Memorandum

To:	Scott Storment, Executive Director, Threatened and Endangered Species, Edwards Aquifer Authority
From:	ICF Project Team
Date:	July 21, 2025
Re:	**Updated Take Assessment Methodology Framework for the EAHCP Permit Renewal**

1. Introduction

The current participants are seeking to renew their Edwards Aquifer Habitat Conservation Plan (EAHCP) Incidental Take Permit (ITP). Since receiving the original EAHCP ITP and implementing activities covered by the ITP ("Covered Activities"), the Edwards Aquifer Authority (EAA) has monitored and observed impacts of the Covered Activities on the Covered Species. These data have informed this proposed update to the methodology for assessing take of Covered Species. The updated take assessment is intended to be more accurate and informative than the original assessment method. The purpose of this technical memorandum is to describe the proposed update to methods for assessing take of Covered Species as part of the EAHCP Permit Renewal.

A draft of this memo was circulated for review with members of the Implementing Committee, Stakeholder Committee, Science Committee, and the U.S. Fish & Wildlife Service (USFWS) from April 18, 2025 to May 9, 2025. Comments received are compiled in Appendix 1. Responses to comments are also provided to indicate how comments are addressed in the revised draft memo, or that comments will be considered in development of draft chapters of the EAHCP.

The previous take assessment method for the existing EAHCP ITP was conducted by the USFWS in 2012. The USFWS used the best available data for each Covered Species at the time. They estimated the potential for Covered Activities to cause take for the 15-year Permit Term. To accomplish this, they split the 15-year Permit Term into two streamflow time series scenarios— (1) average hydrology conditions, and (2) conditions anticipated during the hydrology recorded for a repeat of the 1950s drought of record (DOR).

The first time series was based on an average flow year, in which the USFWS applied a 5% impact to occupied habitat and subsequently converted that habitat amount to number of individuals using density estimates. The total incidental take from this 5% habitat annual impact was then summed over the 7 average flow years in numbers of individuals.

The second time series was based on the streamflow record that included the DOR. The USFWS applied a 95% habitat impact over an 8-year period. To estimate the total incidental take over the 15-year Permit Term, the USFWS added the 7 average year time series total impact to the 8-year DOR time series total impact for each Covered Species.

The proposed updated methods use habitat impact percentages based on observed and inferred relationships between springflow and habitat effects. The proposed updated method uses a 30-year discharge time series to correspond with the proposed 30-year Permit Term.

2. Covered Species

This memo addresses methods for estimating take of proposed covered animal[1] species under the EAHCP Permit Renewal:

- Fountain darter
- Comal Springs riffle beetle
- Comal Springs dryopid beetle
- Peck's cave amphipod
- San Marcos salamander
- Texas blind salamander
- Edwards Aquifer diving beetle[2]

Among the Covered Species proposed for coverage in the EAHCP Permit Renewal, the Texas blind salamander and Edwards Aquifer diving beetle rely entirely on aquifer habitats. Therefore, Biological Objectives for these aquifer species are focused on conserving aquifer habitats by maintaining aquifer discharge to the springs and protecting water quality. This memorandum is divided to first discuss take assessment methods for the surface-dwelling organisms, followed by the aquifer-only species.

The EAHCP Permit Renewal Covered Species memorandum (ICF and BIO-WEST 2023) identifies other species that remain under evaluation for coverage. These species are not addressed in this memorandum; should it be determined that these species should be covered under the renewed

[1] A take estimate for Texas wild-rice, the only covered plant species, is not needed because incidental take of listed plant species from non-federal activities is not prohibited under the Endangered Species Act. However, the EAHCP Permit Renewal may consider addressing impacts to Texas wild-rice to help the USFWS meet its obligations under Section 7. This determination will be made through further coordination with the Service.

[2] Edwards Aquifer diving beetle is a Covered Species under the EAHCP, even though it is not currently federally listed as threatened or endangered.

EAHCP, the methods for assessing take of these species will be addressed in the draft Habitat Conservation Plan (HCP).

3. Updated Methodology

3.1 Method for Surface-Dwelling Covered Species

Below is an overview of the key take assessment methods components for the surface-dwelling organisms. This proposed methodology focuses on four main tasks described in the following subsections:

- Section 3.1.1 determines impact mechanisms for potential take of Covered Species.
- Section 3.1.2 defines springs/river system segments and calculates Covered Species occupied habitat.
- Section 3.1.3 develops impact estimates that describe take by system segment.
- Section 3.1.4 estimates take for each Covered Species by linking the occupied habitat and impact estimates across specific 30-year springflow modeling simulations with monthly output.

3.1.1 Impact Mechanisms and Data Examination

The potential impact mechanisms are based on Covered Species biological monitoring and observations conducted from 2001 to 2024. Total system discharge in cubic feet per second (cfs)—total system discharge and springflow terms are used in this memo interchangeably—is a key driver of adverse impacts on surface-dwelling species. As total system discharge declines, wetted area decreases, water temperatures increase, and water depths decrease, reducing the total area available for the species to inhabit, degrading the quality of the habitat, and increasing the risk of impacts associated with increased human access.

The potential impact mechanisms of decreased discharge on Covered Species include:

Fountain Darter and San Marcos Salamander

- Physical habitat loss from springflow (decreased submerged aquatic vegetation [SAV] for fountain darter)
- Disturbance from aquatic and terrestrial recreation
- Physiological impacts from increased water temperature
- Physical habitat loss from siltation (San Marcos salamander)

Comal Invertebrates *(Comal Springs Riffle Beetle, Comal Springs Dryopid Beetle, and Peck's Cave Amphipod)*

- Physical habitat loss from springflow (wetted area)
- Disturbance from aquatic recreation

- Physiological impacts from water temperature
- Physical habitat loss from siltation

The updated assessment builds upon the hydrological and biological data collected through 2024 and examined in the Biological Goals and Objectives Technical Memorandum (BIO-WEST and ICF 2024). The data examination supports inferences about the amount of take caused by each of the impact mechanisms listed above, as described in Section 3.1.3.

3.1.2 System Segments and Covered Species Occupied Habitat

In order to estimate potential take across the entirety of the Comal and San Marcos Springs systems, we defined system segments as distinct units of analysis covering the entirety of each system. Each system segment contains at least one monitored Long-Term Biological Goal (LTBG) study reach except Spring Lake and the Cape's Dam to Blanco River confluence in the San Marcos system. However, fountain darters, San Marcos salamanders, SAVs, and water temperature are monitored in all of these segments which are also all assessed for take, including those portions that are technically outside of the LTBG study reaches. Additionally, segments were selected to represent recreational use levels by system. The proposed system segments for the Covered Species are summarized below and shown for the fountain darter and San Marcos salamander in Figure 1:

Comal Springs/River

- Fountain darter
  - Upper Spring Run
  - Landa Lake
  - Old Channel
  - New Channel and Comal River
- Comal invertebrates
  - Spring Runs
  - Western shoreline
  - Spring Island

San Marcos Springs/River

- Fountain darter
  - Spring Lake
  - Spring Lake Dam to Cheatham Street
  - Cheatham Street to Cape's Dam
  - Cape's Dam to Blanco River confluence
- San Marcos salamander

- Spring Lake
- Spring Lake Dam

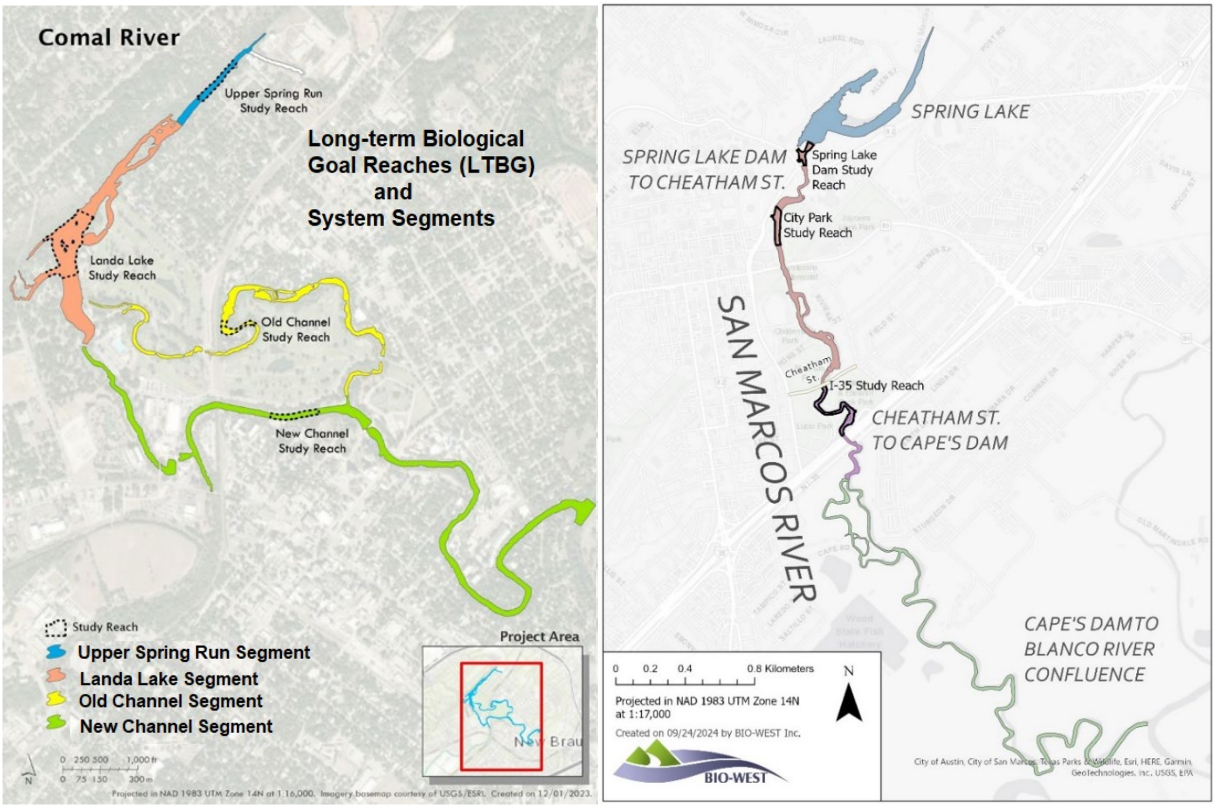

Figure 1. Long-Term Biological Goal Study Reaches and proposed Updated Take Assessment System Segments for the Comal System (left) and the San Marcos System (right)

For the Covered Species, occupied habitat for the Comal and San Marcos Springs/River systems was mapped in a geographic information system (GIS), based on EAHCP biological monitoring data and other sources. Methodology and results are summarized by system in Table 1 and broken out by segment in Table 2. The occupied habitat for the fountain darter was produced by using the latest available set of full-system SAV coverage maps produced in 2023. The Comal invertebrate occupied habitat calculations were updated in summer 2024 following spring comprehensive biological monitoring. Figure 2 shows the area of calculated occupied surface habitat for the Comal invertebrates along with their system segments.

Table 1. Covered Species Occupied Habitat (m^2) per system.

Covered Species	Total Occupied Habitat (m^2)	Notes and Assumptions
Comal Springs/River		
Fountain darter	109,209	Based on collections and known occurrence in aquatic vegetation types sampled over the course of the HCP biological monitoring. Sampling included drop-netting, dip netting, snorkel, SCUBA, and seining throughout the Comal system. Although fountain darters have been collected on bare substrate on occasion, no bare areas were included in this assessment.
Comal Springs riffle beetle	2,678	Based on collection of individuals via cotton lure, drift net, or quadrat sampling over the years. An area of 1 m2 around each collection point was included but did not include any overlap between collection points.
Peck's cave amphipod	2,838	This species is considered subterranean and thus subsurface habitat is the more appropriate calculation. The total area of subsurface habitat for this species is presently unknown. Surface habitat was based on collection of individuals via cotton lure and drift net sampling. An area of 0.5 m^2 around each collection point was included but did not include any overlap between collection points.
Comal Springs dryopid beetle	827	This species is considered subterranean and thus subsurface habitat is the more appropriate calculation. The total area of subsurface habitat for this species is presently unknown. Surface habitat was based on collection of individuals via cotton lure and drift net sampling. An area of 0.5 m^2 around each collection point was included but did not include any overlap between collection points.
San Marcos Springs/River		
Fountain darter	94,596	Based on collections and known occurrence in aquatic vegetation types (including Texas wild-rice) sampled over the course of HCP biological monitoring. Sampling included drop-netting, dip netting, snorkel, SCUBA, and seining throughout the San Marcos system. Although fountain darters have been collected on bare substrate in the river on occasion, no bare river areas were included in this assessment. In contrast, bare substrate areas in Spring Lake were included for this assessment as fountain darters have frequently been observed inhabiting these areas within Spring Lake. Finally, although fountain darters have been collected further upstream in the slough arm of Spring Lake, those collections are considered seasonal and thus were not included in the overall area calculated.
San Marcos salamander	2,520	Based on observation or collection of individuals via snorkel/SCUBA over the course of HCP biological monitoring. Also, based on collections conducted by the USFWS San Marcos Aquatic Resources Center.

Table 2. Covered Species Occupied Habitat per System Segment

Comal Springs / River System					
Covered Species	**Upper Spring Run**	**Landa Lake**	**Old Channel**	**New Channel / Comal River**	**TOTAL**
	Occupied Habitat (m^2)				
Fountain Darter	3,294.0	47,653.0	24,686.0	33,576.0	**109,209**

Comal Springs				
Covered Species	**Spring Runs**	**Western Shoreline**	**Spring Island**	**TOTAL**
	Occupied Habitat (m^2)			
Comal Springs Riffle Beetle	371.2	556.9	1,749.6	**2,678**
Comal Springs Dryopid Beetle	196.9	2.0	628.1	**827**
Pecks Cave Amphipod	373.6	741.0	1,723.2	**2,838**

San Marcos Springs / River System					
Covered Species	**Spring Lake**	**Spring Lake Dam to Cheatham St.; *Spring Lake Dam Only - San Marcos Salamanders***	**Cheatham Street to Cape's Dam**	**Cape's Dam to Blanco Confluence**	**TOTAL**
	Occupied Habitat (m^2)				
Fountain Darter	53,191.0	29,082.0	8,626.1	3,696.9	**94,596**
San Marcos Salamander	990.0	1,530.0			**2,520**

Figure 2. Comal Springs Invertebrate Occupied Surface Habitat per designated Comal System Segment (Spring Runs, Western Shoreline, and Spring Island.

3.1.3 Total System Discharge Impact Categories

To estimate the impact of springflow rates on habitat, we evaluated 2001–2024 biological data and previous hydrological and water quality modeling. One of the earliest indications of a potential impact is when surface area starts to dry. Table 3 describes the total system discharge impact categories based on wetted area reductions to habitat observed or modeled for each system.

Table 3. Total System Discharge Impact Category Designation, Wetted Area Rationale, and Number of Years and Percentage Time Represented since the Inception of the Edwards Aquifer Authority Comprehensive Biological Monitoring Program and Historically Recorded

Comal Springs / River

Impact Category	EAHCP Take Assessment - Total System Discharge (cfs)	Direct Springflow Impacts on Wetted Area	# of Years Observed (%) since 2001*	HISTORICALLY RECORDED - # of Years (%) (1934 to 2024)
A	> 120 to 150 cfs Monthly Average (all months)	Wetted area maintained above 150 cfs with loss starting at Spring Run 5 in the Upper Spring Run below 150 cfs.	19 (79.2%)	77 (84.6%)
B	< 120 cfs Monthly Average (1 or more months per year)	Wetted area loss starting in Spring Runs 1, 2 and Spring Island.	4 (16.7%)	14 (15.4%)
C	< 90 cfs Monthly Average (1 or more months per year)	Wetted area loss increasing at Spring Runs 1, 2 and Spring Island, and starting at Spring Run 3, Western Shoreline and New Channel.	3 (12.5%)	10 (11.0%)
D	< 45 cfs Monthly Average (1 or more months per year)	Considerable wetted area losses in all Spring Runs, Western Shoreline and Spring Island; with wetted area losses increasing in the New Channel.	0 (Modeling projections)	2 (2.2%)
E	< 30 cfs Monthly Average (1 or more months per year)	All Spring Runs surface habitat is dry. Considerable wetted area losses at the Western Shoreline and Spring Island. Wetted area losses experienced in both the Old and New Channels.	0 (Modeling projections)	1 (1.1%)

San Marcos Springs / River

Impact Category	EAHCP Take Assessment - Total System Discharge (cfs)	Direct Springflow Impacts on Wetted Area	# of Years Observed (%) since 2001*	HISTORICALLY RECORDED - # of Years (%) (1947 to 2024)
A	> 100 to 120 cfs Monthly Average (all months)	Wetted area maintained above 120 cfs with minor (< 5%) loss of wetted area below 100 cfs.	17 (70.8%)	53 (67.9%)
B	< 100 cfs Monthly Average (1 or more months during the year)	Slight (0 to 10%) wetted area losses experienced from Spring Lake Dam downstream.	7 (29.2%)	25 (32.1%)
C	< 60 cfs Monthly Average (1 or more months during the year)	Moderate (5 to 20%) wetted area losses downstream of Spring Lake Dam.	0 (Modeling projections)	1 (1.3%)
D	< 45 cfs Monthly Average (at least 1 month during the year)	Larger (5 to 30%) wetted area losses downstream of Spring Lake Dam.	0 (Modeling projections)	0

*First full year of the Edwards Aquifer Authority Comprehensive Biological Monitoring Program from Comal and San Marcos Springs/Rivers. The number of years observed sums any year during which a given threshold was crossed (multiple thresholds could be crossed in a single year).

Table 3 also describes the number of years each flow impact category was observed during the 24-year comprehensive biological monitoring program and during the historical record in each system for context. The similarities of percent time in each category observed since the inception of the comprehensive biological monitoring program to the historical record lends confidence in the applicability of this data set for the take analysis.

Wetted area impacts in categories A through C (Comal) and A through B (San Marcos) were observed and recorded during the comprehensive biological monitoring program period. For example, dried surface area mapped in the Comal system at 60 cfs and 75 cfs total system discharge in fall 2024 demonstrated reductions in wetted area as described in Comal system category C (Figure 3).

Although the wetted area to springflow relationships presented in the remaining categories have not yet been observed from the monitoring program, they have been modeled through various studies using observed data over the course of the monitoring period (Saunders et al. 2000; Hardy et al. 2010; BIO-WEST and ICF 2024).

