DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

50 CFR Part 17

RIN 1018–AC22

Endangered and Threatened Wildlife and Plants; Final Rule To List the Barton Springs Salamander as Endangered

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Final rule.

SUMMARY: The Fish and Wildlife Service (Service) determines the Barton Springs salamander (*Eurycea sosorum*) to be an endangered species pursuant to the Endangered Species Act of 1973, as amended (Act). The Barton Springs salamander is known only from Barton Springs in Zilker Park, Austin, Travis County, Texas. The primary threats to this species are degradation of the quality and quantity of water that feeds Barton Springs due to urban expansion over the Barton Springs watershed. Also of concern is disturbance to the salamander's surface habitat in the pools where it occurs. This action implements Federal protection provided by the Act for the Barton Springs salamander.

EFFECTIVE DATE: May 30, 1997.

ADDRESSES: The complete file for this rule is available for inspection, by appointment, during normal business hours at the Ecological Services Field Office, U.S. Fish and Wildlife Service, 10711 Burnet Road, Suite 200, Austin, Texas 78758.

FOR FURTHER INFORMATION CONTACT: Lisa O'Donnell, Fish and Wildlife Biologist (see **ADDRESSES** section) (telephone: 512/490–0057; facsimile (512/490-0974)).

SUPPLEMENTARY INFORMATION:

Background

The Service determines the Barton Springs salamander (*Eurycea sosorum*) to be an endangered species, under the authority of the Endangered Species Act (Act) (16 U.S.C. 1531 *et seq.*). The Barton Springs salamander is entirely aquatic and neotenic (meaning it does not metamorphose into a terrestrial form and retains its bright red external gills throughout life) and depends on a constant supply of clean, flowing water from Barton Springs. Adults attain an average length of 6.35 centimeters (cm) (2.5 inches (in)). This species is slender, with slightly elongate limbs and reduced eyes. Dorsal coloration varies from pale purplish-brown or gray to yellowish-cream. Irregular spacing of dorsal pigments and pigment gaps results in a mottled, ''salt and pepper'' pattern (Sweet 1978, Chippindale *et al.* 1993a).

The Barton Springs salamander was first collected from Barton Springs Pool in 1946 by Bryce Brown and Alvin Flury (Chippindale *et al.* 1993a,b). Although he did not publish a formal description, Dr. Samuel Sweet (University of California at Santa Barbara) was the first to recognize the Barton Springs salamander as distinct from other central Texas *Eurycea* salamanders based on its restricted distribution and unique morphological and skeletal characteristics (such as its reduced eyes, elongate limbs, dorsal coloration, and reduced number of presacral vertebrae) (Sweet 1978, 1984). Based on Sweet's work and genetic studies conducted by Chippindale *et al.* (1990, 1992, 1993b), the Barton Springs salamander was formally described in June 1993 (Chippindale *et al.* 1993a). An adult male (based on external examination only) collected from Barton Springs Pool in November 1992 was selected to be the holotype (Chippindale *et al.* 1993a).

The water that discharges at Barton Springs originates from the Barton Springs segment of the Edwards aquifer (hereafter referred to as the ''Barton Springs segment''). Barton Springs is the fourth largest spring in Texas, exceeded only by Comal, San Marcos, and San Felipe springs (Brune 1981). The Barton Springs salamander is found near three of four hydrologically connected spring outlets that collectively make up Barton Springs. These three spring outlets are known as Parthenia (=Main), Eliza (=Concession, =Elk's), and Sunken Garden (=Old Mill, =Walsh) springs, and they occur in Zilker Park, which is owned and operated by the City of Austin. No salamanders have been found at the fourth spring outlet, which is in Barton Creek immediately above Barton Springs Pool (Chippindale *et al.* 1993a,b; Sweet, pers. comm., 1993; Robert Hansen, City of Austin, *in litt.*, 1995a; William Russell, Texas Speleological Survey, *in litt.* 1995). The area around the main spring outlet (Parthenia Springs) was impounded in the late 1920's to create Barton Springs Pool. Flows from Eliza and Sunken Garden springs are also retained by concrete structures, forming small pools located on either side of Barton Springs Pool. The salamander has been observed at depths of about 0.1 to 5 meters (m) (0.3 to 16 feet (ft)) of water under gravel and small rocks, submerged leaves, and algae; among aquatic vegetation; and buried in organic debris. It is generally not found on exposed limestone surfaces or in silted areas (Sweet 1978; Dr. Charles Sexton, City of Austin, *in litt.*, 1992; Chippindale *et al.* 1993a,b; Jim Collett, Robert Hansen, and Mateo Scoggins, City of Austin, pers. comms., 1994–1995; Lisa O'Donnell, U.S. Fish and Wildlife Service (USFWS), pers. obs., 1996).

''Dozens or hundreds'' of individuals were estimated to occur among sunken leaves in Eliza Pool during the 1970's (Chippindale *et al.* 1993a,b), while fewer than 15, and occasionally no individuals, were observed during surveys conducted in Eliza Pool between 1987 and 1992 (Chippindale *et al.* 1993a,b). No salamanders were observed at this location between December 1993 and May 1995 (Paul Chippindale, University of Texas at Arlington, Collett, Hansen, and Scoggins; pers. comms., 1994–1995; Hansen *in litt.* 1995b). Numbers ranged from 0 to 28 between June 1995 and July 1996, and dead salamanders have been found (O'Donnell, unpubl. data, 1995–1996).

The Barton Springs salamander was reportedly abundant among the aquatic vegetation in the deep end of Barton Springs Pool when it was collected in 1946 (Hillis and Chippindale 1992; Chippindale *et al.* 1993a,b). Between 1989 and 1991, Sexton (*in litt.*, 1992) reported finding salamanders under rock rubble immediately adjacent to the main spring outflows on ''about one out of four [snorkeling] dives.'' On July 28, 1992, at least 50 salamanders (David Hillis, University of Texas at Austin, pers. comm., 1993) were found over an area of roughly 400 square (sq) m (4,300 sq ft) near the spring outflows in Barton Springs Pool, about 3 to 5 m (10 to 15 ft) below the water (Chippindale *et al.* 1993a,b). Following reports of a fish kill on September 28, 1992, attributed to the improper application of chlorine to clean Barton Springs Pool, only 10 to 11 salamanders were observed and could only be found in an area of about 5 sq m (54 sq ft) in the immediate vicinity of the Parthenia Spring outflows (Chippindale *et al.* 1993a,b). At least 80 individuals were observed during the first comprehensive survey effort conducted in Barton Springs Pool on November 16, 1992, and about 150 individuals were seen on November 24, 1992 (Chippindale *et al.* 1993a,b). A comprehensive survey conducted immediately following an October 1994 flood event reported a total of 16 salamanders, and a total of 10 salamanders was counted in March 1995 (Hansen, *in litt.* 1995c).

The City of Austin initiated monthly transect surveys in June 1993 to provide more consistent data concerning the range and size of the Barton Springs salamander population in Barton Springs Pool. Survey counts ranged from 1 to 27 individuals (mean = 13) between July 1993 and March 1995. The highest survey counts (27 individuals) were reported in November 1993 and May 1994. The lowest counts (ranging from 1 to 6 individuals) occurred during a five-month period following the October 1994 flood event (Hansen, *in litt.* 1995c). Survey counts between April 1995 and April 1996 ranged from 3 to 45 salamanders (City of Austin, unpubl. data).

The salamander was first observed at Sunken Garden Springs on January 12, 1993 (Chippindale *et al.* 1993b). Less than 20 individuals have been reported on any given visit to that outlet (Chippindale 1993b; Hansen, pers. comm., 1995). Because it is part of the Barton Springs complex and is hydrologically connected to Parthenia Springs, biologists had speculated that the salamander occurred at Sunken Garden Springs. However, no salamanders were observed during previous surveys conducted at this location between 1987 and 1992. Low water levels and the presence of large rocks and sediment make searching for salamanders difficult at Sunken Garden Springs (Chippindale *et al.* 1993b; O'Donnell, pers. obs., 1995).

No evidence exists that the species' range extends beyond the immediate vicinity of Barton Springs. Despite survey efforts and searches at other spring outlets, caves, and uncased wells in the Barton Springs segment, no other locations of the Barton Springs salamander have been found (Chippindale *et al.* 1993a,b; Russell, *in litt.* 1995; Russell 1996; Hillis; Andy Price, Texas Parks and Wildlife Department; Sweet; pers. comms., 1993; Hansen, *in litt.* 1995a). No other species of *Eurycea* is known to occur in this portion of the aquifer. Although the extent to which the Barton Springs salamander occurs in the aquifer is unknown, it is likely concentrated near the spring openings where food supplies are abundant, water chemistry and temperatures are relatively constant, and where the salamander has immediate access to both surface and subsurface habitats. Barton Springs is also the main discharge point for the entire Barton Springs segment, and is one of the few perennial springs in the area.

The Barton Springs salamander's diet is believed to consist almost entirely of amphipods (*Hyallela azteca*) and other small invertebrates (James Reddell, Texas Memorial Museum, University of Texas at Austin, pers. comm., 1993; Hillis and Chippindale 1992; Chippindale *et al.* 1993a,b). Primary predators of the Barton Springs salamander are believed to be fish and crayfish (Chippindale *et al.* 1993a,b; Collett, Hansen, and Scoggins, pers. comms., 1995). Observations of larvae and females with eggs indicate breeding occurs year-round (Chippindale, pers. comm., 1993; Collett, Hansen, and Scoggins, pers. comms., 1994–1995). The Barton Springs salamander's eggs are white (Lynn Ables and Streett Coale, Dallas Aquarium; Jim Dwyer, Midwest Science Center; pers. comms., 1996) and have never been observed in the wild (Chippindale, Hillis, and Price, pers. comms. 1993; Collett, Hansen, and Scoggins, pers. comms., 1994–1995; O'Donnell, pers. obs., 1995–1996).

The Barton Springs segment covers roughly 400 sq kilometers (km) (155 sq miles (mi)) from southern Travis County to northern Hays County, Texas, and has a storage capacity of over 37,000 hectare-meters (300,000 acre-feet) (Slade *et al.* 1985, 1986). The watersheds of the six creeks upstream (west) of the recharge zone span about 684 sq km (264 sq mi). This area is referred to as the contributing zone and includes portions of Travis, Hays, and Blanco counties. The recharge and contributing zones (hereafter referred to collectively as the ''Barton Springs watershed'') make up the total area that provides water to the aquifer, which equals about 917 sq km (354 sq mi). A detailed description of the Barton Springs segment of the Edwards aquifer can be found in the Service's February 17, 1994, proposed rule (59 FR 7968). Porous limestone, karst aquifers, such as the Barton springs segment may transport pollutants rapidly once such materials enter the creeks or other recharge features (EPA 1990, TWC 1989, Slade *et al.*1986, Ford and Williams 1994, Notenboom *et al.* 1994)

Because of the characteristics of karst aquifers, Barton Springs is believed to be heavily influenced by the quality and quantity of runoff, particularly in the recharge zone (City of Austin 1991; Slade *et al.* 1986). Thus, increasing urban development over the area supplying recharge waters to the Barton Springs segment can threaten water quality within the aquifer. The Texas Water Commission (now known as the Texas Natural Resource Conservation Commission (TNRCC)) identified the Edwards aquifer as being one of the most sensitive aquifers in Texas to groundwater pollution (TWC 1989; Hart, *in litt.*, 1991; TNRCC 1994).

