Memorandum

To:	Scott Storment, EAHCP Program Manager
From:	Christa Kunkel, Kyle Sullivan, Ed Oborny, Brad Littrell, Casey Williams, Matt Pintar, BIO-WEST Lucas Bare, ICF
Date:	March 7, 2024
Re:	**Revised Recommended Biological Goals and Objectives for the Permit Renewal**

1. Introduction

The Edwards Aquifer Habitat Conservation Plan (EAHCP) Permittees are preparing an application to renew their Incidental Take Permit with the U.S. Fish and Wildlife Service (USFWS). This planning process involves reassessing existing EAHCP components and identifying necessary changes to the EAHCP to include in an amended plan that will be part of the application package to USFWS. The purpose of this memorandum is to recommend new Biological Goals and Objectives for the EAHCP permit renewal. A prior version of this memorandum was distributed for review on November 15, 2023. Attachment 1 includes all comments received on the prior version of the memo, along with comment responses to the main issues raised by commenters.

Biological Goals and Objectives make up the core of a Habitat Conservation Plan's (HCP's) conservation strategy. As such, they are a focal point of the USFWS guidance for developing HCPs in the *Habitat Conservation Planning and Incidental Take Processing Handbook* (HCP Handbook) (USFWS and National Marine Fisheries Service [NMFS] 2016). Generally, Biological Goals and Objectives address each Covered Species; they can also address groups of Covered Species with similar habitat or life history traits. Biological Goals are typically broad statements that indicate future desired conditions for Covered Species or their habitat. Biological Objectives are clear, measurable statements of how the HCP will achieve its Biological Goals. The Biological Goals and Objectives recommended in this memorandum would fully replace what are called "long-term biological goals and objectives" in the current EAHCP (see Section 4.1 of the EAHCP). The original long-term Biological Goals and Objectives were developed in 2011–2012, prior to USFWS (and NMFS) updating the HCP Handbook. The new proposed Biological Goals and Objectives are designed to align better with the HCP Handbook and reflect the many lessons learned from monitoring and adaptive management under the current EAHCP. These new proposed Biological Goals and Objectives also incorporate input from EAHCP stakeholders.

2. Process for Developing Biological Goals and Objectives

The HCP Handbook defines and provides guidance for developing Biological Goals and Objectives that support an effective conservation strategy, align with the overarching purpose and vision of an HCP, and contribute to species' recovery and large-scale conservation efforts. According to the HCP Handbook, Biological Goals broadly define the overall desired future conditions of an HCP and provide guiding principles for the HCP's conservation strategy. Biological Goals should comprise four elements: a key subject of concern, an attribute of interest for that subject, the target condition for the attribute, and the action or effort proposed to achieve the target.

Biological Objectives describe the specific, incremental steps that should be taken to achieve the Biological Goals. When developing Biological Objectives, USFWS recommends considering five criteria, captured by the SMART acronym, to ensure that objectives are effective and focused. Based on these five criteria, objectives should be:

Specific—describing what, who, when, and where

Measurable—able to monitor progress toward the goal

Achievable—the permittee can control or affect the outcome

Result-oriented—descriptive of an outcome

Time-fixed—can be accomplished within the permit term

Goals are descriptive and broad, while objectives are measurable and result-oriented. Together, the goals and objectives of an HCP create an integrated framework that provides the foundation for determining conservation strategies, assessing monitoring effectiveness, and evaluating the success of actions taken.

As part of the permit renewal process, input from stakeholders was requested during workshops and EAHCP subcommittee meetings that convened to review and provide specific recommendations for Biological Goals and Objectives. Listen and Learn workshops were held in 2022 to provide stakeholders with information on the permit renewal process and an opportunity to engage and offer input on elements of the permit renewal. Listen and Learn workshop #2 (August 30, 2022) focused on Biological Goals and Objectives. Meeting attendees provided feedback on recommendations for Biological Goals and Objectives to be considered in the permit renewal.

The EAHCP convened two subcommittees to provide input to this process. Biological Goals and Biological Objectives subcommittees guided development of the goals and objectives for the permit renewal, respectively. The Biological Goals Subcommittee, consisting of Science Committee and Stakeholder Committee members, convened four times, from February 2023 to March 2023. It reviewed the current EAHCP goals and current USFWS HCP guidance and provided recommendations for Biological Goals for the permit renewal. The Biological Objectives Subcommittee, consisting of members of the Science Committee and species experts, was divided into topical areas that focused on one of three species groups: aquatic vegetation/fish, salamanders, and macroinvertebrates. Convening periodically from March 2023 to May 2023, it reviewed the EAHCP's existing Biological Objectives and proposed goals from the Biological Goals Subcommittee and considered options for updating the Biological Objectives for the permit renewal. The Biological Objectives Subcommittee's recommendations were established using baseline-scientific data and included revisions for species-specific objectives.

Other input considered in developing these Biological Goals and Objectives included the following:

- Recommendations in the *Edwards Aquifer Habitat Conservation Plan Permit Options Report* (ICF 2020), which included restructuring the Biological Goals and Objectives to align better with the HCP Handbook and increasing the flexibility in the Biological Objectives for fountain darter (*Etheostoma fonticola*) habitat, based on lessons learned from habitat management and monitoring.
- Advanced comments received from USFWS on Biological Goals and Objectives and recovery criteria for Comal Springs dryopid beetle (*Stygoparnus comalensis*), Comal Springs riffle beetle (*Heterelmis comalensis*), fountain darter, Peck's cave amphipod (*Stygobromus pecki*), Texas blind salamander (*Eurycea rathbuni*), and Texas wild-rice (*Zizania texana*).

The next steps in the process are for USFWS to review the proposed new Biological Goals and Objectives and provide comments and recommendations to EAHCP staff members. After that, EAHCP staff members will discuss USFWS comments and revise the Biological Goals and Objectives to incorporate their feedback, as appropriate. As the permit renewal process moves forward, the Biological Goals and Objectives will be used to guide the update and addition of Conservation Measures and monitoring protocols.

3. Recommended Biological Goals

The following Biological Goals were developed by the Biological Goals Subcommittee, with minor editing and renumbering for clarity.[1] We recommend that the Permittees consider these goals for inclusion in the amended EAHCP. Each of the recommended goals has as its subject Covered Species populations or the habitat or ecosystems upon which Covered Species populations depend.

Goal 1: Conserve the quality and quantity of springflow and maintain suitable ecosystems within the Plan Area to provide for the persistence and resiliency of the Covered Species.

Goal 2: Conserve habitats to support resilient populations of Texas blind salamander, Comal Springs dryopid beetle, Peck's cave amphipod, and Edwards Aquifer diving beetle (*Haidoporus texanus*) in the Plan Area.

Goal 3: Conserve habitats to support resilient Comal Springs riffle beetle populations in the Plan Area.

Goal 4: Conserve San Marcos Springs and river habitats and resilient San Marcos salamander (*Eurycea nana*) populations in the Plan Area.

Goal 5: Conserve and manage resilient Texas wild-rice populations in the San Marcos Springs and river system.

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1 The Biological Goals Subcommittee report is available here: https://www.eahcprenewal.org/wp-content/uploads/2023/05/PREAHCP-Biological-Goals-Subcommittee-Report%E2%80%93Full-2023.pdf.

Goal 6: Conserve habitats, diverse native submerged aquatic vegetation (SAV) assemblages, and resilient fountain darter populations in the Comal and San Marcos Springs and river system.

Goal 7: Promote community engagement and awareness of the EAHCP, support land and water conservation, and mitigate anthropogenic stressors and natural disturbances within the Plan Area that will benefit the Covered Species.

4. Recommended Biological Objectives

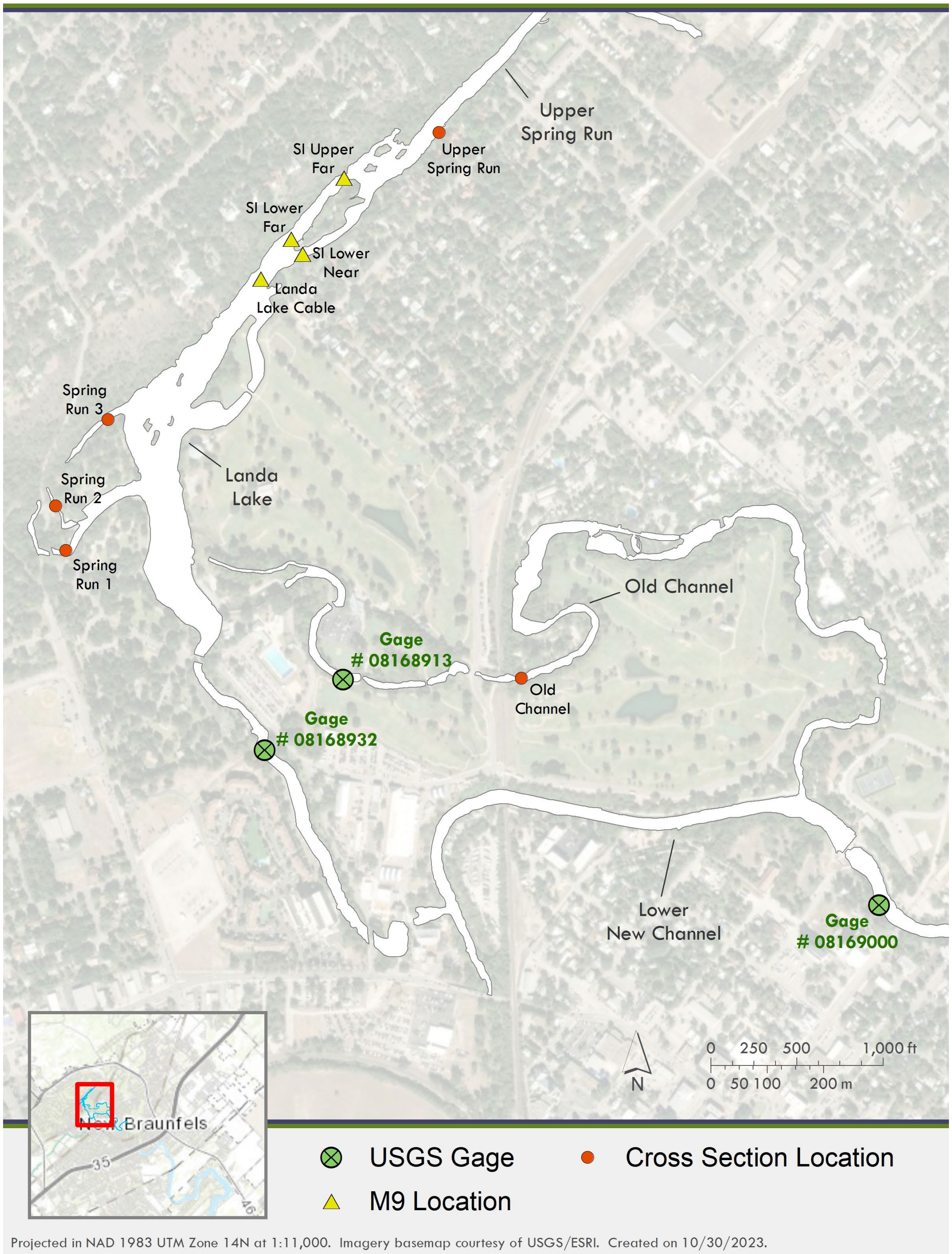
The Biological Objectives below considered input provided by the Biological Objectives Subcommittee, along with biological monitoring data collected over two decades. The objectives include measurable and achievable steps to realize the Biological Goals above. Given its broad scope and multi-faceted nature, objectives for Goal 7 have not yet been developed; therefore, this goal is not addressed further in this memo. We will consider the elements of Goal 7 when evaluating Conservation Measures to be recommended for inclusion in the renewed EAHCP.

4.1 Objectives for Springflow

Adequate springflow in both Comal and San Marcos Springs is vital to providing appropriate conditions for all of the Covered Species. The quality and quantity of available habitat is strongly influenced by springflow in dynamic spring ecosystems. Springflow objectives will continue to serve as a Biological Objective in the next iteration of the EAHCP. The springflow objectives presented below address Goal 1 directly. They also support Goals 2–6 for all Covered Species, which are addressed primarily through protection of habitat.

As part of biological monitoring, trends in river discharge are evaluated using U.S. Geological Survey (USGS) mean daily flow data in the Comal River (gage #08169000) and San Marcos River (gage #08170500). These data are used to compare monthly variations in mean daily discharge during the current monitoring year and assess recent 5-year trends. Springflow is also monitored with transects and an acoustic doppler (M9) at nine transect stations in Comal Springs, one USGS station in the New Channel (gage #08168932), and one USGS station in the Old Channel (gage #08168913) to assess spatial variation in discharge and percent contributions to total river discharge (Figure 1).

We recommend two springflow objectives for both the Comal and San Marcos systems, a minimum objective and a long-term objective. The Comal Springs minimum springflow objective links water temperature and surface habitat for fountain darter, and macroinvertebrate populations in Comal Springs habitats, which should concurrently protect subsurface habitats for subterranean species. The long-term springflow objectives link system-level springflow discharge magnitudes with long-term biological monitoring data. In addition, the Comal system will continue to employ the flow-split strategy from Landa Lake to the Old Channel by referencing real-time flow measured at the Old Channel (gage #08168913) to minimize and mitigate potential impacts during low-flow conditions. This Conservation Measure, further described in the EAHCP, is designed to preserve quality fountain darter habitat within the Old Channel over the course of the permit term. This will continue to be accomplished by providing an appropriate level of flow variability during average to high flow conditions and allowing proportionally more water to flow through the Old Channel versus the New Channel during periods of critically low flows.



Notes: SI = Spring Island. M9 is an acoustic doppler device used by the Edwards Aquifer Authority to measure springflow. Springflow calculations associated with USGS gage 08168710 described herein are based on discharge measured at USGS gage 08169000.

Figure 1. Locations of USGS Gages and Transect Stations Used to Measure Discharge in Comal Springs/River

For the San Marcos system, both objectives are based on system-level springflow discharge due to a lack of discharge data at finer spatial scales within the spring system. The San Marcos Springs objective links physical habitat availability and diverse submerged aquatic vegetation (including Texas wild-rice), wetted area, and water temperature to fountain darters, salamanders, and Texas wild-rice populations in San Marcos Springs, which should concurrently protect subsurface habitats for subterranean species. The San Marcos long-term objective links San Marcos system-level springflow discharge magnitudes with long-term biological monitoring data.

Minimum and long-term springflow objectives were based on USGS mean daily springflow data for Comal Springs (gage #08168710) and San Marcos Springs (gage #08170000), which are both quantified using discharge data for the Comal River (gage #08169000) and San Marcos River (gage #08170500). Specifically, springs discharges are calculated based on normalized flow observed at each river gage. When there is local runoff within the drainage, mean daily springflow for each gage is partitioned from inputs of the surrounding drainage using the baseflow index, separating the springs' baseflow from measured increases due to stormwater runoff.

4.1.1 Objectives for Minimum Springflow Discharge

Springflow objectives for the Comal and San Marcos systems are based on a 1-month average springflow calculated for a given year in tandem with a low-flow objective for all months.

4.1.1.1 Comal Springs

Calculations for the Comal Springs objective were made using springflow discharge measurements (cubic feet per second [cfs]) from eight of the nine biomonitoring stations (hereafter "station"; Old Channel station omitted) (2003–2023) (Figure 1) near the major springs and USGS mean daily springflow data for Comal Springs (gage #08168710 [calculated from gage #08169000, Figure 1]). The variation in station-level discharge in relation to system-level springflow conditions over a 1-month duration was assessed. For analysis, 30-day springflow moving averages (cfs) were calculated for each monitoring event at each station to approximate flow conditions at Comal Springs (gage #08168710) over a 1-month duration to establish an objective threshold.

Predictive modeling was conducted to define an objective criterion that facilitated surface habitat redundancy, which was aimed at identifying a 30-day springflow average magnitude where discharge was greater than 0 cfs at the Spring Island and Spring Run 3 stations. The term *redundancy* in this document is used to describe ecological units that occur multiple times, such as more than one area of habitat, more than one vegetation structure (complex and simple), or more than one species of vegetation. Redundancy facilitates resiliency by having multiple ecological unit buffers against the loss of any one unit.

A multilevel linear model was fit to predict spatial variation in spring discharge as a function of springflow conditions over a 1-month duration. Springflow discharge at eight of the nine stations (Old Channel omitted) per event was the response variable and 30-day springflow average at each event was the predictor variable. Regression coefficients were estimated for each station by including station as a group-level predictor (i.e., random effects) that allowed their intercepts and slopes to vary randomly. Prior to model fitting, 30-day springflow average was z-score transformed to help with model convergence and coefficient interpretation (Gelman and Hill 2007). Model performance was assessed based on root mean squared error (RMSE), R^2, and the proportion of R^2

that was explained by the station-level random effects. Prediction error was further assessed using 10-fold cross-validation repeated five times to estimate the model's ability to generalize to out-of-sample data (Hastie et al. 2009).

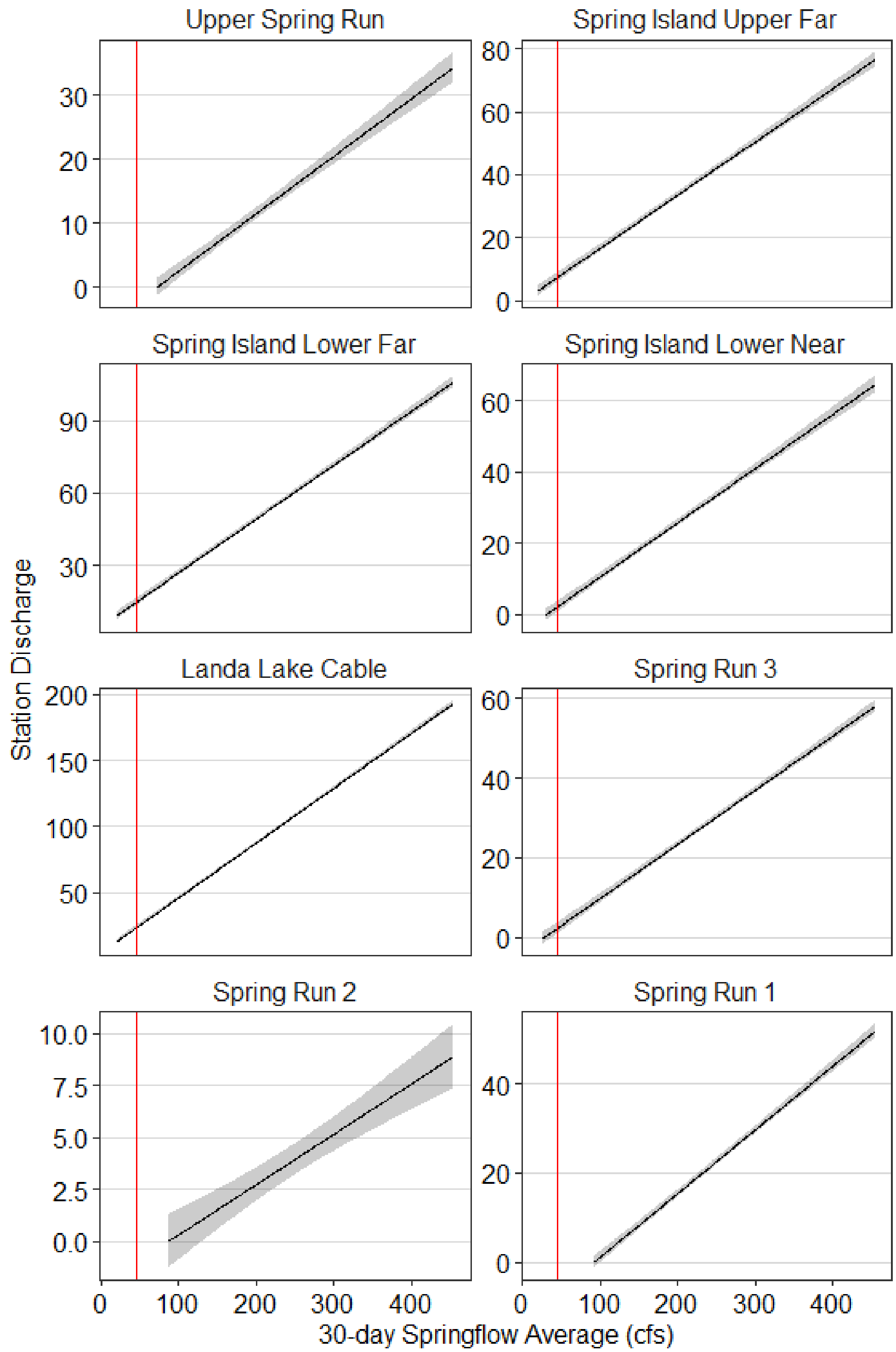
Spring discharge across stations ranged from 0 to 166 cfs (mean = 30 cfs) and 30-day spring average ranged from 64 to 454 cfs (mean = 225 cfs). The fitted multilevel model accurately predicted station-level discharge and explained a large proportion of variation in discharge, indicating high performance (RMSE = 5.04; R^2 = 0.98). Station-level R^2 contribution was 0.69, which also demonstrated that the random effects contributed to most of the variation explained by the model. Repeated cross-validation results showed mean RMSE (± standard error) and R^2 (± standard error) were very similar for both training (5.02 ± 0.02 and 0.97 ± 0.001, respectively) and test (5.24 ± 0.15 and 0.97 ± 0.001, respectively) datasets, suggesting high generalization performance. Summaries of estimated regression coefficients for each station are presented in Table 1.

Table 1. Summary of Multilevel Linear Model Coefficients among Discharge Stations in Comal Springs and River, Excluding the Old Channel Discharge Station

	Coefficients	
Station	**Intercept**	**Springflow**
Upper Spring Run	13.43	10.20
Spring Island Upper Far	37.16	19.15
Spring Island Lower Far	53.99	25.28
Spring Island Lower Near	29.05	17.29
Landa Lake Cable	96.54	47.00
Spring Run 3	26.36	15.39
Spring Run 2	3.25	2.74
Spring Run 1	18.45	16.16

High performance and ability to generalize to new data suggest that this model should be a reliable quantitative tool for selecting a 30-day average springflow objective. To do this, discharge (± standard error) was predicted through interpolation and extrapolation at each station with a 30-day average springflow ranging from 20 to 455 cfs using the fitted model. The threshold for this objective was selected at a 30-day average springflow magnitude where Spring Island stations and Spring Run 3 were predicted to remain flowing.

Predictions across all stations are displayed in Figure 2. Based on the lower bounds of standard error estimates, all stations were predicted to remain flowing at a 30-day average springflow of approximately 130 cfs. Both Spring Island Near and Spring Run 3 were predicted to be flowing when the 30-day average springflow was approximately 40–45 cfs.



Notes: Solid lines and grey polygons represent line-of-best-fit and ±1 standard error, respectively; solid red lines denote the proposed 45 cfs objective threshold.

Figure 2. Fitted Predictions of Discharge as a Function of 30-day Average Springflow across Eight Stations in the Comal System

Based on this analysis and EAHCP biological monitoring and USGS data, the recommended Comal Springs objective is:

> **Objective 1.1, Comal Springs Discharge:** *Maintain mean monthly spring discharge at Comal Springs (gage #08168710) greater than or equal to 45 cfs for at least 11 months per calendar year. Maintain daily average springflow greater than or equal to 30 cfs. This will be quantified by using mean daily springflow data to calculate average springflow for each month per year.*

At 45 cfs, five of eight stations were predicted to remain flowing, with Upper Spring Run, Spring Run 1, and Spring Run 2 not flowing (Table 2). Infrequent excursions down to a 30-cfs daily average are included in the objective, based on the model predicting four of the eight total stations and two of the three Spring Island stations still flowing (i.e., Far stations). At this magnitude, Spring Run 3 is predicted to be near zero flow. However, springs along the deeper portion of the western shoreline of Landa Lake and around Spring Island are expected to continue to support Covered Species habitat conditions. This represents two of the three historically sampled Comal invertebrate study areas, which are strongholds for the Comal Springs riffle beetle. Additionally, 45 cfs is protective of suitable flow (30 cfs) through the Old Channel, which promotes surface habitat for the fountain darter. In August 2023, a minimum mean daily flow of 55 cfs was recorded at Comal Springs. Observations at 55 cfs support model predictions of wetted habitat for Comal Springs riffle beetle at 45 cfs. Most spring runs throughout the system were largely dry from July through September, while Spring Island and Spring Run 3 remained 25–50% and 45–50% watered, respectively (BIO-WEST n.d.). Additionally, discharge through the Old Channel remained within the suitable range during the 2023 low-flow conditions.

Table 2. Fitted Predictions of Discharge (cfs) at the Proposed 30-day Average Springflow Objective Threshold of 45 cfs

	Predicted Discharge (± Standard Error)	
Station	**45 cfs**	**30 cfs**
Upper Spring Run	0.00	0.00
Spring Island Upper Far	7.34 (5.81–8.86)	4.81 (3.19–6.43)
Spring Island Lower Far	14.61 (13.04–16.17)	11.27 (9.60–12.93)
Spring Island Lower Near	2.12 (0.60–3.63)	0.00
Landa Lake Cable	23.34 (21.74–24.94)	17.13 (15.42–18.83)
Spring Run 3	2.39 (0.95–3.83)	0.35 (0.00–1.87)
Spring Run 2	0.00	0.00
Spring Run 1	0.00	0.00

4.1.1.2 San Marcos Springs

The evaluation methodology for the San Marcos Springs objective focused on EAHCP monitoring and USGS gage data with support from predictive models where monitoring data were unavailable, and historical hydrology from San Marcos Springs gage #08170000 (calculated from USGS gage #08170500; San Marcos River at San Marcos). Multiple studies have linked monitoring data to springflow or developed predictive models to determine water temperatures at varying low flows, coverage of SAV and Texas wild-rice at varying low flows, and wetted area necessary for San Marcos salamanders and vegetation (Edwards Aquifer Area Expert Science Subcommittee [EAAESS] 2009;

Hardy 2009). An objective criterion was selected that facilitated surface habitat redundancy, which was aimed at identifying a 30-day moving-average springflow magnitude where modeled water temperatures were not projected to exceed fountain darter reproductive thresholds and where wetted area for SAV and quality habitat for fountain darters and San Marcos salamanders remained at levels projected to support recovery once springflow increases (EAAESS 2009; BIO-WEST n.d.).

Based on EAHCP biological monitoring, USGS data, and water temperature modeling, the recommended San Marcos Springs objective is:

> **Objective 1.2, San Marcos Springs Discharge:** *Maintain mean monthly discharge at San Marcos Springs (gage #08170000) greater than or equal to 60 cfs for at least 11 months per calendar year. Maintain daily average springflow greater than or equal to 45 cfs. This will be quantified by using mean daily springflow data to calculate average springflow for each month per year.*

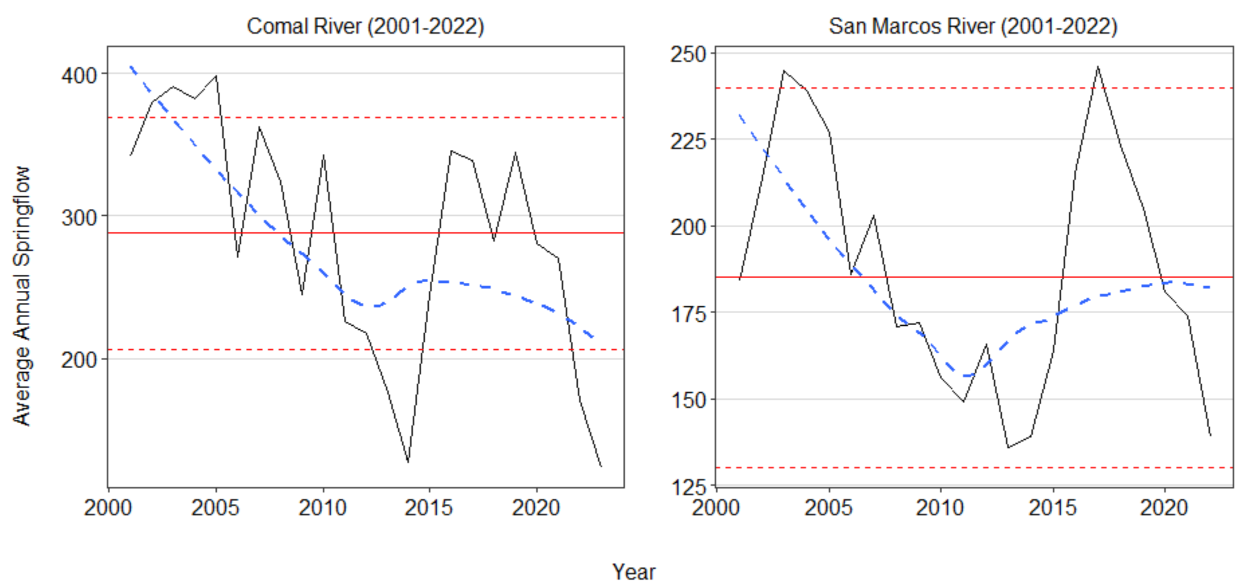
In 2023, mean daily flow was consistently below 80 cfs during August and September, with minimum mean daily flow reaching 66 cfs in August. At springflow nearing 60 cfs, algae build up and siltation increased at Spring Lake, SAV coverage in Long-Term Biological Goal (LTBG) reaches decreased with reductions in wetted width, and reproductive temperature thresholds were exceeded below Spring Lake. Although the EAAESS 2009 models predicted water temperature would remain below 25 degrees Celsius (°C), temperature exceedances above 25°C did occur during the low-flow conditions in 2023. Exceedances occurred from Spring Lake Dam (20 total days) to below Interstate (I-35) (40 total days), ranging from 4 to 8 hours in duration. The greatest impact on SAV coverage was a reduction in Texas wild-rice, yet overall Texas wild-rice areal coverage remained above the minimum 8,000 m^2 persistent coverage (see Section 4.6, *Objectives for Texas Wild-Rice*). Despite increased siltation in Spring Lake and reductions in wetted width at Spring Lake Dam, San Marcos salamanders were observed during all critical period and routine fall surveys which supports the persistence of quality habitat at conditions near 65 cfs. Likewise, fountain darter demonstrated resiliency through maintaining or exceeding long-term densities despite temperature exceedances and reduced SAV (BIO-WEST n.d.).

Infrequent reductions to the 45-cfs daily average are included in the objective because this flow still likely maintains suitable water temperatures, wetted area, and SAV habitat availability. At 45 cfs, water temperatures are likely to exceed the aforementioned reproductive threshold for short durations from Spring Lake Dam downstream to I-35, but it is anticipated that fountain darter densities would still approximate the long-term mean (BIO-WEST n.d.). At 45 cfs, SAV located in the thalweg of the river is preserved for fountain darter habitat. Thus, 45 cfs protects fountain darter reproductive capacity in reaches where fountain darter abundance is greatest.

4.1.2 Objectives for Long-Term Springflow Discharge

It is acknowledged that 2023 conditions have not been observed for an extended period (11 months) and that conditions would likely further degrade at 45 cfs in the Comal system and 60 cfs in the San Marcos system. This uncertainty was inherent in the original EAHCP springflow objectives and remains with the proposed revisions above. Hence, long-term springflow objectives were also developed to limit the occurrence and duration of minimum discharge conditions when compared to existing objectives. This reduction in duration combined with more intermittent periods between disturbance events provides opportunities for habitat conditions to recover throughout the systems, whereas increased duration of extreme low-flow events under the existing objectives limits opportunities for recovery.

Biological Objectives for long-term springflow in the Comal and San Marcos systems were quantified by relating discharge data to biological data. Over the duration of long-term monitoring (2001–2022), hydrology at Comal Springs (gage #08168710) and San Marcos Springs (gage #08170000) has varied annually, representing low-flow, high-flow, and average-flow conditions from year to year. As a simple example, Figure 3 displays a time series of average annual discharge during the monitoring period relative to one standard deviation from the long-term mean for Comal (1999–2022) and San Marcos (1994–2022) Springs. Values where springflow was greater or less than one standard deviation from the mean represent annual averages above and below typical variation, respectively. As such, it is reasonable to suggest monitoring over this time period has characterized both typical and atypical flow conditions. Biological responses show resistance and resilience during and after all low-flow years observed. For example, fountain darter populations do not show substantial declining trends in density or recruitment following periods of low flow (see Section 4.7, *Objectives for Fountain Darter*). In addition, literature supports the observation that positive and negative effects of flow on ecosystem function often involve time lags; it is recommended that these objectives use a rolling statistic to account for lag effects (Gido et al. 2010; Humphries et al. 2014). Short-term low-flow disturbance events would very likely be less severe if optimal conditions occurred prior, whereas extended durations of low flows may increase the risk of ecosystem degradation (Gido et al. 2010; Stanley et al. 2010).



Notes: The dashed blue lines denote fitted LOESS smooth functions. Dashed red lines denote one standard deviation from the long-term mean (solid red line).

Figure 3. Variation in Average Annual Springflow in the Comal and San Marcos Rivers from 2001 to 2022

Based on this, long-term objectives were quantified according to two temporal resolutions. The first objective is based on a minimum 3-year moving-average annual springflow from 2001 to 2022, which was 174 cfs in Comal Springs and 136 cfs in San Marcos Springs. The reason for using 3-year moving averages is to limit long-term environmental degradation due to low flows. The second long-term objective is based on the existing long-term (50 years) modeled average discharge objectives, which was 225 cfs in Comal Springs and 140 cfs in San Marcos Springs (Edwards Aquifer Authority [EAA] 2012).

