

MEMORANDUM

TO: John Moore, PE
Director, Division of Planning

FROM: Bart Asher, PE, PLS
Geotechnical Branch Manager
Division of Structural Design

BY: Erik Scott, PE 
Geotechnical Branch

DATE: January 24, 2017

Subject: Christian County
12F0 C35 D625 02 FH02 0410 C024 E143 9171507P
Item No. 2-381.00
Phase 1 Design Study for Pembroke Corridor
Preliminary Geotechnical Overview

The preliminary geotechnical overview for the subject project has been completed by American Engineers, Inc. This report was prepared in conjunction with the Phase 1 Design Study for the subject project, under Statewide Planning Contract. The project involves construction of a new connector from US 41 near the industrial park to KY 115 south of Pembroke. Additional geotechnical exploration and analyses will be required for the final design phase of the project. The attached report has previously been provided to the Design Consultant, QK4, Inc., and will also be made available on ProjectWise.

If you have any questions or need additional information, please contact the Geotechnical Branch at 502-564-2374.

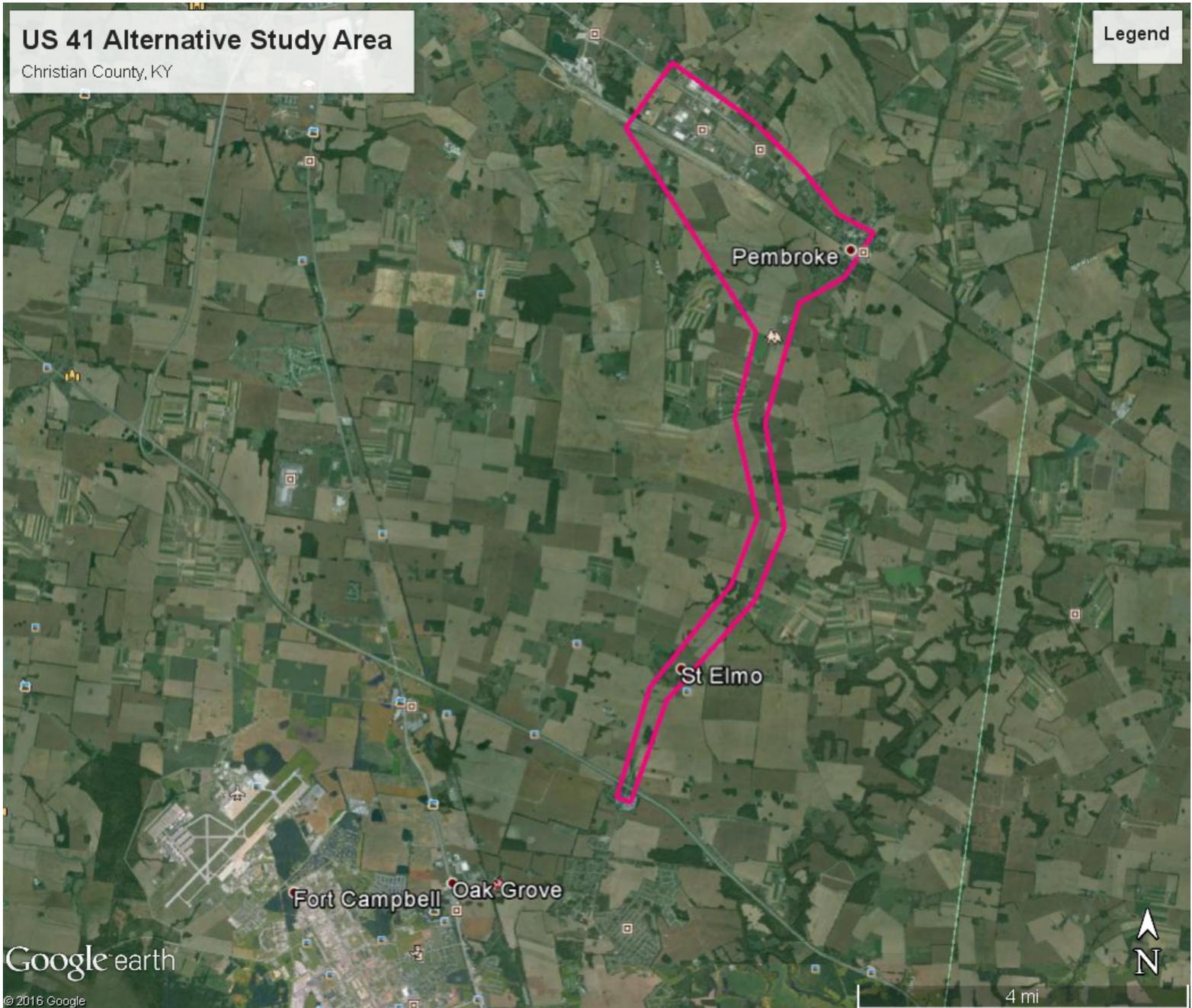
cc: **TEBM for Project Development (District)**
Division of Highway Design
Division of Planning
QK4, Inc.
American Engineers, Inc.

