ZARA
ENVIRONMENTAL LLC
Integrity | Science | Expertise
2104 Hunter Road
San Marcos, Texas 78666
512-291-4555
www.zaraenvironmental.com

TECHNICAL REPORT FOR KARST MANAGEMENT SERVICES AT THE BALCONES CANYONLANDS PRESERVE – KOTRLA UNIT, TRAVIS COUNTY, TEXAS



The pit entrance of Devil's Lair Cave (SW-32).

Prepared for
Travis County TNR – Natural Resources and Environmental Quality
PO Box 1748
Austin, Texas 78767

Report Prepared by: Rachel Barlow, Aubri Jenson, and Peter Sprouse

29 September 2023

Abstract

Karst management of the Balcones Canyonlands Preserve (BCP) Kotrla Unit in 2023 was a continuation of work done in 2017 and 2022 to identify karst features, evaluate features as potential habitat, excavate as necessary to reach sampleable habitat, and document cave fauna with timed biological surveys and/ or collection. As of 2023, the Flying K tract was acquired by the BCP, adding eighteen features to the Kotrla Unit that were previously evaluated by Zara in 2019. Of these, four were selected for additional biological surveys and excavation. Reconnaissance for new karst features on the Flying K tract was performed at 21 locations identified by visual review of LIDAR data; all were depressions, but none were of karst origin. On the Scott & White tract, seven features previously reported by Travis County were evaluated for potential karst invertebrate habitat. All features met initial criteria, and four qualified as caves. Of note, feature SW-32 (Devil's Lair Cave) proved to be extensive and was excavated, mapped, and thoroughly biologically surveyed. Excavation was performed on four features, and continued excavation is recommended for three of these features.

Table of Contents

Abstract ..... **i**
Introduction **1**
Federally Listed Karst Invertebrates *1*
Balcones Canyonlands Conservation Plan – Species of Concern *1*
Methods **3**
Prioritization of Karst Features *3*
Karst Invertebrate Habitat Determinations *3*
Biological Surveys and Specimen Collection *4*
Results **5**
Feature Descriptions of Newly Evaluated Features *8*
Feature SW-29 (Rocky Top); Cave 8
Feature SW-30 (Middle of Nowhere); Cave 10
Feature SW-31 (Downspout); Solution cavity 13
Feature SW-32 (Devil's Lair Cave); Cave 15
Feature SW-33 (Unforeseen); Cave 20
Feature SW-34; Solution cavity 21
Feature SW-35; Sinkhole 23
Description of Work Completed at Previously Evaluated Features *25*
Feature FK-1; Cave 25
Feature FK-2; Cave 28
Feature FK-4; Cave 28
Feature FK-32 (Flying Kave); Cave 29
Feature SW-27 (Artificial Intelligence Cave); Cave 30
Recommendations **31**
References **34**
Appendix A. Summary of Biological Collections **A-1**
Appendix B. Genetic Species Identification Results **B-1**

List of Figures

Figure 1. Feature SW-29 (Rocky Top) was a small cave in a sinkhole. 8
Figure 2. Feature SW-29 was developed along a fracture. 9
Figure 3. The interior of Feature SW-29 contained numerous *Leibonum townsendi.* 9

Figure 4. Field sketch of Feature SW-29. 10
Figure 5. Feature SW-30 (Middle of Nowhere) prior to excavation. 11
Figure 6. A boulder was removed from the entrance of Feature SW-30. 11
Figure 7. The entrance to Feature SW-30 after excavation. 12
Figure 8. Feature SW-30 continues as a mesocavernous drain in bedrock. 12
Figure 9. Field sketch of feature SW-30. 13
Figure 10. Feature SW-31 (Downspout) is a solution cavity with a small entrance. 14
Figure 11. The full extent of Feature SW-31 was not assessed. 14
Figure 12. Field sketch of Feature SW-31. 15
Figure 13. SW-32 (Devil's Lair Cave) had a two-pit entrance requiring rope access. 16
Figure 14. The interior passages of Feature SW-32 contained bedrock, flowstone, and clay. 17
Figure 15. Excavation in Feature SW-32 removed a clay plug from a side passage. 17
Figure 16. A southward trending room was uncovered by excavation in Feature SW-32. 18
Figure 17. Feature SW-32 is habitat for the Tricolored bat *(Perimyotis subflaus)*. 18
Figure 18. Map of SW-32 (Devil's Lair Cave). 19
Figure 19. Feature SW-33 was a cave with a very small entrance. 20
Figure 20. Feature SW-33 continued as a narrow pit. 21
Figure 21. Field sketch of Feature SW-33. 21
Figure 22. Feature SW-34 was a solution cavity. 22
Figure 23. The interior of Feature SW-34 contained organic soil, leaf litter, and rocks. 23
Figure 24. Field sketch of Feature SW-34. 23
Figure 25. Feature SW-35 was a sinkhole with a soil drain. 24
Figure 26. Preliminary excavation of Feature SW-35 revealed no sampleable habitat. 25
Figure 27. Field sketch of Feature SW-35. 25
Figure 28. Excavation was performed following airflow in Feature FK-1. 26
Figure 29. An enterable lower level was uncovered in Feature FK-1. 27
Figure 30. The terminus of Feature FK-1 contained loose rocks and soil. 27

List of Tables

Table 1. Species of Concern addressed in the Balcones Canyonlands Conservation Plan (RECON and USFWS 1996). 2
Table 2. Summary table of features visited October 2022 – September 2023. 6
Table 3. Summary table of USFWS (2022) conditions indicating potential habitat for newly discovered features evaluated October 2022 – September 2023. 7

Table 4. Feature SW-29 assessment.....8
Table 5. Feature SW-30 assessment.....10
Table 6. Feature SW-31 assessment.....13
Table 7. Feature SW-32 assessment.....16
Table 8. Feature SW-33 assessment.....20
Table 9. Feature SW-34 assessment.....22
Table 10. Feature SW-35 assessment.....24
Table 11. Summary of fauna observations at FK-1.....26
Table 12. Summary of fauna observations at FK-2.....28
Table 13. Summary of fauna observations at FK-4.....29
Table 14. Summary of fauna observations at FK-32.....30
Table 15. Summary of fauna observations at SW-27. 31
Table 16. Summary table of results and recommendations.....33

Introduction

This technical report has been prepared in support of karst management activities at the Balcones Canyonlands Preserve (BCP) Kotrla Unit, located in northwest Travis County, Texas. The Kotrla Unit consists of four preserve tracts (Scott & White, Kotrla, Endres, and Flying K) owned and managed by Travis County (County), who contracted Zara Environmental LLC (Zara) to provide karst management services including karst invertebrate habitat assessments, biological surveys, drainage basin delineation, LIDAR based field surveys, and excavation of karst features. The karst management services were conducted at five features described in previous reports on the Flying K and Scott & White tracts, (ZARA 2017, 2020, 2022) and at seven features on the Flying K tract which were recently identified by Travis County.

Federally Listed Karst Invertebrates

Five invertebrate species known only from caves and karst areas in Travis and Williamson counties were federally listed as endangered species under the Endangered Species Act (ESA) by the U.S. Fish and Wildlife Service (USFWS) on 16 September 1988 (USFWS 1988). These species include the Bee Creek Cave harvestman (*Texella reddelli*), Tooth Cave pseudoscorpion (*Tartarocreagris texana*, formerly *Microcreagris texana*), Tooth Cave spider (*Tayshaneta myopica*, formerly *Neoleptoneta myopica*), Tooth Cave ground beetle (*Rhadine persephone*), and the Kretschmarr Cave mold beetle (*Texamaurops reddelli*). Two additional karst invertebrate species, the Bone Cave harvestman (*Texella reyesi*), and the Coffin Cave mold beetle (*Batrisodes texanus*) from Travis and Williamson counties were federally listed as endangered species due to taxonomic revisions on 18 August 1993 (USFWS 1993).

Balcones Canyonlands Conservation Plan – Species of Concern

A regional habitat conservation plan and incidental take permit, known as the Balcones Canyonlands Conservation Plan (BCCP), was issued in 1996 by the USFWS to the City of Austin and Travis County for the protection of two endangered bird species (including the Golden-cheeked Warbler [*Setophaga chrysoparia*]), six endangered karst invertebrate species (described above, with the exception of the Coffin Cave mold beetle), 25 karst Species of Concern (SOC), and two plant SOC (Regional Environmental Consultants [RECON] and USFWS 1996). For the purposes of this report, only the karst SOC are presented below (Table 1). Since the BCCP was issued in 1996, some of the SOC have been synonymized with other species based on recent genetic and taxonomic studies. As such, the protected status of these reclassified species may have changed. Additional details are included as footnotes in Table 1.

Table 1. Species of Concern addressed in the Balcones Canyonlands Conservation Plan (RECON and USFWS 1996).

Group	**Species**
Flatworms	*Sphalloplana mohri*
Ostracods	*Candona* sp. nr. *stagnalis*
Spiders	*Cicurina bandida*[1] *Cicurina cueva*[1] *Cicurina ellioti*[2] *Cicurina reddelli*[3] *Cicurina reyesi*[1] *Cicurina travisae*[3] *Cicurina wartoni*[3] *Tayshaneta concinna*[4] *Tayshaneta devia*[4] *Eidmannella reclusa*
Millipedes	*Speodesmus* N. S.
Pseudoscorpions	*Aphrastochthonius* N. S. *Tartarocreagris comanche* *Tartarocreagris reddelli*[5] *Tartarocreagris intermedia* *Tartarocreagris* N. S. 3
Harvestmen	*Texella spinoperca*
Ground Beetles	*Rhadine s. subterranea* *Rhadine s. mitchelli* *Rhadine austinica*
Isopods	*Caecidotea reddelli* *Miktoniscus* N. S. *Trichoniscidae* N. S.

[1] *Cicurina cueva* and *C. reyesi* have been synonymized under *C. bandida* (Paquin et al. 2008; Paquin and Dupérré 2009; BCP 2016).

[2] *Cicurina ellioti* was originally listed as a SOC (RECON and USFWS 1996); however, this species has been synonymized with *C. buwata* (Cokendolpher 2004), which currently is not listed as a SOC (BCP 2016).

[3] *Cicurina reddelli* and *C. wartoni* have been synonymized under *C. travisae* (Hedin 2015; BCP 2016)

[4] *Tayshaneta concinna* and *T. devia* were originally listed in the BCCP (RECON and USFWS 1996) under the genus *Neoleptoneta*; however, recent studies revised *Neoleptoneta*, thus placing these species in the genus *Tayshaneta* (Campbell et al. 2012; BCP 2016).

[5] *Tartarocreagris reddelli* was originally listed as a SOC (RECON and USFWS 1996); however, this species has been synonymized with *T. infernalis* (Muchmore 2001), which currently is not listed as a SOC (BCP 2016).

Methods

Services completed in this reporting period (October 2022 – September 2023) included reconnaissance and prioritization of potential karst features, karst invertebrate habitat assessments, feature excavation, biological surveys, and cave mapping. Fieldwork occurred on the following dates: 6 & 8 December 2022, 4 January 2023, 24 August 2023, and 1 & 15 September 2023. Habitat assessments, excavations, and specimen collections were conducted by a crew of two to four of the following scientists under USFWS 10(a)(1)(A) permit ESPER0003024: Liza Colucci, Aubri Jenson, Krista McDermid, Kara Posso, Peter Sprouse; Ethan Perrine with ESPER1906200; and with technical field assistance from Lucas Pustka and Jessica Gordon. Cave mapping was done using a DistoX2 and Topodroid mobile phone application.

