APPENDIX 3

GEOTECHNICAL OVERVIEW

US 25 Corridor Study

From KY 14/16 to North of the City of Walton
Boone and Kenton Counties, KY
Item No. 6-105.00

November 2023

M E M O R A N D U M

TO:	**Stephen G. De Witte, PE** **Project Management Coordinator** **Division of Planning**
FROM:	**Michael Carpenter, PE** **Director** **Division of Structural Design**
BY:	**Brad Williams, PG** **Geotechnical Branch**
DATE:	**January 18, 2022**
SUBJECT:	**Boone County** **FD51 008 0075 182-183** **I-75/KY 14 Interchange Study & US 25 Improvements Study** **From Station 11+30 to Station 134+36** **Item # 6-00079.00** **Mars # 1365901P** **Planning Study**

1.0 Project Description

The Kentucky Transportation Cabinet (KYTC) is conducting a study to evaluate the I-75/KY 14 Interchange as well as US 25 improvements in Boone County (please see attached scope map;(Figure 1). This overview will be utilized to identify Geotechnical considerations for the study area.

Topography and Drainage:

The project study area is in Outer Bluegrass Physiographic Region. This area is composed of Ordovician limestones and shales. The limestone and shales in this area is more easily eroded than the limestones of the Inner Bluegrass Physiographic Region. The limestone of this region forms fewer sinkholes than the Ordovician Strata of the Inner Bluegrass. As indicated by the Kentucky Geologic Survey (KGS) the strata underlying the study area is mapped to be prone and non-karst (figure 2) The shales in this region also impede the flow of groundwater and there are fewer springs. The area has a dendritic drainage patten which indicate relatively flat laying resistant bedrock.

2.0 Scope of Work

This study will focus on the geotechnical and geologic features of the designated study area. Overview of the proposed study area will be provided by professional papers, available published geotechnical data, and the Geotechnical Branch’s experience with highway design and construction with comparable projects in the region. The following sources were used:

3.0 Stratigraphy

Bull Fork Formation (Ob):

The Bull Fork Formation is made up of very fossiliferous inter layered limestone and shale. The limestone content of the whole formation ranges locally from about 40 to 60 percent but is commonly about 80 percent near the base and decreases irregularly upward to only 20 percent near the top.

The Limestone is light gray, medium gray, greenish gray, and weathers light gray and yellowish gray. The Limestone is mostly made up of whole and broken fossils, but because of differences in sorting, grain size, and bedding, it can be separated in to four distinct types. Dominate is limestone made up of whole and broken fossils in a very fine grained to medium grained matrix of fossil fragments and crystalline calcite, commonly creating streaks and patches of greenish gray mudstone.

This type of limestone generally forms rough-surfaced irregular plannar beds, 1 to 8 in. thick. Also abundant is sparsely fossiliferous, in part muddy micrograined limestone in smooth surfaced plannar beds, 1 to 6 in. thick. Nodular-bedded limestone, similar to that characterizing the Grant Lake Limestone, is locally common in the lower part of the Bull Fork. This type of limestone consists of abundant whole and coarsely broken brachiopods and bryozoans in a poorly sorted muddy mircograined to medium grained matrix of fossil fragments and microcrystalline to coarsely crystalline calcite. It is irregular and discontinuous beds mostly 2 to 3 in. thick, and weathers to yield a rubble of nodular fragments and whole fossils.

Shale which makes up as much as 60 percent of the Bull Fork and is everywhere dominate in the upper part of the formation, is medium gray to greenish gray. It is very calcitic and locally grades to a muddy limestone; near the top of the formation the shale is partly dolomitic. Most of the shale is moderately fossiliferous, irregularly fissile, in crude to even laminae interlayered with limestone as partings or even sets, whose average thickness increases upward in the formation from a few inches near the base to several feet near the top.

