

**MEMORANDUM**

**P-003-2024**

**TO:** Catherine Davis, PE  
Transportation Engineer Specialist  
Office of Project Development

**From:** Adam Ross, PE  
Geotechnical Services Branch Manager  
Division of Structural Design

**BY:** Christian Wallover, PG  
Geologist Manager - Registered  
Division of Structural Design

**DATE:** July 29, 2024

**SUBJECT:** Ballard, Carlisle, Hickman, and Fulton Counties  
12F0 C35 D625 01 FH02 0410 C004 E143  
US 51 Corridor Study  
Mars # 1807907P  
Geotechnical Overview Report

**1.0 Project Description**

The Division of Planning is conducting a study along US 51 from the Ohio River Bridge crossing north of Wickliffe to Fulton, Kentucky. The study along the north-south route, located in the western portion of the state, traverses four counties (Ballard, Carlisle, Hickman, and Fulton Counties) from the Illinois to Tennessee state lines (Figure 1).

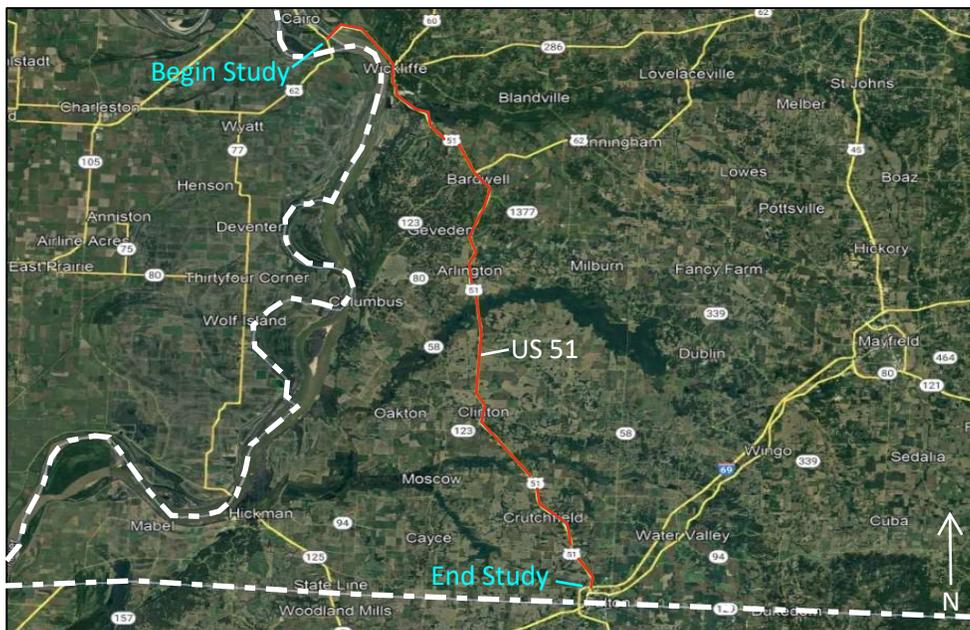


Figure 1. Existing US 51 Alignment

The objective of the study is to identify and evaluate potential options to improve mobility along the US 51 corridor between the US 51 Ohio River crossing and the Purchase Parkway interchange in Fulton. The overview will be utilized to address geotechnical considerations during the selection and evaluation of proposed alignments.

## 2.0 Scope of Work

The scope of work for the US 51 study consists of performing a general summary based upon research of available published data and the Geotechnical Office's experience with highway design and construction within the region. The geotechnical and geologic characteristics relevant to the study area have been identified and are discussed in this report. The following sources were used to perform a literature search:

- Geologic Map of Parts of the Cairo and Barlow Quadrangles, Ballard County, Kentucky (GQ# 885), by Wilds W. Olive, published by the USGS, 1971
- Geologic Map of the Wickliffe Quadrangle, Kentucky-Missouri and Parts of the Wyatt Quadrangle, Kentucky (GQ# 1161), by Wilds W. Olive, published by the USGS, 1974
- Geologic Map of Parts of the Arlington and Wickliffe SW Quadrangles, Carlisle and Hickman Counties, Kentucky (GQ# 1329), by Wilds W. Olive, published by the USGS, 1976
- Geologic Map of the Milburn Quadrangle, Carlisle and Hickman Counties, Kentucky (GQ# 1420), by Roger W. Swanson, published by the USGS, 1977
- Geologic Map of the Oakton Quadrangle and Part of the Wolf Island Quadrangle, Hickman and Fulton Counties, Kentucky (GQ# 1187), by K. Y. Lee, published by the USGS, 1974
- Geologic Maps of the Clinton Quadrangle, Hickman County, Kentucky (GQ# 1030), by Wilds W. Olive, published by the USGS, 1972
- Geologic Map of the Crutchfield Quadrangle, Kentucky (GQ# 270), by Howard G. Wilhire, published by the USGS, 1963
- Water Resources Mission Area. U.S. Geological Survey (2024). Mississippi Embayment Aquifer System Map. <https://www.usgs.gov/media/images/mississippi-embayment-aquifer-system-map>
- Kentucky Geological Survey. (n.d.). KGS Geomap. Kentucky Geologic Map Service. <https://kgs.uky.edu/kygeode/geomap>
- Kentucky Transportation Cabinet. (n.d.). KYTC Division of Structural Design. Geotechnical Projects. <https://transportation.ky.gov/StructuralDesign/Pages/Geotechnical-Projects>

### Geotechnical Reports:

- KYTC Geotechnical Engineering Roadway Reports:
  - R-009-1997, Ballard County, US 51
  - R-013-1980, Fulton County, US 51
  - R-037-1998, Hickman County, US 51
- KYTC Geotechnical Engineering Structure Foundation Reports:
  - S-136-1998, Hickman County, US 51
  - S-108-1996, Carlisle County, US 51
  - S-130-1998, Hickman County, US 51
- KYTC Preliminary Geotechnical Assessment Report:
  - P-006-2004, Carlisle County, US 51
- KYTC Geotechnical Landslide Report:
  - L-041-1997, Ballard County, US 51

## 2.1 Topography and Drainage

The study area falls within the northern region of the Mississippian Embayment Physiographic Region. The Mississippi Embayment (figure 2) is a large low-lying basin that extends from far southern Illinois into southern Louisiana. This basin has been filled with unconsolidated sediment from the Cretaceous to Quaternary Period. As a result, the Jackson Purchase Region of Kentucky is flat lying with numerous lakes, ponds, sloughs, and swamps. Typical vertical relief is on the magnitude of less than 100 feet with broad flood plains and gently rolling uplands.

Drainage along US 51 is directed in the northern portion of the study to Mayfield Creek, Obion Creek throughout the central region, and Bayou de Chien Creek south of Clinton, Kentucky. Each of these creeks flow west, ultimately terminating at the Mississippi River.