Previous Federal Action

The Barton Springs salamander was a Category 2 candidate species on the Service's candidate notices of review from December 30, 1982 (47 FR 58454; September 18, 1985: 50 FR 37958; January 6, 1989: 54 FR 554; and November 21, 1991: 56 FR 58804) until publication of the proposed rule to list the species as endangered (59 FR 7968; February 17, 1994). Dr. Mark Kirkpatrick and Ms. Barbara Mahler petitioned the Service to list the Barton Springs salamander on January 22, 1992, and on December 11, 1992 (57 FR 58779), the Service published a notice in the **Federal Register** that the petition presented substantial information that the requested action may be warranted. A proposed rule to list the Barton Springs salamander was published in the **Federal Register** on February 17, 1994 (59 FR 7968). The Service held a public hearing on June 16, 1994, in Austin, Texas (59 FR 27257). On March 10, 1995, the Service published a notice extending the 1-year deadline for final action on the proposed rule until August 17, 1995, and reopened the public comment period (60 FR 13105).

On April 10, 1995, Congress enacted a moratorium prohibiting work on listing actions (Public Law 104–6) and eliminated funding for the Service to conduct final listing actions. On November 27, 1995, in response to a lawsuit from the Save Our Springs Legal Defense Fund (Save Our Springs Legal Defense Fund, Inc., *et al.* v. Bruce Babbitt), a U.S. District Court invalidated the Service's March 10, 1995, notice of extension and ruled that the Service had to make a final determination on whether or not to list the Barton Springs salamander within 14 days of the court order. The court granted a stay pending the Service's appeal of the order, on the grounds that the moratorium and lack of funding prohibited the Service from making a final listing determination. The moratorium was lifted on April 26, 1996, by means of a Presidential waiver, at which time limited funding for listing actions was made available through the Omnibus Appropriations Act (Pub. L. No. 104–134, 100 Stat. 1321, 1996). The Service published guidance for restarting the listing period on May 16, 1996 (61 FR 24722). Due to the potential for new information during the lapse between the reinstatement of the listing program and the close of the last 45-day comment period (May 17, 1995), the Service reopened the public comment period on June 24, 1996, for 30 days. That comment period closed July 10, 1996, by U.S. District Court order.

On September 4, 1996 (61 FR 46608), the Service withdrew the proposed rule to list the Barton Springs salamander as endangered based on a conservation agreement signed by the Service and the TNRCC, Texas Parks and Wildlife Department (TPWD), and Texas Department of Transportation (TxDOT) on August 13, 1996. The goal of the Barton Springs Salamander Conservation Agreement and Strategy (Agreement) is to continue existing and initiate new management actions to protect the Barton Springs ecosystem and its watershed. The Agreement is administered by the Barton Springs Salamander Conservation Team (BSSCT), which includes representatives from each of the four signatory agencies. In deciding to withdraw the proposed listing rule, the Service found that the Agreement, by protecting water quality at Barton Springs and in the Barton Springs segment of the Edwards aquifer and by conserving water quantity, reduces the threats to the species to the point where listing is no longer warranted.

On March 25, 1997, the U.S. District Court for the Western District of Texas found the Service's withdrawal invalid and ordered the Service to make a listing determination within 30 days. The court ordered the Service to ignore the Agreement in making the new decision. On April 8, 1997, the Service requested the court to delay the due date for the new listing decision until July 23, 1997, so that the Service could reopen the comment period and consider information developed since July 10, 1996, when the comment period on the proposed listing closed. The court denied this request on April 15, 1997. The Service is therefore not able to consider the following information in making a final listing determination: (1) The Agreement and the BSSCT's efforts to implement it, including public and technical input given as part of the BSSCT's March 1, 1997 public workshop; (2) updated salamander survey results; (3) the City of Austin's revised pool maintenance procedures designed to reduce salamander mortality; (4) the discovery of a new salamander location upstream from the Barton Springs Pool; (5) two additional ovipositioning events at the Dallas Aquarium; (6) reinstatement of the Save Our Springs (SOS) ordinance; (7) the Barton Creek Watershed Protection Initiative with private landowners and the Nature Conservancy of Texas; and (8) and adoption of TNRCC's chapters 313 and 216 of the Texas Administrative Code (see discussion under Factor D below).

Summary of Comments and Recommendations

In the February 17, 1994, proposed rule (59 FR 7968) and associated **Federal Register** notices, including notification of a public hearing (59 FR 27257; May 26, 1994) and each of the five comment periods (February 17 to April 18, 1994 (59 FR 7968); May 26 to July 1, 1994 (59 FR 27257; May 26, 1994); July 8 to July 29, 1994 (59 FR 35089; July 8, 1994); March 10 to May 17, 1995 (60 FR 13105; March 10, 1995); and June 24 to July 10, 1996 (61 FR 32413; June 24, 1996)), all interested parties were requested to submit factual reports or information to be considered in making a final listing determination. Appropriate Federal and State agencies, local governments, scientific organizations, and other interested parties were contacted and asked to comment. Legal notices of the public hearing, which invited general public comment were published in the Dripping Springs Century News and Austin-American Statesman on June 8, 1994, in the Drippings Springs Dispatch on June 9, 1994, and in the Austin Chronicle on June 10, 1994. The Service received 657 written and oral comments, 8 videotapes, 5 petitions, and 2 resolutions from individuals and agencies. Of the 657 comments, 524 supported the proposed action, 123 opposed it, and 10 stated neither support nor opposition. Four petitions totaling over 1,800 signatures and one resolution from the City of Austin supported listing, and one petition containing 29 signatures and one resolution from the City of Dripping Springs opposed the listing.

A public hearing was held in two sessions on June 16, 1994, at the Lyndon Baines Johnson Auditorium at the University of Texas at Austin. Over 160 people attended the public hearing, and 74 provided oral testimony.

The Service solicited formal scientific peer review of the proposal from six individuals during the March 10 to May 17, 1995, comment period and received comments from three reviewers. The major comments from these peer reviewers are: the Barton Springs salamander is a distinct species restricted to Barton Springs; the salamander appears to be primarily a surface-dwelling species that retreats underground during unfavorable conditions (such as drought) and to lay eggs; the salamander is vulnerable to declining water quality and quantity and other forms of habitat modification; regulations are inadequate to protect the Barton Springs salamander; the Service should present more data that show increasing levels of pollutants in the groundwater; the Service should provide further explanation as to why the Barton Springs salamander is restricted to Barton Springs; and increased nutrient levels should not affect dissolved oxygen concentrations in the aquifer. The peer reviewers' comments are reflected in this final rule.

Written and oral comments are incorporated into this final rule where appropriate. Comments not incorporated are addressed in the following summary. Comments of a similar nature or point are grouped and summarized. Where differing viewpoints on an issue were expressed, the Service briefly summarizes the general issue.

1. *Comment*: Several commenters questioned whether information regarding threats to the Barton Springs salamander is adequate to support a listing decision. Some commenters stated that threats to the salamander are greater now than ever before.

Service Response: Section 4(a)(1) of the Act states that species shall be listed as threatened or endangered provided that the continued existence of the species is threatened by one or more of the five factors discussed below in the "Summary of Factors Affecting the Species" section of this rule. Under section 4(b)(1), the Service must make its listing decisions based on the best scientific and commercial data available. The Service has met these requirements in this listing decision.

Over 50 percent of the water used by Texans comes from groundwater. The Barton Springs watershed provides the sole source of drinking water for more than 35,000 people living over the aquifer and contributes a significant supply of water to the Colorado River, which is the primary source of drinking water for the City of Austin. In addition to providing a reliable supply of safe drinking water that requires little or no treatment, many people depend on the Barton Springs watershed for other needs, including agriculture and recreational activities.

Amphibians are known to be very sensitive to environmental contaminants (see Factor E below). Because the Barton Springs salamander lives at the main discharge point for the aquifer and is continuously exposed to the waters emanating from it, it is a primary indicator of the health of this natural resource. As an important indicator species, the Barton Springs salamander serves as an early warning sign of deteriorating water quality and quantity in the Barton Springs watershed, which affects the health and well-being of the human population that depends on this resource.

2. *Comment*: The Service received comments questioning the sensitivity of the Barton Springs salamander to changes in water quality and quantity, and asserting that since the salamander has survived past impacts, it appears to be hardy and resilient and able to withstand future impacts.

Service Response: Although the Barton Springs salamander has survived past impacts, only 4 to 6 percent of the Barton Springs watershed is currently developed, and development is expected to continue. Furthermore, although the species as a whole has persisted to date, survey information indicates that individual salamanders have not survived certain impacts, and the species and its prey base are vulnerable to changes in water quality and quantity (see Factors A and E below). As discussed in Factor E, the difficulty in maintaining and propagating the Barton Springs salamander in captivity provides further evidence that this species is sensitive to environmental change. Toxicity data for the salamander's primary food source, *Hyallela azteca*, demonstrate the sensitivity of that amphipod to contaminants.

3. *Comment*: Several people commented on the adequacy of the existing rules and regulations in protecting water quality and quantity in the Barton Springs watershed. One commenter specifically mentioned that, because only two oil pipeline spills have been recorded (see Factor A), regulations are apparently adequate to protect water quality.

Service Response: The Act states that species shall be listed based on one or more of the five factors discussed in this final rule. The Service's analysis of the inadequacy of existing regulatory mechanisms (Factor D) demonstrates that additional measures are needed to protect the Barton Springs salamander from extinction. Although certain rules and regulations provide some water quality and quantity benefits, they do not alleviate all of the identified threats to the Barton Springs salamander.

4. *Comment:* Several inquiries were made regarding possible effects of listing the Barton Springs salamander on land use in the Barton Springs watershed and whether listing would infringe on private property rights. Other comments discussed possible economic impacts and benefits from listing.

Service Response: While economic effects, private property rights, and related concerns, cannot be considered in listing decisions, such factors are considered in recovering listed species. By **Federal Register** notice on July 1, 1994 (59 FR 34272), the Secretaries of Interior and Commerce set forth an interagency policy to minimize social and economic impacts consistent with timely recovery of listed species. Thus, it is the Service's desire that any recovery actions associated with the Barton Springs salamander minimize adverse social and economic impacts to the extent practicable.

5. *Comment:* The Service received several comments on the status of the Barton Springs salamander's population size, stating that this information should be considered in making a listing determination.

Service Response: Data from monthly surveys of the Barton Springs salamander are presented in the Background section and Factor A of this final rule. These survey data further support the need for listing. Although it may be an important listing consideration, the absolute population size does not need to be declining to warrant listing under the Act.

6. *Comment:* The Service received several comments regarding whether the Barton Springs salamander is restricted to Barton Springs.

Service Response: Survey information of other springs, caves, and wells in the Barton Springs segment provided since publication of the proposed rule further substantiate that the Barton Springs salamander's range is limited to the immediate vicinity of Barton Springs (see Background). Because Sunken Garden Springs is part of the Barton Springs complex and scientists assumed that the Barton Springs salamander occurred there, the presence of salamanders at this spring outlet does not indicate that the salamander's range has expanded, as some commenters asserted.

7. *Comment:* Many people questioned whether recreational use of Barton Springs Pool is likely to impact the Barton Springs salamander.

Service Response: The Service recognizes that swimming is a compatible activity with conservation of the salamander. The Service has provided additional discussion on recreation related issues in Factor E (''Other natural or manmade factors affecting its continued existence'') of this final rule. The Service acknowledges in both the proposed and final rules that certain pool maintenance practices may impact the Barton Springs salamander, and that the City of Austin is continuing to seek solutions that benefit both the recreational aspect of Barton Springs Pool and the Barton Springs salamander (see Factor A).

