



Designation: D8512 – 23

Standard Practice for Preliminary Karst Terrain Assessment for Site Development¹

This standard is issued under the fixed designation D8512; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice defines and summarizes various procedures for assessing specific sites for potential adverse impacts that karst conditions might have on site development including proposed construction or site management and impacts to the resource. Resources impacted may include water quality, water supply, cave, or aquifer fauna, and/or cultural or scientific resources. Karst impacts to site development include collapse and subsidence, differential subgrade conditions (for example, shallow bedrock, voids, soft soils, etc.), non-uniform bearing, excavation difficulty, and dewatering. The goal is to identify the relevant conditions for consideration in site selection and design. It is intended to offer various courses of actions that will provide a rational framework for planning and implementing a site characterization program to define potential karst conditions that might impact or be impacted by site development consideration for site suitability assessment. It is of note that the site assessment can use any combination of the included procedures

1.2 Since the site is in mapped or identified karst terrain, final ranking of a site will fit in one of the following categories:

- (1) There could be minimal karst influence (except subsurface influence) on site use and development;
- (2) It is likely that karst will influence or there is future potential that karst will influence site development;
- (3) Karst will play a significant role on future planning and development at the site.

1.3 Objectives guiding the development of this practice are:

- (1) to synthesize and put in writing customary practice for *preliminary karst assessments*,
- (2) to facilitate high quality, standardized *preliminary karst assessments*, and
- (3) to clarify an industry standard practice for *preliminary karst assessments* to provide a protocol for these assessments to assist design professionals, plan reviewers, public works officials, and jurisdictional regulators in making an informed judgment on site development and management.

¹ This test method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.27 on Karst.

Current edition approved Nov. 1, 2023. Published December 2023. DOI: 10.1520/D8512-23

1.4 The use of this practice is limited to the scope as set forth in this section. However, the report might be of interest and useful in endeavors that the site characterization and report do not address. It is beyond the scope of this practice to include recommendations to any facet of the project design or construction processes. Any portion of the scope of this practice should be considered carefully if it is found in conflict with local ordinances or regulations. Such a condition may require a formal variance from the issuing agency.

1.5 This practice offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM practice is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

1.6 Personnel not having specialized training or experience in karst survey and assessment methods should solicit assistance from qualified professionals. All references in this standard to the "qualified professional" refers to individuals (such as engineers, soil scientists, geophysicists, geologists including engineering geologists or hydrogeologists), who have the appropriate experience and, if required by local regulations, applicable certification, licensure or registration. The term "engineering" must be understood to be associated with the practices or activities of that qualified professional.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D5717 Guide for Design of Ground-Water Monitoring Systems in Karst and Fractured-Rock Aquifers (Withdrawn 2005)³

D6429 Guide for Selecting Surface Geophysical Methods

3. Terminology

3.1 *Definitions*—For definitions of common technical terms used in this standard, refer to Terminology **D653**.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *cave, n*—a natural underground space large enough for a person to enter and may have a connection to the surface.

3.2.2 *closed depression, n*—an enclosed topographic low in the land which may be of natural or anthropogenic origin. (See also *sinkhole*.)

3.2.3 *conduit, n*—a void that transmits or has the capacity to transmit turbulently flowing water in karst, which occurs when the void achieves a width of about 1 cm and used generally to describe all segments of karst drainage networks or to refer specifically to segments too small for human entry. Conduits large enough for human entry are called caves.

3.2.4 *covered karst, n*—a karst area where a great majority of the karstic bedrock is below a thick deposit of soil, alluvium, or sedimentary material; also known as mantled karst.

3.2.5 *karst, n*—a terrain with distinctive hydrology and landforms that arise from a combination of rock solubility and well developed porosity and permeability.

3.2.6 *paleokarst*—karst phenomenon that have been formed during the Tertiary or before and refers to karst features that have been preserved in the rock mass.

3.2.6.1 *Discussion*—These preserved features are often masked but their presence can be inferred. This process requires detailed understanding of geological processes, ancient landscapes and geological events that took place at the site of interest.