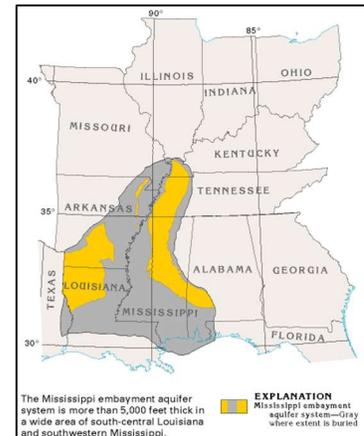


Figure 2. Mississippi Embayment (USGS, 2024)

## 2.2 Stratigraphy

Geologic mapping (Appendix A) indicates that the study area is composed primarily of sediment consisting of a variety of clay, silt, sand, and gravel that are further grouped into subcategories (formations) based on deposition type and age. These formations are Alluvium, Continental Deposits, Loess, Jackson Formation, and Claiborne Formation. Majority of existing US 51 and the surrounding area are underlain by loess deposits followed by alluvium. The Continental Deposits, and Jackson and Claiborne Formations are often buried beneath the loess and alluvium, but occasionally exposed along the tributaries of the Mississippi River. Below is a brief description of the relevant geologic formations:

**Alluvium** is loosely deposited silt, sand, gravel, and clay found in the lowest elevations within the floodplains of the Mississippi River; the Mayfield, Obion, and Bayou de Chien Creeks; and associated tributaries.

**Loess** is primarily silt deposits blanketing much of the project. Loess in the region can exceed 30 feet in thickness and is highly erosive and prone to slumping when over steepened and/or wet due to the high silt content.

**Continental Deposits** are found directly beneath the loess and composed of gravel, sand, and silt.

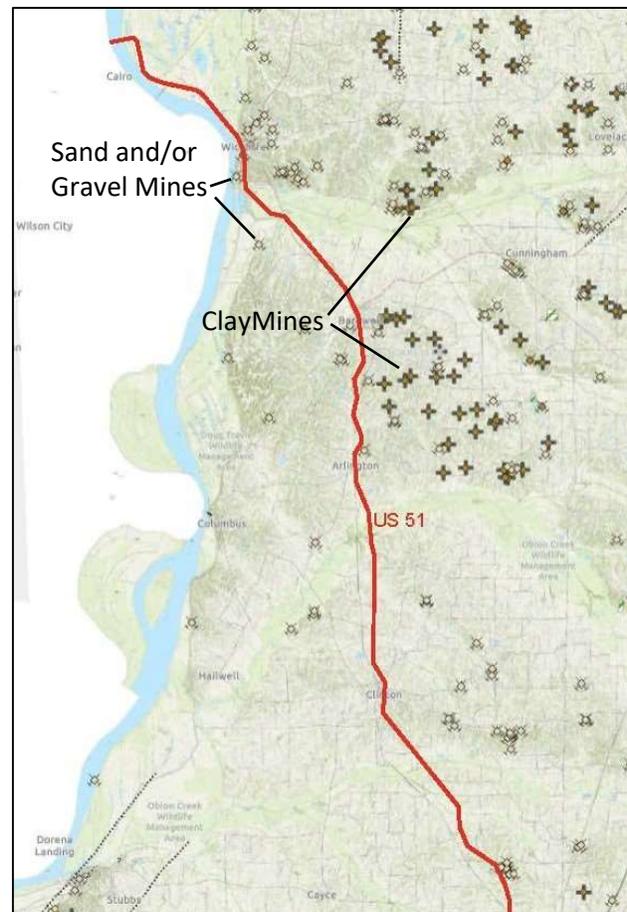


Figure 3. Sand, Gravel, and Clay Mine Locations (KGS Geologic Map Service)

Gravel and sand deposits within this formation have been mined adjacent to US 51 for road metal and construction purposes (Figure 3).

**Jackson and Claiborne Formations** are the oldest sediments that may be encountered along US 51. These deposits are buried beneath the formations listed above but are exposed long the flanks of the stream valleys. The Jackson and Claiborne Formations are composed of sand, silt, clay, and clay breccia. Thick clay beds are found within the Jackson and Claiborne Formations and are commercially mined around the study area for stoneware, pottery, and brick (Figure 3).

### 3.0 Geotechnical Considerations

Foundations for bridges in this area would typically be founded on deep foundations such as steel or concrete friction piles. Culverts and walls are typically supported on shallow (yielding) foundations.

A large portion of the project will encounter Loess Deposits, which are highly erosive. Cut slopes in this material may require flatter slopes (2.5:1 or flatter) especially in areas with high water tables. Slope protection may be recommended to prevent erosion for the cut slopes and embankments.

Soils in the area are generally suitable for embankment construction. Generally, embankments built from the native soils can be constructed to a height of 15 to 20 feet with 2H:1V side slopes if the foundation is suitable and proper compaction methods are used. Due to anticipated wet and compressible soils, embankment settlement could be an issue in areas for embankments over 10 feet tall. Embankments greater than 20 feet may require flatter side slopes and/or greater waiting periods to allow for settlement. Stage construction and the installation of piezometers may be required to monitor and control pore pressures during embankment construction.

A review of the area indicates that there are ponded, wet, or potentially swampy areas in the proposed corridors. Areas prone to flooding (Appendix B) will need to be evaluated when determining the proper embankment materials and fill slopes to utilize. Embankment stabilization and working platforms with durable rock are often recommended. These areas would require site specific subsurface investigations to determine suitability for design of the embankments. Additional structures or lengthening of structures may be required to alleviate flooding issues.

The region contains several thick deposits of clay. These clay beds are extremely sensitive to moisture, and additional mitigation will be required to prevent construction issues due to the shrink and swell factors associated with clay. Undercutting the subgrade by 2 feet and replacing with durable rock is typically recommended when these clay deposits are encountered.

The region has abundant ground water found at moderate to shallow depths. Water wells for industrial, agricultural, and private use can be found along the US 51 corridor (Appendix C).

Springs and continual seepage can be found at the base of sand and gravel deposits that overly impermeable silts and clays (Appendix C). Spring boxes are commonly recommended where springs are encountered to direct water away from the roadway.

California Bearing Ratio (CBR) values used in pavement design generally range from 2-5 with anticipated soils subgrades. Durable rock will not be available from roadway excavation. Chemical modification of the subgrade has been recommended for projects in the area.

Two existing landslides have been identified between Wickliffe and Winford, Kentucky. The landslides are on US 51 at approximate mile points 0.4 and 2.3 in Ballard County. A geotechnical landside report (L-041-1997) was issued on August 28, 1997 with a recommended repair of excavation and replacement with durable rock.

This region is underlain by a system of deep-seated faults related to the New Madrid Seismic Zone. This classifies the study under a Seismic Risk Zone 3 which is considered as a high risk for earthquake damage. Structures should be designed accordingly.

