core 6/24/2011 | **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 | | | | | | | | |
| 1425 | | | | 1427.0 | | | | | | | | | | | | |
| 1430 | | **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. | | | 163 | | | | | | | | | | | |
| 1435 | | | | 358.3 | | | | | | | | | | | | |
| | NQ Core | | | 1437.0 | | | | | | | | | | | | |
| 1440 | | **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 horizontally. Shale is moderately hard; fine grained.<br><br>Note: Approximately 40 percent water loss at 1440.0 feet. | | | 164 | | | | | | | | | | | |
| 1445 | | | | 356.7 | | | | | | | | | | Azimuth: 312.07<br>Inclination: -1.9 | | |
| | | **1447.0 ft to 1457.0 ft (Run No. 165)** **SHALE** - Same as previous run; fractured at 1447.0' to 1450.0'. | | 1447.0 | 165 | | | | | | | | | | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 47 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % (80 60 40 20) | RECOVERY: SOLID CORE % (80 60 40 20) | R.Q.D. % (80 60 40 20) | FRACT. INDEX PER FT (5 10 15 20) | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS (0 30 60 90) | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec ($10^{-6}$ $10^{-5}$ 250 500 750) | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1450 | NQ Core | **1447.0 ft to 1457.0 ft (Run No. 165)** **SHALE** - Same as previous run; fractured at 1447.0' to 1450.0'. | | 355.1 | 165 | | | | | | | | | | | 1266 |
| 1455 | | | | 1457.0 | | | | 355 | | | | | | | | |
| 1460 | | **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. | | | 166 | | | | | | | | | | | |
| 1465 | | | | 353.4 | | | | | | | | | | | | |
| 1470 | | **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. | | 1467.0 | 167 | | | | | | | | | | | |
| 1475 | | | | 351.8 | | | | | | | | | | | | |
| 1480 | | **1477.0 ft to 1485.5 ft (Run No. 168)** **SHALE** - Gray; slightly weathered; moderately to severly fractured with fractures occuring horizonally for length of run; occasional clay at fractures; moderately hard; fine grained; pyritic. | | 1477.0 | 168 | | | | | | | | | Azimuth: 312.18 Inclination: -1.33 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 48 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1485 | NQ Core 6/25/2011 | **1477.0 ft to 1485.5 ft (Run No. 168)** **SHALE** - Gray; slightly weathered; moderately to severly fractured with fractures occuring horizonally for length of run; occasional clay at fractures; moderately hard; fine grained; pyritic. | | 350.4 | 168 | | | 350 | | | | | | | | |
| 1490 | | **1485.5 ft to 1492.5 ft (Run No. 169)** **SHALE** - Same as previous run. | | 1485.5 / 349.3 | 169 | | | | | | | | | | | |
| 1495 | | **1492.5 ft to 1502.0 ft (Run No. 170)** **SHALE** - Same as previous run; moderately hard to soft; fractured horizontally for length of run. | | 1492.5 / 347.7 | 170 | | | | | | | | | | | |
| 1500 | | | | | | | | | | | | | | | | |
| 1505 | NQ Core | **1502.0 ft to 1512.0 ft (Run No. 171)** **SHALE** - Dark gray; slightly weathered; severly fractured; soft; fine grained; with clay at fractures; shale is sound from 1509.5' to 1512.0'. | | 1502.0 / 346.1 | 171 | | | | | | | | Azimuth: 312.18<br>Inclination: -1.33 | | | 1079 |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 49 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1515 | NQ Core | **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. | | 1512.0 | 172 | | | 345 | | | | | | | | |
| 1520 | | | | 344.5 | | | | | | | | | | | | |
| 1525 | NQ Core | **1522.0 ft to 1532.0 ft (Run No. 173)** **SHALE** - Gray; very slight weathering; slightly fractured; moderately hard; fine grained; pyritic. | | 1522.0 | 173 | | | | | | | | | | | |
| 1530 | | | | 342.9 | | | | | | | | | | | | |
| 1535 | NQ Core | **1532.0 ft to 1542.0 ft (Run No. 174)** **SHALE** - Same as previous run; all breaks mechanical. | | 1532.0 | 174 | | | | | | | | | | | |
| 1540 | 6/26/2011 | | | 341.2 | | | | | | | | | | | | |
| | NQ Core | **1542.0 ft to 1552.0 ft (Run No. 175)** **SHALE** - Gray; very slight weathering; sound; moderately hard; fine grained; pyritic; all breaks mechanical. | | 1542.0 | 175 | | | | | | | | | Azimuth: 311.81 Inclination: -0.88 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 50 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1545 | NQ Core | **1542.0 ft to 1552.0 ft (Run No. 175)** **SHALE** - Gray; very slight weathering; sound; moderately hard; fine grained; pyritic; all breaks mechanical. | | 339.6 | 175 | | | 340 | | | | | | | | |
| 1550 | | | | 1552.0 | | | | | | | | | | | | |
| 1555 | | **1552.0 ft to 1562.0 ft (Run No. 176)** **SHALE** - Same as previous run; all breaks mechanical. | | 338.0 | 176 | | | | | | | | | | | |
| 1560 | | | | 1562.0 | | | | | | | | | | | | |
| 1565 | | **1562.0 ft to 1572.0 ft (Run No. 177)** **SHALE** - Same as previous run; all breaks mechanical. | | 336.4 | 177 | | | | | | | | | | | |
| 1570 | | | | 1572.0 | | | | | | | | | | | | |
| 1575 | | **1572.0 ft to 1582.0 ft (Run No. 178)** **SHALE** - Gray; very slight weathering; sound; fine grained; moderately hard; pyritic. | | | 178 | | | | | | | | | Azimuth: 311.81 Inclination: -0.88 | | 6725 |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring



LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1575 | NQ Core | **1572.0 ft to 1582.0 ft (Run No. 178)** **SHALE** - Gray; very slight weathering; sound; fine grained; moderately hard; pyritic. | | 334.7 | 178 | | | 335 | | | | | | | | |
| 1580 | | | | 1582.0 | | | | | | | | | | | | |
| 1585 | | **1582.0 ft to 1592.0 ft (Run No. 179)** **SHALE** - Same as previous run; all breaks mechanical. | | | 179 | | | | | | | | | | | |
| 1590 | 6/27/2011 | | | 333.1 | | | | | | | | | | | | |
| | | | | 1592.0 | | | | | | | | | | | | |
| 1595 | | **1592.0 ft to 1602.0 ft (Run No. 180)** **SHALE** - Same as previous run; all breaks mechanical. | | | 180 | | | | | | | | | | | |
| 1600 | NQ Core | | | 331.5 | | | | | | | | | | | | |
| | | | | 1602.0 | | | | | | | | | | | | |
| 1605 | | **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 | | | | | | | | | Azimuth: 311.97 Inclination: -0.80 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 52 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR / % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1610 | NQ Core 6/28/2011 | **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 | | **1612.0 ft to 1622.0 ft (Run No. 182)** **SHALE** - Same as previous run; all breaks mechanical. | | 328.2 | 182 | | | | | | | | | | | |
| 1620 | | | | 1612.0 | | | | | | | | | | | | |
| 1625 | | **1622.0 ft to 1632.0 ft (Run No. 183)** **SHALE** - Gray; very slight weathering; sound; moderately hard; fine grained; pyritic. | | 326.6 | 183 | | | | | | | | | | | 7499 |
| 1630 | | | | 1622.0 | | | | | | | | | | | | |
| 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 ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 53 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1640 | NQ Core | **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 | NQ Core | | | 323.7 | | | | | | | | | | | | |
| 1655 | NQ Core | **1650.0 ft to 1660.0 ft (Run No. 186)** **SHALE** - Same as previous run; all breaks mechanical. | | 1650.0 | 186 | | | | | | | | | | | |
| 1660 | NQ Core | | | 322.0 | | | | | | | | | | | | |
| 1665 | NQ Core | **1660.0 ft to 1670.0 ft (Run No. 187)** **SHALE** - Same as previous run; all breaks mechanical. | | 1660.0 | 187 | | | | | | | | | Azimuth: 312.02<br>Inclination: -0.83 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

6/29/2011

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 54 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR / % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1670 | NQ Core | | | 320.4 | 187 | | | 320 | | | | | | | | |
| | | **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 | | | | | | | | | | | |
| 1680 | | | | 318.8 | | | | | | | | | | | | |
| | | **1680.0 ft to 1690.0 ft (Run No. 189)** **SHALE** - Gray; very slight weathering; sound; moderately hard; fine grained; all breaks mechanical. | | 1680.0 | 189 | | | | | | | | | | | 0330 |
| 1690 | | | | 317.2 | | | | | | | | | | | | |
| | | **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 | | |
| 1700 | | | | | | | | | | | | | | | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

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

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring



LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

DRILLING DATE: 5/22/2011
DRILL RIG: LM90
DRILLING METHOD: HQ/NQ/AQ

NORTHING:302826.46
EASTING:1247541.18
INCLINATION: -9.36° AZIMUTH: N 306°E

DATUM:

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
CL-CLEAVAGE J-JOINT R-ROUGH UE-UNEVEN MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN S-SLICKENSIDED PL-PLANAR C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR / % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| | 6/30/2011 | | | 315.2 | 190 | | | | | | | | | | | |
| | | **1702.0 ft to 1712.0 ft (Run No. 191)** **SHALE** - Same as previous run; all breaks mechanical. | | 1702.0 | 191 | | | 315 | | | | | | | | |
| 1705 | | | | | | | | | | | | | | | | |
| 1710 | | | | 313.6 | | | | | | | | | | | | |
| | | **1712.0 ft to 1722.0 ft (Run No. 192)** **SHALE** - Gray; very slight weathering; sound to slightly fractured with clay seam at 1713.6' to 1714.8'; moderately hard; fine grained. | | 1712.0 | 192 | | | | | | | | | | | |
| 1715 | | | | | | | | | | | | | | | | |
| 1720 | | | | 312.0 | | | | | | | | | | | | |
| | | **1722.0 ft to 1732.0 ft (Run No. 193)** **SHALE** - Gray; very slight weathering; sound; moderately hard; fine grained. | | 1722.0 | 193 | | | | | | | | | Azimuth: 312.15 Inclination: -0.84 | | |
| 1725 | | | | | | | | | | | | | | | | |
| 1730 | | | | 310.3 | | | | | | | | | | | | |
| | | | | 1732.0 | 194 | | | | | | | | | | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

NQ Core

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 56 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1735 | NQ Core | **1732.0 ft to 1742.0 ft (Run No. 194)** **SHALE** - Same as previous run; all breaks mechanical. | | 308.7 | 194 | | | 310 | | | | | | | | |
| 1740 | | | | 1742.0 | | | | | | | | | | | | |
| 1745 | | **1742.0 ft to 1752.0 ft (Run No. 195)** **SHALE** - Gray; very slight weathering; sound; moderately hard; fine grained. | | 307.1 | 195 | | | | | | | | | | | |
| 1750 | | | | 1752.0 | | | | | | | | | | | | |
| 1755 | | **1752.0 ft to 1762.0 ft (Run No. 196)** **SHALE** - Same as previous run; all breaks mechanical. | | 305.5 | 196 | | | | | | | | | | | |
| 1760 | | | | 1762.0 | 197 | | | | | | | | | Azimuth: 312.15 Inclination: -0.84 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 57 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1765 | NQ Core 7/1/2011 | **1762.0 ft to 1772.0 ft (Run No. 197)** **SHALE** - Same as previous run; all breaks mechanical.<br><br>Note: No water return at start of drilling on 7/1/2011. Water return was at approximately 45 to 50 percent on previous day. | | 303.8 | 197 | | | 305 | | | | | | | | |
| 1770 | | | | 1772.0 | | | | | | | | | | | | |
| 1775 | | **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. | | | 198 | | | | | | | | | | | |
| 1780 | | | | 302.2 | | | | | | | | | | | | |
| 1785 | NQ Core | **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. | | 1782.0 | 199 | | | | | | | | | | | |
| 1790 | | | | 300.6 | | | | | | | | | | | | |
| 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. | | 1792.0 | 200 | | | | | | | | | Azimuth: 312.04<br>Inclination: -1.1 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 58 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR / % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | 300 | | | | | | | | |
| | NQ Core | **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 | | | | | | | | | | | |
| 1800 | NQ Core | **1800.0 ft to 1812.0 ft ( Run No. 201)** **SHALE** - Same as previous run; severly fractured for length of run. | | 1800.0 297.3 | 201 | | | | | | | | | | | 4424 |
| 1810 | NQ Core | **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. | | 1812.0 295.7 | 202 | | | | | | | | | | | |
| 1820 | NQ Core | **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<br>Inclination: -1.59 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring



LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

DRILLING DATE: 5/22/2011
DRILL RIG: LM90
DRILLING METHOD: HQ/NQ/AQ

NORTHING:302826.46
EASTING:1247541.18
INCLINATION: -9.36°  AZIMUTH: N 306°E

DATUM:

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1830 | NQ Core 7/2/2011 | **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. | | 294.1 | 203 | | | | | | | | | | | |
| | | | | 1832.0 | | | | | | | | | | | | |
| 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. | | | 204 | | | | | | | | | | | |
| 1840 | | | | 292.4 | | | | | | | | | | | | |
| | | | | 1842.0 | | | | | | | | | | | | |
| 1845 | NQ 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. | | | 205 | | | | | | | | | | | |
| 1850 | | | | 290.8 | | | | | | | | | | | | |
| | | | | 1852.0 | | | | | | | | | | | | |
| 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. | | | 206 | | | 290 | | | | | | Azimuth: 311.75<br>Inclination: -1.59 | | |
| | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 60 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1860 | NQ Core | **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. | | 289.2 | 206 | | | | | | | | | | | |
| | | | | 1862.0 | | | | | | | | | | | | |
| 1865 | | **1862.0 ft to 1872.0 ft (Run No. 207)** **SHALE** - Gray; very slight weathering; sound; moderately hard; fine grained. | | | 207 | | | | | | | | | | | 1911 |
| 1870 | | | | 287.6 | | | | | | | | | | | | |
| | | | | 1872.0 | | | | | | | | | | | | |
| 1875 | | **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. | | | 208 | | | | | | | | | | | |
| 1880 | | | | 285.9 | | | | | | | | | | | | |
| | | | | 1882.0 | | | | | | | | | | | | |
| 1885 | | **1882.0 ft to 1892.0 ft (Run No. 209)** **SHALE** - Same as previous run; all breaks mechanical. | | | 209 | | | 285 | | | | | | Azimuth: 311.75<br>Inclination: -1.59 | | |
| 1890 | | *--- CONTINUED NEXT PAGE ---* | | | | | | | | | | | | | | |

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear
DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED:

PROJECT: Jefferson County, Louisville Tunnel

# RECORD OF DRILLHOLE: North Bound Boring

SHEET 61 OF 61

LOCATION: Louisville, Kentucky

DRILLING DATE: 5/22/2011

NORTHING:302826.46

DATUM:

PROJECT NUMBER: 1831-10-5629

DRILL RIG: LM90

EASTING:1247541.18

DRILLING METHOD: HQ/NQ/AQ

INCLINATION: -9.36°

AZIMUTH: N 306°E

FR-FRACTURE | F-FAULT | SM-SMOOTH | FL-FLEXURED | BC-BROKEN CORE
CL-CLEAVAGE | J-JOINT | R-ROUGH | UE-UNEVEN | MB-MECH. BREAK
SH-SHEAR | P-POLISHED | ST-STEPPED | W-WAVY | B-BEDDING
VN-VEIN | S-SLICKENSIDED | PL-PLANAR | C-CURVED

| DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. / DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | COLOR % RETURN / FLUSH | ELEVATION | RECOVERY: TOTAL CORE % | RECOVERY: SOLID CORE % | R.Q.D. % | FRACT. INDEX PER FT | DISCONTINUITY DATA: DIP w.r.t. CORE AXIS | DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION | HYDRAULIC CONDUCTIVITY k, cm/sec | DIAMETRAL POINT LOAD INDEX (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *--- CONTINUED FROM PREVIOUS PAGE ---* | | | | | | | | | | | | | | |
| 1890 | 7/3/2011 NQ Core | **1882.0 ft to 1892.0 ft (Run No. 209)** **SHALE** - Same as previous run; all breaks mechanical. | | 284.3 | 209 | | | | | | | | | | | |
| | | | | 1892.0 | | | | | | | | | | | | |
| 1895 | NQ Core | **1892.0 ft to 1900.0 ft (Run No. 210)** **SHALE** - Same as previous run; all breaks mechanical. | | | 210 | | | | | | | | | | | |
| | | | | 283.0 | | | | | | | | | | | | |
| 1900 | | | | 1900.0 | | | | | | | | | | Azimuth: 311.75<br>Inclination: -1.59 | | |
| | | Terminate North Bound Boring at 1900.0 Feet. | | | | | | | | | | | | | | |
| 1905 | | | | | | | | | | | | | | | | |
| 1910 | | | | | | | | | | | | | | | | |
| 1915 | | | | | | | | | | | | | | | | |
| 1920 | | | | | | | | | | | | | | | | |

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:Boart Longyear

DRILLER:D. Sammons

S&ME ENGINEERING INTEGRITY

LOGGED: NJP

CHECKED:

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

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1413 Topside Road
Louisville, TN 37777

## Photo 1


5/23/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound Boring, Box 1, 0.0 ft to 11.3 ft |
| **Remarks** | Louisville Limestone |

## Photo 2


5/23/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 2, 11.3 ft to 22.4 ft |
| **Remarks** | Louisville Limestone |

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Louisville, TN 37777

## Photo 3


5/23/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 3, 22.4 ft to 33.6 ft |
| **Remarks** | Louisville Limestone |

## Photo 4


5/23/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 4, 33.6 ft to 43.9 ft |
| **Remarks** | Louisville Limestone |

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## Photo 5


5/23/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 5, 43.9 ft to 54.9 ft |
| **Remarks** | Louisville Limestone |

## Photo 6


5/24/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound Boring, Box 6, 54.9 ft to 66.2 ft |
| **Remarks** | Louisville Limestone |

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## Photo 7


5/24/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 7, 66.2 ft to 76.8 ft |
| **Remarks** | Louisville Limestone |

## Photo 8


5/24/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 8, 76.8 ft to 89.0 ft |
| **Remarks** | Louisville Limestone |

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## Photo 9


5/24/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 9, 89.0 ft to 94.0 ft |
| **Remarks** | Louisville Limestone |

## Photo 10


5/24/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 10, 94.0 ft to 110.9 ft |
| **Remarks** | Louisville Limestone |

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## Photo 11


| RUN | LENGTH | Distance | REC | RQD |
|---|---|---|---|---|
| 23 cont. | 5.0' | 108.6'-113.6' | 4.3' | 50% |
| 24 | 5.0' | 113.6'-118.8' | 5.2' | 80% |
| 25 | 5.0' | 118.8'-123.9' | 5.1' | 100% |

5/24/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 11, 110.9 ft to 122.6 ft |
| **Remarks** | Louisville Limestone |

## Photo 12


| RUN | LENGTH | Distance | REC | RQD |
|---|---|---|---|---|
| 25 cont. | 5.0' | 118.8'-123.9' | 5.1' | 100% |
| 26 | 5.0' | 123.9'-129.0' | 5.1' | 100% |
| 27 | 5.0' | 129.0'-134.0' | 5.0' | 100% |

5/24/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 12, 122.6 ft to 133.5 ft |
| **Remarks** | Louisville Limestone |

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## Photo 13


5/24/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 13, 133.5 ft to 144.2 ft |
| **Remarks** | Louisville Limestone |

## Photo 14


5/24/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 14, 144.2 ft to 150.4 ft |
| **Remarks** | Louisville Limestone |

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## Photo 15


5/24/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 15, 150.4 ft to 159.2 ft |
| **Remarks** | Louisville Limestone – Terminate HQ core at 159.2 feet and begin AQ directional core. |

## Photo 16


5/30/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound Boring, Box 14, 172.6 ft to 187.6 ft |
| **Remarks** | Louisville Limestone |

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| Photo 17 | |
|---|---|
|  | 5/30/2011<br>Photographer: N. Peterson |
| **Location / Orientation** | North Bound, Box 15, 187.6 ft to 202.6 ft |
| **Remarks** | Louisville Limestone |

| Photo 18 | |
|---|---|
|  | 5/30/2011<br>Photographer: N. Peterson |
| **Location / Orientation** | North Bound, Box 16, 202.6 ft to 217.4 ft |
| **Remarks** | Louisville Limestone |

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## Photo 19


5/30/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 17, 217.4 ft to 232.4 ft |
| **Remarks** | Louisville Limestone |

## Photo 20


5/30/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 18, 232.4 ft to 247.3 ft |
| **Remarks** | Louisville Limestone |

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## Photo 21


5/30/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 19, 247.3 ft to 262.4 ft |
| **Remarks** | Louisville Limestone |

## Photo 22


5/30/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 20, 262.4 ft to 276.8 ft |
| **Remarks** | Louisville Limestone |

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## Photo 23


5/30/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 21, 276.8 ft to 291.6 ft |
| **Remarks** | Louisville Limestone |

## Photo 24


5/30/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 22, 291.6 ft to 306.2 ft |
| **Remarks** | Louisville Limestone |

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| Photo 25 | |
|---|---|
|  | 5/30/2011<br>Photographer: N. Peterson |
| **Location / Orientation** | North Bound, Box 23, 306.2 ft to 320.9 ft |
| **Remarks** | Louisville Limestone |

| Photo 26 | |
|---|---|
|  | 5/30/2011<br>Photographer: N. Peterson |
| **Location / Orientation** | North Bound, Box 24, 320.9 ft to 335.4 ft |
| **Remarks** | Louisville Limestone |

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## Photo 27


5/30/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 25, 335.4 ft to 350.0 ft |
| **Remarks** | Louisville Limestone |

## Photo 28


5/30/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 26, 350.0 ft to 364.9 ft |
| **Remarks** | Louisville Limestone |

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## Photo 29


5/30/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 27, 364.9 ft to 378.9 ft |
| **Remarks** | Louisville Limestone |

## Photo 30


5/30/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 28, 378.4 ft to 393.9 ft |
| **Remarks** | Louisville Limestone |

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## Photo 31


5/30/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 29, 393.9 ft to 409.1 ft |
| **Remarks** | Louisville Limestone |

## Photo 32


5/31/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound Boring, Box 30, 409.1 ft to 424.2 ft |
| **Remarks** | Louisville Limestone |

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## Photo 33


5/31/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 31, 424.2 ft to 440.2 ft |
| **Remarks** | Louisville Limestone |

## Photo 34


5/31/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 32, 440.2 ft to 452.6 ft |
| **Remarks** | Louisville Limestone |

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## Photo 35


6/1/2011

Photographer: N. Peterson

| | |
|---|---|
| **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. |

## Photo 36


6/1/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 34, 467.1 ft to 481.9 ft |
| **Remarks** | Louisville Limestone |

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## Photo 37


6/1/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 35, 481.9 ft to 497.3 ft |
| **Remarks** | Louisville Limestone |

## Photo 38


5/31/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 36, 497.3 ft to 512.1 ft |
| **Remarks** | Louisville Limestone |

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## Photo 39


5/31/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 37, 512.1 ft to 527.2 ft |
| **Remarks** | Louisville Limestone |

## Photo 40


6/1/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 38, 527.2 ft to 541.6 ft |
| **Remarks** | Louisville Limestone |

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## Photo 41


6/2/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 39, 541.6 ft to 556.2 ft |
| **Remarks** | Louisville Limestone |