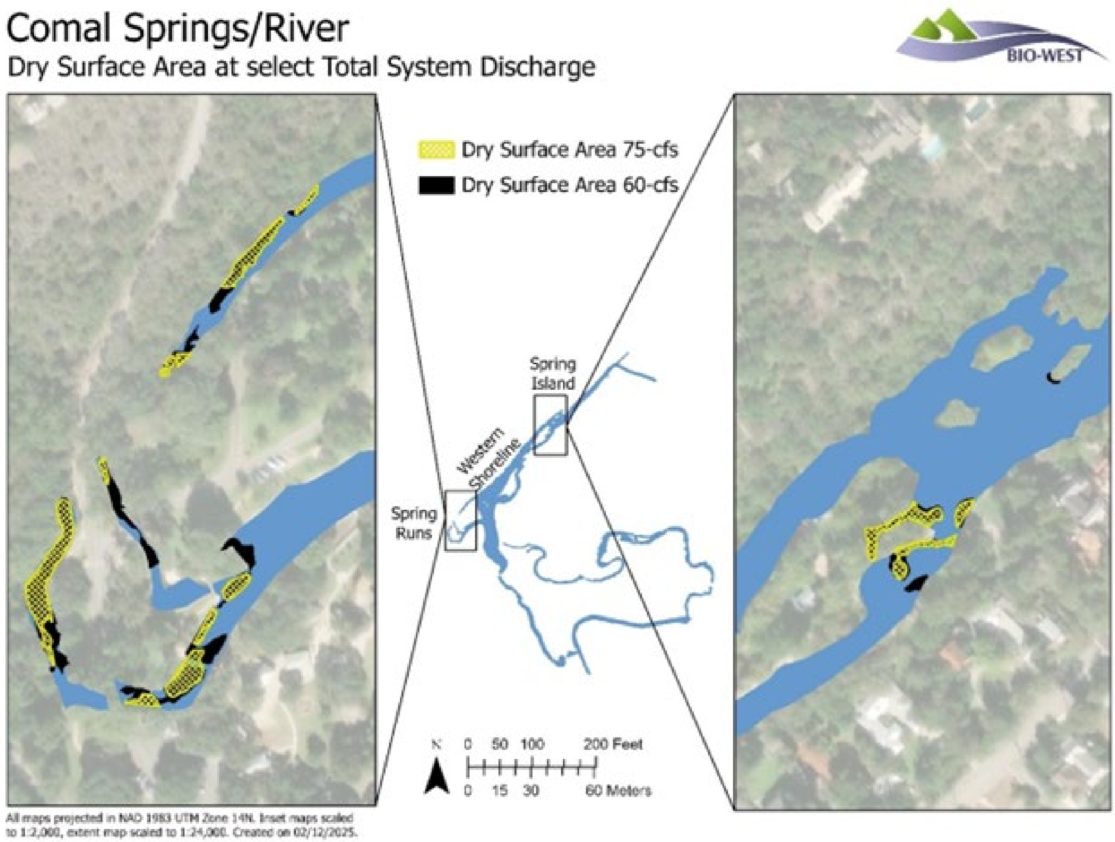

Figure 3. Comal Springs Dried Surface Area at 60 and 75 cfs Total System Discharge

For the Comal system in categories D and E, we used statistical relationships and model results to determine the impact categories at total system discharge. First, we extrapolated from the statistical relationships between flow and spring habitats, developed from the flow partitioning monitoring conducted during the EAHCP biological monitoring program, which also supported the development of the Biological Goals and Objectives (BIO-WEST and ICF 2024). Second, we used modeling estimates for the Old and New Channels from Hardy et al. (2010).

For the San Marcos system categories C and D, we used both the Texas Parks & Wildlife Department (TPWD) instream flow study (Saunders et al. 2001) and updated work for the development of the EAHCP conducted by the River Systems Institute (Hardy et al. 2010). Figure 4 shows the original figures from the TPWD instream flow study, which highlight that wetted area in the San Marcos River is maintained above 120 cfs total system discharge. As described in Saunder et al. (2001), the main channel (full river included Thompson's millrace) and natural channel from Cape's Dam to the

TPWD hatchery outfall were modeled separately in that study because over time the percentage of streamflow diverted through the mill race and natural channel was inconsistent. Additionally, the hydraulic modeling conducted by the River Systems Institute included 11 river segments below Spring Lake and is consistent with the findings of the TPWD study on the inflection point of wetted area reductions. Table 4 presents the overall results when averaged across all 11 reaches in the San Marcos River. It is understood that river channels change over time and that both studies occurred prior to the EAHCP. However, total system discharge declined to nearly 60 cfs in fall 2023 and the approximate percentages of wetted area in Table 4 down to 60 cfs were observed to remain representative in the San Marcos River. Additionally, the San Marcos system has remained mostly under 100 cfs total system discharge with extended periods of approximately 80 cfs in the past 15 months, adding further review of and confidence in these earlier study model results. Overall, the project team is confident in using these modeled values for the development of total system discharge impact categories.

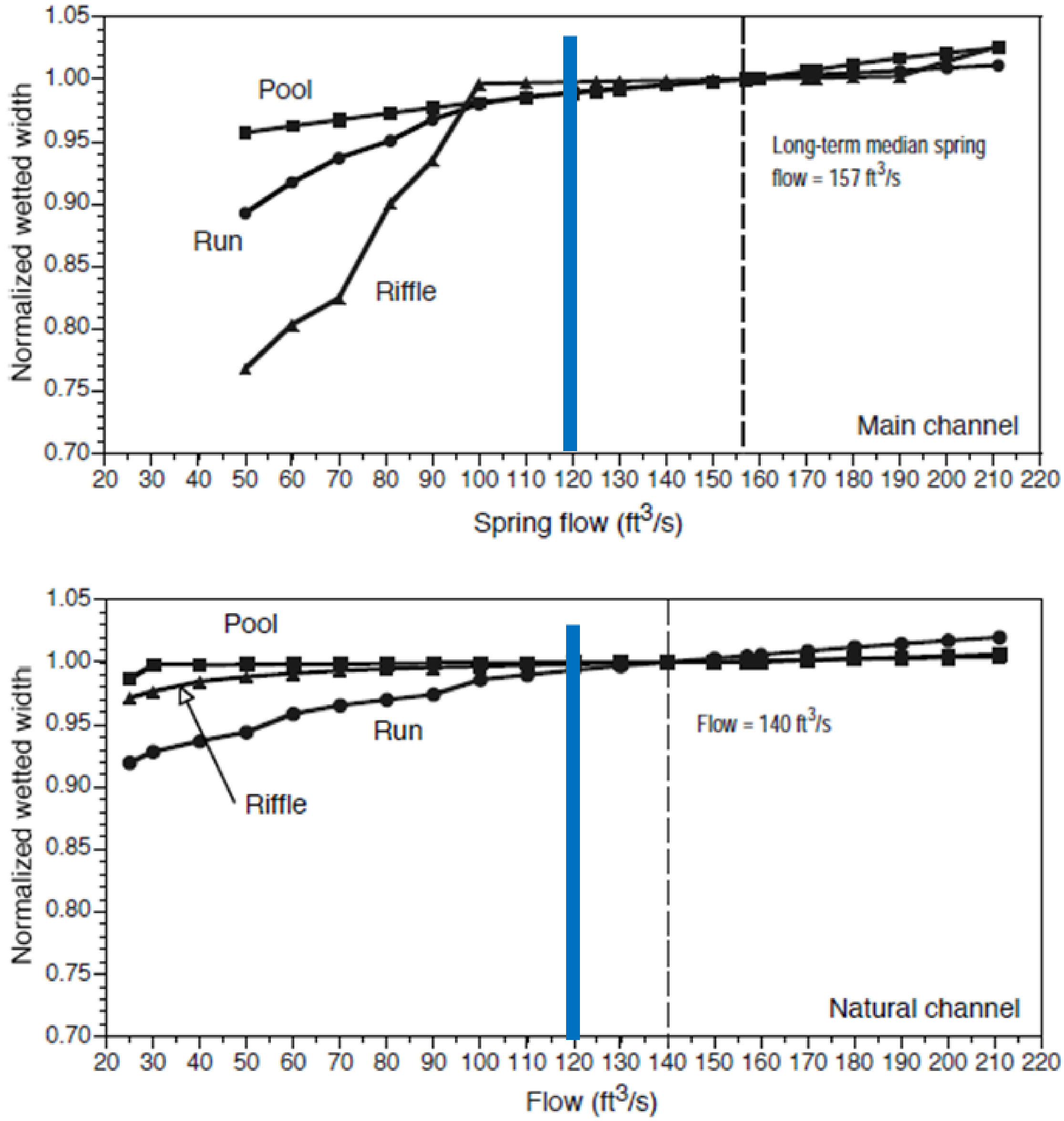

FIGURE 6.—Normalized wetted width in pool, riffle, and run mesohabitats in relation to discharge in the upper San Marcos River. Data based on all modeled cross-sections in the main channel (upper) and in the natural channel (lower). Main channel wetted width normalized to long-term median spring flow (1956-1998). Natural channel wetted width normalized to 140 ft³/s.

Source: Saunders et al. 2001:Figure 6

Note: An additional blue vertical line has been overlaid at 120 cfs total system discharge for illustration purposes.

Figure 4. Wetted Width to Total System Discharge Relationship Presented in the TPWD Instream Flow Study

Table 4. Overall Average and Ranges of Remaining Wetted Area in the San Marcos River at Select Total System Discharges

Total System Discharge (cfs)	Average Remaining Wetted Area
100	~95%; (Range 90% to 100%)
60	~ 85%; (Range 80% to 95%)
45	~ 80%; (Range 70% to 95%)

Source: Hardy et al. 2010

Once these categories were established, the next step was to estimate the impact on each species per segment for each system and for each total system discharge impact category. This was accomplished using: (1) data collected and analysis conducted since implementation of the comprehensive biological monitoring program in 2001, and (2) modeling studies for total system discharge below levels observed. The impact estimates were developed based on the impact mechanisms described in Section 3.1.1. As previously discussed, total system discharge is a key driver that directly influences each effect's pathway. The focal impact mechanisms with quantifiable information include:

- SAV to flow/recreation relationships
- Water temperature to flow relationships
- Wetted area to flow relationships for Comal invertebrate habitat

Effects from siltation were qualitatively assessed via observations during EAHCP biological monitoring for the San Marcos salamander habitat in Spring Lake and Comal invertebrate habitat in Comal Springs.

Submerged Aquatic Vegetation and Recreation

SAV is directly affected by total system discharge and disturbance from recreation. This section explains the methods used to estimate impacts on SAV. First, the seven LTBG study reaches (Figure 1) were categorized as having high, medium, or low recreational activity (Table 5). The difference in SAV coverage between spring and fall (SAV growing season) for LTBG study reaches is shown in Table 6 by discharge impact categories as outlined in Table 3. Table 6 summarizes changes in SAV coverage observed in each system, including each LTBG study reach, over the past 24 years, excluding 2020. To assess direct impacts of recreation only, an independent assessment (described later in this section) was conducted for 2020 when there was minimal to no summertime recreation in key recreated reaches due to the COVID-19 pandemic.

Table 5. Qualitative Assessment of Recreational Activity (Low, Moderate, High) during the Biological Monitoring Program in Proposed System Segments (Figure 1) with the Number of LTBG Study Reaches per Segment

Comal System			San Marcos System		
System Segments	Recreation	LTBG Study Reaches	System Segments	Recreation	LTBG Study Reaches
Upper Spring Run	Moderate	X (1)	Spring Lake	Low	
Landa Lake	Low	X (1)	Spring Lake Dam to Cheatham Street	High	X (2)
Old Channel	Low	X (1)	Cheatham Street to Cape's Dam	Moderate	X (1)
New Channel	High	X (1)	Cape's Dam to Blanco Confluence	Low	

Table 6 shows certain reaches experience greater SAV reductions from spring to fall than others, and in most cases, the reduction in SAV is magnified as total system discharge declines. This is most evident in the Spring Lake Dam and City Park reaches in the San Marcos system, which are highly recreated. For example, in 2019, total vegetation coverage at City Park decreased from 3,062 square meters (m^2) in spring to 2,710 m^2 in fall (Figure 5). The reduction in *Hydrilla* coverage from spring to fall can be attributed to active removal efforts through the EAHCP Conservation Measures, and therefore are not representative of impacts from flow or recreation. However, Texas wild-rice (*Zizania texana*) also contributed to large reductions in total coverage. Vegetation loss, most notably Texas wild-rice, was most noticeable in the center of the reach and along the edges of the bank that correspond to the wadable areas under average flow conditions. Vegetation in these areas is more susceptible to recreation foot traffic and uprooting. In contrast, less recreated study reaches like the Old Channel in the Comal River show average increases in SAV coverage from spring to fall under all discharge conditions, what would be anticipated to occur over the course of the growing season. For example, during the average flow year in 2019, the Old Channel had increased vegetation coverage from spring (981 m^2) to fall (1,143 m^2) (Figure 6). When left undisturbed, dominant taxa in this reach (e.g., bryophytes, *Ludwigia, Cabomba*) expand during the summer growing season with longer sunlight hours.

Table 6. Average Spring to Fall Submerged Aquatic Vegetation Change in Aerial Coverage in the Low, Moderate, and High Recreational Categories per System Based on Long-Term Biological Goal Study Reaches Shown in Figure 1

Comal Springs / River				
Impact Category	**EAHCP Take Assessment - Total System Discharge (cfs)**	**Low Recreation (Landa Lake & Old Channel)**	**Moderate Recreation (Upper Spring Run)**	**High Recreation (New Channel)**
A	>120 to 150 cfs Monthly Average (All Months)	0.0%	-17.5%	0.0%
B	< 120 cfs Monthly Average (1 or more months per year)	0.0%	-22.0%	0.0%
C	< 90 cfs Monthly Average (1 or more months per year)	0.0%	-29.0%	-3.5%
D	< 45 cfs Monthly Average (1 or more months per year)	Unknown	Unknown	Unknown
E	< 30 cfs Monthly Average (1 or more months per year)	Unknown	Unknown	Unknown
San Marcos Springs / River				
Impact Category	**EAHCP Take Assessment - Total System Discharge (cfs)**	**Low Recreation (Spring Lake & below Cape's Dam)**	**Moderate Recreation (I 35)**	**High Recreation (Spring Lake Dam & City Park)**
A	> 100 to 120 cfs Monthly Average (all months)	0%*	0.0%	-16.5%
B	< 100 cfs Monthly Average (1 or more months during the year)	0%*	-12.0%	-30.5%
C	< 60 cfs Monthly Average (1 or more months during the year)	Unknown	Unknown	Unknown
D	< 45 cfs Monthly Average (at least 1 month during the year)	Unknown	Unknown	Unknown

* No LTBG reach data for comparison. Estimated based on Professional Judgement.

Note: Calculated using 2001 to 2024 data set but excludes the COVID year (2020).

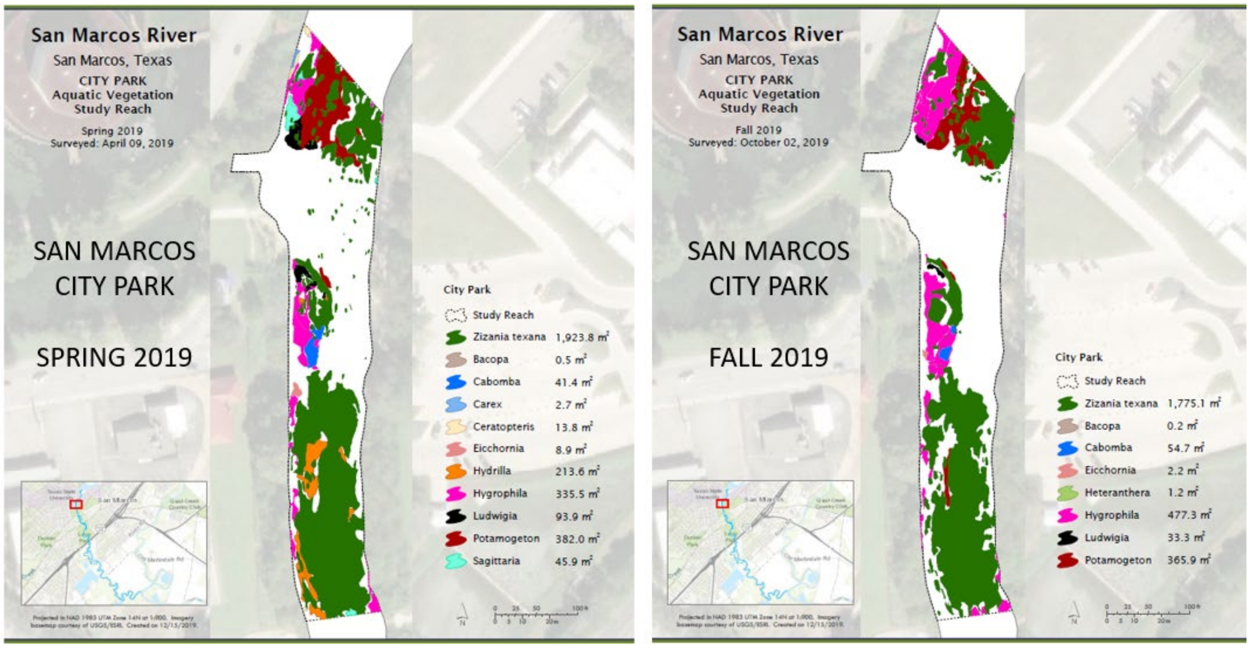

Figure 5. Comparison of Spring and Fall Total Vegetation Coverage during an Average Flow Year (2019) at the Highly Recreated City Park Reach in the San Marcos River

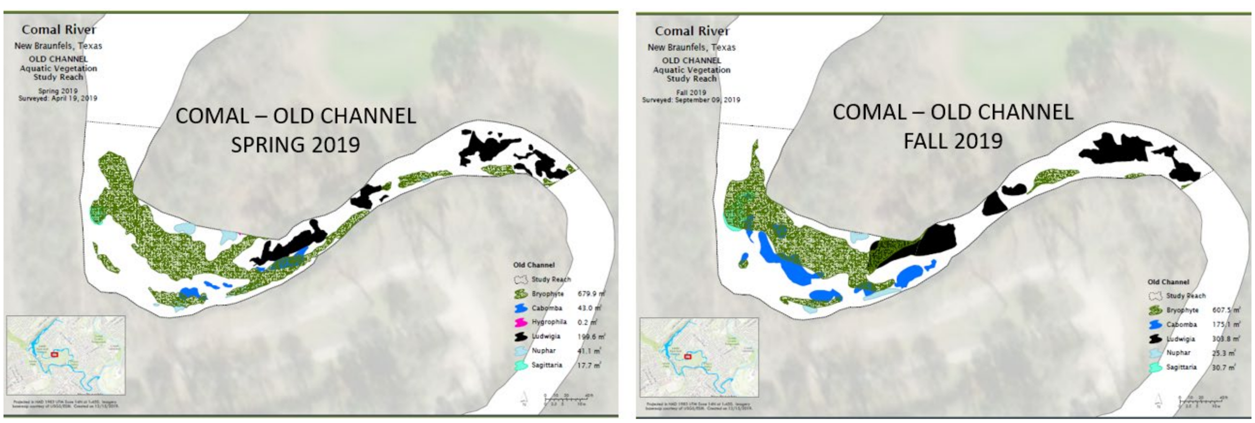

Figure 6. Comparison of Spring and Fall Total Vegetation Coverage during an Average Flow Year (2019) at the Old Channel Reach with Low Recreation

Recreation does not solely explain SAV changes in every reach. For example, the New Channel of the Comal River is highly recreated, yet at higher flow conditions it exhibits large increases in SAV coverage from spring to fall on average (Table 6). This increase is best explained by: (1) the reach is too deep for the tubers to disturb the substrate or physically grab SAV at higher flow conditions, and (2) discharge in the fall is typically less than in the spring, allowing more growth of SAV over the course of the growing season. To further illustrate the ecological complexity in these systems, the Upper Spring Run reach in the Comal system has moderate recreation but shows a rather large decrease in SAV coverage from spring to fall each year regardless of total system discharge. This decrease is explained by extended summertime sunlight conditions contributing to growth of algae in the more lake-like, concrete-bordered environment. This algal growth often covers certain macrophytes and reduces overall SAV coverage each summer. Locations such as the Interstate (I-)35 LTBG study reach in the San Marcos system reveal that although moderately recreated, the decreased discharge in this more riverine stretch during the fall can enhance SAV growth. This enhanced SAV growth often compensates for any recreation impacts with overall increases in SAV coverage over the summer. However, at lower total system discharge, recreation overcomes enhanced growth, resulting in decreased overall coverage (Table 6).