3.2.7 *pinnacle, n*—bedrock remnant between solutionally enlarged fractures where the remnant height is usually substantially greater than its width and at a scale typically less than 30 m in height; common usage implies a surface feature, but it may be fully or partly covered by soil or sediment.

3.2.8 *sinkhole, n*—a naturally formed topographically closed depression in the surface of the Earth formed by solution of bedrock and/or collapse or subsidence of bedrock or overlying soils or sediment.

3.2.9 *sinking stream, n*—a stream that loses all or most of its flow into a feature or group of features (typically a cave or

sinkhole) that recharge an aquifer, as opposed to a losing stream which loses its flow over an extended distance.

4. Summary of Practice

4.1 As described by Denton **(1)**⁴ and Veni **(2)**, procedures of assessment will generally fit into two broad areas:

(1) A desktop review of available information such as digital elevation models (DEMs), Light Detection and Ranging (LiDAR), satellite imagery, topographic maps, aerial photos, and reports of known karst conditions;

(2) Site field reconnaissance.

5. Significance and Use

5.1 This practice may serve to assist qualified professionals in conducting preliminary karst assessments, and helping design professionals, plan reviewers, public works officials, and jurisdictional regulators in determining the minimum elements that should be expected in a site evaluation. It should be emphasized that the protocol presented herein is not intended to serve as a substitute for detailed subsurface investigations, or to supersede any existing karst regulations or codified protocols.

5.2 According to Gutiérrez et al. **(3)** it is important to understand that geo-hazards in karst terrain differ considerably from other natural settings. These geo-hazards are exacerbated by the redirection and concentration of water draining into the subsurface and removal of soil or other natural cover over karst openings. The karst system is often unable to manage the effects of heavy rainfall and flash floods, resulting in the formation and/or reactivation of sinkholes, soil subsidence or slope movement, and these effects become exaggerated by human alteration of the natural drainage. In addition, the lack of filtration inherent to karst hydrogeologic systems can result in transport and migration of a diverse variety of water-borne contaminants, including but not limited to pathogens, heavy metals, sediments, free-product, and dissolved-phase chemicals, as well as residual-phase contaminants adsorbed on sediment. The removal of cover by grading will reduce support over cavities in the subsurface and increase the potential for collapse or subsidence, particularly where surface water concentration occurs.

6. Procedure

6.1 Desktop Review:

6.1.1 *Site Description and Terrain Analysis*—Describe the site, based on examination of the most detailed topographic mapping available and subsequent field observations. More detailed LiDAR can be used if available. LiDAR data can be used to create digital elevation models (DEMs) and topographic maps if practicable, to examine the site for the presence of closed descending contours suggesting the presence of a sinkhole or closed depression. In addition, stereoscopic aerial photograph pairs and aerial photo fracture trace analysis may be used. Note any karst features (that is, caves entrances, sinkholes, closed depressions, etc.) visible on the

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ The last approved version of this historical standard is referenced on www.astm.org.

⁴ The boldface numbers in parentheses refer to a list of references at the end of this standard.

topographic map and remote sensing resources. Note the presence of any water features on the site and directions and pathways for site drainage and surface water flow. Include a careful delineation of the property's metes and bounds in the site description, and its current use and condition (that is, vacant land, agricultural land, developed land and alike).

6.1.2 Description of Soils and Bedrock Geology—Access soil maps for the project site. Examine soils data for the site and adjacent properties, with particular emphasis on the parent materials (that is, whether the soils are residual or transported), their hydrologic characteristics, and textural analysis. Soils in certain geological settings may be noted as being “prone to sinkhole formation” in soils maps. These soils shall be noted and indicated in the final report.

6.1.2.1 Understanding the soils in conjunction with the underlying bedrock is critical to predicting whether sinkholes will form after a site has been cleared of vegetation. Where surficial soils obscure the top of rock, covered or mantled karst condition may exist where numerous soil-filled or open conduits may be present beneath a seemingly homogeneous soil cover. Upon removal of the vegetation and topsoil during stripping operations, infiltration will increase and the cover over expanding subsurface cavities is reduced to the point of collapse, or the soil may begin to ravel due the surface infiltration into covered subsurface voids or conduits and sinkholes may form.

