November 11, 2021

NextEra Energy Resources
1105 Navasota Street
Suite 201
Austin, TX 78702

Attn: Mr. Matt Towery, P.E.
P: (561) 691-2249
E: matt.towery@nexteraenergy.com

Re: Karst Feature Survey and Assessment Report
Green River Solar
Meade and Breckenridge Counties, Kentucky
Terracon Project No. JD215085

Dear Mr. Towery:

As requested, Terracon Consultants, Inc. (Terracon) is submitting this interim report summarizing the data review and field survey of karst features at the proposed Green River Solar site located in Meade and Breckenridge Counties, Kentucky. This report was prepared in general accordance with Terracon Proposal No. PJD215085, dated March 23, 2021.

1.0 PROJECT INFORMATION

We understand the project assessed the feasibility of constructing a solar facility located on a series of parcels in Meade and Breckenridge Counties, Kentucky. The proposed sites encompasses approximately 1,945 acres and an additional 2,550 acres under consideration, for a total of 4,495 acres. All of the parcels are mapped as underlain by soluble carbonate bedrock forming a regional karst terrain (i.e. a landscape characterized by the presence of sinkholes, caves, sinking and losing streams, and a highly irregular "pinnacled" overburden/bedrock interface). Due to the challenges that karst terrain can present to development projects of this kind, the objective of the proposed investigation will be to identify, locate, and characterize existing karst features that are present at the ground surface at the site. This report serves as a final comprehensive document, including the work of multi-staged reporting, KMZ files of the locations and risk ranks of karst features, 25-foot buffer layers, and several mobilizations and field surveys.

2.0 SCOPE OF SERVICES

Terracon assessed the parcels indicated on the file provided to us, hereinafter referred to as the Area of Interest (AOI) and shown in Appendix A, Exhibit 1.

Our karst survey services were limited to a desktop data review of the entire site under consideration (4,495 acres). Two field visits were conducted to "spot check" some of the mapped karst features onsite (4/15/2021 and 4/20/2021). Subsequently, a more comprehensive field verification and assessment of karst features located within the original 1,945 acres and only 200 acres of the additional properties (KY-MEA1-085 and KY-MEA1-088). It is important to note that upon request of the client, the very high and high risk karst features were not verified during the field survey activities and were instead automatically considered for avoidance. This conservative approach was done in order to reduce the amount of field survey time since the number and density of sinkholes was high throughout the site. A comprehensive table of the parcels that underwent desktop and/or field survey is presented in Table 1 below.

Table 1

Parcel ID	Desktop Survey	Field Survey
KY-MEA1-062	YES	NO
KY-MEA1-063	YES	NO
KY-MEA1-073	YES	NO
KY-MEA1-074	YES	NO
KY-MEA1-085	YES	YES
KY-MEA1-088	YES	YES
KY-MEA1-155	YES	YES
KY-MEA1-164	YES	YES
KY-MEA1-165	YES	YES
KY-MEA1-209	YES	NO
KY-MEA1-227	YES	YES
KY-MEA1-228	YES	YES
KY-MEA1-233	YES	NO
KY-MEA1-237	YES	YES
KY-MEA1-248	YES	YES
KY-MEA1-254	YES	YES
KY-MEA1-255	YES	YES
KY-MEA1-258	YES	YES
KY-MEA1-260	YES	YES
KY-MEA1-266	YES	YES
KY-MEA1-268	YES	YES
KY-MEA1-269	YES	YES
KY-MEA1-270	YES	YES
KY-MEA1-275	YES	YES
KY-MEA1-277	YES	YES
KY-MEA1-279	YES	YES
KY-MEA1-287	YES	YES
KY-MEA1-288	YES	YES
KY-MEA1-289	YES	YES

Parcel ID	Desktop Survey	Field Survey
KY-MEA1-291	YES	YES
KY-MEA1-292	YES	YES
KY-MEA1-293	YES	YES
KY-MEA1-300	YES	YES
KY-MEA1-301	YES	YES
KY-MEA1-302	YES	YES
KY-MEA1-305	YES	YES
KY-MEA1-307	YES	YES
KY-MEA1-422	YES	NO
KY-MEA1-700	YES	NO
KY-MEA1-701	YES	NO
KY-MEA1-702	YES	NO
KY-MEA1-708	YES	YES
KY-MEA1-710	YES	NO
KY-MEA1-716	YES	NO
KY-MEA1-720	YES	NO
KY-MEA1-730	YES	NO
KY-MEA1-731	YES	NO

Specifically, Terracon provided the following services:

- Terracon's karst geologists performed a desktop review of readily available resources to identify suspected and/or previously identified and documented karst features (e.g., sinkholes and areas of soil subsidence, cave entrances, closed depressions, and sinking and losing streams) within the AOI, and any features within 0.25 miles of the AOI that were inferred to receive drainage from the AOI. A desktop risk ranking was determined for each identified suspect karst feature.

- Based on the results of the data review, Terracon's karst geologists located and delineated visible surface karst features (e.g., sinkholes and subsidences, cave entrances, closed depressions, and sinking and losing streams) within the planned array areas of the proposed AOI, with particular emphasis on features that were inferred to have direct communication with the phreatic zone (e.g.: "open-throat" sinkholes, karst windows, cave entrances, abandoned wells, sinking streams) and areas of high karst activity that could indicate development of pinnacled bedrock. Field observations were made by walking the AOI. Small Scale site maps showing the AOI which was evaluated are included as Appendix A, Exhibits 1 through 3.

- Terracon delineated zones of karst terrain based on the surface karst feature assessment.

- The findings and conclusions of the data review and field study have been summarized in this report. The report includes recommendations on the feasibility of the planned construction in karst areas, indicates higher or lower risk areas within the AOI, and provides recommendations regarding additional studies or investigations for site specific karst features identified during the survey.

2.1 Methods and Procedures

Desktop Data Review

Potential karst features were identified remotely. Terracon conducted a review of the existing feature locations within the AOI, and up to 0.25 miles outside of the AOIs, that were available from the following sources:

1. The Cave Database of the Kentucky Speleological Survey (KSS);
2. Maps of selected karst features available from the United States Geological Survey (USGS) and the Kentucky Geological Survey GIS Sinkhole Database (https://www.uky.edu/KGS/gis/sinkpick.htm);
3. Digital Elevation Models (DEMs) and LIDAR Data (collected 2014);[1]
4. LiDAR derived two-foot contour interval maps for the AOI and surrounding to within 0.25 miles, in order to determine the presence of surface features not included in the above listed databases based on the presence of closed, descending contours or other suspect karst "fingerprint" features;
5. Aerial photographs (both recent and historical); and
6. USGS Topographic 7.5-minute topographic quadrangles.

In addition, we have reviewed the readily available geologic literature for bedrock and structural characteristics. We also have relied upon the closest resolution geological mapping that exists for the AOIs.

Field Survey

Upon completion of the data review, Terracon initiated the field reconnaissance and survey activities. Specifically, the field reconnaissance entailed:

1. Location and verification of potential surface features previously identified in the desktop review;
2. Location of uncatalogued or previously unidentified surface features, specifically sinkholes, cave entrances, dry runs, and sinking streams.

[1] KyFromAbove (https://kyfromabove.ky.gov/)

Each survey area was delineated and then examined for features (both catalogued and previously unidentified during the desktop review) in the field. This entailed walking over the survey area in a systematic manner, to observe features that fit the criteria. The locations and outlines of all relevant features were recorded using a sub-meter accuracy GPS device. For this study, the outline (parapet) of a closed depression (sinkhole) was defined as either the last closed descending contour at a 2-foot mapping interval or by the presence of a visible parapet. Cave entrances were identified as single points, unless the entrance was located within a larger sinkhole structure, in which case the cave entrance was indicated as a point within the sinkhole's parapet. Sinking streams were located as points of entry into the subsurface; however, losing streams were identified as linear features. Springs were also identified as points.

3.0 GEOLOGY AND TERRAIN

Physiography - The proposed Green River Solar site is situated within the western portion of the Interior Low Plateaus Physiographic Province of Ohio, Kentucky and Tennessee, which extends from the Greater Cincinnati metropolitan region in the Ohio River Valley southward to the Nashville Region of Tennessee. In general, the Interior Low Plateaus range from approximately 380 to 1,200 feet in elevation and predominantly comprise of rolling plains and eroded plateaus. This region is almost completely composed of horizontal beds of sandstone, shale, and limestone from the Paleozoic Era (541 to 252 million years ago). The Interior Low Plateaus exist at the southeastern area of the Central Lowlands, the boundary occurring where the maximum extent of the Pleistocene glaciers reached.

Specifically, the subsection of the Low Plateaus Physiographic Province in Kentucky is locally referred to as the Mississippian Plateaus or the "Pennyrile" (named for the Pennyroyal plant, *Hedeoma puligiodes*). The Mississippian Plateaus wrap around the Western Kentucky Coalfield Province, in a crescent that opens towards the north. This Mississippian Plateaus in the site area are divided by the Dripping Springs Escarpment and a lowland area called the Pennyroyal Plateau. The Green River Site lies within the Muldraughs Hill district of the Pennyroyal Plateau within Meade and Breckenridge Counties, KY.

Topography – Referencing the USGS 7.5-minute topographic quadrangles the site is located in the (Guston, 2016), (Irvington, 2016), and (Garfield, 2016) USGS 7.5 Minute Quadrangles, respectively. The site has an approximate average elevation (EL) of EL 610. The highest point within the site is at EL 720. The site lies along the eastern base of the Dripping Springs Escarpment, and slopes gently away from the escarpment.

There are a few areas of surface water at the site, primarily ponds, which are mostly flooded sinkholes. There are few surface streams locally with the exception of Sinking Creek which is located along the southwest edge of the AOI. As is evident by the name, sections of Sinking Creek are dry, depending upon the frequency of precipitation events and the time of year.

Geology – The Mississippian Plateau Province is named based on its geology, as it is underlain primarily by karst-prone carbonate units dated to the Mississippian Geologic Period. It is important to note that a system of northeast trending normal faults are present to the southeast of the AOI and intersects the north eastern parcels within Meade County. The following bedrock units are mapped within the survey area and are shown in Exhibit 2, Appendix A and described below:

Reelsville Limestone (Mr)
A small sliver of the Reelsville Limestone is present along a high ridge located along the south-westernmost parcel and constitutes a minor region of the AOI. The unit is typically characterized by gray, biomicritic, sandy limestone and is limited in thickness from approximately 4-10 feet.

Sample Sandstone (Msa)
The Sample Sandstone type location is located in Breckinridge County and is typically characterized by thick-bedded and cross-bedded sandstone and minor layers of shale and ranges in thickness from 20 to 40 feet.

Reelsville Limestone and Sample Sandstone, Undivided (Mrs)
Within the AOI, the geology units change to include the Mrs unit, which is a combination of the Reelsville Limestone and the Sample Sandstone. It is common for geology units to either be split apart or combined during different survey efforts. In this case, the majority of the site has these units mapped as “Mrs” while in the northern sections this unit is separated into “Mr” and “Msa”. In either case, the geology of these units should be identical.

Beaver Bend Limestone and Mooretown Formation (Mbm)
The Beaver Bend Limestone is a massive bedded and oolitic rich limestone that ranges in thickness from 0 to 14 feet depending upon the location.

The Mooretown Formation is located beneath the Beaver Bend Limestone and comprised of sandstone and shale and has an irregular thickness ranging between 10 and 60 feet.

Paoli Limestone (Mpa)
The Paoli Limestone is light-olive-gray to light gray, small to medium grained and oolitic limestone that ranges in thickness from 0 to 50 feet. There is very little difference between the underlaying Ste Genevieve Limestone; therefore, it is often difficult to distinguish the limestone.

Ste. Genevieve Limestone (Msg)
In general, the Ste. Genevieve Limestone is composed of medium gray to bluish gray limestone with minor clay-shale beds and interbedded oolitic limestone with coarsely crystalline limestone and fine to medium grained calcarenite and calcilutite. The most significant member of the Ste. Genevieve Limestone ranges in thickness from approximately 200 to 250 feet thick. The limestone comprising this member is broken into three major types, described in detail below.

1. Light-gray and oolitic, found in zones 10 to 30 feet thick;

2. Light-to medium-gray, finely crystalline, commonly dolomitic with rare chert modules (typically found in the lower 60 feet); and
3. Light-to medium-gray, medium-to coarsely crystalline, fossil fragments evident.

The base of this unit is typically cherty limestone as it transitions to the underlying unit, and weathers to a dark reddish-brown soil with dense or oolitic chert fragments.

St. Louis Limestone (Msl)
The Ste. Genevieve Limestone is underlain by this formation which consequently underlies the entirety of the AOI. This formation is separated into an upper and lower member. The upper unit is comprised of mainly thin beds of dark gray limestone with thin layers of shale and nodules of chert present near the top of the formation.

Karst Geology – The caves and hydrogeology of both Meade and Breckenridge Counties have been extensively studied by the Kentucky Geologic Survey (KGS), the academic community, and the caver community. We were able to acquire the proprietary locations of cave entrances from the Kentucky Speleological Society (KSS) within or near the AOI. Additionally, the KGS supplied a digital map of Webster Cave and guidance on dye tracing within the watershed of this cave system. Based on survey data provided by the KSS, Webster Cave is approximately 10 miles in length and is comprised of trunk passages which are floored by significant cave streams and rivers, which widen into periodic deep lakes in various places. Typically, the water within the cave drains to the southwest into the Sinking Creek, but during flooding the water diverts to the northwest before eventually entering the Sinking Creek. The majority of the cave system serves as an "overflow" to the river located within the southeastern most corner of the cave. The cave often fills completely during heavy precipitation events and rainy periods of the year. The northeastern branch of the cave system is believed to be an "in-feeder" bringing surface water into the cave system. It is important to mention that several smaller caves are located within sinkholes near Webster Basin Springs Road which presumably are hydrologically connected to Webster Cave.

Dye tracing within the region has provided a general outline for the extent of the drainage catchment leading to Webster Cave and has demonstrated that the majority of the AOI is located within this area (KGS, 2001, Ray et al., 2005). This indicates that nearly all of the sinkholes located within the AOI eventually lead to the river within Webster Cave.

4.0 DESKTOP DATA REVIEW FEATURE INVENTORY

Based on the methods and procedures for the data review as detailed previously in Section 2.1, suspect karst features were identified throughout the site. In total, one thousand and forty-six (1,046) point karst features and one hundred and thirty-six (136) area karst features were identified within the AOI for a total number of one thousand and one hundred and eighty-two (1,182) suspected karst features (Figure 1; Appendix D, Table 1). The largest area features ranged in size from 100 to 1,000 feet in length and width, but only a few feet in depth; therefore, it would be very difficult to identify these subtle features in the field.

Both point and area karst features were identified throughout the AOI. The parcels with high karst feature density values (e.g. >1.0 feature/acre) are either near an environment that encourages the development of karst features or is mapped as underlain by Webster Cave. For example, parcels KY-MEA1-287, KY-MEA1-288, and KY-MEA1-293 are shown to be underlain or near the mapped passages of Webster Cave. Parcels KY-MEA1-227, KY-MEA1-258, and KY-MEA1-268 are near an existing quarry which are well-documented with causing the development of sinkholes. Pumping of the groundwater and the resulting steepened groundwater gradient towards the quarry causes the movement of soil from the lower sections of a sinkhole resulting in soil raveling which eventually affects the surface. The regions encompassed by parcel KY-MEA1-731 are located near Sinking Creek. Sinkhole numbers and density typically increase with distance to a river or creek, due to the downcutting and headward erosion in the tributaries. Finally, parcel KY-MEA1-254 is adjacent to a large junkyard which may be focusing the surface runoff into the parcel. Increasing the amount of surface runoff or concentrating water to a specific area may increase the likelihood of opening up new sinkholes or exacerbating existing sinkholes.

Figure 1. Map of the AOI showing the distribution of suspect point and area karst features.

5.0 KARST FEATURE RISK – DESKTOP DATA REVIEW

5.1 Desktop Data Review Risk Ranking

Karst risk was assessed per karst feature through the compilation of a data matrix comprising four karst feature variables derived from the desktop data review. These variables were assessed per karst feature through observation of factors contributing to karst feature formation and qualitative calculation of the landscape characteristics. It is of note that this type of data analysis and reduction (i.e. character analysis) is designed to assist in minimizing subjectivity in assessment of karst features for overall risk. The results of the risk analysis are presented in Appendix C, Table 2.

The variables (characters) embodied in creating the risk data matrix and resulting risk assessment summary are:

1. Feature is actively/passively avoided
2. Drainage leading to the karst feature
3. Maximum ruggedness value
4. Within buffer of mapped cave passages

Explanation of the Characters

Character 1 – The fact as to whether a karst feature is avoided or developed by the property owner is an important distinction when assessing features in a desktop review. In cases where the majority of the land is purposed for agriculture, the goal is to utilize as much of the property as possible. Where the landowners have chosen to avoid depressions and karst features indicates that the features may be significant. This process also works for forested areas which may have been avoided for development either due to karst features or prevalent and shallow bedrock.
Coding: Not Avoided = 0; Avoided = 1

Character 2 - An important factor that we note when assessing karst features is evidence for surface drainage focused into the karst feature. This is typically manifested as matted down grass/vegetation in the direction of the sinkhole in the case of surface runoff (sheet flow) or distinct erosion and channel development where water commonly drains into the karst features. Signs of erosion and downcutting in the channel leading to the karst feature further supports the notion that the karst feature base level is decreasing and typically growing.
Coding: No evidence of drainage = 0; Drainage channel = 1

Character 3 – The empirical calculation of the Terrain Ruggedness Index (TRI)[2] utilizing the LiDAR data is a systematic way to measure the architecture and steepness of each sinkhole. These characteristics can be used to infer the activity of the feature, the potential for an open throat/cave within the parapet, and the presence of steep bedrock walls. All of these characteristics are important for determining the risk and potential for the sinkhole to continue to develop or stabilize.
Coding: Maximum value of ruggedness included in score (e.g. ranges from 0.5 to 6)

Character 4 – The presence and orientation of mapped caves and the supporting passages underneath surface sinkholes is an important relationship to document. It is likely that sinkholes or other karst features within a short buffer of 500 feet from a mapped cave system may be linked. This is especially important if the sinkholes that are within this region have open throats.
Coding: No mapped cave = 0; Underlain/within buffer of mapped cave passage = 1

Based on the desktop survey results and character analysis, we have assigned a relative risk rank for the confirmed karst features present, specific to this site. If the defined characteristics sum was 0-1 it is our interpretation that the feature is low risk to site development. If the sum was 1.5-2, we believe the feature is a moderate risk to site development. If the sum was 2.5-4, we believe the feature is a high risk to site development. Features with characteristics summed greater than 4 are believed to present very high risk for continued karstification during site development and throughout the operation of the proposed facility.

