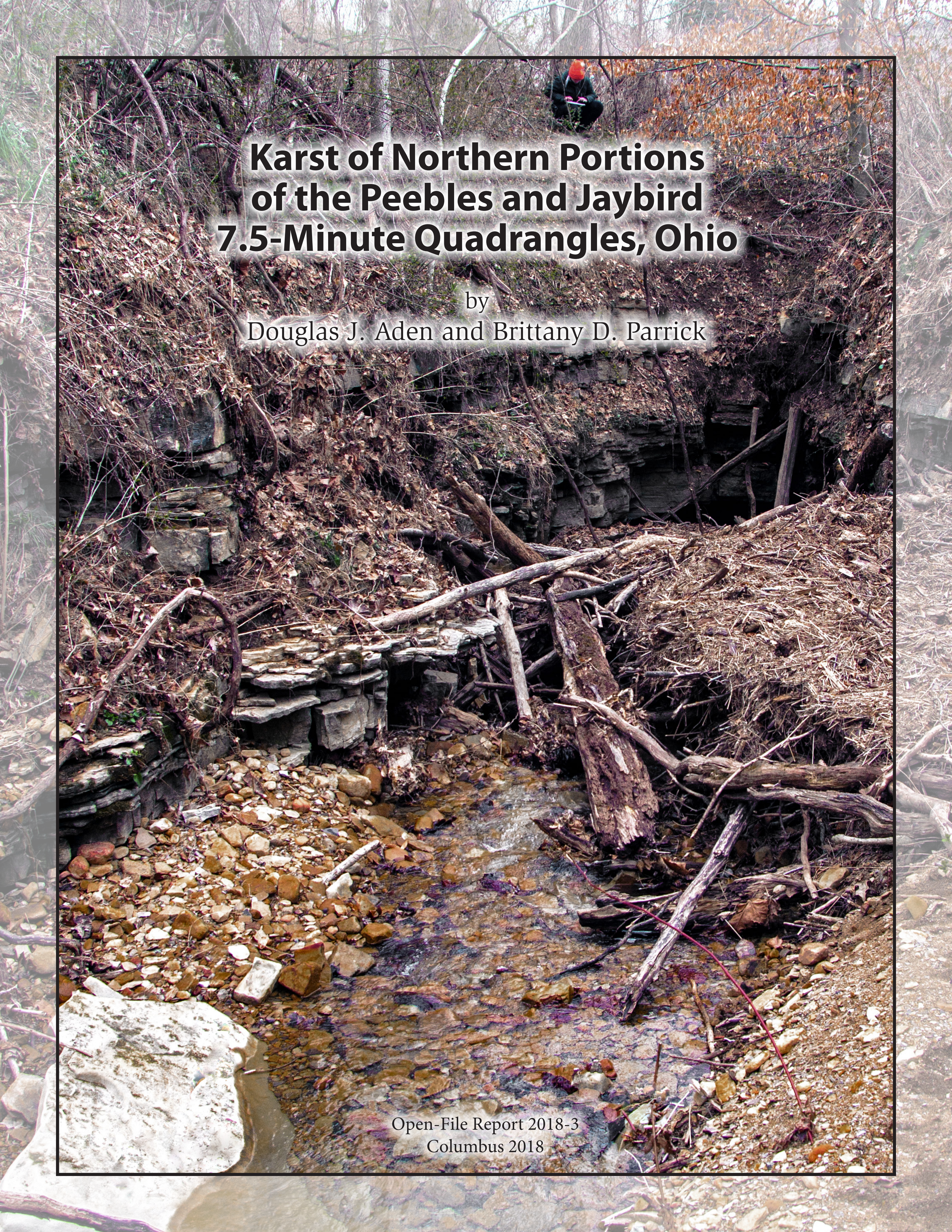

Karst of Northern Portions of the Peebles and Jaybird 7.5-Minute Quadrangles, Ohio

by

Douglas J. Aden and Brittany D. Parrick

Open-File Report 2018-3
Columbus 2018

DISCLAIMER

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Graphic design & layout: David S. Orr
Editing: Charles R. Salmons

Cover image: A dramatically incised sinkhole approximately 22 feet deep, 35 feet wide, and 300 feet long in Adams County, Ohio. This sinkhole is hypothesized to have formed as water ran off of the impermeable Devonian Ohio and Olentangy Shales upslope and was funneled into a fracture in the Silurian-age dolomite (center). This water may resurface at a spring 300 feet to the northeast. Sticks and leaves (center right) intermittently block the drainage, resulting in 3-feet-thick alluvial sand-and-gravel deposits (bottom right) along the stream flank. Eventually, this blockage fails and the stream cuts back down through the sand and gravel. A road (top) is located directly above this sinkhole and should be monitored for stability; small sinkholes are present on both sides of this road.

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FIGURES

This project was funded by the Great Lakes Geologic Mapping Coalition surficial mapping grant program under Cooperative Agreement G17AC00219.

Karst of Northern Portions of the Peebles and Jaybird 7.5-Minute Quadrangle, Ohio

by Douglas J. Aden and Brittany D. Parrick

INTRODUCTION

Karst terrain forms by dissolution of carbonate rocks, such as limestone or dolostone, or evaporites, such as gypsum or salt, and is characterized by features including sinkholes, disappearing streams, caves, and springs. Sinkholes (or sinks) are enclosed depressions that usually do not hold water and often have a "throat" or opening at the bottom that drains to the subsurface. A stream that flows into a sinkhole is known as a *disappearing stream* or ponor. Water flowing into the ground can cause enlargement of natural fractures by dissolution of the rock; these fractures eventually may grow into caves. The Ohio Revised Code defines a cave as "…a naturally occurring void, cavity, recess, or system of interconnecting passages beneath the surface of the earth or within a cliff or ledge…" (State of Ohio, 1989). When water exits these solutional features, a spring is formed.

Solutionally enlarged fractures formed in karst terrain allow for high connectivity between the land surface and the water table. These passageways permit water to bypass soil and rock layers that can filter contaminants. Consequently, when compounds such as fertilizers, pesticides, and waste enter sinkholes, they are rapidly transported to the water table and can quickly pollute water wells, streams, springs, and rivers.

Karst features may pose geologic hazards. Roads, utilities, houses, and other structures built in karst areas are at risk of subsidence, collapse, or other damage. Cattle and other livestock are also at risk in fields with deep pit sinkholes (fig. 1).

FIGURE 1. An active, 12-ft-deep and 22-ft-wide sinkhole in Adams County, Franklin Township off of Frog Hollow Road. Based on historical imagery, the outer portion of this sink is estimated to have begun forming between 2006 and 2009, with the inner collapse opening in 2017.

PREVIOUS WORK

In the interest of health and safety of the public, the Ohio Geological Survey maps known and suspected karst areas throughout Ohio. Four separate regions have been mapped in detail during the last eight years (fig. 2), and research was completed in 2018 comparing sinkhole sizes and shapes across these regions (Aden, 2018). For these areas, detailed geographic information system (GIS) data, including what type of karst features were found, a description of each feature, depth and extent, and many photos, are available (on file at the Ohio Geological Survey). The last four years of mapping have focused on southern Ohio. Southern Ohio is distinct because although the sinkholes have much smaller dimensions on average, they are more numerous (Aden, 2018).

METHODOLOGY

A digital elevation model (DEM), generated from Light Distance and Ranging (LiDAR) data (OGRIP, 2006), was used to create a map layer that identified low, enclosed areas. To locate potential sinkholes, these low spots were cross referenced with known karst points from previous studies by the Ohio Geological Survey (Pavey and others, 1999) and The Wittenberg University Speleological Society; bedrock geology (Swinford, 1991; Schumacher, 1994); aerial photography from the State of Ohio (OGRIP, 2012) and Google Earth; soil maps (Soil Survey Staff, 2017); glacial drift thickness (Powers and Swinford, 2004); and water well logs (on file at the Ohio Geological Survey). Many depressions were removed from consideration when it was determined they were not sinkholes. This determination was made by examining aerial photography for human-made structures and other non-sinkhole depressions.

Depressions then were visited in the field, evaluated, and photographed. Through this process, some of the LiDAR-derived depressions were found not to be sinkholes. Features such as building foundations, broken field tiles, steep-walled streams, road culverts, and glacial features often produced enclosed areas similar in shape to sinkholes. Springs typically do not

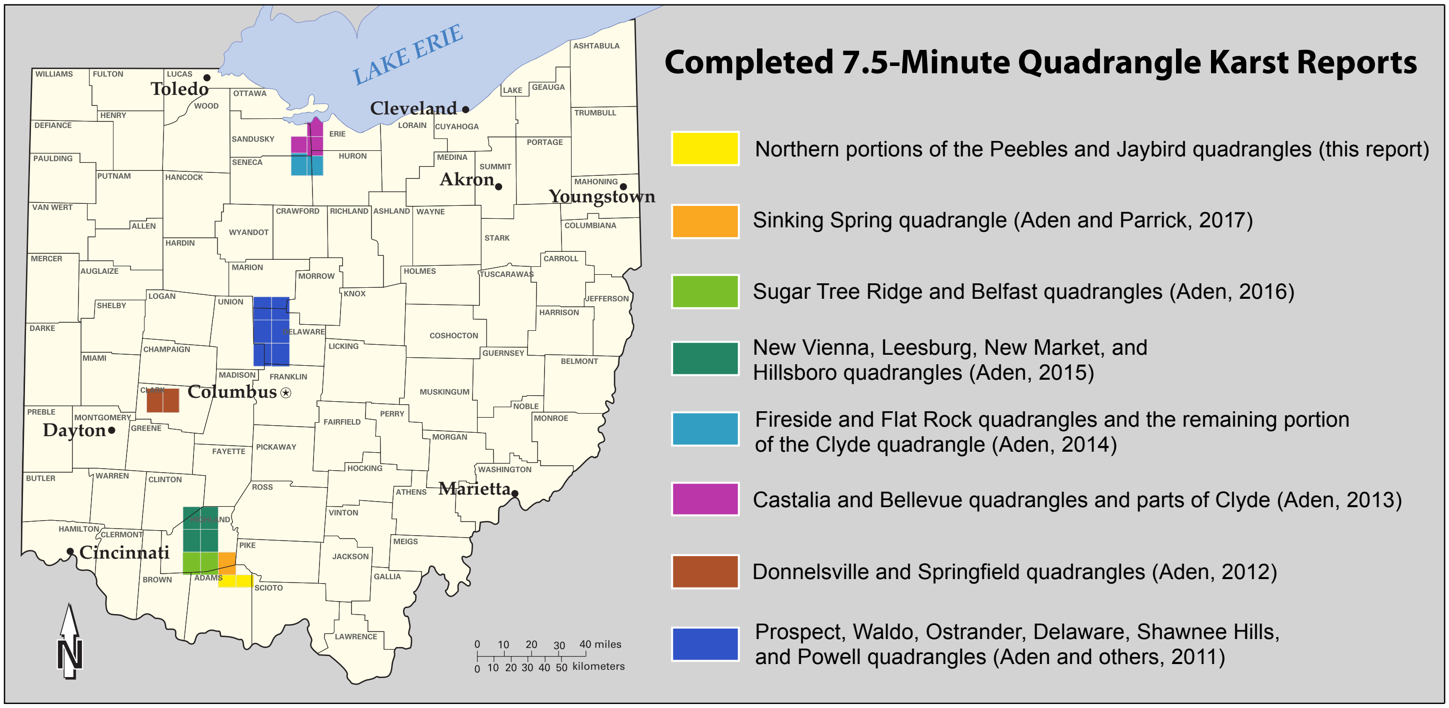

FIGURE 2. Detailed karst mapping project areas completed in the state of Ohio since 2010.

show up as depressions, and they were located during field work by spotting springhouses.

Field visits are critical for confirming sinkhole dimensions because LiDAR often under-reports maximum sinkhole size and depth. LiDAR data does not always represent the lowest point within the depressions. Therefore, to estimate the sizes of sinkholes, a plumb bob was used to measure the depths, lengths, and widths, especially if they were deeper than the LiDAR indicated or not present on the LiDAR. Some small sinkholes had formed since this LiDAR dataset was collected (2006–2010), and every effort was made to measure them in the field. Field mapping was facilitated by using an electronic tablet with ESRI ArcGIS® Collector software. Field digitizing on an electronic tablet with an integrated Global Positioning System (GPS) was helpful for precisely locating new or small sinkholes and springs that were not detected on LiDAR or imagery. Other helpful data sources were the farmers and other land holders who remain critical sources of local information, particularly for historical features, such as drained ponds, old mill works, and even sinkholes that have been filled.

The resulting karst feature dataset was overlain on a reference map and four geologic maps showing the Land Surface, Bedrock Geology, Bedrock Topography, and Drift Thickness. Each of the five maps show the 48 two-km² tiles, and the 7.5-minute quadrangles, that form the project area overlain on a DEM of the land surface. Note that the project area is defined by the tiles and not the 7.5-minute quadrangle boundaries. On all maps, tiles outlined in red contain the karst features identified through this project. No karst features were identified in tiles outlined in black. Tile numbers indicated on the four overlay maps and the reference map represent the maps on pages 3–8.

The maps feature four types of identified karst features:

- Red circles indicate field-verified features (i.e., those that have been visited in the field and confirmed as karst).
- Orange circles indicate sites that were visited but could not be verified, for example, a suspicious depression that is flooded or that lacks an active sink throat and cannot be clearly classified.
- Yellow circles represent areas with suspect characteristics—such as subtle LiDAR depressions—in a location where access to the property could not be gained, or where the field point was not verified.
- Blue squares represent springs where water was found or reported to be flowing from the subsurface.

RESULTS AND DISCUSSION

A reference map is provided to orient the user to the point and tile locations relevant to the roads, streams, counties, and townships (fig. 3). Detailed two-km² map tiles (p. 10–40) contain specific karst point locations, as well as karst depressions represented by yellow to red topographic lines. Each concentric ring represents a drop of one foot in elevation toward the low point of an internally drained area. Many of the depressions were covered by points because the depressions are so small at the scale of the map tiles.

One unusually large depression can be seen on map tile 34 running through the town of Peebles, Ohio. At

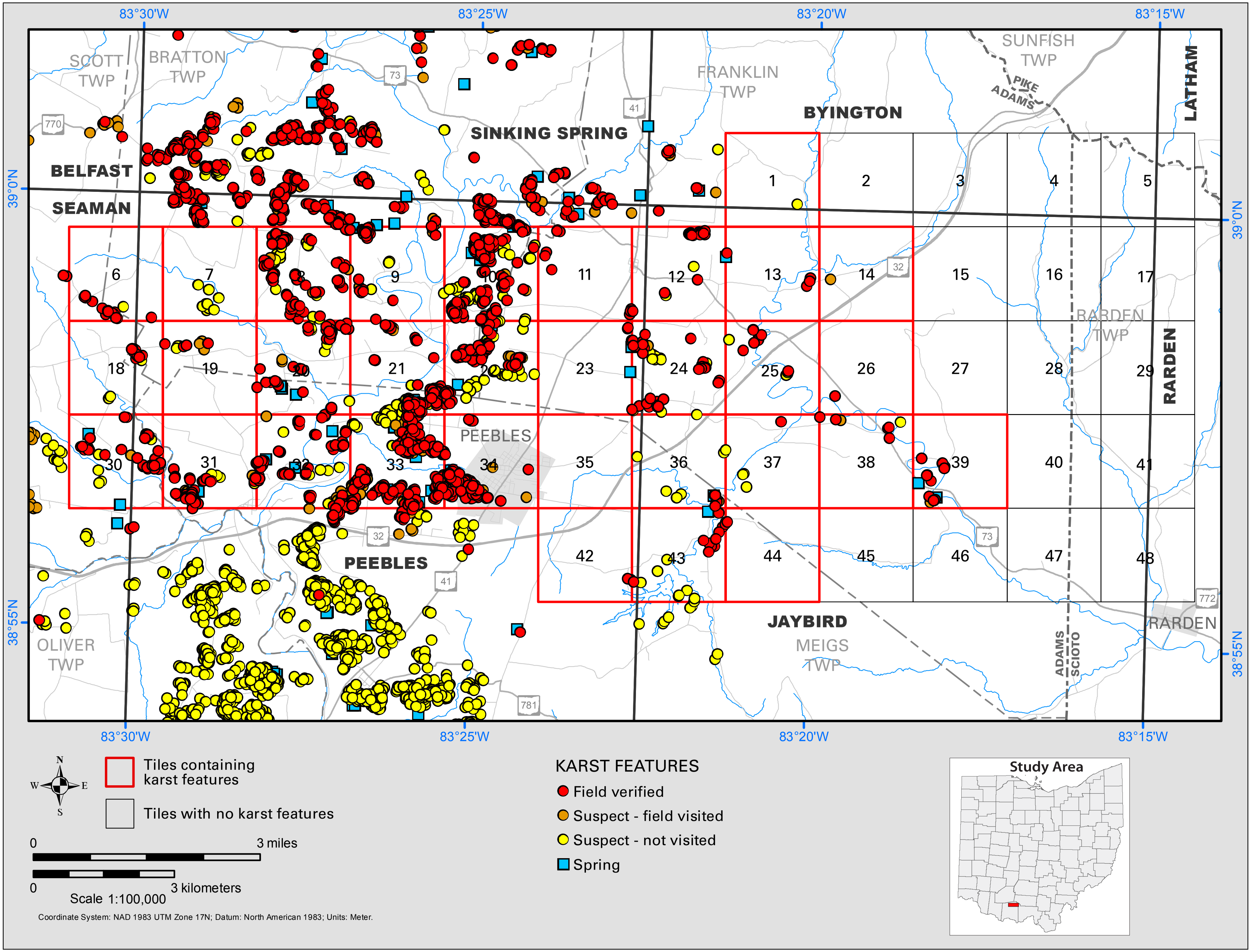

FIGURE 3. Reference map of the study area showing counties, townships, roads, towns, and streams.

