GEOTECHNICAL DATA REPORT
VERTICAL BORINGS

Louisville-Southern Indiana Ohio River Bridges Project
Vertical Borings
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

January 16, 2012

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

Attention: Mr. Daryl Greer, P.E.

Subject: **Geotechnical Data Report**
Louisville Tunnel Project
Vertical Borings
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 the Louisville Tunnel in Jefferson County, Kentucky. The following report presents the data generated from our conventional vertical drilling, laboratory testing, and geophysical exploration.

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 NJP
Nathan J. Peterson, P.G
Geotechnical Professional

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

Craig Lee
Craig Lee, P.E
Senior Geotechnical Engineer

Attachments: Geotechnical Data Report – Vertical Borings

S&ME, INC. / 422 Codell Drive / Lexington, KY 40509 / p 859.293.5518 f 859.299.2481 / www.smeinc.com

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1. INTRODUCTION

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

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

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

2. OBJECTIVES

The objectives of our exploration were to determine general subsurface conditions, to obtain data to evaluate the engineering characteristics of the on-site soil and bedrock within the proposed tunnel entrances. A combination of soil test and rock core borings and geophysical surveys were used to assess the subsurface conditions. The geophysical surveys consisted of electrical resistivity and seismic refraction. An assessment of site environmental conditions or an assessment for the presence or absence of contaminants in the soil, bedrock, surface water, or groundwater of the site was beyond the proposed objectives of our scope of work.

Prior to the vertical borings, a comprehensive exploration program using horizontal directional coring was undertaken for the North and South Bound tunnels as well as the pillar between the tunnels. The Geotechnical Data Reports for the horizontal program for the South Bound Tunnel, North Bound Tunnel, and Pillar Boring were reported under separate covers. The exploration and testing reported in this Geotechnical Data Report is a supplement to the Horizontal Directional program.

3. SCOPE OF WORK

The scope of work was based on project information provided to us by Golder Associates and the Kentucky Transportation Cabinet. It included the following:

- Mobilization of a drill rig and field professionals.
- Drilling 13 geotechnical borings to pre-determined termination depths in order to delineate subsurface conditions. Field sampling included Standard Penetration Tests, relatively undisturbed thin walled (Shelby) tube samples, and rock core samples. Boring locations and depths were determined by Golder Associates representatives. The boring locations were staked in the field by S&ME survey crews.
- Measuring and recording groundwater depths at the termination of the boring, 24 hours after completion, and 24 hours after well installation.
- Conducting packer testing in 9 of the 13 borings.
- Using a downhole camera to record the bedrock conditions in 10 of the 13 borings.
- Installing piezometers in four of the borings to predetermined depths.
- Abandoning the sampled boreholes with cement grout utilizing the tremie grouting method in the borings not receiving a piezometer.
- Performing geotechnical laboratory testing on selected soil samples obtained during the geotechnical exploration.
- Performing geotechnical laboratory testing on selected rock core samples obtained during the geotechnical exploration.
- Performing electrical resistivity and seismic refraction to provide data associated with karst features such as cavities and latent dropouts.
- Prepare a Geotechnical Data Report presenting the boring logs, geotechnical laboratory test results, geophysical survey results, and a summary of the field procedures and activities.

4. SITE GEOLOGY

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

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

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

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

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

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

5. SUBSURFACE CONDITIONS

The subsurface conditions at the site were explored with 13 soil test borings (B-82 through B-94). The locations for the borings were determined by Golder Associates and surveyed in the field by S&ME (see **Figures 2 and 3**). An average ground surface elevation of 542.8 feet msl was determined for the site. The ground surface elevation at the site ranged from 592.8 feet msl (Boring B-82) to 517.6 feet msl (Boring B-92).

Subsurface conditions encountered at each boring location are shown on the boring logs in **Appendix I**. The boring logs represent our interpretation of the subsurface conditions, based on the field logs and visual examination of the samples by one of our geotechnical professionals. The lines designating the interfaces between various strata on the boring logs represent the approximate interface locations. The groundwater levels provided on the logs correspond to levels at the time of boring (i.e., when first encountered) and after 24 hours. A summary of the boring depths is presented in Table 5.1.

Table 5.1
Boring Summary

Boring I.D.	Ground Surface Elevation msl (Feet)[1]	Boring Coordinates[1]		Boring Termination Depth (Feet)	Boring Termination Elevation msl (Feet)[1]
		Northing	Easting		
B-82	592.8	302887.4	1247123.99	103.0	489.00
B-83	583.7	302958.85	1247178.80	36.4	547.00
B-84	569.6	303164.87	1247086.29	37.0	532.00
B-85	537.3	303581.25	1246351.51	79.0	458.30
B-86	532.2	303811.89	1246117.12	81.5	450.22
B-87	528.3	303857.45	1246163.48	28.0	500.22
B-88	533.0	303927.54	1246234.80	32.5	500.22
B-89	546.3	303990.63	1246298.99	96.0	450.22
B-90	526.0	304038.92	1245989.66	29.1	496.9
B-91	536.5	304195.44	1245712.74	91.5	444.87
B-92	517.6	304261.99	1245787.38	72.5	444.87
B-93	521.4	304328.54	1245936.65	76.5	444.87
B-94	532.5	304395.09	1245936.65	87.5	444.87

Notes:
1 - Ground surface elevations are based on S&ME survey information.

All geotechnical boring and sampling operations were conducted in general accordance with the following ASTM International (ASTM) standards: ASTM D6151 – Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling; ASTM D1452 - Standard Practice for Soil Investigation and Soil Sampling by Auger Borings; ASTM D1586 – Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils; and ASTM D1587 – Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes; ASTM D2113 Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation.

The borings were advanced by mechanically rotating three and one-quarter inch internal diameter (I.D.) continuous steel hollow-stem auger flights into the ground. At regular intervals, soil samples were obtained with a standard 1.4-inch I.D., 2-inch outside diameter (O.D.), split-tube sampler. The sampler was first seated six inches to penetrate any loose cuttings and then driven an additional foot with blows of a 140-pound hammer falling 30 inches. The number of hammer blows required to drive the sampler one foot below the six inch seating interval was designated the "standard penetration test (SPT) resistance". Proper evaluation of the penetration resistance provides an index to the soil's consistency or relative density. Relatively undisturbed samples were obtained by pushing 3-inch O.D., 16-gauge steel tubing (Shelby tube) into the soil at the desired sampling level. The relatively undisturbed sampling was performed in general accordance with ASTM D1587. The SPT and relatively undisturbed samples were logged and labeled by S&ME's on site professional and then transported to our laboratory. Upon completion of the soil sampling at each boring location, NQ size rock core was collected down to predetermined depths. The rock core was logged, placed in core boxes, photographed, and then samples were collected to provide laboratory data for each rock type encountered.

5.1 South End of Tunnel Alignment (Station 106+50 to Station 108+50)

Borings B-82, B-83, and B-84 were located along the south end of the tunnel alignment. A thin veneer of surface materials consisting of topsoil with roots was encountered in the borings. The topsoil thickness in the borings varied from about 2.5 to 8 inches. Residual lean clay soil was encountered in the borings underlying the veneer of surface materials. The residual soil typically consisted of silty clay extending to the top of the weathered rock depths ranging from about 7.5 to 12.5 feet. Auger refusal was encountered in Boring B-82 at a depth of 12.8 feet and in Borings B-83 and B-84 at a depth of 8 feet. Auger refusal is a designation applied to any material that cannot be penetrated by the power auger

The standard penetration test (SPT) resistance N-values in the residual clays ranged from 12 to 22 blows per foot (bpf), indicating stiff to very stiff consistency. The N-values in the clay and weathered rock above auger refusal depths ranged from 50 bpf to 50 blows per one inch of penetration.

After encountering auger refusal the augers were removed from the boring and NQ size rock core was obtained. In Borings B-82 and B-84 four inch PVC casing was grouted in place after the removal of the augers. The casing was installed to prevent the overburden from collapsing into the boring after completion, which would interfere with the installation of the piezometers.

In each of the borings the Louisville Limestone was encountered at auger refusal. Boring B-82 encountered the Louisville Limestone down to a depth of 76 feet below ground surface (bgs). Borings B-83 and B-84 encountered the Louisville Limestone at auger refusal to their termination depths of 36.4 feet and 37 feet bgs respectively. The limestone encountered in Borings B-82 and B-83 contained solutional weathering, weathered fractures containing clay, and clay seams to a depth of 29 feet and 16 feet respectively. The limestone within this portion of the borings was discolored to a brownish gray which extended approximately one inch into the rock. The clay seams were observed to be several inches thick to one foot in both borings. Borings B-82 and B-83 lost drilling fluid circulation at 14.2 feet and 13.3 feet respectively which is within the solutional weathering observed in the recovered rock core. Beneath the upper weathered portion of the limestone in these borings, competent limestone was encountered. Boring B-84 encountered competent limestone from auger refusal to the boring termination depth. The competent limestone in all three borings consisted of gray crystalline limestone with stylolites and fossils. The Rock Quality Designation (RQD) values in B-82 and B-83 ranged from 0 to 84 percent with the majority of the values being between 25 to 50 percent within the weathered portion of the limestone. Below the weathered portion in B-82 and B-83 and within the entire depth of B-84 the RQD values ranged from 90 to 100 percent.

Boring B-82 encountered the Waldron Shale at a depth of 76 feet bgs to 87.8 feet bgs. The recovered shale was dark gray, fine grained, and very slightly weathered. Occasional joints and fractures were observed but the majority of the shale recovered was in six inch to one foot pieces. The RQD values were between 94 and 98 percent within the shale.

Beneath the Waldron Shale the Laurel Dolomite was encountered at 87.8 feet bgs to the termination depth of 103 feet bgs in B-82. The dolomite was recovered in two to five foot solid pieces and was slightly weathered, hard, and crystalline. The RQD values within the dolomite were 100 percent.

At the completion of Borings B-82 and B-84 a downhole camera was used to record the entire core section of the boring. The camera was attempted at Boring B-83 but the overburden material had collapsed into the cored portion of the boring which prevented the camera from being lowered into the boring.

The water within Borings B-82 and B-84 was pumped out using a submersible electric pump prior to the installation of the piezometers. Two 3/4 inch PVC piezometers were installed in Boring B-82. The deep well was installed to 103 feet with ten feet of 0.010 slotted well screen. A sand pack composed of #2 filter sand was placed around the well screen from 103 feet up to 91 feet. Bentonite slurry was placed from 91 feet up to 74 feet. A second 3/4 inch piezometer was installed to 73 feet. A one foot sand pack was placed from 74 feet up to 73 feet for the well screen to set on which would keep the bentonite from potentially covering the well screen. Ten feet of 0.010 slotted well screen was installed from 73 feet to 63 feet. A sand pack composed of #2 filter sand was placed from 73 feet to 60 feet and bentonite slurry was placed from 60 feet to 55 feet. The wells were labeled as P-82A (103 ft) and P-82B (73 ft) and secured with a threaded cap.

A one inch PVC piezometer was installed in Boring B-84 to a depth of 37 feet. Ten feet of 0.010 slotted well screen was installed from 37 feet to 27 feet with a #2 filter sand pack from 37 feet to 25 feet. Bentonite slurry was placed from 25 feet up to 20 feet. The piezometer was labeled P-84 and was secured with a threaded cap. The piezometer construction diagrams are included in Appendix III.

5.2 Station 114+50 to Station 123+50

This section of the tunnel alignment is located within the Drumanard property and includes Borings B-85 through B-90. A thin veneer of surface materials consisting of topsoil with roots was encountered in the borings. The topsoil thickness in the borings varied from about 3 to 4 inches. Residual lean clay was encountered in the borings underlying the veneer of surface materials. The residual soil typically consisted of silty clay extending to auger refusal depths ranging from about 1.5 to 12.3 feet. Auger refusal depths for the borings along this section of the alignment are listed in Table 5.2. Auger refusal is a designation applied to any material that cannot be penetrated by the power auger.

Table 5.2
Auger Refusal Depth

Boring No.	Surface Elevation (ft)	Auger Refusal Depth (ft)	Auger Refusal Elevation (ft)
B-85	537.3	4.3	533.0
B-86	532.2	2.1	530.1
B-87	528.3	3.8	524.5
B-88	533.0	9.8	523.2
B-89	546.3	12.3	534.0
B-90	526.0	1.5	524.5

The SPT resistance N-values in the residual clays ranged from 3 to 18 blows per foot (bpf), indicating soft to very stiff consistency. The N-values in the clay and weathered rock above auger refusal depths ranged from 50 bpf to 50 blows per one to two inches of penetration indicating hard to very hard consistency.

After encountering auger refusal the augers were removed from the borings and NQ size rock core was obtained. In each of the borings four inch PVC casing was grouted in place after the removal of the augers. The casing was installed to prevent the overburden from collapsing into the boring after completion, which would interfere with the installation of the piezometers.

5.2.1 Borings B-85, B-86, and B-89

Borings B-85, B-86, and B-89 were selected as deep borings along this section of the alignment. Borings B-86 and B-89 are located outside the proposed tunnel construction limits with B-86 to the west of the alignment and B-89 to the east of the alignment. Boring B-85 is located within the pillar section of the proposed tunnel alignment. These borings encountered the Louisville Limestone at auger refusal. The limestone within these borings is moderately to slightly weathered from auger refusal down to 20 feet in B-85 and B-86 and down to 30 feet in B-89. Borings B-85 and B-86 contained joints with iron staining, occasional clay filled joints, and solutional weathering down to 20 feet. Boring B-89 encountered open voids and clay filled voids from auger refusal down to approximately 20 feet. Drilling fluid return was lost at 13.1 feet in B-89 within the open void. From 20 feet to 30 feet in B-89 joints and clay filled joints were encountered and were approximately one centimeter in aperture. The limestone below this weathered zone was very slightly weathered, hard, sound, and crystalline with stylolites. The RQD values ranged from 22 to 96 percent within the weathered zone and ranged from 88 to 100 percent below the weathered zone.

The Waldron Shale was encountered in Boring B-85 at 30.8 to 42.3 feet, B-86 at 27.9 to 39.6 feet, and B-89 at 41.9 to 53.4 feet. The recovered shale was slightly weathered, fine grained, and moderately hard with fractures occurring along bedding occasionally containing clay. The shale becomes sound towards the contact with the dolomite beneath. The RQD values within the shale ranged from 68 to 100 percent.

The Laurel Dolomite was encountered below the Waldron Shale in Boring B-85 at 42.3 to 79 feet, B-86 at 39.6 to 81.5 feet, and in B-89 at 53.4 to 96 feet. The dolomite recovered was very slightly weathered, hard, and crystalline throughout Boring B-85. In Borings B-86 and B-89 the dolomite is slightly weathered with one section in both borings that is weathered to brownish gray, pitted, and moderately hard to hard. This weathered section was encountered in B-86 at 57.3 to 60.4 feet and in B-89 at 71.7 to 74.9 feet. Borings B-86 and B-89 also encountered shale at 78.5 to 80.5 feet and 91.6 to 93.9 feet respectively. The recovered shale was moderately hard, fine grained, calcareous, pyritic, and sound. The RQD values within the dolomite ranged from 94 to 100 percent.

At the completion of Boring B-89 a downhole camera was used to record the entire core section of the boring. The piezometer installation could not be completed at this location because of property owner issues. Water levels were collected at time of drilling and 24 hours after completion of drilling.

5.2.2 Borings B-87, B-88, and B-90

The shallower borings drilled along this section of the alignment were within the construction limits of the proposed tunnel. Boring B-87 was drilled within the south bound section of the tunnel, B-88 within the north bound section, and B-90 within the tunnel exit slope. The borings encountered the Louisville Limestone at auger refusal to

22.9 feet in B-87, to 29.2 feet in B-88, and to 23.8 feet in B-90. The recovered limestone in Borings B-87 and B-88 was slightly weathered, hard, and crystalline with very close joint spacing and occasional joints containing clay. Thin shale partings were also encountered in B-87 and B-88 within the limestone. The limestone encountered within B-90 was slightly to moderately weathered, moderately hard to hard, crystalline, with clay filled solution channels and iron stained fractures. The RQD values within the limestone ranged from 60 to 100 percent in Borings B-87 and B-88 and from 46 to 88 percent in Boring B-90.

The Waldron Shale was encountered beneath the limestone in each of the borings. The recovered shale was dark gray, moderately hard, fine grained, and pyritic, with thin clay lenses along bedding with an aperture of approximately one millimeter. The RQD values within the shale ranged from 48 to 82 percent.

At the completion of Borings B-87 and B-88 a downhole camera was used to record the entire core section of the boring. The piezometer installation could not be completed at these locations because of property owner issues. Water levels were collected at time of drilling and 24 hours after completion of drilling.

5.3 North End of Tunnel Alignment (Station 123+50 to Station 125+50)

Borings B-91, B-92, B-93 and B-94 were located along the north end of the tunnel alignment. These borings were located within the Shadow Wood subdivision. A thin veneer of surface materials consisting of topsoil with roots was encountered in the borings with thickness of about 3 inches. Residual lean clay soil was encountered in the borings underlying the veneer of surface materials. The residual soil typically consisted of silty clay extending to auger refusal depths ranging from about 8.1 to 18.4 feet. Auger refusal depths for the borings along this section of the alignment are listed in Table 5.3. Auger refusal is a designation applied to any material that cannot be penetrated by the power auger.

Table 5.3
Auger Refusal Depth

Boring No.	Surface Elevation (ft)	Auger Refusal Depth (ft)	Auger Refusal Elevation (ft)
B-91	536.5	18.4	518.1
B-92	517.6	8.1	509.5
B-93	521.4	8.3	513.1
B-94	532.5	13.0	519.5

The SPT resistance N-values in the residual clays ranged from 11 to 22 blows per foot (bpf), indicating stiff to very stiff consistency. The N-values in the clay and weathered rock above auger refusal depths ranged from 50 bpf to 50 blows per one to five inches of penetration.

In general, the soil profile along this portion of the alignment consists of silty clay extending to variable depths ranging from about 8 to 18 feet. Up to four inches of weathered limestone was encountered below the residual clay interval.

After encountering auger refusal the augers were removed from the boring and NQ size rock core was obtained. Each of the borings had four inch PVC casing installed which was grouted in place after the removal of the augers. The casing was installed to prevent the overburden from collapsing into the boring after completion, which would interfere with the installation of the piezometers.

Borings B-91 and B-94 were located outside the construction limits of the proposed tunnel alignment. Borings B-92 was drilled along the south bound tunnel and B-93 was drilled along the north bound tunnel. The borings encountered the Louisville Limestone at auger refusal. The limestone encountered in Borings B-91 and B-92 was gray, slightly weathered, hard, crystalline, with occasional clay filled joints and clays seams with an aperture of approximately one centimeter to depths of 20 feet and 37.7 feet respectively. The RQD values within the limestone ranged from 75 to 100 percent for these borings.

The limestone encountered in Borings B-93 and B-94 was light gray to brownish gray, moderately weathered, moderately hard to hard, and crystalline. Solution channels and clay filled voids were encountered in B-93 from 9.3 feet to 11.4 feet and drilling fluid circulation was lost at approximately 10 feet. A solution channel was encountered at 14.3 to 14.5 feet in B-94 and drilling fluid circulation was lost at this feature. The limestone below these features is hard, slightly weathered, crystalline, with very close joint spacing and occasional clay filled joints. The RQD values within the limestone ranged from 52 to 96 percent for these two borings.

Beneath the limestone the Waldron Shale was encountered at 37.7 feet in B-91, at 20 feet in B-92, at 23.6 feet in B-93, and at 35 feet in B-94. The recovered shale from these borings was dark gray, slightly to very slightly weathered, moderately hard, fine grained, with occasional clay seams occurring along bedding and weathered joints. The RQD values within the shale ranged from 38 to 72 percent for these borings.

The Laurel Dolomite was encountered beneath the shale in each of the borings. The dolomite was encountered at 49.3 feet in B-91, at 31.5 feet in B-92, at 35.1 feet in B-93, and at 43 feet in B-94. The recovered dolomite was gray, slightly weathered to very slightly weathered, hard, and crystalline. A weathered zone within the dolomite was encountered in each boring. The dolomite along this zone was discolored to brownish gray and was pitted. This weathering was observed in B-91 from 64.3 to 71.9 feet, in B-92 from 48.8 to 53.2 feet, in B-93 from 51.9 to 57.1 feet, and in B-94 from 62.6 to 67.9 feet. The dolomite is gray, very slightly weathered, hard, crystalline below this feature. The RQD values within the dolomite were 100 percent. The recovered dolomite was either mechanically broken or recovered in solid five foot pieces.

In each of the borings shale was encountered beneath the dolomite to the termination depths of each boring. The shale was encountered at 88.8 feet in B-91, at 70.9 feet in B-

92, at 74.3 feet in B-93, and at 85.4 feet in B-94. The recovered shale was slightly weathered, moderately hard, fine grained, and calcareous with occasional joints.

At the completion of Borings B-91, B-92, B-93, B-94 a downhole camera was used to record the entire core section of the boring.

The water within Borings B-91 and B-94 was pumped out using a submersible electric pump prior to the installation of the piezometers. Two 3/4 inch PVC piezometers were installed in Boring B-91. The deep well was installed at 91.5 feet with ten feet of 0.010 slotted well screen. A sand pack composed of #2 filter sand was placed around the well screen from 91.5 feet up to 89.5 feet. Bentonite slurry was placed from 89.5 feet up to 43 feet. A sand pack was placed from 43 feet up to 41.5 feet to set the shallow piezometer. The second 3/4 inch piezometer was installed to 41.5 feet. Ten feet to 0.010 slotted well screen was installed from 41.5 feet to 31.5 feet. A sand pack composed of #2 filter sand was placed around the well screen from 41.5 feet to 28 feet and bentonite slurry was placed from 28 feet to 20 feet. The wells were labeled as P-91A (91.5 ft) and P-91B (41.5 ft) and secured with a threaded cap.

The piezometers in Boring B-94 consisted of two 3/4 inch PVC piezometers. The deep well was installed to 87.5 feet with ten feet of 0.010 slotted well screen. A sand pack composed of #2 filter sand was placed around the well screen from 87.5 feet up to 75.5 feet. Bentonite slurry was placed from 75.5 feet up to 39 feet. A sand pack was placed from 39 feet up to 37.5 feet to set the shallow piezometer. The second 3/4 inch piezometer was installed to 37.5 feet. Ten feet of 0.010 slotted well screen was installed from 37.5 feet to 27.5 feet. A sand pack composed of #2 filter sand was placed around the well screen from 37.5 feet to 25.5 feet and bentonite slurry was placed from 25.5 feet to 20 feet. The wells were labeled as P-94A (87.5 ft) and P-94B (37.5 ft) and secured with a threaded cap. The piezometer construction diagrams are included in Appendix III.

6. GROUNDWATER

Groundwater levels were measured in all borings at the time of boring (i.e., when first encountered during the advancement of the boring). Further, groundwater measurements were obtained at approximately 24 hours after the completion of drilling in 10 of the 13 borings. The recorded groundwater levels at the time of boring and at 24 hours are presented in Table 6.1 and on the boring logs.

Table 6.1
Groundwater Data Summary

Boring I.D.	Piezometer Depth (Feet)	Ground Surface Elevation msl (Feet)	Depth to Groundwater at Time of Boring (Feet)	Depth to Groundwater After 24 Hours (Feet)	Groundwater Elevation After 24 Hours msl (Feet)
P-82 A	103	592.8	Dry	98.2	524.9
P-82 B	73	592.8	Dry	34.2	558.6
B-83	None	583.7	Dry	*	--
P-84	37	569.6	Dry	25.5	544.1
B-87	None	528.3	Dry	12.5	515.8
B-88	None	533.0	Dry	22.0	511.0
B-89	None	546.3	Dry	47.5	498.8
P-91 A	91.5	536.5	Dry	62.2	474.3
P-91 B	41.5	536.5	Dry	30.3	506.2
B-92	None	517.6	Dry	14.0	503.6
B-93	None	521.4	Dry	17.62	503.8
P-94 A	87.5	532.5	Dry	60.3	472.2
P-94 B	37.5	532.5	Dry	34.4	498.1

Notes:
* - borehole caved in

Groundwater was not encountered during drilling. The water levels indicated in Table 6.1 indicate water levels within the piezometers (i.e. P-82 A) or within the boring at the completion of coring.

Upon completion of downhole testing, the borings not receiving a piezometer were abandoned by backfilling the full depth with cement bentonite grout utilizing the tremie method. The tremie method utilizes 1-inch diameter PVC pipe (i.e, “tremie pipe”) which is placed in the boreholes. Grout was then pumped through the pipe from the bottom to the top of the borehole until fully sealed.

7. PACKER TESTING

Hydraulic conductivity testing (also known as permeability or “packer” testing) was conducted in all 13 vertical borings 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:

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

The packer system used in the vertical borings was provided by Tam International. A packer system consisting of two inflatable packers two feet in length and two or three inches in diameter were set 12 feet apart. The two inch packers were used within the NQ size core section of the borings. Solid steel centralizers were placed above each packer to protect them during the placement into and retrieval from the boring. A one inch diameter steel pipe containing offset holes to allow water to pressurize the test section was located between the packers. Above the packer at the top of the boring an In-Situ Incorporated transducer was attached. The transducer provided the pressure level within the boring as the water filled the test section between the packers. The transducer assisted in keeping the pressure at each test interval near the selected pressure levels.

The tests were conducted at three pressure intervals with a low pressure of 60 psi and a high pressure of 120 psi. Table 7.1 provides a summary of the Lugeon Values encountered at each boring location.

Table 7.1
Packer Testing Summary

Boring No.	Boring Depth (ft)	Test Interval (ft)	Lugeon Flow
B-82	103	12	Dilation
B-83	36	12	Laminar to Dilation
B-84	37	12	Laminar
B-89	96	12	Laminar
B-90	29.1	12	Wash Out
B-91	91.5	12	Laminar to Dilation
B-92	72.5	12	Laminar to Wash out at 30 feet
B-93	76.5	12	Laminar
B-94	87.5	12	Laminar

The recorded Lugeon values and the hydraulic conductivity summary sheets are included in **Appendix IV**. Refer to the *Legend to Lugeon Values* sheet in Appendix IV 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, and 100 Lugeon units is the type of permeability typically observed in heavily jointed bedrock with relatively open joints, or in slightly to moderately jointed bedrock where joints are wide to very widely open (i.e., severe solution zones).

8. LABORATORY TESTING PROGRAM

8.1 Index Properties

Natural moisture contents, liquid limit, plastic limit, and plasticity index tests (collectively referred to herein as Atterberg limits); and grain size distributions were performed on selected split spoon and relatively undisturbed Shelby tube samples. These tests were used to confirm our visual-manual classifications and classify the unconfined compression test samples.

The laboratory test reports are found in **Appendix II**.

8.3 Rock Mechanics Testing

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 with the exception of the Cerchar Abrasivity, Huder-Amberg, and Thin Section Petrographic Analysis which were performed at the Geotechnical Engineering Center at the University of Texas at Austin.

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

The samples collected for testing were selected from each boring within the different rock formations encountered. The point load, unconfined compressive strength, and Brazilian Split Tensile tests were selected at evenly spaced intervals within each boring.

The Slake Durability Index (SDI) samples were selected from the Waldron Shale. These samples were collected at equally spaced intervals starting at the contact of the Waldron Shale. Samples collected for the Cerchar Abrasivity, Huder-Amberg, and petrographic analysis were also selected from the Waldron Shale and then sent to the University of Texas at Austin. The saturation and void ratio testing were also selected from the Waldron Shale. The samples collected from each boring were selected by the S&ME geologist in the field based on visual observations and characteristics of the shale. The laboratory test results are found in Appendix II.

9. GEOPHYSICAL SURVEY METHODOLOGY

The geophysical exploration performed at the Louisville Twin Tunnel Site on November 7 through November 17, 2011 utilized the electrical resistivity imaging (ERI) and seismic refraction testing methods. The purpose of the geophysical survey was to further explore the subsurface conditions at site to identify the soil/bedrock interface and potential features associated with karst terrain such as cavities.

9.1 Seismic Refraction

Seismic Refraction is a geophysical exploration technique that can be used to provide information on the location of the soil-rock interface. The method consists of measuring travel times of seismic compression waves (P-waves) and/or shear waves (S-waves) at receivers located along a linear array. The velocity at which the seismic waves propagate along the array can be determined from the slope of arrival times. Both P-wave and S-wave velocity provide an indication of density and P-wave velocity an indication of excavation characteristics based on empirical relationships. Waves in soil (low-density) will travel slower than waves in bedrock (high density). Where significant increases in density occur, the seismic waves are refracted much like light in a prism. Depths to denser, higher velocity strata such as rock can be determined from the location of a slope change in the velocity plots.

In this study, compression-wave (P-wave) refraction data were acquired along each of the eleven arrays with lengths that ranged from 260 feet to 1,275 feet as shown in **Appendix V**, **Figure 7**. The seismic refraction survey was performed using a 16-channel Geometrics ES-3000 seismograph in general accordance with ASTM D-5777. Each channel was connected to a 14-Hz geophone placed in the ground at 10-ft intervals along the array. The vertical (P-wave) geophones recorded vibrations generated by the impact of a sledgehammer striking a metal plate. Data were recorded for a period of 0.5 sec at a sampling interval of 0.0625 msec. At each survey line, shot locations were generally spaced at 32.5-foot intervals. Arrival times were determined using the OYO Corporation's SeisImager Pickwin software and analysis was performed using the tomographic method with the Plotrefa software.

9.2 Electrical Resistivity

Electrical Resistivity Imaging (ERI) surveying is an active geophysical technique that involves the introduction of a known amount of current into the ground and measuring the earth's response in order to identify variations in subsurface electrical potentials. By introducing a known amount of current into the ground, the measured voltage potential at the surface is used to calculate the resistivity of a particular volume of earth, based upon the distribution of electrodes used to introduce the current as well as the electrodes used to measure the potential voltage difference. It is important to note that actual ground resistivity is not determined during a resistivity survey. The survey results are used to determine the apparent resistivity of a volume of soil that is dependent upon electrode spacing. Actual resistivities are later determined through the data inversion process.

ERI methods typically require that a series of small current and potential electrodes be pushed into the ground in various configurations. The electrodes are connected to a transmitter/recording instrument that generates the induced current and stores the measurements for later processing and analysis. The configuration of the electrodes (array) is dependent on the objectives of the investigation (i.e., vertical soil and bedrock profiling, cavity detection, contaminant mapping, or fracture mapping). ERI measurements are acquired from the voltage potential difference measured between two electrodes and are dependent upon the distance between the electrodes. Soil included between the electrodes is essentially averaged. Therefore, limitations of this method exist dependent upon the resolution of data acquisition needed versus the depth of a target.

The resistivity of materials partially depends on the substance filling its pore or void space. If a cavity or fracture is air-filled, a high resistive anomaly within the limestone unit is expected. If it is water-or clay-filled, an anomaly more conductive than the limestone unit is expected. Natural variations in porosity and grain size distribution can also cause such anomalies. Clayey soils result in lower resistivity (higher conductivity) readings, while dry sands and competent limestone units exhibit higher resistivity values. Resistivity anomalies can be further specified with knowledge of the local geology and through drilling at identified site locations.

S&ME used an Advanced Geosciences Incorporated (AGI) Sting R8 / IP for the ERI investigation. A total of eleven resistivity arrays were collected in a dipole-dipole configuration. The arrays consisted of 56 electrodes with spacings of 5 or 6 feet and lengths ranging from 275 to 1,260 feet as shown in **Appendix V**, **Figure 7**. Due to the length of several of the ERI lines, the “roll-along” method was utilized. Roll-along is a method where the first string of electrodes is relocated to the end of the original line and data are reacquired. This process is repeated until the desired line length has been analyzed.

10. GEOPHYSICAL SURVEY RESULTS AND DISCUSSION

Appendix V, Figures 8 through 11 present the seismic refraction and electrical resistivity geophysical results. These results are presented together for ease in interpretation. A brief discussion is presented below:

10.1 Seismic Refraction

The P-wave refractor is presented as a dashed line on **Appendix V, Figures 8 through 11** ranging in depths from less than 3 feet to roughly 20 feet. The critical refractor depth generally correlated with the auger refusal/Louisville Limestone depths as indicated from the drilling program. The critical refractor (i.e., Louisville Limestone) also exhibited P-wave velocities ranging from 6,000 to 14,000 feet per second (fps) which, based on our experience, is indicative of highly fractured but competent rock. Velocities of the upper material (i.e., direct arrivals) generally ranged from 1,500 to 2,500 fps which is indicative of unsaturated soils. The velocities of individual lines are not presented on the geophysical results.

The velocities (and densities) of the soil-rock interfaces are somewhat transitional due to the highly weathered nature of the upper portion of the Louisville Limestone, therefore individual variations are not often detected as seismic data can average the conditions between receivers and over the length of the profiles. This is evidenced by the relatively significant variability in the velocity of the refractor. For example, the varying velocities along the array of a refractor (i.e., extremely fractured and non-fractured zones) will be averaged. As such, material with varying velocities could be encountered anywhere along the refractor surface. This also makes predicting the presence of isolated or relatively small areas of nested boulders, differentiating steeply sloping rock surfaces, or identifying discontinuous rock layers less reliable.

10.2 Electrical Resistivity

The ERI results located in **Appendix V, Figures 8 through 11** indicate a varying resistivity contrast across the surveyed area. The results generally show a low resistive layer near the surface that is less than 100 ohm-meters, a second layer of slightly higher resistivity averaging approximately 200 ohm-meters, and a third layer that exhibits higher resistivities above 1,000 ohm-meters. In addition, several localized features above 15,000 ohm-meters and others below 100 ohm-meters were identified within this third layer. Several profiles also exhibited a fourth and fifth layer that had relatively low resistivity values typically below 200 ohm-meters and higher values above 1,000 ohm-meters respectively.

Using soil borings performed at the site and refraction data for interpretation, it appears the upper low resistive layer generally confined within the upper twenty feet corresponds to topsoil and the residual clays. The second layer is likely associated with the upper highly weathered portion of the Louisville Limestone while the third layer is probably the more competent Louisville Limestone. The localized areas within the Louisville Limestone with extremely high resistive anomalies above 15,000 ohm-meters correspond to potential air-filled voids and the low resistive areas below 100 ohm-meters may be related to clay-filled voids and/or solution features. The fourth and fifth layers may be associated with the Waldron Shale and Laurel Dolomite respectively.

11. GEOPHYSICAL LIMITATIONS

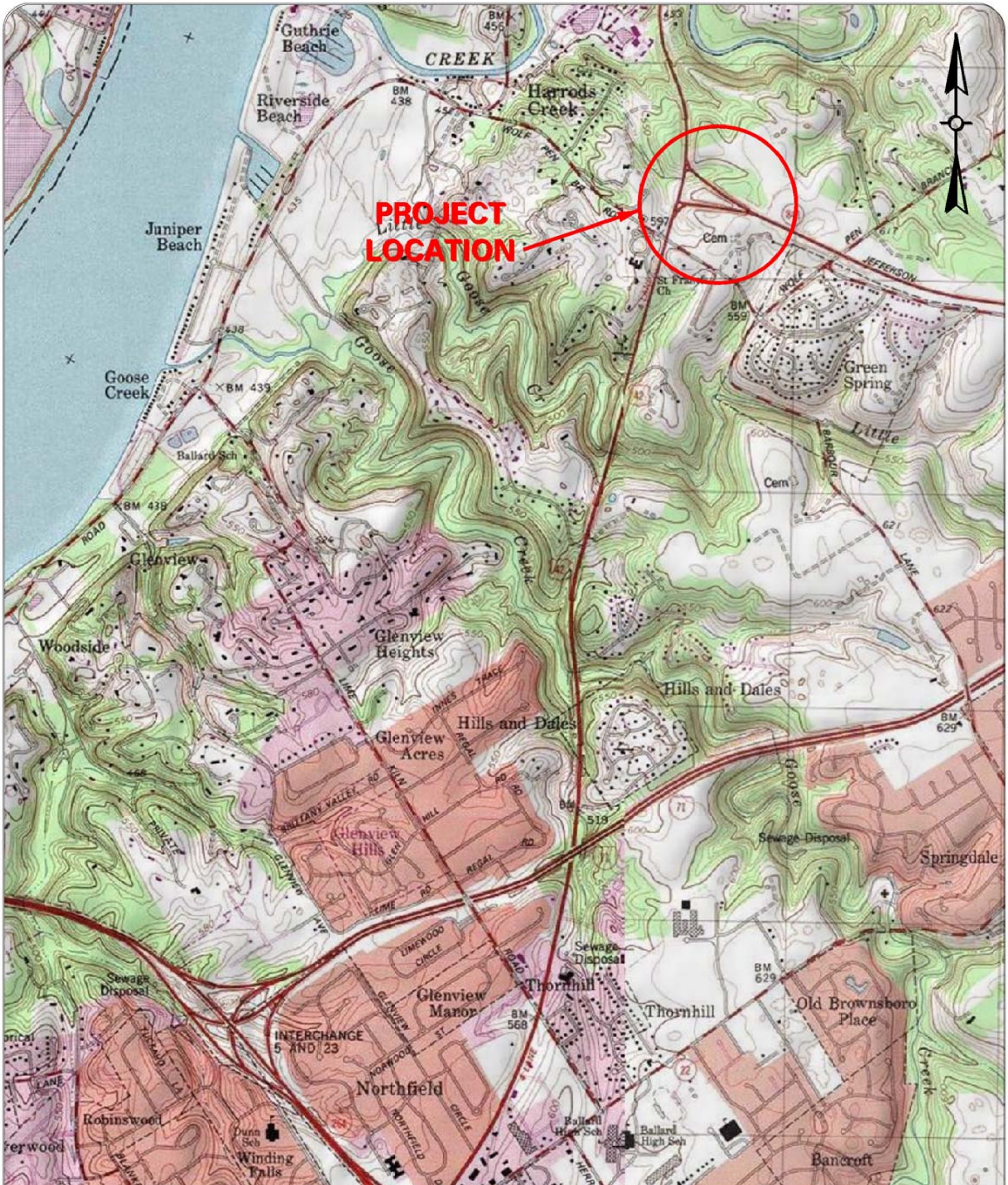
The geophysical methods proposed for this survey have inherent limitations and site features which can cause interference. Site metallic features (e.g., cars, HVAC units, fences, utilities, reinforced concrete, etc.) and overhead transmission lines can produce false responses in the electrical resistivity imaging data. As for P-wave refraction, it should be noted that water in the subsurface can mask the results and be interpreted as rock as saturated soil typically has a velocity in the range of 5,000 to 6,000 ft/s; however, this appears unlikely due to the relatively higher elevations of the site.

In addition, the conclusions submitted herein are based upon the data obtained from the non-invasive testing. As such, even within the surveyed area, the survey cannot be considered 100 percent accurate due to inherent method limitations, survey limitations, site features, and/or unforeseen site-specific conditions. Accordingly, the possibility exists that not all geologic features at the project site have been located due to either subsurface soil conditions or the occurrence of features below the depth of penetration of the methods used. Under no circumstances does S&ME assume any responsibility for damages resulting from the presence of sinkholes, voids, or dropouts that may exist that were or were not identified by our survey.

FIGURES

FIGURES

FIGURES



SCALE: 1" = 2000'	S&ME WWW.SMEINC.COM 422 CODELL DRIVE, LEXINGTON, KY 40509 PHONE: 859.293.5518	GEOTECHNICAL DATA REPORT	FIGURE NO.
DATE: 12-22-11			1
DRAWN BY: CAC		LOUISVILLE SOUTHERN INDIANA OHIO RIVER BRIDGES PROJECT KENTUCKY EAST END APPROACH TUNNEL	
PROJECT NO: 24305629			

DATE: 12-22-11
DRAWN BY: CAC
CHECKED BY:
SCALE: 1"=200'
PROJECT NUMBER: 24305629
DRAWING NUMBER:

S&ME
WWW.SMEINC.COM

BORING LOCATIONS

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

FIGURE NO.
2

BORING #	NORTHING	EASTING	SURFACE ELEVATION
B-82	302887.39	1247123.97	592.8
B-83	302959.07	1247178.79	583.7
B-84	303165.04	1247086.16	569.6
B-85	303581.20	1246351.55	537.3
B-86	303811.59	1246116.81	532.2
B-87	303857.45	1246163.48	528.3
B-88	303927.54	1246234.80	533.0
B-89	303990.63	1246298.99	546.3
B-90	304038.96	1245989.61	526.3
B-91	304195.44	1245712.74	536.5
B-92	304262.00	1245787.38	517.6
B-93	304328.56	1245862.01	521.4
B-94	304395.10	1245936.70	532.5

DATE: 12-22-11
DRAWN BY: CAC
CHECKED BY:
SCALE: 1"=400'
PROJECT NUMBER: 24305629
DRAWING NUMBER:

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BORING LOCATIONS

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

FIGURE NO.
3

GEOPHYSICAL SURVEY LOCATIONS

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

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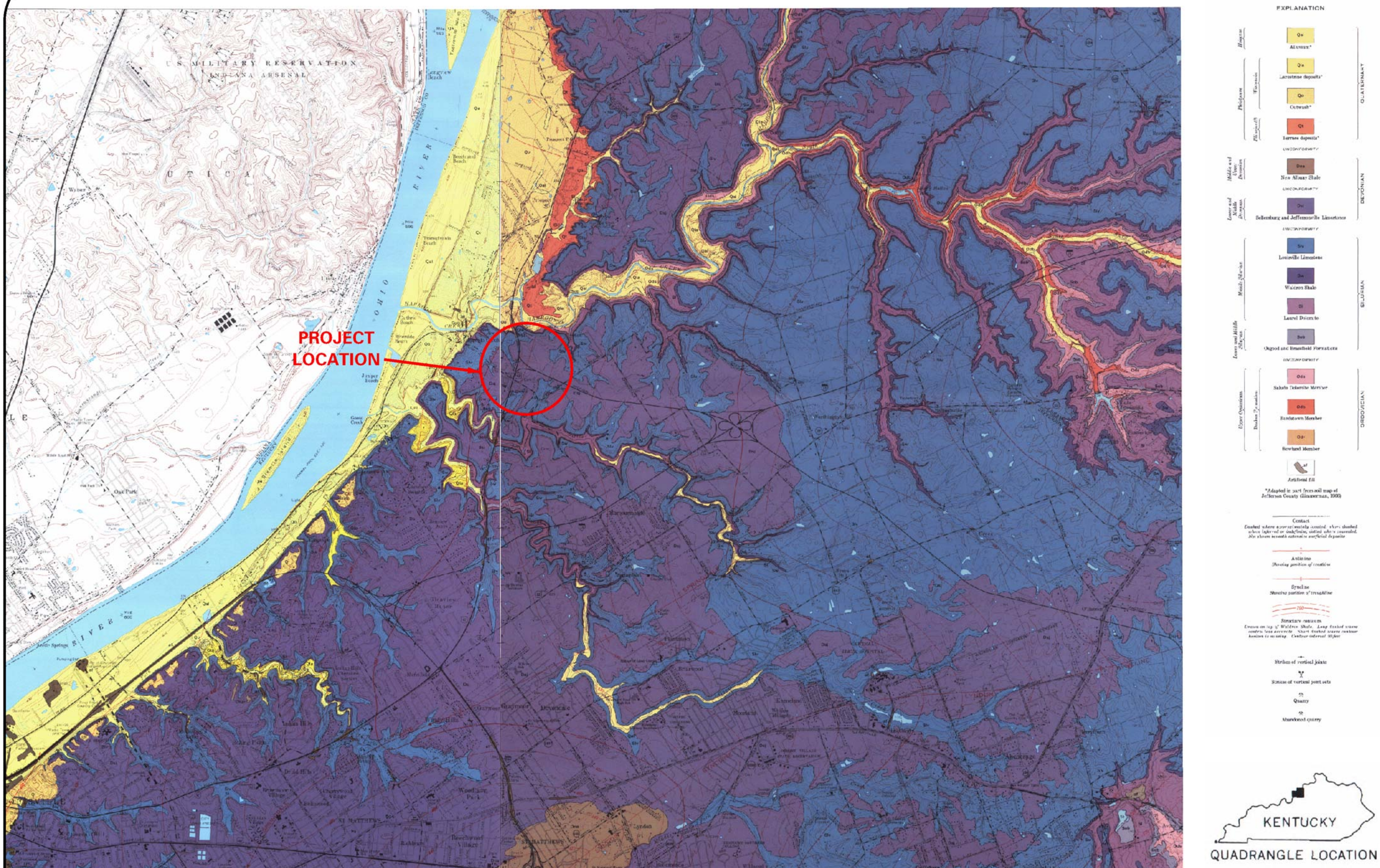
SCALE: 1"=200'
PROJECT NUMBER: 24305629
DRAWING NUMBER:

DATE: 12-22-11
DRAWN BY: CAC
CHECKED BY:

FIGURE NO.
4



DATE: 12-22-11

DRAWN BY: CAC

CHECKED BY:

SCALE: 1"=5000'

PROJECT NUMBER: 24305629

DRAWING NUMBER:

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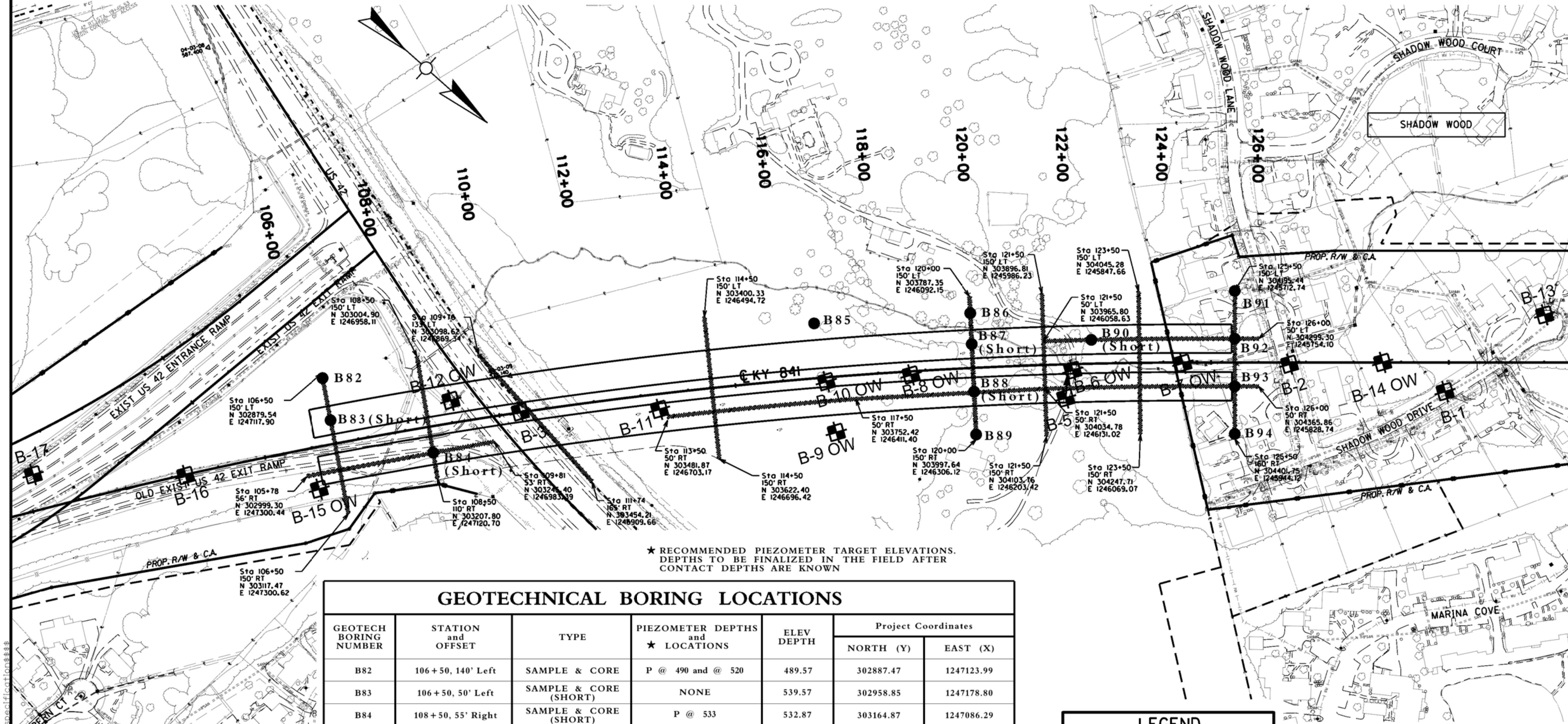
PROJECT AREA GEOLOGIC MAP

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

FIGURE NO.

5



★ RECOMMENDED PIEZOMETER TARGET ELEVATIONS. DEPTHS TO BE FINALIZED IN THE FIELD AFTER CONTACT DEPTHS ARE KNOWN

GEOTECHNICAL BORING LOCATIONS

GEOTECH BORING NUMBER	STATION and OFFSET	TYPE	PIEZOMETER DEPTHS and ★ LOCATIONS	ELEV DEPTH	Project Coordinates	
					NORTH (Y)	EAST (X)
B82	106+50, 140' Left	SAMPLE & CORE	P @ 490 and @ 520	489.57	302887.47	1247123.99
B83	106+50, 50' Left	SAMPLE & CORE (SHORT)	NONE	539.57	302958.85	1247178.80
B84	108+50, 55' Right	SAMPLE & CORE (SHORT)	P @ 533	532.87	303164.87	1247086.29
B85	116+75, 115' Left	SAMPLE & CORE	P @ 457 and @ 510	456.88	303581.25	1246351.51
B86	120+00, 115' Left	SAMPLE & CORE	P @ 451 and @ 500	450.22	303811.89	1246117.12
B87	120+00, 50' Left	SAMPLE & CORE (SHORT)	P @ 501	500.22	303857.45	1246163.48
B88	120+00, 50' Right	SAMPLE & CORE (SHORT)	P @ 501	500.22	303927.54	1246234.80
B89	120+00, 140' Right	SAMPLE & CORE	P @ 451 and @ 500	450.22	303990.63	1246298.99
B90	122+50, 50' Left	SAMPLE & CORE (SHORT)	P @ 497	496.86	304038.92	1245989.66
B91	125+50, 150' Left	SAMPLE & CORE	P @ 445 and @ 495	444.87	304195.44	1245712.74
B92	125+50, 50' Left	SAMPLE & CORE (SHORT)	NONE	444.87	304261.99	1245787.38
B93	125+50, 50' Right	SAMPLE & CORE (SHORT)	NONE	444.87	304328.54	1245862.02
B94	125+50, 150' Right	SAMPLE & CORE	P @ 445 and @ 495	444.87	304395.09	1245936.65

LEGEND

- Previous Geotech Boring
- Proposed Geotech Boring
- Electrical Resistivity & Seismic Refraction

0 100 200 300

TUNNEL GEOTECH TESTING COORDINATES

THE OHIO RIVER BRIDGES

FILE NAME:

DATE:

APPENDICES

APPENDIX I
BORING LOGS WITH PHOTOGRAPHS

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: B-82

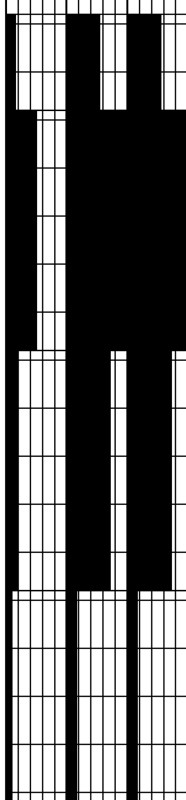
DATUM: NAVD 88

DRILLING DATE: 10/18/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ

NORTHING:
EASTING:
INCLINATION: -90°   AZIMUTH: ---

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

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	ELEV. / DISTANCE (ft)	RUN No.	ELEVATION	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION
0	10/18/2011	GROUND SURFACE				
		Rootmat and topsoil (2.5 inches)	0.2			
	3.25 HSA	**CLAY (CL)** - Light brown; stiff; slightly moist; silty; RESIDUUM	590.0 / 3.0		590	
5–10		**CLAY (CL)** - Reddish brown to tan; very stiff; slightly moist; RESIDUUM	581.0 / 12.0		585	
	10/19/2011	**CLAY (CH)** - Dark red brown; hard; slightly moist; with manganese nodules; RESIDUUM	12.5			
	NQ Core	Weathered Limestone Auger refusal encountered at 12.8 feet and begin NQ core.	12.8		580	
15		**12.8 ft to 14.8 ft (Run No. 1)** **LIMESTONE** - Gray with tan weathered fractures and solutional weathering features. Solutional weathering along fractures at 12.9', 13.3', and 13.5'. From 14.2' to 14.8' limestone is severly weathered with complete water loss at 14.2' in solutional feature. Limestone is moderately hard to hard; crystalline; fossiliferous.	578.2 / 14.8	1		FR, R, solutional weathering FR, R, solutional weathering FR, R, solutional weathering Severly weathered; 100% water loss
20		**14.8 ft to 19.8 ft (Run No. 2)** **LIMESTONE** - Gray and light brown weathered rock. Severly weathered with solutional weathering througout run. Several open voids (3 inches to 1 foot) encountered during run. Limestone is moderately hard; crystalline; fossiliferous.	573.2 / 19.8	2	575	
25		**19.8 ft to 24.8 ft (Run No. 3)** **LIMESTONE** - Gray; severly weathered from 19.8' to 22.1' with solutional weathering features containing clay and discolored rock. Several open voids encountered between 19.8' and 22.1' (3 to 8 inches); Limestone is crystalline, moderately hard, and fossiliferous.	568.2 / 24.8	3	570	
		24.8 ft to 29.3 ft (Run No. 4) **LIMESTONE** - Gray; slightly weathered; slightly fractured with fractures at 25.9', 26.7', and 29.1' occuring along stylolitic features; hard; crystalline; fossiliferous.	563.7 / 29.3	4	565	FR, R FR, R FR, R
30		**29.3 ft to 34.3 ft (Run No. 5)** **LIMESTONE** - Gray; very slight weathering; sound; with pressure solution features throughout; hard; crystalline; fossiliferous.		5		



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DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.
DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

DRILLING DATE: 10/18/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ
NORTHING:
EASTING:
INCLINATION: -90°
AZIMUTH: ---

Legend: 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

Columns: DISTANCE SCALE FEET; DRILLING RECORD; DESCRIPTION; SYMBOLIC LOG; ELEV. / DISTANCE (ft); RUN No.; PENETRATION RATE (ft/min); FLUSH / COLOR / % RETURN; ELEVATION; RECOVERY (TOTAL CORE %, SOLID CORE %); R.Q.D. %; FRACT. INDEX PER FT; DISCONTINUITY DATA (DIP w.r.t. CORE AXIS; TYPE AND SURFACE DESCRIPTION); HYDRAULIC CONDUCTIVITY k, cm/sec; DIAMETRAL POINT LOAD INDEX (psi)

--- CONTINUED FROM PREVIOUS PAGE ---

Depth (ft)	Drilling Record	Description	Elev. / Distance (ft)	Run No.	Elevation	Type and Surface Description
	10/21/2011, NQ Core	**29.3 ft to 34.3 ft (Run No. 5)** **LIMESTONE** - Gray; very slight weathering; sound; with pressure solution features throughout; hard; crystalline; fossiliferous.	558.7 / 34.3	5	560	
35		**34.3 ft to 39.3 ft (Run No. 6)** **LIMESTONE** - Gray; very slight weathering; sound; hard; fossiliferous; with pressure solution features throughout.	553.7 / 39.3	6	555	
40		**39.3 ft to 44.3 ft (Run No. 7)** **LIMESTONE** - Same as previous run; one fracture at 44.2' with slight weathering occuring along stylolitic feature.	548.7 / 44.3	7	550	FR, R
45	NQ Core	**44.3 ft to 49.3 ft (Run No. 8)** **LIMESTONE** - Gray; very slight weathering; sound; hard; crystalline; fossiliferous; with pressure solution features throughout.	543.7 / 49.3	8	545	
50		**49.3 ft to 54.3 ft (Run No. 9)** **LIMESTONE** - Same as previous run; all breaks mechanical.	538.7 / 54.3	9	540	
55		**54.3 ft to 59.3 ft (Run No. 10)** **LIMESTONE** - Same as previous run; fracture at 55.3' along dark gray pressure solution feature with slight weathering; fracture at 58.5' occuring at approximately 30 degrees.	533.7 / 59.3	10	535	FR, R; FR, R
60				11	530	J, R; J, R; J, R, CL; FR, R

--- CONTINUED NEXT PAGE ---

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.
DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

RECORD OF DRILLHOLE: B-82

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

DRILLING DATE: 10/18/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ

NORTHING:
EASTING:
INCLINATION: -90°
AZIMUTH: ---

DATUM: NAVD 88

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

Columns: DISTANCE SCALE FEET; DRILLING RECORD; DESCRIPTION; SYMBOLIC LOG; ELEV. / DISTANCE (ft); RUN No.; PENETRATION RATE (ft/min); FLUSH; COLOR / % RETURN; ELEVATION; RECOVERY (TOTAL CORE %, SOLID CORE %); R.Q.D. %; FRACT. INDEX PER FT; DISCONTINUITY DATA (DIP w.r.t. CORE AXIS; TYPE AND SURFACE DESCRIPTION); HYDRAULIC CONDUCTIVITY k, cm/sec; DIAMETRAL POINT LOAD INDEX (psi)

--- CONTINUED FROM PREVIOUS PAGE ---

Drilling record: NQ Core

Description	Elev. / Distance (ft)	Run No.	Discontinuity Type and Surface Description
59.3 ft to 64.3 ft (Run No. 11) **LIMESTONE** - Gray; dark gray and gray green; slightly weathered; slightly fractured with fractures occuring at 62.8' and 63.8' along pressure solution features. Joints at 59.5', 59.8' and 62.4'. Joint at 62.4' contains thin shale parting weathered to clay. Limestone is hard, crystalline with occasional thin shale partings, trace fossils.	528.7 / 64.3	11	FR, R
64.3 ft to 69.3 ft (Run No. 12) **LIMESTONE** - Gray; very slight weathering; sound; hard; with pressure solution features throughout, some gray green in color; crystalline.	523.7 / 69.3	12	
69.3 ft to 74.3 ft (Run No. 13) **LIMESTONE** - Same as previous run; fractures at 70.4' an d72.3' occuring along stylolitic features; Joint at 70.7' with rock weathered to clay.	518.7 / 74.3	13	FR, R; J, R, CL; FR, R
74.3 ft to 76.0 ft (Run No. 14) **LIMESTONE** - Gray; very slight weathering; slightly fractured with fracture at 75.3' along stylolitic feature; hard; crystalline down to 76.0'.	517.0 / 76.0	14	FR, R
76.0 ft to 79.3 ft (Run No. 14) SHALE - Gray; very slight weathering; sound; hard; fine grained; pyritic; with dark gray shale partings.	513.7 / 79.3	14	
79.3 ft to 84.3 ft (Run No. 15) SHALE - Gray; very slight weathering; moderately hard; wide joint spacing with joint at 80.2'; fine grained.	508.7 / 84.3	15	J, R
84.3 ft to 87.8 ft (Run No. 16) SHALE - Same as previous run with pyrite.	505.2 / 87.8	16	
87.8 ft to 89.3 ft (Run No. 16) **DOLOMITE** - Gray; very slight weathering; sound; hard; crystalline; with calcite veins.	503.7 / 89.3	16	
89.3 ft to 94.3 ft (Run No. 17) **DOLOMITE** - Same as previous run; all breaks mechanical.	498.7	17	
		18	

Distance scale (feet): 65, 70, 75, 80, 85, 90
Elevation: 530, 525, 520, 515, 510, 505, 500

--- CONTINUED NEXT PAGE ---

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: B-82

DRILLING DATE: 10/18/2011

DRILL RIG: D-50 Track

DRILLING METHOD: NQ

NORTHING:

EASTING:

INCLINATION: -90°

AZIMUTH: ---

DATUM: NAVD 88

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 ---														
95	NQ Core	**94.3 ft to 99.0 ft (Run No. 18)** **DOLOMITE** - Same as previous run; all breaks mechanical.		94.3 / 493.7	18			495								
100	NQ Core	**99.3 ft to 103.0 ft (Run No. 19)** **DOLOMITE** - Same as previous run; all breaks mechanical.		99.3 / 490.0	19			490								
		Coring Terminated at 103.0 Feet		103.0												
105																
110																
115																
120																
125																

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.
DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

Louisville Tunnel Project
Louisville, Jefferson County, Kentucky
Project No. 1831-10-5629
Sheet 1 of 3

S&ME
422 Codell Drive
Lexington, KY 40509

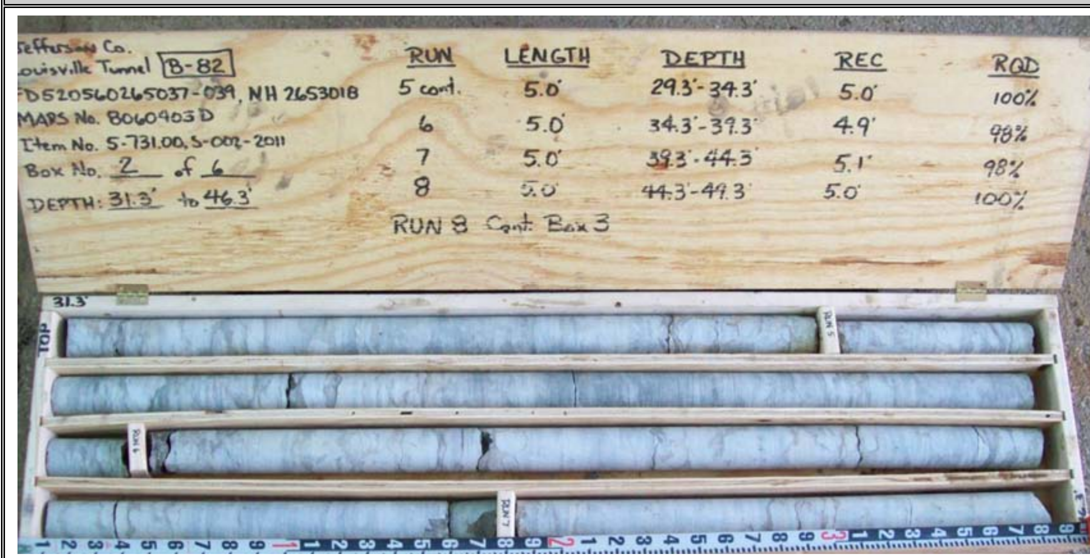
Photo 1

10/21/2011

Photographer: N. Peterson

Location / Orientation	Boring B-82, Box 1 of 6, 12.8 ft to 31.3 ft
Remarks	Louisville Limestone

Photo 2



10/21/2011

Photographer: N. Peterson

Location / Orientation	Boring B-82, Box 2 of 6, 31.3 ft to 46.3 ft
Remarks	Louisville Limestone

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 3

10/21/2011

Photographer: N. Peterson

Location / Orientation	Boring B-82, Box 3 of 6, 46.3 ft to 61.0 ft
Remarks	Louisville Limestone

Photo 4

10/21/2011

Photographer: N. Peterson

Location / Orientation	Boring B-82, Box 4 of 6, 61.0 ft to 75.3 ft
Remarks	Louisville Limestone

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 5

10/21/2011

Photographer: N. Peterson

Location / Orientation	Boring B-82, Box 5 of 6, 75.3 ft to 90.5 ft
Remarks	Louisville Limestone to a depth of 76.0'. Waldron Shale present at 76.0' to 87.8'. Laurel Dolomite begins at 87.8'

Photo 6

10/21/2011

Photographer: N. Peterson

Location / Orientation	Boring B-82, Box 6 of 6, 90.5 ft to 103.0 ft
Remarks	Laurel Dolomite. Boring terminated at a depth of 103.0 feet.

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: B-83

DATUM: NAVD 88

DRILLING DATE: 10/17/2011

DRILL RIG: D-50 Track

DRILLING METHOD: NQ

NORTHING:

EASTING:

INCLINATION: -90°

AZIMUTH: ---

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

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	ELEV. / DISTANCE (ft)	RUN No.	ELEVATION	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION
0	10/17/2011	GROUND SURFACE				
		Rootmat and topsoil (3 inches)	0.3			
	3.25 HSA	**CLAY (CL)** - Tan; slightly moist; silty; stiff; with black oxide staining; RESIDUUM	580.7 / 3.0			
5	10/17/2011	**CLAY (CL)** - Reddish brown; slightly moist; very stiff; RESIDUUM	575.9		580	
		Weathered Limestone Auger refusal encountered at 8.0 feet and begin NQ core.	8.0			
10	NQ Core	**8.0 ft to 10.6 ft (Run No. 1) LIMESTONE** - Gray; slightly weathered; slightly fractured; hard; with pressure solution features and stylolitic features throughout; fossiliferous; solutional weathering at 9.2' to 9.4' and at 9.7', 9.8', and 10.1' along stylolitic features.	573.1 / 10.6	1	575	Solutional Weathering Solutional Weathering Solutional Weathering Solutional Weathering Solutional Weathering
15		**10.6 ft to 15.6 ft (Run No. 2) LIMESTONE** - Same as previous run; clay filled void at 13.3' to 14.3'.	568.1 / 15.6	2	570	Clay Filled Void (1.0 ft)
20		**15.6 ft to 20.6 ft (Run No. 3) LIMESTONE** - Gray; very slight weathering; slightly fractured with one fracture at 19.0'; moderately hard; crystalline; fossiliferous; pressure solution features and stylolitic features throughout.	563.1 / 20.6	3	565	FR, R
25		**20.6 ft to 25.6 ft (Run No. 4) LIMESTONE** - Same as previous run; all breaks mechanical.	558.1 / 25.6	4	560	
30		**25.6 ft to 30.6 ft (Run No. 5) LIMESTONE** - Gray; very slight weathering; sound; hard; crystalline with dark gray pressure solution features and stylolitic features throughout.	553.1 / 30.6	5	555	
				6		

--- CONTINUED NEXT PAGE ---

DISTANCE SCALE 1 inch to 4 feet

DRILLING CONTRACTOR: S&ME, Inc.

DRILLER: L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP

CHECKED: CSL

RECORD OF DRILLHOLE: B-83

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

DRILLING DATE: 10/17/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ

NORTHING:
EASTING:
INCLINATION: -90°   AZIMUTH: ---

DATUM: NAVD 88

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

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	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													FR, R		
														J, R		
35	NQ Core	**30.6 ft to 35.6 ft (Run No. 6)** **LIMESTONE** - Gray; very slight weathering; slightly fractured with fractures at 32.0' along stylolitic features; joint at 33.4'; pressure solution features throughout.		548.1 35.6	6			550								
	NQ Core	**35.6 ft to 36.4 ft (Run No. 7)** **LIMESTONE** - Same as previous run; all breaks mechanical.		547.3 36.4	7											
		Boring Terminated at 36.4 Feet.														
40																
45																
50																
55																
60																

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR: S&ME, Inc.
DRILLER: L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

Louisville Tunnel Project
Louisville, Jefferson County, Kentucky
Project No. 1831-10-5629
Sheet 1 of 1

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 1

10/17/2011

Photographer: N. Peterson

Location / Orientation	Boring B-83, Box 1 of 2, 8.0 ft to 23.1 ft
Remarks	Louisville Limestone

Photo 2

10/17/2011

Photographer: N. Peterson

Location / Orientation	Boring B-83, Box 2 of 2, 23.1 ft to 36.4 ft
Remarks	Louisville Limestone

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: B-84

DATUM: NAVD 88

DRILLING DATE: 10/18/2011
DRILL RIG: D-50 Track
DRILLING METHOD:

NORTHING:
EASTING:
INCLINATION: -90° AZIMUTH: ---

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

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	ELEV. / DISTANCE (ft)	RUN No.	ELEVATION	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION
		GROUND SURFACE				
0	10/18/2011	Crushed stone and clay fill (8 inches)	569.3 / 0.7		570	
		CLAY (CL) - Dark reddish brown with crushed stone; slightly moist; FILL	568.5 / 1.5			
2–7.5	3.25 HSA	**CLAY (CH)** - Yellow brown; stiff; slightly moist to wet at approximately 5 feet; with manganese nodules; RESIDUUM	562.5 / 7.5		568, 566, 564	
	10/19/2011	Weathered Limestone	562.0 / 8.0			
8	NQ Core	Auger refusal encountered at 8.0 feet and begin NQ core. **8.0 ft to 8.7 ft (Run No. 1) LIMESTONE** - Gray with light brown weathered fracture at 8.3' with discoloration extending one inch into rock; ;hard; crystalline; fossiliferous; with pressure solution features throughout.	561.3 / 8.7	1	562	FR, R
10–12		**8.7 ft to 13.7 ft (Run No. 2) LIMESTONE** - Gray; slightly weathered; slightly fractured with fractures at 9.9', 10.2', and 12.4'. Fractures occur along stylolitic features; crystalline limestone; hard; fossiliferous; with pressure solution features throughout.	556.3 / 13.7	2	560, 558	FR, R; FR, R; FR, R
14–18		**13.7 ft to 18.7 ft (Run No. 3) LIMESTONE** - Same as previous run; fractures at 17.4' and 18.4' along stylolitic features.	551.3 / 18.7	3	556, 554, 552	FR, R; FR, R
20				4	550	FR, R; FR, R

--- CONTINUED NEXT PAGE ---

DISTANCE SCALE 1 inch to 2.5 feet

DRILLING CONTRACTOR: S&ME, Inc.
DRILLER:

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

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

RECORD OF DRILLHOLE: B-84

DRILLING DATE: 10/18/2011
DRILL RIG: D-50 Track
DRILLING METHOD:

NORTHING:
EASTING:
INCLINATION: -90°
AZIMUTH: ---

DATUM: NAVD 88

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

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	ELEV. / DISTANCE (ft)	RUN No.	ELEVATION	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION
20		*--- CONTINUED FROM PREVIOUS PAGE ---*			550	
20–23.7	NQ Core	**18.7 ft to 23.7 ft (Run No. 4) LIMESTONE** - Gray; slightly weathered; slightly fractured with fractures at 19.3', 19.9', 20.9', 21.3', and 22.3' occuring along pressure solution features; hard; crystalline.	546.3 / 23.7	4	548	FR, R FR, R FR, R
23.7–28.7	NQ Core	**23.7 ft to 28.7' (Run No. 5) LIMESTONE** - Gray; slightly weathered; slightly fractured with fractures at 26.9' and 28.4' occuring along stylolitic features; hard; crystalline.	541.3 / 28.7	5	546, 544, 542	FR, R FR, R
28.7–33.7	NQ Core	**28.7 ft to 33.7 ft (Run No. 6) LIMESTONE** - Same as previous run; all breaks mechanical.	536.3 / 33.7	6	540, 538	
33.7–37.0	NQ Core	**33.7 ft to 37.0 ft (Run No. 7) LIMESTONE** - Same as previous run; all breaks mechanical.	533.0 / 37.0	7	536, 534	
38		Coring Terminated at 37.0 Feet.				
40						

DISTANCE SCALE
1 inch to 2.5 feet

DRILLING CONTRACTOR: S&ME, Inc.
DRILLER:

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

SME_ROCK GLO NEW.GPJ GLDR_LDN.GDT 10/19/11 DATA INPUT:

Louisville Tunnel Project
Louisville, Jefferson County, Kentucky
Project No. 1831-10-5629
Sheet 1 of 1

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 1

10/19/2011
Photographer: N. Peterson

Location / Orientation	Boring B-84, Box 1 of 2, 8.0 ft to 22.3 ft
Remarks	Louisville Limestone

Photo 2

10/19/2011
Photographer: N. Peterson

Location / Orientation	Boring B-84, Box 2 of 2, 22.3 ft to 37.0 ft
Remarks	Louisville Limestone

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

RECORD OF DRILLHOLE: B-85

DRILLING DATE: 11/15/11
DRILL RIG: D-50 Track
DRILLING METHOD: NQ
NORTHING:303581.25
EASTING:1246351.51
INCLINATION: -90°
AZIMUTH: ---
DATUM: NAVD 88

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

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	ELEV. / DISTANCE (ft)	RUN No.	ELEVATION	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION
0		GROUND SURFACE				
	11/15/2011	Rootmat and Topsoil (3 inches)	0.3			
	3.25 HSA	**CLAY (CL)** - Brown; firm; moist; silty; RESIDUUM	533.1		535	
	11/17/2011	Weathered Limestone Auger refusal encountered at 4.3 feet. Begin NQ core at 4.3 feet.	4.3			
5		**4.3 ft to 9.0 ft (Run No. 1) LIMESTONE** - Gray; slightly weathered; very close joint spacing with joints at 4.8', 5.3', 6.6', 7.0', 7.3', and 9.0' (iron stained with solutional weathering); hard; crystalline.	528.3 / 9.0	1	530	J, R J, R J, R J, R J, R J, Fe, solutional weathering
10		**9.0 ft to 14.0 ft (Run No. 2) LIMESTONE** - Gray; very slight weathering with pressure solution feature weathered at 11.3' to brittle material; all other breaks are mechanical and occur along pressure solution features; hard; crystalline.	523.3 / 14.0	2	525	
15	NQ Core	**14.0 ft to 19.0 ft (Run No. 3) LIMESTONE** - Gray with dark gray interbedded shale; very close joint spacing with joints at 14.7', 15.9', 16.6', 16.9', 17.9', 18.0', 18.1', 18.7', and 18.9'. Limestone is hard, crystalline, with stylolites.	518.3 / 19.0	3	520	J, R J, R J, R J, R J, R J, R J, R J, R J, R
20		**19.0 ft to 23.2 ft (Run No. 4) LIMESTONE** - Gray; very slight weathering; sound; hard; crystalline down to 23.2 feet.	514.1 / 23.2	4	515	
		23.2 ft to 24.0 ft (Run No. 4) SHALE - Dark gray; slightly weathered; joints with clay at 23.2' and 23.7'; moderately hard; fine grained.	513.3 / 24.0			J, CL J, CL
25	11/27/2011	**24.0 ft to 29.0 ft (Run No. 5) LIMESTONE** - Gray; very slight weathering; hard; sound; crystalline.	508.3 / 29.0	5	510	
30	NQ Core	**29.0 ft to 30.8 ft (Run No. 6) LIMESTONE** - Same as previous run down to 30.8 feet.	506.5 / 30.8	6		

--- CONTINUED NEXT PAGE ---

DISTANCE SCALE
1 inch to 4 feet
DRILLING CONTRACTOR:S&ME, Inc.
DRILLER:L. Morrison
S&ME ENGINEERING INTEGRITY
LOGGED: NJP
CHECKED: CSL

DRILLING DATE: 11/15/11
DRILL RIG: D-50 Track
DRILLING METHOD: NQ
NORTHING:303581.25
EASTING:1246351.51
INCLINATION: -90°
AZIMUTH: ---

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

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	ELEV. / DISTANCE (ft)	RUN No.	ELEVATION	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION
		--- CONTINUED FROM PREVIOUS PAGE ---				
	NQ Core	**30.8 ft to 34.0 ft (Run No. 6) SHALE** - Gray; slight weathering with thin clay seams along bedding (1 cm) at 32.7' and 33.0'; mechanical breaks occur along bedding; moderately hard; fine grained.	503.3	6	505	Clay seam Clay seam
35		**34.0 ft to 39.0 ft (Run No. 7) SHALE** - Gray; slightly weathered from 34.0' to 35.1' iwth thin clay seams along bedding (1 cm); becomes very slight weathered and sound from 34.1' to 39.0'; fine grained; moderately hard.	34.0 498.3	7	500	
40		**39.0 ft to 42.3 ft (Run No. 8) SHALE** - Gray; very slight weathering; sound; fine grained; moderately hard down to 42.3'.	39.0 495.0	8	495	
		42.3 ft to 44.0 ft (Run No. 8) DOLOMITE - Gray; very slight weathering; sound; hard; crystalline.	42.3 493.3			
45		**44.0 ft to 49.0 ft (Run No. 9) DOLOMITE** - Same as previous run; all breaks mechanical.	44.0 488.3	9	490	
50		**49.0 ft to 54.0 ft (Run No. 10) DOLOMITE** - Same as previous run; all breaks mechanical.	49.0 483.3	10	485	
55		**54.0 ft to 59.0 ft (Run No. 11) DOLOMITE** - Gray; very slight weathering; sound; hard; crystalline.	54.0 478.3	11	480	
60		**59.0 ft to 64.0 ft (Run No. 12) DOLOMITE** - Same as previous run; all breaks mechanical.	59.0	12	475	
		--- CONTINUED NEXT PAGE ---				

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

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	FLUSH (COLOR / % RETURN)	ELEVATION	RECOVERY (TOTAL CORE % / SOLID CORE %)	R.Q.D. %	FRACT. INDEX PER FT	DISCONTINUITY DATA (DIP w.r.t. CORE AXIS / TYPE AND SURFACE DESCRIPTION)	HYDRAULIC CONDUCTIVITY k, cm/sec	DIAMETRAL POINT LOAD INDEX (psi)
		--- CONTINUED FROM PREVIOUS PAGE ---												
	NQ Core			473.3 / 64.0	12									
65		**64.0 ft to 69.0 ft (Run No. 13)** **DOLOMITE** - Gray; very slight weathering; sound; hard; crystalline.		468.3 / 69.0	13			470						
70		**69.0 ft to 74.0 ft (Run No. 14)** **DOLOMITE** - Same as previous run; all breaks mechanical.		463.3 / 74.0	14			465						
75		**74.0 ft to 79.0 ft (Run No. 15)** **DOLOMITE** - Same as previous run; all breaks mechanical.		458.3 / 79.0	15			460						
80		Coring Terminated at 79.0 Feet												
85														
90														

Louisville Tunnel Project
Louisville, Jefferson County, Kentucky
Project No. 1831-10-5629
Sheet 1 of 3

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 1

11/28/2011

Photographer: N. Peterson

Location / Orientation	Boring B-85, Box 1 of 5, 4.3 ft to 19.0 ft
Remarks	Louisville Limestone

Photo 2

11/28/2011

Photographer: N. Peterson

Location / Orientation	Boring B-85, Box 2 of 5, 19.0 ft to 34.0 ft
Remarks	Louisville Limestone down to 23.2 ft. Shale seam at 23.2 ft to 24.0 ft. Waldron Shale encountered at 30.8 ft.

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 3

11/28/2011

Photographer: N. Peterson

Location / Orientation	Boring B-85, Box 3 of 5, 34.0 ft to 49.0 ft
Remarks	Waldron Shale down to 42.3 ft. Laurel Dolomite encountered at 42.3 ft.

Photo 4

11/28/2011

Photographer: N. Peterson

Location / Orientation	Boring B-85, Box 4 of 5, 49.0 ft to 64.0 ft
Remarks	Laurel Dolomite

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 5

11/28/2011

Photographer: N. Peterson

Location / Orientation	Boring B-85, Box 5 of 5, 64.0 ft to 79.0 ft
Remarks	Laurel Dolomite – Coring Terminated at 79.0 ft.

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: B-86

DATUM: NAVD 88

DRILLING DATE: 11/15/2011

DRILL RIG: D-50 Track

DRILLING METHOD: NQ

NORTHING:303811.89

EASTING:1246117.12

INCLINATION: -90°

AZIMUTH: ---

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

Column headings: DISTANCE SCALE FEET; DRILLING RECORD; DESCRIPTION; SYMBOLIC LOG; ELEV. DISTANCE (ft); RUN No.; PENETRATION RATE (ft/min); FLUSH; COLOR / % RETURN; ELEVATION; RECOVERY (TOTAL CORE %, SOLID CORE %); R.Q.D. %; FRACT. INDEX PER FT; DISCONTINUITY DATA (DIP w.r.t. CORE AXIS; TYPE AND SURFACE DESCRIPTION); HYDRAULIC CONDUCTIVITY k, cm/sec; DIAMETRAL POINT LOAD INDEX (psi)

Drilling record: 11/29/2011 / 11/15/2011, 3.25 HSA; NQ Core

DESCRIPTION	ELEV. / DISTANCE (ft)	RUN No.	ELEVATION	DISCONTINUITY TYPE AND SURFACE DESCRIPTION
GROUND SURFACE				
Rootmat and topsoil (3 inches)	0.3			
CLAY (CL) - Brown; slightly moist; RESIDUUM	530.3 / 2.1		530	
Weathered Limestone Auger refusal encountered at 2.1 feet. Begin NQ core at 2.1 feet.				
2.1 ft to 4.4 ft (Run No. 1) LIMESTONE - Gray; slightly weathered; very close joint spacing with joints at 2.5', 2.8', 3.5', and clay filled joints at 3.8' to 3.9'; limestone is hard; crystalline.	527.8 / 4.4	1		J, R; J, R; J, R; J, R; J, CL
4.4 ft to 9.4 ft (Run No. 2) LIMESTONE - Gray; slightly weathered with solutional weathering along joints with an open joint containing iron staining at 4.9' to 5.0'; very close joint spacing with joints at 5.6', 7.5' (iron stained and solutional weathering), 8.0' to 8.2' with clay and 9.2'; limestone is hard, crystalline.	522.8 / 9.4	2	525	J, Fe; J, Fe; J, Fe; J, CL; J, CL; J, R
9.4 ft to 14.4 ft (Run No. 3) LIMESTONE - Gray; slightly weathered; slightly fractured with fractures occuring along stylolites at 9.8', 10.9', 11.0', and 11.6' and 13.8' occuring along dark gray thin shale partings. Clay filled joints at 14.1' and 14.3' (1 cm); limestone is hard; crystalline.	517.8 / 14.4	3	520	J, R; J, R; J, R; J, R; J, R; J, CL; J, CL
14.4 ft to 19.4 ft (Run No. 4) LIMESTONE - Dark gray; oolitic limestone with fossils; slightly weathered; with one break at 16.1' along stylolite. From 18.7' limestone is gray; hard; sound; crystalline with gray green color along pressure solution features.	512.8 / 19.4	4	515	
19.4 ft to 24.4 ft (Run No. 5) LIMESTONE - Gray green; slightly weathered; fossiliferous; oolitic; clay filled fracture at 20.7'. From 21.1' to 24.4' limestone is gray; very slight weathering; sound; hard; crystalline with stylolites.	507.8 / 24.4	5	510	FR, CL
24.4 ft to 27.9 ft (Run No. 6) LIMESTONE - Gray; very slight weathering; sound; hard; crystalline with calcite vug at 26.4'.	504.3 / 27.9	6	505	Calcite vug
27.9 ft to 29.4 ft (Run No. 6) SHALE - Gray; very slight weathering; moderately hard; calcareous; fine grained.	502.8 / 29.4			
		7		

--- CONTINUED NEXT PAGE ---

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.

DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP

CHECKED: CSL

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

RECORD OF DRILLHOLE: B-86

DRILLING DATE: 11/15/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ

NORTHING:303811.89
EASTING:1246117.12
INCLINATION: -90°
AZIMUTH: ---

DATUM: NAVD 88

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

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	ELEV. / DISTANCE (ft)	RUN No.	ELEVATION
		--- CONTINUED FROM PREVIOUS PAGE ---			
35	NQ Core	**29.4 ft to 34.4 ft (Run No. 7) SHALE** - Gray; very slight weathering; slightly fractured with fractures occuring along bedding at 29.5', 30.5', 31.2', 31.5' to 31.6' with clay, 32.0' and 37.7'. Shale is moderately hard; fine grained.	497.8 / 34.4	7	500
		29.4 ft to 34.4 ft (Run No. 7) SHALE - Gray; very slight weathering; slightly fractured with fractures occuring along bedding at 29.5', 30.5', 31.2', 31.5' to 31.6' with clay, 32.0' and 37.7'. Shale is moderately hard; fine grained.			
		34.4 ft to 39.4 ft (Run No. 8) SHALE - Gray; very slight weathering; sound; moderately hard; fine grained. Dolomite seam at 38.0' to 38.9' then returns to shale down to 39.4'.	492.8 / 39.6	8	495
40		**39.4 ft to 39.6 ft (Run No. 9) SHALE** - Same as previous run down to 39.6'.			
		39.6 ft to 44.4 ft (Run No. 9) DOLOMITE - Gray; very slight weathering; hard; sound; crystalline with stylolites.	487.8 / 44.4	9	490
45		**44.4 ft to 49.4 ft (Run No. 10) DOlOMITE** - Gray; very slight weathering; sound; hard; crystalline with stylolites.	482.8 / 49.4	10	485
50		**49.4 ft to 54.4 ft (Run No. 11) DOLOMITE** - Same as previous run; all breaks mechanical.	477.8 / 54.4	11	480
55		**54.4 ft to 59.4 ft (Run No. 12) DOLOMITE** - Same as previous run down to 57.3'. From 57.3' dolomite is brown and gray; pitted; moderately weathered; hard; sound; crystalline.	472.8 / 59.4	12	475
60		**59.4 ft to 64.4 ft (Run No. 13) DOLOMITE** - Moderately weathered; brown and gray; pitted; hard; sound. From 60.4' to 64.4' dolomite is gray; very slight weathering; hard; sound; crystalline with stylolites.		13	470
		--- CONTINUED NEXT PAGE ---			

Other columns: SYMBOLIC LOG; PENETRATION RATE (ft/min); COLOR % RETURN; FLUSH; RECOVERY (TOTAL CORE %, 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; TYPE AND SURFACE DESCRIPTION); HYDRAULIC CONDUCTIVITY k, cm/sec 10^{-6} 10^{-5}; DIAMETRAL POINT LOAD INDEX (psi)

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.
DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: B-86

DATUM: NAVD 88

DRILLING DATE: 11/15/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ

NORTHING:303811.89
EASTING:1246117.12
INCLINATION: -90°
AZIMUTH: ---

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

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 ---														
	NQ Core			467.8	13											
65		**64.4 ft to 69.4 ft (Run No. 14)** **DOLOMITE** - Gray; very slight weathering; sound; hard; crystalline with stylolites.		64.4 / 462.8	14			465								
70		**69.4 ft to 74.4 ft (Run No. 15)** **DOLOMITE** - Same as previous run; all breaks mechanical.		69.4 / 457.8	15			460								
75		**74.4 ft to 78.5 ft (Run No. 16)** **DOLOMITE** - Same as previous run down to 78.5 feet.		74.4 / 453.7	16			455								
		78.5 ft to 79.4 ft (Run No. 16) SHALE - Gray; very slight weathering; sound; moderately hard; fine grained.		78.5 / 452.8												
80		**79.4 ft to 80.5 (Run No. 17) SHALE** - Gray; very slight weathering; sound; moderately hard; fine grained down to 80.5 feet.		79.4 / 451.7	17											
		80.5 ft to 81.5 ft (Run No. 17) **DOLOMITE** - Gray; very slight weathering; sound; hard; crystalline.		80.5 / 450.7												
		Coring Terminated at 81.5 Feet		81.5												
85																
90																

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

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.
DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 1

11/29/2011

Photographer: N. Peterson

Location / Orientation	Boring B-86, Box 1 of 6, 2.1 ft to 17.3 ft
Remarks	Louisville Limestone

Photo 2

11/29/2011

Photographer: N. Peterson

Location / Orientation	Boring B-86, Box 2 of 6, 17.3 ft to 32.0 ft
Remarks	Louisville Limestone down to 27.9 ft. Waldron Shale encountered at 27.9 ft

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 3

11/29/2011

Photographer: N. Peterson

Location / Orientation	Boring B-86, Box 3 of 6, 32.0 ft to 46.9 ft
Remarks	Waldron Shale down to 39.6 ft. Laurel Dolomite encountered at 39.6 ft.

Photo 4

11/29/2011

Photographer: N. Peterson

Location / Orientation	Boring B-86, Box 4 of 6, 46.9 ft to 62.0 ft
Remarks	Laurel Dolomite

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 5

11/29/2011

Photographer: N. Peterson

Location / Orientation	Boring B-86, Box 5 of 6, 62.0 ft to 77.0 ft
Remarks	Laurel Dolomite

Photo 6

11/29/2011

Photographer: N. Peterson

Location / Orientation	Boring B-86, Box 6 of 6, 77.0 ft to 81.5 ft
Remarks	Laurel Dolomite down to 78.5. Shale from 78.5 ft to 80.5 ft. Laurel Dolomite from 80.5 ft to 81.5 ft. Coring Terminated at 81.5 ft.

RECORD OF DRILLHOLE: B-87

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

DRILLING DATE: 11/15/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ

NORTHING:303857.45
EASTING:1246163.48
INCLINATION: -90°
AZIMUTH: ---

DATUM: NAVD 88

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

Column headings: DISTANCE SCALE FEET | DRILLING RECORD | DESCRIPTION | SYMBOLIC LOG | ELEV. DISTANCE (ft) | RUN No. | PENETRATION RATE (ft/min) | FLUSH | COLOR % RETURN | ELEVATION | RECOVERY (TOTAL CORE %, 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; TYPE AND SURFACE DESCRIPTION) | HYDRAULIC CONDUCTIVITY k, cm/sec (10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}) | DIAMETRAL POINT LOAD INDEX (psi) (250, 500, 750)

Drilling record: 11/15/2011 – 11/17/2011, 3.25 HSA to 3.8 ft; NQ Core 3.8 ft to 28.0 ft.