As previously noted, 2020 (also referred to as the COVID year) highlighted very different SAV coverage results for highly recreated reaches when compared to all non-COVID years, but similar results for less recreated reaches. During 2020, the average annual Comal total system discharge was 284 cfs and the average annual San Marcos total system discharge was 151 cfs. This discharge falls into total system discharge category A in Table 6. At City Park in the San Marcos system, for example, SAV coverage in spring and fall of 2020 was higher than in non-COVID years (Figure 7). Compared to a year with high recreation (Figure 5), there was noticeably more vegetation coverage (specifically Texas wild-rice) in the wadable areas of the reach. It has been documented that recreation limits vegetation growth in wadable areas that could otherwise support vegetation.

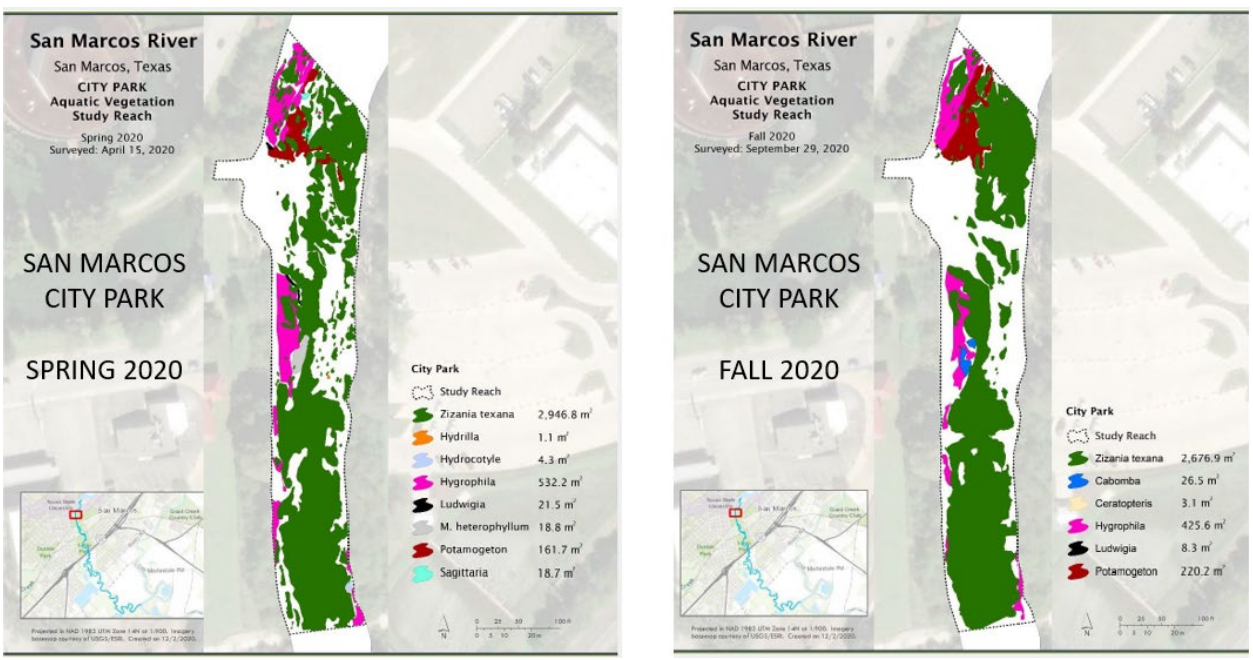

Figure 7. Comparison of Spring and Fall Total Vegetation Coverage during the COVID year (2020) at the City Park Reach with High Recreation in the San Marcos River

On the other hand, the low recreated Old Channel reach exhibited a spring to fall increase in SAV coverage during 2020 (Figure 8). SAV coverage in the Old Channel increased from 1,060 m^2 in spring to 1,262 m^2 in fall 2020, similar to an average flow year (see Figure 6). Under steady flow with limited recreational foot traffic, bryophytes, *Cabomba*, and *Ludwigia* expand from spring to fall. The corresponding increased SAV coverage between an average flow year and the COVID year at this low recreated reach is not surprising given the similarity in flow conditions and limited recreation.

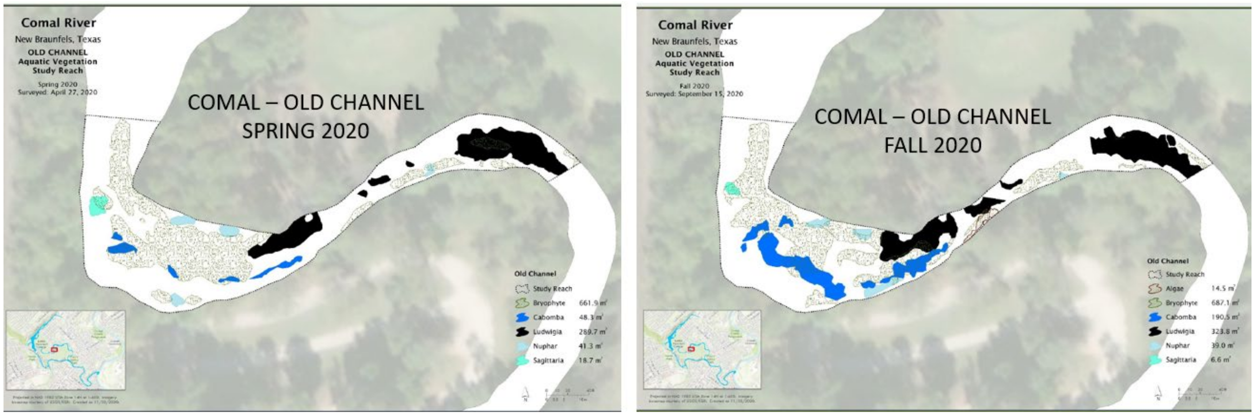

Figure 8. Comparison of Spring and Fall Total Vegetation Coverage during the COVID Year (2020) at the Old Channel Reach with Low Recreation

To estimate the combined impacts from flow and recreation on SAV, the average SAV reductions in the highly recreated reaches of the San Marcos River were compared to 2020 (COVID year). For the highly recreated San Marcos reaches (Spring Lake Dam and City Park), average spring to fall SAV reductions were approximately -16.5%. The average SAV reduction from these two highly recreated reaches during the limited recreated COVID year was approximately -6.5%. Assuming the average SAV coverage reduction between the Spring Lake Dam and City Park LTBG study reaches represents the total impact on SAV coverage from springflow and recreation, dividing this total (-16.5%) by the reduction in SAV coverage without recreation during the COVID year (-6.5%) results in a 2.5 times multiplier for recreation in the San Marcos system.

The highly recreated reach (New Channel) in the Comal system does not provide a valid comparison to the COVID year because of water depths experienced in this reach at the recorded flow conditions. Likewise, no comparison is made for the low recreated reaches (Old Channel and Landa Lake) in the Comal system because they demonstrate average SAV increases.

To estimate the combined impacts on average SAV reductions in the Comal system, the moderately recreated reach (Upper Spring Run) was compared to 2020 (COVID year). For the moderately recreated (Upper Spring Run) Comal reach, average spring to fall SAV reduction at a comparative total system discharge (Category A) was -17.5%. The average SAV reduction from this moderately recreated reach during the COVID year with limited recreation was approximately -11.5%. Assuming that the average SAV coverage reduction for the Upper Spring Run reach represents the total impact on SAV coverage from springflow and recreation, dividing this total (-17.5%) by the reduction in SAV coverage without recreation during the COVID year (-11.5%) results in a 1.5 times multiplier for recreation in the Comal system. These respective multipliers are used in Section 3.1.4 that discusses impact estimates from Covered Activities.

Water Temperature

The *Draft Recovery Plan for the Southern Edwards Aquifer Springs and Associated Aquatic Ecosystems, Second Revision* (U.S. Fish & Wildlife Service 2024), hereafter referred to as the USFWS Draft Recovery Plan, proposes that water temperature in surface habitat not exceed 25 degrees Celsius

(°C) near the springs, other surface habitat not exceed this temperature at least 50% of the days per year at the substrate, and downstream surface habitat at the substrate not exceed 27°C. The proposed water temperature Biological Objectives (25°C and 27°C) were based on these thresholds proposed by the USFWS (BIO-WEST and ICF 2024).

As part of biological monitoring, trends in water temperature are evaluated based on temperature data collected by thermistors (HOBO Tidbit v2 Temp Loggers) at multiple permanent stations in the Comal and San Marcos systems (Figure 9). Data loggers are anchored in surface habitats near the substrate and record water temperature every 10 minutes. Each logger is downloaded at regular intervals and preprocessed prior to any analysis to remove potential measurement errors (e.g., discontinuities, ascending drift).

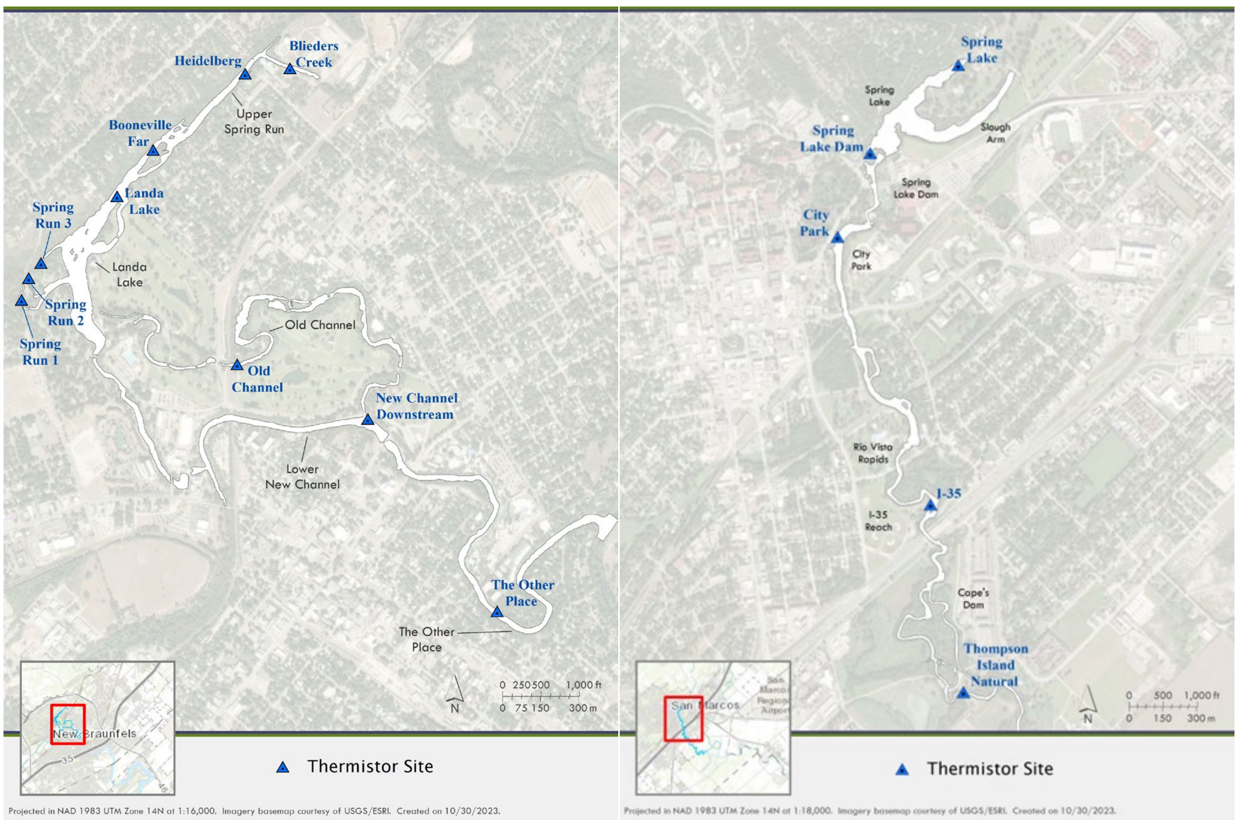

Figure 9. Thermistor Station Locations throughout the Comal (left) and San Marcos (right) Springs and River System

A detailed examination of water temperature at each station is provided in the EAHCP Biological Objectives Technical Memorandum (BIO-WEST and ICF 2024). As described in that document and supported by the USFWS Draft Recovery Plan, maintaining a 25°C water temperature in surface habitats is considered protective of fountain darters, Comal Springs riffle beetles, and San Marcos salamanders. The water temperature Biological Objective supports the maximum optimal temperature requirements for fountain darter larval (≤25°C) and egg (≤26°C) production (McDonald et al. 2007). In long-term persistent water temperature experiments (Nowlin et al.

2017), Comal Springs riffle beetles were relatively sensitive to increased temperatures when compared to the other elmid species examined in that study. Comal Springs riffle beetles exhibited around 20% greater mortality when temperatures were elevated to 26°C, and increased metabolic stress was documented at 30°C. This temperature objective is also considerably below the critical thermal maximum for the San Marcos salamander: 35.8°C and 37.3°C for juveniles and adults, respectively (Berkhouse and Fries 1995).

Long-term thermistor data demonstrates that median daily water temperature does not exceed fountain darter reproductive thresholds at any station across both systems (Figures 10 and 11). However, during 2024 the median values at two (Booneville Far and Blieders) of the 13 sites did exceed these thresholds. Additionally, when analyzing temperature at 4-hour intervals, temperatures have periodically exceeded these thresholds. During average flow years, it is common for at least one 4-hour temperature measurement to exceed the reproductive thresholds during 10 or more days in the summer months. During low flow years, the number of days in which a 4-hour temperature measurement exceeds the fountain darter reproductive threshold increases and can occur earlier in the spring. For example, in 2024, the fountain darter larval production threshold (≥25°C) was exceeded at Booneville Far (located at Spring Island, Comal System) for more than 10 days in May and the egg production threshold (≥26°C) was exceeded almost every day in July and August and for 15–20 days in both September and October. In fact, median water temperature at Booneville Far exceeded 26°C in 2024 (Figure 10), and overall fountain darter spring recruitment was lower than expected (BIO-WEST 2025a). Given that fountain darter peak reproductive output occurs in the spring, sub-daily temperature exceedances in the summer likely have minimal impact on overall fountain darter reproduction. Temperature threshold exceedances that occur in the spring potentially have greater impact on fountain darter reproductive output, though this spring exceedance is rare and has only been observed for sub-daily periods during extremely low flow years. Although we have not observed monthly average total system discharge below 45 cfs, it is expected that temperature thresholds would be exceeded more often under lower flow conditions.

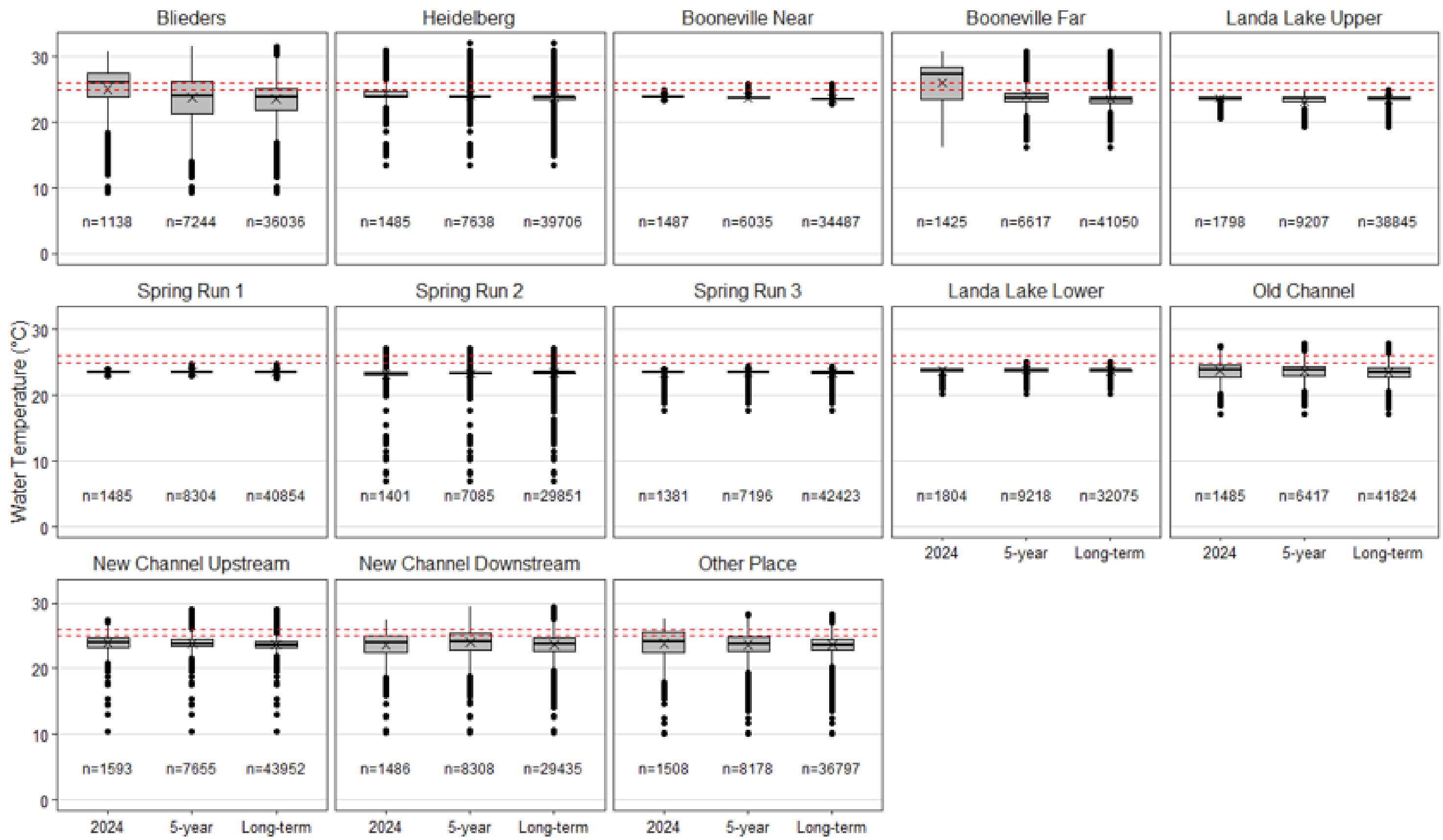

Figure 10. Boxplots displaying 2024, 5-year (2020–2024), and long-term (2001–2024) water temperature trends in the Comal Springs/River. The thick horizontal line in each box is the median, x represents the mean, and the upper/lower bounds of each box represent the interquartile range. Whiskers represent minimum/maximum values up to 1.5 times the interquartile range, and outliers beyond this are designated with solid black circles. The n values along the x-axis represent the number of individual temperature measurements in each category. The lower and upper red dashed lines indicate maximum optimal temperatures for fountain darter larval (25 °C) and egg (26 °C) production, respectively (McDonald et al. 2007).

