Edwards Aquifer Habitat Conservation Plan
Nonroutine Adaptive Management Proposal

All relevant reports, citations, and analysis can be found at www.eahcp.org.

To: **EAHCP Committees**
From: **Nathan Pence, Program Manager**
Date: **September 1, 2016**
Re: **Submerged Aquatic Vegetation Restoration Programs**

Abstract

After four years of implementing Conservation Measures associated with the restoration of submerged aquatic vegetation in the Comal and San Marcos Edwards Aquifer Habitat Conservation Plan (EAHCP) Long-term Biological Goal (LTBG) reaches, unanticipated developments, issues, and challenges associated with the EAHCP restoration programs have been realized by the Spring Communities through their accumulated experience and expertise. In November 2015, the Implementing Committee commissioned a report (SAV Report) to study these issues and recommend possible adaptations to management. This report identified several proposed modifications to the Long-term Biological Goals associated with the fountain darter (*Etheostoma fonticola*) as well as to the management of the flow-split infrastructure in the Old Channel of the Comal River. Having received this report, the EAHCP Program Manager facilitated a stakeholder-driven process to review the SAV Report's recommendations and chart a course for formal Nonroutine Adaptive Management to incorporate the proposed modifications as part of a revised EAHCP program. This document presents (1) an introduction to the issues encountered with the SAV restoration programs in the Comal and San Marcos rivers; (2) a discussion of the analysis and recommendations emerging from the SAV Report commissioned to study these issues; (3) the account of the stakeholder-driven process facilitated by the Program Manager to vet the report recommendations and to develop a consensus-based proposal for Nonroutine Adaptive Management; and (4) the Program Manager's final formal proposal for Nonroutine Adaptive Management, submitted here for consideration by the EAHCP committee review process following the procedure laid out in the Funding and Management Agreement for Nonroutine Adaptive Management.

Introduction

Since its inception in 2013, the Edwards Aquifer Habitat Conservation Plan (EAHCP) has accumulated four years of experience and expertise implementing Conservation Measures involving the restoration of submerged aquatic vegetation (SAV) for the enhancement of fountain darter (*Etheostoma fonticola*) habitat in the Comal and San Marcos river EAHCP Long Term Biological Goal (LTBG) reaches. Given this experience, the EAHCP is now capable, through analysis of data and best professional judgment,

of carrying out an evaluation of these programs, in support of adapting existing goals and methods (if appropriate) to improve efficiencies and overcome challenges.

Several unanticipated developments, issues, and/or challenges with implementing the existing conservation measures for the restoration of SAV in the Comal and San Marcos have been realized over the first 4 years of implementation. Among them are the following:

1. Higher than anticipated rates of success in removing non-native SAV species *(Hydrilla* and *Hygrophila*), inviting consideration of whether areal coverage targets for non-native SAV species should be eliminated from the LTBGs of the EAHCP altogether (i.e., why maintain target levels of exotics if they can be eliminated completely?);
2. Competition for and limitations of physical space between areal coverage of SAV species, Texas wild-rice (*Zizania texana*) and river access points as set by the EAHCP LTBGs and Conservation Measures;
3. The determination that prescribed flow rates for the Old Channel of the Comal River would (a) scour established SAV at the higher range of flows, and (b) potentially cause Comal Springs riffle beetle (CSRB; *Heterelmis comalensis*) habitat around Spring Island to go dry at lower flows;
4. The lack of a timeline, with annual milestones, to ensure the EAHCP meets its SAV LTBGs within the term of the Incidental Take Permit;
5. The lack of an implementation plan for the EAHCP requirement for “proportional expansion” (EAHCP §§4.1.1.1 and 4.1.1.2);
6. The need to establish which vegetation mapping event would be used for the purpose of reporting progress and compliance to the United States Fish & Wildlife Service (USFWS); and
7. The lack of success with *Ludwigia* restoration in certain conditions in the San Marcos River.