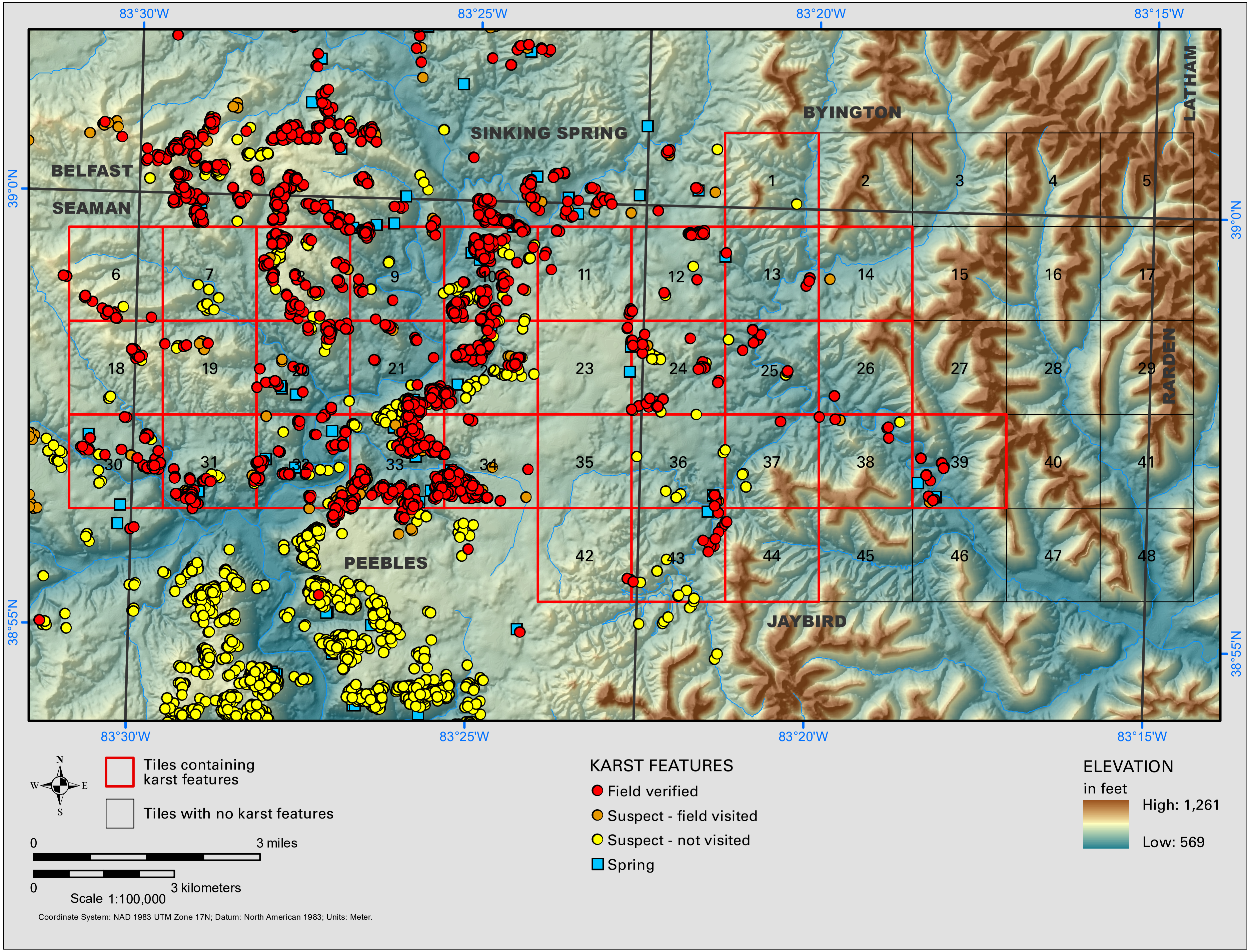

FIGURE 4. Digital elevation model (Land Surface map) showing topographic relief in the study area.

about 700 ft wide and 3,500 ft long (3 million ft^2), this sinkhole is much larger than any outside of a select few found in north-central Ohio near Bellevue (Aden, 2018).

The Land Surface map reveals that in the Peebles region, sinks are concentrated near the break in slope at the tops of hills and often occur in clusters (fig. 4). A directional trend was not observed in this project area. In total, the study area has 1,689 karst features, including 31 springs. These karst features occur in 35 of the 48 mapped tiles.

The Bedrock Geology map (fig. 5) shows that more than 82 percent of karst features are forming by dissolution of Silurian-age dolomite. More detailed bedrock mapping of the Peebles quadrangle (not shown) allows for higher precision in distinguishing lithologic units within the karst terrain and shows that at least 75 percent of the karst is forming by dissolution of the Silurian Lilley Formation. This concentration of karst features in the Lilley Formation is likely the same in the Jaybird quadrangle; however, this is difficult to confirm because the bedrock mapping is not as detailed. According to this map, there are sinks on the Silurian Estill and Devonian Ohio and Olentangy Shales, indicating that either the shale is very thin and the sinks are forming through it, or the bedrock map needs to be refined. Shale also influences water percolating downward through vuggy carbonate rock by redirecting water horizontally along the shale until it reaches the land surface and discharges as a spring.

Formations on the Bedrock Geology map are buried in the east by surficial glacial materials. The elevation of the bedrock below the surficial materials is called *bedrock topography* (fig. 6). The elevations of the bedrock surface were subtracted from the DEM (fig. 4) to create the Drift Thickness map (fig. 7). Knowing the drift thickness is useful because sinkholes generally develop where the drift is shallow (about 25 feet or less). Other sinkholes may exist in areas that have more than 25 feet of drift, but they either were buried beneath the glacial drift or were prevented from forming because of thick drift. The drift thickness is thin or zero in many parts of this project area, and the map shows that the sinkholes are concentrated in these areas (fig. 7).

CONCLUSIONS

Of the 1,689 mapped karst features, 1,009 have photos (from multiple angles for interesting features), and 1,147 have DEM-derived depressions. In the study area, 31 springs were located and found generally associated with clusters of sinkholes. Sixty sinkholes were identified using aerial photography only, likely having formed more recently than the data recorded by the DEM. In total, 449 sinks were found through field work, which demonstrated the need for field verification near known karst areas. In the study area, 127 depressions were reviewed and recorded as not being sinkholes.

It was found that in addition to LiDAR, photographs could be used to monitor how sinkholes change over time and assist in field identification. Identification is important because karst regions are highly susceptible to pollution, and structures built near them are at risk of subsidence. The maps in this report and the available GIS data will allow areas of land development near karst features to be better planned and maintained and impacts of karst features to be better mitigated.

FURTHER READING

For more information on karst in Ohio, visit the Ohio Geological Survey website, OhioGeology.com. The following resources also provide additional information on karst and its effects in Ohio and beyond.

American Geological Institute

Living with Karst—A Fragile Foundation, AGI Environmental Awareness Series, no. 4, accessible at <http://www.agiweb.org/environment/publications/karst.pdf>.

National Speleological Society

Hobbs, H.H., III, 2009, The Glaciated Central Lowlands—Ohio, chap. 4 of Palmer, A.N., and Palmer, M.V., eds., Caves and Karst of the USA— A Guide to the Significant Cave and Karst Areas of the United States of America: National Speleological Society, p. 136–140.

U.S. Geological Survey

USGS Groundwater Information—Karst and the USGS, accessible at <http://water.usgs.gov/ogw/karst/>.

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Aden, D.J., 2013, Karst of the Bellevue quadrangle and portions of the Clyde and Castalia quadrangles, Ohio: Ohio Department of Natural Resources, Division of Geological Survey Open-File Report 2013-1, 4 p., 59 maps, accessible at <http://geosurvey.ohiodnr.gov/portals/geosurvey/PDFs/

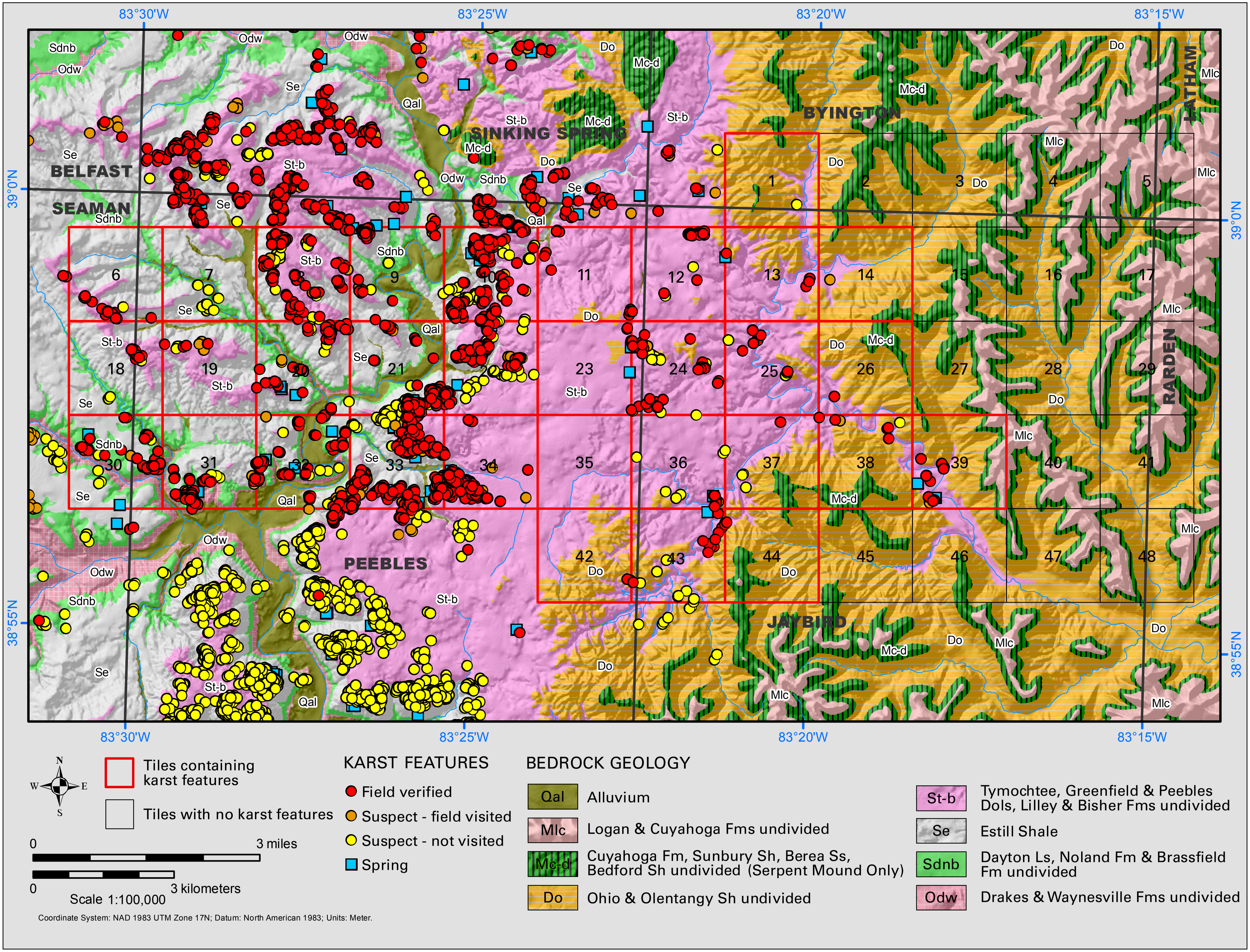

FIGURE 5. Lithified rock (bedrock geology) at the surface or beneath glacial material in the study area.

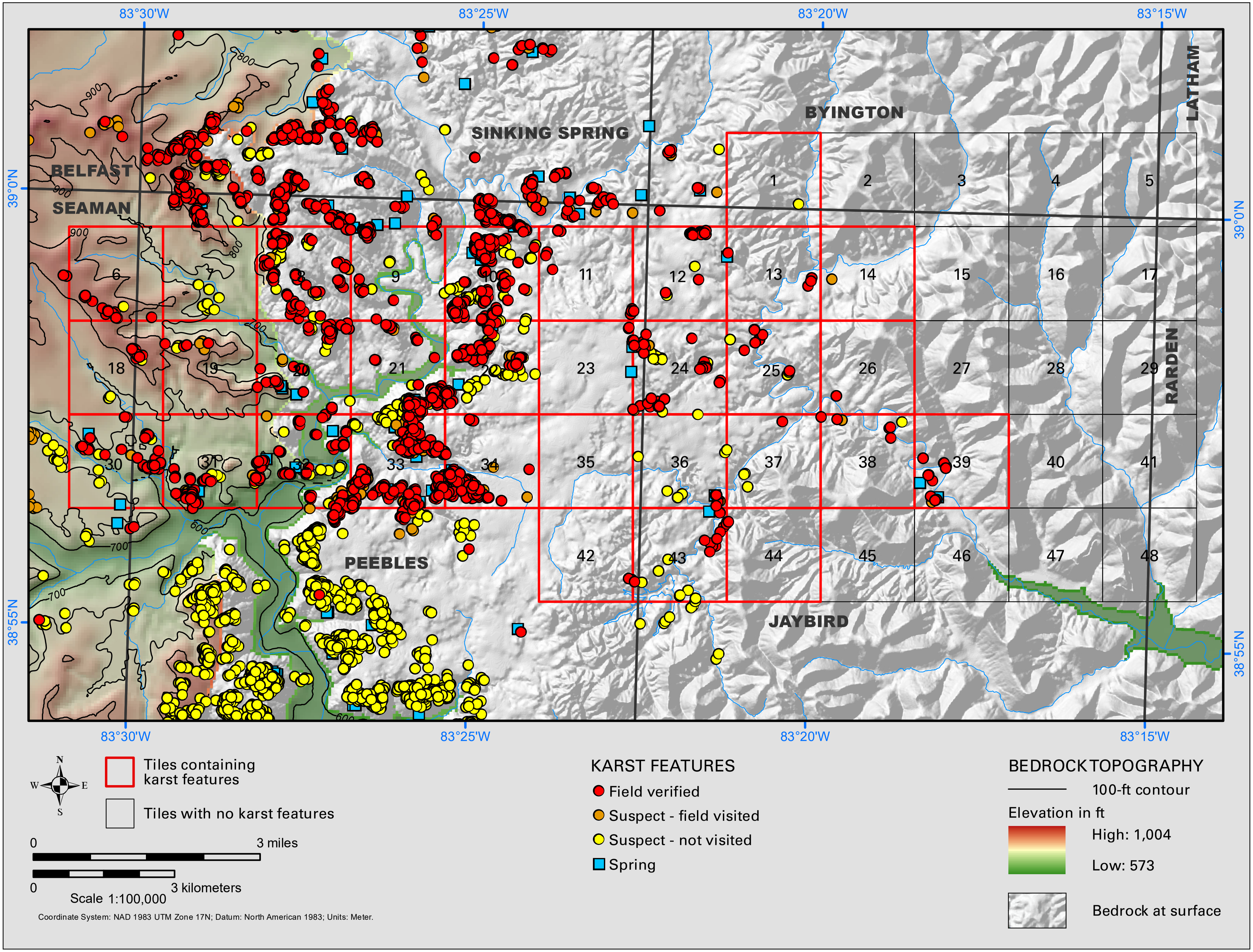

FIGURE 6. Bedrock topography in the study area.

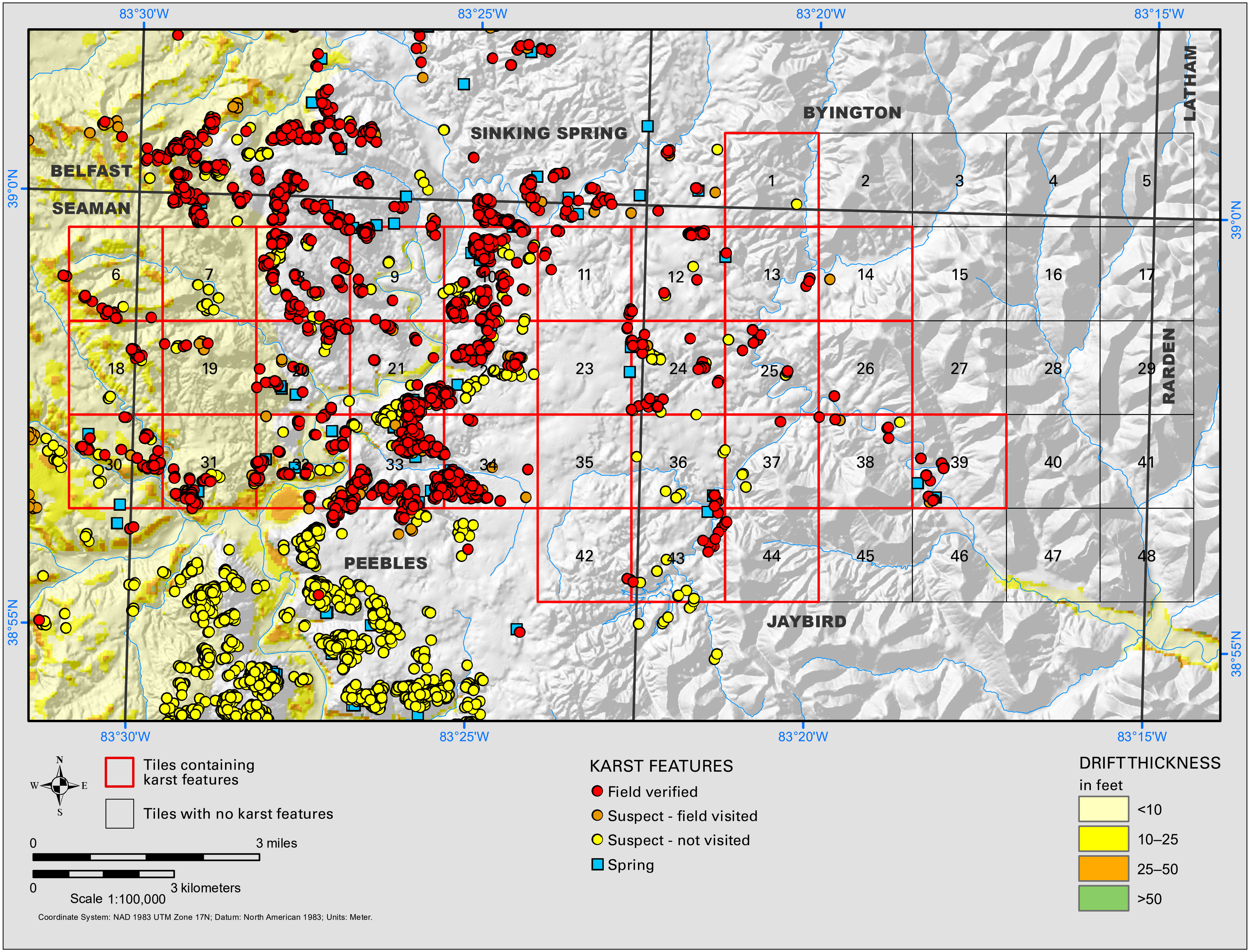

FIGURE 7. Thickness of glacial material (DEM minus Bedrock Topography) in the study area.

OpenFileReports/OFR_2013-1.pdf > .

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Aden, D.J., 2015, Karst of the Hillsboro, New Market, New Vienna, and Leesburg quadrangles, Ohio: Columbus, Ohio Department of Natural Resources, Division of Geological Survey Open-File Report 2015-1, 4 p., 71 maps, accessible at < http://geosurvey.ohiodnr.gov/portals/geosurvey/PDFs/OpenFileReports/OFR_2015-1.pdf > .

