PROPOSED
Draft Habitat Conservation Plan For Groundwater Use and Management of the Barton Springs Segment of the Edwards Aquifer

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Barton Springs/Edwards Aquifer Conservation District

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For:
U.S. Fish & Wildlife Service

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AF	acre-feet
AMP	Adaptive Management Plan
BAT	Biological Advisory Team
BSEACD	Barton Springs/Edwards Aquifer Conservation District
C	Celsius, temperature scale
CAC	Citizens Advisory Committee
CCSP	U.S. Climate Change Science Program
CFR	Code of Federal Regulations
cfs	cubic feet per second
CO2	carbon dioxide
COA	City of Austin
COMM	Commercial water use type
DFC	Desired Future Condition
DO	Dissolved Oxygen
DOR	Drought of Record
EAA	Edwards Aquifer Authority
EIS	Environmental Impact Statement
ERP	Emergency Response Period (drought stage)
ESA	Endangered Species Act
GBRA	Guadalupe-Blanco River Authority
GCD	Groundwater Conservation District
GCM	Global Circulation Model
GMA	Groundwater Management Area
GWSIM- IV	USGS groundwater flow model
HCP	Habitat Conservation Plan
IND	Industrial, water use type
IPCC	Intergovernmental Panel on Climate Change
IRG	Irrigation, water use type
ITP	Incidental Take Permit
LCx	Lethal Concentration [percent values]
MAC	Management Advisory Committee; also Committee
MAG	Modeled Available Groundwater (derived from DFC)
MG	million gallons
mg/L	milligrams per liter (chemical concentration)
mm	millimeter
MP	[District] Management Plan
msl	mean sea level, datum for elevation measurement
NDU	Nonexempt Domestic Use
NEPA	National Environmental Policy Act
NOAEL	No Observed Adverse Effect Level
PEHA	Probabilistic Ecological Hazard Assessment
pH	Concentration of hydronium ion (acid-base measure)

PWS	Public Water Supply, water use type
r	Correlation Coefficient
R^2	Coefficient of Determination
SAP	Synthesis and Assessment Product
SYS	Sustainable Yield Study
TCEQ	Texas Commission on Environmental Quality
TPWD	Texas Parks & Wildlife Department
TWC	Texas Water Code
TWDB	Texas Water Development Board
UCP	User Conservation Plans
UDCP	User Drought Contingency Plans
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

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The Barton Springs/Edwards Aquifer Conservation District is the entity that prepared and is submitting the HCP as the sole Plan Participant, and it alone is responsible for its contents. However, it was assisted in the preparation of various drafts of the HCP and in the conduct of supporting investigations by a set of contractors that provided important contributions to the overall effort. They include:

- Hicks & Company, for environmental impact assessment and NEPA-related documentation;
- Recon Environmental, Inc., for HCP documentation and planning consulting services;
- Bio-West, for ecological impact assessments;
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Moreover, the District has assembled a multi-lateral stakeholder group to serve as a continuing HCP Management Advisory Committee (Committee) to advise the District Board of Directors and assist the District staff in implementing the HCP, as described i in Section 6.5.1.2 of this HCP. The inaugural members of the Committee also participated in a comprehensive, facilitated review process on earlier versions of this HCP, and their comments substantially improved the final draft document. These members and their interest groups include:

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Jon White	Travis County (County Government)
Clif Ladd	Interested Private Citizen (Public At-Large)
Karen Huber	Interested Private Citizen (Public At-Large)

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Other maps and graphics: Robin Gary, BSEACD Senior Public Information and Education Coordinator; and Brian B Hunt.

Draft Habitat Conservation Plan for Groundwater Use and Management of the Barton Springs Segment of the Edwards Aquifer

1.0 Introduction and Background

This habitat conservation plan (HCP) is proposed by the Barton Springs/Edwards Aquifer Conservation District (BSEACD, or District) in support of an application for an incidental take permit (ITP, or Permit) from the U.S. Fish and Wildlife Service (Service) for the Barton Springs salamander, *Eurycea sosorum* , and for the Austin blind salamander, *E. waterlooensis*, both protected species listed as endangered by the Service (together, the Covered Species). The District is a political subdivision of the State of Texas, a local agency of the State that was formed and authorized by the Texas Legislature specifically to manage the groundwater resources within its jurisdiction under applicable state laws and statutes, particularly Texas Water Code Chapter 36 and Special District Local Laws Code Chapter 8802. This document comprises the HCP for withdrawal of groundwater of the Barton Springs segment of the Edwards Aquifer as a water supply by permitted well owners/operators and for its management by the District (hereinafter, District HCP); it proposes a substantial number of regulatory and management measures that will be implemented by the District on issuance of an ITP under Section 10 of the Endangered Species Act (Act).

Issuance of an ITP is a federal action subject to a review by the Service in compliance with the National Environmental Policy Act (NEPA), which may involve preparation and further documentation of overall environmental consequences in an Environmental Assessment or Environmental Impact Statement. The District HCP focuses exclusively on the biological and ecological effects and consequences of certain District actions as they relate specifically to the Covered Species. A separate NEPA document presents the Service’s analysis of the direct, indirect, and cumulative impacts of issuing the requested ITP on all of the natural and the man-made environments.

The District HCP is a public document under the Texas Public Information Act. It is the District’s intent that this document provides such additional context and information, beyond that required by the Service, to be comprehensible and useful to the District’s stakeholders, including District permittees and the state, regional, and local entities affecting and affected by the HCP. However, an HCP is essentially a proposal to the Service that informs a Service-internal consultation process specifically designed to form a Biological Opinion on the likely effects and consequential impacts on the Covered Species, which then becomes the basis for decision-making on issuance of an ITP. As such, its format, content, and level of detail are largely prescribed by Service regulations, policy, and guidance.

The District's statutory mandate is to provide for the conservation, preservation, and protection of groundwater resources of all aquifers in its jurisdictional area, including portions of northwestern Caldwell, northeastern Hays, and southeastern Travis Counties corresponding to the extent of use of the Barton Springs segment of the Edwards Aquifer, sometimes called the Barton Springs aquifer (hereinafter, the Aquifer, unless the narrative's context requires additional specificity). This mandate is entirely consistent with the HCP, and the same measures that benefit the Aquifer's human users, by extending the water supply during drought, also benefit the Covered Species that depend on the Aquifer as habitat. The purpose of the District HCP is to meet the requirements of applying for and receiving an ITP to be compliant with the Act. Not only are the Covered Species conserved, but also the District and its regulated community are benefited by having such a permit, to comply with Federal statute, regulation, and policy in carrying out otherwise lawful activities as authorized by the State of Texas and that may result in incidental take of the Covered Species.

The District's activities described by this HCP are consistent with current statutory authorities of the District and are based on sound science and effective groundwater management practices. They have been formulated and framed in collaboration with other conservation efforts affecting the Covered Species and/or their habitat, especially the HCP for the Barton Springs Pool operations and management developed by the City of Austin, and certain aspects of the Edwards Aquifer Recovery Implementation Plan/HCP for the use and management of the neighboring San Antonio segment of the Edwards Aquifer.

The biological goals and objectives of the District's conservation program are presented in Section 6.1 of this HCP document. Other District goals and objectives are characterized in the current Texas Water Development Board-approved District Management Plan (BSEACD, 2013) and are complementary to and consistent with the goals and objectives described in this HCP.

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2.0 Purpose and Need for ITP/HCP

2.1 Purpose

As described above, the District's statutory mandate is to provide for the conservation, preservation, and protection of groundwater resources of all aquifer systems in its jurisdictional area, including the Aquifer. Certain activities associated with that mission may produce both beneficial and adverse effects on springflow quantity and water chemistry that in turn impact the habitats of the Covered Species. In particular, the District's drought management program both allows and restricts the amount of groundwater withdrawn from the Aquifer by certain well owners. Nevertheless, the federal Endangered Species Act (Act) prohibits take of its listed species except as prescribed in the Act. The purpose of the District Habitat Conservation Plan (HCP) is to meet the requirements of applying for and receiving an Incidental Take Permit (ITP) under the Act (see Section 2.2.2 below) so the District, on a federally authorized exception basis, may continue to carry out its otherwise lawful activities as authorized by the State of Texas that may unavoidably result from time to time in incidental take of the Covered Species.[1]

2.2 Need for the HCP

2.2.1 Programmatic Basis of Need

The District's activities that create the need for an ITP relate to the following groundwater management functions that are explicated in the District Management Plan (District, 2013):

- Adopt, implement, and enforce regulations and management programs that protect existing groundwater supplies, improve aquifer demand management, provide Aquifer and springflow protection during droughts, promote and improve aquifer recharge, and carry out other beneficial management strategies; and

- Avoid, or minimize, and mitigate negative impacts upon federally listed species dependent upon springflow from Barton Springs through adoption and implementation of regulations, management programs, scientific research programs, conservation education programs, and collaborative efforts with other governmental entities.

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[1] [1] The Covered Species may also be stressed by the introduction of pollutants that also affect the quality of the water recharging the Aquifer. Unlike the natural water chemistry changes, these water quality impacts are generally caused by human activities on the land surface that result in pollution from point sources and especially non-point sources. In this document, these are referred to as "water quality" impacts, to distinguish them from the "water chemistry" impacts. The water quality impacts of these actions, over which the District has no control and therefore are not Covered Activities, are cumulative with the natural changes in water chemistry associated with lower springflows, and both are generally antagonistic to aquatic life requirements.

These activities directly and indirectly affect the amount of pumping of the Aquifer and its water-level elevations and consequently the amount of discharge at Barton Springs, as a result of the hydrology of the groundwater system. There is a well-established relationship, within the observed data range available, between the amount of water issuing from the outlets of Barton Springs and the chemistry of that water. As flow decreases, the dissolved oxygen concentration of the water, which is required by the Covered Species for survival, decreases and the concentration of dissolved solids increases. This natural variation in water chemistry derives from the physical system of the Aquifer, and it occurs regardless of whether springflow decreases are due to drought, or to water withdrawals by wells in the Aquifer, or both (most recently, Mahler and Bourgeais, 2013).

During normal and high flow conditions in the Aquifer, the discharges at its natural outlets at Barton Springs are many multiples of the aggregated amount of water that is being withdrawn by wells in the Aquifer. Under these conditions, the District's program elements principally address the long-term sustainability of the Aquifer as a water supply. During these times the pumpage of the Aquifer and the District's regulatory program have essentially no effect on the chemistry of the springflow, so there is essentially no incidental take ascribable to the Covered Activities when the water levels in the Aquifer are above a certain elevation, which determines the amount of discharge of the groundwater at the Aquifer's major outlet, Barton Springs. This threshold elevation and springflow are characterized in Section 3.2.2.1 below.

But during drought, and especially prolonged severe drought (including "Extreme Drought" as defined by the District[2]), the amount of water naturally discharging from the springs is much smaller, similar in magnitude to the amount of water withdrawn from wells. During these drought conditions, the District's groundwater drought management program is key to preserving water levels in the Aquifer and spring flows. The District is mandated by state water planning regulations to utilize a recurrence of the drought of record in the 1950s (DOR) as the planning horizon in its drought management program. The District's integrated regulatory program is designed to protect the water supply of those Aquifer's users who are most vulnerable to supply interruption during those Extreme Drought times and to conserve the flows at Barton Springs for both ecological and recreational purposes. It is during certain of these drought periods that the groundwater levels and springflows unavoidably decline sufficiently to create incidental take of the Covered Species, which creates the programmatic need for the HCP and the ITP. The circumstances that give rise to such incidental take are discussed in more detail in Sections 5.2.2 and 5.2.3.

Demand for and pumping of groundwater for beneficial public water supply and other uses has increased substantially in recent decades (see Figure 3-4), exacerbating the need for programmatic action. The cumulative rate of pumpage of all operating wells in the Aquifer can now have significant impacts on springflow during low flow (severe drought) conditions,

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[2] "Extreme drought" is a term used herein to refer specifically to droughts that are more severe than Stage III-Critical Drought, and are declared by the District Board when springflow at Barton Springs is less than 14 cfs, or water level in the Lovelady monitor well is below 457.1 feet (msl) elevation. The more general term "severe drought" is used herein to refer qualitatively to conditions that represent those groundwater drought conditions in the District that range from prolonged Stage II-Alarm through Stage IV-Exceptional droughts.

even to increase the likelihood of low flow conditions, and concomitantly on habitat-significant water chemistry during low flow, as will be characterized in the following sections of this HCP. The combination of permitted and non-permitted operating wells reached an all-time monthly peak of approximately 13.6 cfs (3.21 billion gallons per year) for the month of June 2008 (BSEACD, unpublished data, 2013).

Since that time, despite increased demand for water supplies in the District, pumpage rates of the Aquifer have generally been lower as a result of groundwater management policies and regulations of the District and of responses by its permittees to projected shortfalls during severe droughts. As the demand for groundwater has increased, the District has gradually changed its drought management and regulatory program to improve the effectiveness of Aquifer and springflow protection, supported in no small part by the studies and planning for the ongoing HCP development. The average monthly pumpage for the three years 2007-2009 was 8.2 cfs, which also included a regulated drought period in 2008-09 with mandatory pumpage reductions of 20 and 30% during District-declared Stage II-Alarm and Stage III-Critical drought, respectively (BSEACD, 2010). The pumping rates were once predicted to increase steadily with urban development over the Aquifer and reach as high as 19.6 cfs by the year 2050 (Scanlon et al., 2001). However, owing to the implementation of conservation plans, demand-management programs, and imposition of extreme drought withdrawal limitations by the District, as described in detail in Section 6.2 of this HCP, the estimated pumpage maxima over the long-term are now considerably lower, no more than 25% of that projected amount of pumping.

The HCP specifies the District commitments to a set of conservation (avoidance, minimization, and mitigation) measures that are consistent with statutory authorities of the District and that are based on sound science and effective groundwater management practices. The District HCP has been formulated and framed in collaboration with other conservation efforts affecting the Covered Species and their respective habitats, viz., the habitat conservation plan of the City of Austin for operation and maintenance at Barton Springs Pool and environs. The well owners and users, especially the District's permittees, who are described in Section 4.1.1, and all those citizens who consider Barton Springs as an ecological, recreational, and aesthetic resource are the key additional stakeholders for this HCP.

Every approved HCP is based on achieving a set of biological goals and objectives as the ITP holder pursues its programmatic activities. The biological goals and specific objectives of the District HCP are presented in Chapter 6, along with specific protective conservation measures.

2.2.2 Statutory Basis of Need: the Endangered Species Act

The Act, at 50 CFR § 17.3 is the relevant federal statute that protects and promotes the recovery of endangered and threatened species. Section 9 of the Act (16 USC 1538(a)) prohibits "take" of any federally endangered wildlife. Take is defined as an action that may harm, harass, pursue, shoot, wound, hunt, kill, trap, capture, or collect members of any threatened or endangered species. Section 10(a)(1)(B) of the Act of 1973 (16 USC

1539(a)(1)(B)) authorizes the Service to issue a permit (or ITP), allowing on an exception basis the take of protected species that is incidental to, and not the purpose of, the carrying out of otherwise lawfully conducted activities (Covered Activities). The District is an applicant for an ITP. For the issuance of an ITP, the applicant must submit a conservation plan that satisfies the requirements of Section 10(a)(2)(A) of the Act. The required elements of an HCP and ITP under the Act are identified in Section 2.3 below.

Section 10(a)(2)(B)(ii) of the Act allows non-federal entities to conduct otherwise lawful activities likely to cause take of endangered species, as long as the detrimental effects of the activities are not purposeful and are minimized and mitigated to the maximum extent practicable, and further provided that the Service determines that jeopardy of the Covered Species' populations related to the Covered Activities is avoided. HCPs are the vehicles by which such take can be authorized, provided that it will be minimized and mitigated by the District to the maximum extent practicable. This HCP is expressly designed to fulfill those obligations of the District.

2.3 Correspondence between HCP Sections and Information Required by the Service

The location of the information required or pertinent for an HCP to comply with Service regulations and guidance is tabulated in the following subsections. This correlation is provided to assist not only the Service but also and especially the District's stakeholders and the public in finding and reviewing information that correlates the District's groundwater management programs to the required conservation plan elements.

2.3.1 Information Requirements of an HCP in Support of an ITP

Service Requirement (16 USC § 1539(a)(2)(A)(i)-(iv)	HCP Report Section(s)
1. The impact that will likely result from the taking;	5.2; 5.3
2a. Steps the applicant will take to monitor, minimize, and mitigate such impacts,	6.0; 6.1; 6.2; 6.3; 6.4; 6.5.1; 7.1; 7.2.2
2b. The funding available to implement the steps, and	8.0
2c. The procedures to be used to deal with unforeseen circumstances;	7.3
3. Alternative actions to the proposed taking considered by the applicant and the reasons why such alternatives are not proposed to be used; and	9.0; 9.1; 9.2
4. Other measures that may be required or appropriate for the purposes of the plan.	None yet identified, but see 6.4; 6.5.1.3; 7.1

2.3.2 Findings for the Service to Issue an ITP

Service Requirement (16 USC § 10(a)(2)(B)	HCP Report Section(s)
1. The taking will be incidental;	1.0; 2.1; 4.1
2. The applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such taking;	6.0-6.4; 7.0-73; 9.2
3a. The applicant will ensure that adequate funding of the conservation plan [will be provided], and	8.0
3b. [The applicant will ensure that] procedures to deal with unforeseen circumstances will be provided;	7.2, 7.3
4. The taking will not appreciably reduce the likelihood of survival and recovery of the species in the wild; and	5.1.3;.5.1.4; 5.2; 5.3
5. The applicant will ensure that other measures as may be required by Service as necessary or appropriate for purposes of the HCP will be implemented.	1.0; 4.1.2.1; 4.1.3; 6.1; 6.3; 6.4; 6.5.1; 7.0-7.3; 8.0

2.3.3 Additional Guidance and Recommendations for Developing HCPs (the "Five Point Policy")

HCP Handbook Addendum (65 FR 32,250-32,256)	HCP Report Section(s)
1. Defined conservation goals and objectives;	1.0; 6.1; 6.2
2. An adaptive management strategy;	6.4; 6.5.1.2; 6.5.1.3; 7.2; 7.3
3. Compliance and effectiveness monitoring;	6.3; 6.3.1- 6.3.4
4. An established permit duration; and	4.2
5. Opportunities for public participation.	4.1.3; 4.1.4

3.0 Description of Areas to Be Analyzed

The geographic area of this Habitat Conservation Plan (HCP) is in central Texas, straddling the Balcones Escarpment at the margin of the Edwards Plateau, with the Blackland Prairie physiographic province on the east and the Texas Hill Country of the Edwards Plateau province on the west. It is an area that is rich in the amount and variety of its natural and human resources but it is undergoing rapid suburbanization associated with burgeoning growth of the Austin-San Marcos metropolitan area, with both land use and cultural aspects converting from dominantly rural to dominantly suburban/commercial character (BSEACD, 2013).

Two areas are described in more detail in this part of the HCP. The first is the larger "Planning Area," which includes the entire area that either affects or is affected by the HCP and in which mitigation measures could take place. The second area is the "Incidental Take Permit Area," or ITP Area, which is the area in which the Covered Activities of the District and any resulting incidental take of Covered Species occur.

3.1 Planning Area

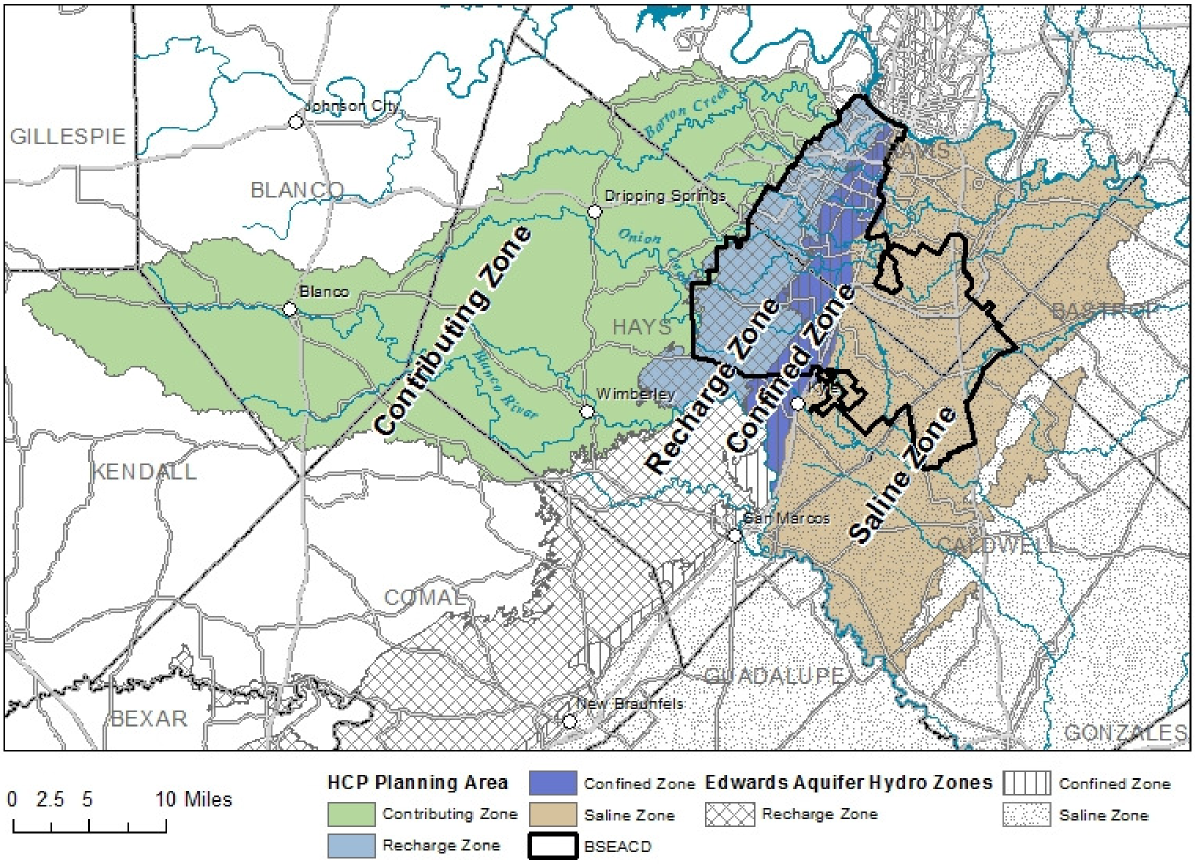
The HCP "Planning Area" is depicted in Figure 3-1. It encompasses not only the jurisdictional area of the District, which includes the Barton Springs complex as well as the geographic area where all wells in the Aquifer are located, but also those areas outside the District that affect the Aquifer's resources, including areas that contribute recharge to the Aquifer and areas that utilize the Aquifer as a water supply. This area is characterized in more detail in the subsections below.

3.1.1 General Environmental Setting of Planning Area

The environmental setting of much of the Planning Area has been described in considerable detail in the recent Barton Springs Pool HCP that addresses the same Covered Species, and those descriptions are incorporated herein by reference (City of Austin, 2013); it may be accessed online at: http://www.austintexas.gov/watershed_protection/publications/document.cfm?id=203078. This section of the HCP is largely based on those descriptions, and highlights those aspects of the environmental setting that are salient with respect to the District's Covered Activities, the Covered Species, and this HCP.

3.1.1.1 Physical Environment

The Planning Area is in the southern extension of the North American Great Plains, at the eastern edge of the large Edwards Plateau region in central Texas. The Balcones Fault Zone is the boundary between the Edwards Plateau to the north and west and the Gulf Coastal Plain to the east and south. A number of large karstic springs, including Barton Springs, are



Basemap: Contributing Zone compiled from Onion Creek, Barton Creek, and Blanco River watersheds;
Recharge Zone extracted from TCEQ Edwards Aquifer Administrative Boundary dataset;
Confined Zone modified from TWDB Major Aquifers, Edwards Aquifer subcrop dataset;
Saline Zone extended from Edwards Aquifer subcrop eastern boundary.
Robin Gary, BSEACD, October 2013.

Figure 3-1. The Planning Area of the District HCP. The District's jurisdictional area, outlined in black, is a small part of the Planning Area but forms the entirety of the ITP Area.

located at the land surface along the fault zone, where more permeable, older limestone strata are juxtaposed against less permeable younger strata. Barton Springs, located along a major tributary (Barton Creek) just upstream of the Colorado River, is the lowest in elevation of these springs, and it and the Colorado River form the regional discharge boundary location for deep, fresh groundwater that is not discharged at other, higher-elevation springs.

The climate of the Planning Area is classified as subtropical humid, with mild winters and hot summers, although during periods of years it may be more accurately considered semi-arid, especially in the western portions in the Hill Country. Heavy rainfall can occur in any month, but generally the winter months are drier and, at least statistically, the early and late summer months are wetter than average. But rainfall and runoff are highly variable in time and space. The concept of "average rainfall" is rather misleading when considered in a predictive sense at any one location, but there is a significant gradient from northeast to southwest across the Planning Area toward smaller rainfall amounts and higher evapotranspiration. Generally, annual evaporation rates exceed annual rainfall rates considerably, often by a factor of two or more; the long-term average factor is about 1.6. Antecedent soil-moisture conditions are deterministic of whether and how much rainfall of a given duration is required to produce runoff to the local streams.

The entire area is prone to drought, which may be severe and persist for months to many years. Virtually every decade has had one or more significant drought periods that has lasted for a substantial part of a year or more. The most extreme drought in recorded history in this area was the drought from 1950-1956, which is designated for water planning purposes as the DOR; during that drought, Barton Springs had its lowest recorded daily flow, 9.6 cfs, and its lowest monthly flow, 11 cfs. (Variations in springflows at Barton Springs are characterized more completely in Section 3.2.2.1.2 below.) Conversely, the area's small streams from time to time are also subject to short-term, sometimes extreme flooding associated with tropical moisture systems moving inland and meeting the Balcones Escarpment and/or cold air masses, producing flooding rainfall intensities in the Planning Area. Floods may actually occur in the midst of a drought period and the rainfalls that created the floods may or may not relieve the droughts, depending on their location and persistence. During the decade that is designated by the Texas Water Development Board (TWDB) as the DOR for this region, there were significant periods of time when streamflows and springflows were near average, at least for a while.

It has been widely recognized that these variations play an integral role in the natural resilience and ecological health of the hydrologic systems of creeks, rivers, and streams and their resident flora and fauna (Service, 2013b; Poff and Ward, 1989; Resh et al., 1988).

The Planning Area is drained by two major Texas river systems, with the Colorado River system tributaries in the northern part and the Guadalupe-Blanco River system tributaries (including the upper part of the main stem of the Blanco) in the southern part of the area. All of the surface streams except the main river stems are non-perennial, although most have base flows that are supported by shallow groundwater contributions during non-drought and non-severe drought periods. Only the primary river systems have large enough catchment areas to support reservoirs for water supply and/or downstream areas that justify flood-control impoundments. Areas distant from the rivers' main stems are typically dependent on wells and groundwater for reliable and economic water supplies; these include the more rural parts of the Planning Area.

The near-surface hydrogeology of the Planning Area is dominated by the karst aquifers associated with the Balcones Fault Zone. The aquifer systems of this zone are central to the need for and development of the HCP, so they are described in much more detail in Section 3.1.2 below.

3.1.1.2 Biological Environment

The Planning Area includes portions of two terrestrial biogeographically-defined ecoregions, with the dissected margin of the Edwards Plateau ecoregion to the west and the southern portion of the Texas Blackland Prairie ecoregion on the east (Texas Parks and Wildlife Department (TPWD), 2012). The rolling topographic aspect, with level to more gently rolling plains in the east and more steeply sloping and dissected uplands in the west, combine with the climate gradients from east to west and the different geological substrates on either side of the Balcones Fault Zone to have produced a variety of soil types with different depths and textures, which in turn support diverse vegetation and wildlife.

The Blackland Prairie is a true prairie grassland community which is dominated by a diverse assortment of perennial and annual grasses. Its dark soil is considered some of the richest soil in the world and supports an active agricultural community, especially to the north of the Planning Area. This ecoregion is predominately comprised of live oak and Ashe juniper, with increasing amounts of post oak, blackjack oak, American elm, winged elm, cedar elm, sugarberry, green ash, osage-orange, honey mesquite, and eastern red cedar in the more northeastern parts of the Planning Area. Pecan, black walnut, black willow, American sycamore, honey locust and bur oak are commonly found in bottomland woodlands throughout this region (Texas Forest Service, 2008).

Common vegetation in the Planning Area includes (TPWD, 2013):

Switchgrass
Bluestem grass
Grama grass
Indiangrass
Wild rye
Curly mesquite
Buffalograss
Live oak
Shinnery oak
Ashe juniper
Mesquite
Bald cypress
Pecan
Possumhaw
Smartweed
Sugarberry
Boxelder
Buttonbush
Black willow
Marsh purslane
Water pennywort
Cattail

Common wildlife in the Planning Area includes (TPWD, 2013):

Muskrat
White-tailed deer
Rio Grande turkey
Raccoon
Javelina
Brazilian freetail bat
Ringtail
Nine-banded armadillo
Tarantula
Northern mockingbird
Guadalupe bass
Salamander
Cricket frog
Gulf Coast toads
Grebes
Blue herons
Green-backed heron
Kingfishers

Both of the ecoregions are undergoing change as the area is increasingly populated by humans. In some areas closer to the urban areas, suburbanization is replacing natural vegetation with turf grasses, non-native plants, and impervious cover, and displacing native wildlife. But perhaps the most pervasive and ecologically significant long-term change for the remainder of the Planning Area is the purposeful suppression of wildfire. As noted in the City of Austin's HCP (City of Austin, 2013):

> The natural vegetation of the Edwards Plateau uplands is characterized by oak savannas and grassy terrains, bisected by canyons and riparian areas with thick forest vegetation and a great diversity of trees and shrubs. The Blackland Prairie was dominated by tall-grass prairie and deciduous bottomland forest. The savanna and prairie ecosystems were maintained by fires and grazing bison. With the suppression of fire [as the area has developed], the openness once characterizing portions of these regions has been severely reduced. This allowed the encroachment and increase in abundance of species once controlled by fire, such as Ashe Juniper (*Juniperus ashei*). Natural savanna and tall-grass prairie are absent in much of both ecoregions today.

The karst springs along the margins of the Edwards Plateau have their own micro-ecological character. The smaller, headwater seeps and springs tend to have shallow water, high canopy cover, fast current, and low nutrient content (City of Austin, 2013; Mabe, 2007), which factors likely underlie naturally low abundance and diversity of aquatic macrophytes and macroalgae. The City of Austin notes that larger springs located within wider, higher order streams, such as the stretch of Barton Creek that contains outlets of Barton Springs, likely had a greater abundance of aquatic macrophytes than headwater springs because the canopy cover is less, current is slower, and nutrient load is greater (City of Austin, 2013).

The fauna within the Planning Area are mostly transitional, with substantially more diversity north of the Colorado River as the river is the southern boundary for many species (Abell et al., 1999). While this ecoregion is home to over 100 fish species, few of them are endemic (found only in a specific location); in contrast, many endemic karst aquatic fauna are found in spring-fed streams of the Edwards Plateau.

More information on the vegetation and fauna that are specifically associated with the Barton Springs complex itself is included in Section 3.2.2.2 below.

A summary listing of those plant and animal species that the TPWD considers to be in greatest need of conservation is found in Appendix A, with separate tables for the Edwards Plateau and Texas Blackland Prairies ecoregions. Federally protected species of potential interest specifically to this HCP are also identified and discussed as to their relationship to the proposed Covered Activities in Section 3.2.4 below.

3.1.1.3 Man-made Environment

As previously noted, the Planning Area is on the suburban fringes of the Austin-San Marcos

Metropolitan Statistical Area, including the City of Austin, the City of Buda, the City of Kyle, and the City of San Marcos, all of which are undergoing rapid growth that extends into the Planning Area. The current population of this area has been estimated by the District, on the basis of geospatial analysis of the latest census data, to be about 583,000, and it is expected to increase to more than 800,000 during the proposed 20-year term of the ITP, using rather conservative growth-rate projections in the ongoing regional water resource planning by the TWDB:

Planning Horizon	**Population in HCP Planning Area**
2010 Census	525,000
2015 (Start of ITP)	583,000
2035 (End of ITP)	803,000
2040	855,000

The City of Austin has indicated that much of the population increase in the Colorado River basin portion of the Planning Area will occur in the Barton and Williamson Creek watersheds (City of Austin, 2013). Growth associated with the Cities of Kyle and San Marcos in the Planning Area will largely be in the Plum Creek and Blanco River watersheds of the Guadalupe-Blanco River basin. The more western and eastern portions of the Planning Area will continue to be mostly rural, although some areas near transportation corridors and exurban communities will increasingly become rural residential and commercial.

Much of the firm-yield water supply throughout the Planning Area is fully subscribed, including supplies of groundwater from the Aquifer. Public water supply (PWS) systems are now actively pursuing alternative surface-water and groundwater supplies from outside the Planning Area to serve their projected growth. Consequently, the number of people who are now provided groundwater from the Aquifer is not expected to increase significantly from the current 70,000 estimate; in fact it may decrease as smaller PWS systems using the Aquifer are subsumed by and become part of larger PWS systems on alternative supplies.

The population growth that takes place in the areas that are outside of the various municipal limits will create wastewater treatment and disposal challenges that may have an adverse effect on water quality. Increasing use of centralized wastewater treatment systems that directly discharge even highly treated wastewater into the small streams that are upstream of the recharge zone is not unlikely, along with continued proliferation elsewhere of land application systems and septic tanks that also have a potential for surface- and groundwater quality degradation if not adequately sited, designed, and/or maintained.

3.1.2 Hydrogeologic Framework of Planning Area

An understanding of the hydrogeologic and hydrologic framework underpins the District HCP. The detail provided in this subsection of the HCP is required to establish and monitor effectiveness of suitable conservation measures for the Covered Species. Even more detailed information is provided in the City of Austin's HCP (2013).

The only known habitats for the Covered Species are the four spring outlets[1] (Main Springs [Parthenia Spring], Eliza (Concession) Spring, Old Mill [Sunken Garden, or Zenobia] Spring, and Upper Barton Spring); their associated surface spring runs; and subterranean areas of the Barton Springs complex (see Figure 3-4 in Section 3.2.2.1, below). These outlets are the primary points of freshwater discharge from the Aquifer. So water passing into, and through, Barton Springs comes primarily from the Aquifer, although also occasionally from a flooding Barton Creek.

The Aquifer is a karst aquifer, characterized by features such as caves, sinkholes, sinking streams (streams that lose water to an aquifer), springs, and other karst conduits that have been enlarged by dissolution of the host carbonate rock (Woodruff and Abbott, 1979). This Aquifer also is located in an area with extensive, complex faulting and fracturing, which provide the potential for additional hydrologic interconnections.

3.1.2.1 Aquifers and Hydrozone Boundaries

At the regional level, the Edwards Aquifer has three segments, commonly referred to as the Southern (or San Antonio) segment, the Barton Springs segment, and the Northern segment, which are separated by hydrologic and geologic divides (as shown in Figure 3-2 in Section 3.1.2.2 below). The freshwater portion of the Barton Springs segment that contributes solely to the habitat for the Covered Species covers about 170 square miles (440 square km) (Slade et al., 1986). The hydrologic region that influences the Aquifer and therefore the District HCP, as shown in Figure 3-1, includes the Aquifer's Contributing Zone (green shaded area), Recharge Zone (light blue shaded area), Confined Zone (dark blue shaded area), and Saline Water Zone (tan shaded area) in Central Texas. Most of the HCP Planning Area is located in northern Hays and southern Travis Counties. Smaller portions of the Planning Area extend into Bastrop, Blanco, Caldwell, Comal, and Kendall Counties.

The freshwater portion of the Barton Springs segment consists of two major zones: (1) the Recharge Zone, where the Edwards Group crops out (is present at the land surface) and which is a hydrologically unconfined area (light blue shaded area in Figure 3-1); and (2) the Confined Zone, where the Edwards subcrops (is present only below other rock units) and which is generally a hydrologically confined area (the darker blue shaded area in Figure 3-1). Each of these are characterized below.

The Recharge Zone as defined herein covers about 107 square miles (277 square km) of the Planning Area. Recharge is the process by which water enters and replenishes an aquifer. The majority of recharge to the Aquifer is derived from streams originating on the contributing zone, located up gradient and generally west of the recharge zone. Water

---

[1] Throughout this HCP, the District designates the specific outlets of the Barton Springs complex by the following names: Main Springs (which actually refers to closely associated multiple sub-outlets within Barton Springs Pool), Eliza Spring, Old Mill Spring, and Upper Barton Spring. All of these have alternative names, shown here in parentheses, which are variably used by various other entities. There is no standard usage.

flowing onto the recharge zone sinks into numerous caves, sinkholes, and fractures along numerous (ephemeral to intermittent) losing streams. For the Barton Springs segment, Slade et al. (1986) estimated that as much as 85% of recharge to the aquifer is from water flowing in these streams. The remaining recharge (15%) occurs as infiltration through soils or direct flow into discrete recharge features in the upland areas of the recharge zone (Slade et al., 1986). However, a more recent study by Hauwert (2009) indicates that upland recharge may constitute a larger fraction of recharge than stated in the Slade et al. (1986) study. Both studies recognize that a significant amount of recharge to the Edwards Aquifer is from flow in the creeks that cross the recharge zone. (Also see discussion in Section 3.1.2 below for other potential recharge sources during certain hydrologic conditions.)

Mean surface recharge to the Barton Springs segment of the Edwards Aquifer should approximately equal mean discharge, or about 53 cubic feet per second (cfs) (1.5 m^3/s); however, maximum recharge rates during flooding may approach 400 cfs (11 m^3/s) (Slade et al., 1986). Studies have shown that recharge is highly variable in space and time and focused within discrete features (Smith et al., 2001). For example, Onion Creek is the largest contributor of recharge to the Barton Springs segment (34% of total creek recharge) with maximum recharge rates up to 160 cfs (4.5 m^3/s) (Slade et al., 1986). Antioch Cave, which is located within the Onion Creek channel, is the largest-capacity discrete recharge feature known in the Barton Springs segment, with an average recharge of 46 cfs (1.3 m^3/s) and a maximum of 95 cfs (2.7 m^3/s) during a 100-day study (Fieseler, 1998). A more recent study (Smith et al., 2011) estimates that Antioch Cave is capable of recharging up to 100 cfs (2.8 m^3/s) and that the recharge portion of Onion Creek upstream of Antioch Cave is capable of recharging about 100 cfs (2.8 m^3/s). The District has constructed a recharge enhancement facility at Antioch Cave to preserve and increase the amount of recharge to the Aquifer derived from this discrete feature.

Protection and conservation of storm runoff and streamflow in the watersheds of these creeks are important to maintaining the water quality and chemistry of the habitat at Barton Springs (Service 2005). The recharge zone has numerous wells, many of them low-capacity individual household supply (domestic use) wells and also a few large-capacity wells, especially where the saturated thickness of the Aquifer is larger and is able to supply larger amounts of water without being overly susceptible to drought impacts.

The Confined Zone (down gradient from the recharge zone in the eastern portion of the Aquifer but up gradient from the saline zone of the Edwards) generally has a full or nearly full saturated thickness; this 63-square mile (163-square km) area is where most of the groundwater production from the Aquifer's wells occurs. It includes both an artesian zone, which is an area farther from the recharge zone that is always confined and under artesian pressure, and an intermediate transitional area closer to the recharge zone that varies between being hydrologically unconfined and confined, depending on the water levels in the Aquifer. Some areas immediately east of the recharge zone are unsaturated to variable depths below the overlying low-permeability units. In the Confined Zone, dipping and faulted impermeable layers of clay and other less permeable rocks overlie the Aquifer; as its groundwater moves deeper, away from the recharge areas, the Aquifer eventually becomes fully saturated and hydraulically confined and then subject to higher than atmospheric pressure, i.e., artesian conditions. Because much of the water moving through the Aquifer is pressurized in dissolution cavities and conduits that transport water from higher elevations, the transitional and recharge zones of the Aquifer near springs exhibit both water-table and artesian characteristics, depending on water levels in the Aquifer (Wong et al., 2012). Accordingly the Barton Springs complex could be considered a hybrid (gravity and artesian) spring complex.

Upstream from the Aquifer is the Contributing Zone, which contributes surface runoff and base flow of streams to the Aquifer but is not considered a part of the Aquifer itself (see green shaded area in Figure 3-1). What has been historically designated as the Contributing Zone of the Aquifer during all hydrologic conditions encompasses the upper watersheds of the six major creeks that cross the recharge zone. However, this definition excludes the upper Blanco River watershed that recent studies (Smith, et al., 2012) have shown to be a contributor of recharge to the Aquifer during drought conditions. Although the six creeks in this area are the source for most of the water that will enter the aquifer as recharge (see discussion in Section 3.1.2 below), the Blanco River is an important contributor during drought conditions. The extended contributing zone spans about 665 square miles (1722 square km) of the Planning Area and includes portions of Travis, Hays, Blanco, Kendall, and Comal counties. The recharge and contributing zones together make up the total area that provides meteoric water (water that is derived from relatively recent precipitation on the land surface) to the Aquifer, and is about 772 square miles (1999 square km) in areal extent (Robin Gary, BSEACD, personal communication in September 2013).

The eastern boundary of the Aquifer is the interface between the fresh-water zone and the saline-water or “bad-water” zone of the aquifer, characterized by a sharp increase in dissolved constituents (more than 1,000 mg/L total dissolved solids, or TDS) and a decrease in permeability (Flores, 1990). The Edwards saline zone, shown in the light tan color in Figure 3-1, has groundwater that ranges from brackish (greater than 1,000 mg/L TDS) to saline (greater than 10,000 mg/L TDS). Smith (2011) provides the following description of the hydrogeology of the saline zone:

> Lithologies of Edwards units east of the saline/freshwater interface are similar to the lithologies to the west. All of these sediments were deposited on a broad, shallow, carbonate shelf. The main difference between Edwards units on either side of the saline/freshwater interface is the degree of dissolution of the rocks and the amount of void space created by dissolution. Flux of fresh water has been high in the portion of the aquifer between the recharge zone and Barton Springs. This flow of slightly acidic water has dissolved a considerable amount of limestone and dolomite along faults, fractures, bedding planes, and even within the matrix. Significant conduits have developed along some of these zones that facilitate flow of even greater quantities of water. To the east of this zone of high flux, the amount of water flowing through the rock is less and therefore less dissolution takes place. However, there is some dissolution, but the minerals that are dissolved from the rock are not carried away from the zone of dissolution as quickly as the area to the west, and therefore

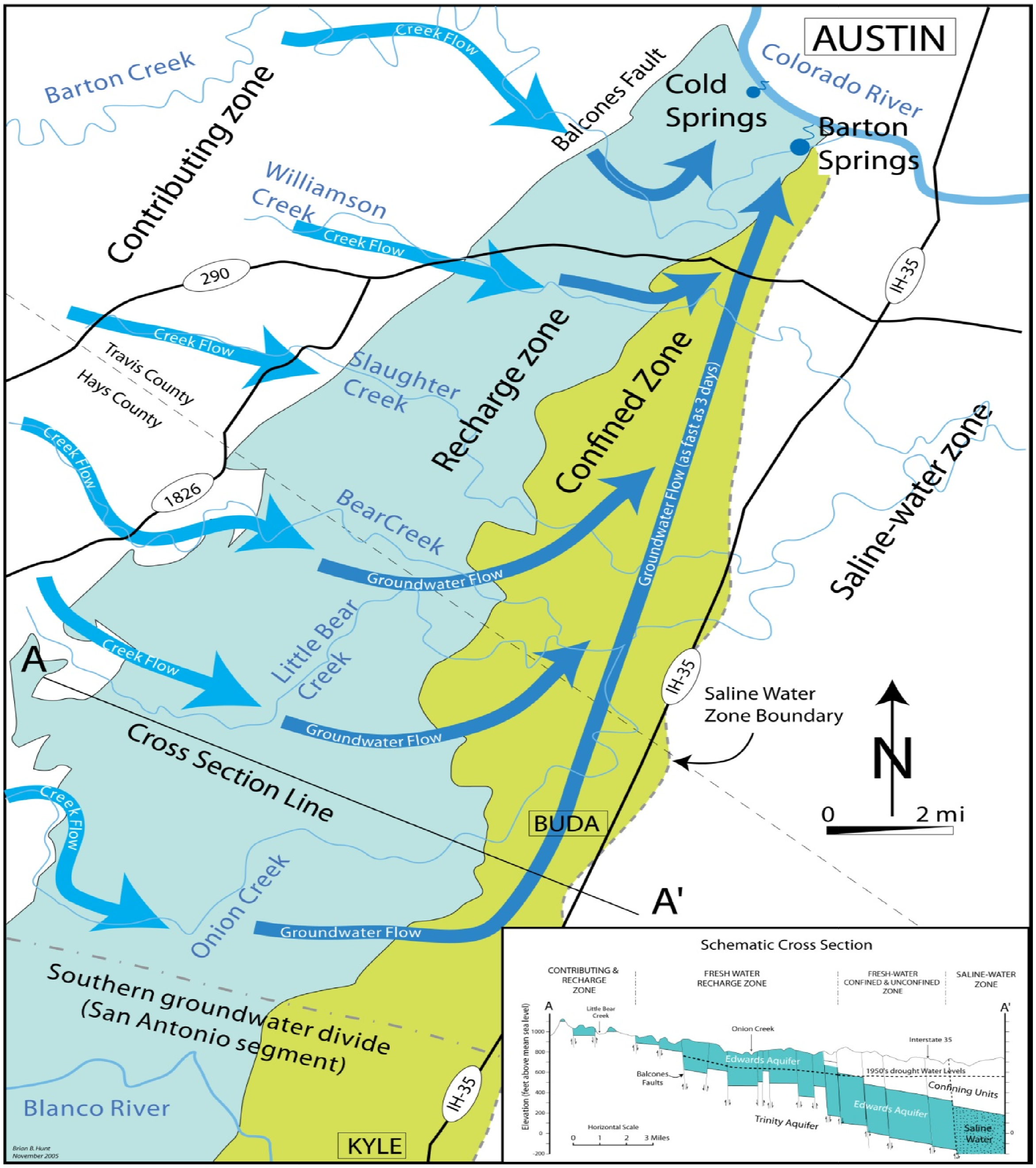
> concentrations of dissolved minerals increase and the water is then considered to be saline or brackish.
>
> Another factor that has contributed to the isolation of the saline zone from the freshwater zone is faulting that has offset similar units by tens to hundreds of feet, with the units on the eastern side of the faults mostly being down-dropped relative to the western side. The combination of horizontal separation from the main flow paths and vertical faulting has limited flow in the saline zone such that salinities increase to the east of the saline/freshwater interface.

The recharge zone and the confined freshwater and saline zones of the Aquifer overlie the Trinity Group, which includes clays, marls, and evaporites interbedded with the dominant limestone and dolostone. The Trinity is also a karst aquifer but with much more variable yield and water chemistry than the Edwards Aquifer, owing to its lithology. The Trinity Aquifer crops out across the entire contributing zone and provides base flow to the larger streams there that eventually recharge the Edwards. In addition, the uppermost part of the Trinity Aquifer and the Edwards Aquifer are in hydrologic communication (Wong et al., 2013), and in some places the Trinity probably contributes interformational flows to the Edwards and vice versa, depending on their respective water-level elevations. Recent studies (Wong et al., 2013; Smith and Hunt, 2011) have shown that the Edwards Aquifer is not in hydrologic communication with the deeper units of the Trinity Aquifer.

3.1.2.2 Groundwater Flow Conditions

In the recharge zone, meteoric water moves vertically from the land surface into the Aquifer through faults, fractures, and dissolution features in streambeds and less dominantly via soil infiltration in the karstic uplands. After reaching the water table, it then moves more laterally through the Aquifer via groundwater flow paths inside caverns, conduits, and other dissolution features that differ in size. Groundwater movement in the western part of the Aquifer shows flow generally to the east and then north (Figure 3-2). Groundwater levels throughout the Aquifer are highly interrelated and, in many areas, correlate well with springflow discharge rates at Barton Springs. Runoff flowing across the recharge zone and entering the Aquifer reaches the water table quickly. Groundwater flow velocities in the Aquifer are also very rapid. Groundwater-tracing studies have delineated several major groundwater flow routes and have been used to measure their groundwater velocities. The major flow routes transmit water derived from different contributing sources, including relatively new recharge, water moving into and out of storage, older recharge from areas distant to Barton Springs, and inter-formational flows of differing characteristics, including the saline part of the Edwards (Mahler and Bourgeais, 2013;Johns, 2006). The flow rates of groundwater along the dominant flow paths ranges from about 1 mile (1.6 km) per day under low groundwater flow conditions to about 5 miles (8 km) per day under moderate to high groundwater flow conditions (BSEACD 2003). The rapid hydrologic response of the Aquifer to precipitation and surface runoff emphasizes the importance of protecting the quality and quantity of water in each of the six major creeks in conserving the habitats of the Covered Species (Johns, 2006; Service, 2005; Hauwert et al., 2004).

Conceptual Hydrology:
Barton Springs segment of the Edwards Aquifer



Barton Springs/Edwards Aquifer Conservation District
1124 Regal Row, Austin, Texas 78748
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www.bseacd.org

Figure 3-2. Conceptual Hydrology of the Aquifer, showing groundwater flow paths and approximate location of the hydrologic divide with the San Antonio segment of the Edwards. This represents an 80 percent reduction from the long-term mean flow of 53 cfs (Source: Adapted by BSEACD from figure in Smith and Hunt, 2004).

The rate of discharge at Barton Springs[2] is directly dependent on the water level in the Aquifer. Under drought conditions, surface flow in the contributing-area creeks ceases, and the Aquifer water levels fall as water is discharged from the Aquifer through pumping and spring outlets. Many of the "over-flow" spring outlets, such as those in Upper Barton Springs, become dry for extended periods, and even the discharges from the main outlets of the Aquifer decrease. At lower water levels in the Aquifer, less groundwater flows solely (albeit rapidly) through large conduits.

In 2004, a first-ever rigorous assessment of the sustainable yield of the Aquifer was made by District hydrogeologists. This Sustainable Yield Study (Smith and Hunt, 2004, included herein as Appendix B) revealed that the then-authorized pumpage of the Aquifer, about 10.2 cfs, equivalent to 2.41 billion gallons per year, was essentially its sustainable yield, as that level of pumping during a recurrence of the DOR, *if un-curtailed*, would reduce the springflow at Barton Springs to less than 1 cfs and would cause some 19% of the wells in the shallower part of the Aquifer to experience substantial yield problems from declining water levels in wells. The Sustainable Yield Study was the impetus for rulemaking that established the District's Conditional-use (interruptible-supply) permitting program for Aquifer permits after September 2004. This study also demonstrated the one-to-one correspondence between changes in pumped volumes and changes in spring flow during extreme drought conditions (Hunt et al., 2011). Taken together, these findings ultimately formed the underpinnings of the groundwater availability modeling for establishing modeled available groundwater (MAG) amounts related to the adopted Extreme Drought Desired Future Condition of the Aquifer, which balances maintaining ecological habitat and well yields with being able to enforce as stringent curtailments as practicably possible.

Recent investigations have shown that the Blanco River immediately south of the District's jurisdictional boundaries may also provide recharge to the Aquifer during extremely low aquifer water-level conditions (Smith et al., 2012; Johnson et al., 2012). In addition, another recent study suggests that under low aquifer conditions, an unknown amount of regional underflow from the Southern segment "bypasses" San Marcos Springs, the usual resurgence for this segment, and enters the Barton Springs segment, some of which undoubtedly discharges at Barton Springs (Land et al., 2011). Because Barton Springs is at considerably lower elevation than the natural outlets of the Southern segment of the Edwards Aquifer, this bypass condition could occur even during exceptionally low water levels in the Southern segment. Taken together, these recent investigations suggest a hydrologic mechanism for extending the recession hydrograph at Barton Springs, which becomes very flat at extreme drought flows, thereby representing a benefit to the Covered Species at Barton Springs.

Periods of high and low water flow are a natural characteristic of the Barton Springs/Barton Creek ecosystem (City of Austin 2013, 2007a, 2007b, 2006, 1997). In the

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[2] Streamflow and springflow discharge rates are conventionally expressed as cubic feet per second, or "cfs." Groundwater use rates or overall production from an aquifer are usually expressed in acre-feet (AF) per time unit, typically per year. Groundwater production from individual wells is usually expressed in gallons per minute or thousand gallons per day. The District's permits are issued in terms of gallons per year. To facilitate comparisons of discharges from both wells and springs, the District uses "cfs" for both in this HCP. 1.00 cfs = 723 AF per year. 1000.0 AF per year = 325.9 million gallons per year = 892,700 gallons per day.

sediment and debris provided by shallower, free-flowing water from both the spring and the creek. For a given flow, shallower streams and creeks have greater flow velocities and consequently, stronger natural cleansing power. In addition, disturbance by episodic flooding is an important feature of streams and rivers (Gordon et al., 2004 and references therein; Poff and Ward, 1989; Resh et al., 1988) and was a natural characteristic of the Barton Springs complex prior to alteration by humans beginning in the late 1800s. The District has no authority or control over the hydrographic conditions and maintenance of the surface water systems that could affect the creeks and spring outlets.

Dye-tracing studies (BSEACD, 2003; Hauwert et al., 2004) and human-controlled pool-drawdown events have shown that the spring sites within Barton Springs are hydrologically related, particularly Main and Eliza Springs. This indicates that any factor that causes a change in water quantity at one spring site could also have the ability to affect water quantity at the other spring sites at Barton Springs (Service, 2005).

3.1.3 BSEACD Jurisdictional Area

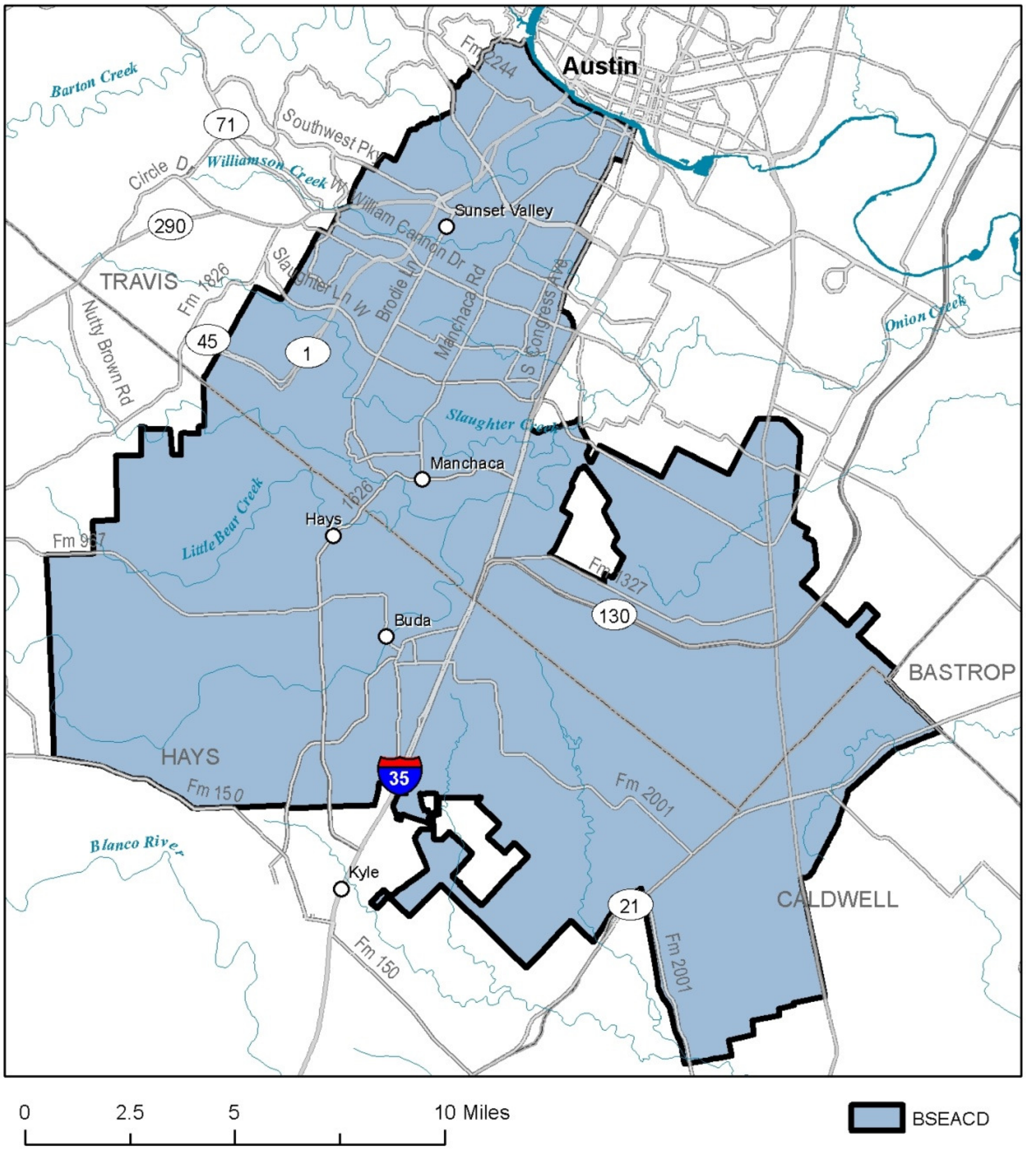
The District's jurisdictional area, bounded by the black lines in Figure 3-1 above, is shown in more detail on the map in Figure 3-3. This territory, which comprises about 255 square miles in northwestern Caldwell, northeastern Hays, and southeastern Travis Counties, is statutorily established and delineates the area where the District's rules and regulations are enforceable. The boundaries of this territory approximate the hydrogeologic boundaries of the Aquifer, as described above, along with certain boundaries of the service areas of several public water supply utilities when the District was formed in 1987.