It should be noted that these rankings have been based on the desktop data review exclusively and that the final risk ranking must be determined by actual verification and observation of the features in the field, as the development of karst is dynamic and can change rapidly (Table 1).

6.0 KARST FEATURE RISK – FIELD SURVEY

6.1 Field Survey Risk Ranking

The field survey was performed from May 5 through May 14, 2021, by Terracon Staff Geologists Sean Vanderhoff and Jacob Helsley, and by Terracon Staff Engineer Munal Pandey. The AOI was assessed for karst development in the parcels where the geological mapping suggested there was the possibility of the development of karst terrain and/or where the data review indicated the possible presence of existing surface karst features (e.g. closed depressions, sinkholes, caves, or karst springs). A total of 888 karst features were verified and characterized in the field. A summary of the karst feature inventory documented during the field survey is included in map format in Appendix B, photolog format in Appendix C, and data format in Appendix D. It is important to note that the client requested that very high and high risk karst features identified in the desktop review risk ranking were not visited during the field survey efforts. These features were automatically placed into an avoidance category. Instead, the very low through moderate

[2] Riley, S. J., DeGloria, S. D., & Elliot, R. (1999). Index that quantifies topographic heterogeneity. *intermountain Journal of sciences*, *5*(1-4), 23-27.

risk features mapped within the planned array areas were surveyed in order to verify the characteristics and change the risk ranking (either up or down) from the desktop review results. In some cases, previously desktop ranked moderate and low risk features became very high and high risk upon closer field inspection.

6.2 Risk Character Analysis and Results

Karst risk for the field survey was assessed per karst feature through the compilation of a data matrix comprising five karst feature variables, in contrast to the karst feature risk based on the desktop data review where four variables were used. These variables were assessed per karst feature by analyzing the field notes, observing the photographs, and considering the overall context and resources from the desktop data review. It is of note that this type of data analysis and reduction is designed to assist in minimizing subjectivity in assessment of karst features for overall risk. The tabulation of the data analysis is present in Appendix D, Table 2.

The variables (characters) embodied in creating the risk data matrix and resulting risk assessment summary are:

1. Parapet characteristics
2. Presence of an open throat
3. Degree of soil raveling
4. Drainage leading to the karst feature
5. Presence and quality of vegetation

Explanation of the Characters

Shown below are examples of each character to assist in the process of feature coding for risk analysis. This typology presents examples of each character, and their specific coding.

Character 1 - The shape and conformation of the parapet of each karst feature is important because the smoothness of the edge indicates the degree of erosion, growth, and overall activity of the karst feature. Typically, the rougher the parapet edge, the more active the karst feature and hence higher risk for the surface to continue to change.

Parapet Stable/Circular = 0

Irregular/Unstable = 1

Character 2 – The presence of an open throat (e.g. an opening into the subsurface, usually at the base of a sinkhole, an opening within a rock outcrop, or a cave entrance) in a karst feature is important since it may allow the unimpeded flow of surface runoff into the subsurface and eventually the groundwater table. This is a serious environmental concern to the groundwater and proper erosion and sediment control and buffering must be utilized during construction around these types of karst features.

Absent = 0

Small/Unknown = 1 (unknown)

Small/Unknown = 1 (small)

Large/Open = 2

Character 3 - Coincident with parapet shape changes and erosion, soil raveling of the sinkhole walls, throat, and subsidiary channels is a good indicator for sinkhole activity and risk. We further distinguish soil raveling into “minor raveling” and “raveling” to differentiate between levels of erosion and growth inside the karst feature.

No Raveling = 0

Minor Soil Raveling = 1

Major Soil Raveling = 3

Character 4 - An important factor that we note when assessing karst features is evidence for surface drainage focused into the karst feature. This is typically manifested as matted down grass/vegetation in the direction of the sinkhole in the case of surface runoff (sheet flow) or distinct erosion and channel development where water commonly drains into the karst features. If the channel leading to the karst feature exhibits signs of erosion and downcutting, then this further supports the notion that the karst feature base level is decreasing and typically growing. It should be noted that it is very difficult to differentiate between “no drainage” and “sheet flow”, as only a slight downward gradient of even gentle slopes will result in sheet flow to a feature. This type of flow is often attenuated by vegetation, plow lines, or soil irregularity. Thus, if it is uncertain that a feature receives sheet flow versus no flow, it is always coded conservatively (i.e. using sheet flow). Finally, it should be noted that some features exhibit flow channels that drain towards the feature (an insurgence or “swallet”), and in some cases away from the feature (i.e. an ephemeral or “wet weather” spring). In rare cases they may receive flow during low water table conditions and reverse their flow during a high water table (referred to as an “estavelle”). However, we code any well-developed flow channel the same (see below).

No evidence of drainage = 0

Sheet flow = 1 (washed-in plant debris)

Drainage channel = 2 (flow towards feature)

Drainage channel = 2 (flow away from feature)

Character 5 - The presence, type, and state of vegetative cover surrounding and within the karst feature is an indicator for sinkhole development and the existence of a natural buffer. If little to no vegetative cover is present within the sinkhole then this indicates that it is changing fast enough to inhibit plant growth and is vulnerable to surface runoff. If the sinkhole is overgrown, then this signifies that the sinkhole is more stable and that a natural vegetated buffer is present, which functions to filter out suspended soil/contamination in surface runoff.

Fully vegetated = 0

Partially vegetated = 1

Soil/rock = 2 (failed backfill)

Soil/rock = 2 (loss of vegetation)

6.3 Examples of Features Used to Develop Risk Ranking

A total of eight different types of karst features with varying characteristics impacting the risk ranking are shown below. The following exemplary karst feature "types" are representative of the various characteristics used to develop the risk ranking. In some cases, the following feature types may have more than one of the characters used in the risk ranking development, nevertheless they are included here as examples.

Type 1 – This type of karst feature is characterized by the presence of an open throat at the base and active erosion along the walls and parapet of the feature. These features are considered the highest risk since they are actively growing and may continue to collapse and widen during construction activities and post development. Two examples of such features are shown below in Image 1.

Image 1. Both sinkholes are undergoing erosion and expansion of the parapet limits as demonstrated by the rough, raveling, and incised surfaces. In addition, the open throats present in the base of the sinkholes readily receive surface runoff with little to no filtration.

Type 2 – This type of karst feature is characterized by the presence of an incised drainage channel leading to the karst feature indicating that focused drainage enters the structure. This commonly results in active erosion and growth of the sinkhole (Image 2). In addition, they nearly always contain an open throat. Additionally, these features can be problematic as potential construction activities within the drainage may result in the uncontrolled flow of water transporting sediment and contaminants into the subsurface via the open throat. Awareness of the drainage catchment extent and implementation of proper erosion and sediment controls (ESC) are crucial for these types of karst features.

Image 2. Example of feature with drainage channel leading to open throat.

Type 3 – This type of karst feature has an open throat and rough, irregular parapet edges, indicating active erosion, collapse, and growth. The features are typically small (<5 feet) yet indicate that the area around the soil piping is undergoing sinkhole development which may widen, deepen, and affect the surrounding area (Image 3). It is commonplace to observe multiple soil piping features which may all be feeding into a single open throat in the subsurface. These features pose a significant risk because the karst features are actively developing; therefore, official remediation or avoidance is necessary.

Image 3. Examples of soil piping structures and open throats which are newly developed and indicate that growth and widening of these features is likely.

Type 4 – This type of karst feature is a sinkhole with a cave entrance located at the base or within the sidewall of the structure (Image 4). Caves pose a significant risk since they are relatively large openings that can receive surface runoff, may contain significantly sized chambers and passages below the surface, and may host cave fauna and sensitive biological habitats. Aside from having certified spelunkers enter the caves and map out the passages, geophysical techniques are often utilized to determine the presence, extent, depth, and size of cave passages in relationship to planned construction.

Image 4. Sinkhole with cave entrance in left sidewall.

Type 5 – This type of karst feature has an open throat within the structure, yet the remainder of the sinkhole is overgrown with vegetation and the parapet appears to be stable[3] (Image 5). Although there is an opening present leading into the subsurface, the protection and stabilization of the feature by maintaining a vegetated buffer dramatically reduces the risk of impacting the subsurface habitat during construction activities.


Image 5. Examples of overgrown open throats located at the base of sinkholes. The presence of the plant life indicates that little to no recent erosion has occurred.

Type 6 – This type of karst feature is characterized by bedrock bound open throats and rock outcrops either located at the base of sinkholes or within generally flat laying bedrock benches (Image 6). Although the open throats clearly connect to the subsurface, the bedrock does not present much risk of collapse or change in architecture unless the bedrock layer is very thin above an open chamber.

Image 6. Bedrock bound open throat located within a bedrock outcrop.

[3] Sinkholes with circular or oval parapets are assumed to have reached equilibrium and are considered stable. Nevertheless, changes in water flow rates, often caused by anthropomorphic actions (e.g. construction) or natural actions (e.g. flash flooding) can result in destabilization of a previously stable sinkhole.

Type 7 – This type of sinkhole has been used by farmers and landowners as a convenient place to deposit field rock, trees, trash, and a menagerie of various items and materials. This practice of depositing trash is highly discouraged since the contaminants originating from the infill material may quickly reach and may affect the subsurface aquifer. Nevertheless, these karst features were present within the AOI and most typically observed to be infilled with trash and occasional trees (Image 7). Since these may have been partially or completely filled, it is impossible to fully characterize these features for the presence or absence of an open throat. Therefore, we assume that there is an open throat at the base in order to be conservative for protection measures during construction activities.

A second type of sinkhole that falls into this category are ones which have been backfilled by local farmers using gravel or soil. These are very common at the Green River Site, and inevitably occur within areas of row crop cultivation. These sinkholes which were "remediated" by the landowner are extremely common within the area of the current field survey, comprising nearly half of all the identified features. In many cases they appeared to be stable, with no evidence of reactivation (i.e. the development of a new throat). However, it is impossible to determine when, and if, features like these might undergo renewed development and collapse, since the point in time when they were actually backfilled is generally unknown. Therefore, interviews with the landowner can assist in determining the stability of the features based on when they were backfilled and how often new features tended to appear within a specific parcel of land.

Image 7. Examples of a trash filled sinkhole observed during the field survey (left), and a backfilled sinkhole in a planted field (right). Note that the backfilled sinkhole has begun to reactivate, and a new throat is beginning to form.

Type 8 – This type of sinkhole is present as a broad and shallow depression, ranging in size from tens to hundreds of feet in diameter and commonly referred to as a "mature" or paleokarst sinkhole (Image 8). Mature sinkholes often have a roughly circular parapet outline, are bowl shaped, lack any opening to the subsurface (i.e. "throat"), and do not show evidence of active soil raveling or tension cracks around the parapet. Thus, whatever conduit or opening into the underlying karst aquifer that may have functioned to create the structure is probably now clogged with soil, which would act as a filter for water infiltrating from the surface.

Image 8. Large closed depression in a previously harvested cornfield.

Based on the character analysis, we have assigned a low, moderate or high-risk category of each of the confirmed karst features present within the parcels that underwent field survey (Table 1). If the defined characteristics sum was 0 it is our interpretation that the feature is very low risk to site development. If the sum was 1-2, we believe the feature is a low risk to site development. If the sum was 3-4, we believe the feature is a moderate risk to site development. If the sum was 5-6, we believe the feature is a high risk to site development. For features that their characteristics summed to 7-9, we believe present very high risk for continued karstification and site development and throughout the operation of the proposed facility.

The degree of risk we identify for these karst features has been based on direct observation, and indicates our professional opinion regarding the likelihood of the karst feature becoming unstable and/or accelerating its growth. The risk rankings should be used as a planning tool to aid in assessing the overall risk of developing the site. However, it should be clearly understood that even karst features designated as low risk can become unstable and negatively impact the proposed development. It is impossible to eliminate the risk of karst features, but measures can be taken to reduce the risk of karst issues.

7.0 KARST RISK RECOMMENDATIONS

The karst risk recommendations entail a suite of approaches for each karst risk level. These various solutions for karst features will depend upon the type and scope of the project, the amount of cut and fill planned for the AOI, the presence of karst dependent rare threatened and endangered species, and the hydrologic significance of the karst aquifer (e.g. municipal drinking water supply). For the specific development of remediation, alternative foundations, or detailed additional studies, it is recommended that a Terracon karst geologist monitor construction activities to ensure that proper protocol is applied and to be available for consultation in the event that new karst features develop during grading activities onsite. The karst avoidance and/or mitigation measures for each karst feature risk level are presented below. Please note that the recommendations from a higher risk category can always be applied to lower risk features as well.

Very High Risk (ranking 7-9)

- Avoidance and buffering
- Additional investigations may lower risk ranking
- Major remediation efforts

Moderate (ranking 3-4) to High Risk (5-6)

- Avoidance and buffering
- Additional Investigations may lower risk ranking
- Remediation (If necessary)

Low Risk (1-2)

- Span karst features

Very Low Risk (0)

- ·Grade and monitor

The preferred option is to avoid all karst features if possible, since every feature brings a variable amount of risk to both the project infrastructure and the karst aquifer. In addition, avoidance preserves the vegetated buffer, especially for features which have reached equilibrium naturally. For this avoidance scenario we recommend a minimum buffer of 25 feet which should remain in an undisturbed natural state[4] through all periods of construction and subsequent facility operations. In addition, a 150-foot buffer should be established around each karst feature during construction where vehicles may not be refueled, and stockpiles of equipment or fuel should not be stored. The 150-foot buffer may need to be extended or modified if a significant drainage area has been delineated outside of an open throat feature. This does not mean construction is prohibited within this buffer, only that certain construction related activities, primarily including the storage of fuel and equipment, should not occur within this area.

In the case where avoidance is not possible, then further investigation may be necessary to provide additional information on the extent, characteristics, and impact that the karst feature may

[4]An "Undisturbed Natural State" is defined for the purpose of karst conservation as not causing any disturbance to the natural vegetation and soils within the 25-foot buffer of a karst feature. This would include (but not be limited to) activities such as cutting, trimming, stripping and grubbing, grading, use of herbicides and/or insecticides, application of fertilizers or soil amendments, and depositing vegetation cuttings or trash of any kind.

have on the surface. This may include the remediation of karst features (e.g. reverse graded filter, cap grouting, etc.) and conducting additional studies (Section 7.0), as necessary. Remediation will vary for each karst feature based on characterization (e.g.: soil type, the architecture of the bedrock, local hydrology, and various other factors). The type of remediation is typically determined upon subsurface exploration and excavation of the karst feature and identification and characterization of the bedrock bound throat if present at the soil bedrock interface.

Specifically, for solar field facilities it may be possible to span some of the karst features with the solar arrays, depending upon the length of the arrays and the spacing of the supporting piles. This option is limited to the low and very low risk karst features since their current characteristics do not suggest continued erosion and growth and appear to have reached equilibrium naturally. It is important to note that periodic monitoring of these karst features post-construction is recommended.

The very low risk karst features may be graded per the construction plans, but it is imperative that the locations of these features be marked with survey grade GPS prior to grading activities. These areas should be monitored during construction in case the grading activities cause these features to reactivate.

Please note the risk rankings presented herein are based on the current condition of the site at the time of our study, and do not encompass the entire set of features known to have been identified in the prior desktop data review. Changes in the risks and changes in the karst features will occur over time. In addition, changes may occur due to changes in surface grades, surface hydrology, nearby construction activities such as blasting, installation of water supply wells, and other similar changes.

8.0 RECOMMENDATIONS

Based on the proposed use of the site for solar development and our desktop data review, Terracon would like to make the following recommendations:

- For the parcels that were limited to a desktop review, it is recommended that field reconnaissance be conducted to verify the findings if these parcels are added to the planned buildable area in the future.
- Prior to site development, additional studies are recommended. Non-invasive geophysical investigations should be used for any features other than very low risk. The preferred method would be electrical resistivity investigation (ERI); however, other methods such as seismic and gravimetry may be utilized. The primary purpose of the ERI will be to reveal if there are any near surface voids that could present a risk during construction or operation of the facility.
- Other investigation methods may be utilized to investigate specific karst features including drilling (hollow stem, air track probe, etc.), test pits, direct push borings, or other appropriate methods. The actual investigation method to be used will be based on the site-specific conditions, access, and the type of the karst features.

9.0 CLOSURE

The information presented herein has been based on the review of both proprietary and publicly available geologic information. However, it should be noted that karst is a dynamic landform and significant changes can occur over time. We understand that a geotechnical investigation will be completed at this site which may reveal additional subsurface karst issues. As indicated herein, karst features may be present below the ground surface that were not identified by this study. These features may not be identified until during construction. Accordingly, Terracon should be engaged during the construction phase of this project to provide oversight of the karst management plan, and to address karst features encountered during construction.

As indicated in this report, the bedrock and overlying soil below the site are susceptible to sinkhole development, and there can be extensive areas of shallow bedrock and shallow groundwater that can pose a risk to the site development process. Risk associated with these factors can be minimized during development with proper planning, design, and the control of site hydrology. Nevertheless, the client must recognize that risk of sinkhole and hydrologic-related damage to foundations, site infrastructure, and pavements does exist.