The Bull Fork is a nonresistant formation, which generally form irregular moderate slopes littered with slabs of limestone. The slopes become gentler upward. Good exposures are restricted to streambanks and artificial cuts.

Grant Lake Limestone (Ogl):

The Grant Lake is composed of limestone 70-90 percent interbedded and intermixed with shale. The limestone, mainly light to medium gray weathering lighter gray to yellowish gray, mostly consists of abundant whole to finely broken fossils in a muddy poorly sorted micrograined to medium-grained calcite matrix. The formation is characterized by irregularly continuous to lensing, nodular thin beds consisting of limestone lenticles, commonly 3 to 4 in. long and 1 to 2 in. thick, separated by curving laminae of shale. The Grant Lake Limestone is made up dominantly od whole and fragmented fossils.

Interlayered irregularly with the nodular-bedded limestone is planar-bedded fossil-fragmental limestone, similar to the limestone characteristic of the Fairview Formation. This planar bedded limestone interstratified with some shale.

Shale of the Grant Lake is medium gray to greenish gray, calcitic, and in part silty. It forms irregular partings and thin interbeds around lenticules of limestone and also is obscurely mixed with limestone in thin beds.

The Grant Lake Limestone as a whole is relatively nonresistant unit and commonly forms gentle moderate slopes interrupted by a few ledges of more resistant limestone. Most outcrops weather readily to yields a rubble of nodular fragments and coarse fossil debris. Where the formation includes thick sets of calcarenite, as in north central and western central Kentucky, it out crops well along streambanks and in steep hollows, and give rise to moderately steep slopes with prominent thick ledges. *(W. Weir, W.L. Peterson, and W C Swadley)*

Fairview Formation (Of):

The Fairview Formation is characterized by evenly bedded limestone interlayered with approximately equal amounts of shale and siltstone. At its type section the Fairview Formation is made up of about 40% limestone and 60% shale and siltstone. The Limestone content increases southward to about 55% in the Walton Quadrangle, northern north central Kentucky.

Limestone of the Fairview, mostly medium gray to olive gray and weathering light gray or yellowish gray where silty, is chiefly of two types. The more abundant type is limestone consisting of whole fossils and fine to very coarse fragments of fossils in a micro grained to medium grained matrix. The fossil fragmental limestone is fairly persistent, evenly to slightly irregular beds that averages 4 inches in thickness. Some layers of limestone of coarse grained limestone is crossbedded in thin sets.

The less abundant type of limestone in the Fairview is micrograined to fine grained, in part clayey to silty, and contains sparse fossil fragments. It is in continuous even beds 1 to 6 in. thick, commonly sheathed with laminae of very calcitic limestone beds have contorted into ball and pillow structures 1 foot thick.

Shale, which makes up 25 to 60 percent of the Fairview, is mostly calcitic and silty, medium gray to greenish gray, and weathers grayish yellow. It is in sets, a fraction of an inch to about 1 foot thick, of obscure to distinct, irregular and even laminae. The shale is irregular fissle and generally contains few fossils.

Siltstone , which makes up as much as 15 percent of the Fairview, is calcitic, sparsely fossiliferous, and locally grades to silty micrograined limestone. The siltstone is medium grained, weathers yellowish brown, and is stratified.

Kope Formation (Ok):

Consists of 60-80 percent shale and 20-40 percent limestone and in places minor siltstone. The shale is medium gray to greenish gray and weathering gray, is commonly calcitic and in part very silty. The shale is crudely to well laminated in sets 2 to 5 feet thick, which locally grade laterally into obscure irregular thin beds.

Most of the limestone in in ledge forming fairly continuous, even irregular beds, 1 to 12 in. thick. Limestone is also commonly interstratified with shale in as single beds, a fraction of an inch to a few inches thick.

