

**U.S. FISH AND WILDLIFE SERVICE  
SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM**

**SCIENTIFIC NAME:** *Eurycea robusta*

**COMMON NAME:** Blanco blind salamander

**LEAD REGION:** Interior Region 6 (Arkansas-Rio Grande-Texas Gulf/Legacy Region 2)

**DATE INFORMATION CURRENT AS OF:** July 30, 2021

**STATUS/ACTION**

Species Assessment – determined species does not meet the definition of “species” under the Endangered Species Act, so was not elevated to the Candidate status

Species Assessment – determined either we do not have sufficient information on threats or the information on the threats does not support a proposal to list the species and, therefore, it was not elevated to Candidate status

Listed species petitioned for uplisting for which we have made a warranted-but-precluded finding or uplisting (this is part of the annual resubmitted petition finding)

Candidate that received funding for a proposed listing determination; assessment not updated

New Candidate

Continuing Candidate

Listing Priority Number Change

Former LPN: \_\_\_\_

New LPN: \_\_\_\_

Candidate Removal; Former LPN: \_\_\_\_

(A) Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of Candidate status

(U) Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of Candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species

(F) Range is no longer a U.S. territory

(I) Insufficient information exists on taxonomy, or biological vulnerability and threats, to support listing

(M) Taxon mistakenly included in past notice of review

(N) Taxon does not meet the Act’s definition of “species”

(X) Taxon believed to be extinct

Date when the species first became a Candidate (as currently defined): N/A

**Petition Information:**

Non-petitioned

Petitioned; Date petition received: 6/25/2007

90-day substantial finding FR publication date: December 16, 2009 (74 FR 66866)

12-month warranted but precluded finding FR publication date:

**FOR PETITIONED CANDIDATE SPECIES:**

- a. Is listing warranted (if yes, see summary of threats below)? N/A
- b. To date, has publication of a proposal to list been precluded by other higher priority listing actions? N/A
- c. Why is listing precluded? N/A

**PREVIOUS FEDERAL ACTIONS:**

On August 21, 1995, the Service received a petition to list the robust blind salamander (referred to hereafter as the Blanco blind salamander) as endangered under the U.S. Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*). The petition was submitted by Walter R. Courtney, Ph.D., on behalf of the American Society of Ichthyologists and Herpetologists. The Service published a 90-day finding on September 9, 1998, that stated uncertainties existed regarding the taxonomic validity and distribution of the Blanco blind salamander and the Service found that the petition did not present substantial information indicating that listing may be warranted (63 FR 48166).

On June 25, 2007, the Service received a petition from Forest Guardians (now WildEarth Guardians) requesting that the Service consider 475 species in the Southwest Region be listed under the Act as endangered or threatened species with critical habitat (Forest Guardians 2007, p. 2). The Blanco blind salamander was included among the list of petitioned species (Forest Guardians 2007, p. 35). The Service published a partial 90-day finding on December 16, 2009, that determined the petition presented substantial information that listing may be warranted for 67 of the species, including the Blanco blind salamander (74 FR 66866). The finding stated that the petition presented substantial information to indicate that listing the Blanco blind salamander may be warranted due to the present or threatened destruction, modification, or curtailment of its habitat or range resulting from water pollutants and water withdrawal (74 FR 66866).

**ANIMAL/PLANT GROUP AND FAMILY:**

Amphibian, Family Plethodontidae (i.e., lungless salamanders)

