DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

50 CFR Part 17

[Docket No. FWS–R2–ES–2012–0035; 4500030113]

RIN 1018–AY22

Endangered and Threatened Wildlife and Plants; Determination of Threatened Species Status for the Georgetown Salamander and Salado Salamander Throughout Their Ranges

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Final rule.

SUMMARY: We, the U.S. Fish and Wildlife Service (Service), determine threatened status for the Georgetown salamander (*Eurycea naufragia*) and the Salado salamander (*Eurycea chisholmensis*) under the Endangered Species Act of 1973 (Act), as amended. The effect of this regulation is to conserve the two salamander species and their habitats under the Act. This final rule implements the Federal protections provided by the Act for these species. We are also notifying the public that, in addition to this final listing determination, today we publish a proposed special rule under the Act for the Georgetown salamander.

DATES: This rule becomes effective March 26, 2014.

ADDRESSES: This final rule is available on the Internet at *http://www.regulations.gov* and *http://www.fws.gov/southwest/es/AustinTexas/*. Comments and materials received, as well as supporting documentation used in preparing this final rule, are available for public inspection, by appointment, during normal business hours, at U.S. Fish and Wildlife Service, Austin Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT**).

FOR FURTHER INFORMATION CONTACT: Adam Zerrenner, Field Supervisor, U.S. Fish and Wildlife Service, Austin Ecological Services Field Office, 10711 Burnet Rd, Suite 200, Austin, TX 78758; by telephone 512–490–0057; or by facsimile 512–490–0974. Persons who use a telecommunications device for the deaf (TDD) may call the Federal Information Relay Service (FIRS) at 800–877–8339.

SUPPLEMENTARY INFORMATION:

Executive Summary

Why we need to publish a rule. Under the Act, a species may warrant protection through listing if it is endangered or threatened throughout all or a significant portion of its range. Listing a species as an endangered or threatened species can only be completed by issuing a rule.

This rule lists the Georgetown and Salado salamanders as threatened species under the Act.

The basis for our action. Under the Act, we can determine that a species is an endangered or threatened species based on any of five factors: (A) The present or threatened destruction, modification, or curtailment of its habitat or range; (B) Overutilization for commercial, recreational, scientific, or educational purposes; (C) Disease or predation; (D) The inadequacy of existing regulatory mechanisms; or (E) Other natural or manmade factors affecting its continued existence. We have determined that the Georgetown and Salado salamanders are threatened under the Act due to threats faced by the species both now and in the future from Factors A, D, and E.

Peer review and public comment. We sought comments from independent specialists to ensure that our designation is based on scientifically sound data, assumptions, and analyses. We invited these peer reviewers to comment on our listing proposal. We also considered all comments and information received during the comment period (see Summary of Comments and Recommendations section below).

Background

Previous Federal Action

The Georgetown salamander was included in 10 Candidate Notices of Review:

- 66 FR 54808, October 30, 2001;
- 67 FR 40657, June 13, 2002;
- 69 FR 24876, May 4, 2004;
- 70 FR 24870, May 11, 2005;
- 71 FR 53756, September 12, 2006;
- 72 FR 69034, December 6, 2007;
- 73 FR 75176, December 10, 2008;
- 74 FR 57804, November 9, 2009;
- 75 FR 69222, November 10, 2010; and
- 76 FR 66370, October 26, 2011.

In the 2008 review, the listing priority number was lowered from 2 to 8, indicating that threats to the species were imminent, but moderate to low in magnitude. This reduction in listing priority number was primarily due to the land acquisition and conservation efforts of the Williamson County Conservation Foundation. In addition, we were petitioned by the Center for Biological Diversity to list the Georgetown salamander as an endangered species on May 11, 2004, but at that time, it was already a candidate species whose listing was precluded by higher priority actions.

The Salado salamander was included in nine Candidate Notices of Review:

- 67 FR 40657, June 13, 2002;
- 69 FR 24876, May 4, 2004;
- 70 FR 24870, May 11, 2005;
- 71 FR 53756, September 12, 2006;
- 72 FR 69034, December 6, 2007;
- 73 FR 75176, December 10, 2008;
- 74 FR 57804, November 9, 2009;
- 75 FR 69222, November 10, 2010; and
- 76 FR 66370, October 26, 2011.

The listing priority number has remained at 2 throughout the reviews, indicating that threats to the species were both imminent and high in magnitude. In addition, on May 11, 2004, the Service received a petition from the Center for Biological Diversity to list 225 species we previously had identified as candidates for listing in accordance with section 4 of the Act, including the Salado salamander.

On August 22, 2012, we published a proposed rule to list as endangered and designate critical habitat for the Austin blind salamander (*Eurycea waterlooensis*), Jollyville Plateau salamander (*Eurycea tonkawae*), Georgetown salamander, and Salado salamanders (77 FR 50768). That proposal had a 60-day comment period, ending October 22, 2012. We held a public meeting and hearing in Round Rock, Texas, on September 5, 2012, and a second public meeting and hearing in Austin, Texas, on September 6, 2012. On January 25, 2013, we reopened the public comment period on the August 22, 2012, proposed listing and critical habitat designation; announced the availability of a draft economic analysis; and an amended required determinations section of the proposal (78 FR 5385). On August 20, 2013, we extended the final determination for the Georgetown and Salado salamanders by 6 months due to substantial disagreement regarding: (1) The short- and long-term population trends of these two species; (2) the interpretation of water quality and quantity degradation information as it relates to the status of these two species; and (3) the effectiveness of conservation practices and regulatory mechanisms (78 FR 51129). That comment period closed on September 19, 2013.

Since that time, the City of Georgetown, Texas, prepared and finalized ordinances for the Georgetown salamander. All 17 of the known Georgetown salamander locations are within the City of Georgetown's jurisdiction for residential and commercial development. The enacted ordinances were directed at alleviating threats to the Georgetown salamander from urban development by requiring geologic assessments prior to construction, establishing occupied site protections through stream buffers, maintaining water quality through best management practices, developing a water quality management plan for the City of Georgetown, and monitoring occupied spring sites by an adaptive management working group. In order to consider the ordinances in our final listing determination, on January 7, 2014 (79 FR 800), we reopened the comment period for 15 days on the proposed listing rule to allow the public an opportunity to provide comment on the application of the City of Georgetown's ordinances to our status determination under section 4(a)(1) of the Act.

This rule constitutes our final determination to list the Georgetown and Salado salamanders as threatened species.

Species Information

Taxonomy

The Georgetown and Salado salamanders are neotenic (do not transform into a terrestrial form) members of the family Plethodontidae. Plethodontid salamanders comprise the largest family of salamanders within the Order Caudata, and are characterized by an absence of lungs (Petranka 1998, pp. 157–158). The Jollyville Plateau (*Eurycea tonkawae*), Georgetown, and Salado salamanders have very similar external morphology. Because of this, they were previously believed to be the same species; however, molecular evidence strongly supports that there is a high level of divergence between the three groups (Chippindale *et al.* 2000, pp. 15–16; Chippindale 2010, p. 2).

Morphological Characteristics

As neotenic salamanders, the Georgetown and Salado salamanders retain external feathery gills and inhabit aquatic habitats (springs, spring-runs, wet caves, and groundwater) throughout their lives (Chippindale *et al.* 2000, p. 1). In other words, these salamanders are aquatic and respire through gills and permeable skin (Duellman and Trueb 1986, p. 217). Also, adult salamanders of these species are about 2 inches (in) (5 centimeters (cm)) long (Chippindale *et al.* 2000, pp. 32–42; Hillis *et al.* 2001, p. 268).

Habitat

Both species inhabit water of high quality with a narrow range of conditions (for example, temperature, pH, and alkalinity) maintained by groundwater from various sources. The Georgetown and Salado salamanders depend on high-quality water in sufficient quantity and quality to meet their life-history requirements for survival, growth, and reproduction. Much of this water is sourced from the Northern Segment of the Edwards Aquifer, which is a karst aquifer characterized by open chambers such as caves, fractures, and other cavities that were formed either directly or indirectly by dissolution of subsurface rock formations. Water for the salamanders is provided by infiltration of surface water through the soil or recharge features (caves, faults, fractures, sinkholes, or other open cavities) into the Edwards Aquifer, which discharges from springs as groundwater (Schram 1995, p. 91).

The Georgetown and Salado salamanders spend varying portions of their life within their surface habitats (the wetted top layer of substrate in or near spring openings and pools as well as spring runs) and subsurface habitats (within caves or other underground areas of the underlying groundwater source). Although surface and subsurface habitats are often discussed separately within this final rule, it is important to note the interconnectedness of these areas. Subsurface habitat does not necessarily refer to an expansive cave underground. Rather, it may be described as the water-filled rock matrix below the stream bed. As such, subsurface habitats are impacted by the same threats that impact surface habitat, as the two exist as a continuum (Bendik 2012, City of Austin (COA), pers. comm.).

Salamanders move an unknown depth into interstitial spaces (empty voids between rocks) within the spring or streambed substrate that provide foraging habitat and protection from predators and drought conditions (Cole 1995, p. 24; Pierce and Wall 2011, pp. 16–17). They may also use deeper passages of the aquifer that connect to the spring opening (Dries 2011, COA, pers. comm.). This behavior makes it difficult to accurately estimate population sizes, as only salamanders on the surface can be regularly monitored. However, techniques have been developed for marking individual salamanders, which allows for better estimating population numbers using ''mark and recapture'' data analysis techniques. These techniques have been used by the COA on the Jollyville Plateau salamander (Bendik *et al.* 2013, pp. 2–7) and by Dr. Benjamin Pierce at Southwestern University on the Georgetown salamander (Pierce 2011, pp. 5–7).

Range

The habitats of the Georgetown and Salado salamanders occur in the Northern Segment of the Edwards Aquifer. The recharge and contributing zones of this segment of the Edwards Aquifer are found in portions of Travis, Williamson, and Bell Counties, Texas (Jones 2003, p. 3).

Diet

Although we are unaware of detailed dietary studies for Georgetown and Salado salamanders, their diets are presumed to be similar to other *Eurycea* species, which consist of small aquatic invertebrates such as amphipods, copepods, isopods, and insect larvae (COA 2001, pp. 5–6). A stomach content analysis by the City of Austin demonstrated that the Jollyville Plateau salamander preys on varying proportions of aquatic invertebrates, such as ostracods, copepods, mayfly larvae, fly larvae, snails, water mites, aquatic beetles, and stone fly larvae, depending on the location of the site (Bendik 2011b, pers. comm.). The feces of one wild-caught Austin blind salamander (*Eurycea waterlooensis*) contained amphipods, ostracods, copepods, and plant material (Hillis *et al.* 2001, p. 273). Gillespie (2013, pp. 5–9) also found that the diet of the closely related Barton Springs salamanders (*Eurycea sosorum*) consisted primarily of planarians or chironomids (flatworms or nonbiting midge flies), depending on which was more abundant, and amphipods (when planarians and chironomids were rare).

Predation

The Georgetown and Salado salamanders share similar predators, which include centrarchid fish (carnivorous freshwater fish belonging to the sunfish family), crayfish (*Cambarus* sp.), and large aquatic insects (Cole 1995, p. 26; Bowles *et al.* 2006, p. 117; Pierce and Wall 2011, pp. 18–20).

Reproduction

The detection of juveniles in all seasons suggests that reproduction occurs year-round (Bendik 2011a, p. 26; Hillis *et al.* 2001, p. 273). However, juvenile abundance of Georgetown salamanders typically increases in spring and summer, indicating that there may be relatively more reproduction occurring in winter and early spring compared to other seasons (Pierce 2012, pp. 10–11, 18, 20). In addition, most gravid (egg-bearing) females of the Georgetown salamander are found from October through April (Pierce 2012, p. 8; Pierce and McEntire

2013, p. 6). Because eggs are very rarely found on the surface, these salamanders likely deposit their eggs underground for protection (O'Donnell *et al.* 2005, p. 18).

Population Connectivity

More study is needed to determine the nature and extent of the dispersal capabilities of the Georgetown and Salado salamanders. It has been suggested that they may be able to travel some distance through subsurface aquifer conduits. For example, it has been thought that Austin blind salamander can occur underground throughout the entire Barton Springs complex (Dries 2011, COA, pers. comm.). The spring habitats used by salamanders of the Barton Springs complex are not connected on the surface, so the Austin blind salamander population could extend a horizontal distance of at least 984 feet (ft) (300 meters (m)) underground, as this is the approximate distance between the farthest two outlets within the Barton Springs complex known to be occupied by the species. However, a mark-and-recapture study failed to document the movement of endangered Barton Springs salamanders (*Eurycea sosorum*) between any of the springs in the Barton Springs complex (Dries 2012, COA, pers. comm.). This finding could indicate that individual salamanders are not moving the distances between spring openings. Alternatively, this finding could mean that the study simply failed to capture the movement of salamanders. This study has only recently begun and is relatively small in scope.

Due to the similar life history of the Austin blind salamander to the Georgetown and Salado salamanders, it is plausible that populations of these latter two species could also extend 984 ft (300 m) through subterranean habitat, assuming the Austin blind salamander is capable of moving between springs in the Barton Springs complex. However, subsurface movement is likely to be limited by the highly dissected nature of the aquifer system, where spring sites can be separated from other spring sites by large canyons or other physical barriers to movement. Surface movement is similarly inhibited by geologic, hydrologic, physical, and biological barriers (for example, predatory fish commonly found in impoundments along urbanized tributaries (Bendik 2012, COA, pers. comm.). Dye-trace studies have demonstrated that some Jollyville Plateau salamander sites located 2.9 miles (mi) (4.7 kilometers (km)) apart are connected hydrologically (Whitewater Cave to R-Bar-B Spring and Hideaway Cave to R-Bar-B Spring) (Hauwert and Warton 1997, pp. 12–13), but it remains unclear if salamanders are travelling between those sites. Also, in Salado, a large underground conduit that conveys groundwater from the area under the Stagecoach Hotel to Big Boiling Spring is large enough to support salamander movement (Texas Parks and Wildlife Department [TPWD] 2011a, pers. comm.; Mahler 2012, U.S. Geological Survey [USGS], pers. comm.; Yelderman Jr. *et al.* 2013, p. 1). In conclusion, some data indicate that some populations could be connected through subterranean water-filled spaces. However, we are unaware of any information available on the frequency of movements and the actual nature of connectivity among populations.

Population Persistence

A population's persistence (ability to survive and avoid extirpation) is influenced by a population's demographic factors (such as survival and reproductive rates) as well as its environment. The population needs of the Georgetown and Salado salamanders are the factors that provide for a high probability of population persistence over the long term at a given site (for example, low degree of threats and high survival and reproduction rates). We are unaware of detailed studies that describe all of the demographic factors that could affect the population persistence of the Georgetown and Salado salamanders; however, we have assessed their probability of persistence by evaluating environmental factors (threats to their surface habitats) and using the available information we know about the number of salamanders that occur at each site.

To estimate the probability of persistence of each population involves considering the predictable responses of the population to various environmental factors (such as the amount of food available or the presence of a toxic substance), as well as the stochasticity. Stochasticity refers to the random, chance, or probabilistic nature of the demographic and environmental processes (Van Dyke 2008, pp. 217–218). Generally, the larger the population, the more likely it is to survive stochastic events in both demographic and environmental factors (Van Dyke 2008, p. 217). Conversely, the smaller the population, the higher its chances are of extirpation when experiencing this demographic and environmental stochasticity.

Rangewide Needs

We used the conservation principles of redundancy, representation, and resiliency (Shaffer and Stein 2000, pp. 307, 309–310) to better inform our view of what contributes to these species' probability of persistence and how best to conserve them. ''Resiliency'' is the ability of a species to persist through severe hardships or stochastic events (Tear *et al.* 2005, p. 841). ''Redundancy'' means a sufficient number of populations to provide a margin of safety to reduce the risk of losing a species or certain representation (variation) within a species, particularly from catastrophic or other events. ''Representation'' means conserving ''some of everything'' with regard to genetic and ecological diversity to allow for future adaptation and maintenance of evolutionary potential. Representation can be measured through the breadth of genetic diversity within and among populations and ecological diversity (also called environmental variation or diversity) occupied by populations across the species range.

A variety of factors contribute to a species' resiliency. These can include how sensitive the species is to disturbances or stressors in its environment, how often they reproduce and how many young they have, how specific or narrow their habitat needs are. A species' resiliency can also be affected by the resiliency of individual populations and the number of populations and their distribution across the landscape. Protecting multiple populations and variation of a species across its range may contribute to its resiliency, especially if some populations or habitats are more susceptible or better adapted to certain threats than others (Service and NOAA 2011, p. 76994). The ability of individuals from populations to disperse and recolonize an area that has been extirpated may also influence their resiliency. As population size and habitat quality increase, the population's ability to persist through periodic hardships also increases.

A minimal level of redundancy is essential for long-term viability (Shaffer and Stein 2000, pp. 307, 309–310; Groves *et al.* 2002, p. 506). This provides a margin of safety for a species to withstand catastrophic events (Service and NOAA 2011, p. 76994) by decreasing the chance of any one event affecting the entire species.

Representation and the adaptive capabilities (Service and NOAA 2011, p. 76994) of both the Georgetown and Salado salamanders are also important for long-term viability. Because a species' genetic makeup is shaped through natural selection by the environments it has experienced (Shaffer and Stein 2000, p. 308), populations should be protected in the array of different environments in which the salamanders occur (surface and subsurface) as a strategy to ensure genetic representation, adaptive capability, and conservation of the species.

To increase the probability of persistence of each species, populations of the Georgetown and Salado salamanders should be conserved in a manner that ensures their variation and representation. This result can be achieved by conserving salamander populations in a diversity of environments (throughout their ranges), including: (1) Both spring and cave locations, (2) habitats with groundwater sources from various aquifers and geologic formations, and (3) at sites with different hydrogeological characteristics, including sites where water flows come from artesian pressure, a perched aquifer, or resurgence through alluvial deposits.

Information for each of the salamander species is discussed in more detail below.

Georgetown Salamander

The Georgetown salamander is characterized by a broad, relatively short head with three pairs of bright-red gills on each side behind the jaws, a rounded and short snout, and large eyes with a gold iris. The upper body is generally grayish with varying patterns of melanophores (cells containing brown or black pigments called melanin) and iridophores (cells filled with iridescent pigments called guanine), while the underside is pale and translucent. The tail tends to be long with poorly developed dorsal and ventral fins that are golden-yellow at the base, cream-colored to translucent toward the outer margin, and mottled with melanophores and iridophores. Unlike the closely related Jollyville Plateau salamander, the Georgetown salamander has a distinct dark border along the lateral margins of the tail fin (Chippindale *et al.* 2000, p. 38). As with the Jollyville Plateau salamander, the Georgetown salamander has recently discovered cave-adapted forms with reduced eyes and pale coloration (TPWD 2011, p. 8).

The Georgetown salamander is known from springs along five tributaries (South, Middle, and North Forks; Cowan Creek; and Berry Creek) to the San Gabriel River (Pierce 2011a, p. 2) and from two caves (aquatic, subterranean locations) in Williamson County, Texas. A groundwater divide between the South Fork of the San Gabriel River and Brushy Creek to the south likely creates the division between the ranges of the Jollyville Plateau and Georgetown salamanders (Williamson County 2008, p. 3–34).

The Service is currently aware of 17 Georgetown salamander localities (15 in or around a spring opening and 2 in caves). We have recently received confirmation that Georgetown salamanders occur at two additional spring sites (Hogg Hollow II Spring and Garey Ranch Spring) (Covey 2013, pers. comm., Covey 2014, pers. comm.) This species has not been observed in more than 20 years at San Gabriel Spring and more than 10 years at Buford Hollow Spring, despite several survey efforts to find it (Chippindale *et al.* 2000, p. 40, Pierce 2011b, c, Southwestern University, pers. comm.). We are unaware of any population surveys in the last 10 years from a number of sites (such as Cedar Breaks Hiking Trail, Shadow Canyon, and Bat Well). Georgetown salamanders continue to be observed at the remaining 12 sites (Avant Spring, Swinbank Spring, Knight Spring, Twin Springs, Cowan Creek Spring, Cedar Hollow Spring, Cobbs Spring/Cobbs Well, Garey Ranch Spring, Hogg Hollow Spring, Hogg Hollow II Spring, Walnut Spring, and Water Tank Cave) (Pierce 2011c, pers. comm.; Gluesenkamp 2011a, TPWD, pers. comm.).

Recent mark-recapture studies suggest a population size of 100 to 200 adult salamanders at Twin Springs, with a similar population estimate at Swinbank Spring (Pierce 2011a, p. 18). Population sizes at other sites are unknown, but visual surface counts result in low numbers (Williamson County 2008, pp. 3–35). In fact, through a review of survey data available in our files and provided during the peer review and public comment period for the proposed rule, we found that the highest numbers observed at each of the other spring sites during the last 10 years is less than 50 (less than 5 salamanders at Avant Spring, Bat Well Cave, Cobbs Spring/CobbsWell, Shadow Canyon, and Walnut Spring; 0 salamanders at Buford Hollow Spring and San Gabriel Spring). There are other springs in Williamson County that may support Georgetown salamander populations, but access to the private lands where these springs are found has not been allowed, which has prevented surveys being done at these sites (Williamson County 2008, pp. 3–35).

Surface-dwelling Georgetown salamanders inhabit spring runs, riffles, and pools with gravel and cobble rock substrates (Pierce *et al.* 2010, pp. 295–296). This species prefers larger cobble and boulders to use as cover (Pierce *et al.* 2010, p. 295). Georgetown salamanders are found within 164 ft (50 m) of a spring opening (Pierce *et al.* 2011a, p. 4), but they are most abundant within the first 16.4 ft (5 m) (Pierce *et al.* 2010, p. 294). However, Jollyville Plateau salamanders, a closely related species, have been found farther from a spring opening in the Bull Creek drainage. A recent study using mark-recapture methods found marked individuals moved up to 262 ft (80 m) both upstream and downstream from the Lanier Spring outlet (Bendik 2013, pers. comm.). This study demonstrates that *Eurycea* salamanders in central Texas can travel greater distances from a discrete spring opening than previously thought, including upstream areas, if suitable habitat is present.

The water chemistry of Georgetown salamander habitat is constant year-round in terms of temperature and dissolved oxygen (Pierce *et al.* 2010, p. 294, Biagas *et al.* 2012, p. 163). Although some reproduction occurs year-round, recent data indicate that Georgetown salamanders breed mostly in winter and early spring (Pierce 2012, p. 8; Pierce and McEntire 2013, p. 6). The cave sites (Bat Well and Water Tank Cave) and the subterranean portion of Cobbs Well where this species is known to occur have been less studied than its surface habitat; therefore, the quality and extent of their subterranean habitats are not well understood.

Salado Salamander

The Salado salamander has reduced eyes compared to other spring-dwelling *Eurycea* species in north-central Texas and lacks well-defined melanophores (pigment cells that contain melanin). It has a relatively long and flat head, and a blunt and rounded snout. The upper body is generally grayish-brown with a slight cinnamon tinge and an irregular pattern of tiny, light flecks. The underside is pale and translucent. The end portion of the tail generally has a well-developed fin on top, but the bottom tail fin is weakly developed (Chippindale *et al.* 2000, p. 42).

The Salado salamander is known historically from four spring sites near the village of Salado, Bell County, Texas: Big Boiling Springs (also known as Main, Salado, or Siren Springs), Lil' Bubbly Springs, Lazy Days Fish Farm Springs (also known as Critchfield Springs), and Robertson Springs (Chippindale *et al.* 2000, p. 43; TPWD 2011, pp. 1–2). These springs bubble up through faults in the Northern Segment of the Edwards Aquifer and associated limestone along Salado Creek (Brune 1975, p. 31). The four spring sites all contribute to Salado Creek. Under Brune's (1975, p. 5) definition, which identifies springs depending on flow, all sites are considered small (4.5 to 45 gallons per minute [17 to 170 liters per minute]) to medium springs (45 to 449 gallons per minute [170 to 1,1700 liters per minute]). Two other spring sites (Benedict and Anderson Springs) are located downstream from Big Boiling Springs and Robertson Springs. These springs have been surveyed by TPWD periodically since June 2009, but no salamanders have been found (Gluesenkamp 2010, TPWD, pers. comm.). In August 2009, TPWD discovered a population of salamanders at a new site (Solana Spring #1) farther upstream on Salado Creek in Bell County, Texas (TPWD 2011, p. 2). Salado salamanders were recently confirmed at two additional spring sites (Cistern and Hog Hollow Springs) on the Salado Creek in March 2010 (TPWD 2011, p. 2). In total, the Salado salamander is currently known from seven springs. A groundwater divide between Salado Creek and Berry Creek to the south likely creates a division between the ranges of the Georgetown and Salado salamander (Williamson County 2008, p. 3–34).

Of the two salamander species, Salado salamanders have been observed the least. Biologists were unable to observe this species in its type locality (location from which a specimen was first collected and identified as a species) despite over 20 visits to Big Boiling Springs that occurred between 1991 and 1998 (Chippindale *et al.* 2000, p. 43). Likewise, TPWD surveyed this site weekly from June 2009 until May 2010, and found one salamander (Gluesenkamp 2010, TPWD, pers. comm.) at a spring outlet locally referred to as ''Lil' Bubbly'' located near Big Boiling Springs. One additional unconfirmed sighting of a Salado salamander in Big Boiling Springs was reported in 2008, by a citizen of Salado, Texas. In 2009, TPWD was granted access to Robertson Springs to survey for the Salado salamander. This species was reconfirmed at this location in February 2010 (Gluesenkamp 2010, TPWD, pers. comm.). In the fall of 2012, all of the spring outlets near the Village of Salado were thoroughly searched over a period of two months using a variety of sampling methods, and no Salado salamanders were found (Hibbitts 2013, p. 2). Salado salamander populations appear to be larger at spring sites upstream of the Village of Salado, probably due to the higher quality of the habitat (Gluesenkamp 2011b, TPWD, pers. comm.).

Summary of Comments and Recommendations

We requested comments from the public on the proposed listing for Georgetown salamander and Salado salamander during three comment periods. The first comment period associated with the publication of the proposed rule (77 FR 50768) opened on August 22, 2012, and closed on October 22, 2012, during which we held public meetings and hearings on September 5 and 6, 2012, in Round Rock and Austin, Texas, respectively. We reopened the comment period on the proposed listing rule from January 25, 2013, to March 11, 2013 (78 FR 5385). During our 6-month extension on the final determination for the Georgetown and Salado salamanders, we reopened the comment period from August 20, 2013, to September 19, 2013 (78 FR 51129). On January 7, 2014, we reopened the comment period and announced the availability of the City of Georgetown's final ordinance for water quality and urban development (79 FR 800). We reopened the comment period to allow all interested parties an opportunity to comment simultaneously on the proposed rule and the effect of the new city ordinance on the threats to the species. That comment period closed on January 22, 2014. We also contacted appropriate Federal, state, and local agencies; scientific organizations; and other interested parties and invited them to comment on the proposed rule during these comment periods.

We received a total of approximately 483 comments during the open comment periods for the proposed listing and critical habitat rules. All substantive information provided during the comment periods has been incorporated directly into the final listing rule for the salamanders and is addressed below in our response to comments. Comments from peer reviewers and state agencies are grouped separately below. Comments received are grouped into general issues specifically relating to the proposed listing for the salamander species. Beyond the comments addressed below, several commenters submitted additional reports and references for our consideration, which were reviewed and incorporated into this final listing rule as appropriate.

Peer Review

In accordance with our peer review policy published on July 1, 1994 (59 FR 34270), we solicited expert opinions from 22 knowledgeable individuals with scientific expertise concerning the hydrology, taxonomy, and ecology that is important to these salamander species. We requested expert opinions from taxonomists specifically to review the proposed rule in light of an unpublished report by Forstner (2012, entire) that questioned the taxonomic validity of the four central Texas salamanders as separate species. We received responses from 13 of the peer reviewers.

During the first comment period, we received some contradictory public comments, and we also found new information relative to the listing determination. For these reasons, we conducted a second peer review on: (1) Salamander demographics and (2) urban development and stream habitat. During this second peer review, we solicited expert opinions from 20 knowledgeable individuals with expertise in the two areas identified above. We received responses from eight peer reviewers during this second review. The peer reviewers generally concurred with our methods and conclusions and provided additional information, clarifications, and suggestions to improve the final listing and critical habitat rule. Peer reviewer comments are addressed in the following summary and incorporated into the final rule as appropriate.

Peer Reviewer Comments

Taxonomy

(1) *Comment:* Most peer reviewers stated that the best available scientific information was used to develop the proposed rule and the Service's analysis of the available information was scientifically sound. Further, most reviewers stated that our assessment that these are four distinct species and our interpretation of literature addressing threats (including reduced habitat quality due to urbanization and increased impervious cover) to these species was well researched. However, some researchers suggested that further research would strengthen or refine our understanding of these salamanders. For example, one reviewer stated that the Jollyville Plateau salamander taxonomy was supported by weak but suggestive evidence, and therefore, it needed more study. Another reviewer thought there was evidence of missing descendants in the group that included the Jollyville Plateau and Georgetown salamanders in the enzyme analysis presented in the original species descriptions (Chippindale *et al.* 2000, entire).

Our Response: Peer reviewers' comments indicate that we used the best available science, and we correctly interpreted that science as recognizing the central Texas salamanders as four separate species. In the final listing rule, we continue to recognize the Austin blind, Jollyville Plateau, Georgetown, and Salado salamanders as four distinct and valid species. However, we acknowledge that the understanding of the taxonomy of these salamander species can be strengthened by further research.

(2) *Comment:* Forstner (2012, pp. 3–4) used the size of geographic distributions as part of his argument for the existence of fewer species of *Eurycea* in Texas than are currently recognized. Several peer reviewers commented that they saw no reason for viewing the large number of *Eurycea* species with small distributions in Texas as problematic when compared to the larger distributions of *Eurycea* species outside of Texas. They stated that larger numbers and smaller distributions of Texas *Eurycea* species are to be expected given the isolated spring environments that they inhabit within an arid landscape. Salamander species with very small ranges are common in several families and are usually restricted to island, mountain, or cave habitats.

Our Response: See our response to comment 1.

(3) *Comment:* Forstner (2012, pp. 15–16) used results from Harlan and Zigler (2009), indicating that levels of genetic variation within the eastern species the spotted-tail salamander (*E. lucifuga*) are similar to those among six currently recognized species of Texas *Eurycea,* as part of his argument that there are fewer species in Texas than currently recognized. Several peer reviewers said that these sorts of comparisons can be very misleading in that they fail to take into consideration differences in the ages, effective population sizes, or population structure of the units being compared. The delineation of species should be based on patterns of genetic variation that influence the separation (or lack thereof) of gene pools rather than solely on the magnitude of genetic differences, which can vary widely within and between species groups.

Our Response: See our response to comment 1.

(4) *Comment:* Several peer reviewers stated that the taxonomic tree presented in Forstner (2012, pp. 20, 26) is difficult to evaluate because of the following reasons: (1) No locality information is given for the specimens; (2) it disagrees with all trees in other studies (which seem to be largely congruent with one another), including that in Forstner and McHenry (2010, pp. 13–16) with regard to monophyly (a group in which the members are comprised of all of the descendants from a common ancestor) of several of the currently recognized species; and (3) the tree is only a gene tree, presenting sequence data on a single gene, which provides little or no new information on species relationships of populations.

Our Response: See our response to comment 1.

(5) *Comment:* Peer reviewers generally stated that Forstner (2012, pp. 13–14) incorrectly dismisses morphological data that have been used to recognize some of the Texas *Eurycea* species on the basis that it is prone to convergence (acquisition of the same biological trait in unrelated lineages) and, therefore, misleading. The peer reviewers commented that it is true that similarities in characters associated with cave-dwelling salamanders can be misleading when suggesting that the species possessing those characters are closely related. However, this in no way indicates that the reverse is true; that is, indicating differences in characters is not misleading in identifying separate species.

Our Response: See our response to comment 1.

Impervious Cover

(6) *Comment:* The 10 percent impervious cover threshold may not be protective of salamander habitat based on a study by Coles *et al.* (2012, pp. 4–5), which found a loss of sensitive species due to urbanization and that there was no evidence of a resistance threshold to invertebrates that the salamanders prey upon. A vast amount of literature indicates that 1 to 2 percent impervious cover can cause habitat degradation, and, therefore, the 10 percent threshold for impervious cover will not be protective of these species.

Our Response: We recognize that low levels of impervious cover in a watershed may have impacts on aquatic life, and we have incorporated results of these studies into the final listing rule. However, we are aware of only one peer-reviewed study that examined watershed impervious cover effects on salamanders in central Texas, and this study found impacts on salamander density in watersheds with over 10 percent impervious cover (Bowles *et al.* 2006, pp. 113, 117–118). Because this impervious cover study was done locally, we are using 10 percent as a current reference point to categorize watersheds that are impacted in terms of salamander density.

(7) *Comment:* While the Service's impervious cover analysis assessed impacts on stream flows and surface habitat, it neglected to address impacts over the entire recharge zone of the contributing aquifers on spring flows in salamander habitat. Also, the surface watersheds analyzed in the proposed rule are irrelevant because these salamanders live in cave streams and spring flows that receive groundwater. Without information on the groundwater recharge areas, the rule should be clear that the surface watersheds are only an approximation of what is impacting the subsurface drainage basins.

Our Response: We acknowledge that the impervious cover analysis is limited to impacts on the surface watershed. Because the specific groundwater recharge areas of individual springs are unknown, we cannot accurately assess the current or future impacts on these areas. However, we recognize subsurface flows as another avenue for contaminants to reach the salamander sites, and we tried to make this clearer in the final rule.

(8) *Comment:* Several of the watersheds analyzed for impervious cover in the proposed rule were overestimated. The sub-basins in these larger watersheds need to be analyzed for impervious cover impacts.

Our Response: We have refined our impervious cover analysis in this final listing rule to clarify the surface watersheds of individual spring sites. Our final impervious cover report containing this refined analysis is available on the Internet at *http://www.regulations.gov* under Docket No. FWS–R2–ES–2012–0035 and at *http://www.fws.gov/southwest/es/AustinTexas/*.

Threats

(9) *Comment:* One peer reviewer stated that the threat to these species from over collection for scientific purposes may be understated.

Our Response: We have reevaluated the potential threat of overutilization for scientific purposes and have incorporated a discussion of this under Factor B ''*Overutilization for Commercial, Recreational, Scientific, or Educational Purposes.''* We recognize that removing individuals from small, localized populations in the wild without any proposed plans or regulations to restrict these activities could increase the population's vulnerability of extinction and decrease its resiliency and ability to withstand stochastic events. However, we do not consider overutilization from collecting salamanders in the wild to be substantial enough to be a threat by itself; however, it may cause population declines and could negatively impact both salamander species in combination with other threats.

Salamander Demographics

(10) *Comment:* Several peer reviewers agreed that COA's salamander survey data were generally collected and analyzed appropriately and that the results are consistent with the literature on aquatic species' responses to urbanizing watersheds. Three reviewers had some suggestions on how the data analysis could be improved, but they also state that COA's analysis is the best scientific data available, and alternative methods of analysis would not likely change the conclusions.

Our Response: Because the peer reviewers examined COA's salamander demographic data, as well as SWCA Environmental Consultants' analysis of the COA's data, and generally agreed that the COA's data was the best information available, we continue to rely upon this data set in the final listing rule.

(11) *Comment:* Two peer reviewers pointed out that water samples were collected by SWCA during a period of very low rainfall and, therefore, under represent the contribution of water influenced by urban land cover. The single sampling effort of water and sediment at the eight sites referenced in the SWCA report do not compare in scope and magnitude to the extensive studies referenced from the COA. The numerous studies conducted (and referenced) within the known ranges of the salamander species provide scientific support at the appropriate scale for recent and potential habitat degradation due to urbanization. One peer reviewer pointed out that if you sort the spring sites SWCA sampled into ''urbanized'' and ''rural'' categories, the urban sites generally have more degraded water quality than the rural sites, in terms of nitrate, nitrite, *Escherichia coli* (*E. coli*) counts, and fecal coliform bacteria counts.

Our Response: The peer reviewers made valid arguments that the SWCA (2012, pp. 21–24) did not present convincing evidence that overall water quality at salamander sites in Williamson County is good or that urbanization is not impacting the water quality at these sites. Water quality monitoring based on one or a few samples is not necessarily reflective of conditions at the site under all circumstances that the salamanders are exposed to over time. Based on this assessment, we continued to rely upon the best scientific information available in published literature that indicate water quality will decline as urbanization within the watershed increases.

(12) *Comment:* The SWCA report indicates that increasing conductivity is related to drought. (Note: Conductivity is a measure of the ability of water to carry an electrical current and can be used to approximate the concentration of dissolved inorganic solids in water that can alter the internal water balance in aquatic organisms, affecting the salamanders' survival. Conductivity levels in the Edwards Aquifer are naturally low. As ion concentrations such as chlorides, sodium, sulfates, and nitrates rise, conductivity will increase. The stability of the measured ions makes conductivity an excellent monitoring tool for assessing the impacts of urbanization to overall water quality. High conductivity has been associated with declining salamander abundance.). While SWCA's report notes lack of rainfall as the dominant factor in increased conductivity, the confounding influence of decreases in infiltration and increases in sources of ions as factors associated with urbanization and changes in water quality in these areas is not addressed by SWCA. Higher conductivity in urban streams is well documented and was a major finding of the U.S. Geological Survey (USGS) urban land use studies (Coles *et al.* 2012). Stream conductivity increased with increasing urban land cover in every metropolitan area studied.

Our Response: While drought may result in increased conductivity, increased conductivity is also a reflection of increased urbanization. We incorporated information from the study by Coles *et al.* (2012) in the final listing rule, and we continue to include conductivity as a measure of water quality.

(13) *Comment:* One peer reviewer stated that SWCA's criticisms of COA's linear regression analysis, general additive model, and population age structure were not relevant and were unsupported. In addition, peer reviewers agreed that COA's mark-recapture estimates are robust and highly likely to be correct. Three peer reviewers agreed that SWCA misrepresented the findings of Luo (2010) and stated that this thesis does not invalidate the findings of COA.

Our Response: Because the peer reviewers examined COA's data, as well as SWCA's analysis of the COA's data, and generally agreed that the COA's data was the best information available, we continue to rely upon this data set in the final listing rule.

(14) *Comment:* One peer reviewer stated that the long-term data collected by the COA on the Jollyville Plateau salamander were simple counts that serve as indices of relative population abundance and are not a measure of absolute abundance. This data assumes that the probability of observing salamanders remains constant over time, season, and among different observers. This assumption is often violated, which results in unknown repercussions on the assessment of population trends. Therefore, the negative trend observed in several sites could be due to a real decrease in population absolute abundance, but could also be related to a decrease in capture probabilities over time (or due to an interaction between these two factors). Absolute population abundance and capture probabilities should be estimated in urban sites using the same methods implemented at rural sites by COA. However, even in the absence of clear evidence of local population declines of Jollyville Plateau salamanders, the proposed rule was correct in its assessment because there is objective evidence that urbanization negatively impacts the density of *Eurycea* salamanders (for example, Barrett *et al.* 2010).

Our Response: We recognize that the long-term survey data of Jollyville Plateau salamanders using simple counts may not give conclusive evidence on the true population status at each site. However, based on the threats and evidence from scientifically peer-reviewed literature, we conclude that the declines in counts seen at urban Jollyville Plateau salamander sites represent the best available information on the status of the Jollyville Plateau salamander and are likely representative of real declines in the population. We expect similar responses by Georgetown and Salado salamanders.

(15) *Comment:* One peer reviewer had similar comments on COA salamander counts and relating them to populations. They stated that the conclusion of a difference in salamander counts between sites with high and low levels of impervious cover is reasonable based on COA's data. However, this conclusion is not about salamander populations, but instead about the counts. The COA's capture-mark-recapture analyses provide strong evidence of both non-detection and substantial temporary emigration, findings consistent with other studies of salamanders in the same family as the Jollyville Plateau salamander. This evidence cautions against any sort of analysis that relies on raw count data to draw inferences about populations.

