S-058-2016

M E M O R A N D U M

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TO: William McKinney, P.E.
TEBM, Division of Structural Design

FROM: Bart Asher, P.E., L.S.
Director
Division of Structural Design

BY: Daryl J. Greer, P.E.
Geotechnical Branch

DATE: August 15, 2017

SUBJECT: **Henderson County**
FD52 051 0060 019-020 D; BRO 5053 026
MARS No. 8675901D
US 60, Replace Bridge over Green River @ KY 1078
Item No. 2-1080.00
Geotechnical Engineering Structure Foundation Report

1.0 LOCATION AND DESCRIPTION

The proposed structure is planned to be a replacement of the existing structure that crosses the Green River near Spottsville, KY. The existing bridge was constructed in 1930 and is located just downstream of Lock and Dam No. 1. The proposed replacement structure will be located north (downstream) of the existing bridge. A site map showing the location of the proposed structure is attached.

The proposed replacement will cross the Green River with a 560-foot truss. Four approach spans will lead from the truss on the east end of the bridge. The proposed layout for the structure is included as an attachment to this report.

The DGN files for the Subsurface Data Sheets have been made available on ProjectWise and through email for use in development of structure plans.

2.0 SITE GEOLOGIC CONDITIONS

This structure is located in the Spottsville Geologic Quadrangle (GQ-1090). The west end (Abutment 1) of the proposed structure is located on a cliff overlooking the Green River. According to geologic mapping the surface soils at Abutment 1 consists of loess (silty clay to clayey silt) and is underlain by the Carbondale Formation. The Carbondale Formation consists of shale, sandstone, coal, limestone, and underclay. According to the geologic mapping, the No. 9 coal seam is located below Abutment 1. This coal bed does not outcrop within the project area but is present near elevation 330 feet. This places the coal seam slightly below the normal pool elevation of the Green River. Geologic mapping also indicates that the seam can vary from 0 to 5 feet thick. Abandoned vertical mine shafts are located in the vicinity of the project site.

Maps of the mined areas west of the Green River were obtained from the Kentucky Geological Survey (KGS). These maps are included in the attachments. Mine maps showing mining methods, pillars, etc., were not found. The outlines shown on the maps came from a set of tracings shown on the topographic maps that are at the KGS Henderson Office. The source of the information on the tracings is unknown. According to KGS sources, Reynolds Aluminum Company owned much of the coal rights in the area, but Emerald Land Company bought these rights. According to local historians, the mine was one of the first commercial coal operations in the region with mining activity starting in the 1800s. In the early 1900s it was revived and produced coal for several years.

The east end of the proposed bridge (Piers 1 through 4 and End Bent 2) are located in a floodplain of the Green River. The geologic mapping indicates that the surface soils consist of alluvium (sand, clay, and gravel) underlain by the Carbondale Formation. The No. 9 coal seam is not present east of the Green River. Geologic mapping indicates a regional dip of approximately 45 feet per mile (< 1%) east to west in the project area.

The plans for the existing bridge (Drawing No. 4053) were also reviewed. These plans included a record of borings performed for the design of the existing structure. This record of borings is included in the attachments.

3.0 FIELD INVESTIGATION

The initial subsurface investigation was undertaken between April and May 2016 by a KYTC Drill Crew. At Abutment 1 three core holes, two sample and core holes, and one mechanical rockline sounding was performed. Casing was installed through the overburden soils for Holes 1004-1006 and 1024 so that a downhole camera could be used to observe the mine opening. After allowing a period of time for drilling fluids and cuttings to settle out of the groundwater, KYTC personnel returned to the site on June 22, 2016, to conduct the downhole videos. For Piers 1 through 4 and End Bent 2 five sample and core holes, two sample holes, and two rockline soundings were obtained. These borings were performed using conventional hollow-stem, solid-stem, and diamond-bit core barrel techniques.

Additional borings (Holes 2001-2011) were performed in the Abutment 1 area in November and December 2016 to further assist in defining the extent of the mined area. These borings were performed using wet-rotary methods with a poly-crystalline diamond bit and extended through the mine opening or coal seam. These borings were cased through the overburden soils. KYTC personnel returned to the site in April 2017 to conduct downhole videos in the borings. Videos of Holes 2002 and 2004 were not obtained because the PVC casing had collapsed.

Samples of the groundwater were obtained during the April 2017 site visit from borings that encountered mine voids. The samples were tested by the Division of Materials Laboratory and met the requirements for total solids, chlorides, pH, and sulfate per ASTM C1602/C1602M-06. The purpose of this testing was to evaluate if groundwater present in the mine openings would be detrimental to grout. The results of these tests are included in the attachments.

Two cone penetrometer tests (CPTs) with pore pressure dissipation measurements were conducted near End Bent 2 during the November/December 2016 field work. The CPTs were taken to supplement the information obtained from the conventional borings.

The drill crews delivered rock core and soil samples to the KYTC Geotechnical Branch where a KYTC geologist logged the cores. Videos of the downhole camera inspection can be viewed at the following link:

https://www.youtube.com/playlist?list=PLFxn4Rhh9fBkXtXP9WjuXAh6V5StUWd4v

4.0 LABORATORY TESTING AND SUBSURFACE CONDITIONS

Soil samples were tested in the Geotechnical Branch's laboratory. Selected rock core samples were tested for Slake Durability and unconfined compressive strength. Please refer to the subsurface data sheets for specific information concerning bedrock descriptions, Rock Quality Designation (RQD), core recovery, Slake Durability Index (SDI) testing, rock unconfined compressive strengths, soil unconfined compressive strengths, groundwater elevations, and other pertinent data.

4.1 Abutment 1

Depths to top of rock for Abutment 1 ranged from 12.0 to 14.1 feet. Top of rock elevations varied from 410.7 to 412.4 feet. The bedrock consisted, in descending order, of a brown to gray weathered shale, a brown non-durable sandstone, and a gray to black shale. Coal seams or mine openings were encountered at or near approximate elevation 330 feet. KY RQD values for the rock cores ranged from 0 to 78% with an average value of 11% and a median value of 0%. Core recoveries varied from 18 to 100% with an average value of 94% and median value of 100%. SDI values ranged from 0 to 97 with an average value of 82 and median value of 91, thus indicating that the bedrock is generally non-durable. Unconfined compressive strengths of rock core samples tested at Abutment 1 ranged from 380 to 7110 psi. The average unconfined compressive strength of the rock core samples was 1425 psi with a median value of 1095 psi.

The soil samples obtained from the borings at Abutment 1 were determined to consist of low-plasticity silty clays and low- to high-plasticity clayey silts. The samples were designated as CL, CL-ML, ML, and MH in the Unified Soil Classification System and as A-4, A-6, and A-7-5 using the AASHTO Method.

Groundwater elevations were measured in borings that encountered mine openings at Abutment 1. Groundwater was measured at elevations between 360.3 and 362.0 feet during the June 2016 site visit. During the April 2017 site visit the groundwater was measured at elevations between 362.9 and 363.3 feet. These groundwater levels are approximately 20 feet above normal pool elevation for the Green River. Groundwater elevations can fluctuate with rainfall, nearby stream levels, seasonal variations, and other factors.

4.2 Piers 1 through 4 and End Bent 2

Depths to top of rock for Piers 1 through 4 and End Bent 2 ranged from 23.3 to 39.6 feet with the exception of Hole 1023. Hole 1023 extended through the approach embankment to refusal at a depth of 74.1 feet. Top of rock elevations varied from 329.5 to 336.8 feet and generally increased in elevation from west to east. The bedrock consisted of gray, clayey to silty shales with sandstone laminations and partings. KY RQD values for the rock cores ranged from 0 to 90 % with an average value of 16% and a median value of 0%. Core recoveries varied from 79 to 100% with an average value of 99% and a median value of 100%. SDI values ranged from 68 to 97 with an average value of 87 and a median value of 88. The SDI values indicate that the bedrock is generally non-durable. Unconfined compressive strengths of rock core samples tested ranged from 370 to 6270 psi. The average unconfined compressive strength of the rock core samples was 2600 psi with a median value of 2125 psi.

Soil samples obtained from the borings for Piers 1 through 4 and End Bent 2 were determined to consist of low-plasticity silty clays and clayey silts with the exception of a one silty sand sample at Hole 1021. The samples were designated as CL, CL-ML, ML, and SM in the Unified Soil Classification System and as A-1-b, A-4, A-6, and A-7-6 using the AASHTO Method.

A groundwater elevation of 347.0 feet was measured on June 22, 2016 in an observation well placed in Hole 1014. A groundwater elevation of 357.9 feet was measured in an observation well placed in Hole 1021 on June 21, 2016. Groundwater elevations can fluctuate with rainfall, nearby stream levels, seasonal variations, and other factors.

Two cone penetrometer tests (CPTs) with pore pressure dissipation measurements were conducted near Pier 4 and End Bent 2. Graphs of the tip and sleeve stress vs. depth are included on the subsurface data sheets.

5.0 ENGINEERING ANALYSIS AND RECOMMENDATIONS

5.1 **Mine Opening Remediation** – We recommend grouting of the mine opening using low-slump grout in order to reduce the potential for collapse of the underground mine and impacts to Abutment 1 from the resulting ground subsidence. The purpose of the grouting is to compact the debris and sediment in the mine opening, partially fill any void space in the mine, and to create grout columns to further support the mine roof. Mine grouting shall be in accordance with the <u>Special Note for Mine Grouting</u> and the <u>Mine Grouting Plan</u> sheet. The <u>Mine Grouting Plan</u> sheet shows a treatment area and typical primary grout hole spacing. The treatment area is based on an approximate draw angle of 35° for mine collapse, the proposed end of bridge station at 508+55, and a base of footing elevation of 400 feet. If these assumptions change, please notify this office for a revised treatment area. Although the grouting is for support of the bridge substructure, the plan sheet will be included in the Roadway Plans as subsurface improvement methods are generally considered part of grade and drain efforts. Copies of the <u>Special Note for Mine Grouting</u> and <u>Mine Grouting Plan</u> sheet are attached as information. Estimated bid quantities and unit costs have been provided to the designer.

5.2 **<u>Abutment 1</u>** - Use spread footings on competent bedrock. The estimated base of footing elevation is 400 feet. Footings shall be embedded a minimum of 2 feet into competent bedrock. Size the footings at the service limit state using a presumptive factored bearing resistance of 20 ksf. Use a nominal bearing resistance of 60 ksf multiplied by resistance factors of 0.45 and 1.0 for checking the strength and extreme limit states respectively. Contact this branch for a more detailed analysis of the nominal bearing resistance if the strength or extreme limit states control the footing design.

Because of the proximity of the edge of the proposed abutment footing to the cliff overlooking the west bank of the Green River, it is recommended that the downhill edge of the footing be placed no closer than 10' from the slope face. The proposed bridge layout provided to this office indicates that this requirement can be achieved, but contact this office for further evaluation if during substructure design it appears this requirement cannot be met.

5.3 <u>Piers 1 through 4</u>

5.3.1 **<u>Spread Footing Alternative</u> –** Use spread footings on unweathered bedrock. The estimated base of footing elevations for each substructure unit is provided in the table below. Footings shall be embedded a minimum of 2 feet into unweathered bedrock. Size the footings at the service limit state using a presumptive factored bearing resistance of 20 ksf. Use a nominal bearing resistance of 60 ksf multiplied by resistance factors of 0.45 and 1.0 for checking the strength and extreme limit states respectively. If competent, unweathered bedrock is encountered at higher elevations, the footings may be raised as long as the minimum embedment depths are maintained.

Substructure Unit	**Estimated Footing Elevation (ft)**
Pier 1	326
Pier 2	329
Pier 3	332
Pier 4	333

5.3.2 **<u>Drilled Shaft Alternative</u>** – Use drilled shafts constructed in accordance with the Special Note for Drilled Shafts. The shaft tips shall extend a minimum of two shaft diameters below the bottom of permanent casing. Drilled shafts were evaluated for axial loading, and the attached tables provide the resulting capacities and resistances for Load & Resistance Factor Design (LFRD) methods. The following table contains relevant elevations needed to both complete the design and determine plan quantities for the drilled shafts.

Estimated Drilled Shaft Elevations

	Elevations (ft)[1]		
Substructure Unit	Estimated Top of Rock (ft)	Estimated Bottom of Permanent Casing/Top of Rock Socket (ft)	Highest Allowable Shaft Tip (ft)[2]
Pier 1	329.5	329	322
Pier 2	331.5	331	324
Pier 3	334	333	326
Pier 4	336	335	328

Notes:

[1] Elevations for all shafts will be verified after construction phase drilling has been performed. The final shaft tip elevations and quantities may be adjusted based on the actual conditions encountered in the field.

[2] The highest tip elevation shown is based on a 3.5 foot diameter shaft. Deeper shaft tips may be required. The shaft tip shall extend a minimum of 2.0 shaft diameters below the bottom of permanent casing.

5.3.3 **<u>Driven Pile Alternative</u>** – Use end bearing steel H-Piles with reinforced pile points driven to bedrock. The approximate point of pile elevations are provided in the table below. We recommend a resistance factor (ϕ_c) of 0.5 to determine the maximum nominal resistance of the piles. An H-Pile foundation is not recommended at Pier 1 due to the anticipated scour depths. For determining Practical Refusal for point-bearing steel H-piles, we recommend using Case 2.

Estimated Point of Pile Elevations	
Substructure Unit	Point of Pile Elevation (ft)
Pier 2	331
Pier 3	334
Pier 4	335

5.4 **End Bent 2** – Use end bearing steel H-Piles with reinforced pile points driven to bedrock. The approximate point of pile elevation is 332 feet. We recommend a resistance factor (ϕ_c) of 0.5 to determine the maximum nominal resistance of the piles. For determining Practical Refusal for point-bearing steel H-piles, we recommend using Case 2.

5.5 **Settlement** – Since the embankment height at End Bent 2 was on the order of 53 feet high, settlement analyses were conducted. These analyses were complicated by the fact that existing embankments were present and the fill was being widened. The existing embankments have been in place for an extended period and should have essentially completed their settlement. The placement of additional fill for the widening will create differential settlement across the End Bent.

Based on our analyses, we expect approximately 20 inches of new settlement beginning at the left toe of the existing embankment that transitions to no new settlement at the right shoulder of the existing embankment. Across the new end bent we expect approximately 15 inches of settlement at the left side of the end bent transitioning to 5 inches on the right side. These analyses also indicate that 90% consolidation will occur in approximately 4 months.

The settlement will result in dragdown loads on the piles unless a waiting period is implemented before driving can commence. These dragdown loads would vary across the end bent because of the differential settlement. In addition, staged embankment construction is required to allow foundation soils to consolidate and gain strength so that embankment stability can be maintained as noted later in this report. Therefore, we recommend implementing a waiting period to allow settlement to occur prior to driving piles at End Bent 2. Please refer to the Geotechnical Engineering Roadway Report R-015-2016 for the requirements for embankment construction and waiting periods.

5.6 **Embankment Stability** – Stability analyses were performed for the approach embankment at Station 520+00. These analyses indicated inadequate factors of safety for total stress (short-term) conditions. Factors of safety for effective stress (long-term) and rapid drawdown conditions were acceptable. As a result, we recommend staged construction of the embankment. Initial embankment construction shall be limited to elevation 395 feet. Embankment construction above elevation 395 shall be performed in a controlled manner based on information obtained from piezometer and settlement platform measurements. Notes for controlling embankment construction will be included in the Geotechnical Engineering Roadway Report.

Analyses also indicate that lateral squeeze of the foundation soil is a possibility at End Bent 2 due to the height of the embankment and strength of the foundation soils. Staged construction of the embankment should help reduce the potential for lateral squeeze; however, foundation construction at Pier 4 shall be subject to the same waiting period as End Bent 2 in order to prevent movement and tilting of the pier due to lateral squeeze. Please refer to Geotechnical Engineering Roadway Report R-015-2016 for the requirements for embankment construction and waiting periods.

5.7 Scour – Preliminary scour information was provided to this office for Piers 1 through 4 and is listed below. Local (abutment) scour is to be resisted by appropriate slope protection.

	Pier 1	**Pier 2**	**Pier 3**	**Pier 4**
Contraction (ft)	2.80	0.27	0.27	0.27
Local (ft)	18.70	12.68	12.68	12.68
Combined (ft)	21.5	12.95	12.95	12.95

Piles at End Bent 2 should be checked for unsupported lengths in the worst case contraction scour conditions. To do this construct a vertical line from the termination point of the slope protection down to the contraction scour depth for the End Bent. Then construct a 1H:1V line back towards the end bent until it intercepts the pile line. A preliminary evaluation of this condition using the contraction scour depths provided for the floodplain areas (0.27') indicates that there should not be an issue with unsupported lengths at End Bent 2.

Pile foundations at the piers, if utilized, must be designed for local and contraction scour conditions. The piles can either be designed for the potential unsupported length, the pile caps can be set below the scour line, or a combination of these measures can be used.

Drilled shaft foundations at the piers, if selected, shall be designed using lateral load analysis as noted below in Section 5.11 neglecting any contribution from overburden soils.

If spread footings are chosen for the pier foundations, scour is not of geotechnical concern if they are designed and constructed in accordance with the recommendations included in this report.

5.8 **Slope Protection** – The use of pile foundations at End Bent 2 will require the use of slope protection meeting the requirements of Sections 703 & 805 of the Standard Specifications. Place a Type I Geotextile Fabric, in accordance with Section 214 and 843 of the Standard Specification for Road and Bridge Construction, current edition, between the embankment and the slope protection. The effects of local (abutment) scour on the end bents can be negated through the use of the aforementioned slope protection.

We also recommend crushed stone slope protection be placed at Abutment 1 to help protect the bedrock from weathering and erosion.

5.9 **Wave Equation Analysis** – Drivability analyses were performed for the piles for Piers 2 through 4 and End Bent 2 assuming 12- and 14-inch, 50-ksi steel H-Piles. These analyses indicate that single-acting diesel hammers with the rated energies listed below are recommended to adequately drive the piles at Piers 2 through 4 and End Bent 2 without encountering excessive blow counts or overstressing the piles. The use of hammers other than single-acting diesel may require different energy ranges. Drivability analyses were performed assuming continuous driving. If interruptions in driving individual piles should occur, difficulties in continuing the installation process will likely occur due to pile "set-up" characteristics.

Substructure Unit	**Minimum Hammer Energy (kip-ft)**	**Maximum Hammer Energy (kip-ft)**
Piers 2 through 4	20	34
End Bent 2	48	90

5.10 **Site Class Definition** - The seismic design procedures outlined in the current AASHTO LRFD Bridge Design Specifications indicate that structural design loads are to be based on site class definitions. Based on the results of the exploration and the geology of the area, a site class of C, as per Table 3.10.3.1.1 – Site Class Definitions, should be used for design purposes.

5.11 **Drilled Shaft Recommendations**

5.11.1 Permanent casing is required in the overburden. It should be noted in the plans that the permanent casing is incidental to the unit bid price for Drilled Shaft, Common or Solid Rock, as applicable. Use permanent casing that is 6 inches larger in diameter than the proposed shaft diameter to the "Bottom of Permanent Casing" elevations noted above. Casings shall meet the requirements of Section 2.3 of the Special Note for Drilled Shafts.