Prioritization of Karst Features

Given the time and personnel allocated for this investigation, the established goal was to evaluate as many karst features as possible by first focusing on those designated as high priority, followed by those designated as secondary priority features. Prioritization of features for excavation, mapping, and biological survey was established using the results of previously submitted technical reports (ZARA 2017, 2020, 2022) and refined based on ease of access, estimated time of excavation effort, probability of reaching potential habitat, weather considerations, and input from the County. For example, large features that likely provide karst invertebrate habitat but required considerable excavation effort were deprioritized compared to those that could be easily excavated and evaluated for the presence of habitat. Newly discovered features were given priority over previously surveyed features unless their habitat potential was deemed very low. Notably, the recently acquired Flying K tract was added to the scope of fieldwork this year and involved revisits to caves previously recommended for additional biological survey and/or excavation. Potential karst features in the Flying K tract were assessed by a visual review of LIDAR-derived digital elevation models (DEM). Point locations were compared to previously evaluated feature locations to reduce duplication of effort and were then verified or ruled out by field visits.

Karst Invertebrate Habitat Determinations

Karst features were evaluated by Zara scientists holding a valid USFWS 10(a)(1)(A) permit (ESPER0003024) covering endangered karst invertebrate species to determine the features' potential to contain suitable habitat for karst invertebrate species. Where necessary, scientists performed reconnaissance excavation to remove loose fill from features and subsequently characterized them based on recommendations contained in USFWS (2022) and paraphrased below. If any of the following criteria were met, the feature was considered potential habitat, subjected to reconnaissance excavation (where applicable), and evaluated for potential to lead to a void:

- Feature contains leaf litter, loose modern soils, and a few rocks;
- Feature exhibits airflow;
- Feature displays channelized recharge of water;

- Feature exhibits collapse development;
- Feature contains loose fill to a depth of at least 30 cm (1 ft);
- Feature contains clean-washed rocks at its base; or
- Feature contains *Ceuthophilus cunicularis* cave crickets, *Cicurina varians* spiders, or other cave-adapted species.

The USFWS (2022) provides additional criteria for features that do not meet the above characteristics. If the evaluated karst features did not meet any of the above criteria but met at least two of the following, the feature was considered potential habitat:

- Feature developed along a fracture;
- Feature extends at least 1 m (3.3 ft) beyond the original surface expression;
- Feature similar in appearance to nearby caves in similar geologic setting; or
- A potentially humanly enterable void is visible.

Additional factors indicating potential habitat include: proximity to known endangered species caves; formation in karst zones 1 or 2; physical characteristics indicative of a cave; presence of artificial fill material; presence of roots/soil in the feature; proximity to fault, photolineament, or an area with high fracture density; or vegetation known to preferentially grow in cave or karst feature entrances.

Five characteristics of features not likely to contain suitable habitat were also considered. These characteristics provided by USFWS (2022) are paraphrased here:

- All or nearly all of the interior surfaces covered with calcite speleothems;
- Absence of cave-adapted species;
- Features are dry or do not have evidence of modern water flow;
- Absence of airflow; and
- Feature not formed by a collapse or related to a collapse.

In some cases, evaluation of potential habitat via excavation was recommended. All excavations were performed by or under the direct supervision of a scientist holding a valid USFWS 10(a)(1)(A) permit. Features were excavated until one of the following was encountered:

- Suitable habitat (i.e., cave passage) for sampling karst invertebrate species;
- A distinct terminus (i.e., bedrock) with no conduits;
- Packed clay with no airflow present;
- Potential archaeological or paleontological materials; or
- Continued excavation would be dangerous (due to large overhanging rocks, high levels of carbon dioxide, etc.)

Biological Surveys and Specimen Collection

Biological surveys were performed by examining visible surfaces and the undersides of rocks for the presence of karst invertebrates. Observed fauna were documented on field sheets, and

notable specimens collected for accessioning, further identification, and/or museum curation. Collected specimens were retained by the County for further taxonomic studies.

Results

Visual review of LIDAR-derived imaging identified 27 potential karst features on the Flying K and Kotrla tracts within the Kotrla Unit. Six of these points matched locations of features previously reported by the County and were eliminated. The remaining twenty-one potential karst features were determined to be non-karst depressions, and many were the result of ground disturbance, either from animal or human activity (i.e., burrows, mounds, ditches, etc.).

Seven features identified by Travis County were evaluated on the Scott & White tract (SW-29, SW-30, SW-31, SW-32, SW-33, SW-34, and SW-35) (**Error! Reference source not found.**). Four of these features qualified as a cave, defined as a humanly enterable void (SW-29, SW-30, SW-32, and SW-33), but only one was extensive enough to require mapping (SW-32 [Devil's Lair Cave]). All seven features met initial criteria for potential habitat; however, SW-35 was ruled out after preliminary excavation. Timed biological surveys were conducted on all features assessed to be potential habitat. Biological surveys were also conducted at SW-27 (Artificial Intelligence Cave) which was evaluated by ZARA in 2022 and recommended for additional sampling.

On the Flying K tract, biological collections were performed at FK-1, FK-2, FK-4, and FK-32 (Flying Kave), which were evaluated by ZARA in 2020, prior to the County's acquisition of the tract (ZARA 2020) and recommended for further work. While there was abundant cave fauna in all these features, no listed species or SOC were detected, and no collections were made. Excavation was performed on one feature, FK-1.

Visual review of Lidar-derived imaging identified 27 potential karst features on the Flying K and Kotrla tracts within the Kotrla Unit. Six of these points matched locations of features previously reported by Travis County and were eliminated. Reconnaissance of the remaining twenty-one potential karst features occurred on 15 September 2023. All these points were determined to be non-karst depressions, and many were the result of ground disturbance, either from animal or human activity (i.e, burrows, mounds, ditches, etc).

A summary of work by feature is presented in Table 2. Potential habitat parameters indicating the need for additional assessment via excavation and/or karst fauna surveys are described in Table 3. Descriptions of the newly evaluated features are provided after Table 3, followed by descriptions of work at previously known features. A summary of biological collections on the Kotrla Unit to date and a discussion of taxonomic identification is included as Appendix A. Results of genetic analysis for taxonomic identification are included as Appendix B.

Table 2. Summary table of features visited October 2022 – September 2023.

Feature Name	Feature Type	Evaluated in 2023	Excavated in 2023	Cave Adapted Species [Specimen ID, if collected]
SW-29 [1] (Rocky Top)	Cave	Y	N	*Ceuthophilus cunicularis, Ceuthophilus secretus, Leibonum townsendi*
SW-30[1] (Middle of Nowhere)	Cave	Y	Y	*Ceuthophilus cunicularis*
SW-31[1] (Downspout)	Solution Cavity	Y	N	None observed
SW-32[1] (Devil's Lair Cave)	Cave	Y	Y	*Agyneta, Aphrastochthonius* sp. [ZARA 14488], *Batrisodes reyesi* [ZARA 14481], *Cambala* sp., *Cicurina* sp. [ZARA 14478], *Cicurina varians,* Collembola*, Eidmanella* sp.*, Leibonum townsendi, Speodesmus, Stygobromus russelli* [ZARA 14480]
SW-33[1] (Unforeseen)	Cave	Y	N	*Ceuthophilus cunicularis, Ceuthophilus secretus, Leibonum townsendi*
SW-34[1]	Solution Cavity	Y	N	*Leibonum townsendi*
SW-35[1]	Sinkhole	Y	Y	None observed
FK-1[2]	Cave	N	Y	*Cicurina* sp. [collected, but not yet accessioned], *Leibonum townsendi*
FK-2[2]	Cave	N	N	*Ceuthophilus secretus, Cicurina varians, Collembola, Leibonum townsendi*
FK-4[2]	Cave	N	N	*Cicurina varians, Collembola, Leibonum townsendi, Scutigeridae*
FK-32[2] (Flying Kave)	Cave	N	N	*Cambala* sp.*, Ceuthophilus cunicularis, Ceuthophilus secretus, Cicurina* sp.*, Collembola, Eidmanella* sp.*,* Lithobiomorpha
SW-27[2] (Artificial Intelligence Cave)	Cave	N	N	*Batrisodes sp., Cicurina sp.*

[1]Priority feature identified by Travis County, [2] Priority cave identified by Zara

Table 3. Summary table of USFWS (2022) conditions indicating potential habitat for newly discovered features evaluated October 2022 – September 2023.

Feature Name	Potential habitat if feature meets any one criterion							Potential habitat if feature meets at least two criteria				Not Habitat if all conditions are met				
	Leaf litter, modern soil, rocks	Airflow	Channelized recharge	Collapse development	Loose fill ≥30 cm	Clean washed rocks	Cave fauna	Developed along fracture	Extends ≥ 1 m	Similar to nearby caves	Enterable void	All surfaces calcite	No cave fauna	No evidence of water flow	No airflow	Not related to collapse
SW-29 (Rocky Top)	X						X		X	X	X				X	X
SW-30 (Middle of Nowhere)	X						X	X	X	X	X				X	X
SW-31 (Downspout)	X								X	X					X	X
SW-32 (Devil's Lair Cave)	X	X					X	X	X	X	X					X
SW-33 (Unforeseen)							X	X	X	X				X	X	X
SW-34							X		X	X				X	X	X
SW-35	X			X									X	X	X	

Feature Descriptions of Newly Evaluated Features

Feature SW-29 (Rocky Top); Cave

Feature SW-29 is a small cave located in the west central area of the Scott & White Tract (Table 4; Figure 1 – Figure 4). The feature was previously reported by the County and flagged for evaluation. The cave was situated in a sinkhole with a diameter of about 2 m and had an entrance approximately 0.5 m wide by 0.6 m long. The overall dimensions of the cave were 1.5 m wide by 2.5 m long and 2.6 m deep. The feature appeared to be developed along a fracture with the general orientation of 80°. The interior substrate of the feature consisted of loose limestone cobbles and gravel, modern organic soil, and leaf litter. Feature SW-29 met the initial criteria for potential habitat (Table 3), indicating that biological sampling is appropriate. Excavation could be done but remains medium priority due to no visible continuation and lack of airflow. Timed biological surveys were conducted on 8 December 2022. Troglobitic fauna were observed, but no listed species were detected. Fauna surveys are recommended to continue with medium priority.

Table 4. Feature SW-29 assessment.

Assessment date	Dimensions (meters)			Airflow	Sediment	Fauna Observed/ Comments
	X	Y	Z			
8 December 2022	1.5	2.5	2.6	N	Modern organic soil, leaf litter, and rocks	*Ceuthophilus cunicularis, Ceuthophilus secretus, Leibonum townsendi*



Figure 1. Feature SW-29 (Rocky Top) was a small cave in a sinkhole.



Figure 2. Feature SW-29 was developed along a fracture.



Figure 3. The interior of Feature SW-29 contained numerous *Leibonum townsendi.*

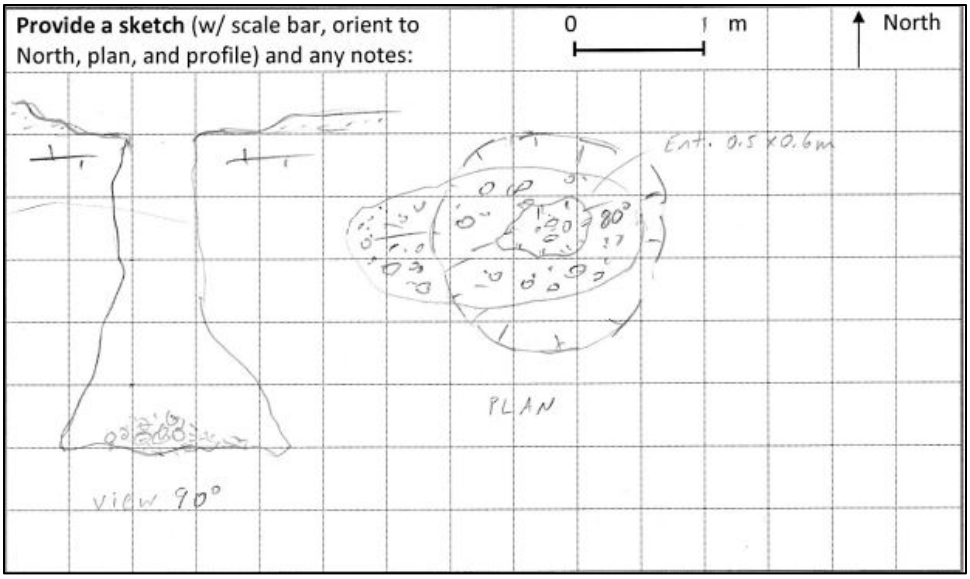


Figure 4. Field sketch of Feature SW-29.

