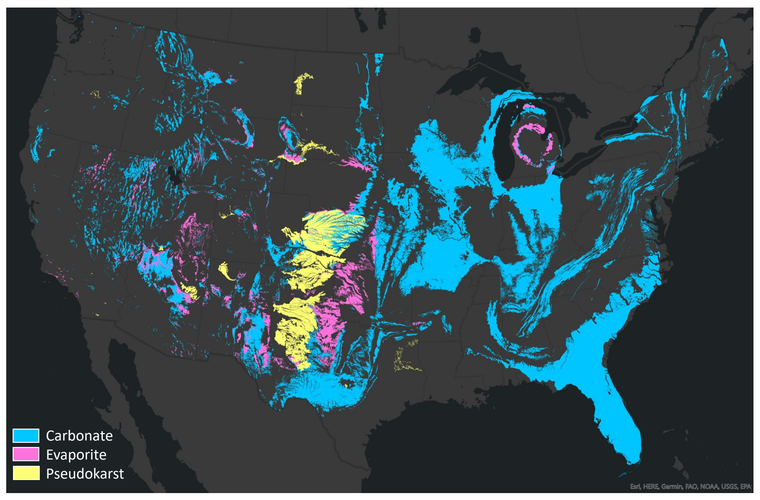
Karst Survey, Construction Monitoring, and Conservation Plans for Solar Sites

Joshua Valentino, PhD, PG, Project Geologist, 540-838-5074, Joshua.Valentino@terracon.com

Abstract

Construction in karst terrains can present a challenge to development, and the energy industry has become increasingly aware of the impact, both to the site infrastructure and to human health and the environment. These impacts include development of new karst features, short term and long-term damage to water wells, and the potential to negatively impact federally listed endangered species. To address these concerns, Terracon has developed a site karst construction plan divided into three main parts: (1) Pre-Construction Survey and Risk Assessment; (2) Construction Monitoring; (3) Conservation. The pre-construction survey and risk assessment phase consists of desktop data review and subsequent field reconnaissance to verify and locate features identified in the data review. After the survey is completed, risk is determined based on variables including: 1) the presence of an open throat, 2) parapet characteristics, 3) degree of soil raveling, 4) drainage leading to the karst feature, and 5) presence and quality of vegetation. Each karst feature is assigned a risk category where the risk recommendations detail approaches for each karst risk level.

Upon completing the survey phase, Terracon works with project engineers to assist in designing appropriate erosion and sediment control (ESC) measures, feature buffering and setbacks to minimize the impact to the karst aquifer. Regardless of the number of karst features identified at the ground surface, there is always the possibility that karst features may become exposed or form during construction. Changes to the surface water flow caused by grading operations and blasting are well-documented to cause development of new or previously undetected karst features. Terracon has developed a more systematic approach implementing construction monitoring measures during ground disturbance activities to reduce the risk of karst issues. The conservation phase runs simultaneously with construction, and it outlines specific avoidance and minimization measures designed to protect the karst aquifer.



Map of areas in the lower 48 States underlain by various types of karst (USGS National Karst Map, 2014)

Why Perform Karst Surveys?

Construction Issues

- Highly Irregular Bedrock-Soil Interface
- Sediment and Erosion Control During Construction
- Sinkhole Development
- Ephemeral Flooding

Regulatory Issues

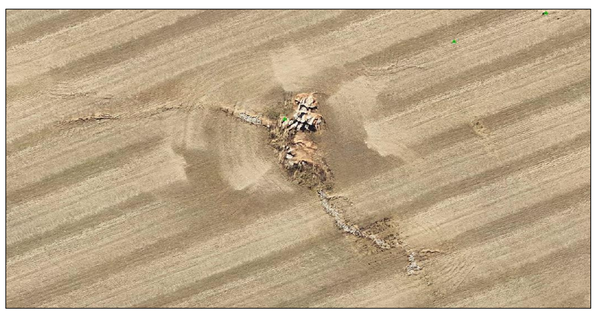
- Many planning boards and jurisdictional engineering departments now require karst surveys for all industrial and commercial development.
- The karst environment is the habitat for numerous Rare Threatened and Endangered (RTES) Species.
- Up to 28 States have Cave and Karst Protection Acts in Place.

Bottom Line

- Karst surveys are used to **focus** subsequent subsurface investigations and development planning, thus **saving both time and money**.

Karst Survey Protocol

1. Desktop Data Review
2. Field Verification and Reconnaissance
3. Risk and Impact Assessment
4. Avoidance, Monitoring and Minimization Measures
5. Additional Studies and Karst Plan



Sinkhole in row crop field identified by aerial photography

Desktop Data Review Phase

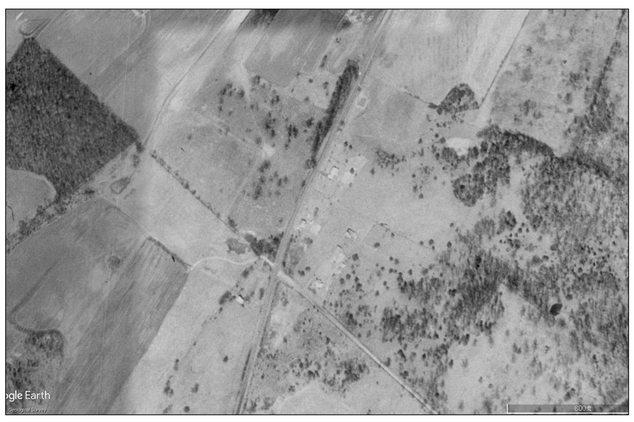
The data review includes examining:

- Geological maps
- State and Federal karst databases
- LiDAR and digital elevation models
- Cave survey data

Features are then identified and classified as “SKFs” (suspect karst features).