5.11.2 Require a 6-inch minimum rebar cover in the uncased rock sockets.

5.11.3 For Load & Resistance Factor Design (LRFD), evaluate the total factored axial resistances using the attached Drilled Shaft Axial Resistance Tables considering the capacity developed in the uncased rock sockets. The total factored resistances must exceed the factored loads at the strength limit state. The highest allowable tip elevations are provided in the recommendations above. Longer uncased sockets may be required to satisfy axial or lateral load design criteria.

5.11.4 Perform lateral load analysis using the geotechnical parameters provided in the attached Idealized Soil and Bedrock Profile. These parameters may be used to perform analyses using LPILE Plus or other similar software. Some of the parameters may not be required to input, depending on the version of software utilized. Design the substructure units neglecting any lateral resistance above the "Bottom of Permanent Casing" elevations provided in the table above.

5.11.5 Additional drilling will be required at each drilled shaft location as noted in Section 3.5, Subsurface Investigation of the Special Note for Drilled Shafts. Estimates of the amount of Rockline Sounding may be made by taking the difference between the ground surface and the rockline at each shaft location. For estimating the amount of Rock Coring at this location, we recommend that the subsurface exploration extend a minimum depth of three (3) shaft diameters (but not less than 10 feet) below the bottom of the anticipated tip elevation of each drilled shaft.

5.11.6 Non-destructive testing **will** be required for drilled shafts in accordance with the Special Note for Non-Destructive Testing in Drilled Shafts.

6.0 PLAN NOTES

Include the notes below at the appropriate locations in the plans:

6.1 Temporary sheeting, shoring, cofferdams, and/or a dewatering method may be required for the installation of the foundations.

6.2 The underground mine located in the vicinity of Abutment 1 shall be grouted in accordance with the Special Note for Mine Grouting and the Mine Grouting Plan sheet. The mine grouting shall be conducted as one of the first efforts during roadway construction. Excavation for and construction of Abutment 1 may not commence until the Mine Grouting Plan has been completed and accepted by the Engineer.

6.3 Solid rock excavation will be required for installation of the foundations for this structure.

6.4 Structure excavation shall be completed just prior to structure foundation construction in order to prevent the bedrock from being exposed for an extended period of time and deteriorating. The contractor shall take care during blasting and other excavation methods to avoid over-breakage and damage to the bedrock beneath the footings.

6.5 The bedrock at this location may be susceptible to weathering and softening in the presence of water. Water must be kept out of the footing excavations. The footing steel and concrete should be placed the same day as or as soon as practical after the footing excavation is made. If the bedrock becomes softened at bearing elevation, the softened material should be undercut to unweathered material prior to placing the concrete.

6.6 Footings shall be embedded a minimum of 2 feet into unweathered bedrock. All footing excavations in bedrock shall be cut neat so that no forming or backfilling is necessary in the construction of the portions of footings located in rock. Concrete and steel should be placed directly against the cut rock faces. Where the top of footing is located below the top of bedrock, the remainder of the excavation shall be filled with mass concrete to the top of bedrock.

6.7 PRACTICAL REFUSAL: Drive point bearing piles to practical refusal. For this project minimum blow count requirements are reached after total penetration becomes ½ inch or less for 10 consecutive blows, practical refusal is obtained after the pile is struck an additional 10 blows with total penetration of ½ inch or less. Advance production piling to the driving resistance specified above and to depths determined by test pile(s) and subsurface data sheet(s). Immediately cease driving operations if the pile visibly yields or becomes damaged during driving. If hard driving is encountered because of dense strata or an obstruction, such as a boulder before the pile is advanced to the depth anticipated, the Engineer will determine if more blows than the average driving resistance specified for practical refusal is required to further advance the pile. Drive additional production and test piles if directed by the Engineer.

6.8 HAMMER CRITERIA: Single-acting diesel hammers with rated energies of 48 to 90 kip-ft are recommended to adequately drive the piles at End Bent 2 without encountering excessive blow counts or overstressing the piles. The use of hammers other than single-acting diesel may require different rated energies. The Contractor shall submit the proposed pile driving system to the Department for approval prior to the installation of the first pile. Approval of the pile driving system by the Engineer will be subject to satisfactory field performance of the pile driving procedures.

6.9 The approach embankments to the bridge shall be placed as one of the first efforts of roadway construction due to the anticipated settlement concerns. These embankments shall be built using staged construction methods to full height within the limits specified in the plans. Refer to the Geotechnical Notes in the Roadway Plans for the requirements for staged construction of the embankment. A minimum four (4) month waiting period will be required following completion of the embankment before installation of the piles at End Bent 2 and construction of the foundation for Pier 4 can begin. Based upon the results of the settlement data, piezometer readings, and visual observations of the embankment, the KYTC Geotechnical Branch will determine when enough settlement has occurred to permit installation of the piles. The waiting period may be increased or decreased as required. The Engineer will be responsible for reading the instrumentation. A pre-qualified Geotechnical Engineer or the KYTC Geotechnical Branch shall be responsible for evaluation of the settlement data. The Contractor shall be responsible for replacing all damaged settlement platforms at no extra cost.

Include the following notes if Drilled Shaft foundations are utilized for the piers:

6.10 Permanent casing is incidental to the unit bid price for "Drilled Shaft - ___-inch (Common)" or "Drilled Shaft - ___-inch (Solid Rock)", as applicable. (Insert sizes for drilled shafts as determined from design.)

6.11 Drilled shafts shall be constructed in accordance with the Special Note for Drilled Shafts. Include all costs (labor, equipment, and materials including spiral and longitudinal reinforcement, reinforcement splices, mechanical couplers, concrete, and temporary or permanent casing) associated with the drilled shafts in the unit price bid for Drilled Shaft, Common or Solid Rock, as applicable.

6.12 The Contractor will be responsible for providing subsurface exploration drilling during construction to finalize the drilled shaft tip elevations. Additional drilling will be required at each drilled shaft location in accordance with the Special Note for Drilled Shafts, current edition.

6.13 Non-Destructive Testing will be required at each drilled shaft location in accordance with the Special Note for Non-Destructive Testing in Drilled Shafts.

Insert the following notes if pile foundations are utilized for the piers:

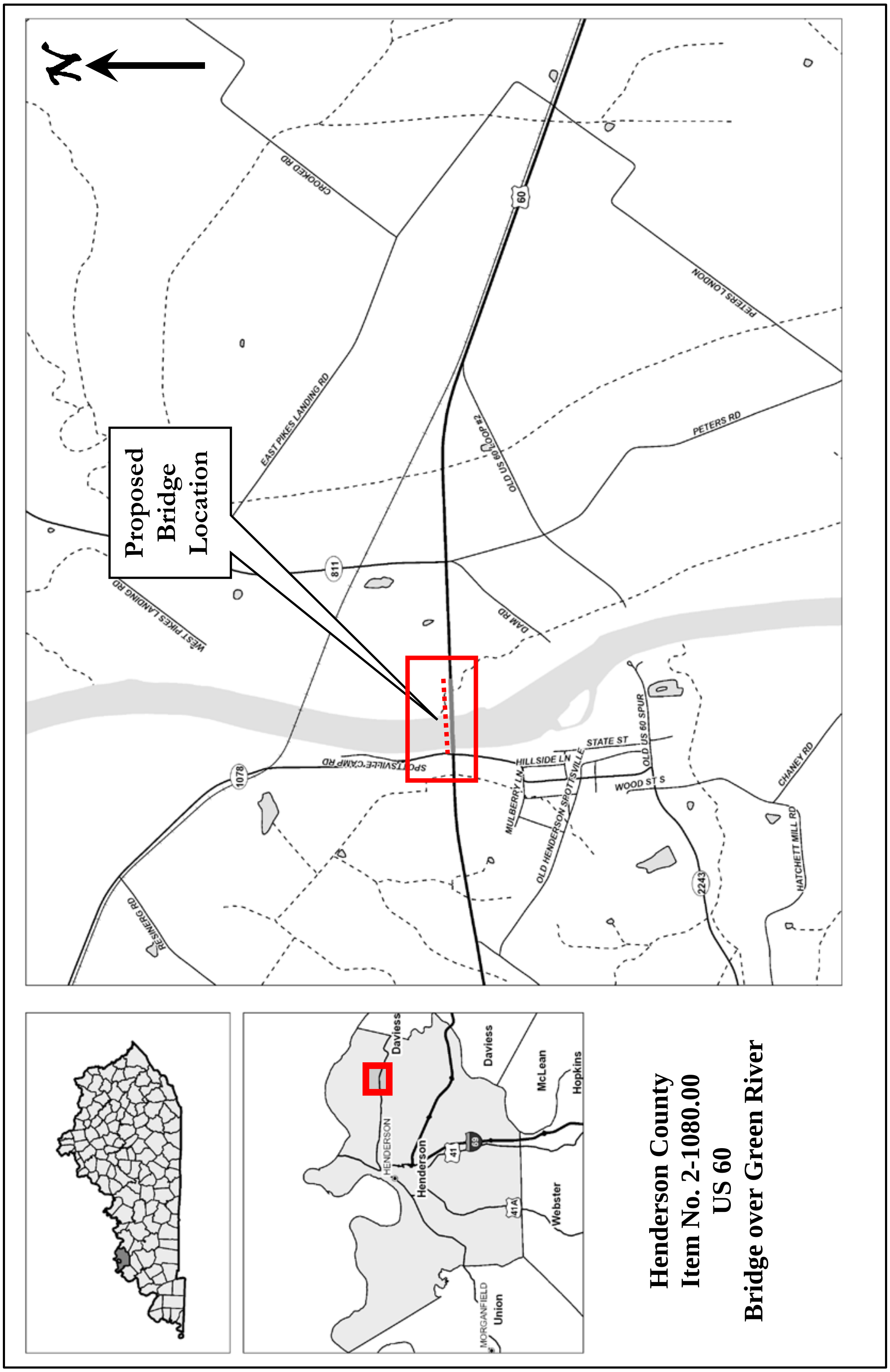
6.14 HAMMER CRITERIA: Single-acting diesel hammers with rated energies of 20 to 34 kip-ft are recommended to adequately drive the piles at Piers 2 through 4 without encountering excessive blow counts or overstressing the piles. The use of hammers other than single-acting diesel may require different rated energies. The Contractor shall submit the proposed pile driving system to the Department for approval prior to the installation of the first pile. Approval of the pile driving system by the Engineer will be subject to satisfactory field performance of the pile driving procedures.

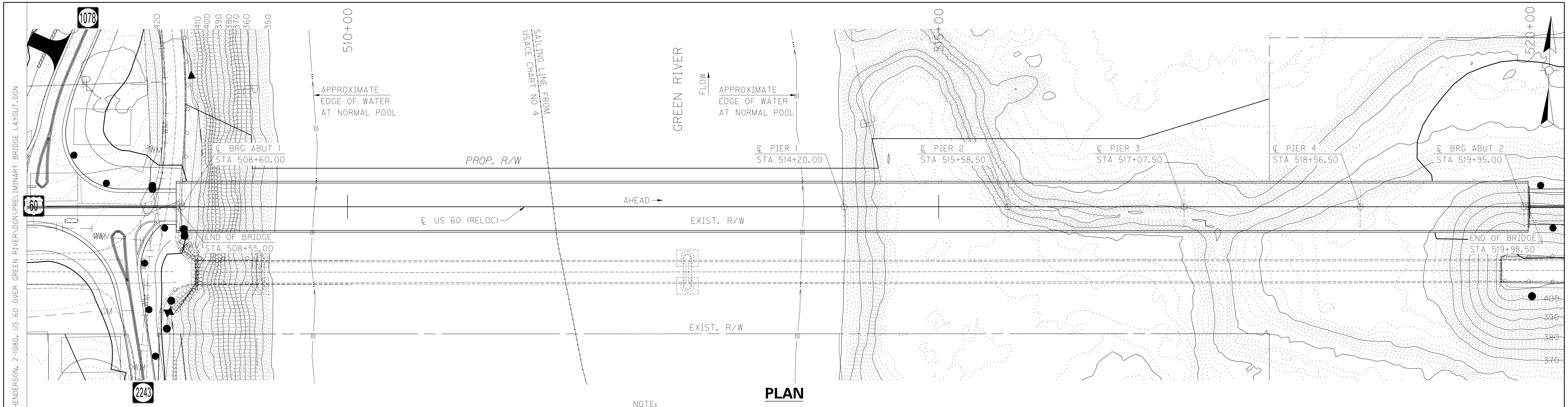
The designer should feel free to contact the Geotechnical Branch at 502-564-2374 for further recommendations or if any questions arise pertaining to this project.

Attachments:

- **Project Location Map**
- **Preliminary Bridge Layout**
- **Mined Area Maps from Kentucky Geological Survey**
- **Record of Borings from Existing Bridge Plans**
- **Groundwater Sample Results – Tested per ASTM C1602/C1602M-06**
- **Subsurface Data Sheets**
- **Special Note for Mine Grouting**
- **Mine Grouting Plan**
- **Idealized Soil and Bedrock Profiles and Drilled Shaft Axial Resistance Tables For Piers 1 through 4**
- **Special Note for Non-Destructive Testing in Drilled Shafts**
- **Coordinate Data Sheet**

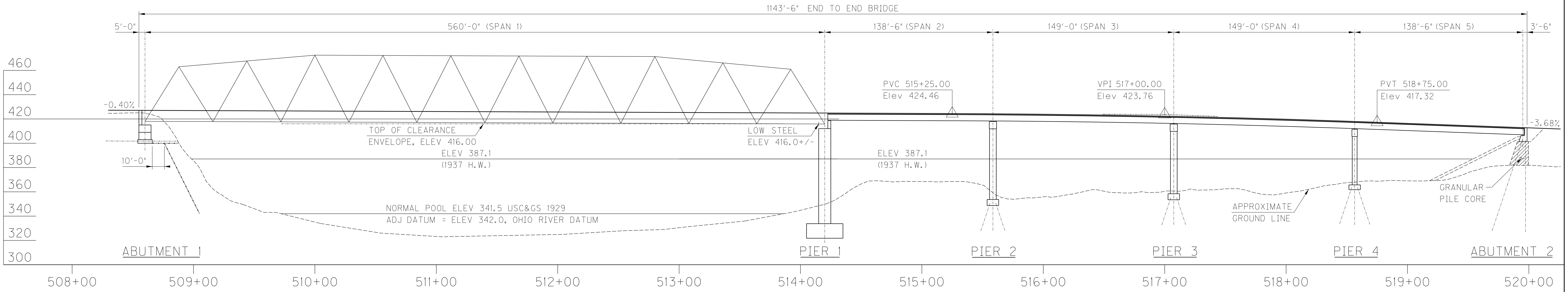
Project Location





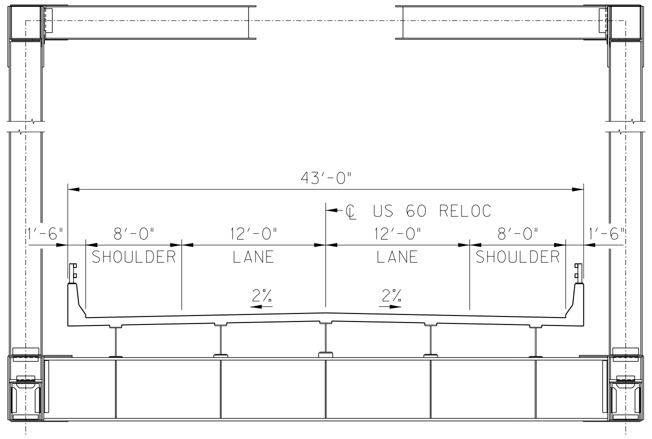
PLAN

NOTE:
THE SUPERSTRUCTURE OF THE EXISTING BRIDGE IS NOT SHOWN FOR CLARITY.
THE TRUSS MEMBERS OF THE NEW BRIDGE ARE NOT SHOWN FOR CLARITY.



SECTION ALONG CL US 60 (RELOC)

MAIN SPAN: 560'-0", STEEL THROUGH TRUSS
APPROACH SPANS: 72" HYBRID PPC I-BEAMS



TYPICAL SECTION

REVISION	DATE

DATE: August 2015 CHECKED BY
DESIGNED BY:
DETAILED BY:

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY
HENDERSON

ROUTE **US 60**
CROSSING **GREEN RIVER**

LAYOUT

PREPARED BY

SHEET NO.

DRAWING NO.

ITEM NUMBER
2–1080.00

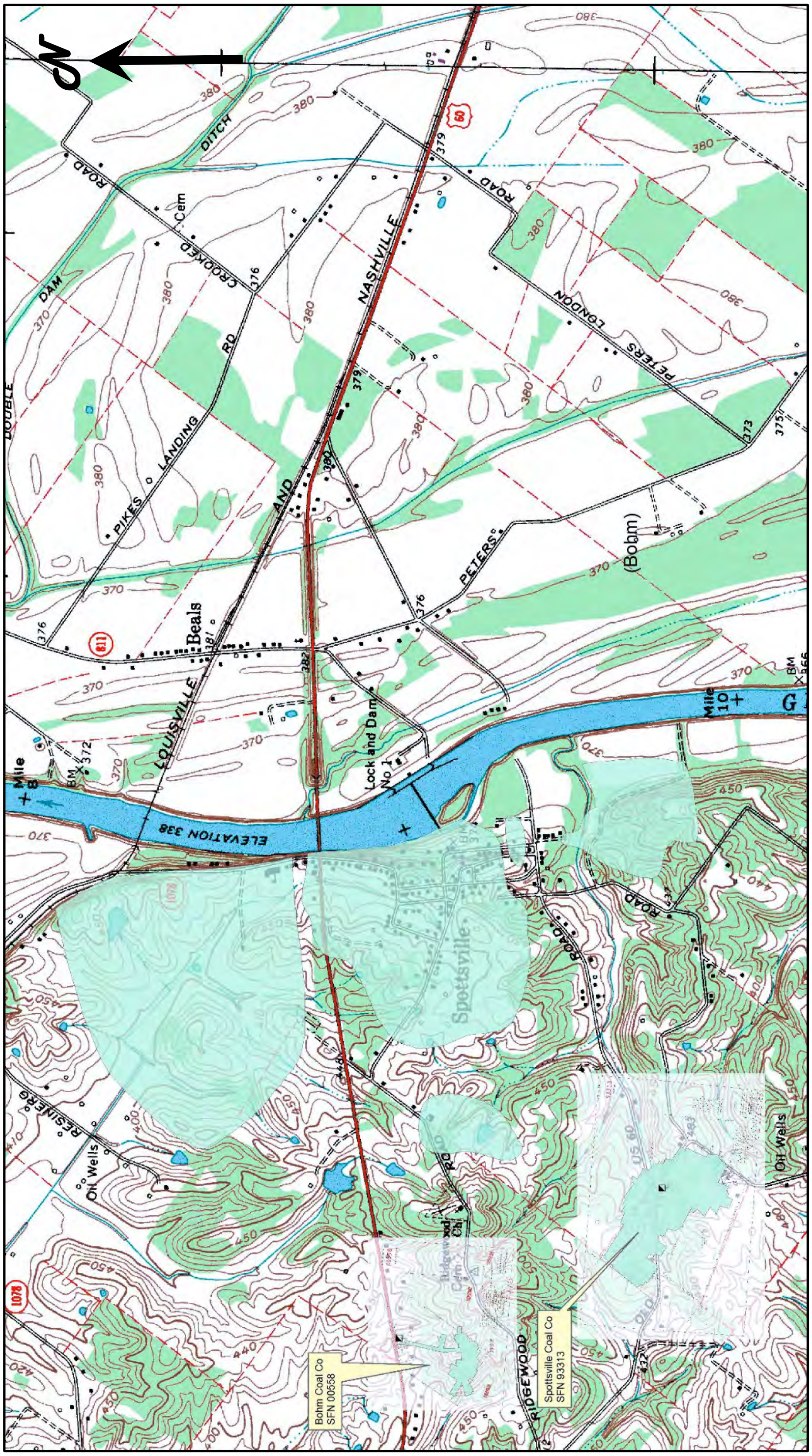
FILE NAME: U:\PROJECTS\DISTRICT 2\HENDERSON, 2-1080, US 60 OVER GREEN RIVER\DGN\PRELIMINARY BRIDGE LAYOUT.DGN