## Photo 42


6/2/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 40, 556.2 ft to 571.1 ft |
| **Remarks** | Louisville Limestone |

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## Photo 43


6/2/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 41, 571.1 ft to 585.9 ft |
| **Remarks** | Louisville Limestone |

## Photo 44


6/2/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 42, 585.9 ft to 601.0 ft |
| **Remarks** | Louisville Limestone |

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## Photo 45


6/2/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 43, 601.0 ft to 616.0 ft |
| **Remarks** | Louisville Limestone |

## Photo 46


6/6/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound Boring, Box 44, 616.0 ft to 631.0 ft |
| **Remarks** | Louisville Limestone |

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Louisville, TN 37777

## Photo 47


6/6/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 45, 631.0 ft to 645.3 ft |
| **Remarks** | Louisville Limestone – Terminate AQ directional core at 637.6 feet and begin NQ core. |

## Photo 48


6/6/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 46, 645.3 ft to 659.9 ft |
| **Remarks** | Louisville Limestone |

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Louisville, TN 37777

## Photo 49


6/1/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 47, 659.9 ft to 674.7 ft |
| **Remarks** | Louisville Limestone |

## Photo 50


6/1/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 48, 674.7 ft to 689.3 ft |
| **Remarks** | Louisville Limestone |

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Louisville, TN 37777

## Photo 51


6/1/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 49, 689.3 ft to 704.5 ft |
| **Remarks** | Louisville Limestone |

## Photo 52


6/6/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 50, 704.5 ft to 719.2 ft |
| **Remarks** | Louisville Limestone |

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| Photo 53 | |
|---|---|
|   | 6/6/2011<br>Photographer: N. Peterson |
| **Location / Orientation** | North Bound, Box 51, 719.2 ft to 734.2 ft |
| **Remarks** | Louisville Limestone |

| Photo 54 | |
|---|---|
|   | 6/6/2011<br>Photographer: N. Peterson |
| **Location / Orientation** | North Bound, Box 52, 734.2 ft to 749.2 ft |
| **Remarks** | Louisville Limestone – Terminate NQ core at 743.6 feet and begin AQ directional core. |

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## Photo 55


6/2/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 53, 749.2 ft to 764.0 ft |
| **Remarks** | Louisville Limestone |

## Photo 56


6/6/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 54, 764.0 ft to 778.5 ft |
| **Remarks** | Louisville Limestone |

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## Photo 57


6/6/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 55, 778.5 ft to 793.1 ft |
| **Remarks** | Louisville Limestone |

## Photo 58


6/6/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 56, 793.1 ft to 808.1 ft |
| **Remarks** | Louisville Limestone |

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## Photo 59


6/6/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 57, 808.1 ft to 822.5 ft |
| **Remarks** | Louisville Limestone |

## Photo 60


6/6/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 58, 822.5 ft to 837.5 ft |
| **Remarks** | Louisville Limestone |

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## Photo 61


6/6/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 59, 837.5 ft to 852.0 ft |
| **Remarks** | Louisville Limestone |

## Photo 62


6/10/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound Boring, Box 60, 852.0 ft to 867.2 ft |
| **Remarks** | Louisville Limestone |

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Louisville, TN 37777

| Photo 63 | |
|---|---|
|   | 6/10/2011<br>Photographer: N. Peterson |
| **Location / Orientation** | North Bound, Box 61, 867.2 ft to 881.8 ft |
| **Remarks** | Louisville Limestone – Terminate NQ core at 869.0 feet and begin AQ directional core. |

| Photo 64 | |
|---|---|
|   | 6/10/2011<br>Photographer: N. Peterson |
| **Location / Orientation** | North Bound, Box 62, 881.8 ft to 896.9 ft |
| **Remarks** | Louisville Limestone |

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## Photo 65


6/10/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 63, 896.9 ft to 911.8 ft |
| **Remarks** | Louisville Limestone |

## Photo 66


6/10/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 64, 911.8 ft to 926.9 ft |
| **Remarks** | Louisville Limestone |

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## Photo 67


6/10/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 65, 926.9 ft to 941.6 ft |
| **Remarks** | Louisville Limestone |

## Photo 68


6/10/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 66, 941.6 ft to 956.7 ft |
| **Remarks** | Louisville Limestone |

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## Photo 69


6/13/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound Boring, Box 67, 956.7 ft to 971.8 ft |
| **Remarks** | Louisville Limestone |

## Photo 70


6/13/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 68, 971.8 ft to 991.8 ft |
| **Remarks** | Louisville Limestone |

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## Photo 71


6/13/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 69, 991.8 ft to 1006.7 ft |
| **Remarks** | Louisville Limestone – Terminate AQ directional core at 998.0 feet and begin NQ core. |

## Photo 72


6/13/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 70, 1006.7 ft to 1021.8 ft |
| **Remarks** | Louisville Limestone |

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## Photo 73


6/13/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 71, 1021.8 ft to 1036.9 ft |
| **Remarks** | Louisville Limestone |

## Photo 74


6/13/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 72, 1036.9 ft to 1051.4 ft |
| **Remarks** | Louisville Limestone |

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## Photo 75


6/13/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 73, 1051.4 ft to 1066.3 ft |
| **Remarks** | Louisville Limestone |

## Photo 76


6/13/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 74, 1066.3 ft to 1081.0 ft |
| **Remarks** | Louisville Limestone |

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## Photo 77


6/13/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 75, 1081.0 ft to 1096.1 ft |
| **Remarks** | Louisville Limestone |

## Photo 78


6/13/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 76, 1096.1 ft to 1110.8 ft |
| **Remarks** | Louisville Limestone |

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## Photo 79


6/13/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 77, 1110.8 ft to 1125.5 ft |
| **Remarks** | Louisville Limestone |

## Photo 80


6/13/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 78, 1125.5 ft to 1140.4 ft |
| **Remarks** | Louisville Limestone |

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## Photo 81


6/13/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 80, 1155.3 ft to 1170.4 ft |
| **Remarks** | Louisville Limestone |

## Photo 82


6/13/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 81, 1170.4 ft to 1184.8 ft |
| **Remarks** | Louisville Limestone |

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## Photo 83


6/13/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 82, 1184.8 ft to 1199.6 ft |
| **Remarks** | Louisville Limestone |

## Photo 84


6/20/2011

Photographer: N. Peterson

| | |
|---|---|
| **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. |

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## Photo 85


6/20/2011

Photographer: N. Peterson

| | |
|---|---|
| **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. |

## Photo 86


6/20/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 85, 1230.3 ft to 1245.7 ft |
| **Remarks** | Waldron Shale |

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## Photo 87


6/21/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 86, 1245.7 ft to 1260.8 ft |
| **Remarks** | Waldron Shale |

## Photo 88


6/21/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 87, 1260.8 ft to 1276.7 ft |
| **Remarks** | Waldron Shale |

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## Photo 89


6/21/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 88, 1276.7 ft to 1290.6 ft |
| **Remarks** | Waldron Shale |

## Photo 90


6/22/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 89, 1290.6 ft to 1313.7 ft |
| **Remarks** | Waldron Shale – Terminate AQ directional core at 1299.0 feet and begin NQ core. |

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## Photo 91


6/22/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 90, 1313.7 ft to 1321.2 ft |
| **Remarks** | Waldron Shale |

## Photo 92


6/22/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 91, 1321.2 ft to 1336.3 ft |
| **Remarks** | Waldron Shale |

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## Photo 93


6/22/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 92, 1336.3 ft to 1351.0 ft |
| **Remarks** | Waldron Shale |

## Photo 94


6/22/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 93, 1351.0 ft to 1366.0 ft |
| **Remarks** | Waldron Shale |

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## Photo 95


6/23/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 94, 1366.0 ft to 1380.8 ft |
| **Remarks** | Waldron Shale |

## Photo 96


36/2/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 95, 1380.8 ft to 1395.7 ft |
| **Remarks** | Waldron Shale |

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## Photo 97


6/23/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 96, 1395.7 ft to 1410.2 ft |
| **Remarks** | Waldron Shale |

## Photo 98


6/23/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 97, 1410.2 ft to 1425.1 ft |
| **Remarks** | Waldron Shale |

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## Photo 99


6/27/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound Boring, Box 98, 1425.1 ft to 1438.5 ft |
| **Remarks** | Waldron Shale |

## Photo 100


6/27/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 99, 1438.5 ft to 1452.7 ft |
| **Remarks** | Waldron Shale |

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## Photo 101


6/27/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 100, 1452.7 ft to 1467.0 ft |
| **Remarks** | Waldron Shale |

## Photo 102


6/27/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 101, 1467.0 ft to 1480.5 ft |
| **Remarks** | Waldron Shale |

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## Photo 103


6/27/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 102, 1480.5 ft to 1494.2 ft |
| **Remarks** | Waldron Shale |

## Photo 104


6/27/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 103, 1494.2 ft to 1509.0 ft |
| **Remarks** | Waldron Shale |

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## Photo 105


6/27/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 104, 1509.0 ft to 1523.6 ft |
| **Remarks** | Waldron Shale |

## Photo 106


6/27/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 105, 1523.6 ft to 1538.1 ft |
| **Remarks** | Waldron Shale |

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## Photo 107


6/27/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 106, 1538.1 ft to 1552.7 ft |
| **Remarks** | Waldron Shale |

## Photo 108


6/27/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 107, 1552.7 ft to 1567.6 ft |
| **Remarks** | Waldron Shale |

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## Photo 109


6/27/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 108, 1567.6 ft to 1582.0 ft |
| **Remarks** | Waldron Shale |

## Photo 110


6/27/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 109, 1582.0 ft to 1596.6 ft |
| **Remarks** | Waldron Shale |

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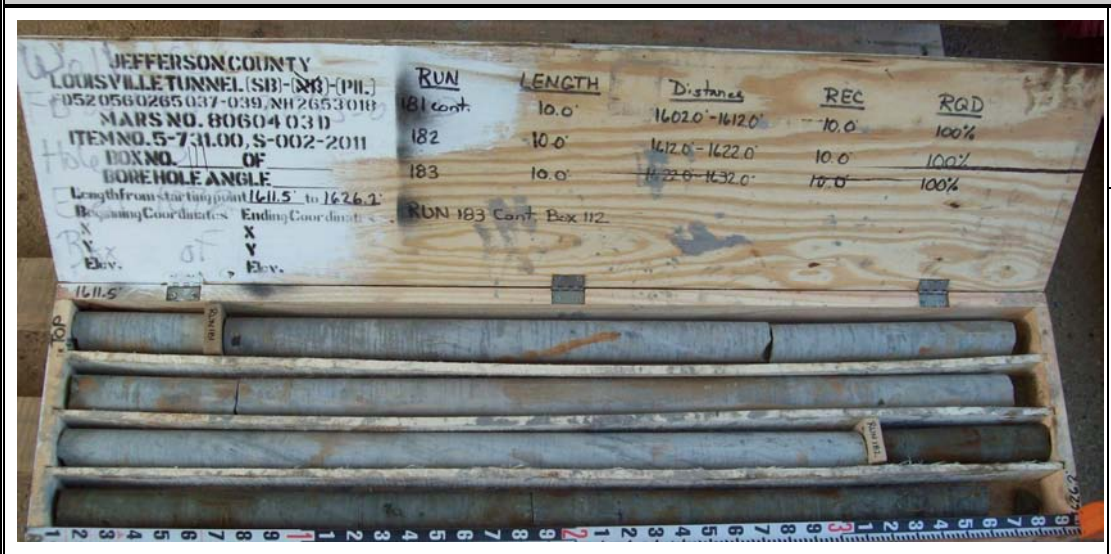
## Photo 111


6/27/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 110, 1596.6 ft to 1611.5 ft |
| **Remarks** | Waldron Shale |

## Photo 112




6/29/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound Boring, Box 111, 1611.5 ft to 1626.2 ft |
| **Remarks** | Waldron Shale |

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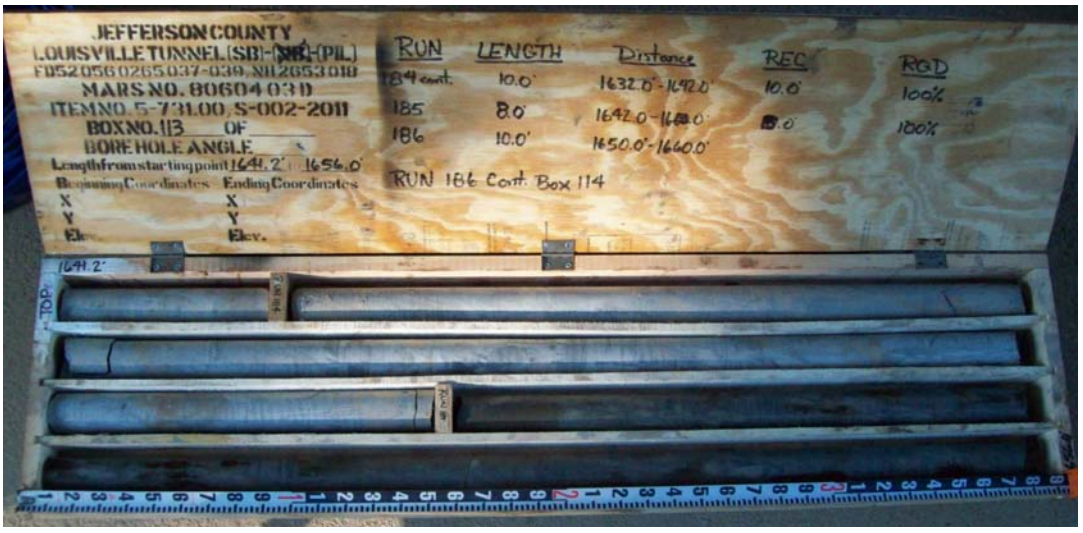
## Photo 113


6/29/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 112, 1626.2 ft to 1641.2 ft |
| **Remarks** | Waldron Shale |

## Photo 114




6/29/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 113, 1641.2 ft to 1656.0 ft |
| **Remarks** | Waldron Shale |

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## Photo 115


6/29/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 114, 1656.0 ft to 1670.9 ft |
| **Remarks** | Waldron Shale |

## Photo 116


6/29/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 115, 1670.9 ft to 1685.7 ft |
| **Remarks** | Waldron Shale |

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## Photo 117


6/30/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 116, 1685.7 ft to 1700.9 ft |
| **Remarks** | Waldron Shale |

## Photo 118


6/30/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 117, 1700.9 ft to 1716.1 ft |
| **Remarks** | Waldron Shale |

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## Photo 119


6/30/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 118, 1716.1 ft to 1730.9 ft |
| **Remarks** | Waldron Shale |

## Photo 120


6/30/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 119, 1730.9 ft to 1745.8 ft |
| **Remarks** | Waldron Shale |

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## Photo 121


6/30/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 120, 1745.8 ft to 1760.9 ft |
| **Remarks** | Waldron Shale |

## Photo 122


7/5/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound Boring, Box 121, 1760.9 ft to 1775.7 ft |
| **Remarks** | Waldron Shale |

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## Photo 123


7/5/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 122, 1775.7 ft to 1790.2 ft |
| **Remarks** | Waldron Shale |

## Photo 124


7/5/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 123, 1790.2 ft to 1806.7 ft |
| **Remarks** | Waldron Shale |

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## Photo 125


7/5/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 124, 1806.7 ft to 1820.4 ft |
| **Remarks** | Waldron Shale |

## Photo 126


7/5/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 125, 1820.4 ft to 1835.2 ft |
| **Remarks** | Waldron Shale |

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## Photo 127


7/5/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 126, 1835.2 ft to 1850.9 ft |
| **Remarks** | Waldron Shale |

## Photo 128


7/5/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 127, 1850.9 ft to 1864.8 ft |
| **Remarks** | Waldron Shale |

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## Photo 129


7/5/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 128, 1864.8 ft to 1880.2 ft |
| **Remarks** | Waldron Shale |

## Photo 130


7/5/2011

Photographer: N. Peterson

| | |
|---|---|
| **Location / Orientation** | North Bound, Box 129, 1880.2 ft to 1894.7 ft |
| **Remarks** | Waldron Shale |

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| Photo 131 | |
|---|---|
|  | 7/5/2011<br>Photographer: N. Peterson |
| **Location / Orientation** | North Bound, Box 130, 1894.7 ft to 1900.0 ft |
| **Remarks** | Waldron Shale – North Bound Boring terminated at 1900.0 ft. |

# APPENDIX B

## GRAPH "Unconfined Compression versus Distance"

## Graph "Point Load Index - Diametral versus Distance"

## Graph "Point Load Index - Axial versus Distance"

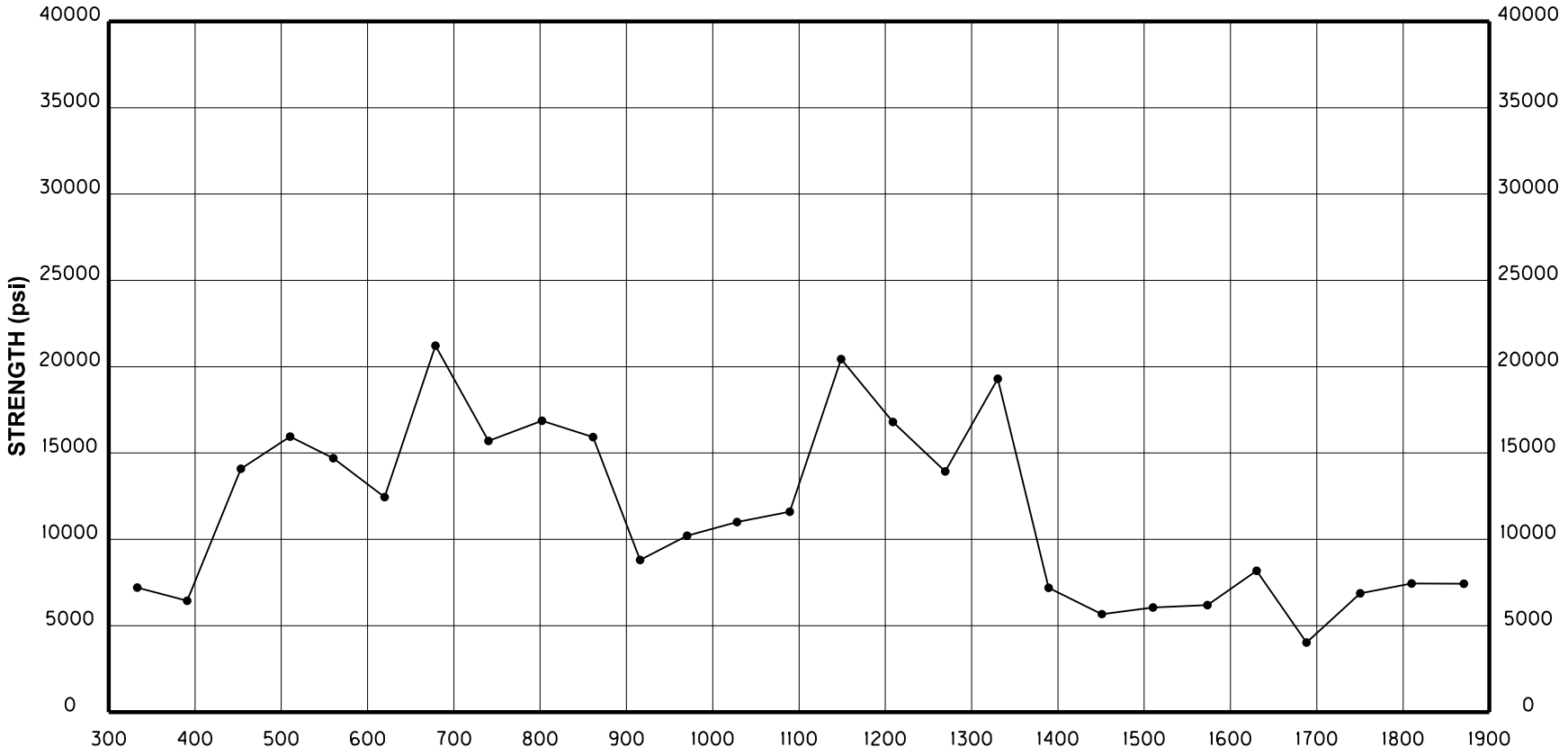
## Graph "Splitting Tensile Strength versus Distance"

## Graph "Splitting Tensile Strength versus Distance"

## TABULATION OF ROCK CORE SAMPLE LOCATIONS

## LABORATORY TEST REPORTS

## SAMPLE COLLECTION LOCATIONS




| | |
|---|---|
| SCALE: | 1"=200' Horiz, 1"=10,000 Vert. |
| DATE: | 8/31/11 |
| DRAWN BY: | CAC |
| PROJECT NO: | 1831-10-5629 |

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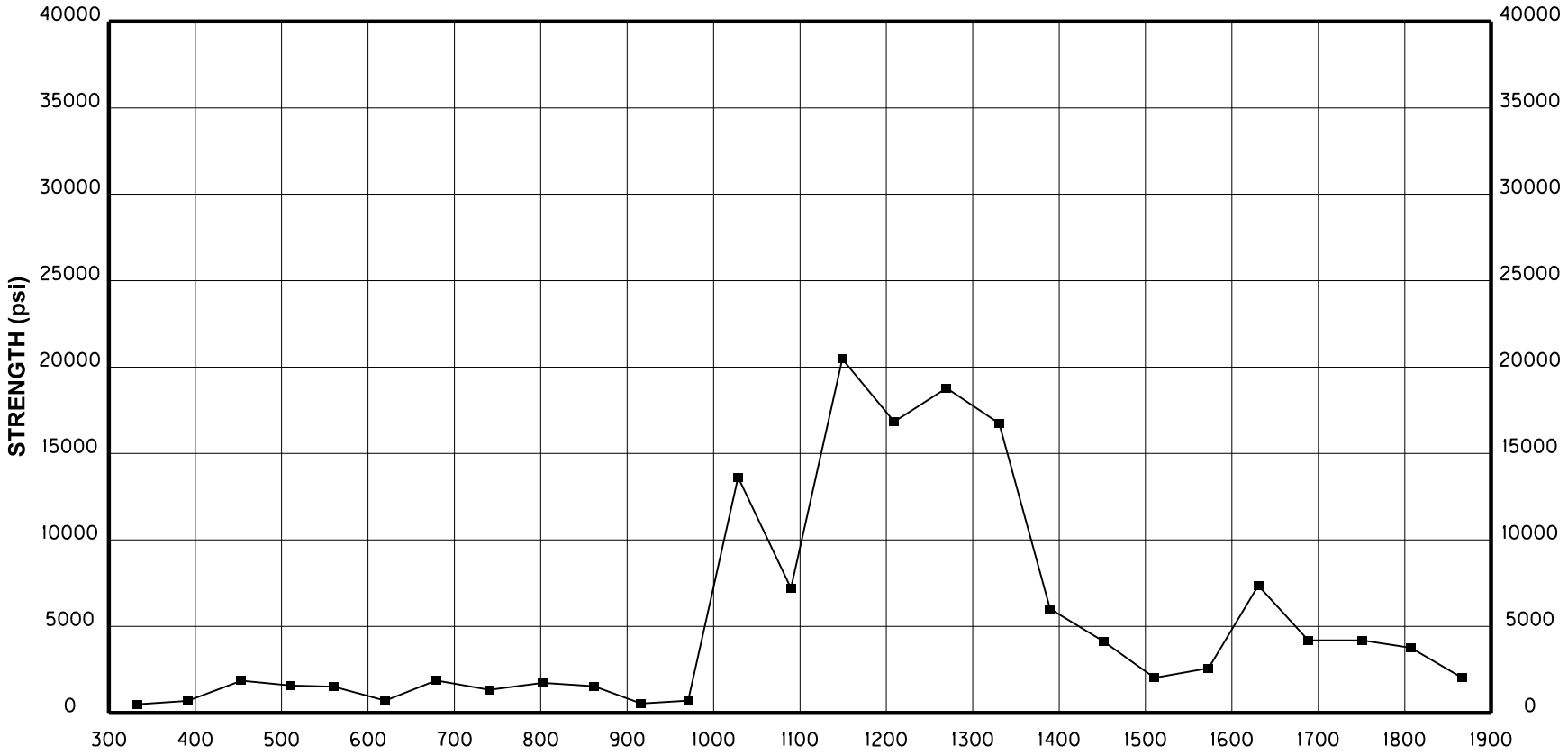
422 CODELL DRIVE, LEXINGTON, KY 40509
PHONE: 859.293.5518

