BCP Land Management Plan (LMP)

Tier II-A Chapter IX

Karst Species Management

2015 Revisions to 2007 LMP document

The following bulleted list highlights updates and revisions made to the 2007 BCP Karst Species Management LMP by BCP staff, reflected in this "red-line" version of the October 2015 final draft for approval by the BCCP Coordinating Committee. Updates and revisions include:

- Addition of background information on the BCCP and its tiered Land Management Plans
- An updated figure of cave clusters and Karst Fauna Regions
- Updated tables for endangered karst invertebrate localities and BCCP-listed Species of Concern (SOC) localities within BCCP caves
- Added tables demonstrating non-BCCP listed caves and karst features with endangered karst invertebrate and SOC localities protected on the BCP
- Updates on new karst species information related to the BCCP, including changes in taxonomy for some karst invertebrate species listed on the BCCP permit
- Updates to Threats section of cave ecosystems to include effects of climate change, tawny crazy ants, and white nose syndrome
- Updates on Karst Management Goals section that reflect new USFWS karst preserve design recommendations (2012)
- Updates in Conservation Actions section to incorporate recent best practices improvements outlined in new USFWS Karst Preserve Management and Monitoring Recommendations (2011)
- Description of BCP partners' cave monitoring strategy for measuring health of karst ecosystems across the BCP
- Updates to Research Needs section
- Addition of Appendix A: BCCP Cave Substitution Policy (accepted by BCCP Coordinating Committee in August 2015)

BALCONES CANYONLANDS PRESERVE

LAND MANAGEMENT PLAN

TIER II-A

CHAPTER IX

KARST SPECIES MANAGEMENT

October 2015

~~August 2007~~

Balcones Canyonlands Conservation Plan (**BCCP**) and the

Balcones Canyonlands Preserve (**BCP**)

The **Balcones Canyonlands Conservation Plan (BCCP)** is a federal Endangered Species Act (ESA) incidental "take" permit for 30 years issued to Travis County and the City of Austin on May 2, 1996 by the US Fish and Wildlife Service (USFWS). Incidental take is the loss of federally listed species or their habitats in the course of (or "incidental to") otherwise legal actions, like development. Such permitting is authorized under ESA Section 10(A)(1)(b), so sometimes the BCCP is called a "10A Permit."

A collection of documents guides BCCP implementation: our Endangered Species Act Permit No. TE 788841-2, the BCCP Final Environmental Impact Statement and Habitat Conservation Plan, the Travis County – City of Austin Interlocal Agreement – Shared Vision, Permit Area and Fee Zone Maps and **tiered Land Management Plans**.

These documents together provide the permit conditions, mitigation requirements, land acquisition areas (also known as the **Balcones Canyonlands Preserve** or **BCP**), management guidelines, and mechanisms by which the City and County can cover the impact of endangered species habitat loss in western Travis County and expedite development projects within the Permit Area.

The Land Management Plans are tiered:

Tier I Overview of the Preserve and Partner Responsibilities

Tier II A BCP Land Management Guidelines (Specific Best Practices)

Tier II B BCCP Administration

Tier II C BCP Macrosite Requirements

Tier III BCP individual tract plans

This plan outlines best practices for **Karst Management, Tier II A-9.**

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## 1.0 PURPOSE

This document outlines the policies and strategies for BCP cave and karst management; individual feature management specifics are outlined in the Tier III Land Management chapter for each BCP Unit or tract.

~~This document will outline the policies and strategies for management of all the karst features managed by the permit holders. However since the karst features are owned and managed by different agencies, the specifics on management of the individual karst features is outlined in the Tier III Karst Management chapter.~~

## ~~1.0~~2.0 BACKGROUND ~~INFORMATION~~

The regional ESA Section 10(a~~)~~)(~~(~~)(B) permit~~,~~ (TE 788841-2), also known as the Balcones Canyonlands Conservation Plan (BCCP), ~~issued in 1996 to the City of Austin (COA) and Travis County (TC) by the U.S. Fish and Wildlife Service (USFWS), required~~requires the creation of the Balcones Canyonlands Preserve (BCP~~). This preserve is designed~~), protection of 62 karst features, and a high standard of protection, stewardship and adaptive management to secure habitat in perpetuity and protect populations of eight endangered species (ES) and 27 species of concern~~.~~ (SOC). The City of Austin and Travis County (Permit Holders~~, COA and TC, are joined by a Managing Partner, the~~), Lower Colorado River Authority (LCRA) and the City of Sunset Valley (Managing Partners), and other cooperating entities (~~including~~e.g. private landowners, Travis Audubon, the City of Lakeway, Texas Cave Management Association, The Nature Conservancy of Texas) ~~Travis Audubon Society and others) in owning and managing designated properties within the BCP. These entities are collectively referred to as the BCP Partners. It is the intent of the permit holders and BCP Partners to protect not only the endangered as much of the ecosystem and supporting habitat for these listed species, thereby protecting whole system and therefore other species~~. own and manage BCP species, habitats, and ecosystems.

~~***1.1 1.1 REGIONAL PERMIT***~~

~~There are six species of endangered karst invertebrate and 25 karst species of concern (SOC) covered by the Balcones Canyonlands Conservation Plan (BCCP), a regional 10(a)1(b) permit issued by the U.S. Fish and Wildlife Service (USFWS) to the City of Austin (COA) and Travis County (TC) in May 1996. If these 25 species of concern become listed as endangered in the future, no additional mitigation would become necessary to protect them if all of the karst protection outlined in the BCCP is fully implemented. Many of the species of concern may actually be as endangered, or more so than the currently listed species. The SOC species have no protection under the Endangered Species Act of 1973, as amended, so the SOC caves lack the federal protections given to the endangered species caves.~~

## 2.1 COVERED SPECIES

Six endangered karst invertebrate species (**Table 1**) and 25 karst SOC are covered by the BCCP (**Table 2**). If these 25 SOC become federally listed as threatened or endangered, no additional mitigation by the Permit Holders would be required if all of the karst protection outlined in the BCCP is fully implemented.

**Table 1~~,~~ Federally Listed Karst Species Covered by the ~~permit~~BCCP**

*Footnotes follow table*

| Common Name | Scientific Name |
|---|---|
| Tooth Cave pseudoscorpion | *Tartarocreagris texana* |
| Tooth Cave spider | *Tayshaneta myopica*[1] |
| Tooth Cave ground beetle | *Rhadine persephone* |
| Kretschmarr Cave mold beetle | *Texamaurops reddelli* |
| Bee Creek Cave harvestman | *Texella reddelli* |
| Bone Cave harvestman | *Texella reyesi* |

[1] *Tayshaneta myopica* is listed in the regional permit as *Neoleptoneta myopica*, a 2012 study revised the genus *Neoleptoneta,* thus identifying this species in the genus *Tayshaneta* (Campbell et al. 2012).

**Table 2. Karst Species of Concern Covered by the BCCP**

*Footnotes follow table*

| Common Name | Scientific Name |
|---|---|
| Flatworm | *Sphalloplana mohri* |
| Ostracod | *Candona* sp. nr. *stagnalis* |
| Isopod | *Caecidotea reddelli* |
| Isopod | *Trichoniscinae N. S.* |
| Isopod | *Miktoniscus N. S.* |
| Spider | *Cicurina bandida* |
| Spider | *Cicurina cueva* |
| Spider | *Cicurina ellioti* |
| Spider | *Cicurina reddelli* |
| Spider | *Cicurina reyesi* |
| Spider | *Cicurina travisae* |
| Spider | *Cicurina wartoni* |
| Spider | *Tayshaneta concinna*[1] |
| Spider | *Tayshaneta devia*[1] |
| Spider | *Eidmannella reclusa* |
| Pseudoscorpion | *Aphrastochthonius* N. S. |
| Pseudoscorpion | *Tartarocreagris comanche*[2] |
| Pseudoscorpion | *Tartarocreagris reddelli* |
| Pseudoscorpion | *Tartarocreagris intermedia* |
| Pseudoscorpion | *Tartarocreagris* N. S. 3 |
| Harvestman | *Texella spinoperca* |
| Millipede | *Speodesmus* N. S |
| Ground Beetle | *Rhadine s. subterranea* |
| Ground Beetle | *Rhadine s. mitchelli* |
| Ground Beetle | *Rhadine austinica* |

[1] *Tayshaneta concinna* and *Tayshaneta devia* are listed in the regional permit with the genus *Neoleptoneta*, but a 2012 study revised the genus *Neoleptoneta,* thus identifying these species in the genus *Tayshaneta* (Campbell et al. 2012).

[2] *Tartarocreagris comanche* is improperly listed in the regional permit as the New Comanche Trail Cave harvestman.

Species descriptions for endangered karst species known to occur in Travis County can be found in the Biological Advisory Team (BAT) report (1990),

Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas (USFWS 1994), and USFWS 5-year reviews (USFWS 2008, 2009a, 2009b, 2009c).

~~The following section describes each endangered karst species known to occur in Travis County from the BAT report (1990) and the Draft Recovery Plan for Endangered Karst Invertebrates in Travis and Williamson Counties, Texas (USFWS 1994).~~

~~***Tooth Cave Pseudoscorpion.*** *Tartarocreagris texana.* The Tooth Cave pseudoscorpion resembles a tiny, tailless scorpion, but it has neither eyes nor a stinger. Reaching a size of four millimeters, it preys on small insects by seizing them with its pincers.~~

~~***Tooth Cave Spider.*** *Neoleptoneta myopica.* The Tooth Cave spider is the smallest of the endangered arthropods in the permit area with a total length of 1.6 millimeters. It is a pale spider with relatively long legs and rudimentary eyes.~~

~~***Tooth Cave Ground Beetle.*** *Rhadine persephone.* The Tooth Cave ground beetle is a reddish-brown predaceous beetle with reduced eyes. It is the largest of the endangered arthropods at seven to eight millimeters.~~

~~***Kretschmarr Cave Mold Beetle.*** *Texamaurops reddelli.* The Kretschmarr Cave mold beetle is a dark, short-winged, long-legged creature whose diet is unknown, although some members of its family are predaceous. It is less than three millimeters in length and lacks eyes.~~

~~***Bone Cave Harvestman.*** *Texella reyesi.* The Bone Cave harvestman is a pale, blind harvestman, or daddy-longlegs, which is orange colored. It ranges from 1.41-2.67 millimeters in length.~~

~~***Bee Creek Cave Harvestman.*** *Texella reddelli.* The Bee Creek Cave harvestman has relatively long legs but attains a length of only 1.9-2.18 millimeters. It is an eyeless predator of small insects which is also orange in color (USFWS 1993a).~~

## 2.2 FEATURES AND RELATIONSHIP TO BCCP SPECIES

Western Travis County ~~may be~~is characterized as a strongly dissected limestone outcrop tableland, bordered abruptly on the east by the Balcones fault zone or Balcones Escarpment (Amos and Gehlbach 1988). ~~The resulting physiography~~

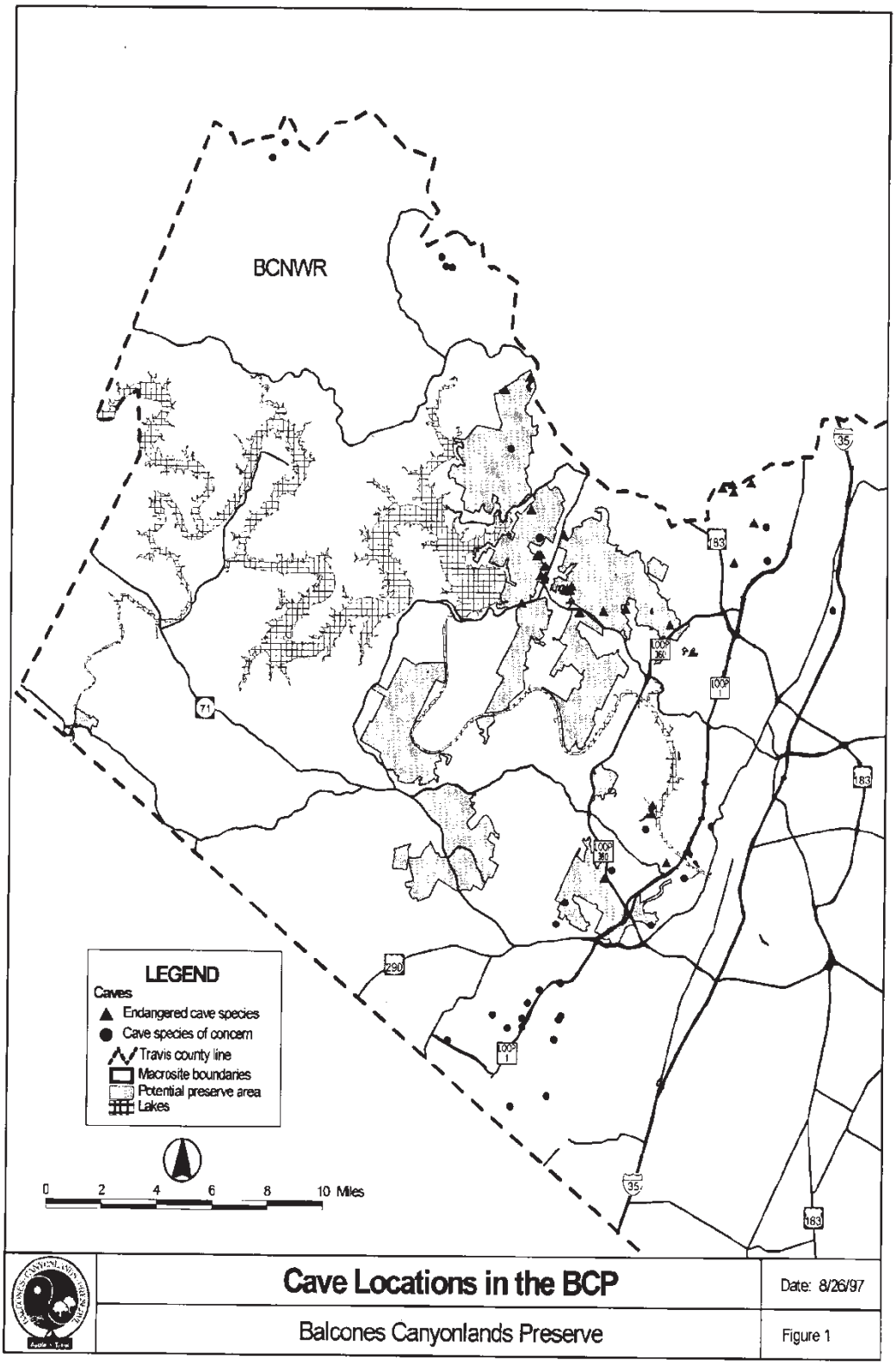
~~offers a variety of habitat types for plant and animal species.~~ In addition to surface habitat, the underlying karstic limestone, ~~with its fracturing~~highly fractured and full of solution ~~dissolving activity~~cavities, provides diverse subterranean ~~habitat~~habitats for specially adapted invertebrate and vertebrate species. The cave environment of central Texas, including that within the permit area, has been recognized to support one of the most important cave faunas in the world (Elliott and Reddell 1989).