Under its enabling legislation, the District's jurisdiction is defined by metes and bounds. On the west the boundary was drawn to approximate the location of the western edge of the Edwards Aquifer outcrop, and on the north by the Colorado River. The eastern boundary is generally formed by what were the easternmost service area limits, at the time the District was formed in 1987, of what are now the Creedmoor-Maha Water Supply Corporation, Monarch Utilities/SouthWest Water Company, and Goforth Special Utility District; changes made in those other entities' boundaries since then have not changed the District's boundaries, although in 2009 the District legislatively de-annexed the small portion of one of the utility's service area in Bastrop County, which is now outside the District. The District's southern boundary is generally established in alignment with the approximate average position of the groundwater divide or "hydrologic divide" between the Barton Springs and the San Antonio segments of the Edwards Aquifer (as shown in preceding Figure 3-2), and to the southeast along the southernmost service area boundaries of several water supply utilities, including Goforth (the District permittee with the largest authorized use, at 351 million gallons annually) and Monarch Utilities, another large Aquifer user.

It should be noted that the native groundwater (water that occurs naturally within an aquifer without influence from pumping or other anthropogenic activities) in the eastern part of the District's jurisdiction is brackish to saline, and freshwater supplies to this area are provided by Edwards wells west of Interstate Highway 35 and transported to these water utilities' customers by various water suppliers that are District permittees. (Other water sources also supply this area.) Also, a single well in the extreme southern part of the

District's jurisdiction is the most prolific well in the District, providing a large amount of water that is exported from the District to the City of Kyle, just outside the District's jurisdictional boundary. However, its well is within the District, and Kyle is one the District's largest permittees (350 million gallons per year).

The District regulates groundwater from all aquifers underlying its jurisdictional area. An increasing amount of groundwater from other aquifers, especially the underlying Middle and Lower Trinity Aquifers, is now being used in this area as an alternative supply to the Edwards and is also managed by the District.



Robin Gary, BSEACD, September 2013.

Figure 3-3 Barton Springs/Edwards Aquifer Conservation District Jurisdictional Area. The subsurface fresh-water environment in this area is the most extensive part of the ITP Area. Source: BSEACD (2013)**.**

3.2 Incidental Take Permit Area for the District HCP

The ITP Area includes both (a) subsurface areas within and throughout the District's jurisdictional area, and (b) the surface/subsurface areas in the immediate vicinity of the natural outlets of the Aquifer at Barton Springs. The ITP Area defines where the Covered Activities are authorized under the ITP and where conservation measures are to be deployed.

3.2.1 Subsurface Portion of the District's Jurisdictional Area

The subsurface, fresh water-bearing strata of the Edwards and Georgetown geologic formations that are within the District's jurisdictional boundary (outlined in black in Figure 3-1 and in Figure 3-3, above) are hydrogeologically and geographically the ITP Area. As described in Section 3.1 above, the area covers the hydrologically unconfined (recharge) zone, the hydrologically confined (transition and artesian in subcrop) zone, and the presumably hydrologically connected saline zone of the Aquifer. The Aquifer's contributing zone is not included. It also includes portions of the Upper Trinity Aquifer (Upper Glen Rose formation) immediately underlying the Edwards Aquifer in this area, inasmuch as recent studies have shown the upper 100 feet of the Upper Glen Rose formation is hydrologically connected with the Edwards Group in the ITP Area. The lower portion of the Upper Glen Rose behaves as an aquitard (a barrier to hydrologic flow) between the Edwards and the Middle Trinity Aquifer (Wong et al., 2013).

The ITP Area includes the locations of all wells in the Aquifer and also the hydrogeologic systems that provide water to the natural outlets of the Aquifer at Barton Springs and several other smaller springs along the Colorado River. It is within this area, and only this area, that the District's rules and regulations for groundwater management apply.

That part of the Edwards Aquifer in the southernmost part of the Planning Area, outside the District's jurisdictional area, is governed by the Edwards Aquifer Authority (EAA) in San Antonio, as shown in Figure 3-2 above. The subsurface portion of the aquifer in this area is not included in the District's ITP Area, rather in EAA's own HCP (Edwards Aquifer Recovery Implementation Plan) and ITP Area.

3.2.2 Spring Outlets Area

3.2.2.1 Physical Setting

3.2.2.1.1 Physical Characteristics of Barton Springs

In addition to the subsurface hydrogeologic components of the Aquifer throughout the District described in the subsection above, the ITP Area also includes the submerged surface substrates and shallow subsurface rock below those substrates in the immediate vicinity of the individual springs that comprise the Barton Springs complex, The complex itself includes the Main (Parthenia) Springs, which is impounded to form Barton Springs Pool; Upper Barton Spring; Eliza (Concession) Spring; and Old Mill (also Zenobia, or Sunken Garden) Spring (Figure 3-4). Any incidental take of Covered Species would be expected to occur in the submerged areas in, below, or just beyond the individual spring outlets, which are the primary natural discharge points of the Aquifer and the only known habitats of the Covered Species. The black line in Figure 3-4 circumscribing the outlets illustrates the inferred area of potential subterranean habitat and migration zones for the Barton Springs salamander, and is the ITP Area for the City of Austin's HCP. The larger area enclosed by the red line is the Service's designated Critical Habitat for the Austin blind salamander (Service, 2013a). The yellow lines indicate present surface-stream habitat ("spring runs") from Eliza and Old Mill Springs, including the ongoing (2014) but soon to be completed "day-lighting" project that will uncover the former spring run from Eliza Spring that was converted many years ago to a buried outflow pipe, which has until now carried water from Eliza in the subsurface into the bypass culvert.

This more localized portion of the District ITP Area encompassing the spring outlets is also included in the ITP Area for the City of Austin's Barton Springs Pool HCP and ITP (City of Austin, 2013), to cover the impacts of the recreational use (swimming, diving, wading) and the maintenance operations (cleaning, caretaking) of the pool and spring outlet areas on the same Covered Species. A detailed description of the habitats provided by the spring outlets that is excerpted from the City of Austin's HCP is provided as Appendix C. The City of Austin owns the land where the individual spring outlets are located; maintains all man-made structural elements around the spring outlets; and operates the Barton Springs Pool dam, impoundment, and bypass under its HCP. The District does not control access to or operate and maintain any part of the infrastructure at Barton Springs; its groundwater management activities only affect, within limits, the amount of water issuing from the spring outlets and the chemistry of that water as related to and determined by its discharge rate.

3.2.2.1.2 Variation in Springflows at Barton Springs

The primary threat to the Covered Species and their ecosystem that is affected by the District's Covered Activities occurs during low flow conditions in the Aquifer and at Barton Springs (Service, 2013b). Variable springflow conditions are the norm, for which the Covered Species appear to be well suited. Cleaveland (2006) concludes on the basis of regional dendrochronological studies that droughts substantially more severe and prolonged than the drought of the 1950s have been a part of the pre-historical record. But increasing frequency of severe to extreme drought and flash flooding also appear to be the "new normal" (IPCC, 2013), which will continue to challenge and stress the salamander population.

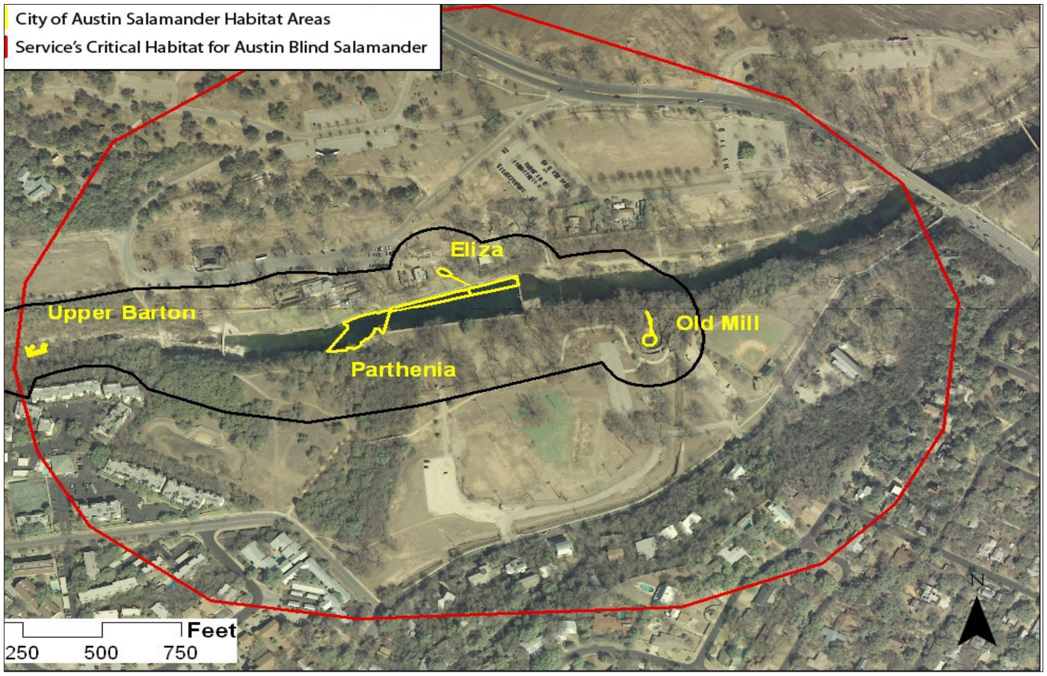


Figure 3-4 ITP Area Map - Barton Springs Ecosystem Vicinity. See text for explanation of features shown. Source: City of Austin (2013)

The long-term mean flow at the Barton Springs outlets, based on U.S. Geological Survey data for combined springs in the Barton Springs complex (Barton Springs Pool, Eliza Springs, and Sunken Garden Springs; Upper Barton Springs is not included in these flows) from 1917 to 1986 was 53 cfs (BSEACD, 2009). In the more recent period of 1978 to 2009, the mean flow was 63 cfs (U.S. Geological Survey 2009). However, springflow has varied by as much as 15-fold from extreme low to extreme high flow conditions. The lowest daily flow recorded at Barton Springs was about 10 cfs during the record drought in the 1950s (Smith and Hunt 2004), and the highest-recorded flow was 166 cfs (Slade et al., 1986). The lowest daily value of the recent extreme drought of 2008-09 (on July 21, 2009) was about 13 cfs (US Geological Survey, 2010); the more recent 2011 and 2013 severe droughts caused minimum daily flows about 16 to 17 cfs. There is considerable uncertainty (as much as ±3 to 4 cfs) in measuring flows at these very low discharge levels, owing to the measurement approaches and tools available (Brian Hunt et al., 2012a).

It should be recognized, however, that pumping from the Aquifer does not *cause* the wide variation in springflows, rather exacerbates it to a variable degree, depending on overall aquifer condition. This is illustrated by Figure 3-5, which is a synthetic hydrograph of springflows that would have existed "naturally," i.e., without any pumping of the Aquifer, at Barton Springs for the period of historical record, 1917-2013. This hydrograph was constructed using measured (for later portions of the period) and inferred (for certain earlier portions of the period) monthly data for both spring discharges and total pumpage. Statistical analysis of the hydrograph, upon its conversion to an exceedence frequency distribution, yields the following natural (i.e., without any pumping occurring) recurrence intervals at several springflows of importance to drought management (discussed further in Section 4.1.2):

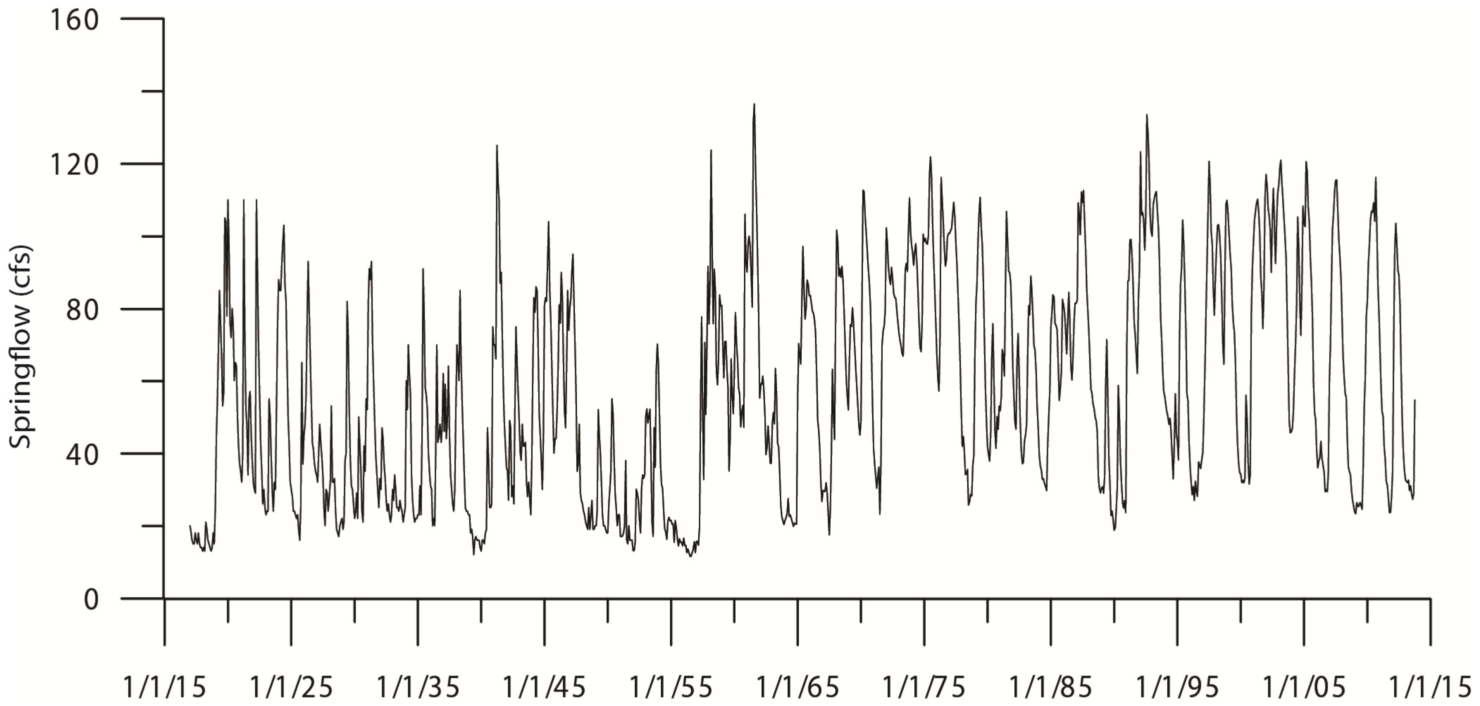


Figure 3-5. Re-constructed hydrograph of total Barton Springs flow from 1917 to 2013 as if no pumping of the Aquifer had occurred during that time. Springflows reflect the many wet and dry periods in the Planning Area over this period of record, which cause Barton Springs to typically be above or below its long-term average discharge of about 53 cfs. The Covered Species apparently are well adapted to these fluctuations in flow and accompanying changes in water chemistry.

Relevant Drought Threshold	Total Flow at Barton Springs (cfs)	Percent of Time Flow Not Exceeded
Average Flow	53	52%
Stage II –Alarm	38	36
Stage III – Critical	20	9
Stage IV – Exceptional	14	2
Emergency Response	10	<0.01
Regulated Minimum	6.5	0
No Springflow	0	0

This analysis shows that the Aquifer would be in a District-declared groundwater drought status, designated by the onset of Stage II-Alarm Drought, slightly more than one-third (36%) of the time even without any pumping, and in a Stage III-Critical Drought almost 10% of the time. These recurrence frequencies are calculated using monthly data, as pumping records used to construct the hydrograph are not available on a more frequent basis. So while strictly speaking, these data relate to monthly flow durations, as a practical matter the natural flows of Barton Springs change very slowly during a prolonged, severe drought, and recurrence for these flow durations would be very similar to those for weekly or even daily flow durations; differences would tend to decrease the percentage of time at or below a given low springflow, as the changes would be derived from storm events that in the short term increase springflow.

Discharge at Barton Springs decreases monotonically as aquifer water level and storage in the Barton Springs segment of the Edwards Aquifer drop. Large declines in aquifer levels and storage have generally been caused by climate-related prolonged periods of rainfall deficit, which in turn reduce the amount of meteoric water recharging the aquifer for extended periods of time, rather than due to the continuing effects of groundwater withdrawal for public and private use, as illustrated by the multi-year recent hydrograph for Barton Springs discharges in Figure 3-6. However, increased groundwater pumping can also reduce the quantity of water in the aquifer (Scanlon et al., 2001; Smith and Hunt, 2004). Water supply wells in the Aquifer include more than 1,200 active wells that pump water for public, domestic, industrial, commercial, irrigation, recreational, and agricultural uses (Hunt et al., 2006). As described in more detail in Section 4.1.1, only about 10 percent of these wells by number but approximately 96% of the total volume of water withdrawn from the Aquifer by wells is regulated by the District (Smith et al., 2013; Smith and Hunt, 2004).

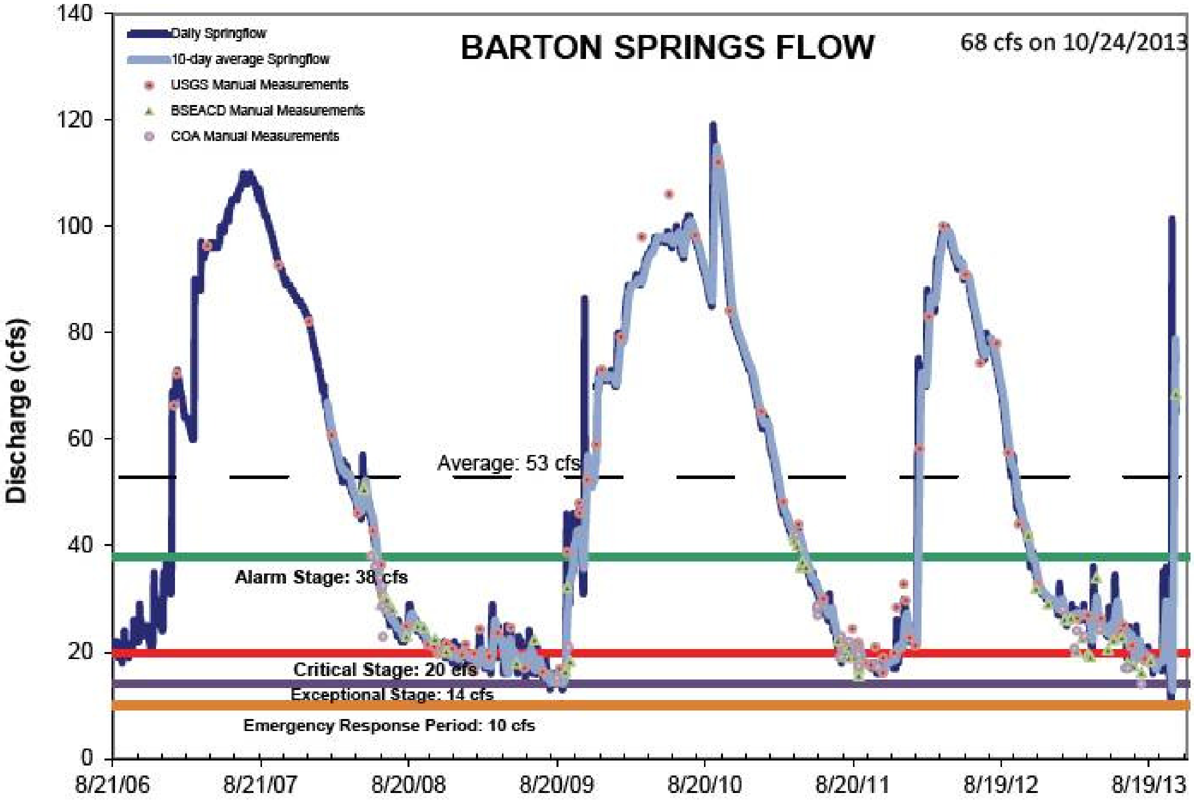


Figure 3-6. Multi-year hydrograph showing variable flows at Barton Springs, September 2006 - October 2013. Note the drought stage thresholds that have groundwater management significance. Source: BSEACD Drought Information page on website, accessed 11/8/2013.

Groundwater flow modeling by Scanlon et al. (2001) had indicated springflow at Barton Springs could possibly cease as pumping in the Aquifer reaches about 10 cfs. In 2004, the BSEACD hydrogeologists performed additional modeling to determine the "sustainable yield" of water in this segment of the Aquifer based specifically on the possible recurrence of the DOR (Smith and Hunt, 2004, included herein as Appendix B). The BSEACD then defined sustainable yield as:

> "the amount of water that can be pumped for beneficial use from the aquifer under drought-of-record conditions after considering adequate water levels in water-supply wells and degradation of water quality that could result from low water levels and low spring discharge" (Smith and Hunt, 2004).

This study recalibrated the model used by Scanlon et al. (2001) to more accurately predict springflow and aquifer declines under DOR conditions. Pumping rates were projected for future years. This first-ever rigorous assessment of the sustainable yield of the Aquifer revealed that the then-authorized pumpage of the Aquifer, about 10.2 cfs, equivalent to 2.41 billion gallons per year, was essentially its sustainable yield, as that level of pumping during a recurrence of the DOR, *if un-curtailed*, would reduce the springflow at Barton Springs to less than 1 cfs and would cause some 19% of the wells in the shallower part of the Aquifer to experience substantial yield problems from declining water levels in wells. More specifically, the recalibrated model indicated that under DOR conditions, the then-current pumping levels of 10 cfs would result in a mean monthly springflow of about 1 cfs for about one month. It also indicated that under continuous DOR conditions, projected pumping rates of 15 cfs, *if un-curtailed,* would cause Barton Springs to cease flowing for at least four months (Smith and Hunt, 2004).

The Sustainable Yield Study was the impetus for rulemaking that established the District's conditional-use (interruptible-supply) permitting program for Aquifer permit applications initiated after September 2004. This study also demonstrated the one-to-one correspondence between changes in pumped volumes and changes in springflow during extreme drought conditions (Smith and Hunt, 2004). Taken together, these findings ultimately formed the underpinnings of the groundwater availability modeling for establishing MAG amounts related to the adopted Extreme Drought Desired Future Condition of the Aquifer, which balances maintaining ecological habitat and well yields with being able to enforce as stringent curtailments as practicably possible.

At the time of the Sustainable Yield Study, the biological needs of the Covered Species were not explicitly and quantitatively addressed, other than the general recognition that nearly total cessation of springflow was not acceptable on ecological grounds. But the results of the numerical simulations had considerable implications for the Covered Species and their habitat. It suggested that, if central Texas again experiences drought conditions similar to that of the 1950s, without active groundwater management the viability of the species could be imperiled by critically low or no discharge at spring outlets. In that circumstance, the low flows at Barton Springs could cause substantial habitat degradation and a loss of plant and animal life (City of Austin, 2013).

Numerous effects of low flows have been observed in various parts of the Barton Springs complex. Upper Barton Spring ceases to flow when the combined discharge from the Barton Springs complex is about 40 cfs. Old Mill Spring begins to experience a significant plunge in dissolved oxygen concentration and ultimately a virtual cessation of flow at lower levels of discharge (about 14 cfs) (City of Austin, 2013; Turner, 2004). Also, Eliza Springs has ceased to flow when the dam gates in Barton Springs Pool are opened and water is drawn down during periods of low spring discharge. This has stranded and killed some salamanders. To prevent Eliza Springs from going dry, the water in Barton Springs Pool is no longer drawn down when flows are less than 54 cfs (City of Austin, 1998). It is possible that both Eliza Spring and Old Mill Spring could cease to flow during an extreme drought under current pumping without additional curtailments, even if the gates of Barton Springs Pool remained closed. The effect of this circumstance on the Covered Species is unknown.

Recent statewide initiatives that involve the establishment of a 50-year "Desired Future Condition" (DFC) and the associated amount of "MAG" have benefited the efficacy of the District's permitting program for managing the Aquifer under this HCP. In effect, the District was able to incorporate biological resource conservation into its drought management program and reset the "sustainable yield" of the Aquifer. Under these initiatives (House Bill 1763, passed by the 79th Legislature, now reflected in various sections of Chapter 36 of the

Texas Water Code), the District worked with the TWDB to utilize new numerical and probabilistic models and scenarios that estimate long-term consequences for Barton Springs flow rates under various pumping and climatic scenarios (Hunt et al., 2011). Accordingly, the District has used the results of groundwater modeling and made concomitant revisions to the District's programs of groundwater management under its continuous incremental rational approach for adaptive management. These activities are described in greater detail in Section 4.1.2 of this HCP.

At least three groundwater models for the Aquifer (Slade et al., 1985; Scanlon et al., 2001, as modified by Smith and Hunt, 2004; and Hutchison and Hill, 2010) now exist that have considerable validity in the opinions of many groundwater management specialists and obvious utility in assuring better management of the Aquifer and protection of the Covered Species. Each model has specific biases and assumptions, and differing means of generating outputs. One may be preferable for average aquifer conditions, while another may be better suited to analyzing conditions comparable to the DOR. No one model is ideal in predicting all present and future aquifer conditions and responses.

The newest model, developed by the TWDB in support of the MAG determination (Hutchison and Hill, 2010), takes a probabilistic approach that is likely to represent actual long-term aquifer performance in a general sense. The new model is less a deterministic simulation model, as the previous models have been, and more a predictive tool that captures the range of uncertainty in real-world performance.

All three of the models seem to confirm that, other factors equal, under prolonged extreme droughts one unit of pumping reduces springflow by that same unit. For example, a regulatory program measure that reduces the total rate of pumpage during drought by 0.5 cfs from the amount that would otherwise be allowed, would correspondingly result in a springflow at Barton Springs that is higher by roughly the same amount (Smith, 2010).

The two deterministic models (Scanlon et al., 2001; Smith and Hunt, 2004) addressed, via calibration to actual springflows, all extant sources of recharge during their calibration periods. However, as mentioned in Section 3.1.2, there is now evidence of two additional sources of recharge to the Barton Springs aquifer that none of the models explicitly incorporate, both of which have potential implications for estimating and managing extreme low flow and drought conditions at Barton Springs.

One is the notion that the southern groundwater divide is dynamic. Recent studies have shown surface water from the Blanco River can flow northward into the Barton Springs segment from the San Antonio segment during drought conditions (Smith et al., 2012). The effectiveness of the divide between the two Edwards groundwater segments dissipates at low flows, and recharge occurs preferentially to the lower elevation Barton Springs aquifer. While the Blanco River flowed continuously during the DOR, it should be noted that increased pumping of wells in its watershed now has adversely affected its base flow in the contributing zone, and such flows now may not be present during extreme drought. Hunt et al. (2012) showed base flows in streams and low springflow are decreasing over the past 40 years. Part of that influence could be climate change, over which the District has no control, but also a likely large influence is the pumping in the contributing zone, affecting springflows and base flow of the creeks in that area. The District also has no control over that. Another recent study (Land et al., 2011) has shown the potential for a portion of the Edwards Aquifer groundwater in the southern San Antonio segment to bypass San Marcos Springs and flow toward Barton Springs under drought conditions. The induced recharge arising from this indicated "leaky divide" would tend to flatten the springflow recession curve at Barton Springs during extreme drought events, although the degree to which such recharge has not been adequately simulated and to what extent that could be meaningful to springflows at Barton Springs under severe drought conditions has not yet been determined, as it would require a recurrence of a prolonged, extreme drought event.

The second source of recharge countervails the assumption that groundwater availability and springflow will decline as a result of urbanization and increased impervious cover in the recharge and contributing zones of the Barton Springs watershed. Investigators have determined that there is a substantial "indirect recharge," or leakage from utility networks (water mains, wastewater and storm sewers, and on-site sanitation systems), lawn irrigation return flow, and stormwater management infiltration devices constructed in the Barton Springs watershed. These indirect sources of recharge appear to generally compensate for the decrease of direct infiltration recharge arising from increased impervious cover (Wiles and Sharp, 2008; Garcia-Fresca and Sharp, 2005; and Sharp and Garcia-Fresca, 2004).

Leakage from pressurized water mains, for example, are typically known to result in utility-scale, unaccounted for water losses on the order of 10-30% (Foster et al., 1994); they have been measured on the order of 12% in the service area of the City of Austin (Sharp and Garcia-Fresca, 2004). Irrigation return flow, or overwatering of lawns, parks and other turfs and pervious landscapes, is especially common in summer months, when the impacts of drought and low flow on the Barton Springs complex may be severe (Garcia-Fresca and Sharp, 2005). Recent studies have indicated that the total recharge to the Barton Springs aquifer in a developed watershed is estimated to be nearly double that of its pre-urban conditions (Sharp and Garcia-Fresca, 2004). In addition, while it was estimated that on average only 4% of the total recharge in 1999-2009 was from anthropogenic recharge sources, the monthly proportions could vary greatly, ranging from less than 1% to some 59% of total recharge (Passarello, 2011). It should also be noted that this indirect recharge source has grown significantly since the DOR calibration period (Smith and Hunt, 2004), when the watersheds were much less urbanized than now. To date, this additional recharge has not been explicitly included in any of the Barton Springs aquifer availability modeling studies.

In summary, some of the principal considerations related to flow conditions at Barton Springs that are important to the Covered Species are as follows:

- Springflow can be highly variable. It has varied as much as 15-fold since the time measurements have been taken (Figure 5-3).
- The lowest measured flow during the DOR (1950-56) was approximately 10 cfs. Such low flows are extremely infrequent during the period of record.

- There are over 1200 operational wells in the Barton Springs Edwards Aquifer. The maximum monthly pumpage rate was13.6 cfs of withdrawal in August 2008, and since then, under more recent regulatory constraints, has averaged approximately 8.2 cfs.
- In recent years, several individual, severe droughts have produced observable adverse impacts to the Covered Species' habitat at Upper Barton Spring, Old Mill Spring, and Eliza Spring, and the habitat has typically not had time to recover from all those impacts between droughts (City of Austin, 2013).
- Groundwater flow models allow for predictions of future aquifer and springflow conditions; and they indicate that pumpage and springflow are related on a 1:1 basis during extreme drought, and a recurrence of DOR climatic conditions with current levels of pumping would result in spring discharge rates considerably lower than the record low discharge of 10 cfs.
- It is not known whether and the extent to which newly ascertained mechanisms and sources of additional recharge to the Aquifer are effectively included in the calibrated modeled results of flows at Barton Springs during extreme drought and on the attendant quality of the habitat of the Covered Species.

3.2.2.2 Ecological Setting

3.2.2.2.1 Overview of Habitat Characteristics and Supported Populations

The four spring outlets of Barton Springs and their associated subterranean areas form the only known habitats for the Covered Species. These habitats and other supported flora and fauna are described in substantial detail in Appendix C.

The salamander populations at Barton Springs experience relatively stable aquatic environmental conditions in their habitat, compared to typical lotic (flowing stream) ecosystems; changes in environmental parameters are typically gradual, and within fairly narrow ranges, with the extremes generally associated with flood events and prolonged drought. These conditions consist of perennially flowing spring water that is usually clear, has a neutral pH (~7), and cool average annual temperatures of ~21 ºC (~70 ºF) (Service, 2005). As is typical of groundwater-dominated systems, the springs exhibit a narrow temperature range (stenothermal). Flows of clean spring water with a relatively constant, cool temperature are essential to maintaining well-oxygenated water necessary for salamander respiration and survival (Service, 2013b; Service, 2005). Dissolved oxygen concentrations (hereafter, DO) differ somewhat among the spring outlets (City of Austin, 2013) and at the larger outlets of Barton Springs DO ranges between 4 and 7 mg/L and average approximately 6 mg/L (Service, 2005) and are directly related to springflow. The DO of surface water tends to be higher and increase with distance away from the actual spring outlets, whether in pool or spring run environments, presumably owing to re-aeration of the water with lower DO, although DO solubility during summer months may limit such increased DO concentrations from time to time (City of Austin, 2013; Smith-Salgado, 2011).

The U.S. Geological Survey (hereafter USGS) has documented the increasing amount of nutrients and organic matter in the recharge streams of the Aquifer, which may have attendant DO demand, but to date there has not been a relationship established between such concentrations in recharging waters and reduced DO at the spring outlets during drought flows (Mahler et al., 2011). However, the City of Austin has recently shown a statistically significant overall downward trend in DO concentrations averaged over the range of Barton Springs discharges, from 5.7 mg/L in 2000 to no more than 4.5 mg/L in 2014 (Porras, 2014); this general trend presumptively relates to additional pollutant discharges in the recharging waters, although some part of that trend may also relate to deeper and more prolonged droughts during that time interval. Sustained lower DO concentrations occur primarily during periods of moderately low spring discharge (Herrington and Hiers, 2010; Turner, 2009; Service 2005). On the other hand, transient low DO concentrations also accompany the higher flows of storm events; a recent USGS study of the water chemistry associated with springflow extremes over the last several drought cycles (Mahler and Bourgeais, 2013) shows that the lowest DO concentrations experienced in this study period were during stormwater events, which presumably arise from oxygen-demanding materials in the "first flushes" of runoff events.

Owing to the factors described above, as well as to the inherent difficulties in surveying populations of cryptic mobile species such as the Covered Species, there is considerable variation in counts of salamanders from time to time even for the same spring outlets and for similar springflows. The City of Austin biologists use a mean-plus-one-standard-deviation calculated metric[1] to represent the population of individual salamanders based on recurrent observations for the various perennial spring outlets for each Covered Species. The following population metrics and their arithmetic totals were most recently reported for approximately monthly counts over a 12-year period ending in 2011 (City of Austin, 2013):

	Population	**Range of Counts**
For Barton Springs salamander:		
Main (Parthenia) Springs	104	1-447
Eliza Spring	445	0-1234
Old Mill Spring	35	0-97
Upper Barton Spring	21	0-100
Total	**605**	
For Austin blind salamander:		
Main (Parthenia) Springs	1	0-8
Eliza Spring	2	0-37
Old Mill Spring	8	0-43
Upper Barton Spring	0	0-0
Total	**11**	

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[1] Salamander counts vary between sampling events. The mean plus 1 standard deviation is representative of the central tendency of the salamander estimates plus an estimate of the variance around that central tendency of salamander counts between sampling events. Assuming a normal distribution of salamander counts, then the mean plus 1 standard deviation would encompass approximately 68% of all salamander survey count estimates. In effect, this metric is a way of representing uncounted individuals in a particular population.

It is patently impossible to infer an accurate population size for an animal that is typically not observable in its habitat solely on the basis of counting its observed occurrences. So there is little confidence in the population number for the Austin blind salamander shown above, which is based on such observations. The small number counts for Austin blind salamander are almost certainly more a function of its inaccessible subterranean habitat as the actual population size. (The counting of Barton Springs salamander also encounters similar problems associated with accessibility of all individuals for counting, but likely to a lesser degree.) By using inference based on density calculated on the basis of observable substrate at Barton Springs and on similar density calculations for the morphologically and physiologically similar Texas blind salamander at San Marcos Springs in the Southern Edwards segment (EARIP, 2012), and applying a set of rational assumptions with respect to the hydrogeological setting in the vicinity of the spring outlets[2], the District estimates that a more realistic value of the Austin blind salamander population in its entire Service-designated, 120 acres of Critical Habitat (Section 5.1.2.2) could be about 1000 individuals, roughly two orders of magnitude larger than shown above. (This does not take into account that the critical habitat designated for the Texas blind salamander is also more than two orders of magnitude larger than that designated for the Austin blind salamander.) The best science available simply doesn't afford an unequivocal estimate of the maximum sizes of these particular populations, especially the Austin blind salamander. Further, the number of individuals in these generally small populations likely varies considerably with environmental conditions, which speaks to both their sensitivity to habitat conditions and the recoverability of the species.

The differences in the maximum counts of observed individuals among the surveys reflect not only the variability in the counts, but also the opportunistic life strategies of these species, and therefore the difficulty in relying upon such counts for predicting future population sizes. The observed number of individuals of both Covered Species is relatively small, and the differences in the observed numbers of the two species is consistent with the Austin blind salamander's being more adapted as a subterranean species and spending the majority if not all of its life underground (Hillis et al, 2001), and only occasionally moves out into the epigean (found at or near the surface) environment where it is visible for counting. Conversely, Barton Springs salamander is more adapted to be an epigean species and the individuals observed in censuses are more likely to be closer to the total population.

The population estimates are given here by spring outlet because the distribution of the Covered Species, the DO regimes, and the activities authorized under the City of Austin's ITP differ among the spring outlets, and even in various portions of the outlet habitats. For the District ITP, the amount or even location of the effects of groundwater withdrawals

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[2] Basis for this first-order approximation: Austin blind salamander epigean density of 0.005 individuals per square foot (Table 11, City of Austin, 2013); subterranean density presumed to be one-half epigean density; active subterranean habitat at any one time presumed to be one-half the 120 acres of Critical Habitat designated by the Service (2012); portion of active habitat range that comprises inhabitable voids at the prevailing water table presumed to be 15% of the active habitat area, with balance either solid rock matrix or smaller, uninhabitable voids.

cannot be parsed among the spring outlets, even though the amount of take from the District's Covered Activities is estimated according to the individual spring outlets on the basis of their specific DO relationship with total springflow. Simply put, the District's Covered Activities cannot target where take occurs and doesn't occur among the outlets, although it is readily apparent that the effects will be disproportionate among the outlets, and take estimates and impact assessment should account for those differences.

3.2.2.2.2 Water Chemistry and Spring Discharge Relationships

As noted above, water quantity, water chemistry, and water quality of springflows are interrelated. Higher flows, especially stormwater runoff, are generally poorer quality with respect to many water chemistry/quality parameters, including suspended solids, nutrients, bacterial loadings, and oxygen-demanding material, but also are rather transient. Such transient stormwater also has rather smaller total dissolved solids concentrations (salinity) and DO concentrations (Mahler and Bourgeais, 2013) that are somewhat below water quality standards for surface-water, owing likely to the higher oxygen demand and/or induced release of water from aquifer storage that is more depleted in oxygen, as well as to more variable, seasonal water temperature that affects DO solubility. On the other hand, while average flows and especially typical drought flows tend to be generally higher in quality, i.e., have smaller pollutant loads, as drought is prolonged and springflows decrease over an extended time, salinity tends to increase and DO tends to decrease over a somewhat restricted observed range (Herrington and Hiers, 2010). These phenomena appear to be related to the amount of older, more saline water from the confined parts of the Aquifer, including possibly the hydrologically connected saline zone or underlying Trinity Aquifer, which have much lower DO (Mahler and Bourgeais, 2013; Lazo-Herencia et al., 2011; Johns, 2006). In addition, these studies suggest that the relative contributions to discharges at the individual spring outlets from various flow routes with different DO concentrations and possibly different salinities could vary with overall flow and also contribute to the relationships observed. The natural introduction of water with higher salinity and lower DO, regardless of other factors that might be reflected in the water chemistry and quality, is caused in part by the Covered Activities. These are the two springflow-related water chemistry parameters that are believed to be of primary importance in determining the amount of take of the Covered Species in the spring habitats by the District's Covered Activities.

Dissolved Oxygen and Spring Discharges

The concentration of DO has been known for some time to correlate directly with spring discharge at Barton Springs (City of Austin, 2013; Herrington and Hiers, 2010; City of Austin, 1998). DO tends to be at relatively higher concentrations during periods of high recharge when a large volume of well-oxygenated surface water that is not stormwater enters the aquifer. DO levels are at their lowest when recharge is minimal or nonexistent and spring discharge is low (Herrington and Hiers, 2010; City of Austin 1997). Extended or frequent periods of low flow, therefore, can be detrimental to the development, reproduction, and even survival of the Barton Springs salamander, although Norris et al. (1963), while confirming the adverse effects of lower DO, also notes that some salamander species physiologically accommodate lower DO. Although the Barton Springs salamander survived the drought of the 1950s, its population may have been adversely, even permanently affected by prolonged low flows at Barton Springs, particularly if DO levels were proportionally low. Depressed DO concentrations also may compound the effects of other stresses on the salamander's survival, such as increased pollutant loading during drought and low flow conditions. A key adaptive management objective of this HCP is to increase the understanding of the relationships of springflow and DO levels in the Barton Springs complex and further afield in the Aquifer, and to develop over time an enhanced capability to minimize or avoid anthropogenic lowering of DO through groundwater management during low flow conditions.

Science staff at the City of Austin, TWDB, USGS, and BSEACD have collaborated for several years to collect, compile and analyze water quantity and quality data in the Barton Springs complex. These collaborations have included studying the correlation of DO, springflow and other relationships. There is considerable agreement that there are strong correlations between DO and discharge, within the ranges of spring discharge for which data have been collected. There is also some variability in the data collection instrumentation, methods of collection and analysis, and frequency and longitudinal extent of data collected by the different entities, which should be recognized in making inferences from the limited data presented in this HCP. Further, it is clear that the relationships differ among the individual spring outlets. Appendix D summarizes the outcomes of several representative investigations of these relationships conducted by the City of Austin Watershed Protection Department, describing the results of these studies in more detail and also presenting summary statistical analyses of these data.

Reliably measuring in-situ DO concentrations of groundwater in an aquifer is a well-known challenge. In one such recent study of the Aquifer (Lazo-Herencia et al., 2011), it was determined that native groundwater in the unconfined (recharge) zone had a median DO concentration of 6.4 mg/L, while the confined zone had substantially lower DO, with a median value of 2.0 mg/L. These results are supportive of the notion that more water from the confined zone adjacent (both laterally and vertically) to the spring outlets discharges from the outlets at lower water levels, resulting in a decrease in the DO concentration with decreasing discharge. An even more recent USGS study (Mahler and Bourgeais, 2013) of the Aquifer and Barton Springs discharges over a 6-year period with very high and very low groundwater levels and springflows found DO concentrations fluctuating by a factor of two, generally related inversely to springflow temperatures and directly with springflow discharge rates, both of which were noted to likely be exacerbated by climate change. Interestingly, the lowest DO concentration observed by those investigators was 4.4 mg/L, consistent with a water-provenance model of mixed types in sub-equal proportions.

A salient aspect of the data and analyses that are in Appendix D is that relatively few paired springflow and DO data exist in the springflow domain below 20 cfs, which is the more critical region for assessing significant take. Figure 3-7 demonstrates the range in predictions of DO concentration that can be expected from various regression formulas under various boundary conditions in the zone of discharge below 20 cfs, for which very few data exist. These regression relationships are discussed in more detail and utilized in the analyses of Section 5.2.4.2.1.

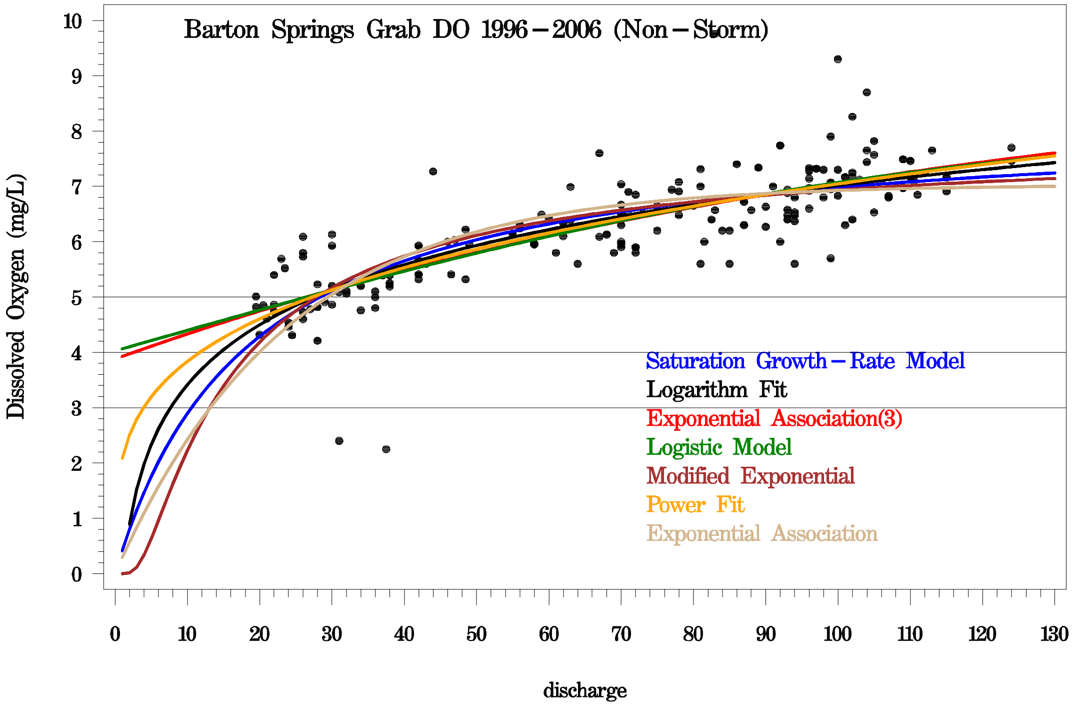

Figure 3-7. Various Regression Models Representing Flow-DO Relationships. All of these curve-fitting regression models are based on data for combined springs discharge at Barton Springs that don't extend into extreme low flows. Source: Turner (2007).

Models of individual spring outlets, such as those shown in the figures in the appendix, do not (yet) have reliable predictors of DO in the zone below 20 cfs owing to sparse or non-existent data. For example, from 1978 to present, the minimum DO concentration *observed* by the USGS at Main Barton Springs is approximately 4 mg/L, when the discharge was reported to be 13 cfs in August 2009 (the previously noted measurement difficulties notwithstanding). The regression model for Main Springs indicates that the *predicted* DO would be 3.4 mg/L at a discharge of 13 cfs, which is considerably lower than the actual observed values at that discharge. The logarithmic function used in this and some other of the curve-fitting equations would predict that DO would decline to 0 mg/L at or above a discharge rate of 0 cfs. While this outcome is conceivable, the prediction is a product of the mathematics, not data at that level of springflow, which are unavailable. Other modeled equations predict different but equally conceivable outcomes, with DO declining only to between 3 and 4 mg/L, and those appear to be more in keeping with the trends established at higher flows where there is data control.

In the laboratory study of salamander response to the stressor of depressed DO concentration, which is presented in Section 5.2.1 of this HCP, there were only 35 DO observations for Main Springs below 4.5 mg/L in the available dataset of the USGS. Woods et al. (2010) in its probabilistic ecological hazard assessment found no statistically significant relationship between these low flow and associated DO values for this more limited data set. Even less information for Eliza Spring and Old Mill precluded similar evaluations in those locations. The relationship between DO and springflow for flows less than 20 cfs is important to a quantitative assessment of take but is simply unknown at this time.

Nevertheless, there is clear evidence of depressed DO with smaller spring discharges observed in the *overall* datasets at specific spring outlets. In particular, DO concentration at Old Mill Spring is known to plunge when the combined Barton Springs discharge falls below 20 cfs. The sustainable yield simulations conducted by the District in 2004 indicated that under 1950s DOR conditions and high rates of pumping, saline water from the "bad-water" zone has a greater potential to move into the freshwater portion of the aquifer (Smith and Hunt, 2004). Consequently, the intrusion of water with higher salinity, which also tends to be more depleted in DO than water in transit or storage in the unconfined and freshwater part of the aquifer, can cause specific conductance and salinity to increase somewhat in salamander habitat under low flow conditions. However, Old Mill Spring, which is noted above as having unusually low DO during low aquifer levels, tends to have the highest specific conductance levels of the four spring outlets, which is most likely attributable to its proximity to the "bad-water" zone and its influence on flow routes that provide a substantial portion of the water to that particular outlet (City of Austin, 1998). The consequences of the relatively small rise in average salinity on the Covered Species are not known.

As mentioned earlier, not all of the data available for the Barton Springs complex have been collected with the same instrumentation, over the same time period and frequency, or compiled and analyzed using the same protocols. Most of the DO data presented in the figures above were collected by the City of Austin, using both datasonde and grab sample data in the various spring orifices, some stationary and some mobile. If different data sources were to be used and compared to the results noted above, the outcomes in the zone of extreme low spring discharge may appear significantly different. In particular, the datasondes produce lots of data related to all flow conditions, and while useful for some purposes the inclusion of data from high (including storm event) flows, which can also have lower DO (Mahler and Bourgeais, 2013), confounds the analysis and prediction of DO during extremely low base flows, which is the flow regime of most import to the Covered Species in assessing take in this HCP.

Further, it should be recognized that at very low flows, the reliability of individual discharge/flow measurements is impaired, because of magnified effects of factors not related to true springflows. Hunt et al. (2012a), showed flow measurements can vary up to 30% during low flows. So there is a corresponding uncertainty in the correlation among flows at different times and in the correlation of flow to DO.

There is also uncertainty, if the DOR were to recur, as to how low and by which influences the combined springflow at the Barton Springs complex might decline. The current drought management program of the District and this HCP is designed to provide a base springflow during a DOR recurrence (refer to Section 6.2.1.8 for the desired outcome of proposed HCP measures). This regulatory program is indexed to authorized groundwater use, but actual groundwater use in aggregate has tended historically to be below the prevailing curtailed authorized use (as also reflected in Figure 3-9 below), allowing for higher-than-predicted springflow rates. Further, the regression models described above are limited by the lack of data under extreme low flow conditions as well as variations in source data and other factors noted. There are as of yet no scientific studies that integrate other independent but related factors into the predictions of DO concentration under extreme low flow conditions. Nevertheless, given the considerable uncertainty that must be addressed in such situations, these models produce better understanding and help frame and prioritize management alternatives on the basis of the possible consequences of various actions (or no action).

An analysis was conducted of DO concentration and several other water quality parameters at Barton Springs over a 25-year study period, adjusting for variations in spring discharge rates (Turner, 2000). The analysis of water quality records, collected by the City of Austin from 1975 to 1999, indicated statistically significant changes in DO over the course of the 25-year period, possibly related to watershed urbanization. DO was found to be decreasing over time, both at high and low discharge levels. The median DO concentration decreased by approximately 0.8 to 1.1 mg/L over 25 years (1975 -1999), from 6.4-6.8 mg/L in 1975 to 5.45-5.7 mg/L in 1999. This is a decrease of 12-16%. Sampling has been much more frequent recently, leading to a higher probability of observing extreme events. Therefore it is possible that the observed change is a sampling artifact (Turner, 2000). Enhanced nonpoint source pollution controls in the Barton Springs springshed have been initiated by the City of Austin, Travis County, and several municipalities to arrest or slow this decline, but the recent statistical analyses by the City of Austin suggest that the temporal trend in decreasing overall DO levels is continuing, and is now below 4.5 mg/L (Porras, 2014). A long-term change in DO of greater than 1.0 mg/L is likely meaningful in any isolated aquatic habitat. Trends in other water quality parameters such as nutrients and total suspended solids were not as clear or notable (Turner, 2000).

Salinity and Spring Discharges

The specific conductance of the spring discharges, a measure of the concentration of total dissolved solids (i.e., salinity) in the water issuing from the Aquifer, as well as individual ion concentrations have been known for some time to increase as springflow decreases (e.g., Slade et al., 1986; Senger and Kreitler, 1984). The general relationship is clearly shown in Figure 3-8, depicting paired data collected by the City of Austin over a seven-year period that includes very high and very low springflows (Herrington and Hiers 2010). The salinity varies within a fairly narrow range, with the difference in conductance between average and lowest flows in this dataset being 75 µSiemens/centimeter; this corresponds to a variation in total dissolved solids (TDS) of less than 50 mg/L. That level of overall variation with drought flows is not much more than the variation in TDS concentrations corresponding to any one typical springflow. Even at the lowest flows the highest TDS concentrations of springflows reflected by these data are about 475 mg/L, less than half the concentration still considered fresh water (less than 1,000 mg/L TDS) and supportive of aquatic life. However, TDS or specific conductance data for extreme low flows, such as would exist during a recurrence of the DOR, are not available, so the actual salinity of such DOR flows is unknown.

Researchers have postulated that the increase in salinity is caused by a greater proportion of the springflows being contributed by water from or influenced by the saline zone of the Edwards Aquifer, which is proximate to Barton Springs, as the water levels and potentiometric pressures in the Aquifer decline (Slade et al. 1986; Johns 2006). Similarly, the contributions of water from the deeper Trinity Aquifer that migrate upward along the faults that relate to the spring outlets cannot be ruled out, but there is no evidence of such inter-formational flows elsewhere in the District (Wong et al, 2013; Smith and Hunt., 2011), so the Trinity seems a less likely source of brackish/saline water resurging at the outlets. On the basis of hydrochemical data analysis and use of mixing models, Hauwert et al., (2004) suggested that about 3% of the springflow at Old Mill and 0.5% at Eliza and Main Springs might be derived from such sources during low flow (17cfs) conditions. This is consistent with the observed small but statistically significant differences in salinity among the various spring outlets, and not all spring outlets have such variation, presumably reflecting differences in source-water provenance, contributions of different flow routes, and degrees of mixing (Johns 2006). This water is also likely to be much older and more depleted in DO than the younger water in the conduits and matrix of the freshwater Edwards Aquifer, and a proximate cause of the smaller DO concentrations observed in low flows.

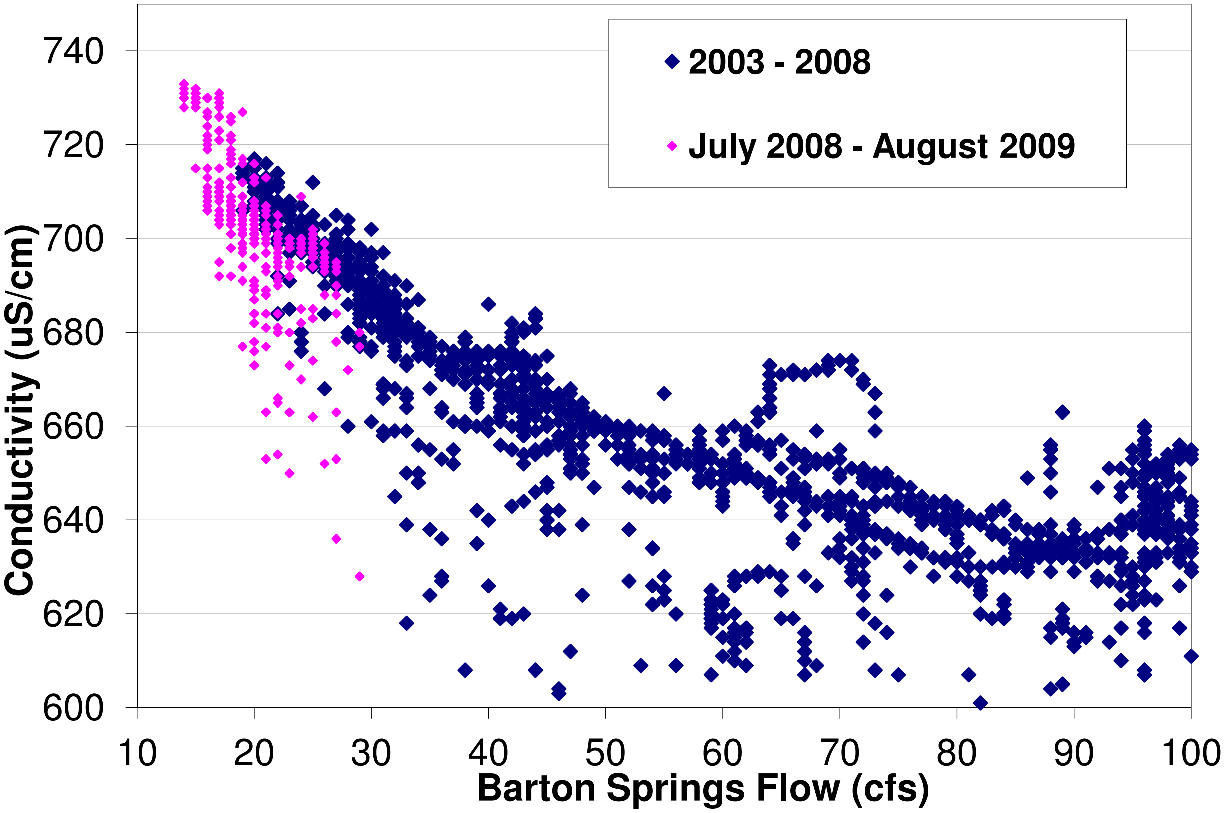

Figure 3-8. Inverse relationship of spring discharges and water salinity, expressed as specific conductance. Note the rather small range of variation, which corresponds to about 70 mg/L of total dissolved solids. Source: Figure taken from Herrington and Hiers (2010).