8. *Comment:* The Service received several comments regarding whether critical habitat should be designated for the Barton Springs salamander.

Service Response: Critical habitat has not been proposed for the Barton Springs salamander (see Critical Habitat section below). The Act requires that critical habitat be designated for a species at the time it is listed unless designation is not prudent or not determinable. Listing regulations at 50 CFR 424.12(a)(1) provide that critical habitat is not prudent if no benefit to the species is derived from its designation. Designation of critical habitat benefits a listed species only when adverse modification or destruction of critical habitat could occur without the survival and recovery of the species also being jeopardized. Because the Barton Springs salamander is restricted to one area that discharges water from the entire Barton Springs watershed, any action that would result in adverse modification or destruction of the salamander's critical habitat would also jeopardize its continued survival and recovery. Designating critical habitat would therefore not provide a benefit to the species beyond the benefits already provided by listing and subsequent evaluation of activities under the jeopardy standard of section 7 of the Act. Because jeopardy to the species and adverse modification of its critical habitat are indistinguishable, the Service has determined that designation of critical habitat for the Barton Springs salamander is not prudent.

9. *Comment:* A few commenters questioned whether the Barton Springs salamander represents a distinct species.

Service Response: The Barton Springs salamander was first recognized as a distinct species in the 1970's (see Background). A formal description of the salamander was peer-reviewed and published in June 1993 (Chippindale *et al.* 1993a). Although the Barton Springs salamander may bear some morphological resemblance to other *Eurycea* salamander species, differences in its morphology, its isolation from other *Eurycea* populations, and genetic research provide sufficient evidence to support its designation as a distinct species.

10. *Comment:* The Service received comments questioning whether a relationship exists between increasing urbanization and declining water quality and quantity.

Service Response: A discussion of the relationship between increasing urbanization and declining water quality and quantity is presented in Factor A of this final rule.

11. *Comment:* Some commenters questioned whether reduced aquifer levels and encroachment of the bad water line constitute threats to the Barton Springs salamander.

Service Response: A discussion of this issue is presented in Factor A. Under the 1996 pumping and drought regime, springflows at Barton Springs reached historically low levels, and both Eliza Pool and Sunken Garden Springs drained completely dry during drawdown of Barton Springs Pool. Barton Springs is located near the bad water line, and encroachment of bad water to the springs has occurred historically under low flow conditions. During periods of low flows, Sunken Garden Springs measures high levels of total dissolved solids, indicating bad water encroachment.

Factor A also presents information on the increasing number of new permitted wells in the Barton Springs segment and a discussion of groundwater pumpage. A substantial increase in groundwater withdrawals (compounded by drought) will increase the frequency, severity, and/or duration of low aquifer levels and springflows and the potential for movement of the bad water line toward Barton Springs. Increased pumpage may also increase leakage from the lower Trinity aquifer, which contains higher levels of total dissolved solids and fluoride than water in the Barton Springs segment, thus further lowering water quality.

12. *Comment:* The Fish and Wildlife Service needs to implement its new directives from the Department of Interior and Commerce, including scientific peer review, minimization of social and economic impacts, greater predictability, the ecosystem approach, and State agency involvement.

Service Response: The Service has followed its policy directives in preparing this final rule. During the reopening of the public comment period following the notice to extend the final listing decision (60 FR 13105; March 10, 1995), the Service formally solicited peer review from six independent specialists to evaluate the information presented in the proposed rule. The beginning of this section (''Summary of Comments and Recommendations'') summarizes the opinions of the three individuals who provided peer review. Informal peer review was also solicited during the public hearing and each public comment period, during which the Service received over 650 letters of comment. The Service solicited information and expertise from Federal, State, and local agencies, including the U.S. Geological Survey, Texas Parks and Wildlife Department, Texas Natural Resource Conservation Commission, Barton Springs/Edwards Aquifer Conservation District, and the City of Austin in preparing the proposed and final rules, and provided written notifications to these agencies of the 90-day finding and proposed rule.

The Available Conservation Measures section of this final rule identifies specific activities that will not be affected by section 9 of the Act regarding ''take'' of the Barton Springs salamander, and provides guidance and recommendations for avoiding impacts to the salamander. The recovery plan will be drafted to minimize social and economic impacts while ensuring the long-term survival and recovery of the Barton Springs salamander. Protecting the ecosystem upon which the salamander and people depend will be an important component in recovery planning.

13. *Comment:* The Service refuses to acknowledge the benefits of existing regulations. The Service's unwillingness to enforce its own limited and inadequate requirements further contributes to the endangered status of the Barton Springs salamander.

Service Response: As stated in the proposed rule, the Service acknowledges that the existing rules and regulations provide some benefits to water quality and quantity. However, the purpose of Factor D is to evaluate the inadequacies of existing regulatory mechanisms. The Service hopes that this evaluation will assist in identifying measures to strengthen efforts to protect water quality and quantity in the Barton Springs watershed and to promote the long-term survival of the Barton Springs salamander.

14. *Comment:* The Service must consider spill response programs designed to remediate the contamination of groundwater resources by hazardous substance and hazardous waste releases.

Service Response: The Service is unaware of any concerted, organized effort among the various Federal, State, and local agencies to implement a contingency plan for emergency spills in the Barton Springs watershed. Also, efforts to restore contaminated groundwater to its original purity may be technologically infeasible and/or cost-prohibitive (see Factor A). Spill remediation is especially problematic for catastrophic spills that occur in proximity to Barton Springs or in areas that are difficult to access. Because remediation is not always effective or possible, prevention is needed to ensure the protection of water resources.

15. *Comment:* Many of the references cited in the proposed rule are not studies or reports specific to Barton Springs, Austin, or even the Edwards aquifer, but instead describe general nationwide or statewide environmental management issues. These are general policy documents, which do not address the circumstances faced by the Barton Springs salamander.

Service Response: Most of the reports and documents cited in this final rule specifically address the effects of urbanization on surface and groundwater, karst aquifers, the Barton Springs watershed, the Barton Springs salamander, and/or the salamander's primary food source, and thus are pertinent to evaluating threats to the Barton Springs salamander. The information presented in these reports is highly consistent with respect to the threat of urbanization on water resources.

16. *Comment:* The Service cites a 1986 study by Slade *et al.* that projected a doubling of water demands from the year 1982 to 2000. Since we are more than halfway through the 18-year time period, are more recent data available?

Service Response: The estimated total pumpage in 1982 was 470 hectare-meters (3,800 acre-feet), at which time discharge from the Barton Springs segment (withdrawal plus springflow) was determined to be roughly equal to recharge. Slade *et al.* (1986) predicted that a substantial increase in groundwater withdrawal (compounded by drought) would cause a decrease in the quantity of water in the aquifer and discharge from Barton Springs. The Barton Springs/Edwards Aquifer Conservation District estimated total pumpage for 1994 at 570 hectare-meters (4,600 acre-feet). However, as stated in Factor A, the exact volume of water that is pumped from the aquifer is difficult to estimate, since meter reports are not required for non-permitted wells. Furthermore, groundwater pumpage varies considerably from year to year, influenced primarily by the amount of rainfall. The volume of pumpage increases and its effects on aquifer levels and springflows become more pronounced during dry spells, whereas periods of high rainfall can mask the effects of increased dependence on groundwater supplies.

17. *Comment:* There appears to be no direct, quantifiable relationship between water quality in Barton Creek and water quality at Barton Springs.

Service Response: The Background section and Factor A of this final rule discuss the hydrologic regime of the Barton Springs watershed. The surface and groundwaters of the Barton Springs watershed are integrally related, and all of the six creeks that cross the recharge zone of the aquifer affect water quality at Barton Springs. Because of the karst characteristics of the aquifer and because Barton Springs is the main discharge point for the entire watershed, pollutants entering the watershed from any of the recharge sources may eventually reach Barton Springs. The USGS has clearly demonstrated that water quality in Barton Creek has the most immediate impact on water quality at Barton Springs of any recharge source in the Barton Springs watershed because of its recharge contribution and proximity to Barton Springs. Data show that contaminants in Barton Creek can enter the aquifer near Barton Springs and discharge from the springs within hours or days of storm events.

18. *Comment:* The waters from the outlying areas of the contributing zone are not the cause of current degradation and will never significantly contribute to the degradation of the springs compared to the existing development around Barton Springs. Many existing land uses were constructed and operated under less stringent standards. Retrofitting existing development would result in far more improvement of water quality than would further restriction of new development.

Service Response: The Service acknowledges that there is a relationship between current water quality and quantity degradation and existing development and considers retrofitting of these developments to be an important factor in protecting Barton Springs. However, water quality at Barton Springs is also influenced by the quality and quantity of water throughout the entire watershed (see Background and Factor A). Although water quality at Barton Springs responds most rapidly to changes in water quality in Barton Creek, Barton Springs represents a mixture of all of the recharge waters in the Barton Springs watershed. High-quality water in the undeveloped portions of the Barton Springs watershed helps disperse and dilute pollutants from the urbanized areas. Because of the karst characteristics of the aquifer, pollution can originate from anywhere within the Barton Springs watershed, especially pollutants that are relatively stable and mobile in water. Thus, as urbanization expands across the watershed, the ability of the aquifer to dilute and disperse increasing pollutant loads will decrease. While the Service concurs that retrofitting of existing development near Barton Springs may be important to protect water quality, measures are also needed to ensure continued protection of water quality and quantity throughout the remainder of the watershed. A report prepared for the City of Austin (1995) examines options for retrofitting developments to improve stormwater quality in the Barton Springs watershed.

19. *Comment:* The proposed rule did not discuss other sources of water contributing to flows from Barton Springs, including the San Antonio segment of the Edwards aquifer and the Colorado River.

Service Response: Independent studies (Slade et al. 1985, 1986; Stein 1995) conclude that most of the water discharging from Barton Springs originates from within the Barton Springs watershed (see Background section). However, under low flow conditions, the bad water zone of the San Antonio segment appears to flow northward toward Barton Springs. Upward leakage from the lower Trinity aquifer may also infiltrate the Barton Springs segment during low flows. Because these aquifers are high in total dissolved solids, their contribution affects the quality of water in the Barton Springs watershed and at Barton Springs.

The Service is unaware of any reports or data indicating that the Colorado River contributes water to the Barton Springs watershed. However, Barton Springs does supply baseflow to the Colorado River, which may be substantial during dry periods.

20. *Comment:* The Service must comply with the National Environmental Policy Act (NEPA) prior to listing the Barton Springs salamander as endangered. This would require the Service to study the social and environmental impacts of the proposed listing and prepare appropriate environmental documentation.

Service Response: The Service has determined that Environmental Assessments and Environmental Impact Statements, as defined under the authority of the National Environmental Policy Act of 1969, need not be prepared in connection with regulations adopted pursuant to section 4(a) of the Endangered Species Act of 1973, as amended. A notice outlining the Service's reasons for this determination was published in the **Federal Register** on October 25, 1983 (48 FR 49244).

21. *Comment:* The statement that ''Loop 360 provides a major route for transportation of petroleum and gasoline products to service stations in the Austin area'' is unsupported by any data or citation of a study. What is the basis of this statement?

Service Response: This statement was based on the fact that no designated hazardous materials routes exist for the Austin area, and thus all major roadways can be considered to be transportation routes for hazardous materials. Because Loop 360 supports a high volume of traffic, and many service stations exist in this part of the Austin area, it is considered to be a major transportation route. The Service's statement is also supported by the Hazardous Materials Water Contamination Risk study prepared for the City of Austin (1994).