The Kope Formation is a nonresistant formation, rarely exposed except in roadcuts and along streambanks. It forms moderate to steep slopes that in places are littered with slabs of limestone. *(W. Weir, W.L. Peterson, and W C Swadley)*

The Kope Formation weathers, slakes and slumps readily. (*W. Andrews*)

Please see Figure 2 standard geologic map with lithologic divisions

Soils and unconsolidated materials:

The designated study area contains soil -units that are unique to Northern Kentucky as well as deposits typically seen throughout Kentucky such as Alluvium (fluvial system deposits) and Colluvium (gravity driven deposits). Glacial deposits are known to overly the Ordovician bedrock within the designated study area. Glacial drift is a general term used for these deposits it refers to all deposits of rock material, clay silt gravel and boulders transported by or deposited the ice. These deposits in study area consist of loess deposits (unstratified silty or loamy deposits primarily deposited by the wind) and eolian deposits (wind deposited materials that consist of sand or silt sized particles. These materials are typically extremely well sorted and free of coarse fragments). Descriptions of these units are below.

Alluvium (Qal):

Dark grayish brown to brown silt loam containing limestone and shale pebbles, gravel, and cobbles as flood plain deposits along streams. Light gray to brownish gray limestone and shale gravel, pebbles, and cobbles as channel deposits. Minor brown to grayish brown and sand in streams draining areas underlain by high-level fluvial deposits *(Swadley 1969*). Up to 15 ft thick in tributaries, and approximately 5 ft thick in smaller stream valleys. Contacts are generally sharp and have been mapped on basis of field observations and topographic expression using LiDAR elevation data.

Glacial Drift (Qgd):

Clay, silt, sand, and gravel, weathered reddish brown at the surface. Gravel includes subangular to angular pebbles of chert and rounded to subrounded pebbles, cobbles, and boulders of quartzite, granite, conglomerate, sandstone igneous and metamorphic rock as much as 7 ft in diameter (Swadley, 1972). Soil Survey (Wiesenburger and others, 1989) notes weathered chert fount 52 in. from the surface. Drift includes indistinguishable deposits of till and outwash; a cap of loess is common on ridgetops. Unit is typically less than 40 ft. thick; Swadley (1969a) reported thickness of 80 ft near Patriot. Contacts with colluvium and residuum are gradational; contact with large deposits of outwash are approximate or inferred (1971a).

Residuum (Qr)

Silt and clay, dark brown to yellowish brown. In-situ weathering of bedrock and locally integrated with loess. Unconsolidated. Found overlying bedrock in uplands throughout the quadrangle. Typically, less than 12 ft thick. Contact with adjacent colluvium and glacial drift is gradational.

Colluvium (Qc)

Brown to dark yellowish brown silt loam along with slabs of weathered shale and limestone. Consists of locally derived deposits of residuum and weathered bedrock. Forms on hillslopes of greater than 12 degrees. Occurs along slopes of stream valleys and artificial cuts along roadways. Thickness of colluvium is variable and depends on the steepness of the slope. Contact with residuum on hilltops is gradational and generally sharp with alluvium.

Alluvium, fluvial terrace undifferentiated (Qat)

Dark yellowish brown to light brownish gray silt loam from locally derived sediments and in-situ weathering of those deposited sediments. Most terrace landforms in the area underlain by benched bedrock of shale from the Kope Formation. These terraces form along meander bends in tributaries. Thickness of sediment and soil on these terraces above the benched bedrock is 2 to 3ft, whereas sediments on terraces not underlain by bedrock that is benched are up to 20 ft thick. The contact with adjacent units is generally sharp and mapped on the basis of field operations and topographic expression using LiDAR elevation data.

4.0 Geologic Structures and Hazards:

Structural Geology

The Project Corridor is located within the Cincinnati Arch, a north-south oriented broad uplift in the sedimentary rock strata. Bedrock layers lie horizontally along the axis of the arch but dip 5-10 ft/mile along the flanks of the arch (figure ???). This is an ancient feature that is no longer being uplifted. Geologic mapping does not indicate any major faulting or folding, there may be localized faults in the area that are currently unmapped.

