Habitat Management Plans for the Barton Springs Pool HCP

City of Austin
Watershed Protection Department
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INTRODUCTION

This document outlines the habitat management plans for each of the four spring sites that comprise the Barton Springs complex, home to the endangered Barton Springs and Austin blind salamanders (*Eurycea sosorum*, and *Eurycea waterlooensis*, respectively). Development of this plan by the City of Austin (hereafter, "City") and its provision to the U.S. Fish and Wildlife Service ("Service") fulfills measure 6.1.1.1 of the Barton Springs Pool Habitat Conservation Plan ("HCP"; City 2013) and condition I of the associated Incidental Take Permit TE 839031-1 ("ITP"). As specified in measure 6.1.1.1 of the HCP, the City will revise these plans as necessary with the written or verbal approval of the Service.

Background information, such as the historical condition of the springs, their current physical and biological characteristics, as well as salamander population information can be found in the HCP (see Section 3.2 for a description of each spring site, and sections 3.3 and 3.4 for detailed information on the status of each species); this information will not be repeated here. The purpose of this document is to outline the specific management actions intended to improve habitat for the Barton Springs and Austin blind salamanders. However, due to physical limitations on access to subterranean habitat, these actions are anticipated to directly affect mostly *E. sosorum*, with the possibility of incidental or indirect benefits to *E. waterlooensis* (due to the fact that the latter is a troglobite, despite occasional surface occurrences).

This document is divided into two main sections. In the first section, we describe our overall goals for habitat management, including the habitat characteristics and restoration practices believed to be important for establishing and maintaining suitable epigean habitat for *E. sosorum*. These goals are based on a combination of ecological theory, knowledge of central Texas *Eurycea* salamander (*Paedomolge,* sensu Hillis et al. 2001) biology, habitat associations, prior experiences with habitat modifications in Barton Springs, and personal observations of City biologists. These goals are not expected to change significantly over time. In the second section, we outline the specific actions intended to meet our management goals, which includes general actions common to all sites as well as management plans that are site-specific. These include a range of activities from routine maintenance to major habitat improvement projects. This list will likely be updated frequently as projects are completed or as new information is gained.

Management Goals

Eurycea sosorum and *E. waterlooensis* were listed as endangered species on May 30, 1997 (62 FR 23377-23392), and September 19, 2013 (78 FR 51278-51326), respectively. This habitat management plan furthers recovery efforts by identifying goals and actions to improve aquatic habitat for *E. sosorum* and restore ecosystem function, thereby facilitating resiliency of the target species to existing habitat degradation and future environmental change. Four primary goals will contribute to these improvements.

I. *Provide and maintain non-embedded cover objects in epigean habitat to maximize availability of interstitial space for salamanders and macroinvertebrates.* Rocks such as gravel, cobble and boulders help provide cover and physical space in interstices for salamanders. Several studies have documented the use of gravel and cobble sized rocks as cover in *Paedomolge* (*E. nana*, Diaz 2010; *E. sosorum*, Dries 2012), with a preference toward larger cobble when size was considered (*E. tonkawae*, Bowles, Sanders, and Hansen 2006; *E. naufragia*, Pierce et al. 2010). The relationship between rock size and interstitial space is an important determinant of aquatic community structure, and likely shapes predator-prey interactions in at least one other paedomorphic *Eurycea* species (Martin et al. 2012). Excess sedimentation may negatively impact salamander habitat when interstices become filled by fine sediment (Wood and Armitage 1997; Welsh and Ollivier 1998).

II. *Restore and maintain shallow, flowing water near springs to provide higher concentrations of dissolved oxygen* (DO)*, less embedded cover, and fewer predatory fish.* Studies examining habitat associations of *Paedomolge* salamanders have shown a positive correlation between abundance and proximity to spring outlets and nearby areas of flowing water (Sweet 1982; Nelson 1993; Bowles, Sanders, and Hansen 2006; Diaz 2010; Pierce et al. 2010). Occupancy of *Eurycea tonkawae* has a strong positive correlation with low temperature variation (an indication of groundwater influence) and a negative correlation with water depth (Bendik 2014). Similar patterns seem to hold for *E. sosorum*: the highest densities are found in areas with higher flow velocities, in shallow water (Dries 2012), and near spring outlets (City, unpublished data). Salamanders may prefer to be within close proximity of the aquifer outlets because subterranean habitat may be used for refugia (Bendik and Gluesenkamp 2013; City, unublished data), egg deposition (Tumlison, Cline, and Zwank 1990; Nelson 1993; Roberts, Schleser, and Jordan 1995; Fries 2002) or other unknown aspects of their life history. Additionally, shallow, flowing spring water may also be preferable to *Paedomolge* salamanders due to higher concentrations of DO, less embedded cover (providing microhabitat for salamanders and their prey), and fewer predatory fish. The latter may be one reason why salamanders are less abundant in Parthenia Spring compared to Eliza Spring.

