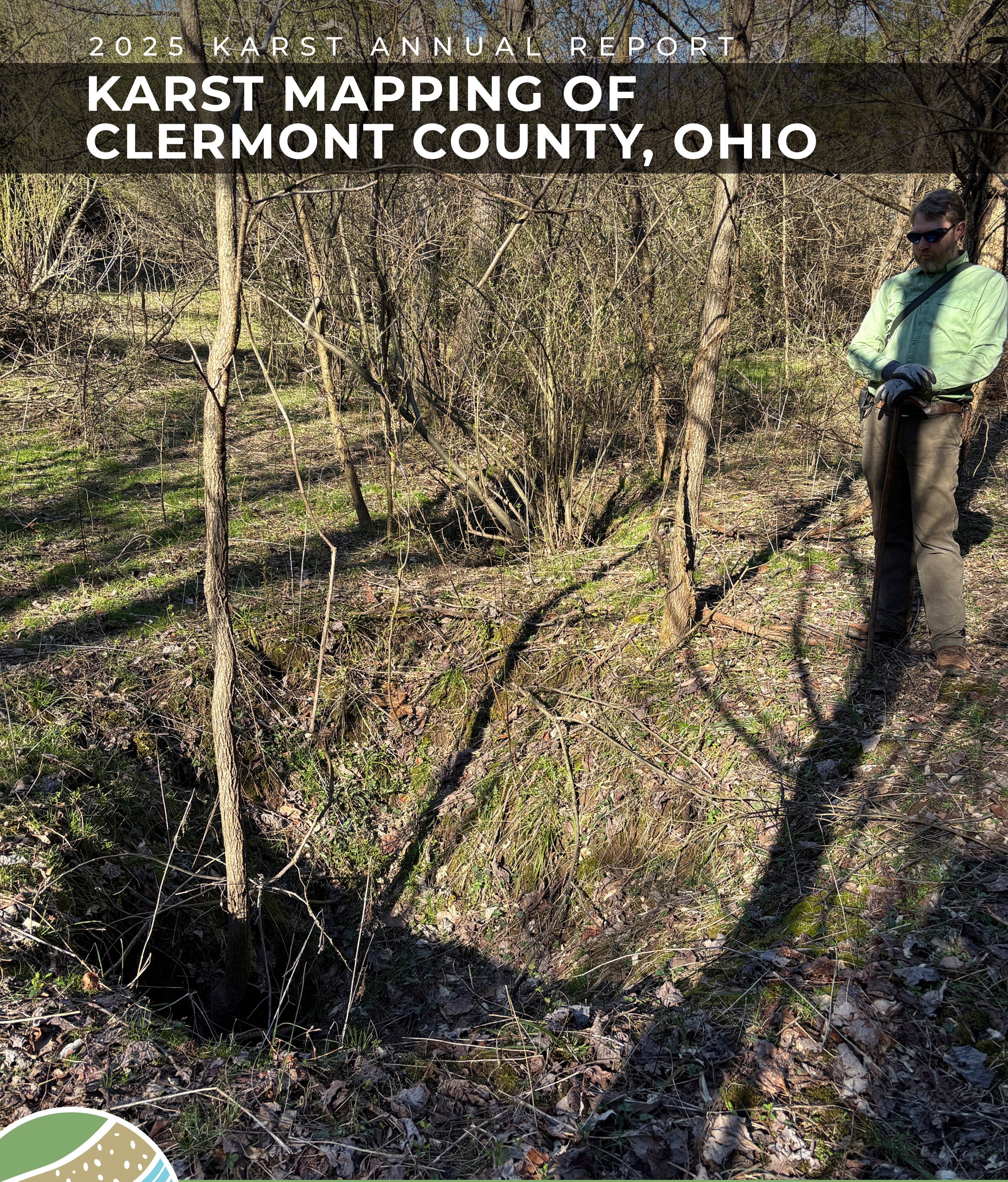
2025 KARST ANNUAL REPORT

KARST MAPPING OF CLERMONT COUNTY, OHIO



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OHIO GEOLOGICAL SURVEY
DEPARTMENT OF NATURAL RESOURCES

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Front cover: An active sinkhole 1.5 m (5 ft) deep near a landfill in Clermont County, Ohio.
Back cover: Sinkhole in a yard in Clermont County, Ohio.

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2025 Karst annual report: Karst mapping of Clermont County, Ohio

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STATE OF OHIO
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL SURVEY
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PREFACE

The 2025 Karst Annual Report describes the 2024–2025 study area and the Ohio Department of Natural Resources (ODNR) Division of Geological Survey's efforts to comprehensively map karst features in Ohio. This includes characteristics of the study area and an updated summary of the statewide status from 2009 until September 2025 (table 1). This dataset is available as an interactive, online map that is continually updated. The Karst Interactive Map is accessible for viewing on the ODNR website at **ohiodnr.gov/karst**. Many karst feature descriptions and photos can be found on the interactive map. For preservation of caves and other sensitive features, details regarding these features are omitted in this report and on the interactive map. Interested scientists may obtain detailed location information for cave research by contacting the ODNR Division of Geological Survey via email at **geo.survey@dnr.ohio.gov** or by phone at (614) 265-6576.

CONTENTS

Preface v
What is Ohio karst? 1
Importance of research 4
Locating karst features 7
Karst 2024–2025 study area 8
Updates, statewide status, and future work 12
References 15
Appendices 17
    Appendix A. Instructions for deriving karst depressions in ArcGIS 17
    Appendix B. Noncarbonate springs map, methods, and examples 21

FIGURES

1. Sinkhole in a wet, muddy farm field 1
2. Block diagram showing the relationships between karst features 2
3. Inactive sinkhole 3
4. Active, steep-sided sinkhole, with exposed roots and ongoing erosion 3
5. Sinkhole located adjacent to a driveway 4
6. Limestone pathways produced through dissolution 5
7. A sinkhole filled with trash 5
8. Exposed, likely spring-fed cistern 6
9. Reactivated sinkhole under snow cover, located during fieldwork 7
10. Map depicting the 2024–2025 study area 8
11. Sinkhole not appearing on DEM but confirmed in the field 10
12. Spring emerging on top of the Grant Lake Formation bedrock 11
13. Sediment-rich muddy water emerging from a spring 12
14. Karst mapping statewide status map 13
15. A spring appearing from a fracture in carbonate rock 14
A-1. Image showing polygons representing an example set of raw depressions extracted from the DEM 19
A-2. Example image of reduced polygons representing potential sinkholes 20
B-1. Map of suspected noncarbonate springs in Ohio 22
B-2. Large spring emerging from the nose of a hill in Guernsey County, Ohio 23
B-3. Long, non-dendritic, spring-fed channel in Coshocton County, Ohio 24
B-4. Irregular ground at the head of a spring in Knox County, Ohio 25
B-5. Spring-fed pond in Columbiana County, Ohio 26
B-6. Water from a springhouse flowing into a pond in Coshocton County, Ohio 27
B-7. Aerial image showing green water emerging from a spring in Clark County, Ohio 28
B-8. Spring points in Licking County, Ohio 29
B-9. DEM showing a spring located in Carroll County, Ohio, using original land survey notes 30

TABLES

1. Summary of karst points found during the 2024–2025 field season and cumulative statewide status 9

ABBREVIATIONS USED IN THIS REPORT

Units of Measure

ft	feet
m	meter(s)
ft^2	square feet
km^2	square kilometer(s)
m^2	square meter(s)
mi^2	square mile(s)

Other

ArcGIS	Arc Geographic Information System
DEM	Digital Elevation Model
DRA	Dynamic Range Adjustment
LiDAR	Light Detection and Ranging
ODNR	Ohio Department of Natural Resources
OGRIP	Ohio Geographically Referenced Imagery Program
USGS	United States Geological Survey

WHAT IS OHIO KARST?

More than 480 million years ago, Ohio was covered by a vast, tropical sea full of life—similar to the modern-day Bahamas. As marine organisms died and were buried in the seafloor, parts of their skeletons slowly cemented together into expansive rock layers of limestone and dolostone. Millions of years later, slow, continuous weathering has shaped the karst terrain found in Ohio (fig. 1). Karst features are found in zones throughout the Devonian, Silurian, and Ordovician bedrock in the central and western portions of the state (Hobbs III, 2009), where glacial deposits are thinner than about 7.6 m (25 ft).

FIGURE 1. Sinkhole in a wet, muddy farm field in Clermont County, Ohio. Despite the muddy surroundings, the vegetated sinkhole area is dry and well-drained.

Sinkholes, disappearing streams, caves, and springs form from dissolution of carbonate rocks (fig. 2), such as limestone and dolostone, or evaporites, such as gypsum or salt, and can be found in many areas of Ohio. **Sinkholes**, or *dolines*, are enclosed depressions, often found with a natural drain, that allow water to flow into subsurface fractures. Because of this, sinkholes rarely hold water unless clogged with debris. Sinkholes vary from currently inactive (without a drain; fig. 3) to very active (with ongoing erosion into a drain; fig. 4). Unique surface-water features called **disappearing streams**, or *ponors*, are waterways that flow into sinkholes. As water flows underground, **caves** may form as dissolution causes fractures to enlarge into passages and chambers. In some places, these underground flows can reemerge from the subsurface as **springs**.