Aden, D.J., 2016, Karst of the Belfast and Sugar Tree Ridge 7.5-minute quadrangles, Ohio: Columbus, Ohio Department of Natural Resources, Division of Geological Survey Open-File Report 2016-4, 7 p., 68 maps, accessible at < http://geosurvey.ohiodnr.gov/portals/geosurvey/PDFs/OpenFileReports/OFR_2016-4.pdf > .

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Pavey, R.R., Hull, D.N., Brockman, C.S., Schumacher, G.A., Stith, D.A., Swinford, E.M., Sole, T.L., Vorbau, K.E., Kallini, K.D., Evans, E.E., Slucher, E.R., and Van Horn, R.G., 1999, Known and probable karst in Ohio: Ohio Department of Natural Resources, Division of Geological Survey Map EG-1, scale 1:500,000. [Revised 2002, 2004, 2007.]

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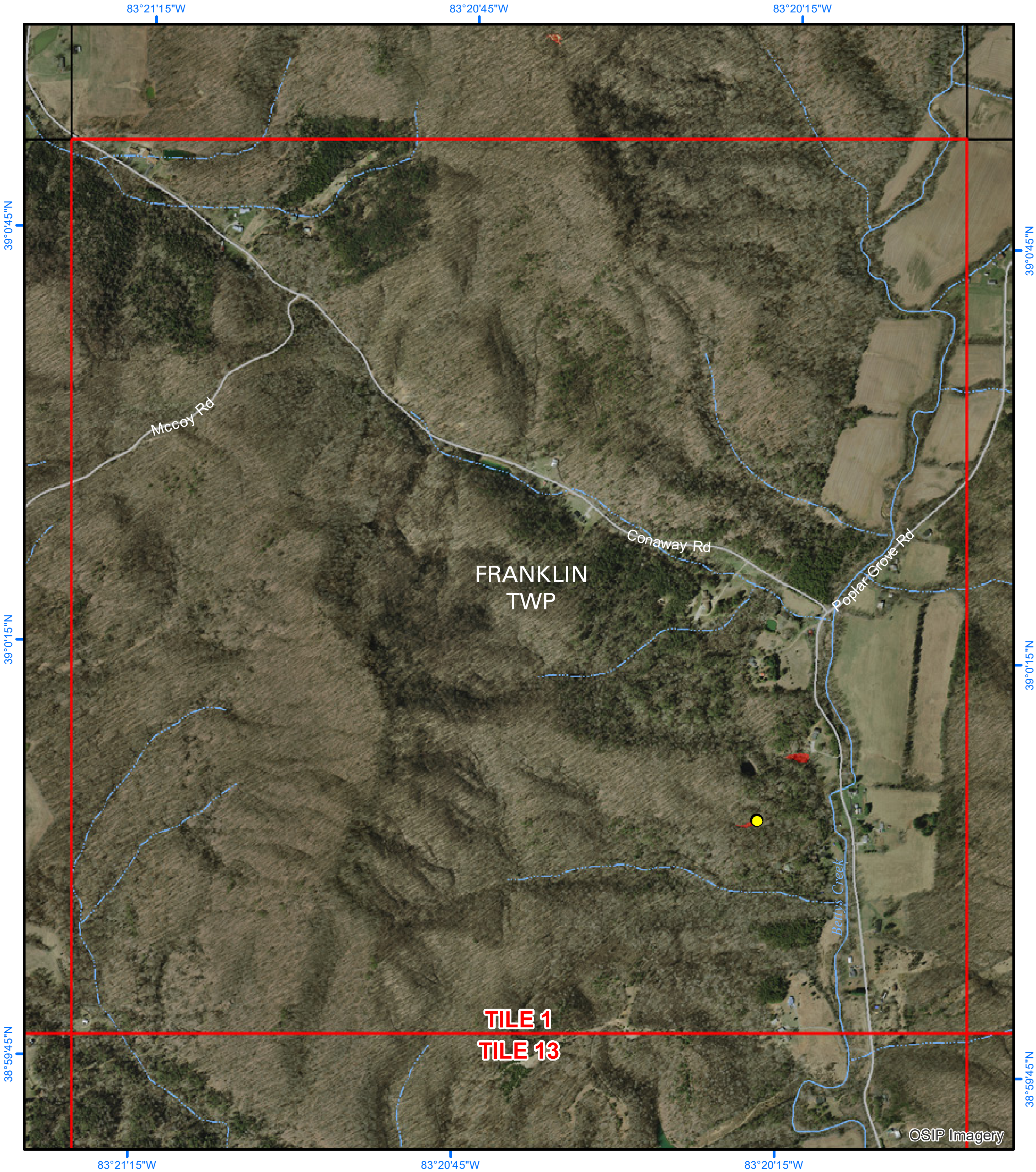

0 0.5 miles

0 0.5 kilometers

Scale 1:12,000

N W E S

KARST FEATURES

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, >10

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

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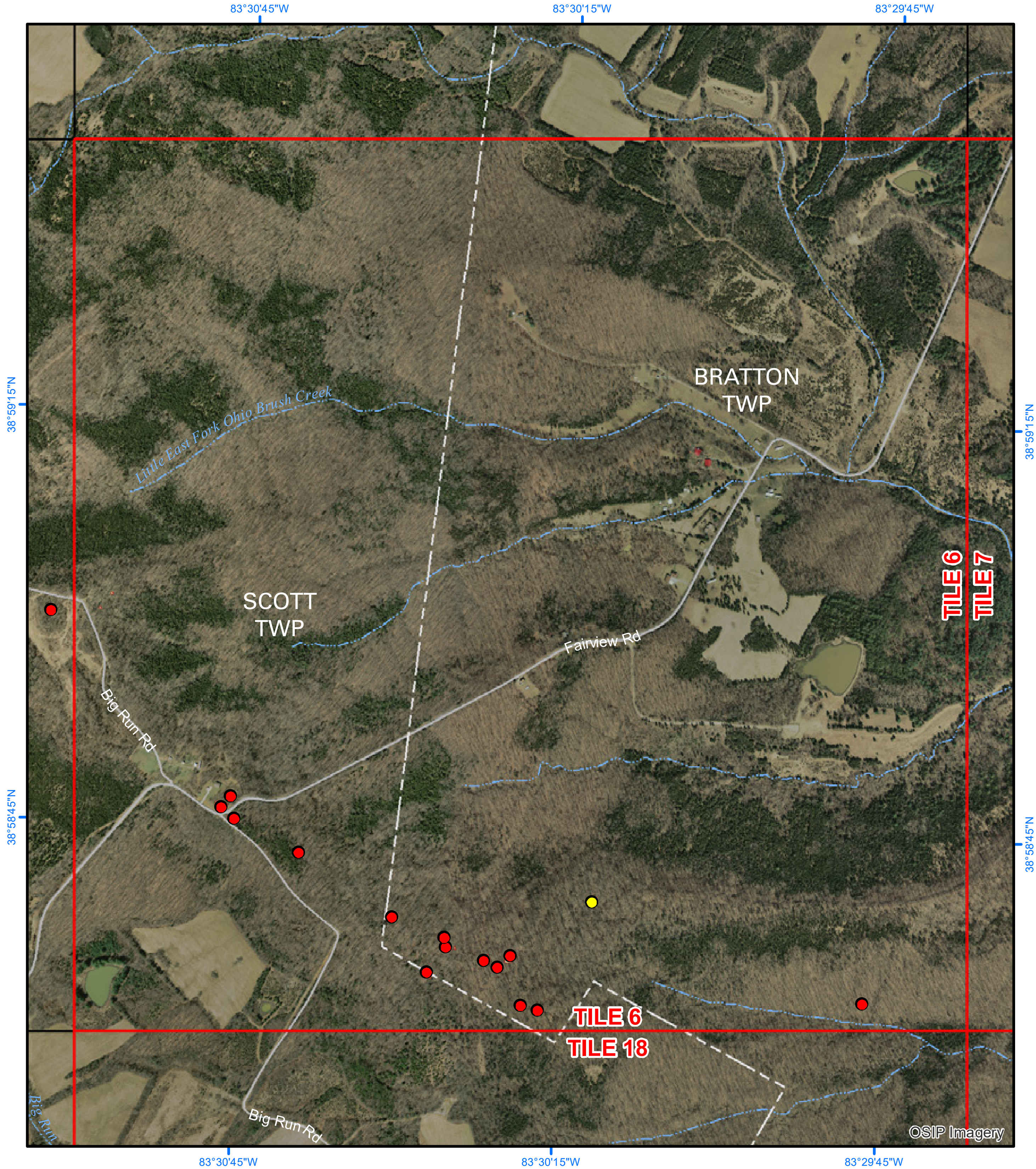

0 0.5 miles

0 0.5 kilometers

Scale 1:12,000

N W E S

KARST FEATURES
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet
1 5 9
2 6 10
3 7 >10
4 8

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

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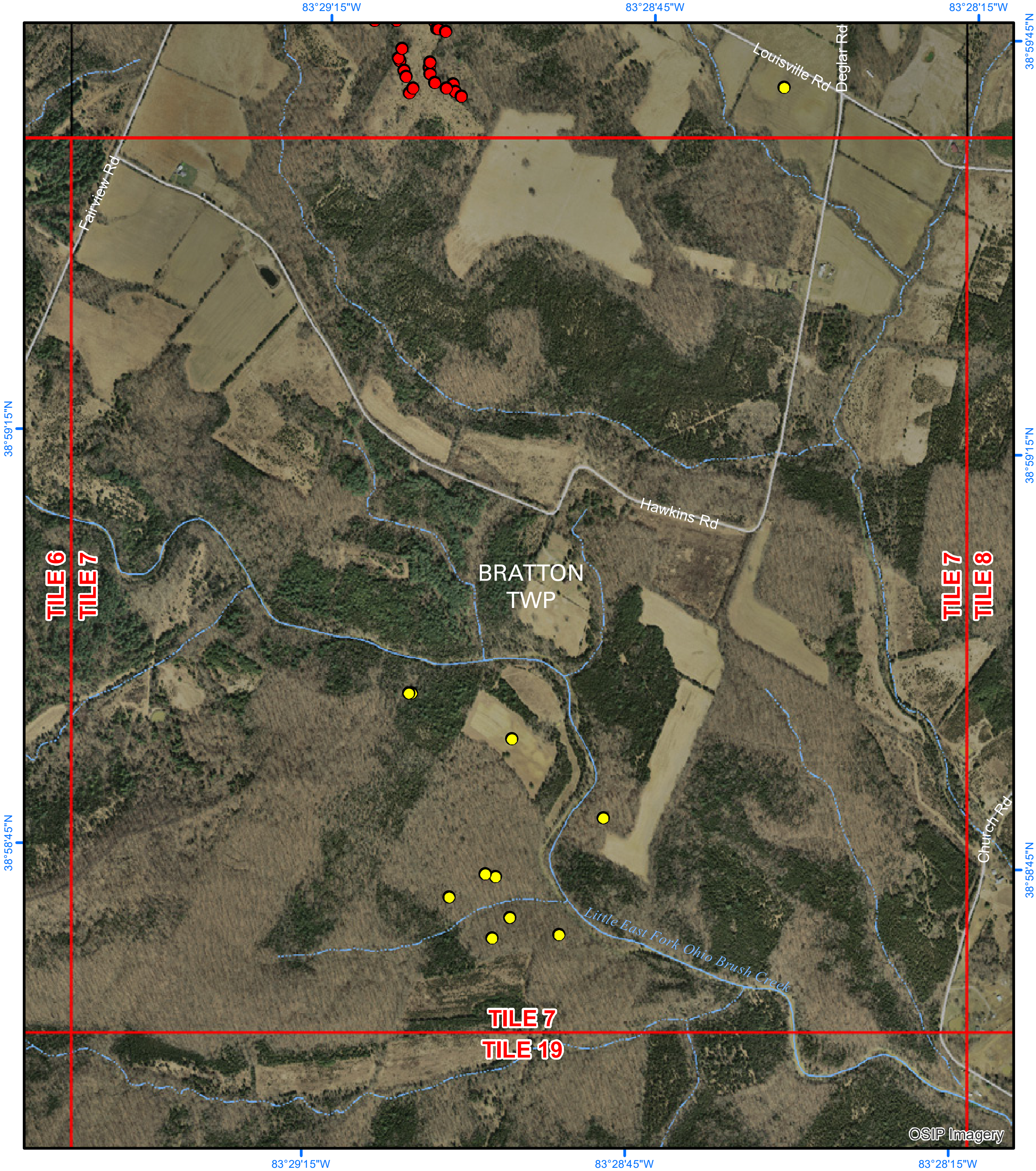

0 0.5 miles

0 0.5 kilometers

Scale 1:12,000

N W E S

KARST FEATURES

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION

Depth in feet

1 5 9

2 6 10

3 7 >10

4 8

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

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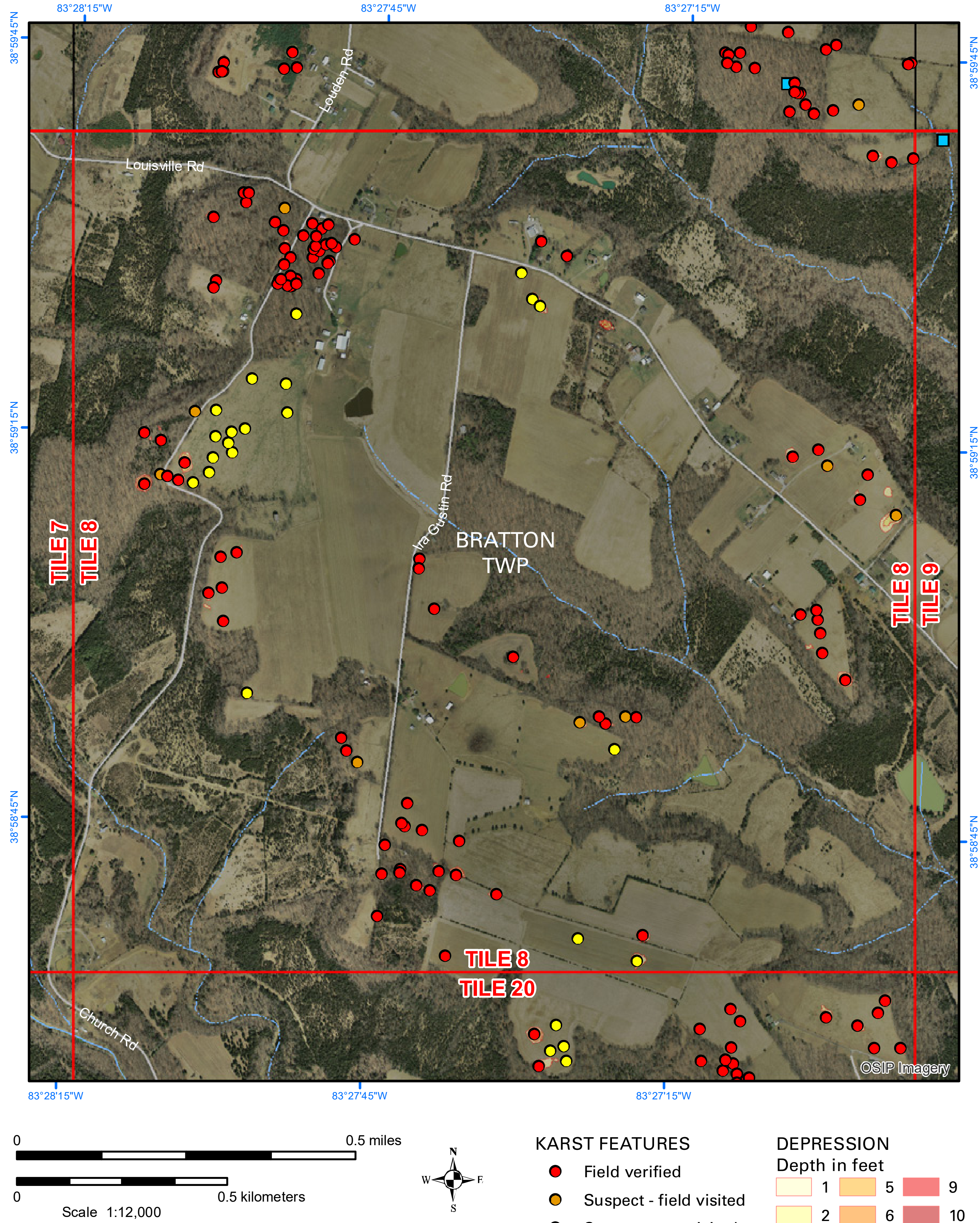

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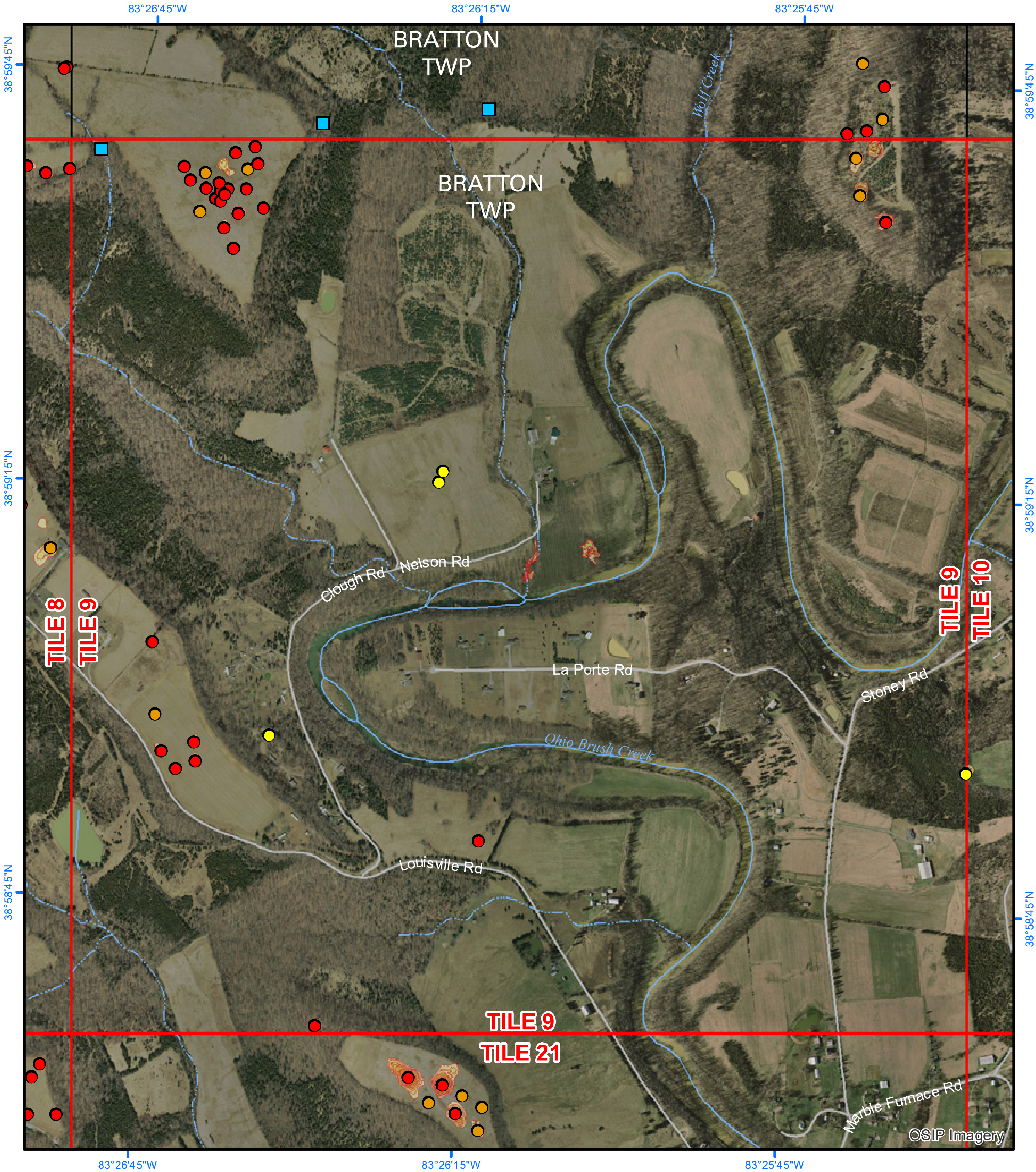