Our Response: See our response to the previous comment.

(16) *Comment:* The SWCA (2012, pp. 70–76) argues that declines in salamander counts can be attributed to declines in rainfall during the survey period and not watershed urbanization. However, one peer reviewer stated that SWCA provided no statistical analysis to validate this claim and misinterpreted the conclusions of Gillespie (2011) to support their argument. A second peer reviewer agrees that counts of salamanders are related to natural wet and dry cycles but points out that COA has taken this effect into account in their analyses. Another peer reviewer points out that this argument contradicts SWCA's (2012) earlier claim that COA's salamander counts are unreliable data. If the data were unreliable, they probably would not correlate to environmental changes.

Our Response: Although rainfall is undoubtedly important to these strictly aquatic salamander species, the best scientific information suggests that rainfall is not the only factor driving salamander population fluctuations. In the final listing rule, we continue to rely upon this evidence as the best scientific and commercial information available, which suggests that urbanization is also a large factor influencing declines in salamander counts.

Regarding comments from SWCA on the assessment of threats, peer reviewers made the following comments:

(17) *Comment:* SWCA's (2012, pp. 84–85) summary understates what is known about the ecology of *Eurycea* species and makes too strong of a conclusion about the apparent ''coexistence with long-standing human development.'' Human development and urbanization is an incredibly recent stressor in the evolutionary history of the central Texas *Eurycea,* and SWCA's assertion that the *Eurycea* will be ''hardy and resilient'' to these new stressors is not substantiated with any evidence. In direct contradiction to this assertion, SWCA (2012, p. 83) explains how one population of Georgetown salamanders was extirpated due to municipal groundwater pumping drying the spring.

(18) *Comment:* SWCA (2012, p. 7) states that, ''Small population size and restricted distribution are not among the five listing criteria and do not of themselves constitute a reason for considering a species at risk of extinction.'' To the contrary, even though the salamanders may naturally occur in small isolated populations, small isolated populations and the inability to disperse between springs should be considered under listing criteria E as a natural factor affecting the species' continued existence. In direct contradiction, SWCA (2012, p. 81) later states that, ''limited dispersal ability (within a spring) may increase the species' vulnerability as salamanders may not move from one part of the spring run to another when localized habitat loss or degradation occurs.'' It is well known that small population size and restricted distributions make populations more susceptible to selection or extinction due to stochastic events. Small population size can also affect population density thresholds required for successful mating.

(19) *Comment:* SWCA (2012, p. v) argues that the Jollyville Plateau salamander is not in immediate danger of extinction because, ''over 60 of the 90-plus known Jollyville Plateau salamander sites are permanently protected within preserve areas, and 4 of the 16 known Georgetown salamander sites are permanently protected (and establishment of additional protected sites is being considered).'' This statement completely ignores the entire aquifer recharge zone, which is not included in critical habitat. Furthermore, analysis of the COA's monitoring and water quality datasets clearly demonstrate that, even within protected areas, there is deterioration of water quality and decrease in population size of salamanders.

(20) *Comment:* SWCA (2012, p. 11) criticizes the Service and the COA for not providing a direct cause and effect relationship between urbanization, nutrient levels, and salamander populations. There is, in fact, a large amount of peer-reviewed literature on the effects of pollutants and deterioration of water quality on sensitive macroinvertebrate species as well as on aquatic amphibians. In the proposed rule, the Service cites just a small sampling of the available literature regarding the effects of pollutants on the physiology and indirect effects of urbanization on aquatic macroinvertebrates and amphibians. In almost all cases, there are synergistic and indirect negative effects on these species that may not have one single direct cause. There is no ecological requirement that any stressor (be it a predator, a pollutant, or a change in the invertebrate community) must be a direct effect to threaten the stability or long-term persistence of a population or species. Indirect effects can be just as important, especially when many are combined.

Our Response to Comments 17–20: We included SWCA's (2012) report as part of the information we asked for peer reviewers to consider. The peer reviewers generally agreed that we used the best information available in our proposed listing rule.

(21) *Comment:* One reviewer stated that, even though there is detectable gene flow between populations, it may be representative of subsurface connections in the past, rather than current population interchange. However, dispersal through the aquifer is possible even though there is currently no evidence that these species migrate. Further, they stated that there is no indication of a metapopulation structure where one population could recolonize another that had gone extinct.

Our Response: We acknowledge that more study is needed to determine the nature and extent of the dispersal capabilities of the Georgetown and Salado salamanders. It is plausible that populations of these species could extend through subterranean habitat. However, subsurface movement is likely to be limited by the highly dissected nature of the aquifer system, where spring sites can be separated from other spring sites by large canyons or other physical barriers to movement. Dye-trace studies have demonstrated that some Jollyville Plateau salamander sites located miles apart are connected hydrologically (Whitewater Cave and Hideaway Cave) (Hauwert and Warton 1997, pp. 12–13), but it remains unclear if salamanders are travelling between those sites. We have some indication that populations could be connected through subterranean water-filled spaces, although we are unaware of any information on the frequency of movements and the actual nature of connectivity among populations.

Comments From States

Section 4(i) of the Act states, ''the Secretary shall submit to the State agency a written justification for his failure to adopt regulations consistent with the agency's comments or petition.'' Comments received from all State agencies and entities in Texas regarding the proposal to list the Georgetown and Salado salamanders are addressed below.

(22) *Comment:* Chippindale (2010) demonstrated that it is possible for Jollyville Plateau salamanders to move between sites in underground conduits. Close genetic affinities between populations in separate watersheds on either side of the RM 620 suggest that these populations may be connected hydrologically. Recent studies (Chippindale 2011 and 2012, in prep) indicate that gene flow among salamander populations follows groundwater flow routes in some cases and that genetic exchange occurs both

horizontally and vertically within an aquifer segment.

Our Response: We agree that genetic evidence suggests subsurface hydrological connectivity exist between sites at some point in time, but we are unable to conclude if this connectivity occurred in the past or if it still occurs today without more hydrogeological studies or direct evidence of salamander migration from mark-recapture studies. Also, one of our peer reviewers stated that this genetic exchange is probably representative of subsurface connection in the past (see comment 21 above).

(23) *Comment:* There were insufficient data to evaluate the long-term flow patterns of the springs and creeks, and the correlation of flow, water quality, habitat, ecology, and community response. Current research in Williamson County indicates that water and sediment quality remain good with no degradation, no elevated levels of toxins, and no harmful residues in known springs.

Our Response: We have reviewed the best available scientific and commercial information in making our final listing determination. We sought comments from independent peer reviewers to ensure that our designation is based on scientifically sound data, assumptions, and analysis. And the peer reviewers stated that our proposed rule was based on the best available scientific information. Additionally, recent research on water quality in Williamson County springs was considered in our listing rule. The peer reviewers agreed that these data did not present convincing evidence that overall water quality at salamander sites in Williamson County is good or that urbanization is not impacting the water quality at these sites (see Comment 19 above).

(24) *Comment:* The listing will have negative impacts to private development and public infrastructure.

Our Response: In accordance with the Act, we cannot consider possible economic impacts in making a listing determination. However, Section 4(b)(2) of the Act states that the Secretary shall designate and make revisions to critical habitat on the basis of the best available scientific data after taking into consideration the economic impact, national security impact, and any other relevant impact of specifying any particular area as critical habitat. Economic impacts are not taken into consideration as part of listing determinations.

(25) *Comment:* It was suggested that there are adequate regulations in Texas to protect the Georgetown and Salado salamanders and their respective habitats. The overall programs to protect water quality—especially in the watersheds of the Edwards Aquifer region—are more robust and protective than suggested by the Service's descriptions of deficiencies. The Service overlooks the improvements in the State of Texas and local regulatory and incentive programs to protect the Edwards Aquifer and spring-dependent species over the last 20 years. Texas has extensive water quality management and protection programs that operate under state statutes and the Federal Clean Water Act. These programs include: Surface Water Quality Monitoring Program, Clean Rivers Program, Water Quality Standards, Texas Pollutant Discharge Elimination System (TPDES) Stormwater Permitting, Total Maximum Daily Load Program, Nonpoint Source Program, Edwards Aquifer Rules, and Local Ordinances and Rules (San Marcos Ordinance and COA Rules). Continuing efforts at the local, regional, and state level will provide a more focused and efficient approach for protecting these species than Federal listing.

Our Response: Section 4(b)(1)(A) of the Act requires us to take into account those efforts being made by a state or foreign nation, or any political subdivision of a state or foreign nation, to protect such species, and we fully recognize the contributions of the state and local programs. We consider relevant Federal, state, and tribal laws and regulations when developing our threats analysis. Regulatory mechanisms may preclude the need for listing if we determine such mechanisms address the threats to the species such that listing is no longer warranted. However, the best available scientific and commercial data available at the time of the proposed rule supported our initial determination that existing regulations and local ordinances were not adequate to remove all of the threats to the Georgetown and Salado salamanders. Since that time, the City of Georgetown approved a new ordinance designed to reduce the threats to the Georgetown salamander. We have added further discussion of existing regulations and ordinances under Factor D in the final listing rule, and we have considered these new ordinances in our threats analysis below.

(26) *Comment:* The requirement in the Edwards Aquifer Rules for wastewater to be disposed of on the recharge zone by land application is an important and protective practice for aquifer recharge and a sustainable supply of groundwater. Permits for irrigation of wastewater are fully evaluated and conditioned to require suitable vegetation and sufficient acreage to protect water quality.

Our Response: Based on the best available science, wastewater disposal on the recharge zone by land application can contribute to water quality degradation in surface waters and the underground aquifer. Previous studies have demonstrated negative impacts to water quality (increases in nitrate levels) at Barton Springs (Mahler *et al.* 2011, pp. 29–35) and within streams (Ross 2011, pp. 11–21) that were likely associated with the land application of wastewater.

(27) *Comment:* A summary of surface water quality data for streams in the watersheds of the salamanders was provided, and a suggestion was made that sampling data indicated high-quality aquatic life will be maintained despite occasional instances where parameters exceeded criteria or screening levels.

Our Response: In reviewing the 2010 and 2012 Texas Water Quality Integrated Reports prepared by the Texas Commission on Environmental Quality (TCEQ), the Service identified 3 of 7 (43 percent) and 2 of 2 (100 percent) stream segments located within surface drainage areas occupied by the Georgetown and Salado salamanders respectively, which contained measured parameters within water samples that exceeded screening level criteria. These included ''screening level concerns'' for parameters such as nitrate, dissolved oxygen, and impaired benthic communities. Water quality data collected and summarized in TCEQ reports supports concerns for the potential for water quality degradation within the surface drainage areas occupied by the salamanders. This information is discussed under *Summary of Factors Affecting the Species* in this final listing rule.

(28) *Comment:* The City of Georgetown ordinance reduces the threats to surface habitat conditions and water quality for the Georgetown salamander.

Our response: The Service agrees that the City of Georgetown ordinance will reduce some of the threats to the Georgetown salamander. We have provided a discussion on the effectiveness of the City of Georgetown's ordinance in reducing the threats to the Georgetown salamander under *Summary of Factors Affecting the Species* below in the final listing rule.

Public Comments

Existing Regulatory Mechanisms

(29) *Comment:* The Service improperly discounts the value of

TCEQ's Optional Enhanced Measures by concluding that, because they are optional as to non-listed species, ''take'' prohibitions do not apply and they are not a regulatory mechanism. However, in February 14, 2005, the Service stated in a letter to Governor Rick Perry that implementation of the Enhanced Measures would result in ''no take'' of various aquatic species, including the Georgetown salamander.

Our Response: With the listing of the Georgetown and Salado salamanders, the Act and its implementing regulations set forth a series of general prohibitions and exceptions that apply to all endangered and threatened wildlife. The prohibitions of section 9(a)(2) of the Act, codified at 50 CFR 17.21 and 50 CFR 17.31, make it illegal for any person subject to the jurisdiction of the United States to take (includes harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect; or to attempt any of these), import, export, ship in interstate commerce in the course of commercial activity, or sell or offer for sale in interstate or foreign commerce any listed species. Under the Lacey Act (18 U.S.C. 42–43; 16 U.S.C. 3371–3378), it is also illegal to possess, sell, deliver, carry, transport, or ship any such wildlife that has been taken illegally. We may issue permits to carry out otherwise prohibited activities involving endangered and threatened wildlife species under certain circumstances, but such a permit must be issued for scientific purposes, to enhance the propagation or survival of the species, and for incidental take in connection with otherwise lawful activities. The Service's 2005 and 2007 letters to Governor Rick Perry were made prior to listing of the Georgetown and Salado salamanders and do not constitute a permit that allows for take under the Act.

We have changed the wording in the final listing rule to more accurately reflect our opinion that the Optional Enhanced Measures may provide protection to the species, but do not constitute a regulatory mechanism because they are voluntary. These measures were intended to be used for the purpose of avoiding harm to the identified species from water quality impacts, not to address any of the other threats to the Georgetown salamander. TCEQ reported that only 17 Edwards Aquifer applications have been approved under the Optional Enhanced Measures between February 2005 and May 2012, and the majority of these applications were for sites in the vicinity of Dripping Springs, Texas, which would not pertain to the Georgetown salamander (Beatty 2012, TCEQ, pers. comm.).

(30) *Comment:* The Service's February 14, 2005, and September 4, 2007, letters to Governor Rick Perry concurred that non-federal landowners and other non-federal managers using the voluntary measures in Appendix A to the TCEQ technical guidance manual for the Edwards Aquifer Protection Program would have the support of the Service that ''no take'' under the Act would occur unless projects met specific criteria listed in the letters.

Our Response: See our response to comment (29) above.

(31) *Comment:* Many commenters expressed concern that the Service had not adequately addressed all of the existing regulatory mechanisms and programs that provided protection to the salamanders. In addition, many of the same commenters believed there were adequate state, Federal, and local regulatory mechanisms to protect the salamanders and their aquatic habitats.

Our Response: Section 4(b)(1)(A) of the Act requires us to take into account those efforts being made by a state or foreign nation, or any political subdivision of a state or foreign nation, to protect such species. Under *D. The Inadequacy of Existing Regulatory Mechanisms* in the final listing rule, we provide an analysis of the inadequacy of existing regulatory mechanisms. During the comment period, we sought out and were provided information on several local, state, and Federal regulatory mechanisms that we had not considered when developing the proposed rule. We have reviewed these mechanisms and have included them in our analysis under *D. The Inadequacy of Existing Regulatory Mechanisms* in the final listing rule. In addition, during the 6-month extension the City of Georgetown approved a new ordinance designed to reduce the threats to the Georgetown salamander. We have included this ordinance in our discussion under *Summary of Factors Affecting the Species* below in the final listing rule.

Protections

(32) *Comment:* The Service fails to consider existing local conservation measures and habitat conservation plans (HCPs) that benefit the salamanders. While the salamanders are not covered in most of these HCPs, some commenters believe that measures are in place to mitigate any imminent threats to the species. The Service overlooks permanent conservation actions undertaken by both public and private entities over the last two or more decades. The HCPs and water quality protection standards are sufficient to prevent significant habitat degradation.

Our Response: In the final listing rule, we included a section titled ''Conservation Efforts to Reduce Habitat Destruction, Modification, or Curtailment of Its Range'' that describes existing conservation measures including the regional permit issued to the Williamson County Regional HCP. These conservation efforts and the manner in which they are helping to ameliorate threats to the species were considered in our final listing determination. The Service considered the amount and location of managed open space when analyzing impervious cover levels within each surface watershed (Service 2012, 2013). We also considered preserves when projecting how impervious cover levels within the surface watershed of each spring site would change in the future. These analyses included the benefits from open space as a result of several HCPs, including Buttercup Creek HCP, Balcones Canyonlands Conservation Plan, Lakeline Mall HCP, Concordia HCP, Four Points HCP, and Grandview Hills HCP. Of these, only the Williamson County HCP and Lakeline Mall HCP created open space within the range of the Georgetown salamander (no HCPs have established open space within the range of the Salado salamander). While these conservation lands contribute to the protection of the surface and subsurface watersheds, there are other factors contributing to the decline of the salamander's habitat. Other factors include, but are not limited to: (1) Other areas within the surface watershed that have high levels of impervious cover, which increases the overall percentage of impervious cover within the watershed; (2) potential for groundwater pollution from areas outside of the surface watershed; and (3) disturbance of the surface habitat of the spring sites themselves.

(33) *Comment:* Multiple commenters stated that the Georgetown salamander's known distribution is entirely contained within the jurisdictional boundaries of the Williamson County Regional HCP (RHCP) and is thusly already protected. The RHCP includes provisions for studying the Georgetown salamander and numerous conservation actions benefitting the species. To date, 47 entities have participated in the RHCP and the Williamson County Conservation Fund (WCCF) has permanently preserved 664 ac (269 ha) within 8 preserves. As part of the RHCP, a commitment was made to conduct a 5-year study of the Georgetown salamander and drafting of a

conservation strategy. In 2008, based on these actions, the Service reduced the listing priority category for the Georgetown salamander from a 2 to an 8.

Our Response: We agree with the commenters that the RHCP permit area contains the entire range of the Georgetown salamander, and also includes a portion of the Jollyville Plateau salamander within its permit area. Furthermore, we agree that some of the land preserved by the RHCP as mitigation for the impacts of covered activities on endangered invertebrate species is contributing to protection of a limited amount of salamander habitat. However, the RHCP does not permit ''take'' of salamanders as covered species, accordingly the permit does not require mitigation for the impacts of the covered actions on any salamander species. The RHCP notes on page 4–19 that actions authorized by the RHCP for covered species ''. . . may impact the Georgetown salamander by degrading water quality and quantity in springs and streams in the watersheds where the species occurs.'' One of the RHCP's biological goals is to help conserve the salamanders by studying the Georgetown salamander's status, distribution, and conservation needs. In addition to a 5-year Georgetown salamander research and monitoring program, Williamson County committed to drafting a conservation strategy for the species, based on initial findings of the research, and coordinating a public education and outreach program. While this research to date has been incorporated in the final listing rule, the best available information supports our conclusion that the threats to the species are not ameliorated by the RHCP.

The listing priority number was lowered from a 2 to an 8 for the Georgetown salamander based on conservation actions by WCCF in 2008 (73 FR 75176, December 10, 2008). A listing priority of 8 indicates that there are imminent threats to the species, but the magnitude of these imminent threats is moderate to low.

(34) *Comment:* The proposed rule directly contradicts the Service's recent policy titled Expanding Incentives for Voluntary Conservation Actions Under the Act (77 FR 15352, March 15, 2012), which concerns the encouragement of voluntary conservation actions for non-listed species and is available at *http://www.gpo.gov/fdsys/pkg/FR-2012-03-15/pdf/2012-6221.pdf*.

Our Response: The commenter did not specify how the proposed rule contradicts the Service's recent policy pronouncements concerning the encouragement of voluntary conservation actions for non-listed species. The recent policy pronouncements specifically state that voluntary conservation actions undertaken are unlikely to be sufficient to affect the need to list the species. However, if the species is listed and voluntary conservation actions are implemented, as outlined in policy pronouncements, the Service can provide assurances that if the conditions of a conservation agreement are met, the landowner will not be asked to do more, commit more resources, or be subject to further land use restrictions than agreed upon. We may also allow a prescribed level of incidental take by the landowner.

(35) *Comment:* Existing protective measures and current land-use conditions in the contributing zone of the Northern Segment of the Edwards Aquifer negate the justification for the proposed listing of the Salado salamander. It was the understanding of Bell County that the development of comprehensive conservation strategies or plans to protect species would be based on additional research that will be conducted in a cooperative effort involving state and Federal environmental agencies and local stakeholders. Consistent with the guidance of agency officials, Bell County and their partners held public hearings and entered into contractual agreements with experts. Fieldwork related to those studies is about to commence.

Our Response: The Service appreciates the efforts of Bell County and their partners to conduct research and collect additional data to support the conservation of the Salado salamander. The Service is required to make a determination on the status of the Salado salamander based on the best available science at the time we make our listing decision. The Service looks forward to continuing to work with Bell County and all of our other partners to further the conservation of the Salado salamander. We anticipate the additional research and information being gathered by Bell County and others will be helpful in refining conservation strategies and adapting management for these species, based on this new information.

(36) *Comment:* The proposed rule cites the vested rights statute found in Chapter 245, Texas Local Government Code as a weakness in local and state regulations. Chapter 245 does not apply to state regulations. Under Chapter 245, a ''regulatory agency'' is defined as a political subdivision of the state such as a county, school district or municipality (Section 245.001(2) & (4), Texas Local Government Code). The Edwards Rules for the Contributing Zone revised in 1999 had a very narrow grandfathering provision from the new regulations: A project did not have to comply with the new rules if the project had all of the permits necessary to begin construction on June 1, 1999, and construction began by December 1, 1999. No projects can possibly exist that are grandfathered from the Edwards Rules for the contributing zone of the Edwards Aquifer.

Our Response: We have revised this discussion in this final rule, as appropriate.

Listing Process and Policy

(37) *Comment:* Reducing the Listing Priority Number of the Georgetown salamander from 2 to 8 indicates no imminent threat to the species.

Our Response: In the 2008 candidate notice of review, the listing priority number was lowered from 2 to 8. However, a listing priority of 8 indicates that there are imminent threats to the species, but the magnitude of these imminent threats is moderate to low.

(38) *Comment:* The Service is pushing these listings because of the legal settlement and not basing its decision on science and the reality of the existing salamander populations.

Our Response: We are required by court-approved settlement agreements to remove the Georgetown and Salado salamanders from the candidate list within a specified timeframe. To remove these salamanders from the candidate list means to propose them for listing as endangered or threatened or to prepare a not-warranted finding. The Act requires us to determine whether a species warrants listing based on our assessment of the five listing factors described in the Act using the best available scientific and commercial information. We already determined, prior to the court settlement agreement, that the Georgetown and Salado salamanders warranted listing under the Act, but were precluded by the necessity to commit limited funds and staff to complete higher priority species actions. These salamanders have been included in our annual Candidate Notices of Review for multiple years, during which time scientific literature and data have and continue to indicate that these salamanders are detrimentally impacted by ongoing threats, and we continued to find that listing each species was warranted but precluded. While the settlement agreement has set a court-ordered timeline for rendering our final decision, our determination is still guided by the Act and its implementing regulations considering the five listing factors and using the best available scientific and commercial information.

(39) *Comment:* Commenters requested that the Service extend the comment period for another 45 days after the first comment period. The commenters were concerned about the length of the proposed listing, which is very dense and fills 88 pages in the **Federal Register**, and that the public hearing was held only 2 weeks after the proposed rule was published. Commenters do not consider this enough time to read and digest how the Service is basing a listing decision that will have serious consequences for Williamson County. Furthermore, the 60-day comment period does not give the public enough time to submit written comments to such a large proposed rule.

Our Response: The initial comment period for the proposed listing and critical habitat designation consisted of 60 days, beginning August 22, 2012, and ending on October 22, 2012. We reopened the comment period for an additional 45 days, beginning on January 25, 2013, and ending on March 11, 2013. During our 6-month extension on the final determination for the Georgetown and Salado salamanders, we reopened the comment period from August 20, 2013, to September 19, 2013 (78 FR 51129). On January 7, 2014, we reopened the comment period and announced the availability of the City of Georgetown's final ordinance for water quality and urban development (79 FR 800). We reopened the comment period to allow all interested parties an opportunity to comment simultaneously on the proposed rule and the effect of the new city ordinances on threats to the Georgetown salamander. That comment period closed on January 22, 2014. We consider the comment periods described above an adequate opportunity for public comment.

(40) *Comment:* The Service has openly disregarded a contractual agreement (RHCP) with Williamson County that provided for additional study, violating mandatory process under the Act. It was our understanding that the development of comprehensive conservation strategies or plans to protect the species would be based on additional research, which would be conducted in a cooperative effort involving state and Federal environmental agencies and local stakeholders. Williamson County has committed funds and entered into contractual agreements with respected experts to perform these additional baseline studies. The Service has violated a contractual agreement under the Act.

Our Response: The RHCP is not a contract. By moving forward with a listing decision for the Georgetown and Salado salamanders, the Service has not violated any mandatory process under the Act or any contractual agreement with Williamson County. The RHCP was established in 2008 to provide incidental take coverage for the federally listed golden-cheeked warbler (*Dendroica chrysoparia*), black-capped vireo (*Vireo atricapilla*), Bone Cave harvestman (*Texella reyesi*), and Coffin Cave mold beetle (*Batrisodes texanus*). A number of conservation actions for the Georgetown salamander were planned in the RHCP, but the Georgetown salamander is not a covered species under the RHCP. One of the conservation actions is for WCCF to conduct a 5-year research and monitoring study for the Georgetown salamander, which was planned with the intention of preparing a Candidate Conservation Agreement with Assurances if the species was still a candidate at the end of the study. The RHCP does not include an agreement between the Service and Williamson County to delay the listing of the Georgetown salamander until the study is completed.

(41) *Comment:* One commenter expressed concern with the use of ''unpublished'' data in the proposed rule. It is important that the Service takes the necessary steps to ensure all data used in the listing and critical habitat designations are reliable, verifiable, and peer reviewed, as required by President Obama's 2009 directive for transparency and open government. In December of 2009, the Office of Management and Budget (OMB) issued clarification on the presentation and substance of data used by Federal agencies and required in its Information Quality Guidelines. Additionally under the OMB guidelines, all information disseminated by Federal agencies must meet the standard of ''objectivity.'' Additionally, relying on older studies instead of newer ones conflicts with the Information Quality Guidelines.

Our Response: Our use of unpublished information and data does not contravene the transparency and open government directive. Under the Act, we are obligated to use the best available scientific and commercial information, including results from surveys, reports by scientists and biological consultants, various models, and expert opinion from biologists with extensive experience studying the salamanders and their habitat, whether published or unpublished. One element of the transparency and open government directive encourages executive departments and agencies to make information about operations and decisions readily available to the public. Supporting documentation used to prepare the proposed and final rules is available for public inspection, by appointment, during normal business hours, at the U.S. Fish and Wildlife Service, Austin Ecological Services Field Office, 10711 Burnet Rd., Suite 200, Austin, TX 78758.

Peer Review Process

(42) *Comment:* One commenter requested that the Service make the peer review process as transparent and objective as possible. The Service should make available the process and criteria used to identify peer reviewers. It is not appropriate for the Service to choose the peer review experts. For the peer review to be credible, the entire process including the selection of reviewers must be managed by an independent and objective party. We recommend that the peer review plan identify at least two peer reviewers per scientific discipline. Further, the peer reviewers should be identified.

Our Response: To ensure the quality and credibility of the scientific information we use to make decisions, we have implemented a formal peer review process. Through this peer review process, we followed the guidelines for Federal agencies spelled out in the Office of Management and Budget (OMB) ''Final Information Quality Bulletin for Peer Review'' released December 16, 2004, and the Service's ''Information Quality Guidelines and Peer Review'' revised June 2012. Part of the peer review process is to provide information online about how each peer review is to be conducted. Prior to publishing the proposed listing and critical habitat rule for these salamanders, we posted a peer review plan on our Web site, which included information about the process and criteria used for selecting peer reviewers, and we posted the peer reviews on *http://www.regulations.gov*.

In regard to transparency, the OMB and Service's peer review guidelines mandate that we not conduct anonymous peer reviews. The guidelines state that we advise reviewers that their reviews, including their names and affiliations, and how we respond to their comments will be included in the official record for review, and once all the reviews are completed, their reviews will be available to the public. We followed the policies and standards for conducting peer reviews as part of this rulemaking process.

(43) *Comment:* The results of the peer review process should be available to the public for review and comment well before the end of the public comment period on the listing decision. Will the public have an opportunity to participate in the peer review process?

Response: As noted above, OMB and the Service's guidelines state that we make available to the public the peer reviewers' information, reviews, and how we respond to their comments once all reviews are completed. The peer reviews are completed at the time the last public comment period closes, and our responses to their comments are completed at the time the final listing decision is published in the **Federal Register**. All peer review process information is available upon request at this time and is available from the U.S. Fish and Wildlife Service, Austin Ecological Services Field Office, 10711 Burnet Rd, Suite 200, Austin, TX 78758. In addition, the peer reviews have been posted at *http://www.regulations.gov*.

(44) *Comment:* New information has been provided during the comment period. The generalized opinions of the initial peer reviewers regarding the proposed rule having the best available science is largely negated by the significant quantity of materials submitted by the public during the first two comment periods. In other words, the large quantity of additional information submitted into the record clearly demonstrates that the proposed rule did not reflect the best available scientific and commercial data. The final listing decision should be peer reviewed.

Response: During the second public comment period, we asked peer reviewers to comment on new and substantial information that we received during the first comment period. We did not receive any new information during the second comment period that we felt rose to the level of needing peer review. Furthermore, as part of our peer review process, we asked peer reviewers not to provide comments or recommendations on the listing decision. Peer reviewers were asked to comment specifically on the quality of information and analyses used or relied on in the reviewed documents. In addition, they were asked to identify oversights, omissions, and inconsistencies; provide advice on reasonableness of judgments made from the scientific evidence; ensure that scientific uncertainties are clearly identified and characterized and that potential implications of uncertainties for the technical conclusions drawn are clear; and provide advice on the overall strengths and limitations of the scientific data used in the document.

(45) *Comment:* One commenter requested a peer review of the four central Texas salamanders' taxonomy and recommended that, to avoid any potential bias, peer reviewers not be from Texas or be authors or contributors of any works that the Service has or is relying upon to diagnose the four central Texas salamanders as four distinct species. This commenter also provided a list of four recommended scientists for the peer review on taxonomy.

Our Response: We requested peer reviews of the central Texas salamander taxonomy from 11 scientific experts in this field. Because we considered the 4 recommended scientists to be qualified as independent experts, we included the 4 experts recommended by the commenter among the 11. Eight scientists responded to our request, and all eight scientists agreed with our recognition of four separate and distinct salamander species, as described in the *Species Information* section of the proposed and final listing rules. The commenter also provided an unpublished paper offering an alternative interpretation of the taxonomy of central Texas salamanders (Forstner 2012, entire), and that information was also provided to peer reviewers. We included two authors of the original species descriptions of the four central Texas salamander species to give them an opportunity to respond to criticisms of their work and so that we could fully understand the taxonomic questions about these species.

(46) *Comment:* One commenter requested a revision to the peer review plan to clarify whether it is a review of non-influential information or influential information.

Our Response: We see no benefit from revising the peer review plan to clarify whether the review was of non-influential or influential information. The Service's ''Information Quality Guidelines and Peer Review,'' revised June 2012, defines influential information as information that we can reasonably determine the dissemination of which will have or does have a clear and substantial impact on important policy or private sector decisions. Also, we are authorized to define influential in ways appropriate for us, given the nature and multiplicity of issues for which we are responsible. As a general rule, we consider an impact clear and substantial when a specific piece of information is a principal basis for our position.

(47) *Comment:* One commenter requested clarification on what type of peer review was intended. Was it a panel review or individual review? Did peer reviewers operate in isolation to generate individual reports or did they work collaboratively to generate a single peer review document.

Our Response: Peer reviews were requested individually. Each peer reviewer who responded generated independent comments.

(48) *Comment:* It does not seem appropriate to ask peer reviewers, who apparently do not have direct expertise on *Eurycea* or central Texas ecological systems, to provide advice on reasonableness of judgments made from generic statements or hyper-extrapolations from studies on other species. The peer review plan states that reviewers will have expertise in invertebrate ecology, conservation biology, or desert spring ecology. The disciplines of invertebrate ecology and desert spring ecology do not have any apparent relevance to the salamanders in question. The *Eurycea* are vertebrate species that spend nearly all of their life cycle underground. Central Texas is not a desert. The peer reviewers should have expertise in amphibian ecology and familiarity with how karst hydrogeology operates.

Our Response: The peer review plan stated that we sought out peer reviewers with expertise in invertebrate ecology or desert spring ecology, but this was an error which was corrected in our correspondence with the peer reviewers. In the first comment period, we asked and received peer reviews from independent scientists with local and non-local expertise in amphibian ecology, amphibian taxonomy, and karst hydrology. In the second comment period, we sought out peer reviewers with local and non-local expertise in population ecology and watershed urbanization.

(49) *Comment:* The peer review plan appears to ask peer reviewers to consider only the scientific information reviewed by the Service. The plan should include the question of whether the scientific information reviewed constitutes the best available scientific and commercial data. The plan should be revised to clarify that the peer reviewers are not limited to the scientific information in the Service's administrative record.

Our Response: The peer review plan states that we may ask peer reviewers to identify oversights and omissions of information as well as to consider the information reviewed by the Service. When we sent out letters to peer reviewers asking for their review, we specifically asked them to identify any oversights, omissions, and inconsistencies with the information we presented in the proposed rule.

(50) *Comment:* The proposed peer review plan falls far short of the OMB Guidelines (2004 Office of Management and Budget promulgated its Final Information Quality Bulletin for Peer Review).

Our Response: This commenter failed to tell us how the plan falls short of the OMB Guidelines. We adhered to the guidelines set forth for Federal agencies and in OMB's ''Final Information Quality Bulletin for Peer Review,'' released December 16, 2004, and the Service's ''Information Quality Guidelines and Peer Review,'' revised June 2012. While the draft peer review plan had some errors, we believe we satisfied the intent of the guidelines and that the errors did not affect the rigor of the actual peer review that occurred.

(51) *Comment:* One commenter stated that an additional peer review plan was not made available to the public for the second peer review.

Our Response: We followed our peer review policy to prepare a peer review plan for our proposed rules, and we made the plan available for public review on our Web site. Both of our peer review processes followed this plan.

Salamander Populations

(52) *Comment:* A recent study by SWCA proposes that the COA's data are inadequate to assess salamander population trends and is not representative of environmental and population control factors (such as seasonal rainfall and drought). The study also states that there is very little evidence linking increased development to declining water quality.

Our Response: We have reviewed the report by SWCA and COA's data and determined that it is reasonable to conclude that a link between increased urban development, declining water quality, and declining salamander populations exists for these species. Peer reviewers have also generally agreed with this assessment.

(53) *Comment:* The WCCF has been conducting research on salamanders of the Northern Edwards Aquifer since 2008. This included population monitoring at two Georgetown salamander sites and recently expanded to include water quality testing in both Georgetown salamander and Jollyville Plateau salamander ranges. Data indicate that populations are stable and healthy and water quality at Williamson County springs is excellent.

Our Response: We acknowledge that two Georgetown salamander sites in Williamson County have been regularly monitored since 2008, and we have considered this data in the final listing rule. However, water quality testing by WCCF at salamander sites has only recently been initiated, and no conclusions regarding long-term trends in water quality at Georgetown salamander sites can be made. Furthermore, this salamander count dataset has not been conducted over a long enough time period to conclude that the salamander populations are stable and healthy at the two monitored sites.

(54) *Comment:* Specifically related to the Salado salamander, we note an apparent inconsistency in the proposed rule related to the locations of specific springs where the animal has been found. The section on impervious cover states, ''The Salado salamander occurs within two watersheds (Buttermilk Creek and Mustang Creek).'' In fact, to our knowledge the animal has been found in neither. The section discussing the specific springs identifies occurrences in springs in the Rumsey Creek and Salado Creek watersheds. The latter section appears to be correct.

Our Response: Buttermilk Creek and Mustang Creek are the names of the 12-digit Hydrologic Unit Codes we used in our initial impervious cover analysis. They are larger watersheds that contain the smaller watersheds of Rumsey Creek and Salado Creek, which contain the springs occupied by the Salado salamander.

(55) *Comment:* The Service has no evidence that shows what the Georgetown salamander population is, or what a healthy average population would look like.

Our Response: Although population data are lacking for most Georgetown salamander sites, population estimates of Georgetown salamanders have recently been completed at Twin Springs (118–216 adults) and Swinbank Spring (102–137 adults) (Pierce 2011a, p. 12). Part of what constitutes a healthy population is that threats have been removed or minimized. In terms of population size, it is unknown how many individuals are needed within a population to ensure its persistence over the long term.

(56) *Comment:* Given the central Texas climate and the general geology and hydrology of the Edwards Limestone formation north of the Colorado River, the description ''surface-dwelling'' or ''surface residing'' overstates the extent and frequency that the Georgetown and Salado salamanders utilize surface water. The phrase ''surface dwelling population'' in the proposed rule appears to be based on two undisclosed and questionable assumptions pertaining to Georgetown and Salado salamanders: (1) There are a sufficient number of these salamanders that have surface water available to them for sufficient periods of times so that the group could be called a ''population''; and (2) there are surface-dwelling Jollyville Plateau salamander populations that are distinct from subsurface dwelling Jollyville Plateau salamander populations. Neither assumption can be correct unless the surface area is within a spring-fed impoundment that maintains water for a significant portion of a year.

Our Response: In the proposed rule, we did not mean to imply or assume that ''surface-dwelling populations'' are restricted to surface habitat only. In fact, we made clear in the proposed rule that these populations need access to subsurface habitat. In addition, we also considered the morphology of these species in our description of their habitat use. The morphology of the Georgetown salamander and Salado salamanders serve as indicators of surface and subsurface habitat use. The Georgetown salamander surface populations have large, well-developed eyes. In addition, the Georgetown salamander has yellowish-orange tails, bright-red gills, and varying patterns of melanophores. The subterranean populations of the Georgetown salamander have reduced eyes and dullness of color, indicating adaptation to subsurface habitat. The Salado salamander has reduced eyes and lacks well-defined melanophores in comparison to other surface-dwelling *Eurycea.* However, they do possess developed eyes and some pigmentation, indicating some use of surface habitat.

(57) *Comment:* There may be uncertainty as to the number of Salado salamander populations, and how prolific the subsurface populations are. However, it is apparent that the species has historically been and currently is extremely difficult to observe and collect during low to average spring flows at the Salado Springs complex and more abundant and readily observable during above-average spring flows at the Salado Springs complex. The exception has been the spring outlets located in the Edwards outcrop upstream of the Salado Springs complex, where the salamander has been observed regularly during below-average spring flow. The consistency in observations from species surveys over the past 60 or more years is important: they do not reflect a trend downward in species population.

Our Response: We agree that the available data on Salado salamander observations do not reflect a declining trend over time. However, these data are also neither quantitative nor consistent enough to conclude that any Salado salamander population has been stable over time. The fact that Salado salamanders are rarely found at sites near the Village of Salado during periods of low flow suggests that this species is sensitive to threats such as drought and urbanization, as has been demonstrated for several closely related salamander species.

Threats

(58) *Comment:* The Service appears reluctant to distinguish between what are normal, baseline physical conditions (climate, geology, and hydrology) found in central Texas and those factors outside of the norm that might actually threaten the survival of the salamander species. Cyclical droughts and regular flood events are part of the normal central Texas climate and have been for thousands of years. The Service appears very tentative about accepting the obvious adaptive behaviors of the salamanders to survive floods and droughts.

Our Response: The final listing rule acknowledges that drought conditions are common to the region, and the ability to retreat underground may be an evolutionary adaptation to such natural conditions (Bendik 2011a, pp. 31–32). However, it is important to note that although salamanders may survive a drought by retreating underground, this does not necessarily mean they are resilient to future worsening drought conditions in combination with other environmental stressors. For example, climate change, groundwater pumping, decreased water infiltration to the aquifer, potential increases in saline water encroachments in the aquifer, and increased competition for spaces and resources underground all may negatively affect their habitat (COA 2006, pp. 46–47; TPWD 2011, pp. 4–5; Bendik 2011a, p. 31; Miller *et al.* 2007; p. 74; Schueler 1991, p. 114). These factors may exacerbate drought conditions to the point where salamanders cannot survive. In addition, we recognize threats to surface habitat at a given site may not extirpate populations of these salamander species in the short term, but this type of habitat degradation may severely limit population growth and increase a population's overall risk of extirpation from cumulative impacts of other stressors occurring in the surface watershed of a spring.

(59) *Comment:* There is no proof that Salado salamanders surfacing from the aquifer after spending lengthy periods subsurface are emaciated, or otherwise in a weakened state, or that they were unable to reproduce.