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

FIGURE NO.




| | |
|---|---|
| SCALE: | 1"=200' Horiz, 1"=10,000 Vert. |
| DATE: | 8/31/11 |
| DRAWN BY: | CAC |
| PROJECT NO: | 1831-10-5629 |

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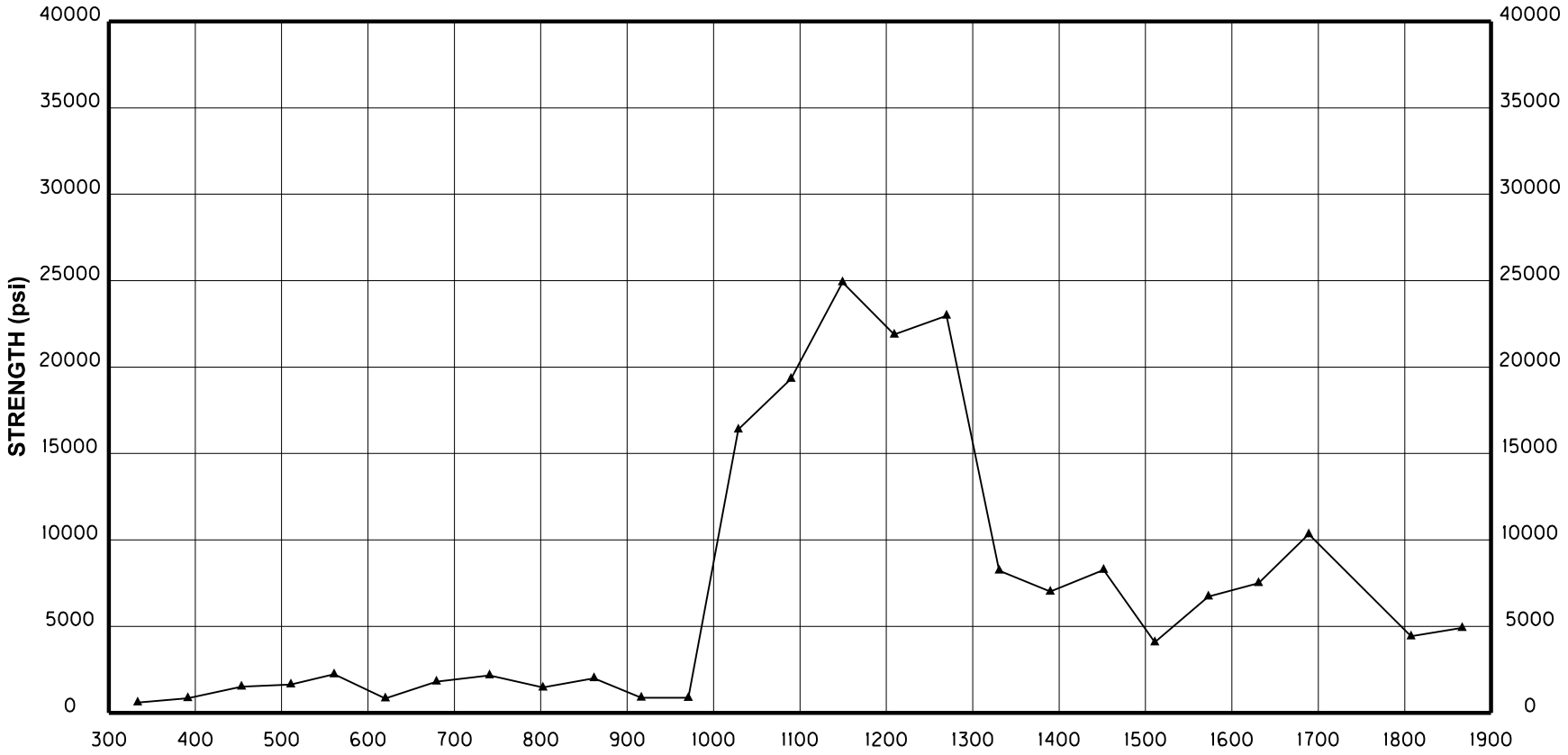
**LOUISVILLE - SOUTHERN INDIANA**
**OHIO RIVER BRIDGES TUNNEL - NORTHBOUND HOLE**
**POINT LOAD STRENGTH INDEX - AXIAL**

FIGURE NO.




| | |
|---|---|
| SCALE: | 1"=200' Horiz, 1"=10,000 Vert. |
| DATE: | 8/31/11 |
| DRAWN BY: | CAC |
| PROJECT NO: | 1831-10-5629 |

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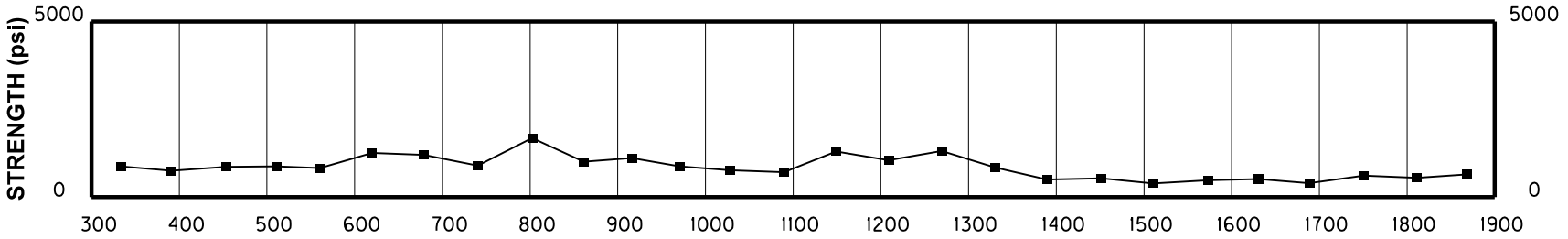
**LOUISVILLE - SOUTHERN INDIANA**
**OHIO RIVER BRIDGES TUNNEL - NORTHBOUND HOLE**
**POINT LOAD STRENGTH INDEX - DIAMETRAL**

FIGURE NO.




**DISTANCE (ft)**
**FROM COLLAR LOCATION**

| | |
|---|---|
| SCALE: | 1"=200' Horiz, 1"=10,000 Vert. |
| DATE: | 8/31/11 |
| DRAWN BY: | CAC |
| PROJECT NO: | 1831-10-5629 |

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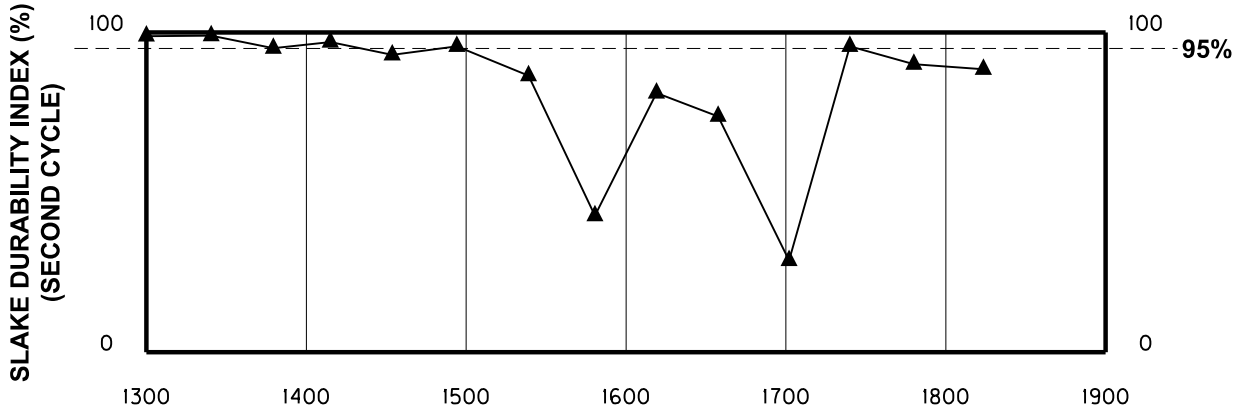
**LOUISVILLE - SOUTHERN INDIANA**
**OHIO RIVER BRIDGES TUNNEL - NORTHBOUND HOLE**
**SPLITTING TENSILE STRENGTH**

FIGURE NO.




**DISTANCE (ft)**
**FROM COLLAR LOCATION**

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

| | |
|---|---|
| SCALE: | NONE |
| DATE: | 8/31/11 |
| DRAWN BY: | CAC |
| PROJECT NO: | 1831-10-5629 |

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

FIGURE NO.

Northbound Boring

# SUMMARY OF LABORATORY DATA

| Sample | Distance | Northing | Easting | Elevation | Unconfined Compression Distance (ft) | Unconfined Compression Strength (psi) | Point Load Strength Index Distance A (ft) | Point Load Strength Index Strength A (psi) | Point Load Strength Index Distance D (ft) | Point Load Strength Index Strength D (psi) | Splitting Tensile Strength Distance (ft) | Splitting Tensile Strength Strength (psi) | Slake Durability Slake Durability Index (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 | 303161.45 | 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 | 303548.22 | 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 | 303588.93 | 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 | 303630.12 | 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% |
| **21** | 1379.4-1380.8 | 303705.84 | 1246486.47 | 505.28 | | | | | | | | | 94.3% |
| **22** | 1389.0-1390.5 | 303712.45 | 1246479.51 | 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% |
| **24** | 1450.7-1452.6 | 303754.93 | 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% |
| **26** | 1494.2-1495.7 | 303784.88 | 1246403.26 | 502.51 | | | | | | | | | 85.6% |
| **27** | 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 | |
| **28** | 1539.0-1540.5 | 303815.82 | 1246370.88 | 501.43 | | | | | | | | | 91.1% |
| **29** | 1572.0-1573.5 | 303838.93 | 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% |
| **31** | 1619.0-1621.0 | 303871.94 | 1246313.89 | 499.51 | | | | | | | | | 97.3% |
| **32** | 1630.0-1631.5 | 303879.66 | 1246306.07 | 499.24 | 1630.2 | 8,178 | 1630.5 | 7,360 | 1630.7 | 7,499 | 1630.4 | 1,035 | |
| **33** | 1657.6-1659.0 | 303899.04 | 1246286.43 | 498.58 | | | | | | | | | 96.2% |
| **34** | 1688.0-1689.5 | 303920.39 | 1246264.79 | 497.84 | 1688.2 | 4,022 | 1688.5 | 4,186 | 1688.9 | 10,330 | 1688.4 | 805 | |
| **35** | 1702.0-1703.5 | 303930.22 | 1246254.83 | 497.51 | | | | | | | | | 91.5% |
| **36** | 1740.0-1741.5 | 303956.90 | 1246227.79 | 496.59 | | | | | | | | | 94.0% |
| **37** | 1750.0-1752.0 | 303963.92 | 1246220.68 | 496.35 | 1750.3 | 6,881 | 1750.6 | 4,198 | | | 1750.5 | 1,232 | |
| **38** | 1753.2-1754.6 | 303966.17 | 1246218.40 | 496.27 | | | | | | | | | |
| **39** | 1780.0-1781.5 | 303985.04 | 1246199.38 | 495.65 | | | | | | | | | 96.5% |
| **40** | 1807.1-1807.0 | 304004.34 | 1246180.36 | 495.13 | | | 1807.2 | 3,761 | 1807.4 | 4,424 | | | |
| **41** | 1809.2-1810.3 | 304005.85 | 1246178.90 | 495.10 | 1809.9 | 7,442 | | | | | | | |
| **42** | 1810.4-1811.3 | 304006.71 | 1246178.07 | 495.08 | | | | | | | 1811.3 | 1,099 | |
| **43** | 1823.5-1824.6 | 304016.13 | 1246168.97 | 494.88 | | | | | | | | | 94.2% |
| **44** | 1859.5-1861.0 | 304042.03 | 1246143.96 | 494.32 | | | | | | | | | 93.5% |
| **45** | 1865.8-1866.8 | 304046.56 | 1246139.59 | 494.22 | | | 1866.7 | 2,023 | 1866.5 | 4,911 | | | |
| **46** | 1867.1-1868.5 | 304047.49 | 1246138.69 | 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 Date: 4/26/2011*

# Point Load Strength Index of Rock

*ASTM D5731, ISRM Point Load Test*

*Quality Assurance*

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

**Project #:** **1831-10-5629** Sample Date: **6/3/2011** Report Date: 6/23/2011

Project Name: **Louisville Tunnel** Test Date(s): 6/22/2011

Client Name:

Client Address:

| | | | | | | | | **Specimen Check (Axial 0.3W<D<W), (Diametral (L>0.5D)** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab ID | Boring ID | Distance (ft) | Rock Type | Moisture Condition | Test Type | Aniso. Load | Folliation / Joint Dip | Diameter of Specimen (in) | | | | Length of Specimen (in) | | | | L (0.5 Length) (Diametral) | W (Diam) (Axial) | D (mm) | D' (mm) | Stress (psi) | Failure Type |
| | | | | | | | | 1 | 2 | 3 | Avg | 1 | 2 | 3 | Avg | | | | | | |
| C11-128 | NB-1 Run 51 Box 24 | 333.3 | Limestone | As-Received | A | N/A | M | 1.24 | 1.24 | 1.24 | 1.24 | 1.01 | 1.01 | 1.02 | 1.01 | N/A | 1.24 | 25.0 | 24.5 | 493 | 3 |
| C11-128 | NB-1 Run 51 Box 24 | 333.4 | Limestone | As-Received | D | N/A | M | 1.24 | 1.24 | 1.24 | 1.24 | 1.87 | 1.87 | 1.87 | 1.87 | 0.94 | N/A | 31.0 | 30.5 | 593 | 2 |
| C11-129 | NB-2 Run 57 Box 28 | 391.3 | Limestone | As-Received | A | N/A | MP | 1.24 | 1.24 | 1.23 | 1.24 | 0.97 | 0.97 | 0.98 | 0.97 | N/A | 1.24 | 24.5 | 24.0 | 687 | 3 |
| C11-129 | NB-2 Run 57 Box 28 | 391.4 | Limestone | As-Received | D | N/A | MP | 1.23 | 1.23 | 1.24 | 1.23 | 1.88 | 1.90 | 1.90 | 1.89 | 0.95 | N/A | 31.0 | 30.0 | 847 | 2 |
| C11-130 | NB-3 Run 64 Box 33 | 453.4 | Limestone | As-Received | A | N/A | MP | 1.86 | 1.86 | 1.86 | 1.86 | 1.52 | 1.50 | 1.50 | 1.51 | N/A | 1.86 | 38.0 | 37.0 | 1859 | 3 |
| C11-130 | NB-3 Run 64 Box 33 | 453.6 | Limestone | As-Received | D | N/A | MP | 1.86 | 1.86 | 1.86 | 1.86 | 2.78 | 2.79 | 2.80 | 2.79 | 1.40 | N/A | 47.0 | 45.5 | 1511 | 2 |
| C11-131 | NB-4 Run 70 Box 36 | 510.5 | Limestone | As-Received | A | N/A | M | 1.86 | 1.86 | 1.86 | 1.86 | 1.44 | 1.46 | 1.46 | 1.45 | N/A | 1.86 | 36.5 | 35.5 | 1584 | 3 |
| C11-131 | NB-4 Run 70 Box 36 | 510.7 | Limestone | As-Received | D | N/A | M | 1.86 | 1.86 | 1.86 | 1.86 | 2.80 | 2.81 | 2.81 | 2.81 | 1.40 | N/A | 47.0 | 46.0 | 1636 | 2 |
| C11-132 | NB-5 Run 75 Box 40 | 560.5 | Limestone | As-Received | A | N/A | M | 1.86 | 1.86 | 1.86 | 1.86 | 1.56 | 1.56 | 1.55 | 1.56 | N/A | 1.86 | 39.0 | 38.0 | 1508 | 3 |
| C11-132 | NB-5 Run 75 Box 40 | 560.7 | Limestone | As-Received | D | N/A | M | 1.86 | 1.86 | 1.86 | 1.86 | 2.82 | 2.81 | 2.79 | 2.81 | 1.40 | N/A | 47.0 | 45.5 | 2228 | 2, 3 |
| C11-133 | NB-6 Run 81 Box 44 | 620.0 | Limestone | As-Received | A | N/A | M | 1.24 | 1.24 | 1.24 | 1.24 | 0.99 | 0.99 | 0.99 | 0.99 | N/A | 1.24 | 25.0 | 24.0 | 702 | 3 |
| C11-133 | NB-6 Run 81 Box 44 | 620.1 | Limestone | As-Received | D | N/A | M | 1.24 | 1.24 | 1.24 | 1.24 | 1.86 | 1.87 | 1.88 | 1.87 | 0.94 | N/A | 31.5 | 30.5 | 833 | 2 |
| | | | | | | | | | | | | | | | | | | | | | |

***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.

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 $I_s$ and $D_e$.

***Notes / Deviations / References:*** ASTM D5731

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*Form No: D5731-1*
*Revision No. 0*
*Revision Date: 4/26/2011*

# Point Load Strength Index of Rock

*ASTM D5731, ISRM Point Load Test*

*Quality Assurance*

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

**Project #:** **1831-10-5629** Sample Date: **6/10/2011** Report Date: 6/28/2011

Project Name: **Louisville Tunnel** Test Date(s): 6/27/2011

Client Name:

Client Address:

| | | | | | | | | Specimen Check (Axial 0.3W<D<W), (Diametral (L>0.5D) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lab ID | Boring ID | Distance (ft) | Rock Type | Moisture Condition | Test Type | Aniso. Load | Folliation / Joint Dip | Diameter of Specimen (in) | | | | Length of Specimen (in) | | | | L (0.5 Length) (Diametral) | W (Diam) (Axial) | D (mm) | D' (mm) | Stress (psi) | Failure Type |
| | | | | | | | | 1 | 2 | 3 | Avg | 1 | 2 | 3 | Avg | | | | | | |
| C11-162 | NB-7 Run 87 Box 48 | 679.0 | Limestone | As-Received | A | 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 | 3 |
| 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 | 2 |
| C11-163 | NB-8 Run 93 Box 52 | 740.5 | Limestone | As-Received | A | 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 | 3 |
| 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 | 3 |
| C11-164 | NB-9 Run 100 Box 56 | 802.5 | Limestone | As-Received | D | 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 | 3 |
| 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 | 2 |
| 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 | 3 |
| 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 | 2 |
| C11-167 | NB-12 Run 117 Box 67 | 970.7 | Limestone | As-Received | A | N/A | MP | 1.24 | 1.24 | 1.24 | 1.24 | 1.00 | 0.99 | 0.98 | 0.99 | N/A | 1.24 | 25.0 | 24.0 | 706 | 3 |
| 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 | 2 |
| | | | | | | | | | | | | | | | | | | | | | |

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Sc calculated using generalized strength conversion factors interpolated from Table 1 in ASTM D5731 and values of $I_s$ and $D_e$.

***Notes / Deviations / References:*** ASTM D5731

Reviewed By: _____ Date: _____

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# Point Load Strength Index of Rock (for Horizontal Borings)

*ASTM D5731, ISRM Point Load Test*

*Quality Assurance*

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

**Project #:** **1831-10-5629** Sample Date: **6/17/2011** Report Date: 7/1/2011

Project Name: **Louisville Tunnel Project**

| Lab ID | Boring ID | Distance (ft) | Rock Type | Moisture Condition | Test Type | Aniso. Load | Folliation / Joint Dip | W (in) | D (in) | D' (in) | $D_e^2$ (in) | $D_e$ (in) | Load (lbs) | $I_s$ (psi) | F | $I_{S(50)}$ (psi) | Failure Type | $s_c$ (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C11-168 | NB-13 Run 122 Box 71 | 1028.5 | Limestone | As-Received | A | ∥ PSF | MP | 1.86 | 1.50 | 1.46 | 3.46 | 1.86 | 2115 | 611 | 0.975 | 596 | 3 | 13,632 |
| C11-168 | NB-13 Run 122 Box 71 | 1028.7 | Limestone | As-Received | D | ⊥ PSF | MP | N/A | 1.85 | 1.81 | 3.35 | 1.83 | 2482 | 741 | 0.968 | 717 | 2 | 16,391 |
| C11-169 | NB-14 Run 128 Box 75 | 1089.5 | Limestone | As-Received | A | ∥ PSF | MP | 1.86 | 1.48 | 1.44 | 3.41 | 1.85 | 1105 | 324 | 0.972 | 315 | 1, 3 | 7,208 |
| C11-169 | NB-14 Run 128 Box 75 | 1089.7 | Limestone | As-Received | D | ⊥ PSF | MP | N/A | 1.85 | 1.79 | 3.31 | 1.82 | 2901 | 876 | 0.965 | 845 | 2 | 19,322 |
| C11-170 | NB-15 Run 134 Box 79 | 1149.0 | Limestone | As-Received | A | N/A | M | 1.86 | 1.52 | 1.48 | 3.50 | 1.87 | 3202 | 915 | 0.977 | 894 | 3 | 20,473 |
| C11-170 | NB-15 Run 134 Box 79 | 1149.2 | Limestone | As-Received | D | N/A | M | N/A | 1.85 | 1.81 | 3.35 | 1.83 | 3772 | 1126 | 0.968 | 1090 | 2 | 24,908 |
| | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
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***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.

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 $I_s$ and $D_e$.