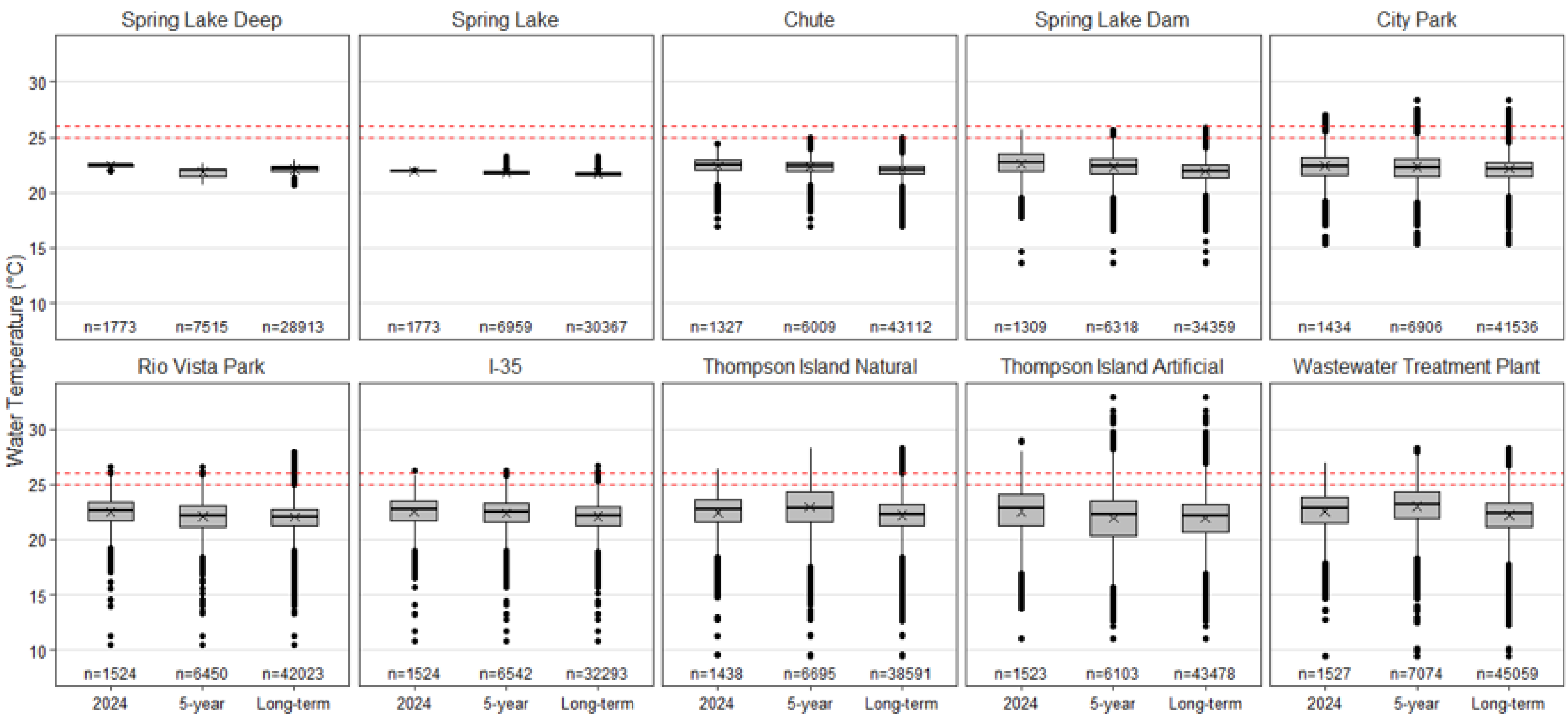

Figure 11. Boxplots displaying 2024, 5-year (2020–2024), and long-term (2001–2024) water temperature trends in the San Marcos Springs/River. The thick horizontal line in each box is the median, x represents the mean, and the upper/lower bounds of each box represent the interquartile range. Whiskers represent minimum/maximum values up to 1.5 times the interquartile range, and outliers beyond this are designated with solid black circles. The n values along the x-axis represent the number of individual temperature measurements in each category. The lower and upper red dashed lines indicate maximum optimal temperatures for fountain darter larval (25 °C) and egg (26 °C) production, respectively (McDonald et al. 2007).

Wetted Area

Calculations for available wetted area were made using springflow discharge measurements (cfs) from existing biomonitoring stations (2003–2024) near the major springs and United States Geological Survey (USGS) mean daily springflow data for Comal Springs (gage #08168710 [calculated from gage #08169000]). The variation in station-level discharge in relation to system-level springflow conditions over a 1-month duration was assessed in the EAHCP Biological Objectives technical memorandum (BIO-WEST and ICF 2024). The site-specific springflow relationships were then assessed in the context of wetted area reductions documented in fixed station photography and GIS mapping at declining discharge levels during critical period triggered biological monitoring.

In the Comal system, as total system discharge declines below 120 cfs, areas of surface habitat (primarily in Spring Runs 1 and 2) become exposed (Table 3). As total system discharge declines below 90 cfs, additional reductions in wetted area along the western shoreline, Spring Island, and New Channel become apparent. Although <45 cfs total system discharge has not been observed during the 24-year monitoring period, modeling projections suggest a majority of surface habitat at the Spring Runs would be dry and reduced wetted area would be magnified in downstream reaches like the New Channel. By 30 cfs, the elevation data suggests that all Spring Runs would be dewatered, a majority of surface area at western shoreline and Spring Island would be dry, and reduced wetted habitat would be apparent in the Old and New Channels. Based on this, impact estimates for each impact category can then be determined by comparing the location and extent of wetted area reductions to Covered Species occupied habitat. For example, impacts on wetted area below 90 cfs were evident in 2024 when total system discharge declined to approximately 60 cfs. Mapping of wetted area at the Spring Runs, western shoreline, and Spring Island depicted large areas of dry land at the Spring Runs which replaced Comal Springs dryopid beetle occupied habitat (Figure 12). Reductions in wetted area were also observed along western shoreline and Spring Island, though a majority of occupied habitat was still wetted at Spring Island. Thus, a percentage impact assumption can be determined for each segment at each impact category.

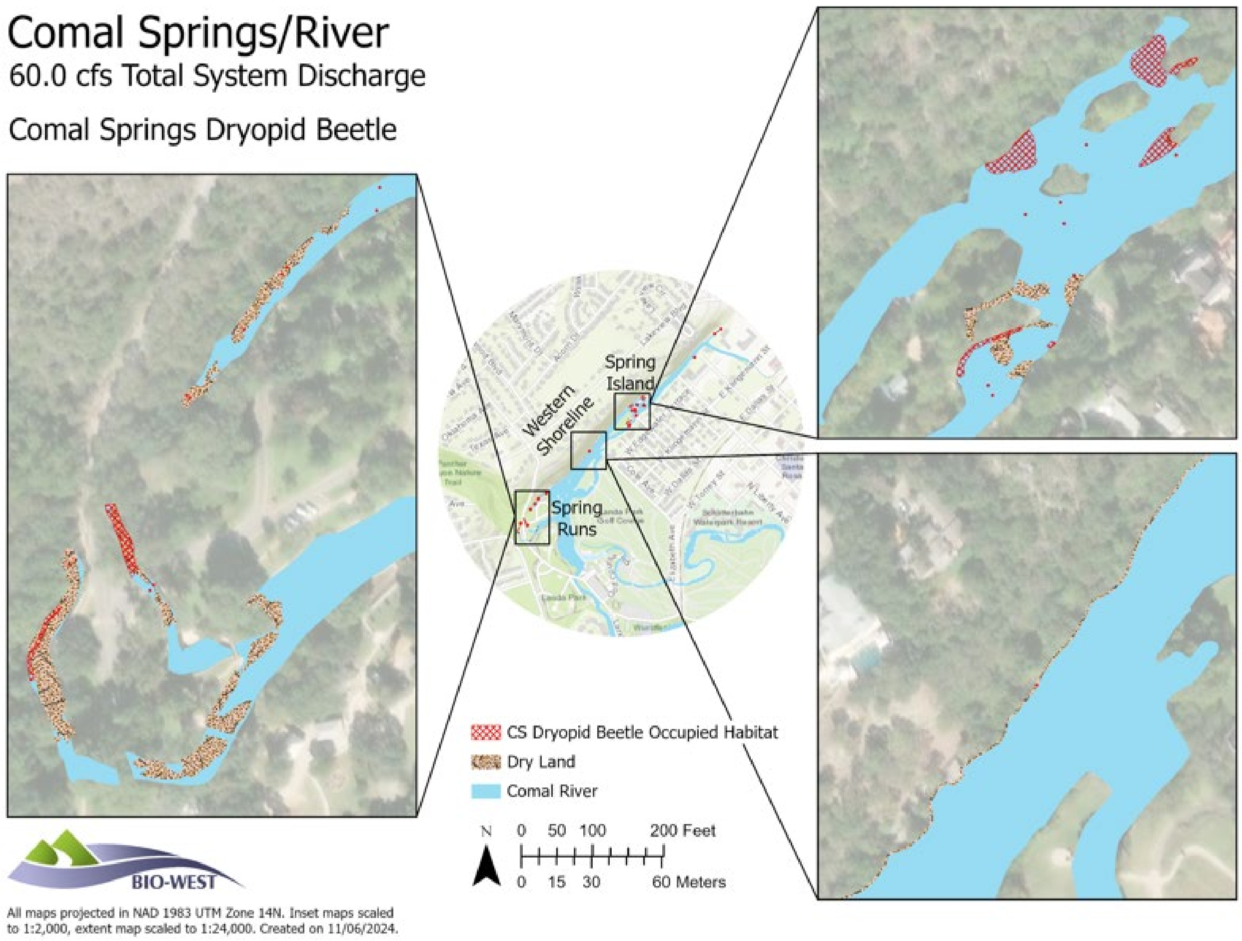

Figure 12. Map Depicting Dry Areas at Spring Runs, Western Shoreline, and Spring Island Mapped at 60 cfs Total System Discharge Overlaid with Comal Springs Dyropid Beetle Occupied Habitat in the Comal Springs/River System

For the San Marcos system, wetted area losses were determined for each impact category based on modeling projections in Hardy et al. (2010). As total system discharge declines to 120 cfs, only minor loss of wetted area is projected (Table 3). Slight losses (0–10%) in wetted area are estimated to occur below 100 cfs and have been observed through monitoring in 2023 and 2024 (BIO-WEST 2025b). Moderate losses are projected downstream of Spring Lake Dam at 60 cfs and loss of up to 30% wetted area is expected downstream of Spring Lake Dam below 45 cfs. Table 7 outlines the projected percentage loss of wetted area per segment according to Hardy et al. (2010).

Table 7. Maximum Percentage of Wetted Area Decline at Select Total System Discharge Categories per Designated Segment in the San Marcos River

Total System Discharge (cfs)	Maximum percentage (%) wetted area loss projected per San Marcos River segment (Hardy et al. 2010)		
	Spring Lake Dam to Cheatham St.	Cheatham Street to Cape's Dam	Cape's Dam to Blanco Confluence
100	5	5	10
60	20	10	20
45	25	15	25

Siltation

Siltation was assessed based on 24 years of observations during San Marcos salamander surveys in the San Marcos system and Comal invertebrate surveys in the Comal Springs system. When total system discharge declines below 100 cfs, observations from both systems suggest that siltation is evident in San Marcos salamander habitat in Spring Lake and Comal invertebrate habitat in the Comal system, which poses an adverse impact on these species.

3.1.4 Estimating Take of Surface-Dwelling Covered Species Habitat

The segments, occupied habitat calculations, impact mechanisms, and data analysis described above are synthesized to estimate take of surface-dwelling Covered Species habitat by springflow class, as summarized in Tables 8a, 8b, 9a, and 9b. Tables 8a and 8b show Comal system impact categories (A–E), independent variables that contributed in each impact category, and proposed percentage impact per Comal system segment for the fountain darter and Comal invertebrate Covered Species. Additionally, percent impact was broken out into flow only and total (flow and recreation) columns to facilitate future discussion on the potential benefits of Conservation Measures. Overall, segments with moderate or high recreational activity, such as Upper Spring Run and New Channel, show the additive increased impact from recreation in the flow and recreation column, whereas segments with low recreational activity, such as the Old Channel, do not.

Table 8a. Impact Estimates for the Fountain Darter for Comal Springs/River System Segments

FOUNTAIN DARTER Comal Springs / River System										
Impact Category	EAHCP Take Assessment Springflow (cfs)	Contributing Impact Mechanisms	Upper Spring Run		Landa Lake		Old Channel		New Channel / Comal River	
			Flow only	Flow and Recreation	Flow only	Flow and Recreation	Flow only	Flow and Recreation	Flow only	Flow and Recreation
			% impact	% impact	% impact	% impact	% impact	% impact	% impact	% impact
A	> 120 to 150 cfs Monthly Average (All Months)	Recreation, SAV changes only	11.5%	17.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
B	< 120 cfs Monthly Average (1 or more months per year)	Recreation, SAV changes	14.7%	22.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
C	< 90 cfs Monthly Average (1 or more months per year)	Recreation, SAV changes	19.3%	29.0%	0.0%	0.0%	0.0%	0.0%	2.3%	3.5%
D*	< 45 cfs Monthly Average (1 or more months per year)	Recreation, SAV changes, water temperature	35.0%	55.0%	40.0%	50.0%	25.0%	25.0%	35.0%	55.0%
E*	< 30 cfs Monthly Average (1 or more months per year)	Recreation, SAV changes, water temperature	75.0%	100.0%	55.0%	65.0%	45.0%	50.0%	75.0%	100.0%

* Not observed during EAA Biological Monitoring Program. Conservative estimates developed based on professional judgement.

For the fountain darter, only SAV and aquatic recreation impact percentages are assigned to the Upper Spring Run segment above 150 cfs. At the Upper Spring Run reach, the percentages for categories A through C reflect the total SAV reductions presented in Table 5 divided by the 1.5 multiplier for flow only as described for the Comal system. As footnoted in Table 8a, total system discharge conditions described for categories D and E have not been observed during the 24-year comprehensive biological monitoring program. Therefore, the percentage of SAV reductions for these categories in the flow only column are based on professional judgement given what has been observed during extreme droughts (e.g., 2014, 2023, 2024) when total system discharge approached those categories. The total (flow and recreation) column for the Upper Spring Run reach includes the 1.5 multiplier for the COVID year and a slight adjustment upward for increased water temperatures observed in this reach that might affect fountain darter reproduction slightly over the course of the summer. The category E 75% flow only value for the Upper Spring Run reach is again based on professional judgement of anticipated SAV loss and increased water temperatures potentially affecting reproduction during more of the year. The total column for category E for the Upper Spring Run reach exceeds 100% with the 1.5 multiplier. Therefore, this uppermost reach is not projected to maintain suitable habitat for the fountain darter with recreation during these extreme conditions. Table 8a does not project any impacts on fountain darter habitat in Landa Lake or the Old Channel until categories D and E based on the historical spring to fall SAV database from comprehensive biological monitoring (Table 5). As shown in Table 5, the New Channel reach experiences a 3.5% reduction in total SAV coverage below 90 cfs total system discharge, which results in 2.3% for flow only based on the 1.5 multiplier.

As referenced for the Upper Spring Run reach, categories D and E are based on professional judgement of anticipated SAV impacts based on wetted area and water temperature modeling (Hardy et al. 2010) conducted for these extreme low flow conditions. Table 8a indicates that recreation in the Old Channel is not considered to be a major factor with only a 5% increase noted in category E. However, with extreme low flows and exposed wetted area in the New Channel, recreation during these times would likely eliminate all SAV coverage in this highly recreated section of the Comal River. Total system discharge conditions defining impact categories D and E have not been observed over the 24 years of biological monitoring. However, flow conditions have approached impact category D during the intense droughts experienced in 2014, 2023 and 2024, which guided the professional judgement. These three drought years had considerable impacts on habitat in the Upper Spring Run and New Channel segments.

Although only minor impacts were experienced during these droughts in Landa Lake, it is anticipated that lower than observed flows and increased durations would cause the proliferation of green algae in the lake and lead to the potential smothering of larger amounts of aquatic macrophytes. Increasing water temperatures would also play a role in shallow and/or fringing areas of the lake, contributing to the higher impact percentages. Although no impacts on the Old Channel were noted during the aforementioned droughts, this reach does hover around the water temperature objectives each summer. As such, water temperatures would exceed the objectives for this reach at times when flows are within category D; thus, an impact level was set at 25%. Although these higher water temperatures typically occur outside of the fountain darter peak reproductive season (spring), this species does have a protracted spawning season with some reproduction still occurring throughout the summer. Thus, some impact on fountain darter reproductive output might be expected at low flows. Finally, impact category E is based primarily on professional judgement, with each of the impacts described from category D assumed to be amplified. The Old Channel Environmental Restoration and Protection Area, which extends from Landa Lake through the Old Channel LTBG study reach would still be receiving approximately 20 to 25 cfs during these conditions. Those flow levels in the Old Channel were experienced in the early 2000s and have shown to be capable of maintaining SAV coverages and water temperatures suitable for the survival and reproduction of the fountain darter.

Using the impact estimates described in Table 8a and a given total system discharge, the percent impact to fountain darter habitat can be estimated. Figure 13 shows a comparison of impact estimates across Comal River segments relative to the fountain darter and demonstrates the impact variability across reaches in context of the whole system. All reaches result in larger impacts on fountain darter habitat from total (flow and recreation) than from flow only. At Landa Lake and Old Channel, the difference between the flow only and total impacts is less drastic due to minimal recreation and stable water temperatures. Furthermore, these two reaches demonstrate the least impacts on fountain darter habitats at the lowest flows compared to other reaches. New Channel also shows differences between total and flow only, with larger differences expected at extremely low flows (e.g., 50 cfs). Impacts on fountain darter habitat at Upper Spring Run begin at 150 cfs and are worse at the same flows compared to other reaches. For example, at 60 cfs, it is anticipated that approximately 70% of habitat would be affected in the Upper Spring Run by flow and recreation. While that is concerning at the reach level, there is at least 50% or more of suitable habitat available at all other reaches. In fact, the Old Channel maintains more than 80% of suitable habitat and is expected to remain a fountain darter refuge.