Attachment

US 41 Alternative Study Area

Christian County, KY

Legend



GEOTECHNICAL OVERVIEW REPORT P-015-2016

Pembroke Corridor Study
(US 41 and KY 115 to I-24)

Christian County, KY

Item No. 2-381.00

12F0 C35 D625 02 FH02 0410 C024 E143 9171507P

November 2016

DESIGNING YOUR FUTURE, TODAY.

AEI



November 11 ,2016

Mr. Tom H. Springer, AICP, CEP
Director: Planning and Environmental
Qk4, Inc.
1046 E. Chestnut Street
Louisville, KY 40204

Re: Geotechnical Overview Report
Pembroke Corridor Study
(US 41 and KY 115 to I-24)
Christian County, Kentucky
12F0 C35 D625 02 FH02 0410 C024 E143 9171507P
AEI Project No. 216-271

Dear Mr. Springer:

American Engineers, Inc. Field Services Center is pleased to submit this geotechnical overview that details the results of our site and mapping reconnaissance at the above referenced site.

The attached report describes the site conditions and near-surface geology and also details potential design recommendations for the proposed project. The Appendices to the report contains a karst potential map for the study area and an oil and gas well location map. Site photographs have also been included following the report.

We appreciate the opportunity to be of service to you on this project and hope to provide further support on this and other projects in the future. Please contact us if you have any questions regarding this report.

Respectfully,
AMERICAN ENGINEERS, INC.

A handwritten signature in blue ink that reads "Brad High".