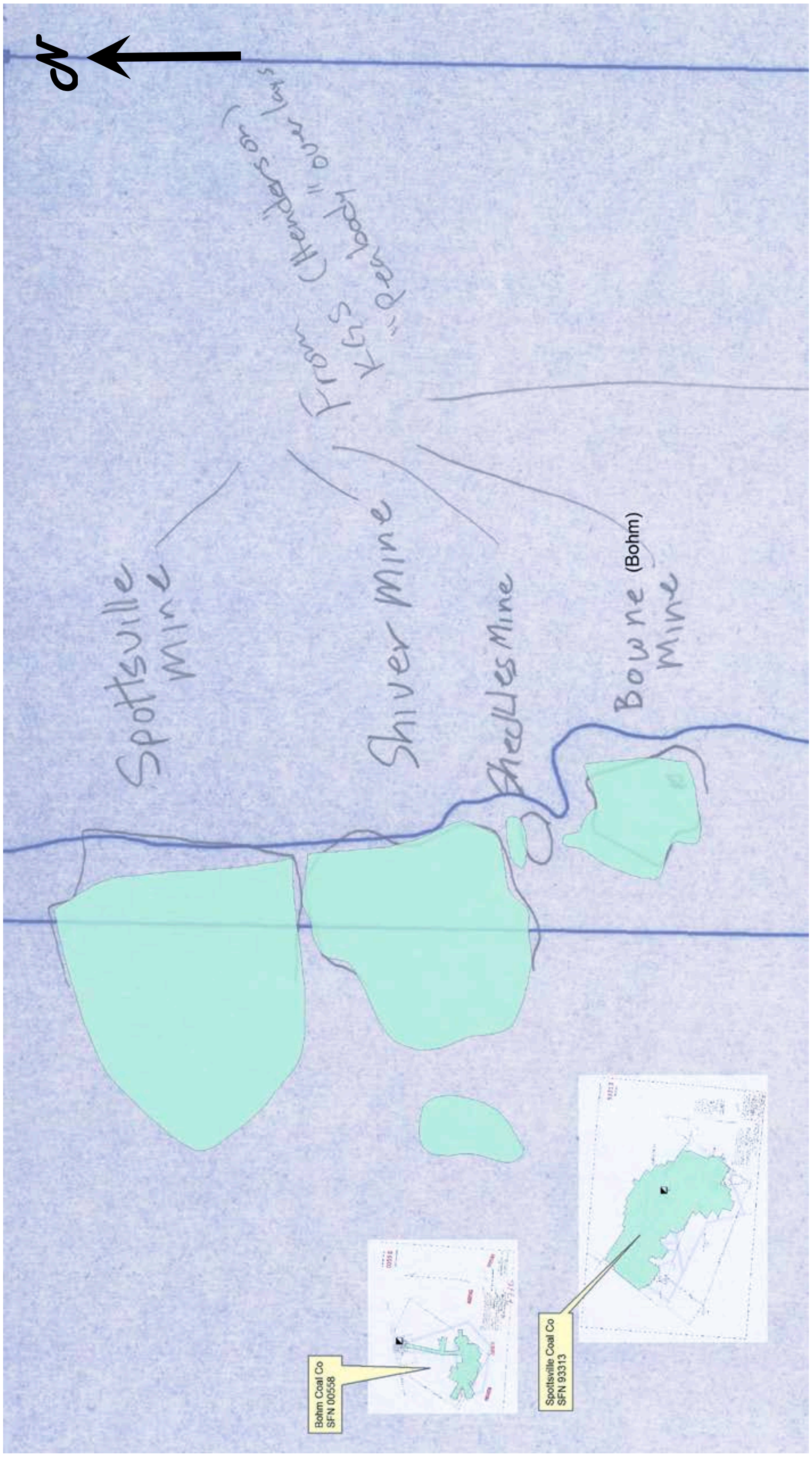
USER: daryl.greer
DATE PLOTTED: July 11, 2017

E-SHEET NAME:

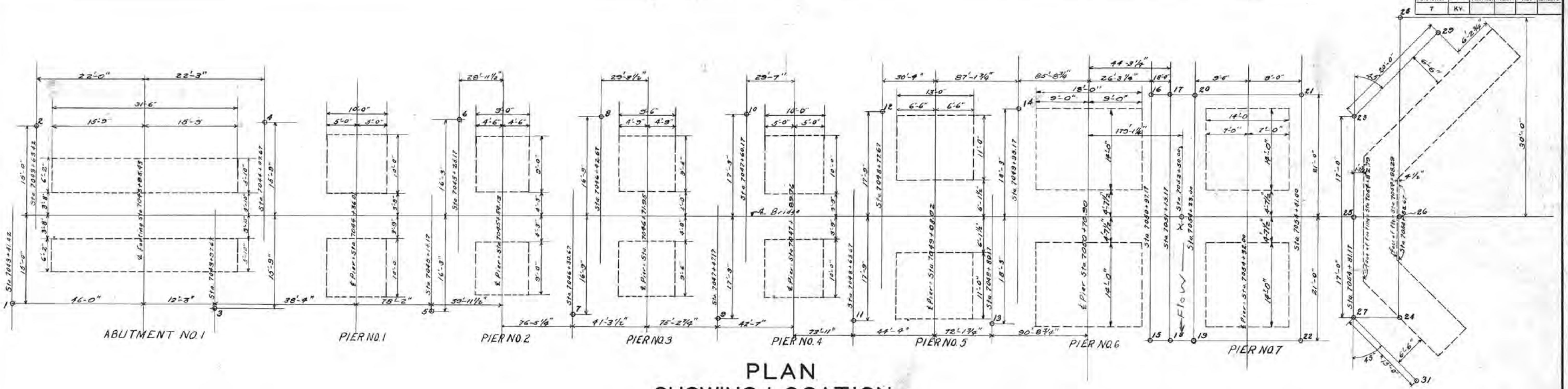
MicroStation v8.11.7.443

Mined Area Maps



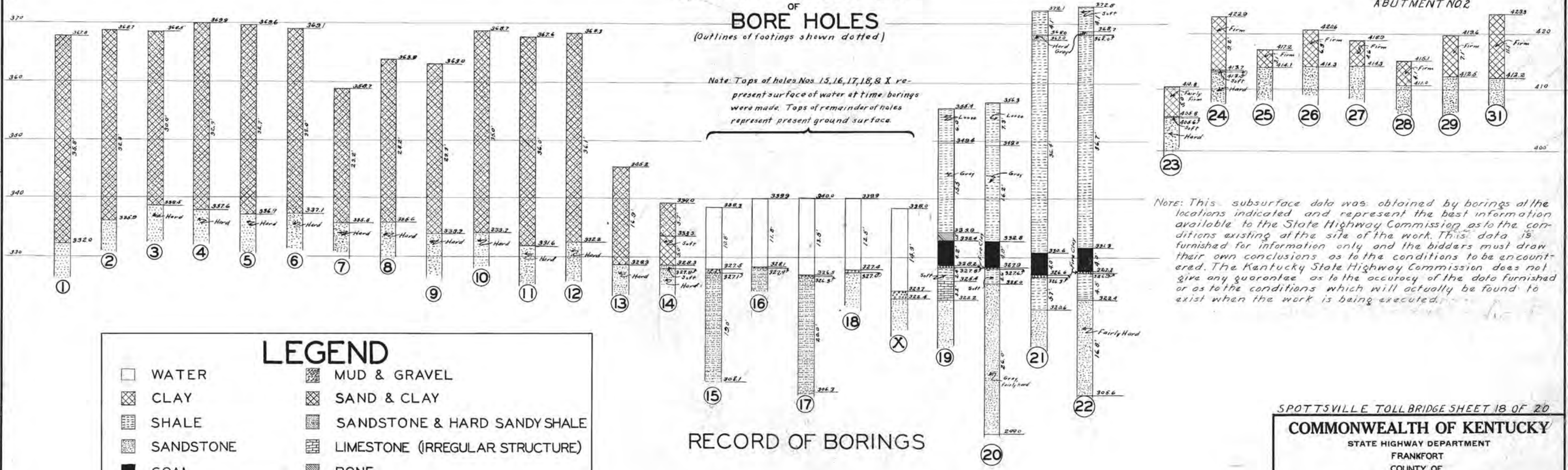

N
(From Crittenden's or KGS "Pen book" overlays
Spottsville Mine
Shiver Mine
Sheckles Mine
Bowne (Bohm) Mine
Bohm Coal Co SFN 00558
Spottsville Coal Co SFN 93313

FED. ROAD DIST. NO.	STATE	FED. AID PRO. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
7	KY.				



PLAN
SHOWING LOCATION OF BORE HOLES

(Outlines of footings shown dotted)



Note: Tops of holes Nos 15, 16, 17, 18, & X represent surface of water at time borings were made. Tops of remainder of holes represent present ground surface.

RECORD OF BORINGS

LEGEND

☐	WATER	▦	MUD & GRAVEL
▩	CLAY	▩	SAND & CLAY
▤	SHALE	▦	SANDSTONE & HARD SANDY SHALE
░	SANDSTONE	▦	LIMESTONE (IRREGULAR STRUCTURE)
■	COAL	▨	BONE

Note: This subsurface data was obtained by borings at the locations indicated and represent the best information available to the State Highway Commission as to the conditions existing at the site of the work. This data is furnished for information only and the bidders must draw their own conclusions as to the conditions to be encountered. The Kentucky State Highway Commission does not give any guarantee as to the accuracy of the data furnished or as to the conditions which will actually be found to exist when the work is being executed.

SPOTTSVILLE TOLL BRIDGE SHEET 18 OF 20

COMMONWEALTH OF KENTUCKY
STATE HIGHWAY DEPARTMENT
FRANKFORT
COUNTY OF
HENDERSON
HENDERSON-OWENSBORO
ROAD

SUBMITTED BY ______ BRIDGE ENGR.
APPROVED BY ______ STATE HIGHWAY ENGR.
DRAWING No. 4053
INDEX

DESIGNED BY H.W. Bush DATE 4/29 REVISED ______ DATE
TRACED BY D.O. Moore DATE 5/6/29 REVISED ______ DATE
CHECKED BY ______ DATE REVISED ______ DATE

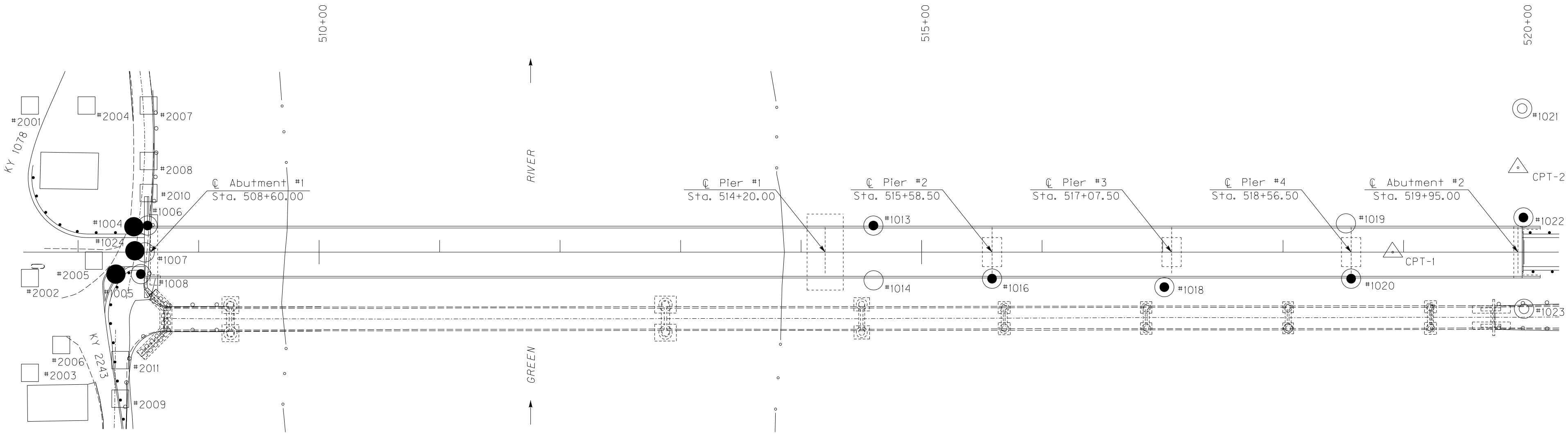
GROUNDWATER SAMPLE RESULTS

Tested per
ASTM C1602/C1602M-06
Samples obtained on April 18, 2017

Hole #	% Solids	% Chloride	pH	Sulfate (SO_4), ppm
1004	0.0685	0.0061	6.945	0.082
1005	0.1353	0.0356	6.746	117.49
1006	0.372	0.0076	6.742	84.5
1024	0.1087	0.0167	6.84	119.34
2001	0.0815	0.0033	7.03	41.97
2009	0.1023	0.0027	7.02	125.10
2011	0.1607	0.0089	7.05	74.00

SUBSURFACE DATA

Plan Scale 1" = 40'



☐ - Borings 2001-2011 were performed using Wet Rotary methods with a Poly-Crystalline Diamond Bit and were extended through the mine opening or coal seam

DATE: 28-JULY-2016
CHECKED BY
DESIGNED BY:
DETAILED BY: E. BAILEY
D. GREER

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY
HENDERSON

ROUTE
US 60

CROSSING
Bridge over Green River

SUBSURFACE DATA

PREPARED BY
Division of Structural Design
GEOTECHNICAL BRANCH

SHEET NO.

DRAWING NO.
00000

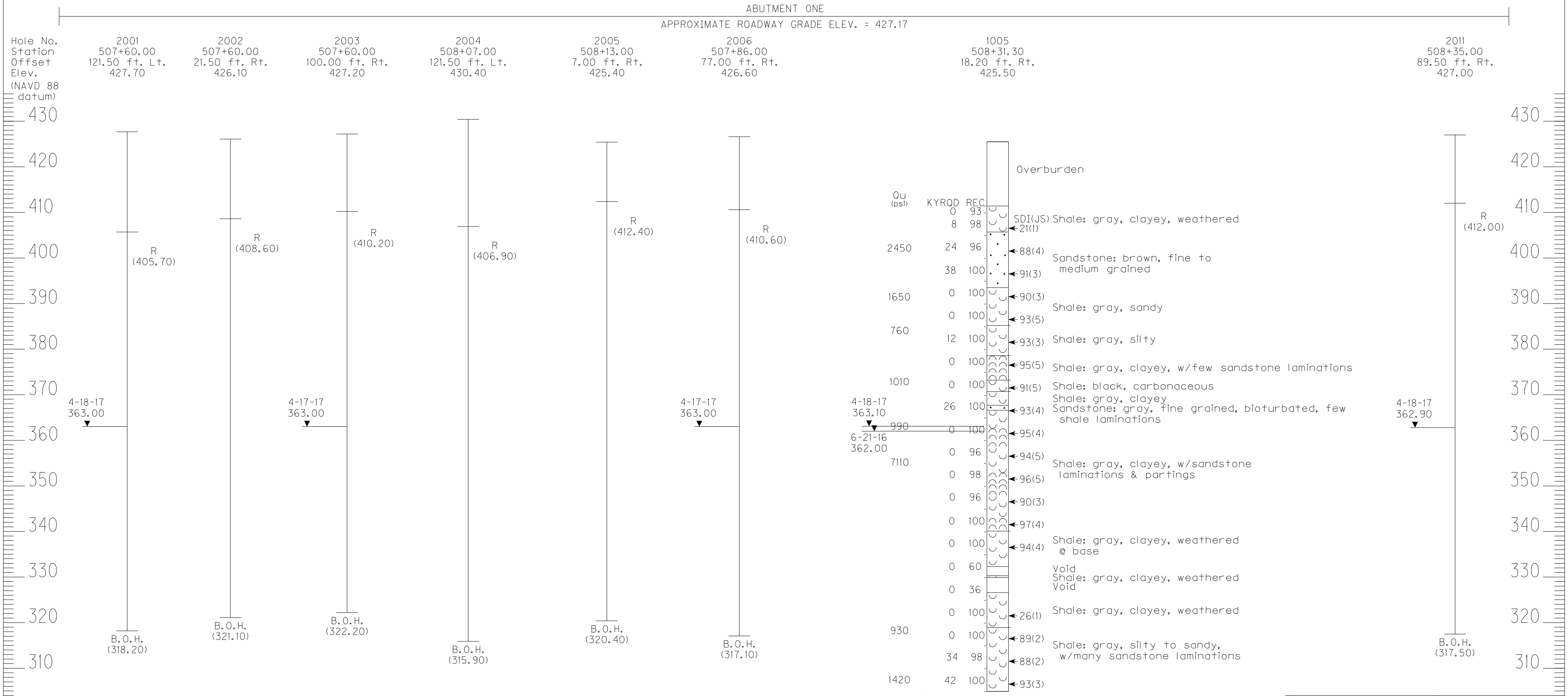
S–058–16

ITEM NUMBER

2–1080.00

SUBSURFACE DATA

Profile Scale:
Vertical 1" = 10'
Horizontal not to scale



300
290
280

B.O.H. = Bottom of Hole

Datum

Borings 2001-2006, & 2011 were performed using Wet Rotary methods with a Poly-Crystalline Diamond Bit and extended through the mine opening or coal seam. Mine openings were encountered in Borings 2001-2003,2005, & 2011.

The Presumptive Factored Bearing Resistance at the Service Limit State is 20 ksf for Spread Footings on Competent Unweathered Bedrock

S–058–16

ITEM NUMBER
2–1080.00

DATE: 28-JULY-2016
CHECKED BY
DESIGNED BY:
DETAILED BY: E. BAILEY
D. GREER

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY
HENDERSON

ROUTE
US 60
CROSSING
Bridge over Green River

SUBSURFACE DATA

PREPARED BY
Division of Structural Design
GEOTECHNICAL BRANCH

SHEET NO.
DRAWING NO.
00000

SUBSURFACE DATA

Profile Scale:
Vertical 1" = 10'
Horizontal not to scale

Borings 2007-2010 were performed using Wet Rotary methods with a Poly-Crystalline Diamond Bit and extended through the mine opening or coal seam. Mine openings were not encountered in Borings 2007, 2008, & 2010. A mine opening was encountered in Boring 2009.