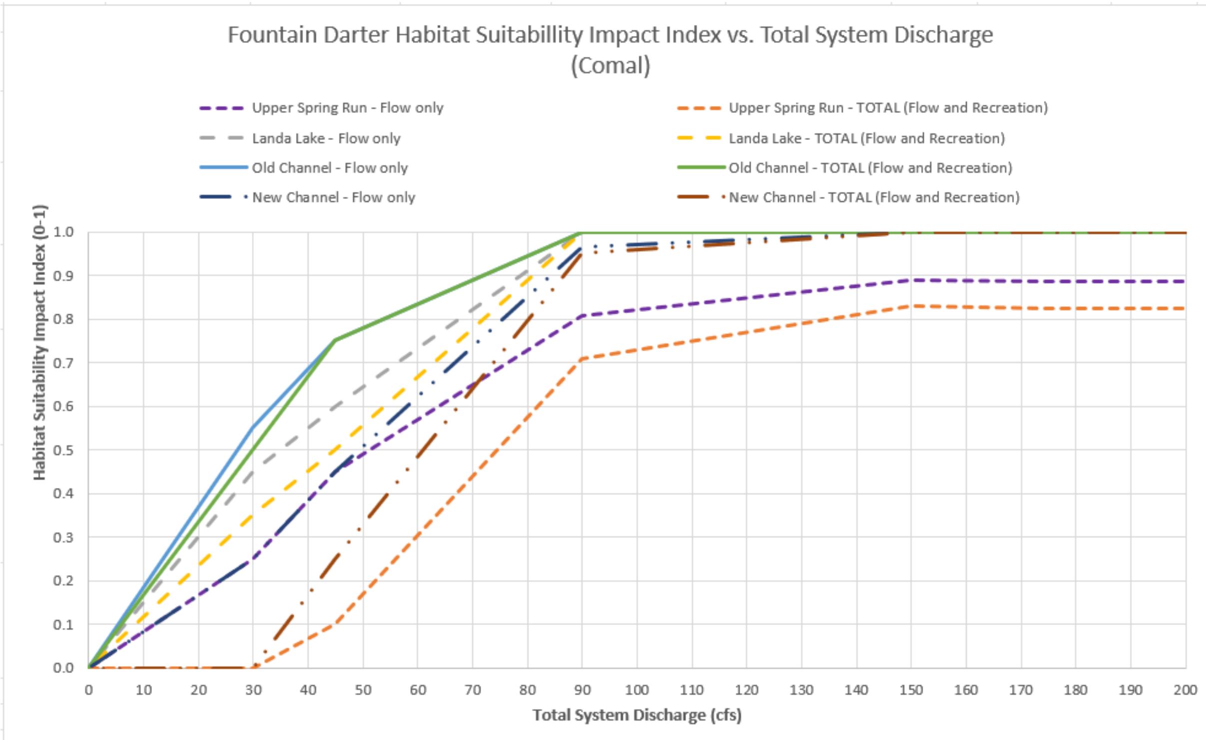

Figure 13. Comparison of Flow only and Total Impacts on Fountain Darter Habitat Suitability Based on Total System Discharge for All Segments in the Comal Springs/River System

Specific to the Comal invertebrates, the main threat to surface habitat of these species is loss of wetted area (Table 3, Table 8b). As total system discharge declines below 90 cfs, the majority of Spring Run 2 is dry and lacks surface flow, and a portion of Spring Run 1 is dry as well. However, Spring Run 3 is mostly wetted and flowing at these levels. This results in the reduction of approximately 35% of wetted area and increased siltation risk (10%) (Table 8b). At these total system discharge levels, the water elevation in Landa Lake declines slightly, exposing approximately 25% of the occupied habitat along the western shoreline and approximately 10% of the wetted area around Spring Island. An additional 5% impact on the Spring Island area was added in impact category B for recreational activity. As total system discharge falls into categories D (45 cfs) and E (30 cfs), the reduction in wetted area is magnified based on modeling. At impact category D levels, all of Spring Run 1 and 2 are subsurface and Spring Run 3 is considerably restricted, whereas all three Spring Runs cease surface flow below 30 cfs (impact category E). Similarly, the reductions in wetted area over Comal invertebrate occupied habitat at the western shoreline and Spring Island segments and risk for siltation are magnified at extreme low flow conditions. The conversion of loss of wetted area from modeling to impact percentage per segment in these unobserved flow categories (D and E) is based on professional judgement. With the Comal invertebrates, all analysis is focused on surface habitat, while all three species utilize subsurface habitats as well in the Comal system.

Table 8b. Impact Estimates for the Comal Invertebrates for Comal Springs/River System Segment

COMAL INVERTEBRATES Comal Springs / River System								
			Spring Runs		**Western Shoreline**		**Spring Island**	
Impact Category	**EAHCP Take Assessment Springflow (cfs)**	Contributing Impact Mechanisms	Flow only	Flow and Recreation	Flow only	Flow and Recreation	Flow only	Flow and Recreation
			% impact	% impact	% impact	% impact	% impact	% impact
A	> 120 to 150 cfs Monthly Average (All Months)	Recreation only	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
B	< 120 cfs Monthly Average (1 or more months per year)	Recreation, wetted area, siltation	5.0%	5.0%	5.0%	5.0%	5.0%	10.0%
C	< 90 cfs Monthly Average (1 or more months per year)	Recreation, wetted area, siltation	45.0%	45.0%	25.0%	25.0%	10.0%	15.0%
D	< 45 cfs Monthly Average (1 or more months per year)	Recreation, wetted area, siltation	95.0%	95.0%	55.0%	55.0%	25.0%	35.0%
E	< 30 cfs Monthly Average (1 or more months per year)	Recreation, wetted area, water temperature, siltation	100.0%	100.0%	95.0%	95.0%	55.0%	75.0%

Total system discharge conditions defining impact categories D and E have not been observed over the 24 years of biological monitoring. However, flow conditions have approached impact category D during the intense droughts experienced in 2014, 2023 and 2024. These drought years showed considerable impacts on Comal invertebrate habitat in the Spring Runs. Using the impact estimates in Table 8b and a given total system discharge, the percent impact on Comal Springs invertebrate surface habitat can be determined. Figure 14 shows a comparison of impact estimates across Comal Springs segments relative to the Comal invertebrates and demonstrates the impact variability across reaches and in context of the whole system. Spring Island demonstrates larger impacts on wetted surface area from total (flow and recreation) compared to flow only. Spring Island also shows the least impacts at the lowest flows compared to the Spring Runs and western shoreline. Although it is assumed that the majority of the Spring Runs would be dry at 45 cfs with only approximately 5% suitable habitat remaining, western shoreline and Spring Island are predicted to retain about 45% and 65% of suitable habitat, respectively.

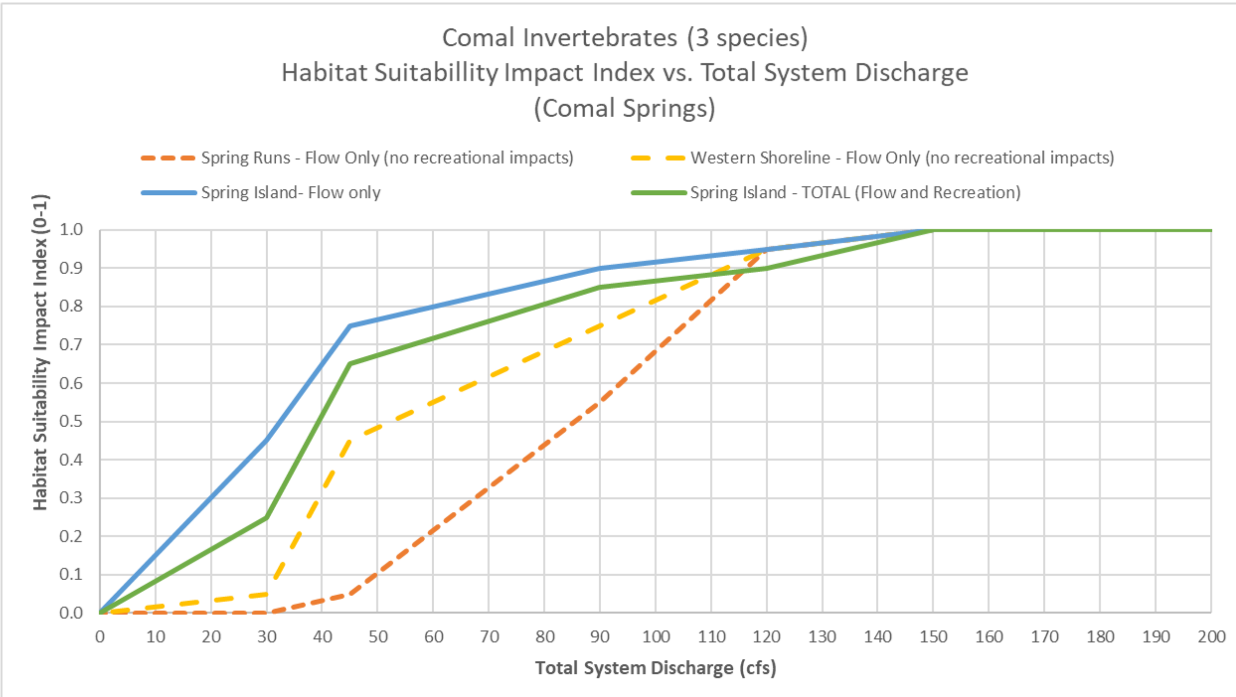

Figure 14. Comparison of Impacts on Comal Invertebrate Habitat Suitability Based on Total System Discharge for Three Segments in the Comal Springs/River System

Tables 9a and 9b show impact categories (A–D), independent variables that contributed in each impact category, and proposed percentage impact per San Marcos system segment for the fountain darter and San Marcos salamander. Additionally, percent impact was broken out into flow only and total (flow and recreation) columns to facilitate future discussion on the potential benefits of Conservation Measures. Segments with high recreational activity, such as Spring Lake Dam to Cheatham Street, show the additive increased impact from recreation in the flow and recreation column, whereas segments with low recreational activity, such as Spring Lake, do not.

Table 9a. Impact Estimates for the Fountain Darter for San Marcos Springs/River System Segment

FOUNTAIN DARTER San Marcos Springs / River System										
Impact Category	**EAHCP Take Assessment Springflow (cfs)**	Contributing Impact Mechanisms	**Spring Lake**		**Spring Lake Dam to Cheatham Street**		**Cheatham Street to Cape's Dam**		**Cape's Dam to Blanco Confluence**	
			Flow only	Flow and Recreation	Flow only	Flow and Recreation	Flow only	Flow and Recreation	Flow only	Flow and Recreation
			% impact	% impact	% impact	% impact	% impact	% impact	% impact	% impact
A	> 120 cfs Monthly Average (All Months)	Recreation	0.0%	0.0%	6.5%	16.5%	0.0%	0.0%	0.0%	0.0%
B	< 100 cfs Monthly Average (1 or more months per year)	Recreation, SAV changes	0.0%	0.0%	10.0%	30.5%	5.0%	12.0%	10.0%	10.0%
C*	< 60 cfs Monthly Average (1 or more months per year)	Recreation, SAV changes, water temperature	10.0%	15.0%	20.0%	50.0%	10.0%	25.0%	20.0%	30.0%
D*	< 45 cfs Monthly Average (1 or more months per year)	Recreation, SAV changes, water temperature	15.0%	25.0%	25.0%	65.0%	15.0%	37.5%	25.0%	40.0%

* Not observed during EAA Biological Monitoring Program. Conservative estimates developed based on professional judgement.

For the fountain darter, only SAV and aquatic recreation impact percentages are assigned to the Spring Lake Dam to Cheatham Street segment above 120 cfs. For the highly recreated LTBGs (in the Spring Lake Dam to Cheatham Street segment; Table 5), the percentages for categories A and B reflect the total SAV reductions presented in Table 6 divided by the 2.5 multiplier for the flow only category. The moderately recreated LTBG reach (in the Cheatham Street to Cape's Dam segment) did not have a total SAV reduction for category A, but there was a 12% total SAV reduction for category B. Dividing the 12% by the 2.5 multiplier for the flow only category is 5% which is equivalent to the maximum potential for loss of wetted area (5%) at 100 cfs for the Cheatham Street to Cape's Dam segment (Table 6). As there is not an LTBG study reach below Cape's Dam for SAV comparison, that segment was assigned the maximum percentage loss of wetted area (Table 7) for both the flow only and recreational column for category B.

As footnoted in Table 9a, total system discharge conditions described for categories C and D have not been observed during the 24-year comprehensive biological monitoring program. However, flow conditions have approached impact category C during the intense drought experienced in 2023. The 10% impact level applied to Spring Lake in category C is for the slight amount of siltation that starts to build up from the settling of plant material as the turnover rate of the lake is reduced. The percentage impact for categories C and D in the flow only column (Table 9a) for downstream river segments is based on the maximum loss of wetted area per segment presented in Table 7 at 60 and 45 cfs, respectively. The total (flow and recreation) column for the high and moderate recreated reaches was calculated by adding the 2.5 multiplier for San Marcos system recreation. Although the 2.5 multiplier was developed on SAV impacts and not wetted area, our professional judgement is that as depths decrease during these lower flow categories, impacts on habitat would increase in these recreated reaches. Similar to the Comal system at lower flows, water temperatures in fringing habitats in these reaches are projected to exceed the established reproductive thresholds for parts of the year which would also contribute to increased total habitat impact. During 2023, considerable impacts were documented in spring to fall SAV reductions and water temperatures started to routinely exceed the stated objectives in all downstream segments (BIO-WEST 2025b). The flow only percentage for the most downstream segment below Cape's Dam was assigned based on the maximum percentage loss of wetted area (Table 7). However, with only limited recreation, in our professional judgement we should not use the 2.5 San Marcos system multiplier for this segment. Instead, we chose to use an additive 10 and 15% increase in this segment for total (flow and recreation) in impact categories C and D to account for some recreational impacts and potential water temperature concerns (Table 9a).

Using the impact estimates described in Table 9a and a given total system discharge, the percent impact on fountain darter habitat can be determined. Figure 15 shows a comparison of impact estimates across San Marcos River segments relative to the fountain darter and demonstrates the impact variability across reaches in context of the whole system. Similar to the Comal system, all reaches show larger impacts on fountain darter habitat from flow and recreation than from flow only. At Spring Lake, the difference between the flow only and total impacts is less drastic due to minimal recreation and stable water temperatures. Additionally, Spring Lake demonstrates the least impacts on fountain darter habitat at the lowest flows compared to other reaches. The greatest impacts on fountain darter habitat occur in the Spring Lake Dam to Cheatham Street segment with flow and recreation. There are more impacts on this segment at higher flows than on other reaches. For example, at 40 cfs, approximately 30% of suitable habitat would remain at this segment. However, at least 50% suitable habitat would be available at all other segments, with Spring Lake retaining about 80% suitable habitat.

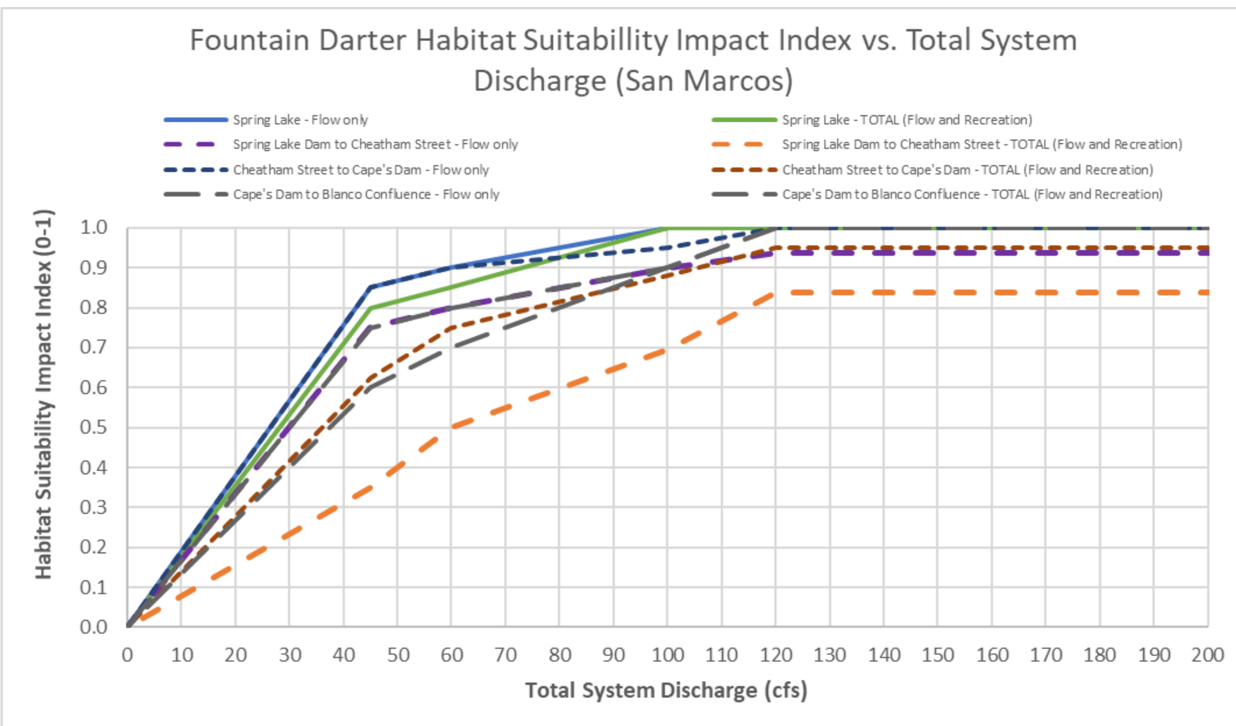

Figure 15. Comparison of Flow Only and Total Impacts on Fountain Darter Habitat Suitability Based on Total System Discharge for all Segments in the San Marcos Springs/River System

Specific to the San Marcos salamander, threats to surface habitat of this species from aquatic recreation are on-going below Spring Lake Dam (Table 9b). As total system discharge declines below 100 cfs, loss of wetted area and siltation create additional impacts. Impact categories A and B total system discharge conditions have occurred multiple times over the biological monitoring period with limited impacts observed in Spring Lake, hence the lower assigned percentages. However, as impact category C levels were approached in 2023, greater levels of impact were observed on San Marcos salamander occupied habitat both in the lake and below the dam. In the lake, this impact was associated primarily with siltation and settling out of plant material, whereas below the dam the impact percentage mostly relates to diminishing water depths and siltation. The percentage impact for categories below Spring Lake Dam are taken primarily from modeled wetted area losses (Table 7) with the San Marcos system recreation multiplier of 2.5 applied for the total impact. Overall, these impacts on occupied habitat are assumed to be magnified during extreme conditions projected in impact category D and thus are represented by higher percentages in all cases. Similar to the Comal invertebrates, all San Marcos salamander take analysis is focused on surface habitat, while acknowledging this species does use subsurface habitat in the San Marcos system.

Table 9b. Impact Estimates for the San Marcos Salamander for San Marcos Springs/River System Segment

SAN MARCOS SALAMANDER San Marcos Springs / River System						
Impact Category	**EAHCP Take Assessment Springflow (cfs)**	Contributing Impact Mechanisms	**Spring Lake**		**Spring Lake Dam**	
			Flow only	Flow and Recreation	Flow only	Flow and Recreation
			% impact	% impact	% impact	% impact
A	> 120 cfs Monthly Average (All Months)	Recreation only	0.0%	0.0%	0.0%	5.0%
B	< 100 cfs Monthly Average (1 or more months per year)	Recreation, wetted area	5.0%	5.0%	5.0%	12.5%
C	< 60 cfs Monthly Average (1 or more months per year)	Recreation, wetted area, siltation	15.0%	20.0%	20.0%	50.0%
D	< 45 cfs Monthly Average (1 or more months per year)	Recreation, wetted area, siltation, water temperature	25.0%	35.0%	25.0%	62.5%

Figure 16 shows a comparison of impact estimates across San Marcos River segments for the San Marcos salamander. Figure 16 demonstrates that greater impacts on San Marcos salamander habitat would occur at Spring Lake Dam with respect to flow and recreation compared to Spring Lake. However, without impacts from recreation, suitable habitat at Spring Lake Dam is projected to be similar to impacts at Spring Lake regardless of recreation in the lake.