III. *Reduce habitat disturbance from humans*. Signs of physical disturbance by humans in the springs, such as building rock dams, moving substrate, and wading, are common during the summer months when Zilker Park and Barton Springs Pool visitation is high. Disturbance is anticipated and accounted for in the ITP at Parthenia Spring and Upper Barton Spring, which are open to the public, by allowing take for recreation. However, habitat disturbance also occurs at Old Mill Spring and Eliza Spring by trespassers, despite being fenced from public access and posted. While the impact of habitat disturbance has not been studied (or even well documented) in this or any closely related species to our knowledge, it is expected to result in the largest amount of non-lethal take for the Barton Springs and Austin blind salamanders (HCP).

IV. *Restore habitat heterogeneity within the epigean zone to aid in the recovery of aquatic macroinvertebrate species diversity and composition.* Establishing and maintaining habitat heterogeneity is important for restoration of aquatic ecosystems (Palmer 2009). Spatial habitat heterogeneity may be beneficial for *Paedomolge* salamanders in several ways. Habitat heterogeneity has been shown to contribute to macroinvertebrate species diversity as well as temporal stability in the insect community in stream environments (Brown 2003). Because *Paedomolge* salamanders are known to consume a diversity of macroinvertebrate species (City 2001; Diaz 2010; Gillespie 2013), spatial variation in habitat is probably important. Restoration of spatial habitat variation may lead to restoration of the native invertebrate community. It is important to consider within-stream diversity prior to restoration, as new species immigration may be difficult (Spänhoff and Arle 2007). Moreover, species diversity may be important for habitat functionality (Naeem et al. 1994; Tilman, Wedin, and Knops 1996); if functional diversity and response diversity within functional groups are high, the ecosystem can be resilient to change (Elmqvist et al. 2003). Therefore, without detailed knowledge of species interactions within the spring ecosystem, management should focus on enhancing habitat heterogeneity over homogeneity to promote macroinvertebrate species diversity in the spring ecosystem.

PLANNED MANAGEMENT ACTIONS

1 The Barton Springs Complex (all sites)

1-1. *Increase habitat heterogeneity by adding a diversity of gravel sizes to areas where rocky cover is homogenous in particle size.* Rocky substrate (e.g. gravel and cobble) seems to be the preferred cover for *E. sosorum* (Dries 2012) as well as for other central Texas *Eurycea* (Nelson 1993; Bowles, Hansen, Sanders 2006; Diaz 2010; Pierce et al. 2010). Although no studies have been done on cover size preferences for *E. sosorum*, *E. naufragia* tends to prefer larger rocks for cover (314 cm2) compared to smaller rocks (122 cm2; Pierce et al. 2010), and *E. tonkawae* also preferentially select larger rocks for cover (Bowles, Hansen, Sanders 2006). Anecdotal observations of adult *E. sosorum* note occurrence under larger substrate and juvenile salamanders (including other *Eurycea*) often are observed in fine sediments. Rocky substrate in some areas currently consists of a mostly homogenous mixture of large gravel and small cobble with few large cobble or small boulder sized rocks (e.g., > 100 mm). A homogenous distribution of small particle cover is particularly evident in Eliza Spring. Increasing the preferred available space may decrease intraspecific competition, increase the carrying capacity (at the surface), or even provide more space for courtship (if it indeed occurs under rocks). Our initial approach will be to systematically introduce patches of larger, flat rocks into Eliza Spring and study the response of *E. sosorum* to help us determine the size and scope of future modifications to rocky cover. This management action address goals I and IV as stated above and helps fulfill measures 6.1.1.4 and 6.1.1.7 of the HCP.