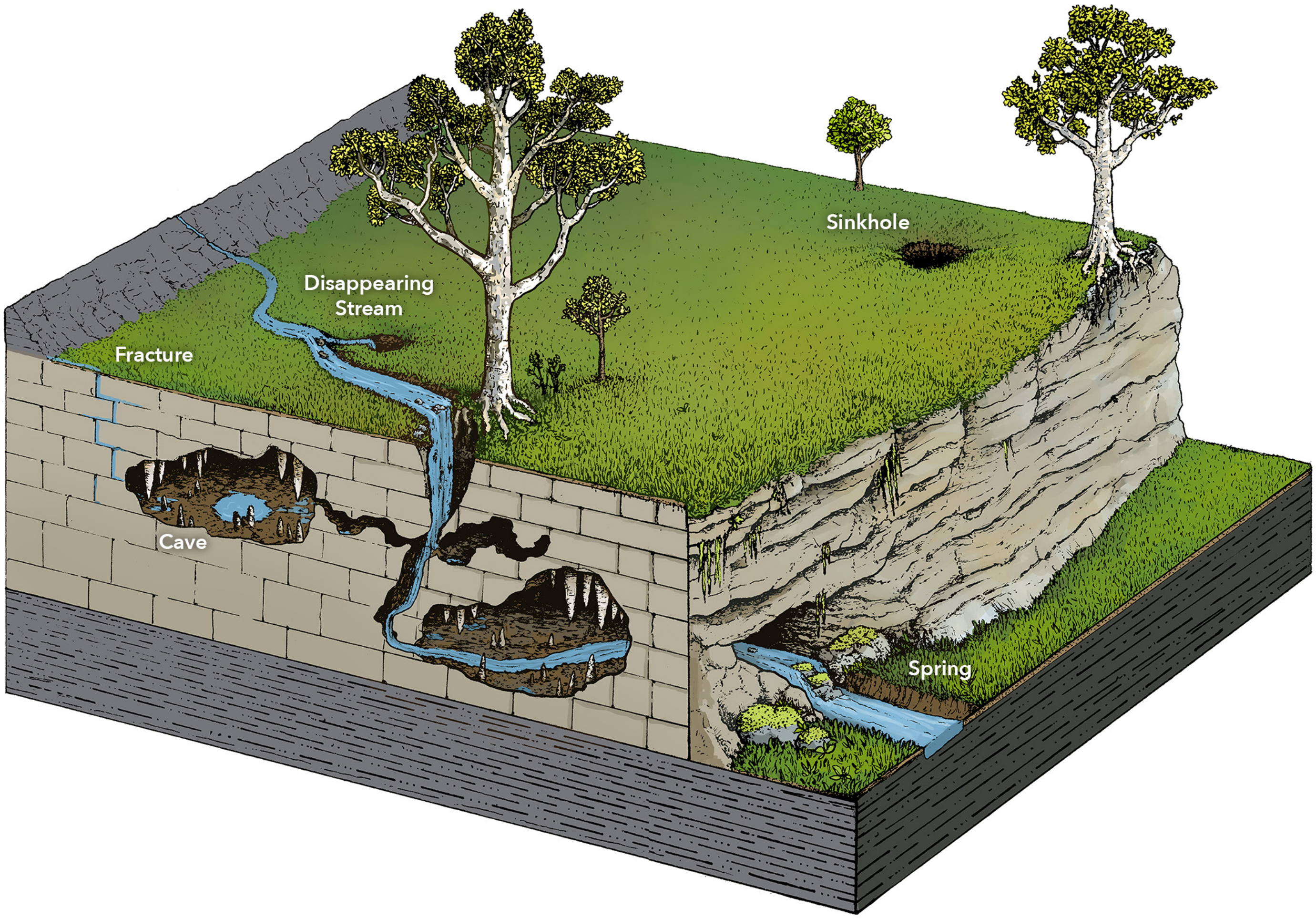

FIGURE 2. Block diagram showing the relationships between karst features. Illustration by Madison Perry.

FIGURE 3. Inactive sinkhole in Clermont County, Ohio.

FIGURE 4. Active, steep-sided sinkhole in a yard with exposed roots and ongoing erosion into the open drain in its bottom. Clermont County, Ohio.

IMPORTANCE OF RESEARCH

Locating and understanding karst features is essential for infrastructure planning and geohazard safety. Roads, buildings, utilities, and other structures built on karst terrain may be subject to damage from ground subsidence, collapse, or flooding (fig. 5). Identifying the locations of these features helps engineers and planners mitigate risks and avoid costly repairs or hazardous conditions.

Karst systems also play a significant role in public health and water resource management. Fractures, joints, and dissolution pathways present in bedrock (fig. 6) provide a direct connection from the land surface to the water table, bypassing soil and rock layers that typically filter contaminants. When compounds such as fertilizers, pesticides, or waste enter sinkholes (fig. 7), they can be rapidly transported to groundwater, potentially affecting water wells, springs, streams, and rivers. Additionally, documenting the locations of caves supports wildlife management efforts. Accurate mapping enables wildlife biologists to track bat populations and monitor the spread of diseases, such as white-nose syndrome.

FIGURE 5. Sinkhole located adjacent to a driveway in Clermont County, Ohio. Subsidence caused by karst features can threaten infrastructure.

FIGURE 6. Limestone pathways produced through dissolution enable greater surface-to-groundwater connectivity. These pathways form along the bottoms of bedding planes, indicating their original orientation. When in place, the pathways would have been roofed by solid rock and open on the base, showing that the center rock in this picture is turned upside down. Clermont County, Ohio.

FIGURE 7. A sinkhole filled with trash, such as a lead- and mercury-containing television, tires, and other refuse in Clermont County, Ohio.

FIGURE 8. Exposed, likely spring-fed cistern in Clermont County, Ohio. This feature was expected to be a sinkhole based on the DEM.

LOCATING KARST FEATURES

The locations of karst features are confirmed using computer-mapping and field verification. Geologists use Esri ArcGIS mapping software to search for enclosed depressions. These depressions can be found on a LiDAR (Light Detection and Ranging)-derived, bare earth Digital Elevation Model (DEM; OGRIP, 2021) of Ohio's topography using a fill-and-subtract method (see Appendix A; Aden, 2018). Geologists use bare earth DEMs, bedrock geology (Slucher and others, 2006), glacial sediment thickness (Powers and Swinford, 2004), past karst mapping (Pavey and others, 1999), and available aerial imagery (OGRIP, 2024) to determine the likelihood of sinkholes in a specific area. Human-made structures, such as culverts, wells, cisterns (fig. 8), old foundations, ponds, or anything that can be mistaken as a sinkhole, such as slopes disturbed by landslides, are identified by geologists and not listed as karst features. Features that cannot be eliminated remotely are field verified. During field verification, sinkholes, caves, and springs are often discovered or pointed out by residents. Fieldwork is especially useful for locating very small or filled sinkholes that are not visible on the DEM but easy to identify on site (fig. 9).

FIGURE 9. Reactivated sinkhole under snow cover, located during fieldwork in Clermont County, Ohio. According to the landowner, a 1.8 m (6 ft) deep sinkhole opened nearby during chisel plowing and was then filled in. Six drains are now present, with walking sticks marking two of the drains.

KARST 2024–2025 STUDY AREA

During the 2024–2025 field season, fieldwork was completed in Clermont County (fig. 10), which is the eleventh fastest-growing county in Ohio (U.S. Census Bureau, 2023). This county was a natural progression from the previous year, as it is adjacent to two previously mapped counties, Hamilton and Warren (Aden and Parrick, 2022, 2024), but had not yet been assessed for karst. Even though the potential sinkholes were widely dispersed across the county, the relatively small total number made it possible to field verify the majority of the potential hazards.

