Edwards Aquifer
Habitat Conservation Plan 2015 Annual Report

Submitted to the U.S. Fish & Wildlife Service
March 22, 2016

On Behalf of
The Edwards Aquifer Habitat
Conservation Plan Permittees

HABITAT CONSERVATION PLAN EDWARDS AQUIFER

Prepared by
Blanton & Associates, Inc.

Edwards Aquifer

Habitat Conservation Plan

2015 Annual Report

Prepared for

The U.S. Fish & Wildlife Service

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EXECUTIVE SUMMARY

Edwards Aquifer Habitat Conservation Plan

The Edwards Aquifer Habitat Conservation Plan (EAHCP)[1] is a cooperative effort to protect the water of the southern portion of the Edwards Aquifer both for people in the region and the endangered species that inhabit the aquifer, and aquatic spring environments whose water largely emanates from the aquifer. This effort began when regional stakeholders and the U.S. Fish & Wildlife Service (Service or USFWS) initiated the Edwards Aquifer Recovery Implementation Plan (EARIP) in 2006. The Texas Legislature mandated participation in the process by the Edwards Aquifer Authority (EAA), Texas Commission on Environmental Quality (TCEQ), Texas Department of Agriculture (TDA), Texas Parks & Wildlife Department (TPWD), and Texas Water Development Board (TWDB). The EARIP process led to the creation of the planning group known as the Edwards Aquifer Recovery Implementation Program Habitat Conservation Plan, which has now transitioned to the implementation group known as the EAHCP. The EAHCP was completed in November 2012 and led to the approval of an Incidental Take Permit (ITP) under the federal Endangered Species Act of 1973 (ESA) issued by the USFWS in March 2013. The ITP was amended in January 2015, and a copy of the amended ITP is included in **Appendix A1** of this Annual Report. This Annual Report has been prepared for submittal to the USFWS, as required by the ITP.

The Permittees under the EAHCP are the EAA, the City of New Braunfels (CONB), the City of San Marcos (COSM), Texas State University (Texas State), and the City of San Antonio acting by and through its San Antonio Water System (SAWS) Board of Trustees.

Covered Species Protected by the EAHCP

The EAHCP addresses the conservation needs of seven endangered species, one threatened species, and three species that have been petitioned for listing, as shown below in **Table ES-1**. Under the EAHCP, the Covered Species are covered by the ITP issued by the Service. The ITP allows "take" of the Covered Species listed in **Table ES-1**, as that term is defined in the ESA. [2]

[1] All acronyms and abbreviations in the Executive Summary are defined in the list of ACRONYMS AND ABBREVIATIONS on pages xxxii-xxxiv of this Annual Report.

[2] "Take," as defined by the ESA, means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." "Harm" is also defined in the implementing regulations as "an act which actually kills or injures wildlife; such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly interfering with essential behavioral patterns including breeding, feeding and sheltering" (50 CFR 17.3). Disturbing or destroying occupied endangered species habitat could be a violation of the ESA if an individual of the species is prevented from breeding, feeding or sheltering and if this ultimately leads to the death or injury of the individual. If it is not possible to change a proposed action to avoid take of a listed species, a non-federal entity may request a permit under Section 10(a)(1)(B) to allow an exception for activities that may incidentally impact species. The USFWS may issue such permits, under the limited circumstances described in Section 10(a). Plants (e.g., Texas wild-rice) are treated differently under the ESA and are not subject to the take rules.

Table ES-1. Covered Species Under the EAHCP ITP

Common Name	Scientific Name	Federal Status	Associated Springs in the EAHCP
Fountain Darter	*Etheostoma fonticola*	Endangered	Comal & San Marcos
San Marcos Gambusia	*Gambusia georgei*	Endangered	San Marcos
Comal Springs Dryopid Beetle	*Stygoparnus comalensis*	Endangered	Comal
Comal Springs Riffle Beetle	*Heterelmis comalensis*	Endangered	Comal & San Marcos
Peck's Cave Amphipod	*Stygobromus pecki*	Endangered	Comal
Texas Wild-Rice	*Zizania texana*	Endangered	San Marcos
Texas Blind Salamander	*Eurycea (+Typhlomolge) rathbuni*	Endangered	San Marcos
San Marcos Salamander	*Eurycea nana*	Threatened	San Marcos
Texas Cave Diving Beetle*	*Haideoporus texanus*	Petitioned	Comal & San Marcos
Comal Springs Salamander	*Eurycea sp.*	Petitioned	Comal
Texas Troglobitic Water Slater	*Lirceolus smithii*	Petitioned	San Marcos

* Also known as the "Edwards Aquifer Diving Beetle."

Geographic Area Covered by the EAHCP

As shown in **Figure ES-1**, the ITP provides incidental take coverage for authorized activities in all or parts of Uvalde, Medina, Atascosa, Bexar, Comal, Guadalupe, Hays and Caldwell counties, Texas. This area is the Plan Area in which pumping from the Edwards Aquifer is regulated by the EAA and affects the springs and spring ecosystems inhabited by the Covered Species. The Plan Area also includes the recreational areas associated with the Comal Springs and the San Marcos Springs that are under the jurisdiction of the CONB, and the COSM and Texas State, respectively.

Effects on Covered Species in 2015

Chapter 5.0, 2015 Annual Take Estimates, and **Appendix N** of the Annual Report provide an overview of net disturbance percentages and a summary of incidental take for 2015 (**Table ES-2**). In the Comal Springs system, only the fountain darter had a net disturbance when considering the project footprint for EAHCP mitigation and restoration activities overlaid on occupied habitat. The net disturbance was 3.4 percent of the total occupied habitat for the fountain darter. No project footprints overlapped with any of the occupied habitat for the endangered Comal Springs invertebrates. In the San Marcos Springs system, both the fountain darter and the San Marcos salamander had a net disturbance per this assessment. The fountain darter had 3.1 percent of its total occupied habitat disturbed, while the San Marcos salamander amount was less than 1.0 percent. For the Texas blind salamander and Comal Springs riffle beetle (CSRB), there were no activities conducted in 2015 that directly impacted any of the orifices where collections have routinely been made over the years. In summary, the net disturbance in 2015 was under the 10 percent disturbance rule, as outlined in items M1a and M2a of the ITP.