The regional permit seeks to prevent the loss of caves known to contain federally endangered species covered by the Permit and ~~also~~ includes protection for significant ~~areas of~~features, karst ~~in cave~~ clusters, and ~~preserve acquisition areas (see~~ preserves**~~Figure 1 – BCCP cave locations~~**~~)~~. The regional permit ~~protects~~, when fully implemented, will protect 35 of the 39 endangered species caves in Travis County that were known when the permit was issued in 1996. In addition, under the permit, 27 caves are proposed to be protected that support SOC for a total of 62 karst features to be protected under the BCCP. These SOC caves are recommended for protection because they support rare invertebrate species and are also important recharge features. These karst features provide water to be recharged to the Edwards Aquifer and help to protect the water quality of the Austin area. **Table 3** depicts **62 BCCP Karst Features - Current Ownership**.

Three cave clusters (~~see~~ **Figure 1~~2~~: BCCP Cave~~Karst~~ Clusters**) have been identified within the BCCP permit area and also immediately outside the ~~BCCP~~ permit area to the northeast: the Four Points Cluster (includes the area northwest and northeast of ~~intersection of~~the FM 2222/RM 620~~ and the area northeast of this~~ intersection), the McNeil Cluster, and the Northwood Cluster. The Northwood and McNeil clusters occur in close proximity to each other in the vicinity of Walnut Creek near Howard Lane and McNeil Drive in North Austin. ~~Thirty-one out~~ Twenty-seven of the 62 karst features (62 = 60 caves, one spring, and one mine) covered by this Karst Management Plan are privately owned~~.~~ (**Table 3**). BCP Partners ~~will~~ work with willing non-profit groups, private landowners and other interested parties to protect ~~the~~these privately owned listed karst features.

**Known species distribution in the BCCP-listed caves and caves not listed on the Permit, but protected in the BCP, are depicted in Table 4 through Table 7.**

The environmental integrity of all 62 karst features is proposed to be protected through acquisition and management, or implementation of a management/conservation agreement with entities that influence the hydrogeological area needed to protect the feature (USFWS ~~1996~~1996a). Management in karst preserves ~~will include~~includes maintenance of native vegetation, red-imported fire ant (RIFA) control, control of disturbance by humans, and protection of water quality and nutrient input.




**~~Figure 1. BCCP Cave Locations~~**

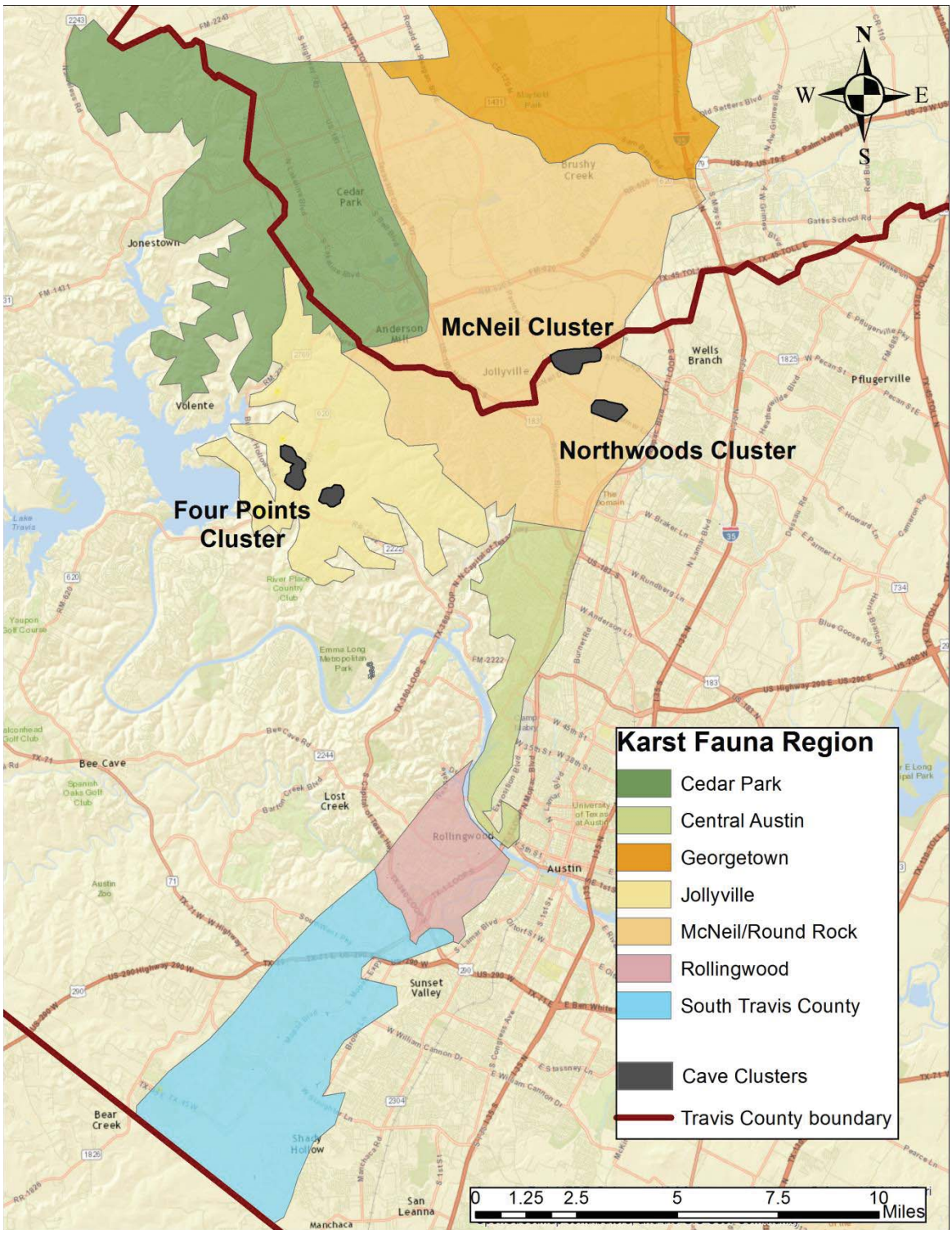



**Figure 1. BCCP Cave~~Karst~~ Clusters**

## Table 3. 62 BCCP Karst Features: Current Ownership Status

*Key and footnotes follow table*

| Cave Name | ES or SOC | Current tract/owner In BCP or Private | Cave Cluster |
|---|---|---|---|
| Adobe Springs Cave | SOC | BCP Lehmann/TNC | |
| Airman's Cave | SOC | BCP Barton Creek/COA | |
| Amber Cave | ES | BCP Jollyville/TC | Four Points (West) |
| Armadillo Ranch Sink | SOC | Private | |
| Arrow Cave | SOC | BCP Slaughter Creek Park./COA | |
| Bandit Cave | ES | Private | |
| Beard Ranch Cave (Featherman's Cave) | ES | BCP Ivanhoe/COA | |
| Bee Creek Cave | ES | Private | |
| Blowing Sink Cave | SOC | BCP COA | |
| Broken Arrow Cave | ES | BCP Lime Creek Preserve/COA | |
| Buda Boulder Spring | SOC | BCP Shoal Creek Greenbelt/COA | |
| Cave X | SOC | Private/COA Protection Agreement | |
| Cave Y[1] | SOC | BCP Barton Creek Greenbelt/COA | |
| Ceiling Slot Cave | SOC | Private | |
| Cold Cave | ES | Private | Northwood |
| Cotterell Cave | ES | BCP Stillhouse Hollow Preserve/COA | |
| Disbelievers Cave | ES | BCP Private 10(a) | Four Points (East) |
| District Park Cave | SOC | BCP Dick Nickols Park/COA | |
| Eluvial Cave | ES | BCP Private 10(a) | Four Points (East) |
| Flint Ridge Cave | SOC | Prop 2 Tabor Tract /COA | |
| Fossil Cave | ES | BCP Schroeter Park/COA | |
| Fossil Garden Cave | ES | Private | McNeil |
| Gallifer Cave | ES | BCP Jollyville/TC | Four Points |

| Cave Name | ES or SOC | Current tract/owner In BCP or Private | Cave Cluster |
|---|---|---|---|
| | | | (West) |
| Get Down Cave | SOC | Private/COA Protection Agreement | |
| Goat Cave | SOC | BCP Goat Cave Karst Preserve/COA | |
| Hole-in-the-Road Cave | ES | Private | Northwood |
| Ireland's Cave | SOC | BCP Ireland's/ TC | |
| Jack's Joint | SOC | Private | |
| Japygid Cave | ES | BCP Private 10(a) | Four Points (East) |
| Jest John Cave | ES | BCP Forest Ridge/COA | |
| Jester Estates Cave | ES | BCP Forest Ridge/COA | |
| Jollyville Plateau Cave | ES | BCP Private 10(a) | Four Points (East) |
| Kretschmarr Cave | ES | BCP Jollyville/TC | Four Points (West) |
| Kretschmarr Double Pit | ES | BCP Jollyville/TC | Four Points (West) |
| Lamm Cave | ES | BCP Private Section 7 | |
| Little Bee Creek Cave | ES | BCP Ullrich WTP/COA | |
| Lost Gold Cave | SOC | Private | |
| Lost Oasis Cave | SOC | Private TCMA | |
| M.W.A. Cave | ES | BCP Private 10(a) | Four Points (East) |
| Maple Run Cave | SOC | BCP Goat Cave Karst Preserve/COA | |
| McDonald Cave | ES | BCP Jollyville/TC | |
| McNeil Bat Cave | ES | Private | McNeil |
| Midnight Cave | SOC | BCP Slaughter Creek Park/COA | |
| Moss Pit | SOC | Private | |
| New Comanche Trail Cave | ES | BCP Lake Travis/TC | |
| No Rent Cave | ES | Private | McNeil |
| North Root Cave | ES | BCP Jollyville/TC | Four Points (West) |

| Cave Name | ES or SOC | Current tract/owner In BCP or Private | Cave Cluster |
|---|---|---|---|
| Pennie's Cave | SOC | Private | |
| Pickle Pit | SOC | BCP Private Section 7 | |
| Pipeline Cave | SOC | Private | |
| Rolling Rock Cave | ES | BCP Lime Creek Preserve/COA | |
| Root Cave | ES | BCP Jollyville/TC | Four Points (West) |
| Slaughter Creek Cave | SOC | BCP Slaughter Creek Park/COA | |
| Spanish Wells Cave | SOC | BCP Kotrla/TC | |
| Spider Cave | ES | BCP Park West/COA | |
| Stark's North Mine[2] | ES | BCP Stark's/ TC | |
| Stovepipe Cave | ES | BCP Canyon Creek/ COA | |
| Talus Springs Cave[3] | N/A | Private/ 10(a) permit | |
| Tardus Hole | ES | BCP Jollyville/TC | Four Points (West) |
| Tooth Cave | ES | BCP Jollyville/TC | Four Points (West) |
| Weldon Cave | ES | Private | McNeil |
| Whirlpool Cave | SOC | Private TCMA | |

*Key and Footnotes*

ES = Endangered (federally listed) Species

SOC = Species of Concern

[1]Cave Y was considered an ES cave *(Texella reddelli*) in the 1996 BCCP Permit, but has since been determined not to contain *Texella reddelli* (Reddell 2004).

[2]Stark's North Mine was listed as a SOC cave in the 1996 BCCP Permit, but has since been determined to contain *Texella reddelli* (USFWS 2009c).