Our Response: No studies have examined the biological effects of drought on Salado salamanders. However, a study on the closely related Jollyville Plateau salamander has documented decreases in body length following periods of drought (Bendik and Gluesenkamp 2013, pp. 3–4). In the absence of species-specific information, we conclude that the Salado salamander responds to drought in a similar way.

(60) *Comment:* In the proposed rule, the Service states that ''Central Texas salamanders are particularly vulnerable to contaminants, because they have evolved under very stable environmental conditions.'' The cycle of droughts and pulse rain events is certainly not a stable environmental condition. Drought is a stressor on all life forms in central Texas and necessitates species adaptability to survive.

Our Response: This statement in the proposed rule refers to the presence of contaminants in the salamanders' habitat, not the occurrence of drought. Contaminants are a relatively new stressor for these species that has been introduced by human activity.

(61) *Comment:* The watershed recharging the Salado salamander occupied springs is largely undeveloped and little urbanization is occurring. There is no evidence that rapid urbanization is likely to occur in the foreseeable future in these watersheds due to lack of infrastructure. The population estimates in the proposed rule are based on countywide figures for Bell and Williamson Counties. Countywide figures grossly overstate the amount of population growth occurring in these specific watersheds. This can be confirmed by a review of census tracts data. Likewise, a significant portion of northwestern Williamson County outside of the jurisdiction of the main cities is undeveloped and lacking in available utilities to support dense development.

Our Response: The proposed rule cites projected population growth and expected increases in demand for residential development, groundwater pumping, infrastructure, and other municipal services as a threat to the species throughout the Edwards Aquifer, including areas of Williamson and Bell Counties in the Northern Segment of the Aquifer. The estimates of growth came from multiple sources, including the Texas Water Development Board, the U.S. Census Bureau, and the Texas State Data Center. We are not aware of census tract data that project future populations at a scale lower than the county level. We maintain our conclusion that the Georgetown and Salado salamanders warrant listing partly due to projected human growth throughout their range.

(62) *Comment:* The average annual low flow of the Salado Springs complex was approximately 4.6 cubic feet per second (cfs), which occurred during the extreme drought in the mid-1950s. The low-end annual average range of spring flows from late 2011 to date exceeds and is nearly double that of the 4.6 cfs benchmark, even though the south central Texas region has been experiencing one of the worst droughts in recorded history. Clearwater Underground Water Conservation District's (CUWCD) records reflect that pumping from the Edwards aquifer within Bell County during the summer months actually decreased from 2011 to 2012 to 2013, which we believe is attributable to implementation of the drought management program. Thus, it is apparent that drought conditions, rather than some human agency, are responsible for low spring flows and that, possibly, groundwater district regulation of pumping could be having a positive effect on flows during the 2011 to 2013 drought conditions.

Our Response: We acknowledge that drought has likely influenced spring flow for Salado salamander habitat more than groundwater pumping. Under Factor D of the final listing rule, we also acknowledge the water quantity protections afforded to Salado salamander habitat by the CUWCD. However, even under these protections, springs occupied by Salado salamanders are known to go dry for periods of time. The Service recognizes the desired future condition adopted by the CUWCD as a valuable tool for protecting groundwater; however, it is not adequate to ensure spring flow at all sites occupied by the Salado salamander.

(63) *Comment:* In regards to the Salado salamander, threats under Factor A are excessively vague and rest on certain assumptions which are clearly false. The Salado salamander has been found in springs in several locations and likely exists at others and the proposed designation of critical habitat treats every location where *Eurycea* has been identified the same. In fact, while the hydrogeologic context is generally consistent across the region, specific structural features may vary widely from one location to the next, so protective measures appropriate for one location may not be appropriate elsewhere. We can divide the springs into two basic types: (1) The Village of Salado springs, which represent the

ultimate outflow from the system as a whole, and (2) numerous lesser springs occurring at various locations up in the recharge (outcrop) zone. In either case, the springs are found in areas where extensive, structural disturbance is unlikely and where no identifiable threats related to possible changes in land use are anticipated at this time.

Because the major spring flows are moving through confined segments, bounded on their upper limit by an impervious unit, they are effectively insulated and protected from infiltration in the near vicinity of the springs. This is supported by the discussion of water temperature presented in the recently released TPWD report, A Biological and Hydrological Assessment of the Salado Springs Complex, Bell County, Texas, August 2012. Normal human activities, including typical construction, in near proximity to the springs, present little threat to the aquifer or the outflow from it. Further, the surrounding area has been fully developed for over 150 years. The lesser springs up in the recharge zone enjoy certain protections as well. Without exception, these are located in undeveloped settings that may be described as pristine. Specifically, the springs where the Salado salamander has been found are on a single, award-winning ranch, which constitutes one of the largest single land holdings in Bell County. The owners of this property have been widely recognized for their committed stewardship of the land. The ranch is operated under a management model that emphasizes low-impact grazing and recreational hunting. Habitat preservation and improvement are central components in this management model.

Our Response: While it is possible that Salado salamanders exist at other unknown spring locations, our evaluation of the status of the species is limited to sites known to be occupied by the species at the time of the proposed listing. We agree that many site-specific variables affect both the degree of threat and potential for habitat modification at springs occupied by Salado salamanders, including land ownership, land uses in the immediate watershed, land uses in recharge areas, spring flow, level of recreation and physical disturbance, water quality, and other factors. Although we recognize the level of threat will vary across the range of the species, and recognize the strong stewardship of many landowners, we conclude that Factor A is neither vague nor based on false assumptions due to documented modifications to habitat within the very restricted range of the Salado salamander. Although construction near spring outlets may have relatively little impact on the entire aquifer, this type of development may likely have large impacts on the surface habitat of the spring. The springs within the Village of Salado have had heavy modification of the surface habitat, as described under Factor A of the proposed rule. Despite numerous field surveys over the last decade, Salado salamanders in many springs near well-developed areas, such as Big Boiling Spring, are rarely found. We consider habitat modification a significant threat, both now and in the future, due to projected growth, current land use practices, threats to water quality and quantity, as well as historical and ongoing physical disturbance to spring habitat.

(64) *Comment:* Through measuring water-borne stress hormones, researchers found that salamanders from urban sites had significantly higher corticosterone stress hormone levels than salamanders from rural sites. This finding serves as evidence that chronic stress can occur as development encroaches upon these spring habitats.

Our Response: We are aware that researchers are pursuing this relatively new approach to evaluate salamander health based on differences in stress hormones between salamanders from urban and non-urban sites. Stress levels that are elevated due to natural or unnatural (that is, anthropogenic) environmental stressors can affect an organism's ability to meet its life-history requirements, including adequate foraging, predator avoidance, and reproductive success. We encourage continued development of this and other non-lethal scientific methods to improve our understanding of salamander health and habitat quality.

(65) *Comment:* Information in the proposed rule does not discern whether water quality degradation is due to development or natural variation in flood and rainfall events. Fundamental differences in surface counts of salamanders between sites are due to a natural dynamic of an extended period of above-average rainfall followed by recent drought.

Our Response: We recognize that aquatic-dependent organisms such as the Georgetown and Salado salamanders will respond to local weather conditions; however, the best available science indicates that rainfall alone does not explain lower salamander densities at urban sites monitored by the COA. Furthermore, there is scientific consensus among numerous studies on the impacts of urbanization that conclude species diversity and abundance consistently declines with increasing levels of development, as described under Factor A in the final listing rule.

(66) *Comment:* Studies carried out by the Williamson County Conservation Foundation (WCCF) do not support the Service's assertions that habitat for the salamanders is threatened by declining water quality and quantity. New information from water quality studies performed at nine Georgetown and Jollyville Plateau salamander sites indicate that aquifer water is remarkably clean and that water quality protection standards already in place throughout the county are working.

Our Response: The listing process requires the Service to consider both ongoing and future threats to the species. Williamson County has yet to experience the same level of population growth as Travis County, but is projected to have continued rapid growth in the future. Therefore, it is not surprising that some areas of Williamson County may exhibit good water quality, because threats to the Georgetown salamander or its habitat are primarily from future development. However, our peer reviewers concluded that the water quality data referenced by the commenter is not enough evidence to conclude that water quality at salamander sites in Williamson County is sufficient (see Comment 19 above). To fully assess the status of salamander populations and water quality requires long-term monitoring data. The water samples collected by the WCCF were comprised of a single sample event consisting of grab samples, so they offer limited insight into long-term trends in water quality (see Comment 19 above). The best available science indicates that water quality and species diversity consistently declines with increasing levels of urban development.

Hydrology

(67) *Comment:* The Service homogenizes ecosystem characteristics across the Austin blind, Georgetown, Jollyville Plateau, and Salado salamanders. The proposed rule often assumes that the ''surface habitat'' characteristics of the Barton Springs salamander and Austin blind salamander (year-round surface water in manmade impoundments) apply to the Salado, Jollyville Plateau, and Georgetown salamanders, which live in very different geologic and hydrologic habitat. The Georgetown and Salado salamanders live in water contained within a ''perched'' zone of the Edwards Limestone formation that is relatively thin and does not retain or recharge much water when compared to the Barton Springs segment of the Edwards Aquifer. Many of the springs where the

Georgetown and Salado salamanders are found are more ephemeral due to the relatively small drainage basins and relatively quick discharge of surplus groundwater after a rainfall event. Surface water at several of the proposed creek headwater critical habitat units is generally short lived following a rain event. The persistence of Jollyville Plateau, Georgetown, and Salado salamanders at these headwater locations demonstrates that the species are not as dependent on surface water as occupied impoundments suggest.

Our Response: The Service recognizes that the Austin blind salamander is more subterranean than the other three species of salamander. However, the Georgetown, Jollyville Plateau, and Salado salamanders all spend large portions of their lives in subterranean habitat. Further, the Jollyville Plateau and Georgetown salamanders have cave-associated forms. There are numerous similarities among all four of these species. On page 50770 of the proposed rule, the similarities of these four salamander species are specified. They are all within the same genus, entirely aquatic throughout each portion of their life cycles, respire through gills, inhabit water of high quality with a narrow range of conditions, depend on water from the Edwards Aquifer, and have similar predators. The Barton Springs salamander shares these same similarities. Based on this information, the Service has determined that these species are suitable surrogates for each other.

Exactly how much these species depend on surface water is unclear, but the best available information suggests that the productivity of surface habitat is important for individual growth. For example, a recent study showed that Jollyville Plateau salamanders had negative growth in body length and tail width while using subsurface habitat during a drought and that growth did not become positive until surface flow returned (Bendik and Gluesenkamp 2012, pp. 3–4). In addition, the morphological variation found in these salamander populations may provide insight into how much time is spent in subsurface habitat compared to surface habitat.

(68) *Comment:* Another commenter stated that salamander use of surface habitat is entirely dependent on rainfall events large enough to generate sufficient spring and stream flow. Even after large rainfall events, stream flow decreases quickly and dissipates within days. As a result, the salamanders are predominately underground species because groundwater is far more abundant and sustainable.

Our Response: See our response to previous comment above.

(69) *Comment:* Several commenters stated that there is insufficient data on long-term flow patterns of the springs and creek and on the correlation of flow, water quality, habitat, ecology, and community response to make a listing determination. Commenters propose that additional studies be conducted to evaluate hydrology and surface recharge area, and water quality.

Our Response: We agree that there is a need for more study on the hydrology of salamander sites, but there are sufficient available data on the threats to these species to make a listing determination. We make our listing determinations based on the five listing factors, singly or in combination, as described in section 4(a)(1) of the Act. In making our listing determination, we considered and evaluated the best available scientific and commercial information.

Pesticides

(70) *Comment:* Claims of pesticides posing a significant threat are unsubstantiated. The references cited in the proposed rule are in some cases misquoted and others are refuted by more robust analysis. The water quality monitoring reports, as noted in the proposed rule, indicate that pesticides were found at levels below criteria set in the aquatic life protection section of the Texas Surface Water Quality Standards, and they were most often at sites with urban or partly urban watersheds. This information conflicts with the statement that the frequency and duration of exposure to harmful levels of pesticides have been largely unknown or undocumented.

Our Response: We recognize there are uncertainties about the degree to which different pesticides may be impacting water quality and salamander health across the range of these salamander species, but the very nature of pesticides being designed to control unwanted organisms through toxicological mechanisms and their persistence in the environment makes them pose an inherent risk to non-target species. Numerous studies have documented the presence of pesticides in water, particularly areas impacted by urbanization and agriculture, and there is ample evidence that full life cycle and multigenerational exposures to dozens of chemicals, even at low concentrations, contribute to declines in the abundance and diversity of aquatic species. Few pesticides or their breakdown products have been tested for multigenerational effects to amphibians and many do not have an applicable state or Federal water quality standard. For these reasons, we maintain that commercial and residential pesticide use contributes to habitat degradation and poses a threat to the Georgetown and Salado salamanders, as well as the aquatic organisms that comprise their diet.

(71) *Comment:* The Service cites Rohr *et al.* (2003, p. 2,391) indicating that carbaryl causes mortalities and deformities in streamside salamanders (*Ambystoma barbouri*). However, Rohr *et al.* (2003, p. 2,391) actually found that larval survival was reduced by the highest concentrations of carbaryl tested (50 µg/L) over a 37-day exposure period. Rohr *et al.* (2003, p. 2,391) also found that embryo survival and growth was not affected, and hatching was not delayed in the 37 days of carbaryl exposure. In the same study, exposure to 400 µg/L of atrazine over 37 days (the highest dose tested) had no effect on larval or embryo survival, hatching, or growth. A Scientific Advisory Panel (SAP) of the Environmental Protection Agency (EPA) reviewed available information regarding atrazine effects on amphibians, including the Hayes (2002) study cited by the Service, and concluded that atrazine appeared to have no effect on clawed frog (*Xenopus laevis*) development at atrazine concentrations ranging from 0.01 to 100 µg/L. These studies do not support the Service's conclusions.

Our Response: We do not believe that our characterization of Rohr *et al.* (2003) misrepresented the results of the study. In their conclusions, Rohr *et al.* (2003, p. 2,391) state, ''Carbaryl caused significant larval mortality at the highest concentration, and produced the greatest percent of malformed larvae, but did not significantly affect behavior relative to controls. Although atrazine did not induce significant mortality, it did seem to affect motor function.'' This study clearly demonstrates that these two pesticides can have an impact on amphibian biology and behavior. In addition, the EPA (2007, p. 9) also found that carbaryl is likely to adversely affect the Barton Springs salamander both directly and indirectly through reduction of prey.

Regarding the Hayes (2002) study, we acknowledge that an SAP of the EPA reviewed this information and concluded that atrazine concentrations less than 100 µg/L had no effects on clawed frogs in 2007. However, the 2012 SAP did re-examine the conclusions of the 2007 SAP using a meta-analysis of published studies along with additional studies on more species (EPA 2012, p. 35). The 2012 SAP expressed concern that some studies were discounted in the 2007 SAP analysis, including studies like Hayes (2002) that indicated that atrazine is linked to endocrine disruption in amphibians (EPA 2012, p. 35). In addition, the 2007 SAP noted that their results on clawed frogs are insufficient to make global conclusions about the effects of atrazine on all amphibian species (EPA 2012, p. 33). Accordingly, the 2012 SAP has recommended further testing on at least three amphibian species before a conclusion can be reached that atrazine has no effect on amphibians at concentrations less than 100 μg/L (EPA 2012, p. 33). Due to potential differences in species sensitivity, exposure scenarios that may include dozens of chemical stressors simultaneously, and multigenerational effects that are not fully understood, we continue to view pesticides in general, including carbaryl, atrazine, and many others to which aquatic organisms may be exposed, as a potential threat to water quality, salamander health, and the health of aquatic organisms that comprise the diet of salamanders.

Impervious Cover

(72) *Comment:* One commenter stated that in the draft impervious cover analysis the Service has provided no data to prove a cause and effect relationship between impervious cover and the status of surface salamander sites or the status of underground habitat.

Our Response: Peer reviewers agreed that we used the best available scientific information in regards to the link between urbanization, impervious cover, water quality, and salamander populations.

(73) *Comment:* On page 18 of the draft impervious cover analysis, the Service dismisses the role and effectiveness of water quality controls to mitigate the effects of impervious cover: ''. . . the effectiveness of stormwater runoff measures, such as passive filtering systems, is largely unknown in terms of mitigating the effects of watershed-scale urbanization.'' It appears that the Service assumed that existing water controls have no effect in reducing or removing pollutants from stormwater runoff. The Service recognized the effectiveness of such stormwater runoff measures in the final rule listing the Barton Springs salamander as endangered in 1997. Since 1997, the Service has separately concurred on two occasions that the water quality controls imposed in the Edwards Aquifer area protect the Barton Springs salamander and the Georgetown salamander. It is not appropriate to rely upon generalized findings regarding the detectability of water quality degradation in watersheds with no water quality controls.

Our Response: Our analysis within this final rule does not ignore the effectiveness of water quality control measures. In fact, we specifically address how these control measures factor into our analysis under Factor D. We recognize that control measures can reduce pollution entering bodies of water. However, as presented in our final impervious cover analysis, data from around the country indicate that urbanization within the watershed degrades water quality despite the presence of water quality control measures that have been in place for decades (Schueler *et al.* 2009, p. 313). Since 1997, water quality and salamander counts have declined at several salamander sites within the City of Austin, as described under Factor A in this final listing rule. This is in spite of water quality control measures implemented in the Edwards Aquifer area. Further discussion of these measures can be found under Factor D of this final listing rule.

(74) *Comment:* The springshed, as defined in the draft impervious cover analysis, is a misnomer because the so called springsheds delineated in the study are not the contributing or recharge area for the studied springs. Calling a surface area that drains to a specific stretch of a creek a springshed is disingenuous and probably misleading to less informed readers.

Our Response: We acknowledge that the term springshed may be confusing to readers, and we have thus replaced this term with the descriptors ''surface drainage area of a spring'' or ''surface watershed of a spring'' throughout this final listing rule and impervious cover analysis document.

(75) *Comment:* During the first public comment period, many entities submitted comments and information directing the Service's attention to the actual data on water quality in the affected creeks and springs. Given the amount of water quality data available to the Service and the public, the Texas Salamander Coalition is concerned that the Service continues to ignore local data and instead focuses on impervious cover and impervious cover studies conducted in other parts of the country without regard to existing water quality regulations. Commenters questioned why the Service sued models, generic data, and concepts when actual data on the area of concern is readily available.

Our Response: The Service has examined and incorporated all water quality data submitted during the public comment periods. However, the vast majority of salamander sites are still lacking long-term monitoring data that are necessary to make conclusions on the status of the site's water quality. The impervious cover analysis allows us to quantify this specific threat for sites where information is lacking.

Disease

(76) *Comment:* The Service concludes in the proposed rule that chytrid fungus is not a threat to any of the salamanders. The Service's justification for this conclusion is that they have no data to indicate whether impacts from this disease may increase or decrease in the future. There appears to be inconsistency in how the information regarding threats is used.

Our Response: Threats are assessed by their imminence and magnitude. Currently, we have no data to indicate that chytrid fungus is a threat to the species. The few studies that have looked for chytrid fungus in central Texas *Eurycea* found the fungus, but no associated pathology was found within several populations and among different salamander species.

Climate Change

(77) *Comment:* Climate change has already increased the intensity and frequency of extreme rainfall events globally (numerous references) and in central Texas. This increase in rainfall extremes means more runoff possibly overwhelming the capacity of recharge features. This has implications for water storage. Implications are that the number of runoff events recharging the aquifer with a higher concentration of toxic pollutants than past events will be occurring more frequently, likely in an aquifer with a lower overall volume of water to dilute pollutants. Understanding high concentration toxicity needs to be evaluated in light of this.

Our Response: We agree that climate change will likely result in less frequent recharge, affecting both water quantity and quality of springs throughout the aquifer. We have added language in the final listing rule to further describe the threat of climate change and impacts to water quality.

(78) *Comment:* The section of the proposed rule addressing climate change fails to include any consideration or description of a baseline central Texas climate. The proposed rule describes flooding and drought as threats, but fails to provide any serious contextual analysis of the role of droughts and floods in the life history of the central Texas salamanders.

Our Response: The proposed and final listing rules discuss the threats of drought conditions and flooding, both in the context of naturally occurring weather patterns and as a result of anthropogenic activities.

(79) *Comment:* The flooding analysis is one of several examples in the proposed rule in which the Service cites events measured on micro-scales of time and area, and fails to comprehend the larger ecosystem at work. For example, the proposed rule describes one flood event causing ''erosion, scouring the streambed channel, the loss of large rocks, and creation of several deep pools.'' Later, the Service describes other flooding events as depositing sediment and other materials on spring openings at Salado Spring (page 50788). Scouring and depositing sediment are both normal results of the intense rainfall events in central Texas.

Our Response: While we agree that scouring and sediment deposition are normal hydrologic processes, when the frequency and intensity of these events is altered by climate change, urbanization, or other anthropogenic forces, the resulting impacts to ecosystems can be more detrimental than what would occur naturally.

Other Threats

(80) *Comment:* The risk of extinction is negatively or inversely correlated with population size. Also, small population size, in and of itself, can increase the risk of extinction due to demographic stochasticity, mutation accumulation, and genetic drift. The correlation between extinction risk and population size is not necessarily indirect (that is, due to an additional extrinsic factor such as environmental perturbation).

Our Response: Although we do not consider small population sizes to be a threat in and of itself to either the Georgetown or Salado salamander, we do conclude that small population sizes make them more vulnerable to extinction from other existing or potential threats, such as major stochastic events.

Water Quality

(81) *Comment:* The City of Georgetown's Unified Development Code requires that all development in this territory, including projects less than 1 ac (0.4 ha), must meet all requirements of the TCEQ for water quality. For commercial sites, the City of Georgetown's Unified Development Code allows a maximum of 70 percent impervious cover for tracts less than 5 ac (2 ha). For tracts greater than 5 ac (2 ha), the Unified Development Code allows 70 percent impervious cover for the first 5 ac (2 ha), and then 55 percent impervious cover over the initial 5 ac (2 ha). The Unified Development Code also allows the area above the initial 5 ac (2 ha) to be upgraded to 70 percent impervious with advanced water quality. The required advanced water-quality systems are retention irrigation, removing 100 percent of the suspended solids; wet ponds, removing 93 percent suspended solids; or bioretention facilities, removing 89 percent suspended solids. For residential projects, the City of Georgetown's Unified Development Code allows a maximum of 45 percent impervious cover.

Our Response: We recognize and agree that best management practices, such as the development codes mentioned by the commenter, provide some protection to water quality. However the protections are not effective in alleviating all the threat of degraded water quality for any of the salamanders. On-site retention of storm flows and other regulatory mechanisms to protect water quality are beneficial and work well to remove certain types of pollutants such as total dissolved solids, but in most cases, habitat quality in urban environments still degrades over time due to persistent pollutants like trace metals and pesticides that can accumulate in sediments and biological tissues.

(82) *Comment:* The Service should have consulted with those federal and state agencies that are charged with protecting water quality and that have the expertise to address water quality issues. The EPA, TCEQ, and the USGS are experts on the reliability of the water quality studies cited by the Service in its determination that water quality in central Texas continues to decline.

Our Response: We notified and invited the EPA, TCEQ, and USGS to comment on our proposed rule and provide any data on water quality within the range of the salamander species. Two USGS biologists provided peer reviews on our proposed rule, and we cited numerous studies from the EPA, TCEQ, and USGS in our final analysis.

Taxonomy

(83) *Comment:* The level of genetic divergence among the Jollyville Plateau, Georgetown, and Salado salamanders is not sufficiently large to justify recognition of three species. The DNA papers indicate a strong genetic relationship between individual salamanders found across the area. Such a strong relationship necessarily means that on an ecosystem wide basis, the salamanders are exchanging genetic material on a regular basis. There is no evidence that any of these salamanders are unique species.

Our Response: The genetic relatedness of the three northern species (Georgetown salamander, Jollyville Plateau salamander, and Salado salamanders) is not disputed. The three species are included together on a main branch of the tree diagrams of mtDNA data (Chippindale *et al.* 2000, Figs. 4 and 6). The tree portraying relationships based on allozymes (genetic markers based on differences in proteins coded by genes) is concordant with the mtDNA trees (Chippindale *et al.* 2000, Fig. 5). These trees support the evolutionary relatedness of the three species, but not their identity as a single species. The lack of sharing of mtDNA haplotype markers, existence of unique allozyme alleles in each of the three species, and multiple morphological characters diagnostic of each of the three species are inconsistent with the assertion that they are exchanging genetic material on a regular basis. The Austin blind salamander is on an entirely different branch of the tree portraying genetic relationships among these species based on mtDNA, and has diagnostic, morphological characters that distinguish it from other Texas salamanders (Hillis *et al.* 2001, p. 267). Based on our review of these differences, and taking into account the view expressed in peer reviews by taxonomists, we conclude that the currently available evidence is sufficient for recognizing these salamanders as four separate species.

(84) *Comment:* A genetics professor commented that Forstner's report (2012) disputing the taxonomy of the four central Texas salamanders represents a highly flawed analysis that has not undergone peer review. It is not a true taxonomic analysis of the *Eurycea* complex and does not present any evidence that call into question the current taxonomy of the salamanders. Forstner's (2012) report is lacking key information regarding exact methodology and analysis. It is not entirely clear what resulting length of base pairs was used in the phylogenetic analysis and the extent to which the data set was supplemented with missing or ambiguous data. The amount of sequence data versus missing data is important for understanding and interpreting the subsequent analysis. It also appears as though Forstner included all individuals with available, unique sequence when, in fact, taxonomic sampling—that is, the number of individuals sampled within a particular taxon compared with other taxa—can also affect the accuracy of the resulting topology. The Forstner (2012)

report only relies on mitochondrial DNA whereas the original taxonomic descriptions of these species relied on a combination of nuclear DNA, mitochondrial DNA as well as morphology (Chippindale *et al.* 2000, Hillis *et al.* 2001). Forstner's (2012) report does not consider non-genetic factors such as ecology and morphology when evaluating taxonomic differences. Despite the limitations of a mitochondrial DNA-only analysis, Forstner's (2012) report actually contradicts an earlier report by the same author that also relied only on mtDNA.

Our Response: This comment supports the Service's and our peer reviewers' interpretation of the best available data (see responses to comments 1 through 6 above).

(85) *Comment:* Forstner (2012) argues that the level of genetic divergence among the three species of Texas *Eurycea* is not sufficiently large to justify recognition of three species. A genetics professor commented that this conclusion is overly simplistic. It is not clear that the populations currently called *Eurycea lucifuga* in reality represent a single species, as Forstner (2012) assumes. Almost all cases of new species in the United States for the last 20 years (*E. waterlooensis* is a rare exception) have resulted from DNA techniques used to identify new species that are cryptic, meaning their similarity obscured the genetic distinctiveness of the species. One could view the data on *Eurycea lucifuga* as supporting that cryptic species are also present. Moreover, Forstner's (2012) comparison was made to only one species, rather than to salamanders generally. Moreover, there is perhaps a problem with the Harlan and Zigler (2009) data. They sequenced 10 specimens of *E. lucifuga,* all from Franklin County, Tennessee; 9 of these show genetic distances between each other from 0.1 to 0.3 percent, which is very low. One specimen shows genetic distance to all other nine individuals from 1.7 to 1.9 percent, an order of magnitude higher. This single specimen is what causes the high level of genetic divergence to which Forstner compares the *Eurycea.* This discrepancy is extremely obvious in the Harlan and Zigler (2009) paper, but was not mentioned by Forstner (2012). A difference of an order of magnitude in 1 specimen of 10 is highly suspect, and, therefore, these data should not be used as a benchmark in comparing *Eurycea.*

The second argument in Forstner (2012) is that the phylogenetic tree does not group all individuals of a given species into the same cluster or lineage. Forstner's (2012) conclusions are overly simplistic. The failure of all sequences of *Eurycea tonkawae* to cluster closely with each other is due to the amount of missing data in some sequences. It is well known in the phylogenetics literature that analyzing sequences with very different data (in other words, large amounts of missing data) will produce incorrect results because of this artifact. As an aside, why is there missing data? The reason is that these data were produced roughly 5 years apart. The shorter sequences were made at a time when lengths of 350 bases for cytochrome b were standard because of the limitations of the technology. As improved and cheaper methods were available (about 5 to 6 years later), it became possible to collect sequences that were typically 1,000 to 1,100 bases long. It is important to remember that the data used to support the original description of the three northern species by Chippindale *et al.* (2000) were not only cytochrome b sequences, but also data from a different, but effective, analysis of other genes, as well as analysis of external characteristics. Forstner's (2012) assessment of the taxonomic status (species or not) of the three species of the northern group is not supported by the purported evidence that he presents (much of it unpublished).

Our Response: This comment supports the Service's and our peer reviewers' interpretation of the best available data (see Responses to Comments 1 through 5 above)

(86) *Comment:* Until the scientific community determines the appropriate systematic approach to identify the number of species, it seems imprudent to elevate the salamanders to endangered.

Our Response: The Service must base its listing determinations on the best available scientific and commercial information, and such information includes considerations of correct taxonomy. To ensure the appropriateness of our own analysis of the relevant taxonomic literature, we sought peer reviews from highly qualified taxonomists, particularly with specialization on salamander taxonomy, of our interpretation of the available taxonomic literature and unpublished reports. We find that careful analysis and peer review is the best way to determine whether any particular taxonomic arrangement is likely to be generally accepted by experts in the field. The peer reviews that we received provide overall support, based on the available information, for the species that we accept as valid in the final listing rule.

Technical Information

(87) *Comment:* The Service made the following statement in the proposed rule: ''Therefore, the status of subsurface populations is largely unknown, making it difficult to assess the effects of threats on the subsurface populations and their habitat.'' In fact, the difficulty of assessing threats for subsurface populations depends upon the threats. One can more easily assess threats of chemical pollutants, for example, because subterranean populations will be affected similarly to surface ones because they inhabit the same or similar water.

Our Response: The statement above was meant to demonstrate the problems associated with not knowing how many salamanders exist in subsurface habitat rather than how threats are identified. We have removed the statement in the final listing rule to eliminate this confusion.

City of Georgetown's Water Quality Ordinance

(88) *Comment:* Several comments supported the City of Georgetown's Edwards Aquifer Recharge Zone Water Quality Ordinance that was adopted by the Georgetown City Council on December 20, 2013. These commenters stated that regulations to protect the Georgetown salamander are better implemented at the local level compared to Federal regulations.

Our response: The Service appreciates the effort put forth by the City of Georgetown and Williamson County to help reduce threats to the Georgetown salamander through the implementation of their Edwards Aquifer Recharge Zone Water Quality Ordinance. Section 4(b)(1)(A) of the Act requires us to take into account those efforts being made by a state or foreign nation, or any political subdivision of a state or foreign nation, to protect such species. We also consider relevant Federal and tribal laws and regulations in our threats analysis. In our analysis, we consider whether or not existing regulatory mechanisms are adequate enough to address the threats to the species such that listing is no longer warranted. For further discussion of existing regulations and ordinances, please see Factors A and D below in this final listing rule.

(89) *Comment:* The combination of plans and promises put forward by the City of Georgetown lack any true staying power and their effectiveness seems largely up to the willingness of all interested parties to cooperate on a voluntary basis. Importantly, the rules and suggested development practices

laid out in the Edwards Aquifer Recharge Zone Water Quality Ordinance and Georgetown Water Quality Management Plan make little mention of the business of granting exceptions. The WCCF is a non-profit corporation with strong allies in for-profit corporations. It is entirely within the realm of reasonable possibility that trusting the front of the WCCF to guide city policy instead would mask a for-profit pro-development agenda. In fact, the City Ordinance 2013–59 makes explicit the City Council's priority ''[. . .] to ensure that future growth and development is unbridled by potential Federal oversight nor Federal permitting requirements that would delay development projects detrimentally to the sustained viability of the city's economy [. . .].'' In this area, I am most concerned such that the real ''teeth'' of the plans rests in the ability of the City of Georgetown to obtain and keep what is almost entirely voluntary compliance.

Our response: The City of Georgetown's Edwards Aquifer Recharge Zone Water Quality Ordinance was adopted by the Georgetown City Council on December 20, 2013, and became effective immediately. All regulated activities within the City of Georgetown and its extraterritorial jurisdiction (ETJ) located over the recharge zone are required to implement the protective measures established by the ordinance. Compliance with the ordinance is not voluntary. The ordinance also established an Adaptive Management Working Group to review Georgetown salamander monitoring data and new research over time and recommending improvements to the ordinance that may be necessary to ensure that it achieves its stated purposes. This Adaptive Management Working Group, which includes representatives of the Service and TPWD, will also review and make recommendations on the approval of any variances to the ordinance.

(90) *Comment:* Once the Federal government passes control to a local government entity, any protection provided to the salamander will eventually disappear.

Our response: The Service supports local involvement and interest in the conservation of salamanders. Section 4(b)(1)(A) of the Act requires us to take into account those efforts being made by a state or foreign nation, or any political subdivision of a state or foreign nation, to protect such species, and we fully recognize the contributions of local programs.

(91) *Comment:* Several commenters stated that the City of Georgetown ordinance does not fully alleviate known threats to the Georgetown salamander and will not significantly reduce its danger of extinction. They acknowledged that the ordinance could provide minor protections to certain aspects of water quality in the immediate vicinity of occupied spring sites, such as to decrease the probability of wholesale destruction by physical disturbance of occupied springs. But, the commenters stated that the ordinance would not protect the quantity of spring flows or threats to water quality from more distant points in the spring watersheds. Further, they noted that the ordinance does not address the threats from small population size, drought, or climate change.

(92) *Comment:* The buffer zones described in the ordinance lessen the potential for further water quality degradation, but they do not remove the threat posed by existing development. Four Georgetown salamander sites are located in areas where the impervious cover estimates exceed thresholds where harm to water quality is expected to occur. The threat of chemical spills from existing highways, sewer lines, and septic systems still exists. Existing development has already affected salamander habitat and degradation will continue with new development.

(93) *Comment:* The City of Austin Save Our Springs Ordinance is a non-degradation ordinance that requires 100 percent removal of total suspended solids (TSS). Despite this, the City of Austin rules were not sufficient to preclude the 2013 listing of the Austin Blind Salamander. Because it requires only 85 percent removal of TSS, the City of Georgetown's water quality ordinance is substantially less protection than the City of Austin's. Thus, it would be inconsistent for the Service to preclude listing of the Georgetown Salamander on this basis.

(94) *Comment:* The City of Georgetown ordinance does not specify a prohibition on sediment discharge during the critical ground-disturbing construction phase of new development, and no performance criteria for sediment removal are specified. Thus, the ordinance is insufficient to eliminate sedimentation of salamander habitat as a result of new development construction.

(95) *Comment:* In addition to the impacts from existing development that would continue under the Georgetown ordinance, projects that were platted or planned prior to the Georgetown ordinance would not be subject to the new ordinance as exempted under Chapter 245 ''grandfathering'' provisions of Texas State law. Five Georgetown salamander sites are exempt from the requirements of the Georgetown ordinance (Cowan Spring, Bat Well Cave, Water Tank Cave, Knight Spring, and Shadow Canyon Spring). The development near Shadow Canyon Spring is currently under consultation with the Service, while the four other sites are all compliant with the Red Zone as described in the ordinance. Because current TCEQ development regulations require removal of 80 percent TSS for every project within the recharge zone of the Edwards Aquifer as opposed to the 85 percent TSS removal required in the new ordinance, the overall effect on the water quality of the Edwards Aquifer from these four small sites is minimal.

(96) *Comment:* The Georgetown ordinance does not include impervious cover limitations in the upstream surface water or groundwater contributing areas to salamander habitat. The effectiveness and protectiveness of the flood and water quality controls included in the Georgetown ordinance decrease with increasing impervious cover.

(97) *Comment:* The City of Georgetown and Williamson County have continually demonstrated their ongoing commitment to establishing and implementing programs to preserve open space, protect species habitat and reduce dependence on groundwater water supplies. The success of these programs to protect endangered karst dwelling invertebrates and songbirds highlights the willingness and intention to implement and enforce the recently approved Georgetown salamander ordinances. The successful working relationship established between Williamson County and the Service also speaks to the likelihood of implementation. In addition, the City of Georgetown staffs a code enforcement division responsible for monitoring both public and private property, commercial and residential, to ensure compliance with all city codes and ordinances. The City of Georgetown has successfully implemented water quality regulations within its jurisdiction in the past.

(98) *Comment:* The certainty of effectiveness of the ordinance is increased by the formation of an Adaptive Management Working Group and an Adaptive Management Plan charged specifically with reviewing salamander monitoring data and new research over time and recommending improvements to the ordinance that may be necessary to ensure that it achieves its stated purposes. This Adaptive Management Working Group, which includes representatives of the Service and TPWD, will also review and make

recommendations on the approval of any variances to the ordinance.

Our response to Comments 91–98: The Service has analyzed the effect of the ordinance on the threats identified below under *Summary of Factors Affecting the Species* and have made a determination as to whether or not the regulatory mechanism (City of Georgetown ordinance) has reduced the threats to the point that listing the species as threatened or endangered under the Act is no longer warranted.

(99) *Comment:* The Red Zone buffer should extend past culverts and roadways because these are not documented impediments to salamander migration.

Our response: The ordinance specifically states that the Red Zone ''. . . shall not extend beyond any existing physical obstructions that prevent the surface movement of Georgetown salamanders . . .'' Therefore, the Service believes that any physical obstructions that do not prevent the surface movement of salamanders would not be included as limiting the size of the Red Zone.

(100) *Comment:* Development activities within the contributing area of the spring outside of the 984-ft (300-m) buffer of the Orange Zone would still affect the quality and quantity of spring discharge.

Our response: The Service agrees that some activities occurring further than 984 ft (300 m) from a spring site could have the potential to impact the quality and quantity of spring discharge. However, overall, we believe that the ordinance has minimized and reduced some of the threats to the Georgetown salamander. See the discussion below under *Summary of Factors Affecting the Species.*

(101) *Comment:* While the City of Georgetown has expressed its intention to rely upon surface water or wells outside the Edwards Aquifer for additional future water supplies, these intentions are purely voluntary and cannot be considered sufficient to remove the threat of inadequate spring flows.

Our response: The Service does not consider the City of Georgetown's intention to rely upon surface water or wells outside the Edwards Aquifer sufficient to entirely remove the threat of inadequate spring flows.

Summary of Changes From the Proposed Rule

Based upon our review of the public comments, comments from other Federal and State agencies, peer review comments, issues addressed at the public hearing, and any new relevant information that may have become available since the publication of the proposal, we reevaluated our proposed rule and made changes as appropriate. The Service has incorporated information related to the Edwards Aquifer Recharge Zone Water Quality Ordinance approved by the Georgetown City Council on December 20, 2013 (Ordinance No. 2013–59). The purpose of this ordinance is to reduce some of the threats to the Georgetown salamander within the City of Georgetown and its ETJ through the protection of water quality near occupied sites known at the time the ordinance was approved, enhancement of water quality protection throughout the Edwards Aquifer recharge zone, and establishment of protective buffers around all springs and streams. Additionally, an Adaptive Management Working Group has been established that is charged specifically with reviewing Georgetown salamander monitoring data and new research over time and recommending improvements to the ordinance that may be necessary to ensure that it achieves its stated purposes. This Adaptive Management Working Group, which includes representatives of the Service and TPWD, will also review and make recommendations on the approval of any variances to the ordinance.

During the two comment periods that were opened during the 6-month extension, the Service did not receive any additional information to assist us in making a conclusion regarding the population trends of either of these two species. However, a report submitted by the Williamson County Conservation Foundation noted that since April 2012 biologists have observed Georgetown salamanders at Swinbank Spring and Twin Springs (Pierce and McEntire 2013, p. 8). These two sites and one additional site (Cowan Spring) are the only Georgetown salamander locations for which population surveys have been conducted over multiple years. We are not aware of any population trend analysis that has been conducted for the Georgetown salamander. Dr. Toby Hibbits conducted surveys for the Salado salamander at nine different locations during the fall of 2013 and was unable to locate any salamanders. He concluded ''. . . even in the best conditions that Salado Salamanders are difficult to find and likely occupy the surface habitat in low numbers'' (Hibbits 2013, p. 3). Therefore, we are not making any conclusions related to the short- and long-term population trends of the Georgetown or Salado salamanders in this final rule.