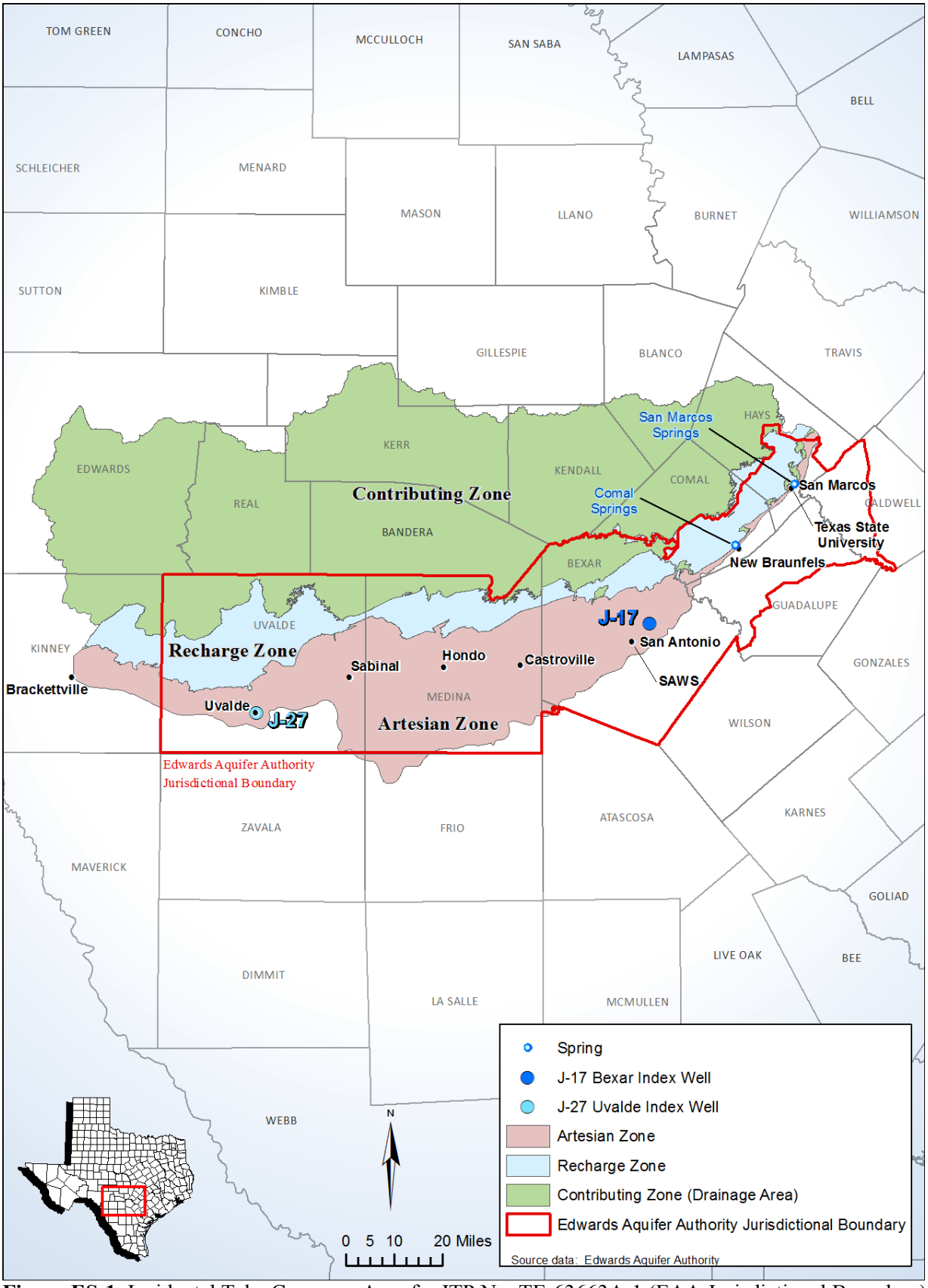

Figure ES-1. Incidental Take Coverage Area for ITP No. TE-63663A-1 (EAA Jurisdictional Boundary)

As indicated in **Table ES-2**, the calculated incidental take on the Comal system with respect to the surface dwelling organisms (CSRB and fountain darter) was considerably less in 2015 than observed during the drought conditions experienced in both 2013 and 2014. The primary cause for this decrease was the above-average discharge conditions throughout most of 2015 that resulted in full inundation of surface habitats within CSRB occupied habitat and inundated habitat and constant water temperatures relative to the fountain darter. For the San Marcos Springs system, incidental take went up slightly in 2015. This slight increase was due to a combination of more EAHCP restoration measures being implemented in 2015 because Condition M of the ITP was not triggered, and because of increases in recreational impacts in the Spring Lake Dam reach of the river. Condition M of the ITP stipulates that when Comal Springs flows decline to 130 cubic feet per second (cfs) or lower, and when San Marcos Springs flows decline to 120 cfs of lower, all habitat mitigation and restoration activities that might result in disturbance of the (a) substrate, (b) water quality, (c) plants, and (d) animals or invertebrates in the systems, must be suspended.

2015 Edwards Aquifer Conditions, Management and Notable Conditions - Flood

In 2015, the Edwards Aquifer Region experienced two major storm events – on May 23-25, 2015 and on October 30, 2015. The October 30th floods were especially detrimental due to increased streamflow, specifically in the San Marcos River. The recorded rainfall was 10 to 16 inches throughout the San Marcos River watershed, and 4 to 7 inches in the Comal River watershed. The COSM and Texas State experienced extensive damage to the riparian restoration fencing that assisted in the continued growth of newly planted vegetation. Additionally, some scouring was recorded throughout the system. Post-flood mapping and observations of the aquatic vegetation indicated significant scouring effects in many locations along the stream bottom in the San Marcos River system.