[3] Talus Springs Cave has never been known to contain ES or SOC (Elliot 1997).

## Table 4. Endangered Karst Invertebrate Locations within BCCP caves of Travis County, Texas

This table, originally in the BCCP 1996 documents, has been revised to show new species' location information.
*Key and footnotes follow table*

| Cave Name | Current Preserve Status | Karst Fauna Region | Tooth Cave Pseudoscorpion *Tartarocreagris texana* | Tooth Cave Spider *Tayshaneta myopica* | Tooth Cave Ground Beetle *Rhadine persephone* | Kretschmarr Cave Mold Beetle *Texamaurops reddelli* | Bee Creek Cave Harvestman *Texella reddelli* | Bone Cave Harvestman *Texella reyesi* |
|---|---|---|---|---|---|---|---|---|
| Amber Cave | BCP Jollyville TC | Jollyville Plateau | X 1996 | - | X 2010 (Reddell) | X 1996 | | - |
| Bandit Cave | Private | Rolling-wood | - | - | | - | P 1996<br>X 2009 | - |
| Beard Ranch Cave | BCP Ivanhoe COA | Jollyville Plateau | - | - | | - | | X 1996 |
| Bee Creek Cave | Private | Rolling-wood | - | - | | - | X 1996 | - |
| Broken Arrow Cave | BCP Lime Creek Preserve COA | Cedar Park | - | - | X 1996 | - | | - |
| Cold Cave | Private | McNeil Round Rock | - | - | | - | - | X 1996 |
| Cotterell Cave | BCP Spicewood Springs Park/COA | Central Austin | - | - | | - | - | X 1996 |
| Disbelievers Cave | BCP Private 10(a) | Jollyville | | | X 1996 | | | |
| Eluvial Cave | BCP Private 10(a) | Jollyville | | | ~~X' HNTB TCC 200~~<br>~~not present Redde~~ | | | X 1996 |

| Cave Name | Current Preserve Status | Karst Fauna Region | Tooth Cave Pseudoscorpion *Tartarocreagris texana* | Tooth Cave Spider *Tayshaneta myopica* | Tooth Cave Ground Beetle *Rhadine persephone* | Kretschmarr Cave Mold Beetle *Texamaurops reddelli* | Bee Creek Cave Harvestman *Texella reddelli* | Bone Cave Harvestman *Texella reyesi* |
|---|---|---|---|---|---|---|---|---|
| Fossil Cave | BCP Schroeter ~~Pk./~~Park/COA | McNeil ~~/~~Round Rock | | | | | | X 1996 |
| Fossil Garden Cave | Private | McNeil ~~/~~Round Rock | | | | | | X 1996 |
| Gallifer Cave | BCP Jollyville/TC | Jollyville Plateau | | P 1996<br>X 2010 (Ledford) | P 1996<br>X ~~HNTB~~ 2005 | X 2009 (Chandler) | | X 1996 |
| Hole-in-the-Road Cave | Private | McNeil ~~/~~Round Rock | | | | | | X 1996 |
| Japygid Cave | BCP Private 10(a) | Jollyville | | | X 1996 | P 1996<br>X ~~Reddell~~ 2005 | | |
| Jest John Cave | BCP Forest Ridge/COA | Jollyville Plateau | | | | | X 1996 | |
| Jester Estates Cave | BCP Forest Ridge/COA | Jollyville Plateau | X 2008 (Cokendolpher) | X 2010 (Ledford) | | | X 1996 | |
| Jollyville Plateau ~~Cv.~~Cave | BCP Private 10(a) | Jollyville | | | X 1996 | | | X 1996 |
| Kretschmarr Cave | BCP Jollyville/TC | Jollyville Plateau | | | X 1996 | X 1996 | | |
| Kretschmarr ~~Dble.~~Double Pit | BCP Jollyville/TC | Jollyville Plateau | P 1996<br>X ~~Reddell~~ 2005 | | P 1996<br>X ~~HNTB~~ 2005 | | P 1996 | |
| Lamm Cave | Private Section 7 | Jollyville Plateau | | | X 1996 | | | |
| Little Bee ~~Cr.~~Creek Cave | BCP Ullrich WTP/COA | ~~Rollingwood~~Rolling-wood | | | | | X 1996 | |

| Cave Name | Current Preserve Status | Karst Fauna Region | Tooth Cave Pseudoscorpion *Tartarocreagris texana* | Tooth Cave Spider *Tayshaneta myopica* | Tooth Cave Ground Beetle *Rhadine persephone* | Kretschmarr Cave Mold Beetle *Texamaurops reddelli* | Bee Creek Cave Harvestman *Texella reddelli* | Bone Cave Harvestman *Texella reyesi* |
|---|---|---|---|---|---|---|---|---|
| McDonald Cave | BCP Jollyville/TC | Jollyville Plateau | | | X' HNTB TCC 200 not present Reddell (2005 | | | X 1996 |
| McNeil Bat Cave | Private | McNeil /Round Rock | | X 2010 (Ledford) | | | | X 1996 |
| Millipede Cave | Not Protected under BCCP | McNeil/Round Rock | - | - | | - | - | X 1996 |
| M.W.A. Cave | BCP Private 10(a) | Jollyville | P 1996 X Reddell 2005 | | X 1996 | P 1996 X Reddell 2005 | | X 1996 |
| New Comanche Tr. Trail Cave | PrivateBCP Lake Travis/TC | Jollyville Plateau | | X 1996 | X' HNTB TCC 200 not present Reddell (2005) | | | X 1996 |
| No Rent Cave | Private | McNeil /Round Rock | | | | | | X 1996 |
| North Root Cave | BCP Jollyville/TC | Jollyville Plateau | | | X 1996 | | | |
| Puzzle Pits Cave | Not Protected under BCCP | Jollyville | - | - | X 1996 | - | - | - |
| Rolling Rock Cave | BCP Lime Cr. Prs./Creek Preserve COA, Sec.10(a) | Cedar Park | | | X 1996 | | | |
| Root Cave | BCP Jollyville/TC | Jollyville Plateau | | X 2010 (Ledford) | X 1996 | | | X 1996 |
| Spider Cave | BCP Park West/COA | Jollyville Plateau | | | P 1996 X HNTB 2005 2004 (Reddell) | | X 2004 (Reddell 2004 ) | P 1996 delete P 2004 Reddell |

| Cave Name | Current Preserve Status | Karst Fauna Region | Tooth Cave Pseudoscorpion *Tartarocreagris texana* | Tooth Cave Spider *Tayshaneta myopica* | Tooth Cave Ground Beetle *Rhadine persephone* | Kretschmarr Cave Mold Beetle *Texamaurops reddelli* | Bee Creek Cave Harvestman *Texella reddelli* | Bone Cave Harvestman *Texella reyesi* |
|---|---|---|---|---|---|---|---|---|
| Stark's North Mine Cave | BCP Stark's/TC | Not within a KFR | | | | | X 2009 (USFWS) | |
| Stovepipe Cave | ~~Private Sec. 7~~BCP Canyon Creek/ COA | Jollyville Plateau | ~~P 1996~~<br>~~delete P Reddell 2005 *~~ | ~~P 1996~~ | X 1996 | X 1996 | | P 1996<br>X 2009 (USFWS) |
| Tardus Hole | BCP Jollyville/TC | Jollyville Plateau | | | X 1996 | X 2009 (Chandler) | | |
| Tooth Cave | BCP Jollyville/TC | Jollyville Plateau | X 1996 | X 1996 | X 1996 | X 1996 | | X 1996 |
| Weldon Cave | Private | McNeil ~~/~~Round Rock | | | | | | X 1996 |
| ~~West Rim Cave~~ | ~~Not Protected under BCCP~~ | ~~Central Austin~~ | ~~-~~ | ~~-~~ | ~~-~~ | ~~-~~ | ~~-~~ | ~~X 1996~~ |

**Sources**: BCCP Permit 1996, Elliott 1992, USFWS 1994, Reddell 2004~~ and~~, 2005, 2010, HNTB 2005, USFWS 2009a, 2009b, 2009c, Ledford 2010.

*Key and Footnotes*

X 1996 = confirmed occurrence based on collected specimen

~~X' = In HNTB 2005 report, reports that Texas Cave Conservancy (TCC) reports~~, the ~~species to occur~~designation in the ~~feature but such reports may not be based on a "confirmed identification". This Table shows some disagreement between TCC and Reddell.~~1996 BCCP permit

P ~~= probably~~1996 = probable occurrence based on observation but not confirmed with collected specimen

~~Delete P = this species is no long thought to occur~~, the designation in ~~this cave.~~ 1996 BCCP permit

~~*~~X 2004 (Reddell) = confirmed by J. Reddell (pers com ~~2005) reported that~~ 2004)

X 2005 = was listed as confirmed in the HNTB summary of James Reddell's data, 2005 report for USFWS

X 2008 = Cokendolpher (pers com 2008) confirmed that Jester Estates Cave is a new site for *Tartarocreagris texana* ~~does NOT occur in~~

X 2009 = USFWS - according to the 2009 5 year review on *Texella reyesi* the report lists *T. reyesi* as confirmed for Stovepipe Cave; *Texella reddelli* 5-year review confirms *T. reddelli* for Bandit Cave and Stark's North Mine (USFWS 2009c).

X 2009 (Chandler) = confirmed by D. Chandler, as reported in USFWS 5-year review (2009b).

X 2010 (Ledford) = confirmed by J. Ledford (pers com 2010)

X 2010 (Reddell) = confirmed by J. Reddell (pers com 2010)

## Table 5. Non-BCCP listed Caves/Karst Features with Listed Invertebrates Protected on BCP

*Key follows table*

| Cave Name | Current Preserve Status | Karst Fauna Region | Tooth Cave Pseudoscorpion *Tartarocreagris texana* | Tooth Cave Spider *Tayshaneta myopica* | Tooth Cave Ground Beetle *Rhadine persephone* | Kretschmarr Cave Mold Beetle *Texamaurops reddelli* | Bee Creek Cave Harvestman *Texella reddelli* | Bone Cave Harvestman *Texella reyesi* |
|---|---|---|---|---|---|---|---|---|
| Cortana Cave | COA | Jollyville Plateau | | X 2010 | | | | X 2008 |
| Down Dip Sink | COA | Jollyville Plateau | | | X 2007a | | | |
| Garden Hoe Cave | COA | Jollyville Plateau | | | X 2007b | | | |
| Geode Cave | TC | Jollyville Plateau | | X 2008 | X 2008 | | | X 2008 |
| LU-11 | TC | Jollyville Plateau | | X 2008 | | | | |
| LU-12 | TC | Jollyville Plateau | | | | | | X 2008 |
| IV-3 | COA | Jollyville Plateau | | | | | | X 2010 |
| Little Black Hole | COA | Rollingwood | | | | | X 2009c | |
| Merkin Hole | COA | Jollyville Plateau | | | | | X 2010 | |
| Pond Party Pit | COA | Jollyville Plateau | | | | | | X 2010 |
| RI-1 | TC | Jollyville Plateau | | | | | X 2010 | |

| Cave Name | Current Preserve Status | Karst Fauna Region | Tooth Cave Pseudoscorpion *Tartarocreagris texana* | Tooth Cave Spider *Tayshaneta myopica* | Tooth Cave Ground Beetle *Rhadine persephone* | Kretschmarr Cave Mold Beetle *Texamaurops reddelli* | Bee Creek Cave Harvestman *Texella reddelli* | Bone Cave Harvestman *Texella reyesi* |
|---|---|---|---|---|---|---|---|---|
| Tight Pit Cave | TC | Jollyville Plateau | | X 2010 | | | | |
| Two Trunks Cave | TC | Jollyville Plateau | | | X 2008 (USFWS) | | | |

**Sources**: USFWS 2008, 2009c, Zara Environmental 2007a, 2007b, 2008, and 2010.

*Key*

X = confirmed occurrence based on collected specimen.