Feature SW-30 (Middle of Nowhere); Cave

Feature SW-30 is a small cave located in the west central area of the Scott & White Tract (Table 5; Figure 5 – Figure 9). The feature was previously reported by the County and flagged for evaluation. The cave was situated in a sinkhole with a diameter of about 3 m and had an entrance approximately 1 m in diameter. The overall dimensions of the cave were 1.5 m wide by 3.0 m long and 2.0 m deep. The feature appeared to be developed along a fracture with the general orientation of 80°. The interior substrate of the feature consisted of loose limestone cobbles and gravel, modern organic soil, and leaf litter. Feature SW-30 met the initial criteria for potential habitat (Table 3), indicating that biological sampling is appropriate. Preliminary excavation for 160 person-minutes was performed on 4 January 2023, removing loose rocks and a boulder from the entrance to reveal a mesocavernous drain in bedrock. Timed biological surveys were conducted on 4 January 2023. Troglobitic fauna were observed, but no listed species were detected.

Table 5. Feature SW-30 assessment.

Assessment date	Dimensions (meters)			Airflow	Sediment	Fauna Observed/ Comments
	X	Y	Z			
4 January 2023	1.5	3.0	2.0	N	Modern organic soil, leaf litter, and rocks	*Ceuthophilus cunicularis*



Figure 5. Feature SW-30 (Middle of Nowhere) prior to excavation.



Figure 6. A boulder was removed from the entrance of Feature SW-30.



Figure 7. The entrance to Feature SW-30 after excavation.



Figure 8. Feature SW-30 continues as a mesocavernous drain in bedrock.

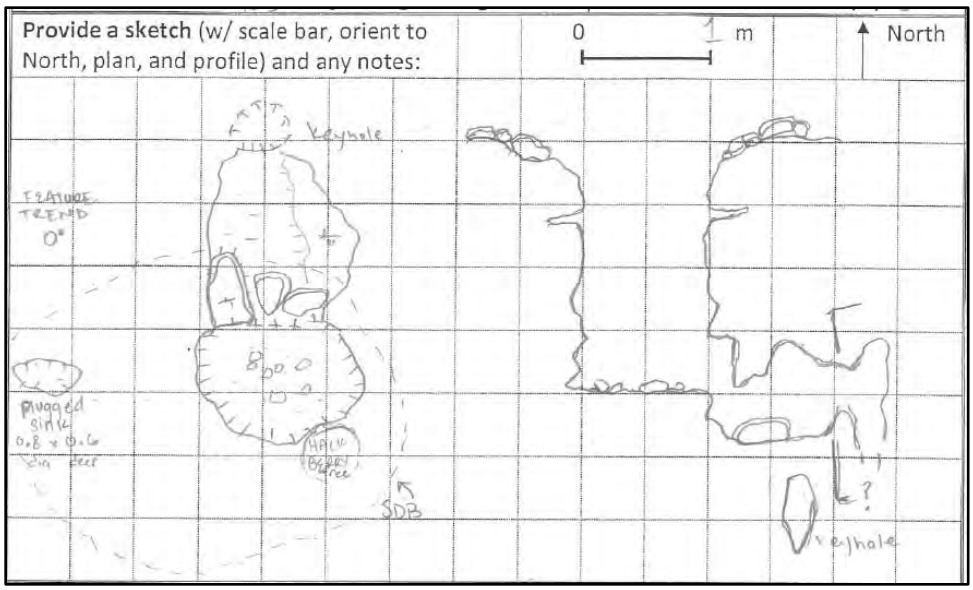


Figure 9. Field sketch of feature SW-30.

Feature SW-31 (Downspout); Solution cavity

Feature SW-31 is a solution cavity near the center of the Scott & White Tract (Table 6; Figure 10 – Figure 12). The feature was previously reported by the County and flagged for evaluation. The solution cavity has an entrance approximately 0.4 m wide by 0.5 m long and trends downward at least 8 m before opening into a low horizontal bedding plane; the full extent was not observable due to a very tight entrance. The interior substrate of the feature consisted of loose limestone cobbles and gravel, modern organic soil, and leaf litter. Feature SW-31 met the initial criteria for potential habitat (Table 3), indicating that biological sampling is appropriate. Excavation could be done but remains low priority due to the extensive effort required to enlarge the entrance and lack of airflow. Biological surveys were not conducted; no troglobitic fauna were observed in the feature at the time of evaluation. Biological survey is recommended by trapping, with a medium priority.

Table 6. Feature SW-31 assessment.

Assessment date	Dimensions (meters)			Airflow	Sediment	Fauna Observed/ Comments
	X	Y	Z			
8 December 2022	0.4	0.5	Unk.	N	Modern organic soil, leaf litter, and rocks	None observed



Figure 10. Feature SW-31 (Downspout) is a solution cavity with a small entrance.



Figure 11. The full extent of Feature SW-31 was not assessed.

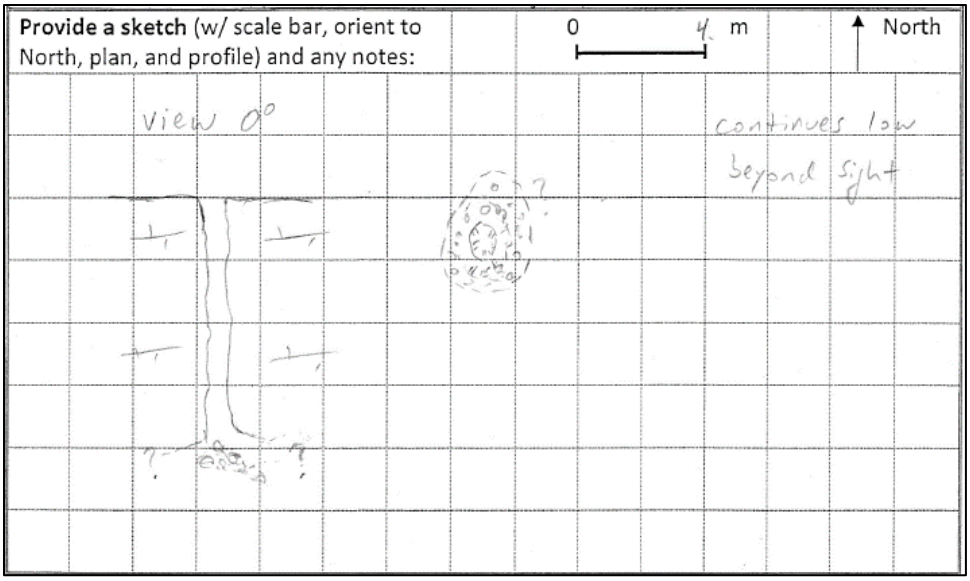


Figure 12. Field sketch of Feature SW-31.

Feature SW-32 (Devil's Lair Cave); Cave

Feature SW-32 is a large cave located in the central area of the Scott & White Tract (Table 7; Figure 13 – Figure 16). The feature was previously reported by the County and flagged for evaluation. There was evidence that this cave had been visited by previous explorers, as a ladder and mud sculptures were present. The cave was situated in a drainage that also contains SW-27 (Artificial Intelligence Cave) described in a previous report (ZARA 2022). The cave entrance consisted of two adjacent pits approximately 1.5 m in diameter and 5 m deep, requiring rope access. The surveyed length of the cave was 140.3, the maximum passage width was approximately 5 m, and the maximum depth was 15.2 m. The cave appeared to be guided by fractures at orientations of 0° and 285°. The interior substrate of the feature consisted of loose limestone cobbles, modern organic soil, and leaf litter near the entrance, and bedrock, flowstone, and clay throughout the remainder of the cave. Feature SW-32 met the initial criteria for potential habitat (Table 3), indicating that biological sampling is appropriate. Excavation was performed on 4 January 2023, removing a clay obstruction from a side passage, and revealing a north-south trending room approximately 4 m wide by 10 m long with steeply sloping walls and a thick clay floor. Additional excavation was attempted on 15 September 2023 but CO2 concentrations in excess of 40,000 ppm (4%) prohibited safe entry. Excavation is recommended to continue in early 2024, when air quality is expected to improve with lower temperatures. Timed biological surveys were conducted on 6 and 8 December 2022, 4 January 2023, and 1 September 2023. Devil's Lair is habitat for a variety of fauna, including salamanders, snakes, rodents, and bats. Tricolored bats (*Perimyotis subflavus)*, which were proposed for Federal endangered species listing in September 2022, were observed hibernating on cave walls in December 2022 and January 2023. Troglobitic fauna were observed, and several were collected for taxonomic identification (Appendix A and Appendix B). Fauna surveys are recommended to continue with high priority. A map of the cave is provided as Figure 18.

Table 7. Feature SW-32 assessment.

Assessment date	Dimensions (meters)			Airflow	Sediment	Fauna Observed/ Comments
	X	Y	Z			
6 December 2023	5.0	140.3	15.2	N	Flowstone, bedrock, clay, modern organic soil, leaf litter, and rocks	*Agyneta* sp., *Aphrastochthonius* sp. [ZARA 14488], *Batrisodes reyesi* [ZARA 14481], *Cambala* sp., *Cicurina sp.* [ZARA 14478], *Cicurina varians,* Collembola, *Eidmanella* sp., *Leibonum townsendi, Speodesmus* sp., *Stygobromus russelli* [ZARA 14480]



Figure 13. SW-32 (Devil's Lair Cave) had a two-pit entrance requiring rope access.



Figure 14. The interior passages of Feature SW-32 contained bedrock, flowstone, and clay.



Figure 15. Excavation in Feature SW-32 removed a clay plug from a side passage.



Figure 16. A southward trending room was uncovered by excavation in Feature SW-32.



Figure 17. Feature SW-32 is habitat for the Tricolored bat *(Perimyotis subflaus).*