These issues raised the possibility that the LTBGs associated with fountain darter habitat in the Comal and San Marcos LTBG reaches, as well as the flow requirements that ensure optimal fountain darter habitat in the Old Channel of the Comal, might need to be revised. In light of these issues, it became clear that a thorough study of the SAV restoration programs was in order to properly address these issues and possibly pursue corrective action through the Adaptive Management Process (AMP) laid out by the Funding and Management Agreement (FMA).

Report: SAV Analysis and Recommendations, Oborny and Hardy 2016

In support of the AMP, in November 2015, the EAHCP Implementing Committee commissioned BIO-WEST, Inc. and Watershed Systems Group, Inc. to conduct an analysis that would evaluate the various

developments, issues, and/or challenges identified with the EAHCP's SAV restoration programs, and provide recommendations that could possibly serve as the basis for a Nonroutine AMP proposal.

The analysis of data for the report required several steps, involving the: evaluation of existing parameters, consideration of historical hydraulic and habitat model runs for different flow rates, and the compilation of numerous aquatic vegetation map files over time. Resulting scenarios and recommendations take into account all of these factors, biotic and abiotic, as affecting assembly of the submerged aquatic vegetation communities for each system (Moyle & Light, 1996; Keddy, 1999; Weiher, Clarke, & Keddy, 1998).

From an administrative perspective, the SAV Report authors were charged with:

1. Forging consensus-based recommendations for both the Comal and San Marcos SAV restoration programs.
2. Producing recommendations that took into account the funding allowances established by Table 7.1 of the EAHCP.
3. Producing multiple scenarios formatted as recommendations, allowing for flexibility in management decisions.
4. Producing timelines for each scenario with annual milestones.

The final report that resulted from this exercise is titled *Submerged Aquatic Vegetation Analysis and Recommendations* (SAV Report), released in June 2016. An addendum to this report, featuring a revision to one section of the analysis, along with a revision to the appendix associated that section, was released in August 2016.

Based on the findings of their analysis, the authors of the SAV Report provided three distinct management scenarios, termed Scenario 1 ("existing"), Scenario 2 ("proposed"), and Scenario 3 ("proposed combined"). Each scenario reflected varying levels of adaptation of management, ranging from maintaining status quo (Scenario 1) to adopting all recommendations (Scenario 3). The publication of the addendum to the report in August 2016 introduced Scenario 4, which used *Hydrocotyle* as a replacement for *Hydrilla* and *Hygrophila* in the San Marcos SAV restoration program, rather than *Heteranthera*, as originally had been proposed in Scenarios 2 and 3.

Constraints on SAV Restoration – Spatial Analysis

A key finding from the SAV Report is that based on the amount of confined space in each LTBG reach, the LTBGs, as represented by m^2 of SAV, cannot be met. Original reach calculations for areal coverage goals for different SAV species were based on historical maxima for each plant species within the given reaches. The limited amount of space available was over-committed when Conservation Measures were established independently. Examples of this include (1) the establishment of EAHCP's permanent access points, that dedicate space to access, rather than SAV restoration; (2) the Texas Wild-rice Enhancement and Restoration Conservation Measure, which is treated separately in the EAHCP from restoration for other SAV species; and (3) SAV restoration to establish fountain darter habitat. Figure 1 (below) illustrates the overlap between each of these Conservation Measures.

Figure 1. *Effect of Spatial Constraints on Achievement of Existing EAHCP Conservation Measures*

Development of the Nonroutine Adaptive Management Proposal

A proposal to amend the EAHCP's LTBGs and/or modify significantly Conservation Measures triggers the Nonroutine AMP per the procedures set out by the Funding and Management Agreement (2012).

Given that this proposal is submitted by the Program Manager, in the following sections, the Program Manager provides his account of the process by which the Nonroutine AMP proposal was developed, and finally, the proposal itself.