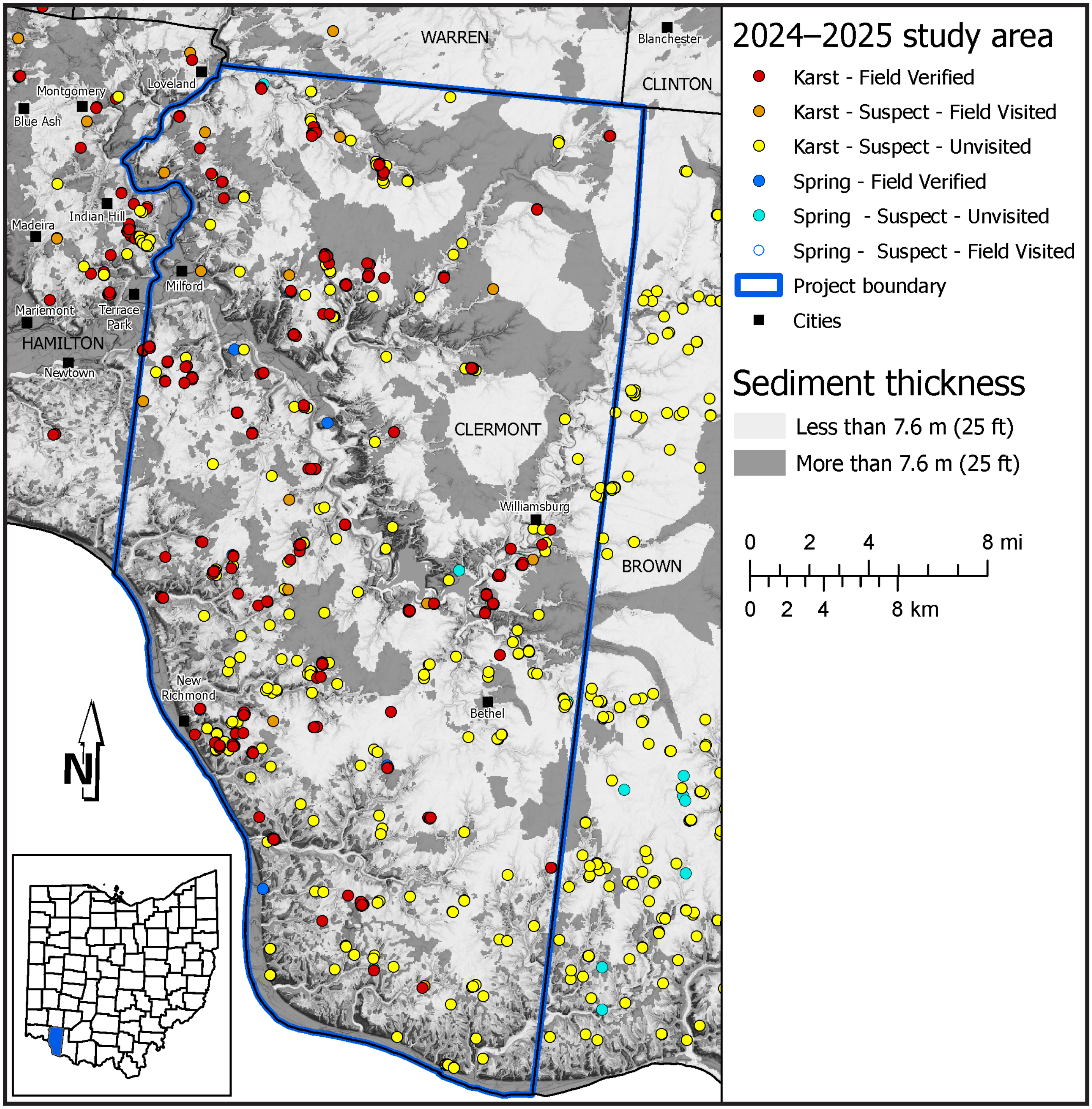

FIGURE 10. Map depicting the karst 2024–2025 study area (blue outline) in southwestern Ohio. Dark-gray areas are covered by more than 7.6 m (25 ft) of glacial material at the surface, and light-gray areas are covered by less than 7.6 m (25 ft) of glacial material at the surface. Note that karst points are found almost exclusively in light-gray areas where glacial material is thin.

Only 28 karst points existed in the ODNR karst database for Clermont County prior to this project; those points were verified during recent mapping of adjacent counties. Initial DEM analysis identified 897 potential points; 628 points remained when the project was completed (table 1). Fieldwork is crucial for confirming potential karst points and distinguishing them from purely erosional features, adding newly located sinkholes (fig. 11), measuring the depth of features, and monitoring changes. Sinkholes that were measured in the field were often deeper than remote-sensing data suggested, adding as much as 3 m (10 ft). Sinkholes do not typically form in sediments thicker than about 7.6 m (25 ft); some points mapped in figure 10 that fall in thicker glacial sediment may represent localized mapping inaccuracies.

TABLE 1. ***Summary of karst points found during the 2024–2025 field season and cumulative statewide status***

Karst Point Type	2024–2025 Total	Statewide Total†
Karst – Field Verified	319	9,103
Karst – Suspect – Field Visited	23	2,286
Karst – Suspect – Unvisited	242	17,294
Spring – Field Verified	27	531
Spring – Suspect – Field Visited	3	13
Spring – Suspect – Unvisited	14	11,391‡
Total Karst Points	**628**	**40,618**

†The inventory of statewide karst points was first created in 2009 (ODNR Division of Geological Survey, [n.d.]).

‡The majority of these are likely non-carbonate springs in eastern Ohio (Appendix B).

Clermont County has new high-resolution data at 0.6 m (2 ft) per pixel; while this data allows for the identification of very small sinkholes, 19 percent of the total points were still added later in the field. In Clermont County, more old house foundations were encountered compared to previous years due to the long history of settlement along the Ohio River. This problem was partially alleviated by using the historic 15-minute topographic maps to identify old home sites (USGS, 1898, 1916, 1931, 1936). Similarly, some tree throws were still visited, with researchers expecting to find a sinkhole. Karst researchers continue improving their methodology for recognizing these unique patterns on the new DEM and OGRIP imagery, and will integrate these identification steps into their process for future projects. The newly released OGRIP ([n.d.]) imagery service provides the best available imagery for each county; the majority of it was captured during leaf-off conditions so as much ground as possible is visible through the trees. This imagery service has proven helpful by allowing rapid access to detailed imagery across the state without the need to download individual files for each county.

Clermont County is very similar to adjacent Hamilton County (Aden and Parrick, 2022) because sinkholes are forming in Ordovician rock that is dominated by shale. The majority of these karst features occur in the Grant Lake Formation (56 percent; fig. 12) or the Miamitown Shale-Fairview Formation, undivided (31 percent), with the remaining 13 percent in other formations. These formations are 50 to 90 percent shale and contain typically thin limestone interbeds. In general, almost no bedrock was observed within sinkholes in glaciated Clermont County. Only four field-verified sinkholes had exposed bedrock—the same as Warren and Clinton Counties (Aden and Parrick, 2024). For contrast, about 1 in 4 sinkholes in unglaciated karst areas of southern Ohio have carbonate bedrock exposed.

FIGURE 11. Sinkhole that was not visible on the DEM but was confirmed during fieldwork in Clermont County, Ohio. This active sinkhole is 1.5 m (5 ft) deep.

Many carbonate springs have been mapped over the years with 41 located this year in Clermont County (fig. 12), including one unusual sediment-laden spring (fig. 13). To better understand the water that travels through underground karst dissolution pathways, ODNR Division of Geological Survey began collecting data using an Apera Instruments PC60-Z Smart Water Tester. This year, 13 springs were tested for pH, conductivity, total dissolved solids, salinity, resistivity, and temperature.

One stream measurement was taken and compared to a nearby spring, with both having similar values. However, since the ground underneath the frost line maintains a constant temperature throughout the year, the spring was slightly warmer than the cold winter stream. The conductivity and total dissolved solids of the spring also measured higher than the stream. These higher measurements indicate the presence of dissolved ions and other substances, potentially from the dissolution of limestone through the karst pathways or past flooding of the nearby Ohio River. In early April 2025, the Ohio River flooded and the spring was under about 3.7 m (12 ft) of water. More spring, stream, and potentially precipitation measurements will be taken during future mapping to detect unusual conditions that warrant further detailed investigation and to grow preliminary spring water dataset measurements.

FIGURE 12. Spring emerging on top of the Grant Lake Formation bedrock in Clermont County, Ohio. Water samples measured here showed that this spring had values similar to other springs measured across the county.

FIGURE 13. Sediment-rich muddy water emerging from a spring on the far bank (white arrow) and mixing with the clear stream water (flowing from left to right) in Clermont County, Ohio.

UPDATES, STATEWIDE STATUS, AND FUTURE WORK

While many dense karst areas have been mapped in Ohio, there are extensive areas where mapping is incomplete. These include parts of western Ohio where carbonate bedrock is present and glacial sediment is thin, and portions of eastern Ohio where limestones occur. Additionally, fieldwork has been deferred in western Adams and eastern Brown Counties owing to the high density of probable karst points and the complexity of processing the updated DEM data. To address this, ODNR Division of Geological Survey has begun a two-year mapping project to map these gaps where possible and to update the statewide karst map (Pavey and others, 1999), which was last revised in 2007. During the 2025–2026 field season, mapping will focus on western Ohio; in 2026–2027, the focus will be on eastern Ohio and a portion of Brown or Adams County as time allows (fig. 14).

New statewide elevation data were collected from 2019 to 2021. ODNR Division of Geological Survey has completed processing these data to create a new higher-resolution, statewide DEM. The last county data was received in May 2025, and the entire state has now been processed into one DEM dataset at 0.6 m (2 ft) per pixel. Ohio's previous DEM (OGRIP, 2007) was at a resolution of 2.1 m (7 ft) per pixel, making the new resolution a substantial improvement.

These new data have allowed researchers to locate a substantial number of additional, previously unknown, small- to medium-sized sinkholes, even in areas where fieldwork occurred in the past (notably Hamilton and Warren Counties). Preparation for future mapping includes completing DEM processing to locate unidentified sinkholes in Fairfield, Preble, Pike, Knox, Licking, Fayette, Union, and Madison Counties (fig. 14). Mapping for Adams, Brown, Clark, Greene, Hamilton, Hancock, Marion, Montgomery, and Seneca, Counties is underway, along with portions of eastern Ohio. See the Karst Interactive Map for the most up-to-date data at **ohiodnr.gov/karst**.