Finally, in addition to minor clarifications and incorporation of additional information on the species' biology and related to the new Georgetown water quality ordinance, this determination differs from the proposal because, based on our analyses, the Service has determined that the Georgetown and Salado salamanders should be listed as threatened species instead of endangered species.

Summary of Factors Affecting the Species

Section 4 of the Act and its implementing regulations (50 CFR 424) set forth the procedures for adding species to the Federal Lists of Endangered and Threatened Wildlife and Plants. A species may be determined to be an endangered or threatened species due to one or more of the five factors described in section 4(a)(1) of the Act: (A) The present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting its continued existence. Listing actions may be warranted based on any of the above threat factors, singly or in combination. Each of these factors is discussed below.

In considering what factors might constitute threats, we must look beyond the mere exposure of the species to the factor to determine whether the species responds to the factor in a way that causes actual impacts to the species. If there is exposure to a factor, but no response, or only a positive response, that factor is not a threat. If there is exposure and the species responds negatively, the factor may be a threat and we then attempt to determine how significant a threat it is. If the threat is significant, it may drive or contribute to the risk of extinction of the species such that the species warrants listing as endangered or threatened as those terms are defined by the Act. This does not necessarily require empirical proof of a threat. The combination of exposure and some corroborating evidence of how the species is likely impacted could suffice. The mere identification of factors that could impact a species negatively is not sufficient to compel a finding that listing is appropriate; we require evidence that these factors are operative threats that act on the species to the point that the species meets the definition of an endangered or threatened species under the Act.

A. The Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range

Habitat modification, in the form of degraded water quality and quantity and disturbance of spring sites, is the primary threat to the Georgetown and Salado salamanders. Water quality degradation in salamander habitat has been cited in several studies as the top concern for closely related salamander species in the central Texas region (Chippindale *et al.* 2000, pp. 36, 40, 43; Hillis *et al.* 2001, p. 267; Bowles *et al.* 2006, pp. 118–119; O'Donnell *et al.* 2006, pp. 45–50). The Georgetown and Salado salamanders spend their entire life cycle in water. They have evolved under natural aquifer conditions both underground and as the water discharges from natural spring outlets. Deviations from high water quality and quantity have detrimental effects on salamander ecology because the aquatic habitat can be rendered unsuitable for salamanders by changes in water chemistry and flow patterns. Substrate modification is also a major concern for aquatic salamander species (City of Austin (COA) 2001, pp. 101, 126; Geismar 2005, p. 2; O'Donnell *et al.* 2006, p. 34). Unobstructed interstitial space is a critical component to the surface habitat for both the Georgetown and Salado salamander species, because it provides cover from predators and habitat for their macroinvertebrate prey items within surface sites. When the interstitial spaces become compacted or filled with fine sediment, the amount of available foraging habitat and protective cover for salamanders with these behaviors is reduced, resulting in population declines (Welsh and Ollivier 1998, p. 1,128; Geismar 2005, p. 2; O'Donnell *et al.* 2006, p. 34).

Threats to the habitat of the Georgetown and Salado salamanders (including those that affect water quality, water quantity, or the physical habitat) may affect only the surface habitat, only the subsurface habitat, or both habitat types. For example, substrate modification degrades the surface springs and spring-runs but does not impact the subsurface environment within the aquifer, while water quality degradation can impact both the surface and subsurface habitats, depending on whether the degrading elements are moving through groundwater or are running off the ground surface into a spring area (surface watershed). Our assessment of water quality threats from urbanization is largely focused on surface watersheds because of the limited information available on subsurface flows and drainage areas that feed into the spring and cave locations. An exception to this would be threats posed by chemical pollutants to water quality, which would negatively impact both surface and subsurface habitats. These recharge areas are additional pathways for impacts to the Georgetown and Salado salamanders to happen that we are not able to precisely assess at each known salamander site. However, we can consider urbanization and various other sources of impacts to water quality and quantity over the larger recharge zone to the aquifer (as opposed to individual springs) to assess the potential for impacts at salamander sites.

The threats under Factor A will be presented in reference to stressors and sources. We consider a stressor to be a physical, chemical, or biological alteration that can induce an adverse response from an individual salamander. These alterations can act directly on an individual or act indirectly on an individual through impacts to resources the species requires for feeding, breeding, or sheltering. A source is the origin from which the stressor (or alteration) arises. The majority of the discussion below under Factor A focuses on evaluating the nature and extent of stressors and their sources related to urbanization, the primary source of water quality degradation, within the ranges of the Georgetown and Salado salamander species. Additionally, other stressors causing habitat destruction and modification, including water quantity degradation and physical disturbance to surface habitat, will be addressed.

Throughout the threats discussion below, we have provided references to studies or other information available in our files that evaluate threats to the Georgetown and Salado salamanders that are occurring or are likely to occur in the future given the considerable human population growth that is projected for the areas known to be occupied by these species. Establishing causal relationships between environmental stressors and observed effects in organisms is difficult because there are no widely accepted and proven approaches for determining such relationships and because experimental studies (either in the laboratory or the field) on the effects of each stressor on a particular organism are rare.

In the field of aquatic ecotoxicology, it is common practice to apply the results of experiments on common species to other species that are of direct interest (Caro *et al.* 2005, p. 1,823). In addition, the field of conservation biology is increasingly relying on information about substitute species to predict how related species will respond to stressors (for example, see Caro *et al.* 2005 pp. 1,821–1,826; Wenger 2008, p. 1,565). In instances where information was not available for the Georgetown and Salado salamander specifically, we have provided references for studies conducted on similarly related species, such as the Jollyville Plateau salamander (*Eurycea tonkawae*) and Barton Springs salamander (*Eurycea sosorum*), which occur within the central Texas area, and other salamander species that occur in other parts of the United States. The similarities among these species may include: (1) A clear systematic (evolutionary) relationship (for example, members of the Family Plethodontidae); (2) shared life-history attributes (for example, the lack of metamorphosis into a terrestrial form); (3) similar morphology and physiology (for example, the lack of lungs for respiration and sensitivity to environmental conditions); (4) similar prey (for example, small invertebrate species); and (5) similar habitat and ecological requirements (for example, dependence on aquatic habitat in or near springs with a rocky or gravel substrate). Depending on the amount and variety of characteristics in which one salamander species can be analogous to another, we used these similarities as a basis to infer further parallels in how a species or population may respond or be affected by a particular source or stressor.

Water Quality Degradation

Urbanization

Urbanization is one of the most significant sources of water quality degradation that can reduce the survival of aquatic organisms, such as the Georgetown and Salado salamanders (Bowles *et al.* 2006, p. 119; Chippindale and Price 2005, pp. 196–197). Urban development leads to various stressors on spring systems, including increased frequency and magnitude of high flows in streams, increased sedimentation, increased contamination and toxicity, and changes in stream morphology and water chemistry (Coles *et al.* 2012, pp. 1–3, 24, 38, 50–51). Urbanization can also impact aquatic species by negatively affecting their invertebrate prey base (Coles *et al.* 2012, p. 4). Urbanization also increases the sources and risks of an acute or catastrophic contamination event, such as a leak from an underground storage tank or a hazardous materials spill on a highway.

Rapid human population growth is occurring within the ranges of the Georgetown and Salado salamanders.

The Georgetown salamander's range is located within an increasingly urbanized area of Williamson County, Texas (Figure 1). In 2010, the human population within the City of Georgetown's extraterritorial jurisdiction was 68,821 (City of Georgetown 2013, p. 3). By one estimate, this population is expected to exceed 225,000 by 2033 (City of Georgetown 2008, p. 3.5), which would be a 227 percent increase over a 23-year period. Another model projects that the City of Georgetown population will increase to 135,005 by 2030, a 96 percent increase over the 20-year period. The Texas State Data Center (2012, pp. 166–167) estimates an increase in human population in Williamson County from 422,679 in 2010, to 2,015,294 in 2050, exceeding the human population size of adjacent Travis County where the City of Austin metropolitan area is located. This would represent a 377 percent increase over a 40-year timeframe. Population projections from the Texas State Data Center (2012, p. 353) estimate that Bell County, where the Salado salamander occurs, will increase in population from 310,235 in 2010 to 707,840 in 2050, a 128 percent increase over the 40-year period. By comparison, the national United States' population is expected to increase from 310,233,000 in 2010 to 439,010,000 in 2050, which is about a 42 percent increase over the 40-year period (U.S. Census Bureau 2008, p. 1).

BILLING CODE: 4310–55–P

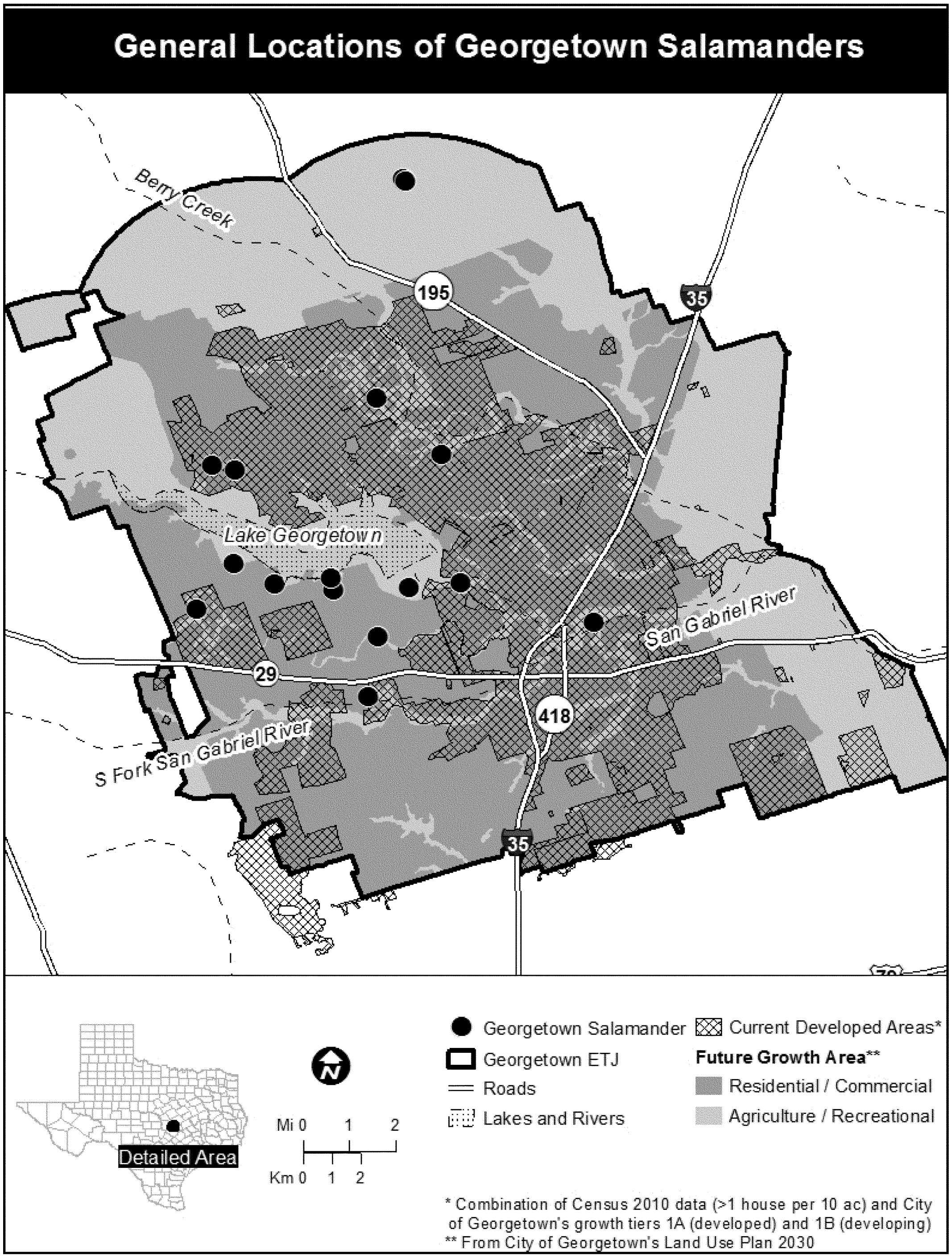

FIGURE 1: Urban development within the range of the Georgetown salamander.

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Growing human population sizes increase demand for residential and commercial development, drinking water supply, flood control, and other municipal foods and services that alter the environment, often degrading salamander habitat by changing hydrologic regimes and decreasing the quantity and quality of water resources (Coles *et al.* 2012, pp. 9–10). As development increases within the watersheds where the Georgetown and Salado salamanders occur, more opportunities exist for the detrimental effects of urbanization to impact salamander habitat without further conservation measures. A comprehensive study by the USGS found that across the United States contaminants, habitat destruction, and increasing stream flow flashiness (rapid response of large increases of stream flow to storm events) resulting from urban development have been associated with the disruption of biological communities, particularly the loss of sensitive aquatic species (Coles *et al.* 2012, p. 1).

Several researchers have examined the negative impact of urbanization on stream salamander habitat by making connections between salamander abundances and levels of development within the watershed. In a 1972 study on the dusky salamander (*Desmognathus fuscus*) in Georgia, Orser and Shure (p. 1,150) were among the first biologists to show a decrease in stream salamander density with increasing urban development. A similar relationship between salamander populations and urbanization was found in another study on the dusky salamander, two-lined salamander (*Eurycea bislineata*), southern two-lined salamander (*Eurycea cirrigera*), and other species in North Carolina (Price *et al.* 2006, pp. 437–439; Price *et al.* 2012a, p. 198), Maryland, and Virginia (Grant *et al.* 2009, pp. 1,372–1,375). Willson and Dorcas (2003, pp. 768–770) demonstrated the importance of examining disturbance within the entire watershed as opposed to areas just adjacent to the stream by showing that salamander abundance in the dusky and two-lined salamanders is most closely related to the amount and type of habitat within the entire watershed. In central Texas, Bowles *et al.* (2006, p. 117) found lower Jollyville Plateau salamander densities in tributaries with developed watersheds as compared to tributaries with undeveloped watersheds. Developed tributaries also had higher concentrations of chloride, magnesium, nitrate-nitrogen, potassium, sodium, and sulfate (Bowles *et al.* 2006, p. 117). Because of the similarities in size, morphology, habitat requirements, and life history traits shared with the dusky salamander, two-lined salamander, southern two-lined salamander, and Jollyville Plateau salamander, we expect development occurring within the Georgetown and Salado salamanders' watersheds to affect these species in a similar manner.

The impacts that result from urbanization can affect the physiology of individual salamanders. An unpublished study has demonstrated that Jollyville Plateau salamanders in disturbed habitats have greater stress levels than those in undisturbed habitats, as determined by measurements of water-borne stress hormones in urbanized (approximately 25 percent impervious cover within the watershed) and undisturbed streams (Gabor 2012, Texas State University, pers. comm.). Chronic stress can decrease survival of individuals and may lead to a decrease in reproduction. Both of these factors may partially account for the decrease in abundance of salamanders in streams within disturbed environments (Gabor 2012, Texas State University, pers. comm.). Because of the similarities in morphology, physiology, habitat requirements, and life history traits shared with the Jollyville Plateau salamander, we expect chronic stress in disturbed environments to decrease survival, reproduction, and abundance of Georgetown and Salado salamanders.

Urbanization occurring within the watersheds of the Georgetown and Salado salamanders has the potential to cause irreversible declines or extirpation of salamander populations with continuous exposure to its effects (such as, contaminants, changes in water chemistry, and changes in stream flow) over a relatively short time span. Although surface watersheds for the Georgetown and Salado salamander are not as developed as that of the Jollyville Plateau salamander at the present time, it is likely that impacts from this threat will increase in the future as urbanization expands within the surface watersheds for these species as well.

Impervious cover is another source of water quality degradation and is directly correlated with urbanization (Coles *et al.* 2012, p. 38). For this reason, impervious cover is often used as a surrogate (substitute) measure for urbanization (Schueler *et al.* 2009, p. 309). Impervious cover is any surface material that prevents water from filtering into the soil, such as roads, rooftops, sidewalks, patios, paved surfaces, or compacted soil (Arnold and Gibbons 1996, p. 244). Once vegetation in a watershed is replaced with impervious cover, rainfall is converted to surface runoff instead of filtering through the ground (Schueler 1991, p. 114). Impervious cover in a watershed has the following effects: (1) It alters the hydrology or movement of water through a watershed, (2) it increases the inputs of contaminants to levels that greatly exceed those found naturally in streams, and (3) it alters habitats in and near streams that provide living spaces for aquatic species (Coles *et al.* 2012, p. 38), such as the Georgetown and Salado salamanders and their prey. During periods of high precipitation levels in highly urbanized areas, stormwater runoff enters recharge areas of the Edwards Aquifer and rapidly transports sediment, fertilizer nutrients, and toxic contaminants (such as pesticides, metals, and petroleum hydrocarbons) to salamander habitat (COA 1990, pp. 12–14). The Adaptive Management Working Group will monitor data and new research over time and recommend improvements to the Ordinance that may be necessary to ensure that it achieves its stated purposes to maintain the Georgetown salamander at its current or improved status.

Both nationally and locally, consistent relationships between impervious cover and water quality degradation through contaminant loading have been documented. Stormwater runoff loads were found to increase with increasing impervious cover in a study of contaminant input from various land use areas in Austin, Texas (COA 1990, pp. 12–14). This study also found that contaminant input rates of the more urbanized watersheds were higher than those of the small suburban watersheds (COA 1990, pp. 12–14). Stormwater contaminant loading is positively correlated with development intensity in Austin (Soeur *et al.* 1995, p. 565). Several different contaminant measurements were found to be positively correlated with impervious cover (5-day biochemical oxygen demand, chemical oxygen demand, ammonia, dissolved phosphorus, copper, lead, and zinc) in a study of 38 small watersheds in the Austin area (COA 2006, p. 35). Using stream data from 1958 to 2007 at 24 Austin-area sites, the COA's water quality index demonstrated a strong negative correlation with impervious cover (Glick *et al.* 2009, p. 9). Mean concentrations of most water quality constituents, such as total suspended solids and other pollutants, are lower in undeveloped watersheds than those for urban watersheds (Veenhuis and Slade 1990, pp. 18–61).

Impervious cover has demonstrable impacts on biological communities within streams. Sites receiving runoff from high impervious cover drainage areas lose sensitive aquatic macroinvertebrate species, which are replaced by species more tolerant of pollution and hydrologic stress (high rate of changes in discharges over short periods of time) (Schueler 1994, p. 104). Considerable losses of algal, invertebrate, and fish species in response to stressors brought about by urban development were documented in an analysis of nine regions across the United States (Coles *et al.* 2012, p. 58). Additionally, a strong negative relationship between impervious cover and the abundance of larval southern two-lined salamander (*Eurycea cirrigera*) was found in an analysis of 43 North Carolina streams (Miller *et al.* 2007, pp. 78–79).

Like the Georgetown and Salado salamanders, larval (juveniles that are strictly aquatic) southern two-lined salamanders are entirely aquatic salamanders within the family Plethodontidae. They are also similar to the Georgetown and Salado salamanders in morphology, physiology, size, and habitat requirements. Given these similarities, we expect a negative relationship between the abundance of Georgetown and Salado salamanders and impervious cover within the surface watersheds of these species as human population growth and development increase.

To reduce the stressors associated with impervious cover, the City of Georgetown recently adopted a water quality ordinance that requires that permanent structural water quality controls for regulated activities over the Edwards Aquifer recharge zone must remove 85 percent of total suspended solids for the entire project. This increases the amount of total suspended solids that must be removed from projects within the City of Georgetown and its ETJ by 5 percent over the existing requirements (i.e., removal of 80 percent total suspended solids) found in the Edwards Aquifer Rules. In addition, the ordinance requires that all regulated activities implement temporary best management practices (BMPs) to minimize sediment runoff during construction. Finally, the Adaptive Management Working Group is charged specifically with reviewing Georgetown salamander monitoring data and new research over time and recommending improvements to the City of Georgetown's water quality ordinance that may be necessary to ensure that it achieves its stated purposes. This Adaptive Management Working Group, which includes representatives of the Service and TPWD, will also review and make recommendations on the approval of any variances to the ordinance.

In another example from a more closely related species, the COA cited five declining Jollyville Plateau salamander populations from 1997 to 2006: Balcones District Park Spring, Tributary 3, Tributary 5, Tributary 6, and Spicewood Tributary (O'Donnell *et al.* 2006, p. 4). All of these populations occur within surface watersheds containing more than 10 percent impervious cover (Service 2013, pp. 9–11). Springs with relatively low amounts of impervious cover in their surface drainage areas (6.77 and 0 percent for Franklin and Wheless Springs, respectively) tend to have generally stable or increasing salamander populations (Bendik 2011a, pp. 18–19). Bendik (2011a, pp. 26–27) reported statistically significant declines in Jollyville Plateau salamander populations over a 13-year period at six monitored sites with high impervious cover (18 to 46 percent) compared to two sites with low impervious cover (less than 1 percent). These results are consistent with Bowles *et al.* (2006, p. 111), who found lower densities of Jollyville Plateau salamanders at urbanized sites compared to non-urbanized sites.

We recognize that the long-term survey data of Jollyville Plateau salamanders using simple counts may not give conclusive evidence on the long-term trend of the population at each site. However, based on the threats and evidence from the literature and other information available in our files (provided by peer reviewers of the Jollyville Plateau salamander listing determination), the declines in counts seen at urban Jollyville Plateau salamander sites are likely representative of real declines in the population. Because of the similarities in morphology, physiology, habitat requirements, and life history traits shared with the Jollyville Plateau salamander, we expect downward trends in Georgetown and Salado salamander populations in the future as human population growth increases within the range of these species. This human population growth is projected to increase by 377 percent in the range of the Georgetown salamander and by 128 percent in the range of the Salado salamander by 2050. As indicated by the analogies presented above, subsequent urbanization within the watersheds occupied by the Georgetown and Salado salamanders will likely cause declines in habitat quality and numbers of individuals.

Impervious Cover Analysis

For this final rule, we calculated impervious cover within the watersheds occupied by the Georgetown and Salado salamanders. In this analysis, we delineated the surface areas that drain into spring sites and which of these sites may be experiencing habitat quality degradation as a result of impervious cover in the surface drainage area. However, we only examined surface drainage areas for each spring site for the Georgetown and Salado salamanders because we did not know the recharge area for specific spring or cave sites. Also, we did not account for riparian (stream edge) buffers or stormwater runoff control measures, both of which have the potential to mitigate some of the effects of impervious cover on streams (Schueler *et al.* 2009, pp. 312–313). Please see the Service's refined impervious cover analysis (Service 2013, pp. 2–7) for a description of the methods used to conduct this analysis. This analysis may not represent the current impervious cover because small areas may have gone undetected at the resolution of our analysis and additional areas of impervious cover may have been added since 2006, which is the year the impervious cover data for our analysis were generated. We compared our results with the results of similar analyses completed by SWCA, and impervious cover percentages at individual sites from these analyses were generally higher than our own (Service 2013, Appendix C).

Impervious Cover Categories

We examined studies that report ecological responses to watershed impervious cover levels based on a variety of degradation measurements (Service 2013, Table 1, p. 4). Most studies examined biological responses to impervious cover (for example, aquatic invertebrate and fish diversity), but several studies measured chemical and physical responses as well (for example, water quality parameters and stream channel modification). In light of these studies, we created the following impervious cover categories:

- None: 0 percent impervious cover in the watershed
- Low: Greater than 0 percent to 10 percent impervious cover in the watershed
- Medium: Greater than 10 percent to 20 percent impervious cover in the watershed
- High: Greater than 20 percent impervious cover in the watershed

Sites in the Low category may still be experiencing impacts from urbanization, as cited in studies such as Coles *et al.* (2012, p. 64), King *et al.* (2011, p. 1,664), and King and Baker (2010, p. 1,002). In accordance with the findings of Bowles *et al.* (2006, pp. 113, 117–118), sites in the Medium category are likely experiencing impacts from urbanization that are negatively impacting salamander densities. Sites in the High category are so degraded that habitat recovery will either be impossible or very difficult (Schueler *et al.* 2009, pp. 310, 313).

Results of Our Impervious Cover Analysis

We estimated impervious cover percentages for each surface drainage area of a spring known to have at least one population of either a Georgetown or Salado salamander (cave locations were omitted). These estimates and maps of the surface drainage area of spring locations are provided in our refined impervious cover analysis (Service 2013, pp. 1–25). Our analysis did not include the watersheds for Hogg Hollow Spring, Hogg Hollow II Spring, or Garey Ranch Spring because confirmation of the Georgetown salamander at these sites was not received until after the analysis was completed.

For the Georgetown salamander, a total of 12 watersheds were delineated, representing 12 spring sites. The watersheds varied greatly in size, ranging from the 1-ac (0.4-ha) watershed of Walnut Spring to the 258,017-ac (104,416-ha) watershed of San Gabriel Spring. Most watersheds (10 out of 12) were categorized as Low impervious cover. Two watersheds had no impervious cover (Knight Spring and Walnut Spring) and Swinbank Spring had the highest amount of impervious cover at 6.9 percent. The largest watershed, San Gabriel Spring, had a low proportion of impervious cover overall. However, most of the impervious cover in this watershed is in the area immediately surrounding the spring site.

The Salado salamander had a total of six watersheds delineated, representing seven different spring sites. The watersheds ranged in size from the 67-ac (27-ha) watershed of Solana Spring to 86,681-ac (35,079-ha) watershed of Big Boiling and Lil' Bubbly Springs. Five of the six watersheds were categorized as Low, and the watershed of Hog Hollow had no impervious cover. Although the largest watershed (Big Boiling and Lil' Bubbly Springs) has a low amount of impervious cover (0.41 percent), almost all of that impervious cover is located within the Village of Salado surrounding the spring site.

Although most of the watersheds in our analysis were classified as low, it is important to note that low levels of impervious cover (that is, less than 10 percent) may degrade salamander habitat. Recent studies in the eastern United States have reported large declines in aquatic macroinvertebrates (the prey base of salamanders) at impervious cover levels as low as 0.5 percent (King and Baker 2010, p. 1,002; King *et al.* 2011, p. 1,664). Several authors have argued that negative effects to stream ecosystems are seen at low levels of impervious cover and gradually increase as impervious cover increases (Booth *et al.* 2002, p. 838; Groffman *et al.* 2006, pp. 5–6; Schueler *et al.* 2009, p. 313; Coles *et al.* 2012, pp. 4, 64).

Although general percentages of impervious cover within a watershed are helpful in determining the general level of impervious cover within watersheds, it does not tell the complete story of how urbanization may be affecting salamanders or their habitat. Understanding how a salamander might be affected by water quality degradation within its habitat requires an examination of where the impervious cover occurs and what other threat sources for water quality degradation are present within the watershed (for example, non-point source runoff, highways and other sources of hazardous materials, livestock and feral hogs, and gravel and limestone mining (quarries); see discussions of these sources in their respective sections in Factor A below). For example, San Gabriel Spring's watershed (a Georgetown salamander site) has an impervious cover of only 1.2 percent, but the salamander site is in the middle of a highly urbanized area: the City of Georgetown. The habitat is in poor condition, and Georgetown salamanders have not been observed here since 1991 (Chippindale *et al.* 2000, p. 40; Pierce 2011b, pers. comm.).

In addition, the spatial arrangement of impervious cover is influential to the impacts that occur to aquatic ecosystems. Certain urban pattern variables, such as land use intensity, land cover composition, landscape configuration, and connectivity of the impervious area are important in predicting effects to aquatic ecosystems (Alberti *et al.* 2007, pp. 355–359). King *et al.* (2005, pp. 146–147) found that the closer developed land was to a stream in the Chesapeake Bay watershed, the larger the effect it had on stream macroinvertebrates. On a national scale, watersheds with development clustered in one large area (versus being interspersed throughout the watershed) and development located closer to streams had higher frequency of high-flow events (Steuer *et al.* 2010, pp. 47–48, 52). Based on these studies, it is likely that the way development is situated in the landscape of a surface drainage area of a salamander spring site plays a large role in how that development impacts salamander habitat.

One major limitation of this analysis is that we only examined surface drainage areas (watersheds) for each spring site for the Georgetown and Salado salamanders. In addition to the surface habitat, these salamanders use the subsurface habitat. Moreover, the base flow of water discharging from the springs on the surface comes from groundwater sources, which are in turn replenished by recharge features on the surface. As Shade *et al.* (2008, p. 3–4) points out, ''. . . little is known of how water recharges and flows through the subsurface in the Northern Segment of the Edwards Aquifer. Groundwater flow in karst is often not controlled by surface topography and crosses beneath surface water drainage boundaries, so the sources and movements of groundwater to springs and caves are poorly understood. Such information is critical to evaluating the degree to which salamander sites can be protected from urbanization.'' So a recharge area for a spring may occur within the surface watershed, or it could occur many miles away in a completely different watershed. A site completely surrounded by development may still contain unexpectedly high water quality because that spring's base flow is coming from a distant recharge area that is free from impervious cover. While some dye tracer work has been done in the Northern Segment (Shade *et al.* 2008, p. 4), clearly delineated recharge areas that flow to specific springs in the Northern Segment have not been identified for any of these spring sites; therefore, we could not examine impervious cover levels on recharge areas to better understand how development in those areas may impact salamander habitat.

Impervious cover within the watersheds of the Georgetown and Salado salamanders alone (that is, without the consideration of additional threat sources that may be present at specific sites) could cause irreversible declines or extirpation of populations with continuous exposure to water quality degradation over a relatively short time span without measures in place to reduce these threats. Although the impervious cover levels for the Georgetown and Salado salamanders remain relatively low at the present time, we expect impacts from this threat to increase in the future as urbanization expands within the surface watersheds for these species as well. This has already been observed in the closely related Jollyville Plateau salamander. Bowles *et al.* (2006, pp. 113, 117–118) found lower Jollyville Plateau salamander densities in watersheds with more than 10 percent impervious cover. Given the similar morphology, physiology, habitat requirements, and life-history traits between the Jollyville Plateau, Georgetown, and Salado salamanders, we expect that downward trends in Georgetown and Salado salamander populations will occur as human population growth increases. As previously noted, the human population is projected to increase by 377 percent in the range of the Georgetown salamander and by 128 percent in the range of the Salado salamander by 2050. Subsequent urbanization will likely cause declines in habitat quality and numbers of individuals at sites occupied by these species. The recently adopted ordinances in the City of Georgetown may reduce these threats. The Adaptive Management Working Group will provide the monitoring and research to track whether the ordinance is helping to reduce this threat.

Hazardous Material Spills

The Edwards Aquifer is at risk from a variety of sources of contaminants and pollutants (Ross 2011, p. 4), including hazardous materials that have the potential to be spilled or leaked, resulting in contamination of both surface and groundwater resources (Service 2005, pp. 1.6–14–1.6–15). Utility structures such as storage tanks or pipelines (particularly gas and sewer lines) can accidentally discharge. Any activity that involves the extraction, storage, manufacture, or transport of potentially hazardous substances, such as fuels or chemicals, can contaminate water resources and cause harm to aquatic life. Spill events can involve a short release with immediate impacts, such as a collision that involves a tanker truck carrying gasoline. Alternatively, the release can be long-term, involving the slow release of chemicals over time, such as a leaking underground storage tank.

A peer reviewer for the proposed rule provided information from the National Response Center's database of incidents of chemical and hazardous materials spills (*http://www.nrc.uscg.mil/foia.html*) from anthropogenic activities including, but not limited to, automobile or freight traffic accidents, intentional dumping, storage tanks, and industrial facilities. The number of incidents is likely to be an underestimate of the total number of incidents because not all incidents are discovered or reported. The database produced 189 records of spill events (33 that directly affected a body of water) in Williamson County between 1990 and 2012. Our search of the database produced 49 records of spill events that all directly affected water in Bell County between 1990 and 2013. Spills that did not directly affect aquatic environments may have indirectly done so by contaminating soils within watersheds that recharge springs where salamanders are known to occur (Gillespie 2012, University of Texas, pers. comm.). The risk of this type of contamination is currently ongoing and expected to increase as urbanization continues within the ranges of the Georgetown and Salado salamanders.

Hazardous material spills pose a significant threat to the Georgetown and Salado salamanders, and impacts from spills could increase substantially under drought conditions due to lower dilution and buffering capability of impacted water bodies. Spills under low-flow conditions are predicted to have an impact at much smaller volumes (Turner and O'Donnell 2004, p. 26). A significant hazardous materials spill within stream drainages of the Georgetown or Salado salamander could have the potential to threaten its long-term survival and sustainability of multiple populations or possibly the entire species. For example, a single hazardous materials spill on Interstate Highway 35 in the Village of Salado could cause three (Big Boiling Springs, Lil' Bubbly Springs, and Lazy Days Fish Farm Springs) of the seven known Salado salamander populations to go extinct. The City of Georgetown ordinances have a requirement that new roadways providing a capacity of 25,000 vehicles per day must provide for hazardous spill containment. This measure reduces the threat of spills on larger roadways in the future. In combination with the other threats identified in this final rule, a catastrophic hazardous materials spill could contribute to the species' risk of extinction by reducing its overall probability of persistence. Furthermore, we consider hazardous material spills to be an ongoing significant threat to the Georgetown and Salado salamanders due to their limited distributions, the abundance of potential sources, and the number of salamanders that could be killed during a single spill event.

Underground Storage Tanks

The risk of hazardous material spills from underground storage tanks is widespread in Texas and is expected to increase as urbanization continues to occur. As of 1996, more than 6,000 leaking underground storage tanks in Texas had resulted in contaminated groundwater (Mace *et al.* 1997, p. 2), including a large leak in the range of the Georgetown salamander (Mace *et al.* 1997, p. 32). In 1993, approximately 6,000 gallons (22,712 liters) of gasoline leaked from an underground storage tank located near Krienke Springs in southern Williamson County, Texas, which is known to be occupied by the Jollyville Plateau salamander (Manning 1994, p. 1). The leak originated from an underground storage tank from a gas station near the salamander site. This incident illustrates that despite laws or ordinances that require all underground storage tanks to be protected against corrosion, installed properly, and equipped with spill protection and leak detection mechanisms, leaks can still occur in urbanized areas despite the precautions put in place to prevent them (Manning 1994, p. 5). As human population growth increases within the ranges of the Georgetown and Salado salamanders, such leaks could be threat to these species.

Several groundwater contamination incidents have occurred within Salado salamander habitat (Price *et al.* 1999, p. 10). Big Boiling Springs is located on the south bank of Salado Creek, near locations of past contamination events (Chippindale *et al.* 2000, p. 43). Between 1989 and 1993, at least four incidents occurred within 0.25 mi (0.4 km) from the spring site, including a 700-gallon (2,650-liter) and 400-gallon (1,514-liter) gasoline spill and petroleum leaks from two underground storage tanks associated with a gas station and a gas distributor business, respectively (Price *et al.* 1999, p. 10). Because no follow-up studies were conducted, we have no information to indicate what effect these spills had on the species or its habitat. However, between 1991 and 1998, only a single salamander was observed at Big Boiling Springs despite multiple surveys (Chippindale *et al.* 2000, p. 43; TPWD 2011, p. 2). Between 2008 and 2010, one salamander was confirmed by biologists (Gluesenkamp 2010, TPWD, pers. comm.) at Lil' Bubbly Spring, and one additional unconfirmed sighting of a Salado salamander in Big Boiling Springs was reported by a citizen of Salado, Texas.

The threat of water quality degradation from an underground storage tank alone (that is, without the consideration of additional threat sources that may be present at specific sites) could cause irreversible declines or extirpation in local populations or significant declines in habitat quality of the Georgetown or Salado salamander with only one exposure event. This is considered to be an ongoing threat of high impact to the Georgetown and Salado salamanders. We expect this to become a more significant threat in the future for these salamander species as urbanization continues to expand within their surface watersheds.

Highways

The transport of hazardous materials is common on many highways, which are major transportation routes (Thompson *et al.* 2011, p. 1). Every year, thousands of tons of hazardous materials are transported over Texas highways (Thompson *et al.* 2011, p. 1).

Transporters of hazardous materials (such as gasoline, cyclic hydrocarbons, fuel oils, and pesticides) carry volumes ranging from a few gallons up to 10,000 gallons (37,854 liters) or more of hazardous material (Thompson *et al.* 2011, p. 1). An accident involving hazardous materials can cause the release of a substantial volume of material over a very short period of time. As such, the capability of standard stormwater management structures (or best management practices) to trap and treat such releases might be overwhelmed (Thompson *et al.* 2011, p. 2).

Interstate Highway 35 crosses the watersheds that contribute groundwater to spring sites known to be occupied by the Georgetown and Salado salamanders. A catastrophic spill could occur if a transport truck overturned and its contents entered the recharge zone of the Northern Segment of the Edwards Aquifer. Researchers at Texas Tech University reviewed spill records to identify locations or segments of highway where spill incidents on Texas roadways are more numerous and, therefore, more likely to occur than other areas of Texas. These researchers found that one such area is a 10-mi (16-km) radius along Interstate Highway 35 within Williamson County (Thompson *et al.* 2011, pp. 25, 44). Three of the five spills reported in this area between 2000 and 2006 occurred on this highway within the City of Georgetown, and one occurred on the same highway within the City of Round Rock (Thompson *et al.* 2011, pp. 25–26, 44). As recently as 2011, a fuel tanker overturned in Georgetown and spilled 3,500 gallons (13,249 liters) of gasoline (McHenry *et al.* 2011, p. 1). A large plume of hydrocarbons was detected within the Edwards Aquifer underneath Georgetown in 1997 (Mace *et al.* 1997, p. 32), possibly the result of a leaking fuel storage tank. Thus, spills from Interstate Highway 35 are an ongoing threat source. The City of Georgetown's water quality ordinance now requires that new roadways or expansions to existing roadways that provide a capacity of 25,000 vehicles per day and are located on the Edwards Aquifer recharge zone must provide for spill containment as described in TCEQ's Optional Enhanced Measures. This measure will reduce the threat of hazardous spills on new roadways or expansions but does not address the threat from existing roadways.

Transportation accidents involving hazardous materials spills at bridge crossings are of particular concern because recharge areas in creek beds can transport contaminants directly into the aquifer (Service 2005, p. 1.6–14). Salado salamander sites located downstream of Interstate Highway 35 may be particularly vulnerable due to their proximity to this major transportation corridor. Interstate Highway 35 crosses Salado Creek just 760 to 1,100 ft (231 to 335 m) upstream from three spring sites (Big Boiling Springs, Lil' Bubbly Springs, and Lazy Days Fish Farm Springs) where the Salado salamander is known to occur. The highway also crosses the surface watershed of an additional Salado salamander site, Robertson Spring. Should a hazardous materials spill occur at the Interstate Highway 35 bridge that crosses at Salado Creek or over the watershed of Robertson Spring, the Salado salamander could be at risk from contaminants entering the water flowing into its surface habitat downstream.

In addition, the Texas Department of Transportation is reconstructing a section of Interstate Highway 35 within the Village of Salado (Najvar 2009, Service, pers. comm.). This work includes the replacement of four bridges that cross Salado Creek (two main lane bridges and two frontage road bridges) in an effort to widen the highway at this location. This project could affect the risk of hazardous materials spills and runoff into Salado Creek upstream of known Salado salamander locations. In August 2009, the Texas Department of Transportation began working with the Service to identify measures, such as the installation of permanent water quality control mechanisms to contain runoff, to protect the Salado salamander and its habitat from the effects of this project (Najvar 2009, Service, pers. comm.).

The threat of water quality degradation from highways alone (that is, without the consideration of additional threat sources that may be present at specific sites) could cause irreversible declines or extirpation in local populations or significant declines in habitat quality of any of the four central Texas salamander species with only one exposure event. We consider this to be an ongoing threat of high impact to the Georgetown and Salado salamanders. Given the amount of urbanization predicted for Williamson and Bell Counties, Texas, the risk of exposure from this threat is expected to increase in the future as well.