The Presumptive Factored Bearing Resistance at the Service Limit State is 20 ksf for Spread Footings on Competent Unweathered Bedrock

DATE: 28-JULY-2016	CHECKED BY
DESIGNED BY:	
DETAILED BY: E. BAILEY	D. GREER

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY
HENDERSON

ROUTE
US 60

CROSSING
Bridge over Green River

S–058–16

ITEM NUMBER

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SUBSURFACE DATA

PREPARED BY
Division of Structural Design
GEOTECHNICAL BRANCH

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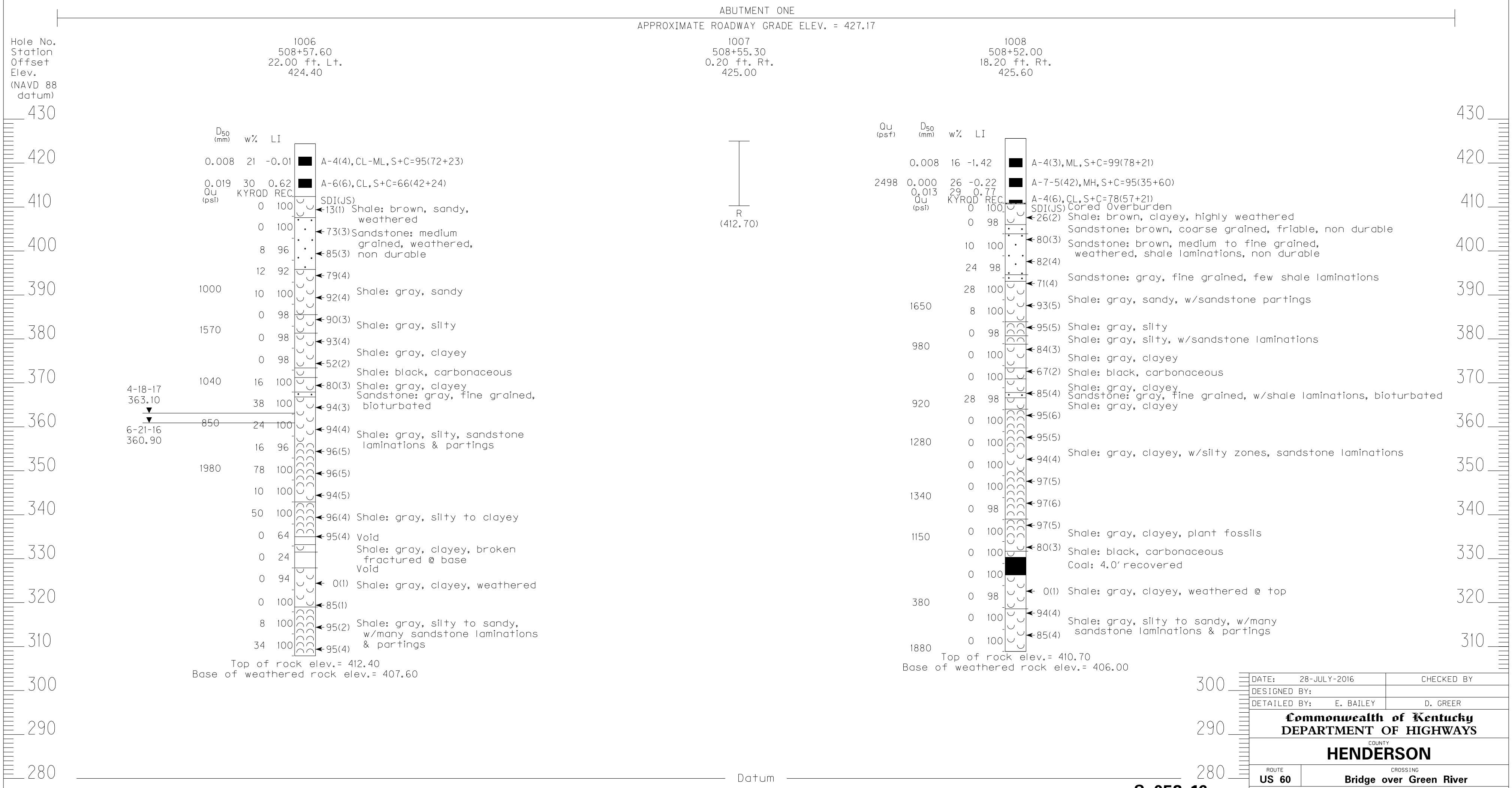
SUBSURFACE DATA

Profile Scale:
Vertical 1" = 10'
Horizontal not to scale



The Presumptive Factored Bearing Resistance at the Service Limit State is
20 ksf for Spread Footings on Competent Unweathered Bedrock

DATE: 28-JULY-2016	CHECKED BY	
DESIGNED BY:		
DETAILED BY: E. BAILEY	D. GREER	

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY
HENDERSON

ROUTE	CROSSING
US 60	Bridge over Green River

S–058–16

SUBSURFACE DATA

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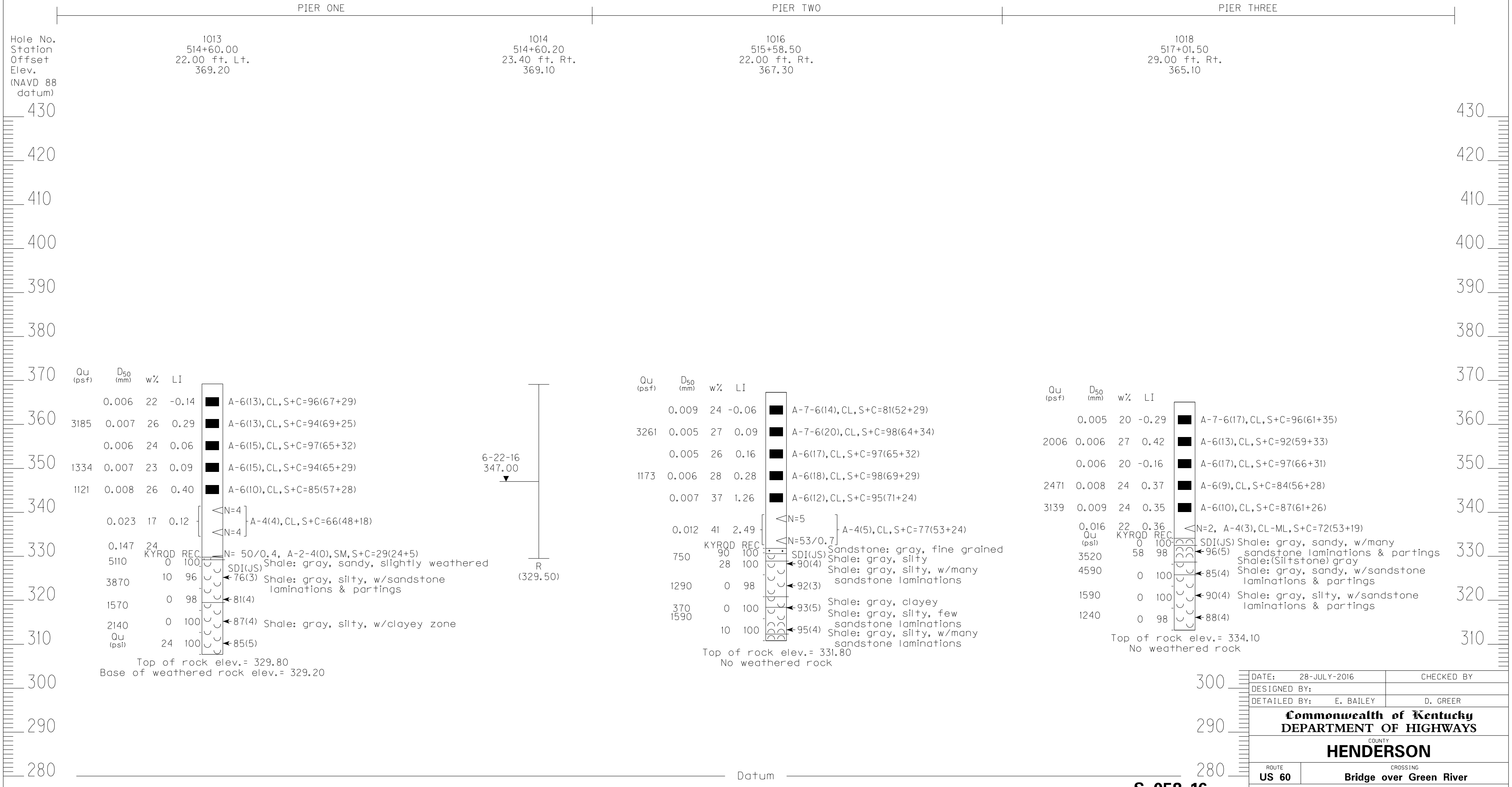
Vertical 1" = 10'
Horizontal not to scale



The Presumptive Factored Bearing Resistance at the Service Limit State is
20 ksf for Spread Footings on Competent Unweathered Bedrock

DATE: 28-JULY-2016	CHECKED BY
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Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY
HENDERSON

ROUTE	CROSSING
US 60	Bridge over Green River

SUBSURFACE DATA

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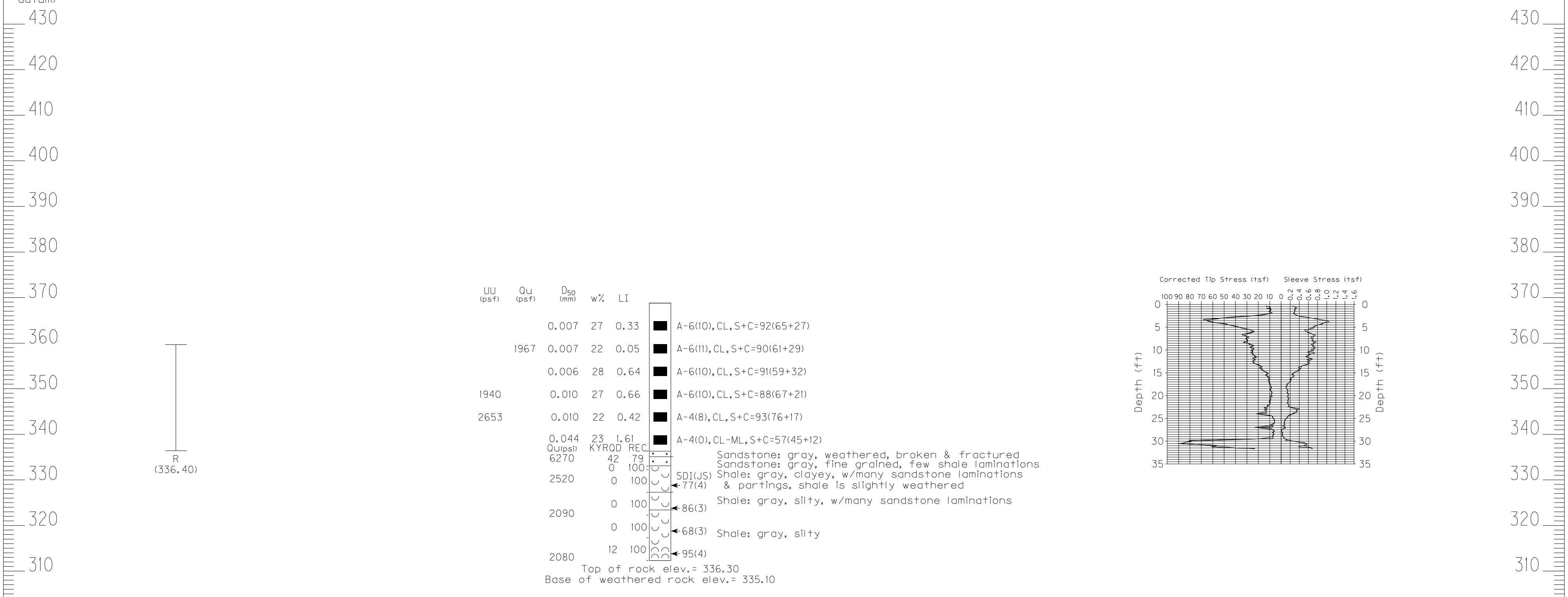
SUBSURFACE DATA

Profile Scale:
Vertical 1" = 10'
Horizontal not to scale

PIER FOUR

Hole No.	1019	1020	CPT-1
Station	518+52.20	518+56.50	518+91.00
Offset	23.80 ft. Lt.	22.00 ft. Rt.	℄
Elev. (NAVD 88 datum)	359.70	368.80	368.50



UU (psf)	Qu (psf)	D_{50} (mm)	w%	LI	
		0.007	27	0.33	A-6(10),CL,S+C=92(65+27)
	1967	0.007	22	0.05	A-6(11),CL,S+C=90(61+29)
		0.006	28	0.64	A-6(10),CL,S+C=91(59+32)
1940		0.010	27	0.66	A-6(10),CL,S+C=88(67+21)
2653		0.010	22	0.42	A-4(8),CL,S+C=93(76+17)
		0.044	23	1.61	A-4(0),CL-ML,S+C=57(45+12)

Qu(psi)	KYRQD	REC	SDI(JS)
6270	42	79	
	0	100	
2520	0	100	77(4)
	0	100	86(3)
2090			
	0	100	68(3)
	12	100	95(4)
2080			

Sandstone: gray, weathered, broken & fractured
Sandstone: gray, fine grained, few shale laminations
Shale: gray, clayey, w/many sandstone laminations & partings, shale is slightly weathered
Shale: gray, silty, w/many sandstone laminations
Shale: gray, silty

Top of rock elev.= 336.30
Base of weathered rock elev.= 335.10

300
290
280

Datum

The Presumptive Factored Bearing Resistance at the Service Limit State is 20 ksf for Spread Footings on Competent Unweathered Bedrock

DATE: 28-JULY-2016	CHECKED BY
DESIGNED BY:	
DETAILED BY: E. BAILEY	D. GREER

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY
HENDERSON

ROUTE
US 60

CROSSING
Bridge over Green River

SUBSURFACE DATA

S–058–16

ITEM NUMBER
2–1080.00

PREPARED BY
Division of Structural Design
GEOTECHNICAL BRANCH

SHEET NO.

DRAWING NO.
00000

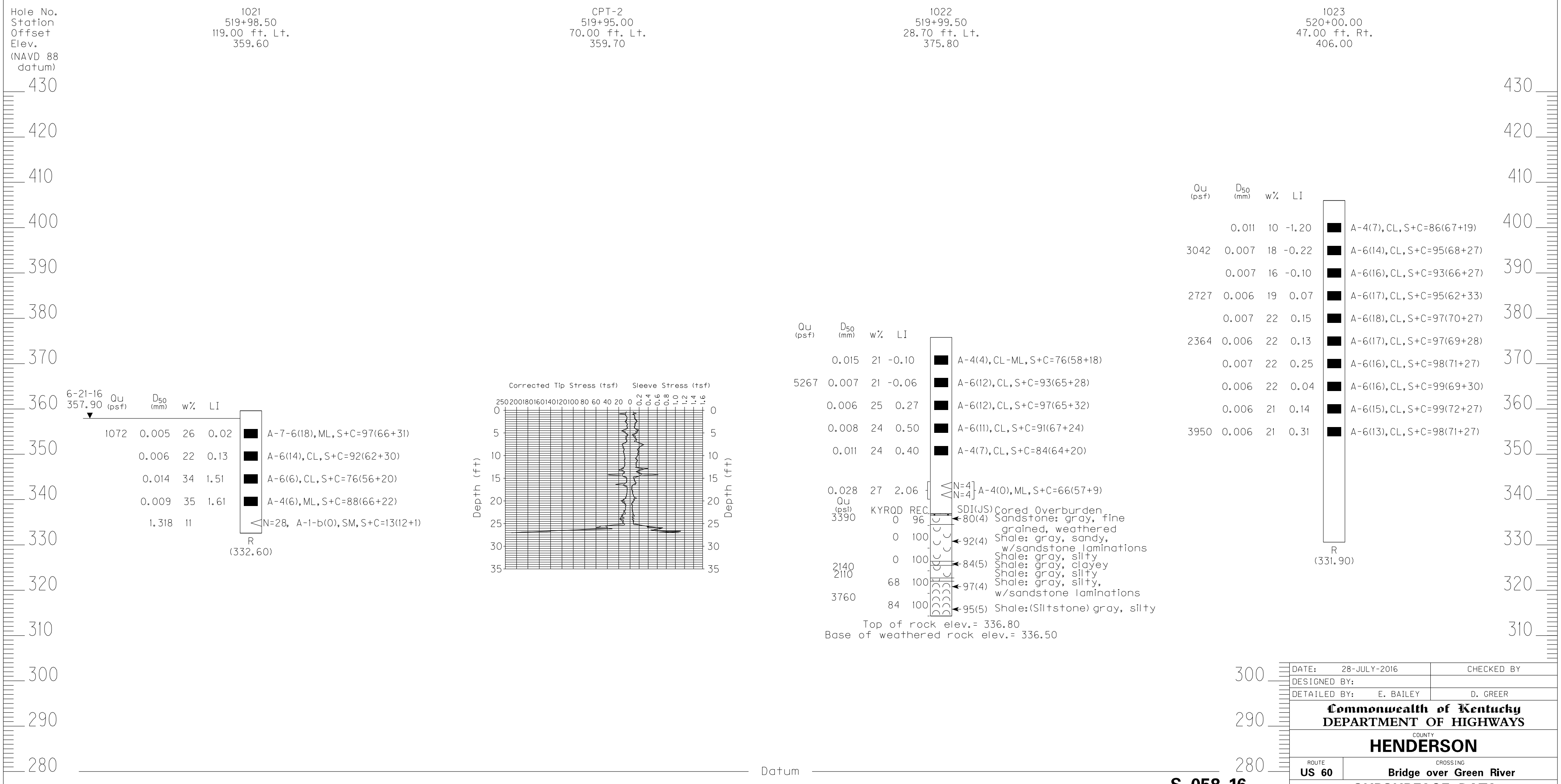
SUBSURFACE DATA

Profile Scale:
Vertical 1" = 10'
Horizontal not to scale

ABUTMENT TWO

APPROXIMATE ROADWAY GRADE ELEV. = 412.77

Hole No.	1021	CPT-2	1022	1023
Station	519+98.50	519+95.00	519+99.50	520+00.00
Offset	119.00 ft. Lt.	70.00 ft. Lt.	28.70 ft. Lt.	47.00 ft. Rt.
Elev. (NAVD 88 datum)	359.60	359.70	375.80	406.00



Hole 1021

Qu (psf)	D50 (mm)	w%	LI	
1072	0.005	26	0.02	A-7-6(18),ML,S+C=97(66+31)
	0.006	22	0.13	A-6(14),CL,S+C=92(62+30)
	0.014	34	1.51	A-6(6),CL,S+C=76(56+20)
	0.009	35	1.61	A-4(6),ML,S+C=88(66+22)
	1.318	11		N=28, A-1-b(0),SM,S+C=13(12+1)

Hole 1022

Qu (psf)	D50 (mm)	w%	LI	
	0.015	21	-0.10	A-4(4),CL-ML,S+C=76(58+18)
5267	0.007	21	-0.06	A-6(12),CL,S+C=93(65+28)
	0.006	25	0.27	A-6(12),CL,S+C=97(65+32)
	0.008	24	0.50	A-6(11),CL,S+C=91(67+24)
	0.011	24	0.40	A-4(7),CL,S+C=84(64+20)
	0.028	27	2.06	N=4 N=4 A-4(0),ML,S+C=66(57+9)

Qu (psi)	KYRQD	REC	SDI(JS)	
				Cored Overburden
3390	0	96	80(4)	Sandstone: gray, fine grained, weathered
	0	100	92(4)	Shale: gray, sandy, w/sandstone laminations
	0	100	84(5)	Shale: gray, silty
2140				Shale: gray, clayey
2110				Shale: gray, silty
	68	100	97(4)	Shale: gray, silty, w/sandstone laminations
3760				
	84	100	95(5)	Shale:(Siltstone) gray, silty

Top of rock elev.= 336.80
Base of weathered rock elev.= 336.50

Hole 1023

Qu (psf)	D50 (mm)	w%	LI	
	0.011	10	-1.20	A-4(7),CL,S+C=86(67+19)
3042	0.007	18	-0.22	A-6(14),CL,S+C=95(68+27)
	0.007	16	-0.10	A-6(16),CL,S+C=93(66+27)
2727	0.006	19	0.07	A-6(17),CL,S+C=95(62+33)
	0.007	22	0.15	A-6(18),CL,S+C=97(70+27)
2364	0.006	22	0.13	A-6(17),CL,S+C=97(69+28)
	0.007	22	0.25	A-6(16),CL,S+C=98(71+27)
	0.006	22	0.04	A-6(16),CL,S+C=99(69+30)
	0.006	21	0.14	A-6(15),CL,S+C=99(72+27)
3950	0.006	21	0.31	A-6(13),CL,S+C=98(71+27)

DATE: 28-JULY-2016	CHECKED BY
DESIGNED BY:	
DETAILED BY: E. BAILEY	D. GREER

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY
HENDERSON

ROUTE
US 60

CROSSING
Bridge over Green River

SUBSURFACE DATA

S–058–16

ITEM NUMBER
2–1080.00

PREPARED BY
Division of Structural Design
GEOTECHNICAL BRANCH

SHEET NO.