***Notes / Deviations / References:*** ASTM D5731

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# Point Load Strength Index of Rock (for Horizontal Borings)

*ASTM D5731, ISRM Point Load Test*

*Quality Assurance*

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

**Project #:** **1831-10-5629** Sample Date: **6/24/2011** Report Date: 7/29/2011

Project Name: **Louisville Tunnel Project**

| Lab ID | Boring ID | Distance (ft) | Rock Type | Moisture Condition | Test Type | Aniso. Load | Folliation / Joint Dip | W (in) | D (in) | D' (in) | $D_e^2$ (in) | $D_e$ (in) | Load (lbs) | $I_s$ (psi) | F | $I_{S(50)}$ (psi) | Failure Type | $s_c$ (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C11-192 | NB-16 Run 140 Box 83 | 1209.0 | L'ville Limestone | As-Received | A | N/A | M | 1.87 | 1.46 | 1.42 | 3.38 | 1.84 | 2565 | 759 | 0.970 | 736 | 3 | 16,838 |
| C11-192 | NB-16 Run 140 Box 83 | 1209.2 | L'ville Limestone | As-Received | D | N/A | M | N/A | 1.85 | 1.77 | 3.27 | 1.81 | 3254 | 995 | 0.963 | 958 | 2 | 21,884 |
| C11-193 | NB-17 Run 147 Box 87 | 1269.6 | Waldron Shale | As-Received | A | ‖ PSF | M | 1.24 | 1.00 | 0.98 | 1.55 | 1.24 | 1513 | 976 | 0.812 | 793 | 3 | 18,787 |
| C11-193 | NB-17 Run 147 Box 87 | 1269.7 | Waldron Shale | As-Received | D | ‖ PSF | M | N/A | 1.22 | 1.18 | 1.44 | 1.20 | 1734 | 1204 | 0.800 | 963 | 2 | 22,972 |
| C11-195 | NB-19 Run 153 Box 91 | 1330.5 | Waldron Shale | As-Received | A | N/A | M | 1.86 | 1.54 | 1.50 | 3.55 | 1.88 | 2647 | 746 | 0.98 | 731 | 3 | 16,739 |
| C11-195 | NB-19 Run 153 Box 91 | 1330.7 | Waldron Shale | As-Received | D | N/A | M | N/A | 1.85 | 1.77 | 3.27 | 1.81 | 1222 | 374 | 0.963 | 360 | 2 | 8,226 |
| C11-198 | NB-22 Run 159 Box 95 | 1389.5 | Waldron Shale | As-Received | A | N/A | M | 1.85 | 1.57 | 1.54 | 3.63 | 1.91 | 965 | 266 | 0.987 | 263 | 3 | 6,019 |
| C11-198 | NB-22 Run 159 Box 95 | 1389.7 | Waldron Shale | As-Received | D | N/A | M | N/A | 1.85 | 1.85 | 3.42 | 1.85 | 1076 | 315 | 0.972 | 306 | 4 | 7,008 |
| C11-200 | NB-24 Run 165 Box 99 | 1451.2 | Waldron Shale | As-Received | A | N/A | M | 1.83 | 1.57 | 1.54 | 3.59 | 1.89 | 661 | 184 | 0.982 | 181 | 3 | 4,140 |
| C11-200 | NB-24 Run 165 Box 99 | 1451.4 | Waldron Shale | As-Received | D | N/A | M | N/A | 1.81 | 1.77 | 3.20 | 1.79 | 1211 | 378 | 0.958 | 362 | 2 | 8,266 |
| | | | | | | | | | | | | | | | | | | |
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Sc calculated using generalized strength conversion factors interpolated from Table 1 in ASTM D5731 and values of $I_s$ and $D_e$.

***Notes / Deviations / References:*** ASTM D5731

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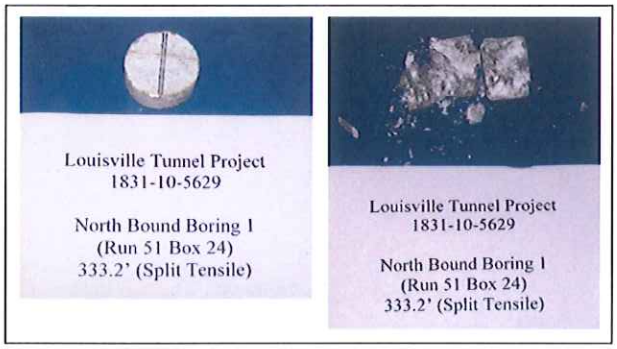
# SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE
## (ASTM D3967)

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

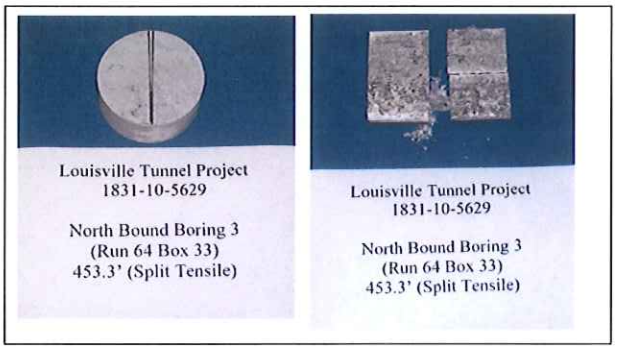
**Project #:** 1831-10-5629 Sample Date: 6/3/2011 Report Date: 6/23/2011
**Project Name:** Louisville Tunnel Project

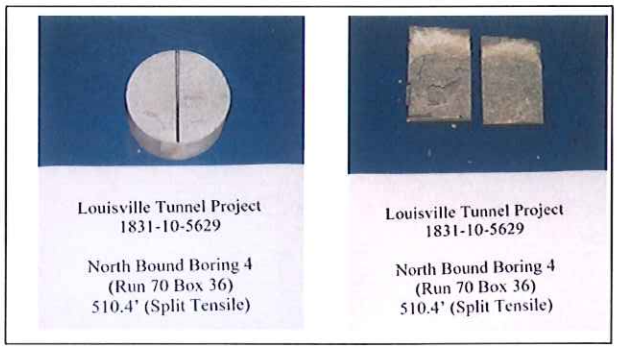
| Hole ID (Sample #) | Distance (ft) | Specimen Dimension | | | Bulk Density ($lb/ft^3$) | Moisture Content (%) | Maximum Load (lbs) | Load Rate (psi/min) | Strength (psi) |
|---|---|---|---|---|---|---|---|---|---|
| | | Diameter (in) | Thickness (in) | t/D Ratio | | | | | |
| NB-1 Run 51 Box 24 | 333.2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

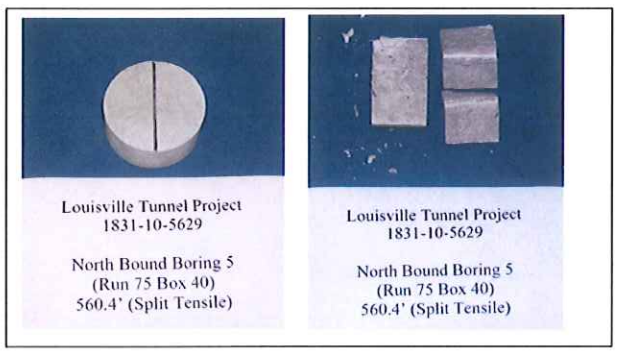
NOTE: Bulk Density includes any moisture that is within the specimen.

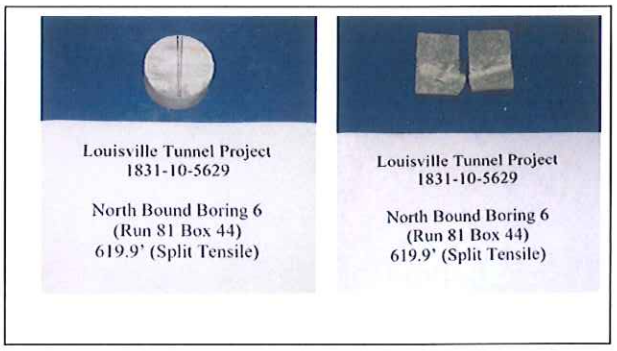




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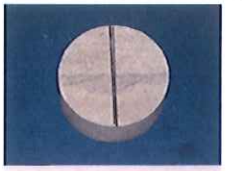
## SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE (ASTM D3967)

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

**Project #:** 1831-10-5629 Sample Date: 6/10/2011 Report Date: 6/28/2011
**Project Name:** Louisville Tunnel Project

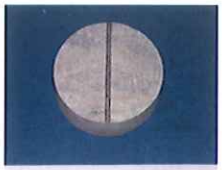
| Hole ID (Sample #) | Distance (ft) | Specimen Dimension | | | Bulk Density ($lb/ft^3$) | Moisture Content (%) | Maximum Load (lbs) | Load Rate (psi/min) | Strength (psi) |
|---|---|---|---|---|---|---|---|---|---|
| | | Diameter (in) | Thickness (in) | t/D Ratio | | | | | |
| NB-7 Run 87 Box 48 | 678.9 | 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 7 (Run 87 Box 48) 678.9' (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 9 (Run 100 Box 56) 802.3' (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 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)

Louisville Tunnel Project 1831-10-5629
North Bound Boring 11 (Run 111 Box 64) 916.1' (Split Tensile)

Louisville Tunnel Project 1831-10-5629
North Bound Boring 11 (Run 111 Box 64) 916.1' (Split Tensile)

Louisville Tunnel Project 1831-10-5629
North Bound Boring 12 (Run 117 Box 67) 970.6' (Split Tensile)

Louisville Tunnel Project 1831-10-5629
North Bound Boring 12 (Run 117 Box 67) 970.6' (Split Tensile)

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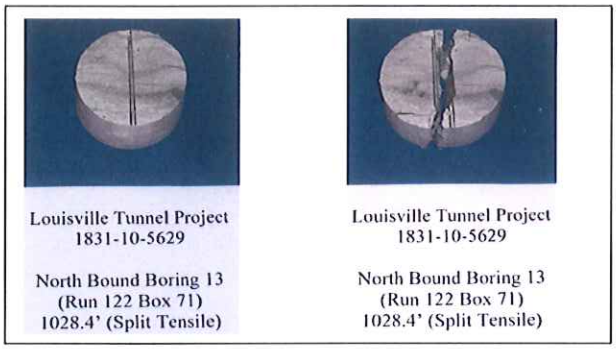
# SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE
## (ASTM D3967)

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

**Project #:** 1831-10-5629 Sample Date: 6/17/2011 Report Date: 7/1/2011
**Project Name:** Louisville Tunnel Project

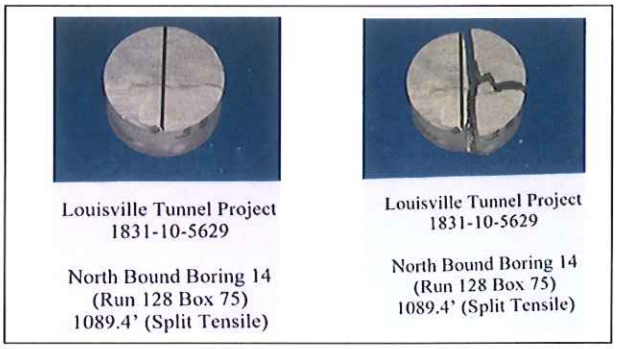
| Hole ID (Sample #) | Distance (ft) | Specimen Dimension | | | Bulk Density ($lb/ft^3$) | Moisture Content (%) | Maximum Load (lbs) | Load Rate (psi/min) | Strength (psi) |
|---|---|---|---|---|---|---|---|---|---|
| | | Diameter (in) | Thickness (in) | t/D Ratio | | | | | |
| NB-13 Run 122 Box 71 | 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.



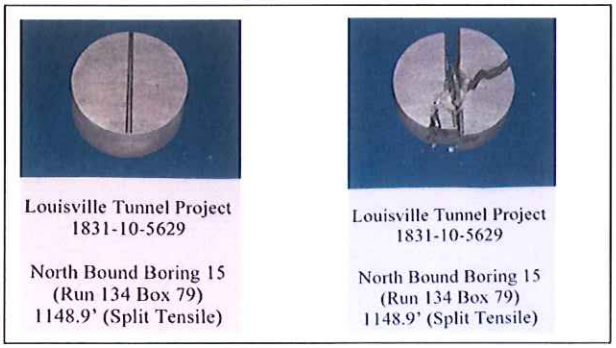
Louisville Tunnel Project 1831-10-5629
North Bound Boring 13 (Run 122 Box 71) 1028.4' (Split Tensile)

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)

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# SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE (ASTM D3967)

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

**Project #:** 1831-10-5629 Sample Date: 6/24/2011 Report Date: 7/29/2011

**Project Name:** Louisville Tunnel Project

| Hole ID (Sample #) | Distance (ft) | Specimen Dimension | | | Bulk Density ($lb/ft^3$) | Moisture Content (%) | Maximum Load (lbs) | Load Rate (psi/min) | Strength (psi) |
|---|---|---|---|---|---|---|---|---|---|
| | | Diameter (in) | Thickness (in) | t/D Ratio | | | | | |
| 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 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 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 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)

Louisville Tunnel Project
1831-10-5629

North Bound Boring 24
(Run 165 Box 99)
1451.1' (Split Tensile)

Louisville Tunnel Project
1831-10-5629

North Bound Boring 24
(Run 165 Box 99)
1451.1' (Split Tensile)

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# UNCONFINED COMPRESSION
(ASTM D7 Method C)

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

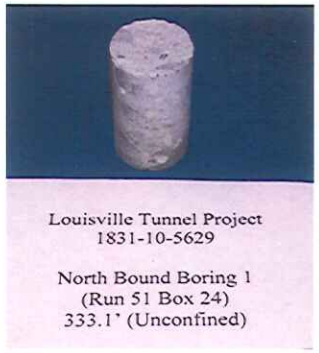
**Project #:** 1831-10-5629
**Project Name:** Louisville Tunnel Project

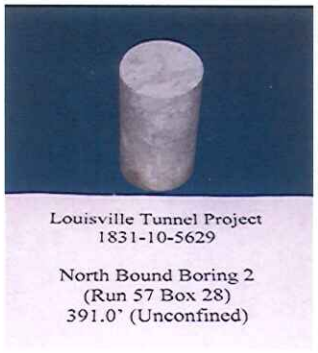
Sample Date: 6/3/2011

Report Date: 6/23/2011

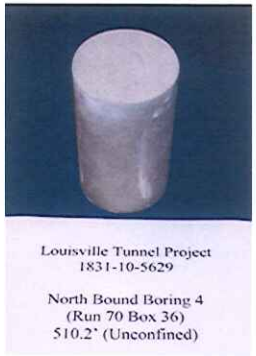
| Sample No. | Boring Location | Distance (ft) | Specimen Dimension, in. | | Area ($in^2$) | Bulk Density ($lb/ft^3$) | Loading Rate (psi/sec) | Max. Load (lb) | Strength (psi) | Moisture (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Length | Diameter | | | | | | |
| NB-1 | Run 51 Box 24 | 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 | 90 | 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 |

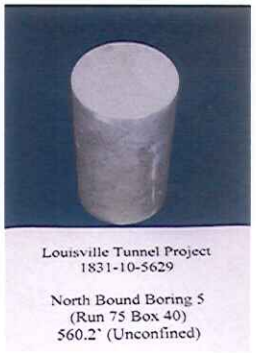
NOTES: Bulk Density includes any moisture that is within the specimen.



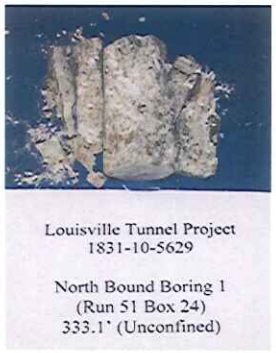

















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# UNCONFINED COMPRESSION
(ASTM D7 Method C)

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

**Project #:** 1831-10-5629 Sample Date: 6/10/2011 Report Date: 6/28/2011

**Project Name:** Louisville Tunnel Project

| Sample No. | Boring Location | Distance (ft) | Specimen Dimension, in. | | Area ($in^2$) | Bulk Density ($lb/ft^3$) | Loading Rate (psi/sec) | Max. Load (lb) | Strength (psi) | Moisture (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Length | Diameter | | | | | | |
| NB-7 | Run 87 Box 48 | 678.7 | 4.07 | 1.87 | 2.75 | 164.2 | 99 | 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 |

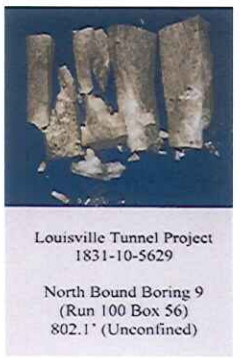
NOTES: Bulk Density includes any moisture that is within the specimen.

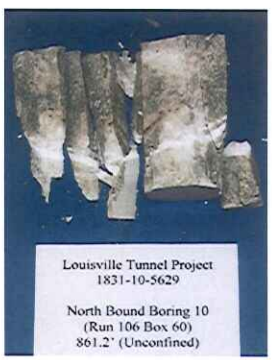




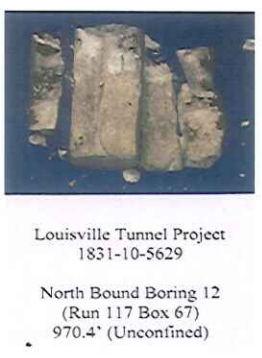








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# UNCONFINED COMPRESSION
(ASTM D7 Method C)

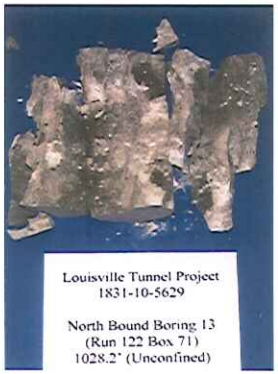
S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

**Project #:** 1831-10-5629 Sample Date: 6/17/2011 Report Date: 7/1/2011
**Project Name:** Louisville Tunnel Project

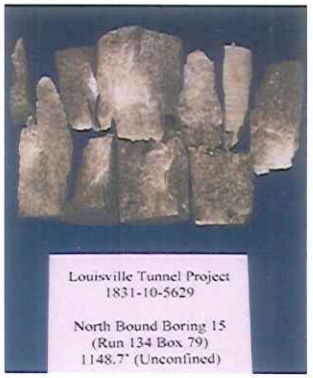
| Sample No. | Boring Location | Distance (ft) | Specimen Dimension, in. | | Area ($in^2$) | Bulk Density ($lb/ft^3$) | Loading Rate (psi/sec) | Max. Load (lb) | Strength (psi) | Moisture (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Length | Diameter | | | | | | |
| NB-13 | Run 122 Box 71 | 1028.2 | 4.07 | 1.86 | 2.72 | 168.2 | 99 | 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 |

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





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# UNCONFINED COMPRESSION
(ASTM D7012 Method C)

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

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

Sample Date: 6/24/2011

Report Date: 7/29/2011

| Sample No. | Boring Location | Distance (ft) | Specimen Dimension, in. | | Area ($in^2$) | Bulk Density ($lb/ft^3$) | Loading Rate (psi/sec) | Max. Load (lb) | Strength (psi) | Moisture (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Length | Diameter | | | | | | |
| 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.











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**UNCONFI[illegible]D COMPRESSION**
**(ASTM D7012 Method C)**

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

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

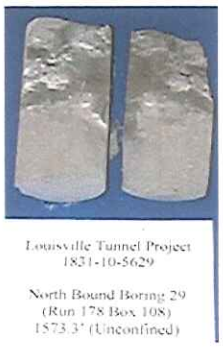
| Sample No. | Boring Location | Distance (ft) | Specimen Dimension, in. | | Area ($in^2$) | Bulk Density ($lb/ft^3$) | Loading Rate (psi/sec) | Max. Load (lb) | Strength (psi) | Moisture (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Length | Diameter | | | | | | |
| NB-27 | Run 172 Box 104 | 1510.2 | 3.91 | 1.84 | 2.66 | 162.8 | 81 | 16,110 | 6,056 | 1.8 |
| NB-29 | Run 178 Box 108 | 1573.3 | 3.94 | 1.85 | 2.69 | 163.1 | 79 | 16,670 | 6,197 | 1.3 |
| NB-32 | Run 183 Box 112 | 1630.2 | 4.05 | 1.85 | 2.69 | 162.9 | 80 | 22,000 | 8,178 | 1.1 |
| NB-34 | Run 189 Box 116 | 1688.2 | 3.97 | 1.85 | 2.69 | 164.9 | 53 | 10,820 | 4,022 | 1.3 |
| NB-37 | Run 195 Box 120 | 1750.3 | 3.88 | 1.85 | 2.69 | 164.1 | 72 | 18,510 | 6,881 | 1.2 |

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













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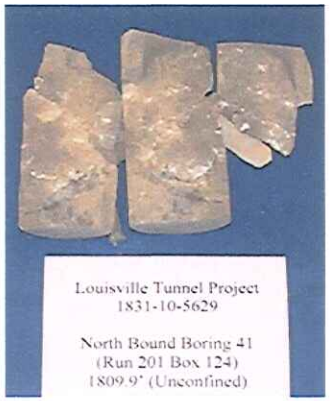
**UNCONFI COMPRESSION**
**(ASTM D7012 Method C)**

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

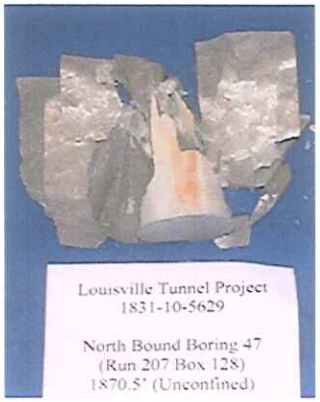
**Project #:** 1831-10-5629 Sample Date: 7/8/2011 Report Date: 8/12/2011
**Project Name:** Louisville Tunnel Project

| Sample No. | Boring Location | Distance (ft) | Specimen Dimension, in. | | Area ($in^2$) | Bulk Density ($lb/ft^3$) | Loading Rate (psi/sec) | Max. Load (lb) | Strength (psi) | Moisture (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Length | Diameter | | | | | | |
| NB-41 | Run 201 Box 124 | 1809.9 | 4.06 | 1.85 | 2.69 | 164.5 | 91 | 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 |

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



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# Point Load Strength Index of Rock (for Horizontal Borings)

*ASTM D5731, ISRM Point Load Test*

*Quality Assurance*

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

**Project #:** **1831-10-5629** Sample Date: **6/24/2011** Report Date: 7/29/2011

Project Name: **Louisville Tunnel Project**

| Lab ID | Boring ID | Distance (ft) | Rock Type | Moisture Condition | Test Type | Aniso. Load | Folliation / Joint Dip | W (in) | D (in) | D' (in) | $D_e^2$ (in) | $D_e$ (in) | Load (lbs) | $I_s$ (psi) | F | $I_{S(50)}$ (psi) | Failure Type | $s_c$ (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C11-192 | NB-16 Run 140 Box 83 | 1209.0 | L'ville Limestone | As-Received | A | N/A | M | 1.87 | 1.46 | 1.42 | 3.38 | 1.84 | 2565 | 759 | 0.970 | 736 | 3 | 16,838 |
| C11-192 | NB-16 Run 140 Box 83 | 1209.2 | L'ville Limestone | As-Received | D | N/A | M | N/A | 1.85 | 1.77 | 3.27 | 1.81 | 3254 | 995 | 0.963 | 958 | 2 | 21,884 |
| C11-193 | NB-17 Run 147 Box 87 | 1269.6 | Waldron Shale | As-Received | A | ‖ PSF | M | 1.24 | 1.00 | 0.98 | 1.55 | 1.24 | 1513 | 976 | 0.812 | 793 | 3 | 18,787 |
| C11-193 | NB-17 Run 147 Box 87 | 1269.7 | Waldron Shale | As-Received | D | ‖ PSF | M | N/A | 1.22 | 1.18 | 1.44 | 1.20 | 1734 | 1204 | 0.800 | 963 | 2 | 22,972 |
| C11-195 | NB-19 Run 153 Box 91 | 1330.5 | Waldron Shale | As-Received | A | N/A | M | 1.86 | 1.54 | 1.50 | 3.55 | 1.88 | 2647 | 746 | 0.98 | 731 | 3 | 16,739 |
| C11-195 | NB-19 Run 153 Box 91 | 1330.7 | Waldron Shale | As-Received | D | N/A | M | N/A | 1.85 | 1.77 | 3.27 | 1.81 | 1222 | 374 | 0.963 | 360 | 2 | 8,226 |
| C11-198 | NB-22 Run 159 Box 95 | 1389.5 | Waldron Shale | As-Received | A | N/A | M | 1.85 | 1.57 | 1.54 | 3.63 | 1.91 | 965 | 266 | 0.987 | 263 | 3 | 6,019 |
| C11-198 | NB-22 Run 159 Box 95 | 1389.7 | Waldron Shale | As-Received | D | N/A | M | N/A | 1.85 | 1.85 | 3.42 | 1.85 | 1076 | 315 | 0.972 | 306 | 4 | 7,008 |
| C11-200 | NB-24 Run 165 Box 99 | 1451.2 | Waldron Shale | As-Received | A | N/A | M | 1.83 | 1.57 | 1.54 | 3.59 | 1.89 | 661 | 184 | 0.982 | 181 | 3 | 4,140 |
| C11-200 | NB-24 Run 165 Box 99 | 1451.4 | Waldron Shale | As-Received | D | N/A | M | N/A | 1.81 | 1.77 | 3.20 | 1.79 | 1211 | 378 | 0.958 | 362 | 2 | 8,266 |
| | | | | | | | | | | | | | | | | | | |
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***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.