## Table 6 Karst Invertebrate SOC within BCCP Caves, Travis County, Texas[1,2]

*Key and footnotes follow table*

| Cave Name | *Aphrastochithonius N.S.* | *Caecidotea reddelli* | *Candona sp. nr. stagnalis* | *Cicurina bandida*[3] | *Cicurina travisae*[4] | *Cicurina sp.*[5] | *Eidmannella reclusa* | *Miktoniscus N.S.* | *Tayshaneta concinna* | *Tayshaneta devia* | *Rhadine austinica* | *Rhadine s. subterranea* | *Rhadine s. mitchelli* | *Speodesmus N.S.* | *Sphaloplana mohri* | *Tartarocreagris comanche* | *Tartarocreagris intermedia* | *Tartarocreagris N.S. 3* | *Texella spinoperca* | *Trichoniscinae N.S.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Adobe Springs Cave | | | | | | | | | | | | | | | | | | | | |
| Airmen's Cave | | | | X | | | | | | | X | | | | | | X | | X | |
| Amber Cave | | | | | X | | | | | | | | X | | | | | | | |
| Armadillo Ranch Sink | | X | | | | | | | | | | | | | | | | | | |
| Arrow Cave | | | | X | | | | | | | X | | | | | | | | | |
| Bandit Cave | | | | X | | | | | | | X | | | | | | | | | X |
| Beard Ranch Cave | | | | | X | | | | | | | | | | | | | | | |
| Bee Creek Cave | | | | X | | | | | | | X | | | | | | | | | |
| Blowing Sink Cave | | | | X | | | | | | | X | | | | | | | | | |
| Broken Arrow Cave | | | | | | | | | | | | | | | | | | | | |
| Buda Boulder Spring | | X | | | | | | | | | | | | | | | | | | |
| Cave X | | X | X | X | | | | X | | | X | | | X | | | | | | |
| Cave Y | | | | X | | | | | | | X | | | | | | | | | |

| Cave Name | *Aphrastochithonius N.S.* | *Caecidotea reddelli* | *Candona sp. nr. stagnalis* | *Cicurina bandida*[3] | *Cicurina travisae*[4] | *Cicurina sp.*[5] | *Eidmannella reclusa* | *Miktoniscus N.S.* | *Tayshaneta concinna* | *Tayshaneta devia* | *Rhadine austinica* | *Rhadine s. subterranea* | *Rhadine s. mitchelli* | *Speodesmus N.S.* | *Sphalloplana mohri* | *Tartarocreagris comanche* | *Tartarocreagris intermedia* | *Tartarocreagris N.S. 3* | *Texella spinoperca* | *Trichoniscinae N.S.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ceiling Slot Cave | | | | | | X | | | | | | | | | | | | | | |
| Cold Cave | | | | | | X | | | | | | | | | | | | | | |
| Cotterell Cave | | | | | X | | | | | | | X | | | | | | | | |
| Disbelievers Cave | | | | | | X | | | | | | | | | | | | | | |
| District Park Cave | | | | X | | | | | | | X | | | | | | | | | |
| Eluvial Cave | | | | | | | | | | | | | | | | | | | | |
| Flint Ridge Cave | | | | X | | | | | | | X | | | | | | | | | |
| Fossil Cave | | | | | | | | | | | | X | | | | | | | | |
| Fossil Garden Cave | | | | | | X | | | | | | X | | | | | | | | |
| Gallifer Cave | | | | | X | | | | | | | | | | | | | | | |
| Get Down Cave | | | | X | | | | | | | X | | | | | | | | | |
| Goat Cave | | | | X | | | | | | | | | | X | | | | | | |
| Hole-in-the-Road Cave | | | | | | X | | | | | | | | | | | | | | |
| Ireland's Cave | | | | X | | | | | | | X | | | | | | | | | |
| Jack's Joint | | X | | | | X | | | | | | | | | | | | | | |
| Japygid Cave | | | | | | | | | | | | | | | | | | | | |

| Cave Name | *Aphrastochithonius N.S.* | *Caecidotea reddelli* | *Candona sp. nr. stagnalis* | *Cicurina bandida*[3] | *Cicurina travisae*[4] | *Cicurina sp.*[5] | *Eidmannella reclusa* | *Miktoniscus N.S.* | *Tayshaneta concinna* | *Tayshaneta devia* | *Rhadine austinica* | *Rhadine s. subterranea* | *Rhadine s. mitchelli* | *Speodesmus N.S.* | *Sphalloplana mohri* | *Tartarocreagris comanche* | *Tartarocreagris intermedia* | *Tartarocreagris N.S. 3* | *Texella spinoperca* | *Trichoniscinae N.S.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jest John Cave | | | | | X | | | | | | | | | | | | | | | |
| Jester Estates Cave | | | | | X | | | | | | | | | | | | | | | |
| Jollyville Plateau Cave | | | | | | | | | | | | | | | | | | | | |
| Kretschmarr Cave | | | | | X | | | | | | | | X | | | | | | | |
| Kretschmarr Double Pit | | | | | X | | | | | | | | | | | | | | | |
| Lamm Cave | | | | | | | | | | | | | | | | | | | | |
| Little Bee Creek Cave | | | | X | | | | | | | X | | | | | | | | | |
| Lost Gold Cave | | | | X | | | | | X | | X | | | | | | | | | |
| Lost Oasis Cave | | | | X | | | | | | | X | | | | | | | | | |
| M.W.A. Cave | | | | | | | | | | | | | | | | | | X | | |
| Maple Run Cave | | | | X | | | | | | | X | | | | | | | | | |
| McDonald Cave | | | | | X | | | | | X | | | | | | | | | | |
| McNeil Bat Cave | | | | | | | | | | | | X | | | | | | | | |
| Midnight Cave | | | | X | | | | | | | X | | | | | | | | | |

| Cave Name | *Aphrastochithonius N.S.* | *Caecidotea reddelli* | *Candona sp. nr. stagnalis* | *Cicurina bandida*[3] | *Cicurina travisae*[4] | *Cicurina sp.*[5] | *Eidmannella reclusa* | *Miktoniscus N.S.* | *Tayshaneta concinna* | *Tayshaneta devia* | *Rhadine austinica* | *Rhadine s. subterranea* | *Rhadine s. mitchelli* | *Speodesmus N.S.* | *Sphalloplana mohri* | *Tartarocreagris comanche* | *Tartarocreagris intermedia* | *Tartarocreagris N.S. 3* | *Texella spinoperca* | *Trichoniscinae N.S.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Moss Pit | | | | | | | | | | | | | | | | | | | | |
| New Comanche Trail Cave | | | | | | X | X | | | | | | | | | X | | | | |
| No Rent Cave | | | | | | | | | | | | X | | | | | | | | |
| North Root Cave | | | | | X | | | | | | | | | | | | | | | |
| Pennie's Cave | | | | | | | | | | | X | | | X | | | | | | |
| Pickle Pit | | | | | X | | | | | | | | | | | | | | | |
| Pipeline Cave | | | | | | | | | | | | | | X | | | | | | |
| Rolling Rock Cave | | | | | | X | | | | | | | | X | | | | | | |
| Root Cave | | | | | X | | | | | | | | | | | | | | | |
| Slaughter Creek Cave | | | | X | | | | | | | | | | | | | | | | |
| Spanish Wells Cave | | X | | | | | | | | | | | | | X | | | | | |
| Spider Cave | | | | | X | | X | | | | | | | | | | | | | |
| Stark's North Mine | | | | | | | | | X | | | | | | | | | | | |
| Stovepipe Cave | X | | | | X | | X | | | | | | | | | | | | | |
| Talus Springs Cave | | | | | | | | | | | | | | | | | | | | |

| Cave Name | *Aphrastochithonius N.S.* | *Caecidotea reddelli* | *Candona sp. nr. stagnalis* | *Cicurina bandida*[3] | *Cicurina travisae*[4] | *Cicurina sp.*[5] | *Eidmannella reclusa* | *Miktoniscus N.S.* | *Tayshaneta concinna* | *Tayshaneta devia* | *Rhadine austinica* | *Rhadine s. subterranea* | *Rhadine s. mitchelli* | *Speodesmus N.S.* | *Sphalloplana mohri* | *Tartarocreagris comanche* | *Tartarocreagris intermedia* | *Tartarocreagris N.S. 3* | *Texella spinoperca* | *Trichoniscinae N.S.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tardus Hole | | | | | | | | | | | | | | | | | | | | |
| Tooth Cave | | | | | X | | X | | | | | | X | | | | | | | |
| Weldon Cave | X | | | | | | | | | | | X | | | | | | | | |
| Whirlpool Cave | | | | X | | | | | | | X | | | | | | | | | |

**Sources**: Elliot 1997, Paquin and Hedin 2005, Paquin et al. 2008, TMM 2007, Zara Environmental 2008, 2010, Hedin 2015.

*Key and Footnotes*

X = confirmed location based on collected specimen.

[1] *Cicurina ellioti* listed as an SOC in the regional permit is not included in this table because this species has now been synonymized with Cicurina buwata, a non-SOC (Cokendolpher 2004).

[2] *Tartarocreagris reddelli* listed as a SOC in the regional permit is not included in this table because this species has now been synonymized with *Tartarocreagris infernalis*, a non-SOC (Muchmore 2001).

[3] Occurrences of *Cicurina bandida* include localities formerly listed as *Cicurina cueva* and *Cicurina reyesi*, which have been formally grouped together into the single species *C. bandida* (Paquin et al. 2008).

[4] Occurrences of *Cicurina travisae* include localities formerly listed as *Cicurina reddelli* and *Cicurina wartoni*, which have been formally grouped together into the single species *C. travisae* (Hedin 2015).

[5] Localities of possible SOCs; blind *Cicurina* specimens not yet confirmed to species level.

## Table 7. Non-BCCP Caves/Karst Features with Karst SOC Protected on BCP[1,2]

*Key and footnotes follow table*

| Cave Name | BCP Owner | *Aphrastochthonius N.S.* | *Caecidotea reddelli* | *Candona sp. nr. staplanis* | *Cicurina bandida*[3] | *Cicurina travisae*[4] | *Cicurina sp.*[5] | *Eidmannella reclusa* | *Miktoniscus N.S.* | *Tayshaneta concinna* | *Tayshaneta devia* | *Rhadine s. subterranea* | *Rhadine s. mitchelli* | *Speodesmus N.S.* | *Sphaloplana mohri* | *Tartarocreagris comanche* | *Tartarocreagris intermedia* | *Tartarocreagris N.S. 3* | *Texella spinoperca* | *Trichoniscinae N.S.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brewpot Cave | TC | | | | | | | | | | X | | | | | | | | | |
| Cortana Cave | COA | | | | | | X | | | | | | | | | | | | | |
| Down Dip Cave | COA | | | | | | X | | | | | | | | | | | | | |
| Geode Cave | TC | | | | | X | | X | | | | | | | | | | | | |
| IV-3 | COA | | | | | X | | | | | | | | | | | | | | |
| LU-29 | TC | | | | | | X | | | | | | | | | | | | | |
| Pond Party Pit | COA | | | | | | X | | | | | | | | | | | | | |
| RI-1 | TC | | | | | | X | | | | | | | | | | | | | |
| RI-3 | TC | | | | | | X | | | | | | | | | | | | | |
| Siebert Sink | COA | | | | X | | | | | X | | | | | | | | | X | |
| Two Trunks Cave | TC | | | | | X | | | | | | | | | | | | | | |

**Sources**: Bayless pers com 2013, Paquin and Hedin 2005, Sanders pers com 2013, TMM 2007, Zara Environmental 2008, 2010, Hedin 2015.

*Key and Footnotes*

X = confirmed location based on collected specimen.

[1] *Cicurina ellioti* listed as an SOC in the regional permit is not included in this table because this species has now been synonymized with Cicurina buwata, a non-SOC (Cokendolpher 2004).

[2] *Tartarocreagris reddelli* listed as a SOC in the regional permit is not included in this table because this species has now been synonymized with *Tartarocreagris infernalis*, a non-SOC (Muchmore 2001).

[3] Occurrences of *Cicurina bandida* include localities formerly listed as *Cicurina cueva* and *Cicurina reyesi*, which have been formally grouped together into the single species *C. bandida* (Paquin et al. 2008).

[4] Occurrences of *Cicurina travisae* include localities formerly listed as *Cicurina reddelli* and *Cicurina wartoni*, which have been formally grouped together into the single species *C. travisae* (Hedin 2015).

[5]Localities of possible SOCs; blind *Cicurina* specimens not yet confirmed to species level.

## 3.0 NEW KARST INFORMATION RELATED TO THE BCCP

For 18 years, "*The Caves of the Balcones Canyonlands Conservation Plan, Travis County, Texas*" (Elliot 1997) has been the primary reference guide for endangered species and SOC location information. Recently, however, the USFWS released 5-year reviews for the six endangered karst species listed on the BCCP permit (USFWS 2008, 2009a, 2009b), which included documentation of new localities for these species. More recent survey work by Zara Environmental, Inc. (2007a, 2007b, 2008, 2010) has also added new location information for four of the endangered karst species and several SOCs listed on the BCCP permit. A complete list of known endangered karst invertebrate locations for the BCCP-listed karst features is summarized in Table 2; known SOC localities within BCCP-listed karst features are summarized in Table 4. Location information for endangered karst species and SOCs found in BCP caves that were not listed in the BCCP are summarized in Table 3 (ES localities) and Table 5 (SOC localities). Though not listed on the permit, these caves and any other BCP caves containing ES or SOC found in the future will be protected in the same manner as those listed on the permit.

Joel Ledford (University of California, Berkeley) conducted a revision of the Family Leptonetidae with particular emphasis on the taxonomy and relationships within the subfamily Archoleptonetinae. This study found new locations for the endangered *Neoleptoneta myopica* and newly described species within the Austin area. Ledford also proposed to change the genus *Neoleptoneta* to *Tayshaneta* (Campbell et al. 2012). USFWS adopted this change in 2015 (Watson pers com 2015).

Marshal Hedin (San Diego State University) conducted a study for USFWS using DNA sequence data to rigorously test the species status of *Cicurina wartoni*, a BCCP-listed SOC known only from Pickle Pit Cave. Hedin's study used specimens collected by BCP staff from multiple caves in northern Travis and southern Williamson counties to determine if *Cicurina* specimens from Pickle Pit were genetically distinguishable from other nearby sites containing *Cicurina* spiders previously identified as *C. buwata* (formerly known as *C. ellioti*), *C. reddelli*, and *C. travisae*. Results of genetic analyses indicate that there are only two distinct species complexes in the study area: *C. buwata*

in the northern range and *C. travisae* in the southern range. Based on these findings, *C. reddelli*, *C. wartoni,* and *C. travisae* should now be treated as a single species: *C. travisae*. Thus, confirmed localities previously identified as *C. reddelli* and *C. wartoni* are now considered as localities for *C. travisae* (Hedin 2015). Following the completion of Hedin's study, USFWS completed a status review of *Cicurina wartoni* and concluded that this species does not warrant protection under the Endangered Species Act (ESA) (USFWS 2014a).

