A Long Lesson in Resiliency: Ha Ha Tonka Karst Natural Area

by Allison J. Vaughn

The complex karst features, the rich surrounding terrestrial landscape, and the ruins of an early 20th century mansion led to the founding of Ha Ha Tonka State Park (HHTSP) in 1978, long after former governor Hadley proposed protection for the area's natural features in 1910. Shortly after the Missouri Department of Natural Resources (MDNR) acquired HHTSP, the Missouri Natural Areas Committee (MoNAC) nominated 70 acres of karst features and karst topography as a natural area in 1980. This 70 acres remains one of Missouri's outstanding geological areas, a classic example of a karst landscape (Image 1, previous page).

Interrelated solution features dramatically involved in this system include: an awe-inspiring cavern-collapse chasm bounded on the north by sheer cliffs nearly 250 ft. high and 800 ft. long, well-developed dry-mesic limestone forest, a long, deep-circulating spring (Missouri's 12th largest); two large sinkholes, a well-formed natural bridge, a moderately large cave (River Cave) with both sinkhole and swallet entrances, five smaller caves, and a losing stream (Dry Hollow) that courses through River Cave and ends in the spring. Notably, all of these significant karst features are located in a very small area, a true "microcosm" of a karst landscape. Today's Ha Ha Tonka Karst Natural Area was featured in *Geologic Wonders and Curiosities of Missouri* (Beveridge, 1980) and was proposed as a National Natural Landmark in the 1990s, 2002 and again in 2013. The NNL board disbanded shortly after the latest proposal was submitted so the designation has never come to fruition.

In the 45 years since the creation of HHTSP, private domiciles—once few and far between in the immediate area—began surrounding the park, with landowners attracted to the landscape just like the early settlers were. However, since the mid-2000s, due to the park's proximity to Lake of the Ozarks, residential development adjacent to the park notably increased along a park conduit, Dry Hollow Road. This once-less traveled gravel road bisects a busy state highway and runs parallel to (and sometimes through) Dry Hollow, the losing stream that flows into River Cave. With the increased development along Dry Hollow Road, county road grading grew more frequent through time, with additions of creek gravel and fines on a regular basis to provide for smoother driving conditions. With each successive heavy rain event, gravel migrated from Dry Hollow Road, through the stream, into River Cave where ultimately, through a shallow underground conduit, it was deposited in Ha Ha Tonka Spring. The spring serves as a common outlet for approximately 100 mi.2 of dry uplands to the south and east.

Beginning around 2003, during routine winter cave surveys of River Cave, park staff began recording gravel levels in the cave. Dry Hollow continued to fill with gravel not only from the surrounding watershed, but notably from the adjacent road. Since around 2013, with more frequent heavy rain events of short duration, gravel pulses coursing through the stream and through the cave (and ultimately the spring) continued apace.

Image 1. This 1979 aerial view of Ha Ha Tonka Spring represents the Ha Ha Tonka Karst Natural Area in the natural area nomination. In the late 1970s, the spring had not been prone to excess gravel accretion from the watershed and was fully open water throughout the spring run.