Based on this, recommended long-term system-level objectives include:

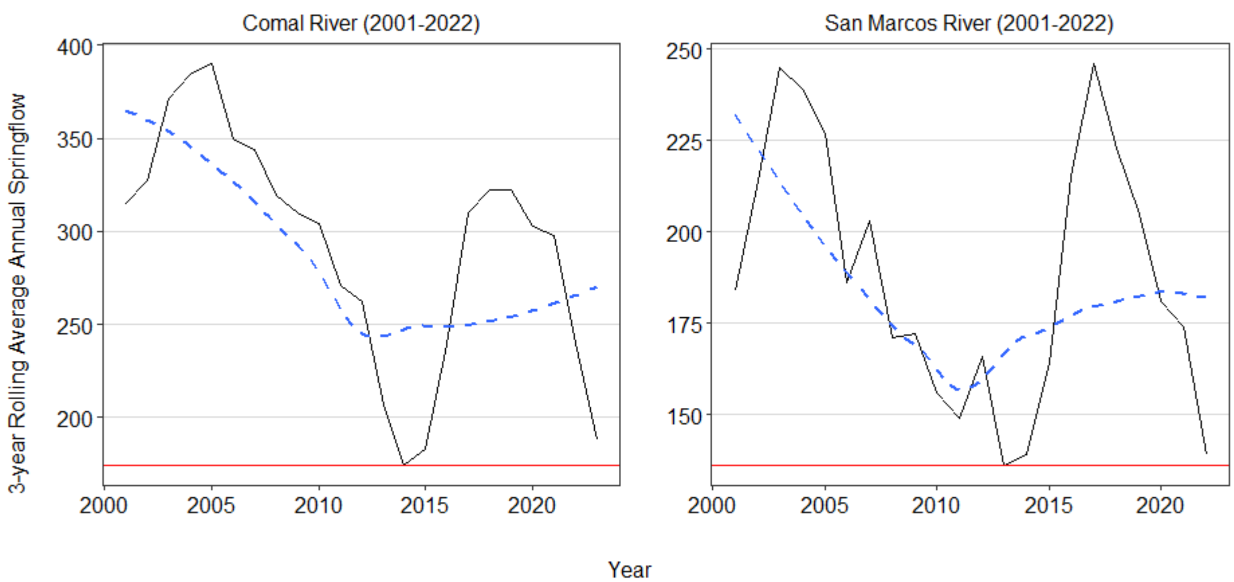
Objective 1.3, Long-Term Comal Springs Discharge:

- *Maintain a 3-year moving-average annual Comal Springs discharge (gage #08168710) above 174 cfs.*
- *Maintain a 30-year long-term average Comal Springs discharge above 225 cfs.*

Objective 1.4, Long-Term San Marcos Springs Discharge:

- *Maintain a 3-year moving-average annual San Marcos Springs discharge (gage #08170000) above 136 cfs.*
- *Maintain a 30-year long-term average San Marcos Springs discharge above 140 cfs.*

Figure 4 displays temporal trends in 3-year moving-average annual springflow from 2001 to 2022 for both systems relative to their respective thresholds. The minimum 3-year moving-average annual springflow occurred in 2014 in the Comal River and in the San Marcos River.



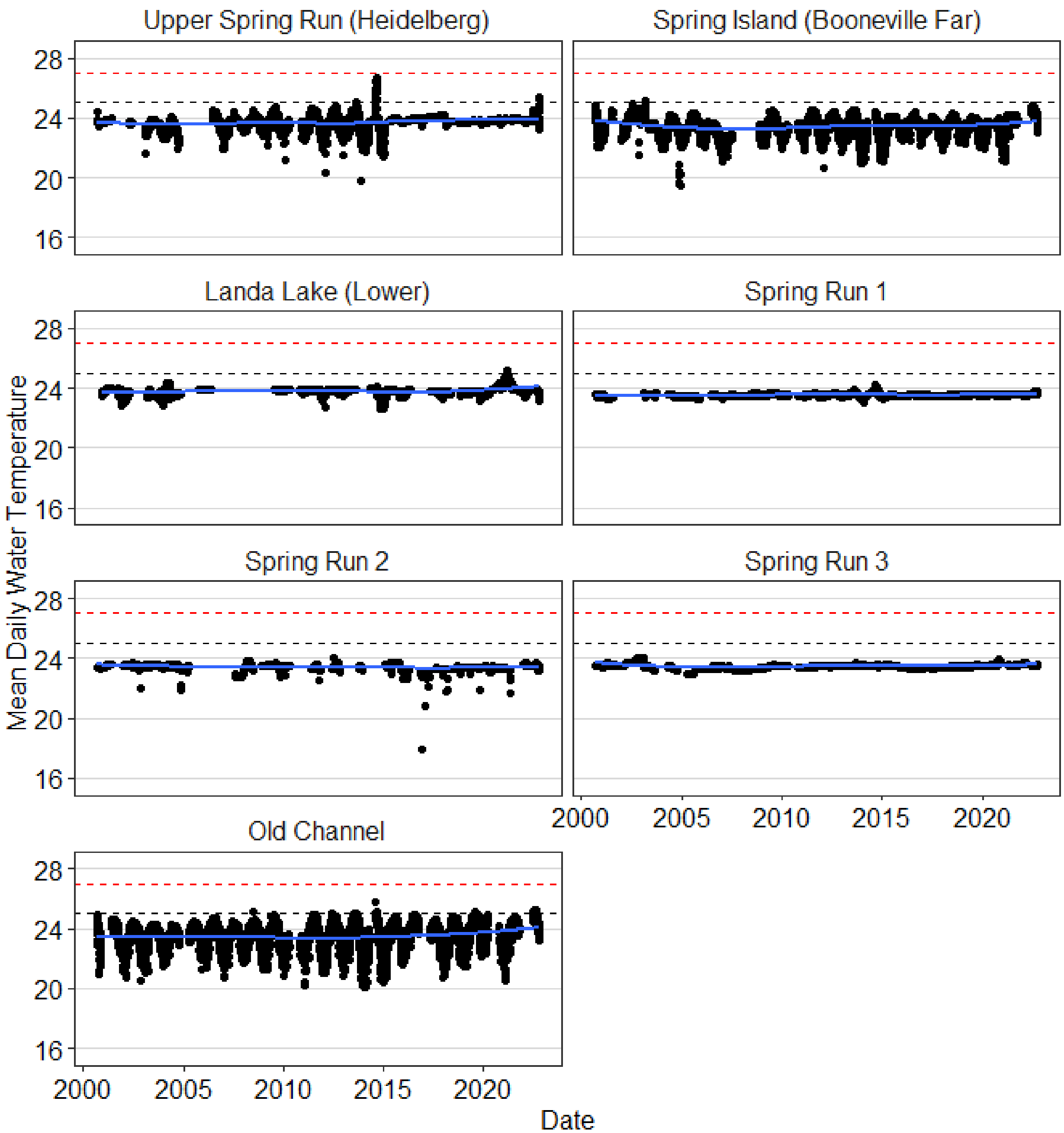
Notes: The dashed blue lines denote fitted LOESS smooth functions and the solid red lines represent the minimum observed.

Figure 4. Long-Term 3-year Average Annual Springflow Trends in the Comal and San Marcos Rivers

4.1.3 Objectives for Water Quality

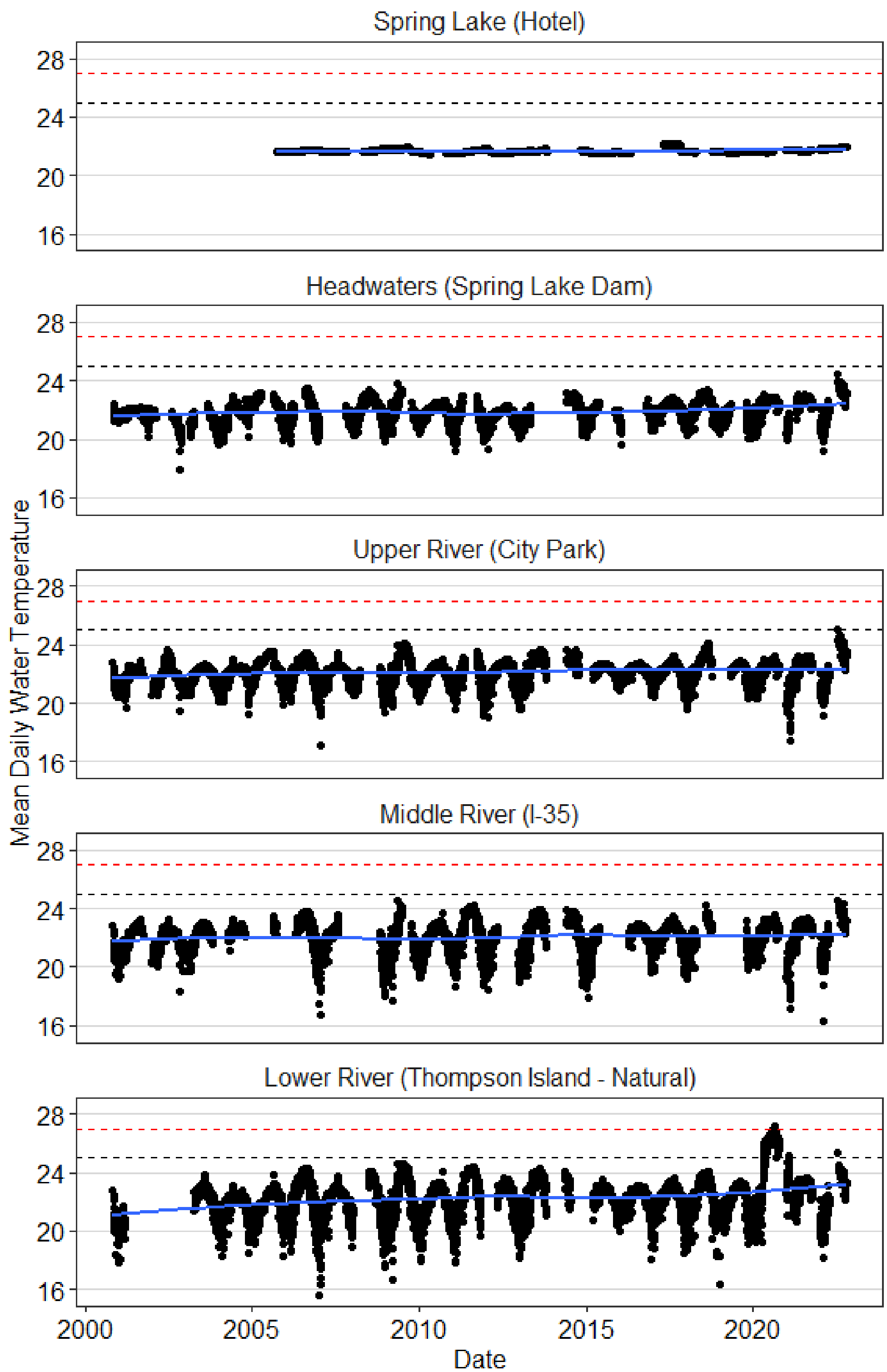
Another important reason to maintain adequate springflow is that it influences the water quality that characterizes both spring systems. Individual environmental attributes such as water temperature, dissolved oxygen, carbon dioxide, and turbidity can influence population dynamics of Covered Species; however, springflow is the driving variable for those environmental parameters. As such, maintaining appropriate springflow in both spring systems should protect suitable water quality for the Covered Species. In addition, we recommend the evaluation of water quality objectives for both systems be based on water temperature due to its direct linkage to springflow and its known physiological effects on Covered Species and their ability to fulfill life history requirements.

Water temperature objectives were established for the Covered Species in both systems and were focused on the springs and the longitudinally downstream thermally stable reaches. Maintaining a 25°C water temperature in surface habitats is considered protective of fountain darters, Comal Springs riffle beetles, and San Marcos salamanders. The temperature 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). It is assumed that water temperature in the aquifer will remain extremely stable, as evidenced by the measurements conducted over the past 20 years in the immediate spring orifices or bottom of Landa Lake and Spring Lake, respectively (Figures 5 and 6).



Notes: The solid blue lines denote fitted LOESS smooth functions. The dashed black line and dashed red line denote the 25°C and 27°C objective thresholds, respectively.

Figure 5. Mean Daily Water Temperature at Stations Chosen for Measuring Biological Objectives in the Comal Springs and River System from 2001 to 2022



Notes: The solid blue lines denote fitted LOESS smooth functions. The dashed black line and dashed red line denote the 25°C and 27°C objective thresholds, respectively.

Figure 6. Mean Daily Water Temperature at Stations Chosen for Measuring Biological Objectives in the San Marcos Springs and River System from 2001 to 2022

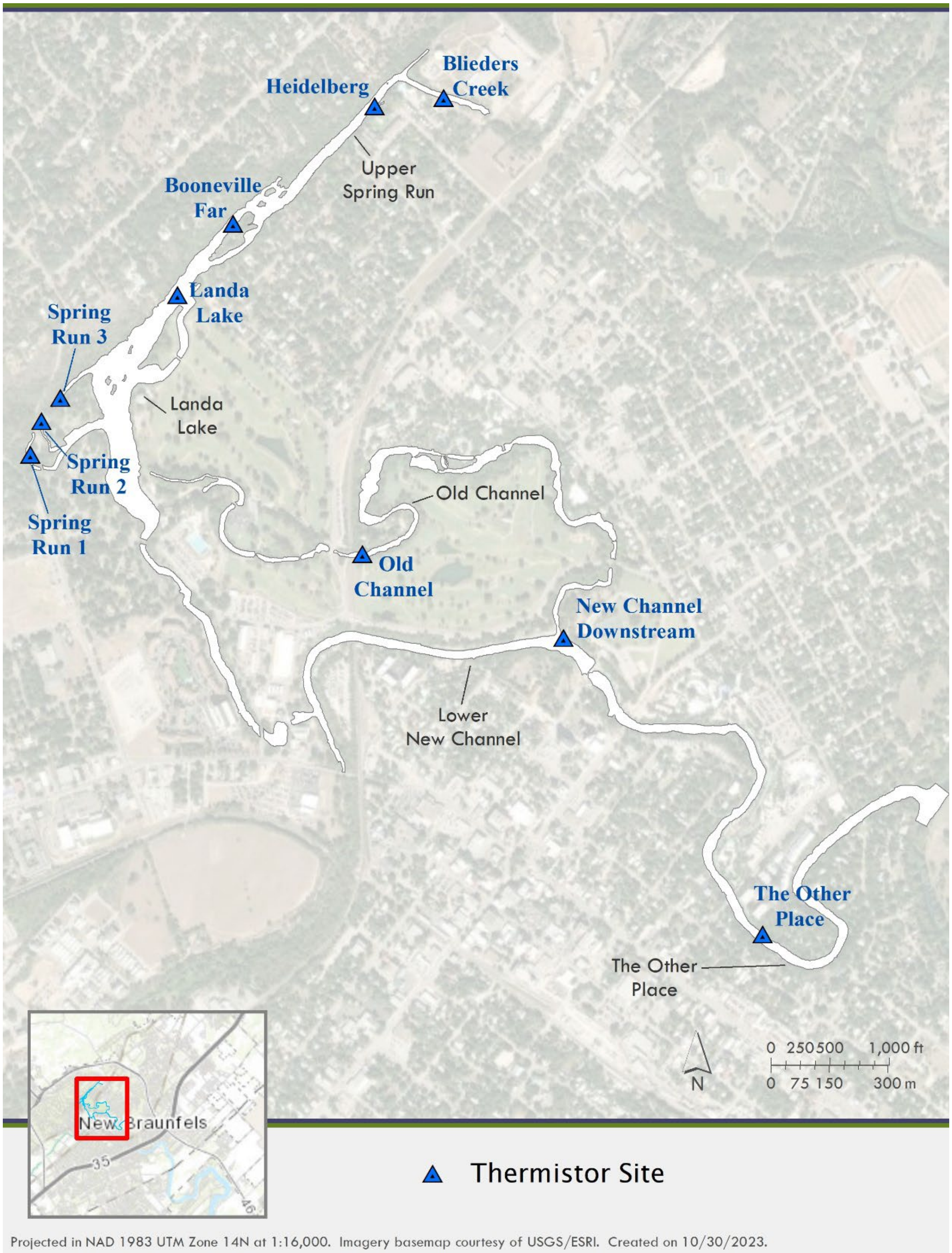
As part of biological monitoring, trends in water temperature are evaluated using temperature data loggers (HOBO Tidbit v2 Temp Loggers) at multiple permanent stations in the Comal (n = 13 stations) and San Marcos (n = 11 stations) systems. Data loggers are anchored in surface habitats near the substrate 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). Data based on 4-hour intervals are then used to assess spatial variation in water temperature compared with maximum optimal temperature requirements for fountain darter larval and egg production.

We recommend that water quality objectives aim to help maintain suitable thermal conditions for Covered Species that utilize subterranean and/or surface habitats. As such, two objectives are proposed for spring habitats and riverine habitats farther downstream per system due to their inherent differences in water temperature variability. Objectives will be measured using the mean daily water temperature calculated, based on 4-hour interval data at select stations, which are spatially representative of spring and riverine habitats, facilitating habitat redundancy to support population resiliency for Covered Species. Stations selected for the Comal system include Upper Spring Run (Heidelberg), Spring Island (Booneville Far), Landa Lake (lower station), Spring Run 1–3, and Old Channel (Figure 7). For the San Marcos system, stations selected include Spring Lake (Hotel), Headwaters (Spring Lake Dam), Upper River (City Park), Middle River (I-35), and Lower River (Thompson Island Natural) (Figure 8). Based on this, recommended water temperature objectives include:

> **Objective 1.5, Comal Springs and River Water Quality:** *Maintain mean daily water temperature in surface habitats near the substrate less than or equal to 25°C within Upper Spring Run, Spring Island, Spring Run 1–3, and Landa Lake. Maintain mean daily water temperature in surface habitats near the substrate less than or equal to 25°C for more than 50% of the days per year and less than or equal to 27°C within the Old Channel.*

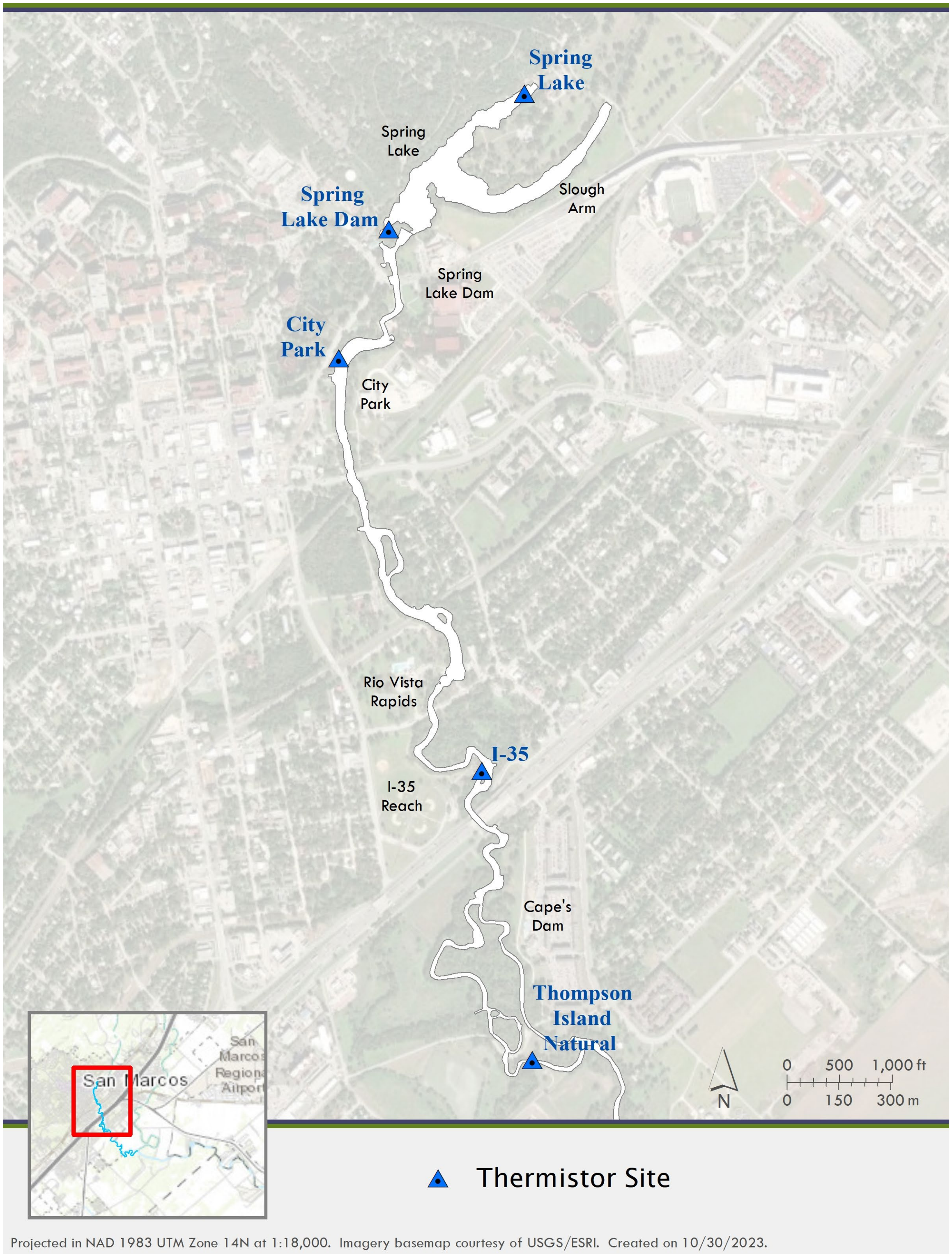
> **Objective 1.6, San Marcos Springs and River Water Quality:** *Maintain mean daily water temperature in surface habitats near the substrate less than or equal to 25°C within Spring Lake. Maintain mean daily water temperature in surface habitats near the substrate less than or equal to 25°C for more than 50% of the days per year and less than or equal to 27°C within the Headwaters, Upper River, Middle River, and Lower River.*

The proposed water temperature objectives are based on specific recommendations provided by USFWS for the Draft Recovery Plan for the Edwards Aquifer species. To exemplify how these objectives would be assessed, Figures 5 and 6 demonstrate temporal trends in water temperature for each station relative to their respective thresholds. Mean daily water temperature in spring habitats exceeded 25°C one or more days at Upper Spring Run (2013, 2014, 2022), Spring Island (2003), and Landa Lake (2021). The maximum percentage for the number of days per year when water temperature was greater than 25°C was 26% at Old Channel (Figure 5). In the San Marcos, mean daily water temperature never exceeded 25°C at Spring Lake, Headwaters, or Middle River. Water temperature at Upper River was greater than 25°C one day in 2022 (less than 1%). At Lower River, the cumulative percent of days in which mean daily water temperature exceeded 25°C was 2.8% which occurred in 2020, 2021, and 2022 (Figure 6).



Notes: Selected stations for analysis were Heidelberg (Upper Spring Run), Booneville Far (Spring Island), Landa Lake, Spring Run 1–3, and Old Channel.

Figure 7. Thermistor Station Locations throughout the Comal Springs and River System



Notes: Selected stations for analysis were Spring Lake, Spring Lake Dam (Headwaters), City Park (Upper River), I-35 (Middle River), Thompson Island Natural (Lower River).

Figure 8. Thermistor Station Locations throughout the San Marcos Springs and River System

It is acknowledged that other water quality constituents, such as contaminants, conductivity, turbidity, and pH, are factors that might affect the Covered Species. However, no quantifiable objectives are proposed for dissolved oxygen or other water quality attributes because these cannot be directly manipulated and managed. Adequate springflow is the driving variable for environmental parameters such as water temperature, dissolved oxygen, carbon dioxide, and turbidity. Due to the direct linkage between springflows and these water quality attributes, maintaining appropriate springflows (as met by the proposed objectives) is assumed protective of suitable water quality within both spring systems.

Although there is no objective for other water quality parameters, monitoring for these constituents (e.g., contaminants, dissolved oxygen, conductivity, turbidity, pH) will continue. Presently, the EAA manages six real-time water quality stations, monthly discrete sampling, low-flow water quality monitoring, and ancillary monitoring conducted by EAA Aquifer Sciences. The EAHCP, in coordination with EAA, will continue to promote best management practices over the watershed while conducting extensive water quality monitoring activities. Furthermore, existing programs in the EAHCP will continue to monitor sensitive areas under critical flow periods.

4.2 Objectives for Aquifer Species

Among the petitioned and endangered species to be covered in the permit renewal EAHCP, two are presumed to rely entirely on aquifer habitats: Texas blind salamander and Edwards Aquifer diving beetle. The Texas blind salamander has been documented in only eight well, spring, or cave locations in and near San Marcos, Texas. The Edwards Aquifer diving beetle has been collected in Comal and San Marcos Springs. However, collection of these species is rare and surface survival is low. For example, the Edwards Aquifer diving beetle has been collected only 28 times since 2003 in both spring systems (BIO-WEST n.d.). As such, demographic-specific analyses are not possible due to low abundances of these aquifer species recorded during the long-term monitoring period (2001–2022).

Biological Objectives for these two species are focused on conserving aquifer habitats and protecting water quality by maintaining suitable springflow and water temperature to ensure population resiliency (Goal 2). Therefore, the objectives in Section 4.1, *Objectives for Springflow*, support the Biological Goal for these species.

4.3 Objectives for Aquifer Species with Surface Utilization

Peck's cave amphipod and Comal Springs dryopid beetle occur in Comal Springs system headwaters and spring upwelling areas. Comal Springs dryopid beetle has been collected in the San Marcos Springs system but is more commonly found in the Comal Springs system. Both species are subterranean and rely on aquifer environments; however, both species occupy surface habitats in the Comal system. Both species are collected using drift nets in Comal Spring Runs 1, 3, and 7. They can also be found on wood throughout Landa Lake or on cotton lures. However, Peck's cave amphipod is more commonly collected than Comal Springs dryopid beetle in drift net sampling, with a total collection of 78 individuals since 2003 (BIO-WEST n.d.). Demographic-specific analyses are limited for each species due to low abundances recorded from non-targeted monitoring since 2001.

Biological Objectives for the Peck's cave amphipod and Comal Springs dryopid beetle are focused on conserving both aquifer and surface habitats by maintaining suitable springflow and water temperature to ensure population resiliency (Goal 2). Therefore, the objectives in Section 4.1, *Objectives for Springflow*, support the Biological Goal for these species.

4.4 Objectives for Comal Springs Riffle Beetle

Comal Springs riffle beetle is an aquatic beetle endemic to the springs of the Edwards Aquifer. This species occupies unembedded, gravelly spring areas in Comal Springs and has occasionally been observed in the Hotel reach of San Marcos Springs. Since 2004, the EAA has conducted regular monitoring of Comal Springs riffle beetle by sampling three areas (Spring Run 3, Landa Lake western shoreline, and Spring Island) in the Comal Springs system using the Cotton Lure standard operating procedure (EAA 2017a).

We recommend that the evaluation methodology for an abundance-specific Biological Objective seek to examine results from a system-level (across study reaches) perspective, exclusively using count data for adults. We also recommend that basis for criteria be made using data from 2013–2022 due to incongruent methods for selecting sample locations compared to 2004–2012. Lures were set in areas with quality habitats that were previously found to have high abundances from 2004–2012. From 2013–2022, lure locations varied more spatially and were also set in areas known to harbor lower beetle abundances. Based on this, data from 2013–2022 are most likely more representative of the different habitats that are available within Comal Springs and therefore should provide estimates of abundance that better generalize the overall population.

The abundance-based Biological Objective for adult Comal Springs riffle beetle was quantified according to two parameters: 1) central tendency, a value for which the results will tend to, and 2) dispersion, how far typical values range from the mean. Calculations were based on parameters from the normal distribution, mean (i.e., central tendency; μ), and standard deviation (i.e., dispersion; σ), which were used to establish objective thresholds at one standard deviation below the mean (μ - σ). This threshold was chosen to approximate time periods when abundance is lower than the average distance from the mean, providing proximal measurements of potential system degradation.

Quantification of this objective was based on relative abundance, indexed as beetle counts per lure (counts/lure). Relative abundances were first used to calculate average counts/lure for each sampling event (n = 31 events). These averages were then used to calculate a long-term mean and standard deviation (Table 3).

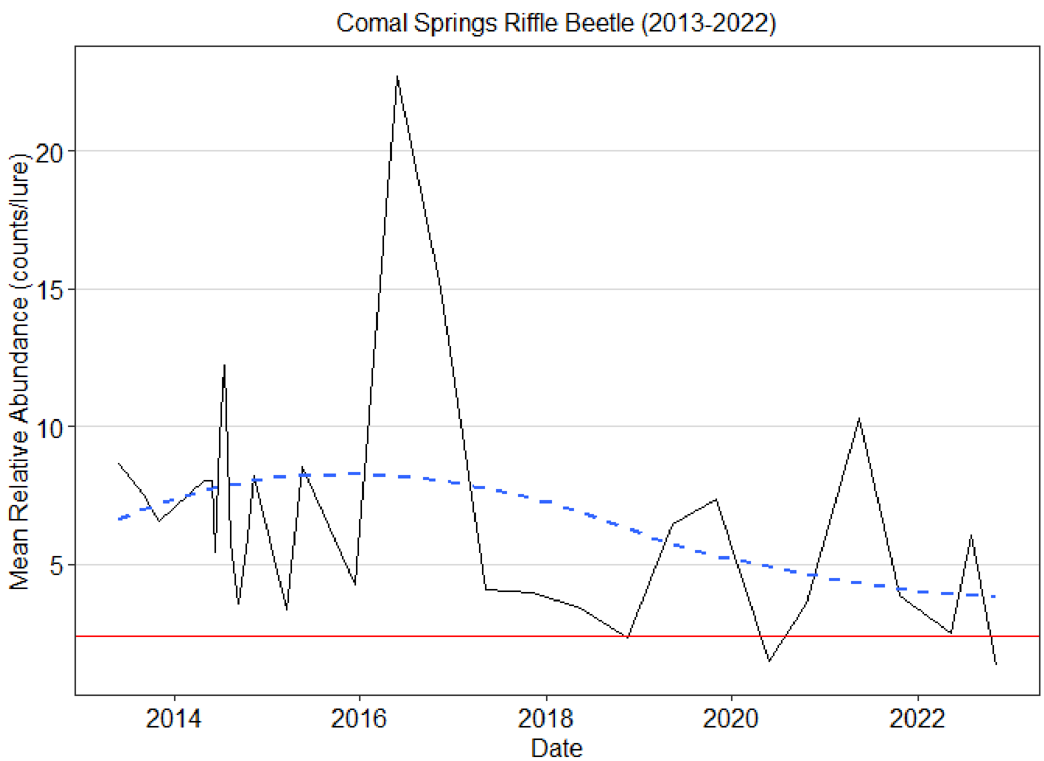
Table 3. Mean and Standard Deviation Calculations of Adult Comal Springs Riffle Beetle Counts/Lure in Comal Springs and Recommended Threshold for This Objective

Parameter	Estimate
Mean (μ)	6.7
Standard deviation (σ)	4.3
Recommended threshold for objective: One standard deviation below the mean (μ – σ)	2.4

Biological Objectives to support conserving resilient Comal Springs riffle beetle populations (Goal 3) are focused on conserving both surface and subsurface habitats by maintaining suitable springflow and water temperature at Comal and San Marcos Springs (Section 4.1, *Objectives for Springflow*) and the following abundance objective in Comal Springs:

> **Objective 3.1, Comal Springs Riffle Beetle Relative Abundance:** *Mean Comal Springs riffle beetle relative abundance should not fall below 2.4 counts/lure for a minimum of three sampling events covering a 12-month period, as measured at long-term biological monitoring areas (Landa Lake, Western Shoreline, Spring Island, Spring Run 3).*

To exemplify how this system-level population objective would be assessed, Figure 9 displays temporal trends in mean relative abundance of Comal Springs riffle beetle compared to the objective threshold of 2.4 counts per lure. Mean relative abundance was lower than the proposed threshold at three events (10%) from 2013 to 2022; it never fell below it for more than one consecutive event.



Notes: The dashed blue lines denote fitted Loess smooth functions and the solid red lines represent one standard deviation below the mean.

Figure 9. Long-Term Trends in Mean Relative Abundance of Comal Springs Riffle Beetle

In addition to analyzing the relative abundance per lure, it is also important to protect the spatial distribution of Comal Springs riffle beetle. Therefore, a second objective was quantified based on likelihood of occurrence, which represents apparent occupancy, the proportion of lures that Comal Springs riffle beetle were detected. The response variable is a relative likelihood rather than a probability due to the fact that the true occurrence states are confounded by imperfect detection (MacKenzie et al. 2006). For this objective, likelihood of occurrence was first calculated for each sampling event as the number of lures where ≥1 beetle was detected divided by the total number of lures sampled across all sites. Likelihood of occurrence per event was then used to calculate a long-term mean and standard deviation (Table 4).

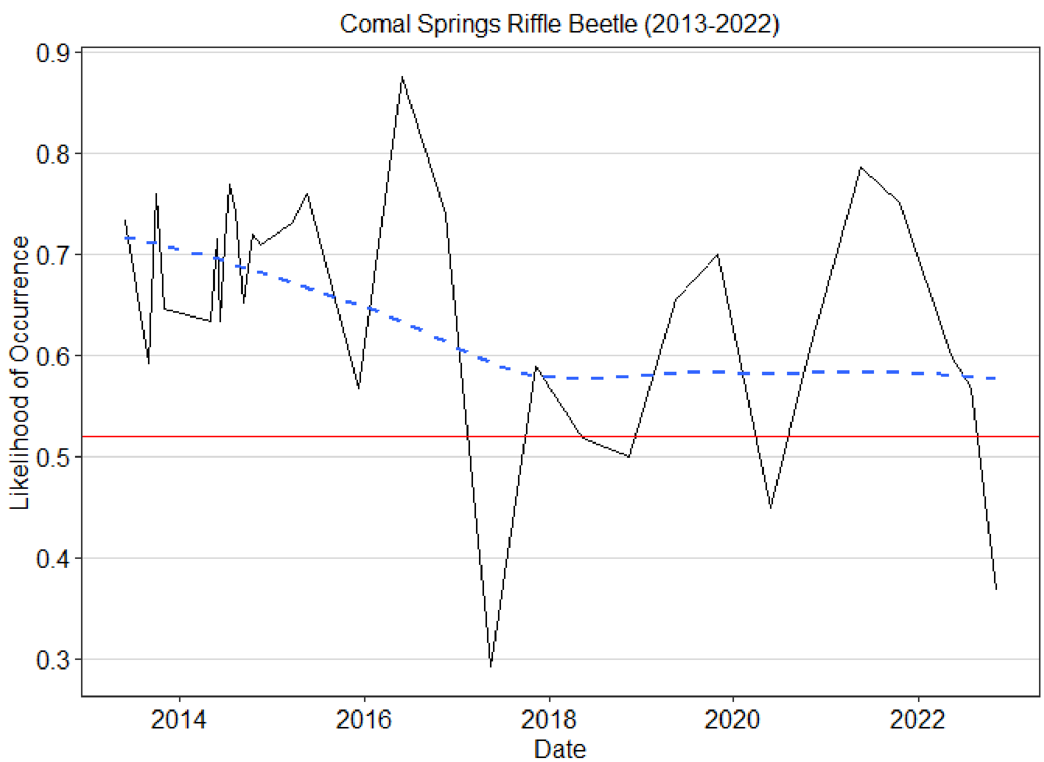
Table 4. Mean and Standard Deviation Calculations of Comal Springs Riffle Beetle Likelihood of Occurrence in Comal Springs and the Threshold for This Objective

Parameter	Comal
Mean (μ)	0.65
Standard deviation (σ)	0.13
Recommended threshold for objective: One standard deviation below the mean (μ – σ)	0.52

Based on this, a system-level objective aimed at conserving resilient Comal Springs riffle beetle populations (Goal 3) states:

> **Objective 3.2, Maintain Comal Springs Riffle Beetle Likelihood of Occurrence 0.52**. *Comal Springs riffle beetle likelihood of occurrence should not fall below 0.52 for a minimum of three sampling events covering a 12-month period.*

Figure 10 displays temporal trends in likelihood of occurrence of Comal Springs riffle beetle compared to the objective threshold of 0.52. Likelihood of occurrence was lower than the proposed threshold at four events (13%) from 2013–2022 and never fell below it for more than one consecutive sampling event.