### ~~*1.3 NEW INFORMATION RELATED TO BCCP*~~

~~In 2003, a petition to list *Cicurina cueva* as an endangered species was published in the Federal Record. Research in 2005 funded by USFWS and TxDOT on Cicurina cueva and its close morphological relatives (C. reyesi and C. bandida) (three of the 25 species of concern included in the permit) has been interpreted to suggest that these three named taxa represent variants of a single species(Paquin and Hedin, 2005). The research authors have not yet formally proposed synonymy which would require publication in a scientific journal. USFWS and other agencies are currently reviewing this study and proposals that may threaten caves containing *Cicurina cueva* habitat. The possibility that these may be one species rather than three separate species may have implications for protection efforts for several BCP karst features listed in the permit.~~

~~The report, "Summary of Information for Assessing Status of the Tooth Cave ground beetle (Radine persephone)" (HNTB, 2005), lists locations for this species that add new locations not listed in the 1996 BCCP permit. These new locations within the 62 karst features in the permit have been added to Table 1. Two Trunks Cave, located on Travis County BCP land, contains Tooth Cave ground beetle but is not in this list of 62 karst features on the permit. Though not listed on the permit, this cave will be protected in the same manner as other BCP caves containing endangered species.~~

## 4.0 ADDITIONAL VALUES FOR CAVE AND KARST ECOSYSTEMS

Beyond protecting the entrances of caves that are localities for endangered karst invertebrates and SOCs, USFWS Karst Preserve Design Recommendations (2012) also describe the importance of protecting the surface environment surrounding caves. One component of this protection involves preserving adequate habitat for trogloxenes such as cave crickets, bats, and mammals (USFWS 2012). Cave crickets are considered a keystone species for cave ecosystems, providing vital nutrients into an

otherwise nutrient poor environment (Taylor et al. 2005). Bats and mammals such as raccoons are also important biotic components of karst ecosystems, supplying nutrient input in the forms of guano and scat which benefits resident karst invertebrates (USFWS 2011e). Providing adequate protection of surface plant and animal communities in cave preserves benefits these trogloxenes, and also protects other sources of nutrient input in the form of roots, leaf-litter, and woody debris, thereby creating a higher probability of long-term survival for protected karst invertebrates (USFWS 2012).

Another component of protecting the surface environment around caves involves maintaining high quality and adequate quantity of water to the cave ecosystem, achieved through protection of a cave's surface and sub-surface drainage basins (USFWS 2012). Well protected drainage basins provide necessary moisture and stable temperatures in cave habitats, and ensure these ecosystems are free from contaminants (USFWS 2012).

## ~~2.0~~5.0 THREATS

One of the main threats to the listed karst species is loss of habitat due to urban development activities. ~~The~~These species occur in an area that is undergoing continued urban expansion at a rapid rate and few caves are protected. Most of the species' localities occur adjacent to or near developed areas, or in areas that are proposed for development (USFWS ~~1996~~1996a).

The most significant effects of urban development on ~~the~~ karst habitat are:

- filling of cave entrances or greatly reduced infiltration due to impervious cover. This blockage decreases the total energy entering the cave through the entrance (Russell pers com 1998) and reduces the moisture input necessary to maintain high humidity in the cave.
- inadequate setbacks for cave cricket foraging areas. Vital nutrient input provided by cave crickets could be lost if efforts are not made to protect their entire foraging range (105 meter radius around the cave footprint) (Taylor et al. 2005).
- pollutants from urban run-off, such as pesticides, which can contaminate caves and possibly harm or kill karst species or ~~the~~ species that provide organic matter. ~~This alters~~Urban run-off can also alter the natural flow of nutrients through the cave system~~,~~ by replacing water flow and animal energy inputs ~~through crickets and mammals,~~ with potentially contaminated seepage from yards ~~or virtually no water or food input.~~ and parking lots. If the surface and sub-surface drainage basins are not adequately protected, contamination of this nature can be expected.

Other threats to ~~the~~ caves related to urban development include alteration of surface plant and animal communities, ~~as well as~~ increased human visitation, vandalism, dumping, habitat fragmentation, and poorly designed cave gates~~, and~~ (USFWS 2011a, 2011b). Land use changes ~~which cause changes in~~can also affect the abundance and spatial arrangement of other organisms in the surface and sub-surface biotic community~~.~~ known to be beneficial to karst invertebrates (USFWS 2011a). Neglect of caves is also a threat since caves that are not visited or monitored may deteriorate due to ~~neglect or their~~inattention to new

developments in cave areas; also, cave locations may be lost. ~~There are also~~Activities at several limestone quarries in northwestern Travis County ~~whose activities~~ may also threaten to destroy surrounding karst habitat. (BAT 1990, USFWS 1994~~),~~).

Twenty percent of the known caves in Travis County have been covered or destroyed in the ~~last~~ 20 years prior to the establishment of the BCP as a result of land use practices and development. This rate of loss is expected to continue (USFWS ~~1996~~1996a).

Recent scientific evidence of climate change demonstrates increases in average air temperatures in the last 50 years, coupled with an increase in heat waves and heavy precipitation events (IPCC 2007). These trends are projected to continue and increase in the next century with the southwestern U.S. being the most impacted of the continental U.S. (IPCC 2007). Karst invertebrates may be affected by the effects of climate change, due to their dependence on stable temperatures and humidity (USFWS 2011a). Climate change may impact karst species directly from increased in-cave temperatures and indirectly through changes in the vegetation and surface environment, which could affect food resource availability (USFWS 2011a). The caves of the Jollyville Plateau may be especially vulnerable to global warming due to the fact that they are shallow (generally 20 to 30 feet in depth). Rainfall regime changes and more extreme rain events may also impact the cave environments by flooding, filling in with debris, or adversely affecting nutrient inputs (USFWS 2011a).

Red imported fire ants (*Solenopsis invicta*) (RIFA) threaten the karst community directly by preying on ~~the~~ karst invertebrates ~~and~~, but could also indirectly threaten them by reducing the amount of organic nutrients brought in by trogloxene species (species that live in the cave during the day and venture out at night foraging for food). Most notable ~~trogloxene~~trogloxenes are cave crickets and mammals such as raccoons. If the cave is overrun by RIFA, ~~the trogloxene will~~trogloxenes may disappear. RIFA will eat cave cricket eggs, nymphs and adults ~~and basically force~~as well as forcing out ~~the~~ mammals, greatly reducing

the availability of organic material entering the cave. RIFA are most abundant in disturbed areas (USFWS ~~1996). The most~~2011b). Current estimates indicate that most of the 62 caves have at least some RIFA activity (Sanders pers com ~~2004).~~2013; Bayless pers com 2013). See Tier II-A, Chapter X for additional information on RIFA.

Tawny crazy ants (*Nylanderia fulva*) are the latest invasive non-native species to threaten karst invertebrates. These newly arrived, non-native ants are a poorly understood species in the Austin area, making it difficult to project what long term impacts this species may have on karst ecosystems. In the Houston area this species has proven to be a major pest, and in areas of heavy infestation they have displaced RIFA (Meyers 2008). This species will likely have adverse effects on ant diversity as well as abundance and diversity of other arthropods in infestation areas (Meyers 2008). Since tawny crazy ants prefer wetter, more humid environments (Meyers 2008), areas around caves may be even more susceptible to invading colonies by providing preferred habitat characteristics. As of July , 2013 tawny crazy ants were confirmed at the entrance of Whirlpool Cave, and documented foraging as far as 100 ft inside the cave itself (Sanders pers com 2013; Bayless pers com 2013). TCAs were also documented infesting No Rent Cave in November 2014 (Sanders pers com 2015; Bayless pers com 2015).

Mammals bring in tremendous amounts of organic material into caves via their scat. ~~Though~~Although the endangered karst fauna are very much dependent on these species to provide this material, the effects of large amounts of scat can also be detrimental when they attract non-cave adapted species (i.e. roaches) (Reddell pers com 2004).

White nose syndrome (WNS) is a newly observed disease responsible for unprecedented mortality of hibernating bats in the northeastern U.S., and since its discovery in 2007 has spread rapidly westward, posing a serious threat to hibernating bats throughout North America (USFWS 2011d). One species that

commonly occurs in Travis County, the tri-colored bat (*Perimyotis subflavus*), has been shown to be susceptible to WNS (USFWS 2011d). In the 2013-2014 monitoring season (winter), WNS was detected and confirmed in Arkansas (USFWS 2014b). This occurrence demonstrates the potential for WNS to spread into the western U.S. in the near future (USFWS 2011d). Therefore, the threat of WNS to these important trogloxenes requires special attention of researchers accessing caves to be aware of potential transmission of this disease as well as appropriate decontamination procedures if WNS finds its way into central Texas caves (USFWS 2011d).

# 6.0 MANAGEMENT PROGRAM

## ~~2.1~~6.1 KARST MANAGEMENT GOALS

The Recovery Plan for Endangered Karst Invertebrates in Travis County, Texas (USFWS 1994) outlines four major recovery actions: (1) research and information needs, (2) long-term protection for karst fauna areas, (3) monitoring, and (4) education. ~~This plan will~~The BCCP's Habitat Conservation Plan/Environmental Impact Statement states that the BCCP should effectively implement these goals in order to assure that the implementation of the BCCP has no negative impact on the population viability of the endangered karst invertebrates (USFWS ~~1996). Secondary management goals include protection of the BCP karst features to protect local water quality.~~ 1996a). Karst preserve design is the most important aspect for guarantying the long term survival of the species. Preserves that have adequate setbacks to ensure that the entire surface and subsurface drainage basins as well as the native plant and animal communities are protected will greatly enhance the long term success of the program (UFSWS 2012). The ultimate goal is wherever possible to have quality preserves that are self-sustaining, thus greatly reducing the need for intensive onsite management. A secondary management goal includes the protection of the BCP karst features to protect local water quality.

Currently protected karst habitat will be maintained and enhanced, and permit holders will attempt to protect or acquire additional ~~BCP~~BCCP caves for karst preserves. BCP partners will attempt to enter into formal management agreement(s) with the landowner(s) for all caves that are recommended for protection but have yet to be acquired or kept in private ownership as cave preserves. The management agreement(s) will detail the area to be managed for cave protection, what such management will entail, and who is responsible for the management. Efforts are needed to increase public awareness and sensitivity to the karst invertebrates and other endangered species.

~~***2.2 3.2 MANAGEMENT OBJECTIVES***~~

~~Management objectives will include: maintaining habitat in karst features with listed species and/or cave crickets; maintaining appropriate nutrient input into karst features with listed species and/or cave crickets, protecting caves with listed species and/or cave crickets from damage or harm due to vandalism and contamination; and maintaining and improving the condition and viability of the surface community.~~

~~(USFWS 2003)~~

~~Red Imported Fire Ants (RIFA) will be controlled using approved methods (see below and Tier II-A, Chapter X).~~

~~Caves with listed species may have to be gated or the area fenced if routine inspections show unauthorized entry and/or vandalism. No unauthorized entry is allowed (USFWS 2003).~~

~~***2.3 3.3 SPECIFIC STRATEGIES***~~

## 6.2 CONSERVATION ACTIONS

The following is a summary of more detailed management information available from ~~libraries~~current literature, TC Natural Resources ~~Department~~and Environmental Quality Division, COA - Austin Water Utility, and the USFWS. The following activities will be undertaken for caves owned or managed by BCP

partner agencies ~~out of~~for the 62 BCCP caves, as well as other BCP caves with ES or SOC.

~~To practice "adaptive management", I~~If monitoring data shows that ~~the~~ management methods are ineffective or can be improved, permit holders should practice "adaptive management"; in these cases the management plan will be revised and/or additional activities will be added ~~such as~~. Such additions may include: fencing of additional areas around caves to control access, more intensive ~~fire ant~~RIFA control, removal of ~~additional~~non-native plant/animal species found to be detrimental to the karst ecosystem, or removal of additional species found to directly harm the species either directly (e.g. predators~~), additional species found to~~) or indirectly ~~harm the species~~ (e.g. species that prey on food base~~, plants that cause drying of~~ or increase the nutrient level (e.g. large amounts of raccoon scat attracting more aggressive surface species into the cave ~~environment~~).