#### **4.0 Conclusions**

The purpose of this overview was to provide a general summary of the bedrock, soil, and geomorphic features likely to be encountered within the proposed study; and to identify geotechnical features that may have an adverse impact on the project. Site specific geotechnical investigations are critical in this region for design.

Please feel free to contact this office for additional information.

#### **Attachments:**

- Appendix A – Geologic Maps
- Appendix B – FEMA Flood Hazard Map
- Appendix C – Wells and Springs

**APPENDIX A**  
**Geologic Maps**

# District 1 - US 51 Planning Study - P-003-2024

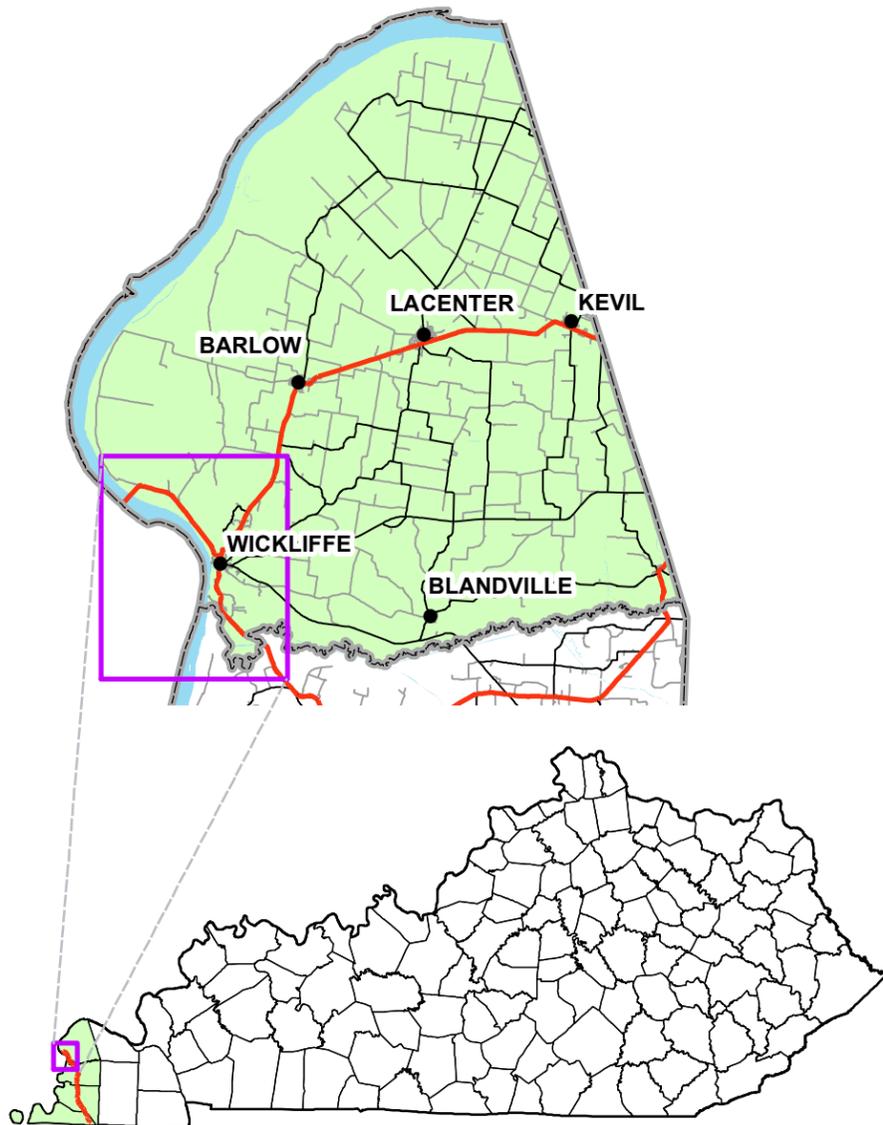
## Ballard County - Geologic Map

### Legend

- City Points
- ▲ State Maintained Roads
- Interstates
- Parkways
- US Highways
- State Roads
- Local Roads
- Waterbodies
- Rivers and Creeks
- Focused Study Area

### Geologic Formations

- Qal Alluvium
- af Artificial Fill
- QTc Continental deposits
- Ql Loess
- Tj Jackson Formation
- cl Clay Bed of the Claiborne Formation
- Tc Claiborne Formation
- Tw Wilcox Formation



# District 1 - US 51 Planning Study - P-003-2024

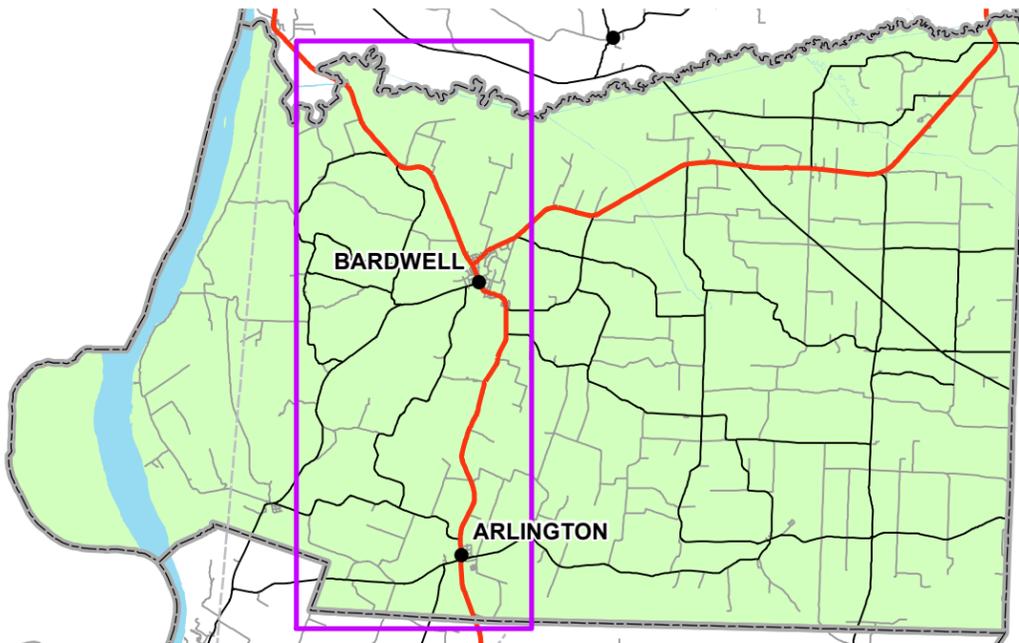
## Carlisle County - Geologic Map

### Legend

- City Points
- ▲ State Maintained Roads
- Interstates
- Parkways
- US Highways
- State Roads
- Local Roads
- Waterbodies
- Rivers and Creeks
- Focused Study Area