This Nonroutine AMP Proposal reflects consideration by the Program Manager of the following sources of information and input:

1. *Submerged Aquatic Vegetation Analysis and Recommendations* (BIO-WEST, Inc. & Watershed Systems Group, Inc., 2016)
2. Input from the Science, Stakeholder and Implementing Committees
3. Discussions with USFWS
4. Discussions with Texas Parks & Wildlife Department (TPWD)
5. The original EAHCP aquatic vegetation analysis, conducted back in 2009, for the creation of the LTBGs (EAHCP, 2012);
6. Hydraulic models and habitat suitability criteria for individual plant species, performed by Hardy, which show preferred habitat based on depth, velocity, and substrate (EAHCP, 2012);
7. Historical aquatic vegetation maps over time for the LTBG reaches, combined to generate a persistence factor for each vegetation type (BIO-WEST, Inc. Biological Monitoring, 2000-2015);
8. Knowledge gained through restoration experiences to date for each proposed LTBG reach (E. Oborny and T. Hardy, personal communication, July 2016)

Stakeholder input is crucial to all EAHCP processes, and the evaluation of SAV restoration and the vetting of the SAV Report duly reflect a stakeholder-driven process. In mid-2015, I as Program Manager met with the City of New Braunfels, the City of San Marcos, and Texas State University--as the three Implementing Committee members responsible for implementation of SAV restoration--to discuss potential solutions to the challenges and strategies that would allow the SAV restoration teams capitalize on unanticipated successes listed above in the introduction.

Out of these initial meetings with the Springs Communities, a plan for gathering data and a strategy to utilize the AMP process was formed. These concepts were presented to USFWS for collaboration purposes. At that point, USFWS stated that it was their belief that the SAV evaluation exercise represented an appropriate use of adaptive management, without endorsing any specific modification. The initial proposal of the strategy to utilize AMP was presented to the Implementing Committee in November 2015, and to the Stakeholder Committee in December 2015. Based on these presentations,

the Implementing Committee directed me to work with Ed Oborny and Thom Hardy to conduct an analysis of the Conservation Measures and to provide recommendations.

Following the release of the resulting SAV Report in June 2016, I first met again with USFWS to vet key concepts and substantive changes contained within the report. After ensuring USFWS support, I began consultation with stakeholders and subject matter experts through a series of informal meetings held in July and August, 2016. The first follow-up meetings on July 19th and July 25th were with the City of San Marcos, Texas State University, and the City of New Braunfels, as the Implementing Committee members with jurisdiction over the SAV restoration programs. Following these initial discussions, additional collaboration included two meetings with TPWD biologists. After developing an executive summary and further shaping some potential recommendations, EAHCP staff and I met with nearly every member of the Science, Stakeholder, and Implementing committees.

This consultation process with USFWS, TPWD, subject matter experts, and EAHCP committee members, resulted in a more thorough and carefully vetted approach to the development of this Nonroutine AMP proposal. Specifically, meetings with committee members resulted in the following additions or modifications to the Nonroutine AMP Proposal:

1. Providing a range of target flows in the Old Channel, rather than set specific flows
2. Consultation, for the purpose of transparency and buy-in, with community stakeholders
3. *Heteranthera*, as originally proposed, should be replaced with *Hydrocotyle*
4. Consultation with as many committee members and subject matter experts as possible
5. Testing SAV species other than *Hydrocotyle*, as a proactive measure, in the event that *Hydrocotyle* establishment is inadequate for the purposes of the SAV restoration program.

Nonroutine Adaptive Management Proposal

With all the before mentioned stated, I, the EAHCP Program Manager, propose that the following two sets of modifications be considered via the Nonroutine AMP:

Modifications to the SAV Conservation Measures and fountain darter LTBGs in the Comal and San Marcos rivers that would (based on Scenario 4 of the SAV Report):

1. Remove non-native plant species (*Hydrilla and Hygrophila*) from the LTBGs for fountain darter habitat, replacing them with native plant species (*Hydrocotyle* and *Zizania* in the San Marcos system, and *Potamogeton* in the Comal system; Exhibit A). Through a review of the literature on

the historical aquatic flora community of the upper San Marcos River, it was determined that *Hydrocotyle* would complement the other native vegetation being planted and fill an empty niche among the plants being restored (BIO-WEST, Inc., 2002; Devall, 1940; Espey Huston & Assoc., 1975; Hannah & Doris, 1970; Lemke, 1989; Owens, Madsen, Smart, & Stewart, 2001). Suitability of *Hydrocotyle* as fountain darter habitat will continue to be assessed through ongoing bio-monitoring efforts conducted by BIO-WEST, Inc.