Notes: The dashed blue lines denote fitted LOESS smooth functions, and the solid red line represents one standard deviation below the mean.

Figure 10. Long-Term Trends in Mean Likelihood of Occurrence of Adult Comal Springs Riffle Beetle

Due to the infrequent observations of Comal Springs riffle beetles in Spring Lake, this area was not included in the monitoring plan during the existing EAHCP. A quantifiable objective cannot be calculated because there has not been standardized monitoring via Cotton Lure standard operating procedure. However, it is recommended that monitoring of Comal Springs riffle beetle at the Hotel area of Spring Lake be incorporated into the monitoring plan in the EAHCP permit renewal and that an objective for Comal Springs riffle beetles in Spring Lake be evaluated as more data becomes available.

4.5 Objectives for San Marcos Salamander

The San Marcos salamander, found in Spring Lake and downstream of Spring Lake Dam, associates with rocky substrates around spring openings. Since 2001, San Marcos salamanders have been monitored at least twice per year at two sites within Spring Lake, Hotel Site and Riverbed Site, and at one site within the San Marcos River, Spring Lake Dam Site (BIO-WEST n.d.). Timed visual surveys in these three locations are conducted in quality habitat by recording the number of rocks turned and the number of salamanders observed. The National Academy of Sciences report and EAHCP Biological Objectives Subcommittee both raised concerns over the sampling methodology to calculate San Marcos salamander population metrics. As such, the project team did not use this long-term dataset to calculate density metrics. However, all three existing monitoring sites have demonstrated persistent occupancy of salamanders over the past 23 years. For example, a total of 5,154 salamanders with an average (±standard deviation) of 101.0 (±22.3) salamanders per 15-minute survey have been observed in the Hotel Reach. In the Riverbed Reach, 4,249 salamanders with an average of 83.3 (±23.4) salamanders per 15-minute survey have been observed. A total of 826 salamanders with an average of 16.2 (±7.8) salamanders per 15-minute survey have been observed in the Spring Lake Dam Reach. Consistently high salamander counts at each of these spatially diverse reaches demonstrate the presence of quality habitat. Quality surface habitat specific to these locations is defined as areas devoid of aquatic macrophytes that support clean, clear substrate conditions underneath approximately twelve to sixteen 8- to 12-centimeter-wide rocks per square meter (m^2). Subsurface use of these habitats in smaller rocks and gravels also occurs and further highlights the importance of maintaining silt-free environments.

Biological Objectives for San Marcos salamander focused on conserving areas with quality habitat demonstrated by persistent occupancy to ensure population resiliency. San Marcos salamanders from multiple size classes have occupied these quality habitats during every survey conducted in these three diverse locations over the past two decades. It is recommended that the evaluation methodology be aimed at helping maintain spatial redundancy of salamander habitat in spring and riverine environments. Therefore, separate Biological Objectives were quantified for the San Marcos Springs and River, based on two parameters: 1) central tendency, a value for which the results will tend to, and 2) dispersion, how far typical values range from the mean.

Calculations were based on monitoring data from 2001 to 2022 parameters from the normal distribution, mean (i.e., central tendency; μ), and standard deviation (i.e., dispersion; σ), which were used to establish objective thresholds at one standard deviation below the mean ($\mu - \sigma$). This threshold was chosen to approximate time periods when areas of quality habitat are lower than the average distance from the mean, providing proximal measurements of potential system degradation. Simulation analyses indicated observed habitat data did not satisfy the assumptions of normality.

That said, we believe parameters of the normal distribution still provide a useful characterization of central tendency and dispersion that is conceptually simple and easier to understand.

Objectives were quantified according to the total area of quality habitat at each site per monitoring event (n = 51 events). Quality habitat within the two most upstream riverine sites below Spring Lake Dam were combined by summing their areas into a single quantity per event. Total areas were then used to calculate long-term means and standard deviations for each site, which are presented in Table 5.

Table 5. Mean and Standard Deviation Calculations of Sampled Quality Habitat (m^2) for San Marcos Salamander at Three Sites and Thresholds for System-Level Objectives

	Sampled Site		
Parameter	**Hotel**	**Riverbed**	**Spring Lake Dam**
Mean (μ)	31.0	51.9	29.6
Standard deviation (σ)	7.63	21.6	15.8
Recommended thresholds for objective: One standard deviation below the mean (μ – σ)	23.3	30.3	13.7

Based on this information, the objectives that support conserving resilient San Marcos salamander populations (Goal 4) include the objectives for San Marcos Springs (Section 4.1, *Objectives for Springflow*) and the following habitat quality objective:

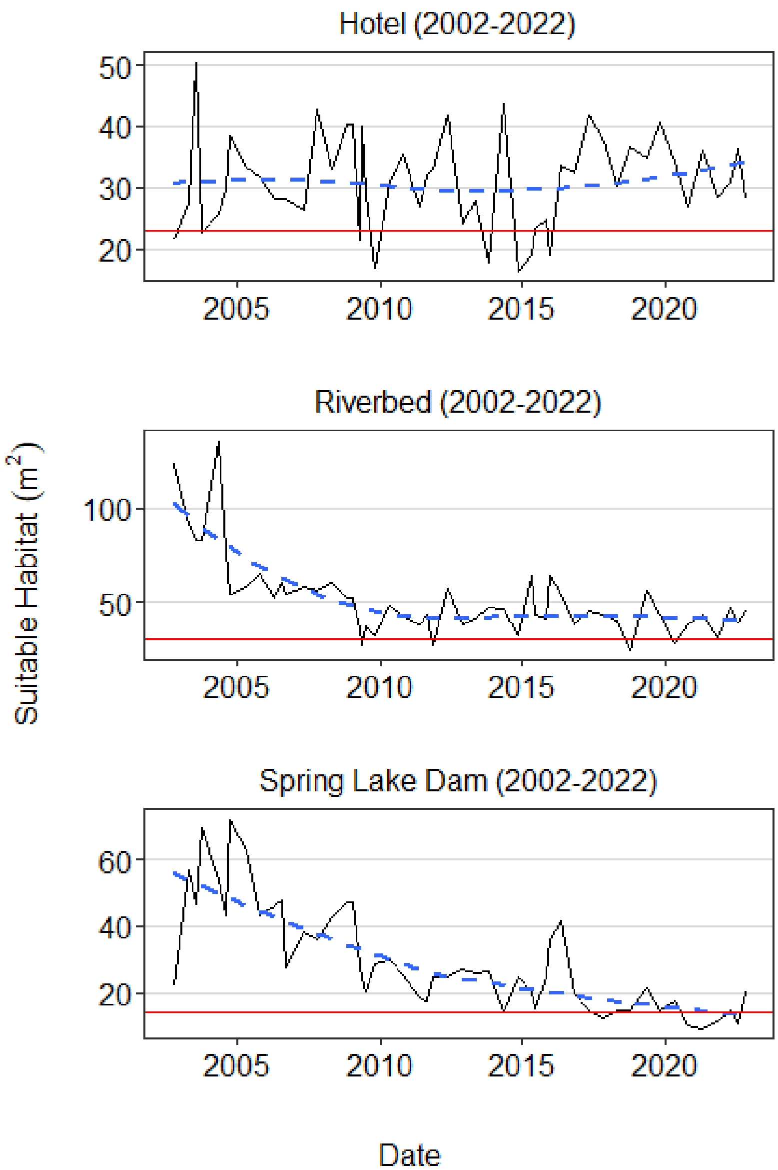
> **Objective 4.1*, San Marcos Salamander Habitat:** *Maintain total area of quality habitat above 23 m^2 at the Hotel site, above 30 m^2 at the Riverbed site, and above 14 m^2 at Spring Lake Dam. Areas of quality habitat should not fall below these values for a minimum of three sampling events covering a 12-month period.*
>
> * **Although habitat quality and protected area criteria are proposed, the San Marcos salamander biological monitoring program will be revised for the EAHCP permit renewal.**

Per recommendation of the Biological Objectives Subcommittee, an additional San Marcos salamander monitoring site at Diversion Springs will be incorporated into the long-term biological monitoring program, upon permit renewal. The inclusion of Diversion Springs as a fourth salamander monitoring area moving forward is supported by the number of San Marcos salamanders consistently observed in this location by USFWS San Marcos Aquatic Resources Center biologists. Following a few years of monitoring, it is anticipated that a habitat area objective at this fourth diverse location for the San Marcos salamander will be added to these interim criteria. To exemplify how these objectives will be assessed, Figure 11 displays temporal trends in sampled quality habitat for each site relative to their respective threshold. The threshold for quality habitat was lower than the proposed threshold at eight events (16%) at Hotel, four events (8%) at Riverbed, and five events (10%) at Spring Lake Dam. At Spring Lake Dam, quality habitat was below its proposed threshold one time during three consecutive events, which occurred from fall 2020 to fall 2021. Quality habitat was also below the threshold one time at Hotel for two consecutive events during sampling in 2014–2015.

Quality habitat in Spring Lake is dependent on human intervention from Meadows Center staff members and volunteer SCUBA divers to keep the Hotel and Riverbed sites free of aquatic macrophytes. Figure 11 highlights the consistency of this intervention since implementation of the

EAHCP. In addition, recreational activities for the general public are restricted in Spring Lake. Given the benefit that management in Spring Lake has on quality salamander habitat, it is recommended that all currently managed spring orifice locations in Spring Lake continue to be actively managed as a Conservation Measure to further enhance and protect quality San Marcos salamander habitat throughout Spring Lake.

In contrast, the Spring Lake Dam site is not actively maintained and has limited restrictions for the general public. A clear downward trend in Spring Lake Dam quality salamander habitat is evident in Figure 11. The downward trend involves more than just recreational impacts; expansion of aquatic macrophytes, such as Texas wild-rice, in this location have also led to increased sedimentation and reduction in quality salamander habitat. Active management in both the lake and the eastern spillway below Spring Lake Dam will be necessary as Conservation Measures to achieve this Biological Objective.



Notes: The dashed blue lines denote fitted LOESS smooth functions, and the solid red lines represent one standard deviation below the mean.

Figure 11. Long-Term Density Trends in Sampled Quality Habitat for San Marcos Salamander

4.6 Objectives for Texas Wild-Rice

Texas wild-rice coverage in the upper San Marcos River has greatly increased as a result of the EAHCP. Since implementation of the EAHCP in 2013, total areal coverage has increased from 4,561 m^2 in 2013 to a maximum of 17,235 m^2 in 2021, an almost fourfold increase. The areal coverage in 2021 was the highest ever recorded. This expansion was enhanced by restoration efforts that included active planting and by the lack of recreation during 2020 and 2021 due to COVID-19 restrictions. Texas wild-rice is a strong colonizer in the upper San Marcos River. It readily expands into new areas, often leading it to outcompete other SAV species. Thus, an objective was developed to balance the needs of Texas wild-rice while maintaining a diverse native SAV community. Monitoring of Texas wild-rice involves visually delineating discrete patches using kayak and collecting geospatial data for each patch. Geospatial data are then processed using GIS to construct polygons that represent discrete patches from which total areal coverage of Texas wild-rice can be quantified (EAA 2017b).

Population objectives were quantified by first determining persistent stands of Texas wild-rice over the course of the EAHCP. Summer full-system Texas wild-rice mapping data were collected from the most recent 10 years of monitoring (2013–2022) and converted to a presence/absence raster with a 25-centimeter spatial resolution. Pixel values were then summed to create a raster with values between 0 and 10, indicating years of presence per area, to demonstrate persistent coverage per location. This yielded 1,932 m^2 coverage across all 10 years. Extending persistence to 9–10 years increased coverage to 3,865 m^2; expanding persistence to 8–10 years increased coverage to 5,612.6 m^2. To illustrate how these Texas wild-rice persistent stands were assessed, Figure 12 displays temporal trends from Sewell Park to Hopkins over the course of EAHCP implementation through 2022.

Building upon persistent stands, overall Texas wild-rice areal coverage has varied between approximately 8,000 m^2 and 12,000 m^2 throughout the upper San Marcos River between 2016 and 2019, which are the years after active planting mostly stopped in reaches above I-35 and before the anomalous years during COVID-19 restrictions. This represents a period with less active control of the Texas wild-rice population while river recreation remained normal. Increasing areal coverage beyond the 5,600 m^2 of persistent stands protects the species' ability to sexually reproduce, which promotes genetic diversity and enhances resiliency. Furthermore, maintaining a spatial distribution with greater abundance in the upstream reaches while retaining some abundance in the downstream reaches also enhances population resiliency by increasing redundancy. Although the population in the Spring Lake reach is small, retaining Texas wild-rice stands in Spring Lake protects stands that have persisted for more than 20 years and are shielded from recreational impacts. Based on a total areal coverage objective of 8,000 m^2 across the upper San Marcos River, the percent of population per reach was determined from long-term monitoring (2000–2023) of Texas wild-rice and professional judgement (Table 6). Since implementation of the EAHCP, this total areal coverage and recommended spatial distribution (Figure 13) has been attainable. It represents what is assumed to be a natural spatial and longitudinal distribution of Texas wild-rice and has shown to be self-sustaining since 2016.

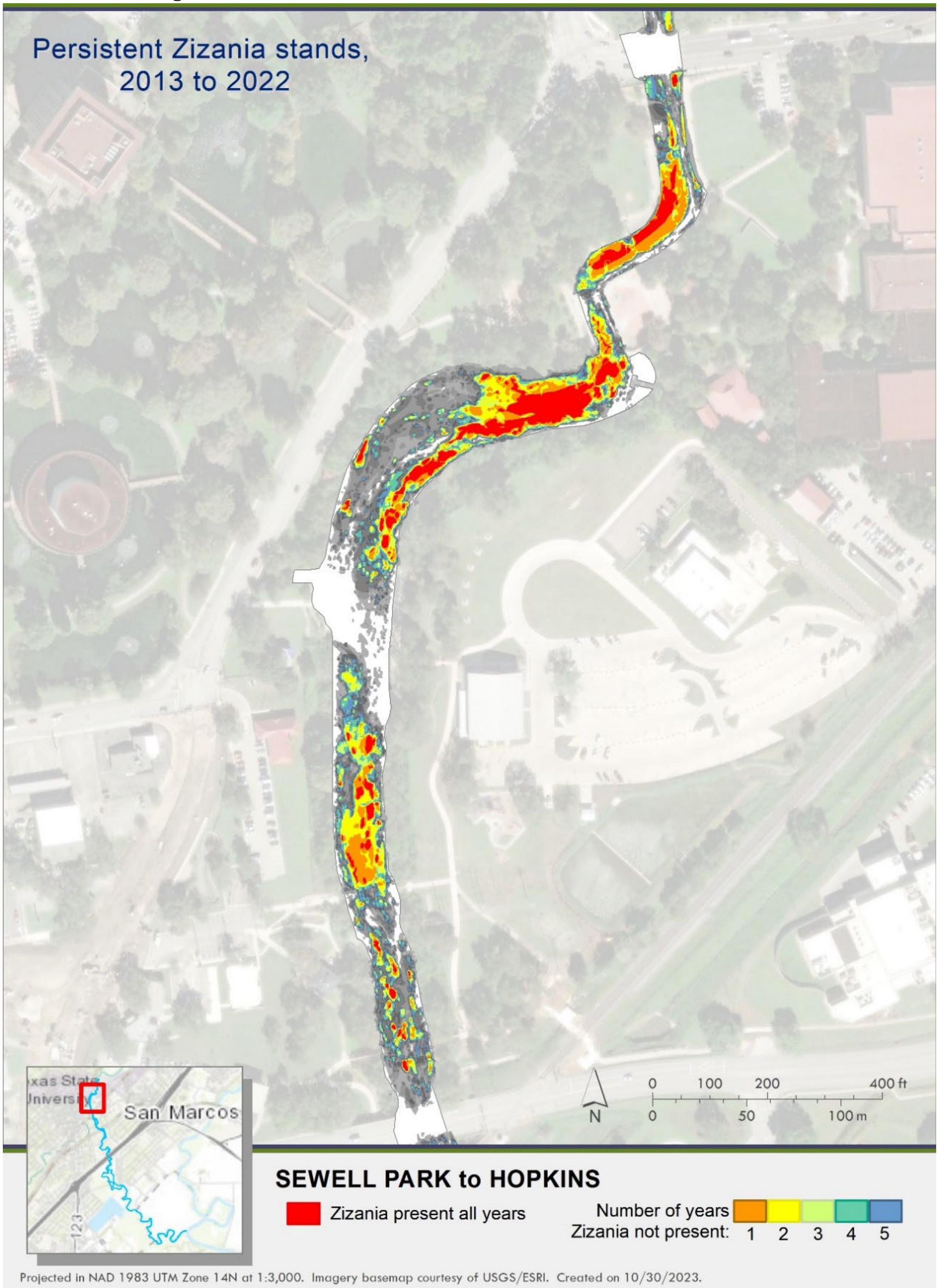


Figure 12. Texas Wild-Rice Persistent Stands from Sewell Park to Hopkins over the Course of the EAHCP

Table 6. Percent of Texas Wild-Rice Population Occurrence and Minimum Coverage Objective in Each Reach, Based on the Total Areal Coverage Objective of 8,000 m²

Percent of Population (by area)	Reach	Coverage (m^2)
0.5	Spring Lake	40
4.5	Spring Lake Dam	360
52.5	Sewell Park to Hopkins	4,200
40.0	Hopkins to I-35	3,200
2.5	Downstream of I-35	200
100	All	8,000

Note: Reaches are shown in Figure 13.

Although there remains uncertainty regarding sexual reproduction, seed viability, and recruitment of Texas wild-rice in the San Marcos River, it has been suggested by stakeholders that preserving at least two large, contiguous stands in upper reaches might promote sexual reproduction. There is limited data on this topic available in the literature to offer guidance on the size of stand necessary; however, maintaining a few large, contiguous stands for sexual reproduction similar to what has been observed since implementation of the EAHCP (greater than 500 m^2) would likely be a benefit to this species. The objectives to conserve and manage resilient Texas wild-rice populations (Goal 5) include the San Marcos Springs objectives (Section 4.1) and the following areal coverage objectives:

Objective 5.1, Texas Wild-Rice System-Wide Areal Coverage: *Maintain a minimum coverage of 8,000 m^2 across the upper San Marcos River system. Maintain two large, contiguous stands, of greater than 500 m^2 each, in the upper reaches of the San Marcos River system.*

Objective 5.2, Texas Wild-Rice Reach-Specific Areal Coverage: *Maintain minimum coverage per reach distributed longitudinally down the San Marcos River:*

- *Spring Lake—40 m^2*
- *Spring Lake Dam—360 m^2*
- *Sewell Park to Hopkins—4,200 m^2*
- *Hopkins to I-35—3,200 m^2*
- *Downstream of I-35—200 m^2*

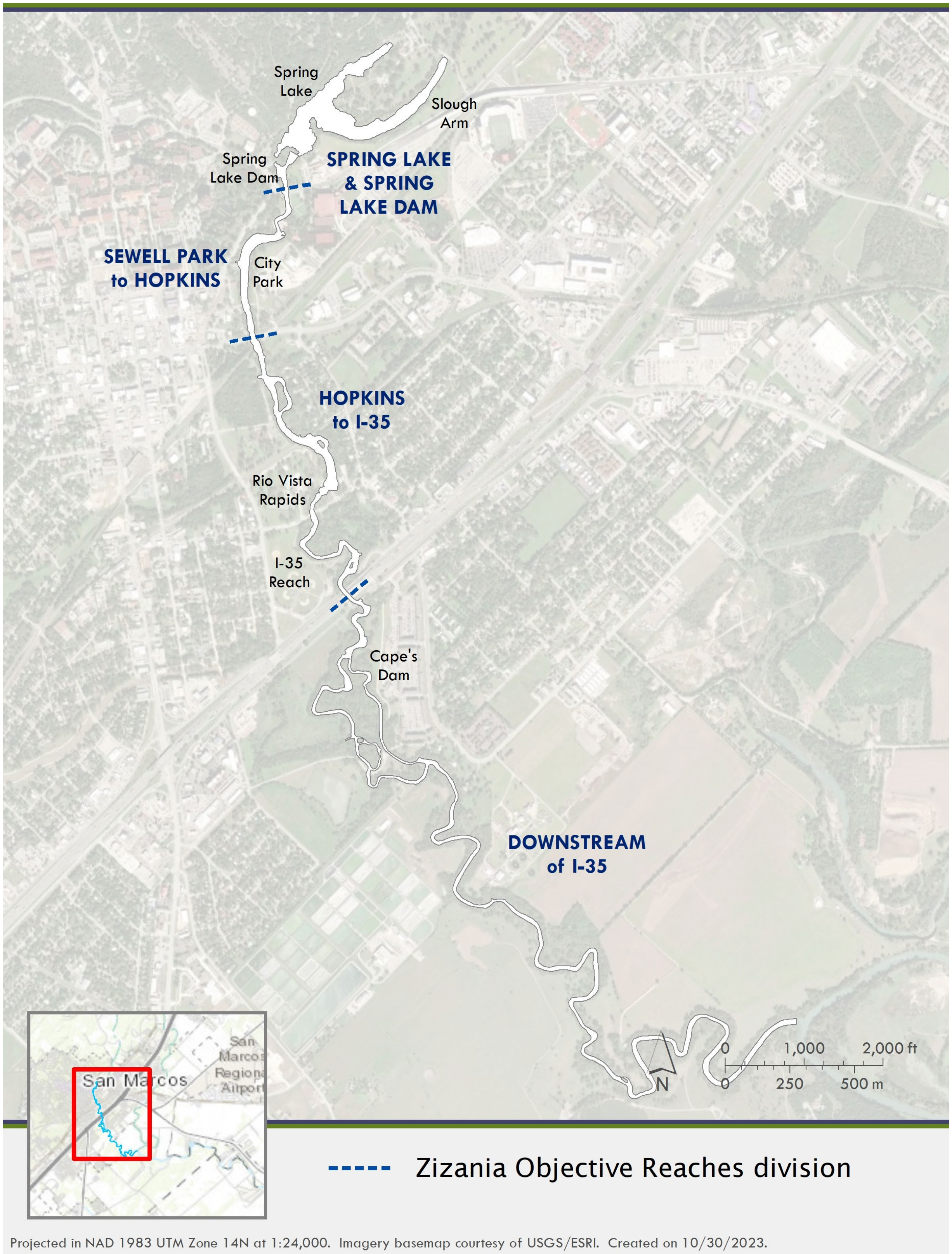


Figure 13. Locations for the Reach-Specific Texas Wild-Rice Objectives in the San Marcos River

4.7 Objectives for Fountain Darter

The fountain darter is a small-bodied fish and endemic to the spring-dominated Comal River and upper San Marcos River systems. Since 2000, the EAHCP has employed a variety of techniques, including drop-netting, dip-netting (i.e., timed, random, fixed), seining, and visual counts (i.e., SCUBA, snorkel) to monitor fountain darter abundance and occurrence indices. In addition to direct abundance and occurrence indices, the EAHCP has monitored aquatic vegetation communities biannually in LTBG reaches since 2000 and conducted full-system assessments every 5 years since 2013 (EAA 2012). As with all other Covered Species, key Biological Objectives for fountain darter are to *achieve the springflow (minimum and long-term) and water temperature objectives in both the Comal and San Marcos spring systems* (Section 4.1, *Objectives for Springflow*).

In the Comal River, reaches that are more resistant to disturbance (i.e., Landa Lake, Old Channel) maintain more stable populations compared to less-resistant reaches (i.e., Upper Spring Run, New Channel). It should not be assumed that failing to meet an abundance-based objective at some reaches reflects a lack of resiliency if other reaches remain stable; it can provide a demographic rescue to degraded areas (Van Looy et al. 2019; Larsen et al. 2021). In considering fountain darter population dynamics in the spring systems, we recommend an evaluation method for demographic-specific Biological Objectives at a broader system level (across study areas) to support populations that are resilient to variation in environmental conditions.

Specifically, we recommend linking system-level objectives to objectives that help maintain the spatial diversity of suitable habitat for fountain darters to fulfill life history requirements. As such, we recommend that SAV objectives be 1) reach specific to ensure adequate SAV coverage so suitable habitat persists throughout both systems during periods of environmental degradation, and 2) based on vegetation taxa that provide optimal habitat.

Biological Objectives for measuring population state and habitat conditions during a given monitoring event or year were quantified according to two parameters: 1) central tendency, a value for which the results will tend to, and 2) dispersion, how far typical values range from the mean. All objectives were quantified using parameters from the normal distribution, mean (i.e., central tendency; μ), and standard deviation (i.e., dispersion; σ). Objectives are intended to limit extended (i.e., 1-year) population states and habitat conditions below one standard deviation from the mean ($\mu - \sigma$). This approximates time periods when areas of suitable habitat are lower than the typical distance from the mean, providing proximal measurements of potential system degradation. Simulation analyses indicated observed SAV coverage data did not satisfy the assumptions of normality. However, parameters of the normal distribution still provide a useful characterization of central tendency and dispersion that is conceptually simple and easy to understand.

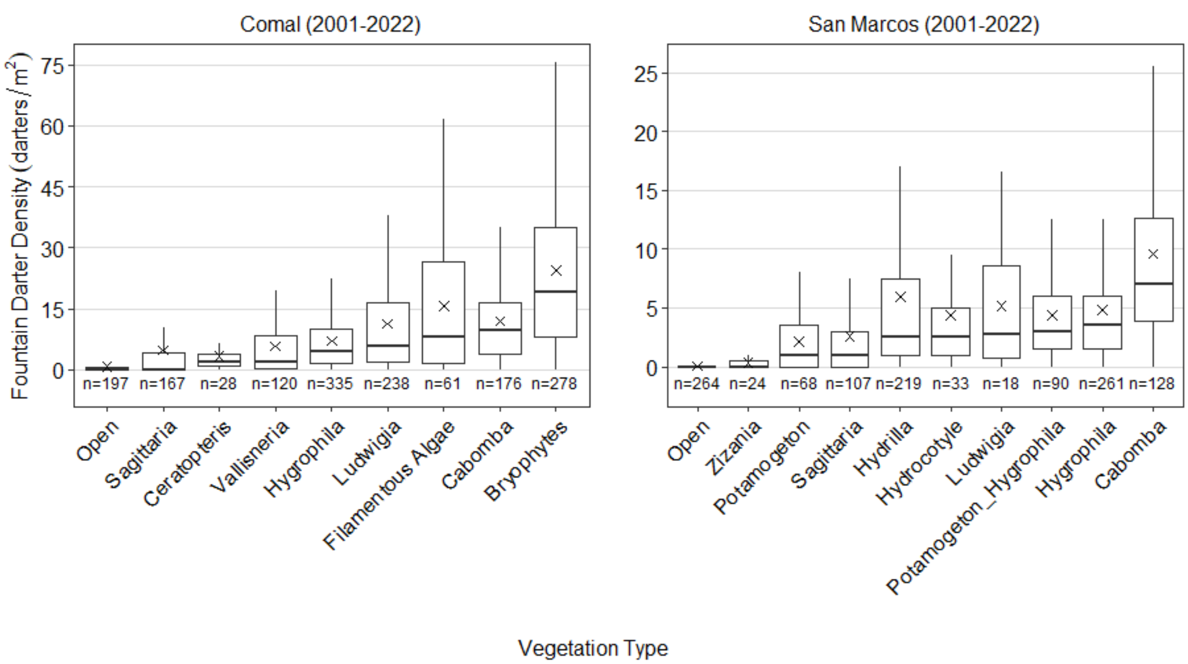
4.7.1 Fountain Darter Density

Fountain darter densities in the Comal and San Marcos Springs systems are estimated with a stratified random sampling design among wadable habitats. During each monitoring event, two sample sites are randomly selected within dominant vegetation taxa and open habitats at each LTBG reach. Densities are quantified at each site with a 2 m^2 drop-net (EAA 2017a, 2017b). Data collected during each monitoring event are used to estimate spatiotemporal trends in population demographics and habitat associations (Figure 14).

The recommended Biological Objectives evaluation methodology for fountain darter density examines results from a system-level perspective. Based on discussions at Biological Objectives Subcommittee meetings, data collected from non-vegetated (i.e., open), filamentous, and green algae taxa; *Hydrilla verticillata*; and Texas wild-rice were omitted from analysis. Density objectives were quantified by first calculating average density per sampling event (2001–2022) in the Comal (n = 60 events) and San Marcos (n = 59 events) systems. These averages were then used to calculate long-term means and standard deviations for each system (Table 7).

Table 7. Mean and Standard Deviation Calculations of Fountain Darter Densities (darters/m^2) in Both Systems and Recommended Thresholds for System-Level Objectives

Parameter	Comal	San Marcos
Mean (μ)	11.5	5.2
Standard deviation (σ)	4.9	2.9
Recommended thresholds for objective: One standard deviation below the mean (μ – σ)	6.6	2.3



Notes: The "x" denotes the mean, the thick horizontal line in each box is the median, and the upper and lower bounds of each box represent the interquartile range. Whiskers represent minimum and maximum values up to 1.5 times the interquartile range.

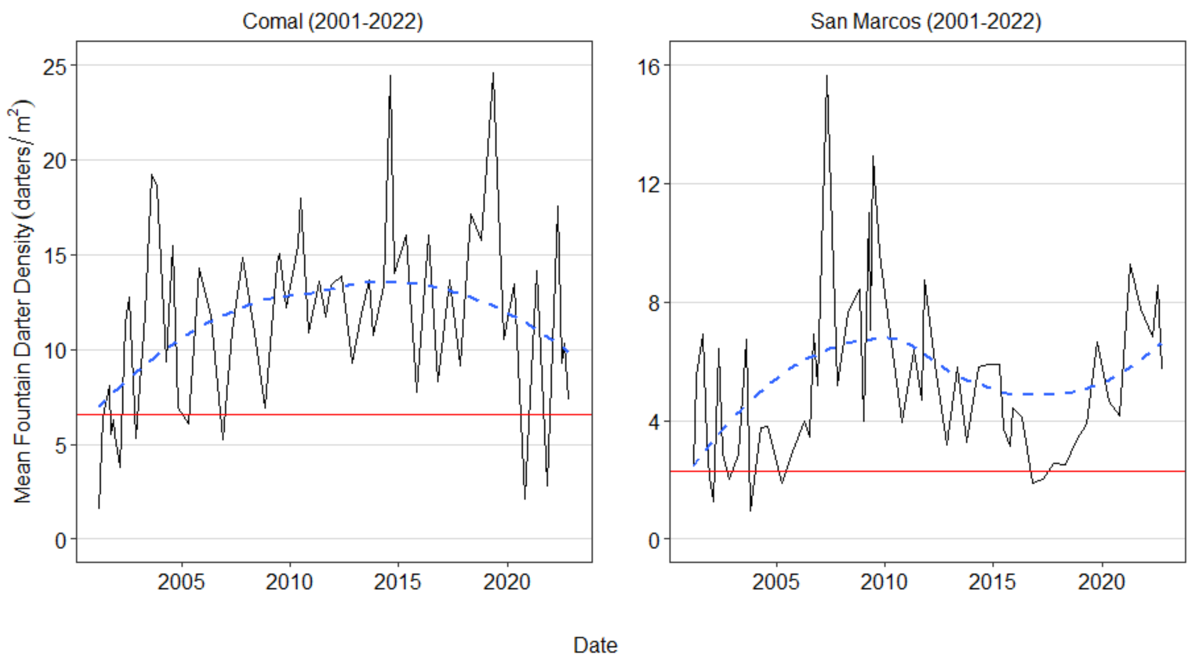
Figure 14. Boxplots Displaying Drop-Net Densities among Vegetation Types in the Comal and San Marcos Springs Systems

Based on this information, system-specific objectives aimed at conserving resilient fountain darter populations (Goal 6) include:

Objective 6.1, Comal Springs System Fountain Darter Density: *Mean fountain darter density should not fall below 6.6 darters/m^2 for a minimum of three sampling events covering a 12-month period throughout the LTBG reaches.*

Objective 6.2, San Marcos Springs System Fountain Darter Density: *Mean fountain darter density should not fall below 2.3 darters/m² for a minimum of three sampling events covering a 12-month period throughout the LTBG reaches.*

Figure 15 displays temporal trends in mean fountain darter density for both systems relative to their respective objectives threshold. Mean density was lower than the proposed threshold at 11 events (18%) in the Comal; it was also below the proposed threshold for three consecutive events conducted during October and November 2001. In the San Marcos, mean density was lower than the proposed threshold at seven events; it was never below it for three consecutive events.



Notes: The dashed blue lines denote fitted LOESS smooth functions, and the solid red lines represent one standard deviation below the mean.

Figure 15. Long-Term Density Trends in the Comal and San Marcos Spring Systems

4.7.2 Fountain Darter Recruitment Objectives

Fountain darter recruitment rates in both systems are estimated by using total length data from drop-net sampling and timed dip-netting. During each monitoring event, timed dip-net sampling is conducted within designated reaches for a fixed duration; surveyors generally target suitable habitats. All darters are measured and enumerated during sampling (EAA 2017a, 2017b). Data collected during each monitoring event are used as an additional abundance index for estimating population trends and for providing more robust assessments of recruitment.

The recommended Biological Objectives evaluation methodology for fountain darter recruitment examines results from a system-level perspective. Objectives for both systems were quantified by first calculating percent recruitment per sampling event for the Comal (n = 65 events) and San Marcos (n = 63 events) systems. To do this, raw fountain darter length frequencies from drop-net and timed dip-net datasets were aggregated for each event. Recruitment rates were calculated as the percent of darters ≤ 20 millimeters, which represents individuals that were most likely less than 3 months old and not sexually mature (Brandt et al. 1993). Average annual recruitment rates were then computed and used to calculate long-term means and standard deviations for each system, which are presented in Table 8.