22. *Comment:* Both Hays County and Dripping Springs experienced high rates of growth in the 1980's, yet are still sparsely populated. The Service's statement in the proposed rule suggests these areas will soon be overrun with people at intensely urbanized levels, which is an unrealistic assumption.

Service Response: The Service quoted a study (see Factor A) conducted by the Capital Area Planning Council. Additional information on population growth for the northern portion of Hays County is presented in this final rule.

23. *Comment:* More of the recharge and contributing zones have been developed than the Service states in the proposed rule. Based on an analysis of historical trends in land development for the recharge zone of the Barton Springs segment, approximately 1,200 hectares (ha) (3,050 acres (ac)) in the recharge zone had been developed in 1979. Approximately 3,000 ha (7,500 ac) had been developed by 1993, which represents approximately 13 percent of the entire recharge zone of the Barton Springs segment.

Service Response: Factor A of the proposed rule states that ''* * * only about 3 to 4 percent of the recharge and contributing zones is currently developed,'' which was based on an estimate of impervious cover provided by the USGS. A report prepared for the City of Austin (1995) has estimated impervious cover over the Barton Springs watershed to be 6 percent (see Factor A). Assuming that the commenter's calculations of development are also equal to the amount of impervious cover, the commenter's assertion that about 13 percent of the recharge zone is developed does not appear to be inconsistent with the estimated 3 to 6 percent impervious cover for the entire watershed.

24. *Comment:* What evidence exists that demonstrates that sediments entering the pools where the salamander occurs actually settle in the salamander's habitat?

Service Response: Biologists with the City of Austin have found that silt and sediments that are hosed from the shallow end into the deep end of Barton Springs Pool during cleaning reduce the amount of available salamander habitat. Increased sediment influxes following major rain events also reduce habitat availability. Sediments cover much of the bottom of Eliza Pool and Sunken Garden Springs, and the Barton Springs salamander is typically found in silt-free areas near the spring outlets.

25. *Comment:* A significant number of references cited in the proposed rule are not peer-reviewed scientific publications and thus should not be given the same level of credibility as those having a more rigorous review and approval process.

Service Response: All official agency reports cited in the proposed rule have undergone extensive internal review, and some have solicited outside peer review. Articles cited from scientific journals have all received formal peer review. Although the Service relies primarily on final documents in making listing decisions, the best available information may also come from other sources such as written correspondence, factual information and data from draft documents, expert opinions, and personal communications. The Service strives to evaluate the accuracy of this ''gray literature'' before considering it in making a listing decision.

26. *Comment:* Several individuals commented on the methods and results of certain reports used by the Service in the proposed rule, including three USGS reports (Slade *et al.* 1985, 1986; Veenhuis and Slade 1990) and a Barton Springs/Edwards Aquifer Conservation District (BS/EACD) report (Hauwert and Vickers 1994). The Service was also criticized for not making available for public review and comment the raw data upon which these and other reports cited by the Service are based.

Service Response: The reports cited in the proposed rule and in this final rule present sufficient information and data needed to review and assess the methodologies used by the investigators, their study results and data analyses, and conclusions. The Service has reviewed these reports and determined that the data were gathered and analyzed in accordance with sound scientific principles, and accepts these reports as valid and relevant scientific information. Furthermore, the results and conclusions of independent studies consistently show similar trends regarding impacts of urbanization on water quality and quantity. The USGS and BS/EACD have both provided written responses to the criticisms of their reports (Raymond Slade, USGS, *in litt.* 1994; Nico Hauwert, BS/EACD *in litt.* 1995; Bill Couch, BS/EACD, *in litt.* 1996).

27. *Comment:* The occurrence of turbidity, accumulation of sediments, and contaminants in Barton Springs watershed could be due to natural phenomena.

Service Response: The volume of sediments observed in urbanizing portions of the Barton Springs watershed and increased turbidity during periods of major construction indicate that such activities influence these phenomena. As discussed in Factor A, the relationship between urban runoff and increased erosion and sedimentation is well documented. Increases in turbidity tend to coincide with land clearing and construction activities, and discharge of turbid runoff from construction projects has been observed entering receiving waters in the Barton Springs watershed.

Research shows that the contaminants discussed in Factor A (including elevated levels of nutrients, heavy metals, petroleum hydrocarbons, and pesticides) are primarily associated with urban runoff. The Service is unaware of any natural sources in the Barton Springs watershed that could result in significant concentrations (or any detectable concentrations for manmade compounds such as pesticides) of these contaminants in water.

28. *Comment:* A report by T.U. Taylor (*in litt.* 1922) states that elevated levels of fecal coliform bacteria have been documented at Barton Springs since 1922. However, the Service stated in the proposed rule that the City of Austin determined that the method used to measure bacterial counts at the time of the report is different from that used today, and thus ''the bacterial counts are not directly comparable to * * * current sampling techniques'' (Austin Librach, City of Austin, *in litt.*, 1991). The City of Austin's review of the report does not provide a basis for refuting its conclusions or excluding them from further consideration. The comparison of fecal coliform counts taken in the context of the standards of the time, to counts taken today and in the context of today's standards, is a valid comparison.

Service Response: To date, the Service has only been provided a copy of a cover letter (dated August 28, 1922) to a supplementary report submitted by Mr. Taylor to the City of Austin. The letter states the need to filter Barton Springs water for human consumption due to contamination with ''B. coli.'' Because no report accompanied the letter, and the Service has been unable to obtain a copy of the report, the Service can draw no further conclusions regarding its findings.

29. *Comment:* What is the basis for the Service's statement that ''contaminants that adsorb to the surface of sediments may be transported through the aquifer and later be released back into the water column ''?

Service Response: The Service based this statement on information presented in Schueler (1987), which states that once deposited, pollutants in ''enriched sediments can be remobilized under suitable environmental conditions posing a risk to benthic life'' (see Factor A).

30. Comment: The Service received a comment letter that contained a document comparing the findings and conclusions of the proposed rule with those made in a report by the Aquatic Biological Advisory Team (ABAT), which concluded that insufficient information appears to exist to support a listing decision.

Service Response: The City of Austin and Texas Parks and Wildlife Department formed the ABAT, which consisted of five nationally recognized specialists, to make research and management recommendations needed to conserve the Barton Springs and Bull Creek watersheds and their resident salamander populations (the Barton Springs and Jollyville Plateau salamanders). The ABAT members were specifically instructed not to make recommendations regarding listing nor to evaluate specific laws or regulations. The Service believes that substantial evidence exists to support a listing determination for the Barton Springs salamander, but also recognizes that additional research is important to assist in making sound management recommendations. The Service concurs with most of the ABAT's management recommendations, which could be incorporated into a regional management plan for the Barton Springs watershed, as well as a recovery plan for the Barton Springs salamander.

31. Comment: The TNRCC and TxDOT provided information regarding existing and proposed rules and regulations, which they state are adequate to protect the Barton Springs salamander.

Service Response: An evaluation of the existing rules and regulations is provided in Factor D of this final rule. The Service encourages State and local entities to identify proposed regulations and additional protective measures that can serve as a basis for a regional management plan for the Barton Springs watershed.

Summary of Factors Affecting the Species

After thorough review and consideration of all information available, the Service has determined that the Barton Springs salamander should be classified as an endangered species. Procedures found at section 4 of the Act and regulations implementing the listing provisions of the Act (50 CFR part 424) were followed. A species may be determined to be endangered or threatened due to one or more of the five factors described in section 4(a)(1). These factors and their application to the Barton Springs salamander (*Eurycea sosorum* Chippendale, Price, and Hillis) are as follows:

A. *The present or threatened destruction, modification, or curtailment of its habitat or range.* The primary threat to the Barton Springs salamander is degradation of the quality and quantity of water that feeds Barton Springs resulting from urban expansion over the Barton Springs watershed (including roadway, residential, commercial, and industrial development). A discussion of some potential effects of contaminants on the salamander and its prey base (amphipods) is provided in this section and under Factor E. Potential factors contributing to declining water quality and quantity in this portion of the Edwards aquifer include chronic degradation, catastrophic hazardous material spills and increased water withdrawals from the aquifer. Also of concern are impacts to the salamander's surface habitat.

Urbanization can dramatically alter the normal hydrologic regime and water quality of an area. As areas are cleared of natural vegetation and topsoil and replaced with impervious cover (paved surfaces), rainfall no longer percolates through the ground but instead is rapidly converted to surface runoff. Creekflow shifts from predominantly baseflow, which is derived from natural filtration processes and discharges from local groundwater supplies, to predominantly stormwater runoff. The amount of stormwater runoff tends to increase in direct proportion to the amount of impervious cover. With increasing stormflows, the amount of baseflow available to sustain water supplies during drought cycles is diminished and the frequency and severity of flooding increases. The increased amount and velocity of runoff increases erosion and streambank destabilization, which in turn leads to increased sediment loadings, channel widening, and changes in the morphology and aquatic ecology of the affected creek (Schueler 1991). Sediment from soil erosion is ''by volume the greatest single pollutant of surface waters and is the potential carrier of most pollutants found in water'' (Menzer and Nelson 1980).

Urbanization introduces many pollutants into an area, including suspended solids, nutrients, petroleum hydrocarbons, bacteria, heavy metals, volatile organic compounds, fertilizers, and pesticides (TWC 1989; EPA 1990; Schueler 1991; Notenboom *et al.* 1994; Menzer and Nelson 1980). Stormwater runoff is a primary source of water pollution. Pollutant loadings in receiving waters, particularly in areas that have little or no pollution controls, generally increase with increasing impervious cover (Schueler 1991). A report by the USGS on the relationship between urbanization and water quality in streams throughout the Austin area (9 of 18 sample sites were along streams in the Barton Springs segment and its contributing zone) demonstrated statistically significant increases in constituent concentrations with increasing impervious cover (Veenhuis and Slade 1990). Degradation of water quality in the Barton Springs watershed is also evidenced by algal blooms, erosion, trash and debris, and accumulations of sediments and toxics (City of Austin 1995).

Water quality in the aquifer and at Barton Springs is directly affected by the quality of water in the six creeks that cross the recharge zone (see Background section). Of these creeks, water quality at Barton Springs responds most rapidly to changes in water quality in Barton Creek (Slade *et al.* 1986; City of Austin 1991). Data show that contaminants in Barton Creek can enter the aquifer near Barton Springs and discharge from the springs within hours or days of storm events (Slade *et al.* 1986; City of Austin 1991). Because groundwater originating from Barton Creek remains in the aquifer for short periods before discharging at the springs, there is little time for attenuation of pollutants before discharging at Barton Springs (Slade *et al.* 1986; City of Austin 1991). Increases in turbidity (a measure of suspended solids or sediment), algal growth, nutrients, and fecal-group bacteria have been documented along Barton Creek between SH 71 and Loop 360 and at Barton Springs, and have been largely attributed to construction activities and the conveyance and treatment of sewage in this area (Slade *et al.* 1986; Austin Librach, City of Austin *in litt.*, 1990; City of Austin 1991, 1993; Barbara Britton, TWC, *in litt.*, 1992).