DRAWING NO.
00000

SPECIAL NOTE FOR MINE GROUTING

Henderson County – US 60 Bridge over Green River
Item No. 2-1080.00

1. DESCRIPTION

1.1. This work shall consist of grouting portions of an existing underground coal mine along US 60 within the limits shown on the contract plans. The purpose of the grouting is to reduce potential ground settlement and subsidence so that the underlying bedrock can support a bridge abutment.

1.2. The Kentucky Standard Specifications for Road and Bridge Construction, current edition governs unless otherwise specified in this Special Note or in the plans. For the purposes of this Special Note, "Department" refers to the Kentucky Department of Highways and/or consultants acting on behalf of the Department of Highways. "Engineer" is defined in Section 101.03 of the Standard Specifications.

1.3. The method of grouting shall consist of systematically drilling vertical or angled holes into mine locations and injecting low-slump grout material to provide bearing support for soil and rock layers beneath the proposed highway facilities.

1.4. Bidders and Contractors shall understand the potential difficulties posed by the nature of the site and the requirements of the work. Parts of the mine may be open, collapsed, silt or muck filled, previously backfilled, or partially backfilled. Ground settlement during drilling and grouting activities may occur. Difficult drilling, high torque, and hole instability may occur.

1.5. The Engineer, using real-time data provided by the contractor during the drilling and grouting operations, will evaluate and determine the extent of treatment work to be conducted at each location specified in the contract plans.

1.6. Monitoring, recording, and analyzing of drilling and grouting data shall be performed in real time.

1.7. No grouting activities shall be performed from the interior of the mine. The mine space is water filled, and measured water level elevations in the exploratory borings are shown on the subsurface data sheets. Several exploratory borings conducted by the Department were cased and are available for inspection using downhole camera equipment. Video recordings taken by the Department of the borings and mine openings are available for viewing.

1.8. The cased exploratory borings are available for the Contractor's use during construction. At the completion of the grouting activities, grout these exploratory borings to the ground surface.

1.9. **Disclaimer.** Acceptance of any of the contractor's submissions required by this note does not constitute endorsement or approval. The acceptance is acknowledgement of the work performed and authorization for the contractor to proceed. The Department is not bound by acceptance of any of the submissions required by this note. Final acceptance will be contingent on the satisfactory completion of the work required by this note.

2. SITE, SUBSURFACE INFORMATION, AND SAMPLE INSPECTION

Bidders are encouraged to consult available geological literature including but not necessarily limited to the Spotsville Geologic Quadrangle Map (GQ-1090) and the U.S. Geological Survey Professional Paper 1151-H, “The Geology of Kentucky -- A Text to Accompany the Geologic Map of Kentucky”, Edited by Robert C. McDowell. Additional geotechnical information may be available via the KYTC Division of Construction Procurement Website under “Project Related Information”. The referenced geological literature and geotechnical information are for information only and are not contract documents. However, available subsurface data are included in the bridge plans which are contract documents.

Soils encountered in the borings drilled near the proposed Abutment 1 consist of low-plasticity clays, low-plasticity silts, and high-plasticity silts. Borings advanced using hollow or solid stem augers indicate that the soils vary from 12 to 15 feet in thickness. Rock core specimens obtained in the borings consist primarily of shales with a non-durable sandstone layer closer to the surface (approximate elevation 405 to 395 feet).

According to geologic mapping the coal seam encountered at the project site is the No. 9 coal bed. This coal bed does not outcrop near the project site but is present near elevation 330. This places the coal seam slightly below the normal pool elevation of the Green River of 341.5 feet. Geologic mapping indicates the seam can vary from 0 to 5 feet thick. Geologic mapping also indicates abandoned vertical mine shafts in the vicinity of the project site.

Appendix A contains maps showing the outlines of mines in the project area. These maps were provided by the Kentucky Geological Survey. Maps of the mines showing mining methods, pillars, etc., were not found. The outlines shown on the map in Appendix A came from a set of tracings shown on topographic maps that are at the Kentucky Geological Survey (KGS) Henderson Office. The source of the information on the tracings is unknown. According to KGS sources, Reynolds Aluminum Company owned much of the coal rights in the area, but Emerald Land Company bought these rights out sometime ago. According to local historians, the mine was one of the first commercial coal operations in the region with mining activity starting in the 1800s. In the early 1900s it was revived and produced coal for several years.

The initial set of exploratory borings (Holes 1004-1008 and 1024) were performed in March 2016. These borings were obtained using conventional boring techniques (hollow-stem augers, solid-stem augers, and diamond-bit core barrels). Several of the borings where mine openings were encountered were cased through the overburden soil so that a downhole camera could be utilized to view the rock in the borings as well as to view conditions in the mine opening. After allowing a period of time for drilling fluids and cuttings to settle out of the groundwater, KYTC personnel returned to the site on June 22, 2016, to conduct the downhole videos.

Additional borings (Holes 2001-2011) were performed in November and December 2016 to further help define the extent of the mined area surrounding the proposed end of the bridge. These borings were performed with poly-crystalline diamond bits and extended through the mine opening or coal seam. These borings were cased through the overburden soils. KYTC personnel returned to the site in April 2017 to conduct downhole videos in the borings. Videos of Borings 2002 and 2004 were not obtained because the PVC casing had collapsed.

The subsurface data sheets are included in the plans. The downhole videos are available for viewing by prospective bidders at the following link:

https://www.youtube.com/playlist?list=PLFxn4Rhh9fBkXtXP9WjuXAh6V5StUWd4v

The videos generally show the mine openings to be sediment and debris filled. In some instances, the videos show a small gap between the top of the sediment and the mine roof, while in other cases no gap can be seen.

During the downhole video inspection in June 2016, groundwater levels were measured in the borings that encountered the mine openings at elevations between 360.3 and 362.0 feet, which is approximately 20 feet higher than the normal pool elevation of the Green River. During the video inspection in April 2017, the groundwater levels were measured in the borings that encountered the mine openings at elevations between 362.9 and 363.3 feet. Measured groundwater elevations are shown on the subsurface data sheets.

Samples of the groundwater were obtained from borings that encountered mine voids during the April 2017 site visit. These samples were tested and met the requirements for total solids, chlorides, pH, and sulfate per ASTM C1602/C1602M-06. Please note that the samples were obtained after allowing a period of time for drilling fluids and cuttings to settle out of the groundwater. Drilling and grouting activities will likely disturb sediment and debris in the mine opening and may create different results. The table below contains the laboratory results for the groundwater samples.

Hole #	% Solids	% Chloride	pH	Sulfate (SO_4), ppm
1004	0.0685	0.0061	6.945	0.082
1005	0.1353	0.0356	6.746	117.49
1006	0.372	0.0076	6.742	84.5
1024	0.1087	0.0167	6.84	119.34
2001	0.0815	0.0033	7.03	41.97
2009	0.1023	0.0027	7.02	125.10
2011	0.1607	0.0089	7.05	74.00

Prospective bidders are strongly encouraged to visit the project site and view the downhole videos. Grouting and backfilling mine contractors/subcontractors are required to inspect available rock cores prior to the letting date. Representatives of the prime contractor and the grouting subcontractor(s) (if applicable) will be required to inspect the rock cores prior to beginning grouting and backfilling mine void operations. To schedule a viewing of the rock cores, contact the Division of Structural Design, Geotechnical Branch (502-564-2374), a minimum of five business days in advance. The bidders are also responsible to familiarize themselves with the available geotechnical data, which provides further information regarding the anticipated soil and bedrock conditions that will impact the grouting operations. Failure to inspect the project site, view the available rock cores, and view the downhole videos will result in the forfeiture of the right to file a claim based on site conditions and may result in disqualification from the project.

3. GENERAL SCOPE AND REQUIREMENTS

Work included consists of providing all labor, equipment, materials, water, and power; performing all operations necessary to complete the intended grouting for the project; cleaning up the area upon completion of the work; and providing all other operations that are incidental to the work specified herein. Key aspects of the work to be performed or furnished by the contractor include, but are not limited to, the following:

1. Provide appropriate drilling equipment and experienced drill operators capable of drilling holes for the injection of grout.
2. Coordinate with relevant utility companies to avoid damage to utilities including, but not limited to, sewer, gas, water, and telecommunication lines.
3. Provide an appropriate system to deliver, mix, and place grout. All data related to volume and pressure of injected materials shall be collected using an automated system. A back-up system consisting of mechanical pressure gauges, in good operating condition, shall be located at the pump so that the pressure may be checked by the operator and the Engineer’s representative. A mechanical counter shall be used at the pump to monitor the quantity of grout placed at each location and during each shift of work. The volume of grout displaced per pump stroke shall be verified by the Contractor prior to grout placement.
4. Comply with Kentucky Energy and Environmental Cabinet (EEC) requirements. Obtain necessary permits and provide proper notification to EEC offices prior to beginning the work.
5. Use proper abandonment techniques for injection holes including injection holes that do not encounter voids.
6. Demobilize equipment and clean-up site.

4. PRECONSTRUCTION SUBMITTALS

4.1. Submit to the Engineer for review in electronic format (PDF) the following at least ten (10) working days prior to the Preconstruction Grouting Meeting.

4.2. **Personnel Qualifications and Site Organization.** The contractor shall submit verification that the supervision of all drilling and grouting work will be conducted by a resident Superintendent with at least five (5) years of recent on-the job supervision in similar applications. In addition, the Project Manager, Project Engineer, and foremen shall each have completed at least three (3) similar projects in the previous five (5) years. The Project Engineer shall be a licensed Professional Engineer. The resumes submitted shall be of the personnel that will be on-site working on the project.

At a minimum, resumes of the following key field personnel shall be included in the submission:

Project Manager
Superintendent(s)
Project Engineer(s)
Foremen

Resumes must demonstrate, by specific project detail, competence and experience in the following areas: (1) drilling and grouting capabilities in similar ground conditions; (2) logging of drilling; (3) automated monitoring of grouting parameters; and (4) ability to process, interpret, display, and act upon these data in real time during the construction process.

The functions of planning and quality control are particular important on this project. The responsibility for carrying out these functions must be clearly addressed within the group of individuals whose resumes are submitted. If during the construction the Contractor proposes to change any of the key personnel, the resume of the proposed replacement person shall be submitted and accepted by the Engineer prior to assuming responsibilities on the project.

4.3. **References for Past Projects.** List of at least three (3) previously completed projects of similar scope and purpose within the last five (5) years for acceptance by the Engineer. The list shall include a description of the project, quantity of material placed, time period that grouting was performed, and client contact person with phone number.

4.4. **Installation and Work Plan**. Submit a detailed step-by-step description of the proposed drilling and grouting construction procedure including personnel, testing, and equipment to assure quality control, as well as procedures and measures to avoid interference between drilling and previously grouted holes. At a minimum, the submittal shall address the following:

- Contractor’s understanding of the scope of work, and interaction with the investigation and treatment activities.

- Practical operational interface with the Engineer in the field.
- Details of health and safety plan.
- Construction operation sequence and schedule.
- Details of delivery of materials and equipment to the project site. Please note that the existing bridge structure has been load rated and posted for reduced weight carrying capacities. The existing bridge is also a narrow through truss and may not be suitable for crossing by large equipment.
- Details of drilling methods including casing advancement and withdrawal; approach to drilling through variable materials including soil, rock, rubble, and previously backfilled areas; and procedures to monitor quality control including sample drilling logs.
- Details of grout type, storage, testing and delivery methods.
- Details of grout placement.
- Details of all automated recording and analysis systems.
- Details of equipment and number of drill rigs to be used.
- Details of video verification equipment.
- Equipment and method of monitoring heave or ground movement.
- Plan describing control and proper disposal of surface water, water displaced from mine void due to grouting activities, drill flush, and excess grout.
- Subcontracting plan, including proposed subcontractors.
- Details for traffic control where necessary.
- Details of quality control including qualifications, certifications, etc.

4.5. **Grout Mix Design Report.** Provide grout mix design report for the low slump grout (LSG) to be used. Include details regarding batching method, batch quantities, mixing method, set times, slump cone, and compressive strength results from laboratory samples or data from representative mixes from previous projects. Include a description of the methods and equipment for accurate automated monitoring, recording, and analyzing of the grout volume and pressure during placement. Finally, provide procedure and equipment for monitoring grout quality control during placement including sample logs for grouting.

4.6. Related work shall not begin until the submittals have been received, reviewed, and accepted in writing from the Engineer. Allow the Engineer ten (10) working days to review the submittals after the complete final set has been received. Additional time required due to incomplete or unacceptable submittals are not cause for delay or impact claims. All costs associated with incomplete or unacceptable submittals shall be the responsibility of the Contractor.

5. DEFINITIONS

The following is a list of technical terms which are used in this Special Note. The list does not include all technical terms used since a general understanding of these is assumed.

5.1. **Admixture:** Substance added to a grout to control bleed and/or shrinkage, improve flowability, reduce water content, or retard setting time.

5.2. **Ascending Stage Drilling/Grouting:** The process of drilling a hole to full depth and then grouting the hole in stages from the bottom up.

5.3. **Casing:** Steel tube introduced during the drilling process in overburden soil and/or fractured rock to temporarily stabilize the drill hole.

5.4. **Low Slump Grout (LSG):** A blend of fine aggregate, cement, and water to achieve a pumpable, thixotropic, viscous grout of low slump to enable pumping at high pressure and remains intact during and after placement. Primary functions are densification of sediment and spoils in the mine void, void filling, and creation of grout columns to provide support to the mine roof.

5.5. **Order of Hole:** In a split spacing pattern, primary holes are drilled and grouted, then secondary holes are drilled and grouted in between the primary holes. Tertiary holes are then drilled and grouted in between the secondary and primary holes. The order of holes refers to a phase of work, be it primary, secondary, or tertiary.

5.6. **Refusal:** A grout stage shall be considered refused when one of the following occurs:

- Grout flow ceases at a header reading pressure of 700 psi.
- Sustained pumping at a header pressure of 500 psi or greater
- Surface Ground heave of 0.125 inches (1/8”) is observed.
- Interconnection or surface breakout is observed.
- Grout injection volume of 15 cubic feet per foot of treatment.

5.7. **Split Spacing:** In a split spacing pattern, low order holes are drilled and grouted first with higher order holes drilled and grouted between lower order holes.

6. PRECONSTRUCTION GROUTING MEETING

6.1. A preconstruction meeting for the grouting work will be scheduled by the Engineer and held at least ten (10) working days prior to the anticipated start of any grouting activities. Attendance by the Contractor and any Subcontractors at the meeting is mandatory.

6.2. The preconstruction meeting for the grouting work will be conducted to clarify the construction requirements and method statement, to review the submittals for the work, to coordinate the construction schedule and activities, and to identify contractual relationships and delineation of responsibilities among the

Contractor and any Subcontractors, specifically those pertaining to ground improvement grouting, anticipated subsurface conditions, testing, survey control, and site drainage control.

7. MATERIALS

7.1. Materials will be furnished new and without defects. Defective materials will be removed from the jobsite and replaced by the Contractor at no additional cost to the Department.

7.2. **Admixtures.** Admixtures shall conform to the requirements of Section 802 of the Standard Specifications. Admixtures that control bleed, improve flowability, reduce water content, and retard set may be used in the grout, subject to the review and acceptance of the engineer. Admixtures shall be compatible with the grout and mixed in accordance with the manufacturer's recommendations. Accelerators and admixtures containing chlorides are not permitted.

7.3. **Bentonite.** High yield sodium montmorillonite at least 200 barrel yield with 100% passing No. 325 screen.

7.4. **Cement.** All cement shall be Portland cement, Type I or II, conforming to Section 801 of the Standard Specifications.

7.5. **Fine Aggregate.** If sand-cement grout is used, sand shall conform to Section 804 of the Standard Specifications.

7.6. **Low Slump Grout (LSG).** A low slump grout (less than 2 inches) with high internal friction and a minimum 28-day compressive strength of 500 psi. Material components may include sand, silt, clay, cement, ground slag, fly ash, water, and other inert materials. Compressive strength of grout is designed to be 500 psi at 28 days and to provide a permanent, non-erodible material.

7.7. **Water**. Water used in the grout mix shall conform to Section 803 of the Standard Specifications and shall be potable, clean, and free from substances that may be injurious to cement and steel. Ground or local surface water may be used provided the Contractor provides documentation the water is not detrimental to grout.

8. EQUIPMENT

8.1. **Drilling.** Use drilling equipment suitable for the work capable of drilling vertical or inclined holes and capable of penetration all subsurface materials including soil, intact bedrock, collapsed bedrock, and rubble. Anticipated mine void elevations are between 320 and 330 feet. Provide equipment capable of drilling to an elevation of 300 feet. The drilling equipment and methods shall not damage the existing underground mine, adjacent ground, or overlying structures. Drilling means and methods shall be selected by the Contractor to match the anticipated ground conditions.

8.2. **Pumps.** Furnish positive displacement pumps suitable for the work. For grout injection, the pumps shall be capable of continuously delivering the grout at pressures of at least 700 psi at rates between 0.5 and 3 cubic feet per minute.

8.3. **Real-Time Grout Injections Monitoring.** Provide either a X-Y recorder or a computer based system capable of accurately monitoring, recording, and displaying the grouting pressures and flow rates in real time at a location suitable for assessing and controlling the grouting operation, as well as allowing the Engineer to view the data as it is collected. The system shall be capable of monitoring as many injection points as the Contractor injects simultaneously. A print-out clearly identifying the injection details (i.e., pressure, rate of injection, and volume) at each stage of grouting shall be submitted after each shift.

8.4. **Grout Injection Pipes.** Furnish steel grout pipes, casing, and connections of sufficient strength to maintain the hole and to withstand the required installation, jacking and pumping stresses. The pipes shall have a minimum 3-inch inside diameter in order to adequately handle the grout without plugging. All casing shall be flush joint threaded, or shall be single piece tubing to provide a smooth inner wall and an unobstructed inside diameter. All fittings (elbows, bends, adapters, reducers, etc.) shall be long sweep, gradual transition pieces specifically designed and manufactured for high pressure grout and concrete pumping applications. Standard pipe elbows and reducers will not be allowed. It shall be the Contractor's responsibility to install casing that does not detrimentally impact the grouting procedure. Casings shall be sized and installed such that grout material will not travel in the annulus area between the pipe and adjacent ground and escape at the surface when pumped.