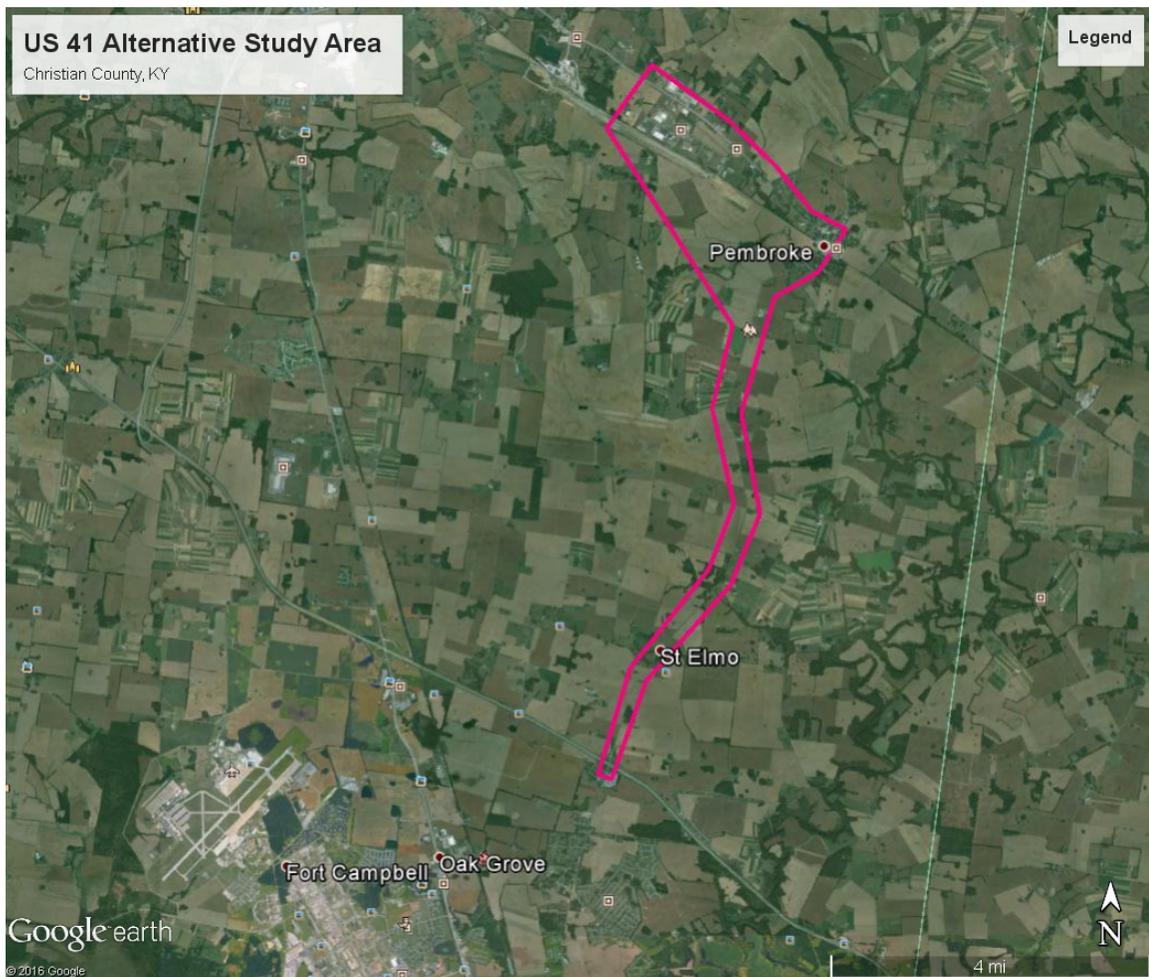
Brad High, PG
Project Geologist

A handwritten signature in blue ink that reads "Dennis Mitchell".

Dennis Mitchell, PE
Geotechnical Project Manager

Geotechnical Overview
Pembroke Corridor Study
(US 41 and KY 115 to I-24)
Christian County, Kentucky
Item No. 2-381.00

1. Project Description.....	2
2. Site Geology.....	3
3. Topography and Drainage.....	5
4. Geotechnical Considerations	6
5. Summary	9
Site Photographs	10



**Geotechnical Overview
Pembroke Corridor Study
(US 41 and KY 115 to I-24)
Christian County, Kentucky**

1. Project Description

The study area includes an area from Pembroke near the intersection with Duffy Way and trends west along US 41 toward Hopkinsville near the intersection with Krusteaz way. The study area also encompasses KY 115 from the north side of the city of Pembroke to just past the interchange with Interstate 24. The overall length of the corridor is about nine miles. The study area also includes an agricultural area south of the existing railway and west of KY 115. Approximate coordinates for the western section of the study area are 36.803103, -87.399573; approximate coordinates for the eastern section of the study area at Pembroke are 36.775244, -87.353704; and 36.679378, -87.405493 on the southern end of the study area near the I-24 interchange with KY 115.

The study area is dissected by several small streams and creeks, roadways, existing roadway structures, a railway and at least two cemeteries. The western portion of the study area near US 41 is heavy industrial, and trends to more commercial and residential east toward the city of Pembroke. The current alignment of KY 115 which lies in the study area is predominantly agricultural outside the city limits of Pembroke.

This geotechnical overview was conducted in relative accordance with the Scope of Work for Geotechnical Overviews for Planning Studies provided by KYTC Planning Division, as well as Section 801 of the Kentucky Transportation Cabinet Geotechnical Manual. The study was conducted during September and October, 2016 and included field reconnaissance and geologic research of available geologic and topographic quadrangle maps, soil survey of Christian County,

Kentucky, as well as online resources available from the Kentucky Geological Survey and the United States Geological Survey. Past reports from geotechnical investigations of portions of the existing roadways and structures in the area were also reviewed in preparation of the overview.

2. Site Geology

United States Geological Survey (USGS) 7.5-minute geologic quadrangle maps were reviewed (*Geologic Map of the Hopkinsville Quadrangle, Christian County, Kentucky, Klemic, 1967; Geologic Map of the Pembroke Quadrangle, Christian and Todd Counties, Kentucky, Moore, 1967; Geologic Map of the Oak Grove Quadrangle, Kentucky- Tennessee, Klemic, 1966; and Geologic Map of the Hammacksville Quadrangle, Kentucky-Tennessee, Klemic, 1966*) for the study area. Available geologic mapping indicates the study area is underlain primarily by, in order of descending order of lithology, Quaternary-aged alluvium, the Bethel Sandstone, Renault Limestone and the Ste. Genevieve Limestone Formations.

Mapping indicates the Quaternary-aged alluvium consists of unconsolidated clay, silt, sand and gravel. Gravel within the alluvium consists mainly of chert and limestone fragments. Alluvium in the study area will typically be encountered near stream valleys. The majority of the alluvial deposits are located in the vicinity of Pembroke where any existing or new roadways will cross streams.