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0 — 0.5 kilometers

Scale 1:12,000

N S W E

KARST FEATURES

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION

Depth in feet

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, >10

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

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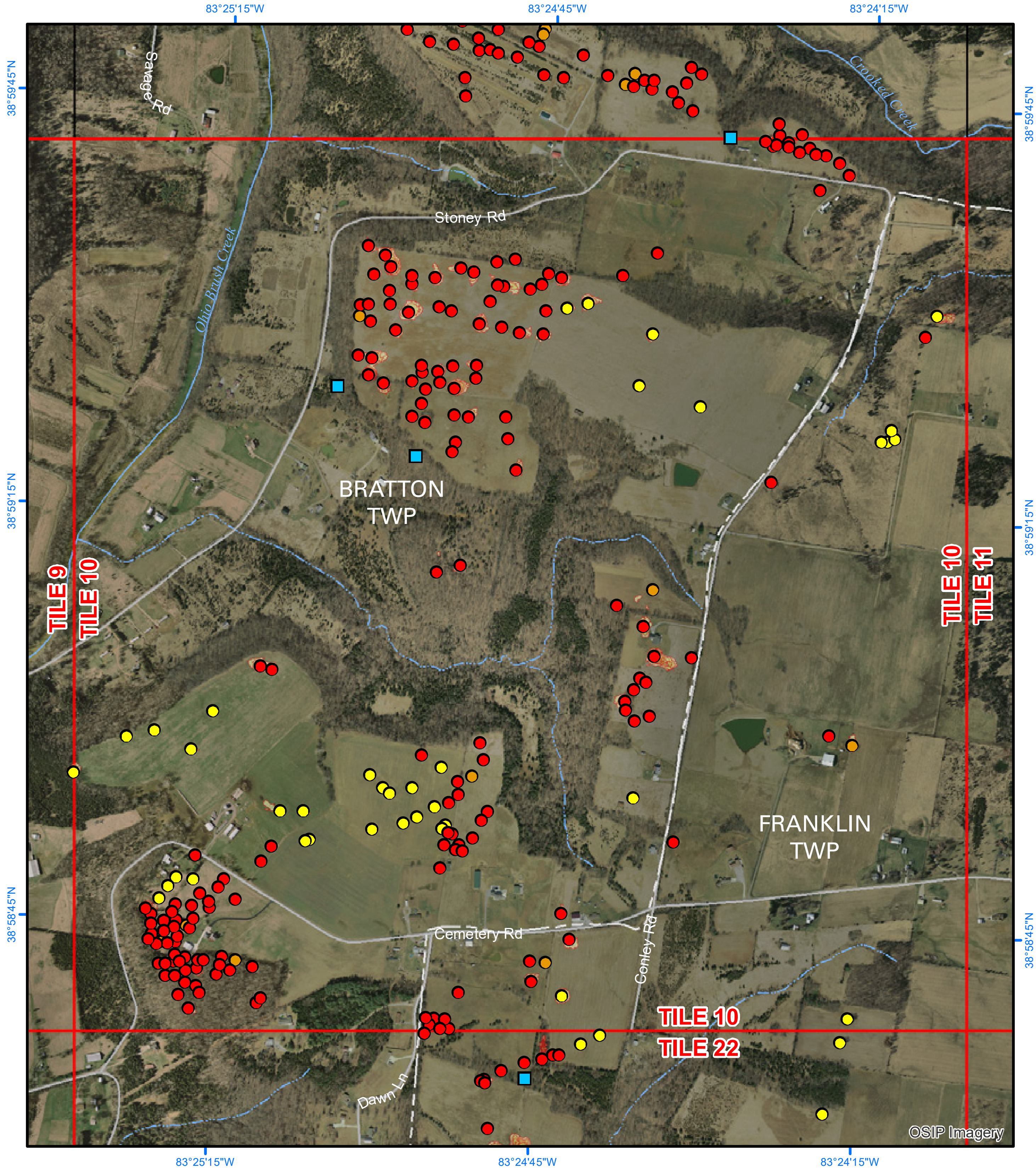

0 0.5 miles

0 0.5 kilometers

Scale 1:12,000

N W E S

KARST FEATURES

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1 2 3 4 5 6 7 8 9 10 >10

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 11

0 0.5 miles

0 0.5 kilometers

Scale 1:12,000

N W E S

KARST FEATURES

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, >10

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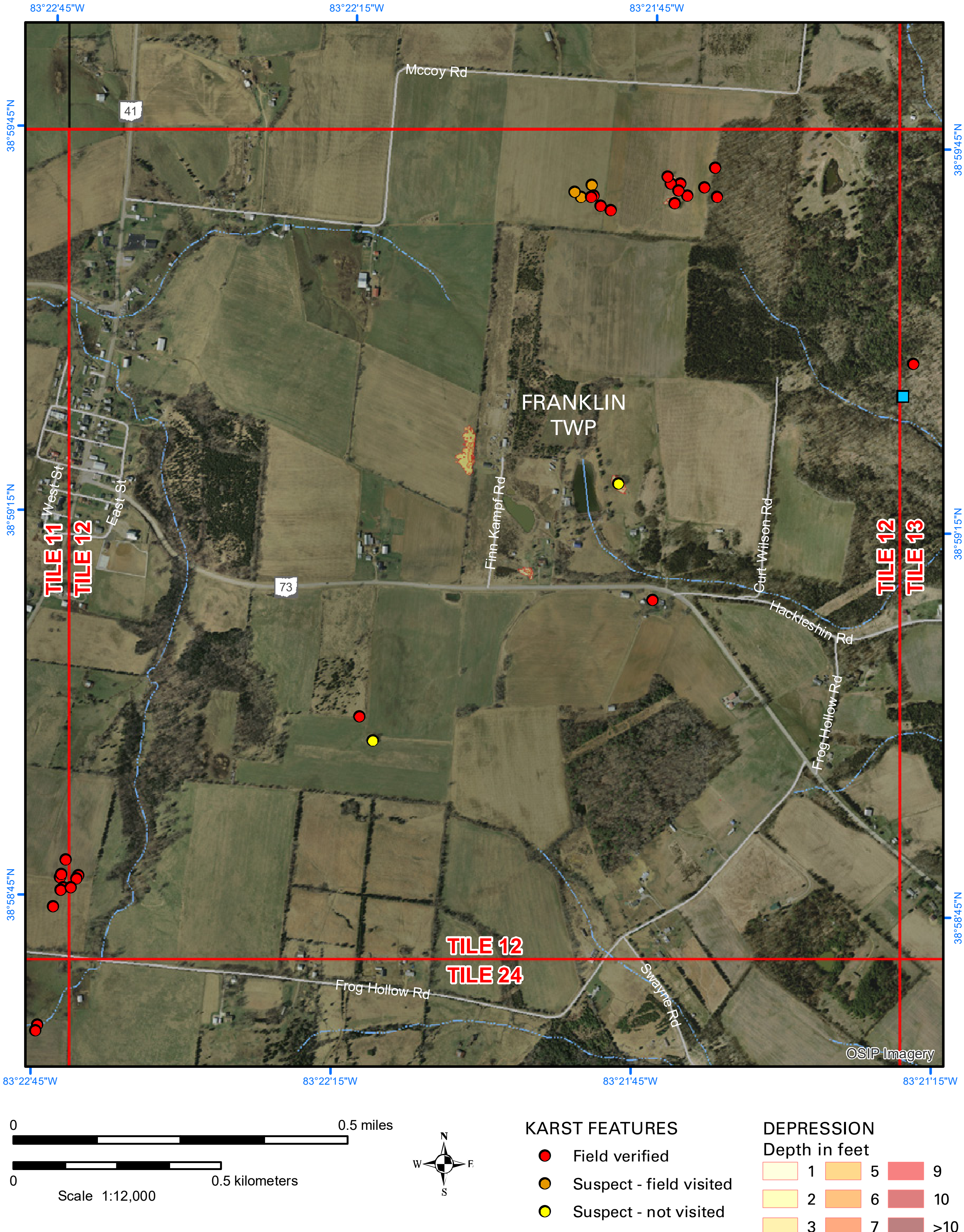

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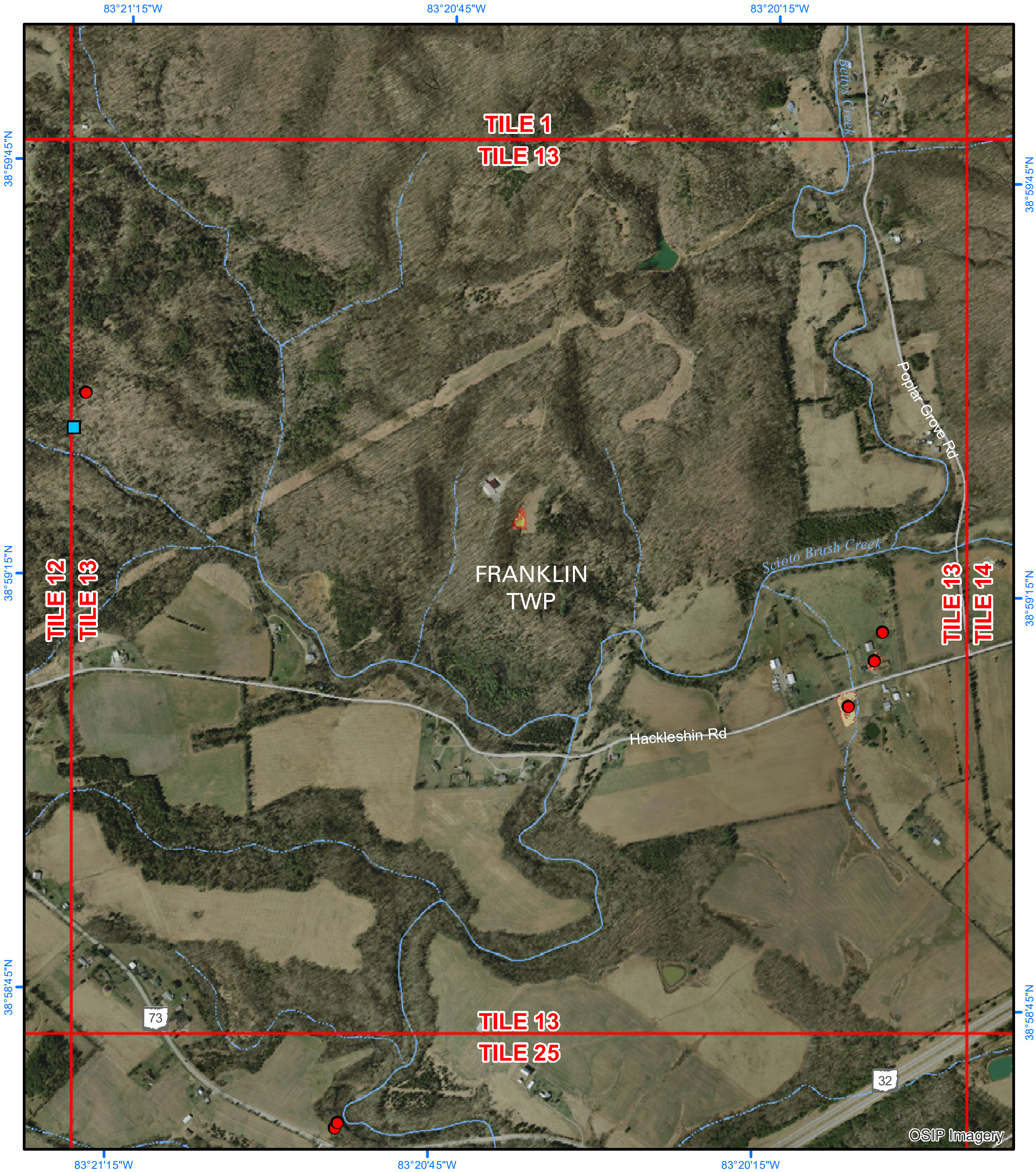

0 0.5 miles

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N W E S

KARST FEATURES

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, >10

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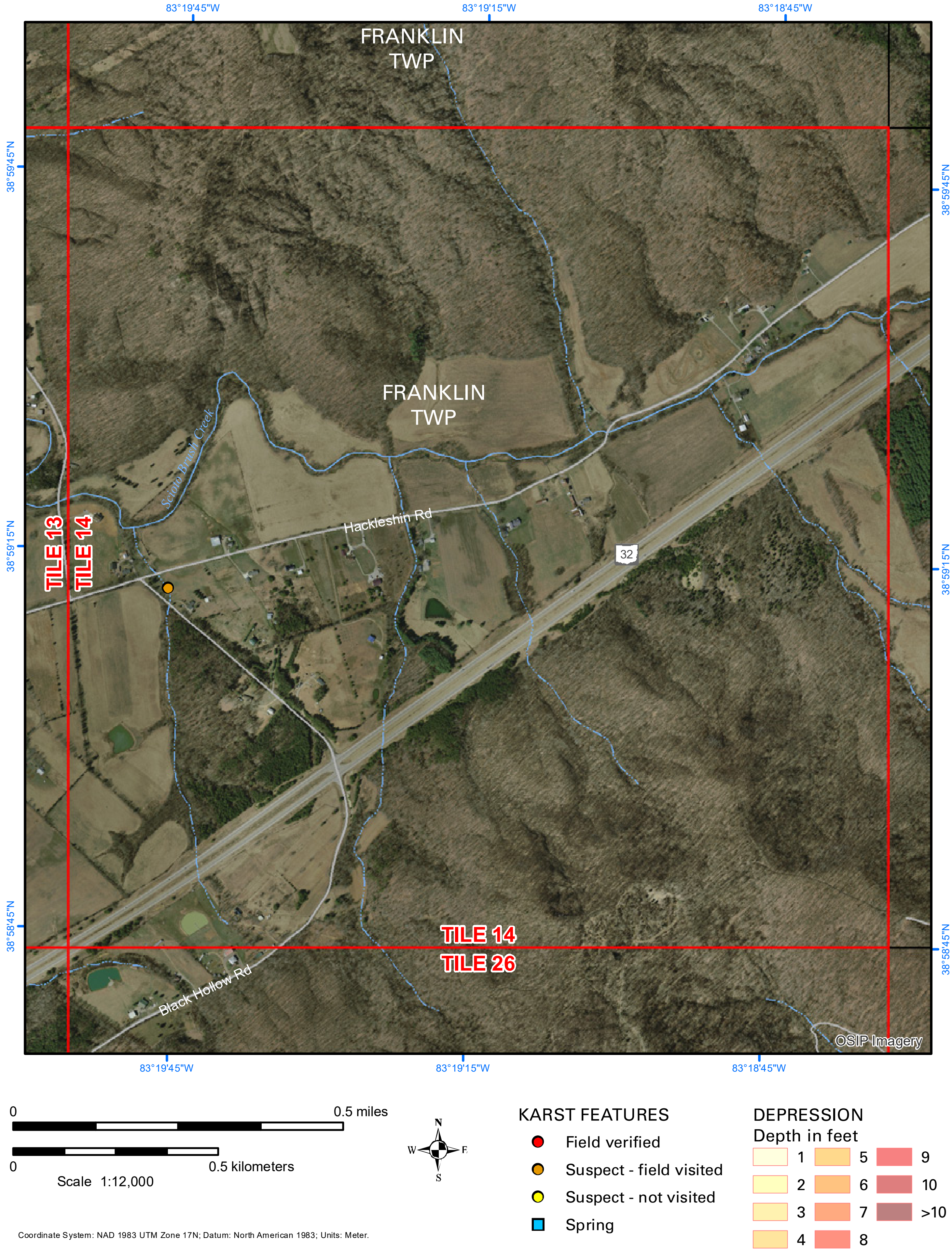