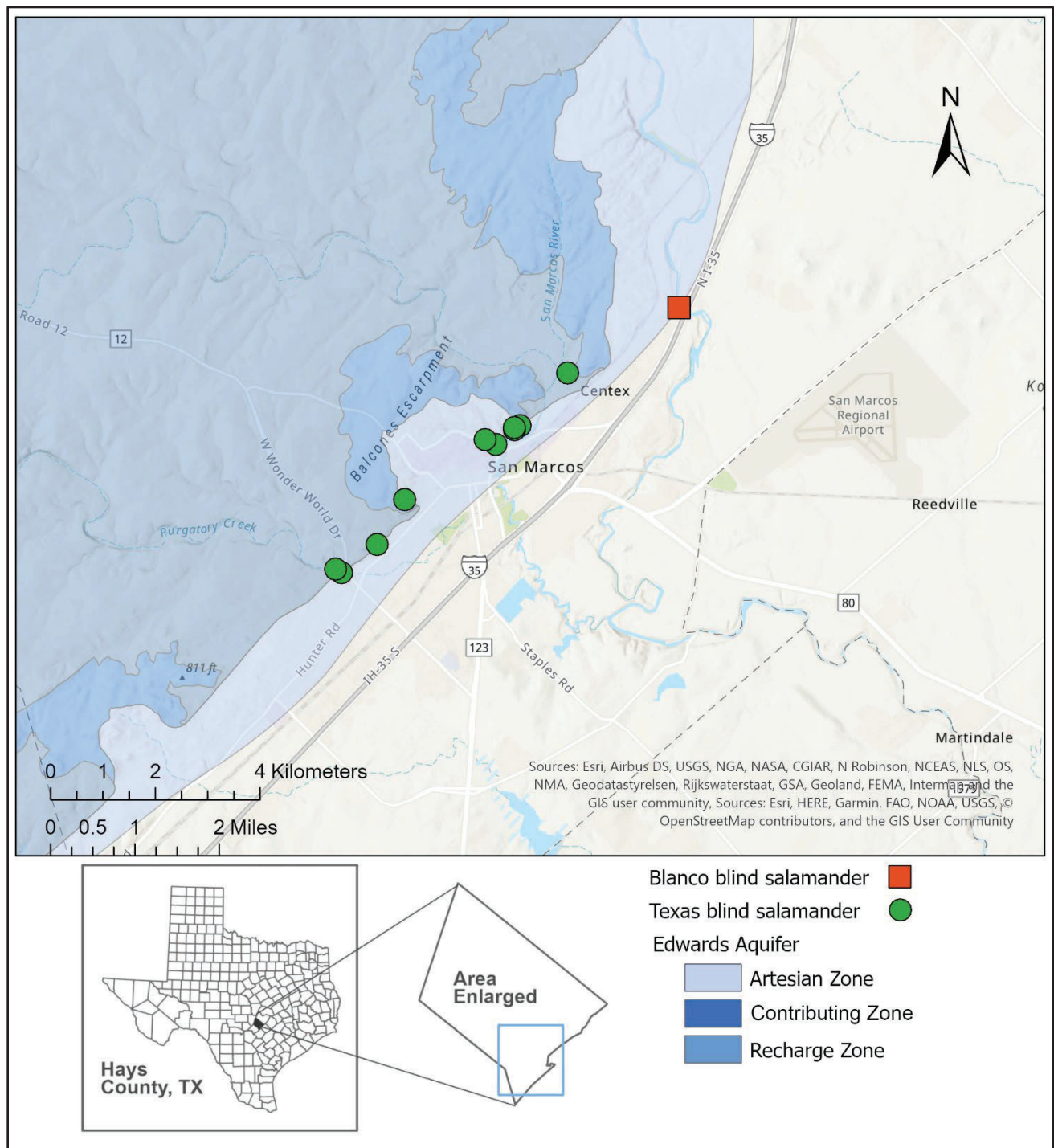
**HISTORICAL STATES/TERRITORIES/COUNTRIES OF OCCURRENCE:**

Texas, United States

**CURRENT STATES/COUNTIES/TERRITORIES/COUNTRIES OF OCCURRENCE:**

Hays County, Texas, United States (Figure 1)

Figure 1. Distribution of the Blanco blind and Texas blind salamanders, along the eastern extent



of the Edwards Aquifer, in the City of San Marcos, Hays County, Texas.

**LAND OWNERSHIP:**

Bed of Blanco River under public ownership, surrounding uplands in private ownership

**LEAD REGION CONTACT:**

Susan Oetker, Classification Branch, Southwest Region, 404-679-7050, susan\_oetker@fws.gov

**LEAD FIELD OFFICE CONTACT:**

Michael Warriner, Austin Ecological Services Field Office, 512-490-0057 ext. 236, michael\_warriner@fws.gov

**BIOLOGICAL INFORMATION**Species Description

The Blanco blind salamander was described based on a single individual collected in 1951 from a water-filled excavation in the bed of the Blanco River, Hays County, Texas (Potter 1963, pp. 1-2; Potter and Sweet 1981, p. 70). This specimen displays characters consistent with other stygobitic (i.e., obligate to aquatic subterranean habitats) Texas *Eurycea*, including the Austin blind (*Eurycea waterlooensis*) and Texas blind salamanders (*E. rathbuni*). The Blanco blind salamander holotype is a mature female that displays distinct morphological adaptations to life underground including lack of skin pigmentation and much reduced eyes (Potter and Sweet 1981, p. 70). The specimen is 100.8 millimeters (mm) (3.99 inches [in]) in total length and described as heavy-bodied with robust limbs and a thick tail with moderately high fins (Potter and Sweet 1981, p. 70). Since publication of the 90-day finding, and as described more in depth below, this description does not constitute a separate taxa but rather an individual that is likely synonymous with the Texas blind salamander, and therefore is not a listable entity under the Act.

Taxonomy

Subsequent to the 90-day finding, the Service has reviewed compelling evidence indicating that the Blanco blind salamander does not exist as a current taxonomic entity and is no longer a listable entity under the Act (Service 2021, pp. 12-26). When the Blanco blind salamander was formally described in 1981, the description was based on a single specimen collected thirty years earlier in 1951. Morphological measurements from the individual were very similar to those of the Texas blind salamander, a congeneric species known from several caves and springs in the City of San Marcos, very close to the Blanco blind salamander type locality (Figure 2).