Unlike the San Marcos River, the Comal River did not experience any major flooding in May. In October 2015, the Comal River experienced a significant flooding event along its entire length, from Bleiders Creek to its confluence with the Guadalupe River. While this high-water event was significant, it caused only localized damage to restored native aquatic plantings.

The EAA's Biological Monitoring Program triggered additional monitoring due to both the May and October flood events. These significant events provided an opportunity for biologists to monitor the systems before and after flood events. Such data is useful in understanding how both systems responded and how the Covered Species and their habitat are affected. Recharge to the Edwards Aquifer from the May event had significant impact on both the San Antonio Pool and Uvalde Pool index wells. This positive impact is associated with the proportion of rain that fell on the Recharge and Contributing zones. The amount and timing of rainfall in 2015 was particularly beneficial to irrigators in that most irrigation wells were not put into service until July. Also in 2015, the widespread and regular rains and program pricing adjustments led to a dramatic increase in Aquifer Storage and Recovery (ASR) leasing activities.

Table ES-2. Incidental Take of EAHCP Covered Species

COVERED SPECIES PER SYSTEM	EAHCP Mitigation / Restoration		EAHCP Measures / Drought	Combined Impacted Habitat 2014 TOTAL (m^2)	INCIDENTAL TAKE		2015 INCIDENTAL TAKE TOTAL	ITP Maximum Permit Amount	ITP Permit Maximum - (combined first three years)
	IMPACTED HABITAT (m^2)	NET Disturbance % OF TOTAL Occupied Habitat	IMPACTED HABITAT (m^2)		EAHCP Mitigation / Restoration	EAHCP Measures / Drought			
COMAL SYSTEM									
Fountain Darter	3,217	3.4%	193	**3,410**	4,826	290	**5,115**	797,000	758,344
Comal Springs Riffle Beetle	0	0.0%	237	**0**	0	0	**0**	11,179	8,933
Comal Springs Dryopid Beetle	0	0.0%	18	**0**	0	0	**0**	1,543	1,528
Peck's Cave Amphipod	0	0.0%	79	**0**	0	0	**0**	18,224	18,060
SAN MARCOS SYSTEM									
Fountain Darter	3,474	3.1%	5,389	**8,863**	5,211	8,084	**13,295**	549,129	507,213
San Marcos Salamander	16	0.6%	337	**353**	48	1,011	**1,059**	263,857	261,264
Texas Blind Salamander	0	0.0%	0	**0**	0	0	**0**	10	10
Comal Springs Riffle Beetle	0	0.0%	0	**0**	0	0	**0**	n/a	n/a

EAHCP 2015 Budget and Expenditures

The EAHCP Expense Report located in **Appendix H** of this Annual Report shows Table 7.1 of the EAHCP funding amounts for 2015 totaling $18,362,597, as compared to the EAA Board-approved 2015 Program Funding Applications totaling $24,729,152. A significant increase in the VISPO budget accounts for the large variation between these two amounts. Actual expenses for 2015 were $16,397,097, and a significant amount of unspent funds in the ASR Leasing, ASR Operations and Maintenance, and Regional Water Conservation Program (RWCP) budgets accounts for the difference between total approved budget and actual expenses.

The EAHCP Expense Report also breaks down the adopted budget, Program Funding Applications budget and actual expenses. Approximately 34 percent of the approved 2015 Program Funding Applications budget and 11 percent of the adopted budget amounts remained at the end of the December 2015. These amounts were due primarily to balances resulting from unexpended funds in the RWCP, ASR, and Refugia programs. By the end of 2015, the reserve balance for the EAHCP was $37,346,135, which includes unspent funds accumulated since the inception of the EAHCP.

The EAHCP Expense Report also shows the actual revenue for 2015 of $18,805,257 compared to the budgeted revenue of $18,466,976, which is a variance of only $338,281. Approximately 95 percent of the actual revenue comes from Aquifer Management Fees. It is anticipated that revenue acquired in 2016 will be similar to the revenue acquired in previous years.

EAHCP Activities Completed in 2015

As stated above, the five Permittees under the EAHCP are the EAA, CONB, COSM, Texas State, and SAWS. The TPWD is an additional cooperating agency, or partner. These are the primary agencies, or partners, working to implement the EAHCP. The Permittees are each tasked with certain responsibilities for implementation of the EAHCP, as directed by the ITP. During Phase I of implementing the EAHCP, the Permittees are undertaking various measures for flow protection, habitat protection, and other measures identified in the EAHCP.

The ITP requires an annual report be submitted to the USFWS to show progress towards permit implementation. **Chapter 3.0**, Plan Implementation in 2015, of this 2015 Annual Report describes permit actions by the Permittees and the TPWD, including subsections discussing their *EAHCP Obligations*, *2015 Compliance Actions*, *Any Modifications or Activities Due to Weather Conditions*, and *Proposed Activities for 2016*.

Highlights of major EAHCP accomplishments for 2015 are summarized below.

- **Springflow Protection Measures –** With regard to the four EAHCP springflow protection elements (the Voluntary Irrigation Suspension Program Option [VISPO], the RWCP, the Critical Period Management Progam [CPMP] – Stage V, and the ASR), the EAHCP is making headway to complete all four of these elements early in the fifteen-year term of the ITP. In 2015, EAHCP staff did not initiate efforts to enroll new participants in the VISPO as the goal of 40,000 acre-feet (ac-ft)

was achieved in 2014 and no more water was needed at this time. At the end of 2015, the EAA and SAWS developed an agreement for SAWS to initiate a five-year leak detection and repair program, which will fulfill the RWCP obligations (10,000 ac-ft of water in the Groundwater Trust) for the remainder of the ITP. The CPMP – Stage V, was approved by the EAA Board of Directors in early 2013, and has been implemented. Lastly, improving weather conditions helped to increase participation in the ASR leasing program. As of December 31, 2015, 12,075.016 ac-ft had been stored for the EAHCP, for a cumulative amount of 17,974 ac-ft of stored groundwater. The EAHCP anticipates an additional 20,000 ac-ft will be leased in 2016, with the goal of storing 20,000 ac-ft. A total of over 37,000 ac-ft will then be stored.