Hazards:

The project corridor is in a low-risk Karst potential zone. Karst features such as sinkholes and springs are present but not prevalent. The Ordovician strata in this area is not as subject to solutioning, the strata have high shale contents machining it less prone to produce typical Karst features. (Figure 3)

A feature of the area that may be of concern is the instability of slopes that lead to numerous landslides in the region. The Kope Formation consists of soft easily deformed shale. Which is unstable and readily slumps when wet. Over steepened banks and artificial cut should be avoided or properly designed and drained.

Mines and Quarries

According to the Kentucky Geological Survey (KGS) mapping service there are no active mines or quarries in the proposed project corridor.

5.0 Geotechnical Considerations

Geotechnical Branch personnel performed a site investigation on 12-8-2021. This was to identify any geotechnical issues and concerns with the proposed alignments. The site visit combined with available resources (such as previously completed reports, previous experience in the region, and geologic mapping) help us to better anticipate geotechnical concerns that may affect a project alignment.

Cut Slope Considerations

A detailed geotechnical exploration will be required for areas that involve widening existing cuts or creating new cuts. Cut slope configuration in rock are generally controlled by bedrock lithology, bedrock quality, results of Slake Durability Index (SDI) tests in shales and siltstones, and by the presence of any fractures and/ or joints. The lithology of the of the rock underlying the project corridor is highly subject to weathering when exposed. Cuts widened or created can be anticipated to be constructed on 2H:1V slopes or flatter.

Embankment Considerations

The project area is susceptible to unstable fill slopes. Failures are common where embankments composed primarily of non-durable shales are constructed on 2H:1V slopes are not properly constructed. Material from roadway excavation is anticipated to consist of primarily non-durable shales. Embankments constructed primarily out of non-durable shale (SDI less than 95 according to KM 65-513) should be constructed using special shale compaction methods as in accordance with Section 206 of the Standard Specifications for Road and Bridge Construction . If construction methods are not followed the shale can break down in a few years causing settlement and potential failures.

With proper construction methods embankments constructed on 2H:1V slope configurations or flatter can be anticipated for slopes up to 20- feet tall. Any embankments built 20-feet or taller will require stability analysis and may require flatter slopes.

Subgrade

It is anticipated that rock from roadway excavation will not be suitable for subgrade stabilization. Other methods of subgrade stabilization should be considered. After review of previously issued Geotechnical Engineering Roadway Reports in the immediate area (R-034-1989 and R-015-2015) Chemical stabilization by use of lime or cement, the decision of what material to use for stabilization will be determined by laboratory testing of soils sampled from the subsurface exploration. In some cases modification of the soil subgrade by use of lime or cement may not be feasible due to crossovers, tie-ins, presence of underground utilities, maintenance of traffic, dust concerns (in urban settings), etc. Other options for subgrade stabilization include construction of a rock roadbed from Kentucky Coarse Aggregate No. 2, No. 3 or No. 23 sized stone with geotextile fabric. Use of a geogrid may also be a viable option for stabilization if properly installed. Shale above or below the RDZ cannot be used in the top 2 feet of the subgrade.

If any pavement is to be removed the material under the pavement is expected to be soft and saturated and may also require manipulation. Pavement cores may need to be taken, as well as samples of the subgrade as well as undisturbed samples of material below the subgrade for pavement design purposes

Water Wells and Springs

Springs may be present within the proposed area. These locations should be inventoried to verify their locations. Spring boxes and/or granular material may be required in the vicinity of springs According to the KGS mapping service there are multiple water wells located in the project corridor .These locations when encountered shall be verified and inventoried. If water wells are encountered during construction, special construction considerations will be required to close those wells. All water wells or cisterns within the limits of construction, weather shown on the plans or not shall be plugged in accordance with Section 708 of the current Standard Specifications for Road and Bridge Construction.