1-2. *Flush sediment periodically by hand to prevent the upper 2–3 inches of cover from becoming embedded, and thereby reducing cover availability.* The negative effects of sedimentation in lotic environments are well-documented (reviewed in Wood and Armitage 1997). Specific threats to *E. sosorum* and *E. waterlooensis* caused by sedimentation in Barton Springs include filling/covering of habitat, declines in aquatic macrophytes, transport and concentration of contaminants and decline of benthic macroinvertebrate prey (Mahler and Lynch 1999; Service 2005; Geismar 2005). Abundance of salamanders at Eliza Spring was significantly lower prior to restoration of a more natural flow regime and removal of the extensive sediment buildup within the spring pool (Dries 2012). Sediment accumulation has occurred for several reasons in Barton Springs. Firstly, impoundment of Barton Creek to create Barton Springs Pool and the impoundments surrounding Eliza and Old Mill springs encourage deposition of fine sediment. Secondly, the highly modified morphology of these springs and the surrounding areas has resulted in a loss of natural processes (e.g. storm flow and flood events) that disturb the substrate (Service 2005; p. 1.6-25). Eliza and Old Mill Springs only partially experience this natural disturbance during 100-yr flood events and Parthenia Spring experiences varying degrees of disturbance with flood events. Upper Barton Spring becomes inundated by storm flow when the creek exceeds average wetted width, providing the most frequent natural disturbance. Thirdly, sediment moving through the aquifer and emerging at the springs is increasing over time (Mahler and Lynch 1999). Ultimately, improving flow regime of the springs will reduce the need to manually remove sediment and will help maintain more available cover for salamanders and macroinvertebrates. This action will be achieved by (1) suspending sediment during routine salamander population surveys, (2) using low-pressure (<30 lb/in^2) spring water delivered via handheld garden hoses to flush sediment from habitat, (3) conducting drawdowns in Barton Springs Pool when conditions permit (discharge is >54 ft^3/s, details in HCP) to allow for additional sediment removal with hoses and (4) regularly monitor and quantify sediment accumulation using standardized, repeatable methods (see Mahler and Lynch 1999; Geismar 2005). This management action addresses goal I and helps fulfill measure 6.1.1.7 of the HCP.

1-3. *Establish native vegetation both in within the springs and within the riparian zone to restore the vegetative community and improve ecosystem function*. Restoring native vegetation within the springs and in the riparian zone has several potential benefits. Within the spring pool, aquatic vegetation, including mosses and vascular plants, can provide habitat for both salamanders and macroinvertebrates and reduce algae by competing for nutrients. Riparian vegetation can provide canopy cover, detritus input, habitat for salamanders and invertebrates, and it can help filter storm water before it reaches salamander habitat. Detritus input from terrestrial sources is an important source of food and habitat (e.g. Phylloicus spp.) for many invertebrates and providing this resource may contribute to a diverse and abundant prey base for salamanders. Shade from canopy cover may provide some shelter from UV rays and reduce water temperature, while shaded cover may provide suitable habitat for some invertebrates. This action will be achieved by (1) planting native riparian hardwood and understory trees, (2) planting native vegetation at the water interface, (3) transplanting aquatic flora in the spring and stream habitats from other springs within the Barton Springs complex, including vascular plants and mosses, (4) reducing compaction of spring or stream banks if necessary, using hand tools, to encourage revegetation, (5) removing non-native vegetation (e.g. *Arundo* spp. and *Ligustrum* spp.) with hand tools or a combination of girdling and direct application of acetic acid in the riparian zone of salamander habitat and (6) providing multiple phases of active restoration as needed to encourage vegetation growth and to replace vegetation removed during floods. This management action addresses goals III and IV and helps fulfill measure 6.1.4.2 of the HCP.

1-4. *Periodic removal of predatory fish and crayfish in the springs.* Impoundments of Barton Creek, creating Barton Springs Pool, and of Eliza Spring and Old Mill Spring have created more lentic environments that are favorable for some species of fish (e.g., *Lepomis spp.*, *Herichthys cyanoguttatus*, *Micropterus salmoides*, *Gambusia affinis*, *Astyanax mexicanus*) that may prey upon salamanders. The frequency of salamander predation by fish in the springs is unknown, but laboratory experiments have shown that chemical cues from predatory fish result in antipredator behavior in captive-hatched *E. sosorum* (Desantis, Davis, and Gabor 2013). In addition to possible predation on salamanders, fish and crayfish may be competing with salamanders for macroinvertebrate prey. Relocation of mosquitofish (*Gambusia affinis*) and crayfish from Eliza Spring appears to have improved conditions for salamanders there (Service 2005). The high predatory fish densities in Barton Springs Pool and Old Mill Spring may make salamanders more susceptible to predation. This action will be achieved by (1) collecting fish using hand-held seines, rod and reel, minnow traps, gill nets, and/or polespears in cooperation with the Texas Parks and Wildlife Department, (2) euthanizing the fish and examining gut contents in cooperation with the University of Texas at Austin and (3) conducting exclosure experiments in Barton Springs Pool near the mouth of Parthenia Spring to determine whether salamander densities increase in fishless areas. This management action addresses goal III and helps fulfill measures 6.3.2 and 6.5.3 of the HCP.