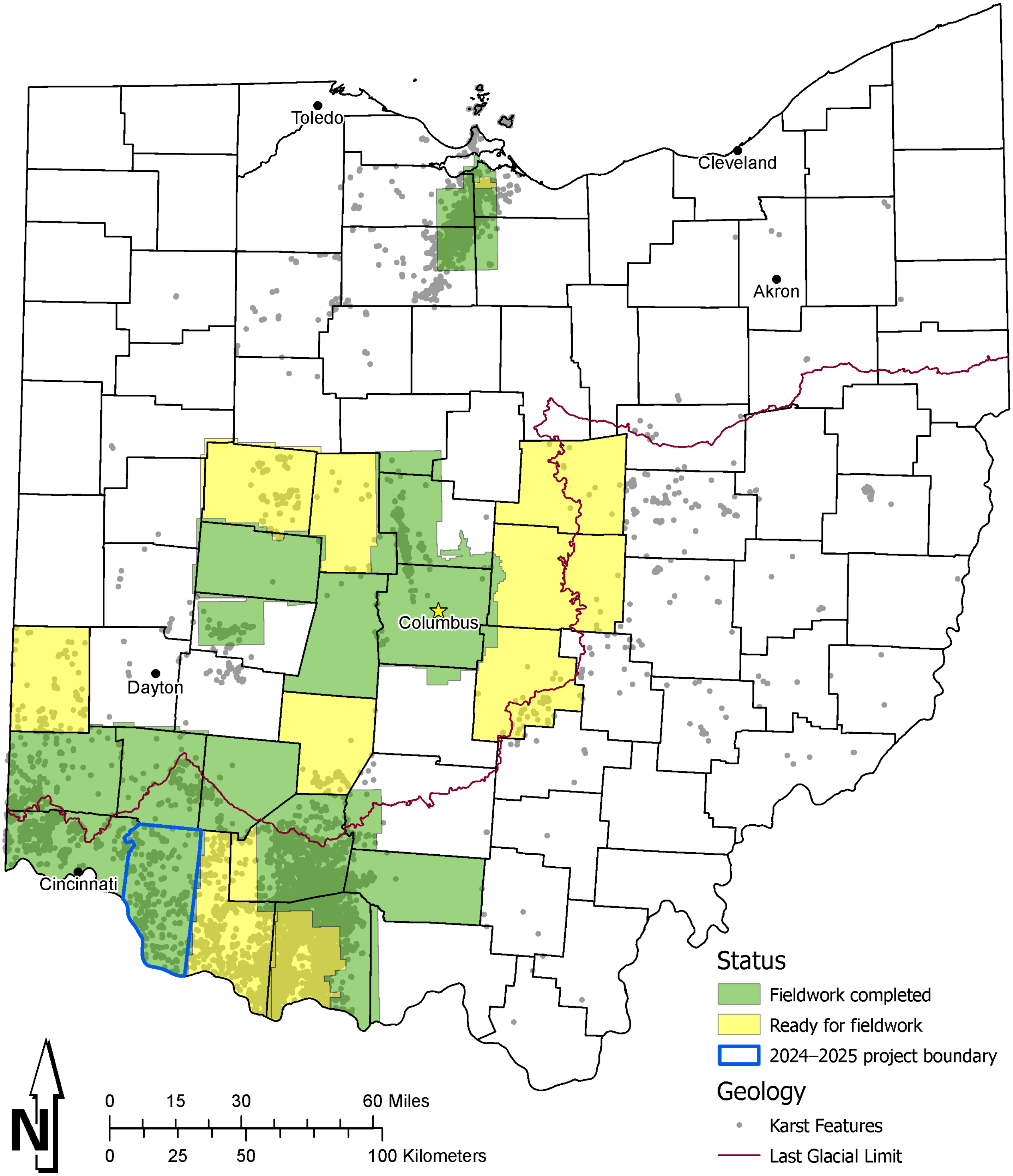

FIGURE 14. Karst mapping statewide status map. Green shading shows areas where data processing and fieldwork are complete; yellow shading shows areas where data processing is complete and the area is ready for fieldwork.

Recent interest in spring mapping, combined with new, higher-resolution DEMs, led to mapping of more than 8,000 potential springs this year, mostly southeast of the last glacial limit (see Appendix B for noncarbonate springs map, methods, and examples). The initial interpretation of data indicates that most of these springs formed in noncarbonate rocks and are not karst. However, there are several generally thin limestones present in eastern Ohio, and a handful of these springs have been confirmed as potential karst based upon nearby measured sections and original land survey notes. Little is known about the extent of karst in these areas since the rocks in eastern Ohio are not mapped to the same level of detail as those in western Ohio.

Another challenge in understanding these springs is finding them. Historically, the 2.1 m (7 ft) per pixel was not detailed enough to locate springs, but the new 0.6 m (2 ft) per pixel DEM has enough resolution to find significant patterns. That said, field verification is necessary to confirm the presence, extent, and characteristics of these springs (fig. 15). Springs are important sources of water statewide and can be used for drinking, fish farming, and to fill ponds.

FIGURE 15. A spring appearing from a fracture in carbonate rock. Located on a branch of Lost Fork Creek in Highland County, Ohio.

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APPENDIX A

Instructions for deriving karst depressions from an approximately 32 km^2 (20 mi^2) or smaller sized Digital Elevation Model (DEM), at a resolution of 0.6 m^2 (2 ft^2), using ArcGIS Pro 3.4.3 and the Spatial Analyst extension (Esri, [n.d]). The advantage of this method for producing contoured polygons for each depression is that the shape and complexity can be easily visualized – as opposed to simply the outside boundary.

ODNR Division of Geological Survey has developed an ArcPro model for automating these steps that is available upon request. Similar steps can be applied for those using QGIS.

1. **Identify all depressions on the DEM.**
   a. On the project area DEM, use the ***fill*** tool to fill enclosed lows.
   b. Use ***minus*** on the filled DEM to subtract the unfilled DEM and identify enclosed low spots.

2. **Convert the DEM into polygons.**
   c. Use ***reclassify*** on the subtracted DEM. Choose *classify* and set the method as *defined interval*. Set the interval size to 1 to set each range to one decimeter (or one foot) or one meter, depending on contour resolution needed. This creates bins where ranges of values are set to one value.
   d. To avoid a polygon that is too complex to generate, set the lowest range as ***0–0.00001 = NODATA***.
   e. Set ***0.00001–1 = 1, 1–2 = 2, etc.***, and ensure *Change missing values to NoData* is unchecked.
   f. Continue setting these ranges until you have reached the maximum expected sinkhole depth for your area. At least 30 classes are recommended.
   g. Use ***raster to polygon*** to create a polygon feature class of depressions. The advantage of using a feature class rather than a raster is that individual depressions can be deleted from the dataset (see figure A-1 for an example image of polygons resulting from steps 1–2).

3. **Delete shallow isolated polygons.**
   h. Steps 1–2 will produce an excessive number of polygons (millions to hundreds of millions) when run on a 32 km^2 (20 mi^2) sized area at 0.6 m^2 (2 ft^2) per pixel resolution. Isolated polygons less than 0.3 m (1 ft) deep can be deleted, as these are unlikely to be sinkholes. Start with the results of Step 2: a polygon feature class with all the depressions in the project area.
   i. Select all gridcode 1 polygons and export to a new feature class using the ***definition query: gridcode = 1***. Isolated polygons below a given minimum size can also be deleted here by using a similar ***definition query***.
   j. Select all gridcode 2 polygons and export to a new feature class using the ***definition query: gridcode = 2***.
   k. Select all gridcode 1 polygons that touch the boundary of gridcode 2 polygons using ***select by location***. Export this selection of the touching gridcode 1 polygons (non-isolated) to a new feature class.
   l. Use a ***definition query*** on the full depression layer (results of Step 2) to set ***gridcode to not equal (<>) 1***. Export all the polygons *except for the gridcode 1 polygons* to a new feature class.

m. Use the ***append*** tool to add the touching gridcode 1 polygons (non-isolated) to the full depression layer without the gridcode 1 polygons. This will produce a feature class of depressions without isolated polygons.

4. **Verify Step 4.**

n. Compare the output from Step 3 (feature class with shallow, isolated polygons removed) to output from Step 2 (full feature class with all polygons).

o. The Step 3 output should not show any of the isolated 0.3 m (1 ft) deep depressions present in the results of Step 2.

5. **Symbolize the polygons.**

p. Use the new gridcode field created by the ***reclassify*** tool, and apply a color ramp.

q. Deep depressions may benefit from a repeating color ramp to improve contrast.

6. **Suggested configuration for combined DEM and slope layers display.**

r. Export a traditional slope or use the *raster function* option to avoid processing time: Analysis -> Raster Functions -> Surface -> **Slope** (use default settings).

s. Symbolize by placing the slope function with 50% transparency on top of the DEM.

t. In the *symbology* pane, set the *stretch type* for BOTH layers as *percent clip*, with min. and max. equal to 2.0. In the *statistics drop-down*, select **DRA** (dynamic range adjustment) for BOTH layers. Slope *color ramp* is set to black-to-white and inverted; DEM *color ramp* is set to a blue-to-red continuous diverging ramp developed by Moreland (2009), now known as the FAST ramp.

u. These steps create a display that can greatly exaggerate elevation changes on the land surface and should be used with caution. The full color ramp is displayed at all scales (see Appendix B, beginning with figure B-2, for examples).

7. **Begin manually deleting extraneous polygons by reviewing DEM and slope shade combination, best available aerial imagery, and culvert data if available (see figure A-2 for an example output with possible sinkhole depressions).**

v. Polygons in quarries, large lakes, and rivers can be deleted first; this will trim the data set and improve drawing speed.

w. Sort the attribute table by gridcode to locate the deepest depressions; these are usually human-made depressions and can be deleted.

x. Bridges and culverts often generate large non-karst depressions.

y. Streams and ditches often produce a series of shallow linear depressions from pools and gravel bars. These rarely represent karst.

z. If a probable sinkhole is located, carefully check the surrounding areas for less obvious features, especially at similar elevations.