Mapping describes the Bethel Sandstone Formation as being comprised of sandstone, siltstone, shale and limestone. The sandstone is commonly light yellowish gray to grayish orange, medium to very fine grained, quartzose, moderately well sorted, thin to thick bedded, locally crossbedded, friable, porous and permeable. The sandstone of the formation is commonly slumped into sinkholes or depressions along bluffs and weathers to a sandy soil containing few sandstone fragments. The remaining rock types in the Bethel Sandstone are less predominant and commonly intertongue with the sandstone bedrock of the

formation. The Bethel Sandstone Formation is indicated to exist at the highest elevations in the northern part of the study area.

The Renault Limestone Formation primarily contains limestone with lesser instances of shale. The limestone is typically very light to medium gray in color, mostly fine to medium grained, thin to thick bedded, fossiliferous, oolitic in part, silty and dolomitic. Chert occurs within the formation, particularly near the base. Shale of the formation is gray and greenish gray, occurs as thin partings and beds from a few inches to as much as four feet thick. Residual soils weathered from the Renault Limestone Formation are often yellowish brown and silty in nature.

The majority of the study area is indicated to be underlain by the Ste. Genevieve Limestone Formation. The Ste. Genevieve Limestone Formation is comprised predominantly of limestone. Dolomite and shale may also be encountered in the formation in the northern parts of the study area. The limestone is typically white to very light gray and gray in color, coarse grained to aphanitic in texture, medium thick bedded, oolitic, argillaceous, fossiliferous and cherty in part. Residual soils weathered from the Ste. Genevieve Limestone are typically variably reddish colored clays which exhibit moderate plasticity.

Karst potential mapping provided by the Kentucky Geologic Survey indicates that the study area exhibits very high karst potential in areas underlain by the Ste. Genevieve Limestone Formation and high karst potential in areas underlain by the Renault Limestone. The majority of the study area is underlain by these two formations. Numerous sinkholes were also indicated on karst potential mapping and noted during the site reconnaissance, particularly south of U.S. 41 and south of Pembroke. Faulting was also noted in the region during review of geologic mapping, however no faults appeared to lie within the study area. One minor unnamed east-west trending fault was noted east of the KY 115 corridor just

north of Anderson Road. More significant faulting was noted north of US 68 but is not expected to impact any construction in the study area.

Regional dip of the area was reviewed based on structure contours drawn on the base of the Ste. Genevieve Limestone Formation on geologic mapping. Regional dip of the study areas was determined to trend toward the northwest ranging from about 20 to 40 feet per mile, or about 0.4 to 0.8 percent. Geotechnical reports reviewed indicate that the residual soils within the potential new corridors typically classify as moderate to high plasticity clay soils with USCS Classifications of CL and CH, with lesser instances of CL-ML, SC or ML. Geotechnical reports also indicate depths to bedrock will likely vary widely, as in most areas underlain by soluble bedrock. Published mapping indicated both active and abandoned quarries to lie within each quadrangle, however none were noted proximate to the proposed corridors during field reconnaissance.

3. Topography and Drainage

The study areas lie within the western Pennyryle physiographic region of Kentucky. Topographic relief throughout the project area ranges from a high of approximately 650 feet in the western section of the study area to a low of approximately 527 south of St. Elmo near the KY 115 and I-24 interchange based upon review of topographic mapping. Generally, the topography of this area is described as a karst landscape, characterized by red clay soils, numerous sinkholes and depressions, gently rolling hills and small streams and creeks. The limestone bedrock in this area is highly soluble and prone to dissolution resulting in the development of sinkholes, caves, springs and other karst features.

Surface runoff in the area is typically intercepted by surface depressions and sinkholes or small intermittent streams. In general, low-lying areas in karst terrain or sinkhole plains such as the study area, will tend to exhibit soft, silty and

wet soils. These areas will also be more prone to sinkhole collapse during and following construction of any new roadway or structures.

Underground drainage is a function of surface and groundwater flows that are controlled by the nature of these rocks and the associated surface features. Slopes generally control the runoff from precipitation and stream drainage, with ridgelines forming drainage boundaries. Underground water in most watersheds and drainage basins tend to follow the lay of the land. Yet, in areas containing soluble limestone or karst regions, the underground drainage may differ from the boundary of its surface watershed; flowing through caves, cracks or faults in the rocks beneath surface ridges. This phenomenon is typically referred to as misbehaved karst drainage (Kentucky Division of Water).