Sincerely,
Terracon Consultants, Inc.

STATE OF KENTUCKY
BENJAMIN W. TAYLOR
27823
LICENSED
PROFESSIONAL ENGINEER

Joshua D. Valentino, PhD, PG
Project Geologist

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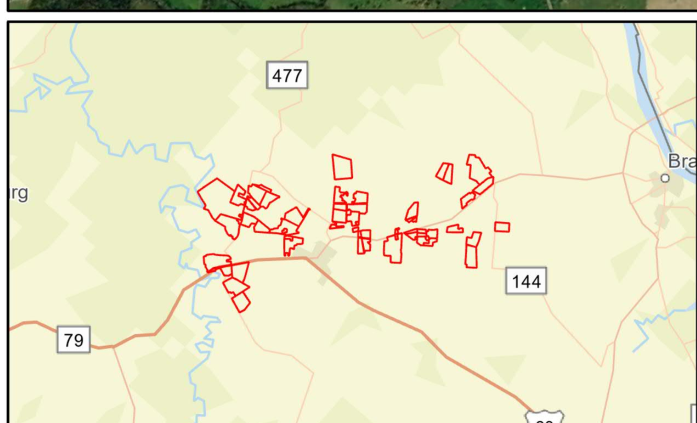
Principal, Regional Manager

AMERICAN INSTITUTE OF PROFESSIONAL GEOLOGISTS
CERTIFICATE NUMBER
10685
AIPG
ROBERT K. DENTON, JR.
CERTIFIED PROFESSIONAL GEOLOGIST

Robert K. Denton, Jr., CPG, LPSS
Senior Geologist, Karst SME

Appendices:
- Appendix A – Overall Site Maps
- Appendix B – Detailed Area Karst Risk Maps
- Appendix C – Karst Feature Description Sheets
- Appendix D – Risk Ranking Data

APPENDIX A
MAPS



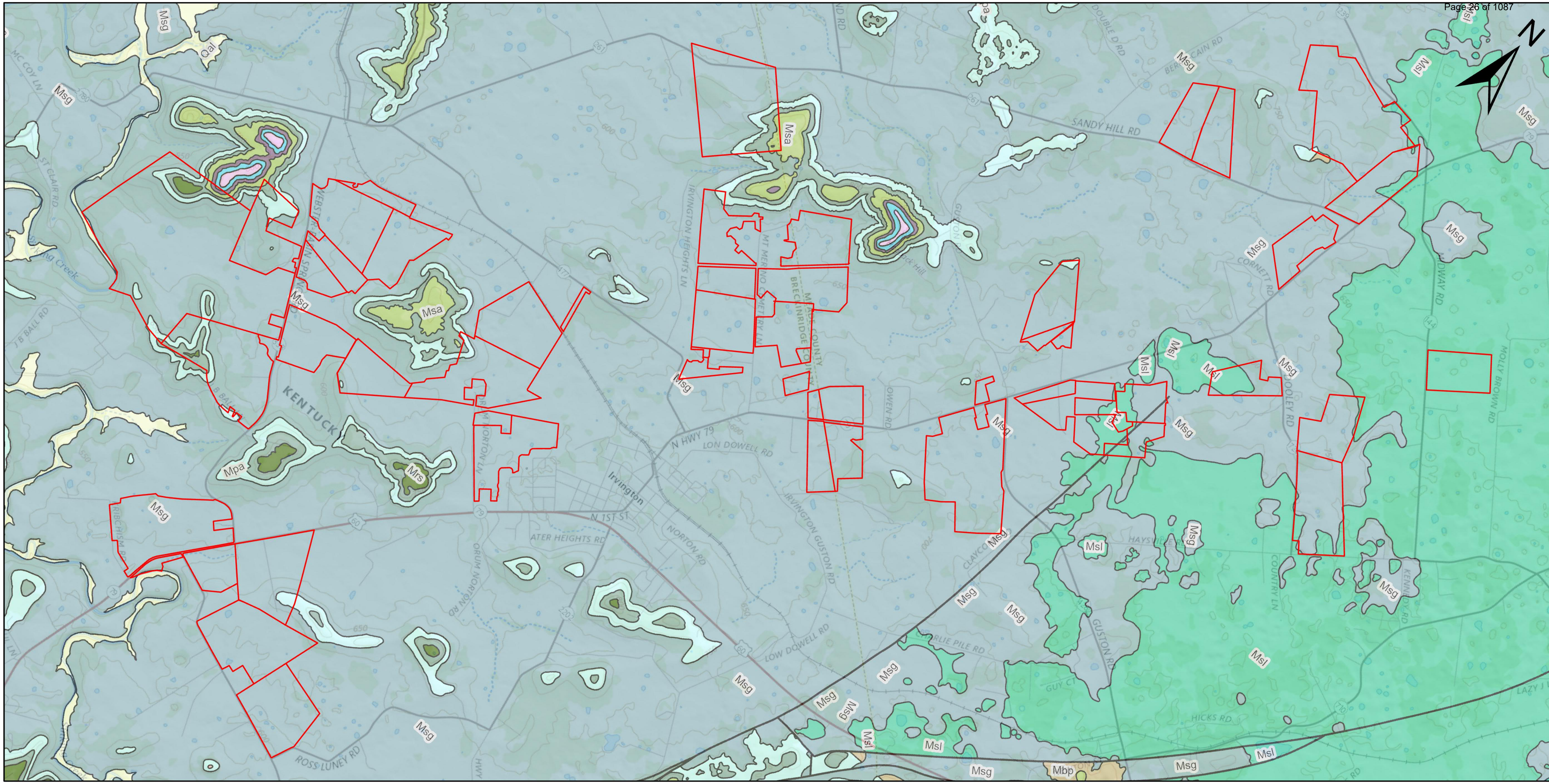
Legend

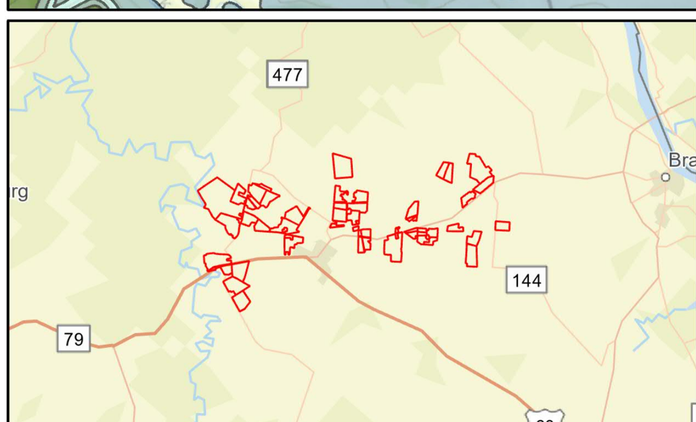
Parcels

DATA SOURCES:
ESRI WMS - World Aerial Imagery, OpenStreetMap
Solar array data from data received from client (MerinoLandownerStatus20201014.kmz, GR-Remaining Field Work)

0 2.5 5 10 Miles

Project No.: JD215085	Terracon 19955 Highland Vista Drive, Suite 170 Ashburn, VA 20147 PH. (703) 726-8030 terracon.com	**Site Vicinity Map**	**Exhibit**
Date: Jul 2021		Green River Solar NextEra Energy Meade and Breckinridge Counties, KY	1
Drawn By: JDV			
Reviewed By: RKD			





Legend

- Parcels
- Reelsville Limestone (Mr)
- Sample Sandstone (Msa)
- Reelsville Limestone and Sample Sandstone (Mrs)
- Beaver Bend Limestone and Mooretown Formation(Mbm)
- Paoli Limestone (Mpa)
- St. Genevieve Limestone (Msg)
- Saint Louis Limestone (Msl)

DATA SOURCES:
ESRI WMS - World Aerial Imagery, OpenStreetMap
Solar array data from data received from client (MerinoLandownerStatus20201014.kmz, GR-Remaining Field Work)
Geology maps sourced from the Kentucky Geological Survey

0 2.5 5 10 Miles

Project No.:	JD215085
Date:	Jul 2021
Drawn By:	JDV
Reviewed By:	RKD

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Geology Map

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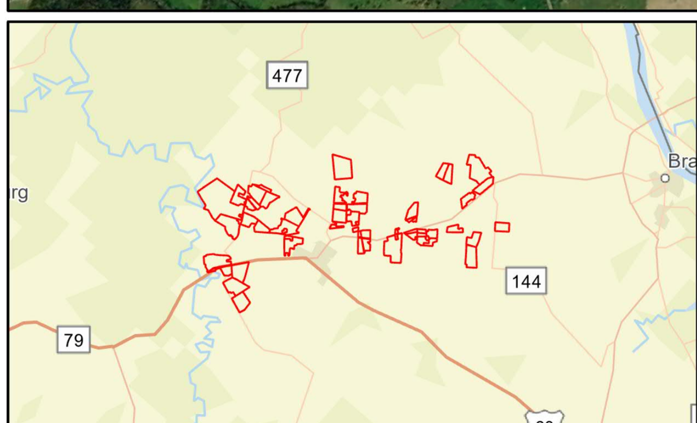
Exhibit

2



Karst Feature Density (feature/acre)

- 0 - 0.5
- 0.5 - 0.9
- 0.9 - 1.4
- 1.4 - 2.6
- 2.6 - 10.3

DATA SOURCES:
ESRI WMS - World Aerial Imagery, OpenStreetMap
Solar array data from data received from client (MerinoLandownerStatus20201014.kmz, GR-Remaining Field Work)

0 2.5 5 10 Miles

Project No.:	JD215085
Date:	Jul 2021
Drawn By:	JDV
Reviewed By:	RKD

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Parcel Karst Feature Density Map

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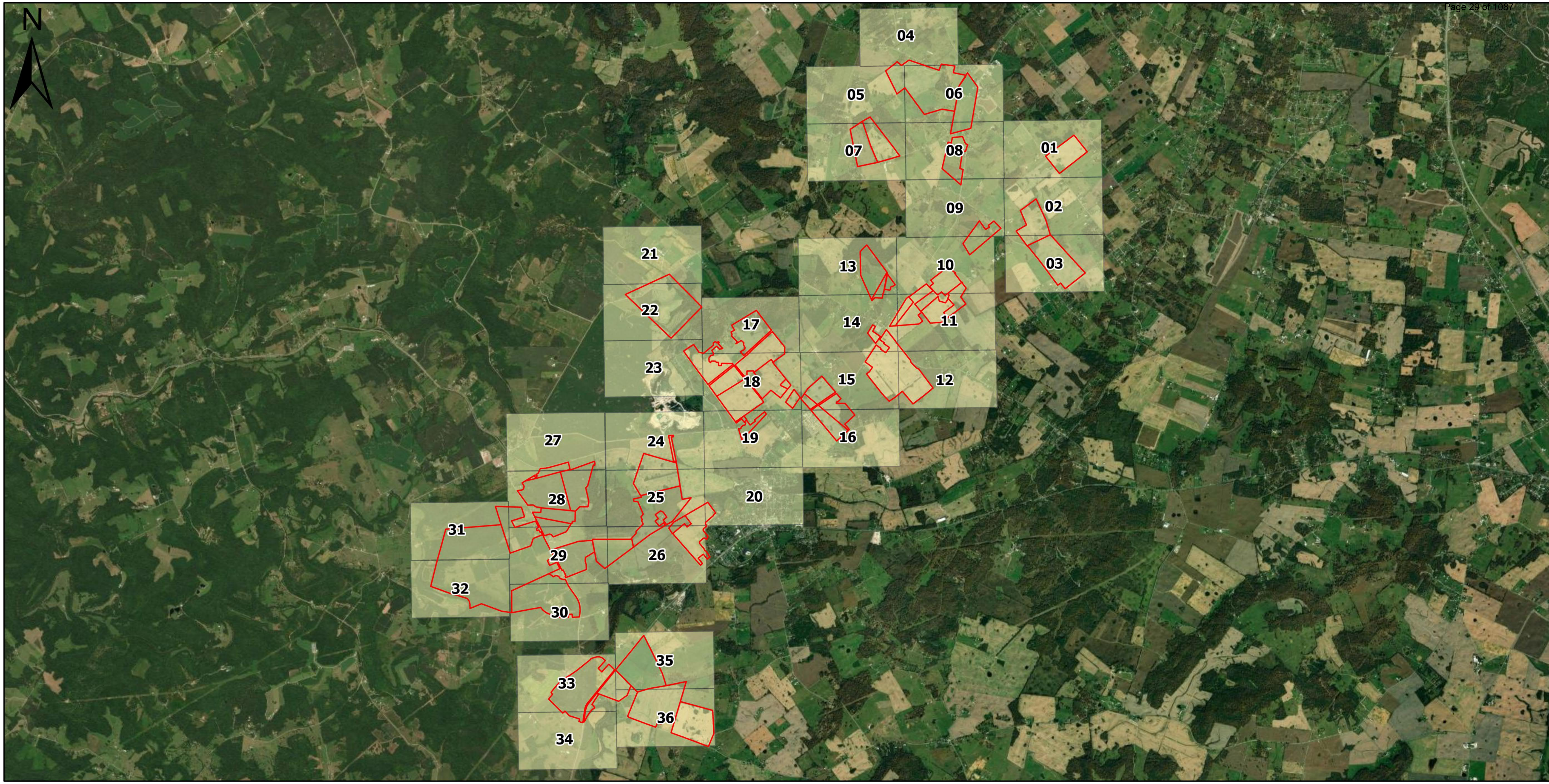
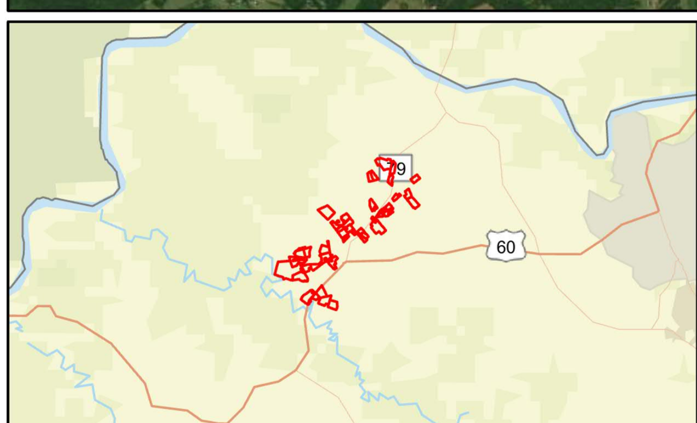
Exhibit

3

APPENDIX B
KARST RISK MAPS





Legend

- Index
- Parcels

DATA SOURCES:
ESRI WMS - World Aerial Imagery, OpenStreetMap
Solar array data from data received from client (MerinoLandownerStatus20201014.kmz, GR-Remaining Parcels.kmz)

0 5 10 20 Miles

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Index Map

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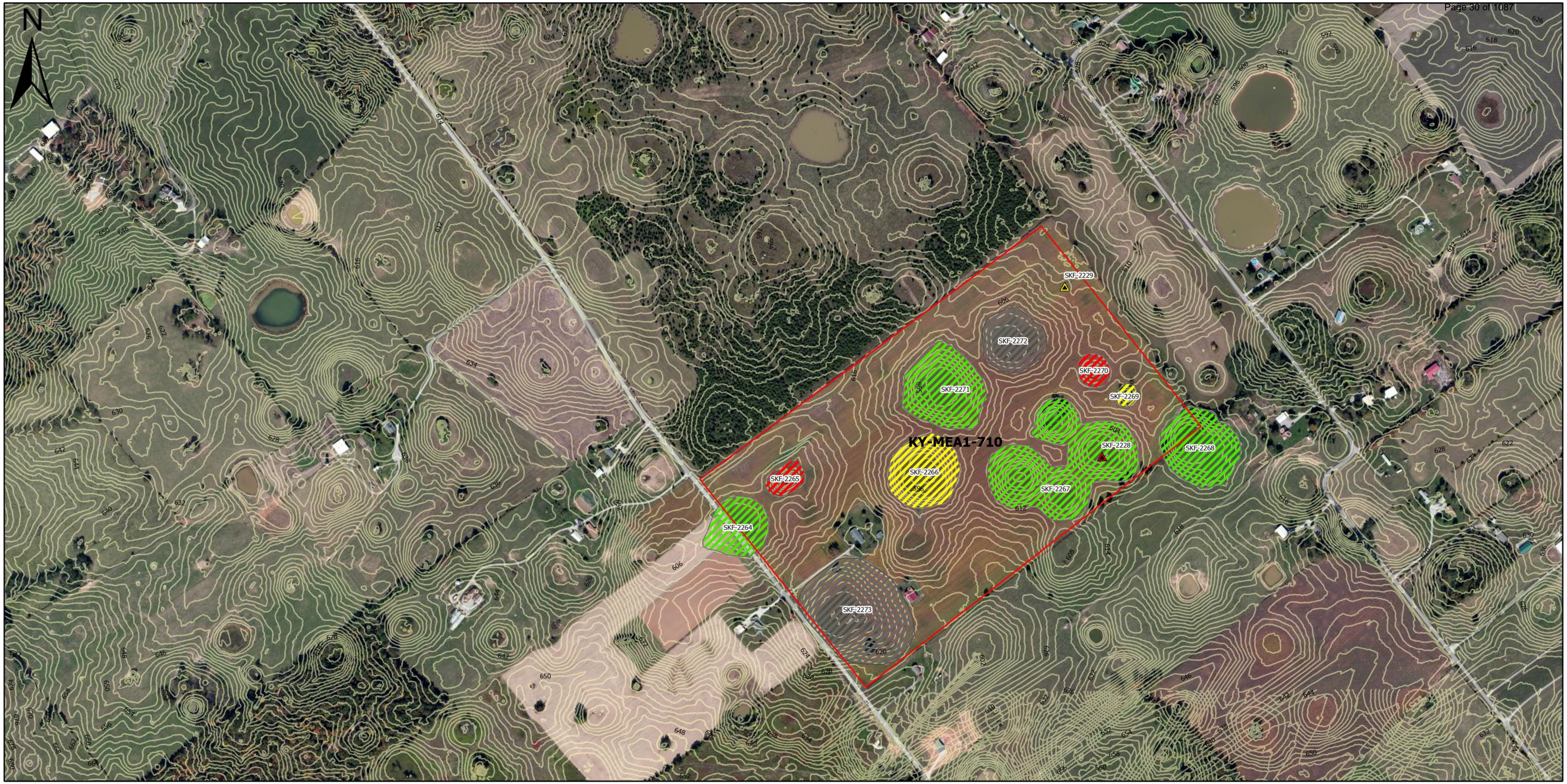
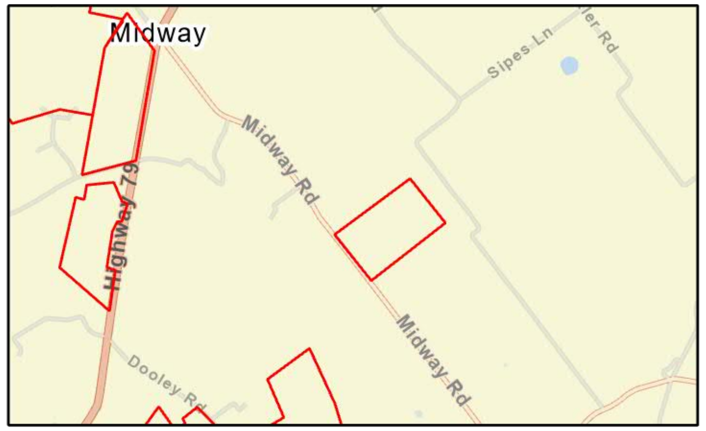
Exhibit

A





Legend

- Property Limit
- Proposed Solar Array
- 2 Foot Contour
- Desktop Point Features*
- Desktop Area Features*

Field Point Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

Field Area Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

*The desktop features follow the same risk color criteria as the field survey features.

