APPENDIX H
GEOTECHNICAL OVERVIEW

GEOTECHNICAL OVERVIEW REPORT

US 31W (Louisville Road) Scoping Study
Old Porter Pike (MP 16.558) to
KY 957 (Plum Springs Loop Road) (MP 18.084)

WARREN COUNTY, KY

JANUARY 2015

DESIGNING YOUR FUTURE, TODAY.

AEI
AMERICAN
ENGINEERS, INC.

January 23, 2015

Ms. Annette Coffey, P.E.
Senior Transportation Engineer
Qk4, Inc.
2225 Lawrenceburg Road
Building C, 2nd Floor
Frankfort, KY 40601

Re: US 31W (Louisville Road) Scoping Study
Old Porter Pike (MP 16.558) to KY 957 (MP 18.084)
Warren County, Kentucky
AEI Project No. 214-389

Dear Ms. Coffey:

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, a Warren County general karst map and karst groundwater basin mapping for part of the Beaver Dam and Bowling Green 30 x 60 Minute Quadrangles. 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.

Brad High, PG
Project Geologist

Dennis Mitchell, PE
Geotechnical Project Manager

Geotechnical Overview of US 31W
Old Porter Pike (MP 16.558) to KY 957 (MP 18.084)
Bowling Green, KY

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Geotechnical Overview of US 31W
Old Porter Pike (MP 16.558) to KY 957 (MP 18.084)
Bowling Green, KY

1. Project Description

The study area begins on the south at Old Porter Pike (MP 16.558) and ends on the north just north of the intersection with Plum Springs Loop Road (MP 18.084) covering a length of about 1.5 miles. The project corridor ranges from about ¼ mile wide on the southern portion of the project and about 1 mile wide on the north side. The study area is highly developed and contains several commercial properties, including restaurants, retail stores, an old quarry, at least one small cemetery, factories and part of the North Industrial Park. The study area is also currently dissected by numerous roadways, existing roadway structures and a railway.

This geotechnical overview is part of a larger scoping study to improve traffic flow during peak hours. The purpose of this overview is to identify potential geotechnical concerns and provide anticipated typical parameters for design throughout the defined study area.

The geotechnical overview was conducted in relative accordance with Section 801 of the Kentucky Transportation Cabinet Geotechnical Manual. The study was conducted during December 2014 and January 2015 and included field reconnaissance and geologic research of available geologic and topographic quadrangle maps, Soil Survey of Warren County, Kentucky, as well as multiple resources available from the Kentucky Geological Survey and the United States Geological Survey. Past reports from geotechnical investigations for roadways and structures in and near the area of the Overview were also reviewed.

2. Site Geology

Review of available geologic mapping for the area (*Geologic Map of the Bowling Green North Quadrangle, Kentucky, Shawe, F.R., 1963 & Geologic Map of the Bristow Quadrangle, Kentucky, Gildersleeve, B., 1963)* indicates the site is underlain by, in descending order of lithology, Upper Mississippian deposits of the Ste. Genevieve and St. Louis Limestone Formations.

The deposits of the Ste. Genevieve formation are described as oolitic limestone, some crystalline, argillaceous, and fossiliferous, gray to white, weathers slightly darker; where exposed to direct sunlight weathered rock may be white; mostly thick bedded and massive, but ranges to thin bedded. Chert occurs as thin beds and stringers near base and rarely as nodules; chert is gray to black and weathers white to red-brown; it is blocky weathering, particularly near base, where large weathered blocks are common in residual soil overlying Ste. Genevieve rocks. The deposits of the St. Louis Limestone formation are described as limestone, cherty, light to dark gray, coarse-grained, thin to medium bedded; covered in most places by thick residuum of tan to red clay containing abundant chert fragments and nodules. Regional dip in the study area was reviewed based on subsurface topographic contours drawn on the top of the underlying Chattanooga Shale Formation and indicates a dip to the northwest of about 40 to 50 feet per mile, or about one percent.