Water and Sewage Lines

Sewage spills often include contaminants such as nutrients, polycyclic aromatic hydrocarbons (PAHs), metals, pesticides, pharmaceuticals, and high levels of fecal coliform bacteria (Turner and O'Donnell 2004, p. 27). Increased ammonia levels and reduced dissolved oxygen are the most likely impacts of a sewage spill that could cause rapid mortality of large numbers of salamanders (Turner and O'Donnell 2004, p. 27). Fecal coliform bacteria from sewage spills cause diseases in salamanders and their prey base (Turner and O'Donnell 2004, p. 27). Municipal water lines that convey treated drinking water throughout the surrounding areas of Georgetown and Salado salamander habitat could break and potentially flow into surface or subsurface habitat, exposing salamanders to chlorine concentrations that are potentially toxic. A typical chlorine concentration in a water line is 1.5 mg/L, and a lethal concentration of chloride for the related San Marcos salamander is 0.088 mg/L (Herrington and Turner 2009, p. 1).

The Georgetown salamander is particularly exposed to the threat of water and sewage lines. As of the date of this rule, there are eight water treatment plants within the Georgetown city limits, with wastewater and chlorinated drinking water lines running throughout Georgetown salamander stream drainages (City of Georgetown 2008, p. 3.37). A massive wastewater line is being constructed in the South San Gabriel River drainage (City of Georgetown 2008, p. 3.22), which is within the watershed of one known Georgetown salamander site. Almost 700 septic systems were permitted or inspected in Georgetown in 2006 (City of Georgetown 2008, p. 3.36). Service staff also noted a sewage line that runs nearby Bat Well Cave. Data submitted to the Service during our comment period (SWCA 2012, p. 20) indicated that one Georgetown salamander site (Cedar Breaks Spring) had a concentration of fecal coliform bacteria [83,600 colony-forming units per 100 milliliters (cfu/100mL)] 418 times the concentration that the Service recommended to be protective of federally listed salamanders (200 cfu/100mL) (White *et al.* 2006, p. 51). It is unknown if this elevated concentration of fecal coliform bacteria was the result of a sewage or septic spill, or what impact this poor water quality had on the Cedar Breaks Spring population.

Spills from sewage and water lines have been documented in the past in the central Texas area within the ranges of closely related salamander species. There are 9,470 known septic facilities in the Barton Springs Segment of the Edwards Aquifer as of 2010 (Herrington *et al.* 2010, p. 5), up from 4,806 septic systems in 1995 (COA 1995, p. 3–13). In one COA survey of these septic systems, over 7 percent were identified as failing (no longer functioning properly, causing water from the septic tank to leak out and accumulate on the ground surface) (COA 1995, p. 3–18). Sewage spills from pipelines also have been documented in watersheds supporting Jollyville Plateau salamander populations (COA 2001, pp. 16, 21, 74). For example, in 2007, a sewage line overflowed an estimated 50,000 gallons (190,000 liters) of raw sewage into the Stillhouse Hollow drainage area of Bull Creek below the area where salamanders are known to occur (COA 2007b, pp. 1–3). The human population is projected to increase by 377 percent in the range of the Georgetown salamander and by 128 percent in the range of the Salado salamander by 2050. We expect that subsequent urbanization will increase the prevalence of water and sewage systems within the areas where Georgetown and Salado salamander populations are known to occur, and thereby increase the exposure of salamanders to this threat source.

The threat of water quality degradation from water and sewage lines alone (that is, without the consideration of additional threat sources that may be present at specific sites) could cause irreversible declines or extirpation in local populations or significant declines in habitat quality with only one exposure event. We consider this to be an ongoing threat of high impact to the Georgetown salamander that is likely to increase in the future as urbanization expands within the ranges of these species. Although we are unaware of any information that indicates water and sewage lines are located in areas that could impact Salado salamanders if spills occurred, we expect this to become a significant threat in the future for this species as urbanization continues to expand within its surface watersheds.

Construction Activities

Short-term increases in pollutants, particularly sediments, can occur during construction in areas of new development. When vegetation is removed and rain falls on unprotected soils, large discharges of suspended sediments can erode from newly exposed areas, resulting in increased sedimentation in downstream drainage channels (Schueler 1987, pp. 1–4; Turner 2003, p. 24; O'Donnell *et al.* 2005, p. 15). This increased sedimentation from construction activities has been linked to declines in Jollyville Plateau salamander counts at multiple sites (Turner 2003, p. 24; O'Donnell *et al.* 2006, p. 34).

Cave sites are also impacted by construction, as Testudo Tube Cave (Jollyville Plateau salamander habitat) showed an increase in nickel, calcium, and nitrates/nitrites after nearby road construction (Richter 2009, pp. 6–7). Barton Springs (Austin blind salamander habitat) is also under the threat of pollutant loading due to its proximity to construction activities and the spring's location at the downstream side of the watershed (COA 1997, p. 237). The COA (1995, pp. 3–11) estimated that construction-related sediment and in-channel erosion accounted for approximately 80 percent of the average annual sediment load in the Barton Springs watershed. In addition, the COA (1995, pp. 3–10) estimated that total suspended sediment loads have increased 270 percent over pre-development loadings within the Barton Springs Segment of the Edwards Aquifer. Because the Jollyville Plateau and Barton Springs salamanders are similar to the Georgetown and Salado salamander with regard to size, morphology, physiology, life history traits and habitat requirements, we expect similar declines to occur for the Georgetown and Salado salamanders from construction activities as the human population growth increases and subsequent development follows within surface watersheds of these species.

At this time, we are not aware of any studies that have examined sediment loading due to construction activities within the watersheds of Georgetown or Salado salamander habitats. However, because construction occurs and is expected to continue in many of these watersheds occupied by the Georgetown and Salado salamanders as the human population is projected to increase by 377 percent in the range of the Georgetown salamander and by 128 percent in the range of the Salado salamander by 2050, we have determined that the threat of construction in areas of new development applies to these species as well. The City of Georgetown's water quality ordinance now requires stream buffers for all streams in the Edwards Aquifer recharge zone within the City of Georgetown and its ETJ that drain more than 64 acres (26 ha). These buffers are similar to those required under similar water quality regulations in central Texas and will help reduce the amount of sediment and other pollutants that enter waterways.

The ordinance also requires that permanent structural water quality controls for regulated activities over the Edwards Aquifer recharge zone must remove 85 percent of total suspended solids for the entire project. This increases the amount of total suspended solids that must be removed from projects within the City of Georgetown and its ETJ by 5 percent over the existing requirements (i.e., removal of 80 percent total suspended solids) found in the Edwards Aquifer Rules. Lastly, the ordinance requires that all developments implement temporary BMPs to minimize sediment runoff during construction. Construction is intermittent and temporary, but it affects both surface and subsurface habitats and is occurring throughout the ranges of these salamanders. Therefore, we have determined that this threat is ongoing and will continue to affect the Georgetown and Salado salamanders and their habitats in the future.

Also, the physical construction of pipelines, shafts, wells, and similar structures that penetrate the subsurface has the potential to negatively affect subsurface habitat for salamander species. It is known that the Georgetown and Salado salamanders inhabit the subsurface environment and that water flows through the subsurface to the surface habitat. Tunneling for underground pipelines can destroy potential habitat by removing subsurface material, thereby destroying subsurface spaces/conduits in which salamanders can live, grow, forage, and reproduce. Additional material can become dislodged and result in increased sediment loading into the aquifer and associated spring systems. In addition, disruption of water flow to springs inhabited by salamanders can occur through the construction of tunnels and vertical shafts to access them. Because of the complexity of the aquifer and subsurface structure and because detailed maps of the underground conduits that feed springs in the Edwards Aquifer are not available, tunnels and shafts have the possibility of intercepting and severing those conduits (COA 2010a, p. 28). Affected springs could rapidly become dry and would not support salamander populations. The closer a shaft or tunnel location is to a spring, the more likely that the construction will impact a spring (COA 2010a, p. 28). Even small shafts pose a threat to nearby spring systems. As the human population is projected to increase by 377 percent in the range of the Georgetown salamander and by 128 percent in the range of the Salado salamander by 2050, we expect subsurface construction of pipelines, shafts, wells, and similar structures to be a threat to their surface and subsurface habitats. However, under the City of Georgetown's water quality ordinance, these types of activities will no longer be permitted within 262 ft (80

m) of occupied Georgetown salamander sites.

The threat of water quality degradation from construction activities alone (that is, without the consideration of additional threat sources that may be present at specific sites) could cause irreversible declines or extirpation in local populations or significant declines in habitat quality of the salamander species with only one exposure event (if subsurface flows were interrupted or severed) or with repeated exposure over a relatively short time span. From information available in our files and provided to us during the peer review and public comment period for the proposed rule, we found that 3 of the 17 Georgetown salamander sites have been known to have had construction activities around their perimeters, and 1 has been modified within the spring site itself. Construction activities have led to physical habitat modification in at least three of the seven known Salado salamander spring sites. Even though the impacts of water quality degradation from construction activities is reduced by the City of Georgetown's water quality ordinance, we consider future construction activities to be an ongoing threat of high impact to both the Georgetown and Salado salamanders that are likely to increase as urbanization expands within their respective surface watersheds.

Quarries

Construction activities within rock quarries can permanently alter the geology and groundwater hydrology of the immediate area, and adversely affect springs that are hydrologically connected to impacted sites (Ekmekci 1990, p. 4; van Beynan and Townsend 2005, p. 104; Humphreys 2011, p. 295). Limestone rock is an important raw material that is mined in quarries all over the world due to its popularity as a building material and its use in the manufacture of cement (Vermeulen and Whitten 1999, p. 1). The potential environmental impacts of quarries include destruction of springs or collapse of karst caverns, as well as impacts to water quality through siltation and sedimentation, and impacts to water quantity through water diversion, dewatering, and reduced flows (Ekmekci 1990, p. 4; van Beynan and Townsend 2005, p. 104). The mobilization of fine materials from quarries can lead to the occlusion of voids and the smothering of surface habitats for aquatic species downstream (Humphreys 2011, p. 295).

Quarry activities can also generate pollution in the aquatic ecosystem through leaks or spills of waste materials from mining operations (such as petroleum products) (Humphreys 2011, p. 295). For example, a spill of almost 3,000 gallons (11,356 liters) of diesel from an above-ground storage tank occurred on a limestone quarry in New Braunfels, Texas (about 4.5 mi (7.2 km) from Comal Springs in the Southern Segment of the Edwards Aquifer) in 2000 (Ross *et al.* 2005, p. 14). Also, perchlorate (a chemical used in producing explosives used in quarries) contamination was detected in the City of Georgetown public water supply wells in November 2003. A total of 46 private and public water wells were sampled in December 2004 in Williamson County (Berehe 2005, p. 44). Out of these, five private wells had detections of perchlorate above the TCEQ interim action levels of 4.0 parts per billion (ppb). Four surface water (spring) samples had detection ranging from 6.3 to 9.2 ppb (Berehe 2005, p. 44). Perchlorate is known to affect thyroid functions, which are responsible for helping to regulate embryonic growth and development in vertebrate species (Smith *et al.* 2001, p. 306). Aquatic organisms inhabiting perchlorate-contaminated surface water bodies contain detectable concentrations of perchlorate (Smith *et al.* 2001, pp. 311–312). Perchlorate has been shown to cause malformations in embryos, delay larval growth and development, and decrease reproductive success in laboratory studies in the African clawed frog (*Xenopus laevis*) (Dumont 2008, pp. 5, 8, 12, 19). Because the thyroid has the same function in salamander physiology as it does for the African clawed frog, we expect perchlorate to affect the Georgetown and Salado salamanders in a similar manner.

Limestone is a common geologic feature of the Edwards Aquifer, and active quarries exist throughout the region. For example, at least 3 of the 17 Georgetown salamander sites (Avant Spring, Knight [Crockett Gardens] Spring, and Cedar Breaks Hiking Trail Spring) occur adjacent to a limestone quarry that has been active since at least 1995. Avant Spring is within 328 ft (100 m) and Knight and Cedar Breaks Hiking Trail Springs are each between 1,640 and 2,624 ft (500 and 800 m) from the quarry. The population status of the Georgetown salamander is unknown at Knight Spring and Cedar Breaks Hiking Trail Spring, but salamanders are seen infrequently and in low abundance at the closest spring to the quarry (Avant Spring; Pierce 2011c, Southwestern University, pers. comm.). In total, there are currently quarries located in the watersheds of 5 of the 12 Georgetown salamander surface sites and 5 of the 7 Salado salamander sites. Therefore, we consider this to be an ongoing threat of high impact given the exposure risk of this threat to the Georgetown and Salado salamanders that could worsen as quarries expand in the future.

Contaminants and Pollutants

Contaminants and pollutants are stressors that can affect individual salamanders or their habitats or their prey. They find their way into aquatic habitat through a variety of ways, including stormwater runoff, point (a single identifiable source) and non-point (coming from many diffuse sources) discharges, and hazardous material spills (Coles *et al.* 2012, p. 21). For example, sediments eroded from soil surfaces as a result of stormwater runoff can concentrate and transport contaminants (Mahler and Lynch 1999, p. 165). The Georgetown and Salado salamanders and their prey species are directly exposed to sediment-borne contaminants present within the aquifer and discharging through the spring outlets. For example, in addition to sediment, trace metals such as arsenic, cadmium, copper, lead, nickel, and zinc were found in Barton Springs in the early 1990s (COA 1997, pp. 229, 231–232). Such contaminants associated with sediments are known to negatively affect survival and growth of an amphipod species, which are part of the prey base of the Georgetown and Salado salamanders (Ingersoll *et al.* 1996, pp. 607–608; Coles *et al.* 2012, p. 50). In addition, various industrial and municipal activities result in the discharge of treated wastewater or unintentional release of industrial contaminants as point source pollution. Urban environments are host to a variety of human activities that generate many types of sources for contaminants and pollutants. These substances, especially when combined, often degrade nearby waterways and aquatic resources within the watershed (Coles *et al.* 2012, pp. 44–53).

As a karst aquifer system, the Edwards Aquifer is more vulnerable to the effects of contamination due to: (1) A large number of conduits that offer no filtering capacity, (2) high groundwater flow velocities, and (3) the relatively short amount of time that water is inside the aquifer system (Ford and Williams 1989, pp. 518–519). These characteristics of the aquifer allow contaminants in the watershed to enter and move through the aquifer more easily, thus reaching salamander habitat within spring sites more quickly than other types of aquifer systems.

Amphibians, especially their eggs and larvae (which are usually restricted to a small area within an aquatic environment), are sensitive to many different aquatic pollutants (Harfenist *et al.* 1989, pp. 4–57). Contaminants found in aquatic environments, even at sublethal concentrations, may interfere with a salamander's ability to develop, grow, or reproduce (Burton and Ingersoll 1994, pp. 120, 125). Salamanders in the central Texas region are particularly vulnerable to contaminants, because they have evolved under very stable environmental conditions, remain aquatic throughout their entire life cycle, have highly permeable skin, have severely restricted ranges, and cannot escape contaminants in their environment (Turner and O'Donnell 2004, p. 5). In addition, macroinvertebrates, such as small freshwater crustaceans (amphipods and copepods), that aquatic salamanders feed on are especially sensitive to water pollution (Phipps *et al.* 1995, p. 282; Miller *et al.* 2007, p. 74; Coles *et al.* 2012, pp. 64–65). For example, studies in the Bull Creek watershed in Austin, Texas, found a loss of some sensitive macroinvertebrate species, potentially due to contaminants of nutrient enrichment and sediment accumulation (COA 2001, p. 15; COA 2010b, p. 16). Below, we discuss specific contaminants and pollutants that may be impacting the Georgetown and Salado salamanders.

Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are a common form of aquatic contaminants in urbanized areas that could affect salamanders, their habitat, or their prey. This form of pollution can originate from petroleum products, such as oil or grease, or from atmospheric deposition as a byproduct of combustion (for example, vehicular combustion). These pollutants accumulate over time on impervious cover, contaminating water supplies through urban and highway runoff (Van Metre *et al.* 2000, p. 4,067; Albers 2003, pp. 345–346). Although information is lacking on PAH loading in Williamson and Bell Counties, research shows that the main source of PAH loading in Austin-area streams is parking lots with coal tar emulsion sealant, even though this type of lot only covers 1 to 2 percent of the watersheds (Mahler *et al.* 2005, p. 5,565). A recent analysis of the rate of wear on coal tar lots revealed that the sealcoat wears off relatively quickly and contributes more to PAH loading than previously thought (Scoggins *et al.* 2009, p. 4,914).

Petroleum and petroleum byproducts can adversely affect living organisms by causing direct toxic action, altering water chemistry, reducing light, and decreasing food availability (Albers 2003, p. 349). Exposure to PAHs at certain levels can cause impaired reproduction, reduced growth and development, and tumors or cancer in species of amphibians, reptiles, and other organisms (Albers 2003, p. 354). Coal tar pavement sealant slowed hatching, growth, and development of a frog (*Xenopus laevis*) in a laboratory setting (Bryer *et al.* 2006, pp. 244–245). High concentrations of PAHs from coal tar sealant negatively affected the righting ability (amount of time needed to flip over after being placed on back) of adult eastern newts (*Notophthalmus viridescens*) and may have also damaged the newt's liver (Sparling *et al.* 2009, pp. 18–20). For juvenile spotted salamanders (*Ambystoma maculatum*), PAHs reduced growth in the lab (Sparling *et al.* 2009, p. 28). Bommarito *et al.* (2010, pp. 1,151–1,152) found that spotted salamanders displayed slower growth rates and diminished swimming ability when exposed to PAHs. These contaminants are also known to cause death, reduced survival, altered physiological function, inhibited reproduction, and changes in community composition of freshwater invertebrates (Albers 2003, p. 352). From the information available above, we conclude that PAHs are known to cause disruptions to the survival, growth, development, and reproduction in a variety of amphibian species and alterations to their prey base of aquatic invertebrates. Therefore, the same effects are expected to occur to the Georgetown and Salado salamanders when exposed to PAHs.

This form of aquatic contaminant has already been documented in the central Texas area within the urbanized ranges of closely related salamander species. Limited sampling by the COA has detected PAHs at concentrations of concern at multiple sites within the range of the Jollyville Plateau salamander. Most notable were the levels of nine different PAH compounds at the Spicewood Springs site in the Shoal Creek drainage area, which were above concentrations known to adversely affect aquatic organisms (O'Donnell *et al.* 2005, pp. 16–17). The Spicewood Springs site is located within an area with greater than 30 percent impervious cover and down gradient from a commercial business that changes vehicle oil. This is also one of the sites where salamanders have shown declines in abundance (from an average of 12 individuals per visit in 1997 to an average of 2 individuals in 2005) during the COA's long-term monitoring studies (O'Donnell *et al.* 2006, p. 47). Another study found several PAH compounds in seven Austin-area streams, including Barton, Bull, and Walnut Creeks, downstream of coal tar sealant parking lots (Scoggins *et al.* 2007, p. 697). Sites with high concentrations of PAHs (located in Barton and Walnut Creeks) had fewer macroinvertebrate species and lower macroinvertebrate density (Scoggins *et al.* 2007, p. 700). This form of contamination has also been detected at Barton Springs, which is the Austin blind salamander's habitat (COA 1997, p. 10).

The threat of water quality degradation from PAH exposure alone (that is, without the consideration of additional threat sources that may be present at specific sites) could cause irreversible declines or extirpation in local populations or significant declines in habitat quality of any of the Georgetown and Salado salamander sites with continuous or repeated exposure. In some instances, exposure to PAH contamination could negatively impact a salamander population in combination with exposure to other sources of water quality degradation, resulting in significant habitat declines or other significant negative impacts (such as loss of invertebrate prey species). We consider water quality degradation from PAH contamination to be a threat of high impact to Georgetown and Salado salamanders now and in the future as urbanization increases within these species' surface watersheds.

Pesticides

Pesticides (including herbicides and insecticides) are also associated with urban areas. Sources of pesticides include lawns, road rights-of-way, and managed turf areas, such as golf courses, parks, and ball fields. Pesticide application is also common in residential, recreational, and agricultural areas. Pesticides have the potential to leach into groundwater through the soil or be washed into streams by stormwater runoff. Pesticides are known to impact amphibian species in a number of ways. For example, Reylea (2009, p. 370) demonstrated that diazinon reduces growth and development in larval amphibians. Another pesticide, carbaryl, causes mortality and deformities in larval streamside salamanders (*Ambystoma barbouri*) (Rohr *et al.* 2003, p. 2,391). The Environmental Protection Agency (EPA) (2007, p. 9) also found that carbaryl is likely to adversely affect the

Barton Springs salamander both directly and indirectly through reduction of prey. Additionally, atrazine has been shown to impair sexual development in male amphibians (African clawed frogs) at concentrations as low as 0.1 parts per billion (Hayes 2002, p. 5,477). Atrazine levels were found to be greater than 0.44 parts per billion after rainfall in Barton Springs Pool (Mahler and Van Mere 2000, pp. 4, 12). From the information available above, we conclude that pesticides are known to cause disruptions to the survival, growth, development, and reproduction in a variety of amphibian species. Therefore, we conclude such effects may occur to the Georgetown and Salado salamanders when exposed to pesticides as well.

We acknowledge that in 2007 a Scientific Advisory Panel (SAP) of the EPA reviewed the available information on atrazine effects on amphibians and concluded that atrazine concentrations less than 100 µg/L had no effects on clawed frogs. However, the 2012 SAP is currently re-examining the conclusions of the 2007 SAP using a meta-analysis of published studies along with additional studies on more species (EPA 2012, p. 35). The 2012 SAP expressed concern that some studies were discounted in the 2007 SAP analysis, including studies like Hayes (2002, p. 5,477) that indicated that atrazine is linked to endocrine (hormone) disruption in amphibians (EPA 2012, p. 35). In addition, the 2007 SAP noted that their results on clawed frogs are insufficient to make global conclusions about the effects of atrazine on all amphibian species (EPA 2012, p. 33). Accordingly, the 2012 SAP has recommended further testing on at least three amphibian species before a conclusion can be reached that atrazine has no effect on amphibians at concentrations less than 100 µg/L (EPA 2012, p. 33). Due to potential differences in species sensitivity, exposure scenarios that may include dozens of chemical stressors simultaneously, and multigenerational effects that are not fully understood, we continue to view pesticides, including carbaryl, atrazine, and many others to which aquatic organisms may be exposed, as a potential threat to water quality, salamander health, and the health of aquatic organisms that comprise the diet of salamanders.

The threat of water quality degradation from pesticide exposure alone (that is, without the consideration of additional threat sources that may be present at specific sites) could cause irreversible declines or extirpation in local populations or significant declines in habitat quality of the Georgetown and Salado salamanders. In some instances, exposure to pesticide contamination could negatively impact a salamander population in combination with exposure to other sources of water quality degradation, resulting in significant habitat declines or other significant negative impacts (such as loss of invertebrate prey species). Although the best available information does not indicate that pesticides have been detected in the aquatic environments within the ranges of the Georgetown and Salado salamanders to date (SWCA 2012, pp. 17–18), we expect this to become a significant threat in the future for these species as the human population expands within their surface watersheds.

Nutrients

Nutrient input (such as phosphorus and nitrogen) to watershed drainages, which often results in abnormally high organic growth in aquatic ecosystems, can originate from multiple sources, such as human and animal wastes, industrial pollutants, and fertilizers (from lawns, golf courses, or croplands) (Garner and Mahler 2007, p. 29). As the human population grows and subsequent urbanization occurs within the ranges of the Georgetown and Salado salamanders, they will likely become more susceptible to the effects of excessive nutrients within their habitats because their exposure increases. To illustrate, an estimated 102,262 domestic dogs and cats (pet waste is a potential source of excessive nutrients) were known to occur within the Barton Springs Segment of the Edwards Aquifer in 2010 (Herrington *et al.* 2010, p. 15). Their distributions were correlated with human population density (Herrington *et al.* 2010, p. 15).

Human population growth will bring about an increase in the use of nutrients that are harmful to aquatic species, such as the Georgetown and Salado salamanders. This was the case as urban development increased within the Jollyville Plateau salamander's range. Various residential properties and golf courses use fertilizers to maintain turf grass within watersheds where Jollyville Plateau salamander populations are known to occur (COA 2003, pp. 1–7). Analysis of water quality attributes conducted by the COA (1997, pp. 8–9) showed significant differences in nitrate, ammonia, total dissolved solids, total suspended solids, and turbidity concentrations between watersheds dominated by golf courses, residential land, and rural land. Golf course tributaries were found to have higher concentrations of these constituents than residential tributaries, and both golf course and residential tributaries had substantially higher concentrations for these five water quality attributes than rural tributaries (COA 1997, pp. 8–9).

Residential irrigation of wastewater effluent is another source that leads to excessive nutrient input aquatic systems, as has been identified in the recharge and contributing zones of the Barton Springs Segment of the Edwards Aquifer (Ross 2011, pp. 11–18; Mahler *et al.* 2011, pp. 16–23). Wastewater effluent permits do not require treatment to remove metals, pharmaceutical chemicals, or the wide range of chemicals found in body care products, soaps, detergents, pesticides, or other cleaning products (Ross 2011, p. 6). These chemicals remaining in treated wastewater effluent can enter streams and the aquifer and alter water quality within salamander habitat. A USGS study found nitrate concentrations in Barton Springs and the five streams that provide most of its recharge much higher during 2008 to 2010 than before 2008 (USGS 2011, pp. 1–4). Additionally, nitrate levels in water samples collected between 2003 and 2010 from Barton Creek tributaries exceeded TCEQ screening levels and were identified as screening level concerns (TCEQ 2012a, p. 344). The rapid development over the Barton Springs contributing zone since 2000 was associated with an increase in the generation of wastewater (Mahler *et al.* 2011, p. 29). Septic systems and land-applied treated wastewater effluent are likely sources contributing nitrate to the recharging streams (Mahler *et al.* 2011, p. 29).

As of November 2010, the permitted volume of irrigated flow in the contributing zone of the Barton Springs Segment of the Edwards Aquifer was 3,300,000 gallons (12,491 kiloliters) per day. About 95 percent of that volume was permitted during 2005 to 2010 (Mahler *et al.* 2011, p. 30). As the human population is projected to increase by 377 percent in the range of the Georgetown salamander and by 128 percent in the range of the Salado salamander by 2050, we expect the permitted volume of irrigated flow of wastewater effluent in the contributing zone of the Northern Segment of the Edwards Aquifer to increase considerably.

Excessive nutrient input into aquatic systems can increase plant growth (including algae blooms), which pulls more oxygen out of the water when the dead plant matter decomposes, resulting in less oxygen being available in the water for salamanders to breathe (Schueler 1987, pp. 1.5–1.6; Ross 2011,

p. 7). A reduction in dissolved oxygen concentrations could not only affect respiration in salamander species, but also lead to decreased metabolic functioning and growth in juveniles (Woods *et al.* 2010, p. 544), or death (Ross 2011, p. 6). Excessive plant material can also reduce stream velocities and increase sediment deposition (Ross 2011, p. 7). When the interstitial spaces become compacted or filled with fine sediment, the amount of available foraging habitat and protective cover is reduced (Welsh and Ollivier 1998, p. 1,128).

Increased nitrate levels have been known to affect amphibians by altering feeding activity and causing disequilibrium and physical abnormalities (Marco *et al.* 1999, p. 2,837). Nitrate toxicity studies have indicated that salamanders and other amphibians are sensitive to these pollutants (Marco *et al.* 1999, p. 2,837). Some studies have indicated that nitrate concentrations between 1.0 and 3.6 mg/L can be toxic to aquatic organisms (Rouse 1999, p. 802; Camargo *et al.* 2005, p. 1,264; Hickey *et al.* 2009, pp. ii, 17–18). Nitrate concentrations have been documented within this range (1.85 mg/L) at one Salado salamander site (Lazy Days Fish Farm, which is reported as Critchfield Springs in Norris *et al.* 2012, p. 14) and higher than this range (4.05 mg/L, 4.28 mg/L, and 4.21 mg/L) at three Salado salamander sites (Big Boiling, Lil' Bubbly, and Robertson Springs, respectively) (Norris *et al.* 2012, pp. 23–25). Likewise, nitrate samples taken at a Georgetown salamander site (Swinbank Springs) were found to be as high as 3.32 mg/L (SWCA 2012, pp. 15, 20). For comparison, nitrate levels in undeveloped Edwards Aquifer springs (watersheds without high levels of urbanization) are typically close to 1 mg/L (O'Donnell *et al.* 2006, p. 26). From the information available on the effects of elevated nitrate levels on amphibian species, we conclude that the salamanders at these sites may be experiencing impairments to their respiratory, metabolic, and feeding capabilities.

We also assessed the risk of exposure to sources of excessive nutrient input for the Georgetown and Salado salamanders by examining 2012 Google Earth aerial imagery. For the 12 known surface sites of the Georgetown salamander, we found 3 have golf courses; 3 have livestock; and we assumed that 10 of the surface watersheds are accessible to feral hogs given that they are common across the landscape and because we could not identify any fencing that would exclude them from these areas. In addition, we found that surface watersheds for six of the seven known Salado salamander sites have livestock access. We also assumed these six surface watersheds contain feral hogs.

The threat of water quality degradation from excessive nutrient exposure alone (that is, without the consideration of additional threat sources that may be present at specific sites) could cause irreversible declines or extirpation in local populations or significant declines in habitat quality of any of the Georgetown and Salado salamanders with continuous or repeated exposure. In some instances, exposure to excessive nutrient exposure could negatively impact a salamander population in combination with exposure to other sources of water quality degradation, resulting in significant habitat declines. The City of Georgetown's water quality ordinance requires that permanent structural water quality controls for regulated activities over the Edwards Aquifer recharge zone must remove 85 percent of total suspended solids for the entire project. This increases the amount of total suspended solids that must be removed from projects within the City of Georgetown and its ETJ by 5 percent over the existing requirements (i.e. removal of 80 percent total suspended solids) found in the Edwards Aquifer Rules. Although structural water quality controls are generally less efficient at removing nutrients from stormwater, by increasing the required removal of total suspended solids, the implementation of the ordinance will result in an increase in the amount of nutrients removed from stormwater. In addition, the ordinance now requires stream buffers for all streams in the Edwards Aquifer recharge zone within the City of Georgetown and its ETJ that drain more than 64 ac (26 ha). These buffers are similar to those required under similar water quality regulations in central Texas and will help reduce the amount of nutrients and other pollutants that enter waterways. However, we still consider excessive nutrient exposure to be an ongoing threat of high impact for the Georgetown and Salado salamanders that is likely to continue in the future.

Changes in Water Chemistry

Conductivity

Conductivity is a measure of the ability of water to carry an electrical current and can be used to approximate the concentration of dissolved inorganic solids in water that can alter the internal water balance in aquatic organisms, affecting the four central Texas salamanders' survival. Conductivity levels in the Edwards Aquifer are naturally low, ranging from approximately 550 to 700 microsiemens per centimeter ($\mu S\ cm^{-1}$) (derived from several conductivity measurements in two references: Turner 2005, pp. 8–9; O'Donnell *et al.* 2006, p. 29). As ion concentrations, such as chlorides, sodium, sulfates, and nitrates rise, conductivity will increase. These compounds are the chemical products or byproducts of many common pollutants that originate from urban environments (Menzer and Nelson 1980, p. 633), which are often transported to streams via stormwater runoff from impervious cover. This combined with the stability of the measured ions makes conductivity an excellent monitoring tool for assessing the impacts of urbanization to overall water quality.

Conductivity can be influenced by weather. Rainfall serves to dilute ions and lower conductivity while drought has the opposite effect. The trends of increasing conductivity in urban watersheds were evident under baseflow conditions and during a period when precipitation was above average in all but 3 years, so drought was not a factor (NOAA 2013, pp. 1–7). The COA also monitored water quality as impervious cover increased in several subdivisions with known Jollyville Plateau salamander sites between 1996 and 2007. They found increasing ions (calcium, magnesium, and bicarbonate) and nitrates with increasing impervious cover at four Jollyville Plateau salamander sites and as a general trend during the course of the study from 1997 to 2006 (Herrington *et al.* 2007, pp. 13–14). These results indicate that developed watersheds can alter the water chemistry within salamander habitats.

High conductivity has been associated with declining salamander abundance in a species that is closely related to the Georgetown and Salado salamanders. For example, three of the four sites with statistically significant declining Jollyville Plateau salamander counts from 1997 to 2006 are cited as having high conductivity readings (O'Donnell *et al.* 2006, p. 37). Similar correlations were shown in studies comparing developed and undeveloped sites from 1996 to 1998 (Bowles *et al.* 2006, pp. 117–118). This analysis found significantly lower numbers of salamanders and significantly higher measures of specific conductance at developed sites as compared to undeveloped sites (Bowles *et al.* 2006, pp. 117–118). Tributary 5 of Bull Creek has had an increase in conductivity, chloride, and sodium and a decrease in invertebrate diversity from 1996 to 2008 (COA 2010b, p. 16). Only one Jollyville Plateau salamander has been observed here from 2009 to 2010 in quarterly surveys (Bendik 2011a, p. 16). A separate analysis found that ions such as chloride and sulfate increased in Barton Creek despite the enactment of city-wide water quality control ordinances (Turner 2007, p. 7). Poor water quality, as measured by high specific conductance and elevated levels of ion concentrations, is cited as one of the likely factors leading to statistically significant declines in salamander counts at the COA's long-term monitoring sites (O'Donnell *et al.* 2006, p. 46). Because the Jollyville Plateau salamander is similar to the Georgetown and Salado salamanders with regard to morphology, physiology, habitat requirements, and life history traits, we expect similar declines of Georgetown and Salado salamanders as impervious cover increases within Williamson and Bell Counties, Texas. The human population is projected to increase by 377 percent in the range of the Georgetown salamander and by 128 percent in the range of the Salado salamander by 2050, so we expect that conductivity levels within the areas where Georgetown and Salado salamander populations are known to occur will increase the exposure of salamanders to this stressor.

The threat of water quality degradation from high conductivity alone (that is, without the consideration of additional threat sources that may be present at specific sites) could cause irreversible declines or extirpation in local populations or significant declines in habitat quality of the Georgetown and Salado salamanders with continuous or repeated exposure. In some instances, exposure to high conductivity could negatively impact a salamander population in combination with exposure to other sources of water quality degradation, resulting in significant habitat declines. Although the best available information does not indicate that increased conductivity is occurring within the ranges of the Georgetown and Salado salamanders to date (SWCA 2012, p. 19), we expect this to become a significant threat in the future for these species as urbanization continues to expand within their surface watersheds.

Changes in Prey Base Community

As noted above, stressors from urbanization such as contaminants can alter the invertebrate community of a water body by replacing sensitive species with species that are more tolerant of pollution (Schueler 1994, p. 104; Coles *et al.* 2012, pp. 4, 58). This shift in community can have negative, indirect effects on Georgetown and Salado salamander populations. Studies on closely related species of salamanders have shown these predators to be sensitive to changes in the species composition of their prey base. For example, Johnson and Wallace (2005, pp. 305–306) found that when the Blue Ridge two-lined salamander (*Eurycea wilderae*) fed on an altered composition of prey species, salamander densities were lower compared to salamanders feeding on an unaltered prey community. The researchers partly attributed this difference in density to reduced larval growth caused by the lack of nutrition in the diet (Johnson and Wallace 2005, p. 309). Another study on the Tennessee cave salamander (*Gyrinophilus palleucus*) found the prey composition of salamanders within one cave differed from another cave, and this difference resulted in significant differences in salamander densities and biomass (Huntsman *et al.* 2011, pp. 1750–1753). Based on this literature, we conclude that the species composition of invertebrates is an important factor in determining the health of Georgetown and Salado salamander populations. Although the best available information does not indicate shifting invertebrate communities within the ranges of the Georgetown and Salado salamanders, we expect this to become a significant threat in the future for these species as urbanization continues to expand within their surface watersheds.

Water Quantity Degradation

Water quantity decreases and spring flow declines are considered threats to *Eurycea* salamanders (Corn *et al.* 2003, p. 36; Bowles *et al.* 2006, p. 111) because drying spring habitats can cause salamanders to be stranded, resulting in death of individuals (O'Donnell *et al.* 2006, p. 16). It is also known that prey availability is low underground due to the lack of primary production (Hobbs and Culver 2009, p. 392). Therefore, relying entirely on subsurface habitat during dry conditions on the surface may negatively impact the salamanders' feeding abilities and slow individual and population growth. Ultimately, dry surface conditions can exacerbate the risk of extirpation in combination with other threats occurring at the site. In addition, water quantity increases in the form of large spring discharge events and flooding may impact salamander populations by flushing individuals downstream into unsuitable habitat (Petranka and Sih 1986, p. 732; Barrett *et al.* 2010, p. 2,003) or forcing individuals into subsurface habitat refuge (Bendik 2011b, COA, pers. comm.; Bendik and Gluesenkamp 2012, pp. 3–4). Below, we evaluate the sources of water quantity alterations in Georgetown and Salado salamander habitat.

Urbanization

Increased urbanization in the watershed has been cited as one factor, particularly in combination with drought that causes alterations in spring flows (COA 2006, pp. 46–47; TPWD 2011, pp. 4–5; Coles *et al.* 2012. p. 10). This is partly due to increases in groundwater pumping and reductions in baseflow due to impervious cover. Urbanization removes the ability of a watershed to allow slow filtration of water through soils following rain events. Instead rainfall runs off impervious surfaces and into stream channels at higher rates, increasing downstream ''flash'' flows and decreasing groundwater recharge and subsequent baseflows from springs (Miller *et al.* 2007, p. 74; Coles *et al.* 2012, pp. 2, 19). Urbanization can also impact water quantity by increasing groundwater pumping and altering the natural flow regime of streams. These stressors are discussed in more detail below.

Urbanization can also result in increased groundwater pumping, which has a direct impact on spring flows, particularly under drought conditions. From 1980 to 2000, groundwater pumping in the Northern Segment of the Edwards Aquifer nearly doubled (TWDB 2003, pp. 32–33). Municipal wells within 500 ft (152 m) of San Gabriel Springs (Georgetown salamander habitat) now flow in the summer only intermittently due to pumping from nearby water wells (Booker 2011, Service, pers. comm.). Georgetown salamanders have not been found there since 1991 despite searches for them (Chippindale *et al.* 2000, p. 40; Pierce 2011b, Southwestern University, pers. comm.).

Furthermore, water levels in Williamson County wells were lower in 2005 than in 1995 (Boghici 2011, pp. 28–29). The declining water levels are attributed in part to groundwater pumping by industrial and public supply users (Berehe 2005, p. 18). Pumpage from the Edwards Aquifer has consistently exceeded the estimate available supply between 1985 and 1997 in Williamson County (Ridgeway and Petrini 1999, p. 35). Over a 50-year horizon (2001 to 2050), models predict a gradual long-term water-level decline will occur in the Pflugerville-Round Rock-Georgetown area of Williamson County (Berehe 2005, p. 2). There are 34 active public water supply systems in Williamson County (Berehe 2005, pp. 3, 63). Through water conservation programs and other efforts to meet new demands, TCEQ believes that water purveyors in Williamson County can generally maintain their present groundwater systems (Berehe 2005, pp. 3, 63). In addition, all wholesale and retail water suppliers are required to prepare and adopt drought contingency plans on TCEQ rules (Title 30, Texas Administrative Code, Chapter 288) (Berehe 2005, p. 64). However, there is no groundwater conservation district in place with authority to control large-scale groundwater pumping for private purposes (Berehe 2005, pp. 3, 63). Thus, groundwater levels may continue to decline due to private pumping.

The City of Georgetown predicts the average water demand to increase from 8.21 million gallons (30,000 kiloliters) per day in 2003, to 10.9 million gallons (37,000 kiloliters) per day by 2030 (City of Georgetown 2008, p. 3.36). Under peak flow demands (18 million gallons [68,000 kiloliters] per day in 2003), the City of Georgetown uses seven groundwater wells in the Edwards Aquifer (City of Georgetown 2008, p. 3.36). Total water use for Williamson County was 82,382 acre feet (ac ft) in 2010, and is projected to increase to 109,368 ac ft by 2020, and to 234,936 ac ft by 2060, representing a 185 percent increase over the 50-year period (TWDB 2011, p. 78). Similarly, Bell County predicts a 59 percent and 91 percent increase in total water use over the same 50-year period, respectively (TWDB 2011, pp. 5, 72).