### ~~2.3.1~~6.2.1 ~~3.3.1~~ *Vegetation Management ~~Procedures~~*

~~Natural~~Ashe juniper-oak woodlands and other native vegetation will be ~~left~~protected within the ~~critical area around cave entrances and also a needed buffer area outside this critical area~~preserve areas. Thick vegetation will be left to help protect caves by camouflaging their entrances. The size of the ~~critical~~surface area ~~and buffer~~ needed to protect individual caves will be determined ~~by the~~ based on karst preserve design recommendations (USFWS~~.~~ 2012). Non-native vegetation in the critical area around a cave will be controlled to protect the cave ecosystem ~~(USFWS Draft Protocol for Karst Preserve Design, 2003).~~, preferably by mechanical control methods (USFWS 2011b). If chemical control methods to eliminate non-native plants around caves are absolutely necessary, herbicide treatments will be limited to cut-stump methods only (applying herbicide individually to freshly cut stumps or stems, which eliminates potential of drift and run-off); no foliar spray treatments will be used within the

105 m cave cricket foraging area of ES/SOC caves, or within the surface or subsurface drainage basin if run-off is potentially an issue.

When possible, the permit holders will work with nearby developers and landowners in the cave vicinity to encourage xeriscaped landscaping~~,~~ using native plants, ~~with little~~which promotes less watering, fertilizers or pesticides ~~to minimize~~, thereby minimizing groundwater contamination ~~and to~~. Permit holders will also discourage the presence of non-native fauna ~~that~~such as feral hogs, which may ~~prey upon the~~ damage native vegetation on cave ~~fauna~~surfaces.

### ~~2.3.2~~6.2.2 ~~3.3.2~~ *Animal Management ~~Procedures~~*

~~Red Imported Fire Ants~~RIFA should be controlled using ~~U.S. Fish and Wildlife~~USFWS approved methods (USFWS 2011b; see also Tier II-A, Chapter X). Surveys for ~~imported fire ant~~RIFA mounds should be conducted at least twice per year. ~~Fire ants~~ RIFA do not maintain their mounds during the summer, making them more difficult to see, but begin rebuilding them as soon as rains and cooler temperatures return (Vinson and Sorensen 1986). Because of this, at least one monitoring survey should be ~~done~~conducted in ~~the~~both spring and ~~at least one should be done in the~~ fall. These surveys should be conducted over the ~~entire Karst Feature~~ minimum cave cricket foraging area (within ~~164~~80 m (262 ft) of cave entrances) and should be sufficient to yield actual ~~fire ant~~RIFA mound densities, not merely indices of ~~fire ant~~RIFA density. ~~During each survey, fire ant mound density should be measured across the entire Karst Features Area and, for those karst features supporting listed invertebrates and/or cave crickets, density of fire ant mounds should be measured within 164 ft (the minimum cave cricket foraging radius) of cave entrances.~~ In addition, every routine maintenance inspection should include a search for ~~fire ant~~RIFA mounds within 10 m (33 ft) of the cave entrance (USFWS ~~2003~~2011b). To avoid impacting the native ant population, the site must be surveyed for the presence of native ants ~~and~~ prior to any RIFA treatment.

Control of ~~imported fire ants~~RIFA should also be conducted at least twice per year if monitoring indicates their presence. ~~Fire ants~~ RIFA may remain relatively inactive and deep within their mounds during long periods of drought or cold (Vinson and Sorensen 1986), making them more difficult to eradicate. Because of this, ~~fire ant~~RIFA control should be conducted at least once in the spring and at least once in the fall. ~~These~~This control should be done shortly after the scheduled monitoring and not before so as not to artificially reduce the apparent ~~fire ant~~RIFA density. An increase in the frequency of ~~fire ant~~RIFA control ~~will~~may be ~~required if~~necessary based on (1) ~~fire ant densities are greater than 40 mounds per acre~~declines in cave cricket abundance or (2) ~~there are greater than 40~~an increase in the number of RIFA mounds within ~~164 ft (the approximate cave cricket foraging radius)~~80 m of the cave entrance ~~to any karst feature that has listed species or cave crickets. The frequency of fire ant control should be increased until the density of fire ants has decreased to less than 40 mounds by the next fire ant survey.~~(USFWS 2011b). Additionally, if ~~fire ant~~RIFA mounds are ~~ever~~ observed within 10 m (33 ft) of any ~~karst feature in the Karst Feature Area~~protected cave during fire ant surveys, routine maintenance, or any other management or monitoring activity or if biological investigations find any ~~fire ants~~RIFA within any cave that has endangered invertebrates ~~and/or cave crickets~~, all mounds within 10 m (33 ft) of that cave entrance should be treated within ~~15 days.~~one week (USFWS 2011b). Staff conducting ~~fire ant~~RIFA surveys as well as those conducting routine maintenance and other biological surveys on a Karst Feature Area should be trained to distinguish ~~imported fire ants~~RIFA and their mounds from native ants and their mounds (USFWS ~~2003~~2011b).

Within ~~164 ft~~105 m of the ~~footprint~~entrance of any karst features that support listed invertebrates and/or ~~cave crickets, fire ant~~ SOCs, RIFA control ~~should~~must be restricted to the use of boiling water~~. More than 164 ft~~, which ensures protection from ~~any karst feature supporting listed invertebrates and/or~~pesticides of the entire cave cricket foraging area (Taylor et al. 2005). In addition, RIFA bait treatments are not recommended outside of the cave ~~crickets, either boiling water or chemical~~cricket foraging area due to the fact that the baits ~~(such as Amdro or Logic) may be used (see the following restrictions). Greater than 500 ft~~

~~from any karst feature supporting listed invertebrates and/or cave crickets, baits may be "broadcast" (USFWS 2003).~~can harm native ant species. For boiling water treatments, boiling or near-boiling water should be poured directly onto the mounds. Sufficient boiling water should be used that the mound collapses in on itself. This should typically be 1-4 gallons. These treatments ~~are best done during early to mid-morning or anytime of the day~~should be conducted when ~~it's~~the brood is high in the mound (typically on cool, cloudy ~~and humid will~~days) to ensure that the queen(s) and larvae are likely to be near the top of the mound. During long periods of drought or cold, the queen(s) and larvae will most likely be deep within the mound, making them more difficult to eradicate (Vinson and Sorensen 1986). Mounds should not be disturbed before treatment as this will cause the ants to move the queen(s) and larvae to deeper locations within the mound or to a remote location~~.~~ (USFWS 2011b). Small amounts (1-2 teaspoons) of detergent may be added to the boiling water~~; this may help~~, which helps the water penetrate the soil ~~(USFWS 2003).~~.

~~If chemical baits are used between 164 and 500 ft from a karst feature containing listed invertebrates and/or cave crickets, the following protocols should be met. The bait should be placed out in mid-morning and all uneaten bait should be removed by sunset. This is intended to limit the possible exposure of cave crickets that may be foraging beyond 164 ft from being exposed to the chemicals and bringing those chemicals back into the cave ecosystem. Because baits should be removed at the end of the day, they should be placed in containers appropriate to allow fire ant access but that will allow baits to be removed at the end of the day (USFWS 2003).~~

~~For broadcasting baits in areas greater than 500 ft from any karst feature supporting listed invertebrates and/or cave crickets, no more than 1.5 pounds of bait per acre may be used and broadcast baits should not be used if the presence of imported fire ants has not been verified within the previous year (USFWS 2003).~~

~~For any use of baits within a Karst Feature Area the following protocols should be followed. The ground should be dry with no rain forecast for that day because the baits are not suitable to be picked up by foraging ants when they become wet. The bait should be placed out in the midmorning and temperatures for the day should be between 70°F and 95°F so that the ants will be active and foraging and because the baits are quickly degraded at high temperatures and lose their effectiveness. Baits should be placed near any mound observed, but baits should~~

~~also be spread out across the preserve area to control any mounds that may be inconspicuous. Baits should be placed at least 1-3 ft away from any mound. Baits should not be placed directly on mounds because the ants will only recognize the baits as food some distance from their mound and may confuse the bait with building material if found on the mound (Vinson and Sorensen 1986, USFWS 2003).~~

Passive management strategies should be implemented in conjunction with active management (boiling water treatments to mounds). Passive management strategies include: allowing woody vegetation to flourish and avoiding clearing of native vegetation with the cave cricket foraging area to create a closed canopy which deters RIFA (RIFA's habitat preference is open/ disturbed habitat); controlling deer densities and feral hog populations, which can greatly increase woody growth and decrease soil disturbance; and not allowing public trails or picnic tables within the cave cricket foraging area.

Inspections will be made at cave sites during field visits for the presence of tawny crazy ant infestation. Managers will use current collection and reporting procedures of suspect infestations to confirm presence of new tawny crazy ant colonies, and if found, will work with the USFWS on control options.

Larger mammals, in particular raccoons, using cave features for shelter especially in and around urban areas can produce large amounts of ~~skat~~scat inside the caves. The ~~skat~~scat alters the nutrient content, especially nitrogen levels, within the cave ecosystem and can be detrimental to karst invertebrates~~.~~ (USFWS 2011e). Evidence of raccoon populations within caves should be monitored and populations controlled as needed.

### ~~2.3.3~~6.2.3 ~~3.3.3~~ *Cave Gating and Fencing in BCP Caves and Bat Management*

~~Cave gates should be designed to permit normal airflow, water flow, and nutrient input (for more information see Elliott 1996). Fences are an alternative to gating that may pose less interference with the nutrient regime and other environmental factors (air and water movement). If the cave has bats, then a fence would be~~

~~more appropriate. The fence should be designed to be very difficult or close to impossible to climb over. The larger setback from the entrance, the better (Sanders 1997 pers com). (See Tier III-Karst Management chapter for cave gate status and future plans).~~

The need for a cave gate or protective fencing will be determined by each cave managing organization based on the following general criteria:

1. In cases where caves are isolated~~,~~ (not near any neighborhoods), and/or with camouflaged entrances that do not appear to be a cave, no gates are warranted.
2. In situations where the cave has either a history of public access~~,~~ or is in near proximity to neighborhoods with a very obvious entrance, gating or ~~a fence~~fencing is recommended.
3. A gate or fence may also be necessary for liability reasons especially if the cave is vertical, unstable, or is a known “bad air” cave~~.~~ (USFWS 2011b).

Cave gates ~~protect the cave from unpermitted access, may prevent it from being filled or paved over, but may also affect bat populations or alter the airflow and nutrient input into the cave. Cave gates~~, where necessary, should be designed to permit normal airflow, water flow, and nutrient input, and should allow bat and small mammal (raccoon, ~~possum~~opossum, fox~~)~~, rodents, etc.) access~~. As~~ (USFWS 2011b). Fences are an alternative to gating that may pose less interference with the nutrient regime and other environmental factors (air and water movement). If the cave contains bats, then a ~~cave gate, fencing can~~ fence may be ~~used~~more appropriate. The fence should be designed to ~~protect the cave if set back~~be very difficult or close to impossible to climb over, and placed away from the cave entrance as far ~~enough.~~as possible (Sanders 1997 pers com). However, neither gates nor fences can prevent people from throwing toxic or other materials into a cave. Cave gates and fences may also serve to attract attention to an otherwise unknown cave which may encourage vandalism.

~~Bat populations will be maintained in BCP caves whenever possible to maintain the ecology of the entire karst ecosystem. All cave gates installed should be bat gates if there is any indication that the cave is or could in the future be used by bats.~~ Therefore, decisions about the need and desirability of gating or fencing BCP caves should be made on a case-by-case basis.

Bat gates should be installed on caves with suitable bat habitat. Prior to the construction of a cave gate, the cave should be evaluated for suitability as historic or current bat habitat. The criteria include historic bat use, numbers of bats currently using the cave, size of the entrance, size and arrangement of the interior rooms, surrounding habitat use, unavoidable disturbances from surrounding land use, and compatibility with other cave uses~~, etc~~. Specialized gates will also be necessary for caves that receive large amounts of recharge. The design of bat gates should allow for access by the bats, by property managers, and by raccoons and small mammals, and should be as visually natural looking as possible. Information on bat gate design ~~can~~should be obtained from Bat Conservation International ~~and~~(www.bci.org) and/or the American Cave Conservation Association (www.cavern.org) to ensure there are no inadvertent impacts on karst invertebrates, bats or other ~~local bat gate designers.~~species (USFWS 2011b).

Bat populations in caves should be monitored for potential effects of WNS on their numbers, and observations of multiple live or dead bats that exhibit signs of WNS should be reported immediately to the USFWS Austin Ecological Field Office. No bats are to be handled unless authorized to do so by the appropriate governmental agency (WNS Decontamination Team 2012). If WNS is discovered in the region in the future, BCP staff will follow appropriate decontamination procedures as outlined by the most recent National White-nose Syndrome Decontamination Protocol (WNS Decontamination Team 2012). Visitors from outside of central Texas or who have caved in Europe or any state where WNS has been suspected or confirmed, or researchers that request access to BCP caves must agree to adhere to the current WNS decontamination protocol prior to access or scientific research permit approval.

### ~~2.3.4~~6.2.4 *Physical Management* ~~*Procedures*~~

~~The~~ Cave areas should be protected from spills or contamination. The cave area is defined as the protection area designated by a ~~hydrogeologic study~~hydrogeological investigation, or in the absence of a study, the area within

1/4-mile radius of the cave entrance. ~~Informal consultation~~ Coordination with USFWS is ~~encouraged~~required if there are any possible contamination issues. Pesticides~~, herbicides~~ and fertilizers are prohibited from use within the area designated as needed for protection~~, with the exception of RIFA control~~.

Electric power lines with transformers should be prohibited from critical cave areas because they could leak onto the ground or explode and adversely affect the cave fauna.