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 $I_s$ and $D_e$.

***Notes / Deviations / References:*** ASTM D5731

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*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*

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

**Project #:** **1831-10-5629** Sample Date: **7/1/2011** Report Date: 8/9/2011

Project Name: **Louisville Tunnel Project**

| Lab ID | Boring ID | Distance (ft) | Rock Type | Moisture Condition | Test Type | Aniso. Load | Folliation / Joint Dip | W (in) | D (in) | D' (in) | $D_e^2$ (in) | $D_e$ (in) | Load (lbs) | $I_s$ (psi) | F | $I_{S(50)}$ (psi) | Failure Type | $s_c$ (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C11-225 | NB-27 Run 172 Box 104 | 1510.5 | Waldron Shale | As-Received | A | N/A | M | 1.82 | 1.46 | 1.42 | 3.29 | 1.81 | 302 | 92 | 0.963 | 89 | 3 | 2,023 |
| C11-225 | NB-27 Run 172 Box 104 | 1510.7 | Waldron Shale | As-Received | D | ∥ bed | M | N/A | 1.83 | 1.77 | 3.24 | 1.80 | 603 | 186 | 0.961 | 179 | 4 | 4,079 |
| C11-227 | NB-29 Run 178 Box 108 | 1573.0 | Waldron Shale | As-Received | A | N/A | M | 1.85 | 1.50 | 1.46 | 3.44 | 1.85 | 398 | 116 | 0.972 | 113 | 3 | 2,581 |
| C11-227 | NB-29 Run 178 Box 108 | 1572.8 | Waldron Shale | As-Received | D | ∥ bed | M | N/A | 1.85 | 1.81 | 3.35 | 1.83 | 1020 | 304 | 0.968 | 294 | 3 | 6,725 |
| C11-230 | NB-32 Run 183 Box 112 | 1630.5 | Waldron Shale | As-Received | A | N/A | M | 1.86 | 1.54 | 1.50 | 3.55 | 1.88 | 1166 | 328 | 0.98 | 321 | 3 | 7,360 |
| C11-230 | NB-32 Run 183 Box 112 | 1630.7 | Waldron Shale | As-Received | D | N/A | M | N/A | 1.85 | 1.81 | 3.35 | 1.83 | 1137 | 339 | 0.968 | 328 | 2 | 7,499 |
| C11-234 | NB-34 Run 189 Box 116 | 1688.5 | Waldron Shale | As-Received | A | N/A | M | 1.85 | 1.57 | 1.54 | 3.63 | 1.91 | 671 | 185 | 0.987 | 183 | 3 | 4,186 |
| C11-234 | NB-34 Run 189 Box 116 | 1688.9 | Waldron Shale | As-Received | D | ⊥ bed | M | N/A | 1.85 | 1.81 | 3.35 | 1.83 | 1564 | 467 | 0.968 | 452 | 2 | 10,330 |
| C11-235 | NB-37 Run 195 Box 120 | 1750.6 | Waldron Shale | As-Received | A | N/A | M | 1.85 | 1.59 | 1.57 | 3.70 | 1.92 | 686 | 185 | 0.989 | 183 | 3 | 4,198 |
| | | | | | | | | | | | | | | | | | | |
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***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.

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 $I_s$ and $D_e$.

***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.

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*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*

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

**Project #:** **1831-10-5629** Sample Date: **7/8/2011** Report Date: 8/12/2011

Project Name: **Louisville Tunnel Project**

| Lab ID | Boring ID | Distance (ft) | Rock Type | Moisture Condition | Test Type | Aniso. Load | Folliation / Joint Dip | W (in) | D (in) | D' (in) | $D_e^2$ (in) | $D_e$ (in) | Load (lbs) | $I_s$ (psi) | F | $I_{S(50)}$ (psi) | Failure Type | $s_c$ (psi) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C11-243 | NB-40 Run 201 Box 124 | 1807.2 | Waldron Shale | As-Received | A | N/A | M | 1.84 | 1.36 | 1.34 | 3.14 | 1.77 | 542 | 173 | 0.953 | 165 | 3 NOTE | 3,761 |
| C11-243 | NB-40 Run 201 Box 124 | 1807.4 | Waldron Shale | As-Received | D | ∥ bed | M | N/A | 1.85 | 1.81 | 3.35 | 1.83 | 671 | 200 | 0.968 | 194 | 3 NOTE | 4,424 |
| C11-248 | NB-45 Run 207 Box 128 | 1866.7 | Waldron Shale | As-Received | A | N/A | M | 1.84 | 1.42 | 1.40 | 3.28 | 1.81 | 302 | 92 | 0.963 | 89 | 3 | 2,023 |
| C11-248 | NB-45 Run 207 Box 128 | 1866.5 | Waldron Shale | As-Received | D | N/A | M | N/A | 1.85 | 1.81 | 3.35 | 1.83 | 743 | 222 | 0.968 | 215 | 3 NOTE | 4,911 |
| | | | | | | | | | | | | | | | | | | |
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***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.

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 $I_s$ and $D_e$.

***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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# SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE
## (ASTM D3967)

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

**Project #:** 1831-10-5629 Sample Date: 6/24/2011 Report Date: 7/29/2011
**Project Name:** Louisville Tunnel Project

| Hole ID (Sample #) | Distance (ft) | Specimen Dimension | | | Bulk Density ($lb/ft^3$) | Moisture Content (%) | Maximum Load (lbs) | Load Rate (psi/min) | Strength (psi) |
|---|---|---|---|---|---|---|---|---|---|
| | | Diameter (in) | Thickness (in) | t/D Ratio | | | | | |
| 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 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 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 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)

Louisville Tunnel Project
1831-10-5629

North Bound Boring 24
(Run 165 Box 99)
1451.1' (Split Tensile)

Louisville Tunnel Project
1831-10-5629

North Bound Boring 24
(Run 165 Box 99)
1451.1' (Split Tensile)

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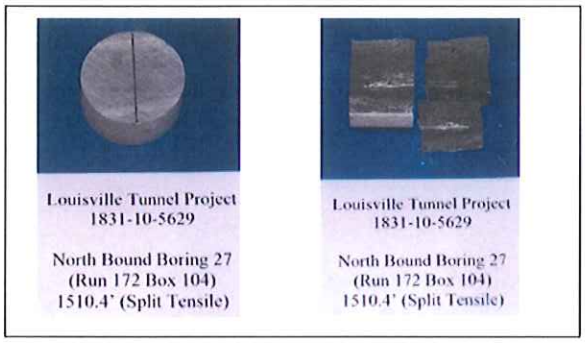
# SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE
## (ASTM D3967)

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

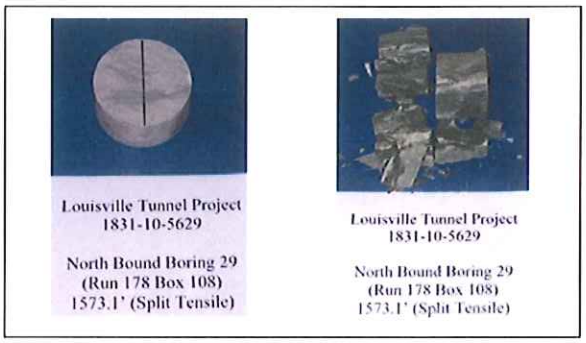
**Project #:** 1831-10-5629 Sample Date: 7/1/2011 Report Date: 8/9/2011
**Project Name:** Louisville Tunnel Project

| Hole ID (Sample #) | Distance (ft) | Specimen Dimension | | | Bulk Density ($lb/ft^3$) | Moisture Content (%) | Maximum Load (lbs) | Load Rate (psi/min) | Strength (psi) |
|---|---|---|---|---|---|---|---|---|---|
| | | Diameter (in) | Thickness (in) | t/D Ratio | | | | | |
| 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 |

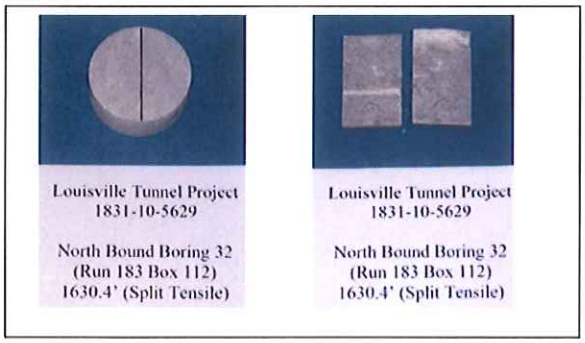
NOTE: Bulk Density includes any moisture that is within the specimen.


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

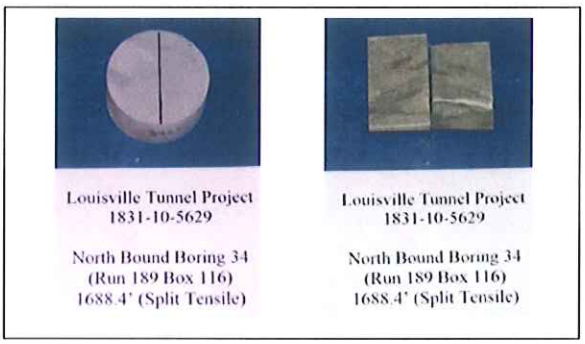

Louisville Tunnel Project 1831-10-5629 North Bound Boring 27 (Run 172 Box 104) 1510.4' (Split Tensile)


Louisville Tunnel Project 1831-10-5629 North Bound Boring 29 (Run 178 Box 108) 1573.1' (Split Tensile)

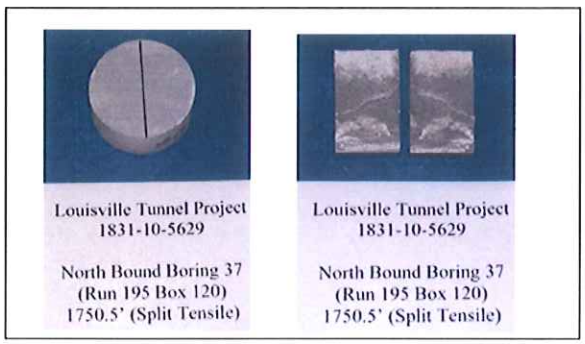

Louisville Tunnel Project 1831-10-5629 North Bound Boring 29 (Run 178 Box 108) 1573.1' (Split Tensile)


Louisville Tunnel Project 1831-10-5629 North Bound Boring 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 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)


Louisville Tunnel Project 1831-10-5629 North Bound Boring 37 (Run 195 Box 120) 1750.5' (Split Tensile)


Louisville Tunnel Project 1831-10-5629 North Bound Boring 37 (Run 195 Box 120) 1750.5' (Split Tensile)

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

| | | | |
|---|---|---|---|
| Project: | Louisville Tunnel | Sample Date: | 6/24/2011 |
| S&ME Project No. | 1831-10-5629 | Report Date: | 7/29/2011 |
| Material: | Waldron Shale | | |
| Sample ID: | NB-18 Run 150 Box 89 (1300.0' - 1301.7') | | |
| Date Tested: | 7/27/2011 to 7/28/2011 | | |

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

Sample Description (Check which applies)

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


Before Test


After Second Cycle

*Phone: 865-970-0003 Fax: 865-970-2312*

*1413 Topside Road, Louisville, Tennessee 37777*

S&ME

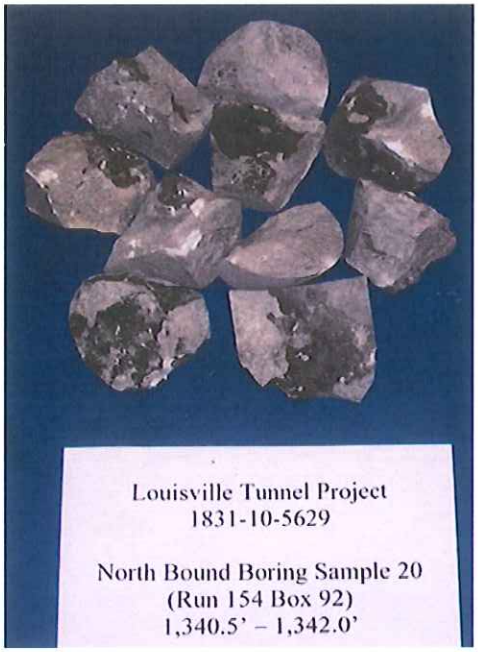
# Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

| | | | |
|---|---|---|---|
| Project: | Louisville Tunnel | Sample Date: | 6/24/2011 |
| S&ME Project No. | 1831-10-5629 | Report Date: | 7/29/2011 |
| Material: | Waldron Shale | | |
| Sample ID: | NB-20 Run 154 Box 92 (1340.5' - 1342.0') | | |
| Date Tested: | 7/27/2011 to 7/28/2011 | | |

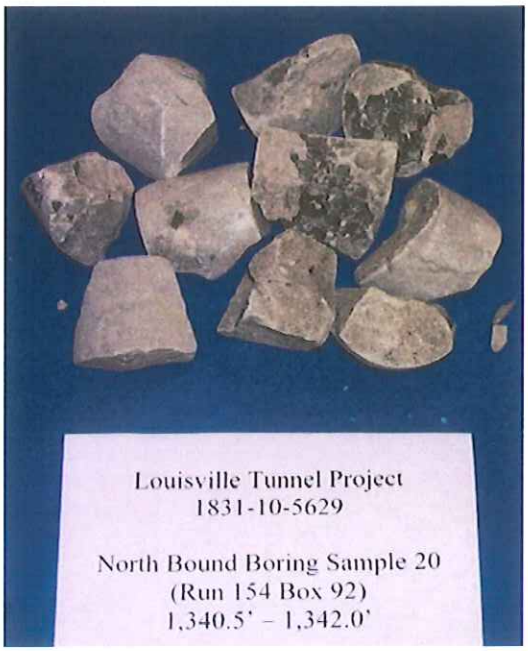
| | | |
|---|---|---|
| Slake Durability Index (Second Cycle) | 98.8 | % |
| Range of water temperature (Cycle 1) | 0.5 | °F |
| Average water temperature (Cycle 1) | 75.8 | °F |
| Range of water temperature (Cycle 2) | 0.5 | °F |
| Average water temperature (Cycle 2) | 75.3 | °F |
| Natural Moisture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

Sample Description (Check which applies)

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




Before Test




After Second Cycle

*Phone: 865-970-0003 Fax: 865-970-2312*

*1413 Topside Road, Louisville, Tennessee 37777*

S&ME

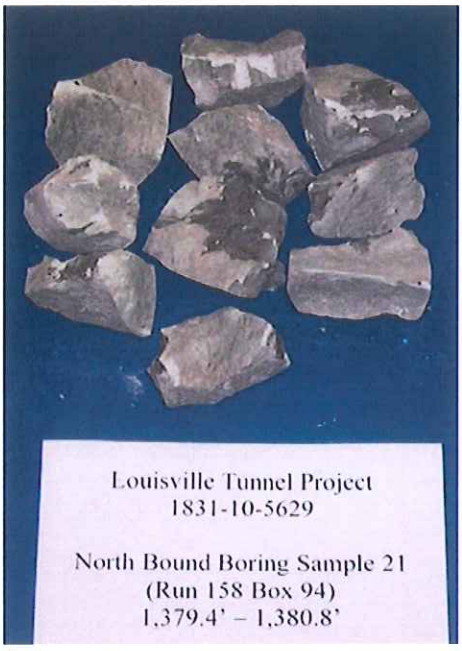
# Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

| | | | |
|---|---|---|---|
| Project: | Louisville Tunnel | Sample Date: | 6/24/2011 |
| S&ME Project No. | 1831-10-5629 | Report Date: | 7/29/2011 |
| Material: | Waldron Shale | | |
| Sample ID: | NB-21 Run 158 Box 94 (1379.4' - 1380.8') | | |
| Date Tested: | 7/27/2011 to 7/28/2011 | | |

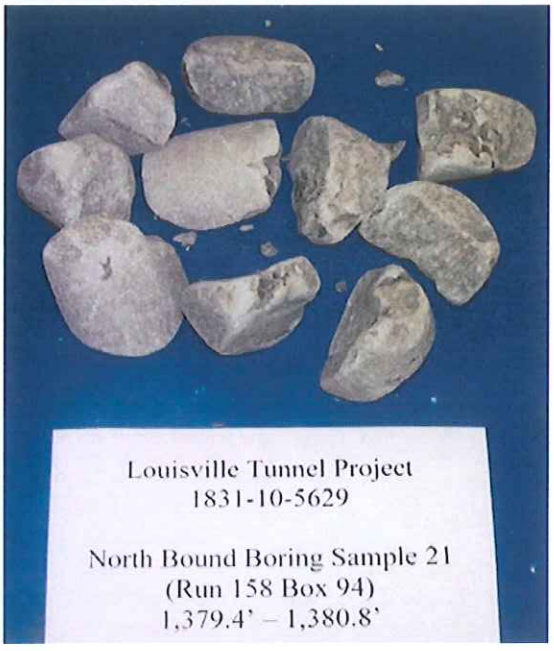
| | | |
|---|---|---|
| Slake Durability Index (Second Cycle) | 94.3 | % |
| Range of water temperature (Cycle 1) | 0.0 | °F |
| Average water temperature (Cycle 1) | 75.5 | °F |
| Range of water temperature (Cycle 2) | 0.0 | °F |
| Average water temperature (Cycle 2) | 75.5 | °F |
| Natural Moisture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

Sample Description (Check which applies)

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




Before Test




After Second Cycle

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

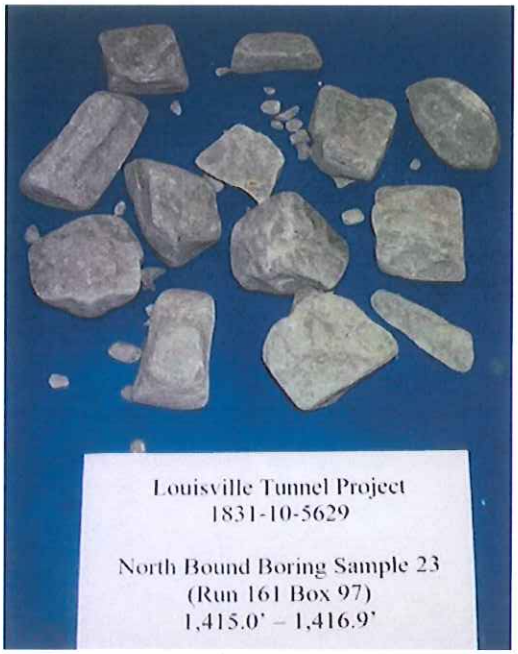
| | | | |
|---|---|---|---|
| Project: | Louisville Tunnel | Sample Date: | 6/24/2011 |
| S&ME Project No. | 1831-10-5629 | Report Date: | 7/29/2011 |
| Material: | Waldron Shale | | |
| Sample ID: | NB-23 Run 161 Box 97 (1415.0' - 1416.9') | | |
| Date Tested: | 7/27/2011 to 7/28/2011 | | |

| | | |
|---|---|---|
| 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)

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


Before Test




After Second Cycle

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S&ME

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

| | | | |
|---|---|---|---|
| Project: | Louisville Tunnel | Sample Date: | 7/1/2011 |
| S&ME Project No. | 1831-10-5629 | Report Date: | 8/9/2011 |
| Material: | Waldron Shale | | |
| Sample ID: | NB-25 Run 165 Box 100 (1453.7' - 1454.8') | | |
| Date Tested: | 8/01/2011 to 8/02/2011 | | |

| | | |
|---|---|---|
| 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)

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


Before Test


After Second Cycle

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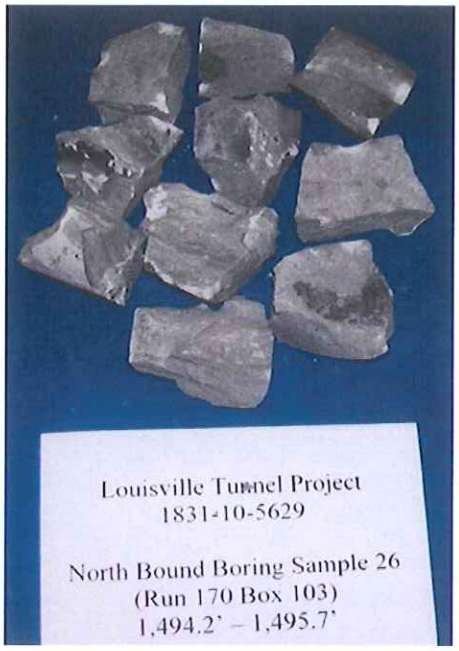
# Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

| | | | |
|---|---|---|---|
| Project: | Louisville Tunnel | Sample Date: | 7/1/2011 |
| S&ME Project No. | 1831-10-5629 | Report Date: | 8/9/2011 |
| Material: | Waldron Shale | | |
| Sample ID: | NB-26 Run 170 Box 103 (1494.2' - 1495.7') | | |
| Date Tested: | 8/01/2011 to 8/02/2011 | | |

| | | |
|---|---|---|
| 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)

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




Before Test


After Second Cycle

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*Phone: 865-970-0003 Fax: 865-970-2312*

S&ME

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

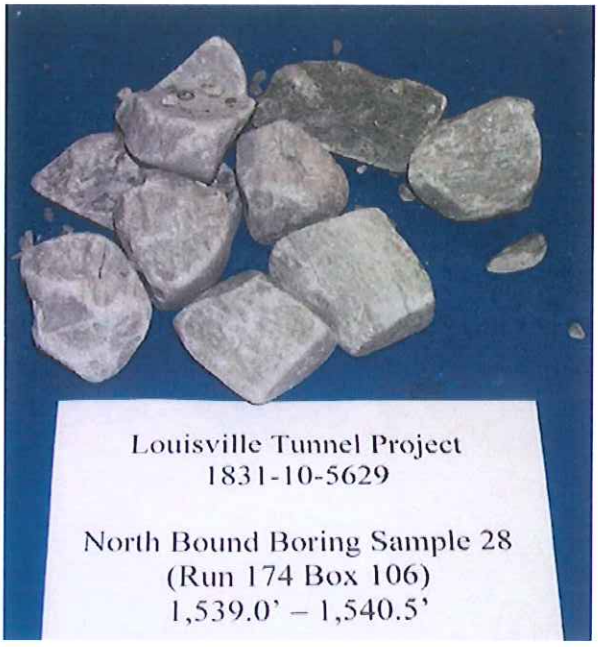
| | | | |
|---|---|---|---|
| Project: | Louisville Tunnel | Sample Date: | 7/1/2011 |
| S&ME Project No. | 1831-10-5629 | Report Date: | 8/9/2011 |
| Material: | Waldron Shale | | |
| Sample ID: | NB-28 Run 174 Box 106 (1539.0' - 1540.5') | | |
| Date Tested: | 8/01/2011 to 8/02/2011 | | |

| | | |
|---|---|---|
| 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)