2. Adjust areal coverage targets for SAV to be consistent with Scenario 4 in the *Submerged Aquatic Vegetation Analysis and Recommendations* and *SAV Addendum* (BIO-WEST, Inc. & Watershed Systems Group, Inc., 2016; Exhibit A).

3. Recognize Texas wild-rice as fountain darter habitat, not just an endangered plant to be restored, by including Texas wild-rice as one of the SAV restoration plants associated with the LTBGs for fountain darter habitat in the San Marcos River.

4. Have the City of San Marcos and Texas State University, in minimal amounts, proactively field-test two other native SAV species to replace *Hydrocotyle*, in the event it is unsuccessful. The two species to be tested will be determined through collaboration between the City of San Marcos, Texas State University, the Program Manager, and TPWD. If *Hydrocotyle* is not succeeding by 2019, without utilizing the AMP process, one of the two test species will be used as a replacement for *Hydrocotyle*, after meeting the following criteria:
    a. The test species is identified as native in existing literature and research
    b. The test species is endorsed as an appropriate replacement species by the EAHCP Science Committee
    c. The test species is endorsed as an appropriate replacement species by USFWS
    d. The Implementing Committee approves submittal of the appropriate documentation associated with the substitution, if necessary, to the USFWS

5. Clarify “proportional expansion,” as required by EAHCP §§4.1.1.1 and 4.1.1.2., with quantifiable and measurable metrics:
    - Amounts and species of vegetation to be restored (Exhibit B)

- Identification of geographic locations of restoration reaches[1] (Exhibit C). These locations were chosen to complement existing LTBG reaches (prevent fragmentation and reestablishment of non-natives) and to address areas of concern (large stands of non-natives).

6. Follow successful suggested field methodologies for implementation that have been realized through four years of "lessons learned" as documented in §2.1.3 of the SAV Report, including the recommendation that these methodologies should be incorporated into Annual Work Plans by Permittees as appropriate.

7. Utilize the Fall Comprehensive Vegetation Mapping event, from the Biomonitoring Program, to quantify vegetation amounts reported in the EAHCP Annual Reports.

8. Adoption of Scenario 4 impacts the number of estimated fountain darters, as modeled, that the SAV habitat can support, specifically resulting in a decrease of an estimated 5,055 fountain darters in the San Marcos LTBG reaches and an increase of an estimated 568 fountain darters in the Comal LTBG reaches (Table 1). The restoration reaches more than make up for any decrease in the San Marcos system.

Table 1

San Marcos - Estimated Number of Fountain Darters, as Modeled			
Scenario	LTBG Reaches	Restoration Reaches	Total
HCP	34,325		34,325
Scenario 4	29,270	9,940	39,210
Comal - Estimated Number of Fountain Darters, as Modeled			
Scenario	LTBG Reaches	Restoration Reaches	Total
HCP	176,150		176,150
Scenario 4	176,718	3,462	180,180

[1] Active native vegetation restoration and protection will be implemented in Landa Lake and the Old Channel (Comal) and in all three representative study reaches (San Marcos). Restoration activities will extend beyond the study reaches in equal proportion to effort expended per study area in relation to the total area of the river segment. By the establishment of known "restoration reaches" in addition to the current study reaches, aquatic vegetation will include the majority of key fountain darter habitat in areas (1) upstream and downstream of the Landa Lake study reach as well as the entire stretch of the Old Channel from the Landa Lake dam to the existing Old Channel study reach (Comal); as well as (2) the majority of key fountain darter habitat in areas upstream and downstream of the City Park study reach, as well as the entire stretch of the river from downstream of the IH-35 study reach to the IH-35 bridge (San Marcos).