The continued drought into early 2015 caused stress to the Edwards Aquifer and springs systems, and resulted in EAHCP springflow protection measures being triggered (e.g., VISPO and CPMP-Stage V). Continued commitment by the Permittees to follow-through with these EAHCP elements contributed to minimizing the impacts of the drought on the spring systems and their ability to survive the drought.

- **Habitat Restoration: Comal and San Marcos Spring Systems –**
  - *a. Comal –*
    - i. Flow-Split Management – High-springflow conditions caused adjustments to the fall/winter guidelines so that higher flow rates would not erode and scour previous aquatic restoration work and submerged aquatic vegetation (SAV). Working with the Adaptive Management Science Committee (SC), flows were not adjusted to higher than 65 cfs for October – December 2015 to allow for further analysis.
    - ii. Vegetative Restoration in Landa Lake (LL) and the Old Channel – Aquatic vegetation restoration activities in 2015 included removal of non-native aquatic plant species, planting of target native aquatic plant species and maintenance of restored areas within LL and the Old Channel of the Comal River. In 2015, 926 square meters (m^2) was planted in seven plots in LL, for a three-year total area planted in the lake of 2,694 m^2. For the Old Channel, an area of 1,130 m^2 was planted in eight restoration areas bringing the three-year total for area planted to 2,673 m^2.
  - *b. San Marcos –*
    - i. Texas wild-rice Enhancement and Restoration – Restoration activities in 2015 involved removal of non-native plant species, propagation of new Texas wild-rice plants, and continued monitoring of new stands. COSM staff estimates that since 2013, Texas wild-rice has increased through plantings and natural expansion an estimated 2,140 m^2 within Meadows Center for Water and the Environment (MCWE)-specified work sites. Since 2014, Texas wild-rice continued to expand by an estimated 633 m^2 at those same sites.
    - ii. Riparian Restoration – The COSM removed non-native trees, shrubs and vines from Riverhouse, Wildlife Annex, and Ramon Lucio parks throughout the summer and fall of 2015. The COSM implemented a new strategy in 2015 to combat drought conditions and possible water restrictions, and planted drought tolerant species and littoral species, and began relying on native seed stock to repopulate the riparian areas.

- **Refugia –** EAHCP staff recommended implementing refugia operations in two phases, a short-term or salvage phase and a long-term phase, in an effort to comply with the ITP. The Salvage Refugia Program is aimed at quickly providing refugia capabilities over the short-term to ensure against the imminent threat of salvage triggers. Construction of the Salvage Refugia Facility is nearing completion and will be operational in early 2016. The Long-Term Refugia Operations are designed to provide a long-term facility and refugia for the Covered Species for the duration of the ITP. The selection of a contractor to provide for long-term refugia will be made in early 2016.
- **Adaptive Management Science Committee –** In 2015, the Implementing Committee (IC) developed and implemented a new process to apply SC members' technical knowledge and expertise to EAHCP research programs. This new process was designed to obtain their scientific input upfront on research design and the scientific merit of proposals as these studies and projects are being developed.
- ***National Academy of Sciences Report 1* –** Phase 1 of the National Academy of Sciences (NAS) review was completed with delivery of the Phase 1 report, titled *National Academy of Sciences – Review of the Edwards Aquifer Habitat Conservation Plan: Report 1* (NAS *Report 1*) in March 2015. In the Permittees' opinion, the report validated all of the work being done by the EAHCP and the resources being expended to accomplish this work. The EAHCP carefully considered the report's contents, and is continuing to move forward to implement select recommendations.
- **Applied Research Work Group –** In response to the NAS *Report 1* recommendations, the IC created the Applied Research Work Group (ARWG) to provide the EAHCP with guidance for applied research studies to analyze and support the EAHCP.
- **EAHCP Program Activity –** The EAHCP completed another very active year, with program staff facilitating over 40 public meetings.

The table below summarizes the Permittees' 2015 compliance measures, and TPWD's 2015 activities, which are discussed more fully in **Chapter 3.0**, Plan Implementation in 2015, of the Annual Report.

Measure **(EAHCP Reference; 2015 Annual Report Section Reference)**	**Activities Undertaken in 2015**
Edwards Aquifer Authority (EAA)	
Applied Research (EAHCP §6.3.4; Annual Report (AR) Section 3.1.1)	Tier A research projects conducted in 2015 were: • (Test Spring Run Connectivity) *Comal Springs Riffle Beetle (CSRB) Connectivity Study*: Testing of spring run connectivity to evaluate importance of surface habitat, riparian detritus, and the subsurface habitat of the CSRB. Additional Studies conducted in 2015 were: • Ludwigia repens *Interference Plant Competition Study*: Data collected will be directly incorporated in the EAHCP ecological model to refine plant interactions for predictions of change in fountain darter habitat, and to guide EAHCP mitigation/restoration efforts.