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


Before Test




After Second Cycle

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S&ME

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

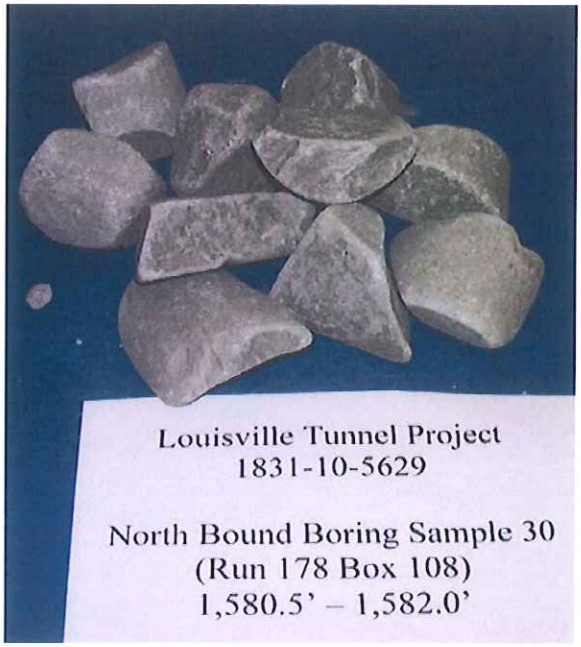
| | | | |
|---|---|---|---|
| Project: | Louisville Tunnel | Sample Date: | 7/1/2011 |
| S&ME Project No. | 1831-10-5629 | Report Date: | 8/9/2011 |
| Material: | Waldron Shale | | |
| Sample ID: | NB-30 Run 178 Box 108 (1580.5' - 1582.0') | | |
| Date Tested: | 8/01/2011 to 8/02/2011 | | |

| | | |
|---|---|---|
| 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)

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


Before Test




After Second Cycle

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S&ME

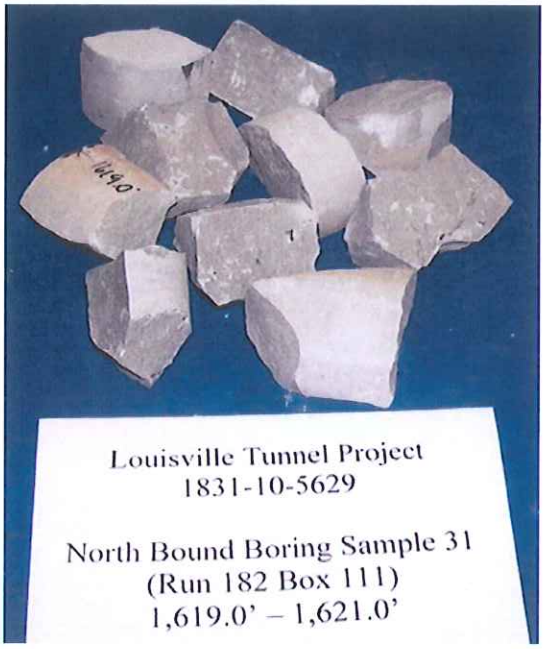
# Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

| | | | |
|---|---|---|---|
| Project: | Louisville Tunnel | Sample Date: | 7/1/2011 |
| S&ME Project No. | 1831-10-5629 | Report Date: | 8/9/2011 |
| Material: | Waldron Shale | | |
| Sample ID: | NB-31 Run 182 Box 111 (1619.0' - 1621.0') | | |
| Date Tested: | 8/02/2011 to 8/03/2011 | | |

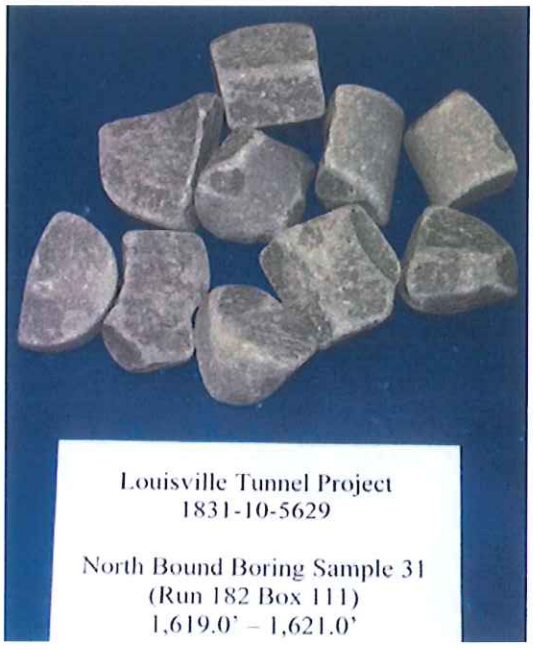
| | | |
|---|---|---|
| Slake Durability Index (Second Cycle) | 97.3 | % |
| Range of water temperature (Cycle 1) | 0.0 | °F |
| Average water temperature (Cycle 1) | 78.5 | °F |
| Range of water temperature (Cycle 2) | 1.0 | °F |
| Average water temperature (Cycle 2) | 76.0 | °F |
| Natural Moisture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

Sample Description (Check which applies)

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




Before Test




After Second Cycle

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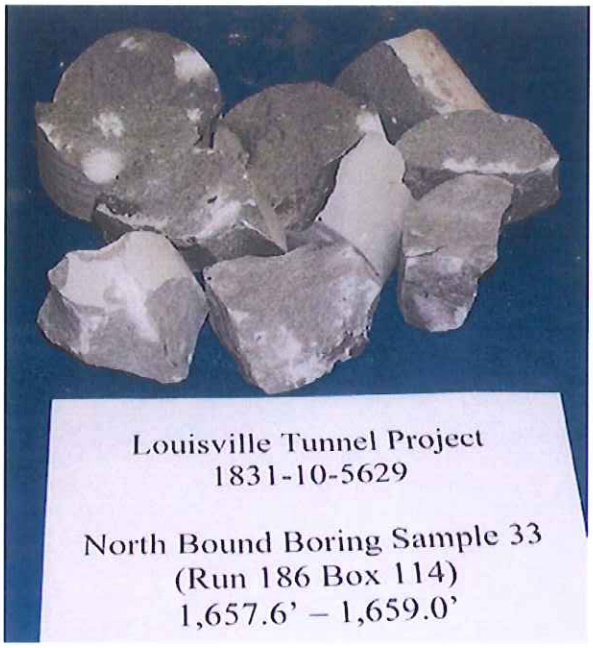
## Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

| | | | |
|---|---|---|---|
| Project: | Louisville Tunnel | Sample Date: | 7/1/2011 |
| S&ME Project No. | 1831-10-5629 | Report Date: | 8/9/2011 |
| Material: | Waldron Shale | | |
| Sample ID: | NB-33 Run 186 Box 114 (1657.6' - 1659.0') | | |
| Date Tested: | 8/02/2011 to 8/03/2011 | | |

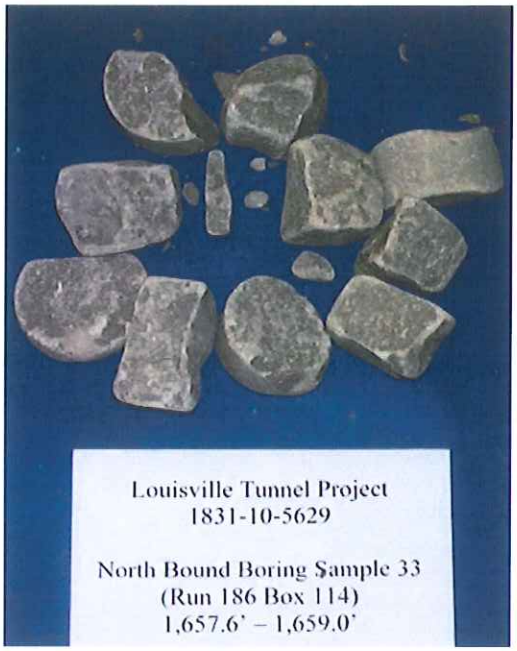
| | | |
|---|---|---|
| Slake Durability Index (Second Cycle) | 96.2 | % |
| Range of water temperature (Cycle 1) | 0.0 | °F |
| Average water temperature (Cycle 1) | 78.5 | °F |
| Range of water temperature (Cycle 2) | 0.0 | °F |
| Average water temperature (Cycle 2) | 75.5 | °F |
| Natural Moisture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

Sample Description (Check which applies)

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




Before Test




After Second Cycle

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

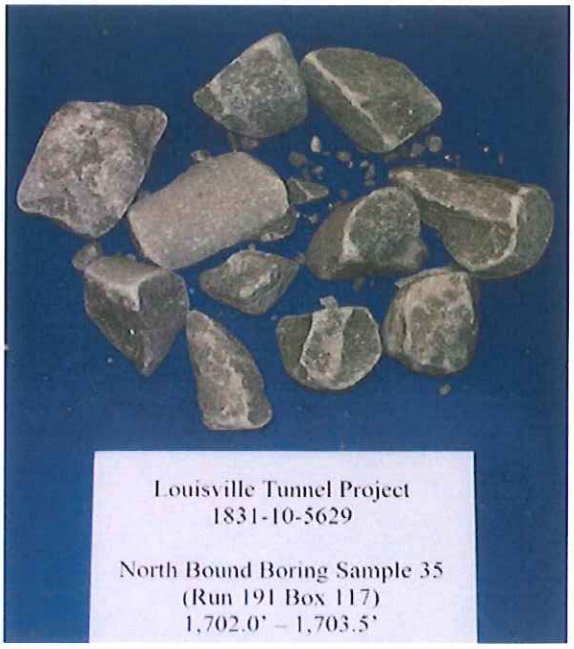
| | | | |
|---|---|---|---|
| Project: | Louisville Tunnel | Sample Date: | 7/1/2011 |
| S&ME Project No. | 1831-10-5629 | Report Date: | 8/9/2011 |
| Material: | Waldron Shale | | |
| Sample ID: | NB-35 Run 191 Box 117 (1702.0' - 1703.5') | | |
| Date Tested: | 8/02/2011 to 8/03/2011 | | |

| | | |
|---|---|---|
| Slake Durability Index (Second Cycle) | 91.5 | % |
| Range of water temperature (Cycle 1) | 0.0 | °F |
| 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)

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


Before Test




After Second Cycle

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

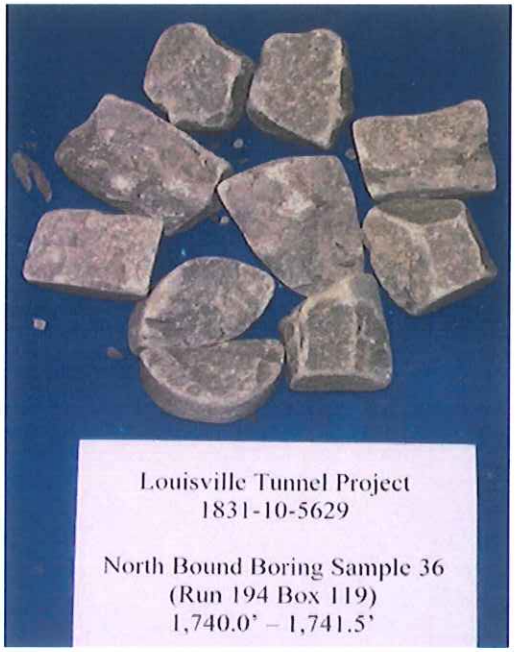
| | | | |
|---|---|---|---|
| Project: | Louisville Tunnel | Sample Date: | 7/1/2011 |
| S&ME Project No. | 1831-10-5629 | Report Date: | 8/9/2011 |
| Material: | Waldron Shale | | |
| Sample ID: | NB-36 Run 194 Box 119 (1740.0' - 1741.5') | | |
| Date Tested: | 8/02/2011 to 8/03/2011 | | |

| | | |
|---|---|---|
| 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)

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


Before Test




After Second Cycle

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

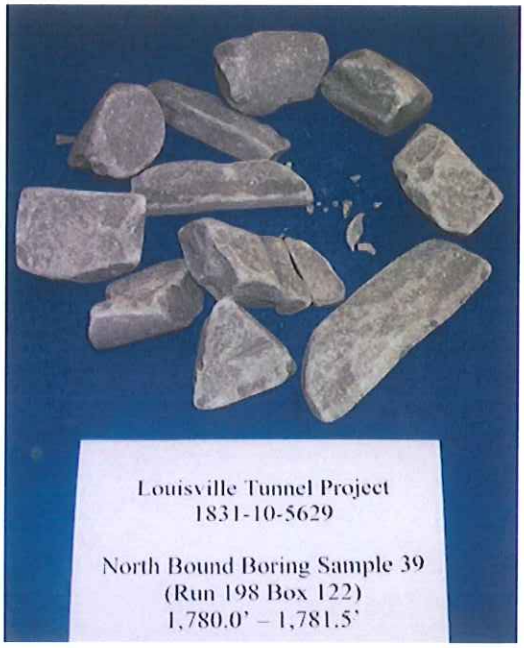
| | | | |
|---|---|---|---|
| Project: | Louisville Tunnel | Sample Date: | 7/8/2011 |
| S&ME Project No. | 1831-10-5629 | Report Date: | 8/12/2011 |
| Material: | Waldron Shale | | |
| Sample ID: | NB-39 Run 198 Box 122 (1780.0' - 1781.5') | | |
| Date Tested: | 7/29/2011 to 8/01/2011 | | |

| | | |
|---|---|---|
| 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)

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


Before Test




After Second Cycle

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S&ME

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

| | | | |
|---|---|---|---|
| Project: | Louisville Tunnel | Sample Date: | 7/8/2011 |
| S&ME Project No. | 1831-10-5629 | Report Date: | 8/12/2011 |
| 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)

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


Before Test


After Second Cycle

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

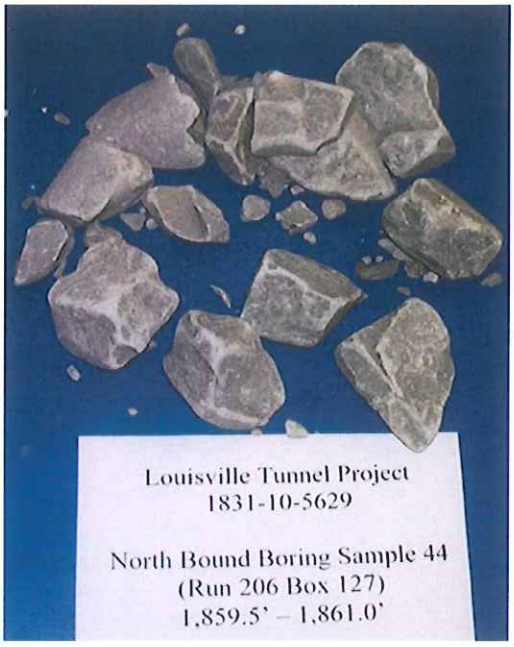
| | | | |
|---|---|---|---|
| Project: | Louisville Tunnel | Sample Date: | 7/8/2011 |
| S&ME Project No. | 1831-10-5629 | Report Date: | 8/12/2011 |
| Material: | Waldron Shale | | |
| Sample ID: | NB-44 Run 206 Box 127 (1859.5' - 1861.0') | | |
| Date Tested: | 7/29/2011 to 8/01/2011 | | |

| | | |
|---|---|---|
| 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)

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


Before Test




After Second Cycle

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

S&ME

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 ($cm^2$) | 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 ($g/cm^3$) | 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:** [1]These 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

S&ME

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 ($cm^2$) | 17.50 | 17.62 | | |
| Volume ($cm^3$), 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 ($lb/ft^3$)** | **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:** [1]These 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: Louisville Tunnel Project
S&ME Project Number: 1831-10-5629
Test Procedure: ASTM D 2216

| Location | Distance (ft) | Tare ID | Tare Weight (g) | Moisture Specimen including tare | | Percent Moisture (%) | Tested By | Date |
|---|---|---|---|---|---|---|---|---|
| | | | | Wet Weight (g) | Oven Dry Weight (g) | | | |
| 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 | 1389.2 | 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 | 1389.4 | 3 | 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 |
| | | | | | | | | |
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Reviewed By: _____ Date: _____



# Cerchar

301 East Dean Keeton building ECJ B220
1 University Station C1792, Austin TX 78712 USA

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**CERCHAR Abrasiveness test**

**Test procedure: ASTM D7625**

**The University of Texas at Austin**

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

| | |
|---|---|
| Project Name | Louisville Tunnel |
| Client Project No. | 1831-10-5629 |
| UT reference | 2011_SME_001_01 |
| Test Date | 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 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 Apparatus No.100225 | |

Note:

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

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

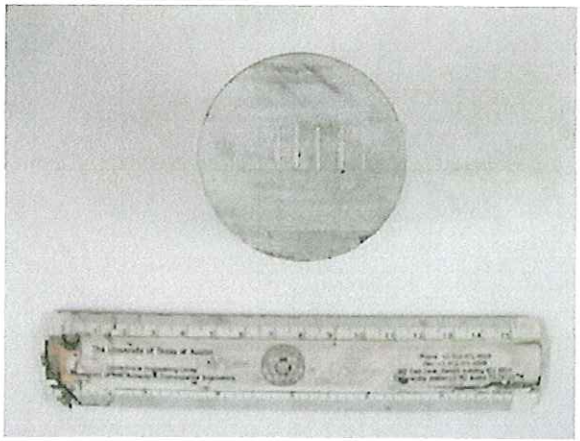

Photo after test

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**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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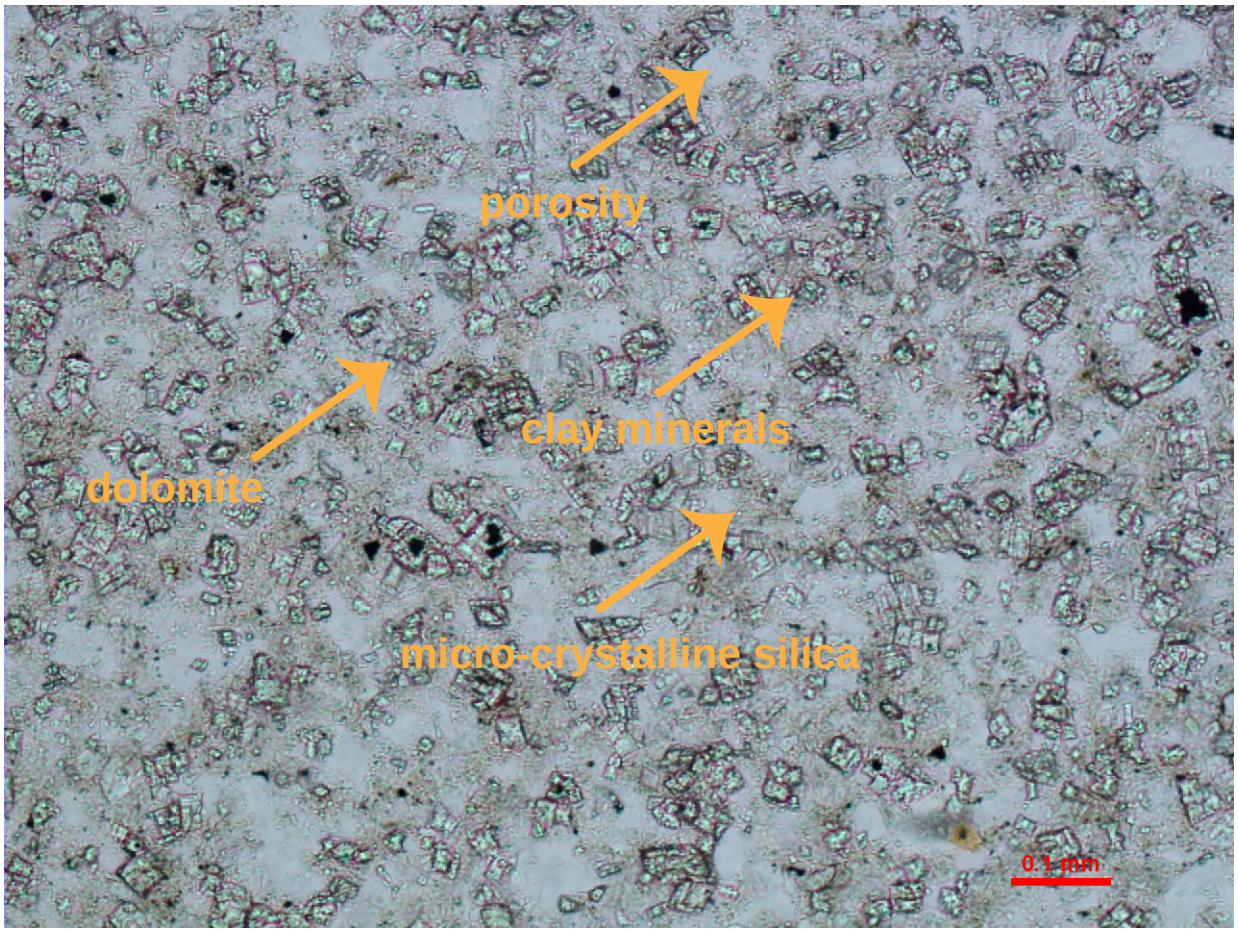
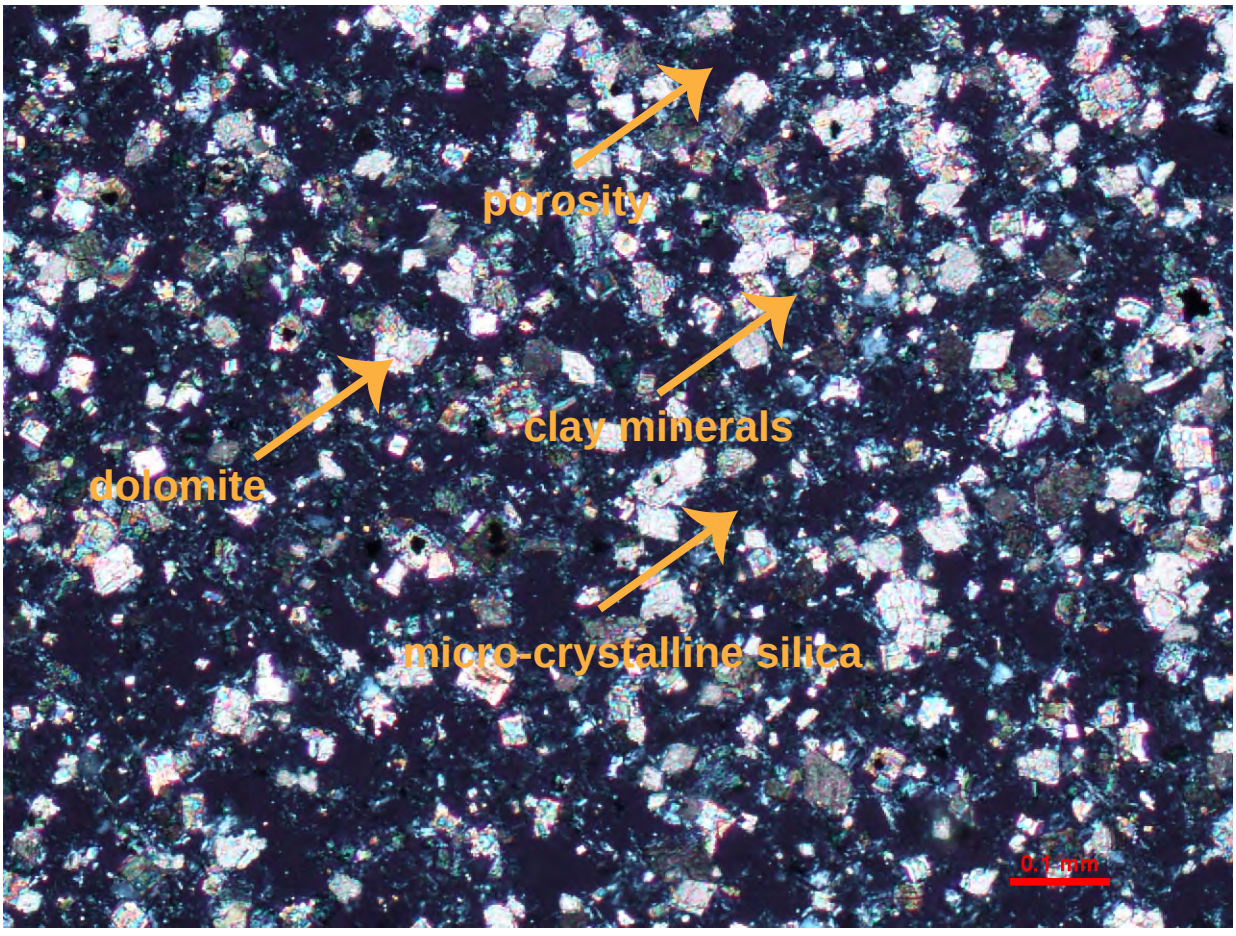
# NB2 1822.0-1823.5 ft, unstained slide