3.2.3 Antecedent Conditions within the ITP Area

There are pre-existing conditions in the ITP Area, originating prior to the initiation of the HCP and continuing to the present day, that have a significant bearing on the affected environment of the Covered Species and on the ability of the District to manage the Aquifer. Accordingly, the consideration of the protective enhancements and conservation measures taken under this HCP must be framed within the context and realities of these pre-existing conditions.

Many of these conditions stem from historical patterns of development and associated water and land use, all of which have various legal protections under other law but nevertheless influence the quality and quantity of water discharging from Barton Springs. These historical land use and development trends in the ITP Area have contributed to a gradual but progressive degradation of surface recharge quality (Mahler et al., 2013) and consequently in the water quality of springflow discharging at Barton Springs (City of Austin, 2012), although so far such springflow degradation has been small. The District does not have authority to manage or control land use or the quality of Barton Springs discharges that arise from the impact of development on surface water that recharges the Aquifer.

Figure 3-9 illustrates the history of production from all permitted wells in the Aquifer, in association with several District milestones. Before the establishment of the District in 1987, there was no legal authority or ability to regulate groundwater production from the Aquifer. The Aquifer then was a readily available, sole source of high quality water that served a growing suburban and exurban population. Not until 1989, when the first groundwater management plan and rules were adopted by the District and meters began to be set on permitted wells, was there any operational permit program to manage groundwater production in this rapidly developing area. By 1989, the estimated average pumpage rate in the District was about 5 cfs.

Before the federal listing of the Barton Springs salamander in 1997, there was no basis of reference to measure how much groundwater production or what limitation of production would be needed for protection of the salamander population at Barton Springs. In the mid-1990s, when Barton Springs salamander was first described as a newly identified species and subsequently listed as endangered, *actual* pumpage under approved permits or exemptions to permits was already in the range of 5 to 6 cfs, contributing then to diminution of springflows along with their natural variations during drought cycles.

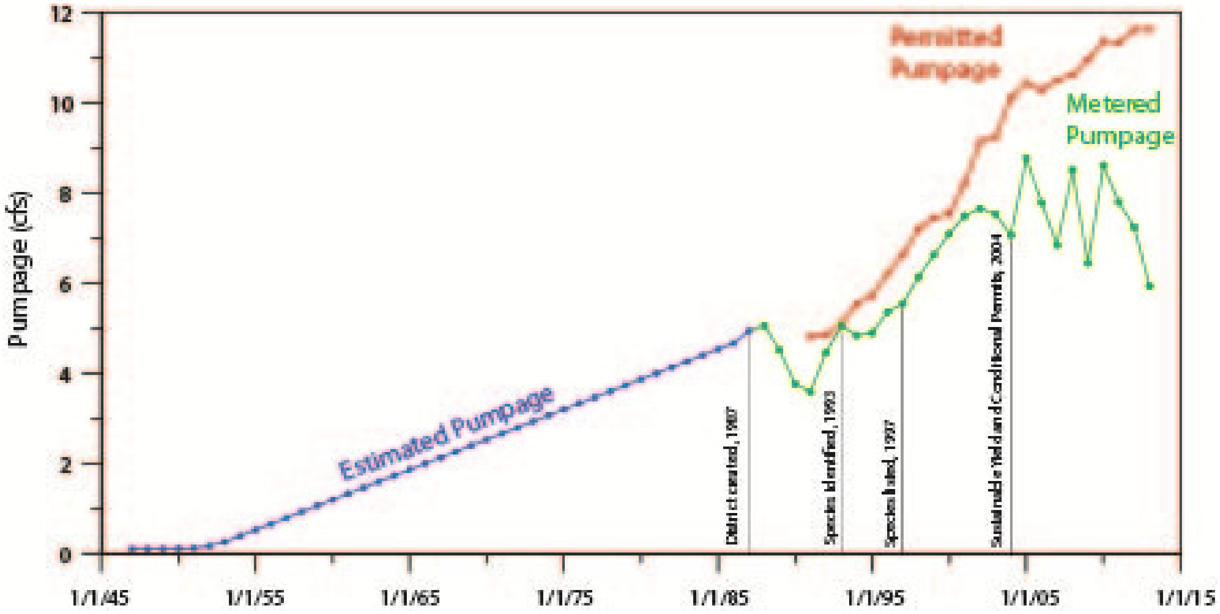

Figure 3-9. Pumpage history showing District milestones. Actual Pumpage rates are annual averages, in cfs, for nonexempt wells in the District. Data before 1988, when wells first began to be metered, are estimated; after 1988 data are self-reported meter readings. Source: Data through 2006 are from: Hunt et al., 2006. Data after 2006 are unpublished BSEACD data.

From an historical perspective, the District's intent and actions in developing this HCP are a continuation of those the District has voluntarily and proactively followed, inasmuch as the District's mission was congruent with the Act's purpose, i.e., reducing water demand and/or increasing supply that results in source-substitution during drought to preserve aquifer water levels and springflows, and thereby generally reduce adverse impact to the habitats of the Covered Species. In 2004, when the District initiated the habitat conservation planning process, the *actual* total pumpage from the Aquifer, under approved permits and exemptions to permits, was about 7 to 8 cfs, even though authorized pumpage under permit was just over 10 cfs. This HCP, which is the result of this long-term planning process, now establishes the District's commitment to implement actions that avoid additional adverse impacts to the Covered Species and to minimize and mitigate those impacts of District activities that cannot be avoided.

Drought is another, different type of pre-existing condition that is also germane to this HCP. The ITP Area is prone to rather severe drought cycles, and the Covered Species are stressed "naturally" on a variable, generally cyclic basis by drought in exactly the same way withdrawals of groundwater by wells that are regulated as a Covered Activity stress the species (refer to Figure 3-6 in Section 3.2.2.1.2 above for an illustrative hydrograph). So the effects of the Covered Activities, which represent a specific level of take that is analyzed in Section 5.2, are overprinted on similar and variable effects from a natural drought cycle that exist regardless of whether and how much groundwater is withdrawn by wells in the Aquifer in the ITP Area.

3.2.4 Protected Species in the ITP Area

Table 3-1 lists those species that are federally protected in the three counties in which the ITP Area is located (Service database, http://www.fws.gov/southwest/es/ES_Lists_Main.cfm, accessed December 30, 2013). Most of these species are either endemic to areas of these counties that are well outside the ITP Area or otherwise are not known to exist in the ITP Area. Only the first two of the species listed are known to exist in the ITP Area and may reasonably be expected to have habitat affected by the proposed Covered Activities, and those two species are the proposed Covered Species for this HCP.

Table 3-1. Federally protected species in Travis, Hays, and Caldwell Counties, Texas. Status is denoted as endangered (E), threatened (T), candidate (C), and of concern (D) (Service, 2014).

Group	Species	Common Name	Status
Amphibians	*Eurycea sosorum*	Barton Springs Salamander	E
	Eurycea waterlooensis	Austin Blind Salamander	E
	Eurycea tonkawae	Jollyville Plateau Salamander	C
	Eurycea nana	San Marcos Salamander	T
	Typhlomolge rathbuni	Texas Blind Salamander	E
Birds	*Dendroica chrysoparia*	Golden-Cheeked Warbler	E
	Vireo atricapilla	Black-Capped Vireo	E
	Grus americana	Whooping Crane	E
Insects	*Texamaurops reddelli*	Kretschmar Cave Mold Beetle	E
	Rhadine Persephone	Tooth Cave Ground Beetle	E
	Heterelmis comalensis	Comal Springs Riffle Beetle	E
	Stygoparnus comalensis	Comal Springs Dryopid Beetle	E
Arachnids	*Texella reddelli*	Bee Creek Cave Harvestman	E
	Texella reyesi	Bone Cave Harvestman	E
	Tartarocreagris texana	Tooth Cave Pseudoscorpion	E
	Leptoneta myopica	Tooth Cave Spider	E
	Circurina wartoni	Warton's Cave Meshweaver	C
Plants	*Zizania texana*	Texas Wild Rice	E
Fishes	*Gambusia georgei*	San Marcos Gambusia	E
	Etheostoma fonticola	Fountain Darter	E

4.0 Proposed Actions

4.1 Proposed Covered Activities

The District seeks coverage under the prospective Incidental Take Permit (ITP) for withdrawal of groundwater from the Aquifer by well owners/operators holding a valid permit from the District for their groundwater supply and for the District's associated groundwater management program activities. These activities, result from time to time in incidental take of the Covered Species by adversely affecting the quantity and associated chemistry of water that is naturally discharged from the aquifer at Barton Springs. The activities for which the District seeks coverage arise from pumpage from both nonexempt and exempt registered wells and from the District's permitting program for regulating the groundwater production[1] by nonexempt wells in the District. These are lawful activities with a publicly beneficial purpose, and any associated take, as defined by the Endangered Species Act (Act), is incidental.

These Covered Activities directly relate to and affect primarily the groundwater resources and the groundwater-user community in the District. The withdrawal of groundwater from the Aquifer by this regulated community using wells registered and permitted by the District is a principal activity for which the ITP is sought. It is also important to the understanding of the Habitat Conservation Plan (HCP) that the District's groundwater regulatory program is both a Covered Activity <u>and</u> the vehicle for the primary conservation measures for the Covered Species.

The regulation of the groundwater-user community, which is accordingly also the focus of the HCP avoidance, minimization, and mitigation measures, is described in Section 4.1.1 below. The evolution and status of this regulatory program, its statutory and regulatory authorities, and the public participation in its development are then characterized in following subsections.

A number of other important District activities are not included as Covered Activities. The District is not seeking coverage under the ITP for them, primarily because by design they will not lead to take of the Covered Species, and/or the activities and benefits are unable to be mandated or controlled by the District.

4.1.1 The Regulated Groundwater Community

The District is requesting coverage under the ITP for its regulatory program that controls the conditions under which groundwater is used in the District and especially the amount of groundwater withdrawn by permitted well owners. The end-user customers of water

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[1] Groundwater production limits apply only to District-permitted wells; the production is considered a Covered Activity only if the well and the permittee are in compliance with the District's rules, including permit conditions, prevention of waste, and water conservation plan and drought contingency commitments.

utilities using the Aquifer as public water supplies are not directly regulated by the District so they are not included in this community and their individual usage of the Aquifer water is not considered part of the Covered Activities. Components of the District regulatory program include permitting, compliance monitoring, enforcement, assessment and administration of various District fees, user conservation planning, and user drought contingency planning and response. This program has the purpose of reducing withdrawals of groundwater from the Aquifer to those minimum volumes reasonably needed by well owners and permittees during both drought and non-drought periods to conserve the water supply for as long as possible and to maintain sufficient flows at Barton Springs to support the Covered Species. However, the maximum reductions in water withdrawals prescribed under this program are unable to completely avoid adverse effects on the Covered Species during severe drought periods.

More than 1200 water wells exist in the District's jurisdictional area (Figure 4-1). Nearly all of them are now registered with the District, and nearly all of their production (almost 97%) is currently from the Edwards Aquifer. Many more are in the HCP Planning Area outside the District boundaries, but none of those other wells are in the Aquifer. The large majority of wells in the District draw water only from the Aquifer. Moreover, usage of other aquifers in the District is currently very small. Most wells by number serve small-volume users, typically domestic wells for individual households and are exempt from permitting and therefore not regulated or monitored by the District as to the amount of water withdrawn. Water withdrawals from these wells are not Covered Activities.

The District classifies its registered wells into four major categories, which determine whether and specify how the District regulates its groundwater use (BSEACD, 2012). These are summarized in Table 4-1 and characterized in the four subsections below.

Table 4-1. Estimated/Authorized Amount of Groundwater Use. Exempt use is estimated from geospatial analysis (Banda et al., 2010); others are 2013 use by District permit type. Historical production use amount includes 91.525 MG per year from Trinity Aquifer permits.

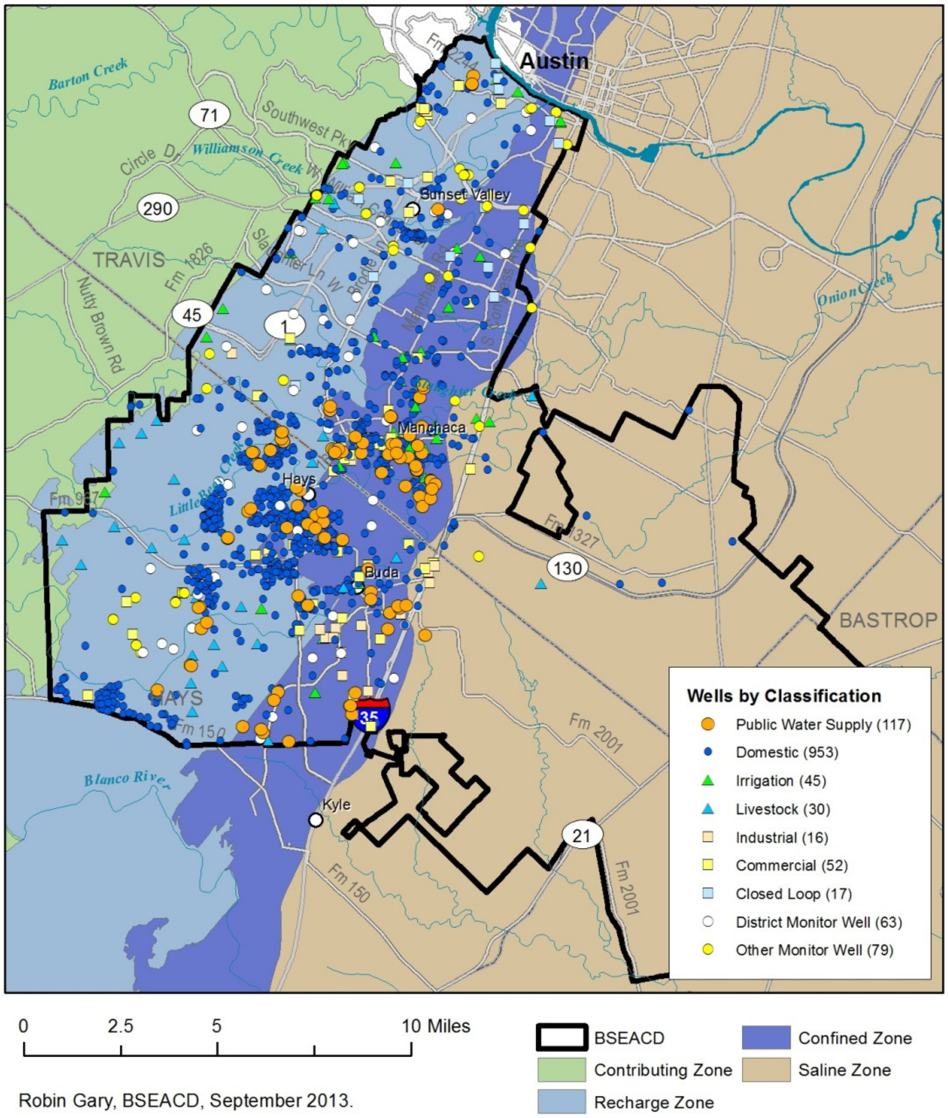
Production Type	Number of Wells	Withdrawal Regulated by District?	Estimated/Authorized Use (Thousands Gallons Per Year)
Exempt Use	997	No	105,000
Nonexempt Domestic Use	77	Yes	21,020
Nonexempt Historical	110*	Yes	2,462,513
Nonexempt Conditional	30*	Yes	348,700

*Some wells may have authorized production under both historical and conditional production permits. Numbers shown are for the dominant type of authorized production.

4.1.1.1 Exempt Wells and Users

An exempt well by state law is not subject to the District's permitting program and therefore has no authorized pumpage level set by the District. However, they are registered by the District and are subject to District Rules concerning well construction standards and avoidance of waste, pollution, and excessive use.

Individual exempt wells generally use only small volumes of groundwater. An exempt well is generally defined as a well that is used solely to supply domestic use or for providing water for livestock or poultry if the well is: (1) incapable of producing more than 10,000 gallons of groundwater a day, *and* (2) located or to be located on a tract of land larger than 10 acres. Exempt wells also include by definition several other use types, including injection wells, oil and gas wells, and monitor wells, but in the District, very few of these



Robin Gary, BSEACD, September 2013.

Figure 4-1. Location of Wells in District and Classification by Use Category. See text for explanation of differently colored hydrologic zones. Source: BSEACD wells database, 2013.

other exempt wells exist, and none withdraw other than negligible amounts of groundwater.

Exempt wells are generally used as water supplies for livestock (including windmill-powered wells) and/or for residences on large-tract households, ranch, or farm lands. The District recently estimated on the basis of GIS analysis that there were about 1000 exempt wells in the District but they produced only about 4% of the total volume of groundwater withdrawn by all wells in the District; further, the number of wells in service and amount of exempt production are apparently decreasing as the ITP Area becomes more developed with centralized water systems (Banda et al., 2010). Most existing exempt wells were in place at the time the District was formed in 1987. Very few new wells in the District meet all the criteria to be exempt.

Exempt wells are capable of only limited production because they are generally equipped to produce no more than about 7 gallons per minute on a daily average basis. The amount of their production is limited by the well size and equipment, rather than by regulation. These wells are not usually metered and are not required to report water use or charged for their water use at any time. Exempt wells do not have the permits that are used by the District as the vehicle to specify User Conservation Plan (UCP) and User Drought Contingency Plan (UDCP) requirements, so mandatory, enforceable drought-time curtailments are not applicable to them. Therefore, under Service regulations, exempt wells cannot be a Covered Activity for this HCP.

Even though water withdrawals from exempt wells by state law are not subject to limitation by the District, the total groundwater production by exempt wells does affect the allowable amount of water to be withdrawn by other wells during Extreme Drought conditions.

4.1.1.2 Nonexempt Wells and Users

Production by all nonexempt wells in the Aquifer is regulated through District production permits and is a Covered Activity. The permits are the vehicles for implementing the District’s drought rules that form its Drought Contingency Plan.

All permittees must adopt UCPs and UDCPs, which are integral, mandatory parts of every permit. Templates for UCPs and UDCPs that have been developed by the District and made available to its permittees as guidance are included in Appendix E of this HCP. UDCPs in particular are central to the District’s drought management program. This program involves a declaration by the District Board of the severity of groundwater drought on the basis of actual Aquifer conditions, as defined by the District’s Drought Trigger Methodology developed for this HCP (see Appendix F for details on the drought trigger methodology, and Appendix G for the rule-based definitions of the various groundwater drought stages used by the District for drought management). Permittees are required to curtail their monthly groundwater use according to the declared drought stage and their approved baseline volume for a given month, as specified in their UDCP. All individual permittees are required to report their actual groundwater use monthly to the District, which data are used to assess compliance with monthly UDCP requirements and to initiate pre-enforcement and enforcement actions, if and as warranted, during drought, and to evaluate whether overpumpage of their annual authorized amount has occurred.

The requirements of UCPs and UDCPs and the penalties for non-compliance are specified by District Rules and the District's Board-approved Enforcement Plan; they are legally enforceable by the District. The District's enforcement scheme includes assessment of daily penalties, up to $10,000 per day, that are indexed to the amount of authorized use, the degree of non-compliance, and drought stage; more information on the District's Enforcement Plan is included in Section 6.5.1.4 of this HCP. The District typically achieves more immediate compliance, which is the objective, for those egregious and recurring violations of the monthly pumping limits through agreed settlement orders that apply early resolution incentives through a prescribed reduced percentage of the monetary penalties and the applicable sanctions and compliance requirements. But enforcement can also be achieved through litigation in district court, where the full amount of the penalty then becomes a matter before the court; the District has never had to instigate this latter step to achieve satisfactory compliance by permittees.

The relationship between production permit types and degree of curtailment under specified drought conditions is summarized in Table 4-2. The various regulatory drought stages and related curtailment provisions of the District's drought management program are explained in greater detail in the two appendices referenced above.

4.1.1.2.1 Nonexempt Domestic Use Wells and Users

A nonexempt domestic use (NDU) well is a well used by, and connected to, a household for personal needs or for household purposes such as drinking, bathing, heating, cooking, sanitation or cleaning, and landscape irrigation but that does not meet the criteria for exemption from permitting. These wells must be on a single-ownership plot smaller than 10 acres that contains a household. (If on a tract larger than 10 acres, these wells typically would be exempt.) NDUs typically operate under a "general permit by rule" which applies only to wells that:

(1) are used only for domestic use;
(2) were drilled and completed on or after August 14, 2003;
(3) are not located in an area in which a water supplier has a valid certificate of convenience and necessity (CCN) service area, unless that water supplier is not readily able to supply water;
(4) have a requested annual pumpage that does not exceed 500,000 gallons per household; and
(5) have a requested volume that does not exceed acceptable standards for both domestic use and landscape irrigation.

NDUs are required to have water meters and the owners must periodically report water usage. Presently, no water use fee is charged to NDUs for water withdrawals, but the

District does charge their users a small one-time administrative permit application fee. As of the end of FY 2013 there were approximately 77 NDUs in the District.

4.1.1.2.2 Other Nonexempt Wells and Users

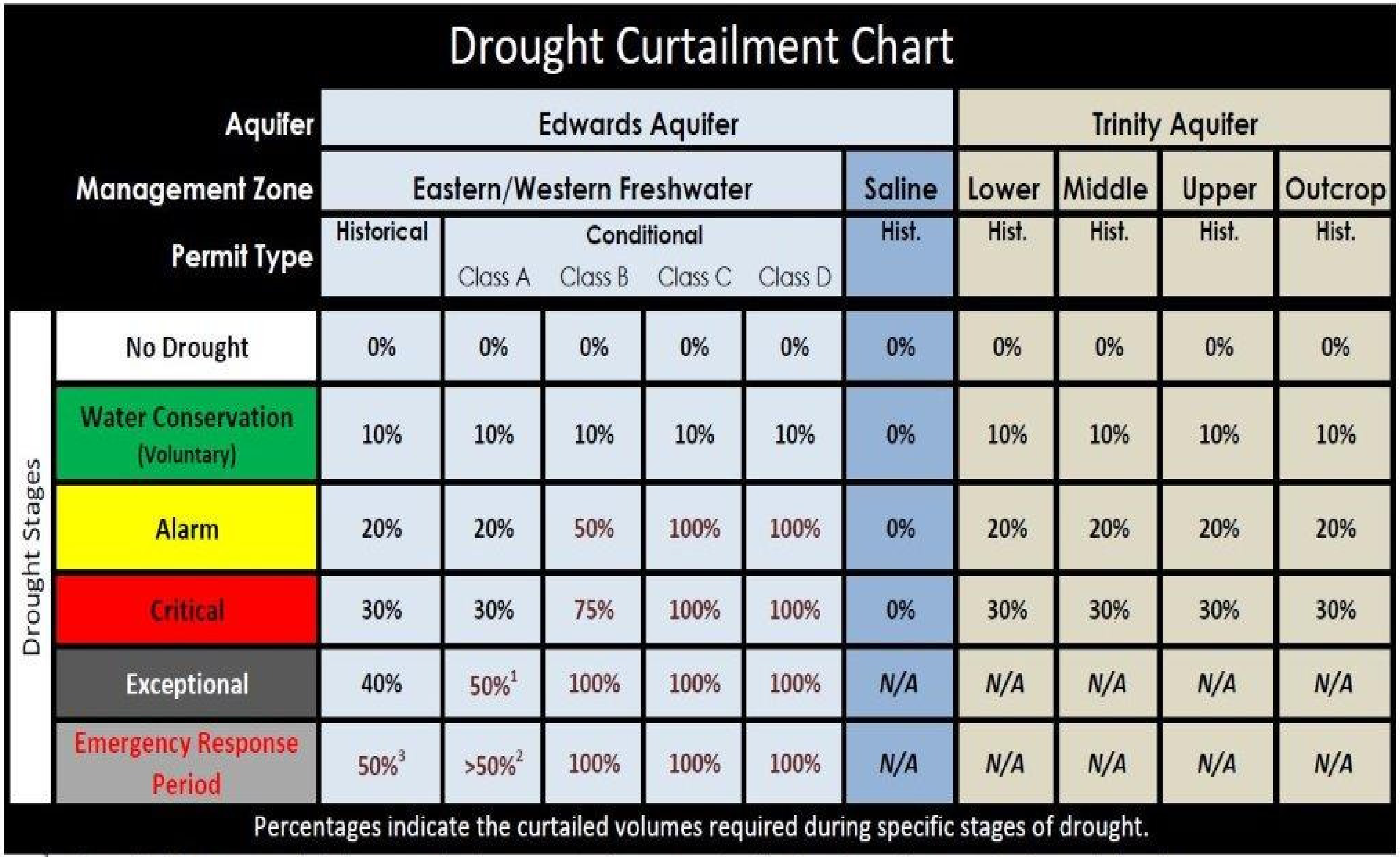
Most other nonexempt wells not authorized by general permits are required to have individual production permits from the District, to pay an annual water-use fee based on their authorized use, to be metered, and to report actual water use monthly. In 2014, nonexempt well users paid water use fees ranging from $0.17 to $0.46 per 1000 gallons of water used, depending on the type of permit (see below). The District has about 90 nonexempt permittees, not including NDUs. At the time of preparation of this HCP, an estimated 96 percent of all groundwater withdrawn in the District was by nonexempt wells.

Such wells are categorized by use type: agricultural, commercial, industrial, irrigation, and public water suppliers (see Figure 4-1). The permittees include churches, office parks, quarry operations, schools, community athletic fields, golf courses, municipalities, and water supply utilities. The largest use by far is for public water supplies. Type of use is one determinant of the provisions that the District Board considers when it examines the permittees' UCPs and UDCPs.

An example of a public water supply UDCP is the City of Buda's UDCP (see http://tx-buda.civicplus.com/DocumentCenter/View/103). The City of Buda amended its UDCP in early 2012, as did the other nonexempt permittees, to comply with 2011 amended requirements of the District's Rules and Bylaws, which called for enhanced curtailments or reductions of 40% of permitted pumpage during a District-declared Exceptional Stage Drought. The District amended its Rules again in October 2012, requiring even greater curtailment to 50% of permitted pumpage during a District-declared Emergency Response Period to implement a prospective HCP measure and to achieve the newly established Desired Future Condition of the Aquifer (described in Section 6.2.1.8). All permittees will be required to amend their UDCPs again to accommodate that new maximum curtailment which will become effective two years after the Rules were adopted, viz., October 11, 2015. In the example here, the City of Buda is in the process of developing a plan and amending its UDCP accordingly prior to the 2015 effective date.

There are two primary types of individual production permits for nonexempt wells: Historical Production Permits, and Conditional Production Permits. Each type has very different impacts on the habitats of the Covered Species.

Table 4-2. Mandatory curtailment of water withdrawals for different well permit types, aquifers, and drought conditions. (Curtailment expressed as percent of authorized monthly water production in designated drought stage**.)**



Drought Curtailment Chart

	Aquifer	Edwards Aquifer						Trinity Aquifer			
	Management Zone	Eastern/Western Freshwater					Saline	Lower	Middle	Upper	Outcrop
	Permit Type	Historical	Conditional				Hist.	Hist.	Hist.	Hist.	Hist.
			Class A	Class B	Class C	Class D					
Drought Stages	No Drought	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Water Conservation (Voluntary)	10%	10%	10%	10%	10%	0%	10%	10%	10%	10%
	Alarm	20%	20%	50%	100%	100%	0%	20%	20%	20%	20%
	Critical	30%	30%	75%	100%	100%	0%	30%	30%	30%	30%
	Exceptional	40%	50%[1]	100%	100%	100%	N/A	N/A	N/A	N/A	N/A
	Emergency Response Period	50%[3]	>50%[2]	100%	100%	100%	N/A	N/A	N/A	N/A	N/A

Percentages indicate the curtailed volumes required during specific stages of drought.

[1] Only applicable to NDUs and existing unpermitted nonexempts after A to B reclassification triggered by Exceptional Stage declaration

[2] Curtailment > 50% subject to Board discretion

[3] ERP (50%) curtailments become effective October 11, 2015. ERP curtailments to be measured as rolling 90-day average after first three months of declared ERP.

Wells with Historical Production Permits

Withdrawals from existing wells that were nonexempt and registered with the District as of September 9, 2004, were designated with Historic-use Status and authorized under permits designated as Historical Production Permits. A large majority of the authorized withdrawals from the Aquifer are authorized under such permits. Withdrawals under Historical Permits are required to curtail monthly pumpage by 20, 30, and 40 percent during Stage II-Alarm, Stage III-Critical, and Stage IV-Exceptional Droughts, respectively, and after October 11, 2015, by 50% during a Board-declared Emergency Response Period (these groundwater drought status terms are defined and discussed in Appendix D, and the curtailment program is summarized in Table 4-2 above). Historical Permits amended after September 9, 2004, to increase authorized withdrawals from the Aquifer, as well as all new production permits after that date have groundwater production that is subject to conditional-permitting rules for the increase (see immediately below).

Wells with Conditional Production Permits

Withdrawals from wells that received initial permits or existing Historical Permits that have been amended to increase authorized withdrawals after September 9, 2004, were authorized under permits designated as Conditional Production Permits. This date was established by the Board following the findings and conclusions of the District's Sustainable Yield Study, as discussed in Section 3.1.2 above. The distinction from Historical Production Permits is important, because unlike those permits, withdrawals under Conditional Production Permits are authorized by the District only on an interruptible-supply basis. That is, the water supply under that permit is authorized only on the condition that the allowed monthly production will be increasingly curtailed during prolonged groundwater drought, up to and including complete cessation of pumping during extreme drought (see Table 4-2 above). These permits have UDCPs that provide for mandatory pumpage curtailments of 50, 75, or 100 percent of their authorized monthly usage during deepening stages of declared droughts. The District has further categorized Conditional Permits by whether they initially existed or were in processing on April 27, 2007 (Class A Conditional Permits), or after that date but before March 24, 2011 (Class B Conditional Permits), or on or after March 24, 2011 (Class C Conditional Permits). Class B and Class C Conditional-use Permits have an accelerated curtailment schedule during drought; certain Class As will be permanently converted to Class Bs upon declaration of a Stage IV-Exceptional Drought. All conditional production wells are expected under their permit terms to have ceased pumping during Stage IV-Exceptional Drought or deeper drought, which is the drought condition that is of most concern to the sustainability of the Covered Species.

4.1.2 Historical Perspective of the Covered Activities

4.1.2.1 Evolution of the Regulatory Program

The groundwater drought of the 1950s, which actually began in 1947, has become the reference period for water resource planning in most of Central Texas. This drought of record

(DOR) signified that both surface-water and groundwater management programs needed to incorporate drought management as a principal goal. In the ITP Area, the DOR produced the lowest recorded flows at Barton Springs, with the lowest measured daily flow of 9.6 cfs and the lowest average monthly flow of 11 cfs. At that time, most water supplies in the area came from surface water; the USGS estimated that average groundwater use of the Barton Springs segment of the Edwards Aquifer then was only 0.66 cfs (Slade et al., 1986). So the lowest total monthly discharge from the Aquifer during the DOR was about 11.7 cfs.

But the area has grown rapidly since then and much of the new development was beyond the reach of the centralized surface water supply systems of the City of Austin or the Lower Colorado River Authority (LCRA). The Aquifer provided a readily accessible, high-quality, and cheap source of water for the area, and its use by individual residential users, developments, and smaller suburban cities increased rapidly. But there was no authority that could implement a drought management program that could protect the water levels in the Aquifer or the springflow at Barton Springs.

When the District was formed in 1987, there was no restriction of any kind on pumping from the Aquifer, or any other groundwater in the region. In fact, it was concern over that fact that led to the creation of the District. The District put into place its initial permitting program in 1989, which became fully implemented in 1990. This program was successfully used to identify and regulate pumping within the District, including notably a relatively novel drought management program with curtailments of up to 20% relative to normal, authorized use and based on declared drought stages (although those stages were then defined differently than now). But after a decade or so, the amount of water being pumped from the aquifer to serve the fast-growing area on the then-southern fringe of Austin had increased to the point where it created concern about its impact on Barton Springs during a recurrence of an extreme drought like in the 1950s. The District undertook a study (Smith and Hunt, 2004) based on the best science then available to ascertain the sustainable yield of the aquifer, and somewhat alarmingly discovered that during a recurrence of the DOR, the volume of water then authorized to be withdrawn from the aquifer, if un-curtailed, would cause almost one-fifth of the wells in the District to experience yield problems and Barton Springs flow would be reduced to near zero (Smith and Hunt, 2004).

These findings confirmed the need for changes in the District's regulatory and drought management program and, further, the need for even more accelerated and larger curtailments. It also marked the end of the first generation groundwater management program that is denoted herein as the "Pre-HCP Program." That program comprised no upper boundary on the total amount of pumping under permit, and the drought curtailments were linked to percentiles of monthly flow at Barton Springs, with no curtailment above the 50th percentile (51 cfs); 10% curtailment below the 50th percentile; 20% curtailment below the 25th percentile (30 cfs); and 30% curtailment at or below 10 cfs (which of course has only been reached during the DOR). In practice, little enforcement of these curtailment limits actually occurred, and the actual curtailments were likely considerably smaller while the amount of pumping grew steadily. A more effective drought management plan became a priority in the early 2000s.

The need for additional resources to help define the new drought management program and its ecological benefits led to several consultations with the Service and eventually to the first HCP grant awarded to the District in 2004, marking the initial phase of the HCP. This work produced a more rigorous and meaningful drought trigger methodology and a more rigorous and stringent drought management program that was based on the imposition of a junior-senior permitting scheme that included conditional-use permits with interruptible production, as well as a preliminary integrated HCP and Environmental Impact Statement (EIS) document. Significant droughts in 2006, 2008-2009, and 2011 provided the impetus for a series of amendments to the permit-based drought rules, such that the drought management program became one of, if not the most stringent in the state. This regulatory program was developed under the Texas Open Meetings Act and in accordance with the statutory requirements for rulemaking, providing multiple opportunities for public and stakeholder input at each rulemaking step.

In the second phase of the HCP development, the pioneering experimental work concerning DO concentrations and salamander mortality (Poteet and Woods, 2007; Woods et al., 2010), funded by the District HCP and described in more detail in Section 5.2.1 of this document, strongly suggested that the discharge from Barton Springs needed to be still higher, and therefore the pumping less than what could be achieved by the then-current regulatory program. This result informed the District's 2010 recommendation to the Groundwater Management Area (GMA) 10 joint regional planning committee for a new, statutorily mandated set of groundwater planning objectives called Desired Future Conditions (DFCs) of the Aquifer that a consensus of the GMA considered to be protective of the Aquifer, both as a water supply and as habitat for the Covered Species, and to be achievable (see TWDB (2014). The Aquifer now has two DFCs: (1) an effective upper limit of 16 cfs on all pumping from the Aquifer, so groundwater production would not unacceptably accelerate the Aquifer into drought; and (2) maintenance of springflow that is not less than 6.5 cfs during a recurrence of conditions like those of the DOR, meaning that total withdrawals from all wells in the Aquifer during those times needed to be no more than 5.2 cfs on an average annual basis. The District's then-current regulatory program, which was developed after numerous informative consultations with other advisory groups and stakeholders, could produce a minimum of 6.7 cfs of pumping, rather than the 5.2 cfs needed.

The 1.5 cfs "gap," which is the difference between the modeled maximum 5.2 cfs of averaged annual pumping that could be allowed during DOR-like conditions and the 6.7 cfs authorized under the regulatory-mandated curtailment program at the time of the study was then addressed in a stakeholder process, which culminated in late 2012 with the phased measures that were incorporated or to-be incorporated into the current regulatory-based drought management program, along with a commitment to promote the long-term development of alternative supplies when and where feasible and where such supplies would provide benefit to management of the Aquifer during extreme drought. The District anticipates that this level of curtailment, while very stringent, will be able to be achieved on an aggregate basis within the next three years; currently (2014) the gap has already been reduced to 0.5 cfs. This confidence that it will be completely closed is based on ongoing efforts to encourage the retirement of currently permitted historical production; new rules requiring higher levels of curtailment if a DOR-level drought should recur; new rules incentivizing higher curtailments during extreme drought in exchange for proportional increases in permitted production during non-drought; historical experience with some permittees that voluntarily substitute available alternative supplies for authorized Aquifer production during severe drought; right-sizing provisions; as warranted, utilization of improved aquifer modeling to account better for all recharge sources, including urban recharge; and the District's and permittees' continuing efforts to develop and extend alternative supplies to historical-production permittees. On the other hand, it is now judged by District hydrogeologists as extremely unlikely that a recurrence of DOR-like conditions would be reached before the 2015 implementation date, when the key new rules would become effective and enforceable and permittees will have had an opportunity to take advantage of substitution incentives. Additional alternative supplies may help assure that outcome, but that will depend on the commitments of the individual permittees as much, if not more than the District. In aggregate, this robust and stringent regulatory program constitutes the groundwater management scenario denoted herein as the "HCP Program."

The small gap of less than 0.5 cfs that currently remains is expected to be bridged by the issuance date of the ITP, with or without factoring in the difference between smaller actual pumpage typically realized in aggregate and the authorized pumpage used in calculating the gap; this difference has routinely accompanied even severe droughts. As necessary and at the Board's discretion, some additional rulemaking and policy development, both currently undefined, as well as individual, stop-gap Board Orders may also be used, providing assurance that the gap will be closed and the springflow-based DFC will be achieved in the future.

In 2011, the Texas Legislature passed Senate Bill 332, reinforcing the private property ownership of groundwater in place and also requiring that groundwater conservation be balanced by producing the maximum amount of water feasible. Then the Texas judicial system issued two decisions, one by the Supreme Court in mid 2012 in *EAA v. Day* (369 S.W.3d 814 (Tex. 2012)) and another by the 4th Appellate Court in early 2013 in *EAA v. Bragg* (No. 04–11–00018, 2013 WL 5989430 (Tex. App.—San Antonio, November 13, 2013)), that held unequivocally the possibility of compensable regulatory takings by groundwater regulation, even if a groundwater conservation district (GCD) is acting fairly and within its authority and rules. These two cases and their implications for groundwater management are discussed in more detail in Section 7.2.1.7 of this HCP.

4.1.2.2 Changes to Pre-HCP Baseline

Taken together, the internal and external developments in 2011-2013 described in the preceding subsection indicate the District may now be (or soon will be) essentially at the practical limit of what it can legally and statutorily accomplish with its regulatory-based demand reduction program, without incurring potentially catastrophic legal and financial risks associated with compensable regulatory takings. The District considers this program as currently proposed to represent minimization and mitigation "to the maximum extent now practicable," subject to possible future changes via statutory and adaptive management processes. The Service will consider and determine what is practicable in its Findings documentation as part of its intra-Service consultation process.

The beneficial effect that the District's drought-management regulatory program has on springflows in the context of total springflow is shown in Figure 4-2. The figure depicts calculated hydrographs of discharges at Barton Springs for the current (2014) nonexempt pumpage now authorized by the District (11.6 cfs) and as regulated alternatively by the two groundwater management scenarios, viz., before and after the HCP measures were in place. It also includes a comparison to the springflows that would have existed at the time only with the small amount of groundwater withdrawals from exempt wells, designated as the "No (Nonexempt) Pumping" scenario. The blue line in the figure presents a synthetic hydrograph at Barton Springs for the period from 1917-2013, which includes the DOR in the 1950s, that excludes the effects of nonexempt pumpage that actually occurred each month during this period; this approximates what the springflows would have potentially been with only exempt use of the Aquifer. The red line shows how the hydrograph would have changed by regulating permitted pumpage only with the curtailment program as it existed up to 2004, when the District's conditional permitting program was instituted and the HCP development project was initiated. (At that time, there was 10.2 cfs of authorized-nonexempt use; with 0.45 cfs of exempt use, total withdrawals were about 10.6 cfs). The green line corresponds to the hydrograph that reflects a regulatory program with the full complement of proposed HCP measures in place.

To facilitate comparison, both the Pre-HCP and the HCP measures in Figure 4-2 are applied to the same amount of pumpage, viz., the 11.6 cfs that comprises the current year's (2014's) pumpage under permit. As noted above, each of those scenarios restricts pumping during drought in different ways and to different degrees, which in turn affect springflow differently. However there is another important distinction between the two pumpage scenarios that is not reflected in the graphs of Figure 4-2. The two scenarios would place substantially different management restrictions on the total amount of water that ultimately could be authorized to be withdrawn from the Aquifer in the future.

In the Pre-HCP pumping scenario, there would be essentially no upper limit on the amount of water that could be authorized to be withdrawn from the Aquifer to meet demand, which of course would accelerate the onset of drought conditions within the Aquifer and also reduce springflow even further during future droughts even with the Pre-HCP curtailments. For example, Scanlon et al. (2001), citing projections in the Region K Plan, indicated that by 2050, unregulated Aquifer use would increase to 210% of what it was in 2000, or about 19.6 cfs without effective limitation, even during a DOR recurrence. Without the District's current and proposed regulatory program, the growth in *total* pumpage from the Aquifer would have continued to be largely unchecked during the course of the ITP.

The proposed HCP program provides a regulatory mechanism to restrict the total amount of water authorized to be withdrawn from the Aquifer in the future, while providing for increased use of the Aquifer only during non-drought conditions. Only the proposed HCP program's management scheme has an upper limit on the amount of authorized pumpage, at 16 cfs, which has been established by the District Board to be an acceptable level of acceleration into drought, viz., approximately one month. The Pre-HCP program imposes no such cap. Only the HCP program differentiates that part of the water supply that is

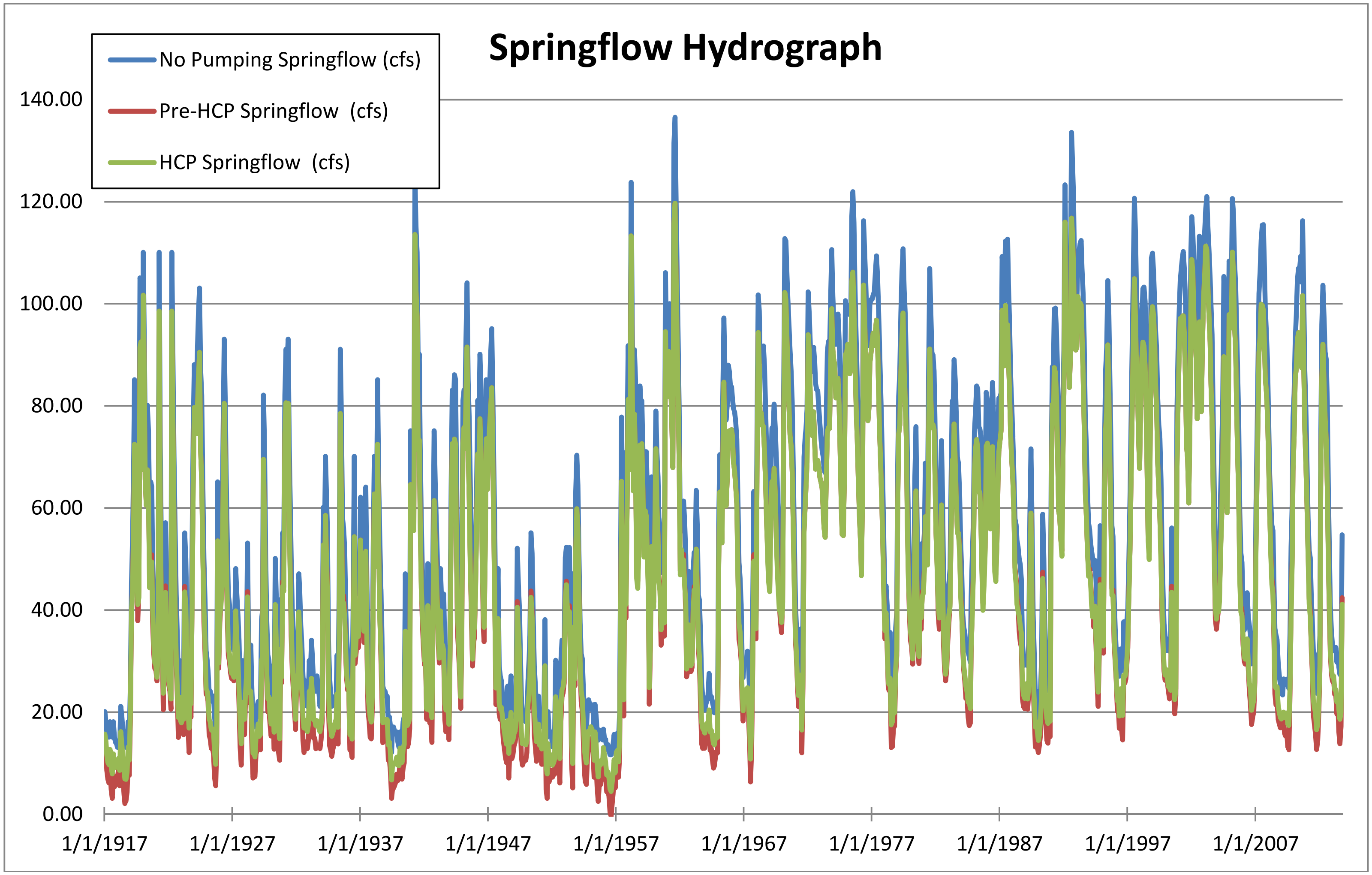


Figure 4-2. Computed hydrographs of Barton Springs flow from 1917 to 2013, comparing the effect of two groundwater management scenarios relative to the springflow that would have existed with no nonexempt pumping**.** The benefit of the HCP pumping scenario is clearly seen, and is most effective in preserving springflow at the lower Barton Springs discharges, when the Covered Species are most stressed by extreme drought conditions.

interruptible (all authorized pumpage greater than 10.6 cfs), which is subject to accelerated curtailment up to and including complete curtailment, from that part of the supply (up to 10.6 cfs authorized under permit) that is not interruptible but subject to curtailment that provides a minimum firm-yield supply during extreme drought. Thus, the proposed HCP program has an assured regulatory limitation on all pumpage to only 5.2 cfs (including 0.5 cfs of exempt use) during a DOR recurrence, even inthe future. The Pre-HCP program does not. These differences signify that the graph in Figure 4-2 for the HCP Scenario does not depend on what additional total pumpage is authorized, while the springflows under the Pre-HCP Scenario may be further reduced from those shown in the figure, especially during severe drought.

4.1.3 Statutory and Regulatory Authorities for Covered Activities and Integrated Conservation Measures

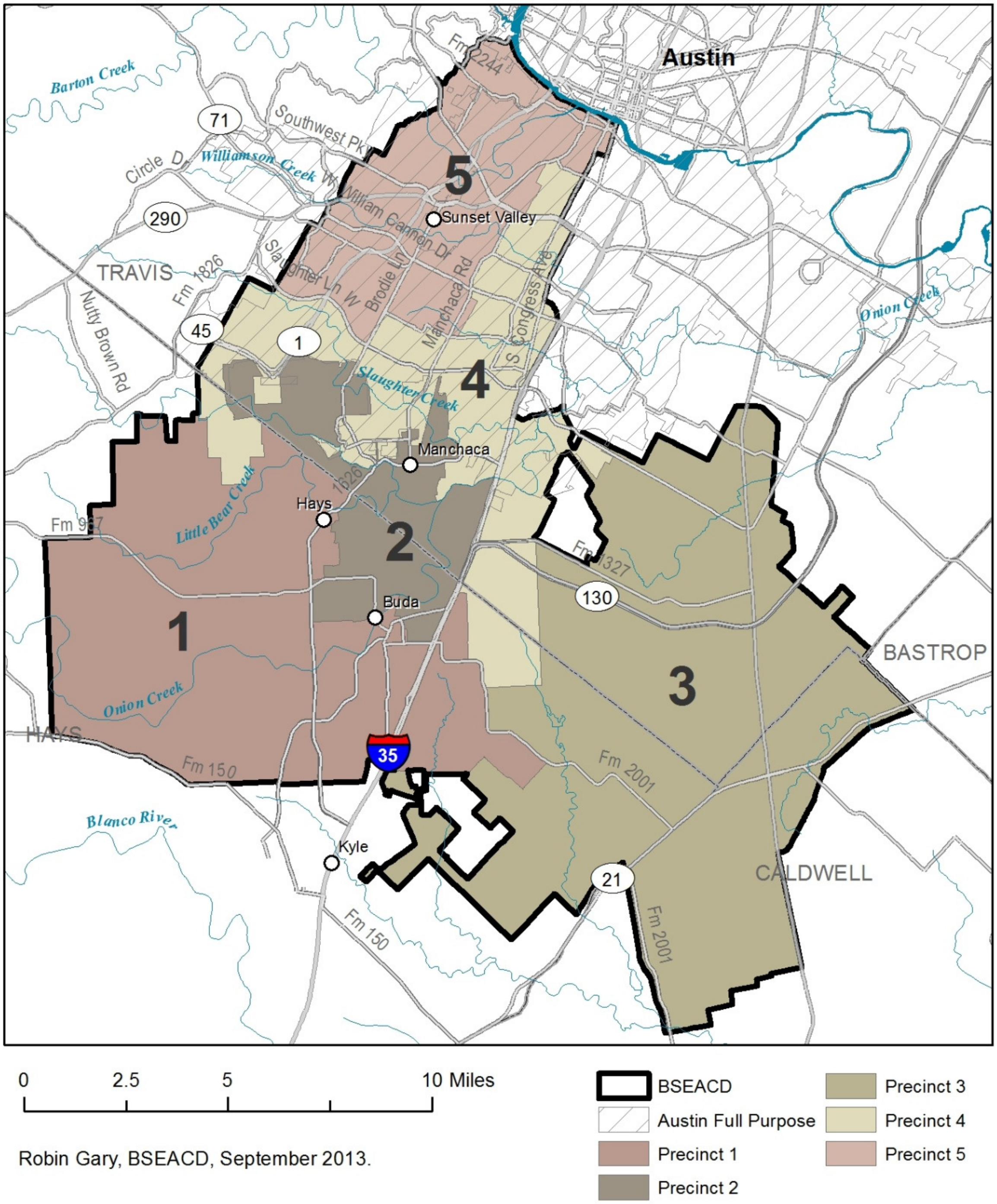
The District's statutory authority and purpose are to preserve, conserve, and protect the groundwater resources of the District. A principal dimension in meeting this legislative charge is implementation of a regulatory program to manage the withdrawal of groundwater from the Aquifer during both drought and non-drought conditions. The District HCP relies on this authority, as elaborated in this section.

The powers vested in the District stem from the laws enacted by the State of Texas, namely Senate Bill 988, 70th Regular Session, the District's enabling legislation now codified in the Special District Local Laws Code, Chapter 8802, Barton Springs Edwards Aquifer Conservation District; and the Texas Water Code, Chapter 36. Chapter 36 is the over-arching statutory authority for virtually all GCDs in Texas.

Except as specifically altered by the supervening statutory authority of enabling legislation, Chapter 36 establishes how groundwater is managed and administered by GCDs. Additional and revised authorities and requirements affecting the District were enacted by the Texas Legislature in Senate Bill 1212 (71st Session), Senate Bill 1 (74th Session), Senate Bill 2 (77th Session), House Bill 1763 (79th Session), Senate Bill 3 (80th Session), Senate Bill 747 (80th Session), and Senate Bill 433 (82nd Session).

The District is governed by a five-member Board of Directors, elected by the voters in five single-member precincts (Figure 4-3.) The internal precinct boundaries may change through redistricting with any change in the external boundaries or with each decennial census. Upon decennial redistricting, no more than two of the precincts can have any part be within the then-current (full purpose) municipal limits of the City of Austin, with its utility's service area provided solely by surface-water. Such redistricting is a normal, expected part of the District's governance and changes in director precinct boundaries are neither Changed Circumstances under the HCP nor proposed to require ITP amendment. Each elected Board ensures the management and policies of the District, including its groundwater management program, are aligned with local interests and are sworn to comply with all applicable federal, state, and local laws, which will include the prospective ITP and HCP.

Under its statutory powers, the District's Board has adopted and from time to time amends a set of Rules and Bylaws (BSEACD, 2012), under which it has registered essentially all known wells and has permitted those certain wells that are subject to its jurisdiction and are not exempted from permitting by law or rule. Rule changes that support or are otherwise not inconsistent with the biological goals and objectives of the District HCP in Section 6.1 of this



Robin Gary, BSEACD, September 2013.

Figure 4-3. BSEACD director precinct boundaries. Board members are elected by popular vote of all residents within their single-member precincts.

document are also proposed to be neither Changed Circumstances nor a requirement for an amended ITP. Important to the success of the HCP is the fact that some 95% of the groundwater withdrawn from the Aquifer is nonexempt and therefore actively managed under District permit authorizations.

The production limits now imposed on wells in the District have been adopted and implemented in an effort to protect groundwater resources and reduce drought-stage groundwater production, to sustain water supplies for its permittees and to maintain springflow at Barton Springs, to the maximum achievable extent, subject to the limits of state law. The most current set of Rules and Bylaws pertaining to Barton Springs flow can be found on the District's website under the tabbed menu heading, "About Us/Governing Documents" (http://www.bseacd.org/about-us/governing-documents/); information on the permitting program and other regulations applicable to the Barton Springs segment of the Edwards Aquifer is under the "Regulatory Program" menu (http://www.bseacd.org/regulatory/).

The Rules and Bylaws are adopted in accordance with the District Management Plan (BSEACD, 2013), which is reviewed, revised as warranted, and readopted at least every five years; it was most recently amended and adopted by Board Resolution on September 27, 2012, and approved by the TWDB on January 7, 2013. (The Management Plan, in turn, is prepared in accordance with Texas Water Code, Chapter 36, Section 1071, and TWDB requirements under Texas Administrative Code, Chapter 356, Sections 5 and 6.)

The District's authority mainly relates to groundwater quantity; it has only limited and indirect authority to protect groundwater quality. Its ability to offer such protection derives primarily from its authority to avoid and minimize waste of groundwater, which by definition includes contamination or pollution of water that is within or recharges the Aquifer and that harmfully alters the character of the groundwater.

As a practical matter, most groundwater quality protective measures are afforded by other regulatory entities with more explicit authority to regulate land-use activities, even for groundwater within the District's jurisdictional area. The programs and entities that are involved in groundwater quality protection are discussed in more detail in Appendix H.

4.1.4 Public Participation in Developing the Covered Activities and Integral Conservation Measures

As a political subdivision of the State of Texas, the District is obligated to operate in a highly transparent fashion and to routinely involve the public in its normal business operations, with only a few statutorily prescribed exceptions. Further, the "Five Point Policy" developed by the Service as recommendations and guidance in developing HCPs prescribes "opportunities for public participation" as one of the five elements.

During the time period in which this HCP was being developed, the District held more than eighty (80) Board meetings, including work sessions, in which the HCP was specifically identified as a discussion item on the agenda. These were all public meetings under the Texas Open Meetings Act, with agendas posted with the Texas Secretary of State (until September 2011), at county courthouse bulletin boards, and at the District office typically six days (and no less than 3 days) in advance of the meeting. With few exceptions, all of these Board meetings offered opportunity for public comment and participation as desired on the ongoing HCP evolutionary process, including consideration of both the regulatory program and the proposed conservation measures, and their documentation. The HCP has had a webpage on the District website since 2007, which has been utilized as a communication vehicle for HCP project progress and documentation.

The District has provided additional opportunities for structured participation by stakeholders and the public, and it has utilized perspectives of other knowledgeable members of the scientific community in developing the HCP:

- During the active investigation and development stages of the HCP, the District used from time to time several external advisory groups to assist the District's efforts, including:
    (a) a hydrogeological/technical advisory committee, in the evaluation of aquifer drought management options and drought trigger methodologies;
    (b) a biological/technical advisory committee, in the planning and monitoring of needed research on stressor-responses, the effectiveness of potential conservation measures, and the assessment of residual harm to salamander organisms and populations;
    (c) two topical stakeholder advisory committees on the efficacy of (1) options for stringent conservation measures that would take effect during extreme drought, and (2) options for the District to promote development and use of alternative water supplies; and
    (c) a public/stakeholder advisory committee, in determining the scope of the HCP, recommending possible avoidance, minimization, and mitigation measures, providing a forum for public discourse on HCP development and progress, and building consensus where possible.