Depth (ft) / Elev.	Run No.	Description	Discontinuity data
0.0		GROUND SURFACE	
0.0 – 0.3		Rootmat and topsoil (3 inches)	
0.3 – 3.8 (524.6)		**CLAY (CH)**- Brown and light brown; firm; moist; RESIDUUM	
3.8 – 4.9 (523.4)	1	Weathered Limestone Auger refusal encountered at 3.8 feet. Begin NQ core at 3.8 feet. **3.8 ft to 4.9 ft (Run No. 1) LIMESTONE** - Gray; slight weathering; joint at 4.4' with solutional weathering and clay; hard; crystalline.	J, R, solutional weathering
4.9 – 9.9 (518.4)	2	**4.9 ft to 9.9 ft (Run No. 2) LIMESTONE** - Gray; slight weathering; very close joint spacing with joints at 5.2', 5.7', 6.1', 6.3', 7.5', 7.8', 8.3', 8.5', 8.9', and 9.2'. Limestone is hard; crystalline; with stylolites.	J, R; J, R; J, R; J, R; J, R; J, R; J, R; J, R; J, R; J, R
9.9 – 14.9 (513.4)	3	**9.9 ft to 14.9 ft (Run No. 3) LIMESTONE** - Gray; slight weathering; very close joint spacing with joints at 10.2', 10.9' with clay, 11.1' with clay, and 11.2'. Thin shale partings encountered at 10.9' to 12.9'; hard; crystalline.	J, R; J, R, CL; J, R, CL; J, R
14.9 – 19.9 (508.4)	4	**14.9 ft to 19.9 ft (Run No. 4) LIMESTONE** - Gray; slightly weathered with moderately weathered section at 16.4' to 17.2' which is soft with clay and thin shale partings. Limestone is hard; crystalline; with stylolites.	
19.9 – 22.9 (505.4)	5	**19.9 ft to 22.9 ft (Run No. 5) LIMESTONE** - Gray; very slightly weathered; hard; sound; crystalline; with stylolites down to 22.9'.	
22.9 – 24.9 (503.4)	5	**22.9 ft to 24.9 ft (Run No. 5) SHALE** - Gray; very slight weathering with interbedded limestone; fine grained; moderately hard; pyritic.	
24.9 – 28.0 (500.3)	6	**24.9 ft to 28.0 ft (Run No. 6) SHALE** - Dark gray; slightly weathered; with very close joint spacing and joints at 25.0' with clay, 25.6', 26.2', 26.4', and 26.6'; moderately hard; fine grained; pyritic.	J, R, CL; J, R; J, R; J, R; J, R
28.0		Coring Terminated at 28.0 Feet	

Elevation marks: 525, 520, 515, 510, 505

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.
DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

Louisville Tunnel Project
Louisville, Jefferson County, Kentucky
Project No. 1831-10-5629
Sheet 1 of 1

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 1

11/17/2011

Photographer: N. Peterson

Location / Orientation	Boring B-87, Box 1 of 2, 3.8 ft to 18.7 ft
Remarks	Louisville Limestone

Photo 2

11/17/2011

Photographer: N. Peterson

Location / Orientation	Boring B-87, Box 2 of 2, 18.7 ft to 28.0 ft
Remarks	Louisville Limestone down to 22.9 feet. Waldron Shale encountered at 22.9 feet.

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: B-88

DRILLING DATE: 11/15/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ

NORTHING:303927.54
EASTING:1246234.8
INCLINATION: -90°
AZIMUTH: ---

DATUM: NAVD 88

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

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	ELEV. / DISTANCE (ft)	RUN No.	ELEVATION	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION
0	11/15/2011	GROUND SURFACE Rootmat and topsoil (3.5 inches)	0.3			
	3.25 HSA	**CLAY (CH)** - Dark brown; soft; moist; with fine roots; RESIDUUM	529.5 / 3.5		530	
5		**CLAY (CH)** - Reddish brown; very stiff; moist; with chert fragments; with manganese nodules; RESIDUUM	523.3 / 9.8		525	
10	11/17/2011	Weathered Limestone Auger refusal encountered at 9.8 feet. Begin NQ core at 9.8 feet. **9.8 ft to 14.2 ft (Run No. 1) LIMESTONE** - Gray; slightly weathered; very close joint spacing with joints at 10.2', 10.7', 11.2', 12.4', and 12.9'; hard; crystalline; with thin shale partings and pressure solution features throughout.	518.8 / 14.2	1	520	J, R J, R J, R J, R J, R
15	NQ Core	**14.2 ft to 19.2 ft (Run No. 2) LIMESTONE** - Gray; slightly weathered; very close joint spacing with joint at 15.4' and 15.5' occuring along thin shale partings containing clay; hard; crystalline; with stylolites.	513.8 / 19.2	2	515	J, R J, R, CL
20		**19.2 ft to 24.2 ft (Run No. 3) LIMESTONE** - Gray; slightly weathered; very close joint spacing with joints at 20.4' with clay, 20.7', 20.8', 21.0', and 21.1' with clay; Shale seam at 20.2' to 21.5' which is moderately hard; slightly weathered; fine grained; Limestone is hard; crystalline; with stylolites.	508.8 / 24.2	3	510	J, R, CL J, R J, R J, R J, R, CL
25		**24.2 ft to 29.2' (Run No. 4) LIMESTONE** - Gray; very slight weathering; sound with mechanical breaks occuring along stylolites. Interbedded shale at 27.5' to 29.2'; moderately hard; fine grained.	503.8 / 29.2	4	505	
30		**29.2 ft to 32.5 ft (Run No. 5) SHALE** - Dark gray; slightly weathered; very close joint spacing with joints at 30.3' to 30.9' with clay and at 31.6' and 31.9'; moderately hard; fine grained.		5		J, R, CL

--- CONTINUED NEXT PAGE ---

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.
DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: B-88

DATUM: NAVD 88

DRILLING DATE: 11/15/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ

NORTHING:303927.54
EASTING:1246234.8
INCLINATION: -90°
AZIMUTH: ---

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

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	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	HYDRAULIC CONDUCTIVITY k, cm/sec	DIAMETRAL POINT LOAD INDEX (psi)
		--- CONTINUED FROM PREVIOUS PAGE ---														
				500.5 32.5	5									J, R J, R		
		Coring Terminated at 32.5 Feet														
35																
40																
45																
50																
55																
60																

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.
DRILLER:L. Morrison

ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

Louisville Tunnel Project
Louisville, Jefferson County, Kentucky
Project No. 1831-10-5629
Sheet 1 of 1

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 1

11/17/2011

Photographer: N. Peterson

Location / Orientation	Boring B-88, Box 1 of 2, 9.8 ft to 24.2 ft
Remarks	Louisville Limestone

Photo 2

11/17/2011

Photographer: N. Peterson

Location / Orientation	Boring B-88, Box 2 of 2, 24.2 ft to 32.5 ft
Remarks	Louisville Limestone down to 29.2 feet. Waldron Shale encountered at 29.2 feet.

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: B-89

DRILLING DATE: 11/15/2011

DRILL RIG: D-50 Track

DRILLING METHOD: NQ

NORTHING:303990.63

EASTING:1246298.99

INCLINATION: -90°

AZIMUTH: ---

DATUM: NAVD 88

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	

Column headings: DISTANCE SCALE FEET; DRILLING RECORD; DESCRIPTION; SYMBOLIC LOG; ELEV. DISTANCE (ft); RUN No.; PENETRATION RATE (ft/min); FLUSH COLOR % RETURN; ELEVATION; RECOVERY (TOTAL CORE % 80 60 40 20; 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; TYPE AND SURFACE DESCRIPTION); HYDRAULIC CONDUCTIVITY k, cm/sec 10^{-6} 10^{-5} 10^{-4} 10^{-3}; DIAMETRAL POINT LOAD INDEX (psi) 250 500 750

Drilling record: 11/15/2011, 3.25 HSA (0–12.3 ft); 11/16/2011, NQ Core (12.3 ft and below).

Depth (ft)	Description	Elev. / Distance (ft)	Run No.	Discontinuity Data
0	GROUND SURFACE			
0–0.3	Rootmat and topsoil (4 inches)	0.3		
0.3–7.0	**CLAY (CL)** - Light brown; firm; slightly moist; silty; RESIDUUM	539.3 / 7.0		
7.0–10.0	**CLAY (CH)** - Brown; stiff; slightly moist; with manganese nodules; RESIDUUM	536.3 / 10.0		
10.0–12.3	Weathered Limestone; wet at contact with overburden. Auger refusal encountered at 12.3 feet. Begin NQ core at 12.3 feet.	534.0 / 12.3		
12.3–14.6	**12.3 ft to 14.6 ft (Run No. 1)** **LIMESTONE** - Gray; moderately to severly weathered; open void with solutional weathering at 13.1' to 13.3' (100% water loss at 13.1'); calcite vugs 13.3' to 13.5'; clay filled void at 13.5' to 14.6'; Limestone is hard; crystalline; with stylolites.	531.7 / 14.6	1	Open void; 100% water loss; Clay filled void
14.6–19.6	**14.6 ft to 19.6 ft (Run No. 2)** **LIMESTONE** - Gray; slightly weathered with small open void with moderate weathering at 16.8' to 16.9'; hard; very close joint spacing with joints at 15.3', 16.5', 17.6', and 17.9'; crystalline; with stylolites.	526.7 / 19.6	2	J, R; J, R; Open void; J, R; J, R
19.6–24.6	**19.6 ft to 24.6 ft (Run No. 3)** **LIMESTONE** - Gray; slightly weathered; very close joint spacing with joints at 20.0', 21.1', 21.2', 22.0', 22.8', 23.5', 23.7', 24.0'. Limestone is hard, crystalline, with pressure solution features throughout.	521.7 / 24.6	3	J, R; J, R; J, R; J, R; J, R; J, R; J, R; J, R
24.6–29.6	**24.6 ft to 29.6 ft (Run No. 4)** **LIMESTONE** - Gray to dark gray; slightly weathered; very close joint spacing with joints at 24.7', 25.4', 25.5', 26.2', 28.2', and 29.0'. Limestone is hard, crystalline with pressure solution features and thin shale partings present at 28.9' to 29.6'.	516.7 / 29.6	4	J, R; J, R; J, R; J, R; J, R; J, R
29.6–	**29.6 ft to 34.6 ft (Run No. 5)** **LIMESTONE** - Gray to dark gray; slightly weathered; clay seam at 30.1' (1 cm); hard; crystalline; with pressure solution features.		5	Clay seam

Elevation scale: 545, 540, 535, 530, 525, 520, 515

--- CONTINUED NEXT PAGE ---

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.

DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: B-89

DRILLING DATE: 11/15/2011

DRILL RIG: D-50 Track

DRILLING METHOD: NQ

NORTHING:303990.63

EASTING:1246298.99

INCLINATION: -90°

AZIMUTH: ---

DATUM: NAVD 88

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

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	ELEV. / DISTANCE (ft)	RUN No.	ELEVATION	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION
		--- CONTINUED FROM PREVIOUS PAGE ---				
	NQ Core	**29.6 ft to 34.6 ft (Run No. 5) LIMESTONE** - Gray to dark gray; slightly weathered; clay seam at 30.1' (1 cm); hard; crystalline; with pressure solution features.	511.7	5		
35		**34.6 ft to 39.6' (Run No. 6) LIMESTONE** - Dark gray with thin shale partings 34.6' to 35.5' then is gray, very slightly weathered, sound, hard, crystalline, stylolitic.	34.6 / 506.7	6	510	
40		**39.6 ft to 41.9 ft (Run No. 7) LIMESTONE** - Gray; very slight weathering; sound; hard; crystalline with interbedded shale at 40.9' to 41.9'.	39.6 / 504.4		505	
		41.9 ft to 44.6 ft (Run No. 7) SHALE - Dark gray; slightly weathered; sound; moderately hard; fine grained.	41.9 / 501.7	7		
45		**44.6 ft to 49.6 ft (Run No. 8) SHALE** - Dark gray; moderately weathered 44.6' to 46.2' with clay seams at 45.6' to 45.7' and 45.9' to 46.1'. From 46.2' slightly weathered; sound; moderately hard; fine grained.	44.6 / 496.7	8	500	Clay seam Clay seam
50		**49.6 ft to 53.4 ft (Run No. 9) SHALE** - Dark gray; very slight weathering; sound; moderately hard; fine grained; dolomite lense at 50.7' to 52.6'.	49.6 / 492.9	9	495	
		53.4 ft to 54.6 ft (Run No. 9) DOLOMITE - Gray; very slight weathering; sound; fine grained; hard.	53.4 / 491.7			
55		**54.6 ft to 59.6 ft (Run No. 10) DOLOMITE** - Gray; very slight weathering; close joint spacing with joints at 56.7' and 58.6'; crystalline; hard.	54.6 / 486.7	10	490	J, R J, R
60		**59.6 ft to 64.6 ft (Run No. 11) DOLOMITE** - Same as previous run; all breaks mechanical.	59.6	11	485	
		--- CONTINUED NEXT PAGE ---				

SME_ROCK GLO NEW.GPJ GLDR_LDN.GDT 11/16/11 DATA INPUT:

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.

DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP

CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: B-89

DATUM: NAVD 88

DRILLING DATE: 11/15/2011

DRILL RIG: D-50 Track

DRILLING METHOD: NQ

NORTHING:303990.63

EASTING:1246298.99

INCLINATION: -90°

AZIMUTH: ---

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

--- CONTINUED FROM PREVIOUS PAGE ---

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	ELEV. / DISTANCE (ft)	RUN No.	ELEVATION	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION
	NQ Core	**59.6 ft to 64.6 ft (Run No. 11)** **DOLOMITE** - Same as previous run; all breaks mechanical.	481.7 / 64.6	11		
65		**64.6 ft to 69.6 ft (Run No. 12)** **DOLOMITE** - Same as previous run; very thin clay seam at 68.5' (1 mm); all other breaks mechanical.	476.7 / 69.6	12	480	Clay seam
70		**69.6 ft to 74.6 ft (Run No. 13)** **DOLOMITE** - Gray; very slightly weathered; weathered joint with clay at 69.8' (1 cm); hard; crystalline down to 71.7'. From 71.7' to 74.6' dolomite is brown; moderately weathered; pitted; hard.	471.7 / 74.6	13	475	J, R, CL
75		**74.6 ft to 79.6 ft (Run No. 14)** **DOLOMITE** - Brownish gray; moderately weathered; pitted; hard down to 74.9'. From 74.9' to 79.6' dolomite is gray; very slightly weathered; sound; hard; crystalline.	466.7 / 79.6	14	470	
80		**79.6 ft to 84.6 ft (Run No. 15)** **DOLOMITE** - Gray to gray green; very slight weathering; one break at 84.2' along joint with clay; all other breaks are mechanical; hard; crystalline; with stylolites.	461.7 / 84.6	15	465	J, R, CL
85		**84.6 ft to 89.6 ft (Run No. 16)** **DOLOMITE** - Gray to gray green; very slight weathering; sound; hard; crystalline.	456.7 / 89.6	16	460	
90		**89.6 ft to 91.6 ft (Run No. 17)** **DOLOMITE** - Same as previous run down to 91.6'.	454.7 / 91.6		455	
		91.6 ft to 93.9 ft (Run No. 17) SHALE - Gray; very slight weathering; moderately hard; calcareous; pyritic; fine grained.	452.4 / 93.9	17		

--- CONTINUED NEXT PAGE ---

DISTANCE SCALE 1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.

DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP

CHECKED: CSL

SME_ROCK GLO NEW.GPJ GLDR_LDN.GDT 11/16/11 DATA INPUT:

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: B-89

DRILLING DATE: 11/15/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ

NORTHING:303990.63
EASTING:1246298.99
INCLINATION: -90°
AZIMUTH: ---

DATUM: NAVD 88

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

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 ---														
95	NQ Core	**93.9 ft to 94.6 ft (Run No. 17)** **DOLOMITE** - Gray green; very slight weathering; hard; crystalline; with pressure solution features.		451.7 / 94.6	18											
		94.6 ft to 96.0 ft (Run No. 18) **DOLOMITE** - Gray; very slight weathering; sound; hard; with thin shale partings throughout.		450.3 / 96.0												
		Coring Terminated at 96.0 Feet														
100																
105																
110																
115																
120																
125																

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.
DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

SME_ROCK GLO NEW.GPJ GLDR_LDN.GDT 11/16/11 DATA INPUT:

Louisville Tunnel Project
Louisville, Jefferson County, Kentucky

Project No. 1831-10-5629
Sheet 1 of 3

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 1

11/16/2011

Photographer: N. Peterson

Location / Orientation	Boring B-89, Box 1 of 6, 12.3 ft to 28.0 ft
Remarks	Louisville Limestone

Photo 2

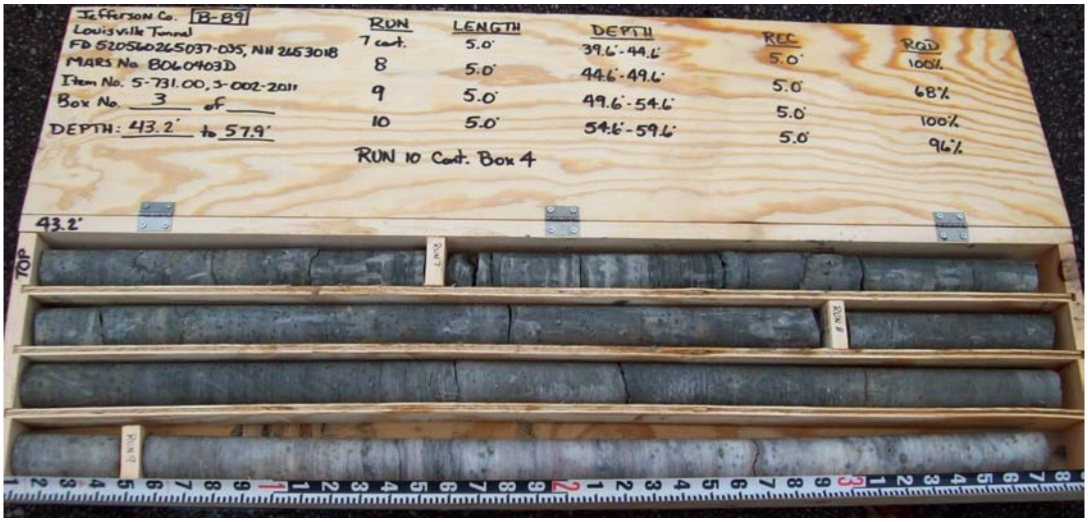
11/16/2011

Photographer: N. Peterson

Location / Orientation	Boring B-89, Box 2 of 6, 28.0 ft to 43.2 ft
Remarks	Louisville Limestone to a depth of 41.9 feet. Waldron Shale encountered at 41.9 feet.

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 3



11/16/2011

Photographer: N. Peterson

Location / Orientation	Boring B-89, Box 3 of 6, 43.2 ft to 57.9 ft
Remarks	Waldron Shale down to 53.4 feet. Laurel Dolomite encountered at 53.4 feet.

Photo 4

11/16/2011

Photographer: N. Peterson

Location / Orientation	Boring B-89, Box 4 of 6, 57.9 ft to 72.7 ft
Remarks	Laurel Dolomite

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 5

11/16/2011

Photographer: N. Peterson

Location / Orientation	Boring B-89, Box 5 of 6, 72.7 ft to 87.3 ft
Remarks	Laurel Dolomite

Photo 6

11/16/2011

Photographer: N. Peterson

Location / Orientation	Boring B-89, Box 6 of 6, 87.3 ft to 96.0 ft
Remarks	Laurel Dolomite down to 91.6 ft. Shale at 91.6 ft to 93.9 ft. From 93.9 ft to 96.0 ft Laurel Dolomite.

RECORD OF DRILLHOLE: B-90

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

DRILLING DATE: 11/15/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ

NORTHING:304038.92
EASTING:1245989.66
INCLINATION: -90°
AZIMUTH: ---

SHEET 1 OF 1
DATUM: NAVD 88

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

DRILLING RECORD: 11/15/2011 3.25 HSA; NQ Core

DESCRIPTION	ELEV. / DISTANCE (ft)	RUN No.	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION
GROUND SURFACE			
Rootmat and topsoil (4 inches)	0.3		
CLAY (CH) - Brown; moist; firm; RESIDUUM	524.5 / 1.5		
Auger refusal encountered at 1.5 feet. Begin NQ core at 1.5 feet.			
1.5 ft to 4.1 ft (Run No. 1) LIMESTONE - Gray; slightly weathered; clay seam at 2.2' to 2.5'. Limestone is hard; crystalline; with stylolites and fossils.	521.9 / 4.1	1	Clay seam
4.1 ft to 9.1 ft (Run No. 2) LIMESTONE - Gray; moderately weathered to slightly weathered with clay filled joint at 4.7' to 4.8'; iron stained joints with solutional weathering at 5.0', 5.6', 5.8', and 6.1'; clay filled joint at 8.1'; limestone is hard, fossiliferous, crystalline.	516.9 / 9.1	2	J, CL; J, Fe; J, Fe; J, Fe; J, Fe; J, CL
9.1 ft to 14.1 ft (Run No. 3) LIMESTONE - Gray; moderately weathered with iron stained, clay filled joints with solutional weathering at 9.9' to 10.3', 11.0', and 11.5'; limestone is hard, crystalline with fossils and stylolites. From 11.5' to 14.1' limestone is hard, sound, crystalline with fossils and stylolites.	511.9 / 14.1	3	J, CL; J, CL; J, CL; J, CL
14.1 ft to 19.1 ft (Run No. 4) LIMESTONE - Gray; slightly weathered with fractures occuring along thin gray green shale partings at 15.5', 15.8', 16.3', 16.6', 16.9', 17.4' with clay, and 17.5' with discoloration. Limestone at breaks is moderately hard with surrounding limestone being hard, crystalline.	506.9 / 19.1	4	FR, R; FR, R; FR, R; FR, R; FR, R; FR, R, CL; FR, R, Fe
19.1 ft to 23.8 ft (Run No. 5) LIMESTONE - Brownish gray; moderately weathered with vertical fracture at 19.1' to 21.2' with iron staining. Limestone is hard, crystalline. From 21.2' to 23.8' limestone is gray, hard, crystalline, with joint at 23.3' with clay.	502.2 / 23.8	5	J, CL
23.8 ft to 24.1 ft (Run No. 5) SHALE - Dark gray; slightly weathered; moderately hard; fine grained.	24.1		
24.1 ft to 24.4 ft (Run No. 6) SHALE - Gray; very slight weathering; sound; moderately hard; calcareous.	24.4		
24.4 ft to 26.2 ft (Run No. 6) LIMESTONE - Gray; very slight weathering; hard; sound; fossiliferous; with pyrite.	499.8 / 26.2	6	
26.2 ft to 29.1 ft (Run No. 6) SHALE - Gray; slightly weathered; moderately fractured with fractures occuring along bedding planes with clay at fractures at 26.3', 26.8', 27.1', 27.5', 28.3', and 28.5'; moderately hard; fine grained.	496.9 / 29.1		FR, R; FR, R; FR, R; FR, R; FR, R; FR, R
Coring Terminated at 29.1 Feet			

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.
DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 1

11/30/2011

Photographer: N. Peterson

Location / Orientation	Boring B-90, Box 1 of 2, 1.5 ft to 17.0 ft
Remarks	Louisville Limestone

Photo 2

11/30/2011

Photographer: N. Peterson

Location / Orientation	Boring B-90, Box 2 of 2, 17.0 ft to 29.1 ft
Remarks	Louisville Limestone to a depth of 26.2 ft. Waldron Shale encountered at 26.2 ft. Coring terminated at 29.1 ft.

RECORD OF DRILLHOLE: B-91

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

DRILLING DATE: 10/30/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ

NORTHING:304195.44
EASTING:1245712.74
INCLINATION: -90°
AZIMUTH: ---

DATUM: NAVD 88

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

DEPTH (ft)	DRILLING RECORD	DESCRIPTION	ELEV. / DISTANCE (ft)	RUN No.	ELEVATION	DISCONTINUITY TYPE AND SURFACE DESCRIPTION
0	10/30/2011	GROUND SURFACE				
		Rootmat and topsoil (3 inches)	0.3			
		CLAY (CL) - Light brown; stiff to very stiff; slightly moist; silty; with black oxide staining; RESIDUUM	528.5 / 8.0		535, 530	
	3.25 HSA	**CLAY (CL)** - Reddish brown; very stiff; moist; with black oxide staining; RESIDUUM	518.5 / 18.0		525, 520	
	11/1/2011	Weathered Limestone	18.4			
		Auger refusal encountered at 18.4 feet. Begin NQ core at 18.4 feet.				
	NQ Core	**18.4 ft to 20.0 ft (Run No. 1)** **LIMESTONE** - Gray; very slight weathering; sound; hard; crystalline.	516.5 / 20.0	1		
20		**20.0 ft to 25.0 ft (Run No. 2)** **LIMESTONE** - Gray; slightly weathered; very close joint spacing with joints at 20.6', 20.8', and 21.9'. Limestone is hard, crystalline with stylolites throughout.	511.5 / 25.0	2	515	J, R; J, R; J, R
25		**25.0 ft to 30.0 ft (Run No. 3)** **LIMESTONE** - Gray; slightly weathered; very close joint spacing with joints containing clay at 25.3' and 26.4'; all other breaks mechanical; hard; crystalline.	506.5 / 30.0	3	510	J, CL; J, CL
30		**30.0 ft to 35.0 ft (Run No. 4)** **LIMESTONE** - Same as previous run; clay filled joints at 30.2' to 30.4'; joints at 30.9', 33.4', 34.2', and 34.6'.		4	505	J, CL; J, R

--- CONTINUED NEXT PAGE ---

DISTANCE SCALE 1 inch to 4 feet
DRILLING CONTRACTOR:S&ME, Inc.
DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

DRILLING DATE: 10/30/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ

NORTHING: 304195.44
EASTING: 1245712.74
INCLINATION: -90°
AZIMUTH: ---

DATUM: NAVD 88

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

--- CONTINUED FROM PREVIOUS PAGE ---

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	ELEV. / DISTANCE (ft)	RUN No.	ELEVATION	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION
	NQ Core	**30.0 ft to 35.0 ft (Run No. 4)** **LIMESTONE** - Same as previous run; clay filled joints at 30.2' to 30.4'; joints at 30.9', 33.4', 34.2', and 34.6'.	501.5 / 35.0	4	505	J, R; J, R; J, R
35	NQ Core	**35.0 ft to 37.7 ft (Run No. 5)** **LIMESTONE** - Gray; very slight weathering; very close joint spacing with joint at 35.9'; hard; crystalline; interbedded shale at 36.8' to 37.2'.	498.8 / 37.7	5	500	J, R
	11/2/2011	**37.7 ft to 40.0 ft (Run No 5) SHALE** - Gray; very slight weathering with very close joint spacing; moderately hard; fine grained; trace fossils at contact with limestone.	496.5 / 40.0	5		
40		**40.0 ft to 45.0 ft (Run No. 6) SHALE** - Gray; slightly weathered; very close joint spacing at 40.0' to 42.2' with clay at joints; spacing increases with depth; moderately hard; fine grained.	491.5 / 45.0	6	495	J, CL
45		**45.0 ft to 49.3 ft (Run No. 7) SHALE** - Gray; very slight weathering; one joint at 48.5' all other breaks mechanical; moderately hard; fine grained down to 49.3'.	487.2 / 49.3	7	490	J, R
		49.3 ft to 50.0 ft (Run No. 7) DOLOMITE - Gray; very slight weathering; sound; hard; crystalline; fossiliferous.	486.5 / 50.0	7		
50	NQ Core	**50.0 ft to 55.0 ft (Run No. 8) DOLOMITE** - Gray; very slight weathering; slightly fractured with fractures at 51.6' and 53.1' occuring along stylolites; hard; crystalline.	481.5 / 55.0	8	485	F, R; F, R
55		**55.0 ft to 60.0 ft (Run No. 9) DOLOMITE** - Same as previous run; fracture along stylolite at 59.7' and clay seam at 60.0'.	476.5 / 60.0	9	480	F, R Clay seam
60		**60.0 ft to 65.0 ft (Run No. 10) DOLOMITE** - Same as previous run; all breaks mechanical.		10	475	

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RECORD OF DRILLHOLE: B-91

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

DRILLING DATE: 10/30/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ

NORTHING:304195.44
EASTING:1245712.74
INCLINATION: -90°
AZIMUTH: ---

DATUM: NAVD 88

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	ELEV. / DISTANCE (ft)	RUN No.	ELEVATION	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION
		--- CONTINUED FROM PREVIOUS PAGE ---				
	NQ Core	**60.0 ft to 65.0 ft (Run No. 10)** **DOLOMITE** - Same as previous run; all breaks mechanical.	471.5 / 65.0	10		J, R
65		**65.0 ft to 70.0 ft (Run No. 11)** **DOLOMITE** - Gray to light brownish gray; slightly weathered with pitting; one joint at 64.3'; hard; crystalline.	466.5 / 70.0	11	470	
70		**70.0 ft to 75.0 ft (Run No. 12)** **DOLOMITE** - Same as previous run down to 71.9' then is gray; very slightly weathered; sound; hard; crystalline.	461.5 / 75.0	12	465	
75		**75.0 ft to 80.0 ft (Run No. 13)** **DOLOMITE** - Gray; very slightly weathered; sound; hard; crystalline; with stylolites throughout.	456.5 / 80.0	13	460	
80		**80.0 ft to 85.0 ft (Run No. 14)** **DOLOMITE** - Same as previous run; all breaks mechanical.	451.5 / 85.0	14	455	
85		**85.0 ft to 88.8 ft (Run No. 15)** **DOLOMITE** - Same as previous run down to 86.4'. From 86.4' to 88.8' dolomite with thin shale partings; trace fossils; crystalline; hard; sound.	447.7 / 88.8	15	450	
		88.8 ft to 90.0 ft (Run No. 15) SHALE - Gray; very slight weathering; sound; moderately hard; fine grained.	446.5 / 90.0			
90		**90.0 ft to 91.5 ft (Run No. 16) SHALE** - Gray; very slight weathering; sound; moderately hard; fine grained down to 91.1'.	445.4 / 91.1	16	445	
		91.1 ft to 91.5 ft (Run No. 17) **DOLOMITE** - Gray; very slight weathering; sound; hard; crystalline.	91.5			
		Coring Terminated at 91.5 Feet				

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.
DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 1

11/2/2011

Photographer: N. Peterson

Location / Orientation	Boring B-91, Box 1 of 5, 18.4 ft to 33.7 ft
Remarks	Louisville Limestone

Photo 2

11/2/2011

Photographer: N. Peterson

Location / Orientation	Boring B-91, Box 2 of 5, 33.7 ft to 48.7 ft
Remarks	Louisville Limestone to a depth of 37.7 feet. Waldron Shale encountered at 37.7 feet.

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 3

11/2/2011

Photographer: N. Peterson

Location / Orientation	Boring B-91, Box 3 of 5, 48.7 ft to 63.6 ft
Remarks	Waldron Shale to a depth of 49.3 feet. Encountered Laurel Dolomite at 49.3 feet.

Photo 4

11/2/2011

Photographer: N. Peterson

Location / Orientation	Boring B-91, Box 4 of 5, 63.6 ft to 78.7 ft
Remarks	Laurel Dolomite

422 Codell Drive
Lexington, KY 40509

Photo 5

11/2/2011

Photographer: N. Peterson

Location / Orientation	Boring B-91, Box 5 of 5, 78.7 ft to 91.5 ft
Remarks	Laurel Dolomite

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: B-92

DATUM: NAVD 88

DRILLING DATE: 10/30/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ

NORTHING:304261.99
EASTING:1245787.34
INCLINATION: -90°
AZIMUTH: ---

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

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DISTANCE (ft)	RUN No.	ELEVATION	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION
0	10/30/2011	GROUND SURFACE					
		Rootmat and topsoil (3 inches)		0.3			
5	3.25 HSA; 11/1/2011	**CLAY (CL)** - Light brown; very stiff; slightly moist; silty; with black oxide staining; RESIDUUM		509.5		515, 510	
	NQ Core	**8.1 ft to 9.3 ft (Run No. 1) LIMESTONE** - Gray with light brown weathered section 8.1' to 8.6' with remaining rock being slightly weathered; sound; hard; crystalline.		8.1 / 508.3	1		
10		**9.3 ft to 14.3 ft (Run No. 2) LIMESTONE** - Gray; slightly weathered with discolored seam at 10.0' to 10.5' along high angle fracture occuring at 75 degrees. Light brown discolored rock at 11.1' to 11.7'; clay seam at 11.7' to 12.0' and discolored rock 12.0' to 12.4'; limestone is hard; crystalline with pressure solution features throughout.		9.3 / 503.3	2	505	Clay seam
15		**14.3 ft to 19.3 ft (Run No. 3) LIMESTONE** - Gray; very slight weathering; slightly fractured; clay seam at 17.6' to 17.7'; crystalline; hard.		14.3 / 498.3	3	500	Clay seam
20		**19.3 ft to 20.0 ft (Run No. 4) LIMESTONE** - Gray; slightly weathered; sound; hard; crystalline with clay seam at 20.0'.		19.3 / 497.6			Clay seam
		20.0 ft to 24.3 ft (Run No. 4) SHALE - Dark gray; slightly weathered with thin clay seams occuring along bedding planes; slightly fractured; thinly bedded with apparent dip of 0 to 3 degrees; moderately hard.		20.0 / 493.3	4	495	
25		**24.3 ft to 29.3 ft (Run No. 5) SHALE** - Dark gray; slightly weathered with clay seam at 28.3' to 28.6'; slightly fractured with fractures occuring along bedding at 0 degrees; fine grained; moderately hard.		24.3 / 488.3	5	490	Clay seam
30		**29.3 ft to 31.5 ft (Run No. 6) SHALE** - Same as previous run with clay seam at 30.7'.		29.3 / 486.1	6		Clay seam

--- CONTINUED NEXT PAGE ---

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.
DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

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

RECORD OF DRILLHOLE: B-92

DRILLING DATE: 10/30/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ
NORTHING:304261.99
EASTING:1245787.34
INCLINATION: -90°
AZIMUTH: ---
DATUM: NAVD 88

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

--- CONTINUED FROM PREVIOUS PAGE ---

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	ELEV. / DISTANCE (ft)	RUN No.	ELEVATION	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION
	NQ Core	**31.5 ft to 34.3 ft (Run No. 6) DOLOMITE** - Gray and brownish gray; very slight weathering; slightly fractured with high angle fracture at 32.9' to 33.0' (70 degrees); crystalline; hard; with pressure solution features.	31.5 / 483.3	6	485	FR, R
35	NQ Core	**34.3 ft to 38.7 ft (Run No. 7) DOLOMITE** - Light gray and brown; slightly weathered; sound; crystalline; hard.	34.3 / 478.9	7	480	
40	NQ Core	**38.7 ft to 43.7 ft (Run No. 8) DOLOMITE** - Gray; very slight weathering; sound; hard; crystalline.	38.7 / 473.9	8	475	
45	NQ Core	**43.7 ft to 48.8 ft (Run No. 9) DOLOMITE** - Same as previous run; all breaks mechanical.	43.7 / 468.8	9	470	
50	NQ Core	**48.8 ft to 53.9 ft (Run No. 10) DOLOMITE** - Light brown; slightly weathered with pitting from 48.8' to 53.2' then becomes gray; very slightly weathered; sound; hard; crystalline.	48.8 / 463.7	10	465	
55	NQ Core	**53.9 ft to 59.1 ft (Run No. 11) DOLOMITE** - Gray; very slight weathering; sound; hard; crystalline; with stylolites.	53.9 / 458.5	11	460	
60	NQ Core	**59.1 ft to 64.1 ft (Run No. 12) DOLOMITE** - Gray; very slight weathering; sound; hard; crystalline; with calcite vugs; stylolites throughout.	59.1	12	455	

--- CONTINUED NEXT PAGE ---

DISTANCE SCALE
1 inch to 4 feet
DRILLING CONTRACTOR:S&ME, Inc.
DRILLER:L. Morrison
S&ME ENGINEERING INTEGRITY
LOGGED: NJP
CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: B-92

DATUM: NAVD 88

DRILLING DATE: 10/30/2011

DRILL RIG: D-50 Track

DRILLING METHOD: NQ

NORTHING:304261.99

EASTING:1245787.34

INCLINATION: -90°

AZIMUTH: ---

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

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	ELEV. / DISTANCE (ft)	RUN No.	ELEVATION	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION
		--- CONTINUED FROM PREVIOUS PAGE ---				
	NQ Core		453.5 / 64.1	12		
65	NQ Core	**64.1 ft to 69.1 ft (Run No. 13) DOLOMITE** - Gray; very slight weathering; sound; hard; crystalline; pyritic; pressure solution features throughout.	448.5 / 69.1	13	450	
70	NQ Core	**69.1 ft to 70.9 ft (Run No. 14) DOLOMITE** - Same as previous run down to 70.9'	446.7 / 70.9	14		
	NQ Core	**70.9 ft to 72.5 ft (Run No. 14) SHALE** - Gray; slightly weathered; very close joint spacing with joints containing clay at 72.0' and 72.1'; moderately hard; fine grained.	445.1 / 72.5			J, w/clay
		Coring Terminated at 72.5 Feet				
75						
80						
85						
90						

DISTANCE SCALE

1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.

DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP

CHECKED: CSL

SME_ROCK GLO NEW.GPJ GLDR_LDN.GDT 11/2/11 DATA INPUT:

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 1	
	11/1/2011 Photographer: N. Peterson
Location / Orientation	Boring B-92, Box 1 of 5, 8.1 ft to 22.8 ft
Remarks	Louisville Limestone to a depth of 20.0 feet. Waldron Shale encountered at 20.0 feet.

Photo 2	
	11/1/2011 Photographer: N. Peterson
Location / Orientation	Boring B-92, Box 2 of 5, 22.8 ft to 38.1 ft
Remarks	Waldron Shale to a depth of 31.5 feet. Laurel Dolomite encountered at 31.5 feet.

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 3

11/1/2011

Photographer: N. Peterson

Location / Orientation	Boring B-92, Box 3 of 5, 38.1 ft to 48.8 ft
Remarks	Laurel Dolomite

Photo 4

11/1/2011

Photographer: N. Peterson

Location / Orientation	Boring B-92, Box 4 of 5, 48.8 ft to 63.5 ft
Remarks	Laurel Dolomite

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 5

11/1/2011

Photographer: N. Peterson

Location / Orientation	Boring B-92, Box 5 of 5, 63.5 ft to 72.5 ft
Remarks	Laurel Dolomite

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

RECORD OF DRILLHOLE: B-93

DRILLING DATE: 10/31/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ

NORTHING:304328.54
EASTING:1245862.02
INCLINATION: -90°
AZIMUTH: ---

DATUM: NAVD 88

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

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	ELEV. / DISTANCE (ft)	RUN No.	ELEVATION	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION
0	10/31/2011	GROUND SURFACE				
		Rootmat and topsoil (3 inches)	0.3			
5	3.25 HSA	**CLAY (CL)** - Brown and gray to tan; stiff to very hard; slightly moist; silty; RESIDUUM Auger refusal encountered at 8.3 feet. Begin NQ core at 8.3 feet.	513.1 / 8.3		520, 515	
	11/2/2011	**8.3 ft to 9.3 ft (Run No. 1) LIMESTONE** - Gray with light brown weathering at joints (8.7' and 8.9'); hard; crystalline.	512.1 / 9.3	1		J, R
10		**9.3 ft to 14.3 ft (Run No. 2) LIMESTONE** - Brownish gray and gray; moderately weathered with solutional weathering at 9.5', clay filled void at 10.0' to 10.4'; clay filled joints at 10.6' and 11.4'. From 11.4' to 14.3' rock is slightly weathered; hard; crystalline with joints at 12.3', 13.3', and 13.7'.	507.1 / 14.3	2	510	Solution weathering Clay filled void J, CL J, CL J, R J, R J, R
15		**14.3 ft to 19.3 ft (Run No. 3) LIMESTONE** - Gray; moderately weathered with clay filled void at 14.9' to 16.9'. Clay is reddish brown fat clay with manganese nodules. From 16.9' to 19.3' limestone is gray; slightly weathered; hard; crystalline; with stylolites throughout.	502.1 / 19.3	3	505	Clay filled void (2 feet) 100% Water Loss
20	NQ Core	**19.3 ft to 23.6 ft (Run No. 4) LIMESTONE** - Gray; very slight weathering; close to very close joint spacing with joints at 22.7' and 23.6'. Thin shale partings present 22.7' to 23.6'; hard; crystalline.	497.8 / 23.6	4	500	J, R J, R
		23.6 ft to 24.3 ft (Run No. 4) SHALE - Gray; very slight weathering; moderately hard; fine grained.	497.1 / 24.3			J, CL
25		**24.3 ft to 29.3 ft (Run No. 5) SHALE** - Gray; slightly weathered; very close joint spacing with joints at 24.3' to 26.9' some containing clay; shale is moderately hard; fine grained; friable at some joints.	492.1 / 29.3	5	495	J, R
30				6	490	

--- CONTINUED NEXT PAGE ---

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.
DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: B-93

DATUM: NAVD 88

DRILLING DATE: 10/31/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ

NORTHING:304328.54
EASTING:1245862.02
INCLINATION: -90°
AZIMUTH: ---

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

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	ELEV. / DISTANCE (ft)	RUN No.	ELEVATION
		--- CONTINUED FROM PREVIOUS PAGE ---			
	NQ Core	**29.3 ft to 34.3 ft (Run No. 6) SHALE** - Gray; slightly weathered with close joint spacing 29.3' to 30.3' then rock becomes sound to 33.8'. From 33.8' to 34.3' moderately weathered; very close joint spacing with clay at joints. Moderately hard, fine grained throughout.	487.1 / 34.3	6	
35		**34.3 ft to 35.1 ft (Run No. 7) SHALE** - Gray; very slight weathering; sound; moderately hard; fine grained down to 35.1'.	486.3 / 35.1		
		35.1 ft to 39.3 ft (Run No. 7) DOLOMITE - Gray; very slight weathering; sound; hard; crystalline with stylolites.	482.1 / 39.3	7	485
40		**39.3 ft to 44.3 ft (Run No. 8) DOLOMITE** - Same as previous run; all breaks mechanical.	477.1 / 44.3	8	480
45	11/3/2011	**44.3 ft to 49.3 ft (Run No. 9) DOLOMITE** - Same as previous run; all breaks mechanical.	472.1 / 49.3	9	475
50		**49.3 ft to 54.3 ft (Run No. 10) DOLOMITE** - Same as previous run down to 51.9' then dolomite is light brown and gray; slightly pitted; hard; crystalline.	467.1 / 54.3	10	470
55	NQ Core	**54.3 ft to 59.3 ft (Run No. 11) DOLOMITE** - Light brown; moderately weathered with pitting; hard; crystalline; sound down to 57.1'. From 57.1' to 59.3' dolomite is gray; very slight weathering; hard; sound; crystalline.	462.1 / 59.3	11	465
60		**59.3 ft to 64.3 ft (Run No. 12) DOLOMITE** - Gray; very slight weathering; sound; hard; crystalline; stylolites throughout with one stylolite weathered to gray green at 60.1'.		12	460
		--- CONTINUED NEXT PAGE ---			

Other columns: SYMBOLIC LOG; PENETRATION RATE (ft/min); COLOR % RETURN; FLUSH; RECOVERY (TOTAL CORE %, SOLID CORE %); R.Q.D. %; FRACT. INDEX PER FT; DISCONTINUITY DATA (DIP w.r.t. CORE AXIS; TYPE AND SURFACE DESCRIPTION); HYDRAULIC CONDUCTIVITY k, cm/sec; DIAMETRAL POINT LOAD INDEX (psi)

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.
DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel	RECORD OF DRILLHOLE: B-93		SHEET 3 OF 3
LOCATION: Louisville, Kentucky	DRILLING DATE: 10/31/2011	NORTHING:304328.54	DATUM: NAVD 88
PROJECT NUMBER: 1831-10-5629	DRILL RIG: D-50 Track	EASTING:1245862.02	
	DRILLING METHOD: NQ	INCLINATION: -90° AZIMUTH: ---	

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

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	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	HYDRAULIC CONDUCTIVITY k, cm/sec	DIAMETRAL POINT LOAD INDEX (psi)
		--- CONTINUED FROM PREVIOUS PAGE ---														
	NQ Core			457.1 / 64.3	12											
65		**64.3 ft to 69.3 ft (Run No. 13)** **DOLOMITE** - Same as previous run; all breaks mechanical.		452.1 / 69.3	13			455								
70		**69.3 ft to 74.3 ft (Run No. 14)** **DOLOMITE** - Same as previous run; all breaks mechanical.		447.1 / 74.3	14			450								
75		**74.3 ft to 76.5 ft (Run No. 15) SHALE** - Gray; very slight weathering; joints at 75.2' and 76.2'; moderately hard; fine grained; calcareous.		444.9 / 76.5	15			445						J, R J, R		
80		Coring Terminated at 76.5 Feet.														
85																
90																

DISTANCE SCALE	DRILLING CONTRACTOR:S&ME, Inc.	LOGGED: NJP
1 inch to 4 feet	DRILLER:L. Morrison	CHECKED: CSL

S&ME ENGINEERING INTEGRITY

Louisville Tunnel Project
Louisville, Jefferson County, Kentucky
Project No. 1831-10-5629
Sheet 1 of 3

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 1

11/3/2011

Photographer: N. Peterson

Location / Orientation	Boring B-93, Box 1 of 5, 8.3 ft to 25.5 ft
Remarks	Louisville Limestone to a depth of 23.6 feet. Waldron Shale encountered at 23.6 feet.

Photo 2

11/3/2011

Photographer: N. Peterson

Location / Orientation	Boring B-93, Box 2 of 5, 25.5 ft to 40.8 ft
Remarks	Waldron Shale to a depth of 35.1 feet. Laurel Dolomite encountered at 35.1 feet.

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 3

11/3/2011

Photographer: N. Peterson

Location / Orientation	Boring B-93, Box 3 of 5, 40.8 ft to 55.5 ft
Remarks	Laurel Dolomite

Photo 4

11/3/2011

Photographer: N. Peterson

Location / Orientation	Boring B-93, Box 4 of 5, 55.5 ft to 70.4 ft
Remarks	Laurel Dolomite

Louisville Tunnel Project
Louisville, Jefferson County, Kentucky
Project No. 1831-10-5629
Sheet 3 of 3

422 Codell Drive
Lexington, KY 40509

Photo 5

11/3/2011

Photographer: N. Peterson

Location / Orientation	Boring B-93, Box 5 of 5, 70.4 ft to 76.5 ft
Remarks	Laurel Dolomite down to 74.3 feet. Shale encountered at 74.3 feet to 76.5 feet.

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

RECORD OF DRILLHOLE: B-94

DRILLING DATE: 10/31/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ

NORTHING:304395.09
EASTING:1245936.65
INCLINATION: -90°
AZIMUTH: ---

DATUM: NAVD 88

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

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	ELEV. / DISTANCE (ft)	RUN No.	ELEVATION	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION
0	10/31/2011	GROUND SURFACE				
		Rootmat and topsoil (3 inches)	0.3			
5	3.25 HSA	**CLAY (CH)** - Reddish brown; stiff to hard; slightly moist; RESIDUUM Auger refusal encountered at 13.0 feet. Begin NQ core at 13.0 feet.			530, 525	
10	11/3/2011		519.5		520	
	NQ Core	**13.0 ft to 15.0 ft (Run No. 1)** **LIMESTONE** - Light gray; moderately weathered with solution channel at 14.3' to 14.5' with clay (100% water loss at 14.3'); hard; crystalline.	13.0 517.5	1		Solutional weathering with clay filled voids
15		**15.0 ft to 20.0 ft (Run No. 2)** **LIMESTONE** - Gray; moderately weathered with staining at joints; very close joint spacing; joints at 16.1' and 18.2'; severly discolored; solutional weathering. Limestone is hard; crystalline with thin shale partings at 19.0' to 20.0'.	15.0 512.5	2	515	J, R J, R
20		**20.0 ft to 25.0 ft (Run No. 3)** **LIMESTONE** - Gray; slightly weathered; very close joint spacing with joints at 21.0', 21.4', 22.0' with clay, and 23.1'; limestone is moderately hard with thin shale partings down to 23.2'; becomes fine grained almost oolitic at 23.2' to 25.0'; fossiliferous.	20.0 507.5	3	510	J, R J, R J, CL J, R
25		**25.0 ft to 30.0 ft (Run No. 4)** **LIMESTONE** - Gray; slightly weathered to moderately weathered 26.9' to 27.6'; which has thin shale partings; some weathered to clay. From 27.6' limestone is gray; very slight weathering; sound; hard; fine grained.	25.0 502.5	4	505	
30		**30.0 ft to 35.0 ft (Run No. 5)** **LIMESTONE** - Gray; slightly weathered with weathered and discolored joint at 33.0' to 33.2'; hard; crystalline.	30.0	5		

--- CONTINUED NEXT PAGE ---

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.
DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

PROJECT: Jefferson County, Louisville Tunnel

LOCATION: Louisville, Kentucky

PROJECT NUMBER: 1831-10-5629

RECORD OF DRILLHOLE: B-94

DATUM: NAVD 88

DRILLING DATE: 10/31/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ

NORTHING:304395.09
EASTING:1245936.65
INCLINATION: -90°
AZIMUTH: ---

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

--- CONTINUED FROM PREVIOUS PAGE ---

Depth (ft)	Description	Elev./Distance (ft)	Run No.	Elevation	Discontinuity type and surface description
30.0–35.0	**30.0 ft to 35.0 ft (Run No. 5) LIMESTONE** - Gray; slightly weathered with weathered and discolored joint at 33.0' to 33.2'; hard; crystalline.	497.5 / 35.0	5	500	J, R, stained
35.0–40.0	**35.0 ft to 40.0 ft (Run No. 6) SHALE** - Dark gray; slightly weathered; very close joint spacing with joints at 35.4', 35.6', 36.9', 37.4', 37.9' with clay, 38.5' with clay; 39.2' with clay; moderately hard; fine grained; calcareous.	492.5 / 40.0	6	495	J, R J, R J, R J, R J, CL J, CL J, CL
40.0–43.0	**40.0 ft to 43.0 ft (Run No. 7) SHALE** - Dark gray; slightly weathered; with very close joint spacing 40.0' to 43.0' with clay at joints; moderately hard; fine grained.	489.5 / 43.0	7	490	
43.0–45.0	**43.0 ft to 45.0 ft (Run No. 7) DOLOMITE** - Gray; slightly weathered; very close joint spacing with thin shale partings down to 44.0'; moderately hard; fine grained.	487.5 / 45.0			
45.0–50.0	**45.0 ft to 50.0 ft (Run No. 8) DOLOMITE** - Gray with shale seam and clay filled joints at 45.0' to 46.0'; from 46.0' to 50.0' gray; very slight weathering; sound; hard; crystalline; stylolites throughout.	482.5 / 50.0	8	485	
50.0–55.0	**50.0 ft to 55.0 ft (Run No. 9) DOLOMITE** - Gray; very slight weathering; sound; hard; crystalline with one joint at 54.9'.	477.5 / 55.0	9	480	
55.0–60.0	**55.0 ft to 60.0 ft (Run No. 10) DOLOMITE** - Gray; very slight weathering; hard; one clay filled joint at 56.1' to 56.3'; all other breaks mechanical; crystalline.	472.5 / 60.0	10	475	
60.0–65.0	**60.0 ft to 65.0 ft (Run No. 11) DOLOMITE** - Gray; very slight weathering; sound; hard; crystalline with stylolites down to 62.6'. From 62.6' to 65.0' moderately weathered; brown; pitted; hard; crystalline; with stylolites.		11	470	

Drilling record: NQ Core; 11/4/2011; NQ Core

--- CONTINUED NEXT PAGE ---

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR:S&ME, Inc.
DRILLER:L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

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

RECORD OF DRILLHOLE: B-94

DRILLING DATE: 10/31/2011
DRILL RIG: D-50 Track
DRILLING METHOD: NQ

NORTHING: 304395.09
EASTING: 1245936.65
INCLINATION: -90°
AZIMUTH: ---

DATUM: NAVD 88

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

DISTANCE SCALE FEET	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DISTANCE (ft)	RUN No.	PENETRATION RATE (ft/min)	FLUSH (COLOR / % RETURN)	ELEVATION	RECOVERY (TOTAL CORE % / SOLID CORE %)	R.Q.D. %	FRACT. INDEX PER FT	DIP w.r.t. CORE AXIS	TYPE AND SURFACE DESCRIPTION	HYDRAULIC CONDUCTIVITY k, cm/sec	DIAMETRAL POINT LOAD INDEX (psi)
		--- CONTINUED FROM PREVIOUS PAGE ---													
	NQ Core			467.5 / 65.0	11										
65		**65.0 ft to 70.0 ft (Run No. 12)** **DOLOMITE** - Brownish gray; moderately weathered with pitting; hard; crystalline; down to 67.9'. From 67.9' to 70.0' gray; very slight weathering; sound; hard; with stylolites.		462.5 / 70.0	12			465							
70		**70.0 ft to 75.0 ft (Run No. 13)** **DOLOMITE** - Gray; very slight weathering; sound; hard; crystalline with stylolites.		457.5 / 75.0	13			460							
75		**75.0 ft to 80.0 ft (Run No. 14)** **DOLOMITE** - Same as previous run; all breaks mechanical.		452.5 / 80.0	14			455							
80		**80.0 ft to 85.0 ft (Run No. 15)** **DOLOMITE** - Same as previous run; all breaks mechanical.		447.5 / 85.0	15			450							
85		**85.0 ft to 85.4 ft (Run No. 16)** **DOLOMITE** - Same as previous run down to 85.4'.		85.4	16										
		85.4 ft to 87.5 ft (Run No. 16) SHALE - Dark gray; very slight weathering; sound; moderately hard; fine grained; calcareous.		445.0 / 87.5				445							
		Coring Terminated at 87.5 Feet													
90															

DISTANCE SCALE
1 inch to 4 feet

DRILLING CONTRACTOR: S&ME, Inc.
DRILLER: L. Morrison

S&ME ENGINEERING INTEGRITY

LOGGED: NJP
CHECKED: CSL

Louisville Tunnel Project
Louisville, Jefferson County, Kentucky
Project No. 1831-10-5629
Sheet 1 of 3

422 Codell Drive
Lexington, KY 40509

Photo 1

11/4/2011

Photographer: N. Peterson

Location / Orientation	Boring B-94, Box 1 of 5, 13.0 ft to 28.4 ft
Remarks	Louisville Limestone

Photo 2

11/4/2011

Photographer: N. Peterson

Location / Orientation	Boring B-94, Box 2 of 5, 28.4 ft to 43.3 ft
Remarks	Louisville Limestone to a depth of 35.0 feet. Waldron Shale encountered at 35.0 feet.

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 3

11/4/2011

Photographer: N. Peterson

Location / Orientation	Boring B-94, Box 3 of 5, 43.3 ft to 58.8 ft
Remarks	Waldron Shale down to 43.0 feet. Laurel Dolomite encountered at 43.0 feet.

Photo 4

11/4/2011

Photographer: N. Peterson

Location / Orientation	Boring B-94, Box 4 of 5, 58.8 ft to 72.7 ft
Remarks	Laurel Dolomite

S&ME
422 Codell Drive
Lexington, KY 40509

Photo 5

11/4/2011

Photographer: N. Peterson

Location / Orientation	Boring B-94, Box 5 of 5, 72.7 ft to 87.5 ft
Remarks	Laurel Dolomite down to 85.4 feet. Shale encountered at 85.4 feet to 87.5 feet.

APPENDIX II
ROCK LABORATORY TESTING

UNCONFINED COMPRESSION
(ASTM D7012 Method C)

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

Project #: 1831-10-5629 Sample Date: 11/28/2011 Report Date: 12/7/2011
Project Name: Louisville Tunnel Project

Sample No.	Boring Location	Depth (ft)	Specimen Dimension, in.		Area (in^2)	Bulk Density (lb/ft^3)	Loading Rate (psi/sec)	Max. Load (lb)	Strength (psi)	Moisture (%)
			Length	Diameter						
1	B-85 Run 2 Box 1	9.2	4.26	1.97	3.05	168.1	88	36,250	11,885	0.1
2	B-85 Run 7 Box 3	36.4	4.53	1.97	3.05	163.7	84	23,640	7,751	2.5
5	B-85 Run 12 Box 4	61.2	4.24	1.98	3.08	162.6	84	31,410	10,198	0.2

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

UNCONFINED COMPRESSION
(ASTM D7012 Method C)

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

Project #: 1831-10-5629   Sample Date: 11/30/2011   Report Date: 12/8/2011
Project Name: Louisville Tunnel Project

Sample No.	Boring Location	Depth (ft)	Specimen Dimension, in.		Area (in^2)	Bulk Density (lb/ft^3)	Loading Rate (psi/sec)	Max. Load (lb)	Strength (psi)	Moisture (%)
			Length	Diameter						
1	B-86 Run 2 Box 1	6.4	4.23	1.97	3.05	169.1	86	57,520	18,859	0.1
4	B-86 Run 8 Box 3	37.2	4.21	1.97	3.05	165.7	78	16,160	5,298	2.5
5	B-86 Run 13 Box 5	62.2	4.24	1.98	3.08	157.0	90	27,060	8,786	0.1

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

UNCONFINED COMPRESSION
(ASTM D7012 Method C)

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

Project #: 1831-10-5629 Sample Date: 11/17/2011 Report Date: 12/2/2011
Project Name: Louisville Tunnel Project

Sample No.	Boring Location	Depth (ft)	Specimen Dimension, in. Length	Diameter	Area (in^2)	Bulk Density (lb/ft^3)	Loading Rate (psi/sec)	Max. Load (lb)	Strength (psi)	Moisture (%)
1	B-87 Run 2 Box 1	6.8	4.12	1.96	3.02	168.7	84	42,710	14,142	0.1
3	B-87 Run 4 Box 1	15.1	4.22	1.98	3.08	160.9	87	33,600	10,909	0.3
5	B-87 Run 6 Box 2	27.0	4.50	1.95	2.99	165.6	65	21,230	7,100	2.0

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

UNCONFINED COMPRESSION
(ASTM D7012 Method C)

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

Project #: 1831-10-5629 Sample Date: 11/17/2011 Report Date: 12/3/2011
Project Name: Louisville Tunnel Project

Sample No.	Boring Location	Depth (ft)	Specimen Dimension, in. Length	Specimen Dimension, in. Diameter	Area (in^2)	Bulk Density (lb/ft^3)	Loading Rate (psi/sec)	Max. Load (lb)	Strength (psi)	Moisture (%)
2	B-88 Run 1 Box 1	11.5	4.42	1.97	3.05	167.5	97	40,130	13,157	0.1
3	B-88 Run 2 Box 1	15.7	4.10	1.97	3.05	163.9	93	33,870	11,105	0.4
4	B-88 Run 3 Box 1	22.1	4.33	1.97	3.05	172.1	100	65,050	21,328	0.1
5	B-88 Run 5 Box 2	29.4	4.33	1.97	3.05	163.5	87	29,740	9,751	0.6

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

UNCONFINED COMPRESSION
(ASTM D7012 Method C)

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

Project #: 1831-10-5629 Sample Date: 11/16/2011 Report Date: 12/5/2011
Project Name: Louisville Tunnel Project

Sample No.	Boring Location	Depth (ft)	Specimen Dimension, in. Length	Diameter	Area (in^2)	Bulk Density (lb/ft^3)	Loading Rate (psi/sec)	Max. Load (lb)	Strength (psi)	Moisture (%)
1	B-89 Run 2 Box 1	18.2	4.26	1.97	3.05	169.1	103	61,430	20,141	0.1
2	B-89 Run 8 Box 3	48.4	4.29	1.97	3.05	166.0	83	25,880	8,485	2.0
5	B-89 Run 14 Box 5	75.4	4.27	1.97	3.05	157.7	101	32,430	10,633	0.1

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

UNCONFINED COMPRESSION
(ASTM D7012 Method C)

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

Project #: 1831-10-5629 Sample Date: 11/30/2011 Report Date: 12/9/2011
Project Name: Louisville Tunnel Project

Sample No.	Boring Location	Depth (ft)	Specimen Dimension, in.		Area (in^2)	Bulk Density (lb/ft^3)	Loading Rate (psi/sec)	Max. Load (lb)	Strength (psi)	Moisture (%)
			Length	Diameter						
1	B-90 Run 2 Box 1	7.1	4.32	1.97	3.05	169.4	85	37,140	12,177	0.3
2	B-90 Run 4 Box 1	14.8	4.35	1.97	3.05	169.2	84	54,090	17,734	0.2

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

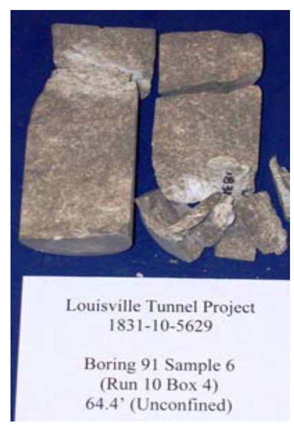
UNCONFINED COMPRESSION
(ASTM D7012 Method C)

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

Project #: 1831-10-5629   Sample Date: 11/2/2011   Report Date: 11/23/2011
Project Name: Louisville Tunnel Project

Sample No.	Boring Location	Depth (ft)	Specimen Dimension, in. Length	Specimen Dimension, in. Diameter	Area (in^2)	Bulk Density (lb/ft^3)	Loading Rate (psi/sec)	Max. Load (lb)	Strength (psi)	Moisture (%)
1	B-91 Run 2 Box 1	21.0	4.37	1.98	3.08	168.7	96	49,280	16,000	0.1
2	B-91 Run 6 Box 2	43.5	4.28	1.97	3.05	163.0	85	28,110	9,216	1.3
6	B-91 Run 10 Box 4	64.4	4.34	1.98	3.08	166.9	103	66,400	21,558	0.1
7	B-91 Run 14 Box 5	82.9	4.38	1.98	3.08	168.5	89	35,080	11,390	0.1

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



UNCONFINED COMPRESSION
(ASTM D7012 Method C)

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

Project #: 1831-10-5629 Sample Date: 11/1/2011 Report Date: 11/18/2011
Project Name: Louisville Tunnel Project

Sample No.	Boring Location	Depth (ft)	Specimen Dimension, in. Length	Diameter	Area (in^2)	Bulk Density (lb/ft^3)	Loading Rate (psi/sec)	Max. Load (lb)	Strength (psi)	Moisture (%)
1	B-92 Run 2 Box 1	13.0	4.24	1.98	3.08	171.6	94	75,590	24,542	0.1
3	B-92 Run 5 Box 2	24.7	4.29	1.97	3.05	163.8	97	26,020	8,531	1.7
5	B-92 Run 7 Box 2	34.5	4.28	1.98	3.08	169.1	96	43,890	14,250	0.1
6	B-92 Run 10 Box 4	51.8	4.19	1.98	3.08	156.1	96	23,150	7,516	0.1
7	B-92 Run 14 Box 5	69.5	4.22	1.98	3.08	168.3	97	34,010	11,042	0.3

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

UNCONFINED COMPRESSION
(ASTM D7012 Method C)

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

Project #: 1831-10-5629   Sample Date: 11/3/2011   Report Date: 11/30/2011
Project Name: Louisville Tunnel Project

Sample No.	Boring Location	Depth (ft)	Specimen Dimension, in.		Area (in^2)	Bulk Density (lb/ft^3)	Loading Rate (psi/sec)	Max. Load (lb)	Strength (psi)	Moisture (%)
			Length	Diameter						
1	B-93 Run 4 Box 1	19.5	4.13	1.98	3.08	168.5	101	50,090	16,263	0.1
4	B-93 Run 6 Box 2	31.3	4.53	1.97	3.05	164.7	83	29,230	9,584	1.9
6	B-93 Run 11 Box 3	54.5	4.24	1.98	3.08	166.1	98	50,160	16,286	0.1
7	B-93 Run 14 Box 5	71.2	4.43	1.98	3.08	171.0	89	60,800	19,740	0.1
8	B-93 Run 15 Box 5	74.9	4.45	1.97	3.05	163.3	88	30,440	9,980	1.2

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

UNCONFINED COMPRESSION
(ASTM D7012 Method C)

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

Project #: 1831-10-5629 Sample Date: 11/4/2011 Report Date: 12/1/2011
Project Name: Louisville Tunnel Project

Sample No.	Boring Location	Depth (ft)	Specimen Dimension, in.		Area (in^2)	Bulk Density (lb/ft^3)	Loading Rate (psi/sec)	Max. Load (lb)	Strength (psi)	Moisture (%)
			Length	Diameter						
2	B-94 Run 2 Box 1	17.6	4.19	1.97	3.05	168.9	84	43,990	14,423	0.1
5	B-94 Run 7 Box 2	40.8	4.09	1.96	3.02	164.7	82	28,150	9,321	1.5
6	B-94 Run 11 Box 4	64.0	4.21	1.97	3.05	161.8	89	34,360	11,266	0.1
7	B-94 Run 15 Box 5	81.6	4.25	1.97	3.05	170.7	83	42,400	13,902	0.2
8	B-94 Run 16 Box 5	85.9	4.26	1.98	3.08	164.0	84	31,810	10,328	1.1

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

CERCHAR Abrasiveness test Test procedure: ASTM D7625	Tonon USA Engineering, Measurements, and Testing, LLC

Project Name	Louisville Tunnel
Client Project No.	1831-10-5629
Tonon USA Reference	2011_ SME_001_02
Test Date	10/28/11
Test Performer	Fulvio Tonon
Checked by	Gloria Tonon-Kozma
Location	Louisville, Kentucky
Boring	B-82 Sample 1
Depth	83.2-84.3 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)
	0.054	0.031
	0.025	0.018
	0.05	0.03
	0.03	0.02
	0.032	0.025
Average (mm)	0.0315	
CAI	0.315	
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

2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

CERCHAR Abrasiveness test	Tonon USA
Test procedure: ASTM D7625	Engineering, Measurements, and Testing, LLC

Project Name	Louisville Tunnel
Client Project No.	1831-10-5629
Tonon USA Reference	2011_ SME_001_03
Test Date	12/6/11
Test Performer	Fulvio Tonon
Checked by	Gloria Tonon-Kozma
Location	Louisville, Kentucky
Boring	B-85 Sample 1
Depth	39.0-39.8 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)
	0.047	0.036
	0.058	0.048
	0.052	0.044
	0.036	0.018
	0.045	0.034
Average (mm)	0.045	
CAI	0.45	
Equipment	Ergo Tech CERCHAR Test Apparatus No.100225	

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.

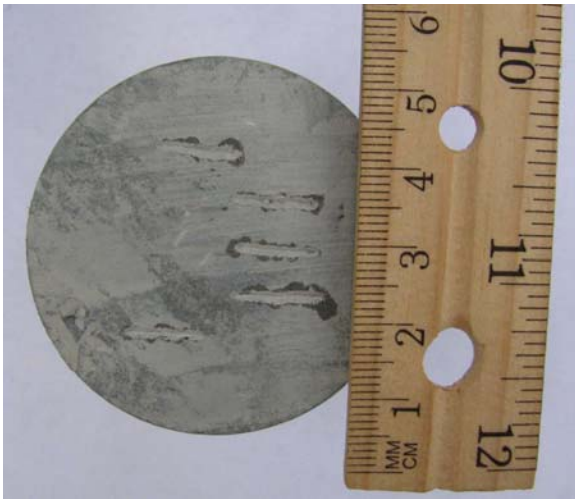


Photo after test

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Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

CERCHAR Abrasiveness test Test procedure: ASTM D7625	Tonon USA Engineering, Measurements, and Testing, LLC

Project Name	Louisville Tunnel
Client Project No.	1831-10-5629
Tonon USA Reference	2011_ SME_001_03
Test Date	12/6/11
Test Performer	Fulvio Tonon
Checked by	Gloria Tonon-Kozma
Location	Louisville, Kentucky
Boring	B-86 Sample 1
Depth	32.9-34.1 ft
Rock Type	Shale
Formation	Waldron Shale
Pin Rockwell Hardness	55/56

Surface condition	Cut by slab saw	
Direction of scratch	Perpendicular to core axis	
Pin Wear	Max width (mm)	Min width (mm)
	0.036	0.029
	0.031	0.030
	0.050	0.044
	0.035	0.029
	0.039	0.037
Average (mm)	0.036	
CAI	0.36	
Equipment	Ergo Tech CERCHAR Test Apparatus No.100225	

Note: Sample chipped along bedding plane while taking scratch 1. Scratch 1 was disregarded.

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.

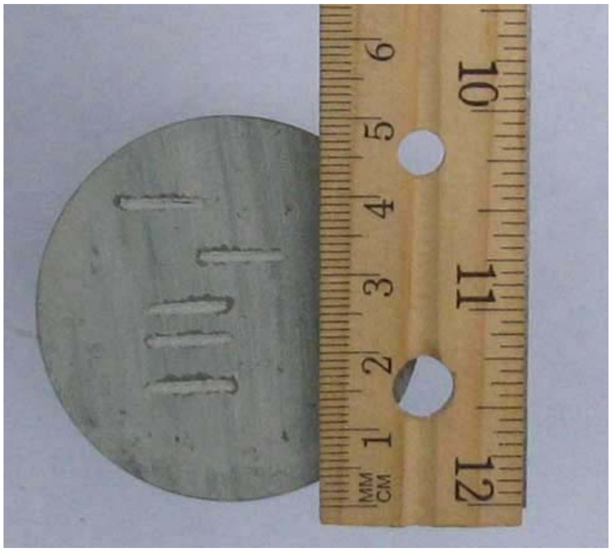

Photo after test

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Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

CERCHAR Abrasiveness test Test procedure: ASTM D7625	Tonon USA Engineering, Measurements, and Testing, LLC

Project Name	Louisville Tunnel
Client Project No.	1831-10-5629
Tonon USA Reference	2011_ SME_001_03
Test Date	12/6/11
Test Performer	Fulvio Tonon
Checked by	Gloria Tonon-Kozma
Location	Louisville, Kentucky
Boring	B-89 Sample 3
Depth	46.1-46.5 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)
	0.040	0.033
	0.038	0.032
	0.049	0.047
	0.042	0.039
	0.049	0.037
Average (mm)	0.041	
CAI	0.41	
Equipment	Ergo Tech CERCHAR Test Apparatus No.100225	

Note: Sample chipped along bedding plane while taking scratch 1. Scratch 1 was disregarded.

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.

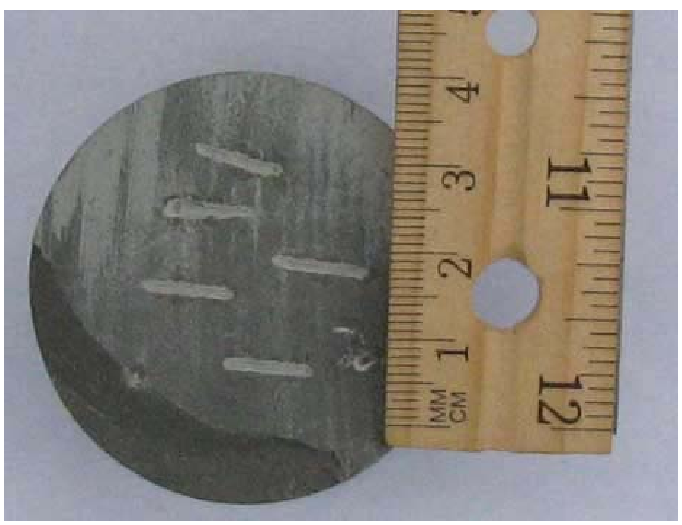


Photo after test

2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

CERCHAR Abrasiveness test

Test procedure: ASTM D7625

Tonon USA

Engineering, Measurements, and Testing, LLC

Project Name	Louisville Tunnel
Client Project No.	1831-10-5629
Tonon USA Reference	2011_ SME_001_02
Test Date	11/15/11
Test Performer	Fulvio Tonon
Checked by	Gloria Tonon-Kozma
Location	Louisville, Kentucky
Boring	B-91 Sample 3
Depth	44.5-45.0 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)
	0.053	0.049
	0.037	0.03
	0.04	0.033
	0.049	0.045
	0.051	0.042
Average (mm)	0.046	
CAI	0.46	
Equipment	Ergo Tech CERCHAR Test Apparatus No.100225	

Note: Sample chipped along bedding plane while taking scratch 1. Scratch 1 was disregarded.

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.

Scratch 1

Photo after test

2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

CERCHAR Abrasiveness test	**Tonon USA**
Test procedure: ASTM D7625	**Engineering, Measurements, and Testing, LLC**

Project Name	Louisville Tunnel
Client Project No.	1831-10-5629
Tonon USA Reference	2011_ SME_001_02
Test Date	11/15/11
Test Performer	Fulvio Tonon
Checked by	Gloria Tonon-Kozma
Location	Louisville, Kentucky
Boring	B-92 Sample 2
Depth	29.7-30.5 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)
	0.065	0.058
	0.053	0.046
	0.058	0.045
	0.043	0.036
	0.059	0.048
Average (mm)	0.0511	
CAI	0.511	
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.

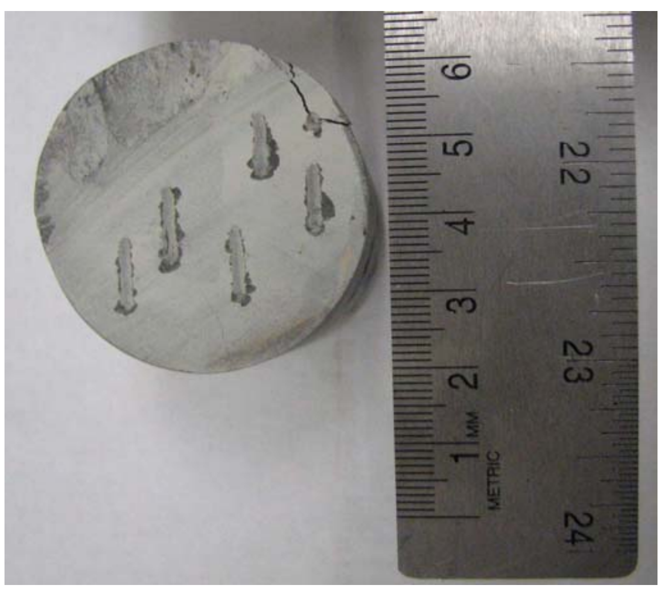


Photo after test

2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

CERCHAR Abrasiveness test

Test procedure: ASTM D7625

Tonon USA

Engineering, Measurements, and Testing, LLC

Project Name	Louisville Tunnel
Client Project No.	1831-10-5629
Tonon USA Reference	2011_ SME_001_02
Test Date	11/14/11
Test Performer	Fulvio Tonon
Checked by	Gloria Tonon-Kozma
Location	Louisville, Kentucky
Boring	B-93 Sample 2
Depth	29.8-30.3 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)
	0.038	0.033
	0.045	0.04
	0.041	0.037
	0.051	0.036
	0.043	0.034
Average (mm)	0.0398	
CAI	0.398	
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.

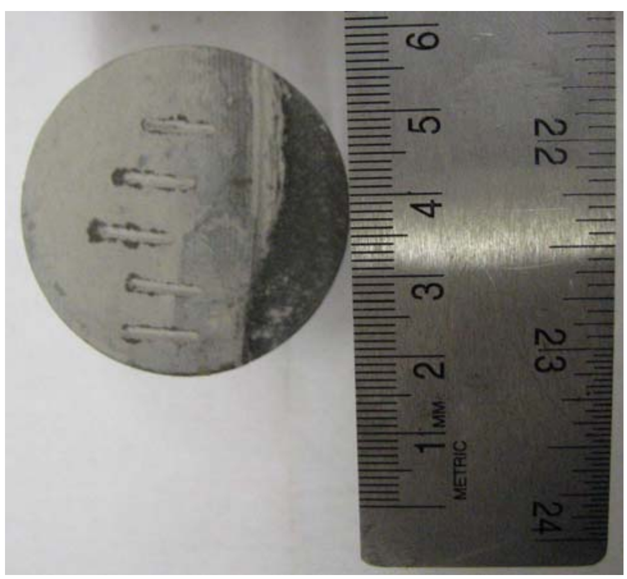


Photo after test

2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

CERCHAR Abrasiveness test	**Tonon USA**
Test procedure: ASTM D7625	**Engineering, Measurements, and Testing, LLC**

Project Name	Louisville Tunnel
Client Project No.	1831-10-5629
Tonon USA Reference	2011_ SME_001_02
Test Date	11/15/11
Test Performer	Fulvio Tonon
Checked by	Gloria Tonon-Kozma
Location	Louisville, Kentucky
Boring	B-94 Sample 3
Depth	37.9-38.3 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)
	0.058	0.046
	0.045	0.039
	0.047	0.037
	0.054	0.047
	0.063	0.051
Average (mm)	0.0487	
CAI	0.487	
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.