4. Geotechnical Considerations

- Subgrade soils which lie within the study area are anticipated to have a design CBR value ranging from 3 to 5. Chemical treatment, such as lime stabilization may be desired to effectively stabilize road subgrades. In areas where rock is encountered during roadway excavations, it should be considered for use as a more affordable yet effective alternative.
- Wet areas could require stabilization for embankment construction. Likewise, subgrade soils under existing pavements could be very wet and might require stabilization if pavements are removed due to grade changes, etc.
- Any open sinkholes or solution cavities identified within the construction limits that are not utilized for drainage purposes should be filled and/ or capped in accordance with Section 215 of the current edition of the Standard Specifications for Road and Bridge Construction.
- Sinkholes were noted within the study area both during field reconnaissance and from review of geologic mapping. Any sinkholes utilized for drainage purposes for new roadway construction should incorporate adequate measures to minimize water infiltration into the subgrade and erosion control measures to minimize siltation of open sinkholes and adhere to KYTC Drainage policy.

- High plasticity clays may be encountered within the study area. High plasticity clays tend to shrink and swell with corresponding changes in moisture content. These areas will best be delineated after a thorough geotechnical investigation and subsequent lab testing. Treatment methods will vary dependent upon lateral and vertical extent of any high plasticity clays. Chemical treatment of subgrade soils such as lime or cement is one method to minimize the shrink/ swell potential of expansive clays.
- Any new structures or existing structures scheduled for widening as part of the roadway realignment are likely to be designed for nonyielding foundations. Yielding foundations may require stabilization if soft soils are encountered as indicated in previous structure reports for the area. Specific site investigations will be required for any new structures or additions to existing structures once locations are known.
- Adequate drainage will be of primary concern with any new design or new construction in the area to minimize environmental impacts by surface runoff into the underlying karst network. Proper management of surface water will also lessen the occurrence of sinkhole dropouts during construction. Mitigation of surface runoff should be performed by silt checks, silt traps, sediment basins and lined ditches where appropriate. Siltation of sinkholes should be avoided, especially those to remain open after construction.
- Roadway embankments and cut slopes will likely be required for construction of any new roadway or widening of the current roadway realignment. Based on prior experience with residual soils weathered from the Ste. Genevieve Limestone and Renault Limestone Formations, embankments constructed at 2H:1V or flatter will likely provide an acceptable factor of safety for embankments less than 30 feet in height. Roadway embankments over approximately 30 feet may require flattening to as much as 3H:1V. Soil cuts in the residual soils can be problematic due to softening of the clays upon exposure in the cuts. Soil cuts deeper than 20 feet may require slopes flatter than 2H:1V for slope stability. Based on review of the KYTC Geotechnical Manual, typical cut slope configurations for massive limestone of ½H:1V will likely be used. During design of cut slopes in bedrock, the presence of joints, fractures, solution features and crossbedding should be taken into consideration.
- Oil and gas wells, many of which have been abandoned, were identified through review of online mapping review of the study area. Any oil or gas wells identified prior to or during construction should be closed in

accordance with Section 708 of the current edition of the Standard Specifications for Road and Bridge Construction. Approximate locations of mapped wells are indicated on a drawing at the conclusion of this report. Locations were derived from the oil and gas well database on the Kentucky Geological Survey database online.

- Numerous domestic water wells and several monitoring wells were indicated to lie within the study area upon review of online mapping. Any water wells, cisterns, manholes or catch basins not incorporated into any new design and identified prior to or during construction should be closed in accordance with Section 708 of the current edition of the Standard Specifications for Road and Bridge Construction.
- A list of previously completed Geotechnical Investigations proximate to the study area is included below. These reports can be accessed through the KYTC Geotechnical Branch Database.

List of Projects & Reports

Project ID	Project Type	Route	Project Description
R-005-2005	Roadway	KY 115	KY 115 & KY 911 Intersection
R-023-1989	Roadway	KY 115	Interchange at KY 115 and I-24
P-003-2013	Planning		Hopkinsville Small Urban Area Study
R-002-1993	Roadway	US 41	Nashville Road Widening
S-041-1993	Culvert	US 41	6'x5' RCBC Extension @ Sta. 61+22.97
S-005-2011	Bridge Widening	US 41A	US 41A over Rock Ridge Branch
R-051-2001	Roadway	US 41	US 41-Pembroke to Hopkinsville Road
S-010-2002	Culvert	US 41	Double 10'x4' RCBC @ Sta. 316+56
S-011-2002	Culvert	US 41	10'x3' RCBC @ Sta. 334+78
S-012-2002	Culvert	US 41	Double 9' x 6' RCBC @ Sta. 369+27
S-013-2002	Culvert	US 41	8'x3' RCBC @ Sta. 381+08
S-014-2002	Culvert	US 41	4'x4' RCBC @ Sta. 421+78
S-015-2002	Culvert	US 41	4'x3' RCBC @ Sta. 428+23
S-016-2002	Culvert	US 41	6'x4' RCBC Extension @ Sta. 450+40
S-017-2002	Culvert	US 41	6'x5' RCBC Extension @ Sta. 505+84
L-024-2007	Sinkhole	CS 5127	Sinkhole affecting both driving lanes and shoulder
S-104-1994	Culvert	SE Bypass	14'x7'x140' RCBC @ Sta 52+42.1, CSX Railroad
S-107-1994	Bridges	SE Bypass	Twin four-span bridges over South Fork of Little River

5. Summary

Karst terrain in the study area will be likely be the most detrimental factor to any new construction in the area. The Renault Limestone and Ste. Genevieve Limestone Formations are typically the uppermost bedded formations which underlie each of the proposed corridors. Each of these formations exhibit significant potential for karst impacts during construction, as indicated on karst potential mapping. A karst potential map of the study area is included at the conclusion of this report. Soft, silty soils also may be encountered in low lying areas, especially in surface depressions.

Much of the study area is also highly developed which can mask the existence of karst features such as sinkholes and surface depressions. At the time of the field review much of the southern area was covered in row crops as well as partially wooded which made it difficult to identify individual sinkholes. While any new construction within the study area will not likely be at any greater risk to ground subsidence or other impact from karst than existing roadways and structures which lie within the study area, a site specific geotechnical investigation will provide critical information with regard to karst potential, problematic soils and other pertinent information for design. Two electric substations and several commercial and manufacturing facilities exist in the western portion of the study area along the existing US 41 alignment, especially on the south side of the alignment. It may be desirable for any new route to avoid these areas to minimize the potential for environmental concerns associated with roadway construction.

Site Photographs



Figure 1 Typical surface depression near KY 115



Figure 2 Rolling karst terrain along KY 115



Figure 3 Private drywell installation near KY 115



Figure 4 Overhead electric transmission lines crossing KY 115



Figure 5 Pavement/ subgrade failure, common on KY 115



Figure 6 Pembroke Road Electric Substation



Figure 7 Industrial Park Electric Substation



Figure 8 Rosedale Cemetery, KY 115, south of Pembroke



LEGEND



- Qal** Alluvium (Quaternary - Quaternary)
- Uib** Hardinsburg Sandstone (Upper Mississippian - Upper Mississippian)
- Mgh** Haney Limestone Member (Upper Mississippian - Upper Mississippian)
- Mgb** Big Clifty Sandstone Member (Upper Mississippian - Upper Mississippian)
- Mgc** Beech Creek Limestone Member (Upper Mississippian - Upper Mississippian)
- Mgcc** Beech Creek Limestone Member and Cypress Sandstone (Upper Mississippian - Upper Mississippian)
- Mc** Cypress Sandstone (Upper Mississippian - Upper Mississippian)
- Mpr** Paint Creek Limestone, Bethel Sandstone, and Renault Limestone (Upper Mississippian - Upper Mississippian)
- Mpc** Paint Creek Limestone (Upper Mississippian - Upper Mississippian)
- Mbe** Bethel Sandstone (Upper Mississippian - Upper Mississippian)
- Mre** Renault Limestone (Upper Mississippian - Upper Mississippian)
- ss** Unnamed sandstone (Upper Mississippian - Upper Mississippian)
- Msg** St. Genevieve Limestone (Upper Mississippian - Upper Mississippian)
- Msgs** St. Genevieve sandstone and shale (Upper Mississippian - Upper Mississippian)
- Msl** St. Louis Limestone (Upper Mississippian - Upper Mississippian)



REVISIONS	
NO.	DESCRIPTION

GEOLOGIC QUADRANGLE MAP

CLIENT:
QK4, INC.

PROJECT:
Pembroke Corridor Study (US 41 and KY 115 to I-24) Christian County, KY
Item no. 2-381.00

PLANS PREPARED AND SUBMITTED BY:
AEI
AMERICAN ENGINEERS, INC.
A PROFESSIONAL ENGINEERING FIRM
20701 E. 17th AVE.
DENVER, CO 80232
Tel: (303) 751-1000
Fax: (303) 751-1001
www.aei.com

SCALE:
NTS

DATE:
10-12-16

DRAWN BY:
S.COOTS

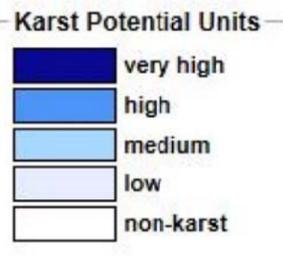
CHECKED BY:
B. HIGH

FILE:
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US 41 Pembroke\Report\Map
Pembroke_GQ_Map.dgn

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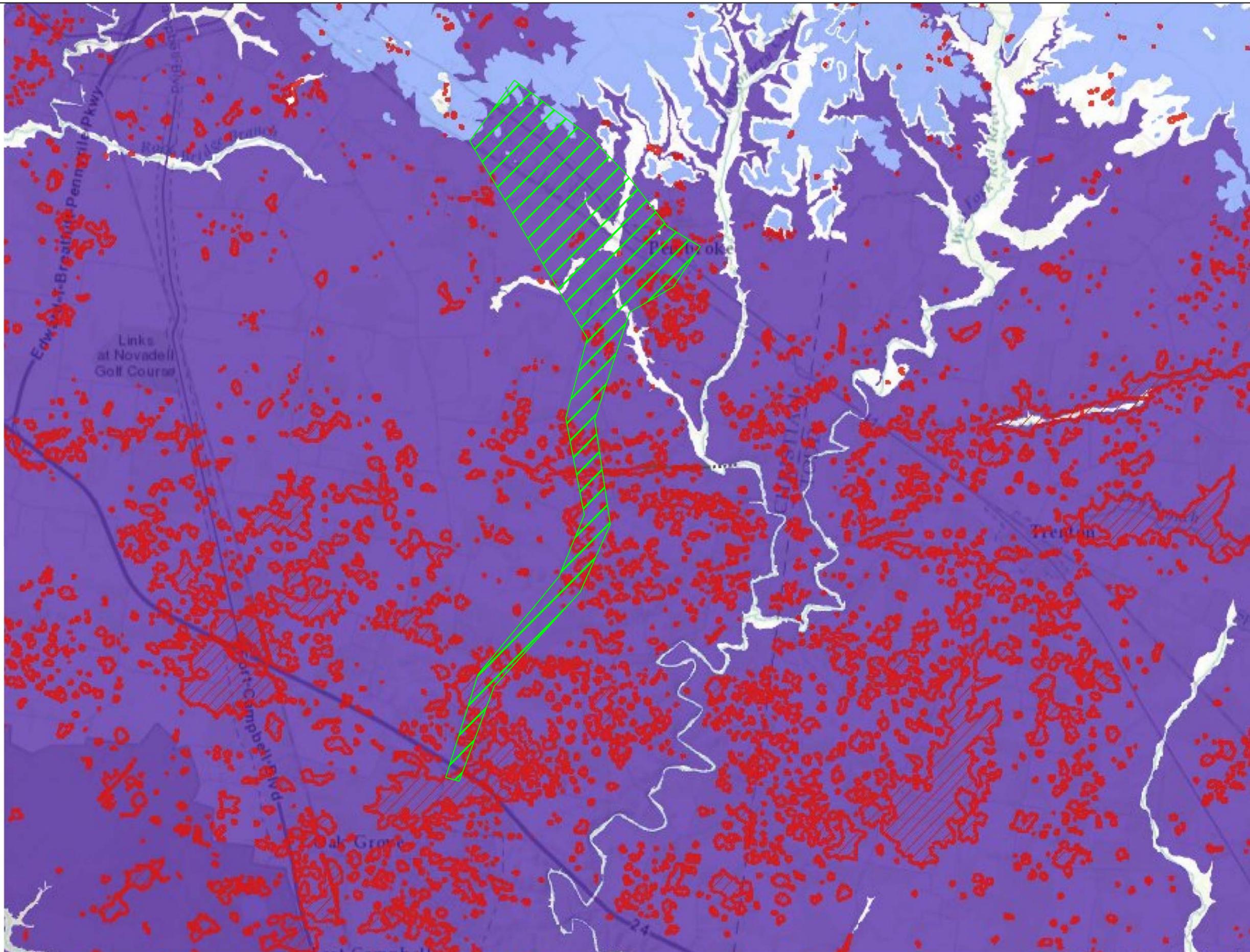


LEGEND



 APPROXIMATE STUDY AREA

 SINKHOLE



REVISIONS	
NO.	DESCRIPTION

KARST POTENTIAL MAP

CLIENT: **QK4, INC.**

PROJECT: **Pembroke Corridor Study (US 41 and KY 115 to I-24) Christian County, KY**
Item no. 2-381.00

PLANS PREPARED AND SUBMITTED BY:
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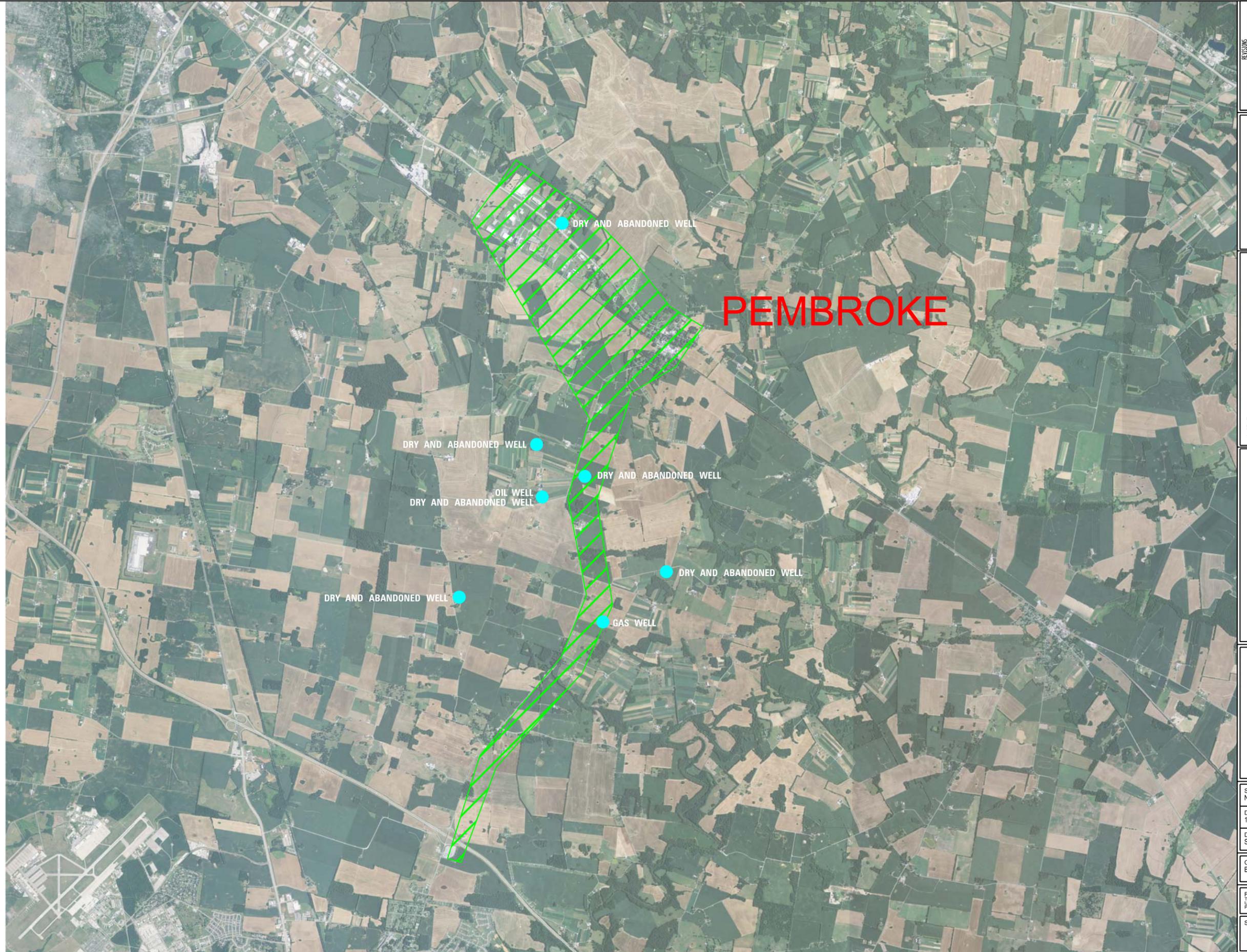
DATE: 10-12-16

DRAWN BY: S.COOTS

CHECKED BY: B. HIGH

FILE: T:\Geotech_Support\KYTC216-XXX US 41 Pembroke\Report\Map\Pembroke Karst Map.dgn

SHEET: **Q1**



LEGEND

 APPROXIMATE STUDY AREA

 APPROXIMATE LOCATION OF EXISTING OIL OR GAS WELLS

NO.	DATE	DESCRIPTION

SOUTHERN STUDY AREA
OIL AND GAS WELL
LOCATIONS

CLIENT:

QK4, INC.

PROJECT:
Pembroke Corridor Study
(US 41 and KY 115 to I-24)
Christian County, KY
Item no. 2-381.00

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FILE:
T:\Geotech_Support\KYC216-000
US 41 Pembroke\Report\Mapa
Pembroke Oil Gas Map.dgn

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