# APPENDIX G:

## Geotechnical Assessment

KSWA

[KS WARE & ASSOCIATES]



# REPORT OF GEOTECHNICAL OVERVIEW

## Owensboro Outer Loop
## Owensboro, Kentucky

*Prepared For:*
HMB Professional Engineers, Inc.
3 HMB Circle
Frankfort, Kentucky 40601

*Prepared By:*
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350 Cal Batsel Road
Bowling Green, Kentucky 42101

KSWA Project No. 500-21-0004

July 15, 2021

July 15, 2021

Ms. Lindsay Walker, PE, PTOE, AICP
HMB Professional Engineers, Inc.
3 HMB Circle
Frankfort, KY 40601

**Subject:** **Report of Geotechnical Overview**
**Owensboro Outer Loop**
**Owensboro, Kentucky**

Dear Ms. Walker:

K. S. Ware and Associates, L.L.C. (KSWA) is pleased to present to you this this geotechnical overview report for the Owensboro Outer Loop project in Owensboro, Kentucky. The attached report summarizes the project information provided to us, describes the site conditions observed during our site reconnaissance, and summarizes the general site geologic conditions. The Appendices include figures depicting topographic information and mapped geologic information.

We appreciate the opportunity to be of service to you on this project. Please contact us if you have any questions regarding this report. We look forward to serving as your geotechnical consultant on the remainder of this project.

Respectfully submitted,

**K. S. Ware and Associates, L.L.C.**



Nathan Long, P.E
VP of Geotechnical Engineering
KY PE No. 35624

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VP of Engineering

Enclosures: Report of Geotechnical Overview

Distribution: File (1)



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**APPENDICES**

# 1.0 INTRODUCTION

## 1.1 PROJECT INFORMATION

The project consists of evaluating the feasibility of an outer looper around Owensboro in Daviess County, Kentucky. A specific alignment has not been proposed at this time, but would generally be south of Highway 60. The study area is shown on the Project Site Map in Appendix 1. We anticipate a new roadway through the study area would include between 15 and 30 miles of new roadway embankments and numerous new bridges at overpasses and creeks.

## 1.2 PURPOSE AND SCOPE OF STUDY

The purpose of the study was to perform a geotechnical overview for the project to address geotechnical issues that may affect the potential improvement options discussed above. To identify potential geotechnical issues, we performed a desktop study of available published geotechnical data/information for the proposed project area. We also performed a site visit to observe the project area, paying particular attention to existing cut and fill embankments within the area. We performed the geotechnical overview in accordance with Section 801 of the KYTC Geotechnical Guidance Manual. Below is a list of KYTC geotechnical reports reviewed as part of this study:

- Bridge and roadway reports associated with the US-60 Bypass Extension Project. KYTC geotechnical report numbers are SA-002-2009, SA-003-2009, SA-007-2010, SA-025-2008, SA-026-2008, SA-030-2008, and R-022-2005.
- US-60 Widening project west of Owensboro (R-008-1991)
- Lewis Street Widening (R-019-1986)
- US-60 east of Owensboro (R-022-1993)
- KY-144 Realignment (R-022-2014)
- US-60 Reconstruction west of Owensboro (R-031-2015)
- KY-54 Widening (R-039-2015)
- KY-2121 Widening (R-095-2007)
- US-60 Culvert (S-076-1993)
- Graves Lane 9CR-1053) Bridge Replacement (SA-003-2020)

# 2.0 SITE GEOLOGY

## 2.1 PHYSIOGRAPHIC PROVINCE

Owensboro is located in the Western Coal Field Physiographic Region, which is characterized by hilly upland of low to moderately high relief. The bedrock of the Western Coal Field typically consists of sandstone, shale, and coal of the Pennsylvanian age. The bedrock is typically overlain by Quaternary soils such as alluvial, loess, outwash, and lacustrine deposits.

## 2.2 GEOLOGIC FORMATIONS

The Kentucky Geological Survey's (KGS) online Geologic Map Service indicates 7 mapped geologic units within the study area. Appendix B includes a Geologic Map depicting each of these units, which are further discussed below.

### 2.2.1 QAL –ALLUVIUM

Alluvium is mapped adjacent to the Ohio River and along portions of its tributaries. The alluvium is typically composed of varying quantities of clay, silt, sand, and gravel. Sand and fine-grained gravel are generally confined to alluvium along the Ohio River. A blanket of silty clay and sandy silt mantle the Ohio River floodplain surface and along larger creeks.