DATA SOURCES:
ESRI WMS - World Aerial Imagery, OpenStreetMap
2 foot contours derived from LiDAR data
LiDAR data from KyFromAbove
Solar array data from data received from client (MerinoLandownerStatus20201014.kmz, GR-Remaining Field Work.kmz)

0 0.5 1 2 Miles

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Karst Feature Risk

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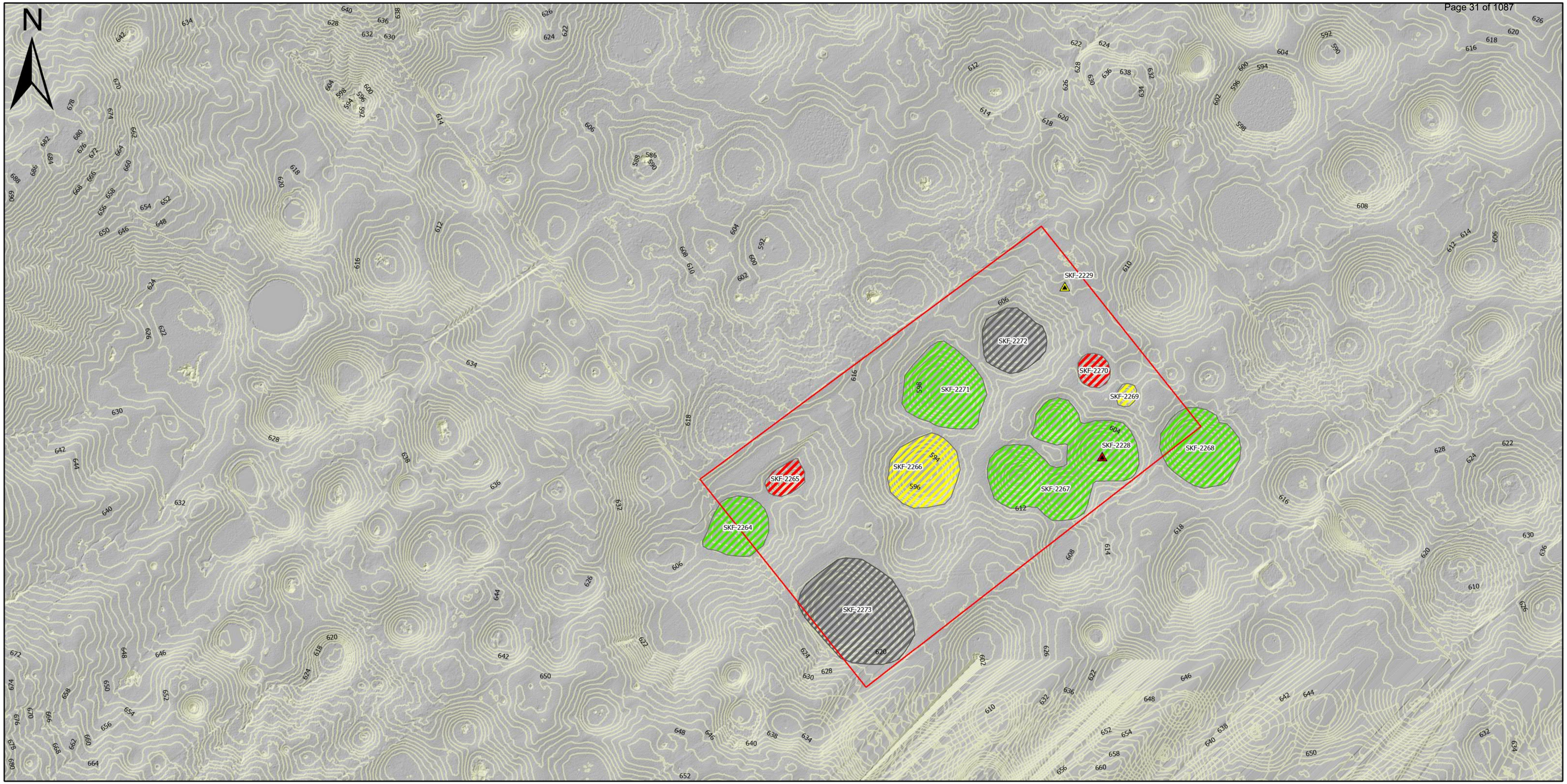
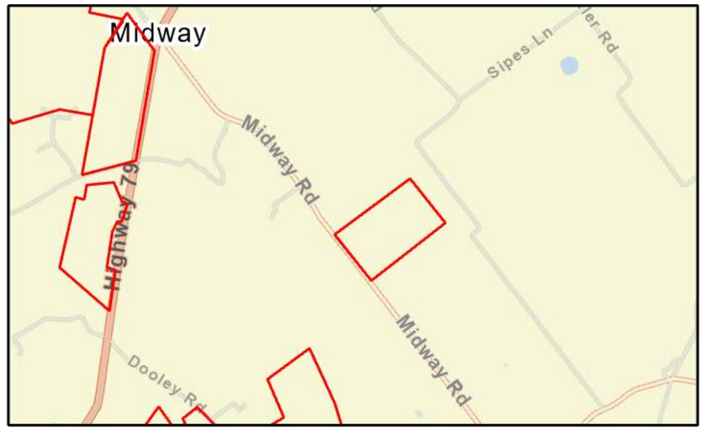
Exhibit

B1





Legend

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Karst Feature Risk

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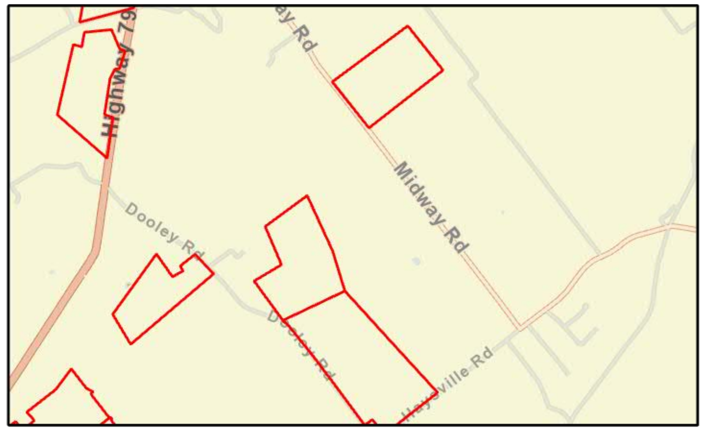
Exhibit

C1



Legend

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Karst Feature Risk

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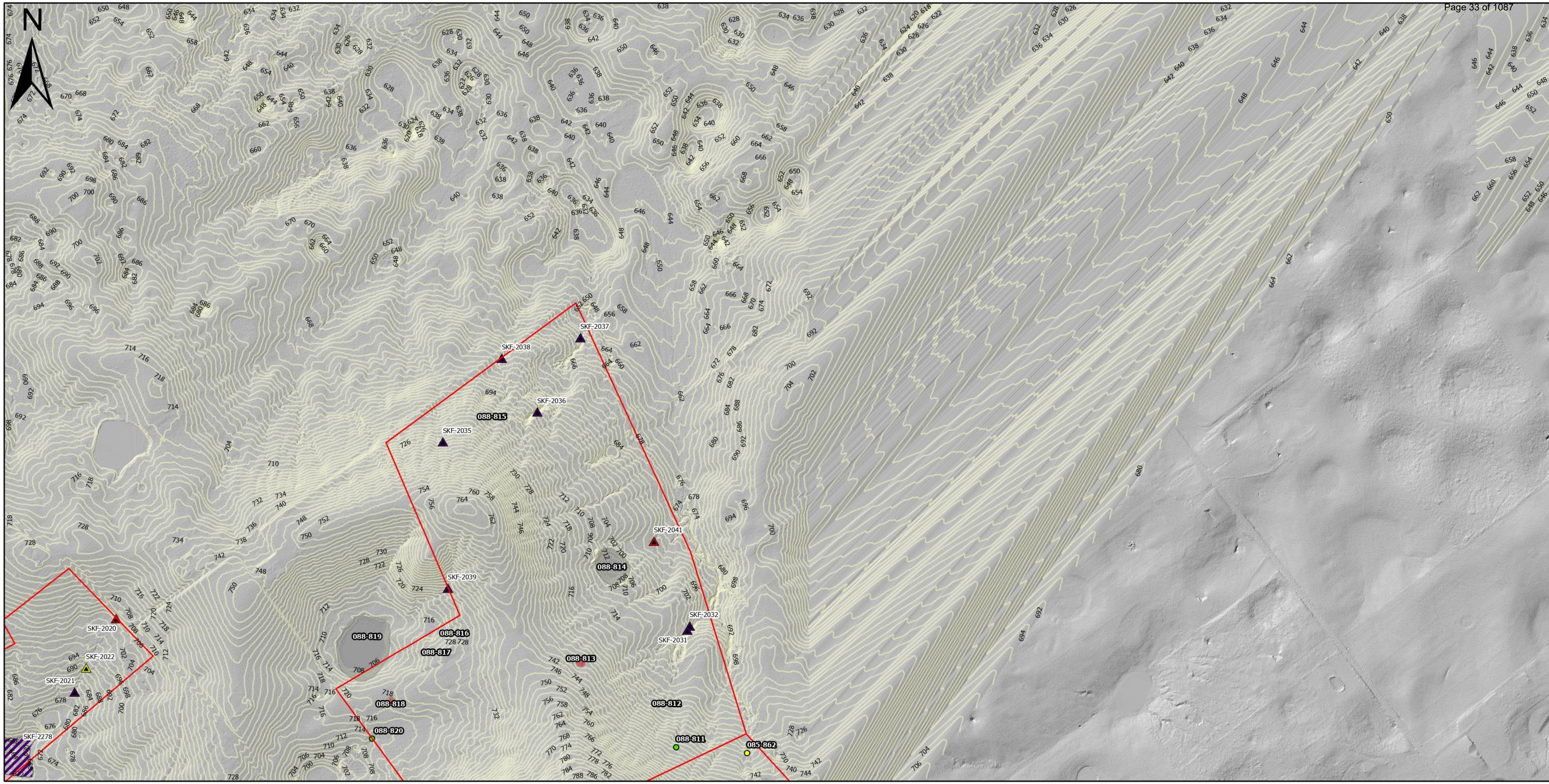
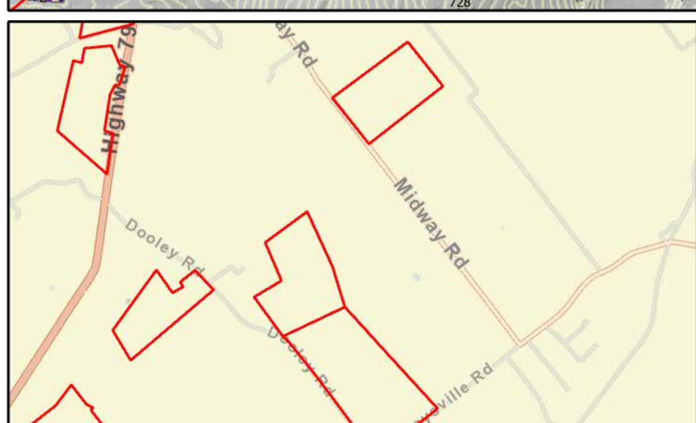
Exhibit

B2





Legend

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Karst Feature Risk

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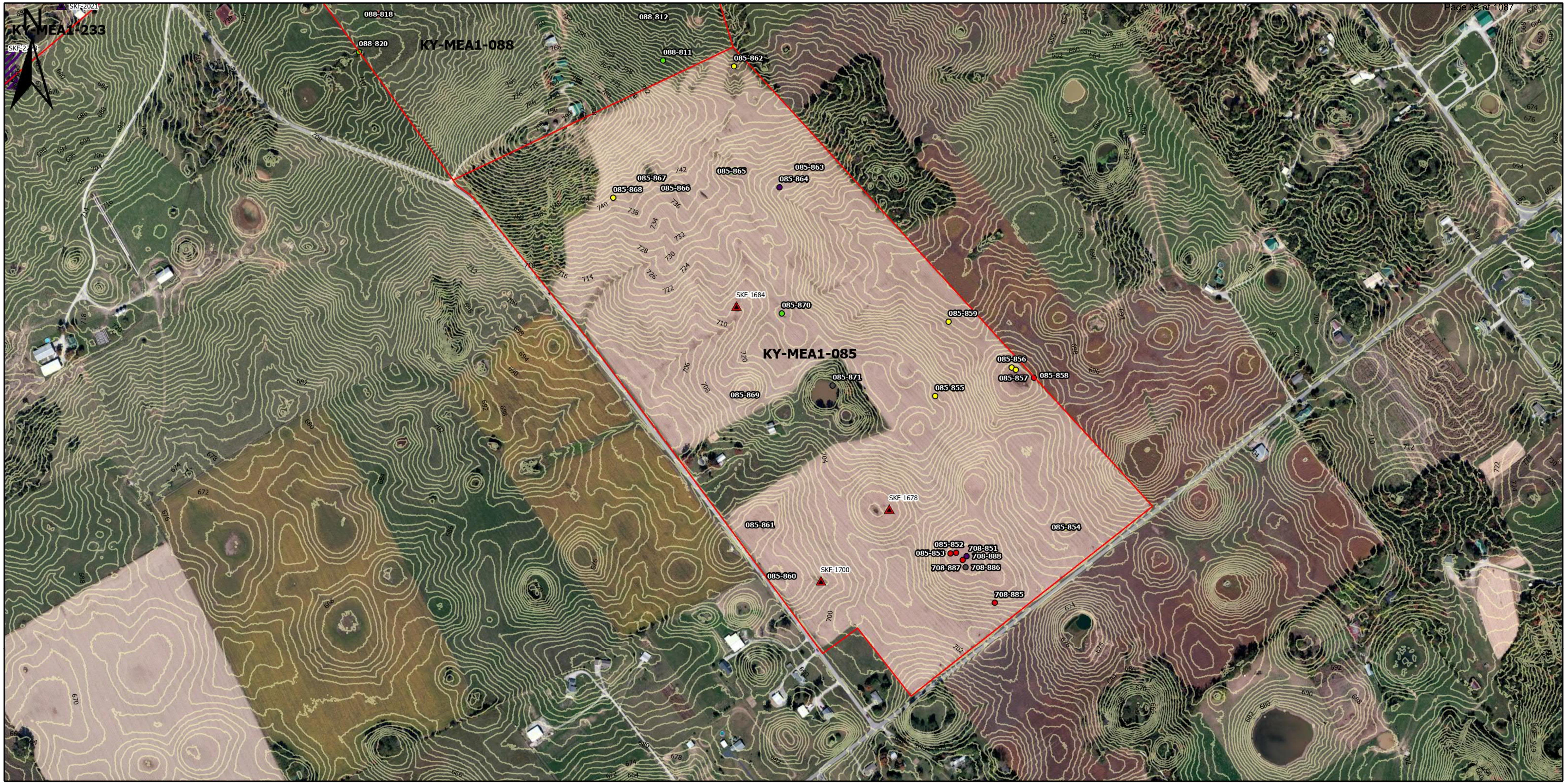
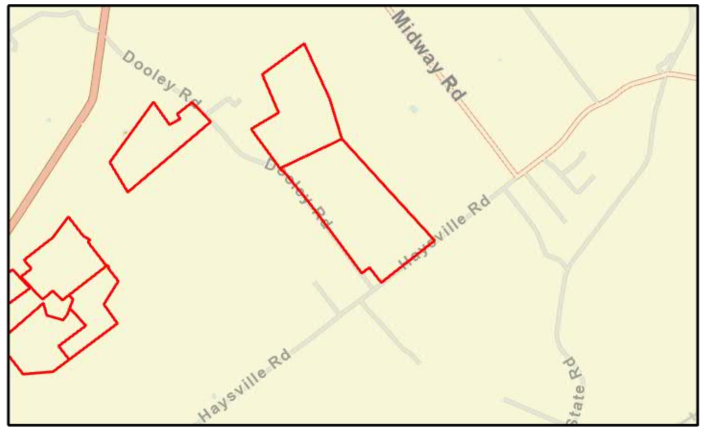
Exhibit