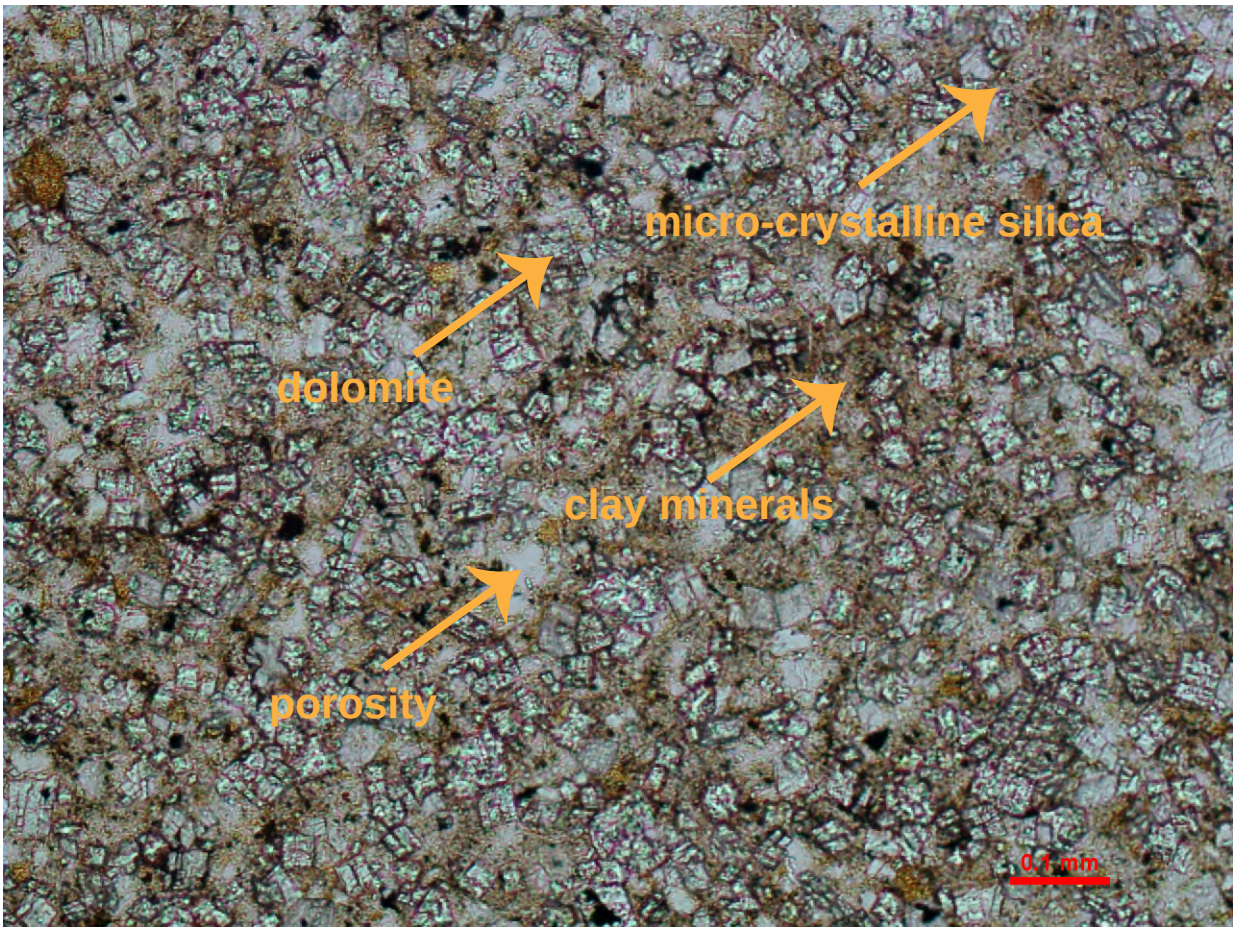



plane light

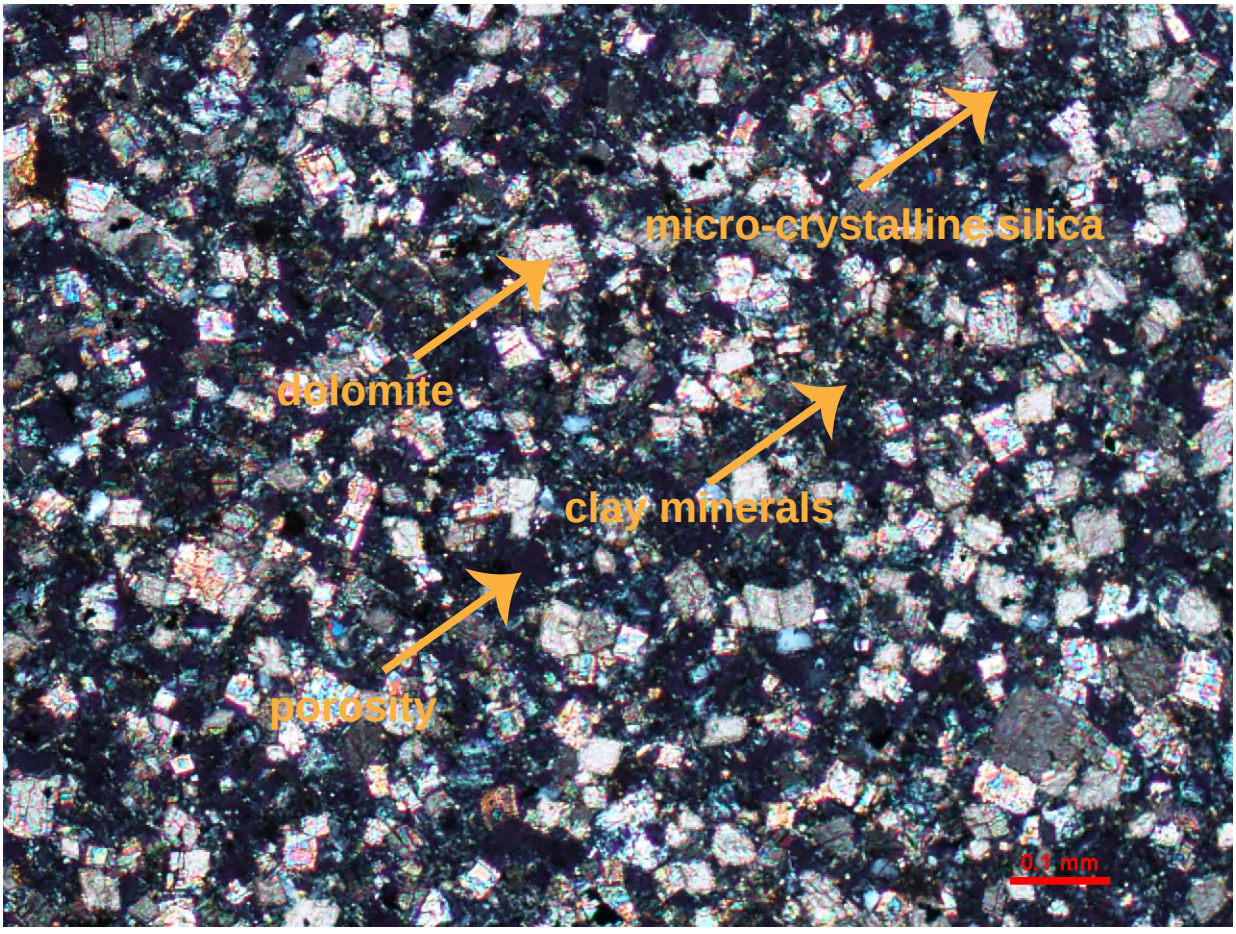



crossed polars

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




plane light




crossed polars

## Huder-Amberg Test

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

**The University of Texas at Austin**

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

| | |
|---|---|
| Project name | Louisville Tunnel |
| Client project no. | 1831-10-5629 |
| Date samples were received | 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 in |
| Maximum pressure requested | 4644 kPa | 9700 psf |
| Diameter of specimen | 47.19 mm | 1.86 in |
| Test temperature | 20.0 °C | 68.0 °F |

Testing set-up

Testing set-up

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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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**Huder-Amberg Test**

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

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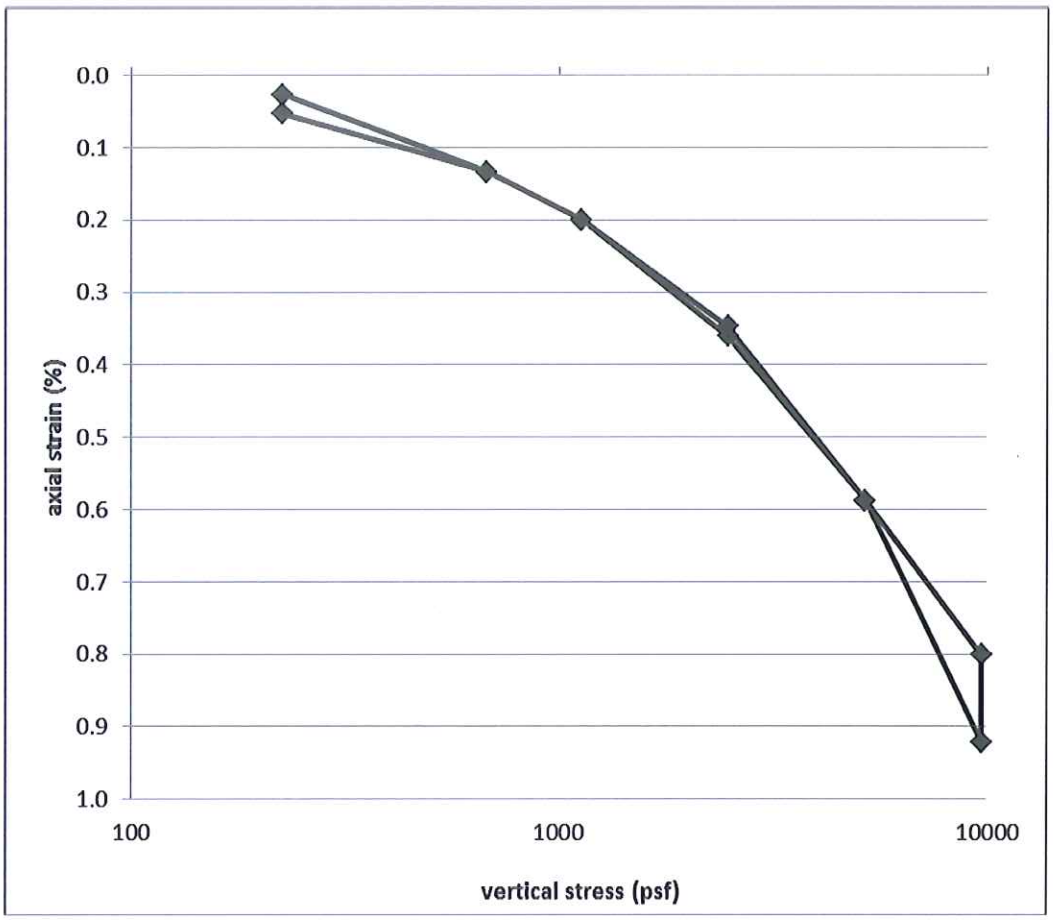
**Geotechnical Engineering**
**Department of Civil, Architectural and Environmental Engineering**

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**The University of Texas at Austin**

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

| | |
|---|---|
| Project name | Louisville Tunnel |
| Client project no. | 1831-10-5629 |
| Date samples were received | 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 in |
| Maximum pressure requested | 4644 kPa | 9700 psf |
| Diameter of specimen | 46.75 mm | 1.84 in |
| Test temperature | 20.0 °C | 68.0 °F |

Testing set-up 1

Testing set-up 2


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**Huder-Amberg Test**

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

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

| Date | Axial load increment | | Axial displacement | | Axial strain (%) |
|---|---|---|---|---|---|
| | kPa | Psf | mm (x 1,000) | in (x 1,000) | |
| 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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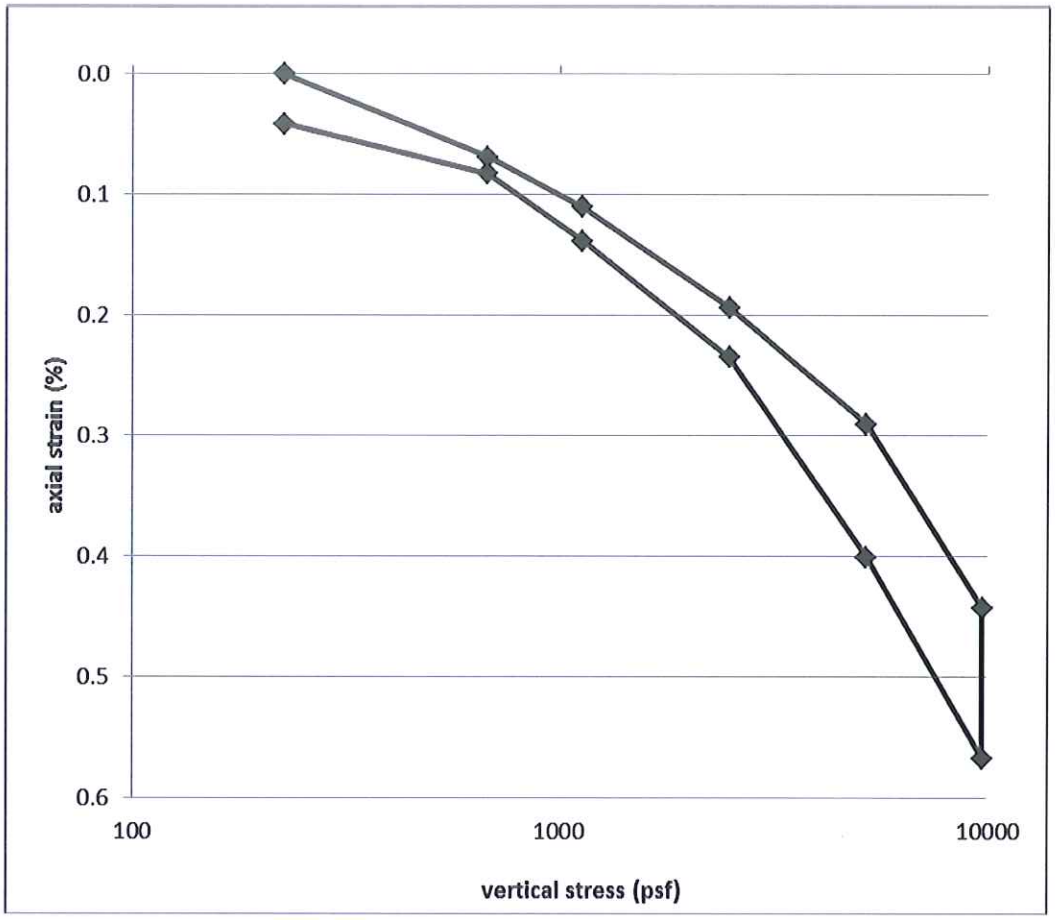


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**THIN SECTION PETROGRAPHIC ANALYSIS**

**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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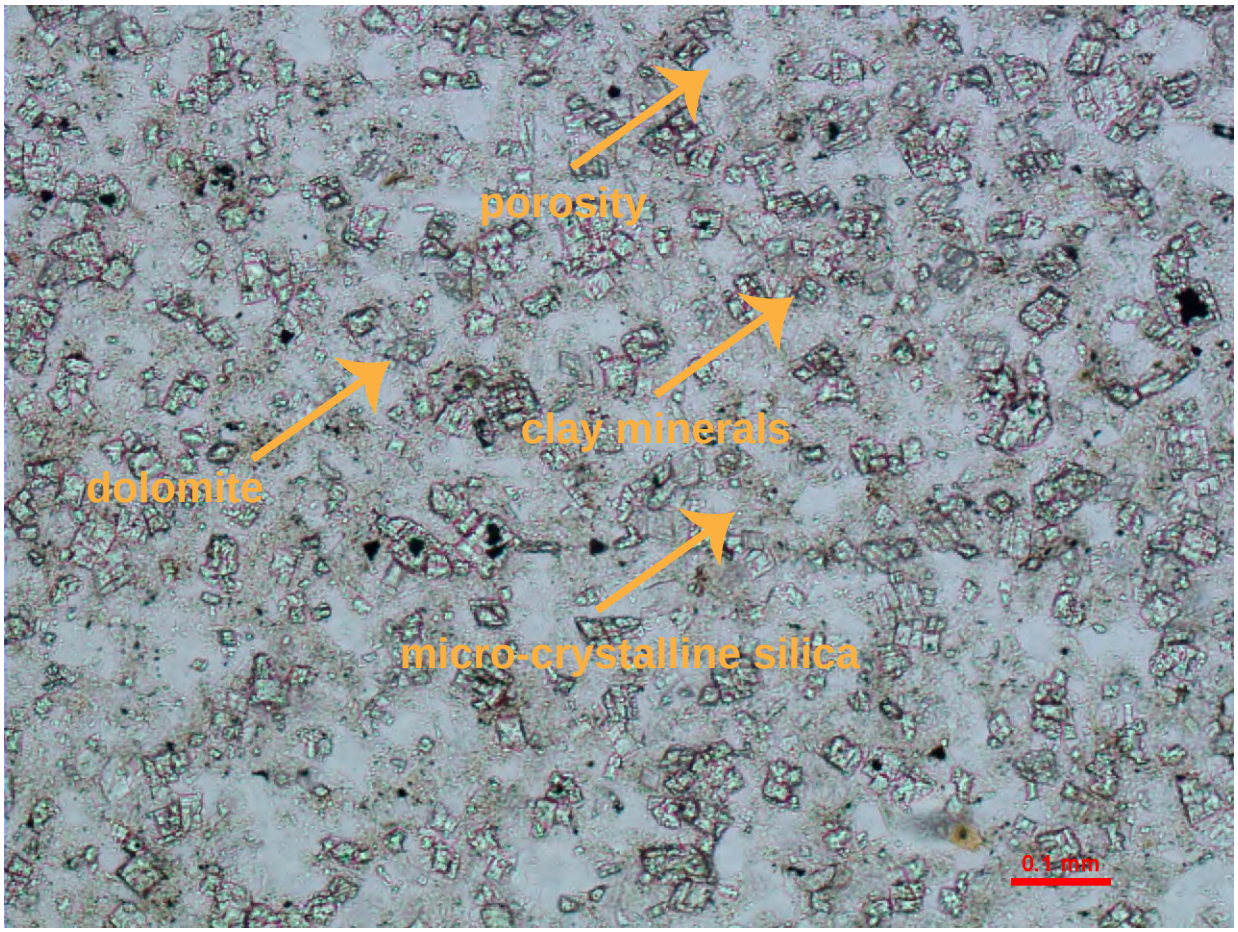
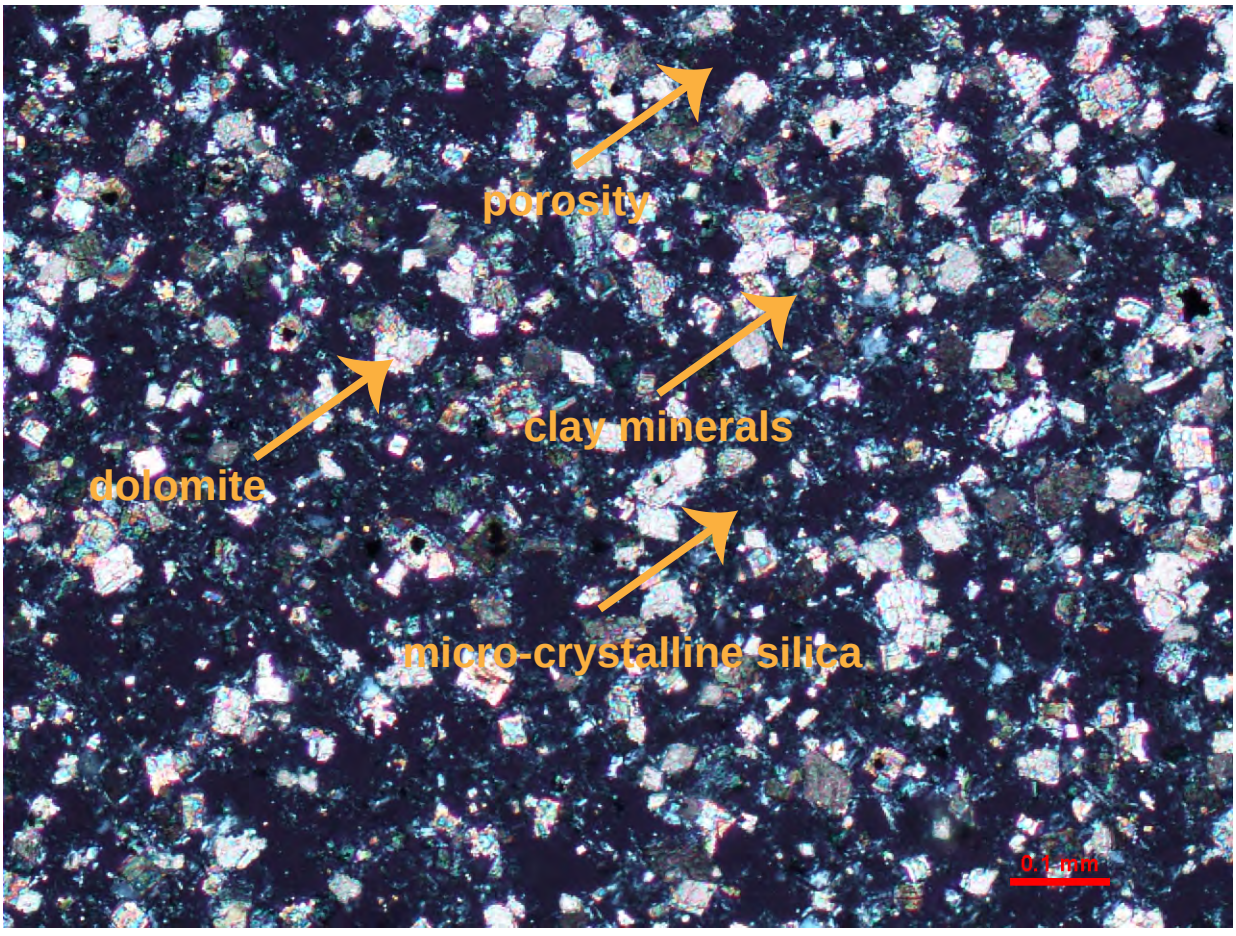
# NB2 1822.0-1823.5 ft, unstained slide