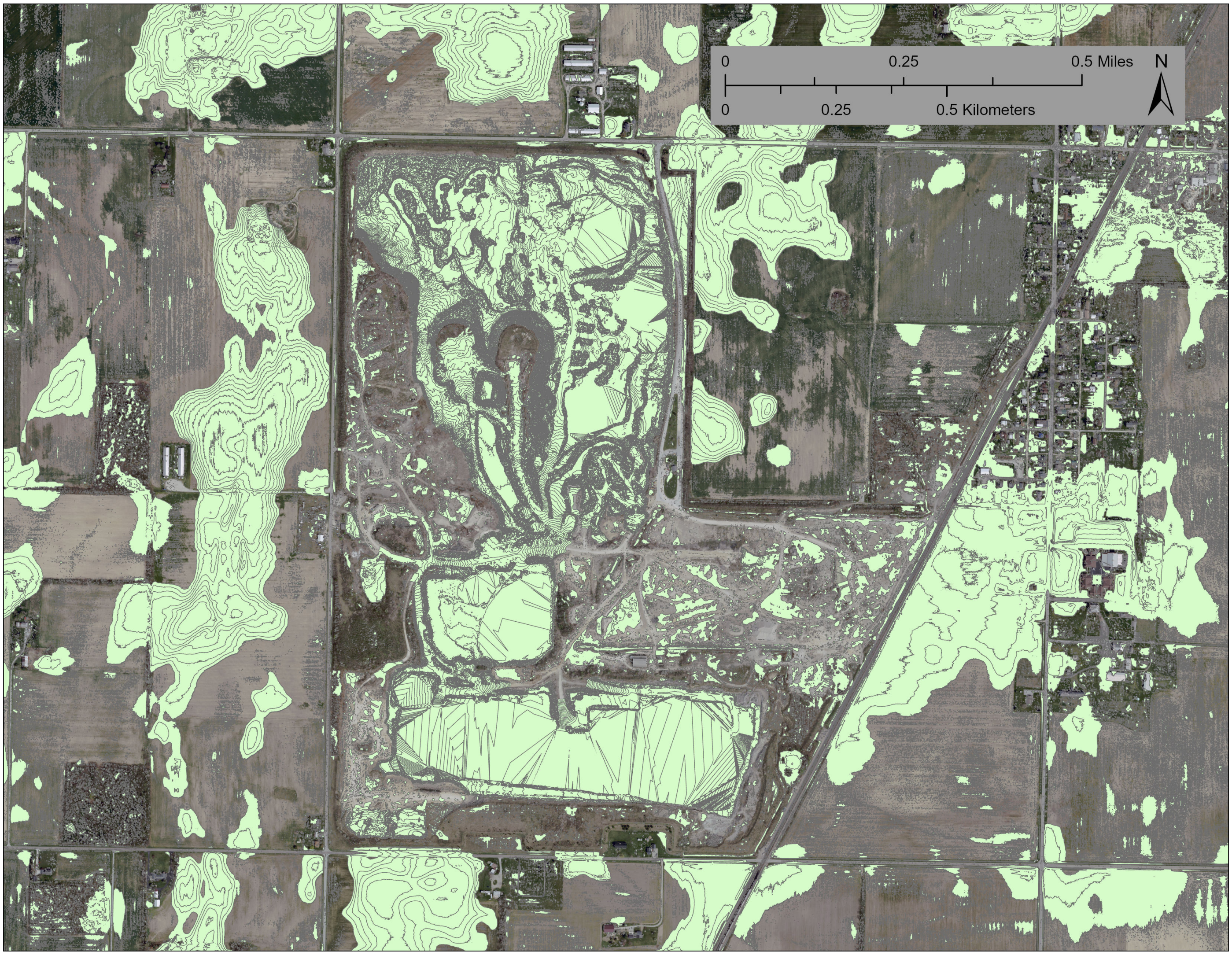


FIGURE A-1. Unsymbolized polygons representing an example set of raw depressions, extracted from the DEM by completing Steps 1–2 of the instructions in Appendix A.

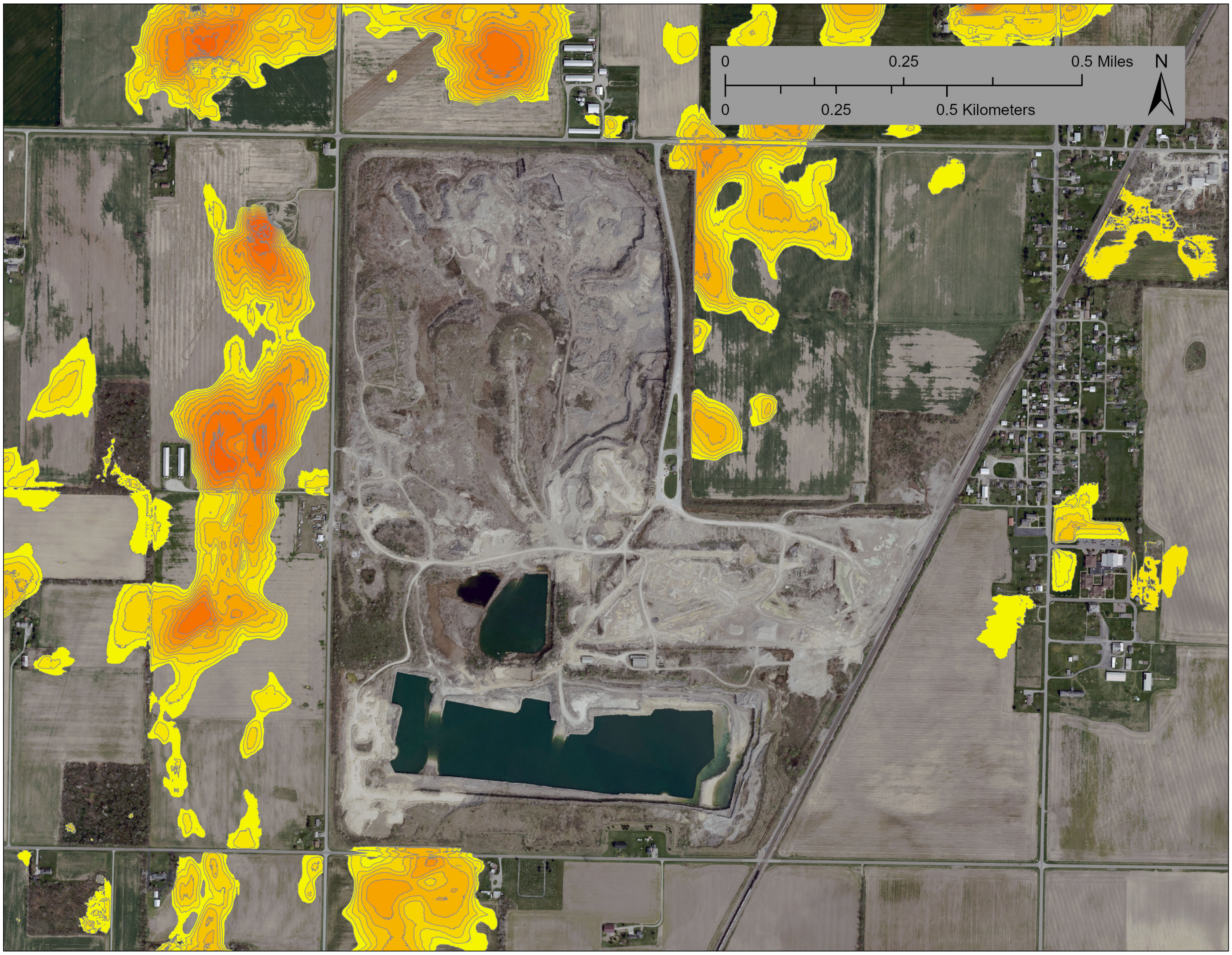


FIGURE A-2. Numerous polygons are automatically removed during Step 3 of the instructions in Appendix A. During Step 7, other non-karst–related polygons are manually removed—such as those in this quarry and along roads—until only the depressions that are likely to be sinkholes remain.

APPENDIX B

Suspected springs can be identified remotely with DEM and aerial imagery data. These features are mapped as the new 0.6 m (2 ft) DEM is reviewed for karst points (fig. B-1). See the Karst Interactive Map for the most up to date information at **ohiodnr.gov/karst.**

Springs are remotely identified using DEM and aerial imagery in ArcGIS software. Criteria used to locate these springs are outlined below:

Spring morphology

- Appears abruptly, especially from the base, side, or nose of a hill (fig. B-2), or the base of a landslide or cliff.
- Does not follow a dendritic drainage pattern. No smaller, uphill drainage branches. Appears to be point source (fig. B-3).
- Water appears perpendicularly from side of streambank but is not an old meander scar (fig. B-3).
- An incised downslope channel indicating water flow (fig. B-3).
- Springhead is rounded into a hillside (fig. B-2) instead of narrowing upslope to a point.
- Ground at the springhead may look uneven and eroded (fig. B-4).
- Ponds and old dams on the side of hills with no feeder streams or an indent on the uphill side (fig. B-5).

Imagery indicators

- Presence of springhouses on aerial or street view (fig. B-6).
- Lush green patches in woods or fields, although tile drainage (buried or outflows) may appear similarly (fig. B-7).

Regional patterns

- More common where bedrock is near the surface, especially in unglaciated portion of Ohio (fig. B-1).
- Often follow specific bedrock contacts (fig. B-8).
- Historic land surveys (fig. B-9) and topographic maps may indicate spring locations or historic home sites (fig. B-6) where springs are commonly found.