The Blanco blind salamander's published description does not fully address the possibility that the specimen is instead an aberrant, variant, or altered individual of the nearby Texas blind salamander for a few reasons. First, the 1981 species description for the Blanco blind salamander did not account for natural morphological variation and relied on characters that may have been influenced by fixation and preservation. Along with natural variation, the effects of standard herpetological fixation and preservation methods can alter the morphology of preserved amphibians (Service 2021, pp. 17-18). Several studies have documented the effects of common preservation methods on specimen morphology (Lee 1982, pp. 267-268; Bernal and Clavijo

2009, pp. 33, 28, 42; Shu et al. 2017, pp. 5, 10; Pierson et al. 2020, pp. 138-139). Fixation and/or preservation of amphibians can result in changes to soft tissue and bony morphological traits, skewing assessment of actual traits exhibited by living individuals. The preservation method first applied to the Blanco blind salamander specimen is unknown. Chemical preservative has potentially made genetic assessment of this individual impossible as DNA has never been successfully isolated from the specimen (Chippindale and Hillis 1994, p. 4; Chippindale et al. 2000, p. 5; Hillis et al. 2001, p. 267; Wiens et al. 2003, p. 504; Devitt et al. 2019, p. 2631), and we do not know if genetic assessment will be possible in the future with improved methods or if all traces of DNA have already been permanently lost. The specimen had been preserved for over 10 years before it was described and 30 years when redescribed. The distinctiveness of the Blanco blind salamander is largely premised on soft tissue traits (e.g., torso body tissue and rounded tail) that may have been altered by fixative and/or preservatives.

Second, the published description (Potter and Sweet 1981, entire) relied on a small series of Texas blind salamanders (i.e., 10 individuals) measured for comparison to the Blanco blind salamander; however, the range of morphological variability for the Texas blind salamander is much greater than that considered. Older and larger individuals of the Texas blind salamander may display morphological values that overlap or exceed those noted for the Blanco blind salamander (Service 2021, pp. 14-15). Reliance on a small number of individuals limited consideration of the potential range of morphological variation inherent to the Texas blind salamander (Dayrat 2005, pp. 408-408, 411; Thessen et al. 2012, pp. 1, 22; Service 2021, p. 22). Rather, similar morphology and close geographic proximity suggest that these two species are not separate taxa.



Figure 2. Blanco blind salamander type specimen (A) and Texas blind salamander (B) from the San Marcos Aquatic Resources Center, San Marcos, Texas. Images taken June 21, 2021.

#### Habitat/Life History

If the Blanco blind salamander is a valid taxonomic entity (see Taxonomy, above), we assume that it has a life history similar to that of the Texas blind and other stygobitic salamanders in Texas. It is expected to inhabit the subterranean areas of the Edwards Aquifer, though individuals may reach the surface via spring openings.

#### Historical Range/Distribution

The only known locality for the Blanco blind salamander is an excavated fissure in the bed of the Blanco River in the City of San Marcos, Hays County, Texas (Figure 3). The fissure was excavated in the dry bed of the Blanco River during a period of intense drought by local gravel company employees searching for a water supply for operations (Potter 1963, pp. 1-3; Russell 1976, pp. 14, 30-31). When flow returned to the river, the fissure was filled with debris and its current location is unknown. The sole collected individual likely inhabited water-filled voids,

formed in underlying rock layers, deep in the subsurface below the Blanco River. The collection locality for the Blanco blind salamander supports our finding that it is actually a Texas blind salamander. The collection location is 3 kilometers (km) (2 miles [mi]) northeast of the nearest known occurrence of the Texas blind salamander. A string of Texas blind salamander sites occurs in caves and springs roughly on a line to the southwest of the Blanco blind salamander's collection locality. The Texas blind salamander is found along southwest to northeast trending faults, most notably the San Marcos Springs Fault (Figure 4). Groundwater connections exist among several of those subterranean karst features, the San Marcos Springs Fault, and the Edwards Aquifer (Ogden et al. 1986, pp. 117-118; Johnson et al. 2012, pp. 8-10, 22-87; Johnson et al. 2019, pp. 286, 288, 291). Cretaceous-age, highly permeable Edwards Group formations are the primary water-bearing strata of the Edwards Aquifer (DeCook 1963, pp. 11-12, 30-31; MacLay 1995, p. 13; Clark et al. 2018, p. 4). Less permeable strata, like the Austin Chalk, overlay and confine the Edwards Group in this area (DeCook 1963, pp. 37-38, 45; Grimshaw and Woodruff 1986, p. 72; Hanson and Small 1995, pp. 5-7; Clark et al. 2018, p. 4).