### Geologic Formations

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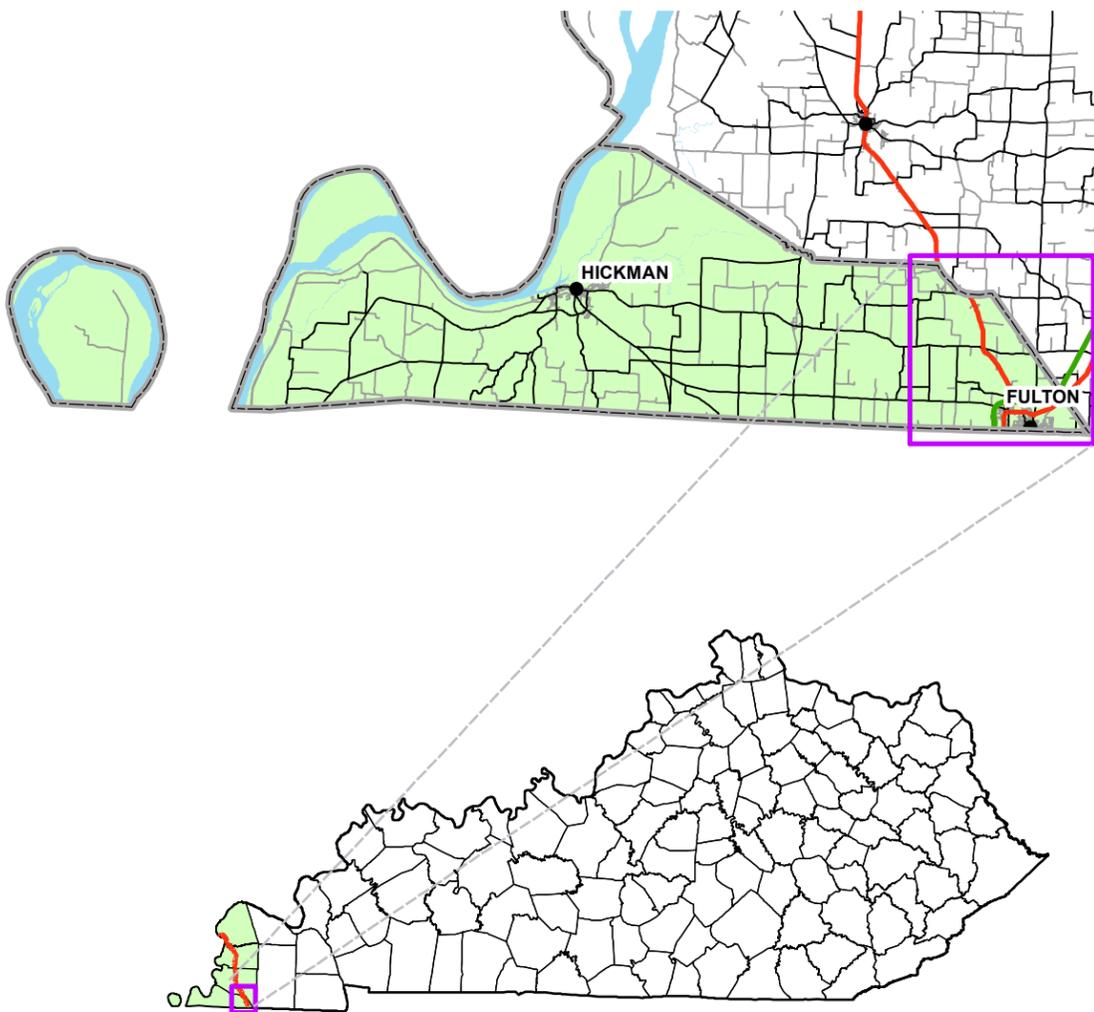
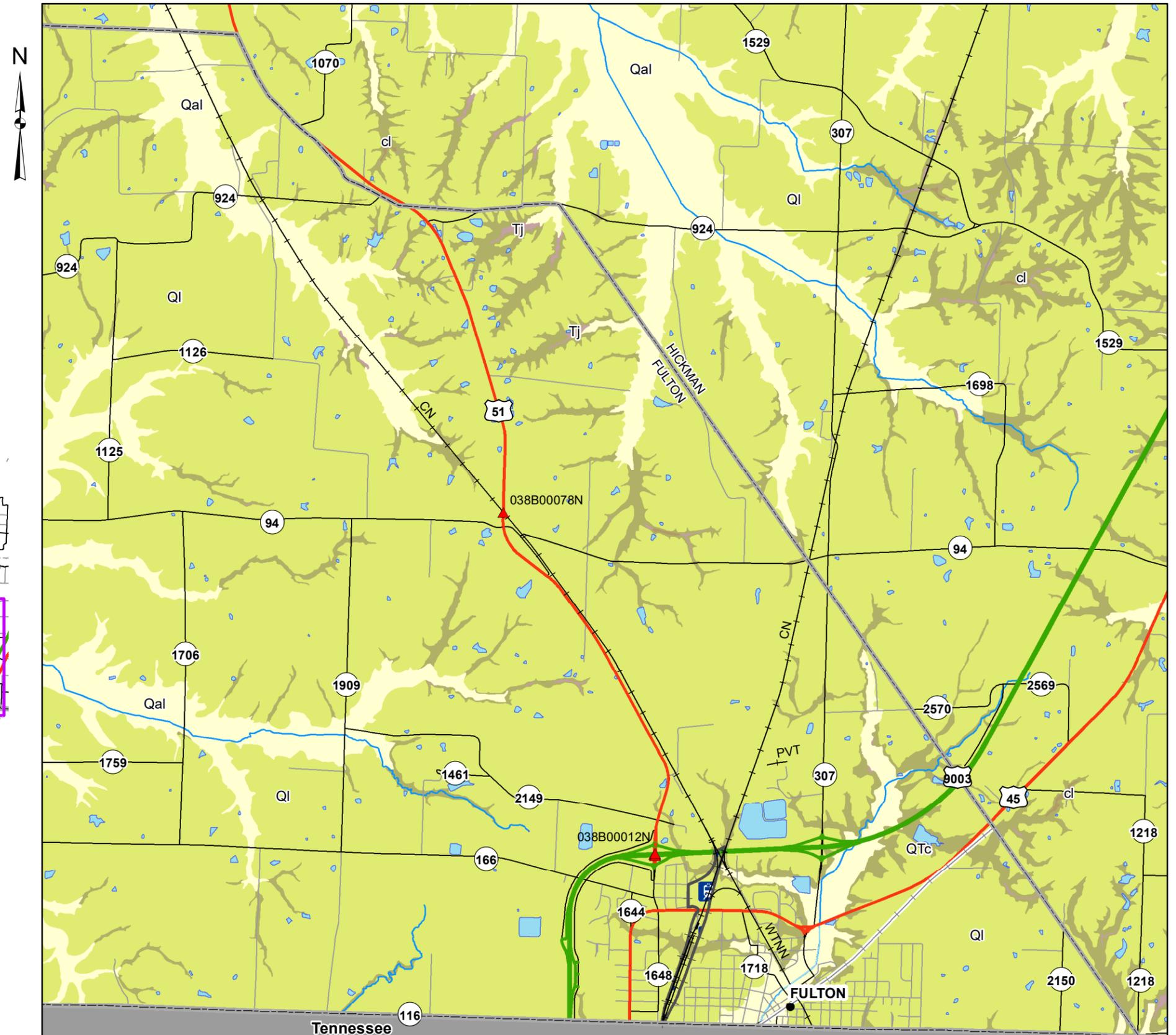
## Fulton County - Geologic Map