Measure (EAHCP Reference; 2015 Annual Report Section Reference)	Activities Undertaken in 2015
Edwards Aquifer Authority (EAA)	
	• *Suspended Sediment Impacts on Texas wild-rice and other Aquatic Plant Growth Characteristics and Aquatic Macroinvertebrates Study*: The study will evaluate the impacts of suspended sediments in the San Marcos River, and their impacts on the aquatic vegetation and macroinvertebrate communities for use in the EAHCP Ecological Model. • *Algae Dynamics and Dissolved Oxygen Depletion Study:* Understanding the changes and effects caused by algae build-up on rooted aquatic vegetation, especially under low-flow conditions, will directly support the refinement of threshold functions in the aquatic vegetation module of the EAHCP Ecological Model. • *Development of Husbandry and Captive Propagation Techniques for EAHCP Covered Invertebrate Species:* To implement a portion of the EAHCP refugia program by developing a successful captive propagation program for the invertebrate species covered under the EAHCP, including captive rearing, life history, and environmental requirement needs. In addition to carrying out the above studies, a new process for planning associated with the 2016 Applied Research Program was implemented in 2015. This process, informed by the recommendation in NAS *Report 1*, involved incorporating greater scientific review for the Applied Research Program through the role of the SC. The "Suspended Sediment Impacts" study was given a no-cost time extension to May 31, 2016 due to flood-related disruption impacts on *in-situ* elements. The applied research facilities at the Freeman Aquatic Building (FAB) were heavily impacted by the October 2015 flooding event of the San Marcos River. Following the flood, electrical receptacles and ground fault interrupters (GFI) were replaced, and pond conduits drained by Texas State to restore the FAB applied research facilities to working order.
Refugia (EAHCP §5.1.1, §6.4.2, §6.4.3, and §6.4.4; AR Section 3.1.2)	Given the importance of breaking ground on refugia facilities before a salvage recovery operation was triggered, EAHCP staff pursued obtaining a minor administrative amendment to both the ITP and the EAHCP to allow the EAA to contract with entities other than the USFWS to procure a functioning refugia program for the EAHCP's Covered Species. The USFWS approved this change to the EAHCP, and issued an amended ITP on January 21, 2015. EAHCP staff recommended to phase refugia operations into a salvage refugia program aimed at quickly providing refugia capabilities over the short-term to ensure against the imminent threat of salvage triggers, and a long-term refugia program to provide a long-term facility and refugium for the Covered Species for the duration of the ITP. On March 30, 2015, the EAA issued an RFP titled *Salvage Refugia Operations*. Permitting and construction of the Salvage Refugia Project took approximately six months. The Salvage Refugia Project is expected to be operational in early 2016. On September 21, 2015, the EAA issued an RFP titled *Long Term Refugia Operations*. A contractor will be selected in early 2016.
Voluntary Irrigation Suspension Program Option (VISPO) (EAHCP §5.1.2; AR Section 3.1.3)	In 2015, existing VISPO enrollees were monitored for groundwater withdrawals, and no compliance problems were reported. No new enrollment occurred in 2015 because VISPO program enrollment goals were attained in 2014, with a total combined enrollment of 40,921 ac-ft. All VISPO participants were paid a higher amount in 2015, with combined total VISPO payments amounting to $8,677,263. On October 1, 2015, the aquifer level at the J-17 index well was 645.2 feet at mean sea level (ft msl); VISPO enrollees were informed that all water enrolled in VISPO would not be suspended for 2016.

Measure (EAHCP Reference; 2015 Annual Report Section Reference)	Activities Undertaken in 2015
Edwards Aquifer Authority (EAA)	
Regional Water Conservation Program (RWCP) (EAHCP §5.1.3; AR Section 3.1.4)	The goal for 2015 was to fully develop and begin implementation of the recommendations from the RWCP Work Group, including the required four individual elements of the RWCP: lost water and leak detection; high efficiency plumbing fixtures and toilet distribution; commercial/ industrial retrofit rebate; and water reclamation for efficient water use. EAA continued to meet the obligations described in the U.S. Bureau of Reclamation WaterSMART Grant. The EAA has continued to assist the City of Uvalde with implementation of their water conservation measures (primarily distribution of high efficiency/low flow toilets and plumbing kits). EAA staff has continued to implement recommendations of the RWCP Work Group, including conversations with industrial users in the region. In the summer of 2015, the EAA successfully executed a contract with an engineering firm to perform a water audit in the City of Natalia. At the end of 2015, the EAA and SAWS developed an agreement for SAWS to initiate a five-year leak detection and repair program, which will fulfill RWCP obligations for the remainder of the ITP.
Critical Period Management-Stage V (EAHCP §5.1.4; AR Section 3.1.5)	In 2015, Stage V was in effect in the Uvalde Pool for a total of 154 days. San Antonio, however, did not enter Stage V in 2015. Due to drought conditions in south central Texas in early 2015, the EAA enforced CPMP restrictions in both pools of the Edwards Aquifer. In 2015, the San Antonio Pool began the year in Stage III and the Uvalde Pool began the year in Stage V. While the Uvalde Pool aquifer level increased beginning in June, the San Antonio Pool aquifer level fluctuated up and down throughout the year. Effective August 4, 2015, the Uvalde Pool was no longer in any stage of CPMP restrictions and on November 9, 2015, the EAA declared expiration of Stage I CPMP restrictions for the San Antonio Pool. For the remainder of 2015, the EAA did not declare any stages of CPMP restrictions for either pool. The 2015 CPMP enforced reductions resulted in a total reduction in annual permit amounts of 20.4 percent in the Uvalde Pool, and 19.7 percent in the San Antonio Pool.
Expanded Water Quality Monitoring (EAHCP §5.7.2; AR Section 3.1.6)	The EAA continued the Expanded Water Quality Monitoring Program in 2015, collecting additional samples and sample types to detect early signs of water quality impairments to the Comal and San Marcos rivers and spring systems. Data collection and sampling occurred throughout the year. Sampling activities were minimally affected by on-going drought conditions in the area. Significant rainfall occurred during the first half of 2015 and rain events were generally scattered in nature and often too small in magnitude to generate sufficient runoff to sample. However, on October 23-24, 2015, stormwater samples were obtained from the Comal and San Marcos rivers due to sufficient rain levels.
Biological Monitoring (EAHCP §6.3.1, §6.4.3, and §6.4.4; AR Section 3.1.7)	Rainfall in January 2015 ended critical period monitoring by January 30, 2015, in the Comal system. Rainfall over October 28-29, 2015 was intense enough to create flooding conditions in both the San Marcos and Comal rivers, which triggered high-flow, critical period sampling. The timing of the high-flow occurred shortly after the fall comprehensive sampling event and will now provide the best "before, after and recovery" data to date for evaluating system memory. In addition to this critical period high-flow sampling, the following sampling location strategies were employed: system-wide sampling, select longitudinal sampling, reach sampling, springs sampling, and river section/segment sampling.
Groundwater Modeling (EAHCP §6.3.2; AR Section 3.1.8)	During 2015, the updated MODFLOW groundwater flow model was used to develop an initial drought-of-record scenario using recharge and pumping estimates for years 1947 through 1958. Following recommendations from the Science Review Panel/National Academy of Sciences (SRP/NAS), EAA staff began to develop a set of MODFLOW model scenarios to be used in a comprehensive analysis of the effects of model uncertainty on