Ponds

Ponds are located with in the project corridor. If these ponds are to be impacted by roadway construction due to alignment, these ponds will require treatment. Such as removing soft and unstable material and stabilization of the area more than likely by use of Kentucky Corse Aggregate #2’s, #3’s or 23’s and underlain by geotechnical fabric.

Gas and Oil Wells

According to the KGS mapping, there are no known oil or gas wells in the specified project corridor

Landslide Repair

Embankment stability problems area well documented engineering problem in Northern Kentucky. Shales of the Upper Ordovician Formations located in the Specified project area are well known for there rapid slaking and low shear strength when used in fills. Due to this there are numerous completed landslide mitigation reports on the Geotechnical report database, close in proximity to the specified project corridor. Mitigation of Landslides in the area include the use of drilled in railroad steel, berms, excavate and replace , and retaining walls. Please see L-006-1980, L-006-1983, L-013-1986

During a site visit conducted on December 8th, 2021 Geotechnical Branch personnel multiple landslides were documented on US 25, located between Chambers Road and M Tagher Drive.

6.0 Conclusion

This is a general overview of the geotechnical considerations that need to be taken in to account during alignment selection and construction. This includes the bedrock, soil, and geotechnical hazards that are expected to be encountered in the project corridor. These features may have adverse impacts on the project.

A complete Geotechnical investigation including drilling, sampling, and testing of materials will be needed to anticipate and plan for any special treatment of issues encountered during that phase. This may include the taking of pavement cores were directed by the project team. Analysis of rock core and soil sample testing will be compiled and presented in a Geotechnical Engineering Roadway Report and A Structures Report if needed.

References:

U.S. Geological Survey Professional Paper 1151-5; Lithostratigraphy of Upper Ordovician Strata Exposed in Kentucky

Geologic map of the Walton Quadrangle (GQ #1080), by: Stanley J Luft; Published by the USGS, 1973.

Geologic map of the Verona Quadrangle (GQ #819), by; W C Swadley; Published by the USGS, 1969.

Geologic map of the Independence Quadrangle (GQ #785), by; Stanley J Luft; Published by the USGS, 1969

Geologic map of the Union Quadrangle (GQ #779), by; W C Swadley, Published by the USGS 1969

USDA Web Soil Survey

KYTC Projects Nearby (KYTC Geotechnical Report Number):