Table 8. Mean and Standard Deviation Calculations of Fountain Darter Recruitment Rates (percent) in Both Systems and Recommended Thresholds for System-Level Objectives

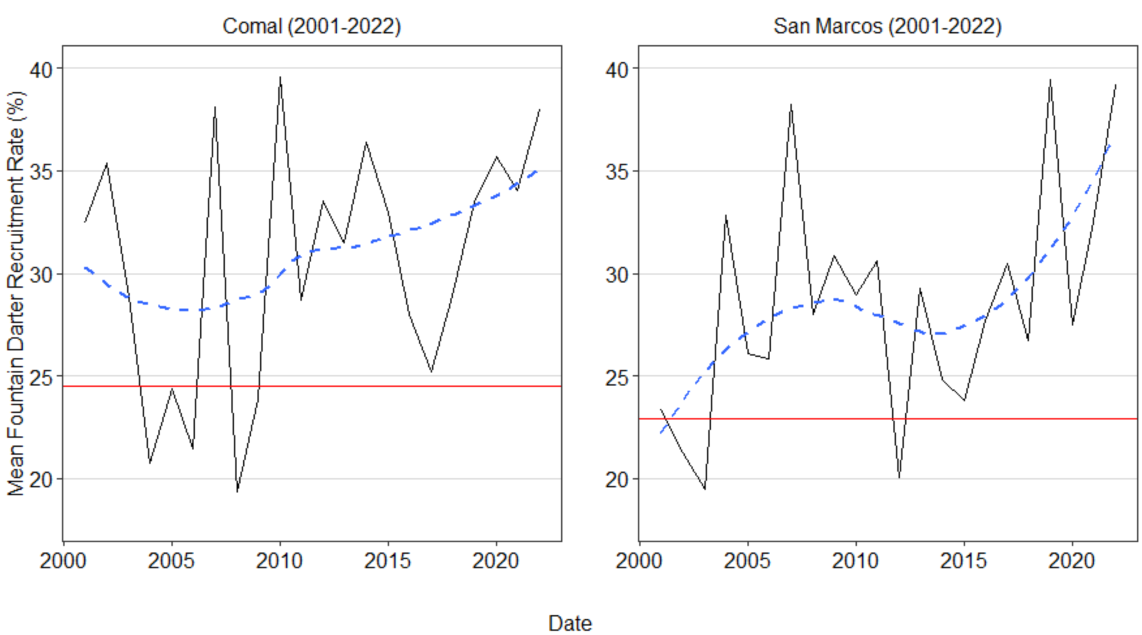
Parameter	Comal	San Marcos
Mean (μ)	30.5	28.5
Standard deviation (σ)	6.0	5.6
Recommended thresholds for objectives: One standard deviation below the mean (μ – σ)	24.5	22.9

Based on this information, objectives aimed at conserving resilient fountain darter populations (Goal 6) include:

Objective 6.3, Comal Fountain Darter Recruitment: *Mean annual recruitment should not fall below 25 percent.*

Objective 6.4, San Marcos Fountain Darter Recruitment: *Mean annual recruitment should not fall below 23 percent.*

To illustrate how these objectives would be assessed, Figure 16 displays temporal trends in mean fountain darter recruitment rates for both systems relative to their respective objectives threshold. In the Comal, mean recruitment was lower than the proposed threshold for 5 years, which occurred from 2004 to 2006 and in 2008 and 2009. In the San Marcos, mean recruitment was lower than the proposed threshold three times in 2002, 2003, and 2012.



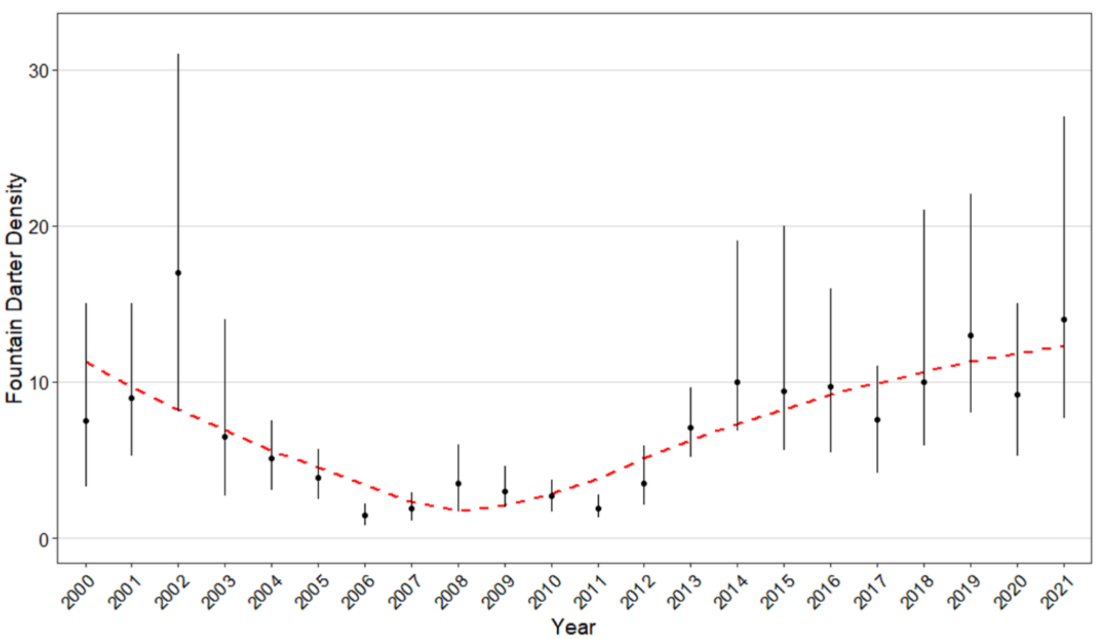
Notes: The dashed blue lines denote fitted LOESS smooth functions, and the solid red lines represent one standard deviation below the mean.

Figure 16. Long-Term Recruitment Trends in the Comal and San Marcos Spring Systems

4.7.3 Submerged Aquatic Vegetation

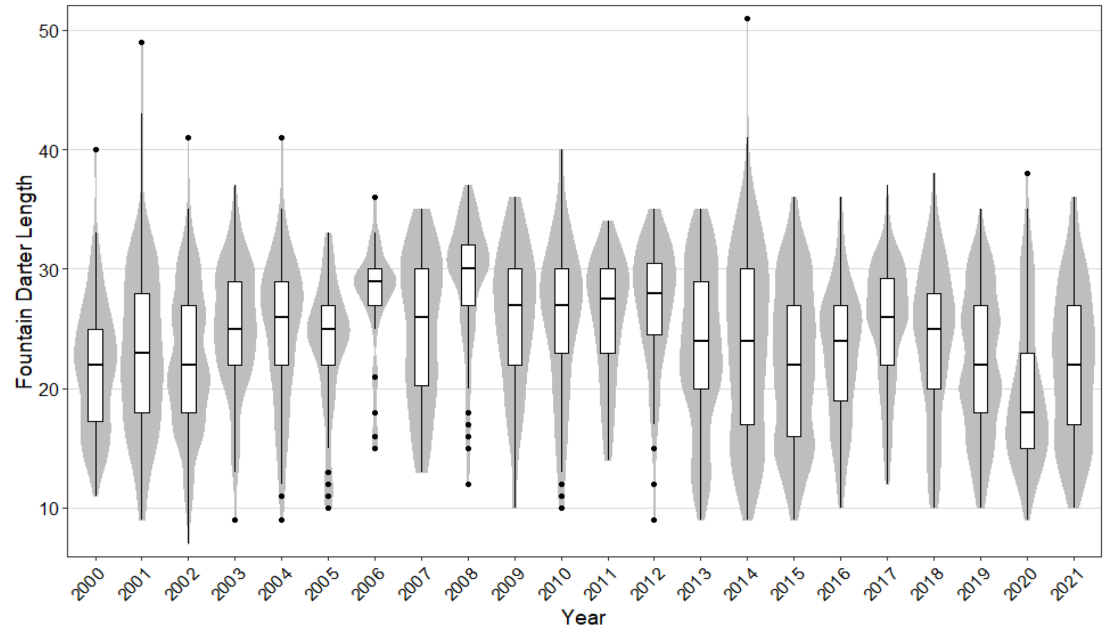
Aquatic vegetation communities in both systems are assessed by quantifying the areal coverage of taxa present. Mapping is conducted within each reach by collecting geospatial data for discrete patches of various taxa, which are visually delineated using kayak. Geospatial data are processed to construct polygons that represent discrete patches, and the total areal coverage of all vegetation taxa is calculated (EAA 2017a, 2017b). Data collected during each monitoring event are used to estimate spatiotemporal trends in vegetation assemblage structure, total areal coverage, and fountain darter habitat suitability.

We recommend linking system-level density and recruitment objectives to vegetation taxa that provide suitable habitat for fountain darters to fulfill life history requirements. As such, objectives for both systems were quantified according to areal coverage of SAV within two functional guilds. The first guild includes taxa that provide complex physical structure (hereafter referred to as *complex SAV*); data support optimal fountain darter habitats across ontogenetic stages. Multiple studies demonstrate that fountain darters associate with and have higher densities in complex SAV (Edwards and Bonner 2022; BIO-WEST n.d.:Figure 14). A taxa was considered complex if it has small branches or leaves that create a dense and ornate structure near the substrate. SAV restoration efforts in the Old Channel provide a model example of how increased coverage for multiple complex SAV taxa can enhance fountain darter populations. Figures 17 and 18 display the increased density and prevalence of recent recruits, respectively, since starting Old Channel restoration in 2013.



Notes: Error bars denote 95 percent confidence intervals, and the red dashed line is a fitted LOESS smooth function. SAV restoration efforts in this reach began in 2013.

Figure 17. Annual Trends in Mean Fountain Darter Density (darters/m²) at the Old Channel Reach of the Comal River from 2000 to 2021



Notes: The thick horizontal line in each box is the median, 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; outliers beyond this are designated with solid black circles.

Figure 18. Annual Trends in Fountain Darter Size Structure (total length [millimeters]) at the Old Channel Reach of the Comal River from 2000 to 2021

The second guild includes taxa with a simpler physical structure (hereafter referred to as *simple SAV)*, which generally are considered suboptimal, but can provide suitable habitat when complex taxa are present (e.g., bryophyte in *Vallisneria* at Landa Lake). A taxa was considered simple if it lacks branches or has long leaves that extend toward the surface, reducing dense cover near the substrate. Despite providing suboptimal habitat, simple SAV dominate the vegetation assemblages in most reaches and very likely provide important dispersal corridors that facilitate connectivity among patches of complex SAV (Fagan 2002). Simple SAV more readily colonize areas, so separate SAV objectives for complex and simple guilds were developed to protect presence of complex SAV throughout the systems and prevent simple SAV from comprising the entire vegetation assemblage.

Taxa used for reach-level objectives for each guild are presented in Table 9. These taxa were chosen for analysis because they are prevalent within both systems. These taxa are also the most frequently sampled SAV during drop-netting and can therefore be linked to estimates of average fountain darter density per monitoring event. Several complex taxa not sampled during drop-netting were used to calculate the San Marcos complex SAV objective. Additional taxa included *Myriophyllum heterophyllum* because other studies observed its use as suitable habitat for darters (Edwards and Bonner 2022), *Heteranthera* because it is a taxa used to replace non-native vegetation during restoration efforts (EAA 2016), and bryophyte because it has shown to be highly suitable habitat in the Comal system (BIO-WEST n.d.). In addition to coverage objectives, we recommend that a minimum richness threshold of three SAV taxa including at least one complex SAV taxon per designated reach to ensure optimal fountain darter habitat is present within each reach.

The proposed SAVs for fountain darter habitat objectives in Table 9 include one species of non-native aquatic vegetation (*Hygrophila polysperma*) as an acceptable complex habitat in the Comal and San Marcos Rivers. Fountain darter densities are high for this non-native species (Figure 14), which qualifies it as complex habitat for the endangered fountain darter. As stated in Goal 6, the focus throughout each system will be on native vegetation restoration and protection. No planting or restoration of non-native *Hygrophila* is proposed in the Conservation Measures. However, if native SAV species are unable to establish as fountain darter habitat in select reaches of the rivers, removal efforts pertaining to non-native *Hygrophila* may need to be reduced to maintain habitat diversity of complex and simple taxa.

Table 9. List of Vegetation Taxa Used to Calculate Reach-Level Objectives for Complex and Simple SAV Coverage in Both Systems

Taxa by Category	Comal	San Marcos
Complex SAV		
Bryophyte	X	X
Cabomba	X	X
Heteranthera	—	X
Hydrocotyle	—	X
*Hygrophila**	X	X
Ludwigia	X	X
Myriophyllum	—	X
Simple SAV		
Potamogeton	X	X
Sagittaria	X	X
Vallisneria	X	—
Zizania	—	X

*Denotes non-native species

4.7.3.1 Long-Term Biological Goal Reaches

Calculations of submerged aquatic vegetation objectives for the Comal system LTBG reaches were based on data from 2001 to 2022, except for the Upper New Channel, which was first added to the EAHCP program in 2014. Simple SAV objectives were not calculated for the Old Channel, Upper New Channel, and Lower New Channel because simple taxa are not prevalent within these reaches. As such, minimum simple SAV taxa richness is also not included as an objective for these reaches.

Complex SAV objectives for the Spring Lake Dam and City Park LTBG reaches in the San Marcos system were calculated based on data from 2002 to 2022. Simple SAV objectives for these reaches were made using data from 2013 to 2022. Because Texas wild-rice restoration began in 2013, coverage for other simple SAV has decreased substantially. Therefore, data from 2013 to 2022, as opposed to the full monitoring record, were used to more accurately reflect variations in simple SAV coverage within a now Texas wild-rice-dominated community. Complex and simple vegetation objectives for the I-35 LTBG reach were calculated using data from 2014 to 2022 because this reach was expanded in 2014, making data collected during previous monitoring incompatible. For each system, complex and simple SAV objectives were first summed across taxa within each LTBG reach for each monitoring event per system. Average annual coverages of complex and simple SAV objectives were then computed per reach and used to calculate reach-level long-term means and standard deviations, which are presented in Tables 10 and 11.

Table 10. Sample Size (n), Mean (μ), and Standard Deviation (σ) Calculations of Complex SAV Coverages (m^2) among LTBG Reaches in Both Systems

Reach	*n*	Parameter		
		μ	σ	μ – σ
Comal				
Upper Spring Run	22	1,210	989	221
Landa Lake	22	2,850	1,112	1,738
Old Channel	22	1,142	558	584
Upper New Channel	9	1,055	414	641
Lower New Channel	22	2,036	981	1,055
San Marcos				
Spring Lake Dam	21	148	40	108
City Park	21	713	345	368
I-35	9	710	176	534

Table 11. Sample Size (n), Mean (μ), and Standard Deviation (σ) Calculations of Simple SAV Coverages (m^2) among LTBG Reaches in Both Systems

Reach	*n*	Parameter		
		μ	σ	μ – σ
Comal				
Upper Spring Run	22	774	366	408
Landa Lake	22	14,940	1,214	13,726
Old Channel	—	—	—	—
Upper New Channel	—	—	—	—
Lower New Channel	—	—	—	—
San Marcos				
Spring Lake Dam	10	1,198	338	860
City Park	10	2,036	815	1,221
I-35	9	915	363	552

4.7.3.2 Restoration Reaches

To support SAV objectives across longer stretches of each system, restoration reaches were evaluated for Biological Objectives. Figures 19 and 20 display the current LTBG study reaches along with the proposed restoration reaches in both systems, respectively. In the Comal River, the LTBG and proposed restoration reach footprint covers the majority of the upper system from Upper Spring Run to Lower Landa Lake and through the Old Channel Environmental Restoration and Protection Area. The recommended restoration reaches for the Comal system include: 1) Upper Landa Lake; 2) Lower Landa Lake; and 3) Upper Old Channel (Figure 19).

In the San Marcos system, the LTBG and proposed restoration reach footprint covers the majority of the upper San Marcos River from Spring Lake Dam to I-35. As shown in Figure 20, the recommended restoration reaches in the San Marcos River include: 1) Spring Lake Dam to City Park; and 2) City Park to Rio Vista Pool.

Figure 19. Proposed LTBG/Restoration Reach Delineation for the Comal River

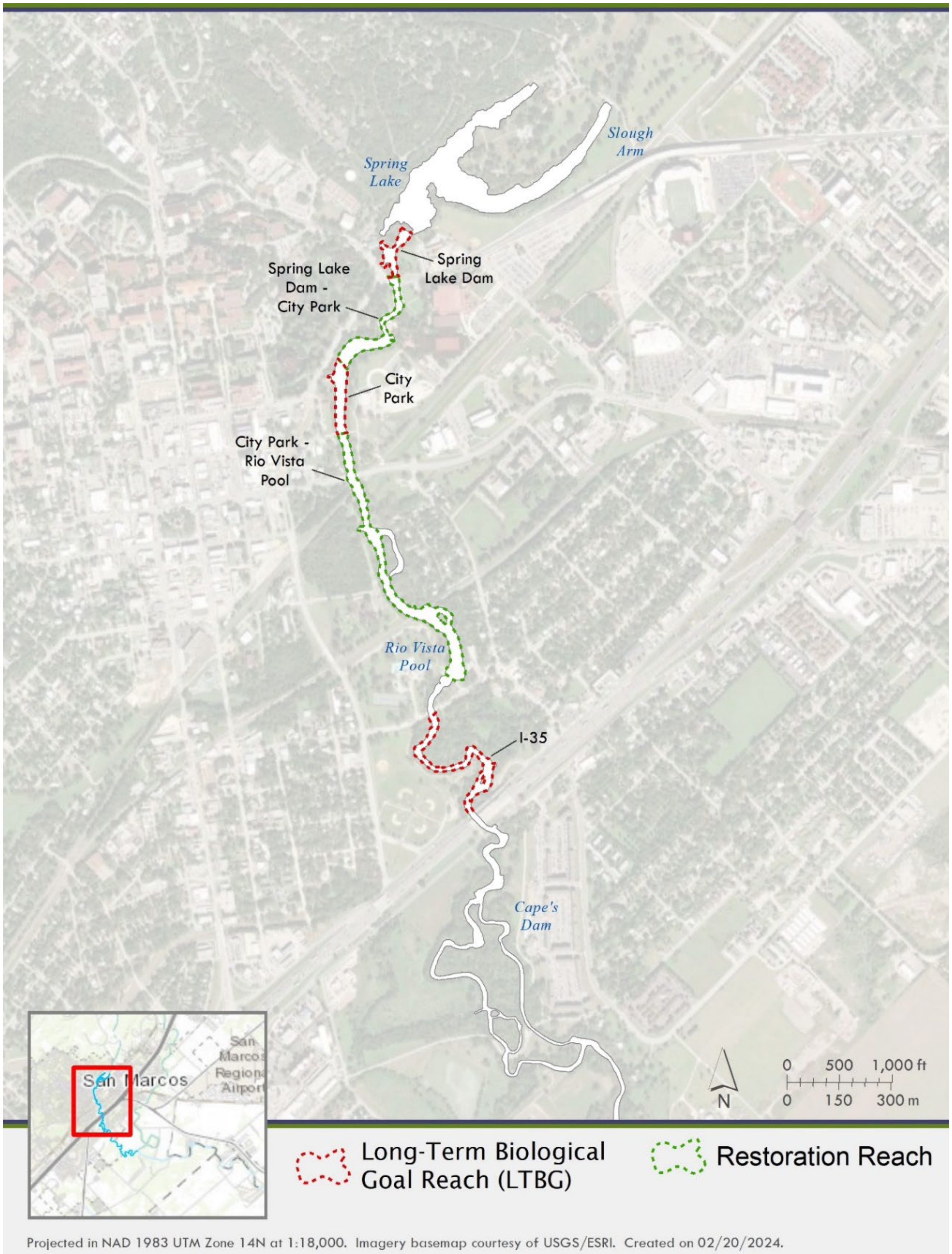


Figure 20. Proposed LTBG/Restoration Reach Delineation for the San Marcos River

Complex and simple SAV objectives for the proposed restoration reaches were established based on data from three full system mapping events in 2013, 2018, and 2023. SAV polygons per mapping event were clipped to the extent of each reach's defined boundaries using GIS software. Areas of each clipped polygon were then recalculated to estimate the areal coverage of each taxon per reach. SAV objectives were calculated using the same methodology and taxa list in Table 9. Long-term means and standard deviations for complex and simple SAV are presented for each restoration reach in Tables 12 and 13, respectively.

Table 12. Mean (μ) and Standard Deviation (σ) Calculations of Complex SAV Coverages (m^2) among Proposed Restoration Reaches in Both Systems. Sample size (n=3).

	Parameter		
Reach	μ	σ	μ – σ
Comal			
Upper Landa Lake	5,886	3,527	2,359
Lower Landa Lake	312	261	51
Upper Old Channel	2,110	952	1,158
San Marcos			
Spring Lake Dam - City Park	1,305	1,179	126
City Park - Rio Vista Pool	2,364	614	1,750

Table 13. Mean (μ) and Standard Deviation (σ) Calculations of Simple SAV Coverages (m^2) among Proposed Restoration Reaches in Both Systems. Sample size (n=3).

	Parameter		
Reach	μ	σ	μ – σ
Comal			
Upper Landa Lake	4,077	1,330	2,747
Lower Landa Lake	16,239	1,916	14,323
Upper Old Channel	1,946	518	1,428
San Marcos			
Spring Lake Dam - City Park	4,083	1,345	2,738
City Park - Rio Vista Pool	3,885	1,389	2,496

Based on the SAV observed in the LTBG and proposed restoration reaches during the EAHCP biological monitoring program, objectives aimed at conserving habitats and diverse native submerged aquatic vegetation assemblages (Goal 6) include:

Objective 6.5, Comal SAV Areal Coverage: *Maintain a minimum of three SAV taxa including at least one complex structured SAV taxon in each reach (Table 9). Maintain total areal coverages of complex and simple SAV above the following thresholds per reach:*

	Minimum Total Coverage (m^2)	
Reach	***Complex SAV***	***Simple SAV***
Upper Spring Run	*220*	*410*
*Upper Landa Lake**	*2,360*	*2,750*
Landa Lake	*1,740*	*13,730*
*Lower Landa Lake**	*50*	*14,320*

	Minimum Total Coverage (m²)	
Reach	***Complex SAV***	***Simple SAV***
*Upper Old Channel**	*1,160*	*1,430*
Old Channel	*580*	—
Upper New Channel	*640*	—
Lower New Channel	*1,060*	—
Total	*7,810*	*32,640*

**Denotes Proposed Restoration Reach*

Taxa richness and areal coverages should not fall below these thresholds within each reach for a minimum of three sampling events covering a 12-month period.

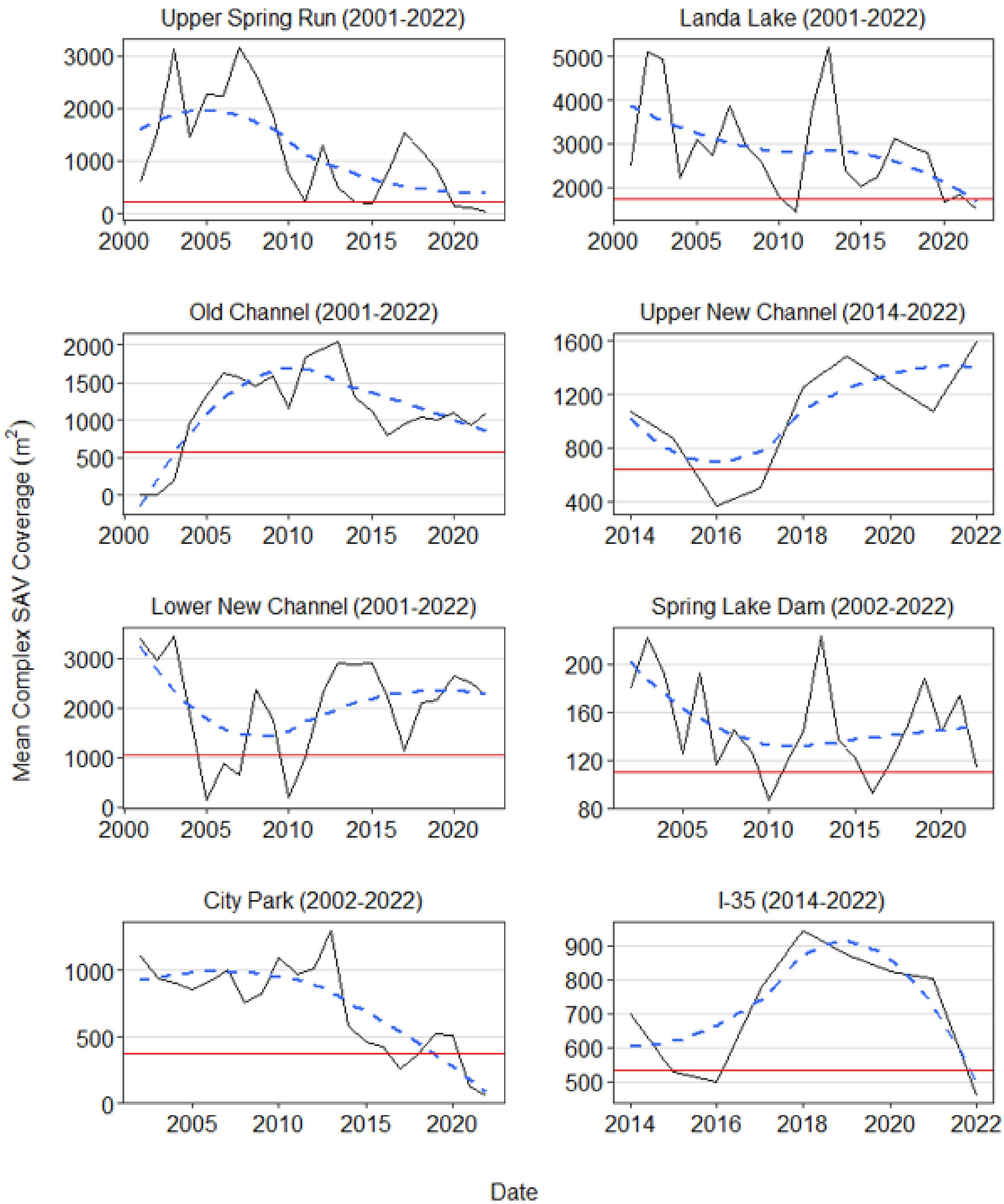
Objective 6.6, San Marcos SAV Areal Coverage: *Maintain a minimum of three SAV taxa including at least one complex structured SAV taxon in each reach (Table 9). Maintain total areal coverages of complex and simple SAV above the following thresholds per reach:*

	Minimum Total Coverage (m²)	
Reach	***Complex SAV***	***Simple SAV***
Spring Lake Dam	*110*	*860*
*Spring Lake Dam - City Park**	*130*	*2,740*
City Park	*370*	*1,220*
*City Park - Rio Vista Pool**	*1,750*	*2,500*
I-35	*530*	*550*
Total	*2,890*	*7,870*

**Denotes Proposed Restoration Reach*

Taxa richness and mean areal coverages should not fall below these thresholds within each reach for a minimum of three sampling events covering a 12-month period.

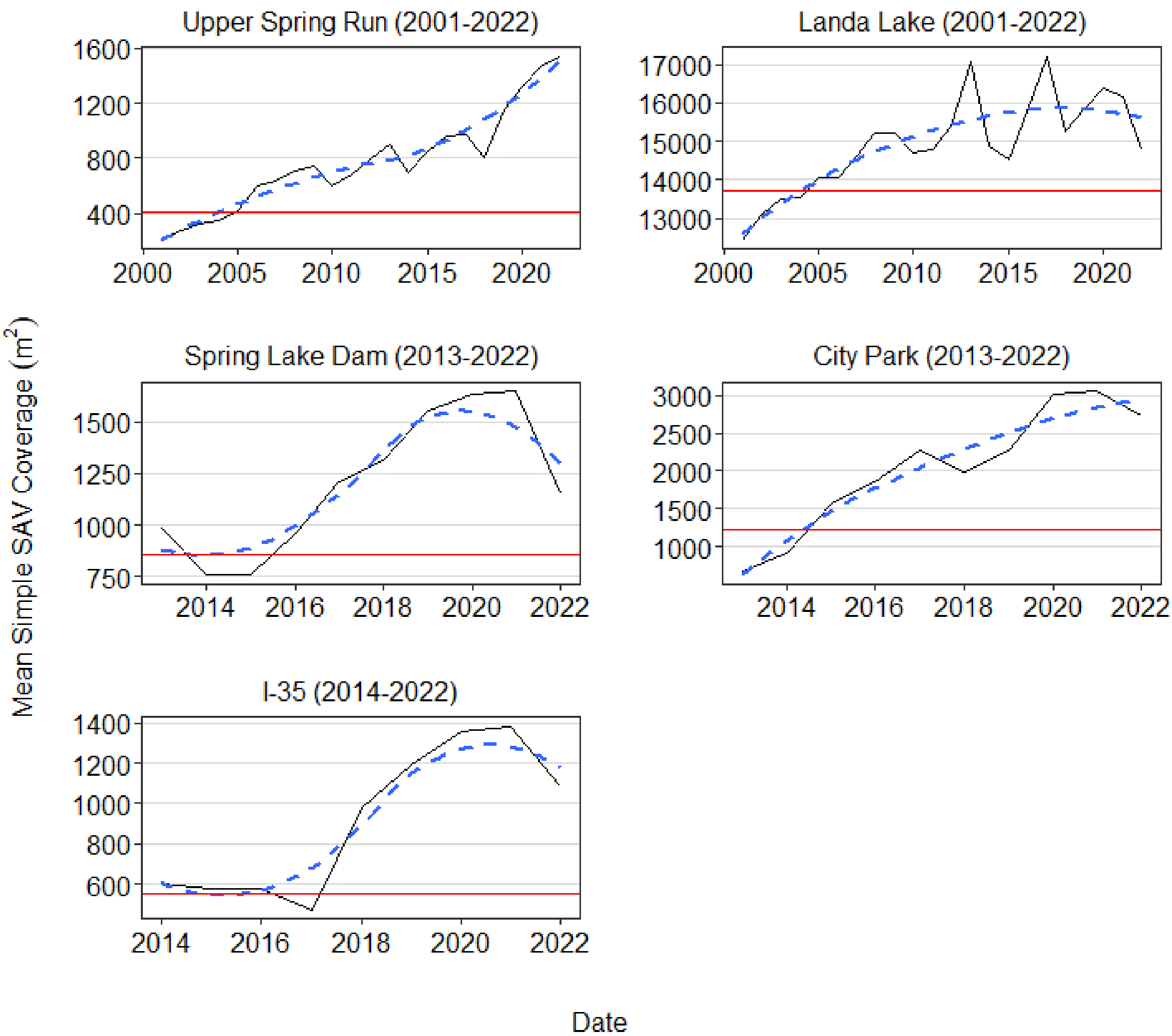
To illustrate how these objectives will be analyzed, Figure 21 shows annual trends in total coverage of complex SAV relative to each LTBG reach's respective objective thresholds in the Comal and San Marcos systems. Mean complex SAV was lower than the proposed threshold for 5 years (23%) in Upper Spring Run and Lower New Channel, 3 years (14%) in Old Channel and Landa Lake, and 2 years (22%) in Upper New Channel. Some years, when mean coverage substantially decreased below proposed thresholds (e.g., Lower New Channel and Spring Lake Dam in 2010), were a direct result of an extreme flood event. This warrants potentially modifying objectives calculations contingent upon whether high-flow pulses occurred (e.g., moving average), which would specifically help account for irrepressible stochastic events. Among the San Marcos River LTBG reaches, mean complex SAV was lower than the proposed threshold for 2 years (10%) in Spring Lake Dam, 3 years (14%) in City Park, and 1 year (5%) in I-35. It is evident that expansion success and the present dominance of Texas wild-rice in the study reaches has affected the amount of complex SAV coverage in each LTBG reach.



Notes: The dashed blue lines denote fitted LOESS smooth functions, and the solid red lines represent one standard deviation below the mean.

Figure 21. Long-Term Complex SAV Trends in the LTBG Reaches of the Comal (Upper Spring Run, Landa Lake, Old Channel, Upper and Lower New Channels) and San Marcos (Spring Lake Dam, City Park, and I-35) Systems

Figure 22 shows annual trends in total coverage for simple SAV relative to each LTBG reach's respective objective thresholds in the Comal and San Marcos systems. Although the simple SAV calculations for the LTBG reaches in the San Marcos system were made from post-EAHCP implementation data, the full monitoring record is presented in Figure 22 for historical context. Mean simple SAV was lower than the proposed threshold during 1 year in City Park (5%) and I-35 (13%). Similar to the complex SAV coverage in the LTBG reaches of the San Marcos River, the simple SAV guild has been affected by the dominance of Texas wild-rice in recent years.



Notes: The dashed blue lines denote fitted LOESS smooth functions, and the solid red lines represent one standard deviation below the mean.

Figure 22. Long-Term Simple SAV Trends in the LTBG Reaches of the Comal (Upper Spring Run and Landa Lake) and San Marcos (Spring Lake Dam, City Park, and I-35) Systems

As noted above, calculations for the proposed restoration reach objectives in the Comal and San Marcos systems (Tables 12 and 13) were determined using only three annual full system surveys. Therefore, there is no illustration to demonstrate the trends in total coverage of complex or simple SAV relative to each restoration reach's respective objective thresholds. However, the proposed restoration reach objectives are necessary to maintain system-wide flexibility in restoration efforts and are aimed at conserving habitats and diversity. By supporting diversity and habitat connectivity, the restoration reach objectives promote healthier SAV assemblages and conserve Covered Species habitat throughout a greater extent in the Comal and San Marcos systems.

5. Summary

Biological Goals and Objectives form the basis of the conservation strategy. This memorandum recommends Biological Goals and Objectives to replace those in the existing EAHCP and to include in the amended EAHCP as part of the permit renewal. The recommended Biological Goals and Objectives are based on biological monitoring data collected through the current EAHCP, input from the Biological Goals and Biological Objectives Subcommittees, and conformance with the structure of Biological Goals and Objectives described in the HCP Handbook. The list below summarizes the recommended Biological Goals and Objectives, with each objective nested under the goal it supports. Ultimately, the Biological Goals and Objectives will be used to guide development of Conservation Measures, the monitoring plan, adaptive management actions, and additional components of the EAHCP's conservation strategy, which will be completed in subsequent stages of the permit renewal process.