Water quality in the more heavily developed areas of the Barton Springs segment and at Barton Springs is also beginning to show signs of degradation (Slade *et al.* 1986; Librach *in litt.*, 1990; City of Austin 1991, 1993; Slade 1992; Hauwert and Vickers 1994; Texas Groundwater Protection Committee (TGPC) 1995). The BS/EACD found elevated levels of sediment, fecal-group bacteria, trace metals, nutrients, and petroleum hydrocarbons in certain springs and wells between Sunset Valley and Barton Springs (Hauwert and Vickers 1994, TGPC 1994). Slade *et al.* (1986) reported that levels of fecal-group bacteria, nitrate nitrogen, and turbidity were highest in wells near creeks draining developed areas. In addition to sediments and bacteria, tetrachloroethene, a commonly used drycleaning solvent, has been detected in water samples from Barton Springs (Slade 1991). Possible sources of groundwater contamination include urban runoff, construction activities, leaking septic tanks and pipelines, and petroleum storage tank releases (Slade *et al.* 1986; TWC 1989; EPA 1990; Hauwert and Vickers 1994).

One of the most immediate threats to the Barton Springs salamander is siltation of its habitat, owing primarily to construction activities in the Barton Creek watershed (Slade *et al.* 1986, City of Austin 1991, Hauwert and Vickers 1994, TGPC 1994). Major highway, subdivision, and other construction projects along Barton Creek increased during the early 1980's and 1990's. While high turbidity has been observed in Barton Springs Pool following major storm events since the early 1980's (Slade *et al.* 1986; Hauwert 1995), the duration and frequency of sediment discharges from Barton Springs increased substantially during the 1990's (Hauwert 1995; TGPC 1994). Barton Springs discharged large amounts of sediments following most major rain events in 1993, 1994 (Hauwert and Vickers 1994; TGPC 1994), and 1995 (Collett, pers. comms., 1994–1995). Sediments have been observed emanating directly from the spring outlets in Barton Springs Pool (Doyle Mosier, Lower Colorado River Authority; Debbie Dorsey, City of Austin; pers. comms., 1993; Collett and Hansen, pers. comms., 1994–1995) about 8 to 12 hours following the start of a heavy rain (Slade *et al.* 1986; City of Austin 1991; Hauwert and Vickers 1994; David Johns, City of Austin, pers. comm. 1996).

Several uncased wells in the Barton Creek watershed, one of which is located 5 km (3 mi) south of Barton Springs near the Loop 360 bridge, have been completely filled with a cream-colored, carbonate silt (up to 45 m (150 ft)) (Hauwert and Vickers 1994). A well in Sunset Valley measured 1 to 1.5 ft accumulations of cream-colored sediment over an eight-month period prior to July 1993, and reportedly caused the well pump to seize (Hauwert and Vickers 1994). Several well owners, drillers, and operators also reported a significant influx of sediments during 1993, particularly during periods of heavy rainfall and low water-level conditions (Hauwert and Vickers 1994).

Studies have shown that high levels of suspended solids reduce the diversity and density of aquatic fauna (EPA 1986; Barrett *et al.* 1995). In Barton Springs Pool, the lowest recorded population counts of the salamander (ranging from 1 to 6 individuals) occurred over the five-month period following an October 1994 flood event (see Background section). The flood deposited a large amount of silt and debris over the salamander's habitat in the pool, and the area occupied by the salamander during the following months was reduced to the silt-free areas immediately adjacent to the spring outlets (Hansen, *in litt.*, 1995c).

In addition to covering the salamander's habitat, problems resulting from increased sediment loads may include: Clogging of the gills of aquatic species, causing asphyxiation (Garton 1977; Werner 1983; Schueler 1987); smothering their eggs and reducing the availability of spawning sites (EPA 1986; Schueler 1987); filling interstitial spaces and voids, thereby reducing water circulation and oxygen availability (EPA 1986); filling and blocking of recharge features and underground conduits, restricting recharge and groundwater storage volume and movement; reducing light transmission needed for photosynthesis, food production, and the capture of prey by sight-feeding predators (EPA 1986; Schueler 1987); and exposing aquatic life to contaminants that readily bind to sediments (such as petroleum hydrocarbons and heavy metals). Once deposited, pollutants in ''enriched sediments can be remobilized under suitable environmental conditions, posing a risk to benthic life'' (Schueler 1987).

Research indicates that species in or near contaminated sediments may be adversely affected even if water-quality criteria are not exceeded (Landrum and Robbins 1990; Medine and McCutcheon 1989). Sediments act as a sink for many organic and inorganic contaminants (Menzer and Nelson 1980; Landrum and Robbins 1990; Medine and McCutcheon 1989) and can accumulate these contaminants to levels that may impact aquatic ecosystems (Landrum and Robbins 1990; Medine and McCutcheon 1989). Metal-contaminated sediment toxicity studies have shown *Hyallela azteca*, the primary food item of the Barton Springs salamander, to be the most sensitive organism of those tested (Phipps *et al.* 1995; Burton and Ingersoll 1994). Most polycyclic aromatic hydrocarbons (PAHs), a component of oil, are associated with sediments in aquatic ecosystems, which may be ingested by benthic organisms (Eisler 1987). *Hyallela azteca* has been shown to assimilate PAHs from contaminated sediments (Eisler 1987). Sediments collected from the main stem of Barton Creek on November 21, 1994, about 150 m above Barton Springs Pool, contained several PAHs that were 2.5 to 22 times the levels shown to always have a toxic effect (survival, growth, or maturation) on *Hyallela azteca* (City of Austin, unpubl. data, 1994; Ingersoll *et al.*, in press). Sediments collected from Barton Springs on April 20, 1995, also contained PAHs at levels up to 6.5 times those shown to be toxic to *Hyallela azteca* (City of Austin, unpubl. data, 1995; Ingersoll *et al.*, in press).

In addition to sediment concentrations, high levels of total petroleum hydrocarbons have been detected in water samples from Sunken Garden Springs (Hauwert and Vickers 1994). Petroleum hydrocarbons include both aliphatic hydrocarbons and PAHs (Albers 1995). Normal concentrations of petroleum hydrocarbons in the Edwards aquifer are below the detection limit of 1.0 mg/l. However, levels of total petroleum hydrocarbons measured 1.9 mg/l following a 9-mm (0.35-in) rain event in March 1994, and 1.3 mg/l in April 1994. A well that is hydrologically connected with Barton Springs contained a level of 2.1 mg/l in May 1993 (Hauwert and Vickers 1994; BS/EACD 1994). Petroleum hydrocarbons may enter water supplies through sewage effluents, urban and highway runoff, and chronic leakage or acute spills of petroleum and petroleum products (Eisler 1987; Hauwert and Vickers 1994; Albers 1995).

Water samples from Sunken Garden Springs also contained elevated levels of lead, which are commonly found in petroleum-contaminated waters. Total and dissolved lead levels at Sunken Garden Springs measured 0.024 and 0.015 mg/l, respectively (Hauwert and Vickers 1994; BS/EACD 1994). Typical freshwater concentrations for lead are between 0.001 and 0.01 mg/l (Menzer and Nelson 1980). The EPA drinking water standard for total lead is 0.015 mg/l. In aquatic environments, dissolved lead is the most toxic form, and adverse effects (including reduced survival, impaired reproduction, and reduced growth) on aquatic biota have been reported at concentrations of 0.001 to 0.005 mg/l (Eisler 1988a). Sources of lead in water may include industrial discharges, highway runoff, and sewage effluent (Pain 1995).

Aquatic organisms may absorb lead through skin, gills, intestines, and other organs, and may ingest lead through feeding (Pain 1995). Lead concentrations tend to be highest in benthic organisms, which may assimilate lead directly from sediments (Eisler 1988a). Research indicates that lead is not essential or beneficial to living organisms, and that all known effects are deleterious, including those on survival, growth, reproduction, development, behavior, learning, and metabolism (Eisler 1988a; Pain 1995). Adverse effects increase with elevated water temperatures, reduced pH, younger life stages, and long exposures (Eisler 1988a; Pain 1995). Synergistic and additive effects may also occur when lead is mixed with other metals or toxic chemicals (Eisler 1988a). Studies have shown that lead is highest in urban streams and lowest in rural streams, and that species diversity is also greater in rural streams than urban ones (Eisler 1988a).

Arsenic, which has been used in the manufacture of agricultural pesticides and other products (Eisler 1988b) and may be found in roadway and urban runoff, has been detected in wells in the Barton Springs watershed at levels exceeding EPA drinking water standards (0.05 mg/l) (Hauwert and Vickers 1994) and in other areas of Texas (TWC 1989). Concentrations of arsenic compounds adversely affecting aquatic biota have been reported at 0.019 to 0.048 mg/l (Eisler 1988b). Toxicity of arsenic to aquatic life depends on many factors, including water temperature, pH, suspended solids, organic content, phosphate concentration, presence of other contaminants, arsenic speciation, and duration of exposure. As with many contaminants, early life stages are most sensitive, and large differences in responses exist between species (Eisler 1988b).

Leaking underground storage tanks ''are considered to be one of the principal contributing sources of ground-water pollution, placing a significant loading on the State's aquifers, due to their regional distribution and high number which are estimated to be leaking'' (TWC 1989). Chronic releases from leaking tanks represent a serious risk of water contamination (City of Austin 1994). The TNRCC (1994) lists leaking underground storage tanks as one of the top three most frequently encountered sources of groundwater contamination in the Edwards aquifer. Common pollutants from leaking underground storage tanks include gasoline, diesel, and other oil products (TWC 1989). The TNRCC's ''Leaking Petroleum Storage Tank Case Report'' lists 626 leaking petroleum storage tanks for Hays and Travis counties for the period between October 1984 and April 1995, of which 158 cases resulted in some form of groundwater contamination. Fifteen of the reports specifically identified impacts to the Edwards aquifer, of which only three had been officially closed or were near closure.

The conveyance and treatment of sewage in the watershed, particularly in the recharge zone, may also impair water quality. Sewage effluent may contain organics (including PAHs), metals, nutrients (nitrogen and phosphorus), inorganic acids, and microorganisms (Eisler 1987; Menzer and Nelson 1980; TWC 1989; City of Austin 1991, 1993; Notenboom *et al.* 1994). Sewage contamination has occurred at Barton Springs following major rain events (TWC 1989), and high bacterial counts and algal blooms have been reported (Slade *et al.* 1986; City of Austin 1991). In 1982, high levels of fecal coliform bacteria at Barton Springs were attributed to a sewerline leak upstream from Barton Springs Pool. While fecal coliform bacteria are believed to be harmless, they indicate the presence of other organisms that may be pathogenic to aquatic life (Lager *et al.* 1977), some of which may pose a threat to salamanders and/or their prey base.

Wastewater discharges have been identified as a primary cause of algal blooms, which have been a recurring problem in both Barton Creek and at Barton Springs (City of Austin 1991, 1993). Increased nutrients promote eutrophication of aquatic ecosystems, including the growth of bacteria, algae, and nuisance aquatic plants, and lowered oxygen levels. Menzer and Nelson (1980) note that ''changes in nutrient pools must eventually directly affect the productivity of the entire ecosystem, even though the effects may not be measurable in biologic terms until a number of years later.'' Because most nutrients in urban runoff are present in soluble form and are thus readily consumed by algae, nutrient concentrations present in urban runoff tend to stimulate algal blooms (Schueler 1987). A 5 km-(3-mi) long algal bloom observed along Barton Creek in April 1993 may have been the result of an accidental discharge of 1.6 million liters (440,000 gallons) of effluent and irrigation water from a golf course (City of Austin 1993, 1995).