C2





Legend

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- Desktop Area Features*

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Karst Feature Risk

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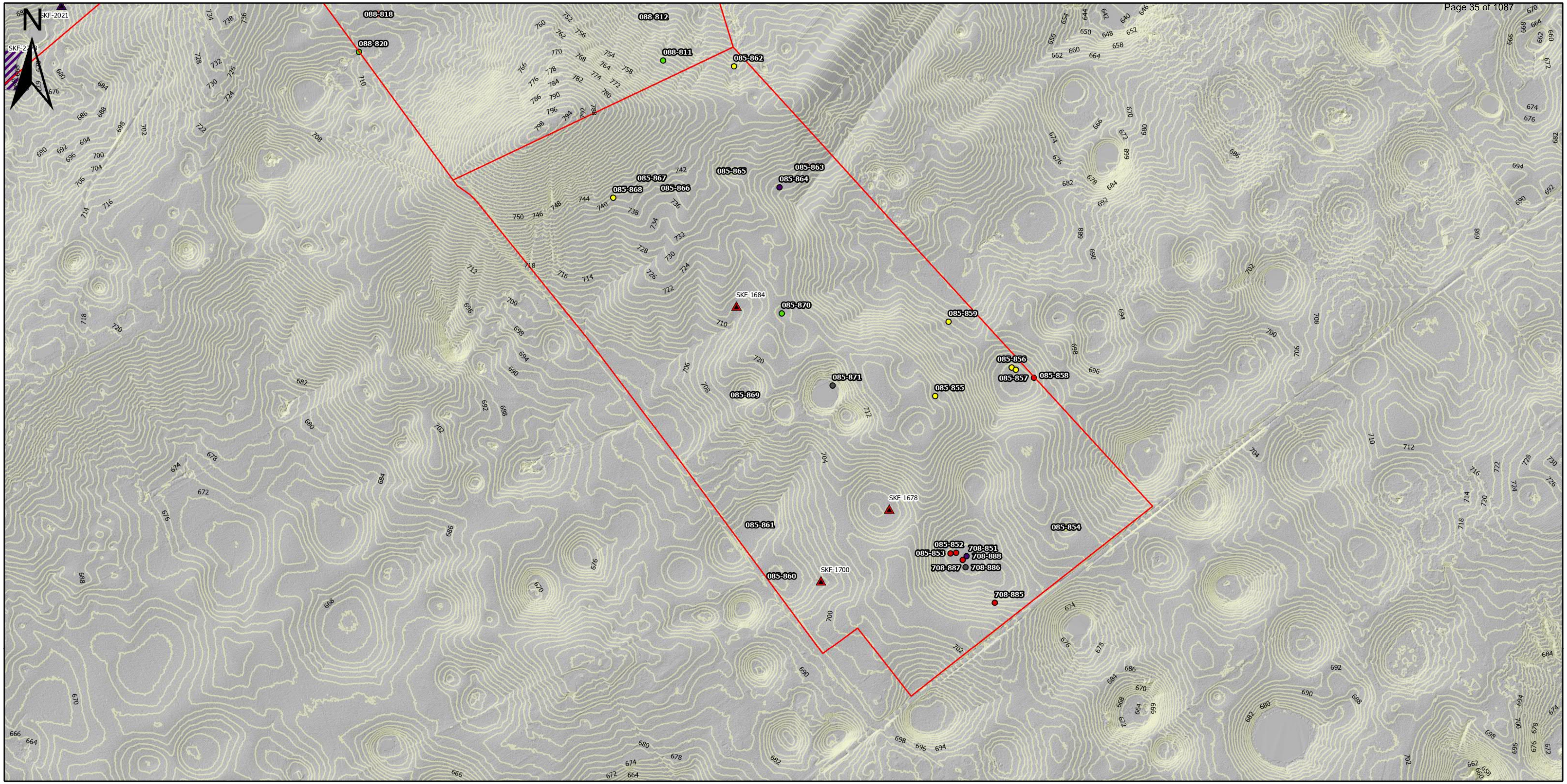
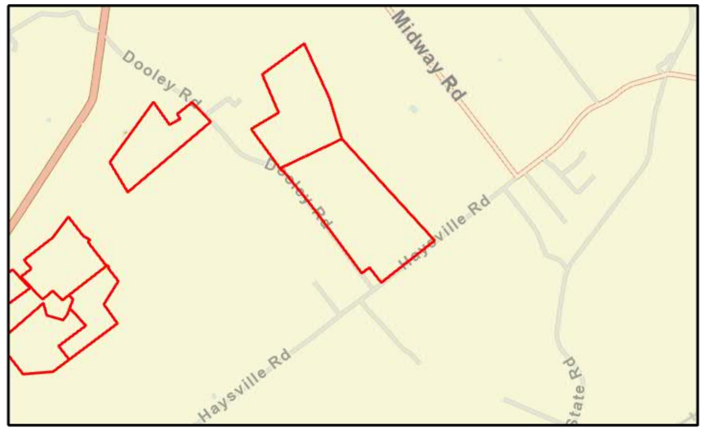
Exhibit

B3





Legend

- Property Limit
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- 2 Foot Contour
- Desktop Point Features*
- Desktop Area Features*

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LiDAR data from KyFromAbove
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0 0.5 1 2 Miles

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Karst Feature Risk

Green River Solar
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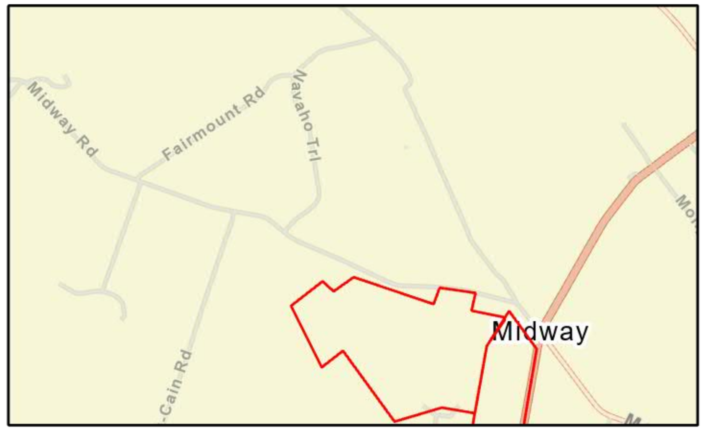
Exhibit

C3



Legend

- Property Limit
- Proposed Solar Array
- 2 Foot Contour
- Desktop Point Features*
- Desktop Area Features*

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0 0.5 1 2 Miles

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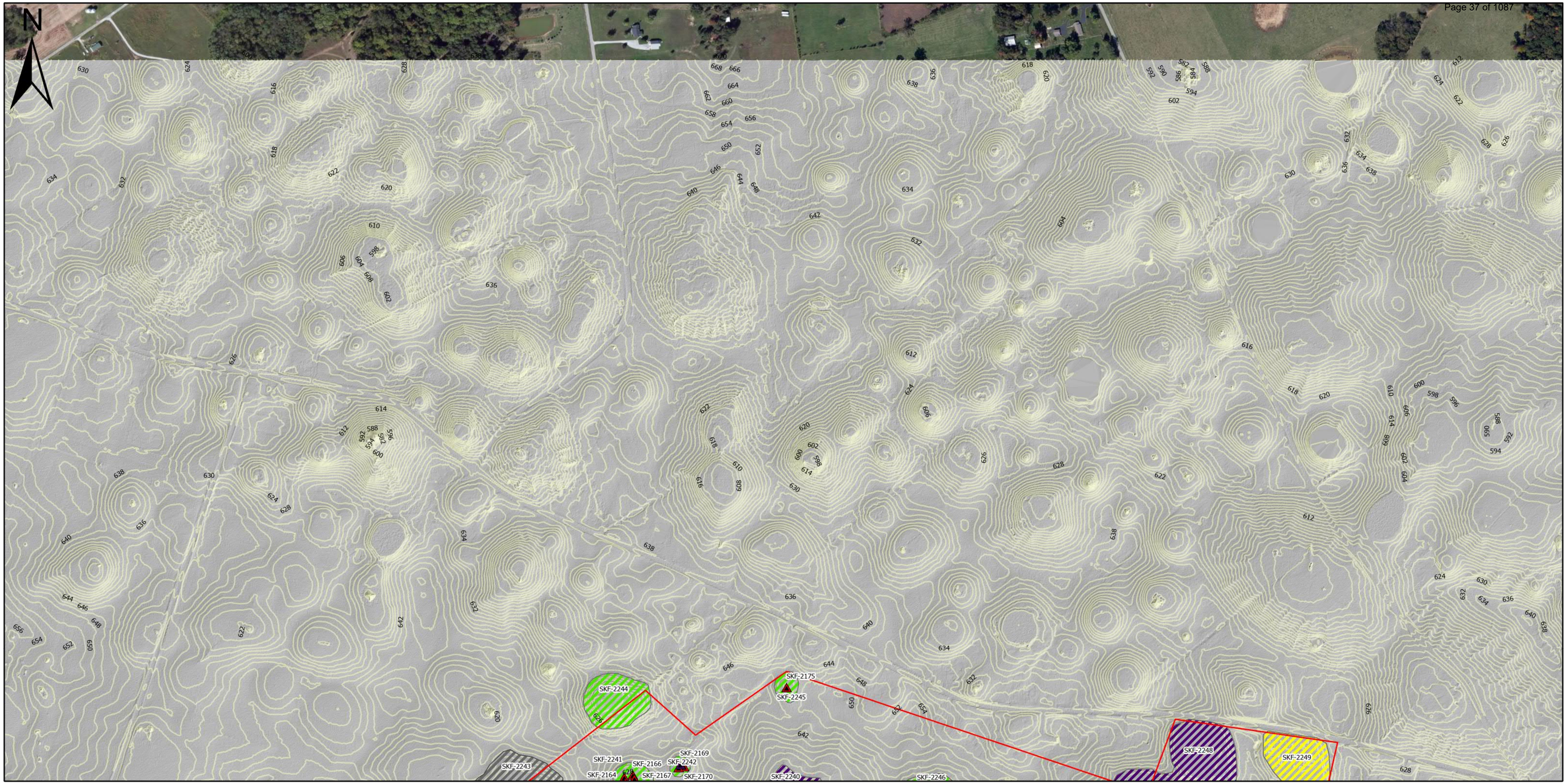
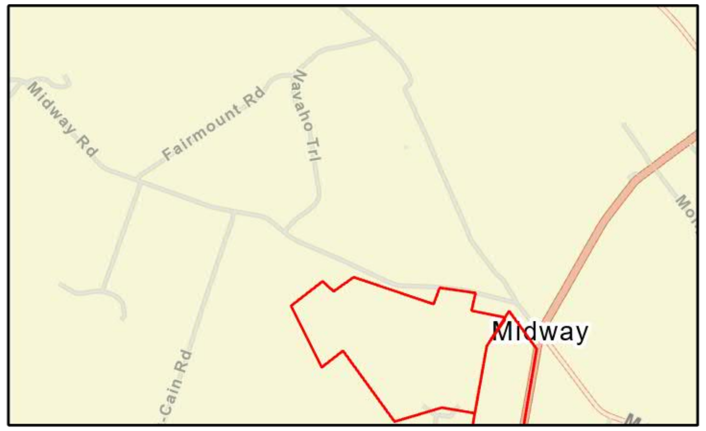
Karst Feature Risk

Green River Solar
NextEra Energy
Meade and Breckinridge Counties, KY

Exhibit

B4





Legend

- Property Limit
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- 2 Foot Contour
- Desktop Point Features*
- Desktop Area Features*

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Karst Feature Risk

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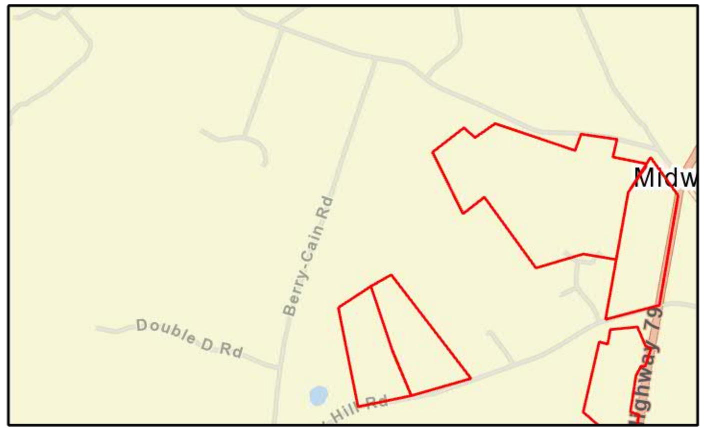
Exhibit

C4



Legend

- Property Limit
- Proposed Solar Array
- 2 Foot Contour
- Desktop Point Features*
- Desktop Area Features*

Field Point Karst Risk

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Field Area Karst Risk

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2 foot contours derived from LiDAR data
LiDAR data from KyFromAbove
Solar array data from data received from client (MerinoLandownerStatus20201014.kmz, GR-Remaining Field Work.kmz)

0 0.5 1 2 Miles

Project No.:	JD215085
Date:	Jul 2021
Drawn By:	JDV
Reviewed By:	RKD

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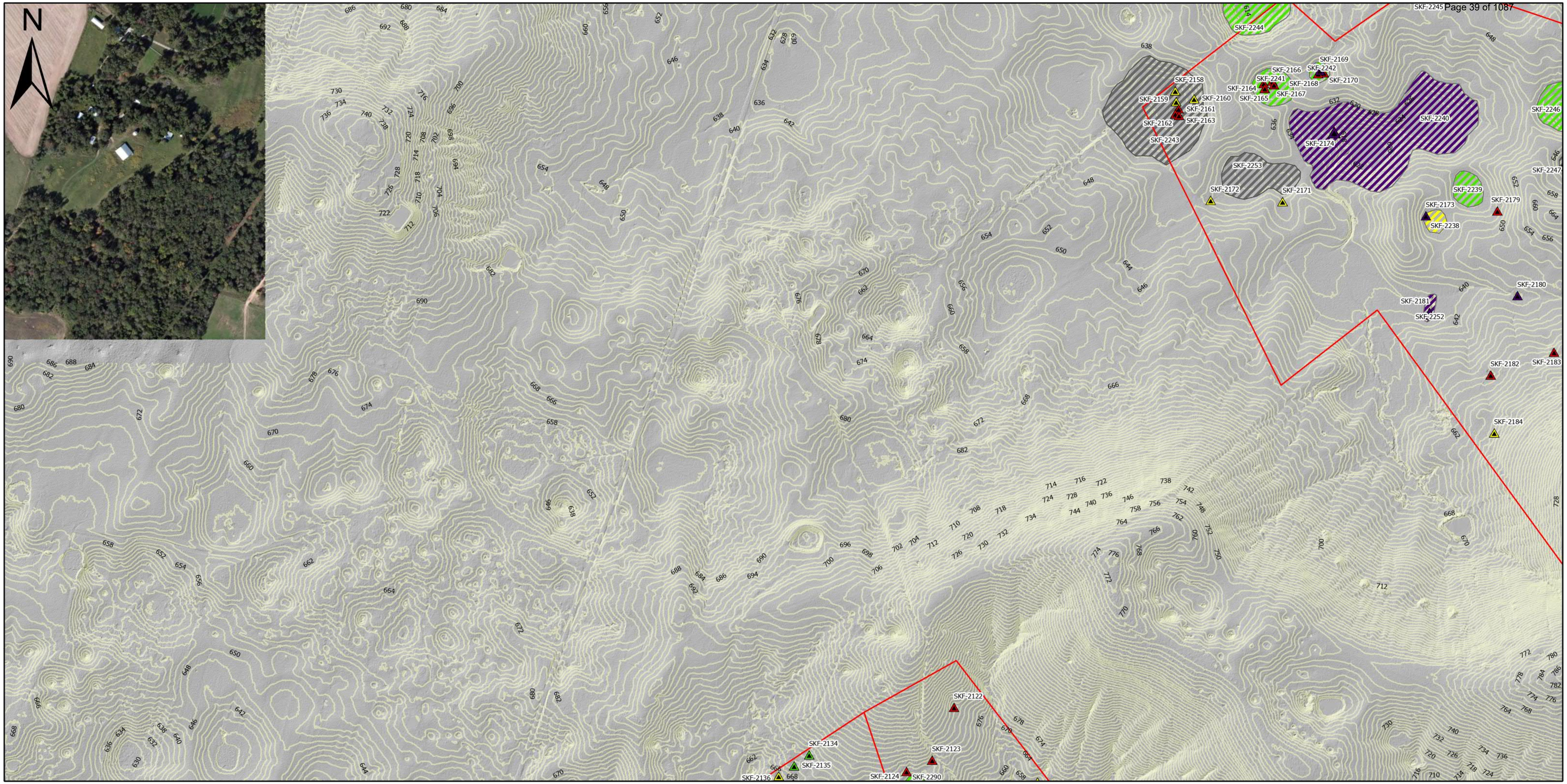
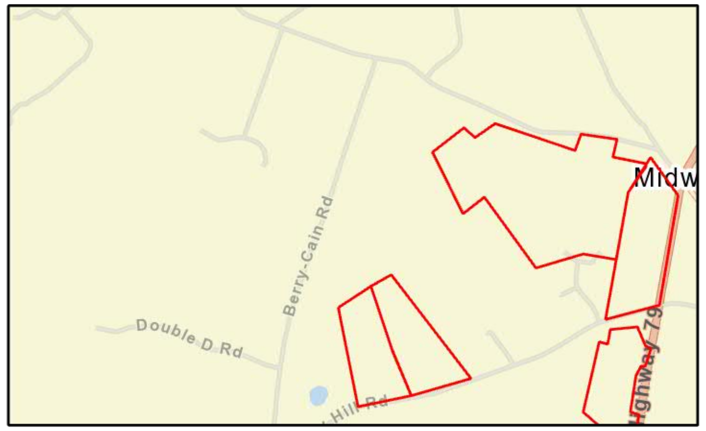
Karst Feature Risk

Green River Solar
NextEra Energy
Meade and Breckinridge Counties, KY

Exhibit

B5





Legend

- Property Limit
- Proposed Solar Array
- 2 Foot Contour
- Desktop Point Features*
- Desktop Area Features*

Field Point Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

Field Area Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

*The desktop features follow the same risk color criteria as the field survey features.