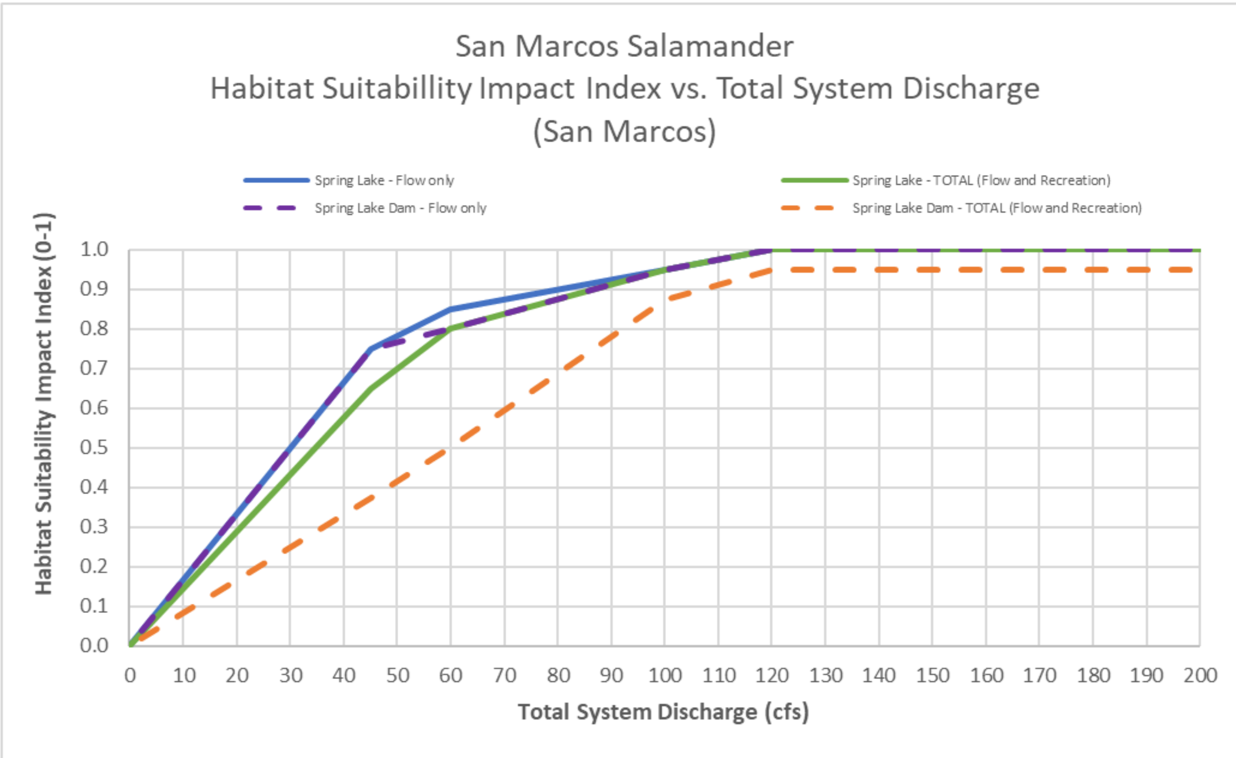

Figure 16. Comparison of Flow Only and Total Impacts on San Marcos Salamander Habitat Suitability Based on Total System Discharge for Spring Lake and Spring Lake Dam in the San Marcos Springs/River System

3.2 Applying the Method over the Permit Term

This section illustrates the application of the proposed updated take methodology to a 30-year Permit Term and various pumping operation scenarios. The EAA conducted downscaled climate modeling and developed springflow projections to evaluate the potential effects of climate change over the proposed 30-year permit term (Edwards Aquifer Authority 2024; ICF 2024; Wooten et al. 2024). Downscaled climate modeling indicates a warming and drying trend for the plan area through 2059, with more certainty in the warming trend than the drying trend. Warming trends may lead to increased risk of drought in the future during periods of anomalously low precipitation. The downscaled ensemble of global climate models does not project a drought scenario with greater intensity and longevity than the DOR occurring by 2060 (Edwards Aquifer Authority 2024).

3.2.1 Comparing Total System Discharge Impact Categories with Springflow Projections

Figures 17 and 18 show the discharge time series for each pumping scenario relative to the impact categories for Comal and San Marcos. The discharge time series shows the monthly modeled output through the DOR (30-year simulation from 1947 through 1976) for the full pumping (572,000 acre-feet per year [ac-ft/yr]) with the full suite of EAHCP flow protection measures, which is the existing

EAHCP permitted scenario; Full pumping (572,000 ac-ft/yr) without any flow protection measures; and the actual recorded discharge values from 1947 through 1976.

For each Covered Species, take would be estimated by first finding the percentage impact for the lowest discharge month in each year using Figures 13–16 and Table 10 for the Covered Species for any modeled scenario employed. The total cumulative habitat impacts (m^2 for surface species) would then be summed over the 30-year Permit Term to represent total incidental take from aquifer pumping and recreation.

4. Aquifer-Only Covered Species

As noted in Section 2, the Texas blind salamander and Edwards Aquifer diving beetle rely entirely on aquifer habitats. The *Draft Recovery Plan for the Southern Edwards Aquifer Springs and Associated Aquatic Ecosystems, Second Revision* (U.S. Fish & Wildlife Service 2024) states that for subsurface species, including the Texas blind salamander, "sufficient resiliency is achieved when: surface species have also achieved sufficient resiliency, subsurface species are observed biannually from known spring outflows during non-drought conditions, and subsurface species are observed in accessible subsurface habitat (e.g., caves, wells) during all springflows when wet." The main threats to these subsurface species are decreased aquifer levels and potential degradation of water quality within the aquifer and/or recharge zone. Therefore, protection of these aquifer species in the existing HCP and proposed renewal focuses on conserving aquifer habitats by maintaining aquifer discharge to the surface and protecting water quality through continued implementation of EAHCP Critical Period Management (CPM) and enforcement of existing water quality protection rules in the recharge zone.

Texas blind salamanders are routinely collected by the USFWS at Diversion Springs in Spring Lake and occasionally observed in other areas such as Primers and Johnson wells and Rattlesnake cave. At present, there has only been one study attempting to estimate Texas blind salamander population sizes in area caves (Krejca and Gluesenkamp 2007). However, that study was conducted for only 1 year and the resulting dataset was very small (n=12 salamanders) making it difficult to estimate with any certainty the population size or occupied habitat at the aquifer level. There is no quantitative data estimating population size of the Edwards Aquifer diving beetle. Approximately 30 individual Edwards Aquifer diving beetles have been collected from Comal Springs since the inception of drift net sampling over spring orifices, which has been conducted bi-annually since 2003. They are typically collected in drift nets during wet periods with high springflow output. The diving beetle has also been collected in the Texas State University artesian well in the San Marcos system but in limited numbers.

Although limited information is available for these aquifer species, the existing HCP and Permit Renewal Conservation Measures are designed to maintain aquifer levels and springflows supportive of the surface species' resiliency by mimicking historic conditions, such that flows do not drop appreciably below DOR levels. In the current EAHCP, these important Conservation Measures have been assumed to suffice as mitigation for any minimal impact associated with Covered Activities. Given the lack of sufficient data to quantify take of these species that could result from Covered Activities, additional consideration and coordination with the USFWS is necessary to determine the approach to conducting an effects analysis for these species in the permit renewal. No changes to the methods for estimating take of these species are proposed at this time.

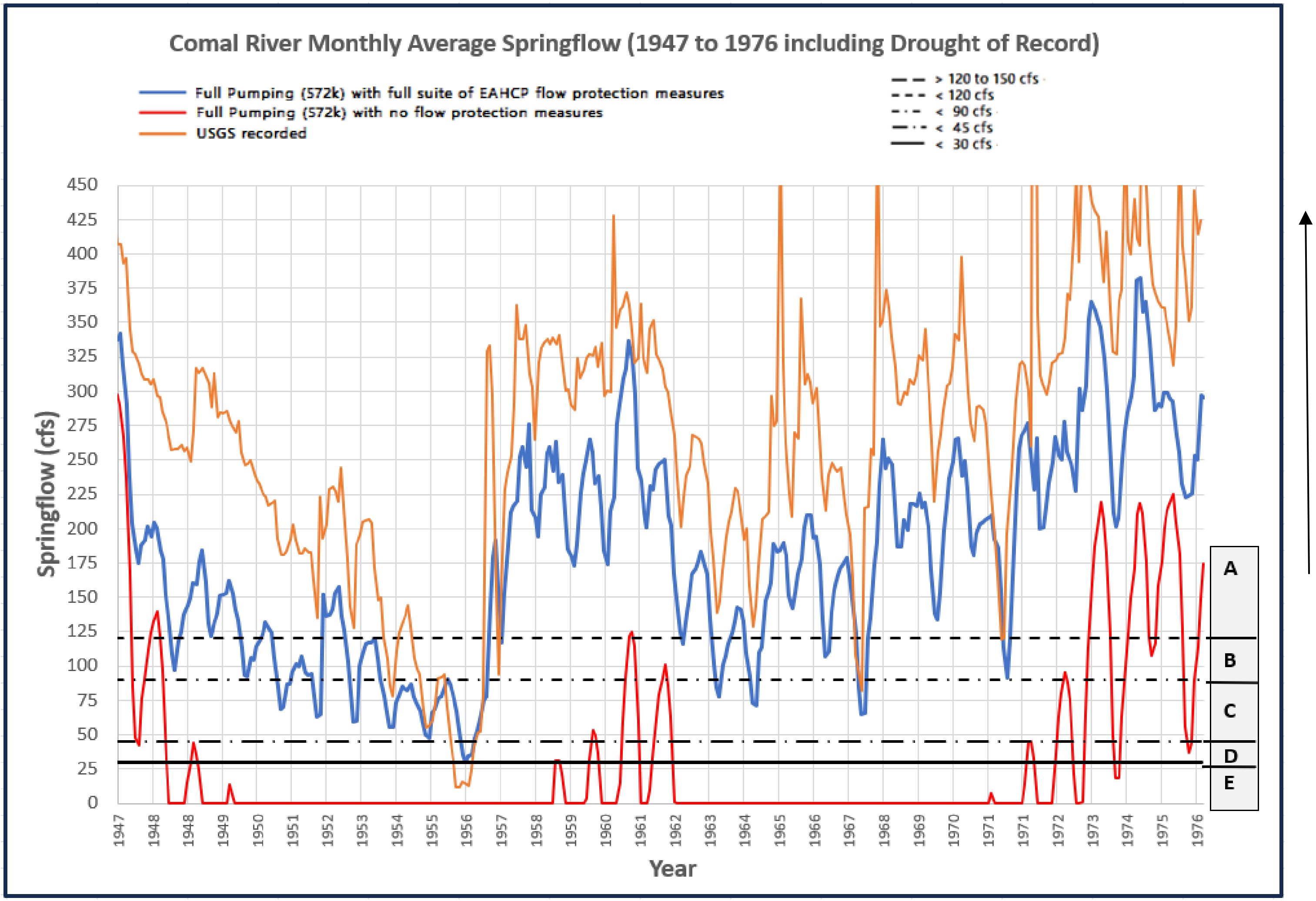

Figure 17. Modeled Monthly Total System Discharge for Full Pumping with and without full suite of EAHCP flow protection measures (Modeled 1947 to 1976), and Actually Recorded for the Comal River from 1947 to 1976.

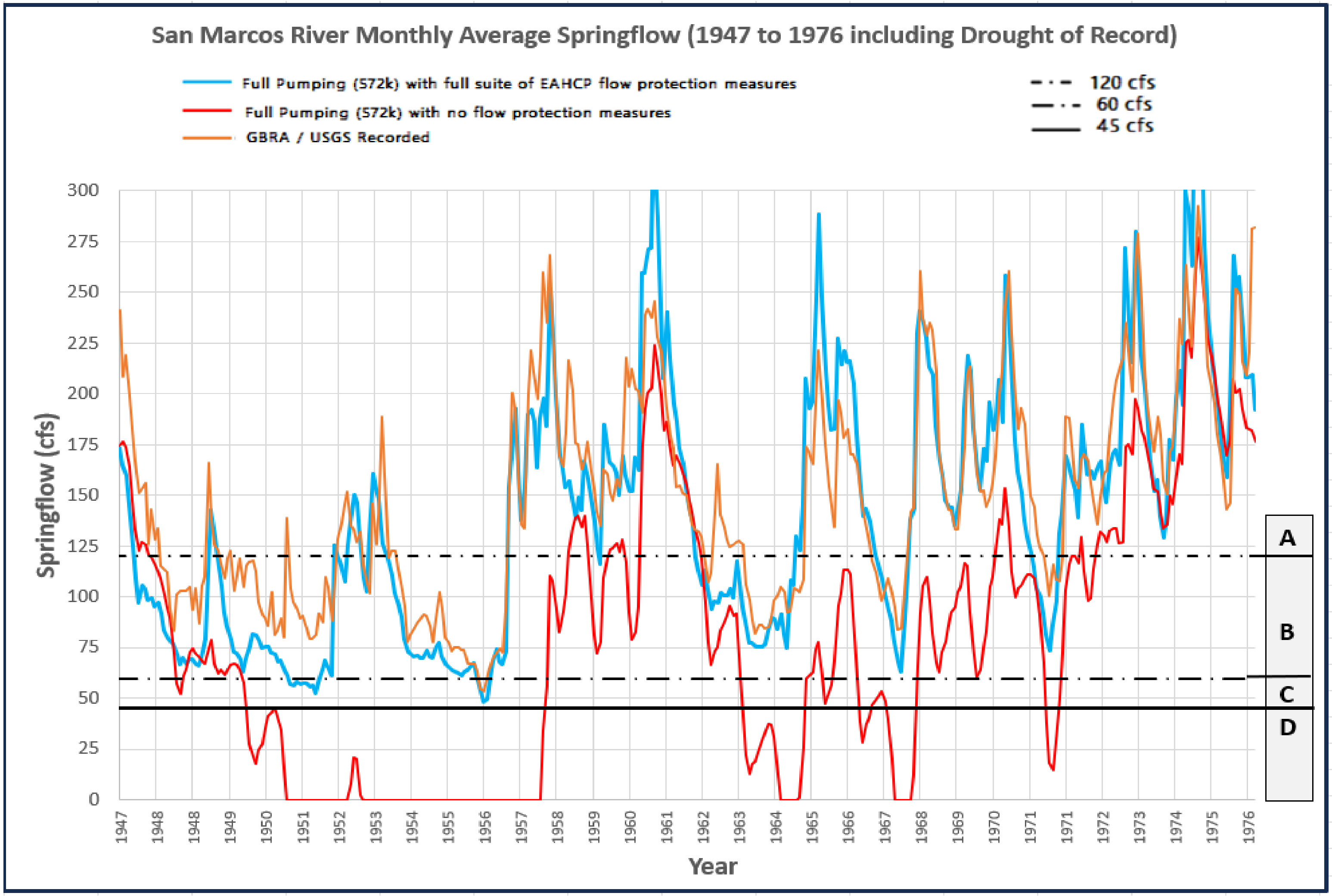

Figure 18. Modeled Monthly Total System Discharge for Full Pumping with and without full suite of EAHCP flow protection measures (Modeled 1947 to 1976), and Actual GBRA/USGS Recorded for the San Marcos River from 1947 to 1976.

5. Next Steps

In addition to aquifer pumping and recreation, there are other Covered Activities that would disturb Covered Species habitats. For example, these activities include but are not limited to:

- Vegetation maintenance around USGS gage stations
- Infrastructure maintenance, repair, and construction within and adjacent to the springs systems
- Management of recreational/educational use of Spring Lake
- Vegetation management
- Management of sediment accumulation in Sewell Park

During the HCP, take for these activities would be calculated by mapping the area of impact based on the extent of the activity. The area of impact would then be compared to Covered Species occupied habitat at that time to determine the amount of occupied habitat that would be affected. However, for this permit renewal, these components can only be estimated with assumptions required for the impact footprint and occupied habitat overlay. Additionally, for each activity, the frequency of impact would need to be assumed to calculate take over the permit term. For example, vegetation maintenance around USGS gage stations in both systems is not an on-going activity but would likely occur annually, as needed. Finally, the assumed total habitat affected would be estimated over the duration term by summing the area of occupied habitat impacted based on the frequency of impact assumed per species per Covered Activity. The estimated take from the Covered Activities in this category would be added to the aforementioned cumulative take from aquifer pumping and recreation for consideration in the ITP.

There are also several Covered Activities for which there are no direct effects pathways. For example, these activities include but are not limited to:

- Boat operations in Spring Lake
- Diving classes in Spring Lake
- Research programs
- Management of recreational fields and facilities

These activities present a challenge to quantify measurable take because the extent and intensity of effects on Covered Species are uncertain even in real time, the activities are dispersed or infrequent, and there is low potential for physical injury or mortality. Therefore, it is expected that limited to no take would occur from these activities.

The methodology described in this take assessment provides a way to estimate take of Covered Species habitat based on relationships observed from the 24-year biomonitoring program and professional judgement. The methodology includes buffered assumptions for areas of uncertainty (e.g., relationships at total system discharge for flow levels lower than those observed during the monitoring period) and uses a worst-case 30-year modeling scenario involving a repeat of the 1950s DOR. Therefore, this approach is conservative when considering potential impacts on Covered

Species for purposes of the ITP. In practice, the overall take of Covered Species habitat is expected to be lower than in this take assessment due to the Conservation Measures, biological monitoring, and adaptive management to be implemented.

6. Literature Cited

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Appendix 1: Comment Matrix, Take Assessment Memo Draft