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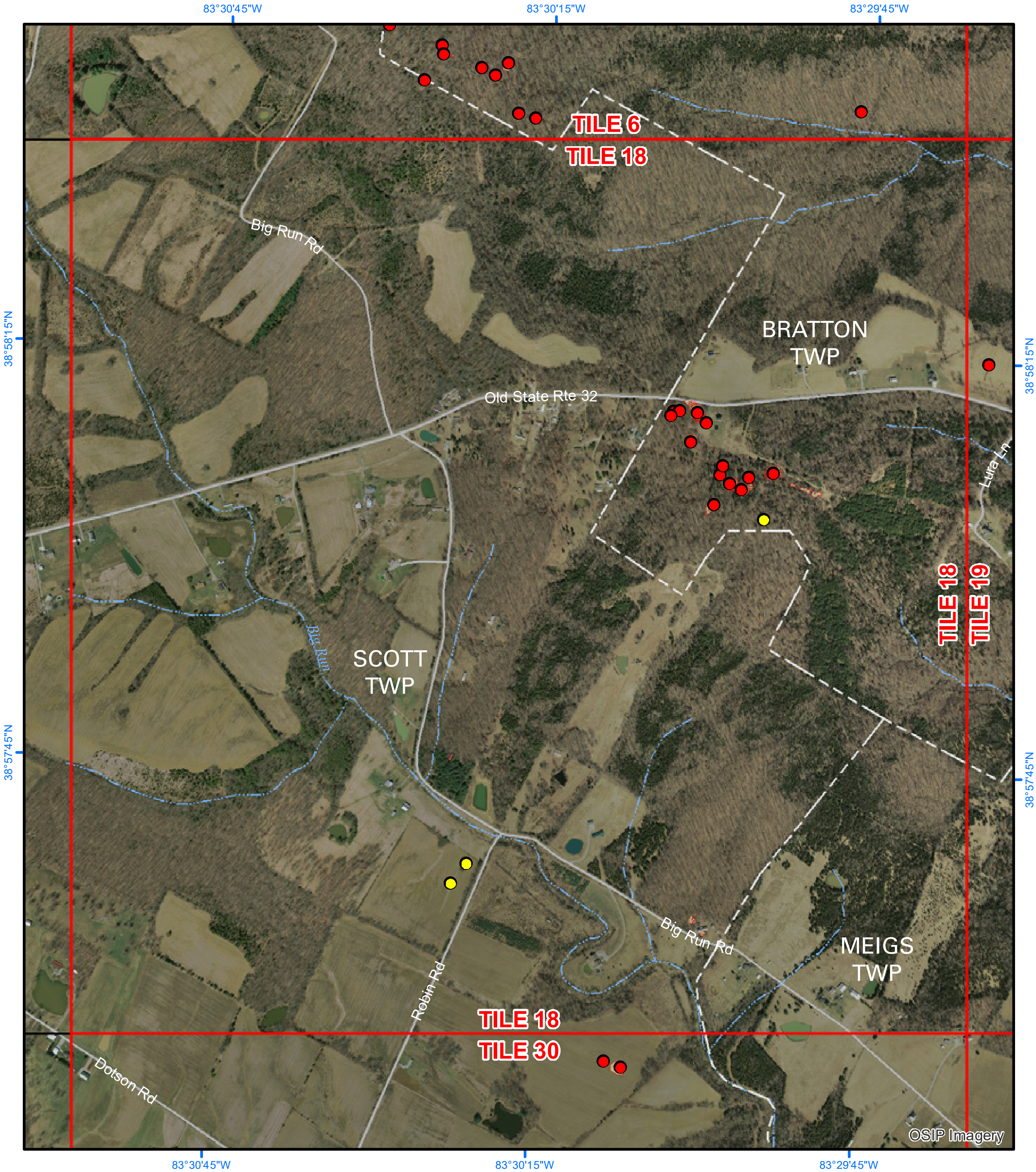

0 0.5 miles

0 0.5 kilometers

Scale 1:12,000

N W E S

KARST FEATURES

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, >10

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

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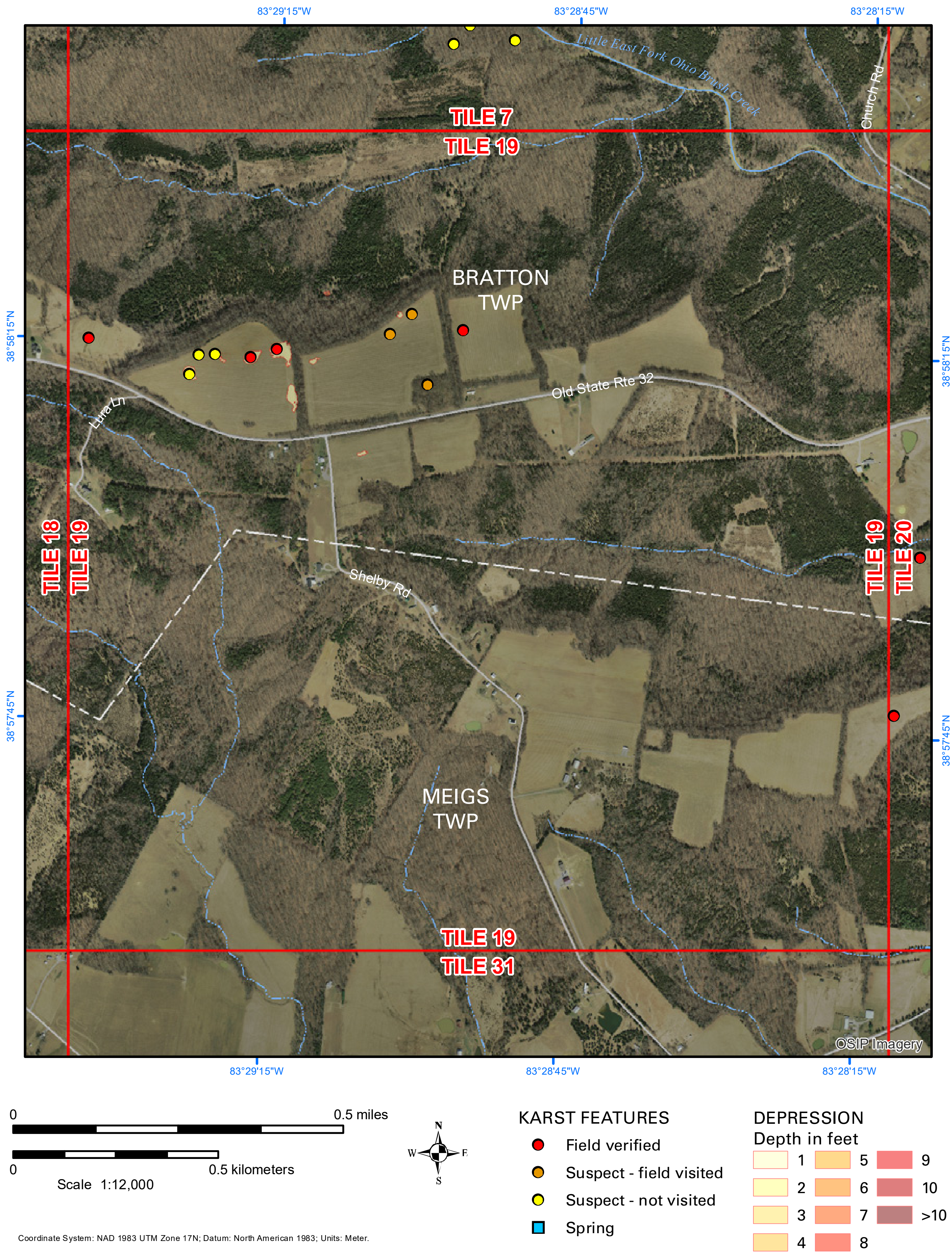

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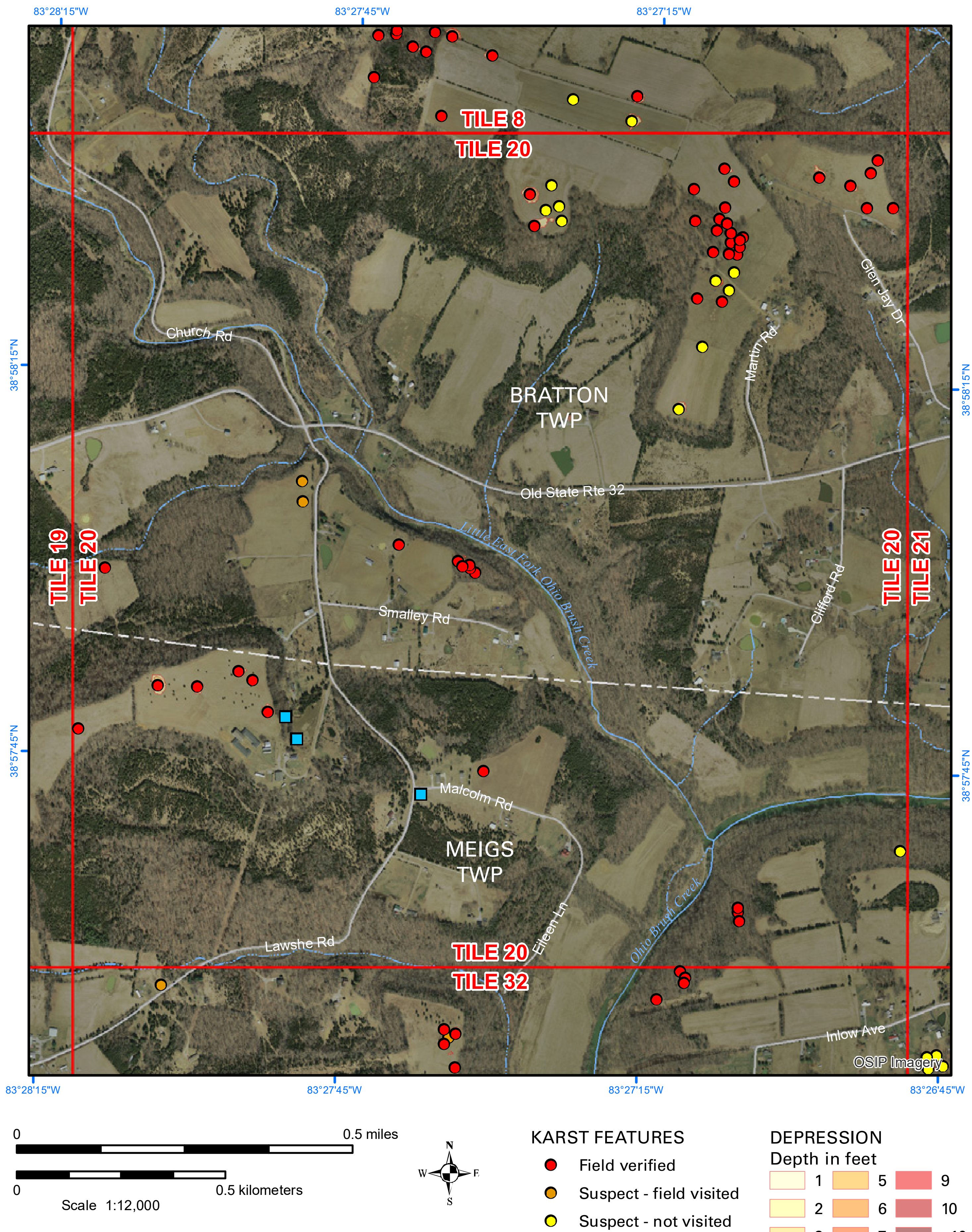

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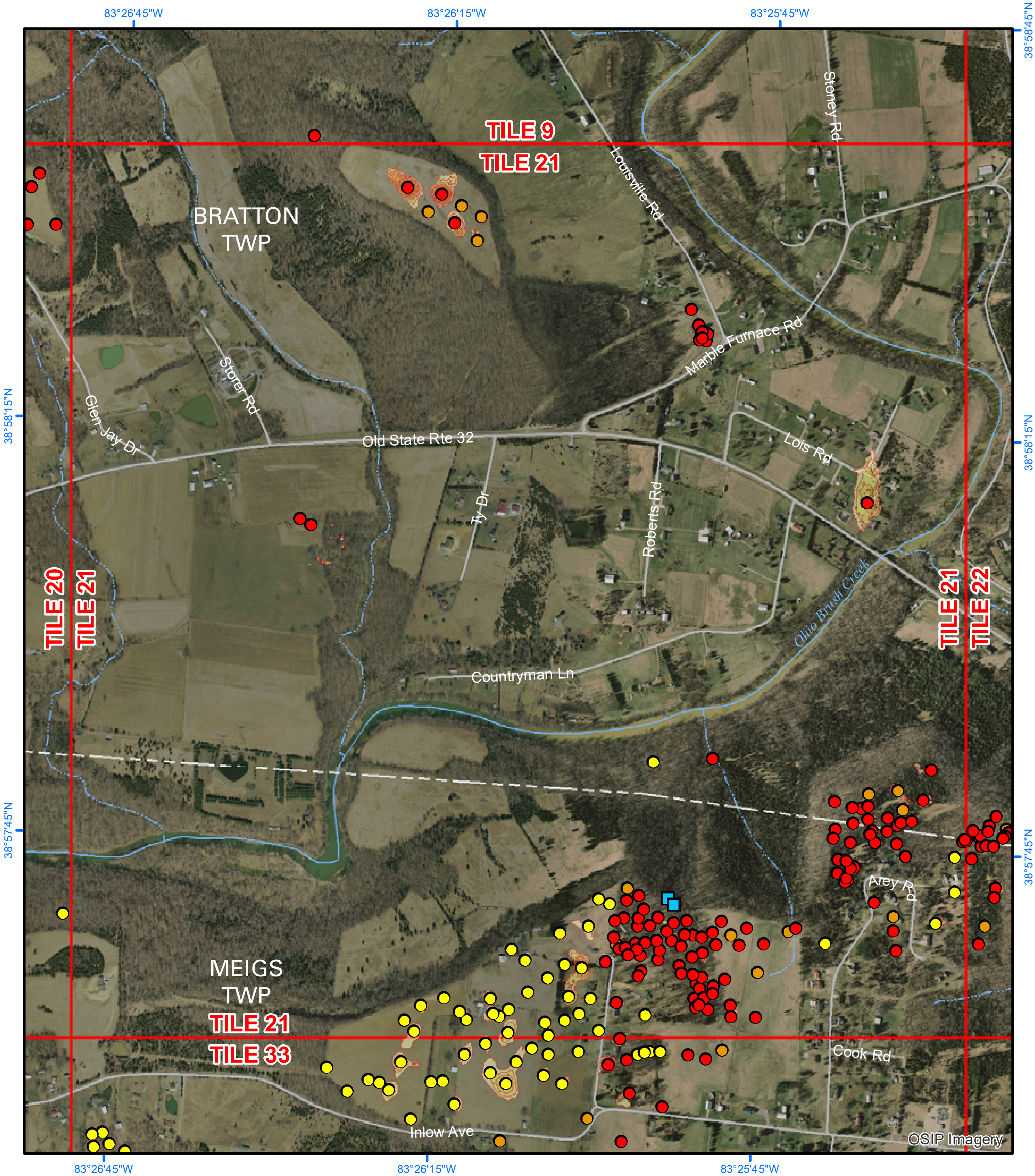