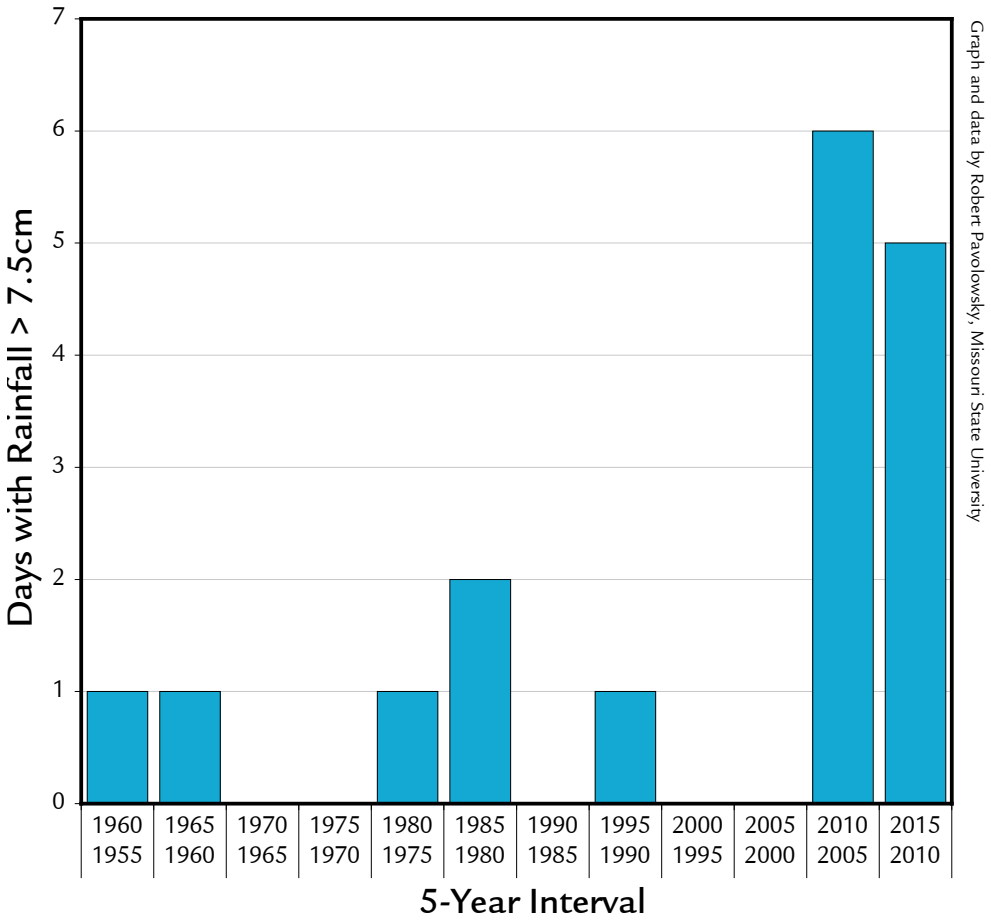

Figure 1. Graph illustrating days of rainfall higher than 7.5 cm (3 inches) that elevate to higher levels in the mid 2010s.

According to Pavlowsky, et al. (2016), high rainfall events occurred more frequently and with higher magnitude during the last decade compared to the 50 years prior (Figure 1):

> For example, the 1% exceedance daily rainfall event has increased by 21% over the last decade (2005–2015) compared to the previous 20 years (1985–2005)....There were a total of 16 days with rainfall totals greater than 3 in. over the last 60 years (Figure 3B). However, these events were not evenly distributed over time. Daily rainfall totals only exceeded 3 in. six times from 1955–2005 (0.12 events/year), while exceeding that threshold ten times during the period from 2005 to 2015 (1 event/year) for a 8.3-times increase in frequency over the past decade.

One of those high rainfall events occurred at HHTSP July 1–2, 2015 in which 10 inches of rain fell in short duration, causing major flash flooding throughout the region. The event was so significant that Camden Co. declared a State of Emergency, triggering the Federal Emergency Management Administration to assess and repair the incurred damages to private and public property. In this event, approximately 300 cubic yards of ditch and road base material from Dry Hollow Road moved downstream through the culvert system and into the east entrance to River Cave, a secondary entrance protected by an angled iron gate to prevent trespass. As the cobble, road fines and larger sized gravel accumulated against the 7 ft. tall gate, the east sinkhole filled with water and overtopped the hillside separating the east entrance from the primary cave entrance in the

west sinkhole. The intensity of the flooding and whirlpool effect promulgated by the gate blockage resulted in a massive land slump in the west sinkhole which partially blocked the cave entrance and destroyed the 20 ft. tall primary chute gate built to allow for bat passage. The land slump left large boulders, gravel, and soil in front of the primary passage, thereby altering the airflow into the cave (Image 2). River Cave is home to a significant maternity colony of endangered gray bats, estimated at 150,000.

Shortly after the rain event, MDNR hydrologists, engineers, and Missouri Geological Survey (MGS) staff assessed the damage and provided a strategy to mitigate continued gravel input in the cave. In an unpublished MGS report, it was recommended to culvert the road out of the stream bed, and for park staff to seek permission to remove gravel following heavy rain events from the stretch of the stream on park property above the east entrance to River Cave. Included in the report was a recommendation to ultimately seek funding to pave Dry Hollow Road and dredge gravel out of Ha Ha Tonka Spring. The immediate work ahead involved a FEMA contract utilizing cranes and bulldozers to remove debris and the 20 ft. tall damaged cave gate, which consisted of several tons of steel, from the primary sinkhole entrance to River Cave (Image 3). This costly endeavor resulted in park staff and volunteers tackling the debris in the east sinkhole by hand with buckets. The FEMA contract also funded the cave gate replacement that was built by park staff and Americorps-St. Louis.

By 2016, gravel in River Cave increased to the level that entry into the secondary 7 foot tall east entrance (which historically housed wintering Indiana bats) required crawling to enter. Interstitial spaces continued to fill with road fines, and gravel blocked some smaller cave passages. Together, this negatively impacted River Cave's invertebrate and salamander populations.

Photo by Allison Vaughn, Missouri Department of Natural Resources

Image 2. The left side of the main River Cave entrance in the winter after the debris collapse in July essentially blocked air flow and passage with boulders and gravel fines. A large section of the entrance was cleared of debris in August, 2015, but some still remains.