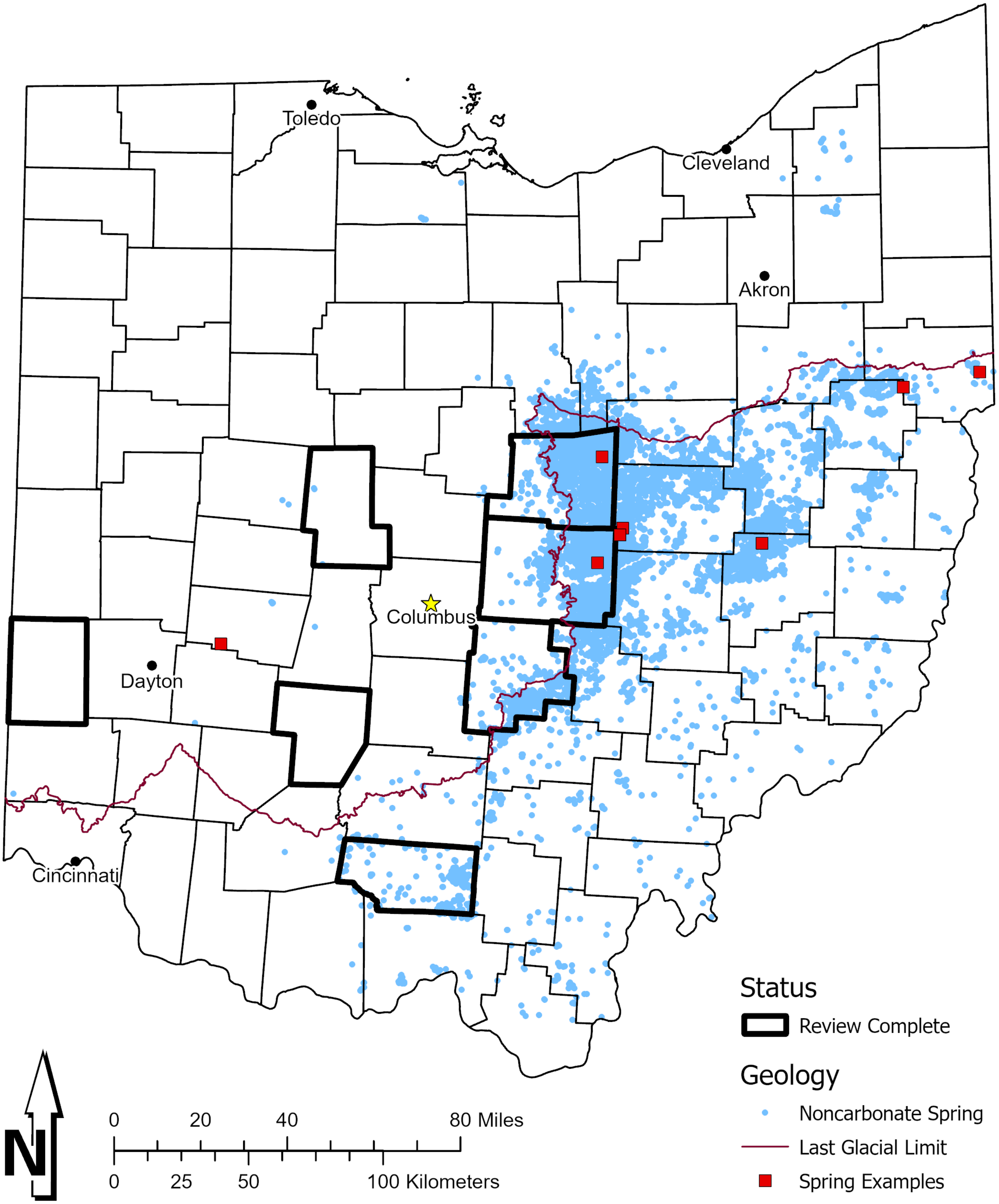


FIGURE B-1. Suspected noncarbonate springs (*n* ≈ 12,000) in Ohio. DEM review is complete for Fairfield, Fayette, Knox, Licking, Pike, Preble, and Union Counties. Most springs are located beyond the extent of the last glacial limit. Spring examples are described in Appendix B.

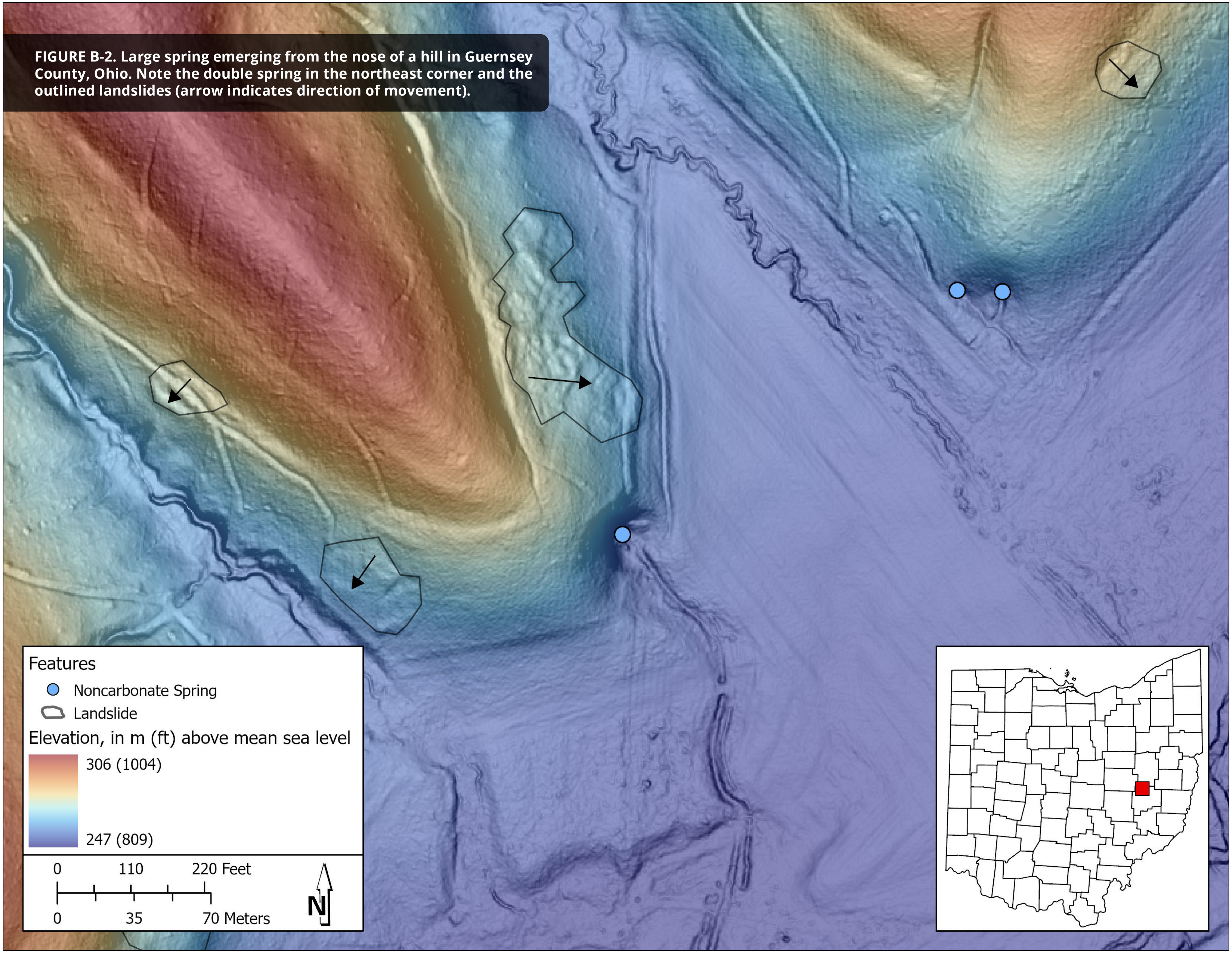


FIGURE B-2. Large spring emerging from the nose of a hill in Guernsey County, Ohio. Note the double spring in the northeast corner and the outlined landslides (arrow indicates direction of movement).