A modification to the Flow-split Conservation Measure in the Comal system that would:

9. Revise Table 5-3, *Flow-split Management for Old and New Channels* to provide maximum benefit to sustaining fountain darter habitat in the Old Channel and keeping CSRB habitat around Spring Island wetted (Exhibit D). This revision:
    - lowers the high flow rates in the Old Channel in the Fall/Winter from 80 cubic feet per-second (cfs) to 65 cfs
    - does not decrease the minimum flow targets to the Old Channel during times of total system flow of 30 cfs.
    - establishes a flow requirement ranging from 35-40 cfs at total system flows of 60 cfs and 50 cfs. The actual flow would be set by the City of New Braunfels in collaboration with the Program Manager, and will be set to provide wetted CSRB habitat around Spring Island, while maintaining the maximum possible flow to the Old Channel. In the event that flow reduction to 35 cfs in the Old Channel does not add benefit to CSRB habitat, Old Channel flow shall be set at 40 cfs to benefit fountain darter habitat by maintaining the maximum flow possible to the Old Channel. Benefit (wetted versus exposed CSRB habitat around Spring Island and maximum flows to the Old Channel) will be determined and balanced based on the data and observations provided by the Biological Monitoring Program conducted by BIO-WEST, Inc.

This Nonroutine AMP proposal relates to the following sections of the EAHCP:

- City of New Braunfels
    - 4.1.1.1 Long-term Biological Goals & Objectives – Comal Springs
    - 5.2.1 Flow-Split Management in the Old and New Channel
    - 5.2.2 Native Aquatic Vegetation Restoration and Maintenance

- City of San Marcos
    - 4.1.1.2 Long-term Biological Goals & Objectives - San Marcos Springs
    - 5.3.1 Texas Wild-Rice Enhancement and Restoration
    - 5.3.8 Control of Non-Native Plant Species

- Texas State University
    - 4.1.1.2 Long-term Biological Goals & Objectives - San Marcos Springs

- o 5.4.1 Texas Wild-Rice Enhancement and Restoration
- o 5.4.12 Control of Non-Native Plant Species

Fiscal Impact

From the beginning of this evaluation, this exercise was designed to respect the funding allowances established by the FMA and Table 7.1 of the EAHCP. Adoption of this Proposal will not result in any budget deviations from Table 7.1 of the EAHCP. It should be noted, that this Proposal does include the monitoring of the "restoration reaches," which will add approximately $10,000 to the bio-monitoring budget annually.

References - *All relevant reports, citations, and analysis can be found at* www.eahcp.org.

BIO-WEST, Inc. & Watershed Systems Group, Inc. (2016). Submerged aquatic vegetation analysis and recommendations. Including SAV Addendum (Section 3.1.2) and revised Appendix B. Prepared for Edwards Aquifer Authority, San Antonio, TX.

BIO-WEST, Inc. 2002. Comprehensive and critical period monitoring program to evaluate the effects of variable flow on biological resources in the San Marcos Springs/River aquatic ecosystem. Edwards Aquifer Authority Final Report for 2001.

Devall, L.L. 1940. A comparative study of plant dominance in a spring fed lake. Unpubl. M.A. thesis, Southwest Texas State University, San Marcos, TX.

Espey, Huston and Associates, Inc. 1975. Investigation of flow requirements from Comal and San Marcos Springs to maintain associated aquatic ecosystems (Guadalupe River basin). Edwards Underground Water Conservation District Report #7503 (EH&A Job #0072).

Hannan, H.H., and C.T. Dorris. 1970. Succession of a macrophyte community in a constant temperature river. *Limnol. and Oceanogr*., 15:442-453.

Keddy, P. (1999). Wetland restoration: the potential for assembly rules in the service of conservation. *Wetlands*, 19(4), 716-732.

Lemke, D.E. 1989. Aquatic macrophytes of the upper San Marcos River, Hays Co., Texas. *The Southwestern Naturalist*, V34, 2:289-291.

Moyle, P. B., & Light, T. (1996). Biological invasions of fresh water: empirical rules and assembly theory. *Biological Conservation*, *78*(1), 149-161.

Owens, C.S., J.D. Madsen, R.M. Smart and R.M. Stewart. 2001. Dispersal of native and nonnative aquatic plant species in the San Marcos River, Texas. *J. Aquat. Plant Manage*. 39:75-79.

Weiher, E., Clarke, G. P., & Keddy, P. A. (1998). Community assembly rules, morphological dispersion, and the coexistence of plant species. *Oikos*, 309-322.