  These advisory groups each met many times during the course of the HCP development, and nearly all of the meetings, which typically were attended by one or more District directors as well as staff, were posted as Texas Open Meetings, with publicized agendas and were open to the public at-large.

- In the latter stages of the HCP development and documentation, the District voluntarily established, utilized, and intends to continue using a standing <u>Management Advisory Committee</u> (MAC, or Committee) of experts, stakeholders, and private citizens to provide independent initial reviews and annual assessments of the HCP and the progress being made toward the HCP goals, and to identify and evaluate additional minimization and mitigation measures or modification to existing ones that appear warranted, making appropriate recommendations to the

District Board on a periodic basis. This Committee is an integral part of the District's continuous improvement process and adaptive management.

The Committee was formed by the Board in February 2013; its functions are characterized and its members are identified in Section 6.5.1.2. In effect, the MAC is the continuing advisory vehicle for the previous advisory groups, and quite a few of the MAC members earlier participated in one or more of those advisory groups during the HCP's active development. In addition to their prospective involvement in the annual review and reporting process, the District also used the Committee members to review and comment on preliminary drafts of the HCP before it was submitted as part of the ITP application, and to help the District (and the Service) respond to public and agency comments on this HCP, to ensure that responses address stakeholder and public needs. The MAC meetings are also posted as Open Meetings for encouraging public participation.

4.2 Requested Permit Duration

The proposed ITP for the District would be issued for a term of twenty (20) years and be renewable thereafter, subject to administrative procedures extant at that time.
Local, regional and state water-resources planning entities in Texas are mandated to use a 50-year time horizon for almost all water resource planning functions, ranging from the establishment of DFCs of a groundwater reservoir managed by a GCD, including the Aquifer, to the regional and statewide water resource planning programs of the TWDB. Water supply strategies are required to supplement the firm-yield supply available during a recurrence of the DOR within that planning horizon. In the HCP Planning Area, the DOR is the decade-long drought from1947-1956 (using the District's drought trigger definitions discussed in Section 4.1.1.2), and Cleaveland et al. (2011) has used tree-ring data and dendrochronological analysis to estimate that a decadal drought like the DOR has a recurrence interval in the HCP Planning Area of about 100 years. Conversely, the effects of climate change are just now being elucidated, especially at the regional level, but it is already clear that they may have a profound impact on drought management imperatives; that consideration may be particularly important to the habitat of the Covered Species, suggesting the advisability of a shorter permit term. A term of 20 years represents a rational balance between these two countervailing factors.

The groundwater management plans, regulatory strategies, and tactical measures used by water-resource management agencies like the District are continuing functions, requiring periodic updating through the course of longer-term planning horizons. As specified in Sections 6.3.2, 6.4, and 6.5.1 of this HCP, the measures to be implemented by the District to minimize or mitigate the impacts of take will be reviewed periodically throughout the term of the ITP and beyond. Since the ITP relates to an ongoing groundwater management program, it is the District's intent to apply for its renewal, amended as appropriate, near the end of the initial term.

5.0 Analysis of Impacts Likely to Result from the Taking

5.1 Covered Species

This HCP proposes incidental take coverage for two endangered species, Barton Springs salamander (*Eurycea sosorum*), listed as endangered in 1997, and Austin blind salamander (*E. waterlooensis*), listed as endangered in 2013. Both of these species are known only from the springs and outlets of the Barton Springs complex of the Edwards Aquifer. This section describes each species and provides information on life history, distribution, threats and reasons for decline, and the survival needs for each species in individual descriptive subsections. The following Section 5.2 assesses the taking of these Covered Species by the Covered Activities and its consequences.

The descriptions in the following subsections draw from several sources compiled by biologists with expertise in the Covered Species, especially the Barton Springs salamander --its life history, population characteristics, habitat, and the influences that may cause incidental take. Three of the principal sources referred to in this section include the Barton Springs Salamander Recovery Plan (Service, 2005); the Service's final rule that listed the Austin blind salamander (Service, 2013b); and the City of Austin's Amended Barton Springs Pool Habitat Conservation Plan (City of Austin, 2013.) Citations to the primary sources are made, as well as to the above referenced secondary sources.

5.1.1 Species Descriptions and Life Histories

5.1.1.1 Barton Springs Salamander

The Barton Springs salamander (Figure 5-1) is a member of the Family Plethodontidae (lungless salamanders). Texas species within the genus *Eurycea* inhabit springs, spring-runs, and water-bearing karst formations of the Edwards Aquifer (Chippindale et al., 1993). They are aquatic and neotenic--they retain larval, gill-breathing morphology throughout their lives, and do not metamorphose and leave water. Instead, they live in water throughout their life cycle where they mature and reproduce. The species was first collected from Barton Springs in 1946 (Brown, 1950, Texas Natural History Collection specimens 6317-6321) and formally described in 1993 (Chippindale et al.). This species has been a continuing focus of various studies by the biologists of the City of Austin's Watershed Protection Department for more than a dozen years; these studies have been conducted both in the field around the spring outlets and in the specialized salamander laboratory/refugium operated by the City. Documentation of most of these studies is found in the City's approved HCP (City of Austin, 2013).

Figure_5-1. Above: *Eurycea sosorum*, Barton Springs salamander; Below: *E. waterlooensis*, Austin blind salamander (City of Austin, Watershed Protection Dept)

Adults reach about 2.5 to 3 inches (63-76 mm) in total length. The coloration on the adult salamander's upper body varies from light to dark brown, purple, reddish brown, yellowish cream, or orange. The characteristic mottled salt-and-pepper color pattern on the upper body surface is due to brown or black melanophores (cells containing pigments called melanin) and silvery-white iridiophores (cells containing pigments called guanine) in the skin. On either side of the base of the head is a set of three feathery gills that are bright red (Service, 2005).

Juveniles closely resemble adults (Chippindale et al., 1993). Newly hatched larvae are about 0.5 inch (12 mm) in total length and may lack fully developed limbs or pigment (Chamberlain and O'Donnell, 2003).

The Barton Springs salamander is more closely related to the San Marcos salamander than either the Austin blind or Texas blind salamanders (Hillis et al., 2001).

The Barton Springs salamander is carnivorous and appears to be an opportunistic predator. Known prey items include ostracods, chironomids, copepods, mayfly larvae, amphipods, oligochaetes, and planarians (Chippindale et al., 1993; Gillespie, unpublished data). An analysis of the gastro-intestinal tracts of 18 adult and juvenile Barton Springs salamanders and fecal pellets from 11 adult salamanders collected from Eliza Springs, Barton Springs Pool, and Old Mill Springs were most commonly found to contain ostracods, amphipods, and chironomids (City of Austin, 2013).

Gravid females, eggs, and larvae of Barton Springs salamander are typically found throughout the year in Barton Springs, which suggests that the salamander can reproduce year-round (Hillis et al., 2001). It is hypothesized that the Covered Species lay their eggs in the aquifer below the surface because only a few eggs have been found in the wild. The eggs hatch in 3-4 weeks. Hatchlings are about half an inch total length (snout to tip of tail), often still with yolk sacs and limb buds. Juvenile Barton Springs salamander become sexually mature at about 11 months (43-50mm total length) and grow to about 3 inches total length as adults (City of Austin, 2013). In captivity, Barton Springs salamander has been observed reproducing to an age of at least eight years (City of Austin, 2013).

Observations of courtship among captive pairs of Barton Springs salamanders (Chamberlain and O'Donnell, 2003) are consistent with Arnold's (1977) description of the tail-straddling walk which is a behavior unique to plethodontid salamanders (Service, 2005). Females of some salamander species may store spermatophores for up to 2.5 years before ovulation and fertilization occur (Duellman and Treub, 1986). In 2001, a captive Barton Springs salamander female laid viable eggs one month after being isolated, which indicates that females of this species can store sperm for at least this length of time (Chamberlain and O'Donnell, 2003).

Since the City of Austin began surveying salamanders in 1993, very few eggs have been found in the wild. The first egg was found detached near a spring orifice in Sunken Gardens Springs in May 2002. The other three eggs were found near spring orifices in Barton

Springs Pool (December 2002, May and August 2003) (City of Austin's Dee Ann Chamberlain, City of Austin, pers. comm., 2003). Hatching of eggs in captivity has occurred within 16 to 39 days after eggs have been laid (Chamberlain and O'Donnell, 2003). Hatching success in captive Barton Springs salamanders may be highly variable as indicated by hatching rates of 0 to 100 percent that have been reported by the City of Austin (Chamberlain and O'Donnell, 2002, 2003). Egg mortality has been attributed to fungus, hydra (small invertebrates with stinging tentacles), and other possible factors such as infertility (Service, 2005).

Eggs are laid by female salamanders one at a time and receive no parental care. Although a female can lay a single egg in minutes, the entire egg-laying event may take several hours, depending on clutch size (Chamberlain and O'Donnell 2003). Biologists associated with the City of Austin's captive breeding program have observed clutch sizes ranging from 5 to 39 eggs with an average of 22 eggs as based on 32 clutches (Chamberlain and O'Donnell. 2003, City of Austin, unpublished data).

City of Austin biologists have generally found the first three months following hatching to be a critical period for juvenile survival (Chamberlain and O'Donnell, 2003). Newly hatched larvae have a yolk sac to sustain their nutritional needs in the early days after hatching. Larvae feeding on prey items have been observed 11 and 15 days after hatching (Lynn Ables, Dallas Aquarium, pers. comm., 1999). Although reproduction has occurred in captivity, it has been sporadic. No consistent methods or techniques have been found to enhance egg production (Service, 2005).

At times, females have held eggs for over a year before the eggs are either laid or reabsorbed. City of Austin biologists believe that stable environmental conditions, water quality, adequate space, habitat heterogeneity, and food availability may influence egg laying (Chamberlain and O'Donnell 2003). Providing substrates that have a rough surface (not smooth like glass) may facilitate successful spermatophore deposition and transfer (Service, 2005).

The life span of the Barton Springs salamander in the wild is unknown. Assuming that collected salamanders were at least one year old when collected, reported longevity for individual Barton Springs salamanders in captivity is at least 10 years (Service, 2005).

Other than gas bubble trauma (see Service, 2005, section 1.6), only a few physiological anomalies have been reported in the wild for the Barton Springs salamander. They include an infection of one male adult and possibly one gravid female with immature trematodes (Chamberlain and O'Donnell, 2002), an unknown myxosporidian parasite, and bacteria in the genera of *Aeromonas* and *Pseudomonas* that have affected salamanders in captivity (Chamberlain and O'Donnell 2003). It is not known whether these pathogens are present in the spring habitats of the salamanders or what threat they may pose to salamanders in the wild (Service, 2005).

Predation on Barton Springs salamanders in the wild is probably minimal when adequate cover is available for salamanders to hide from predators. Most of the potential predators that are native to the Barton Springs ecosystem are opportunistic feeders. Crayfish (*Procambarus clarkii*) and other large predatory invertebrates may prey on salamanders or salamander larvae and eggs (Gamradt and Kats, 1996). Predatory fish found at Barton Springs include mosquitofish (*Gambusia affiinis*), longear sunfish (*Lepomis megalotis*), and largemouth bass (*Micropterus salmoides*). Mexican tetras are non-native fish and are aggressive generalist predators that are occasionally found in Barton Creek, Barton Springs Pool, Upper Barton Springs, and Old Mill Springs (Service. 2005); they are reasonably inferred to be potential predators, but no observations of such predation on the salamander have been reported. The City of Austin (2013) also reports that the two *Eurycea* species at Barton Springs may opportunistically prey on one another.

The sex, age, and number of individuals of the Barton Springs salamander are not precisely known because the population is believed to be small and the habitat is underwater and from time to time subterranean, so some of it is inaccessible under any circumstances, making the species not reliably surveyable at any one time. As mentioned, the population size varies in a more or less cyclical fashion in response to natural variations in resources and environmental conditions. Only long-term trends can be inferred from transect surveys of observable individuals, in association with recorded variations in climate, spring flow, dissolved oxygen, and other relevant factors influencing habitat (City of Austin, 2013, 2007b).

5.1.1.2 Austin Blind Salamander

The Austin blind salamander was formally described by Hillis et al. (2001). The Service provides a rather comprehensive description of this species and its ecological requirements in its recent listing rule (Service, 2013b), which is incorporated by reference into this section.

The Austin blind salamander (Figure 5-1) is also a member of the Family Plethodontidae (lungless salamanders), one of the several Texas species within the genus *Eurycea* that inhabit springs, spring-runs, and water-bearing karst formations of the Edwards Aquifer (Chippindale et al., 1993). It is closely related to the Texas blind salamander (*Eurycea* [formerly *Typhlomolge*] *rathbuni*), found in the southern segment of the Edwards Aquifer in San Marcos, Texas (Hillis et al,. 2001).

The Austin blind salamander averages about 2 inches in length (Service, 2013), so it is slightly smaller than its sympatric species. Other morphological characteristics that distinguish the Austin blind salamander from the Barton Springs salamander include eyespots covered by skin instead of image-forming lenses, an extended snout, fewer costal grooves, and pale to dark lavender coloration (Hillis et al., 2001). In June 2001, the Austin blind salamander was designated a candidate for listing as endangered or threatened (Service, 2005). The species was listed as endangered on August 20, 2013 (Service, 2013b).

The Austin blind salamander is also carnivorous and appears to be an opportunistic predator. There is evidence of partial overlap in diet composition and egg deposition sites of the Covered Species, which is indicative of selection for ecological niche-partitioning to reduce competition (Vrijenhoek, 1979; Pianka, 1983). Austin blind salamander is believed to feed mostly on blind amphipods and isopods found within the aquifer, but when they are at the surface of the springs, will also consume other small invertebrates (City of Austin, 2013). These factors can maintain genetic divergence between these species (Paterson, 1985).

The eggs hatch in 3-4 weeks.

The uncertainties and limitations of surveying to determine the sex, age, and number of individuals of the Austin blind salamander are not precisely known because the population is believed to be small and the dominant habitat is subterranean and aquatic (Hillis et al., 2001), so most of it is inaccessible under any circumstances, making the species not reliably surveyable at any one time. Accordingly, less is known about these parameters and therefore life cycle characteristics for Austin blind salamander than for Barton Springs salamander.

5.1.2 Species Distribution

5.1.2.1 Barton Springs Salamander

Both species are observed in the vicinity of the Aquifer's spring outlets, although the epigean Barton Springs salamander is more likely to be found at and near the subaqueous surface of the substrate, including submerged rock ledges and gravelly areas. Such areas at some distance from the immediate vicinity of the spring outlets and in spring runs, particularly after the City of Austin completes its spring-run restoration efforts, typically will have higher DO than the groundwater issuing from the Aquifer at the outlet itself, especially during lower flow conditions. This is important, in that some researchers (for example, Turner, 2007; Hillis et al., 2001) have suggested the salamanders appear to be able to migrate locally to areas of less stress (higher flow, higher water velocities, higher DO, more prey, fewer predators) in the Aquifer and in spring runs during certain times of even moderate drought. No Critical Habitat has been designated by the Service for the Barton Springs salamander.

The Barton Springs salamander is sympatric (occurs in the same or substantially overlapping range) with the Austin blind salamander (see discussion immediately below).

5.1.2.2 Austin Blind Salamander

The Austin blind salamander is sympatric with the Barton Springs salamander, probably in an incidental fashion. The Critical Habitat for Austin blind salamander, as designated by the Service (2013b), is depicted in Figure 5-2. Its range away from the spring outlets is in the subsurface, within the Aquifer, and is largely inferred from ranges reported for other similar species (Service, 2013b). Its presence and migration away from the spring outlets are implied by the Critical Habitat designation. Unlike Barton Springs salamander, Austin blind salamander has not been regularly observed at the non-perennial Upper Barton Springs. The hydrogeologic setting suggests the subterranean habitat close by the outlets is a complex, three-dimensional network of solution-enlarged openings, and because the

Barton Springs complex resurges water from both confined and unconfined portions of the Aquifer (Hauwert et al., 2004), different DO regimes likely exist in the nearby subterranean environment (Lazo-Herencia et al., 2011). While both species have been observed in the vicinity of the other spring outlets, Austin blind salamander is more likely to be in the subterranean portions of and between the outlets and in the dissolution cavities in the rock matrix underlying spring runs.

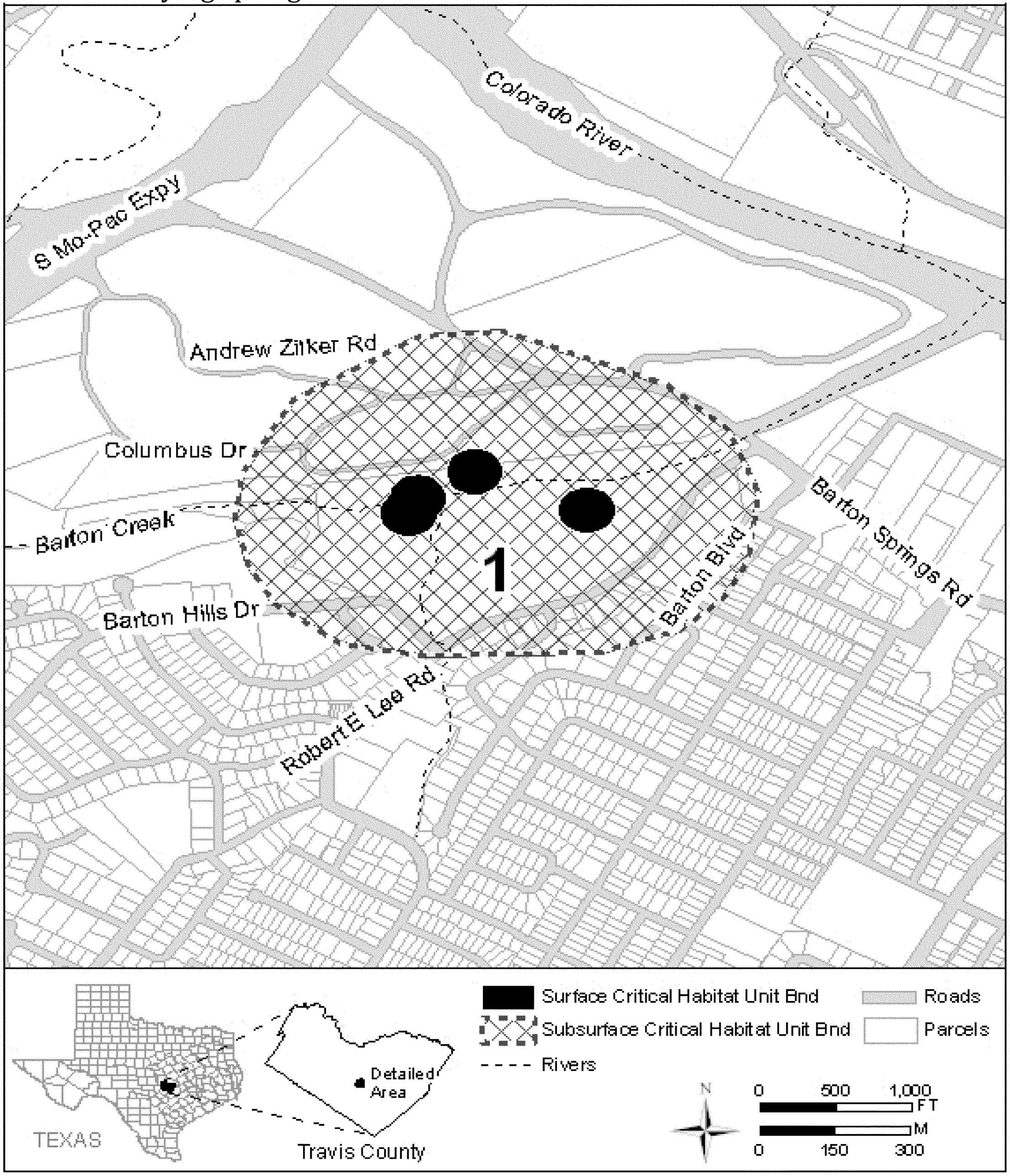


Figure 5-2. The Service-designated Critical Habitat for the Austin blind salamander has both surface and subsurface components. All of the surface habitat and most of the subsurface habitat, totaling about 120 acres, are within the City of Austin's Zilker Park and protected from future development. Source: Service, 2013a.

5.1.3 Reasons for Decline and Threats to Survival

The Service recently issued its final rulemaking on the Austin blind salamander (FR, vol. 78, no. 161, p. 51278 et seq.), which contains a rather comprehensive compendium of current information on, and analysis of stresses on and threats to, this species (Service, 2013b); it is incorporated herein by reference. Such a comprehensive assessment was not made in the much earlier listing process for Barton Springs salamander, but similar factors were identified and addressed in its Recovery Plan (Service, 2005).

In its listing rule, the Service has identified a relatively large number of specific stressors that are adversely affecting the Covered Species and that, either singly or cumulatively in combination, are reasons for decline and threats to survival of these species (Service, 2013b). These are summarized in Table 5-1, which also provides an indication of the District's ability (legal authority; regulatory purview; financial wherewithal) to take actions that affect each of the stressors and thereby have a role in responding to those threats. The District's Covered Activities do not relate to most of these threats; they are included herein primarily as an indication of the overall risks to the ecosystem of the Covered Species.

The primary threat for the Covered Species is seen to be the present and threatened degradation of the habitat by reduced water quality and quantity at the surface, in the subsurface, or both, and also by the physical disturbance of the spring sites' surface habitat (Service, 2013b). The Service has determined that in aggregate the threats identified are both imminent and high in impact on the Covered Species. For example, in its most recent listing rule documentation, the Service concludes that "…the Austin blind salamander is in danger of extinction now throughout all of its range…" and goes on to explain that this finding "…is based on our conclusions that this species has only one known population that occurs…in Barton Springs, the habitat of this population has experienced impacts from threats, and these threats are expected to increase in the future. We find that the [species] is at an elevated risk of extinction now, and no data indicate that the situation will improve without significant additional conservation intervention" (Service, 2013b). While this specific determination addresses the Austin blind salamander, which was just recently listed, the same threats and stressors exist for the Barton Springs salamander population and that species is considered equally at risk for exactly the same reasons and in need of conservation to reduce the risk of extinction.

But as the table also indicates, most of the stressors and circumstances that are inimical to the two species are beyond the District's ability and authority to affect, avoid, ameliorate, minimize, or mitigate. Only those reasons for decline and threats to the survival of the Covered Species that the District's activities affect in either a positive or negative sense are addressed further in this section of the District HCP. The District HCP's Covered Activities relate solely to groundwater withdrawals from the Aquifer and the effect of the District's groundwater regulations on such water withdrawals under its integrated drought management program. These directly affect only the amount of groundwater that issues from the spring outlets, since water that is not withdrawn from wells is discharged at the spring outlets, generally on an equivalent-volume basis (Smith and Hunt, 2004). In turn, as described in Section 3.2.2.2 above, as springflow decreases so does dissolved oxygen concentrations of the water discharged (Herrington and Hiers, 2010), while the total dissolved solids concentrations increase, as older, more saline water becomes a larger proportion of the spring flow (Johns, 2006). These changes in water chemistry are affected indirectly by the District's groundwater management program, which in turn affects the amount of take of the Covered Species.

5.1.3.1 Barton Springs Salamander

The threats to and stressors of the Barton Springs salamander that are addressable by the District actions and decisions and that potentially relate to the existence and amount of take and therefore its impact are the following (Service, 2013b):

1. Reduced springflow at the Barton Springs outlets during severe (Stage III Critical and Stage IV Exceptional) droughts, a type of stochastic (random expression of a probability-distributed series) event on which groundwater pumping is over-printed;
2. Decreased dissolved oxygen in springflows during severe drought; and
3. Somewhat higher ionic constituent concentrations (as expressed by conductivity) in springflows during severe drought.

The Service's Barton Springs Salamander Recovery Plan includes an examination of the various cultural/anthropogenic threats and stresses and recommends guidelines and action steps and an implementation program to minimize or avoid them as integral elements of the recovery measures (Service 2005). This District HCP is a complement to the Barton Springs Salamander Recovery Plan with respect to minimizing groundwater withdrawals during drought. It is also worth noting that natural processes such as super-saturation of dissolved gases in the salamander's body have occurred in the past and pose continuing threats to the salamander (Service, 2005; 2013) and may also bear on the efficacy of potential conservation measures.

5.1.3.2 Austin Blind Salamander

The same factors identified and observations made above for the Barton Springs salamander are also pertinent to the Austin blind salamander. This is especially true for those aspects of habitat change that can be affected by the District's Covered Activities, viz., the quantity and resultant water chemistry of spring discharges during severe and particularly extreme drought that in turn produce take and its impact:

1. Reduced springflow at the Barton Springs outlets during severe (Stage III-Critical and Stage IV-Exceptional) droughts, a type of stochastic event on which groundwater pumping is over-printed;
2. Decreased dissolved oxygen in springflows during severe drought; and
3. Somewhat higher ionic constituent concentrations (as expressed by conductivity) in springflows during severe drought.

Table 5-1. Summary of Threats to Covered Species (Adapted from: FR, vol. 78, no. 161, p. 51278 et seq.)

Threat Factor	Ecological Impact	Source of Concern	Deleterious Effects	District Has Role?
Factor A: Present or threatened destruction, modification, or curtailment of its habitat or range	Water Quality Degradation	Urbanization	Increased impervious cover and chronic degradation of stream hydrology and contamination of aquatic habitat from expansion of roadways, residential, commercial and industrial development	No
			Increased magnitude and frequency of high flows and flashiness that disrupts biotic communities	No
			Changes in stream morphology and water chemistry, including increased contamination and toxicity	No
			Negative effects on prey base	No
			Increased sedimentation that covers graveled habitat	No
		Hazardous Materials Spills and Releases	Highway-transport accidents may release gasoline, chemicals, heavy metals like lead and arsenic, oil and grease, and toxic petroleum hydrocarbons to stream courses and then the Aquifer	No

			Releases of toxic organics and hydrocarbons from breaks in oil and gas pipelines and related facilities	No
Factor A (continued)	Water Quality Degradation (continued)	Hazardous Materials Spills and Releases (continued)	Leaking underground storage tanks that release gasoline and petrochemicals to the Aquifer	No
			Breaks and overflows in conveyance lines and failures of treatment facilities for water and sewage that introduce a panoply of contaminants to streams and the Aquifer	No
		Construction Activities	Siltation and increased sediment and chemical loads from excavations for roads, tunnels, pipelines, and shafts	No
			Siltation and increased sediment and chemical loads from excavation and operation of quarries and gravel pits	No
			Disruption of hydrologic pathways from excavations (although none are known or likely for these species)	No
		Introduced Specific Contaminants and Pollutants	Acute and chronic toxicity to Covered Species and prey, through sediment or water column	No
			Adverse effect on eggs and larvae	No
			Impaired reproduction, growth, and development of life cycle requirements	No
			Adverse effect on prey species availability	No

			Morphological deformities	No
			Altered capability for feeding, moving, and reproduction: loss of survivability	No
			Nutrient enrichment and subsequent changes in trophic state and biological growth- and decomposition-related oxygen availability problems	No
Factor A (continued)	Water Quality Degradation (continued)	Changes in Water Chemistry	Conductivity may indicate other pollutants as well as elevated ionic stress	No
			Salinity and its specific ions can alter the internal water balance and create mortality in various species, including prey species	**Yes**
			Dissolved oxygen depression reduces respiratory efficiency, metabolic energy, and reproduction rates, and ultimately survival	**Yes**
	Water Quantity Degradation	Urbanization	Change in magnitude, frequency, and duration of runoff reduces baseflow of recharge stream and concomitant decrease in aquatic community diversity	No
			Increased storm runoff increases erosion and sedimentation, and more easily flushes larvae from substrate	No
			Reduction in infiltration increases flashy runoff, reduces recharge and therefore decreases springflow	No

		Natural Drought	Reduced springflows are associated with lower dissolved oxygen, lower water velocities, higher salinity, higher temperature variations, and increased sedimentation of habitat, all of which adversely affect the Covered Species and availability of their prey	No
Factor A (cont'd)	Water Quantity Degradation (continued)	Climate Change	Increased drought period intensity and duration and higher average temperatures leads to more water demand, larger temperature variations, less recharge, smaller springflows, and more saline intrusion component, all of which adversely affect the Covered Species and availability of their prey	No
		Increased Well Use	Reduced spring flows may cause stranding and interference with feeding/predation, as well as somewhat reduced dissolved oxygen and slightly higher salinity	**Yes**
	Physical Modification of Surface Habitat	Modification of Existing Habitat	Flooding may alter substrate and channel morphology, adversely, remove protective vegetation, and flush individuals away from their habitat	No

			Sedimentation mobilizes silt and clays that are suspended in water column and make water turbid, which impairs breathing because of clogged gills and reduces ability to locate food or avoid predators	No
			Sedimentation mobilizes sediments, and associated contaminants, that are then re-deposited and cover/fill substrates necessary for life activities.	No
Factor A (continued)	Physical Modification of Surface Habitat (continued)	Modification of Existing Habitat (continued)	Impoundments alter stream morphology and flow regimes that allow increased siltation and support larger predators.	No
			Other human activities, including frequent human visitation and vandalism, result in habitat disturbance/destruction and loss of cover available for breeding, feeding, and sheltering of Covered Species	No

Factor B: Overutilization for commercial, recreational, scientific, or educational purposes	Reduction in population size	Significant population declines	Over-collection for scientific purposes could negatively impact the species in combination with other threats; not considered a serious threat at this time	No
Factor C: Disease or predation	Reduction in population size	Not considered a threat	No problems observed; not considered a threat to population	N/A
Factor D: The inadequacy of existing regulatory mechanisms	Past, current, and future impacts to species as noted above	Inability to prevent further impacts to species in the future	Federal and State laws have not sufficiently prevented such impacts	No
			Local laws, regulations, and ordinances are not sufficient to prevent such impacts.	No
			Groundwater Conservation District regulations are not sufficient to prevent such impacts.	**Yes**

Factor E: Other natural or man-made factors affecting continued existence of the species	Synergistic and additive adverse interactions among stressors above	Result of stochastic events on very small population size	Extreme drought, abetted by groundwater pumping, may reduce quantity and change chemistry of springflows that exacerbate other impacts on species, especially as re-colonization is not probable	**Yes**
			Catastrophic contaminant spills or leaks of harmful substances that exacerbate other impacts on species	No
		Other natural factors	Ultraviolet-B radiation may exacerbate other impacts	No
			The highly restricted range (one location) and the entirely aquatic environment make the Covered Species highly vulnerable to stochastic events such as catastrophic spills, storm events, and extreme droughts that could extirpate the species	No

5.1.4 Survival Needs Affected by Covered Activities

Both the Barton Springs salamander and the Austin blind salamander are believed to have very similar needs to ensure their survival. At the present time, there are insufficient data and information to distinguish major differences among them in this regard. Accordingly, the discussion in this section applies to both species.

Chief among their survival needs, as inferred from their sole habitat characteristics discussed in Section 5.1.1 and 5.1.2, are the following:

1. A supply of high-quality fresh water having a relatively narrow range of physicochemical conditions of pH, alkalinity, and water temperature: these conditions are met by groundwater continuously resurging from a non-polluted karst aquifer (City of Austin, 2013; Service, 2013b);
2. Sufficient dissolved oxygen flux, representing a combination of DO concentration and water velocity past the highly adapted salamander gill structures: the minimum flux required is unknown (Poteet and Woods, 2007; Mahler and Bourgeais, 2013);
3. Water with ionic constituents (expressed as total dissolved solids concentration) that is sufficiently low such that it supports the egg and larval life stages of the salamander (Service, 2013b): the ionic constituent strength threshold is unknown but is not believed to be especially low, or so low that the minor amount of saline water incursion during extreme drought flows and concomitant ionic-constituent increases of springflow affect those stages;
4. Interconnected, submerged surface and subsurface habitat for various life activities and from time to time for protection: given the morphological differences, the Austin blind salamander utilizes the submerged subsurface environment mostly, whereas the Barton Springs salamander utilizes the submerged surface and near-surface environment more, although their interconnected-ness may be critically important to both species for providing food and avoiding predation (Service, 2013b);
5. Given the small size of both populations and the lack of redundancy for each, the population's persistence (i.e., survivability) in the face of environmental and demographic challenges may depend on the number, duration, frequency, and magnitude of those stochastic events not exceeding the resiliency of the species (Service, 2013b).

These survival needs and life history requirements are characterized in more detail by the Service (2013b), which should be referenced if further information is required.

The District's Covered Activities and conservation program affect and address the second and third of these needs, and its drought management program is intended to reduce incrementally the magnitude of that type of stochastic event that could affect the persistence of the population (the fifth need above.) In the following Section 5.2, the take by the Covered Activities is characterized and quantified, and then the impacts of take on the populations are described. The beneficial aspects of the conservation program on minimizing and mitigating take are addressed in Section 6.2.4.

5.2 Effects of Take on Covered Species

The discussion in Section 5.1.3 and 5.1.4 above strongly suggests the scientific basis and factors for considering take by the Covered Activities are essentially the same for both Austin blind salamander and Barton Springs salamander, differing primarily in amount of supporting information available. The District HCP's Biological Advisory Team has indicated on the basis of currently available information that the relevant measures that are protective of Barton Springs salamander are also reasonably inferred to be similarly protective of Austin blind salamander. Indeed, the City of Austin's Barton Springs Pool HCP (City of Austin, 2013) does not distinguish differences in the efficacy of protections afforded by its conservation measures between the two species. Further, substantially more information than is now known on the habitat requirements and life histories of both species, but especially Austin blind salamander, and their response to stressors would be needed in order to propose and assess differential requirements between the two species.

The unavoidable effects of the District's Covered Activities are also not able to be differentiated between effects on one of these species and not the other. Therefore, the effects on the species are addressed together in this section; however, potential differential impacts, i.e., consequential results of the take on each of the species populations, are addressed in the following Section 5.3. An important operational premise of this HCP is that the measures to be adopted for the conservation of Barton Springs salamander also will only benefit and will not substantially harm Austin blind salamander and its habitat, and vice versa. The current state of knowledge appears to provide no compelling basis to refute this premise. In particular, there is no known difference in the sensitivity to DO concentrations and salinity between the two species, and while opportunistic predation may occur between the species, neither is known to be dominant in this regard (City of Austin, 2013).

Accordingly, in this section of the HCP addressing the effect of take, unless otherwise specified, the term "Covered Species" refers to both of the species and their attributes.

5.2.1 Experimental Assessment of Salamander Responses to Changes in Water Chemistry Related to Springflow

Dissolved oxygen (DO) and specific conductivity (a measure of ionic constituent concentrations, or salinity) have been identified as potentially significant variable parameters that should be investigated during the course of the District HCP, to understand the levels of stress and mortality of the salamander to each (see, for example, Turner, 2004). Before this HCP, no scientific study of the physiological responses of the salamander to these variables was known to exist. To provide information that can be used to begin the evaluation of the species response to changes in these variables, a pioneering laboratory study was commissioned and funded by the District as part of this HCP. The research was conducted by investigators at The University of Texas at Austin, Section of Integrative Biology, and later supplemented by researchers at Baylor University's Department of Environmental Science. The investigators evaluated stressor-response relationships across a range of DO and conductivity levels on the species (Poteet and Woods, 2007). Approaches that identify such stressor-response thresholds are recognized as highly valuable for supporting robust environmental management decisions (Suter, 2006). Risk analysis in this toxicity study for the District HCP was designed to determine risks to individuals from just one of the stressors of the Covered Species, not all stressors for the entire population. As noted above, Covered Species are susceptible to cumulative risks from a variety of natural and anthropogenic stressors. Stress from DO variability is the primary stressor to which the District's Covered Activities contribute. This approach is preferred when considering threatened and endangered species, for which an adverse impact on individuals of the population can be significant (Suter, 2006).

The original study documented in the final report by Drs. Mary Poteet and Art Woods (2007) was subsequently enhanced with further investigation, computations, and analysis as part of the HCP investigation, employing a Probabilistic Ecological Hazard Assessment (PEHA) approach to relate the study findings to threshold responses of salamanders to DO concentrations in spring habitats for the first time. This study thus provided a unique contribution to understanding DO stress to an endangered species in general, because a closely related salamander species (described below) and historical data allowed for robust analysis. The enhanced study has since been submitted to considerable peer review and has been published in *Copeia*, the journal of the American Society of Ichthyologists and Herpetologists (Woods et al., 2010); this peer-reviewed article is included in its entirety as Appendix I of this HCP. The HCP relies heavily on the conclusions in this peer-reviewed published report, but data included in the original study report are also instructive.

5.2.1.1 Laboratory Study Design

The investigators selected and used a closely related salamander species, the San Marcos salamander (*Eurycea nana*), as a surrogate for the Covered Species, because its genetics and life history are similar to those of the Barton Springs salamander (Chippindale et al., 2000). *E. nana* occupies similar karst-fed springs in central Texas, and the two species have similar physiologies. Both species are federally protected, but the population size of *E. nana* is considerably larger than that of Barton Springs salamander, *E. sosorum,* and especially Austin blind salamander, *E. waterlooensis.* On the basis of metabolic tests run on both species to evaluate response to changes in DO and conductivity, *E. nana* appeared to respond similarly to the Barton Springs salamander under a variety of test conditions. As noted above, availability of surrogate species, *E. nana*, which was so similar to the Covered Species, was quite fortuitous and exceptionally rare for stressor-response studies with endangered amphibians (Woods et al., 2010).

Experiments were performed to determine adult mortality and juvenile growth responses to DO. Survival and sub-lethal growth measurements are routinely used in ecological risk assessments because these response variables are highly relevant for population sustainability of threatened and endangered species (Suter, 2006). In fact, the work by Woods et al., (2010) is considered by those researchers to represent the most comprehensive understanding of adverse effects of DO on any salamander to date.

The testing procedure generated 28-day mortality estimates and also described sub-lethal effects such as metabolic growth and behavioral response to various treatment levels under controlled laboratory conditions (Poteet and Woods, 2007) (see Figure 5-3). In addition, a 60-day study was conducted on juvenile *E. nana*, exposing individuals to various DO concentrations (Woods et al., 2010).

As mentioned in the preceding sections of the District HCP, the estimated response of the Barton Springs salamander population to changes in DO and conductivity addresses only two of the many cumulative stressors that influence the population during reduced discharge. However, these limitations notwithstanding, the models developed from these data, which examined more than one life stage, and particularly the juvenile stage, which is typically considered more sensitive to stresses than adults, provide the most robust method currently available for evaluating potential impacts of reduced discharge conditions on the salamander population in the wild.

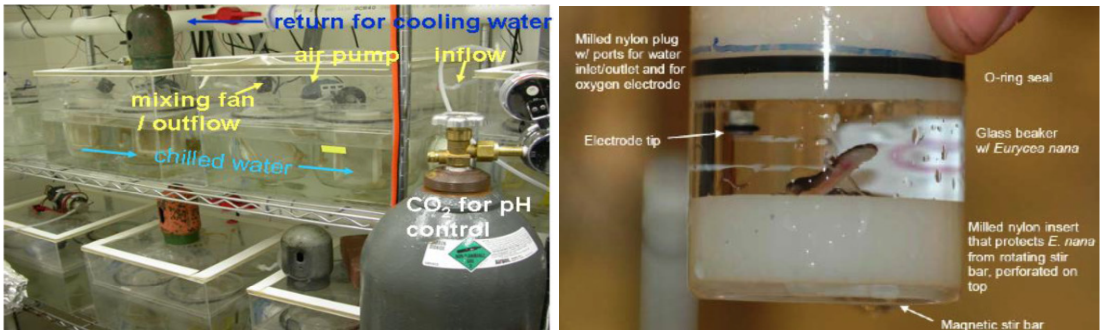


Figure 5-3. Representation of two laboratory experimental setups to measure salamander response in the University of Texas toxicity study. Image on left is for 28-day toxicity study; and image on right is for metabolic rate study. (Photo courtesy of M. Poteet and A. Woods).

The DO and spring discharge datasets examined by the PEHA approach were obtained from the U.S. Geological Survey. In these datasets, there were very few available observations of DO concentration at low flows or values below 4.5 mg/L. The DO dataset for Main Barton Springs was the most robust. However, there were only 27 observations of flow below 20 cfs at that locality. Those low flow observations had a mean DO value of 4.69 ±0.28 mg/L. Notably, no statistically significant relationship was observed between flows below 20 cfs and associated DO levels.

5.2.1.2 Stressor-Response Study Findings and Applications

One of the primary findings of Woods et al. (2010) was that increases in conductivity (ionic constituent concentrations) do not result in salamander mortality, even at very high concentration. This finding is the result of what appears to be the most controlled, systematic, and replicable laboratory study available. Further, such an observation is not surprising, particularly for organisms adapting to natural habitat changes in the past. However, it should be noted that this finding relates only to adult and juvenile salamanders; it has been suggested by others that increased salinity could have adverse consequences on the egg and larval stages of the salamander (Service, 2013b). No empirical studies of this possibility have been documented so adverse outcomes, if any, of the relatively small increase in TDS concentrations (from about 400mg/L to less than 500 mg/L) for the Covered Species populations and their adaption to this natural phenomenon is unknown but is likely de minimus for ecological risk to the Covered Species. In fact, the Covered Species experience similar and even larger salinity variations during high flow periods, although the durations of such events are over much shorter time intervals than severe drought. Accordingly, this variable was not considered to be nearly as important a factor as DO in affecting habitat quality for purposes of the biological evaluation in the District HCP. Like the experimental investigations, the narrative that follows consequently focuses only on DO. Of all the natural and anthropogenic chemical constituents that may occur in groundwater and could adversely affect the Covered Species and about which the Service, the District, and other entities are rightfully concerned, the District's Covered Activities only affect the concentration of those few natural constituents that are specifically related to springflow; in this regard, only DO is judged to be determinative of take of the Covered Species in the meaning of the Act.

In the 28-day adult stressor-response study, groups of salamanders were progressively exposed to several levels of DO exposure: 1.3, 2.4, 3.6, 4.6, and 7.5 mg/L, each in individual aquaria. Figure 5-4 presents a response curve to the varying DO exposure concentrations. Mortality rates fell abruptly between approximately 2 and 4 mg/L. Some salamander mortality occurred within 28 days in all three of the lowest three treatments (1.3, 2.4, and 3.6 mg/L), and no DO related mortalities were observed in either of the two highest treatments (4.6 and 7.5 mg/L).

Lethal Concentration (LC_x) values are computed threshold measurements of an environmental condition at which level a certain animal or organism has a given likelihood (% chance) of dying in a given amount of time, under constant controlled conditions. Woods *et al* re-computed a series of LC_x values of DO for the Barton Springs salamander in their earlier laboratory study--the DO concentrations that would presumably cause 5%, 10%, 25% and 50% mortality for adult *E. nana* individuals if exposed continuously over a 28-day period (Woods et al., 2007):

NOAEL$_{Adult}$ -- 4.5 mg/L
LC$_5$ -- 4.5 ±0.5 mg/L
LC$_{10}$ -- 4.2 ±0.3 mg/L
LC$_{25}$ -- 3.7 ±0.1 mg/L
LC$_{50}$ -- 3.4 ±0.2 mg/L

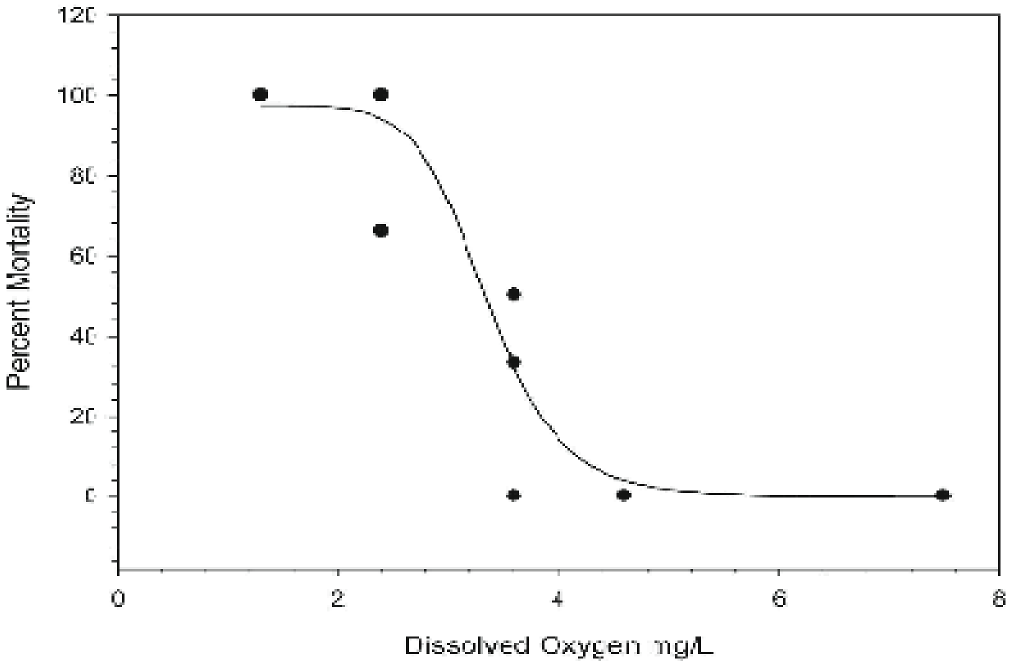


Figure 5-4. Percent mortality of *Eurycea nana* exposed to varying dissolved oxygen concentrations in laboratory. The data were modeled using a 3-parameter logistic model. Source: Woods et al (2010).

These values are considered thresholds of response for *E. nana* and, by inference *E. sosorum* and, for this HCP, also *E. waterlooensis*, when exposed to varying DO concentrations. In particular, the LC$_{50}$ and the LC$_5$ or the No Observed Adverse Effect Level (NOAEL) each may provide useful benchmarks for estimating the quantity of take and de minimus ecological risk that is likely to occur under the anticipated discharge conditions of the District HCP. For example, the level of DO at LC$_{50}$ (causing 50% chance of mortality after 28 days of exposure) was found to be approximately 3.4 mg/L which, if it occurred for a continuous 28-day period in one of the springs, would appear to pose a grave threat to salamander survival. On the other hand, DO levels at or above 4.5 mg/L showed no observable effects in any experiment (Woods et al., 2010).

The stressor-response study also determined the observed NOAEL threshold DO levels for juvenile as well as adult *E. nana*. Juvenile growth rate studies were conducted over a 60-day period to determine the effects of exposure to various DO levels on metabolic activity and growth. The lowest DO concentration set for the 60-day juvenile growth study was 4.4 mg/L.

The results of the analysis are presented in Table 5-2. Although juveniles in the lowest DO exposure concentration (4.4 mg/L) had growth rates that were approximately 30% lower than control salamanders, the growth rates were positive, and when analyzed by linear mixed-effects models the differences from controls were not significant (the minimum significant difference was just 0.006) (Woods et al., 2010). Using a toxicological approach, the investigators determined that the specific growth rate NOAEL was 4.4 mg/ L, the lowest DO level examined. Other researchers have also noted that the Barton Springs salamander seems to be adapted to waters that are variably under-saturated with respect to DO (Turner, 2007). Uncertainties should be considered, but on the basis of these unique laboratory studies salamanders frequenting spring localities with DO values at or higher than 4.44 mg/L are not expected to encounter stress on account of DO concentration.[8]

Table 5-2 Summary of growth rates of juvenile *Eurycea nana* over 60 days in different dissolved oxygen concentrations. Source: Woods et al., (2010).

Treatment	Dissolved Oxygen (mg/L)	Number	Growth Rate (mg/day)
1	4.44	5	0.15
2	5.17	4	0.33
3	5.31	4	0.26
4	6.35	5	0.24
5	8.22	4	0.23

In the absence of complete information of DO dynamics in *Eurycea* species habitats, a Probabilistic Ecological Hazard Assessment (PEHA) was employed to develop an initial predictive understanding of the likelihood of encountering DO levels in springflows in Main Barton Springs, Eliza Spring, or Old Mill (Sunken Garden) Spring at or below *E. nana* thresholds to DO. The results of this assessment using the USGS springflow-DO dataset are

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[8] Some reviewers of early drafts of this HCP noted that a higher standard, specifically the 5.0 mg/L DO criteria for lentic systems should be used, in keeping with existing surface water quality standards and/or for providing a safety margin. These are not comparable standards and are employed for different purposes. The surface water quality standard is intended to provide a general condition that would support a diversity of aquatic life under all ambient conditions in lakes and reservoirs with other constituents and is applied only outside a mixing zone. In any event, it is not applicable to aquifer discharges per se or spring-fed pools. Further, it is not intended to be equivalent to a NOAEL for any specific aquatic species, nor is it designed to be used as a threshold for assessing take. Certainly sound environmental management incorporates margins of safety in actual enforceable standards whenever feasible to accommodate cumulative effects by all constituents. But standards that have such safety margins do not denote when physiological and/or behavioral effects for a given species are manifested, including in particular these Covered Species. Woods et al. (2010) assert that the typical 5.0 mg/L DO surface water quality criteria, if it were applicable, would likely be protective of the Barton Springs salamander, but those researchers are not maintaining that such a lake or reservoir standard is applicable nor even the minimum water quality criteria for the salamander, below which DO toxicity is manifested.

presented in Table 5-3 (Woods et al., 2010).

Table 5-3 Lethal Concentrations (LC_x) of Dissolved Oxygen and Corresponding Springflows. DO levels required to cause mortality in 5, 10, 25, and 50% of adult *Eurycea nana* after 28 days of exposure, and the No Observed Adverse Effect Level (NOAEL) for juvenile *E. nana* growth following a 60-day study, and corresponding total Barton Springs flow for perennial Spring outlets. Source: Woods et al., (2010).

Effect	Type of Study	Lethal Concentration of DO (mg/L)	Probability of Exceedence (% of values below threshold)		
			Main Barton Springs	Eliza Spring	Old Mill Spring
LC_5	28-day	4.5 +/- 0.5	5.2	6.8	30
LC_{10}	28-day	4.2 +/- 0.3	2.3	3.024	
LC_{25}	28-day	3.7 +/- 0.1	0.4	0.4	15
LC_{50}	28-day	3.4 +/- 0.2	0.08	0.1	11
NOAEL	60-day	4.4	4.5	5.8	28

The PEHA performed by these investigators determined that the exceedence probability statistic associated with the LC_5, or level of DO that would likely cause 5% mortality after exposure for a 28-day period for *E. nana*, is 4.5 mg/L. This concentration has a Probability of Exceedence (the probability that DO concentration would fall below the specified biological threshold of 4.5 mg/L, in this case) of 5.2% for Main Barton Springs; 6.8% for Eliza Spring; and 30% for Old Mill Spring. Similar computations are shown in Table 5-2 for the other LC_x values.

The probability of exceedence of the NOAEL for Main Barton and Eliza Springs are 4.5% and 5.8%, respectively (i.e., there is a 4.5 % likelihood of encountering a DO concentration at or below 4.4 mg/L at Main Barton Springs. Old Mill Spring had substantially higher exceedence estimates than the other two springs, largely on account of lower measured DO values. However, the correlation coefficient for the regression line fitted to the Old Mill data was also much lower (0.65) than those for Barton Springs and Eliza Spring (Woods et al., 2010).

The probability of exceedence of the LC_{50} concentration of 3.4 mg/L (the level at which 50% mortality of salamanders would be expected, if exposed continuously for 28 days) has a probability of occurring 0.1% of the time, or less, for the Main Barton Springs and Eliza Spring. The LC_{50} has an 11% probability of occurring at Old Mill Spring (Table 5-2).

Results from the PEHA approach were also expressed in the form of toxicological benchmark concentrations (see Table 5-4). For example, only 5% of all DO observations would be expected to be observed at or below a specific concentration of 4.5 mg/L DO in Main Barton Springs and 4.4 mg/L DO in Eliza Spring.

Table 5-4. Toxicological Benchmark Concentrations for low centiles, based on the dissolved oxygen (DO) distributions for Barton Springs, Eliza Spring, and Sunken Garden Spring. Estimates are based on the 28-day adult mortality and 60-day juvenile growth studies. Source: Woods et al., (2010).

	Dissolved Oxygen Concentration (mg/L)		
Likelihood that DO declines below specified amount	Main Barton Springs	Eliza Spring	Old Mill Spring
≤ 1%	4.0	3.9	2.3
≤ 5%	4.5	4.4	2.9

The PEHA by Woods et al. and the probabilities reported in the study utilized a more limited but homogeneous data set from the US Geological Survey only. But it should be noted that the discharge statistics based on the USGS dataset reflect the effect of an indeterminate mixture of pre-HCP and HCP conservation measures. Moreover, a more robust dataset that includes additional data, including low flow data, have been collected by the City of Austin, and both these data and the USGS data are now accessible and further analyzed (Turner, 2007; Turner, 2009). For these reasons, a different springflow-DO dataset, in conjunction with the lethal concentration statistics of Woods et al. (2010), is used to associate springflows and DO in estimating the frequency and amount of take for this HCP, as described in Section 5.2.4.2 below. However, as would be expected, the datasets are not dissimilar and the general relationships revealed by the earlier PEHA are considered valid, although some variations in values of various parameters accompany utilization of the larger dataset.

5.2.1.3 Implications and Limitations of the Stressor-Response Study

The PEHA and other methods applied in this research are helpful in characterizing some of the parameters of potential take of the Barton Springs salamander, and by extension the Covered Species, in the wild. There are, however, additional areas of uncertainty that should be acknowledged. As in all laboratory studies, the response of the test organisms under controlled conditions may not be the same as in the wild. Response also varies among individuals, affecting the precision of mortality estimations. This potential variability is accounted for by presenting 95 percent confidence intervals around the mean value of each estimate of mortality. As described above, the surrogate species *E. nana* appeared to react similarly to Barton Springs salamander among laboratory treatments when metabolism was monitored, but *E. nana* mortality estimates may or may not align as well with those expected in the Covered Species populations in the wild, particularly in any given time period (Woods et al., 2010). Mortality estimates are only for adult salamanders, so other life stages may have different or more variable sensitivities to reduced DO or elevated ionic constituent concentrations in groundwater.

Further gaps in knowledge that would have been useful to examine but were not able to be included within the scope of the project include how DO (and specific conductivity) affects reproduction, egg development, and hatching (Wood et al., 2010). If other stages—eggs or juveniles—are more sensitive (exhibit higher LC_{50}s), higher levels of DO than those determined for the adult NOAEL may still constitute a considerable threat. For example, no data are available to evaluate mortality responses of *Eurycea* eggs to DO.

Salamanders will occupy habitat containing higher and lower DO (or of other factors, such as water flow velocities, that affect DO availability). Although sensing and responding to such varying DO conditions may be irrelevant at high DO levels, it surely becomes more important at low DO. In this HCP's salamander stressor-response experimental program, salamanders clearly perceived and responded to low (or falling) DO -- the infrared detection system measured the onset of activity during falling DO and cessation of activity during subsequent rising DO. In the wild, counts of salamanders tend to decline in Barton Springs when DO falls below approximately 5 mg/L (Turner, 2004b). As such, salamanders in local pockets of low-DO water may migrate and find higher-DO water, either in the submerged surface environment outside the outlets (Turner, 2007) or inside the subterranean karst system (Service, 2013b; Hillis et al. 2001). Water flow rates in the salamander experiments were, for technical reasons, fairly low (1 cm/sec), likely giving substantial boundary layers. Consequently, another possible response mechanism to lower DO would be for salamanders to increase oxygen flux to sites of respiratory exchange by disrupting those boundary layers—e.g., by bobbing, flicking their heads, or swimming. Thus, the novel stressor-response thresholds observed by Woods et al. (2010) appear robust.

DO concentrations and conductivity measurements may be heterogeneous in the springs inhabited by the Covered Species, possibly due to poor mixing of waters from different flow routes resurging along the faults as well as differences in re-aeration potential between confined and unconfined aquifers adjacent to the spring orifices. Microhabitats may be higher or lower than data measured by the City of Austin collection methods. In addition, test organisms during the laboratory study were not able to move to higher quality habitat conditions (i.e., areas with higher flow velocities to increase oxygen exchange across the gills), as they can in the wild. On the other hand, sub-lethal effects observed in the laboratory (such as reduced activity) may not have contributed directly to mortality estimates in the tests, but in the wild such behavioral changes may increase predation risk, reduce foraging, or have other effects that increase take and even the chances of mortality. Finally, there is a possibility that reduced DO contributes to cumulative effects with changes in other springflow-related and non-springflow related water chemistry parameters during reduced discharge, which could not be accounted for in these tests.