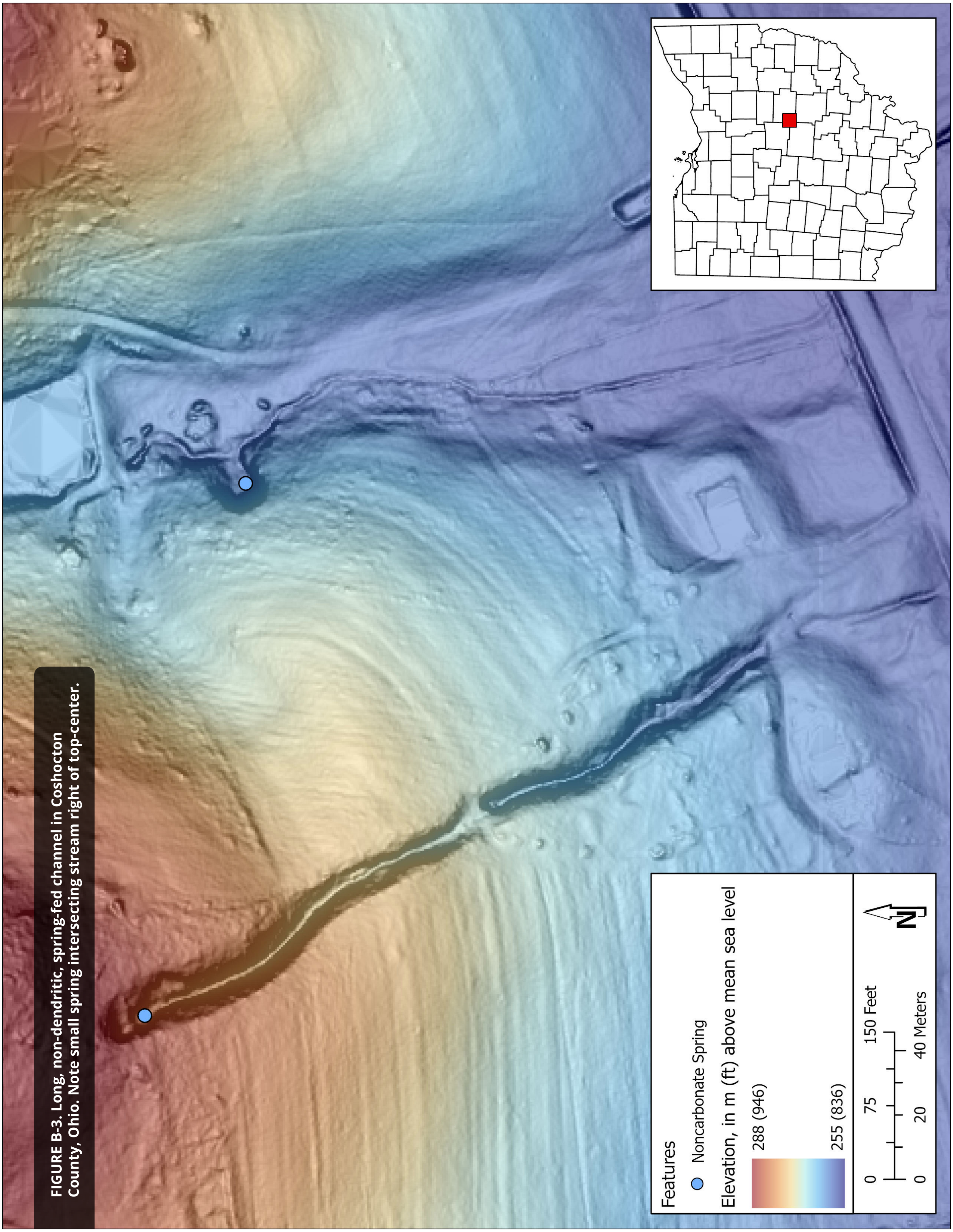


FIGURE B-3. Long, non-dendritic, spring-fed channel in Coshocton County, Ohio. Note small spring intersecting stream right of top-center.

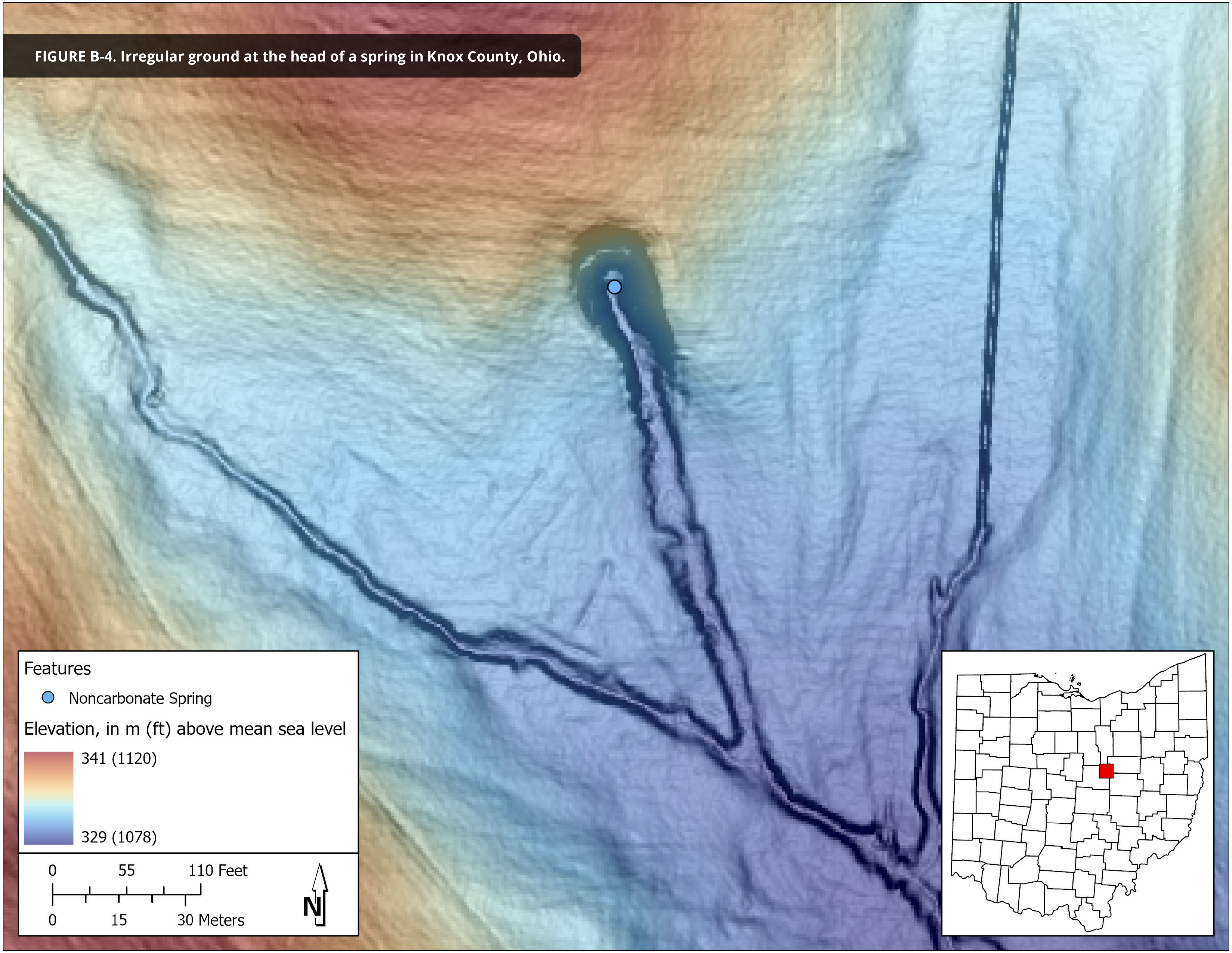


FIGURE B-4. Irregular ground at the head of a spring in Knox County, Ohio.

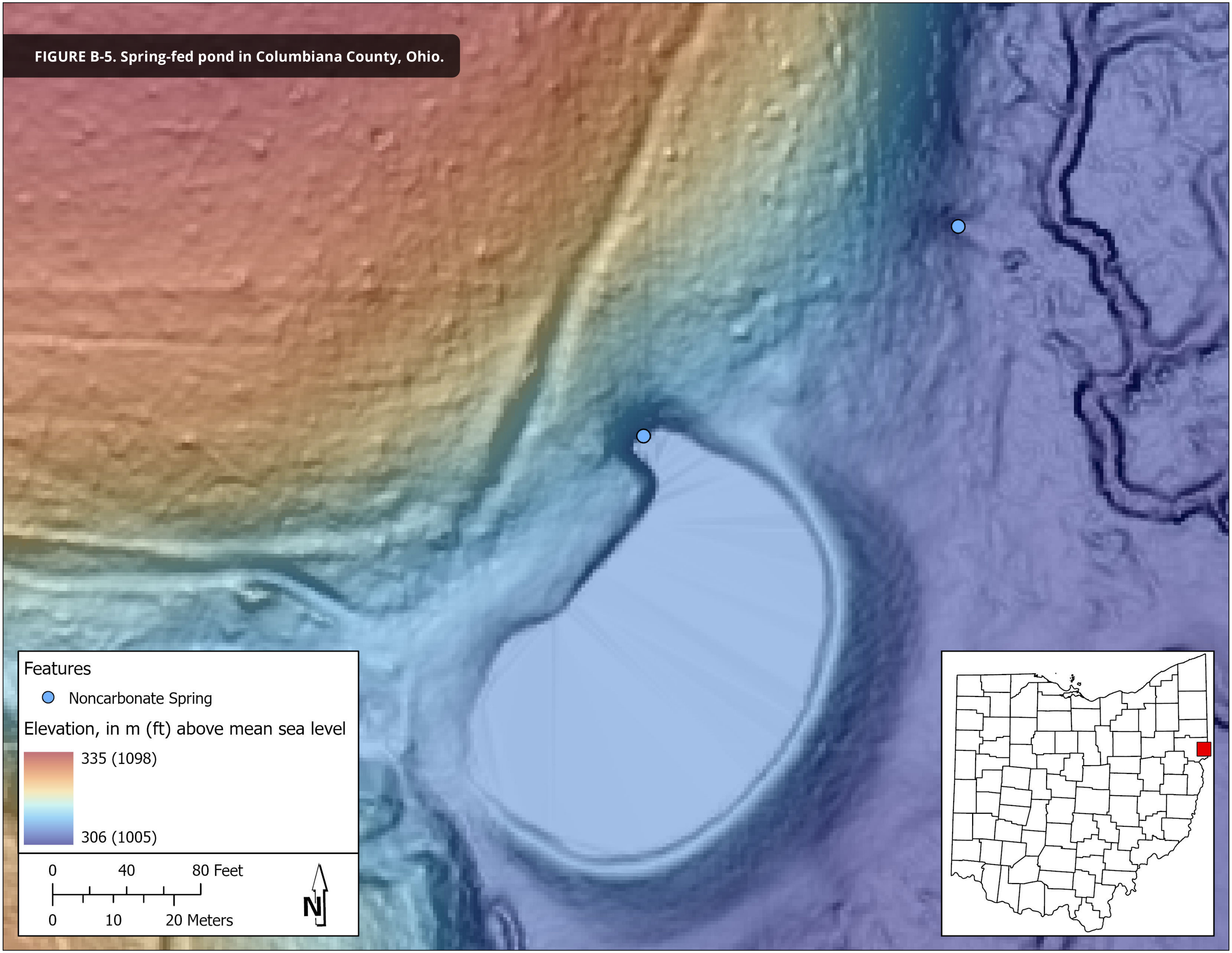


FIGURE B-5. Spring-fed pond in Columbiana County, Ohio.