### Legend

- City Points
- ▲ State Maintained Roads
- Interstates
- Parkways
- US Highways
- State Roads
- Local Roads
- Waterbodies
- Rivers and Creeks
- Focused Study Area

### Geologic Formations

- Qal Alluvium
- QTc Continental deposits
- Ql Loess
- cl Clay Bed of the Jackson Formation
- Tj Jackson Formation



**APPENDIX B**  
**FEMA Flood Hazard Map**

# District 1 - US 51 Planning Study - P-003-2024

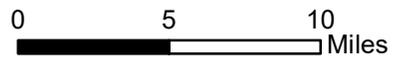
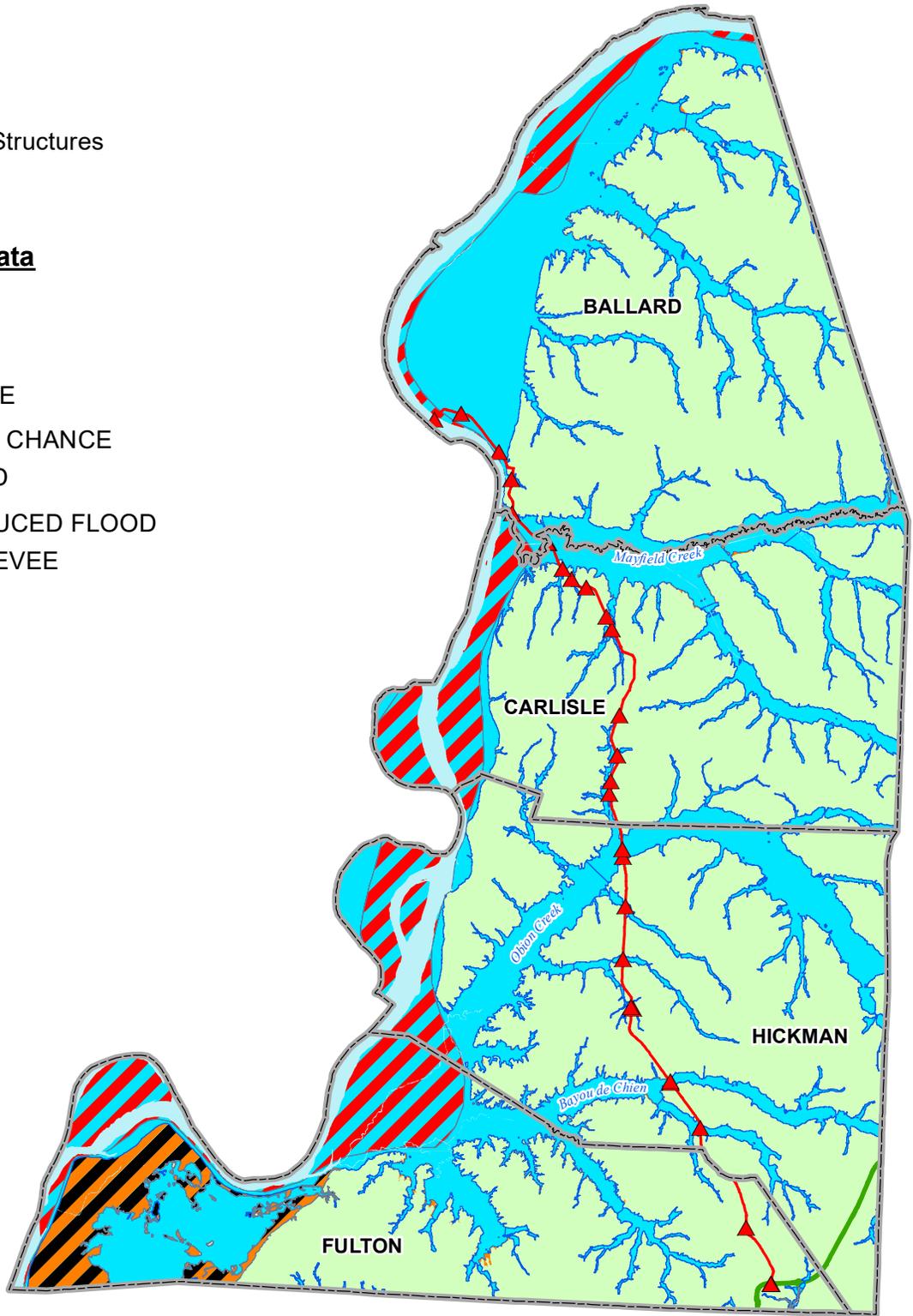
## FEMA Flood Hazard Map

### Legend

- ▲ State Maintained Structures
- US 51

### FEMA Flood Hazard Data

- FLOODWAY
- "A" FLOOD ZONE
- "AE" FLOOD ZONE
- 0.2 PCT ANNUAL CHANCE FLOOD HAZARD
- AREA WITH REDUCED FLOOD RISK DUE TO LEVEE



### NOTES:

A flood zones have an 1% annual chance of flooding (100-year flood).

AE flood zones are areas that present a 1% annual chance of flooding (100-year flood) and a 26% chance over the life of a 30-year mortgage.