While the demand for water is expected to increase with human population growth, future groundwater use in this area is predicted to drop as municipalities convert from groundwater to surface water supplies (TWDB 2003, p. 65). To meet the increasing water demand, the 2012 State Water Plan recommends more reliance on surface water, including existing and new reservoirs, rather than groundwater (TWDB 2012, p. 190). For example, one recommended project conveys water from Lake Travis to Williamson County (TWDB 2012, pp. 192–193). There is also a recommendation to augment the surface water of Lake Granger in Williamson County with groundwater from Burleson County and the Carrizo-Wilcox Aquifer (TWDB 2012, pp. 164, 192–193). However, it is unknown if this reduction in groundwater use will occur, and if it does, how that will affect spring flows for salamanders. Water supply from the Edwards Aquifer in Williamson and Bell Counties is projected to remain the same through 2060 (Berehe 2005, p. 38; Hassan 2011, p. 7). The Georgetown City Manager has recently indicated that the City of Georgetown will not use water from the Edwards Aquifer in plans for future and additional municipal water supplies (Brandenburg 2013, pers. comm). Instead, the City of Georgetown intends to use surface water or non-Edwards wells for future sources of water.

The COA found a negative correlation between urbanization and spring flows at Jollyville Plateau salamander sites (Turner 2003, p. 11). Field studies have also shown that a number of springs that support Jollyville Plateau salamanders have already gone dry periodically, and that spring waters resurface following rain events (O'Donnell *et al.* 2006, pp. 46–47). Through a site-by-site assessment from information available in our files and provided during the peer review and public comment period for the proposed rule, we found that at least 2 out of the 15 known Georgetown salamander surface sites and 3 out of the 7 known Salado salamander surface sites have gone dry for some period of time. Because we lack flow data for some of the spring sites, it is possible that even more sites have gone dry for a period of time as well.

Flow is a major determining factor of physical habitat in streams, which in turn, is a major determining factor of aquatic species composition within streams (Bunn and Arthington 2002, p. 492). Various land-use practices, such as urbanization, conversion of forested or prairie habitat to agricultural lands, excessive wetland draining, and overgrazing can reduce water retention within watersheds by routing rainfall quickly downstream, increasing the size and frequency of flood events and reducing baseflow levels during dry periods (Poff *et al.* 1997, pp. 772–773). Over time, these practices can degrade in-channel habitat for aquatic species (Poff *et al.* 1997, p. 773).

Baseflow is defined as that portion of stream flow that originates from shallow, subsurface groundwater sources, which provide flow to streams in periods of little rainfall (Poff *et al.* 1997, p. 771). The land-use practices mentioned above can cause stream flow to shift from predominately base flow, which is derived from natural filtration processes, to predominately stormwater runoff. For example, an examination of 24 stream sites in the urbanized Austin area revealed that increasing impervious cover in the watersheds resulted in decreased base flow, increased high-flow events of shorter duration, and more rapid rises and falls of the stream flow (Glick *et al.* 2009, p. 9). Increases in impervious cover within the Walnut Creek watershed (Jollyville Plateau salamander habitat) have likely caused a shift to more rapid rises and falls of that stream flow (Herrington 2010, p. 11).

With increasing stormwater runoff, the amount of baseflow available to sustain water supplies during drought cycles is diminished and the frequency and severity of flooding increases (Poff *et al.* 1997, p. 773). The increased quantity and velocity of runoff increases erosion and streambank destabilization, which in turn, leads to increased sediment loadings, channel widening, and detrimental changes in the morphology and aquatic ecology of the affected stream system (Hammer 1972, pp. 1,535–1,536, 1,540; Booth 1990, pp. 407–409, 412–414; Booth and Reinelt 1993, pp. 548–550; Schueler 1994, pp. 106–108; Pizzuto *et al.* 2000, p. 82; Center for Watershed Protection 2003, pp. 41–48; Coles *et al.* 2012, pp. 37–38). The City of Georgetown's water quality ordinance requires that regulated activities occurring on the Edwards Aquifer recharge zone shall not cause any increase in the developed flow rate of stormwater for the 2-year, 3-hour storm. Most municipalities currently enforce this or a similar standard for new developments, and it is unclear the effect this requirement will have on the quantity and velocity of runoff from developments in Georgetown or its ETJ.

Changes in flow regime can directly affect salamander populations. For example, the density of aquatic southern two-lined salamanders (*Eurycea cirrigera*) declined more drastically in streams with urbanized watersheds compared to streams with forested or pastured watersheds in Georgia (Barrett *et al.* 2010, pp. 2,002–2,003). A statistical analysis indicated that this decline in urban streams was due to an increase in flooding frequency from stormwater runoff. In artificial stream experiments, salamander larvae were flushed from sand-based sediments at significantly lower velocities, as compared to gravel, pebble, or cobble-based sediments (Barrett *et al.* 2010, p. 2,003). This has also been observed in the wild in small-mounted salamanders (*Ambystoma texanum*) whereby large numbers of individuals were swept downstream during high stream discharge events resulting in death by predation or physical trauma (Petranka and Sih 1986, p. 732). We expect increased flow velocities from impervious cover will cause the flushing of Georgetown and Salado salamanders from their habitats.

The threat of water quantity degradation from urbanization could cause irreversible declines in population sizes or habitat quality for the Georgetown and Salado salamanders. Also, it could cause irreversible declines or the extirpation of a salamander population at a site with continuous exposure. Although we do not consider water quantity degradation from urbanization to be a significant threat to Georgetown and Salado salamanders at the present time, we expect this threat to become significant in the future as urbanization expands within these species' surface watersheds.

Drought

Drought conditions cause lowered groundwater tables and reduced spring flows. The Northern Segment of the Edwards Aquifer, which supplies water to Georgetown and Salado salamander habitat, is vulnerable to drought (Chippindale *et al.* 2000, p. 36). A drought lasting from 2008 to 2009 was considered one of the worst droughts in central Texas history and caused numerous salamander sites to go dry in the central Texas region (Bendik 2011a, p. 31). An even more pronounced drought throughout Texas began in 2010, with the period from October 2010 through September 2011 being the driest 12-month period in Texas since rainfall records began (Hunt *et al.* 2012, p. 195). Rainfall in early 2012 lessened the intensity of drought conditions, but 2012 monthly summer temperatures continued to be higher than average (NOAA 2013, p. 6). Moderate to extreme drought conditions continued into 2013 in the central Texas region (LCRA 2013, p. 1). Weather forecasts called for near to slightly less than normal rainfall across Texas through August 2013, but there was not enough rain to break the drought (LCRA 2013, p. 1). Year-end totals show that 2013 was the second lowest year of inflows into the Highland Lakes region of central Texas since the dams were built in the 1940s. There was some heavy rain in late-2013 in central Texas but much of it fell in Austin or downstream of Austin having little effect on recharging the Edwards Aquifer (LCRA 2014, p. 1).

The specific effects of low flow on the Georgetown and Salado salamanders can be inferred by examining studies on the closely related Barton Springs salamander. Drought decreases spring flow and dissolved oxygen levels and increases temperature in Barton Springs (Turner 2004, p. 2; Turner 2009, p. 14). Low dissolved oxygen levels decrease reproduction in Barton Springs salamanders (Turner 2004, p. 6; 2009, p. 14). Turner (2009, p. 14) also found that Barton Springs salamander counts decline with decreasing discharge. The number of Barton Springs salamander observed during surveys decreased during a prolonged drought from June 2008 through September 2009 (COA 2011, pp. 19, 24, 27). The drought in 2011 also resulted in dissolved oxygen concentrations so low that COA used an aeration system to maintain oxygenated water in Eliza and Sunken Gardens Springs (Dries 2011, COA, pers. comm.).

The Georgetown and Salado salamanders may be able to persist through temporary surface habitat degradation because of their ability to retreat to subsurface habitat. Drought conditions are common to the region, and the ability to retreat underground may be an evolutionary adaptation of *Eurycea* salamanders to such natural conditions (Bendik 2011a, pp. 31–32). However, it is important to note that although salamanders may survive a drought by retreating underground, this does not necessarily mean they are resilient to long-term drought conditions (particularly because sites may already be affected by other, significant stressors, such as water quality declines). Studies on other aquatic salamander species have reported decreased occupancy, loss of eggs, decreased egg-laying, and extirpation from sites during periods of drought (Camp *et al.* 2000, p. 166; Miller *et al.* 2007, pp. 82–83; Price *et al.* 2012b, pp. 317–319).

Dry surface conditions can affect salamanders by reducing their access to food. Surface habitats are important for prey availability as well as individual and population growth. Therefore, sites with suitable surface flow and adequate prey availability are likely able to support larger population densities (Bendik 2012, COA, pers. comm.). Research on related salamander species, such as the grotto salamander (*Typhlotriton spelaeus*) and the Oklahoma salamander (*Eurycea tynerensis*), demonstrates that resource-rich surface habitat is necessary for juvenile growth (Tumlison and Cline 1997, p. 105). Prey availability for carnivores, such as the Georgetown and Salado salamanders, is low underground due to the lack of sunlight and primary production (Hobbs and Culver 2009, p. 392). Complete loss of surface habitat may lead to the extirpation of predominately subterranean populations that depend on surface flows for biomass input (Bendik 2012, COA, pers. comm.). In addition, length measurements taken during a COA mark-recapture study at Lanier Spring demonstrated that individual Jollyville Plateau salamanders exhibited negative growth (shrinkage) during a 10-month period of retreating to the subsurface from 2008 to 2009 (Bendik 2011b, COA, pers. comm.; Bendik and Gluesenkamp 2012, pp. 3–4). The authors of this study hypothesized that the negative growth could be the result of soft tissue contraction and/or bone loss, but more research is needed to determine the physical mechanism with which the shrinkage occurs (Bendik and Gluesenkamp 2012, p. 5). Although this shrinkage in body length was followed by positive growth when normal spring flow returned, the long-term consequences of catch-up growth are unknown for these salamanders (Bendik and Gluesenkamp 2012, pp. 4–5).

Therefore, threats to surface habitat at a given site may not extirpate populations of these salamander species in the short term, but this type of habitat degradation may severely limit population growth and increase a population's overall risk of extirpation from other stressors occurring in the surface watershed.

The threat of water quantity degradation from drought alone (that is, without the consideration of additional threat sources that may be present at specific sites) could cause irreversible declines in population sizes or habitat quality for the Georgetown and Salado salamanders. Also, it could negatively impact salamander populations in combination with other threats and contribute to significant declines in the size of the populations or habitat quality. For example, changes in water quantity will have direct impacts on the quality of that water in terms of concentrations of contaminants and pollutants. Therefore, we consider water quantity degradation from drought to be a threat of high impact for the Georgetown and Salado salamanders now and in the future.

Climate Change

Our analyses under the Endangered Species Act include consideration of ongoing and projected changes in climate. The terms ''climate'' and ''climate change'' are defined by the Intergovernmental Panel on Climate Change (IPCC). The term ''climate'' refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007a, p. 78). The term ''climate change'' thus refers to a change in the mean or variability of one or more measures of climate (for example, temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007a, p. 78).

According to the IPCC (2007b, p. 1), ''Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.'' Average Northern Hemisphere temperatures during the second half of the 20th century were very likely higher than during any other 50-year period in the last 500 years and likely the highest in at least the past 1300 years (IPCC 2007b, p. 1). It is very likely that from 1950 to 2012 cold days and nights have become less frequent, and hot days and hot nights have become more frequent on a global scale (IPCC 2013, p. 4). It is likely that the frequency and intensity of heavy precipitation events has increased over North America (IPCC 2013, p. 4).

The IPCC (2013, pp. 15–16) predicts that changes in the global climate system during the 21st century are very likely to be larger than those observed during the 20th century. For the next two decades (2016 to 2035), a warming of 0.3 °C (0.5 °F) to 0.7 °C (1.3 °F) per decade is projected (IPCC 2013, p. 15). Afterwards, temperature projections increasingly depend on specific emission scenarios (IPCC 2007b, p. 6). Various emissions scenarios suggest that by the end of the 21st century, average global temperatures are expected to increase 0.3 °C to 4.8 °C (0.5 °F to 8.6 °F), relative to 1986 to 2005 (IPCC 2013, p. 15). By the end of 2100, it is virtually certain that there will be more frequent hot and fewer cold temperature extremes over most land areas on daily and seasonal timescales, and it is very likely that heat waves and extreme precipitation events will occur with a higher frequency and intensity (IPCC 2013, pp. 15–16).

Global climate projections are informative, and, in some cases, the only or the best scientific information available for us to use. However, projected changes in climate and related impacts can vary substantially across and within different regions of the world (for example, IPCC 2007b, p. 9). Therefore, we use ''downscaled'' projections when they are available and have been developed through appropriate scientific procedures, because such projections provide higher resolution information that is more relevant to spatial scales used for analyses of a given species (see Glick *et al.* 2011, pp. 58–61, for a discussion of downscaling). With regard to our analysis for the Georgetown and Salado species, downscaled projections are available.

Localized projections suggest the southwest may experience the greatest temperature increase of any area in the lower 48 States (IPCC 2007b, p. 8). Temperature in Texas is expected to increase by up to 4.8 °C (8.6 °F) by the end of 2100 (Jiang and Yang 2012, p. 235). The IPCC also predicts that hot extremes and heat waves will increase in frequency and that many semi-arid areas like the western United States will suffer a decrease in water resources due to climate change (IPCC 2007b, p. 8). Model projections of future climate in southwestern North America show a transition to a more arid climate that began in the late 20th and early 21st centuries (Seager *et al.* 2007, p. 1183). Milly *et al.* (2005, p. 349) project a 10 to 30 percent decrease in stream flow in mid-latitude western North America by the year 2050 based on an ensemble of 12 climate models. Based on downscaling global models of climate change, Texas is expected to receive up to 20 percent less precipitation in winters and up to 10 percent more precipitation in summers (Jiang and Yang 2012, p. 238). However, most regions in Texas are predicted to become drier as temperatures increase (Jiang and Yang 2012, pp. 240–242).

An increased risk of drought in Texas could occur if evaporation exceeds precipitation levels in a particular region due to increased greenhouse gases in the atmosphere (CH2M HILL 2007, p. 18). A reduction of recharge to aquifers and a greater likelihood for more extreme droughts, such as the droughts of 2008 to 2009 and 2011, were identified as potential climate change-related impacts to water resources (CH2M HILL 2007, p. 23). Extreme droughts in Texas are now much more probable than they were 40 to 50 years ago (Rupp *et al.* 2012, pp. 1053–1054).

Various changes in climate may have direct or indirect effects on species. These effects may be positive, neutral, or negative, and they may change over time, depending on the species and other relevant considerations, such as interactions of climate with other variables (for example, habitat fragmentation) (IPCC 2007a, pp. 8–14, 18–19). Identifying likely effects often involves aspects of climate change vulnerability analysis. Vulnerability refers to the degree to which a species (or system) is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the type, magnitude, and rate of climate change and variation to which a species is exposed, its sensitivity, and its adaptive capacity (IPCC 2007a, p. 89; see also Glick *et al.* 2011, pp. 19–22). There is no single method for conducting such analyses that applies to all situations (Glick *et al.* 2011, p. 3). We use our expert judgment and appropriate analytical approaches to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change.

Climate change could compound the threat of decreased water quantity at salamander spring sites. Recharge, pumping, natural discharge, and saline intrusion of Texas groundwater systems could all be affected by climate change (Mace and Wade 2008, p. 657). Although climate change predictions on the Northern Segment of the Edwards Aquifer are not available, the Southern Edwards Aquifer is predicted to experience additional stress from climate change that could lead to decreased recharge (Loáiciga *et al.* 2000, pp. 192–193). In addition, CH2M HILL (2007, pp. 22–23) identified possible effects of climate change on water resources within the Lower Colorado River Watershed (which contributes recharge to the Barton Springs Segment of the Edwards Aquifer, just south of the range of the Georgetown and Salado salamanders). We therefore conclude that the best available evidence indicates that the Northern Segment of the Edwards Aquifer will respond similarly to climate change as the rest of the Edwards Aquifer.

Rainfall and ambient temperatures are factors that may affect Georgetown and Salado salamander populations. Different ambient temperatures in the season that rainfall occurs can influence spring water temperature if aquifers have fast transmission of rainfall to springs (Martin and Dean 1999, p. 238). Gillespie (2011, p. 24) found that reproductive success and juvenile survivorship in the Barton Springs salamander may be significantly influenced by fluctuations in mean monthly water temperature. This study also found that groundwater temperature is influenced by the season in which rainfall events occur over the recharge zone of the aquifer. When recharging rainfall events occur in winter when ambient temperature is low, mean monthly water temperature within the aquatic habitat of this species can drop as low as 65.5 °F (18.6 °C) and remain below the annual average temperature of 70.1 °F (21.2 °C) for several months (Gillespie 2011, p. 24).

In summary, the threat of water quantity degradation from climate change could negatively impact the Georgetown and Salado salamanders in combination with other threats and contribute to significant declines in population sizes or habitat quality. We consider this to be a threat of moderate impact for the Georgetown and Salado salamanders now and in the future.

Physical Modification of Surface Habitat

The Georgetown and Salado salamanders are sensitive to direct physical modification of surface habitat from sedimentation, impoundments, flooding, feral hogs, livestock, and human activities. Direct mortality to salamanders can also occur as a result of these stressors, such as being crushed by feral hogs, livestock, or humans.

Sedimentation

Elevated mobilization of sediment (mixture of silt, sand, clay, and organic debris) is a stressor that occurs as a result of increased velocity of water running off impervious surfaces (Schram 1995, p. 88; Arnold and Gibbons 1996, pp. 244–245). Increased rates of stormwater runoff also cause increased erosion through scouring in headwater areas and sediment deposition in downstream channels (Booth 1991, pp. 93, 102–105; Schram 1995, p. 88). Waterways are adversely affected in urban areas, where impervious cover levels are high, by sediment loads that are washed into streams or aquifers during storm events. Sediments are either deposited into layers or become suspended in the water column (Ford and Williams 1989, p. 537; Mahler and Lynch 1999, p. 177). Sediment derived from soil erosion has been cited as the greatest single source of pollution of surface waters by volume (Menzer and Nelson 1980, p. 632).

Excessive sediment from stormwater runoff is a threat to the physical habitat of salamanders because it can cover substrates (Geismar 2005, p. 2). Sediments suspended in water can clog gill structures in aquatic animals, which can impair breathing and reduce their ability to avoid predators or locate food sources due to decreased visibility (Schueler 1987, p. 1.5). Excessive deposition of sediment in streams can physically reduce the amount of available habitat and protective cover for aquatic organisms, by filling the interstitial spaces of gravel and rocks where they could otherwise hide. As an example, a California study found that densities of two aquatic salamander species were significantly lower in streams that experienced a large infusion of sediment from road construction after a storm event (Welsh and Ollivier 1998, pp. 1,118–1,132). The vulnerability of the aquatic salamander species in this California study was attributed to their reliance on interstitial spaces in the streambed habitats (Welsh and Ollivier 1998, p. 1,128).

Excessive sedimentation has contributed to declines in Jollyville Plateau salamander populations in the past. Monitoring by the COA found that, as sediment deposition increased at several sites, salamander abundances significantly decreased (COA 2001, pp. 101, 126). Additionally, the COA found that sediment deposition rates have increased significantly along one of the long-term monitoring sites (Bull Creek Tributary 5) as a result of construction activities upstream (O'Donnell *et al.* 2006, p. 34). This site has had significant declines in salamander abundance, based on 10 years of monitoring, and the COA attributes this decline to the increases in sedimentation (O'Donnell *et al.* 2006, pp. 34–35). The location of this monitoring site is within a large preserved tract. However, the headwaters of this drainage are outside the preserve and the development in this area increased sedimentation downstream and impacted salamander habitat within the preserved tract.

Effects of sedimentation on the Georgetown and Salado salamanders are expected to be similar to the effects on the Barton Spring salamanders based on similarities in their ecology and life-history needs. Barton Spring salamander population numbers are adversely affected by high turbidity and sedimentation (COA 1997, p. 13). Sediments discharge through Barton Springs, even during baseflow conditions (not related to a storm event) (Geismar 2005, p. 12). Storms can increase sedimentation rates substantially (Geismar 2005, p. 12). Areas in the immediate vicinity of the spring outflows lack sediment, but the remaining bedrock is sometimes covered with a layer of sediment several inches thick (Geismar 2005, p. 5). Further, urban development within the watersheds of Georgetown and Salado salamander sites will increase sedimentation and degrade water quality in salamander habitat both during and after construction activities. However, the City of Georgetown's water quality ordinance requires that permanent structural water quality controls for regulated activities over the Edwards Aquifer recharge zone must remove 85 percent of total suspended solids for the entire project. This increases the amount of total suspended solids that must be removed from projects within the City of Georgetown and its ETJ by 5 percent over the existing requirements (i.e. removal of 80 percent total suspended solids) found in the Edwards Aquifer Rules. Additional threats from sediments as a source of contaminants were discussed in the ''Contaminants and Pollutants'' under the ''Water Quality Degradation'' section above.

The threat of physical modification of surface habitat from sedimentation by itself could cause irreversible declines in population sizes or habitat quality for the Georgetown and Salado salamanders. It could also negatively impact the species in combination with other threats to contribute to significant declines. Although we do not consider this to be an ongoing threat to the Georgetown and Salado salamanders at the present time, we expect physical modification of surface habitat from sedimentation to become a significant threat in the future as urbanization expands within these species' surface watersheds.

Impoundments

Impoundments can alter the Georgetown and Salado salamanders' physical habitat in a variety of ways that are detrimental. Impoundments can alter the natural flow regime of streams, increase siltation, support larger, predatory fish (Bendik 2011b, COA, pers. comm.), leading to a variety of impacts to the Georgetown and Salado salamanders and their surface habitats. For example, a low water crossing on a tributary of Bull Creek occupied by the Jollyville Plateau salamander resulted in sediment build-up above the impoundment and a scour hole below the impoundment that supported predaceous fish (Bendik 2011b, COA, pers. comm.). As a result, Jollyville Plateau salamanders were not found in this degraded habitat after the impoundment was constructed. When the crossing was removed in October 2008, the sediment build-up was removed, the scour hole was filled, and Jollyville Plateau salamanders were later observed (Bendik 2011b, COA, pers. comm.).

Impoundments have also impacted some of the Georgetown and Salado salamanders' surface habitats. Two sites for the Georgetown salamander (Cobb Spring and Shadow Canyon) have spring openings that are surrounded at least in part by brick and mortar impoundments (White 2011, SWCA, pers. comm.; Booker 2011, Service, pers. comm.), presumably to collect the spring water for cattle. San Gabriel Springs is also impounded with a substrate of aquarium gravel (Booker 2011, Service, pers. comm.). However, the future threat of impoundments at occupied Georgetown salamander sites has been reduced through the City of

Georgetown's water quality ordinance. The ordinance established a 984-ft (300-m) buffer zone within which the construction of impoundments would not be permitted. In addition, all springs within the City of Georgetown or its ETJ will be protected by a 164-ft (50-m) buffer zone. Two sites for the Salado salamander (Cistern Springs and Lazy Days Fish Farm) have been modified by impoundments.

The threat of physical modification of surface habitat from impoundments by itself may not be likely to cause significant population declines, but it could negatively impact the Salado salamander in combination with other threats and contribute to significant declines in the population size or habitat quality. We consider impoundments to be an ongoing threat of moderate impact to the Salado salamander and their surface habitats that will continue in the future. Due to the City of Georgetown's water quality ordinance, we do not expect additional Georgetown salamander sites to be impounded in the future.

Flooding

Flooding as a result of rainfall events can considerably alter the substrate and hydrology of salamander habitat, negatively impacting salamander populations and behavior (Rudolph 1978, p. 155). Extreme flood events have occurred in the Georgetown and Salado salamanders' surface habitats (Pierce 2011a, p. 10; TPWD 2011, p. 6; Turner 2009, p. 11; O'Donnell *et al.* 2005, p. 15). A flood in September 2010 modified surface habitat for the Georgetown salamander in at least two sites (Swinbank Spring and Twin Springs) (Pierce 2011a, p. 10). The stormwater runoff caused erosion, scouring of the streambed channel, the loss of large rocks, and the creation of several deep pools. Georgetown salamander densities dropped dramatically in the days following the flood (Pierce 2011a, p. 11). At Twin Springs, Georgetown salamander densities increased some during the winter following the flood and again within 2 weeks after habitat restoration took place (returning large rocks to the spring run) in the spring of 2011 (Pierce 2011a, p. 11). Likewise, three storm events in 2009 and 2010 deposited sediment and other material on top of spring openings at Salado Spring (TPWD 2011, p. 6). The increased flow rate from flooding causes unusually high dissolved oxygen concentrations, which may exert direct or indirect, sub-lethal effects (reduced reproduction or foraging success) on salamanders (Turner 2009, p. 11).

Salamanders also may be flushed from the surface habitat by strong flows during flooding, which can result in death by predation or by physical trauma, as has been observed in other aquatic salamander species (Baumgartner *et al.* 1999, p. 36; Sih *et al.* 1992, p. 1,429). Bowles *et al.* (2006, p. 117) observed no Jollyville Plateau salamanders in riffle habitat at one site during high water velocities and hypothesized that individual salamanders were either flushed downstream or retreated to the subsurface. Rudolph (1978, p. 158) observed that severe floods could reduce populations of five different species of aquatic salamanders by 50 to 100 percent.

Flooding can alter the surface salamander habitat by deepening stream channels, which may increase habitat for predaceous fish. Much of the Georgetown and Salado salamanders' surface habitat is characterized by shallow water depth (COA 2001, p. 128; Pierce 2011a, p. 3). However, deep pools are sometimes formed within stream channels from the scouring of floods. As water depth increases, the deeper pools support more predaceous fish populations. However, several central Texas *Eurycea* species are able to survive in deep water environments in the presence of many predators. Examples include the San Marcos salamander in Spring Lake, *Eurycea* species in Landa Lake, and the Barton Springs salamander in Barton Springs Pool. All of these sites have vegetative cover, which may allow salamanders to avoid predation. Anti-predator behaviors may allow these species to co-exist with predaceous fish, but the effectiveness of these behaviors may be species-specific (reviewed in Pierce and Wall 2011, pp. 18–19), and many of the shallow surface habitats of the Georgetown and Salado salamanders do not have much vegetative cover.

The threat of physical modification of surface habitat from flooding by itself may not be likely to cause significant population declines, but it could negatively impact the species in combination with other threats and contribute to significant declines in the population size or habitat quality. We consider this to be a threat of moderate impact to the Georgetown and Salado salamanders that will likely increase in the future as urbanization and impervious cover increases within the surface watersheds of these species, causing more frequent and more intense flash flooding (see discussion in the ''Urbanization'' section under ''Water Quantity Degradation'' above).

Feral Hogs

Feral hogs are another source of physical habitat disturbance to Georgetown and Salado salamander surface sites. There are between 1.8 and 3.4 million feral hogs in Texas, and the feral hog population in Texas is projected to increase 18 to 21 percent every year (Texas A&M University (TAMU) 2011, p. 2). Feral hogs prefer to live around moist areas, including riparian areas near streams, where they can dig into the soft ground for food and wallow in mud to keep cool (Mapson 2004, pp. 11, 14–15). Feral hogs disrupt these ecosystems by decreasing plant species diversity, increasing invasive species abundance, increasing soil nitrogen, and exposing bare ground (TAMU 2012, p. 4). Feral hogs negatively impact surface salamander habitat by digging and wallowing in spring heads, which increases sedimentation downstream (O'Donnell *et al.* 2006, pp. 34, 46). This activity can also result in direct mortality of amphibians (Bull 2009, p. 243).

Feral hogs have become abundant in some areas where the Georgetown and Salado salamanders occur. Evidence of hogs has been observed near one Georgetown salamander site (Cobbs Spring) (Booker 2011, Service, pers. comm.). The landowner of Cobbs Spring is actively trapping feral hogs (Booker 2011, Service, pers. comm.), but the effectiveness of this management has not been assessed. Feral hogs are also present in the area of several Salado salamander sites. At least one private landowner has fenced off three spring sites known to be occupied by the Salado salamander (Cistern, Hog Hollow, and Solana Springs) (Glen 2012, Sedgwick LLP, pers. comm.), which likely provides protection from feral hogs at these sites.

The threat of physical modification of surface habitat from feral hogs by itself may not be likely to cause significant population declines, but it could negatively impact the Georgetown and Salado salamanders in combination with other threats and contribute to significant declines in the population size or habitat quality. We consider physical modification of surface habitat from feral hogs to be an ongoing threat of moderate impact to the Georgetown and Salado salamanders that will likely continue in the future as the feral hog population increases.

Livestock

Similar to feral hogs, livestock can negatively impact surface salamander habitat by disturbing the substrate and increasing sedimentation in the spring run where salamanders are often found. Poorly managed livestock grazing results in changes in vegetation (from grass-dominated to brush-dominated), which leads to increased erosion of the soil profile along stream banks (COA 1995, p. 3–59) and sediment in salamander habitat. Evidence of trampling and grazing in riparian areas from cattle was found at one Georgetown salamander site (Shadow Canyon) (White 2011, SWCA, pers. comm.), and cattle are present on at least one other Georgetown salamander site (Cobbs Spring). Cattle are also present on lands where four Salado salamander sites occur (Gluesenkamp 2011c, TPWD, pers. comm.; Texas Section Society for Range Management 2011, p. 2). However, a private landowner has fenced three spring sites where Salado salamanders are known to occur (Cistern, Hog Hollow, and Cistern Springs), which likely provide the salamander and its habitat protection from the threat of livestock at these locations (Glen 2012, Sedgwick LLP, pers. comm.).

We assessed the risk of exposure of the Georgetown and Salado salamanders to the threat of physical habitat modification from livestock by examining 2012 Google Earth aerial imagery. Because livestock are so common across the landscape, we assumed that where present, these animals have access to spring sites unless they are fenced out. For our assessment, we assumed that unless we could identify the presence of fencing or unless the site is located in a densely urbanized area, livestock have access and present a threat of physical habitat modification to as many as 9 of the 15 Georgetown salamander surface sites and 1 of the 7 Salado salamander sites.

There is some management of livestock occurring that reduces the magnitude of negative impacts. An 8,126-ac (3,288-ha) property in Bell County with at least three Salado salamander sites (Cistern, Hog Hollow, and Solana Springs) has limited its cattle rotation to a maximum of 450 head (Texas Section Society for Range Management 2011, p. 2), which is considered a moderate stocking rate. In addition, the landowner of Cobbs Spring (a Georgetown salamander site) is in the process of phasing out cattle on the property (Boyd 2011, Williamson County Conservation Foundation, pers. comm.).

The threat of physical modification of surface habitat from livestock by itself may not be likely to cause significant population declines, but it could negatively impact the Georgetown and Salado salamanders in combination with other threats and contribute to significant declines in the population size or habitat quality, particularly with repeated or continuous exposure. We consider livestock to be an ongoing threat of moderate impact to the Georgetown salamander because 9 of its 15 surface sites are likely affected. On the other hand, because only 1 of the 7 Salado salamander surface sites is exposed to livestock, we do not consider this to be a threat to the Salado salamander now or in the future.

Other Human Activities

Some of the Georgetown and Salado salamander sites have been directly modified by human-related activities. In the summer of 2008, a spring opening at a Salado salamander site was covered with gravel (Service 2010, p. 6). Although we received anecdotal information that at least one salamander was observed at the site after the gravel was dumped at Big Boiling Springs, the Service has no detailed information on how the Salado salamander was affected by this action. Heavy machinery is currently used in the riparian area of Big Boiling and Lil' Bubbly Springs to clear out vegetation and maintain a grassy lawn to the water's edge (Gluesenkamp 2011a, c, TPWD, pers. comm.), which has led to erosion problems during flood events (TPWD 2011, p. 6). The modification of springs for recreation or other purposes degrades natural riparian areas, which are important for controlling erosion and attenuating floodwaters in aquatic habitats.

Other recent human activities at Big Boiling Spring include pumping water from the spring opening, contouring the substrate of the spring environment, and covering spring openings with gravel (TPWD 2011, p. 4). In the fall of 2011, the outflow channels and edges of Big Boiling and Lil' Bubbly Springs were reconstructed with large limestone blocks and mortar. In addition, the U.S. Army Corps of Engineers issued a cease and desist order to the Salado Chamber of Commerce in October 2011, for unauthorized discharge of dredged or fill material that occurred in this area (Brooks 2011, U.S. Army Corps of Engineers, pers. comm.). This order was issued in relation to the need for a section 404 permit under the Clean Water Act (33 U.S.C. 1251 *et seq.*). Also in October 2011, a TPWD game warden issued a citation to the Salado Chamber of Commerce due to the need for a sand and gravel permit from the TPWD for these activities being conducted within TPWD's jurisdiction (Heger 2012a, TPWD, pers. comm.). The citation was issued because the Salado Chamber of Commerce had been directed by the game warden to stop work within TPWD's jurisdiction until they obtained a permit, which the Salado Chamber of Commerce did temporarily, but work started again despite the game warden's directive (Heger 2012a, TPWD, pers. comm.). A sand and gravel permit was obtained on March 21, 2012. The spring run modifications were already completed by this date, but further modifications in the springs were prohibited by the permit. Additional work on the bank of Salado Creek upstream of the springs was permitted and completed (Heger 2012b, TPWD, pers. comm.).

At the complex of springs occupied by the Georgetown salamander within San Gabriel River Park, a thick bed of nonnative aquarium gravel has been placed in the spring runs (TPWD 2011, p. 9). This gravel is too small to serve as cover habitat and does not form the interstitial spaces required for Georgetown salamanders. Georgetown salamanders have not been observed here since 1991 (Chippindale *et al.* 2000, p. 40; Pierce 2011b, Southwestern University, pers. comm.). Aquarium gravel dumping has not been documented at any other Georgetown salamander sites. The City of Georgetown's water quality ordinance establishes a 262-ft (80-m) no-disturbance zone around occupied sites within which only limited activities such as maintenance of existing improvements, scientific monitoring, and fences will be permitted. In addition, the ordinance establishes a no-disturbance zone that extends 164 ft (50 m) around all springs within the Edwards Aquifer recharge zone in Georgetown and its ETJ. These measures will reduce the threat of habitat modification as the result of human activities. Additionally, for the Georgetown salamander, the Adaptive Management Working Group is charged specifically with reviewing Georgetown salamander monitoring data and new research over time and recommending improvements to the ordinance that may be necessary to ensure that it achieves its stated purposes. This Adaptive Management Working Group, which includes representatives of the Service and TPWD, will also review and make recommendations on the approval of any variances to the ordinance.

Frequent human visitation of sites occupied by the Georgetown and Salado salamanders may negatively affect the species and their habitats. The COA has documented disturbed vegetation, vandalism, and the destruction of travertine deposits (fragile rock formations formed by deposit of calcium carbonate on stream bottoms) by pedestrian traffic at one of their Jollyville Plateau salamander monitoring sites in the Bull Creek watershed (COA 2001, p. 21), and it may have resulted in direct destruction of small amounts of the salamander's habitat. Eliza Spring and Sunken Garden Spring, locations for both the Barton Springs and Austin blind salamanders, also experience vandalism despite the presence of fencing and signage (Dries 2011, COA, pers. comm.). Frequent human visitation can reduce the amount of cover available for salamander breeding, feeding, and sheltering. We are aware of impacts from recreational use at one Georgetown salamander site (San Gabriel Springs) and two Salado salamander sites (Big Boiling and Lil Bubbly Springs) (TPWD 2011, pp. 6, 9). However, as the human population is projected to increase by 377 percent in the range of the Georgetown salamander and by 128 percent in the range of the Salado salamander by 2050, we expect more Georgetown and Salado salamander sites will be negatively affected from frequent human visitation.

The threat of physical modification of surface habitat from human visitation, recreation, and alteration is not significantly affecting the Georgetown and Salado salamanders now. However, we consider this will be a threat of moderate impact in the future as the human population increases in Williamson and Bell Counties.

Conservation Efforts To Reduce Habitat Destruction, Modification, or Curtailment of Its Range

When considering the listing determination of species, it is important to consider conservation efforts that are nonregulatory, such as habitat conservation plans, safe harbor agreements, habitat management plans, memorandums of understanding, or other voluntary actions that may be helping to ameliorate stressors to the species' habitat, but are not legally required. There have been a number of efforts aimed at minimizing the habitat destruction, modification, or curtailment of the salamanders' ranges. For example, the WCCF, a nonprofit organization established by Williamson County in 2002, is currently working to find ways to conserve endangered species and other unlisted species of concern in Williamson County, Texas. This organization held a Georgetown salamander workshop in November 2003, in an effort to bring together landowners, ranchers, farmers, developers, local and state officials, Federal agencies, and biologists to discuss information currently known about the Georgetown salamander and to educate the public on the threats faced by this species.

In a separate undertaking, and with the help of a grant funded through section 6 of the Act, the WCCF developed the Williamson County Regional Habitat Conservation Plan (HCP) to obtain a section 10(a)(1)(B) permit for incidental take of federally listed endangered species in Williamson County, Texas. This HCP became final in October 2008. Although the Georgetown salamander was not a covered species in the incidental take permit, the WCCF included some considerations for the Georgetown salamander in the HCP. In particular, they included work to conduct a status review of the Georgetown salamander, which is currently underway. The WCCF began allocating funding for Georgetown salamander research and monitoring beginning in 2010. The WCCF plans to fund at least $50,000 per year for 5 years for monitoring, surveying, and gathering baseline data on water quality and quantity at salamander spring sites. They intend to use information gathered during this status review to develop a conservation strategy for this species. A portion of that funding supported mark-recapture studies of the Georgetown salamander at two of its known localities (Twin Springs and Swinbank Spring) in 2010 and 2011 (Pierce 2011a, p. 20) by Dr. Benjamin Pierce of Southwestern University, who had already been studying the Georgetown salamander for several years prior to this. Additional funds have been directed at water quality assessments of at least two known localities and efforts to find previously undiscovered Georgetown salamander populations (Boyd 2011, WCCF, pers. comm.). We have received water quality data on several Georgetown salamander locations (SWCA 2012, pp. 11–20) and the location of one previously undiscovered Georgetown salamander population (Hogg Hollow Spring 2; Covey 2013, pers. comm.) as a result of this funding.

The Service worked with the WCCF to develop the Williamson County Regional HCP for several listed karst invertebrates, and it is also expected to benefit the Georgetown salamander by lessening the potential for water quality degradation where karst invertebrate preserves are established in the surface watersheds of known Georgetown salamander sites. As part of the Williamson County Regional HCP, the WCCF has begun establishing preserves that are beneficial to karst invertebrate species. In addition, the WCCF has purchased an easement on the 64.4-ac (26.1-ha) Lyda tract (Cobbs Cavern) in Williamson County through the Service's section 6 grant program. This section 6 grant was awarded for the protection of listed karst invertebrate species; however, protecting this land also benefits the Georgetown salamander. Although the spring where salamanders are located was not included in the easement, a portion of the contributing surface watershed was included. For this reason, some water quality benefits to the salamander are expected. In January 2008, the WCCF also purchased the 145-ac (59-ha) Twin Springs preserve area. This area contains one of the sites known to be occupied by the Georgetown salamander. This species is limited to 17 known localities, 2 of which (Cobbs Spring and Twin Springs) have some amount of protection by the WCCF. The population size of Georgetown salamanders at Cobbs Spring is unknown, while the population size at Twin Springs is estimated to be 100 to 200 individuals (Pierce 2011a, p. 18). Furthermore, the surface watersheds of both springs are currently only partially protected by the WCCF, and there is uncertainty about where subsurface flows are coming from at both sites and whether or not these subsurface areas are protected as well.