R-001-2017; Improve Intersection at US 42 & Rice Pike/Hicks Pike Mile points 8-9

R-018-2015; I-75 New Ramp from Mall Rd. Interchange to Southbound 1-75

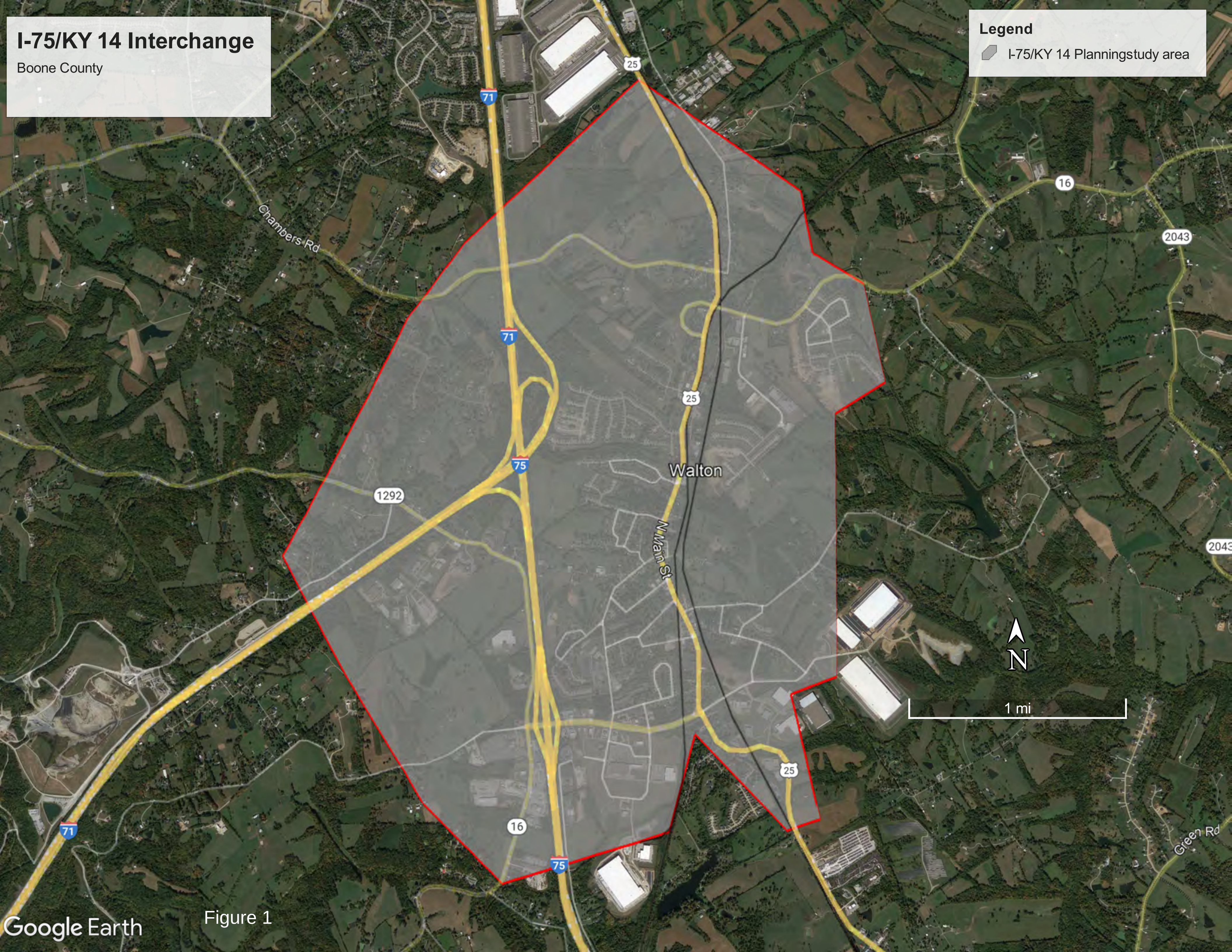
Mile points 180-181

R-034-1989; US 25 Over Southern Railroad at the Southeast City Limits of Walton.

L-006-1980; Walton-Nicholson Road, Embankment Landslide

L-001-1981; 1-75 Embankment Landslide (Boone County mile points 166-186)

L-001-1996; US 42 @ Duck Head Hill (mile points 2-3)


I-75/KY 14 Interchange
Boone County
Legend
I-75/KY 14 Planningstudy area
Chambers Rd
Walton
N Main St
71
75
25
16
1292
2043
Green Rd
1 mi
N
Google Earth
Figure 1