Measure (EAHCP Reference; 2015 Annual Report Section Reference)	Activities Undertaken in 2015
Edwards Aquifer Authority (EAA)	
	the modeled response of the aquifer to the various EAHCP Conservation Measures. This uncertainty analysis is scheduled to be completed by December 2016. The new finite-element model of the Edwards Aquifer was evaluated by EAA modeling staff during 2015. Overall, this model is not as effective as the updated MODFLOW model in matching observed water levels and springflows for the 2001–2011 calibration period; however, it can be useful as a tool to evaluate conceptual models for inter-formational movement of water between the Glen Rose and Edwards formations.
Ecological Modeling (EAHCP §6.3.3; AR Section 3.1.9)	Two modeling efforts began in 2014 and extended into 2015, the first being the development of a model for the principal categories of SAV in the Comal and San Marcos systems. As part of the project team, Baylor University researchers conducted several observational studies to better quantify the behavior of the vegetation communities in 2015. The second main modeling effort addressed the fountain darter population. To more effectively calibrate the Ecological Model, an *in-situ* study to measure fountain darter mortality was conducted. In addition, validation studies of the Ecological Model began in 2015, with one study designed to collect fountain darter data from randomly selected sampling sites beginning in 2015 and ending in 2016. A detailed presentation on the Ecological Model was provided at the February 11, 2015 meeting of the SC.
Impervious Cover and Water Quality Protection (EAHCP §5.7.6; AR Section 3.1.10)	All actions required by the EAA were completed prior to the current reporting period.
Program Management (Funding and Management Agreement; AR Section 3.1.11)	Program management activities completed in 2015 consisted of: undertaking budget process and financial duties; facilitating committee, public, stakeholder, and workgroup meetings; coordinating a kayak tour of the San Marcos and Comal springs systems for the SRP/NAS; photographing progress of restoration activities; undertaking the development of the *EAHCP Steward*, a bi-monthly newsletter for the EAHCP; coordinating regular monthly meetings between EAHCP staff and IC members from COSM, Texas State, and CONB to facilitate communication and coordination among Permittees; and presenting details of the current implementation of the EAHCP measures to educate students, teachers, and others on the fundamental background of the EAHCP. In 2015, EAHCP staff assisted the COSM, Texas State, and CONB in completing and submitting all permit applications and coordination letters appropriate for full compliance.

Measure (EAHCP Reference; 2015 Annual Report Section Reference)	Activities Undertaken in 2015
City of New Braunfels (CONB)	
Flow-Split Management in the Old and New Channel (EAHCP §5.2.1; AR Section 3.2.1)	The CONB routinely monitored stream flow conditions in the Comal River system, per U.S. Geological Survey (USGS) streamflow gauging stations, and for the first nine months of 2015 adjusted the flow-control gate. As supported by the SC, flows were not adjusted beyond 65 cfs in October, November, and December 2015, to allow for further analysis to determine whether sustained flow rates greater than 65 cfs would cause adverse impacts to habitat. Activities in 2015 included the weekly removal of accumulated vegetative material from the culvert area to prevent flow impediments from LL to the Old Channel.
Native Aquatic Vegetation Restoration and Maintenance (EAHCP §5.2.2; AR Section 3.2.2)	Aquatic vegetation restoration activities in 2015 included removal of non-native aquatic plant species, planting of target native aquatic plant species, and maintenance of restored areas within LL and the Old Channel of the Comal River. A total of 3,423 m^2 of *Hygrophila* was removed from target areas in 2015. 1,130 m^2 of area was planted in eight restoration plots bringing the three-year total of area planted in the Old Channel to 2,673 m^2. A total of 11,438 plants were planted. 926 m^2 of area was planted in seven restoration plots in LL bringing the three-year total of area planted in the lake to 2,694 m^2. A total of 9,989 plants were planted. It is estimated that approximately 5-10 percent of restored vegetation in LL and 10-15 percent of restored vegetation in the Old Channel was scoured by high flow velocities associated with the flood event on October 30, 2015. Flood debris such as large trees, vegetation, and litter was immediately removed from within the restoration areas following the flood event.
Management of Public Recreational Use of Comal Springs and River Ecosystems (EAHCP §5.2.3; AR Section 3.2.3)	The CONB continued to enforce City Ordinance Section 142-5, which restricts access to LL, the spring runs, and portions of the Comal River. The CONB Parks Department utilized trained park rangers who routinely patrolled Landa Lake Park to prevent access to these water bodies.
Decaying Vegetation Removal and Dissolved Oxygen Management (EAHCP §5.2.4; AR Section 3.2.4)	In 2015, the CONB contracted with SWCA to operate and maintain the existing water quality sonde and aeration system in LL. The CONB also contracted with BIO-WEST, Inc., Baylor University, and AquaStrategies in 2015 to conduct additional dissolved oxygen (DO) research in LL in response to concerns associated with the DO data collected during low-flow conditions in the summer and fall of 2014. DO monitoring was conducted in 2015 to further define spatial and temporal DO patterns within LL. A one-week spatial evaluation of DO was conducted within LL and the Upper Spring Run reach in 2015. A diffuser trial study in LL, aimed at evaluating the efficacy of the current aeration system, was also conducted. Based on the preliminary calculations and observations, additional work is recommended to more narrowly focus future diffuser deployments towards specific management objectives and to determine the most efficient mechanical technology capable of accomplishing objectives.
Control of Harmful Non-Native Animal Species (EAHCP §5.2.5; AR Section 3.2.5)	Removal efforts continued in 2015, with 113 vermiculated sailfin catfish, 516 tilapia, 8 nutria, and 411 ramshorn snails (totaling 1,308.83 pounds (lbs) of biomass) removed from LL. In the three years of removal efforts, noticeable impacts have already been observed on both the nutria and vermiculated sailfin catfish populations.