EXHIBIT A

Revised Long-term Biological Goals for the Submerged Aquatic Vegetation Habitat Restoration for the Fountain Darter in the Comal River.

FOUNTAIN DARTER HABITAT (AQUATIC VEGETATION) IN METERS SQUARED (M2) AND FOUNTAIN DARTER MEDIAN DENSITY (NUMBER/M2) PER HABITAT TYPE

Fountain darter habitat (aquatic vegetation) goal in meters squared (m^2)

Study Reach	*Bryophytes*	~~*Hygrophila*~~ *Potamogeton*	*Ludwigia*	*Cabomba*	~~Fil. Algae~~	*Sagittaria*	*Vallisneria*
Upper Spring Run Reach	~~1,850~~ 1,750	~~650~~ 0	~~150~~ 25	~~0~~ 25	~~0~~	~~600~~ 850	0
Landa Lake	~~4,000~~ 3,950	~~250~~ 25	900	500	~~0~~	~~1250~~ 2,250	~~13,500~~ 12,500
Old Channel	~~150~~ 550	~~200~~ 0	~~1,500~~ 425	~~0~~ 180	~~300~~	~~0~~ 450	0
New Channel	150	~~1,350~~ 0	~~0~~ 100	~~350~~ 2,500	~~0~~	0	0
TOTAL	~~6,150~~ 6,400	~~2,450~~ 25	~~2,550~~ 1,450	~~850~~ 3,205	~~300~~	~~1850~~ 3,550	~~13,500~~ 12,500

Fountain darter median density number/m^2

Bryophytes	~~*Hygrophila*~~ *Potamogeton*	*Ludwigia*	*Cabomba*	~~Fil. Algae~~	*Sagittaria*	*Vallisneria*
20	~~4~~ 3.3	7	7	~~14~~	1	1

EXHIBIT A (continued)

Revised Long-term Biological Goals for the Submerged Aquatic Vegetation Habitat Restoration for the Fountain Darter in the San Marcos River.

FOUNTAIN DARTER HABITAT (AQUATIC VEGETATION) IN METERS SQUARED (M2) AND FOUNTAIN DARTER MEDIAN DENSITY (NUMBER/M2) PER HABITAT TYPE

Fountain darter habitat (aquatic vegetation) goal in meters squared (m^2)								
Study Reach	~~*Hygrophila*~~	*Ludwigia*	*Cabomba*	~~*Hydrilla*~~	*Potamogeton*	*Sagittaria*	~~*Vallisneria*~~ *Hydrocotyle**	*Zizania*
Spring Lake Dam	~~50~~	~~200~~ 100	~~25~~ 50	~~100~~	~~1,000~~ 200	~~100~~ 200	~~125~~ 50	700
City Park	~~200~~	~~1,000~~ 150	~~50~~ 90	~~500~~	~~2,000~~ 1,450	300	~~50~~ 10	1,750
IH-35	~~50~~	~~200~~ 50	~~300~~ 50	~~100~~	~~300~~ 250	~~100~~ 150	~~25~~ 50	600
TOTAL	~~300~~	~~1,400~~ 300	~~375~~ 190	~~700~~	~~3,300~~ 1,900	~~500~~ 650	~~200~~ 110	3,050
Fountain darter median density number/m^2								
	~~*Hygrophila*~~	*Ludwigia*	*Cabomba*	~~*Hydrilla*~~	*Potamogeton*	*Sagittaria*	~~*Vallisneria*~~ *Hydrocotyle**	*Zizania*
	~~4~~	7	7	~~5~~	5	1	~~1~~ 4	5

* Include flexibility that if, after two years of implementing (2019), *Hydrocotyle* is not succeeding in the San Marcos system, that other native submerged aquatic vegetation (SAV) be considered for the fountain darter Long-term Biological Goals, as long as the replacement species meets the certain criteria.

EXHIBIT B

Species and amounts of submerged aquatic vegetation to be restored under proportional expansion in the Comal River.