This process significantly **reduces the amount of time** spent on field verification and survey tasks.

Aerial photograph does not indicate karst features



Survey area during period of dry weather

LiDAR imagery of the area above reveals suspect karst features

Survey area during period of wet weather showing flooded sinkholes

Field Survey Phase

Upon completion of the data review a field survey is conducted by karst geologists in order to verify the desktop review findings. Specifically, the field reconnaissance involves:

- Locating and verifying all of the surface features identified in the desktop review.
- Locating and characterizing uncatalogued or previously unidentified surface features not observed in the desktop review.
- Documenting karst feature characteristics necessary for the risk assessment.

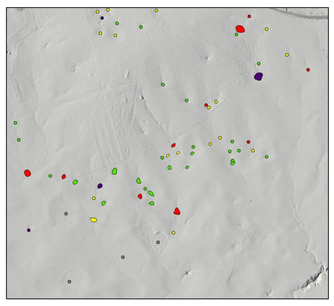
Assessing sinkhole location and characteristics

Open Throat

Irregular “ragged” parapet with soil raveling

Sinking Stream

Pinnacled bedrock surface exposed by erosion



Results of Risk Assessments

Risk Assessment

The risk assessment utilizes a Data Matrix consisting of 5 variables:

- Open throat
- Parapet characteristics
- Soil raveling
- Drainage
- Vegetation

This method reduces subjectivity in evaluating surface karst features.

Conservation

Avoidance and Minimization

- Each feature is ranked using risk score.
  - Very Low Risk
  - Low Risk
  - Moderate Risk
  - High Risk
  - Very High Risk
- The preferred approach is:
  - 1) Avoid if possible
  - 2) Minimize impact
  - 3) Remediate

Dye Tracing

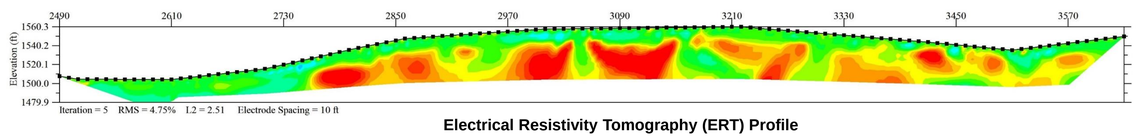
Buffered Sinkhole

Supplemental Work

- Non-Invasive Services
  - Geophysics
  - Dye Tracing
  - UAV Surveys
- Physical Investigations
  - Air Track Borings
  - Soil Borings
  - Trenching

Geophysical Survey

Groundwater Monitoring in Caves



Electrical Resistivity Tomography (ERT) Profile

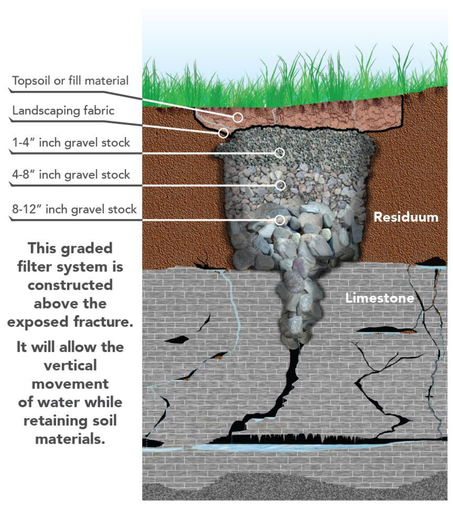
Construction Monitoring

Karst Plan

- Establish the standard set of monitoring and management protocols for karst features during the construction phase.
- Reduce delays when karst features are encountered.
- SOPs for karst remediation included in karst plan.
- Address potential public opposition.

Monitoring

- Utilize Karst Specialist during specific critical junctures to limit risk of new karst issues.
- Remediation protocols are typically considered standard of practice that limits uncertainty in the regulatory environment.



Reverse Graded Filter (Missouri Geological Survey)

Erosion and Sediment Control

Airtrack probe drill investigation

Conclusions

- The survey protocol provides to the client an easy-to-understand assessment of where there is an increased geohazard risk from karst geology, with emphasis on the construction phase, but also for the life of the facility.
- This study allows for a more focused approach in the development of subsequent geotechnical and geophysical subsurface investigations, ultimately saving the client both time and money.
- The survey protocol satisfies or exceeds the requirements for karst assessments which are now required by many engineering reviewers who report to jurisdictional planners.
- The development of a karst survey plan and proactive monitoring reduces the risk of construction delays and change orders from contractors.

Terracon
Explore with us

- Facilities
- Environmental
- Geotechnical
- Materials