**APPENDIX C**  
**Wells and Springs Map**

# District 1 - US 51 Planning Study - P-003-2024

## Ballard County - Wells and Springs Map

### Legend

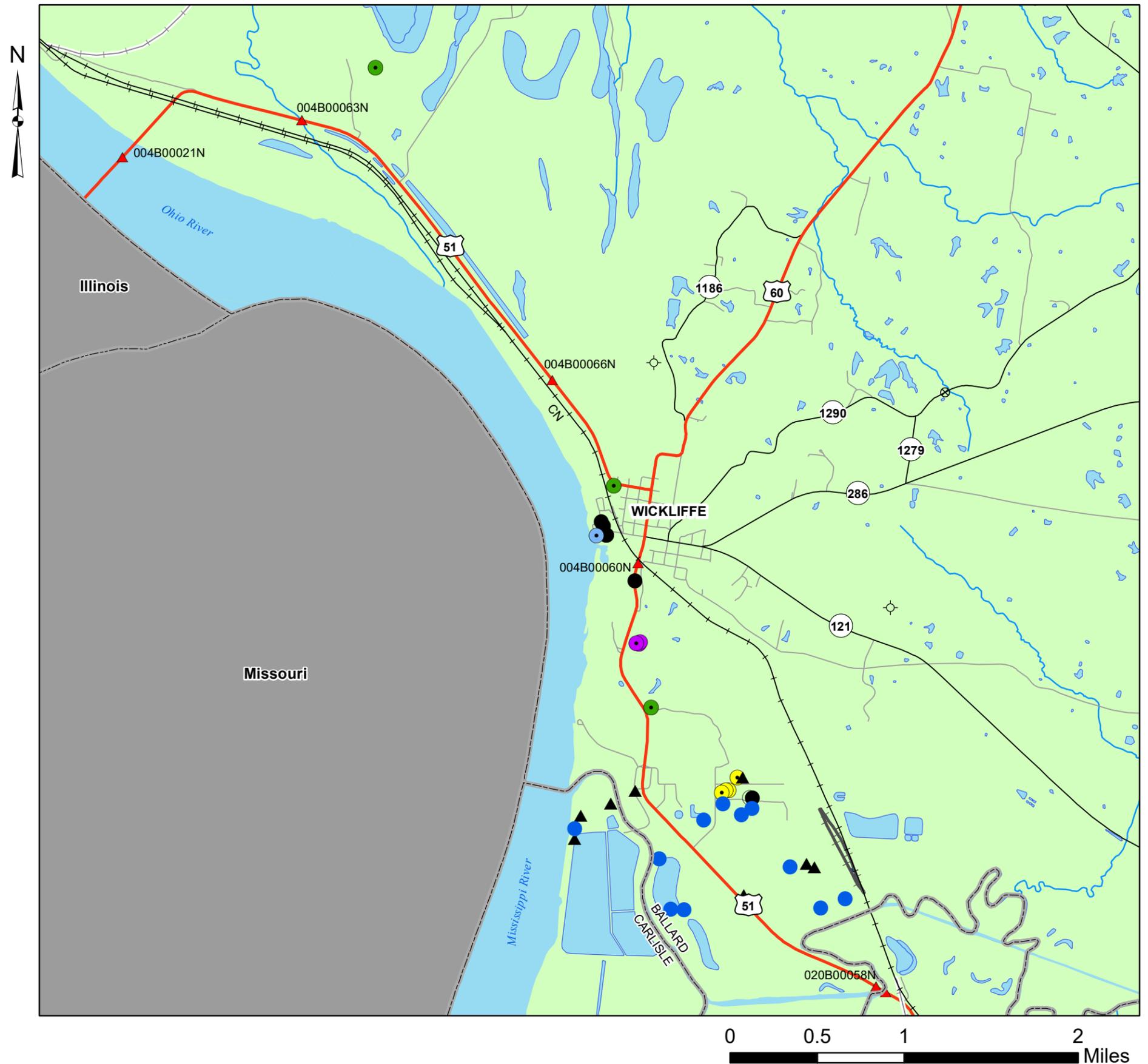
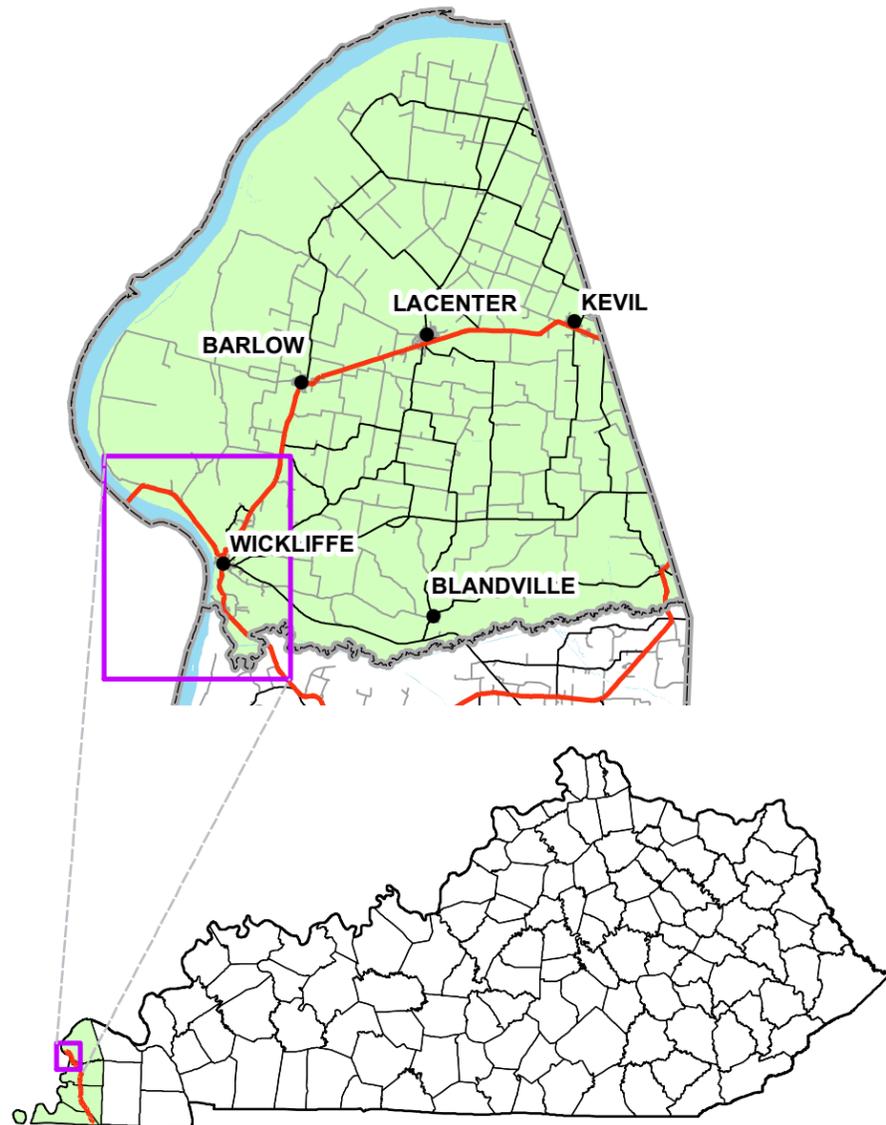
-  State Maintained Roads
-  Interstates
-  Parkways
-  US Highways
-  State Roads
-  Local Roads
-  Waterbodies
-  Rivers and Creeks
-  Focused Study Area

### Wells & Springs

-  Groundwater - Springs
-  Plugged Groundwater Wells
-  Plugged Water Wells
-  Agriculture Water Wells
-  Domestic Water Wells
-  PWS Water Wells
-  Industrial Water Wells