FIGURE B-6. (Top): topographic map showing historic homestead locations that align with springs (USGS, 1910). (Bottom): Google Street View of center point on map above, showing water from a springhouse flowing into a pond in Coshocton County, Ohio (Google, 2023).

FIGURE B-7. (Top): Aerial showing green water emerging from a spring in Clark County, Ohio. (Bottom): DEM of same location showing irregular head of this spring in Clark County, Ohio.

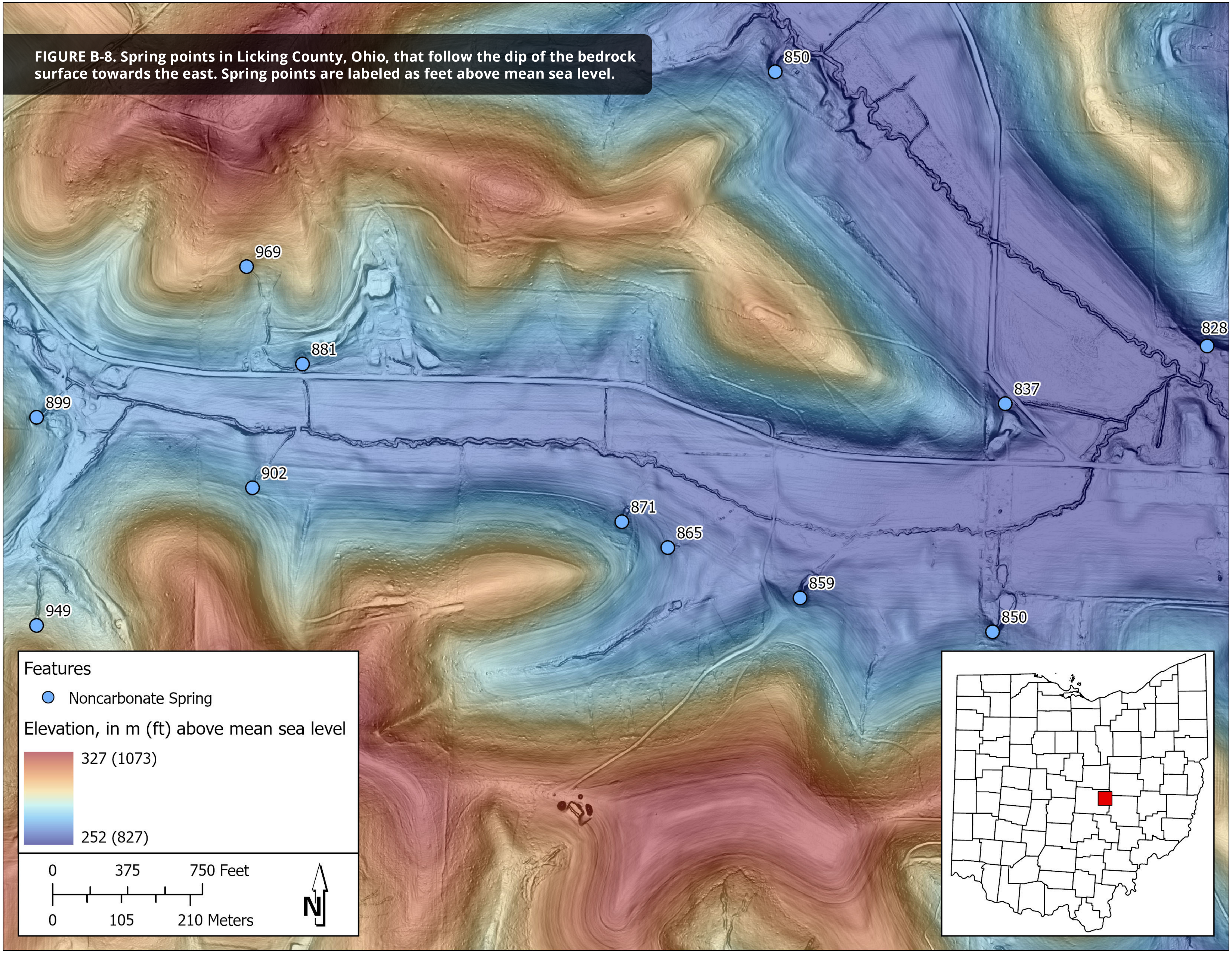
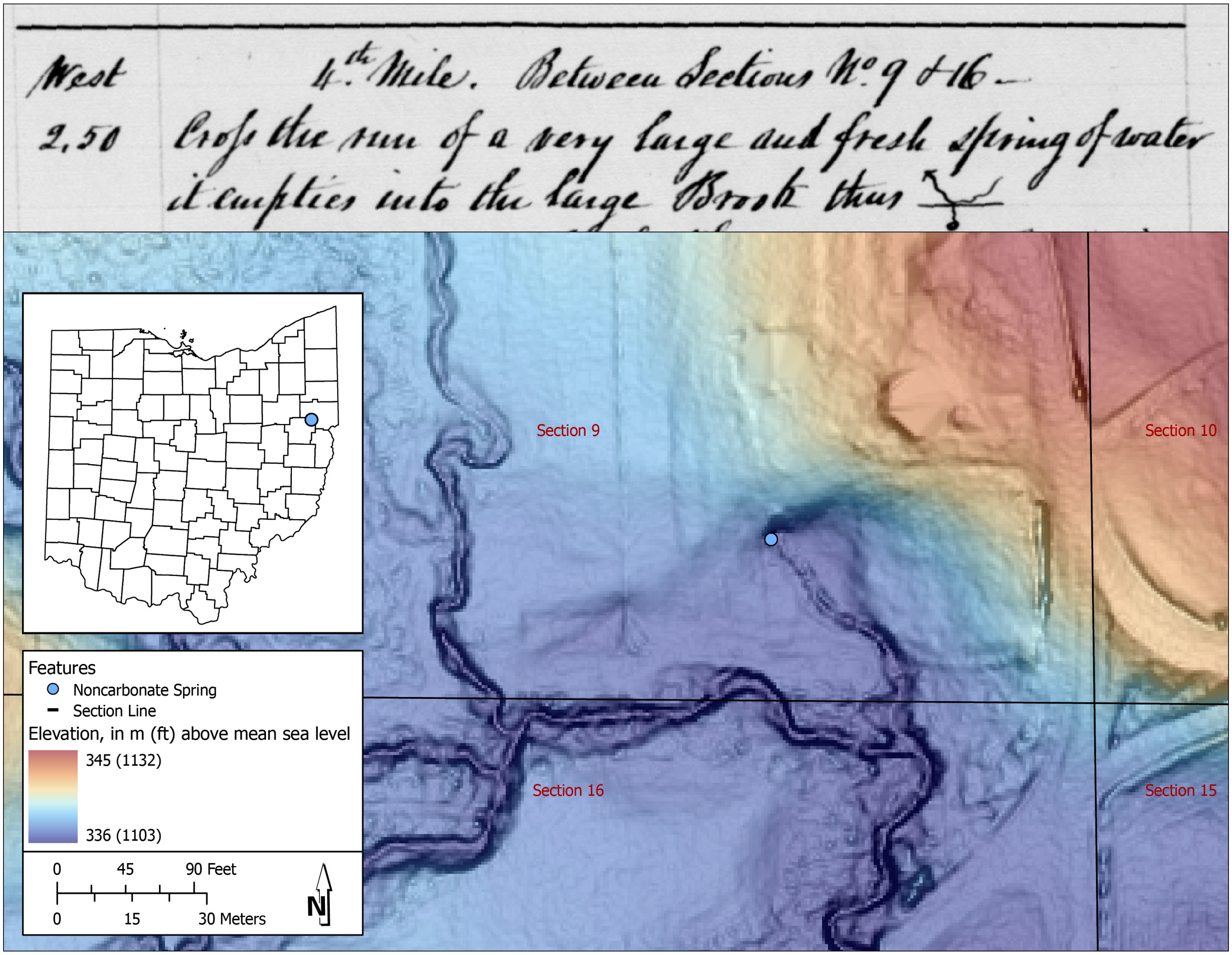


FIGURE B-8. Spring points in Licking County, Ohio, that follow the dip of the bedrock surface towards the east. Spring points are labeled as feet above mean sea level.



West 4th Mile. Between Sections No. 9 & 16 —
2,50 Croſs the run of a very large and fresh spring of water
it empties into the large Brook thus

FIGURE B-9. DEM showing a spring located in Carroll County, Ohio, using the original Land Survey notes (Bever, 1801). This spring is still present today, 224 years later. Top inset reads: "West 4th mile. Between Sections No. 9 & 16. 2.50 [chains (50 m, 165 ft)] Cross the run of a very large and fresh spring of water it empties into the large Brook thus [drawing]."

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