In Bell County, the landowners of a 8,126-ac (3,288-ha) property (Solana Ranch) with at least three Salado salamander sites along with the landowner of another property (Robertson Ranch) that contains one Salado salamander site have shown a commitment to natural resource conservation and land stewardship practices that benefit the Salado salamander. Neither ranch owner has immediate plans to develop their land, which means that the Salado salamander is currently not faced with threats from urbanization (see discussion above under Factor A) at these four sites. Furthermore, in early 2013, the Texas Nature Conservancy acquired funding to obtain a conservation easement over 256 acres (104 hectares) of the Solana Ranch that encompasses all three spring outlets (Cistern, Hog Hollow, and Solana Springs) occupied by Salado salamanders. This easement would permanently protect the area around these springs from urban development. In addition, the Solana Ranch has fenced off feral hogs and livestock around its three springs.

The conservation efforts implemented thus far for the Salado salamander represent over half of the known spring sites occupied by this species. This includes about 21 percent of the surface watershed for the three Salado salamander sites is contained within the Solana Ranch property boundary, and only 3 percent of the surface watershed for the one Salado salamander site (Robertson Spring) is contained within the Robertson Ranch property boundary. The efforts by these landowners represent an important step toward the conservation of the Salado salamander.

The remaining area of the surface watersheds and the recharge zone for these springs is not contained within the properties and is not protected from future development. Considering the projected growth rates expected in Bell County (from 310,235 in 2010 to 707,840 in 2050, a 128 percent increase over the 40-year period; Texas State Data Center 2012, p. 353), these four Salado salamander spring sites are still at threat from the detrimental effects of urbanization that could occur outside of these properties. Although the pattern of existing infrastructure suggests that much of the urbanization will occur along IH–35 and downstream of the three Solana Ranch springs, the threat of development and urbanization continues into the future because more than 75 percent of the surface watershed for these sites is located outside the boundaries of these properties. There are no long-term, binding conservation plans currently in place for either of these properties as the conservation easement for Solana Ranch has not been finalized. In addition, the regulations in place in Bell County are not adequate to protect water quality within occupied watersheds or within the Edwards Aquifer recharge zone.

Although these conservation efforts likely contribute water quality benefits to surface flow, surface habitats can be influenced by land use throughout the recharge zone of the aquifer that supplies its spring flow. Furthermore, the surface areas influencing subsurface water quality (that is draining the surface and flowing to the subsurface habitat) is not clearly delineated for many of the sites (springs or caves) for the Georgetown and Salado salamanders. Because we are not able to precisely assess additional pathways for negative impacts to the Georgetown and Salado salamanders to occur, many of their sites may be affected by threats that cannot be mitigated through the conservation efforts that are currently ongoing.

Conclusion of Factor A

Degradation of habitat, in the form of reduced water quality and quantity and disturbance of spring sites (physical modification of surface habitat), is the primary threat to the Georgetown and Salado salamanders. This threat may affect only the surface habitat, only the subsurface habitat, or both habitat types. In consideration of the stressors currently impacting the salamander species and their habitats along with their risk of exposure to potential sources of this threat, we find the threat of habitat destruction and modification within the ranges of the Georgetown and Salado salamanders to be of low severity now, but will become significant in the future as the human population is projected to increase by 377 percent in the range of the Georgetown salamander and by 128 percent in the range of the Salado salamander by 2050.

B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

There is little available information regarding overutilization of the Georgetown and Salado salamanders for commercial, recreational, scientific, or educational purposes, although we are aware that some individuals of these species have been collected from their natural habitat for a variety of purposes. Collecting individuals from populations that are already small enough to experience reduced reproduction and survival due to inbreeding depression or become extirpated due to environmental or demographic stochasticity and other catastrophic events (see the discussion on small population sizes under *Factor E—Other Natural or Manmade Factors Affecting Its Continued Existence* below) can pose a risk to the continued existence of these populations. Additionally, there are no regulations currently in place to prevent or restrict the collections of salamanders from their habitat in the wild for scientific or other purposes, and we know of no plans within the scientific community to limit the amount or frequency of collections at known salamander locations. We recognize the importance of collecting for scientific purposes; such as for research, captive assurance programs, taxonomic analyses, and museum collections. However, removing individuals from small, localized populations in the wild, without any proposed plans or regulations to restrict these activities, could increase the population's vulnerability and decrease its resiliency and ability to withstand stochastic events.

Currently, we do not consider overutilization from collecting salamanders in the wild to be a threat by itself, but it may contribute to significant population declines, and could negatively impact the Georgetown and Salado salamanders in combination with other threats.

C. Disease or Predation

Chytridiomycosis (chytrid fungus) is a fungal disease that is responsible for killing amphibians worldwide (Daszak *et al.* 2000, p. 445). The chytrid fungus has been documented on the feet of Jollyville Plateau salamanders from 15 different sites in the wild (O'Donnell *et al.* 2006, pp. 22–23; Gaertner *et al.* 2009, pp. 22–23) and on Austin blind salamanders in captivity (Chamberlain 2011, COA, pers. comm.). However, the Austin blind and Jollyville Plateau salamanders did not display any noticeable health effects (O'Donnell *et al.* 2006, p. 23). We do not consider chytridiomycosis to be a threat to the Georgetown and Salado salamanders at this time. The best available information does not indicate that impacts from this disease on the Georgetown or Salado salamander may increase or decrease in the future, and therefore, we conclude that this disease is not a threat to either species.

Regarding predation, COA biologists found Jollyville Plateau salamander abundances were negatively correlated with the abundance of predatory centrarchid fish (carnivorous freshwater fish belonging to the sunfish family), such as black bass (*Micropterus* spp.) and sunfish (*Lepomis* spp.) (COA 2001, p. 102). Predation of a Jollyville Plateau salamander by a centrarchid fish was observed during a May 2006 field survey (O'Donnell *et al.* 2006, p. 38). The Georgetown and Salado salamanders have been observed retreating into gravel substrate after cover was moved, suggesting these salamanders display anti-predation behavior (Bowles *et al.* 2006, p. 117). Studies have found that San Marcos salamanders (*Eurycea nana*) and Barton Springs salamanders both have the ability to recognize and show anti-predator response to the chemical cues of introduced and native centrarchid fish predators (Epp and Gabor 2008, p. 612; DeSantis *et al.* 2013, p. 294). However, the best available information does not indicate that predation of the Georgetown and Salado salamanders is significantly limiting these species.

In summary, while disease and predation may be affecting individuals of these salamander species, these are not significant factors affecting the species. Neither disease nor predation is occurring at a level that we consider to be a threat to the Georgetown and Salado salamanders now or in the future.

D. The Inadequacy of Existing Regulatory Mechanisms

The primary threats to the Georgetown and Salado salamanders are habitat degradation related to a reduction of water quality and quantity and disturbance at spring sites that will increase in the future as human populations continue to grow and urbanization increases. The human population in Georgetown is expected to grow by 375 percent between 2000 and 2033 (City of Georgetown 2008, p. 3.5). The Texas State Data Center also estimates a 377 percent increase in human population in Williamson County from 2010 to 2050. Population projections from the Texas State Data Center (2012, p. 353) estimate that Bell County, where the Salado salamander resides, will increase in population by 128 percent over the same 40-year period. Therefore, regulatory mechanisms that protect water quality and quantity of the Edwards Aquifer from development related impacts are crucial to the future survival of these species. Federal, State, and local laws and regulations have been insufficient to prevent past and ongoing impacts to the habitat of Georgetown and Salado salamanders from water quality degradation, reduction in water quantity, and surface disturbance of spring sites. They are unlikely to prevent further impacts to the Salado salamander in the future. The new ordinance approved by the Georgetown City Council in December 2013 is intended to reduce the threats to the Georgetown salamander in the future and is discussed in detail below.

State and Federal Regulations

Laws and regulations pertaining to endangered or threatened animal species in the state of Texas are contained in Chapters 67 and 68 of the Texas Parks and Wildlife Department Code and Sections 65.171–65.176 of Title 31 of the Texas Administrative Code (T.A.C.). TPWD regulations prohibit the taking, possession, transportation, or sale of any of the animal species designated by State law as endangered or threatened without the issuance of a permit. The Georgetown and Salado salamanders are not listed on the Texas State List of Endangered or Threatened Species (TPWD 2013, p. 3). Therefore, these species are receiving no direct protection from State of Texas regulations.

Under authority of the T.A.C. (Title 30, Chapter 213), the TCEQ regulates activities having the potential for polluting the Edwards Aquifer and hydrologically connected surface streams through the Edwards Aquifer Protection Program or ''Edwards Rules.'' The Edwards Rules require a number of water quality protection measures for new development occurring in the recharge, transition, and contributing zones of the Edwards Aquifer. The Edwards Rules were enacted to protect existing and potential uses of groundwater and maintain Texas Surface Water Quality Standards. Specifically, a water pollution abatement plan (WPAP) must be submitted to the TCEQ in order to conduct any construction-related or post-construction activities on the recharge zone. The WPAP must include a description of the site and location maps, a geologic assessment conducted by a geologist, and a technical report describing, among other things, temporary and permanent best management practices (BMPs) designed to reduce pollution related impacts to nearby water bodies.

The permanent BMPs and measures identified in the WPAP are designed, constructed, operated, and maintained to remove at least 80 percent of the incremental increase in annual mass loading of total suspended solids from the site caused by the regulated activity (TCEQ 2005, p. 3–1). The use of this standard results in some level of water quality degradation since up to 20 percent of total suspended solids are ultimately discharged from the site into receiving waterways (for example, creeks, rivers, lakes). Furthermore, this standard does not address the concentration of dissolved pollutants, such as nitrates, chloride, pesticides, and other contaminants shown to have detrimental impacts on salamander biology. Separate Edwards Aquifer protection plans are required for organized sewage collection systems, underground storage tank facilities, and aboveground storage tank facilities. Regulated activities exempt from the requirements of the Edwards Rules are: (1) The installation of natural gas lines; (2) the installation of telephone lines; (3) the installation of electric lines; (4) the installation of water lines; and (5) the installation of other utility lines that are not designed to carry and will not carry pollutants, stormwater runoff, sewage effluent, or treated effluent from a wastewater treatment facility.

Under the Edwards Rules, temporary erosion and sedimentation controls are required to be installed and maintained during construction for any exempted activities located on the recharge zone. Individual land owners who seek to construct single-family residences on sites are exempt from the Edwards Aquifer protection plan application requirements provided the plans do not exceed 20 percent impervious cover. Similarly, the Executive Director of the TCEQ may waive the requirements for permanent BMPs for multifamily residential subdivisions, schools, or small businesses when 20 percent or less impervious cover is used at the site.

The jurisdiction of the Edwards Rules does not extend into Bell County (TCEQ 2001, p. 1), which is where all seven of the known Salado salamander populations are located. Therefore, many salamander populations do not directly benefit from these protections. The Service recognizes that implementation of the Edwards Rules in northern Williamson County has the potential to positively influence conditions at some spring sites occupied by the Salado salamander in southern Bell County. However, all seven occupied sites and more than half of the associated surface watersheds are located within Bell County and receive no protection from the Edwards Rules.

The Edwards Rules provide some benefit to water quality, however, they were not designed to remove all types of pollutants and they still allow impacts to basic watershed hydrology, chemistry, and biology. The Edwards Rules do not address land use, impervious cover limitations, some nonpoint-source pollution, or application of fertilizers and pesticides over the recharge zone (30 TAC 213.3). They also do not contain requirements for stream buffers, surface buffers around springs, or the protection of stream channels from erosion, all of which would help to minimize water quality degradation in light of projected human population growth in Williamson and Bell Counties. In addition, the purpose of the Edwards Rules is to ''. . . protect existing and potential uses of groundwater and maintain Texas Surface Water Quality Standards'', which may not be entirely protective of the Georgetown and Salado salamanders. We are unaware of any State or Federal water quality regulations that are more restrictive than the TCEQ's Edwards Rules in Bell or Williamson Counties outside the City of Austin.

Texas has an extensive program for the management and protection of water that operates under State statutes and the Federal Clean Water Act (CWA). It includes regulatory programs such as the following: Texas Pollutant Discharge Elimination System (to control point-source pollution), Texas Surface Water Quality Standards (to protect designated uses like recreation or aquatic life), and Total Maximum Daily Load Program (under Section 303(d) of the CWA) (to reduce pollution loading for impaired waters)

In 1998, the State of Texas assumed the authority from the Environmental Protection Agency (EPA) to administer the National Pollutant Discharge Elimination System. As a result, the TCEQ's TPDES program has regulatory authority over discharges of pollutants to Texas surface water, with the exception of discharges associated with oil, gas, and geothermal exploration and development activities, which are regulated by the Railroad Commission of Texas. In addition, stormwater discharges as a result of agricultural activities are not subject to TPDES permitting requirements. The TCEQ issues two general permits that authorize the discharge of stormwater and non-stormwater to surface waters in the State associated with: (1) Small municipal separate storm sewer systems (MS4) (TPDES General Permit #TXR040000) and (2) construction sites (TPDES General Permit #TXR150000). The MS4 permit covers small municipal separate storm sewer systems that were fully or partially located within an urbanized area, as determined by the 2000 Decennial Census by the U.S. Bureau of Census, and the construction general permit covers discharges of stormwater runoff from small and large construction activities impacting greater than 1 acre of land. In addition, both of these permits require new discharges to meet the requirements of the Edwards Rules.

To be covered under the MS4 general permit, a municipality must submit a Notice of Intent (NOI) and a copy of their Storm Water Management Program (SWMP) to TCEQ. The SWMP must include a description of how that municipality is implementing the seven minimum control measures, which include the following: (1) Public education and outreach; (2) public involvement and participation; (3) detection and elimination of illicit discharges; (4) construction site stormwater runoff control (when greater than 1 ac (0.4 ha) is disturbed); (5) post-construction stormwater management; (6) pollution prevention and good housekeeping for municipal operations; and (7) authorization for municipal construction activities (optional). The City of Georgetown and the Village of Salado were not previously considered urbanized areas and covered under the MS4 general permit. Therefore, they were not operating under a SWMP authorized by TCEQ. However, the City of Georgetown is now considered a small MS4 under the new TPDES general permit and must develop and implement a Storm Water Management Program (SWMP) within five years (TCEQ 2013, p. 22).

To be covered under the construction general permit, an applicant must prepare a stormwater pollution and prevention plan (SWP3) that describes the implementation of practices that will be used to minimize, to the extent practicable, the discharge of pollutants in stormwater associated with construction activity and non-stormwater discharges. For activities that disturb greater than 5 ac (2 ha), the applicant must submit an NOI to TCEQ as part of the approval process. As stated above, the two general permits issued by the TCEQ do not address discharge of pollutants to surface waters from oil, gas, and geothermal exploration and geothermal development activities, stormwater discharges associated with agricultural activities, and from activities disturbing less than 5 acres (2 ha) of land. Despite the significant value the TPDES program has in regulating point-source pollution discharged to surface waters in Texas, it does not adequately address all sources of water quality degradation, including nonpoint-source pollution and the exceptions mentioned above, that have the potential to negatively impact the Georgetown and Salado salamanders.

In reviewing the 2012 Texas Water Quality Integrated Report prepared by the TCEQ, the Service identified 5 of 9 (56 percent) stream segments located within surface watersheds occupied by the Georgetown and Salado salamanders where parameters within water samples exceeded screening level criteria (TCEQ 2012b, pp. 646–736). The analysis of surface water quality monitoring data collected by TCEQ indicated ''screening level concerns'' for nitrate, dissolved oxygen, and impaired benthic communities. The TCEQ screening level for nitrate (1.95 mg/L) is within the range of concentrations (1.0 to 3.6 mg/L) above which the scientific literature indicates may be toxic to aquatic organisms (Camargo *et al.* 2005, p. 1,264; Hickey and Martin 2009, pp. ii, 17–18; Rouse 1999, p. 802). In addition, the TCEQ screening level for dissolved oxygen (5.0 mg/L) is similar to that recommended by the Service in 2006 to be protective of federally listed salamanders (White *et al.* 2006, p. 51). The Service also received baseline water quality data from grab samples (that is, samples collected at one point in time) collected during the summer of 2012 at four springs (Hogg Hollow, Swinbank, Cedar Breaks Hiking Trail, and Cobb Springs) occupied by the Georgetown salamander (SWCA 2012, pp. 11–20). Of these four samples, one sample (collected from Swinbank Springs) had nitrate levels that exceeded the TCEQ screening level, and one sample (collected from Cedar Breaks Hiking Trail Spring) exceeded the TCEQ screening levels for *E. coli* and fecal coliform bacteria. Therefore, water quality data collected and analyzed by the TCEQ and specific water quality data collected by SWCA at springs occupied by the Georgetown salamander support our concern with the adequacy of existing regulations to protect the Georgetown and Salado salamanders from the effects of water quality degradation.

The TCEQ and Service jointly developed voluntary water quality protection measures, also known as Optional Enhanced Measures, for developers to implement that would minimize water quality effects to springs systems and other aquatic habitats within the Edwards Aquifer region of Texas by providing a higher level of water quality protection (TCEQ 2005, p. i). In February 2005, the Service concurred that these measures, if implemented, would protect several aquatic species, including the Georgetown, Barton Springs, and San Marcos salamanders from ''take under Section 9 of the Act'' due to water quality degradation resulting from development in the Edwards Aquifer (TCEQ 2007, p. 1). This concurrence does not cover projects that: (1) Occur outside the area regulated under the Edwards Rules; (2) result in water quality impacts that may affect federally listed species not specifically named above; (3) result in impacts to federally listed species that are not water quality related; or (4) occur within 1 mile (1.6 km) of spring openings that provide habitat for federally listed species.

These ''Optional Enhanced Measures'' were intended to be used for the purpose of avoiding take to the identified species from water quality impacts, and they do not address any of the other threats to the Georgetown or Salado salamanders. Due to the voluntary nature of the measures, the Service does not consider them to be a regulatory mechanism. In addition, TCEQ reported that only 17 Edwards Aquifer applications have been approved under the Optional Enhanced Measures between February 2005 and May 2012, and the majority of these applications were for sites in the vicinity of Dripping Springs, Texas, which is outside the range of the Georgetown and Salado salamanders (Beatty 2012, TCEQ, pers. comm.).

Quarry operation is a regulated activity under the Edwards Aquifer Rules (Title 30, Texas Administrative Code, Chapter 213, or 30 TAC 213) and owners must apply to the TCEQ in order to create or expand a quarry located in the recharge or contributing zone of the Edwards Aquifer. However, as stated above, the jurisdiction of the Edwards Rules does not extend into Bell County (TCEQ 2001, p. 1), which is where all seven of the known Salado salamander populations are located. TCEQ conducted an inventory of rock quarries in 2004 (Berehe 2005, pp. 44–45). Out of the TCEQ inventoried quarries statewide, 40 quarry sites were inventoried in Burnet, Travis and Williamson counties. More than half of these sites in the study area had no permit or were violating the minimum standards of their permits either by an unauthorized discharge of sediment or by air quality violation. (Berehe 2005, pp. 44–45)

In 2012, TCEQ produced a guidance document outlining recommended measures specific for quarry operations (Barrett and Eck 2012, entire). These measures include spill response measures, separating quarry-pit floor from the groundwater level, setbacks and buffers for sensitive recharge features and streams, creating berms to protect surface runoff water from draining into quarry pits, and safely storing and moving fuel (Barrett and Eck 2012, pp. 1–17). Quarry operators can seek variances, exceptions, or revisions to these recommendations based on site-specific facts (Barrett and Eck 2012, p. 1). This clarifying guidance document could aid in protecting Georgetown salamander habitat from the threat of quarry activities if quarry operators implement the recommended measures, but future study is needed to determine how quarry sites in Williamson County are complying with the Edwards Rules.

Local Ordinances

The Service has reviewed ordinances administered by each of the municipalities and counties to determine if they contain measures protective of salamanders above and beyond those already required through other regulatory mechanisms (Clean Water Act, T.A.C., etc.).

The City of Georgetown has standards, such as impervious cover limits, that relate to the protection of water quality. According to Chapter 11 of the Georgetown Unified Development Code, impervious cover limits have been adopted to minimize negative flooding effects from stormwater runoff and to control, minimize, and abate water pollution resulting from urban runoff. The impervious cover limits and stormwater control requirements apply to all development in the City of Georgetown and its extraterritorial jurisdiction. Impervious cover limits are as high as 70 percent for small commercial developments to as low as 40 percent for some single family residential developments within its extraterritorial jurisdiction.

The Georgetown City Council approved the Edwards Aquifer Recharge Zone Water Quality Ordinance on December 20, 2013 (Ordinance No. 2013–59). The purpose of this ordinance is to reduce the principal threats to the Georgetown salamander within the City of Georgetown and its extraterritorial jurisdiction through the protection of water quality near occupied sites, enhancement of water quality protection throughout the Edwards Aquifer recharge zone, and establishment of protective buffers around all springs and streams. Specifically, the primary conservation measures that will be implemented within the Edwards Aquifer recharge zone include: (1) A requirement for geological assessments to identify all springs and streams on a development site; (2) the establishment of a no-disturbance zone that extends 262 ft (80 m) upstream and downstream from sites occupied by Georgetown salamanders; (3) the establishment of a zone that extends 984 ft (300 m) around all occupied sites within which development is limited to Residential Estate and Residential Low Density District as defined in the City of Georgetown's Unified Development Code; (4) the establishment of a no-disturbance zone that extends 164 ft (50 m) around all springs; (5) the establishment of stream buffers for streams that drain more than 64 acres (26 hectares); and (6) a requirement that permanent structural water quality controls (BMPs) remove eighty-five percent (85 percent) of total suspended solids for the entire project which is an increase of 5 percent above what was previously required under the Edwards Aquifer Rules.

As required by the new ordinance, the City of Georgetown adopted the Georgetown Water Quality Management Plan, which will implement many of the minimum control measures required under the TPDES general permit for small municipal separate storm sewer systems (MS4) (see above discussion). Because the City of Georgetown is considered a small MS4 under the new TPDES general permit, they are required to develop and implement a Storm Water Management Program (SWMP) and the associated minimum control measures within 5 years (TCEQ 2013, p. 22). However, the City of Georgetown has committed to developing minimum control measures under their Water Quality Management Plan within 6 months (City of Georgetown 2013, p. 1). In addition, the Williamson County Conservation Foundation (WCCF) also recently adopted an adaptive management plan as part of their overall conservation plan for the Georgetown salamander (WCCF 2013, p. 1). This plan will enable the continuation and expansion of water quality monitoring, conservation efforts, and scientific research to conserve the Georgetown salamander.

As discussed above under Factor A, habitat modification, in the form of degraded water quality and quantity and disturbance of spring sites, has been identified as the primary threat to the Georgetown salamander. The ordinance and associated documents approved by the Georgetown City Council reduce some of the threats from water quality degradation and disturbance at spring sites. Specifically, water quality threats have been reduced by requiring permanent structural water quality controls in developments to remove eighty-five percent (85 percent) of total suspended solids from the entire site. Previous regulations, under TCEQ's Edwards Rules, do not require existing impervious cover on a site to be included in the calculation of total suspended solids and only require eighty percent (80 percent) of total suspended solids be removed.

The new ordinance increases the required amount of total suspended solids that must be removed from stormwater leaving a development site. In addition, requirements for stream buffers and surface buffers around springs reduces water quality degradation by providing vegetated filters that can assist in the further removal of sediments and pollutants from stormwater. Surface buffers around occupied sites will minimize the possibility that the physical disturbance of salamander habitat will occur as the result of construction activities. The ordinance permits Residential Estate and Residential Low Density District residential uses to occur as close as 262 ft (80 m) from occupied Georgetown salamander sites and does not limit the type of development that can occur outside of the 984-ft (300-m) buffer. The ordinance also requires that roadways or expansions to existing roadways that provide a capacity of 25,000 vehicles per day shall provide for spill containment as described in the TCEQ's Optional Enhanced Measures. This will reduce some of the future impacts to salamander habitat by preventing some hazardous spills from entering water bodies.

Five developments within the City of Georgetown or its ETJ are exempted from the requirements of the new ordinance because they were platted before the ordinance was approved. The plats for these developments show lots and other development activities proposed or currently occurring within 984 ft (300 m), and for some within 262 ft (80 m), of six occupied Georgetown salamander sites (Shadow Canyon Spring, Cowan Spring, Bat Well Cave, Water Tank Cave, Knight Spring and Cedar Breaks Hiking Trail) (Covey 2014, pers. comm.). Although some of these developments appear to avoid the no-disturbance zone (262 ft (80 m)), we were not provided enough information to determine if all or some of the requirements of the ordinance would be met by each of the developments as planned. According to the County, it does appear that these developments meet the intent of the ordinance (Covey 2014, pers. comm.)

There are no additional standards specifically related to water quality required by Bell or Williamson Counties or for development within the Village of Salado.

Groundwater Conservation Districts

The Clearwater Underground Water Conservation District (CUWCD) is responsible for managing groundwater resources within Bell County. They are statutorily obligated under Chapter 36 of the Texas Water Code to regulate water wells and groundwater withdrawals that have the potential to impact spring flow and aquifer levels. The CUWCD adopted a desired future condition (that is, goal) for the Edwards Aquifer in Bell County as the maintenance of at least 100 acre-feet (123,348 cubic meters) per month of spring flow in Salado Creek under conditions experienced during the drought of record in Bell County (Aaron 2012, CUWCD, pers. comm.). The CUWCD has also developed a Drought Management Plan that requires staff to monitor discharge values and determine when the CUWCD needs to declare a particular drought stage, from Stage 1 ''Awareness'' to Stage 4 ''Critical'' (Aaron 2012, CUWCD, pers. comm.). However, water conservation goals and reduction of use for each drought stage are voluntary.

One of the two gauges (FM 2843 bridge) used by the CUWCD to monitor Salado Springs discharge measured no surface flow in 6 of 15 months during the period of time between November 2011 and January 2013 (Aaron 2013, CUWCD, pers. comm.). In addition, during visits to Salado salamander sites Service personnel observed no surface flow at Robertson Springs (September 2011 and April 2013) and Lil' Bubbly Springs (April 2013 and July 2013). Despite the documented loss of flow in areas where the Salado salamander occurs, the desired future condition of 100 ac-ft (123,348 cubic meters) per month as measured by the CUWCD was exceeded throughout this timeframe. The Service recognizes the desired future condition adopted by the CUWCD as a valuable tool for protecting groundwater; however, it is not adequate to ensure spring flow at all sites occupied by the Salado salamander.

Williamson County does not currently have a groundwater conservation district that can manage groundwater resources countywide. A 1990 study by the TCEQ and TWDB determined that Williamson County did not meet the criteria to be designated as a ''critical area'' primarily because of the availability of surface water supplies to meet projected needs (Berehe 2005, p. 1). In 2005, TCEQ again declined to designate Williamson County a priority groundwater management area, which would lead to the creation of a groundwater conservation district (Berehe 2005, p. 3). This decision was based on TCEQ's opinion that Williamson County's water supply concerns are mostly solved with current management strategies to increasingly rely on surface water (as laid out in TWDB 2012, p. 190) (Berehe 2005, p. 3). The City Manager has recently indicated that the City of Georgetown will not use water from the Edwards Aquifer in plans for future and additional municipal water supplies (Brandenburg 2013, p .1). Instead, the City of Georgetown intends to use surface water or non-Edwards wells for future sources of water.

TCEQ noted that nearly all of Williamson County is within certificated water purveyor service areas, and through conservation programs and efforts to meet new demands with surface water sources, these entities can largely maintain their present groundwater systems (Berehe 2005, p. 65). All wholesale and retail water suppliers are required to prepare and adopt drought contingency plans under TCEQ rules (Title 30, Texas Administrative Code, Chapter 288) (Berehe 2005, p. 64). However, these types of entities do not have authority to control large-scale groundwater pumpage for private purposes that could potentially impact a shared groundwater supply (Berehe 2005, p. 65). Thus, groundwater levels may continue to decline due to private pumping. The CUWCD in Bell County noted the effectiveness of their groundwater management measures may be lessened if surrounding areas (for example, Williamson County) are not likewise managing the shared groundwater resource (Berehe 2005, p. 3). However, in comments on our proposed rule, CUWCD stated that their ability to protect spring flow is not impacted by pumping in Travis or Williamson Counties (Aaron 2012, CUWCD, pers. comm.).

Conclusion of Factor D

Surface water quality data collected by TCEQ and SWCA indicate that water quality degradation is occurring within many of the surface watersheds occupied by the Georgetown and Salado salamanders despite the existence of State and local regulatory mechanisms to manage stormwater and protect water quality (SWCA 2012, pp. 11–20; TCEQ 2012b, pp. 646–736). Additionally, the threat to the Salado salamander from a reduction in water quantity and the associated loss of spring flow has not been completely alleviated despite efforts made in Bell County by the CUWCD. No regulatory mechanisms are in place to manage groundwater withdrawals in Williamson County. The human population in Williamson and Bell Counties is projected to increase by 377 and 128 percent, respectively, between 2010 and 2050. The associated increase in urbanization is likely to result in continued impacts to water quality absent additional regulatory mechanisms to prevent this from occurring.

The City of Georgetown's Edwards Aquifer Recharge Zone Water Quality Ordinance, Water Quality Management Plan, and Adaptive Management Plan will help to reduce some of the threats to groundwater pollution that are typically associated with urbanized areas. Additionally, for the Georgetown salamander, the Adaptive Management Working Group is charged specifically with reviewing Georgetown salamander monitoring data and new research over time and recommending improvements to the ordinance that may be necessary to ensure that it achieves its stated purposes. This Adaptive Management Working Group, which includes representatives of the Service and TPWD, will also review and make recommendations on the approval of any variances to the ordinance to ensure that granting a variance will not be detrimental to the preservation of the Georgetown salamander. While the beneficial actions taken by the Georgetown City Council will reduce some of the threats to the Georgetown salamander, there are additional threats that have not been addressed by the ordinance. Therefore, we consider the inadequacy of existing regulatory mechanisms to be an ongoing threat to the Georgetown and Salado salamanders now and in the future.

E. Other Natural or Manmade Factors Affecting Their Continued Existence

Small Population Size and Stochastic Events

The Georgetown and Salado salamanders may be susceptible to threats associated with small population size and impacts from stochastic events. The risk of extinction for any species is known to be highly indirectly correlated with population size (O'Grady *et al.* 2004, pp. 516, 518; Pimm *et al.* 1988, pp. 774–775). In other words, the smaller the population the greater the overall risk of extinction. Stochastic events from either environmental factors (random events such as severe weather) or demographic factors (random causes of births and deaths of individuals) increase the risk of extinction of the Georgetown and Salado salamanders because of their limited range and small population sizes (Melbourne and Hastings 2008, p. 100). At small population levels, the effects of demographic stochasticity alone greatly increase the risk of local extinctions (Van Dyke 2008, p. 218).

Genetic factors play a large role in influencing the long-term viability of small populations. Although it remains a complex field of study, conservation genetics research has demonstrated that long-term inbreeding depression (a pattern of reduced reproduction and survival as a result of genetic relatedness) can occur within small populations (Frankham 1995, p. 796; Latter *et al.* 1995, p. 294; Van Dyke 2008, pp. 155–156). Inbreeding depression contributes to further population decline and reduced reproduction and survival in small populations, and can contribute to a species' extinction (Van Dyke 2008, pp. 172–173). Small populations may also suffer a loss of genetic diversity, reducing the ability of these populations to evolve to changing environmental conditions, such as climate change (Visser 2008, pp. 649–655; Traill *et al.* 2010, pp. 29–30).

In addition, ecological factors such as Allee effects may manifest at small population sizes, further increasing the risk of extinction (Courchamp *et al.* 1999, p. 405). Allee effects are defined as a positive relationship between any component of individual fitness (the ability to survive and reproduce) and either numbers or density of individuals of the same species (Stephens *et al.* 1999, p. 186). In other words, an Allee effect refers to the phenomenon where reproduction and survival rates of individuals increase with increasing population density. For example, when a species has a small population, it may be more difficult for individuals to encounter mates, reducing their ability to produce offspring. Small population sizes can act synergistically with ecological traits (such as being a habitat specialist and having a limited distribution as in the Georgetown and Salado salamanders) to greatly increase risk of extinction (Davies *et al.* 2004, p. 270).

Current evidence from integrated work on population dynamics shows that setting conservation targets at only a few hundred individuals does not properly account for the synergistic impacts of multiple threats facing a population (Traill *et al.* 2010, p. 32). As discussed above, small populations are vulnerable to both stochastic demographic factors and genetic factors. Studies across taxonomic groups have found both the demographic and genetic constraints on populations require sizes of at least 5,000 adult individuals to ensure long-term persistence (Traill *et al.* 2010, p. 30). Populations below this number are considered small and at increased risk of extinction. It is also important to note that this general estimate does not take into account species-specific ecological factors that may impact extinction risk, such as Allee effects.

The population size of Georgetown and Salado salamanders is unknown for most sites. Recent mark-recapture studies on the Georgetown salamander estimated surface population sizes of 100 to 200 adult salamanders at two sites thought to be of the highest quality for this species (Twin Springs and Swinbank Springs, Pierce 2011a, p. 18). Georgetown salamander populations are likely smaller at other, lower quality sites. There are no population estimates available for any Salado salamander sites, but recent surveys have indicated that Salado salamanders are exceedingly rare at the four most impacted sites and much more abundant at the three least impacted sites (Gluesenkamp 2011a, b, TPWD, pers. comm.). Because most of the sites occupied by the Georgetown and Salado salamanders are not known to have many individuals, any of the threats described above or stochastic events that would not otherwise be considered a threat could extirpate populations.

The highly restricted ranges of the Georgetown and Salado salamanders and their entirely aquatic environmental habitat make them extremely vulnerable to threats such as decreases in water quality and quantity. The Georgetown salamander is only known from 15 surface and 2 cave sites. This species has not been observed in more than 20 years at San Gabriel Spring and more than 10 years at Buford Hollow Spring, despite several survey efforts to find it (Chippindale et al. 2000, p. 40, Pierce 2011b, c, Southwestern University, pers. comm.). We are unaware of any population surveys in the last 10 years from a number of sites (such as Cedar Breaks Hiking Trail, Shadow Canyon, and Bat Well). Georgetown salamanders continue to be observed at the remaining 12 sites (Avant Spring, Swinbank Spring, Knight Spring, Twin Springs, Cowan Creek Spring, Cedar Hollow Spring, Cobbs Spring/Cobbs Well, Garey Ranch Spring, Hogg Hollow Spring, Hogg Hollow II Spring, Walnut Spring, and Water Tank Cave) (Pierce 2011c, pers. comm.; Gluesenkamp 2011a, TPWD, pers. comm.). Similarly, the Salado salamander has only been found at seven spring sites, and two of these sites (Big Boiling and Lil' Bubbly Springs) are very close together and are likely one population. Due to their very limited distribution, these salamanders are especially sensitive to stochastic incidences, such as severe and unusual storm events (which can dramatically affect dissolved oxygen levels), catastrophic contaminant spills, and leaks of harmful substances.

Although rare, catastrophic events pose a significant threat to small populations because they have the potential to eliminate all individuals in a small group (Van Dyke 2008, p. 218). Although it may be possible for *Eurycea* salamanders to travel through aquifer conduits from one surface population to another, or that two individuals from different populations could breed in subsurface habitat, there is no direct evidence that they currently migrate from one surface population to another on a regular basis. Although gene flow between populations has been detected in other central Texas *Eurycea* salamander species (TPWD 2012, pers. comm.), this does not necessarily mean that there is current or routine dispersal between salamander populations that could allow for recolonization of a site should the population be extirpated by a catastrophic event (Gillespie 2012, University of Texas, pers. comm.).

In conclusion, we do not consider small population sizes to be a threat in and of itself to the Georgetown and Salado salamanders, but their small population sizes make them more vulnerable to extinction from other existing or potential threats, such as stochastic events. Restricted ranges could negatively affect the Georgetown and Salado salamanders in combination with other threats (such as water quality or water quantity degradation) and lead to the species being at a higher risk of extinction. We consider the level of impacts from stochastic events to be moderate for the Georgetown salamander, because this species has 17 populations over a broader range. On the other hand, recolonization following a stochastic event is less likely for the Salado salamander due to its more limited distribution and low numbers. Therefore, the impact from a stochastic event for the Salado salamander is a significant threat.

Ultraviolet Radiation

Increased levels of ultraviolet-B (UV–B) radiation, due to depletion of the stratospheric ozone layers, may lead to declines in amphibian populations (Blaustein and Kiesecker 2002, pp. 598–600). For example, research has demonstrated that UV–B radiation causes significant mortality and deformities in developing long-toed salamanders (*Ambystoma macrodactylum*) (Blaustein *et al.* 1997, p. 13,735). Exposure to UV–B radiation reduces growth in clawed frogs (*Xenopus laevis*) (Hatch and Burton, 1998, p. 1,783) and lowers hatching success in Cascades frogs (*Rana cascadae*) and western toads (*Bufo boreas*) (Kiesecker and Blaustein 1995, pp. 11,050–11,051). In lab experiments with spotted salamanders, UV–B radiation diminished their swimming ability (Bommarito *et al.* 2010, p. 1151). Additionally, UV–B radiation may act synergistically (the total effect is greater than the sum of the individual effects) with other factors (for example, contaminants, pH, pathogens) to cause declines in amphibians (Alford and Richards 1999, p. 141; see ''Synergistic and Additive Interactions among Stressors'' below). Some researchers have indicated that future increases in UV–B radiation will have significant detrimental impacts on amphibians that are sensitive to this radiation (Blaustein and Belden 2003, p. 95).

The effect of increased UV–B radiation on the Georgetown and Salado salamanders is unknown. It is questionable whether the few cave populations of the Georgetown salamander that are restricted entirely to the subsurface are exposed to UV–B radiation. Surface populations may receive some protection from UV–B radiation through shading from trees or from hiding under rocks at some spring sites. Removal of natural riparian vegetation and substrate alteration may put the Georgetown and Salado salamanders at greater risk of UV–B exposure. Because eggs are likely deposited underground (Bendik 2011b, COA, pers. comm.), UV–B radiation may have no impact on the hatching success of these species.

In conclusion, the effect of increased UV–B radiation has the potential to cause deformities or developmental problems to individuals, but we do not consider this to significantly contribute to the risk of extinction for the Georgetown and Salado salamanders at this time. However, UV–B radiation could negatively affect any of these salamanders in combination with other threats (such as water quality or water quantity degradation) and contribute to significant declines in population sizes.

Synergistic and Additive Interactions Among Stressors

The interactions among multiple stressors (for example, contaminants, UV–B radiation, pathogens, sedimentation, and drought) may be contributing to amphibian population declines (Blaustein and Kiesecker 2002, p. 598). Multiple stressors may act additively or synergistically to have greater detrimental impacts on amphibians compared to a single stressor alone. Kiesecker and Blaustein (1995, p. 11,051) found a synergistic effect between UV–B radiation and a pathogen in Cascades frogs and western toads. Researchers demonstrated that reduced pH levels and increased levels of UV–B radiation independently had no effect on leopard frog (*Rana pipiens*) larvae; however, when combined, these two caused significant mortality (Long *et al.* 1995, p. 1,302). Additionally, researchers demonstrated that UV–B radiation increases the toxicity of PAHs, which can cause mortality and deformities on developing amphibians (Hatch and Burton 1998, pp. 1,780–1,783). Beattie *et al.* (1992, p. 566) demonstrated that aluminum becomes toxic to amphibians at low pH levels. Also, disease outbreaks may occur only when there are contaminants or other stressors in the environment that reduce immunity (Alford and Richards 1999, p. 141). For example, Christin *et al.* (2003, pp. 1,129–1,132) demonstrated that mixtures of pesticides reduced the immunity to parasitic infections in leopard frogs. Finally, the interaction of different stressors may interfere with a salamander species' ability to adapt to a stressor. Miller *et al.* (2007, pp. 82–83) found that although southern two-lined salamander larvae could adapt to low-flow conditions by migrating down into the water table, they were unable to perform this behavior when the interstitial spaces between rocks were filled with sediment.