Online karst potential mapping was also reviewed for the site http://www.uky.edu/KGS/. The Kentucky Geologic Survey identified the study area and the surrounding areas as exhibiting very high or intenste potential for the development of karst features. Numerous surface depressions were also noted within the study area both from review of geologic mapping and during field reconnaissance. At least one existing cave entrance was also mapped on the 7.5-minute Bowling Green Quadrangle map just south of US 31W. A karst potential map inclusive of the study area is included in the Appendix. An overall karst potential map of Warren County was also obtained from the Kentucky Geological Survey website and is attached at the conclusion of this report. Karst basin groundwater mapping available from KGS was also reviewed for the project and surrounding areas and indicates a general trend of groundwater inflow toward the Barren River near the study area. A copy of the combined Bowling Green and Beaver Dam 30 x 60 minute quadrangle maps is included in the appendix.

Both the Ste. Genevieve Limestone and the St. Louis Limestone Formations are known for karst landscapes. These formations are a result of lithified calcium carbonate-rich deposits derived from warm, shallow sea environments during the Mississippian Geologic Period. Limestone, especially relatively pure limestones like those which underlie the study area, are soluble in water and weak acid solutions. Sinkholes, springs and caves are typical of landscapes underlain by these soluble limestones. As with most karst landscapes, soil overburden thickness varies greatly due to variant rates of chemical weathering and patterns of surface drainage. The weathering of limestone bedrock in such formations commonly results in knife-like ridges surrounding the surface depressions, where depth to bedrock tends to be much less than near the base of surface depressions where weathering tends to be more continuous. In general, soil overburden thickness tends to be greater in areas underlain by the St. Louis Limestone Formation which mapping indicates lies at the surface in the southern and eastern extents of the study area.

3. Topography and Drainage

The study area lies within the Mississippian Plateaus Region of southern Kentucky in Warren County. Topography of the study area is typically described as gently rolling to rolling and is largely defined by the underlying limestone bedrock. Topographic relief throughout the study area ranges from a low of about 420 feet near Barren River on the western end of the study area and in the lower surface depressions to a high of about 550 feet or more near the eastern end of the study area. Generally, this area is known for its karst landscape; characterized by gently rolling hills, red clay soils and numerous sinkholes and depressions. The limestone bedrock which lies below the ground surface in the study area is highly soluble and prone to dissolution and the resulting development of karst features such as sinkholes, caves, springs and disappearing streams. Surface runoff in the area is typically intercepted by surface depressions and sinkholes or ultimately drains toward the Barren River. 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 and cracks 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 2 to 5. Chemical treatment, such as lime or cement stabilization may be desired to effectively stabilize road subgrades, however past projects have indicated large cobbles and boulders (chert) in the soils could make chemical modification problematic. In areas where rock is encountered during roadway excavations, it should be utilized 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 some type of stabilization if pavements are removed.

- 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 on commercial properties which are currently utilized for drainage purposes. 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.

- 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 or H-piles on bedrock. In addition to drilling at proposed foundation locations during a geotechnical investigation, it will likely be desirable to predrill foundation elements just prior to construction. Pre-drilling of structure foundations in regions underlain by karst terrain can help identify possible voids or clay seams in the underlying limestone bedrock. Foundation elements can be lowered to an elevation below any voids or seams identified during pre-drilling to minimize the potential of settlement due to karst**.**

- 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 be required for construction of the new roadway. Based on prior experience with residual soils weathered from the Ste. Genvieve Limestone and St. Louis Limestone Formations, embankments constructed at 2H:1V or flatter will likely provide an acceptable factor of safety for embankments less than 60 feet in height. Soil cuts in the residual soils can be problematic due to softening of the clays upon exposure in the cuts. Soil cut slopes should not be steeper than 2H:1V. Based on review of the KYTC Geotechnical Manual, typical cut slope configurations for massive limestone will vary from ½H:1V to ¼H:1V. During design of cut slopes in bedrock, the presence of joints, fractures, solution features and crossbedding should be taken into consideration.

- No oil or gas wells were identified through review of online mapping or during field 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.