6.1.2.2 Research bedrock geology by referencing the highest resolution geological mapping available. This information often can be found by accessing the websites of the local or regional geological survey and water resources agencies. Note dip and strike of the bedrock, and any significant structural features (mapped faults, anticlines, synclines, etc.). It is often of value to examine geologic maps contained in water resource reports as well as mining and minerals maps that would reflect the presence of carbonate rock resources, quarries, and mines in the site vicinity. Bedrock will be considered “soluble” if its lithology consists of a significantly soluble mineralogical component (for example, carbonate or evaporite), though solubility is often less important than the magnitude and nature of prior dissolution. In highly soluble evaporites, ongoing dissolution of rock can be a significant factor in assessing risk to development but is not typically a concern in many limestones and dolomites. It is of note that in some unconsolidated siliciclastic units the dissolution of accessory carbonate fossils (for example, molluscan and bryozoan beds) and thin carbonate beds can cause surficial deformation karst issues if close enough to the land surface or create small preferential hydrologic changes at depth which may be counter to the regional hydrogeology.

6.1.2.3 Finally, in some settings, insoluble bedrock may overlie karst-forming rock below and surface depressions, sinkholes and cave entrances may form when the insoluble overlying bedrock collapses into cavernous voids beneath. Therefore, in any setting where this stratification is present, the insoluble overlying unit shall be examined for the presence of documented sinkholes, depressions, or cave entrances. This is particularly important in regions where paleokarst is present. As discussed by Lund, et al. (4) when exposed on or near the

surface, breccia pipes and paleokarst will seldom cause problems beyond those presented by typical karst features. However, when encountered in the subsurface (for example, during mining and/or tunneling) these features can be, and have been, life threatening. As with most adverse construction conditions, early recognition and avoidance is the most effective way to mitigate potential problems. However, breccia pipes and paleokarst terrain susceptible to subsidence and sinkhole formation can be widespread in some areas. Therefore, according to Fischer and McWhorter (5) mitigation methods (for example, reverse graded filters, transit-mix plugs, various types of grouting, dynamic compaction, special foundation designs such as piles, and careful drainage design to keep water away from karst features) should be used to minimize the impact of reactivated paleokarst.

6.1.3 Description of Surface Drainage and Water Features—Evaluate the surface drainage patterns at the site by examination of the topography. Identify limits of the drainage basin and primary discharge points into major waterbodies. Conduct research for publicly available hydrological assessments that may have been performed for the region by governmental or other entities.

6.1.3.1 The analysis of drainage patterns shall determine if the site has outlets (that is, if drainage is directed offsite) or if it is internally drained as these factors can profoundly affect site planning, especially in regard to stormwater management. Drainage to sinkholes shall be clearly delineated.

6.1.3.2 The locations of springs, streams, and water bodies (lakes, ponds, wetlands, etc.) shall be noted. The locations of losing streams, gaining streams, and sinking streams shall be carefully noted where these conditions can be identified. Note any discontinuous drainage ways and disappearing streams. It can be helpful to review historical maps to evaluate whether there have been changes in the site drainage over time. Such changes may be reflective of karst activity or alter the risk of areas where drainage has recently been directed. If such conditions are observed, they shall be noted.

6.1.4 Identification of Previously Inventoried Karst Features—Prior to the field observation phase of the assessment, access available karst and cave survey databases to determine which, if any, features have been previously located or mapped at the site or on adjacent areas. The International Union of Speleology (www.uis-speleo.org) provides links to national organizations that include such databases for their countries.

6.1.4.1 In addition, many agencies in karst areas maintain inventory maps of karst features such as caves, closed depressions, sinkholes, etc. Some agencies also publish karst risk maps and other karst related data. The investigator shall investigate the availability of such maps and review them as part of the desktop review. In evaluating any prior database or mapping, note the effective dates, basis, authors, and limitations of the mapping.

6.1.5 Aerial Imagery—Aerial imagery provides a useful source of information. In developed areas being considered for redevelopment, review of historical aerial images that predate development may enable identifying karst features that have been obscured by regrading. Aerial images of undeveloped