Currently, the synergistic effect between multiple stressors on the Georgetown and Salado salamanders is not fully known. Furthermore, different species of amphibians differ in their reactions to stressors and combinations of stressors (Kiesecker and Blaustein 1995, p. 11,051; Relyea *et al.* 2009, pp. 367–368; Rohr *et al.* 2003, pp. 2,387–2,390). Studies that examine the effects of interactions among multiple stressors on the Georgetown and Salado salamanders are lacking. However, based on the number of examples in other amphibians, the possibility of synergistic effects on the salamanders cannot be discounted.

Conclusion of Factor E

The effect of increased UV–B radiation is an unstudied stressor to the Georgetown and Salado salamanders that has the potential to cause deformities or development problems. There is no evidence that the salamander species' exposure to UV–B radiation is increasing or spreading. In addition, small population sizes at most of the sites for the Georgetown and Salado salamanders increases the risk of local extirpation events. We do not consider small population sizes to be a threat in and of itself to the Georgetown and Salado salamanders, but their small population sizes make them more vulnerable to extinction from other existing or potential threats, such as stochastic events. Thus, we consider the level of impacts from stochastic events to be high for the Georgetown and Salado salamanders due to their limited distributions and low number of populations. Finally, the synergistic and additive interactions among multiple stressors (contaminants, UV–B radiation, pathogens) may impact Georgetown and Salado salamanders based on studies of other amphibians.

Conservation Efforts To Reduce Other Natural or Manmade Factors Affecting Its Continued Existence

We have no information on any conservation efforts currently underway to reduce the effects of UV–B radiation, small population sizes, stochastic events, or the synergistic and additive interactions among multiple stressors on the Georgetown and Salado salamanders.

Cumulative Impacts

Cumulative Effects From Factors A Through E

Some of the threats discussed in this finding could work in concert with one another to cumulatively create situations that impact the Georgetown and Salado salamanders. Some threats to these species may seem to be of low significance by themselves, but when you consider other threats that are occurring at each site, such as small population sizes, the risk of extirpation is increased. Furthermore, we have no direct evidence that salamanders currently migrate from one population to another on a regular basis, and many of the populations are isolated in a way that makes re-colonization of extirpated sites very unlikely. Cumulatively, as threats to the species increase over time in tandem with increasing urbanization within the surface watersheds of these species, more and more populations will be lost, which will increase the species' risk of extinction.

Overall Threats Summary

The primary threat to the Georgetown and Salado salamanders is the present or future destruction, modification, or curtailment of their habitat or range (Factor A) in the form of reduced water quality and quantity and disturbance of spring sites (surface habitat). Reductions in water quality will occur primarily as a result of urbanization, which increases the amount of impervious cover in the watershed and exposes the salamanders to more hazardous material sources. Impervious cover increases storm flow, erosion, and sedimentation. Impervious cover also changes natural flow regimes within watersheds and increases the transport of contaminants common in urban environments, such as oils, metals, fertilizers, and pesticides. Expanding urbanization results in an increase of these contaminants within the watershed, which degrades water quality at salamander spring sites. Additionally, urbanization increases nutrient loads at spring sites, which can lead to decreases in dissolved oxygen levels. Construction activities associated with urbanization are a threat to both water quality and quantity because they can increase sedimentation and exposure to contaminants, as well as dewater springs by intercepting aquifer conduits.

Various other threats to habitat exist for the Georgetown and Salado salamanders as well. Drought, which may be compounded by the effects of global climate change, also degrades water quantity and reduces available habitat for the salamanders. Water quantity can also be reduced by groundwater pumping and decreases in baseflow due to increases in impervious cover. Flood events contribute to the salamanders' risks of extinction by degrading water quality through increased contaminants levels and sedimentation, which may damage or alter substrates, and by removing rocky substrates or washing salamanders out of suitable habitat. Impoundments are also a threat to these species' habitat because of their tendency to alter the stream substrate and increase predacious fish abundance. Feral hogs and livestock are threats because they can physically alter the salamander's surface habitat and increase nutrients. Additionally, catastrophic spills and leaks remain a threat for many salamander locations due to the abundance of point-sources and history of past spill events. All of these threats are projected to increase in the future, as the human population and development increases within watersheds that provide habitat for these salamanders. The human population is projected to increase by 377 percent in the range of the Georgetown salamander and by 128 percent in the range of the Salado salamander by 2050. Some of these threats are moderated, in part, by ongoing conservation efforts, preserves, and other programs in place to protect land from the effects of urbanization and to gather water quality data that would be helpful in designing conservation strategies for the salamander species. Overall, we consider the combined threats of Factor A to be ongoing and with a high degree of impact to the Georgetown and Salado salamanders and their habitats in the future.

Another factor we considered is Factor D, the inadequacy of existing regulatory mechanisms. Surface water quality data collected by TCEQ indicates that water quality degradation is occurring within many of the surface watersheds occupied by the Georgetown and Salado salamanders despite the existence of numerous state and local regulatory mechanisms to manage stormwater and protect water quality. Additionally, the threat to the Salado salamander from a reduction in water quantity and the associated loss of spring flow has not been completely alleviated through the management of groundwater in Bell County by the CUWCD. Groundwater resources are not holistically managed in Williamson County to protect the aquifer from depletion from private pumping. Human population growth and urbanization in Williamson and Bell Counties is projected to continue into the future as well as the associated impacts to water quality and quantity (see Factor A discussion above). However, the Edwards Aquifer Recharge Zone Water Quality Ordinance approved by the Georgetown City Council in December 2013 is expected to reduce some of the threats to the Georgetown salamander from water quality degradation and direct impacts to surface habitat. Existing regulations are not providing adequate protection for the Georgetown and Salado salamanders and their habitats. Therefore, we consider the existing regulatory mechanisms inadequate to protect the Georgetown and Salado salamander now and in the future.

Under Factor E, we identified several stressors that could negatively impact any of the Georgetown and Salado salamanders, including the increased risk of local extirpation events due to small population sizes and stochastic events, UV–B radiation, and the synergistic and additive effects of multiple stressors. Although none of these stressors rose to the level of being considered a threat by itself, small population sizes and restricted ranges make the Georgetown and Salado salamanders more vulnerable to extirpation from other existing or potential threats, such as stochastic events. Thus, we consider the level of impacts from stochastic events to be high for the Georgetown and Salado salamanders due to their low number of populations and limited distributions.

Determination

Standard for Review

Section 4 of the Act, and its implementing regulations at 50 CFR part 424, set forth the procedures for adding species to the Federal Lists of Endangered and Threatened Wildlife and Plants. Under section 4(b)(1)(a), the Secretary is to make endangered or threatened determinations required by subsection 4(a)(1) solely on the basis of the best scientific and commercial data available after conducting a review of the status of the species and after taking into account conservation efforts by States or foreign nations. The standards for determining whether a species is endangered or threatened are provided in section 3 of the Act. An endangered species is any species that is "in danger of extinction throughout all or a significant portion of its range." A threatened species is any species that is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." Per section 4(a)(1) of the Act, in reviewing the status of the species to determine if it meets the definitions of endangered or threatened, we determine whether any species is an endangered species or a threatened species because of any of the following five factors: (A) The present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; and (E) other natural or manmade factors affecting its continued existence.

We evaluated whether the Georgetown and Salado salamanders are in danger of extinction now (that is, an endangered species) or are likely to become in danger of extinction in the foreseeable future (that is, a threatened species). The foreseeable future refers to the extent to which the Secretary can reasonably rely on predictions about the future in making determinations about the future conservation status of the species. A key statutory difference between a threatened species and an endangered species is the timing of when a species may be in danger of extinction, either now (endangered species) or in the foreseeable future (threatened species).

Listing Status Determination for the Georgetown Salamander

In the proposed rule (77 FR 50768, August 22, 2012), the Georgetown salamander species was proposed as endangered, rather than threatened, because at that time, we determined the threats to be imminent, and their potential impacts to the species would be catastrophic given the very limited range of the species. For this final determination, we took into account data that were made available after the proposed rule published, information provided by commenters on the proposed rule, and further discussions within the Service to determine whether the Georgetown salamander should be classified as endangered or threatened. Based on our review of the best available scientific and commercial information, we conclude that the Georgetown salamander is likely to become in danger of extinction in the foreseeable future throughout all of its range and, therefore, meets the definition of a threatened species. This finding, explained below, is based on our conclusions that some habitat supporting populations of the species have begun to experience impacts from threats, and threats are expected to increase in the future. As the threats increase, we expect Georgetown salamander populations to decline and be extirpated, reducing the overall representation and redundancy across the species range and increasing the species risk of extinction. We find the Georgetown salamander will be at an elevated risk of extinction in the future. While beneficial actions taken by the Georgetown City Council are expected to reduce the threats to the Georgetown salamander, additional threats have not been addressed by their recent water quality ordinance. We, therefore, find that the Georgetown salamander warrants a threatened species listing status determination. Elsewhere in today's **Federal Register**, we propose special regulations for the Georgetown salamander under section 4(d) of the Act. We invite public comment on that proposed special rule.

There is a limited amount of data on the current status of most Georgetown salamander populations and how these populations respond to stressors. Of the 17 known Georgetown salamander populations, only 3 have been regularly monitored since 2008, and we only have population estimates for 2 of those sites. In addition, no studies have used controlled experiments to understand how environmental changes might affect Georgetown salamander individuals. To deal with this uncertainty and evaluate threats to the Georgetown salamander that are occurring now or in the future, we used information on substitute species, which is an accepted practice in aquatic ecotoxicology and conservation biology (Caro *et al.* 2005, p. 1,823; Wenger 2008, p. 1,565). In instances where information was not available for the Georgetown salamander specifically, we have provided references for studies conducted on similarly related species, such as the Jollyville Plateau salamander and Barton Springs salamander, which occur within the central Texas area, and other salamander species that occur in other parts of the United States. We concluded that these were appropriate comparisons to make based on the following similarities between the species: (1) A clear systematic (evolutionary) relationship (for example, members of the Family Plethodontidae); (2) shared life-history attributes (for example, the lack of metamorphosis into a terrestrial form); (3) similar morphology and physiology (for example, the lack of lungs for respiration and sensitivity to environmental conditions); and (4) similar habitat and ecological requirements (for example, dependence on aquatic habitat in or near springs with a rocky or gravel substrate).

Present and future degradation of habitat (Factor A) is the primary threat to the Georgetown salamander. This threat primarily occurs in the form of reduced water quality from introduced and concentrated contaminants, increased sedimentation, and altered stream flow regimes. Reduced water quality from increased conductivity, PAHs, pesticides, and nutrients have all been shown to have detrimental impacts on salamander density, growth, and behavior (Marco *et al.* 1999, p. 2,837; Albers 2003, p. 352; Rohr *et al.* 2003, p. 2,391; Bowles *et al.* 2006, pp. 117–118; O'Donnell *et al.* 2006, p. 37; Reylea 2009, p. 370; Sparling *et al.* 2009, p. 28; Bommarito *et al.* 2010, pp. 1,151–1,152). Sedimentation causes the amount of available foraging habitat and protective cover for salamanders to be reduced (Welsh and Ollivier 1998, p. 1,128), reducing salamander abundance (Turner 2003, p. 24; O'Donnell *et al.* 2006, p. 34). Sharp declines and increases in stream flow have also been shown to reduce salamander abundance (Petranka and Sih 1986, p. 732; Sih *et al.* 1992, p. 1,429; Baumgartner *et al.* 1999, p. 36; Miller *et al.* 2007, pp. 82–83; Price *et al.* 2012b, p. 319). In the absence of species-specific information, we conclude that Georgetown salamanders respond negatively to these stressors because aquatic invertebrates (the prey base of the Georgetown salamander) and several species of closely related stream salamanders have demonstrated direct and indirect negative responses to these stressors.

Reduced water quality, increased sedimentation, and altered flow regimes are primarily the result of human population growth and subsequent urbanization within the watersheds and recharge and contributing zones of the groundwater supporting spring and cave sites. Urbanization in the range of the Georgetown salamander is currently at relatively low levels. However, based on our current knowledge of the Georgetown salamander and observations made on the impacts of urbanization on other closely related species of aquatic salamanders, urbanization at current levels is likely affecting both surface and subsurface habitat. Based on our analysis of impervious cover (which we use as a proxy for urbanization) throughout the range of the Georgetown salamander, 10 of 12 surface watersheds known to be occupied by Georgetown salamanders in 2006 had levels of impervious cover that are likely causing habitat degradation now. Although we do not have long-term survey data on Georgetown salamander populations, the best available information indicates that habitat degradation from urbanization is causing declines in Georgetown salamander populations throughout most of the species' range now or will cause population declines in the future, putting these populations at an elevated risk of extirpation.

Further degradation of the Georgetown salamander's habitat is likely to continue into the foreseeable future based on the current projected increases in urbanization in the region. Substantial human population growth is ongoing within this species' range, indicating that the urbanization and its effects on Georgetown salamander habitat will likely increase in the future. The human population within the range of the Georgetown salamander is expected to increase by 375 percent from the year 2000 to 2033 (City of Georgetown 2008, p. 3.5).

Hazardous materials that could be spilled or leaked resulting in the contamination of both surface and groundwater resources add to the additional threats affecting the Georgetown salamander. For example, a number of point-sources of pollutants exist within the Georgetown salamander's range, including fuel tankers, fuel storage tanks, wastewater lines, and chlorinated drinking water lines, and some of these sources have contaminated groundwater in the past (Mace *et al.* 1997, p. 32; City of Georgetown 2008, p. 3.37; McHenry *et al.* 2011, p. 1). It is unknown what effect these past spills have had on Georgetown salamander populations thus far. As development around Georgetown increases, the number of point-sources will increase within the range of the Georgetown salamander, subsequently increasing the likelihood of a hazardous materials spill or leak. However, the City of Georgetown's ordinance to protect water quality will help reduce the risk of a significant hazardous materials spill impacting surface stream drainages of the Georgetown salamander by requiring roadways that have a capacity of 25,000 vehicles per day to provide for spill containment as described in the TCEQ's Optional Enhanced Measures.

In addition, construction activities resulting from urban development or rock quarry mining activities may negatively impact both water quality and quantity because they can increase sedimentation and dewater springs by intercepting aquifer conduits. There are currently five Georgetown salamander sites that are located within 1 mile (1.6 km) of active rock quarries within Williamson County, Texas, which may impact the species and its habitat, and which could result in the destruction of spring sites, collapse of karst caverns, degradation of water quality, and reduction of water quantity (Ekmekci 1990, p. 4). In 2004, elevated levels of perchlorate (a chemical used in producing quarry explosives) were detected in multiple springs within Williamson County, indicating that quarry activities were having an impact on local water quality (Berehe 2005, p. 44). At this time, we are not aware of any studies that have examined sediment loading due to construction activities within the watersheds of Georgetown salamander habitat. While the City of Georgetown's new water quality ordinance will reduce construction-related sediment loading, it will not remove all such loading, and given that construction-related sediment loading has been shown to impact other salamander species (Turner 2003, p. 24; O'Donnell *et al.* 2006, p. 34), sediment loading is likely to occur within the rapidly developing range of the Georgetown salamander. Thus, we expect that effects from construction activities will increase as urbanization increases within the range of the Georgetown salamander.

The habitat of Georgetown salamanders is sensitive to direct physical habitat modification, such as those resulting from human recreational activities, impoundments, feral hogs, and livestock. Present disturbance of Georgetown salamander habitat has been attributed to direct human modification of spring outlets (TPWD 2011a, p. 9), feral hog activity (Booker 2011, pers. comm.), and livestock activity (White 2011, SWCA, pers. comm.).

The effects of present and future climate change could also affect water quantity and spring flow for the Georgetown salamander. Climate change could compound the threat of decreased water quantity at salamander spring sites by decreasing precipitation, increasing evaporation, increasing groundwater pumping demands, and increasing the likelihood of extreme drought events. Climate change could cause spring sites with small amounts of discharge to go dry and no longer support salamanders, reducing the overall redundancy and representation for the species. For example, at least two Georgetown salamander sites (Cobb and San Gabriel Springs) are known to lose surface flow for periods of time (Booker 2011, p. 1; Breen and Faucette 2013, p. 1). Climate change is causing extreme droughts to become much more probable than they were 40 to 50 years ago (Rupp *et al.* 2012, pp. 1,053–1,054). Therefore, climate change is an ongoing threat to this species that could add to the likelihood of the Georgetown salamander becoming an endangered species within the foreseeable future.

Although there are several regulations in place (Factor D) that benefit the Georgetown salamander, none have proven adequate to protect this species' habitat from degradation. Data indicate that some water quality degradation in the range of the Georgetown salamander has occurred and continues to occur despite relatively low impervious cover and the existence of state and local regulatory mechanisms in place to protect water quality (SWCA 2012, pp. 11–20; TCEQ 2012b, pp. 646–736). In addition, Williamson County does not currently have a groundwater conservation district that can manage groundwater resources countywide and prevent groundwater levels from declining from private pumping. Existing regulations have not prevented the disturbance of surface habitat that has occurred at several sites. The City of Georgetown's Edwards Aquifer Recharge Zone Water Quality Ordinance, Water Quality Management Plan, and Adaptive Management Plan, approved in December 2013, will help to reduce some of the threats from water quality degradation and direct impacts to surface habitat that are typically associated with urbanized areas. However, these mechanisms are not adequate to protect this species and its habitat now, nor do we anticipate them to sufficiently protect this species and its habitat in the future.

Other natural or manmade factors (Factor E) affecting all Georgetown salamander populations include UV–B radiation, small population sizes, stochastic events (such as floods or droughts), and synergistic and additive interactions among the stressors mentioned above. For example, the only mark-recapture studies on the Georgetown salamander estimated surface population sizes of 100 to 200 adult salamanders at 2 sites thought to be of the highest quality for this species (Twin Springs and Swinbank Springs, Pierce 2011a, p. 18). Georgetown salamander populations are likely smaller at other, lower quality sites. In fact, this species has not been observed in more than 10 years at two locations (San Gabriel Spring and Buford Hollow Spring), despite several survey efforts to find it (Pierce 2011b, c, Southwestern University, pers. comm.). Factors such as small population size, especially in combination with the threats summarized above, make Georgetown salamander populations less resilient and more vulnerable to population extirpations in the foreseeable future.

Because of the fact-specific nature of listing determinations, there is no single metric for determining if a species is ''in danger of extinction'' now. In the case of the Georgetown salamander, the best available information indicates that habitat degradation will result in significant impacts on salamander populations. The threat of urbanization indicates that most of the Georgetown salamander populations are currently at an elevated risk of extirpation, or will be at an elevated risk in the future. These impacts are expected to increase in severity and scope as urbanization within the range of the species increases. Also, the combined result of increased impacts to habitat quality and inadequate regulatory mechanisms leads us to the conclusion that Georgetown salamanders will likely be in danger of extinction within the foreseeable future. As Georgetown salamander populations become more degraded, isolated, or extirpated by urbanization, the species will lose resiliency and be at an elevated risk from climate change impacts, small population sizes, and catastrophic events, such as drought, floods, and hazardous material spills. These events will affect all known extant populations, putting the Georgetown salamander at a high risk of extinction. Therefore, because the resiliency of populations is expected to decrease in the foreseeable future, the Georgetown salamander will be in danger of extinction throughout all of its range in the foreseeable future, and appropriately meets the definition of a threatened species (that is, in danger of extinction in the foreseeable future).

Under the Act and our implementing regulations, a species may warrant listing if it is endangered or threatened throughout all or a significant portion of its range. The threats to the survival of this species occur throughout its range and are not restricted to any particular significant portion of its range. Accordingly, our assessments and determinations apply to this species throughout its entire range.

In conclusion, as described above, the Georgetown salamander is subject to significant current and ongoing threats now and will be subject to more severe threats in the future. After a review of the best available scientific information as it relates to the status of the species and the five listing factors, we find the Georgetown salamander is not currently in danger of extinction, but will be in danger of extinction in the future. Therefore, on the basis of the best available scientific and commercial information, we list the Georgetown salamander as a threatened species in accordance with section 3(6) of the Act. We find that an endangered species status is not appropriate for the Georgetown salamander because the species is not in danger of extinction at this time. While some threats to the Georgetown salamander are occurring now, the impacts from these threats are not yet at a level that puts this species in danger of extinction now. However, with future urbanization and the added effects of climate change, we expect habitat degradation and Georgetown salamander count declines to continue into the future to the point where the species will then be in danger of extinction.

Listing Status Determination for the Salado Salamander

In the proposed rule (77 FR 50768, August 22, 2012), the Salado salamander species was proposed as endangered, rather than threatened, because at that time, we determined the threats to be imminent, and their potential impacts to the species would be catastrophic given the very limited range of the species. For this final determination, we took into account data that were made available after the proposed rule published, information provided by commenters on the proposed rule, and further discussions within the Service to determine whether the Salado salamander should be classified as endangered or threatened. Based on our review of the best available scientific and commercial information, we conclude that the Salado salamander is likely to become in danger of extinction in the foreseeable future throughout all of its range and, therefore, meets the definition of a threatened species. This finding, explained below, is based on our conclusions that few (seven) Salado salamander sites exist (some of these sites are close to each other and likely part of the same population), some populations have begun to experience impacts from threats to its habitat, and these threats are expected to increase in the future. As the threats increase, we expect Salado salamander populations to decline and be extirpated, reducing the overall representation and redundancy across the species range and increasing the species risk of extinction. We find the Salado salamander will be at an elevated risk of extinction in the future. We, therefore, find that the Salado salamander warrants a threatened species listing status determination.

There is a limited amount of data on Salado salamander populations and how these populations respond to stressors. There are no population estimates for any of the seven known Salado salamander populations, and salamanders are very rarely seen at four of the seven sites. In addition, no studies have used controlled experiments to understand how environmental changes might affect Salado salamander individuals. To deal with this uncertainty and evaluate threats to the Salado salamander that are occurring now or in the future, we used information on substitute species, which is an accepted practice in aquatic ecotoxicology and conservation biology (Caro *et al.* 2005, p. 1823; Wenger 2008, p. 1,565). In instances where information was not available for the Salado salamander specifically, we have provided references for studies conducted on similarly related species, such as the Jollyville Plateau salamander and Barton Springs salamander, which occur within the central Texas area, and other salamander species that occur in other parts of the United States. We concluded that these were appropriate comparisons to make based on the following similarities between the species: (1) a clear systematic (evolutionary) relationship (for example, members of the Family Plethodontidae); (2) shared life history attributes (for example, the lack of metamorphosis into a terrestrial form); (3) similar morphology and physiology (for example, the lack of lungs for respiration and sensitivity to environmental conditions); and (4) similar habitat and ecological requirements (for example, dependence on aquatic habitat in or near springs with a rocky or gravel substrate).

Present and future degradation of habitat (Factor A) is the primary threat to the Salado salamander. This threat primarily occurs in the form of reduced water quality from introduced and concentrated contaminants, increased sedimentation, and altered stream flow regimes. Reduced water quality from increased conductivity, PAHs, pesticides, and nutrients have all been shown to have detrimental impacts on salamander density, growth, and behavior (Marco *et al.* 1999, p. 2,837; Albers 2003, p. 352; Rohr *et al.* 2003, p. 2,391; Bowles *et al.* 2006, pp. 117–118; O'Donnell *et al.* 2006, p. 37; Reylea 2009, p. 370; Sparling *et al.* 2009, p. 28; Bommarito *et al.* 2010, pp. 1,151–1,152). Sedimentation causes the amount of available foraging habitat and protective cover for salamanders to be reduced (Welsh and Ollivier 1998, p. 1,128), reducing salamander abundance (Turner 2003, p. 24; O'Donnell *et al.* 2006, p. 34). Sharp declines and increases in stream flow have also been shown to reduce salamander abundance (Petranka and Sih 1986, p. 732; Sih *et al.* 1992, p. 1,429; Baumgartner *et al.* 1999, p. 36; Miller *et al.* 2007, pp. 82–83; Price *et al.* 2012b, p. 319). In the absence of species-specific information, we conclude that Salado salamanders respond negatively to these stressors because aquatic invertebrates (the prey base of the Salado salamander) and several species of closely related stream salamanders have demonstrated direct and indirect negative responses to these stressors.

Reduced water quality, increased sedimentation, and altered flow regimes are primarily the result of human population growth and subsequent urbanization within the watersheds and recharge and contributing zones of the groundwater supporting spring and cave sites. Urbanization in the range of the Salado salamander is currently at relatively low levels. However, based on our current knowledge of the Salado salamander and observations made on the impacts of urbanization on other closely related species of aquatic salamanders, urbanization is likely affecting both surface and subsurface habitat and is likely having impacts on Salado salamander populations. Based on our analysis of impervious cover (which we use as a proxy for urbanization) throughout the range of the Salado salamander, five of the six surface watersheds occupied by Salado salamanders had levels of impervious cover in 2006 that are likely causing habitat degradation. Although we do not have long-term survey data on Salado salamander populations, recent surveys have indicated that Salado salamanders are exceedingly rare at the three most impacted sites (no salamanders were found during surveys conducted in 2012; Hibbitts 2013, p. 2) and more abundant at the three least impacted sites (Gluesenkamp 2011a, b, TPWD, pers. comm.). The best available information indicates that habitat degradation from urbanization or physical disturbance is causing declines in Salado salamander populations throughout most of the species' range now, or will cause population declines in the future, putting these populations at an elevated risk of extirpation.

Further degradation of the Salado salamander's habitat is expected to continue into the future, primarily as a result of an increase in urbanization. Substantial human population growth is ongoing within this species' range, indicating that the urbanization and its effects on Salado salamander habitat will increase in the future. The Texas State Data Center (2012, p. 353) has reported a population increase of 128 percent for Bell County, Texas, from the year 2010 to 2050. Because subsurface flow into some Salado salamander sites may originate in Williamson County to the southwest, human population growth in Williamson County also could have increasing negative impacts on Salado salamander habitat. The Texas State Data Center estimates a 377 percent increase in human population in Williamson County from 2010 to 2050.

Adding to the likelihood of the Salado salamander becoming endangered in the future is the risk from hazardous materials that could be spilled or leaked, potentially resulting in the contamination of both surface and groundwater resources. Three of the seven Salado salamander sites are located less than 0.25 mi (0.40 km) downstream of Interstate Highway 35 and may be particularly vulnerable to spills due to their proximity to this major transportation corridor. Should a hazardous materials spill occur at the Interstate Highway 35 bridge that crosses at Salado Creek, this species could be at risk from contaminants entering the water flowing into its surface habitat downstream. In addition, multiple petroleum leaks from underground storage tanks have occurred near Salado salamander sites in the past (Price *et al.* 1999, p. 10). Because no follow-up studies were conducted, we have no information to indicate what effect these spills had on the species or its habitat. A significant hazardous materials spill within stream drainages of the Salado salamander has the potential to threaten the long-term survival and sustainability of multiple populations, and we expect the risk of spills will increase in the future as urbanization increases.

In addition, construction activities resulting from urban development or rock quarry mining activities may negatively impact both water quality and quantity because they can increase sedimentation and dewater springs by intercepting aquifer conduits. There is currently an active rock quarry located within 1.25 mi (2.0 km) of three Salado salamander sites within Bell County, Texas, which may impact the species and its habitat, and which could result in the collapse of karst caverns, degradation of water quality, and reduction of water quantity (Ekmekci 1990, p. 4). At this time, we are not aware of any studies that have examined sediment loading due to construction activities within the watersheds of Salado salamander habitat. However, given that construction-related sediment loading has been shown to impact other salamander species (Turner 2003, p. 24; O'Donnell *et al.* 2006, p. 34) and is likely to occur within the developing range of the Salado salamander, we expect that effects from construction activities will increase as urbanization increases within the range of the Salado salamander.

The habitat of Salado salamanders is sensitive to direct physical habitat modification, such as those resulting from human recreational activities, impoundments, feral hogs, and livestock. Destruction of Salado salamander habitat has been attributed to direct human modification, including heavy machinery use, outflow channel reconstruction, substrate alteration, and impoundments (Service 2010, p. 6; Gluesenkamp 2011a, c, pers. comm.). One of the seven Salado salamander sites is unfenced and vulnerable to access and damage from livestock and feral hogs.

The effects of present and future climate change could also affect water quantity and spring flow for the Salado salamander. Climate change will likely compound the threat of decreased water quantity at salamander spring sites by decreasing precipitation, increasing evaporation, increasing groundwater pumping demands, and increasing the likelihood of extreme drought events. Climate change could cause spring sites with small amounts of discharge to go dry and no longer support salamanders, reducing the overall redundancy and representation for the species. For example, at least two Salado salamander sites (Robertson Spring and Lil' Bubbly Spring) are known to lose surface flow for periods of time (Gluesenkamp 2011a, pers. comm.; Breen and Faucette 2013, p. 1). Climate change is currently causing extreme droughts to become much more probable than they were 40 to 50 years ago (Rupp *et al.* 2012, pp. 1,053–1,054). Therefore, climate change is an ongoing threat to this species and will add to the likelihood of the Salado salamander becoming an endangered species within the foreseeable future.

Although there are several regulations in place (Factor D) that benefit the Salado salamander, none have proven adequate to protect this species' habitat from degradation. Data indicate that some water quality degradation in the range of the Salado salamander has occurred and continues to occur despite relatively low impervious cover and the existence of state and local regulatory mechanisms in place to protect water quality (TCEQ 2012b, pp. 646–736). In addition, although Bell County does have a groundwater conservation district that can manage groundwater resources countywide, this management has not prevented Salado salamander spring sites from going dry during droughts (TPWD 2011a, p. 5; Aaron 2013, CUWCD, pers. comm.; Breen and Faucette 2013, pers. comm.). Finally, no regulations have prevented the disturbance of the physical surface habitat that has occurred at three sites within the Village of Salado. Therefore, the existing regulatory mechanisms are not adequate to protect this species and its habitat now, nor do we anticipate them to sufficiently protect this species in the future.

Other natural or manmade factors (Factor E) affecting all Salado salamander populations include UV–B radiation, small population sizes, stochastic events (such as floods or droughts), and synergistic and additive interactions among the stressors mentioned above. Because of how rare Salado salamanders are at most sites (Gluesenkamp 2011a, b, TPWD, pers. comm.; TPWD 2011a, pp. 1–3), we assume that population sizes are very small. Factors such as small population size, in combination with the threats summarized above, make Salado salamander populations less resilient and more vulnerable to population extirpations in the foreseeable future.

Because of the fact-specific nature of listing determinations, there is no single metric for determining if a species is ''in danger of extinction'' now. In the case of the Salado salamander, the best available information indicates that habitat degradation will result in significant impacts on salamander populations. The threat of urbanization indicates that most of the Salado salamander populations are currently at an elevated risk of extirpation, or will be at an elevated risk in the future. These impacts are expected to increase in severity and scope as urbanization within the range of the species increases. Also, the combined result of increased impacts to habitat quality and inadequate regulatory mechanisms leads us to the conclusion that Salado salamanders will likely be in danger of extinction within the foreseeable future. As Salado salamander populations become more degraded, isolated, or extirpated by urbanization, the species will lose resiliency and be at an elevated risk from climate change impacts, small population sizes, and catastrophic events (for example, drought, floods, hazardous material spills). These events will affect all known extant populations, putting the Salado salamander at a high risk of extinction. Therefore, because the resiliency of populations is expected to decrease in the foreseeable future, the Salado salamander will be danger of extinction throughout all of its range in the future, and it appropriately meets the definition of a threatened species (that is, in danger of extinction in the foreseeable future).

Under the Act and our implementing regulations, a species may warrant listing if it is endangered or threatened throughout all or a significant portion of its range. The threats to the survival of this species occur throughout its range and are not restricted to any particular significant portion of its range. Accordingly, our assessments and determinations apply to this species throughout its entire range.

In conclusion, the Salado salamander is subject to significant current and ongoing threats now and will be subject to more severe threats in the future. After a review of the best available scientific information as it relates to the status of the species and the five listing factors, we find the Salado salamander is not in danger of extinction now, but will be in danger of extinction in the foreseeable future. Therefore, on the basis of the best available scientific and commercial information, we list the Salado salamander as a threatened species, in accordance with section 3(6) of the Act. We find that an endangered species status is not appropriate for the Salado salamander because the species is not in danger of extinction now. While some threats to the Salado salamander are occurring now, the impacts from these threats are not yet at a level that puts this species in danger of extinction at this time. However, with future urbanization and the added effects of climate change, we expect habitat degradation and Salado salamander count declines to continue into the foreseeable future to the point where the species will then be in danger of extinction.

Available Conservation Measures

Conservation measures provided to species listed as endangered or threatened species under the Act include recognition, recovery actions, requirements for Federal protection, and prohibitions against certain practices. Recognition through listing results in public awareness and conservation by Federal, state, tribal, and local agencies, private organizations, and individuals. The Act encourages cooperation with the states and requires that recovery actions be carried out for all listed species. The protection required by Federal agencies and the prohibitions against certain activities are discussed, in part, below.

The primary purpose of the Act is the conservation of endangered and threatened species and the ecosystems upon which they depend. The ultimate goal of such conservation efforts is the recovery of these listed species, so that they no longer need the protective measures of the Act. Subsection 4(f) of the Act requires the Service to develop and implement recovery plans for the conservation of endangered and threatened species. The recovery planning process involves the identification of actions that are necessary to halt or reverse the decline in the species' status by addressing the threats to its survival and recovery. The goal of this process is to restore listed species to a point where they are secure, self-sustaining, and functioning components of their ecosystems.

Recovery planning includes the development of a recovery outline shortly after a species is listed and preparation of a draft and final recovery plan. The recovery outline guides the immediate implementation of urgent recovery actions and describes the process to be used to develop a recovery plan. Revisions of the plan may be done to address continuing or new threats to the species, as new substantive information becomes available. The recovery plan identifies site-specific management actions that set a trigger for review of the five factors that control whether a species remains endangered or may be downlisted or delisted, and methods for monitoring recovery progress. Recovery plans also establish a framework for agencies to coordinate their recovery efforts and provide estimates of the cost of implementing recovery tasks. Recovery teams (comprising species experts, Federal and state agencies, non-governmental organizations, and stakeholders) are often established to develop recovery plans. When completed, the recovery outline, draft recovery plan, and the final recovery plan will be available on our Web site (*http://www.fws.gov/endangered*), or from our Austin Ecological Services Field Office (see **FOR FURTHER INFORMATION CONTACT**).

Implementation of recovery actions generally requires the participation of a broad range of partners, including other Federal agencies, states, tribes, non-governmental organizations, businesses, and private landowners. Examples of recovery actions include habitat restoration (for example, restoration of native vegetation), research, captive propagation and reintroduction, and outreach and education. The recovery of many listed species cannot be accomplished solely on Federal lands because their range may occur primarily or solely on non-Federal lands. To achieve recovery of these species requires cooperative conservation efforts on private, state, tribal, and other lands.

Once these species are listed, funding for recovery actions will be available from a variety of sources, including Federal budgets, state programs, and cost-share grants for non-Federal landowners, the academic community, and nongovernmental organizations. In addition, pursuant to section 6 of the

Act, the State of Texas will be eligible for Federal funds to implement management actions that promote the protection or recovery of the Georgetown and Salado salamanders. Information on our grant programs that are available to aid species recovery can be found at: *http://www.fws.gov/grants.*

Section 7(a) of the Act requires Federal agencies to evaluate their actions with respect to any species that is proposed or listed as endangered or threatened and with respect to its critical habitat, if any is designated. Regulations implementing this interagency cooperation provision of the Act are codified at 50 CFR part 402. Section 7(a)(4) of the Act requires Federal agencies to confer with the Service on any action that is likely to jeopardize the continued existence of a species proposed for listing or result in destruction or adverse modification of proposed critical habitat. If a species is listed subsequently, section 7(a)(2) of the Act requires Federal agencies to ensure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of the species or destroy or adversely modify its critical habitat. If a Federal action may affect a listed species or its critical habitat, the responsible Federal agency must enter into formal consultation with the Service.

Federal agency actions within the species habitat that may require conference or consultation or both as described in the preceding paragraph include management, construction, and any other activities with the possibility of altering aquatic habitats, groundwater flow paths, and natural flow regimes within the ranges of the Georgetown and Salado salamanders. Such consultations could be triggered through the issuance of section 404 Clean Water Act permits by the Army Corps of Engineers or other actions by the Service, U.S. Geological Survey, and Bureau of Reclamation; construction and maintenance of roads or highways by the Federal Highway Administration; landscape-altering activities on Federal lands administered by the Department of Defense; and construction and management of gas pipelines and power line rights-of-way by the Federal Energy Regulatory Commission.

The Act and its implementing regulations set forth a series of general prohibitions and exceptions that apply to all endangered wildlife. The prohibitions of section 9(a)(2) of the Act, codified at 50 CFR 17.21 for endangered wildlife, in part, make it illegal for any person subject to the jurisdiction of the United States to take (includes harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect; or to attempt any of these), import, export, ship in interstate commerce in the course of commercial activity, or sell or offer for sale in interstate or foreign commerce any listed species. Under the Lacey Act (18 U.S.C. 42–43; 16 U.S.C. 3371–3378), it is also illegal to possess, sell, deliver, carry, transport, or ship any such wildlife that has been taken illegally. Certain exceptions apply to agents of the Service and state conservation agencies.

We may issue permits to carry out otherwise prohibited activities involving endangered and threatened wildlife species under certain circumstances. Regulations governing permits are codified at 50 CFR 17.22 for endangered wildlife, and at 50 CFR 17.32 for threatened wildlife. With regard to endangered wildlife, a permit must be issued for the following purposes: for scientific purposes, to enhance the propagation or survival of the species, and for incidental take in connection with otherwise lawful activities.

Required Determinations

Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et seq.)

This rule does not contain any new collections of information that require approval by OMB under the Paperwork Reduction Act. This rule will not impose recordkeeping or reporting requirements on state or local governments, individuals, businesses, or organizations. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number.

National Environmental Policy Act

We have determined that environmental assessments and environmental impact statements, as defined under the authority of the National Environmental Policy Act (NEPA; 42 U.S.C. 4321 *et seq.*), need not be prepared in connection with listing a species as an endangered or threatened species under the Act. We published a notice outlining our reasons for this determination in the **Federal Register** on October 25, 1983 (48 FR 49244).

Data Quality Act

In developing this rule, we did not conduct or use a study, experiment, or survey requiring peer review under the Data Quality Act (Pub. L. 106–554).

References Cited

A complete list of all references cited in this rule is available on the Internet at *http://www.regulations.gov* or upon request from the Field Supervisor, Austin Ecological Services Field Office (see **ADDRESSES**).

Author(s)

The primary author of this document is staff from the Austin Ecological Services Field Office (see **ADDRESSES**) with support from the Arlington, Texas, Ecological Services Field Office.

List of Subjects in 50 CFR Part 17

Endangered and threatened species, Exports, Imports, Reporting and recordkeeping requirements, Transportation.

Regulation Promulgation

Accordingly, we amend part 17, subchapter B of chapter I, title 50 of the Code of Federal Regulations, as follows:

PART 17—[AMENDED]

■ 1. The authority citation for part 17 continues to read as follows:

Authority: 16 U.S.C. 1361–1407; 1531–1544; 4201–4245; unless otherwise noted.

■ 2. Amend § 17.11(h) by adding entries for ''Salamander, Georgetown'' and ''Salamander, Salado'' in alphabetical order under Amphibians to the List of Endangered and Threatened Wildlife to read as follows:

§ 17.11 Endangered and threatened wildlife.

* * * * *

(h) * * *

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
* * * * * * *							
Amphibians							
* * * * * * *							
Salamander, Georgetown	*Eurycea naufragia*	U.S.A. (TX)	Entire	T		NA	NA
* * * * * * *							
Salamander, Salado	*Eurycea chisholmensis*	U.S.A. (TX)	Entire	T		NA	NA
* * * * * * *							

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Dated: February 14, 2014.

Daniel M. Ashe,

Director, U.S. Fish and Wildlife Service.

[FR Doc. 2014–03717 Filed 2–21–14; 8:45 am]

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