2 Eliza Spring

2-1. *Daylight Eliza Spring outlet pipe and maintain stream as salamander habitat.* The addition of a free-flowing stream to the outflow path of Eliza Spring will provide additional surface habitat for *E. sosorum*, potentially increasing the carrying capacity of this site. The existing pipe is structurally unsound and failure of this pipe could be catastrophic to the resident population and habitat. Removing the pipe and opening the stream removes that threat. This will be achieved by (1) removing the masonry in the amphitheater "keyhole", (2) excavating fill from above the buried pipe, (3) stabilizing the stream banks with hardscaping and vegetation, (4) constructing the banks and channel to withstand flood events, (5) vegetating riparian areas around Eliza Spring, (6) installing gates at the upstream and downstream ends of the stream to allow maximum flexibility in maintaining wetted habitat in both the spring pool and stream, and (7) installing fencing around or overtop the stream to prohibit access by the public. These actions are expected to be completed in 2016. This management action addresses goals I, II, and IV as stated above and fulfills measure 6.1.4.1 of the HCP. Take for this action is estimated in Tables 18 and 20 of the HCP.

2-2. *Remove the concrete floor in Eliza Spring in sections and restore uninhibited spring flow to the spring pool as much as is feasible.* Removal of the concrete floor in Eliza Spring serves several purposes. First, it can lower surface water elevation of the spring, reducing the hydraulic head required to keep this habitat wetted during periods of low aquifer discharge and drawdowns of water level in Barton Springs Pool for maintenance or flood events. Secondly, it will allow restoration of a more natural substrate and discharge pattern across the spring area. The latter will still be limited somewhat by constraints of historic structures within the flow path (i.e. amphitheater, bypass culvert, Barton Springs Pool dams, and Lady Bird Lake dams). Thirdly, elimination of the concrete and exposing the natural spring orifices could improve access to subterranean habitat for salamanders. The concrete floor may act as a restrictive barrier for salamanders and spring flow, except at the upwellings and vents. Fourth, creating a more heterogeneous environment with respect to water depth and substrate composition may help restore natural community composition and therefore improve ecological function of the spring. While a detailed plan has not been developed for this action, it will generally be achieved by removing small sections of the concrete floor piecemeal and restoring the exposed substrate as much as is feasible. If salamanders are observed in the newly exposed habitat, additional sections of floor will be removed and the process repeated until the entire floor is removed. Prior to floor removal, we will identify and characterize the substrate beneath the concrete floor in the spring pool using non-destructive methods. This may include the use of underwater video/photography and use of historical photographs that pre-date the concrete floor. These steps will occur after completion of 2-1. This management action addresses goals I, II, III, IV, and fulfills measure 6.1.4.1 of the HCP. Take for this action is estimated in tables 18 and 20 of the HCP.

3 Parthenia Spring

3-1. *Remove impacted concrete from the fissures to improve flow through the fissures and allow light penetration into the fissures.* Removing the impacted concrete from the fissures may improve habitat by opening blocked fissures, thereby increasing spring flow, reducing sediment accumulation, and increasing light penetration to increase aquatic flora growth within the fissures, potentially creating additional salamander and macroinvertebrate habitat. This action will be achieved by (1) removing small areas of concrete using handheld tools underwater, (2) removing larger section using a pneumatic jackhammer during drawdown events and (3) hauling the concrete from the Pool using wheelbarrows and a dump truck stationed outside of the Pool. This management action addresses goals I, II, III, IV, and fulfills measure 6.1.4.3 of the HCP.