### Oil & Gas Wells

-  Dry and Abandoned Well
-  Stratigraphic Core, Public



# District 1 - US 51 Planning Study - P-003-2024

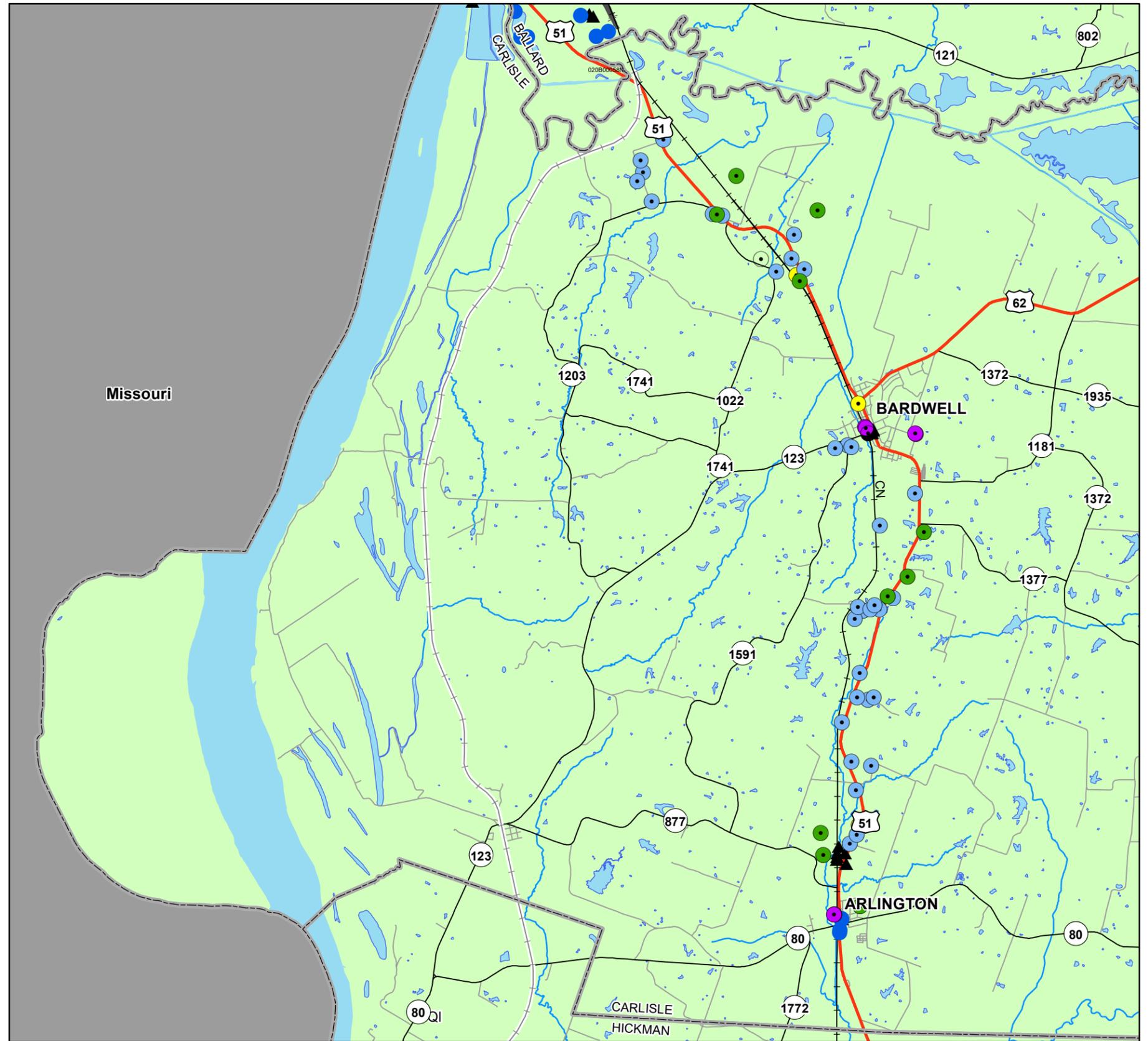
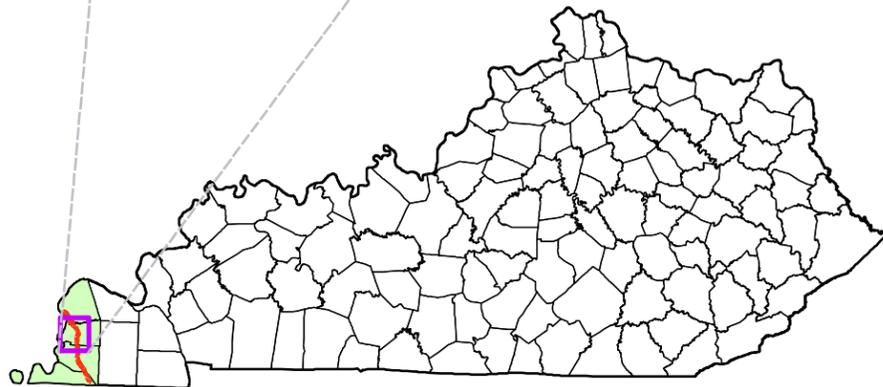
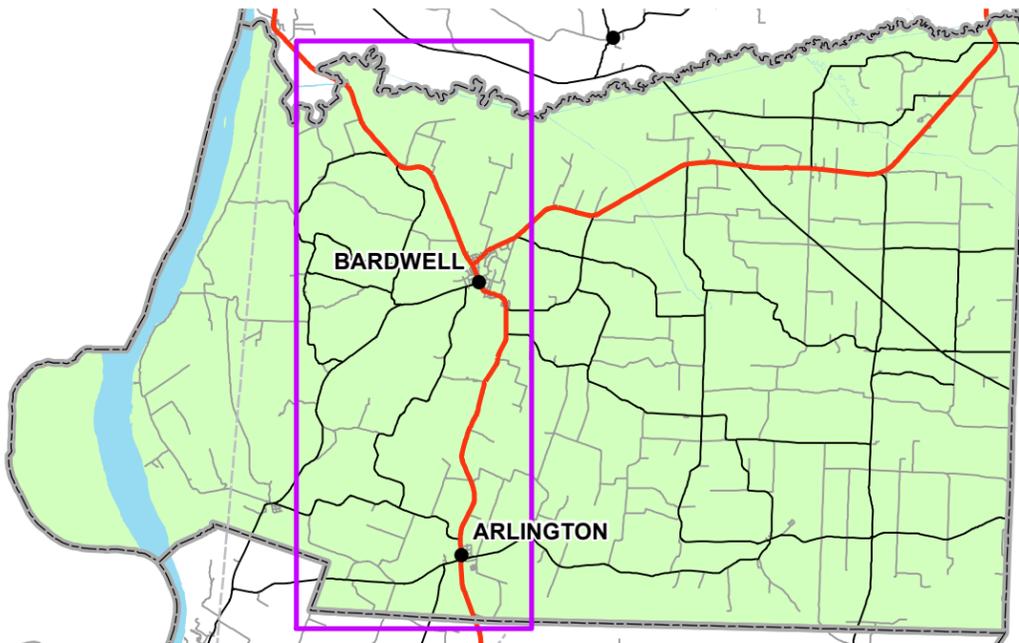
## Carlisle County - Wells and Springs Map