Based on USGS data (Slade *et al.* 1986), the average level of nitrates at Barton Springs Pool has increased from about 1.0 mg/l (measured as nitrate nitrogen) prior to 1955 to a 1986 level of about 1.5 mg/l. Sunken Garden Springs measured greater than 2.0 mg/l nitrate nitrogen during the BS/EACD study (Hauwert and Vickers 1994). Elevated nitrate concentrations in groundwater are attributed primarily to human activities (TWC 1989). Total nitrogen (as nitrogen) concentrations measured in wells in the more urbanized areas of the Barton Springs watershed are typically two to six times higher than in rural areas (Slade 1992). Elevated levels of total phosphorus and orthophosphorus have also been detected in certain springs and wells in the Barton Springs watershed (Slade 1992; Hauwert and Vickers 1994). In addition to wastewater discharge, other possible sources of nutrients in the Barton Springs watershed include fertilizers, solid wastes, animal waste, and decomposition of natural vegetation (Hauwert and Vickers 1994; Slade *et al.* 1986).

Over 145 km (90 mi) of wastewater lines occur in the recharge zone of the Barton Springs segment (Maureen McReynolds, City of Austin Water and Wastewater Utility, pers. comm., 1993). Most of the creeks contributing recharge to the Barton Springs segment are underlain by wastewater lines, and five wastewater treatment plants are located within the Barton Springs watershed (City of Austin 1991). Leaking septic tanks and inadequate filtering in septic fields have also been identified as a major source of groundwater contamination, particularly for older systems (TWC 1989; EPA 1990; City of Austin 1991; Hauwert and Vickers 1994; TNRCC 1994). The TNRCC (1994) cites septic tanks as the most frequently encountered source of groundwater contamination in the Edwards aquifer. Although the amount of effluent leached from an individual septic system may be small, the cumulative impact over the landscape can be significant, especially for karst aquifers (EPA 1990). An estimated 4,800 septic systems currently exist in the Barton Springs watershed and may contribute as much as 23 percent of the total nitrogen load to the aquifer (City of Austin 1995).

Highways can have major impacts on groundwater quality (TNRCC 1994; Barrett *et al.* 1995). The TNRCC (1994) lists highways and roads as the fifth most common potential source of groundwater contamination in the Edwards aquifer. Elevated concentrations of metals, Kjeldahl nitrogen, and organic compounds have been detected in groundwater near highways and their control structures. Highway construction can also cause large increases in suspended solids to receiving waters (Barrett *et al.* 1995). Several major highways have been built over the recharge zone since the late 1980's, and the expansion of US 290 from SH 71 through Oak Hill to a six-lane freeway is underway. US 290 crosses the Barton Creek watershed and discharges stormwater runoff from detention ponds into tributaries of Barton Creek. Bypass events from a regional water quality pond at the US 290/Loop 360 interchange have resulted in significant sediment deposition along the entire length of an unnamed tributary and a portion of Barton Creek (City of Austin, *in litt.* 1995; City of Austin, unpubl. data, 1996; USFWS, *in litt.* 1996), less than 5 km (3 mi) from Barton Springs.

Organophosphorus pesticides commonly used in urban areas tend to degrade rapidly in the environment, but certain pesticides may remain biologically active for some time (Eisler 1986, Hill 1995). For example, diazinon, which is commonly used in commercial and residential areas, may remain biologically active in soils for up to 6 months under conditions of low temperature, low moisture, high alkalinity, and lack of microbial degraders (Eisler 1986). Diazinon has shown adverse effects on stream insects at concentrations of 0.3 micrograms/l (Eisler 1986). To ensure protection of sensitive aquatic fauna, Eisler (1986) recommends that levels of diazinon in water not exceed 0.08 micrograms/l. Many organophosphorus compounds may result in adverse effects after short-term exposures. Exposure may include contact with or ingestion of contaminated water, sediments, or food items (Hill 1995).

Increasing urbanization also increases the risk of catastrophic spills. Because of the Barton Springs salamander's limited range, a single catastrophic spill has the potential to impact the entire species and its habitat. Catastrophic spills can result from major transportation accidents, underground storage tank leaks, pipeline ruptures, sewage spills, vandalism, and other sources. Because no designated route for hazardous materials exists for the Austin area, potentially hazardous materials may be transported on major roadways crossing the Barton Springs watershed (City of Austin 1994). Expansion of major roadways and increasing volumes of traffic, particularly across the recharge zone near Barton Springs, increases the threat of catastrophic spills.

Oil pipeline ruptures also represent a source of groundwater contamination with potentially catastrophic consequences. Three oil pipelines run roughly parallel to each other across the Barton Springs watershed and cross Barton Creek near the Hays/Travis county line. Two of these lines have ruptured within the recharge zone about 13 km (8 mi) south of Barton Springs, which constitute the largest spills reported from Hays and Travis counties between 1986 and 1992 (TWC, unpubl. data). The first major spill occurred in 1986, about 270 m (300 yards) from Slaughter Creek, when an oil pipeline was severed during a construction operation and released about 366,000 liters (96,600 gallons) of oil. Although about 91 percent of the spill was reportedly recovered (Rose 1986), petroleum hydrocarbon fumes were detected about six weeks later in caves located up to 2.7 km (1.7 mi) northeast of the spill (Russell 1987). The second pipeline break occurred in 1987 near the first spill site and released over 190,000 liters (49,000 gallons) of oil. According to the TWC database, more than 97 percent of this spill was recovered (TWC, unpubl. data).

Response times to hazardous materials spills vary, depending on several factors including detection capability, location and size of the spill, weather conditions, whether or not the spill is reported, and the party performing the cleanup. In some cases, spills may go undetected and/or unreported. Generally, cleanup is initiated within several hours once the spill has been detected and reported, but many weeks or possibly years may be necessary to complete the cleanup effort. In areas where access is difficult (due to remoteness, steep terrain, or other factors), remediation may not be possible or may be ineffective due to delays in initiating cleanup.

Increased demands on water supplies from the aquifer can also reduce the quality and quantity of water in the Barton Springs segment and at Barton Springs. The volume of springflow is regulated by the level of water in the aquifer. Discharge decreases as water storage in the aquifer drops, which historically has resulted primarily from a lack of recharging rains rather than groundwater withdrawal for public consumption. During these low flow conditions, ‘‘bad water’’ within the San Antonio segment of the Edwards aquifer may move northward and contribute to flows from Barton Springs (Slade *et al.* 1986; Stein 1995). In addition, increased withdrawals could result in upward leakage from the underlying Trinity aquifer, which has higher levels of dissolved solids and fluoride than water in the Barton Springs segment (Slade *et al.* 1986).

Under low flow conditions, Barton Springs and a well near the bad water line (YD–58–50–216) have shown increased dissolved solids concentrations, particularly sodium and chloride, indicating encroachment of bad water (Slade *et al.* 1986). The BS/EACD (Hauwert and Vickers 1994) measured high levels of dissolved solids at Sunken Garden Springs, indicating a significant influence of bad water during low flow conditions. The potential for encroachment of the bad water line and/or recharge from the Trinity aquifer increases with pumpage of the aquifer and extended low recharge or low flow conditions (Slade *et al.* 1986). The encroachment of bad water could have negative impacts on the plants and animals associated with Barton Springs. High sodium and chloride levels have been shown to increase fish mortality by disturbing ion balances (Werner 1983).

Based on water-budget analyses and pumpage estimates for 1982 (Slade *et al.* 1985, 1986), discharge from the Barton Springs segment (withdrawal plus springflow) was determined to be roughly equal to recharge from surface waters. Thus, a substantial increase in groundwater withdrawal would be expected to cause a decrease in the quantity of water in the aquifer and discharge from Barton Springs. The estimated total pumpage in 1982 was 470 hectare-meters (3,800 acre-feet), or about 10 percent of the long-term mean discharge of 1,400 l/s (50 cfs) for Barton Springs (Slade *et al.* 1985, 1986). The BS/EACD estimated total pumpage for 1994 to be about 570 hectare-meters (4,600 acre-feet) (Botto and Rauschuber 1995). The exact volume of water that is pumped from the aquifer is difficult to estimate, since meter reports are only required for municipal, industrial, irrigation, and commercial wells and not for wells that pump less than 38,000 l (10,000 ga) per day, domestic wells, or agricultural wells used for non-commercial livestock and poultry operations (BS/EACD 1994). Groundwater pumpage increases considerably and its effects on aquifer levels and springflows become more pronounced during dry spells (Slade *et al.* 1986; D.G. Rauschuber & Associates and R.J. Brandes Co. 1990; BS/EACD 1994; Nico Hauwert and Ron Fiesler, BS/EACD, pers. comms., 1995).

The number of wells in the Barton Springs segment is growing with the increasing dependence on the Edwards aquifer for drinking water, irrigation, and industrial use (BS/EACD 1994 and 1995; Botto and Rauschuber 1995). In the 235 sq mi area of the Barton Springs segment, a total of 54 new wells were drilled between fiscal year (FY) 1989 (September 1, 1988 to August 31, 1989) and FY 1993, with a maximum of 18 wells drilled during a single year (BS/EACD 1995). During FY 1994, 46 new wells were drilled, which is more than two and a half times the number drilled in FY 1993 (BS/EACD 1994). An additional 45 wells were drilled in FY 1995 (BS/EACD 1995). As urbanization in the outlying areas of Austin expands and reliance on groundwater supplies increases, the number of wells and the total volume of water withdrawal is also expected to continue to increase.

In addition to contributing to declining groundwater supplies, the TWC (1989) cites water wells as a major source of groundwater contamination by providing direct access of pollutants into the aquifer and possibly through inter-aquifer transfer of bad water. Reduced groundwater levels exacerbate the problem through decreased dilution of pollutants.

Under the 1996 pumping and drought regime, flows from Barton Springs approached historically low conditions. Because the flows from Eliza and Sunken Garden springs are considerably less than flows from the main springs in Barton Springs Pool (see Background section), the impacts of increased groundwater withdrawals and drought are realized more quickly for these spring outlets. As of July 1996, the water level in both Eliza Pool and Sunken Garden Springs was less than a foot deep (O'Donnell, pers. obs., 1996). Both springs ceased flowing during the drawdown of Barton Springs Pool (Hansen, pers. comm., 1996; O'Donnell, pers. obs. 1996).

Other potential impacts to the salamander's surface habitat may include the use of high pressure fire hoses in areas where the salamander occurs, hosing silt from the shallow end of Barton Springs Pool into the salamander's habitat, diverting water from Sunken Garden Springs into Barton Creek below Barton Springs, and runoff from the train station above Eliza Pool. Following the 1992 fish kill (see Background section), chlorine is no longer used to clean Barton Springs Pool. The City of Austin has drafted a management plan to avoid, minimize, and mitigate impacts to the salamander from pool cleaning and other park maintenance practices.

Impervious cover over the Barton Springs watershed is currently estimated at 4 to 6 percent (Slade 1992; City of Austin 1995). This area is under increasing pressure from urbanization (Austin Transportation Study (ATS) 1994). The ATS has projected that the Austin metropolitan area will support a population of over 1.3 million by the year 2020, up from 815,000 in 1994. Southwest Austin, which covers only a portion of the Barton Springs watershed, is projected to almost double in size, from an estimated 32,000 people in 1994 to 58,000 by the year 2020. Likewise, the population in northern Hays County is expected to more than triple in size by the year 2020, from 18,000 in 1994 to 68,000 in 2020 (ATS 1994). According to the Capital Area Planning Council (CAPCO), Hays County has the second highest growth rate in the ten-county CAPCO region. Dripping Springs, which is located in the contributing zone between Onion Creek and Barton Creek, ''will likely continue to experience a high rate of growth as development continues along U.S. 290 from the Oak Hill area westward'' (CAPCO 1990).