Photo by Allison Vaughn, Missouri Department of Natural Resources

Image 3. After the debris from the flood event was removed, contractors also removed tons of steel from the chute cave gate, revealing the natural entrance to River Cave. The cave gate was replaced the same week to prevent trespass. The wooden steps leading into the sinkhole remain out of commission in 2024 due to instability of the hillside in which the steps are anchored.

Photo by Allison Vaughn, Missouri Department of Natural Resources

Image 4. Gravel islands formed quickly in Ha Ha Tonka Spring as this photo from 2016 illustrates. By 2020, the islands were vegetated with roadside vegetation, including tall fescue.

The sump at the back of River Cave continued to clog with gravel as it coursed its way through the cave, with hydrostatic pressure ultimately forcing the gravel through the underground conduit and into the spring. Spring discharge is strong enough to move large amounts of gravel. However, through time, improvements to Dry Hollow Road and regular gravel removal from the stream slowly began to lessen the gravel input in the cave, but there remained much in the cave system. By summer 2016, large gravel islands with roadside vegetation began to develop in the spring (Images 4 and 5).

In 2019, in collaboration with MDNR, the Camden County Road Commission sought grant funding to allow for the paving of a one mile stretch of Dry Hollow Road that runs adjacent to the stream. They secured a Community Block Grant from the State of Missouri, but work could not begin immediately. However, the gravel road improvements and continued removal of gravel from the stream significantly

Photo by Allison Vaughn, Missouri Department of Natural Resources

Image 5. By August 2023 two months after the dredging project ended, native spring vegetation had recolonized the spring.

lessened the input into the cave. By 2021, winter cave surveys revealed much less gravel, as it was coursing through the karst system, and wildlife populations began to rebound in the cave; for example, the rimstone pools that house grotto salamanders were free of gravel for the first time in several years. In Ha Ha Tonka Spring, however, gravel islands increased in size to the degree that they blocked water flow from parts of the spring branch, resulting in stagnant isolated shallow pools scattered throughout the lower reaches of the spring. Native spring vegetation began to diminish, with the large stands of bur reed and watercress slowly disappearing. The spring was slowly filling with gravel.

Botanist Julian Steyermark catalogued the flora of multiple freshwater springs in Missouri, including Ha Ha Tonka Spring, creating comprehensive plant lists and spring descriptions in his article Phanerogamic Flora of Freshwater Springs in the Ozarks of Missouri (1940). He described Ha Ha Tonka Spring as a vegetated spring, with notable spring species in abundance:

> At the very beginning, in deep water, are large beds of milfoil, alternating with water cress. Along the sides are rocks covered with algae and mosses. … All along the margin and in the center of the basin are long strands of water milfoil *(Myriophyllum heterophyllum)*, and along the deeper portions of the margin grow plants of hornwort *(Ceratophyllum demersum).* These two species are the only ones found in the basin. The right spring branch runs along the base of a precipitous, rocky wall and is deep. The only plants which occur in it are hornwort, milfoil, and occasionally water cress *(Nasturtium nasturtium-aquaticum).* The left spring branch is very rich in aquatic plants. It is narrow, about 10 to 12 feet wide, and has a deep blue-gray color. Here are beds of broad-leaved, purple or green mild water pepper *(Polygonum hydropiperoides),* bur reed *(Sparganium americanum),* water starwort *(Callitriche heterophylla),* and water speedwell *(Veronica concatenata),* the last very abundant. Mild water pepper grows where the current is fastest, while bur-reed occurs mostly along the margin of the branch. The spring empties into the Niangua River about a half-mile away from its source. (p. 162)

In late 2022, after much planning and securing of additional grant funds, Camden County paved the one mile stretch of Dry Hollow Road that was impacting the stream. By this time, River Cave and Dry Hollow Stream possessed far less gravel than in previous years, and with the paving of the road, the gravel input is now slated to come only from the stream and surrounding watershed. The next activity was to secure funding for the dredging of the spring. Understanding the significance of this natural feature in the park, MDNR funded the dredging through the Fiscal Year 2024 Capital Improvement Budget. Research into this project involved using late 1970s reports from then-Division of Geology and Land Survey's (now MGS) renowned hydrologist Jerry Vineyard, his landmark book *Springs of Missouri* (1982) and images of the spring from Steyermark's 1940 publication. MDNR staff collaborated with engineers and spring experts to determine the historic depth of the spring. Permitting and planning required significant effort from both MDNR and the engineering firm, but in summer 2023, the two months-long dredging project concluded in early June with the final total removal of 10,565 cubic yards of gravel and road fines. The isolated gravel islands that had formed from the deposition of gravel from River Cave over eight or more years were removed.