0 0.5 miles

0 0.5 kilometers

Scale 1:12,000

KARST FEATURES

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

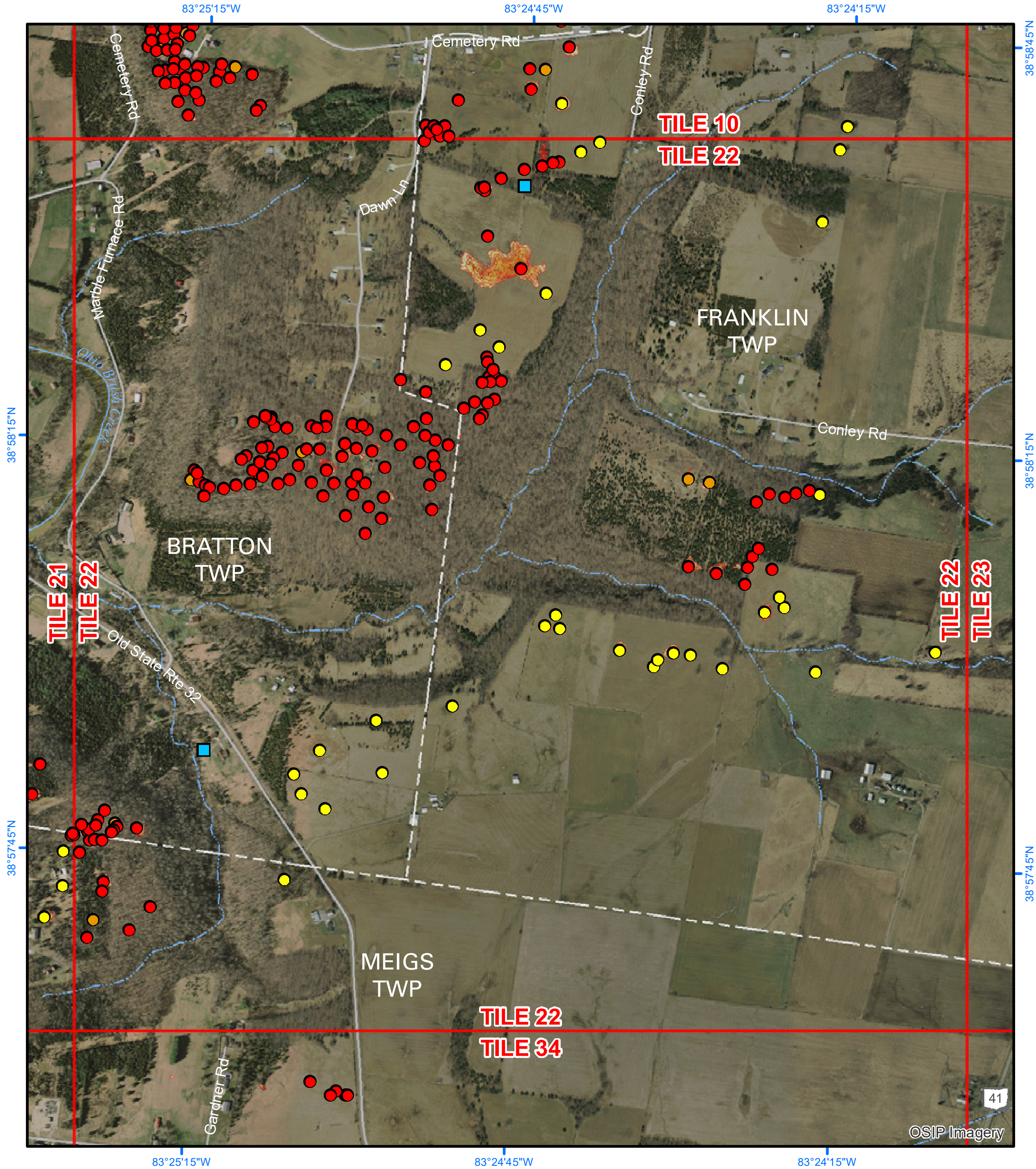
DEPRESSION

Depth in feet

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, >10

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 22



0 — 0.5 miles

0 — 0.5 kilometers

Scale 1:12,000

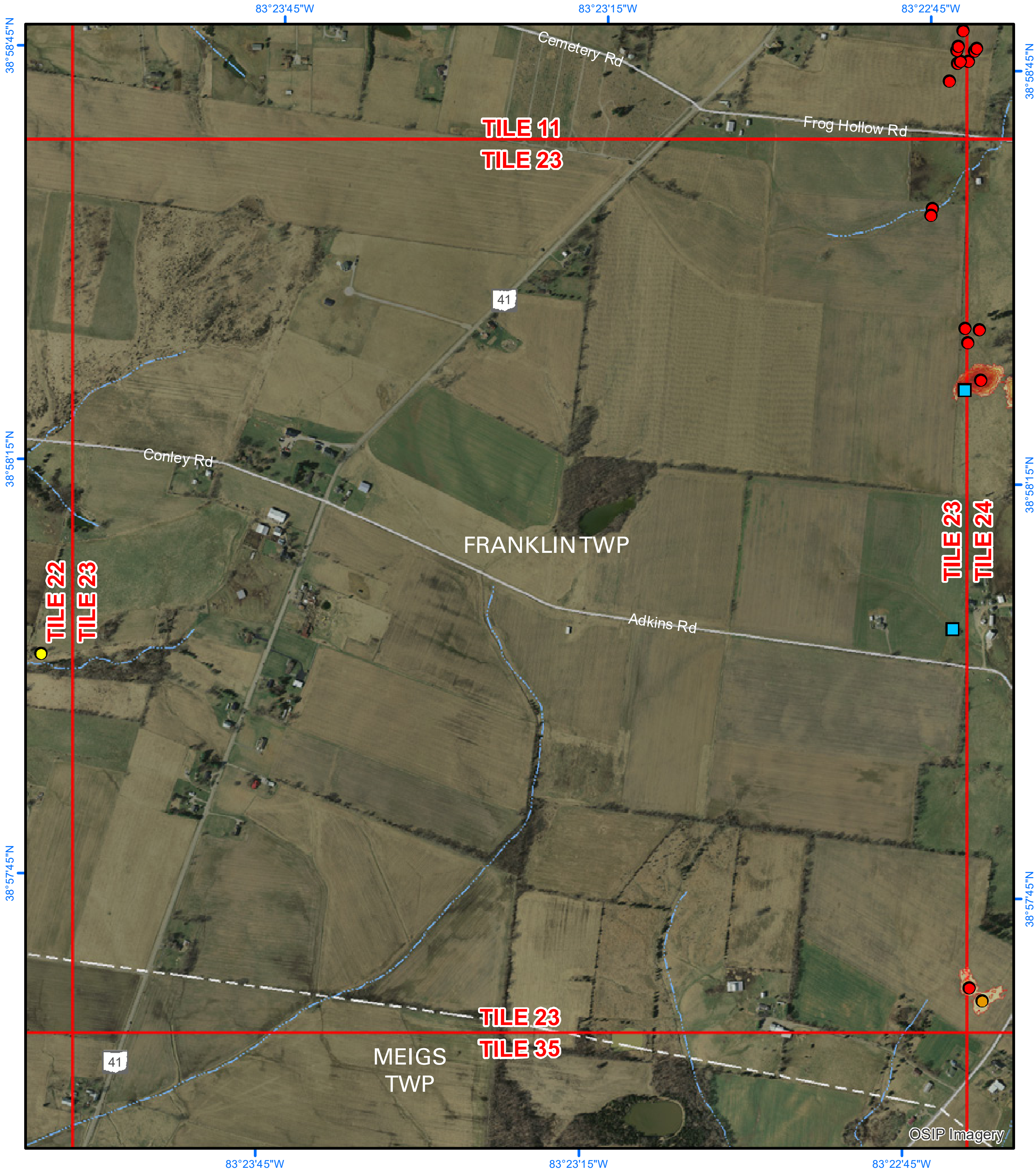
N S E W

KARST FEATURES
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, >10

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 23



0 0.5 miles

0 0.5 kilometers

Scale 1:12,000

KARST FEATURES

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

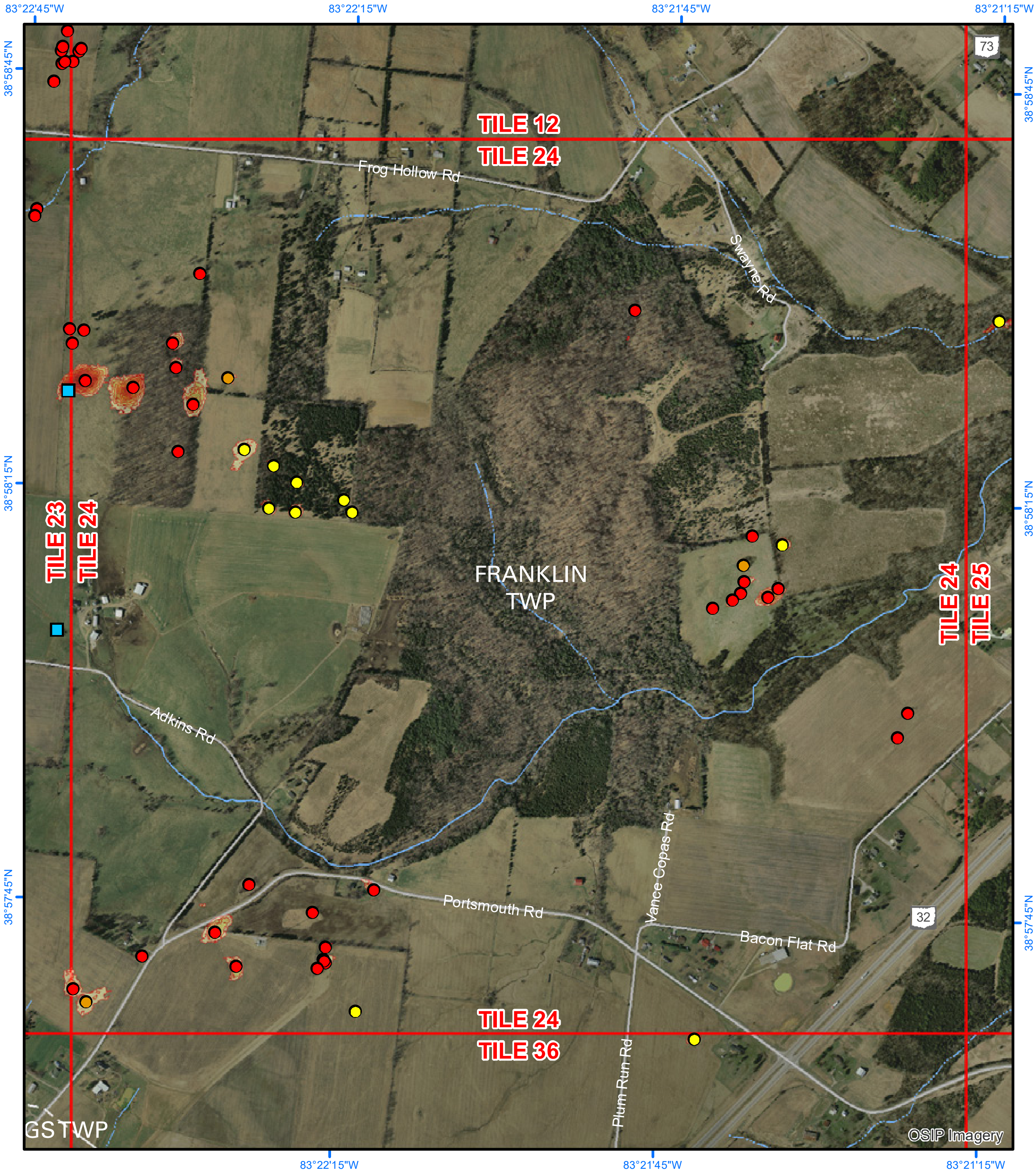
DEPRESSION

Depth in feet

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, >10

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 24



0 0.5 miles

0 0.5 kilometers

Scale 1:12,000

KARST FEATURES

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

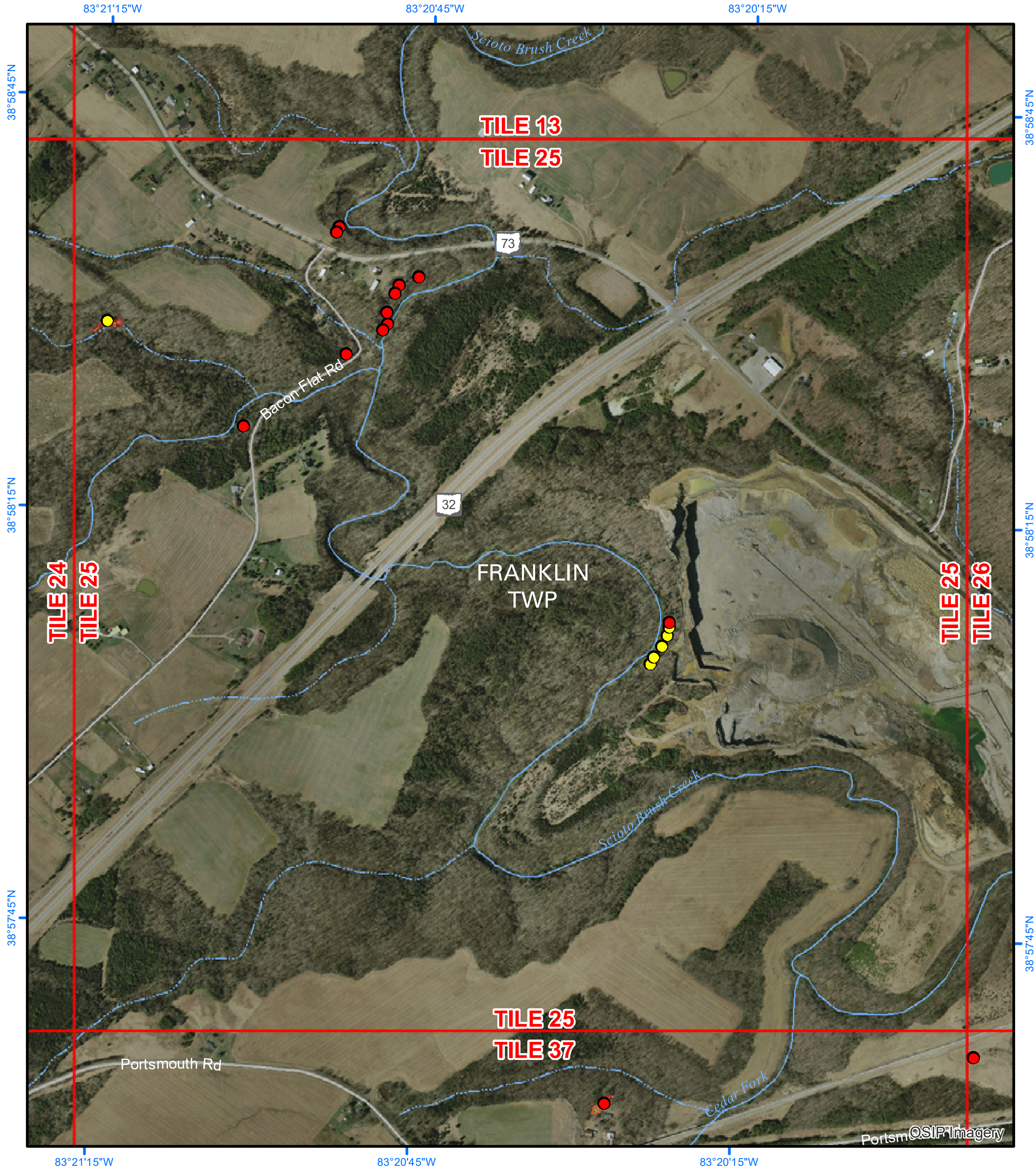
DEPRESSION

Depth in feet

1	5	9
2	6	10
3	7	>10
4	8	

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 25



0 0.5 miles

0 0.5 kilometers

Scale 1:12,000

N W E S

KARST FEATURES

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION

Depth in feet

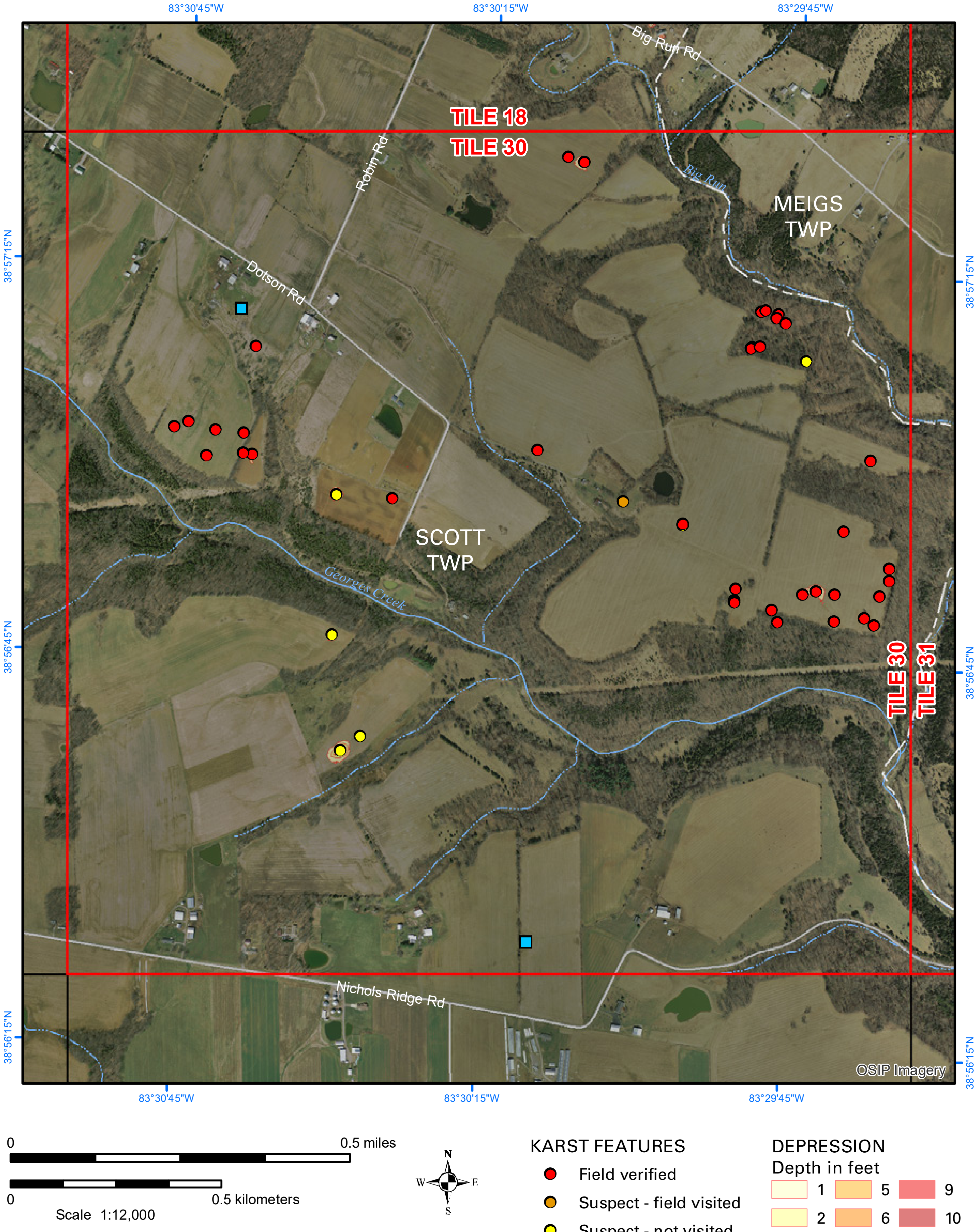
1	5	9
2	6	10
3	7	>10
4	8	

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 26

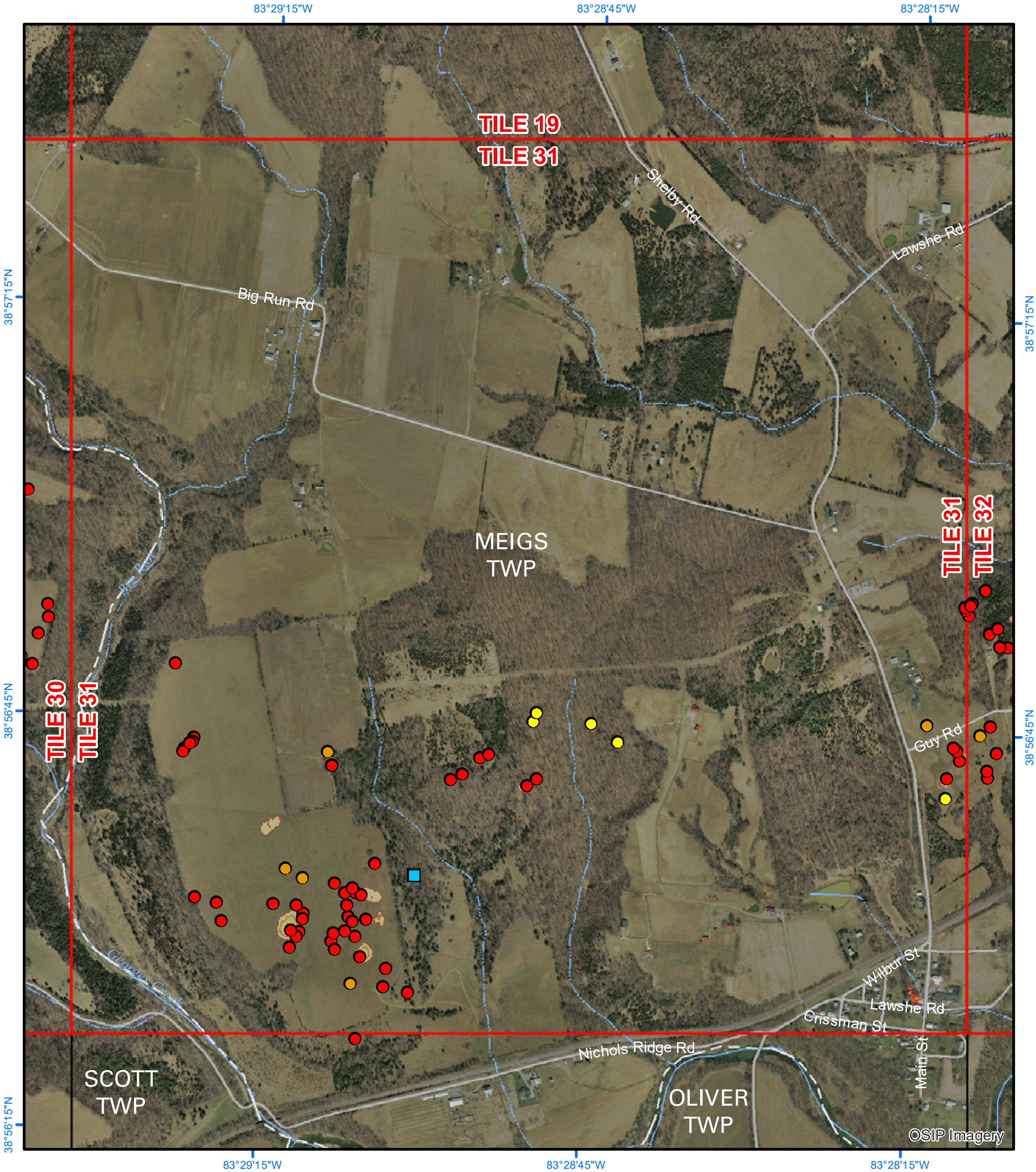
Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