### Legend

-  State Maintained Roads
-  Interstates
-  Parkways
-  US Highways
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-  Local Roads
-  Waterbodies
-  Rivers and Creeks
-  Focused Study Area

### Wells & Springs

-  Groundwater - Springs
-  Plugged Groundwater Wells
-  Plugged Water Wells
-  Agriculture Water Wells
-  Domestic Water Wells
-  PWS Water Wells
-  Industrial Water Wells
-  Other Water Wells



# District 1 - US 51 Planning Study - P-003-2024

## Hickman County - Wells and Springs Map

### Legend

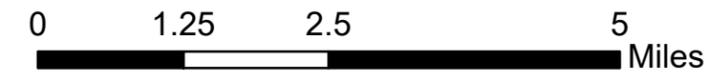
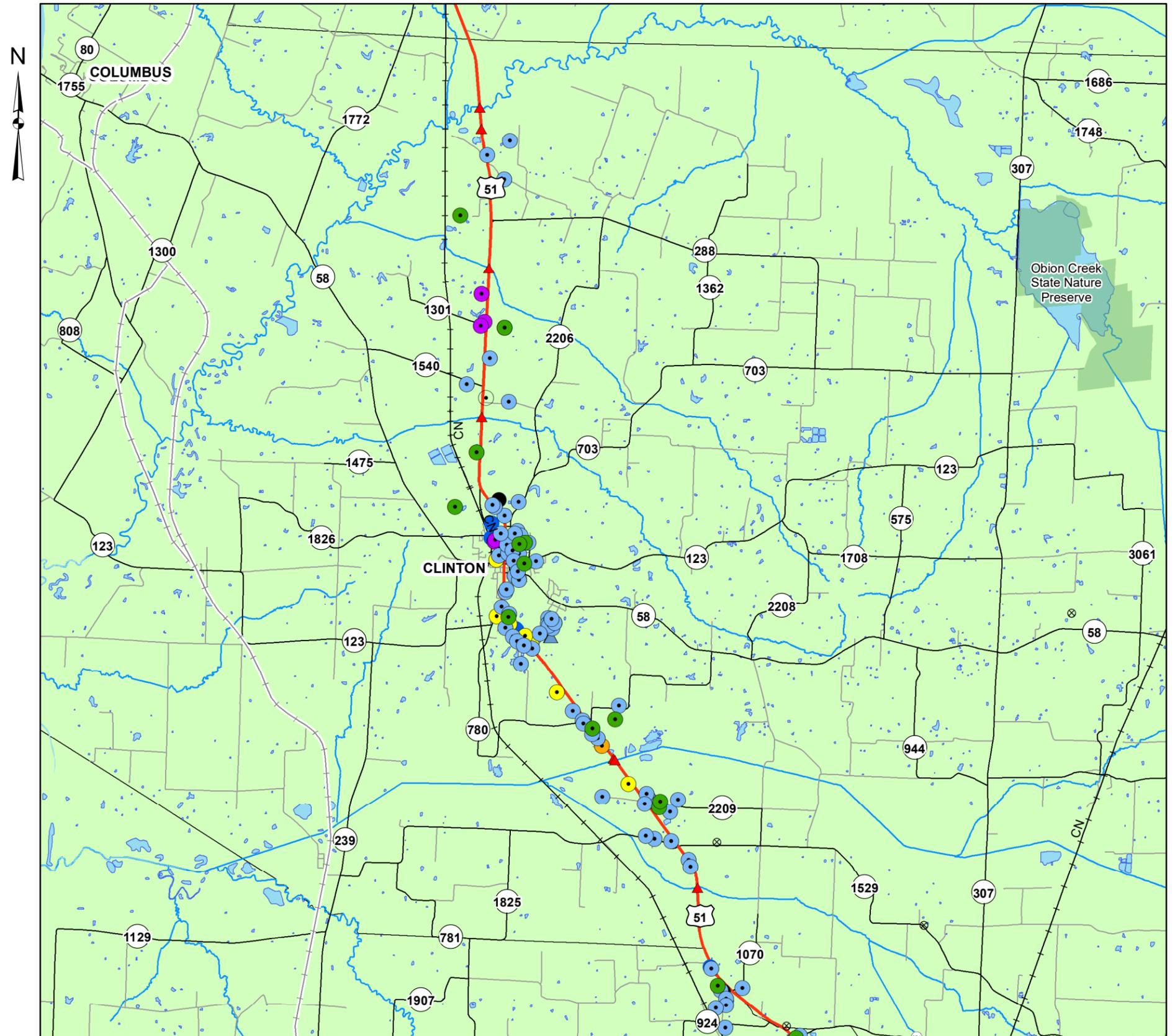
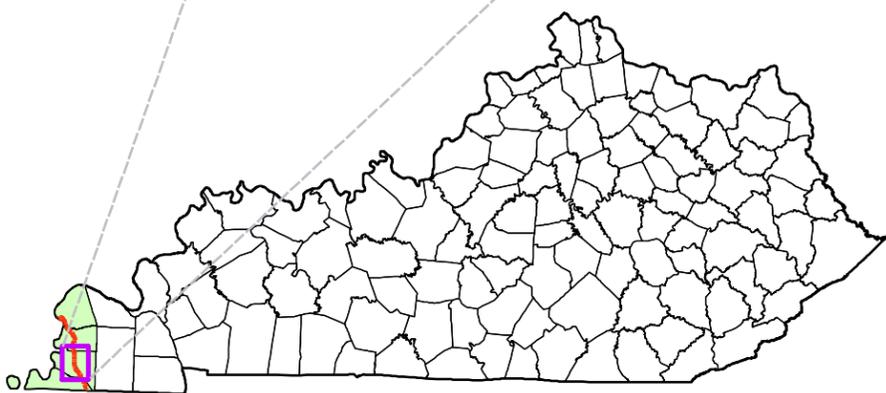
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- Interstates
- Parkways
- US Highways
- State Roads
- Local Roads
- Waterbodies
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- Focused Study Area

### Wells & Springs

- Groundwater - Springs
- ▲ Plugged Groundwater Wells
- Plugged Water Wells
- Agriculture Water Wells
- Domestic Water Wells
- PWS Water Wells
- Industrial Water Wells
- Other Water Wells

### Oil & Gas Wells

- ◇ Dry and Abandoned Well
- ⊗ Stratigraphic Core, Public



# District 1 - US 51 Planning Study - P-003-2024

## Fulton County - Wells and Springs Map

### Legend

- ▲ State Maintained Roads
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