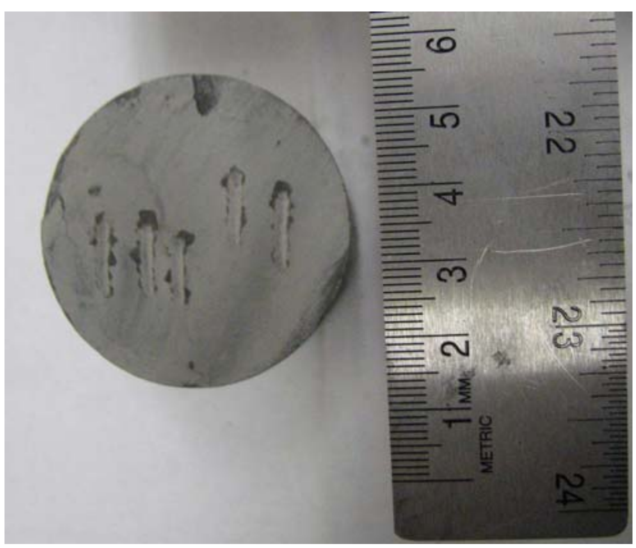


Photo after test

2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

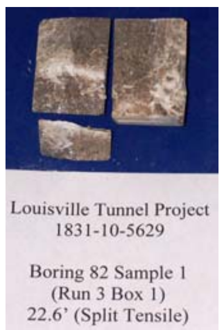
SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE
(ASTM D3967)

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

Project #: 1831-10-5629 Sample Date: 10/21/2011 Report Date: 11/11/2011
Project Name: Louisville Tunnel Project

Hole ID (Sample #)	Depth (ft)	Specimen Dimension Diameter (in)	Specimen Dimension Thickness (in)	Specimen Dimension t/D Ratio	Bulk Density (lb/ft^3)	Moisture Content (%)	Maximum Load (lbs)	Load Rate (psi/min)	Strength (psi)
Boring 82 Sample 1 Run 3 Box 1	22.6	1.98	1.22	0.62	162.3	0.1	7,700	435	2,029
Boring 82 Sample 2 Run 8 Box 3	50.4	1.98	1.24	0.63	166.8	0.0	7,220	451	1,872
Boring 82 Sample 4 Run 15 Box 5	80.3	1.98	1.09	0.55	164.6	1.4	4,000	463	1,180
Boring 82 Sample 7 Run 18 Box 6	96.7	1.98	1.26	0.64	165.6	0.0	10,630	482	2,713

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



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: 10/17/2011 Report Date: 11/3/2011
Project Name: Louisville Tunnel Project

Hole ID (Sample #)	Depth (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					
Boring 83 Sample 2 Run 3 Box 1	12.7	1.98	1.15	0.58	166.5	0.1	5,730	1,373	1,602
Boring 83 Sample 4 Run 6 Box 2	32.4	1.98	1.28	0.65	168.0	0.1	7,310	1,185	1,836

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

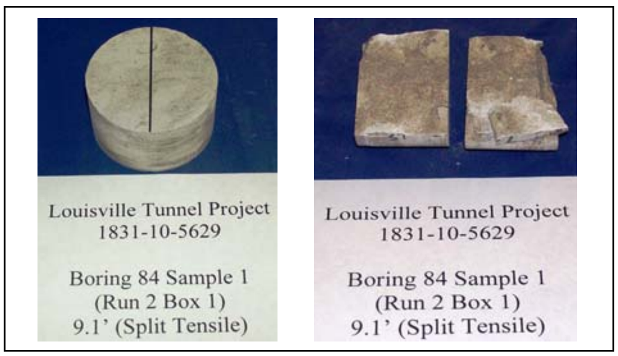
SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE
(ASTM D3967)

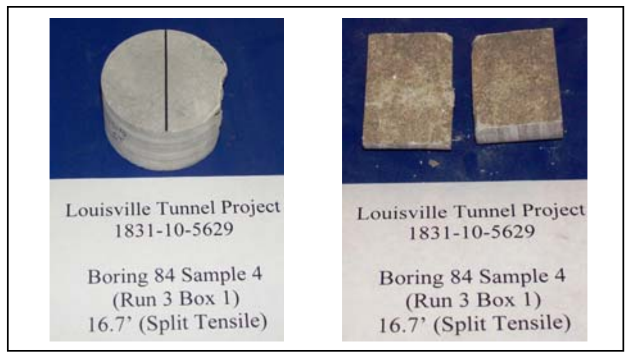
S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

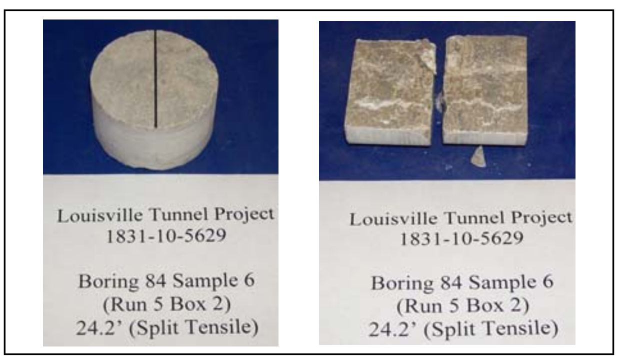
Project #: 1831-10-5629 Sample Date: 10/19/2011 Report Date: 11/3/2011
Project Name: Louisville Tunnel Project

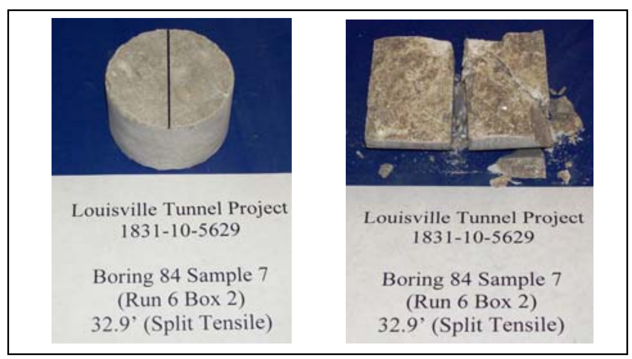
Hole ID (Sample #)	Depth (ft)	Specimen Dimension			Bulk Density (lb/ft^3)	Moisture Content (%)	Maximum Load (lbs)	Load Rate (psi/min)	Strength (psi)
		Diameter (in)	Thickness (in)	t/D Ratio					
Boring 84 Sample 1 Run 2 Box 1	9.1	1.98	1.29	0.65	164.3	0.2	9,290	1,208	2,315
Boring 84 Sample 4 Run 3 Box 1	16.7	1.98	1.30	0.66	163.9	0.1	8,610	1,503	2,129
Boring 84 Sample 6 Run 5 Box 2	24.2	1.98	1.29	0.65	166.8	0.1	6,020	1,034	1,500
Boring 84 Sample 7 Run 6 Box 2	32.9	1.98	1.31	0.66	167.4	0.1	6,710	1,040	1,647

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









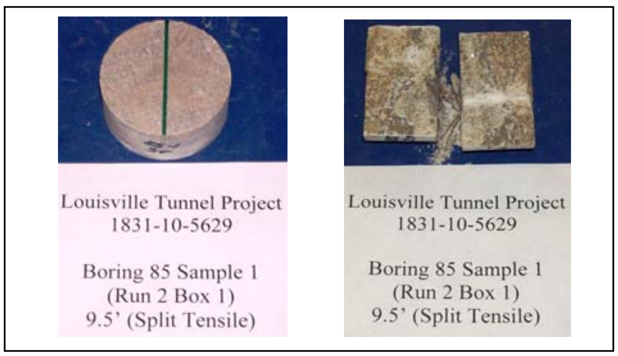
SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE
(ASTM D3967)

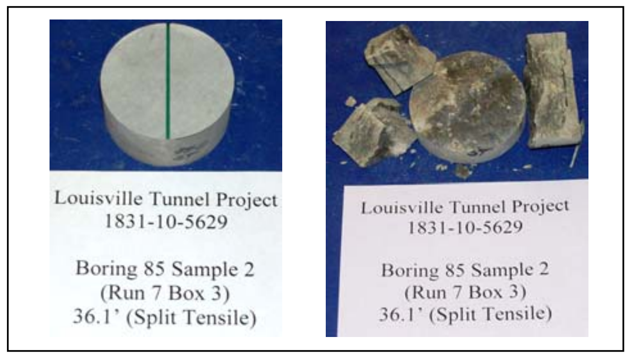
S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

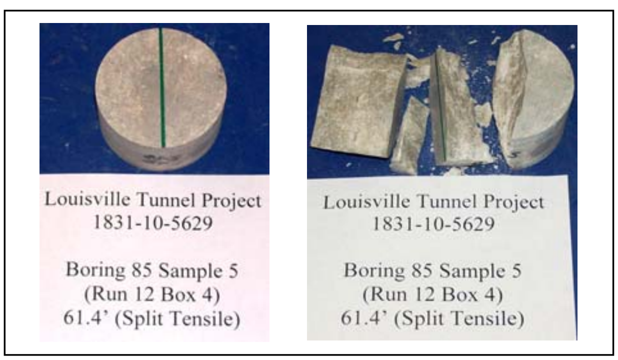
Project #: 1831-10-5629 Sample Date: 11/28/2011 Report Date: 12/7/2011
Project Name: Louisville Tunnel Project

Hole ID (Sample #)	Depth (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					
Boring 85 Sample 1 Run 2 Box 1	9.5	1.98	1.12	0.57	166.8	0.1	6,790	818	1,949
Boring 85 Sample 2 Run 7 Box 3	36.1	1.97	1.21	0.61	162.8	2.5	2,740	477	732
Boring 85 Sample 5 Run 12 Box 4	61.4	1.98	1.24	0.63	162.2	0.2	7,190	643	1,864

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







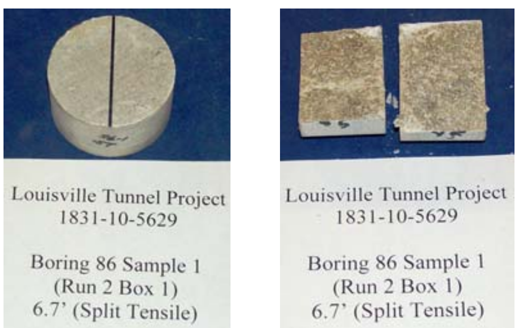
SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE
(ASTM D3967)

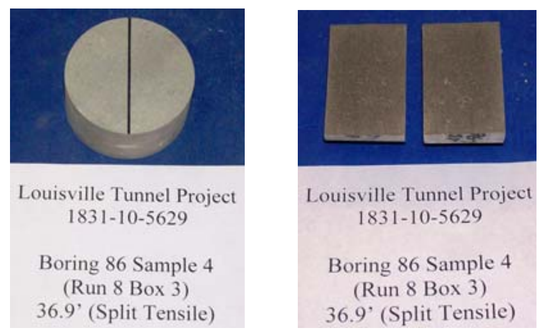
S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

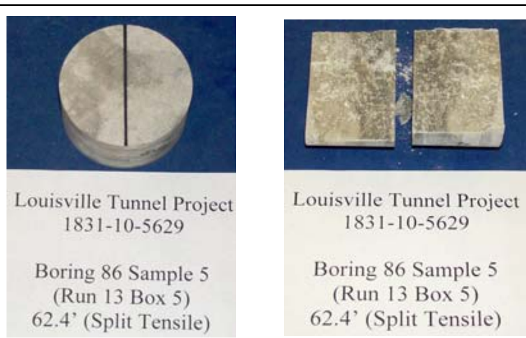
Project #: 1831-10-5629 Sample Date: 11/30/2011 Report Date: 12/8/2011
Project Name: Louisville Tunnel Project

Hole ID (Sample #)	Depth (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					
Boring 86 Sample 1 Run 2 Box 1	6.7	1.97	1.28	0.65	168.7	0.1	6,770	657	1,709
Boring 86 Sample 4 Run 8 Box 3	36.9	1.97	1.17	0.59	166.0	2.5	4,080	676	1,127
Boring 86 Sample 5 Run 13 Box 5	62.4	1.97	1.29	0.65	172.5	0.1	9,940	799	2,490

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







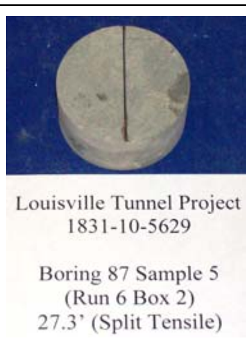
SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE
(ASTM D3967)

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

Project #: 1831-10-5629 Sample Date: 11/17/2011 Report Date: 12/2/2011
Project Name: Louisville Tunnel Project

Hole ID (Sample #)	Depth (ft)	Specimen Dimension Diameter (in)	Thickness (in)	t/D Ratio	Bulk Density (lb/ft^3)	Moisture Content (%)	Maximum Load (lbs)	Load Rate (psi/min)	Strength (psi)
Boring 87 Sample 1 Run 2 Box 1	6.6	1.96	1.16	0.59	167.2	0.1	7,840	1,135	2,195
Boring 87 Sample 3 Run 4 Box 1	15.3	1.97	1.29	0.65	165.7	0.4	5,890	820	1,476
Boring 87 Sample 5 Run 6 Box 2	27.3	1.96	1.17	0.60	163.4	2.1	3,360	629	933

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



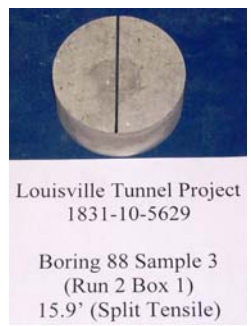
SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE
(ASTM D3967)

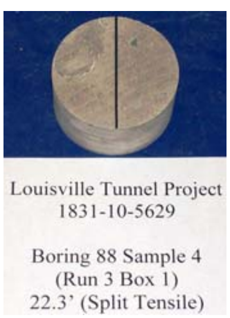
S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

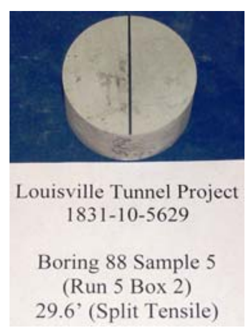
Project #: 1831-10-5629 Sample Date: 11/17/2011 Report Date: 12/3/2011
Project Name: Louisville Tunnel Project

Hole ID (Sample #)	Depth (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					
Boring 88 Sample 2 Run 1 Box 1	11.3	1.97	1.30	0.66	167.2	0.1	7,080	583	1,760
Boring 88 Sample 3 Run 2 Box 1	15.9	1.96	1.09	0.56	165.6	0.4	5,780	584	1,722
Boring 88 Sample 4 Run 3 Box 1	22.3	1.97	1.20	0.61	172.9	0.1	10,800	864	2,908
Boring 88 Sample 5 Run 5 Box 2	29.6	1.97	1.25	0.63	163.6	0.6	4,670	458	1,207

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







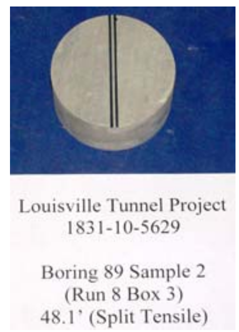
SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE
(ASTM D3967)

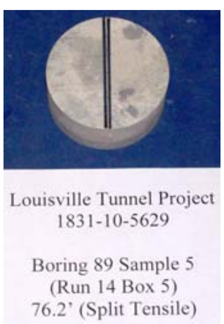
S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

Project #: 1831-10-5629 Sample Date: 11/16/2011 Report Date: 12/5/2011
Project Name: Louisville Tunnel Project

Hole ID (Sample #)	Depth (ft)	Specimen Dimension Diameter (in)	Thickness (in)	t/D Ratio	Bulk Density (lb/ft^3)	Moisture Content (%)	Maximum Load (lbs)	Load Rate (psi/min)	Strength (psi)
Boring 89 Sample 1 Run 2 Box 1	18.5	1.97	1.35	0.69	168.8	0.1	9,260	594	2,217
Boring 89 Sample 2 Run 8 Box 3	48.1	1.97	1.37	0.70	164.9	2.1	4,900	434	1,156
Boring 89 Sample 5 Run 14 Box 5	76.2	1.97	1.32	0.67	162.4	0.1	7,020	621	1,719

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





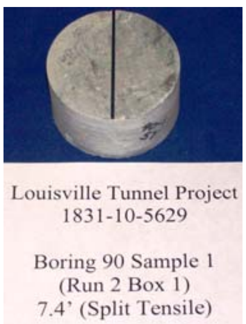
SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE
(ASTM D3967)

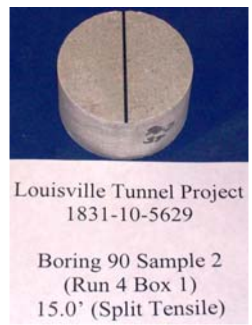
S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

Project #: 1831-10-5629 Sample Date: 11/30/2011 Report Date: 12/9/2011
Project Name: Louisville Tunnel Project

Hole ID (Sample #)	Depth (ft)	Specimen Dimension Diameter (in)	Thickness (in)	t/D Ratio	Bulk Density (lb/ft^3)	Moisture Content (%)	Maximum Load (lbs)	Load Rate (psi/min)	Strength (psi)
Boring 90 Sample 1 Run 2 Box 1	7.4	1.97	1.26	0.64	170.0	0.3	5,750	708	1,475
Boring 90 Sample 2 Run 4 Box 1	15.0	1.97	1.24	0.63	170.5	0.2	7,330	707	1,910

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





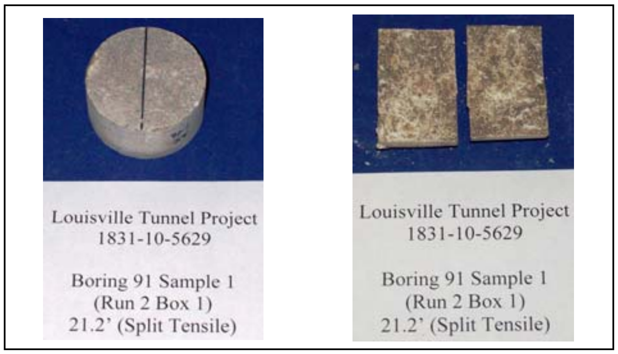
SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE
(ASTM D3967)

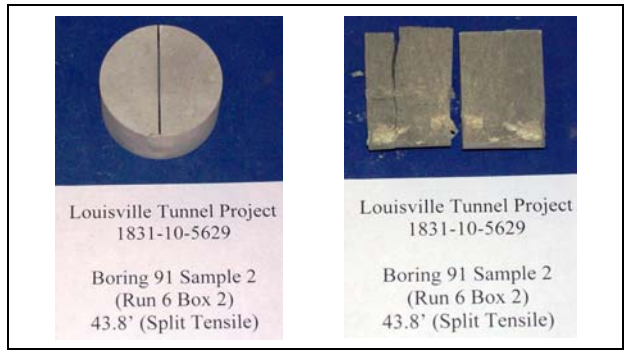
S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

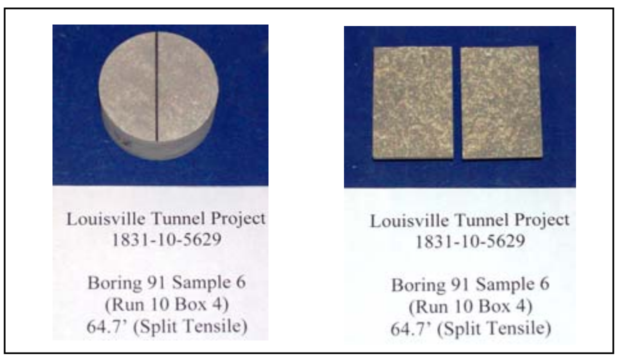
Project #: 1831-10-5629 Sample Date: 11/2/2011 Report Date: 11/23/2011
Project Name: Louisville Tunnel Project

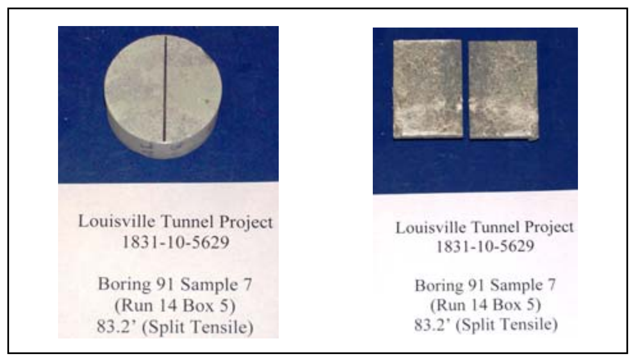
Hole ID (Sample #)	Depth (ft)	Specimen Dimension			Bulk Density (lb/ft^3)	Moisture Content (%)	Maximum Load (lbs)	Load Rate (psi/min)	Strength (psi)
		Diameter (in)	Thickness (in)	t/D Ratio					
Boring 91 Sample 1 Run 2 Box 1	21.2	1.98	1.22	0.62	167.0	0.1	7,040	675	1,855
Boring 91 Sample 2 Run 6 Box 2	43.8	1.97	1.30	0.66	162.1	1.2	5,100	624	1,268
Boring 91 Sample 6 Run 10 Box 4	64.7	1.98	1.32	0.67	168.0	0.1	12,040	850	2,933
Boring 91 Sample 7 Run 14 Box 5	83.2	1.98	1.29	0.65	168.8	0.2	7,610	711	1,897

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









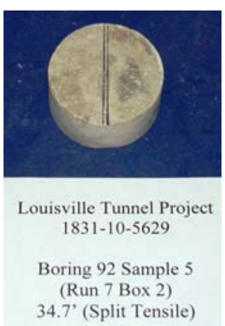
SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE
(ASTM D3967)

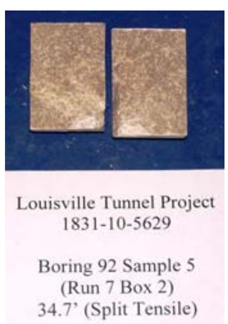
S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

Project #: 1831-10-5629 Sample Date: 11/1/2011 Report Date: 11/18/2011
Project Name: Louisville Tunnel Project

Hole ID (Sample #)	Depth (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					
Boring 92 Sample 1 Run 2 Box 1	13.3	1.98	1.24	0.63	171.2	0.1	9,260	779	2,401
Boring 92 Sample 3 Run 5 Box 2	24.4	1.97	1.26	0.64	163.1	1.3	4,360	799	1,118
Boring 92 Sample 5 Run 7 Box 2	34.7	1.98	1.25	0.63	169.6	0.1	8,650	742	2,225
Boring 92 Sample 6 Run 10 Box 4	52.0	1.98	1.26	0.64	160.1	0.1	6,810	729	1,738
Boring 92 Sample 7 Run 14 Box 5	69.7	1.98	1.33	0.67	168.7	0.2	8,020	676	1,939

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





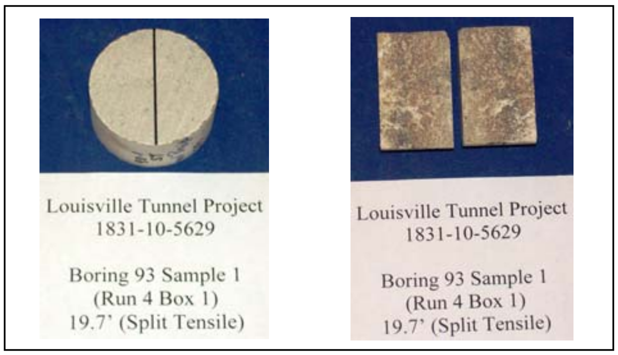
SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE
(ASTM D3967)

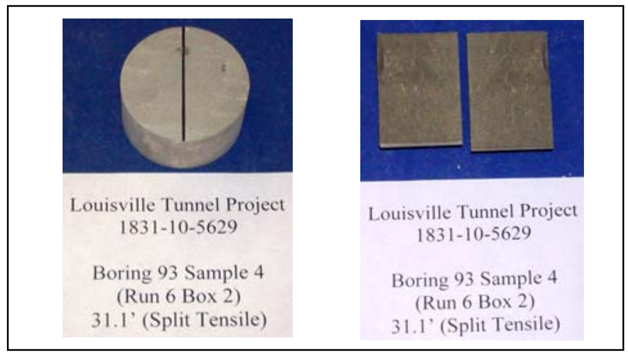
S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

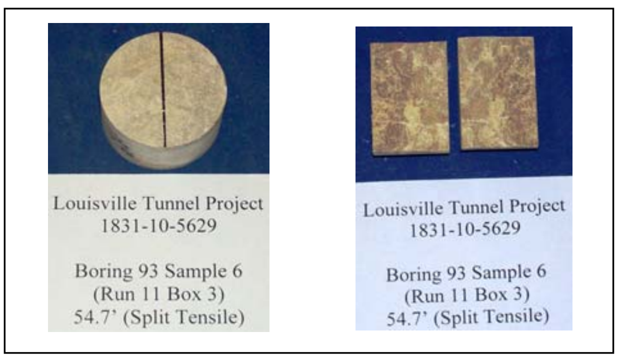
Project #: 1831-10-5629 Sample Date: 11/3/2011 Report Date: 11/30/2011
Project Name: Louisville Tunnel Project

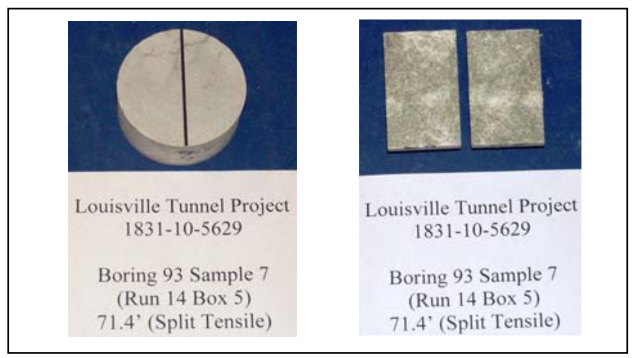
Hole ID (Sample #)	Depth (ft)	Specimen Dimension			Bulk Density (lb/ft^3)	Moisture Content (%)	Maximum Load (lbs)	Load Rate (psi/min)	Strength (psi)
		Diameter (in)	Thickness (in)	t/D Ratio					
Boring 93 Sample 1 Run 4 Box 1	19.7	1.98	1.14	0.58	168.3	0.1	5,890	773	1,661
Boring 93 Sample 4 Run 6 Box 2	31.1	1.97	1.29	0.65	164.7	1.8	4,380	633	1,097
Boring 93 Sample 6 Run 11 Box 3	54.7	1.98	1.26	0.64	163.4	0.1	7,810	813	1,993
Boring 93 Sample 7 Run 14 Box 5	71.4	1.98	1.15	0.58	169.6	0.1	8,320	746	2,326
Boring 93 Sample 8 Run 15 Box 5	74.6	1.96	1.25	0.64	162.5	1.0	5,290	717	1,375

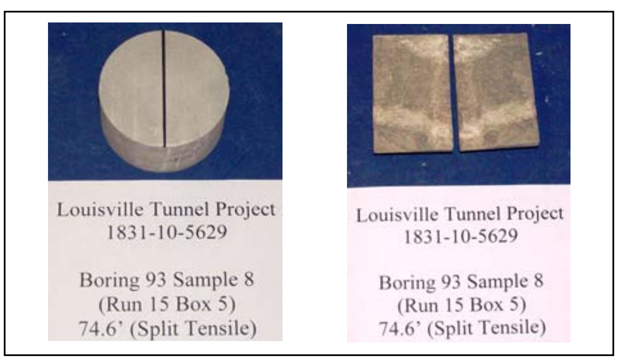
NOTE: Bulk Density includes any moisture that is within the specimen.











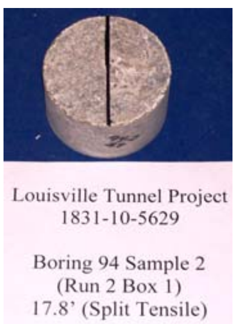
SPLITTING TENSILE STRENGTH OF INTACT ROCK CORE
(ASTM D3967)

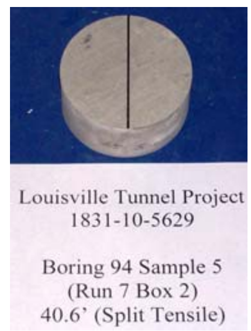
S&ME, Inc. - Knoxville 1413 Topside Road, Louisville, TN 37777

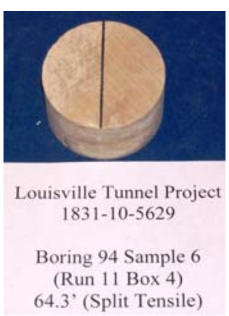
Project #: 1831-10-5629 Sample Date: 11/4/2011 Report Date: 12/1/2011
Project Name: Louisville Tunnel Project

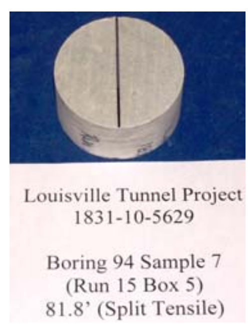
Hole ID (Sample #)	Depth (ft)	Specimen Dimension Diameter (in)	Thickness (in)	t/D Ratio	Bulk Density (lb/ft^3)	Moisture Content (%)	Maximum Load (lbs)	Load Rate (psi/min)	Strength (psi)
Boring 94 Sample 2 Run 2 Box 1	17.8	1.97	1.34	0.68	168.6	0.1	6,330	721	1,527
Boring 94 Sample 5 Run 7 Box 2	40.6	1.96	1.11	0.57	165.4	1.4	3,960	1,140	1,159
Boring 94 Sample 6 Run 11 Box 4	64.3	1.97	1.39	0.71	159.0	0.1	6,580	1,043	1,530
Boring 94 Sample 7 Run 15 Box 5	81.8	1.98	1.26	0.64	171.1	0.1	7,430	1,161	1,896
Boring 94 Sample 8 Run 16 Box 5	86.1	1.98	1.31	0.66	165.9	1.2	4,940	1,085	1,212

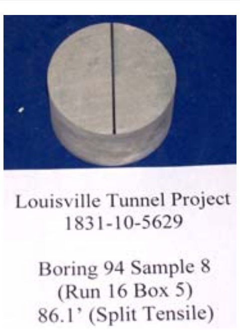
NOTE: Bulk Density includes any moisture that is within the specimen.

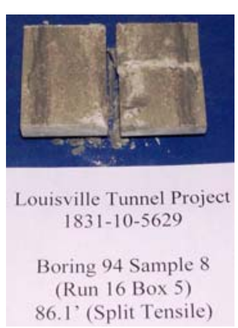












THIN SECTION PETROGRAPHIC ANALYSIS

Tonon USA

Engineering, Measurements, and Testing, LLC

Project Name	Louisville Tunnel	Rock Type	dolomite
Project location	Louisville, KY	Alteration	dolomitized
Client	SM&E	Texture	microcrystalline
Client's Project No.	1831-10-5629	Rock name	Dolomite (or dolomitized shale)
Tonon USA No.	SM&E_2011_01	Studied by	Kathleen Surpless
Drill hole and depth	B-82 Sample 1 83.2'-84.3'	Date Studied	November 16, 2011
Formation	Waldron Shale	Reviewed by	Fulvio Tonon

Description of Individual Minerals:

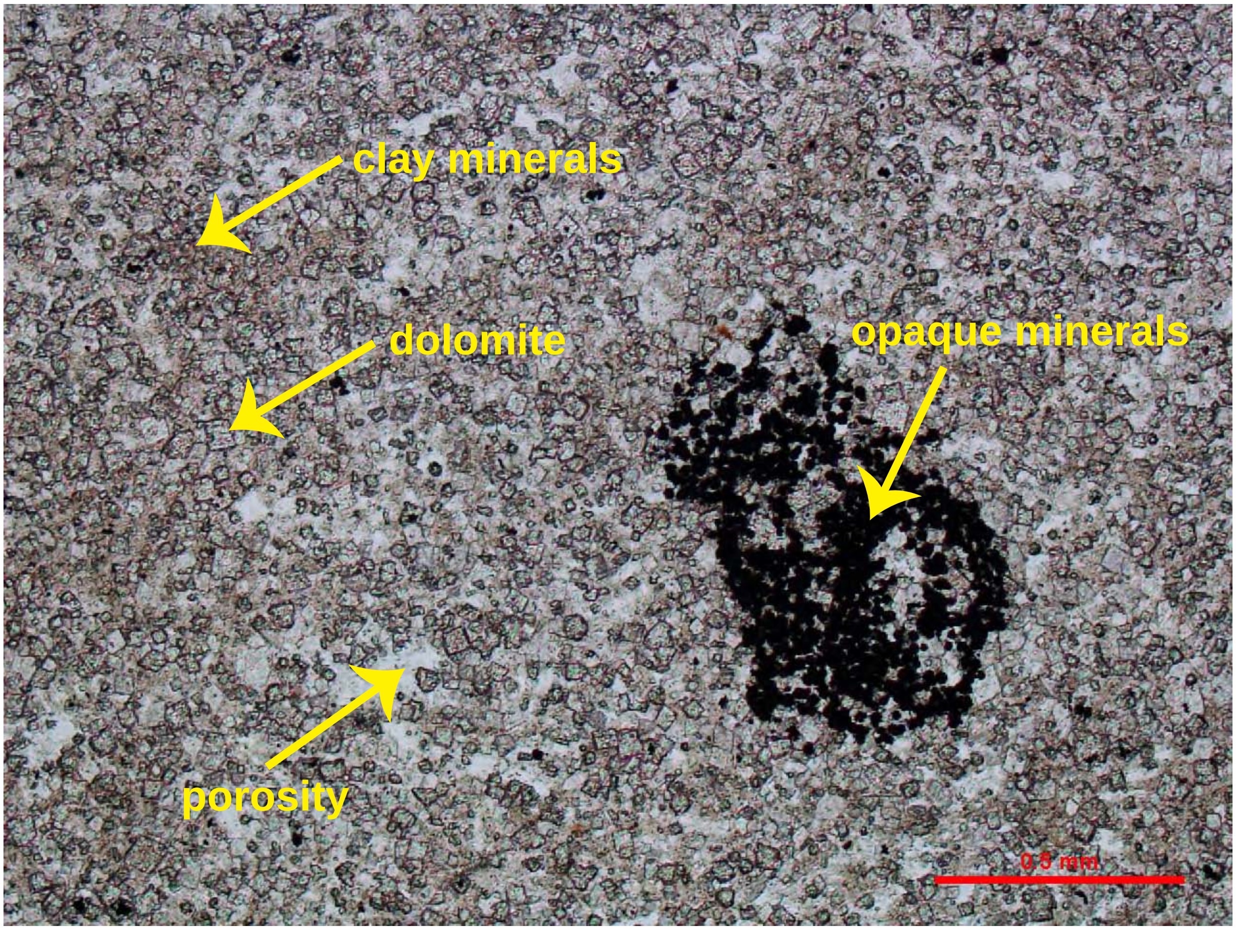
Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Dolomite	75%	3.5-4	0.02-0.09	Distinctive rhombic shape, high relief, high birefringence; evenly distributed throughout sample
Matrix	10%	1-3	<0.01	Likely clay minerals, but too small to determine composition
Opaque minerals	3%	4-5	Variable, <0.06	Round shape, concentrated in specific areas of slide (probably former fossils); could be iron oxide minerals or organic material
Quartz	2%	7	0.04-0.1	Silt to very fine sand sized grains of quartz
porosity	10%	NA	<0.1	Pore space is evenly distributed throughout slide
Weighted Average:		3.7	Excludes porosity	

Remarks: thoroughly dolomitized fine-grained rock; may have originally been micritic or shale

2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

B-82 Sample 1, 83.2-84.3 ft



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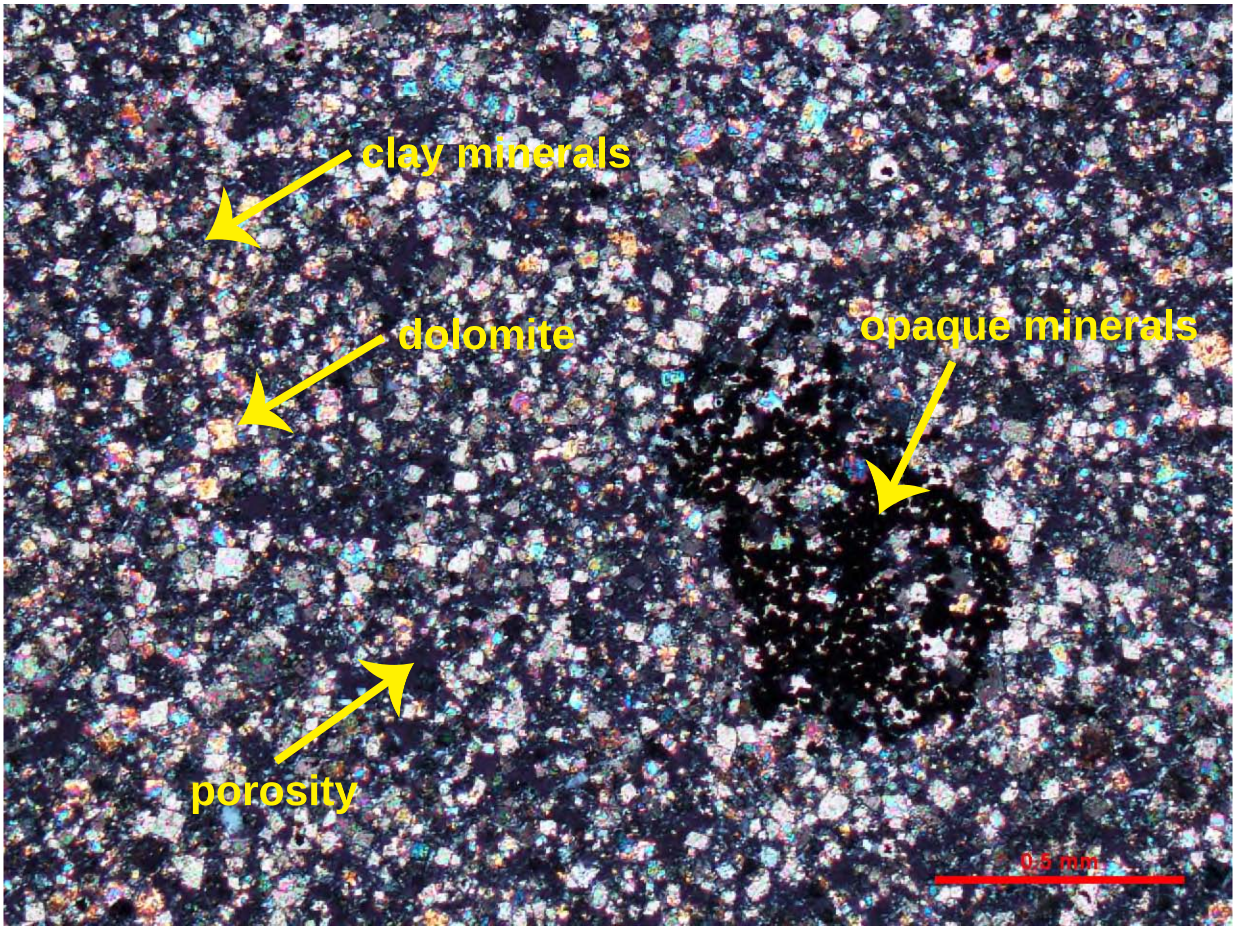
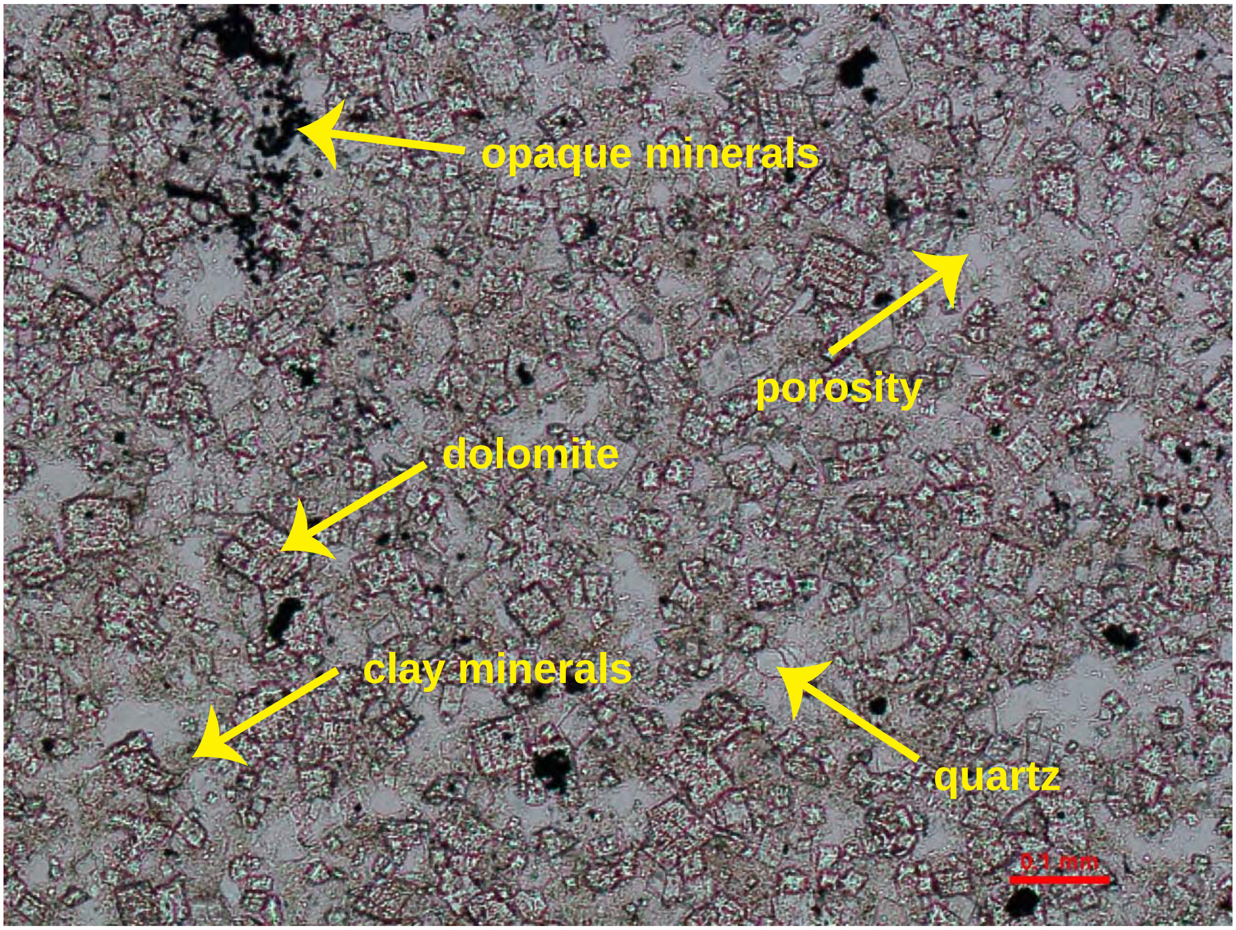


crossed polars

B-82 Sample 1, 83.2-84.3 ft



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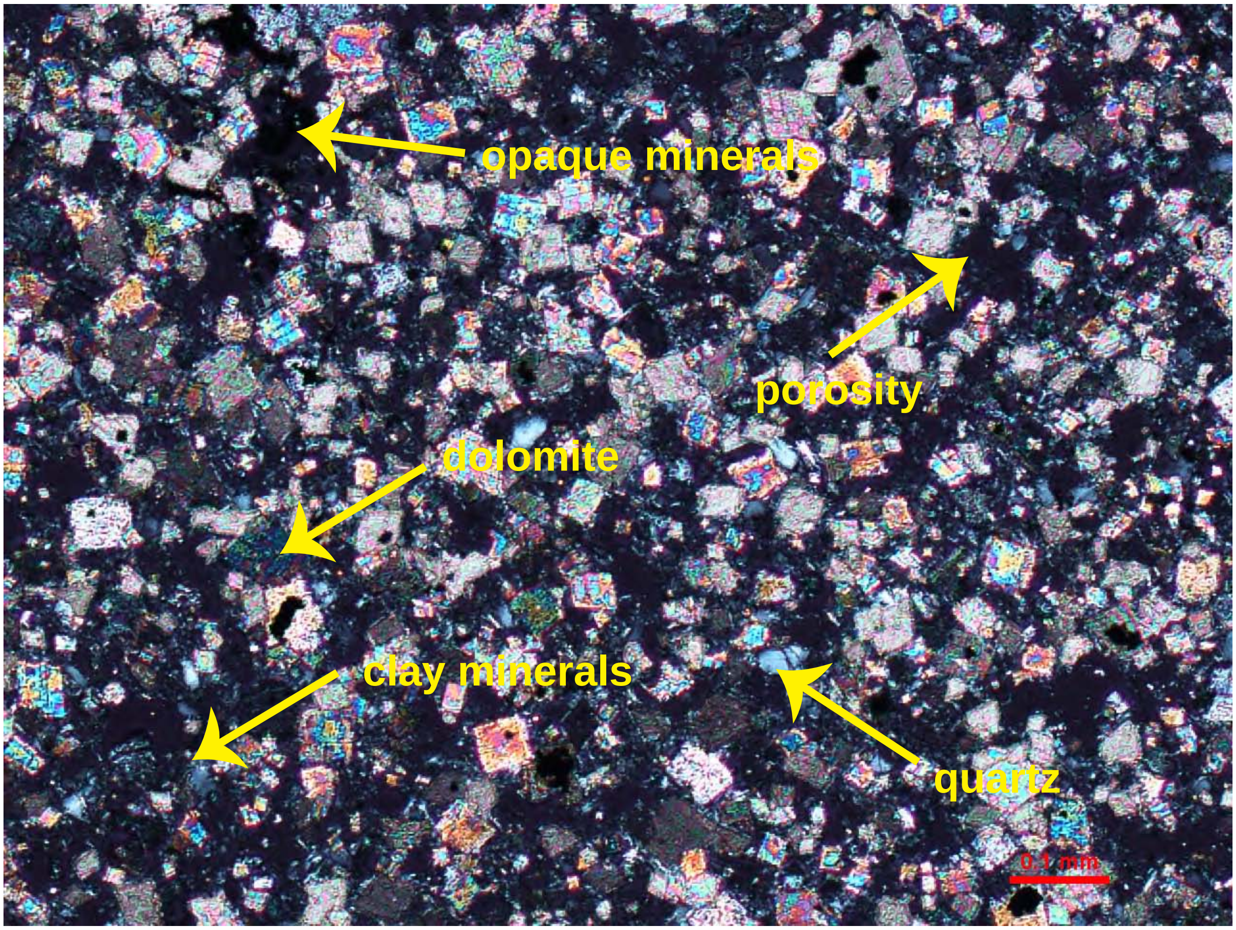


crossed polars

THIN SECTION PETROGRAPHIC ANALYSIS

Tonon USA

Engineering, Measurements, and Testing, LLC

Project Name	Louisville Tunnel	Rock Type	shale
Project location	Louisville, KY	Alteration	Partially dolomitized
Client	SM&E	Texture	shale
Client's Project No.	1831-10-5629	Rock name	Dolomitic shale
Tonon USA No.	SM&E_2011_03	Studied by	Kathleen Surpless
Drill hole and depth	B-85 Sample 1 39.0′ – 39.8′	Date Studied	January 10, 2012
Formation	Waldron Shale	Reviewed by	Fulvio Tonon

Description of Individual Minerals:

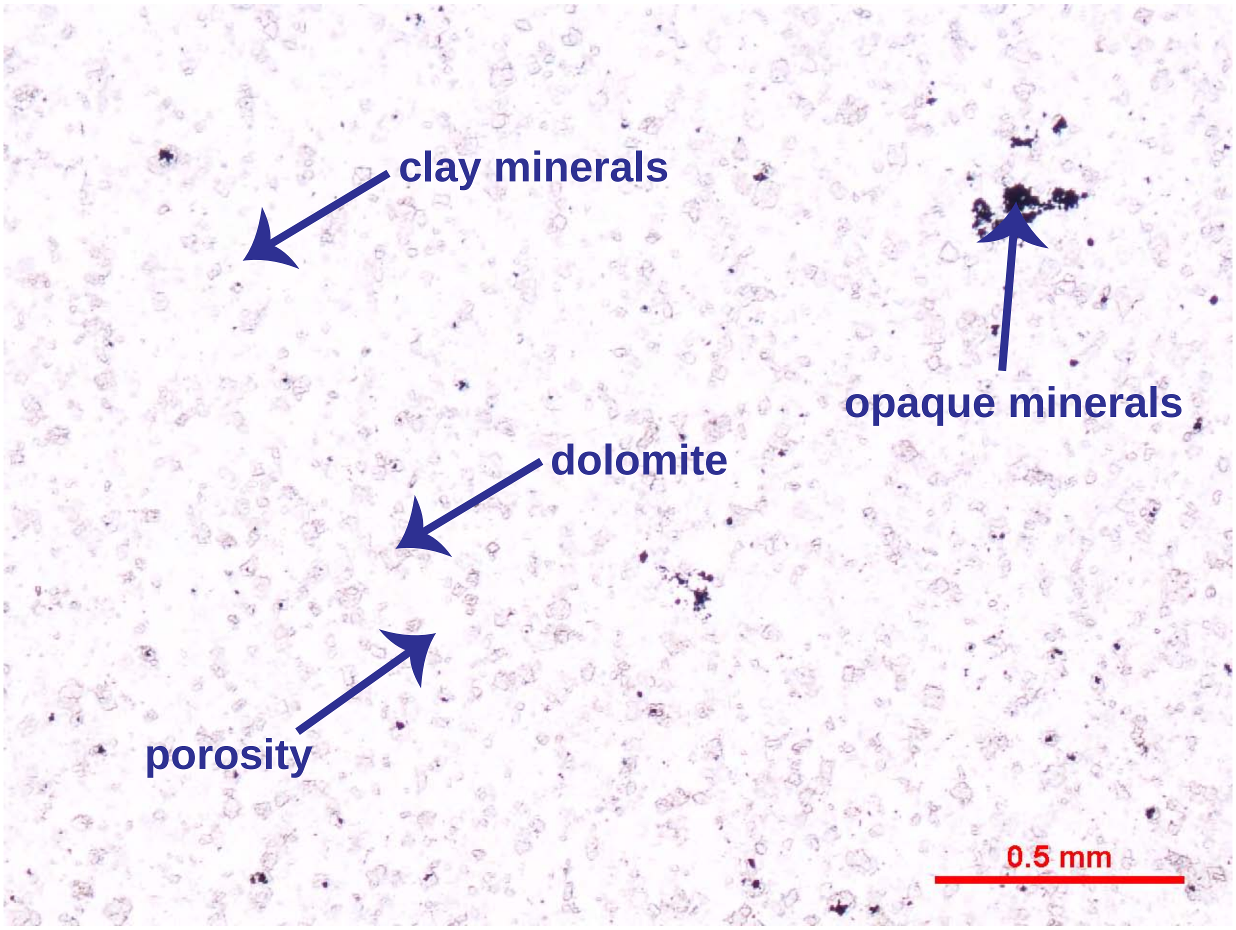
Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Dolomite	25	3.5-4	0.02-0.07	Distinctive rhombic shape, high relief, high birefringence
Matrix	45	1-3	<0.01	Likely clay minerals, but too small to determine composition
Opaque minerals	2	4-5	variable	Blotchy shape; could be iron oxide minerals or organic material
Quartz	3	7	0.02-0.06	Silt sized, angular grains of quartz
porosity	25	NA	variable	Pore space is unevenly distributed throughout slide; one part of slide is much more porous than the rest
Weighted Average:		2.8	Excludes porosity	

Remarks: highly porous in one zone of the slide and highly dolomitized on the other; some preferred alignment visible in overall sample; likely that the zones of intense dolomitization reduced original porosity

2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

B-85 Sample 1, 39.0-39.8 ft



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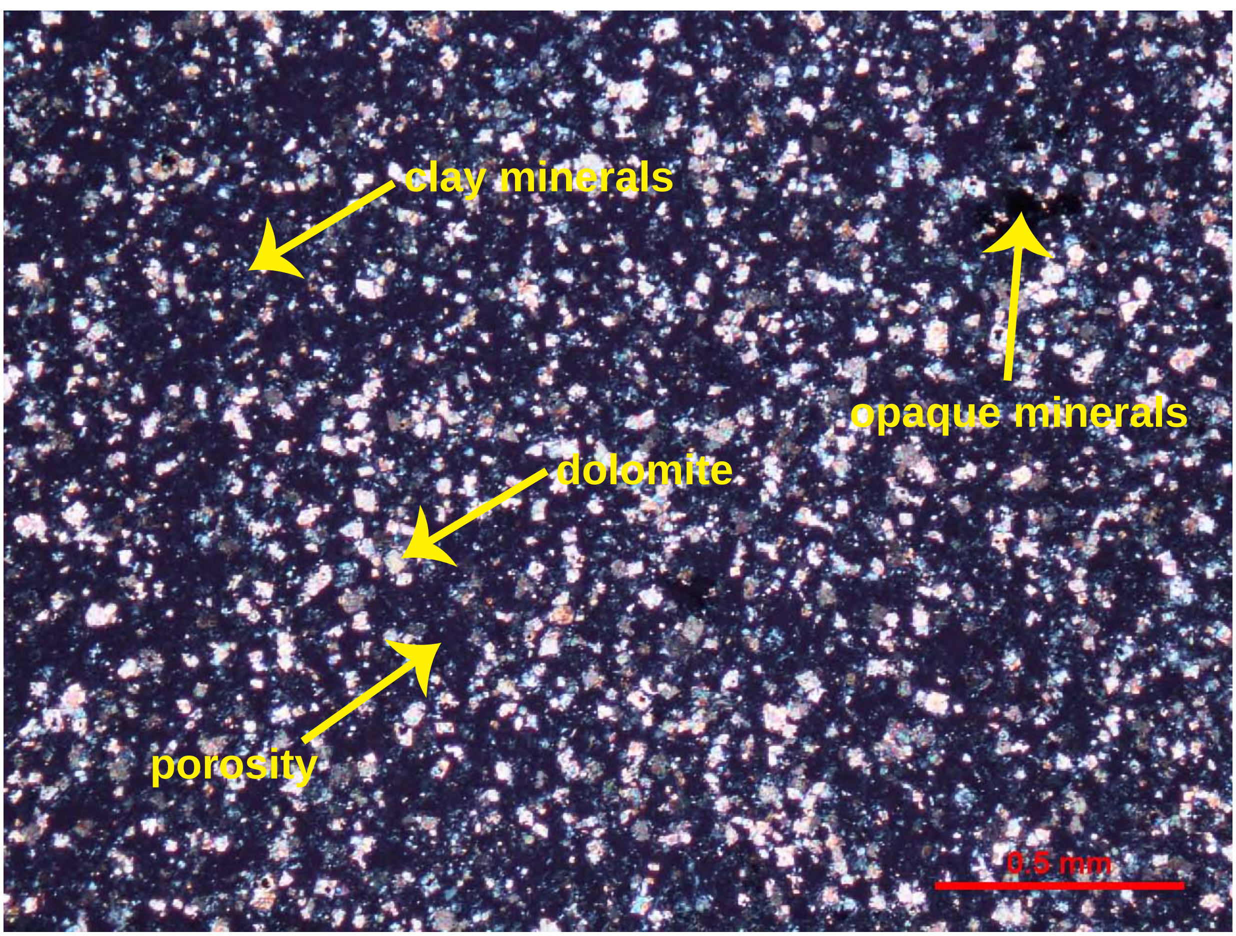
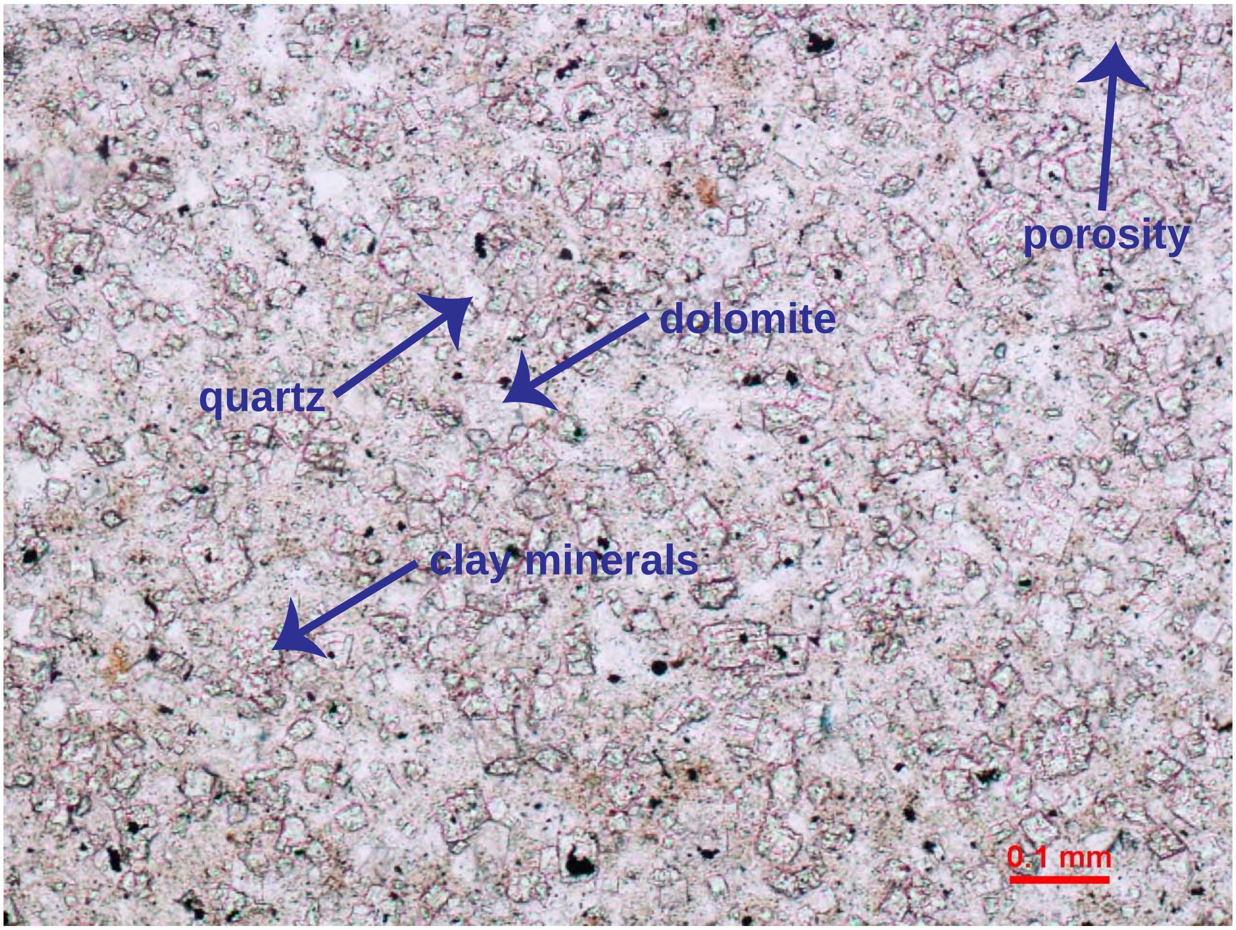


crossed polars

B-85 Sample 1, 39.0-39.8 ft



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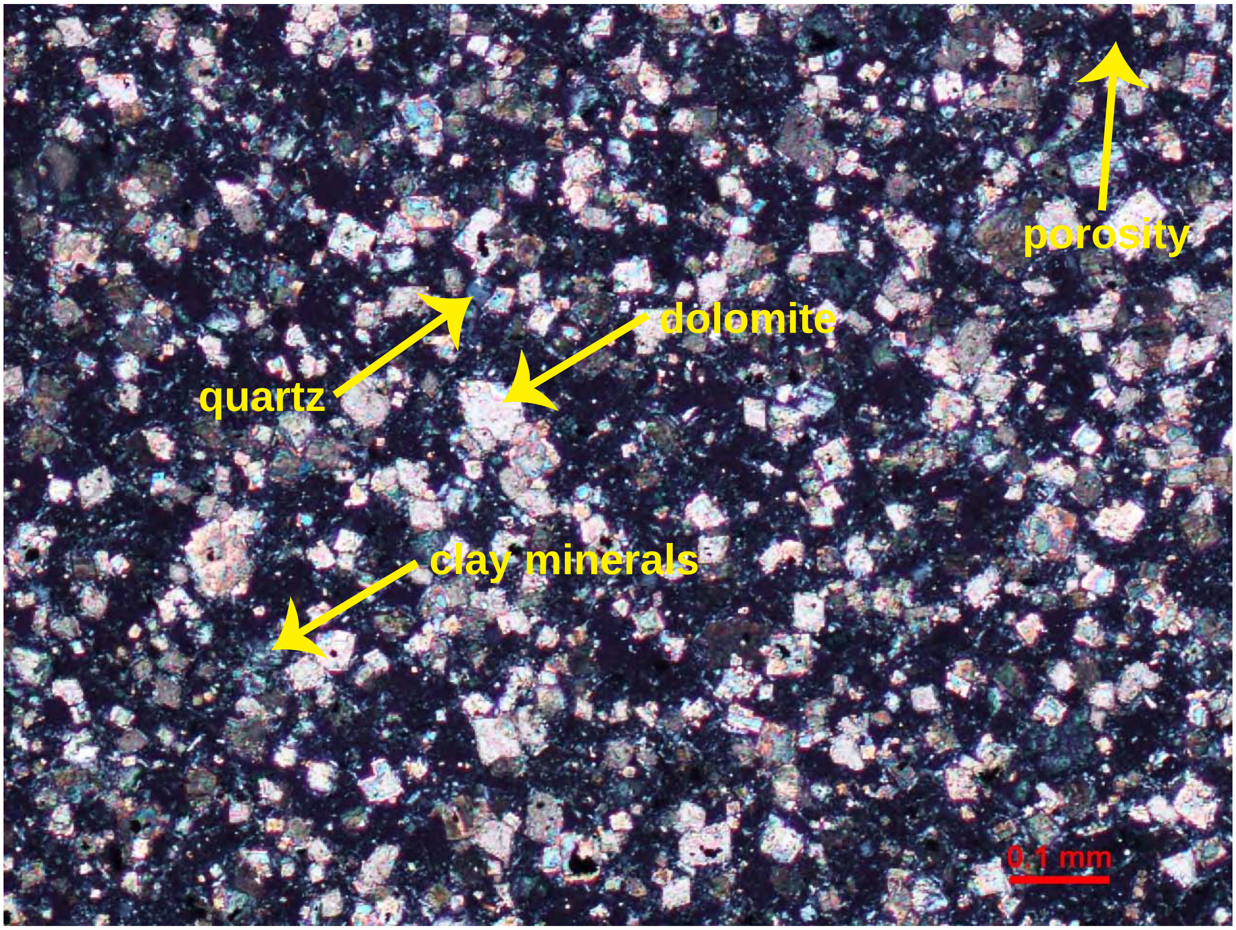


crossed polars

THIN SECTION PETROGRAPHIC ANALYSIS

Tonon USA

Engineering, Measurements, and Testing, LLC

Project Name	Louisville Tunnel	Rock Type	Dolomitized shale
Project location	Louisville, KY	Alteration	dolomitized
Client	SM&E	Texture	Crystalline (shale-rich zones)
Client's Project No.	1831-10-5629	Rock name	dolomite
Tonon USA No.	SM&E_2011_03	Studied by	Kathleen Surpless
Drill hole and depth	B-86 Sample 1 32.9' – 34.1'	Date Studied	January 10, 2012
Formation	Waldron Shale	Reviewed by	Fulvio Tonon

Description of Individual Minerals:

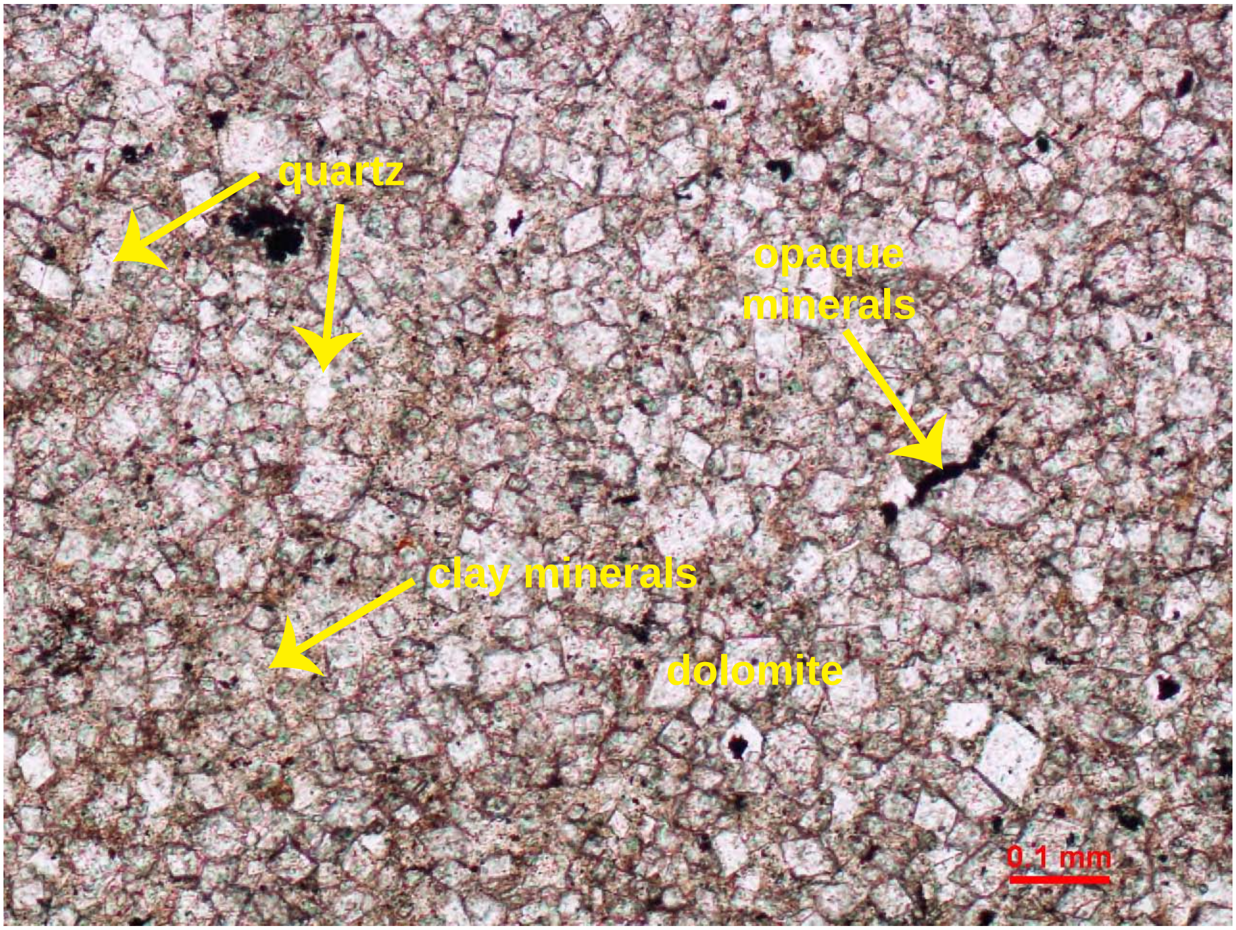
Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Dolomite	65	3.5-4	0.02-0.08	Distinctive rhombic shape, high relief, high birefringence; evenly distributed throughout sample
Matrix	15	1-3	<0.01	Likely clay minerals, but too small to determine composition
Opaque minerals	5	4-5	variable	Blotchy shape; could be iron oxide minerals or organic material
Quartz	5	7	0.02-0.07	Silt sized grains of quartz
porosity	10	NA	variable	Pore space is unevenly distributed throughout slide; one area of slide is much more porous than the rest
Weighted Average:		3.7	Excludes porosity	

Remarks: highly porous in one area and highly dolomitized throughout the rest of the slide; no preferred alignment visible in overall sample; likely that intense dolomitization reduced original porosity

2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

B-86 Sample 1, 32.9-34.1 ft



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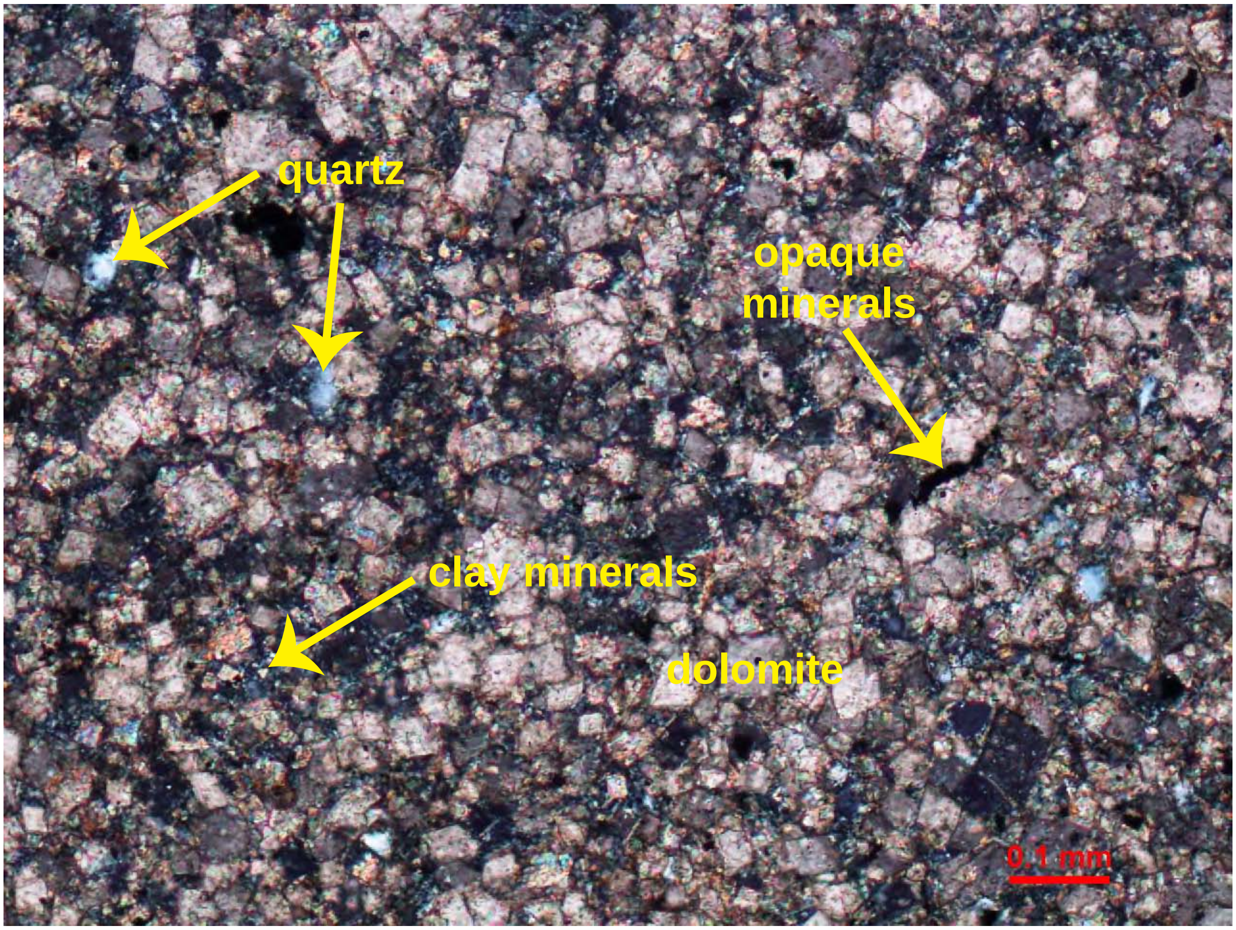
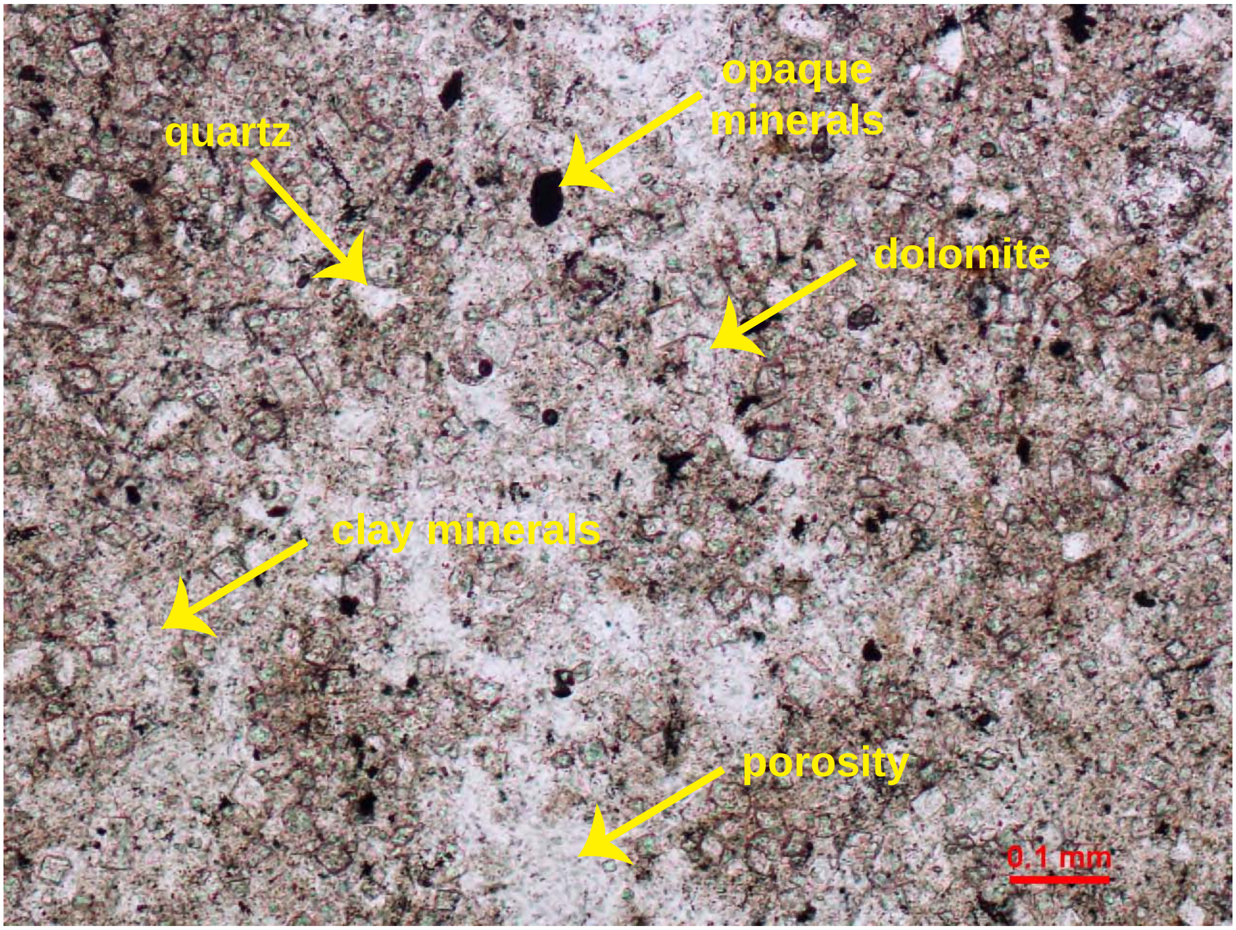


crossed polars

B-86 Sample 1, 32.9-34.1 ft



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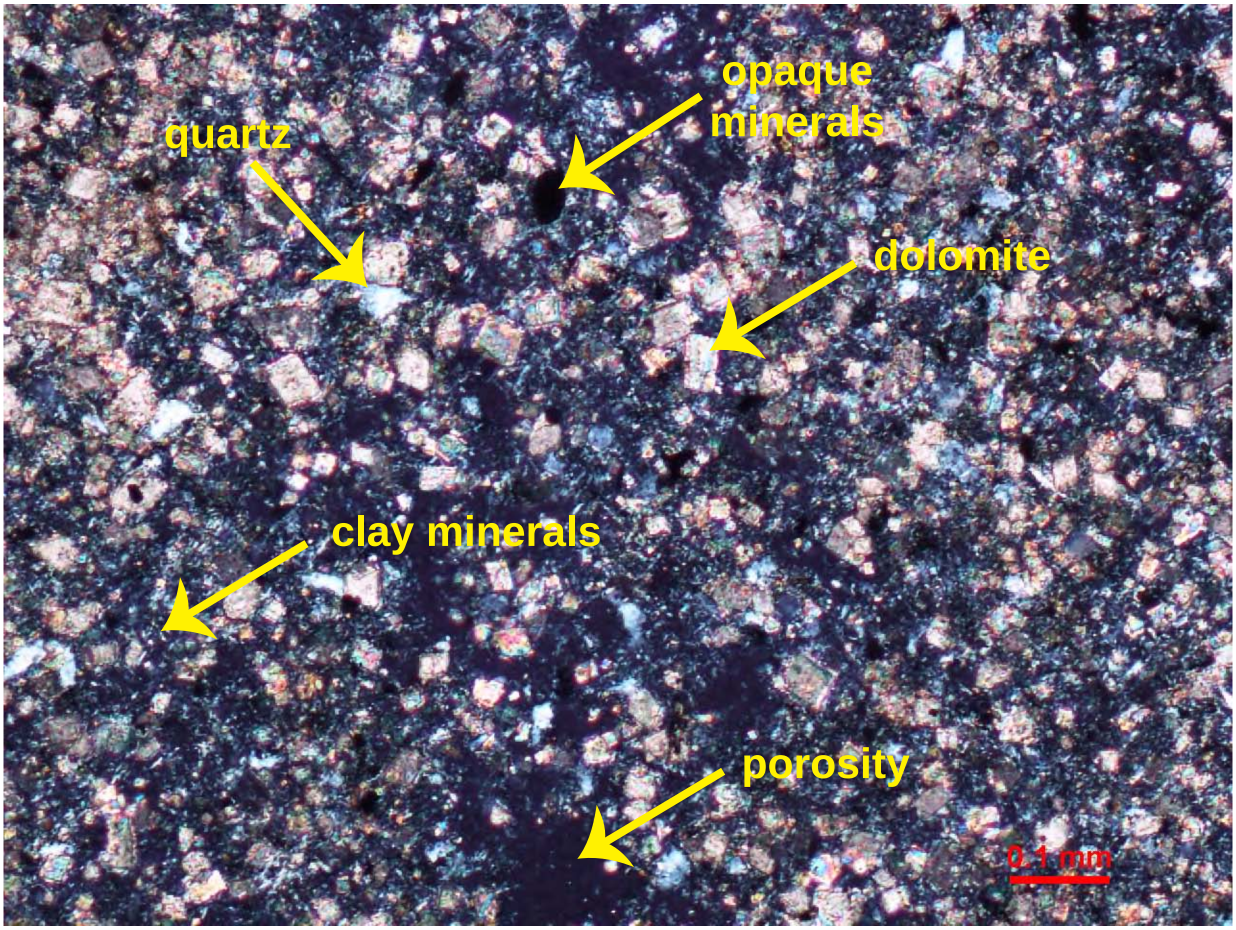


crossed polars

THIN SECTION PETROGRAPHIC ANALYSIS	**Tonon USA** **Engineering, Measurements, and Testing, LLC**

Project Name	Louisville Tunnel	Rock Type	Silty dolomitic shale
Project location	Louisville, KY	Alteration	dolomitized
Client	SM&E	Texture	Silty shale
Client's Project No.	1831-10-5629	Rock name	Silty dolomitic shale
Tonon USA No.	SM&E_2011_03	Studied by	Kathleen Surpless
Drill hole and depth	B-89 Sample 1 50.4′-50.7′	Date Studied	January 10, 2012
Formation	Waldron Shale	Reviewed by	Fulvio Tonon

Description of Individual Minerals:

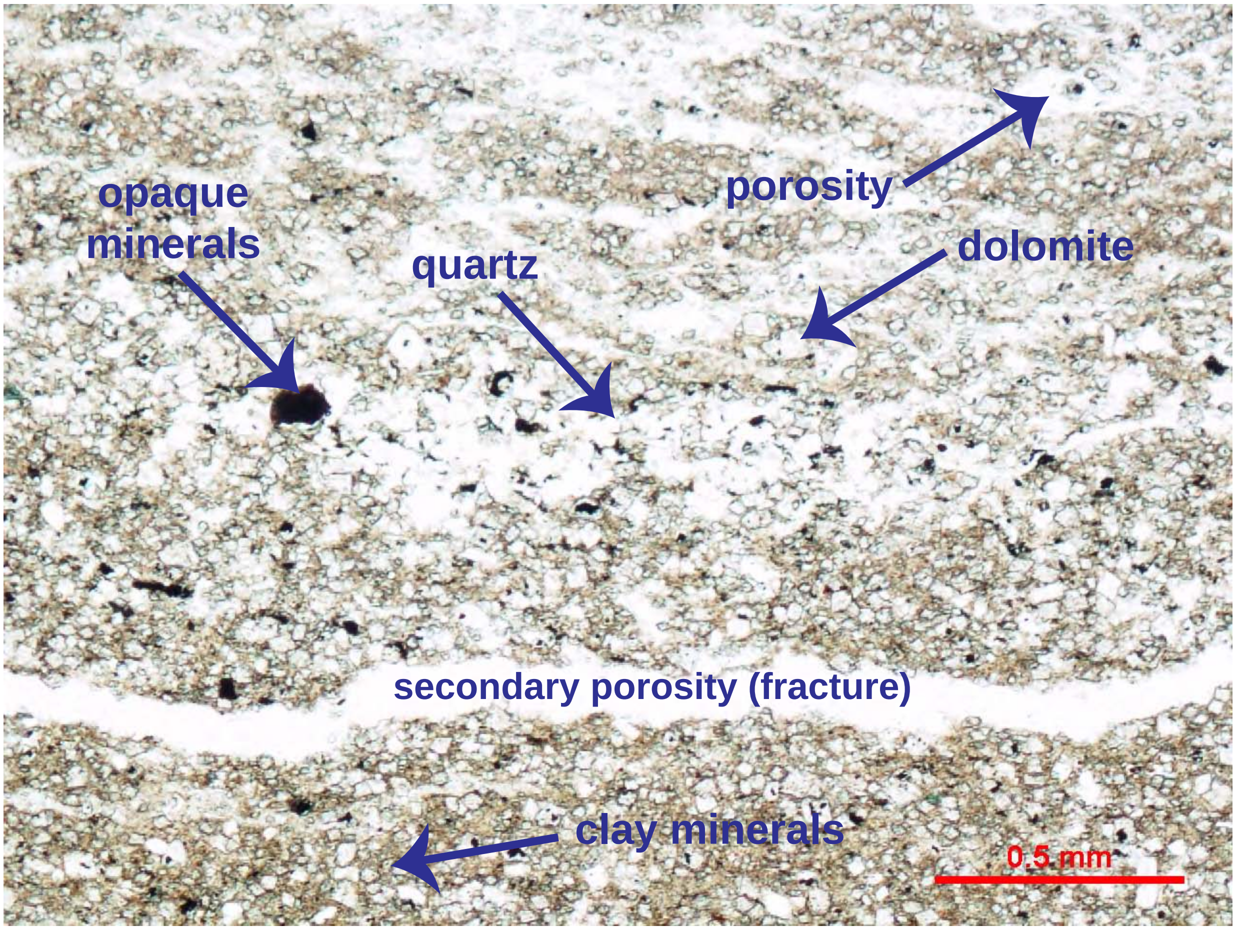
Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Dolomite	45	3.5-4	0.02-0.1	Distinctive rhombic shape, high relief, high birefringence
Matrix	20	1-3	<0.01	Likely clay minerals, but too small to determine composition
Opaque minerals	5	4-5	variable	Blotchy shape; could be iron oxide minerals or organic material
Quartz	10	7	0.03	Silt sized grains of quartz
porosity	20	NA	variable	Pore space is unevenly distributed throughout slide; one side of slide is much more porous than the other
Weighted Average:		3.8	Excludes porosity	

Remarks: secondary fractures and regions of more or less dolomitization or porosity define preferred alignment visible in overall sample; fissile sample

2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

B-89 Sample 1, 50.4-50.7 ft



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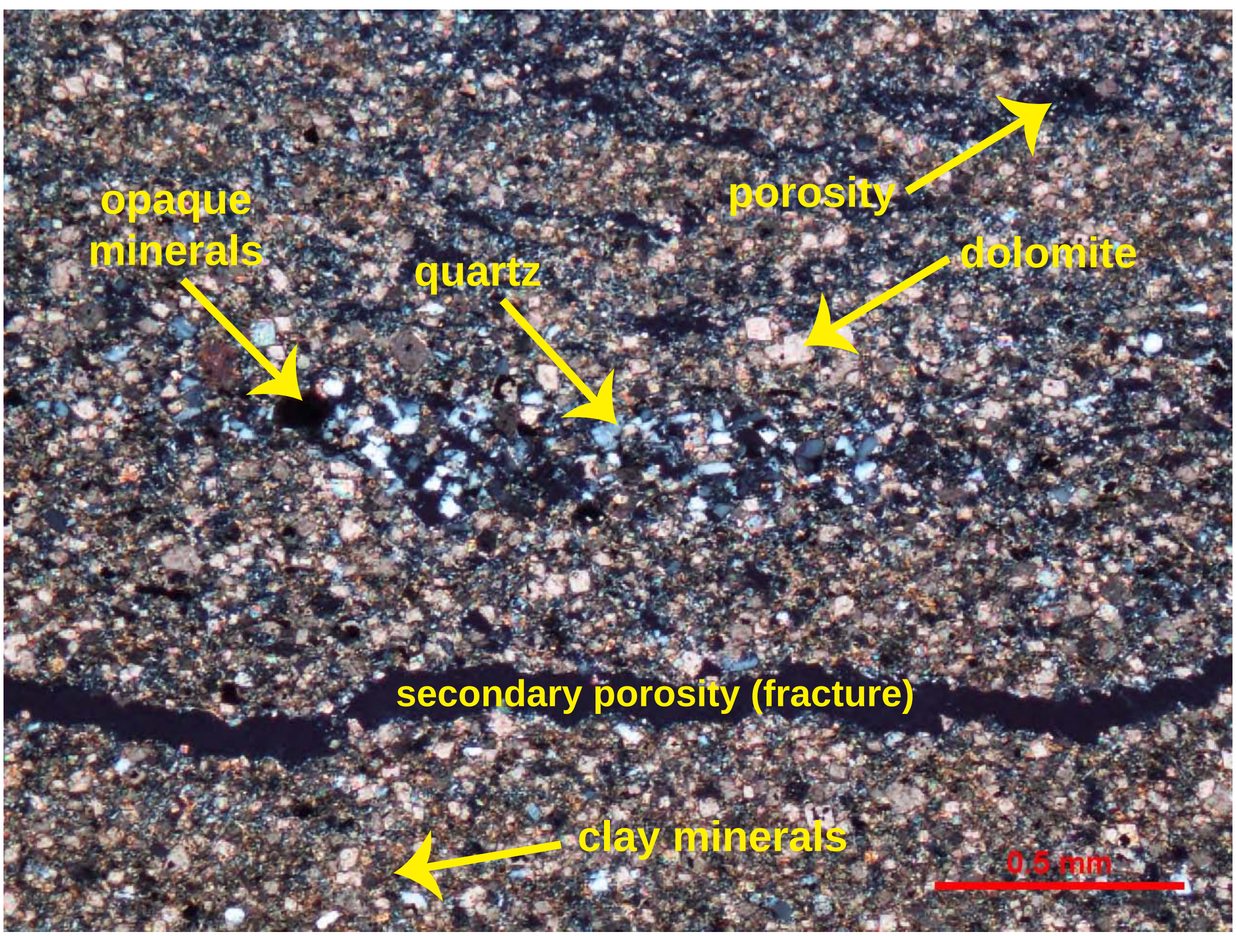
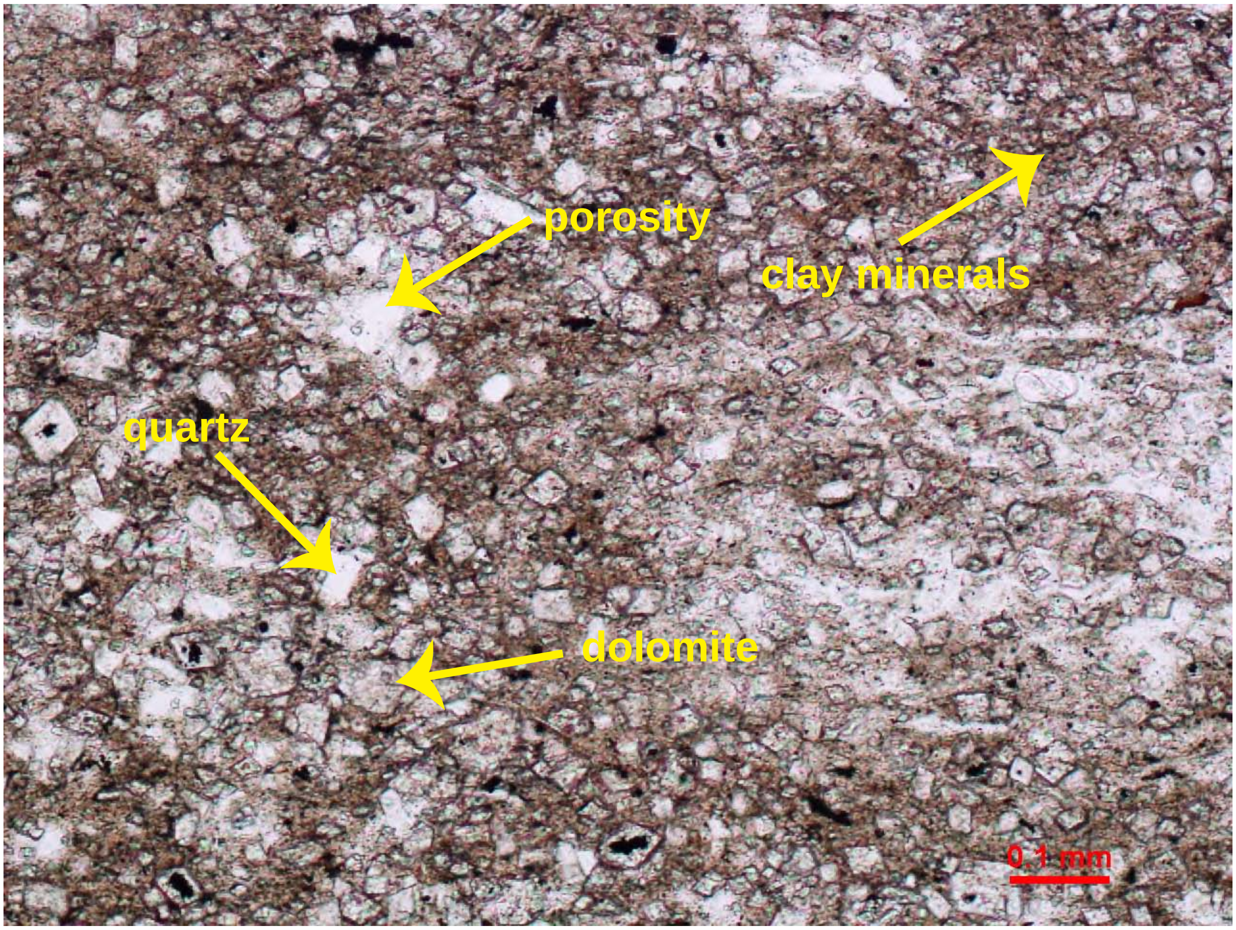


crossed polars

B-89 Sample 1, 50.4-50.7 ft



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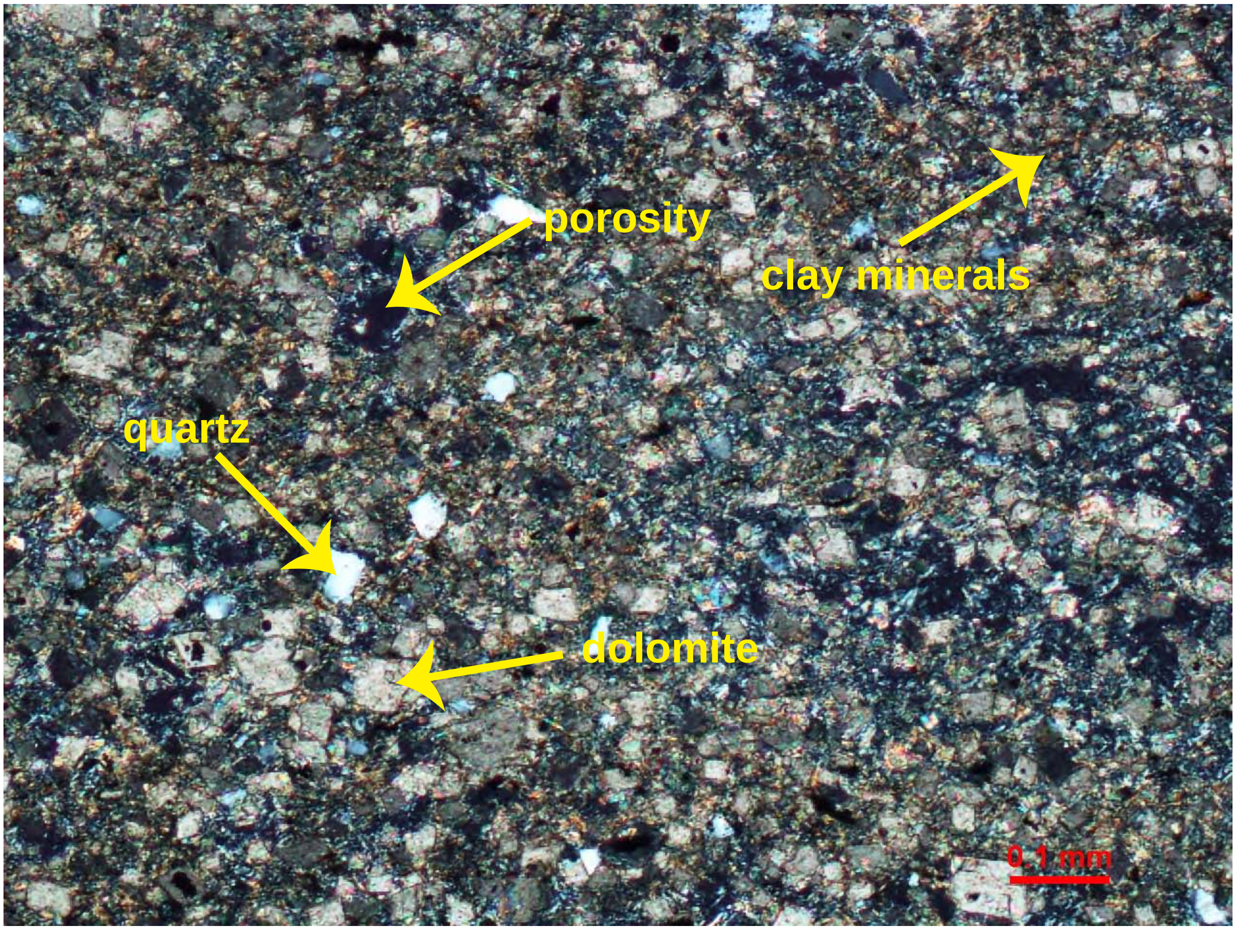


crossed polars

THIN SECTION PETROGRAPHIC ANALYSIS	Tonon USA Engineering, Measurements, and Testing, LLC

Project Name	Louisville Tunnel	Rock Type	Shale
Project location	Louisville, KY	Alteration	dolomitized
Client	SM&E	Texture	Shaley texture with some recrystallization
Client's Project No.	1831-10-5629	Rock name	Dolomitic shale
Tonon USA No.	SM&E_2011_02	Studied by	Kathleen Surpless
Drill hole and depth	B-91 Sample 1 41.8'-42.1'	Date Studied	December 9, 2011
Formation	Waldron Shale	Reviewed by	Fulvio Tonon

Description of Individual Minerals:

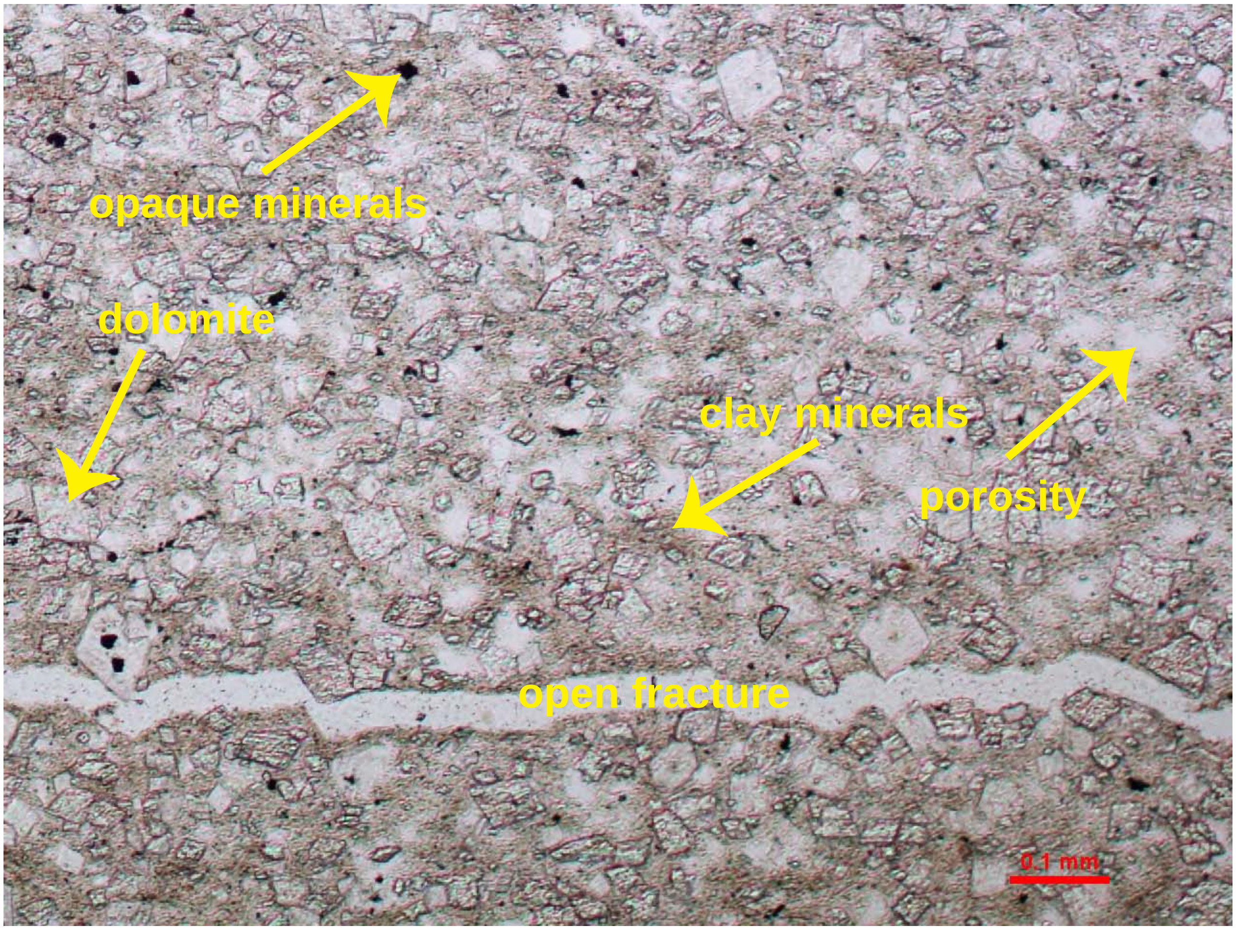
Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Dolomite	45	3.5-4	0.03-0.08; average 0.05	Distinctive rhombic shape, high relief, high birefringence; evenly distributed throughout sample
Matrix	40	1-3	<0.01	Likely clay minerals, but too small to determine composition; alignment defines preferred orientation in sample
Opaque minerals	<3	4-5	variable	Round shape; could be iron oxide minerals or organic material
porosity	12	NA	variable	Pore space is throughout slide
Weighted Average:		3.0	Excludes porosity	

Remarks: fissile character with preferred alignment defined by clay minerals in the matrix; fractures are oriented parallel to this alignment