8.5. **Grout Hoses.** Use grout hoses suitable for the execution of the work. The hoses shall be sized and rated to accommodate the required pumping pressures and flows with acceptable factors of safety against rupture.

8.6. **Grout Plant.** For grout produced on site, provide a grout plant suitable for the execution of the work. The plant shall be sized to accommodate the Contractor's selected pumping rates and shall be capable of continuously producing uniformly mixed grout. The plant shall be capable of accurately and routinely proportioning materials used in the grouts.

The grout shall be either batched on site or brought to the site by agitator trucks. If the grout is batched on site, the mixer shall be a continuous auger type to ensure complete and uniform mixing of the materials used and shall be of sufficient capacity to continuously provide the pumping unit with mixed grout at its normal pumping range. The mixer must be capable of accurately proportioning the grout materials.

The maximum distance between the mixing/supply point of grout and its point of injection shall be less than 300 feet unless otherwise approved by the Engineer.

8.7. **Communication System.** An appropriate voice communication system shall be maintained between the mixing and pumping location(s) and the drilling and injection locations(s).

9. DETAILED PHILSOPHY, SCOPE, AND DERIVATION OF QUANTITIES

9.1. **Philosophy and Scope.** Each hole shall be drilled to the elevations of the mine voids/coal seams identified on the contract plans. The contractor shall log each hole to identify subsurface materials and voids. Each hole will also be used for grout injection or backfilled as indicated by the Engineer. Casing shall be installed to allow drilling to proceed without loss of drilling flush into the overburden and to maintain an open hole during grouting operations.

It is anticipated that ascending stage drilling and grouting principles shall be used for LSG operations. No payment will be made for redrill of grout.

The treatment holes shall be systematically drilled and grouted. At any one location, each order of treatment hole (e.g., primary) shall be drilled and grouted prior to starting drilling for the next higher order of treatment hole (e.g., secondary). The Contractor shall allow sufficient time between drilling and grouting in any one area to ensure that freshly placed grout is not disturbed by subsequent drilling operations. At a minimum grouting may not take place within 10 feet of locations grouted within the previous 12 hours; however, the size of the area and amount of time required will be dependent on the means and methods selected by the Contractor and the local ground conditions.

A typical primary hole pattern is shown on the contract plans. The actual number and location of drill holes is dependent on the subsurface conditions encountered and the Contractor's means and methods. The need to install additional higher order holes (secondary or tertiary) at any given location shall depend upon the results of the drilling and grouting of the initial lower order holes (i.e., primary and secondary). Addition or deletion of holes and/or rows is at the discretion of the Engineer. Thus, monitoring, processing, and interpreting the drilling and grouting data is necessary in real time to avoid delays or interruptions. The Engineer will collaborate with the contractor in reviewing the drilling and grouting data, but will be the final decision-maker for instructing the scope of work.

An appropriate steel pipe shall be installed full depth to the mine floor and the hole shall be grouted, in 1-foot stages within the feature (void, collapse, or previously infilled space) and in 10-foot ascending stages in intact rock (i.e., in the event a drill hole encounters a pillar or unmined area).

Each stage shall be grouted until refusal, as defined in this Special Note. Grouting pressure shall ease at the top of rock. The remainder of the hole shall be backfilled with grout to the ground surface. Holes not encountering voids will be backfilled with grout to the ground surface.

9.2. Derivation of Quantities. The planned approach to drilling and grouting is uniform and consistent in general philosophy. The foreseen amount and type of drilling and grouting activities are estimated using the current understanding of local subsurface conditions and the treatment area geometry. Estimates of grout are based on treatment of the mine mass as a whole, and not on a hole by hole quantity. A typical primary hole pattern within the ground improvement area is shown on the contract plans.

This data and this Special Note represent the current best estimate of the scope of work to be conducted. Modifications to the scope of work at each location will be directed by the Engineer based on the data provided by the Contractor regarding drilling and grouting conditions actually encountered. Addition or deletion of holes is at the discretion of the Engineer.

In estimating the quantities shown on the contract plans, the depth of drilling is dictated by achieving a target depth elevation corresponding to the original mine floor elevation.

The estimated quantities of drilling and grouting are provided solely for the purpose of providing bidders with an introduction to the scope of the work to be conducted. They are not a guarantee of quantities, absolute or relative, and can reasonably be expected to vary depending on the actual site conditions encountered.

10. EXECUTION OF WORK

10.1. Site Drainage Control. Control and properly dispose of drill flush and construction related waste, groundwater, displaced groundwater from mine void grouting, excess grout, and equipment washout water, in accordance with the Standard Specifications, project plans, and all applicable local codes and regulations. All work shall be done in accordance with EEC regulations. On-site disposal is permitted, with the approval of the Engineer, with control of solids content to prevent runoff of uncontrolled sediment, grout, etc., directly off of KYTC property. Maintain all pipes or conduits used to control surface water during construction. Repair damage caused by surface water control pipes or conduits from the site. At completion of the work, restore the site to the grades and conditions required by the project plans and specifications. No direct payment will be made for meeting these requirements.

10.2. **Dust Suppression.** Dust suppression shall conform to the applicable portions of Section 107 of the Standard Specifications. In addition to any requirements set forth by a health and safety plan required elsewhere in this Special Note, the Contractor shall have no prolonged and significant emission of dust. No direct payment will be made for any expenses incurred by the Contractor for compliance with this requirement except for those items which have been included in the contract as a pay item.

10.3. **Drilling.** The drilling equipment and methods shall be suitable for drilling through all the conditions to be encountered, and shall be selected and modified, if necessary, by the Contractor. The drilling method shall not cause damage to the adjacent ground, underground mine, or adjacent structures. The Contractor is to observe the boring during drilling and provide the Engineer a log of all pertinent information. Parameters to be recorded shall include penetration rate, high torque zones, strata changes, drill actions, flush characteristics, and hole stability. The information from these logs will be used to confirm voids and grouting zones.

10.4. **Grouting.** Once initiated, the Contractor shall methodically proceed to complete all grouting activities in a continuous operation until refusal criteria are met. Areas of excessive grout takes may be required to rest between grouting intervals to control runaway grout. The Contractor shall monitor grouting activities from both the surface and subsurface for flow of material outside of the limits of ground improvement shown on the contract plans. Cost incurred to remove grout from areas outside the work limits shall be borne by the Contractor.

10.5. **Monitoring of Ground Heave/Settlement.** During construction, the Contractor shall monitor the ground for heave/settlement in the vicinity of the drilling and grouting locations. The Contractor shall immediately notify the Engineer of any instances of suspected or observed tilt, ground surface heave, or settlement and suspend or modify drilling or backfilling operations pending resolution with the Engineer.

No direct payment will be made for any expenses incurred by the Contractor for compliance with this Special Note except for those items which have been included in the contract as a pay item.

11. CONTRACTOR'S QUALITY CONTROL

11.1. The Contractor's Quality Control Representative (CQCR) shall perform slump tests (ASTM C143) at least once per day of injection or at any time as requested by the Engineer. Preparation and testing for compressive strength testing shall be in accordance with ASTM D4832. The CQCR shall cast 6-inch by 12-inch cylinders at the rate three sets for every 100 cubic yards of grout injected, but not less than once during each shift grout is placed. One set of the cylinders is to be tested for compressive strength at 7 days, one is to be tested at 28 days, and one set is extra to be used if needed. All test data shall be promptly forwarded to the Engineer. Testing of the 28-day and extra cylinders will not be required if the required minimum strength is obtained at 7 days. Temperature readings of the grout are to be taken each time compressive strength cylinders are cast.

11.2. The CQCR shall verify the layout of injection and verification holes. The Contractor shall provide survey data accurate to within 0.1 foot for horizontal control and 0.1 foot for vertical control for all injection and verification holes drilled by the contractor. Proposed locations for such holes (if not already indicated with the initial plan provided before start of construction) shall be provided by the Contractor at least one week prior to hole drilling. Survey data for all hole locations shall be provided no later than one week following hole drilling.

11.3. In addition, the CQCR shall submit records to the Engineer as follows:

1. Accurate daily reports providing technical details and quantities associated with drilling, grout installation, verification drilling and videoing, and results of material tests.
2. The Contractor shall provide a log for each boring used for installing grout. Such logs shall be neat, legible, and include an accurate characterization of all material encountered in the hole and notation of special features such as voids, soft or broken rock, ground water, loss of circulation of drilling fluids, rod drop, or any other item of interest. The Contractor shall prepare and submit to the Engineer full installation logs for each drilling or grouting operation at each work location. The records shall be submitted within one work shift after the drilling or grouting operation has been completed. A separate log shall be provided for each operation with the format established in the preconstruction submittals and meeting. All automated data generated during drilling and grouting operations shall be made available in real time to the Engineer, with hard copies included in the daily logs.
3. The contractor shall submit the laboratory test results to the Engineer as they become available.

11.4. In all cases the Department reserves the right to request raw data, field notes and/or other available information that may be necessary to evaluate the results of the work specified in this Special Note. Upon request, provide any available information at no additional cost to the Department.

In all cases the Department reserves the right to perform testing to obtain independent results of testing specified in this Special Note. The Department may also conduct other ancillary testing as needed to verify the adequacy of the work performed. Upon request provide any assistance required for the Department or the Department's representative to perform such testing at no additional cost to the Department.

The Department reserves the right to perform drilling, coring, and downhole video inspection at any time to evaluate the results of the work specified in this Special Note. Provide any required assistance (e.g., access, etc.) to the Department or the Department's representative for these independent inspections at no additional cost to the Department.

12. METHOD OF MEASUREMENT AND BASIS OF PAYMENT

No direct payment will be made for any expenses incurred by the Contractor for compliance with this Special Note except for those items which have been included in the contract as a pay item.

12.1. **Mobilization for Grouting.** Mobilization will be paid as a lump sum.

12.2. **Drilling.** Payment will be measured to the 0.1 Linear Foot for accepted length measured from the ground surface to the depths directed and approved by the Engineer. This item may be overrun or underrun at the direction of the Engineer without adjustment in the contract unit price. All costs associated with and incidental to drilling (including casing and layout of grout injection locations) of the hole for the grouting operations shall be included in the contract unit price for Drilling, Linear Foot.

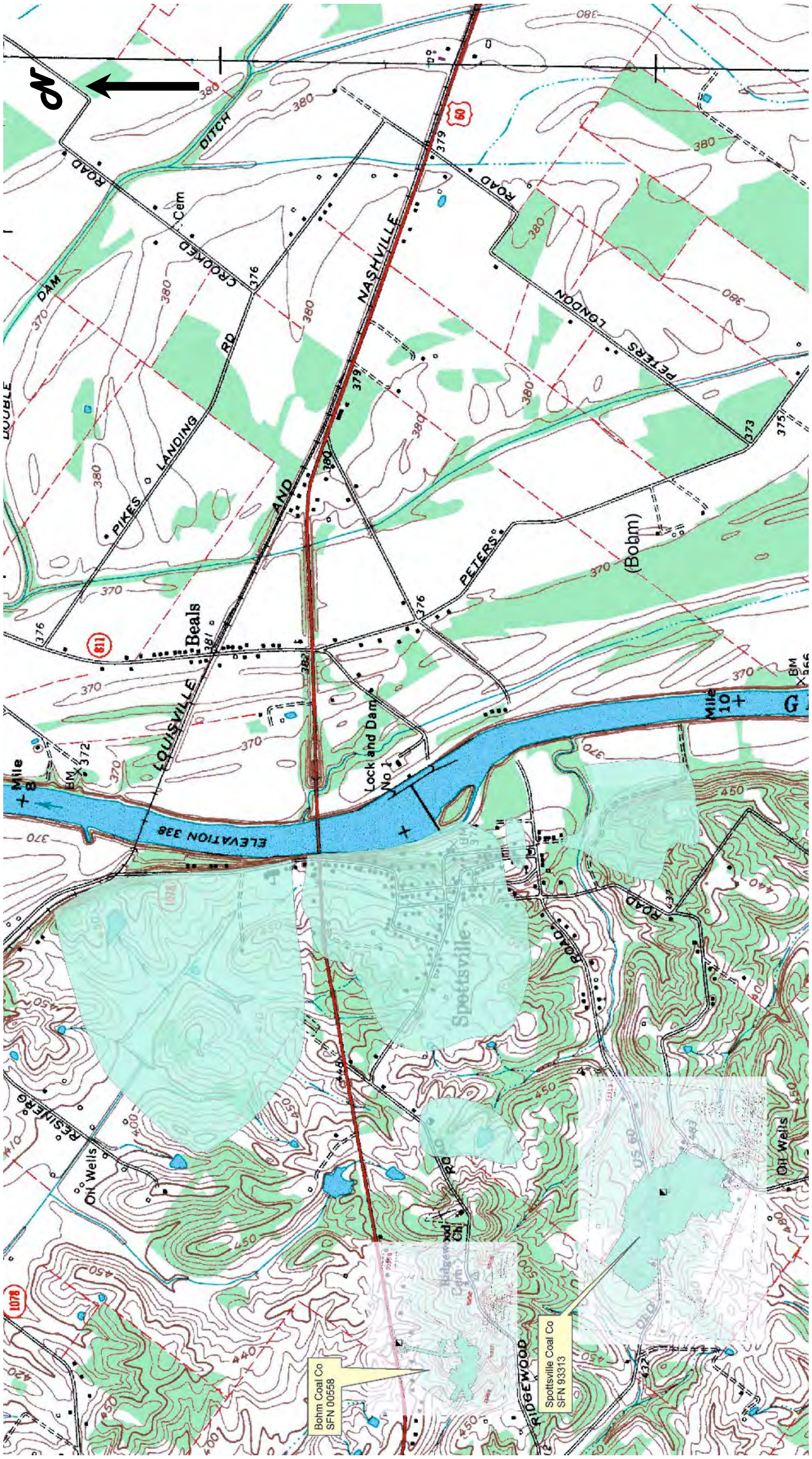
12.3. **Low Slump Grout (LSG).** Payment will be measured to the 0.1 Cubic Yards for accepted quantity of grout placed as approved by the Engineer. This also includes the quantity grout required to backfill holes, overburden, and exploratory borings. This item may be overrun or underrun at the direction of the Engineer without adjustment in the contract unit price. All costs associated with and incidental to providing, placing, and testing of LSG for the grouting operations shall be included in the contract unit price for Low Slump Grout, Cubic Yards.

12.4. Payment. Payment will be made under:

Code	Pay Item	Pay Unit
xxxxxXX	Mobilization for Grouting	Lump Sum
xxxxxXX	Drilling	Linear Foot
xxxxxXX	Low Slump Grout	Cubic Yard

APPENDIX A

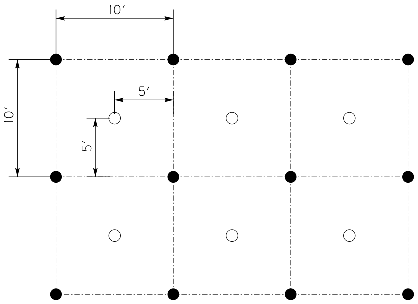
MINED AREA MAPS


N
Bohm Coal Co
SFN 00558
Spottsville Coal Co
SFN 93313
LOUISVILLE AND NASHVILLE
PETERS LONDON ROAD
PETERS
PIKES LANDING RD
CROOKED ROAD
DOUBLE DITCH DAM
Cem
Beals
(Bohm)
Lock and Dam No 1
ELEVATION 338
Mile 8
Mile 10
Spottsville
RIDGEWOOD
Oil Wells
60
811
1078

From Crittenden's or KGS "Peabody" overlays
Spottsville Mine
Shiver Mine
Sheelles Mine
Bowne (Bohm) Mine
Bohm Coal Co SFN 00558
Spottsville Coal Co SFN 93313

MINE GROUTING PLAN

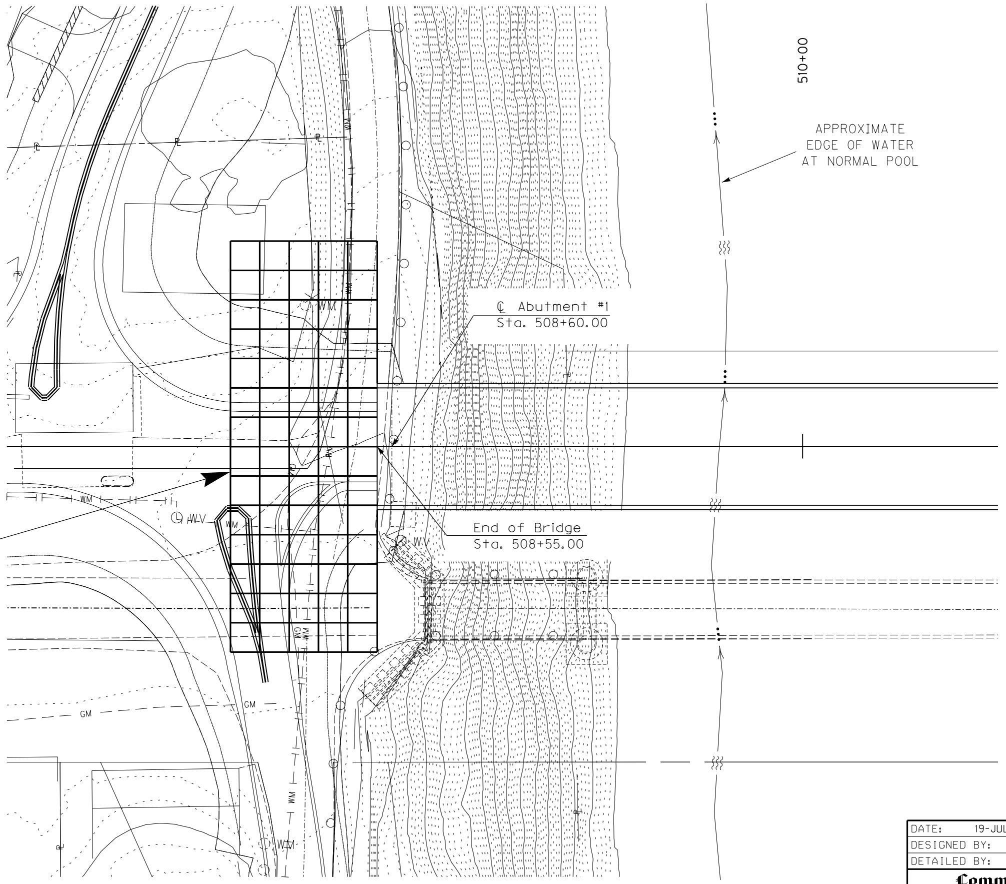
Plan Scale 1" = 20'



Typical Split Spacing Detail
Not to Scale

- ● Primary LSG Hole
- ○ Secondary LSG Hole

Notes:
1. Perform grouting in accordance with the Special Note for Mine Grouting.
2. Actual Number of drill holes is dependent on subsurface conditions encountered and the contractor's means and methods. Addition or deletion of holes is at the discretion of the Engineer.
3. Primary hole pattern shown indicates typical spacing. Adjustments may be required in the field to avoid obstructions, utilities, etc.
4. Depth of drilling measured from ground level at time of drilling.



DATE: 19-JULY-2017	CHECKED BY
DESIGNED BY:	
DETAILED BY: E. BAILEY	D. GREER

Commonwealth of Kentucky
DEPARTMENT OF HIGHWAYS

COUNTY
HENDERSON

ROUTE
US 60

CROSSING
Bridge over Green River

SUBSURFACE DATA

S–058–16

ITEM NUMBER
2–1080.00

PREPARED BY
Division of Structural Design
GEOTECHNICAL BRANCH

SHEET NO.