Measure (EAHCP Reference; 2015 Annual Report Section Reference)	Activities Undertaken in 2015
City of New Braunfels (CONB)	
Monitoring and Reduction of Gill Parasites (EAHCP §5.2.6; AR Section 3.2.6)	An identified concern for the fountain darter in the Comal Springs ecosystem is the continued presence of an Asian trematode, *Centrocestus formosanus*. A non-native snail, *Melanoides tuberculatus*, has been confirmed as *C. formosanus'* first intermediate host in central Texas. A system-wide snail survey was initiated in 2013 and repeated in 2014 and 2015 to investigate temporal changes in distribution, such as potential local colonization or extinction events. Overall, observed 2015 densities were lower and more stable over time than in 2014. In addition to studies on the host snails and drifting parasites, an effort was begun in 2014 and continued in 2015 to quantify parasite concentrations in the gills of wild fountain darters. DNA markers and morphological characters tested on preliminary 2015 data show the presence of variation and the existence of groups of snails.
Prohibition of Hazardous Materials Transport Across the Comal River and its Tributaries (EAHCP §5.2.7; AR Section 3.2.7)	The CONB finalized a map of proposed routes crossing the Comal River and its tributaries on which hazardous material (HAZMAT) transport will be prohibited. The proposed route prohibitions were presented to the CONB Transportation and Traffic Advisory Board on October 8, 2015, to gather input on the proposed route prohibitions.
Native Riparian Habitat Restoration (Riffle Beetle) (EAHCP §5.2.8; AR Section 3.2.8)	The CONB continued to improve CSRB habitat through riparian restoration tasks conducted in 2015 along the northwestern banks of Spring Run 3 and along approximately 600 ft of the western shoreline of LL. Restoration activities included: (1) removal and/or treatment of exotic vegetation; (2) construction and maintenance of erosion control structures; (3) revegetation utilizing native vegetation; and (4) sediment and vegetation monitoring.
Reduction of Non-Native Species Introduction and Live Bait Prohibition (EAHCP §5.2.9; AR Section 3.2.9)	The CONB developed educational materials designed to inform the public of invasive species issues and the negative impacts of aquarium dumping, including the CONB's *Making the Most of our Resources* newsletter that was distributed as an insert in 10,000 copies of the Sunday, July 5, 2015 edition of the local *New Braunfels Herald-Zeitung* newspaper. An educational piece was also included in the spring 2015 edition of the CONB's Parks and Recreation Program Guide referred to as "The Fun Things in Life." CONB also communicated with TPWD representatives regarding potential live bait restrictions and aquarium dumping prohibitions in LL.
Litter Collection and Floating Vegetation Management (EAHCP §5.2.10; AR Section 3.2.10)	The CONB continued to implement a program to remove litter and dislodge floating vegetation mats from LL and portions of the Comal River where Covered Species habitat is present. Litter collection efforts in 2015 consisted of litter removal from the surface of LL and the Spring Runs and litter removal from select portions of the Old Channel and from the bottom of LL utilizing Self-Contained Underwater Breathing Apparatus (SCUBA) equipment.
Management of Golf Course Diversions and Operations (EAHCP §5.2.11; AR Section 3.2.11)	The CONB continued to update the Integrated Pest Management Plan (IPMP) (part of the Golf Course Management Plan), as needed, and maintained a vegetative buffer between the golf course and LL and the Old Channel of the Comal River in order to provide increased water quality protection.

Measure (EAHCP Reference; 2015 Annual Report Section Reference)	Activities Undertaken in 2015
City of New Braunfels (CONB)	
Native Riparian Habitat Restoration (Old Channel Improvements) (EAHCP §5.7.1; AR Section 3.2.12)	The final design for Old Channel bank stabilization was completed after review by the SC, and final review and approval of the IC in early 2014. Based on input from the SC that resulted in integration of riparian zone improvements into the plan, and presented to the IC, a bid package was completed. Bids for the project were received in 2015, and Freese and Nichols, Inc. (F&N) was selected to provide bid-phase services. F&N processed the CONB floodplain permit, which included applicable hydrologic and hydraulic information.
Management of Household Hazardous Wastes (HHW) (EAHCP §5.7.5; AR Section 3.2.13)	The CONB held three HHW collection events in 2015. Overall, 483 car-visits were recorded, and a total of 54,595 lbs. of hazardous waste collected. The CONB produced educational materials to increase awareness of the HHW program and the EAHCP.
Impervious Cover and Water Quality Protection (EAHCP §5.7.6; AR Section 3.2.14)	The CONB continued the development of a Low Impact Development (LID) rebate program aimed at providing funding to homeowners, commercial business, and other property owners within the Comal River watershed to implement LID/water quality improvement projects on their properties. The program offers rebates specifically for impervious cover removal (and subsequent replacement with pervious concrete/paving), as well as for the installation of rain gardens and rainwater harvesting systems. In 2015, the CONB developed guidelines for the rebate program, a map of the rebate area, a rebate program application, and associated advertising materials In addition, the CONB developed a guide to be distributed to local residents to inform them of ways in which they can prevent potential pollutants from reaching endangered species habitat within the Comal system by adopting good lawn care, vehicle maintenance, and landscaping practices.
Measure (EAHCP Reference; 2015 Annual Report Section Reference)	**Activities Undertaken in 2015**
City of San Marcos (COSM)	
Texas wild-rice Enhancement and Restoration (EAHCP §5.3.1 and §6.3.5; AR Section 3.3.1)	Non-native aquatic vegetation was removed in areas suggested as optimal Texas wild-rice habitat. Non-native vegetation was also removed in mixed stands of Texas wild-rice, and the original Texas wild-rice stands were monitored for expansion. Similarly, for Texas wild-rice stands occupying optimal areas with adjacent non-native vegetation, the non-native vegetation was removed and the Texas wild-rice monitored for expansion. Portions of the denuded areas were planted with Texas wild-rice obtained from the San Marcos Aquatic Research Center (SMARC) (seed-derived) or from raceways (tiller-derived) located at the FAB. The estimated (based on an average number of individuals per pot) number of Texas wild-rice individuals planted November 2014 – November 2015 in the San Marcos River downstream of Sewell Park was 17,741. The net gain of Texas-wild rice area between 2014 and 2015 was 633 m^2. Areas of the San Marcos River downstream of Sewell Park were scoured during the October 30, 2015 flood event, resulting in loss of Texas wild-rice areal coverage.