"Emergency Response Plans" (where needed) will be written ~~along~~in coordination with the Texas Commission on Environmental Quality (TCEQ~~,~~), the COA~~,~~ Watershed Protection Department (WPD), and the Barton Springs/ Edwards Aquifer Conservation District (BS/EACD) for any cave near a pipeline or road where a major spill can occur. Most of the responsibilities for response will fall on these above agencies ~~but~~; however, creating such a plan before a spill may be critical to having the BCCP's interests represented and considered in a timely manner ~~to protect the~~for protection of karst species.

No subsurface utility lines, roads or any other construction should enter or cross the cave area ~~because of~~due to possible cave collapse, leakage ~~due to~~from pipe corrosion ~~and~~, or related stresses. Altering and severing interstitial spaces ~~would~~ negatively ~~impact~~impacts and ~~alter~~alters sensitive karst areas.

~~The BCP Partners will prevent dumping, vandalism, and remove trash from the caves. When removing trash, we will work to remove cave animals from the trash, and return them to the cave.~~ Alteration of surface drainage patterns on BCP preserves without approval of USFWS will not be allowed.

~~Additional information on cave management can be found in the booklet, *Living on Karst* (Cave Conservancy of the Virginias, 1997) and from the *Guidelines for Cave and Karst Protection* (IUCN, 1997).~~

BCP Partners will prevent dumping and vandalism at caves, and will remove trash from caves when encountered. When removing trash, BCP land managers will work to remove karst invertebrates from collected trash and return them to the cave.

### ~~2.3.5~~6.2.5 *Access Guidelines ~~and Monitoring~~*

In general, access to publicly-owned BCCP caves should be limited to necessary monitoring, management and research efforts that either directly benefit the endangered species or ~~species of concern as well as~~SOC or provide necessary maintenance (including RIFA control, gate maintenance, and insuring the security of the cave preserve). However, some publicly-owned BCCP caves have allowed public visitation since before the signing of the BCCP; this public access is considered to be grandfathered based on these prior allowances. Publicly owned BCCP caves with grandfathered status are: Airmen's Cave, District Park Cave, Goat Cave, Maple Run Cave, and Midnight Cave.

The Permit states that "all access to caves must be restricted to permits issued by the appropriate land management agency, based on an appropriate program in the land management plan for the preservation of the caves' ecosystem~~.~~" (USFWS 1996a). BCP Partners will determine ~~what~~the type and ~~what~~ amount of access ~~for the~~at publicly-owned caves ~~is to be allowed~~ for the purposes of research, monitoring, or education, ~~or recreation, which will ensure that the~~with priority focusing on adequate protection of karst species ~~are adequately protected~~ (See Tier II-A, Chapter XII). USFWS requires that anyone entering an endangered species cave without a 10(a)1(A) permit should be accompanied by someone who does have this permit.

~~Until sufficient survey information is available to better determine the effects of human visitation on karst invertebrate species, it is assumed that human visitation may adversely affect their populations. Any BCCP caves that are open to the public through controlled, guided or open access should be considered as "test access caves" and should be accompanied by regular biological surveys of karst invertebrates as well as human visitation counts to assess if impacts are occurring.~~

USFWS (2011a) urges land managers to minimize access into caves due to impacts caused by visitation such as: increasing soil compaction, trash, and vandalism; scaring away trogloxenes; and direct mortality of cave organisms crushed by human disturbance. Human visitation may also disrupt cave ecosystems through introduction of non-native microorganisms, introduction of

lint from clothing, increases in carbon dioxide, temperature, and nutrients, decreased humidity, and damage to speleothems (Hunter et al. 2004, Ilkner et al. 2007, Jablonsky et al. 1995, Lavoie and Northup 2005, Legatzki et al. 2011, Pulido-Bosch et al. 1997, U.S. Geological Survey 2013). Visitation impacts can be especially detrimental to low-energy caves (Gillieson 2011). Excessive or uncontrolled visitation may also endanger inexperienced people entering the caves that are unguided, and/or lack proper safety devices and training. Uncontrolled visitation may endanger sensitive features within the cave. If unabated, these problems can, which could contribute to poor landowner relations and poor public opinion about caves, and can adversely affect the efforts of the BCCP. Public education is essential for the continued existence and recovery Because of these concerns, any BCCP caves that are open to the public through controlled, guided access should be accompanied by regular biological surveys of karst invertebrates. Controlled public access to karst areas and specific caves is a necessary part of public education. If no listed endangered species are found or known as well as human visitation counts to exist in a karst feature, public access will be allowed (USFWS 2003). However USFWS assess impacts. Cave visitor impact monitoring may also urges the BCP Partnersbe implemented to minimize access into species of concern caves. Since detect damage and guide visitor management. Trained volunteer cave monitors within Austin caving organizations and volunteers are currently and will continue tocould also play a vital part in the effort to protect and monitor these caves, continued use of karst volunteers will to be important to cave protection efforts. Also education of the public about cave biology and cave protection will likely require the continuation of some access into the non-endangered species caves. Trained volunteer cave monitors within the Austin caving organizations will likely play a vital part in the effort to protect these BCP caves and other caves in the Austin area.BCP caves. These cavers can be a significant resource in cave management and will be allowed access to caves to assist with cave protection. All access to the publicly-owned caves will be restricted to permits issued by the appropriate land management agency, based on an appropriate program in the land management plan for the preservation of the caves' ecosystem (See Table 2). and education programs.

Prior to any regular visitation other than necessary research or maintenance, background populations of invertebrates will be assessed within any caves listed on the federal permit or added to the permit that may be considered for test access. Baseline biological surveys should be conducted once every quarter for

~~the first year at a cave to establish background levels. Where baseline surveys are conducted under extended unrepresentative climatic conditions, such as under an extended drought, the surveys should be extended into more average conditions.~~

~~Following baseline surveys, at least two surveys a year should he conducted. Results from the surveys should be reviewed annually to better assess the impacts of visitors on cave invertebrates, and if the limits on visitation should be changed.~~

COA WPD staff is currently in the process of identifying new non-BCCP caves that will have the potential to reduce current levels of public access to BCCP caves while still providing valuable educational opportunities to the public.

If managing BCCP caves on private land, permission of the property owner or appropriate representative must always be obtained prior to entering. Good relationships with property owners of caves are valuable for promoting the goals of the BCCP, which includes securing the survival of rare and endangered karst species.

### ~~2.3.6~~6.2.6 *Public Education and Outreach*

Education ~~for~~ both for land management professionals and the general public should be implemented in order to raise awareness of cave conservation issues and encourage protection of caves and karst ecosystems~~ should be implemented. Education should be encouraged where appropriate, where such activities are done at a frequency and manner that does not harm the species. Some sites may be suited for visitation while others may not.~~. Education for BCP preserve managers, consultants, other professionals, and private landowners with BCP caves should be the immediate focus, ~~with~~which should include relaying up-to-date management strategies and monitoring efforts for determining and responding to the threats to karst ecosystems addressed above. Education for the general public ~~as the~~should be a primary focus ~~for~~in the long term, to better inform citizens on the importance of protecting karst areas and how that protection also benefits them.

For the purposes of this document, public education includes literature, curriculum, web media, interpretive kiosks, and guided surface and subsurface tours that can be made available for the general public, agencies, and individuals interested in learning more about karst areas and their inhabitants. ~~It also includes education~~Also included is educational media for cave managers and supporting staff, as well as the agencies involved with invertebrate species protection. A higher public awareness is an important step ~~for~~towards the recovery of the endangered cave invertebrates and continued preservation of ~~the~~karst species of concern.

~~Literature, such as a "Living on Karst" booklet, similar to that produced by the Virginia Cave Conservancy (VCC), should be produced to introduce the public to unique aspects of karst areas, including photographs and descriptions of cave species. One approach to introducing cave invertebrates to the public is to include them within the context of many other aspects of karst, rather than limiting the media to just cave invertebrate species listed on the permit. This approach will attract a wider audience and can provide a more holistic education about other parts of the system, such as water quality, groundwater flow, geology, other karst species (such as the Barton Springs salamander, *Euycrea sosorum*) and cave development processes (speleogenesis). The need for clean water and a desire for undisturbed natural Texas land is shared by karst invertebrates, well users, and city dwellers. Several groups, including the COA Watershed Protection and Development Review, the BS/EACD, and TCMA have expressed interest in revising the Virginia book to apply to either the Edwards Aquifer or karst areas of Texas. A book such as this could potentially be used to introduce the karst invertebrates and show their place in the system. The VCC has given permission to BS/EACD to revise their book, with proper acknowledgement.~~

## ~~2.4~~6.3 ~~3.4~~ MANAGEMENT COORDINATION ~~OF MANAGEMENT~~

~~Coordination of management will include:~~

BCP partners will continue ~~the effort~~efforts to standardize management strategies and research/monitoring methods for all BCP caves based on best management practices.

~~The~~ BCP partners will attempt to ~~cooperate~~work with and/or obtain landowner agreements with the following groups which are now protecting BCP caves~~: TNC (one cave), TCMA (3 caves), the Four Points (Perot area) cluster 10(a) agreement holder (5 caves), and Canyon Creek as Section 7 agreement holder (2 caves). Canyon Creek's Sec. 7 agreement for Stovepipe Cave requires them to convey or dedicate a 55-acre preserve around this cave and actively manage it. Lamm Cave is protected by a 150' setback area around the cave and their permit requires the owners to allow reasonable access for research purposes.~~ (**Table 3**):

- TNC (one cave),
- TCMA (two caves),
- the Four Points cluster 10(a) agreement holder (five caves), and
- Canyon Creek as Section 7 agreement holder (one cave).

BCP partners will ~~also~~ attempt to protect the remaining privately owned caves through acquisition, easements, or ~~landowner~~cave management agreements with the landowner. The precise location of some of these privately owned caves is currently unknown; therefore, the COA and TC should attempt to locate these caves in order to make a meaningful assessment.

Per BCCP Permit Conditions S2 and T2, if new karst features "are discovered with a significant diversity of troglobitic fauna, those karst features may be submitted to the Service for consideration for exchange with karst features identified for protection by the BCCP" (USFWS 1996b). In order to allow the Permit holders to implement these Permit conditions, COA and TC created a Cave Substitution Policy that provides a process that allows caves listed in the BCCP permit to be substituted with other suitable caves in a manner that is transparent, science based, and consistent with the vision and intent established for BCCP. This policy includes a definition of "significant diversity of troglobitic fauna" as it applies to eligibility of a cave for substitution, and determines parameters that quantify preservation of environmental integrity for BCCP-listed caves and candidate substitution caves as it applies to management of caves.

These defined criteria will be used in determining both the need to substitute a feature listed on the Permit as well as whether the substitution cave will adequately replace the previously identified BCCP cave or caves. The BCCP Cave Substitution Policy was adopted by the BCCP Coordinating Committee in August 2015, and is attached to this Land Management Plan as Appendix A.

~~As allowed in the permit and to be approved by USFWS, it may be necessary to exchange which caves will be protected by BCP (the total not to exceed 62 caves). A process will be established to analyze updated cave species information in the chance that there is the discovery of new cave locations of the BCP endangered karst species or the discovery of endangered species in existing SOC BCP caves.~~

The COA and TC will continue to monitor proposals for infrastructure projects that may impact BCP caves (see Management Handbook: Infrastructure).

~~The~~ BCP partners will continue to submit ~~an~~ annual ~~report(s)~~reports to the USFWS for all 62 caves ~~telling how the~~ detailing implementation of site specific management plans~~ have been implemented, as well as dealing with other management issues and~~, cave acquisitions and agreements, research/monitoring results~~ to be approved by the Coordinating Committee~~, and ~~reviewed by the Scientific Advisory Committee~~ management actions and issues (USFWS ~~1996~~1996a).

~~The BCP Partners should investigate if additional protections are available to the Permit holders from Texas Commission on Environmental Quality (TCEQ) for some of the private caves that serve as recharge features. The Permit holders should encourage TCEQ not to sanction the "filling in" of private SOC caves, under the guise of protecting the aquifer. We should investigate the possibility of getting TCEQ to designate as "significant recharge features (sensitive features)" caves such as Ireland's Cave, Flint Ridge Cave, and Blowing Sink Cave before development occurs (Russell 1998).~~

## ~~3.0~~7.0 ~~4.0~~ MONITORING / RESEARCH

Monitoring Objectives ~~will~~ include the following:

- ~~There will be~~ Routine site inspections for signs of vandalism, unauthorized entry, trash dumping~~;~~, presence of RIFA/tawny crazy ants, and damage to vegetation due to ~~visitors going off-trail,~~ deer, feral hogs, ~~etc.;~~or visitor off-trail use (USFWS 2011b).
- Verification of all BCP cave locations using established, systematic protocols. All BCP caves should also have interiors mapped using the most up-to-date survey methods available. When verifying cave locations, each site should be given a unique ID number using a tree tag and ~~presence of fire ants (See Karst Management Forms in Appendix A).~~photos taken of each entrance.
- ~~There will be~~Baseline monitoring of cave species (listed and unlisted), cave crickets, vegetation, environmental conditions (in-cave and on the surface), RIFA, and mammals (USFWS 2011b).
- Monitoring of vegetation around karst features and within the features themselves for presence of feral hogs, deer, raccoons, etc. Monitoring will follow USFWS approved guidelines (USFWS ~~2003~~2011b).