Several major highways, including a segment of State Highway 45, the southern extension of Loop 1 (''MOPAC''), and the Southwest Parkway have been built in the last decade to accommodate the projected population growth, real estate speculation, and traffic demands in this area. Justification for the Highway 290 expansion was largely based on the population growth projected for and already occurring in this area (ATS 1994). In addition to these roadways, the remainder of State Highway 45, an 82-mi loop around Austin, is proposed to be built within the next 20 to 25 years. This highway would cross Barton Creek and several other creeks in the Barton Springs watershed (City of Austin 1994).

Less than 2,400 ha (6,000 ac) of preserve lands currently exist in the Barton Springs watershed (USFWS 1996). Much of the remaining area along Barton Creek and within the City of Austin's Extra-territorial Jurisdiction (ETJ) is slated for development at levels of greater than 30 percent impervious cover (City of Austin unpubl. data).

B. *Overutilization for commercial, recreational, scientific, or educational purposes.* No threat from overutilization of this species is known at this time.

C. *Disease or predation.* No diseases or parasites of the Barton Springs salamander have been reported. Primary predators of the Barton Springs salamander are believed to be predatory fish and crayfish; however, no information exists to indicate that predation poses a major threat to this species.

D. *The inadequacy of existing regulatory mechanisms.* No existing rules or regulations specifically require protection of the Barton Springs salamander or the Barton Springs ecosystem, and no comprehensive plan is in place to protect the Barton Springs watershed from increasing threats to water quality and quantity. The salamander is not included on the TPWD's list of threatened and endangered species, so the species is not protected by that agency.

Since the publication of the proposed rule, the City of Austin's ''Save Our Springs'' (SOS) ordinance was overturned by a Hays County jury in November 1994 (*Jerry J. Quick, et al.* v. *City of Austin*). Prior to its invalidation, the SOS ordinance was the most stringent water quality protection regulation in the Barton Springs watershed, requiring impervious cover limitations of 15 to 25 percent (based on net site area), buffers along major creeks, no increases in loadings of 13 pollutants, barring of exemptions and variances from the ordinance provisions, and attempts to reduce the risk of accidental contamination (Camille Barnett, City of Austin, *in litt.*, 1993).

In addition to the overturning of the SOS ordinance, several bills passed during the State's 74th (1995) legislative session that curtail the City of Austin's ability to implement water quality protective measures within its five-mile ETJ. Senate Bill 1017 and House Bill 3193 exempt large developments (over 1,000 acres, or 500 acres if approved by the TNRCC) from all City of Austin water quality ordinances and land use regulations. The TNRCC has determined that this legislation conflicts with State and Federal regulations; does not address groundwater quality; is inadequate to ensure protection of surface water quality and would not meet State water quality standards; provides little or no inspection, enforcement, or compliance safeguards; and would allow surface and groundwater quality to degrade (Mark Jordan, TNRCC, *in litt.*, 1995). Other laws passed during the 1995 session that limit the enforcement authority of local governments include Senate Bill 14, which allows landowners to sue local and State governments to invalidate regulations or seek compensation for actions that would decrease property values by 25 percent or more; and Senate Bill 1704, which ''grandfathers'' developers from updated health and safety ordinances.

Other laws and regulations potentially affecting water quality in the Barton Springs watershed include the Federal Clean Water Act, Safe Drinking Water Act, Resource Conservation and Recovery Act, and Comprehensive Environmental Response, Compensation, and Liability Act; the Edwards Rules and Texas Underground Storage Tanks Act (30 Texas Administrative Code, Chapters 313 and 334), which are promulgated and enforced by the TNRCC; the City of Austin's water quality protective ordinances (Williamson Creek Ordinance (1980), Barton Creek Watershed Ordinance (1981), Lower Watersheds Ordinance (1981), Comprehensive Watersheds Ordinance (1986), ''Composite Ordinance'' (1991), and the amended Composite Ordinance (1994); and the City of Dripping Springs' Site Development Ordinance 52B. In addition to the inadequacies of these rules and regulations (discussed below), many of the agencies charged with their administration lack adequate resources to carry out their responsibilities (TNRCC 1994).

The purpose of the Clean Water Act is ''to restore and maintain the physical, chemical, and biological integrity of the Nation's waters.'' Section 304 of the Clean Water Act provides the EPA authority to develop water quality criteria to protect water resources, including groundwater. However, the primary focus of the Clean Water Act is on surface water, and the law does not mandate protection of groundwater resources. Furthermore, surface and groundwater tend to be treated as separate and distinct resources rather than interactively, and protection focuses on human use rather than effects on aquatic organisms. Section 302, which provides for a National Pollution Discharge Elimination System (NPDES), primarily addresses point source pollution and not non-point source pollution or groundwater contamination. Efforts are needed to integrate the relationship between surface and groundwater into the regulatory framework and to assess the impact of surface water regulations and management practices on groundwater resources.

Part C of the Safe Drinking Water Act, the Underground Injection Control Program, requires that the injection of fluids underground not endanger drinking water supplies. Section 1427 (Sole Source Aquifer Program) requires that federally funded projects potentially affecting a sole source aquifer ensure that drinking water will not be contaminated. A portion of the Barton Springs watershed has been designated as a Sole Source Aquifer. The Sole Source Aquifer Program applies only to Federal projects and not to State or private projects, unless they receive Federal funds, and no requirements related to aquatic organisms are included.

The Federal Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act focus on remedial actions once groundwater contamination has occurred, rather than on prevention. Under these Acts, monitoring is required to determine when remediative cleanup actions following groundwater contamination by chemical and waste sites is complete. In addition, the RCRA requires that all underground storage tanks installed since 1988 be equipped with spill and overfill protection devices, protected from corrosion that could result in releases, and equipped with devices that would detect any releases that might occur. Previously existing tanks are to be upgraded to these same standards over a ten-year period.

Much of the responsibility for protecting surface and groundwaters is directed to and administered by the states. Section 106 of the Clean Water Act provides funds to the states for water quality programs, including comprehensive groundwater protection programs. Section 303 requires states to set water quality standards for surface waters, employing the criteria established by the EPA under section 304, and to designate uses for each water body. Section 319 provides technical and financial assistance to the states to implement programs to control nonpoint source pollution for both surface water and groundwater. The EPA's policy, ''Protecting the Nation's Groundwater: EPA's Strategy for the 1990's'' also recognizes states as having the primary role of protecting groundwater. Section 1428 of the Safe Drinking Water Act, the Wellhead Protection Program, directs states to control sources of contaminants near public supply wells used for drinking water. Most of the State of Texas' efforts to protect surface and groundwater resources focus on point sources of pollution, monitoring, and remediative actions (TNRCC 1994). The TNRCC's Tier II Antidegradation Policy applies only to regulatory actions that would exceed fishable/swimmable quality of Barton and Onion creeks, and allows degradation if necessary for important economic or social development.

The Edwards Rules regulate construction-related activities on the recharge zone of the Edwards aquifer that may ''alter or disturb the topographic, geologic, or existing recharge characteristics of a site'' as well as any other activity ''which may pose a potential for contaminating the Edwards aquifer,'' including sewage collection systems and hazardous materials storage tanks. The Edwards Rules regulate construction activities though review of Water Pollution Abatement Plans (WPAPs). The WPAPs do not require site-specific water quality performance standards for developments over the recharge zone nor do they address land use, impervious cover limitations, nonpoint source pollution, application of fertilizers and pesticides, or retrofitting for developments existing prior to the implementation of the Rules. (Travis County was incorporated into the Rules in March 1990; Hays County was incorporated in 1984.) The WPAPs also do not apply to development activities in the aquifer's contributing zone. To date, the Edwards Rules do not include a comprehensive plan to address the effects of cumulative impacts on water quality in the aquifer or its contributing zone.

The Edwards Rules and the Texas Underground Storage Tanks Act (Title 31, Chapters 313 and 334 of the Texas Administrative Code) require that all tanks installed after September 29, 1989, be equipped with release detection devices, corrosion protection, and spill/overflow protection; that all previously existing tanks be upgraded to the same standards by December 22, 1994; and that tanks located in the Edwards aquifer recharge and transition zones be of double-walled or equivalent construction with continuous monitoring of the space between the tank and piping walls for leak detection. The adequacy of these measures in preventing groundwater contamination, particularly over the long term, has not been demonstrated. Routine testing of tanks to ensure proper functioning is not required until after a leak has been detected, and no routine monitoring or testing by the TNRCC is conducted to determine compliance with the regulations. Formal approval by the TNRCC of construction plans for new tanks is only required for the recharge zone and not the contributing zone. The TNRCC does not maintain a database of the total number of storage tanks that have been upgraded, those that still need to be upgraded, or those that are in violation of the regulations (Jackie Hardee, TNRCC, pers. comm., 1995).

A Section 10(a)(1)(B) permit allowing the incidental taking of two endangered songbirds and six endangered karst invertebrates, known as the Balcones Canyonlands Conservation Plan (BCCP), was issued to Travis County and the City of Austin in May 1996 (USFWS 1996). The BCCP does not allow incidental taking of the Barton Springs salamander, and requires that all permit applicants ensure that their activities do not degrade waters in the Barton Springs watershed. The guidance provided in the Available Conservation Measures section of this final rule is intended to assist landowners in achieving this goal. Acquisition of 4,000 acres in the Barton Creek watershed as BCCP preserve land will provide additional benefits to the salamander by preserving the natural integrity of the landscape and positively contributing to water quality and quantity in Barton Creek and Barton Springs. The BCCP does not apply to development activities in Hays County.

To protect water quantity in the Barton Springs segment, the BS/EACD has developed a Drought Contingency Plan (D.G. Rauschuber & Associates and R.J. Brandes Co. 1990). Barton Springs has always flowed during recorded history, and one of the BS/EACD's goals is to assure that Barton Springs flow ''does not fall appreciably below historic low levels'' (D.G. Rauschuber & Associates and R.J. Brandes Co. 1990). The BS/EACD regulates about 60 to 80 percent of the total volume that is pumped from the Barton Springs segment and has the ability to limit development of new wells, impose water conservation measures, and curtail pumpage from these wells during drought conditions (Bill Couch, BS/EACD, pers. comm., 1992, and *in litt.* 1994; Botto and Rauschuber 1995). According to the BS/EACD (B. Couch, pers. comm., 1992), water well production in the higher elevations of the Barton Springs segment has been limited during periods of lower aquifer levels in recent years. However, the ability of the BS/EACD to ensure the success of the plan is limited, since it does not regulate 20 to 40 percent of the total volume that is pumped from the Barton Springs segment.

E. *Other natural or manmade factors affecting its continued existence.* The very restricted range of the Barton Springs salamander makes this species especially vulnerable to acute and/or chronic groundwater contamination. Since the salamander is fully aquatic, there is no possibility for escape from contamination or other threats to its habitat. A single incident (such as a contaminant spill) has the potential to eliminate the entire species and/or its prey base. Crustaceans, particularly amphipods, on which the salamander feeds are especially sensitive to water pollution (Mayer and Ellersieck 1986; Phipps *et al.* 1995; Burton and Ingersoll 1994).