Goal 1: Conserve the quality and quantity of springflow and maintain suitable ecosystems within the Plan Area to provide for the persistence and resiliency of the Covered Species.

- **Comal Springflow**
  - **Objective 1.1, Minimum Comal Springflow Discharge:** *Maintain mean monthly spring discharge at Comal Springs (gage #08168710) greater than or equal to 45 cfs for at least 11 months per calendar year. Maintain daily average springflow greater than or equal to 30 cfs. This will be quantified by using mean daily springflow data to calculate average springflow for each month per year.*
  - **Objective 1.3, Long-Term Comal Springflow Discharge:**
    - *Maintain a 3-year moving-average annual Comal Springs discharge (gage #08168710) above 174 cfs.*
    - *Maintain a 30-year long-term average Comal Springs discharge above 225 cfs.*
- **San Marcos Springflow**
  - **Objective 1.2, Minimum San Marcos Springflow Discharge:** Maintain mean monthly discharge at San Marcos Springs (gage #08170000) greater than or equal to 60 cfs for at least 11 months per calendar year. Maintain daily average springflow greater than or equal to 45 cfs. This will be quantified by using mean daily springflow data to calculate average springflow for each month per year.
  - **Objective 1.4, Long-Term San Marcos Springflow Discharge:**
    - *Maintain a 3-year moving-average annual San Marcos Springs discharge (gage #08170000) above 136 cfs.*
    - *Maintain a 30-year long-term average San Marcos Springs discharge above 140 cfs.*
  - **Objective 1.5, Comal Springs and River Water Quality:** *Maintain mean daily water temperature in surface habitats near the substrate less than or equal to 25°C within Upper*

Spring Run, Spring Island, Spring Run 1–3, and Landa Lake. Maintain mean daily water temperature in surface habitats near the substrate less than or equal to 25°C for more than 50% of the days per year and less than or equal to 27°C within the Old Channel.

- **Objective 1.6, San Marcos Springs and River Water Quality:** *Maintain mean daily water temperature in surface habitats near the substrate less than or equal to 25°C within Spring Lake. Maintain mean daily water temperature in surface habitats near the substrate less than or equal to 25°C for more than 50% of the days per year and less than or equal to 27°C within the Headwaters, Upper River, Middle River, and Lower River.*

Goal 2: Conserve habitats to support resilient populations of Texas blind salamander, Comal Springs dryopid beetle, Peck's cave amphipod, and Edwards Aquifer diving beetle in the Plan Area.

- *See Objectives 1.1 through 1.6*

Goal 3: Conserve habitats to support resilient Comal Springs riffle beetle populations in the Plan Area.

- **Objective 3.1, Comal Springs Riffle Beetle Relative Abundance**: *Mean Comal Springs riffle beetle relative abundance should not fall below 2.4 counts/lure for a minimum of three sampling events covering a 12-month period, as measured at long-term biological monitoring areas (Landa Lake, Western Shoreline, Spring Island, Spring Run 3).*
- **Objective 3.2, Comal Springs Riffle Beetle Occurrence:** *Maintain Comal Springs riffle beetle likelihood of occurrence 0.52. Comal Springs riffle beetle likelihood of occurrence should not fall below 0.52 for a minimum of three sampling events covering a 12-month period.*

Goal 4: Conserve San Marcos Springs and River habitats and resilient San Marcos salamander populations in the Plan Area.

- **Objective 4.1*, San Marcos Salamander Habitat:** *Maintain total area of quality habitat above 23 m^2 at the Hotel site, above 30 m^2 at the Riverbed site, and above 14 m^2 at Spring Lake Dam. Areas of quality habitat should not fall below these values for a minimum of three sampling events covering a 12-month period.*

  * **Although habitat quality and protected area criteria are proposed, the San Marcos salamander biological monitoring program will be revised for the EAHCP permit renewal.**

Goal 5: Conserve and manage resilient Texas wild-rice populations in the San Marcos springs and river system.

- **Objective 5.1, Texas Wild-Rice System-Wide Areal Coverage:** *Maintain a minimum coverage of 8,000 m^2 across the upper San Marcos River system. Maintain two large, contiguous stands (each greater than 500 m^2) in the upper reaches of the San Marcos River system.*
- **Objective 5.2, Texas Wild-rice Reach-Specific Areal Coverage:** *Maintain minimum coverage per reach distributed longitudinally down the San Marcos River:*
  - *Spring Lake—40 m^2*
  - *Spring Lake Dam—360 m^2*
  - *Sewell Park to Hopkins—4,200 m^2*

- *Hopkins to I-35—3,200 m^2*
- *Downstream of I-35—200 m^2*

Goal 6: Conserve habitats, diverse native SAV assemblages, and resilient fountain darter populations in the Comal and San Marcos Springs and River system.

- **Objective 6.1, Comal Springs System Fountain Darter Density:** *Mean fountain darter density should not fall below 6.6 darters/m^2 for a minimum of three sampling events covering a 12-month period throughout the LTBG reaches.*
- **Objective 6.2, San Marcos Springs System Fountain Darter Density:** *Mean fountain darter density should not fall below 2.3 darters/m^2 for a minimum of three sampling events covering a 12-month period throughout the LTBG reaches.*
- **Objective 6.3, Comal Fountain Darter Recruitment Objective:** *Mean annual recruitment should not fall below 25%.*
- **Objective 6.4, San Marcos Fountain Darter Recruitment:** *Mean annual recruitment should not fall below 23%.*
- **Objective 6.5, Comal SAV Areal Coverage:** *Maintain a minimum of three SAV taxa including at least one complex structured SAV taxon in each reach (Table 9). Maintain total areal coverages of complex and simple SAV above the following thresholds per reach:*

	Minimum Total Coverage (m^2)	
Reach	***Complex SAV***	***Simple SAV***
Upper Spring Run	*220*	*410*
*Upper Landa Lake**	*2,360*	*2,750*
Landa Lake	*1,740*	*13,730*
*Lower Landa Lake**	*50*	*14,320*
*Upper Old Channel**	*1,160*	*1,430*
Old Channel	*580*	*—*
Upper New Channel	*640*	*—*
Lower New Channel	*1,060*	*—*
Total	*7,810*	*32,640*

** Denotes Proposed Restoration Reach*

Taxa richness and areal coverages should not fall below these thresholds within each reach for a minimum of three sampling events covering a 12-month period.

- **Objective 6.6, San Marcos SAV Areal Coverage:** *Maintain a minimum of three SAV taxa including at least one complex structured SAV taxon in each reach (Table 9). Maintain total areal coverages of complex and simple SAV above the following thresholds per reach:*

	Minimum Total Coverage (m^2)	
Reach	***Complex SAV***	***Simple SAV***
Spring Lake Dam	*110*	*860*
*Spring Lake Dam - City Park**	*130*	*2,740*
City Park	*370*	*1,220*
*City Park - Rio Vista Pool**	*1,750*	*2,500*
I-35	*530*	*550*
Total	*2,890*	*7,870*

** Denotes Proposed Restoration Reach*

Taxa richness and mean areal coverages should not fall below these thresholds within each reach for a minimum of three sampling events covering a 12-month period.

Goal 7: Promote community engagement and awareness of the EAHCP, support land and water conservation, and mitigate anthropogenic stressors and natural disturbances within the Plan Area that will benefit the Covered Species.

- *Given its broad scope and multi-faceted nature, objectives for Goal 7 have not yet been developed. We will consider the elements of Goal 7 when evaluating Conservation Measures to be recommended for inclusion in the renewed EAHCP.*

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Attachment 1

Edwards Aquifer Habitat Conservation Plan, Recommended Biological Goals and Objectives for the Permit Renewal Comment Response

[Note to reviewer: Attachment 1 provides responses to public comments received on the recommended EAHCP permit renewal Biological Goals and Objectives. It focuses on several key topics needing further clarification, based on the comments received. These key topics are 1) the EAHCP permit renewal process used to develop Biological Goals and Objectives; 2) clarification of language, analysis, or organization of the document; 3) springflow and river discharge objectives and how they compare to existing EAHCP objectives; 4) water quality objectives; and 5) species-specific objectives. Rather than address each comment individually, since many are repetitive, we reviewed all comments and grouped them into key topics, to which we provided responses in this attachment. All written comments received by EAA are included as an appendix to this attachment. A summary of each key topic noted above is provided below.]

1. EAHCP Permit Renewal Process

Commenters emphasized a need for the Science Committee to review and discuss the proposed goals and objectives as an entity rather than individually.

Response:

Following the guidance in the Edwards Aquifer Habitat Conservation Plan (EAHCP) Permit Renewal Work Plan, a draft of the Biological Goals and Objectives technical memorandum (BGO memo; November 15, 2023) was developed and reviewed by EAHCP staff, the U.S. Fish and Wildlife Service (USFWS), and members of the Implementing, Stakeholder, and Science Committees. The guidance recommends that once finalized and approved by the Implementing Committee, each memo will be incorporated into amended chapters of the EAHCP. The Work Plan process does not recommend the formation of additional subcommittees for every task or include approval of each memo by the Science Committee; however, two subcommittees were formed and their recommendations were considered in developing the memorandum. The Biological Goals Subcommittee and Biological Objectives Subcommittee were formed to provide guidance for the development of the Biological

Goals and Objectives (BGOs). The Biological Objectives Subcommittee included Science Committee members and species experts split into three different groups that focused on salamanders, macroinvertebrates, and fountain darter and Texas wild-rice. The Biological Goals Subcommittee provided a report (EAHCP Biological Goals Subcommittee 2023), while the Biological Objectives Subcommittee provided feedback and recommendations on their respective species, which informed the recommendations in the draft BGO memo. The draft BGO memo was shared with EAHCP Staff, USFWS, and EAHCP Implementing, Stakeholder, and Science Committee members; members from all the groups, including several Science Committee members, provided edits and comments (see appendix).

Per Implementing Committee preference in December 2023, a formal EAHCP Science Committee meeting and presentation of the recommended BGOs has been scheduled for March 7, 2024. The EAHCP Science Committee will then generate a response memorandum for the EAHCP Implementing Committee and EAHCP Program Manager. Comments on the BGO memo received from the EAHCP Science Committee memorandum will be taken into consideration prior to amending the EAHCP chapter on BGOs. Finally, it is important to clarify that the purpose of the BGO memo was to develop BGOs using the extensive EAHCP biomonitoring dataset to examine patterns in Covered Species population demographics and habitats. The memo did not consider pumping scenarios, management implications, or conservation strategies. Those will be addressed in subsequent tasks according to the Work Plan.

2. Clarification

Commenters requested clarification on a variety of points which included overall organization and formatting, explanation of analysis methodology, and requests for raw data.

The comments and suggestions to provide further clarification throughout the BGO memo are greatly appreciated. Several helpful comments pointed out areas of ambiguity that are addressed in the revised draft of the memo, and these areas will be subsequently considered as the memorandum is developed into the draft chapter of the HCP. The suggestion of restructuring the organization to present recommended objectives, and then to provide justification for the objectives has been noted for further consideration in the HCP chapter development. Additional or revised maps will be developed in the HCP to better clarify the geography and nomenclature of the reaches in each system. As the EAHCP renewal process considers impact analysis, Conservation Measures, and long-term monitoring, we will explore elaborating on the analysis methodology and expanding the explanation of some figures in the memorandum (e.g., Figures 14 and 16) in the draft HCP. Additionally, any direct requests for the raw data to the EAA Variable Flow Study reports (2000–2012) and the HCP Biological Monitoring Program reports (2013–2022) can be made to EAHCP staff. Raw data from 2000–2022 can also be found in the HCP Biological Monitoring Annual Reports on the Technical Reports Document Library webpage (Edwards Aquifer Authority › Science Document Library - Edwards Aquifer Authority).

3. Springflow

This section summarizes the original recommended objectives for springflow included in the November 15, 2023 version of the memo to provide contextual reference for the specific issues raised in comments.

3.1 Objectives for Springs and River Discharge

The recommended springs discharge springflow objectives include:

Objective 1.1, Comal Springs Discharge: *Maintain mean monthly spring discharge at Comal Springs (gage #08168710) greater than or equal to 45 cubic feet per second (cfs) for at least 11 months per calendar year. Maintain daily average springflow greater than or equal to 30 cfs. This will be quantified by using mean daily springflow data to calculate average springflow for each month per year.*

Objective 1.3, Long-Term Comal River Discharge: *Maintain a 3-year rolling-average annual Comal River discharge (gage #08169000) above 178 cfs.*

Objective 1.2, San Marcos Springs Discharge: *Maintain mean monthly discharge at San Marcos Springs (gage #08170000) greater than or equal to 60 cfs for at least 11 months per calendar year. Maintain daily average springflow greater than or equal to 45 cfs. This will be quantified by using mean daily springflow data to calculate average springflow for each month per year.*

Objective 1.4, Long-Term San Marcos River Discharge: *Maintain a 3-year rolling-average annual San Marcos River discharge (gage #08170500) above 138 cfs.*

Revisions are recommended to the flow-related objectives in the existing EAHCP (developed between 2009 and 2011) because additional data on flow-related responses of Covered Species populations are available through the biomonitoring program from 2000 to 2022. The recommended BGOs were developed independent of any pumping projections. This approach is consistent with the USFWS HCP Handbook (USFWS and National Marine Fisheries Service 2016). The primary focus was to use biomonitoring data to inform desired springflow and river discharge magnitudes that facilitate surface habitat redundancy.

Springflow objectives for Comal Springs were developed using models aimed at identifying a 30-day average springflow magnitude at which discharge was greater than 0 cfs at three key areas for the Comal Springs riffle beetle (Spring Run 3, Spring Island, and the western shoreline) and at which discharge conditions were greater than 30 cfs through the Old Channel Environmental Restoration and Protection Area (ERPA) specific to fountain darter. Springflow objectives for San Marcos Springs were developed using models aimed at identifying a 30-day average springflow magnitude at which water temperatures did not consistently exceed fountain darter reproductive thresholds and suitable physical habitat for the San Marcos salamander, fountain darter, and Texas wild-rice remained available in the system. Predictive models were developed based on existing biomonitoring data and regression coefficients were applied to unobserved data to determine the objectives. Thus, the springflow objectives were designed to represent the level of springflow necessary to maintain Covered Species resiliency and habitat redundancy based on observed data.

However, there is still a level of uncertainty in what conditions will be present throughout the systems at the predicted springflow outputs. For example, Spring Run 3 is predicted to remain flowing at the recommended objective of 30 cfs, but the standard error estimates include zero.

Commenters expressed concern that the recommended objectives do not provide the same level of protection to the species as the existing objectives and that additional justification is needed to demonstrate how the lower and more sustained recommended objectives are protective of the species. Related to this were concerns that a 3-year period was too short and the study period did not include the drought of record.

Response:

We provide an example using a 1- and 3-year timeframe to compare the existing flow-related objectives to the recommended springs and discharge objectives for the Comal Springs and River system. Assumptions include that Spring Run 3, Spring Island, and the western shoreline remain flowing (i.e., >0 cfs) under a mean monthly discharge of 45 cfs as predicted by the springflow models and that the necessary mechanisms are in place to meet the objectives as written. It is understood that the system likely cannot be managed to produce the springflow objectives as written. However, assuming that the system can be managed specifically to meet the objectives is necessary to compare the two scenarios. Therefore, hypothetical examples of implementation scenarios are provided below.

Flow-related objectives for the Comal System in the existing EAHCP (Edwards Aquifer Authority [EAA] 2012:Table 4-2, included below) are to achieve a modeled minimum daily average of 30 cfs lasting no longer than 6 months followed by a daily average of 80 cfs lasting at least 3 months and to maintain a long-term (50 years) daily average of 225 cfs. This modeled period includes the Drought of Record.

TABLE 4-2
LONG-TERM AVERAGE AND MINIMUM TOTAL COMAL DISCHARGE MANAGEMENT OBJECTIVES

Description	Total Comal Discharge (cfs)[a]	Time-step
Long-term average	225	Daily average
Minimum	30[b]	Daily average

[a]Assumes a minimum of a 50-year modeling period that includes the drought of record
[b]Not to exceed six months in duration followed by 80 cfs (daily average) flows for 3 months.

After 80 cfs for 3 months, the existing objective has no protections against flow decreasing below 80 cfs again. In fact, daily average flow could return to 30 cfs for another 6 months. This means that over the course of 1 year, daily average flow could be 30 cfs for a total of 9 months and 80 cfs for 3 months (Figure 1). In spring habitats for the Comal Springs riffle beetle, discharge at the western shoreline and Spring Island would occur for 9 months, while discharge at all three key areas would occur for only 3 months. With the EAHCP Old Channel flow-split management program in place, the

Old Channel ERPA would flow around 20 cfs (below the suitable range in terms of fountain darter habitat) for 9 months and around 45 cfs (within the suitable range) for only 3 months.

The recommended objectives are to maintain a monthly discharge of 45 cfs for at least 11 months per year, with daily average discharge never falling below 30 cfs. This prevents daily average flow of 30 cfs from extending more than 1 month in duration annually. Therefore, under the recommended objectives, daily average discharge could be 30 cfs for only 1 month and mean monthly discharge could be 45 cfs for 11 months (Figure 1). In terms of spring habitats for the Comal Springs riffle beetle, the western shoreline and Spring Island are predicted to remain flowing the entire time while all three key areas (including Spring Run 3) are predicted to flow for all but 1 month. With the EAHCP Old Channel flow-split management program in place, discharge through the Old Channel ERPA would be 20 cfs (below the suitable range) for only 1 month and 35 cfs (within the suitable range) for the other 11 months. Therefore, over a 1-year period, the recommended objectives would provide 11 of 12 months (>90%) in which all three key Comal Springs riffle beetle areas are predicted to flow and in which the Old Channel ERPA remains within the suitable flow range, whereas the existing objectives would provide only 3 of 12 months (25%) in which these conditions were met.

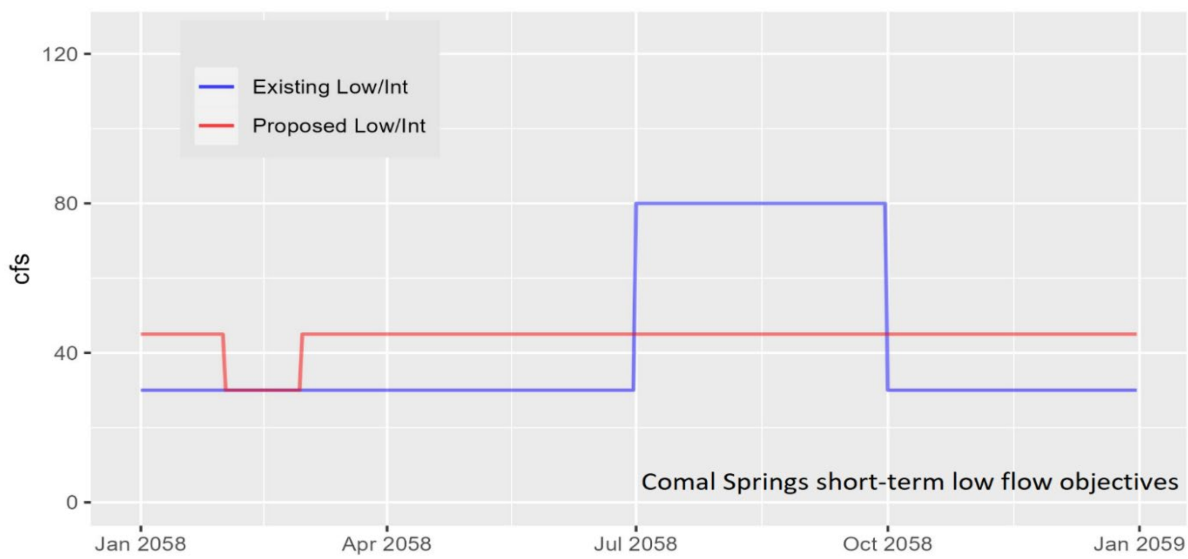

Figure 1. One-Year Comparison of the Existing and Proposed Springflow Objectives if Implemented to their Minimums

Due to the 3-year moving average proposed in the recommended objectives, additional protections are provided when applied over a hypothetical 3-year timeframe. Under the recommended objectives, only 1 year at the minimums would be allowable to adhere to the recommended 3-year moving average annual discharge of 178 cfs (Figure 2). This contrasts with the existing flow objectives (EAA 2012:Table 4-2) which only include a long-term average of 225 cfs to be maintained over the course of a 50-year modeled scenario. Under the existing objectives, the 30 cfs and 80 cfs minimum scenario could occur for greater than 10 consecutive years during a severe drought, if followed by 40 years of higher flow conditions, while still meeting the long-term average objective of 225 cfs.

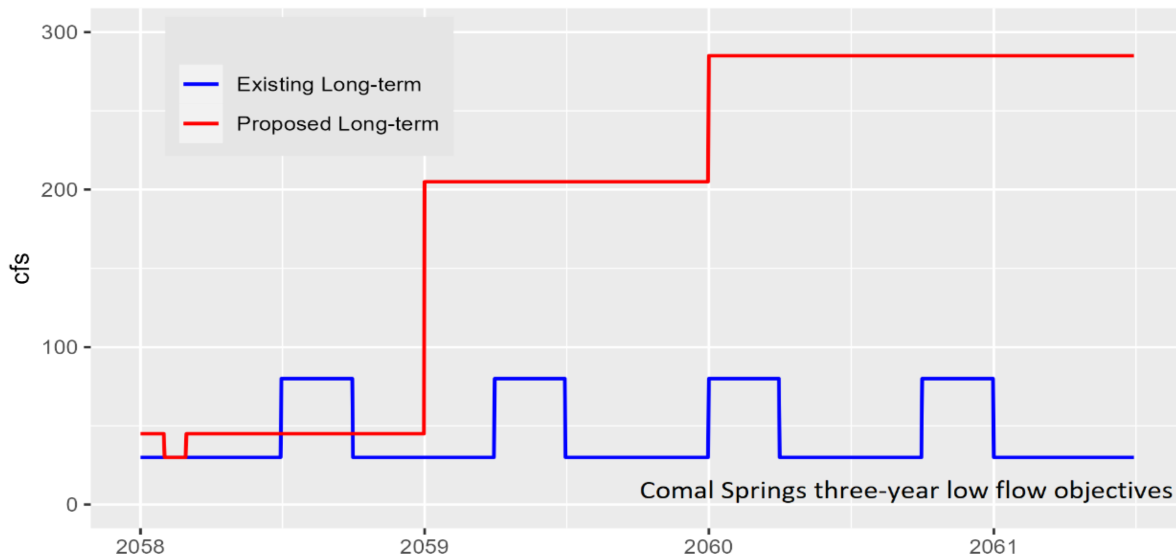

Figure 2. The Springflow Necessary to Maintain the Proposed Comal Springs Springflow Objectives in a 3-Year Period if Implemented to their Minimums

In this way, the recommended objectives attempt to guard against prolonged periods of low flow and offer intermittent periods to support recovery in between disturbance events. They also demonstrate the validity of using a shorter 3-year period compared to the existing 50-year period. The 3-year period enables managers to use observed gage data to assess whether the objectives are being exceeded on a regular basis, whereas a long-term period (e.g., 50 years) cannot be frequently evaluated.

Following the same rationale, a similar comparison can be made on a 1- and 3-year timeframe to compare the existing flow-related objectives to the recommended springs and discharge objectives for the San Marcos Springs and River System (Figures 3 and 4). The differences are that 1) the discharge values for both the existing discharge objectives (EAA 2012:Table 4-13, included below) and proposed (referenced above) are different in the San Marcos system than in the Comal system, and 2) the analysis in the San Marcos system focused on supporting suitable fountain darter, San Marcos salamander, and Texas wild-rice habitats during minimum flow conditions over the course of 1 year, while protecting for periods of extended drought by having a 3-year moving average of 138 cfs.

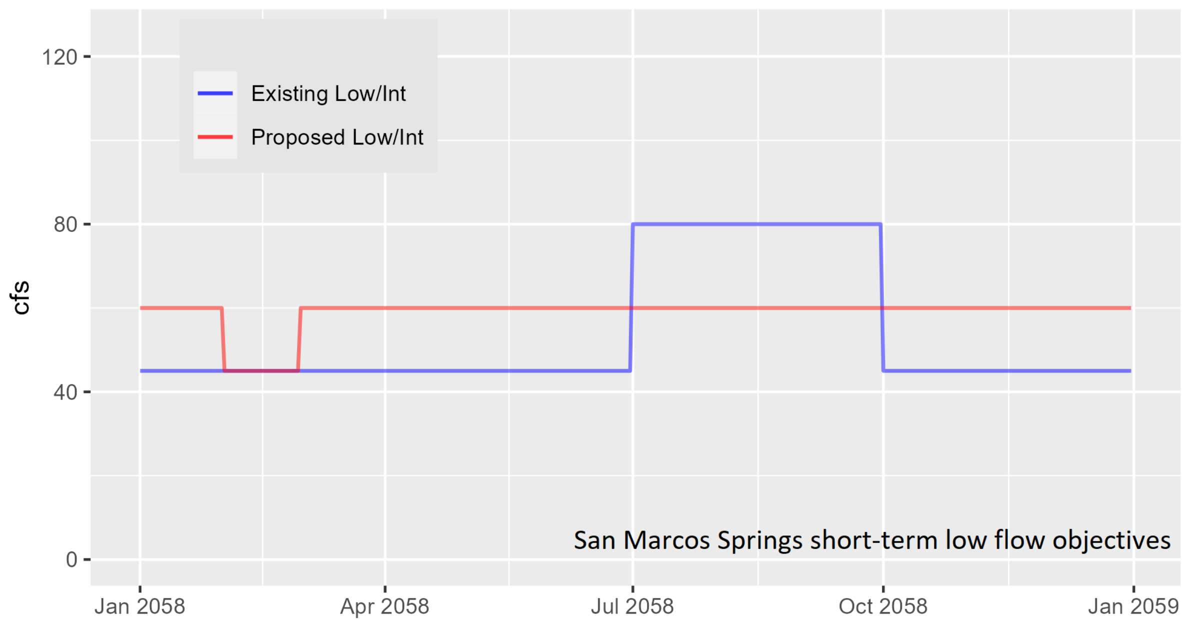

Figure 3. One-year Comparison of the Existing and Proposed San Marcos Springs Springflow Objectives if Implemented to their Minimums

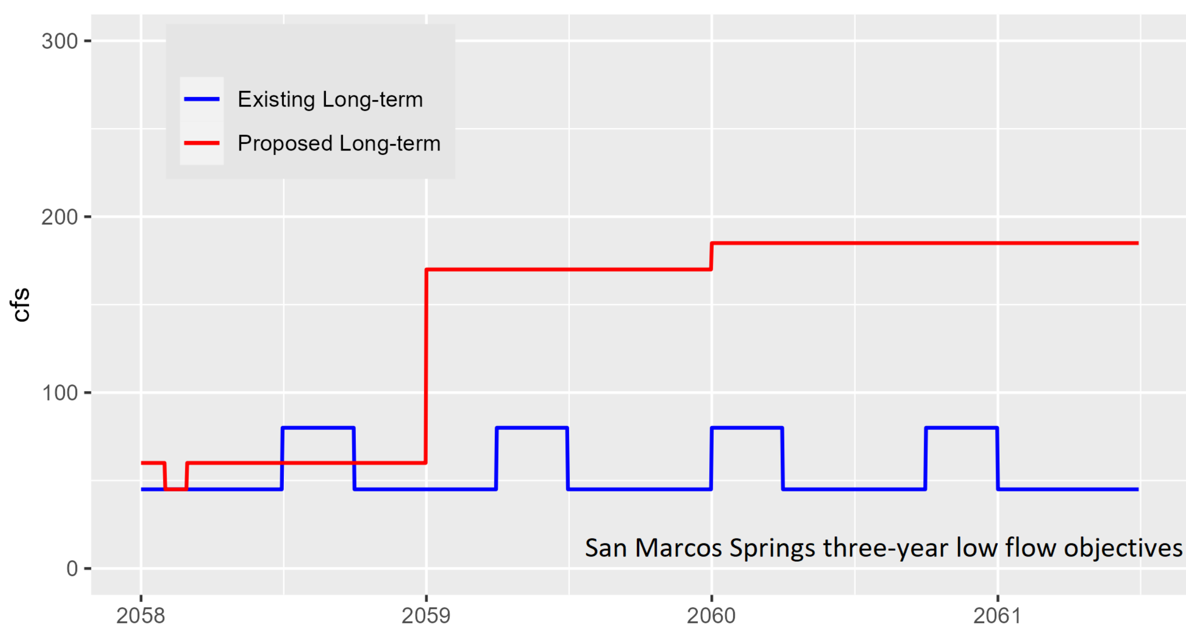

Figure 4. The springflow Necessary to Maintain the Proposed San Marcos Springs Springflow Objectives and River Discharge Objectives in a 3-year Period if Implemented to their Minimums

TABLE 4-13
LONG-TERM AVERAGE AND MINIMUM TOTAL SAN MARCOS DISCHARGE OBJECTIVES

Description	Total San Marcos Discharge (cfs)[a]	Time-step
Long-term average	140	Daily average
Minimum	45[b]	Daily average

[a] Assumes a minimum of a 50-year modeling period that includes the drought of record

[b] Not to exceed six months in duration followed by 80 cfs (daily average) flows for 3 months.

Finally, in response to multiple requests for a longer-term discharge requirement, the project team will add back in the existing criteria 225 cfs (Comal) and 140 cfs (San Marcos) over the proposed 30-year permit renewal period.

ACTION: The springflow objectives in the revised memorandum are revised to include:

Objectives 1.1 and 1.3, Comal Springs Discharge (gage #08168710)**:**

- *Maintain mean monthly spring discharge at Comal Springs greater than or equal to 45 cfs for at least 11 months per calendar year. Maintain daily average springflow greater than or equal to 30 cfs. This will be quantified by using mean daily springflow data to calculate average springflow for each month per year.*
- *Maintain a 3-year moving-average annual Comal Springs discharge above 174 cfs.*
- *Maintain a 30-year long-term average discharge above 225 cfs at Comal Springs.*

Objective 1.2 and 1.4, San Marcos Springs Discharge (gage #08170000)**:**

- *Maintain mean monthly discharge at San Marcos Springs greater than or equal to 60 cfs for at least 11 months per calendar year. Maintain daily average springflow greater than or equal to 45 cfs. This will be quantified by using mean daily springflow data to calculate average springflow for each month per year.*
- *Maintain a 3-year moving-average annual San Marcos River discharge above 136 cfs.*
- *Maintain a 30-year long-term average discharge above 140 cfs at San Marcos Springs.*

Commenters expressed concerns that the recommended flow-related objectives are not appropriate because there have been no instances of sustained low flows at those levels within the study period.

Response:

The 3-year moving average river discharge objectives have been observed during the biomonitoring study period. As shown in the BGO memo, the minimum 3-year moving average annual discharge was set based on the minimum observed over the study period in both systems during 2014. Covered Species demographic parameters (e.g., fountain darter density) initially declined with low flows in 2014 but increased within a year, indicating resiliency after this disturbance event.

For the most part, it is true that the minimum springflow objectives have not been observed during the biomonitoring study period. That said, discharge levels which approached the 45 cfs (Comal) and 60 cfs (San Marcos) objective levels have been observed in both systems in recent years. In August 2023, a minimum mean daily flow of 55 cfs was recorded at Comal Springs. Observations at 55 cfs support model predictions of wetted habitat for Comal Springs riffle beetle at 45 cfs. Most spring runs throughout the system were largely desiccated from July through September 2023, while Spring Island and Spring Run 3 remained 25–50% and 45–50% watered, respectively (BIO-WEST 2024a). Additionally, discharge through the Old Channel remained within the suitable range during the 2023 low flows.

Similarly, a minimum mean daily flow of 66 cfs was recorded in August 2023 in the San Marcos system. Based on observations at discharges consistently below 80 cfs in 2023, habitat degradation (e.g., siltation in Spring Lake, reduced submerged aquatic vegetation [SAV] coverage) occurred throughout the system and fountain darter reproductive temperature thresholds were exceeded throughout portions of the river. Despite the degraded habitat conditions in both systems, the Covered Species persisted during all low-flow sampling with multiple fountain darter population metrics that approximated or were higher than long-term averages (BIO-WEST 2024a, 2024b).

2023 conditions have not been observed for an extended period (11 months) and conditions would likely further degrade at 45 cfs in the Comal system and 60 cfs in the San Marcos system. This uncertainty was inherent in the original EAHCP discharge objectives (Tables 4-2 and 4-13, above) and remains with these proposed revisions. Hence, the proposed springflow objectives were developed to limit the occurrence and duration of minimum discharge conditions when compared to existing objectives. This reduction in duration combined with more intermittent periods between disturbance events provides opportunities for habitat conditions to recover throughout the systems, whereas increased duration of extreme low-flow events under the existing objectives limits opportunities for recovery.

ACTION: We will consider the implications of sustained low flows when developing Conservation Measures and long-term monitoring actions for the HCP.

Commenters noted that outdated data analyses (EAAESS/Hardy 2009; Saunders et al. 2001) used to predict wetted width in the San Marcos River and to validate the San Marcos River springflow objectives should be removed in place of more current data.

ACTION: The revised memorandum and HCP chapter will move away from the 2009 models to focus on habitat conditions observed and measured over the course of the EAHCP implementation period.

Commenters raised concerns about using river discharge data (U.S. Geological Survey [USGS] gages #08169000 and #08170500) instead of springflow and that high-flow pulses skew estimates of mean annual river discharge.

Response:

It is well supported in the literature that high-flow pulses have long-term positive effects on the function of riverine ecosystems (Poff et al. 1997; Humphries et al. 2014). During extended durations of low and stable flows, local production and inputs have the largest influence on river function.

High-pulse events transport resources from upstream sources and the surrounding watershed landscape and maintain geomorphic complexity of river channels (Humphries et al. 2014). It is also well documented over the course of the biomonitoring program that high-flow events can have acute negative impacts on fountain darter habitat availability in these systems by scouring out SAV in some reaches. Based on these complexities, it is important to recognize the potential effects of other flow regime characteristics (i.e., high flows) on ecosystem function. This makes mean annual river discharge a reasonable and useful index in addition to the separate springflow objectives, which do partition springflow from runoff events. That said, because differences between the springs and river discharge are not present during drought and are minimal during other periods, the team proposes to remove the river discharge gage calculation completely to avoid any confusion in the future.