3-2. *Remove accumulated flood debris in Parthenia Spring by hand and through large-scale removal as necessary to help reduce accumulation of flood debris over time.* Impoundment of Barton Creek to create Barton Springs Pool causes debris (gravel, sediment, downed wood, etc.) to accumulate following floods. While improvement of the natural flow regime via modification of the dams is a goal of the HCP (measure 6.1.3), implementation is not expected to occur in the near future and it will not completely resolve debris accumulation. Two short-term strategies have been used instead to remove flood debris in the past: pool drawdowns and vacuum dredging (City 2013). Preliminary data suggest full drawdowns result in less sediment deposition during cleanings versus partial drawdowns, and are more efficient both in terms of required staff time and number of days the pool is closed for cleaning (City 2013). Prior to 1998, debris removal was performed roughly biannually and was generally environmentally destructive (City 2013). Following listing of *E. sosorum* in 1997, these methods were abandoned. Most recently in 2011, vacuum dredging of accumulated sediment and flood debris in the deep end of the pool (outside of salamander habitat) occurred following an approved plan by the Service. Vacuum dredging is thought to be the most feasible method available for removing large amounts of accumulated flood debris from BSP because it is less intrusive than excavation and may be implemented on a small scale (City 2013). Dredging is performed on an irregular basis given the unpredictable nature of central Texas flood events (City 2013). This action will be achieved by (1) conducting full drawdowns during flood events and continuing after the event as conditions permit (discharge >54 ft^3/s) to reduce retention time and increase flow velocity of flood water and debris in the Pool to discourage settling, (2) remove some woody debris by hand and (3) vacuum dredging deep channel areas downstream of salamander habitat as needed and as outlined in the Flood Debris Removal Plan. This management action addresses goals I, II, and fulfills measure 6.1.1.8 of the HCP.

4 Old Mill Spring

4-1. *Modify the Old Mill spring pool and stream to maintain the spring pool at a shallower depth and reduce water velocities in the stream.* Old Mill Spring has been impounded since the late 19th century and salamander habitat within the spring pool and stream has varied greatly (City 2013). Currently, the spring pool is less than two meters deep and water velocity within the spring pool is minimal (City, unpublished data). As it exits the spring pool, the elevation of the stream increases and then decreases until it reaches the manmade waterfall at Barton Creek. Shallower water in the spring pool could facilitate sediment removal, increase DO by increasing water velocity through the spring pool, and discourage large predatory fish from inhabiting the spring. Reducing the stream water velocity will provide a more conducive environment for salamanders to move from the stream back into the spring pool and may reduce one-way migration into Barton Creek. This action may be achieved by (1) reconstructing or altering the stream channel to remove any positive grades within the stream channel and reduce the overall negative grade of the existing channel, (2) widening the stream channel to provide additional salamander habitat and reduce flow velocities and (3) if feasible, widening the outflow in the impoundment from the spring pool to the stream. The City is currently investigating engineered solutions to these problems and continues to perform manual (i.e., by-hand) adjustment of substrate to achieve some of the desired conditions. This management action addresses goals I, II, III, IV, and fulfills measure 6.1.3.1 of the HCP.

5 Upper Barton Spring

5-1. *Relocate the existing trail around Upper Barton Spring to reduce degradation of the riparian zone and spring habitat by limiting access.* Endangered species habitat in Upper Barton Spring is heavily disturbed, particularly during summer months when it is flowing. The existing trail leading to Upper Barton Spring runs immediately adjacent and partially through salamander habitat. By directing trail-users around the spring, a buffer may be constructed between the trail and the spring, and intentional paths can be constructed to direct traffic around the spring and to Barton Creek as opposed to the entire spring being accessible. The ultimate goal is to minimize impacts to the spring from recreation. This action will be achieved by (1) using on-site fallen tree limbs to redirect traffic onto alternative trails and creating a physical barrier from the existing trail, (2) moving additional fallen on-site vegetation onto the existing trail and anchoring with natural materials where necessary, (3) installing temporary "Habitat Restoration" signs, (4) installing a split rail cedar fence (two posts wide) to provide an additional physical barrier across existing trail, (5) maintaining the alternative trail as the new primary trail until it is established as such, (6) using native vegetation to impede access to the spring and to direct trail users towards an access point at the confluence of the downstream flow of the spring and Barton Creek and (7) re-vegetating the existing trail. This management action addresses goal III as stated above and helps fulfill measure 6.1.1.6 of the HCP.

5-2. *Discourage and provide remediation for habitat disruption and vandalism.* Construction of temporary dams or any other alteration of spring flow is detrimental to salamander habitat at the spring. Disturbance of cover objects and foot traffic within the spring can cause salamander injuries and mortalities (City, unpublished data). Prohibition and remediation of these activities will be achieved by (1) manually removing dams built immediately upon discovery, (2) redistributing substrate within the spring pool, (3) removing obstructions from the spring pool, (4) posting signs to educate the public about which activities are prohibited, (5) requesting increased patrols by in this area by law enforcement and park rangers and (6) if necessary, constructing additional fencing in park grounds to limit access to the site. This management action addresses goals II and III, and helps fulfill measure 6.1.1.6 of the HCP.

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