Despite such uncertainties that affect the use of laboratory-derived mortality estimates to describe the mortality risk to the population in the wild, the data collected and analyzed by Woods et al. (2010) provide the best basis to describe the anticipated impact of low-discharge conditions at the Barton Springs complex to the Covered Species. As noted above, the Woods et al. (2010) study likely represents the most robust study of DO stress to any salamander. These study results can be used in conjunction with continuous water quantity and corresponding, appropriate water chemistry data and salamander survey data collected by the City of Austin, U.S. Geological Survey, and the District to describe parameters of incidental take of the Covered Species under the District HCP. With an estimated response to changes in DO (Woods et al., 2010) and known relationships between DO and the combined discharge in the Barton Springs complex (City of Austin 2004, 2007, 2009 and 2010), and salamander survey data during a range of aquifer conditions, it is possible to estimate the response of the Covered Species to reduced discharge in Barton Springs. These estimates form a rational and the best-available basis for determining adverse effects, and ultimately take.

5.2.2 Form of Take

Take of the species (as defined by 50 CFR 17.3) includes harm from “significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering”. It also includes harassment, defined as “annoying wildlife so as to significantly impair [those] behavioral patterns”.

In this ecological setting take must be estimated indirectly by indexing it to changes in habitat conditions rather than documenting actual loss of individual organisms. The individual spring outlets are not a closed system, so the salamanders have the capability not only of dwelling in the various spring outlets and runs where their population can be monitored using transect surveys, but also moving to areas in the substrate below the spring runs, inside the spring orifices, and in subterranean aquifer conduits and fissures, where physical counts of individuals are not possible. Because of this limitation, and on the basis of research conducted for this HCP (described in Section 5.2.1 above), estimates of take for the salamander are based primarily on two measurable life requirements of the species that serve as a proxy of counts of these cryptic (typically hidden from observation) individual organisms: rate of springflow discharge, and its related changes in water chemistry, especially the DO concentrations and ionic constituents of discharged groundwater at the spring outlets. (Water temperature also may be important in defining the short-term temporal DO regime, owing to the reduction in DO solubility with higher temperatures; but its effects are reflected primarily in the variability of DO observed for a particular discharge amount. Under base-flow conditions, temperature of water discharging at the outlets tends to be cooler and more uniform and less likely to control DO than the proportion of saline and other older, less meteoric groundwater contributed to the springflow (Mahler and Bourgeais, 2013).) The degree and extent to which changes in these parameters arising from the District’s Covered Activities cause harassment and harm to occur appear to be generally determinative of the level of take under this ITP. In addition, temporary reduction and loss of habitat area from recurring drought cycles occur at certain spring outlets, most notably the non-perennial Upper Barton Spring, and such habitat changes also produce take.;

Take occurs incrementally and each outlet is affected to different degrees and at different times, dependent on the total spring discharge and resultant water levels and chemistry.

The entire population of the Covered Species doesn't occur at one location at one time, so what form and number of individuals expressing take at any one time is indeterminate. However, as drought is prolonged and deepens, the effects on *individual* organisms are deemed likely to proceed from an initial non-lethal, annoyance/harassment form of take, and, if and as drought is prolonged, then both increasing numbers of individual organisms are affected and the form of take has an increasing harm component, ultimately including mortality. In addition to the physiological response of individuals, take also may be caused by sub-lethal effects at the population level, including reduction and cessation of reproduction, reduction and cessation of growth, reduction in prey abundance, and increased intra-and inter-specific competition; in absence of robust data and vetted analyses that would allow quantification of these effects, for purposes of this assessment, sub-lethal take arising from these factors for these species is assumed to begin at the same time that the initial mortality caused by DO stress to individual organisms begins, i.e., $LC_{0.01}$, and also is assumed to be equivalent in magnitude to the lethal take of then-extant organisms.

The maximum number of individuals that have been counted, aggregating all spring outlets, would represent a reasonable estimate of the maximum number of individuals that could be potentially affected. The Covered Species have population sizes that appear to be highly variable in response to variable resource availability and environmental conditions, so the actual population at any one time is also highly variable. Certainly some individuals will be more or less vulnerable to the effects of particular reductions in springflow, dependent on both their location and their particular physiology, and the form of take would similarly also be expected to differ among individual organisms. The fraction of the population that is physiologically affected varies and is characterized and estimated in Section 5.2.4.

5.2.3 Spatial and Temporal Extent of Take

While the Covered Activities, viz., water withdrawals from pumping of the Aquifer, take place over the entire ITP Area, the resultant take will occur at or close by the spring outlets, as described generally in Section 3.2.2 above, Section 5.2.4 below, and in more detail in Appendix C.

The Covered Activities have been and will be continuously occurring. But those activities do not always produce take. During non-drought conditions, no alteration of habitat from the Covered Activities occurs, and no take occurs. At the onset of drought, the non-perennial Upper Barton Spring outlet stops flowing, and the first instances of take occurs for its small population, primarily a non-lethal form from annoyance and harassment. During continuing but non-severe drought periods, the incrementally smaller springflows as a result of the Covered Activities are not accompanied by changes in water chemistry that have physiological relevance to the Covered Species. More specifically, when no outlet has a DO concentration below 4.5 mg/L DO, the laboratory-established No Observed Adverse Effect Level (NOAEL) for DO where no physiological response was elicited, the amount of water being withdrawn from the Aquifer by wells is immaterial to the water chemistry and no take occurs from that circumstance and cause of take. As elaborated in

Section 5.2.4.1.1 below, this threshold corresponds to the baseline flows and recurrence frequencies (percent of time flow is below a designated discharge amount) for each outlet that are shown in Table 5-5. Note that these flows and frequencies pertain to the Pre-HCP program scenario, *before implementation of the conservation measures* (described in Section 6.2 below) above which the Covered Activities do not harm or harass the Covered Species:

Table 5-5. Onset of take by spring outlet. Flows and frequencies that correspond to initiation of physiological effects at perennial outlets and to habitat loss at the non-perennial outlet before the HCP conservation measures are implemented. Additional explanation is provided in Section 5.2.4.1.1 of this HCP.

Outlet	Total Barton Springs Flow When Take at Outlet Begins	Recurrence Frequency
Main Springs	7.8 cfs	5 %
Eliza Spring	19 cfs	19 %
Old Mill Spring	20 cfs	20 %
Upper Barton Spring	40 cfs	48 %

Only when Barton Springs discharge falls below the highest of these flows, i.e., about 20 cfs, would physiological responses to DO changes be expected. Specifically, no adverse effect related to spring flow, and therefore no take, will occur at Old Mill pring, or either of the other two perennial outlets, when Barton Springs discharge exceeds 20 cfs, which occurs 80 % of the time under the Pre-HCP pumping scenario.

As mentioned earlier, the non-perennial outlet of Upper Barton Spring is a special case of take at the Barton Springs complex. This outlet is known habitat for the Barton Springs salamander, but only recently the Austin blind salamander has also been observed there. The City of Austin has estimated the population associated with this outlet to be no more than 100 individual organisms. As the water levels in the Aquifer decline, this “overflow spring” outlet stops flowing, at about 40 cfs of total springflow discharge. Springflows equal to or less than this amount occur about 38% of the time with no pumping, and about 48% with either of the groundwater management scenarios. As discussed above, there is likely no adverse physiological response associated with the water chemistry at these water levels and discharge amounts; this likelihood is buttressed by the re-appearance of a relatively robust Barton Springs salamander population at this outlet when the Aquifer water levels rise and springflow at Upper Barton Spring is re-established (City of Austin, 2013). But it is reasonable to presume that the physical loss of most of the surface habitat at Upper Barton Springs affects its salamander population at this outlet by causing a retreat of this epigean species into the subterranean habitat, and perhaps forcing a migration to other outlets for some part of the resident population. While no life functions are known to be impaired by this loss of physical habitat, which has inherently occurred many times in the past, the population is reasonably inferred to be annoyed and some adverse effects on feeding and sheltering behavior are not unlikely. Because pumping of the Aquifer contributes to the decline of water levels in the Aquifer, even though only a very small amount at springflows of 40 cfs where physical habitat loss occurs, some fraction of the adverse effects on the Upper Barton Spring population is attributable to the Covered Activities, and is therefore take. Accordingly, up to 100 individual Barton Spring salamanders at Upper Barton Spring are affected by some form of take for as much as 48% of the time.

At all outlets the *initial* response, likely to be more aptly characterized as harassment than harm, is caused by a combination of natural stochastic variations in springflow (primarily) and the Covered Activities, viz., well withdrawals (secondarily). At intermittent Upper Barton Spring, the form of take may well continue to be harassment until the Aquifer water levels and resultant springflows reach the physiological response threshold at one or more other outlets. At the perennial outlets, take, which would comprise that proportion of the response attributable to well withdrawals, is rationally considered to begin at 20 cfs, and the amount of take from Covered Activities could be represented theoretically by the following risk (i.e., risk = hazard x exposure) equation:

$$\text{Take} = \text{Elicited Response} \times [\text{Well Withdrawals} / (\text{Well Withdrawals} + \text{Springflow})]$$

As springflows decrease, both the amount of the elicited response and the fraction attributable to the Covered Activities increase, which means the amount of take will increase. In addition, as springflow continues to decrease, the form of the take changes from harassment to harm, which may include mortality for a relatively few individual organisms, and if the extreme, low springflow episode is prolonged, then to mortality of larger numbers of organisms.

As discussed above, whether and when take is thought to occur and the form of the take manifested relate to the overall aquifer water levels and the resulting springflow. When springflow falls below 20 cfs as a result of both groundwater drought conditions and pumping of the Aquifer, the first perennial outlet where take occurs is Old Mill Spring, followed thereafter by the Eliza outlet when the combined springflow drops to 19 cfs; the Main Barton outlet will not have springflow-related take occurring until total springflow is less than about 8 cfs. Further, the Old Mill outlet ceases flowing when the total discharge from all outlets is below 14 cfs (City of Austin, 2013).

It is not unreasonable to infer that at about this level of springflow, which corresponds to the onset of extreme drought as defined by the District in this HCP, without mitigation of some type: (a) the form of take changes from dominantly harassment to dominantly harm, and (b) the take may tend to become more homogeneous among the outlets as the organisms begin to migrate away from and even between the outlets in the subsurface, in an area that corresponds to the enclosed area in Figure 5-2 above. (While the area depicted in this figure refers to the Critical Habitat of the Austin blind salamander, it likely includes the probably smaller area of subsurface migration of the Barton Springs salamander as well, for which Critical Habitat has not been officially designated.) In any event, the Covered Activities are not outlet-specific, and alteration of water chemistry among the outlets is derived from the natural flow regimes of the individual outlets, on which the aggregated pumping-induced reductions in flow are overprinted.

Take is the difference between the adverse effect created as a result of the Covered Activities and adverse outcomes to the Covered Species, if any, that exists without the Covered Activities. So, alternatively, with sufficient available data, take in this HCP is calculated as:

Take = Elicited Response for Springflow Affected by Well Withdrawals – Elicited Response for Natural Springflow Only

The District recognizes two types of "elicited responses" in this HCP. The first, more obvious one is the increased mortality of individual salamanders from DO reductions that adversely affect the habitat of the Covered Species and related sub-lethal effects. This is the primary response that is assessed for the perennial outlets in this HCP. The pioneering work of Poteet and Woods (2007) and Woods et al. (2010) and the long-term, thorough field investigations of the Covered Species and their habitats performed by the City of Austin (compiled in City of Austin, 2013) informed this assessment. The District produced a spreadsheet-based model to incorporate these findings and estimate lethal take on an outlet-by-outlet basis during a 97-year period of record under various pumpage-management scenarios (BSEACD, 2014).

The second type of adverse response is the reduced natality and recruitment of the Covered Species in an environment with depressed DO, which affects reproduction, egg and larval viability, and juvenile persistence to reproductive age. There are insufficient data to quantify each of those aspects under the range of springflows and DO of interest to this HCP, or even to confidently make an inference as to the overall rate of population increase under specific conditions; accordingly, the District has not attempted to construct an actual "population model" for either Covered Species.. While a very conservative stipuation, especially for an assessment period that lasts for many years, the District has not included in its take estimation spreadsheet model any population increase from natality and recruitment in its estimate of take from the Covered Activities at any time in the modeled period. From a population perspective, this is unrealistically conservative for these species and overstates the significance of the take estimate on residual population characteristics, including the ability to survive and recover from extremely stressful circumstances.

5.2.4 Integration of Experimental Data, Field Observations, and Statistical Modeling to Estimate Amount of Take

Take as defined by the Service may be categorized as lethal and non-lethal. Both require an ITP and an HCP that avoids, minimizes, and mitigates such take to the maximum extent practicable. For the Covered Activities in this HCP, without the conservation measures described in Section 6 of the HCP, take increases progressively as severe drought deepens past a threshold in habitat conditions where physiological and behavioral effects are manifested. However, even with the HCP conservation measures, take can only be retarded in reaching its threshold during drought, and after its onset it can only be minimized as to the amount, not avoided.

5.2.4.1 Estimation of Non-Lethal Take

Because of the nature of the cause of take, viz., incremental reductions in the DO concentration of water in which all individuals of the Covered Species live and are therefore affected by changes in DO concentration, it seems very likely that some fraction of the entire population present at a given time is at least potentially adversely affected and, as described in Section 5.2.3 immediately above, a fraction of that adverse effect is derived from pumping, a Covered Activity. That therefore constitutes take, and while it includes some indeterminate part of the entire species populations of the perennial outlets, it occurs only 20% of the time (Section 5.2.3). During that time take ranges in amount and form from a vanishingly small harassment form of non-lethal take to increasing amounts of non-lethal harassment, to increasing non-lethal harm, and then to increasing amounts of lethal take, if the severe drought is prolonged.

The City of Austin has observed in its HCP that salamander abundance based on census counts varies with environmental conditions, and that the range of cumulative annual salamander abundance provides a measure of potential take that incorporates an assessment of cumulative effects over the ITP term; further, using the maxima of the ranges accommodates the uncertainty of future environmental conditions (City of Austin, 2013). Similarly to the City's approach, the District has designated the maxima in the annual sum ranges for the outlets as the number of individual organisms of each species potentially subjected to non-lethal take, or

For Barton Springs salamander:
  at Main Spring: 447;
  at Eliza Spring: 1234;
  at Old Mill Spring: 97; and
  at Upper Barton Spring: 100.

For Austin blind salamander, transformed proportionately to presumed population (see discussion in Section 3.2.2.2.1):
  at Main Spring: 91;
  at Eliza Spring: 420; and
  at Old Mill Spring: 489.

However, the District considers take from harassment to involve the variable amount of actual salamander population present in a particular perennial outlet's orifice for those times below its take-initiation threshold (Section 5.2.3), rather than a single numerical estimate; the City of Austin does as well in its HCP (City of Austin, 2013). For the non-perennial Upper Barton Spring, since the entire surface habitat is lost when the combined Barton Springs flows decrease below 40 cfs, its entire population is adversely affected;

further, since pumping contributes proportionately to the loss of that habitat, the entire population at this outlet at that time (as many as 100 individual organisms) is considered take, primarily if not solely of a non-lethal form.

5.2.4.2 Estimation of Lethal Take

Estimates of lethal take at the perennial outlets have been made by the District in a more rigorous fashion than for non-lethal take and are discussed in this subsection. A spreadsheet model was developed to facilitate the thousands of calculations on which this estimate is based (BSEACD, 2014).

5.2.4.2.1 Methodology and Results

The District has established a step-wise process for estimating lethal take that incorporates: the probabilistic estimates of springflows under various scenarios; their correlations with water chemistry; estimates of harm determined from experimental studies showing the effects of changes in dissolved oxygen (DO) on the physiology and behavior of salamanders (Poteet and Woods, 2007; Woods et al., 2010); the reduction in number of individuals due to mortality; and finally the apportionment of those reductions to the Covered Activities by subtracting out similarly derived effects of springflows as not affected by pumping. The experimental stressor-response studies were substantiated with further analysis and incorporation of ecological risk assessment methodologies (Woods et al,. 2010) that provided the framework for the more robust assessment of adverse effects on Barton Springs salamander and, by extension, Austin blind salamander that is used in this HCP.

Step One: Developing and Analyzing Hydrographs

The synthetic hydrographs described in Section 4.1.2.2 were used to develop a series of monthly frequency curves, one for each of the following three groundwater management scenarios: an approximation of springflow with only the minor amount of exempt, i.e., no non-exempt, pumping; pre-HCP "take baseline" springflow; and HCP springflow, with all three scenarios using the period of record from 1917-2013, as shown in Figure 5-5. These recurrence curves are based on the following stipulations and assumptions:

1. The exceedence curve corresponding to the natural-flow hydrograph reflects what the springflow would have been without any pumping of the Aquifer. It was computed by taking actual monthly-average springflows as measured and/or inferred by USGS techniques and personnel (Slade et al., 1986), and adding the actual total monthly pumpage from the Aquifer during the period of record. (This synthetic hydrograph for total discharges from the aquifer is shown in Figure 3-5 above.)
2. The Pre-HCP and HCP groundwater management scenarios are both based on a total authorized pumpage of 11.6 cfs, which is the currently (2014) authorized pumpage under permit under non-drought conditions.

3. The 11.6 cfs of total non-exempt pumpage was allocated to individual months of the year on the basis of the aggregated monthly allowable pumpage during non-drought reported historically by the District's permittees, ranging between 7 cfs for each February and 16 cfs for each August.
4. For each month, 5% of the indicated non-exempt pumpage was incrementally added back to the springflow in the No Pumping scenario to account for the exempt water withdrawals that are not Covered Activities (Banda et al., 2010)
5. The Pre-HCP scenario corresponds to the curtailments specified in District rules as they existed before 2004, described in more detail in Section 4.1.2.1.
6. The HCP scenario corresponds to the full implementation of the HCP conservation measures described in more detail in Section 6.2 below. It is worth noting that in the District's experience, total actual pumping during non-drought (un-curtailed) periods is variably but considerably below the authorized amounts of production, so total pumpage included in this scenario tends to be overstated for most months in the period of record.

Recurrence (non-exceedence)-frequency springflow statistics for the two management scenarios were then generated for flow thresholds of interest to the HCP and compared to analogous statistics for the No Pumping springflows (Table 5-6). These data were used to inform other analyses in subsequent steps. The data indicate that the lowest historically recorded instantaneous springflow at Barton Springs (9.6 cfs, in 1956) would be exceeded 98% of the time with pumping under the HCP conservation measures, but only 93% with pumping under the Pre-HCP management scenario; further, the Pre-HCP scenario would produce no springflow almost 1% of the time, but the HCP scenario would have a minimum monthly springflow of slightly less than 6.5 cfs.

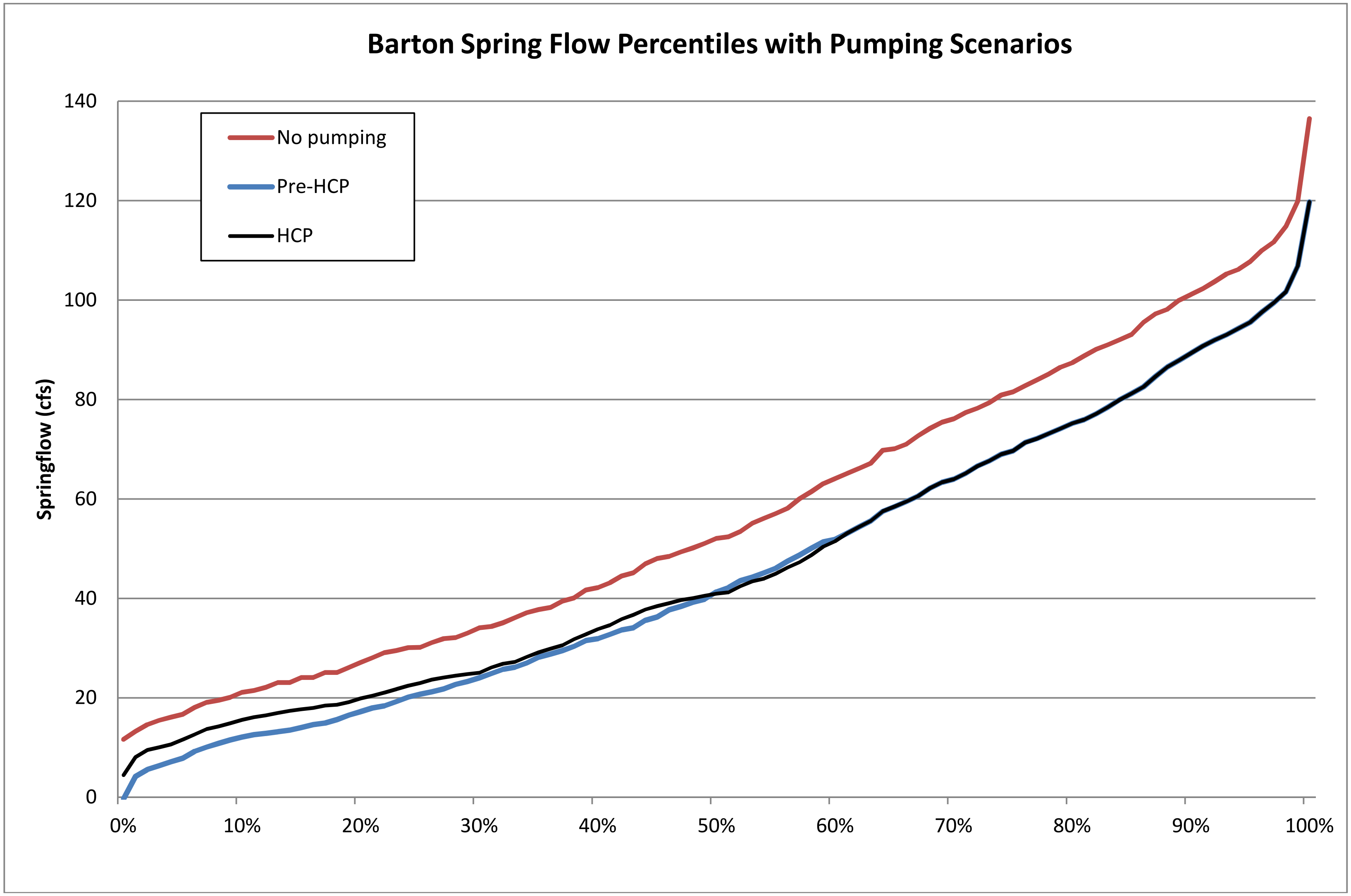

Figure 5-5. Recurrence frequency of springflows less than amounts shown under three assumed groundwater management scenarios. The effect of the HCP conservation measures becomes increasingly more beneficial, especially when compared to the Pre-HCP scenario, as the lower-than average springflows continue to decrease, where by design the Covered Species are benefited the most.

Table 5-6. Comparison of springflow statistics for flows of interest to the HCP. The HCP management scenario's flow characteristics are closer to those of the No Pumping scenario during extreme drought periods. Source: BSEACD (2014).

Relevant Management Thresholds		Percent of Time Springflow Is Less Than Designated Amount in Scenario		
Aquifer Stage	**Total Springflow**	**No Pumping**	**Pre-HCP**	**HCP**
Average Flow	53 cfs	52%	61%	61%
Stage II-Alarm	38-20	36	47	44
Stage III-Critical	20-14	9	24	20
Stage IV-Exceptional	14-10	2	15	8
Emergency Response	<10	<0.01	7	3
Regulated Minimum	6.5	0	3	<1
No Springflow	0	0	<1	0

Step Two: Associating Springflows and Dissolved Oxygen Concentrations

For each month in the 1917-2013 period of record and for each of the hydrographs for each scenario, appropriate regression formulas relating observed DO-springflow pairs (Turner, 2007; Porras, 2014) were selected and used to generate calculated DO concentrations for each springflow under base-flow (i.e., non storm flows) and no-recharge conditions, respectively. Turner (2007) surveyed at least seven non-linear curve-fitting routines for these data pairs, noting that all of them were very similar in standard errors and correlation coefficients for any one outlet, concluding that some other criteria should be used to select among them. The District selected the Logarithmic Fit routine for the Old Mill outlet, and the Exponential Association-3 routine for both Eliza and Main Springs. The DO-flow relationships are very different between Old Mill and either of the other two outlets, which are quite similar. Porras (2014) updated the data pairs to include those collected from 2007-2014 under no-recharge (i.e., low-flow) conditions, and extended the statistical analyses performed by Turner on the earlier data set.[9]

The District believes that use of data pairs under no-recharge flows only in these calculations avoids the confounding influence of highly variable DOs, from quite low to quite high, in various storm events being part of the datasets. For purposes of looking at effects of drought on water chemistry, using only no-recharge pairs was judged statistically to be more appropriate. (However, this also results in the predictions of DO at flows higher than average to be more suspect.)

As noted earlier, Old Mill outlet appears to reflect a different water provenance than the other two, and its DO "behavior" suggests that a Logarithmic Fit option is more appropriate for it, as its DO declines increasingly more rapidly below about 15 cfs of combined

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[9] The regression coefficients used by the District in the analysis in this Draft HCP are based on a draft of this City of Austin report; the City subsequently revised its analysis slightly, which resulted in small differences in the coefficients, especially for Main Springs. These differences would not materially affect the overall results and conclusions of the HCP, but will affect the exact take amounts predicted. The regression analysis and take amounts will be updated for the Draft HCP submitted with the ITP application.

springflows, while neither Eliza nor Main Springs does. Owing to the absence of data at extreme low flows (i.e., below 14 cfs), it does not seem reasonable to select a curve-fitting routine for those two that behaves similarly to Old Mill, rather to select one that is more consistent with the trends established at somewhat higher flows where there is more data control. The Exponential Association-3 routine does that. The District also notes that this routine seems more consistent than the Logarithmic Fit routine with the fact that the Covered Species have survived through the millennia when there were more extreme and prolonged droughts than the DOR.

The regression formulas used in this step are taken from Porras (2014) and are as follows:

Main Springs:	DO = 5.00*(1.8434-EXP(-0.008*Q))	(R^2 = TBD)
Eliza Spring:	DO = 3.50*(1.95-EXP(-0.025*Q))	(R^2 = 0.TBD)
Old Mill Spring:	DO = 1.49 + (1.0459*LN(Q))	(R^2 = 0.TBD)

where DO is calculated DO in mg/L, Q is total springflow in cfs, LN is the natural logarithm function, and EXP is base e of the natural logarithm raised to the power in the argument; and the metric R^2 is the coefficient of determination, a measure of the proportion of variability accounted for by the equation, which is computed by squaring the computed Pearson's product-moment correlation coefficient, "r".

Porras (2014) provided a confidence region that contained a family of regression coefficients that statistically were all equally valid. This region essentially defined the error bounds associated with a mid-point set of coefficients at ±0.2 mg/L DO concentration. For the take analysis, the District selected a set of coefficients at the upper bound of this confidence region, which tends to offset partially the otherwise ignored but presumptively beneficial effects of factors that were not included in making the take estimates.

The DO concentrations that correspond to the springflows of drought management interest for each of the three outlets and that are derived from the regression equations above are shown in Table 5-7. Main Springs has substantially higher DO concentrations at all springflows than the other two outlets, which tend to have similar DO concentrations in all but the most extreme drought conditions, when Old Mill decreases rather precipitously.

Table 5-7. Calculated DO concentrations at each of the three spring outlets corresponding to groundwater management thresholds for the HCP.

Relevant Management Thresholds		Calculated DO Concentrations At Each of Three Spring Outlets		
Aquifer Stage	**Total Springflow**	**Main Springs**	**Eliza Spring**	**Old Mill Spring**
Average Flow	53 cfs	5.93 mg/L	5.89 mg/L	5.64 mg/L
Stage II-Alarm	38	5.51	5.47	5.29
Stage III-Critical	20	4.94	4.70	4.62
Stage IV-Exceptional	14	4.73	4.36	4.25
Emergency Response	10	4.58	4.10	3.90
Regulated Minimum	6.5	4.45	3.85	3.45

No Springflow	0	4.20	3.33	0.00

Extending the type of analyses similar to those in Table 5-7 for the entire 97-year period of record produces a set of recurrence frequency curves for DO concentrations at the individual outlets. The results of this step are shown in Figure 5-6, with different graphs for each of the three outlets.

Similarly to the statistical analysis presented for flow, Table 5-8 highlights the information in Figure 5-6 to show the recurrence (non-exceedence) frequency for those DO concentrations of physiological and behavioral importance for the Covered Species by spring outlet. This is the final result of Step 2, which then informs the following steps.

Step Three: Converting DO to Salamander Mortality Estimates

In actuality the DO concentrations at the outlets shown in Figure 5-6 are unlikely to apply to the entire population of the Covered Species there simultaneously. It has been noted by several investigators that the DO concentration typically increases with distance away from the outlet at/near the surface (City of Austin, 2013; Smith-Salgado, 2011), presumably as the resurging water is able to re-aerate in the environments open to the atmosphere. Especially for epigean organisms like the Barton Springs salamander that are motile, some DO stress at the outlet will tend to be relieved by moving away from the outlet to higher-DO water in spring runs, , especially following the completion of habitat restoration work under the City's HCP that is intended to increase the re-aeration in the vicinity of the outlets.

Table 5-8. Recurrence Frequencies of DO Less than Designated Concentrations at Three Spring Outlets for the Three Pumpage Scenarios. These percentages correspond to the continuous data shown in Figure 5-6. Source: BSEACD, 2014.

DO Levels (mg/L)	Main Outlet			Eliza Outlet			Old Mill Outlet		
	No pumping	Pre-HCP	HCP	No pumping	Pre-HCP	HCP	No pumping	Pre-HCP	HCP
4.5 or below (LC5)	0%	4%	1%	5%	18%	10%	6%	20%	14%
4.2 or below (LC10)	0%	<1%	0%	<1%	8%	5%	1%	11%	7%
3.7 or below (LC25)	0%	0%	0%	0%	1%	<1%	0%	5%	1%
3.4 or below (LC50)	0%	0%	0%	0%	<4%	0%	0%	3%	<1%
0	0%	0%	0%	0%	0%	0%	0%	<1%	0%

On the other hand, for subterranean organisms like the Austin blind salamander, moving into epigean habitats for DO stress relief is likely only incidental, as suggested by the low abundance numbers of the censuses. But the Austin blind salamander may exist at some distance away from the outlets in the subsurface, finding either subterranean zones with higher water velocity that facilitates oxygen exchange and/or subterranean conduits and passages that have a greater proportion of unconfined water being transmitted. As both Lazo-Herencia et al. (2011) and Mahler and Bourgeais (2013) note, unconfined portions of the Aquifer tend to have considerably higher DO concentrations (mean 6.5 mg/L) than confined portions of the Aquifer (mean approximately 2 mg/L). The confined and unconfined portions of the Aquifer converge at the spring outlets, with each outlet having different proportions of each, dependent on the mix of the flow routes that provide water to the particular spring outlet (Mahler and Bourgeais, 2013; Hauwert et al., 2004). However, for purposes of the take estimate, the beneficial effects of such likely but un-quantified migration were ignored, and the DO calculated for the outlet was applied to the entire population. The offset provided by the selection of regression coefficients described in Step Two above notwithstanding, on the basis of sensitivity analyses performed by the District in this analysis, ignoring this migration factor is considered a very conservative assumption for this step.

Another fundamental presumption in this step is that the mortality curve developed by Woods and Poteet (2007) applies to both the Barton Springs salamander and the Austin blind salamander, although the confirming metabolic behavior comparisons were only made experimentally between the surrogate San Marcos salamander, *E. nana,* and Barton Springs salamander. No other information quantitatively relating DO to mortality of Austin blind salamander appears to exist.

Using these presumptions and assumptions along with the mortality curves of Poteet and Woods (2007), the District then assigned and applied sequentially the appropriate Lethal Concentrations associated with the calculated DO concentrations at each outlet for each month in the 97-year period of record.

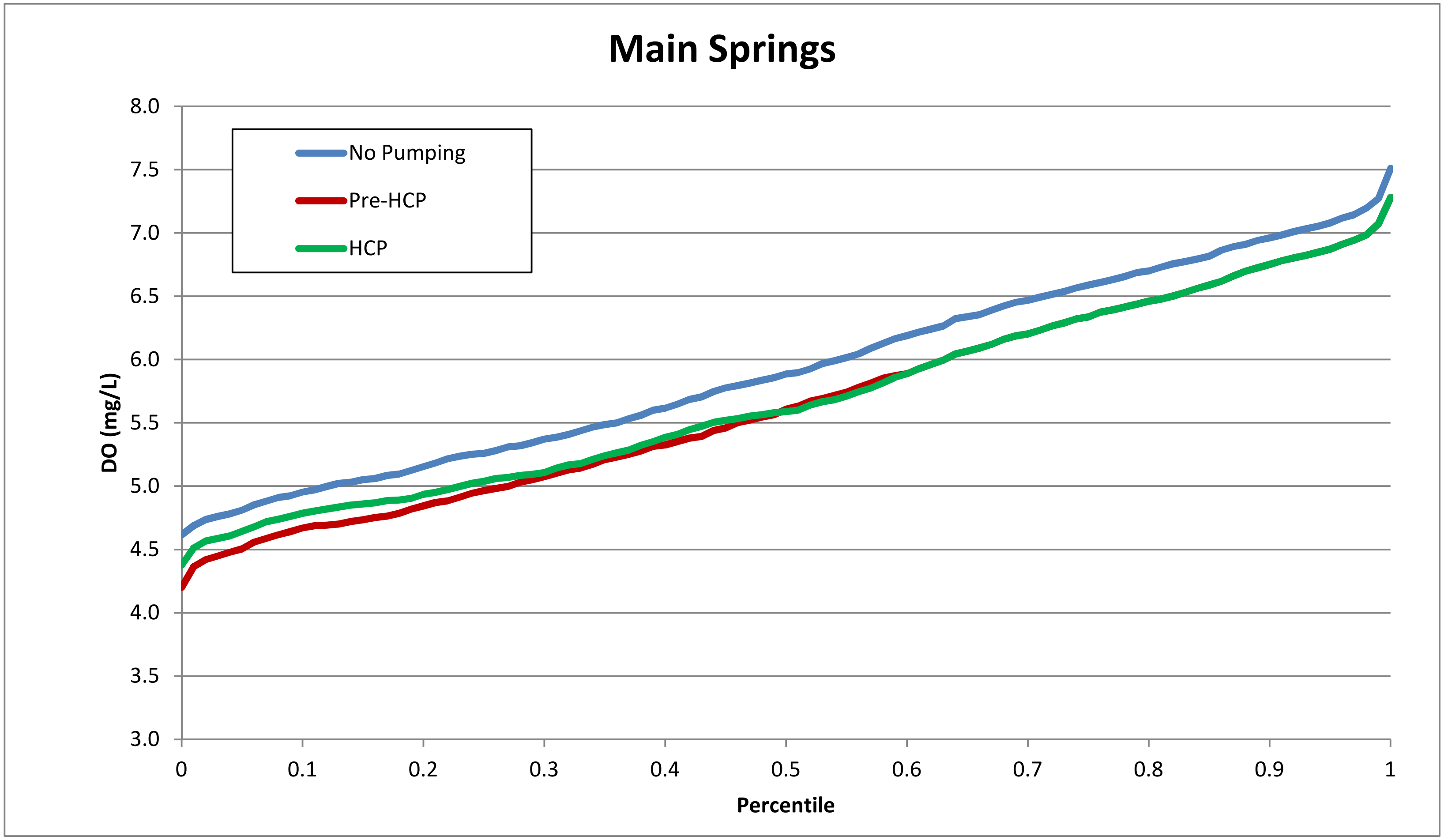

Figure 5-6(a). Recurrence frequency of DO (fraction of DO concentrations less than values shown) at the Main Spring outlet that corresponds to total springflow for the three pumping scenarios. The DO was calculated on the basis of a selected regression equation for this outlet based on measured flow-DO pairs under low flow conditions.

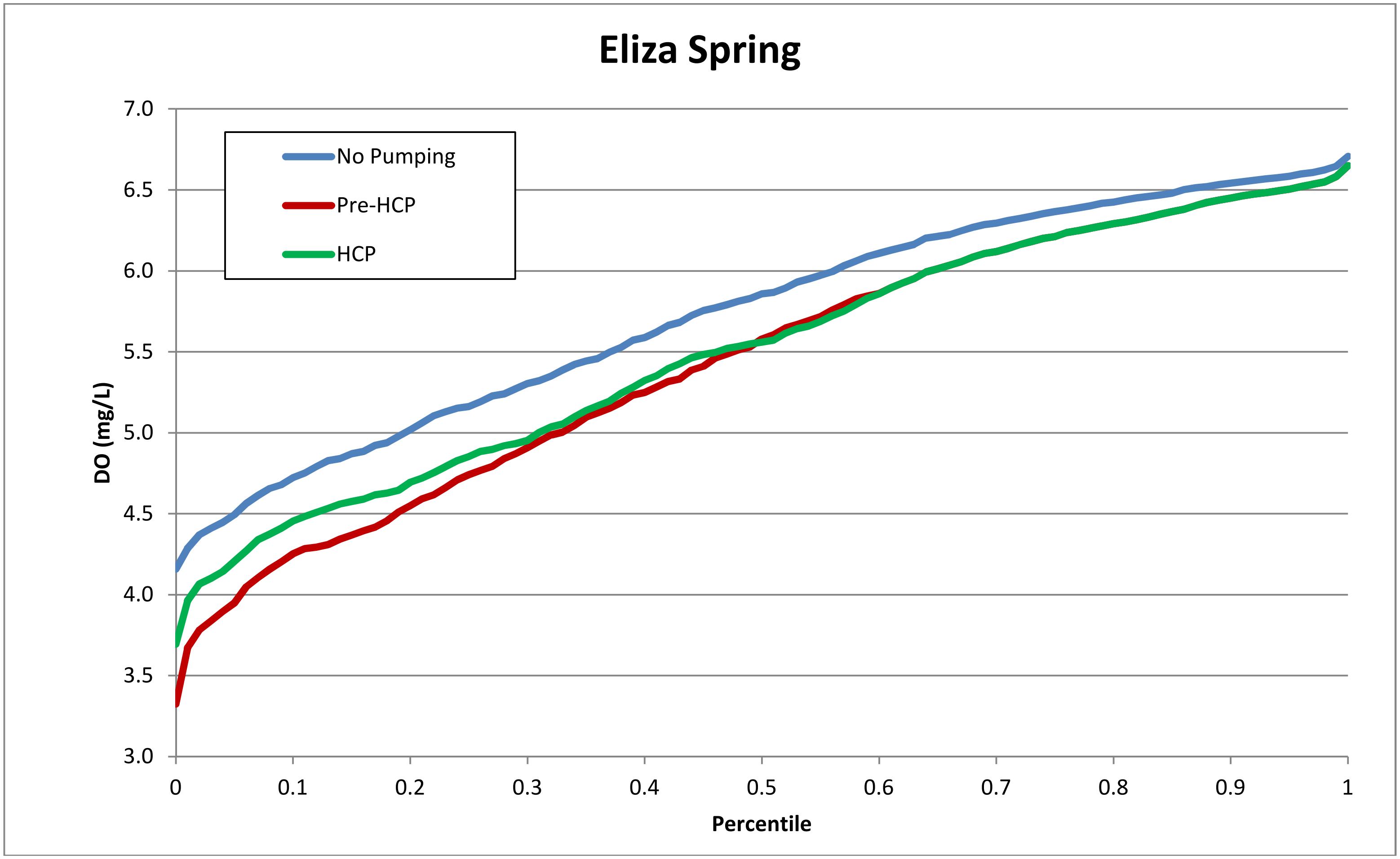

Figure 5-6(b). Recurrence frequency of DO (fraction of DO concentrations less than values shown) at the Eliza Spring outlet that corresponds to total springflow for the three pumping scenarios. The DO was calculated on the basis of a selected regression equation for this outlet based on measured flow-DO pairs under low flow conditions.

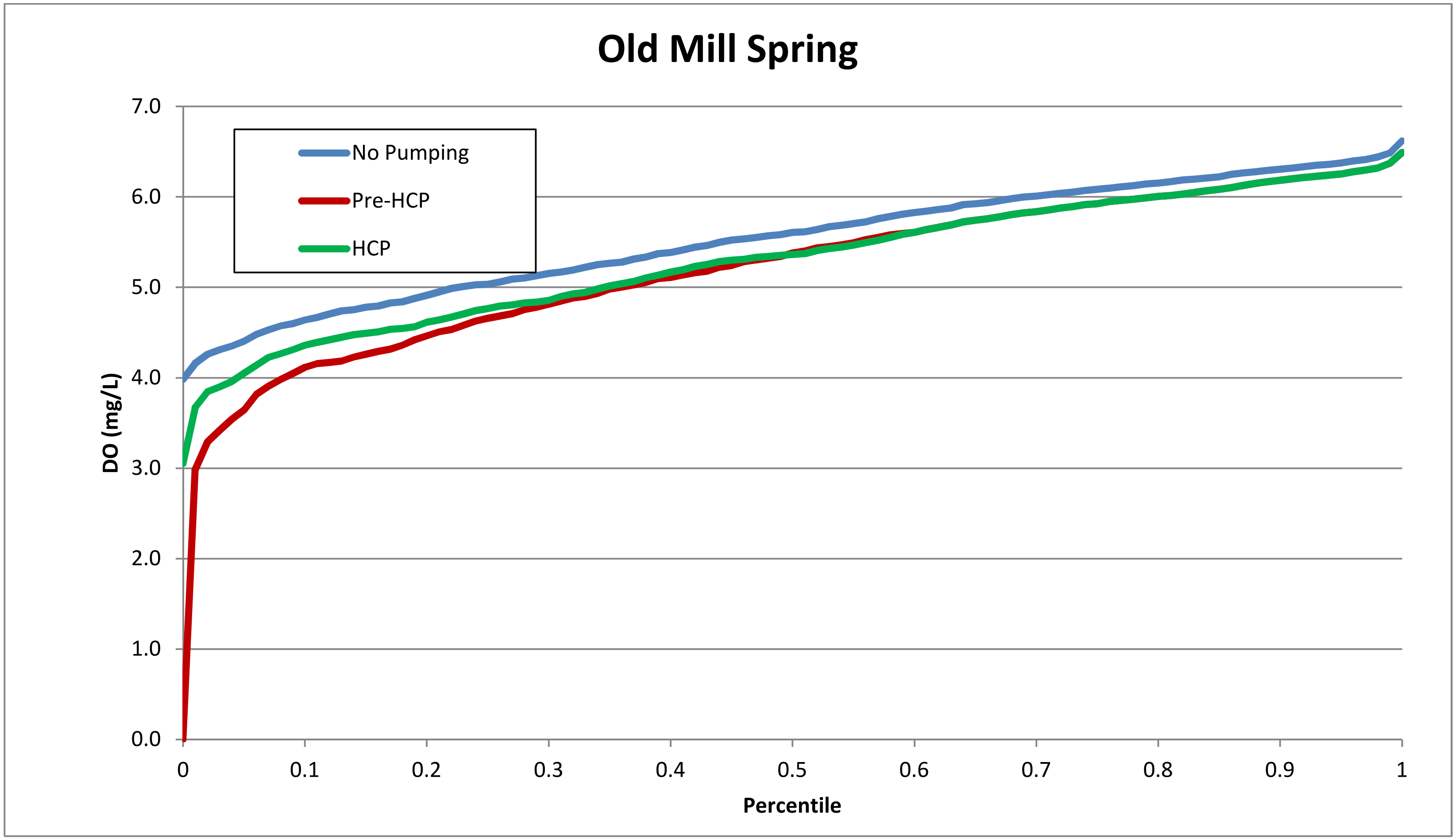

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Figure 5-6(c). Recurrence frequency of DO (fraction of time that DO is below the indicated value) at the Old Mill Spring outlet that corresponds to total springflow for the three pumping scenarios. The DO **fraction of DO concentrations less than values shown** was calculated on the basis of a selected regression equation for this outlet based on measured flow-DO pairs under low flow conditions.

The results of this analysis demonstrated, not surprisingly, that the Drought of Record (DOR) scenario consisted of the largest number of months with the lowest overall DO concentrations and the largest number of consecutive months with lethal concentrations of DO. The seven-year period of the DOR, from June 1950 through May 1957, was ultimately selected to be the reasonable worst-case for the take analysis. A second, more recent period, using an equivalent length severe drought interval from March 2005 through February 2012, was selected for comparison, comprising a less extreme but still severe drought that is more likely to be the worst drought to occur in a typical 20-year period, which is the ITP term. The springflows associated with these two periods under the three groundwater management scenarios used in this analysis are shown in Figure 5-7, along with a hydrograph of the entire period of record for comparison of the two time series.

The District applied the mortality estimates as indicated by the prevailing DO for each month of the modeled period in a sequential, cumulative fashion to the calculated population in the preceding month. The average populations of each of the Covered Species and at each of the outlets (Section 3.2.2.2.1) were designated the initial condition for this analysis. The DO regimes were defined by the pumping scenarios and were outlet-specific. At the end of each of the two modeled drought periods, the difference between the initial condition and the residual number of individual salamanders was calculated to represent the adverse effect associated with the DO regime for that pumping scenario.

Step Four: Computing Take as Differences Between No Pumping and Pre-HCP Pumping HCP Scenarios

The District then subtracted the residual number of individuals n the No Pumping scenario, i.e., the population at the end of the period, from those similarly calculated in the Pre-HCP scenario for each outlet, and then aggregated to determine the total *incremental* effect from the change in DO associated with the Covered Activities, as represented by the Pre-HCP Pumping scenario. This difference constitutes the estimate of lethal take of the Covered Species by the Covered Activities. Because the DOR modeled in this analysis had the lowest DOs and the highest number of consecutive months of anticipated lethal conditions, the resulting number of individuals is considered the estimated maximum lethal "take" by the District's Covered Activities for any seven-year period.

Step Five: Computing the Benefit of the Conservation Measures to the Amount of Take

The District then used an analogous procedure between the Pre-HCP residual conditions and the HCP residual conditions to calculate the benefit associated with the conservation measures of the proposed HCP program scenario during the same DOR period, producing what it has termed "net residual take" after implementing all the proposed HCP conservation measures.

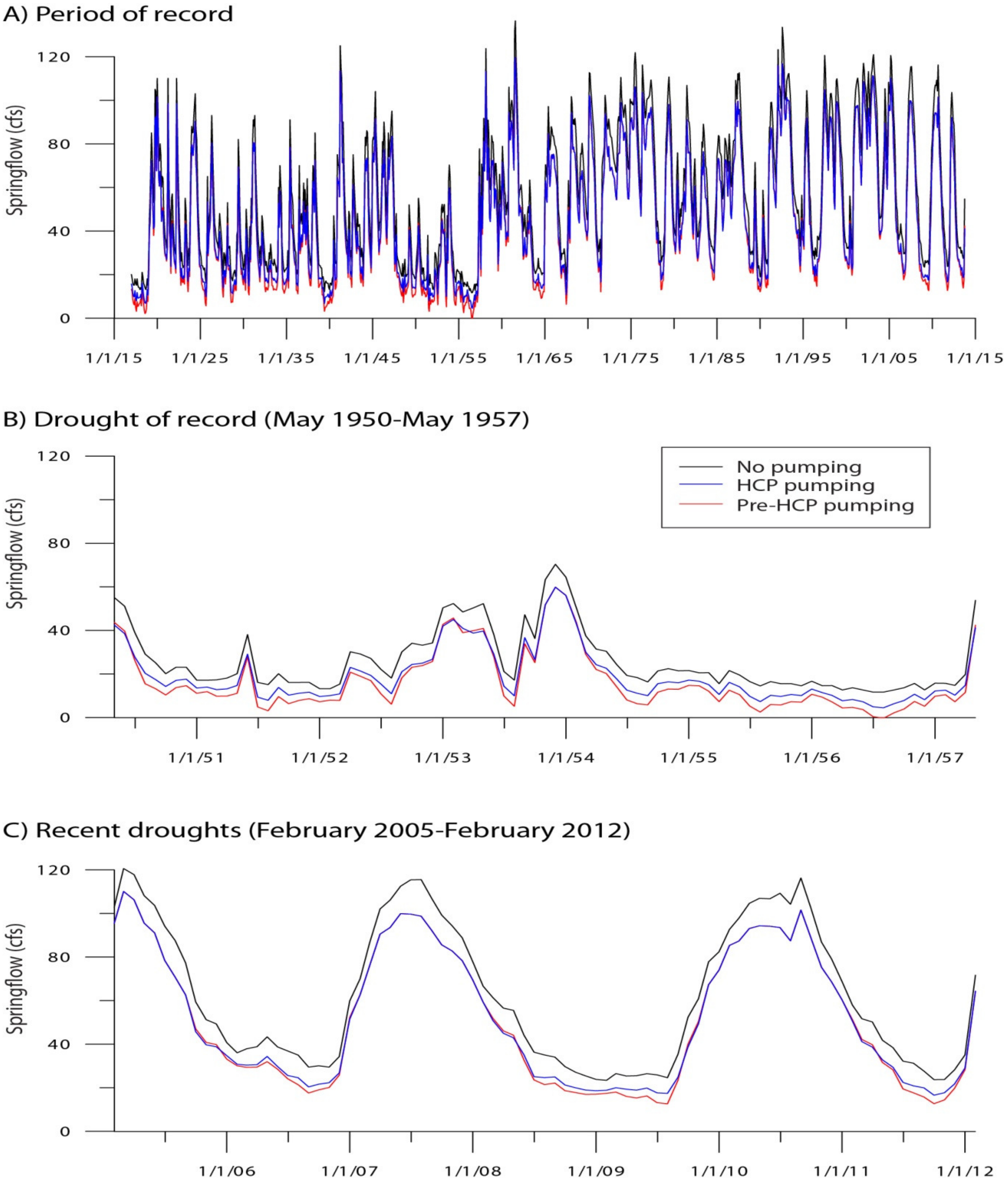

Figure 5-7. Springflow hydrographs for two severe drought periods. The analyses compared the effects of the two management scenarios and the no-pumping scenario on resulting springflows for each of these droughts, which informed the calculations of the DO concentrations during these two periods. The hydrograph of the entire period of record is shown for comparison. Even during severe drought, the pumping scenarios closely follow the no-pumping scenario, indicating the dominance of natural-system variations in the hydrographs.

The results of this five-step analysis are displayed and discussed in the next subsection. While this analysis is rational and uses the best information available to the District, it obviously requires a number of assumptions and stipulations, so the results should be viewed as a first approximation rather than an absolute certainty in its outcome; the comparisons among scenarios and the relationships among various factors may be more reliably instructive. The District has attempted to provide transparency into the procedure and the rationale for the assumptions and stipulations in this HCP.

5.2.4.2.2 Estimated Lethal Take

As previously noted, Service regulations define take as the difference in specified adverse effects for circumstances that arise (a) with and (b) without the Covered Activities, or for this HCP between a “no (nonexempt) pumping” scenario and a pumping scenario before application of the HCP’s conservation measures, designated herein as “Pre-HCP”. The District has used a rational basis for estimating these adverse effects that are based on data and reasonable inference to produce a quantitative estimate of lethal take of two species that are cryptic in nature and therefore with populations of indeterminate size. The results of this estimation process for the seven years comprising the Drought of Record are shown in Table 5-9 below.

Table 5-9. Estimated Lethal Take and Conservation of the Covered Species Without and With the HCP Measures During a Drought of Record Recurrence

Barton Springs Salamander During Drought of Record Period							
	Initial Condition	**Residual Condition at End of Period for Scenarios:**			**Take Calculations**		
Spring Outlet	**(Maximum Population of Outlets)**	**No Non-exempt Pumping**	**Pre-HCP Measures**	**HCP Conservation Measures**	**Lethal Take**	**Conservation Measures Benefit**	**Net Take With Benefit**
Main	**104**	104	22	76	82	54	28
Eliza	**446**	50	0	3	50	3	47
Old Mill	**35**	2	0	0	2	0	2
ALL	**585**	**156**	**22**	**79**	**134**	**57**	**77**
Mortality (All Sources)*		73%	96%	86%			
	Change From Initial Condition Solely By Covered Activities				-23%	10%	**-13%**

*Mortality is expressed as the percentage of the total population shown that were not alive at the end of the end of the modeled period after application of the designated groundwater management scenario.

Table continues on next page

Table 5-9 (continued). Estimated Lethal Take and Conservation of the Covered Species Without and With the HCP Measures During a Drought of Record Recurrence

Austin Blind Salamander During Drought of Record Period							
	Initial Condition	Residual Condition at End of Period for Scenarios:			Take Calculations		
Spring Outlet	(Maximum Population of Outlets)	No Non-exempt Pumping	Pre-HCP Measures	HCP Conservation Measures	Lethal Take	Conservation Measures Benefit	Net Take With Benefit
Main	**91**	91	19	67	72	48	24
Eliza	**182**	21	0	1	21	1	20
Old Mill	**727**	44	0	0	44	0	44
ALL	**1000**	**156**	**19**	**68**	**137**	**49**	**88**
Mortality (All Sources)*		73%	97%	88%			
	Change From Initial Condition Solely By Covered Activities				-14%	5%	**-9%**

*Mortality is expressed as the percentage of the total population shown that were not alive at the end of the end of the modeled period after application of the designated groundwater management scenario.

The table demonstrates that most (almost three quarters) of these adverse effects on the Covered Species occur as a result of “natural” drought flow variations. This is consistent with the implications of the preceding Figure 5-7, which shows that the effects of pumping on springflows even during extreme drought are overprinted on and relatively small compared to the variations from natural causes. The estimated Lethal Take, attributable to non-exempt pumping *without the HCP conservation measures* during a DOR-like period is expected to be about 23% of the presumptive Barton Springs salamander population and 14% of the Austin blind salamander population. Table 5-8 also indicates that the HCP conservation measures, nearly all of which are already implemented, substantially reduce the adverse effects attributable to pumping such that the “net take”, *with the HCP conservation measures*, decreases to 13% for Barton Springs salamander and 9% for Austin blind salamander.

However, during a DOR recurrence, these data and analyses also indicate that Eliza and especially Old Mill Spring outlets will bear the brunt of the impact of low springflows, and the effects on their populations from DO-related stress arising from drought and pumping of the Aquifer are likely to be dire. Natural tendencies of the Covered Species to migrate if possible from the outlets to adjacent areas with higher DO, and deployment of mitigation measures under both the District’s and the City’s HCPs (in particular, the spring-run rehabilitations) will be critically important to preserving these springs as habitat if a DOR recurrence should occur during the term of the ITP.

During prolonged extreme drought conditions similar to a DOR, clearly most of the adverse effects on the salamander arise as a result of drought *per se*. But the differences between the two non-exempt pumping management scenarios during such a stressful drought period underscore the importance of the District’s conservation measures in minimizing take and avoiding jeopardy for both Covered Species.

During a more recent period of severe and prolonged drought, which is more likely to characterize the ITP term than a DOR recurrence, the Covered Species will be substantially less stressed, including in particular stresses arising from non-exempt pumping sources. The results of modeling of the seven-year period from 2005-2012, which includes three severe drought cycles, including the single year (2011) generally regarded as the most severe (driest, hottest) single-year drought period in Texas history, is shown in Table 5-10. This table indicates that fewer than ten individual organisms, less than 1% of the Barton Spring salamander population, all at Old Mill Spring, would have been taken with all HCP conservation measures in place; without those measures, about 32% would have been taken, comprising about one-half each of those at Eliza and Old Mill Springs. For the Austin blind salamander in this more recent drought, slightly more than one-half of the population would have been taken without the conservation measures, but the HCP measures would reduce the net take to 14%, and would be restricted to Old Mill Spring, where less than one-fifth the population would be affected.

The modeling also shows that unlike the DOR, the natural drought conditions *per se*, without any non-exempt pumpage contributions, during this more recent severe drought period would not have lethal effects on the organisms from a DO-stress standpoint. Consequently, the calculated adverse effects on the Covered Species from DO changes during this drought period arise in the model from the non-exempt pumping, and the HCP conservation measures have a substantial beneficial impact on reducing not only take but overall lethality.

Table 5-10. Estimated Lethal Take and Conservation of the Covered Species Without and With the HCP Measures During a a Recent Severe Drought Period

Barton Springs Salamander During 2005-2012 Drought Period							
Spring Outlet	**Initial Condition**	**Residual Condition at End of Period for Scenarios:**			**Take Calculations**		
	(Maximum Population of Outlets)	**No Non-exempt Pumping**	**Pre-HCP Measures**	**HCP Conservation Measures**	**Lethal Take**	**Conservation Measures Benefit**	**Net Take With Benefit**
Main	**104**	104	104	104	0	0	0
Eliza	**446**	446	280	446	166	166	0
Old Mill	**35**	35	14	29	21	15	6
ALL	**585**	**585**	**398**	**579**	**187**	**181**	**6**
Mortality (All Sources)*		0%	32%	1%			
	Change From Initial Condition Solely By Covered Activities				-32%	31%	**-1%**

*Mortality is expressed as the percentage of the total population shown that were not alive at the end of the end of the modeled period after application of the designated groundwater management scenario.