ID	Page	Line	Comment	Commentor	Status / Response
1	5	Figure 1	I wonder if a legend for the four segments in the San Marcos System would make it more clear to readers that there are four segments in this system (i.e., make it consistent with the left panel for the Comal System).	Science Committee Member	We will revise this Figure in the Draft HCP chapter.
2	9	Table 3	It might be more intuitive to provide ranges of discharge for each Impact Category instead of just listing the minimum threshold. For example, in the Comal Springs / River section of the table Impact Category A shows > 120 to 150, while B shows <120. Suggested ranges might be A: 121-150, or simply >120; B: 91-120; C: 46-90; D: 31-45; E: <30. This comment would also apply to Table 6, Table 8a, Table 8b, Table 9a, and Table 9b.	Science Committee Member	We will revise these tables in the Draft HCP chapter.
3	10	Figure 3	Minor point but the legend values show - 75 and 60; I think the dash before the 75 could be removed.	Science Committee Member	Edit made.
4	11-12	Lines 1-14 and Figure 4	It might be more clear to readers if the main channel and natual channel areas shown in the figure are defined either in the text or the figure caption.	Science Committee Member	Edit made.
5	19	Figure 9	For the Comal system 10 locations are shown, but in Figure 10 data for 13 locations is given. For the San Marcos system, 5 locations are shown, but in Figure 11 data for 10 locations is given. Can the other locations be added to the maps?	Science Committee Member	Agreed. Both water temperature figures will be updated in the Draft HCP chapter to include all measured locations referenced in the Tables.
6	28	Figure 13	Very minor point but the legend symbols for New Channel do not match the lines in the figure (maybe elongate the legend symbols?)	Science Committee Member	Edit made. Legend updated by stretching.
7	37-38	Figures 17 and 18	Maybe define the Critical Period Management (CPM) acronym in the legend?	Science Committee Member	Thank you for your comment. Critical Period Management (CPM) involves the full suite of EAHCP flow protection measures. Text and figure captions have been modified for clarification and additional detail will be provided, as needed on Critical Period Management in the context of the revised EAHCP in the Draft HCP chapter when the actual take analysis is presented.
8	Global	Global	An overarching concern that arose in reviewing the document is the proposed use of monthly average flows for take evaluations or, more specifically, how impact of monthly average flow levels is assessed. In particular, the discussion about observations of impacts associated with various flow levels appears to equate observations of impacts for daily average flows with anticipated impacts for predicted monthly average flows of the same magnitude. That seems questionable or at least not adequately justified/explained in the memo. For example, a month for which the monthly average flow is 60 cfs at Comal Springs likely would include many days with flows below a daily average of 60 cfs, which would seem to make an evaluation of impacts for that monthly average flow based on observations of impacts for days with a daily average flow of 60 cfs potentially inappropriate/inadequately protective. See, for example, daily flow values for Comal Springs in March (ranging from 62 to 88 cfs) and April (ranging from 56 to 78 cfs) of this year and for May of 2024 (ranging from 94 to 149 cfs), based on data from the EAA data portal. The potential for intramonthly variation likely would, as it has historically, continue to be less for San Marcos springs. At minimum, some explanation/justification of the reasonableness of that impact comparison between monthly and daily average flows is needed. Although monthly average flow values match model outputs, the use of those values, particularly without consideration of impacts associated with intramonthly variation, for take evaluations seems problematic and likely to underestimate impacts. The use of calendar years as the grouping metric (i.e., one or more months per year) may merit further consideration and/or explanation. For example, a four-month period of low flows that extends across the end of a calendar year would seem to result in a calculation of double the impacts of a four-month period of comparable flows that occurs solely within a single year. Is that the intent? Is that representative of impacts to the species?	Texas Living Waters	The use of monthly average flows for the final calculation in the take analysis is done for two main reasons. First, the cfs values for determining impact thresholds are neither daily or monthly averages, rather the specific cfs to habitat relationship used as a starting point for analysis. The same amount of area is dry at 60 cfs for 1 hour, 1 day or at 60 cfs for 1 month. As noted by the reviewer, the difference between instantaneous, daily and monthly is the potential variability around the daily and monthly averages. We have seen that these systems don't revolve around one cfs number but rather the condition before, during and throughout a chosen time step. Based on our observations, an hourly and daily time step is too short to capture ecological variation, and thus, the monthly time-step was chosen to describe this ecological condition. That said, when applying the above mentioned relationships to the monthly time step, it is important to add a level of conservatism to account for this potential variability (both higher and lower) or range of condition. The project team did that in the determination of the % impact level at each Category. For example, if an instantaneous or daily time step had been proposed for use, the % impact levels in Tables 8 and 9 would be considerably less. Secondly, and also noted by the reviewer, the use of monthly time step allows for a direct comparision of the springflow modeling results. Further disaggredation into a daily time step using historical variability brings in another level of uncertainty that would then need to be calculated, explained and justified. Finally, the reviewer is correct in their interpretation of the 4 month example extending across a calendar year versus within the same year. The calculated take would be doubled in a carry over situation assuming no other months in either year went below the threshold. This is intended as an added measure of protection to the program. The project team will work to clarify these concepts while presenting the actual take calculations in the Draft HCP chapter.
9	4	Lines 10-11	This sentence is a bit confusing. It likely should read something like the following: However, fountain darters, San Marcos salamanders, SAVs, and water temperature are monitored in all of these segments, which are also all assessed for take, ~~even though they~~ including those portions that are technically outside of the LTBG~~s~~ study reaches.	Texas Living Waters	Edit made.
10	4	Lines 14-33	Suggest adding some reference to approach for riffle beetles found in Spring Lake, whether that is a justification for not doing take assessment or proposing an approach for a take assessment.	Texas Living Waters	At this time, reference to the Comal Springs riffle beetle in the San Marcos system in this take methodology memo is not warranted, in our opinion. Monitoring for the CS riffle beetle in Spring Lake is proposed in the renewal to collect the baseline information to potentially assess take of this species in Spring Lake into the future. Further explanation of this will be provided in the Draft HCP chapter.
11	5	Figure 1	A key should be added to the graphic showing the San Marcos system comparable to the key provided for Comal system.	Texas Living Waters	Agreed. We will revise this Figure in the Draft HCP chapter.
12	5	Line 5	Substitute "was" for "were": "occupied habitat ... was mapped"	Texas Living Waters	Edit made.
13	5	Line 10	Reference to Figure 2 as "an example" of calculated occupied habitat is confusing. Is this the mapping used to come up with the values in Table 2 or is this something else? For example, is this just a snapshot in time of occupied habitat, but not a representation of what was used in Table 2? Also, suggest inserting "surface" between "occupied" and "habitat" in this line to maintain consistency in the discussion.	Texas Living Waters	The mapping shown in Figure 2 is used to come up with the occupied habitat in Table 2. Text was modified to clarify. Additionally, "Surface" was added to the Figure title and text as that is the current designation of these species' habitat for purposes of the Take assessment.
14	5	Line 11	Reference to "their proposed system segments" is a bit confusing. Figure 1 also refers to system segments but with different nomenclature and segmentation than is used in Figure 2. Figure 2 segments seem to match those used in the "Comal Springs" portion of Table 2.	Texas Living Waters	Edit made. The word "proposed" was deleted as the invertebrate segments are the same as described in the text in Section 3.1.2.
15	7	Table 2	Perhaps the "Comal Springs" portion in Table 2 might be relabeled as the Landa Lake Invertebrate Subsegments. That seems to be more consistent with terminology in Figure 1. Again, for consistency, it seems appropriate for the invertebrate occupied habitat portions to be referred to as the invertebrate occupied surface habitat portions.	Texas Living Waters	Thank you for your comment. An additional call out specific to the Comal invertebrate segments will be provided in a revised Figure 1 for the Draft HCP Chapter. Figure 1 will then directly repsent all Table 2 segments.
16	8	Figure 2	Suggest inserting "Surface" between "Occupied" and "Habitat" to more clearly describe what is in the Figure. Also, suggest deleting the references to "/River" in the individual figures to better track what is being shown and to better match Table 2.	Texas Living Waters	Edit made in text and to labels in Figure 2.

17	9	Table 3 Impact Category A (Comal)	The approach of only assessing impact if the monthly average for all months falls within the indicated values for this category is difficult to understand. If habitat impacts occur whenever flows fall below 150 cfs, why are impacts only recognized if all 12 months fall below 150 cfs as a monthly average? The rationale for that difference in approach from other impact categories is not clear. It seems unlikely, based on a visual comparison to flow records, that flows fell within this category, as currently defined (i.e., all months between 120 cfs and 150 cfs), in 77 years within the POR. Perhaps this category would be more consistent with the described approach for other impact categories, and easier to understand, if labeled, and applied, as <150 cfs Monthly Average (1 or more months per year). Also recommend careful consideration of monthly avg versus daily average issue.	Texas Living Waters	Catagory A is assigned at all times when flow conditions are above the 120 cfs monthly average for that year. This includes periods where flows dip below 150 cfs for a month or several months, or are greater than 200+ cfs for the entire year. The key is that they constantly remain above 120 cfs. The rationale is that habitat impacts below 150 cfs are minimal and occur at the fringes of the system (i.e upper spring run). That said, habitat impacts to the Upper Spring Run do occur every year during the summer because of the uniqueness of that locale and thus, why we have Category A. If the total system discharge falls below 120 cfs for 1 month or more it gets assigned to Category B to be conservative. Below 120cfs is where impacts to habitat are evident beyond the fringes. We will work on revised terminology and labeling for Category A for the Draft HCP chapter to clarify.
18	9	Table 3, Impact Category E (Comal)	This impact category, like the others, does not specify a minimum flow level, however that is particularly problematic here because there is no category to address impacts as flows move farther below a monthly average of 30 cfs. However, as flows drop, impacts are likely to continue to increase, including for fountain darters in Landa Lake and the Old Channel. Finally, a "monthly average" flow of 30 cfs is lower than is predicted to occur with modeling and is lower than the target monthly average of 45 cfs, which has been equated to a daily average of 30 cfs. Impacts at a monthly average flow of 30 cfs likely would be greater than those anticipated for a daily average flow of 30 cfs and, it seems likely, greater than assessed in the memo.	Texas Living Waters	A minimum threshold is not proposed for the Take analysis as these levels are not routinely projected in the modeling and the percent impact levels in Category E are high for Comal. As such, the overall allowance of take would be quickly exceeded following a few unpredicted / unexpected Category E years over the 30-year term of the ITP. The project team intends to use monitoring and Adaptive managment as the tools to deal with flow conditions beyond those projected, and assist the EAHCP with refugia and salvage measures should these conditions persist.
19	9	Table 3, Impact Category A (San Marcos)	The different approach of only assessing impact if the monthly average for all months falls within the indicated values for this category is difficult to understand. If habitat impacts occur whenever flows fall below 120 cfs, why are impacts only recognized if all 12 months fall below 120 cfs as a monthly average? The rationale for that difference in approach from other impact categories is not clear. It seems unlikely, based on a visual comparison to flow records, that flows fell within this category, as currently defined (i.e., all months), in 53 years within the POR. Perhaps this category would be more consistent with the described approach for the other categories and with the imacts analysis, as well as easier to understand, if labeled as <120 cfs Monthly Average (1 or more months per year). And, consistent with comments above, careful consideration of monthly avg versus daily average issue is needed in assessing impacts for a given flow level.	Texas Living Waters	Category A for the San Marcos system applies at all times over 100 cfs, if the conditions do not warrant a higher impact category (based on monthly values within a given year). Similar to the Comal, habitat impacts in the San Marcos system between 100 and 120 cfs are mostly on the fringes of the system or due to recreational pressure in the main city segment. We will work on revised terminology in the Draft HCP chapter to better explain this concept and rationale for applying impacts to Category A.
20	9	Table 3, Impact Category D (San Marcos)	This impact category, like the others, does not specify a minimum flow level, however that is particularly problematic here because there is no category to address impacts as flows move farther below a monthly average of 45 cfs. Impacts to fountain darters would be expected to increase beyond the estimates set out in Category D in Table 9a. Also, suggest that terminology be revised to be consistent with all of the other flow categories instead of using "at least 1 month during the year" here compared to "1 or more months per year" for all other comparable categories unless there is a specific rationale for using different language. If there is such a rationale, it should be explained. Finally, a "monthly average" flow of 45 cfs is lower than is predicted to occur with modeling and is lower than the current target monthly average of 52 cfs, which has been equated to a daily average of 45 cfs. Impacts at a monthly average flow of 45 cfs likely would be greater than those anticipated for a daily average flow of 45 cfs and potentially than addressed in the memo.	Texas Living Waters	Similar to Comal, there is no minimum threshold for the San Marcos system as Category D is meant to cover the projected extremes with respect to potential take. It is understood that as flows decreases in cfs and extends in duration, impacts will be more severe. However, using this approach, the overall take numbers included in an ITP would quickly be exceeded should unpredicted / unexpected minimum flow years requiring Category D calculations occur repeatedly. Monitoring and Adaptive Management will be the tools to address extended and lower flow conditions beyond what has been modeled for the Permit Renewal.
21	9	line 19	Because of the confusing references to monthly and daily average flows in the document, suggest clarifying that the flows referenced here are daily average flows--at least that is what flow records seem to indicate--so that habitat impacts observed are linked to the appropriate flow levels.	Texas Living Waters	The cfs values for determining impact thresholds are neither daily or monthly averages, rather the specific cfs to habitat relationship. The same amount of area is dry at 60 cfs for 1 hour, 1 day or at 60 cfs for 1 month. As noted by the reviewer, the difference between instantaneous, daily and monthly is the potential variability around the daily and monthly averages. Therefore, when applying these relationships to the monthly time step, it is important to add a level of conservatism to account for this potential variability (both higher and lower). The project team did that in the determination of the % impact level at each Category. For example, if instantaneous or daily time step had been proposed for use, the % impact levels in Tables 8 and 9 would be considerably less. The project team will work to clarify this concept in the Draft HCP chapter.
22	10	Figure 3	For clarity, suggest indicating if flow levels noted are daily or monthly values.	Texas Living Waters	See previous response on daily versus monthly average
23	11	Line 3	For clarity, suggest indicating if flow level noted is daily or monthly value.	Texas Living Waters	See previous response on daily versus monthly average
24	11	Line 9	For clarity, suggest indicating if flow level noted is daily or monthly value.	Texas Living Waters	See previous response on daily versus monthly average
25	11	Line 10	For clarity, suggest indicating if flow level noted is daily or monthly value.	Texas Living Waters	See previous response on daily versus monthly average
26	11	Line 11	For clarity, suggest indicating if flow level noted is daily or monthly value.	Texas Living Waters	See previous response on daily versus monthly average
27	12	Figure 4	Some clarification of the difference between the Main channel and the Natural channel would be helpful. Again, because of use of monthly and daily average flows, suggest clarifying what the flow levels in the figure are referring to.	Texas Living Waters	Edit made.
28	13	Table 4	Again, suggest clarifying when flow values are daily average versus monthly average.	Texas Living Waters	See previous response on daily versus monthly average. Impact thresholds are specific cfs to habitat relationships, and impact % in Tables 8 and 9 are applicable when applied to a monthly timestep.
29	13	Lines 7-8	Suggest rephrasing clause (2) to read something like "modeling studies for total system discharges below levels observed." As currently drafted, this language could be understood to suggest that some areas have not experienced low total discharge levels.	Texas Living Waters	Edit made. Changed to "(2) modeling studies for total system discharge below levels observed."
30	15	Table 6 (Caption)	Substitute "areal" for "aerial."	Texas Living Waters	Edit made.
31	15	Table 6	Recommend changes in terminology for Total System Discharge column consistent with those recommended for Table 3.	Texas Living Waters	As responded for Table 3, we will work on terminology to clarify the Total Discharge column in these tables for the Draft HCP chapter.
32	17	Line 15	Although I recognize causation is not proven, "suggests" seems like an unduly weak verb for use here. Recommend substituting "supports the common-sense conclusion" for "suggests."	Texas Living Waters	Edit made to remove "suggests" and state, "It has been documented that recreation limits vegetation growth in wadable areas that could othewise support vegetation."
33	18	Figure 8 (Caption)	Caption introduces ambiguity about whether low recreation levels are being identified as a driver of change in coverage. The text indicates graphic actually is showing seasonal changes for area where recreation always is low. Suggest rephrasing by substituting "which always has" for "with" in the caption.	Texas Living Waters	Edit made.
34	18	Lines 6-12	The addition of a table with the data from Figures 5-7 that are used for the calculations summarized here would be helpful. The small font size used in those figures makes those data extremely difficult to read and interpret.	Texas Living Waters	Thank you for your comment. We will either increase the font size or consider an additional table to describe Figures 5-7 in the Draft HCP chapter.

35	19	Line 1	Although acknowledging that the water temperature criteria, which are set out in the goals memo, are only being referenced here, I will note that the protectiveness of a criterion that only applies for 50% of the days per year, and which, under any reasonably imaginable scenario, is virtually guaranteed to be met that percentage of time in the late Fall through early Spring periods--periods that do not necessarily correspond with prime spawning periods for fountain darters--is not obvious. Regardless, it is not clear that impacts from take associated with temperature exceedances are adequately accounted for during periods of low flows.	Texas Living Waters	The 50% of the time criterion was taken directly from the USFWS Draft Recovery Plan for the fountain darter. To be consistent with that plan, we used their language. Overall, the habitat impact percentages from loss of wetted and vegetation change to algal build-up vastly outweigh potential water temperature impacts to darters or riffle beetles. The fountain darter is also capable of reproducing year round in these systems, and the riffle beetle is capable of subsurface habitat use where water temperatures remain cooler.
36	29	Lines 18-20	As noted in the previous comment, the water temperature biological objective, when only applied during 50% of days in any year as currently proposed, does not effectively support the maximum optimal temperature requirements for fountain darters.	Texas Living Waters	See previous water temperature comment response.
37	20	Lines 2-4	Because, in practical terms, the 25° C temperature criterion would be satisfied during cool season months, the temperature criteria do not appear to be effective in protecting, during the hotter months, against the increased mortality for riffle beetles noted at temperatures beginning at 26° C.	Texas Living Waters	See previous water temperature comment response.
38	Page 20	Lines 7-8	The basis for this statement is unclear. As acknowledged in the same paragraph, it appears, from Figure 10, that, in 2024, median temperature values did exceed thresholds at the Booneville Far site and either equalled or slightly exceeded one threshold at the Blieders Creek site. Some clarification is needed for harmonizing the statement with the results. As the remainder of this paragraph seems to acknowledge, although only in the context of fountain darter impacts, the current statement is overbroad.	Texas Living Waters	The statement is accurate with respect to "long-term median averages" in both systems. It is important to understand the long-term conditions to assess the current ecological health of these species. That said, the reviewer is correct in that the 2024 median at Booneville Far and Blieders Creek did exceed this criteria. A statement has been added to state this as follows.
39	20	lines 21-25	With an extended period of low flows, it seems that adverse impacts on reproduction of a short-lived species such as the fountain darter from elevated temperatures could be substantial. The 2024 monitoring report appended to the 2024 Annual Report, at p. 31, acknowledges fountain darter water temperature thresholds at various locations often were exceeded from spring through summer in 2024. That report also acknowledges low recruitment levels. Although that was a year of very low flows, the potential for years of even lower flows is significant. Table 13 of the 2024 Incidental Take Assessment, on p. 27, notes that over half of the incidental take calculated for the fountain darter was because of elevated water temperatures. The proposed take methodology appears not to include temperature impacts. Although an approach that does not consider temperature impacts might be justifiable, at least in theory, the memo does not appear to provide such justification, particularly for extremely low flow years. If the flow only impact component is intended to include temperature impacts, that intention is not clear nor is the basis on which that inclusion rests.	Texas Living Waters	The fountain darter is a relatively short-lived species with a life-spann of approximately 2 to 3 years in the wild. However, this species also has the ability to reproduce year round and even during 2024, the majority of habitat in the Comal system was amenable to reproduction in the spring and in fact, the entire year. It would take back to back years above reproductive thresholds for the majority of the Comal system, for the entire year to warrant "substantial" in our professional opinion. The incidental take calculation reference is correct but does not reflect real world conditions. The current incidental take calculation is extremely conservative with respect to elevated temperatures as mortality temperatures have not been approached and there is no way of determining sublethal effects. Therefore, if one site in a reach experiences higher than threshold temperatures that year, the entire habitat within that reach is designated as take. This calculation does not hold in the real world monitoring as young of year darters were found in the upper spring run reach throughout 2024. As previously mentioned, the largest potential of take at low flows if via loss of wetted area or algal build up and subsequent submerged aquatic vegetation deteriation. The project team will work to clarify this concept and the use / reference to water temperature as a potential impact mechanism to these Covered species in the Draft HCP chapter.
40	25	Table 7	Suggest clarifying if the discharge values used here reflect monthly average or daily average flow values.	Texas Living Waters	See previous response on daily versus monthly average. Impact thresholds are specific cfs to habitat relationships, and impact % in Tables 8 and 9 are applicable when applied to a monthly timestep.
41	26	Table 8a (Impact Categories C-E)	It does not appear that temperature impacts are specifically factored into the calculations. Daily average flows at the lower end of Category C and in Categories D and E would be in the range where temperature impacts might be substantial.	Texas Living Waters	At present, there is not a way to determine sublethal impacts from elevated water temperatures to Covered species at low flows, thus it was determined that the conservative nature of habitat impact percentages would account for potential water temperature impacts.
42	28	Figure 13	For X axis, suggest clarifying if total system discharge values represent monthly average or daily average flows.	Texas Living Waters	The X axis cfs values for determining impact thresholds are neither daily or monthly averages, rather the specific cfs to habitat relationship. Please see previous comment responses on this topic.
43	29	Line 14	To acknowledge that the conditions being referenced have not been observed during monitored periods, suggest inserting something like "are predicted to" between "Island" and "retain." The "70%" value stated here for Spring Island at flows less than 45 cfs does not appear to line up with the impact value shown in Table 8b. Presumably, the percentage stated here should be 65% (100-35=65)?	Texas Living Waters	Text was modified to include "are predicted to" as requested. Additionally, math was corrected and the Spring Island value mentioned was changed to 65%.
44	30	Figure 14	Suggest clarifying if the discharge values used here reflect monthly average or daily average flow values.	Texas Living Waters	The X axis cfs values for determining impact thresholds are neither daily or monthly averages, rather the specific cfs to habitat relationship. Please see previous comment responses on this topic.
45	30	Line 4	The table references here appear to be wrong. Likely should refer to Tables 9a and 9b.	Texas Living Waters	Edit made to reflect Table 9a and 9b.
46	31	Table 9a (Impact Category A)	The approach to the applicability criterion for Impact Category A is different from that used elsewhere in the document, which is confusing. Elsewhere, Impact Category A for the San Marcos system is characterized as having flows ">100 to 120 cfs Monthly Average (all months)." Here, it is characterized as ">120 cfs Monthly Average (all months). In this instance, as compared to Table 6 for example, the use of a flow greater than the listed amount for "all months" as the indicator may make sense because the Category, as described here, is applicable only when all flows are greater than 120 cfs. However, the rationale for including a flow impact estimate for flows above 120 cfs is less clear. Table 3 indicates wetted area in this system is maintained above 120 cfs. Table 4 does not have wetted area values for flows above 100 cfs. Similarly, on page 11, line 3, the draft text characterizes Table 4 as indicating that wetted area is maintained above 120 cfs. Table 6, which shows SAV changes, does not address impacts at flows greater than 120 cfs for the San Marcos system. If Impact Category A is intended to address flows greater than 120 cfs, discussion of the rationale is needed. In addition, some adjustment would seem to be needed to address impact estimates for flows between 120 and 100 cfs. If the intent is to address flows <120 cfs, then, in addition to clarifying that aspect, the estimate likely should apply, consistent with other impact categories, when flow drops to that level in one or more months/year).	Texas Living Waters	Category A for the San Marcos system applies at all times over 100 cfs, if the conditions do not warrant a higher category (based on monthly values within a given year). Similar to the Comal, habitat impacts in the San Marcos system between 100 and 120 cfs are mostly on the fringes of the system or due to recreational pressure in main city segment. We will work on revised terminology in the Draft HCP chapter to better explain this concept and rationale for applying impacts to Category A.
47	31	Line 6	The text references SAV reductions presented in Table 5, but that seems incorrect because Table 5 addresses recreation activity and Table 6 addresses SAV reductions.	Texas Living Waters	Edit made to reference Table 6.