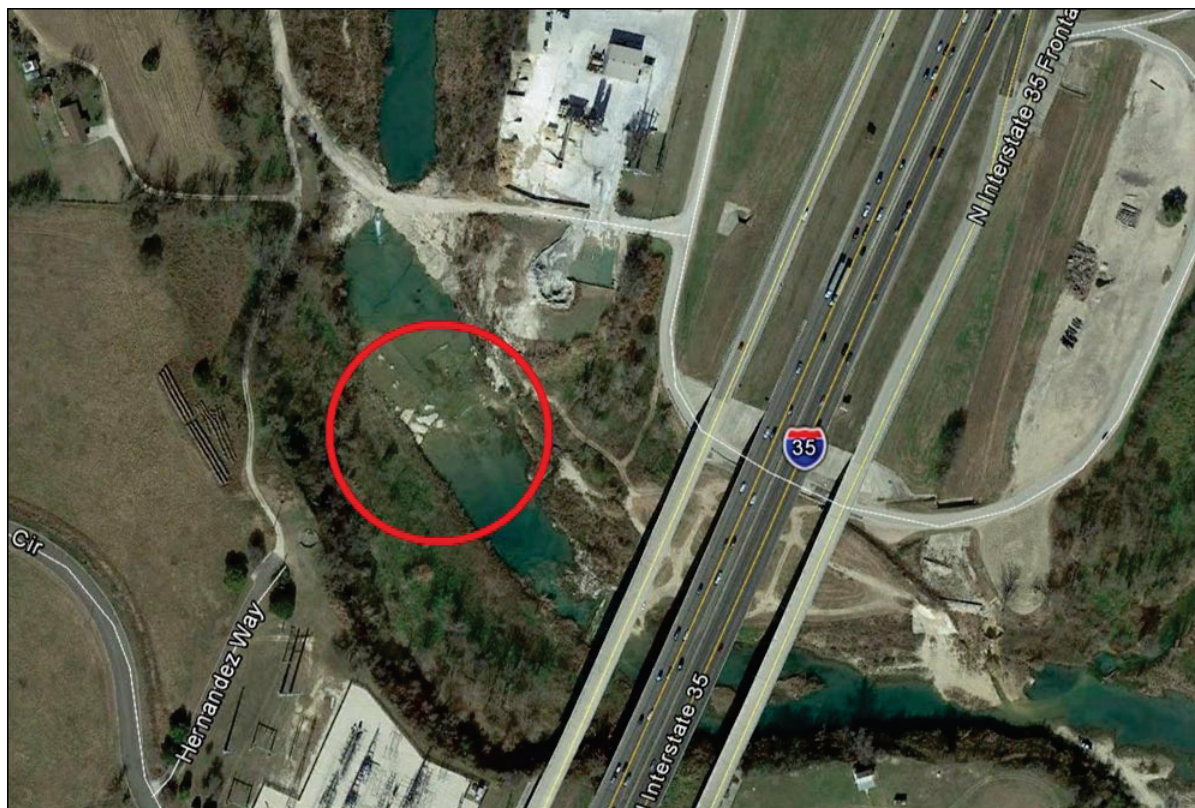


Figure 3. General vicinity (red circle) of Blanco blind salamander collection site in the Blanco River, Hays County, Texas.

Uhlenhuth (1921, pp. 79, 85-86, 88, 90, 92-95, 98, 101) postulated that water in Texas blind salamander caves was interconnected and from the same source as San Marcos Spring. Dye-tracing studies have since confirmed groundwater connectivity among many of these water-filled caves, San Marcos Springs, and smaller springs in the area (Figure 4; Ogden et al. 1986, pp. 117-

118; Johnson et al. 2012, pp. 8-10, 22-87; Johnson et al. 2019, pp. 286, 288, 291). These studies have delineated a complex network of conduits that facilitate groundwater flow in and around the City of San Marcos (Johnson et al. 2012, pp. 9, 24, 26, 33, 40, 52, 67, 69, 75, 83).