2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

B-91 Sample 1, 41.8 to 42.1 ft



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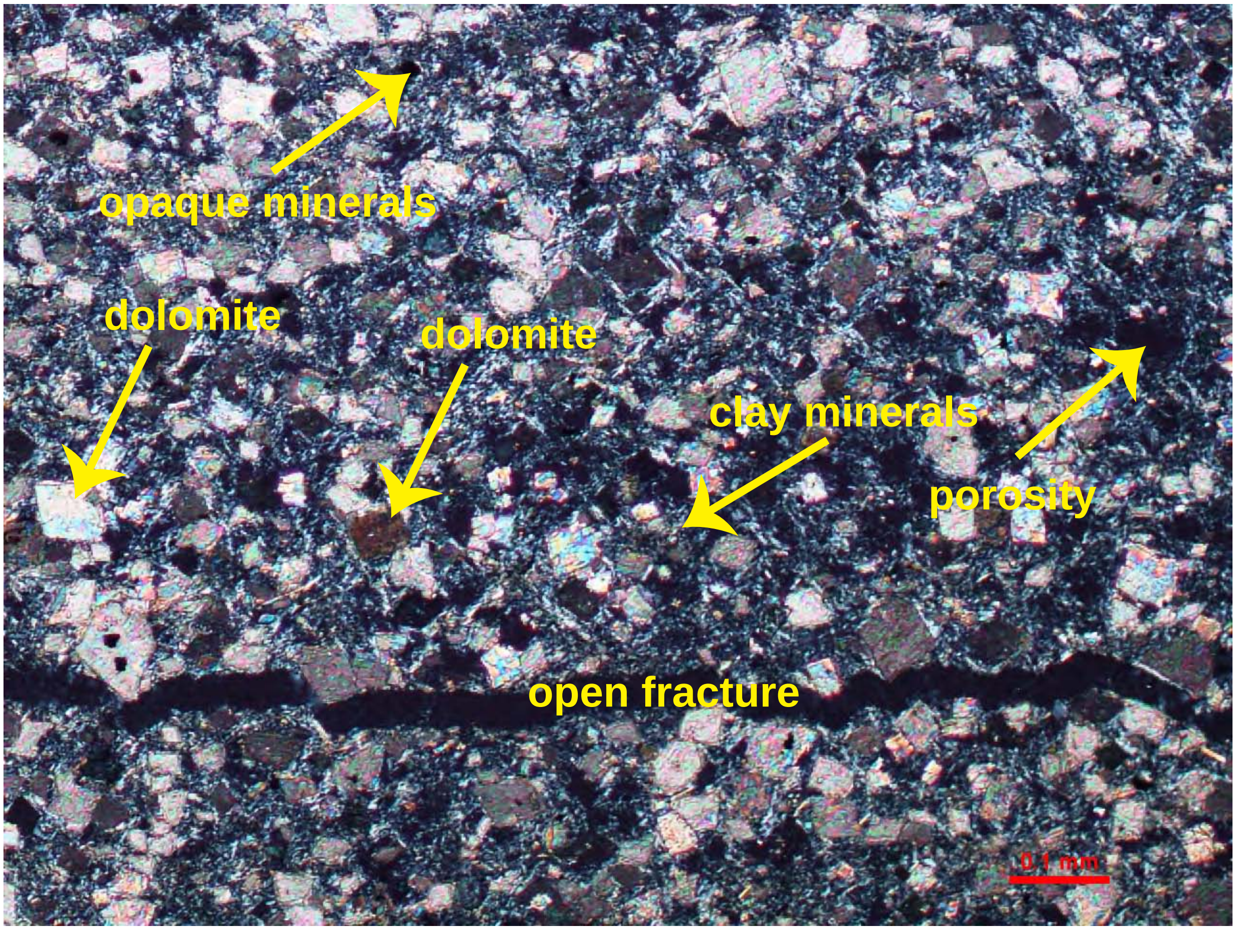


crossed polars

THIN SECTION PETROGRAPHIC ANALYSIS	Tonon USA Engineering, Measurements, and Testing, LLC

Project Name	Louisville Tunnel	Rock Type	shale
Project location	Louisville, KY	Alteration	dolomitized
Client	SM&E	Texture	Silty-shale
Client’s Project No.	1831-10-5629	Rock name	Dolomitized shale
Tonon USA No.	SM&E_2011_02	Studied by	Kathleen Surpless
Drill hole and depth	B-92 Sample 1 29.3’-29.7’	Date Studied	December 7, 2011
Formation	Waldron Shale	Reviewed by	Fulvio Tonon

Description of Individual Minerals:

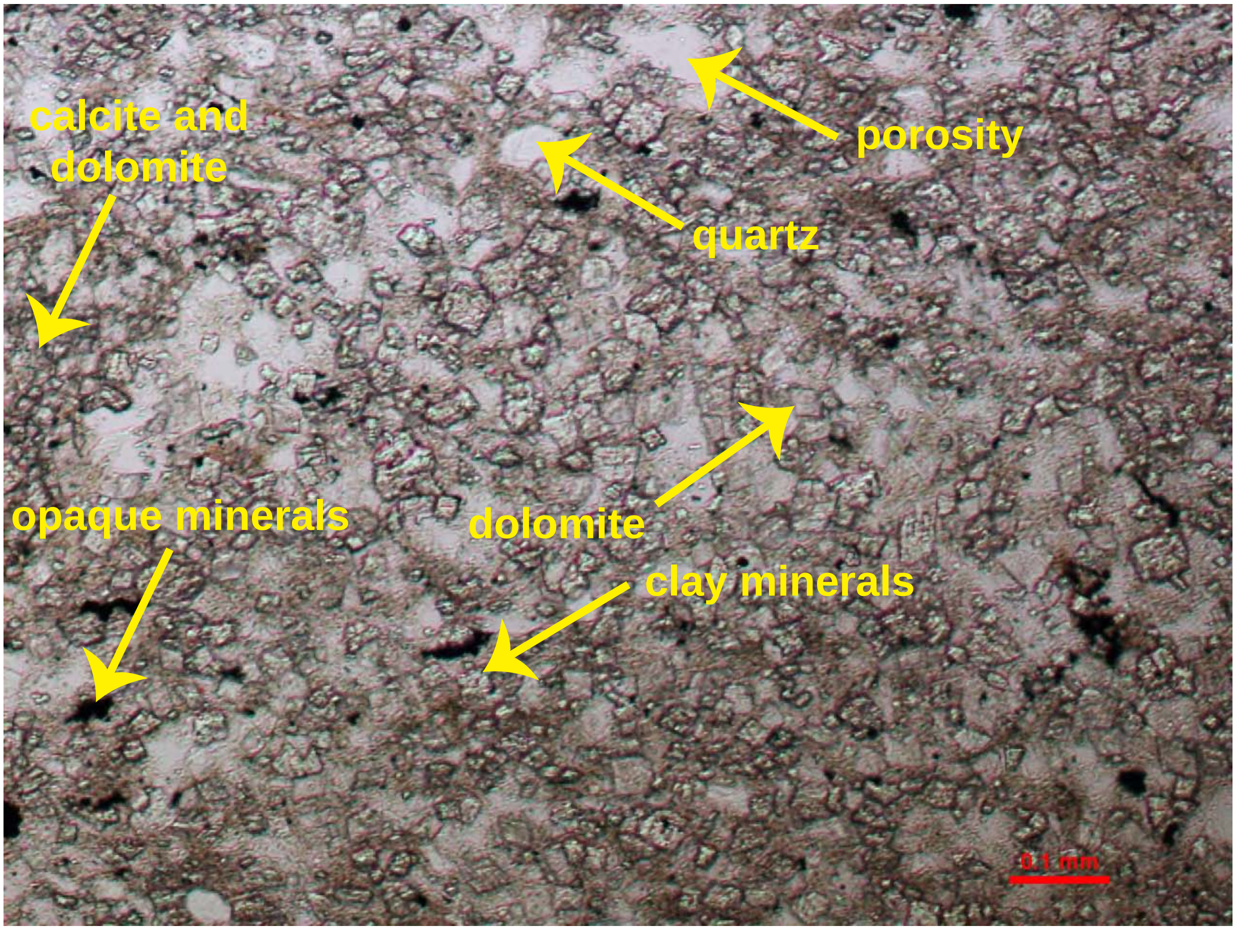
Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Dolomite	45	3.5-4	0.03-0.08	Distinctive rhombic shape, high relief, high birefringence; evenly distributed throughout sample
Matrix	25	1-3	<0.01	Likely clay minerals, but too small to determine composition
Opaque minerals	3	4-5	variable	Round to elongate shape, concentrated where post-depositional fluids moved through shale; could be iron oxide minerals or organic material
Quartz	5	7	0.02-0.07	Silt to very fine sand sized grains of quartz
Calcite	5	3	variable	Possibly filling pore space
porosity	17	NA	variable	Pore space is evenly distributed throughout slide
Weighted Average:		3.4	Excludes porosity	

Remarks: some preferred orientation results in fissile sample

2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

B-92 Sample 1, 29.3 to 29.7 ft



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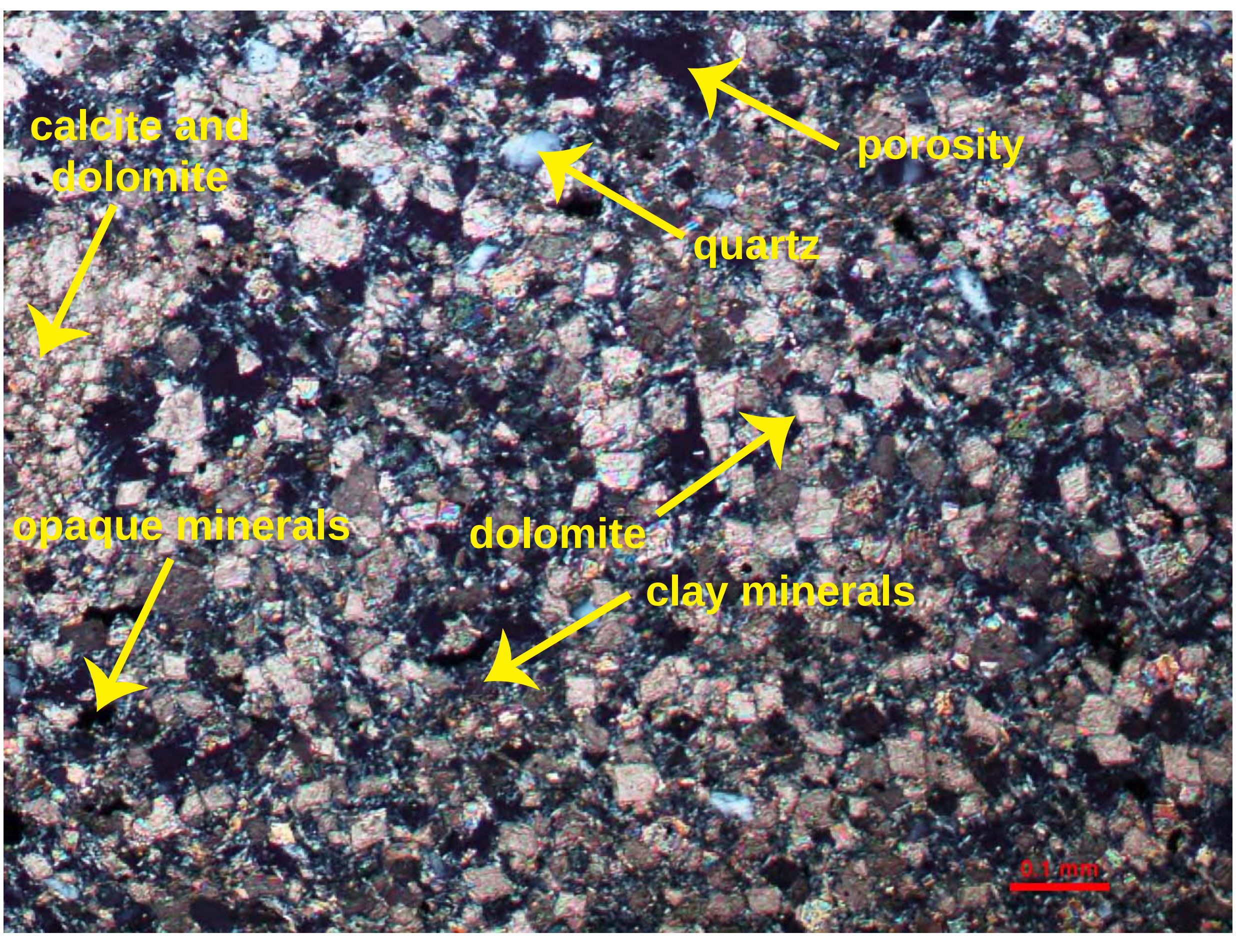
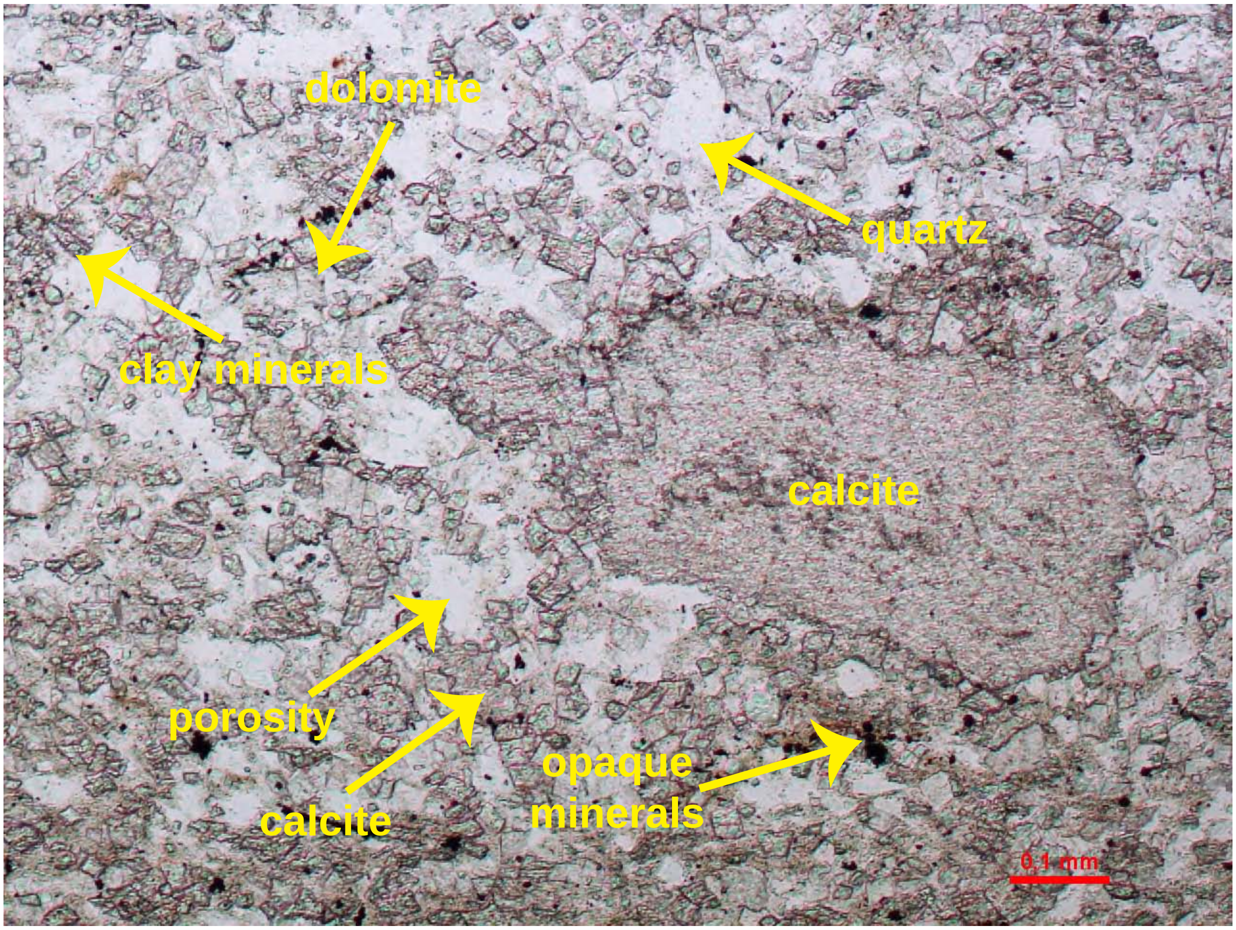


crossed polars

B-92 Sample 1, 29.3 to 29.7 ft



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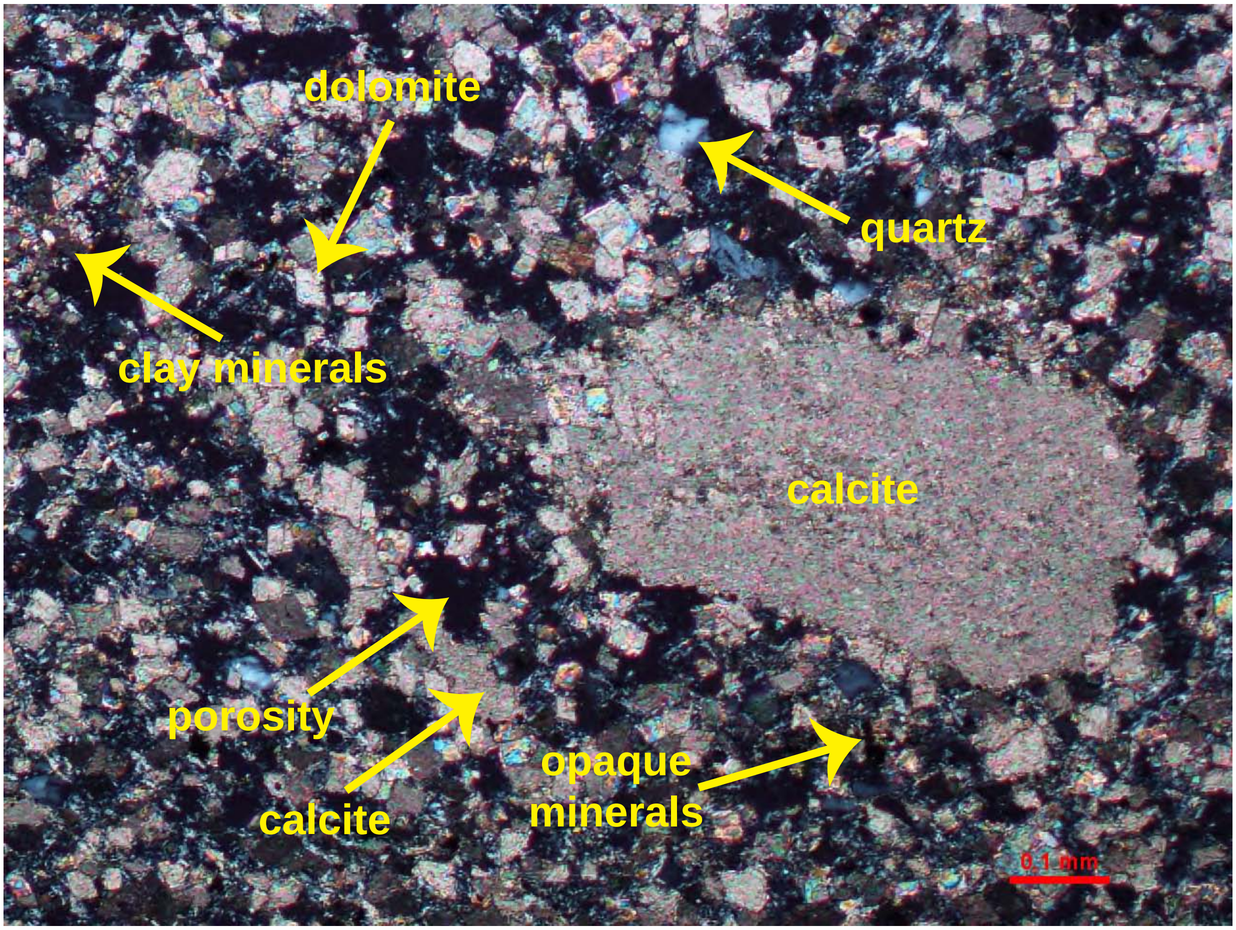


crossed polars

THIN SECTION PETROGRAPHIC ANALYSIS

Tonon USA

Engineering, Measurements, and Testing, LLC

Project Name	Louisville Tunnel	Rock Type	shale
Project location	Louisville, KY	Alteration	Dolomitized
Client	SM&E	Texture	Partially recrystallized silty shale
Client's Project No.	1831-10-5629	Rock name	Dolomitic shale
Tonon USA No.	SM&E_2011_02	Studied by	Kathleen Surpless
Drill hole and depth	B-93 Sample 1 29.5'-29.85'	Date Studied	December 7, 2011
Formation	Waldron Shale	Reviewed by	Fulvio Tonon

Description of Individual Minerals:

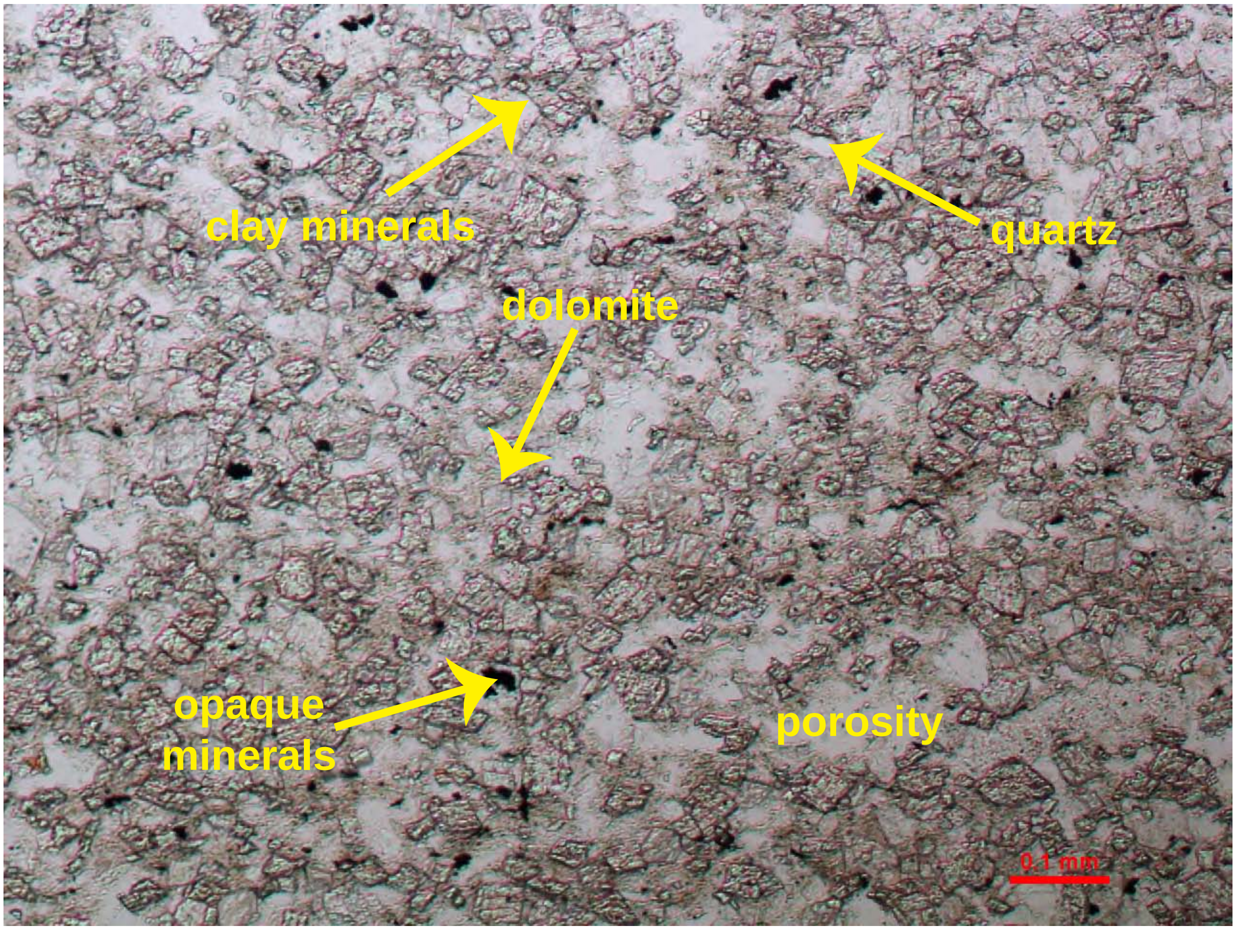
Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Dolomite	50	3.5-4	0.02-0.08	Distinctive rhombic shape, high relief, high birefringence; evenly distributed throughout sample
Matrix	30	1-3	<0.01	Likely clay minerals, but too small to determine composition
Opaque minerals	3	4-5	variable	could be iron oxide minerals or organic material
Quartz	5	7	0.02-0.04	Silt sized grains of quartz
porosity	12	NA	variable	Pore space throughout slide; a few large openings may be from plucked or dissolved fossils
Weighted Average:		3.4	Excludes porosity	

Remarks:

2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

B-93 Sample 1, 29.5 to 29.85 ft



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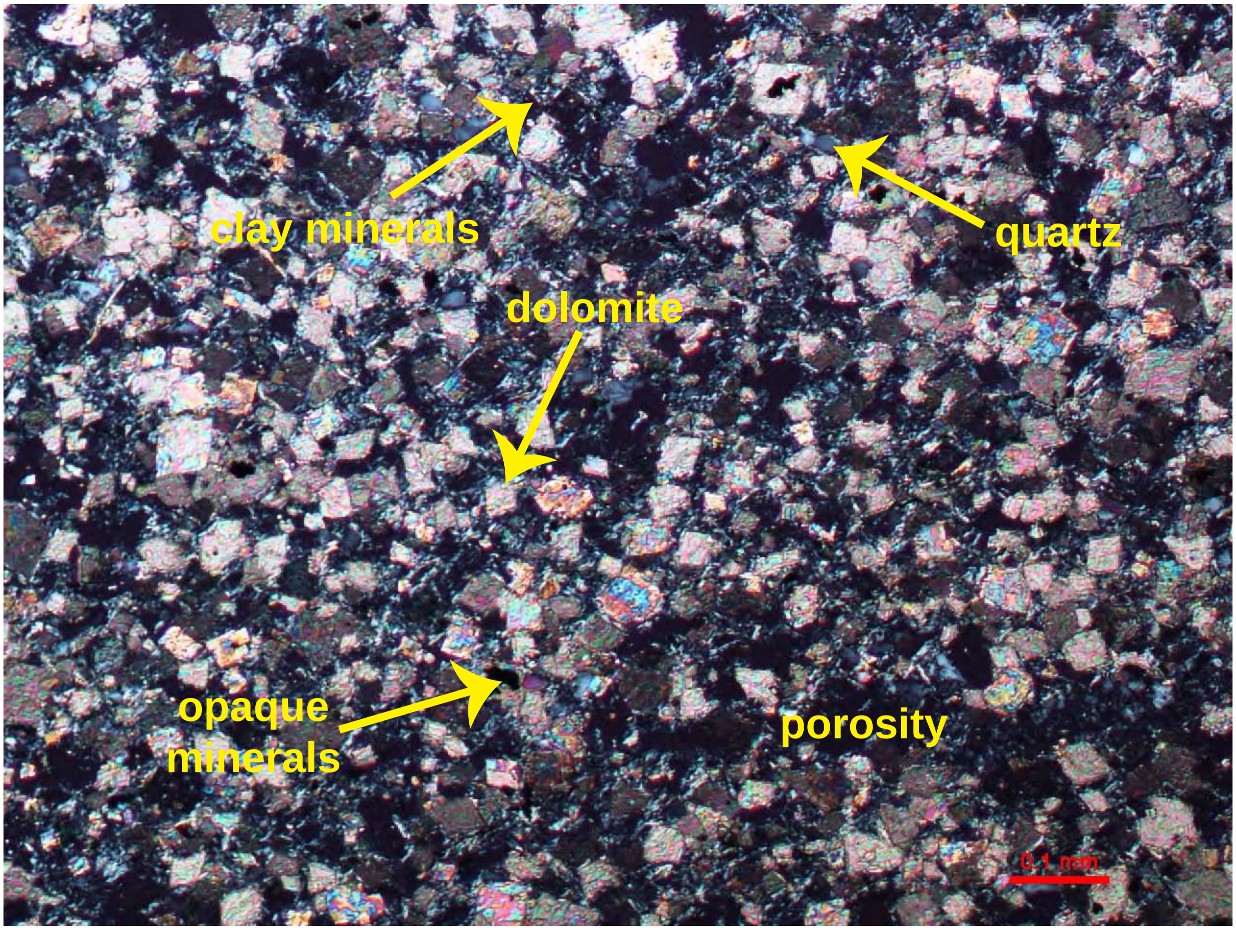


crossed polars

THIN SECTION PETROGRAPHIC ANALYSIS	Tonon USA Engineering, Measurements, and Testing, LLC

Project Name	Louisville Tunnel	Rock Type	Dolomitic shale
Project location	Louisville, KY	Alteration	dolomitized
Client	SM&E	Texture	Microcrystalline (recrystallized) shale
Client's Project No.	1831-10-5629	Rock name	Dolomitic shale or Shaley dolomite
Tonon USA No.	SM&E_2011_02	Studied by	Kathleen Surpless
Drill hole and depth	B-94 Sample 1 35.0'-35.4'	Date Studied	December 7, 2011
Formation	Waldron Shale	Reviewed by	Fulvio Tonon

Description of Individual Minerals:

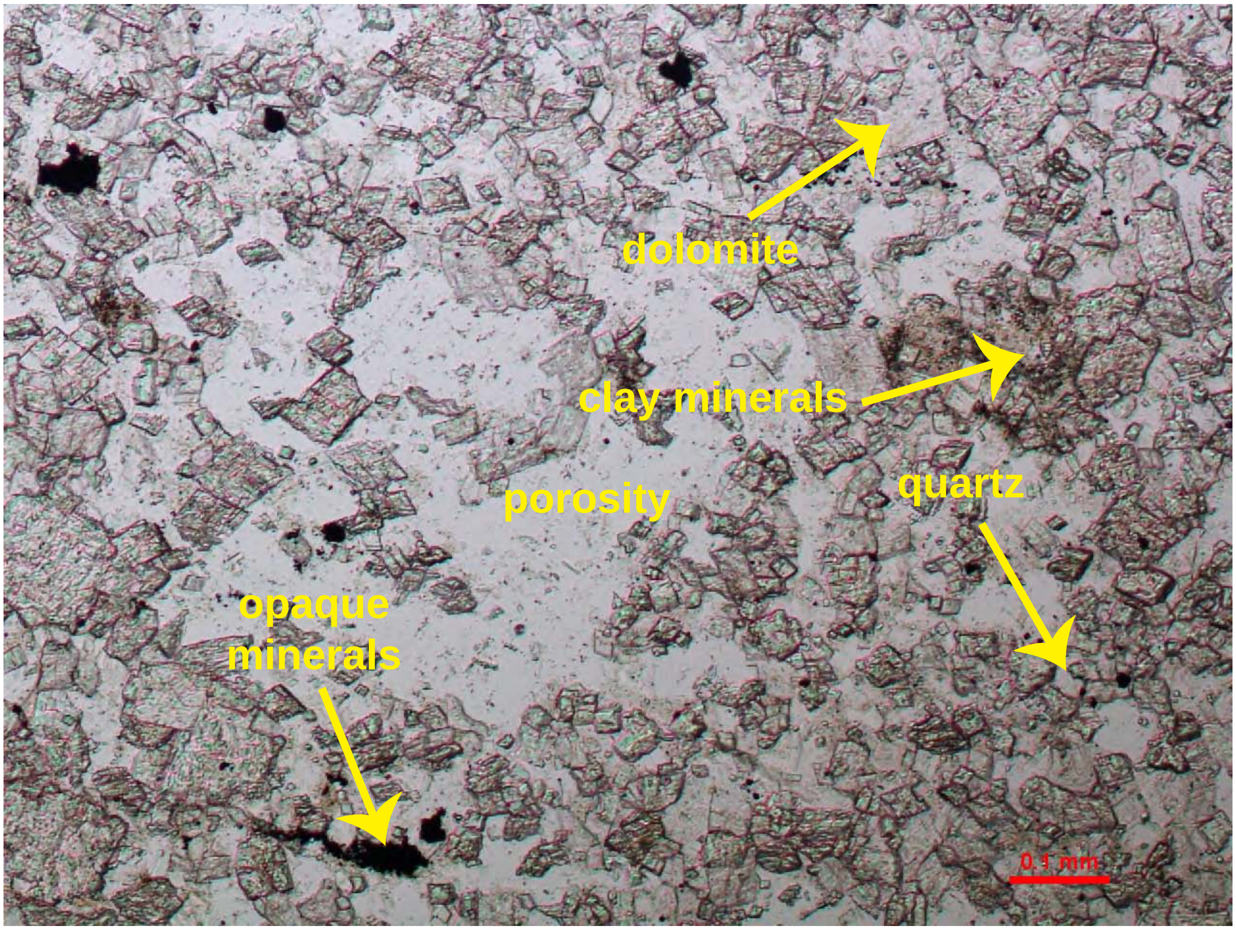
Minerals	Mineral Content (%)	Mohs Hardness	Grain Size (mm)	Description and Comments
Dolomite	70	3.5-4	0.02-0.1	Distinctive rhombic shape, high relief, high birefringence; evenly distributed throughout sample
Matrix	8	1-3	<0.01	Likely clay minerals, but too small to determine composition
Opaque minerals	5	4-5	variable	Blotchy shape; could be iron oxide minerals or organic material
Quartz	2	7	0.03	Silt sized grains of quartz
porosity	15	NA	variable	Pore space is unevenly distributed throughout slide; one side of slide is much more porous than the other
Weighted Average:		3.7	Excludes porosity	

Remarks: highly porous on one side and highly dolomitized on the other; some preferred alignment visible in overall sample; likely that the zones of intense dolomitization reduced original porosity

2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

B-94 Sample 1, 35.0 to 35.4 ft



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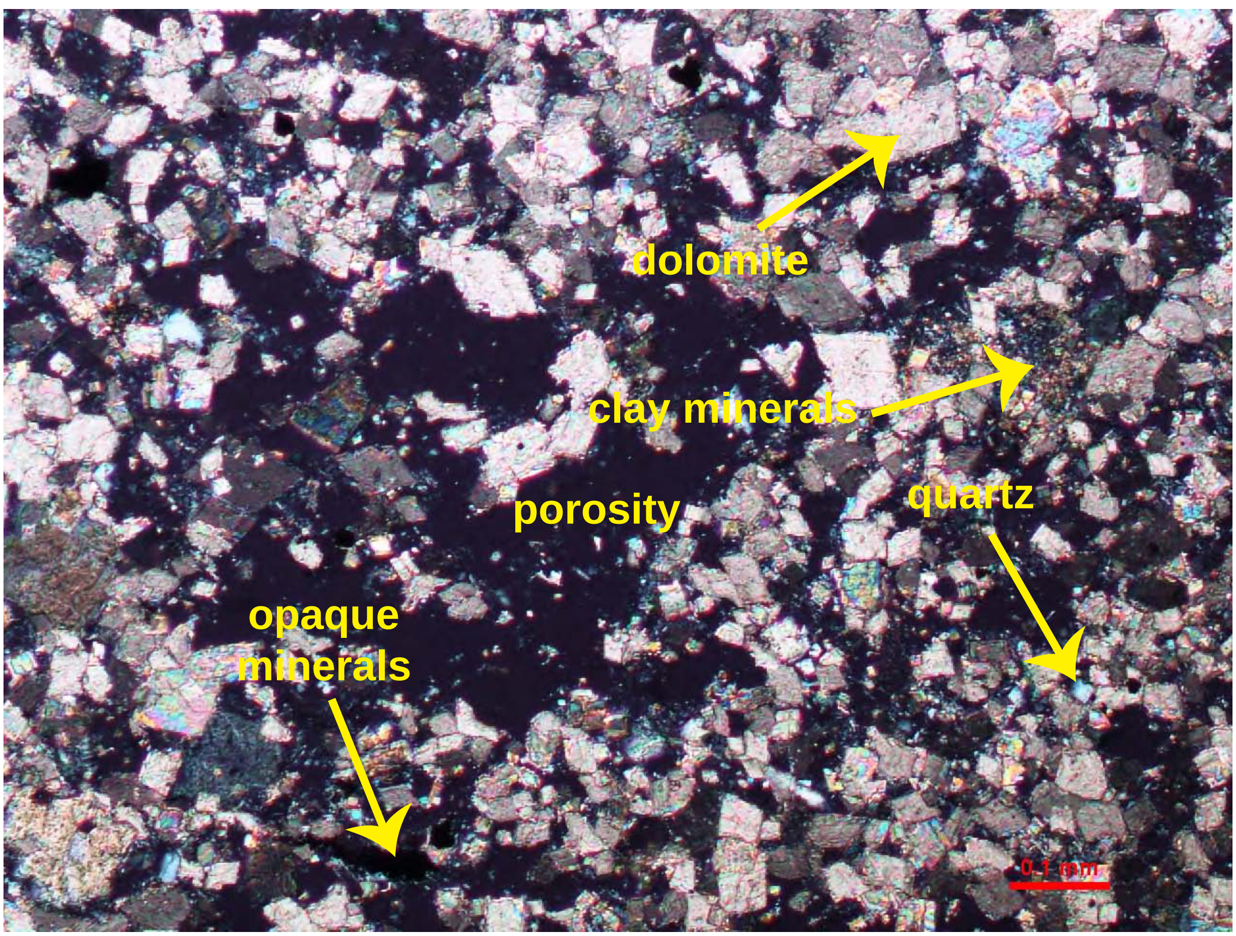
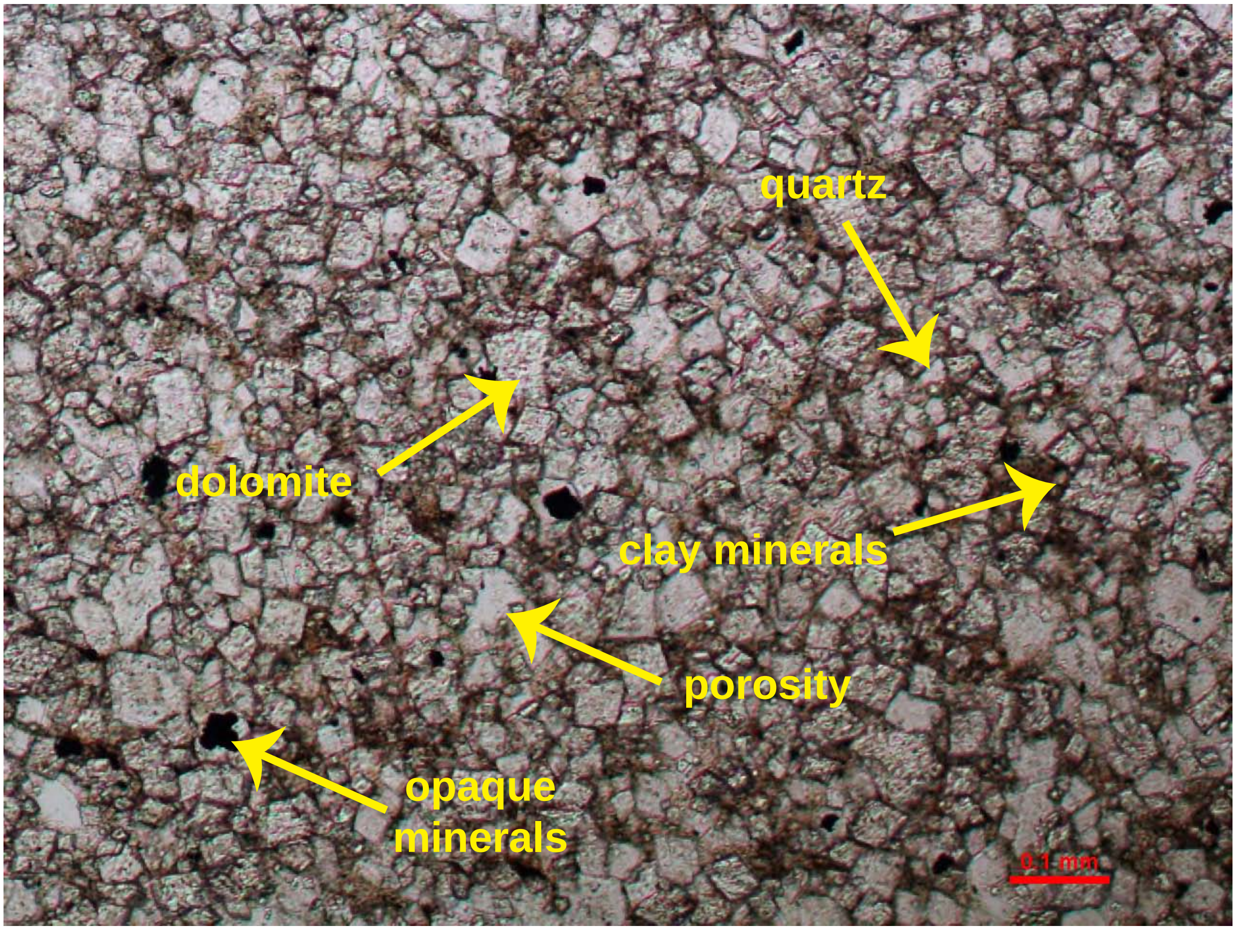
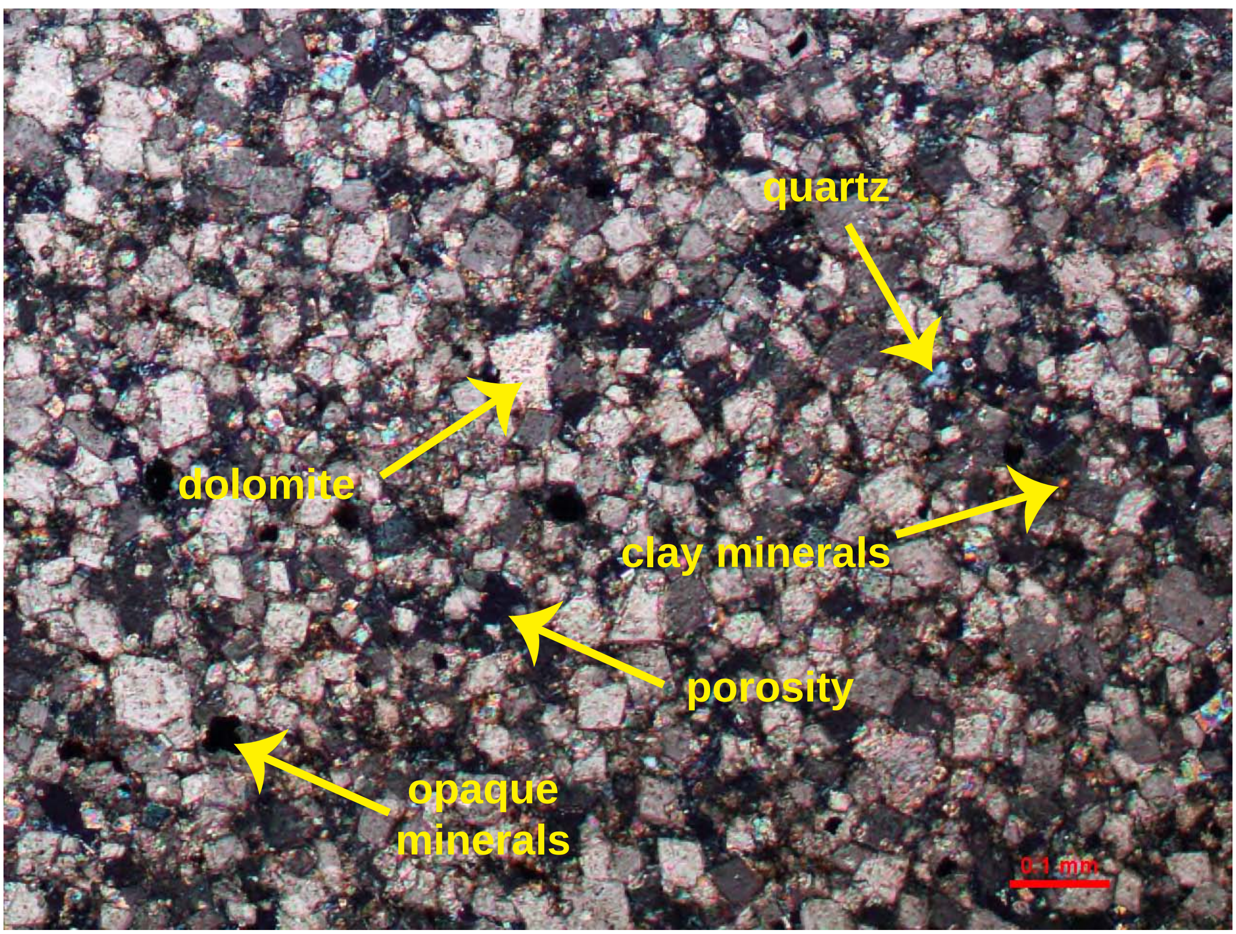


crossed polars

B-94 Sample 1, 35.0 to 35.4 ft



plane light



crossed polars

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

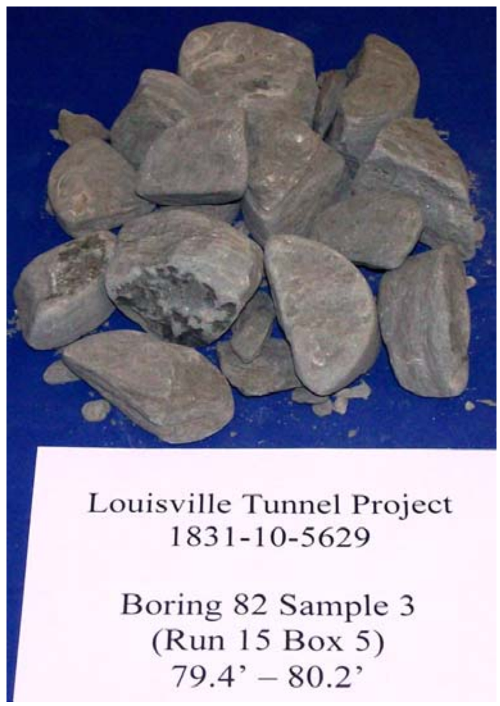
Project:	Louisville Tunnel	Sample Date:	10/21/2011
S&ME Project No.	1831-10-5629	Report Date:	11/11/2011
Material:	Waldron Shale		
Sample ID:	B-82 Sample 3 Run 15 Box 5 (79.4 - 80.2)		
Date Tested:	10/31/2011 to 11/2/2011		

Slake Durability Index (Second Cycle)	89.2	%
Range of water temperature (Cycle 1)	0.0	^{o}F
Average water temperature (Cycle 1)	71.5	^{o}F
Range of water temperature (Cycle 2)	0.5	^{o}F
Average water temperature (Cycle 2)	71.3	^{o}F
Natural Moisture Content	2.34	%

Sample Description (Check which applies)

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

Before Test



After Second Cycle

Phone: 865-970-0003 Fax: 865-970-2312
1413 Topside Road, Louisville, Tennessee 37777

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

Project:	Louisville Tunnel		Sample Date:	10/21/2011
S&ME Project No.	1831-10-5629		Report Date:	11/11/2011
Material:	Waldron Shale			
Sample ID:	B-82 Sample 5 Run 16 Box 5 (84.3 - 85.3)			
Date Tested:	10/31/2011 to 11/2/2011			

Slake Durability Index (Second Cycle)	94.9	%
Range of water temperature (Cycle 1)	0.0	^{o}F
Average water temperature (Cycle 1)	71.5	^{o}F
Range of water temperature (Cycle 2)	0.0	^{o}F
Average water temperature (Cycle 2)	71.0	^{o}F
Natural Moisture Content	2.18	%

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

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

Project:	Louisville Tunnel	Sample Date:	11/28/2011
S&ME Project No.	1831-10-5629	Report Date:	12/7/2011
Material:	Waldron Shale		
Sample ID:	B-85 Sample 3 Run 7 Box 3 (36.7 - 37.4)		
Date Tested:	12/5/2011 to 12/7/2011		

Slake Durability Index (Second Cycle)	96.4	%
Range of water temperature (Cycle 1)	1.0	^{o}F
Average water temperature (Cycle 1)	73.5	^{o}F
Range of water temperature (Cycle 2)	0.0	^{o}F
Average water temperature (Cycle 2)	72.5	^{o}F
Natural Moisture Content	2.86	%

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

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

Project:	Louisville Tunnel	Sample Date:	11/30/2011
S&ME Project No.	1831-10-5629	Report Date:	12/8/2011
Material:	Waldron Shale		
Sample ID:	B-86 Sample 2 Run 7 Box 2 (29.5 - 30.5)		
Date Tested:	12/5/2011 to 12/7/2011		

Slake Durability Index (Second Cycle)	93.3	%
Range of water temperature (Cycle 1)	0.5	^{o}F
Average water temperature (Cycle 1)	73.3	^{o}F
Range of water temperature (Cycle 2)	0.0	^{o}F
Average water temperature (Cycle 2)	72.5	^{o}F
Natural Moisture Content	3.65	%

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

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

Project:	Louisville Tunnel	Sample Date:	11/17/2011
S&ME Project No.	1831-10-5629	Report Date:	12/2/2011
Material:	Waldron Shale		
Sample ID:	B-87 Sample 4 Run 6 Box 2 (24.9 - 25.9)		
Date Tested:	11/29/2011 to 12/1/2011		

Slake Durability Index (Second Cycle)	94.1	%
Range of water temperature (Cycle 1)	0.5	^{o}F
Average water temperature (Cycle 1)	66.3	^{o}F
Range of water temperature (Cycle 2)	0.5	^{o}F
Average water temperature (Cycle 2)	69.8	^{o}F
Natural Moisture Content	2.83	%

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

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

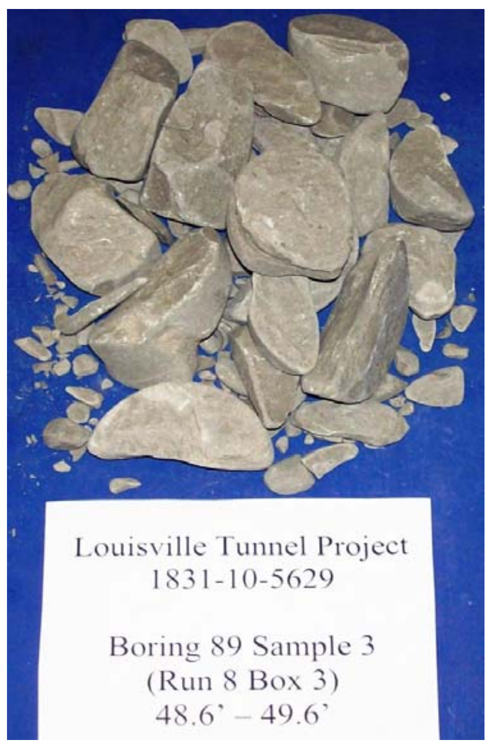
Project:	Louisville Tunnel	Sample Date:	11/16/2011
S&ME Project No.	1831-10-5629	Report Date:	12/5/2011
Material:	Waldron Shale		
Sample ID:	B-89 Sample 3 Run 8 Box 3 (48.6 - 49.6)		
Date Tested:	11/29/2011 to 12/1/2011		

Slake Durability Index (Second Cycle)	92.2	%
Range of water temperature (Cycle 1)	0.5	^{o}F
Average water temperature (Cycle 1)	66.8	^{o}F
Range of water temperature (Cycle 2)	1.0	^{o}F
Average water temperature (Cycle 2)	69.5	^{o}F
Natural Moisture Content	1.86	%

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

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

Project:	Louisville Tunnel		Sample Date:	11/2/2011
S&ME Project No.	1831-10-5629		Report Date:	11/23/2011
Material:	Waldron Shale			
Sample ID:	B-91 Sample 3 Run 7 Box 2 (45.0 - 46.0)			
Date Tested:	11/15/2011 to 11/17/2011			

Slake Durability Index (Second Cycle)	86.6	%
Range of water temperature (Cycle 1)	0.0	^{o}F
Average water temperature (Cycle 1)	75.0	^{o}F
Range of water temperature (Cycle 2)	1.0	^{o}F
Average water temperature (Cycle 2)	76.0	^{o}F
Natural Moisture Content	2.42	%

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

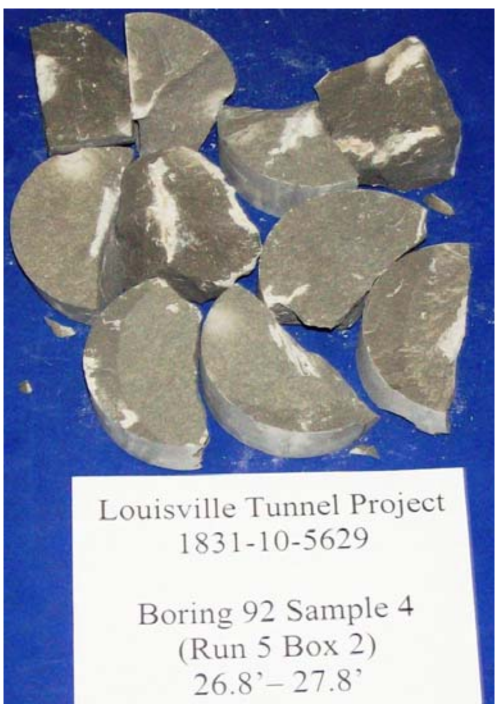
Slake Durability of Shales of Similar Weak Rocks (ASTM D4644)

Project:	Louisville Tunnel		Sample Date:	11/1/2011
S&ME Project No.	1831-10-5629		Report Date:	11/18/2011
Material:	Waldron Shale			
Sample ID:	B-92 Sample 4 Run 5 Box 2 (26.8 - 27.8)			
Date Tested:	11/15/2011 to 11/17/2011			

Slake Durability Index (Second Cycle)	87.4	%
Range of water temperature (Cycle 1)	0.5	^oF
Average water temperature (Cycle 1)	75.3	^oF
Range of water temperature (Cycle 2)	1.5	^oF
Average water temperature (Cycle 2)	76.3	^oF
Natural Moisture Content	2.64	%

Sample Description (Check which applies)

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



Before Test

After Second Cycle

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1413 Topside Road, Louisville, Tennessee 37777

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

Project:	Louisville Tunnel	Sample Date:	11/3/2011
S&ME Project No.	1831-10-5629	Report Date:	11/30/2011
Material:	Waldron Shale		
Sample ID:	B-93 Sample 5 Run 6 Box 2 (31.9 - 33.0)		
Date Tested:	11/15/2011 to 11/17/2011		

Slake Durability Index (Second Cycle)	87.5	%
Range of water temperature (Cycle 1)	0.0	^{o}F
Average water temperature (Cycle 1)	75.5	^{o}F
Range of water temperature (Cycle 2)	1.0	^{o}F
Average water temperature (Cycle 2)	76.0	^{o}F
Natural Moisture Content	2.51	%

Sample Description (Check which applies)

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

Before Test

After Second Cycle

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

1413 Topside Road, Louisville, Tennessee 37777

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

Project:	Louisville Tunnel	Sample Date:	11/3/2011
S&ME Project No.	1831-10-5629	Report Date:	11/30/2011
Material:	Shale		
Sample ID:	B-93 Sample 9 Run 15 Box 5 (75.1 - 76.1)		
Date Tested:	11/15/2011 to 11/17/2011		

Slake Durability Index (Second Cycle)	91.1	%
Range of water temperature (Cycle 1)	0.0	^{o}F
Average water temperature (Cycle 1)	75.0	^{o}F
Range of water temperature (Cycle 2)	0.5	^{o}F
Average water temperature (Cycle 2)	75.3	^{o}F
Natural Moisture Content	2.30	%

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

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

Project:	Louisville Tunnel	Sample Date:	11/4/2011
S&ME Project No.	1831-10-5629	Report Date:	12/1/2011
Material:	Waldron Shale		
Sample ID:	B-94 Sample 3 Run 6 Box 2 (35.7 - 36.9)		
Date Tested:	11/29/2011 to 12/1/2011		

Slake Durability Index (Second Cycle)	94.7	%
Range of water temperature (Cycle 1)	0.5	^{o}F
Average water temperature (Cycle 1)	66.8	^{o}F
Range of water temperature (Cycle 2)	1.0	^{o}F
Average water temperature (Cycle 2)	69.5	^{o}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

Phone: 865-970-0003 Fax: 865-970-2312
1413 Topside Road, Louisville, Tennessee 37777

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

Project:	Louisville Tunnel
S&ME Project No.	1831-10-5629
Material:	Shale
Sample ID:	B-94 Sample 9 Run 16 Box 5 (86.5 - 87.2)
Date Tested:	11/29/2011 to 12/1/2011

Sample Date:	11/4/2011
Report Date:	12/1/2011

Slake Durability Index (Second Cycle)	91.1	%
Range of water temperature (Cycle 1)	0.5	^{o}F
Average water temperature (Cycle 1)	66.8	^{o}F
Range of water temperature (Cycle 2)	0.5	^{o}F
Average water temperature (Cycle 2)	69.3	^{o}F
Natural Moisture Content	1.73	%

Sample Description (Check which applies)

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

Before Test

After Second Cycle

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

1413 Topside Road, Louisville, Tennessee 37777

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

Job Name: **Louisville Twin Tunnels**

Job Number: **1831-10-5629 (B)**

Operator: LP, DB
Checked By: NRR

.

Specimen ID:	B-82, S6	B-92, S2	B-91, S4	B-93, S3	
Depth (ft):	85.3-86.3	20.8-21.5	46.0-46.6	28.6-29.3	
Specimen Mass (g):	523.28	530.60	516.50	487.60	
Specimen Volume:					
Avgerage Dia. (mm)	**50.37**	**50.25**	**50.22**	**50.15**	
Average Length (mm)	**99.41**	**103.14**	**100.67**	**94.89**	
Area (cm^2)	**19.92**	**19.83**	**19.81**	**19.76**	
Volume (cm^3), V	**198.05**	**204.51**	**199.44**	**187.46**	
Water Content (ratio)	0.0150	0.0220	0.029	0.018	
Crushed Minus No. 4 Mass					
Mass of Solids (g)	**510.99**	**512.22**	**496.01**	**484.72**	
Effective Unit Weight (g/cm^3)	**2.64**	**2.59**	**2.59**	**2.60**	
Dry Unit Weight (g/cm^3)	**2.58**	**2.50**	**2.49**	**2.59**	
Dry Unit Weight (lb/ft^3)	**161.1**	**156.4**	**155.3**	**161.4**	
Specific Gravity of Solids from RTH 108	2.83	2.83	2.81	2.83	
Grain Unit Weight (lb/ft^3)	**176.4**	**176.2**	**174.8**	**176.1**	
Total Porosity (%), $n=V_v/V$	**8.71**	**11.28**	**11.15**	**8.35**	
Volume of Solids (cm^3), V_s	180.8	181.4	177.2	171.8	
Volume of Voids (cm^3), V_v	17.25	23.08	22.25	15.65	
Volume of Water (cm^3), V_w	7.68	11.29	14.41	8.74	
[1]Void Ratio, $e=V_v/V_s$	**0.0954**	**0.1272**	**0.1255**	**0.0911**	
[1]Degree of Saturation (%), $S=V_w/V_v$	**45%**	**49%**	**65%**	**56%**	

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 a 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 (B)**

Sampl Date: **11/28/2011**

Operator: LP, DB
Checked By: NRR

Specimen ID:	B-85 S-4	B-86 S-3			
Depth (ft):	38.2 - 39.0	30.5 - 31.3			
Specimen Mass (g):	388.4	437.2			
Specimen Volume:					
Avgerage Dia. (mm)	**49.96**	**49.99**			
Average Length (mm)	**74.49**	**85.08**			
Area (cm^2)	**19.61**	**19.63**			
Volume (cm^3), V	**146.04**	**166.99**			
Water Content (ratio)	0.0240	0.0290			
Crushed Minus No. 4 Mass					
Mass of Solids (g)	**376.94**	**420.67**			
Effective Unit Weight (g/cm^3)	**2.66**	**2.62**			
Dry Unit Weight (g/cm^3)	**2.58**	**2.52**			
Dry Unit Weight (lb/ft^3)	**161.1**	**157.3**			
Specific Gravity of Solids from RTH 108	2.83	2.83			
Grain Unit Weight (lb/ft^3)	**176.2**	**176.5**			
Total Porosity (%), $n=V_v/V$	**8.54**	**10.89**			
Volume of Solids (cm^3), V_s	133.6	148.8			
Volume of Voids (cm^3), V_v	12.47	18.19			
Volume of Water (cm^3), V_w	9.07	12.22			
[1]**Void Ratio, $e=V_v/V_s$**	**0.0934**	**0.1223**			
[1]**Degree of Saturation (%), $S=V_w/V_v$**	**73%**	**67%**			

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

Job Name: **Louisville Twin Tunnels**

Job Number: **1831-10-5629 (B)**

Sampl Date: **11/4/2011**

Operator: LP, DB
Checked By: NRR

Specimen ID:	B-89, S4	B94, S4			
Depth (ft):	49.6 - 50.4	36.9 - 37.4			
Specimen Mass (g):	521.4	500.9			
Specimen Volume:					
Avgerage Dia. (mm)	**50.13**	**50.04**			
Average Length (mm)	**100.37**	**96.74**			
Area (cm^2)	**19.73**	**19.67**			
Volume (cm^3), V	**198.08**	**190.28**			
Water Content (ratio)	0.0290	0.0240			
Crushed Minus No. 4 Mass					
Mass of Solids (g)	**501.74**	**484.71**			
Effective Unit Weight (g/cm^3)	**2.63**	**2.63**			
Dry Unit Weight (g/cm^3)	**2.53**	**2.55**			
Dry Unit Weight (lb/ft^3)	**158.1**	**159.0**			
Specific Gravity of Solids from RTH 108	2.84	2.83			
Grain Unit Weight (lb/ft^3)	**176.7**	**176.3**			
Total Porosity (%), n=V_v/V	**10.53**	**9.80**			
Volume of Solids (cm^3), V_s	177.2	171.6			
Volume of Voids (cm^3), V_v	20.86	18.66			
Volume of Water (cm^3), V_w	14.58	11.66			
[1]Void Ratio, e=V_v/V_s	**0.1177**	**0.1087**			
[1]Degree of Saturation (%), S=V_w/V_v	**70%**	**62%**			

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

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: **10/21/2011** Report Date: 11/11/2011

Project Name: **Louisville Tunnel Project**

Lab ID	Boring ID	Depth (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)
C11-361	B-82 (1) Run 3 Box 1	22.7	L'ville Limestone	As-Received	A	N/A	M	1.98	1.50	1.46	3.68	1.92	1847	502	0.989	496	3	11,391
C11-361	B-82 (1) Run 3 Box 1	22.9	L'ville Limestone	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	2115	557	0.996	555	2	12,746
C11-362	B-82 (2) Run 8 Box 3	50.6	L'ville Limestone	As-Received	A	⊥PSF	MP	1.98	1.57	1.52	3.83	1.96	2951	770	0.998	768	3	17,668
C11-362	B-82 (2) Run 8 Box 3	50.7	L'ville Limestone	As-Received	D	‖PSf	MP	N/A	1.97	1.93	3.80	1.95	2408	634	0.996	631	2, 3	14,508
C11-364	B-82 (4) Run 15 Box 5	80.4	Waldron Shale	As-Received	A	⊥Bed	MB	1.98	1.57	1.50	3.78	1.94	1574	416	0.993	413	3	9,493
C11-364	B-82 (4) Run 15 Box 5	80.6	Waldron Shale	As-Received	D	‖Bed	MB	N/A	1.97	1.93	3.80	1.95	590	155	0.996	154	2	3,547
C11-367	B-82 (7) Run 18 Box 6	96.9	Laurel Dolomite	As-Received	A	N/A	M	1.98	1.59	1.54	3.88	1.97	3707	955	1.000	955	3	21,974
C11-367	B-82 (7) Run 18 Box 6	97.1	Laurel Dolomite	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	3562	937	0.996	933	2	21,441

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

Point Load Strength Index of Rock (for Horizontal Borings)

ASTM D5731, ISRM Point Load Test

S&ME

Quality Assurance

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

Project #: **1831-10-5629** Sample Date: **10/17/2011** Report Date: 11/3/2011

Project Name: **Louisville Tunnel Project**

Lab ID	Boring ID	Depth (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)
C11-346	B-83 (1) Run 3 Box 1	11.2	L'ville Limestone	As-Received	A	⊥PSF	MP	1.98	1.50	1.46	3.68	1.92	2631	715	0.989	707	3	16,225
C11-346	B-83 (1) Run 3 Box 1	11.4	L'ville Limestone	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	1357	357	0.996	356	2	8,169
C11-348	B-83 (3) Run 6 Box 2	30.7	L'ville Limestone	As-Received	A	⊥PSF	MP	1.98	1.56	1.54	3.88	1.97	2516	648	1.000	648	3	14,910
C11-348	B-83 (3) Run 6 Box 2	30.9	L'ville Limestone	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	2526	665	0.996	662	2, 3	15,217

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

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: **10/19/2011** Report Date: 11/3/2011

Project Name: **Louisville Tunnel Project**

Lab ID	Boring ID	Depth (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)
C11-351	B-84 (2) Run 2 Box 1	10.4	L'ville Limestone	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	2842	748	0.996	745	2	17,116
C11-352	B-84 (3) Run 2 Box 1	11.0	L'ville Limestone	As-Received	A	N/A	M	1.98	1.54	1.50	3.78	1.94	3440	910	0.993	904	3	20,765
C11-354	B-84 (5) Run 3 Box 1	18.2	L'ville Limestone	As-Received	A	N/A	M	1.98	1.46	1.42	3.58	1.89	2998	837	0.982	822	3	18,834
C11-354	B-84 (5) Run 3 Box 1	18.0	L'ville Limestone	As-Received	D	N/A	M	N/A	1.97	1.91	3.76	1.94	2496	664	0.993	659	2	15,152
C11-355	B-84 (6) Run 5 Box 2	24.4	L'ville Limestone	As-Received	A	N/A	M	1.98	1.54	1.50	3.78	1.94	2671	707	0.993	702	3	16,133
C11-355	B-84 (6) Run 5 Box 2	24.6	L'ville Limestone	As-Received	D	N/A	M	N/A	1.97	1.91	3.76	1.94	2398	638	0.993	634	2	14,559
C11-357	B-84 (8) Run 7 Box 2	34.4	L'ville Limestone	As-Received	A	N/A	M	1.98	1.48	1.42	3.58	1.89	2586	722	0.982	709	3	16,246
C11-357	B-84 (8) Run 7 Box 2	34.2	L'ville Limestone	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	1989	523	0.996	521	2	11,968

Nomenclature

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

Anisotropic Load: $\perp$ = 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

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: **11/28/2011**   Report Date: 12/7/2011

Project Name: **Louisville Tunnel Project**

Lab ID	Boring ID	Depth (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)
C11-416	B-85 (1) Run 2 Box 1	9.6	L'ville Limestone	As-Received	A	N/A	M	1.98	1.59	1.56	3.93	1.98	2697	686	1.003	688	3	15,828
C11-416	B-85 (1) Run 2 Box 1	9.8	L'ville Limestone	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	2731	719	0.996	716	2	16,453
C11-417	B-85 (2) Run 7 Box 3	36.2	Waldron Shale	As-Received	A	$\perp$bed	MB	1.97	1.56	1.52	3.81	1.95	1362	357	0.996	356	3	8,169
C11-417	B-85 (2) Run 7 Box 3	35.8	Waldron Shale	As-Received	D	$\parallel$bed	MB	N/A	1.95	1.93	3.76	1.94	282	75	0.993	74	2	1,711
C11-420	B-85 (5) Run 12 Box 4	61.6	Laurel Dolomite	As-Received	A	N/A	M	1.98	1.61	1.57	3.96	1.99	3093	781	1.005	785	3	18,070
C11-420	B-85 (5) Run 12 Box 4	61.8	Laurel Dolomite	As-Received	D	N/A	M	N/A	1.97	1.91	3.76	1.94	1979	526	0.993	522	2	12,003

Nomenclature

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

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

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: **11/30/2011** Report Date: 12/8/2011

Project Name: **Louisville Tunnel Project**

Lab ID	Boring ID	Depth (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)
C11-423	B-86 (1) Run 2 Box 1	7.0	L'ville Limestone	As-Received	A	N/A	M	1.98	1.44	1.40	3.53	1.88	2687	761	0.980	746	3	17,075
C11-423	B-86 (1) Run 2 Box 1	7.2	L'ville Limestone	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	2071	545	0.996	543	2	12,471
C11-426	B-86 (4) Run 8 Box 3	36.8	Waldron Shale	As-Received	A	⊥ bed	MB	1.97	1.56	1.52	3.81	1.95	1283	337	0.996	336	3	7,711
C11-426	B-86 (4) Run 8 Box 3	36.6	Waldron Shale	As-Received	D	‖ bed	MB	N/A	1.95	1.91	3.72	1.93	360	97	0.991	96	2 note	2,207
C11-427	B-86 (5) Run 13 Box 5	62.5	Laurel Dolomite	As-Received	A	N/A	M	1.98	1.56	1.52	3.83	1.96	2816	735	0.998	734	3	16,865
C11-427	B-86 (5) Run 13 Box 5	62.7	Laurel Dolomite	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	2305	607	0.996	605	2	13,890

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: Failure did not go through both loading points.

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: **11/17/2011** Report Date: 12/2/2011

Project Name: **Louisville Tunnel Project**

Lab ID	Boring ID	Depth (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)
C11-402	B-87 (2) Run 2 Box 1	7.2	L'ville Limestone	As-Received	A	⊥PSF	MP	1.97	1.57	1.54	3.86	1.96	2292	594	0.998	593	3	13,630
C11-402	B-87 (2) Run 2 Box 1	7.3	L'ville Limestone	As-Received	D	‖PSF	MP	N/A	1.95	1.91	3.72	1.93	1177	316	0.991	313	2	7,191
C11-403	B-87 (3) Run 4 Box 1	15.5	L'ville Limestone	As-Received	A	N/A	M	1.97	1.61	1.57	3.94	1.98	2982	757	1.003	759	3	17,466
C11-403	B-87 (3) Run 4 Box 1	15.7	L'ville Limestone	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	3553	935	0.996	931	2, 3	21,395
C11-405	B-87 (5) Run 6 Box 2	27.4	Waldron Shale	As-Received	A	⊥bed	MB	1.96	1.42	1.38	3.44	1.85	845	246	0.972	239	4	5,473
C11-405	B-87 (5) Run 6 Box 2	27.9	Waldron Shale	As-Received	D	‖bed	MB	N/A	1.93	1.91	3.69	1.92	129	35	0.989	35	2	794

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

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: **11/17/2011** Report Date: 12/3/2011

Project Name: **Louisville Tunnel Project**

Lab ID	Boring ID	Depth (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)
C11-406	B-88 (1) Run 1 Box 1	10.8	L'ville Limestone	As-Received	A	N/A	M	1.97	1.50	1.46	3.66	1.91	2472	675	0.987	666	3	15,274
C11-406	B-88 (1) Run 1 Box 1	11.0	L'ville Limestone	As-Received	D	N/A	M	N/A	1.95	1.91	3.72	1.93	1901	511	0.991	506	2	11,628
C11-408	B-88 (3) Run 2 Box 1	16.0	L'ville Limestone	As-Received	A	⊥bed	M	1.97	1.32	1.26	3.16	1.78	2650	839	0.956	802	3	18,293
C11-408	B-88 (3) Run 2 Box 1	16.2	L'ville Limestone	As-Received	D	‖bed	M	N/A	1.95	1.91	3.72	1.93	1963	528	0.991	523	2	12,015
C11-409	B-88 (4) Run 3 Box 1	22.5	L'ville Limestone	As-Received	A	N/A	M	1.98	1.67	1.63	4.11	2.03	4290	1044	1.014	1059	3	24,420
C11-409	B-88 (4) Run 3 Box 1	22.7	L'ville Limestone	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	5115	1346	0.996	1341	2, 3	30,800
C11-410	B-88 (5) Run 5 Box 2	29.8	L'ville Limestone	As-Received	A	N/A	MP	1.97	1.61	1.57	3.94	1.98	1458	370	1.003	371	3 note	8,537
C11-410	B-88 (5) Run 5 Box 2	30.0	L'ville Limestone	As-Received	D	N/A	MP	N/A	1.97	1.93	3.80	1.95	474	125	0.996	125	2 note	2,860

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: Specimen failed through a pressure solution feature.

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

S&ME

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: **11/16/2011** Report Date: 12/5/2011

Project Name: **Louisville Tunnel Project**

Lab ID	Boring ID	Depth (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)
C11-411	B-89 (1) Run 2 Box 1	18.6	L'ville Limestone	As-Received	A	N/A	M	1.97	1.57	1.54	3.86	1.96	2851	739	0.998	738	3	16,957
C11-411	B-89 (1) Run 2 Box 1	18.8	L'ville Limestone	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	2004	527	0.996	525	2	12,059
C11-412	B-89 (2) Run 8 Box 3	48.0	Waldron Shale	As-Received	A	N/A	M	1.97	1.56	1.50	3.76	1.94	1217	324	0.993	322	3	7,393
C11-412	B-89 (2) Run 8 Box 3	47.8	Waldron Shale	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	1288	339	0.996	338	2	7,757
C11-415	B-89 (5) Run 14 Box 5	75.8	Laurel Dolomite	As-Received	A	N/A	M	1.98	1.65	1.61	4.06	2.01	2861	705	1.009	711	3	16,401
C11-415	B-89 (5) Run 14 Box 5	76.0	Laurel Dolomite	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	3117	820	0.996	817	2	18,764

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

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

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

Point Load Strength Index of Rock

ASTM D5731, ISRM Point Load Test

S&ME

Quality Assurance

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

Project #: **1831-10-5629**   Sample Date: **11/30/2011**   Report Date: 12/9/2011

Project Name: **Louisville Tunnel Project**

Lab ID	Boring ID	Depth (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)
C11-428	B-90 (1) Run 2 Box 1	7.5	L'ville Limestone	As-Received	A	N/A	M	1.98	1.48	1.44	3.63	1.91	2408	663	0.987	654	3	15,003
C11-428	B-90 (1) Run 2 Box 1	7.7	L'ville Limestone	As-Received	D	‖PSF	MP	N/A	1.97	1.93	3.80	1.95	1494	393	0.996	391	2	8,993
C11-429	B-90 (2) Run 4 Box 1	15.2	L'ville Limestone	As-Received	A	N/A	M	1.98	1.56	1.52	3.83	1.96	3072	802	0.998	800	3	18,403
C11-429	B-90 (2) Run 4 Box 1	14.2	L'ville Limestone	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	1696	446	0.996	444	2	10,206

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

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: **11/2/2011**   Report Date: 11/23/2011

Project Name: **Louisville Tunnel Project**

Lab ID	Boring ID	Depth (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)
C11-376	B-91 (1) Run 2 Box 1	21.4	L'ville Limestone	As-Received	A	N/A	M	1.98	1.67	1.61	4.06	2.01	2336	575	1.009	580	3	13,377
C11-376	B-91 (1) Run 2 Box 1	21.6	L'ville Limestone	As-Received	D	‖PSF	MP	N/A	1.97	1.93	3.80	1.95	1763	464	0.996	462	2	10,617
C11-380	B-91 (5) Run 10 Box 4	63.7	Laurel Dolomite	As-Received	A	N/A	M	1.98	1.50	1.44	3.63	1.91	4025	1109	0.987	1095	3	25,095
C11-380	B-91 (5) Run 10 Box 4	63.9	Laurel Dolomite	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	3907	1028	0.996	1024	2	23,523
C11-382	B-91 (7) Run 14 Box 5	83.3	Laurel Dolomite	As-Received	A	N/A	M	1.98	1.52	1.48	3.73	1.93	3257	873	0.991	865	3	19,866
C11-382	B-91 (7) Run 14 Box 5	83.5	Laurel Dolomite	As-Received	D	N/A	M	N/A	1.97	1.91	3.76	1.94	1955	520	0.993	516	2	11,866

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

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: **11/1/2011** Report Date: 11/18/2011

Project Name: **Louisville Tunnel Project**

Lab ID	Boring ID	Depth (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)
C11-369	B-92 (1) Run 2 Box 1	13.4	L'ville Limestone	As-Received	A	N/A	M	1.98	1.61	1.57	3.96	1.99	5026	1269	1.005	1275	3	29,360
C11-369	B-92 (1) Run 2 Box 1	13.6	L'ville Limestone	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	3334	877	0.996	873	2	20,068
C11-373	B-92 (5) Run 7 Box 2	34.9	Laurel Dolomite	As-Received	A	N/A	M	1.98	1.61	1.57	3.96	1.99	3107	785	1.005	789	3	18,162
C11-373	B-92 (5) Run 7 Box 2	35.1	Laurel Dolomite	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	3233	851	0.996	848	2	19,473
C11-374	B-92 (6) Run 10 Box 4	52.2	Laurel Dolomite	As-Received	A	N/A	M	1.98	1.50	1.46	3.68	1.92	2179	592	0.989	585	3	13,434
C11-374	B-92 (6) Run 10 Box 4	52.4	Laurel Dolomite	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	2443	643	0.996	640	2	14,713
C11-375	B-92 (7) Run 14 Box 5	69.9	Laurel Dolomite	As-Received	A	N/A	M	1.98	1.30	1.26	3.18	1.78	2472	777	0.956	743	3	16,941
C11-375	B-92 (7) Run 14 Box 5	70.1	Laurel Dolomite	As-Received	D	‖ bed	MB	N/A	1.97	1.95	3.84	1.96	297	77	0.998	77	2	1,767

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

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: **11/3/2011** Report Date: 11/30/2011

Project Name: **Louisville Tunnel Project**

Lab ID	Boring ID	Depth (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)
C11-384	B-93 (2) Run 4 Box 1	20.6	L'ville Limestone	As-Received	A	N/A	M	1.98	1.56	1.52	3.83	1.96	2631	687	0.998	686	3	15,764
C11-384	B-93 (2) Run 4 Box 1	20.4	L'ville Limestone	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	1963	517	0.996	515	2	11,830
C11-386	B-93 (4) Run 6 Box 2	30.9	Waldron Shale	As-Received	A	⊥bed	MB	1.97	1.63	1.57	3.94	1.98	1439	365	1.003	366	3	8,422
C11-386	B-93 (4) Run 6 Box 2	30.7	Waldron Shale	As-Received	D	∥bed	MB	N/A	1.95	1.93	3.76	1.94	96	26	0.993	26	2	593
C11-388	B-93 (6) Run 11 Box 3	54.9	Laurel Dolomite	As-Received	A	N/A	M	1.98	1.57	1.54	3.88	1.97	1915	494	1.000	494	3	11,367
C11-388	B-93 (6) Run 11 Box 3	54.7	Laurel Dolomite	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	2159	568	0.996	566	2	12,997
C11-389	B-93 (7) Run 14 Box 5	71.6	Laurel Dolomite	As-Received	A	N/A	M	1.98	1.57	1.54	3.88	1.97	3148	811	1.000	811	3	18,661
C11-389	B-93 (7) Run 14 Box 5	71.8	Laurel Dolomite	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	2882	758	0.996	755	2	17,345

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

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: **11/4/2011** Report Date: 12/1/2011

Project Name: **Louisville Tunnel Project**

Lab ID	Boring ID	Depth (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)
C11-392	B-94 (1) Run 2 Box 1	15.4	L'ville Limestone	As-Received	A	N/A	M	1.97	1.59	1.56	3.91	1.98	2243	574	1.003	576	3	13,244
C11-392	B-94 (1) Run 2 Box 1	15.6	L'ville Limestone	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	2169	571	0.996	569	2	13,066
C11-396	B-94 (5) Run 7 Box 2	40.5	Waldron Shale	As-Received	A	$\perp$ bed	MB	1.97	1.22	1.18	2.96	1.72	1534	518	0.941	487	3	11,097
C11-396	B-94 (5) Run 7 Box 2	40.2	Waldron Shale	As-Received	D	$\parallel$ bed	MB	N/A	1.95	1.91	3.72	1.93	1362	366	0.991	363	2	8,329
C11-397	B-94 (6) Run 11 Box 4	64.4	Laurel Dolomite	As-Received	A	N/A	M	1.97	1.54	1.50	3.76	1.94	2447	651	0.993	646	3	14,855
C11-397	B-94 (6) Run 11 Box 4	64.6	Laurel Dolomite	As-Received	D	N/A	M	N/A	1.95	1.91	3.72	1.93	2349	631	0.991	625	2 Note	14,359
C11-398	B-94 (7) Run 15 Box 5	81.9	Laurel Dolomite	As-Received	A	N/A	M	1.98	1.57	1.54	3.88	1.97	3435	885	1.000	885	3	20,363
C11-398	B-94 (7) Run 15 Box 5	82.1	Laurel Dolomite	As-Received	D	N/A	M	N/A	1.97	1.93	3.80	1.95	2661	700	0.996	697	2	16,018

Nomenclature

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

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

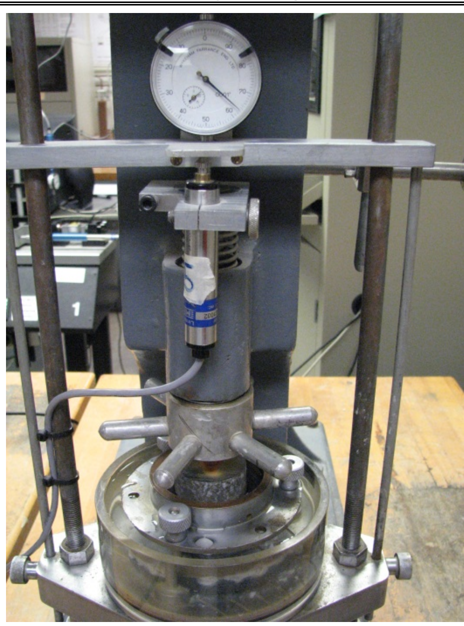
Note: Specimen did not fail through both loading points.