Research indicates that amphibians, particularly their eggs and larvae, are sensitive to many pollutants, such as heavy metals; certain insecticides, particularly cyclodienes (endosulfan, endrin, toxaphene, and dieldrin), and certain organophosphates (parathion, malathion); nitrite; salts; and petroleum hydrocarbons (Harfenist *et al.* 1989). Christine Bishop (Canadian Wildlife Service) states that ''the health of amphibians can suffer from exposure to pesticides (Harfenist *et al.* 1989). Because of their semipermeable skin, the development of their eggs and larvae in water, and their position in the food web, amphibians can be exposed to waterborne and airborne pollutants in their breeding and foraging habitats * * *. [Furthermore] pesticides probably change the quality and quantity of amphibian food and habitat (Bishop and Pettit 1992).'' Toxic effects to amphibians from pollutants may be either lethal or sublethal, including morphological and developmental aberrations, lowered reproduction and survival, and changes in behavior and certain biochemical processes.

Observations of central Texas *Eurycea* salamanders in captivity indicate that these species, including the Barton Springs salamander, are very sensitive to changes in water quality and are ''quite delicate and difficult to keep alive'' (Sweet, *in litt.*, 1993). Sweet reported that captive individuals exhibit adverse reactions to plastic containers, aged tapwater, and detergent residues. The water in which these salamanders are kept also requires frequent changing (Sweet, *in litt.*, 1993). Unsuccessful attempts at captive propagation of the San Marcos salamander (Janet Nelson, Southwest Texas State University, pers. comm., 1992) and very limited success at inducing captive spawning in the Barton Springs salamander (Ables, Coale, and Dwyer, pers. comms., 1996) may also be due to these species' sensitivity to environmental stress.

Several citizens have expressed concern over impacts to the salamander from recreational use of Barton Springs Pool for swimming. However, no evidence exists to indicate that swimming in Barton Springs Pool poses a threat to the salamander population, which is located 3 to 5 m (10 to 15 ft) below the water's surface. The survey data show no correlation between recreational use of the pool and salamander abundance. Furthermore, salamander population declines have occurred in Eliza Pool, which is closed to the public. Although certain pool maintenance practices may impact individual salamanders occurring in the pools, they are unlikely to have a major impact on the entire species.

The Service has carefully assessed the best scientific and commercial information available regarding the past, present, and future threats faced by this species in determining to make this rule final. The best scientific data indicate that listing the Barton Springs salamander as endangered is warranted. Critical habitat is determined to be not prudent for this species for the reasons discussed below.

Critical Habitat

Critical habitat is defined in section 3 of the Act as: (i) The specific areas within the geographical area occupied by a species, at the time it is listed in accordance with the Act, on which are found those physical or biological features (I) essential to the conservation of the species and (II) that may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by a species at the time it is listed, upon a determination that such areas are essential for the conservation of the species. ''Conservation'' means the use of all methods and procedures needed to bring the species to the point at which protection under the Act is no longer necessary.

Section 4(a)(3) of the Act, as amended, and implementing regulations (50 CFR 424.12) require that, to the maximum extent prudent and determinable, the Secretary designate critical habitat at the time the species is determined to be endangered or threatened. Service regulations (50 CFR 424.12(a)(1)) state that designation of critical habitat is not prudent when one or both of the following situations exist—(1) The species is threatened by taking or other human activity, and identification of critical habitat can be expected to increase the degree of such threat to the species, or (2) such designation of critical habitat would not be beneficial to the species. The Service finds that designation of the springs occupied by the Barton Springs salamander as critical habitat would not be prudent because it would not provide a conservation benefit to the species.

Designation of critical habitat benefits a listed species only when adverse modification or destruction of critical habitat could occur without the survival and recovery of the species also being jeopardized. Because the Barton Springs salamander is restricted to one area that discharges water from the entire Barton Springs watershed, any action that would result in adverse modification or destruction of the salamander's critical habitat would also jeopardize its continued survival and recovery. Designating critical habitat would therefore not provide a benefit to the species beyond the benefits already provided by listing and subsequent evaluation of activities under the jeopardy standard of section 7 of the Act. Because jeopardy to the species and adverse modification of its critical habitat are indistinguishable, the Service has determined that designation of critical habitat for the Barton Springs salamander is not prudent.

Available Conservation Measures

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

The health of the aquifer and Barton Springs, and the long-term survival of the Barton Springs salamander, can only be ensured through a concerted, organized effort on the part of all affected Federal, State, and local governments and the private citizenry to protect the Barton Springs watershed. Conservation and management of the Barton Springs salamander will entail removing threats to its survival, including—(1) protecting the quality and quantity of springflow from Barton Springs by implementing comprehensive management programs to control and reduce point and nonpoint sources of pollution throughout the Barton Springs watershed; (2) minimizing the risk and likelihood of pollution events that would affect water quality; (3) strengthening efforts to protect groundwater and springflow quantity; (4) continuing to examine and implement pool cleaning practices and other park operations that protect and perpetuate the salamander's surface habitat and population; and (5) public outreach and education. It is also anticipated that listing will encourage continued research on the critical aspects of the Barton Springs salamander's biology (e.g., longevity, natality, sources of mortality, feeding and breeding ecology, and sensitivity to contaminants and other water quality constituents).

Section 7(a) of the Act, as amended, 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)(1) requires Federal agencies to use their authorities to further the purposes of the Act by carrying out programs for listed species. Section 7(a)(2) requires Federal agencies to ensure that activities they authorize, fund, or carry out are not likely to jeopardize the continued existence of a listed species. If a Federal action may affect a listed species, the responsible Federal agency must enter into consultation with the Service, unless the Service agrees with the agency that the action is not likely to adversely affect the species.

The Act and its implementing regulations set forth a series of general prohibitions and exceptions that apply to all endangered wildlife. These prohibitions, codified at 50 CFR 17.21, 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, or collect, or to attempt any of these), import or 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. It also is 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. The Barton Springs salamander is not known to be commercially traded and such permit requests are not expected.

Permits may be issued to carry out otherwise prohibited activities involving endangered wildlife species under certain circumstances. Regulations governing permits are at 50 CFR 17.22 and 17.23. Such permits are available for scientific purposes, to enhance the propagation or survival of the species, and/or for incidental take in connection with otherwise lawful activities.

It is the policy of the Service (59 FR 34272; July 1, 1994) to identify to the maximum extent practicable at the time a species is listed, those activities that would or would not constitute a violation of section 9 of the Act. The intent of this policy is to increase public awareness of the effect of listing on proposed and ongoing activities within a species' range, and to assist the public in identifying measures needed to protect the species. Aside from the potential for catastrophic spills, no single development activity or water withdrawal in and of itself is likely to significantly impact water quality and quantity in the Barton Springs watershed. Rather, it is the sum of all of these activities and their associated impacts that threaten this resource and the survival of the Barton Springs salamander. Because most of the threats to the salamander come from diffuse sources that are cumulative in nature, their effects will be observable at the ecosystem and population level rather than at the individual level. Thus, the purpose of this guidance is not only to identify activities that would or would not likely result in ''take'' of individuals, but activities that in combination will ultimately affect the long-term survival of the Barton Springs salamander. This guidance should not be used to substitute for local efforts to develop and implement comprehensive management programs for the Barton Springs watershed.

Activities that the Service believes are unlikely to result in a violation of section 9 for the Barton Springs salamander are:

(1) Range management and other agricultural practices that promote good vegetative cover and soil conditions (for example, low to moderate stocking rates, rotational and deferred grazing, and maintaining native bunchgrasses);

(2) Swimming in Barton Springs pool;

(3) Buying or selling of property;

(4) Improvements to existing structures, such as renovations, additions, repairs, or replacement;

(5) New developments or construction that do not result in an appreciable change in the quality or quantity of water in the Barton Springs watershed above normal background conditions (non-degradation). Generally, new developments and construction designed and implemented pursuant to State and local water quality protection regulations in effect as of the date of this rule will not result in a violation of section 9;

(6) Routine residential lawn maintenance; and

(7) Upgrading or replacing existing structures (such as bridge crossings, BMPs, septic systems, underground storage tanks) in order to minimize pollutant loadings into receiving waters.

Activities that the Service believes could potentially harm the Barton Springs salamander and result in a violation of section 9 include:

(1) Collecting or handling of the species without appropriate permits;

(2) Alteration or disturbance of the Barton Springs salamander's habitat in the pools where it occurs (including use of chemicals to clean the pools where the salamander occurs; use of high pressure fire hoses in salamander habitat; removal of beneficial aquatic plants; dredging; and frequent and/or prolonged drawdown, particularly during drought);

(3) Illegal discharges or dumping of chemicals, silt, sewage, fertilizers, pesticides, heavy metals, oil, organic wastes, or other pollutants into the Barton Springs watershed;

(4) New developments or construction not designed and/or implemented pursuant to State and local water quality protection regulations in effect as of the date of this rule, that result in an appreciable change in the quality or quantity of water in the Barton Springs watershed above normal background conditions (non-degradation);

(5) Withdrawal of water from the aquifer to the point at which springflows at Barton Springs appreciably diminish;

(6) Withdrawal of water from the contributing zone to the point at which baseflows in the creeks appreciably diminish;

(7) Introduction of non-native aquatic species (fish, plants, other) into Barton Springs or the Barton Springs segment of the Edwards aquifer;

(8) Destruction or alteration of caves, sinkholes, or other significant recharge features (including dumping, vandalism, and/or diverting contaminated water into these features); and

(9) Destruction or alteration of spring orifices that provide water to Barton Springs.

Questions as to whether specific activities will constitute a violation of section 9 should be directed to the Service's Austin Ecological Services Field Office (see **ADDRESSES** section). Requests for copies of the regulations regarding listed wildlife and inquiries regarding prohibitions and permits should be addressed to the U.S. Fish and Wildlife Service, Branch of Endangered Species/Permits, P.O. Box 1306, Albuquerque, New Mexico 87103 (telephone: 505/248–6920; facsimile: 505/248–6922).

National Environmental Policy Act

The Fish and Wildlife Service has determined that Environmental Assessments and Environmental Impact Statements, as defined under the authority of the National Environmental Policy Act of 1969, need not be prepared in connection with regulations adopted pursuant to section 4(a) of the Endangered Species Act of 1973, as amended. A notice outlining the Service's reasons for this determination was published in the **Federal Register** on October 25, 1983 (48 FR 49244).

Required Determinations

The Service has examined this regulation under the Paperwork Reduction Act of 1995 and found it to contain no information collection requirements.

References Cited

A complete list of all references cited in this rule is available upon request from the Austin Ecological Services Field Office (see **ADDRESSES** section).

Author: The primary author of this final rule is Lisa O'Donnell, Austin Ecological Services Field Office (see **ADDRESSES** section).

List of Subjects in 50 CFR Part 17

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

Regulation Promulgation

Accordingly, part 17, subchapter B of chapter I, title 50 of the Code of Federal Regulations, is amended as set forth below:

PART 17—[AMENDED]

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

Authority: 16 U.S.C. 1361–1407; 16 U.S.C. 1531–1544; 16 U.S.C. 4201–4245; Pub. L. 99–625, 100 Stat. 3500, unless otherwise noted.

2. Section 17.11(h) is amended by adding the following, 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, Barton Springs	*Eurycea sosorum*	U.S.A. (TX)	Entire	E	612	NA	NA
*	*	*	*	*	*	*	

Dated: April 24, 1997.

John G. Rogers,

Acting Director, Fish and Wildlife Service.

[FR Doc. 97–11194 Filed 4–29–97; 8:45 am]

BILLING CODE 4310–55–P