DRAWING NO.
00000

IDEALIZED SOIL AND BEDROCK PROFILE

Perry, Morton Boulevard over KY 15
Pier 1

DJG 7/31/17

Top of Shaft

Elev.
(ft.)

Overburden, Neglect for Support

Top of Rock Socket

*

Strata **Parameters for Lateral Load Analyses**

Shale		**Weak Rock**		
γ_t (lb/ft^3) =	150	Effective Unit Weight,	γ_e (lb/in^3) =	0.087
q_u (psi) =	5000	Elastic Modulus,	E_r (psi) =	500,000
q_{eb} (ksf) =	60	Uniaxial Compressive Strength,	q_u (psi) =	5000
f_s (ksf) =	21.1	Cohesive Strength,	c_u (psi) =	2500

(Side friction limited by Concrete Strength)

*

Shaft Tip

* **Elevations vary and are provided in the report body.**

ADDITIONAL DATA FOR GEOTECHNICAL CALCULATIONS ONLY:	
min. f'_c (psi) =	3500
p_a (psi) =	14.7

Load and Resistance Factor Design (LRFD)

DRILLED SHAFT AXIAL RESISTANCE TABLE

Perry, Morton Boulevard over KY 15
Pier 1

Rock Socket Diameter = 3.5 feet
Rock Socket Diameter = 42 inches

DJG 7/31/17

Rock Socket Length (ft.)	Nominal Unit Side Shear q_{ss} (ksf)	Nominal Unit End Bearing q_{eb} (ksf)	Nominal Side Resistance R_{sr} (kips)	Nominal End Bearing Resistance R_{eb} (kips)	Factored Side Resistance ϕR_{sr} (kips)	Factored End Bearing Resistance ϕR_{eb} (kips)	Total Factored Axial Resistance ϕR_t (kips)	Total Factored Uplift Resistance ϕR_{tu} (kips)
0.0								
1.0	21.1	60	232	577	116	289	405	93
2.0	21.1	60	464	577	232	289	521	186
3.0	21.1	60	696	577	348	289	637	278
4.0	21.1	60	928	577	464	289	753	371
5.0	21.1	60	1160	577	580	289	869	464
6.0	21.1	60	1392	577	696	289	985	557
>>> 7.0	21.1	60	1624	577	812	289	1101	650
8.0	21.1	60	1856	577	928	289	1217	742
9.0	21.1	60	2088	577	1044	289	1333	835
10.0	21.1	60	2320	577	1160	289	1449	928
11.0	21.1	60	2552	577	1276	289	1565	1021
12.0	21.1	60	2784	577	1392	289	1681	1114
13.0	21.1	60	3016	577	1508	289	1797	1206
14.0	21.1	60	3248	577	1624	289	1913	1299
15.0	21.1	60	3480	577	1740	289	2029	1392
16.0	21.1	60	3712	577	1856	289	2145	1485
17.0	21.1	60	3944	577	1972	289	2261	1578
18.0	21.1	60	4176	577	2088	289	2377	1670
19.0	21.1	60	4408	577	2204	289	2493	1763
20.0	21.1	60	4640	577	2320	289	2609	1856
AASHTO Table 10.5.5.2.4-1				Resistance Factor, ϕ	0.50	0.50		0.40
>>> = Min. Socket Length							D (ft.) =	3.5

Load and Resistance Factor Design (LRFD)

DRILLED SHAFT AXIAL RESISTANCE TABLE

Perry, Morton Boulevard over KY 15
Pier 1

Rock Socket Diameter = 4.0 feet
Rock Socket Diameter = 48 inches
DJG 7/31/17

Rock Socket Length (ft.)	Nominal Unit Side Shear q_{ss} (ksf)	Nominal Unit End Bearing q_{eb} (ksf)	Nominal Side Resistance R_{sr} (kips)	Nominal End Bearing Resistance R_{eb} (kips)	Factored Side Resistance ϕR_{sr} (kips)	Factored End Bearing Resistance ϕR_{eb} (kips)	Total Factored Axial Resistance ϕR_t (kips)	Total Factored Uplift Resistance ϕR_{tu} (kips)
0.0								
1.0	21.1	60	265	754	133	377	510	106
2.0	21.1	60	530	754	265	377	642	212
3.0	21.1	60	795	754	398	377	775	318
4.0	21.1	60	1061	754	530	377	907	424
5.0	21.1	60	1326	754	663	377	1040	530
6.0	21.1	60	1591	754	795	377	1172	636
7.0	21.1	60	1856	754	928	377	1305	742
>>> 8.0	21.1	60	2121	754	1061	377	1438	848
9.0	21.1	60	2386	754	1193	377	1570	955
10.0	21.1	60	2652	754	1326	377	1703	1061
11.0	21.1	60	2917	754	1458	377	1835	1167
12.0	21.1	60	3182	754	1591	377	1968	1273
13.0	21.1	60	3447	754	1723	377	2100	1379
14.0	21.1	60	3712	754	1856	377	2233	1485
15.0	21.1	60	3977	754	1989	377	2366	1591
16.0	21.1	60	4242	754	2121	377	2498	1697
17.0	21.1	60	4508	754	2254	377	2631	1803
18.0	21.1	60	4773	754	2386	377	2763	1909
19.0	21.1	60	5038	754	2519	377	2896	2015
20.0	21.1	60	5303	754	2652	377	3028	2121
AASHTO Table 10.5.5.2.4-1				Resistance Factor, ϕ	0.50	0.50		0.40
>>> = Min. Socket Length							D (ft.) =	4.0

Load and Resistance Factor Design (LRFD)

DRILLED SHAFT AXIAL RESISTANCE TABLE

Perry, Morton Boulevard over KY 15
Pier 1

Rock Socket Diameter = 4.5 feet
Rock Socket Diameter = 54 inches

DJG 7/31/17

Rock Socket Length (ft.)	Nominal Unit Side Shear q_{ss} (ksf)	Nominal Unit End Bearing q_{eb} (ksf)	Nominal Side Resistance R_{sr} (kips)	Nominal End Bearing Resistance R_{eb} (kips)	Factored Side Resistance ϕR_{sr} (kips)	Factored End Bearing Resistance ϕR_{eb} (kips)	Total Factored Axial Resistance ϕR_t (kips)	Total Factored Uplift Resistance ϕR_{tu} (kips)
0.0								
1.0	21.1	60	298	954	149	477	626	119
2.0	21.1	60	597	954	298	477	775	239
3.0	21.1	60	895	954	447	477	925	358
4.0	21.1	60	1193	954	597	477	1074	477
5.0	21.1	60	1491	954	746	477	1223	597
6.0	21.1	60	1790	954	895	477	1372	716
7.0	21.1	60	2088	954	1044	477	1521	835
8.0	21.1	60	2386	954	1193	477	1670	955
>>> 9.0	21.1	60	2685	954	1342	477	1819	1074
10.0	21.1	60	2983	954	1491	477	1969	1193
11.0	21.1	60	3281	954	1641	477	2118	1312
12.0	21.1	60	3580	954	1790	477	2267	1432
13.0	21.1	60	3878	954	1939	477	2416	1551
14.0	21.1	60	4176	954	2088	477	2565	1670
15.0	21.1	60	4474	954	2237	477	2714	1790
16.0	21.1	60	4773	954	2386	477	2863	1909
17.0	21.1	60	5071	954	2536	477	3013	2028
18.0	21.1	60	5369	954	2685	477	3162	2148
19.0	21.1	60	5668	954	2834	477	3311	2267
20.0	21.1	60	5966	954	2983	477	3460	2386
AASHTO Table 10.5.5.2.4-1				Resistance Factor, ϕ	0.50	0.50		0.40

D (ft.) = 4.5

>>> = Min. Socket Length

Load and Resistance Factor Design (LRFD)

DRILLED SHAFT AXIAL RESISTANCE TABLE

Perry, Morton Boulevard over KY 15
Pier 1

Rock Socket Diameter = 5.0 feet
Rock Socket Diameter = 60 inches

DJG 7/31/17

Rock Socket Length (ft.)	Nominal Unit Side Shear q_{ss} (ksf)	Nominal Unit End Bearing q_{eb} (ksf)	Nominal Side Resistance R_{sr} (kips)	Nominal End Bearing Resistance R_{eb} (kips)	Factored Side Resistance $\phi\ R_{sr}$ (kips)	Factored End Bearing Resistance $\phi\ R_{eb}$ (kips)	Total Factored Axial Resistance $\phi\ R_t$ (kips)	Total Factored Uplift Resistance $\phi\ R_{tu}$ (kips)
0.0								
1.0	21.1	60	331	1178	166	589	755	133
2.0	21.1	60	663	1178	331	589	920	265
3.0	21.1	60	994	1178	497	589	1086	398
4.0	21.1	60	1326	1178	663	589	1252	530
5.0	21.1	60	1657	1178	829	589	1418	663
6.0	21.1	60	1989	1178	994	589	1583	795
7.0	21.1	60	2320	1178	1160	589	1749	928
8.0	21.1	60	2652	1178	1326	589	1915	1061
9.0	21.1	60	2983	1178	1491	589	2081	1193
>>> 10.0	21.1	60	3314	1178	1657	589	2246	1326
11.0	21.1	60	3646	1178	1823	589	2412	1458
12.0	21.1	60	3977	1178	1989	589	2578	1591
13.0	21.1	60	4309	1178	2154	589	2743	1723
14.0	21.1	60	4640	1178	2320	589	2909	1856
15.0	21.1	60	4972	1178	2486	589	3075	1989
16.0	21.1	60	5303	1178	2652	589	3241	2121
17.0	21.1	60	5634	1178	2817	589	3406	2254
18.0	21.1	60	5966	1178	2983	589	3572	2386
19.0	21.1	60	6297	1178	3149	589	3738	2519
20.0	21.1	60	6629	1178	3314	589	3903	2652
AASHTO Table 10.5.5.2.4-1				Resistance Factor, ϕ	0.50	0.50		0.40
>>> = Min. Socket Length							D (ft.) =	5.0

SPECIAL NOTE FOR NON-DESTRUCTIVE TESTING IN DRILLED SHAFTS

The following sections provide the requirements for non-destructive testing (Crosshole Sonic Logging and Thermal Integrity Profiling) of the drilled shaft foundations, including technique shafts, schedule requirements for submittals, reporting requirements and Contractor/Testing Subcontractor/Department responsibilities. The purpose of the non-destructive testing is to evaluate whether the Contractor's means and methods are suitable for proposed drilled shaft foundation construction and to potentially detect air-, clay- or debris-filled voids or other discontinuities within and along the perimeter of the drilled shafts.

1.0 Crosshole Sonic Logging

1.1 Description

Crosshole Sonic Logging (CSL) is a nondestructive method to test the integrity of drilled shafts. It is the responsibility of the Contractor to supply all equipment and materials necessary to perform this testing and for obtaining the services of a CSL Testing Firm, which is experienced with CSL testing in accordance with Section 1.4.1 of this note and approved by the Engineer, to perform the testing.

The Contractor will be responsible for providing:

1. access tubes to be used for CSL testing of the drilled shafts;
2. watertight shoes, watertight caps, and non-shrink grout;
3. suitable working space and access to every shaft;
4. a reliable 600 watt (minimum) generator; and
5. any other equipment or materials necessary to accomplish the testing.

1.2 Materials

1.2.1 Access Tubes

1. Provide access tubes meeting the requirements below:
    a. 2-inch ID schedule 40 steel pipe conforming to ASTM A 53, Grade A or B, Type E, F, or S;
    b. contains round, regular internal diameters free of defects or obstructions, including any at pipe joints;
    c. capable of permitting the free, unobstructed passage of a 1.5-inch-diameter source and receiver probes; and
    d. watertight and free from corrosion with clean internal and external faces to ensure passage of the probes and a good bond between the concrete and the tubes.
2. Provide watertight shoes on the bottom and removable watertight caps on the top of the tubes.
3. The Engineer will accept access tubes based on visual inspection, certification, and that the steel pipe meets the requirements above.

1.2.2 Grout

Provide non-shrink grout to fill the access tubes and any cored holes at the completion of the CSL tests. Use grout conforming to Section 601.03.03 of the Standard Specifications.

1.3 Execution

1.3.1 Access Tube Installation

1. Install 6 access tubes as shown in Section 2.4.2 of this Special Note in each of the drilled shafts having a rock socket diameter of 5.5 feet or greater, unless directed by the Engineer to omit any access tubes. Install 4 access tubes as shown in Section 2.4.2 of this Special Note in each of the drilled shafts having a rock socket diameter of 3.5 feet to 5 feet, unless directed by the Engineer to omit any access tubes.
2. Securely attach the CSL tubes that are along the inside periphery to the spiral reinforcement. Wire-tie the tubes a minimum of every 3 ft. so they will stay in position during placement of reinforcement and concrete. Place the tubes so they will be parallel with each other and as near to vertical as possible in the finished shaft. Even moderate bending of the tubes will result in large regional variations in the data.
3. Place the tubes from 6 inches above the shaft tip to at least 3 ft. above the top of rebar cage, at least 3 ft. above water level, at least to the top of concrete, and at least 3 ft. above the top of casing. Under no circumstances may the tubes be allowed to come to rest on the bottom of the excavation.
4. Ensure that any joints in the tubes are watertight.
5. During placement of the reinforcement cage, exercise care so that the tubes will not be damaged to the extent that would prevent a 1.5-inch diameter probe from passing through them.
6. After placing the reinforcing cage and before beginning concrete placement, **fill the tubes with clean potable water** and cap or seal the tube tops to keep debris out of the tubes. Replace the watertight caps immediately after filling the tubes with water.
7. Before placing concrete, investigate at least one tube per shaft to make sure that there are no bends, crimps, obstructions or other impediments to the free passage of the testing probes.
8. During removal of the caps from the tubes, exercise care so as not to apply excess torque, hammering, or other stresses which could break the bond between the tubes and concrete.
9. After concrete placement and before the beginning of CSL testing, inspect the access tubes and report any access tubes that the 1.5-inch diameter test probe cannot pass through to the Engineer. The Engineer will make an evaluation to determine if the CSL testing can be successfully performed without the tube(s); the Engineer may require the contractor to, at its own expense, replace one or more

tubes with 2-inch-diameter holes cored through the concrete for the entire length of the shaft, excluding the bottom 6 inches. Unless directed otherwise by the Engineer, locate core holes approximately 6 inches inside the reinforcement such that it does not damage the reinforcement. For each core hole drilled, record a log with descriptions of inclusions and voids in the cored holes and submit a copy of the log and photographs to the Engineer. Preserve the cores, identify as to location and make available for inspection by the Engineer.

1.3.2 Grouting

After completion of the CSL and TIP testing, evaluation of results and upon being directed by the Engineer, remove the water from the access tubes and any cored holes, completely fill the tubes and holes with approved grout. After grouting, cut the tubes flush with the tops of the drilled shafts.

1.4 CSL Testing and Evaluation of Test Results

Make submittals electronically in accordance with the Project requirements for submittals. See Table 1 below. The Department will respond to the Contractor regarding acceptability of submittals within ten (10) business days, unless indicated otherwise in this special note. A “Business Day” is defined as any day except Saturdays, Sundays and Holidays, as defined in Section 101.03 of the Standard Specifications.

Table 1 – Schedule of CSL Submittals

Submittal Number	Submittal Item	Calendar Days	Event
1	Technical Proposal with CSL Testing Firm qualifications	60 before	Start of Drilled Shaft Construction
2	CSL Testing Reports	5 After	Completion of testing on an individual drilled shaft

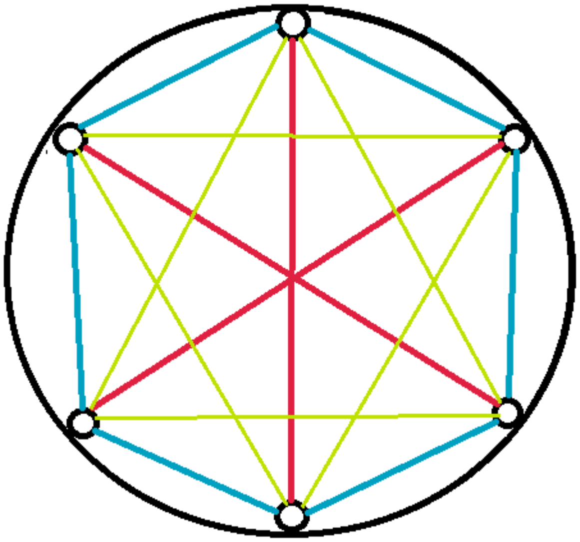
Provide all submittals and reports in .pdf format

1.4.1 Technical Proposal

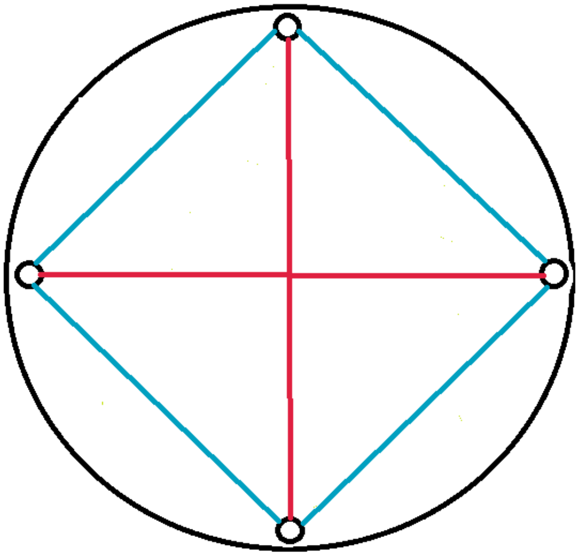
Submit a technical proposal prepared by the CSL Testing Firm that addresses the testing procedures and qualifications and experience of the testing firm. Include at least 3 similar deep foundation projects for which the testing organization has been engaged in CSL Testing. Use personnel having a minimum of 3 similar deep foundation projects experience in CSL Testing and interpretation. Within 10 business days, the Department will review the proposal and report to the Contractor whether the CSL Testing Firm is approved.

1.4.2 Testing

1. Provide access to the top of the shaft for testing personnel and equipment.
2. Perform CSL testing on all shafts, unless directed otherwise by the Engineer.
3. Perform CSL testing in general accordance with ASTM D 6760.
4. Perform CSL testing on all completed shafts designated for testing by the Engineer, after the shaft concrete has cured at least 72 hours and has obtained a minimum strength of 2500 psi.
5. For drilled shafts with diameters of 5.5 feet and greater, obtain a minimum of 15 CSL logs per shaft (6 perimeter, 3 major diagonal and 6 minor diagonal logs), unless otherwise directed by the Engineer (see figure below). For drilled shafts with diameters of 3.5 feet to 5 feet, obtain a minimum of 6 CSL logs per shaft (4 perimeter and 2 major diagonal logs), unless otherwise directed by the Engineer (see figure below).
6. If the CSL testing firm believes that additional testing is required (such as Angled CSL, Crosshole Tomography, Singlehole Sonic Logging, or Sonic Echo/Impulse Response, etc.), contact the Engineer immediately. The Department will determine if additional testing is required, and such testing, if not due to a drilled shaft defect, would be paid for using a change order.