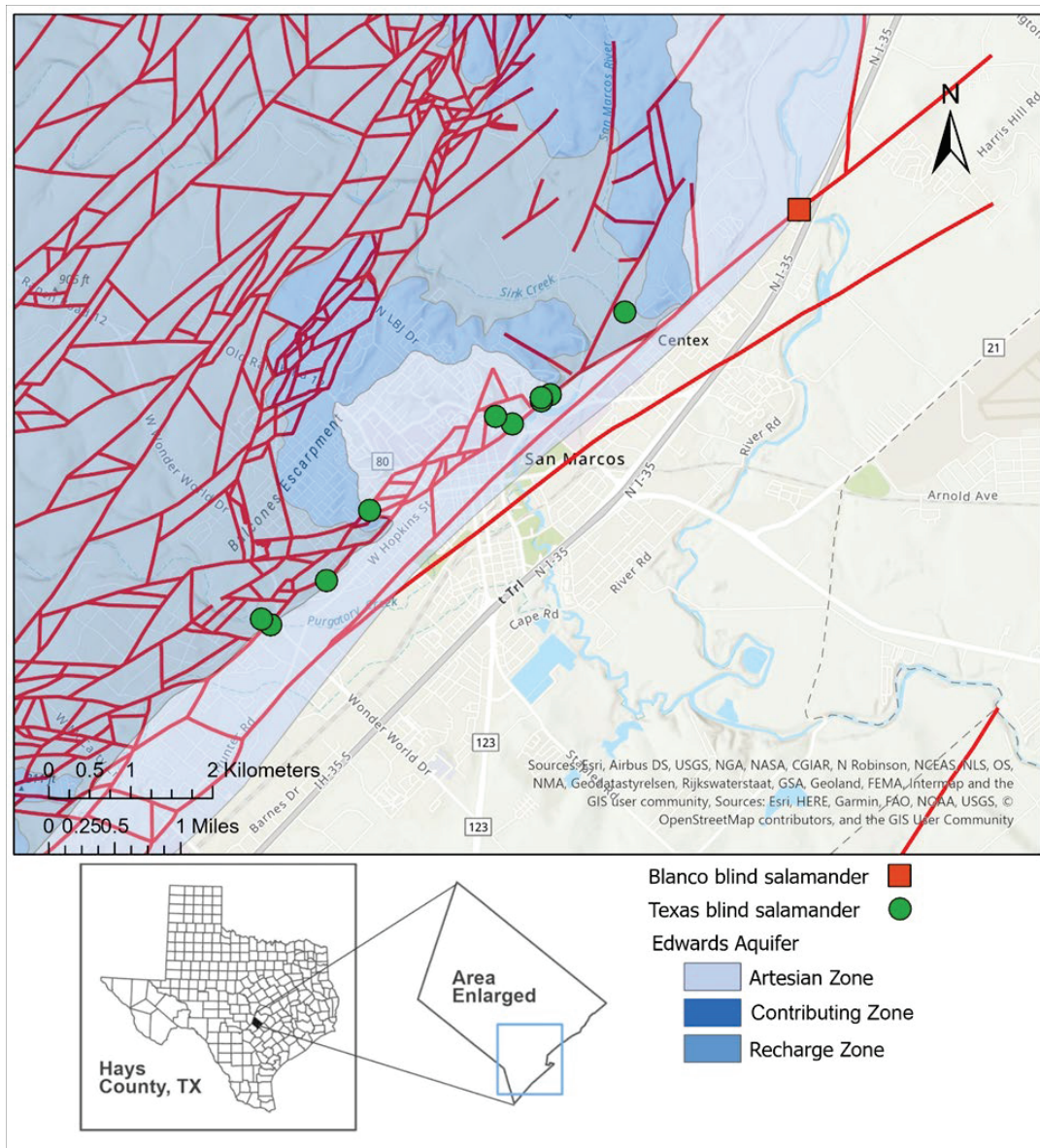


Figure 4. Distribution of Blanco blind salamander and Texas blind salamander in relation to faults in the City of San Marcos, Hays County, Texas. Red lines depict observed, concealed, and inferred faults from Grimshaw (2013).

This groundwater flow system plausibly serves as dispersal corridors for the Texas blind salamander. However, research to evaluate movement patterns (i.e., mark-recapture) of that species has been limited given the relative inaccessibility of its habitat (Krejca and Gluesenkamp



2007, entire). Preliminary evaluation of Texas blind salamander genetic population structure suggests that sampled localities for this species are not reproductively isolated and interbreed (Chippindale 2009, pp. 8-9; Corbin 2020, p. 75), indicative of connectivity among cave and spring sites. At many of the same springs and wells inhabited by the Texas blind salamander, similar patterns of occurrence have also been documented for several Edwards Aquifer groundwater invertebrates (e.g., *Artesia subterranea*, *Cirolandes wassenichae*, *Palaemonetes antrorum*, and *Seborgia relictia*) (ZARA Environmental LLC 2010, pp. 52, 54-55; Hutchins et al. 2013, p. 15; Schwartz et al. 2019, p. 503), which indicates that the invertebrates likely use the same underground corridors to move between sites.

If the dispersal corridors exist, then only one species of *Eurycea* is likely to inhabit the area since species of stygobitic *Eurycea* are not known to co-exist in any other location (Service 2021, p. 10). Given the connectivity, it is unlikely that a unique salamander species would be isolated from the larger population of Texas blind salamanders such a short distance (3 km [2 mi]) away. Due to the connectivity of the groundwater system, and the occurrence of the Texas blind salamander so close to the one collection site of the Blanco blind salamander, it is likely that the individual collected from the Blanco River is a Texas blind salamander.

#### Current Range/Distribution

If the Blanco blind salamander is a valid taxonomic entity (see Taxonomy, above), there is no evidence that it continues to occupy the area of the Blanco River where it was initially discovered. Additionally, even after surveys in the areas (see Population Estimates/Status, below) no other Blanco blind salamanders have been located to provide information on the range of the species if it is a valid taxonomic entity.

If the Blanco blind salamander is not a valid taxon and is synonymous with the Texas blind salamander, then the Blanco River site should be recognized as a historical occurrence of that species.

#### Population Estimates/Status

Like species with similar characteristics, the Blanco blind salamander is likely to have a low detectability. Despite being mostly subterranean, stygobitic *Eurycea* salamanders are often surveyed at springs and caves. Surveys were conducted in 2006 to relocate the Blanco blind salamander at the Blanco River site and several groundwater wells north of that site in Hays and Travis Counties (Gluesenkamp and Krejca 2007, pp. 3, 7, 9). Researchers excavated three surface fissures in the dry bed of the Blanco River but none of the excavations extended to subterranean voids and no salamanders were observed (Gluesenkamp and Krejca 2007, p. 4). Excavations that extended into the subterranean voids would have provided more thorough evidence that salamanders were truly not present, rather than hiding out of sight. Groundwater wells surveyed north of the Blanco River were 8 to 25 km (5 to 15 mi) away and did not yield stygobitic *Eurycea* salamanders, though they did extend into subterranean habitats (Gluesenkamp and Krejca 2007, pp. 4-6, 8). Recent survey efforts of wells and springs in Hays County in 2020 and 2021 have also not resulted in discovery of Blanco blind salamanders or

other stygobitic *Eurycea* salamanders to date (Tovar 2021, pers. comm.).