Table continues on next page

Table 5-10 (continued). Estimated Lethal Take and Conservation of the Covered Species Without and With the HCP Measures During a Recent Severe Drought Period

Austin Blind Salamander During 2005-2012 Drought Period							
	Initial Condition	Residual Condition at End of Period for Scenarios:			Take Calculations		
Spring Outlet	(Maximum Population of Outlets)	No Non-exempt Pumping	Pre-HCP Measures	HCP Conservation Measures	Lethal Take	Conservation Measures Benefit	Net Take With Benefit
Main	**91**	91	91	91	0	0	0
Eliza	**182**	182	114	182	68	68	0
Old Mill	**727**	727	286	592	441	306	135
ALL	**1000**	**1000**	**491**	**865**	**509**	**374**	**135**
Mortality (All Sources)*		0%	51%	14%			
	Change From Initial Condition Solely By Covered Activities				-51%	37%	**-14%**

*Mortality is expressed as the percentage of the total population shown that were not alive at the end of the end of the modeled period after application of the designated groundwater management scenario.

5.2.4.2.3 Uncertainties in Lethal Take Estimates

These lethal take estimates are considered useful approximations that are based on a number of assumptions and stipulations to account for uncertainties. Many of the more important of these uncertainties have been discussed in various preceding subsections of the HCP; they and others are summarized below, in no particular order, to facilitate appreciation of their scope and significance to the take estimates.

Effect of All Recharge Sources on Groundwater Declines

Groundwater modeling may not have explicitly included the effects of all sources of groundwater recharge on the recession of the Aquifer during extreme drought. Recent information suggests that the 1:1 correspondence between pumping and springflow, on which the springflow analysis in this HCP is based, may be less than 1:1 during extreme drought, in which more pumping would be effectively required for a given unit of springflow reduction. This uncertainty is conservative toward springflow and calculated DO, but the actual DO regime associated with that extended recession curve is unknown.

Magnitude of Likely Droughts During the ITP Term

During the 20-year ITP term, it is not likely that a recurrence of the Drought of Record would happen, which was used in the springflow-DO modeling in this HCP. Modeling of more likely encountered severe-to-extreme drought events during the ITP term, such as those that occurred in the 2005-2012 drought periods, indicates that the take for such an event, i.e., without the HCP measures, would be much less than that of the DOR period. And during the ITP term, there will likely be prolonged periods with no drought or droughts that are not sufficiently severe to produce DOs in springflows that have adverse physiological or behavioral impacts. The use of a DOR recurrence as a sole reference period for springflow and DO is a very conservative assumption.

Note: It should be recognized that because the DOR has a much larger portion of its total adverse effect arising from natural conditions, which in turn substantially reduces the baseline quantity, a take specification numerically may be lower for a DOR than for less severe droughts, even though the number of individual organisms harmed in total in a DOR is far larger; for example, compare the residual Pre-HCP numbers and the Lethal Take amounts of the Barton Springs salamander in Tables 5-9 (for a DOR) and 5-10 (for the recent severe droughts). This circumstance is an unusual artifact of the Service's take calculation formula as applied in this HCP, and it must be accommodated in both the ITP specifications and in monitoring and reporting of actual take.

Durations of Springflows Expressed As Other Than Monthly Averages

The natural flows of Barton Springs as well as the aggregate amount of pumping change very slowly during a prolonged, severe drought, and recurrence for these flow durations would be very similar to those for weekly or even daily flow durations. As discussed in

Section 3.2.2.1.1, actual flows expressed as shorter flow durations would tend to increase the percentage of time at or above a given low springflow, because the changes would be derived primarily from storm events that in the shorter-term increase springflow.

Likely Differences Between Authorized and. Actual Pumpage by Permitted Groundwater Users

The relationship between pumping and springflow that was modeled for the HCP was based on use of the entire authorized amount each month by each permittee, which is a conservative assumption in the HCP. Even though curtailments during drought are more likely to increase the fraction of curtailed use represented by actual use, the District's recent experience in drought management indicates that actual use is still below the authorized curtailed usage otherwise permitted.,

Springflow-related Factors Other Than Dissolved Oxygen Concentration

The District's Covered Activities, viz., managed pumping of the Aquifer, can only affect those physical and chemical habitat factors directly related to springflow. Of these, only DO was modeled, inasmuch as the quantitative influence of other factors, other than temperature, has not been established. Temperature variations are less controlled by the amount of springflow and more related to seasonality or the amount of higher stormflows in the springflow, neither of which are controlled by the Covered Activities; prolonged drought tends to reduce the amount of temperature variations in springflow. Concentrations of ionic constituents does exhibit some variation with springflow but it is over a rather narrow range of about 100 mg/L TDS, for which no physiological or behavioral changes are known to be attributable, even for non-adult life stages of the Covered Species.

Covered Species Population Size and Distribution

Because of their cryptic nature, spending an appreciable portion of their time in subterranean or otherwise inaccessible epigean habitats, the population sizes of both of the Covered Species have not been firmly established. This is especially pertinent to the Austin blind salamander, for which only a small part of its Critical Habitat is observable.

For the Barton Springs salamander, the District has assumed the maximum in the range of counts at Upper Barton Spring as the number that could be potentially harassed, i.e., non-lethally taken. The population sizes at the perennial outlets are based on the mean-plus-one-standard deviation observed metric that has been used in the City's approved HCP for estimating such take. For all outlets, their distribution will vary with time and water chemistry conditions in an indeterminate fashion.

The population size of the Austin blind salamander is simply unknown. It was inferred on the basis of observed density of subterranean salamander species in epigean environments in both Barton and San Marcos Springs, adjustment for areal distribution of presumptive habitat-supporting conduits and fissures at the water table, and then extension to the

Critical Habitat size. This approach is accompanied by substantial uncertainty in the overall population size, inasmuch as the incidental epigean density may not be representative of its subterranean density for such subterranean species and because the known habitat of other similar subterranean salamanders is more than two orders of magnitude larger (EARIP, 2012) than the Critical Habitat-designated area for Austin blind salamander.

Another related assumption that was made for both species has to do with the DO regime to which they are exposed and the location of that regime. The indicated DO at the spring outlets was applied to the entire extant populations for both species. The District believes that an unknown but likely substantial fraction of the Barton Springs salamander population will move away from the outlet in the surface environment to water that has higher DO concentrations, although how much higher is also indeterminate. The re-establishment of accessible spring runs at the spring outlet will, among other things, re-aerate the water and provide a driving force for such migration. Similarly, an unknown but likely substantial fraction of the Austin blind salamander population will either exist normally or move in the subsurface away from the outlet once the DO concentrations decrease to stressful levels, seeking subterranean areas with a greater proportion of unconfined water at that outlet that has higher DO concentrations. It is not reasonable to assert that the entire mobile population of either species will continue to be exposed to the same DO regime at the outlet at any one point in time when less stressful environments with higher-DO water are readily accessible to those populations.

However, because this tendency to migrate, the proportion of populations involved, and the degree of stress relief provided are all indeterminate, a very conservative assumption has been made that the entire population has no recourse to being exposed only to the DO at the outlet. Sensitivity analysis by the District in preparing this HCP suggests that such migration of a relatively small part of the population to areas that have slightly higher DO would produce substantially less take during extreme droughts like the DOR, other factors equal. The District considers it not unlikely that this may well be a primary mechanism that allows these endemic species to have persisted through many and more extreme droughts during its natural history.

Indirect Effects of Pumping on Other Species Important to the Covered Species

The take estimates in this HCP are based on habitat changes as they relate directly to the Covered Species themselves, and not on the macroinvertebrate community on which the salamanders rely for prey (City of Austin, 2013). For example, the effect of depressed DO at smaller springflows on the size and predator avoidance behavior on the population of amphipod or other prey in the habitat has not been evaluated. The District is unaware of a *quantitative* relationship between springflows or DO concentrations and the macroinvertebrate prey that could be compared to the effects on the salamander species. In essence, the District is making an assumption that the macroinvertebrates either are present in sufficiently large population numbers that they are not a limiting factor for the salamanders, or are not impacted physiologically by lower DO to the same extent as the Covered Species, or both. The validity of this assumption is unknown, but it introduces uncertainty that can only be judged qualitatively, not quantitatively presently. The City has noted that some 100 taxa of macroinvertebrates have been catalogued at the outlets, and while the abundance of the macroinvertebrate community decreases with decreasing springflow, the decreases are not uniform across the entire community (City of Austin, 2013); such diversity would be beneficial to the predator Covered Species. Furthermore, the Covered Species are known as invertevores, which means that they do not discriminate as to what species of invertebrates become their prey, an adaptation that is especially useful in energy production and conservation during drought. Nevertheless, the relationship of springflow, DO, and macroinvertebrate abundance and diversity may be important to cumulative impacts and could be a useful focus of future research, although extreme low flows would be required for proper evaluation in the field.

Non-modeled Differences Between the Two Covered Species

Notwithstanding the differences in population sizes and their locations, for the most part the two Covered Species are considered to react and behave similarly, in absence of data to the contrary. However, Austin blind salamander is in a separate evolutionary branch from both the Barton Springs salamander and the San Marcos salamander that was used in the laboratory studies, so its similarity in DO stress-response to Barton Springs salamander is not assured. In fact, it seems to spend a substantially greater portion its life in a naturally somewhat lower DO regime than the Barton Springs salamander, so it could be not unreasonably asserted that it could be better adapted genetically to such environments. Again, because the existence, direction, and magnitude of differences in the mortality curves for the two species is indeterminate, no differences in the Austin blind salamander's lethality is assumed in the modeling, which the District suggests may tend to overstate its mortality at a given DO level. That said, other assertions could be made that no differences are known to exist, and that lack of data requires no difference to be imputed.

Lack of Data on DO Variations at Extreme Low Flows

The relationship between springflow and DO was defined for each outlet by regression equations based on observed Outlet DO-Total Springflow pairs. There were very few pairs below 20 cfs, and no pairs below 14 cfs, which is the zone of most interest to salamander physiology and behavior. Relying solely upon trends established by data only in a higher-flow domain is problematic and introduces additional uncertainty into the modeling (but see immediately below).

Differences in DO Regimes Among the Individual Spring Outlets

Whether and what trends actually exist between DO and springflows and how they differ among the outlets in the extreme low flow realm is currently indeterminate, as the springflows have not been that low since DO measurements were initiated. For the HCP, the markedly different low-flow water chemistry exhibited at Old Mill Spring, in comparison to Eliza and especially Main Springs, along with its resurgence along a different fault suggested that it might have a fundamentally different relationship in DO-springflow, as is observed in the field. Old Mill Spring was modeled using a different type of regression equation than the other two perennial outlets because of this tendency. But statistically there is not a basis to judge what regression relationship(s) should be used.

Effect of DO Variations on Other Life Stages

Funding limitations required the laboratory study in this HCP to focus on the life stages of the salamander typically encountered. Most of the stressor-response study addressed adult salamander stages, with a limited investigation of DO stress to juveniles. While these stages may be the lengthier stages and therefore are exposed to the largest range in DO variation, the effect of DO variations on egg and larval forms is potentially also important, but unaccounted for in this HCP. On the other hand, there are no known data or studies that suggest the Covered Species are especially susceptible to such variations of the magnitude introduced by the Covered Activities.

Effect of DO Variations on Sub-lethal Behavior and Population Dynamics

This HCP does not quantitatively estimate or differentiate presumptive sub-lethal effects from variable DO (at some unknown concentrations) on reducing or cessation of reproduction, natality, and/or recruitment, reducing other growth, reducing prey/food abundance, and increasing intra-and inter-specific competition (Gillespie, 2011). To our knowledge, quantitative relationships between and among these factors and DO concentrations for the Covered Species do not exist. In absence of relevant data, the District has made the following assumption to account for sub-lethal effects at the perennial outlets: the take from sub-lethal effects begins when lethal take begins and is equivalent in magnitude to the amount of lethal take that occurs at the prevailing springflow. The District acknowledges this assumed value may either under-estimate or over-estimate such non-lethal take and its importance in a general ecological sense to the two populations. It should also be noted that proportionate effect of these factors to the numerical take calculations will actually tend to be smaller with more extreme droughts, since larger proportions of adverse effects in extreme droughts are attributable to natural variations rather than to non-exempt pumping.

Differences Between Predicted and Observed DO Concentrations

The DO concentrations predicted by the regression equations on total springflow systematically deviated from the DO concentrations actually measured for recent drought springflows by 0.6 mg/L, with the measured DO higher than that predicted (Turner, 2009). Some of this deviation may arise from within margins of variability and error associated with statistical manipulations (Porras (2014) indicates by statistical analysis that this may be on the order of ±0.2 mg/L), or simply the randomness and variability of any individual environmental event (in this instance, the 2008-2009 drought). But generally, this deviation suggests that some of the uncertainties mentioned in this section, such as the absence of extremely low flow DO data and regression relationships that are consequently skewed, are in fact conservatively accommodated in this HCP, and that actual effective DO is higher than predicted in the take estimate. Alternatively or additionally, this deviation supports this HCP's use of different regression equation families for Main and Eliza Springs than for Old Mill Springs and of using their upper-bound regression coefficients (Porras, 2014).

Application of Laboratory Data to In-the-Wild Conditions

Sec 5.2.1.3 noted the following: "…this research [is] helpful in characterizing some of the parameters of potential take of the Barton Springs salamander, and by extension the Covered Species, in the wild. There are, however, additional areas of uncertainty that should be acknowledged. As in all laboratory studies, the response of the test organisms under controlled conditions may not be the same as in the wild. Response also varies among individuals, affecting the precision of mortality estimations. This potential variability is accounted for by presenting 95 percent confidence intervals around the mean value of each estimate of mortality. As described above, the surrogate species *E. nana* appeared to react similarly to Barton Springs salamander among laboratory treatments when metabolism was monitored, but *E. nana* mortality estimates may or may not align as well with those expected in the Covered Species populations in the wild, particularly in any given time period (Woods et al., 2010). Mortality estimates are only for adult salamanders, so other life stages may have different or more variable sensitivities to reduced DO or elevated conductivity."

Cumulative Risk Factors beyond the District's Control

Adverse effects on the Covered Species resulting from anthropogenic water quality changes, e.g., nonpoint-source pollution arising from watershed modification, may be exacerbated by or additive, synergistic, or antagonistic to adverse effects from springflow-related water chemistry changes such as DO variations. These may have significant consequence to the Covered Species, but the District has no control over the existence or magnitude of such factors, so those cumulative effects have not been considered in the take estimate *per se*, in accordance with the Service's guidance. Rather, the impacts of these sources of additional risk are to be addressed in the environmental assessment prepared by the Service under NEPA for this HCP.

The sources of uncertainty and variation discussed in this subsection notwithstanding, the District is reasonably confident that the take estimates developed herein provide a relative sense of the overall benefit of the proposed HCP conservation measures. On the basis of the recent severe drought conditions, the District would suggest that in aggregate the take estimates are conservatively high; in reality using these estimates provides a buffer of additional protection.

5.2.4.3 Summary of Estimated Take and Cumulative Take

This subsection provides a synopsis of the estimates of total take associated with groundwater withdrawals. Take is referenced to a baseline that includes natural drought and other effects, excluding only the effects of the Covered Activities; the baseline population for more extreme drought is much smaller than that of the recent severe drought.

It should be reinforced for purposes of this summary that the lethal take estimate is not based on a dynamic population model, rather it is only a differential comparison to lethal physiological effects caused solely by DO changes attributable to the Covered Activities under various groundwater management scenarios. While the term "population" is used in this section, the numbers presented herein do not refer to a predicted actual population size, as the effects of natality and recruitment on actual population (and the currently indeterminate effect of DO variations on those and other population-determining factors) are not considered here. In effect, they are modeled as if no births or growth to maturity ever occurred over the ITP period, so the reported amounts are not indicative of actual population size.

The take estimates in this section also include non-lethal/sub-lethal take, which may arise at the perennial spring outlets for both species from: reduction to cessation of reproduction and growth; reduction in prey abundance; increased intra-and inter-specific competition; and an incremental, small amount of wetted habitat loss attributable to the Covered Activities. At the non-perennial Upper Barton Spring, non-lethal take arises only for the Barton Springs salamander, primarily from the temporary habitat loss as the spring outlet stops flowing, presumptively causing migration from the outlet and back. Non-lethal take in all of its forms is difficult to quantify, so for purposes of the total take estimate, the District has simply stipulated that the aggregated non-lethal take is equivalent in magnitude to the lethal take that arises during drought from the physiological effects related to the DO at the prevailing perennial springflows, plus the maximum number of Barton Springs salamander ever observed at Upper Barton Spring (100 individuals). Obviously, actual non-lethal effects may be more or less than this amount, but the District considers it a reasonably conservative estimate in that some double counting probably occurs between lethal and non-lethal impacts at the individual organism level, especially deep in severe droughts. The total take is capped at the residual population of each species extant during baseline conditions, which is the no non-exempt pumping scenario.

While a recurrence of the DOR during the term of the ITP is very unlikely, in this HCP the District considers that circumstance a reasonable worst-case that would produce the maximum expected adverse effects on the populations of the Covered Species. Over such an extreme seven-year period, the following take is estimated to occur:

Drought of Record	**Initial Population**	**No Pumping** Population Estimate	**Pumping, Pre-HCP Measures**		
			Population Estimate	Lethal Take	Total Take
Barton Springs Salamander	585	156	22	134	256
Austin Blind Salamander	1000	156	19	137	156
Drought of Record		**No Pumping** Population	**Pumping with HCP Measures**		
			Population	Lethal Take	Total Take

		Estimate	Estimate		
Barton Springs Salamander	585	156	79	77	254
Austin Blind Salamander	1000	156	68	88	156

Clearly, during a DOR recurrence scenario, the amount of lethality arising over that period from even the baseline scenario of no non-exempt pumping is at a maximum. During such an extreme drought, every individual organism is almost certain to be at least harassed or annoyed eventually by unavoidable lower DO concentrations. And the large proportion of lethal take, even with the HCP conservation measures, will put a premium on the implementation of mitigation measures in both the District's and the City's HCPs, should a DOR recurrence occur.

The actual amount of take that is incurred in a DOR recurrence scenario will depend on the initial condition of the populations when the seven-year period begins; as these species' populations are typically variable, the take could be less than the amount shown, since the initial condition used in this analysis corresponds to a best estimate of the population sizes at or near the top of a cycle. The distribution of the take with time within the seven years will depend upon the variability of the meteorological and hydrological conditions; it is no more likely that it will be spread evenly across the seven-year time span as it will occur over one or two years in that span.

In contrast, the recent severe droughts, which comprise a more typical seven-year period of severe drought during the ITP term, would have far larger residual populations and much smaller proportions of lethal take than during the presumptive worst-case DOR scenario:

Recent Severe Droughts (2005-12)	**Initial Population**	**No Pumping**	**Pumping ,Pre-HCP Measures**		
		Population Estimate	Population Estimate	Lethal Take	Total Take
Barton Springs Salamander	585	585	398	187	474
Austin Blind Salamander	1000	1000	491	509	1000
Recent Severe Droughts (2005-12)	585	**No Pumping**	**Pumping with HCP Measures**		
	1000	Population Estimate.	Population Estimate	Lethal Take	Total Take
Barton Springs Salamander	585	585	579	6	112
Austin Blind Salamander	1000	1000	865	135	270

It is noteworthy that during this more recent period of severe droughts, the baseline population was the same as the initial population, i.e., without pumping, there would be no lethal effects from the springflow DO during that period. The take of Barton Springs salamander over this seven-year period with the HCP conservation measures would be only 112 of the initial 685 individual organisms (16%, cf. 30% during the DOR period); a large majority of this take would be non-lethal take and occur at Upper Barton Spring, and the small balance would be lethal take at Old Mill Spring For comparison, the take of that species without the HCP measures would remain substantial: some 474 individuals, or 69% of the initial 685 organisms, which would occur at not only the Old Mill and Upper Barton outlets but also substantially at Eliza Spring, without management of the non-exempt pumping.

The actual take realized cumulatively over the entire term of the ITP will depend upon the drought conditions actually experienced over that 20-year period. The following cumulative scenario is proposed as a basis for assessing cumulative take during the ITP term:

1. One (1) seven-year period of extreme drought equivalent to the DOR recurrence;
2. One (1) seven-year period of severe drought equivalent to the 2005-2012 droughts;
3. Three (3) years of no severe drought, in which the Covered Species populations recover to their currently modeled initial conditions and the only take that occurs each year is to the population at Upper Barton Springs; and
4. Three (3) years of no drought, where no take of any form occurs.

The District believes this cumulative take scenario, while obviously just one possible future, is reasonably more conservative than likely to be experienced in a typical 20-year period. Further, it comports with the basis on which the District's Sustainable Yield Study (SYS) modeling was performed in simulating the 7-year Drought of Record. The model started with 3 average years, as did the lead-up to the actual DOR, and then simulated the 7 year drought period; this ten-year sequence was repeated five times for a 50-year planning period in the SYS. For the HCP cumulative take over the 20-year ITP term, we would model an initial 3-year period of no drought, followed by a 7-year recurrence of the more recent 2005-2012 drought, followed by a three-year period of moderate, but not severe drought, and then ending with the 7-years of a recurrence of the DOR. From the cumulative take estimate standpoint, the two 3-year periods are interchangeable and the two 7-year DOR and more recent severe drought periods are also interchangeable, as the order doesn't matter. This is because the presumption is that either of the three years of no drought or non-severe drought is long enough for the Covered Species to rebound to the initial condition used in the model.

This scenario yields the following cumulative estimates of the number of individual organisms affected both lethally and non-lethally by the Covered Activities over the 20-year ITP term for the three groundwater management scenarios evaluated in the take analyses:

	Barton Springs Salamander	Austin Blind Salamander
No Pumping:	929	844
Pre-HCP Pumping:	1250	1490
HCP Pumping:	1012	1067

Since actual take is calculated relative to the No (Nonexempt) Pumping baseline condition and before application of the HCP conservation measures, cumulative take of the Barton Springs salamander and the Austin blind salamander is 321 and 646, respectively. With the conservation measures, the net residual cumulative take is estimated to be 83 and 223, respectively.

The effect of the activities covered by the City of Austin's ITP, along with its HCP's conservation measures, must also be considered in the District's cumulative take estimate and impact assessment, and in the Biological Opinion by the Service. The City's activities are programmed, mostly recurring activities but are subject to postponement or cancellation during periods of time when the Covered Species are under duress from natural or anthropogenic causes. While also subject to annual limits, the total cumulative take during the City's 20-year ITP is 38,365 Barton Springs salamanders and 1,025 Austin blind salamanders. The District's cumulative take estimates are 0.4% and 44% of the City's cumulative take of Barton Springs and Austin blind salamanders, respectively. (The disparity between the species is caused by the City's activities' causing take of only the incidental numbers of Austin blind salamanders in the epigean environments of the outlets, rather than potentially affecting the entire subterranean population as the District's Covered Activities do.) However, in reality, the City's and the District's takes are not likely to be contemporaneous or cumulative with each other: at those times when the District's take is at a maxima, the City is likely to have suspended/postponed/cancelled its pool maintenance operations under the terms of its HCP/ITP, and the City's take at those times will be near a minimum. Further, the City's mitigation measures will benefit the Covered Species even though its covered activities are not underway. The District and the City will strive to minimize all such cumulative impacts and memorialize those commitments and needed actions in the prospective MOU/ILA between the two government agencies.

5.3 Impact of Take on Covered Species Populations

5.3.1 Assessment of Population Impacts

In this habitat setting, the Covered Species are subjected on a recurring basis to highly variable springflows, accompanied at the lower flows by naturally smaller DO concentrations at the individual outlets having a direct correlation to springflow. During such times, data show the observed population diminishes in size, which is likely a combination of mortality of individuals and migration to less accessible areas in and near the spring outlets. These low springflow episodes during drought are followed by extended periods of time of much higher than average springflow and the rapid return of

DO to more normal ranges. The salamander population is observed to increase substantially during these flow recovery periods after an apparent lag period of about six months, although the amount and rate of increase differ among the individual spring outlets and are also dependent on the timing of the droughts to one another. In this situation, it is difficult to discern unequivocally an overall trajectory concerning either of the species' population's robustness with time; it varies naturally with the time step selected and its meteorological drought conditions, on which groundwater withdrawals by wells are overprinted.

Organismal responses to chemical stressors are inherently linked to the magnitude, frequency and duration with which organisms are exposed to the stressor(s) (Newman, 2009). For the Covered Species, data indicate that DO stress represents the primary factor influenced by the District's activity. But there is only a limited amount of protection for the Covered Species from regulatory institutions with respect to DO. In the State of Texas, surface water quality standards are intended to protect aquatic life and uses of surface-water bodies, and DO water quality criteria for high aquatic life use is historically defined by either lotic (rivers and streams) or lentic (lakes and reservoirs) habitats (Brooks et al., 2008). For example, a 24-hour DO minimum (3 mg/L) that does not extend beyond 8 hours and a 24-hour minimum mean (5 mg/L) during a 24-hour period is employed for lentic systems (TCEQ, 2003). However, habitats supporting the Covered Species are neither river nor lake, but aquifer, spring runs, and spring-fed pools. The current understanding of the oxygen requirements of the Covered Species (Woods et al., 2010) does not allow for a confident determination of whether existing DO criteria and standards are adequate to protect these spring-fed habitats. Similarly, in spite of the innovative investigations and adaptive management practices associated with the District's HCP, the protections provided by the HCP measures are also uncertain.

This is not an unusual circumstance. Environmental assessments of stressor-response relationships for threatened and endangered species are consistently limited by lack of experimental data for the covered species. In such cases, use of surrogate species is commonly employed owing to limited availability of protected species. Because closely related species are not necessarily common, US EPA developed the Web-based Interspecies Correlation Estimation (Web-ICE) to assist with such efforts (http://www.epa.gov/ceampubl/fchain/webice/). Unfortunately, data for aquatic salamanders within this software are not available, which prevented its application for the Covered Species. Further, before initiation and development of this HCP, a quantitative understanding of DO stress on *Eurycea* (and other salamanders) was poorly understood. Thus, to assess the suitability of *E. nana* serving as a surrogate for *E. sosorum*, a laboratory stressor-response study was initiated to define metabolic rate relationships between *E. sosorum* and *E. nana* (Woods et al., 2010). Owing to these metabolic rate data and also genetic and life history similarities between *E. sosorum* and *E. nana* (Chippindale, et al., 2000), *E. nana* was selected as a surrogate species for DO stressor response studies of relevance to the Covered Species (Woods et al., 2010). Use of this surrogate species for assessing take impacts on the Barton Springs salamander in particular seems well founded.

Survival and growth responses to stressors have high relevance to the population level of biological organization and are thus routinely employed as measures of effect to support ecosystem protection goals defined within ecological risk assessments (Suter, 2006). For DO, an adverse outcome pathway framework can be used to examine stress caused by hypoxia and resulting impacts to individuals and populations of Covered Species (Figure 5-8). To examine responses to DO by a surrogate species, Woods et al .(2010) identified mortality and growth DO thresholds during a 28 d study with adult and a 60 d study with juvenile *E. nana*, respectively. As described in Section 5.2.1 above, 60 d NOAEL for juvenile growth was 4.4 mg/L and a 28 d LC_5 estimate for adult mortality was 4.5 mg/L. These findings from Woods et al (2010) appear to represent the most robust data available for DO stress to any aquatic salamander, and thus provide a reasonable foundation for interpreting DO risks to the Covered Species.

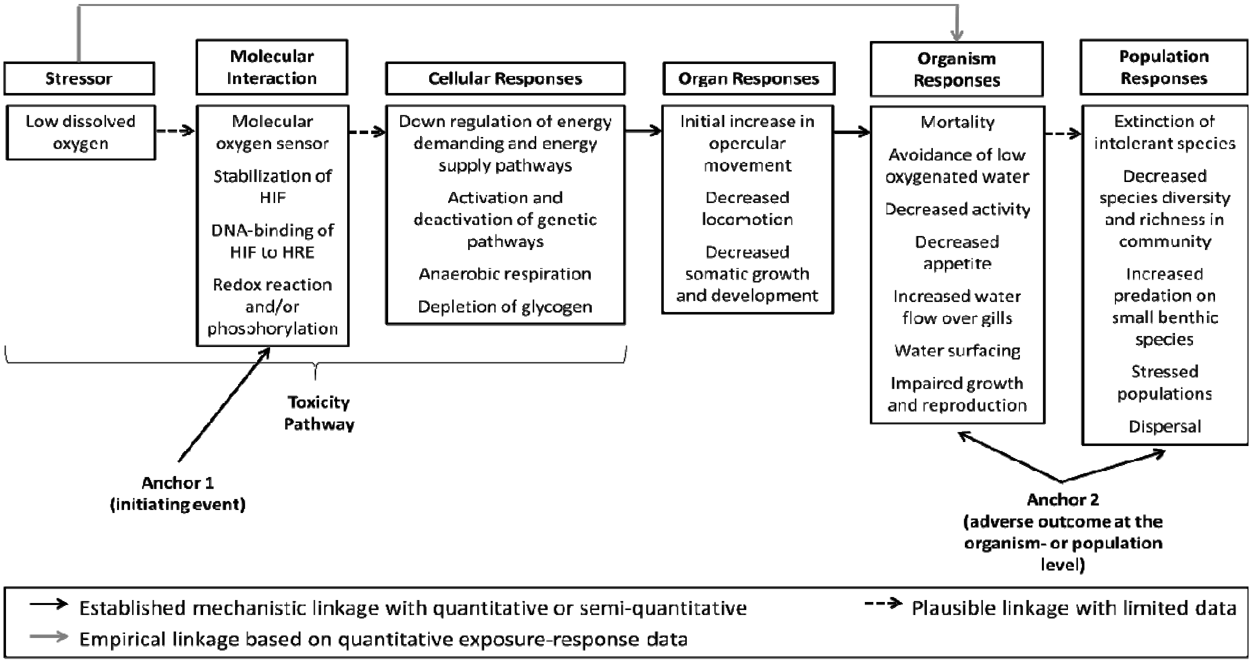

Figure 5-8. A proposed adverse outcome pathway (AOP) in the Covered Species for dissolved oxygen. This AOP represents a conceptual model linking a molecular initiating event to adverse effects at higher levels of biological organization. Source: Modified from Saari and Brooks, 2014.

The estimates of incidental take associated with the Covered Activities with the conservation measures in place are rather small in comparison to the magnitude of the adverse effects arising from both natural drought without the Covered Activities and with the Covered Activities but before the HCP conservation measures (Section 5.2.4.3) . But during severe and extreme drought, the additional reduction in springflows due to pumping may have a disproportionate effect on physiological-related take related to the non-linearity of changes in the DO concentrations in that domain, as shown in the lethal concentration curve in the preceding Figure 5-3. This introduces an element of uncertainty about the precision of the model and therefore about the accuracy of the estimate on which it is based. But the take analysis also includes a number of apparently conservative assumptions and stipulations that, in aggregate, tend to be make the take estimate overstated, providing an offset to concerns about the overall impact of DO on the populations. These include:

- Extreme drought frequency – The take estimate included a worst-case seven-year drought of record scenario that is estimated to have a recurrence frequency of 100 years. It is very unlikely that such a DOR recurrence will occur in the 20-year ITP term. Further, it is even more unlikely that a single ITP term would include both a seven-year DOR recurrence scenario *and* a recurrence of the seven year recent severe drought scenario that were included in the cumulative take analysis.

- Migration to less-stressful portions of the habitat – The modeling used for the take estimation ignored the reasonable likelihood that at least some portion of the population will migrate from the outlets where DO is measured to adjacent connected areas with somewhat higher DO, either within the Aquifer (for Austin blind salamander especially) or in the newly re-established spring runs (for Barton Springs salamander), where additional re-aeration can occur. Sensitivity analysis conducted in this HCP indicates that the benefits of just a portion of the population experiencing a relatively small amount of DO stress relief are disproportionately large.

- Evolutionary life-history strategies - The Covered Species have population characteristics and individual organism traits that appear to represent more an "opportunistic" than "equilibrium" life-history strategy[10]. That connotes an evolutionary development in response to the not infrequent occurrences of disturbances like droughts and floods in their springflow-dominated endemic environment, which cause rather indiscriminant, density-independent mortality and then recovery of the residual population from the temporally variable availability of resources in their habitats (Pianka, 2000). Opportunistic species generally may accommodate larger adverse effects related to constrained resources (such as lower DO, within limits) that governed their evolution without jeopardizing the species more than could equilibrium species.

These factors would suggest, other factors equal (including the effects of other uncertainties), the uncertainties in the take estimate are more likely to lead to an overstated impact of take on the populations, rather than an understated impact.

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[10] These terms have been used as short-hand descriptors for a complex set of evolutionary life-history causative factors that in reality are not uniformly one paradigm or the other, and/or that may differ for different life-stages. A more mechanistic demographic framework includes interactions among age-specific mortality, density-dependent regulation, predation risk, as well as density-independent factors such as extrinsic mortality, resource availability, and environmental fluctuations (Reznick, et al., 2002). A model of this framework accounting for these many interactions for the Covered Species is not available.

In addition to the physiological-related direct and indirect effects of DO reductions on the Covered Species, another potential source of incidental take is the small reductions in the wetted habitat area that might otherwise be attributable to the Covered Activities ("small" especially relative to habitat reductions attributable to "natural drought" conditions). However, the City's ongoing habitat restoration efforts preclude making a quantitative assessment of how much, if any, of the "new" wetted habitat, which is the baseline for the District's HCP, could be attributable to pumping-induced springflow reductions at the reconfigured perennial springs during extreme drought. In any event, these effects would likely be a more important factor to a dominantly density-dependent equilibrium species than to these species where habitat size is less of a concern than habitat conditions.

The foregoing discussion notwithstanding, in an absolute sense there is so much variability and uncertainty in this ecological system (as discussed in Section 5.2.4.2.3 above) that they preclude making conclusive determinations regarding effects on organisms and impacts on the populations based upon empirical observations of the Covered Species. But in any event, it is also clear that the District HCP implements management and conservation measures intended to reduce risks of DO stress to the Covered Species, particularly those associated with naturally occurring extreme droughts, more than would otherwise exist.

5.3.2 Comparison with Take Impact Assessment in EARIP

The Final HCP for the Southern Edwards segment by the Edwards Aquifer Recovery Implementation Program (EARIP, 2012) covers a very large area and addresses many listed species and many activities. It includes *Eurycea* salamander species that are quite similar to the two Covered Species in this HCP, and one of its covered activities, viz., managed groundwater pumping, is also the Covered Activity in this HCP. The EARIP HCP was recently approved and an ITP issued by the Service in 2013. Generally, the bases for the take impacts and for the Service's findings as to jeopardy related to this particular activity and to those similar species should not be inconsistent. In that regard, the similarities and differences between the two HCPs should be noted:

- The EARIP acknowledges the uncertainties associated with life requirements of its salamander species vis a vis springflows. In fact, it related its minimum flow requirements for these species to those of a listed plant species, and documented that this requirement was supported by the rough approximations established by the Service in the early 1990s for gauging take and jeopardy for these species at Comal and San Marcos Springs. While these thresholds incorporated the best science then available for evaluating take and jeopardy of the salamander species, the Service acknowledged then that significant data gaps existed, requiring a more conservative approach and the mandatory use of more professional judgment than usual in setting the take and jeopardy thresholds. However, even though substantially more information and site-specific data exist today, the EARIP did not propose different thresholds for the listed salamander species. The Service developed the original thresholds on a rather quick-response basis as an outcome of federal litigation concerning Southern Edwards groundwater regulation, and no analogous thresholds exist for the Barton Springs segment. In their absence, and on the basis of best science now available, this HCP proposes new salamander-specific thresholds for the outlets at Barton Springs.

- The EARIP acknowledged that the indeterminate size of the actual total populations and the uncertainties as to factors affecting their natural variability confounded quantitative take estimates and impact analysis, necessitating use of assumptions and professional judgments. This HCP does the same.
- The EARIP concluded that the amount of uncertainty that existed about the impact of smaller springflows of varying durations on the salamander species precluded definitive statements as to the amount of take and its impacts. It essentially assumed that maintenance of continuous springflow at least above the lower of the Service's older, general thresholds (along with protection of water quality from pollution) would enable the species to survive a repeat of DOR-like conditions. This HCP expresses similar concerns about the uncertainties in evaluating take and population impacts, even though utilizing the new thresholds developed as part of this HCP and evaluating adverse effects informed by specific DO-springflow statistical relationships.
- The EARIP's take analysis for these species primarily focused on physical habitat changes and related effects by surface activities, which its participating entities can control. It did not quantitatively evaluate hydrochemical effects, such as DO and salinity changes, on salamander physiology related to springflows as performed in this HCP, which is the only aspect that the District can control.
- The EARIP essentially assumed that the subterranean species would retreat into the Aquifer even if springflow ceased and would generally not be adversely affected by smaller springflows, although potential risk associated with take was assumed qualitatively to increase at flows below the Service's older lowest-flow threshold. This HCP reaches a similar conclusion, but supports it with a more quantitative analysis of effects on organisms over time and impacts on populations.
- The EARIP asserted that the uncertainties associated with the qualitative analyses for these species highlights the necessity of applied research, expanded biological and water quality monitoring, and ecological modeling, and that those future developments will be factors in assuring that the species are not jeopardized. This HCP does the same.

The analyses and assessments of the salamander species in both HCPs are best characterized as qualitative, with quantitative approximations only and with some significant uncertainties that are not readily accounted for or overcome. On the basis of best science available and not unreasonable assumptions and stipulations, both HCPs conclude that the conservation measures are necessary and sufficient to minimize take to the maximum extent practicable and to avoid jeopardy.

5.3.3 Uncertainties in Assessment

Considerable uncertainty exists about the impacts of groundwater pumping on the Covered Species. These have been elaborated in Section 5.2.4.2 above. However, it seems clear that extreme drought-time spring flows, whether affected by human water withdrawals or not, have sufficiently reduced DO concentrations to be of primary concern to the near-term and long-term health of the Covered Species, and also that the DO is directly related to rate of discharge of the groundwater at Barton Springs. In one sense, it is fortunate that it isn't actually *known* what the nature of the relationship between DO and discharge is below 14 cfs, which is the flow regime that is more critical to the salamander population. Such an exceptionally low discharge rate has not been experienced during the many years that the Barton Springs complex has been investigated for water chemistry-flow relationships and in fact will not likely be experienced during the term of the proposed ITP. But, given the ecological setting and the population characteristics, take must be inferred rather than directly observed, and the discharge-duration of flow at Barton Springs is a rational proxy for DO concentrations to be used for assessing take.

The HCP investigations reported above indicate rather confidently that the salamander is not adversely affected by DO at 4.5 mg/L or above, and is only mildly affected by DO concentrations slightly lower. Using available field and experimental data and inference, take is indicated to begin at about 21 cfs of spring flow, which occurs about 22% of the time, even with the proposed HCP measures in place. If DO declined to 3.9 mg/L for an extended period of time, take in the form of individual salamander mortality could be expected to be noticeable (in the absence of population adaptation, which is not empirically defined) and of concern; if DO were to decline to less than 3.4 mg/L, the situation could be dire for salamander individuals, and if prolonged, for the population recovery of the Covered Species.

However, there simply isn't information available that can reliably establish whether any level of springflow (above zero flow) would produce those DO concentrations of concern, or the frequency distribution of their occurrence. Moreover, the synoptic observations of DO and springflow in the recent most severe Stage III-Critical drought in 2009 (which was more severe in the Aquifer than the 2011 drought) suggest that the modeled relationships between DO and springflow are conservatively stated; the *observed* DO concentrations at a given, low spring discharge are *considerably higher than what would have been predicted* by the model. That is, more protection is afforded the Covered Species than the modeled flow-DO values would indicate. This is consistent with the very conservative, multiple worst-case assumptions built in to the modeling method.

The measures now proposed under the HCP are more protective of the springflows than any of the prior alternative management scenarios and, in fact, are believed to be the most protective that can be applied under current law and with the current state of knowledge. Nevertheless, during a repeat of the DOR and under the District's most stringent pumping-curtailment program, springflows as cfs will likely be in the mid- to high single digits, which would be unprecedented in the historical record. The DO concentration of such a spring-flow regime and the level of salamander mortality and the disruption of salamander life activities associated with it are unknown, but will probably be appreciable. The DFC of ensuring that springflow during a DOR recurrence is no less than 6.5 cfs has been established by the District as its primary groundwater management objective, representing a balance among various risks and uncertainties and also curtailments that are at the maximum extent practicable.

A number of additional facts and factors were identified in earlier sections of this HCP that bear on the evaluation of take, although these currently can only be addressed in a qualitative fashion. These include the following:

1. The stresses on the salamander from deterioration in water quality of the streams in the contributing and recharge zones as the watersheds develop have not been evaluated, as they are not controllable by the District. It is reasonable to believe they will tend to have an antagonistic effect on the salamanders, although the magnitude of that effect has not been established and cannot be controlled by the District.
2. New information (Land, 2011; Hauwert, 2011; Hunt et al., 2012b; Sharp and Garcia-Fresca, 2004) indicates that additional recharge to the Barton Springs segment by water exogenous to that segment may be occurring both (a) from leaking and operational infrastructure (pressurized water mains, on-site septic fields, lawn irrigation systems) in the segment with Highland Lakes water and (b) from relatively small regional in-flows from what heretofore has been the Southern segment of the Edwards Aquifer during low flow conditions. These may be new factors to consider in future modeling of the Aquifer. It should be emphasized that the prior modeling has accounted for all water in the Aquifer during the DOR, whether from known or unknown sources, in the calibration process. However the effect of having a source of water from which to induce additional recharge, rather than being a closed boundary condition, and the effect of additional recharge water being available now than in the 1950s may create new considerations for evaluating spring flows during extreme drought. But the existence, magnitude, and significance of any differences in results between previous and future models, and even whether differences would be positive or negative for the Covered Species, remain uncertain.
3. Climate change over time probably will change the drought frequency-duration-springflow relationships (IPCC, 2013), but those relationships in the relatively short ITP term are not likely, in a probabilistic sense, to skew the current analysis.
4. There is little experimental information available related to the adverse effects of reduced DO concentrations on the Covered Species for time periods longer than those used in the research commissioned as part of this HCP, yet those longer time scales may well be realized in long-term drought.
5. Conversely, the laboratory research was not expressly designed to simulate actual behavior of salamander individuals, as the individuals were not allowed to move to escape the immediate stress caused by depressed DO concentrations, and so the lethality in the laboratory will tend to overstate the lethality in the wild, other factors equal.
6. Significant differences exist in the susceptibility of individual spring outlets to drought and in the relationships between DO and springflows; the species

populations in certain outlets (e.g., Old Mill Spring) will be more affected than those in other outlets (e.g., Main Springs). The higher stress in one outlet area of the aquifer may be a driver for animal migration into the Aquifer and the flow regimes of other, more favorable subterranean conduits and outlets.

7. The relatively short ITP term militates against the likelihood of a recurrence of the DOR or other extreme events occurring during the term of the ITP.

6.0 Conservation Program

The proposed conservation measures described in Section 6 of the Review Draft HCP are preliminary and presented for discussion purposes. The Board of Directors of the District has not yet approved any particular avoidance, minimization, or mitigation measure for inclusion in the Draft HCP.

The District is seeking a Section 10(a) Incidental Take Permit (ITP) to cover use of the Aquifer as a water supply and management of the Aquifer by the District's regulatory program related to pumping of the Aquifer. Everything that the District does relates to responsible groundwater use and to management of the aquifers in its jurisdiction, including the Aquifer. By design, all District activities are intended to directly or indirectly benefit the Aquifer and therefore the habitats of the Covered Species, especially in comparison to conditions that would exist without them. So the Covered Activities integrate the conservation measures for the Covered Species. However, these activities will not completely avoid or prevent take of the species all the time, rather minimize and mitigate the take as it occurs, so the ITP is being sought to accommodate those circumstances.

As a groundwater conservation district (GCD) in Texas, these activities are derived from and authorized by inclusion in the District Management Plan and the District Rules. The District cannot legally perform any activities, not even conservation activities, that are not authorized by statute (TWC Chapter 36, or the District's enabling legislation codified as Special District Local Laws Code Chapter 8802) *and* also that are not at least implicitly a part of the prevailing District Management Plan. The legal authority for the Rules & Bylaws (BSEACD, 2012) that comprise the District's regulatory program flows directly from the statutes under which the District operates and from the District Management Plan.

The District Management Plan (MP) must be reviewed; revised as needed to accommodate new information, priorities, and statutory requirements; re-adopted; and approved by the Texas Water Development Board (TWDB) at least every five years. The current MP was most recently revised and approved by the TWDB on January 7, 2013; it will now require review and re-adoption no later than November 2017. The current MP largely anticipates and includes the authorities needed for the initial set of the proposed District HCP measures described below; others that might be utilized to assure achieving planned objectives may or may not require additional authorities; a substantially revised set of measures in the approved HCP could necessitate an earlier-than-planned MP revision and re-adoption. This duality in authorities illustrates that the measures committed in the HCP and the requirements of the MP are intertwined: future revisions to the MP must honor the commitments and requirements of the HCP once approved, and the HCP's current measures and future adaptive measures are restricted to those that are authorized by statute and by the prevailing approved MP.

In addition, the District may carry out its statutory powers and responsibilities to amend rules from time to time and substitute alternative requirements for reduction in pumping and/or alternative practices, procedures, and methods for promoting enhanced groundwater levels. Such rulemaking is an anticipated part of the District's function as a regulatory agency. However, any rules amendments must not reduce the effectiveness of the restrictions on pumping described in the District HCP and incorporated in the ITP to protect springflows, unless the HCP and ITP are also amended.

6.1 Biological Goal and Objectives of the HCP

The biological goal and objectives of the District HCP are established in recognition of a) the direct relationship between the volume of water remaining in the Aquifer and the hydrochemistry of the natural discharges from the Aquifer as springflows, and b) the life requirements of the Covered Species with respect to dissolved oxygen (DO) concentrations of the groundwater as it is discharged from the Aquifer.

The biological goals of the District HCP are to:

- Minimize drought-related decreases in size and health of the Barton Springs salamander population to greatest extent practicable,
- Minimize drought-related decreases in size and health of the Austin blind salamander population to greatest extent practicable, and
- Promote recovery of the populations from those decreases to levels required for their long-term viability.

The following objectives, supported by the impact analysis described in Section 5.2, underpin the HCP in pursuit of these overarching goals:

- Adopt and implement groundwater-management measures to minimize the areal extent, concentration range, and time duration that springflow-dependent DO concentration at the Aquifer resurgences is 3.3 mg/L or less under all Aquifer conditions;
- Adopt and implement groundwater-management measures to maintain minimum springflows that a scientific consensus indicates correspond to DO concentrations with a 10-day average of at least 3.9 mg/L during all but Extreme Drought conditions; and
- Adopt and implement groundwater-management and related measures that do not proximally cause other natural water chemistry parameters to exceed their historical ranges under all Aquifer conditions.

These objectives as they relate to managing groundwater withdrawals are believed to be consistent with the best scientific information currently available and within the District's statutory authorities for groundwater management. Their implementation is integrated directly into the operating conservation and management programs, policies, and rules of the District, evidencing a commitment to their achievement. However, both natural system variations and anthropogenic variations over which the District has no control prevent a guarantee that the overarching goals will be reached.

Specific measures to accomplish these objectives are discussed in more detail in the following section. These measures, both individually and in aggregate, represent the best attainable legal plan of the District to conserve the species and are designed to be commensurate with the scope of the HCP. The District believes these measures substantially improve the probabilities that all of these objectives are achieved throughout the life of the ITP.

6.2 Minimization and Mitigation Measures

The key to conserving and minimizing take of the Covered Species is maintenance of adequate habitat and ambient conditions to provide the necessary life requirements for the species. This goal can be accomplished (1) if exogenous factors beyond the District's control (e.g., substantial increases in oxygen-demanding material from point-source and non point-source pollutants in runoff) do not become determinative of habitat quality; (2) if the measures in the City of Austin's Amended HCP for Barton Springs Pool afford the designed protection during recreational use and maintenance of the pool; and (3) if the management of the aquifer as proposed in this District HCP protects and maintains springflows sufficient to provide minimum acceptable habitat consistent with those life requirements.

As mentioned previously, the nature of the Covered Activities is inconsistent with the avoidance of take in an absolute sense. However, it should be noted that the minimization and mitigation measures that have been established by the District reduce the amount of all groundwater withdrawals during the key Extreme Drought period to an amount that is about the same as existed when the District was formed and when an unfettered vested property right attached to such pumping (about 5 cfs, as described in Section 4.1.2.) In this sense, the District's groundwater management program proposed herein not only minimizes take during all drought conditions, but during the most critical period for the Covered Species also avoids the take associated with all pumping that was initiated after the District was established and its regulatory program (one of the Covered Activities) began.

6.2.1 Direct HCP Measures

The conservation measures that will be undertaken directly by the District under the HCP to conserve the Covered Species, by minimizing and/or, under prescribed conditions, also mitigating take to the greatest extent possible, are identified and discussed in this section of the HCP. Because these measures are integral to the District as an operating GCD, they are discussed in categories that correspond to the overarching *statutory* goals for all GCDs in Texas. The numerical order of these goals in the subsections below conforms to their listing in statute, not in the order of importance to the HCP. These measures are now supported as District-specific objectives or performance standards in the District's 2013 MP. Taken together, they comprise the "Enhanced Best Attainable Management" alternative for the HCP that is the existing manifestation of the District's own, internal adaptive management process, as discussed in section 6.4 below. All of these measures are currently authorized and being performed or, for a few, will be initiated as of the issuance of the ITP. They include both ongoing (currently authorized and continuously operating, as warranted) and episodic avoidance/minimization measures. By design and as required by law, they provide a necessary balance between maximizing the amount of groundwater available for use and conserving and protecting the groundwater resource, including Covered Species protection.

During the 20-year term of the ITP, it is envisioned that some changes to these measures will be required or prudent, but unless the underlying ITP permit is amended, the effect of any changes to the measures will be at least as, if not more, protective of the Covered Species by reducing attendant incidental take.

The following subsections describe the direct minimization measures proposed by the District in its HCP. Other, indirect conservation measures, including research and mitigation measures, are identified and discussed in the next Section 6.2.2 of this HCP. Section 6.2.3 contains a synopsis of the HCP program, including a summary table of HCP commitments.

6.2.1.1 Providing the Most Efficient Use of Groundwater

This goal encompasses actions that assure the relevant statutory, regulatory, scientific, administrative, and education dimensions of the District programs promote a balance between the least consumption of groundwater for each type of use and the benefits of using groundwater for those uses. Such efficiency optimizes on a continuing basis using groundwater as a water supply and preserving, conserving, and protecting the groundwater resources for future uses, including as endangered species habitat. Therefore, <u>all measures under this goal are ongoing Minimization Measures except 1-3, which is chiefly an adaptive prelude to adjusted minimization</u>.

- HCP Measure 1-1: Provide and maintain on an ongoing basis a sound statutory, regulatory, financial, and policy framework for continued District operations and programmatic needs.
- HCP Measure 1-2: Monitor aggregated use of various types of water wells in the District, as feasible and appropriate, to assess overall groundwater use and trends on a continuing basis.
- HCP Measure 1-3: Evaluate at least every five years the amount of groundwater used by exempt wells in the District to ensure an accurate accounting of total pumping in a water budget that includes both regulated and non-regulated withdrawals, so that appropriate groundwater management actions are taken.
- HCP Measure 1-4: Develop and maintain programs that inform and educate citizens of all ages about groundwater and springflow-related matters, which affect both water supplies and salamander ecology.

6.2.1.2 Controlling and Preventing Waste of Groundwater

This goal encompasses functions related to ensuring that all groundwater that is withdrawn from wells is used beneficially, and that activities that may cause or contribute to wasteful use of groundwater and to the pollution or harmful alteration of the groundwater resource are prevented. Only reasonable demand for beneficial use can be authorized through the permitting process, and no well is allowed to waste groundwater, including allowing the commingling of poor-quality and high-quality groundwater. For purposes of the HCP, measures under this goal minimize the amount of groundwater withdrawn without purpose or reasonable use and that allows subsurface deterioration of the reservoir, and thereby maximizes high-quality spring flow for salamander habitat. Therefore, all measures under this goal are ongoing Minimization Measures.

- HCP Measure 2-1: Require all newly drilled exempt and nonexempt wells and all plugged wells to be registered and to comply with applicable District Rules, including Well Construction Standards.
- HCP Measure 2-2: Ensure permitted wells and well systems are operated as intended by requiring reporting of periodic meter readings, making periodic inspections of wells, and reviewing pumpage compliance at regular intervals that are meaningful to the existing aquifer conditions.

6.2.1.3 Addressing Conjunctive Surface Water Management Issues

This goal promotes measures and policies that utilize joint surface water – groundwater systems effectively, without imposition of adverse quantity or quality impacts on either the surface or groundwater resource. In the context of the HCP, conjunctive use is alternative water use in lieu of utilizing the fully subscribed Edwards resource as a water supply and that allows for needed pumpage curtailments, especially during Extreme Drought. The District itself may be able to undertake certain of these activities directly, either on its own or as part of a partnership, thereby providing a potential model or framework by which its permittees could undertake such actions.

- HCP Measure 3-1: Assess the physical and institutional availability of existing regional surface-water and alternative groundwater supplies and the feasibility of those sources as viable supplemental or substitute supplies for District groundwater users. This is an ongoing Minimization Measure that is an adaptive prelude to a Research and possibly a Mitigation measure.
- HCP Measure 3-2: Encourage and assist District permittees to diversify their water supplies by assessing the feasibility of alternative water supplies and fostering arrangements with currently available alternative water suppliers. This generally is an ongoing Minimization Measure, but depending on the specific arrangements pursued, it could also be an episodic Minimization Measure.
- HCP Measure 3-3: Demonstrate the importance of the relationship between surface water and groundwater, and the need for implementing prudent conjunctive use

through educational programs with permittees and public outreach programs. This is an ongoing Minimization Measure.

6.2.1.4 Addressing Natural Resource Management Issues

This goal focuses on protecting the natural resources of the Aquifer and of other aquifers within the District's jurisdiction, including not only the groundwater of those aquifers but also soils and agriculture; air quality; economic resources such as sand and gravel and oil and gas; and the flora and fauna dependent on them, including endangered species. By using sound science to increase the understanding of the natural resource systems, including relationships with underlying and overlying reservoirs and up-gradient surface waters, and to delineate the impacts associated with the amount and location of pumping, recharge, and discharge, appropriate and acceptable policies and rules can be developed and effective regulatory decisions can be made by the District.

- HCP Measure 4-1: Assess ambient conditions in District aquifers on a recurring basis by (1) sampling and collecting groundwater data from selected wells and springs, (2) conducting scientific investigations to better determine groundwater availability for the District aquifers; and (3) conducting studies to help increase our understanding of the Aquifer and, to the extent feasible, detect possible threats to water quality and evaluate their consequences. This is an ongoing Minimization measure that is also an adaptive prelude to Research and possibly a Mitigation measure.
- HCP Measure 4-2: Evaluate site-specific hydrogeological data from applicable production permits to assess potential impact of production to groundwater quantity and quality, public health and welfare, contribution to waste, and unreasonable well interference. This is an ongoing Minimization Measure.
- HCP Measure 4-3: Implement separate management zones and as warranted different management strategies to address more effectively the groundwater management needs for the various aquifers in the District, particularly the Aquifer. This is an ongoing Minimization Measure.
- HCP Measure 4-4: Actively participate in the joint planning processes for the relevant aquifers in the District to establish and refine Desired Future Conditions (DFCs) that are protective of the Aquifer and other aquifers and the Covered Species. This is an ongoing Minimization Measure that is an adaptive prelude to an episodic Minimization Measure.

6.2.1.5 Addressing Drought Conditions

This goal involves developing and implementing policies that effectively manage groundwater drought conditions in the Aquifer. The regulation of pumpage and its curtailment during drought, especially during prolonged severe drought, is the principal institutional minimization tool that allows the otherwise lawful pumpage of the Aquifer to occur while being protective of the Covered Species. For example, now the only permits available to withdraw water from the Aquifer are Conditional Production Permits, which is an interruptible supply that is subject to complete cessation of pumping during drought and is issued only if an alternative supply is available. All these are ongoing Minimization Measures, although during Extreme Drought, the step-wise implementation of increasingly stringent curtailments of water withdrawals could also be considered episodic Minimization Measures; over time they also would inform an adaptive outcome.