- Multiple water 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-045-2013	Roadway	US 31W	Bristow Rd & Moorman Lane (Realignment of int. at 31W)
R-049-1998	Roadway	I-65	I-65 Widening from S of Barren River to N of Bristow Rd
R-051-1998	Roadway	I-65	I-65 Widening from S of Natcher Pkwy to S of Barren River
R-041-1998	Roadway	KY 234	Cemetery Rd (Station 10+065 to 13+927.441)
R-006-1981	Roadway	US 68	North-South Arterial (US 68) Station 11+35 to 145+00
R-031-2010	Roadway	I-65	I-65/31W Connector (New Interchange)
S-162-1998	Structure	I-65	I-65 over 31W Connector
S-161-1998	Structure	I-65	I-65 over Porter Road

5. Summary

Karst terrain in the study area will be likely be the most detrimental factor to any new construction in the area. Recently, a significant, highly publicized sinkhole collapse occurred within the Skydome area of the National Corvette Museum. Part of the study area is bound by property owned by the National Corvette Museum.

Much of the study area is also highly developed which can mask the existence of karst features such as sinkholes and surface depressions. Subsurface groundwater mapping also indicates inflow from both the south and the north towards the study area and the Barren River which is another indication of the likely presence of karst features in the soluble limestone which underlies the area.

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.

In addition to the significant potential for encounter with karst features during construction, the entire study area is highly developed with numerous commercial properties, industry, a railway with existing rail crossings and spurs, at least one small cemetery and includes a few residential areas near the study area boundaries. It is anticipated that any new widening or realignment will be impacted greatly by existing structures in addition to the karst which underlies the area.

Site Photographs

Figure 1-Railroad Crossing Plum Springs Road

Figure 2-North Industrial Park

Figure 3-Typical Sinkhole Plain Topography, North of 31W

Figure 4- Sinkhole near GM Access Road, typical of the study area

Figure 5-Sinkhole near Northgate Shopping Center

Figure 6-Drywell installed in Sinkhole Depression off Parker Drive

Figure 7-Sinkhole behind Art's Corvette showing significant relief with crushed stone lining drainage ditch