FOUNTAIN DARTER HABITAT (AQUATIC VEGETATION) IN METERS SQUARED AND MEDIAN DENSITY (NUMBER/M²) PER HABITAT TYPE TO DEFINE "RESTORATION REACHES" IN THE COMAL RIVER

Fountain darter habitat (aquatic vegetation) in meters squared (m^2)							
Study Reach	*Bryophytes*	*Potamogeton*	*Ludwigia*	*Cabomba*	*Sagittaria*	*Vallisneria*	TOTAL
Landa Lake UP[A]	5,500		25	250	250		6,025
Landa Lake DOWN[B]	500		50	125	100	22,500	23,275
Old Channel UP[C]	1,250	100	850	200	750	750	3,900
Total	7,250	100	925	575	1,100	23,250	33,200
Fountain darter median density (number/m^2)							
	Bryophytes 20	*Potamogeton* 3.3	*Ludwigia* 7	*Cabomba* 7	*Sagittaria* 1	*Vallisneria* 1	*TOTAL*
# darters *veg total	145,000	330	6,475	5,025	1,100	23,250	180,180

[A] Landa Lake LTBG reach to downstream boundary of Spring Island
[B] Landa Lake LTBG reach to weir across from City of New Braunfels Park Office
[C] Old Channel from LTBG reach upstream to Landa Lake Dam

EXHIBIT B (continued)

Species and amounts of submerged aquatic vegetation to be restored under proportional expansion in the San Marcos River.

FOUNTAIN DARTER HABITAT (AQUATIC VEGETATION) IN METERS SQUARED AND MEDIAN DENSITY (NUMBER/M^2) PER HABITAT TYPE TO DEFINE "RESTORATION REACHES" IN THE SAN MARCOS RIVER

Fountain darter habitat (aquatic vegetation) in meters squared (m^2)							
Study Reach	*Ludwigia*	*Cabomba*	*Potamogeton*	*Sagittaria*	*Hydrocotyle*	*Zizania*	TOTAL
Sewell Park	25	25	152	25	10	1,100	1,335
Below Sewell to City Park[A]	50	50	500	700	20	2,300	3,620
Hopkins Street – Snake Island	50	50	475	750	10	950	2,285
Cypress Island – Rio Vista	50	50	150	50	0	350	650
IH-35 Expanded[B]	50	100	250	450	50	450	1,350
Total	225	275	1,525	1,975	90	5,150	9,240
Fountain darter median density (number/m^2)							
	Ludwigia 7	*Cabomba* 7	*Potamogeton* 5	*Sagittaria* 1	*Hydrocotyle* 4	*Zizania* 5	*TOTAL*
# darters *veg total	1,575	1,925	7,625	1,975	360	25,750	39,210

[A] Sewell Park to the upstream boundary of the City Park LTBG reach
[B] Immediately downstream of the established IH-35 LTBG reach to IH-35