Conversely, Texas blind salamanders are regularly observed and collected during surveys of caves, spring openings, and groundwater wells by permitted researchers from several localities in the City of San Marcos. Since 1951, no stygobitic *Eurycea* have been collected from the Blanco River or areas to the north of the river in Hays County. Despite its low detectability, given the combination of surveys at the original locality and repeated surveys from surface and subterranean habitats nearby, we conclude that the effort was adequate to detect the Blanco blind salamander should individuals exist. If the Blanco blind salamander was a valid taxon, we have no evidence that the species has remained extant for the past 70 years; thus, we conclude it is extinct (see Finding, below).

### SUMMARY OF BIOLOGICAL INFORMATION

There are several lines of compelling evidence indicating that the Blanco blind salamander does not exist as a current taxonomic entity, and therefore is not a listable entity under the Act. The specimen type on which the species' description was based either represents a historical occurrence of the Texas blind salamander or it represents a unique species that is no longer extant. When it was described, the description relied on characters that could have been influenced by chemical fixation and preservation and may not be reflective of living or freshly dead individuals. Also, in the description the single specimen was compared to a series of ten Texas blind salamander individuals that did not sufficiently account for natural morphological variation of the species. Several morphological characters of the Blanco blind salamander overlap or are identical to the Texas blind salamander. Genetic analyses of the single specimen have been attempted but were unsuccessful and its DNA has never been isolated. We do not know if genetic assessment will be possible in the future with improved methods or if all traces of DNA have already been permanently lost.

In addition, the type locality of the Blanco blind salamander is located along the northeastern reach of the San Marcos Springs Fault. Significant groundwater connectivity has been documented among several springs inhabited by the Texas blind salamander in the City of San Marcos. Hydrogeological connectivity also exists along the San Marcos Springs Fault, among those sites, and the Blanco River. As a result, subterranean dispersal corridors likely existed to facilitate movement of Texas blind salamanders to water-filled voids beneath that river.

Nowhere in North America do two species of stygobitic *Eurycea* co-exist at a location, and given potential for groundwater connectivity, it is unlikely that a group of salamanders would be isolated from the larger population of Texas blind salamanders less than 3 km (2 mi) to the southwest. The type locality of the Blanco blind, therefore, could be recognized as the most northeastern occurrence of the Texas blind salamander.

Additionally, if the Blanco blind salamander was a valid taxon, we have no evidence that the species remains extant. Since 1951, no stygobitic *Eurycea* have been collected from the Blanco River or areas to the north of that river in Hays County. Texas blind salamanders are collected on an annual basis from several sites immediately to the south of the Blanco River in the City of San

Marcos, but no Blanco blind salamanders have been found in these surveys. Additional surveys at the location of the Blanco blind salamander type specimen did not locate salamander individuals of any species. For these reasons, if the Blanco blind salamander was a valid taxon we have no evidence to support that it remains extant and we conclude it is extinct (see Finding, below).

#### **DISTINCT POPULATION SEGMENT (DPS)**

Not applicable.

#### **SIGNIFICANT PORTION OF THE RANGE (SPR)**

Not applicable.

#### **THREATS**

An assessment of threats is not applicable because the taxon no longer qualifies as a listable entity as defined under the Act. For more information, see the Summary of Biological Information, above. Any assessment of threats would apply to Texas blind salamander, not the Blanco blind salamander separately.

#### **SUMMARY OF THREATS**

Not applicable.

#### **FINDING**

We have carefully assessed the best scientific and commercial information available regarding the Blanco blind salamander and evaluated the petition's claims that the species warrants listing under the Act. We determined the type specimen on which the species' description was based either represents a historical occurrence of the Texas blind salamander or it represents a unique species that is no longer extant.

To be considered endangered or threatened under the Act, a species' taxonomy must be valid. In our evaluation of the species' status, we found evidence that the Blanco blind salamander does not exist as a current taxonomic entity. In summary of the findings more fully addressed above, several morphological characters of the Blanco blind salamander overlap or are identical to the Texas blind salamander; the Blanco blind salamander specimen's size may have been influenced by chemical fixation and preservation and may not reflect the original size of the living individual; and the hydrogeological connectivity would likely facilitate movement between the Blanco River site and locations the Texas blind salamander inhabits. Given this, we find that the Blanco blind salamander type specimen is likely a Texas blind salamander individual. If it is a Texas blind salamander, then the Blanco blind salamander is not a valid taxonomic entity. Accordingly, it no longer remains a listable entity under the Act.

While the best available science does indicate that the specimen collected in 1951 is a Texas blind salamander, due to the inability to conduct conclusive genetic testing, we have determined that we should also consider whether the Blanco blind salamander is extinct.