- HCP Measure 5-1: Adopt and keep updated a science-based drought trigger methodology and frequently monitor drought stages for the Aquifer on the basis of actual aquifer conditions, and declare drought conditions as determined by analyzing data from the District's defined drought triggers and from the existing and such other, new drought-declaration factors, especially the prevailing DO trends at the spring outlets, as warranted..
- HCP Measure 5-2: Promulgate a drought management program that step-wise curtails Aquifer use to at least 50% by volume of currently (2014) authorized aggregate monthly use during the most extreme drought stage, and that designs/utilizes other programs that provide an incentive for additional curtailments where possible (for example, cap-and-retire of historical production permits; accelerated and/or larger extreme drought curtailments in exchange for additional authorized use during non-drought periods).
- HCP Measure 5-3: Inform and educate permittees and other well owners of Edwards groundwater, about the significance of declared drought stages and the severity of drought and encourage practices and behaviors that reduce water use by a stage-appropriate amount.
- HCP Measure 5-4: Assist and, where feasible, incentivize individual historic-production permittees in developing drought planning strategies that foster compliance with promulgated District drought rules, including step-wise demand curtailment by drought stage to at least 50% of currently (2014) authorized use, on a three-month rolling average basis, during Extreme Drought; "right-sizing" authorized use over the long term to reconcile actual water demands and permitted levels; and as necessary and with appropriate conditions, the substitution by surface water, reclaimed water, and/or other groundwater resources such as the Trinity Aquifer to achieve curtailments.
- HCP Measure 5-5: Promulgate a Conservation Permit that is held by the District and accumulates and preserves previously authorized production from the Aquifer with historic-use status that is retired or that is otherwise additionally curtailed during severe drought, for use as ecological flows at Barton Springs during Extreme Drought and thereby increase springflows for a given set of hydrological conditions.

6.2.1.6 Addressing Demand Reduction through Conservation

This goal encompasses all activities that strive to reduce consumption of groundwater of the Aquifer by educating District stakeholders about water conservation and extraordinary demand-reduction measures. This initiative provides tools by which all end-users of the Aquifer can preserve springflow and the quality of habitat of the Covered Species, as well as Aquifer water levels in wells, by reducing their per-capita water use during non-drought times as well as episodically during severe drought. These are primarily ongoing

<u>Minimization Measures once developed, although the temporary demand reductions during drought that are enabled here have an episodic Minimization aspect as well</u>.

- HCP Measure 6-1: Develop and maintain programs that inform, educate, and support District permittees in their efforts to educate their end-user customers about water conservation and its benefits, and about drought-time temporary demand reduction measures.
- HCP Measure 6-2: Encourage use of conservation-oriented rate structures by water utility permittees to discourage egregious water demand by individual end-users during declared drought.
- HCP Measure 6-3: Develop and maintain programs that educate and inform District groundwater users and constituents of all ages about water conservation practices and resources.

6.2.1.7 Addressing Supply through Structural Enhancement

This goal encompasses various structural activities, i.e., typically engineered solutions, that are undertaken by the District directly to increase the amount of water in the Aquifer than would otherwise be available. By increasing the water in storage and by providing means of supply enhancement, either at all times or during certain times, droughts can be less frequent, less severe, and of shorter duration, springflows can be preserved, and endangered-species habitat impairment can be minimized. These are generally adaptive preludes to Research measures and Mitigation, as the ability to deploy them varies with knowledge and with time, but to the extent they are deployed from time to time, they have either or both <u>ongoing</u> and episodic Minimization dimensions as well.

- HCP Measure 7-1: Improve recharge to the Aquifer by conducting studies and as feasible and allowed by law, physically altering (cleaning, enlarging, protecting, diverting surface water to) discrete recharge features that will lead to an increase in recharge and water in storage beyond what otherwise would exist naturally.
- HCP Measure 7-2: Conduct technical investigations and, as feasible, assist water supply providers in implementing engineered enhancements to the regional supply portfolio, including desalination, aquifer storage and recovery, and effluent reclamation and re-use, to increase the options for water-supply substitution and reduce dependence on the Aquifer.

6.2.1.8 Addressing Quantitatively the Established Desired Future Conditions

This goal involves developing, supporting, monitoring, and keeping updated the adopted DFCs for the Aquifer that are protective of water-well yields and of springflows, and consequently of the Covered Species. The DFCs for the Aquifer provide the statutory and regulatory basis, in the consensus of all GCDs in the State's Groundwater Management Area (GMA)10, for mandatory curtailments of pumpage and aggregated firm-yield pumpage caps and increases in recharge so that the DFCs are achieved. They are perhaps best considered the first-order HCP measures, and all the others are supportive of these two measures; the DFCs are also continuing adaptive management measures, as they are statutorily iterative and re-adopted at least every five years. In a very real sense, achieving these two measures is the principal metric for gauging success of the District's groundwater management program and HCP.

- HCP Measure 8-1: As deemed appropriate by the Board, adopt rules that restrict, to the greatest extent practicable, the total amount of groundwater authorized to be withdrawn annually from the Aquifer to an amount that will not substantially accelerate the onset of drought conditions in the Aquifer; this is established as a running seven-year average springflow at Barton Springs of no less than 49.7 cfs during average recharge conditions. <u>This is an ongoing Minimization Measure.</u>
- HCP Measure 8-2: As deemed appropriate by the Board, adopt rules that restrict, to the greatest extent practicable and as legally possible, the total amount of groundwater withdrawn monthly from the Aquifer during Extreme Drought conditions in order to minimize take and avoid jeopardy of the Covered Species as a result of the Covered Activities, as established by the best science available; this is established as a limitation on actual withdrawals from the Aquifer to a total of no more than 5.2 cfs on an average annual (curtailed) basis during Extreme Drought, which will produce a minimum springflow of not less than 6.5 cfs during a recurrence of the drought of record (DOR). <u>This is an episodic Minimization Measure that operates during the most extreme stage of drought when the Covered Species are under highest stress</u>.

6.2.2 Other HCP Measures and Strategies

As a complement to the direct HCP measures identified in the preceding subsection 6.2.1, the District will employ a number of other measures and strategies primarily to research and mitigate consequences of groundwater use in the District's jurisdiction on the Covered Species. These other measures and strategies, collectively termed "indirect HCP measures" herein, are characterized in this section of the HCP.

To a substantial extent, all of these indirect measures require the involvement of other parties in addition to the District. Such measures will be further defined and undertaken through available and appropriate mechanisms, which may include grant funding, other external funding, in-kind contributions, partnerships, and negotiation of requisite interlocal and other agreements. In particular, the prospective interlocal agreement with the City of Austin offers strategic benefits to the District in conducting these indirect HCP measures in multiple ways. Some of these indirect measures may be continuing commitments of in-kind and other resources for a specified beneficial purpose, and others may be participation in various ways for discrete special-purpose projects that are authorized in prospect by the HCP but will be subject to future Board approval of scope, funding sources and amounts, and opportunity costs. While to a considerable extent these indirect measures are HCP-specific, they leverage existing information from other parties and avoid redundant efforts; are consistent with the District's charge to expand the knowledge of the Aquifer system; and are beneficial to the District's permittees in helping to acquire a legal shield against assertions of violating the Act.

6.2.2.1 Research Measures

Substantial uncertainties continue to exist concerning a number of factors that at least potentially affect take: the hydrologic performance of the Aquifer, especially during extreme low-flow conditions; the relationship between springflow and its DO concentrations, especially at extreme low-flow conditions; the ecological effects and physiological impacts of antagonistic contaminants in recharge water; and salamander behavior, both individually and as a population, under ecological stress. The Research Measures identified in this subsection are intended to address some of these uncertainties.

- HCP Research Measure R-1: The District from time to time during the term of the ITP will consider working with universities, the City of Austin, and other qualified parties on projects to better inform and determine the level of risk associated with springflow-related changes in water chemistry affecting the viability and recovery of the Covered Species' population, by supporting:

    1. surveys of the temporal and spatial DO variability of the Aquifer and the surface environments around Barton Springs complex,,
    2. continuing the support of laboratory stressor-response studies of salamander species, or
    3. efforts to restore the spring-run habitat to allow improved re-aeration at the springs outlets.

- HCP Research Measure R-2: : The District from time to time during the term of the ITP will consider working with the U.S. Geological Survey (USGS), the Texas Water Development Board, universities, the City of Austin, Edwards Aquifer Authority, and other qualified parties to:

    1. develop a refined conceptual model to improve the numerical models for the District aquifers, and
    2. Improve geohydrological characterization of aquifer performance during extreme low flows, including assessments of new potential recharge sources from urban recharge and bypasses from the San Antonio segment, and their changes over the term of the ITP.

6.2.2.2 Mitigation Measures

The District recognizes that the proposed conservation program is unable to avoid take at all times. Consequently, it proposes the following Mitigation Measures:

- HCP Mitigation Measure M-1: The District may support the operations of an existing refugium with facilities capable of maintaining backup populations of the Covered species to preserve the capacity to re-establish the species in the event of the loss of population due to a catastrophic event such as an unexpected cessation of springflow or a hazardous materials spill that decimates the species habitat. Such supplemental support would be provided through a commitment of in-kind, contracted support, and/or cash contributions or other appropriate means of support that would contribute to:

1. continuing the study of salamander behavior, and/or
2. conserving wild and captive populations.

Commitments of in-kind, contracted support, and/or cash contributions to the support of the refugium and its research program may be authorized by the Board.

- HCP Mitigation Measure M-2: The District, in cooperation with the City of Austin, will participate in conducting feasibility studies and, as warranted, pilot and implementation projects to evaluate the potential for beneficial subsurface DO augmentation of resurging water in the immediate vicinity of the spring outlets and improved surface DO augmentation in the outlets (only) during Extreme Drought conditions. In-kind, contracted support, and/or cash contributions, deployed in a phased fashion for the feasibility studies and, if the project is feasible, for the pilot study and implementation of the augmentation project, may be authorized.

- HCP Mitigation Measure M-3: The District will extend the currently committed time period to operate the Antioch Recharge Enhancement Facility to continue after the 319(h) grant commitments (September 2014 or later), thereby improving recharge water quality and reducing non-point source pollution at the outlets from runoff events during that time.

- HCP Mitigation Measure M-4: The District will establish a fund to be applied towards an abandoned well plugging program that will serve to eliminate high risk abandoned wells as potential conduits for contaminants from the surface or adjacent formations into the aquifer with priority given to problematic wells closer to the Barton Springs outlets. The fund would be established with repurposed seed money currently held in the Drought Reserve Account which would be re-designated as a new Aquifer Protection Reserve Account. The new account would exist solely to fund the abandoned well program and would be replenished with any collected enforcement penalties and an annual budgeted supplement at the discretion of the Board.

- HCP Mitigation Measure M-5: Throughout the term of the ITP, the District commits to provide leadership and technical assistance to other government entities, organizations, and individuals when prospective land-use and groundwater management activities in those entities' purview will have, in the District's assessment, significant effects on the quantity or quality of groundwater from the Aquifer, to include responding actively and appropriately to legislative initiatives or projects that affect Aquifer characteristics, provided such actions are not inconsistent with established District rules, ongoing initiatives, or existing agreements.

(Examples include contesting unsustainable wastewater management or actions that contravene the District's consent decree(s) that are projected to adversely affect the Aquifer, and providing technical support to GMA 9 and other GCDs whose practices may affect the Aquifer).

6.2.3 Summary of HCP Measures to Minimize and Mitigate Take

A summary of all the direct and indirect measures that comprise the heart of the District HCP is presented in Table 6-1. Each measure is designated as to whether it is a more or less continuously operating minimization measure for implementing the HCP, an episodically or periodically deployed minimization measure, whether the measure is adaptive in nature, and/or a research or mitigation measure, Taken together, these are an explication of the District's preferred option for HCP Conservation Measures that are proposed in this HCP. In addition, the table specifies the applicable performance standard(s) from the District's approved 2013 Management Plan (MP) as they correspond to each measure. The applicable performance standards essentially authorize the District to perform that HCP measure, and also provide success metrics for each standard. The Management Plan, which is revised as necessary and re-approved by the TWDB at least every five years, is found on the District website, at: http://www.bseacd.org/about-us/governing-documents/.

Table 6-1. Summary of HCP Measures, Classification as to Type, and Relation to Management Plan Performance Standards

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive[11]	Management Plan Standards[12]	Comments
1-1	Provide and maintain on an ongoing basis a sound statutory, regulatory, financial, and policy framework for continued District operations and programmatic needs.	●		●	PS 1-3, PS 2-1	
1-2	Register and monitor aggregated use of various types of water wells in the District, as feasible and appropriate, to assess overall groundwater use and trends on a continuing basis..	●			PS 2-3, PS 2-4, PS 3-1, PS 6-1, PS 6-2	
1-3	Evaluate at least every five years the amount of groundwater used by exempt wells in the District to ensure an accurate accounting of total pumping in a water budget that includes both regulated and non-regulated withdrawals so that appropriate groundwater management actions are taken.			●	PS 4-2	At least each five years

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[11] Designates those measures that over time may have an adaptive dimension that affects the implementation of that and/or other conservation measures. It does not refer to measures that are to be pursued using the DOI/FWS Adaptive Management Plan protocol (discussed in Section 6.4).

[12] Corresponding Performance Standards designated in the District's 2013 Management Plan, at http://www.bseacd.org/about-us/governing-documents/

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive[11]	Management Plan Standards[12]	Comments
1-4	Develop and maintain programs that inform and educate citizens of all ages about groundwater and springflow-related matters, which affect both water supplies and salamander ecology.	●			PS 3-3, PS 4-4	
2-1	Require all newly drilled exempt and nonexempt wells and all plugged wells to be registered and to comply with applicable District Rules, including Well Construction Standards.	●			PS 2-2, PS 2-3 (Existing wells)	Includes compliance with Well Construction Standards
2-2	Ensure permitted wells and well systems are operated as intended by requiring reporting of monthly meter readings, making periodic inspections of wells, and reviewing pumpage compliance at regular intervals that are meaningful to the existing aquifer conditions.	●			PS 2-3, PS 2-4, PS 3-1	

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive [11]	Management Plan Standards[12]	Comments
3-1	Assess the physical and institutional availability of regional surface-water and alternative groundwater supplies, and the feasibility of those sources as viable supplemental or substitute supplies for District groundwater users.			●	PS 5-1	
3-2	Encourage and assist District permittees to diversify their water supplies by assessing the feasibility and availability of alternative water supplies and fostering arrangements with currently available alternative water suppliers.	●	●		PS 5-1	Depending on arrangements, e.g., shifts only during extreme drought, could also be an Episodic Measure

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive [11]	Management Plan Standards[12]	Comments
3-3	Demonstrate the importance of the relationship between surface water and groundwater, and the need for implementing prudent conjunctive use, through educational programs with permittees and public outreach programs.	●		●	PS 4-4, PS 5-4	
4-1	Assess ambient conditions in District aquifers by (a) sampling and collecting groundwater data on a recurring basis from selected wells and springs, (b) conducting scientific investigations to better determine groundwater availability for the District aquifers; and (c) conducting studies to help increase our understanding of the Aquifer and, to the extent feasible, detect possible threats to water quality and evaluate their consequences. .	●		●	PS 6-1 PS4-2 5-1, 5-2, 5-3, 6-2 PS4-2, 5-3, 6-2	Some aspect of this measure is informing adaptive changes for future rulemaking

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive [11]	Management Plan Standards[12]	Comments
4-2	Evaluate site-specific hydrogeological data from applicable production permits to assess potential impact to groundwater quantity and quality, public health and welfare, contribution to waste, and unreasonable well interference.	●		●	PS2-2, 2-3, 4-3, 6-2	
4-3	Implement separate management zones, and as warranted different management strategies to address variable groundwater management needs for the various aquifers in the District, particularly the Barton Springs aquifer.	●			PS 2-1, PS 5-1	
4-4	Actively participate in the joint planning processes for the relevant aquifers in the District to establish and refine Desired Future Conditions that are protective of the Barton Springs and other aquifers and the Covered Species.	●		●	PS 4-2	Ongoing activities related to HCP Measures 8-1 and 8-2

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive [11]	Management Plan Standards[12]	Comments
5-1	Adopt and keep updated a science-based drought trigger methodology and frequently monitor drought stages for the Aquifer on the basis of actual aquifer conditions, and declare drought conditions as determined by analyzing data from the District's defined drought triggers and from the existing and such other, new drought-declaration factors, especially the prevailing DO trends at the spring outlets, as warranted. .	●	●	●	PS 3-2	
5-2	Promulgate a drought management program that step-wise curtails Aquifer use to at least 50% by volume of currently (2014) authorized aggregate monthly use during the most extreme drought stage, and that designs/utilizes other programs that provide an incentive for additional curtailments where possible (for example, cap-and-retire of historical production permits; accelerated and/or larger extreme drought curtailments in exchange for additional authorized use during non-drought periods).	●	●	●	PS 3-1, PS 4-2, PS 5-1	

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive [11]	Management Plan Standards[12]	Comments
5-3	Inform and educate permittees and other well owners of Edwards groundwater, about the significance of declared drought stages and the severity of drought and encourage practices and behaviors that reduce water use by a stage-appropriate amount.	●	●	●	PS 3-1, PS 3-3, PS 4-4, PS 5-4	
5-4	Assist and, where feasible, incentivize individual historic-production permittees in developing drought planning strategies that foster compliance with promulgated District drought rules, including step-wise demand curtailment by drought stage to at least 50% of currently (2014) authorized use, on a three-month rolling average basis, during Extreme Drought; "right-sizing" authorized use over the long term to reconcile actual water demands and permitted levels; and as necessary and with appropriate conditions, the substitution by surface water, reclaimed water, and/or other groundwater resources such as the Trinity Aquifer to achieve curtailments.	●	●	●	PS 3-1, PS 5-1	

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive [11]	Management Plan Standards[12]	Comments
5-5	Promulgate a Conservation Permit that is held by the District and accumulates and preserves previously authorized production from the Aquifer with historic-use status that is retired or that is otherwise additionally curtailed during severe drought for use as ecological flows at Barton Springs during Extreme Drought and thereby increase spring flows for a given set of hydrological conditions.	●		●	Objective 3, PS 4-5	The outcomes of this goal's other measures produce an adaptive dimension over time
6-1	Develop and maintain programs that inform, educate, and support District permittees in their efforts to educate their end-user customers about water conservation and its benefits and drought-time temporary demand reduction measures.	●	●		PS 3-3, PS 5-4	Increased intensity during severe droughts has an Episodic dimension.

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive[11]	Management Plan Standards[12]	Comments
6-2	Encourage use of conservation-oriented rate structures by water utility permittees to discourage egregious water demand by individual end-users during declared drought.	●		●	PS 3-1	Will be a Minimization Measure if/once deployed by water supply permittees
6-3	Develop and maintain programs that educate and inform District groundwater users and constituents of all ages about water conservation practices and resources.	●	●		PS 5-4	Increased intensity during severe droughts has a Mitigation dimension.
7-1	Improve recharge to the Barton Springs aquifer by conducting studies and as feasible, physically altering (cleaning, enlarging, diverting surface water to, and protecting) discrete recharge features that will lead to an increase in recharge and water in storage beyond what otherwise would exist naturally.	●		●	PS 5-2	Some aspect of this measure is taking place nearly all of the time.

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive[11]	Management Plan Standards[12]	Comments
7-2	Conduct technical investigations and, as feasible, assist water supply providers in implementing engineered enhancements to the regional supply portfolio, including desalination, aquifer storage and recovery, and effluent reclamation and re-use, to increase the options for water-supply substitution and reduce dependence on the Aquifer.	●		●	PS 5-1, 5-3,	Some aspect of this measure is taking place nearly all the time.
8-1	As deemed appropriate by the Board, adopt rules that restrict, to the greatest extent practicable, the total amount of groundwater authorized to be withdrawn annually from the Aquifer to an amount that will not substantially accelerate the onset of drought conditions in the Aquifer; this is established as a running seven-year average spring-flow at Barton Springs of no less than 49.7 cfs during average recharge conditions.	●		●	PS 4-5	Established via the joint planning process of GMA 10, with major but not sole input by the District; statutory adaptive dimension

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive [11]	Management Plan Standards[12]	Comments
8-2	As deemed appropriate by the Board, adopt rules that restrict, to the greatest extent practicable and as legally possible,, the total amount of groundwater withdrawn monthly from the Aquifer during Extreme Drought conditions in order to minimize take and avoid jeopardy of the Covered Species as a result of the Covered Activities, as established by the best science available; this is established as a limitation on actual withdrawals from the Aquifer to a total of no more than 5.2 cfs on an average annual (curtailed) basis during Extreme Drought, which will produce a minimum spring flow of not less than 6.5 cfs during a recurrence of the drought of record.	●	●	●	Objective 3, PS 4-2, PS 4-5	Established via the joint planning process of GMA 10, with major but not sole input by the District; statutory adaptive dimension
	RESEARCH MEASURES					

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive[11]	Management Plan Standards[12]	Comments
R-1	The District from time to time during the term of the ITP will consider working with universities, the City of Austin, and other qualified parties on projects to better inform and determine the level of risk associated with springflow-related changes in water chemistry affecting the viability and recovery of the Covered Species' population, by supporting: a. surveys of the temporal and spatial DO variability of the Aquifer and the surface environments around Barton Springs complex, b. continuing the support of laboratory stressor-response studies of salamander species, or c. efforts to restore the spring run habitat to allow improved re-aeration of the water at the spring outlets.			●	PS 6-2	
R-2	The District from time to time during the term of the ITP will consider working with the U.S. Geological Survey (USGS), the Texas Water Development Board, universities, the City of Austin, Edwards Aquifer Authority, and other qualified parties to: a. develop a refined conceptual model to improve the numerical models for the District aquifers, and b. improve geohydrological characterization of aquifer performance during extreme low flows, including assessments of new potential recharge sources from urban recharge and bypasses from the San Antonio segment, and their changes over the term of the ITP..			●	PS 6-2	
	MITIGATION MEASURES					

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive [11]	Management Plan Standards[12]	Comments
M-1	The District may support the operations of an **existing refugium** with facilities capable of maintaining backup populations of the Covered Species to preserve the capacity to re-establish the species in the event of the loss of population due to a catastrophic event such as an unexpected cessation of springflow or a hazardous materials spill that decimates the species habitat. Such supplemental support would be provided through a commitment of in-kind, contracted support, and/or cash contributions that would contribute to: a. continuing the study of salamander behavior, and b. conserving wild and captive populations.			●	Within authority; no related standard; implemented at Board's discretion	
M-2	The District, in cooperation with the City of Austin, will participate in conducting feasibility studies and, as warranted, pilot and implementation projects to evaluate the potential for beneficial subsurface **DO augmentation** of resurging water in the immediate vicinity of the spring outlets and/or improved surface DO augmentation within the outlets, (only) during Extreme Drought conditions. In-kind, contracted support, and/or cash contributions, deployed in a phased fashion for the feasibility studies and, if the project is feasible, for the pilot study and implementation of the augmentation project may be authorized.			●	Within authority, no related standard; implemented at Board's discretion	
M-3	Extend the currently committed time period to operate the **Antioch Recharge Enhancement Facility to continue** after the 319(h) grant commitments (September 2014 or later), thereby improving recharge water quality and reducing non-point source pollution at the outlets from runoff events during that time.				PS 5-2	

ID No.	Description	Ongoing Minimization	Episodic Minimization	Adaptive[11]	Management Plan Standards[12]	Comments
M-4	Establish a fund to be applied towards an **abandoned well plugging program** that will serve to eliminate high risk abandoned wells as potential conduits for contaminants from the surface or adjacent formations into the aquifer with priority given to problematic wells closer to the Barton Springs outlets. The fund would be established with repurposed seed money currently held in the Drought Reserve Account which would be re-designated as a new Aquifer Protection Reserve Account. The new account would exist solely to fund the abandoned well program and would be replenished with any collected enforcement penalties and an annual budgeted supplement at the discretion of the Board.				Within authority; no related standard; implemented at Board's discretion	
M-5	Throughout the term of the ITP, the District commits to provide **leadership and technical assistance** to other government entities, organizations, and individuals when prospective land-use and groundwater management activities in those entities' purview will have, in the District's assessment, significant effects on the quantity or quality of groundwater from the Aquifer, to include responding actively and appropriately to legislative initiatives or projects that affect Aquifer characteristics, provided such actions are not inconsistent with established District rules, ongoing initiatives, or existing agreements.			●	PS 1-6, PS 4-3	

6.3 Monitoring Activities

All of the District operations are based on the philosophy that "you can't manage what you don't measure." The HCP program will be no different, and the District will routinely and regularly monitor a suite of parameters that delineate its progress and outcomes, and the continuing deployment of the adaptive management process (Section 6.4) to improve performance. These monitoring activities, many of which are already being performed, address Aquifer characteristics, Covered Species status, and overall conservation program management and performance. The monitoring program to be used by the District is described in more detail in the following subsections of this document. In addition, the monitoring data will be reported to and assessed annually by the Board and by the HCP Management Advisory Committee (MAC), as described in Section 6.4.1 and 6.4.2, respectively, as part of the HCP compliance monitoring and reporting initiatives.

6.3.1 General Groundwater Management Actions

Aquifer management will focus on an array of conservation measures directly or indirectly affecting the production of water from wells in the Aquifer to maintain springflows in Barton Springs, as outlined in Section 6.2.1.

A validation monitoring program will be developed and implemented to measure future success of Aquifer-management activities, and to modify management actions based on the availability of new information. This program will be conducted in collaboration with the City of Austin under an Interlocal Agreement for each entity's HCP monitoring reports. The following data and information will be compiled by the District for this HCP each year and reviewed annually by the Board and the HCP MAC:

- Survey data on the Covered Species, collected bimonthly by the City of Austin; water quality and other habitat data collected by the District, City of Austin, and/or other entities, and their trends, to consider the need to re-evaluate biological risk during low flow conditions;

- Results of any numerical and analytical modeling of both the Aquifer and of the salamander population dynamics on which the HCP is based that are reported each year, to assess the currency and continuing validity of such tools and concepts; and

- Available data on the total annual discharge of Barton Springs, its temporal and spatial variations, and the aggregate production from wells in the Aquifer, to inform periodic water-balance modeling.

6.3.2 General Performance Metrics and Reporting

A process will be developed to evaluate performance of the District HCP measures and groundwater management strategies, including:

- Frequency or necessity of Stage II Alarm-, Stage III Critical-, and Stage IV Exceptional- Drought Measures;
- Levels of the Aquifer as measured by springflow and indicator wells;
- Total (of all outlets) daily discharge from Barton Springs;
- Through coordination with the City of Austin staff, reporting of:
    - current and historic biological data to evaluate responses to groundwater management actions during any low flow conditions;
    - availability of suitable habitat during various low flow conditions;
    - relative salamander abundance and population characteristics based on observations during low flow and other conditions;
    - water-chemistry characteristics related to flow through the spring orifices during normal and low flow conditions; and
- Educational outreach program summaries, including quantity, quality, and timeliness of information disseminated to the general public and stakeholder interests about water use, demand management, and aquifer conditions.

These performance metrics, generally comprising the HCP effectiveness monitoring program, will be compiled, analyzed, and presented in a report to the HCP MAC and to the U.S. Fish & Wildlife Service (Service) on or before the third year anniversary of ITP issuance and every five years or less thereafter, for the duration of the ITP.

6.3.3 Implementation Monitoring

The District will ensure that all management objectives are realized to meet requirements specified in the Performance Metrics through execution of the MP and the reporting procedure outlined in Section 6.5.1.1 below.

6.3.4 Effectiveness Monitoring

The District determines actual groundwater withdrawals through required monthly water-use reports from all nonexempt users. The Board reviews reported metered data on a periodic basis during declared drought, and confirms/clarifies production trends in the District, both overall and by permittee. Setting of the meters and their calibration are required to be in compliance with standards and rules of the District. The results of comparisons of metered groundwater withdrawals relative to then-authorized amounts, including both aggregate and individual permittee performance, are the fundamental tool used to monitor effectiveness of the District HCP and MP with respect to aquifer water withdrawals.

The District will, in coordination with the City of Austin and under the auspices of the Interlocal Agreement that both entities intend to inform their respective HCPs, obtain and report biological survey data and analyses being evaluated on a continuing basis by the City of Austin. The District believes the City of Austin's biological data collection activities under its HCP are sufficient for the purposes and needs of the District HCP, with no benefit in duplicative efforts nor need to augment the frequency or extent of current City of Austin data-collection efforts. As specific data needs and gaps are identified that may require a focused research effort, commensurate with adaptive management measures specified in

Section 6.2 or in the AMP, the District will consult with the Service and the City of Austin and commit resources for such research, to the extent that additional funds and in-kind labor are available (see Section 8 for more details on funding).

6.4 The District HCP Adaptive Management Process

The District reasonably believes that the initial HCP conservation measures to be funded by the District HCP will be effective in conserving both habitats and the Covered Species for the term of the ITP. However, monitoring the implementation of these measures, including the proposed Research Measures, will continue to provide feedback on the efficacy of those measures and also may continue to produce data and information that can be used to identify and evaluate improvements and other management options. In addition, over time changed and unforeseen circumstances (see Section 7 below) may affect the status of habitats and the condition of the species within the Barton Springs ecosystems, and the uncertainties identified in Section 7.2.1 of this HCP may be resolved or clarified.

The District has historically used an incremental rational approach to adaptive management as part of its evolutionary rulemaking associated with its drought management planning (as described in Section 4.1.2). For the HCP, the District has evaluated the AMP promulgated by the U.S. Department of Interior (DOI) in its Adaptive Management Implementation Policy (DOI, 2008) and stipulated for use in HCPs by the Service, a part of DOI. Adaptive management has been a primary vehicle by which the District evaluates and incorporates alternative management actions. This will continue under the HCP as the proposed measures are implemented, as monitoring data are collected, and as uncertainties in the natural systems are resolved, essentially adding new management activities under the direct measures for avoidance, minimization, and mitigation as they prove prudent, feasible, and warranted, using the DOI/Service AMP if and when appropriate .

The DOI/Service AMP is an active, structured process and a defined method for addressing uncertainty in natural systems when:

a. one or more issues can be articulated as outcomes of management options,
b. a relatively frequently *recurring* decision must be made (which allows for regular and controlled testing and therefore optimization of results),
c. various management approaches or strategies can be applied by an agency to the system to affect observable results on a planned, iterative basis,
d. uncertainty can be expressed in terms of testable hypotheses or models of management options, and
e. monitoring can be designed and implemented to reduce uncertainty and deliver timely conclusions that can affirm or be used to adjust resource management outcomes for the next iteration of testing.

Section 7.2.1 of this HCP identifies in some detail a number of uncertainties that may affect the HCP during the term of the ITP. At a fundamental level, the overarching management issues for the District HCP arising from these uncertainties are:

(1) What are the hydrographic and hydrochemical responses of the Aquifer system during Extreme Drought conditions that are equivalent to a recurrence of the DOR, as those conditions have not been experienced since the Covered Species were first identified?
(2) Does the current DFC of the Aquifer during Extreme Drought, i.e., springflows no less than 6.5 cfs averaged on a monthly basis, actually provide, as intended, a water chemistry that allows the populations of the Covered Species to survive and to recover?
(3) Does the ability of the Covered Species to migrate into the subsurface environment between and around spring outlets provide a safe harbor when the surface environment is critically deficient in one or more of their life requirements?
(4) Does provision of alternative water supplies to existing users of the Aquifer translate confidently into actual reductions in pumping of the Aquifer during drought periods and into increased springflows?

These issues comprise the focal points and potential objectives for this HCP's adaptive approaches.

The Covered Activities in this HCP constitute a natural resource management program itself, specifically designed to address the system variations (aquifer water levels and springflows) induced by a natural driver (drought, along with water supply demand) and that occur in a natural system (the Aquifer). There is a mandate for protection of the Covered Species, and the District has the institutional stability and legal wherewithal to be a resource management agency. Such characteristics per se suggest that this program would be a candidate for the defined adaptive management planning that is described in the DOI Technical Guidance for Adaptive Planning (DOI, 2008); further, there are several "AMP success factors" present, including committed executive leadership, long-standing stakeholder involvement, and a perceived high value associated with new information for reducing uncertainty.

However, there are a number of other factors that, in aggregate, militate against deploying a more active AMP under the DOI guidance for this HCP:

a. Despite best science and sound resource management practices, it is difficult in this instance to confidently gauge effects and responses of alternative management actions of various types without utilizing a forcing function (variable) that puts the Covered Species' populations at mortal risk.
b. The District cannot control the existence and variable recurrence frequency of either the forcing functions or the Aquifer system responses to provide useful information on impact to the Covered Species, especially in the time periods of interest for an AMP.
c. The District cannot control the variable magnitude of the forcing functions, except within some fairly narrow limits, that would yield useful interpretative information on management options.
d. Monitoring of the response of the Covered Species to management actions is confounded by the small and not easily observable populations of the Covered

Species and by the multiple environmental factors that affect that population, only one of which (groundwater withdrawals) is within the District's statutory purview.

e. As discussed elsewhere in the HCP (Section 4.1.2), as an outgrowth of recent state legislation, the District now has a statutory obligation to allow the maximum practicable level of groundwater production while administering a drought management program that is consistent with achieving the DFCs of the Aquifer; that is to say, it cannot arbitrarily (from a groundwater owner's perspective) reduce the amount of otherwise authorized pumping as part of a hypothesis-testing program.

Therefore, the District has concluded that the primary direct HCP measures that are the proposed components of this management system (Section 6.2.1) are not amenable to the Service's active, structured AMP implementation and that this AMP is inappropriate for use in the District's HCP. In lieu of using the structured, active adaptive processes of the AMP for these measures, the District will continue to evaluate its proposed HCP conservation measures using its currently employed incremental rational approach to adaptive management, to help resolve the fundamental issues articulated above. For example, if pertinent new statutory authority is provided by the Texas Legislature to GCDs such that the District could differentiate levels of curtailment during Extreme Drought by groundwater use type (currently not legally possible), the District would consider and then could adjust its drought curtailment program to reduce pumping even further by certain types of permittees and thereby further minimize take of the Covered Species.

6.5 Implementation Roles of the Plan Participants

The District is applying for a 20-year ITP to allow incidental take of Covered Species in the Barton Springs ecosystem. Responsibilities of the participant and cooperating entities are outlined below. The ITP generally will specify responsibilities of the permit holder, conservation and mitigation measures to be implemented, monitoring and research procedures, and any other permit conditions that may be required, and the District will ensure they are addressed during HCP implementation.

6.5.1 Barton Springs/Edwards Aquifer Conservation District

The District, or BSEACD, is the applicant for the ITP and is the only Participant, as the term is defined by the Service, in the District HCP. The District will be the ITP holder. The ITP will cover the District, as the groundwater management entity, and all groundwater producers in the District's jurisdiction that hold production permits from the District, as the authorized users of groundwater being managed by the District.

As the District issues and renews groundwater production permits, the permittees' water-use fees and other fees paid by the City of Austin that are associated with use by the permittees will generate funding for the HCP. Typically and generally, this funding will support the implementation of the HCP conservation program and of the administration and reporting associated with the HCP by offsetting the direct and indirect cost of internal labor and other direct costs. The bulk of the funding commitment discussed in Section 8 of the HCP will be utilized in this fashion. Beyond the internal support needs of the HCP, the District will provide the administrative framework to distribute part of this revenue to other entities, if and as authorized by bilateral contractual agreements, or to pay for both in-kind services of the District and for external goods and services provided by other entities, so that mitigation and minimization measures and adaptive management strategies, as are specified under the ITP and in the HCP, can be implemented efficiently.

The District will be responsible for implementing drought-stage management as well as comprehensive management of the aquifer, using its rules and statutory authorities, and for monitoring compliance and effectiveness.

The District will report no less frequently than annually to the Service on the status of Aquifer pumping, drought-stage management, results of monitoring programs, efficacy and issues associated with minimization and mitigation measures, and adaptive management needs and opportunities.

More details on each of these processes are presented in the following subsections.

6.5.1.1 Administration and Reporting

The District will provide to the Service an annual report on the progress of and plans for implementing the District HCP at the same time each year as specified by the Board. More specifically, this report will summarize information on the management and monitoring of the Aquifer including:

- Reported groundwater withdrawals from permitted wells;
- Reference well levels;
- Springflows at Barton Springs;
- Total Aquifer discharges, measured for permitted wells, estimated for exempt wells, gaged/measured for Barton Springs; and estimated for Cold & Deep Eddy Springs;
- Drought-Stage management reductions;
- Adaptive management activities undertaken during the year or indicated as prudent by outcomes of the conservation program;
- Expenditures by the District on implementation activities; and
- Proposed activities for the next year.

In addition, the report will summarize any groundwater management actions undertaken by the District and any species-specific research reports compiled or completed by investigators in the reporting year that relate to the biological objectives identified for the Covered Species or improvements in the assessment of and appropriate responses to actual take. This annual report may also contain other, non-HCP information and may also be used to report the progress and plans of the District as a GCD to the Texas Commission on Environmental Quality (TCEQ), as required by District bylaws.

This annual report will be submitted simultaneously to the Service and to the HCP MAC, described in the subsection immediately following, for their respective review and comment by February 28th of each year.

6.5.1.2 District HCP Management Advisory Committee

The District has established an HCP MAC to advise and assist the Board in the coordination of conservation activities affecting Covered Species at Barton Springs, and in monitoring and helping the Board improve the implementation of the District HCP for the District. This MAC is an additional measure of ensuring continued improvement of the HCP and compliance with the ITP as well as ensuring the Board is aware of any stakeholder concerns concerning the execution of the HCP and revisions to the HCP. The primary role for the MAC is to review and comment to the District's Board of Directors on the District's HCP annual reports, in a manner of the MAC's choosing. At the Board's discretion, the MAC may also be utilized to:

- Provide a forum for exchange of information relative to Covered Species;
- Provide advice on Covered Species management activities;
- Advise the District on priorities for conservation actions; and
- Provide input and recommendations, as warranted, on the development and implementation of actions through the adaptive management program.

The MAC was appointed by the District Board in early 2013, and includes independent volunteer representatives with biological or natural-resource management roles from designated interest groups. MAC composition focused on perspectives useful to the active management of the Aquifer and the habitat of Covered Species at Barton Springs. The interest groups that comprise the MAC are:

Texas Parks and Wildlife Department (TPWD)
City of Austin Watershed Protection Department (COA WPD)
Environmental community
Technical/ecological research expertise
Salamander biologist/expert
Public water supply permittee
Large private-sector permittee
Aquifer-using landowner
Private property conservation interests
River authority
County government
Interest private citizen/public at-large (2)
District technical staff

The Service was also requested to provide a non-voting representative to be in a liaison role between the District, the Service, and the MAC.

This MAC is a standing advisory group to the Board for the HCP. The individuals serving as MAC members are reasonably expected to change from time to time over the 20-year term of the ITP. However, provided replacement members are appointed by the District Board from the same interest group, such changes are proposed to be considered administrative in nature.

The MAC will convene in some manner appropriate to the purpose of each meeting and no less frequently than annually, and at such other times as requested by the Board. The MAC at its discretion may form subcommittees to address specific issues or topical areas pertinent to the HCP and the MAC's charge. It will receive and review the District's annual progress report and associated other documentation pertaining to the ITP. In a forum of its discretion each year, it will evaluate the HCP progress and identify any concerns that a consensus of the MAC finds important to convey, and at its discretion report its findings in a presentation directly to the District Board each year.

In addition, every five years the MAC will review the District-prepared report on the performance of the HCP measures, as described in Section 6.3 above, and make recommendations for adjustments or improvements, as warranted, in a letter-style report to the District's Board.

6.5.1.3 Adaptive Management Process

The District HCP's adaptive management process is targeted at:

- Guiding long-term aquifer-management monitoring and research planning;
- Further defining critical attributes and linkages within and between physical components of the spring ecosystem;
- Promoting an improved understanding of uncertainties and other key factors that drive changes in the spring ecosystem;
- Making qualitative and quantitative assessments of resource changes resulting from various flow regimes and impacts to the Covered Species;
- Providing information to stakeholders regarding the potential impacts and benefits of various flow regimes in the Barton Springs ecosystem.

Certain direct and indirect measures, especially the Research measures, as presented in Table 6-1, and the actions taken in response to Changed or some Unforeseen Circumstances, as described in Section 7, may identify needs for a specific adaptive management response. These needs will be characterized and future action recommended, if feasible, in the Annual Report. As appropriate, a future AMP project will conform to the DOI/Service technical guidance document, as discussed in the preceding Section 6.4.

6.5.1.4 District Enforcement Program

The District has established an aggressive enforcement policy and program under District Rule 3-8, Enforcement (Appendix J provides the entire District Board-approved Enforcement Plan). The District enforces all of its Rules, whether for permit violations (e.g., overpumpage), well-construction violations, wasteful water use, or failure to make timely use reports and fee payments. Enforcement measures include, in typical order of their use: warning letters, assessment of fines and penalties through agreed enforcement orders, show-cause hearings,, “red-tagging” of wells that limit or prohibit production from permitted wells, temporary suspension of permits, revocation of permits, and finally litigation in District court (which is rarely needed). Under the District policy, enforcement priorities in any one drought stage focus first on the most egregious non-compliant users, those with the largest amounts of permitted pumpage and/or those with the largest percentage of monthly over-pumpage.

Of particular note with respect to the District HCP are the enforcement measures and penalties that have been established during declared droughts. Each day that a violation occurs is a separate violation, and the penalties are cumulative. Every District permit contains both a User Conservation Plan (UCP) and a User Drought Contingency Plan (UDCP) as an agreed part of the permit, specifying both voluntary and mandatory actions that the permittee and end users, as warranted, will take under various drought stages. The UDCPs include drought-time curtailment charts that specify the allowed pumpage each month during various drought stages and emergency response periods of various durations. Penalties related to pumpage violations during Critical-Stage and Exceptional-Stage drought carry twice the dollar fines as those during Alarm-Stage Drought. These penalties have been determined to have considerable deterrent value and success in attaining compliance with District pumpage regulations. The daily penalties for violations related to failure to reduce pumpage during District-declared drought are shown in Table 6-2 below. Changes to the penalty structure and amounts that do not affect compliance and therefore take would be a proposed administrative change under the HCP and not require an HCP or ITP amendment.

Table 6-2. Daily Penalties for Violations of District Drought Rules

Table 6-2a. Daily Penalties During **Stage II-Alarm Drought**, Rule 3-7.7.B(1)

	Overpumpage Level		
	Level A	**Level B**	**Level C**
Tier 1	$50-$100	$100-$200	$200-$400
Tier 2	$200-$400	$400-$800	$800-$1,600
Tier 3	$800-$1,600	$1,600-$3,200	$3,200-$5,000

Table 6-2b. Daily Penalties During **Stage III-Critical and Stage IV-Exceptional Drought**, Rule 3-7.7.B(2)

	Overpumpage Levels		
	Level A	**Level B**	**Level C**
Tier 1	$100-$200	$200-$400	$400-$800
Tier 2	$400-$800	$800-$1,600	$1,600-$3,200
Tier 3	$1,600-$3,200	$3,200-$6,400	$6,400-$10,000

Table 6-2c. Definition of Tiers of Permitted Pumpage and Levels Of Overpumpage During All Drought Stages

Permitted Pumpage (gallons/year):		**% Pumpage Over Monthly Target:**	
Tier 1:	< 12,000,000	Level A:	< 25%
Tier 2:	≥ 12,000,000 and < 120,000,000	Level B:	> 25% and < 100%
Tier 3:	≥ 120,000,000	Level C:	> 100%

6.5.2 Cooperating Federal and State Agencies

6.5.2.1 U.S. Fish and Wildlife Service

The Service is the federal agency responsible for issuing the ITP and monitoring compliance with the ITP conditions. The Service, as the regulatory agency for the District ITP, will review and comment on the Annual Report and other HCP monitoring reports provided by the District.

6.5.2.2 Texas Parks and Wildlife Department

The Covered Species are also species listed by the TPWD as Species of Greatest Conservation Need (TPWD, 2012), and therefore the TPWD is a supporting governmental entity of this HCP. Involvement by the TPWD as well as other state governmental agencies and political subdivisions in the development of HCPs is guided by provisions of Subchapter B, § 83.011 through §83.020 of the Texas Statutes, Parks and Wildlife Code. These subsections lay out definitions of HCPs, regional HCPs, land development standards, and plan participants, structure and function of advisory committees, while providing guidance in the acquisition of habitat preserves. TPWD is also providing a member of the proposed MAC to assist the District in the implementation of the District HCP. Other TPWD activities—including biological consultation, coordination, or participation in future adaptive management strategies — remain unspecified and will be consistent with their authorities and needs during the implementation of the HCP.

6.5.3 City of Austin and Barton Springs Pool HCP

The City of Austin is not an applicant in the District HCP. However, the City, which is traditionally a collaborative partner with the District in many of its programs, is currently providing a substantial portion of the total funding for the District, including in part the conservation measures of the District HCP. In addition, the City of Austin has a complementary HCP for operation and maintenance of Barton Springs Pool (City of Austin, 2013.) The District intends to take advantage of the opportunities that likely exist for synergies between the two related HCPs. Under the District HCP, the District and the City of Austin propose to collaborate through an Interlocal Agreement and/or a Memorandum of Understanding in the following areas, as one of the Indirect HCP Measures arising from the District's adaptive management process:

- Provision of data and evaluation reports, in preliminary and final formats, to the District so that mutual interests on the viability of the Covered Species and on aquifer/spring dynamics are always being met;
- Collaboration and participation with the District in long-range planning, to provide City of Austin water supplies and possibly other alternative sources, to new and existing communities and businesses in the District HCP planning area in lieu of the Aquifer water supply; and
- Collaboration and participation in a variety of investigations, mitigation measures, and adaptive management measures, as specified in Section.6.2.2, as well as the continuing collaboration with the City of Austin in dye tracing, springflow measurements, and the adjustment and validation of low springflow-discharge rating curves.

While perhaps not included explicitly in the ILA provisions, the City of Austin representatives on the MAC, including a senior salamander biologist and the engineer that manages the City's HCP, will be invaluable in conveying the results and conclusions of the City of Austin's complementary investigations to other members of the MAC.

6.5.4 Other Entities

Other governmental entities, political subdivisions, universities, or private research groups may be involved cooperatively in conducting studies or other actions identified or included as District HCP measures. If they become an essential condition in maintaining ITP compliance, specific responsibilities of the parties would be identified in District HCP contracts or implementation agreements with the District. The current statutory and/or management roles of certain entities could either directly or indirectly affect HCP implementation:

- U.S. Geological Survey – This agency is expected to continue to administer programs monitoring aquifer recharge, springflows, aquifer levels, and water quality. The USGS currently operates monitoring wells and telemeters water level data at both locations that the District uses in its drought trigger methodology for assessing drought stages.
- Texas Commission on Environmental Quality – This agency has, as a primary responsibility, management and protection of water quality through regulation of point- and nonpoint sources of water pollution in the Edwards Aquifer and the contributing surface watershed. TCEQ also serves as the administrative regulatory authority for all GCDs in the state, including the District.

- Texas Water Development Board – This agency will review and approve the District's MP and provide additional support to the District on compliance with state laws pertaining to groundwater management, especially those related to specifying the Modeled Available Groundwater associated with DFCs.
- Other Groundwater Conservation Districts – The five other GCDs in GMA 10 are statutorily charged with establishing and reviewing the DFCs for the Aquifer at least every five years. A two-thirds super-majority is required to amend and approve (and re-adopt) the DFCs set by the GMA. In addition, GCDs in GMA 9, especially the Hays Trinity GCD and Blanco Pedernales GCD, authorize the pumping from the Trinity Aquifer in the contributing zone of the Barton Springs segment of the Edwards Aquifer, which may affect the quantity and quality of contributions of base flow to the up-gradient creeks that recharge the Aquifer.

7.0 Changed and Unforeseen Circumstances

The proposed responses to changed and unforeseen circumstances described in Section 7 of the Review Draft HCP are preliminary and presented for discussion purposes. The Board of Directors of the District has not yet approved any particular response by the District for inclusion in the Draft HCP.

Regulations implementing Section 10 of the Act [50 CFR 17.22(b)(2)(iii)] require that a Habitat Conservation Plan (HCP) specify the procedures to be used for dealing with changed and unforeseen circumstances that may arise during HCP implementation. In addition, the HCP Assurances ("No Surprises") Rule [50 CFR 17.2, 17.22(b)(5) and (6); 63 FR 8859] defines "unforeseen circumstances" and "changed circumstances," and describes the obligations of the permittees and the U.S.. Fish & Wildlife Service (Service) under such circumstances.

7.1 Responding to Changed Circumstances and Unforeseen Circumstances

The District has made a concerted effort to anticipate the minimization and mitigation measures (conservation measures) and monitoring that are necessary to conserve the Covered Species and preserve the habitats that support the species and that are within its statutory authorities. To that end, the District has relied upon the best scientific and experiential information available in preparing this HCP. The District also sponsored and contracted for original research and for relevant new data to be collected, as a part of the District HCP development process, to provide new information and complement existing knowledge where necessary, to manage groundwater production and springflow for the benefit of the Covered Species. In addition, the flexible provisions regarding the expenditure of funds authorized by the District Board for specific mitigation measures, including the indirect measures described in Section 6.2.2 and specifically the Adaptive Management Plan (AMP) measures in Section 6.4.2 of this HCP, are designed to address future exigencies and emergency situations in a beneficial fashion. Thus, the District HCP intends to minimize the potential for adverse changed or unforeseen circumstances on the Covered Species and its habitat.

However, these provisions notwithstanding, changed or unforeseen circumstances may occur during the course of a long-term permit program like the Incidental Take Permit (ITP). So provisions for addressing such conditions are part of each HCP. In this context, only those circumstances that the Covered Activities may affect or may be affected by are relevant to the District HCP.

The District HCP's AMP, described in Section 6.4 above, is one mechanism that the District will use to anticipate optional responses and evaluate outcomes to certain changed circumstances and unforeseen circumstances. Additional information on how the District will respond to these circumstantial elements is presented in the following sections and subsections of this chapter.

7.1.1 Resolving Adverse Changes

A principal aspect of the HCP is a commitment by the District that a) should certain changed or unforeseen circumstances result in or threaten a substantial adverse change in the population of the Covered Species or the overall quality of any habitat of the species, and b) should it be determined that the Covered Activities in the District HCP contribute to either the cause or the resolution of the adverse change, as determined pursuant to the procedure outlined herein, the District and the Service shall cooperate to resolve the adverse impacts in accordance with the definitions and guidance provided by the Services' HCP Assurances ("No Surprises") Rule:

- **For Changed Circumstances –** If additional conservation and mitigation measures for the Covered Activities are deemed necessary to respond to changes in circumstances provided for in the District HCP, the District as the ITP permittee will be expected to implement the responsive measures specified in the HCP, but only those measures and no others; and

- **For Unforeseen Circumstances –** The Service statutorily may not require the commitment of additional land or water resources or financial compensation - including additional restrictions on the use of land, water, or other natural resources - even upon a finding of unforeseen circumstances, unless the permittee consents. Upon a finding of unforeseen circumstances, the Service may have only limited ability to require additional measures or modifications within the conserved habitat areas that are inconsistent with the District's approved Management Plan (MP) that authorizes its groundwater management program and the District HCP. Additional required conservation and mitigation measures will not involve the commitment of additional land, water, or financial compensation or additional restrictions on the use of land, water, or other natural resources.

Consultation between the Service and the District also may indicate that the adverse changes may be most appropriately addressed through an amendment of the ITP and HCP.

7.1.2 Methodology for Developing Criteria for Changed *Versus* Unforeseen Circumstances

The District has determined that changes in several specific circumstances are reasonably foreseeable and therefore should not be considered unlikely to occur during the course of the HCP and the term of the ITP. The District has made a determination of which of these are related to Covered Activities of the District HCP and are therefore actual Changed Circumstances under the Act. These circumstances are discussed in more detail in Section 7.2.2 immediately below. Not reasonably foreseeable and unforeseen circumstances (discussed in Section 7.3) could also affect the District HCP, as provided for under the

Service's HCP rules and guidelines. In addition, several dimensions of the ecosystem are either not known or only poorly known, as characterized in Section 7.2.1; the likelihood of those factors affecting the efficacy of HCP conservation measures is uncertain. They could result in either changed or unforeseen circumstances. The District will consult with the Service and seek a determination by the Service whether a particular event or change in a relevant circumstance or factor constitutes a changed or unforeseen circumstance under the District HCP, generally on the basis of the likelihood of the change or event reasonably being anticipated to occur during an average 20-year period (the proposed term of the District HCP) and reasonably being related to the Covered Activities. The responsibilities of the District and the role of the Service in determining unforeseen (and therefore not "changed") circumstances are discussed in Section 7.3.1.

7.2 Changed Circumstances and Uncertainties

The Service defines the term "changed circumstances" to mean "changes in circumstances affecting a species or geographic area covered by a conservation plan…that can reasonably be anticipated by plan…developers and the Service, and that can be planned for" (40 CFR §17.3). Examples provided include listing of new species in the plan area (as discussed in Section 7.2.2.1) or some extreme event in areas prone to such events, most notably drought severity equivalent to the so-called "drought of record."

Substantial uncertainties exist in the various bases for developing conservation measures for the Covered Activities, and to the extent these uncertainties manifest themselves in unplanned ways that affect the ITP during the term of the ITP, they may produce changed circumstances. These uncertainties are addressed in the next section of this HCP.

7.2.1 Considering Specific Uncertainties

A number of issues and uncertainties could create changed circumstances, including the uncertain existence and magnitudes of various factors that could affect the ITP, HCP effectiveness, or that are not otherwise quantifiably taken into account in the District HCP. Under the District HCP, District staff will continue to monitor and to develop new information that will address and resolve known issues, elucidate others, reduce uncertainties, and mitigate impacts associated with the Covered Activities, and consult with the Service as warranted to evaluate the need for amendments to the HCP and ITP. This subsection identifies the more important of these and their possible effects and impacts, without attempting to characterize or evaluate them in detail.

7.2.1.1 Global Climate Change: Effects and Probabilities

Probably the largest uncertainty that may substantively affect the long-run effectiveness of the District HCP measures relates to "climate change" in the larger sense. The uncertainty isn't related to whether climate change is now occurring in an extraordinary fashion. As reported by the Service (2013),

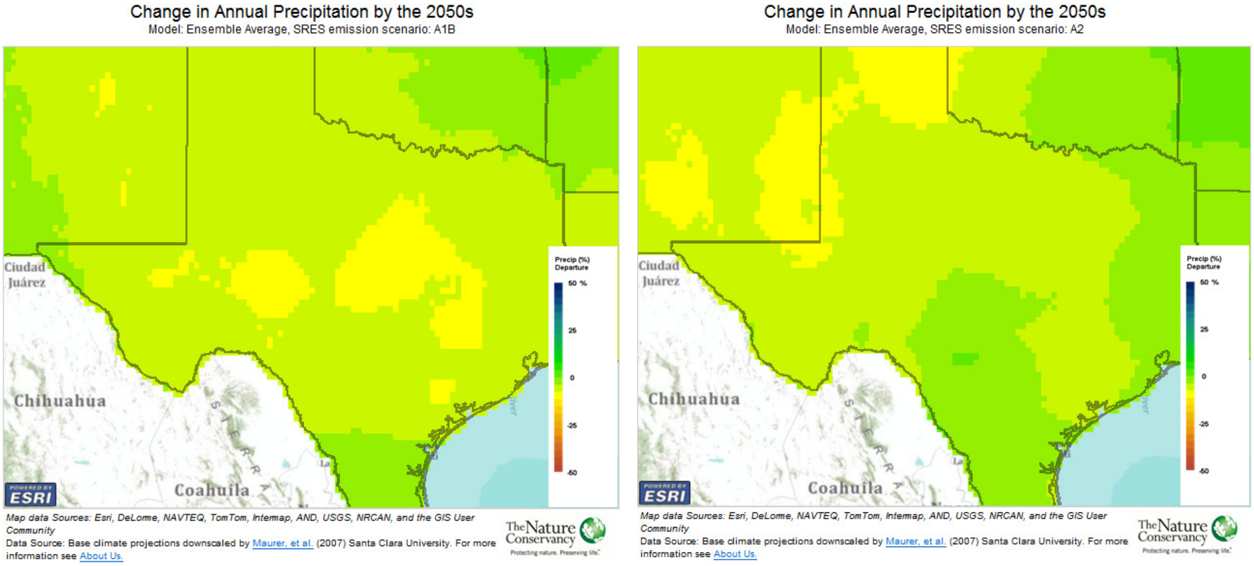
> The U.S. Climate Change Science Program (CCSP) has concluded that the global climate is changing. Effects of this change on the existing environment has been evaluated in a 2008 U.S. national scientific assessment (National Science and Technology Council, 2008) which integrates, evaluates, and interprets the findings of the CCSP and draws from and synthesizes findings from previous assessments of the science, including reports and products by the Intergovernmental Panel on Climate Change (IPCC).
>
> The conclusions in the National Science and Technology Council assessment build on the vast body of observations, modeling, decision support, and other types of activities conducted under the auspices of CCSP and from previous assessments of the science, including reports and products by the IPCC, CCSP, and others. This assessment and the underlying assessments have been subjected to and improved through rigorous peer reviews. According to CCSP's Synthesis and Assessment Product (SAP) 4.3 (Backlund et al. 2008), it is very likely that temperature increases, increasing carbon dioxide levels, and altered patterns of precipitation are already affecting U.S. water resources, agriculture, land resources, biodiversity, and human health, among other things. SAP 4.3 also concluded that it is very likely that climate change will continue to have significant effects on these resources over the next few decades and beyond.