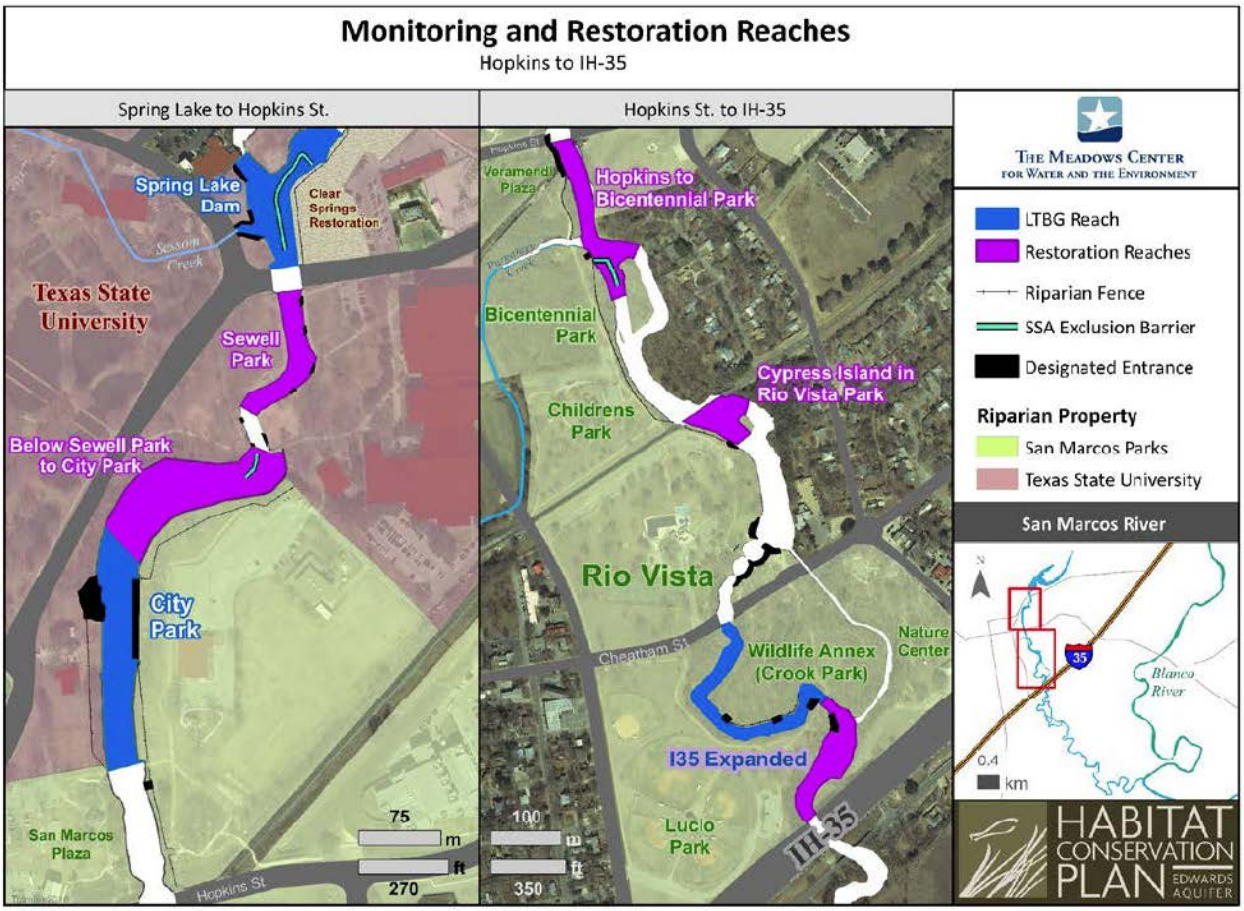
EXHIBIT C

Defined “restoration reaches” to define “proportional expansion” in the Comal River.

Long-term Biological Goal reaches and proposed “restoration reaches” for the Comal system.

EXHIBIT C (continued)

Defined “restoration reaches” to define “proportional expansion” in the San Marcos River.



Long-term Biological Goal Reaches and proposed “restoration reaches” for the San Marcos system.

EXHIBIT D

Revised Table 5-3, Flow-Split Management for Old and New Channels.

Table 1: Proposed revisions for the Flow-Split Management for the Old and New Channels (Table 5-3):

Total Comal Springflow (cfs)	Old Channel (cfs)		New Channel (cfs)	
	Fall, Winter	Spring, Summer	Fall, Winter	Spring, Summer
350+	~~80~~ 65	60	~~270+~~ 280+	290+
300	~~80~~ 65	60	~~220~~ 235	240
250	~~80~~ 60	~~60~~ 55	~~170~~ 190	~~190~~ 195
200	~~70~~ 60	~~60~~ 55	~~130~~ 140	~~140~~ 145
150	~~60~~ 55		~~90~~ 95	
100	~~60~~ 50		~~40~~ 50	
80	~~50~~ 45		~~30~~ 35	
70	~~50~~ 40		~~20~~ 30	
60*	~~40~~ 40-35		~~10~~ 25	
50*	~~40~~ 40-35		~~10~~ 15	
40	30		10	
30	20		10	

*This revision will raise the Old Channel flow to a range of 35-40 cfs at total system flows of 60 and 50 cfs, with the caveat that, ensuring all control valves have been manipulated to provide the maximum benefit to CSRB habitat around Spring Island as possible, while maintaining the maximum flow possible to the Old Channel.