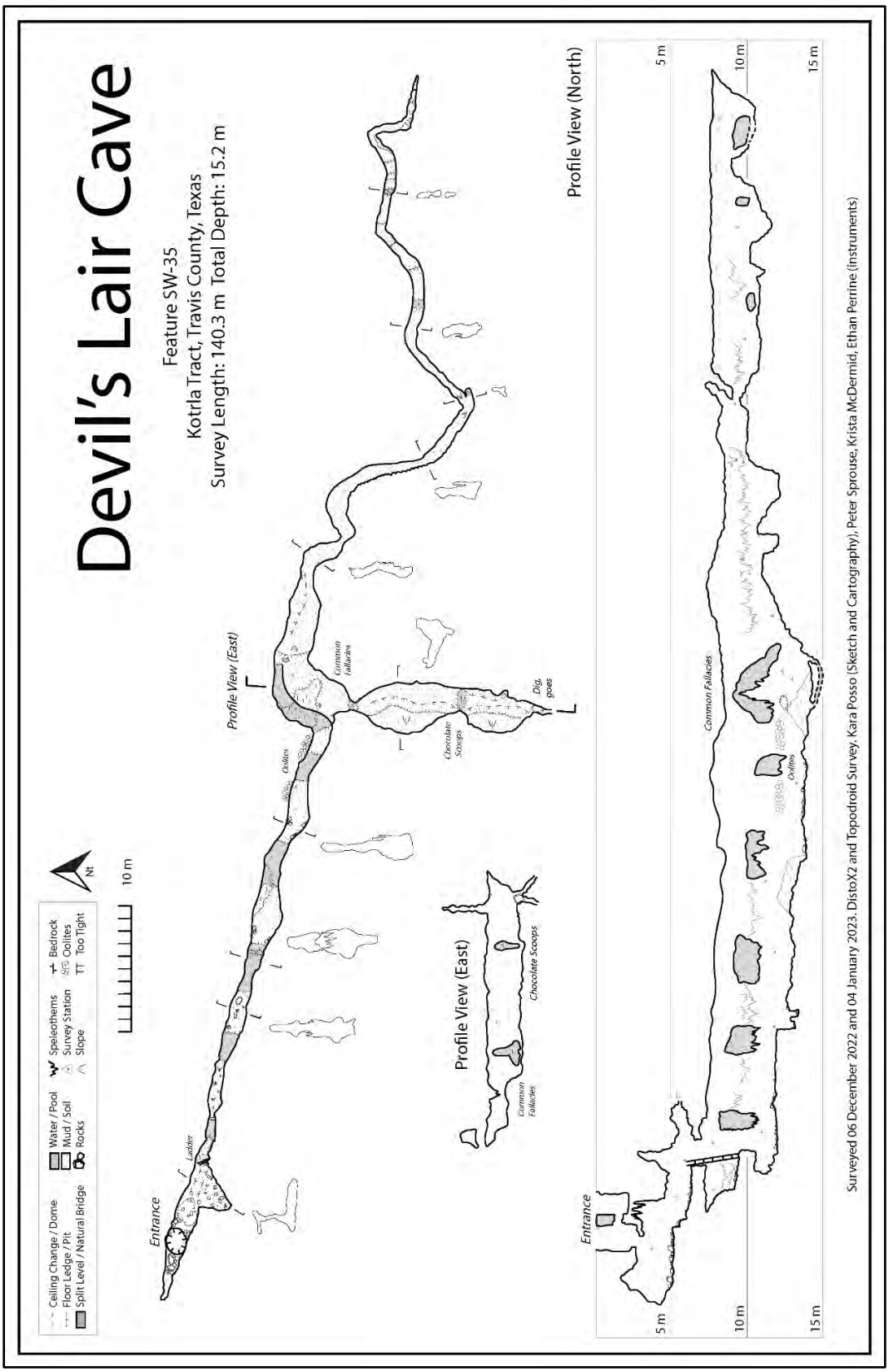


Figure 18. Map of SW-32 (Devil's Lair Cave).

Feature SW-33 (Unforeseen); Cave

Feature SW-33 is a small cave located in the eastern area of the Scott & White Tract (Table 8; Figure 19 – Figure 21). The feature was previously reported by the County and flagged for evaluation. The cave had an entrance approximately 0.4 m in diameter, and continued as a narrow pit to a depth of 5.6 m. The feature was developed along a fracture with a trend of 175°. The interior contained modern soil, leaf litter, and rocks. Feature SW-33 met the initial criteria for potential habitat (Table 3), indicating that biological sampling is appropriate. Excavation could be done but remains low priority due to the extensive effort required to enlarge the entrance and lack of airflow. Biological surveys were not conducted, although troglobitic species were observed within the feature at the time of evaluation. Biological survey is recommended by trapping with a medium priority.

Table 8. Feature SW-33 assessment.

Assessment date	Dimensions (meters)			Airflow	Sediment	Fauna Observed/ Comments
	X	Y	Z			
8 December 2022	0.4	0.4	5.6	N	Modern organic soil, leaf litter, and rocks	*Ceuthophilus cunicularis, Ceuthophilus secretus, Leibonum townsendi*



Figure 19. Feature SW-33 was a cave with a very small entrance.



Figure 20. Feature SW-33 continued as a narrow pit.

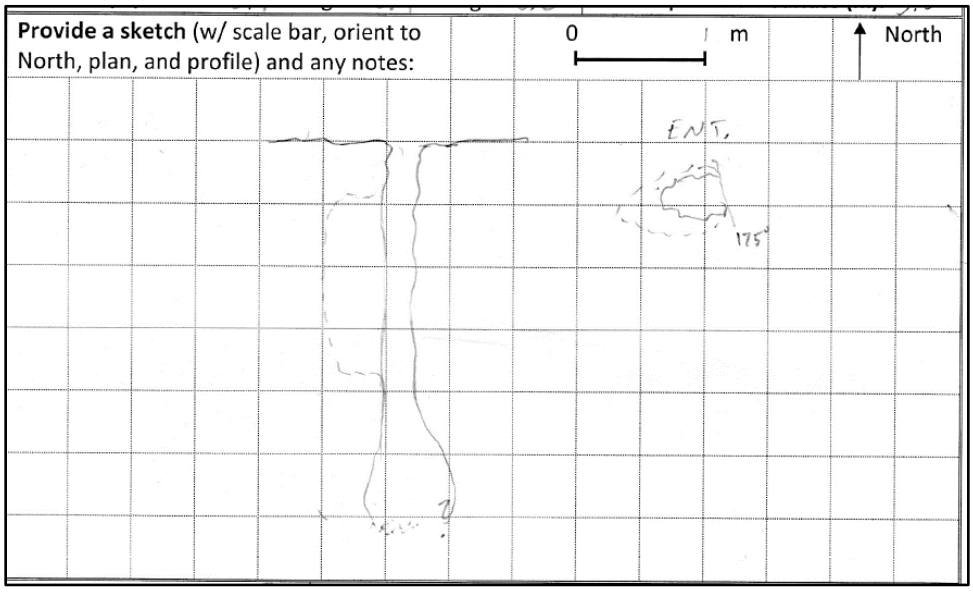


Figure 21. Field sketch of Feature SW-33.

Feature SW-34; Solution cavity

Feature SW-34 is a solution cavity located near the center of the Scott & White Tract (Table 9; Figure 22 – Figure 24). The feature was previously reported by the County and flagged for evaluation. The solution cavity had an entrance approximately 0.3 m in diameter and continued as a narrow pit to a depth of 3.2 m. The feature appeared to bell out near the bottom to a maximum width of 0.5 m. The interior of Feature SW-34 contained modern soil, leaf litter, and

rocks. Feature SW-34 met the initial criteria for potential habitat (Table 3), indicating that biological sampling is appropriate. Excavation could be done but remains low priority due to the extensive effort required to enlarge the entrance and lack of airflow. Biological surveys were not conducted, although troglobitic species were observable within the feature at the time of evaluation. Biological survey is recommended using passive detection by trapping, with a medium priority.

Table 9. Feature SW-34 assessment.

Assessment date	Dimensions (meters)			Airflow	Sediment	Fauna Observed/ Comments
	X	Y	Z			
15 September 2023	0.5	0.5	3.2	N	Modern organic soil, leaf litter, and rocks	*Leibonum townsendi*



Figure 22. Feature SW-34 was a solution cavity.



Figure 23. The interior of Feature SW-34 contained organic soil, leaf litter, and rocks.

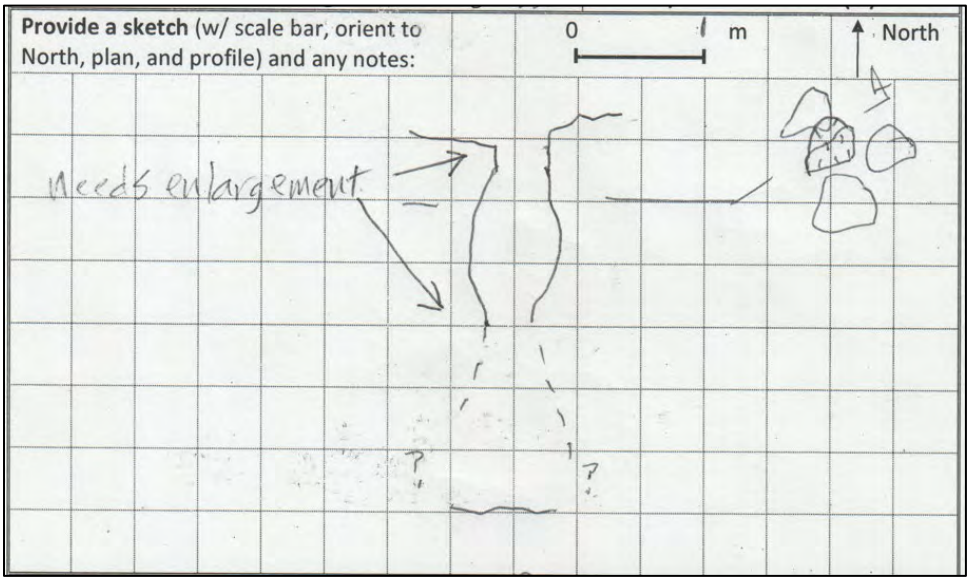


Figure 24. Field sketch of Feature SW-34.

Feature SW-35; Sinkhole

Feature SW-35 is a sinkhole located near the eastern edge of the Scott & White Tract (Table 10; Figure 25 – Figure 27). The feature was previously reported by the County and flagged for evaluation. The sinkhole had a diameter of approximately 10 m and a depth of 1.5 m. A soil drain was visible at the center of the sinkhole. The interior of Feature SW-35 contained modern soil, leaf litter, and rocks. Feature SW-35 met the initial criteria for potential habitat (Table 3);

however, preliminary excavation for 30 person-minutes revealed thick organic soil and boulders and no sampleable habitat. No further excavation is recommended due to low potential to encounter sampleable habitat. No troglobitic fauna were observed during excavation, and no additional biological surveys are recommended.

Table 10. Feature SW-35 assessment.

Assessment date	Dimensions (meters)			Airflow	Sediment	Fauna Observed/ Comments
	X	Y	Z			
8 December 2022	10	10	1.5	N	Modern soil, leaf litter, rocks	None observed



Figure 25. Feature SW-35 was a sinkhole with a soil drain.



Figure 26. Preliminary excavation of Feature SW-35 revealed no sampleable habitat.

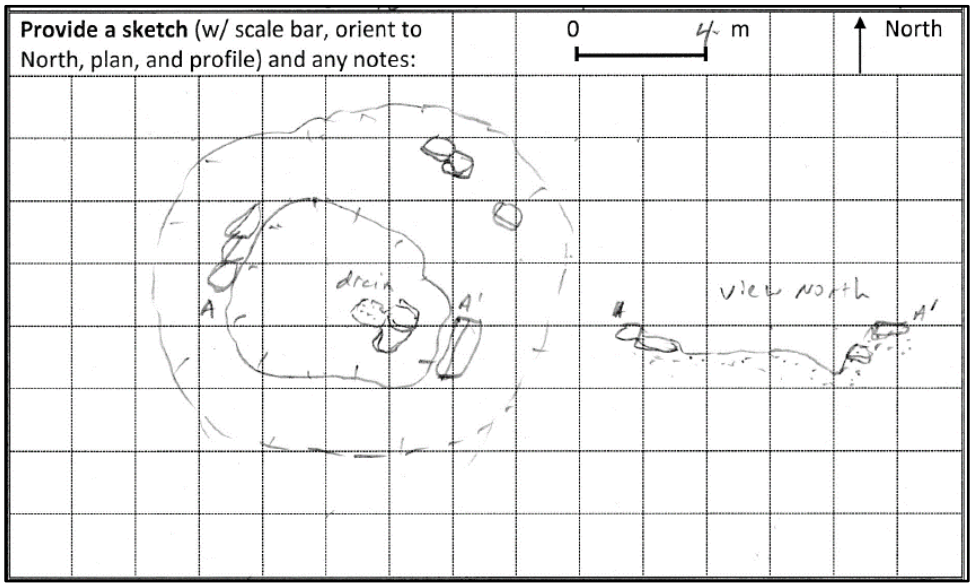


Figure 27. Field sketch of Feature SW-35.

Description of Work Completed at Previously Evaluated Features

Feature FK-1; Cave

Feature FK-1 is a cave located on the southwestern edge of the Flying K Tract. The feature was previously evaluated by Zara in 2020 and recommended for additional biological surveys and excavation. Timed biological surveys were conducted on 1 September 2023 for 60 person-

minutes. Cave temperature was 31°C (88°F) and relative humidity was 61%. Troglobitic fauna were observed, but no listed species were detected (Table 11). Airflow was noted from a soil drain and a field crew returned for excavation on 15 September 2023 (Figure 28 – Figure 30). Approximately 0.4 m^3 (14 ft^3) of organic soil and rock fragments were removed during 360 person-minutes of effort. An enterable lower level was uncovered with a terminus consisting of loose rocks and soil. Enlargement using a jackhammer is recommended to enable further excavation. The continued effort is estimated to be 1 to 2 days of digging, with high priority due to air flow.