To undertake this project, terrestrial vegetation typical of a dry-mesic limestone forest along

the lower Spring Trail was negatively impacted to allow passage for dredging equipment. Efforts were made to prevent erosion after the operation was complete, and it is hoped that through time, the herbaceous vegetation will recover. To conduct the gravel dredging, contractors created a wide passage along the Spring Trail at the base of the forest, and a gravel road into the heart of the spring pool for the equipment to reach the gravel islands slated for removal. Notably, by August 2023, spring vegetation, including mats of watercress at the bottom of the spring, burreed, water milfoil, hornwort, water speedwell, and water starwort began to repopulate the spring and spring branch (Image 6).

The 8-year long process to complete the action items set forth in the MGS report following the July 2015 rain event required many moving parts and partners. Ha Ha Tonka SP has always been a stable and resilient landscape. With development and other threats occurring at the park's borders, park managers recognize the importance of monitoring these threats that come part and parcel with land management in the 21st century. The vegetative response in Ha Ha Tonka Spring and the surrounding Ha Ha Tonka Karst NA following such dramatic alterations, the wildlife response in River Cave and the spring, will hopefully continue to improve to continue the park's legacy of serving as a gem in the crown of Missouri state parks.

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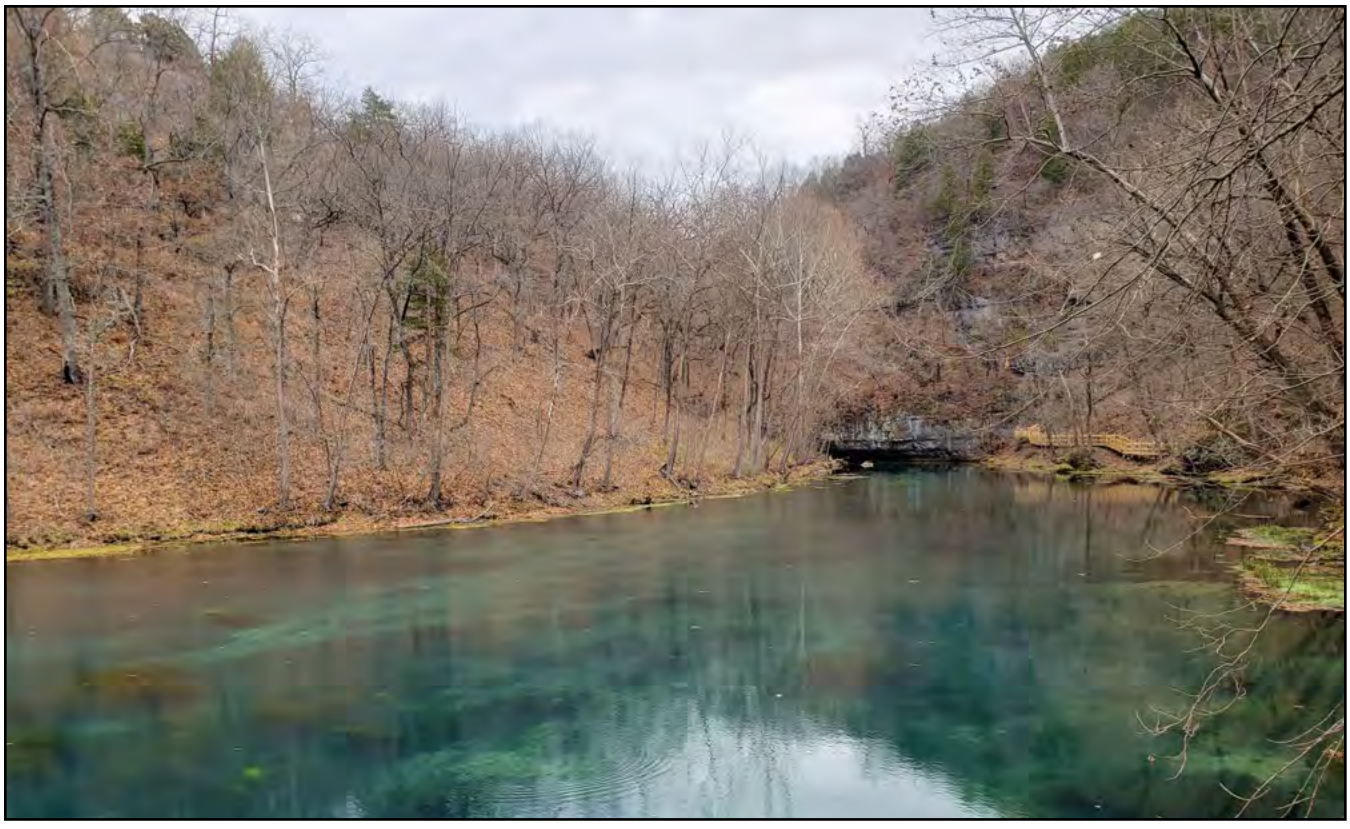

Photo by Allison Vaughn, Missouri Department of Natural Resources

Image 6. Ha Ha Tonka Spring in November, 2023 after the native spring vegetation went dormant.