Huder-Amberg Test	**Tonon USA**
(W. Wittke, Rock Mechanics, Springer 1991, pages 176-178)	**Engineering, Measurements, and Testing, LLC**

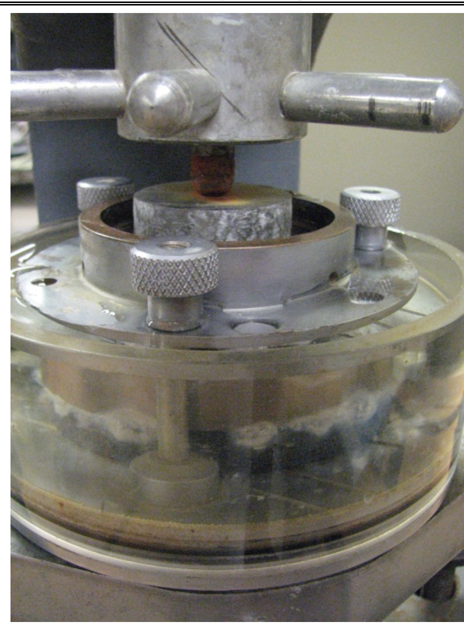
Project name	Louisville Tunnel
Client project no.	1831-10-5629
Date samples were received	10/26/11
Start Test Date	10/28/11
Test Performer Checker	Fulvio Tonon Gloria Tonon-Kozma
Boring no.	B-82
Depth	83.2-84.3
Rock Type	Waldron Shale

Orientation of specimen axis	Orthogonal to bedding	
Method of sampling	Core boring	
Method of specimen preparation	Cut by slab saw	
Max. axial strain	0.87 %	
Original height of specimen	16.57 mm	0.65 in
Maximum pressure requested by client	4644 kPa	9700 psf
Diameter of specimen	50.32 mm	1.98 in
Test temperature	20.0 °C	68.0 °F

Testing set-up 1

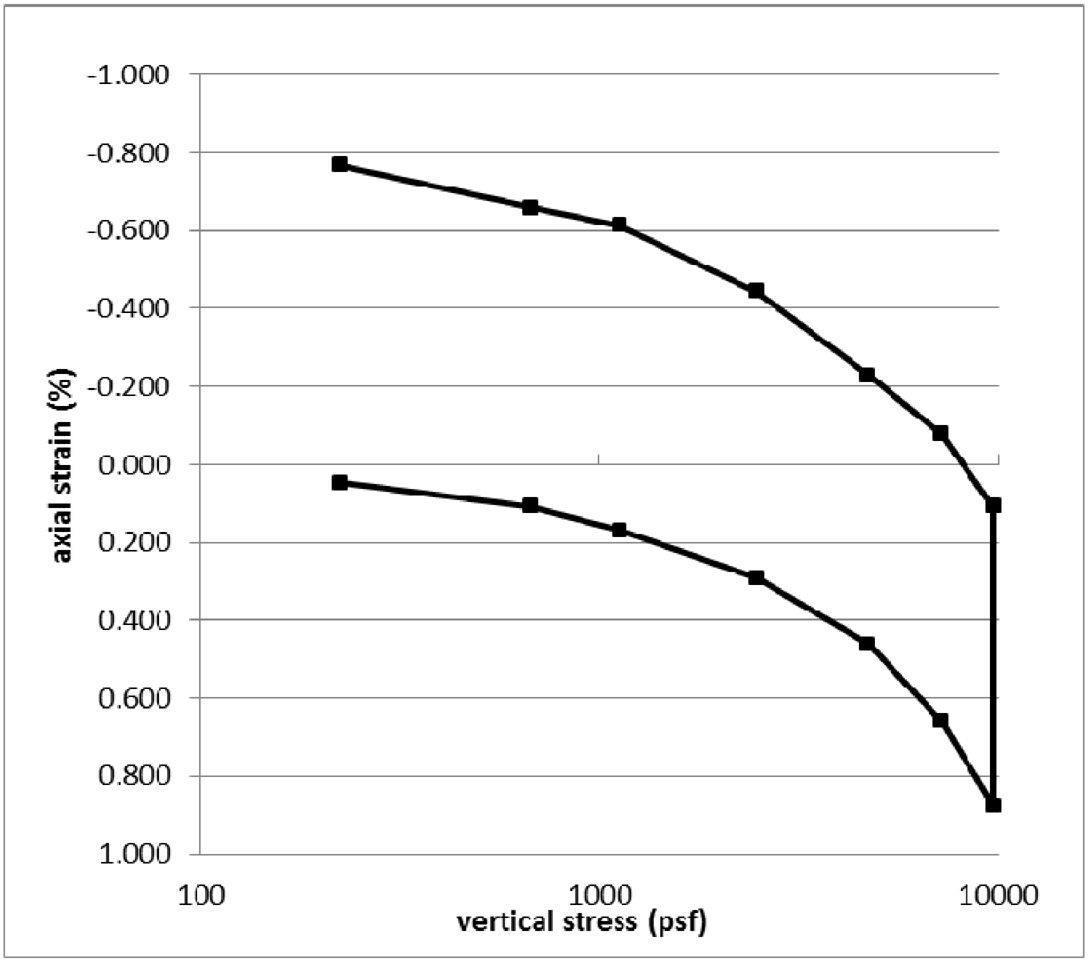


Testing set-up 2



Date	Axial load increment		Axial displacement		Axial strain (%)
	kPa	psf	mm (x 1,000)	in (x 1,000)	
11/15/11	110	225	7.6	0.3	0.046
11/16/11	215	450	17.8	0.7	0.107
11/17/11	215	450	27.9	1.1	0.169
11/18/11	645	1350	48.3	1.9	0.291
11/19/11	1075	2250	76.2	3.0	0.460
11/20/11	1200	2500	109.2	4.3	0.659
11/21/11	1200	2500	144.8	5.7	0.874
11/24/11	--------	--------	17.8	0.7	0.107
11/26/11	-1200	-2500	-12.7	-0.5	-0.077
11/28/11	-1200	-2500	-38.1	-1.5	-0.230
11/29/11	-1075	-2250	-73.7	-2.9	-0.445
11/30/11	-645	-1350	-101.6	-4.0	-0.613
12/1/11	-215	-450	-109.2	-4.3	-0.659
12/2/11	-215	-450	-127.0	-5.0	-0.766

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


-1.000
-0.800
-0.600
-0.400
-0.200
0.000
0.200
0.400
0.600
0.800
1.000
axial strain (%)
100
1000
10000
vertical stress (psf)

Huder-Amberg Test

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

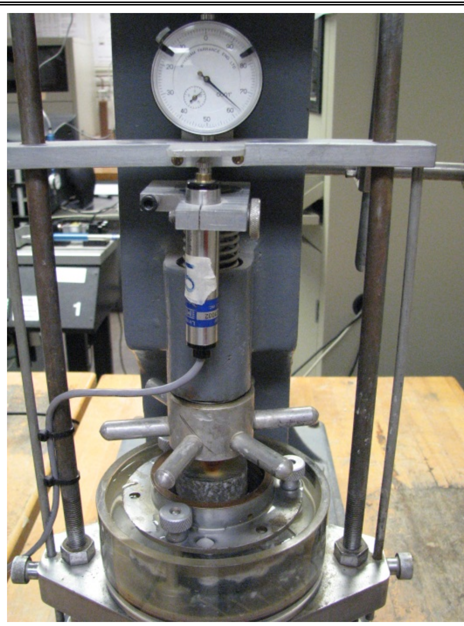
Tonon USA

Engineering, Measurements, and Testing, LLC

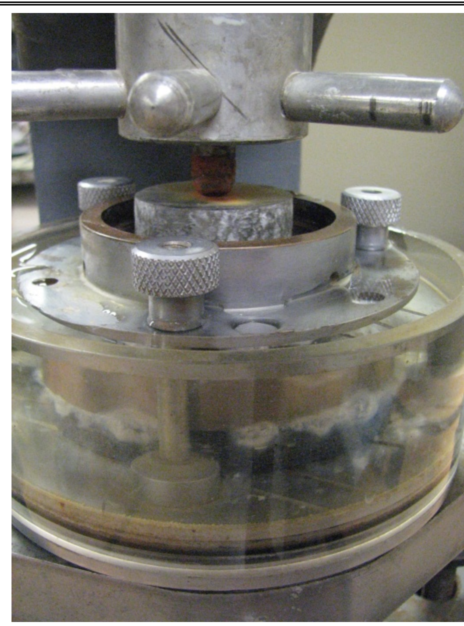
Project name	Louisville Tunnel
Client project no.	1831-10-5629
Date samples were received	12/5/11
Start Test Date	12/10/11
Test Performer Checker	Fulvio Tonon Gloria Tonon-Kozma
Boring no.	B85, Sample 1
Depth	39.0-39.8 ft
Rock Type	Waldron Shale

Orientation of specimen axis	Orthogonal to bedding	
Method of sampling	Core boring	
Method of specimen preparation	Cut by slab saw	
Max. axial strain	-2.54 %	
Original height of specimen	16.69 mm	0.66 in
Maximum pressure requested by client	4644 kPa	9700 psf
Diameter of specimen	50.13 mm	1.97 in
Test temperature	20.0 °C	68.0 °F

Testing set-up 1



Testing set-up 2

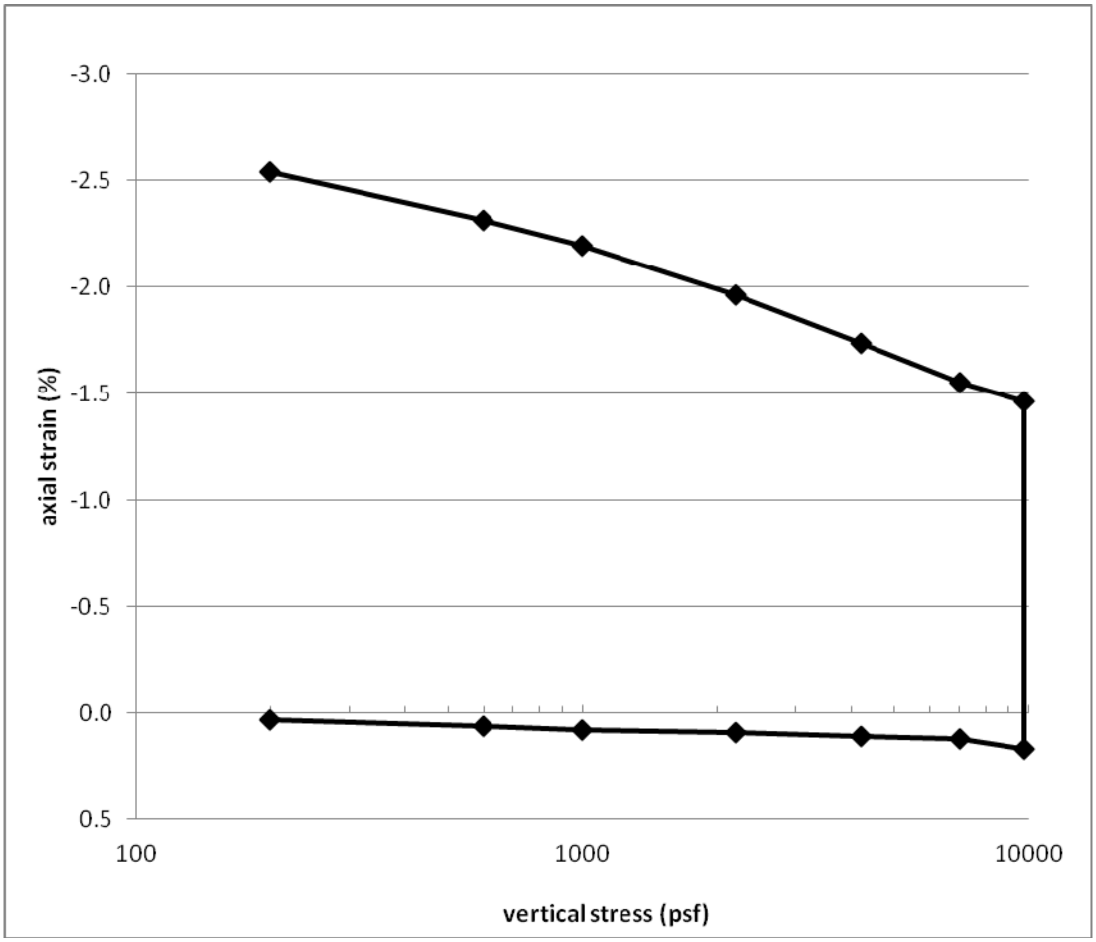


2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

Date	Axial load increment		Axial displacement		Axial strain (%)
	kPa	psf	mm (x 1,000)	in (x 1,000)	
12/1/11	95.76	200	5.08	0.2	0.03
12/1/11	191.52	400	10.16	0.4	0.06
12/2/11	191.52	400	12.7	0.5	0.08
12/2/11	574.56	1200	15.24	0.6	0.09
12/3/11	957.6	2000	17.78	0.7	0.11
12/4/11	1340.64	2800	20.32	0.8	0.12
12/5/11	1340.64	2800	27.94	1.1	0.17
12/8/11	-------	-------	-243.84	-9.6	-1.46
12/10/11	-1340.64	-2800	-259.08	-10.2	-1.55
12/12/11	-1340.64	-2800	-289.56	-11.4	-1.73
12/13/11	-957.6	-2000	-327.66	-12.9	-1.96
12/14/11	-574.56	-1200	-365.76	-14.4	-2.19
12/15/11	-191.52	-400	-386.08	-15.2	-2.31
12/16/11	-191.52	-400	-424.18	-16.7	-2.54

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


-3.0
-2.5
-2.0
-1.5
-1.0
-0.5
0.0
0.5
axial strain (%)
100
1000
10000
vertical stress (psf)

Huder-Amberg Test

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

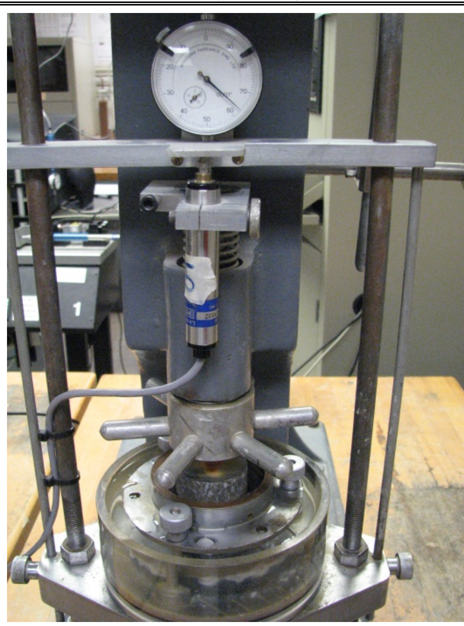
Tonon USA

Engineering, Measurements, and Testing, LLC

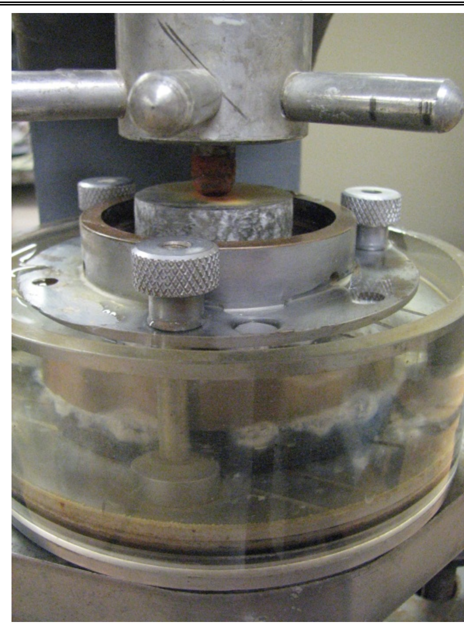
Project name	Louisville Tunnel
Client project no.	1831-10-5629
Date samples were received	12/5/11
Start Test Date	12/10/11
Test Performer Checker	Fulvio Tonon Gloria Tonon-Kozma
Boring no.	B86, Sample 1
Depth	32.9-34.1 ft
Rock Type	Waldron Shale

Orientation of specimen axis	Orthogonal to bedding	
Method of sampling	Core boring	
Method of specimen preparation	Cut by slab saw	
Max. axial strain	-0.90 %	
Original height of specimen	16.41 mm	0.65 in
Maximum pressure requested by client	4644 kPa	9700 psf
Diameter of specimen	50.05 mm	1.97 in
Test temperature	20.0 °C	68.0 °F

Testing set-up 1



Testing set-up 2

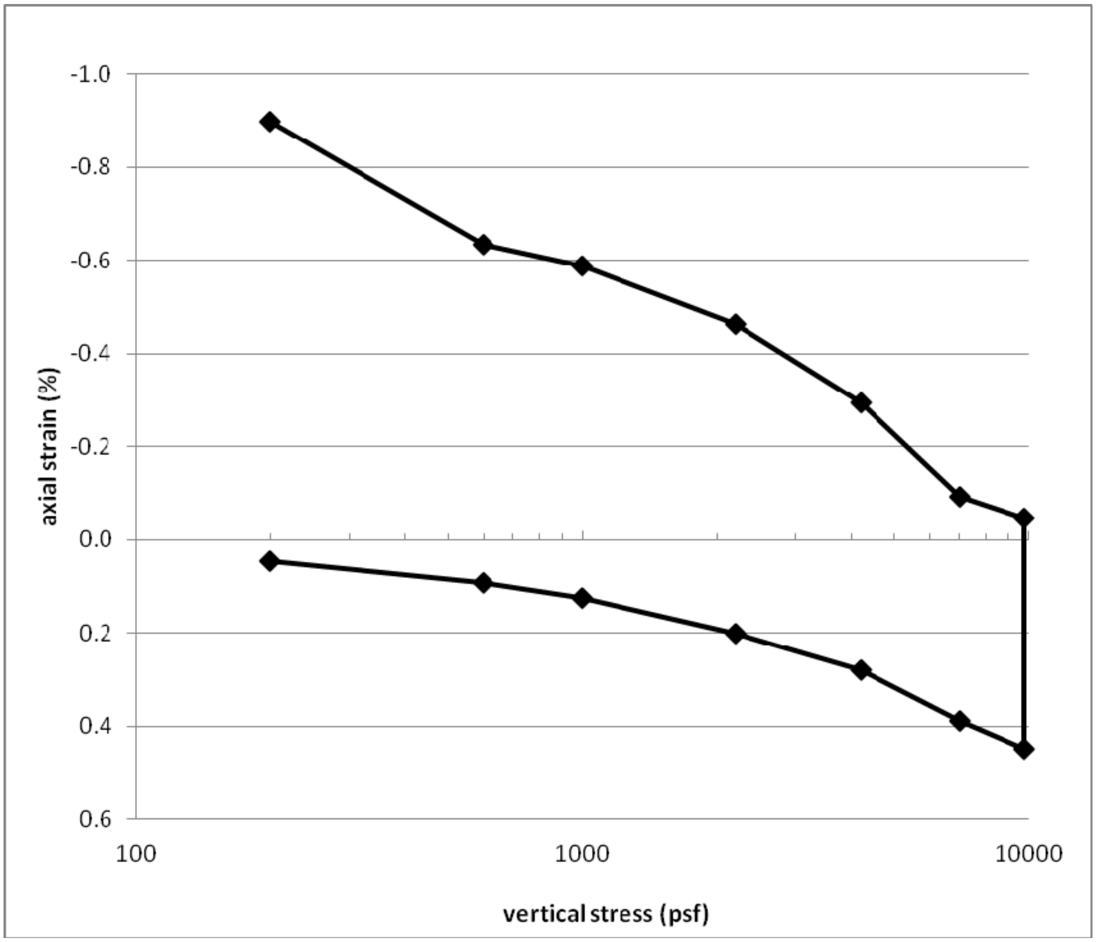


2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

Date	Axial load increment		Axial displacement		Axial strain (%)
	kPa	psf	mm (x 1,000)	in (x 1,000)	
12/1/11	95.76	200	7.62	0.3	0.05
12/1/11	191.52	400	15.24	0.6	0.09
12/2/11	191.52	400	20.32	0.8	0.12
12/2/11	574.56	1200	33.02	1.3	0.20
12/3/11	957.6	2000	45.72	1.8	0.28
12/4/11	1340.64	2800	63.5	2.5	0.39
12/5/11	1340.64	2800	73.66	2.9	0.45
12/8/11	-------	-------	-7.62	-0.3	-0.05
12/10/11	-1340.64	-2800	-15.24	-0.6	-0.09
12/12/11	-1340.64	-2800	-48.26	-1.9	-0.29
12/13/11	-957.6	-2000	-76.2	-3	-0.46
12/14/11	-574.56	-1200	-96.52	-3.8	-0.59
12/15/11	-191.52	-400	-104.14	-4.1	-0.63
12/16/11	-191.52	-400	-147.32	-5.8	-0.90

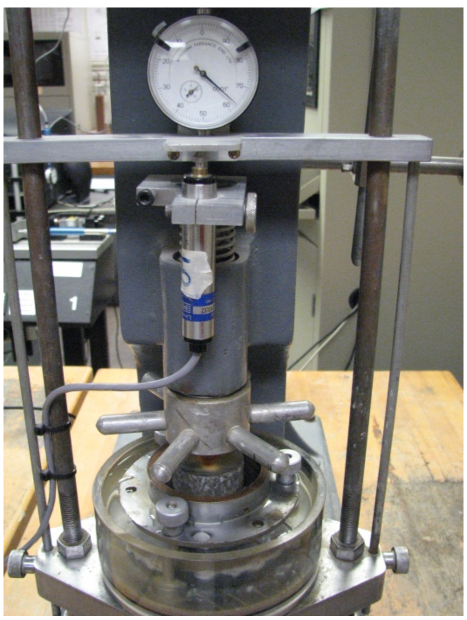
Note: axial load, displacement and strains increments are positive if compressive, negative is tensile or extensional.


-1.0
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
axial strain (%)
100
1000
10000
vertical stress (psf)

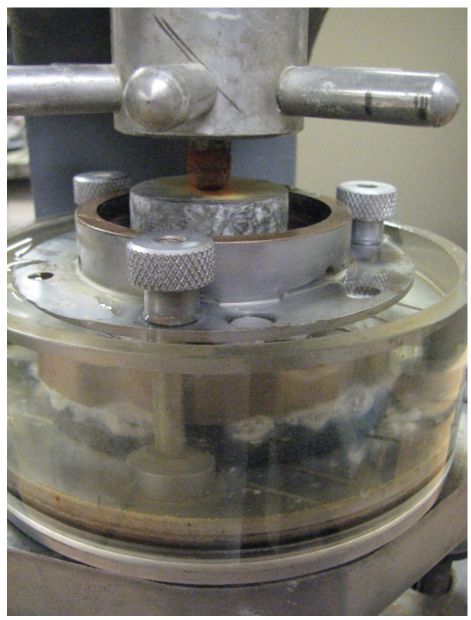
Project name	Louisville Tunnel
Client project no.	1831-10-5629
Date samples were received	12/5/11
Start Test Date	12/10/11
Test Performer Checker	Fulvio Tonon Gloria Tonon-Kozma
Boring no.	B89, Sample 1
Depth	50.7-51.1 ft
Rock Type	Waldron Shale

Orientation of specimen axis	Orthogonal to bedding	
Method of sampling	Core boring	
Method of specimen preparation	Cut by slab saw	
Max. axial strain	-6.24 %	
Original height of specimen	16.78 mm	0.66 in
Maximum pressure requested by client	4644 kPa	9700 psf
Diameter of specimen	50.06 mm	1.97 in
Test temperature	20.0 °C	68.0 °F

Testing set-up 1

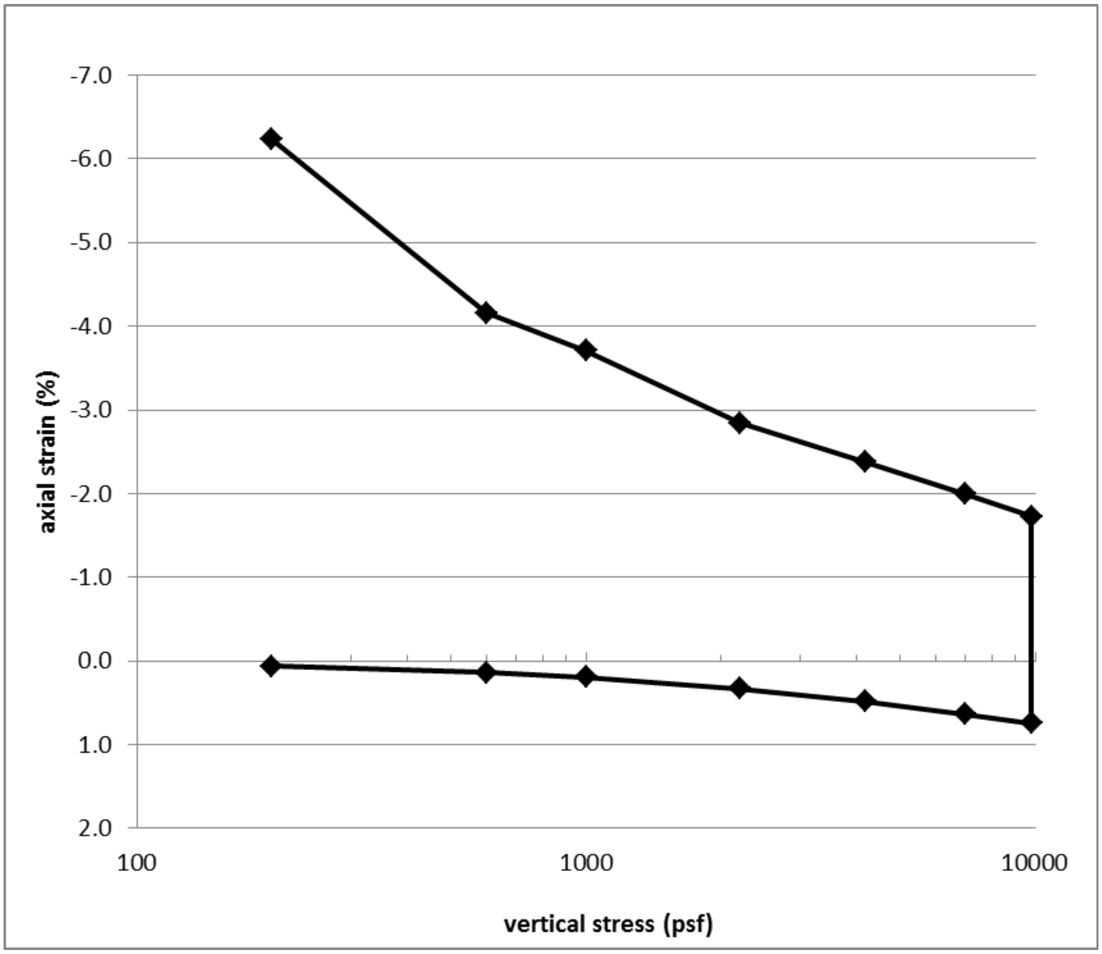


Testing set-up 2



Date	Axial load increment		Axial displacement		Axial strain (%)
	kPa	psf	mm (x 1,000)	in (x 1,000)	
12/15/11	95.76	200	10.16	0.4	0.06
12/15/11	191.52	400	22.86	0.9	0.14
12/16/11	191.52	400	33.02	1.3	0.20
12/16/11	574.56	1200	55.88	2.2	0.33
12/17/11	957.6	2000	81.28	3.2	0.48
12/18/11	1340.64	2800	106.68	4.2	0.64
12/19/11	1340.64	2800	124.46	4.9	0.74
12/22/11	-------	-------	-289.56	-11.4	-1.73
12/24/11	-1340.64	-2800	-335.28	-13.2	-2.00
12/26/11	-1340.64	-2800	-398.78	-15.7	-2.38
12/27/11	-957.6	-2000	-477.52	-18.8	-2.85
12/28/11	-574.56	-1200	-622.3	-24.5	-3.71
12/29/11	-191.52	-400	-698.5	-27.5	-4.16
12/30/11	-191.52	-400	-1046.48	-41.2	-6.24

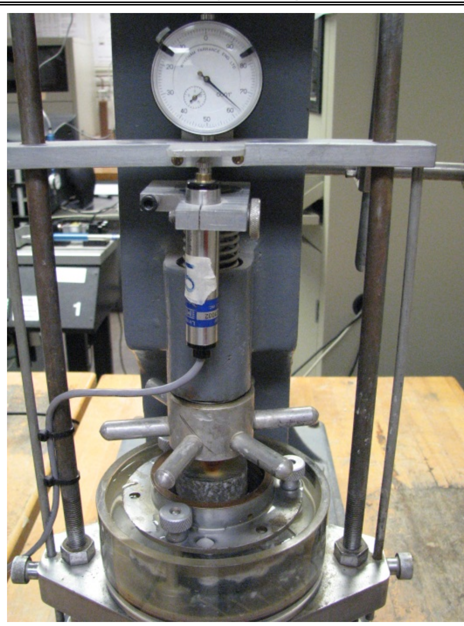
Note: axial load, displacement and strains increments are positive if compressive, negative is tensile or extensional.


-7.0
-6.0
-5.0
-4.0
-3.0
-2.0
-1.0
0.0
1.0
2.0
axial strain (%)
100
1000
10000
vertical stress (psf)

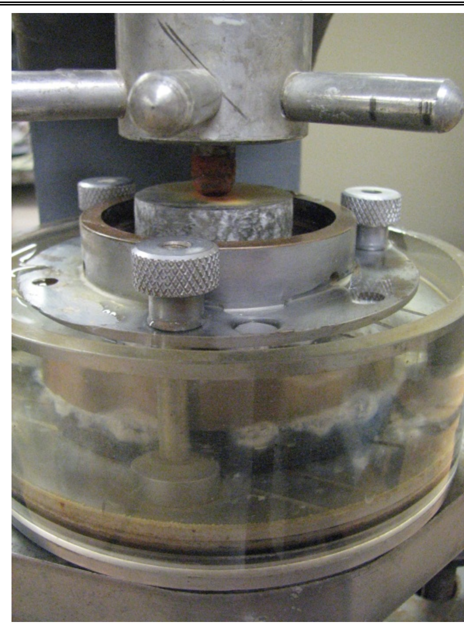
Project name	Louisville Tunnel
Client project no.	1831-10-5629
Date samples were received	11/09/11
Start Test Date	11/12/11
Test Performer Checker	Fulvio Tonon Gloria Tonon-Kozma
Boring no.	B91, Sample 2
Depth	42.1-42.64 ft
Rock Type	

Orientation of specimen axis	Orthogonal to bedding	
Method of sampling	Core boring	
Method of specimen preparation	Cut by slab saw	
Max. axial strain	-0.80 %	
Original height of specimen	20.76 mm	0.82 in
Maximum pressure requested by client	4644 kPa	9700 psf
Diameter of specimen	50.15 mm	1.97 in
Test temperature	20.0 °C	68.0 °F

Testing set-up 1



Testing set-up 2



2304 Bowman Ave.
Austin, TX, 78703

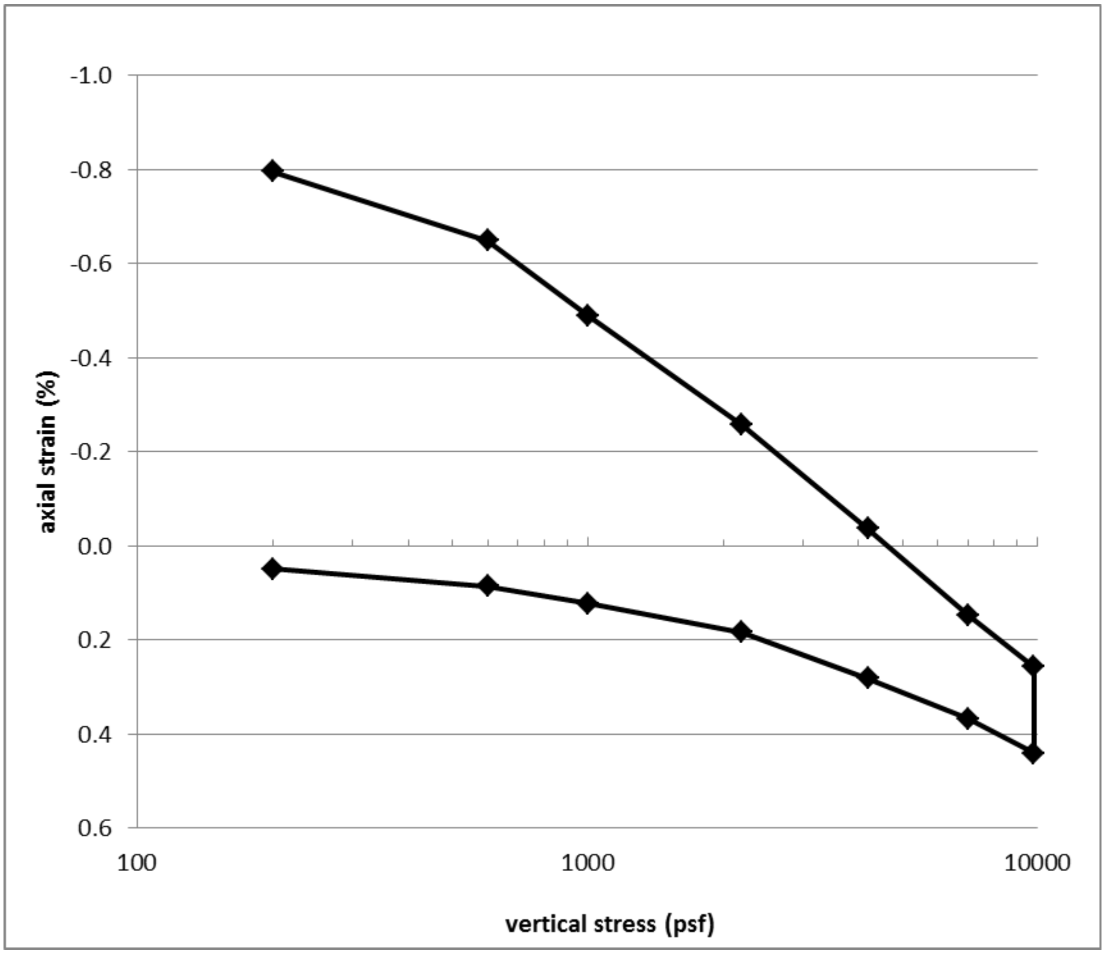
Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

Date	Axial load increment		Axial displacement		Axial strain (%)
	kPa	psf	mm (x 1,000)	in (x 1,000)	
12/1/11	95.76	200	10.16	0.4	0.05
12/1/11	191.52	400	17.78	0.7	0.09
12/2/11	191.52	400	25.4	1	0.12
12/2/11	574.56	1200	38.1	1.5	0.18
12/3/11	957.6	2000	58.42	2.3	0.28
12/4/11	1340.64	2800	76.2	3	0.37
12/5/11	1340.64	2800	91.44	3.6	0.44
12/8/11	-------	-------	53.34	2.1	0.26
12/10/11	-1340.64	-2800	30.48	1.2	0.15
12/12/11	-1340.64	-2800	-7.62	-0.3	-0.04
12/13/11	-957.6	-2000	-53.34	-2.1	-0.26
12/14/11	-574.56	-1200	-101.6	-4	-0.49
12/15/11	-191.52	-400	-134.62	-5.3	-0.65
12/16/11	-191.52	-400	-165.1	-6.5	-0.80

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

2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com


-1.0
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
axial strain (%)
100
1000
10000
vertical stress (psf)

Huder-Amberg Test

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

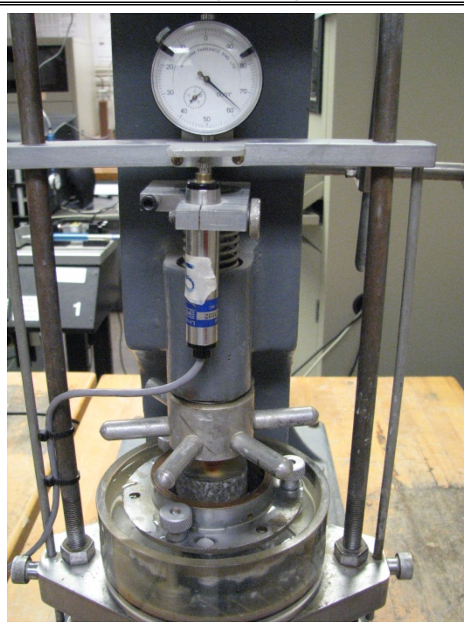
Tonon USA

Engineering, Measurements, and Testing, LLC

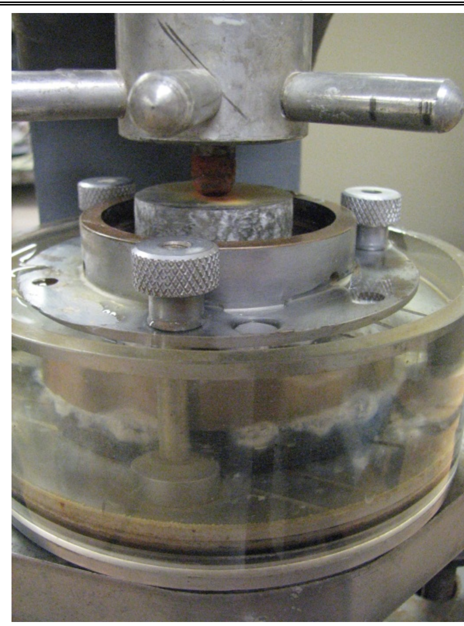
Project name	Louisville Tunnel
Client project no.	1831-10-5629
Date samples were received	11/09/11
Start Test Date	11/12/11
Test Performer / Checker	Fulvio Tonon Gloria Tonon-Kozma
Boring no.	B92, Sample 2
Depth	29.7-30.5 ft
Rock Type	Waldron Shale

Orientation of specimen axis	Orthogonal to bedding	
Method of sampling	Core boring	
Method of specimen preparation	Cut by slab saw	
Max. axial strain	-5.75 %	
Original height of specimen	18.51 mm	0.73in
Maximum pressure requested by client	4644 kPa	9700 psf
Diameter of specimen	50.15 mm	1.97 in
Test temperature	20.0 °C	68.0 °F

Testing set-up 1



Testing set-up 2

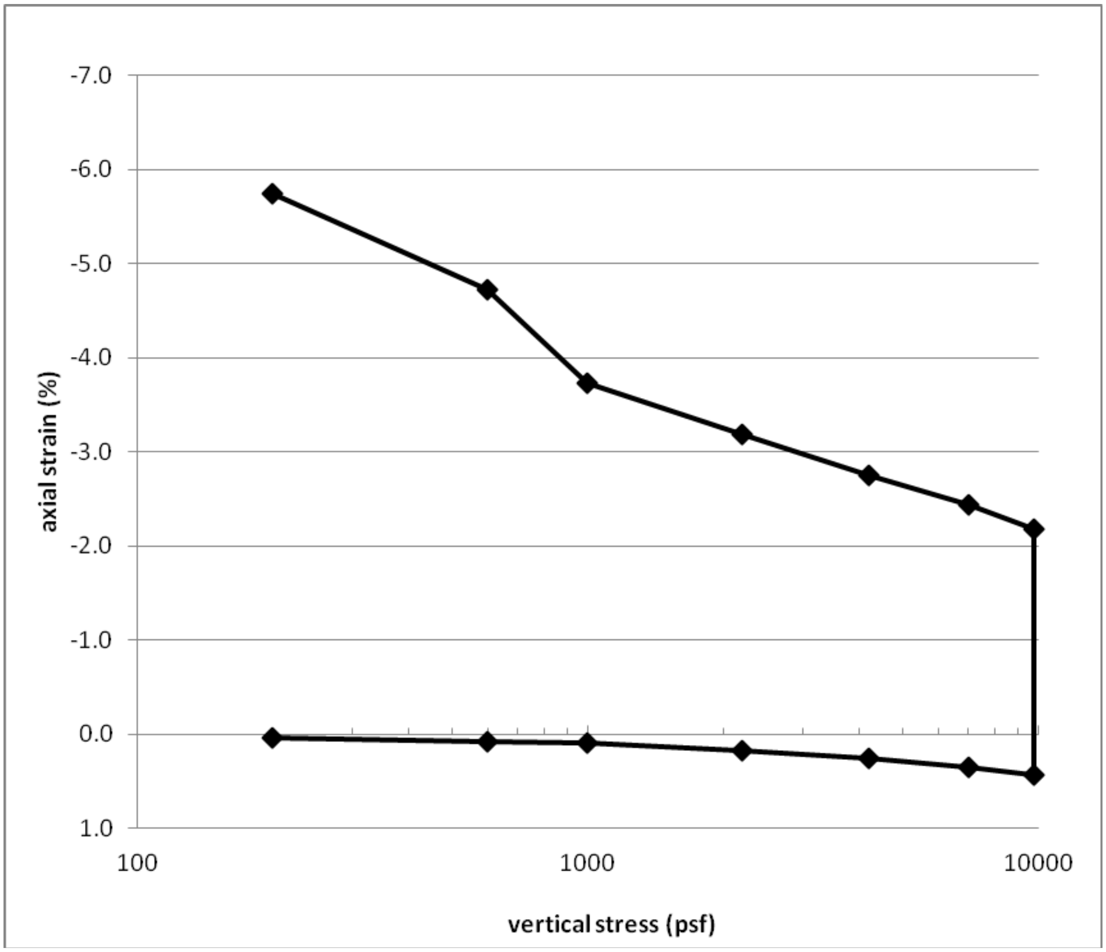


2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

Date	Axial load increment		Axial displacement		Axial strain (%)
	kPa	psf	mm (x 1,000)	in (x 1,000)	
12/10/11	95.76	200	7.62	0.3	0.04
12/10/11	191.52	400	15.24	0.6	0.08
12/12/11	191.52	400	17.78	0.7	0.10
12/12/11	574.56	1200	33.02	1.3	0.18
12/13/11	957.6	2000	48.26	1.9	0.26
12/14/11	1340.64	2800	63.5	2.5	0.34
12/15/11	1340.64	2800	78.74	3.1	0.43
12/18/11	0	0	-403.86	-15.9	-2.18
12/20/11	-1340.64	-2800	-452.12	-17.8	-2.44
12/22/11	-1340.64	-2800	-510.54	-20.1	-2.76
12/23/11	-957.6	-2000	-589.28	-23.2	-3.18
12/24/11	-574.56	-1200	-690.88	-27.2	-3.73
12/25/11	-191.52	-400	-873.76	-34.4	-4.72
12/26/11	-191.52	-400	-1064.26	-41.9	-5.75

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

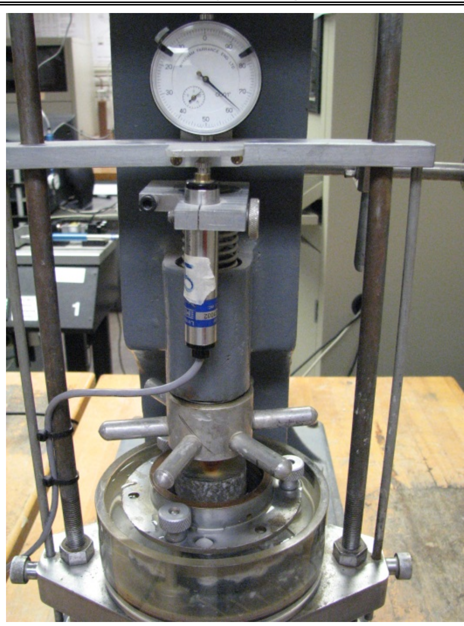

-7.0
-6.0
-5.0
-4.0
-3.0
-2.0
-1.0
0.0
1.0
axial strain (%)
100
1000
10000
vertical stress (psf)

Huder-Amberg Test	**Tonon USA**
(W. Wittke, Rock Mechanics, Springer 1991, pages 176-178)	**Engineering, Measurements, and Testing, LLC**

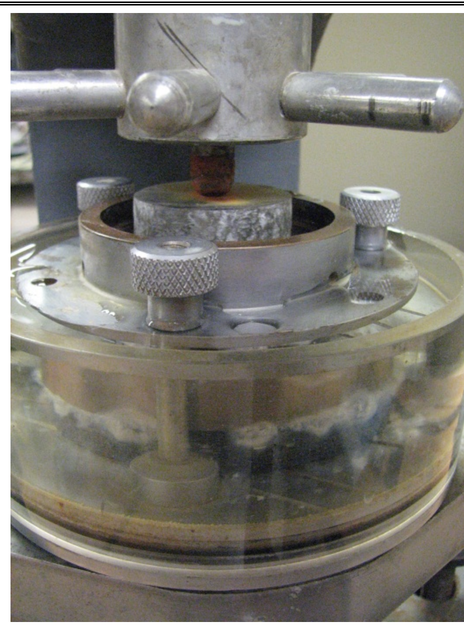
Project name	Louisville Tunnel
Client project no.	1831-10-5629
Date samples were received	11/09/11
Start Test Date	11/12/11
Test Performer Checker	Fulvio Tonon Gloria Tonon-Kozma
Boring no.	B93, Sample 3
Depth	31.5-31.9 ft
Rock Type	Waldron Shale

Orientation of specimen axis	Orthogonal to bedding	
Method of sampling	Core boring	
Method of specimen preparation	Cut by slab saw	
Max. axial strain	-3.74 %	
Original height of specimen	20.43 mm	0.80 in
Maximum pressure requested by client	4644 kPa	9700 psf
Diameter of specimen	50.15 mm	1.97 in
Test temperature	20.0 °C	68.0 °F

Testing set-up 1



Testing set-up 2

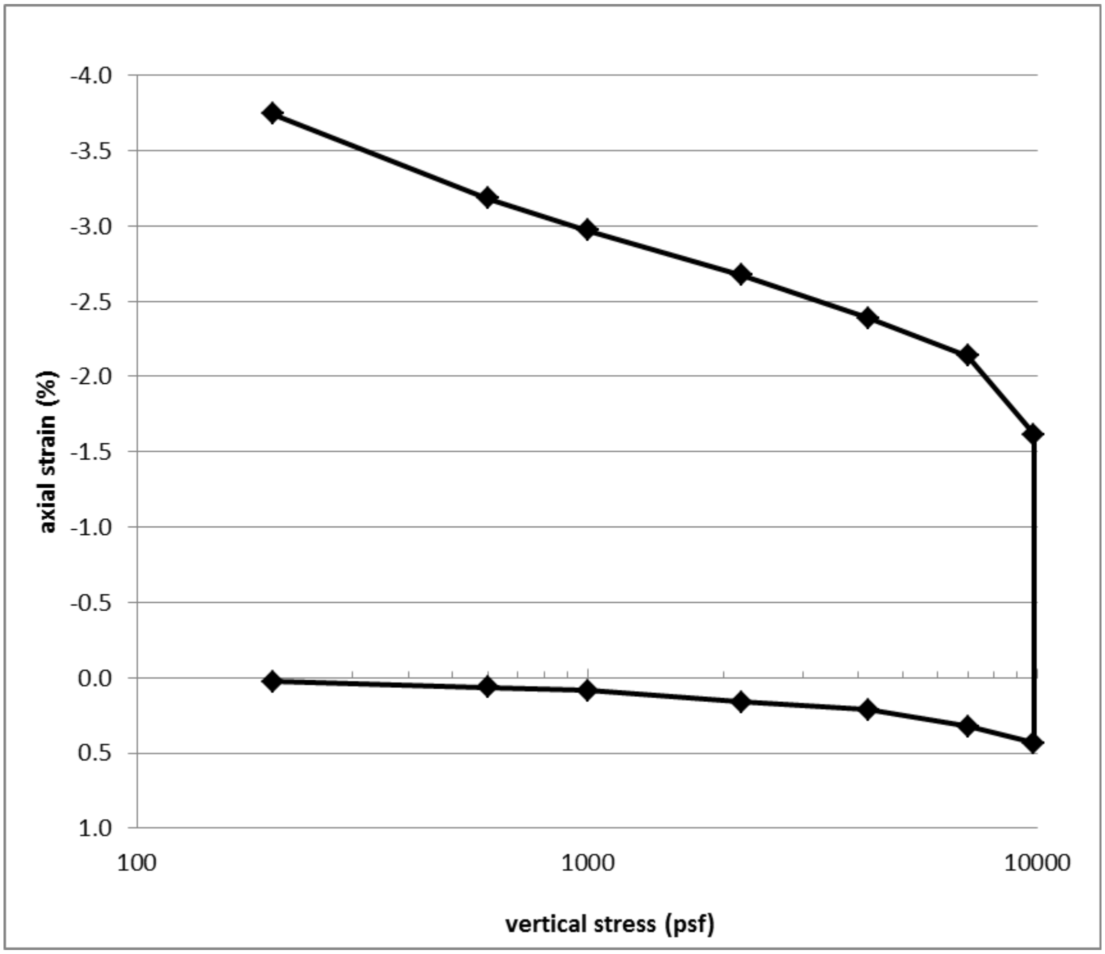


2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

Date	Axial load increment		Axial displacement		Axial strain (%)
	kPa	psf	mm (x 1,000)	in (x 1,000)	
12/1/11	95.76	200	5.08	0.2	0.02
12/1/11	191.52	400	12.7	0.5	0.06
12/2/11	191.52	400	17.78	0.7	0.09
12/2/11	574.56	1200	33.02	1.3	0.16
12/3/11	957.6	2000	43.18	1.7	0.21
12/4/11	1340.64	2800	66.04	2.6	0.32
12/5/11	1340.64	2800	88.9	3.5	0.44
12/8/11	-------	-------	-330.2	-13	-1.62
12/10/11	-1340.64	-2800	-436.88	-17.2	-2.14
12/12/11	-1340.64	-2800	-487.68	-19.2	-2.39
12/13/11	-957.6	-2000	-546.1	-21.5	-2.67
12/14/11	-574.56	-1200	-607.06	-23.9	-2.97
12/15/11	-191.52	-400	-650.24	-25.6	-3.18
12/16/11	-191.52	-400	-764.54	-30.1	-3.74

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

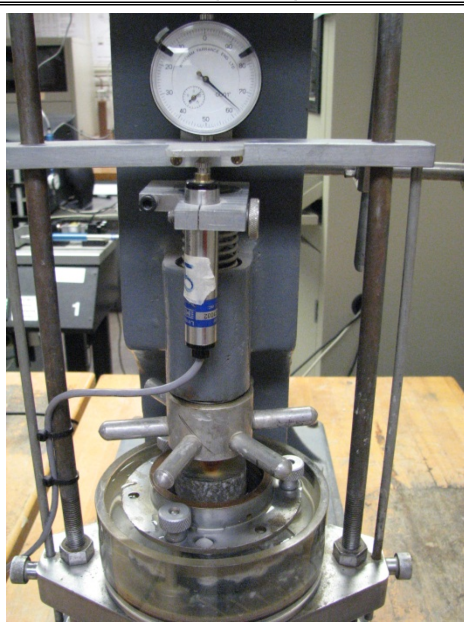

-4.0
-3.5
-3.0
-2.5
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
axial strain (%)
100
1000
10000
vertical stress (psf)

Huder-Amberg Test (W. Wittke, Rock Mechanics, Springer 1991, pages 176-178)	**Tonon USA** **Engineering, Measurements, and Testing, LLC**

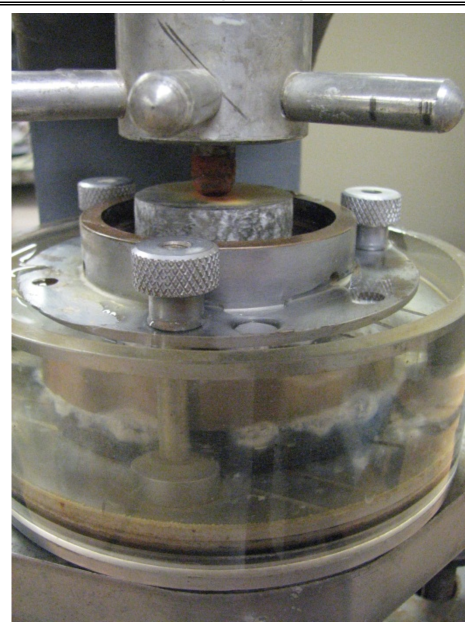
Project name	Louisville Tunnel
Client project no.	1831-10-5629
Date samples were received	11/09/11
Start Test Date	11/12/11
Test Performer Checker	Fulvio Tonon Gloria Tonon-Kozma
Boring no.	B94, Sample 2
Depth	37.4-37.9 ft
Rock Type	Waldron Shale

Orientation of specimen axis	Orthogonal to bedding	
Method of sampling	Core boring	
Method of specimen preparation	Cut by slab saw	
Max. axial strain	-5.51 %	
Original height of specimen	20.45 mm	0.81 in
Maximum pressure requested by client	4644 kPa	9700 psf
Diameter of specimen	49.96 mm	1.97 in
Test temperature	20.0 °C	68.0 °F

Testing set-up 1



Testing set-up 2



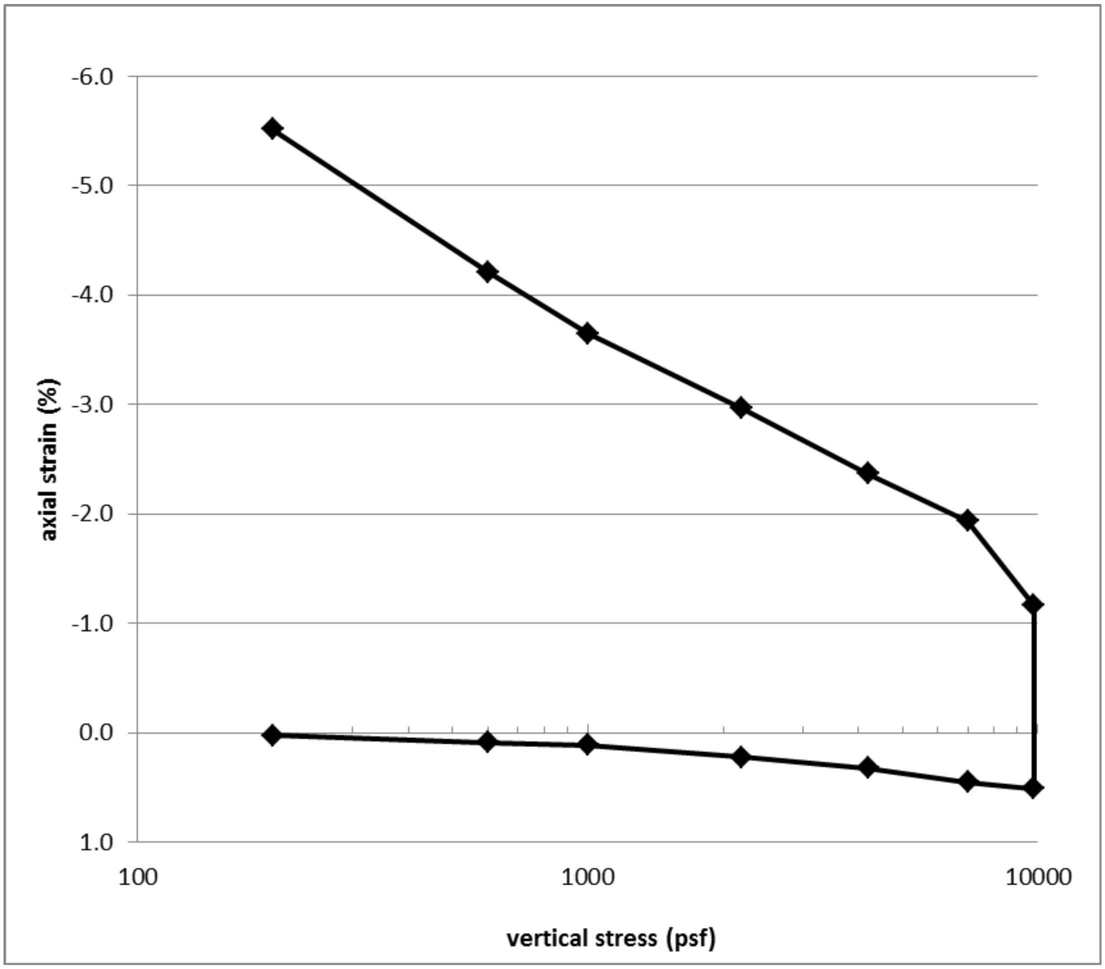
2304 Bowman Ave.
Austin, TX, 78703

Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com

Date	Axial load increment		Axial displacement		Axial strain (%)
	kPa	psf	mm (x 1,000)	in (x 1,000)	
12/1/11	95.76	200	5.08	0.2	0.02
12/1/11	191.52	400	17.78	0.7	0.09
12/2/11	191.52	400	22.86	0.9	0.11
12/2/11	574.56	1200	45.72	1.8	0.22
12/3/11	957.6	2000	66.04	2.6	0.32
12/4/11	1340.64	2800	91.44	3.6	0.45
12/5/11	1340.64	2800	104.14	4.1	0.51
12/8/11	-------	-------	-238.76	-9.4	-1.17
12/10/11	-1340.64	-2800	-396.24	-15.6	-1.94
12/12/11	-1340.64	-2800	-485.14	-19.1	-2.37
12/13/11	-957.6	-2000	-607.06	-23.9	-2.97
12/14/11	-574.56	-1200	-746.76	-29.4	-3.65
12/15/11	-191.52	-400	-861.06	-33.9	-4.21
12/16/11	-191.52	-400	-1127.76	-44.4	-5.51

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

2304 Bowman Ave.
Austin, TX, 78703
Dr. Fulvio Tonon, P.E.
Phone: +1-512-200-3051
E-mail: fulvio@tononeng.com


-6.0
-5.0
-4.0
-3.0
-2.0
-1.0
0.0
1.0
axial strain (%)
100
1000
10000
vertical stress (psf)

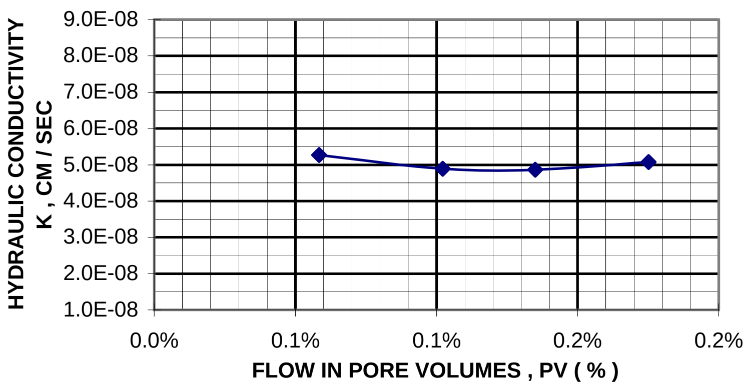
APPENDIX II
SOIL LABORATORY TESTING

FLEXIBLE WALL PERMEABILITY TEST REPORT
(ASTM D 5084)

S&ME

AASHTO R18

JOB NAME :	*Louisville Bridge Twin Tunnels*				
JOB NO. : *1831-10-5629*	**SAMPLE DATE:** *10/20/11*	**REPORT DATE:**	*11/03/11*	**REVIEWED BY :**	*JJB*
DEPTH / ELEV. :	*5.0'-7.0'*	**SAMPLE NO.:**	*3*	**SAMPLE TYPE:**	*UD*
SAMPLE LOCATION:	*B-82*			**DIAMETER , INCHES :**	*2.821*
SOIL DESCRIPTION :	*CL- Brown Lean clay*			**LENGTH , INCHES :**	*3.806*
LIQUID LIMIT, % : *45*	**PLASTICITY INDEX , %** *24*	**FINES , % :**	*97.8*	**SPECIFIC GRAVITY, Gs :**	*2.65*



HYDRAULIC CONDUCTIVITY, k	
5.0E-08	**CM / SEC @ 20 °C**

SPECIMEN PROPERTIES			
INITIAL			
MOISTURE CONTENT	W_o	*18.8*	%
DRY BULK DENSITY	γ_{dryo}	*105.8*	pcf
SATURATION	S_o	*91.5*	%
VOID RATIO	e_o	*0.563*	
AFTER CONSOLIDATION			
MOISTURE CONTENT	W_c	*20.7*	%
DRY BULK DENSITY	γ_{dryc}	*106.8*	pcf
B-VALUE		*0.95*	%
VOID RATIO	e_c	*0.549*	
PERMEATION			
FINAL BACK PRESSURE	u_o	*60.0*	psi
EFFECTIVE CONSOLIDATION PRESSURE	σ_3'	*6.0*	psi
MAXIMUM HYDRAULIC GRADIENT	i_{max}	*5.1*	
MINUMUM HYDRAULIC GRADIENT	i_{min}	*5.0*	
QUANTITY OF FLOW	Q	*0.2*	cm^3
TOTAL PORE VOLUME OF FLOW	PV	*0.2*	%

TEST CONDITIONS

PERMEANT DESCRIPTION : *Water* @ 24 °C

METHOD: *C - Falling Head, Rising Tailwater*

REMOLDED SOIL PROPERTIES

The specimen was remolded to *99.5%* *of in- situ density , at a moisture content of* 18.8%

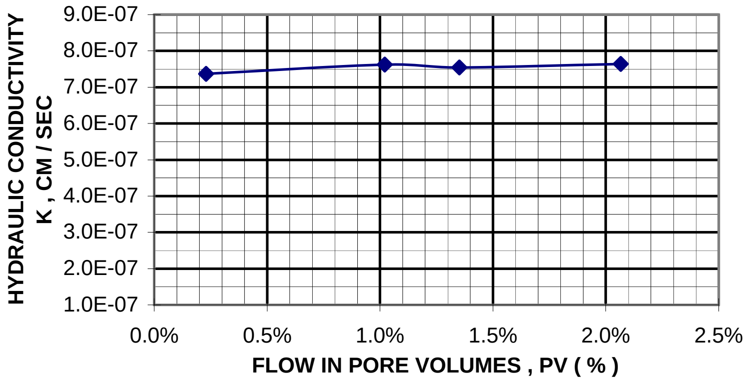
IN- SITU DENSITY :	*125.7*	PCF
NATURAL MOISTURE CONTENT :	*18.8*	%

FLEXIBLE WALL PERMEABILITY TEST REPORT
(ASTM D 5084)

S&ME

AASHTO R18

JOB NAME : *Louisville Bridges Twin Tunnels*					
JOB NO. : *1831-10-5629*	**SAMPLE DATE:** *10/20/11*	**REPORT DATE:**	*11/03/11*	**REVIEWED BY :**	*SB*
DEPTH / ELEV. : *10.0'-12.0'*		**SAMPLE NO.:**	*6*	**SAMPLE TYPE:**	*UD*
SAMPLE LOCATION: *B-82*				**DIAMETER , INCHES :**	*2.808*
SOIL DESCRIPTION : *CL- Brown Lean clay*				**LENGTH , INCHES :**	*4.013*
LIQUID LIMIT, % : *37*	**PLASTICITY INDEX , %** *19*	**FINES , % :**	*97.4*	**SPECIFIC GRAVITY, Gs :**	*2.65*



HYDRAULIC CONDUCTIVITY, k	
7.5E-07	**CM / SEC @ 20 °C**

SPECIMEN PROPERTIES			
INITIAL			
MOISTURE CONTENT	W_o	*16.6*	%
DRY BULK DENSITY	γ_{dryo}	*111.9*	pcf
SATURATION	S_o	*91.5*	%
VOID RATIO	e_o	*0.478*	
AFTER CONSOLIDATION			
MOISTURE CONTENT	W_c	*17.8*	%
DRY BULK DENSITY	γ_{dryc}	*112.3*	pcf
B-VALUE		*0.95*	%
VOID RATIO	e_c	*0.473*	
PERMEATION			
FINAL BACK PRESSURE	u_o	*65.0*	psi
EFFECTIVE CONSOLIDATION PRESSURE	σ_3'	*10.0*	psi
MAXIMUM HYDRAULIC GRADIENT	i_{max}	*4.8*	
MINUMUM HYDRAULIC GRADIENT	i_{min}	*3.7*	
QUANTITY OF FLOW	Q	*2.7*	cm^3
TOTAL PORE VOLUME OF FLOW	PV	*2.1*	%

TEST CONDITIONS

PERMEANT DESCRIPTION : *Water* @ 24 °C

METHOD: *C - Falling Head, Rising Tailwater*

REMOLDED SOIL PROPERTIES

The specimen was remolded to 99.7% *of in- situ density , at a moisture content of* 16.6%

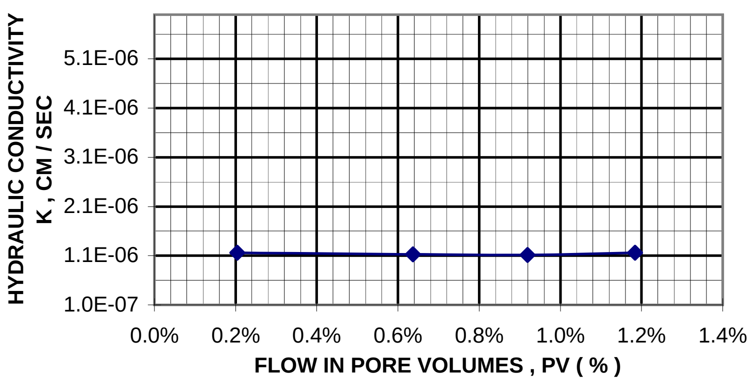
IN- SITU DENSITY :	*130.8*	PCF
NATURAL MOISTURE CONTENT :	*16.6*	%

FLEXIBLE WALL PERMEABILITY TEST REPORT
(ASTM D 5084)

S&ME

AASHTO R18

JOB NAME : *Louisville Bridges Twin Tunnels*					
JOB NO. : *1831-10-5629*	**SAMPLE DATE:** *10/20/11*	**REPORT DATE:**	*11/03/11*	**REVIEWED BY :**	*SB*
DEPTH / ELEV. : *5.0'-7.0'*		**SAMPLE NO.:**	*2*	**SAMPLE TYPE:**	*UD*
SAMPLE LOCATION: *B-84*				**DIAMETER , INCHES :**	*2.853*
SOIL DESCRIPTION : *CH- Red Fat clay with sand*				**LENGTH , INCHES :**	*4.680*
LIQUID LIMIT, % : *52*	**PLASTICITY INDEX , %** *31*	**FINES , % :**	*83.6*	**SPECIFIC GRAVITY, Gs :**	*2.65*



HYDRAULIC CONDUCTIVITY, k	
1.1E-06	**CM / SEC @ 20 °C**

SPECIMEN PROPERTIES			
INITIAL			
MOISTURE CONTENT	W_o	*26.0*	%
DRY BULK DENSITY	γ_{dryo}	*91.8*	pcf
SATURATION	S_o	*85.5*	%
VOID RATIO	e_o	*0.802*	
AFTER CONSOLIDATION			
MOISTURE CONTENT	W_c	*28.5*	%
DRY BULK DENSITY	γ_{dryc}	*94.2*	pcf
B-VALUE		*0.95*	%
VOID RATIO	e_c	*0.756*	
PERMEATION			
FINAL BACK PRESSURE	u_o	*60.0*	psi
EFFECTIVE CONSOLIDATION PRESSURE	σ_3'	*5.0*	psi
MAXIMUM HYDRAULIC GRADIENT	i_{max}	*4.2*	
MINUMUM HYDRAULIC GRADIENT	i_{min}	*3.2*	
QUANTITY OF FLOW	Q	*2.4*	cm^3
TOTAL PORE VOLUME OF FLOW	PV	*1.2*	%

TEST CONDITIONS

PERMEANT DESCRIPTION : *Water* @ 24 °C

METHOD: *C - Falling Head, Rising Tailwater*

REMOLDED SOIL PROPERTIES

The specimen was remolded to - *of in- situ density , at a moisture content of* -

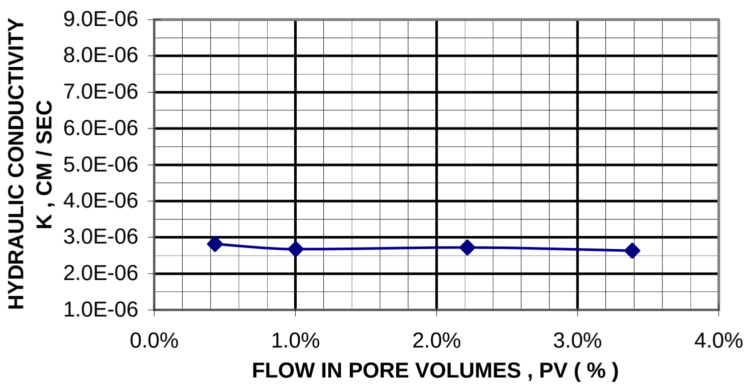
IN- SITU DENSITY :	*115.6*	PCF
NATURAL MOISTURE CONTENT :	*26.0*	%

FLEXIBLE WALL PERMEABILITY TEST REPORT
(ASTM D 5084)

S&ME

AASHTO R18

JOB NAME : *Louisville Bridge Twin Tunnels*			
JOB NO. : *1831-10-5629* **SAMPLE DATE:** *11/15/11*		**REPORT DATE:** *12/16/11*	**REVIEWED BY :** SB
DEPTH / ELEV. : *8.0'-10.0'*		**SAMPLE NO.:** *4*	**SAMPLE TYPE:** *UD*
SAMPLE LOCATION: *B-88*			**DIAMETER , INCHES :** *2.89*
SOIL DESCRIPTION : *CL- Orange brown Lean clay*			**LENGTH , INCHES :** *4.36*
LIQUID LIMIT, % : *33*	**PLASTICITY INDEX , %** *12*	**FINES , % :** *98.1*	**SPECIFIC GRAVITY, Gs :** *2.69*



HYDRAULIC CONDUCTIVITY, k	
2.7E-06	**CM / SEC @ 20 °C**

SPECIMEN PROPERTIES			
INITIAL			
MOISTURE CONTENT	W_o	*21.4*	%
DRY BULK DENSITY	γ_{dryo}	*97.2*	pcf
SATURATION	S_o	*78.8*	%
VOID RATIO	e_o	*0.728*	
AFTER CONSOLIDATION			
MOISTURE CONTENT	W_c	*25.7*	%
DRY BULK DENSITY	γ_{dryc}	*99.2*	pcf
B-VALUE		*0.96*	%
VOID RATIO	e_c	*0.692*	
PERMEATION			
FINAL BACK PRESSURE	u_o	*40.0*	psi
EFFECTIVE CONSOLIDATION PRESSURE	σ_3'	*7.4*	psi
MAXIMUM HYDRAULIC GRADIENT	i_{max}	*4.4*	
MINUMUM HYDRAULIC GRADIENT	i_{min}	*2.3*	
QUANTITY OF FLOW	Q	*6.4*	cm^3
TOTAL PORE VOLUME OF FLOW	PV	*3.4*	%

TEST CONDITIONS

PERMEANT DESCRIPTION : *Water* @ 25 °C

METHOD: *C - Falling Head, Rising Tailwater*

REMOLDED SOIL PROPERTIES

The specimen was remolded to - *of in- situ density , at a moisture content of* -

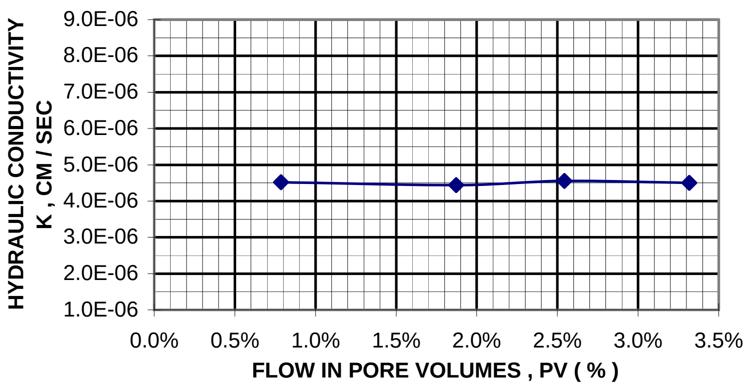
IN- SITU DENSITY :	*118.0*	PCF
NATURAL MOISTURE CONTENT :	*21.4*	%

FLEXIBLE WALL PERMEABILITY TEST REPORT
(ASTM D 5084)

S&ME

AASHTO R18

JOB NAME :	*Louisville Bridge Twin Tunnels*				
JOB NO. :	*1831-10-5629*	**SAMPLE DATE:** *11/15/11*	**REPORT DATE:** *12/16/11*	**REVIEWED BY :**	*SB*
DEPTH / ELEV. :	*4.0'-6.0'*		**SAMPLE NO.:** *2*	**SAMPLE TYPE:**	*UD*
SAMPLE LOCATION:	*B-89*			**DIAMETER , INCHES :**	*2.784*
SOIL DESCRIPTION :	*CL- Orange brown Lean clay*			**LENGTH , INCHES :**	*3.709*
LIQUID LIMIT, % :	*33*	**PLASTICITY INDEX , %** *11*	**FINES , % :** *99.5*	**SPECIFIC GRAVITY, Gs :**	*2.68*



HYDRAULIC CONDUCTIVITY, k	
4.5E-06	**CM / SEC @ 20 °C**

SPECIMEN PROPERTIES

INITIAL			
MOISTURE CONTENT	W_o	*21.4*	%
DRY BULK DENSITY	γ_{dryo}	*99.7*	pcf
SATURATION	S_o	*83.7*	%
VOID RATIO	e_o	*0.685*	
AFTER CONSOLIDATION			
MOISTURE CONTENT	W_c	*22.7*	%
DRY BULK DENSITY	γ_{dryc}	*104.2*	pcf
B-VALUE		*0.96*	%
VOID RATIO	e_c	*0.611*	
PERMEATION			
FINAL BACK PRESSURE	u_o	*40.0*	psi
EFFECTIVE CONSOLIDATION PRESSURE	σ_3'	*4.2*	psi
MAXIMUM HYDRAULIC GRADIENT	i_{max}	*5.2*	
MINUMUM HYDRAULIC GRADIENT	i_{min}	*3.6*	
QUANTITY OF FLOW	Q	*4.5*	cm^3
TOTAL PORE VOLUME OF FLOW	PV	*3.3*	%

TEST CONDITIONS

PERMEANT DESCRIPTION : *Water* @ 26 °C

METHOD: *C - Falling Head, Rising Tailwater*

REMOLDED SOIL PROPERTIES

The specimen was remolded to - *of in- situ density , at a moisture content of* -

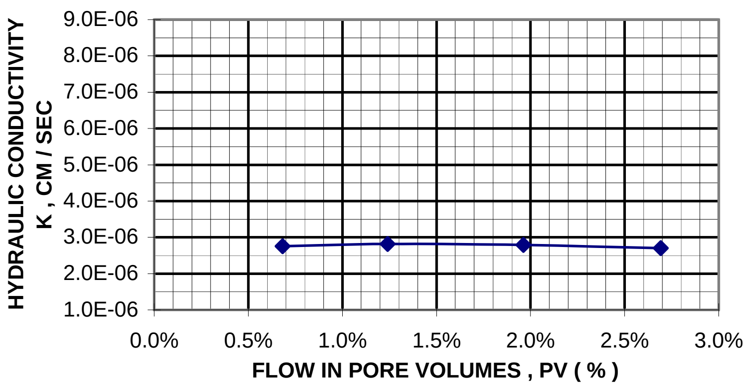
IN- SITU DENSITY :	*121.1*	PCF
NATURAL MOISTURE CONTENT :	*21.4*	%

FLEXIBLE WALL PERMEABILITY TEST REPORT
(ASTM D 5084)

S&ME

AASHTO R18

JOB NAME : *Louisville Bridge Twin Tunnels*					
JOB NO. : *1831-10-5629*	**SAMPLE DATE:** *11/15/11*	**REPORT DATE:**	*12/16/11*	**REVIEWED BY :**	*SB*
DEPTH / ELEV. : *8.0'-10.0'*		**SAMPLE NO.:**	*4*	**SAMPLE TYPE:**	*UD*
SAMPLE LOCATION: *B-89*				**DIAMETER , INCHES :**	*2.826*
SOIL DESCRIPTION : *CL- Brown Lean clay*				**LENGTH , INCHES :**	*3.709*
LIQUID LIMIT, % : *35*	**PLASTICITY INDEX , %** *15*	**FINES , % :**	*96.8*	**SPECIFIC GRAVITY, Gs :**	*2.68*



HYDRAULIC CONDUCTIVITY, k	
2.8E-06	CM / SEC @ 20 °C

SPECIMEN PROPERTIES			
INITIAL			
MOISTURE CONTENT	W_o	*22.6*	%
DRY BULK DENSITY	γ_{dryo}	*100.5*	pcf
SATURATION	S_o	*91.0*	%
VOID RATIO	e_o	*0.665*	
AFTER CONSOLIDATION			
MOISTURE CONTENT	W_c	*23.9*	%
DRY BULK DENSITY	γ_{dryc}	*102.0*	pcf
B-VALUE		*0.95*	%
VOID RATIO	e_c	*0.641*	
PERMEATION			
FINAL BACK PRESSURE	u_o	*40.0*	psi
EFFECTIVE CONSOLIDATION PRESSURE	σ_3'	*7.4*	psi
MAXIMUM HYDRAULIC GRADIENT	i_{max}	*5.2*	
MINUMUM HYDRAULIC GRADIENT	i_{min}	*4.0*	
QUANTITY OF FLOW	Q	*4.0*	cm^3
TOTAL PORE VOLUME OF FLOW	PV	*2.7*	%

TEST CONDITIONS

PERMEANT DESCRIPTION : *Water* @ 23 °C

METHOD: *C - Falling Head, Rising Tailwater*

REMOLDED SOIL PROPERTIES

The specimen was remolded to - *of in- situ density , at a moisture content of* -

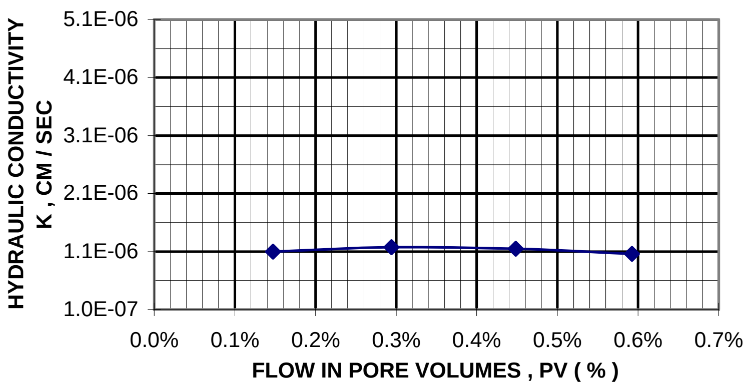
IN- SITU DENSITY :	*123.2*	PCF
NATURAL MOISTURE CONTENT :	*22.6*	%

FLEXIBLE WALL PERMEABILITY TEST REPORT
(ASTM D 5084)

S&ME

AASHTO R18

JOB NAME : *Louisville Bridge Twin Tunnels*					
JOB NO. : *1831-10-5629*	**SAMPLE DATE:** *10/20/11*	**REPORT DATE:**	*12/16/11*	**REVIEWED BY :**	*SB*
DEPTH / ELEV. : *9.0'-11.0'*		**SAMPLE NO.:**	*4*	**SAMPLE TYPE:**	*UD*
SAMPLE LOCATION: *B-91*				**DIAMETER , INCHES :**	*2.857*
SOIL DESCRIPTION : *CL- Orange brown Lean clay*				**LENGTH , INCHES :**	*3.956*
LIQUID LIMIT, % : *38*	**PLASTICITY INDEX , %** *19*	**FINES , % :**	*96.8*	**SPECIFIC GRAVITY, Gs :**	*2.69*



HYDRAULIC CONDUCTIVITY, k	
1.1E-06	**CM / SEC @ 20 °C**

SPECIMEN PROPERTIES			
INITIAL			
MOISTURE CONTENT	W_o	*17.7*	%
DRY BULK DENSITY	γ_{dryo}	*107.7*	pcf
SATURATION	S_o	*84.8*	%
VOID RATIO	e_o	*0.560*	
AFTER CONSOLIDATION			
MOISTURE CONTENT	W_c	*20.4*	%
DRY BULK DENSITY	γ_{dryc}	*108.5*	pcf
B-VALUE		*0.95*	%
VOID RATIO	e_c	*0.548*	
PERMEATION			
FINAL BACK PRESSURE	u_o	*50.0*	psi
EFFECTIVE CONSOLIDATION PRESSURE	σ_3'	*8.0*	psi
MAXIMUM HYDRAULIC GRADIENT	i_{max}	*1.0*	
MINUMUM HYDRAULIC GRADIENT	i_{min}	*0.9*	
QUANTITY OF FLOW	Q	*0.9*	cm^3
TOTAL PORE VOLUME OF FLOW	PV	*0.6*	%

TEST CONDITIONS

PERMEANT DESCRIPTION : *Water*
@ 24 °C

METHOD: *C - Falling Head, Rising Tailwater*

REMOLDED SOIL PROPERTIES

The specimen was remolded to - *of in- situ density , at a moisture content of* -

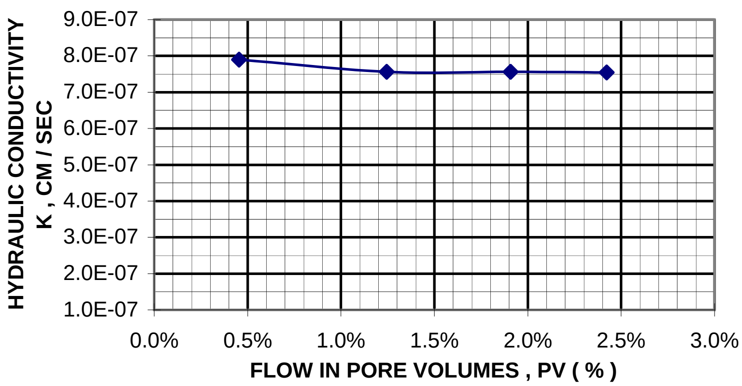
IN- SITU DENSITY :	*126.7*	PCF
NATURAL MOISTURE CONTENT :	*17.7*	%

FLEXIBLE WALL PERMEABILITY TEST REPORT
(ASTM D 5084)

S&ME

AASHTO R18

JOB NAME : *Louisville Bridge Twin Tunnels*			
JOB NO. : *1831-10-5629* **SAMPLE DATE:** *11/2/11*	**REPORT DATE:** *12/16/11*	**REVIEWED BY :** *SB*	
DEPTH / ELEV. : *4.0'-6.0'*	**SAMPLE NO.:** *2*	**SAMPLE TYPE:** *UD*	
SAMPLE LOCATION: *B-92*		**DIAMETER , INCHES :** *2.789*	
SOIL DESCRIPTION : *CL- Brown Lean clay*		**LENGTH , INCHES :** *4.046*	
LIQUID LIMIT, % : *34* **PLASTICITY INDEX , %** *15*	**FINES , % :** *98.0*	**SPECIFIC GRAVITY, Gs :** *2.68*	



HYDRAULIC CONDUCTIVITY, k	
7.6E-07	CM / SEC @ 20 °C

SPECIMEN PROPERTIES			
INITIAL			
MOISTURE CONTENT	W_o	*11.7*	%
DRY BULK DENSITY	γ_{dryo}	*111.1*	pcf
SATURATION	S_o	*61.2*	%
VOID RATIO	e_o	*0.512*	
AFTER CONSOLIDATION			
MOISTURE CONTENT	W_c	*18.6*	%
DRY BULK DENSITY	γ_{dryc}	*111.9*	pcf
B-VALUE		*0.99*	%
VOID RATIO	e_c	*0.501*	
PERMEATION			
FINAL BACK PRESSURE	u_o	*55.0*	psi
EFFECTIVE CONSOLIDATION PRESSURE	σ_3'	*8.8*	psi
MAXIMUM HYDRAULIC GRADIENT	i_{max}	*4.8*	
MINUMUM HYDRAULIC GRADIENT	i_{min}	*3.7*	
QUANTITY OF FLOW	Q	*3.3*	cm^3
TOTAL PORE VOLUME OF FLOW	PV	*2.4*	%

TEST CONDITIONS

PERMEANT DESCRIPTION : *Water* @ 23 °C

METHOD: *C - Falling Head, Rising Tailwater*

REMOLDED SOIL PROPERTIES

The specimen was remolded to - *of in- situ density , at a moisture content of* -

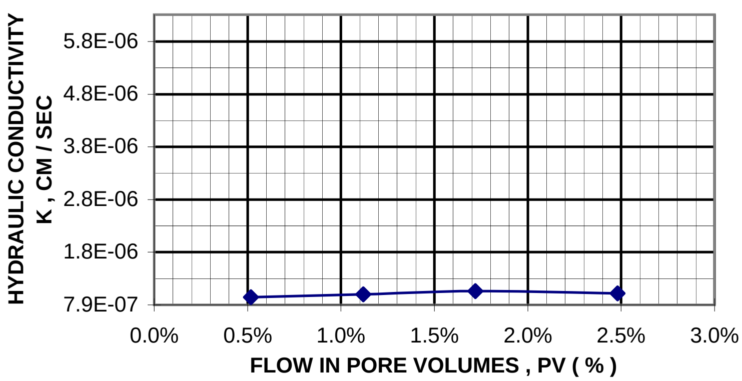
IN- SITU DENSITY:	*124.0*	PCF
NATURAL MOISTURE CONTENT:	*11.7*	%

FLEXIBLE WALL PERMEABILITY TEST REPORT
(ASTM D 5084)

S&ME

AASHTO R18

JOB NAME :	*Louisville Bridge Twin Tunnels*				
JOB NO. :	*1831-10-5629* **SAMPLE DATE:** *11/2/11*	**REPORT DATE:**	*12/16/11*	**REVIEWED BY :**	*SB*
DEPTH / ELEV. :	*4.0'-6.0'*	**SAMPLE NO.:**	*2*	**SAMPLE TYPE:**	*UD*
SAMPLE LOCATION:	*B-93*			**DIAMETER , INCHES :**	*2.853*
SOIL DESCRIPTION :	*ML- Brown Silt*			**LENGTH , INCHES :**	*3.979*
LIQUID LIMIT, % :	*34* **PLASTICITY INDEX , %** *6*	**FINES , % :**	*98.8*	**SPECIFIC GRAVITY, Gs :**	*2.68*



HYDRAULIC CONDUCTIVITY, k	
1.0E-06	**CM / SEC @ 20 °C**

SPECIMEN PROPERTIES			
INITIAL			
MOISTURE CONTENT	W_o	*22.5*	%
DRY BULK DENSITY	γ_{dryo}	*100.7*	pcf
SATURATION	S_o	*91.1*	%
VOID RATIO	e_o	*0.661*	
AFTER CONSOLIDATION			
MOISTURE CONTENT	W_c	*23.3*	%
DRY BULK DENSITY	γ_{dryc}	*103.1*	pcf
B-VALUE		*0.97*	%
VOID RATIO	e_c	*0.623*	
PERMEATION			
FINAL BACK PRESSURE	u_o	*55.0*	psi
EFFECTIVE CONSOLIDATION PRESSURE	σ_3'	*4.3*	psi
MAXIMUM HYDRAULIC GRADIENT	i_{max}	*4.8*	
MINUMUM HYDRAULIC GRADIENT	i_{min}	*3.5*	
QUANTITY OF FLOW	Q	*3.9*	cm^3
TOTAL PORE VOLUME OF FLOW	PV	*2.5*	%

TEST CONDITIONS

PERMEANT DESCRIPTION : *Water*
@ 24 °C

METHOD: *C - Falling Head, Rising Tailwater*

REMOLDED SOIL PROPERTIES

The specimen was remolded to - *of in- situ density , at a moisture content of* -

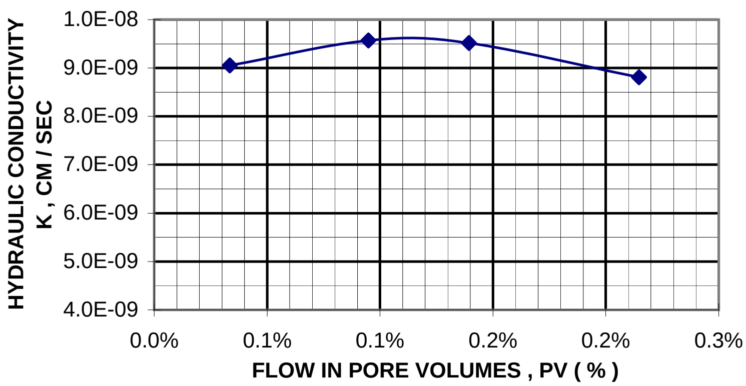
IN- SITU DENSITY :	*123.4*	PCF
NATURAL MOISTURE CONTENT :	*22.5*	%

FLEXIBLE WALL PERMEABILITY TEST REPORT
(ASTM D 5084)

S&ME

AASHTO R18

JOB NAME : *Louisville Bridge Twin Tunnels*			
JOB NO. : *1831-10-5629*	**SAMPLE DATE:** *10/20/11*	**REPORT DATE:** *12/16/11*	**REVIEWED BY :** *SB*
DEPTH / ELEV. : *9.0'-11.0'*		**SAMPLE NO.:** *3*	**SAMPLE TYPE:** *UD*
SAMPLE LOCATION: *B-94*			**DIAMETER , INCHES :** *2.86*
SOIL DESCRIPTION : *CL- Orange brown Fat clay with sand*			**LENGTH , INCHES :** *4.45*
LIQUID LIMIT, % : *70*	**PLASTICITY INDEX , % :** *44*	**FINES , % :** *80.6*	**SPECIFIC GRAVITY, Gs :** *2.74*



HYDRAULIC CONDUCTIVITY, k	
9.2E-09	CM / SEC @ 20 °C

SPECIMEN PROPERTIES			
INITIAL			
MOISTURE CONTENT	W_o	*24.2*	%
DRY BULK DENSITY	γ_{dryo}	*103.3*	pcf
SATURATION	S_o	*100.0*	%
VOID RATIO	e_o	*0.655*	
AFTER CONSOLIDATION			
MOISTURE CONTENT	W_c	*23.2*	%
DRY BULK DENSITY	γ_{dryc}	*104.6*	pcf
B-VALUE		*0.96*	%
VOID RATIO	e_c	*0.635*	
PERMEATION			
FINAL BACK PRESSURE	u_o	*69.0*	psi
EFFECTIVE CONSOLIDATION PRESSURE	σ_3'	*8.8*	psi
MAXIMUM HYDRAULIC GRADIENT	i_{max}	*16.7*	
MINUMUM HYDRAULIC GRADIENT	i_{min}	*16.5*	
QUANTITY OF FLOW	Q	*0.4*	cm^3
TOTAL PORE VOLUME OF FLOW	PV	*0.2*	%

TEST CONDITIONS

PERMEANT DESCRIPTION : *Water* @ 24 °C

METHOD: *C - Falling Head, Rising Tailwater*

REMOLDED SOIL PROPERTIES

The specimen was remolded to - *of in- situ density , at a moisture content of* -

IN- SITU DENSITY :	*128.5*	PCF
NATURAL MOISTURE CONTENT :	*24.2*	%

PARTICLE- SIZE DISTRIBUTION TEST REPORT

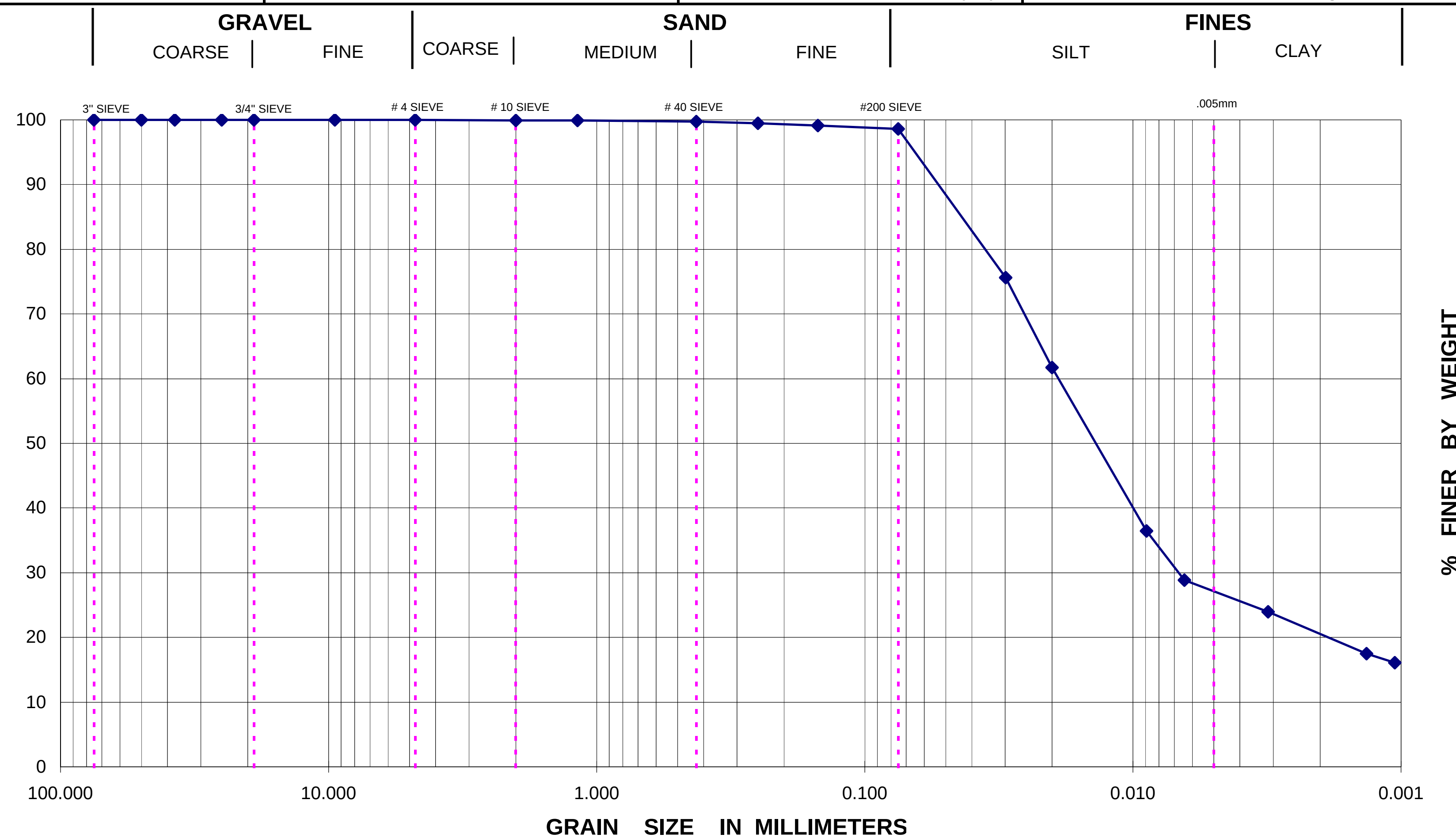
SIEVE AND HYDROMETER (ASTM D422)

S&ME

422 Codell Drive, Lexington, KY 40509

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/12/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-82*	**DEPTH / ELEV. :**	*1.0' - 2.5'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*1*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL- Brown Lean clay*					**SP. GRAVITY, Gs :**	*2.68*
LIQUID LIMIT, % :	*33*	**PLASTICITY INDEX , % :**	*12*	**MOISTURE , % :**	*17.7*	**FINES , % :**	*98.6*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-6 (12)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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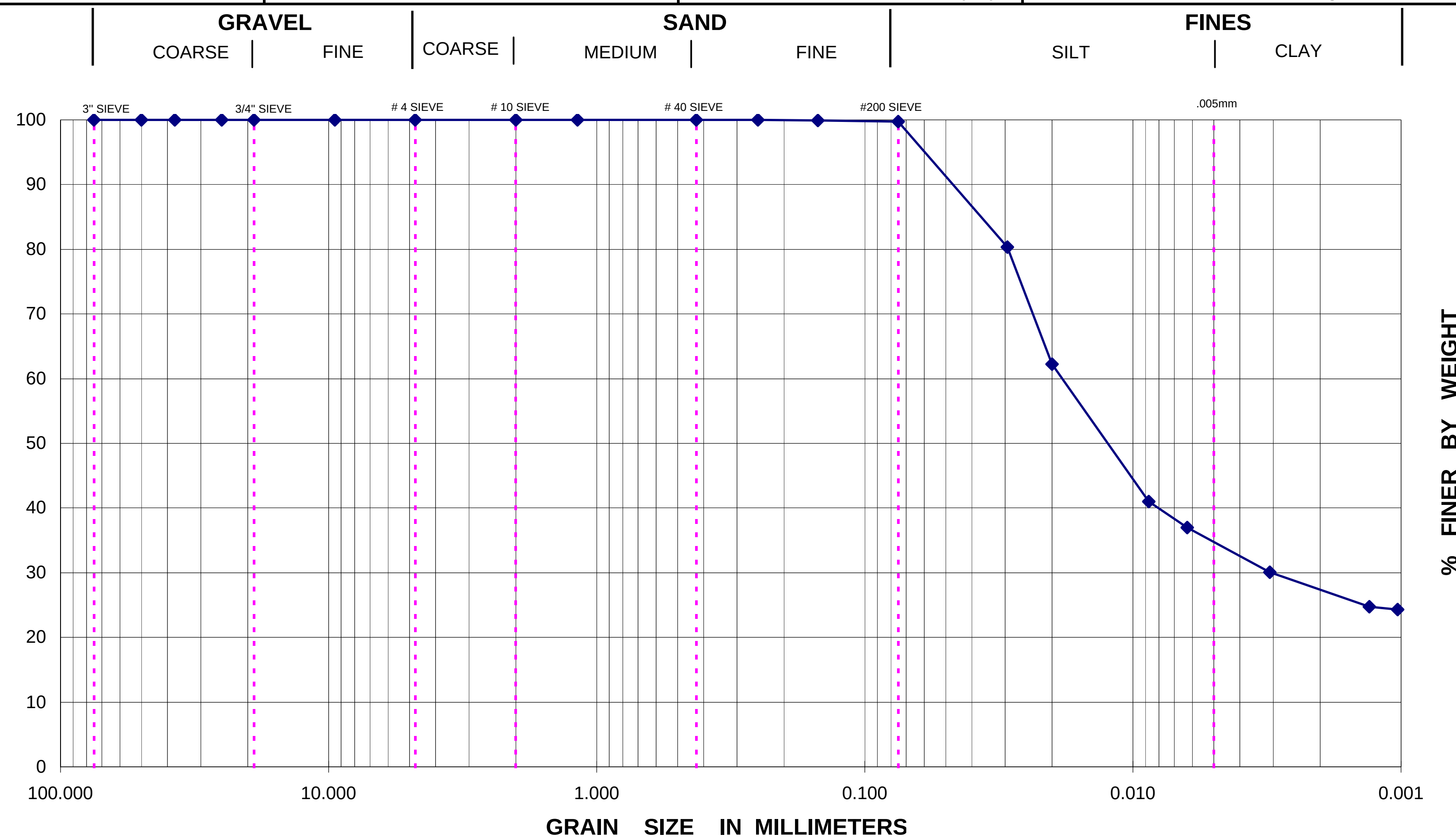
422 Codell Drive, Lexington, KY 40509

PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/13/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-82*	**DEPTH / ELEV. :**	*3.0'-5.0'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*2*	**REPORT DATE:**	*12/14/11*
SOIL DESCRIPTION :	*CL- Brown Lean clay*					**SP. GRAVITY, Gs :**	*2.69*
LIQUID LIMIT, % :	*39*	**PLASTICITY INDEX , % :**	*18*	**MOISTURE , % :**	*19.0*	**FINES , % :**	*99.7*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-6 (19)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



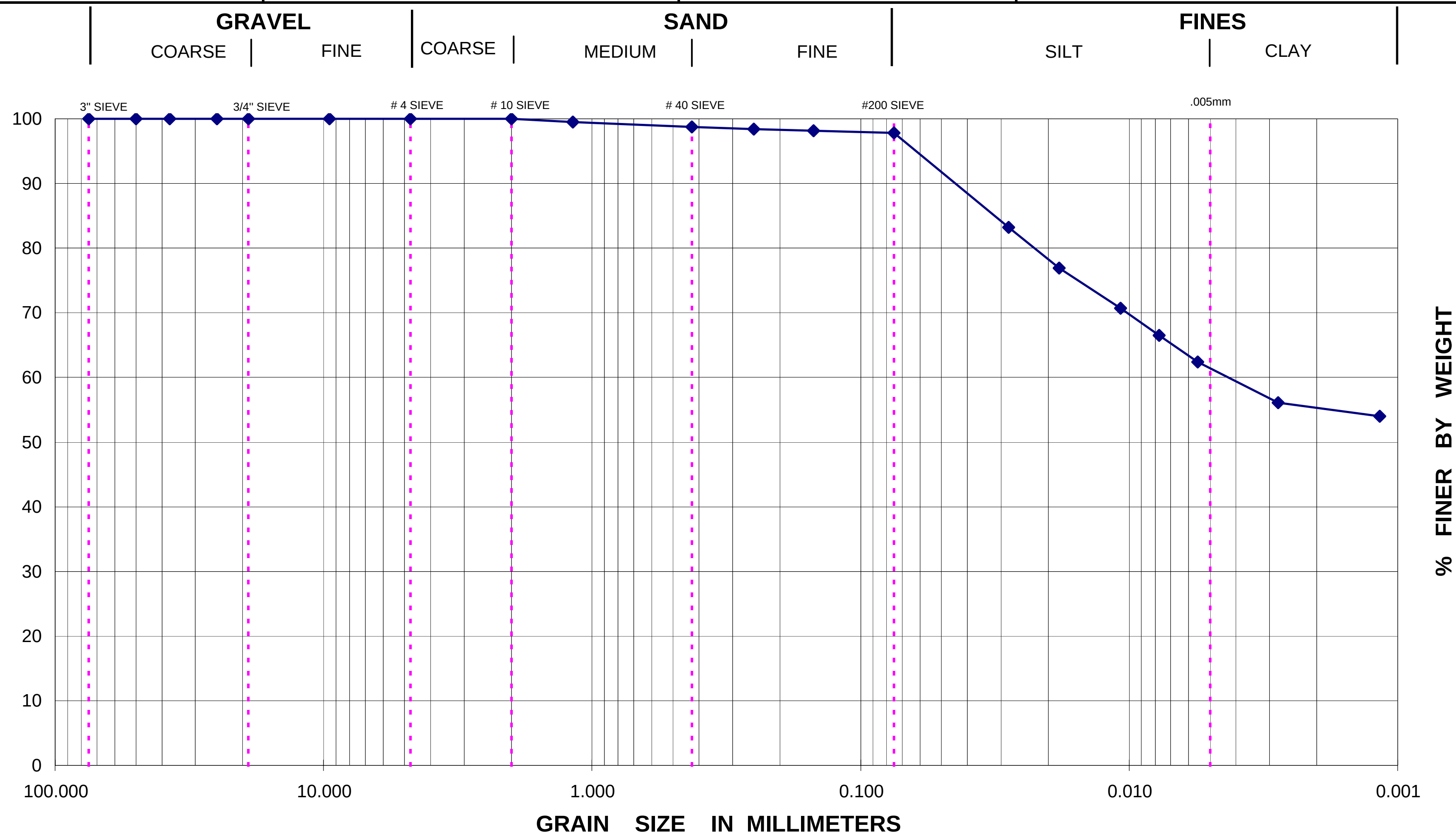
PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

S&ME
422 Codell Drive, Lexington, KY 40509

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831-10-5629*			**TEST DATE:**	*11/2/12*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-82*	**DEPTH / ELEV. :**	*5.0'-7.0'*	**SAMPLE TYPE:**	*UD*	**SAMPLE RECEIVED:**	*11/15/2011*
SAMPLE LOCATION :	-			**SAMPLE NO:**	*3*	**REPORT DATE:**	*12/16/2011*
SOIL DESCRIPTION :	*CL- Brown Lean clay*					**SP. GRAVITY, Gs :**	*2.65*
LIQUID LIMIT, % :	*45*	**PLASTICITY INDEX , % :**	*24*	**MOISTURE , % :**	*18.8*	**FINES , % :**	*97.8*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-7-6 (26)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



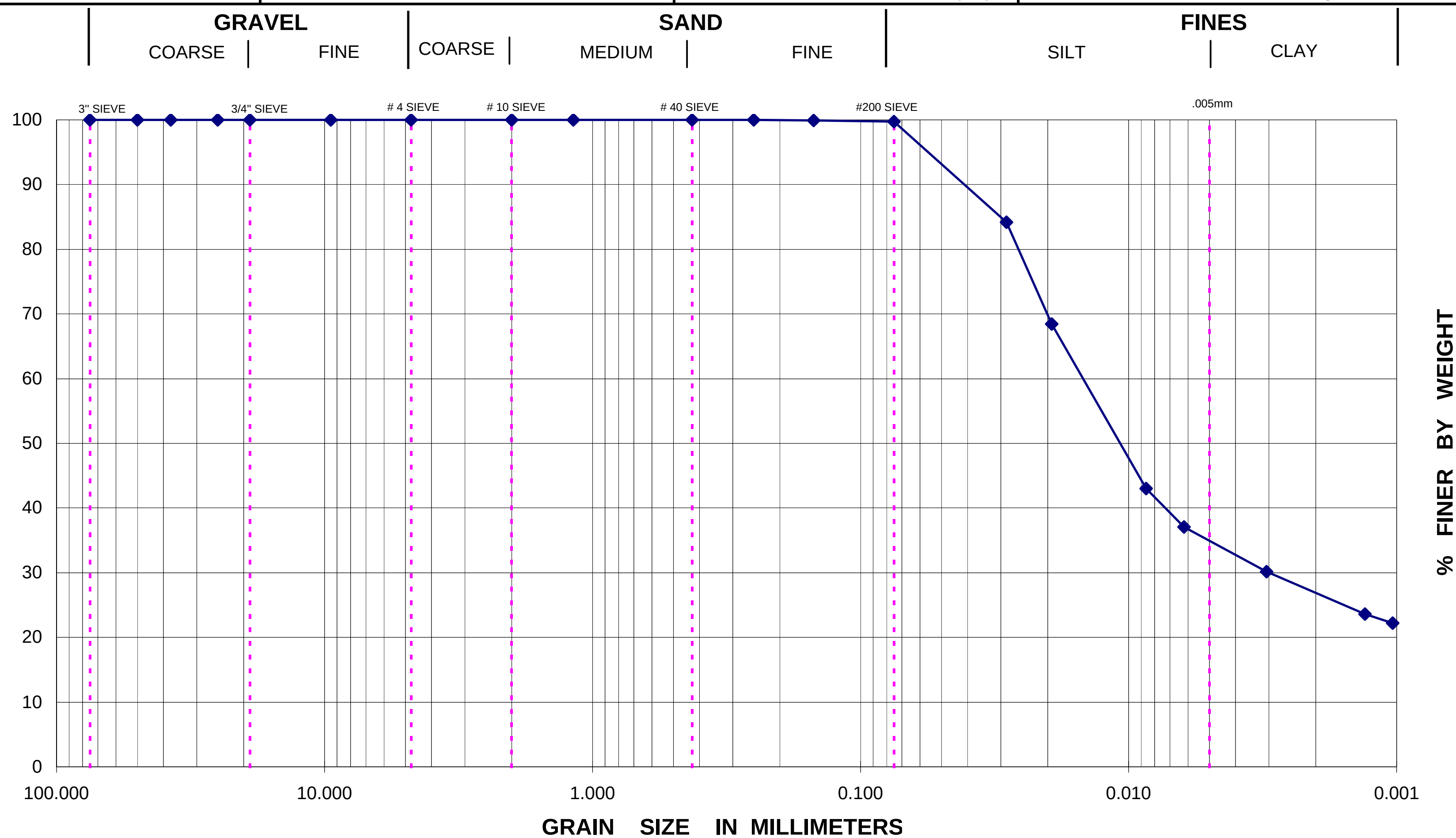
422 Codell Drive, Lexington, KY 40509

PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/13/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-82*	**DEPTH / ELEV. :**	*7.0'-8.5'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*4*	**REPORT DATE:**	*12/14/11*
SOIL DESCRIPTION :	*Brown Lean clay*					**SP. GRAVITY, Gs :**	*2.70*
LIQUID LIMIT, % :	*36*	**PLASTICITY INDEX , % :**	*16*	**MOISTURE , % :**	*14.8*	**FINES , % :**	*99.7*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-6 (17)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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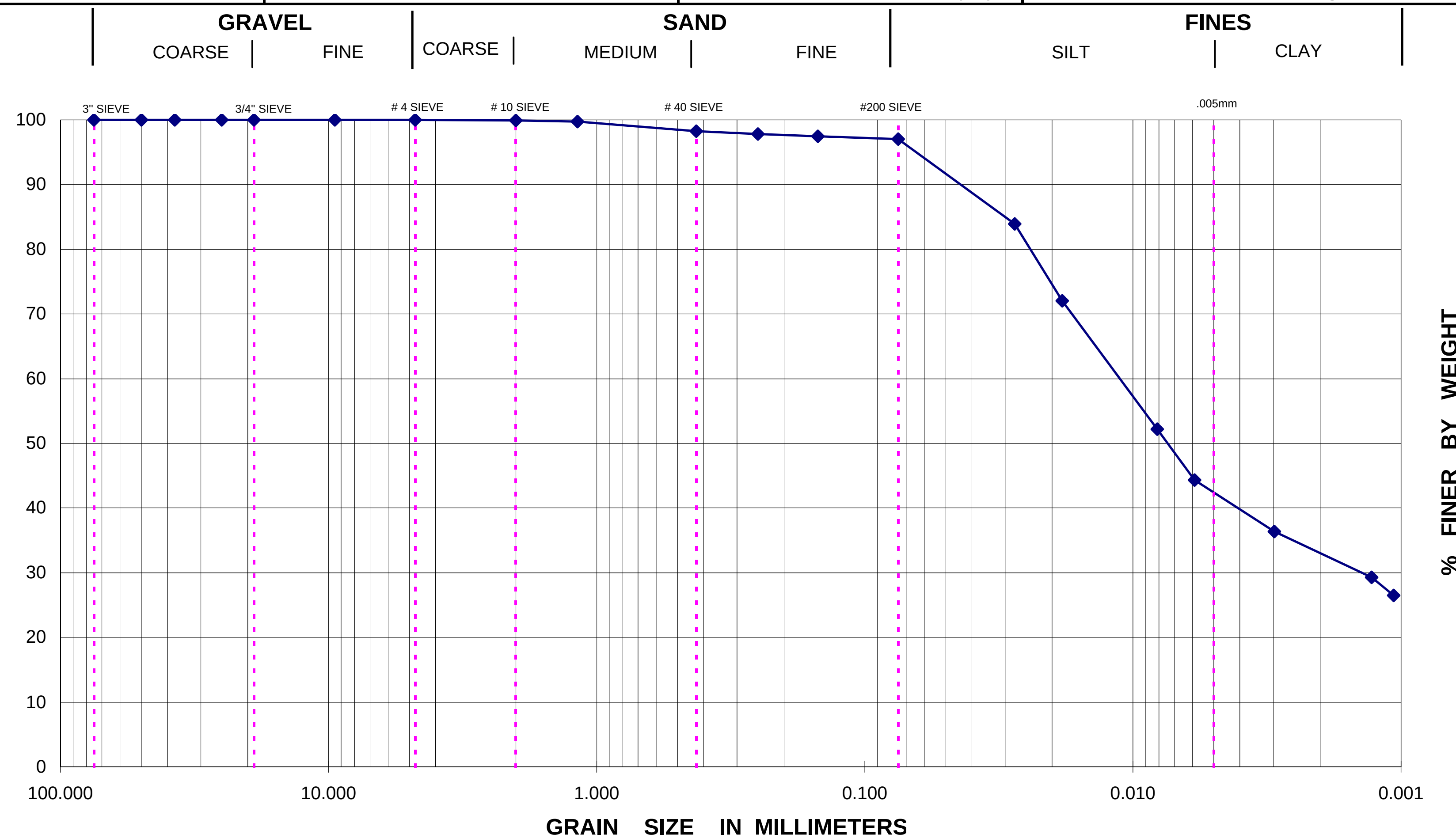
PARTICLE- SIZE DISTRIBUTION TEST REPORT
SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

422 Codell Drive, Lexington, KY 40509

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/13/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-82*	**DEPTH / ELEV. :**	*8.5' - 10.0'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*5*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL- Orange brown Lean clay*					**SP. GRAVITY, Gs :**	*2.70*
LIQUID LIMIT, % :	*40*	**PLASTICITY INDEX , % :**	*19*	**MOISTURE , % :**	*48.5*	**FINES , % :**	*97.0*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-6 (20)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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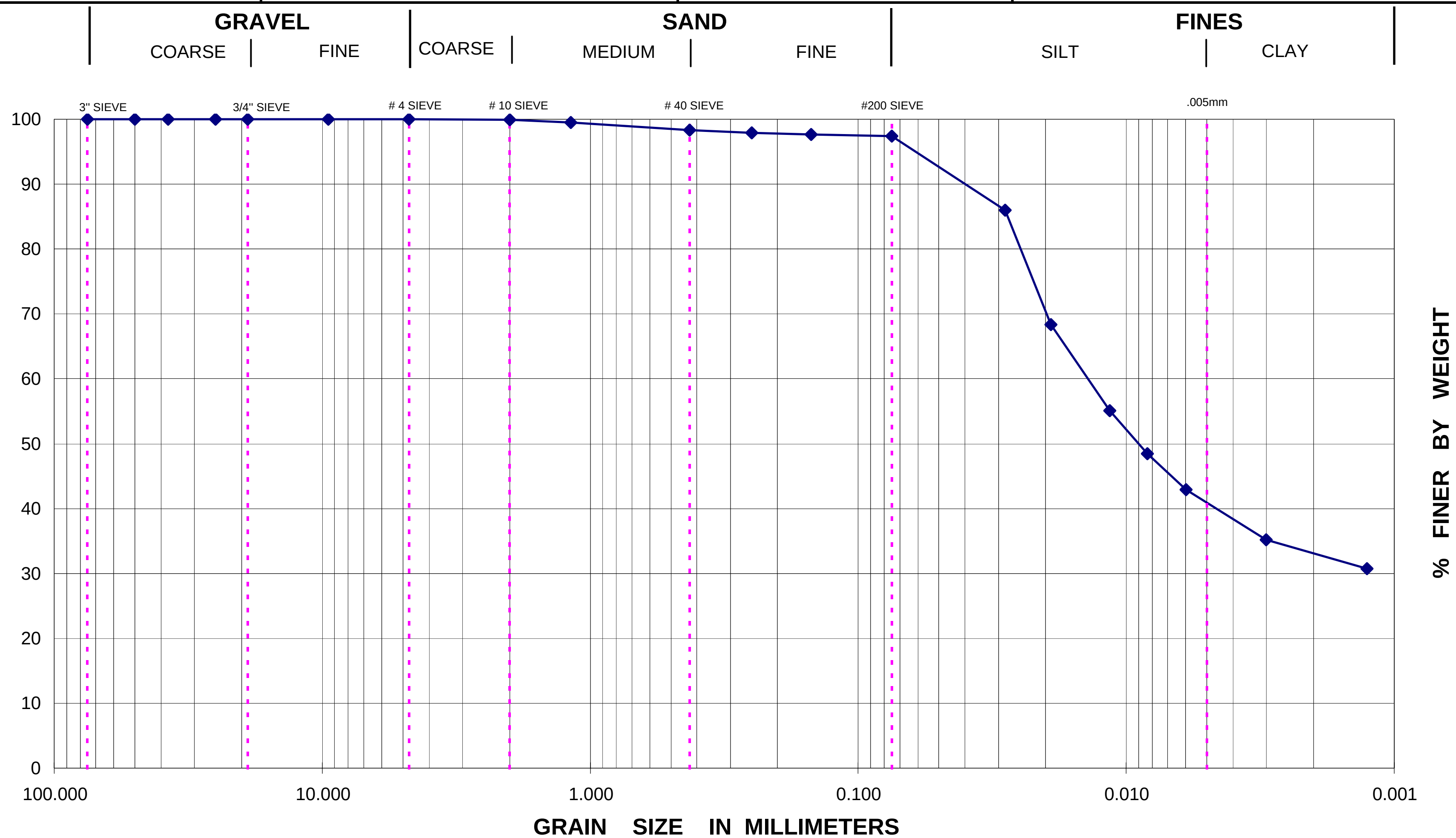
422 Codell Drive, Lexington, KY 40509

PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831-10-5629*			**TEST DATE:**	*11/01/11-11/02*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-82*	**DEPTH / ELEV. :**	*10.0'-12.0'*	**SAMPLE TYPE:**	*UD*	**SAMPLE RECEIVED:**	*11/15/2011*
SAMPLE LOCATION :	-			**SAMPLE NO:**	*6*	**REPORT DATE:**	*12/16/2011*
SOIL DESCRIPTION :	*CL- Brown Lean clay*					**SP. GRAVITY, Gs :**	*2.65*
LIQUID LIMIT, % :	*37*	**PLASTICITY INDEX , % :**	*19*	**MOISTURE , % :**	*16.6*	**FINES , % :**	*97.4*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-6 (26)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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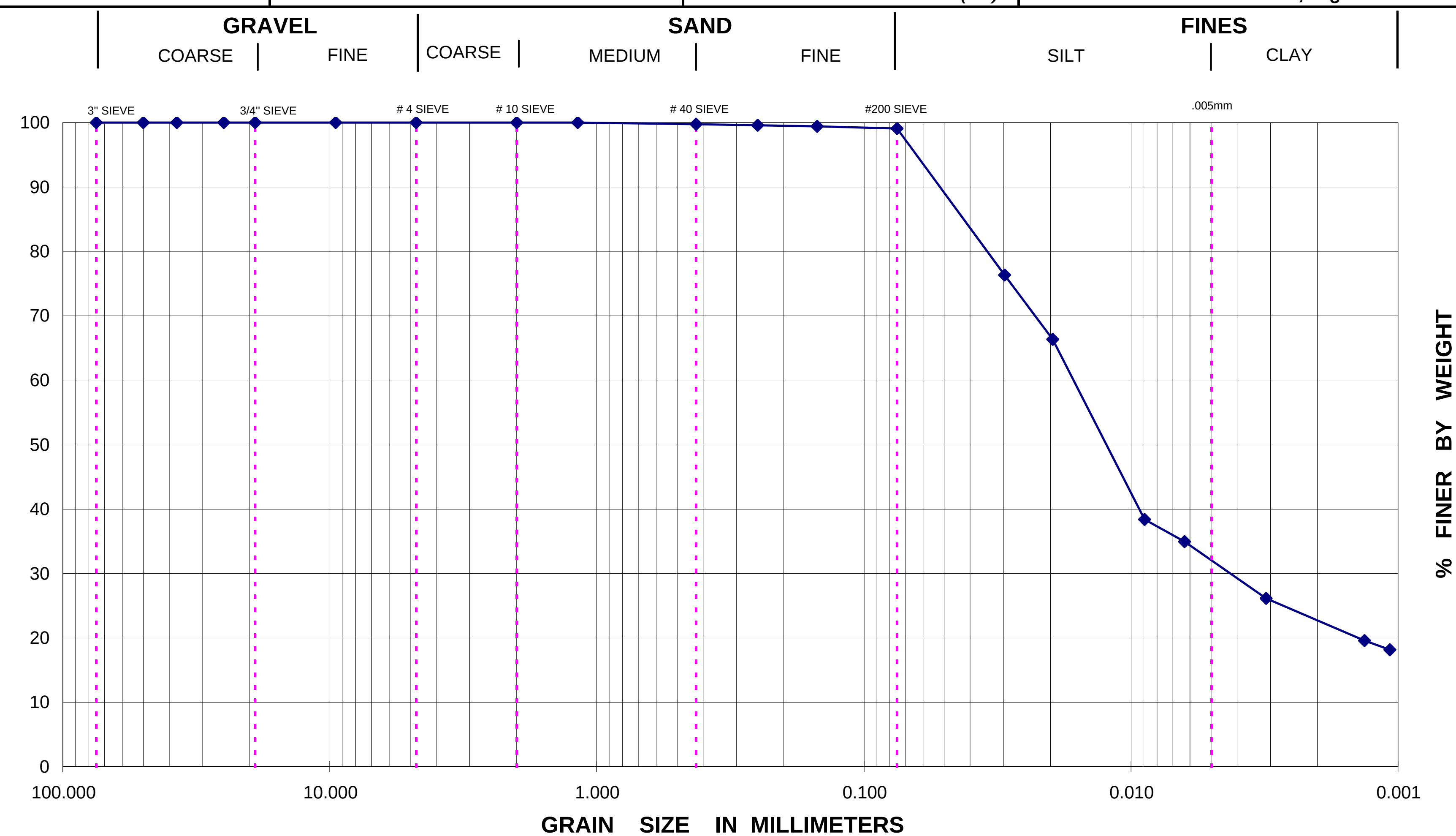
422 Codell Drive, Lexington, KY 40509

PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*				
PROJECT NUMBER:	*1831105629B*	**TEST DATE:**	*12/4/11*	**REVIEWED BY :**	
BORING / PIT NO. : *B-83*	**DEPTH / ELEV. :** *1.0' - 2.5'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -		**SAMPLE NO:**	*1*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL- Brown Lean clay*			**SP. GRAVITY, Gs :**	*2.68*
LIQUID LIMIT, % : *32*	**PLASTICITY INDEX , % :** *12*	**MOISTURE , % :**	*18.1*	**FINES , % :**	*99.1*
D10 , MM : *N/A*	**D30, MM :** *N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION	**UNIFIED :** *CL*	**AASHTO :**	*A-6 (12)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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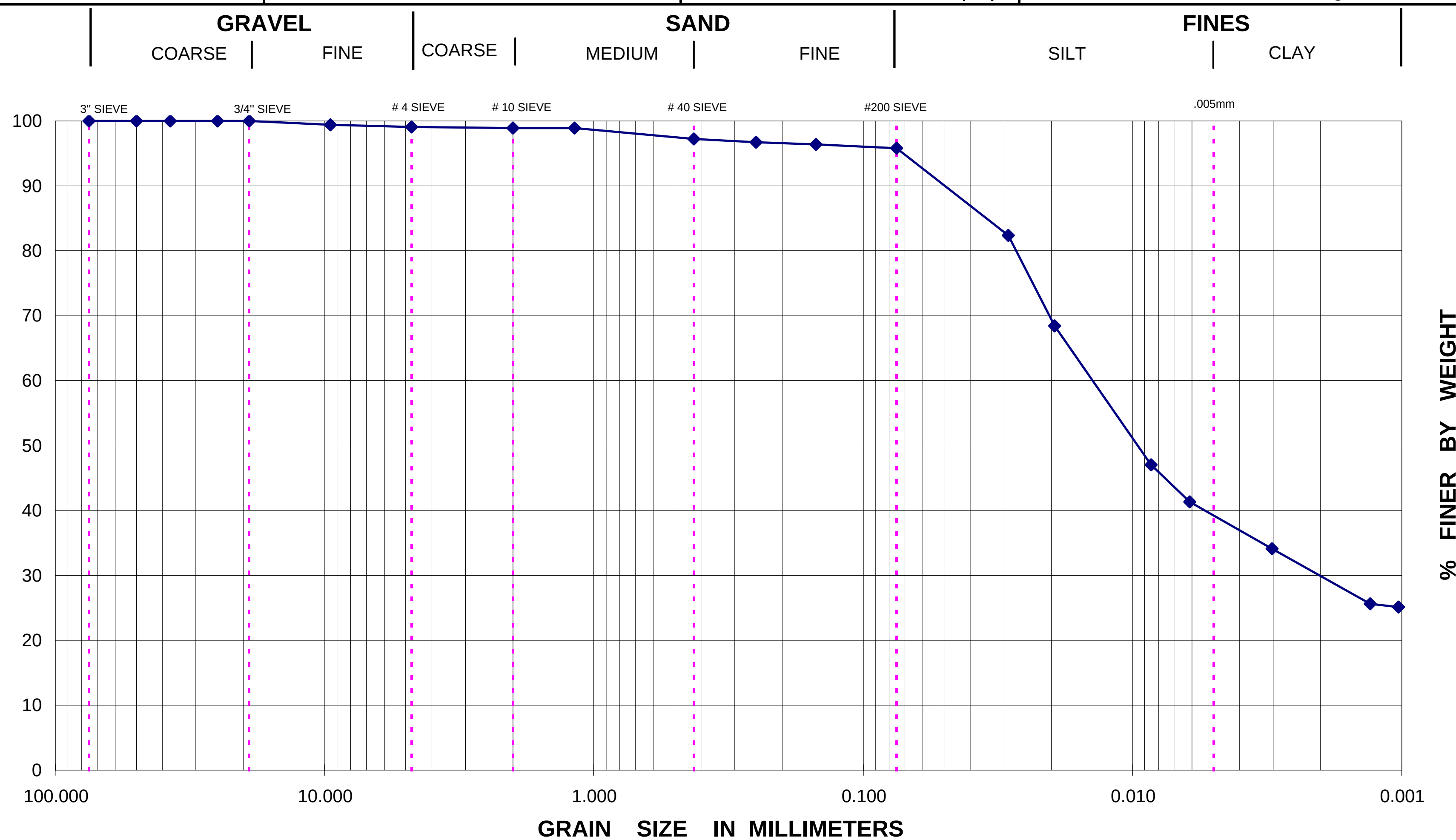
PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

422 Codell Drive, Lexington, KY 40509

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/4/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-83*	**DEPTH / ELEV. :**	*3.5'-5.0'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*2*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL- Brown Lean clay*					**SP. GRAVITY, Gs :**	*2.68*
LIQUID LIMIT, % :	*39*	**PLASTICITY INDEX , % :**	*18*	**MOISTURE , % :**	*13.7*	**FINES , % :**	*95.8*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-6 (18)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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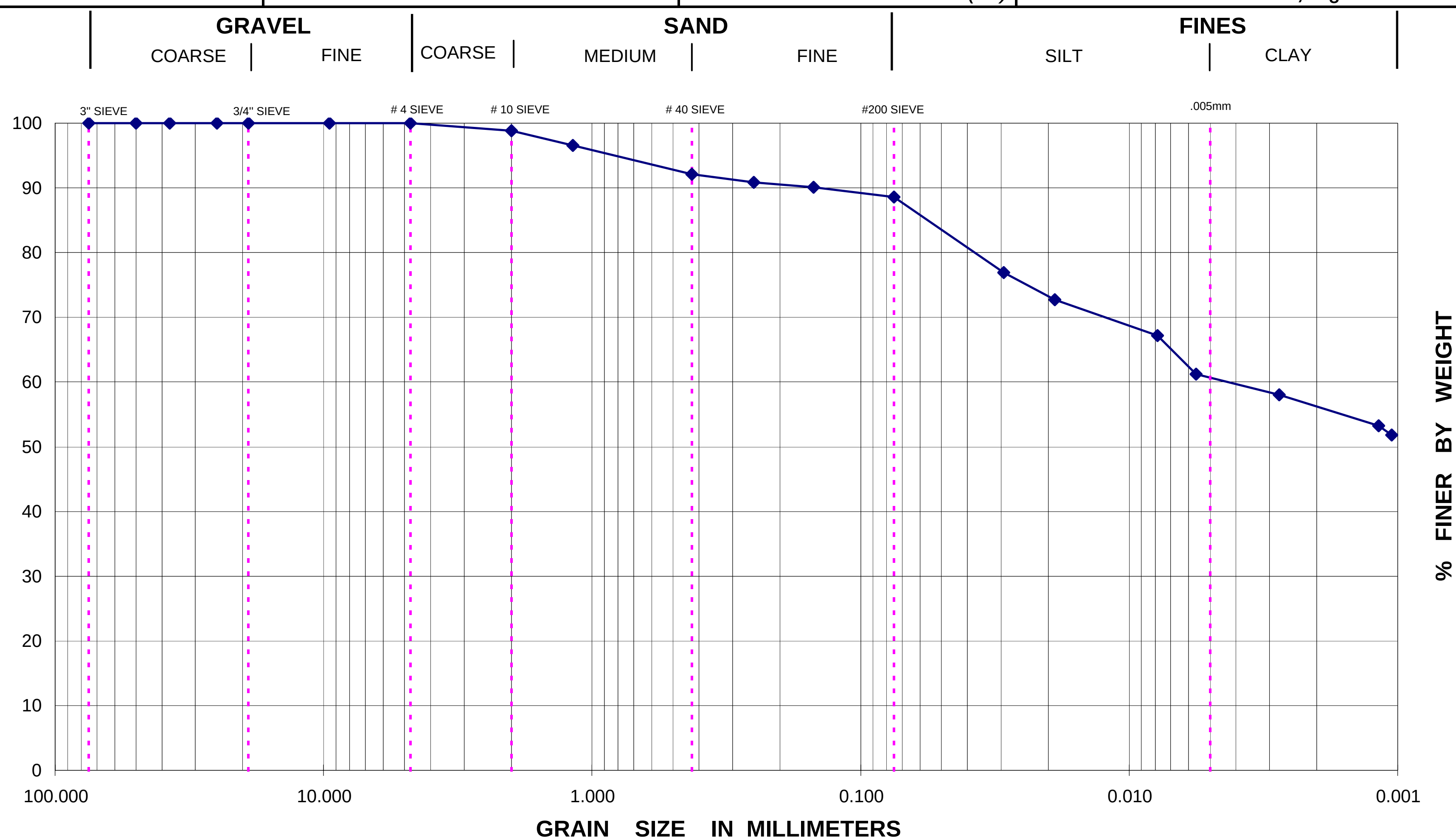
422 Codell Drive, Lexington, KY 40509

PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/4/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-83*	**DEPTH / ELEV. :**	*6.0' - 7.5'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*3*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CH- Red brown Fat clay*					**SP. GRAVITY, Gs :**	*2.75*
LIQUID LIMIT, % :	*71*	**PLASTICITY INDEX , % :**	*49*	**MOISTURE , % :**	*27.5*	**FINES , % :**	*88.5*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-7-6 (48)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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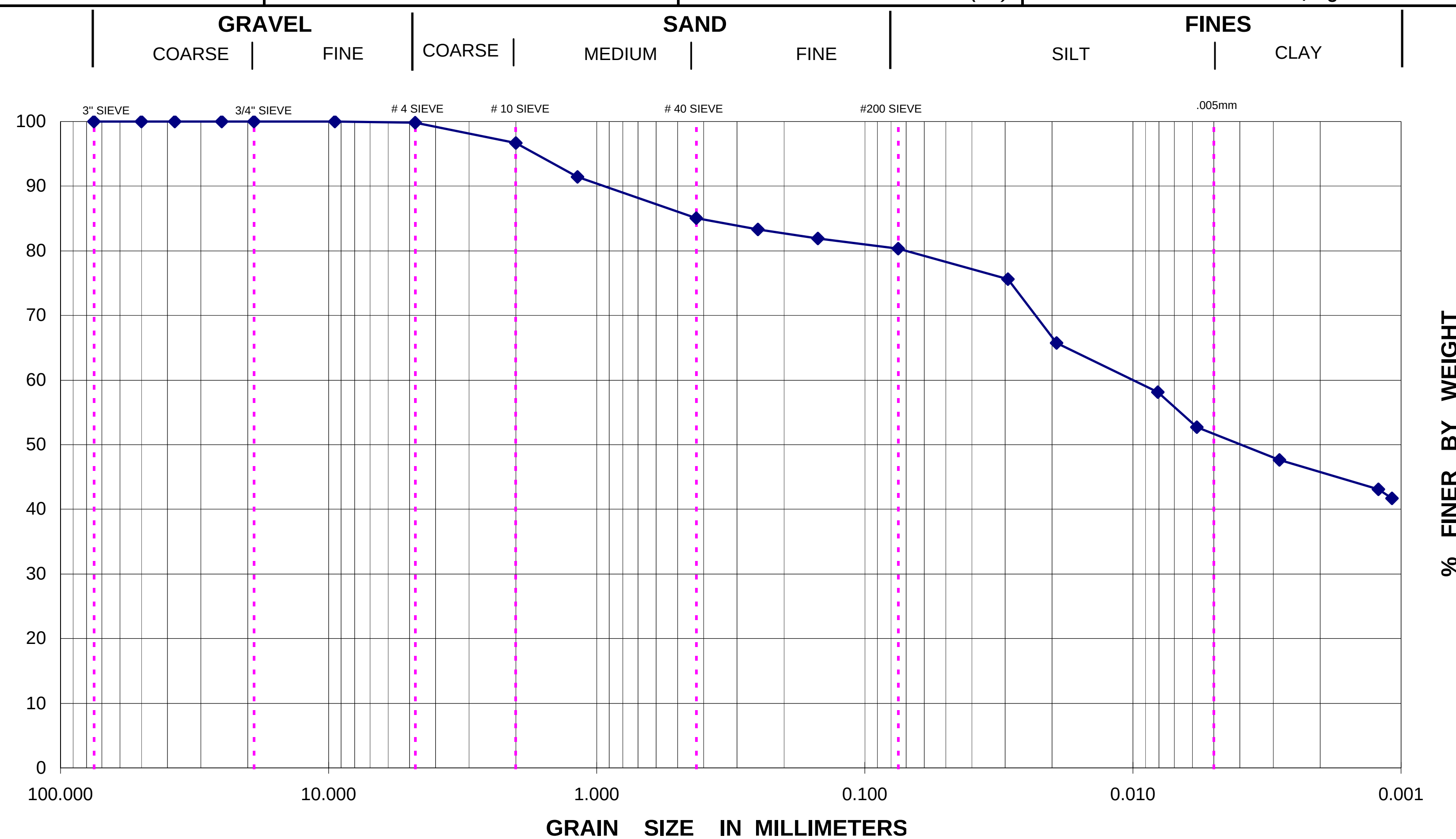
422 Codell Drive, Lexington, KY 40509

PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/12/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-84*	**DEPTH / ELEV. :**	*3.5' - 5.0'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*1*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CH- Orange brown Fat clay with sand*					**SP. GRAVITY, Gs :**	*2.74*
LIQUID LIMIT, % :	*69*	**PLASTICITY INDEX , % :**	*45*	**MOISTURE , % :**	*23.8*	**FINES , % :**	*80.4*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CH*	**AASHTO :**	*A-7-6 (38)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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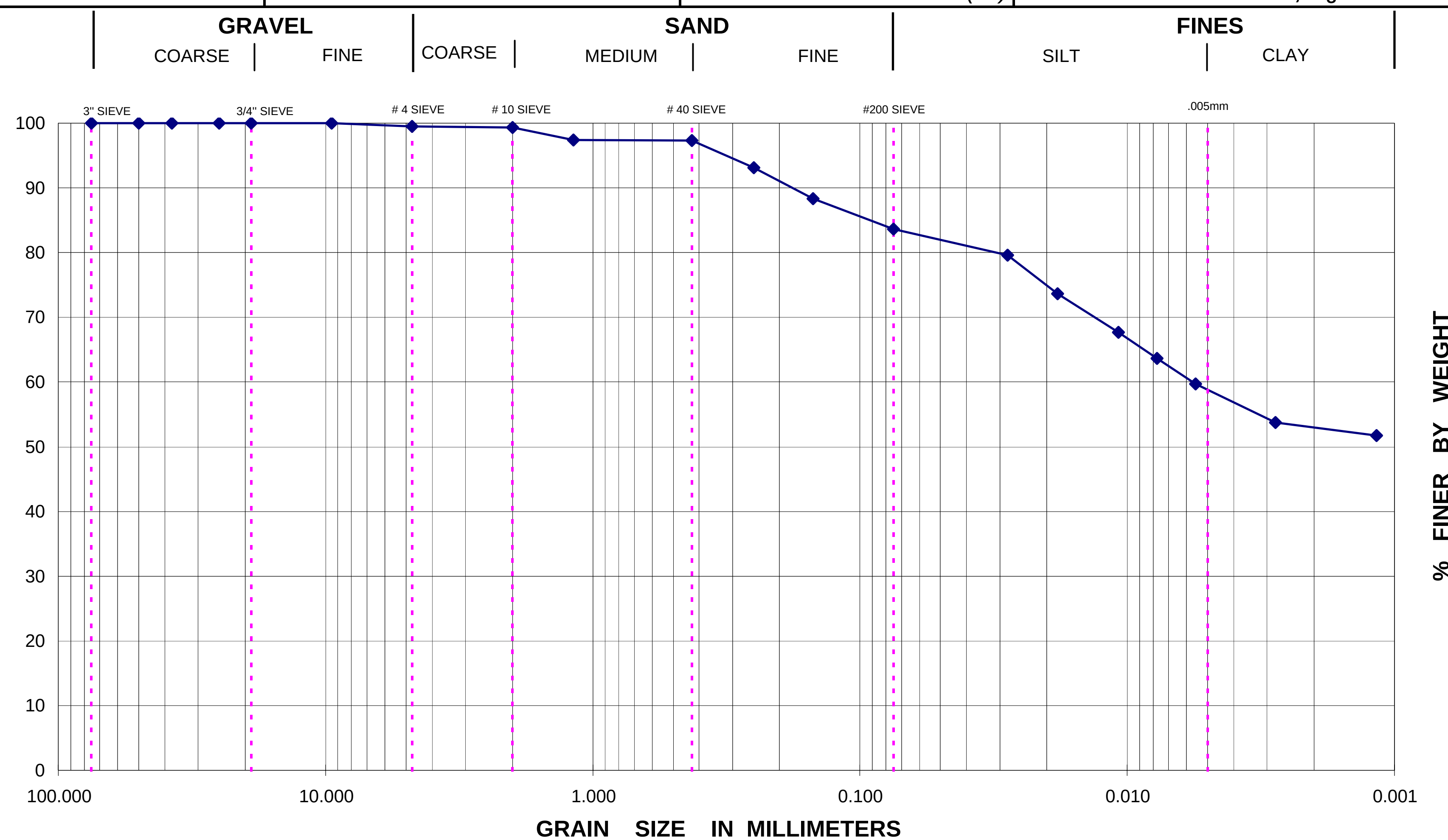
PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831-10-5629*			**TEST DATE:**	*11/01/11-11/02*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-84*	**DEPTH / ELEV. :**	*5.0'-7.0'*	**SAMPLE TYPE:**	*UD*	**SAMPLE RECEIVED:**	*11/15/2011*
SAMPLE LOCATION :	-			**SAMPLE NO:**	*2*	**REPORT DATE:**	*12/16/2011*
SOIL DESCRIPTION :	*CH- Red Fat clay with sand*					**SP. GRAVITY, Gs :**	*2.65*
LIQUID LIMIT, % :	*52*	**PLASTICITY INDEX , % :**	*31*	**MOISTURE , % :**	*26.0*	**FINES , % :**	*83.6*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CH*	**AASHTO :**	*A-7-6 (27)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

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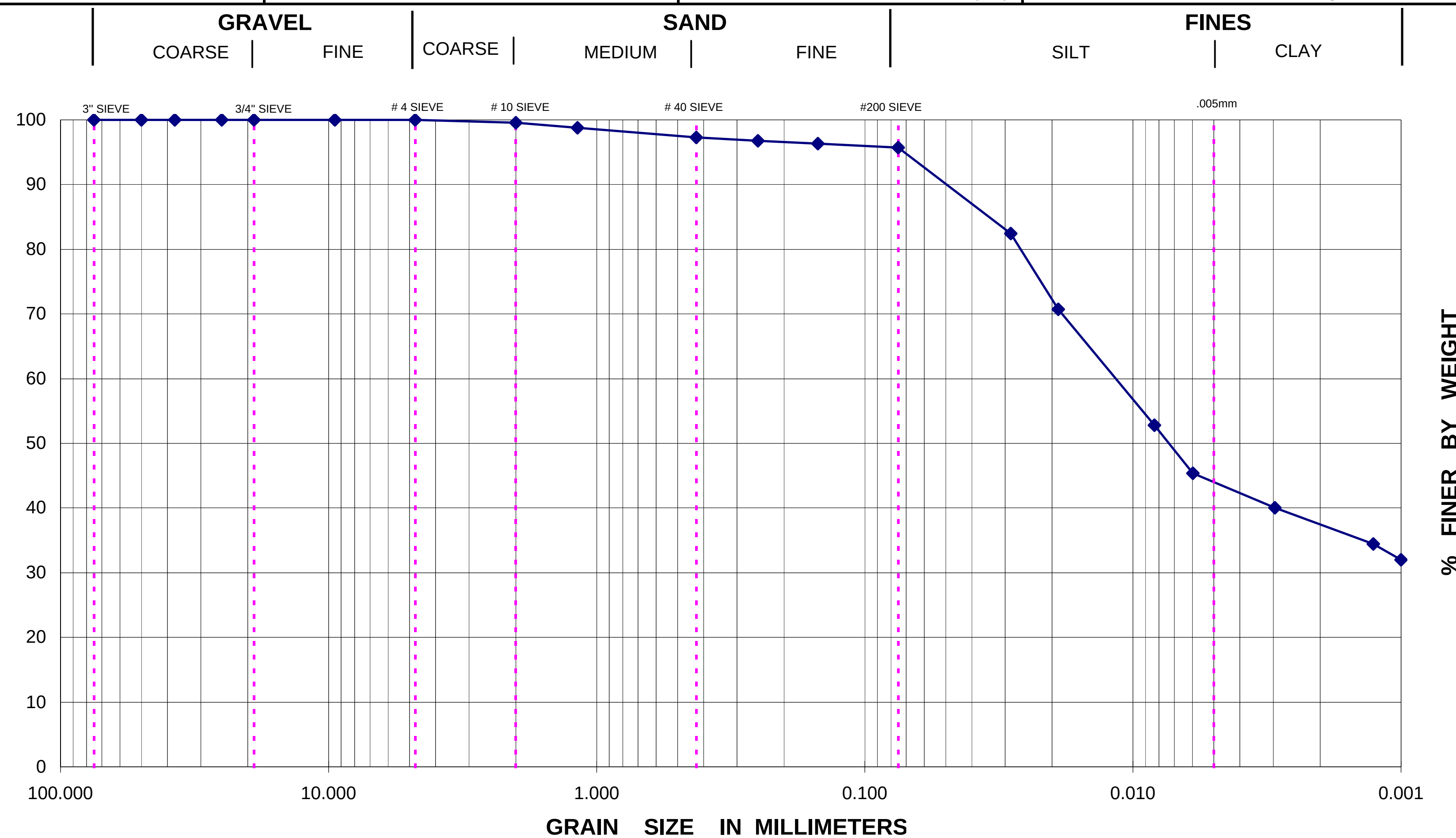
422 Codell Drive, Lexington, KY 40509

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/12/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-85*	**DEPTH / ELEV. :**	*1.0' - 2.5'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*1*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL- Orange brown Lean clay*					**SP. GRAVITY, Gs :**	*2.70*
LIQUID LIMIT, % :	*43*	**PLASTICITY INDEX , % :**	*21*	**MOISTURE , % :**	*24.9*	**FINES , % :**	*95.7*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-7-6 (22)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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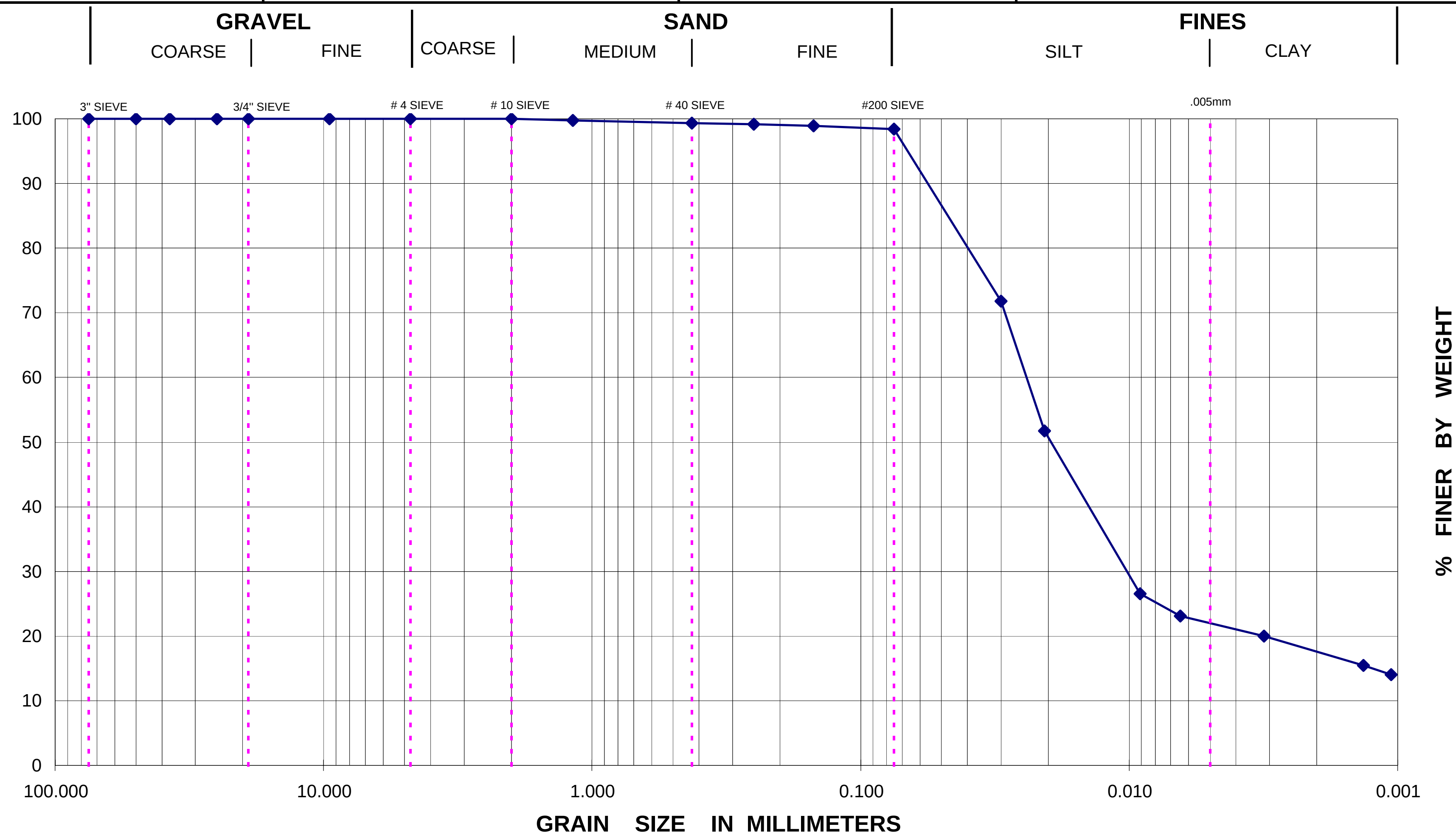
PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

422 Codell Drive, Lexington, KY 40509

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/4/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-87*	**DEPTH / ELEV. :**	*1.0'-2.5'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*1*	**REPORT DATE:**	*12/14/11*
SOIL DESCRIPTION :	*CL- Orange brown Lean clay*					**SP. GRAVITY, Gs :**	*2.68*
LIQUID LIMIT, % :	*31*	**PLASTICITY INDEX , % :**	*10*	**MOISTURE , % :**	*17.7*	**FINES , % :**	*98.4*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-4 (10)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



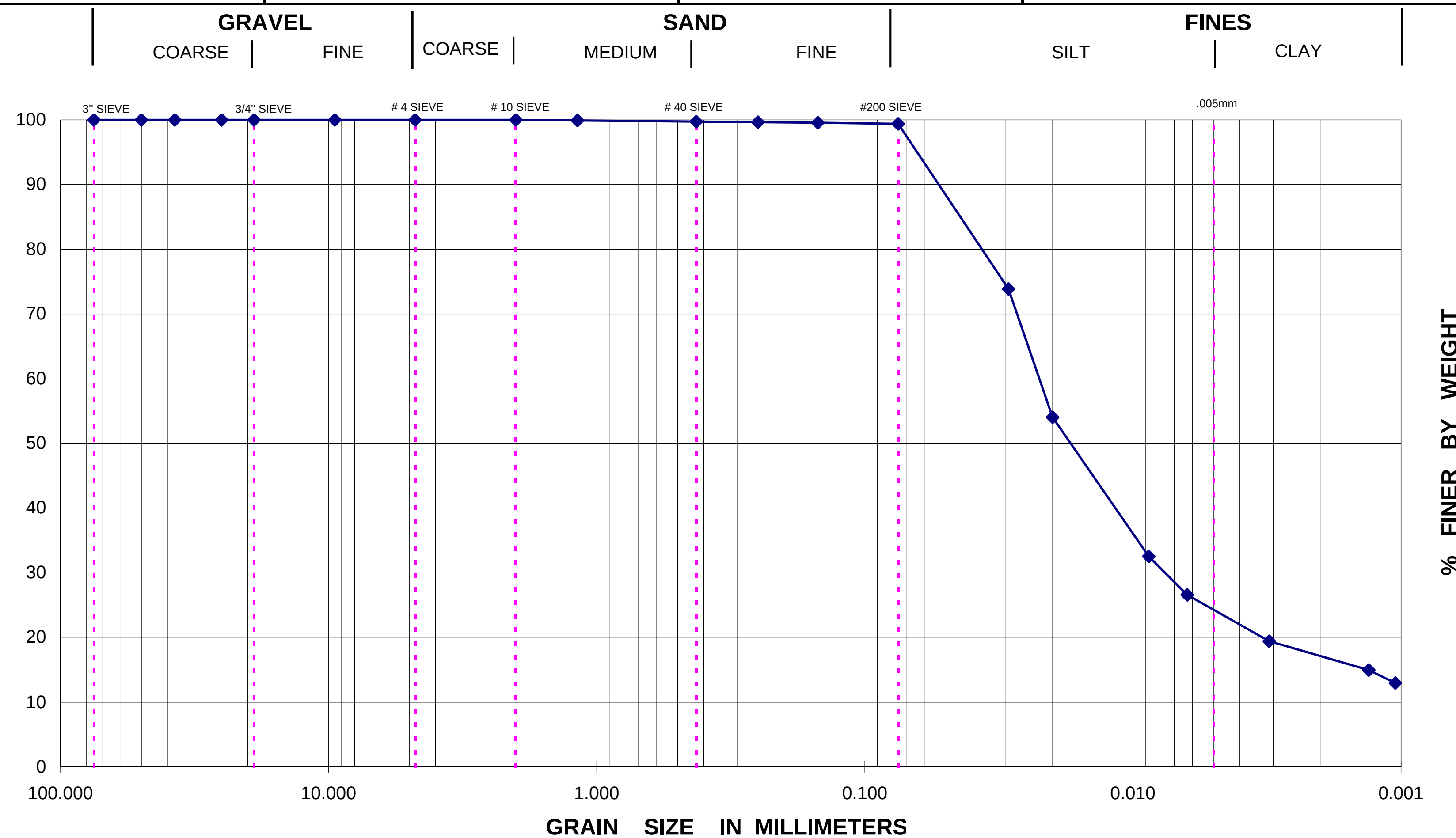
PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

S&ME
422 Codell Drive, Lexington, KY 40509

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/12/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-88*	**DEPTH / ELEV. :**	*1.0'-2.5'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*1*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL- Brown Lean clay*					**SP. GRAVITY, Gs :**	*2.68*
LIQUID LIMIT, % :	*30*	**PLASTICITY INDEX , % :**	*8*	**MOISTURE , % :**	*25.9*	**FINES , % :**	*99.3*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-4 (8)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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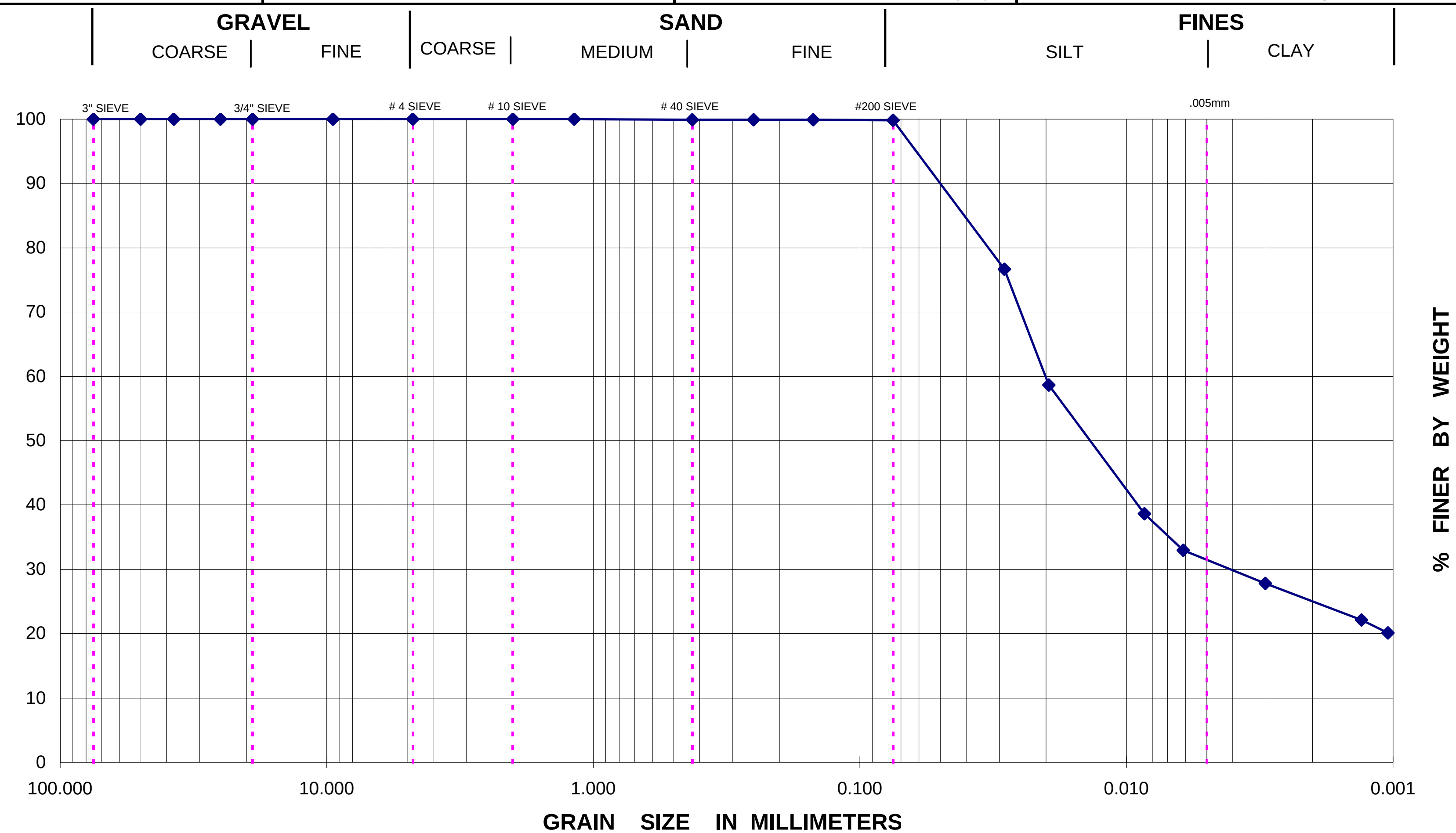
PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

422 Codell Drive, Lexington, KY 40509

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/12/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-88*	**DEPTH / ELEV. :**	*4.0'-5.0'*	**SAMPLE TYPE:**	*UD*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*2*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL- Brown Lean clay*					**SP. GRAVITY, Gs :**	*2.70*
LIQUID LIMIT, % :	*44*	**PLASTICITY INDEX , % :**	*23*	**MOISTURE , % :**	*21.2*	**FINES , % :**	*99.8*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-6 (25)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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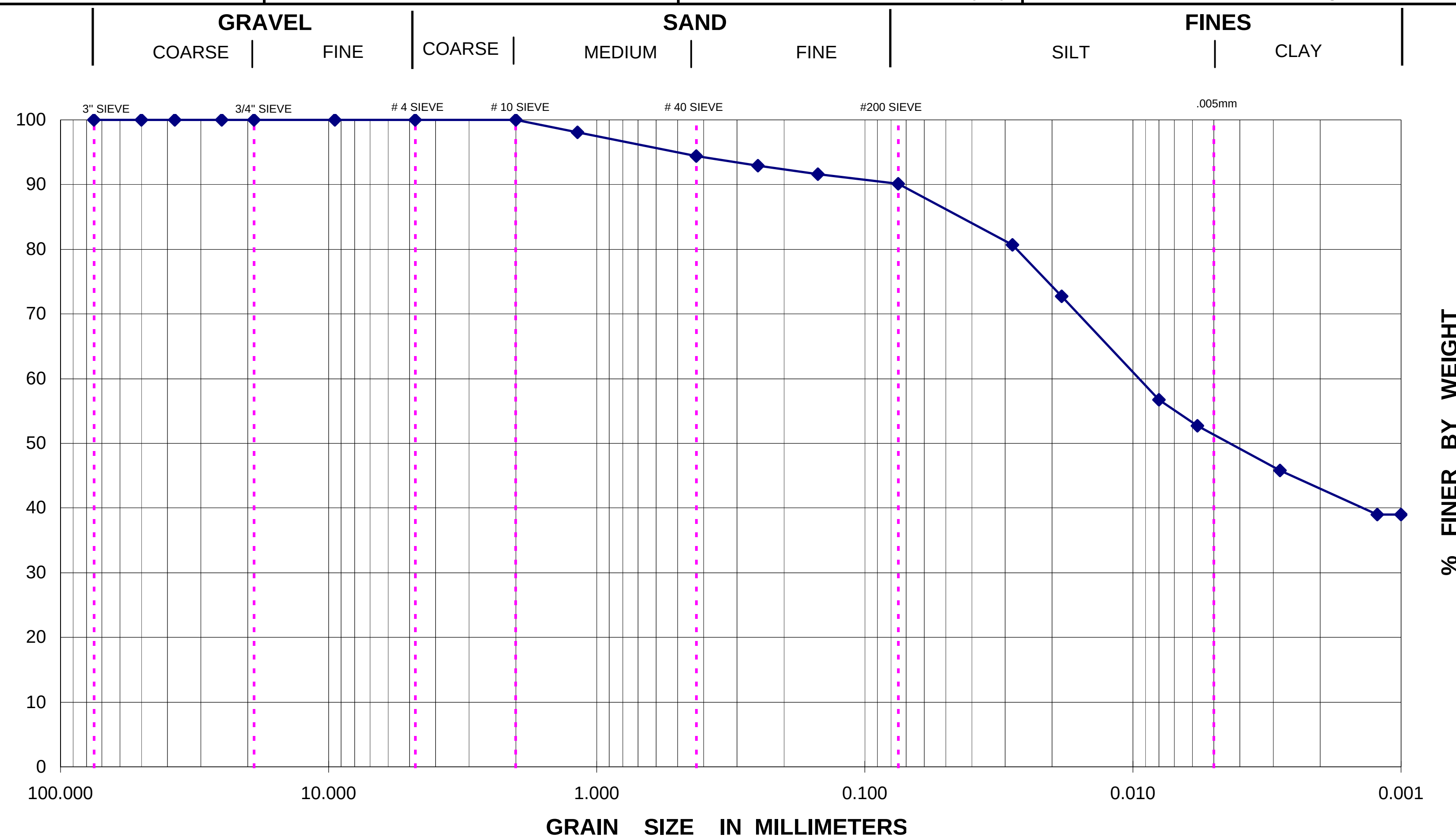
PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/12/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-88*	**DEPTH / ELEV. :**	*6.0'-7.5'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*3*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL- Orange brown Lean clay*					**SP. GRAVITY, Gs :**	*2.69*
LIQUID LIMIT, % :	*44*	**PLASTICITY INDEX , % :**	*26*	**MOISTURE , % :**	*17.3*	**FINES , % :**	*90.2*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-7-6 (24)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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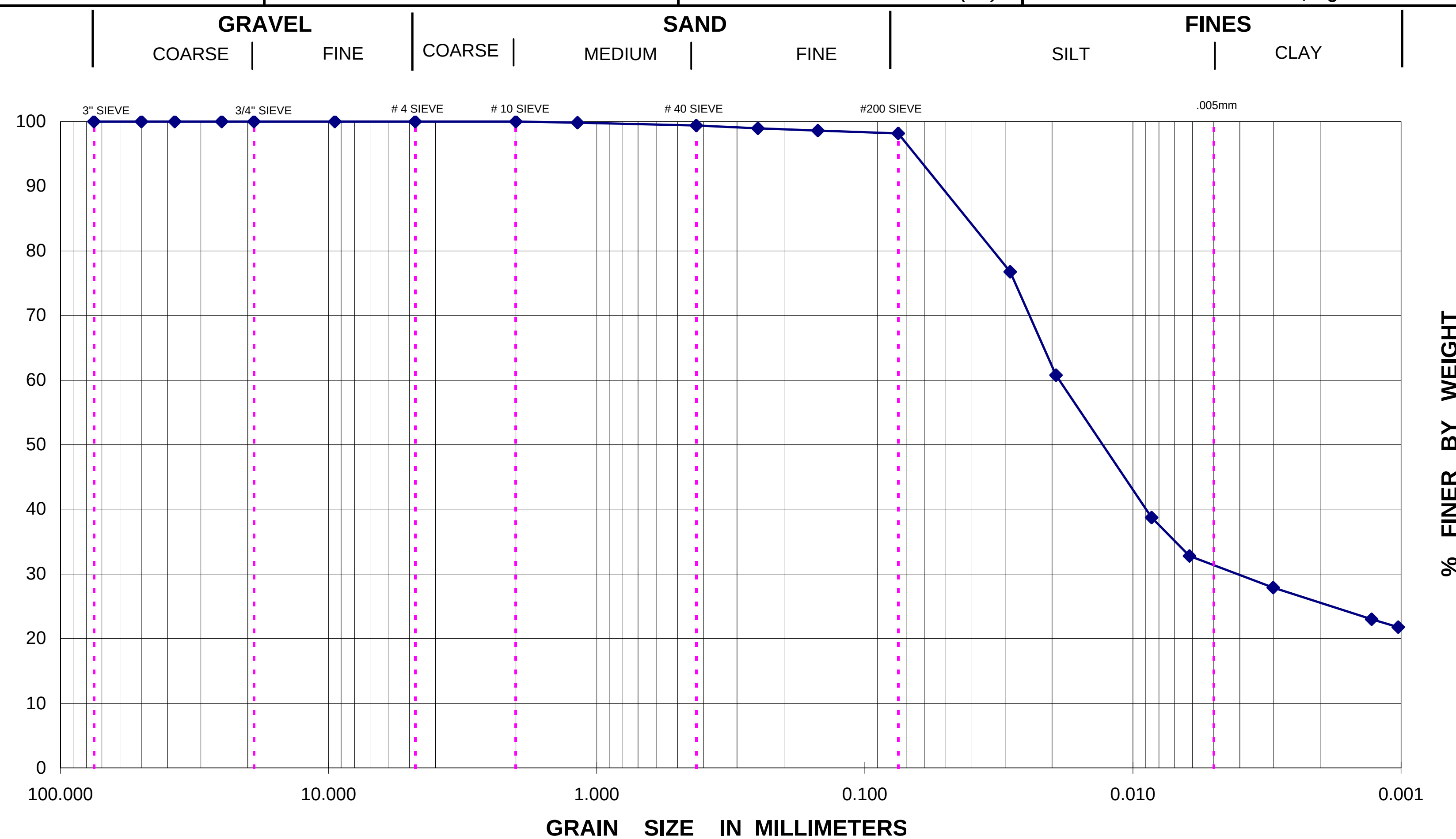
PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*				
PROJECT NUMBER:	*1831105629B*	**TEST DATE:**	*12/12/11*	**REVIEWED BY :**	
BORING / PIT NO. : *B-88*	**DEPTH / ELEV. :** *8.0'-10.0'*	**SAMPLE TYPE:**	*UD*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -		**SAMPLE NO:**	*4*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL- Orange brown Lean clay*			**SP. GRAVITY, Gs :**	*2.69*
LIQUID LIMIT, % : *33*	**PLASTICITY INDEX , % :** *12*	**MOISTURE , % :**	*21.4*	**FINES , % :**	*98.1*
D10 , MM : *N/A*	**D30, MM :** *N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION	**UNIFIED :** *CL*	**AASHTO :**	*A-6 (12)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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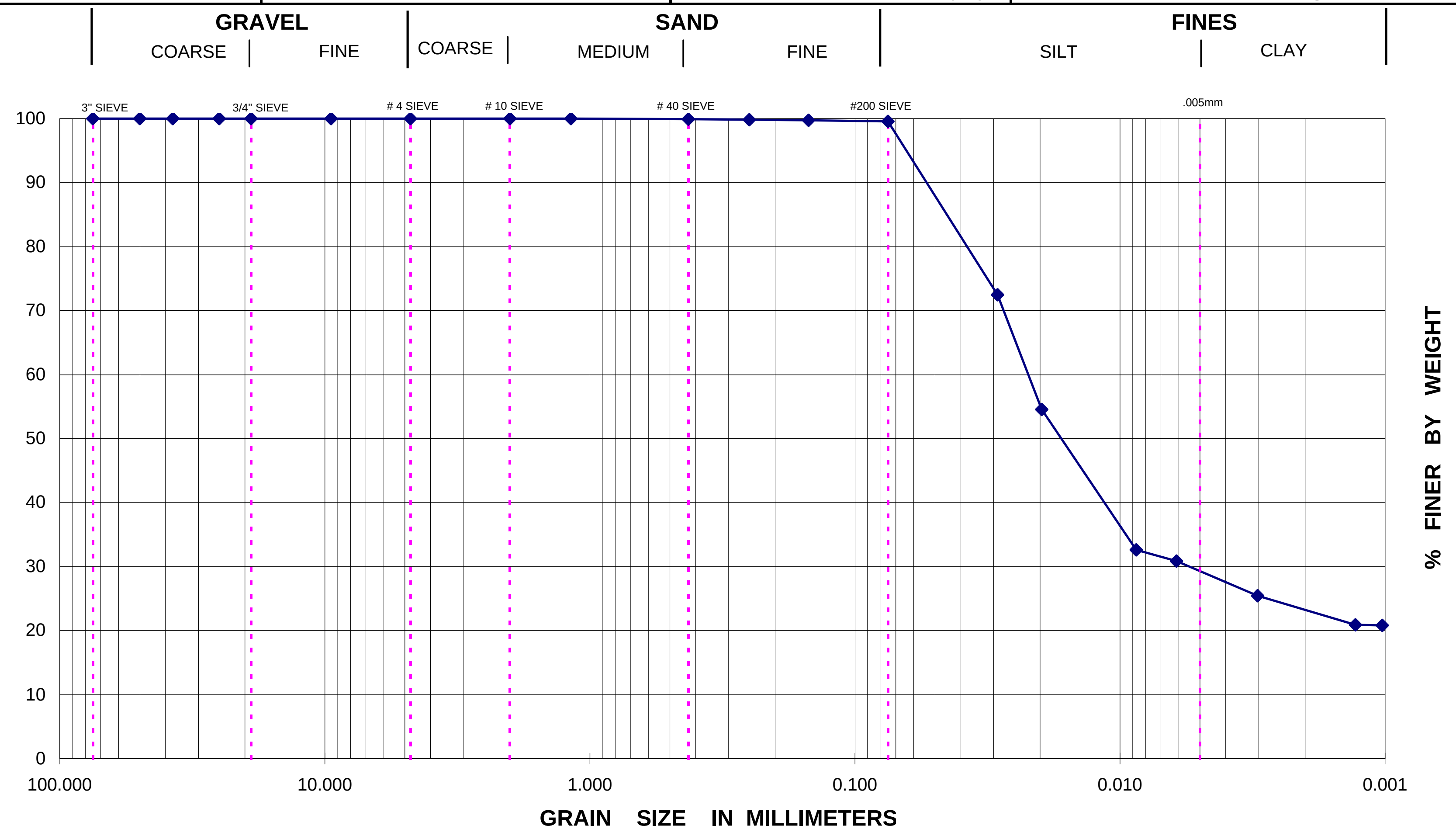
PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/12/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-89*	**DEPTH / ELEV. :**	*1.0'-2.5'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*1*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL- Brown Lean clay*					**SP. GRAVITY, Gs :**	*2.70*
LIQUID LIMIT, % :	*38*	**PLASTICITY INDEX , % :**	*14*	**MOISTURE , % :**	*23.3*	**FINES , % :**	*99.5*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-6 (16)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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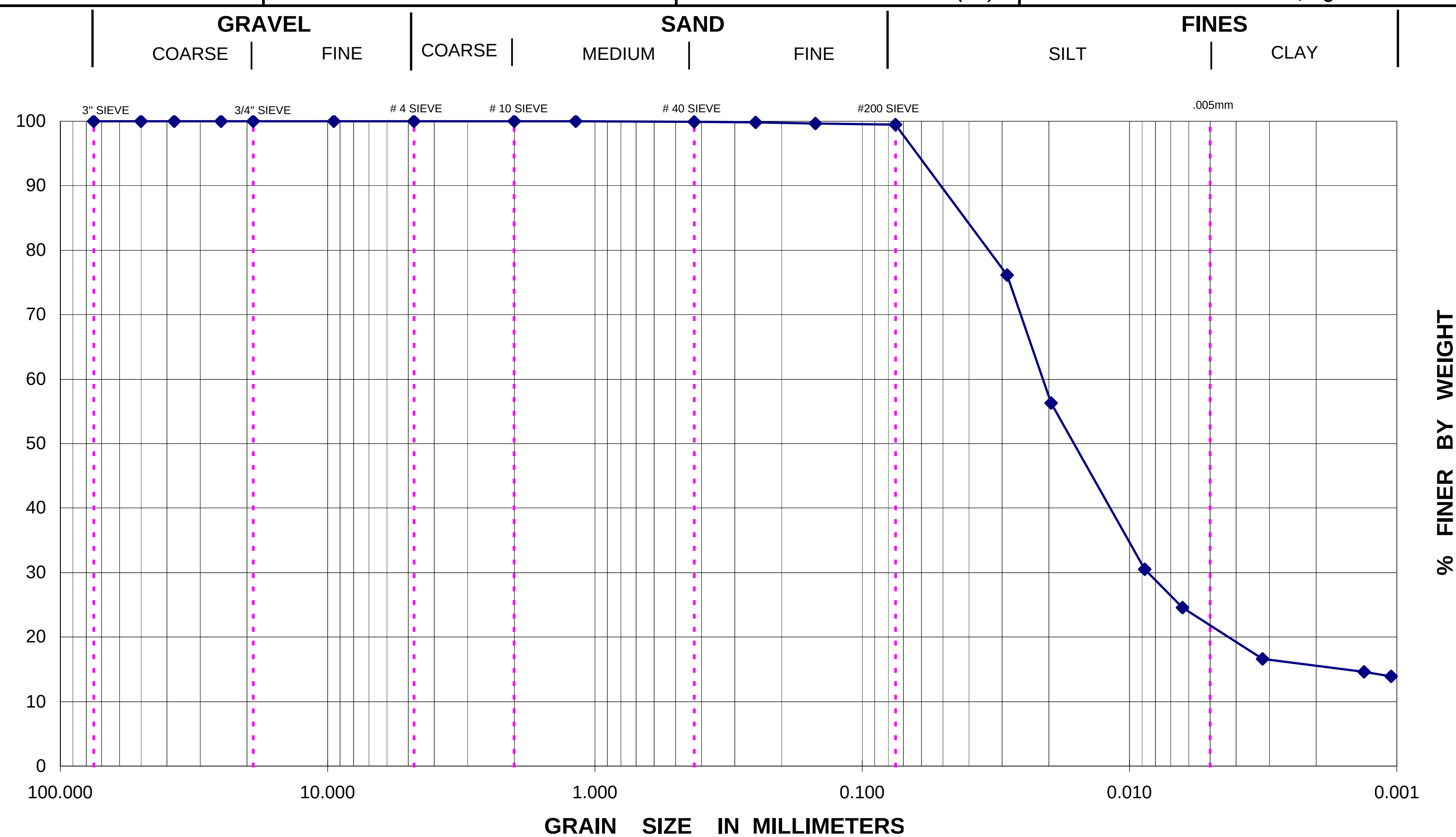
PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/12/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-89*	**DEPTH / ELEV. :**	*4.0'-6.0'*	**SAMPLE TYPE:**	*UD*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION :	-			**SAMPLE NO:**	*2*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL- Orange brown Lean clay*					**SP. GRAVITY, Gs :**	*2.68*
LIQUID LIMIT, % :	*33*	**PLASTICITY INDEX , % :**	*11*	**MOISTURE , % :**	*21.4*	**FINES , % :**	*99.5*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-6 (11)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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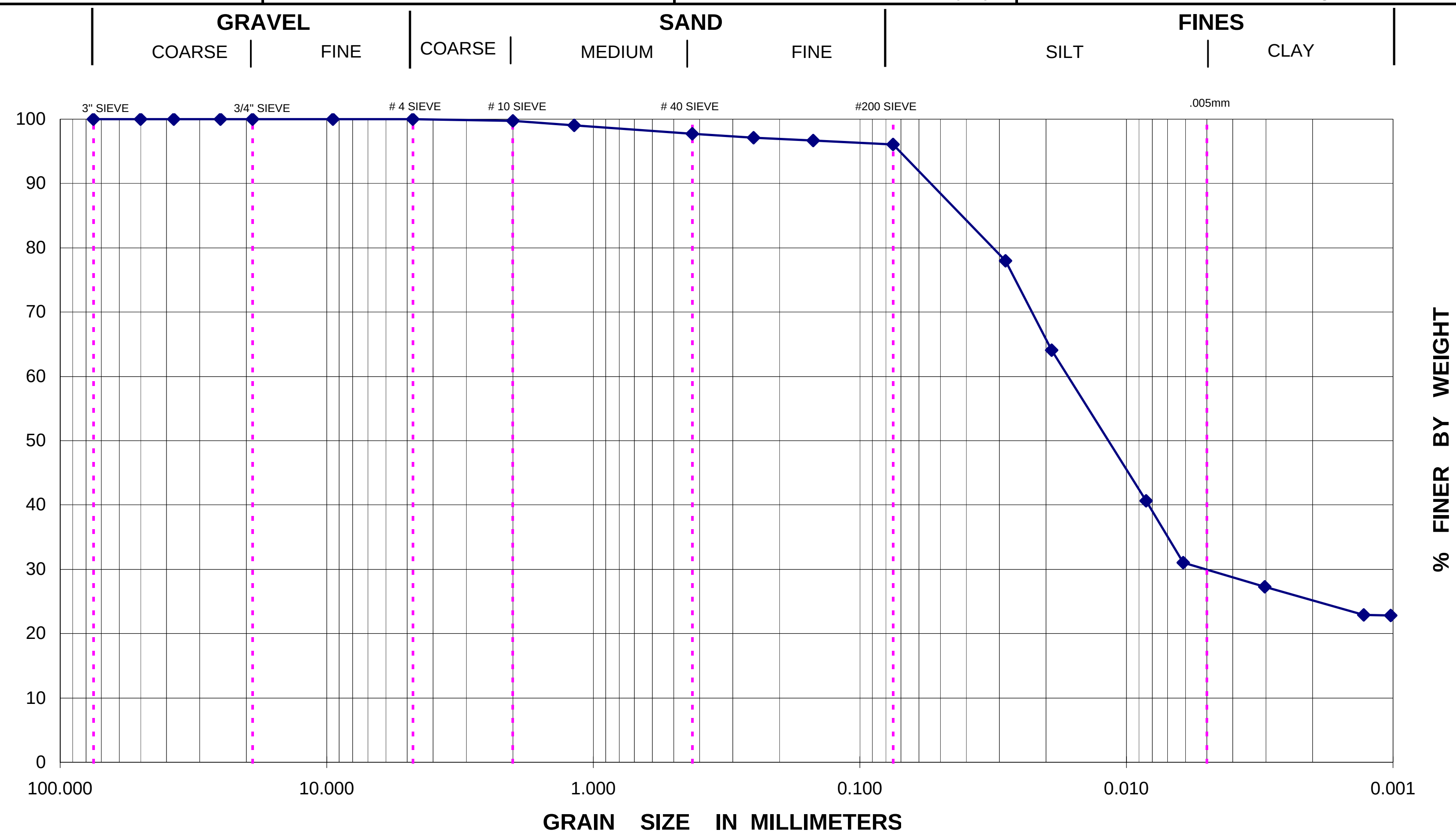
PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

422 Codell Drive, Lexington, KY 40509

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/12/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-89*	**DEPTH / ELEV. :**	*6.0'-7.5'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*3*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL- Brown Lean clay*					**SP. GRAVITY, Gs :**	*2.68*
LIQUID LIMIT, % :	*39*	**PLASTICITY INDEX , % :**	*18*	**MOISTURE , % :**	*20.6*	**FINES , % :**	*96.1*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-6 (18)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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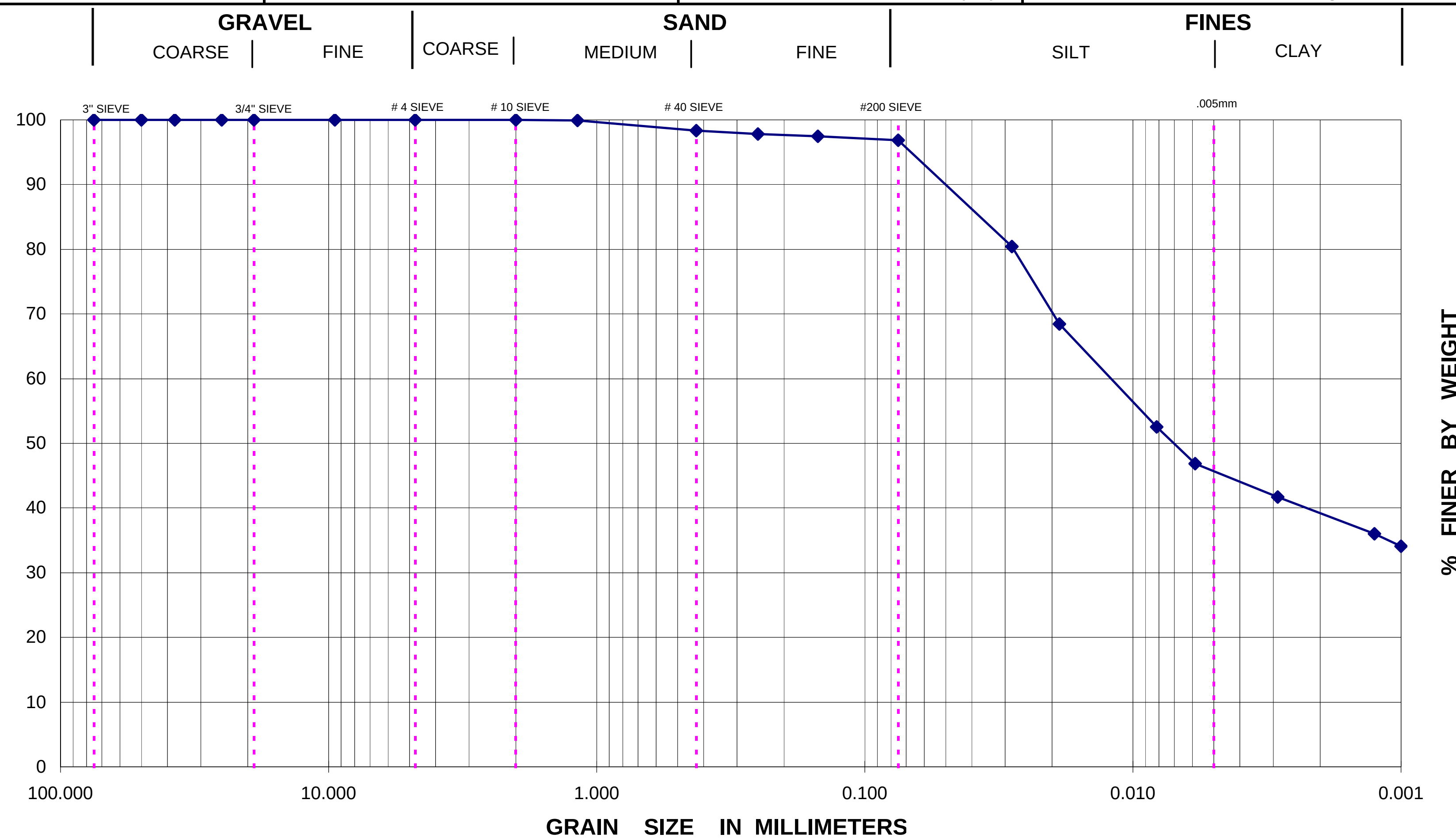
PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/12/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-89*	**DEPTH / ELEV. :**	*8.0'-10.0'*	**SAMPLE TYPE:**	*UD*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*4*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL- Brown Lean clay*					**SP. GRAVITY, Gs :**	*2.68*
LIQUID LIMIT, % :	*35*	**PLASTICITY INDEX , % :**	*15*	**MOISTURE , % :**	*22.6*	**FINES , % :**	*96.8*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-6 (15)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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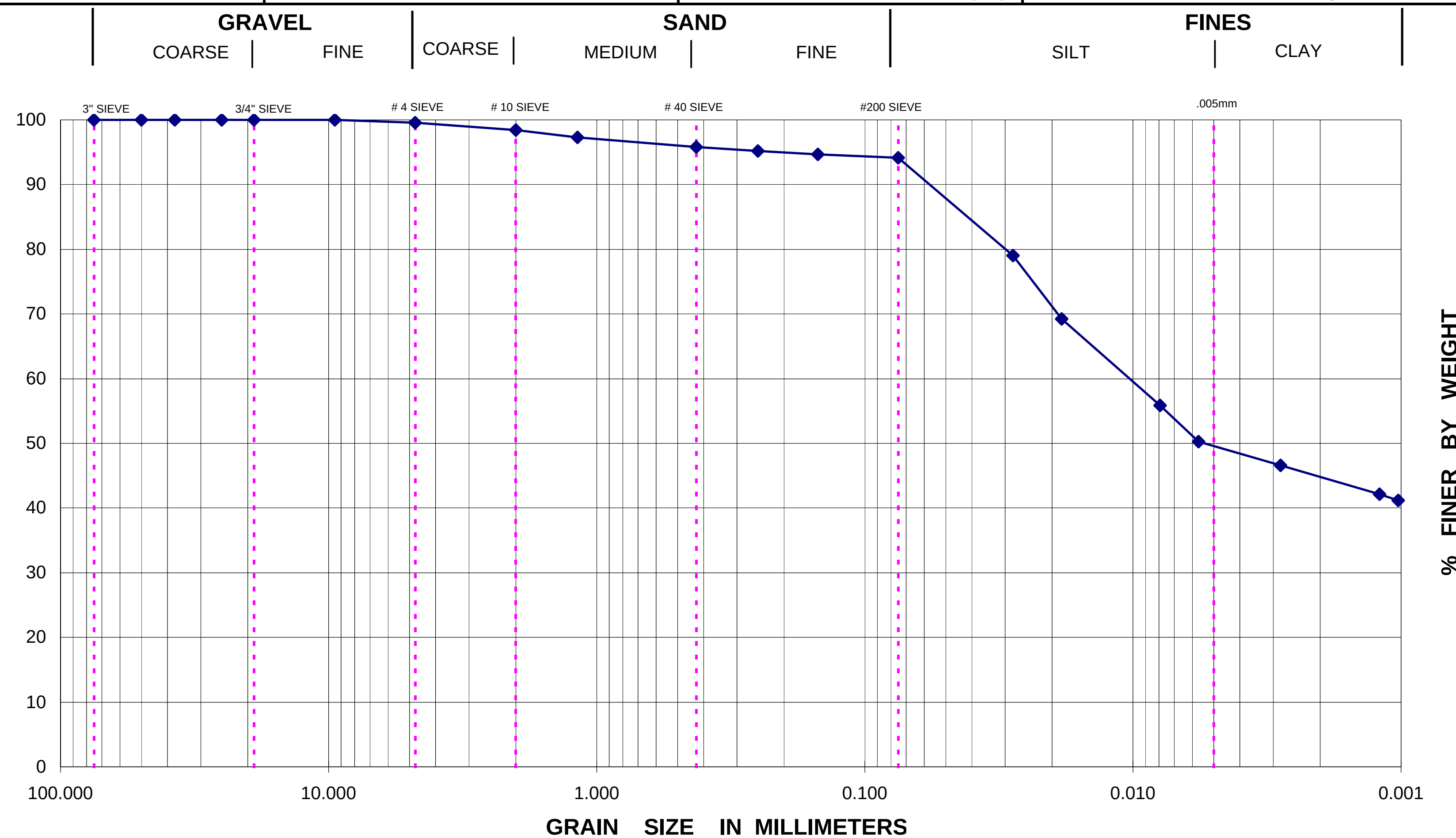
PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

422 Codell Drive, Lexington, KY 40509

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*11/30/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-90*	**DEPTH / ELEV. :**	*1.0'-2.5'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*1*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CH- Orange brown Fat clay*					**SP. GRAVITY, Gs :**	*2.71*
LIQUID LIMIT, % :	*58*	**PLASTICITY INDEX , % :**	*36*	**MOISTURE , % :**	*37.1*	**FINES , % :**	*94.1*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CH*	**AASHTO :**	*A-7-5 (38)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*

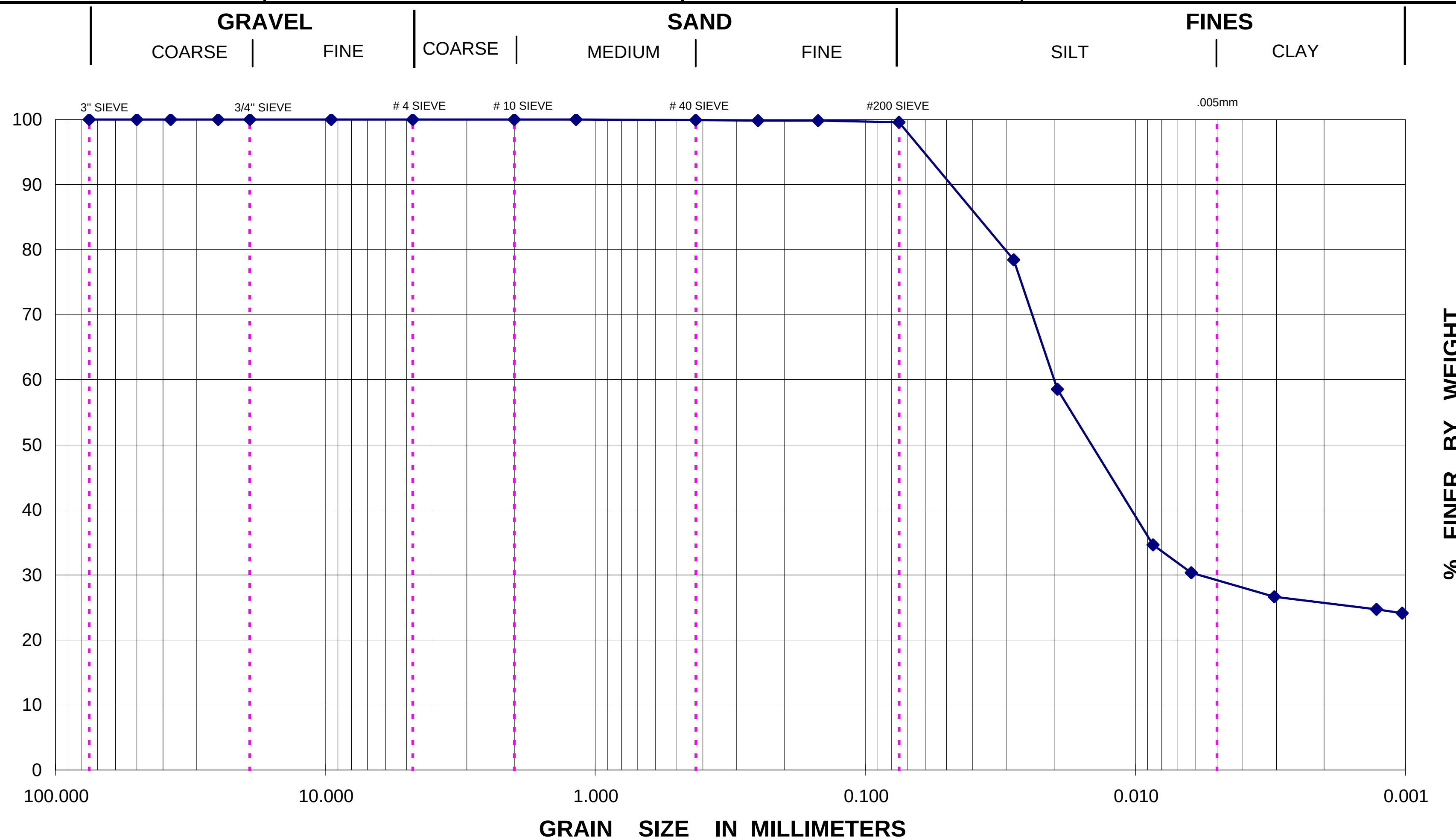


PARTICLE- SIZE DISTRIBUTION TEST REPORT
SIEVE AND HYDROMETER (ASTM D422)