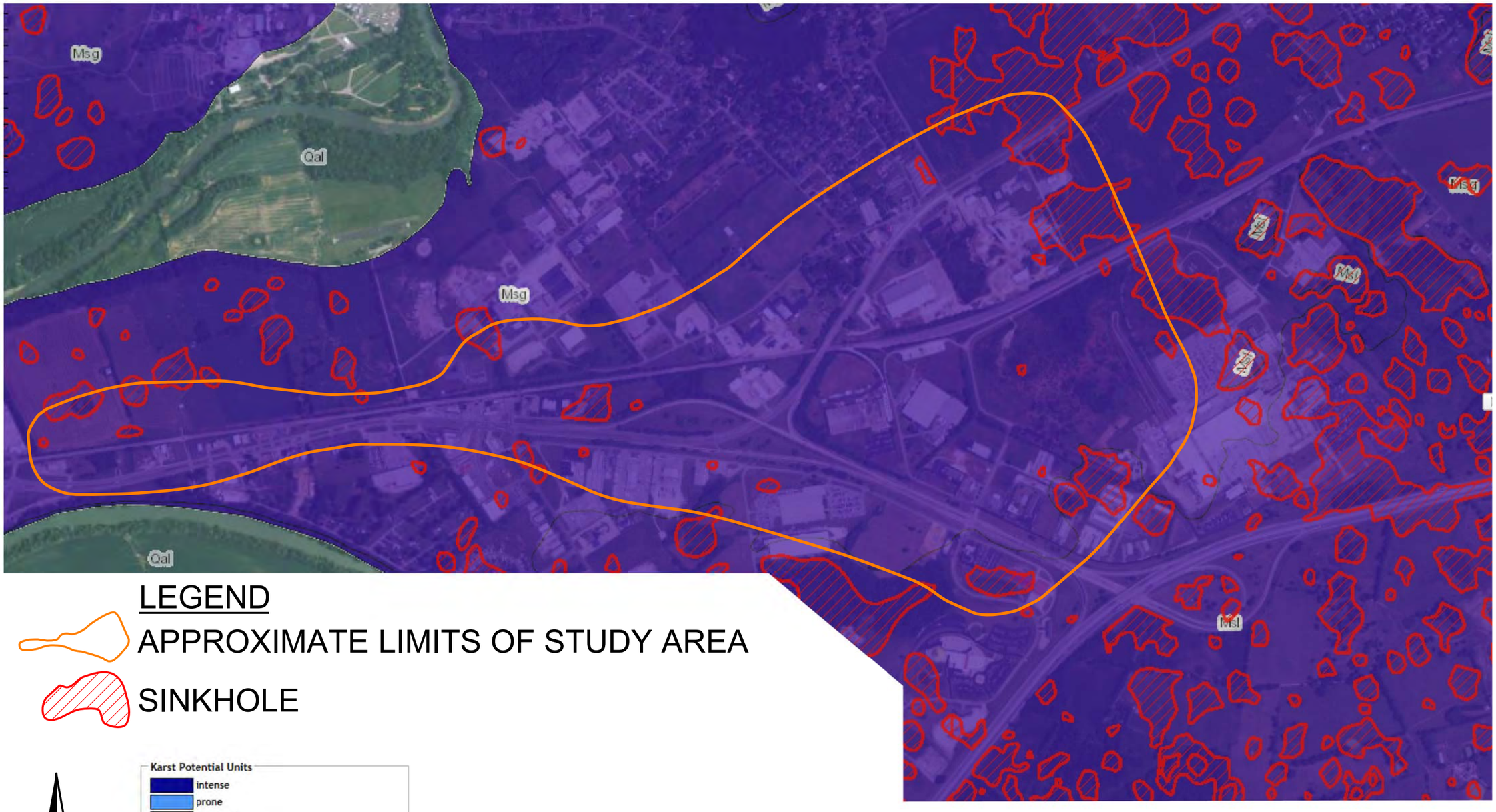
Figure 8- Lined surface depression utilized for drainage in commercial area

Figure 9-Large sinkhole depression near Hwy 446 and 31 W interchange

Figure 10- Drywell Installation in residential area north of 31 W

Appendix

Karst and Groundwater Mapping



LEGEND

APPROXIMATE LIMITS OF STUDY AREA

SINKHOLE

Karst Potential Units
- intense
- prone
- non-karst

NO.	DATE	REVISIONS DESCRIPTION

KARST POTENTIAL

KYTC

CLIENT:

PROJECT:
Warren County US 31W (Louisville Road)
Scoping Study
Bowling Green, KY

PLANS PREPARED AND SUBMITTED BY:
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DRAWN BY: J. CHILDRESS

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FILE: T:/Geotech Support/KYTC/214-389/DGNs/Karst PotentialLdgn