DATA SOURCES:
ESRI WMS - World Aerial Imagery, OpenStreetMap
2 foot contours derived from LiDAR data
LiDAR data from KyFromAbove
Solar array data from data received from client (MerinoLandownerStatus20201014.kmz, GR-Remaining Field Work.kmz)

0 0.5 1 2
Miles

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Karst Feature Risk

Green River Solar
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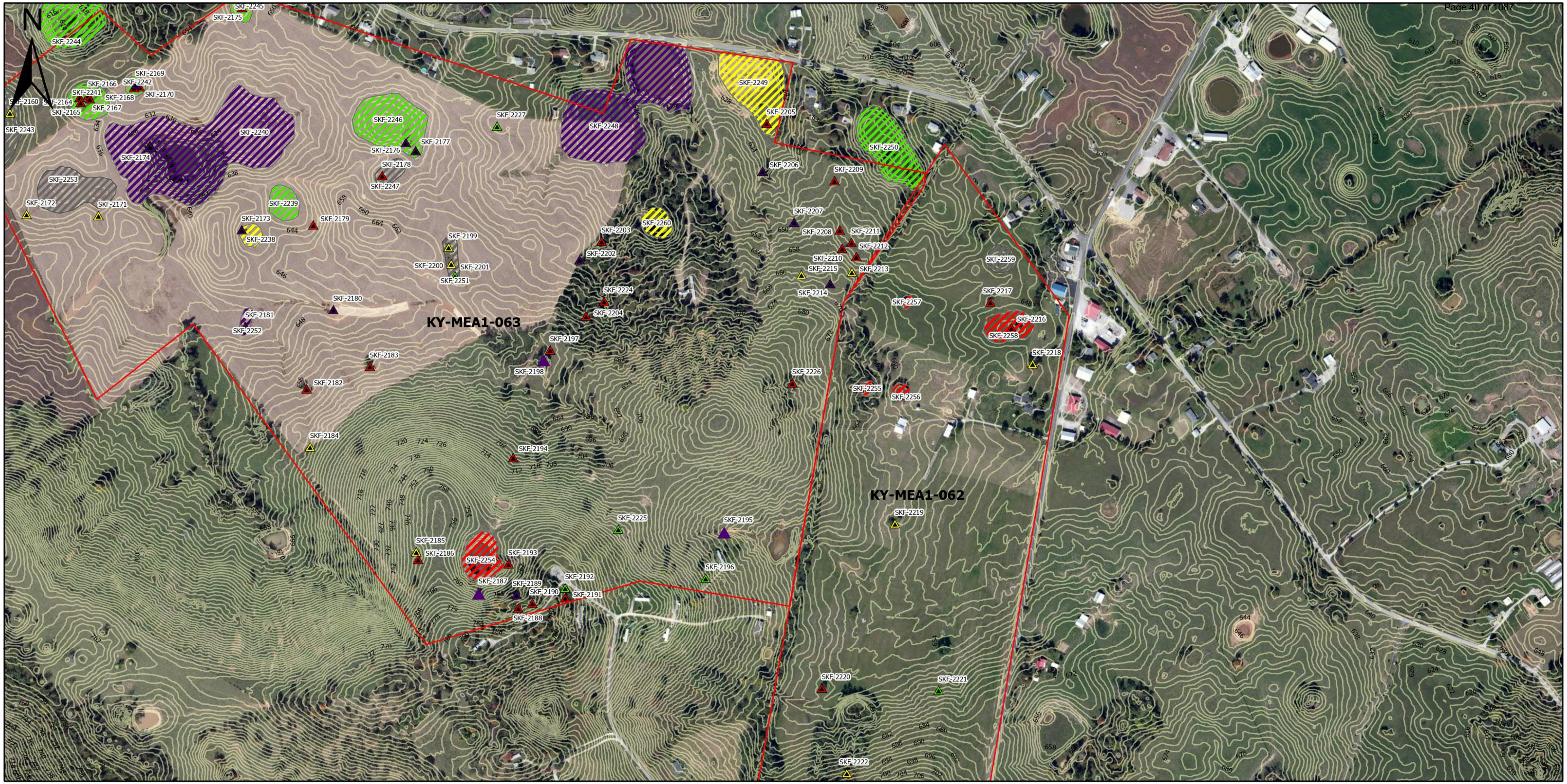
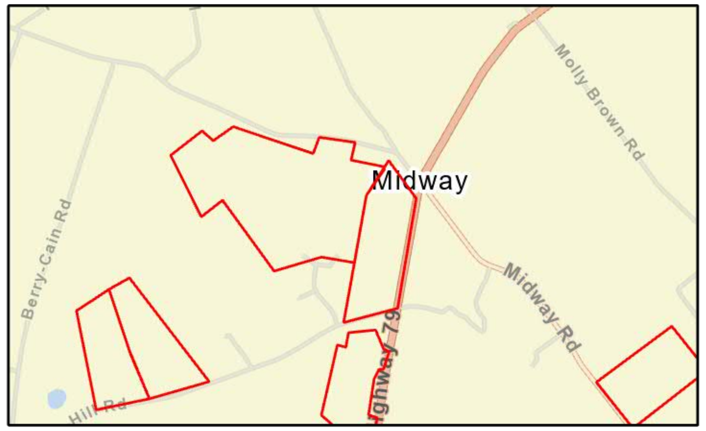
Exhibit

C5





Legend

Legend	Field Point Karst Risk	Field Area Karst Risk
Property Limit	Very High	Very High
Proposed Solar Array	High	High
2 Foot Contour	Moderate	Moderate
Desktop Point Features*	Low	Low
Desktop Area Features*	Very Low	Very Low

*The desktop features follow the same risk color criteria as the field survey features.

DATA SOURCES:
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LiDAR data from KyFromAbove
Solar array data from data received from client (MerinoLandownerStatus20201014.kmz, GR-Remaining Field Work.kmz)

0 0.5 1 2 Miles

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Karst Feature Risk

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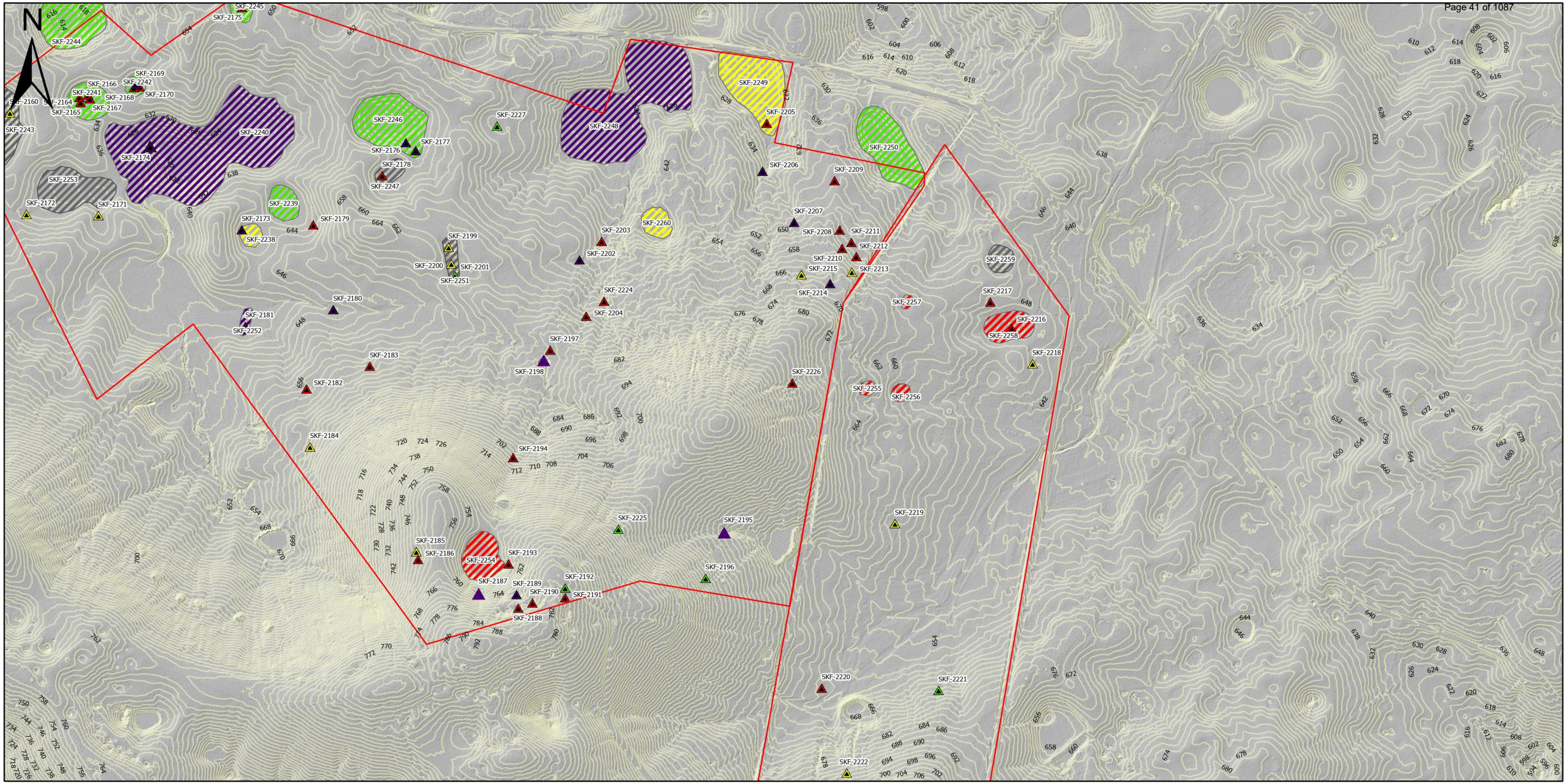
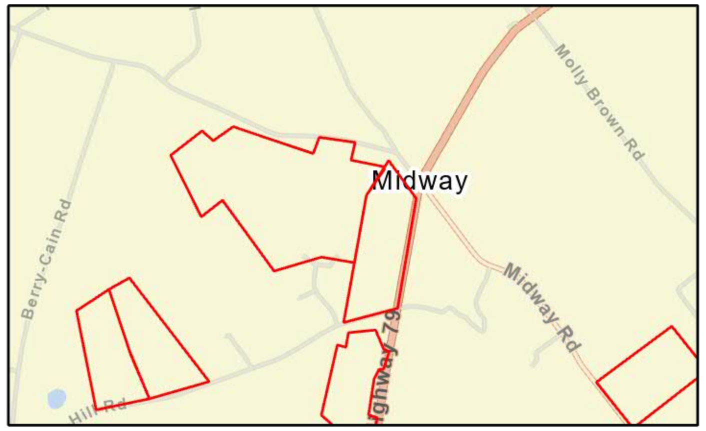
Exhibit

B6





Legend

- Property Limit
- Proposed Solar Array
- 2 Foot Contour
- Desktop Point Features*
- Desktop Area Features*

Field Point Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

Field Area Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

*The desktop features follow the same risk color criteria as the field survey features.

DATA SOURCES:
ESRI WMS - World Aerial Imagery, OpenStreetMap
2 foot contours derived from LiDAR data
LiDAR data from KyFromAbove
Solar array data from data received from client (MerinoLandownerStatus20201014.kmz, GR-Remaining Field Work.kmz)

0 0.5 1 2 Miles

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Karst Feature Risk

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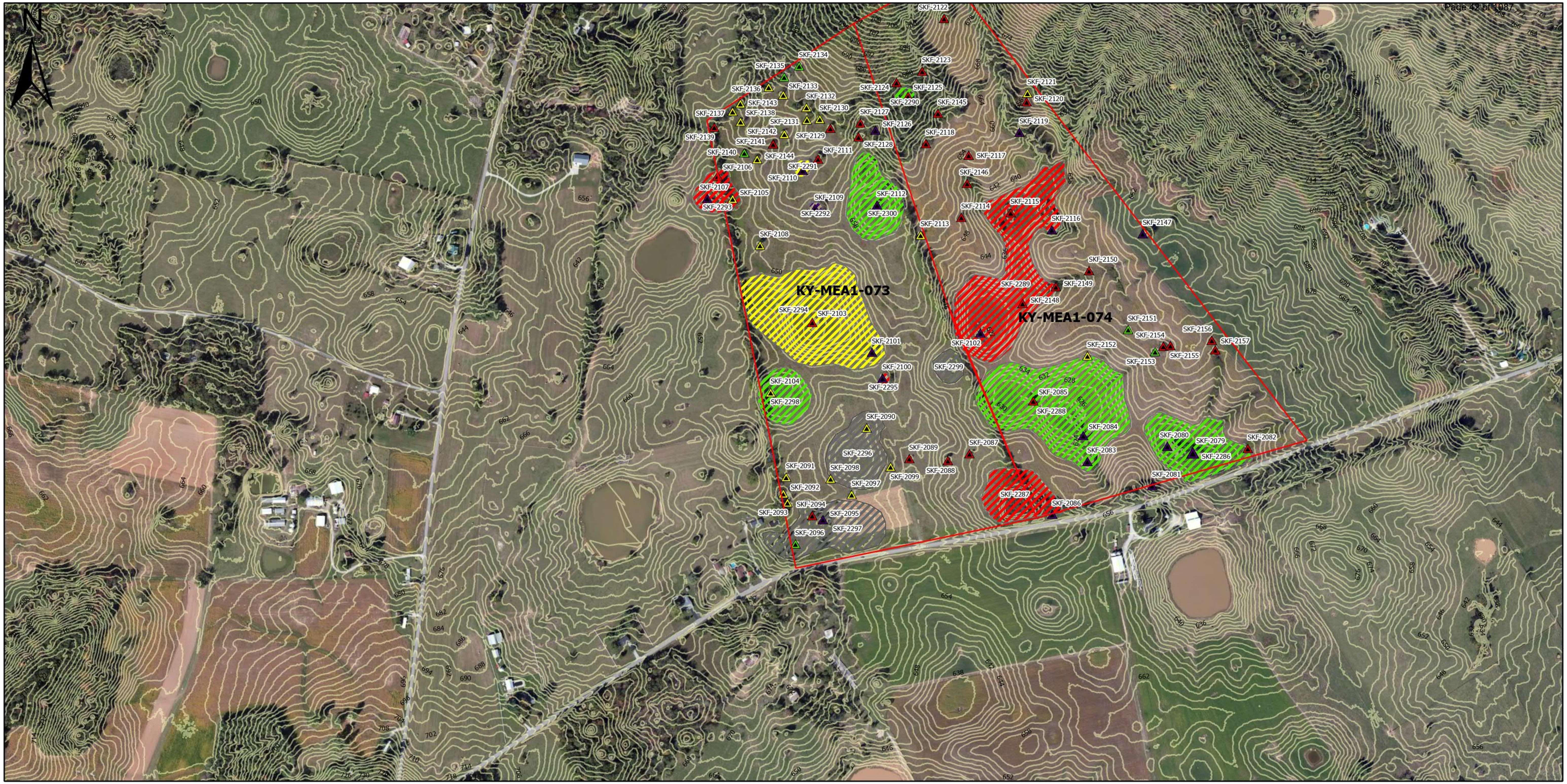
Exhibit

C6



Legend

- Property Limit
- Proposed Solar Array
- 2 Foot Contour
- Desktop Point Features*
- Desktop Area Features*

Field Point Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

Field Area Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

*The desktop features follow the same risk color criteria as the field survey features.

DATA SOURCES:
ESRI WMS - World Aerial Imagery, OpenStreetMap
2 foot contours derived from LiDAR data
LiDAR data from KyFromAbove
Solar array data from data received from client (MerinoLandownerStatus20201014.kmz, GR-Remaining Field Work.kmz)

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Karst Feature Risk

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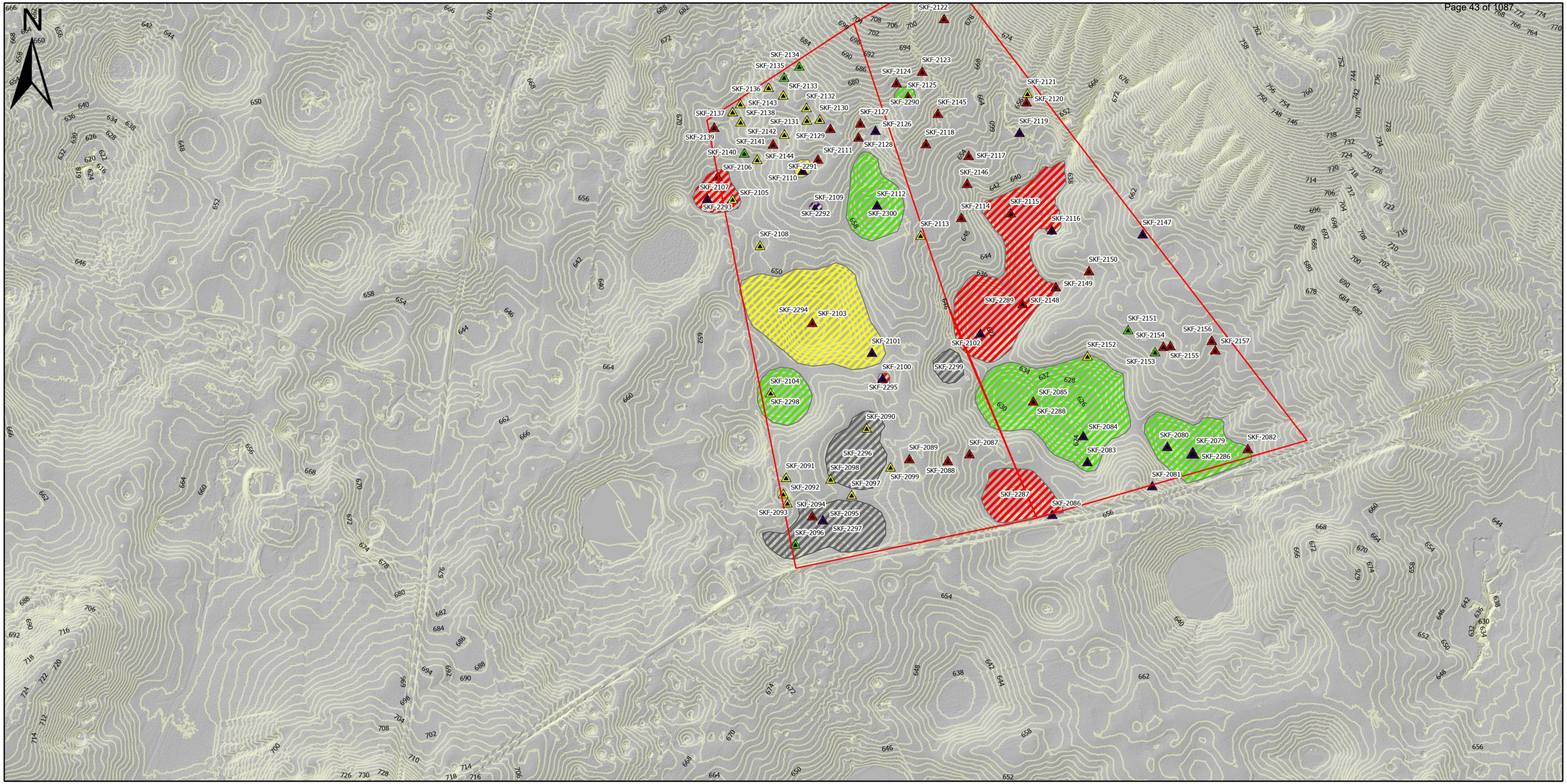
Exhibit

B7



Legend

- Property Limit
- Proposed Solar Array
- 2 Foot Contour
- Desktop Point Features*
- Desktop Area Features*

Field Point Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

Field Area Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

*The desktop features follow the same risk color criteria as the field survey features.