Table 11. Summary of fauna observations at FK-1.

Common Name	**Lowest Taxonomic Identification**
Snail	Gastropoda
Spider	Aranea
Harvestmen	*Leiobunum townsendi*
Cave Meshweaver	*Cicurina sp.*
Woodlice	Armadillidae
Bristletail	Dipluran
RIFA	*Solenopsis invicta*



Figure 28. Excavation was performed following airflow in Feature FK-1.



Figure 29. An enterable lower level was uncovered in Feature FK-1.



Figure 30. The terminus of Feature FK-1 contained loose rocks and soil.

Feature FK-2; Cave

Feature FK-2 is a cave located near the center of the Flying K Tract. The feature was previously evaluated by Zara in 2020 and recommended for additional biological surveys and excavation. Timed biological surveys were conducted on 1 September 2023 for 70 person-minutes. Cave temperature was 31°C (88°F) and relative humidity was 61%. Troglobitic fauna were observed, but no listed species were detected (Table 12). Of note, nearly all harvestmen had ectoparasitic mites. Excavation was not done due to time constraints; excavation will require boulder removal to increase access to the lower level. The continued effort is estimated to be 1 to 2 days of digging, with medium priority due to very low cave ceilings and tapering passage.

Table 12. Summary of fauna observations at FK-2.

Common Name	**Lowest Taxonomic Identification**
Springtail	Collembola
Slender springtail	*Pseudosinella*
Spider	Aranea
Mite	*Laelapidae*
Rove beetle	*Staphylinidae*
Harvestmen	*Leiobunum townsendi*
Cave meshweaver	*Cicurina varians*
Cave cricket	*Ceuthophilus (nymph)*
Field cricket	*Gryillidae*
Bristletail	Dipluran
RIFA	*Solenopsis invicta*
Cliff chirping frog	*Eleutherodactylus*

Feature FK-4; Cave

Feature FK-4 is a cave located in the northwest portion of the Flying K Tract. The feature was previously evaluated by Zara in 2020 and recommended for additional biological surveys. Timed biological surveys were conducted on 1 September 2023 for 50 person-minutes. Cave temperature was 31°C (88°F) and relative humidity was 61%. Troglobitic fauna were observed, but no listed species were detected (Table 13). No excavation is recommended due to low potential for continuation.

Table 13. Summary of fauna observations at FK-4.

Common Name	**Lowest Taxonomic Identification**
Springtail	Collembola
Spider	Aranea
House centipede	Scutigeridae
Roach	Blattaria
Beetle	Coleoptera
Harvestmen	*Leiobunum townsendi*
Cave meshweaver	*Cicurina varians*
Cave cricket	*Ceuthophilus secretus*
Garter snake	*Thamnophis* sp.

Feature FK-32 (Flying Kave); Cave

Feature FK-32 is a cave located at the northwest edge of the Flying K Tract. The feature was previously evaluated by Zara in 2020 and recommended for additional biological surveys. Timed biological surveys were conducted on 24 August 2023 for 270 person-minutes. Cave temperature and humidity were not recorded at the time of survey. Troglobitic fauna were observed, but no listed species were detected (Table 14). No excavation is recommended due to already easily sampleable habitat.

Table 14. Summary of fauna observations at FK-32.

Common Name	**Lowest Taxonomic Identification**
Compound coil snail	*Helicodiscus*
Springtail	Collembola
Mite	Laelapidae
Roach	Blattaria
Flea	Siphonaptera
Beetle	Coleoptera
Rove beetle	Staphylinidae
Millipede	*Cambala* sp.
Centipede	Lithobiomorpha
Bark scorpion	*Centruroides vittatus*
Harvestmen	*Leiobunum townsendi*
Cave meshweaver	*Cicurina* sp.
Scaffold web spider	*Eidmanella* sp.
Celler spider	Pholcidae
Cave cricket	*Ceuthophilus secretus*
Cave cricket	*Ceuthophilus cunicularis*
Ant	Formicidae
Mosquito	Culicidae
Western narrow-mouthed toad	*Gastrophryne olivacae*

Feature SW-27 (Artificial Intelligence Cave); Cave

Feature SW-27 is a cave located in the north-central portion of the Scott & White Tract. The feature was previously evaluated by Zara in 2022 and recommended for additional biological surveys. Timed biological surveys were conducted on 1 September 2023 for 114 person-minutes. Near the cave entrance, the temperature was 34°C (93°F) and relative humidity was 55%. Further into the cave, the temperature was 27°C (81°F) and relative humidity was 64%. Troglobitic fauna were observed, but no listed species were detected (Table 15). Evidence of porcupines and mice was also observed. No excavation is recommended due to already easily sampleable habitat.

Table 15. Summary of fauna observations at SW-27.

Common Name	Lowest Taxonomic Identification
Compound coil snail	*Helicodiscus*
Mite	*Laelapidae*
Darkling beetle	*Tenebrionidae*
Rove beetle	*Staphylinidae*
Armored millipede	*Polydesmus*
Harvestmen	*Leiobunum townsendi*
Fungus moth	Tineidae
Cliff chirping frog	*Eleutherodactylus*
Western narrow-mouthed toad	*Gastrophryne olivacae*

Recommendations

Seven features previously identified by the County were evaluated for potential karst invertebrate habitat during this investigation on the Kotrla Unit. All features met the initial criteria for habitat as provided by USFWS (2022). The highest priority for continued biological surveys is Devil's Lair Cave due to the diversity of fauna and potential for listed or undescribed troglobitic species. The remaining enterable features (Rocky Top [SW-29], Middle of Nowhere [SW-30], and Unforeseen [SW-33]), should be given medium priority over the less easily enterable features (Downspout [SW-31] and SW-34) as timed searches allow for more thorough sampling. However, passive sampling with traps can be done in all features and is recommended for the next field effort. No sampling is recommended at SW-35 due to a lack of sampleable habitat. Black plastic should be placed over the entrance of features to stabilize the temperature and humidity prior to future fauna surveys.

Three of the newly evaluated features were excavated during this effort. Excavation was completed at SW-30 to enable human entry, but additional excavation is not recommended as the continuation appears small and lacks airflow. Excavation in Devils Lair Cave is recommended to evaluate the full extent of the side passage uncovered on 4 January 2023. However, very high CO_2 concentrations (40,000+ ppm) were measured in Devil's Lair Cave on 15 September 2023. Work in this cave should be done during winter months to ensure adequate air quality, and a CO_2 meter should be carried by any team entering the cave. Excavation was completed at SW-35 to evaluate the full extent of the feature and found no indication of sampleable habitat; no further excavation is recommended. Of the remaining features, only SW-29 holds medium priority for excavation to clear out loose rocks that may be obscuring continuation. All other features are ranked low priority due to the extensive effort required to enlarge the entrances in bedrock with limited potential for the continuation of enterable passage.

Five previously described features were revisited during this effort for biological surveys and/or excavation. Biological surveys were conducted at FK-1, FK-2, FK-4, FK-32 (Flying Kave) and SW-27 (Artificial Intelligence Cave). The highest priority for biological sampling is Artificial Intelligence Cave due to potential for listed or undescribed troglobitic species. The other features have medium priority due to species richness. FK-1 was excavated, revealing a small continuation in bedrock. Further excavation with a jackhammer is recommended with high priority to enable access to enterable void space, with an estimated 1 to 2 days of effort. Excavation is also recommended with medium priority to enlarge the entrance at FK-2, with an estimated 1 to 2 days of effort.

A summary of the above results and recommendations is provided in Table 16.

Table 16. Summary table of results and recommendations.

Feature Name	Excavated?	Fauna Surveyed?	Future Excavation Recommended? (priority)	Future Karst Fauna Surveys Recommended? (priority)
SW-29 (Rocky Top)	N	Y	Y - Medium	Y - Medium
SW-30 (Middle of Nowhere)	Y	Y	Y - Low	Y - Medium
SW-31 (Downspout)	N	N	Y - Low	Y - Low
SW-32 (Devil's Lair Cave)	Y	Y	Y - High	Y - High
SW-33 (Unforeseen)	N	Y	Y - Low	Y - Medium
SW-34	N	N	Y - Low	Y - Low
SW-35	Y	N	No	No
FK-1	Y	Y	Y - High	Y - High
FK-2	N	Y	Y - Medium	Y - Medium
FK-4	N	Y	N	Y - Medium
FK-32 (Flying Kave)	N	Y	N	Y - Medium
SW-27 (Artificial Intelligence Cave)	N	Y	N	Y - High

References

Balcones Canyonlands Preserve (BCP). 2016. Balcones Canyonlands Preserve Land Management Plan; Tier II-A, Chapter 1X Karst Species Management. March 2016. Austin, TX.

Campbell, J., Cokendolpher, J., Griswold, C., Ledford, J., and P. Paquin. 2012. Systematics, conservation and morphology of the spider genus *Tayshaneta* (Araneae, Leptonetidae) in Central Texas Caves. Zookeys, (167): 1-102.

Cokendolpher, J.C. 2004. *Cicurina* spiders from caves in Bexar County, Texas (Araneae: Dictynidae). Texas Memorial Museum, Speleological Monographs, 6:13-58.

Hedin, M. 2015. High-stakes species delimitation in eyeless cave spiders (Cicurina, Dictynidae, Araneae) from central Texas. Molecular Ecology 24(2): 346- 361.

Muchmore, W.B. 2001. Review of the genus *Tartarocreagris*, with descriptions of new species (Pseudoscorpionida: Neobisiidae). Texas Memorial Museum, Speleological Monographs, 5:57-72.

Paquin, P., N. Dupérré, J.C. Cokendolpher, K. White, and M. Hedin. 2008. Fundamental importance of taxonomy in conservation biology: the case of the case of the eyeless spider *Cicurina bandida* (Araneae: Dictynidae) of Central Texas, including new synonyms and the description of the male of the species. Invertebrate Systematics, 22. 11 pp.

Paquin, P., and N. Dupérré. 2009. A first step towards the revision of *Cicurina*: redescription of type specimens of 60 troglobitic species of the subgenus *Cicurella* (Araneae: Dictynidae), and a first visual assessment of their distribution. Zootaxa. 4 February 2009, pp. 1-67.

Regional Environmental Consultants (RECON) and U.S. Fish and Wildlife Service (USFWS). 1996. Final Environmental Impact Statement/Habitat Conservation Plan for proposed issuance of a permit to allow incidental take of the Golden-cheeked Warbler, Black-capped Vireo, and six karst invertebrates in Travis County, Texas (Balcones Canyonlands Conservation Plan, Permit PRT-788841). Prepared on behalf of the City of Austin and Travis County. Austin, TX.

United States Fish and Wildlife Service (USFWS). 1988. Endangered and Threatened Wildlife and Plants; Final Rule to Determine Five Texas Cave Invertebrates to Be Endangered Species. ederal Register 53: 36029-36033. 16 September 1988.

United States Fish and Wildlife Service (USFWS). 1993. Endangered and Threatened Wildlife and Plants; Coffin Cave Mold Beetle (*Batrisodes Texanus*) and the Bone Cave Harvestman (*Texella reyesi*) Determined to be Endangered. Federal Register 58: 43818-43820. 18 August 1993.

United States Fish and Wildlife Service (USFWS). 2022. Section 10(a)(1)(A) Scientific Permit Requirements for Conducting Presence/Absence Surveys for Endangered Karst Invertebrates in Central Texas. USFWS Ecological Services Field Office, Austin, Texas. Revised 27 April 2022. 24 p.

ZARA Environmental. 2017. Technical Report for Karst Management Services at the Balcones Canyonlands Preserve – Kotrla Unit, Travis County, Texas. 71 p.