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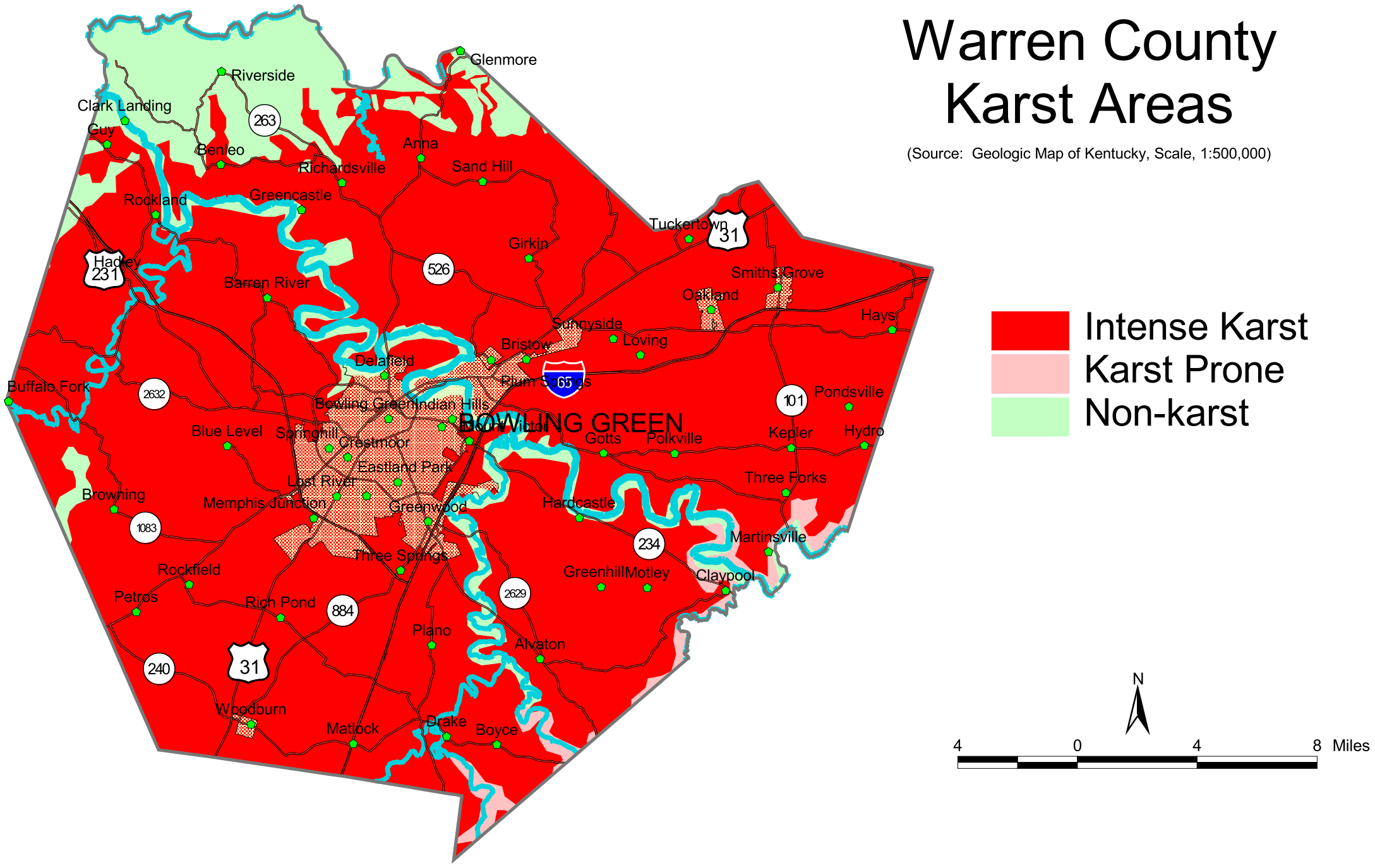
Warren County
Karst Areas
(Source: Geologic Map of Kentucky, Scale, 1:500,000)
Intense Karst
Karst Prone
Non-karst
N
4 0 4 8 Miles
BOWLING GREEN
Glenmore
Riverside
Clark Landing
Guy
263
Benleo
Anna
Sand Hill
Richardsville
Greencastle
Rockland
Tuckertown
31
Girkin
Hadley
231
526
Barren River
Smiths Grove
Oakland
Hays
Sunnyside
Loving
Bristow
Delafield
65
Buffalo Fork
2632
Bowling Green
Indian Hills
Pondsville
101
Blue Level
Springhill
Crestmoor
Gotts
Polkville
Kepler
Hydro
Eastland Park
Three Forks
Lost River
Browning
Memphis Junction
Greenwood
Hardcastle