### 2.2.2 QL – LOESS

Loess is mapped in areas at the west and east ends of the study area. The loess consists of silt, commonly clayey to sandy, deposited by wind. The greatest thickness is adjacent to the Ohio River valley and thins away from the valley. The maximum mapped thickness is about 25 feet.

### 2.2.3 QTD – TAZEWELL OUTWASH

This unit is mapped within the majority of the study area and was deposited by glacial outwash in the Ohio River valley. The outwash deposits are composed of varying quantities of clay, silt, sand, and gravel. Clay occurs mainly in the upper part and boulders overlie the bedrock in some areas. The outwash merges with alluvium and is mapped with a maximum thickness of approximately 170 feet.

### 2.2.4 QCD – CARY OUTWASH

This unit is mapped at the west end of the study area and was deposited by glacial outwash deposits in the Ohio River valley. The outwash deposits are composed of sand and gravelly sand that are generally indistinguishable from Tazewell deposits. Maximum thickness is approximately 30 feet.

### 2.2.5 QE – EOLIAN SAND DUNE

This unit is mapped along ridges at the west and northern portions of the study area. These dunes consist of windblown sand and silt deposits on ridges of the upper Tazewell Outwash.

#### 2.2.6 PC– CARBONDALE AND PT– TRADEWATER FORMATIONS

These formations are mapped at higher elevations at the east end of the study area. The formations consist of shale, siltstone, sandstone, and coal.

### 2.3 FAULTS

The KGS' online Geologic Map Service depicts several mapped faults within the west and northeast ends of the project area. Additional faults are also mapped just south of the study area. These faults are associated with the Rough Creek Fault System and are located within the bedrock that underlies the outwash deposits in these areas. Additional geotechnical information may be needed for structures in these areas. However, we do not expect them to have a detrimental effect on the project.

### 2.4 COAL MINES

A coal mine mapped as inactive is present at the west end of the study area as shown on the Coal Mine Map in Appendix C. The area is depicted on the Geologic Map of Part of the Owensboro West Quadrangle (KGS, 1971) as the Bon Harbor Hills. According to the referenced map, the No. 9 coal bed was mined extensively in this area through shaft and drift mines. The map also indicates that much of the coal has been removed on either side of US-60 in this area. The No. 9 coal bed is within the Carbondale Formation at elevations between about 375 and 450 feet and averages about 4½ feet thick.

### 2.5 OIL AND GAS WELLS

KGS' online Geologic Map Service depicts numerous oil and gas wells within the study area as shown on the Oil and Gas Well Map in Appendix D. The majority of the wells are shown as dry and abandoned, but there are still many active oil and natural gas wells shown within the study area, especially west of Owensboro between US-60 and Auburndale Parkway. The majority of the oil has been produced by limestone and sandstone units at depths greater than 800 feet. The Waltersburg Formation has been the main producer of natural gas along with the Palestine and Tar Springs Sandstones. These formations are generally at depths greater than 1,000 feet.

### 2.6 SEISMICITY

The subject area is located within an active seismographic area that it is influenced by activity associated with the Wabash Valley and New Madrid seismic zones. The hazards associated with seismic activity at the site will need to be evaluated during the design phase geotechnical investigation. However, based on our review of AASHTO's LRFD Bridge Design Specifications (8th Edition), we anticipate a Seismic Performance Zone of 1 for the bridges along the alignment. We also anticipate Site Classes will range from C (Soft Rock) to D (Stiff Soil) depending on overburden thickness at the structure.

## 3.0 SITE CONDITIONS

On June 25, 2021, KSWA's Nathan Long, PE performed a site reconnaissance to review the site conditions within the study area. The reconnaissance was performed by visually observing features along existing roadways while driving through the area. We also occasionally stopped along the shoulder to take photographs, which are included in Appendix E.

The project area primarily consists of open, agricultural fields. Occasional wooded areas were also observed, especially in areas higher in elevation or along creeks. We estimate existing cut and fill slopes were generally less 20 feet each for the existing highways in this area. The cut and fill slopes appear to generally be at about 2H:1V or flatter. We did not observe any rock cuts or outcrops along the existing alignments. Surface drainage within the project area is generally directed towards various creeks that flow west to the Green River, which is a tributary of the Ohio River.

