DRAFT

Post-Delisting Monitoring Plan

Concho Water Snake

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U.S. Fish and Wildlife Service

Austin Ecological Services Field Office

Austin, Texas

Disclaimer

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Cover photos credit: N. Allan, U.S. Fish and Wildlife Service

Upper photo: A captured Concho water snake

Lower photo: Riffle habitat on the upper Colorado River

Executive Summary

The U.S. Fish and Wildlife Service (Service) has proposed to remove the Concho water snake from the Federal list of threatened species under the Endangered Species Act due to recovery and new information. Post-delisting monitoring (PDM) is required to ensure the species remains secure from risk of extinction after delisting. PDM for Concho water snakes will consist of two monitoring components: biological (to monitor the status of the snake) and hydrological (to monitor instream flow conditions). Over a 15-year period, surveys to measure the presence, reproduction, and abundance of snakes will be conducted twice per year at 18 sample sites across the range of the snake. Biological monitoring frequency will occur in three phases, decreasing over time, for seven years of surveys over the 15-year PDM period. Evaluation of stream conditions will consist of analysis of hydrologic data collected at eight existing stream gages from across the snake's range. Monitoring triggers (both quantitative and qualitative) are based on results of the snake's distribution, presence, reproduction, and abundance, as well as, an evaluation of instream flow conditions. If monitoring results in concern regarding the status of the snake or increasing threats, possible responses may include an extended or intensified monitoring effort, additional research (such as modeling metapopulation dynamics or assessing the status of the fish prey base), enhancement of riverine or shoreline habitats, or an increased effort to improve habitat connectivity by additional translocation of snakes between reaches. If future information collected from the PDM, or any other reliable source, indicates an increased likelihood that the species may become endangered with extinction, the Service will initiate a status review of the Concho water snake and determine if relisting the species is warranted.

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I. Introduction

Post-delisting monitoring (PDM) refers to activities undertaken to verify that a species delisted due to recovery remains secure from risk of extinction after the protections of the Endangered Species Act (ESA) no longer apply. One primary goal of PDM is to monitor the species to ensure the status does not deteriorate, and if a substantial decline in the species (numbers of individuals or populations) or an increase in threats is detected, to take measures to halt the decline so that re-proposing it as a threatened or endangered species is not needed.

Section 4(g) of the ESA requires the U.S. Fish and Wildlife Service (Service) to implement a system in cooperation with the States to monitor for not less than five years the status of all species that have recovered and been removed from the list of threatened and endangered plants and animals (list). Section 4(g)(2) of the ESA directs the Service to make prompt use of its emergency listing authorities under section 4(b)(7) of the ESA to prevent a significant risk to the well-being of any recovered species. While not specifically mentioned in section 4(g) of the ESA, authorities to list species in accordance with the process prescribed in sections 4(b)(5) and 4(b)(6) may also be used to reinstate species on the list, if warranted.

The Service and States have latitude to determine the extent and intensity of PDM that is needed and appropriate. The ESA does not require the development of a formal PDM "plan." However, the Service generally desires to follow a written planning document to provide for the effective implementation of section 4(g) by guiding collection and evaluation of pertinent information over the monitoring period and articulating the associated funding needs. Thus this document was prepared to describe the PDM plan for the Concho water snake (*Nerodia paucimaculata*[1]). This PDM plan follows the Service's August 2008, *Post-Delisting Monitoring Plan Guidance Under the Endangered Species Act* (available on-line at http://endangered.fws.gov).

[1] Concho water snake nomenclature is based on Densmore et al. (1992). Some authors continue to refer to the snake as a subspecies, *Nerodia harteri paucimaculata* (Forstner et al. 2006, p. 1). Emerging data support genetic distinction from the Brazos water snake, *Nerodia harteri* and full species nomenclature for Concho water snake (Forstner 2008, p. 13).

The Concho water snake is a reptile endemic to central Texas. It was listed as threatened under the ESA on September 3, 1986, primarily due to threats of habitat modification and destruction (51 FR 31412). On July 8, 2008, the Service published a proposed rule to remove the Concho water snake from the list of threatened species (73 FR 38956). The proposal was based on a finding that the best available scientific and commercial data, including new information, indicate that the Concho water snake has recovered because threats have been eliminated or reduced to the point that it no longer meets the definition of threatened or endangered under the ESA. For example, Concho water snakes can survive lower flows than previously thought necessary. Natural inflows and downstream senior water rights, in concert with assurances from the 2008 Memorandum of Understanding (2008 MOU, see *Appendix A*), will maintain instream flows and reduce the impacts of uncontrollable extreme drought periods. Viable populations of Concho water snakes continue to exist in all three reaches of the species' range. Studies have confirmed that the snake is capable of using and reproducing in reservoirs and persisting during droughts and in apparently degraded habitats. The Service is in the process of making a final determination on whether or not to delist the Concho water snake.

For more background information on the Concho water snake refer to the final listing rule published in the *Federal Register* on September 3, 1986 (51 FR 31412), the proposed delisting rule published in the *Federal Register* on July 8, 2008 (73 FR 38956), Werler and Dixon (2000, pp. 209-216), Campbell (2003, pp. 1-4), and the 1993 Concho Water Snake Recovery Plan (Service 1993, available on-line at http://endangered.fws.gov).

II. Roles of PDM Cooperators

A. U.S. Fish and Wildlife Service

The Service has the statutory responsibility to ensure effective post-delisting monitoring of the Concho water snake is accomplished and to cooperate with the State of Texas in so doing. The Service does not have sufficient personnel resources available for conducting the necessary field work, data analysis, and reporting required for this PDM effort. The Service will work with our partners to seek funding opportunities through existing grant programs, such as, but not limited to, the Section 6 Endangered Species Cooperative Grant Program and the State Wildlife Grant Program. Both of these programs are administered by the TPWD and require competitive selection[2]. The PDM work will probably best be accomplished through one or more grant agreements with a third party—most likely a university research program (Freese and Nichols 2006, p. 8.12). Alternately, one or more contracts could be awarded to a private consulting agency with the appropriate biological expertise.

Ultimately, the Service has the lead responsibility for this monitoring effort. Service staff will therefore participate in and maintain oversight of all activities undertaken as part of PDM. This will include developing and managing one or more grants or contracts, interpreting the intent of the PDM plan, reviewing and commenting on draft reports, distributing final reports and other information to interested parties, approving and documenting any changes to the PDM plan, conducting any necessary future status reviews of the snake, and determining when PDM is complete.

B. Texas Parks and Wildlife Department

The ESA specifically requires the Service to cooperate with TPWD in carrying out PDM. In September 2008, the Service contacted TPWD seeking assistance in developing and implementing a PDM plan for the Concho water snake. The Service will request TPWD's review and comment on this draft PDM plan and will work with

[2] More information on these TPWD grant programs is available on-line at www.tpwd.state.tx.us/business/grants. Also, see the later discussion under, "Potential funding sources."

TPWD to use our cooperative grant programs to provide adequate funding to support PDM activities.

C. Colorado River Municipal Water District[3]

The recovery of the Concho water snake and its potential removal from the list of threatened species is largely due to the efforts of the Colorado River Municipal Water District (District). The District maintains and manages water supplies in the upper Colorado River throughout much of the range of the Concho water snake (District 2005, pp. 1-5). The District conducted extensive monitoring of the snake and its habitats following the initial listing in 1986 and continuing through 1997 (Service 1986, pp. 12-14; District 1998, p. 29). In 2008, the District committed to minimum reservoir releases in perpetuity on the Colorado River (*Appendix A*), consistent with the reservoir releases described in the 2004 Biological Opinion (Service 2004, pp. 11-12). The District has agreed to maintain these flows, to the extent there is inflow to the reservoirs, even if the Concho water snake is removed from the Federal list of threatened species. The 2008 MOU acknowledges the requirement for PDM and the Service's ability to add the Concho water snake back to the list of protected wildlife, even under emergency listing provisions, if future conditions warrant.

In September 2008, the Service requested the District's help to develop and implement a PDM plan. The District has indicated they will provide technical assistance to review and comment on this draft PDM plan and can serve as a liaison between the private landowners and the investigators conducting PDM field work to identify and reestablish monitoring sites. This assistance is vitally important because most of the river reaches where monitoring sites are needed occur on private land and we will need voluntary cooperation of landowners to allow access to field personnel carrying out monitoring activities.

[3] More information on the Colorado River Municipal Water District is available on-line at http://www.crmwd.org.

III. Concho Water Snake Status at Time of Delisting

A. Biological parameters

Figure 1. Adult Concho water snake (photo by M. Whiting).

Life History—The Concho water snake spends its entire life cycle in or very near the water (Werler and Dixon 2000, p. 211) and feeds almost exclusively on fish (Greene et al. 1994, p. 167). The snake hibernates in burrows or brush piles over winter and emerges in the spring (Werler and Dixon 2000, pp. 212-214). Adults mate in the spring and give birth to live young (clutch sizes average 11) in late summer (Greene et al. 1999, p. 703). Male Concho water snakes can become reproductively mature at one year old, while females may take two or three years to mature; and snakes rarely live beyond five years (Greene et al. 1999, p. 707).