48	31	Lines 22-29	This discussion acknowledges the potential for significant temperature impacts, but, again, it is unclear that such impacts are accounted for in the impact estimate tables. From the explanation provided, flow impacts appear to be based solely on wetted area reductions.	Texas Living Waters	The referenced text states, "Similar to the Comal system at lower flows, water temperatures in fringing habitats in these reaches are projected to exceed the established reproductive thresholds for parts of the year which would also contribute to increased total habitat impact. During 2023, considerable impacts were documented in spring to fall SAV reductions and water temperatures started to routinely exceed the stated objectives in all downstream segments (BIO-WEST 2025b)." It is our professional opinion that the impact %s assigned based on wetted area account for the potential sublethal impacts to fountain darters from water temperature. See previous responses on fountain darter reproductive strategies.
49	35-36	Lines 39-41 on p. 35 & lines 1-2 on p. 36	It is unclear to me if the CPM scenario, described as the existing EAHCP permitted scenario, actually includes only CPM or the full suite of EAHCP flow protection measures. The results appear to indicate it is the latter. There is no output representing a no pumping scenario. Presumably, this sentence also should include references to the scenario at San Marcos or a sentence should be added to reference that output.	Texas Living Waters	The CPM includes the full suite of EAHCP flow protection measures. Text and Figure captions were modified in the memo to clarify. All reference to the No Pumping scenario has been removed.
50	37	Figure 17 (Caption)	The reference in the caption to "No Pumping" is confusing, no such modeling output is presented in the Figure. Consistent with previous comment, reference to "EAHCP Critical Period Management" in the caption likely should be to "EAHCP Flow Protection Measures."	Texas Living Waters	The No Pumping reference was removed in both the text and figure caption.
51	37	Figure 17	Does the blue line reflect full pumping with EAHCP CMP or with full suite of EAHCP protective measures? Appears to be the latter, if so, the description should be corrected. Thirty cfs is labeled as the minimum monthly criteria. Thirty cfs is the minimum daily criterion, not the minimum monthly criterion. Suggest dropping all references to criteria and substituting references to impact categories.	Texas Living Waters	The CPM includes the full suite of EAHCP flow protection measures. Text and Figure captions were modified in the memo to clarify. All labels referencing monthly were removed and just cfs triggers remain in these two figures.
52	38	Figure 18 (Caption)	The reference in the caption to "No Pumping" is confusing, no such modeling output is presented in the Figure. Consistent with previous comment for pp. 35-36, reference to "EAHCP Critical Period Management" in the caption likely should be to "EAHCP Flow Protection Measures."	Texas Living Waters	The No Pumping reference was removed as it was not applicable.
53	38	Figure 18	Does the blue line reflect full pumping with EAHCP CMP or with full suite of EAHCP protective measures? Appears to be the latter, if so, the description should be corrected. Forty-five cfs is labeled as the minimum monthly criteria. That is the minimum daily criterion, not the minimum monthly criterion. Suggest dropping all references to criteria and substituting references to impact categories.	Texas Living Waters	The CPM includes the full suite of EAHCP flow protection measures. Text and Figure caption modified to clarify. All labels referencing monthly were removed and just cfs triggers remain in these two figures.
54	39	Lines 29-30	It seems like research programs that involve collection would result in take. Would it be better to address that in some more direct manner?	Texas Living Waters	This will be addressed in the Draft HCP chapter. However, this calculated amount will be extremely minor compared to flow related incidental take.
55	39	Line 34	The reference to a "total system discharge < 45 cfs" is confusing. What is the total system being referenced (Comal, San Marcos, both)? Is this a daily or monthly average flow level? Suggest just substituting language acknowledging assumptions for flow levels lower than those observed during the monitoring period.	Texas Living Waters	Text modified to "..for flow levels lower than those observed during the monitoring period."
56	40	Lines 1-2	The statement is confusing. It is my understanding that the take assessment, which is based, at least in substantial part, on impacts observed with current conservation measures, biological monitoring, and adaptive management implemented, actually is premised on those activities continuing.	Texas Living Waters	This understanding is correct. However, several levels of buffering were incorporated into the revised habitat approach in an attempt to offset inherent uncertainity in biological systems. As previously mentioned, the level of take calculated in this exercise is likely greater than anticipated impact to be realized in each respective system.
57	4	lines 27-30	Were these the ones chosen by recreational impact zone, as referenced in lines 11-12 above? They are the only ones where I can see a gradient of impact for recreation.	Science Committee Member	The segments and rankings referenced in Table 5 are based on the gradient in recreation observed over the monitoring period.
58	7	Table 2	add total area of each reach and grand total on the covered species row of each River system subheading.	Science Committee Member	We will consider these revisions in the Draft HCP Chapter.
59	8	Figure 2	might we see a similar map for occupied FD habitat?	Science Committee Member	The fountain darter occupied habitat map exists and is presented in each annual EAHCP incidental take assessment. We will consider adding all occupied habitat maps for all covered species as appendices to the Draft HCP chapter.
60	10	Lines 10-11	The authors state that "we extrapolated from the statistical relationships between flow and spring habitats...", and cite BioWest and ICP, 2024. I never got adequate answers to my questions on this work	Science Committee Member	Please refer to the final 2024 memorandum and specific comment responses attached to that document.
61		Figures 5, 6 , 7,	It seems as though the authors are trying to make inferences (estimates) about vegetation cover .. Isn't there a vegetation model that could be used/developed?	Science Committee Member	There is not a vegetation model at present with predictive capabilities. There are indeed areas where professional judgement was incorporated.
62	18	lines 17-26.	These reduction multipliers seem to be interpretations of vegetation maps, namely, the difference between two maps (i.e., 1 observation). Not seeing computations, what confidence limits would the authors posit for these multipliers?	Science Committee Member	Confidence limits are not possible on this limited data set under lower flow conditions.
63	39	line 33	The authors refer to "buffered assumptions" regarding relationships at total system discharge < 45 cfs. The current document makes heavy reference to the BGO memo, and extrapolates beyond the observed data using a model that was not elucidated fully enough to allow third party assessment. This extrapolation violates standard practice, and therefore needs to be fully explained and justified, particularly if it is to be the basis of subsequent work.	Science Committee Member	Buffered assumptions as presented in this take methodology memorandum are based on professional judgement, not references from the BGOs memo. Using professional judgement in the absence of data is common scientific practice for developing take assessments for an HCP.
64	15, 18	Table 6, Pg 18,	If I am interpreting correctly, the average Spring to Fall SAV reductions for the SLD and City Park LTBG reaches, -16.5%, are assumed to be representative of the Spring Lake Dam to Cheatham St segment. This assumption may result in overestimating FD take as these LTBG reaches exhibit perhaps the highest degree of recreational impacts in the entire system.	COSM	We acknowledge that the proposed approach is conservative and may overestimate fountain darter take in this reach.
65	15	Line 4, Table 6	Spelling error. Update "Extimated"	COSM	Change made.
66	33	Lines 6-14, Tab	The % impact estimates for Spring Lake Dam salamander occupied habitat (1,530m2) for flow and recreation combined for impact categories C & D, 50% and 62.5%, seems like it would result in an overestimation of salamander take attributed to recreational activities especially given the current and anticipated future managment of this area.	COSM	We acknowledge that the proposed approach is conservative and may overestimate San Marcos salamanders take in this reach.
67	14	table 5	Recreation from capes dam to stokes park is better described as medium, Recreation below stokes park is low.	TPWD	We will consider this in the Draft HCP Chapter.
68	15	table 6	Recreation from capes dam to stokes park is better described as medium, Recreation below stokes park is low.	TPWD	We will consider this in the Draft HCP Chapter.
69	global	global	Please ensure citations are included throughout the document for statements made that should be cited.	USFWS	We will consider this in the Draft HCP Chapter.
70	global	global	FWS requests clarity of how and when the actual take assessment will be presented.	USFWS	The take assesment will be included in HCP Draft Chapter 4, Effects Analysis. An outline of the Amended EAHCP is available in the permit renewal workplan here: https://www.eahcprenewal.org/wp-content/uploads/2024/04/Work-Plan-EAHCP-Renewal-v4.pdf. Modifications to the take assessment methods will be the addressed in future coordination effort with FWS as the draft Chapter 4 is prepared.

71	2	24-27	FWS requests the take memo be comprehensive by addressing all potentially covered species. for the entire proposed plan area.	USFWS	A take assessment will only be included in the draft HCP Chapter 4 for proposed covered species. A take estimate will not be calculated for those species not proposed for coverage.
72	3	14-15	Terminology needs clear and consistent definition and usage. What is "spring flow terms" What are the units, both volume and duration/time? What gauges were used for this calculation? Consider including a glossary to ensure consistent use of terminolgy.	USFWS	We will consider this in the Draft HCP Chapter.
73	3	16-18	This does not seem to consider a no pumping scenario, which we still would like to see. What is impact between no pumping and where this analysis starts?	USFWS	This component of the take assessment methods will be addressed in future coordination effort with FWS as the draft Chapter 4 is prepared.
74	3	27	Comal Springs Riffle Beetles have been documented from Spring Lake, as noted in the species 5-year review. Also Comal Springs Dryopid Beetle has been found in Sessions Creek.	USFWS	We will consider this in the Draft HCP Chapter.
75	4	30	The plan area includes Martindale, so please add the Martindale fountain darter population.	USFWS	We will consider this in the Draft HCP Chapter.
76	6	Table 1	Re: Total Occupied Habitat -- For all species please include all areas that the species are potentially occupying not just the areas sampled e.g. bare areas for fountain darters and area between collection points for invertebrates.	USFWS	This component of the take assessment methods will be addressed in future coordination effort with FWS as the draft Chapter 4 is prepared. It is unclear whether USFWS is asking the project team to consider all designated Critical Habitat for each species to be incorporated into the take assessment? Potentially occupying would also refer to subsurface and aquifer habitat for the Comal invertebrates, San Marcos Salamander, and Texas Blind Salamander. Is the USFWS asking for the inclusion of this potentially occupied subsurface and aquifer habitat?
77	6	Table 1	Above text states use of 2023 maps. This text indicates the full biological monitoring record was used. Please rectify with clarity of the data record being used. FWS would prefer use of biological monitoring years (2001-2023).	USFWS	When the BGOs process started, the project team only had through 2023 data available. Over the course of the Take methodology memorandum development a couple things happened: 1) The memorandum process has now extended long enough to allow incorporation of 2024 available data, and 2) 2024 was an extremely low-flow year which assisted in providing observed levels of impact for consideration. As such, the project team would like to include all 2024 data to the degree practicable in both the BGOs and Take analysis preparation in the HCP drafting. The one inconsistency will be the last set of full-system aquatic vegetation maps for each system were completed in 2023 and are not scheduled again until 2028. Therefore, that 2023 base data set supplemented with 2024 reach data will be used for the fountain darter calculations. The use of this data and time periods applied will be clarified in the Draft HCP chapters.
78	6	Table 2	It is stated: Finally, althrough fountain darters have been collected further upstream in the slough arm of Spring Lake, those collections are considered seasonal and ths were not included in the overall area calculated. Please include all areas with documented occupancy including areas used seasonally.	USFWS	We will consider this in the Draft HCP Chapter.
79	8	Figure 2	FWS requests copies of higher resolution maps of occupied habitat. The FWS wants to ensure the population of Comal Springs riffle beetles at the headwaters of Spring Lake and that the Comal Springs dryopid beetle and Peck's cave amphipod populations in Panther Canyon are included.	USFWS	This component of the take assessment methods will be addressed in future coordination effort with FWS as the draft Chapter 4 is prepared.
80	9	5	Please add citation to confirm assumption that this modeling effort was Hardy.	USFWS	The assumption is incorrect. Table 3, column 3 was generated with data from EAA biological moitoring statistical analysis/modeling, TPWD (Saunders et. al), and Hardy citations as further described in the text.
81	9	Table 3	FWS recommends adding a column for future projections, which should be the basis for calculating take.	USFWS	We will consider this in the Draft HCP Chapter.
82	9	Table 3	FWS does not object to these categories. For clarity please include the biological and habitat basis for the impact categories to support the categories..	USFWS	We will consider this in the Draft HCP Chapter.
83	9	Table 3	How is monthly average used to determine the years of observance?	USFWS	The criteria set in column 2 of Table 3 are used to determine the percentages in column 4.
84	9	Table 3	Please explain why the model does not include conditions that have been observed in the historical record.	USFWS	Column 4 of Table 3 only represents what has been "observed" over the course of the biological monitoring period. The paranthetical (Modeling Projections) in Column 4 will be removed in this table in the Draft HCP chapter. It was included just to note that modeling would be needed to evaluate these conditions, but we understand how that is confusing in the current context of Table 3.
85	12	Figure 6	Please provide context to the use of this figure as part of the wetted width discussion. This should include a comparison of methods for each study and this proposed method for determining wetted width.	USFWS	This component of the take assessment methods will be addressed in future coordination effort with FWS as the draft Chapter 4 is prepared.
86	13	Table 4	Please provide context of the biological relevance of this information. That is, what is the biological response of the ranges (e.g. 80%-85). FWS anticipates this will be revised per above request for biological basis of categories..	USFWS	The average ranges of wetted area at select discharges is used to estimate impacts to covered species habitat.
87	13	Table 4	Why is 120 cfs used above and apparently changed to 100 cfs here and below.	USFWS	120 cfs is shown in Table 3 and Figure 6. However, as evident in Figure 6, 120 cfs is the point at which impacts start, but the impacts are very minor or non existant until 100 cfs. Thus, 100 cfs is used in Table 4 and subsequently the main reference from this point on in the technical memo. Using 100 cfs as the first data point still creates an impact line from 120 to 100 cfs that is used in the take analysis as evident in Figures 15 and 16.
88	14	Table 5	How were these categories defined? FWS recommends this be based on the entire period of record spring to fall vegetation map comparison.	USFWS	This component of the take assessment methods will be addressed in future coordination effort with FWS as the draft Chapter 4 is prepared.
89	21	Figure 10	Please explain why for several of the plots the low outlier temperatures seem extremely low (10 C).	USFWS	We will reevaluate these colder water temperature outliers to make sure they are accurate measurements and that the thermister was in fact in the water during these readings. Often times in shallow thermister areas with slower velocities and during extremely cold air temperatures (e.g. deep freeze 2021), water temperatures even in these spring fed systems can adjust for short periods to reflect closer to air temperatures because of the strong influence of ambient conditions.
90	21	Figure 10	Concern that long term average masks temperature extremes from low flow events. FWS requests temperature be shown for each of the impact categories above?	USFWS	We will consider this in the Draft HCP Chapter.
91	23	7-9	Please provide detail on how fixed station photography was used to determine wetted area including any field verification of photography based observations. FWS request this explanation and suggest the detail may be appropriate to include as an appendix.	USFWS	We will consider this in the Draft HCP Chapter.

92	24	Figure 12	Please specify if mapped occupied habitat is limited to area sampled, or considers all potential occupied habitat. Editorial request to revise color scheme to enable clear distinction of occupied habitat from dry land. Additional mapping of all impact categories is needed for each species. Consider adding as an appendix.	USFWS	It considers all potential occupied surface habitat. It does not include all potential subsurface habitat. We will consider these additional revisions (color scheme and appendix) in the Draft HCP Chapter.
93	25	4	Additional explanation is needed for how this was assessed and the effects from sedimentation. What variable or observations informed the qualitative assessment? This requested explanation needs to provide details of observed conditions not just defer to best professional judgment.	USFWS	This component of the take assessment methods will be addressed in future coordination effort with FWS as the draft Chapter 4 is prepared.
94	26	5-6	What is this and what is the basis of it's derivation? More details needed.	USFWS	This multiplier references the paragraph on Comal SAVs described on page 18, lines 17 through 26. That section discusses "flow only" versus "flow and recreation" through use of the Covid year analysis and concludes with a 1.5 multiplier. We will work on clarity surrounding this concept for the Draft HCP Chapter.
95	27	14-15	Additional detail is needed on how the impact level of 25% was determined to justify this estimate.	USFWS	This impact level is primarily based on professional judgement from observations over the past 20 years, previous water temperature modeling, and familiarity with the full length of the Old Channel. Technically, a 25% impact level would not apply in the Old Channel ERPA as it was designed to avoid this condition. However, the portion of the Old Channel downstream of the ERPA could be impacted. As such, the project team selected 25% as a conservative value and applied it to the whole Old Channel. This component of the take assessment methods will be addressed in future coordination efforts with the FWS as the draft Chapter 4 is prepared.
96	28	Figure 13	Habitat suitability impact index is not defined. FWS requests addition of an explanation of the methodology. FWS needs this basic understanding of HSII before we can assess the approach.	USFWS	Habitat suitability index is presented in tabular format in Tables 8a and 8b and in graphical form in Figures 13 and 14. This component of the take assessment methods will be the addressed in future coordination effort with FWS as the draft Chapter 4 is prepared.
97	29	Table 8b	Comments held until previous method questions above are resolved for both systems and all species.	USFWS	This component of the take assessment methods will be addressed in future coordination effort with FWS as the draft Chapter 4 is prepared.
98	30	Figure 14	Comment above regarding need for definition and method of derivation for HSII applicable here too. Also please separate the three species into individual plots.	USFWS	This component of the take assessment methods will be addressed in future coordination effort with FWS as the draft Chapter 4 is prepared.
99	37	Figure 17	Please confirm the details of this graph. Caption says no pumping scenario included but it appears to have been left off. Please also add the future scenarios. This comment also applies to figure 18.	USFWS	This component of the take assessment methods will be addressed in future coordination effort with FWS as the draft Chapter 4 is prepared. Revisions were made to the Technical Memorandum to remove all reference to a No Pumping scenario as it was not evaluated for this initial methods exercise.