DATA SOURCES:
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Solar array data from data received from client (MerinoLandownerStatus20201014.kmz, GR-Remaining Field Work.kmz)

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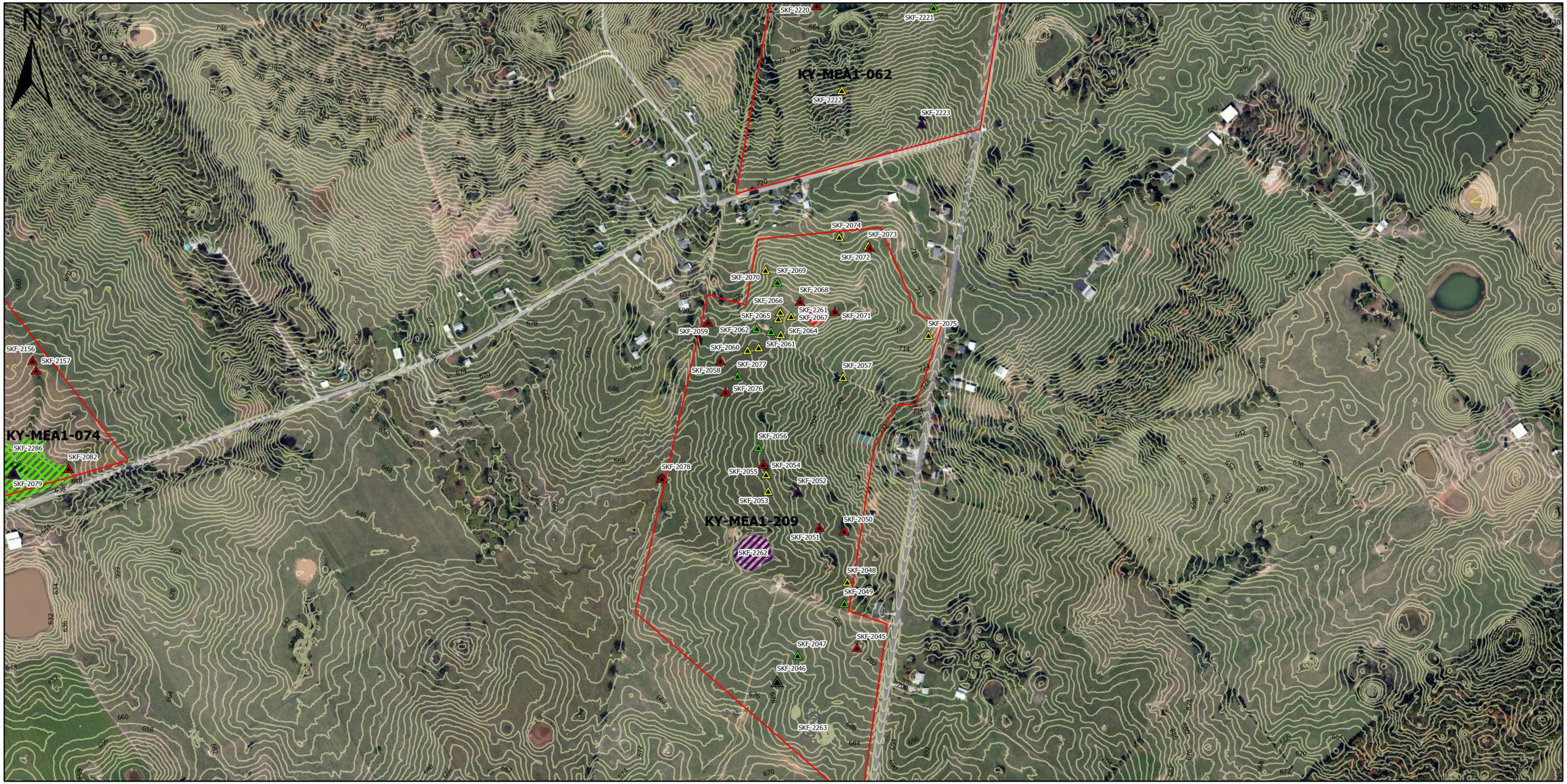
C7



Legend

- Property Limit
- Proposed Solar Array
- 2 Foot Contour
- Desktop Point Features*
- Desktop Area Features*

Field Point Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

Field Area Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

*The desktop features follow the same risk color criteria as the field survey features.

DATA SOURCES:
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Solar array data from data received from client (MerinoLandownerStatus20201014.kmz, GR-Remaining Field Work.kmz)

0 0.5 1 2 Miles

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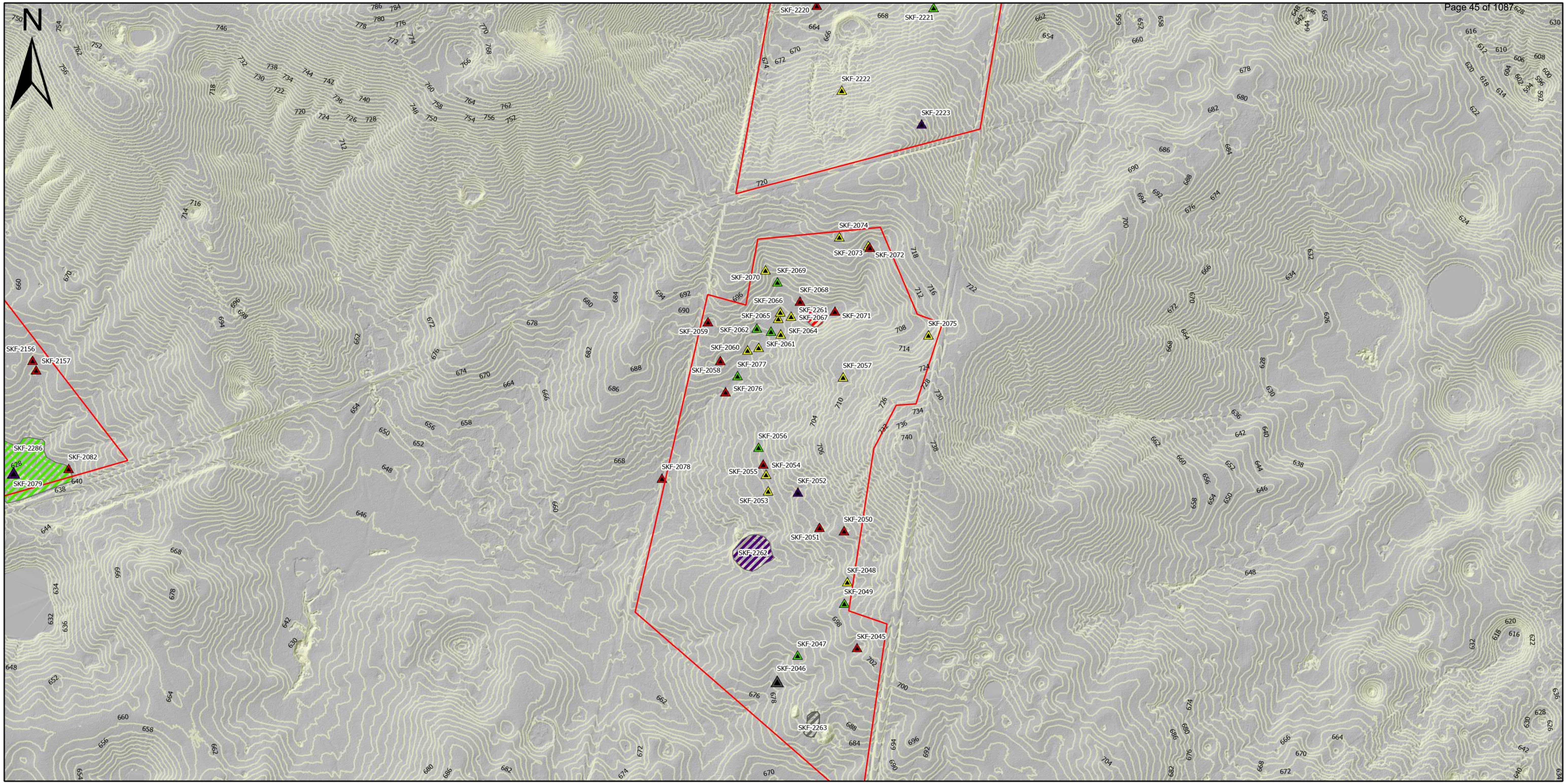
B8



Legend

- Property Limit
- Proposed Solar Array
- 2 Foot Contour
- Desktop Point Features*
- Desktop Area Features*

Field Point Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

Field Area Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

*The desktop features follow the same risk color criteria as the field survey features.

DATA SOURCES:
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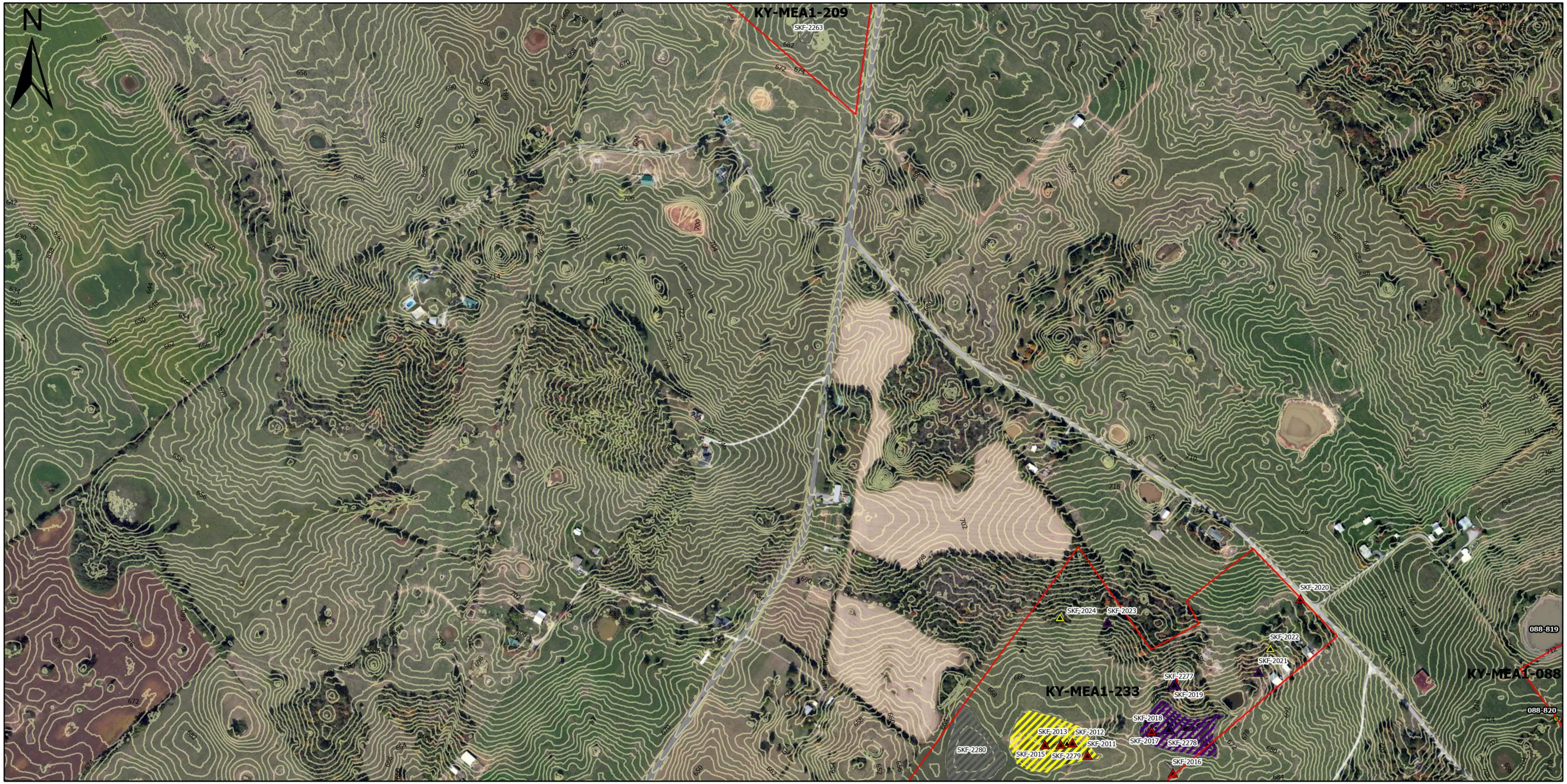
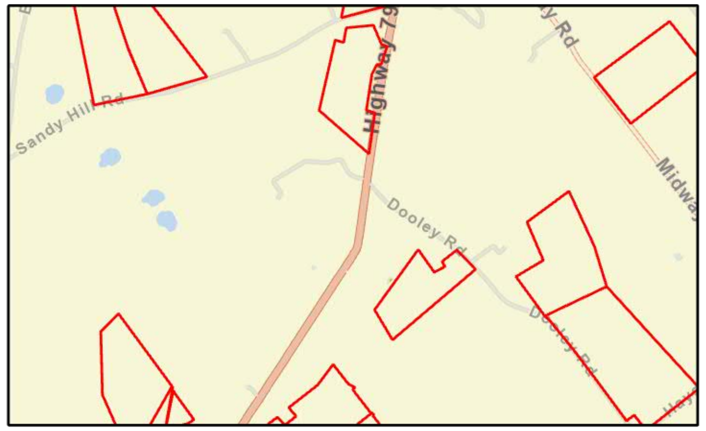
C8





Legend

- Property Limit
- Proposed Solar Array
- 2 Foot Contour
- Desktop Point Features*
- Desktop Area Features*

Field Point Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

Field Area Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

*The desktop features follow the same risk color criteria as the field survey features.