ACTION: All discharge objectives will be developed and measured via springs discharge only at each respective USGS gage. The use of the springs discharge data instead of the river discharge data caused a decrease of the long-term 3-year rolling average in Comal from 178 cfs to 174 cfs and in San Marcos from 138 cfs to 136 cfs. See discussion of springflow objectives on pages 8 and 9.

3.2 Statistics for Comal Springs Objective

One commenter had several comments about the methods and results presented for the regression model used to predict station-level discharge, which were recommendations to revise descriptions of the modeling procedures for clarity and include additional analysis/results, as well as concerns about statements regarding model accuracy.

Response:

We appreciate the suggestions to help clarify the model structure and acknowledge that descriptions of our methods for model fitting can be improved.

The comments about centering and scaling are appreciated. Centering and scaling were conducted in tandem to standardize the predictor variable (i.e., 30-day springflow average) into z-score. 30-day springflow average data were centered by subtracting each data point by its mean and scaled by dividing the centered value by its standard deviation. The standardized predictor then has a mean of zero and standard deviation of one (i.e., standard normal distribution). Further, 30-day springflow average was standardized to help with model convergence and interpretation of model coefficients. For example, centering predictors make it easier to interpret the intercepts, representing the expected value of station-level discharge when 30-day springflow average is set to its mean, rather than it being at zero (i.e., marginal effect) (Gelman and Hill 2007; Hastie et al. 2009). These justifications for predictor standardization will be included in the revised memorandum.

We think including results on more rigorous multi-model inference is beyond the scope of this document because the main goal is modeling for prediction. That said, results from additional analyses are described and provided here. Performance of the fitted model was compared with two alternatively structured models using information criteria, root mean squared errors (RMSE), R^2, and stational-level contributions to R^2. Model 1 is a “null” model with a station-level random effect (varying intercept-only), Model 2 includes 30-day average springflow as a fixed effect and station-level random effect (varying intercept-only), and Model 3 is the model used for this objective described above (varying intercept and slope). Model 3 was the best supported for data inference, which had the lowest AIC_c score (1845) and RMSE (5.04), as well as the highest AIC_c weight (0.99) and R^2 (0.98).

Regarding the comment about RMSE for the fitted model, we agree that "highly accurate" may be an exaggeration, though we believe that "accurate" is a reasonable descriptor of performance. RMSE should be put into context with the distribution of the response variable and requirements of the problem being addressed. Given that discharge across stations ranged from 0 to 166 cfs and that variability of the middle 50% of observations (i.e., interquartile range) was ~35 cfs, we argue that an average prediction error of ~5 cfs is accurate. The range of discharge across stations can be added into the results to provide context for RMSE estimates.

To see how well the model generalizes to new data, 10-fold cross-validation repeated five times (50 total resampling iterations) was used to simulate new data based on the out-of-sample data (Hastie et al. 2009). Predictive performance was evaluated across all iterations by calculating RMSE and R^2. Cross-validation results showed mean RMSE (± standard error) and R^2 (± standard error) were very similar for both training (5.02 ± 0.02 and 0.97 ± 0.001, respectively) and test (5.24 ± 0.15 and 0.97 ± 0.001, respectively) datasets. Strong generalization performance demonstrates that the model is reliable for predicting station-level discharge. We can include these cross-validation results into the revised memorandum to further illustrate the reliability of the model for this objective.

ACTION: The revised memorandum includes descriptions of the methods for model fitting to make the procedures easier to understand for the reader and clarifications have been made to better explain the methods of centering and scaling.

4. Water Quality

Recommended water temperature objectives include:

Objective 1.5, Comal Springs and River Water Quality: *Maintain mean daily water temperature in surface habitats near the substrate less than or equal to 25°C within Upper Spring Run, Spring Island, Spring Run 1–3, and Landa Lake. Maintain mean daily water temperature in surface habitats near the substrate less than or equal to 25°C for more than 50% of the days per year and less than or equal to 27°C within the Old Channel.*

Objective 1.6, San Marcos Springs and River Water Quality: *Maintain mean daily water temperature in surface habitats near the substrate less than or equal to 25°C within Spring Lake. Maintain mean daily water temperature in surface habitats near the substrate less than or equal to 25°C for more than 50% of the days per year and less than or equal to 27°C within the Headwaters, Upper River, and Middle River.*

Commenters voiced concern that maintaining the water temperature objectives for 50% of days per year does not adequately protect the species. Commenters also suggested that, in

addition to water temperature, other water quality parameters should be included in the objective.

Response:

The suggestions regarding the water temperature objectives are appreciated. The proposed water temperature objectives are based on recovery criteria being considered by USFWS in its draft recovery plan for the Edwards Aquifer springs species.

In addition to input provided by USFWS, several studies demonstrate that the recommended temperature objectives are suitable for the Covered Species (Berkhouse and Fries 1995; McDonald et al. 2007; Nowlin et al. 2017). Spatial determination for the water temperature objectives was focused on the springs and thermally stable reaches of both systems as biomonitoring data indicates and some reaches downstream of Interstate (I-)35 and within fountain darter designated critical habitat are less thermally stable than the middle and upper reaches that are near the spring headwaters. It is expected that maintaining appropriate springflow is protective of suitable water temperatures in both systems as demonstrated by existing monitoring data (BGO memo Figures 5 and 6).

No objective was proposed for dissolved oxygen or other water quality attributes because these cannot be directly manipulated and managed. Adequate springflow is a driving variable for environmental parameters such as water temperature, dissolved oxygen, carbon dioxide, and turbidity. Due to the direct linkage between springflows and these water quality attributes, maintaining appropriate springflows (as met by the proposed objectives) is assumed protective of suitable water quality within both spring systems. Although there is no objective for other water quality parameters, monitoring for these constituents (e.g., contaminants, dissolved oxygen, conductivity, turbidity, pH) will remain in place and be conducted by the EAA Aquifer Sciences during monthly discrete sampling and opportunistically during disturbance events such as reduced flows.

ACTION: We will consider water quality indicators (contaminants, dissolved oxygen, conductivity, turbidity, pH) when developing Conservation Measures and long-term monitoring actions for the HCP.

5. Species

5.1 Statistics

Multiple comments by reviewers addressed concerns that one standard deviation from the mean is not the appropriate statistic for determining the fountain darter population metric and vegetation objectives, the Comal Springs riffle beetle population metric objective, and San Marcos salamander habitat objectives.

Response:

The standard deviation (σ), like the mean, is a statistical form of expectation. The standard deviation of a sample represents the level of dispersion from the mean (μ) that is expected on average.

Therefore, variables of interest would be expected to range from one standard deviation below the mean to one standard deviation above the mean from event to event (Rice 2007).

Establishing criteria based on one standard deviation below the mean was proposed by Dr. Chad Furl, P.E. (Chief Science Officer, EAA) during the Biological Objectives Subcommittee meetings in spring 2023. The criteria were suggested to balance between the HCP Handbook requirement of 'Achievable Objectives' while ensuring adequate protection of the species. Over the course of the 23-year biological monitoring program, consecutive routine biological surveys (spring and fall, approximately 6 months apart) have observed species counts less than one standard deviation below the mean. In 23 years, the condition has rarely been observed in three consecutive (i.e., spring, fall, spring) routine sampling periods, which essentially covers a 12-month period. Hence, the additional criteria of three consecutive routine monitoring events covering a 12-month period is proposed. The rationale is that two events have been observed several times with habitat and species rebounding quickly, but a third consecutive routine event is rare. Therefore, in our professional opinion, this is a good place to establish threshold criteria.

Developing objective criteria based on a sampling model framework and parameters associated with the normal distribution is justified because variation is a fundamental component to population dynamics since ecological processes are inherently stochastic. Statistical properties of the normal distribution provide a method to establish objective criteria that account for variability to better estimate whether changes in a given objective variable are ecologically meaningful. In a normally distributed dataset, more than ~16% of the data typically falls below one standard deviation below mean. The main utility of this sampling model framework is that these parameters provide simple descriptions of the processes that generated the data as well as numerical summaries of expectation that general practitioners can understand. Outcomes below the range of expected values (i.e., below one standard deviation) can therefore help define thresholds for indicating potential population/habitat pressures (i.e., stress or disturbance). Outcomes more than two standard deviations from the mean have been used as thresholds to represent catastrophic disturbance events that cause major shifts in population trajectories (Resh et al. 1988; Grossman and Sabo 2010). One standard deviation below the mean was chosen as an objective criterion to indicate stress (rather than a catastrophic disturbance) based on its common use in population and disturbance ecology (Battisti et al. 2016).

ACTION: This comment will be considered in developing long-term monitoring actions for the HCP.

5.2 Objectives for Fountain Darter

Commenters raised concerns that proposed objectives for fountain darter density are not protective of healthy, reproducing, and resilient populations. Several comments also questioned evaluating objectives on a calendar year basis.

Response:

The Biological Objectives for fountain darter density attempt to account for variation in density that would be expected during a given event. Densities lower than one standard deviation from the mean were characterized as potential population pressure and the objectives aim to limit extended durations of this type of population state. Although such events have occurred during the monitoring period, long-term monitoring data provide supporting evidence to suggest the density objectives are protective of resilient fountain darter populations. Following events where mean density was below the objective, the time for mean density to return to values within one standard deviation of the mean was less than 1 year for both systems. This demonstrates resiliency since the population recovered following declines. Populations would not be considered resilient if mean densities failed to return to the range of expected values following potential population pressure. These objectives were measured on a calendar year basis because existing monitoring data demonstrates fountain darter densities can recover to expected levels within 1 year. Annual analysis allows for acute deviations in a given event but attempts to capture patterns in population performance on a time scale relevant to overall population persistence given the life span of the fountain darter. In short, monitoring data supports that fountain darter populations should be resilient and persistent in the future if the parameters used to characterize their temporal variation from 2001 to 2022 (i.e., mean and standard deviation) remain at similar levels.

ACTION: No changes proposed to the density values. However, wording is clarified from "one calendar year" to "… a minimum of three sampling events covering a 12-month period". This comment will also be taken into consideration for development of long-term monitoring.

Commenters raised issues concerning the SAV objectives, which involved recommendations to include additional vegetation taxa, establishing system-level objectives, questions about why certain taxa were omitted, and concerns about including the non-native* Hygrophila*.

Response:

SAV taxa used to calculate each objective were selected because they represent the dominant vegetation types present in the system, were sampled during drop-net sampling as part of the EAHCP biomonitoring program, and have associated fountain darter density values. Texas wild-rice was not originally included in the simple SAV objective for the San Marcos River because this species has its own objective criteria independent of fountain darter habitat. Criteria were developed at the reach level rather than system level so that activities of any Conservation Measure (e.g., SAV restoration) could be explicitly linked to the objectives established for each reach. That said, system-level approach comments were common and adding additional reaches to provide better spatial representations of each system were further considered and agreed upon.

Consideration of non-native *Hygrophila* as suitable habitat for fountain darter was discussed during Texas wild-rice and fountain darter EAHCP Biological Objectives Subcommittee meetings. There was a general consensus that *Hygrophila* is recognized as suitable habitat, which is supported by drop-net data and previous studies (e.g., Edwards and Bonner 2022). Given this recognition, it was also suggested during these meetings that any *Hygrophila* removed during restoration efforts should be replaced by native taxa that also provide suitable habitat for fountain darter (e.g., *Ludwigia*). One reviewer's comment raised concerns about whether natives can persist after *Hygrophila* is removed. Data from past restoration in the Comal Springs and River support that natives can persist following *Hygrophila* removal in non-shaded areas with appropriate substrate conditions. Restoration efforts in the Comal River's Old Channel provide a model success story, demonstrating the persistence of exclusively native SAV assemblages (e.g., bryophyte*, Ludwigia*) from 2019 to the present following removal of *Hygrophila* and thinning of riparian coverage to allow ample sunlight (BIO-WEST 2023).

ACTION: Further discussion and analysis has been conducted and additional complex vegetation types (water stargrass [*Heteranthera dubia*]*,* Eurasian watermilfoil [*Myriophyllum spicatum*] and bryophytes) have been added to the San Marcos system. Texas wild-rice is also now included in the simple vegetation category.

Additional reaches outside of the Long-Term Biological Goals study reaches were added in each system to provide better spatial representation of each system. These restoration reaches are as follows and are displayed in Figures 19 and 20 in the revised memorandum:

- Comal—Upper Landa Lake, Lower Landa Lake, and Upper Old Channel.
- San Marcos—Spring Lake Dam to City Park, City Park to Rio Vista.

5.3 Objectives for Texas Wild-rice

Commenters recommended adding an objective to maintain at least two large, contiguous Texas wild-rice stands for their viable seed production ability in the upper most portions of the San Marcos River.

Response:

There remains uncertainty regarding sexual reproduction, seed viability, and recruitment of Texas wild-rice in the San Marcos River. Although data on this topic is not available in the literature to offer guidance, it is agreed that maintaining a few large, contiguous stands for sexual reproduction would likely be a benefit.

ACTION: Maintenance of two large, contiguous Texas wild-rice stands specific to seed production in the upper most portions of the San Marcos River is included as a Texas wild-rice objective in the revised memorandum.

One commenter recommended increasing the Texas wild-rice coverage value below I-35.

Response:

The persistence of Texas wild-rice stands throughout the last 10 years of EAHCP implementation was used to guide objectives recommendations. Based on persistence analysis over this period, the higher levels of turbidity in this stretch, limited amounts of carbon dioxide in the water, and high risk for flood scour, the team does not agree with increasing the coverage above $200m^2$ below I-35.

ACTION: We will consider Texas wild-rice coverage below I-35 in developing Conservation Measures and long-term monitoring and adaptive management for the HCP.

5.4 Objectives for Salamander

Commenters noted the objectives are centered on habitat only, and asked about the number of salamanders observed in these locations over the years and if additional sampling areas might be pertinent.

Response:

The National Academy of Sciences report and Biological Objectives Subcommittee both raised concerns over the sampling methodology to calculate San Marcos salamander population metrics. As such, the project team did not use this long-term count dataset to calculate population metrics. However, it is important to understand that all three existing and proposed monitoring areas have had persistent occupancy over the past 23 years. When examining just the total numbers during 15-minute timed counts in these areas, 5,154 total salamanders have been counted in the Hotel Reach with an average (±standard deviation) of 101.0 (±22.3) salamanders per 15-minute survey, 4,249 total salamanders counted in the Riverbed study area with an average of 83.3 (±23.4) salamanders per 15-minute survey, and 826 total salamanders counted in the proposed Spring Lake Dam study area with an average of 16.2 (±7.8) salamanders per 15-minute survey since the inception of the biological monitoring program. The reason for the consistently high numbers of salamanders throughout wide-ranging flow conditions over two decades is the quality of the habitat available. Differences in the numbers counted per standardized timed survey per event typically revolve around disturbances to the available habitat. The main disturbances are siltation or rooted vegetation encroachment in Spring Lake and recreation activity (foot traffic and rock removal or arrangement) below Spring Lake Dam. Therefore, only habitat quality and protected area criteria were proposed. This allows time for the new biological monitoring program for this species to be implemented during the permit renewal with the goal of developing population metrics once sufficient data is available.

Additionally, the addition of diversion springs as a fourth salamander monitoring area is supported by the number of San Marcos salamanders consistently observed in this location by USFWS San Marcos Aquatic Research Center biologists. The project team believes a protective approach is to establish additional habitat quality and area criteria for this fourth location and continue monitoring to document persistent occupancy, while developing population metrics into the future.

ACTION: The revised memorandum includes information on the number of salamanders observed over time in these study reaches to document to persistent occupancy of these spatially diverse habitat areas.

The revised document includes further definition and description of "quality habitat" specific to the persistent occupancy documented over the past 23 years.

To enhance protectiveness of this objective, language has been added to the revised memorandum regarding additional locations for Diversion Springs management to be continued in Spring Lake as part of the Conservation Measure for this species.

One reviewer stated, "Could there be a biological objective to maintain X area of recreation free salamander habitat in the Spring Lake Dam Reach? I'm trying to figure out a way to provide protection from recreation when the river is not in Condition M with SSA exclusions."

Response:

The project team concurs that recreation in the San Marcos River is a contributor to take of the Covered Species, which is even more detrimental at lower flows.

ACTION: We will consider the recreational impacts on salamander habitat in developing Conservation Measures and long-term monitoring and adaptive management for the HCP.

5.5 Objectives for Comal Springs Riffle Beetle

Commenters were concerned that including the standard deviation to set the objective at 2.4 counts/lure makes the objective criterion too low. It was also recommended that the San Marcos population in Spring Lake be included in the objective to facilitate redundancy and indicate overall species state.

Response:

The Comal Springs riffle beetle objective was developed using data from 2013 to 2022 and did not include data from 2004 to 2012. From 2004 to 2012, lures were set in areas with high-quality habitats that were known to have high beetle abundances. Some of this data was used to establish the existing reach-level density objectives (Spring Run 3: ≥20 beetles/lure; western shoreline: ≥15 beetles/lure; Spring Island Area: ≥15 beetles/lure). From 2013 to 2022, lure locations were fixed, more spatially varied, and were also set in areas known to harbor lower beetle abundances. Therefore, data from 2013 to 2022 likely better represent the range of available habitats within Comal Springs and thus better characterize the overall population. With this in mind, the recommended lower count objective at the system level is not directly comparable to the existing higher density objectives at the reach level and should not be assumed to be less protective of the species. Furthermore, including the standard deviation in the objective criteria accounts for variation in density that we would expect during any given event. It is acknowledged and was highlighted by the National Academy of Sciences report that the Comal Springs riffle beetle lure methodology has limitations. One could meet the proposed objective of 2.4 beetles per lure with all the beetles being collected on a single lure regardless the total amount of lures placed. As such, to enhance the protectiveness of the measure, further examination of the presence/absence percentage per total lure set will be added as a subcomponent to this objective.

ACTION: Based on comments, language has been added to the revised memorandum to incorporate monitoring of Comal Springs riffle beetle at the Hotel area of Spring Lake with the goal of developing population metrics.

Additionally, the project team has added language to the revised memorandum regarding the presence/absence per lure percentages in the Comal system to enhance the spatial protectiveness of this Biological Objective.

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Document: Recommended Biological Goals and Objectives for the Permit Renewal
12/27/2023

Reference Page Number	Line/Table/Figure Number	Reviewer Name	Reviewer Organization	Reviewer Comment
general		Phillip Quast/Amy Niles/Greg Malatek	CONB (IC-SH)	Overall, we find the biological goals and objectives well-written and largely agreeable. We understand the complexity of renewing the ITP and updating the HCP. The City of New Braunfels looks forward to the permit renewal and updated HCP finalization over the next few years.
3	11 16	Phillip Quast/Amy Niles/Greg Malatek	CONB (IC-SH)	The City of New Braunfels, and all other permitees and stakeholders, should be provided the same information to base comments as EAHCP staff was provided by USFWS. All permitees should have a voice in how the HCP is finalized with respect to comments and changes requested by USFWS. Footnotes with brief descriptions of current biological objectives that accompany the new proposed objectives would be helpful for comparison and to understand how and why changes have been made. We also think that it is critical that the EAHCP science committee be provided a chance to comment on documents such as this memo as a group and not just individually.
6	14 - 20	Phillip Quast/Amy Niles/Greg Malatek	CONB (IC-SH)	Please explain why USGS gage #08169000 was selected to base the spring discharge calculations on instead of gage #08168710? If gage #08168710 data is not used, clarify how the data taken from gage #08169000 will be manipulated to represent the actual spring flow and not take additional stormwater runoff into account.
6	41-42	Phillip Quast/Amy Niles/Greg Malatek	CONB (IC-SH)	Provide clarification on the flow objective threshold for Spring Run #3. The surface flow for the spring orifices in Spring Run #3 furthest from the Landa Lake confluence cease flow before most of the other orifices closer to the lake. Clarify the target objective regarding how much of Spring Run #3 should have surface flow during a low-flow scenario to preserve CSRB habitat. What is the justification for allowing most of this critical habitat to go dry at the surface?
7	22	Phillip Quast/Amy Niles/Greg Malatek	CONB (IC-SH)	The City of New Braunfels would like to obtain additional information about how this spring flow objective would interact with two activities that occur on Landa Lake: Old Channel Flow Management and Vegetation Mat Management. The City has serious concerns that these conservation measures could not be appropriately executed during a prolonged low-flow scenario. The predicted minimum flow may allow the fountain darters to have adequate spring flow to survive, but would create conditions within the lake that would impair habitat. Have the changes in habitat composition created by these low flow scenarios (increased shade from vegetation mats, decreased dissolved oxygen) also been accounted for? What is the justification for selecting 11 months as the timeframe for the mean monthly spring discharge? How would this timeframe specifically benefit the species? The City recommends decreasing the duration at which flow would remain at 45 cfs, perhaps to only 4 - 6 months rather than 11, and/ or increasing minimums.
7	9 - 12	Phillip Quast/Amy Niles/Greg Malatek	CONB (IC-SH)	From reading the memo, it is not apparent how or if short-term spring flow fluctuations and current conservation activities were taken into account when developing the spring flow objectives. How would these lower minimum flow rates allow for the management of increased floating vegetation mats on Landa Lake during low flow? Has there been a holistic evaluation regarding the changes in flow regimes to ensure the continued benefit of the endangered species while some conservation measures are prohibited by Condition M or are not physically possible during low flow scenarios?
11	Objective 1.3	Phillip Quast/Amy Niles/Greg Malatek	CONB (IC-SH)	Please clarify how the current long-term average flow objective for Comal Springs (225 cfs) is assessed and how the proposed long-term average would be assessed. A comparison of current and proposed flow objectives in this memo or an associated document would be helpful.
11	Objective 1.3	Phillip Quast/Amy Niles/Greg Malatek	CONB (IC-SH)	The proposed 3-yr rolling average for Comal, 178 cfs, is significantly different from the existing flow objective for long-term avg, 225 cfs. Provide justification for making such a significant change.
12	35 - 39	Phillip Quast/Amy Niles/Greg Malatek	CONB (IC-SH)	Please provide justification for the substantial change of temperature objectives from the current plan to the proposed plan as a water quality objective and how this change benefits the species.
19	31-34, Objective 3.1	Phillip Quast/Amy Niles/Greg Malatek	CONB (IC-SH)	Provide explanation on Spring flow Objective 1.1. Is it adequate to support CSRB habitat in Spring Run #3 with reduced minimum spring flow and increased temperatures?
2,3	35 on page 2 to 10 on page 3	Tom Taggart	COSM (IC-SH)	The Stakeholders and IC members were assured that the spring flow numbers objectives would not change as part of the ITP renewal process. The process description indicates ICF recommended "increasing flexibility" in the BO for the fountain darter. Why did EAA and ICF change the BO in this draft versus prior assurance? How does this change "increase flexibility" and what does that equate to species needs. It certainly reduces flow targets vs. 2012 ITP.
3	Line 11-16	Tom Taggart	COSM (IC-SH)	This section should be revised to include review and approval of the BGO's by both Stakeholders and IC members (as well as any EAHCP Science Committee and independant reviews as assigned) and show the appropriate level of interface in the process. All the parties should have a view and voice on the proposed finalization process and not just EAA staff and ICF when USFWS concerns and comments/changes are addressed.
3	22-34	Tom Taggart	COSM (IC-SH)	The Goals are broad and appropriate. I can support these as shown. It would be nice to have Biological Objectives for Goal 7 completed earlier but I understand the constraints to that.
4	5,6	Tom Taggart	COSM (IC-SH)	It is recommended a report be prepared summarizing the biological objectives subcommittee work, recommendations and how their recommendations were incorporated into the draft BGO report, noting which recommendations were and weren't incorporated. Despite assertions of transparency, the content and methodology don't lend themselves to transparency.
Section 4	all	Tom Taggart	COSM (IC-SH)	The organization of this section makes it difficult to follow. Tables and figures should be in the sections they augment and not scattered into other areas. The Comal/San Marcos sections are one example of this. Explanations of choices and assumptions should be expanded. Clarity is important.
6	Line 41-42	Mark Enders	COSM (IC-SH)	Provide clarification on the flow objective threshold for Spring Run #3. Surface flow from individual springs in SR#3 will cease flowing from upgradient to downgradient as you near Landa Lake confluence. Clarify the target objective regarding how much of SR3 should and will remain flowing at 45cfs.
7	Line 6-7	Mark Enders	COSM (IC-SH)	At observed total Comal springflow of 60cfs, only approx. half of SR3 exhibits flow. Recommend increasing Comal minimim springflow objective to ensure flow through at least 75% of SR3 and/ or decrease duration at which a majority of SR3 would remain dry. Recommend including a statement in the memo clarifying that only a small portion of SR3 will exhibit flow at 40-45cfs (perhaps only 10-20% of the SR3 would exhibit flow at 40-45cfs).
6	21-42	Tom Taggart	COSM (IC-SH)	Further explanation of the modeling done and what criterion was chosen will help us understand this. When it states that SR3 is still flowing does that mean a surface flow? Subsurface? What extent will SR3 flow? Describe how the modeling takes any climate change effects into consideration when evaluating the historical use of data. Is the "objective criterion" future or retrospective as the model was used.
7	Objective 1.1	Tom Taggart	COSM (IC-SH)	Provide supporting documentation on the basis of how the 11 month average vs. a 12 month period was selected? Given the high degree of uncerctainty in these systems, why would we leave a month out? This is very different than our last effort and it is not clear how this benefits the species more than the original ITP values. Please explain how the proposed objectives for spring flow are more protective?

7	Line 9-12, Objective 1.1 (Comal Springs Discharge)	Mark Enders	COSM (IC-SH)	Provide more information on how the duration of 11 months at 45cfs was derived to be protective of species and habitat. Having worked in, closely observed and managed the Comal system for almost 10 yrs, I find it would it be diffcult to maintain sufficient suitable habitat in Landa Lake and Old Channel with sustained flow 45 cfs. In general, it is felt that the development of the springflow objectives don't adequately account for dynamic system processes and managment needs (i.e. expanded coverage and feasible mgmt of floating veg mats on Landa Lake, flood scouring, DO concentrations, ability to route flow into Old Channel, etc). Recommend decreasing the duration at which flow would remain at 45cfs or increase minimum flow objectives to align with feasibility of being able to "manage" the system and implement effective conservation measures and to be able to meet other Bio Objectives.
7,8	21page 7 through 33 Page9	Tom Taggart	COSM (IC-SH)	The section methodolgy doesn't provide the same level of protection as prior ITP (or that isn't presented clearly enough to ascertain). River morphology has changed since the 2009 study, which is based on 2001 channel geomteries, and no adjustment is shown. The 11 of 12 months approach is also used again and given the single monitoring guage the averages could differ wildly with surface flows also passing through the gauge. Low flow tolerance is not adequate with the "long term" 3 year period shown. **Why was 3 years vs a longer period chosen and what was the need to change the prior methodology the EARIP and EAHCP ITP 1 used?** The 2023 sampling of salamanders at low flow used to "confirm" conditions as suitable even though the report elsewhere is careful to point out that drought and other stressor effects may be delayed. We may not know all the effects of this drought condition yet. The assumptions have a high degree of uncertainty and seem more subjective than best available science. Recommend re-evaluation with Science Committee or independant review help.
9	21-31	Tom Taggart	COSM (IC-SH)	The declarative statement (Thus...) on 45 cfs beilng protective of the darter is not adequately supported and should be evaluated further.
9	Line 22-25, Objective 1.2 (San Marcos Springs Discharge)	Mark Enders	COSM (IC-SH)	The methodology used to arrive at the springflow objective for San Marcos relies on the Hardy 2009 model to estimate wetted area in the SM River at given flow rates. Assumptions listed on Page 9, Lines 4-20, may not hold true as channel geometries have likely changed since 2001. Hardy 2009 used 2001 channel geometries. May need to try to test/ validate Hardy model based on actual observed low flow in the San Marcos River over the past 5-10 yrs or perform new modeling exercise to verify wetted area at varying flows and at low-flow objectives.
9	Line 22-25, Objective 1.2 (San Marcos Springs Discharge)	Mark Enders	COSM (IC-SH)	Provide additional justification on how the duration of 11 months at 60cfs will be protective of species. In general, it is felt that the development of the springflow objectives don't adequately account for dynamic system processes and managment needs (i.e. ability to achieve proposed SAV coverage goals under sustained low-flow at 60cfs, magnified recreational impacts under sustainded low-flows, channelization, sedimentation/ algal & detritus accumulation in SM Salamader habitat, flood scouring). Recommend decreasing the duration at which flow would remain at 60cfs or increase minimum flow objectives to align with feasibility of being able to "manage" the system and implement effective conservation measures and to be able to meet other Bio Objectives. In general, it is felt that the duration of low-flow defined in the springflow objectives will not provide for resiliency of the species and align with the Bio Goals.
9	Line 15-18, Objective 1.2 (San Marcos Springs Discharge)	Mark Enders	COSM (IC-SH)	45-60 cfs for sustained periods may not be adequate to prevent significant siltation of SM Salamaner habitat. Significant siltation occurred in SM Salamander habitat at sustained flows of 70-90cfs as experienced 2022-23. Statement on Lines 18-20 is not necessarily supportive of the proposed flow objective as conditions during the Summer of 2023 (70-90cfs sustained for 3 month) is not predictive of 60cfs for 11 months. In addition, the presence of salamanders observed during low-flows of 2023 does not mean that lag effects as a result of low-flows and sub-optimal habitat conditions may not be realized in the future.
9	Line 7	Mark Enders	COSM (IC-SH)	Report states "At 60cfs, the majority of FD habitat is still conserved. Define "majority".
9	Line 13-15	Mark Enders	COSM (IC-SH)	Statement that springflow in Spring Lake keeps rocks utilized by SM Salamander silt free as long as water issues from springs is not necessarily true. Significant siltation of spring orifices occurs routinely even at higher flows. While it is assumed that maintenance of the spring opening areas will occur as a conservation measure, it is uncertain that maintenance efforts will be able to keep pace with needs to maintain suitable habitat at low-spring flow objective levels without causing negative impacts.
11	Objectives 1.3, 1.4	Tom Taggart	COSM (IC-SH)	Please show comparative analysis of the proposed flow objectives vs. those in the existing EAHCP. Provide a justification of how the proposed flow objectives are equal protective of the species.
11	Line 1-4, Objectives 1.3 and 1.4	Mark Enders	COSM (IC-SH)	Recommend using spring/ baseflow based on gages 08168710 and 08170000 for the 3yr rolling discharge average in lieu of 8169000 and 08170500 to avoid the 3yr rolling average being skewed by stormflows and watershed contributions. The proposed 3-yr rolling average for Comal, 178cfs, is significantly different from the existing flow objective for long-term avg, 225cfs. Provide more justification for making such a significant change.
11	Objectives 1.3 and 1.4	Mark Enders	COSM (IC-SH)	Provide information either in the memo or in other format to describe and compare existing flow objectives vs. those proposed in this memo. Provide clarification on how the current long-term average flow objective for Comal (225cfs) and SM (140 cfs) are currently assessed.
Misc	Flow Objectives 1.1, 1.2, 1.3, 1.4,	Mark Enders	COSM (IC-SH)	While observed springflow and river discharge from 2001-2022 does represent varied hydrological conditions within both the Comal and San Marcos River system, representing both low- and high-flow conditions, the amount of biological data available during extreme and prolonged low-flow periods is limited to draw conclusions about species health and resiliency through low-flow periods defined by the objectives. A primary concern is the species response to the proposed proposed flow objectives, which are significantly lower and more sustained than have been observed during the period of record for biological monitoring (2001-2022). While Comal and SM flows have come close to hitting the minimum flow values for very brief periods (+/- 1 month), there is no instance 2001-2022 of sustained low-flow at 60cfs and 40cfs.
12	Objective 1.5,1.6	Tom Taggart	COSM (IC-SH)	We should add other factors than just temperature and evaluate the effects of climate change etc. when establishing the flow objectives. Ambient air temperature is modelled to rise significantly even in the best case as presented on December 14, 2023. We should factor that in especially given we seek a longer ITP term.
12	Line 40-44, WQ Objective 1.6	Mark Enders	COSM (IC-SH)	To be more protective and to expand optimal habitat for the FD, recommend expanding this objective to Stokes Park or throughout the full extent of FD Critical Habitat. Also recommend high-end thermal threshold be 26c and not 27c (i.e. Maintain mean daily water temp <25c more than 50% of year and <26c from Headwaters to Stokes Park.) Flow objectives may need to be adjusted accordingly to achieve these temperature objectives. Climate change may also impact ability to achieve Temp Objectives during sustained low-flow periods at 60cfs (i.e. if number of days >100F increases, downstream T could be increased under prolonged low flow-conditions).
18	39	Tom Taggart	COSM (IC-SH)	Comments that the study and conclusions referenced in 4.1 as protective related to 4.2, 4.3, 4.4 etc. are subject to the same concerns listed previously. We are betting a lot on those assumptions. Recommend this also be referred for additional evaluation and modelling should include the drought of record for comparison with results of the 20 year data period. Analysis of the uncertainty of using a 20 year data set to forecast the 30 years going forward from 2028 should also be explored.
22	Objective 4.1	Mark Enders	COSM (IC-SH)	Consider increasing the objective for total area of maintained high-quality habitat for the SM Salamander. The additional area may include other potential spring openings or potential high quality habitat areas in Spring Lake. With limited habitat area within the SMR system, it makes sense to increase the area of high-quality habitat to allow for population resiliency and redundancy.
22	Objective 4.1	Mark Enders	COSM (IC-SH)	I understand that a monitoring section for the new EAHCP will be developed at a later date, but would like to recommend that SM Salamander monitoring, as well as genetics work, be included within the program to monitor changes in populations over time. I understand the issue with including a species-based population or density objective and am not necessarily recommending this but do want to ensure adequate, long-term monitoring of the SM Salamander.
24	obj 4.6	Tom Taggart	COSM (IC-SH)	TWR coverage objectives should be expanded further downstream and reach designations evaluated for changes given the bank hardening, fencing and other factors such as prolonged low-flow and recreation and the resulting effect on TWR in the upper reaches of the river. Also, add discussion of flood scouring effects and data that shows how the objective is conservative in those events, if it is. SAV objectives should be responsive to observed conditions and additional consideration of the observations of those doing the work in the habitat,