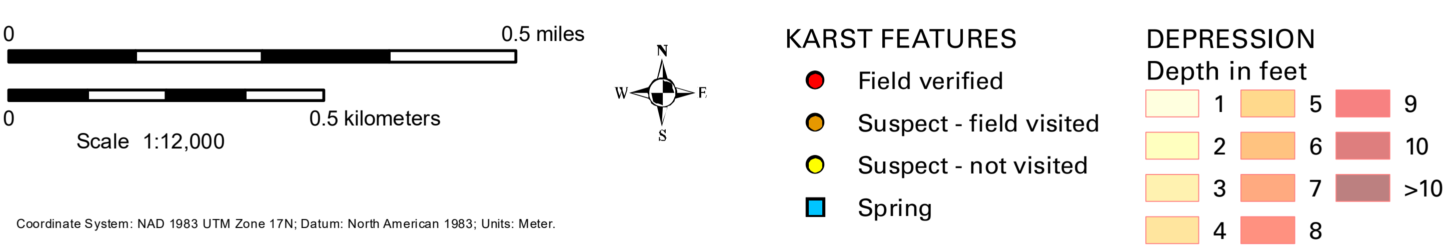
Tile Number: 30



Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

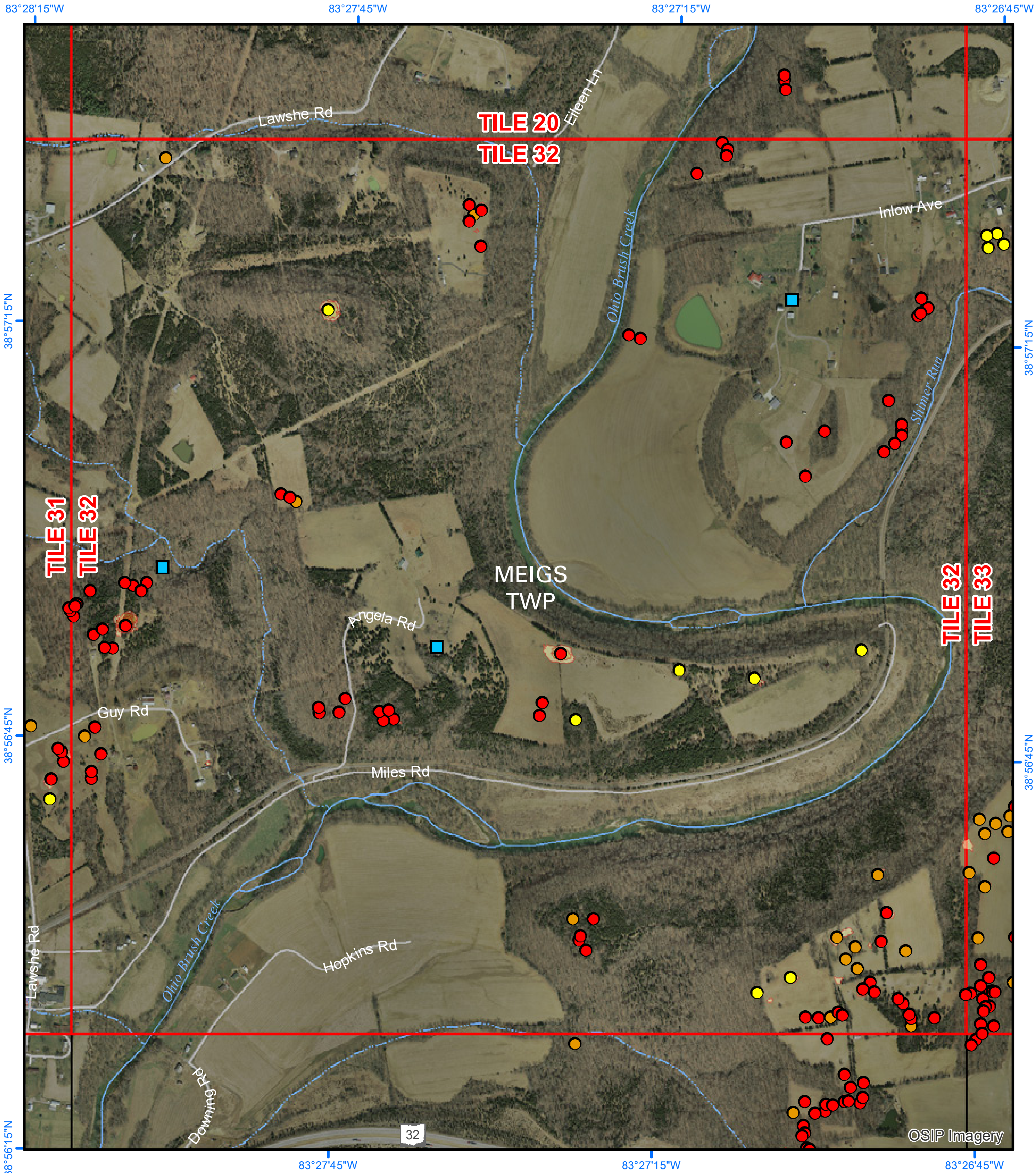
Tile Number: 31





Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 32



0 0.5 miles

0 0.5 kilometers

Scale 1:12,000

N W E S

KARST FEATURES

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

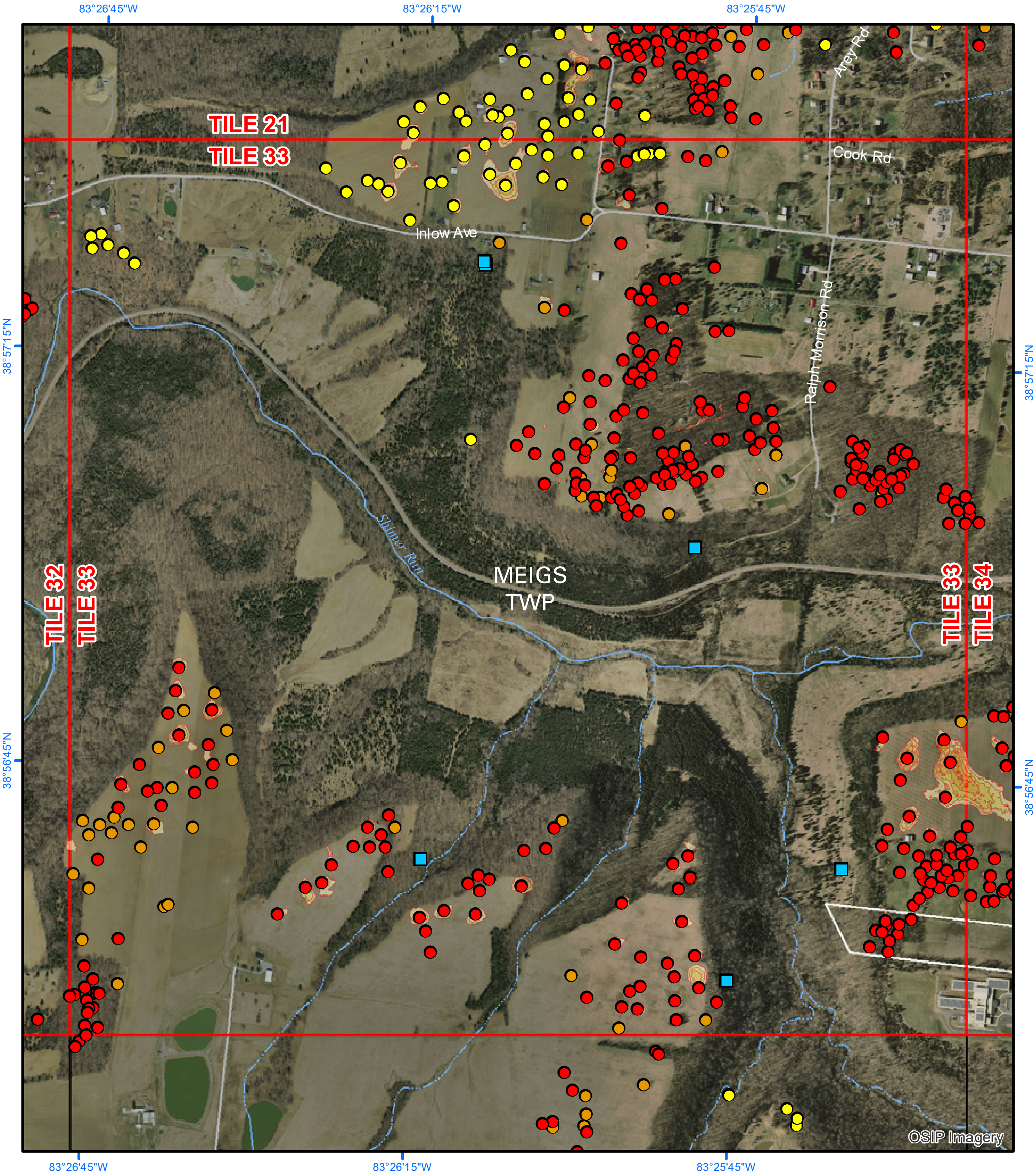
DEPRESSION

Depth in feet

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, >10

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 33



0 0.5 miles

0 0.5 kilometers

Scale 1:12,000

KARST FEATURES

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

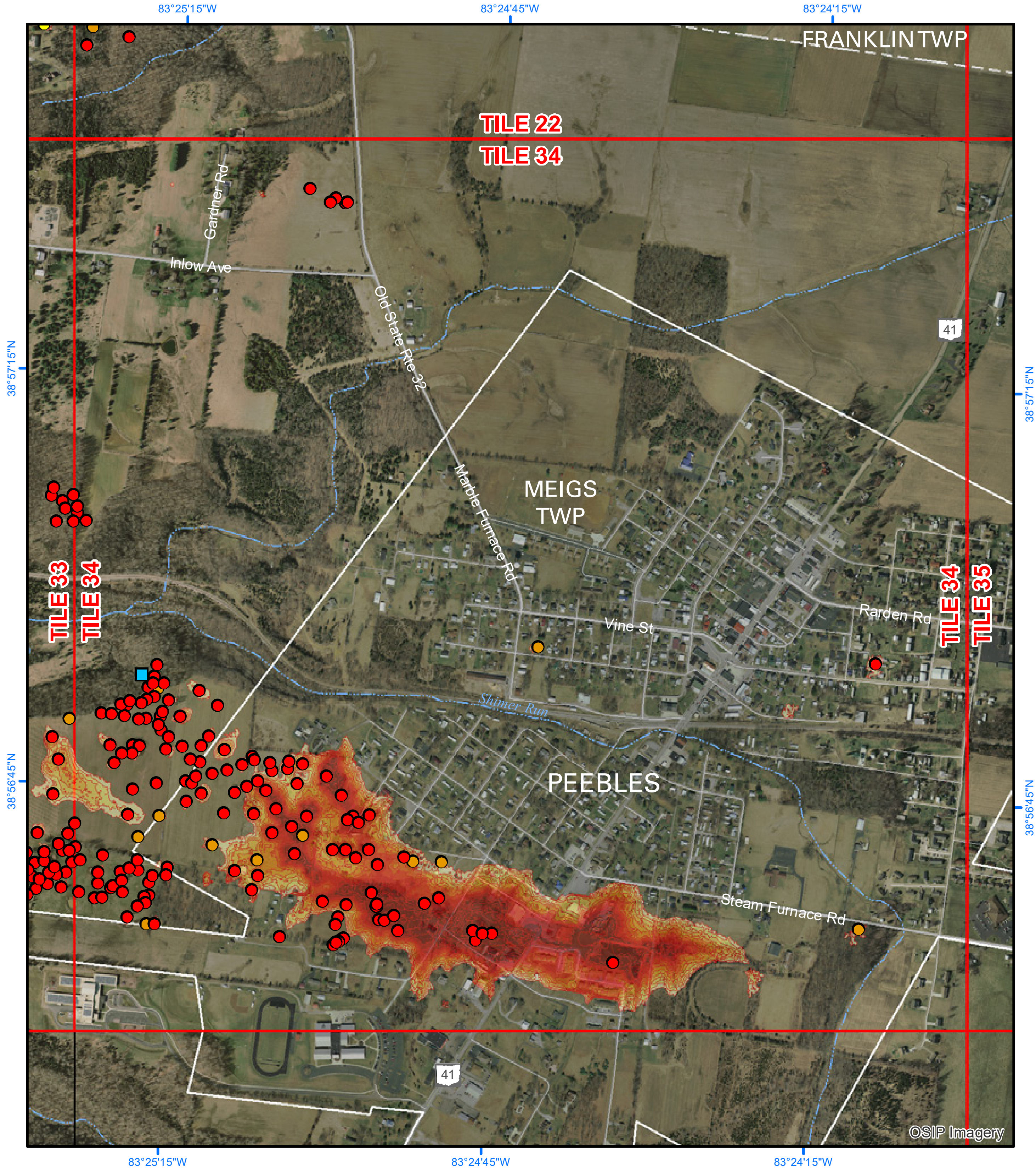
DEPRESSION

Depth in feet

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, >10

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 34



0 0.5 miles

0 0.5 kilometers

Scale 1:12,000

N W E S

KARST FEATURES

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

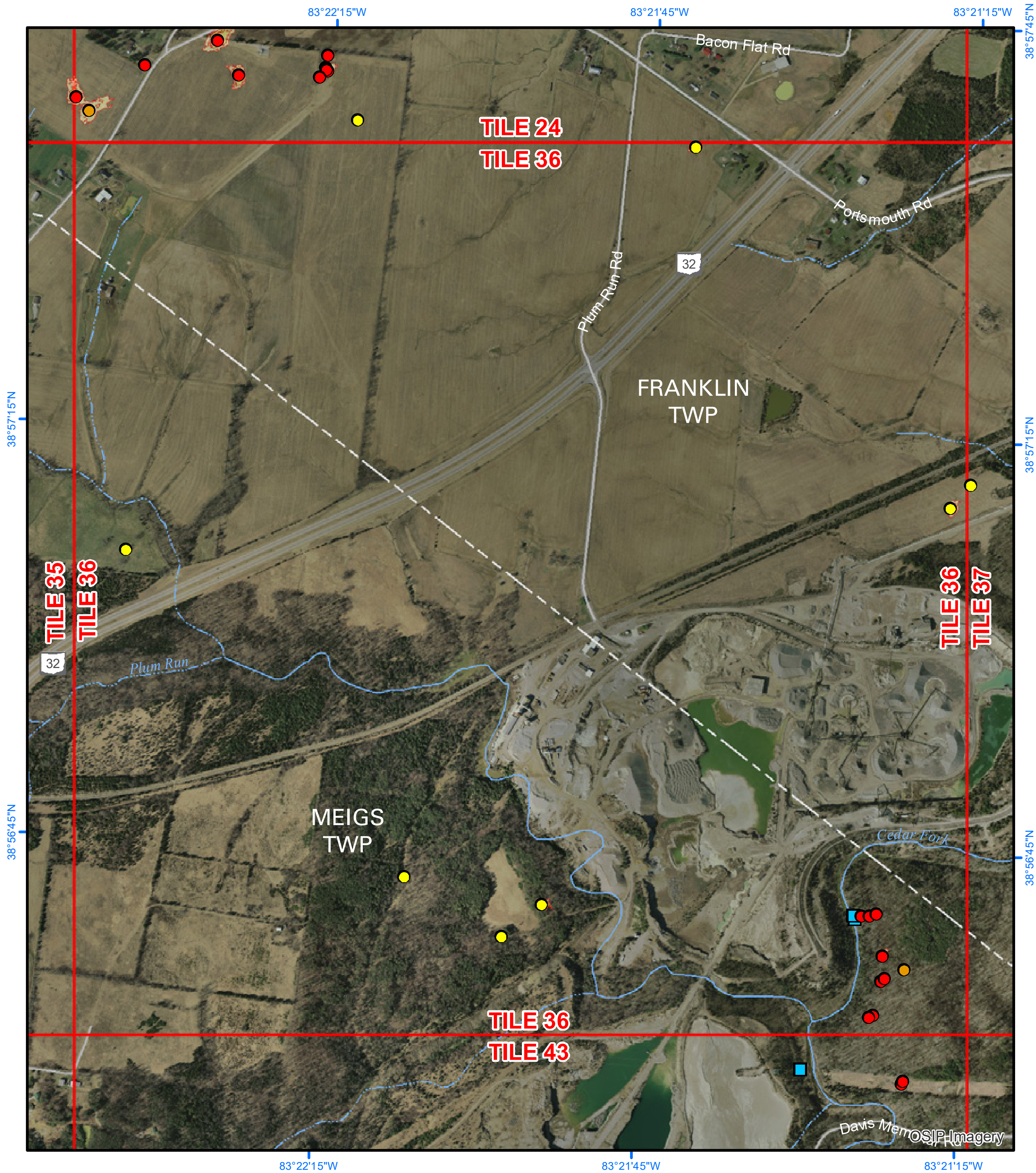
DEPRESSION

Depth in feet

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, >10

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 36



0 0.5 miles

0 0.5 kilometers

Scale 1:12,000

N W E S

KARST FEATURES

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

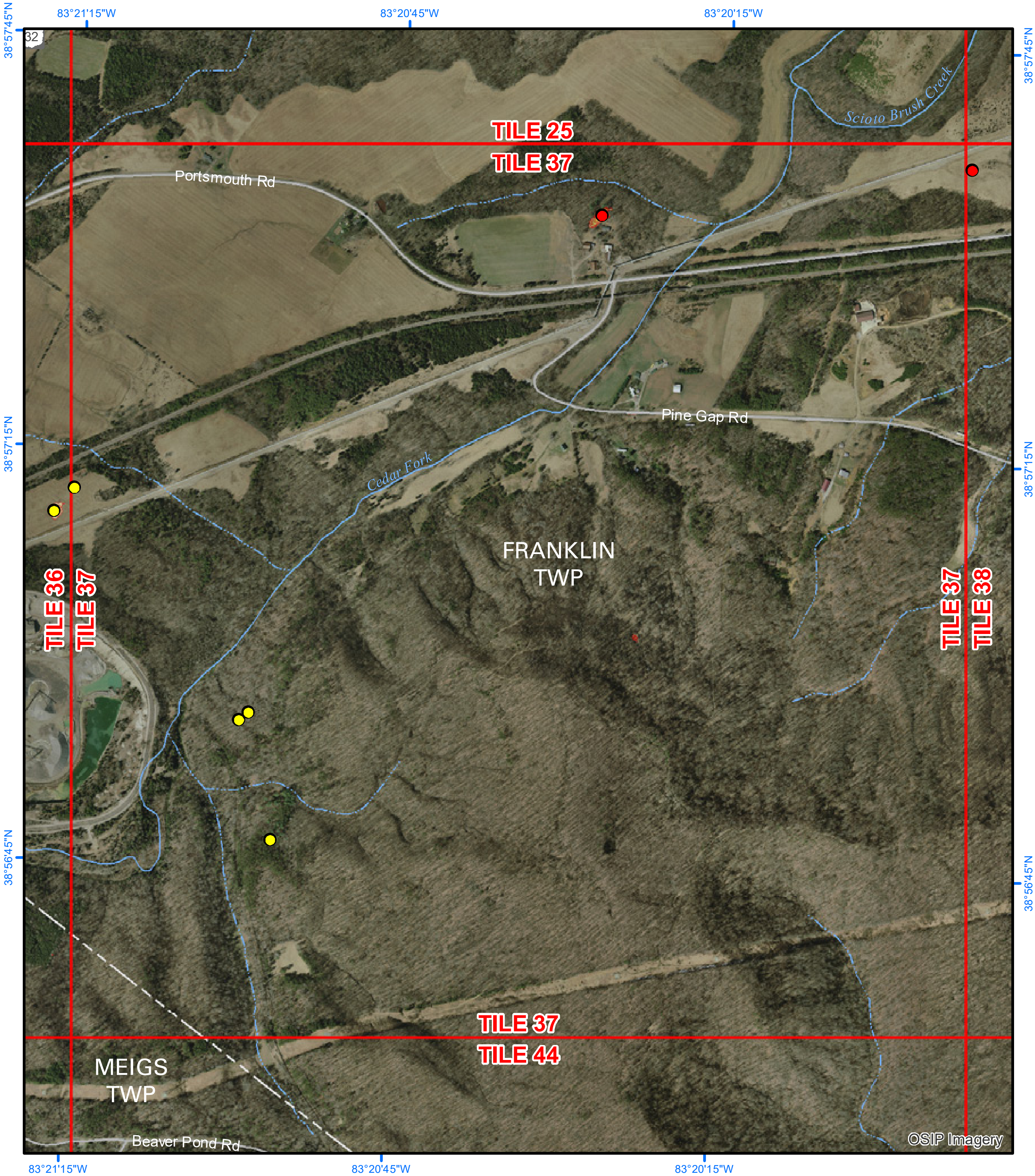
DEPRESSION

Depth in feet

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, >10

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 37



0 0.5 miles