# 4.0 GEOTECHNICAL CONSIDERATIONS

Based upon observations from our site reconnaissance, our review of the readily available reports and maps, and KSWA's understanding of the project, KSWA reached the conclusions provided herein. These general conclusions should be preliminary for planning purposes only. A detailed geotechnical investigation with borings, laboratory testing, and geotechnical analyses should be performed for the design phase of the project.

## 4.1 PAVEMENT SUBGRADE

Based on the reviewed information, we estimate the subgrade for new roadways in the project area will primarily consist of clay and silt with some sand. The upper clay and silt in this area are moisture sensitive and will likely be soft and wet. Therefore, stabilization prior to new fill placement will likely be required for the roadway's subgrade and is typically performed by constructing a working platform of granular soils or aggregate wrapped in geotextile fabric. Additionally, the final subgrade is often stabilized using chemical modifications (i.e., lime or cement) to protect the final subgrade. We note that cuts for the project are unlikely to produce sufficient quantity of rock for stabilization.

Based on the classification of the anticipated subgrade soil within the project area, we generally expect the soil will have design CBR values ranging from 3 to 6.

## 4.2 EMBANKMENT SLOPES

We estimated the existing observed embankment fills were constructed at 2H:1V or flatter inclinations. We anticipate similar slope inclinations can be used for new fill slopes, assuming proper fill placement and subgrade evaluations. We expect soil cuts will also be required for the project. Cut slopes in soil may be assumed to be between 2H:1V and 2.5H:1V based on our review of previous reports within the study area.

We expect that fill embankments over 20 feet tall will be required at new bridge approaches for the project. Based on our review of previous reports, we anticipate that a waiting period of up to 6 months may be required to allow for embankment settlement to occur prior to bridge construction and reduce downdrag loads on the bridge abutment foundations. Vertical drains or other methods could be used to reduce the anticipated consolidation time.

A detailed geotechnical investigation should be performed during the design phase to analyze slope stability and settlement for embankments over 20 feet tall and cut slopes over 10 feet tall.

## 4.3 BRIDGES STRUCTURES

As previously mentioned, we expect new bridges would be needed at roadway overpasses and creeks. Based on our review of available geotechnical and geologic information, we expect the foundations will primarily consist of driven friction pile foundations. However, it may be possible for bridges further from the river to be supported by piles end bearing on the underlying bedrock. We expect culverts may be supported by a yielding shallow foundation.

A detailed geotechnical investigation should be performed during the design phase of the project to determine the appropriate foundation system for bridge and culvert structures.

### 4.4 COAL MINE

An inactive coal mine is located at the west end of the study area, in the Bon Harbor Hills area. Also, a mine shaft is mapped along one of the preliminary roadway alignments. Additional geotechnical investigation will be required to determine impact if the final alignment traverses this mine area.

### 4.5 OIL AND GAS WELLS

There are numerous oil and gas wells located within the study area, especially west of Owensboro between US-60 and Auburndale Parkway. The design phase should include surveying potentially impacted wells and contacting the Department of Natural Resources to determine current status and production of the wells. Additional construction costs may be incurred for addressing impacted wells.

### 4.6 PYRITIC MATERIALS

The referenced geologic maps indicate the shale and coal seams within the Carbondale and Tradewater Formations is pyritic and has the potential to produce acidic runoff if exposed in embankment or cut areas. If new excavations are required in this area, then additional testing during the design geotechnical study should be performed to evaluate the potential for acidic runoff and provide recommendations for mitigation, which may include capping cut slopes, encapsulating fill embankments, and/or treating stormwater runoff.

## 5.0 QUALIFICATIONS OF RECOMMENDATIONS

KSWA's professional services were performed, findings obtained, and recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. KSWA is not responsible for the conclusions, opinions, or recommendations made by others based upon the data included herein. The scope of this geotechnical exploration did not include assessment or exploration for the presence or absence of hazardous or toxic materials in the soil, rock, groundwater, surface water, or air within or beyond the site.