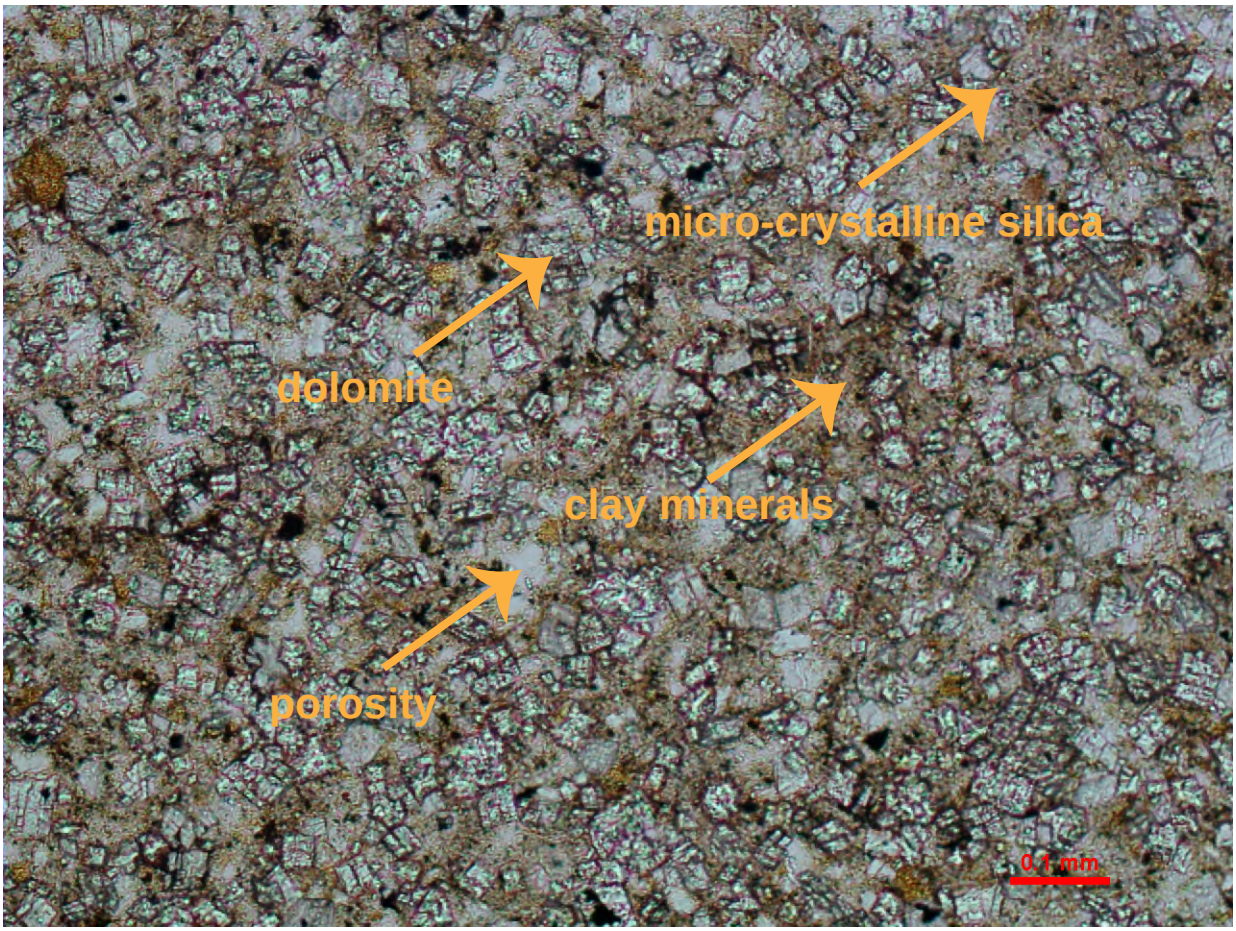



plane light

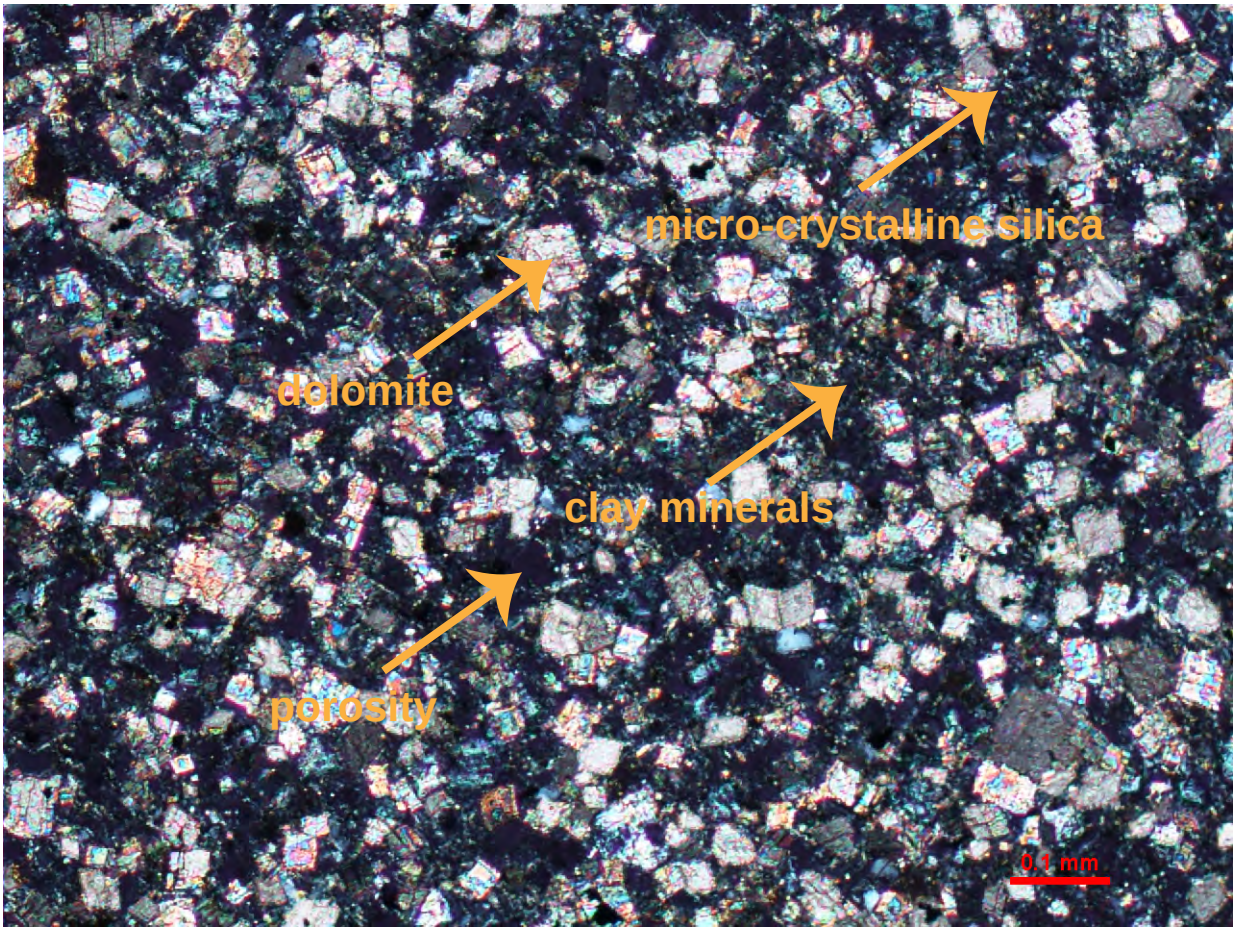



crossed polars

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




plane light




crossed polars

# APPENDIX C

# PACKER TEST RESULTS

# LEGEND TO LUGEON VALUES

Louisville Tunnel Project
Louisville, KY
1831-10-5629

**Field Test Data**

**Boring No** North Bound

**Tested By:** **N. Peterson** .

**Ground Surface Elev.** _____ .

| Date | Stage | Time (Reqd = 10 min.) | | | Guage Pressure | | Flow Meter Start (gallons) | Flow Meter Stop (gallons) | Water Take (gallons) |
|---|---|---|---|---|---|---|---|---|---|
| 7/7/2011 | | From | To | Actual | Reqd | Actual | | | |
| Packer Pressures | from | 1613 | 1623 | 10 | 30 | 37.08 | 274.19 | 278.04 | 3.85 |
| Top | 1371.0 ft | 1627 | 1637 | 10 | 60 | 61.01 | 278.04 | 280.01 | 1.97 |
| 200 | 1400.0 ft | 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 | _____ ft. | 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 |
| Top | 1350.0 ft | 1805 | 1815 | 10 | 60 | 60.3 | 321.26 | 321.44 | 0.18 |
| 200 | to 1321.0 ft. | 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 | _____ ft. | 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 |
| Top | 1300.0 ft. | 757 | 807 | 10 | 60 | 60.3 | 355.45 | 355.9 | 0.45 |
| 200 | to 1271.0 ft. | 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 |
| Top | 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 | _____ ft. | 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 | To | Actual | Reqd | Actual | (gallons) | (gallons) | |
| Packer Pressures | from | 12:39 | 12:49 | 10 | 30 | 32.0 | 438.72 | 438.72 | 0.00 |
| Top | 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 |
| Top | 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 |
| Top | 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 |
| Top | 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 | To | Actual | Reqd | Actual | (gallons) | (gallons) | |
| Packer Pressures | from | 7:47 | 7:57 | 10 | 30 | 30.5 | 1051.51 | 1054.27 | 2.76 |
| Top | 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 |
| Top | 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 |
| Top | 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 |
| Top | 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 |
| Top | 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 : ***North Bound*** Test by: ***N. Peterson***
Elevation: Date: ***7/7/2011***

Formula for Lugeon (Lu) calculation:

(water take in gallons ÷ 7.48 gal/ft$^3$) x (142 psi ÷ gauge pressure in psi)
divided by (stage length in feet x test time in minutes x 0.0107620)

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

| Borehole Stage Interval (ft) | Vertical Stage Interval (ft) | Increment | Stage Length (ft) | Test Time (min.) | Gauge Pressure (psi) | Water Take (gallons) | Lu (incr.) | Lu (stage) |
|---|---|---|---|---|---|---|---|---|
| 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 : ***North Bound*** Test by: ***N. Peterson***
Elevation: **510.7** Date: ***7/8/2011***

Formula for Lugeon (Lu) calculation:

(water take in gallons ÷ 7.48 gal/ft$^3$) x (142 psi ÷ gauge pressure in psi)
divided by (stage length in feet x test time in minutes x 0.0107620)

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

| Borehole Stage Interval (ft) | Vertical Stage Interval (ft) | Increment | Stage Length (ft) | Test Time (min.) | Gauge Pressure (psi) | Water Take (gallons) | Lu (incr.) | Lu (stage) |
|---|---|---|---|---|---|---|---|---|
| 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 : ***North Bound*** Test by: ***N. Peterson***
Elevation: **512.5** Date: ***7/9/2011***

Formula for Lugeon (Lu) calculation:

(water take in gallons ÷ 7.48 gal/ft$^3$) x (142 psi ÷ gauge pressure in psi)
divided by (stage length in feet x test time in minutes x 0.0107620)

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

| Borehole Stage Interval (ft) | Vertical Stage Interval (ft) | Increment | Stage Length (ft) | Test Time (min.) | Gauge Pressure (psi) | Water Take (gallons) | Lu (incr.) | Lu (stage) |
|---|---|---|---|---|---|---|---|---|
| 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 | |

# LEGEND TO LUGEON VALUES

## TURBULENT FLOW

Ten Minute Runs:


PERMEABILITY DECREASES AS THE PRESSURE AND RESULTANT FLOW INCREASES BECAUSE OF THE TURBULENT FLOW IN THE FRACTURES.

## WASH-OUT

Ten Minute Runs:


PERMEABILITY INCREASES BECAUSE FRACTURES ARE ENLARGED BY THE TEST.

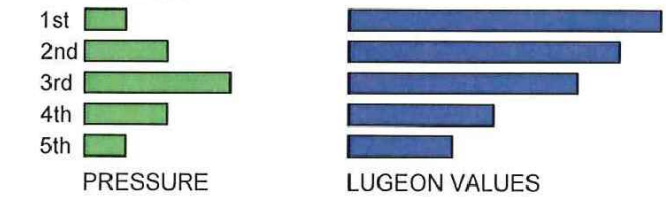
## DILATION

Ten Minute Runs:


PERMEABILITY INCREASES AT THE HIGHEST WATER TEST PRESSURE AS FRACTURES ARE BEING HYDRAULICALLY JACKED OPEN. FLOW IS LAMINAR AT THE LOWER PRESSURES.

## VOID FILLING

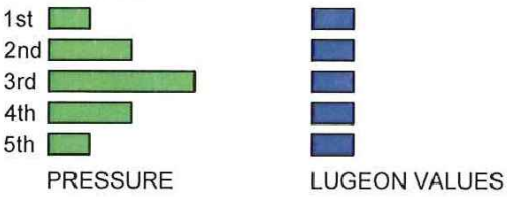
Ten Minute Runs:




PERMEABILITY DECREASES DUE TO FRACTURES THAT ARE BEING FILLED AND PARTIALLY OR COMPLETELY BLOCKED AS WATER FLOWS. SWELLING ROCK THAT CLOSES FRACTURES OVER TIME BECAUSE OF THE INTRODUCTION OF WATER BY THE TEST CAN ALSO CAUSE THIS REDUCED PERMEABILITY.

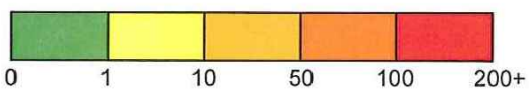
## LAMINAR FLOW

Ten Minute Runs:




THE PERMEABILITY IS ESENTIALLY THE SAME NO MATTER WHAT THE PRESSURE AND RESULTANT WATER TAKE.

LUGEON VALUE SCALE




**TERMS**

THE LUGEON UNIT IS A UNIT OF PERMEABILITY USED IN GROUTING APPLICATIONS.

DEFINITION OF THE LUGEON UNIT:

- 1 LUGEON UNIT = 0.0107620 CUBIC FEET OF WATER TAKEN PER FOOT OF TEST LENGTH PER MINUTE AT 142 POUNDS PER SQUARE INCH.

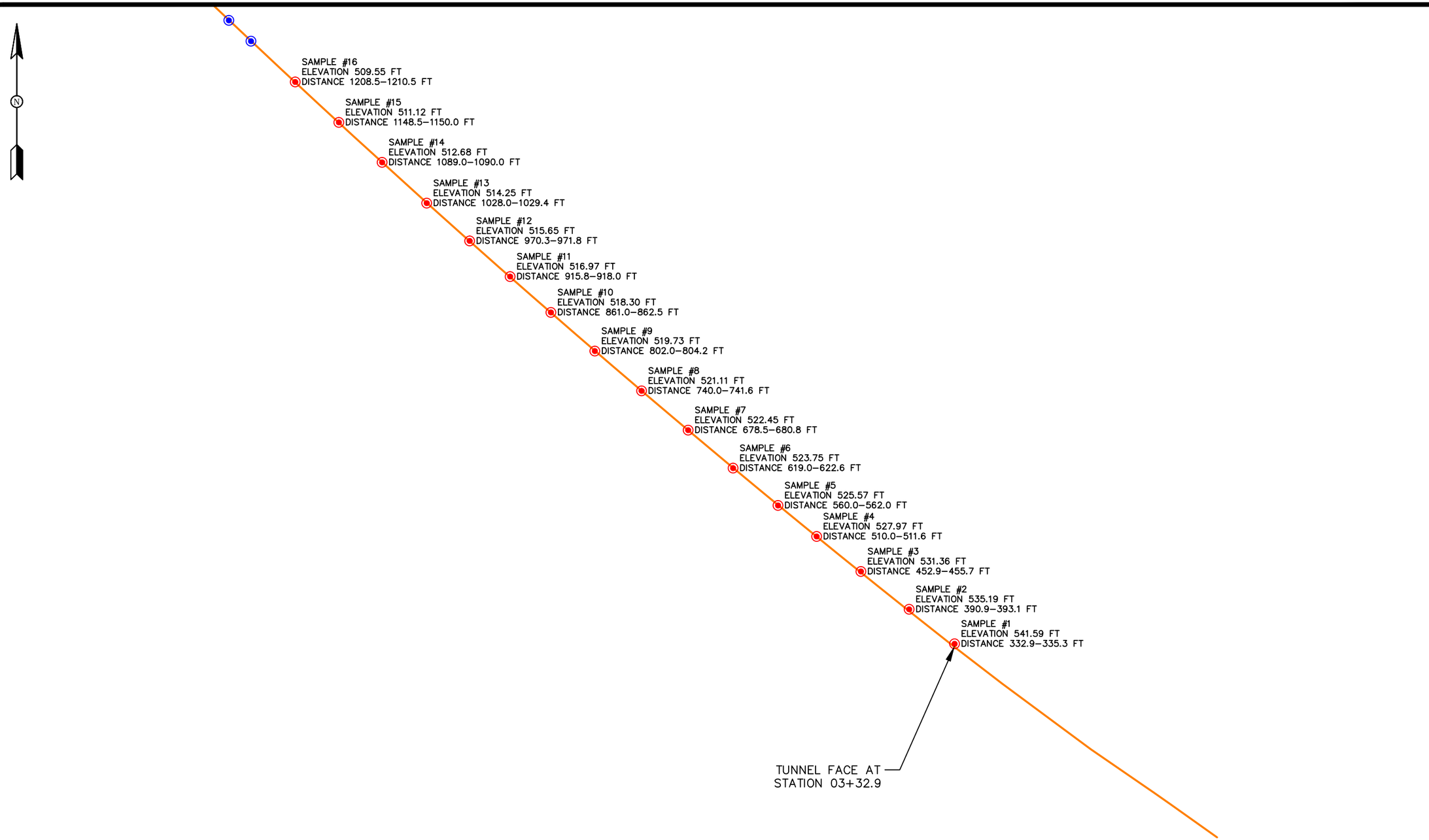
IN TERMS OF VELOCITY TYPE PERMEABILITY UNITS:

- 1 LUGEON UNIT = $10 \frac{FT}{YEAR} = 1x10^{-5} \frac{CM}{S}$

TO GIVE A SENSE OF THE PROPORTION OF THE LUGEON UNIT:

- 1 LUGEON UNIT IS THE TYPE OF PERMEABILITY FOR SOUND BEDROCK.
- 10 LUGEON UNITS TYPICALLY INDICATES SEEPAGE THROUGH BEDROCK.
- 100 LUGEON UNITS IS THE TYPE OF PERMEABILITY TYPICALLY OBSERVED IN HEAVILY JOINTED BEDROCK UNITS WITH RELATIVELY OPEN JOINTS OR IN SLIGHTLY TO MODERATELY JOINTED UNITS WHERE JOINTS ARE WIDE TO VERY WIDELY OPEN (i.e. SEVERE SOLUTION ZONES.

S&ME



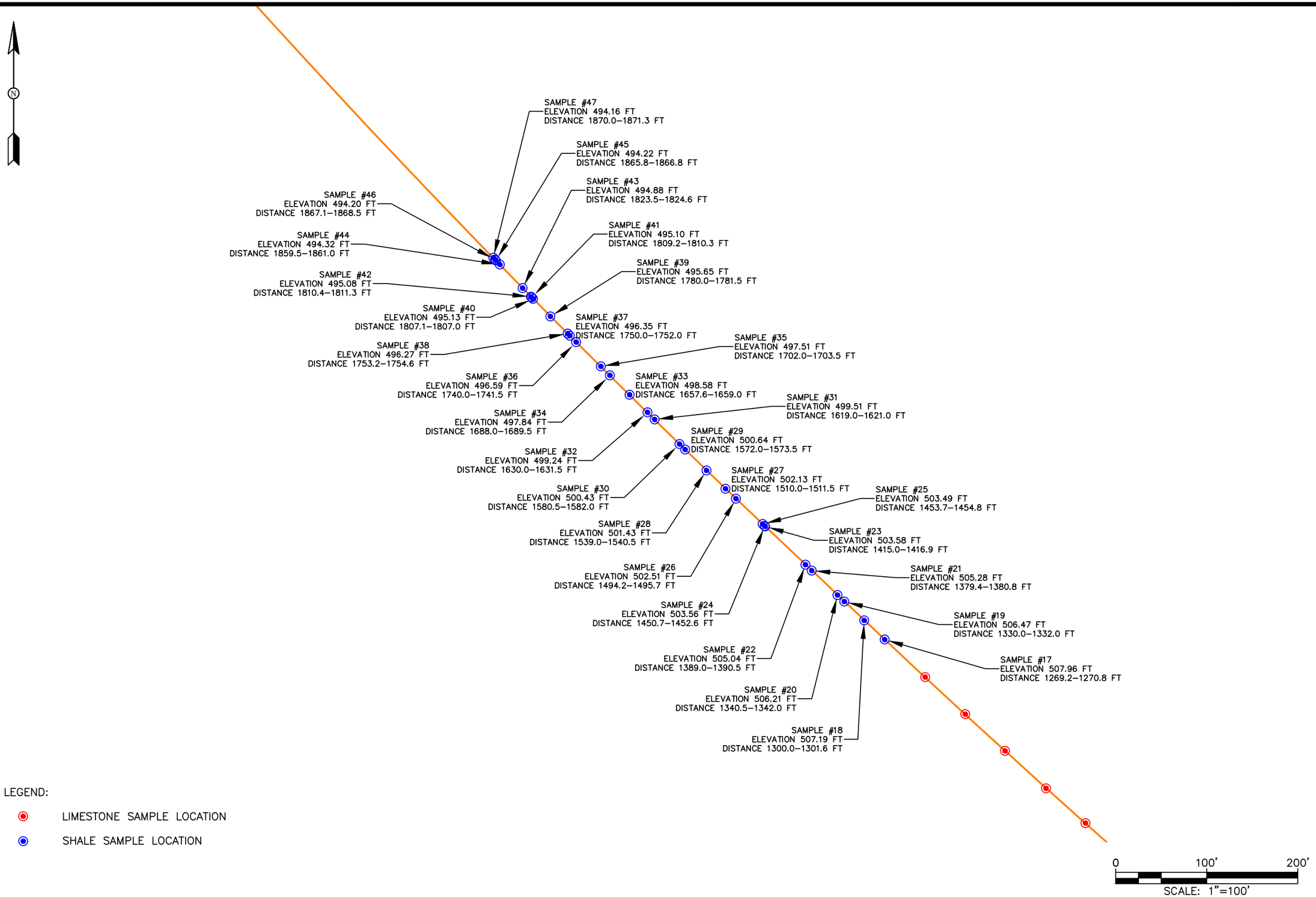

SCALE: 1”=100’
DATE: 07–28–11
PROJECT NO. 1831–10–5629
DRAWN BY: BCW
CHECKED BY:

S&ME
WWW.SMEINC.COM

NORTH BOUND BORING
LIMESTONE SAMPLE LOCATIONS
STA 03+32.9 TO STA 12+20

LOUISVILLE TUNNELS
LOUISVILLE, KENTUCKY

FIGURE NO.
1




LEGEND:

- LIMESTONE SAMPLE LOCATION
- SHALE SAMPLE LOCATION

SCALE: 1"=100'
DATE: 07-28-11
PROJECT NO. 1831-10-5629
DRAWN BY: BCW
CHECKED BY:

S&ME
WWW.SMEINC.COM

NORTH BOUND BORING
SHALE SAMPLE LOCATIONS
STA 12+20 TO STA 19+00

LOUISVILLE TUNNELS
LOUISVILLE, KENTUCKY

FIGURE NO.
2