ZARA Environmental. 2020. Karst Management Services for the Balcones Canyonlands Preserve Flying K Ranch, Travis County, Texas. 65 p.

ZARA Environmental. 2022. Technical Report for Karst Management Services at the Balcones Canyonlands Preserve – Kotrla Unit, Travis County, Texas. 70 p.

Appendix A. Summary of Biological Collections

ZARA
ENVIRONMENTAL LLC
Integrity | Science | Expertise
2104 Hunter Rd
San Marcos, Texas 78666
512-291-4555
www.zaraenvironmental.com

SUMMARY OF BIOLOGICAL COLLECTIONS AT THE BALCONES CANYONLANDS PRESERVE – KOTRLA UNIT, TRAVIS COUNTY, TEXAS



An eyeless pseudoscorpion in Devil's Lair Cave.

Prepared for
Travis County TNR – Natural Resources and Environmental Quality
PO Box 1748
Austin, Texas 78767

Report Prepared by: Aubri Jenson and Ethan Perrine

29 September 2023

Introduction

This appendix summarizes the fauna that have been collected during karst management activities at the Kotrla Unit conducted by Zara Environmental over the course of the management period (May 2017 to present). Twelve invertebrate specimens that were potentially a protected species, or undescribed, were sent out for taxonomic identification to aid in determining the substitution eligibility of caves or other karst features at the Kotrla Unit for the Balcones Canyonlands Conservation Plan (BCCP) Cave Substitution Policy. The taxonomy results of specimens that have been identified to species are discussed in the results section below. All Zara collections are listed in Table 1; specimens sent for taxonomic identification are emphasized in bold type.

Methods

Biological collections were conducted by Zara scientists holding a valid U.S. Fish and Wildlife Service (USFWS) 10(a)(1)(A) permit (ESPER0003024) in 2017, 2019, 2020, 2022, and 2023. Specimens were accessioned, examined under a microscope, and identified to the lowest level possible using morphometric keys. Generally, specimens were then sent to the University of Texas at Austin for curation unless otherwise requested. Selected eyeless specimens were sent to specialists for species-level identification. *Stygobromus sp.* were identified by Randy Gibson, Supervisory biologist for USFWS at the San Marcos Aquatic Resource Center, San Marcos, Texas. *Batrisodes sp*. were identified by Dr. Don Chandler, Professor of Zoology and Curator (retired) at the University of New Hampshire, Durham, New Hampshire. Pseudoscorpiones were identified by Dr. Charles Stephen, Professor of Biology at Georgia State University, Atlanta, Georgia. Genetic identification of *Cicurina sp.* was completed by Dr. Caleb Phillpis, Professor of Biology and Curator at Texas Tech University, Lubbock, Texas. Results of genetic analysis are provided as Appendix B.

Results

<u>Devil's Lair Cave</u>

SW-32 (Devil's Lair Cave) is one of the most extensive known caves on the Kotrla Unit and was the focus of much of the work done in late 2022 and 2023. The cave was mapped on 6 and 8 December 2022, with further survey on 4 January 2023 following excavation of a mud plug that opened into a large side room. Biological surveys in Devil's Lair Cave were conducted alongside mapping and excavation. Devil's Lair Cave contains suitable habitat for a broad range of species and Zara surveyors have observed bats, salamanders, mice, snakes, toads, and a diverse array of invertebrates. Among the specimens collected from Devil's Lair Cave, three amphipods identified as *Stygobromus reddelli*, one *Batrisodes reyesi*, two *Cicurina buw*ata, and one eyeless pseudoscorpion identified as *Apochthonius "n. sp. 7,"* were noteworthy and sent to specialists for taxonomic identification (Figure 1 – Figure 4).



Figure 1. *Stygobromus reddelli* [ZARA 14480] were collected from a drip pool in Devil's Lair Cave.



Figure 2. A female *Batrisodes (Excavodes) reyesi* [ZARA 14481] was collected from Devil's Lair Cave.



Figure 3. Two of the four *Cicurica sp*. [ZARA 14491] collected from Devil's Lair Cave were sent for genetic analysis and were identified as *Cicurina buwata.*



Figure 4. A pseudoscorpion collected from Devil's Lair Cave was an undescribed species *Apochthonius "n. sp. 7"* [ZARA 14488].

Artificial Intelligence Cave

Biological survey was also performed in SW-27 (Artificial Intelligence Cave), which lies within the same surface drainage basin as Devil's Lair Cave. Like Devil's Lair Cave, Artificial Intelligence Cave is a fauna rich and is habitat for rodents and porcupines, as well as salamanders, snakes, and toads. Biological collections at SW-27 included an undescribed species of pseudoscorpion, *Aphrastochthonious "n. sp. 2,"* (Figure 5) as well as other karst invertebrates including *Speodesmus sp.* millipedes and a *Batrisodes sp.* beetle that was determined to have eyes. An eyeless *Cicurina sp.* was observed and photographed but not collected (Figure 6).



Figure 5. An undescribed species of pseudoscorpion was collected from Artificial Intelligence Cave.



Figure 6. An eyeless *Cicurina* sp. was observed in Artificial Intelligence Cave.

McMac Cave

During the biological survey of the relatively large cave SW-04 (McMac Cave), Zara surveyors collected four pseudoscorpions identified as *Tartarocreagris cookei*, and one that was identified as *Aphrastochthonius "n. sp. 2."* Collections from McMac Cave also included a *Cicurina buwata*. Other notable observations included *Eidmanella sp., Rhadine sp.*

Faceplant Cave

Nearby to McMac Cave, Faceplant Cave (SW-13) produced a *Batrisodes reyesi*, despite not having a very extensive humanly accessible search area. Other notable observations included numerous *Cicurina varians* and *Staphylinidae sp.*

Puncture Pit

During the excavation of SW-16 (Puncture Pit), the removed soil was sifted for invertebrates and an accompanying survey of the excavated interior of the feature yielded many invertebrates, several of which were collected. Notably, two *Batrisodes sp.* beetles that were collected and determined to be *Batrisodes uncicornis* (Figure 7).



Figure 7. A *Batrisodes uncicornis* [ZARA 14179] was collected from Puncture Pit.

Table 1. Summary of biological collections from May 2017 to September 2023. Specimens in bold were sent to specialists for taxonomic identification to the species level.

Zara #	Feature Name	Taxa	Collection Date
09733	SW-8	*Ceuthophilus secretus* n=1	23-May-17
09734	SW-8	*Tachys* sp. n=1	23-May-17
09735	SW-8	Staphylinidae n=1	23-May-17
09737	SW-8	Coleoptera n=1	23-May-17
09982	Cave SW-3	*Batrisodes reyesi* n=1	12-Sep-17
09983	Cave SW-3	*Cicurina sp.* (eyeless) n=1	12-Sep-17
09984	Cave SW-3	*Leiobunum townsendi* n=1	12-Sep-17
09985	Cave SW-3	Coleoptera (Tachys?) n=1	12-Sep-17
10015	SW-13	*Cicurina varians* n=1	29-Jun-17
10016	SW-13	Nematomorpha n=1	29-Jun-17
10017	SW-13	Araneae n=1	29-Jun-17
10097	SW-13	Speodesmus n=1	22-Jun-17
10098	SW-13	Ceuthophilus nymph n=1	22-Jun-17
10099	SW-13	Araneae n=1	22-Jun-17
10100	SW-16	*Ceuthophilus secretus* n=1	16-Jun-17
10101	SW-16	Araneae n=1	16-Jun-17
10102	SW-16	Collembola n=2	16-Jun-17
12793	FK-32 (Flying Kave)	*Ceuthophilus secretus* n=1	12-Dec-19
12794	FK-32 (Flying Kave)	*Ceuthophilus sp.* n=1	12-Dec-19
12795	FK-32 (Flying Kave)	*Staphylinidae* n=2	12-Dec-19
12796	FK-32 (Flying Kave)	Isopods n=8	12-Dec-19
12797	FK-32 (Flying Kave)	Symphyla n=1	12-Dec-19
12798	FK-32 (Flying Kave)	Araneae n=4	12-Dec-19
12799	FK-32 (Flying Kave)	*Cicurina varians* n=1	12-Dec-19
12800	FK-2	*Ceuthophilus secretus* n=1	05-Dec-19
12801	FK-2	Pseudoscorpion n=1	05-Dec-19
12802	FK-2	Gastropoda n=13	05-Dec-19
12803	FK-2	Acari n=2	05-Dec-19
12804	FK-2	*Tibellus* sp. n=1	05-Dec-19
12805	FK-2	Araneae n=14	05-Dec-19
12806	FK-2	Oligochaeta n=1	05-Dec-19
12807	FK-2	Dipluran n=3	05-Dec-19
12808	FK-2	Ixodida n=1	05-Dec-19
12809	FK-2	Collembola n=1	05-Dec-19
12810	FK-2	*Reduviidae* n=1	05-Dec-19
12811	FK-2	Lithobiomorpha n=4	05-Dec-19
12812	FK-2	Geophilomorpha n=5	05-Dec-19

12813	FK-2	Chilopoda n=3	05-Dec-19
12814	FK-2	Isoptera n=1	05-Dec-19
12815	FK-1	*Parasteatoda sp.* n=1	02-Jan-20
12816	FK-32 (Flying Kave)	Araneae (eyed) n=8	12-Dec-19
12817	FK-32 (Flying Kave)	*Ceuthphilus cunicularis* n=1	12-Dec-19
12818	FK-32 (Flying Kave)	Cambala sp. n=3	12-Dec-19
12819	FK-32 (Flying Kave)	Coleoptera (eyed) n=2	12-Dec-19
12820	FK-32 (Flying Kave)	Lithobiomorpha n=1	12-Dec-19
12821	FK-32 (Flying Kave)	Gastropoda n=2	12-Dec-19
12822	FK-1	*Cicurina varians* n=3	17-Dec-19
12823	FK-1	Aranea (eyed) n=6	17-Dec-19
12824	FK-1	*Ceuthphilus cunicularis* n=1	17-Dec-19
12825	FK-1	*Ceuthophilus secretus* n=1	17-Dec-19
12826	FK-1	Geophilomorpha n=1	17-Dec-19
12827	FK-1	Staphylinidae n=1	17-Dec-19
12828	FK-1	Isopoda n=2	17-Dec-19
12829	FK-1	Lithobiomorpha n=1	17-Dec-19
12830	FK-1	Gastropoda n=1	17-Dec-19
12831	FK-6	*Siphonophoridae* n=1	02-Jan-20
12832	FK-2	*Cicurina sp.* (eyeless) sp. n=1	12-Dec-19
12833	FK-2	Araneae (eyed) n=1	12-Dec-19
12834	FK-2	*Staphylinidae* n=1	17-Dec-19
12835	FK-2	*Cicurina sp.* (eyeless) n=1	17-Dec-19
12836	FK-2	Araneae (eyed) n=1	17-Dec-19
12837	FK-32	Gastropoda n=1	07-Jan-20
12838	FK-32	Gastropoda n=2	07-Jan-20
12839	FK-32	Gastropoda n=1	07-Jan-20
12840	FK-32	Araneae (eyed) n=1	07-Jan-20
12841	FK-1	*Ceuthphilus cunicularis* n=1	31-Dec-19
12842	FK-1	Araneae (eyed) n=1	31-Dec-19
12843	FK-2	*Cicurina varians* n=1	31-Dec-19
12844	FK-2	Araneae (eyed) n=5	31-Dec-19
12845	FK-4	Acari n=3	31-Dec-19
12846	FK-4	Collembola n=1	31-Dec-19
12847	FK-4	Isopoda n=1	31-Dec-19
12848	FK-4	Lithobiomorpha n=1	31-Dec-19
12849	FK-4	Araneae (eyed) n=2	31-Dec-19
12904	FK-13	*Helicodiscus sp*. n=1	29-Jan-20
12905	FK-13	*Staphylinidae* n=1	29-Jan-20
12906	FK-13	*Texoreddellia sp.* n=1	29-Jan-20
12907	FK-13	Coleoptera n=1	29-Jan-20