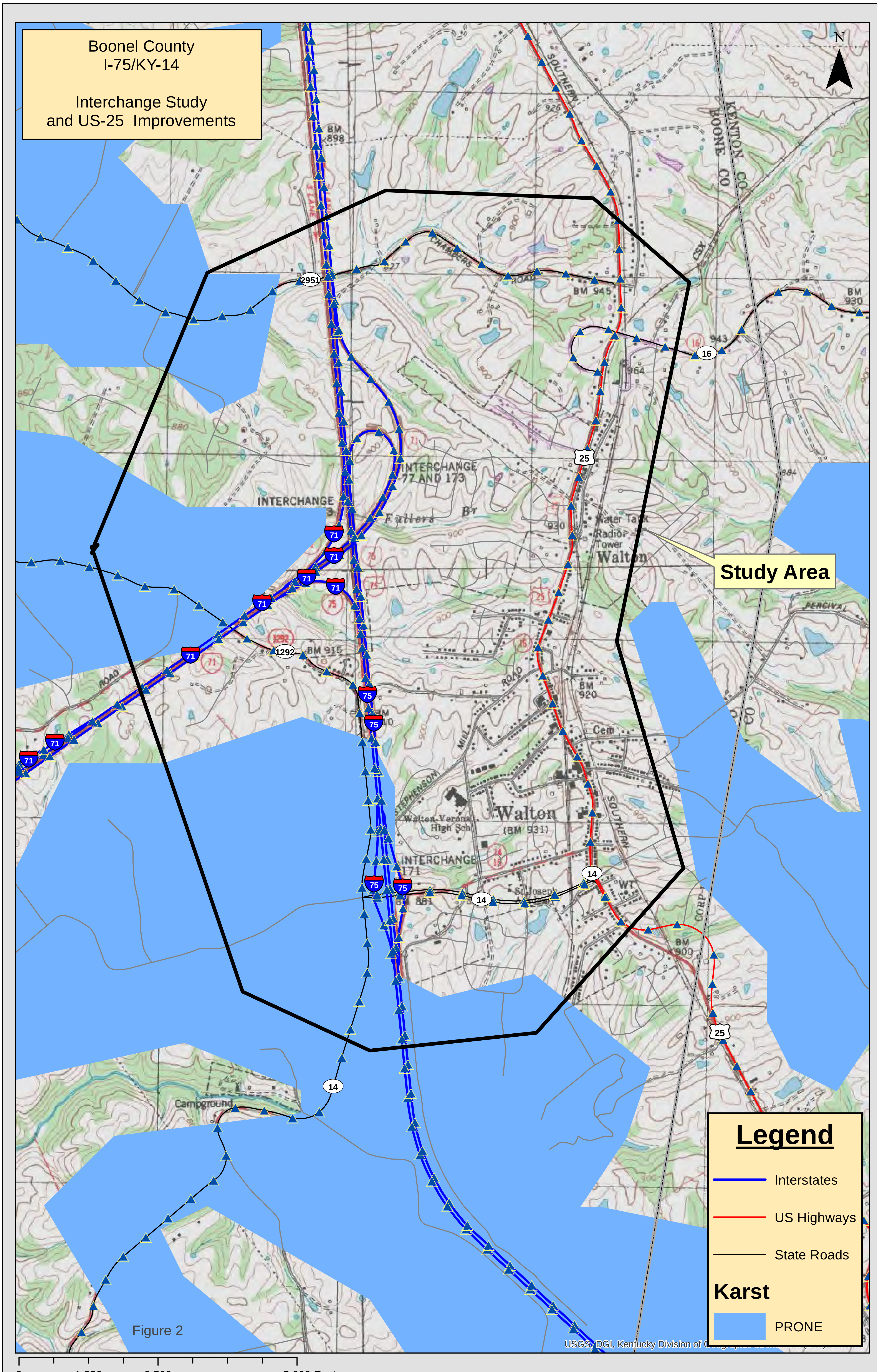
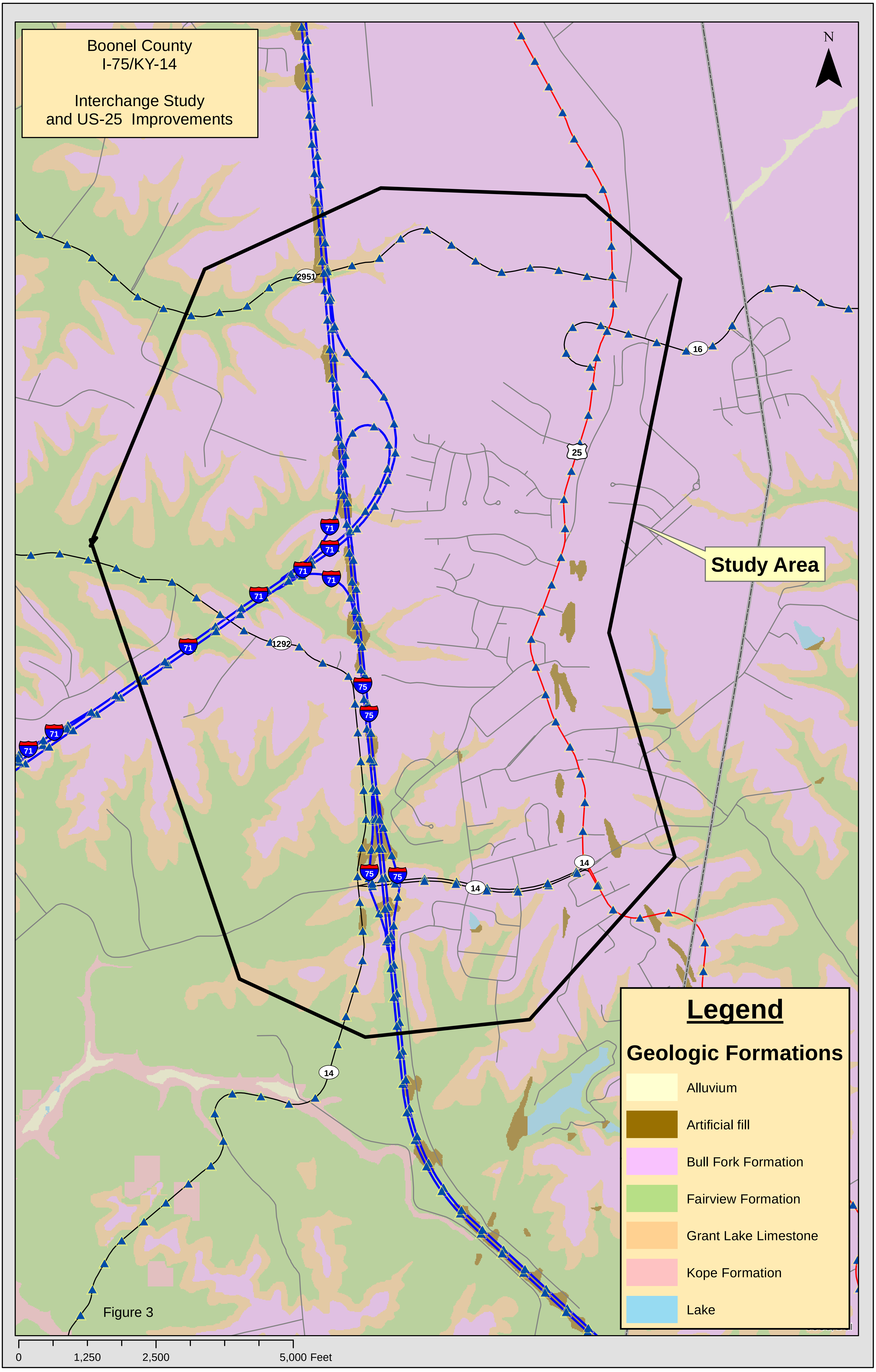

Boonel County
I-75/KY-14
Interchange Study
and US-25 Improvements
N
Study Area
INTERCHANGE 77 AND 173
INTERCHANGE 171
Walton
Walton-Verona High Sch
Fullers Br
Water Tank
Radio Tower
Campground
CHAMBERS ROAD
BOONE CO
KENTON CO
SOUTHERN
CSX
Legend
Interstates
US Highways
State Roads
Karst
PRONE
USGS, DGI, Kentucky Division of Geographic Information
0
1,250
2,500
5,000 Feet

Figure 2


Boonel County
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Study Area
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Geologic Formations
Alluvium
Artificial fill
Bull Fork Formation
Fairview Formation
Grant Lake Limestone
Kope Formation
Lake
71
75
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Figure 3