The International Panel on Climate Change (IPCC) has also determined that warming of the global climate is unequivocal, and emissions of greenhouse gases emitted by humans are largely responsible for the warming over the past 100 years (IPCC, 2007; 2013). In the future, the net global effect of the warming, even if no additional greenhouse gases are emitted, will be increased precipitation, though with variable spatial distribution and intensity. Extreme weather events, such as heat waves, flooding, and drought, will continue to increase in frequency and intensity, as well as adverse impact (IPCC, 2007, 2013; USGCRP, 2014).

The uncertainties arise as to what that means for the HCP region generally and for the Covered Species particularly. The Summary for Policy Makers prepared by the IPCC (2007b, and reinforced in 2013) suggests there is high confidence (8 out of 10 chances) that drought and flooding will be both more severe and frequent, and those conditions will have mostly negative consequences for ecosystem structure, function, inter-species interactions, and therefore biodiversity. It includes more detailed predictions of long-term changes in precipitation patterns, at both global and regional levels (IPCC 2007a). The impacts that have been predicted for central Texas, according to one model (A1B), would result in a 10-20% reduction in precipitation during the winter months by 2090-99, relative to 1980-99 conditions; but no clear trend in the direction of change for precipitation during the summer months by 2090-99. These slight and variable differences are reflected in Figure 10-1 below from modeling of these data by the Nature Conservancy (Maurer et al., 2007), which shows the sensitivity of the precipitation projections by this model to emission scenarios, especially in Central Texas.

Joseph Alcamo, a lead author of many IPCC publications on climate change and water resources, has developed and applied another global water model to analyze the impacts of climate change and socio-economic driving forces on future global water stress, derived from the A2 and B2 scenarios of the IPCC (Alcamo et al., 2007). The investigators define "water stress" as the intensity of pressure put on water resources and aquatic ecosystems by external drivers of change. The principal cause of *increasing* water stress, where it occurs, is growing water withdrawals. Alcamo and other investigators show increases in water stress for the central Texas region of between 50% and 100% by the time of the 2050s, under two different IPCC scenarios (A2 and B2). This work and other more local, as well as large-scale scenarios indicate that significant additional challenges and competition for water consumption, and correspondingly less water availability for wildlife and other in-stream functions, must be anticipated and confronted.

The uncertainty in climate change effects on local precipitation has been underscored by Nielson-Gammon (2011), who noted that observed variations in precipitation over the past century in Texas are larger than most future climate projections of precipitation changes by mid-century.


Change in Annual Precipitation by the 2050s
Model: Ensemble Average, SRES emission scenario: A1B

Change in Annual Precipitation by the 2050s
Model: Ensemble Average, SRES emission scenario: A2

Map data Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community
Data Source: Base climate projections downscaled by Maurer, et al. (2007) Santa Clara University. For more information see About Us.

Figure 7-1. Change in annual precipitation projected over Texas by mid-century based on the ensemble average (median value) of models used in the IPCC Fourth Assessment and the A1B emissions scenario (medium) on the left and the A2 (high) on the right. Areas in darker shades of green are projected to increase by half the models and areas in yellow and lighter shades of green are projected to decrease by half the models (Maurer et al., 2007).

Nevertheless, governmental agencies and other organizations that participate in water resource planning are either currently planning for the potential changes due to climate change, or they intend to incorporate that into future planning. Hirsch (2008) recommended the following approach to water resource managers: 1) collect more data; 2) consider paleoclimate records; 3) keep an eye on climate science and change; and 4) don't lose sight of other stresses (e.g. population & demand, urbanization, return flows, etc.).

7.2.1.2 Effects of Extant Climate Change on Regional Groundwater Systems and the Aquifer

A growing consensus among climatologists suggests that the next 50 years is likely to be warmer and drier *in the HCP Planning Area* than the previous 50 years (Seager 2007a, 2007c), especially if anthropogenic climate changes continue to accelerate, but also even if atmospheric carbon dioxide concentrations stay at current levels (Seager et al., 2007a):

> According to research compiled by the IPCC, from 1970 to 2004, much of the region that includes central Texas has encountered a warming trend on the order of 0.2-1.0°C (IPCC, 2007a). The IPCC findings include new and stronger evidence of observed impacts of climate change on unique and vulnerable systems, with increasing levels of adverse impacts as temperatures increase further. An increasing risk of species extinction is projected. Confidence has increased that a 1 to 2°C increase in global mean temperature above 1990 levels (about 1.5 to 2.5°C above pre-industrial levels) poses significant risks to many unique and threatened systems including many biodiversity hotspots.

While Global Circulation Models (GCMs) are a key tool for predicting and analyzing climate change, and regional predictions for Texas are reported (Seager et al., 2007), GCMs are not yet useful enough for predicting and assessing impacts in regional areas such as Texas. For example, rainfall is a key variable to assess environmental impacts (Leung, 2008). However, rainfall predictions from GCMs have the lowest confidence of simulated results and a lot of variability. Most GCM models suggest a "general drying" for Texas (Washington, 2008), but this is not consistent with Texas's regional rainfall and streamflow trends (Hunt et al., 2012; Nielson-Gammon, 2008; Singh, 2008; Leung, 2008;). The last 30 years have been warming faster than the global average, and have been accompanied by an unusually wet period in Texas, punctuated with more extreme events that are expected to continue into the future (Nielson-Gammon, 2008; North, 2008).

Texas will get hotter and climate change will exacerbate stresses already imposed upon water resources (Hayhoe, 2008). Climate in Texas continues to change, although current impacts from those changes have not been observed as they have in the U.S. Southwest such as Arizona (Woodhouse). Generally, it is expected that rapidly responding aquifers, such as the Edwards Aquifer, will be more sensitive to changes in climate (Mace, 2008). However, to date, no trends have been observed, either up or down, in recharge since the 1930s for the San Antonio segment of the Edwards Aquifer (Loaiciga, 2008). A study of hydrologic and geohydrologic responses by Hunt et al., (2012) in the Central Texas area concluded that while there has been an overall increase in the amount of water in water budgets of various stream systems, the base flows of streams and springflows have slightly decreased over the past several decades since the drought of record, likely owing to increased use of the groundwater resources (Hunt et al., 2012). This is particularly germane for the rather poorly controlled pumping from the Trinity Aquifer up gradient from the ITP Area, which will tend to produce lower base flows and flows of shorter duration in the creeks that contribute recharge to the Aquifer. But a study of global warming impacts on the San Antonio segment of the Edwards Aquifer by Chen et al., (2001) predicts that annual temperatures will rise (~3F) and annual rainfall will decrease (~4 in) by 2030 resulting in a 20% decrease in recharge during droughts. However, these effects and their impacts are both uncertain. Increasing demand due to population growth and rising temperatures will be the dominant factors impacting springs and water availability (Mace, 2008; Loaiciga, 2008). It seems clear that climate change will likely exacerbate these impacts, and vice versa.

As the Service (2013) summarizes,

> "Climate change could impact groundwater resources by affecting recharge, pumping, natural discharge, and saline intrusion (Mace and Wade 2008). They suggest that climate change will more adversely affect karstic aquifers (like the Edwards Aquifer) that recharge locally from streams and rivers in comparison to dripping aquifers where effective recharge is increased through pumping and the capture of intermediate and local groundwater flow paths. A warmer, dryer climate will increase demand for water to support agriculture, municipal, and industrial use. This will result in greater demand for both surface and groundwater. Decreases in surface water supply due to climate change may also increase demand for groundwater use (Kundzewicz et al., 2007; Mace and Wade 2008). Natural aquifer discharge to springs and seeps is affected by recharge to the aquifer, discharge by pumping, and changes in groundwater gradients as affected by plants, including phreatophytic species that demand higher amounts of water.
>
> Mace and Wade (2008) and Loáiciga et al., (1996) suggest that the Edwards Aquifer is probably Texas's most vulnerable aquifer and groundwater resource with respect to climate change and variability and if there is a long-term drying of the climate in south-central Texas, area groundwater users can expect to be under more frequent drought restrictions.
>
> Loáiciga et al., (2000) studied the climate change impacts on the Edwards Aquifer. Climate change scenarios were created from scaling factors derived from several general circulation models to assess the likely impacts of aquifer pumping on the water resources of the Edwards Aquifer. Aquifer simulations using GWSIM IV indicate that, given the predicted growth and water demand in the Edwards Aquifer region, the aquifer's ground water resources appear threatened under 2×CO_2 climate scenarios. Their simulations indicate that 2×CO_2 climatic conditions could exacerbate negative impacts and water shortages in the Edwards Aquifer region even if pumping does not increase above its present average level. The historical evidence and the results of this research indicate that without proper consideration to variations in aquifer recharge and sound pumping strategies, the water resources of the Edwards Aquifer could be severely impacted under a warmer climate."

It is possible that progressive increases in the ambient atmospheric temperature in central Texas would lead to seasonal or year-round increases in the temperature of springflow at Barton Springs, possibly causing increased stress and vulnerability to disease for the salamander species there and possible reductions in dissolved oxygen (DO) saturation levels. Such temperature increases could be moderated to some variable, though unquantifiable extent by the long residence time of groundwater issuing from the Aquifer, especially during severe drought. It is also possible that any reduction in the long-term average precipitation in central Texas during the winter months could result in reduced storage in the Edwards Aquifer at the onset of spring- and summer-time periods when water losses through natural and cultural processes are elevated. Such a condition could also exacerbate the reduction in summertime springflow during droughts.

Further, while the State of Texas mandates use of the drought of record (DOR) for water-planning purposes, such DORs may not represent the worst-case condition that actually could be experienced in the ITP permit period (Cleaveland 2006; Nielsen-Gammon 2008; Woodhouse 2008; see also the discussion in Section 7.2.1.3 immediately below). Put another way, it is possible that the DOR could occur with higher frequency than history otherwise indicates. Under such circumstances, the sustainable yield of the Edwards Aquifer could be somewhat less than that modeled and the lowest expected flows at Barton Springs could be concomitantly lower, other factors being equal. On the other hand, the DOR has been estimated to have a recurrence interval about five times longer than the 20-year duration of the District HCP, as described in Section 4.2. These factors suggest that a recurrence of a drought causing Barton Springs discharge to diminish to a level lower than has ever been recorded during the course of the ITP permit period is not likely.

Nevertheless, taken together these are trends for which additional attention and concern are warranted. There is a finite, albeit indeterminate likelihood that an extreme record event would occur during the term of the ITP, and that while still probably small, the likelihood will increase under recent climatic trends to some indeterminate degree.

7.2.1.3 Ecological Significance of Paleoclimatic Indications

Tree-ring studies and stable isotopic evidence suggest that the part of the North American continent containing the study area has experienced much more severe (especially longer) droughts than the DOR during medieval times and even in prerecorded history (e.g., Cleaveland et al., 2006; Seager et al., 2007b and 2007c). It is not known whether or how many times Barton Springs has stopped flowing over the course of several millennia. Yet the salamanders at Barton Springs have somehow survived. The District HCP is based on a premise that extremely low flows or no flow at the Barton Springs outlets could jeopardize the continued existence of the species, but there is no certainty that is the case. The size and distribution of the Covered Species populations before the historic and prehistoric droughts are unknown, so it is not known if the populations are particularly persistent or are the last surviving remnants of much larger populations at one time. Clearly the additional stresses contributed by cultural factors in the last century (e.g., increased impervious cover and urban storm runoff) distinguish current and future responses from those of historic or prehistoric times.

7.2.1.4 Lack of Water Chemistry, Water Quality, and Flow Data to Calibrate Models During Extreme Low Springflow Conditions

Modeling efforts to predict springflow conditions as described in Section 3.2.2.1.2, like any modeling exercise,, produce outcomes of predicted springflow values that are not absolute. Rather, they are theoretical, predicted estimates affected by the limitations and accuracy of the model, quality of input data, and major assumptions. Therefore, analyses of predicted springflows are limited in this document to the evaluation and comparison of alternative groundwater management strategies in a broad sense, not in a precise replication of a future scenario that is currently indeterminate. While they are instructive, use of the predicted springflow values beyond the described analyses should be exercised with caution.

Because the lowest recorded flow at Barton Springs is just under 10 cfs, during a time when little groundwater was being withdrawn from the aquifer, there are no data available to corroborate predicted or modeled flow and water-chemistry relationships below 10 cfs. In fact, almost all of this type of information comes from flows that are no lower than about 14 cfs. Accordingly, extrapolation of trends in flow, chemical components, and their relationships to flows less than 14 cfs is problematic. It is not known, for example, whether DO continues to decline with flow or whether it “plateaus” at some small sub-saturated concentration. Water temperature, even though it varies over a relatively small range in the Aquifer, may play a role in the level of DO of springflows independent of spring discharges and water levels, as it relates to DO saturation (Mahler and Bourgeais, 2013). These same investigators note that critically low DO levels can be caused by recharge from storm flows, especially during hot months. It is also not known whether and at what rate the flow itself continues to decline under prolonged Extreme Drought, or plateaus as a result of induced recharge of water that would otherwise be in the larger and topographically higher San Antonio segment. A statistical analysis of correlations between DO and springflow between 1993 and 2011 by the City of Austin may indicate a minimum concentration under ambient conditions that could be as high as 3.5 mg/L or as low as 0 mg/L DO (City of Austin, 2013). While the City of Austin has inferred, not unreasonably, a worst-case scenario, there currently is no unequivocal basis for reliably projecting the DO concentration at extremely low flow.

7.2.1.5 Cumulative Negative Effect of Pollutants in Groundwater Discharges on Salamanders

In development of the District HCP, studies funded by the District have focused on the relationship of DO and specific conductance with toxicity and other adverse effects on the Covered Species. Of these parameters, DO and springflow are now believed to be controlling. However, the Service recently has suggested that conductance, indicative of the relative salinity of the resurging groundwater, may also be important, especially to eggs and larvae (Service, 2013b), although it is not known if the relatively small increases in salinity at lower flows produce adverse effects. Springflow is presumably correlated with water-flow velocity in the habitat zones near the spring outlets, which in turn may be correlated with oxygen exchange potential across salamander gills (having potential importance in times of depressed DO concentration). The DO and salinity (and water temperature) are variations of the natural system, not pollutants, but sources of contamination and pollutants may produce adverse effects either on their own or in combination with the changes in natural water chemistry.

Little information exists in the biological literature on impacts of other chemical constituents and physical conditions to the Covered Species. But nonpoint-source pollution in the contributing and recharge zones of the Aquifer is already increasing the amount of anthropogenic pollutants like pesticides, domestic wastewater from decentralized and centralized treatment facilities, fertilizers and other nutrient sources, other oxygen-demanding constituents such as pet waste, suspended sediment, and some heavy metals in spring discharges (Mahler et al., 2011). Concentrations of those pollutants are likely to increase with time along with development, as additional volumes of treated domestic wastewater (sewage) and its oxygen-demanding waste loads are discharged directly and indirectly to streams that recharge the Aquifer. However, Mahler and Bourgeais (2013) suggests that there has been more recently a trend toward increasing DO concentrations overall in the Aquifer, indicative of the complex controls on this parameter.

There has been no attempt in this HCP or in any other investigation to assess the impacts of different concentrations and mixes of these water quality pollutants or their possible adverse impacts on the Covered Species, primarily owing to their vulnerability. Since management and control of land uses and associated development activities that generate these pollutant loads are beyond the authority of the District and the scope of its possible programs, they are therefore not proposed for management or research under the District HCP.

7.2.1.6 Response of Salamanders to Variations in Habitat Condition

By necessity, status of the Covered Species' populations is based on counts of observable individuals at the spring outlets and in spring runs. Lower counts clearly are associated with stress-related impacts, including population declines (City of Austin, 2013). As noted in Section 5.1.2.1, however, it has been suggested by other experts that salamanders appear to be able to migrate locally to areas of less stress in the Aquifer and in spring runs during certain times, but to some unknown extent. It seems not unreasonable that migration into the Aquifer and even to and from Main Springs is partly responsible for the re-emergence of a substantial portion of the population of salamanders at Upper Barton Spring when that outlet starts flowing again after many months of no flow and no observable organisms during the earliest stages of drought. On the other hand, during very severe prolonged drought conditions, the populations of both Covered Species at Old Mill Spring outlet decline substantially to just a few individual organisms after extremely low flow at the outlet. Those very low observable numbers continue to persist for months to years, even with re-establishment of some springflow.

The difference in behavior and ability to accommodate drought of these two populations maybe related to known differences in their hydrogeologic conditions at their outlets. In turn, that may be associated with the amount of subsurface migration that is possible. For the subterranean Austin blind salamander especially, lower observable numbers during prolonged and/or severe drought may not be an indicator of mortality, although some population decline during such periods of DO stress is reasonably expected. But the areal extent and proportional amount of such migration and their differences for either species, while inferred to occur, are largely unknown. These factors confound the quantitative interpretation of salamander reactions to stress and population impacts. . It seems clear that these uncertainties probably reduce the reliability of stress and quantitative take estimates determined on counts. However, no other deterministic approach currently exists.

Other, more hydrological uncertainties may relate to migration. The majority of water naturally discharging from the Aquifer resurges at Barton Springs. However, smaller springs have been noted that release directly into Barton Creek, upstream of Upper Barton Springs and also into the Colorado River. The springs upstream of Upper Barton Springs only discharge under moderate to high-flow conditions. Some small springs (e.g., Cold Springs) are visible on the south shore of Lady Bird Lake at the level of the water in the lake. Other discharges into the riverbed, but below the lake level, are also possible, but are difficult to discern either by direct observation or by monitoring temperature differences in the lake. The elevation of the lowest point in the Colorado River near the confluence with Barton Creek is about 412 ft msl. With an elevation of the main discharge point at Main Springs of about 420 ft msl, there is the potential for discharge of water into the Colorado River along some of these likely pathways owing to the head difference between the spring outlets and the base level of the river (TWDB, 1999). Although the presence of small springs below the lake level is unproven and would likely be only a very small component of the water balance for the aquifer system as a whole, the conceptual model of the aquifer suggests that there are numerous small pathways for flow along faults, fractures, and bedding planes. Geologic mapping in the vicinity of Barton Springs shows that there are about six major faults that extend to the Colorado River between the downstream end of Barton Creek and Cold Springs. Fractures are commonly seen at outcrops of the various Edwards Aquifer units. It is not unlikely that small discharges occur where these faults, fractures, and bedding planes intersect the riverbed. Such discharges into the Colorado River may be foreseen to occur even at no flow at the major spring outlets. They may offer alternative groundwater flow paths and therefore possible flow environments with sufficiently high water velocities to support the salamander ecosystem.

In addition, the conceptual model used by the District for the take estimate is that the spring outlets are hybrid springs, where both confined and unconfined waters resurge. The relative proportion of each of those groundwater types has been shown to vary with time and to differ among outlets. In the unconfined portion, the access for the salamanders from the outlets to various conduits and fissures at the water table, which is in contact with the atmosphere and provides a source of re-aeration within the Aquifer, seems likely to characterize the subterranean-only habitat of the Austin blind salamander.

However, this is simply hydrogeologically informed conjecture at this point, as no studies have been performed to address this uncertainty in subsurface flow environments and suitability and use as habitat of the Covered Species.

7.2.1.7 Recent Texas Court Decisions and Aftermath

In a series of decisions, culminating in the *EAA v. Day and McDaniel* opinion in 2012, the Texas Supreme Court has now clarified that 'groundwater in place' below the surface of the land is real property owned by the owner of the surface estate. It follows from the Court's decision that as real property, it is severable from the land and may be sold separately, although no specific amount of owned groundwater can be inferred *a priori*. Further, the Court has determined that, even though its withdrawal is subject to reasonable and equitable regulation by a groundwater conservation district (GCD), a GCD's regulation that arguably produces an inequitable or unfair economic burden on a landowner with investment-backed expectations may outweigh the public interest in managing groundwater and is potentially regulatory "taking," subject to compensation.

Moreover, a recent appellate court ruling, in *EAA v. Bragg*, suggests that even rational, well-considered groundwater regulation may in fact be a taking for which the regulating GCD is financially liable. The assessment of compensable takings will be determined by future legislative action and judicial opinions, including likely appeals to the Supreme Court.

While the actual implications of these decisions for the District's operations are almost certainly to be elaborated further during the term of this HCP and ITP, it clearly represents a new factor in the authority with which the District, or any GCD, may be able to limit groundwater production, without putting at risk its financial wherewithal to manage the groundwater resources in an overall sense. It also should be mentioned that should the latter scenario be manifested with the District, it is not clear whether such a fundamental change in the District's regulatory capability is a changed circumstance or an unforeseen circumstance for its HCP or, alternatively, a basis for suspension or termination of the ITP by the Service. Ultimately the Service will be expected to make the determination of what sort of HCP circumstance exists for that eventuality.

7.2.2 Responding to Changed Circumstances

While the District believes that the initial measures to be funded by the District HCP will be effective in conserving both habitats and the Covered Species, it is anticipated that conditions within the aquifer, the status of habitats, and the overall condition of the species over time will change. In addition, it is likely that additional and different conservation measures, not contained within the District HCP, will be suggested and be proven to be effective during the term of the District HCP. Finally, it may be found that measures currently funded by the District HCP may prove to be ineffective to conserve either the species or the habitats in which they dwell. All these situations potentially constitute changed or unforeseen circumstances. Therefore, the District is proposing to monitor and gauge the effectiveness of existing conservation measures on an ongoing basis, to evaluate alternatives in accordance with the monitoring reporting in Section 6.3.2 and the adaptive management processes described in Section 6.4, and to propose modifications, additions, or alternative conservation measures that could be implemented or supported by the District within its regulatory purview, including dealing with different circumstances as described below.

Events or situations likely to occur or that could be reasonably anticipated during an average 20-year period and to affect the ITP would be considered "changed circumstances." Events not reasonably expected to occur, or anticipated to occur less frequently than once during an average 20-year period (such as a drought worse than the DOR itself) would be "unforeseen circumstances." For changed circumstances reasonably related to the Covered Activities and the proposed conservation measures in the District HCP, the District includes in this section of the HCP a specific proposed response plan, in keeping with 50 CFR §17.22(b)(5)(i) for such changed circumstances. Except as noted in the subsections below, the contingency actions described as part of the response plans are able to be implemented within the funding commitments of the District discussed in Section 8 of this HCP, by reprogramming internal labor of District staff and/or certain contracted support.

7.2.2.1 Listing of New Species Not Covered by HCP

The listing of a new species by the Service as threatened or endangered within the ITP Area and that is determined to be not covered by the District HCP may constitute a changed circumstance. The two ecoregions of the HCP Planning Area have numerous vulnerable aquatic and terrestrial species (see Appendix A for a current listing), but none of those vulnerable species (or others) are known to exist in the ITP Area. The Service is statutorily required to notify the District and/or publish notice in the *Federal Register* upon becoming aware that a species associated with the habitats found in Barton Springs and not a Covered Species (but rather an "Uncovered Species") that may be or has been proposed for listing.

Proposed Response:

a. Upon receipt of notice of the listing of an Uncovered Species, the District will seek to partner with the Service regarding confirmation of this circumstance as a Changed Circumstance for the District HCP as determined by the Service, and the necessity of modification and amendment of the District HCP. If the District elects to pursue amendment of the applicable permit, the District will ask the Service to provide technical assistance to the District in identifying any modifications to the District HCP warranted by the changed circumstance and necessary to amend the applicable federal permit.
b. The District shall assess the efficacy of the conservation and mitigation measures as already provided in the District HCP as they provide for avoidance, minimization, and mitigation of take of the Uncovered Species, and provide that analysis to the Service.
c. The District shall seek guidance from the Service in determining whether any further conservation or mitigation measures are required and whether the District ITP requires an amendment to authorize any incidental take of such Uncovered Species.
d. The District shall provide the Service with an assessment of whether the District's Covered Activities and the proposed response to the listing of the Uncovered Species will adversely affect take of Covered Species, consistent with section 10 of the Act.

e. The District will incorporate any needed conservation measures that are within its regulatory authority and financial wherewithal into its amended HCP and ITP.

7.2.2.2 Drought with *Unexpectedly,* Sustained Low DO Levels

It is conceivable, though not likely, that a range of drought and non-drought springflows during the term of the ITP could exhibit DO concentrations related to springflows that were substantially different across-the-board and/or significantly more adverse to the Covered Species than now anticipated on the basis of current knowledge, which has been developed over more than a decade from existing data, current models, and inferred relationships. If this were to occur on a systemic, sustained basis without other apparent exogenous causes, the District would propose that this be considered an Unforeseen Circumstance. However, it is also possible that severe droughts during the term of the ITP could suddenly degrade the habitat substantially more than anticipated in this HCP on a shorter-term, rapid-onset basis and in a way that had immediate adverse consequences for the Covered Species. This circumstance would be considered a Changed Circumstance. It would be associated with a persistent declared Stage III-Critical or more severe drought condition, indicating the likely relationship of the DO to springflows, and would be triggered by confirmed daily measurements of dissolved oxygen levels in the Main (Parthenia) and/or Eliza spring outlets that averaged below 3.4 mg/L, the *laboratory* LC_{50} concentration, for more than one month, to eliminate transient and non-springflow related causes of low DO.

<u>Proposed Response</u>:

Following consultation with the Service as to the need for immediate and extraordinary mitigation, the District Board could provide one or both of two sequential responses:

1. If the DO Augmentation Project, developed as a Mitigation Measure and described in Section 6.2.2.2, proved feasible and had been implemented in its planned stand-by mode at the time of this circumstance, the Board would trigger its deployment under the terms of its Implementation Agreement with the City of Austin, and monitor the response of the spring outlets with respect to DO concentrations, until it improved to the point where the extraordinary stress on the species was relieved, as indicated by weekly average dissolved oxygen levels in Main and Eliza Springs' increasing above 4.5 mg/L.
2. If the DO Augmentation Project was not deployable for any reason or failed to provide the intended benefit, the Board is committed to induce selected individual permittees that have unused alternative water supplies to voluntarily agree to temporary pumping curtailments greater than otherwise required by District Rules until the extraordinary stress on the species was relieved, as indicated by weekly average DO levels in Main and Eliza Springs' increasing above 3.7 mg/L, the LC_{25}, on a sustained basis. The inducement for such temporary curtailments could be temporary increases in the permittees' permitted volumes once drought ends. This provision will require a change in the District's Rules but not its MP, to be initiated upon ITP approval for ready implementation.

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7.2.2.3 Substantial Change in Statutory, Legal, or Financial Wherewithal to Execute the Conservation Measures According to the ITP

A change in the District's legal authority or a substantial reduction in the level of annual revenues available to the District for implementation of the District HCP may constitute a changed circumstance. The District is dependent on annual revenues from usage fees derived from well-production permits, based on statutory authority granted by the Texas Legislature, and also from prescribed contributions by the City of Austin under a statutory mandate. These revenues may vary somewhat each year, as explained in Section 8, and they are not anticipated to be curtailed or terminated during the course of the ITP; but neither are they guaranteed sources or amounts of revenue. GCDs are currently the Legislature's preferred means of managing groundwater, but the scope of this authority is subject to both legislative pressures and constitutional challenges in court. It is not unforeseeable that during the term of this HCP; in particular, legislative changes could affect both, and legal defense expenses, such as noted in subsection 7.2.1.7 above, could adversely affect the District's financial condition. However, the District maintains funds in a contingency account as a routine policy of fiscal management to provide protection from emergency conditions affecting its revenues or expenses, and it will deploy them as needed to maintain the necessary funding of conservation measures and other ITP requirements.

<u>Proposed Response</u>:

If the District's statutory authority was substantially reduced, or its normal annual revenues were to be curtailed by more than 25 percent, or its non-labor related expenses net of capital expense increased by more than a factor of 1.5 in any two-year period, but not to a level at which the District would be unable to maintain the funding levels specified in the District HCP, the District will notify and enter into consultation with the Service to develop an analysis of the impact on proposed take of the Covered Species and a mechanism to prioritize measures and resolve the changed circumstance as it relates to take. In the alternative, following consultation and Board action, the District may request the Service to amend the District ITP and HCP.

7.2.2.4 Other Changes in Circumstances

There are other changes in circumstances that are foreseeable and that might affect the status of the Covered Species. For example:

- Intentional, illegal human activities (e.g., vandalism; terrorism) that are destructive to the Covered Species and/or their habitat.
- Major accidental pollution events in the ITP Area (e.g., toxic chemical spills; wastewater spills; petroleum and petrochemical pipeline leaks) that are destructive to the Covered Species and/or their habitat.
- Increased pollutant discharges from either or both point-sources or nonpoint sources.

- Floods, erosion, and sedimentation of Barton Creek that, via a single event or by cumulative effect, degrade the health of the Covered Species or adversely change the quality of their habitat throughout a substantial portion of their distribution.
- Changes in non-abiotic factors such as increased predation and inter-species competition that alter the present ecological conditions.
- Decreased recharge to the Aquifer arising from smaller base flows in the creeks in the contributing zone over time, owing to the effects of climate change and especially the impacts of pumping up gradient that reduces the amount of Trinity groundwater discharging to those streams.
- Alternative water supply benefits in the form of prospective reduced pumping of the Aquifer are not realized.

However, unlike the others identified in the subsections above, these changes are not related to the Covered Activities and the District is not able to address them directly as they are not within the statutory authority of the District, nor does the District have the financial resources available for their remediation or even evaluation. Accordingly, these are not considered Changed Circumstances for the District HCP, and no specific contingency plan is provided in this HCP as part of the proposed response for other changes.

<u>Proposed Response</u>:

Should events or changes such as these occur, each will be evaluated jointly by the District and the Service as to significance to the Covered Species and confirm whether or not they are, in fact, changed circumstances and circumstances that the District is able to address. It is also anticipated that the District will coordinate with the City of Austin in making such evaluations, as the changes could represent changed (or unforeseen) circumstances under that entity's HCP as well.

7.3 Unforeseen Circumstances

The Service defines the term "unforeseen circumstances" to mean "changes in circumstances affecting a species or geographic area covered by [an HCP] that could not reasonably be anticipated by plan developers and the Service at the time of the HCP's negotiation and development and that result in a substantial and adverse change in the status of the covered species" (50 CFR §17.3.) Such circumstances are not "unimaginable," rather simply unreasonable to be expected during the term of the ITP. Unlike identified Changed Circumstances, the Service rather than the Applicant (the District) is responsible for Unforeseen Circumstances and responding to them. In addition, the necessity to make amendments, clarifications and minor administrative amendments to the ITP and HCP forms a special class of unforeseen circumstances.

7.3.1 Responding to Unforeseen Circumstances

In making the determination that such an event constitutes an unforeseen circumstance, under its statutory obligations the Service will consider, but not be limited to, the level of knowledge about the affected species and the degree of specificity of the species' conservation program under the District HCP and whether failure to adopt additional conservation measures that within the District's regulatory authority and financial ability would appreciably reduce the likelihood of survival and recovery of the affected species in the wild.

7.3.1.1 Procedure for Determining Occurrence of Unforeseen Circumstances

In making a determination regarding the occurrence of any unforeseen circumstance, the Service has developed and will follow the procedures set forth in its applicable regulations (50 CFR 17.22(b)(1)(iii)). These are summarized below, but the statutory language is controlling:

Notice to Applicants and Participants

The Service shall provide written notice to the District together with a detailed statement of the facts regarding the unforeseen circumstance involved, the anticipated impact thereof on the Covered Species and its habitat, and all information and data that support the allegation. In addition, the notice shall include any proposed conservation measure(s) believed to address the unforeseen circumstance, an estimate of the cost of implementing such a conservation measure, and the likely effects upon (a) the District and its permittees and (b) the existing plans and policies of any involved Federal or State agencies.

Responses as a Result of New Information Derived Through Adaptive Management

The research and investigative measures that the District commits to undertake as a part of its adaptive management efforts may indicate or otherwise call for specific other responses to changed or unforeseen circumstances. As new information is obtained during the course of the ITP period and in consultation with the Service, the District and the Service may agree to modify or redirect existing conservation measures to mitigate the effects of unforeseen circumstances, within the scope of existing approved and funded conservation actions and ITP terms. To the extent that these modified or redirected conservation measures do not affect conservation of other species or habitats, this approach may be deemed an adequate response to the unforeseen circumstance. However, if the proposed modifications or redirected conservation actions could affect the conservation of another Covered Species or its habitat, the procedure outlined below will be followed.

Submission of Information by Others

The District shall have a meaningful opportunity to submit information to the Service and shall do so within 60 days of the written notice, as provided above. Upon the written request of the District or any other participant in the District HCP, the time for submission of said information may be extended by the Service, and the request will not be unreasonably denied.

District Review

Within 90 days after the close of the period for submission of additional information, the District shall assess (a) the alleged unforeseen circumstances, (b) the proposed additional conservation measure(s), (c) its effects upon the Covered Species and its habitat and the economy and lifestyles of the District and permittees, and (d) possible alternatives to the proposed additional conservation measures that would result in the least adverse impacts upon the economy and lifestyles of the District and permittees, while at the same time leading to the survival and recovery of the Covered Species.

Findings

The Service has the burden of demonstrating that an unforeseen circumstance has occurred, and that such unforeseen circumstance is having or is likely to have a significant adverse impact on Covered Species or its habitat. The findings of the Service must be clearly documented and be based upon the best scientific and commercial data available regarding the status and habitat requirements of the species. In addition, based on the results of its own expedited analysis of the changed or unforeseen circumstance and the information provided by the District or other participants in the District HCP, the Service must provide the justification and approval for any reallocation of funds or resources necessary to respond to the unforeseen circumstance within the existing commitments of the District under the District HCP.

7.3.1.2 Response to Determination of Unforeseen Circumstances

In accordance with the Service's statutory authorities and obligations, which are controlling (50 CFR 17.22(b)(1)(iii)), after the conclusion of the process outlined above, the Service would determine that an unforeseen circumstance has occurred, and that additional conservation measures are likely required to address the circumstance but are not contemplated or capable of implementation by the District HCP. Then, provided that the District has fully complied with the terms of the District HCP, any proposed additional conservation measures by the District would be limited, to the maximum extent possible, to those within the terms of the District HCP and its ITP.

Under the Service's "No Surprises" rules, additional conservation measures may not require the payment of additional compensation by the District or its permittees. If additional expenditures are required, the Service or any other federal agency must take additional actions that might lead to the conservation or enhancement of a species that is being adversely affected by an unforeseen circumstance. The costs of these additional actions are intended to be borne by the Service or any other federal agency. However, prior to undertaking or attempting to impose any actions or conservation measures, the Service may consider all practicable alternatives to the proposed conservation measures, and adopt only such actions or conservation measures that would have the least effect upon the economy and lifestyle of the District and permittees, while at the same time addressing the unforeseen circumstance and the survival and recovery of the affected species and its habitat. The purpose of this provision is to recognize that Congress intended, even in the event of unforeseen, extraordinary, or changed circumstances, that additional mitigation requirements not be imposed upon a section 10 permittee who has fully implemented the requirements undertaken by it pursuant to an approved HCP.

7.3.2 Clarifications, Minor Administrative Amendments, and Amendments

Circumstances may arise that necessitate HCP and/or ITP amendments. Such circumstances have been interpreted by the Service to be a special category of unforeseen circumstances that may be triggered by either changed or other unforeseen circumstances or otherwise, and therefore must comply with the requirements of 50 CFR 17.22(b)(1)(iii): "the procedures to be used to deal with unforeseen circumstances."

Amendments may include those actions or decisions that would affect the scope of mitigation or method of implementation of the District HCP or ITP and would require consent of the Service. Generic examples of amendments include but are not limited to the following (although none are currently planned or imminently envisioned):

- Addition of parties to the ITP;
- Changes in the ITP areal boundaries, with possible material effect on Barton Springs flows during Extreme Drought;
- Additions to or deletions from the species protected under the HCP;
- Changes in state or local legislation that materially diminish the authority of parties to the ITP to carry out the terms and conditions of the ITP;
- Changes in the conservation, monitoring, compliance, or enforcement programs likely to affect the level of incidental take of species; and
- Renewal of the ITP beyond the initial term.

In considering whether a prospective amendment is a minor or a major amendment of the existing ITP, the District will provide the Service with its analysis of whether the prospective take of the Covered Species would increase, decrease, or stay the same with the amendment, and the basis for that assessment. The District will then seek to consult with the Service as to its concurrence with the findings of that analysis. Any amendment that increases take is to be considered a "major amendment" under the Service's statute, requiring execution of the procedures described in subsection 7,3.1.3.2 below, before the amended ITP would be approved and issued. Further, renewal of the ITP beyond its then-current term or the issuance of a new ITP for the Covered Species will trigger a review under National Environmental Policy Act (NEPA) and by rule is considered a major amendment.

7.3.2.1 Clarifications and Minor Administrative Amendments

From time to time, it may be necessary for the Service and the District, as Administrator of the District HCP, to clarify provisions of the District HCP or the ITP to deal with issues that arise with respect to the administration of the process; or the District may find it necessary to be more specific regarding the precise meaning and intent of the language contained within the HCP or ITP documents. Clarifications do not change the provisions of any of the documents in any way but merely clarify and make more precise the provisions as they exist.

The District HCP may, under certain circumstances and at the discretion of the Service, be amended without amending its associated ITP, provided such amendments are of a minor or technical nature and that the effect on the species involved and the levels of take resulting from the amendment are not increased from those analyzed when the ITP was issued.

In addition, from time to time it may be necessary to make Minor Administrative Amendments to the documents that do not make substantive changes to any of the provisions but that may be necessary or convenient over time to represent the overall intent of the District and the Service. Clarifications and Minor Administrative Amendments to the documents may be approved by the Field Supervisor of the Austin Ecological Field Office of the Service and, after review by the District, the General Manager or President of the Board of Directors of the District and shall be memorialized by letter agreement or by substituted Plan Documents modified to contain only the Clarification or Minor Administrative Amendment.

7.3.2.2 All Other Amendments

Except as provided for Clarifications and Minor Administrative Amendments in the subsection above, and subject to the Service's concurrence with the District's assessment of changes in take for an existing ITP, all other amendments are considered major amendments and will follow the procedures summarized in this subsection. The District HCP, ITP, or any (future) Implementation Agreement with other parties may not be amended or modified in any way without the written approval of the District (as Administrator of the District HCP), all signatories (currently, only the District), and the Service. All proposed material changes or amendments shall be reviewed by the District. Material changes shall be processed as an amendment to the permit in accordance with the provisions of the Act and regulations at 50 CFR Parts 13 and 17, and shall be subject to appropriate environmental review under NEPA provisions.

Amendments of the District HCP and ITP permit would be required for any change in the following: (a) the listing under the Act of a new species not currently addressed in the HCP that may be taken by project actions; (b) the modification of any project action or mitigation component under the HCP, including funding, that may significantly and adversely affect authorized take levels, effects of the project, or the nature or scope of the mitigation program with the exception of those plan modifications specifically addressed in the original District HCP and ITP application; and (c) any other modification of the project likely to result in significant adverse effects to the Covered Species not addressed in the original District HCP and ITP application.

Amendment of a section 10(a) permit must be treated in the same manner as an original ITP application. ITP applications typically require a revised HCP, a permit application form, an Implementing Agreement if another Plan Applicant is added, a NEPA document, and a 30-day public comment period. However, the specific documentation needed in support of a permit amendment may vary depending on the nature of the amendment.

Proposed amendments to the District HCP or ITP can be initiated by the District or Service, or by other participating entities executing an Implementing Agreement, if they are approved for addition after the initial ITP and HCP are authorized. A proposed amendment would be submitted as a formal proposal to the District and Service for possible action. The proposal must state the reason the amendment is being requested, description of the proposed change, and an analysis of the potential effects of the proposed revision on the Covered Species and the terms and conditions of the ITP. Additional information may be requested. The approval process is as follows:

- Action on a proposed amendment under the District's jurisdiction must first be taken by the District. In a timely manner, the District Board must approve or deny the request;
- The plan amendment would be referred to other potentially affected Section 10(a)(1)(B) permit holders (here, the City of Austin) for review and comment; and
- A plan amendment approved by the District Board (and any other parties to a future Implementation Agreement, if any) would then be forwarded to the Service for action consistent with its rules, regulations, and policy.

As specified by Service regulations, the same procedure would be followed when plan amendments are initiated by the Service, such as listing of a new species that could result in a change to the District HCP terms and conditions.

8.0 District HCP Funding Assurances

The proposed amounts and approach to funding described in Section 8 of the Review Draft HCP are preliminary and presented for discussion purposes. The Board of Directors of the District has not yet approved any particular level of funding, either in total or for specific measures, for inclusion in the Draft HCP.

Essentially all of the Habitat Conservation Plan (HCP) measures to be put into practice by the District (including the prospective avoidance, minimization, mitigation, and monitoring measures and their administration) are now specified in and authorized by the District's revised, approved Management Plan (MP) (BSEACD, 2013). Most of the direct measures called for in the HCP, including the District's well permitting and drought management programs, are already part of the MP and annual budget. As such, the funding for these measures over the 20-year term of the District HCP comprises a significant share of the District's annual operating budget that is already being expended in these efforts. The District's budgeted revenue is based on water-use fees from permittees and other related fees that are authorized statutorily and collected from the District's groundwater production permittees, and also from a statutorily mandated, very substantial supplemental fee paid by the City of Austin, which amount is linked by formula to the water-use fees paid by the permittees. These revenues will be augmented from time to time by enforcement penalties and by other external funds for special initiatives, such as grants, neither of which are under District control and therefore are not considered a part of the sustainable operational funding of the District. Accordingly, because the entire continuing-operations budget of the District is by law established to serve the District's statutory purpose through implementation of the District's Management Plan (and nothing else), a major share of the normal District operating budget provided by continuing water-use fees paid to the District by its permittees and supplemented by the City of Austin will in effect be committed to implementing the HCP incorporated within the Management Plan (MP).

Because the HCP conservation measures are integrated with the Covered Activities, in that both are groundwater-use management, it is not possible to differentiate funds for groundwater management between Covered Activities and conservation measures. Similarly, there is no separate or additional funding represented by the conservation measures in the HCP and the Pre-HCP periods; the difference is not how much is being spent but how those funds are being deployed. Simply put, the District's regulatory program has evolved over the past decade such that the District funds now support a much more effective groundwater management program than the program that existed before the HCP, for essentially the same amount of dollars.

The District HCP conservation measures, including the overhead associated with their provision, will require a variable amount of expenses year to year, but always substantially more than one half of the total level of effort in executing the District's MP. Some flexibility in annual funding of the HCP is needed by the District to ensure its continuing operations, which also contributes to the variability in expenditures among the years. The actual level of effort and that portion associated with the HCP are expressed by the composition of each annual budget, which is already being used by the District to defray the costs of the personnel, programs, and special projects required to implement and manage most of the conservation measures in the proposed HCP, as they are integrated with the Covered Activities. The component parts of these budgets related to the HCP may also be expected to vary from year to year in the types of expense involved. Because of these factors, the District considers it more appropriate to commit to some minimum level of annual funding associated with the HCP conservation measures, rather than an average level or the specification of an exact amount each year of the ITP.

The District is committed to fully implementing the proposed HCP and meeting ITP requirements. Therefore, <u>the District stipulates funding of the District HCP via its MP elements during the term of the ITP will be no less than 60% of each year's annual budget that is derived from its statutorily authorized annual operating revenues related to Aquifer use (i.e., not including use of financial reserves).</u> For example, in Fiscal Year 2014, the District's Board-approved annual budget is approximately $1,717,000, of which $198,000 is from reserves, so the nominal HCP Funding Commitment would be $911,000. In most years during the term of the ITP, the actual dollar value of expenditures for the HCP will be substantially greater than this minimum amount, as the MP is executed in a robust fashion. The funding by the District includes both in-kind labor provided by District staff and directors, and cash contributions and expenditures for other goods and services, all in support of the HCP conservation measures. The District's annual financial audit report will be the used for documenting actual operational expenditures as being equal to or greater than the percentage-based commitment to funding groundwater management and conservation under the HCP.

Barring significant changes in the statutory authorities and/or legal landscape, which would likely require a major amendment to the ITP and this HCP, the District anticipates being able to continue annual funding from these sources in that same or greater amount, since the revenue is statutorily authorized. State law requires the District's expenditures to be approximately equivalent to its revenues (which may include use of financial reserves) each year. However, also by State law the District cannot commit funds in advance to any purpose except those budgeted each fiscal year, and it is allowed to budget for only one year at a time. These restrictions notwithstanding, it is the District's intent, as demonstrated by its Board's agreement to the ITP terms, to continue to fund all of the activities that support the District HCP measures in the committed amount, as a minimum, throughout the life of the ITP and HCP. The District will report the actual funding provided for implementing the HCP each year in its annual implementation monitoring report to the U.S. Fish & Wildlife Service (Service).

The District will implement the HCP program in the form of District labor, program expenditures, and/or cash each year for the aggregated HCP program in that year, which will include various measures that may be individual time-phased projects active in that year. For example, in the third year following ITP issuance, some of the HCP funding might be earmarked to fund two project-oriented measures that are active in the third year, say, one research project and one mitigation initiative, just as illustrative examples.

Specific conservation-, research-, and mitigation-project measures will be identified and funded in the out-years, as other collaborating parties are identified and become involved, as required funds from other parties are committed, and/or as participation agreements are negotiated. However, it should be understood that the actual years and the committed amounts (of in-kind and/or cash contributions) under which any specific project measure is undertaken are largely indeterminate now, because the ability and efficacy to conduct those project-oriented measures and the timing of them are uncertain. The District will identify in its HCP annual report those specific conservation, research, and mitigation projects that have been and/or will be initiated and the project-specific District in-kind services and funding (and funding from other sources, if applicable) that are planned for the then-upcoming year(s), once such clarity is available during the course of the ITP term. Similarly, if, say, because of exigencies beyond the District's control some planned project was unable to be started when planned and/or was not able to be funded at the planned level in one or more years, the District would explain the source of the deviation from plan in its implementation monitoring report to the Service. Provided the Service subsequently determines that explanation to be adequate and that the overall District funding commitment is achieved, such deviation from the planned funding is proposed to not require an amendment to the HCP/ITP.

9.0 Alternatives to the Taking

The Act requires that each Habitat Conservation Plan (HCP) address "the alternative actions to [the proposed incidental] taking the applicant considered and the reasons why such alternatives are not being utilized."

The Covered Activities in this HCP relate exclusively to groundwater withdrawals by third-party well owners and the District's own regulatory program concerning such withdrawals, which is overprinted on the natural variability of the Aquifer. The natural variation in Aquifer storage and springflows by itself produces a condition in which <u>any</u> amount of groundwater withdrawal during severe droughts will constitute take. Simply put, there is no alternative action that allows use of the Aquifer as a water supply without producing take of the Covered Species for substantial periods of time. Accordingly, any alternative that could completely *avoid* take of the Covered Species would require imposition of a regulatory program by the District that allows <u>no</u> use of the Aquifer as a water supply during severe drought.

9.1 Analysis of Potential Alternatives to Avoid Take

Two basic options were considered by the District in assessing the efficacy of an alternative approach that could eliminate the use of the Aquifer as a water supply and thereby avoid, not just minimize take: reduction in demand for Aquifer water, and water supply enhancement and substitution. Under certain conditions, each of these, either individually or in combination, could comprise an alternative to the taking; they are evaluated in this subsection.

9.1.1 Demand Reduction Alternative

The District's authority allows it to mandate reductions in demand for Aquifer water, but only in a limited sense. More particularly, the District's permitting program provides the means by which pumping of the aquifer by larger-capacity wells and other wells of certain types can be controlled, both in absolute-use terms and especially in response to drought conditions. These regulatory curtailments, backed with effective enforcement to ensure compliance, provide a non-structural, assured vehicle for increasing the water levels in the aquifer, which benefit well owners/users in the western part of the District where saturated thicknesses of the Aquifer are relatively thin, and also, of critical import to this HCP, such curtailments will benefit the amount of flow and the dissolved oxygen (DO) concentrations of water issuing from Barton Springs, which is the habitat of the Covered Species.

However, the District's authority does not extend to ordering complete cessation of pumping of all wells in the Aquifer, even during Extreme Drought. Under State law and recent court interpretations, landowners have a vested property right to withdraw groundwater under their land as a real property interest. Further, the District's regulatory program is underpinned by permitting that is based on actual reasonable and nonspeculative demand such that there is very little permitted pumping that is not committed to being fully utilized for beneficial use, especially after factoring in severe drought curtailments. So the Demand Reduction Alternative *per se* legally and practically must allow some amount of existing and future freshwater Edwards Aquifer groundwater withdrawals from wells to continue. It also should be noted that the Aquifer has been designated as a "sole-source water supply" for many residents in the ITP (Incidental Take Permit) Area, which imposes certain protections and considerations applicable to other federal programs, including those of the Service. District regulation-mandated curtailments during drought that minimize but do not prevent withdrawals and that are authorized under an ITP would be consistent with applicable state and federal statutes. Such an alternative mitigates but does not avoid take.

9.1.2 Supply Enhancement and Substitution Alternative

During drought, <u>if</u> the District <u>could</u> mandate that all Aquifer users stop pumping their wells during drought in favor of switching over completely to another, standby supply, then the wells in the Aquifer would not be decreasing the springflows and increasing the amount and frequency of take. The enhanced availability of alternative water supplies would facilitate and allow the substitution for Aquifer water. But as explained below, this Supply Enhancement and Substitution Alternative *per se* is not statutorily, economically or even physically feasible in aggregate for all groundwater users across the District – the District is not legally authorized to make such demands on all of its permittees, or even to require its permittees to develop alternative water supplies.

Some well-resourced permittees have voluntarily broadened their water-supply portfolios to include alternative sources of water, and some of them do voluntarily curtail their pumping of groundwater from the Aquifer during drought and utilize substitute supplies. But there are simply not enough firm-yield alternative water supplies available now to all groundwater users, either at any price or at something less than prohibitive cost for their situations. In any event, the District cannot legally mandate such substitutions *per se* for existing, authorized supplies of Edwards groundwater; it can only encourage and incentivize acquiring such replacement water by its scientific investigations and regulatory programs. With one minor exception, the District itself does not own any alternative water rights, and its financial resources do not allow it to acquire others, at least on the scale that would be meaningful to having an effect on springflows.

The District is actively working with its stakeholders, especially its permittees that are water supply providers, and with others to foster development of alternative supplies of water. The District's regulatory programs can be a driver in that, and so the proposed option can work for some permittees in concert with the Demand Reduction Option described in 9.1.1 to provide a means for greater curtailments while meeting water demands, or a greater likelihood of being able to meet the regulatory required curtailments. As new water supplies become available, for example through desalination of brackish groundwater, aquifer storage and recovery, and water reclamation, there will then be increased opportunities to substitute those waters for freshwater Edwards water. But the time frame for that is not immediate, it is not likely to be available over a wide geographic area, and it will be much more expensive than the greatly under-valued and -

priced freshwater Edwards groundwater. Even if it were technologically possible, the District does not own or control those alternative water resources, and even if it did, the cost of such alternative supplies that could provide complete replacement of Edwards Aquifer water is orders of magnitude greater than the District's existing and likely future financial resources. So for those reasons, while the Supply Enhancement and Substitution Alternative might support the proposed option that is mostly based on demand reduction in something of a hybrid fashion on a case-by-case basis, it is not *per se* an alternative that could be deployable as the primary, preferred option in this HCP and avoid take.

The District has for years also worked to enhance the amount of recharge that can enter the Aquifer through its natural openings in streambeds, to maximize the amount of water available from natural rainfall/runoff events. It continues to do so, to preserve if not increase the recharge capacity and prevent the discrete recharge features from getting clogged with sediment-laden runoff. However, the number of those features available to the District for such operations is limited, too few to make a real difference as *additional* supply. And the same dearth of alternative water supplies described above prevents introduction of such alternative water into the recharge features during extreme drought conditions, which is when the additional supply is most needed.

While structural projects and alternative water supply projects such as those described above can play a useful, supporting role in management of the Aquifer, such activities are typically not under District control or always available to the District. Provision of the entire volume of currently permitted pumping (nearly 2.9 billion gallons annually) with alternative water supplies from non-Aquifer sources to even the current Aquifer users would be prohibitively expensive (into the hundreds of millions of dollars), and further there is no mechanism available to the District to recover most such costs. So simply put, to a substantial extent, the District cannot afford the level of infrastructure development that would replace all of the current water supplies of the Aquifer and allow large-scale substitution of water supplies. Without such complete substitution with alternative water, take of the Covered Species would continue to occur during drought periods. Moreover, the District has no legal authority to force an existing groundwater user to stop using that groundwater supply in favor of another; further, the District cannot legally unilaterally reduce the property interest in groundwater from the Aquifer even if a substitute supply is provided.

9.2 Basis of Proposed Groundwater Management Program

The District has concluded that the primary option that produces the needed balance between legal groundwater production/use and conservation of the Covered Species is the non-structural regulatory program that comprises the Covered Activity, viz., the Enhanced Best Available Alternative measures described in Section 6. The basis for this determination and selection is discussed in this section.

The District is a political subdivision of the State of Texas, a groundwater conservation district (GCD) charged by the State legislature to preserve, conserve, protect, and prevent waste of the groundwater resources within its jurisdictional area, <u>and</u> to allow use of the groundwater resources to the maximum extent feasible by well owners in that area. More importantly, the District is the only governmental entity that is able to serve that mission, as the groundwater is owned by the surface landowner, rather than the State or the public, and the landowners have a legal right to produce the groundwater from the Aquifer for their own beneficial uses. Without the District's programs, the groundwater withdrawals in the District would be unregulated, and the discharges from Barton Springs would not be able to be managed, raising the specter of zero springflows for many months at a time during extreme drought. And concomitantly, without the District's regulatory restrictions, there could be no control on the impacts associated with the springflow-induced stress on the Covered Species.

Further, the District as a GCD has a legal requirement to manage the groundwater and protect other related natural resources, including the Covered Species at Barton Springs. An ITP's required HCP offers a vehicle that can provide longer-term, more systematic assurance of such protection than would otherwise be available to the District without the permit. (It also provides a legal shield for not only the District but its permittees against claims that could otherwise be asserted against them, as they exercise their legal right to use their "fair share" of groundwater, under the Act, which obligates real property owners to protect endangered species.)

Within this selected approach are sub-options, related to balancing risks to continued District operations and rewards in terms of aquifer and habitat protection, which the District evolved through over time in developing this HCP; that evolution was described above, in Section 4.1.2. The District Board considered several of the intermediate steps as potential options for the HCP program, each having differing levels of curtailment and resulting springflow but also with differing implementation challenges and probabilities of success. But ultimately the Board determined that the District had an obligation to provide the maximum protection to the endangered species that it legally and financially could at the current time, so the only acceptable optional level of demand reduction in the final analysis is the Enhanced Best Attainable Alternative demand reduction option aided by alternative-supply enhancement and substitution where feasible,, which comprises the minimization, mitigation, and adaptive management measures described in Sections 6.2, 6.3, and 6.4. There is a practical limit on how much regulatory curtailment of water use by any one permittee is feasible, and also a legal and financial limit on how much curtailment is "reasonable" and "fair," before a *regulatory* takings ensues that arguably represents compensable loss to the groundwater owner/user. The Board considers the current expression of this option at that limit, comprising conservation measures equivalent "to the greatest extent practicable."

Therefore, the Enhanced Best Attainable Alternative, based on a hybrid of demand reduction and alternative supply development, is considered the preferred and proposed option for groundwater management in the District that affects the Covered Species, both now and over the term of the ITP. At its maximum curtailment expression, this alternative, which constitute the Covered Activities, essentially produces water levels and spring flows that would meet the Desired Future Condition of the Aquifer, which is specifically promulgated to minimize take during a recurrence of the drought of record (DOR) to the maximum extent feasible.

In summary, the Covered Activities of this HCP provide the primary vehicle to minimize the risks of both incidental take of the Covered Species and compensable regulatory take of real property. The District's regulatory program is the only statutorily authorized option that the District can use to balance both, and therefore it is considered the principal option for groundwater management in the HCP.

10.0 Other Information That the Secretary May Require

This section of the Habitat Conservation Plan provides assurance that no other information besides that contained elsewhere in this document is required to be presented for compliance with Section 10(a)(2)(A)(iv) of the Act. The Secretary of the Interior and the Director of the U.S. Fish & Wildlife Service have not identified other specific informational or other requirements of the District for this HCP at this time.

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