12908	FK-13	*Cicurina varians* n=3	29-Jan-20
12909	FK-13	Araneae (eyed) n=1	29-Jan-20
12910	FK-13	Coleoptera n=1	29-Jan-20
12911	FK-13	*Campodeidae* n=1	29-Jan-20
12934	FK-4	Pseudoscorpiones n=1	20-Nov-19
12935	FK-4	Pseudoscorpiones n=1	20-Nov-19
12982	FK-2	*Cicurina sp.* (eyeless) n=1	09-Jan-20
12983	FK-2	*Dictynidae* n=3	09-Jan-20
12984	FK-1	*Cicurina varians* n=1	09-Jan-20
12985	FK-1	Araneae (eyed) n=3	09-Jan-20
13758	Millipede Cave	*Tayshaneta sp.* n=1	22-Jun-21
13789	Flying K Well	Opiliones n=1	20-Nov-19
14146	SW-21 (Travis Pit)	Cicurina sp. (eyeless, female) n=1	27-Jan-22
14147	SW-21 (Travis Pit)	*Cicurina sp.* (eyed, male) n=1	27-Jan-22
14148	SW-21 (Travis Pit)	*Cicurina varians* n=1	27-Jan-22
14149	SW-21 (Travis Pit)	*Helicodiscus sp* n=1	27-Jan-22
14150	SW-21 (Travis Pit)	*Eidmannella sp*. n=1	27-Jan-22
14151	**SW-13 (Faceplant Cave)**	***Batrisodes reyesi* (female) n=1**	**10-Feb-22**
14152	**SW-4 (McMac Cave)**	***Cicurina buwata* (eyeless) n =1**	**10-Feb-22**
14153	SW-4 (McMac Cave)	*Cicurina sp.* (eyed) n=3	10-Feb-22
14154	SW-4 (McMac Cave)	*Parasteatoda sp*. n=1	10-Feb-22
14155	SW-4 (McMac Cave)	*Eidmannella sp.* (eyed) n=3	10-Feb-22
14156	**SW-4 (McMac Cave)**	***Tartarocreagris cookei* n=1**	**10-Feb-22**
14157	**SW-4 (McMac Cave)**	***Tartarocreagris cookei* n=1**	**10-Feb-22**
14158	**SW-4 (McMac Cave)**	***Tartarocreagris cookei* n=1**	**10-Feb-22**
14159	SW-4 (McMac Cave)	*Rhadine howdeni* n=1	10-Feb-22
14160	SW-4 (McMac Cave)	*Cambala sp.* n=1	10-Feb-22
14161	SW-4 (McMac Cave)	Diplura n=4	10-Feb-22
14162	SW-4 (McMac Cave)	Lithobiomorpha n=1	10-Feb-22
14163	**SW-4 (McMac Cave)**	***Tartarocreagris cookei* n=1**	**15-Feb-22**

14164	SW-4 (McMac Cave)	*Eidmannella sp.* n=4	15-Feb-22
14165	SW-4 (McMac Cave)	*Speodesmus sp.* n=1	15-Feb-22
14166	SW-4 (McMac Cave)	*Helicodiscus sp.* n=1	15-Feb-22
14167	**SW-4 (McMac Cave)**	**Aphrastochthonius "n. sp. 2" n=1**	**15-Feb-22**
14168	SW-27 (Artificial Intelligence Cave)	*Cicurina varians* n=4	15-Feb-22
14169	SW-27 (Artificial Intelligence Cave)	*Speodesmus sp*. n=2	15-Feb-22
14170	SW-27 (Artificial Intelligence Cave)	*Heliocodiscus sp.* n=2	15-Feb-22
14171	SW-27 (Artificial Intelligence Cave))	Dipluran n=1	15-Feb-22
14172	SW-27 (Artificial Intelligence Cave)	*Eidmannella sp*. n=1	15-Feb-22
14173	SW-24 (Natural Intelligence Cave)	*Ceuthophilus secretus* n=2	01-Feb-22
14174	SW-24 (Natural Intelligence Cave)	*Ceuthophilus cunicularis* n=1	01-Feb-22
14175	Flag Spring	Ostracoda n=1	27-Jan-22
14176	Flag Spring	Gastropoda (aq) n=1	27-Jan-22
14177	Flag Spring	Gastropoda (aq) n=1	27-Jan-22
14178	Flag Spring	Gastropoda (aq) n=6	27-Jan-22
14179	SW-16 (Puncture Pit)	*Batrisodes uncicornis* n=2	08-Feb-22
14180	SW-16 (Puncture Pit)	Symphyla n=2	08-Feb-22
14181	SW-16 (Puncture Pit)	Diplura n=2	08-Feb-22
14182	SW-16 (Puncture Pit)	Lithobiomorpha n=2	08-Feb-22
14183	SW-16 (Puncture Pit)	Geophilomorpha n=5	08-Feb-22
14184	Puncture Pit (SW-016)	*Staphylinidae sp*. n=3	08-Feb-22
14185	SW-16 (Puncture Pit)	*Helicodiscus sp.* n=2	08-Feb-22
14186	SW-16 (Puncture Pit)	*Cicurina varians* n=2	08-Feb-22
14187	SW-16 (Puncture Pit)	*Eidmannella sp*. n=1	08-Feb-22
14188	SW-16 (Puncture Pit)	*Agyneta sp*. n=1	08-Feb-22

14350	SW-011	*Cicurina sp.* (eyed) n=1	15-Sep-22
14351	SW-018	*Lycosidae sp.* n=1	13-Sep-22
14352	SW-Cave 4 (McMac Cave)	*Rhadine sp.* (eyed) n=1	22-Sep-22
14353	SW-Cave 4 (McMac Cave)	*Texoreddellia sp.* n=1	22-Sep-22
14354	SW-Cave 4 (McMac Cave)	*Agalenidae sp.* n=2	22-Sep-22
14355	SW-Cave 4 (McMac Cave)	*Staphylinidae sp*. (larvae) n=1	22-Sep-22
14356	**SW-27 (Artificial Intelligence Cave)**	**Aphrastochthonius "n. sp. 2" n=1**	**15-Sep-22**
14357	SW-27 (Artificial Intelligence Cave)	*Batrisodes sp.* (eyed) n=1	15-Sep-22
14358	SW-21 (Travis Pit)	Blattodea n=1	22-Sep-22
14478	SW-32 (Devil's Lair Cave)	*Cicurina sp.* (eyed) n=1	08-Dec-22
14479	SW-32 (Devil's Lair Cave)	*Tachys sp.* (eyed) n=1	08-Dec-22
14480	**SW-32 (Devil's Lair Cave)**	***Stygobromus russelli* (eyeless) n=3**	**08-Dec-22**
14481	**SW-32 (Devil's Lair Cave)**	***Batrisodes (Excavodes) reyesi* (female) n=1**	**06-Dec-22**
14482	SW-32 (Devil's Lair Cave)	*Speodesmus sp.* (eyeless) n=1	06-Dec-22
14483	SW-32 (Devil's Lair Cave)	*Cambala speobia* (eyeless) n=3	06-Dec-22
14484	SW-32 (Devil's Lair Cave)	*Trichoniscidae* (eyeless) n=1	06-Dec-22
14485	SW-32 (Devil's Lair Cave)	*Cicurina sp.* (eyeless) n=2	06-Dec-22
14486	SW-32 (Devil's Lair Cave)	Araneae (eyed) n=2 (1 male, 1 female)	06-Dec-22
14487	SW-32 (Devil's Lair Cave)	*Eidmannella sp.* (eyed) n=2	06-Dec-22
14488	**SW-32 (Devil's Lair Cave)**	***Apochthonius "n. sp. 7"* n=1**	**06-Dec-22**
14489	SW-32 (Devil's Lair Cave)	*Speodesmus sp.* (eyeless) n=2	06-Dec-22
14490	SW-32 (Devil's Lair Cave)	*Trichoniscidae* (eyeless) n=1	06-Dec-22
14491	**SW-32 (Devil's Lair Cave)**	***Cicurina sp.* (eyeless) n=4; two specimens *Cicurina buwata***	**06-Dec-22**
14492	SW-32 (Devil's Lair Cave)	Araneae (eyed) n=2	06-Dec-22
14493	SW-32	Formicidae n=1	06-Dec-22

NA*	FK-1	Aranea n=1	01-Sep-23
NA*	FK-1	*Cicurina* sp. n=1	01-Sep-23
NA*	FK-2	Aranea n=1	01-Sep-23
NA*	SW-32 (Devil's Lair Cave)	Pseudoscorpiones n=1	01-Sep-23
NA	SW-32 (Devil's Lair Cave)	*Cicurina* sp. (eyeless) n=2	01-Sep-23
NA	SW-32 (Devil's Lair Cave)	Pseudoscorpiones n=2	01-Sep-23
NA	SW-32 (Devil's Lair Cave)	Araneae n=1	15-Sep-23
NA	SW-32 (Devil's Lair Cave)	Formicidae n=1	15-Sep-23

*Specimens collected in September 2023 are pending accession.

Conclusion

The larger and more complex caves that were biologically inventoried were host to more troglobites than the less extensive karst features that are not easily accessible for surveying. Feature SW-32, Devil's Lair Cave is one of the most complex caves in the area, and serves as habitat for mammals, reptiles, amphibians, and a diverse assemblage of karst invertebrates. Along with Artificial Intelligence Cave and McMac Cave, Devil's Lair Cave is home to undescribed species that are known from very few if any other localities. If possible, preserving these features above and below ground will help to ensure these unique ecosystems can continue hosting these incredibly isolated species. Further excavation, biological survey, and exploration of these and other karst features will increase the chances of encountering a federally listed endangered species under the Endangered Species Act (ESA), which could create the opportunity to substitute one of these Kotrla Unit caves for a current BCCP cave that may be impacted or inaccessible.

Appendix B. Genetic Species Identification Results

Cicurina Species Identification Report to Zara

Caleb D. Phillips, caleb.phillips@ttu.edu, phone: 806-834-8181

September 5, 2023

Specimens examined

Zara14152 from location McMac Pit (SW-04) (Coordinates: 30.5644 -97.92897)
Zara14491A from location SW-32 Devil's Lair (Coordinates: 30.563426 -97.926462)
Zara14491B from location SW-32 Devil's Lair (Coordinates: 30.563426 -97.926462)