26	Line 14, TWR Objective 5.1	Mark Enders	COSM (IC-SH)	Proposed TWR coverage objective for the Hopkins to I-35 reach may need to be reconsidered and possibly decreased given the need to allow for other native SAV establishment and sub-optimal habitat suitability in some portions of this reach. Increase TWR coverage objective for Downstream of IH-35 reach to account for decrease in Hopkins to 35 reach. A potntial ecommendation would be to decrease the Hopkins to 35 TWR cover to 2,800m2 and increase Dwnstm of 3 to 600m2 or similar.
26	TWR Objective	Mark Enders	COSM (IC-SH)	Recommend adding an objective to maintain at least two large, contiguous TWR stands for their viable seed production ability. Per USFWS Chris Hathcock recommendation/ input that only large, contiguous stands have been found to produce viable seed which is important for maintainin long-term genetic diversity of TWR.
30	Objective 6.1 and 6.2	Mark Enders	COSM (IC-SH)	It is unclear how the proposed objectives for FD Density (long term mean minus the standard deviation), justify or are protective of healthy, reproducing, resilient FD populations, especially given the proposed changes in WQ (temp) and springflow objectives.
36-37	San Marcos SAV Objective 6.6	Mark Enders	COSM (IC-SH)	Based on observation and experience managing SAV in San Marcos River, it may prove difficult to maintain proposed coverage of SAV in the established reaches through sustained periods of low-flow at the proposed low-flow objective (45 & 60cfs). Over the past 10 years, it has been difficult to maintain this level of SAV coverages in these reaches due to various factors including recreation and low-flow. Two of these reaches, Spring Lake Dam and City Park have designated access points that focus recreation to these areas as part of an EAHCP strategy to manage recreational access (i.e. focus recreation to designated, harded access points and limit or restrict access to other areas). It is recommended that SAV objectives be applied to other reaches and/ or to assess SAV coverage on a more system-wide basis. I'd like to ensure that adequate FD habitat (i.e. SAV coverage) is established and maintained in areas outside of the current LTBG reaches which would also consider ensuring adequate FD habitat in Spring Lake given its buffer against negative impacts associated with recreation and low-flow. Perhaps we can shift the LTBG reaches or add new reaches that are more representative of the system as a whole and/ or are within areas demonstrated to support sustainable SAV coverage. Or perhaps develop FD SAV objectives for larger river segments similar to the TWR objectives. The spring flow objectives don't fully support or align with the SAV coverage objectives. It has been observed that low-flows have negative impacts on SAV coverage in the SM River, not due to recreation alone.
36-37	San Marcos SAV Objective 6.6	Mark Enders	COSM (IC-SH)	Recommend including Bryophyte as a complex SAV type, and Vallisneria & Stargrass (Heteranthera) as simple SAV type to be used to achieve SAV objective.
General comments		Tom Taggart	COSM (IC-SH)	Clearer information on the changes and additional review by Science Committee or other independent review will help us understand if these biological objectives are appropriate for the goals. Also, "independent" comments vs. group engagement in discussing them with EAA/ICF as the decision maker on the results is not compatible with or equivalent to the process we used to reach consensus. We should again perform to that standard in the renewal. There is an overemphasis on the minimum requirements vs. a recovery oriented conservation minded approach. That has not been characteristic of this effort previously.
Section 3 Recommended Biologic Goals		Charles Kreitler	SC	Biologic goals are fine and reflect the Goals Committee's thoughts
4.1 Objective .Springs and associated rivers		Charles Kreitler	SC	This section on quantity and quality requirements for Comal Springs, San Marcos Springs and associated river appear appropriate. They are well thought out and well presented.
Sections 4.2 and 4.3 . Aquifer species		Charles Kreitler	SC	Text is appropriate, but no mention of blind catfish. Should not this species be mentioned.
Section 4.4 Objectives for Comal Springs Riffle Beatle		Charles Kreitler	SC	No comment. No hydrology
Section 4.5. Objectives for San Marcos Salamander		Charles Kreitler	SC	Interesting decreases in habitat that may have resulted by man's perturbation of man's impact or from HCP imapct
Section 4.6 Objectives for wild rice		Charles Kreitler	SC	No comment. No hydrology? Habitat conservation does not appear to be related to spring discharge?
Section 4.7 1-2 Objectives for fountain darters		Charles Kreitler	SC	No comment. No hydrology? Habitat conservation does not appear to be related to spring discharge?
Section 4.7.3 Submerged Aquativ Vegetation		Charles Kreitler	SC	No comment. No hydrology? Habitat conservation does not appear to be related to spring discharge?
Section 5 Summary		Charles Kreitler	SC	Summary appears to capture the detail descriptions in the previous sections. Question? Should the habitats have minimum spring flow requirements or is this captured by establishing spring flow minimums for individual species?
2	8,9	Jason Martina	SC	maybe add an example of each of the 4 elements in parentheses
4	27	Jason Martina	SC	unsure of what "surface habitat" refers to. Is it in reference to the shore terrestrial habitat or the habitat directly above the water (e.g., emergent vegetation)?
6	26,27	Jason Martina	SC	but species aren't redundant (in the ecological sense) unless they are functionally redundant and there is definitely a difference among species in their funtion (submerged, floating, emergent, etc). However, I didn't really see this used in the report, so you can omit this comment
7	Table 1	Jason Martina	SC	confused about the way the table is structed. Why is intercept under coefficent, or is that the intercept only model?
9	22-25	Jason Martina	SC	How different are these target flow rates compared to the original biological goals?
11	1,2	Jason Martina	SC	It is unclear to me how you would manage for a 3-year average in discharge. Therefore, is this useful?

11	14-22	Jason Martina	SC	It might be useful to include in the text how these recommendations are different from the past BG recommendations. That seems to be the most transparent approach
12	33-44	Jason Martina	SC	How do you manage for water temp? What would be done if the water exceeds the upper limit? For all the other limits I can see a way to manage the system to reach the goal, but I don't see it for temp. Is it to just increase flow?
18	33	Jason Martina	SC	Does "wood" mean living or dead and is this just refering to detritus?
20	1 to 5	Jason Martina	SC	Does each location have to reach that minumum or is it the average of the three locations, the objective isn't clear. Three sampling events per location or three total?
22	Table 4	Jason Martina	SC	This focuses on habitat, but I was wondering what the sampling numbers look like. Number of salamanders found per m2 per sampling event or something like that. Is the number just too low to be useful?
26	Table 5	Jason Martina	SC	Might want to include the same type of analysis as before, finding the mean for a reach and then using one std dev to determine the minimum coverage. Is the worry that it would be too high?
29	2 to 4	Jason Martina	SC	why were these veg type omitted? Might be good to state why here. These are included in Figure 13 even though the text said they would be omitted
34	18 to 22	Jason Martina	SC	The problem is if the reason the natives aren't establishing is because of Hygrophila, then it seems to me that we still need to control and remove Hygrophila. Would need to determine if the natives can persist if the invasive is removed
35	Table 9	Jason Martina	SC	Coverage units? m2?
36	Table 10	Jason Martina	SC	Coverage Units?
20	17	Nathan Bendik	SC	I think this could include more areas of the river (at least), so may need to be more specific that this is areas near springs in the lake and just downstream of the dam. As written, this is somewhat simplistic. I think good quality habitat could also include smaller gravel and free interstitial spaces. For example Eliza Spring would not be considered high quality habitat under this definition but to my knowledge it has the highest documented densities of any central Texas Eurycea.
20	17	Nathan Bendik	SC	The fact that these statements are not supported at all by the primary literature significantly weakens them.
21	8	Nathan Bendik	SC	one st dev below the mean seems like an awfully low bar. Is there any scientific justification for this? How does one decide? Furthermore it is based on a poorly described method of measuring habitat. As we discussed in the subcommittee, we had serious reservations about these methods so I wouldn't base the biological objectives on how habitat was measured in the past. We need to get past the 70's paper and the 1993 unpublished thesis in what we use to base our knowledge on.
22	11	Nathan Bendik	SC	I think it would be more rigorous to take a step back and build an argument from first principles and primary literature rather than this haphazard sampling data. For example, it might read something like this: "Studies x, y, and z have shown densities of central Texas Eurycea salamanders from r to s; in habitats with characteristics a,b and c, these densities are highest (citations). Studies have estimated populations sizes for these species at these densities at the surface that range from j to k. Comparing our haphazard count data to these studies, we think we could achieve similar population sizes and densities if we maintain H amount of habitat.... Therefore, we strive to maintain this baseline of available quality habitat based on characteristics a, b, and c....etc."
22	2	Nathan Bendik	SC	a key component of having good habitat relates to flow to the springs, so you should conceptually combine those ideas here. Good flow, good habitat we should expect salamander occupancy to improve, so that could be part of the metric. So maintaining habitat is a good objective, but it should be bolstered by the other factors (maintaining flow and demonstrating that good quality habitat has salamanders in it). If flow goes down we may not expect "high quality habitat" either to be present or to matter (depending on how you define it). So establishing how flow, habitat and salamander occupancy/abundance are related is important. Building upon that, how management actions influence each of those things. Then you will have a more complete picture of how this system works, how your interventions are helping and how the species is responding.
22	11	Nathan Bendik	SC	I think the rock size and habitat structure could be better than what this document calls "high quality" habitat. The argument for it being high quality is not well supported. It may be high quality, but no one went through the effort to demonstrate in a scientific manner as to why.
23	1	Nathan Bendik	SC	I think what I would like to see is a commitment to understanding how management influences salamander occupancy or abundance. Thats how we will know if the objectives ultimately are worthwhile. You can then tie those actions to improving habitat. For example, see if salamander habitat can be expanded beyond your "core" areas via intervention. Demonstrate it is effective and keep doing it. Otherwise, you'll need to change it. So it would be tying the science to the management - via adaptive management. To do that well, we need to measure high quality habitat, we need to measure salamander's response to that, and we need to measure or track our management efforts.
21	2	Nathan Bendik	SC	Riffle beetle plot out of place in the middle of salamander section
4	Line 7-10	Virginia Parker	SMRF (SH)	SMRF would like to see more specificity around Goal #7. There needs to be a plan for land conservation over the recharge zone in order to protect quantity of recharge, as well as the riparian zone for water quality purposes. There also needs to be a plan for recreational disturbances during extremely low flows.
4	Line 19-20, 25-26	Virginia Parker	SMRF (SH)	We need to be able to decipher between the springflow contribution and stormwater runoff contribution at the San Marcos River gauge. How does gauge #08170500 do this? There needs to be a plan to separate the 2 sources.
4	Line 25-26	Virginia Parker	SMRF (SH)	A possible 3rd objective for springflow: Modeling to see what happens to cfs in a drought of record
7	Line 25-27	Virginia Parker	SMRF (SH)	The study describing wetted areas in the San Marcos River is dated back to 2009, and the area has changed over time. There needs to be new modeling done to determine any changes in the river channel and wetted areas, especially considering the risk of future drought, changes in vegetation, and recreational patterns, especially in low flow periods.
9	Line 22-25	Virginia Parker	SMRF (SH)	A mean monthly discharge of 60 cfs for at least 11 months of the calendar year is entirely too low. 60 cfs should be the low for no more than ONE month, as we have recently experienced, and a range of 80-120 cfs should be applied to 11 months, dependent upon circumstances. A large flood event could skew the mean severely, which begs the question of whether or not median numbers should also be referenced.
9	Line 22-25	Virginia Parker	SMRF (SH)	There needs to be mention of the impacts of high flows as well as low flows.
10	Line 20-22	Virginia Parker	SMRF (SH)	SMRF is very concerned with only looking at the 3 year rolling average. There needs to be a 10 year average goal as well. We should not only manage to the minimum, in order to have a long-term healthy system.
11	Line 19-22	Virginia Parker	SMRF (SH)	There needs to be more water quality monitoring other than just temperature, if for no other reason than to look for and understand increasing trends, and to be able to respond to any increasing trends appropriately.
12	Line 35-39	Virginia Parker	SMRF (SH)	Maintaining mean daily water temperature for more than 50% of the year for the Comal does not seem protective. This means that the entire summer could be significantly higher and still meet the objective.
12	Line 40-44	Virginia Parker	SMRF (SH)	Maintaining mean daily water temperature for more than 50% of the year for the San Marcos River does not seem protective. This means that the entire summer could be significantly higher and still meet the objective. In addition, the upper river and middle river need to be more clearly defined. There should also be an objective for temperature max for the lower river as well.
19	Line 17-23	Virginia Parker	SMRF (SH)	Including the standard deviation in the goal for the Riffle Beetle does not seem protective and should possibly be removed from the objective.
19	Line 5-6	Virginia Parker	SMRF (SH)	The Hotel area should be included as a sampling location.
26	Line 7-10	Virginia Parker	SMRF (SH)	In addition to persistent strands, there needs to be an objective for large contiguous emergent flowering strands, particularly 1) between Sewell and City Park and 2) Bicentennial Park
30	Line 3-8	Virginia Parker	SMRF (SH)	Include genetic monitoring of the species to set up an adaptive management plan for the future.
42	Line 15-17	Virginia Parker	SMRF (SH)	This needs to be much more specific through objectives. Lots of opportunity here. One objective needs to be included related to SMARC, continued data on the genetics of the different species, and set adaptive management plan based on the results.

40	Line 15-18	Virginia Parker	SMRF (SH)	30-45 cfs for the Comal Springs does not seem protective of the Riffle Beetle.
40	Line 19-23	Virginia Parker	SMRF (SH)	A mean monthly discharge of 60 cfs for at least 11 months of the calendar year is entirely too low. 60 cfs should be the low for no more than ONE month, as we have recently experienced, and a range of 80-120 cfs should be applied to 11 months, dependent upon circumstances. A large flood event could skew the mean severely, which begs the question of whether or not median numbers should also be referenced.
40	Line 24-27	Virginia Parker	SMRF (SH)	SMRF is concerned with only looking at the 3 year rolling average. There needs to be a 10 year average goal as well. We should not only manage to the minimum, in order to have a long-term healthy system.
40	Line 28-37	Virginia Parker	SMRF (SH)	There needs to be more water quality monitoring parameters other than just temperature, if for no other reason than to look for and understand increasing trends, and to be able to respond to any increasing trends appropriately.
40	Line 26-27	Virginia Parker	SMRF (SH)	A 3 year rolling average above 138cfs may be protective as long as springflow can be differentiated against urban stormwater runoff
40	Line 15-23	Virginia Parker	SMRF (SH)	Should median flow goals be assessed as well as mean? This may be more protective against extereme floods skewing the numbers
40	Line 28-37	Virginia Parker	SMRF (SH)	There needs to be an objective for protecting the watershed for water quality protection. (Also, could be included in Goal #7)
40	Line 28-32	Virginia Parker	SMRF (SH)	25 degrees C seems too high in the Comal for a protective target, especially if it is only the target for at least 50% of the year, which would allow the summer months to be much higher.
40	Line 33-37	Virginia Parker	SMRF (SH)	25 degrees C seems too high in the San Marcos River for a protective target, especially if it is only the target for at least 50% of the year, which would allow the summer months to be much higher.
41	Line 3-7	Virginia Parker	SMRF (SH)	2.4 seems too low. This is a significant difference from the current plan. There also needs to be a genetic data component added to the objective.
41	Line 10-13	Virginia Parker	SMRF (SH)	There needs to be a genetic component added to the objective.
41	Line 14-4	Virginia Parker	SMRF (SH)	There needs to be a 3rd objective added related to large contiguous strands in the river to ensure protection of seed production and protection.
6	Line 12-14	Virginia Parker	SMRF (SH)	The calculations do not include the drought of record. Should this be taken into account somehow?
10	Line -5	Virginia Parker	SMRF (SH)	The calculations do not include the drought of record. Should this be taken into account somehow?
39	Line 8-14	Virginia Parker	SMRF (SH)	There needs to be a clearly defined system-wide approach to SAV management for fountain darters.
11	Line 15-17	Virginia Parker	SMRF (SH)	Impervious cover very near the headwaters and river is also an important factor with regards to water quality. SMRF would like to see something stated that "X" amount of pervious cover will be conserved within "Y" buffer of the river and springs for both systems.
22	Line 7-10	Virginia Parker	SMRF (SH)	SMRF would like to see an objective added that some coverage of recreation-free habitat is maintained that is not dependent upon the Condition M criteria to protect the salamanders.
42	Line 12-14	Virginia Parker	SMRF (SH)	SMRF would like to see watershed protection include things like hazardous waste. One objective could be to hold 1-2 events per year in each springs community.
3	line 3	Kimberley Meitzen	TXST (IC-SH)	It would be good to include recognition of feedback/comments from the three committees (Implementing, Stakeholder, Science), public, etc., or any others that are providing feedback, and how those comments were addressed.
4	line 4	Kimberley Meitzen	TXST (IC-SH)	Would be very helpful to provide a map of the SM system with names used for the reaches referred to throughout the biological objectives. There were occasionally different names used for overlapping areas (Headwaters and Spring Lake Dam) and occasional inconsistent use of names for reaches (Upper vs. Middle, no mention of Lower?). A very clear map of polygons, or boundaries to reference the geographic locations mentioned in the document would be very helpful. Figure 8 used for water quality objective 1.6 demonstrates this and could be improved. in the text Headwaters, Upper, and Middle river are used, in other places all of this area is referred to as "Upper " river.
4	line 18-24	Kimberley Meitzen	TXST (IC-SH)	Suggest mentioning diff between San Marcos Spring gage and San Marcos River discharge gage and how each is used for the objectives.
6	line 1-2	Kimberley Meitzen	TXST (IC-SH)	Need more clarity on gages and objectives 1.2 and 1.4
7	line 21-23	Kimberley Meitzen	TXST (IC-SH)	Needs more clarity on the data used.
7	line 30	Kimberley Meitzen	TXST (IC-SH)	Modeled wetted area for SAV and salamander habitat was conducted almost 15 years ago. This has likely changed, and It would be valuable to have an updated wetted habitat mapping. This also needs to take into account what we now know about % area lost to recreation impacts during low flow conditions.
9	line 15-20	Kimberley Meitzen	TXST (IC-SH)	Was this observation before or after the modifications of the western spillway boards at Spring Lake to move more flow to the Eastern Spillway? Do salamanders have stress-induced lag effects from prolonged low flows? These observations seem too isolated to make an assessment low flow response.
9	line 22-25	Kimberley Meitzen	TXST (IC-SH)	Why 11 months? And why calendar months? Why not a sequential period of 11 mos., regardless of calendar year? With this you could have a consecutive period of up to 22 months at 60 cfs in back to back calendar years. 45 cfs per day average is too low. There is no evidence the system would be "healthy" and resilient under these low flow conditions.
9	line 26-27	Kimberley Meitzen	TXST (IC-SH)	Is this from the 2009 model? May not be accurate currently. Does not take into account habitat lost to recreation impacts.
9	line 14	Kimberley Meitzen	TXST (IC-SH)	Suggest word choice revision for water 'issues', although issues is a technically correct verb to use, it is not commonly used to describe spring flow, suggest replacing with flows, discharges, emerges, emanates...
11	line 3-4	Kimberley Meitzen	TXST (IC-SH)	Why not use the full available period of record? Or constrain both to the shortest of those i.e. 1996 - present. Why use calendar year and not hydrologic water year? Please justify use of 'average' instead of 'median' values. If means are used - are high, urban runoff flows teased out of the calculations? They can skew the average - hence preference for median values.
10	1	Kimberley Meitzen	TXST (IC-SH)	In addition to the three-year rolling average I suggest a longer term goal for both Comal and San Marcos - maybe 10 year rolling average? Something to align more with the longer permit and room for adaptive management with climate change realizations down the road. What would that look like?
11	line 13	Kimberley Meitzen	TXST (IC-SH)	I'm glad temperature is included, but I am wondering if there is away to include other water quality parameters that get at watershed condition and high-intensity recreation, like turbidity or e-coli ? Maybe that can be addressed in Goal 7.
19	line 1	Kimberley Meitzen	TXST (IC-SH)	Recommend adding an objective for CSRB in SM System/Spring Lake/Hotel Reach, even if just maintaining habitat and monitoring for presence.
19	1	Kimberley Meitzen	TXST (IC-SH)	Recommend language to enable testing new sampling/surveying techniques and flexibility in evaluating population numbers during such a process to determine best techniques and methods to be using.
22	line 11-14	Kimberley Meitzen	TXST (IC-SH)	Recommendation to include more sites in addition to Diversion Springs, and make this a stated objective.
22	line 8	Kimberley Meitzen	TXST (IC-SH)	Provide more clarity on the 14m2 area at Spring Lake Dam, all one big patch, or total area of a few small patches? Just in the reach downstream of Eastern Spillway?
23	line 31-33	Kimberley Meitzen	TXST (IC-SH)	Could there be a biological objective to maintain X area of recreation free salamander habitat in the Spring Lake Dam Reach? I'm trying to figure out a way to provide protection from recreation when the river is not in Condition M with SSA exclusions.
26	line 7-8	Kimberley Meitzen	TXST (IC-SH)	Clarify geography of 'upper' San Marcos to be consistent with use throughout the document.
26	line 9-15	Kimberley Meitzen	TXST (IC-SH)	Recommend adding language in Objective 5.2 or as a new Objective 5.3 that focuses on maintaining at least 2-3 large*, contiguous Texas wild-rice stands with emergent, flowering capability to support seed production, with one of those locations including a stand between Sewell and City Park. *May need to quantify large in terms of square meters.
27	line 115	Kimberley Meitzen	TXST (IC-SH)	What does the long term data reveal for coverage below I-35 compared the recent restoration work conducted through SARP? Very little TWR restoration work has been conducted here compared to other areas maintained through the HCP and I think the potential for more coverage is there. I would suggest increasing this lower river TWR coverage value and then increasing the overall system value, even if just by 500 m2 .
26	Table 5	Kimberley Meitzen	TXST (IC-SH)	Can you create a table or figure showing the percent coverage of TWR for each of these reaches over the 2013-2022 time frame and if possible incorporate the 2023 spatial data?

36	line 10, Figure 18	Kimberley Meitzen	TXST (IC-SH)	I think it is good to maintain the consistency of using the LTBG reaches, but given the 30 year permit- it may be a good idea to provide an objective to add new reaches, or be more flexible with the spatial area of the LTBG reach - for example adding an upstream or downstream buffer based on different system stressors, for example recreation in the City Park reach can have a big effect on the upstream portion of that reach and as shown in Figure 18 and 19 this reduces the complex and simple SAV coverage.
34	Table 8	Kimberley Meitzen	TXST (IC-SH)	Add bryophyte to San Marcos list, include Heteranthera for San Marcos list (not sure if it should be complex or simple), provide a place holder for another regionally native veg type that may be added to the system in the future.
36-37	line 10 (Page 36) - line 3 (page 37)	Kimberley Meitzen	TXST (IC-SH)	It may be beneficial to approach this from more of a system-wide approach instead of by the LTBG reaches. Would it be possible to quantify areal coverage for longer river segments similar to the TWR objectives?
42	lines 12-17	Kimberley Meitzen	TXST (IC-SH)	Would appreciate more clarity on when and how these will be incorporated. These objectives may be an opportunity to include objectives for species genetic studies, refugia being maintained at SMARC, ensuring watershed water quality mitigation parameters are considered like an objective for one annual household hazards waste events (e.g., Objective for one household hazardous waste collection event per year (or every other year) that includes EAHCP community outreach). etc...
Overall	general concerns/comments	Kimberley Meitzen	TXST (IC-SH)	Concerned there is not enough justification for using one standard deviation below the mean for the species population targets, and a general concern there are a lot of objectives focused toward minimums.
Overall	general concerns/comments	Kimberley Meitzen	TXST (IC-SH)	Should there be any objectives for species genetics?
Overall	general concerns/comments	Kimberley Meitzen	TXST (IC-SH)	Should there be objectives for maintaining recreation-free habitat other than SSA areas protected by Condition M?
Overall	general concerns/comments	Kimberley Meitzen	TXST (IC-SH)	I think it would be beneficial to have more system wide objectives - for example instead of just focusing the fountain darter biomonitoring to the LTBG reaches - can there be an inter-annual objective to sample the full longitudinal extent of the river from Spring Lake to Blanco confluence? I also recommend system-wide objectives for SAV instead of just LTBG reaches.
Overall	general concerns/comments	Kimberley Meitzen	TXST (IC-SH)	Would like to see some form of science committee review of the objectives.
Overall	general concerns/comments	Kimberley Meitzen	TXST (IC-SH)	Would like to see all the raw data used in the formulation of the objectives available for use.
26	Table 5; Lines 11-15	Chris Hathcock	USFWS (TWR)	Segments A and B are arguably the most important segments for resiliency of the species since they contain the most important flowering stands and make up 75% of the total population. Based on the annual rice survey data over the past 10 years, minimum goals of 360 sq. meters for Segment A and 4,200 sq. meters for Segment B correspond to each segment's coverage before 2011 and before 2014, respectively (i.e., before restoration of these segments through the original HCP). For persistence of the species, I recommend that future goals build upon and/or at least preserve areas of wild-rice achieved through successful efforts of the 2013 HCP. Additionally, based on 2017-2021 annual Texas wild-rice surveys, there are currently at least 2,400 sq. m and 8,500 sq. m of potential Texas wild-rice habitat in Segments A and B, respectively. Given changing river conditions in future years, but also recognizing the priority that should be given to these segments compared to those farther downstream, I recommend minimum areal coverages of at least 1,200 sq. m for Segment A and 7,000 sq. m for Segment B. In my opinion, these minimum coverages would allow for 1) successful production and dispersal of seed to downstream segments to achieve self-sustainability and resiliency in the natural population, and 2) maintenance of an ex situ seed bank by USFWS. The species' seeds are viable in refrigerated storage for only 4-6 months, so must be collected on a regular seasonal basis at least 3-4 times each year. There are currently no other river segments from which viable seed of the species can be reliably collected.
24	lines 37-40	Chris Hathcock	USFWS (TWR)	There have been no catastrophic events on the river since 2016 to test whether the population would be self-sustainable over the long term. The current drought may be considered a catastrophic event but its effects are currently on-going. Although low water levels allow expansion of rice into mid-stream channels previously too deep to support wild-rice, and although wild-rice is capable of dispersing to shallow-water areas more successfully than other submerged aquatic vegetation, extended drought will probably result in a net-decrease of wild-rice long-term. In fact, BioWest recently reported current areal cover of wild-rice to be around 8,000 sq. meters (i.e., about half that than reported earlier in year). This highlights the extreme variability in wild-rice coverage within a given time period. In fact, overall aquatic plant community cover/sp. diversity/sp. distribution within any stream system is highly dynamic. Therefore, degree of self-sustainability and minimum coverage requirements cannot be understood based on short-term (i.e., over 1 to a few years) observations.
24	34-37	Chris Hathcock	USFWS (TWR)	It seems that the objective of 8,000 sq. m was determined first, and then segment numbers were devised to add up to this total. As I stated above, Spring Lake Dam and Sewell Park to Hopkins are the most important segments in preventing species extinction and can support nearly 11,000 sq. m of wild-rice combined. The minimum coverages denoted in Table 5 for these segments, however, do not reflect this nor protect any of the gains in wild-rice coverage achieved in the current HCP. The proposed minimum coverages also do not take advantage of the greater conservation value of certain areas and segments over others. Instead, I think it is important to recognize total available habitat in each segment and the importance of each segment to long-term resiliency, self-sustainability, redundancy, etc. As previously stated, Segments A (Spring Lake Dam) and B (Sewell Park to Hopkins) contribute most to prevention of extinction because they are in the most ideal habitat, support the largest contiguous stand (i.e., stands most capable of pollination since more plants are in close proximity and in different stages of flowering), and are most capable of promoting self-sustainability because their seeds disperse to the greatest area of potential germination sites downstream. Additionally, available habitat for the species, based on annual rice surveys by both USFWS and Biowest, has been consistently over at least 14,650 sq. m over the past 10 years. Starting with total available habitat per segment seems like a reasonable springboard for devising a minimum coverage goal per segment. I think a total system coverage of at least 11,600 sq. m is appropriate given species needs and total available habitat. Making the most of this available habitat would involve prioritizing certain large stands (e.g., currently those in Segments A and B) as "Species Resiliency/Seed-Bank Stands" and others (e.g., Downstream of I-35) as "Redundancy Stands". Resiliency/Seed-Bank Stands would require more active protection from recreation, floating vegetation mats, etc.; however, Redundancy Stands are largely vegetative (non-emergent and non-flowering) and more protected naturally because they are submerged in deeper water away from recreational and other impacts. In my opinion, separating and prioritizing in this way would allow the most efficient use of resources to achieve species preservation over the next 30 years.
7	9-12	Nathan Pence	GBRA (IC-SH)	While the minimum springflow of 30 cfs remains unchanged from the current EAHCP, the 45 cfs goal for 11 months is not fully vetted. The current EAHCP allows for the 30 cfs so long as it does not exceed 6 months in duration and calls for that to be followed by a minimum of 80 cfs for 3 months. It is important to note that the 80 cfs pulse represented an opportunity to allow for Fountain Darter reproduction during a repeat of the Drought of Record in the Comal system and was also intended to ensure Spring Run 3 connectivity to the system is not lost for greater than 6 months. This timeframe is about equivalent to the life span of a riffle beetle, so the flow objective and timeframe was intended to ensure no generations of riffle beetles would be lost. Without this pulse, what is the plan to allow for Fountain Darter reproduction and riffle beetle connectivity and reproduction during a repeat of the Drought of Record?

9	22-25	Nathan Pence	GBRA (IC-SH)	While the minimum springflow of 45 cfs remains unchanged from the current EAHCP, the 60 cfs goal for 11 months is not fully vetted. The current EAHCP allows for the 45 cfs so long as it does not exceed 6 months in duration and calls for that to be followed by a minimum of 80 cfs for 3 months. There is insufficient information provided to understand how this metric would impact actual pumpage, CPM curtailment, and springflows through a repeat of the drought of record, as compared to the current EAHCP.
10	3	Nathan Pence	GBRA (IC-SH)	The 2001-2022 monitoring period does not include the drought of record, and contains a single severe drought period (that wasn't of such duration as the drought of record). The lack of a significant drought doesn't reflect conditions present during a repeat of the drought of record. There is insufficient information provided to understand how this metric compares to the current EAHCP.
10	3	Nathan Pence	GBRA (IC-SH)	Springflows during this 2001-2022 period were managed during certain periods, partially by pre-HCP EAA Critical Period Management rules and then later in the period with the current EAHCP mitigation strategies and conservation measures in place. Such springflow management doesn't allow for a true representation of flow/species analysis. There is insufficient information provided to understand how this metric compares to the current EAHCP.
11	1-2	Nathan Pence	GBRA (IC-SH)	The lowering of the long-term average from 225 cfs to 187 cfs will undoubtedly have impacts on springflow through drought periods, and presumably would drive springflows to minimums more often and for longer periods. This is a concern on many fronts, including water quality and species survival. Additionally, the use of USGS gage #08169000 includes local runoff. In a drought period there may be small local events that contribute to this gaged flow, thus skewing the springflow calculation under this objective. There is insufficient information provided to understand how this metric would impact actual pumpage, CPM curtailment, and springflows through a repeat of the drought of record, as compared to the current EAHCP.
11	3-4	Nathan Pence	GBRA (IC-SH)	The lowering of the long-term average from 140 cfs to 138 cfs may have impacts on springflow through drought periods, and presumably would drive springflows to minimums more often and for longer periods. This is a concern on many fronts, including water quality and species survival. Additionally, the use of USGS gage #08170500 includes local runoff. In a drought period there may be small local events that contribute to this gaged flow, thus skewing the springflow calculation under this objective. There is insufficient information provided to understand how this metric would impact actual pumpage, CPM curtailment, and springflows through a repeat of the drought of record, as compared to the current EAHCP.
12	35-44	Nathan Pence	GBRA (IC-SH)	The thermal requirement (EAHCP objective) of 25 and 27 degrees in the Comal system for 50 percent of the time are a significant deviation from previous thermal objectives that were minimums. The purpose of these thermal requirements were not only related to survivability of species, but also to protect reproduction. Allowing water temps to fall below previously defined thresholds 50 percent of the time without any justification or discussion on the subject is contrary to the processes that made the EAHCP a success.
12	35-44	Nathan Pence	GBRA (IC-SH)	While these objectives are questionable biologically, it is also unclear how these practically get implemented in the management of pumpage during drought periods. As such, these objectives present as goals without any mechanism to control aquifer management to meet such goals.
19	17-23	Nathan Pence	GBRA (IC-SH)	The abundance-based objectives for CSRB derived from mean minus the standard deviation are questionable. There is no indication or justification that this level of abundance is adequate to indicate a healthy reproducing, resilient population of CSRB, especially under the newly proposed thermal and springflow objectives, which would conceivably allow the springs to flow at lower levels for longer periods of time and attain temperatures higher than those previously identified as protective under the current HCP.
22	7-11	Nathan Pence	GBRA (IC-SH)	The biological objectives proposed are not consistent with those proposed by the Salamander Biological Objectives subcommittee and they should include some sort of numeric criteria based on sound surveying protocols. Historic presence/absence data is used to justify using only maintenance of high quality habitat, but the methods behind this abundance data is not discussed. By only requiring the maintenance of "high quality habitat", significant observation of salamander presence/absence is lost.
30	3-8	Nathan Pence	GBRA (IC-SH)	The abundance-based objectives for Fountain Darter derived from mean minus the standard deviation are questionable. There is no indication or justification that this level of abundance is adequate to indicate a healthy reproducing, resilient population of Fountain Darter, especially under the newly proposed thermal and springflow objectives, which would conceivably allow the springs to flow at lower levels for longer periods of time and attain temperatures higher than those previously identified as protective under the current HCP.
40-44	N/A	Nathan Pence	GBRA (IC-SH)	This contains the summary of the TM, reiterating the objectives commented upon above. Similar comments apply here as well.
Overall	N/A	Nathan Pence	GBRA (IC-SH)	The modeling performed during the development of the current EAHCP included assumptions regarding full pumping of permits (subject to Critical Period Management) for the entire ~572k AF/yr of permits. The analyses performed here do not reflect a condition in which the resulting springflow that would reflect a full permitted pumpage scenario. In fact, it is likely that year-to-year pumpage for the 2001-2022 period evaluated varied significantly. Shouldn't such analysis be adjusted to account for the potential under-pumpage experienced in the aquifer during this period as compared to a full permitted pumpage scenario?
Overall		Donelle Robinson	USFWS	**Biological Goals**-We liked the biological goals and think that they consider the species needs well. We have a few minor comments with regard to wording-Goals 4-6 specify the locations to conserve. It would be helpful if Goals 2 and 3 can also be worded this way (e.g., subsurface habitat, spring habitat).
Overall		Donelle Robinson	USFWS	**Biological Objectives General**-Overall, it is difficult for us to tease apart the Biological Objectives from the rest of the HCP because the effects are occurring in the same areas as the Biological Objectives and Conservation Measures, but we do not have that other information yet to fully understand the effects to the species. When reading Biological Objectives for specific areas, we had a hard time understanding what would occur in other areas. As mentioned at the meeting, we believe that management and monitoring should be a systemwide approach, and it would make more sense to have systemwide objectives. For example, we don't fully understand the status of fountain darters outside of representative reaches, San Marcos salamanders outside of proposed management areas, Comal Springs riffle beetles in the San Marcos system, and Texas blind salamanders in caves and wells managed by the Permittees. We believe that this HCP should be geared toward a robust adaptive management program based on the monitoring and results.
Overall		Donelle Robinson	USFWS	**Biological Objectives Organization**-We would recommend starting with each Biological Objective then following it with the rationale. Currently the objectives have information before and after them and the organization was difficult for reading them. Using additional subsection headers may also help organize the information.
		Donelle Robinson	USFWS	**SMART Objectives and Issuance Criteria**-We appreciate the effort involved in ensuring that the objectives are measurable and achievable. However, we need more information that the objectives are based on biological needs for permit issuance criteria (discussed in 9.2.1 under Achievable in the HCP handbook, and the Issuance Criteria (14.3.2 and 16.1.3 HCP handbook and ESA section 10(a)(2)(B); 50 CFR 17.22(b)(2), 17.32(b)(2), and 50 CFR 222.307(c)(2)]). This includes considering whether the conservation is adequate to avoid precluding recovery of the species and to avoid adversely modifying critical habitat. We need additional information for this with regards to the springflow and habitat objectives.