0 0.5 kilometers

Scale 1:12,000

N W E S

KARST FEATURES

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION

Depth in feet

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, >10

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 38

0 0.5 miles

0 0.5 kilometers

Scale 1:12,000

N W E S

KARST FEATURES

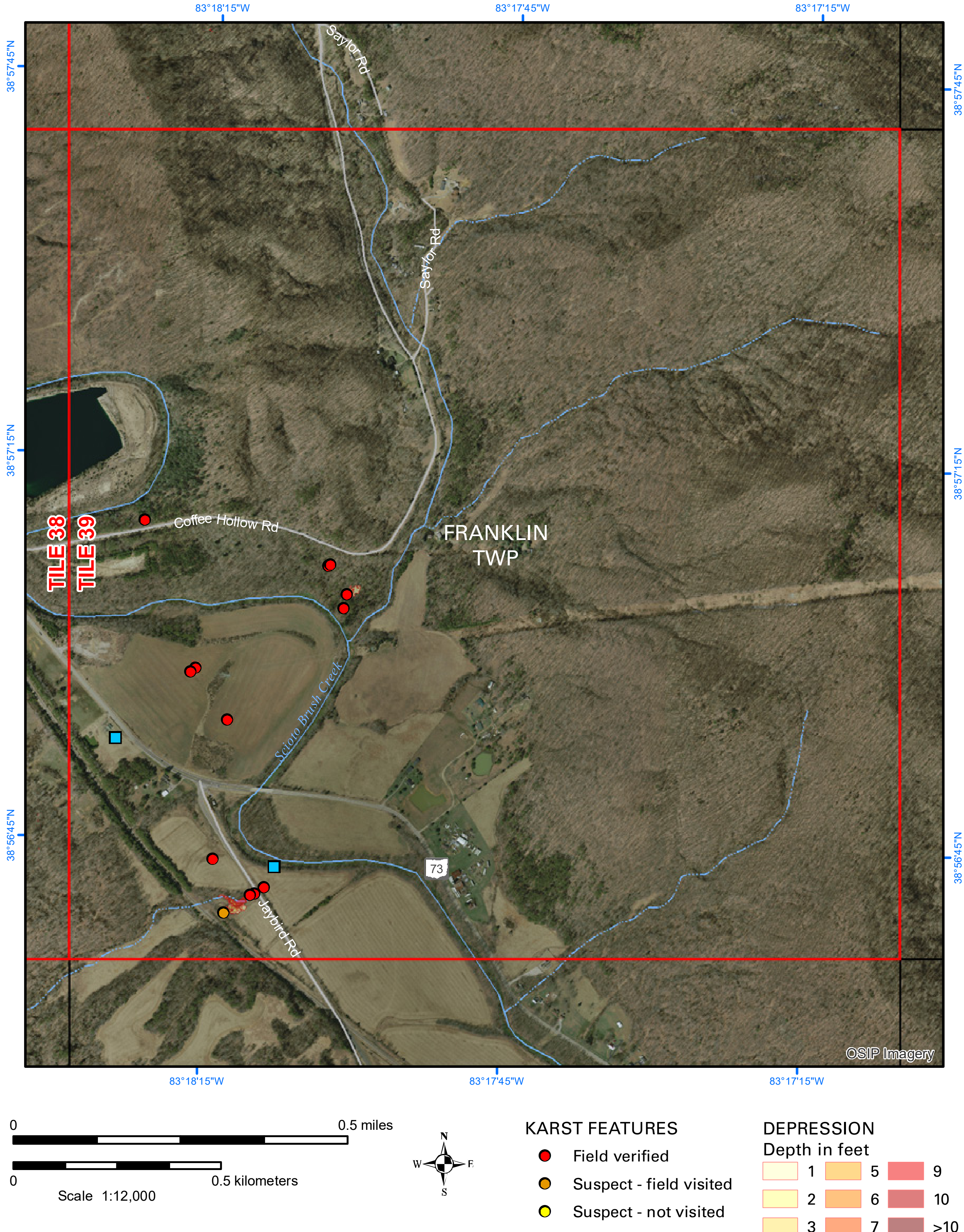
- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, >10

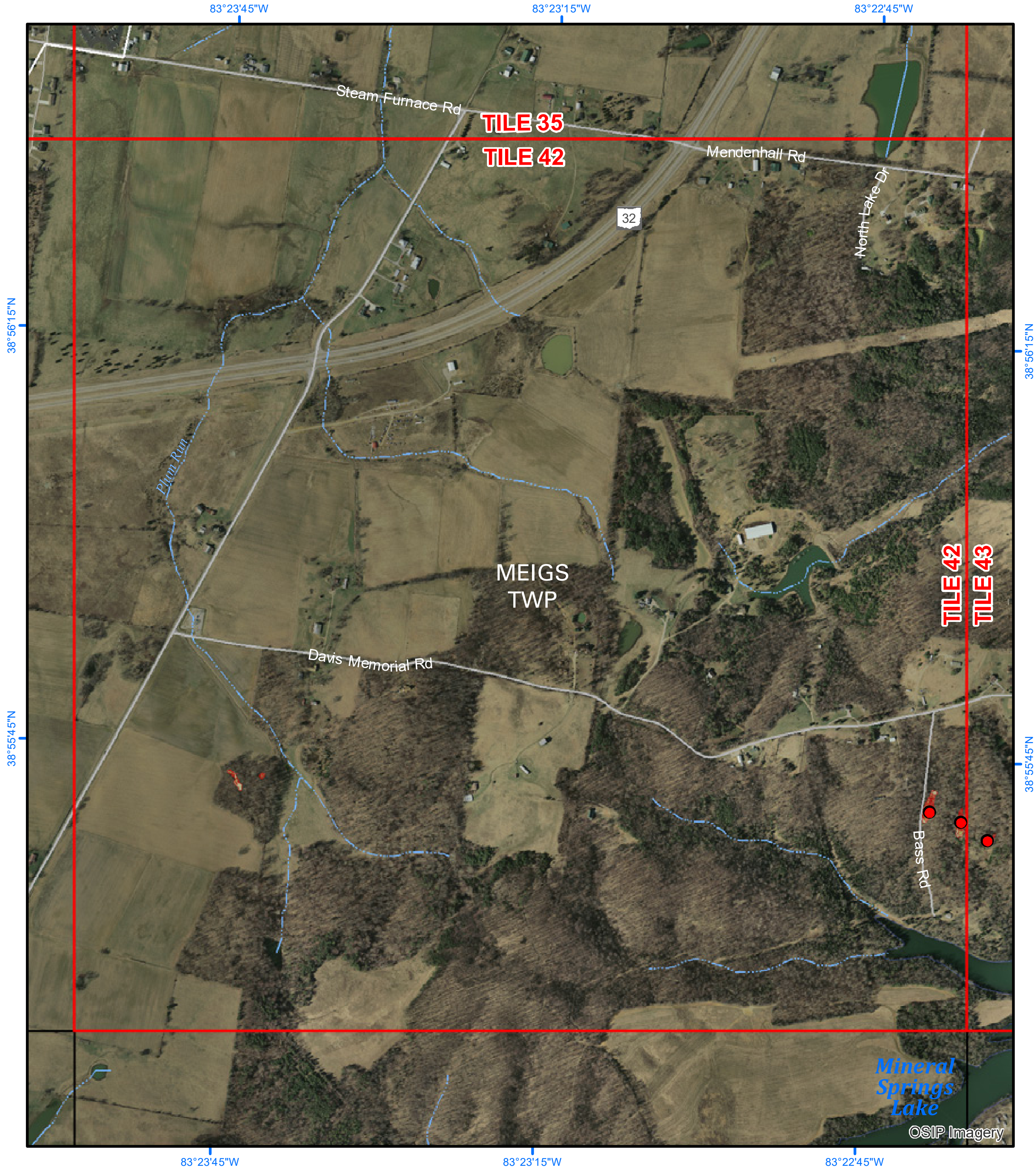
Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 39



Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 42



0 0.5 miles

0 0.5 kilometers

Scale 1:12,000

N W E S

KARST FEATURES

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

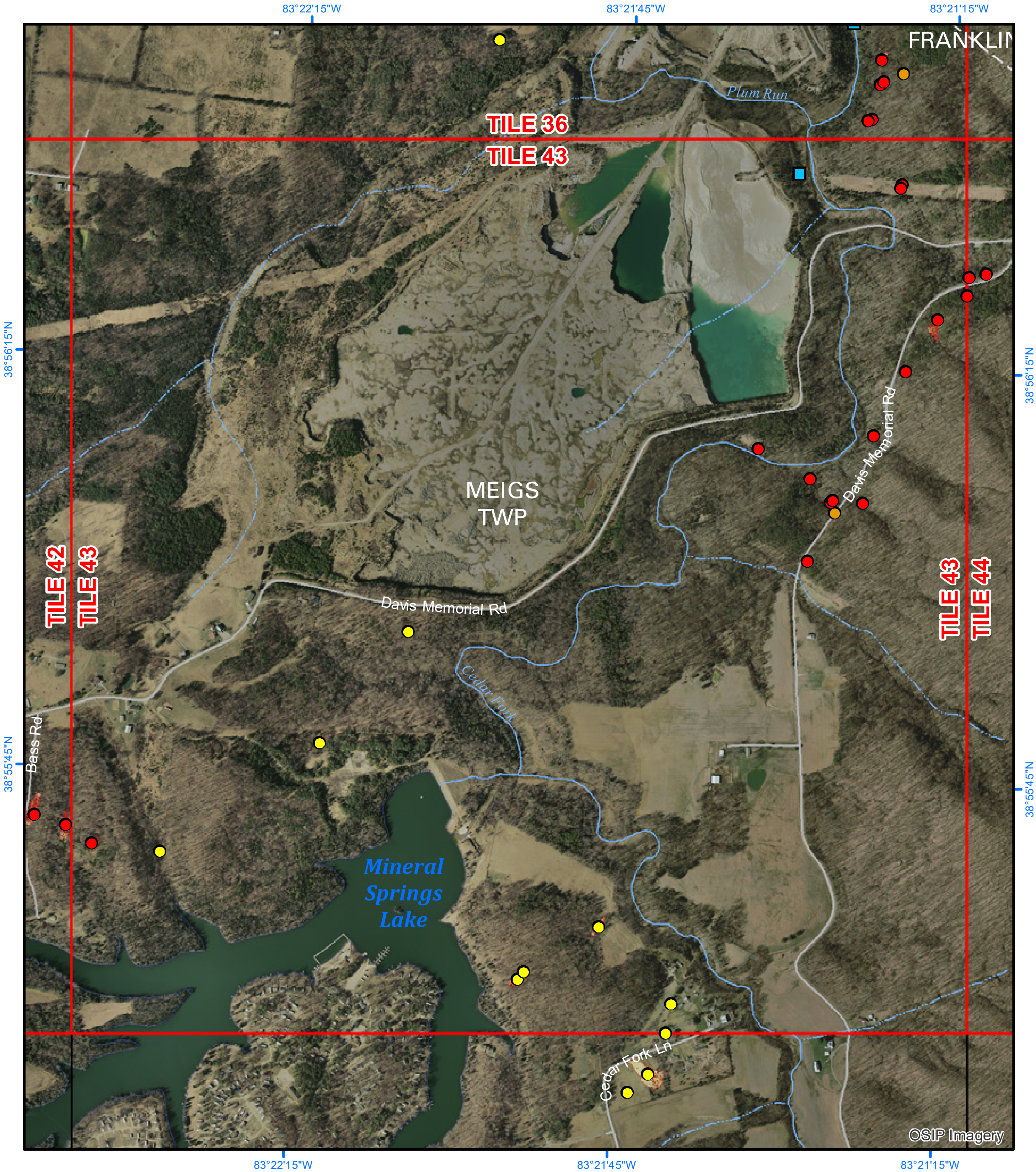
DEPRESSION

Depth in feet

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, >10

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 43



0 0.5 miles

0 0.5 kilometers

Scale 1:12,000

N W E S

KARST FEATURES

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

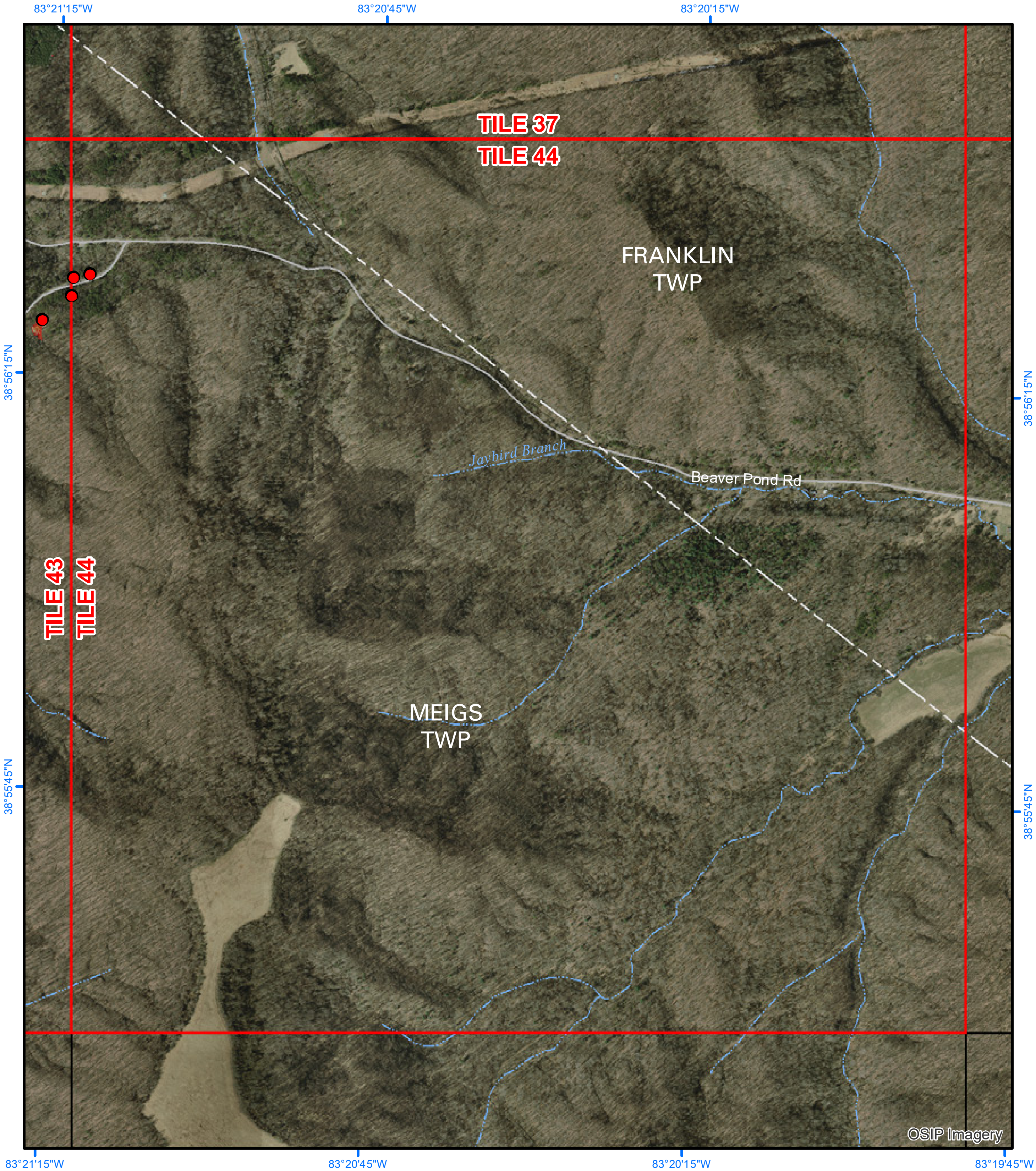
DEPRESSION

Depth in feet

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, >10

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Tile Number: 44



0 0.5 miles

0 0.5 kilometers

Scale 1:12,000

KARST FEATURES

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

DEPRESSION
Depth in feet

1, 2, 3, 4, 5, 6, 7, 8, 9, 10, >10

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

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