S&ME
422 Codell Drive, Lexington, KY 40509

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/4/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-91*	**DEPTH / ELEV. :**	*1.0'-2.5'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*1*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL- Brown Lean clay*					**SP. GRAVITY, Gs :**	*2.69*
LIQUID LIMIT, % :	*38*	**PLASTICITY INDEX , % :**	*16*	**MOISTURE , % :**	*16.7*	**FINES , % :**	*99.6*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-6 (17)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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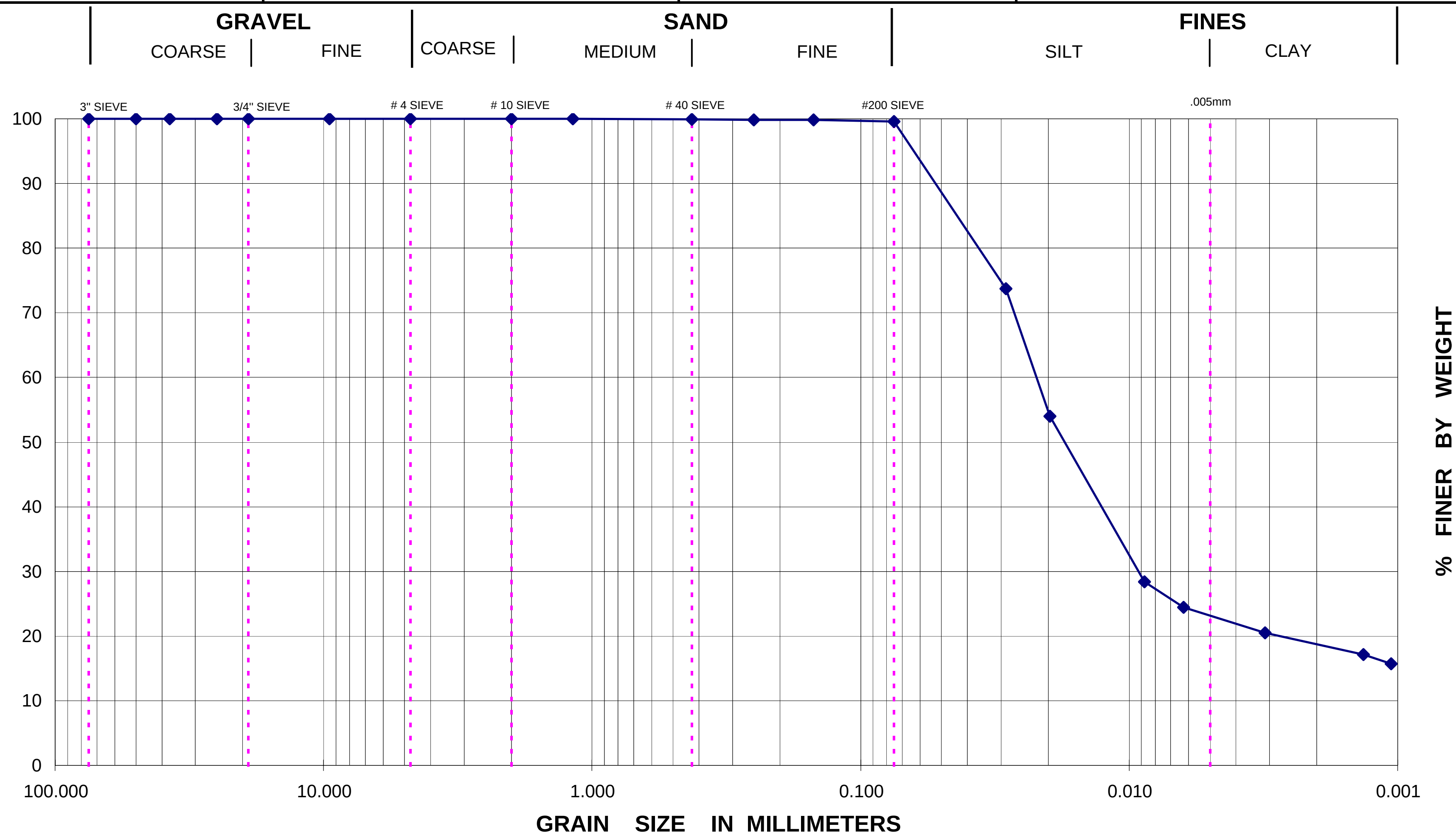
422 Codell Drive, Lexington, KY 40509

PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*				
PROJECT NUMBER:	*1831105629B*	**TEST DATE:**	*12/4/11*	**REVIEWED BY :**	
BORING / PIT NO. : *B-91*	**DEPTH / ELEV. :** *3.0'-5.0'*	**SAMPLE TYPE:**	*UD*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -		**SAMPLE NO:**	*2*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL- Brown Lean clay*			**SP. GRAVITY, Gs :**	*2.68*
LIQUID LIMIT, % : *34*	**PLASTICITY INDEX , % :** *13*	**MOISTURE , % :**	*11.8*	**FINES , % :**	*99.6*
D10 , MM : *N/A*	**D30, MM :** *N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION	**UNIFIED :** *CL*	**AASHTO :**	*A-6 (13)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



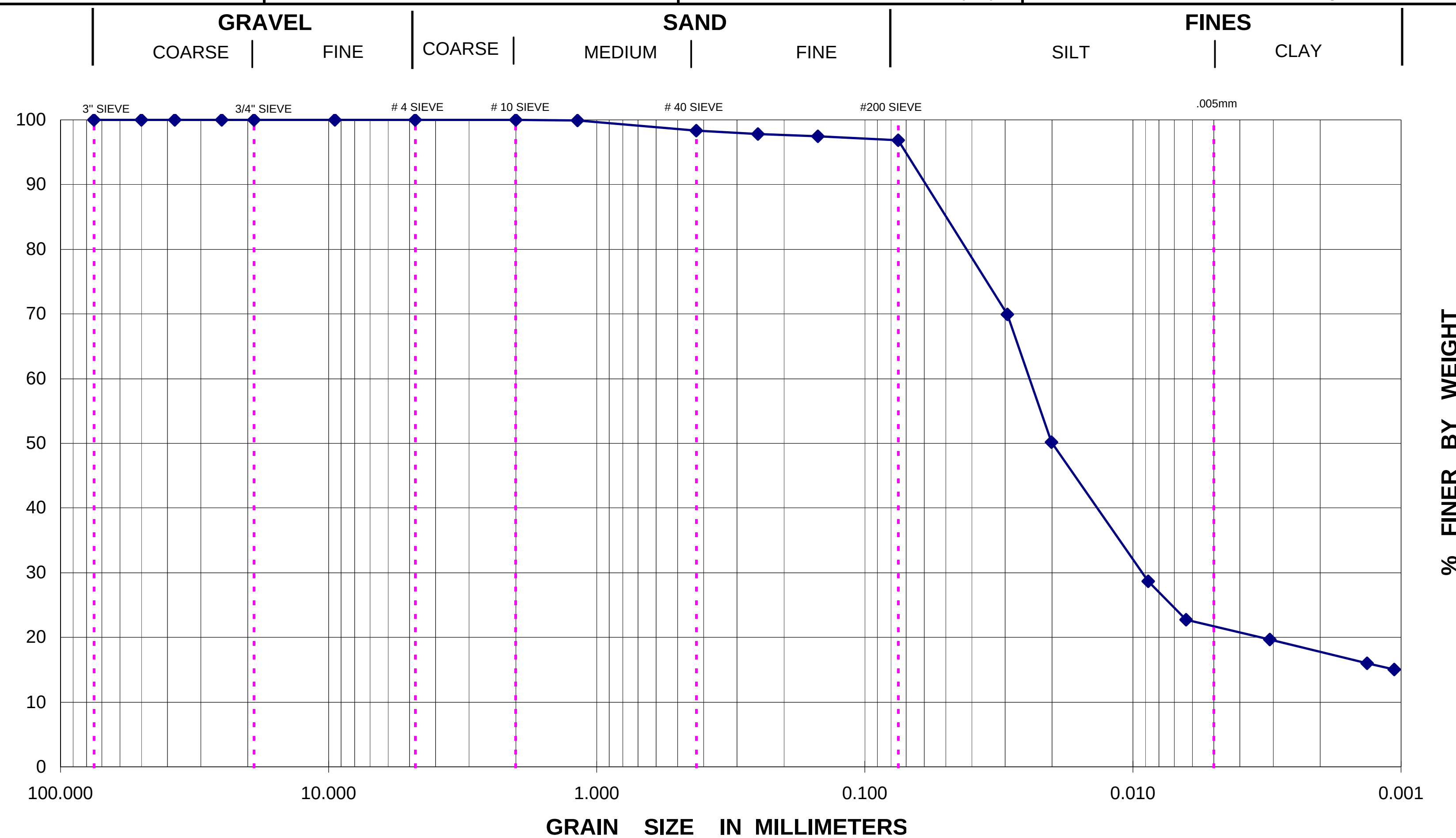
PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

S&ME
422 Codell Drive, Lexington, KY 40509

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*11/30/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-91*	**DEPTH / ELEV. :**	*5.0'-7.0'*	**SAMPLE TYPE:**	*UD*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*3*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL- Orange brown Lean clay*					**SP. GRAVITY, Gs :**	*2.68*
LIQUID LIMIT, % :	*33*	**PLASTICITY INDEX , % :**	*10*	**MOISTURE , % :**	*9.1*	**FINES , % :**	*96.9*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-4 (10)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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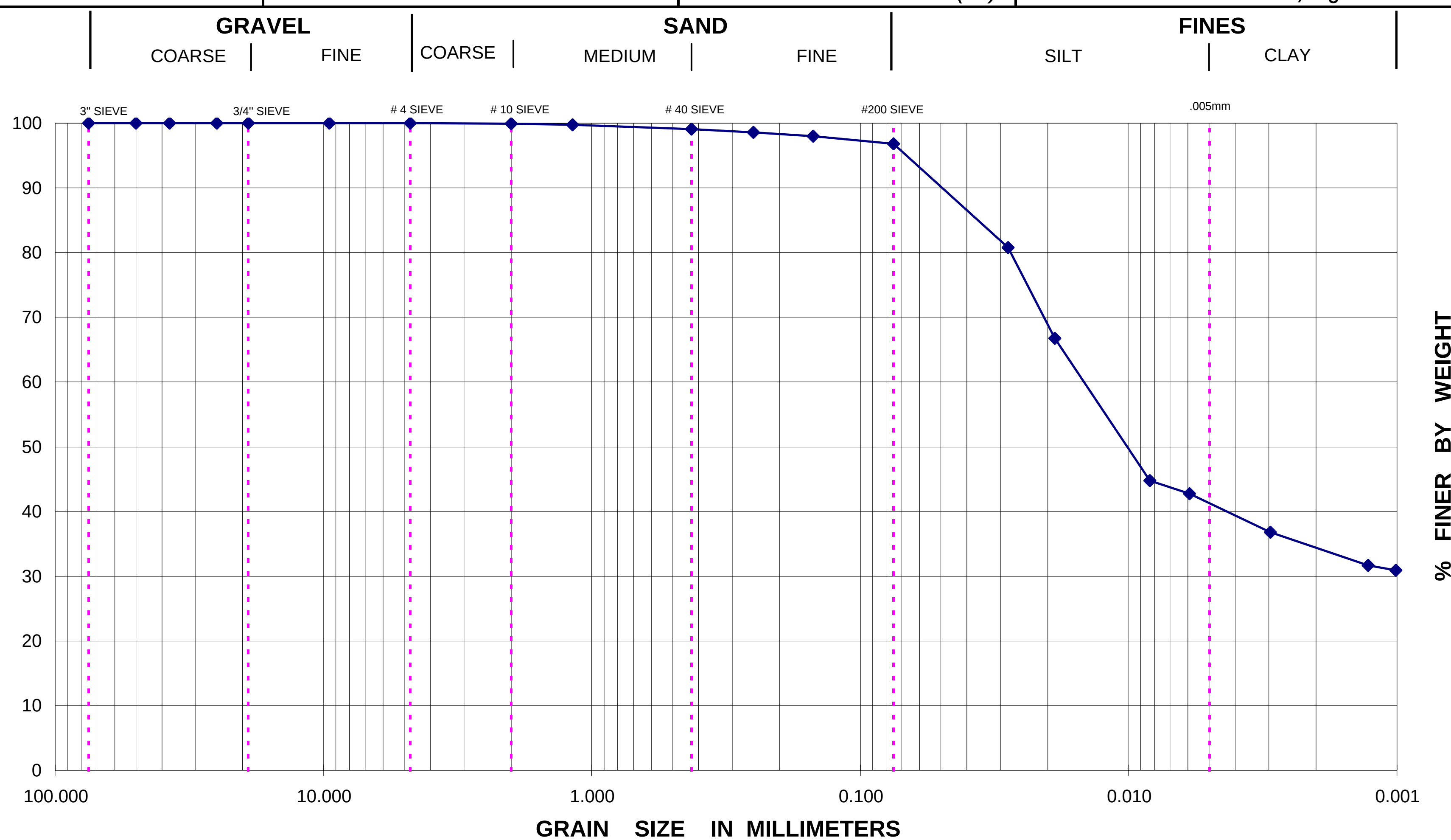
422 Codell Drive, Lexington, KY 40509

PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/4/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-91*	**DEPTH / ELEV. :**	*9.0'-11.0'*	**SAMPLE TYPE:**	*UD*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*4*	**REPORT DATE:**	*12/14/11*
SOIL DESCRIPTION :	*CL- Orange brown Lean clay*					**SP. GRAVITY, Gs :**	*2.69*
LIQUID LIMIT, % :	*38*	**PLASTICITY INDEX , % :**	*19*	**MOISTURE , % :**	*17.7*	**FINES , % :**	*96.8*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-6 (19)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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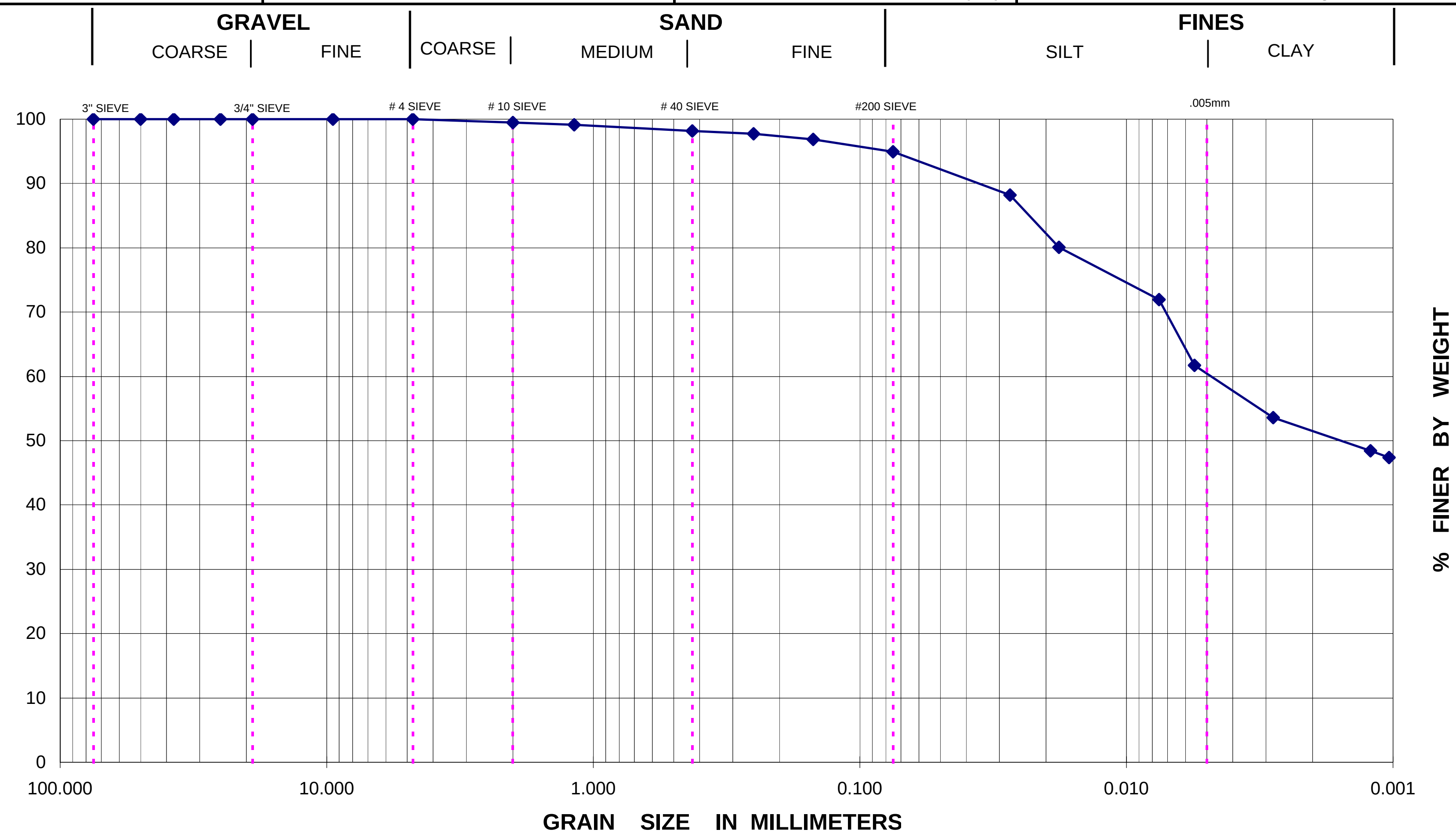
PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

422 Codell Drive, Lexington, KY 40509

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*11/30/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-91*	**DEPTH / ELEV. :**	*13.5' - 15.0'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*5*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL - Brown Lean clay*					**SP. GRAVITY, Gs :**	*2.70*
LIQUID LIMIT, % :	*45*	**PLASTICITY INDEX , % :**	*26*	**MOISTURE , % :**	*20.1*	**FINES , % :**	*95.0*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-7-6 (26)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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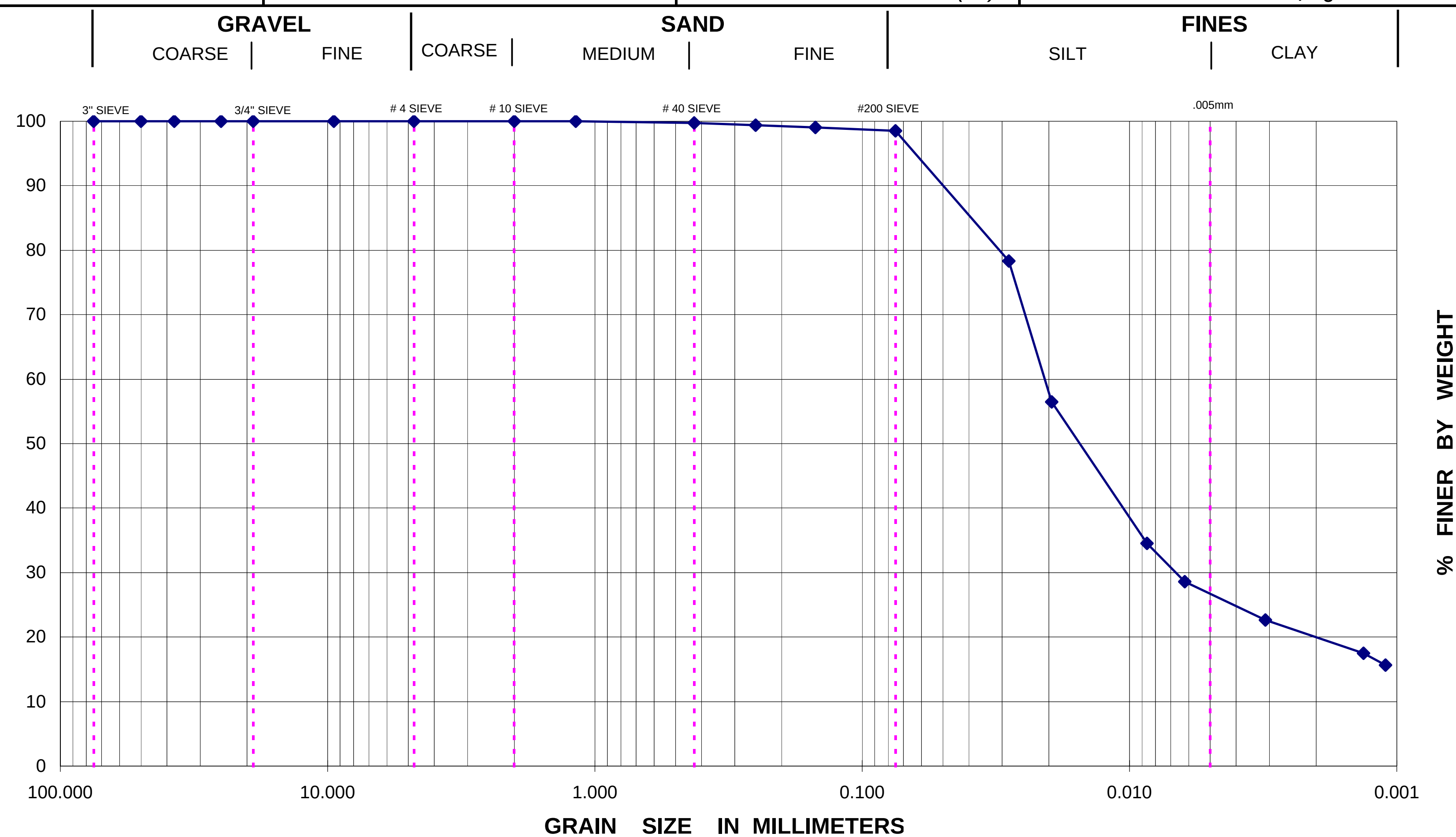
422 Codell Drive, Lexington, KY 40509

PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*11/30/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-92*	**DEPTH / ELEV. :**	*1.0' - 2.5'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*1*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL - Brown Lean clay*					**SP. GRAVITY, Gs :**	*2.68*
LIQUID LIMIT, % :	*33*	**PLASTICITY INDEX , % :**	*12*	**MOISTURE , % :**	*11.0*	**FINES , % :**	*98.5*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-6 (12)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



PARTICLE- SIZE DISTRIBUTION TEST REPORT

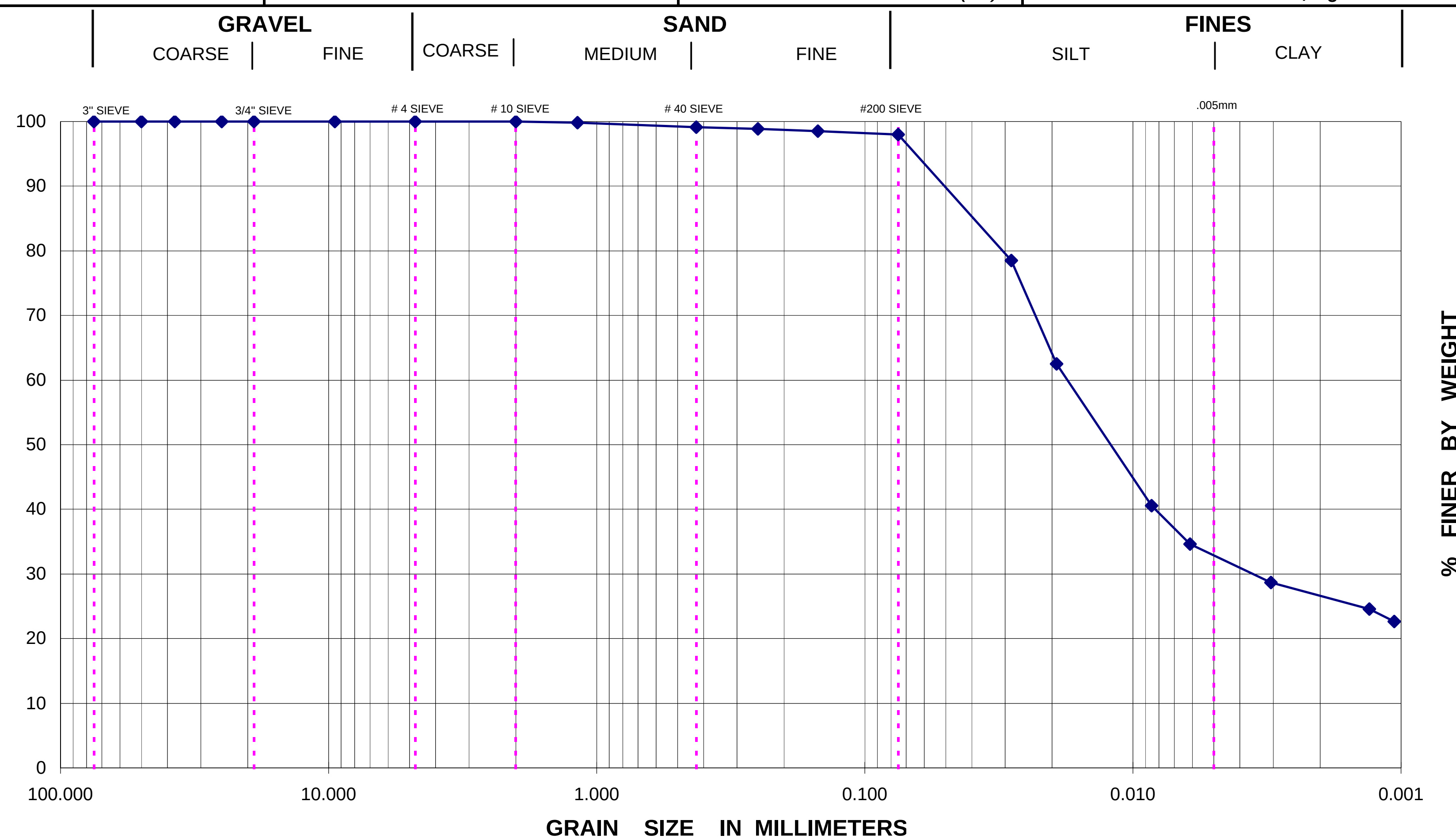
SIEVE AND HYDROMETER (ASTM D422)

S&ME

422 Codell Drive, Lexington, KY 40509

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*				
PROJECT NUMBER:	*1831105629B*	**TEST DATE:**	*11/30/11*	**REVIEWED BY :**	
BORING / PIT NO. : *B-92*	**DEPTH / ELEV. :** *4.0'-6.0'*	**SAMPLE TYPE:**	*UD*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -		**SAMPLE NO:**	*2*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION : *CL - Brown Lean clay*				**SP. GRAVITY, Gs :**	*2.68*
LIQUID LIMIT, % : *34*	**PLASTICITY INDEX , % :** *15*	**MOISTURE , % :**	*11.7*	**FINES , % :**	*98.0*
D10 , MM : *N/A*	**D30, MM :** *N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION	**UNIFIED :** *CL*	**AASHTO :**	*A-6 (15)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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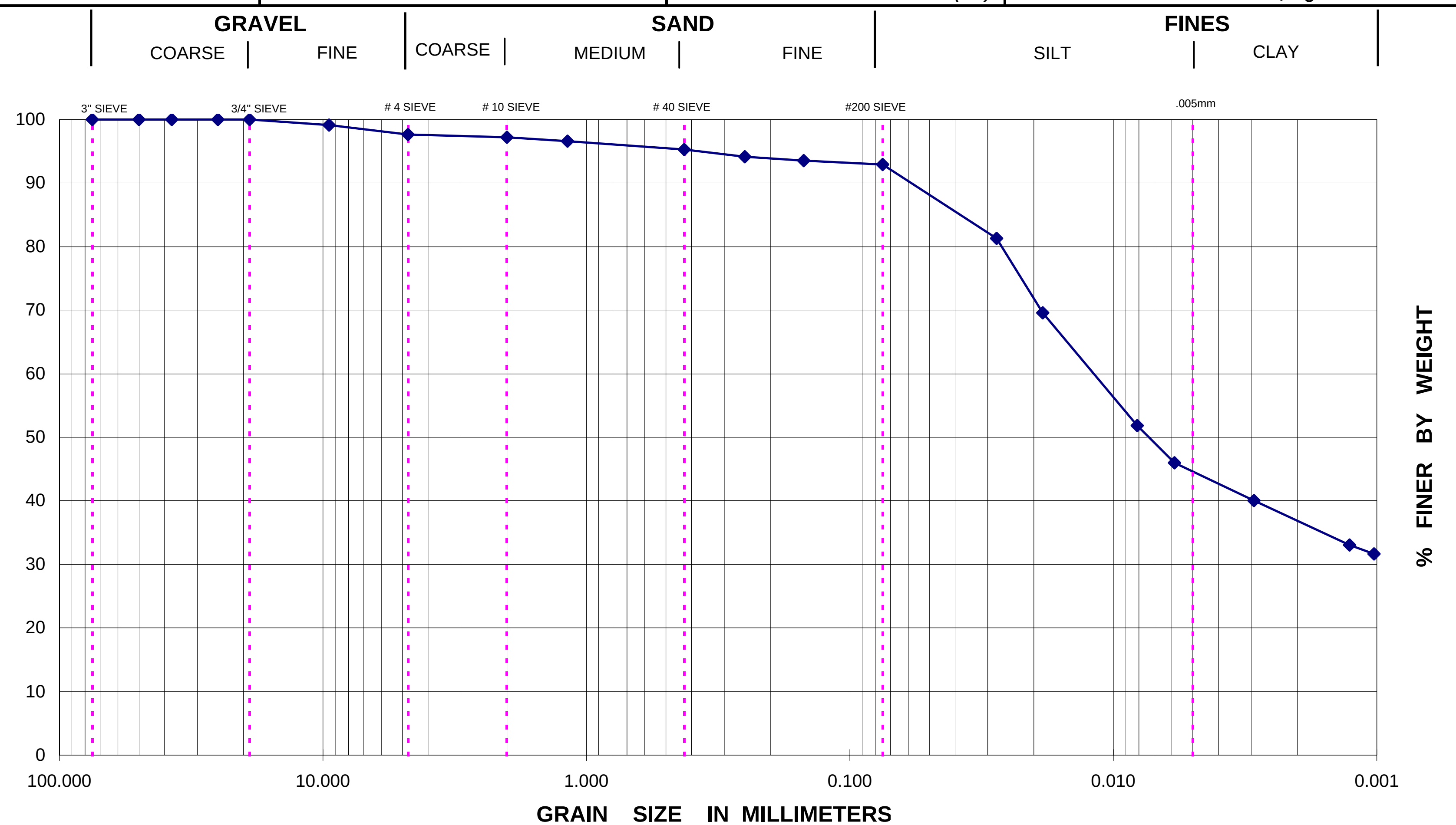
422 Codell Drive, Lexington, KY 40509

PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*11/30/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-92*	**DEPTH / ELEV. :**	*6.0' - 7.5'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*3*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL - Brown Lean clay*					**SP. GRAVITY, Gs :**	*2.70*
LIQUID LIMIT, % :	*45*	**PLASTICITY INDEX , % :**	*25*	**MOISTURE , % :**	*19.3*	**FINES , % :**	*92.9*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-7-6 (25)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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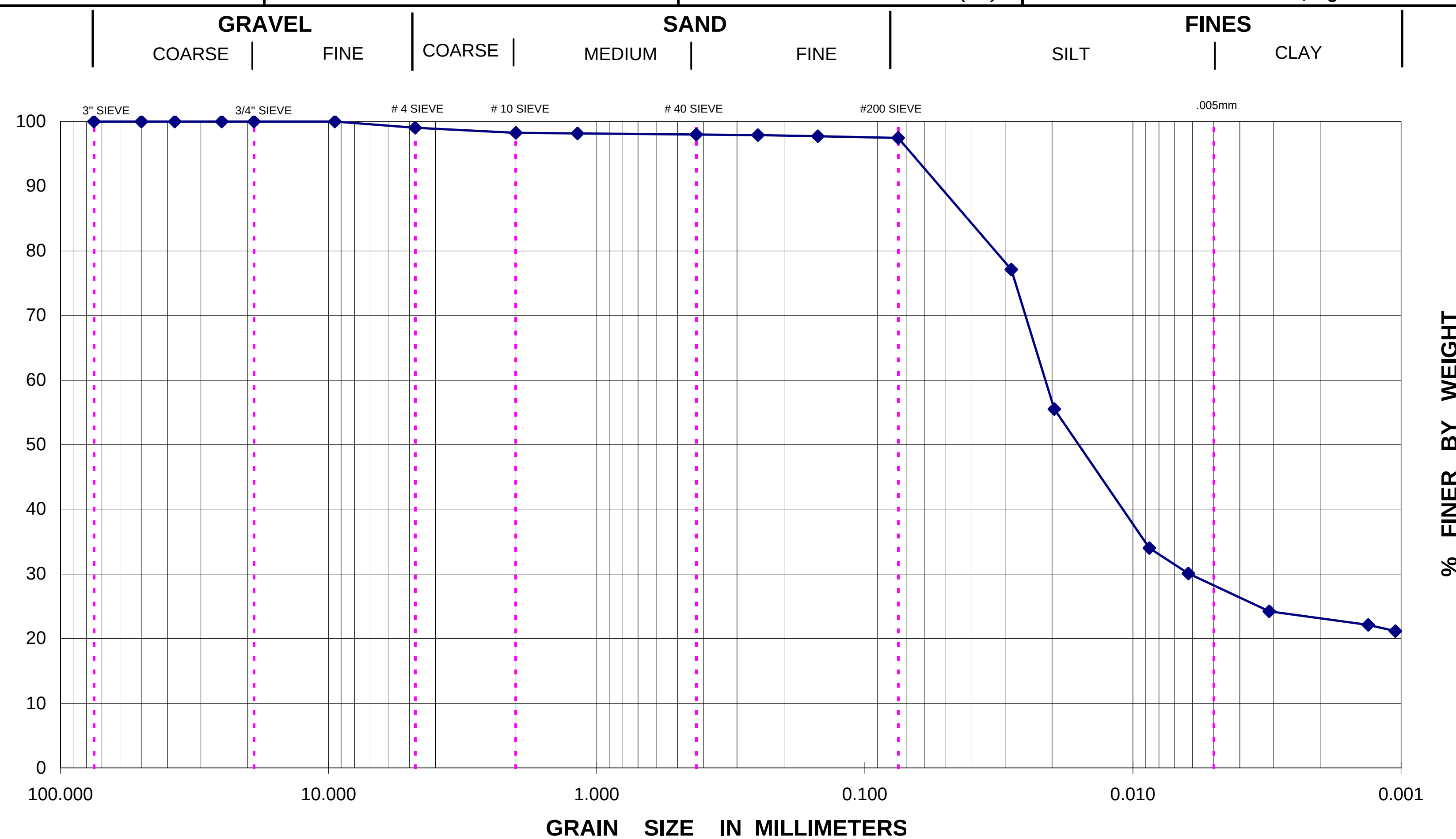
422 Codell Drive, Lexington, KY 40509

PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*11/30/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-93*	**DEPTH / ELEV. :**	*1.0' - 2.5'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*1*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL - Brown Lean clay*					**SP. GRAVITY, Gs :**	*2.68*
LIQUID LIMIT, % :	*34*	**PLASTICITY INDEX , % :**	*12*	**MOISTURE , % :**	*17.2*	**FINES , % :**	*97.5*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-6 (12)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



PARTICLE- SIZE DISTRIBUTION TEST REPORT

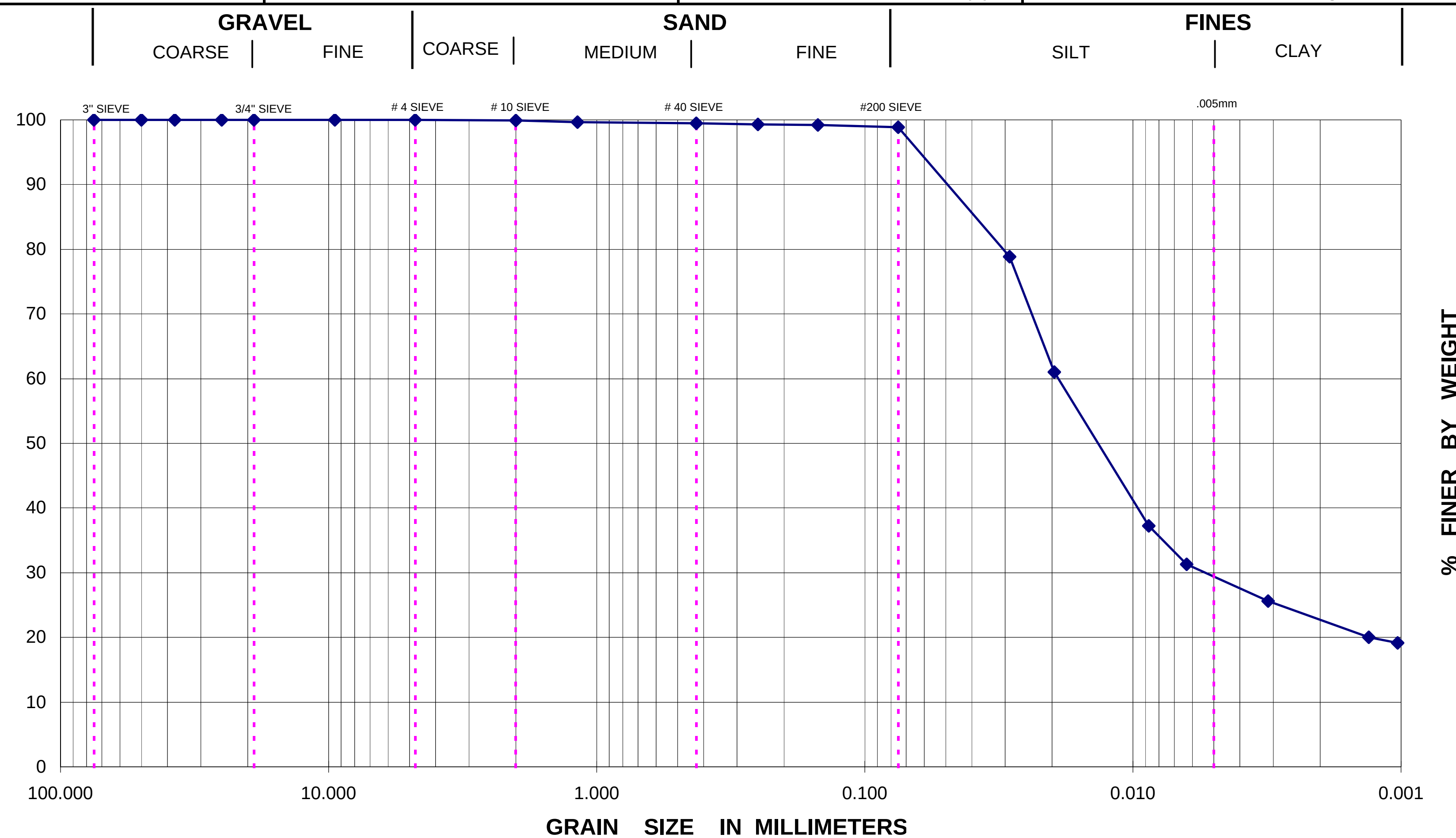
SIEVE AND HYDROMETER (ASTM D422)

S&ME

422 Codell Drive, Lexington, KY 40509

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*				
PROJECT NUMBER:	*1831105629B*	**TEST DATE:**	*11/30/11*	**REVIEWED BY :**	
BORING / PIT NO. : *B-93*	**DEPTH / ELEV. :** *4.0' - 6.0'*	**SAMPLE TYPE:**	*UD*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -		**SAMPLE NO:**	*2*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*ML - Brown Silt*			**SP. GRAVITY, Gs :**	*2.68*
LIQUID LIMIT, % : *34*	**PLASTICITY INDEX , % :** *6*	**MOISTURE , % :**	*22.5*	**FINES , % :**	*98.8*
D10 , MM : *N/A*	**D30, MM :** *N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION	**UNIFIED :** *ML*	**AASHTO :**	*A-4 (7)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



PARTICLE- SIZE DISTRIBUTION TEST REPORT

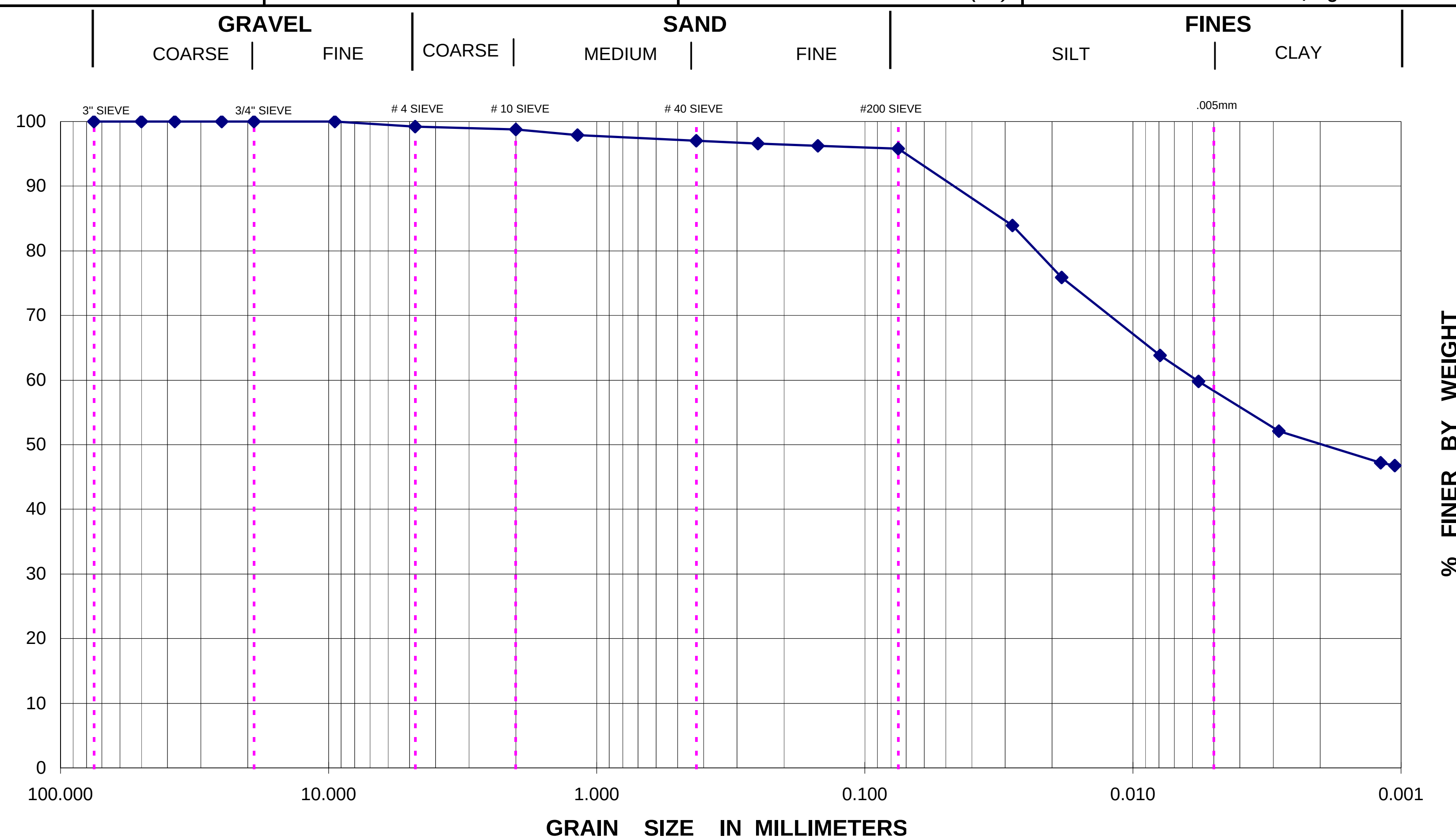
SIEVE AND HYDROMETER (ASTM D422)

S&ME

AASHTO R18

422 Codell Drive, Lexington, KY 40509

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*11/30/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-93*	**DEPTH / ELEV. :**	*6.0' - 7.5'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*3*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CH - Brown Fat clay*					**SP. GRAVITY, Gs :**	*2.72*
LIQUID LIMIT, % :	*55*	**PLASTICITY INDEX , % :**	*21*	**MOISTURE , % :**	*26.2*	**FINES , % :**	*95.8*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CH*	**AASHTO :**	*A-7-6 (26)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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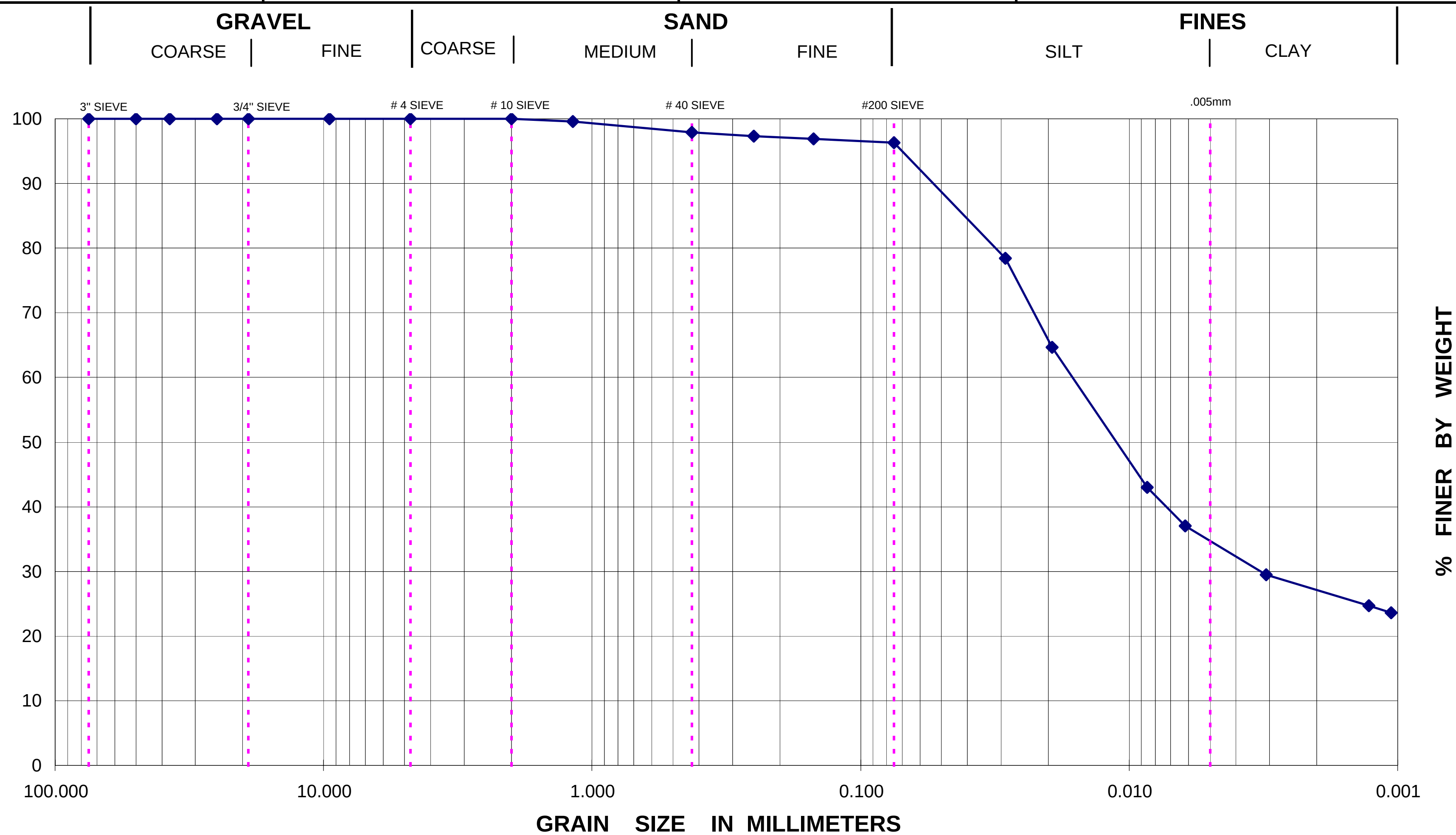
PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

422 Codell Drive, Lexington, KY 40509

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/4/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-94*	**DEPTH / ELEV. :**	*1.0' - 2.5'*	**SAMPLE TYPE:**	*SPT*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*1*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL - Brown Lean clay*					**SP. GRAVITY, Gs :**	*2.68*
LIQUID LIMIT, % :	*34*	**PLASTICITY INDEX , % :**	*15*	**MOISTURE , % :**	*15.7*	**FINES , % :**	*96.3*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-6 (14)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



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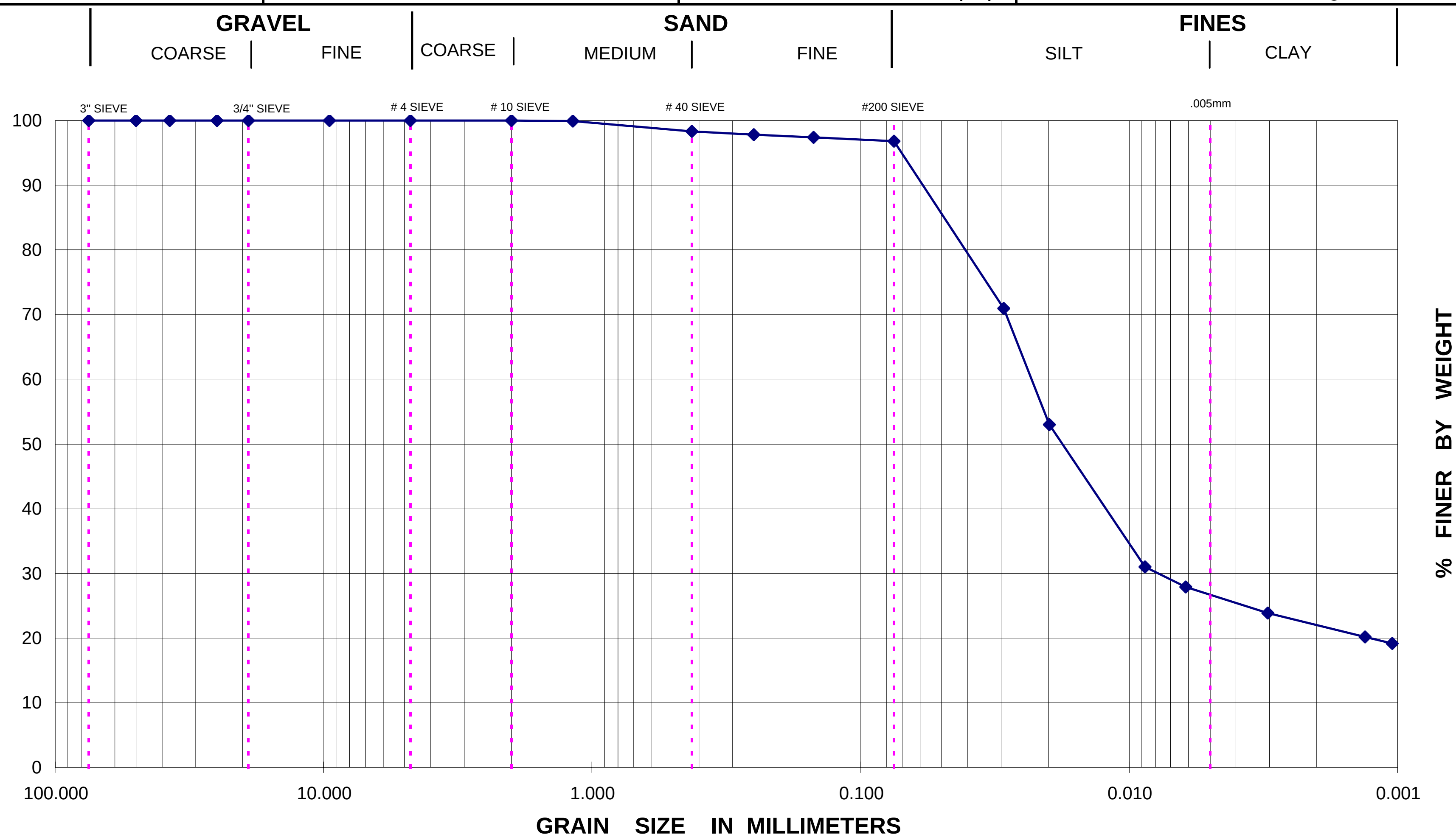
PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

AASHTO R18

422 Codell Drive, Lexington, KY 40509

PROJECT NAME:	*Louisville Bridges Twin Tunnels*						
PROJECT NUMBER:	*1831105629B*			**TEST DATE:**	*12/4/11*	**REVIEWED BY :**	
BORING / PIT NO. :	*B-94*	**DEPTH / ELEV. :**	*4.0'-6.0'*	**SAMPLE TYPE:**	*UD*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -				**SAMPLE NO:**	*2*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CL- Orange brown Lean clay*					**SP. GRAVITY, Gs :**	*2.69*
LIQUID LIMIT, % :	*36*	**PLASTICITY INDEX , % :**	*14*	**MOISTURE , % :**	*28.2*	**FINES , % :**	*96.8*
D10 , MM :	*N/A*	**D30, MM :**	*N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION		**UNIFIED :**	*CL*	**AASHTO :**	*A-6 (14)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



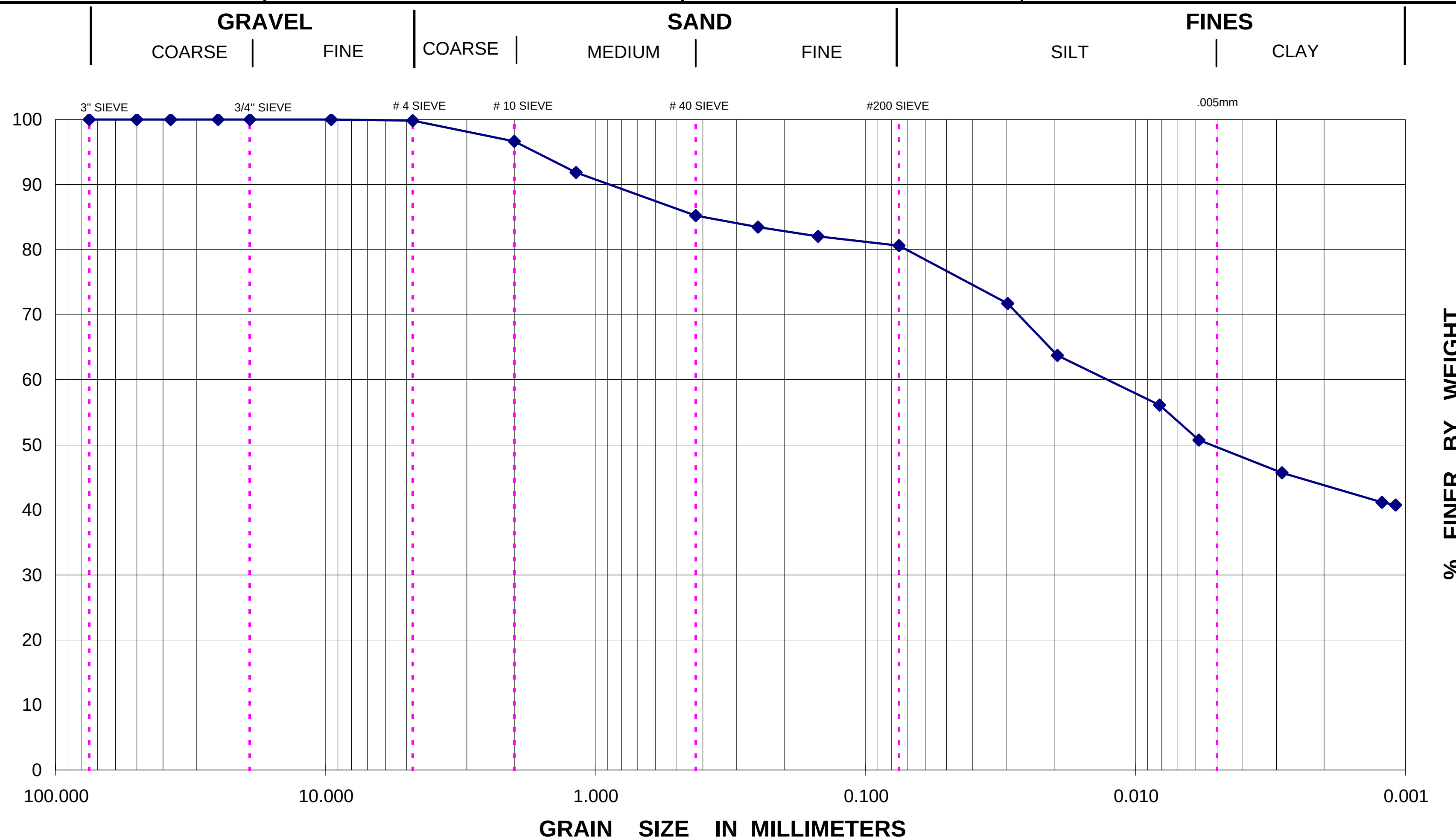
PARTICLE- SIZE DISTRIBUTION TEST REPORT

SIEVE AND HYDROMETER (ASTM D422)

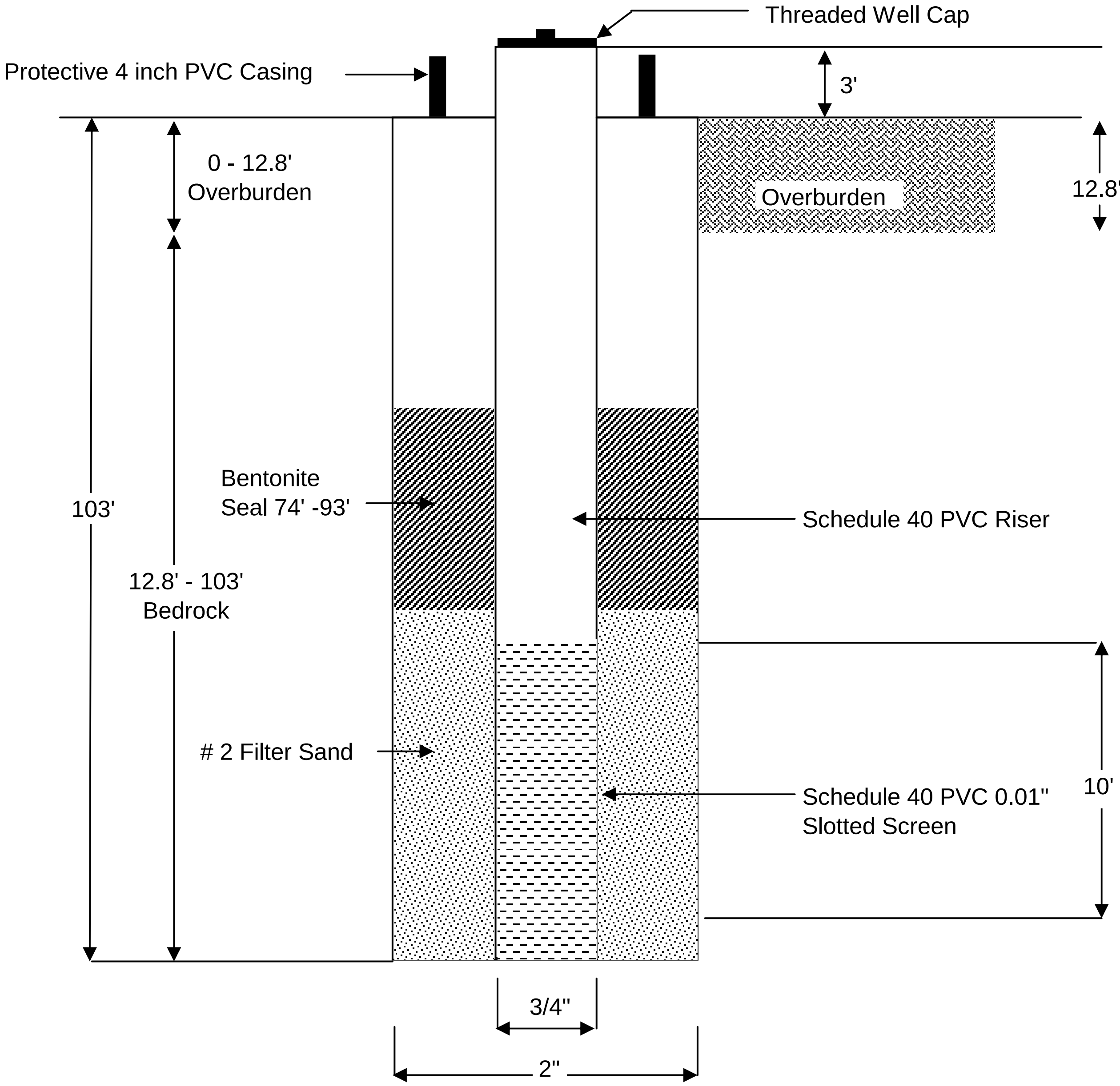
S&ME
422 Codell Drive, Lexington, KY 40509

AASHTO R18

PROJECT NAME:	*Louisville Bridges Twin Tunnels*				
PROJECT NUMBER:	*1831105629B*	**TEST DATE:**	*12/4/11*	**REVIEWED BY :**	
BORING / PIT NO. : *B-94*	**DEPTH / ELEV. :** *9.0'-11.0'*	**SAMPLE TYPE:**	*UD*	**SAMPLE RECEIVED:**	*11/15/11*
SAMPLE LOCATION : -		**SAMPLE NO:**	*3*	**REPORT DATE:**	*12/16/11*
SOIL DESCRIPTION :	*CH- Orange brown Fat clay with sand*			**SP. GRAVITY, Gs :**	*2.74*
LIQUID LIMIT, % : *70*	**PLASTICITY INDEX , % :** *44*	**MOISTURE , % :**	*24.2*	**FINES , % :**	*80.6*
D10 , MM : *N/A*	**D30, MM :** *N/A*	**D60 , MM :**	*N/A*	**COEFF. OF CURVATURE , C_C :**	*N/A*
CLASSIFICATION	**UNIFIED :** *CH*	**AASHTO :**	*A-7-6 (38)*	**COEFF. OF UNIFORMITY , C_U :**	*N/A*



APPENDIX III
WELL CONSTRUCTION FIGURES



Date Constructed	11/14/2011	Ground Surface Elev.	592.8
Boring Depth	103'	Boring Termination Elev.	489.8
Bottom of Well	103'	Total Well Depth	103'
Length of Screen	10'	Length of Riser	96'
Top of Sand	91'		
Top of Bentonite	74'		
Top of Grout	N/A		

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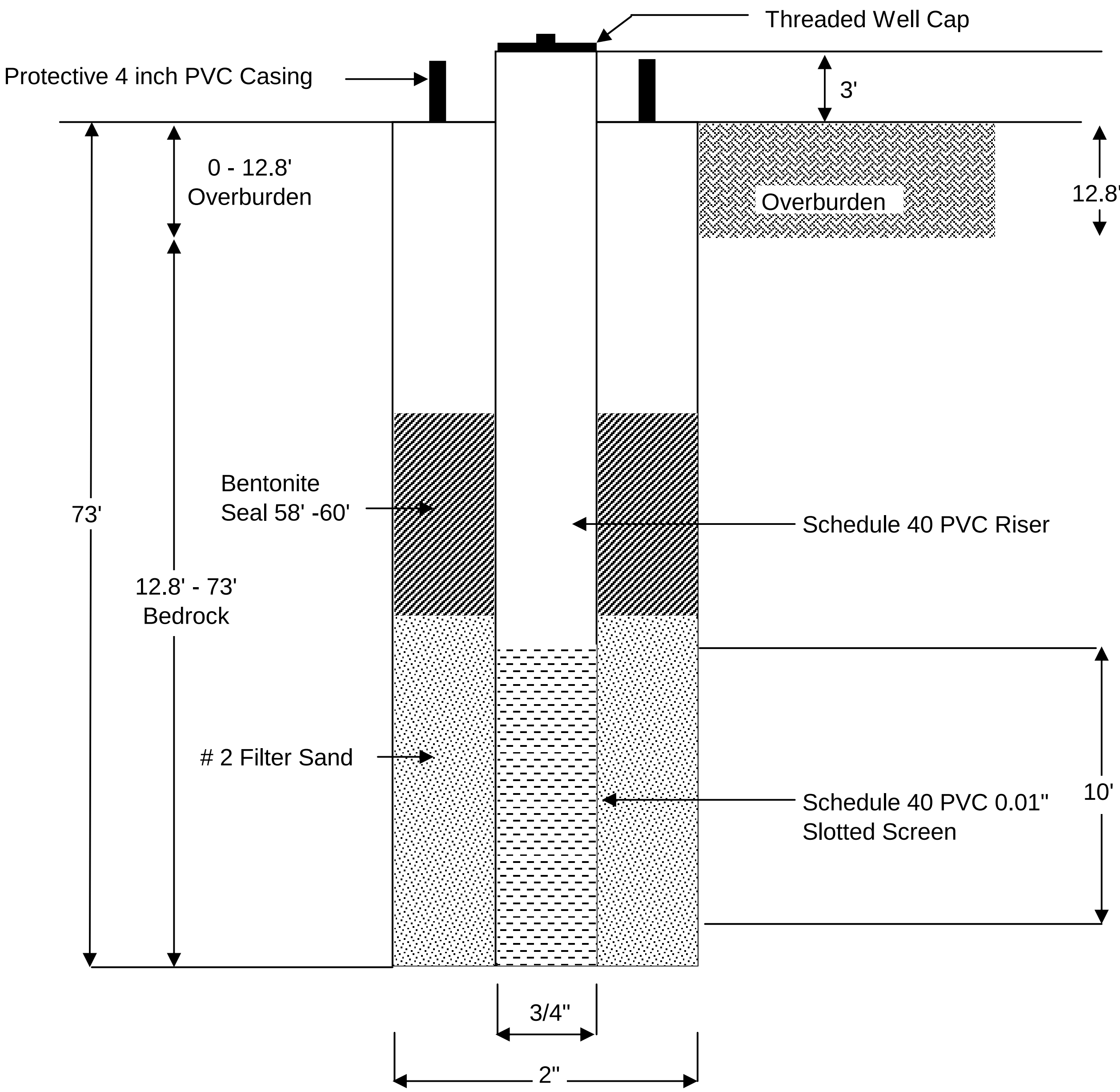
Well Construction Figure

Monitoring Well I.D.: P-82A

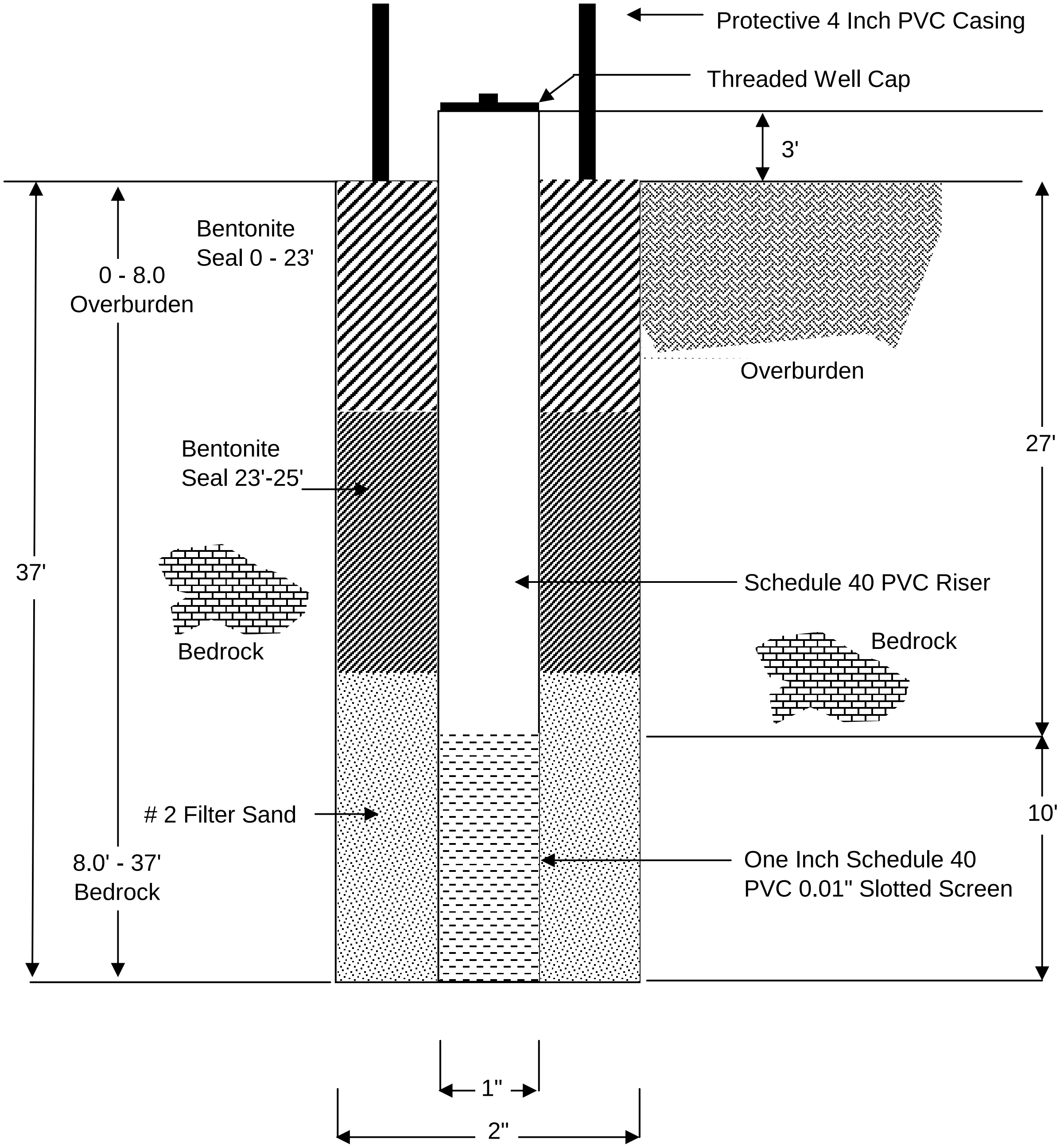
Project Name: Louisville Tunnel Project | Project Number: 1831-10-5629

Scale : NTS Drawn By: NJP Checked By: CSL Date: 12/8/2011



Date Constructed	11/14/2011	Ground Surface Elev.	592.8
Boring Depth	103'	Boring Termination Elev.	489.8
Bottom of Well	73'	Total Well Depth	73'
Length of Screen	10'	Length of Riser	66'
Top of Sand	60'		
Top of Bentonite	58'		
Top of Grout	N/A		

S&ME	Well Construction Figure			
	Monitoring Well I.D.: P-82B			
	Project Name: Louisville Tunnel Project		Project Number: 1831-10-5629	
	Scale : NTS	Drawn By: NJP	Checked By: CSL	Date: 12/8/2011



Date Constructed	11/14/2011	Ground Surface Elev.	569.6
Boring Depth	37'	Boring Termination Elev.	532.6
Bottom of Well	37'	Total Well Depth	37'
Length of Screen	10'	Length of Riser	27'
Top of Sand	25'		
Top of Bentonite	23'		
Top of Grout	Ground Surface		

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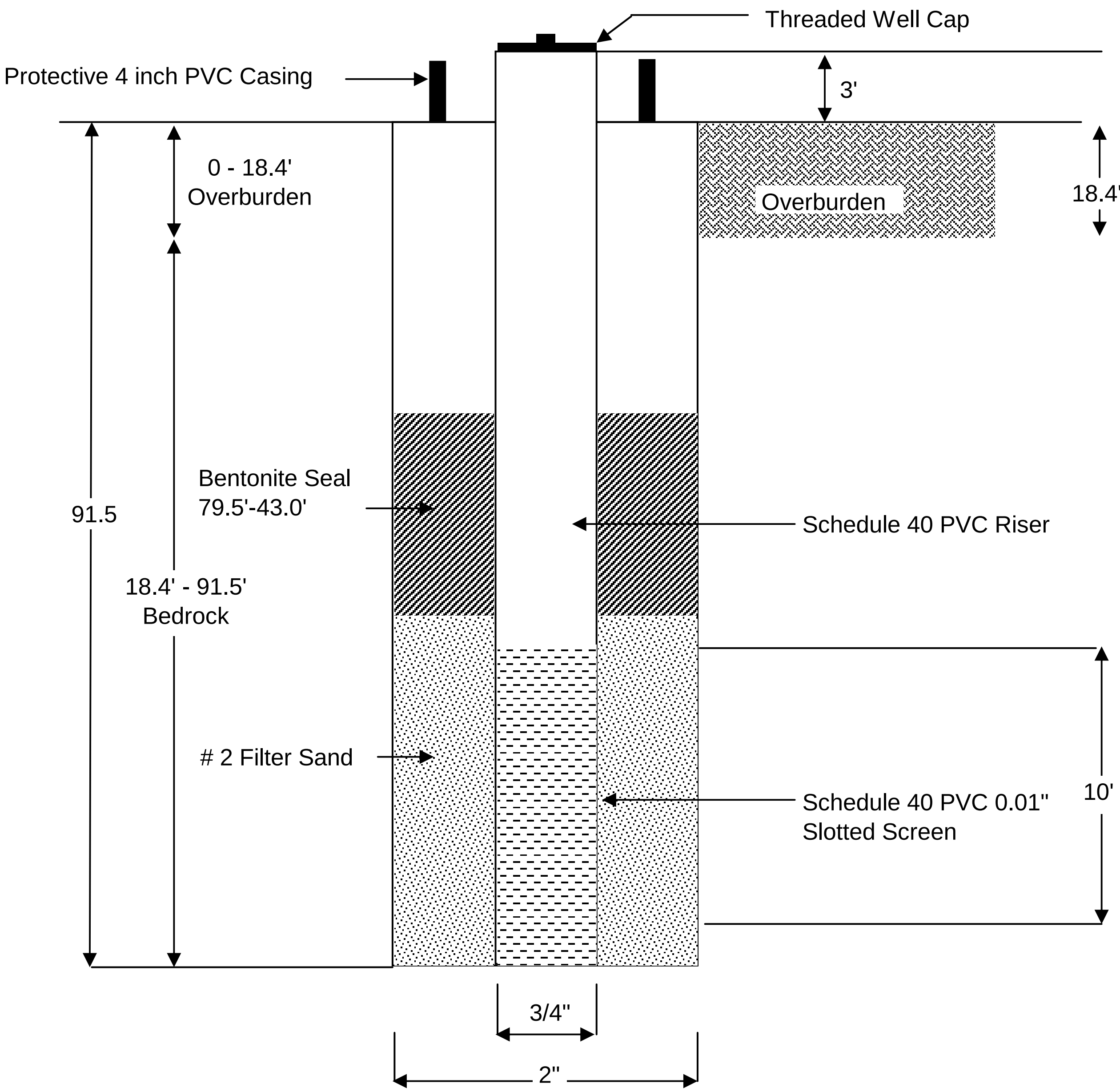
Well Construction Figure

Monitoring Well I.D.: P-84			
Project Name: Louisville Tunnel Project		Project Number: 1831-10-5629	
Scale : NTS	Drawn By: NJP	Checked By:	11/14/2011



Date Constructed	11/14/2011	Ground Surface Elev.	536.5
Boring Depth	91.5'	Boring Termination Elev.	445
Bottom of Well	91.5'	Total Well Depth	91.5'
Length of Screen	10'	Length of Riser	84.5'
Top of Sand	79.5'		
Top of Bentonite	43'		
Top of Grout	N/A		

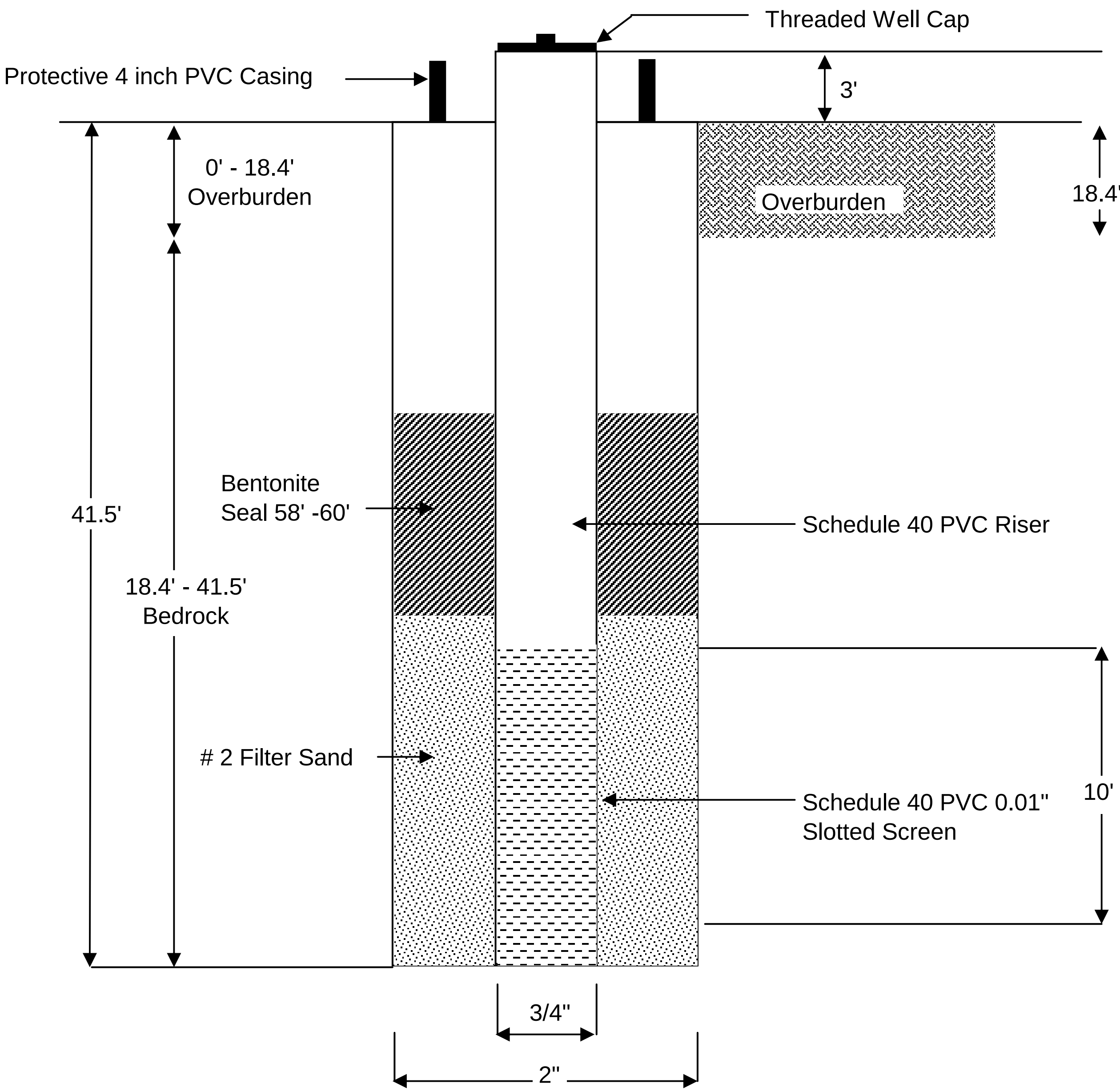
S&ME

Well Construction Figure

Monitoring Well I.D.: P-91A

Project Name: Louisville Tunnel Project | Project Number: 1831-10-5629

Scale : NTS | Drawn By: NJP | Checked By: CSL | Date: 12/8/2011



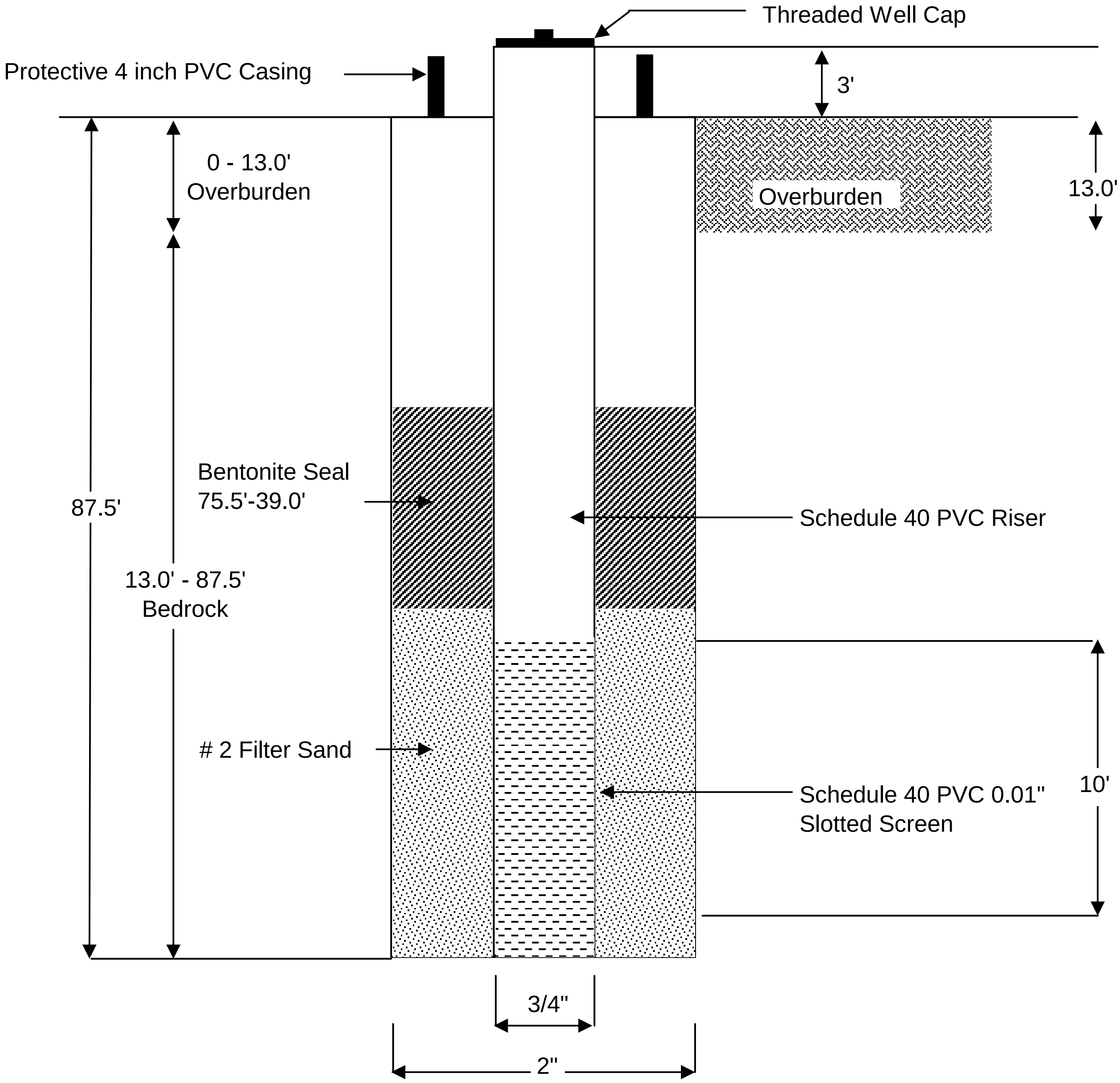
Date Constructed	11/14/2011	Ground Surface Elev.	536.5
Boring Depth	91.5'	Boring Termination Elev.	495
Bottom of Well	41.5'	Total Well Depth	41.5'
Length of Screen	10'	Length of Riser	34.5'
Top of Sand	29.5'		
Top of Bentonite	22.0'		
Top of Grout	N/A		

S&ME

Well Construction Figure

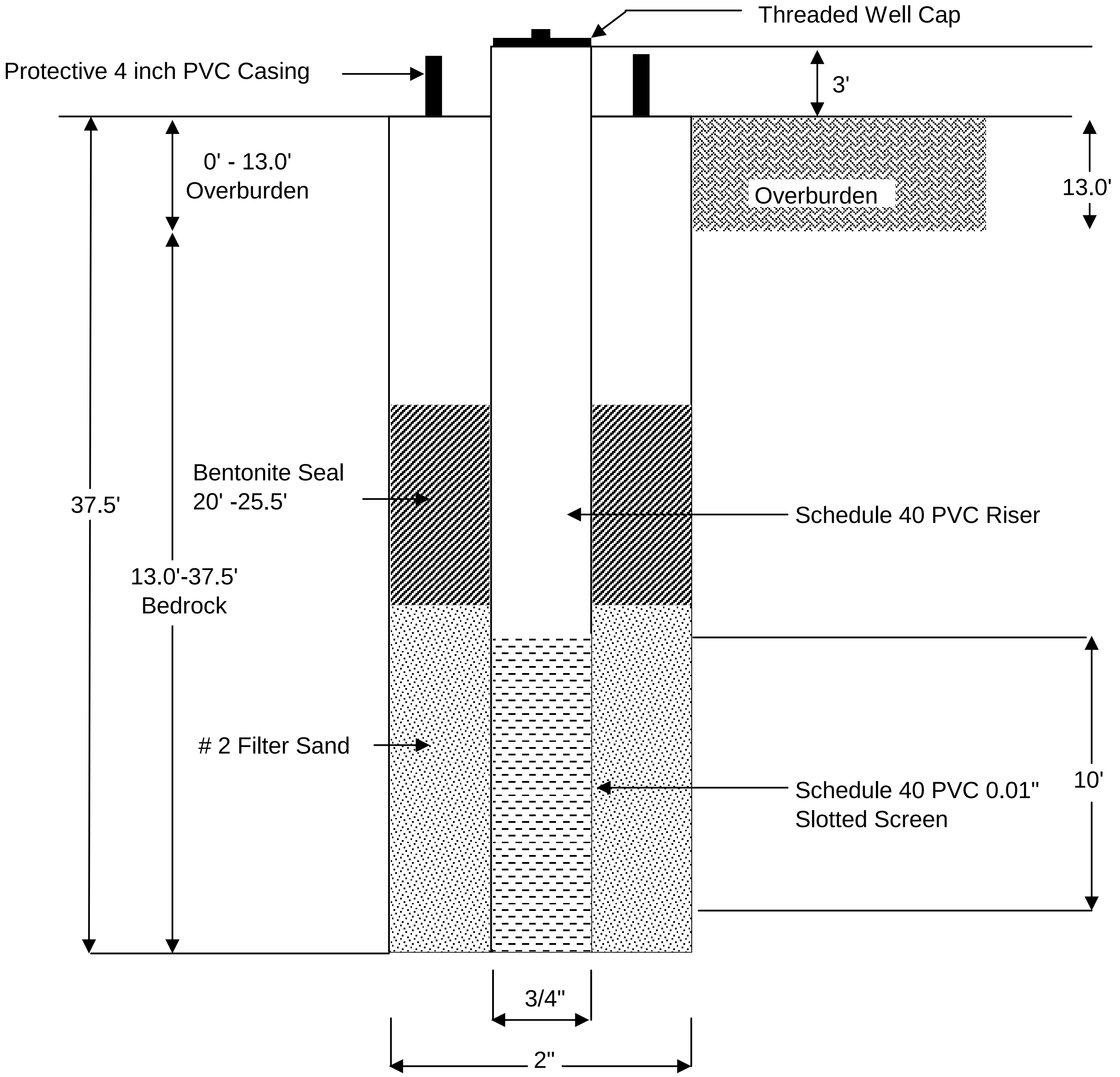
Monitoring Well I.D.: P-91B	
Project Name: Louisville Tunnel Project	Project Number: 1831-10-5629

Scale : NTS   Drawn By: NJP   Checked By: CSL   Date: 12/8/2011



Date Constructed	11/14/2011	Ground Surface Elev.	532.5
Boring Depth	87.5'	Boring Termination Elev.	445
Bottom of Well	87.5'	Total Well Depth	87.5'
Length of Screen	10'	Length of Riser	80.5'
Top of Sand	75.5'		
Top of Bentonite	39'		
Top of Grout	N/A		

S&ME	**Well Construction Figure**			
	Monitoring Well I.D.: P-94A			
	Project Name: Louisville Tunnel Project		Project Number: 1831-10-5629	
	Scale : NTS	Drawn By: NJP	Checked By: CSL	Date: 12/8/2011



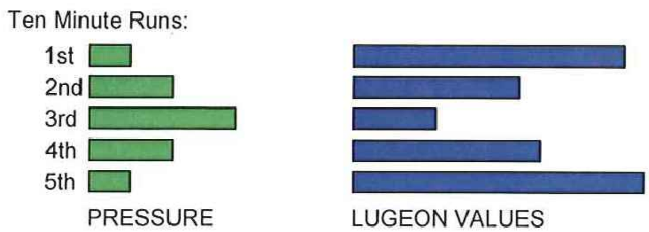
Date Constructed	11/14/2011		Ground Surface Elev.	532.5
Boring Depth	87.5'		Boring Termination Elev.	495
Bottom of Well	37.5'		Total Well Depth	37.5'
Length of Screen	10'		Length of Riser	30.5'
Top of Sand	25.5'			
Top of Bentonite	20.0'			
Top of Grout	N/A			

S&ME	**Well Construction Figure**	
	Monitoring Well I.D.: P-94B	
	Project Name: Louisville Tunnel Project	Project Number: 1831-10-5629
	Scale : NTS Drawn By: NJP Checked By: CSL	Date: 12/8/2011

APPENDIX IV
PACKER TEST

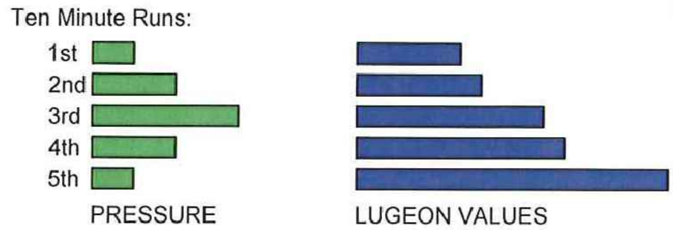
LEGEND TO LUGEON VALUES

TURBULENT FLOW



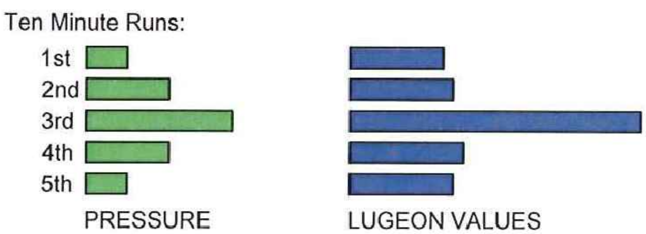
PERMEABILITY DECREASES AS THE PRESSURE AND RESULTANT FLOW INCREASES BECAUSE OF THE TURBULENT FLOW IN THE FRACTURES.