Methods

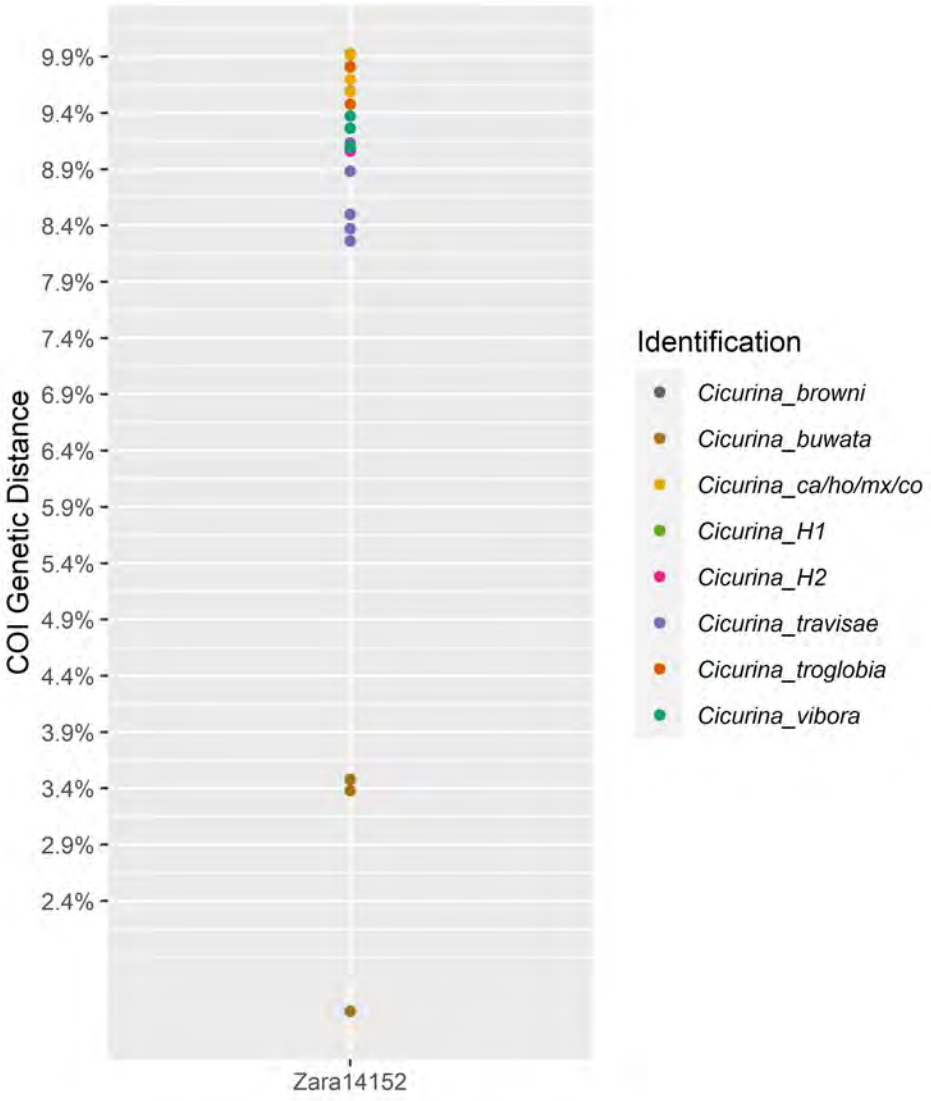
A portion of the mitochondria Cytochrome C Oxidase Subunit I gene was amplified and sequenced using primers reported in McDonald et al (2022). Digital sequence data was compared to a database of *Cicurina* COI sequences reported in McDonald et al. and available at https://doi.org/10.5061/dryad.3bk3j9kmg. Pairwise genetic distance of each specimen was compared to each database specimen. Analysis employed p-distances and uniform rates of mutation among sites. Resulting pairwise genetic distance matrix was parsed and visualized using custom R code.

Based on the results of analysis the following species idenfications are provided.

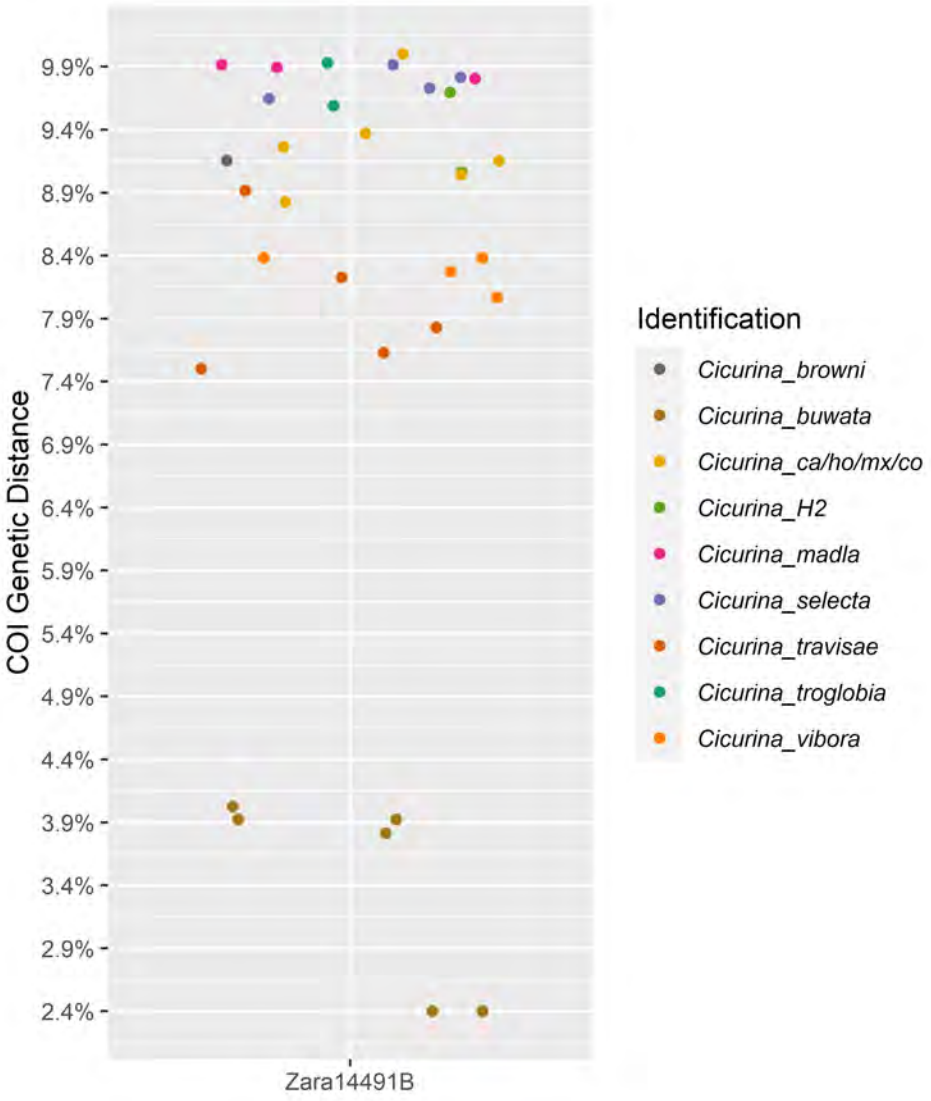
Zara14152 *Cicurina buwata*
Zara14491A *Cicurina buwata*
Zara14491B *Cicurina buwata*

Figures

Figure(s) provided below illustrate genetic divergence of specimens examined in this report relative to database entries. Comparisons are colored according to the species identification of each database entry. Instances in which an abbreviation rather than a species name is provided reflect specimens examined by McDonald et al. for which species status is currently uncertain. The key to species/clade names are available in the legend of the last figure of this report.


9.9%
9.4%
8.9%
8.4%
7.9%
7.4%
6.9%
6.4%
5.9%
5.4%
4.9%
4.4%
3.9%
3.4%
2.9%
2.4%
COI Genetic Distance
Zara14152
Identification
Cicurina_browni
Cicurina_buwata
Cicurina_ca/ho/mx/co
Cicurina_H1
Cicurina_H2
Cicurina_travisae
Cicurina_troglobia
Cicurina_vibora


10.4%
9.9%
9.4%
8.9%
8.4%
7.9%
7.4%
6.9%
6.4%
5.9%
5.4%
4.9%
4.4%
3.9%
3.4%
2.9%
2.4%
COI Genetic Distance
Zara14491A
Identification
Cicurina_bandida
Cicurina_browni
Cicurina_buwata
Cicurina_ca/ho/mx/co
Cicurina_H2
Cicurina_madla
Cicurina_travisae
Cicurina_troglobia
Cicurina_vibora


COI Genetic Distance
9.9%
9.4%
8.9%
8.4%
7.9%
7.4%
6.9%
6.4%
5.9%
5.4%
4.9%
4.4%
3.9%
3.4%
2.9%
2.4%
Zara14491B
Identification
Cicurina_browni
Cicurina_buwata
Cicurina_ca/ho/mx/co
Cicurina_H2
Cicurina_madla
Cicurina_selecta
Cicurina_travisae
Cicurina_troglobia
Cicurina_vibora

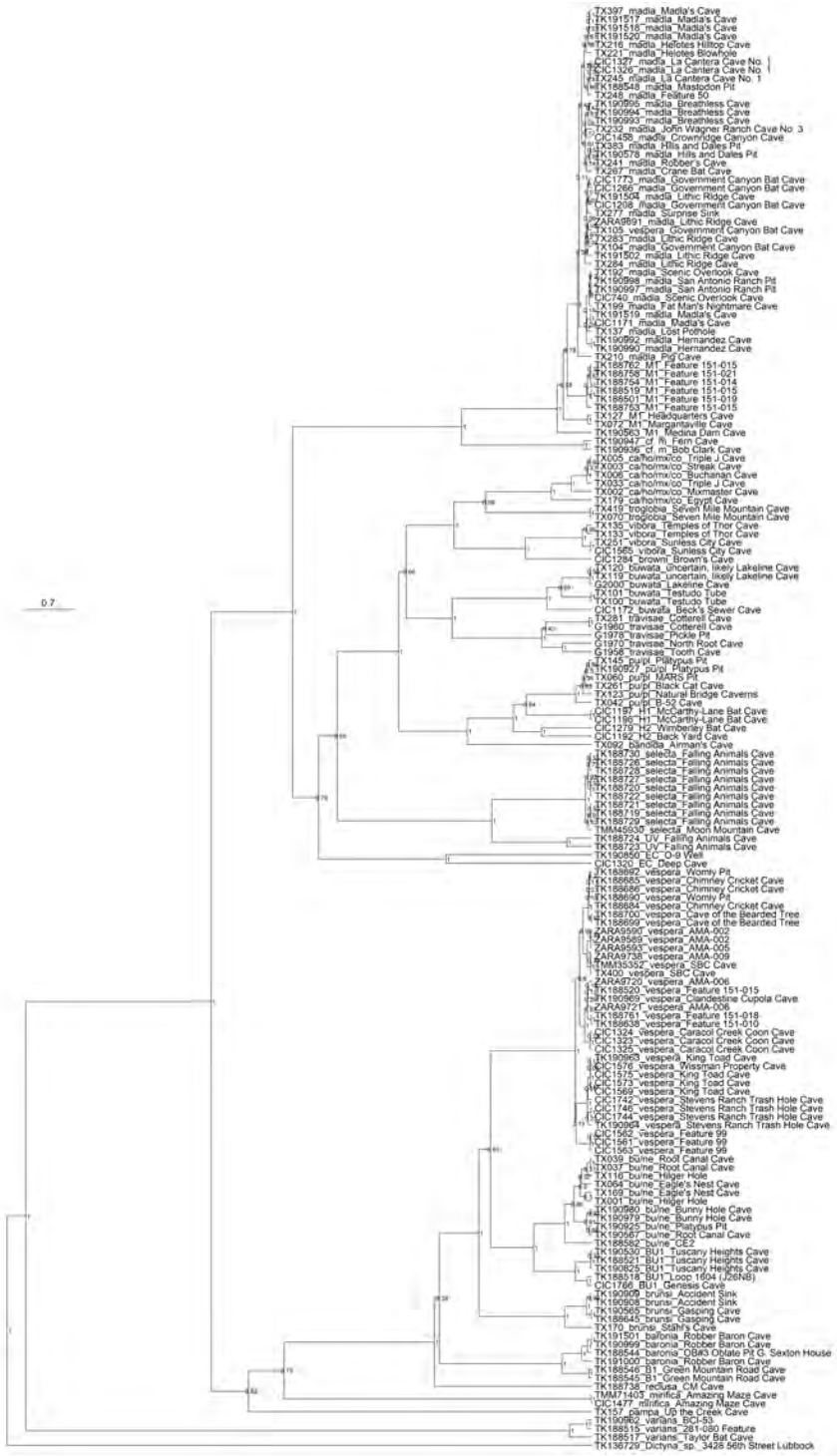


Figure 1: Bayesian phylogenetic reconstruction displayed as an ultrametric tree of eyeless Cicurina from central Texas based on the mitochondrial COI locus. Tip names include specimen accession numbers, posterior species/clade designations, and locality names. Node values are posterior support values. The scale bar is in units of substitutions/site. Species/clade designation are as follows: C. cf. madla = cf.m, Hays County, McCarthy-Lane Bat Cave locality = H1, Hays County, Wimberley Cave and Back Yard Cave localities = H2, Uvalde County = UV, Edwards and Crocket Counties = EC, M1 = separate C. madla clade, BU1 = separate clade containing morphologically identified C. bullis.