Range—The current known range of the Concho water snake (Service 2004, p. 32) includes 11 counties in Texas (Figure 2). It includes the Colorado River from the confluence of Beals Creek (upstream of E.V. Spence Reservoir) downstream to Colorado Bend State Park (downstream of O.H. Ivie Reservoir), and the Concho River downstream of the City of San Angelo to the confluence with the Colorado River (Figure 2). This includes about 450 km (280 mi) of river and about 64 km (40 mi) of reservoir shoreline. While the Concho water snake has been extirpated from some reaches of its historical distribution, mainly upstream of San Angelo (Flury and Maxwell 1981, p. 31), since the time of listing it has been confirmed farther downstream from Ivie Reservoir and farther upstream from E.V. Spence Reservoir (Dixon et al. 1988, p. 12; 1990, pp. 50, 62-65; 1991, pp. 60-67; 1992, pp. 84, 87, 96-97; Scott et al. 1989, p. 384).

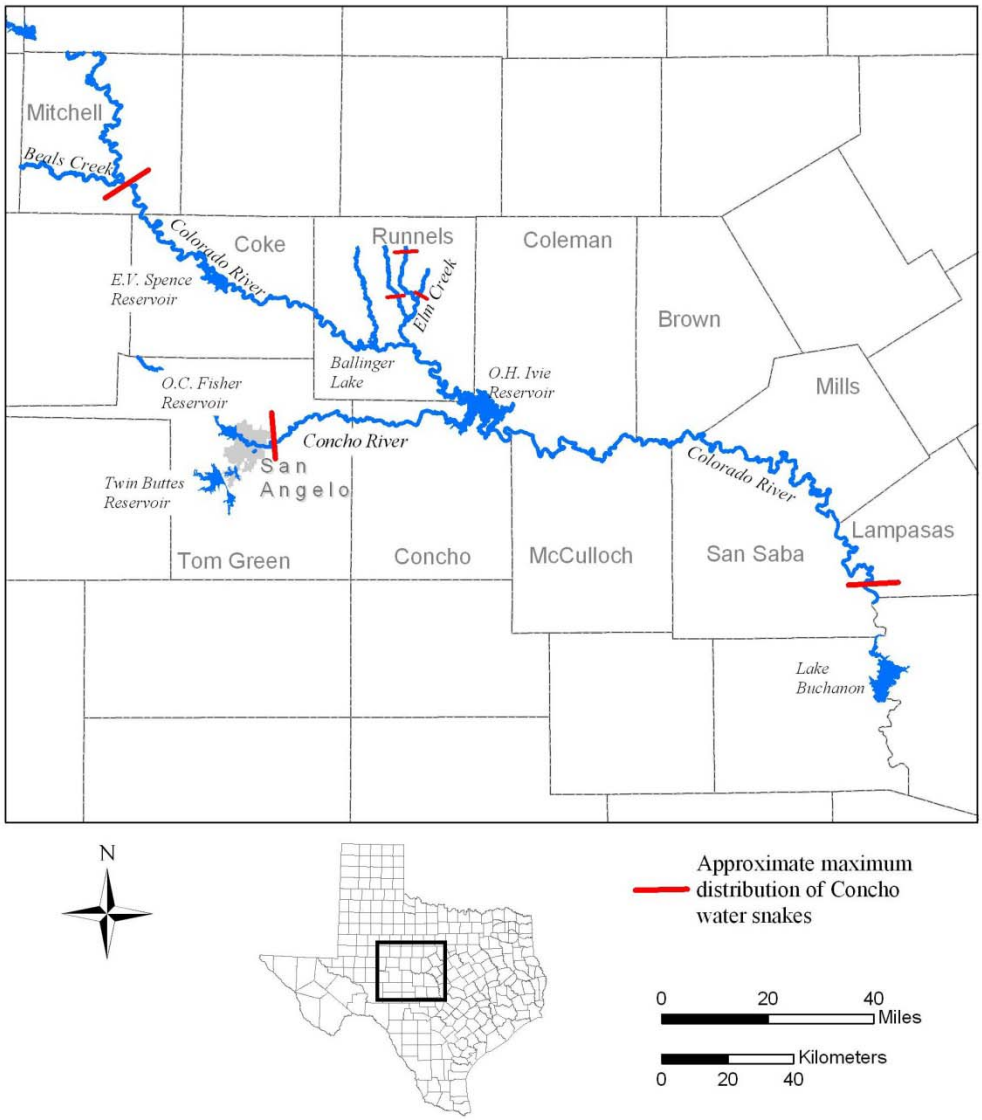

Figure 2. Range of the Concho water snake.

Abundance—Analysis of the earlier 10 years of snake monitoring did not include trend analysis of relative abundance due to variations in study efforts and methods and in environmental conditions (District 1998, p. 18; Service 2004, p. 23; Forstner et al. 2006, p. 12-13; Whiting et al. 2008, p. 343). The proposed delisting of the Concho water snake was based on the confirmed persistence of the species and evidence of reproduction over time throughout its range.

Habitat—Stream and river habitats used by the Concho water snake are primarily associated with riffles (Greene 1993, p. 96; Werler and Dixon 2000, p. 210; Forstner et al. 2006, p. 13) where the water is usually shallow and the current is of greater velocity than in the connecting pools. Riffles begin when an upper pool overflows at a change in gradient and forms rapids. The stream flows over rock rubble or solid to terraced bedrock substrate through a chute channel that is usually narrower than the streambed. The riffle ends when the rapids enter the next downstream pool. Riffles are believed to be the favored habitat for foraging, with young snakes using shallow parts of riffles and adult snakes using deeper parts of riffles (Williams 1969, p. 8; Scott et al. 1989, pp. 380-381; Greene 1993, pp. 13, 96; Werler and Dixon 2000, p. 215; Forstner et al. 2006, p. 13). Juvenile snakes are closely associated with gravel shallows or riffles (Scott and Fitzgerald 1985, p. 35; Rose 1989, pp. 121-122; Scott et al. 1989, p. 379). This habitat is likely the best for juvenile snakes to successfully prey on small fish because the rocky shallows concentrate prey and are inaccessible to large predatory fish. The exposed rocky shoals act as thermal sinks, which may help keep the juvenile snakes warm and maintain a high growth rate (Scott et al. 1989, pp. 380-381). Observations on the Concho and Colorado rivers also found Concho water snakes in the shallow pools between riffles (Williams 1969, p. 8; Dixon 2004, p. 16). Dixon et al. (1989, p. 16) stated that adult snakes used a variety of cover sites for resting, including exposed bedrock, thick herbaceous vegetation, debris piles, and crayfish burrows. Adult and maturing Concho water snakes use a wider range of habitats than do juveniles including pools with deeper, slower water (Williams 1969, p. 8; Scott et al. 1989, pp. 379-381; Werler and Dixon 2000, p. 211).

In the reservoirs, Concho water snake habitat is found in shallow water with minimal wave action and rocks along the shoreline (Scott et al. 1989, pp. 379-380; Whiting 1993, p. 112). Juvenile Concho water snakes are generally found in low-gradient, loose-rock shoals adjacent to silt-free cobble. However, Concho water snakes have also been observed on steep shorelines (Whiting 1993, p. 112) and around the foundations of boat houses (Scott et al. 1989, p. 379).

Productivity and Survival—Whiting et al. (2008, pp. 443) characterized Concho water snakes as fast-growing, early-maturing, and relatively short-lived. Under natural conditions in rivers, they can occur at high densities. The estimated annual survival of adult Concho water snakes ranged from 0.23 to 0.34 and annual juvenile survival ranged from 0.14 to 0.16 (Whiting et al. 2008, pp. 441-442).

B. Residual threats

The most significant residual threat to the Concho water snake is the potential habitat degradation associated with reduction of instream flows in the Colorado and Concho rivers where the snake occurs. Flow reductions (both extended periods of low discharge or no flows and the reduction in frequency of high discharge flood events) may result from a combination of construction and operation of upstream reservoirs, withdrawal of water for human use, and reduced precipitation during droughts. The PDM plan addresses the concern of this residual threat in two ways. The first is to extend the biological monitoring period to span 15 years following removal of the species from the list of threatened species occurs. We expect this to be a reasonable time frame to assess the status of the snake following delisting. This duration should capture much of the natural variation inherent in biological population dynamics and the hydrological system. If this PDM plan is implemented in the coming years, the combined efforts of monitoring through this plan and by the District, which began in 1986, will result in a total monitoring duration of nearly 40 years. Secondly, the PDM plan includes specific reporting requirements regarding monitoring of instream flows throughout the snake's range. Concurrent reporting of biological monitoring of the snake along with instream flow rates will allow this residual threat to be integrated (correlating hydrological conditions with changes in distribution and abundance) in future evaluations of the snake's status.

C. Legal and management commitments

The 2008 MOU between the Service and the District (*Appendix A*) documents several management commitments for conservation of the Concho water snake if it is removed from the list as a threatened species. The District committed to maintaining

specific minimum reservoir release rates from E.V. Spence and O.H. Ivie reservoirs. These releases may be suspended to provide water for human health and safety under specific conditions that constitute an extended hydrologic drought. The District also agreed to unspecified high discharge releases from both reservoirs for maintenance of stream channels. In addition, the District will, in cooperation with the Service and depending on the availability of funds, move five male Concho water snakes from below Spence and Freese dams to locations above these dams once every 3 years.

IV. Monitoring Methods

PDM for Concho water snakes will consist of two monitoring components: biological (to monitor the status of the snake) and hydrological (to monitor instream flow conditions). First, biological sampling will measure the presence, abundance, reproduction, and range of the Concho water snake by repeated sampling of snakes at specific sites throughout its range over time. This monitoring will require specific and labor-intensive data collection by biologists in the field. To the extent possible, site selection and collection methods will follow those used in previous studies and will allow for analysis of trends in presence and distribution over time. The second component of PDM is hydrological monitoring of stream flows within the river reaches where aquatic habitat for the Concho water snake occurs. Hydrological sampling will not require any new data collection but will use data already being collected by the U.S. Geological Survey (USGS) from existing stream gages.

A. Locations of biological sampling

The 18 sites listed in Table 1 and mapped in Figure 3 are proposed for biological sampling based on the following criteria. Sites used in the biological monitoring should:

1) Coincide as much as possible with monitoring sites used during prior monitoring studies.
2) Extend throughout the majority of the snake's range and include all reaches where the snake is currently known to occur.
3) Include both reservoir and river habitats.
4) Have a high likelihood of capturing Concho water snakes.
5) Be limited to the number of sites that can be reasonably sampled within time and cost constraints, but include a sufficient number of sites to assess the status of the snake.
6) Have voluntary access provided by cooperative landowners to allow personnel access to the sample site.

Table 1. Proposed sample site locations for biological sampling for post-delisting monitoring of Concho water snake.

PDM Site#	Site Name	County	Water Body	Reach	Lat	Long	Location Description	Notes
1	Spence Reservoir	Coke	Reservoir	Spence	31.91666667	-100.57555556	E.V. Spence Reservoir Shoreline	Multiple locations along reservoir shoreline
2	Rusk	Coke	Colorado River	Upper Colorado River	31.88302500	-100.47130900	Colorado River, Rusk Site, 1.1 miles SE of Robert Lee	CRMWD#17; Thornton 1996, p. 15; Artificial Riffle Site #2
3	Smith_AR	Coke			31.84910500	-100.38887900	Colorado River, Smith Site, 6.5 miles ESE of Robert Lee	CRMWD#20; Thornton 1996, p. 17; Artificial Riffle Site #5
4	Cervenka Dam	Coke			31.82966667	-100.24272222	Colorado River, upstream of Coke/Runnels county line	Dixon 2004, pp. 5-6
5	HWY 83	Runnels			31.72427778	-99.94008333	Colorado River, 0.5 miles SSE of Ballinger, 0.2 miles E of Highway 83 bridge crossing, near USGS Gage 08126380 CoRi near Balinger	CRMWD #1; Thornton 1996, p. 3
6	Blair	Runnels			31.67888889	-99.84150000	Colorado River, Blair's, 6.0 miles SE of Ballinger, consists of two sites, 1.3 km apart, upstream and downstream of Mustang Creek confluence	CRMWD#4; Thornton 1996, p. 5;
7	Lake Ballinger	Runnels	Reservoir		31.73227778	-100.04755556	Ballinger Municipal Lake (formerly Lake Moonen), 6.0 miles WSW of Ballinger, shoreline northwest of dam	CRMWD#5; Thornton 1996, p. 6; Lake is on Valley Creek tributary about 4 km by air north of Colorado River
8	Elm Creek	Runnels	Tributary		31.78530556	-99.94608333	Elm Creek, 3.2 miles N of Ballinger, Low water crossing on County Road #261	CRMWD#2; Thornton 1996, p. 4

Table 1. ***Continued.***

PDM Site#	Site Name	County	Water Body	Reach	Lat	Long	Location Description	Notes
9	FM_380	Tom Green	Concho River	Concho River	31.47116800	-100.34002300	Concho River at FM 380 bridge crossing	
10	Vinson Dam	Concho			31.51691667	-99.96711111	Concho River, Vinson Dam, 3.6 miles W of Paint Rock, downstream of Little Concho Creek confluence	CRMWD#12; Thornton 1996, p. 11; on Concho Creek Ranch
11	Paint Rock	Concho			31.51135700	-99.90365900	Concho R., Paint Rock Park, 0.4 mi NE of Paint Rock, 500 m downstream of Hwy 83	CRMWD#11; Thornton 1996, p. 10; near USGS gage 08136500 at Paint Rock
12	Glasscock	Concho			31.54669444	-99.88311111	Concho River, Glasscock's, 3.2 miles NE of Paint Rock	CRMWD#15; Thornton 1996, p. 13
13	Ivie Reservoir	Coleman	Reservoir	Ivie Reservoir	31.59166667	-99.71916667	O.H. Ivie Reservoir shoreline	Thornton 1996, p. 1, 25; Multiple locations along reservoir shoreline
14	Freese Dam	Coleman	Colorado River	Lower Colorado River	31.49508333	-99.66175000	Colorado River below Frees Dam (Ivie Reservoir outflow), below and downstream of FM 1929 bridge crossing	CRMWD#22; Thornton 1996, p. 18; Dixon 2004, pp. 5-7, First riffle below Freese Dam
15	Smith	McCulloch			31.48111500	-99.53495200	Colorado River, Smith's, 6.0 miles SW of Gouldbusk, 2.5 miles E of FR 503, at Panther Creek confluence	CRMWD#10; Thornton 1996, p. 10
16	Cooper	Coleman			31.45499100	-99.39975100	Colorado River, Cooper's site, 3.5 miles SW of Rockwood, about 1.5 miles upstream of Hwy 283 bridge	CRMWD#6; Thornton 1996, p. 7; consists of 2 riffles separated by 200-300 m of pool
17	Theriot	Coleman			31.41786111	-99.33850000	Colorado River, Theriot's, 5.0 miles SSE of Rockwood, upstream of Deer Hollow confluence	CRMWD#7; Thornton 1996, p. 7; The Riverbend Ranch,
18	HWY 377	Brown			31.45460400	-99.18224100	Colorado River about 2 miles upstream (west) of U.S. Highway 377	

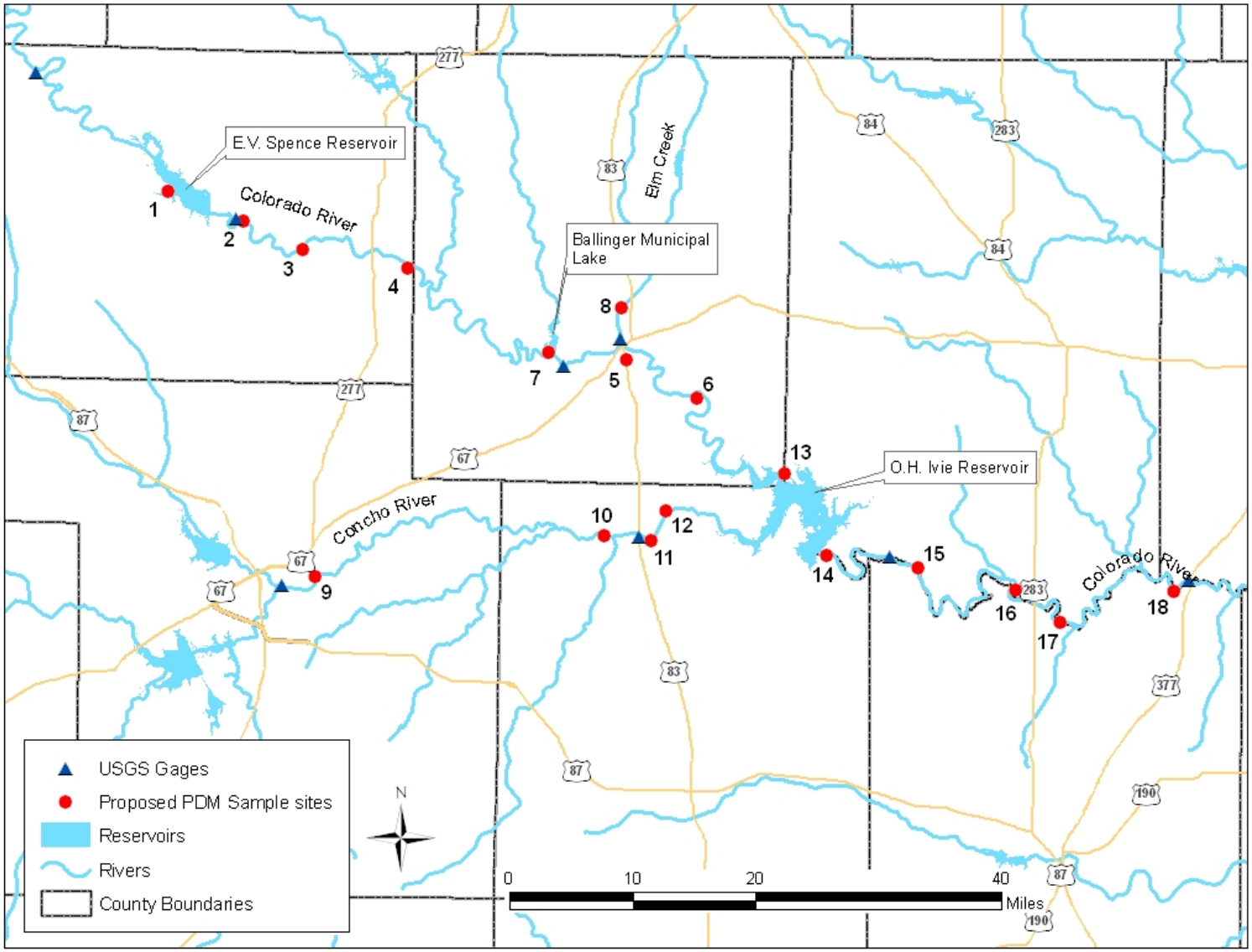

Figure 3. Location of proposed biological sampling sites and stream gages for Concho water snake post-delisting monitoring.

1) Former sites—Using as many of the sites formerly sampled as possible will be helpful to allow PDM results to be comparable with previous monitoring data (Freese and Nichols 2006, p. 8.12). The District's 10-year monitoring included repeated snake surveys at 15 established sites, along with O.H. Ivie Reservoir and six sites where artificial riffles were constructed (Thornton 1996, pp. 3-14). Forstner et al. (2006, p. 6) returned to several of these sites during their studies in 2004 and 2005. Fourteen of the eighteen proposed PDM sites (Table 1) were part of the District's ten-year routine monitoring sites (Thornton 1996, pp. 1-18) and two sites (PDM Site #'s 1 and 4; E.V. Spence Reservoir and Cervenka Dam) were extensively sampled as part of past biological studies (Dixon et al. 1992, p. 56-68) and were recently resurveyed (Dixon 2004, pp. 3-6; Forstner et al. 2006, p. 6).

2) Range—Monitoring sites should encompass the range of the snake to allow for monitoring of the status of the species in all three river reaches and both major reservoirs. The reach boundaries (three river reaches and two reservoirs) are consistent with the designation of five subpopulations from Whiting et al. (2008, p. 439). The sample sites do not necessarily need to extend to the extreme extent of the snake's range, but instead encompass the majority of the range and sufficiently sample each of three river reaches where the snake occurs. The three river reaches are the upper Colorado River (from E.V. Spence Reservoir downstream to O.H. Ivie Reservoir), the Concho River (from the City of San Angelo downstream to O.H. Ivie Reservoir), and the lower Colorado River reach (downstream of O.H. Ivie Reservoir). The two major reservoirs are O.H. Ivie and E.V. Spence reservoirs.

Two sites were added to the proposed sample locations to better cover the range of the snake. One site was added upstream in the Concho River (Table 1, PDM Site # 9) and one site was added downstream in the lower Colorado River reach (Table 1, PDM Site # 18). Snakes have been collected at both sites in the past (District 1998, p. 10). Overall, proposed sample sites include seven sites from the upper Colorado River reach, four sites from the Concho River reach, five sites from the lower Colorado River reach, and one site each in E.V. Spence and O.H. Ivie reservoirs (Figure 3).

Two non-typical sites that were extensively sampled in prior surveys are also proposed from the upper Colorado River reach. Ballinger Municipal Lake (Table 1, PDM Site # 7) is a smaller reservoir located a few miles from the main Colorado River, and Elm Creek (Table 1, PDM Site # 8) is one of the few tributary streams where snakes have been found (District 1998, p. 26).

3) Reservoirs—One important rationale for proposing to delist the snake was its ability to persist in reservoirs (73 FR 38960). Therefore, one or more sites along the shorelines should be monitored in both E.V. Spence and O.H. Ivie reservoirs and Ballinger Municipal Lake (Table 1, PDM Site #'s 1, 13, and 7). Because reservoir levels fluctuate significantly from year to year, selecting a defined length of shoreline to monitor repeatedly may not be possible for reservoir sites. As reservoir elevations move up or down, preferred Concho water snake habitat (i.e., rocky structure with a moderate slope and abundant minnow populations) will vary accordingly (Thornton 1991, p. 1; Whiting et al. 1997, pp. 329-331). As a result, the exact sample sites may vary depending on the elevation of the reservoirs, and multiple locations along the reservoir shorelines may need to be sampled.

4) Habitat—Sample sites should include shallow riffle habitats where Concho water snakes are likely to occur and where biological sampling can be effectively deployed. In proposing some of the same sites that were including in the District's monitoring efforts, sites with higher catch rates were favored to meet this criteria. As such, these sites are not randomly selected, and we do not assume that all sites will have the same quality of habitat or probability of capturing snakes. The resulting data, therefore, will not lend themselves to calculating overall population estimates. Instead, they will allow effective monitoring to measure basic demographic features over time and provide for trend assessments.

5) Feasibility—Presumably the larger the number of sites sampled, the more robust the results will be to monitor and assess the status of the snake. However, the field work to implement this monitoring effort requires substantial effort with many biologist-hours per site and long distances of driving between sites. Therefore, we have proposed

18 sites to effectively represent the status of the species throughout its range (Figure 3).

6) Access—Access to any monitoring locations will require voluntary cooperation of the landowner along the river at the various sites. Permission to enter private lands will be sought at the proposed sites. However, many of the landowners have not been contacted in many years. Many sites have likely changed ownership since previous monitoring efforts. Working through the District, researchers will need to contact landowners and fully explain the monitoring study and need for access. Permissions to access private land should be documented in writing. All contacts with landowners (whether favorable or not) should be documented in reports for future reference. Nothing in this PDM plan is intended to compel cooperation by any landowners or allow anyone to enter private property without specific landowner permission. Anyone granted access to private property to carry out data collection for this PDM program should treat the landowners and their property with the greatest respect and conduct themselves in a professional manner at all times. Authorization from the District will be required to access the shorelines of E.V. Spence and O.H. Ivie reservoirs (where access is best achieved by boat). The Ballinger Municipal Lake shoreline is readily accessible by vehicle with prior authorization from the City of Ballinger.

Once researchers begin field reconnaissance and contacting potential landowners, some landowners may not be comfortable granting the requested access[4]. In those cases, alternate sites within the same river reach should be sought out (using the above criteria) and permission for access requested. Any alternate sites selected (different from those proposed in this PDM plan) for any reason should be fully explained in annual reports. The above criteria should guide the selection of alternate sample sites for biological monitoring of Concho water snakes.

[4] In the past, some private landowners were unwilling to provide permission for river access due to the "endangered species scare" previously prevalent in Texas (District 1998, p. 22). We anticipate this is no longer the case with most landowners.

B. Timing of biological sampling

All surveys for Concho water snakes should be conducted during the snake's peak activity periods during the spring, between April 15 to June 15, and during the summer, August 1 to October 1 (Freese and Nichols 2006, p. 8.13). These time frames are when snakes are most active (reproducing and feeding) and when the capture probability is greatest. Biological sampling will include annual surveys for snakes during these two activity periods (spring and summer) at designated sampling locations (described above in *Locations of biological sampling* section). Weather changes will negatively affect the success rate of snake collections, particularly following weather events with rainfall or cold air temperatures (Thornton 1990, p. 2). Biological sampling should occur during warm weather days and more than 2 days following any cold weather where low temperatures dropped below about 50ºF (10ºC). Biological sampling should also only occur when river discharge is near or below average flow rates when the river is well within its banks because catch efforts significantly decline during high flows. High flows also put researchers at an increased safety risk and can drown snakes captured in minnow traps.

C. Frequency and duration of biological sampling

Concho water snakes will be monitored over a period of 15 years following the delisting determination. Biological monitoring will occur in three phases, with decreasing frequency over time (see Implementation Schedule, Table 4):

Phase I: Spring and summer biological sampling in Years 2, 3, and 4.

Phase II: Spring and summer biological sampling in Years 6 and 8.

Phase III: Spring and summer biological sampling in Years 11 and 14.

D. Snake capture methods

There are two methods that will be used to sample Concho water snakes at each sample location during each sample effort: active foot searches to collect snakes by hand

and minnow trapping. We note that capturing snakes for PDM may require a Scientific Collecting Permit from TPWD[5].

An active foot survey should include thoroughly searching all riffles and other shallow waters by turning over rocks (by hand or with a potato rake) and capturing snakes by hand. Search areas should include herbaceous vegetation, debris piles, and burrows. Searches should involve at least 2 person-hours per about 300 feet (100 m) of stream reach or lake shoreline. The snakes are primarily diurnal, so searches should be conducted during daylight hours (Freese and Nichols 2006, p. 8.13).

Minnow traps should be used in addition to active foot searches. Standard minnow traps should be deployed at a density of about 25 traps per about 300 feet (100 m) of stream reach or reservoir shoreline. Standard minnow traps, or funnel traps, should have 0.25-inch (6-mm) galvanized steel mesh, a 1-inch (2.5-cm) opening, and be 16.5 inches (42 cm) long (Figure 4). Traps should be set in shallow riffles or shallow edges of pools with funnel openings aligned along rocks or debris to facilitate snakes that are foraging for fish to be funneled into the traps. Traps should be about half submerged within the water and must not be fully submerged (Figure 5). Traps must be checked every 8 to 16 hours to reduce stress on snakes. Traps may be set overnight. Traps should be maintained at sample sites for a minimum of 24 hours and maximum of 48 hours at a given location.

Figure 4. Standard minnow trap.

Figure 5. Example of minnow trap set *(photo by N. Allan, Service).*

[5] See information on-line at http://www.tpwd.state.tx.us/business/permits/land/wildlife/.

In general, surveys for snakes should not be attempted when the river or reservoir is at a high (or increasing) stage of discharge because of safety concerns for researchers, potential for drowning snakes in traps (Freese and Nichols 2006, p. 8.13), and the difficulty of collecting snakes in high-water conditions (Thornton 1990, p. 2). If water rises are observed or expected due to rain forecasts or reservoir releases (this can be verified by the District), traps should be removed immediately. At locations with public access, minnow traps will need to be closely watched because of potential human disturbance of the traps.

There are considerable variations in the ability of researchers to locate and capture snakes. This variability should be reduced as much as possible by using trained, experienced personnel to conduct the field work. Persons participating in sampling for snakes should be experienced in collecting water snakes and identifying them to species or they should be working closely with an experienced person.

For each sampling event the following information should be recorded:

- Name and location of sample site (GPS coordinates, including coordinate system and datum used).
- Date and time of survey.
- Names of people participating in the survey.
- Name of landowner and documentation of permission for access.
- Approximate length of river or shoreline surveyed by foot searches and amount of time and number of people spent searching.
- Number of minnow traps set, approximate length of river or shoreline where traps were set, and amount of time traps were set.
- Weather (air temperature and any recent weather events, etc.).
- General aquatic habitat conditions during the survey (low, normal, or high discharge, dominate substrates, etc.) and water temperature.
- Number of Concho water snakes collected for each sampling method.

All Concho water snakes collected under this PDM plan should be scanned for containing a unique PIT[6] (Passive Integrated Transponder) tag number. All unmarked snakes should be carefully inserted with a PIT tag into the abdomen of the lower body cavity. Insertion points of the PIT tags should be treated with disinfectant and snakes should be released otherwise unharmed at their location of capture. To reduce chances of injuring snakes, the time spent handling snakes should be kept to the minimum amount of time necessary to collect the intended data. Snakes should generally be processed and released within two hours of capture and held in cloth bags to reduce stress on snakes. Any accidental mortality should be recorded and the specimens maintained in appropriate preservative and donated to a museum for permanent curation.

The following information should be recorded from captured Concho water snakes:

- Site location (identifying name or number, GPS coordinates, including coordinate system and datum used).
- Time and date of collection.
- PIT tag number, whether it is a new capture or recaptured snake.
- Snout-vent length (SVL) in millimeters.
- Weight in grams.
- Sex of snake and number of embryos (determined by palpating for gravid females).
- Collection method used.
- Specific habitat characteristics where collection occurred (air temperature, water temperature, other snake species, and cover type).

[6] PIT tags, also referred to as microchips, are a reliable and effective method to identify individual animals. The small size of PIT tags virtually eliminates negative impact on animals with little or no influence on growth-rate, behavior, health or predator susceptibility (Elbin and Burger 1994, pp. 680-681; Keck 1994, pp. 226-228). PIT tag readers identify a unique numeric code of the tag inserted in individual animals. This technology has been used in mark-recapture studies of animals for many decades, including previous studies of the Concho water snake (District 1987, p. 1; Dixon 1992, p. 54; District 1998, pp. 18-22; Whiting et al. 2008, p. 439).

- Notes on condition of the snake (e.g., injured or emaciated).
- Photos of snakes and the habitats where they are collected should be taken.

Other species of snakes that are captured (Dixon et al. 1991, p. 3) incidental to the PDM should be recorded (species, SVL, and weight) and released at the location of capture.

E. Hydrological monitoring

Monitoring instream flow rates during the PDM period will be an important indicator to measure changes in habitat quality throughout the range of the snake. The extreme of the range of flows are most vital to monitor. First, the frequency and duration of low flows or zero flows are important because these conditions may stress snake populations. Secondly, the frequency and duration of high flows are expected to provide necessary channel-shaping flood events that maintain natural habitat conditions in the stream channel by scouring fine sediments from riffle areas. Hydrological monitoring will involve analyzing stream flow conditions at eight stream flow gages that occur throughout the range of the Concho water snake (Table 2, Figure 3). Discharge data are continuously collected by the USGS at each of these stations and are available on-line.[7] Stream discharge data from these gages will be downloaded and analyzed as part of the PDM reporting.

[7] Website for USGS in Texas is http://tx.usgs.gov/.

Table 2. USGS stream gages with discharges to be analyzed as part of Concho water snake post-delisting monitoring.

Site Number	Station Name	Purpose of Monitoring
8123850	Colorado River above Silver, TX	Inflow to E.V. Spence Reservoir
8124000	Colorado River at Robert Lee, TX	Outflow of E.V. Spence Reservoir
8126380	Colorado River near Ballinger, TX	Flow in upper Colorado River reach
8127000	Elm Creek at Ballinger, TX	Flow in tributary in upper Colorado River reach
8136000	Concho River at San Angelo, TX	Flow in upstream portion of Concho River reach
8136500	Concho River at Paint Rock, TX	Flow in middle portion of Concho River reach
8136700	Colorado River near Stacy, TX	Outflow of O.H. Ivie Reservoir
8138000	Colorado River at Winchell, TX	Flow in lower Colorado River reach

V. Reporting Procedures

There will be two types of reporting procedures under this PDM plan, annual reports and phase completion reports.

A. Annual reports

Annual reports are due at the end of each calendar year when biological monitoring has been completed (Table 4). This report will describe the biological monitoring that occurred, report all activities and results carried out under the plan. The format of annual reports should include the following sections: introduction/background, methods, results, and discussion. The discussion sections should describe any deviations from the PDM plan and make any necessary recommendations for changes in future PDM data collection or analysis.

Annual reports will also include a hydrologic section to report instream flow conditions during the prior water year (October 1 to September 30). This section will include a hydrograph of daily mean discharge and the following statistics for each of the eight relevant USGS stream gages (Table 2): annual mean discharge, annual median discharge, annual peak discharge (Asquith et al. 2007a, pp. 1-5, 469-474, 491-494), annual harmonic mean[8] (Asquith and Heitmuller 2008, pp. 1-10, 810-813, 846-853), and the number of days where the mean daily discharge was zero (Asquith et al. 2007b, pp. 1-5, 469-474, 493-494).

[8] The harmonic mean streamflow is a statistic derived from daily mean flow used in evaluation of low flow conditions to explain hydrologic changes resulting from streamflow regulation, climate change, or land-use practices (Asquith and Heitmuller 2008, p. 2).

Figure 6. Neonate Concho water snakes *(photo by N. Allan, Service).*

The annual report should include, as both written appendices and electronic databases (Access or Access compatible), data tables reporting results of the biological monitoring efforts and Concho water snakes captured by age class for each site visit, including all data collected described above (see *Snake capture methods* section). Data tables should also be provided in electronic form for all snakes captured that include the date, time, site location (site name and coordinates in decimal degrees, NAD 83 datum), sex, SVL, size class[9] (adult, juvenile, or neonate, Figure 6), PIT tag number, original capture or recapture, and notes on condition. All data reporting should be of sufficient detail that future researchers could reconstruct the data collection methods and effectively repeat the efforts using the same methods and data analysis. Each annual report will comment on any concerns on the overall status of the Concho water snake relative to the need for relisting.

Annual reports for biological monitoring will be due in years 2, 3, 6, and 11 (see Implementation Schedule, Table 4). Annual reports will be submitted to the Service, TPWD, and District by December 31 of the year data are collected.

B. Phase completion reports

The second reporting procedure will be the phase completion reports. Phase reports will include the data provided in the annual report for the final year of the phase (same information described above for annual reports). Phase reports will also include a detailed statistical trend analysis of all data collected to date during the PDM, including both biological and hydrological monitoring results of previous years. The total number of snake captures and snake captures by size class will be reported by reach by year.

[9] Adult males are >380 mm SVL, adult females are >420 mm SVL; juvenile males are <380 mm SVL, juvenile females are <420 mm SVL (Greene et al. 1999, p. 702); neonates are Age 0 snakes in their first activity season during the fall, estimated at <250 mm SVL. This is based on maximum size at birth of about 200 mm SVL (Dixon et al. 1992, p. 26; Greene et al. 1999, p. 704).

Catch-per-unit-effort (CPUE) will be reported for both sample methods (foot searching and minnow trapping) for all snakes collected by reach and year. CPUE will be calculated in two separate ways. First, as the number of snakes captured per biologist-hour spent during foot searches. Secondly, the number of snakes captured per trap-hour for minnow trap sets. The CPUE results at each site may be grouped by river reach, season, year, and/or age class of snakes. Appropriate statistical analysis will be used to determine if any differences are evident among the years of biological sampling. The analysis of biological sampling will be discussed in the context of the riverine hydrologic conditions during the five years prior to the most recent biological monitoring (including years where biological samples were not made).[10] Each phase completion report will comment on any concerns on the overall status of the Concho water snake, including any changes in threats to the snake's continued existence.

Draft phase reports will be due by December 31 of the last year of data collection for that phase (years 4, 8, and 14, see Table 4). The draft phase reports will be made available to cooperators and interested parties for review and comment during January and February of the following year. The final phase reports will be due for completion on or before May 31 of years 5 (for Phase I), 9 (Phase II), and 15 (Phase III and final PDM report) (see Table 4). The Phase III Final Report will incorporate results of the entire PDM period of data collection and analysis and will also include a discussion of whether monitoring should continue for any reason.

Final annual reports and final phase reports will be made available to the public upon request and by posting on the Service's web page (http://endangered.fws.gov) and the Austin Ecological Service Field Office web page (http://www.fws.gov/southwest).

[10] Five years is suggested as a minimum time-frame for hydrological analysis because the expected life span of the snake is 5 years. Therefore, if flow conditions are affecting snake abundance, the relationship will be most pronounced over about a 5-year history of instream river flows. Longer time-frames for analysis will also be useful to track trends in stream flow conditions and potential long-term trends in snake abundance or distribution.

VI. Monitoring Thresholds

To effectively implement PDM plans for the Concho water snake, it is essential to identify the circumstances that trigger concern about the snake's status to warrant increased frequency or intensity of the monitoring. Conversely, it is also important to identify the circumstance under which there is no new concern for the snake's status and the PDM requirement has been fulfilled. The quantitative triggers and responses described below are based on the information to be collected under this PDM plan and provide a structured process for evaluating the status of the snake during PDM. However, other circumstances could arise, such as new threats or increased intensity of existing threats that would warrant additional concern and responses for ensuring the status of the snake remains healthy.

Possible responses for each trigger are described below. Generally, the alternative responses may include an extended or intensified monitoring effort, additional research (such as modeling metapopulation dynamics,[11] assessing the status of the fish prey base, evaluating the effects of predators), enhancement of riverine or shoreline habitats (possibly through increasing stream flows), or an increased effort to improve habitat connectivity by additional translocation of snakes between reaches. Other responses may be proposed in the future if warranted based the collection of new information arising from the monitoring.

It is important to note that apparent declines in distribution, abundance, reproduction, or persistence of Concho water snakes can be confounded by density-dependent population fluctuations or other environmental variables that reduce capture rates. PDM reporting should consider that low capture rates could be due to absence of snakes at monitoring sites (mortality or emigration), very low density, high juvenile mortality and low recruitment, or other factors such as individual trap-shyness, weather, habitat changes at individual sample sites, or human variation in capture efficiency.

[11] Metapopulation dynamics is intended to describe the potential interactions of populations or subpopulations of the Concho water snake.

We will also include qualitative considerations concerning changes related to snake abundance (changes in CPUE over time) and habitat conditions based on stream flow conditions. It is not possible to identify specific quantification of these two triggers at this time because of the multiple, unidentified factors that can influence the CPUE and flow rates. Also, there is limited baseline CPUE analysis[12] upon which to determine a useful level to trigger concern. However, the PDM methods should produce sufficient sample sizes with standardized data collection to evaluate general trends in snake abundance over time. Results of biological sampling in Phases II and III should allow for comparisons with results in Phase I to evaluate potential abundance trends over time.

A. Snake distribution triggers

- Concho water snakes should be captured in at least 75 percent of overall total sites surveyed during each year of biological monitoring.

If the biological sampling results in captures of Concho water snakes at less than 75 percent of the sites surveyed in a survey year (i.e., snakes are found at less than 14 out of 18 sites surveyed), then the following year's monitoring efforts should intensify. Results from the initial sampling effort will continue to be reported for comparison with previous years. Seventy-five percent is a minimum success rate to expect given the intensity of survey methods proposed and the results of past monitoring efforts. All of the sites selected for biological monitoring where the District monitored for 10 years had snakes captures during every year of monitoring (Thornton 1996, pp. 29-50). A brief survey (one visit per site) by Dixon (2004, pp. 4-5) captured snakes at 8 of 11 sites. If this trigger is reached, increased monitoring efforts should include more sites surveyed, increased survey effort (i.e., more biologist-hours spent searching or more minnow traps set) at given sites, or more sampling trips (beyond the two surveys per year) to given sites within any reach of concern. If this trigger occurs during the last year of Phase I or during Phases II or III, then biological monitoring should occur during the next year (i.e.,

[12] However, for some CPUE results see District (1988, pp. 6-35), Service (2004, pp. 24-26), and Forstner *et al*. (2006, p. 9).

the annual monitoring frequency should not be reduced as planned in the schedule in Table 4).

- Concho water snakes should be captured in at least two sites in each of the three river reaches (Concho, upper Colorado, and lower Colorado) and in each of the two large reservoirs (E.V. Spence and O.H. Ivie) during each year of biological monitoring.

If surveys in any one calendar year (consisting of two sampling efforts) result in Concho water snakes being captured at less than two sites in any one of the river reaches or reservoirs, then the following year's monitoring efforts should intensify in that reach. Results from the initial sampling effort will continue to be reported for comparison with previous years. Increased monitoring efforts could include more sites surveyed, increased survey effort (i.e., more biologist-hours spent searching or more minnow traps set) at given sites, or more sampling trips (beyond the two surveys per year) to given sites within the reach of concern. If this trigger occurs during the last year of Phase I or during Phases II or III, then biological monitoring should occur during the next year (i.e., the annual monitoring frequency should not be reduced as planned in the schedule in Table 4).

B. Snake persistence trigger

- Either of the distribution triggers (described above) occur in two consecutive years of data collection.

If either distribution trigger occurs in two consecutive years of data collection, then the long-term persistence of the snake may be of concern. If the trigger occurs, consideration for management actions, such as enhancement of riverine or shoreline habitats (possibly through increasing stream flows) or an increased effort to improve habitat connectivity by additional translocation of snakes between reaches, will be taken in addition to increasing monitoring efforts.

C. Snake reproduction trigger

- Evidence of annual successful reproduction should be found in each of the three river reaches and both reservoirs during each year of biological monitoring.

Evidence of successful annual reproduction is best documented by the presence of neonates in the late summer, early fall samples. Neonates are best captured by foot searches under rocks in shallow water or along flat stream banks or shorelines within a few feet of the water's edge. At a minimum, neonates should be documented in each river reach and reservoir each year. If biological sampling cannot confirm that successful annual reproduction has occurred during each year of biological monitoring, then the following year's monitoring efforts should intensify and concentrate on documenting successful reproduction in all reaches and reservoirs. Increased monitoring efforts should include more sites surveyed, increased survey effort (i.e., more biologist-hours spent searching or more minnow traps set at sites of concern) at given sites, or more sampling trips (beyond the two surveys per year) to given sites within any reach of concern. Results from the initial sampling effort will continue to be reported for comparison with previous years. In addition, future monitoring should more closely evaluate the number or embryos per female (Greene et al. 1999, p. 701) to consider whether reproduction decline is a result of reduced fecundity in female snakes or reduced survival of new-born snakes.

D. Snake abundance evaluation

Analysis of past data collections on snake abundance has not been sufficient to quantify a trigger for snake abundance levels. Sufficient baseline CPUE results do not exist as a basis upon which to determine useful criteria for identifying a level of abundance that might be of concern. However, the reporting of CPUE results during PDM should produce sufficient sample sizes with standardized data collection to evaluate general trends in snake abundance over time. Results of biological sampling in terms of CPUE during Phases II and III will allow for comparisons with results of CPUE during Phase I to evaluate possible trends in abundance over time during PDM. Trend analysis should be conducted using accepted statistical methods. If these analyses show declining

trends in abundance, the Service will consider possible causes and determine an appropriate course of action. Possible responses could include increased monitoring efforts, review of monitoring methods, or initiating a status review of the snake.

E. Instream flow evaluation

Evaluation of the hydrological conditions in the rivers and reservoirs where the snake occurs is an important context within which to evaluate the status of the Concho water snake. If any of the above triggers are met, a more detailed analysis of the flow conditions over the preceding five years should be conducted to assess if there is any correlation between instream flow conditions and the status of the snake. Flow rates in the Colorado River should also be analyzed to confirm that the District is operating E.V. Spence and O.H. Ivie reservoirs consistent with the 2008 MOU (see *Appendix A*).

F. Relisting considerations

If any of the above triggers are met and indicate substantial concerns regarding the status of the snake, or other significant concerns arise, the Service will initiate a status review of the Concho water snake under section 4 of the ESA to evaluate the potential causes, including assessing habitat quality and quantity trends, prey base changes, weather conditions including potential climate change, and any other possible limiting factors. The Service will work with our cooperators to consider necessary remedial actions or more intensive monitoring or research needs.

During any stage of the PDM period the Service will initiate procedures to re-list the Concho water snake if data from this monitoring effort or from some other reliable source indicates that the species or its habitat is experiencing a significant decline and that a proposal to relist the species as threatened or endangered is warranted. Any relisting action taken by the Service under section 4(a)(1) of the ESA will be based on the best available information related to the five listing factors and will require public notice and comment. If the best available information indicates an emergency posing a significant risk to the well being of the species, then the Service will use ESA section 4(b)(7) authority (emergency listing) to prevent any significant risk to the well being of

the Concho water snake. While it is not possible to predict all conditions that could result in initiating emergency relisting, we can provide examples of outcomes that would cause us to seriously re-evaluate the status of the species, such as, but not limited to: repeated lack of detection of Concho water snakes in any of the reaches within its current range; lack of determination of reproductive success (based on the absence of neonate snakes) in more than one reach within its range; a substantial decline in abundance of snakes throughout its range; or substantial reductions in instream flows beyond the range of average historic flow conditions.

VII. Funding

A. Estimated funding requirements

Table 3 itemizes the estimated cost of $250,000 for completing Phase I of PDM for the Concho water snake. Assuming similar costs for Phases II and III (but with only 2 years of biological monitoring for each phase), we estimate that each of these phases would cost an additional $175,000. Therefore, the total cost estimate for the proposed 15-year PDM for the Concho water snake is approximately $600,000. These estimates are not adjusted for inflation and assume that the monitoring schedule is consistent with the methodology and schedule contained in this PDM plan. The actual costs of completing the PDM could be more or less than this estimate. Additional costs not included in these estimates are those of staff time that would accrue by personnel of the Service, TPWD, CRMWD, and other potential partners in coordinating PDM activities and reviewing draft reports. These costs will likely be born as in-kind services provided by the cooperating agencies.

B. Potential funding sources

Funding of PDM presents a challenge for all partners following removal of ESA protections. While the ESA authorizes expenditure of both recovery funds and section 6 grants to the States to plan and implement PDM, to date Congress has not allocated any funds expressly for this purpose. Funding of PDM activities, therefore, will require trade-offs with other competing endangered species' conservation needs. Working closely with TPWD, we anticipate using grant programs to fund at least Phase I of the PDM for Concho water snake. Opportunities exist to compete for Traditional Section 6 Grant funds or State Wildlife Grant funds to implement the Texas Wildlife Action Plan. The Service, the District, and TPWD will continue to work together to secure funding to implement this PDM plan.

C. Anti-Deficiency Act disclaimer

Post-delisting monitoring is a cooperative effort among the Service, State, other Federal agencies, and nongovernmental partners. Funding of PDM presents a challenge

for all partners committed to ensuring the continued viability of the Concho water snake following removal of ESA protections. To the extent feasible, the Service intends to provide funding for post-delisting monitoring efforts through the annual appropriations process. Nonetheless, nothing in this PDM plan should be construed as a commitment or requirement that any Federal agency, including the Service, obligate or pay funds in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation.

Table 3. Cost estimate for completing Phase I of post-delisting monitoring for the Concho water snake. Estimates are in 2009 dollars and do not adjust for inflation. Year 1 is the first calendar year following the removal of the snake from the Federal threatened list.

Phase I: Years 1--5		**Years 1-2**		**Year 3**		**Year 4**		**Year 5**		**5-year Costs**
		Unit	Cost	Unit	Cost	Unit	Cost	Unit	Cost	
Personnel*	**Rate**	**hours**		**hours**		**hours**		**hours**		
PI, Planning/Field/Reporting, $50/hr	$50	400	$20,000	280	$14,000	280	$14,000	120	$6,000	$54,000
Bio Tech, Planning/Field, $15/hr	$15	1520	$22,800	1440	$21,600	1440	$21,600	0	$0	$66,000
Fringe Benefits, +15% personnel costs	15%		$6,420		$5,340		$5,340		$900	$18,000
Travel		**days**		**days**		**days**				
Lodging, meals, per diem $109/day	$109	160	$17,440	160	$17,440	160	$17,440			$52,320
		miles		**miles**		**miles**				
Mileage, $0.55/mile	$0.55	2500	$1,375	2500	$1,375	2500	$1,375			$4,125
Equipment										
Minnow traps, potato rakes, etc.			$2,000		$1,000		$1,000			$4,000
PIT tag readers	$1,000	2	$2,000	0	$0	0	$0			$2,000
Computer, Information Technology			$2,500		$1,000		$1,000			$4,500
Supplies		**tags**		**tags**		**tags**				
PIT tags	$5	1000	$5,000	500	$2,500	500	$2,500			$10,000
Other			$1,000		$500		$500			$2,000
Subtotal of Direct Costs			$80,535		$64,755		$64,755		$6,900	$216,945
Indirect Charges, +15% of Direct Costs	15%		$12,080		$9,713		$9,713		$1,035	$32,542
Total Cost Estimate		**Yrs 1-2:**	**$92,615**	**Yr 3:**	**$74,468**	**Yr 4:**	**$74,468**	**Yr 5:**	**$7,935**	**$249,487**

* Notes to Personnel costs: "PI" = Principal Investigator; "Bio Tech" = Biological Technician and/or Graduate Students. For PI for first 2 years costs, hours estimated: pre-field trip planning, 120 hours; field work, 40 hours per trip for 2 field trips; planning second trip, 80 hours; post-field work reporting, 80 hours. For Bio Tech for first 2 years costs, hours estimated: pre-field work planning, 160 hours; field work 600 hours per trip (3 people working 20 days at 10 hours per day) for 2 field trips; planning second trip, 80 hours; post-field work reporting, 80 hours.

VIII. PDM Implementation Schedule

Table 4. General schedule for post-delisting monitoring of the Concho water snake. If the snake were delisted in 2009, then "Year 1" would be Calendar Year 2010, etc. The schedule is subject to change if monitoring results in a need for more or less intensive sampling as described in annual and phase completion reports and documented by the Fish and Wildlife Service.

YEAR:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PHASE I															
Contracting / Reconnaissance	X														
Spring Biological Sampling		X	X	X											
Summer Biological Sampling		X	X	X											
Annual Reporting		X	X												
Phase I Completion Report					**X**										
PHASE II															
Phase II Study Plan					X										
Spring Biological Sampling						X		X							
Summer Biological Sampling						X		X							
Annual Reporting						X									
Phase II Completion Report									**X**						
PHASE III															
Phase III Study Plan										X					
Spring Biological Sampling											X			X	
Summer Biological Sampling											X			X	
Annual Reporting											X				
Phase III Final Report															**X**

IX. Conclusion of PDM

At the end of the planned PDM period the Service will conduct a final review following submission of the Phase III final report due for completion in Year 15. Any relisting decision by the Service will require evaluating the status of the Concho water snake relative to the ESA's five listing factors (section 4(a)(l)). The Service intends to work with all of our partners toward maintaining continued recovery of the Concho water snake so as not to require relisting the species. The following four conclusions are possible at the end of PDM for the Concho water snake:

1. *PDM indicates that the species remains secure without ESA protections.* PDM will be concluded at the completion of Phase III of the PDM plan and no further monitoring will be required. Additional monitoring may continue at the discretion of the Service and its partners which is dependent upon available funding and resources.

2. *PDM indicates that the species may be less secure than anticipated at the time of delisting, but information does not indicate that the species meets the definition of threatened or endangered.* The duration of the PDM period may be extended and additional monitoring may be planned and carried out. A new monitoring plan should build upon the information gained from this PDM effort and describe future monitoring activities.

3. *PDM yields substantial information indicating a decline in the species' status since delisting, such that listing the species as threatened or endangered may be warranted*. In addition to further monitoring activities discussed above, the Service should initiate a formal status review under section 4 of the ESA to assess changes in threats to the species, its abundance, productivity, survival, and distribution. The purpose of the review is to determine whether a proposal for relisting the snake as a protected species under section 4 of the ESA is warranted.

4. *PDM documents a decline in the species' probability of persistence, such that the species once again meets the definition of a threatened or endangered species under*

the ESA. If PDM reveals that the Concho water snake is again threatened (i.e., likely to become endangered in the foreseeable future throughout all or a significant portion of its range) or endangered, then the snake should be promptly proposed for relisting under the ESA in accordance with procedures in section 4(b)(5). Likewise, if the best available information indicates an emergency that poses a significant risk to the well-being of the snake, then the Service should exercise its emergency listing authority under section 4(b)(7).

X. Review and Adaptation of PDM Plan

This draft PDM plan for the Concho water snake will be made available for review and comment by the public through a **Federal Register** notice. In addition, the Service will seek peer review of this draft PDM plan in accordance with the 1994 peer review policy (59 FR 34270). The Service will solicit independent expert opinions from knowledgeable individuals with scientific expertise that includes ecology of water snakes and conservation biology principles. All comments received from the public or peer reviewers will be considered and incorporated as appropriate into a final PDM plan.

Once finalized and approved by the Service's Southwest Regional Director, this PDM plan may be updated as needed to account for and respond to new information discovered as part of the ongoing data collection and analysis. If substantial changes are made to the PDM plans or if significant deviations to described PDM procedures set forth in this document occur, this PDM plan will be revised by the Service to document the changes and/or deviations. Recognizing the need for future changes to the PDM plans will provide the necessary flexibility to ensure effective PDM for the Concho water snake. The final PDM plan for the Concho water snake and any future revisions to the PDM plan for the Concho water snake will be made available on the Service's web page (http://endangered.fws.gov) and the Austin Ecological Service Field Office web page (http://www.fws.gov/southwest).

XI. Other Research Considerations

There is a wealth of additional information that could be collected as part of the monitoring for the Concho water snake. However, the planned PDM efforts are limited to the minimum amount of information needed to accomplish the purpose of ensuring that the snake does not warrant protections under the ESA.

Examples of past monitoring efforts by the District include the collection of extensive information on the riverine fish community that serves as the prey base for the snake. This work documented that Concho water snakes are not species-specific predators and will prey on small-bodied fish generally in proportion to their availability in shallow waters (Greene et al. 1994, pp. 167-171; Thornton 1996, p. 19). The District also expended considerable resources in monitoring the stream channel geomorphology of the Colorado River over an 8-year period. Since the snakes have since been found to be less specific in their use of habitat (in other words using pools and reservoir shorelines) this research is not considered as vital as once believed (District 1997, p. 11). However, it provides an excellent baseline for future research of changes in stream channel morphology and could be useful for further studies.

Although beyond the scope of PDM, two additional areas of research that could assist in further understanding of Concho water snake biology include genetic variation among subpopulations and population viability analysis. A comprehensive analysis of genetic variation across the range of the snake would be valuable in directing the future need for translocations of snakes among subpopulations and other possible management considerations. These movements were recommended in earlier genetic studies (Sites and Densmore 1991, pp. 10-11). Forstner (2008, pp. 14-15) is working to define genetic variation of Concho water snakes compared to related taxa using nuclear microsattelites. However, genetic studies using modern techniques to evaluate intra-specific variation has not been completed and would be useful for informing future management decisions regarding Concho water snake subpopulations. Collection of tissues samples (usually blood) could be added to the PDM monitoring techniques with minimal additional effort

or cost. However, additional funding would be necessary to complete analysis and reporting of genetic information and is beyond the scope of the PDM requirements.

Another area of interest is modeling Concho water snake population dynamics using capture-recapture data to estimate survival rates and construct a population viability analysis. Efforts to complete such analysis in the past were hampered by the inability to estimate the effect of dispersal of adult snakes out of the study areas (Whiting et al. 2008, pp. 442-443). This resulted in biased estimates of survival rates lower than otherwise expected. In order to improve these estimates, additional sample sites would need to be surveyed. Five to ten sites would need to be evenly spaced along a shorter section of river, taking into consideration needed riffles at sample locations. Capture-recapture data would need to be collected consistently for 3 consecutive years to estimate dispersal. These data, if collected in combination with the information already being collected as part of PDM, would allow a more robust estimate of survival and provide the basis for additional population viability modeling. Much of the information needed for population demographic analysis will already be collected as part of the PDM, but more intensive sampling and additional statistical analysis beyond the scope of the PDM, would be necessary to complete this research.

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Appendix A

2008 Memorandum of Understanding

Between the

Colorado River Municipal Water District

And the

U.S. Fish and Wildlife Service

Memorandum of Understanding

between the

Colorado River Municipal Water District

and the

United States Fish and Wildlife Service

Article 1. Background

Section 1.1. The Colorado River Municipal Water District (District) was authorized in 1949 by an Act of the 51st Legislature of the State of Texas for the purpose of providing water to the District's member cities, which include Odessa, Big Spring, and Snyder, Texas. The District also provides water to the cities of Midland, San Angelo, Stanton, Robert Lee, Grandfalls, Pyote, and Abilene, Texas. The mission of the Colorado River Municipal Water District is to maintain an adequate supply of the best quality water possible, at a reasonable cost, for its service area in West Texas. The District owns and operates three major surface water supply reservoirs on the Colorado River, four groundwater well fields, and associated water delivery systems in west Texas.

Section 1.2. The mission of the U.S. Fish and Wildlife Service (Service) is working with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. The Service administers the Federal Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.).

Section 1.3. The Concho water snake (*Nerodia harteri paucimaculata*) was federally listed as threatened on September 3, 1986 (51 FR 31412) and critical habitat was designated on June 29, 1989 (54 FR 27377). The District has consulted with the Service (under section 7 of the Act, through the U.S. Army Corps of Engineers, Clean Water Act, section 404

permitting process) concerning construction and operation of its water storage and delivery systems beginning in 1986 and culminating in a revised biological opinion (BO) from the Service, dated December 3, 2004 (2004 BO). Additional information on the consultation history, District operations, biology of the snake, and analysis of effects of the District operations on the snake and its habitat can be found in the 2004 BO.

Article 2. Purpose

Section 2.1. The purpose of this Memorandum of Understanding (MOU) is for the District to provide assurance that minimum reservoir releases will continue in perpetuity, consistent with the 2004 BO ("Future District Operations" pages 11-12). The release rates specified in Article 3 below will be maintained following removal of the snake from the Federal list of threatened species. In addition, the MOU ensures that individual snakes will be periodically moved to maintain genetic integrity of fragmented snake populations.

Article 3. Reservoir Releases

Section 3.1. As stated in the 2004 BO, the District will maintain flows in the Colorado River downstream of the E.V. Spence Reservoir as follows:

Section 3.1.1. To provide flow to support the aquatic ecosystem of the Concho water snake and to the extent there is inflow into Spence Reservoir, the District will maintain a minimum flow in the Colorado River below the Spence dam of not less than 4.0 cubic feet per second (cfs) (0.11 cubic meters per second, cms) during the months of April through September and 1.5 cfs (0.04 cms) during the months of October through March.

Section 3.1.2. These flows will maintain riverine habitat for the Concho water snake downstream from the E.V. Spence Reservoir. In addition to maintaining the minimum flows in the Colorado River below the E.V. Spence dam, the District will periodically make additional discharges of varying flow rates from the E.V.

Spence Reservoir as a part of its reservoir management activities and to manage water quality in the reservoir. Some of these discharges may be at high rates of flow coupled with flood runoff events. High discharges will function as channel maintenance flow to maintain suitable rock substrates and abate vegetation invasion of riffle habitat.

Section 3.1.3. The District may periodically cause a total cessation of flow for necessary dam maintenance activities. Flow cessation periods will vary in length; however, they will generally be infrequent and short-termed and will typically occur during the months of November through March.

Section 3.1.4. During periods of extended hydrologic drought and to provide water for the health and human safety needs of its customers, the District will not be required to maintain flow in the Colorado River below the Spence dam when the elevation of the E.V. Spence Reservoir is below elevation 1,843.5 feet (561.9 meters) MSL (mean sea level) (12.1 percent of the reservoir capacity).

Section 3.2. As stated in the 2004 BO, the District will maintain flows in the Colorado River downstream of the O.H. Ivie Reservoir as follows:

Section 3.2.1. To provide flow to support the aquatic ecosystem of the Concho water snake and to the extent there is inflow into Ivie Reservoir, the District will maintain a minimum flow in the Colorado River below the Ivie dam of not less than 8.0 cfs during the months of April through September and 2.5 cfs during the months of October through March.

Section 3.2.2. These flows will maintain riverine habitat for the range of the Concho water snake downstream from the O.H. Ivie Reservoir. In addition to maintaining the minimum flows in the Colorado River downstream of O.H. Ivie Reservoir, the District will periodically make additional discharges of varying flow rates from the O.H. Ivie Reservoir as a part of its reservoir management activities and to manage water quality in the reservoir. Some of these discharges may be at high

rates of flow coupled with flood runoff events. High discharges will function as channel maintenance flow to maintain suitable rock substrates and abate vegetation invasion of riffle habitat.

Section 3.2.3. The District may periodically cause a total cessation of flow for necessary dam maintenance activities. Flow cessation periods will vary in length; however, they will generally be infrequent and short-termed and will typically occur during the months of November through March.

Section 3.2.4. During periods of extended hydrologic drought and to provide water for the health and human safety needs of its customers, the District will not be required to maintain flow in the Colorado River downstream of O.H. Ivie Reservoir when the elevation of the O.H. Ivie Reservoir is below elevation 1,504.5 feet (458.6 meters) MSL (11.9 percent of the reservoir capacity).

Article 4. Movement of Concho Water Snakes

Section 4.1. In the springtime, the District, in coordination with the Service, should move 5 male snakes from below Spence and Freese dams to above these dams, once every 3 years. Moving snakes will be dependent upon availability of funding for the District.

Article 5. Monitoring

Section 5.1. In accordance with Section 4(g) of the Act, the Service, in coordination with the District, will develop and implement for at least 5 years, a post-delisting monitoring plan for the Concho water snake following removal of the species from the list.

Section 5.2. If during the post delisting monitoring period, or at any time following removal of the Concho water snake from the Federal list of threatened species, the Service finds that the species is endangered or likely to become so in the foreseeable future, the Service will take action to add the species back to the list. This includes action under the emergency listing provisions of Section 4 of the Act.

Article 6. General Provisions

Section 6.1. Nothing herein shall constitute, nor be deemed to constitute, an obligation of future appropriations by the signatories to this MOU where creating such an obligation would be inconsistent with applicable federal, state, or local laws. No funding commitments are being made under this MOU. This MOU is subject to and is intended to be consistent with all applicable federal, state, and local laws.

Section 6.2. Both signatories to this MOU recognize that each have statutory responsibilities that cannot be delegated. Nothing in this MOU shall be construed to abrogate any of the statutory responsibilities of either signatory of the MOU.

Section 6.3. This MOU is effective on the date signed by both signatories.

United States Fish and Wildlife Service

By: _____ Date: February 11, 2008
Regional Director, Region 2

Colorado River Municipal Water District

By: _____ Date: February 13, 2008
General Manager

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