WASH-OUT



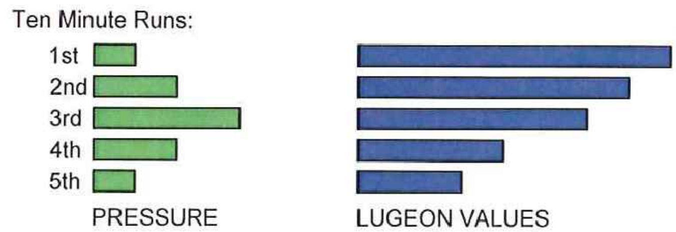
PERMEABILITY INCREASES BECAUSE FRACTURES ARE ENLARGED BY THE TEST.

DILATION



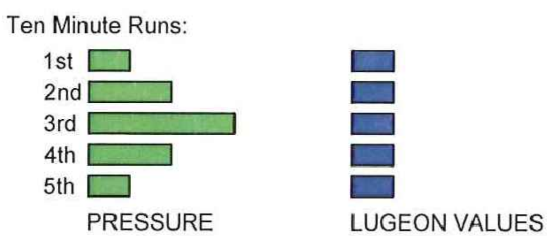
PERMEABILITY INCREASES AT THE HIGHEST WATER TEST PRESSURE AS FRACTURES ARE BEING HYDRAULICALLY JACKED OPEN. FLOW IS LAMINAR AT THE LOWER PRESSURES.

VOID FILLING



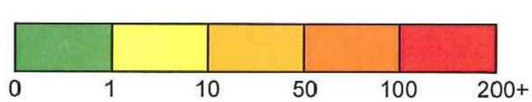
PERMEABILITY DECREASES DUE TO FRACTURES THAT ARE BEING FILLED AND PARTIALLY OR COMPLETELY BLOCKED AS WATER FLOWS. SWELLING ROCK THAT CLOSES FRACTURES OVER TIME BECAUSE OF THE INTRODUCTION OF WATER BY THE TEST CAN ALSO CAUSE THIS REDUCED PERMEABILITY.

LAMINAR FLOW



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 = $10\ \frac{FT}{YEAR} = 1\text{x}10^{-5}\ \frac{CM}{S}$

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

LOUISVILLE TUNNEL PROJECT
GEOTECHNICAL INVESTIGATION
WATER PRESSURE TESTING

Field Test Data

Boring : ***B-82***
Elevation: **592.8**

Test by: ***N. Peterson***
Date: ***10/25/2011***

Formula for Lugeon (Lu) calculation:

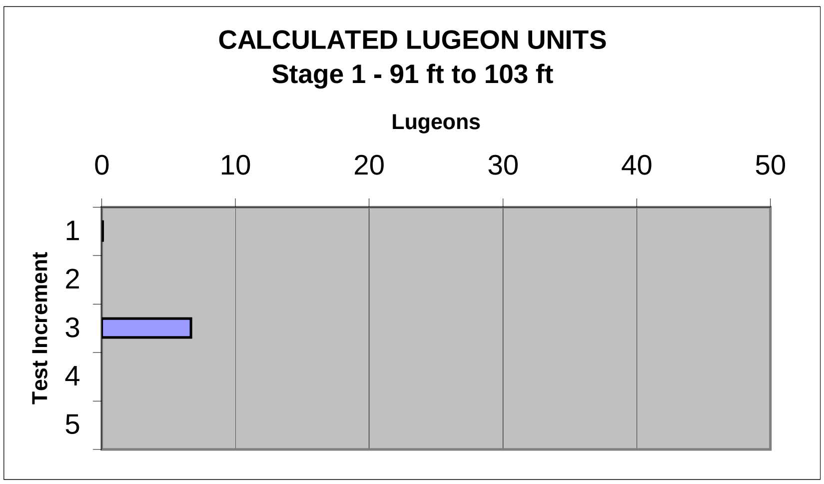
(water take in gallons ÷ 7.48 gal/ft^3) x (142 psi ÷ gauge pressure in psi)
divided by (stage length in feet x test time in minutes x 0.0107620)

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)
91.0	91.0	1	12.0	10	60.0	0.3	0	
103.0	103.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	54.5	7	**1**
		4	12.0	10	90.0	2.0	0	
		5	12.0	10	60.0	0.0	0	
81.0	81.0	1	12.0	10	60.0	1.1	0	
93.0	93.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	29.5	4	**2**
		4	12.0	10	90.0	1.1	0	
		5	12.0	10	60.0	0.0	0	
71.0	71.0	1	12.0	10	60.0	0.0	0	
83.0	83.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	67.9	8	**3**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
61.0	61.0	1	12.0	10	60.0	0.0	0	
73.0	73.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	88.9	11	**4**
		4	12.0	10	90.0	0.4	0	
		5	12.0	10	60.0	0.0	0	
51.0	51.0	1	12.0	10	60.0	0.0	0	
63.0	63.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	68.0	8	**5**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
41.0	41.0	1	12.0	10	60.0	0.2	0	
53.0	53.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	53.5	7	**6**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
31.0	31.0	1	12.0	10	60.0	0.8	0	
43.0	43.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	52.4	6	**7**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
21.0	21.0	1	12.0	10	60.0			
33.0	33.0	2	12.0	10	90.0	Free Flow. Could not achieve test pressure.		
		3	12.0	10	120.0			**8**
		4	12.0	10	90.0			
		5	12.0	10	60.0			

Boring: B-82

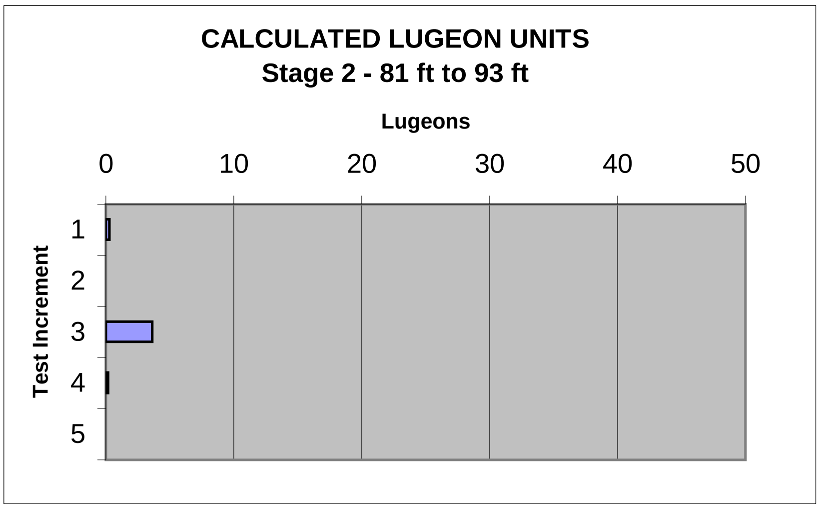


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	7
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Dilation**

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

Boring: B-82

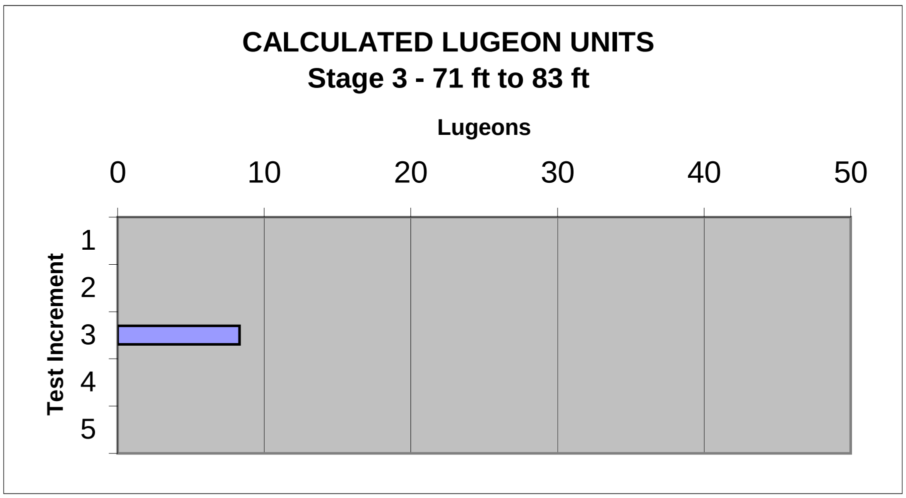


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	4
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Dilation**

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

Boring: B-82

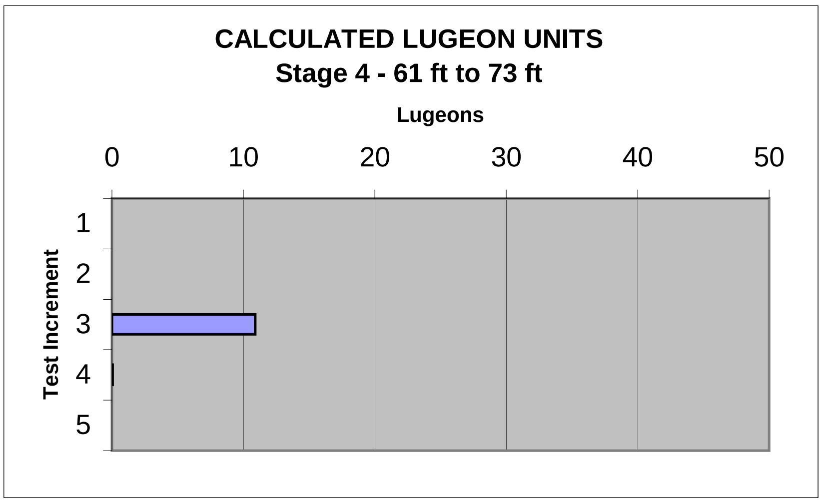


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	8
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Dilation**

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

Boring: B-82

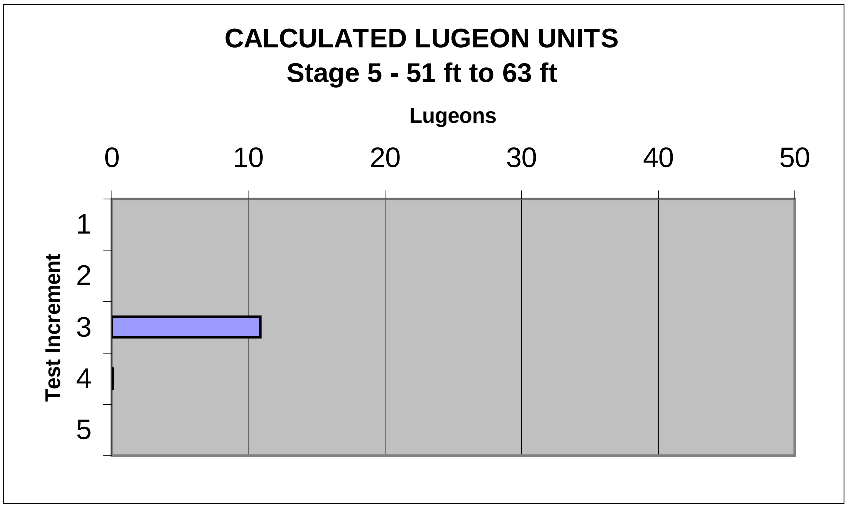


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	11
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Dilation**

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

Boring: B-82

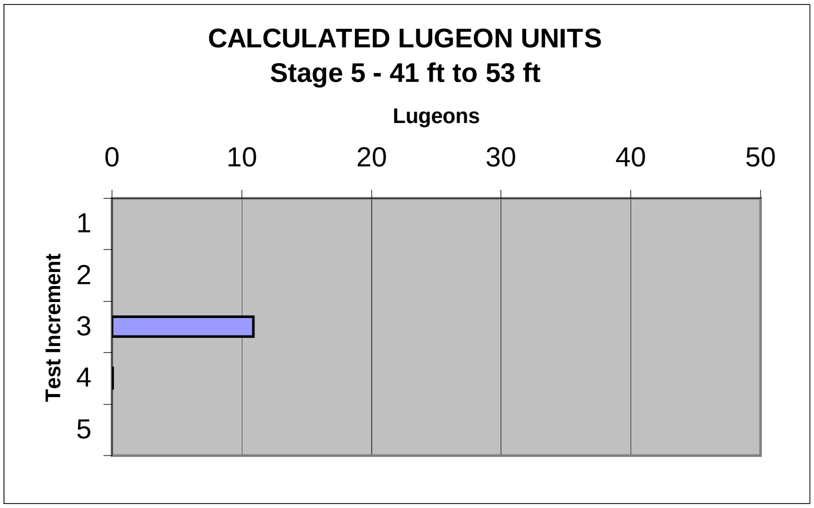


	TEST PRESSURE (psi)	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	11
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Dilation**

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

Boring: B-82

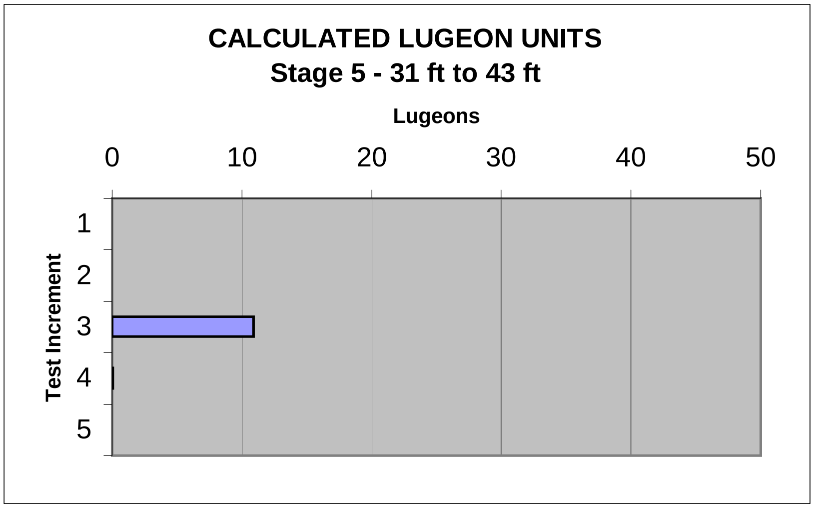


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	7
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Dilation**

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

Boring: B-82



	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	6
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Dilation**

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

LOUISVILLE TUNNEL PROJECT
GEOTECHNICAL INVESTIGATION
WATER PRESSURE TESTING

S&ME

Field Test Data

Boring : ***B-83***
Elevation: **583.7**

Test by: ***D. Durman***
Date: ***10/26/2011***

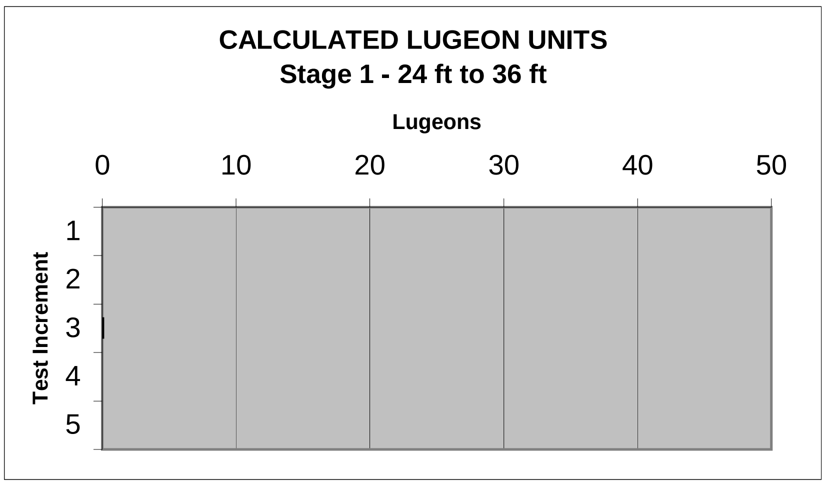
Formula for Lugeon (Lu) calculation:

(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 $_{(stage)}$
24.0	24.0	1	12.0	10	60.0	0.0	0	
36.0	36.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.5	0	**1**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
14.0	14.0	1	12.0	10	60.0	0.0	0	
26.0	26.0	2	12.0	10	90.0	2.1	0	
		3	12.0	10	120.0	48.4	6	**2**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	

Boring: B-83

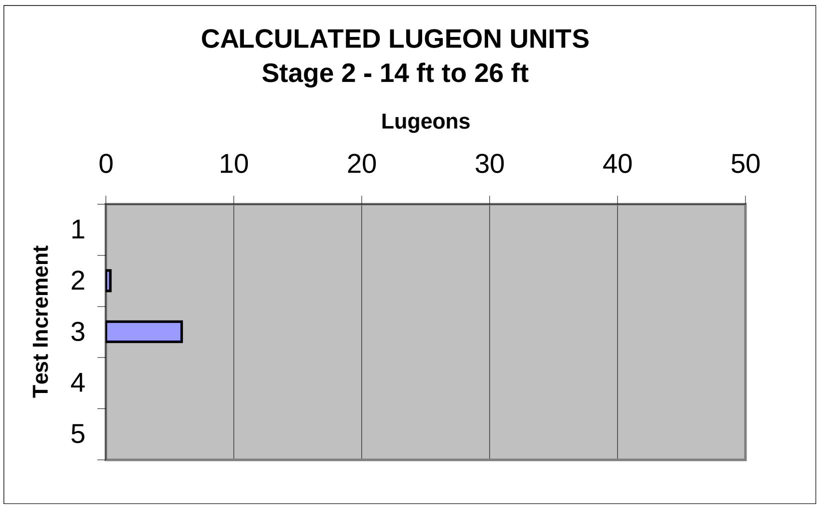


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

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

Boring: B-83



	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	6
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Dilation**

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

LOUISVILLE TUNNEL PROJECT
GEOTECHNICAL INVESTIGATION
WATER PRESSURE TESTING

S&ME

Field Test Data

Boring : ***B-84***
Elevation: **569.6**

Test by: ***D. Durman***
Date: ***10/27/2011***

Formula for Lugeon (Lu) calculation:

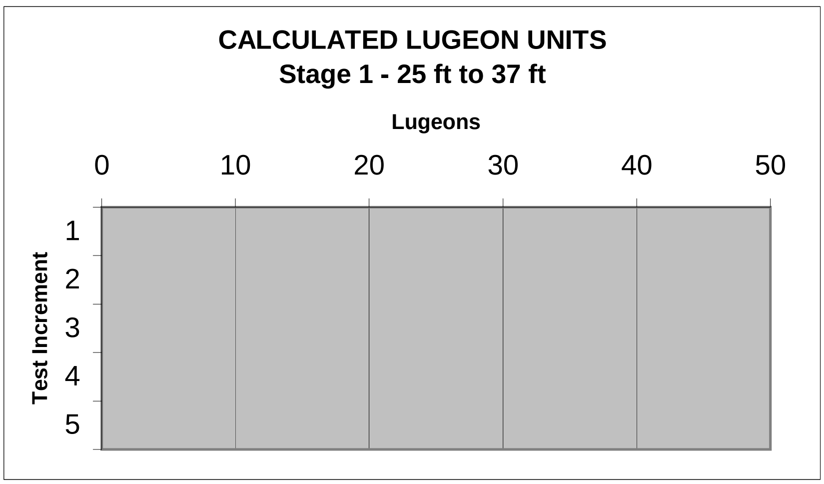
(water take in gallons ÷ 7.48 gal/ft^3) x (142 psi ÷ gauge pressure in psi)
divided by (stage length in feet x test time in minutes x 0.0107620)

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)
25.0	25.0	1	12.0	10	60.0	0.0	0	
37.0	37.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**1**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
15.0	15.0	1	12.0	10	60.0	0.5	0	
27.0	27.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**2**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	

Boring: B-84

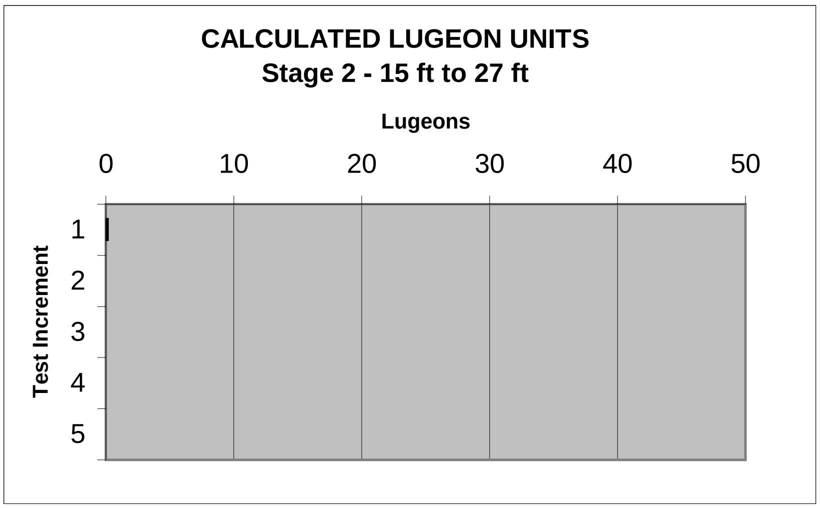


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

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

Boring: B-84



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

INTERPRETATION OF RESULTS: **Laminar**

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

LOUISVILLE TUNNEL PROJECT
GEOTECHNICAL INVESTIGATION
WATER PRESSURE TESTING

S&ME

Field Test Data

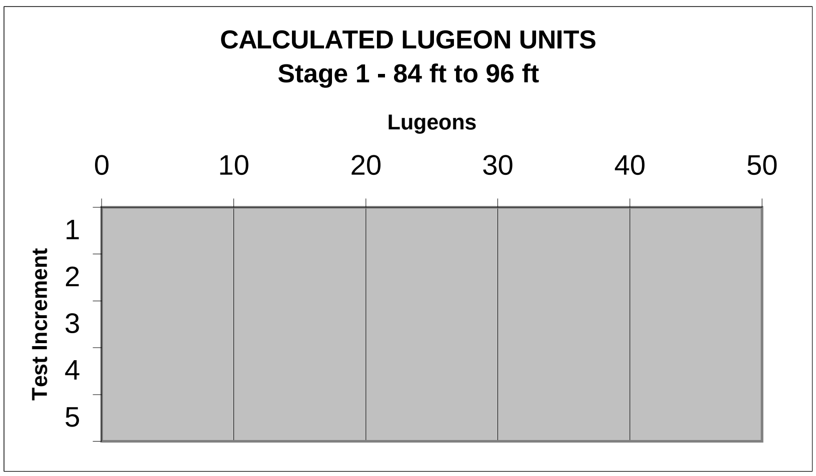
Boring : ***B-89*** Test by: ***N. Peterson***
Elevation: **546.3** Date: ***11/30/2011***

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)
84.0	84.0	1	12.0	10	60.0	0.0	0	
96.0	96.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**1**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
74.0	74.0	1	12.0	10	60.0	0.0	0	
86.0	86.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**2**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
64.0	64.0	1	12.0	10	60.0	0.0	0	
76.0	76.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**3**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
54.0	54.0	1	12.0	10	60.0	0.0	0	
66.0	66.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**4**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
44.0	44.0	1	12.0	10	60.0	0.0	0	
56.0	56.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**5**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	

Boring: B-89

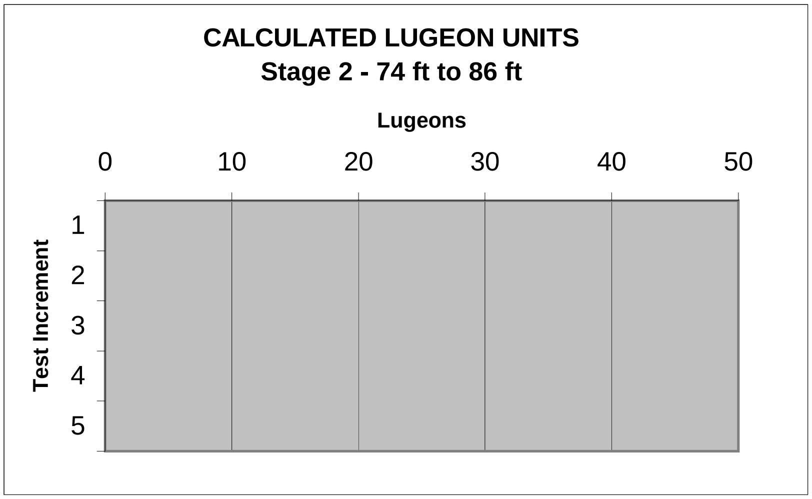


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar Flow**

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

Boring: B-89

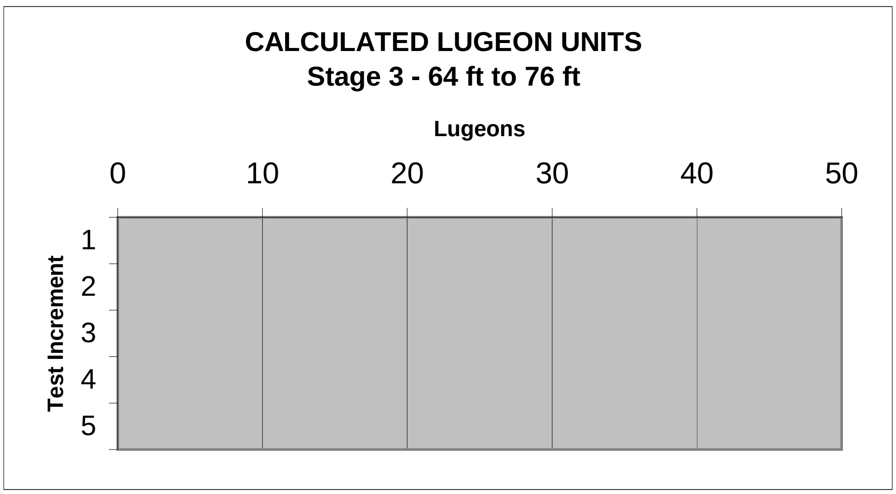


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar Flow**

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

Boring: B-89

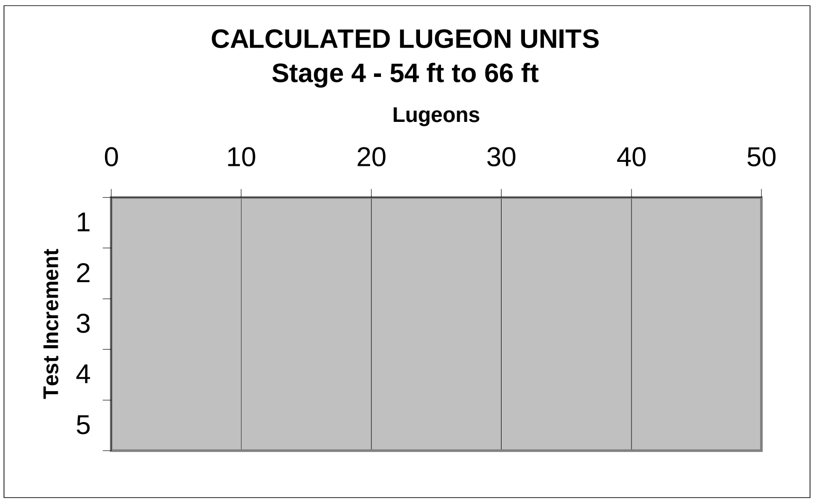


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar Flow**

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

Boring: B-89

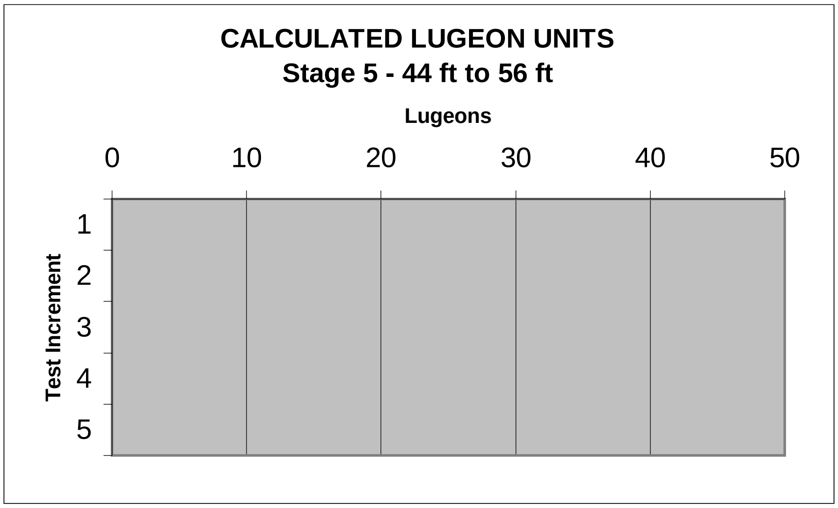


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar Flow**

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

Boring: B-89



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

INTERPRETATION OF RESULTS: **Laminar Flow**

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

LOUISVILLE TUNNEL PROJECT
GEOTECHNICAL INVESTIGATION
WATER PRESSURE TESTING

S&ME

Field Test Data

Boring : ***B-90***
Elevation: **526.0**

Test by: ***N. Peterson***
Date: ***11/30/2011***

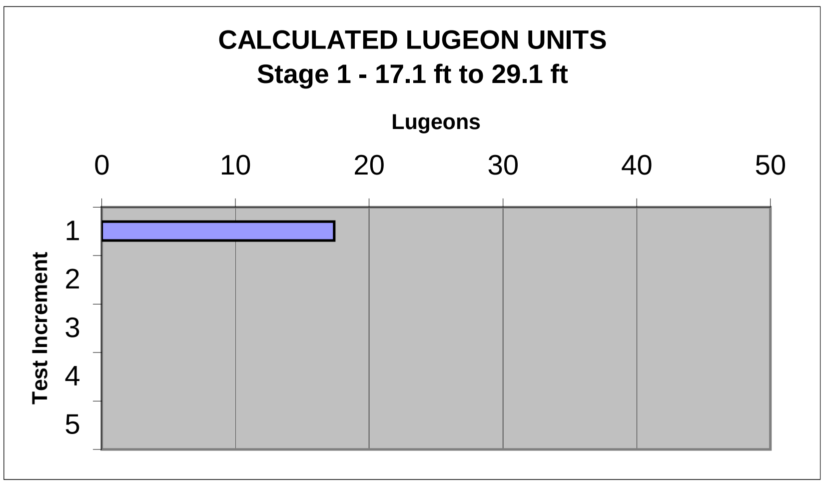
Formula for Lugeon (Lu) calculation:

(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)
17.1	17.1	1	12.0	10	60.0	71.0	17	**1**
29.1	29.1	2	12.0	10	90.0			
		3	12.0	10	120.0			
		4	12.0	10	90.0	Free Flow. Could not maintain pressure above 60 psi.		
		5	12.0	10	60.0			
7.1	7.1	1	12.0	10	60.0	0.0	0	
19.1	19.1	2	12.0	10	90.0	75.4	12	**2**
		3	12.0	10	120.0			
		4	12.0	10	90.0	Free Flow. Could not maintain pressure above 90 psi.		
		5	12.0	10	60.0			

Boring: B-90

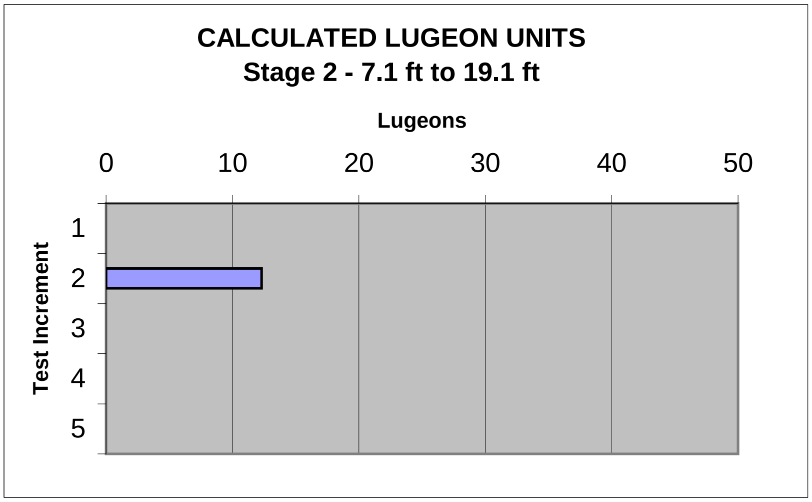


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	17
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Wash Out**

Permeability increases because fractures are enlarged by the test.

Boring: B-90



	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	12
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Wash Out**

Permeability increases because fractures are enlarged by the test.

LOUISVILLE TUNNEL PROJECT
GEOTECHNICAL INVESTIGATION
WATER PRESSURE TESTING

Field Test Data

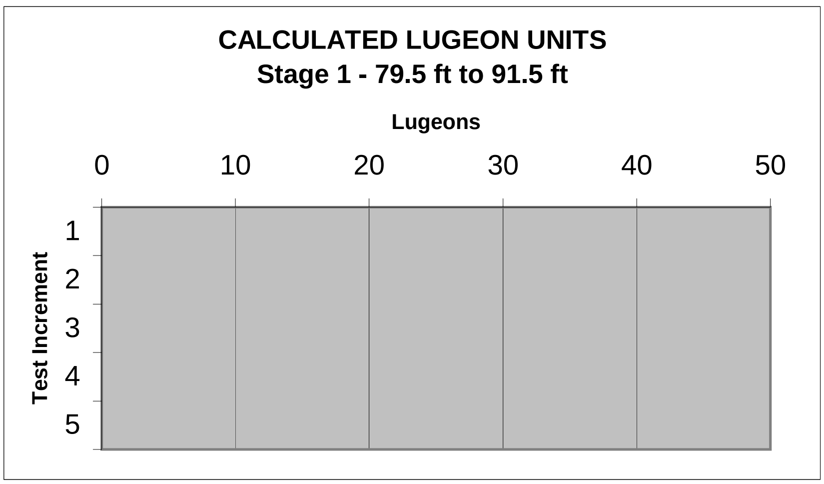
Boring : ***B-91*** Test by: ***D. Durman***
Elevation: **536.5** Date: ***11/10/2011***

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)
79.5	79.5	1	12.0	10	60.0	0.0	0	
91.5	91.5	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**1**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
69.5	69.5	1	12.0	10	60.0	0.0	0	
81.5	81.5	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**2**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
59.5	59.5	1	12.0	10	60.0	0.0	0	
71.5	71.5	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**3**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
49.5	49.5	1	12.0	10	60.0	0.0	0	
61.5	61.5	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**4**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
39.5	39.5	1	12.0	10	60.0	0.0	0	
51.5	51.5	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	17.0	2	**5**
		4	12.0	10	90.0	4.8	1	
		5	12.0	10	60.0	0.0	0	
29.5	29.5	1	12.0	10	60.0	0.0	0	
41.5	41.5	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**6**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
19.5	19.5	1	12.0	10	60.0	0.0	0	
31.5	31.5	2	12.0	10	90.0	Could not maintain pressure above 57 psi. Free Flow		
		3	12.0	10	120.0			**7**
		4	12.0	10	90.0			
		5	12.0	10	60.0			

Boring: B-91

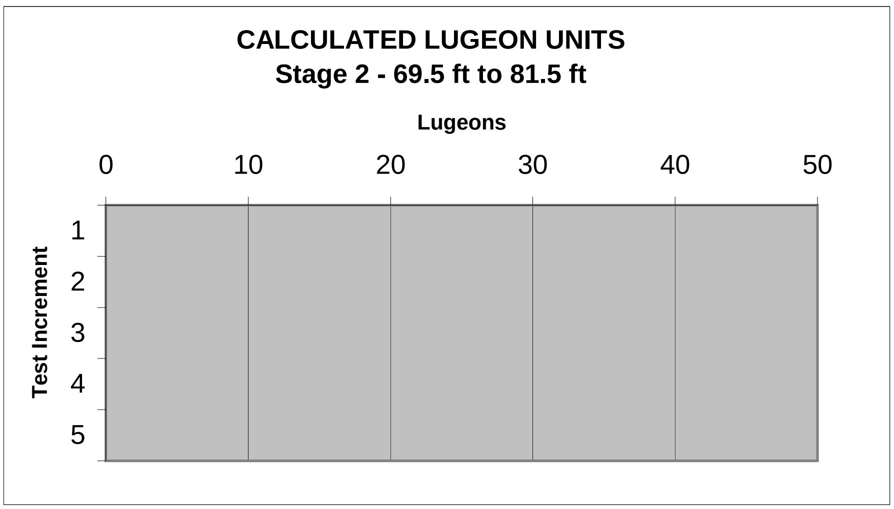


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

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

Boring: B-91

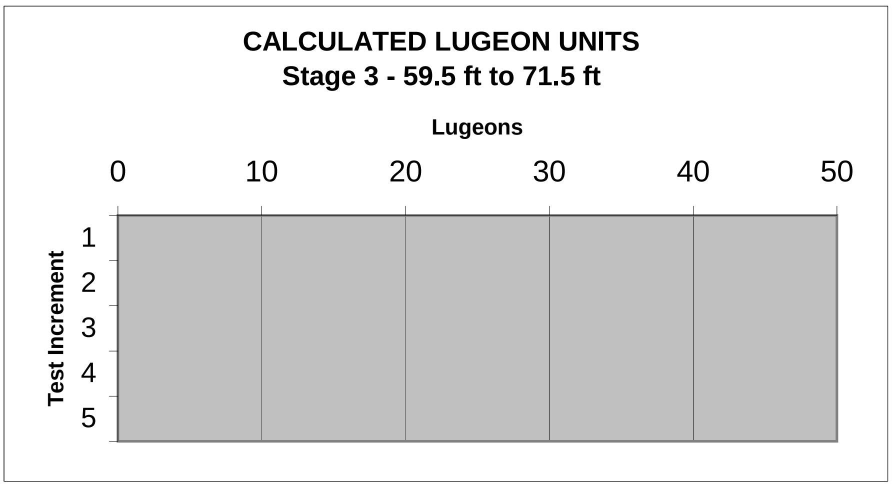


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

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

Boring: B-91

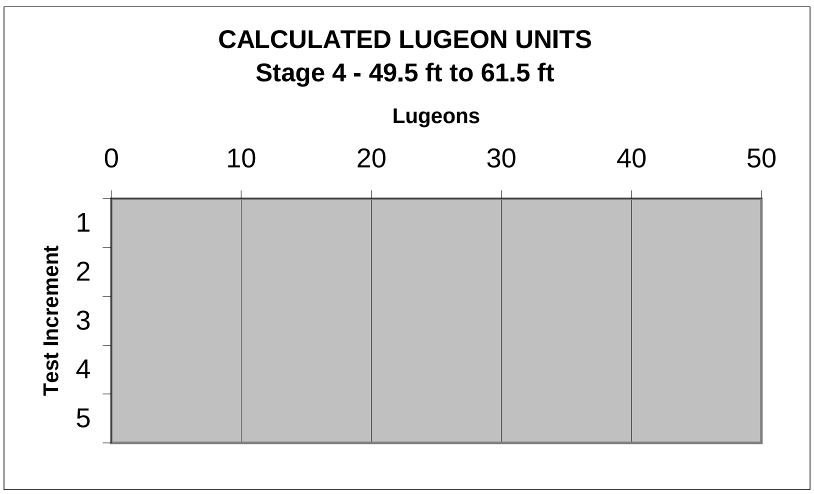


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

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

Boring: B-91

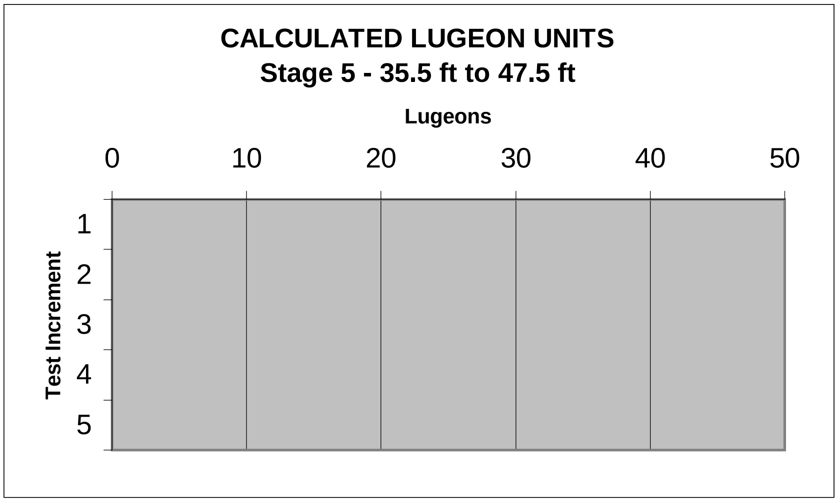


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

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

Boring: B-94

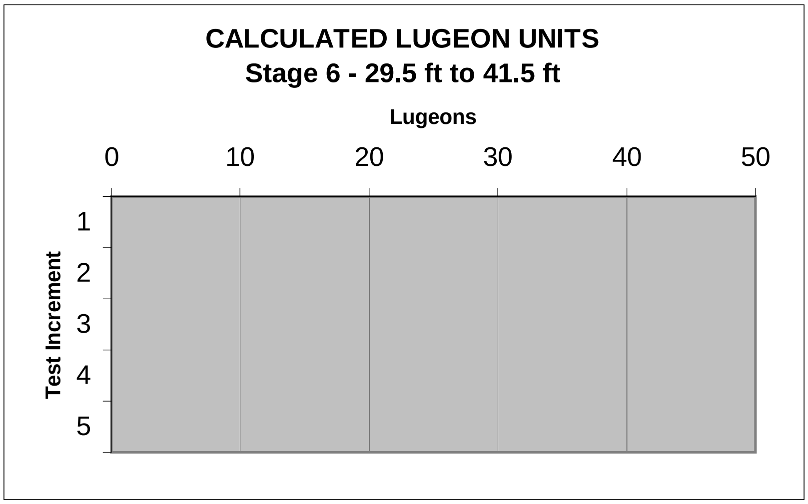


	TEST PRESSURE (psi)	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	2
Test Increment 4	90	1
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Dilation**

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

Boring: B-91



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

INTERPRETATION OF RESULTS: **Laminar**

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

LOUISVILLE TUNNEL PROJECT
GEOTECHNICAL INVESTIGATION
WATER PRESSURE TESTING

S&ME

Field Test Data

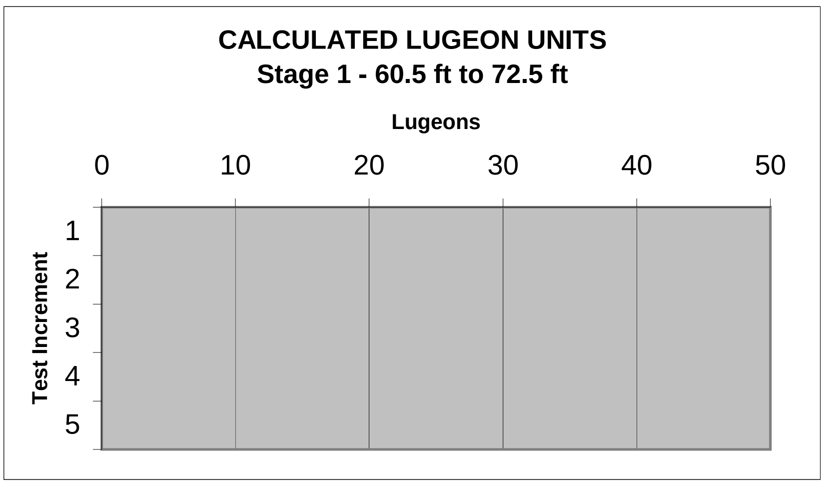
Boring : ***B-92*** Test by: ***D. Durman***
Elevation: **517.6** Date: ***11/11/2011***

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)
60.5	60.5	1	12.0	10	60.0	0.0	0	
72.5	72.5	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**1**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
50.5	50.5	1	12.0	10	60.0	0.0	0	
62.5	62.5	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**2**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
40.5	40.5	1	12.0	10	60.0	0.0	0	
52.5	52.5	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**3**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
30.5	30.5	1	12.0	10	60.0	15.0	4	
42.5	42.5	2	12.0	10	90.0	68.4	11	
		3	12.0	10	120.0	180.4	22	**4**
		4	12.0	10	90.0	119.4	20	
		5	12.0	10	60.0	117.8	29	
20.5	20.5	1	12.0	10	53.0	209.8	58	
32.5	32.5	2	12.0	10	90.0	Could not maintain pressure above 53 psi. Free Flow		
		3	12.0	10	120.0			**5**
		4	12.0	10	90.0			
		5	12.0	10	60.0			
10.5	10.5	1	12.0	10	53.0	299.6	83	
22.5	22.5	2	12.0	10	90.0	Could not maintain pressure above 53 psi. Free Flow		
		3	12.0	10	120.0			**6**
		4	12.0	10	90.0			
		5	12.0	10	60.0			

Boring: B-92

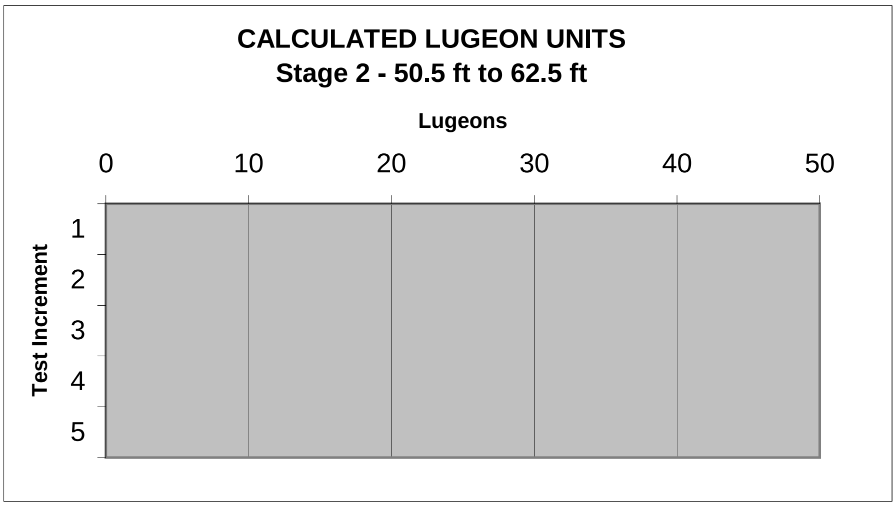


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

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

Boring: B-92

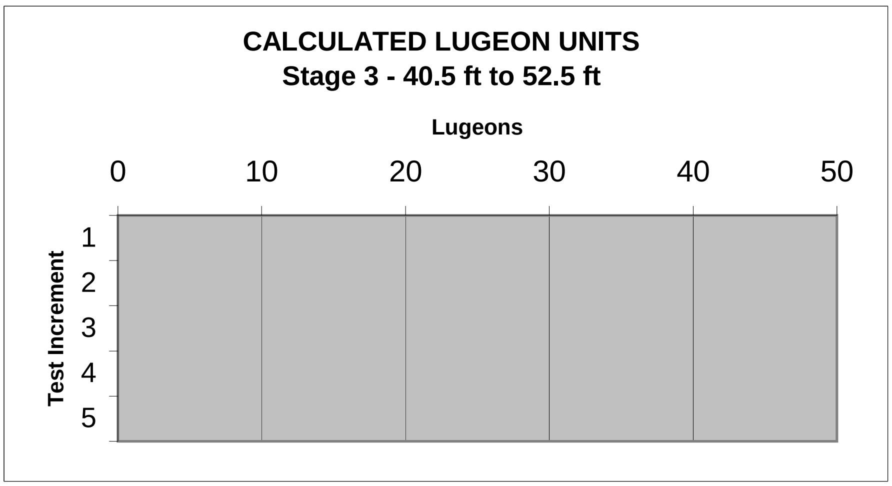


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

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

Boring: B-92

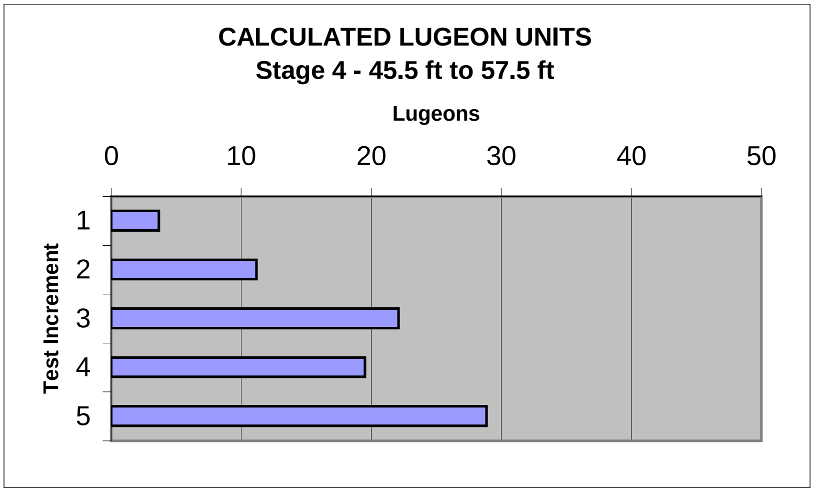


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

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

Boring: B-92



	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	4
Test Increment 2	90	11
Test Increment 3	120	22
Test Increment 4	90	20
Test Increment 5	60	29

INTERPRETATION OF RESULTS: **Wash Out**

Permeability increases because the fractures are enlarged by the test.

LOUISVILLE TUNNEL PROJECT
GEOTECHNICAL INVESTIGATION
WATER PRESSURE TESTING

S&ME

Field Test Data

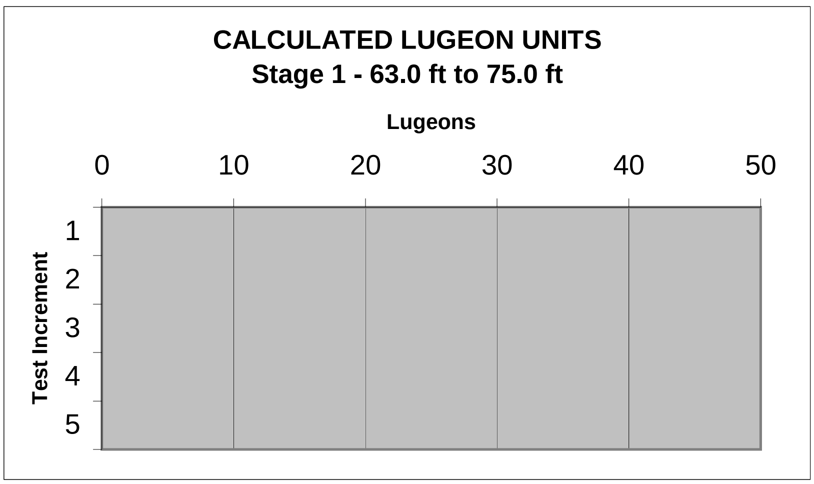
Boring : ***B-93*** Test by: ***D. Durman***
Elevation: **521.4** Date: ***11/8/2011***

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)
63.0	63.0	1	12.0	10	60.0	0.0	0	
75.0	75.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**1**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
53.0	53.0	1	12.0	10	60.0	0.0	0	
65.0	65.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**2**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
43.0	43.0	1	12.0	10	60.0	0.0	0	
55.0	55.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**3**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
33.0	33.0	1	12.0	10	60.0	0.0	0	
45.0	45.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**4**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
23.0	23.0	1	12.0	10	60.0			
35.0	35.0	2	12.0	10	90.0	Free Flow. Could not achieve test pressure.		
		3	12.0	10	120.0			**5**
		4	12.0	10	90.0			
		5	12.0	10	60.0			
13.0	13.0	1	12.0	10	60.0			
25.0	25.0	2	12.0	10	90.0	Free Flow. Could not achieve test pressure.		
		3	12.0	10	120.0			**6**
		4	12.0	10	90.0			
		5	12.0	10	60.0			

Boring: B-93

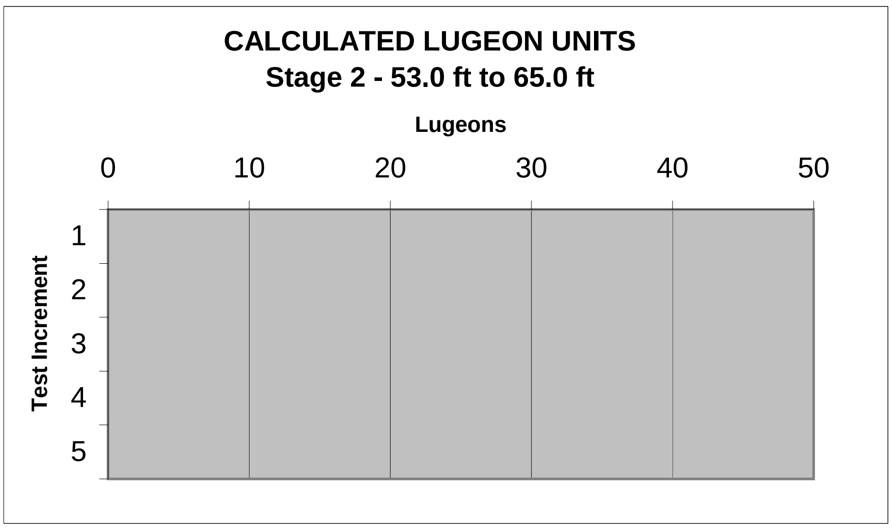


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

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

Boring: B-93

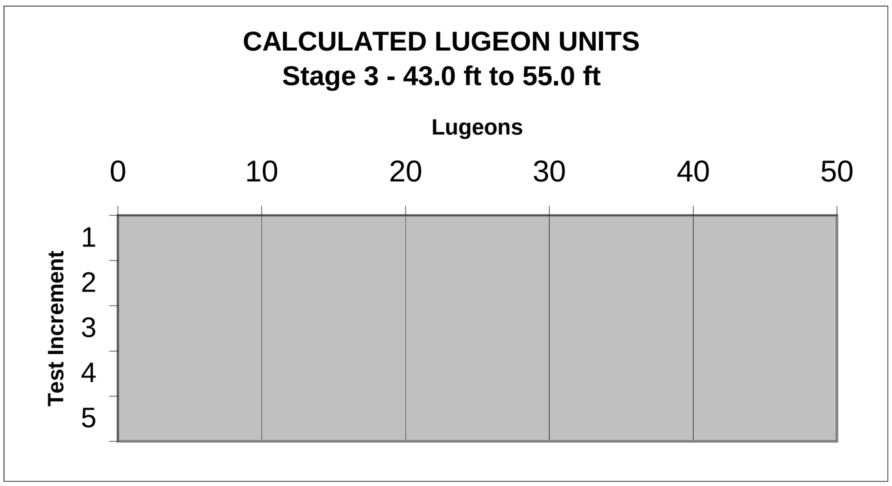


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

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

Boring: B-93

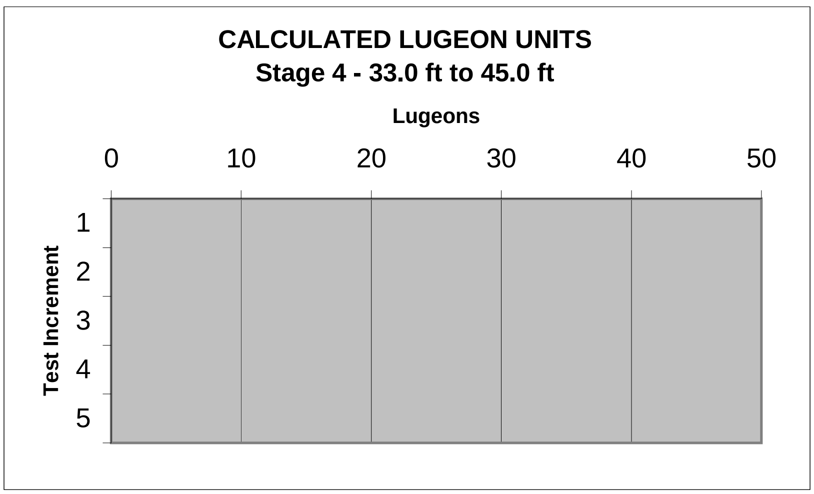


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

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

Boring: B-93



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

INTERPRETATION OF RESULTS: **Laminar**

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

LOUISVILLE TUNNEL PROJECT
GEOTECHNICAL INVESTIGATION
WATER PRESSURE TESTING

S&ME

Field Test Data

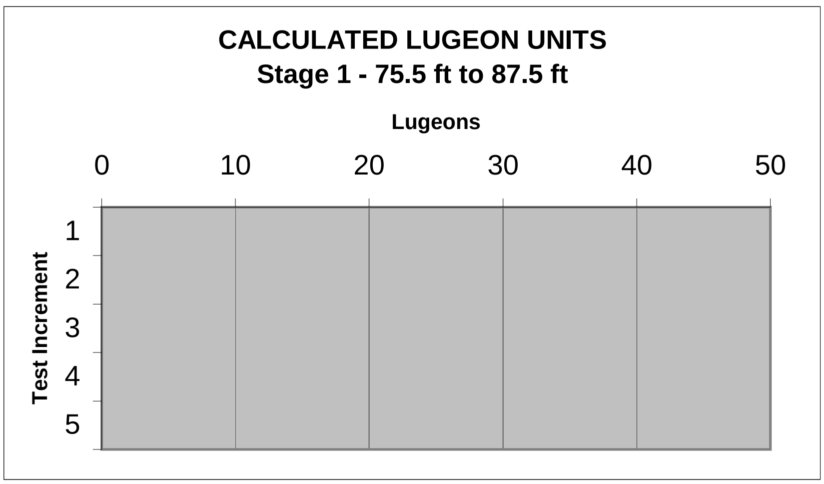
Boring : ***B-94*** Test by: ***D. Durman***
Elevation: **532.5** Date: ***11/7/2011***

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)
75.5	75.5	1	12.0	10	60.0	0.0	0	
87.5	87.5	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**1**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
65.5	65.5	1	12.0	10	60.0	0.0	0	
77.5	77.5	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**2**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
55.5	55.5	1	12.0	10	60.0	0.0	0	
67.5	67.5	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**3**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
45.5	61.0	1	12.0	10	60.0	0.0	0	
57.5	73.0	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**4**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
35.5	35.5	1	12.0	10	60.0	0.0	0	
47.5	47.5	2	12.0	10	90.0	3.2	0	
		3	12.0	10	120.0	20.0	0	**5**
		4	12.0	10	90.0	9.4	0	
		5	12.0	10	60.0	0.0	0	
25.5	25.5	1	12.0	10	60.0	0.0	0	
37.5	37.5	2	12.0	10	90.0	0.0	0	
		3	12.0	10	120.0	0.0	0	**6**
		4	12.0	10	90.0	0.0	0	
		5	12.0	10	60.0	0.0	0	
15.5	15.5	1	12.0	10	60.0			
27.5	27.5	2	12.0	10	90.0	Free Flow		
		3	12.0	10	120.0			**7**
		4	12.0	10	90.0			
		5	12.0	10	60.0			

Boring: B-94

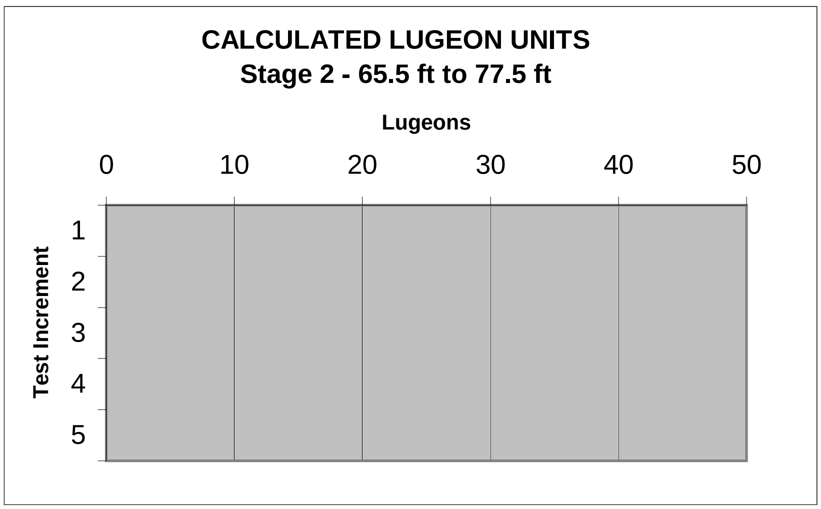


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

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

Boring: B-94

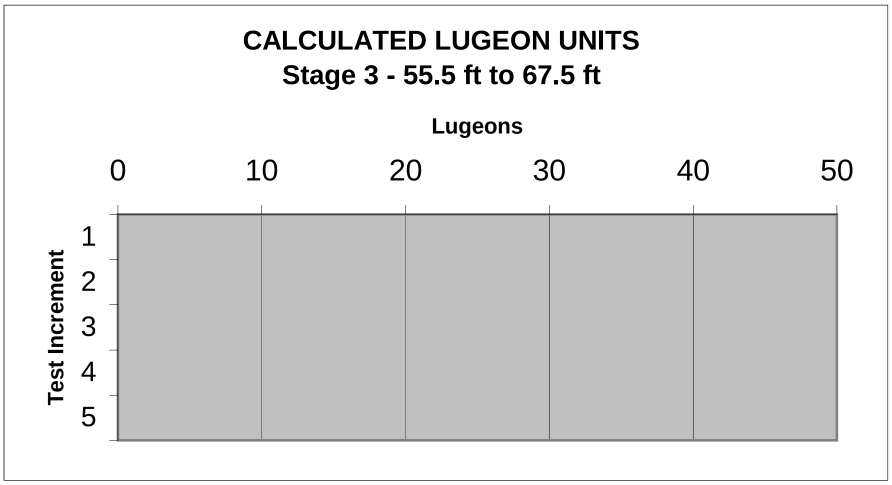


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

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

Boring: B-94

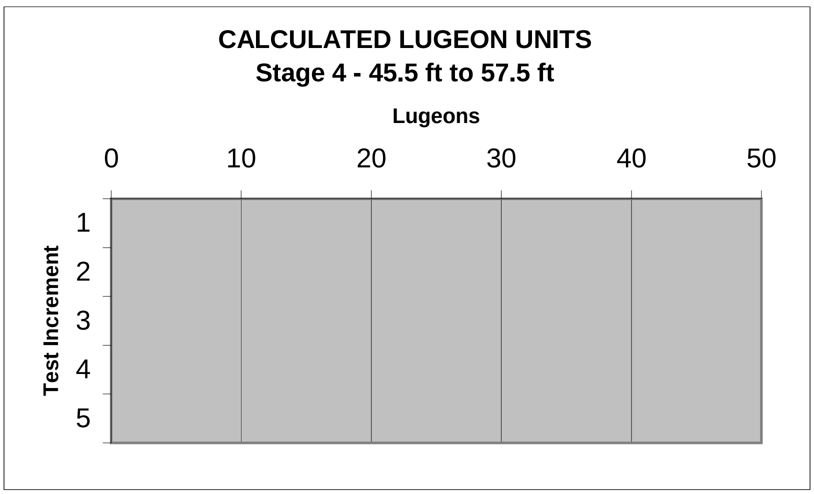


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

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

Boring: B-94

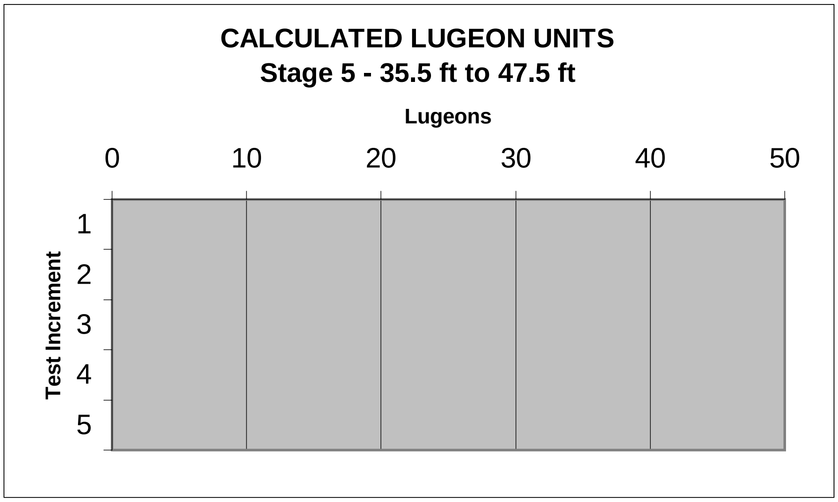


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

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

Boring: B-94

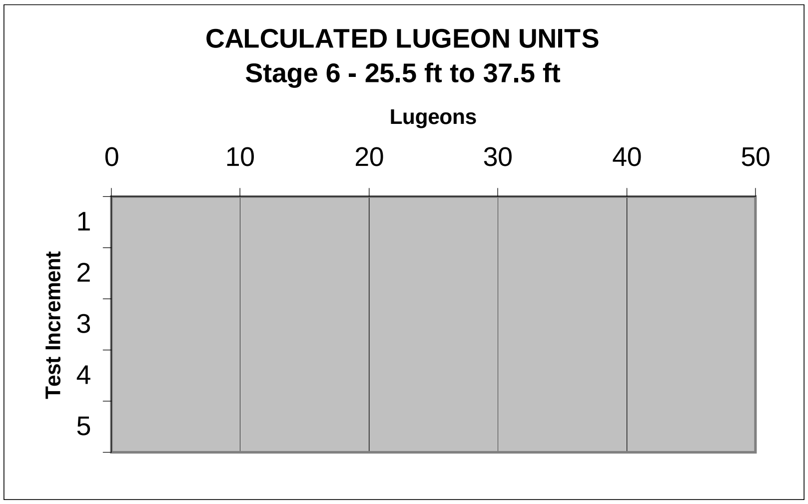


	TEST PRESSURE (psi)	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

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

Boring: B-94

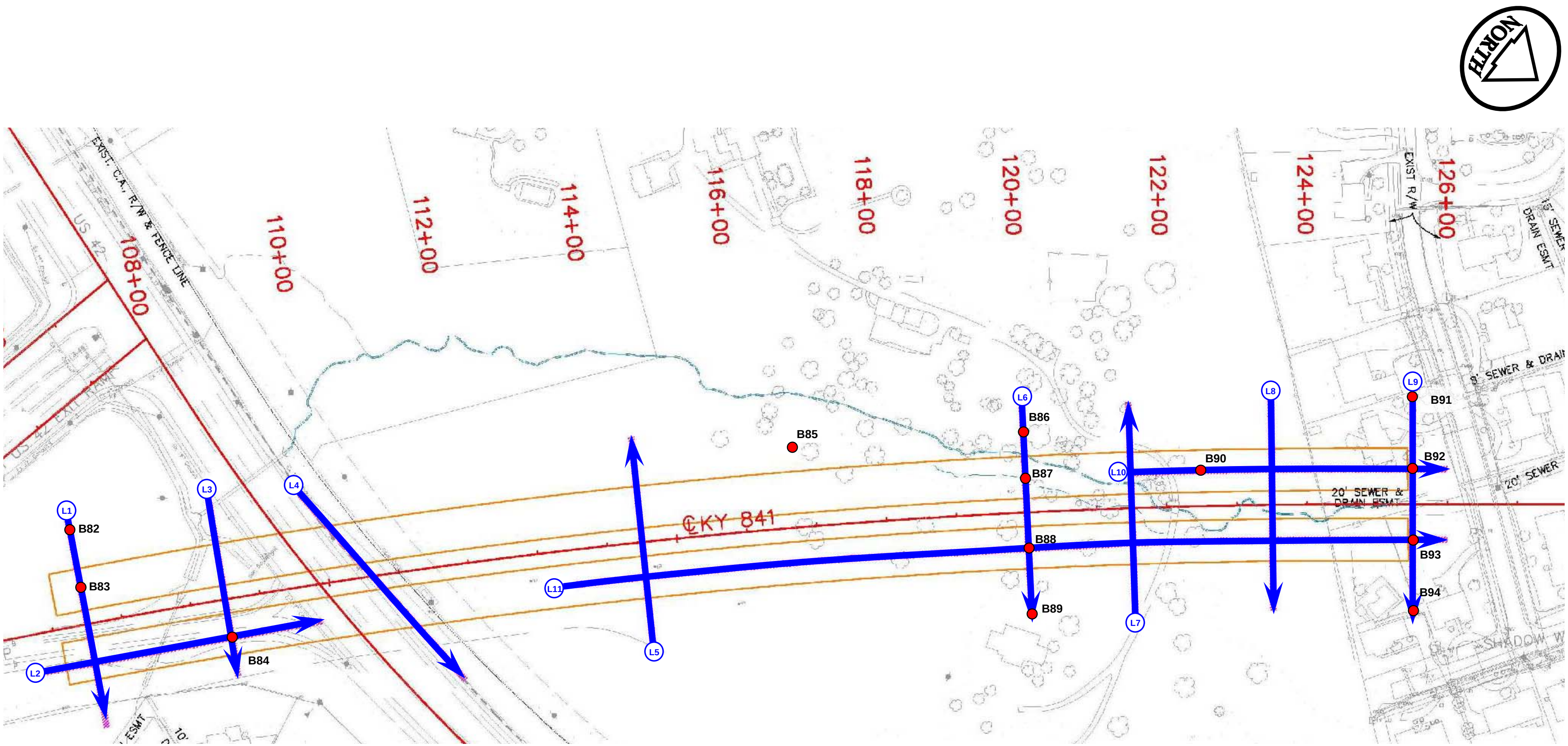


	TEST PRESSURE	LUGEON VALUE
Test Increment 1	60	0
Test Increment 2	90	0
Test Increment 3	120	0
Test Increment 4	90	0
Test Increment 5	60	0

INTERPRETATION OF RESULTS: **Laminar**

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

APPENDIX V
GEOPHYSICAL SURVEY RESULTS



LEGEND

Geophysical Line Location (Resistivity and Seismic Refraction)

Approximate Boring Location

Feet

0 100 200 300

SCALE:	AS SHOWN
DRAWN BY:	KDH
CHECKED BY:	DDB
DATE:	12-15-11

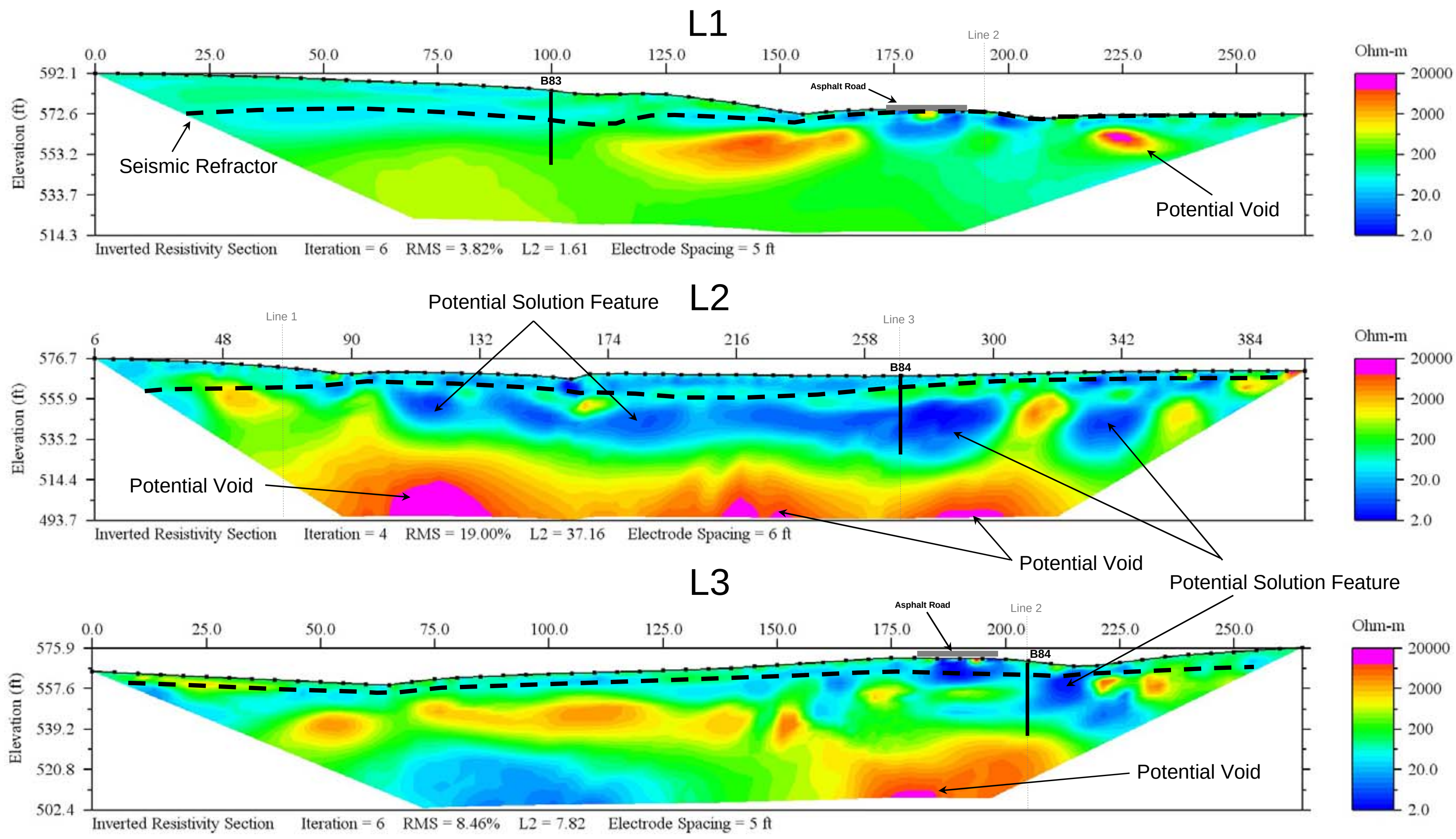
S&ME
ENGINEERING • TESTING
ENVIRONMENTAL SERVICES

GEOPHYSICAL TEST LOCATION PLAN
LOUISVILLE SOUTHERN INDIANA
OHIO RIVER BRIDGES PROJECT
KENTUCKY EAST END APPROACH TUNNEL

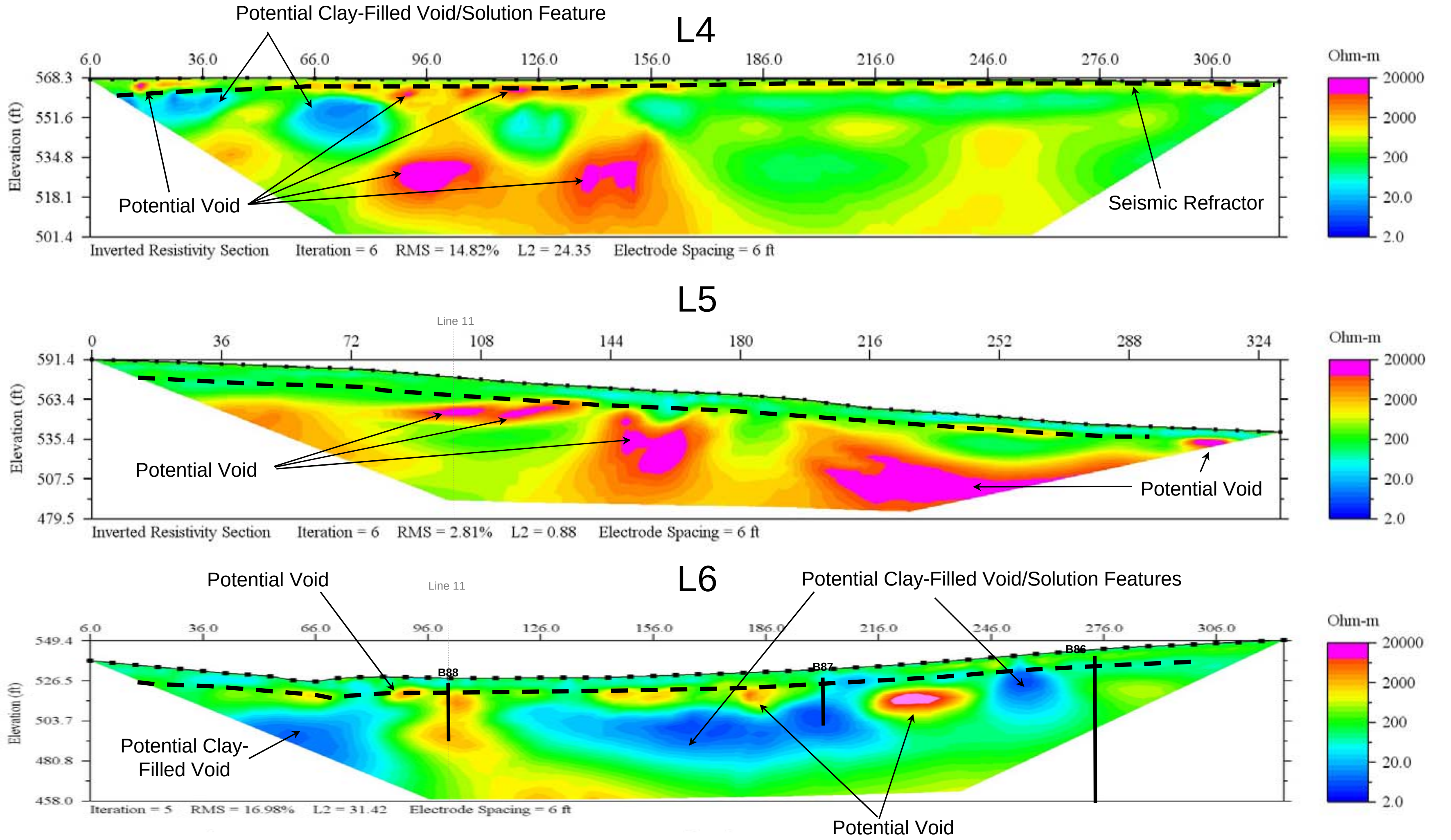
JOB NO.: 1831-10-5629

FIGURE NO.

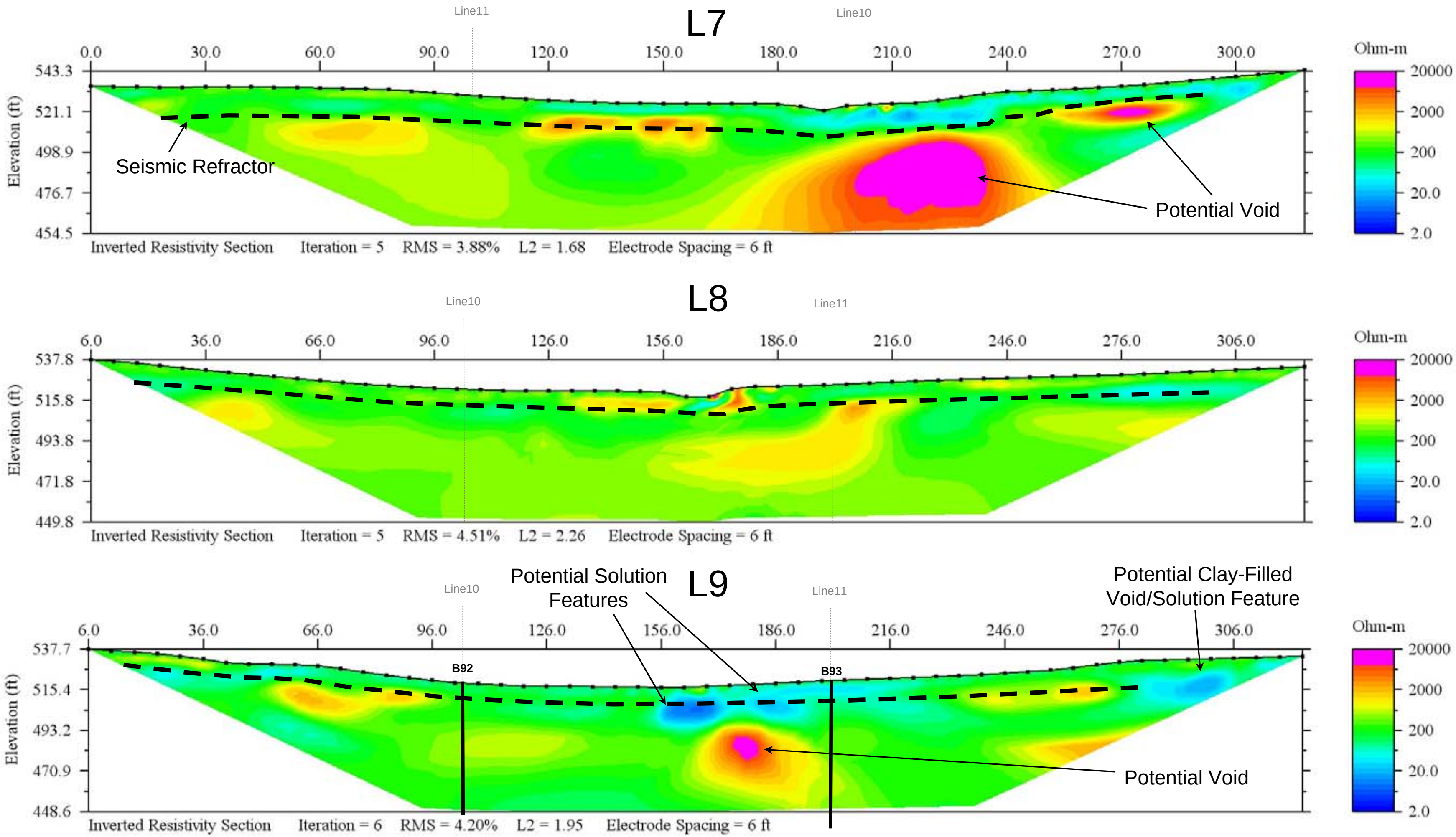
7



SCALE: AS SHOWN	S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES	**RESISTIVITY PROFILES – L1, L2 AND L3** **LOUISVILLE SOUTHERN INDIANA** **OHIO RIVER BRIDGES PROJECT** **KENTUCKY EAST END APPROACH TUNNEL**	FIGURE NO. 8
DRAWN BY: KDH			
CHECKED BY: DDB			
DATE: 12-15-11		JOB NO.: 1831-10-5629	

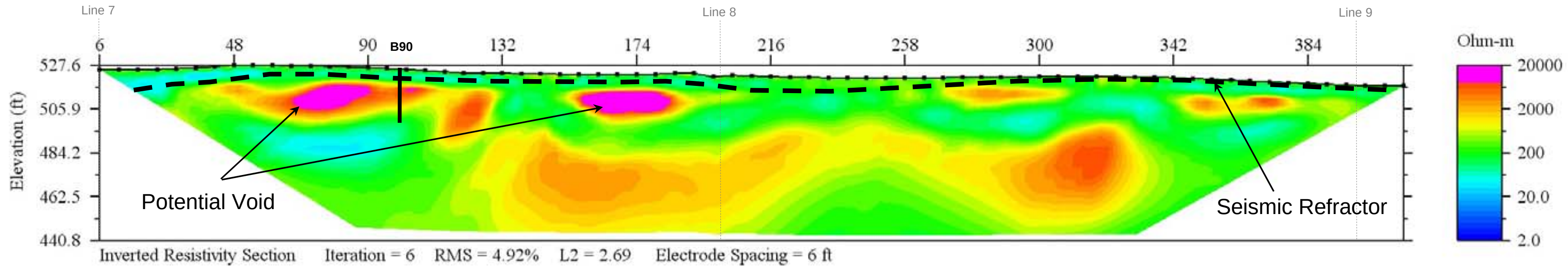


SCALE: AS SHOWN	S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES	**RESISTIVITY PROFILES – L4, L5 AND L6** **LOUISVILLE SOUTHERN INDIANA** **OHIO RIVER BRIDGES PROJECT** **KENTUCKY EAST END APPROACH TUNNEL**	FIGURE NO.
DRAWN BY: KDH			9
CHECKED BY: DDB			
DATE: 12-15-11		JOB NO.: 1831-10-5629	

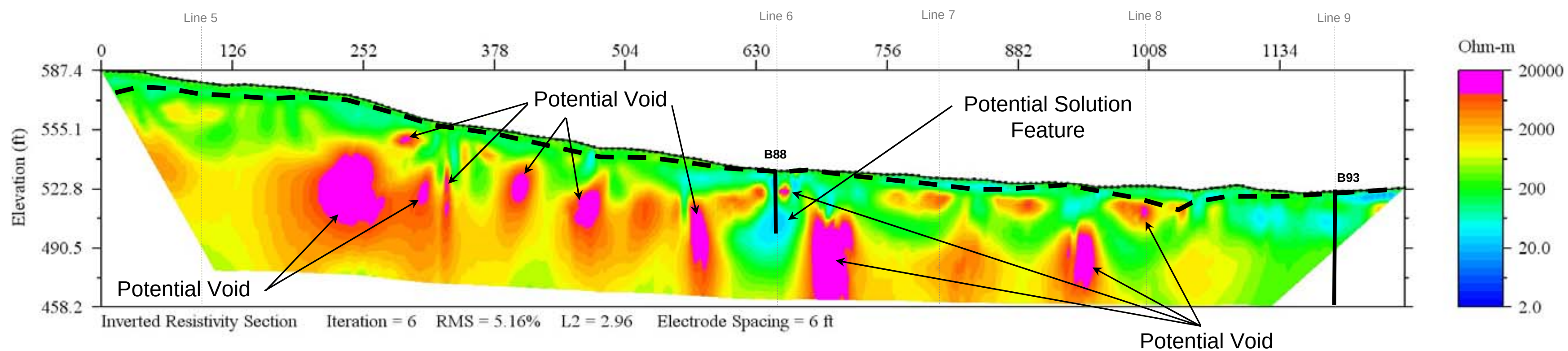


SCALE: AS SHOWN	S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES	**RESISTIVITY PROFILES – L7, L8 AND L9** **LOUISVILLE SOUTHERN INDIANA** **OHIO RIVER BRIDGES PROJECT** **KENTUCKY EAST END APPROACH TUNNEL**	FIGURE NO. 10
DRAWN BY: KDH			
CHECKED BY: DDB			
DATE: 12-15-11		JOB NO.: 1831-10-5629	

L10



L11



SCALE: AS SHOWN	S&ME ENGINEERING • TESTING ENVIRONMENTAL SERVICES	**RESISTIVITY PROFILES – L10 AND L11** **LOUISVILLE SOUTHERN INDIANA** **OHIO RIVER BRIDGES PROJECT** **KENTUCKY EAST END APPROACH TUNNEL**	FIGURE NO. 11
DRAWN BY: KDH			
CHECKED BY: DDB			
DATE: 12-15-11		JOB NO.: 1831-10-5629	

422 Codell Drive, Lexington, Kentucky 40509