When evaluating the possibility of extinction, we attempted to minimize the possibility of either (1) prematurely determining that the species is extinct where individuals exist but remain undetected, or (2) assuming the species is extant when extinction has already occurred. Our determinations of whether the best available information indicates that a species is extinct included an analysis of the following criteria: detectability of the species, adequacy of survey efforts, and time since last detection. All three criteria require taking into account applicable aspects of species' life history. Other lines of evidence may also support the determination and be included in our analysis. In conducting our analyses of whether the Blanco blind salamander is extinct, we considered and thoroughly evaluated the best scientific and commercial data available. We reviewed the information available in our files, and other available published and unpublished information. These evaluations include information from recognized experts; Federal and State governments; academic institutions; and private entities.

The Edwards Aquifer, in the area of southeastern Hays County, has been and continues to be intensively sampled for its diverse and unique groundwater fauna. Beginning in the late 19th century, caves, springs, and wells in the area have yielded many new species including the Texas blind salamander and a contingent of endemic groundwater invertebrates (Benedict 1896, entire; Ulrich 1992, pp. 85-98; Reddell and Michell 1969, pp. 3-6, 8-9, 11, 14; Bowman and Longley 1976, pp. 490-494; Young and Longley 1976, pp. 788-791; Holsinger and Longley 1980, pp. 1-3, 5-50; Klkylođlu et al. 2017, pp. 176-182; Schwartz et al. 2019, pp. 501-509; Alvear et al. 2020, pp. 12; Hutchins et al. 2021, pp. 2-3, 6-13).

Like species with similar characteristics, the Blanco blind salamander is likely to have a low detectability. However, despite being mostly subterranean, stygobitic *Eurycea* salamanders are often surveyed at springs and caves. As discussed above, surveys were conducted in 2006 to relocate the Blanco blind salamander at the Blanco River site and several groundwater wells north of that site in Hays and Travis Counties (Gluesenkamp and Krejca 2007, pp. 3, 7, 9). Additionally, researchers excavated three surface fissures in the dry bed of the Blanco River but none of the excavations extended to subterranean voids and no salamanders were observed (Gluesenkamp and Krejca 2007, p. 4). Groundwater wells were surveyed north of the Blanco River 8 to 25 km (5 to 15 mi) away from the locality of the Blanco specimen and did not yield stygobitic *Eurycea* salamanders, though they did extend into subterranean habitats (Gluesenkamp and Krejca 2007, pp. 4-6, 8). Recent survey efforts of wells and springs in Hays County in 2020 and 2021 have also not resulted in discovery of Blanco blind salamanders or other stygobitic *Eurycea* salamanders to date (Tovar 2021, pers. comm.). Conversely, Texas blind salamanders are regularly observed and collected during surveys of caves, spring openings, and groundwater wells by permitted researchers from several localities in the City of San Marcos.

Since 1951, no stygobitic *Eurycea* have been collected from the Blanco River or areas to the north of the river in Hays County. Despite its low detectability, given the combination of surveys

at the original locality and repeated surveys from surface and subterranean habitats nearby, we conclude that the effort was adequate to detect the Blanco blind salamander should individuals exist. If the Blanco blind salamander was a valid taxon, we have no evidence that the species has remained extant for the past 70 years; thus, we conclude it is extinct.

In conclusion, based on the best available information, we have determined that the Blanco blind salamander is not a valid taxonomic entity and, accordingly, does not meet the statutory definition of a listable entity under the Act. Conversely, even if the Blanco blind salamander was a valid taxonomic entity, it has not been collected in over 70 years despite survey efforts; thus, we have no evidence it has remained extant. Because the Blanco blind salamander either does not meet the definition of a listable entity or is extinct, it does not warrant listing under the Act. A detailed discussion of the basis for this finding can be found in the Blanco blind salamander species assessment and other supporting documents (see **ADDRESSES**, above).

## **RECOMMENDED CONSERVATION MEASURES**

Not applicable as the taxon is no longer a listable entity as defined in the Act.

## **COORDINATION WITH STATES**

A draft report of the status of the Blanco blind salamander was provided to Paul Crump, herpetologist with the Texas Parks and Wildlife Department, for partner review.

## **LITERATURE CITED**

- Bernal, M.H. and J.A. Clavijo. 2009. An essay on precision in morphometric measurements in anurans: inter-individual, intra-individual and temporal comparisons. *Zootaxa* 2246: 32-44.
- Chippindale, P. 2009. Population genetic analysis of the Texas blind salamander, *Eurycea rathbuni*. Final Report Grant No. TX E-78-R, Texas Parks and Wildlife Department. 26 pp.
- Clark, A.K. D.E. Pedraza, D.E., and R.R. Morris. 2018. Geologic framework and hydrostratigraphy of the Edwards and Trinity aquifers within Hays County, Texas. U.S. Geological Survey Scientific Investigations Map 3418, 1 sheet, scale 1:24,000, pamphlet, <https://doi.org/10.3133/sim3418>. 11 pp.
- Corbin, A.B. 2020. Population genomics and conservation of Texas cave and spring salamanders (Plethodontidae: Eurycea). Ph.D. Dissertation, University of Texas at Arlington. 92 pp.
- Dayrat, B. 2005. Towards integrative taxonomy. *Biological Journal of the Linnean Society* 85: 407–415.
- DeCook, K.J. 1963. Geology and ground-water resources of Hays County, Texas. Geological Survey Water-Supply Paper 1612. 72 pp.