# APPENDIX A

## PROJECT LOCATION MAP

7/9/2021

# Topographic Map

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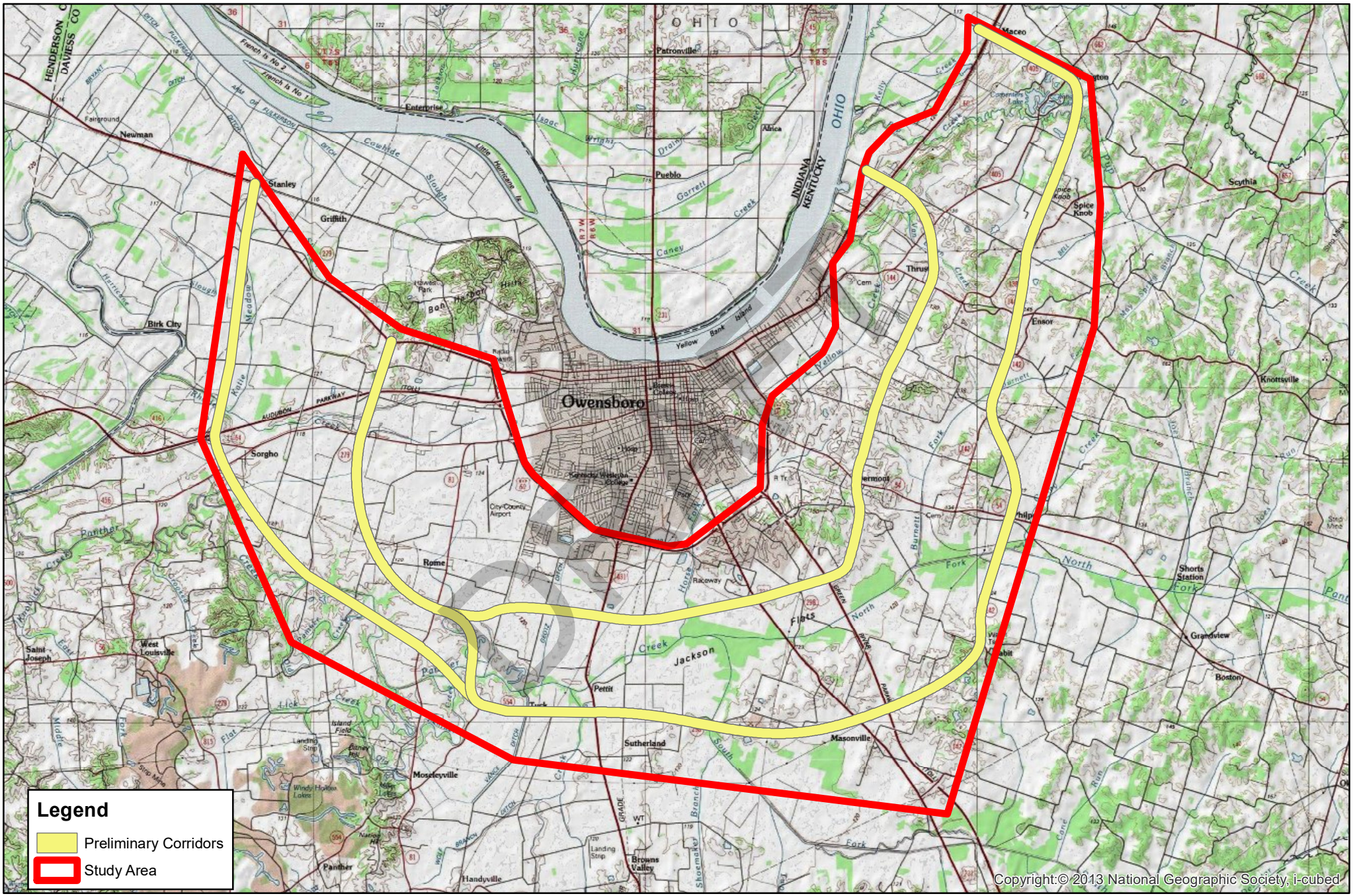


Owensboro Outer Loop Study
Daviess County, Kentucky
KSWA Project No. 500-21-0004

0 1 2 3 4 Miles

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# APPENDIX B

GEOLOGIC MAP

# Geologic Map

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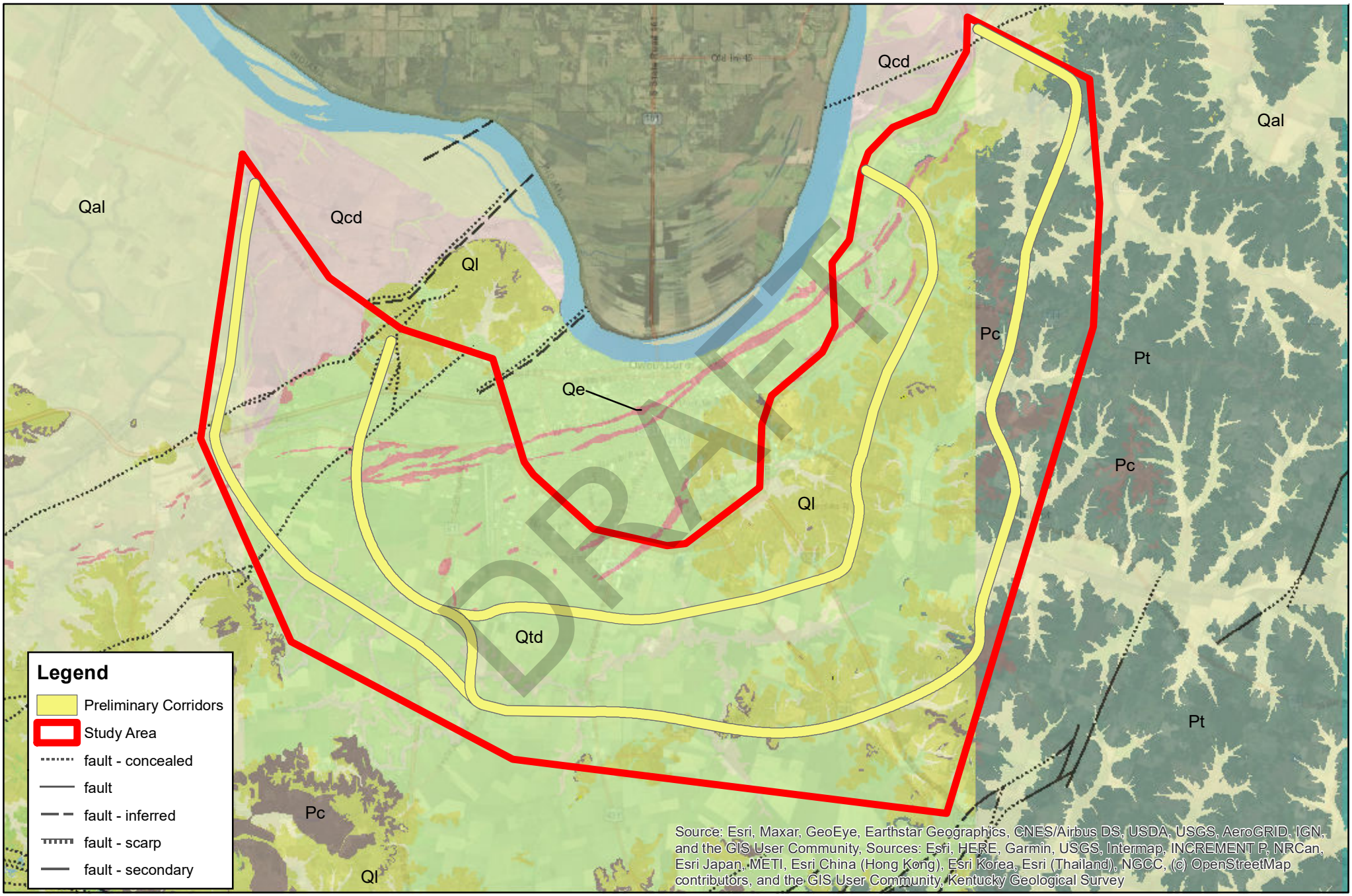


Qal - Alluvium
Ql - Loess
Qcd - Cary Outwash
Qtd - Tazewell Outwash
Qe - Eolian Sand Dune
Pc - Carbondale Formation
Pt - Tradewater Formation

Geologic information obtained from Kentucky Geological Survey's on-line GIS database.

Owensboro Outer Loop Study
Daviess County, Kentucky
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0 1 2 3 4 Miles

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# APPENDIX C

COAL MINE MAP

7/9/2021

# Coal Mine Map

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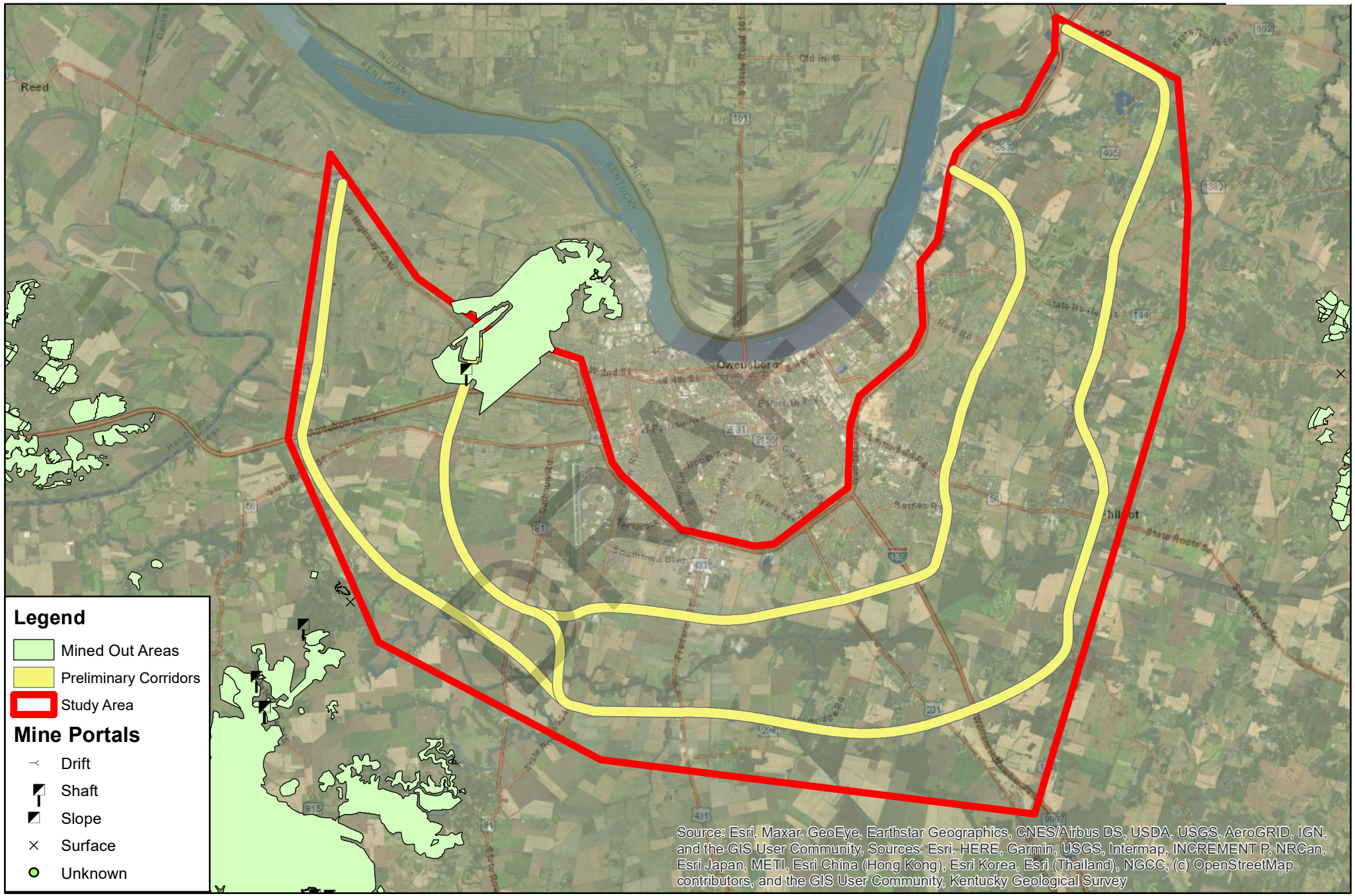


Mine data obtained from online
Kentucky Mine Mapping Information System.

Owensboro Outer Loop Study
Daviess County, Kentucky
KSWA Project No. 500-21-0004

0 1 2 3 4 Miles

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# APPENDIX D

## OIL AND GAS WELL MAP

7/9/2021

# Oil and Gass Well Map

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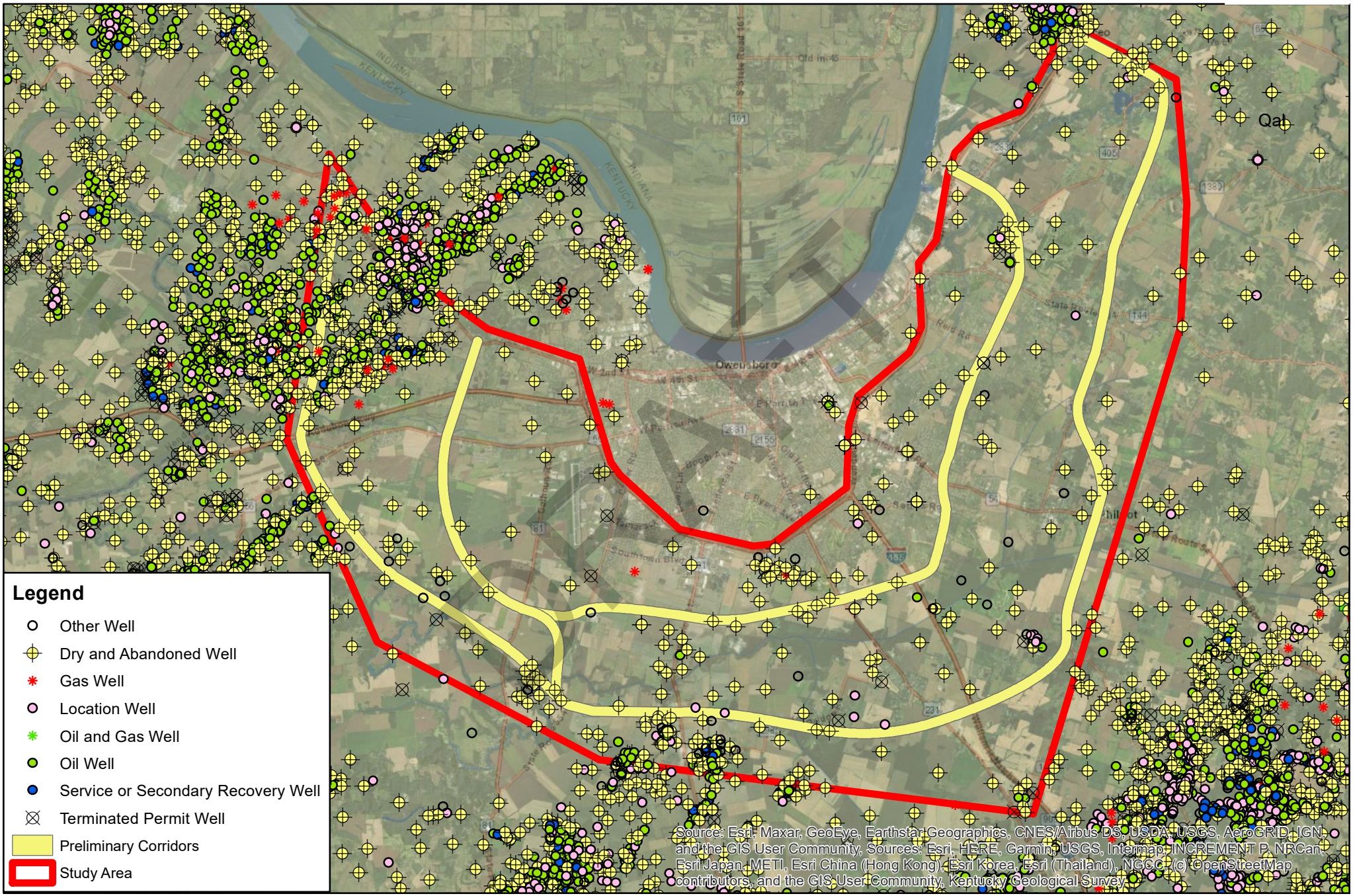


Oil and gas well data obtained from Kentucky Geological Survey's on-line GIS database.

Owensboro Outer Loop Study
Daviess County, Kentucky
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0 1 2 3 4 Miles

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# APPENDIX E

PHOTOGRAPHS

**Photographs**
**Owensboro Outer Loop**
**June 25, 2021**

Photo No. 1 – View along Auburndale Parkway looking east

Photo No. 2 – View of typical cut setting along I-165 looking south

**Photographs**
**Owensboro Outer Loop**
**June 25, 2021**

Photo No. 3 – View of typical bridge approach embankment (US-64 Bypass over Daniels Lane)

Photo No. 4 – View of typical agricultural field setting in study area