~~There will be baseline monitoring of: cave species (listed and unlisted) cave crickets, vegetation, environmental conditions (in cave and on surface), fire ants, and mammals (USFWS 2003).~~

~~There will be periodic monitoring of: vandalism, unauthorized entry, and trash (USFWS 2003).~~

Caves containing endangered and rare karst invertebrates on BCP properties will be monitored to determine long term trends in populations of cave organisms and overall cave conditions. ~~Caves will be surveyed during cool, wet, periods in the spring and/or fall. Biomonitoring of the caves should follow in frequency and methodology techniques~~ All COA and TC owned BCCP caves will be surveyed annually. Other BCP caves with ES/SOC will also be surveyed annually dependent on staff availability. In addition, COA and TC identified 25 caves within Travis County managed by BCP partners that provide a more evenly distributed data set across cave clusters and karst faunal regions (KFRs). This new monitoring plan began in FY2011, with the number and frequency of karst faunal surveys and cricket counts synchronized among managing partners to

better accommodate comparisons and determine trends. The goal of these changes to the cave monitoring program is to provide a clearer understanding of the species distribution and health of karst ecosystems across the BCP. Biomonitoring of the caves should follow methodology supported by USFWS to provide results that can be compared between caves throughout the region for better study and analysis.

All research, whether by BCP partners or outside researchers should not result in the "take" of an endangered species or in any way degrade endangered species habitat. All researchers must obtain approval from the land managers of ~~the~~BCP tracts ~~to be~~being used for the research. If the proposed research involves endangered species the researchers must obtain a 10(a)1(A) permit from USFWS~~.~~ (USFWS 2011c). Land managers should also have potential researchers sign a standard form stating that they will abide by the rules of the BCP management plans or preserve rules.

~~The BCP partners will regularly monitor the caves with permitted staff or volunteers and will supervise their efforts to assure protection for the listed species. Regular monitoring may be done by groups such as Texas Cave Management Association (TCMA), University of Texas Speleological Society volunteers, Austin Nature Center trained guides and others that will assist with monitoring for vandalism, fire ants, etc.~~

The protocol for research and monitoring of cave fauna involves the use of 1-~~3~~5 (depending on size of cave and logistics) ~~predesignated~~pre-designated, permanent transects or zones per cave in which all living organisms encountered are identified and enumerated. Survey areas should be approximately 5 meters in length and span the width of the cave~~.~~, or when possible, survey areas should occur in discreet units of the cave such as a small room or an easily discernible section. Most importantly, the size and location of the survey area should remain constant during the course of the study. A non-toxic method of marking the transect boundaries (i.e. plastic flagging) may be necessary.

Ideally, each survey should be conducted by at least two people according to the cave's safety protocol. For each survey area, start and end time~~, degree of fire~~

~~ant infestation (light, moderate, heavy, or none),~~ and the presence of trash or new vandalism will be recorded. Relative humidity~~,~~ and temperature will be recorded both outside the cave and at each transect~~.~~ or zone. Preferably, in order to standardize counts, the same observers will conduct all surveys. Typically observers start at opposite ends of the survey area and move toward each other~~,~~ while searching the cave floor, walls, ceilings, and beneath rocks for invertebrates. Any rocks that are lifted during the search will be replaced to their original position. Observers will be able to identify cave organisms to the nearest possible taxa (often genus or species), and will use a checklist of known invertebrates from the cave being surveyed. ~~Because spiders are difficult to identify, they may be placed into two categories: "wall web" and C*icurina* sp~~All data collected during cave surveys will be entered into the BCP Karst Database.

Any unknown invertebrates will be collected and identified by a karst invertebrate specialist~~ (except.~~ In caves containing endangered species, collecting should only occur in these caves with a special collecting permit obtained by USFWS~~ ).~~. Observers should be extremely careful to not harm cave organisms while conducting surveys. All collected specimens should be deposited within the Texas Memorial Museum, or other reputable facility (USFWS 2011c). The date of deposition and collection number should also be recorded (USFWS 2011c). Additional procedures should continue to be developed to further define acceptable survey methods.

For caves that have controlled access, managers will keep records of every visit including information on: date, time, number of visitors, observations, temperature, ~~and~~ humidity, etc.

Land managers will also monitor the entrances of caves containing endangered species at least ~~once a year~~twice yearly for anything that might harm the rare invertebrates including presence of toxic substances, unauthorized use by recreational cavers, and surface disturbances which might have erosive potential or cause changes in surface drainage patterns. In addition, the interior of caves containing endangered species or ~~species of concern~~SOC will be surveyed

annually during dry, hot~~,~~ periods to check for ~~red imported fire ant~~RIFA infestation.

The overall health of caves can also be monitored by using semi-annual cave cricket exit counts. Cricket counts are done as they emerge from caves during good weather nights (i.e. not raining, warm etc.). The duration of the counts should remain constant (timed for ~~2~~two hours starting ~~with the first observed exiting cricket which usually starts a little~~just after ~~dusk).~~sunset). Additional information should be ~~developed telling the purpose~~researched and ~~procedure~~incorporated into the methodology for ~~doing~~conducting these cricket counts, ~~defining a good weather night,~~ as well as ~~information~~insight on how to relate ~~this~~survey data to cave health~~ and what will be done with this data. Another method being used at Get Down Cave to monitor overall cave health involves measuring the amount of organic material deposited on a series of plates (Russell 1998).~~.

Groundwater and drip water samples should be collected to determine the impact of development on groundwater quality. ~~Base-line~~ Baseline sampling should be done in critical caves and springs. ~~Test~~ Tests should be done for geochemical mineral parameters as well as tests for heavy metals, organic chemicals and other likely pollutants. ~~This~~ These tests should be done during development and for several years after development to determine if the groundwater and cave fauna are being adversely impacted by the changes in land use (Veni and Associates 1988). A list of parameters will be developed to standardize ~~what~~ monitoring ~~should test for.~~objectives. These should be listed in order of priority, should include sampling protocols~~ for correct sample gathering~~, and should include a table of estimated and current year costs to assist landowners in budgeting management costs.

### ~~3.1~~7.1 ~~4.1 MONITORING FOR~~ NEWLY DISCOVERED KARST FEATURES IN THE PERMIT AREA

If~~ the~~ BCP Partners become aware of new cave and karst features (i.e. in projects submitted to these agencies during the development process~~,~~), these

features should be reported to the appropriate organizations such as USFWS, TCEQ, etc. ~~These~~Newly discovered karst features on BCP properties should be ~~mapped~~documented and species inventories done by ~~the~~ BCP partners ~~for potential new BCP cave locations (to replace any of the 62 caves that may be lost)~~ to provide information on ~~locations of~~ potential new endangered species or ~~species of concern. Educational materials~~SOC localities. When considering excavation of newly discovered karst features for monitoring access, BCP land managers should ~~be written and distributed to developers and land owners in potential areas of concern.~~consult cave excavation guidelines provided by USFWS (2011c).

### ~~3.2~~7.2 ~~4.2~~ RESEARCH NEEDS

There is currently insufficient information about ~~many~~some of the aspects of karst species and management of their habitat. In addition to the basic information listed above, ~~the~~ BCP Partners should try to obtain information about the following topics and encourage research proposals and projects in these areas~~, however:~~. This is not an exhaustive list, and research needs should be reviewed periodically. Research topics include:

- Cave Environments~~. Humidity, Temperature~~ (humidity, temperature, airflow, and ~~Airflow.~~$CO_2$ concentrations). Increased airflow can cause the desiccation of cave passages. ~~The frequency of airflow~~Also, the fluctuations of these abiotic conditions are not well documented in local caves and should be monitored to better understand potential impacts to karst invertebrates.
- Effects of opening or enlarging cave entrances. Excavating cave openings probably allows organic matter and nutrients to enter, and may enhance invertebrate diversity. ~~Example:~~For example, in Electromag Cave of Sun City, cave crickets became numerous after opening the entrance. However, it is possible that excavating these cave openings would enhance airflow and sunlight that may lead to drying of the cave. The general effect of opening caves probably results in returning the cave environment to pre-Colonial period conditions. This is because over

grazing, agriculture, and other land-disturbance activities appear to have caused widespread filling of sinkhole depressions and cave entrances over the last few hundred years. The possible effect of opening or enlarging cave entrances requires further study. Criteria for determining the need for excavating karst features should be developed for the BCP, following cave excavation guidelines provided by USFWS (2011c).

- ~~Water sources~~Delineating surface and sub-surface drainage basins to all BCP caves. Observations of flow inside caves and groundwater tracing should be used to better understand the ~~source of waters for caves~~water source for caves. Hauwert and Cowan (2013) provide methodology to adequately delineate the source area of cave drips and streams for achieving these goals.
- Life history studies. Information on the life history of karst invertebrate species on the BCCP permit is lacking and should he conducted. Life history studies that occur inside caves are best. Research of this type could potentially also be conducted at simulated cave environments, such as in the Austin Nature Center or in the Barton Springs Splash exhibit. Additionally there is a need to study habitat requirements of key trogloxene species such as cave crickets.
- Invasive species. RIFA, pill bugs, roaches, hothouse millipedes, and fleas can compete with or prey on other invertebrates. The degree of impact of these invasive species could be better understood. Attempts should be made to collect ~~fire ants~~RIFA carrying prey to determine which species are most impacted. Understanding the effects of tawny crazy ants on karst ecosystems is also necessary. Finally, quantifying the effects of large amounts of scat in caves could be useful in understanding how this could attract non-cave adapted species such as roaches.
- Chemical impacts. Sampling and water-quality analysis of cave drips should be performed in urban areas, especially for pesticides~~ and metals. The possible effects of Logic (fenoxycarb) on karst invertebrates should be studied since this pesticide is commonly used as a fire ant deterrent in difficult to reach areas. A study of the effects on invertebrates of another common fire ant pesticide, Amdro (hydramethylnon), has been conducted by the U.S. Department of Agriculture in Gainsville, Florida. The BS/EACD occasionally tests groundwater for water-quality constituents that originate in southern Travis County. It found the~~, fertilizers, and metals. COA WPD

tests groundwater for water-quality constituents from selected caves throughout the BCP. Local groundwater studies have found occurrences of lead, arsenic, petroleum hydrocarbons, and pesticides like bromacil and 4-nitrophenol in the groundwater under urban areas. Levels of ~~hydrocathon~~hydrocarbon fumes have been documented in and near caves containing ~~species of concern~~SOC (Get Down and Midnight caves), following a petroleum pipeline spill in 1986. ~~The Longhorn petroleum pipeline that is proposed to carry gasoline has the potential to affect a number of caves listed on the permit in southern Travis County.~~ The constituents of air in ~~the caves of southern~~ Travis County caves should be monitored periodically or in association with biological surveys.

- Aquatic life ~~in~~within the aquifer. Very little is known about life inside the aquifer in Travis County. Abundant diversity has been found in the Edwards Aquifer of the San Marcos to San Antonio area after investigation. ~~Downhole camera~~ Possible research could include: down-hole cameras and baited traps ~~could be~~ utilized in open bore wells~~,~~; fine nets ~~could be~~ used to catch body parts in large capacity pumping wells~~,~~; and surveys ~~can be~~ conducted in caves extending down to the water table. Efforts should be made to discover cave routes that extend to the water table, as these present tremendous opportunities to examine aquatic life.

- ~~What is the effect of fires on cave invertebrates? A severe fire at Fort Hood did not seem to affect cave species there. The property adjacent to Whirlpool Cave Preserve experienced a severe fire several years ago. Some charred wood was visible in the cave, although no detrimental impacts are obvious. Fires do affect local vegetative cover and consequently can affect the shallow subsurface moisture content.~~
- ~~Cave cricket foraging.~~
- ~~RIFA control methods: effect of broadcasting baits vs. boiling water on overall ant community.~~
- ~~Field Guide with BCCP karst species photos, life history and habitat information of all karst species to assist with karst species identification~~
- Cave cricket abundance as an indicator of cave ecosystem health. Cave cricket exit count data should be analyzed to determine trends. Studies on cave cricket foraging and surface habitat preferences should be conducted. Cave cricket survey methodology should be examined for improvements based on future scientific studies.

- Species identification. Efforts should be made to identify to species level yet undetermined troglobites in BCP caves, with special emphasis on species that may be identified as endangered or SOC as listed on the regional permit. Such examples include blind *Eidmannella* spiders, *Speodesmus* millipedes, *Rhadine* beetles, and Trichoniscidae isopods.
- Long-term trends in populations of cave organisms and overall cave conditions.
- Impacts on the species by recreational uses of caves (in caves with allowed access~~) ~~).
- Impacts of surface disturbances on ~~the~~karst species~~, such as~~. Such disturbances may include reduced habitat area around the cave, erosion, changes in surface drainage patterns, ~~etc.~~and habitat restoration projects (mechanical clearing of vegetation and prescribed burns).
- ~~Best control methods for Red Imported Fire Ants~~
- ~~Determine if the groundwater and cave fauna are being adversely impacted by the~~Impacts from changes in surrounding land use~~ related~~. There is a need to better understand how development around cave areas may adversely impact groundwater, nutrient input, or the cave fauna themselves.

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# APPENDIX A

# BCCP CAVE SUBSTITUTION POLICY