Proposed CSL Tube and Reading Configuration
5.5 ft. to 7 ft. Diameter Shafts – 6 CSL Tubes
3 Major Diagonal Readings
6 Perimeter Readings
6 Minor Diagonal Readings



Proposed CSL Tube and Reading Configuration
3.5 ft. to 5 ft. Diameter Shafts – 4 CSL Tubes
2 Major Diagonal Readings
4 Perimeter Readings

1.4.3 Test Reports

1. Submit a test report prepared by the CSL Testing Firm within 5 business days of completion of testing which, as a minimum, contains:
   a. Date of test;
   b. Plan Shaft No. and Reference Elevation;
   c. Schematic showing a plan view of the access tube locations;
   d. CSL logs with reference elevations;
   e. CSL logs presented for each tube pair tested with any discontinuity. zones indicated on the logs and discussed in the report as appropriate;
   f. Analyses of initial pulse arrival time versus depth or velocity versus depth; and
   g. Analyses of pulse energy/amplitude versus depth.
   h. A narrative portion of the report will be used to present items a through f.
2. Complete all reports using English units.

1.4.4. Evaluation of CSL Test Results

1. Allow direct communication between the CSL Testing Firm and the Department.
2. The Department will evaluate the CSL test results in the test report to determine whether or not the drilled shaft integrity is acceptable. Within 5 business days after receiving a test report, the Engineer will report to the Contractor whether the construction is acceptable or additional analyses are needed. Thermal Integrity Testing (TIP) as described in Section 2.0 will also be used by the Department to determine the presence of anomalies.
3. Perform CSL testing on the first shaft constructed. Continue with subsequent drilled shaft rock socket excavation and concrete placement only after receiving written approval and acceptance of the first shaft of each specified diameter, based on the results and analysis of the CSL testing for the first shaft. Drilled shaft operations such as casing placement and overburden excavation will be allowed during the waiting period.
4. Continue with construction of the structure above the drilled shafts only after receiving written approval from the Engineer to do so, based on evaluation of the CSL test results.
5. If the CSL records are inconclusive (e.g. records do not clearly indicate discontinuity, good conditions or missing data), the Engineer may require additional testing, such as Angled CSL, or Singlehole Sonic Logging or concrete cores to sample the concrete in question to verify shaft conditions. If core samples are needed, obtain cores with a minimum diameter of 2 inches using a double tube core barrel at a minimum of 4 locations selected by the Department, unless directed otherwise by the Engineer. Unless directed otherwise by the

Engineer, locate core holes approximately 6 inches inside the reinforcement such that they do not damage the reinforcement. For each core hole drilled, record a log with descriptions of inclusions and voids in the cored holes and submit a copy of the log to the Engineer. Place the cores in crates properly marked showing the shaft depth at each interval of core recovery. Transport the cores and logs to the Geotechnical Branch in Frankfort for inspection and testing. Grout the core holes in accordance with Section 1.3.2 above.

6. If the additional testing or evaluation of cores indicate that concrete for any drilled shaft on which additional testing or coring was required is acceptable, the Department will pay for the direct cost of additional testing and concrete coring and grouting by change order. If the additional testing or evaluation of cores indicates that the concrete for any drilled shaft concrete is unacceptable, the additional testing and concrete coring and grouting will be at the expense of the Contractor.
7. If discontinuities are found, an independent structural and/or geotechnical consultant hired by the Contractor will perform structural and/or geotechnical evaluation at the expense of the Contractor. Hire consultants who are prequalified by KYTC in applicable areas. Based on the design criteria established for the structure and the evaluation of the independent structural engineer, the Engineer will assess the effects of the defects on the structural performance of the drilled shaft. If the results of the analyses indicate that there is conclusive evidence that the discontinuity will result in inadequate or unsafe performance under the design loads, as defined by the design criteria for the structure, the Engineer will reject the shaft.
8. If any shaft is rejected, provide a plan for remedial action to the Engineer for approval. Any modifications to the foundation shafts and/or other substructure elements caused by the remedial action will require calculations and working drawings by consultant(s) hired by the contractor, at the expense of the Contractor, which will be subject to review by the Engineer. Begin remediation operations only after receiving approval from the Engineer for the proposed remediation. All remedial action will be at no cost to the Department and with no extension of contract time.

2.0 Thermal Integrity Profiling

2.1 Description

Thermal Integrity Profiling (TIP) will be used as part of the program to test the integrity of drilled shafts. The Contractor will be responsible for supplying all equipment and materials necessary to perform this testing, and obtaining the services of a TIP Testing Firm, experienced with TIP testing and approved by the Engineer, to perform the testing. TIP testing will be performed using the CSL tubes installed in the drilled shafts. Proposed alternate methods of performing the TIP testing may be considered by the Department.

Alternate methods of performing the TIP testing would be subject to acceptance by the Department, and installation of any sensors/instrumentation to the reinforcing cage would be incidental to the applicable contract unit bid price for TIP Testing. Ensuring that the TIP instrumentation is operational and provides the required information is the responsibility of the TIP Testing Firm. Overseeing the installation of the TIP testing instrumentation and properly training the Contractor in the installation of the TIP testing instrumentation is the responsibility of the TIP Testing Firm and is incidental to applicable unit bid price for TIP Testing. If any additional training for the Contractor is required for the TIP instrumentation, it is the responsibility of the TIP Testing Firm and is incidental to applicable unit bid price for TIP Testing.

The Contractor will be responsible for providing:
1. wires or probes which will be used for TIP testing of the drilled shafts;
2. dewatering equipment for CSL tubes if probes will be used;
3. suitable working space and access to every shaft;
4. a reliable 600 watt (minimum) generator; and
5. other equipment or materials necessary to accomplish the testing.

2.2 Materials

Refer to Section 1.2 for CSL tube materials.

2.3 Execution

2.3.1 Access Tube Installation

Refer to CSL access tube installation in Section 1.3.1 of this Special Note.

2.3.2 Grouting

After completion of the TIP and CSL testing, evaluation of results and upon being directed by the Engineer, remove the water from the access tubes and any cored holes, completely fill the tubes and holes with approved grout. After grouting, cut the tubes flush with the tops of the drilled shafts.

2.4 TIP Testing and Evaluation of Test Results

Make submittals electronically in accordance with the Project requirements for submittals. See Table 2 below. The Department will respond to the Contractor regarding acceptability of submittals within ten (10) business days, unless indicated otherwise in this special note. A “Business Day” is defined as any day except Saturdays, Sundays and Holidays, as defined in Section 101.03 of the Standard Specifications.

Table 2 – Schedule of TIP Submittals			
Submittal Number	Submittal Item	Calendar Days	Event
1	Technical Proposal with TIP Testing Firm qualifications, including any alternate testing methods and information required for alternate methods discussed in Section 2.1	60 before	Start of Drilled Shaft Construction
2	TIP Testing Reports	5 After	Completion of testing on an individual drilled shaft
Provide all submittals and reports in .pdf format			

2.4.1 Technical Proposal

Submit a technical proposal prepared by the TIP Testing Firm that addresses the testing procedures and qualifications and experience of the testing firm. It is acceptable for the TIP and CSL Testing Firm to be the same firm, provided they meet requirements for both TIP (this Section) and CSL (Section 1.4.1) Testing Firms. Include at least 3 similar deep foundation projects for which the testing organization has been engaged in TIP Testing. Documented participation in the development of ASTM Standard Test Method D7949-14 may be counted as one project for the purposes of this pre-qualification. Experience in at least one similar project using CSL Testing and interpretation may be counted as one project. If used, this CSL project must be a different project than that used to satisfy the actual TIP Testing project experience. Include at least one project where TIP Testing was performed and interpreted. Use personnel having a minimum of 3 similar deep foundation projects experience in TIP Testing and interpretation. Within 10 business days, the Engineer will review the proposal and report to the Contractor whether the TIP Testing Firm is approved.

2.4.2 Testing

1. Provide access to the top of the shaft for testing personnel and equipment.
2. Perform TIP testing on all shafts, unless directed otherwise by the Engineer.
3. Perform TIP testing in accordance with generally accepted TIP Testing methods.

4. Perform TIP testing on all completed shafts designated for testing by the Engineer, within the time frame indicated by the TIP testing firm after of the completion of concrete placement in the drilled shaft. Do not exceed 60 hours after completion of the placement of the drilled shaft concrete.
5. If embedded thermal sensor wires are used, securely attach the wires to the full length of the longitudinal reinforcing steel, per the manufacturer's recommendations and at the same spacing and number as the CSL tubes.
6. If probes are used, verify the length of the tubes and pump water from the tubes prior to testing.
7. Perform TIP testing in the shafts designated for testing using either thermal probes in each CSL tube or the embedded thermal wire array, and in accordance with the ASTM Test Method D7949-14.
8. Immediately report potential local discontinuities indicated by locally low temperatures relative to the average temperature at that depth, or average temperatures significantly lower than the average temperatures at other depths to the Department.
9. If shaft discontinuities or thermal sensor/probe damage/defects are detected in the field, perform any confirmatory TIP testing deemed necessary by the TIP Testing Firm at no additional cost to the Department.

2.4.3 Test Reports

1. Submit a test report prepared by the TIP Testing Firm within 5 business days of completion of testing which, as a minimum, contains:
    a. Date of test;
    b. Plan Shaft No. and Reference Elevation;
    c. Schematic showing a plan view of the access tube locations;
    d. Graphical displays of all temperature measurements versus depth;
    e. Indication of unusual temperatures, particularly significantly cooler local deviations of the average at any depth from the overall average over the entire length;
    f. The overall average temperature. This temperature is proportional to the average radius computed from the actual total concrete volume installed (assuming a consistent concrete mix throughout). Radius at any point can then be determined from the temperature at that point compared to the overall average temperature;
    g. Variations in temperature between wires (at each depth) which may correspond to variations in cage alignment (where concrete volume is known, the cage alignment or offset from center should be noted); and
    h. Where shaft specific construction information is available (e.g. elevations of the top of shaft, bottom of casing, bottom of shaft, etc.), these values should be noted on all pertinent graphical displays.

  i. Drilled shaft radius calculations and the shaft quality, based upon the collected data, as well other available data, such as, as shaft alignment and wall profile from the SC Testing, top/bottom shaft/concrete elevations and concrete volume records collected during construction of the drilled shaft.
  j. A narrative portion of the report which addresses items a through i above.
2. Complete all reports using English units.

2.4.4 Evaluation of TIP Test Results

1. Allow direct communication between the TIP Testing Firm and the Department.
2. The Engineer will evaluate the TIP test results in the test report to determine whether or not the drilled shaft integrity is acceptable. Within 5 business days after receiving a test report, the Engineer will report to the Contractor whether the construction is acceptable or additional more detailed analyses are needed.
3. Perform TIP testing on the first shaft constructed. Continue with subsequent drilled shaft rock socket excavation and concrete placement only after receiving written approval and acceptance of the first shaft, based on the results and analysis of the TIP testing for the first shaft. Drilled shaft operations such as casing placement and overburden excavation will be allowed during the waiting period.
4. Continue with construction of the structure above the drilled shafts only after receiving written approval from the Engineer to do so, based on evaluation of the TIP and CSL test results.
5. If the TIP and the CSL records are inconclusive, the Engineer may require additional testing (such as Angled CSL, Crosshole Tomography, Singlehole Sonic Logging, or Sonic Echo/Impulse Response, etc.) or concrete cores to sample the concrete in question to verify shaft conditions. If either the TIP or CSL records are inconclusive, the Engineer may elect to require additional testing, based on the results of the conclusive TIP or CSL records. If core samples are needed, obtain cores with a minimum diameter of 2 inches, double tube core barrel at a minimum of four locations specified by the Department, unless directed otherwise by the Engineer. Unless directed otherwise by the Engineer, locate core holes approximately 6 inches inside the reinforcement such that they do not damage the reinforcement. For each core hole drilled, record a log with descriptions of inclusions and voids in the cored holes and submit a copy of the log to the Engineer. Place the cores in crates properly marked showing the shaft depth at each interval of core recovery. Transport the cores and logs to the Geotechnical Branch in Frankfort for inspection and testing. Grout the core holes in accordance with Section 2.3.2 above.

6. If the additional testing or evaluation of cores indicate that concrete for any drilled shaft on which additional testing or coring was required is acceptable, the Department will pay for the direct cost of additional testing and concrete coring and grouting by change order. If the additional testing or if evaluation of cores indicates that the concrete for any drilled shaft concrete is unacceptable, the additional testing and concrete coring and grouting will be at the expense of the Contractor.
7. If defects are found, the original structural designer will perform structural and/or geotechnical analyses, at the expense of the Contractor, based on the design criteria established for the structure to assess the effects of the defects on the structural performance of the drilled shaft. If the results of the analyses indicate that there is conclusive evidence that the defects will result in inadequate or unsafe performance under the design loads, as defined by the design criteria for the structure, the Engineer will reject the shaft.
8. If any shaft is rejected, provide a plan for remedial action to the Engineer for approval. Any modifications to the foundation shafts and/or other substructure elements caused by the remedial action will require calculations and working drawings by independent consultant(s) hired by the Contractor, at the expense of the Contractor. The calculations and working drawings will be reviewed by the Engineer. Begin remediation operations only after receiving acceptance from the Engineer for the proposed remediation. All remedial action will be at no cost to the Department and with no extension of contract time.

3.0 Measurement and Payment

3.1 Method of Measurement CSL Testing

The Department will pay for the authorized and accepted quantities of “CSL Testing” at the contract unit price per each shaft tested (production and technique drilled shafts). This will constitute full compensation for all costs associated with providing access for testing personnel and equipment, performing the CSL Testing in a single shaft, and reporting the results to the Engineer.

Installation of CSL Access Tubing is incidental to the applicable contract unit bid price for Drilled Shaft, Common, and Drilled Shaft, Solid Rock. This will constitute all costs and delays associated with installing the CSL Access Tubing in a single shaft, including but not limited to providing and installing access tubing, providing and installing all required bracing for access tubes, providing and placing grout in access tubes.

The Department will pay using a change order for the direct cost of additional testing and concrete coring, authorized by the Engineer, required to investigate shafts with inconclusive CSL records if evaluation of the additional testing or cores indicates that concrete for that drilled shaft is acceptable. This will constitute full compensation for all costs and delays associated with performing additional tests, obtaining and delivering concrete cores to the Geotechnical Branch, and grouting core holes.

3.2 Method of Measurement TIP Testing

The Department will pay for the authorized and accepted quantities of “TIP Testing” at the contract unit price per each shaft tested (production and technique drilled shafts). This will constitute full compensation for all costs associated with providing access for testing personnel and equipment, performing the TIP Testing in a single shaft, and reporting the results to the Engineer.

Installation of CSL/TIP Access Tubing and/or thermal sensor wires is incidental to the applicable contract unit bid price for Drilled Shaft, Common, and Drilled Shaft, Solid Rock. This will constitute all costs and delays associated with installing the CSL Access Tubing in a single shaft, including but not limited to providing and installing access tubing, providing and installing all required bracing for access tubes, providing and placing grout in access tubes.

The Department will pay using a change order for the direct cost of additional testing and concrete coring, authorized by the Engineer, required to investigate shafts with complex or inconclusive TIP records if evaluation of the additional testing or cores indicates that concrete for that drilled shaft is acceptable. This will constitute full compensation for all costs and delays associated with performing additional tests, obtaining and delivering concrete cores to the Geotechnical Branch, and grouting core holes.

3.3 Payment

The Department will pay for the completed and accepted quantities under the following. The Pay Unit of “Each” refers to each individual shaft.

Code	**Pay Item**	**Pay Unit**
21322NC	CSL Testing (6 tubes)	Each
21321NC	CSL Testing (4 tubes)	Each
24742EC	TIP Testing (6 tubes)	Each
24743EC	TIP Testing (4 tubes)	Each

The Department will consider payment as full compensation for all work required under this Section.

COORDINATE DATA SUBMISSION FORM

KYTC DIVISION OF STRUCTURAL DESIGN -- GEOTECHNICAL BRANCH

County Henderson

Date

Road Number US 60 over Green River

Survey Crew / Consultant Stantec

Contact Person

Item # 2-1080.00

Mars # 8675901D

Project # S-058-2017

Notes:

(circle one)

Elevation Datum NAVD88 Assumed

HOLE NUMBER	LATITUDE (Decimal Degrees)	LONGITUDE (Decimal Degrees)	HOLE NUMBER	STATION	OFFSET	ELEVATION (ft)
1004	37.86259449	-87.41338023	1004	508+46.2	21 Lt	424.1
1005	37.86248476	-87.41342449	1005	508+31.3	18.2 Rt	425.5
1006	37.86259877	-87.41334099	1006	508+57.6	22 Lt	424.4
1007	37.86253768	-87.41334488	1007	508+55.3	0.2 Rt	425.0
1008	37.86248765	-87.41335299	1008	508+52	18.2 Rt	425.6
1009	37.86267858	-87.41144725	1009	514+05	22 Lt	347.2
1010	37.86255793	-87.41143915	1010	514+05	22 Rt	346.7
1011	37.8626831	-87.4113435	1011	514+35	22 Lt	357.8
1012	37.86256239	-87.41133547	1012	514+35	22 Rt	357.3
1013	37.8626867	-87.4112571	1013	514+60	22 Lt	369.2
1014	37.862562	-87.41124801	1014	514+60.2	23.4 Rt	369.1
1015	37.8627072	-87.41088974	1015	515+58.50	22 Lt	364.1
1016	37.86258001	-87.41090858	1016	515+58.5	22 Rt	367.3
1017	37.86272259	-87.41040088	1017	517+07.5	22 Lt	362.4
1018	37.86259374	-87.41039248	1018	517+01.5	29 Rt	365.1

HOLE NUMBER	LATITUDE (Decimal Degrees)	LONGITUDE (Decimal Degrees)	HOLE NUMBER	STATION	OFFSET	ELEVATION (ft)
1019	37.86274881	-87.40990062	1019	515+58.50	23.8 Lt	359.7
1020	37.86262381	-87.40987753	1020	517+07.50	22 Lt	368.8
1021	37.8630476	-87.40941316	1021	517+07.50	119 Lt	359.6
1022	37.86278361	-87.40939208	1022	518+56.50	28.7 Lt	375.8
1023	37.86257582	-87.40938169	1023	518+56.50	47 Rt	406.0
1024	37.86253996	-87.4133736	1024	519+98.50	1.1 Lt	424.9
2001	37.86285671	-87.41370016	2001	507+60	121.5 Lt	427.7
2002	37.86244553	-87.41366847	2002	507+60	21.5 Rt	426.1
2003	37.86224953	-87.41365336	2003	507+60	100 Rt	427.2
2004	37.86286429	-87.41353485	2004	508+07	121.5 Lt	430.4
2005	37.86251279	-87.41348989	2005	508+13	7 Rt	425.4
2006	37.86231675	-87.41356928	2006	507+86	77 Rt	426.6
2007	37.86287184	-87.41335615	2007	508+58.5	121.5 Lt	421.0
2008	37.86274569	-87.41334769	2008	508+58.5	75.5 Lt	422.6
2009	37.86220199	-87.41339274	2009	508+35	121.5 Rt	427.8
2010	37.862679	-87.41335	2010	508+58.5	49 Lt	423.8
2011	37.862329	-87.413387	2011	508+35	89.5 Rt	427.0
CPT-1	37.86268916	-87.40976213	CPT-1	518+91	CL	368.5
CPT-2	37.86289629	-87.40941523	CPT-2	519+95	70 Lt	359.7
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