1083
234
Martinsville
Three Springs
Rockfield
Greenhill
Motley
Claypool
Petros
Rich Pond
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Plano
Alvaton
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Woodburn
Matlock
Drake
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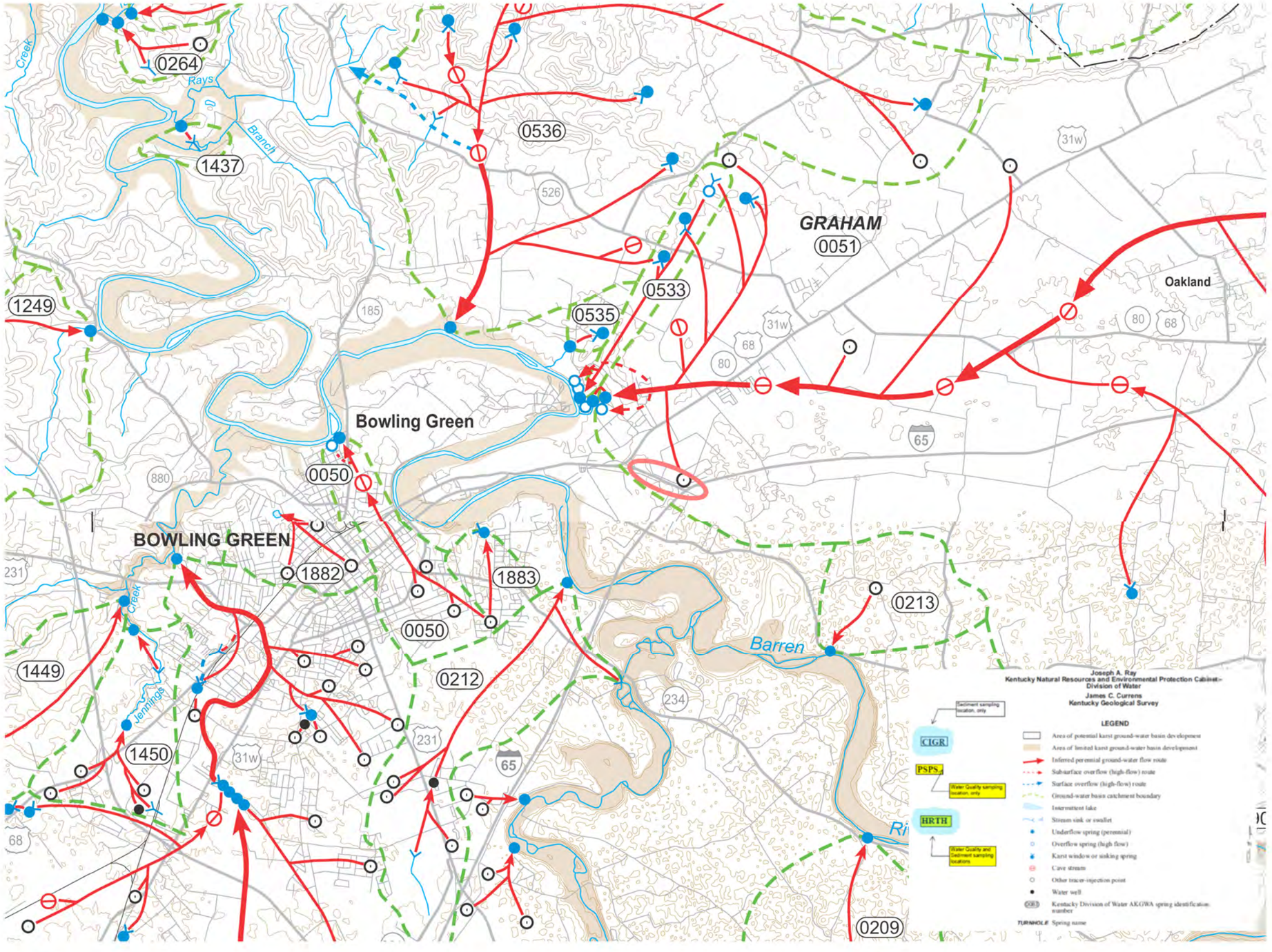

LEGEND

APPROXIMATE LIMITS OF STUDY AREA

REVISION	
DATE	
DESCRIPTION	
NO.	

GROUNDWATER FLOW MAPPING

CLIENT: KYTC

PROJECT: Warren County US 31W (Louisville Road) Scoping Study Bowling Green, KY

AMERICAN ENGINEERS, INC.

SCALE: NTS

DATE: 1-15-15

DRAWN BY: J. CHILDRESS

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