- Forest Guardians. 2007. A petition to list all critically imperiled or imperiled species in the southwest United States as threatened or endangered Under the Endangered Species Act, 16 U.S.C. §§ 1531 et seq. Petition submitted to the U.S. Fish and Wildlife Service. 55 pp.
- Gluesenkamp, A.G. and J.K. Krejca. 2007. Assessing the status of *Eurycea* salamanders and aquifer invertebrates in northern Hays County, Texas. Final Report Grant No. E – 70-R, Texas Parks and Wildlife Department. 15 pp.
- Grimshaw, T.W. and C.M. Woodruff, Jr. 1986. Structural style in an en echelon fault system, Balcones Fault Zone, central Texas: Geomorphologic and hydrological implications. Pages 71-75 in Abbott, P.L. and C.M. Woodruff, Jr., editors. The Balcones Escarpment Geology, Hydrology, Ecology and Social Development in Central Texas. Geological Society of America. 200 pp.
- Hanson, J.A. and T.A. Small. 1995. Geologic framework and hydrogeologic characteristics of the Edwards Aquifer outcrop, Hays County, Texas. U.S. Geological Survey, Water-Resources Investigations Report 95-4265. 10 pp.
- Johnson, S., G.M. Schindel, and J.V. Brahana. 2019. Tracer testing in the Edwards Aquifer. Pages 283-292 in Abbott, P.L. and C.M. Woodruff, Jr., editors. The Balcones Escarpment Geology, Hydrology, Ecology and Social Development in Central Texas. Geological Society of America. 200 pp.
- Johnson, S., G. Schindel, G. Veni, N. Hauwert, B. Hunt, B. Smith, and M. Gary. 2012. Tracing groundwater flowpaths in the vicinity of San Marcos Springs, Texas. Edwards Aquifer Authority Report No. 12-03. 139 pp.
- Krejca, J.K. and A.G. Gluesenkamp. 2007. Mark-recapture study of *Eurycea rathbuni* at two sites in San Marcos, Texas. Final Report Grant No. E-68-R, Texas Parks and Wildlife Department. 22 pp.
- Lee J.C. 1982. Accuracy and precision in anuran morphometrics: artifacts of preservation. Systematic Biology 31: 266-281.
- MacLay, R.W. 1995. Geology and hydrology of the Edwards Aquifer in the San Antonio area, Texas. U.S. Geological Survey, Water-Resources Investigations Report 95-4186. 64 pp.
- Ogden, A.E., R.A. Quick, and S.R. Rothermel. 1986. Hydrochemistry of the Comal, Hueco, and San Marcos Springs, Edwards Aquifer, Texas. Pages 115-130 in Abbott, P.L. and C.M. Woodruff, Jr., editors. The Balcones Escarpment Geology, Hydrology, Ecology, and Social Development in Central Texas. Geological Society of America. 200 pp.
- Pierson, T.W., T.J. Kieran, A.G. Clause, and N.L. Castleberry. 2020. Preservation-induced morphological change in salamanders and failed DNA extraction from a decades-old museum specimen: implications for *Plethodon ainsworthi*. Journal of Herpetology 54(2): 137-143.

- Potter, F.E., Jr., and S.S. Sweet. 1981. Boundaries in Texas cave salamanders, and a redescription of *Typhlomolge robusta* (Amphibia: Plethodontidae). *Copeia* 1981(1): 64-75.
- Russell, W.H. 1976. Distribution of troglobitic salamanders in the San Marcos area, Hays County, Texas. BITE Report 7601. 35 pp.
- Shu, G., Y. Gong, F. Xie, N.C. Wu, and C. Li. 2017. Effects of long-term preservation on amphibian body conditions: implications for historical morphological research. *PeerJ* 5:e3805; DOI 10.7717/peerj.3805.
- Thessen, A.E., D.J. Patterson, S.A. Murray. 2012. The taxonomic significance of species that have only been observed once: The genus *Gymnodinium* (Dinoflagellata) as an example. *PLoS ONE* 7(8): e44015. doi:10.1371/journal.pone.0044015.
- Tovar, R. Re: Blanco Blind Salamander. Email message to Michael Warriner, February 26, 2021.
- Uhlenhuth, E. 1921. Observations on the distribution and habits of the blind Texan cave salamander, *Typhlomolge rathbuni*. *Biological Bulletin* 40: 73-104.
- U.S. Fish and Wildlife Service (Service). 1996. San Marcos & Comal Springs & associated aquatic ecosystems (revised) recovery plan. Southwest Region, Albuquerque, NM. 93 pp.
- U.S. Fish and Wildlife Service. 2021. Review of the Blanco blind salamander (*Eurycea robusta*). Version 1.0. July 6, 2021. Austin, TX and Falls Church, VA. 39 pp.

APPROVAL/CONCURRENCE: Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

**AMY LUEDERS** Digitally signed by AMY LUEDERS  
Date: 2021.10.07 09:31:40 -06'00'

Approve:

Regional Director, U.S. Fish and Wildlife Service

Concur:

Do not concur

Director,  
U.S. Fish and Wildlife Service

Director's Remarks:

Date of annual review:  
Conducted by: