United States Department of the Interior

FISH AND WILDLIFE SERVICE
Austin Ecological Services Office
10711 Burnet Road, Suite 200
Austin, Texas 78758
(512)490-0057

NOV 5 1999

2-15-98-F-759

David M. Cannan, Brigadier General, USAF
Department of the Air Force
Air Education and Training Command
HQ AETC/CE
266 F Street West
Randolph AFB, TX 78150-4321

Dear Gen. Cannan:

This document transmits the U.S. Fish and Wildlife Service's (Service) biological opinion based on our review of the effects of Edwards aquifer withdrawals incidental to the combined ongoing activities and projected mission increases anticipated at four Department of Defense (DOD) military installations (Fort Sam Houston, Lackland Air Force Base (AFB), Kelly AFB, and Randolph AFB), located in San Antonio, Bexar County, Texas. Species evaluated for effects are the fountain darter (*Etheostoma fonticola*), Texas wild-rice (*Zizania texana*), San Marcos salamander (*Eurycea nana*), Texas blind salamander (*Typhlomolge rathbuni*), San Marcos gambusia (*Gambusia georgei*), Comal Springs riffle beetle (*Heterelmis comalensis*), Comal Springs dryopid beetle (*Stygoparnus comalensis*), and Peck's cave amphipod (*Stygobromus pecki*) and designated critical habitat for the fountain darter, Texas wild-rice, San Marcos salamander, and San Marcos gambusia in accordance with section 7 of the Endangered Species Act of 1973 (ESA), as amended, (16 U.S.C. 1531 et seq.).

Brooks AFB was originally being considered under this consultation. However, DOD decided to remove it from the consultation because Brooks AFB does not pump its own water, but rather, it buys it from a San Antonio water purveyor, San Antonio Water System (SAWS). Camp Stanley and Camp Bullis were also not included because they do not withdraw water from the Edwards Aquifer. Your February 12, 1998 request for formal consultation was received on February 18, 1998. Kelly AFB was not originally included in your request because it had already undergone consultation and a biological opinion issued on June 26,1997 (Consultation # 2-15-97-F-039). This biological opinion (2-15-98-F-759) represents an amendment to the Kelly AFB biological opinion and a new biological opinion for the other three military installations, Lackland AFB, Fort Sam Houston, and Randolph AFB.

This biological opinion is based on information provided in your February 1998 biological assessment, supplemental information provided by DOD, information in our files, discussions with involved parties, and other information available to us. A complete administrative record of this consultation is on file in the Austin Ecological Services Field Office.

Table of Contents

Consultation History

DOD contacted the Service for assistance in fulfilling their endangered species responsibilities in a manner that would acknowledge and compensate for their activities that adversely impact the quantity and quality of Edwards aquifer water resources by initiating informal consultation with the Service on September 27, 1996, during a meeting to discuss a Programmatic Environmental Impact Statement (PEIS) for the disposal of Kelly AFB. Other topics discussed included ongoing activities and proposed mission changes that would result in potential increases in water use by the five DOD installations (Lackland AFB, Fort Sam Houston, Randolph AFB, Kelly AFB, and Brooks AFB) in San Antonio, efforts to reduce their withdrawal from the Edwards aquifer and other alternative sources. It was agreed at that time that the disposal of Kelly AFB would be handled separately because of time constraints and the remaining military installations, including the portion of Kelly scheduled for realignment to Lackland, would be addressed in a separate analysis under Section 7 of the ESA. However, to simplify the consultation and allow Lackland and Kelly AFB to share water we decided to include the portion being realigned to Lackland in the Kelly AFB disposal consultation. Other joint meetings with base representatives during the development of the Kelly AFB PEIS where the larger four base (Lackland AFB, Fort Sam Houston, Randolph AFB, and Brooks AFB) consultation was discussed were November 18, 1996 and November 24, 1996 and February 7, 1997. On June 26, 1997 a final biological opinion was issued to Kelly AFB (Cons# 2-15-97-F-039). On June 24, 1997 our office met with Gen. Cannan and other representatives to discuss format and information needed to formulate a biological assessment (BA) on the remaining four base consultation. The BA was to analyze both the ongoing activities and projected mission increases at the five bases. The ongoing activities included activities currently being conducted at Fort Sam Houston and at Lackland, Randolph, and Brooks AFBs. For the purpose of the BA, DOD assumed that Kelly AFB military water consumption would remain constant through Fiscal year 2001, as agreed to in the biological opinion issued to Kelly AFB (Cons.# 2-15-97-F-039). Therefore, for water withdrawal effects Kelly AFB was not included, and only four bases (Lackland AFB, Fort Sam Houston, Randolph AFB, and Brooks AFB) were to be included as part of the consultation and biological opinion.

On February 12, 1998, DOD transmitted to the Service three copies of the BA and request for formal consultation. The Service received their request and BAs on February 18, 1998. The BA was reviewed and a phone request was made by our office, on February 24, 1998, to provide us with other reviewer's comments. The Service sent written acknowledgment of receipt of DOD's February 12, 1998 request for formal consultation on March 23, 1998.

A meeting was held on April 7, 1998 with Gen. Cannan and representatives from the four bases. DOD and the Service recognized there would be significant practical constraints in solving these complicated resource issues because of the logistical constraints of time needed to put effective reduction measures in place and the complicated nature of many regional users contributing to the decline of the resource. We also agreed that a fair and equitable approach was necessary for all users. At that time the Service requested drought management plans for each base and it was agreed the Service would begin a draft biological opinion and the consultation period was scheduled to end July 3, 1998. On June 3, 1998, DOD provided the drought plans and requested further information on the Edwards aquifer conservation fund.

On June 29,1998, in a telephone conversation with Dan Soto, the Service and DOD agreed to a 60 day extension because new information had become available regarding the proposed permits to be issued by the Edwards Aquifer Authority (EAA). The new date for completion was set for August 31, 1998.

On July 7, 1998, the Service submitted the draft opinion for DOD review. After review DOD requested a conference with Service representatives to discuss the draft biological opinion. Alisa Shull and Mary Orms attended the meeting at Randolph AFB on July 27, 1998. Discussion points included ways to minimize take, water withdrawal reduction figures, calculations used to determine the reduction figures, nondiscretionary vs. discretionary use, and the possibility of Kelly AFB reinitiating or amending the biological opinion and being included in this biological opinion and dropping Brooks AFB out of the consultation. DOD needed time to gather further information on issues discussed and make a decision on Kelly AFB and Brooks AFB. Our next meeting was tentatively scheduled for August 17, 1998.

On August 4, 1998, in a telephone conversation, and a follow-up letter on August 18, 1998, DOD requested a 90-day extension on the consultation to better formulate their response to the draft biological opinion. At that time they also requested that Brooks AFB be removed from the consultation to alleviate the irregularities in the draft biological opinion due to the fact that Brooks does not directly pump from the aquifer but rather purchases its water from SAWS. The extension was set to November 31, 1998.

On November 19, 1998, in a telephone conversation the Service and DOD mutually agreed to extend the consultation to January 31, 1999 to give each of us sufficient time to discuss and resolve the details in this complex issue. On November 24, 1998, DOD presented comments and proposed changes to the draft biological opinion. The response was a DOD consensus position that had been coordinated with the leadership of each installation.

On January 7, 1999, a meeting was held to discuss supplemental information needed to resolve issues on what the Service and DOD considered to be nondiscretionary and discretionary uses and limits and trigger levels for military Drought Management Plans. In a letter dated January 26, 1999, DOD stated they were still in the process of compiling information from each installation and obtaining the necessary coordination for submitting a consolidated response and requested an extension of 60 days to March 31, 1999, to which the Service agreed.

On March 19, 1999, DOD provided the supplemental information requested. On March 22, 1999, in a telephone conversation between Mary Orms and Dan Soto and Marion Erwin the Service explained that it would need time to review the material sent, and that it would be difficult to resolve some major issues and complete consultation by March 31, 1999. Therefore, the Service was not requesting another extension but the Service was going to take the necessary time to complete an adequate review of the information provided. On March 25, 1999, in a telephone conversation, Mary Orms and Pat Connor discussed the supplemental information with Dan Soto and Marion Erwin from DOD. During the same phone conversation DOD advised the Service that Kelly AFB would be part of the consultation. We stated we would need to recalculate their figures, and the Service would need adequate time to review the proposed reduction figures, multipliers being proposed in the Drought Management Plan, and a new request from DOD that the biological opinion state that this consultation would culminate in the issuance of the biological opinion and would also meet the requirements to consult with the Service under both Sections 7(a)1 and 7(a)2.

On April 13, 1999, in a conference call between Marion Erwin, Col. Sullivan, Dan Soto, DOD, and Service representatives, Alisa Shull, Pat Connor, and Mary Orms, we further discussed the issues in DOD's supplemental information provided March 19, 1999. A conference call was held April 22, 1999 with Gen. Cannan, Marion Erwin, and Col. Stuebben, DOD, and Mary Orms and Alisa Shull of the Service. We agreed that additional information from EAA was needed to help determine DOD's percent of overall pumping. We also agreed Lackland AFB's maximum figure had not been corrected in the EAA database. Gen. Cannan agreed to contact Col. Sullivan and provide the Service with additional information in the form of a written example of how much reduction the proposed drought management plan would be providing and the effects multipliers would have to help us understand whether the multipliers were really accomplishing significant reductions that would minimize impacts to the species and help them survive low flows during drought. We also discussed the need to recalculate Kelly AFB's percent with the new database figures and also recalculate their share of take minimization efforts. We informed them that the Service had a meeting scheduled with Steve Walthour of EAA on April 26, 1999 to discuss the database and needed information. We mutually agreed to continue working on the consultation until that information was gathered and DOD had time to provide us with further supplemental information that would help the Service better evaluate what the multipliers proposed in the drought management plan were accomplishing.

On April 26, 1999, Alisa Shull, Mary Orms, and Pat Connor met with Steve Walthour of EAA. The new database was forwarded to our office on May 6, 1999. The additional information from Col. Sullivan was received on May 12, 1999. On June 22, 1999, the Service provided DOD a revised draft biological opinion for their review. On August 30, 1999, DOD provided us with official comments on the revised draft. On October 22, 1999, a conference call was held between Alisa Shull and Mary Orms of the Service, and Marion Erwin and Lt. Col. Borland of DOD to discuss the Drought Management Plan Stage V trigger levels, Fort Sam Houston's totals, the domestic and livestock number and a few wording changes. DOD revised Tables 2, 5, and 6 and provided them to the Service on October 25 and 26th. On October 26th another conference call was held with DOD representatives, Col. Sullivan, Marion Erwin, Dan Soto and Lt. Col. Borland and Mary Orms and Alisa Shull of the Service. Col. Sullivan was unable to attend the October 22nd conference call, therefore additional discussion regarding the Drought Management Plan was held on October 26th. Different methods of calculating the Stage V installations total maximum monthly withdrawal amount and multiplier were discussed in the 10/26 conference call between Marion Erwin, Lt. Col. Borland, Dan Soto, Col. Sullivan and Alisa Shull and Mary Orms. Both parties agreed on a multiplier of 1.185 and a total of 1,002 ac-ft withdrawal amount. However, the inclusion of the San Marcos 80 cfs trigger level was still of concern to DOD. Their concern was that a trigger level of 80 cfs at San Marcos in Stage V could possibly trigger the installations to enter Stage V earlier than the rest of the region and skip some stages. DOD and the Service mutually agreed to look further at the previous data and discuss it within a day or two. In a telephone call on October 27th, between Marion Erwin and Mary Orms, progress on Stage V and the issue of the need for re-consultation if EAA was to have a regional permit in place at the conclusion of DOD's 5-year consultation were discussed. In a telephone conversation on October 29th, Alisa Shull and Marion Erwin discussed including the San Marcos trigger level of 80 cfs at all stages. This would allow the installations to progressively work down toward the Stage V level and avoid skipping a stage.

On November 1st in a telephone conversation between Mary Orms and Marion Erwin an oversight in the EAA database (that was brought to the Service's attention on October 29th) was discussed. It was noted that 19 pumpers, a majority irrigators, had not been given a proposed permit amount in one of the columns of the database. Steve Walthour explained that for one reason or another there had been a problem with the information submitted to EAA, therefore, a permit amount was not calculated pending further review. The result was that the amount we had been using as total average historic use was lower than it should have been. This total was used to calculate DOD's percentage and withdrawal amounts for the purpose of this biological opinion. DOD and the Service agreed that verification of these numbers and re-calculation of DOD's percentage and withdrawal amounts would cause a lengthy delay. Therefore, since finalization of this biological opinion was to occur in the next few days, both parties agreed the numbers would remain unchanged for the purpose of this DOD biological opinion.

On November 2nd in a telephone conversation between Marion Erwin and Mary Orms, Ms. Erwin conveyed that Col. Sullivan was in agreement with the inclusion of the San Marcos trigger level but Gen. Cannan and other base representatives still needed to be briefed. On November 3rd Marion Erwin called Mary Orms and updated her on the progress. A draft copy of Table 10, DOD Drought Management Plan of Staged Reductions was faxed to DOD to assist them in the briefing. She also explained that the laundry facility on Lackland had already been closed and conversion of the cooling towers were already in progress. DOD also anticipated that Fort Sam Houston would be online for reuse water by April 2000 and Lackland AFB sometime in calendar year 2000. In another telephone conversation later that same morning with Col. Borland, Marion Erwin and Mary Orms and Pat Connor, DOD presented us with a revised Table 10. The revision did not include changing the trigger levels but rather rewording to make the table more easily understandable for the installations to implement. The Service and DOD were in agreement on the changes. Later that afternoon DOD provided the Service with a letter from Brigadier General David Cannan that DOD installations in San Antonio will be able to adequately perform their missions under the provisions of the current draft biological opinion with the attached mutually agreed upon minor changes to Table 10. Therefore, this represents the final biological opinion for DOD on this topic.

BIOLOGICAL OPINION

Description of the Proposed Action

Water Use

The four installations, Fort Sam Houston, Kelly, Lackland, and Randolph AFBs are located throughout the city of San Antonio, Bexar County, Texas (Figure 1). Full descriptions of each base's locations, missions and proposed actions are described in the February 1998 Biological Assessment titled *"The Effect of Water Draw on the Edwards Aquifer by the Department of Defense Installations in the San Antonio Area"* and supplemental information provided by DOD. The actions proposed for the installations that were discussed in the BA have either been or will be reviewed in separate NEPA documents, but are considered part of overall mission activities for the purposes of this consultation.

The principal conclusion of the DOD BA was that when aquifer levels were low because of drought or near-drought conditions, aquifer withdrawals specifically associated with the current and proposed actions, as a component of total withdrawals by all users throughout the Edwards aquifer region, may affect threatened and endangered species. The Service concurred with the "may affect" finding. For the purposes of this consultation the action area includes the Edwards aquifer, the San Marcos and Comal aquatic systems (including their springs, lakes and rivers), and caves associated with the aquifer that are connected to, dependent on and an integral part of the larger Edwards aquifer ecosystem. When referring to the Edwards aquifer in this document, we mean the San Antonio segment of the Edwards (Balcones Fault Zone) aquifer, which extends from Brackettville (Kinney Co.) to near Kyle (Hays Co.).

Water use associated with Kelly AFB was handled in Consultation # 2-15-97-F-039, but DOD has decided to amend the consultation and reconsider Kelly AFB water withdrawal in this current consultation (# 2-15-98-F-759). In the original 5 ½ year (June 1997- December 2002) Kelly AFB consultation, DOD was responsible for apportioning the total water use figures issued under that biological opinion between the various components of the realigned areas, that is between Greater Kelly Development Corporation (GKDC) and Lackland AFB. GKDC was also made responsible for obtaining the necessary Endangered Species Act (ESA) permits for any continued Edwards aquifer water use beyond the 5 ½ year time frame. This four base consultation covers the portions of Kelly AFB realigned to Lackland and the other three military installations from November 1999 to December 2003 (4 years). The amount of time

Figure 1

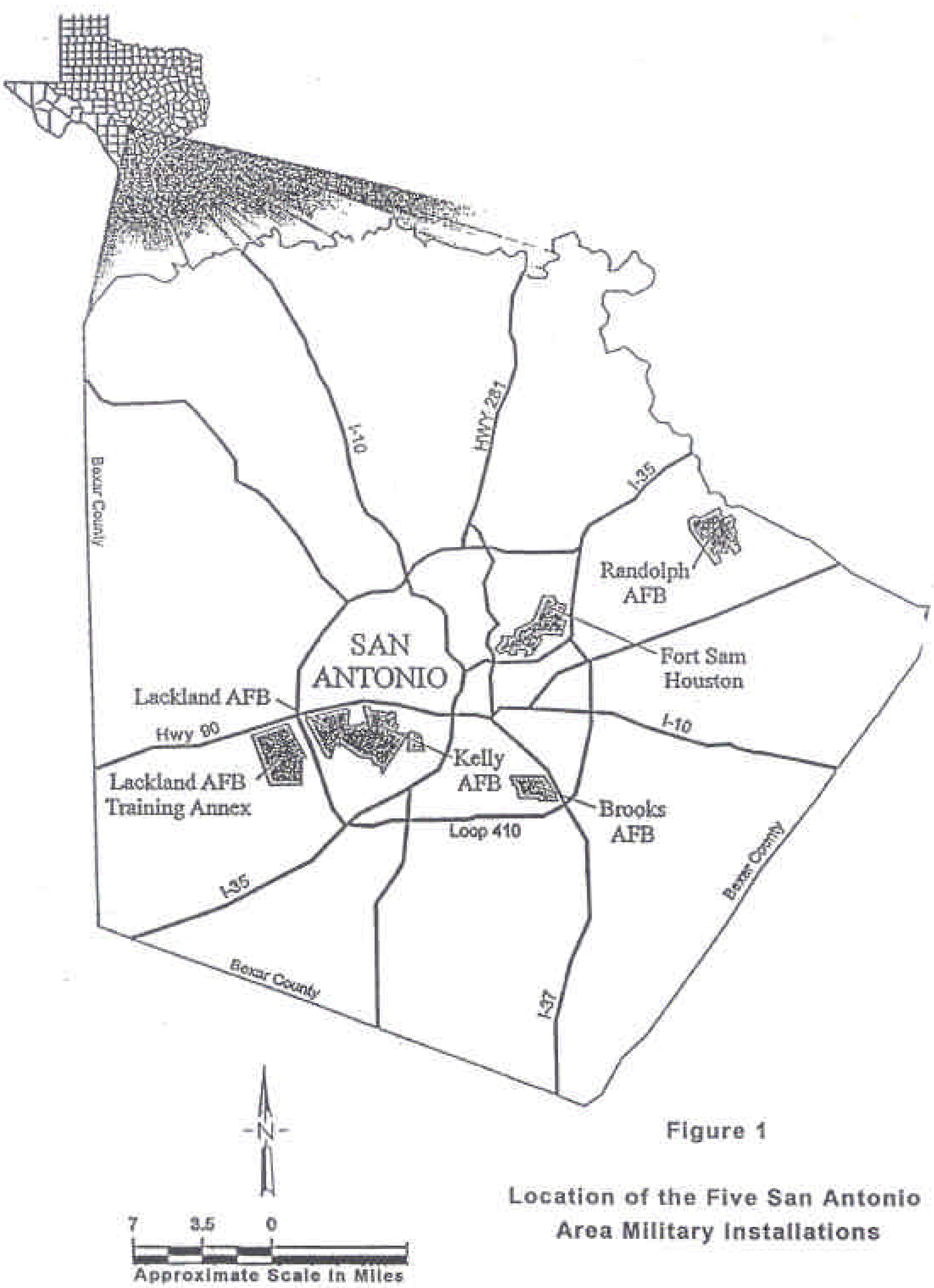


Figure 1

Location of the Five San Antonio Area Military Installations that GKDC's water use will be covered under a DOD biological opinion will remain December 2002. To avoid a lapse in coverage for incidental take under the ESA, GKDC should begin working with the Service to prepare their permit application well before the end of the 5 ½ year time frame as agreed to in the original Kelly AFB consultation.

The four installations are continually subject to actions that affect water use, such as base closures, remodeling, renovation, construction of new facilities to support existing installation activities, or additional or expanded missions. Each of the four military installations covered by this biological opinion directly withdraw water from the Edwards aquifer and have their own unique specific mission. These missions include flying training, ground-based training, medical training, flying operations and aircraft maintenance.

The installations are like small municipalities, and as such, use water for varied purposes similar to the uses of other municipalities. Mission(s) could be added or decreased and could differ from existing installation(s) activities and require a similar increase or decrease in water than currently used. Some of these uses are discretionary, while others are nondiscretionary. Nondiscretionary water uses are necessary to accomplish the missions and support the health and safety of resident employees and their families living on the military installations that pump water directly from the Edwards aquifer. Discretionary water uses on military installations that pump water directly from the Edwards aquifer include water used for irrigation; watering landscaping around administrative buildings and military housing areas, golf courses, parade grounds and similar areas; ornamental fountains; car washing; and maintaining levels in swimming pools used exclusively for recreation and not training.

Table 1 includes individual and total combined water use by the four installations as reported by DOD to EAA for the 21 year historical period from 1973 to 1993. The total of the maximum annual water used by the four bases, after EAA technical review, was 15,124.348 ac-ft/yr. The historic 21-year average, after EAA technical review, for the four bases was 12,264.638 ac-ft/yr.

The total of average historic uses for all pumpers with historic use in 3 or more years (eligible for an EAA permit) after EAA technical review was calculated at 459,388.281 ac-ft/yr. Three applicants that had less than three years historical use were not included in the average historical use numbers provided to us by EAA, but EAA indicated that they would likely be given a permit. Their total, according to the numbers provided by EAA, was 7,147.594 ac-ft/yr making the total of average historic uses for all pumpers (eligible for an EAA permit) 466,535.875 ac-ft/yr.

This total excludes certain domestic and livestock users that are exempt from EAA permit requirements. We are assuming this amount is <13,000 ac-ft/yr (Steve Walthour, EAA, pers. comm., Brown et. al 1992). If this figure proves to be more than 20,000 ac-ft/yr, then DOD may need to reconsult.

Table 1. Historical 21-year average for four military installations

EAA Docket Number	Military Installation	Maximum Claimed (ac-ft/yr)	Historical 21-Year Avg (ac-ft/yr)	Maximum Claimed (ac-ft/yr) after EAA Technical Review	Historic 21-year Average (ac-ft/yr) after Technical Review
BE00151	Lackland AFB	5,327.202	4,144.238	4,794.482	3,729.814
BE00178	Fort Sam Houston	4,735.714	4,099.380	4,262.142	3,689.442
BE00239	Kelly AFB	4,724.948	3,905.163	4,252.453	3,514.647
BE00180	Randolph AFB	2,016.968	1,478.594	1,815.271	1,330.735
Total		16,804.832	13,627.375	15,124.348	12,264.638

Note: In the case of DOD military bases "EAA Technical Review" resulted in 10% reduction across-the-board for water assumed lost in distribution due to line leakage and similar losses.

We believe 20,000 ac-ft/yr is a significant number, however, we are willing to accept that number as a trigger for re-evaluating the need for DOD to reconsult because DOD's biological opinion only covers four years. Dividing the combined total of average historic uses of the four installations (12,264.638) by the total of average historic uses of all pumpers from the Edwards aquifer (eligible for an EAA permit) (466,535.875) gives the four bases' historic percentage of total water withdrawal. The combined percentage for the four bases is 2.6% (0.0262887).

The approximate recent annual water usage (1998) for each of the four military installations that pump water directly from the Edwards aquifer and activities and amounts that are considered nondiscretionary and discretionary are outlined in Tables 2-5 provided by DOD to the Service in their response dated March 19, 1999 and revised on October 25, 1999. Table 6 summarizes recent discretionary and non-discretionary Edwards aquifer water use in 1998 and projected future year 2001 Edwards aquifer water usage data for the four military installations that pump water directly from the Edwards aquifer. The 1998 percentage of discretionary water use at the installations ranges from 6.7% at Kelly AFB to 25% at Fort Sam Houston. Water savings have been realized through implementation of large-scale wastewater reuse systems at Randolph and Kelly and repairs and modifications to the installations' water distribution systems. Kelly and Randolph currently use recycled Edwards aquifer water for irrigating their golf courses and use relatively lower percentages of discretionary water from the Edwards aquifer, 6.7% and 12.4% respectively. The other two installations, Fort Sam Houston and Lackland have a higher percentage of their discretionary water use coming from the Edwards aquifer, 25% and 18.7% respectively. These installations currently use water from the Edwards aquifer to irrigate their golf courses. Both Fort Sam Houston and Lackland are planning to further decrease their dependence on the Edwards Aquifer by using recycled water for irrigating their golf courses as well as for other uses. Both installations have already signed contracts with San Antonio Water System (SAWS) reserving options to procure 1,294.7

Table 2.

TABLE 2. Fort Sam Houston Current and Projected (Year 2001) Edwards Aquifer Annual Water Usage (Approximate)

Water Use		Volume (Acre-Feet/Year)	Current Source	Future Source (YR 2001)	Discretionary
Domestic	Military Family Housing	379.2	Edwards Aquifer	Edwards Aquifer	No
	Barracks, Dorms, Food Service Operations, Office & Administration Areas	1078.3	Edwards Aquifer	Edwards Aquifer	No
Industrial	Medical Center	354.7	Edwards Aquifer	Edwards Aquifer	No
	Cooling Towers	44.3	Edwards Aquifer	Edwards Aquifer	No
		177.5	Edwards Aquifer	Reuse Water	No
		29.8	Edwards Aquifer	Convert to Air Cooled System	No
Other	Laundry	47.3	Edwards Aquifer	Close Plant in FY99	No
	Wash Racks	0.5	Edwards Aquifer	Edwards Aquifer	Yes
	Car Wash	0.7	Edwards Aquifer	Reuse Water	Yes
Swimming Pools	Aquatic Center (Military Training)	0.3	Edwards Aquifer	Edwards Aquifer	No
	Fitness Center	0.1	Edwards Aquifer	Edwards Aquifer	Yes
Irrigation	Golf Course	402.1	Edwards Aquifer	Reuse Water	Yes
	Athletic Fields	85.2	Edwards Aquifer	Reuse Water	Yes
	Office Complex	43.1	Edwards Aquifer	Edwards Aquifer	Yes
		16.9	Edwards Aquifer	Reuse Water	Yes
	Residential	69.4	Edwards Aquifer	Edwards Aquifer	Yes
	VA Cemetery	91.3	Edwards Aquifer	Reuse Water	Yes
TOTAL DISCRETIONARY (1998): TOTAL DISCRETIONARY PROPOSED FOR REUSE WATER		**709.3 acre-feet /year** 596.2 acre-feet/year			
TOTAL NONDISCRETIONARY (1998): NONDISCRETIONARY PROPOSED FOR REUSE WATER		**2111.4 acre-feet/year** 177.5 acre-feet/year			
TOTAL USAGE (1998): TOTAL PROPOSED FOR FUTURE REUSE WATER		**2820.7 acre-feet/year** 773.7 acre-feet/year			

Table 3.

TABLE 3. Kelly AFB Current and Projected Edwards Aquifer Annual Water Usage (Approximate)

Water Use		Volume (Acre-Feet/Year)	Current Source	Future Source	Discretionary
Domestic	Military Family Housing, Dorms, Billeting, Food Service, Offices, Medical Facilities	885.2	Edwards Aquifer	Edwards Aquifer	No
Industrial	Cooling Towers	370.5	Edwards Aquifer	Edwards Aquifer	No
	Industrial Processes	1132	Edwards Aquifer	Edwards Aquifer	No
Other	Car Washing	1.4	Edwards Aquifer	Edwards Aquifer	Yes
Swimming Pools	Three	4.2	Edwards Aquifer	Edwards Aquifer	Yes
Irrigation	Military Family Housing	50	Edwards Aquifer	Edwards Aquifer	Yes
	Main Base	114.6	Edwards Aquifer	Edwards Aquifer	Yes
TOTAL DISCRETIONARY (1998): TOTAL DISCRETIONARY PROPOSED FOR REUSE WATER			**170.2 acre-feet /year** 0 acre-feet/year		
TOTAL NONDISCRETIONARY (1998): NONDISCRETIONARY PROPOSED FOR REUSE WATER			**2387.7 acre-feet/year** 0 acre-feet/year		
TOTAL USAGE (1998): TOTAL PROPOSED FOR FUTURE REUSE WATER			**2557.9 acre-feet/year** 0 acre-feet/year		

Table 4.

TABLE 4. Lackland AFB Current and Projected (Year 2001) Edwards Aquifer Annual Water Usage (Approximate)

Water Use		Volume (Acre-Feet/Year)	Current Source	Future Source (FY 2001)	Discretionary
Domestic	Military Family Housing, Dorms, Billeting, Food Service, Offices	1515.6	Edwards Aquifer	Edwards Aquifer	No
Industrial	Total Energy Plant Cooling Towers	92	Edwards Aquifer	Reuse Water	No
	Other Cooling Towers	454.0	Edwards Aquifer	Edwards Aquifer	No
	Medical Center	233.0	Edwards Aquifer	Edwards Aquifer	No
Other	Car Washing	0.6	Edwards Aquifer	Edwards Aquifer	Yes
Swimming Pools	Confidence Course, Fitness Center, Medical Center Therapy Pools	0.6	Edwards Aquifer	Edwards Aquifer	No
	Other	6.8	Edwards Aquifer	Edwards Aquifer	Yes
Irrigation	Golf Course	276	Edwards Aquifer	Reuse Water	Yes
	Parade Field	153	Edwards Aquifer	Resue Water	Yes
	Athletic Fields	93.0	Edwards Aquifer	Edwards Aquifer	Yes
TOTAL DISCRETIONARY (1998): TOTAL DISCRETIONARY PROPOSED FOR REUSE WATER			**529.4 acre-feet /year** 429.0 acre-feet/year		
TOTAL NONDISCRETIONARY (1998): NONDISCRETIONARY PROPOSED FOR REUSE WATER			**2295.2 acre-feet/year** 92.0 acre-feet/year		
TOTAL USAGE (1998): TOTAL PROPOSED FOR FUTURE REUSE WATER			**2824.6 acre-feet/year** 521.0 acre-feet/year		

Table 5.

TABLE 5. Randolph AFB Current and Projected Edwards Aquifer Annual Water Usage (Approximate)

Water Use		Volume (Acre-Feet/Year)	Current Source	Future Source	Discretionary
Domestic/Industrial	Military Family Housing, Dorms, Billeting, Food Service, Offices Cooling Towers Medical Clinic	1010.8	Edwards Aquifer	Edwards Aquifer	No
Industrial	Cooling Towers	65.5	Edwards Aquifer	Edwards Aquifer	No
Swimming Pools	One (Military Training)	0.2	Edwards Aquifer	Edwards Aquifer	No
	Two	0.6	Edwards Aquifer	Edwards Aquifer	Yes
Other	Car Washing	0.8	Edwards Aquifer	Edwards Aquifer	Yes
Irrigation	Military Family Housing	100.9	Edwards Aquifer	Edwards Aquifer	Yes
	Athletic Fields	11.4	Edwards Aquifer	Edwards Aquifer	No
	Main Base	51.5	Edwards Aquifer	Edwards Aquifer	Yes
TOTAL DISCRETIONARY (1998): TOTAL DISCRETIONARY PROPOSED FOR REUSE WATER			**153.8 acre-feet /year** 0 acre-feet/year		
TOTAL NONDISCRETIONARY (1998): NONDISCRETIONARY PROPOSED FOR REUSE WATER			**1087.9 acre-feet/year** 0 acre-feet/year		
TOTAL USAGE (1998): TOTAL PROPOSED FOR FUTURE REUSE WATER			**1241.7 acre-feet/year** 0 acre-feet/year		

Table 6.

TABLE 6. Percentages of Discretionary Water Usage

		Fort Sam Houston	Kelly AFB	Lackland AFB	Randolph AFB	All Installations
Current (1998)	Discretionary (Acre-Feet/Year)	709.3	170.2	529.4	153.8	1562.7
	Non-Discretionary (Acre-Feet/Year)	2111.4	2387.7	2295.2	1087.9	7882.2
	Total (Acre-Feet/Year)	2820.7	2557.9	2824.6	1241.7	9444.9
	Percent Discretionary	25%	6.7%	18.7%	12.4%	16.5%
Future	Discretionary (Acre-Feet/Year)	113.1	170.2	100.4	153.8	537.5
	Non-Discretionary (Acre-Feet/Year)	1856.8*	2387.7	2203.2	1087.9	7535.6
	Total (Acre-Feet/Year)	1969.9*	2557.9	2303.6	1241.7	8073.1
	Percent Discretionary	5.7%	6.7%	4.4%	12.4%	6.7%

NOTE: This table shows Edwards Aquifer water usage only.
* Totals accounts for 29.8 ac-ft/yr for the cooling tower conversion to an air-cooled system and 47.3 ac-ft/yr for the laundry facility that was closed in FY99. The total of these two (77.1 ac-ft/yr) will not be Edwards aquifer water nor reuse water.

ac-ft per year of recycled water. It is anticipated that Fort Sam Houston will be on reuse water by April 2000 and Lackland AFB by sometime in calendar year 2000. Upon implementation of the recycled water plans and conservation projects, Fort Sam Houston and Lackland will use substantially less water from the Edwards aquifer than they used in 1998. Their percentages of discretionary water use coming from the Edwards are projected to be much lower: 4.4% for Lackland and 5.7% for Fort Sam Houston.

In addition, installation personnel are considering the following three groups of alternatives which could reduce withdrawals from the Edwards aquifer: new water sources, reclaimed water sources for industrial uses as well as grounds and golf course irrigation, and conservation measures. New potable water sources include obtaining surface water from projects being posed by existing surface water purveyors. One potential surface water project involves the Guadalupe-Blanco River Authority (GBRA) transferring treated Guadalupe River water from Lake Dunlap to Bexar County. If initiated the project would be completed in 2001 at the earliest and would provide either 15,000 or 65,000 acre-feet/year, depending on the construction option selected. The second potential source of surface water is Bexar Metropolitan Water District's (BMWD) plan to transfer about 10,080 acre-feet/year of Medina River water to southern areas of San Antonio. Other alternative new water sources could include the purchase or lease of irrigation water rights. These options require investigation and would be highly dependent upon regulatory and, in some cases, other environmental issues being resolved, and may not be available until after the time period associated with the scope of this consultation.

Reclaimed wastewater effluent (reuse water) is another means to reduce Edwards aquifer water withdrawal. The uses of non-potable reclaimed water are broad, with turf irrigation being the primary proposed use at the military facilities. Randolph AFB holds rights to obtain reclaimed
water from the Cibolo Creek Municipal Authority (CCMA) equal to 70% of the volume of wastewater the base conveys to CCMA. SAWS is currently beginning construction of two water recycling systems that can serve three military installations considered in this opinion. The SAWS Leon Creek branch could serve Lackland and potentially provide more reuse water to Kelly AFB and the SAWS Salado Creek Branch will pass near Fort Sam Houston and the VA Cemetery located on Fort Sam Houston. The use of reclaimed water for industrial purposes such as aircraft washing, vehicle washing, and cooling systems is also being planned. DOD is committed to converting all portions of the installations that would benefit from the use of reuse water and are investigating all options. However, some portions of the installations may not be converted from Edwards water because it is economically impossible to run reuse lines to those parts of the bases. In the supplemental information provided on the biological assessment on March 19, 1999, DOD states it does believe curtailing discretionary use is appropriate. The installations are committed to using water from the Edwards aquifer wisely.

Water for both discretionary and nondiscretionary purposes will continue to be used efficiently and conservation efforts will be increased. Conservation measures are grouped into two categories: infrastructure components and educational programs. Each installation assesses the feasibility and compatibility of various conservation methods with its missions. A secondary objective for on-installation conservation measures and education programs is for employees to apply these programs at their residences.

Infrastructure conservation includes studies, modifications or improvements to the water distribution systems and water use fixtures. These may include leak detection, repairs, metering, repair and replacement of faulty fixtures and conversion to low or no flow devices. Industrial conservation could include cooling tower recycle studies, kitchen operations, car wash water recycling systems, and aircraft/large vehicle wash water recycling. Other miscellaneous conservation methods could include using pool covers, reusing water for irrigation, xeriscaping, rainwater and grey water collection, and curtailing use of ornamental fountains.

Educational conservation practices that have been and/or could be implemented include such actions as wide-spread distribution of water conservation goals, practices, and achievements in the form of kits, pamphlets, posters, ads, fact sheets, conservation training seminars, and incentive programs to reduce water use.

Drought Management Plans (DMPs)

Drought management plans currently being implemented at the four bases were based on EAA's Critical Period Management Plan that was in effect until EAA's rules were declared invalid for want of substantial compliance on December 1, 1998. (Cause No. 97-13983: *Carson B. Wells, et al. V. Edwards Aquifer Authority, et al.* and Cause No. 98-02644: *Living Waters Artesian Springs v. Edwards Aquifer Authority*). The trigger levels in both DOD's and EAA's plans are based on the elevation of the J-17 index well located on Fort Sam Houston. Each base has three to four stages, which vary from base to base, and prescribe specific demand reduction measures and the associated Edwards aquifer J-17 well level at which they occur. Stages are usually required to run 10 days unless the well level drops sufficiently to impose the next stage. Table 7 summarizes the various stages and trigger levels used at the installations now.

Reduction goals are accomplished by setting time and/or day restrictions on irrigation of lawns, landscapes, or golf courses. The type of irrigation method may also be set. Limits are set on car washing, fire hydrant and sewer line flushing, and water to be served at eating establishments. Ongoing public education campaigns are intensified. Each stage gets progressively more restrictive and prohibitive of some actions. Other reduction methods may include closing pools and gymnasiums or non-essential facilities and prohibiting all water use not necessary for military readiness, safety of personnel and mission of the installation.

Table 7. DOD Current Drought Plans

Stage Level	J-17 Trigger Level	Reduction Goal
I	655 to 650 feet	1.7 X average base usage*
II	642 to 640 feet	1.6 X average base usage
III	636 to 620 feet	1.4 X average base usage
IV	632 to 628 feet	1.3 X average base usage
V	628 feet and below	

*Average base usage is defined as the average usage for the three lowest usage months of winter during the November 1995 to February 1996 time frame.

The Service has indicated that the probability of survival and recovery is significantly reduced for certain endangered species when flows go below 150 cfs at Comal Springs and 100 cfs at San Marcos Springs (USFWS letters dated April 28, 1993 and June 25, 1993). The existing DMPs allow flows at Comal to go to about 160 cfs during level I and down to 60 cfs before level V (the emergency level) is implemented. During litigation procedures, *Sierra Club, et. al. v. Lujan, et. al.* (it would later become *Sierra Club, et. al. v. Babbitt, et. al.),* No. MO-91-CA-069, Joe G. Moore, Jr., Court Monitor for Judge Lucius D. Bunton, US District Court, Western District of Texas was appointed and made the recommendation to the Court in August 1, 1994, and in a revised plan on March 31, 1995, that to assure necessary flows for listed species at Comal and San Marcos Springs, spring flow rates at Comal (and possibly San Marcos) should be used as triggers instead of the J-17 index well level. The Service is concerned that during low springflows the J-17 well levels and springflows do not correlate well and existing DMP stages do not provide enough protection to protect spring flows and avoid jeopardy. Therefore, the Service concurs with the court monitor's suggestion that springflows should be used and reductions should be started much earlier (for example, by 250 cfs at Comal Springs).

DOD, in their supplemental information for the biological assessment dated March 19, 1999, proposed an alternative DMP (Table 8), based on the J-17 index well and correlations to Comal Springs springflow levels (Guyton and Associates, 1979; Wanakule 1988). The stages in this new proposed DMP are triggered earlier than DOD's current drought plan and EAA's plan. DOD stated they believed that the military's proposed alternative DMP would result in earlier protection levels and minimize impacts to the species in times of drought.

To address the Service's concerns that relying solely on aquifer levels in J-17 as a trigger level may not be adequate to protect necessary flows for the listed species, the Service recommended the triggers in Table 10 be used rather than those in Table 8. Using this scenario, aquifer levels could be used unless springflow drops to or below the Service's recommended springflow trigger level for 3-5 consecutive days. If after 5 days the Comal

Table 8

TABLE 8. Various Recommended Critical Period Management Stage Controls (Proposed by DOD as of 3/19/99)

Stage Level	USFWS Recommended Trigger Flow at Comal Springs	Military Trigger Level at J-17 Well	EAA Trigger Level at J-17 Well	Average Comal Flow for EAA Trigger	Multiplier	Installations Maximum Monthly Withdrawal
I	250 cfs	657.5 ft	650 ft	214.0 cfs	1.7	1,436 ac-ft
II	200 cfs	647.0 ft	642 ft	180.0 cfs	1.6	1,352 ac-ft
III	180 cfs	642.0 ft	636 ft	134.5 cfs	1.4	1,183 ac-ft
IV	160 cfs	640.5 ft	632 ft	103.5 cfs	1.3	1,098 ac-ft

NOTES:
1. cfs = cubic feet per second ft = feet ac-ft = acre-feet

springflow (cfs) level has dropped to or below the Service's recommended trigger level or after 3 days at or below 80 cfs at San Marcos, but the J-17 well level has not triggered the respective stage, then the springflow discharge will supercede the aquifer level as a trigger and the next stage will be implemented. The Service also recommended adding a Stage V, for when conditions are even more dire at Comal and/or San Marcos (See Table 10). The reason that such a low flow (80 cfs) was used as a trigger for San Marcos is because during a typical decline in aquifer levels San Marcos springflows decreased at a slower rate than Comal discharge, and Comal levels would more likely trigger initial stages of the DMP. However, there are periods in the historic record where this would not have been the case. Having the San Marcos 80 cfs trigger level at each stage would be more feasible for DOD to progressively move from one stage to another and avoid a situation where DOD would have to skip a stage. Each stage will be in effect for 10 consecutive days unless a more restrictive stage is implemented and will not be rescinded until the 10 day rolling (moving) average of the J-17 index well and springflow levels trigger a less restrictive stage.

DOD has agreed to the proposed drought management plan in Table 10. All four installations considered under this opinion will adopt the same trigger levels and implement them simultaneously. DOD also agrees that once EAA has adopted a DMP of their own, that if EAA's plan is more stringent than the one in Table 10 they will abide by the EAA DMP.

Required water reductions will be determined using the Installation Base Withdrawal Volumes (BWVs). BWVs will be established by averaging monthly usage data for the period November 1995 through February 1996 using the lowest three months of that period. This is the same period EAA has used in their Critical Period Management Plan. The base volume approximates the installations' monthly nondiscretionary usage and will be used to determine maximum allowable pumped withdrawals during low flow critical management periods. (Note: annual limits may also not be exceeded.) The total BWV for the four military installations that pump from the Edwards aquifer is 844.9 acre-ft/month (Supplemental Information provided on March 19, 1999) (Table 9).

The base volume approximates the installations' monthly nondiscretionary usage (i.e. without the impact of irrigation demands) (Supplemental Information provided March 19, 1999). When the critical period stage controls are implemented, installations will adhere to stage restrictions as specified in the DMP. Critical period reduction multipliers (shown in Table 9) are multiplied times the installations' BWV and establish the monthly allowable pumped volume during the respective stages. Maximum Pumped Volumes (MAX-PV) represent the maximum monthly withdrawal for the installations under critical period stage reductions. The installations aggregate MAX-PV for each stage is shown in Table 10.

Table 9. Monthly use volumes (in kilo-gallons/month)

Installation	Nov 95	Dec 95	Jan 96	Feb 96	Monthly Average
Fort Sam Houston	~~87,865~~	67,200	84,600	84,035	78,611.7
Kelly AFB	70,196	73,402	~~77,408~~	74,806	72,801.3
Lackland AFB	91,585	98,728	~~105,579~~	102,038	97,450.3
Randolph AFB	~~29,446~~	25,288	26,354	27,679	26,440.3
Total					275,303.6

Notes:
(1) Values with strike-through were not used in calculating monthly averages.
(2) 275,303.6 kilo-gallons/month = 844.9 acre-ft./month

The multiplier and maximum monthly withdrawal for Stage V is calculated as follows. Employing a Seasonal Demand Curve developed for the San Antonio Water System (SAWS) by their consultant engineer (Pape-Dawson Engineers, Inc.) and referred to in DOD's August 30, 1999 letter, the current (1998) DOD discretionary water usage (1562.7 ac-ft/yr) can be distributed over an annual period. The resulting curve was then overlaid on the DOD 10-year Groundwater Withdrawal Record, using the years 1989 to 1998 minus the highest and lowest years (1989 and 1997). The total annual discretionary usage for the San Antonio military installations during 1998 was 1562.7 ac-ft or 16.5% of the annual record. Using this data point as representative of a typical year, the total volume of discretionary usage extrapolated from the DOD 8-year Groundwater Withdrawal Record is calculated as 16.5% of the 8-year average withdrawal volume (11,378.675 ac-ft) or 0.165 X 11,378.675 ac-ft = 1,877.4813 ac-ft/yr. Using the critical month August (which according to DOD's last 10 years of record is their highest use month, on average) with 13% of the annual discretionary usage volume (per the Seasonal Demand Curve), the volume of discretionary usage for August is calculated as 0.13 X 1,877.4813 ac-ft = 244.07256 ac-ft. Subtracting the August discretionary volume (244.07256 ac-ft) from the monthly 8-year historical average for August (1,245.75 ac-ft) or 1245.75 - 244.07256 = 1001.6775 ac-ft, the mission critical (non-discretionary) volume required to sustain installation operations. The Stage V multiplier is calculated by dividing the mission critical volume by the DOD BWV or 1001.6775 ac-ft / 844.9 ac-ft = 1.185. Therefore, DOD should be able to reduce Edwards water use to this level (basically cutting out all discretionary water use) during a dire situation when flows are below those levels at which the fountain darter, Texas wild-rice, and Comal Springs riffle beetle's probabilities of surviving are being significantly reduced. It is important to note that this method or time frame may not be the most appropriate for other applicants seeking coverage under a Section 7 consultation or Section 10(a)(1)(B) permit, and will need to be determined on a case-by-case basis for other applicants, using the most appropriate method for determining water use necessary to maintain human health and safety.

Table 10

Table 10. New DOD Drought Management Plan Staged Reductions

Stage	Triggers*			Multiplier	Installations Total Maximum Monthly Withdrawal
	J-17	Comal	San Marcos		
I	5 days where Level ≤ 657.5 ft	5 days at or below 250 cfs	3 days at or below 80 cfs	1.7	1,436 acre-ft
II	5 days where Level ≤ 647.0 ft	5 days at or below 200 cfs	Any Stage I trigger, plus 3 days at or below 80 cfs	1.6	1,352 acre-ft
III	5 days where Level ≤ 642.0 ft	5 days at or below 180 cfs	Any Stage II trigger, plus 3 days at or below 80 cfs	1.4	1,183 acre-ft
IV	5 days where Level ≤ 640.5 ft	5 days at or below 160 cfs	Any Stage III trigger, plus 3 days at or below 80 cfs	1.3	1,098 acre-ft
V	3 days where Level ≤ 637.0 ft	3 days at or below 100 cfs	Any Stage IV trigger, plus 3 days at or below 80 cfs	1.185	1,001 acre-ft

* Whichever comes first.

Water Quality

Monitoring and maintaining good water quality is also important. Faults and wells that penetrate both aquifers are potential routes by which contaminants may flow into the Edwards. The potential for contamination of the aquifer is addressed in the DOD's Installation Restoration Program (IRP). The (IRP) is a program that evaluates past disposal sites, controls the migration of contaminants, minimizes potential hazards to human health and the environment, and cleans up the contamination. The Kelly AFB PEIS identified 52 IRP sites and three Areas of Concern. Some of the contaminants identified at Kelly AFB included low-level radioactive waste, jet fuel, solvents, cyanide solutions, tar, chromium plating sludge solvents, gasoline, PCBs, phenols, pesticides, TCE, PCE, DCE, JP-5, and TPH. Significant areas of the shallow aquifer and soils were found to be contaminated and are addressed in the original Kelly biological opinion, which still stands. Well inspections and IRP studies have not identified other water quality issues on the remaining installations, therefore this biological opinion does not address any water contamination impacts directly to the aquifer from DOD, other than those in the Kelly biological opinion. If any aquifer contamination issues are later identified or expected, DOD will need to consult with the Service further.

Other Measures

As stated previously, DOD and the Service recognize the logistical constraints of time needed to put effective reduction measures in place and the complicated nature of the cumulative effects of many regional users contributing to the decline of the resource. It will be a difficult task to find ways to solve these issues, implement projects, and fairly and equitably distribute the responsibility of accomplishing these tasks among all users.

The Service examined the biological and logistical issues involved and determined that an approach that involves steady reductions in aquifer withdrawals over a certain time could meet the time and economic/logistical needs of planners trying to implement comprehensive solutions to meet reduction goals that can ensure the survival of the species and their critical habitat. In addition, the Service believes that in the interim period as measures are being put in place to reach these reduction goals, the risk to species survival will still be high. The risk can be reduced by implementing a significant drought management plan for further cut-backs to protect flows during drought and by implementing additional conservation actions in those initial years to reduce negative impacts to the species during drought and low flows and increase the species' chances of surviving during temporary low flows. These actions may include such things as:

- improving the condition of species and habitat in the wild so that they are in better condition going into the low flows and so that the relative portion of the population impacted will be less;
- answering information needs to better manage flows and minimize impacts to species and;

- maintaining captive populations to act as a backup for wild populations and enhance the chances of restoration.

We have developed a list of possible projects that could serve one of these functions (See Appendix A). Each project on this list has been assigned a point value (based primarily on relative cost). The total of all of these points = 10,000. To determine a pumper's "fair share" of these impact and risk reduction/minimization measures, we multiply the pumper's percent water use (average historic use) by the total points (10,000). So in the case of the four installations, whose combined average historic water use (12,264.638 acre-ft/yr.) is 2.6%, their fair share of these measures would be 0.0262887 X 10,000 = 262.887 points. DOD has decided to fund refinement of the regional Edwards aquifer model to improve the ability to manage the aquifer in a way that minimizes impacts to the species. This task has applicability to pumpers and to aquifer management region wide. This task was also assigned a high priority by a Technical Advisory Group (TAG) appointed by the EAA to help identify and design research necessary to assist in aquifer optimization. The Service assigned a point value to the model of 200 points and anticipated the share of funding that would be contributed for these 200 points to be $200,000. The total cost of the project is estimated to be $400,000 in years 1 and 2 for model/GIS construction. DOD has agreed to fund a minimum of $262,887. The extra $62,887 should free up EAA funds that would have been spent on this project that can now be spent on other tasks on this list such as flow path studies around San Marcos or the establishment of a monitor well in San Marcos to correlate aquifer level and springflow.

Status of the Species

Fountain darter (*Etheostoma fonticola*)

The fountain darter occurs in both the upper San Marcos and Comal rivers. The fountain darter was listed as endangered on October 13, 1970 and critical habitat was designated on July 14, 1980. Critical habitat was designated in Hays County and includes Spring Lake and its outflow, the San Marcos River, downstream to approximately 0.5 miles below the Interstate Highway 35 bridge. A field identifier of the downstream end of critical habitat is considered to be the U.S. Geological Survey defunct gaging station. There is no critical habitat designated for this species in the Comal Springs system.

The fountain darter is a small reddish brown fish, averaging about 29 mm (about 1 1/4 inches) total length. Habitat requirements described in the recovery plan (USFWS 1996) include: undisturbed stream floor habitats; a mix of submergent plants (algae, mosses, and vascular plants), in part for cover; clear and clean water; food supply of living organisms; constant water temperatures within the natural and normal river gradients; and adequate springflows.

Fountain darters feed primarily during daylight in response to visual cues (Schenck and Whiteside 1977*a*). Bergin (1996) investigated the fountain darter's diet in detail. The food items selected depend on the size of the individual, but primarily includes copepods, dipteran larvae, and emphemeropteran larvae (Bergin 1996).

Fountain darters use and may prefer a mix of submergent plants and mats of filamentous algae (Schenck and Whiteside 1976; Linam 1993). Schenck and Whiteside (1976) found that young fish prefer vegetated habitats in areas with little water velocity, while adults occur in all types of suitable habitats including riffles.

Although natural populations of fountain darters appear to spawn year-round (Strawn 1955, 1956 as cited in USFWS 1994; Schenck and Whiteside 1977*b*), they appear to have two peak spawning periods, in August and late winter to early spring (Schenck and Whiteside 1977b). Bonner et al. (1998) described the effects of temperature on egg production and early stages of the fountain darter.

Historic and present distributions of the fountain darter are presented in the *San Marcos & Comal Springs and Associated Aquatic Ecosystems (Revised) Recovery Plan* (Recovery Plan) (USFWS 1996). Historically within the San Marcos River, the fountain darter is known from the headwaters down to the vicinity of Martindale (USFWS 1996). Current distribution extends from Spring Lake to a point between the San Marcos Waste Water Treatment Plant (WWTP) outfall and the confluence with the Blanco River (USFWS 1996). Fountain darters have been collected below the WWTP outfall during July 1994, November 1994, February 1995, April 1995, and September 1996 by this office.

The original population of fountain darters in the Comal River was extirpated (Schenk and Whiteside 1976). The primary cause of extirpation is thought to be the 1956 drought, when springflow ceased for nearly four months. Cessation of flow probably caused large temperature fluctuations in residual pools. In 1954, rotenone was applied to remove nonnative and exotic fish. Although fountain darters were seined and held during rotenone application, the total number of fountain darters probably was reduced since all darters were not caught (Ball et al. 1952; USFWS 1996). The species was re-established in the Comal River in 1975 and 1976, and the species now occupies Landa Lake downstream to the vicinity of the confluence of the Comal and Guadalupe Rivers.

The population of fountain darters in the San Marcos River was estimated to be about 103,000 by Schenck and Whiteside (1976) and 45,900 (excluding Spring Lake) by Linam (1993). Darter densities appear to be highest in the upper segments of the river and decreases markedly in an area below Cape's Dam (Linam 1993; USFWS unpublished data; Whiteside *et al*. 1994). The area below the WWTP outfall has been identified in the recovery plan as an area to evaluate for possible restoration of habitat for the fountain darter. Linam et al. (1993) estimated that the Comal River population was about 168,078 individuals above Torrey Mill Dam in the 1990 survey.

Dr. Thomas Brandt (in litt. 1997) has summarized the parasite problems faced by the fountain darter. None of the fountain darters collected in the Comal system in June and early July, 1996 were observed to have swollen gills. On July 19, 1996, one of 11 fountain darters collected and released was noted as having swollen gills. This was the first indication of parasites attacking fountain darter gills in the Comal system. In October, 1996, heavy parasite loads were documented in Comal fountain darters including: metacercarial digenetic trematodes, a myxosporean, and an epithelial flagellate.

A significant threat to the health of fountain darters is the damage to gills and gill arches caused by the trematodes. The risk posed by these parasites appears to be related to spring discharge in the system. The summer of 1996 was well below average in terms of discharge at Comal Springs.

Currently, this trematode has not become established in the fountain darters of the upper San Marcos. A total of two trematodes has been found in San Marcos darters; one in each of two individuals. A recent cooperative study (SMNFH, Southwest Texas State University, and National Aquaculture Research Center (Stuttgart, Arkansas) found this trematode on every fountain darter collected in the Comal system. A major threat to health of fountain darters in the San Marcos system is this same undescribed trematode. Alternate hosts for these gill parasites may include animals found in both Comal and San Marcos systems. Yellow-crowned night herons, the trematode's postulated host, may easily fly from Comal to San Marcos.

San Marcos gambusia (*Gambusia georgei*)

The San Marcos gambusia was listed as endangered in 1980. Critical habitat includes the San Marcos River, from the Highway 12 bridge downstream to approximately 0.5 miles below the Interstate Highway 35 bridge (45 FR 47355). Intensive searches for *G. georgei* in May, July, and September of 1990 did not yield any pure San Marcos gambusia. Past attempts to establish a captive population were unsuccessful and no pure *G. georgei* have been found recently to try captive propagation again.

The San Marcos gambusia, one of three Gambusia species native to the San Marcos River system, was first described in 1969. The San Marcos gambusia has strong crosshatchings and a prominent dark pigment stripe across the distal edges of its dorsal fin. A mid-lateral stripe may be present from the base of the pectoral fin to the caudal peduncle. *Gambusia georgei* has a dark subocular bar and fewer spots than *G. affinis*. The median fins tend to be lemon yellow in wild-caught specimens, with dominant males exhibiting a bright yellowish-orange color. *Gambusia georgei* has more than five segments in ray 4a and a compound claw on the end of ray 4p (Hubbs and Peden 1969). According to the recovery plan (USFWS 1996), the habitat requirements of the San Marcos gambusia include: thermally constant water; quiet, shallow, open water adjacent to sections of moving water; muddy substrates without appreciable quantities of silt; partial shading; clean and clear water; and a food supply of living organisms. Food habits of *G. georgei* are unknown but are presumed to include insect larvae and other invertebrates. Hybridization between *G. georgei* and *affinis* was first noted by Hubbs and Peden in 1969. Hybrid individuals may now be competing with *G. georgei*.

Texas wild-rice (*Zizania texana*)

Texas wild-rice was listed as endangered on April 26, 1978 and its critical habitat was designated on July 14, 1980. Critical habitat includes Spring Lake and its outflow, the San Marcos River, downstream to the confluence with the Blanco River.

The first collection of Texas wild-rice was by G.C. Neally in 1892 (USFWS 1996). The plant was formally described and named by Hitchcock in 1933 (taken from Terrell *et al*. 1978). Texas wild-rice is an aquatic, monoecious, perennial grass, which is generally 1-2 m (3.281 - 6.562 ft.) long and usually immersed and prostrate in the swift-flowing water of the San Marcos River. The inflorescence and the upper culms and leaves become emergent as flowering commences. Flowering and seed set occur primarily from late spring through fall but inflorescence may occur sporadically at other times in warm years (USFWS 1996). In slow moving waters Texas wild-rice plants function as annuals, exhibiting less robust vegetative growth, then flowering, setting seed and dying within a single season.

Texas wild-rice occurs only in Spring Lake and the upper San Marcos River, before the confluence with the Blanco River. Plants form extensive stands over the substrate, rooted in the limestone sand and gravel river bottom, which overlays Crawford black silt and clay (Vaughan 1986). Other native species that occur in the same general area of the river inhabited by Texas wild-rice include pondweed (*Potamogeton illinoensis*), eelgrass (*Vallisneria americana*), arrowhead (*Sagittaria platyphylla*), hornwort (*Ceratophyllum demersum*), and water primrose (*Ludwigia repens*). Non-native species now commonly present include hydrilla (*Hydrilla verticillata*), elodea (*Egeria densa*), and *Hygrophila polysperma*.

Distribution - When described in 1933, Texas wild-rice was indicated to be abundant in the San Marcos River, including Spring Lake and its irrigation waterways (Silveus l933, Terrell et al. l978).

In the 1960's and 70's investigators found very little Texas wild-rice remaining. In 1967 Emery found only one plant in Spring Lake, none in the upper 0.8 km (0.5 miles) of the San Marcos River, only scattered plants in the lower 2.4 km (1.5 miles), and none below this (Emery 1967). In 1976 no plants were found in Spring Lake, with the majority of plants concentrated in the extreme upper and lower segments of the San Marcos River (Emery 1977). Calculated areal measurement of wild-rice at that time was 1,131 m2 (Emery 1977). Vaughan (1986) reported areal coverage of the rice from 1983 through 1986 to be 541, 462, 489, and 454 m2, respectively. Texas Parks and Wildlife Department (TPWD 1989) has been monitoring Texas wild-rice annually since 1989, and this ongoing effort has documented that recently Texas wild-rice had been growing through a slightly greater geographic area than during its most sparse period of record in the late 60's and mid 70's, though not all of these recorded stands have persisted (Poole and Bowles, l996).

Records of wild-rice plants below the WWTP are limited to two. Sampling reports from yearly surveys (TPWD, 1989 through 1996) document that one stand of rice was located below the outfall in 1989, but this plant has not been relocated. A note included on a *Z. texana* habitat map from Emery's work dated 2-07-78, indicates 1 clump of Texas wild-rice at the entrance to a 10" diameter pipe on the north bank about 400 meters downstream from the city sewage outfall in 1976. This stand has not been relocated and is presumed lost.

Habitat and Life History - Silveus (1933) stated that Texas wild-rice was found growing in the swiftest currents at some distance from the bank rather than along the stream margins as he had expected.

Since these early habitat observations, our understanding of optimum habitat for Texas wild-rice has been refined. Optimum habitat for Texas wild-rice consists of relatively clear waters with high to moderate current velocities (0.3-0.6 m/sec) and depths between .5 m and l m (1.640-3.281 ft) (Poole and Bowles, l996). Optimum depths and velocities are synergistic in determining optimum habitat. It has been observed in sites deeper than about 1.5 m, but stands do not do well. Minimum depths tolerable for Texas wild-rice are believed to be in the .2 to .3 m range, and this could be sustained only for a relatively short time (on the order of possibly a week to 10 days) as mechanical forces and vulnerability to other threats at these depths severely limit persistence. At the lower limits of depth, velocities of 0.3 to 0.6 m/sec are probably too high and would result in damage to the plants (Seal and Ellis l997).

Flow rates may be extremely important to optimum growth for Texas wild-rice. Texas wild-rice requires carbon dioxide as its inorganic carbon source for photosynthesis rather than bicarbonate, which other aquatic plants commonly use (TPWD 1994; Seal & Ellis 1997) While bicarbonate is commonly available in solution in aquatic systems, carbon dioxide diffuses very slowly in water and is readily available only in relatively fast-moving waters and near spring openings. Obligate carbon dioxide using species may be carbon limited in low flow situations. Velocity has been shown to influence photosynthesis of submerged vegetation (Madsen and Sondergaard 1983; Prins and Elzenga 1989).

Substrate texture requirements are unclear. Experimental work by Power (1990) and Power and Fontyn (1995) concluded that seed germination was triggered by low oxygen in anaerobic sediments, and that seedlings grow well in fine textured sediments. Power has continued to grow plants from seed successfully in fine sediments for cultivated collections and subsequent experimental work. Poole and Bowles challenge that finding and state, based on transect studies of Texas wild-rice in its natural habitat in l994 and l995, that Texas wild-rice grows preferentially in coarse to sandy substrate. However, it should be noted that Poole and Bowles took substrate samples on the edges of the wild-rice stands to avoid root impacts. Substrate characteristics there may be influenced in part by the impact of the stand itself on flow dynamics around the stand, and may be slightly different than those on the interior of stands. Later (1996) collection of wild-rice specimens for the captive conservation collection involved collecting plants from over 80 sites in the river and observations about substrate texture were made at the time of collection. These collections were taken for the most part more in the interior, receding half of stands. Observations of these collections include many sands and fine sands, frequently with silty components. Additional work is probably needed to clarify the sediment texture tolerances and requirements of Texas wild-rice.

Reproduction of *Z. texana* occurs either sexually via seeds or asexually (clonally) through stolons. Sexual reproduction occurs through formation of seed produced from wind pollinated florets. Texas wild-rice seed is not long-lived, and no appreciable seed bank would be expected. Viability begins to drop markedly within one year of seed production. Asexual reproduction occurs where shoots arise as clones at the ends of rooting stolons (Emery and Guy 1979).

The genetic variability present in the wild population of Texas wild-rice is currently under investigation, and complete results are not yet available. It has been demonstrated that plants in patchy or changeable environments with a variety of microsites may have high genetic variability that is of adaptive importance (Harper l977). In spite of the fact that the species has reproduced predominately clonally for many years, it cannot be assumed that this has resulted in a relatively homogeneous population. Most clonal plant species surveyed for genetic variation have shown a high degree of genetic diversity (Silander 1985). Established stands of clonal grasses of *Festuca rubra* have been documented to average as many as 5 different clones in a 15 by 15 cm quadrant (Harberd and Owen l969, as discussed in Harper 1977). Preliminary tests on three samples of Texas wild-rice taken within less than a quarter mile length of river revealed that all three samples were genetically different individuals (Christie McKinnon, University of the Incarnate Word, pers. comm.). Until complete results of genetic variability levels within and between stands are available for evaluation, the potential for adaptively significant variability within stands and between stands cannot be discounted, and all existing stands should be accorded high priority for protection.

Most areas where Texas wild-rice still occurs are within areas recorded as having plants in the location of "clones" mapped by Emery in the late 70's and earlier. TPWD monitoring since 1989 has demonstrated stands are capable of relatively long-term persistence and expansion over large areas of substrate. Based on these observations of persistence and its perennial nature, Texas wild-rice does not appear to be a purely successional species with a dynamic, cyclic life history strategy. Successional species adapted for rapid colonization of highly disturbed environments generally rely on frequent dispersal of large numbers of propagules to colonize open sites. Successional stands that become established are usually relatively short-lived, declining and becoming displaced as the site is stabilized and occupied.

Few new stands of wild-rice have been documented in the river system since 1989. While rooted floating fragments of Texas wild-rice have been observed, which could potentially become established if deposited in suitable conditions, this mechanism is not believed to give rise to significant numbers of new stands. Clonal reproduction appears to be the primary mechanism for expansion of an established stand, but it does not appear to be an efficient mechanism for dispersal and colonization of new areas. A life-history strategy using sexual reproduction for dispersal and asexual reproduction within the parental habitat is common in both plants and animals (Sebens and Thorne l985). Seed production may be essential for dispersal and establishment of new stands in Texas wild-rice.

Abundance and trends - In l989 TPWD initiated a new monitoring program with new techniques. Data from 1989 on is likely not comparable to previous areal coverage measurements due to differences in techniques. Continuing from 1989 through 1994, areal coverage over the river as a whole has been 1005, 1380, 1406, 1406, 1592, 1501, 1624, and 1652 m^2, respectively (Poole and Bowles 1996).

TPWD reports generally include total cover in the river in m^2, total cover designated within lettered (A,B,C, etc.) river segments, and individual stand-by-stand history. Evaluating the condition of Texas wild-rice based on total areal coverage alone and even by comparison of cover within individual segments could give the impression that overall Texas wild-rice is increasing and doing well in the habitat. However, such an evaluation would fail to recognize events that are of great conservation concern. A more detailed, stand-by-stand analysis of the fate of individual stands is necessary. Although more frequent monitoring would be desirable, because of financial and staff constraints, TPWD has only been able to conduct quantitative monitoring annually. As discussed later, in some situations (such as events that occur seasonally or short-term low flow events) this may result in underestimates of losses and impacts.

Examining all the segments of the river monitored reveals that only in 2 of 14 river segments recognized to have potential habitat has wild-rice achieved significant, persistent expansion (segments B and K). Many stands have fluctuated in size from year to year, with frequent significant drops in cover. This raises concern about overall stability in the area and the potential loss of genetic material with each significant loss. Within almost every segment several stands have disappeared altogether, which also represents a loss of potentially important adaptive genetic material. Many stands and several entire segments (A,H,I, and J which together represent 16% of the recovery area needed for downlisting) show an overall decline in the recent monitoring record (1989-present). These low-level and/or progressive losses of genetic material are of particular concern since sexual reproduction and recruitment of significant numbers of new plants or stands is not occurring. On close examination some records of new stands may be due to the fragmentation and thinning of existing stands rather than to expansion. These fluctuations need to be carefully analyzed in the context of their location and local and system-wide threats to identify and manage problems that may be causing losses or declines (USFWS 1996).

Plants have not successfully been producing any significant quantity of seed in the San Marcos River for many years (Emery 1977; Vaughan 1986; USFWS 1996). Photos taken near the A.E. Wood Fish Hatchery (historically one of the most robust areas for Texas wild-rice) in the 80's show a stand blooming well (Paula Power, research photos). Since TPWD's annual monitoring began in l989 however, little inflorescence formation has been noted, and only on one or two occasions have any inflorescence been observed to have set a few seed (Jackie Poole, TPWD, and Paula Power, SMNFH, pers. comm. 1995). Plants grown in raceways in cultivation under protected conditions bloom well and produce seed in quantity (Rose and Power 1992). The failure of river grown wild-rice to produce seed in the wild is not thought to be a result of genetic, cytological, or embryological problems, but rather to some extrinsic factor or factors (Emery and Guy 1979). Triggers for flowering are not well understood. Herbivory, particularly by waterfowl, is believed to contribute to inflorescence losses. Impacts by recreational users of the river has also been postulated to interfere with flowering and seed set.

Low flow incidents are of particular concern because of the potentially catastrophic impact such events can have on Texas wild-rice. During recent low flow years in l990 and l996 significant numbers of Texas wild-rice stands were recorded in depths below optimum. Six out of 11 segments identified that currently have stands of wild-rice had more than 30% of their stands below optimum depth conditions. Four out of 11 segments had more than one-third of stands at depths below the minimum needed for survival (Table 11). Table 11 likely under-represents actual losses in dry years because sampling frequency was limited and may not have encompassed and reflected the total change as flows declined. (See note at the bottom of Table 11.)

The drought conditions in 1996 resulted in direct and indirect adverse impacts to the existing Texas wild-rice plants. In May low flows resulted in the dewatering of significant portions of large stands in TPWD monitoring segments, particularly segments A, E, and F with these stands suffering losses of over 50% of stand area. These three segments together comprise about 25% of the proposed recovery area needed for downlisting of the species. Most plants that died had not resprouted from potential below ground root material by the following spring. Some areas formerly occupied by Texas wild-rice were colonized by hydrilla, and the ability of wild-rice to recover and recolonize these sites is unknown (USFWS photo documentation and observations).

Several high velocity areas not actually dewatered became significantly shallower and had increased velocities that resulted in very short yellowish leaf growth and eroding root balls and some plants eventually being washed out. Low flow areas that became shallow and accessible suffered severe predation by nutria and other predators, resulting in the loss of significant leaf biomass.

In deeper water areas, reduced flows resulted in leaves of wild-rice floating at the water's surface rather than streaming just below the surface in the current as is normally the case.

This resulted in increased accessibility for herbivorous waterfowl (ducks and geese), which were observed feeding on Texas wild-rice (USFWS photo documentation and observations).

In some deep water areas, (particularly in segments B, G, J, and K) root balls of large established plants were also observed to be eroding and exposed, apparently because changes in flow characteristics changed the velocities through these areas (USFWS/TPWD observations, l996).

Low flows also resulted in floating mats of vegetation fragments (which normally move slowly downriver) becoming hung up in wild-rice leaves that were near the surface, increasing in size and shading out wild-rice as well as mechanically damaging plants (Paula Power, Southwest Texas State University, and Melani Howard, City of San Marcos, pers. comm., and USFWS observations). Detrimental contacts from recreational users were also thought to have caused more severe and frequent damage to wild-rice because leaves were closer to the surface and more extensive shallow areas resulted in wading and horseplay in areas where under more normal flows greater depths would have afforded plants more protection.

Recovery needs - The recovery plan calls for establishing healthy, self-sustaining, and reproductive populations throughout the historic range before the species can be considered for downlisting. Recovery criteria call for 75% cover in prescribed areas of potential habitat for wild-rice, which is the percent cover typical of that found in healthy, vigorous stands (USFWS 1996). These prescribed areas which need 75% cover are delineated by the segment designations used in the TPWD monitoring program on Table 11.

Threats - The Recovery Plan identifies the potential loss of springflows needed to support riverine habitats as a primary threat for Texas wild-rice. Current water use trends indicate that without conservation action and reduction in demands for Edwards aquifer water, low flow periods of increasing frequency and duration can be expected, with associated significant impacts to Texas wild-rice.

Various threats to the wild-rice documented by Emery in 1967 included floating debris, bottom plowing, plant collection, and pollution. Although by 1977 Emery reported that the impact of bottom plowing and plant collecting had been significantly abated, restoration of sexual reproduction or appreciable spread of existing clones had not occurred.

Beaty (1975) noted that the location of the habitat for the wild-rice was in a densely populated and high use area, which subjected these waters to pollution by inflows of the city storm drainage system, occasional raw sewage leaks, and normal stormwater runoff from streets, railroads, and recreational areas. In addition, Vaughan (1986) identified competition by introduced and native species of plants, predation by animals (*Myocaster coypus* [nutria], and *Marissa cornuarietis* [the giant rams-horn snail]), recreational use of the river, and dam placement along the river as potential factors impacting the wild-rice.

Table 11

Table 11. Texas wild-rice

Segment delineated	Square meters needed for downlisting	% of total recovery area needed for downlisting	% of existing stands below min. depth in dry yrs. 7/90 or 7/96	% of existing stands below optimum depth in dry years 7/90 or 7/96
Spring Lake	1500	13%	no rice	no rice
Segment A	1400	12%	63%	83%
Segment B	5000	42%	1%	17.7%
Segment C	1000	8%	24%	50%
Segment D	100	1%	no rice	no rice
Segment E	500	4%	12%	23%
Segment F	900	8%	0 ***	14%
Segment G	100	1%	0	0
Segment H	30	0.3%	50%	75%
Segment I	50	0.4%	50%	56%
Segment J	400	3%	35%	57%
Segment K	700	5.9%	17%	28%
Segment L	100	1%	no rice	no rice
Segment M	100	1%	no rice	no rice
Total	11,930			

*** Note that while monitoring conducted in July 1990 and 1996 in segment F did not reveal any stands below minimum depths for survival, it was observed that several large stands in segment F were partially dewatered and suffered losses of over 50% of their stand area in May of 1996. By the July monitoring session this loss had already occurred, and thus the depth of stand recorded was the depth of the "remainder" which was above the minimal survival depth. Therefore July 1996 monitoring depth measurements did not catch the stand expanses dewatered and lost earlier that year. Interestingly enough these losses were not reflected in areal coverage figures for segment F as a whole either, as expansion of a few deep-water stands in the segment over the coverage of the year before (1995) masked these effects in overall percent cover measurements. Only when examining the cover of individual stands in segment F between 1995 and 1996 do losses within segment F become apparent. Even these stand-by-stand measurements may be under-representative of losses, as pictorial records seem to show a more extensive percentage loss than the monitoring data. This may have occurred because stands that suffered losses had expanded in cover over the previous year (as had the deep water stands), until low flows exposed the stands. These phenomena may represent a potential to underestimate degree of risk to stands and losses actually sustained. If it could be implemented, more frequent quantitative stand-by-stand monitoring would provide a more accurate synopsis of events, particularly during low-flow events.

Rose and Power (1992) noted that nonpoint source pollution, floating mats of vegetation, recreational users of the river, and herbivorous waterfowl most likely have a negative impact on wild-rice, as well as changes in the composition of sediments, depletion of the soil seed bank, and plant competition particularly from the introduced hydrilla (*Hydrilla verticillata*) which has been observed surrounding stands of Texas wild-rice.

Additionally, Texas wild-rice may be more susceptible to damage from recreational activities and/or herbivores such as nutria, during times of decreased flow.

San Marcos salamander (*Eurycea nana*)

Eurycea nana was listed as a threatened species on July 14, 1980. Critical habitat includes Spring Lake and its outflow, the San Marcos River, downstream approximately 164 feet (50 m) from the Spring Lake Dam.

The San Marcos salamander is a neotenic form and retains its external gills throughout life. The salamander becomes sexually mature and breeds in the water. This small, slender salamander has moderately large eyes with a dark ring around the lens, well developed and highly pigmented gills, relatively short, slender limbs with four toes on the forefeet and five on the hindfeet, and a slender tail with well developed dorsal fin. Habitat requirements described in the recovery plan (USFWS 1996) include: thermally constant waters; flowing water; clean and clear water; sand, gravel, and rock substrates with little mud or detritus; vegetation for cover; and an adequate food supply. Captive salamanders do not actively pursue prey, but stay stationary until prey items are close enough to engulf. The San Marcos salamander's diet consists of amphipods, tendipedid (midge fly) larvae and pupae, other small insect pupae and naiads, and small aquatic snails. Most evidence suggests reproduction occurs throughout the year with a possible peak about May and June (USFWS 1996).

Recent sampling found the San Marcos salamander distributed throughout Spring Lake among rocks near spring openings, in algal mats, and in rocky areas just downstream from the dams (Nelson 1993). *Eurycea nana* occurs near all the major spring openings scattered throughout Spring Lake and is quite abundant at some of these springs (Nelson 1993). Nelson (1993) estimated a total population of 53,200 salamanders in and just below Spring Lake, including 23,000 associated with algal mats, 25,000 among rocky substrates around spring openings, and 5,200 in rocky substrates below Spring Lake.

Threats to the San Marcos salamander include loss of protective cover, lack of flowing water, water temperature elevated above ambient spring conditions, contaminants, siltation, and predators. *Eurycea nana* appears to require flowing water, as no specimens were found in still waters of the lake or river.

Habitat availability for the San Marcos salamander is adversely affected when springflows decline. The contingency plan for the salamanders is being implemented and salamanders are being collected for captive propagation/maintenance at several different facilities. Techniques for breeding this species and maintaining its genetic diversity have not been worked out and there are no known techniques to ensure the survival of this species in captivity. Reintroduction techniques have also not been developed.

Texas blind salamander (*Typhlomolge rathbuni*)

The Texas blind salamander was listed as endangered on March 11, 1967. *Typhlomolge rathbuni* is a smooth, unpigmented troglobitic (cave-adapted) species. Adult salamanders attain an average length of about 12 cm (4.7 in.) with a large, broad head and reduced eyes. The limbs are slender and long with four toes on the fore legs and five toes on the hind legs. The salamander is neotenic and remains aquatic throughout its life in water-filled, cavernous areas in the San Marcos area of the Edwards aquifer. *Typhlomolge rathbuni* is believed to be adapted to the relatively constant 21° C (69.8° F) temperature of the subterranean waters in the Edwards aquifer (Longley 1978). The diet of the salamander includes amphipods, blind shrimp (*Palaemonetes antrorum*), daphnia, small snails, and other invertebrates. Cannibalism has also been documented (Longley, *in litt*., 1994). The salamander appears to be sexually active throughout the year, which is expected since there is little seasonal change in the aquifer (Longley 1978).

The total distribution of this species may be as small as 10 km^2 (25.9 mi^2) in a portion of the Edwards aquifer beneath and near the city of San Marcos. All collections or sightings of the Texas blind salamander have occurred in Hays County, Texas. After its first collection at the former Federal fish hatchery site, the salamander has been found at Ezell's Cave, San Marcos Springs, Rattlesnake Cave, Primer's Fissure, Southwest Texas State University's artesian well, and Frank Johnson's well (Russell 1976, Longley 1978). The species was previously known to occur in Wonder Cave but searches in 1977 did not locate any specimens (Longley 1978).

The species could be negatively impacted by declines in water quality or quantity in the aquifer. Decreased water quality could also result from a reduction in the water level in the aquifer resulting in possible movement of the "bad water" line and decreased dilution potential.

Attempts are being made to collect Texas blind salamanders as part of the contingency plan implementation. However, very few specimens have been found at collection sites and these low numbers in captivity are inadequate to maintain good genetic representation. There are also no techniques developed to reintroduce this species back into the aquifer.

Invertebrates

The Service listed three aquatic invertebrate species known only from Comal and Hays counties, Texas, as endangered under the ESA on December 18, 1997 (Federal Register Volume 62, Page 66295). These species are dependent on the Edwards aquifer. The primary threat to these species is described as a decrease in water quantity and quality as a result of water withdrawal and other activities by humans throughout the San Antonio Segment of the Edwards aquifer. Critical habitat was not designated for these species. The three species are reviewed below.

Peck's Cave amphipod (*Stygobromus pecki*)

Peck's cave amphipod, *Stygobromus pecki*, is a subterranean, aquatic crustacean that is eyeless and unpigmented. This amphipod is an obligate aquatic stygobiontic species, an aquatic species ecologically restricted to caves and subterranean groundwaters, found around spring openings of the Edwards aquifer. Limiting conditions for the amphipod may include decreased spring flow, stagnation of water, and decreased water quality.

The first recorded specimen of Peck's cave amphipod was collected at Comal Springs in June, 1964. Since then over 300 specimens have been collected, most from crevices in rock and gravel near the orifices of the three largest Comal Springs on the west side of Landa Park. The species has also been collected from a fourth Comal spring run adjacent to Landa Park and one specimen has been collected from Hueco Springs, about 7 km (4 miles) north of Comal Springs (Barr 1993).

Comal Springs riffle beetle (*Heterelmis comalensis*)

The Comal Springs riffle beetle, *Heterelmis comalensis*, has been collected from spring runs 1, 2, and 3 at Comal Springs in Landa Park and a single specimen has been collected from San Marcos Springs 32 km (20 miles) to the northeast.

The Comal Springs riffle beetle, in the family Elmidae, is an aquatic beetle about 2 mm (1/10 inch) long . The beetle is found in gravel substrate and shallow riffles in spring runs at depths of 2 to 10 cm (1 to 4 inches), sometimes deeper. Populations are at their highest from February to April (Bosse *et al*, 1988). Natural water flow is important for the respiration and survival of the riffle beetle, which has a mass of tiny, hydrophobic (unwettable) hairs on its underside to maintain a bubble of air for gas exchange (Chapman 1982). Stagnation of water and/or drying within the spring runs and the photic (lighted) zone of the spring orifices would probably be limiting for the riffle beetle, which depends on natural spring flows for respiration and survival (Chapman 1982).

In 1984 and 1990, some of the higher elevation Comal Springs ceased flowing and water levels in the index well (J-17) in San Antonio dropped to within twelve feet of the historic low of 612.5 feet that occurred in 1956 (Wanakule 1990). Flows also ceased in the upper spring run (Spring Run 1) in 1991 and 1996. Captive breeding techniques for this species have not been developed.

Comal Springs dryopid beetle (*Stygoparnus comalensis*)

The Comal Springs dryopid beetle has been collected from all 4 spring runs at Comal Springs and from Fern Bank Springs about 32 km (20 miles) to the northeast in Hays County. *Stygoparnus comalensis* is the only known subterranean member of the family Dryopidae. Adult beetles are about 3.0-3.7 mm (1/8 inch) long with vestigial (non-functional) eyes and weakly pigmented, translucent thin cuticle (Barr and Spangler 1992). This beetle does not swim and, since all known dryopid beetle larvae are terrestrial, the species may be associated with air-filled voids inside spring openings. Water flow is important for this species, which uses tiny, hydrophobic hairs on its underside to maintain a bubble of air for gas exchange (Chapman 1982). Decreased water flow and stagnation of water would be limiting factors for the beetle.

Other Species of Concern

In addition to the listed species, a great diversity of other unique species occur in these aquatic ecosystems. Some may be threatened with extinction, but insufficient information is available to fully assess their status. Some of the species associated with the Edwards aquifer include the Texas cave diving beetle (*Haideoporus texanus*), San Marcos saddlecase caddisfly (*Protoptila arca*), Ezell's cave amphipod (*Stygobromus flagellatus*), Texas salamander (*Eurycea neotenes*), Comal blind salamander (*Eurycea tridentifera*), robust (=Blanco) blind salamander (*Typhlomolge robusta*), Comal salamander (*Eurycea sp.*), widemouth blindcat (*Satan eurystomus*), and toothless blindcat (*Trogloglanis pattersoni*). While these species of concern have no legal protection, efforts to reduce adverse effects and/or further studies at this stage would benefit the health of the ecosystem and may help prevent future listing. Efforts to reduce effects or studies could include such things as studying well entrainment of blind catfish; developing or improving captive breeding techniques; or assessing habitat and flow requirements of these species of concern.

Environmental Baseline

The revised San Marcos and Comal recovery plan (USFWS 1996) identifies several local and regional threats to the aquifer and spring systems, and to the threatened and endangered species dependent on these ecosystems. The main regional threats are related to the quality and quantity of aquifer and spring water. Decreased and potential cessation of springflows threaten the survival of the aquatic species. Activities that may pollute the Edwards aquifer and its springs and streamflows may also threaten or harm the species. Additional threats include impacts from increased urbanization near the rivers, recreational activities, alteration of the rivers, habitat modification (for example, dams, bank stabilization, flood control), and predation, competition, and habitat alteration by non-native species (for example, elephant ears, giant ramshorn snails, nutria, tilapia).

Springflows at San Marcos and Comal Springs are inseparably tied to water usage from the entire San Antonio Segment of the Edwards aquifer. The discharge of groundwater from wells in the aquifer decreases the flow of water from the springs. Total withdrawal from the aquifer has been increasing since at least 1934, when total well discharge was 101,900 ac-ft, and it reached a maximum of about 542,000 ac-ft in 1989. The increasing volume of withdrawals is approaching the aquifer's 1934-1995 average recharge volume of 674,200 ac-ft/year (Brown and Patton 1996). To illustrate the impact of groundwater withdrawals on springflows, Figure 2 shows the discharge hydrograph from Comal Springs during the period of record and Figure 3 shows the discharge from wells and the aquifer recharge for those years. The hydrograph for the springs can be defined in two periods: before and after the drought of record, which resulted in the drying of the springs in 1956. During the first period, pumping and recharge were both significantly lower than during the second period, and discharge levels had relatively small fluctuations. Following the 1956 drought, recharge increased, but not enough to offset the greater increase in pumping. As a result, the frequency and magnitude of fluctuations in Comal Springs' discharge increased substantially, and several declines in discharge extended below the take/jeopardy levels, as described in the Recovery Plan (USFWS 1996) and indicated on Figure 2 by the horizontal lines. Overall, the average discharge from the Comal Springs decreased from 330 cfs for 1934-1949, prior to the drought of record, to 286 cfs for 1957-1996 after the drought when pumping increased.

Because of the anticipated continued population growth in the Edwards aquifer region, and an associated increase in water use, the trend of declining spring discharge will continue if those water needs are met from the Edwards aquifer. Several estimates have been made that project the increase in regional water demand, and the influence of increased pumping on flows from San Marcos and Comal Springs:

* Data from the Bureau of Reclamation (USDI 1972, 1973, 1974) suggested that demands on the Edwards aquifer, even considering a "low" and unlikely rate of growth for this region, will far exceed the recharge to the aquifer (Longley 1975). Given various scenarios of water usage, the Bureau projected that the probability of continuous flow from the San Marcos Springs by the year 2020 was only 50-75 percent certain.

* The Texas Department of Water Resources' estimated water use from the aquifer through the year 2020, and projected a continued increase in demand for well water into the 21st century; much of this demand was estimated to arise in the San Antonio area (TDWR 1977).

* The first detailed computer simulation of flow in the Edwards aquifer (Klemt et al. 1979), with assumptions of full continued development and average hydrologic conditions, projected that continuous flow from the San Marcos Springs would cease around the year 2010.

Figure 2

Figure 2. Comal Springs Monthly Mean Discharge CFS

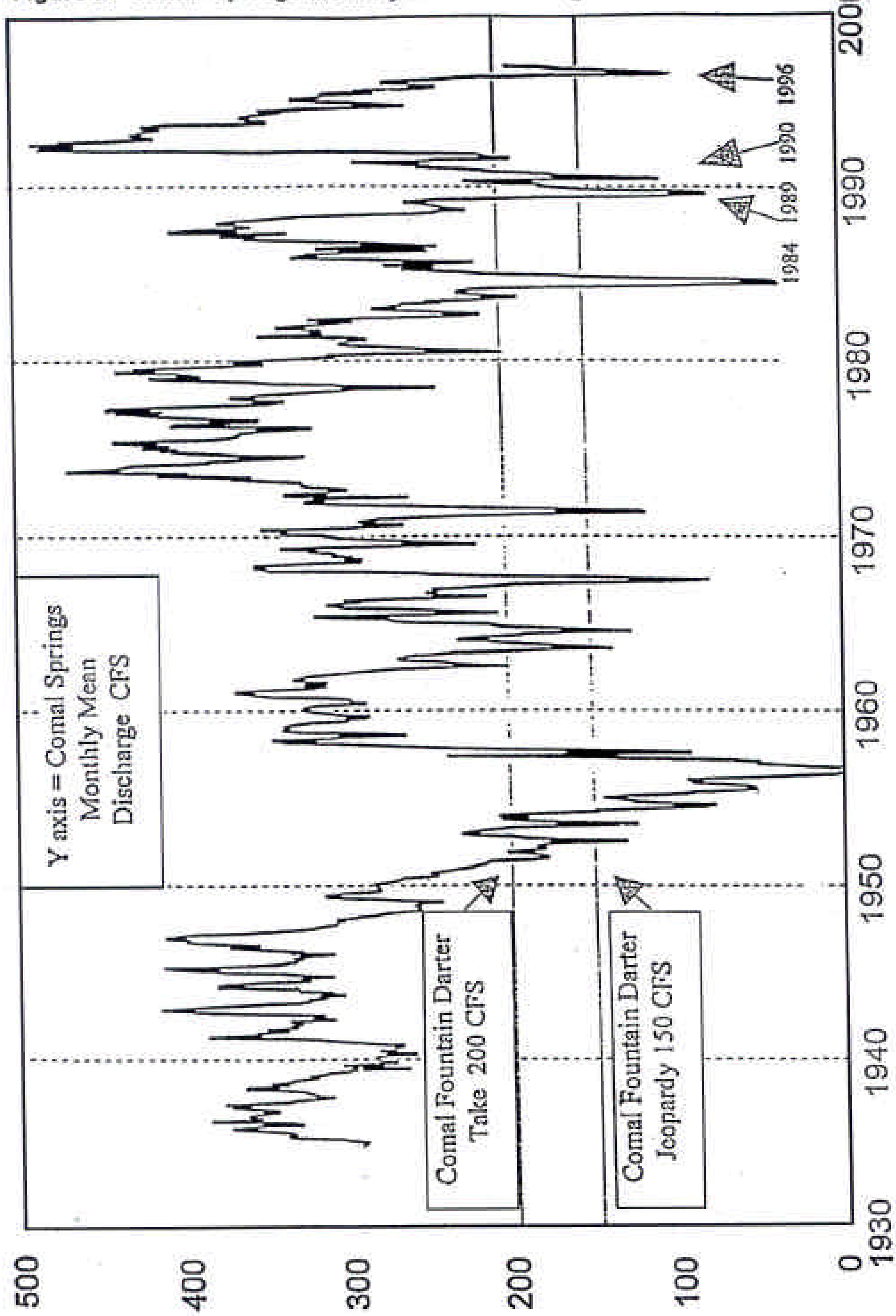


Figure 3

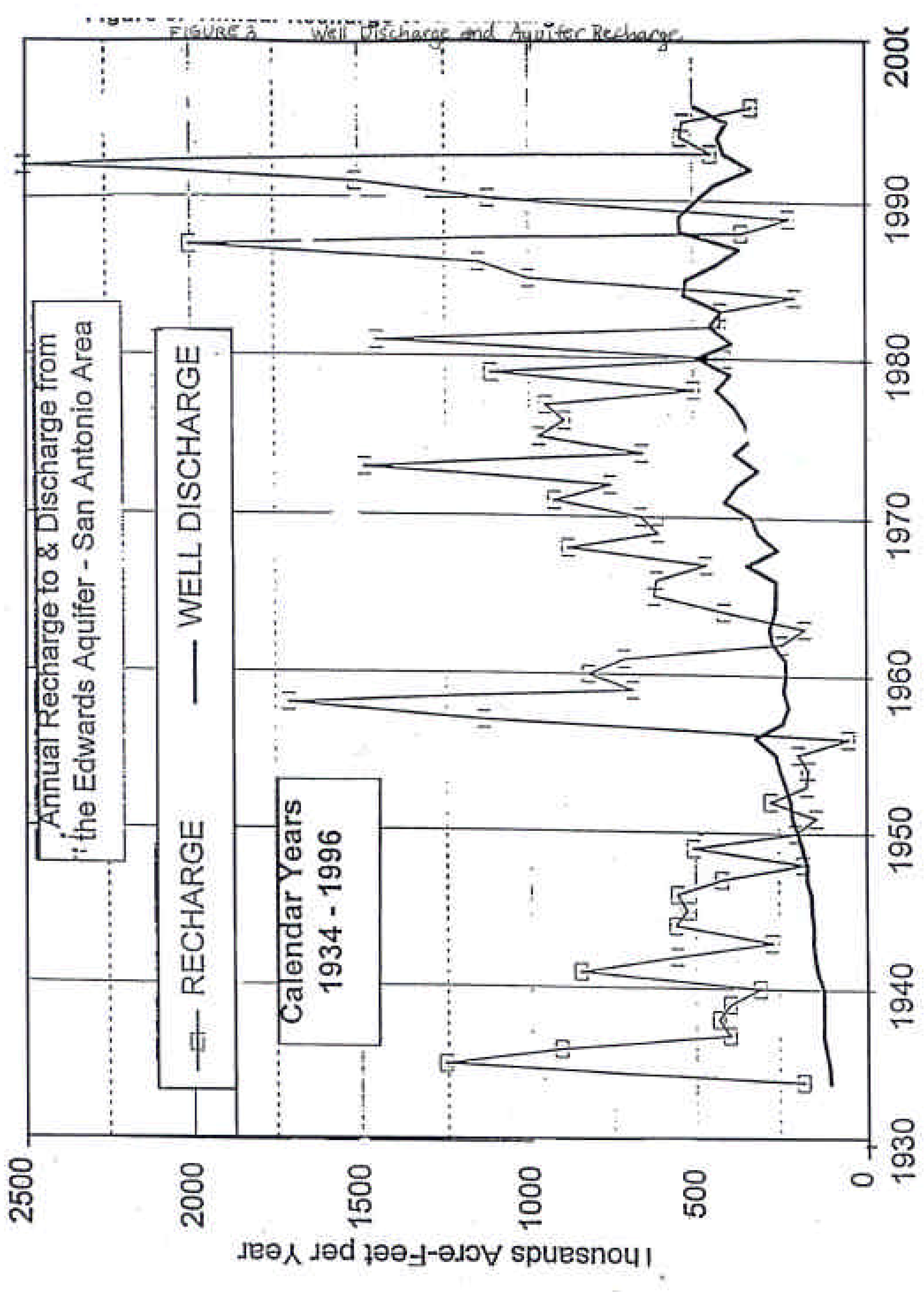


FIGURE 3 Well Discharge and Aquifer Recharge.
Annual Recharge to & Discharge from the Edwards Aquifer - San Antonio Area
RECHARGE
WELL DISCHARGE
Calendar Years 1934 - 1996
Thousands Acre-Feet per Year
2500
2000
1500
1000
500
0
1930
1940
1950
1960
1970
1980
1990
2000

* Based on his Edwards research, Wanakule (1990) stated: "The present problem facing the Edwards aquifer is the overdrafting of the annual average recharge rate."

* A number of recent studies have modeled springflow at Comal and San Marcos Springs (Texas Water Development Board (TWDB) 1992; McKinney and Watkins 1993) and found that regulation of groundwater withdrawal will be necessary to maintain their continuous flow.

* Population and water use projections developed by the TWDB, Texas Natural Resource Conservation Commission, and the TPWD (1996) show an increase in water demand in the Edwards region that by 2050 will exceed current 1934-1995 mean recharge rates by 43-57%. These figures include consideration for expected water conservation measures.

A special underground water authority (EAA) was recently created, under The Edwards Aquifer Authority Act (EAA Act) (Chapter 626, Laws of the 73rd Texas Legislature, 1993, as amended by Chapter 621, Laws of the 74th Texas legislature, 1995), to manage and issue permits for the withdrawal of groundwater from the Edwards aquifer for the purposes of water conservation and drought management and to make and enforce rules. The Edwards aquifer was found to be a unique aquifer and a distinctive natural resource of this state. It is a complex hydrological system and the sole source of water for a diverse group of social and economic interests. The EAA was designated a special regional management district to protect terrestrial and aquatic life, domestic and municipal water supplies, the operation of existing industries, and the economic development of the state. All reasonable measures are to be taken to conserve water; protect water quality in the aquifer; protect water quality of surface streams provided with springflows from the aquifer; maximize the beneficial use of water available to be drawn from the aquifer; protect aquatic and wildlife habitat; protect threatened and endangered species under federal or state law; and provide for instream uses, bays and estuaries. Under the EAA Act, except as provided under the Critical Period Management Plan, water withdrawals from the aquifer may not exceed 450,000 acre-ft of water for each calendar year for the period ending December 31, 2007. At the beginning of January 1, 2008, the amount of permitted withdrawals from the aquifer may not exceed 400,000 acre-ft of water for each calendar year, and not later than December 31, 2012, continuous minimum springflows of the Comal Springs and San Marcos Springs are to be maintained to protect endangered and threatened species to the extent required by federal law.

Texas also recently passed Senate Bill 1 that states no later than September 1, 2001, and every five years thereafter, a comprehensive state water plan will be adopted that incorporates development, management, and conservation of water resources and preparation for the response to drought conditions, in order that sufficient water will be available at a reasonable cost to ensure public health, safety, and welfare; further economic development; and protect the agricultural and natural resources of the entire state. The goal is to find reasonable and effective ways to involve public participation to establish a reasonable population growth rate compatible with available water resources; estimate water availability, maximize water conservation, develop effective drought and groundwater management plans; protect water quality, instream flow, and surface waters; enforce water rights and help fund water resource activities.

As part of a February 1, 1993, Judgement (as amended on May 26, 1993) in the case of Sierra Club vs. Secretary of the Interior (No. MO-91–CA-069, U.S. Dist. Ct., W.D. Texas), the Service used its best professional judgement and available information to determine minimum springflows needed to prevent take, jeopardy, or adverse modification to critical habitat of listed species. Determination of take and jeopardy vary from species to species depending on each species' unique requirements, ecology, and life history. In addition, factors associated with the specific action such as magnitude, timing, duration, frequency, and extent also affect a specific take or jeopardy determination. Table 12 contains the Service's determination of minimum springflows necessary to prevent take, jeopardy, or adverse modification of critical habitat for the Edwards aquifer dependent endangered and threatened species (see also USFWS letters dated April 28, 1993 and June 25, 1993).

It may be possible for some of these levels to be reduced under certain conditions, such as with the implementation of an aquifer management plan that significantly influences the magnitude and duration of springflows of Comal and San Marcos Springs combined with control of certain limiting factors such as non-native (exotic) species. Significant control of non-native species would be that which would eliminate threats from species, such as loss or alteration of essential habitat, increased predation, disruption of normal behaviors, or hybridization.

Data gathered by the U.S. Geological Survey (summarized by McKinney and Sharp 1995) show that Comal and San Marcos Springs have little natural variation in water quality. A review of the numbers shows that parameters like temperature, pH, conductivity, total dissolved solids, and major ions generally vary less than 10% and usually less than 5% from the mean. For example, temperature in the San Marcos Springs typically varies less than 0.5°C (32.9° F) in the headwaters and only slightly more at the lower end of the spring run habitat (Guyton & Associates 1979). Vaughan (1986) reported a constant temperature of 21.5°C (70.7° F), with ranges in the streamflow from 25.5°C (77.9° F) in August to 20.4°C (68.7° F) in February at the lower end of the wild-rice zone. Oxygen content reported by Vaughan (1986) was between 5-6 ppm. Springflows tend to be alkaline or neutral, which is typical of limestone aquifers (USFWS 1996). The pH range of the San Marcos Springs was reported as 6.9-7.9 (TWDB 1968; Vaughan 1986). Whiteside et al. (1994) reported the lowest pH levels at 6.3 in the upper portions of the river and up to 7.9 in the lower.

Table 12. U.S. Fish and Wildlife Service determination of minimum springflows needed to prevent take, jeopardy, or adverse modification of critical habitat. All flows rates are given in cubic feet per second (cfs).

Species	Take	Jeopardy	Adv. Mod.
Fountain darter in Comal	200	150	N/A
Fountain darter in San Marcos	100	100	100
San Marcos gambusia	100	100	100
San Marcos salamander	60	60	60
Texas blind salamander	50*	50	N/A
	Damage & Destruction		
Texas wild-rice	100	100	100

*Refers to San Marcos springflow

The U.S. Geological Survey data also show a high drinking water quality for the springflows and aquifer in general. However, there are increasing risks of aquifer, springflow, and streamflow contamination. Pollution threats include:

1) groundwater pollution of the Edwards Aquifer from land-based hazardous material spills and leaking underground storage tanks;

2) cumulative impact of urbanization (road runoff, leaking sewer lines, residential pesticide and fertilizer use, etc.);

3) increased impact of contaminants due to decreased dilution from smaller volumes of water in the aquifer and springflows; and,

4) surface, stormwater, and point and nonpoint source discharges into the streamflows.

Although the aquifer is generally not contaminated to exceed federal drinking water standards, contaminants have been found with greater frequency in the aquifer by the following U.S. Geological Survey reports, and include some wells with pollutant levels that exceed the standards. Reeves (1976) noted the occurrence of fecal coliform and fecal strep bacteria, and elevated nitrate and phosphate levels in some wells on the recharge zone. Most of these sites were near suburban developments. Buszka (1987) found elevated levels of nitrates, bacteria, volatile and nonvolatile organic compounds, and pesticides throughout much of the aquifer, but concentrated near Uvalde and San Antonio. Some of these sites were from a leaking landfill in San Antonio and from another point source contamination site in Uvalde, but many are too far removed to be firmly attributed to those sources and likely reflect other contaminant sources. Roddy (1992) reported similar results and additional contaminant localities. Rice (1994) found that 54 wells in Bexar County have reported mercury and chlorinated solvents. While only a few wells had contaminant levels above those permitted by drinking water standards, the presence of any compounds found in Edwards wells demonstrates the potential for aquifer contamination. As a result of these and other related factors that threaten aquifer water quality, the Edwards Underground Water District concluded (Kipp et al. 1993):

"The lack of adequate comprehensive standards and regulatory controls to protect the aquifer against water quality degradation, coupled with the rapid pace of development over the ERZ [Edwards aquifer recharge zone] *at this time, and presumably for some time to come, suggests that degradation of water in the Edwards aquifer is imminent."*

Many of the threats by urbanization to aquifer water quality also threaten spring-based streamflows. Runoff from streets, highways, and commercial and residential landscapes, and potential spills of hazardous materials pose the greatest risks to streamflow quality.

Effects of the Action

One of the major threats to the fountain darter, Texas wild-rice, San Marcos gambusia, San Marcos salamander, Texas blind salamander, Comal springs riffle beetle, Comal springs dryopid beetle, and Peck's cave amphipod is loss of springflows and reductions in aquifer levels. Loss of springflows also results in impacts to critical habitat for the four species that have designated critical habitat.

Flows at San Marcos and Comal Springs are tied directly to water usage from the Edwards aquifer. Use of groundwater in the region decreases flow of water from the springs. The TWDB used their Edwards Balcones Fault Zone flow model to simulate aquifer response to several constant withdrawal pumpage scenarios under various recharge conditions. The model was to examine springflows expected at the San Marcos and Comal Springs under various pumping scenarios. The model's ability to predict springflows on a monthly average at Comal Springs is generally accepted. The model is less accurate in predicting conditions in the San Marcos Springs. The TWDB model shows that at both a 450,000 and a 400,000 ac-ft/year constant pumpage scenarios, in a repeat of the historic recharge record, a high probability of springflow decline resulting in jeopardy to the species remains. In fact, the probability is high that springflows could cease in the Comal Springs for a period of years (Figure 4 and Figure 5). Figure 6 shows that a 140,000 ac-ft constant pumping level would result in a constant flow above 100 cfs at Comal Springs and flows only drop below 200 cfs once during the part of the historic record that corresponds to the most severe drought of record.

The four DOD installations currently rely on the Edwards aquifer as the source of their water. Existing water use levels will be reduced from historic use by transferring a portion of the current Edwards water to reuse water and through conservation practices. The proposed projects include measures to conserve water, to implement reuse measures and analyze the feasibility of expanding reuse lines to other areas of the bases, and reduce reliance on groundwater.

The greatest threats to water quality are non-point source contamination from spills, urban runoff, construction activities and impurities associated with human activities, particularly in the recharge zone (Seal 1996). As flows and water quantity decrease the spatial distribution of water quality parameters (temperature, pH, turbidity, conductivity, dissolved gases) increase in magnitude in a manner that may have a negative impact on the listed species (Seal & Ellis 1997). The Balcones Fault Zone- San Antonio Region is bounded on the south and east by a saline water interface known as the “bad water” line. Groundwater goes from fresh to saline to brackish. Lowered water levels due to cumulative groundwater pumpage or decreased recharge may result in movement of the saline water line into fresh water sections increasing the potential for impacts to species dependent on freshwater. Lower aquifer levels and springflows may also result in increased concentration of contaminants because less water would decrease the potential for dilution.

The USAF identified 52 IRP sites and 3 AOC's on Kelly AFB as described in the proposed action. Other installations have similar programs looking at contaminant issues and their effect on water quality. Some proposed actions at the installations would also result in impacts to soils, geology, water and biological resources from ground disturbance associated with construction or redevelopment. Airfield-related activities would continue to require the use of aboveground and underground storage tanks for fuels and other hazardous materials.

If contaminants and potential pathways (for example, wells, faults) are not controlled, remediated properly, or monitored regularly contamination may increase and threaten plant and animal species as well as humans. To reduce the impacts of hazardous waste and contamination that may reduce water quality, DOD is committed to continue remediation of all sites by retaining the necessary interests (for example, easements), in order to operate and maintain all remediation and monitoring systems; ensuring that any site-specific land-use limitations are identified and enforced, coordinating IRP activities with the environmental regulators; keeping the community abreast of the IRP activities; and, continuing well maintenance program and implementing remediation.

Kelly AFB water quality impacts are being dealt within the previous consultation (2-15-97-F-039). This biological opinion does not address any water contamination impacts directly to the aquifer from DOD, other than those in the Kelly biological opinion. If any aquifer contamination issues are later identified or expected, DOD will need to consult with the Service further.

Figure 4

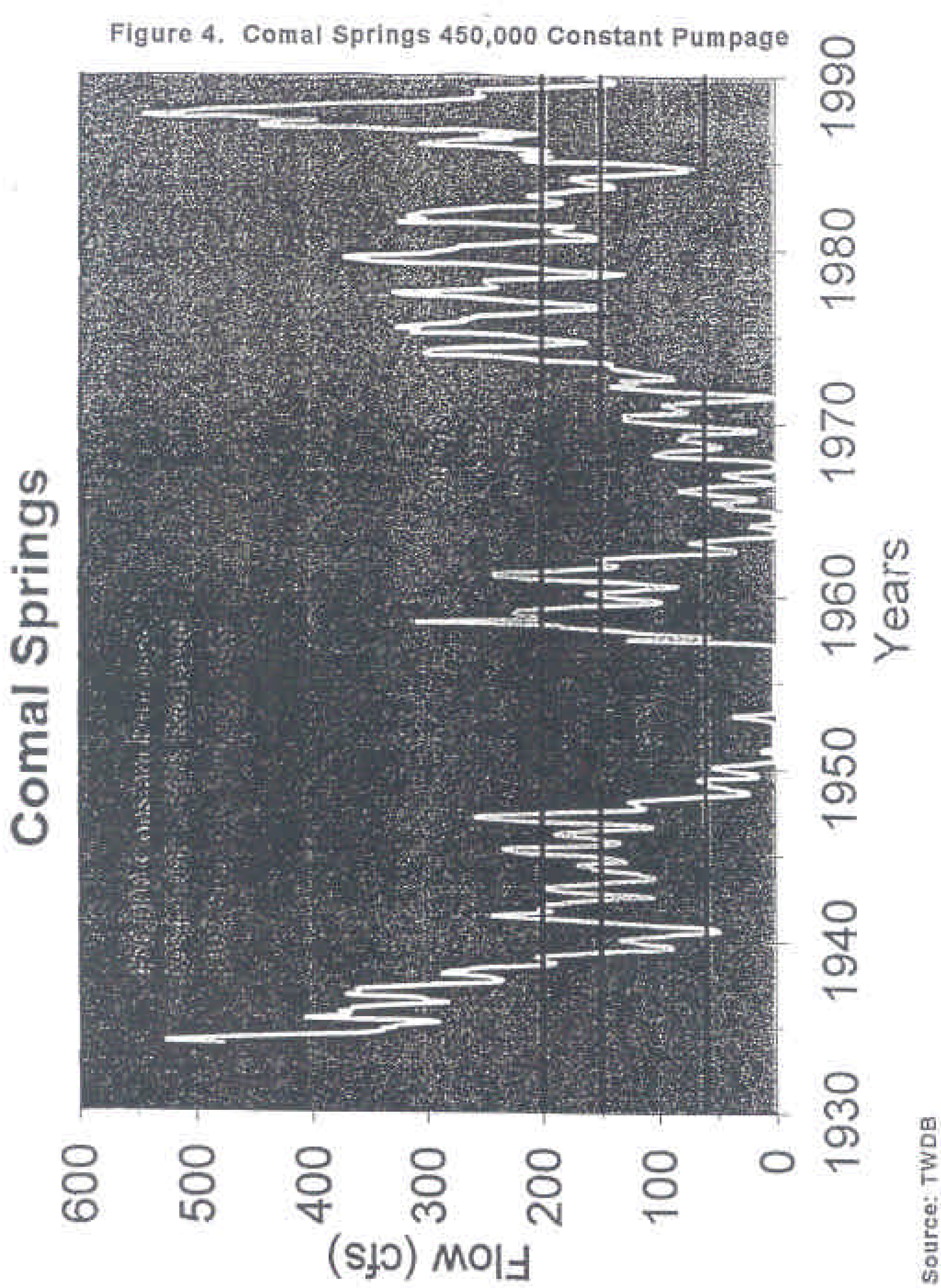
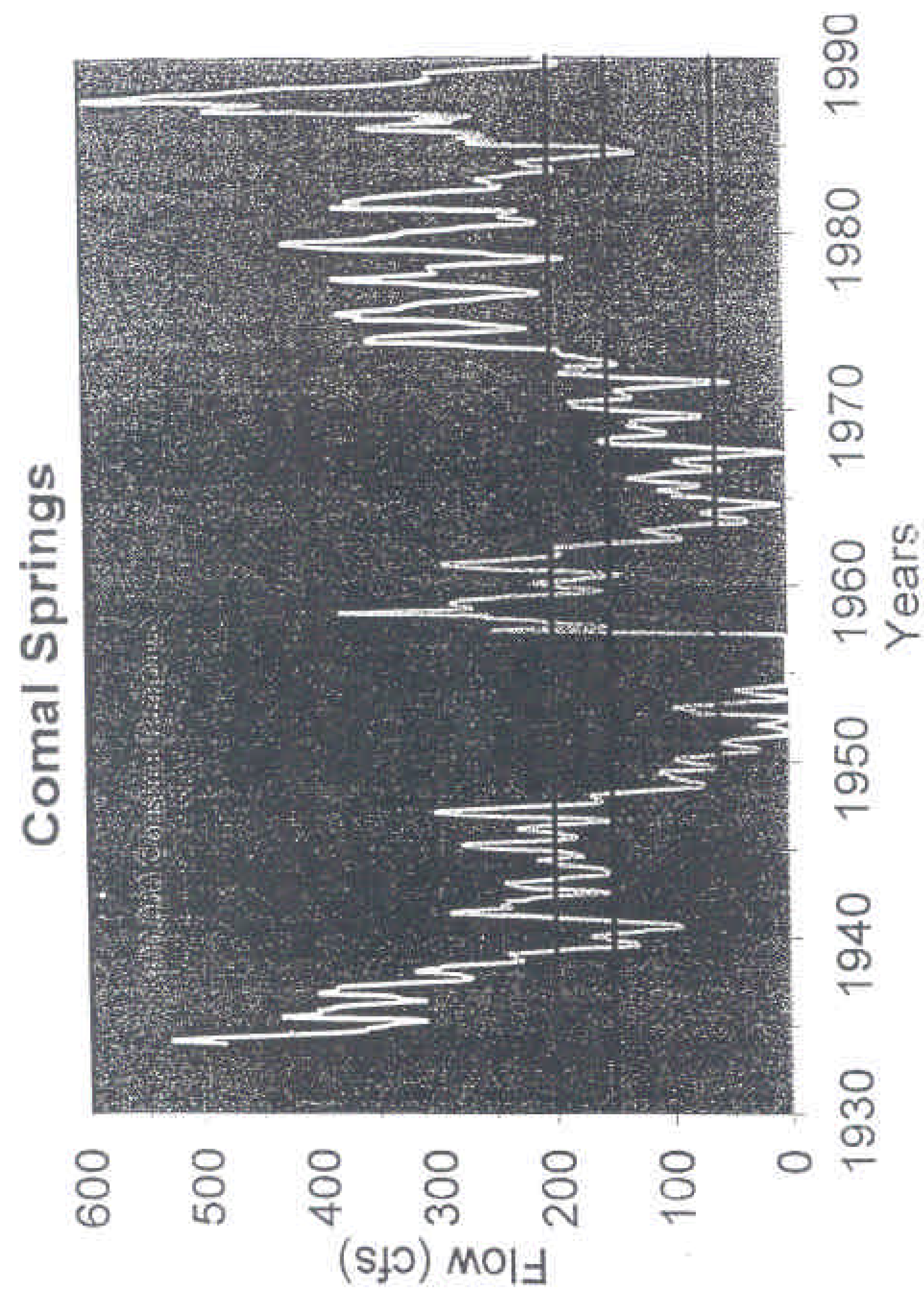


Figure 4. Comal Springs 450,000 Constant Pumpage
Comal Springs
Flow (cfs)
600
500
400
300
200
100
0
1930
1940
1950
1960
1970
1980
1990
Years
Source: TWDB

Figure 5

Figure 5. Comal Springs 400,000 Constant Pumpage



Source: TWDB

Figure 6

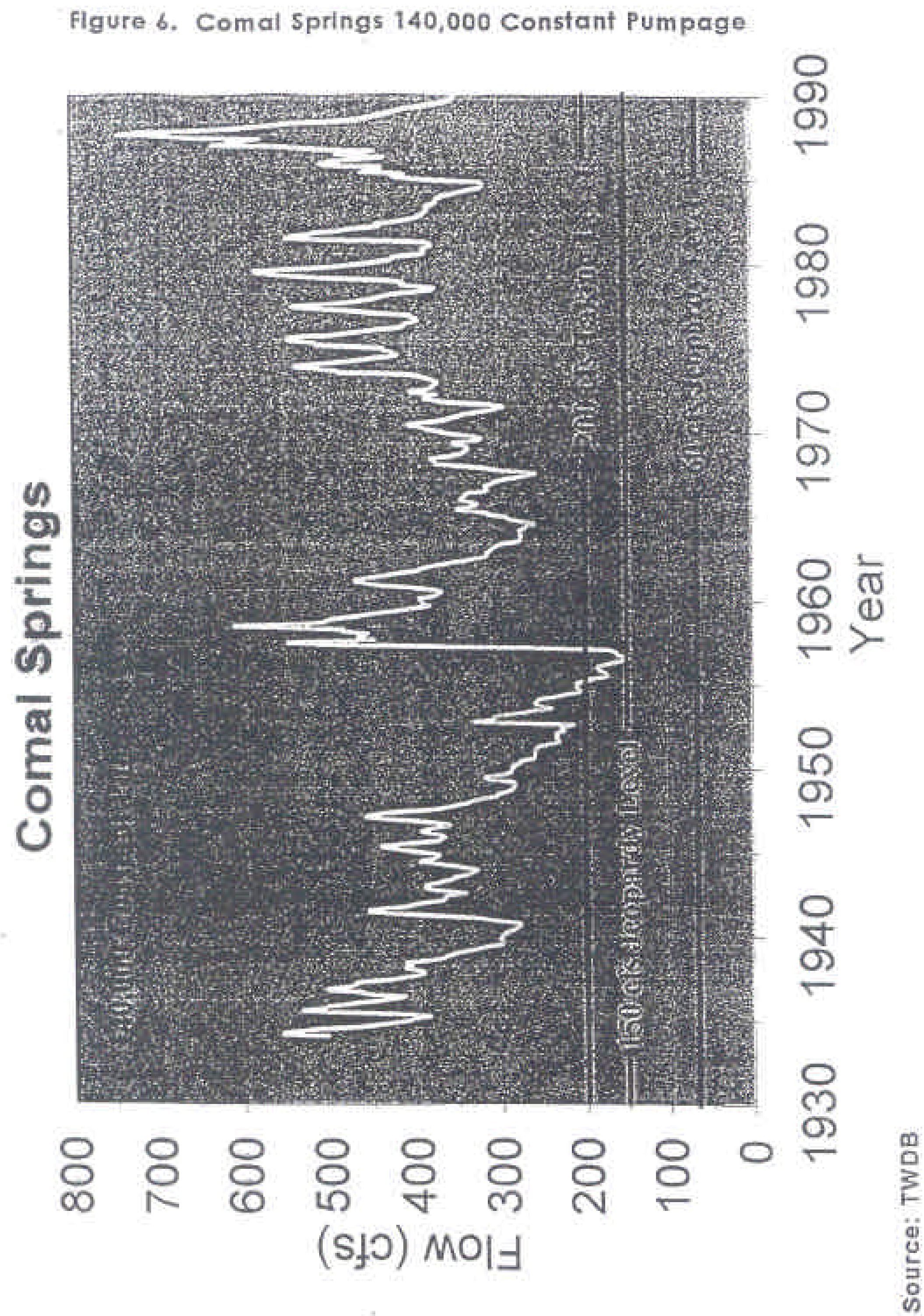


Figure 6. Comal Springs 140,000 Constant Pumpage
Comal Springs
Flow (cfs)
800
700
600
500
400
300
200
100
0
1930
1940
1950
1960
1970
1980
1990
Year
150 cfs Jeopardy Level
Source: TWDB

Cumulative Effects

Cumulative effects include the effects of future State, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

As the BA and recovery plan state a number of biological factors contribute to the continued risks to the species, including competition between non-native and native plants, introduced species, parasites, recreation, human population growth and development, and runoff; but one of the most significant cumulative impacts is that of groundwater withdrawal from the Edwards aquifer. Groundwater withdrawal has historically been based on a "right of capture." In 1993, the Texas legislature passed the EAA Act creating the Edwards Aquifer Authority with the authority to regulate groundwater withdrawal. Section 1.14 of the EAA Act indicates that authorizations to withdraw water from the aquifer shall be limited in accordance with that section to "protect species that are designated as threatened or endangered under applicable federal or state law" among other purposes. Except as provided in certain exceptions, the amount of withdrawals permitted may not exceed 450,000 ac-ft for each calendar year through December 31, 2007. For the period beginning January 1, 2008 the amount of permitted withdrawals may not exceed 400,000 ac-ft/year. In addition, the Authority "shall implement and enforce water management practices, procedures, and methods to ensure that, not later than December 31, 2012, the continuous minimum springflows of the Comal Springs and the San Marcos Springs are maintained to protect endangered and threatened species to the extent required by federal law." The Authority has been challenged by legal actions questioning EAA's authority, structure and rules. However, the Authority's board began operating in the summer of 1996, and in 1998 issued proposed interim withdrawal permits and began operating the Critical Period Management Plan prescribed in the EAA rules. On 1 December 1998, the 126th District Court (Travis County), invalidated the proposed withdrawal permits and the Critical Period Management Plan. It is expected that EAA will re-adopt rules, and re-issue permits. Under the EAA Act the Authority is also to develop and implement a comprehensive water management plan consistent with Section 1.14. In the interim, several local drought management plans are in operation and local communities have been undertaking some conservation actions including citizens planning groups, seeking alternative water supplies and other efforts. These actions have not been sufficient to decrease water withdrawals to a level that assures conservation of the listed species. In 1996, flows declined into the mid-80 cfs range in the Comal system and mid-70 cfs range in the San Marcos system. Additionally other local threats are likely to continue to occur, some of which will be exacerbated by low flows, further reducing the chances of conservation and recovery of the species.

Conclusion

After reviewing the current status of the fountain darter, Texas wild-rice, San Marcos gambusia, San Marcos salamander, Texas blind salamander, Comal springs riffle beetle, Comal springs dryopid beetle, and Peck's cave amphipod; the environmental baseline for the action area; the effects of ongoing and proposed actions of the four DOD installations (Fort Sam Houston, Kelly, Lackland, and Randolph AFBs) and the cumulative effects; it is the Service's biological opinion that as proposed, this action is not likely to jeopardize the continued existence of these species or to adversely modify designated critical habitat. The actions proposed as a part of this project to reduce reliance on groundwater withdrawal from the Edwards aquifer, implement stringent drought management plans, protect water quality, and fund conservation actions (including refinement of the Edwards aquifer model) will reduce the impacts of the four DOD installation's actions on the species. The Service believes these actions are in proportion to the four DOD installations' overall average historic water use and represent their fair share of reducing those overall impacts over the time covered by this consultation (November 1999 - December 2003). The Service believes the reductions in Edwards aquifer water use from the historical average pumped by the four bases to those identified in this biological opinion represents a reasonable goal for the four DOD installations to meet in the time frame covered by this consultation. However, as evidenced by the figures presented, further water withdrawal reductions will be needed beyond the time frame covered by this consultation to reduce the probability of the species extinctions due to low spring flows to an acceptable low level (as well as to provide minimum continuous springflows at Comal and San Marcos springs as called for in the EAA Act). It is possible that by December 2003 the EAA may have completed a comprehensive aquifer management plan and habitat conservation plan that can form the basis for a region wide ESA incidental take permit application that will cover water use by the entire region. Federal agencies such as DOD must still comply with section 7(a)(2) consultation requirements of the ESA. The Service will need to determine whether DOD is in compliance with the regional permit. If it is determined that DOD is not covered under the region wide habitat conservation plan and incidental take permit, an individual section 7 consultation may be necessary. We recommend DOD participate or partner in the development of the Habitat Conservation Plan to ensure DOD’s coverage.

This non-jeopardy conclusion is based in large part on DOD's commitment to expeditiously reduce their reliance on withdrawals from the Edwards aquifer to an amount not to exceed 11,830 acre-ft/yr for the calendar year 2000 and 2001 and not to exceed 10,515 acre-ft/yr for each calendar year 2002 and each year beyond until the end of the time covered by this consultation, December 31, 2003; and in the interim to take those actions outlined in the description of the proposed action (implementing stringent drought management plans, seeking and using alternative water sources, working with appropriate partners to improve the Edwards aquifer model). These interim actions will increase the species' chances of making it through a repeat episode of temporary low spring flows in the interim before a region wide management plan is implemented that assures the species are not jeopardized and that critical habitat is not adversely modified.

INCIDENTAL TAKE

Incidental Take

Section 9 of the ESA, and Federal regulation pursuant to section 4(d) of the ESA as amended, prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering. Incidental take is any take of listed animal species that results from, but is not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or the applicant. Under the terms of sections 7(b)(4) and 7(o)(2) of the ESA, taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with an Incidental Take Statement.

The measures described below as reasonable and prudent measures and terms and conditions in this biological opinion are non-discretionary and must be undertaken by DOD so that they become binding conditions of any condition of any grant or permit issued to DOD, as appropriate, in order for the exemption in section 7(o)(2) to apply. DOD and the four installations (Fort Sam Houston, Kelly, Lackland, Randolph) have a continuing duty to regulate the activity covered by this incidental take statement. If DOD and the four installations (1) fail to assume, implement, or adhere to the terms and conditions of the incidental take statement, and/or (2) fail to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, DOD and the four installations must report the progress of the action and its impacts on the species to the Service as specified in the incidental take statement. [50 CFR §402.14(i)(3)]

Even though the Service expects that groundwater withdrawals that are facilitated by the ongoing and proposed actions of DOD's four installations will contribute to incidental take of fountain darters, San Marcos gambusia, and Comal Springs riffle beetle, and possibly Texas blind salamander, San Marcos salamander, Comal Springs dryopid beetle, and Peck's cave amphipod, the best scientific and commercial data available are not sufficient to enable an estimate of a specific amount of incidental take to the species. In instances such as these, the Service has designated the expected level of take as unquantifiable. The Service is willing to provide DOD with an incidental take statement for the Texas blind salamander, San Marcos salamander, Comal springs dryopid beetle, and Peck’s cave amphipod because although DOD cannot avoid jeopardizing the species by themselves, because they do not control pumping over the entire aquifer region the actions described in this BO that DOD has committed to do represent their "fair share" of the overall picture needed to minimize take and avoid jeopardy and reduce the risk of species extinction. Equivalent efforts to reduce withdrawals, and provide springflow for the listed species, and minimize and mitigate any take, and reduce the risk of jeopardizing the species or adversely modifying their critical habitats to low levels is the responsibility of all pumpers. If a habitat conservation plan were developed and implemented by a regional permit applicant designed to avoid jeopardy to all species (a permit requirement) then the take of the Texas blind salamander, San Marcos salamander, Comal Springs dryopid beetle, and Peck's cave amphipod would not likely occur.

Sections 7(b)(4) and 7(o)(2) of the ESA generally do not apply to the incidental take of listed plant species like Texas wild-rice. However, protection of listed plants is provided to the extent that ESA prohibits the removal, reduction to, and possession of Federally listed endangered plants or the malicious damage of such plants on areas under Federal jurisdiction, or the destruction of endangered plants on non-Federal areas in violation of State law or regulation or in the course of any violation of a State criminal trespass law.

This biological opinion does not authorize any form of take that is not incidental to the withdrawal of Edwards aquifer groundwater by the four DOD installations, in the authorized water withdrawal amounts specified and in conjunction with other take minimizing measures described in this biological opinion.

Effect of Take

In this biological opinion, the Service determined that this unquantifiable level of anticipated take from DOD's actions is not likely to result in jeopardy to the fountain darter, Texas wild-rice, San Marcos gambusia, San Marcos salamander, Texas blind salamander, Comal springs riffle beetle, Comal springs dryopid beetle, and Peck's cave amphipod or the destruction or adverse modification of critical habitat for these species.

Reasonable and Prudent Measures

The Service believes that the reasonable and prudent measures presented below are necessary and appropriate to minimize the incidental taking authorized by this biological opinion.

1. Progressively reduce DOD's four installations (Kelly AFB, Fort Sam Houston, Lackland AFB, and Randolph AFB) dependence on Edwards aquifer groundwater within the time frame covered by this consultation (November 1999 to December 2003); implement water conservation measures and other alternative water sources to reduce Edwards aquifer water withdrawals to DOD's fair share of 450,000 acre-ft/yr (that is, 11,830 ac-ft) for the calendar year 2000 and 2001 and not to exceed DOD's fair share of 400,000 acre-ft/yr (that is, 10,515 ac-ft) for calendar year 2002 and each year beyond until the end of the time covered by this consultation, December 31, 2003.

DOD and the four installations will evaluate their performance in achieving the necessary cutbacks in Edwards aquifer use and make the necessary adjustments to meet those levels, and manage and accommodate growth and increased water needs without surpassing these permitted levels.

2. Implement a significant Drought Management Plan on all four DOD installations as outlined in Table 10 at the appropriate J-17 well levels or springflows and evaluate its adequacy. During increasing springflows or aquifer levels, each stage will be in effect for 10 consecutive days unless a more restrictive stage is implemented and will not be rescinded until the 10 day rolling (moving) average of the J-17 index well and springflow levels triggers a less restrictive stage.

3. Partner with the appropriate parties to help develop and refine the Edwards aquifer computer model for technical analysis of the aquifer and springs' responses to various pumping regimes and optimization alternatives. This should assist in avoiding and/or reducing impacts to species and their habitats by improving the ability region-wide to manage for aquifer levels and springflows necessary to avoid jeopardy and minimize take.

4. Actively promote public information and education on water use, quantity, quality, and conservation efforts. Monitor and include in annual report the progress and effectiveness of such programs implemented.

5. Encourage partnerships among the installations and other Edwards aquifer users, such as local, regional, state, and Federal agencies and other private or public entities for cooperative efforts to manage the Edwards aquifer waters in a way that provides for continuous spring flows needed by the endangered and threatened species.

6. Investigate alternative sources of water, particularly for longer-term additional reductions beyond the 4-year life of this biological opinion.

7. All Reasonable and Prudent Measures except for # 1 and 2 of the Kelly biological opinion (#2-15-97-F-039) are still in effect. (Appendix B) Numbers 1 and 2 are recalculated, revised, and considered in this four base biological opinion.

8. Submit all annual reports to U.S. Fish and Wildlife Service, 10711 Burnet Rd., Suite 200, Austin, TX 78758. Annual reports are due on February 28th of each year covered by this biological opinion. The first report will be due 2/28/2000 for part of 1999 covered under this opinion and the last report will be due 2/28/2004 for calendar year 2003.

Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, DOD and the four installations are responsible for compliance with the following terms and conditions, which implement the reasonable and prudent measures described above.

1. DOD will implement water conservation measures and other alternative water sources to reduce the DOD's four installations (Kelly, Fort Sam Houston, Lackland, and Randolph) Edwards aquifer water withdrawals, within the time frame covered by this consultation (November 1999 to December 2003). Withdrawals of all bases combined are not to exceed 11,830 acre-ft/yr for the calendar years 2000 and 2001 and are not to exceed 10,515 acre-ft/yr for calendar year 2002 and each year beyond until the end of the time covered by this consultation, December 31, 2003. DOD and the four installations will evaluate their performance in achieving the necessary cutbacks in Edwards aquifer use and make the necessary adjustments to meet those levels. Management must accommodate for growth and increased water needs without surpassing these permitted levels. Future needs for additional water may be accommodated through such mechanisms as purchasing or leasing water rights from others, using reuse water, and seeking alternative water sources. Construction, intra- or inter-water basin water transfers or other activities associated with potential future mechanisms for decreasing Edwards aquifer withdrawals may result in impacts to endangered species. Therefore, each project will need to be evaluated separately for impacts to federally listed species and determinations made whether these mechanisms and/or projects are in compliance with the ESA and if re-consultation would be necessary. If DOD or the four installations covered by this consultation fail to demonstrate satisfactory progress (as determined by the Service and/or not meeting these targets) toward reducing pumping demands on the Edwards aquifer, DOD will reinitiate formal consultation with the Service.

2. Implement a significant Drought Management Plan on all four bases as outlined in Table 10 and evaluate its adequacy. If after the specified number of days the springflow (cfs) level has dropped to or below the Service's recommended trigger level, but the J-17 well level has not triggered the respective stage, then the cfs springflow level will supercede the J-17 index well aquifer level as a trigger and the next stage will be implemented. Each stage will be in effect for 10 consecutive days unless a more restrictive stage is implemented and will not be rescinded until the 10 day rolling (moving) average of the J-17 index well and springflow levels triggers a less restrictive stage. To meet Stage V reductions, future non-discretionary water demand from the aquifer should not exceed that necessary to meet Stage V limits. Monitor the effectiveness of the drought management plan and include in the annual report to the Service.

3. Partner with the appropriate parties and contribute $262,877.00 to the development and/or refinement of the Edwards aquifer computer model so that the model provides a more accurate tool for predicting springflows based on various aquifer levels and aquifer management scenarios and coordinate with the Service and EAA throughout the process. The model should be more user-friendly and readily available for use by those involved in aquifer management, or assessment of effects of pumping and or aquifer management alternatives. For further information refer to the study recommended by the Technical Advisory Group titled Modflow Computer Model/GIS Data Sets. The project will be initiated and funds made available no later than twelve (12) months after issuance of this BO. Progress should be reported in the annual report to the Service and at completion of the project.

4. Design and implement a voluntary program or partner with EAA, SAWS, and/or other organizations to educate and assist employees achieve water conservation on base and off base at personal residences. Such program activities could include information on such things as retrofitting with low flow toilets and shower heads or xeriscaping.

5. DOD and the four installations will work with other aquifer users and participate in regional aquifer management planning to develop a comprehensive approach to aquifer management that avoids jeopardizing the species and avoids adversely modifying their critical habitat and minimizes and mitigates negative impacts to the species and their ecosystems as much as possible. Progress will be summarized in the annual report to be submitted February 28th of each year covered by this biological opinion.

6. Investigate and partner with appropriate parties to find alternative sources of water that will yield longer-term, additional reductions of water beyond the life of this biological opinion.

7. All Reasonable and Prudent Measures except for #1 and 2 and all Terms and Conditions except for # 2, 4, 5, and 12 of the Kelly biological opinion (2-15-97-F-039) are still in effect (Appendix B). Terms and Condition numbers 2, 4, 5, and 12 have been recalculated, revised and considered in this four base biological opinion.

8. DOD will submit annual reports informing the Service of progress made to meet the Reasonable and Prudent Measures and Terms and Conditions set forth in this biological opinion and the effectiveness of those activities for the length of the permit. The reports should include total annual water withdrawal for each of the four installations, broken down on a monthly basis. The report should also include discussion of the public outreach program, progress on refined Edwards aquifer model, progress on funding and implementing measures to reduce Edwards water use, and the Drought Management Plan to show necessary progress and effectiveness of implemented measures to prevent jeopardy to the species and minimize impacts to the species during times of drought and low spring flows. Annual reports should be sent to the U.S. Fish

and Wildlife Service, 10711 Burnet Rd., Suite 200, Austin, TX 78758 and due February 28th of each year covered by this biological opinion.

9. DOD will submit the report required by the Kelly AFB biological opinion combined with that required by Term and Condition # 8 of this four base biological opinion. This report should include discussion of the IRP remediation effort at Kelly AFB, Edwards well monitoring program, and any other water quality issues.

10. DOD will maintain responsibility for assuring these terms and conditions and measures are accomplished during the time frame covered by this consultation. If EAA completes a comprehensive aquifer management plan and habitat conservation plan that can form the basis for a region wide ESA incidental take permit application that will cover water use by the entire region the Service will determine whether DOD is in compliance with the regional permit. If it is determined that DOD is not covered under the region wide habitat conservation plan and incidental take permit, an individual section 7 consultation will be necessary regarding impacts to the listed species and their critical habitats from any continued DOD Edwards aquifer water use beyond the time frame covered by this consultation.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. The term conservation recommendations has been defined as Service suggestions regarding discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or develop information. The Service makes these conservation recommendations:

1. Further reduce water dependency beyond the levels set in this biological opinion. (Task 2.31 of Recovery Plan)

2. Provide extra protective measures for aquifer-dependent species either by contributing directly to projects on the Edwards aquifer project list (Appendix A) or by contributing to a Conservation Fund set up for the conservation of these species. (Task 2.31 of Recovery Plan)

3. Assist in identifying and sampling Edwards wells that may be causing entrainment of two species of blind catfish (two unlisted species of concern, which could become candidates for listing) and consider them for closure and/or assist in developing a method for preventing entrainment.

4. Assist with habitat and flow requirement studies of the listed species as needed (may include such things as assisting in fieldwork, or flying over and taking aerial photographs to monitor vegetation). (Task 1.15 in Recovery Plan)

5. Study of recharge enhancement potential on base, including effects on water quality and native fauna in recharge features.

6. Take samples of sediments in recharge features and check for contaminants.

7. Contribute to captive propagation efforts.

8. Provide mechanical and technical assistance in the modification and/or repair of Cape's Dam (and possibly others) on the San Marcos river so that they are modified to manage water in the river in such a way that best provides for the species and their habitats.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

REINITIATION

This concludes formal consultation on the ongoing and proposed actions at four DOD installations. Reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained and if: 1) DOD and the four installations fail to demonstrate progress toward reducing pumping demands on the Edwards aquifer; 2) Edwards aquifer water withdrawals exceed those outlined in the reasonable and prudent measures; 3) information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this biological opinion. An example here would be if EAA did not meet its legal mandates for regulating aquifer withdrawals as discussed in the Cumulative Effects section of this opinion, in which case the cumulative effects would be greater than considered in this opinion; 4) the agency action is subsequently modified in a manner that causes an effect to a listed species or critical habitat that was not considered in this biological opinion; or 5) a new species is listed or critical habitat designated that may be affected by this action (50 CFR 402.16).

In future communications on this project, please refer to consultation number 2-15-98-F-759. If we may be of further assistance, please contact Mary Orms, Alisa Shull, or me at (512/490-0057).

Sincerely,

/s/ William Seawell
for

David C. Frederick
Supervisor

Attachments

LITERATURE CITED

Ball, J., W., Brown, and Kuehne. 1952. Landa Park Lake is renovated. Texas Game and Fish 10:8-10

Barr, C.B. 1993. Survey for two Edwards aquifer invertebrates: Comal Springs dryopid beetle *Stygoparnus comalensis* Barr and Spangler (Coleoptera:Dryopidae) and Peck's cave amphipod *Stygobromus pecki* Holsinger (Amphipoda:Crangonyctidae). Prepared for U.S. Fish and Wildlife Service. 70 pp.

Barr, C.B., and P.J Spangler. 1992. A new genus and species of stygobiontic dryopid beetle, *Stygoparnus comalensis* (Coleoptera:Dryopidae), from Comal Springs, Texas. Proc. Biol. Soc. Wash. 105(1):40-54.

Beaty, H.E. 1975. Texas wild-rice. Texas Horticulturist 2(1):9-11.

Bergin, S.J. 1996. Diet of the fountain darter, *Etheostoma Fonticola* in the Comal River, Texas. M.S. Thesis, Southwest Texas State University.

Bonner, T.M., T.M. Brandt, J.N. Fries, and B.G. Whiteside. 1998. Effects of temperature on egg production and early life stages of the fountain darter. Transactions of the American Fisheries Society 127: 971 - 978.

Bosse, L.S., D.W. Tuff. and H.P. Brown. 1988. A new species of *Heterelmis* from Texas (Coleptera:Elmidae). Southwestern Naturalist 33(2):199-203.

Brown, D.S., B.L. Petri, and G.M. Nalley. 1992. Compilation of hydrologic data fro the Edwards aquifer, San Antonio area, Texas, 1991, with 1934-91 summary. U.S. Geological Survey Bulletin 51., 18 pp.

Brown. David S., and Joan T. Patton. 1996 Recharge to and discharge from the Edwards aquifer in the San Antonio area, Texas, 1995. U.S. Geological Survey Open-File Report 96-181, 2 pp.

Buszka, Paul M. 1987. Relation of water chemistry of the Edwards aquifer to hydrogeology and land use, San Antonio region, Texas. U.S. Geological Survey Water-Resources Investigation Report 87-4416, 100 pp.

Chapman, R.F. 1982. The Insects: Structure and Function. Harvard University Press, Cambridge, MA. 919 pp.

Emery, W.H.P. 1967. The decline and threatened extinction of Texas wild-rice (*Zizania texana* Hitchc.). The Southwestern Naturalist 12:203-3204.

Emery, W.H.P. 1977. Current status of Texas wild-rice. The Southwestern Naturalist 22:393-394.

Emery, W.H.P., and M.N. Guy. 1979. Reproduction and embryo development in Texas wild-rice (Zizania texana Hitchc.). Bulletin of the Torrey Botanical Club 106:29-31.

Guyton and Associates. 1979. Geohydrology of Comal, San Marcos, and Hueco Springs. Tex. Dept. Water Res. Rep. 234. 85 pp.

Harper, J. 1977. Population Biology of Plants. Academic Press, New York.

Hubbs, C. and A.E. Peden. 1969. *Gambusia georgei* sp. nov. from San Marcos, Texas. *Copeia* 1969 (2):357-364.

Kipp, Gayle K., Philip T. Farrington, and Michael J. Albach. 1993. Urban development on the Edwards aquifer recharge zone. Staff report to the Edwards Underground Water District Board of Directors, 80 pp.

Klemt, W.B., T.R. Knowles, G.R. Elder, and T.W. Sieh. 1979. Ground-water resources and model applications for the Edwards (Balcones Fault Zone) Aquifer in the San Antonio Region, Texas. Tex. Dept. Water Resources Rep. 239, 88 pp.

Linam, L.A. 1993. A reassessment of the distribution, habitat preference, and population size estimate of the fountain darter (Etheostoma fonticola) in the San Marcos River, Texas. Section 6 report, Texas Parks and Wildlife Department, Job 2.5. March 12, 1993. 34 pp.

Longley, G. 1975. Environmental assessment, upper San Marcos River Watershed. Contract No. AG-48-SCS 02156 for the Soil Conservation Service. Environmental Sciences of San Marcos, Texas. 367 pp.

Longley, G. 1978. Status of the Texas Blind Salamander. Endangered Species Report 2. U.S. Fish and Wildlife Serv., Albuquerque, NM. 45 pp.

Madsen, T. V., and M. Sondergaard. 1983. The effects of current velocity on the photosynthesis of *Callitriche stagnalis* Scop. Aquatic Botany, 15:187-193.

McKinney, D.C. and D.W. Watkins. 1993. Management of the Edwards Aquifer: A critical assessment. Bureau of Engineering Research, University of Texas at Austin, Balcones Research Center, Austin, Texas 78712. 94 pp.

McKinney and J. Sharp. 1995. Springflow augmentation of Comal Springs and San Marcos Springs, Texas: phase I-feasibility study. Texas Water Development Board.

Nelson, J. 1993. Population size, distribution, and life history of *Eurycea nana* in the San Marcos River. M.S. Thesis, Southwest Texas State University, 43 pp.

Poole, J. and D. Bowles. l996. Texas wild-rice (Zizania texana Hitchcock) habitat characterization. Final Section 6 Project Report. Texas Parks and Wildlife Project number 49. U.S. Fish and Wildlife Service files, Austin, Texas.

Power, P. l990. Effects of oxygen concentration and substrate on seed germination and seedling growth of Zizania texana (Texas wild-rice). Unpublished Masters Thesis, Southwest Texas State University, San Marcos, Texas 36 pp.

Power, P. and P. Fonteyn. l995. Effects of oxygen concentration and substrate on seed germination and seedling growth of Texas wild-rice (Zizania texana)

Prins, A.B., and J.T. Elzenga. 1989. Bicarbonate utilization: function and mechanism. Aquatic Botany, 34:59-83.

Reeves, R.D. 1976. Chemical and bacteriological quality of water at selected sites in the San Antonio area, Texas, August 1968 - January 1975. Edwards Underground Water District Report, 122 pp.

Rice, G. 1994. Contamination of the Edwards aquifer in Bexar County. AGUA report. San Antonio, Texas. 25pp.

Roddy, W.R. 1992. Water quality of the Edwards Aquifer and streams recharging the aquifer in the San Antonio region, Texas. U.S. Geological Survey, Hydrologic Investigations Atlas HA-723, 3 sheets.

Rose, F.L., and P.J. Power. 1992. Effects of habitat and herbivory on growth and reproduction in Texas wildrice (*Zizania texana*). Report submitted to the U.S. Fish and Wildlife Service, Region 2.

Russell, B. 1976. Distribution of Troglobitic Salamanders in the San Marcos area, Hays County, Texas. Texas Association for the Biological Investigations of Troglobitic *Eurycea* (BITE) Report 7601. 35 pp.

Schenck, J.R., and B.G. Whiteside. 1976. Distribution, habitat preference and population size estimate of *Etheostoma fonticola*. *Copeia* 1976(4):697-703.

Schenck, J.R., and B.G. Whiteside. 1977a. Food habits and feeding behavior of the fountain darter, *Etheostoma fonticola* (Osteichthyes:Percidae). The Southwest Naturalist 21(4):487-492.

Schenck, J.R., and B.G. Whiteside. 1977b. Reproduction, fecundity, sexual dimorphism and sex ratio of *Etheostoma fonticola* (Osteichthyes:Percidae). The American Midland Naturalist 98(2):365-375.

Seal, U. S. (Editor) IUCN/SSC Conservation Breeding Specialist Group. l996. Draft Report of Edwards Aquifer Workshop, San Marcos Texas, 28-31 October. IUCN/SSC Conservation Breeding Specialist Group: Apple Valley, MN.

Seal, U. S. and Ellis, S. (Eds.) 1997. *Fountain Darter Working Group. Discussion Notes (Revised).* Austin Texas, 19 November. IUCN/SSC Conservation Breeding Specialist Group: Apple Valley, MN.

Seal, U. S. and Ellis, S. (Eds.) IUCN/SSC Conservation Breeding Specialist Group. l997. Texas wild-rice working group. discussion notes (revised). Austin Texas, 21 Nov. l996. IUCN/SSC Conservation Breeding Specialist Group: Apple Valley, MN.

Sebens, K. and B. Thorne. l985. Coexistence of Clones, Clonal Diversity, and Disturbance. In: Population Biology and Evolution of Clonal Organisms. B. Jackson, L. Buss, and R. Cook, eds. Yale University Press, New Haven.

Silander, J., Jr. l985. Microevolution in Clonal Plants. In: Population Biology and Evolution of Clonal Organisms. B. Jackson, L. Buss, and R. Cook, eds. Yale University Press, New Haven.

Silveus, W.A. 1933. Texas grasses. The Clegg Col, San Antonio, Texas. 782 pp.

Strawn, K. 1955. A method of breeding and raising three Texas darters. Part I. Aquarium J. 26:408-412.

Strawn, K. 1956. A method of breeding and raising three Texas darters. Part II. Aquarium J. 27:11, 13-14, 17, 31-32.

Terrell, E.E., W.H.P. Emery, and H.E. Beatty. 1978. Observations on Zizania texana (Texas wild-rice), an endangered species. Bulletin of the Torrey Botanical Club 105:50-57.

Texas Department of Water Resources (TDWR). 1977. Continuing water resources planning and development for Texas. Phase I. Draft

Texas Parks and Wildlife Department (TPWD) 1989. Interim report on conservation of the upper San Marcos ecosystem: Texas wild-rice (Zizania texana). Submitted to U.S. Fish and Wildlife Service, Region 2.

Texas Parks and Wildlife Department (TPWD) 1994. Section 6 interim performance report. Project 38-management and continued research on Texas wild-rice (Zizania texana). Submitted to U.S. Fish and Wildlife Service, Region 2.

Texas Water Development Board (TWDB). 1968. Reconnaissance of the chemical qualities of the surface waters of the Guadalupe River Basin, Texas. Report 88. Austin, Texas.

Texas Water Development Board (TWDB). 1992. Water for Texas: Today and Tomorrow. Austin, Texas.

U.S. Bureau of Reclamation (USDI). 1972. Memorandum: San Marcos Pool of Edwards Underground Aquifer. Bureau of Reclamation (Southwest Region). 8 pp.

U.S. Bureau of Reclamation (USDI). 1973. Memorandum: Performance of Edwards Aquifer when subjected to a rapid increase in well discharge. Bureau of Reclamation (Southwest Region). Looseleaf n. p.

U.S. Bureau of Reclamation (USDI). 1974. Memorandum: Performance of Edwards Aquifer when subjected to increasing well discharge. Bureau of Reclamation (Southwest Region). Looseleaf n. p.

U.S. Fish and Wildlife Service (USFWS). 1996. San Marcos & Comal Springs & Associated Aquatic Ecosystems (Revised) Recovery Plan. Albuquerque, New Mexico. 121 pp.

Vaughan, Jr., J.E. 1986. Population and autecological assessment of Zizania texana Hitchc. (Poaceae) in the San Marcos River. Masters Thesis, Southwest Texas State University.

Wanakule, N. 1988. Regression analysis of the San Marcos Springflows and water levels of the index well in San Antonio. Edwards Aquifer Research and Data Center No. R1-88. San Marcos, Texas. 34 pp.

Wanakule, N. 1990. Stochastic drought analysis of the Edwards Aquifer. Edwards Aquifer Research and Data Center No. R1-90, San Marcos, Texas. 32 pp.

Whiteside, B.G., A.W. Groeger, P.F. Brown, and T.C. Kelsey. 1994. Physicochemical and fish survey of the San Marcos River. Southwest Texas State University, San Marcos.

Appendix A.

Edwards Aquifer Projects

Edwards Aquifer Projects

The Service has expressed concern that the deterioration of water quality and/or the combined current level of water withdrawal for all consumers from the Edwards Aquifer adversely affects aquifer-dependent species located at Comal and San Marcos Springs under low flow conditions. The main actions necessary to avoid jeopardy to these species and minimize take from aquifer withdrawals are those measures necessary to assure adequate springflows for the listed species. However, the Service recognizes that to put sufficient measures in place to assure those spring flows will take time. Therefore, while expeditious progress needs to be made to put measures in place to assure adequate springflows, in the meantime, measures will be needed to minimize take and increase the species' chances of making it through low flows and recovering from impacts. The attached menus include very abbreviated explanations of projects that can be considered by parties involved in Section 7 consultations and/or Section 10 (a)(1)(B) Habitat Conservation Plans to meet part of the requirements for minimizing and/or mitigating take,, monitoring, adaptive management, and other measures that would benefit conservation. Monitoring and adaptive management provisions should be included as part of any HCP for Edwards Aquifer dependent species. Some of this work has been initiated, but additional work and funding is needed to complete. The Service should be consulted for further details. Each project on this list has been assigned a point value (based primarily on relative cost). The total of all of these points = 10,000.

Menu A. Additional measures to minimize and mitigate take

The items in Menu A. are focused primarily on reducing take during low flows and mitigating take through restoration efforts. Some items represent projects to fill information gaps to better manage (1) springflows so that adequate springflows ran be provided, (2) impacts to species during low flows to further reduce those impacts, (3) restoration efforts, increasing their likelihood of success.

la. Research on Restoration and Reintroduction of Texas wild-rice (150 pts.)

- research is needed to develop and test specific habitat restoration and reintroduction techniques for Texas wild-rice

lb. Reintroduction, restoration, and management of Texas wild-rice (215 pts.)

- aimed at increasing total areal coverage of wild-rice to increase the chances of making it through short periods of low flow and decrease the proportion of the population affected

2a. Restoration of aquatic vegetation (150 pts.)

- techniques must be developed and tested for habitat restoration

2b. Vegetation restoration after low flow events (200 pts.)

- aimed primarily at restoring habitat for fountain darters and their prey base

3. What causes vegetation loss during low flow? (303 pts.)

- research to determine cause(s) of vegetation loss, devise management methods to prevent it if possible, and assist in developing restoration techniques to promote vegetation recovery.

4a. Control structure repair/modification (350 pts.)

- modification and/or repair of a number of water control structures (such as low water dams) to improve the ability to move water to those areas that have the best remaining habitat as flows decline.

4b. Improve water control structures and optimize management (50 pts.)

- in some cases additional research may be necessary to determine optimum redesign of structure

5. Captive propagation (5,147 pts.)

- for restoration work a good genetically representative captive stock is needed
- research is needed to develop reliable captive breeding and reintroduction protocols
- equipment needs
- operation needs

6. Genetic diversity and distribution information (225 pts.)

- this information for wild populations is critical to a number of management concerns, impact assessments, and mitigation design

7. Control and management of exotic plant species (50 pts.)

- develop and test techniques to remove and possibly replace invasive exotic aquatic plants that are increasing at the expense of Texas wild-rice or other native plant species and that could hamper restoration efforts

Information gaps

1. **GIS localities for Texas wild-rice** (15 pts.)

2. Parasites

    a. Active management needed to address the impact to fountain darter's condition (200 pts.)
    b. Parasite life history, population dynamics, and management research (200 pts.)

3. **Physiological requirements of Texas wild-rice** (100 pts.)

4. **Texas wild-rice conditions for sexual reproduction** (100 pts.)

5. **More accurate model (hydraulic) of San Marcos** (150 pts.)

   - This model will help design and evaluate management options related to effects on surface habitat such as water depths and velocities. For example, it could be used to assess potential habitat available for Texas wild-rice under various flows, information useful for planning reintroduction efforts.

6. **More accurate Edwards Aquifer model to predict springflows** (200 pts.)

7. **Improve knowledge of the geohydrology in the San Marcos region** (1,000 pts.)

   - additional information is needed on flow paths, flow barriers, and regional/local recharge and discharge features

   Impacts of snails and other exotic species and development of control techniques (540 pts.)

<u>Additional water withdrawal reductions</u>
Funds may also be put in reserve to be used to purchase or lease water rights to reduce withdrawals below required cutback levels from those who are in compliance with required cutback levels.

Menu B. Monitoring

1. **Species and habitat monitoring** (325 pts.)

2. **Improve ability to accurately monitor flows**

    a. improve accuracy of USGS gage just below Spring Lake (80 pts.)

b. establish discharge monitoring (gage) on old (original) channel of Comal River (175 pts.)

c. establish a monitor well in San Marcos to correlate aquifer level and springflow (75 pts.)

Menu C. Optional Items

These items may provide a conservation benefit to the species and/or their habitat, and in some cases may influence flow requirements and/or impacts to the species during low flows.

1 . **Exotic (non-native) and predator species control** (1,250 pts.)

2. **Relationship of stage/head of spring Lake to San Marcos springs discharge, particularly at low aquifer levels** (30 pts.)

3. **Floating mats of vegetation** (36 pts.)

- involves both a program of reducing mats (through better vegetation management) and active, but careful, removal of mats that form in the San Marcos River system; may also be needed in Comal River system

4. **Improve local water quality (surface and nearby recharge)** (500 pts.)

- may include identifying sources of pollutants from site-specific areas (including surface and subsurface sources of pollutants) and assisting in developing and implementing comprehensive watershed management plans (particularly in the local San Marcos and New Braunfels areas), mechanisms for addressing pollutants

6. **Rivers Recreation Master Plan - develop and implement** (200 pts.)

7. **Recreational impacts and management options** (125 pts.)

- additional studies are needed to further delineate direct and indirect recreational impacts on the listed species

8. **Work with adjacent landowners to reduce threats** (70 pts.)

- landowner education program to inform and request their cooperation in implementing best management practices to protect and improve river conditions; could include pesticide and herbicide use, wastewater system conditions, bank erosion, aquatic plan management, recreational practices, etc.

Appendix B

Excerpts from Kelly AFB Biological Opinion (2-15-97-F-039).

beetle, Comal springs dryopid beetle, and Peck's cave amphipod or the destruction or adverse modification of critical habitat for these species.

Reasonable and Prudent Measures

The Service believes that the reasonable and prudent measures presented below are necessary and appropriate to minimize the incidental taking authorized by this biological opinion.

1. Reduce Kelly AFB's dependence on Edwards aquifer groundwater to 2,700 ac-ft/yr beginning in calendar year 1999, and 2,200 ac-ft/yr beginning in calendar year 2002. The USAF will evaluate (on at least an annual basis) its performance in achieving the necessary cutbacks in Edwards aquifer dependency and make the necessary adjustments to meet those levels. Management must accommodate for growth and increased water needs without surpassing these permitted levels. Future needs for additional water may be accommodated through such mechanisms as purchasing or leasing water rights from others. These mechanisms must, however, be evaluated separately for impacts to endangered species.

   If EAA issues a water withdrawal permit for Kelly AFB and it is different from the levels described above, the USAF may request reinitiation of this consultation if they would like the Service to evaluate whether replacing their EAA permit levels with these would be in compliance with Section 7 of the ESA.

2. Contribute $200,000 to the National Fish and Wildlife Foundation (or other foundation mutually acceptable to the USAF and the Service). Monies in the fund will be used, along with contributions from other aquifer users, to help fund such things as mechanisms to improve the condition of the species and the habitat; meet information needs that will help in developing future management options, evaluating impacts, and evaluating the success of ongoing management; captive propagation programs; or/and a contingency fund.

3. Protect water quality through monitoring programs, implementation of contingency plans, remediation activities, and regular review of effectiveness and success of such plans and programs.

4. Actively promote public information and education on water use, quantity, quality, and conservation efforts.

5. Encourage partnerships among USAF and other Edwards aquifer users, such as local, regional, state, and federal agencies and other private or public entities for cooperative efforts to manage the Edwards aquifer waters.

Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA, the USAF and GKDC are responsible for compliance with the following terms and conditions, which implement the reasonable and prudent measures described above.

1. The USAF and GKDC will work with other aquifer users and participate in regional aquifer management planning to develop a comprehensive approach to aquifer management that avoids jeopardizing the species and avoids adversely modifying their critical habitat. Progress will be summarized in the annual report called for in item 5 below.

2. Within the next two years, the USAF will implement conservation measures and other alternative water sources to reduce Kelly AFB's Edwards aquifer water withdrawals to no more than 2,700 ac-ft/yr beginning in calendar year 1999 and 2,200 ac-ft/yr beginning in calendar year 2002. The USAF will be responsible for apportioning the total water use figures between the various components of the realigned areas (for example between GKDC and Lackland AFB). If USAF or GKDC fails to demonstrate satisfactory progress (as determined by the Service) toward reducing pumping demands on the Edwards aquifer, the USAF will reinitiate formal consultation with the Service.

3. Techniques and/or alternatives used to achieve specified water reductions in item 2 above must be evaluated to determine if they have any impacts on these or any other listed species. If they do and those impacts have not been considered in this biological opinion, then those impacts will need to be addressed in a separate Section 7 consultation.

4. Contribute $200,000 to a Conservation Fund administered by National Fish and Wildlife Foundation (or other foundation mutually acceptable to the USAF and the Service). Contributions will be used to fund such things as mentioned in item 2 of the Reasonable and Prudent Measures and that are consistent with the Recovery Plan for these species. Some examples of such projects may include but are not limited to exotic and predator species control, control structure repair/modification, fountain darter parasite research, vegetation restoration, and entering historic stand localities of wild-rice into a geographic information system. In an effort to enhance the capability to accomplish the highest priority needs and for adaptive management to address unforeseen circumstances, or the development of new information which may dictate new priorities, the funding priorities will be decided by the Service. The USAF will make the contribution no later than twelve (12) months after receiving notification from the Service that the fund manager is in place and a list of projects being considered for funding.

5. Annual reports informing the Service of progress made to meet the terms and conditions set forth in this biological opinion and/or effectiveness of those programs for the length of the permit. The reports should include total annual water withdrawal of Kelly AFB, broken down on a monthly basis. The report may also include discussion of the IRP remediation effort, public outreach, Edwards well monitoring program, and the development or implementation of contingency, water conservation and drought management plans as necessary to show progress during reporting period. Annual reports should be sent to the U.S. Fish and Wildlife Service, 10711 Burnet Rd. Suite 200, Austin, Texas 78578.

6. Continue remediation of IRP sites in accordance with state and federal regulations to prevent further contamination of the shallow groundwater and soils and migration of contaminants into the deeper aquifer and or surface waters. The USAF will acquire all necessary easements or sites to ensure the remediation efforts and monitoring programs will continue after the expiration of this permit until all sites are fully remediated.

7. Cooperate with and participate in an Edwards well monitoring group and program with the EAA, City of San Antonio, SAWS, Bexar Metropolitan Water District and other parties to acknowledge, identify and monitor the integrity of Edwards aquifer wells in the San Antonio area to protect water quality. If programs are not active, the USAF will take reasonable steps to facilitate such efforts.

8. Continue Edwards well monitoring program on the base to identity faulty wells, or wells that need to be retired. Monitor on-base Edwards wells that have potential to allow communication between IRP sites and AOCs and the Edwards aquifer and include findings in the annual report to the Service. Cooperative efforts with water purveyors or individual owners should be undertaken to assure Edwards wells identified to be within a plume of contamination originating on Kelly AFB and outside the base boundary have not been contaminated and are not impacting human health and the environment.

9. Hazardous Material and Waste Spill Contingency plans will be developed, improved or modified as necessary and required by state and federal regulations to ensure water quality of surface and subsurface waters.

10. Continue and facilitate active public outreach program to inform and educate surrounding neighborhoods near contaminated sites of ongoing remediation efforts, potential hazards, and successfully completed remediations.

11. Design and implement a voluntary program or partner with EAA, SAWS and/or other organizations to educate and assist employees achieve water conservation off base at personal residences. Such program activities could include information on retrofitting with low flow toilets and shower heads or xeriscaping.

12. Implement the Water Conservation and Drought Management Plan for Kelly AFB (1996). The plan would prescribe specific demand reduction measures and the associated Edward aquifer level at which they occur and be flexible enough to respond to further reductions during a drought crises. Modify, if necessary, to ensure compliance with any existing and future aquifer management plan(s) that may be implemented by the EAA, state, or Service in response to concerns over threatened and endangered species.

13. The USAF will maintain responsibility for assuring these terms and conditions and measures are accomplished during this 5½-year time frame. GKDC (possibly in partnership with other entities) will be responsible for working with the Service to obtain the necessary ESA permits for any continued Edwards aquifer water use beyond the 5½-year timeframe. To avoid a lapse in coverage for incidental take under the ESA, GKDC will begin working with the Service to prepare their permit application well before the end of the 5½-year time frame.

CONSERVATION RECOMMENDATIONS

Sections 2(c) and 7(a)(1) of the ESA direct Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. The term conservation recommendations has been defined as Service suggestions regarding discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or develop information. The Service makes these conservation recommendations:

1. Further reduce water dependency beyond the levels set in this permit for the first five years. (Task 2.31 of Recovery Plan)

2. Provide extra protective measures for aquifer-dependent species of concern by further contributions to the Conservation Fund. (Task 2.31 of Recovery Plan)

3. Assist in identifying and sampling Edwards wells that may be causing entrainment of blind catfish and consider them for closure and/or assist in developing a method for preventing entrainment.

4. Assist co-sponsoring and contributing $50,750 to the Conservation Breeding Specialist Group to continue Edwards aquifer workshop series.

5. Assist with Habitat and Flow requirements studies as needed (may include such things as assisting in fieldwork, or flying over and taking aerial photographs to monitor vegetation). (Task 1.15 in Recovery Plan)