DATA SOURCES:
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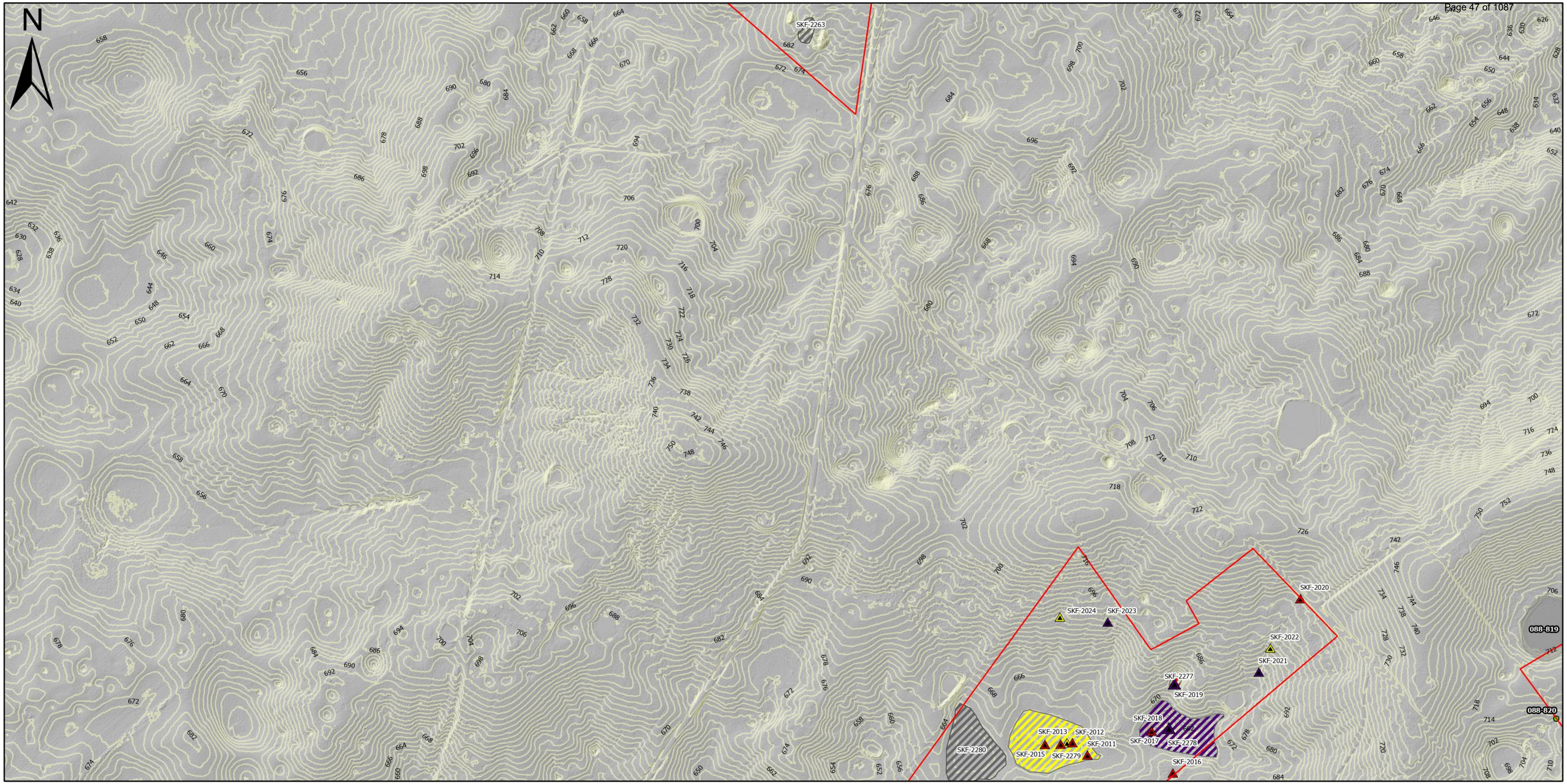
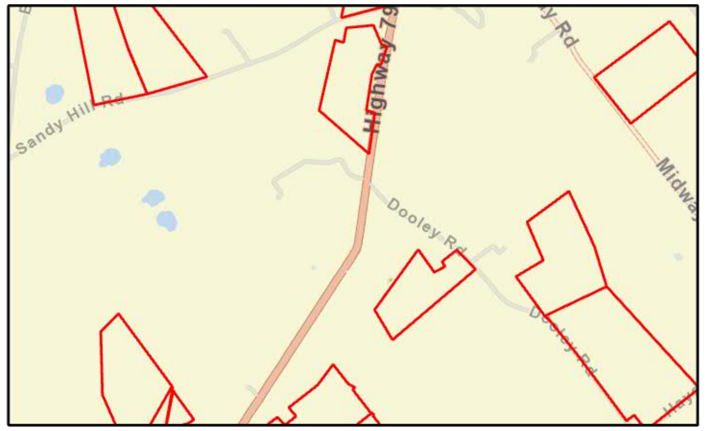
B9





Legend

- Property Limit
- Proposed Solar Array
- 2 Foot Contour
- Desktop Point Features*
- Desktop Area Features*

Field Point Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

Field Area Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

*The desktop features follow the same risk color criteria as the field survey features.

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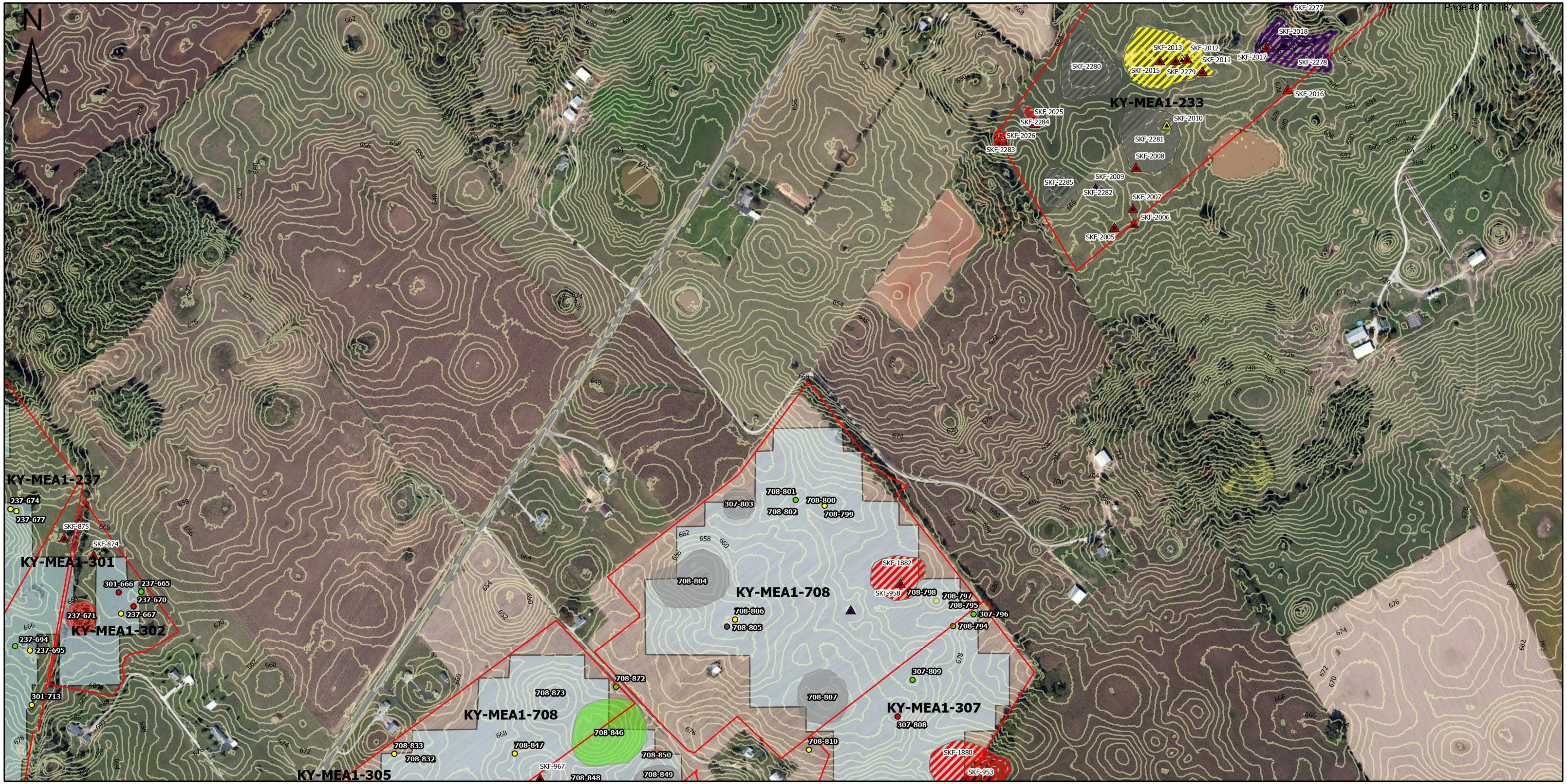
C9



Legend

- Property Limit
- Proposed Solar Array
- 2 Foot Contour
- Desktop Point Features*
- Desktop Area Features*

Field Point Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

Field Area Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

DATA SOURCES:
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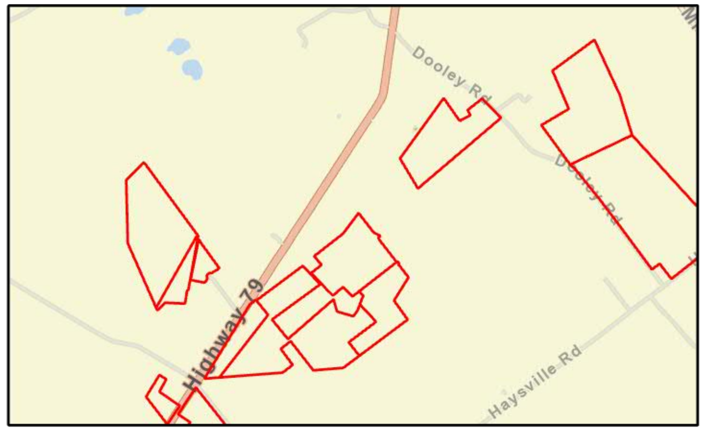

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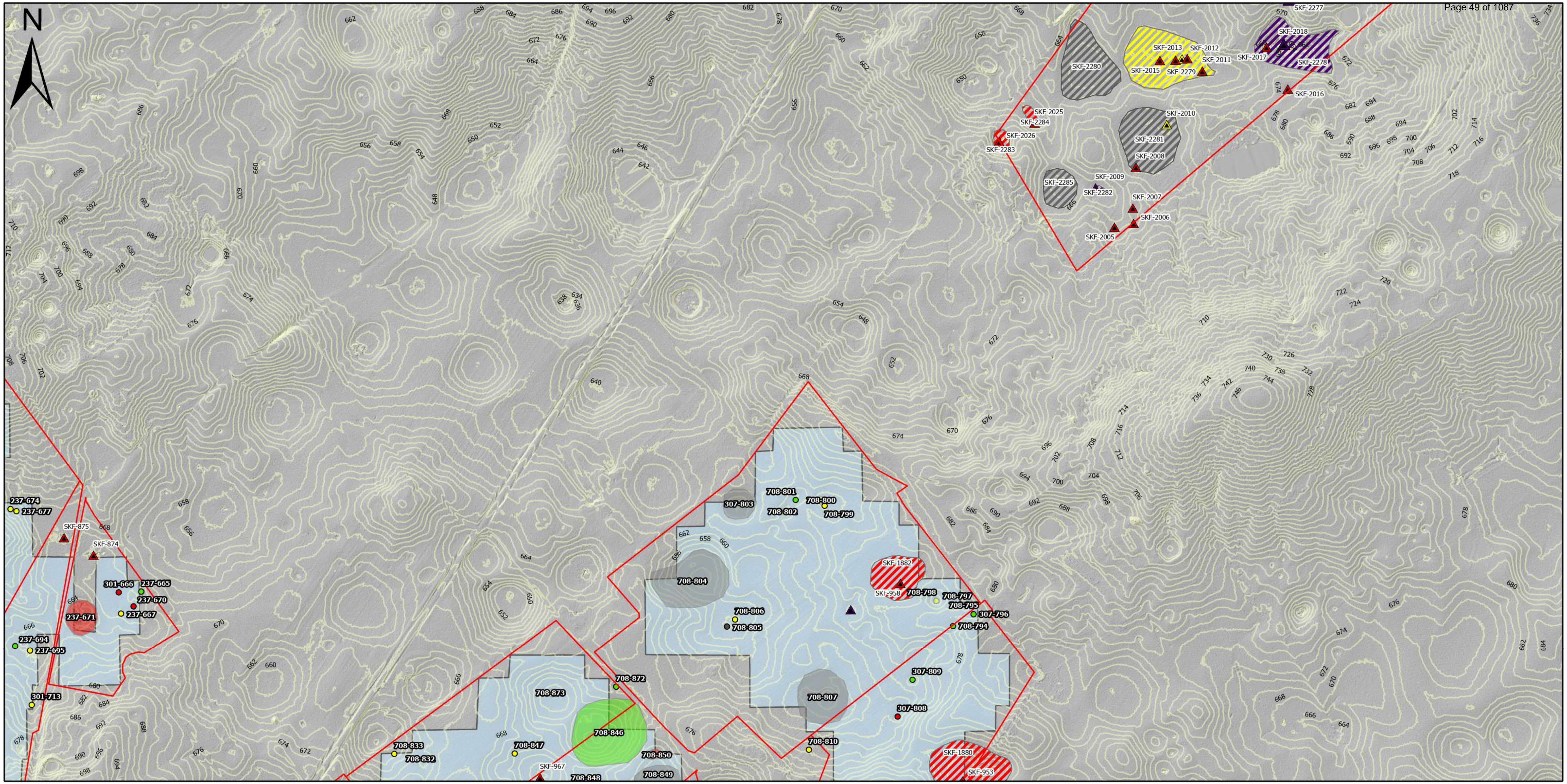
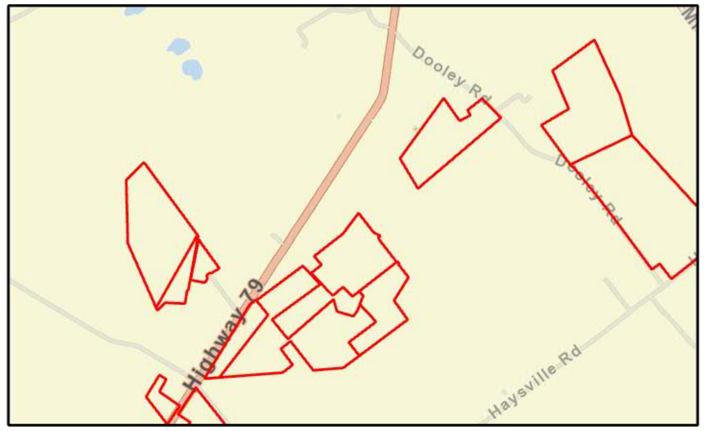
B10





Legend

- Property Limit
- Proposed Solar Array
- 2 Foot Contour
- Desktop Point Features*
- Desktop Area Features*

Field Point Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

Field Area Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

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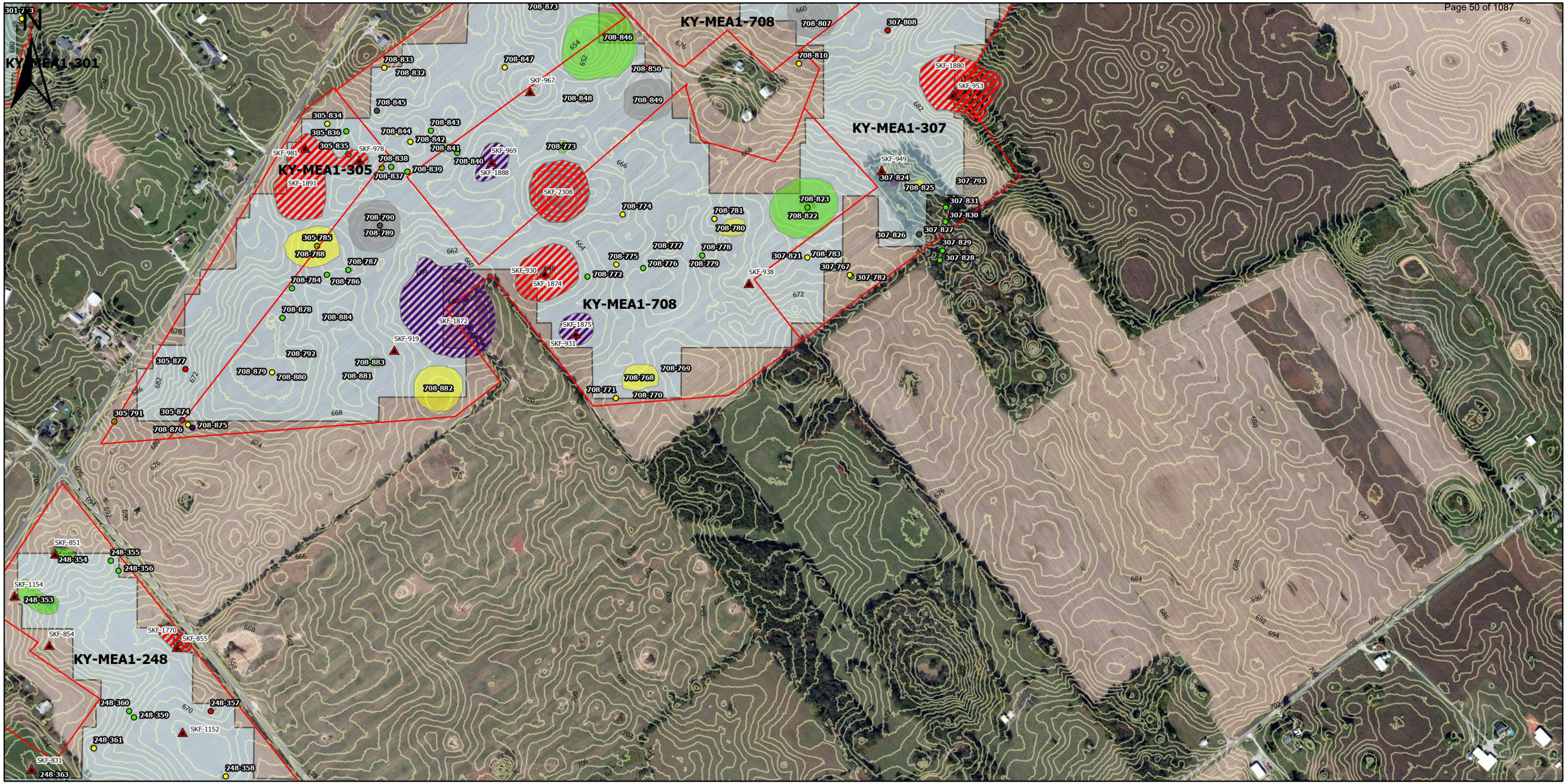
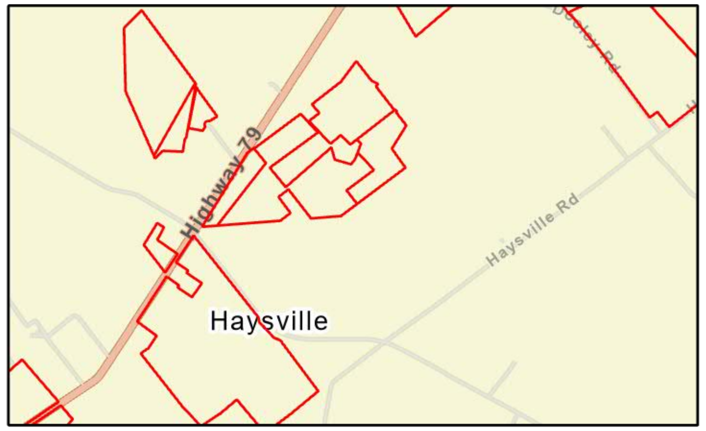
C10





Legend

- Property Limit
- Proposed Solar Array
- 2 Foot Contour
- Desktop Point Features*
- Desktop Area Features*

Field Point Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

Field Area Karst Risk

- Very High
- High
- Moderate
- Low
- Very Low

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