		Donelle Robinson	USFWS	**Springflow Objectives and Effects**-To fully understand the springflow objectives, we will need to be able to tease apart how the pumping effects the springflows. The figures below (from the Barton Springs Edwards Aquifer Conservation District HCP) are good examples of how to show this {***see reference photos in Sheet 2*** } . We also will need the climate change analyses to understand how the frequency of different flow rates may change. Please note that consideration of springflows for species needs should also consider habitat conditions that are interrelated with springflows, such as lower DO, increased sedimentation, and increased effects of recreation, unless there are other ways to mitigate for the interrelated effects.
		Donelle Robinson	USFWS	**Water Quality Objectives**-We agree with the temperature objective. Based on our discussion, we understand that DO monitoring will continue but will not have an associated objective because springflows are the primary factor that can be controlled for DO. Please explain why it's not an objective in the HCP.
		Donelle Robinson	USFWS	**Habitat Objectives**- As discussed when we met, we do not think that the objectives for normal conditions should be based on the worst-case scenarios. We suggest considering extreme conditions such as drought of record and scouring floods separately.
		Donelle Robinson	USFWS	**Using Counts or Densities as Objectives**-We are not sure that it makes sense to use specific numbers as biological objectives since it is not entirely in the control of the HCP. The habitat, springflow, and water quality that can be controlled make more sense to focus on and ensuring that the habitat is suitable enough that the species continue to persist throughout it.
		Donelle Robinson	USFWS	**Other Comments**- Please note that we will likely have additional comments after the major comments from above are addressed, but we do not think it makes sense to address items at this time that may change.
		Donelle Robinson	USFWS	**Other Species**-We understand that other species are still under evaluation for coverage, and these species would need Biological Goals and Objectives if it is determined that these species need to be covered by the HCP because take will occur as a result of the Covered Activities.
		Donelle Robinson	USFWS	**Other Factors**-Based on our discussion, we understand that recreation, captive refugia, and parasite or disease control will be covered in the conservation measures. We believe that these are important to address but do not necessarily need to be their own Biological Objectives.
		Donelle Robinson	USFWS	**Monitoring**-Based on our discussion, we understand that monitoring will be addressed in a separate section. We should set up another meeting on the monitoring approach and the data needed for compliance monitoring. We would also like to have a discussion to better understand the methodology for the fountain darters for this evaluation and suggest having a meeting for that. We want to emphasize that monitoring needs for the Biological Objectives may not cover all of the compliance monitoring needed to evaluate take for the HCP, and a systemwide approach will be needed for this. We are also concerned that current monitoring does not adequately capture the total population or total habitat for the animal species, which is important for understanding take. Both monitoring for take and for the biological objectives will need to be included in the HCP. For example, recreational take of fountain darter habitat has occurred in areas outside of the representative reaches but is not directly monitored, so it is difficult to assess what take, if any, occurred. Similarly, San Marcos salamander habitat is not fully monitored, but all of the habitat may be directly affected by sedimentation due to low flow conditions in Spring Lake. We also would like to encourage an approach that fulfills monitoring requirements but would allow for flexibility in the 30-year permit term in case monitoring needs change. An example of this flexibility is in the language below from the Barton Springs Pool HCP: *6.1.7.1 The City will monitor salamander populations and habitat. Salamander population surveys will be conducted at perennial Parthenia, Eliza, and Old Mill springs and at intermittent Upper Barton Spring when flowing at least bimonthly throughout the year or other interval sufficient to determine the status of the species and population dynamics as deemed appropriate by a City salamander biologist and approved by the Service. The City will develop and maintain a written monitoring plan. The City will ensure that all people surveying for salamanders are properly trained. Surveys can include methods to elucidate life history characteristics of both species. Methods will* *be evaluated by the Service and conducted under the terms and conditions of a valid federal Endangered Species Act 10(a)(1)(A) scientific permit issued to the City.* *6.5.4 Wild Population Monitoring* *The overall goal of population monitoring is to collect data from which the status of the species can be inferred. Measurement of salamander abundance in each spring site is one method for inferring population size and long-term trends in population growth. The Plan proposes to conduct bi-monthly census surveys of salamander populations and use time-series statistical methods to evaluate trends in population size and factors that covary with salamander abundance. Additional data collected on salamander size and age category are used to test for recruitment using common parametric and non-parametric statistical methods. Additional research that contributes to an understanding of factors influencing survival, reproduction, and recruitment in wild populations of E. sosorum and E. waterlooensis would be positive contributions to predicting the fate of populations. A better understanding of genetic variation in protected species and mean evolutionary fitness of populations as well as of individuals, phenotypes, and genotypes would provide baselines upon which to assess probabilities of species persistence. Assessments of population response to natural and artificial selection would provide a basis for evaluating the long-term fate of protected species in the wild. All of these research avenues may require experimental designs other than the bi-monthly abundance estimates proposed. Therefore, the proposed survey frequency should be modified based on monitoring plans approved by the Service.*
2	35-40	Robert Mace	TXST (IC-SH)	Who was on the Biologic Objectives Subcommittee, and where are their recommendations? The web page for this effort does not include membership or the recommendations. Consider amending the web page and/or including the recommendations as an attachment to this memo. Should also include information on membership of the three species groups. How was governance handled on these committees? Did all members sign off on the recommendations? Do the subcommittees fully endorse this memo?
3	12-13	Robert Mace	TXST (IC-SH)	No feedback with subcomittees and comittees on USFWS comments? Suggest adding a feedback loop with the subcommittees and committee on this.
4	25-26	Robert Mace	TXST (IC-SH)	"We" is used here, which suggests the authors of the memo. Are these recommendations from the authors of the memo or the subcommittee?
6	9-10	Robert Mace	TXST (IC-SH)	Suggest clarifying here that the low-flow objective is daily.
7, 9	Objectives 1.1 and 1.2	Robert Mace	TXST (IC-SH)	These objectives are not protective of the species or the systems. As written, they are solely focused on minimum flows whcih is not enough to support a healthy ecosystem. Accordingly, the recommendations act as an objective function through which groundwater production can (or will?) be optmized to producng an outcome of the lowest flows mentioned.
7, 9	Objectives 1.1 and 1.2	Robert Mace	TXST (IC-SH)	These objectives are substantial changes from the current numbers. As the chair of the Science Committee for the current HCP, there was a great deal of heated discussion and negotiation to arrive at the numbers the committee recommended. Changes in these numbers should be accompanied by a rigorous discussion of evidence supporting the changes including a review by the Science Committee.
11	Objectives 1.3 and 1.4	Robert Mace	TXST (IC-SH)	Odd that the low flows are based on system flows and not spring flows. This is a change from the current standard with no discussion of the reason for the change. Uncomfortable with this change since compliance could be achieved with no benefit to springflows.
11	Figure 4	Robert Mace	TXST (IC-SH)	Unclear what the LOESS smooth functions are here for (not discussed in text)--they added confusion. If they are kept, then the caption needs to describe what the black lines are.

		Patrick Shriver	SAWS (IC-SH)	Comment for 4.1.1 - Springs >Though this is a complicated section to quantitatively understand these relate to the species of coverage and represent the modeled targets for springflow protection generally in our current approved ITP and Plan. The 11 month threshold for higher CFS of 45 is beyond current and any contemplated measures (other than mother nature). *Without these specificities the National Academies of Science (NAS) found "flow protection measures will be effective in meeting flow components" of the plan at minimum continuous flows of 30 CFS. However as noted in overarching issues there are catastrophic scenarios (spills, floods, etc.) that have additional considerations. (It is not that I or even SAWS don't recognize this as a good thing, but it is both a stretch based on the covered species, cost effective/justifiable conservation methods, permit duration as it relates to climate assumptions or models and again those maybe 25th percentile flow benchmarks for rivers feel out of scope). I think ok to benchmark ourselves but surely SAWS has shown through diversification and permit management that we are committed.
		Patrick Shriver	SAWS (IC-SH)	Comment for 4.1.2 - Riverine >There are no specific conservation measures that cost effectively can guarantee 3- year rolling averages inserted as the current objectives for Comal River and or San Marcos River. I would suggest either lowering the threshold by half (90 CFS and 70 CFS respectively) or greatly expanding out the time-period of the rolling average (min. 10 years). Or it ought to be difficult to conscribe to this as an objective. An offer of adaptive management if specific science within the scope of the habitats and species of the plan indicates something other this may be changes in variables outside of permitted water management activity. {Recharge?}
Pp. 3 - 4	P.3 line 17 -- p. 4, line 3	Myron Hess	SH Chair	The Biological Goals generally appear to reflect the Goals Subcommittee recommendations and seem to be appropriate.
P.4	Lines 9-10	Myron Hess	SH Chair	It would be helpful to have some elaboration of the anticipated process for establishing the elements of Goal 7. Will specific objectives be developed? If so, what process and timing is anticipated for that development? If not, how will that goal be considered and what process is anticipated for implementing the goal and providing for stakeholder input ?
P. 6	Lines 24-28	Myron Hess	SH Chair	The concept of redundancy, although critically important, has more limited utility in these systems than is often true for other species because all units of the system are dependent on a single aquifer. Because it is not possible to ensure habitat redundancy for these species in the absence of adequate springflow, it is doubly important to develop protective springflow targets.
P. 7	Table 1	Myron Hess	SH Chair	The accuracy of the referenced modeling is critical to evaluation of the proposed springflow discharge objective. It would be helpful to have access to additional explanation of the model and modeling effort.
P. 7	Lines 9-12	Myron Hess	SH Chair	The ordering of the sentences in this objective introduces unnecessary ambiguity. The last sentence appears to be intended only to apply to the first sentence and determination of mean monthly discharge, as it should. However, in its current placement it could be mistakenly interpreted as applying, in some way, to both prior sentences, which would undermine the critical role of the 30 cfs daily minimum criterion. The third sentence should follow immediately after the first sentence to make its limited applicability more clear.
P. 9	Lines 5-7	Myron Hess	SH Chair	Protection of aquatic vegetation, including TWR, is a function of, at minimum, flow protection and recreation management. This statement, and those surrounding it, seem to suggest that flow protection alone would be sufficient to protect the vegetation, which does not seem to be borne out by the history of management under the EAHCP. Based on what has been learned about the impacts of recreation, the failure to acknowledge, in any objective, the importance of recreation management, which must be balanced with reasonable access, appears to be a critical shortcoming that should be addressed. Modeling of aquatic vegetation and flow also is dependent on channel morphology which can change dramatically over time, and has changed since the referenced modeling was undertaken. Given a 30-year permit period, additional dramatic changes are virtually uncertain. Accordingly, a robust adaptive management component that provides for periodic reassessment of key aspects and appropriate adjustments will be needed.
P. 9	Lines 13-15	Myron Hess	SH Chair	This statement seems to be contrary to the frequent acknowledgement in reports and presentations of the importance of mechanical approaches for maintaining high quality salamander habitat, including this document at p. 22, lines 23-25. I had understood, perhaps incorrectly, that vegetation management and fanning of the substrate were relied upon to help reduce sedimentation. In 2023, reduced flow levels, although not sustained at levels as low as 60 cfs, did result in visually obvious reductions in flow velocity. Do we have adequate information to support a conclusion that a sustained flow of 60 cfs, or 45 cfs, is adequate to prevent siltation?
P. 9	Lines 15-20	Myron Hess	SH Chair	This statement may be overbroad. My understanding is that during low flow periods in 2023, flow conditions at Spring Lake Dam, even with flow above 60 cfs, became questionable for maintenance of salamander habitat and that adjustments were made to help redirect a portion of the flow at the dam. It seems that consideration of ongoing assessments and adjustments should be acknowledged and potentially included going forward.
P. 9	Lines 22-25	Myron Hess	SH Chair	The ordering of the sentences in this objective introduces unnecessary ambiguity. The last sentence appears to be intended only to apply to the first sentence and determination of mean monthly discharge, as it should. However, in its current placement it could be mistakenly interpreted as applying, in some way, to both prior sentences, which would undermine the critical role of the 45 cfs daily minimum criterion. The third sentence should follow immediately after the first sentence to make its limited applicability more clear.
P. 9	Lines 31-33	Myron Hess	SH Chair	See comment above (p. 9, lines 5-7) regarding changes in channel morphology.
P. 10	Lines 20-22	Myron Hess	SH Chair	I certainly agree that using a 3-year rolling average is superior to relying only on minimum flow levels. However, using a 3-year rolling average based on a flow level that is 1 standard deviation below the mean dramatically limits the role of that criterion in limiting long-term environmental degradation. Higher flow levels play a critical role in maintaining the health of these spring ecosystems on which the entire wild populations of these species depend. Accordingly, a longer-term flow criterion, such as a 10-year rolling average flow, also should be considered, as should the appropriateness of using 1 standard deviation below the mean as the criterion. I had hoped to review such flow data, but a limitation of time and my technical ability precluded doing that type of review in order to inform these comments. This is not a typical HCP, dealing with only a portion of the habitat for a species, and, consistent with the current HCP, the role of higher flows in maintaining long-term ecosystem health needs more consideration.
P. 11	Lines 1-2	Myron Hess	SH Chair	See comment above (p. 10, lines 20-22) regarding long-term flow criteria.
P. 11	lines 3-4	Myron Hess	SH Chair	See comment above (p. 10, lines 20-22) regarding long-term flow criteria.
P. 12	line 5	Myron Hess	SH Chair	The ≥ (greater than) symbols in this line should be replaced with ≤ (less than) symbols to accurately reflect temperature requirements for the species.
P. 12	lines 35-39	Myron Hess	SH Chair	Strongly support inclusion of temperature objective for Comal System. It is a known critical factor affecting fountain darters and is a criterion for which compliance can be controlled through a combination of flow protection, including flow split management, and riparian vegetation management. The portion of the objective referring to Upper Spring Run, Spring Island, Spring Run 1-3, and Landa Lake is straight-forward but should it be limited solely to habitats near the substrate for Landa Lake? Is the near substrate qualification appropriate for use throughout Landa Lake? Second sentence is both less clear and excessively qualified. It appears likely that the entire sentence is intended to apply only to the Old Channel and, accordingly, it should be clarified accordingly: e.g., by moving "Within the Old Channel" to the beginning of the sentence. Allowing exceedance of 25° C for up to 49.9% of the days in any year, which also means that level of exceedance would be acceptable every year, and in any area not covered by the first sentence, does not appear to be protective and deviates significantly from the current objectives. That approach would effectively eliminate the 25° C criterion for these areas during the hottest six months of every year, when a temperature criterion is most important and when it is likely to be relevant to conditions in the aquatic system. It appears from Figure 6, that such exceedances have been infrequent. That approach would leave only a maximum of 27° C as the temperature criterion for the hottest months in all years in the Old Channel, which is not adequately protective.

P. 12	lines 40-44	Myron Hess	SH Chair	Strongly support inclusion of temperature objective for San Marcos System. It is a known critical factor affecting fountain darters and is a criterion for which compliance can be controlled through a combination of flow protection and riparian vegetation management. The portion of the objective referring to Spring Lake is clear and based on Figure 7 appears very achievable. Is the near substrate qualification appropriate for use at the Spring Lake Dam location? Temperature farther up in the water column at that location will determine temperatures at locations just downstream of the dam. Second sentence is both less clear and excessively qualified. The differentiation would be clearer if the second sentence began with "Within the Headwaters, Upper River, and Middle River, maintain ...." Allowing exceedance of 25° C for up to 49.9% of the days in any year, which also means that level of exceedance would be acceptable every year, and in any area not covered by the first sentence, does not appear to be protective and deviates significantly from the objectives in the current HCP. That approach would effectively eliminate the 25° C criterion for these areas during the hottest six months of every year, when a temperature criterion is most important and when it is likely to be relevant to conditions in the aquatic system. It appears from Figure 7, that such exceedances have been extremely rare. That approach would leave only a maximum of 27° C as the temperature criterion for the hottest months in all years in those reaches, which is not adequately protective.
p. 18	lines 1-8	Myron Hess	SH Chair	Suggest adding an objective to acknowledge the importance of water quality parameters beyond just temperature. Again, that is included in the current HCP. Although it may not be appropriate, at least at this time, to establish specific numerical criteria for additional pollutants, it would be appropriate, particularly with a proposed 30-year permit term, to incorporate an objective providing for the continued monitoring of a suite of such pollutants in order to be able to detect a potentially problematic trend in water quality. The response to such a detection could be to initiate efforts to identify potential sources/causes and potential solutions. It likely would not be realistic to propose, at this time, specific responses beyond such investigation but identification of trends and the investigation of potential causes and solutions has the potential to produce valuable information that could be used outside of the EAHCP or in future iterations of the EAHCP to address an identified threat. Such an objective could be included under this Goal or under Goal 7. Why is there no consideration of retaining a dissolved oxygen criterion?
p. 20	lines 1-5	Myron Hess	SH Chair	The rationale for focusing on three consecutive occurrences <u>within a calendar year</u> is unclear. If three consecutive occurrences is the appropriate criterion, why would it be less concerning if those three occurrences were spread over two calendar years? Unless there is a specific supporting rationale for the calendar year approach, suggest rephrasing to refer to three consecutive occurrences within any 12 month period. It is unclear why 1 standard deviation below the mean is an appropriate criterion. Why is it not appropriate to include a longer-term criterion that is focused on maintaining overall healthy population trends instead of focusing solely on minimum numbers? As suggested above, in relation to flow objectives, strongly encourage adding an objective that considers longer-term population health, which would be more consistent with approach in current HCP. Given the acknowledged importance of redundancy elsewhere in the document, why is the continued presence of CSRB at the hotel area springs in Spring Lake not an important indicator of species well-being that should be included in an objective? Even if existing data are insufficient to support a quantitative criterion, maintaining a population at that location seems appropriate as an objective.
P. 22	lines 7-10	Myron Hess	SH Chair	Again, the rationale for focusing on consecutive sampling events within a calendar year is unclear. Would it not be problematic to have three consecutive sampling events below the criterion if two were in one year and the third in the following year? Does this criterion apply separately for each of the three sites or would it be violated only if all three sites fell below the areal values? Strongly suggest that some criterion for presence of salamanders be added. I recognize that there was concern expressed about count methodology during the subcommittee process, but this species only occurs in this system so the focus should be on more than maintaining habitat.
P. 22	lines 11-15	Myron Hess	SH Chair	The addition of the Diversion Spring area seems appropriate based on the discussion during the subcommittee meetings. In the absence of quantitative data, it is understandable that an specific numerical objective is not proposed. However, a relatively specific plan for adding that area to the objective should be incorporated into the actual language in the objective rather than simply generally referring to its anticipated addition.
P.26	lines 7-15	Myron Hess	SH Chair	Although all are important, not all TWR stands are equally valuable. In particular, it seems important to incorporate into these objectives a focus on maintaining, within key areas, stands that are capable of sexual reproduction in order to help maintain genetic diversity. Many other proposed objectives incorporate a monitoring frequency. Would that be appropriate here?
P. 28	lines 28-30	Myron Hess	SH Chair	Although this is a straight-forward statement of the specifics of the objective, there is no discussion or explanation of why that is an appropriate or adequate objective. The objective would be achieved as long as fountain darter density rose just slightly above that very low level for at least one sampling event in three. At minimum, the addition of a more protective longer-term density level seems appropriate. Again, as mentioned elsewhere, it is unclear why a calendar year is more appropriate for use than a 12-month period. Given rapid advancements in genetics work, consideration also should be given to developing data to allow for incorporation of genetic criteria.
p. 30	lines 1-2	Myron Hess	SH Chair	This introductory language, unlike for many other objectives, does not expressly incorporate the various flow objectives. That likely is an oversight, but, regardless, those flow objectives should be incorporated for Objectives 6.1 and 6.2.
P. 30	lines 3-5	Myron Hess	SH Chair	As noted above, the rationale for use of a calendar year for the criterion is unclear. At least in theory it would allow for 4 consecutive sampling events below the criterion at the end of one year and the beginning of another. The addition of a longer-term density criterion more reflective of healthy populations, than just identifying a minimum, would appear to be appropriate and consistent with the basic approach of the EAHCP. Given rapid advancements in genetics work, consideration also should be given to developing data to allow for incorporation of genetic criteria.
P. 30	lines 6-8	Myron Hess	SH Chair	The comment immediately above is incorporated here by reference.
P. 30	lines 10-12	Myron Hess	SH Chair	Data from 2001--prior to when habitat management efforts commenced--may not be representative of what should be expected with ongoing management of the flow split and vegetation. Figure 16, if I'm reading it correctly, shows increasing densities corresponding with EAHCP implementation. Some acknowledgement of the differences would seem appropriate.
P. 30	lines 12-13	Myron Hess	SH Chair	Although I find Figure 14 difficult to interpret with any precision in terms of number of sampling events, it appears that most occurrences below the proposed criterion occurred prior to implementation of the EAHCP and thus prior to efforts aimed at management of vegetation and recreation. That is true for the three consecutive events occurring in 2001. Figure 16 also appears to be consistent with that interpretation. Accordingly, it is unclear how to interpret those data and some elaboration would be helpful, including clarification of whether data in the table are limited to LTBG reaches.
P. 31	lines 3-4	Myron Hess	SH Chair	It is unclear to me why the number of sampling events shown here is greater for each of the systems than the numbers shown on p. 29 at lines 5-6. Are these separate sampling efforts from those referenced in the intensity discussion?
P. 31	lines 13-14	Myron Hess	SH Chair	This introductory language, unlike for many other objectives, does not expressly incorporate the various flow objectives. That may simply be an oversight, but, unless there is a specific basis for not doing so, those flow objectives should be incorporated for Objectives 6.3 and 6.4.
P. 31	lines 15-16	Myron Hess	SH Chair	Am I correct in interpreting this as indicating that mean annual recruitment in any year should not fall below 25 percent?
P. 31	lines 17-18	Myron Hess	SH Chair	Am I correct in interpreting this as indicating that mean annual recruitment in any year should not fall below 23 percent?
Pp. 36-37	P. 36, line 10 thru p. 37, line 2	Myron Hess	SH Chair	As discussed previously for other objectives, particularly given the large standard deviations, the addition of a longer term average value as a management goal is needed to provide a target for long-term ecosystem health. The reference in line 1 to "within each reach" introduces ambiguity. Would the objective be violated only if the values in <u>each</u> reach were below the applicable minimum total coverage or if the value in <u>any</u> reach were below the minimum total coverage? Presumably, the latter interpretation is intended, but clarification is needed because of the dramatic difference in resulting protection levels.
P. 37	lines 12-16	Myron Hess	SH Chair	It is unclear what specific approach is being suggested, but this concept seems logical. Can you provide further discussion of what is anticipated and how an approach will be developed?
General Comments		Myron Hess	SH Chair	The process of developing goals and objectives is a critical step. Although the BGO memo provides extremely helpful information, the opportunity for group discussion and for posing specific questions has been very limited. As discussed during the December Implementing Committee meeting, a presentation to the Science Committee with the opportunity for that Committee to further discuss these issues and provide input could be valuable and could offer an opportunity for interested stakeholders to gain a better understanding of the rationale for the proposed objectives and of potential options that might improve upon them.

6	12 to 28	Conrad Lamon	SC	Explanation of the data used needs work. On line15 “Data from gage #08168710 are a calculated springs discharge”. If they are calculated values, they are not data in a statistical sense, but predictions, or estimates. If they are estimates, we should be able to determine the formula used to calculate them without regression.
6	19	Conrad Lamon	SC	A better explanation of “each monitoring event at each station”. It is unclear what is being measured and what is being used from the gage. Is the “30 day rolling average” centered on the “monitoring events”? Describe and summarize the data used in text, table and graphical form. For use in a predictive model (later comments), you would want a 30 day period prior to “monitoring event” because you can't predict using a 30 day average centered on today, as only half of the data have been observed. A better explanation is needed to justify the use of a the “rolling average” in lieu of instantaneous measurements.
6	29 to 30	Conrad Lamon	SC	This is quite a mouthful, but not very informative. It leaves many questions unanswered. Show model form (formula), define units for station discharge (and describe the sampling involved in previous paragraph), provide sample sizes by location and most will be answered. Was the Old Channel station taken as a reference station? Model Formula would let us know.
6	32 to 33	Conrad Lamon	SC	Centering and scaling of the predictor is not to approximate a normal distribution. “better”. No distributional assumptions are enforced on the predictor variable in regression. A description of the process used to center and scale the predictor variable would be useful. The order is likely reversed, in that if you rescale, it should be done before centering. Show graphs depicting scaled and unscaled data. Show plot of data to illustrate the effects of rescaling.
6	34 to 35	Conrad Lamon	SC	I am wondering what the performance of the null model would be. Why not provide an anova table (or better yet a graph) so we can see the contributions of each model component? “High accuracy” might be an exaggeration with a 5.04 RMSE, assuming that is in units CFS and not rescaled
6	39	Conrad Lamon	SC	Extrapolation is to be avoided with regression models. This is the reason we should always summarize the data used to fit the models, to avoid their use outside of this range. Use of the historical record could serve to increase the sample size and include observations in the range of interest. the range needed.
7	Table 1	Conrad Lamon	SC	Need to have ability to perform a t test with table 1, so include SE of the estimates. Sample sizes could be included.
8	Figure 2	Conrad Lamon	SC	With each subplots vertical axis rescaled, the slopes all look the same. Use same scale in each panel.
8	Figure 2	Conrad Lamon	SC	Include data on plots of predictions so we see the fit.
8	Figure 2	Conrad Lamon	SC	I was under the impression that the predictor variables were centered, but the appear untransformed in these plots.
8	Figure 2	Conrad Lamon	SC	I am not confident that these are predictions, but maybe just plots of the regression lines with 1 SE error. Prediction intervals are not commonly 1SE. Again, include data and my question is answered.
8	Figure 2	Conrad Lamon	SC	shows only (partial) uncertainty in slope, and therefore it's a CI about the slope, not fitted values. Fitted predictions (or residuals), if they were shown, would also include prediction intervals, which account not only for the uncertainty in slope, but also of observations about that uncertain slope (see, for instance, Fig 2.7, Lawrence C Hamilton, Regression with Graphics, Duxbury, Belmont California, 1992.). So, the 1-alpha CI will be slope estimate +/- t (alpha, df) * (SE). So instead of slope +/- SE it's actually a 50% CI with df=1. Unusual choice.
9	Table 2	Conrad Lamon	SC	Need prediction intervals here, not just +/- SE, Are we afraid they will include zero? We should be, and the probability implied by these models of doing so should be quantified and stated. That makes for better risk assessment.
10	6	Conrad Lamon	SC	should be annual average not average annual. Both in text and on figure 3 caption
10	11 and 12	Conrad Lamon	SC	“both typical and atypical” flows are not evident from the graph. Any dataset will leave the +/- 1SE band, likely about 50% of the time. see comments regarding slope CI. Above, 1SE is only 50% of the distribution.
10	Figure 3	Conrad Lamon	SC	we're losing the important variability, that can dry it out for months, and has twice, none of which shows in Figure 3. It is unclear what is meant to be shown by this figure. By smoothing the annual averages with a three year window (if that is what was done, I'm not sure), we are effectively smoothing twice. show the variability in each of the annual means, or just plot the data...and technically, it's called a moving average, not a rolling average.
11	Figure 4	Conrad Lamon	SC	This and all figures with line graphs need to have points added, to help count years, which is difficult now.
15 and 16	Figure 6 and Fig 7	Conrad Lamon	SC	again we are smoothing a mean (i.e., smoothed) daily water temp. Should we use daily max, if that is the reason we are concerned with temperature?
19	22-23	Conrad Lamon	SC	the explanation for the threshold choice is unclear.
20	26 and 27plus Tables 3,4 6,7,9 and their referring text	Conrad Lamon	SC	This approach is only conservative if the Statistical distribution of Salamanders in Spring Lake is normal (or at least symmetrical) AND stationary. One major point of long term monitoring is determining stationarity. While we may think we see it now, we can't depend on it in future monitoring. In fact. this distribution can be thought of as a statistical distribution, a convolution of many separate distributions describing the number of salamanders found at each location and at at each time of the sampling in Spring Lake (and each substrate and veg cover as well), The best way to keep track of all these factors is a model, to explain the “biases” introduced by including multiple sites, times, etc. A similar exercise to the one outlined here may be taken, using model residuals to determine whether the process is trending based on movement measured by the residual mean (hopefully near zero) and the residual or unexplained variability (smaller than that for the whole sample) providing a more sensitive “alarm”, able to detect smaller changes faster. This comment is offered for all species' objectives so treated (CSRB, Fountain darter density and recruitment) as well as complex/simple SAV coverage and San Marcos Salamander habitat coverage objectives, in that it applies to the methodological approach..
various	Figures 4, 9, 10, 14, 15, 16 17,18 19	Conrad Lamon	SC	All these figures claim to show trends, but trend assessment was not performed in any formal way. These figures do not show trends, but fitted LOESS smooth functions of the data. As such, they will invite a good deal of “bump hunting” from the reader, a purpose for which they are not well suited, due to lack of a “universal” error estimate. For this reason it is a good idea to include the “pointwise” uncertainty estimates associated with the loess estimates on the plots, so the reader does not “see” bumps that are highly uncertain. Edge effects are also a know feature of smoothers, and loess is no exception. Inclusion of uncertainty bounds would show this added uncertainty near the edges, which is often the portion of the graph that holds the most interest to managers. Are these Loess curves with default settings for the window width (span in loess terminology)? The span or window width is the most important feature of non parametric smoothers, and indeed it's adjustment leads to a family of smoothes. Need to justify the choice of span.
33	Fig 16	Conrad Lamon	SC	“Annual trends in mean fountain darter density” should be “ Annual mean fountain darter density”.
33	Fig 17	Conrad Lamon	SC	Caption should read Annual boxplots and violin plots displaying fountain darter total length [millimeters] at the …
21	6 to 8 and Tables 3,4 6,7,9 and their referring text	Conrad Lamon	SC	These are not parameters from a normal distribution. The mean and Sd are sample quantities. The distribution of CSRB abundance is not nearly normal. Mu and sigma are population parameters and are therefore unknown (unknowable by frequentist rules), use our estimates of the true parameters.
29	Table 6	Conrad Lamon	SC	Is this the mean for all stations aggregated together? What if our future samples are in different substrates, vegetation types? Won't the mean be biased?
30	Figure 14	Conrad Lamon	SC	Are these average densities for all Comal sites, substrates, and veg types , averaged by sampling event? See bias comment above.
7	10	Melani Howard	Recreation (SH)	Why was the springflow approach changed from the original HCP and why was it minimized? Sustained low flows are not conducive to healthy habitat. Does this approach help protect the dynamic of springflow? How was the "11 months" derived?
9	5	Melani Howard	Recreation (SH)	Was any model besides Thom Hardy's used? His model is based on 2009 bathymetry data and the river has changed since that date.
11	19-21	Melani Howard	Recreation (SH)	Is this limiting monitoring WQ to just one variable (temperature)? Recommend continuing to monitor the WQ variables that are now monitored. The statement that adequate springflow "should" maintain healthy habitat suggests that it might be important to continue to be aware of a more holistic picture of water quality over time.
12	44	Melani Howard	Recreation (SH)	define the geographic range of Headwater, Upper river, Midddle River - or reference the geographic range
19	4	Melani Howard	Recreation (SH)	Add monitoring of the Hotel reach of the SMR. At least a presence/absence to monitor their existence
22	16	Melani Howard	Recreation (SH)	Add a literature citation for "high quality habitat"
22	29-31	Melani Howard	Recreation (SH)	Is the objective written in such a manner that Conservation Measures can be built to address recreation and sedimentation that are impacting the salamander pop?
26	7-8	Melani Howard	Recreation (SH)	add specific protection for the seed- bearing TWR stands in upper & lower Sewell and Bicentennial

34	12-14	Melani Howard	Recreation (SH)	Remove the addition of Hygrophila as acceptable for the SMR . By 2025, it will be eliminated from reaches above IH35 and continued maintenance of this effort needs to be authorized in the next HCP
36	10-12	Melani Howard	Recreation (SH)	Is this limiting the establishment of SAV to only the LTBG reaches? This was a problem in the old HCP and it was amended to include the Restoration Reaches. We need a sysyem-wide approach. What about establishing Recreation Reaches (low expectations of SAV/TWR) and Restoration Reaches (higher effort to establish SAV)
Overall	Overall	Melani Howard	Recreation (SH)	How will climate change be rolled into the objectives?
Overall	Overall	Melani Howard	Recreation (SH)	Developing watershed land conservation and mgt of recreation during low flows Conservation Measures will need to be based on a Biological Objective. Need to evaluate if the WQ BO is adequate to support these CMs.
Overall	Overall	Melani Howard	Recreation (SH)	The BOs are managing to the minimum. A sustained minimum threshold would not be beneficial to listed species.
Overall	Overall	Melani Howard	Recreation (SH)	Add an objective to continue improving our knowledge of the HCP species. Strive to continuously improve protections for listed species.