Measure (EAHCP Reference; 2015 Annual Report Section Reference)	Activities Undertaken in 2015
City of San Marcos (COSM)	
Management of Recreation in Key Areas (EAHCP §5.3.2; AR Section 3.3.2)	The COSM managed recreation in key areas through a variety of strategies, including: access control; activities undertaken by the Conservation Crew (CC) such as education, vegetation removal, Texas wild-rice surveys, litter removal, and support of the State Scientific Area (SSA); designating buffer zones; implementing the Master Interpretation Plan; replacing stencils on rented tubes with signage and a video loop at City Park; and partnership with Texas State.
Management of Aquatic Vegetation and Litter below Sewell Park (EAHCP §5.3.3; AR Section 3.3.3)	Pristine Texas Rivers, Inc. (PTR) removed inorganic litter from upper Sewell Park to City Park, and from Rio Vista to Stokes Island. PTR used SCUBA equipment to remove underwater litter from the substrate and surface. Two flood events in 2015 deposited large amounts of litter, particularly below Interstate Highway (IH)-35. PTR shifted focus from the upstream section to the lower reaches to respond to these events.
Prohibition of Hazardous Materials Transport across the San Marcos River and Its Tributaries (EAHCP §5.3.4; AR Section 3.3.4)	The COSM initiated coordination with the Texas Department of Transportation (TxDOT) to designate Wonder World Drive from IH-35 to RR 12 as a Non-Radioactive Hazardous Materials (NRHM) Route. COSM staff contacted TxDOT to request a meeting to confirm the extent of supporting materials required to establish an NRHM route. The COSM has not, as of the time of writing this report, received a response from TxDOT.
Reduction of Non-Native Species Introduction (EAHCP §5.3.5; AR Section 3.3.5)	The COSM developed an education campaign outline to be implemented by Atlas Environmental, the CC, and student interns intended to increase public awareness regarding the harm of releasing non-native fish into the San Marcos River. The plan includes, but is not limited to, advertising, flyers, kiosk signage, donation locations for unwanted fish, and other strategies.
Sediment Removal below Sewell Park (EAHCP §5.3.6; AR Section 3.3.6)	In 2015, the COSM and Texas State obtained a TPWD Sand, Shell, and Gravel and Marl Permit (Permit No. 2015-I003). Sediment removal was conducted using a three-inch hydrosuction hose to remove accumulations of fine sediment. Before dredging, vegetation was removed and the area was fanned to encourage fountain darters and other biota to move out of the area. Texas State continued to remove fine sediment in the San Marcos River near the confluence with Purgatory Creek. Approximately 284 m^2 (i.e., 85 cubic meters [m^3]) of fine sediment was removed in the San Marcos River from November 2014 – November 2015.
Designation of Permanent Access Points and Bank Stabilization (EAHCP §5.3.7; AR Section 3.3.7)	A team of COSM, TPWD, and EAHCP personnel surveyed all the access points and made recommendations for changes to strengthen the access points. Temporary repairs were made in 2015 using concrete bags to stabilize the access points until permanent repairs can be accomplished.

Measure (EAHCP Reference; 2015 Annual Report Section Reference)	Activities Undertaken in 2015
City of San Marcos (COSM)	
Control of Non-Native Plant Species (EAHCP §5.3.8; AR Section 3.3.8)	Non-native aquatic vegetation removal focused on *Hydrilla verticillata*, *Hygrophila polysperma*, and *Nasturtium officinale*, as these species were the most actively invasive. Denuded areas were targeted for Texas wild-rice or selected native aquatic species planting based on habitat preferences for each native species. Texas wild-rice and native species were obtained from the USFWS, SMARC, or from raceways located at the FAB. An estimated 3,017.77 m^2 of non-native aquatic vegetation was removed in the San Marcos River downstream of Sewell Park to IH-35, from December 2014 – October 2015. An estimated number of native species planted in the San Marcos River downstream of Sewell Park was 24,552 individuals from December 2014 – October 2015. Estimated area planted with native species was 1,457 m^2 in the San Marcos River downstream of Sewell Park within areas removed of non-native vegetation. The removal of non-native littoral vegetation (such as elephant ear) consisted of the use of herbicide treatments.
Control of Harmful Non-Native and Predator Species (EAHCP §5.3.9; AR Section 3.3.9)	Non-native species control efforts in 2015 focused on tilapia, suckermouth catfish, red-rimmed melania, and giant ramshorn snails. From March through June (when tilapia are spawning), removal efforts focused on Spring Lake by bowfishing, spearfishing, and using gill nets. Suckermouth catfish were captured from Spring Lake to IH-35 using pole spears and hand-collection while snorkeling. Removal of red-rimmed melania and giant ramshorn snails consisted of hand-collection in areas of large concentrations in and near Spring Lake.
Native Riparian Habitat Restoration (EAHCP §5.7.1; AR Section 3.3.10)	The COSM undertook non-native tree, shrub and vine removal in Riverhouse, Wildlife Annex and Ramon Lucio parks throughout the spring and autumn of 2015. Erosion control and soil protection practices placed all the straight branches and trunks on contour and produced mulch on-site to fill between the contour logs. Most plantings were performed in March-April 2015 and October-November 2015 to take advantage of spring and fall rains. Sites planted included City, Rio Vista, Wildlife Annex, Crooks and Ramon Lucio parks. Across all sites, a five- to ten-foot buffer zone of access-prohibitive trees, shrubs and vines was planted along the length of the planting zone. Species were selected as recommended by local plant experts, the U.S. Department of Agriculture (USDA), USFWS, TPWD and TCEQ for riparian restoration projects.
Septic System Registration and Permitting Program (EAHCP §5.7.3; AR Section 3.3.11)	As of January 1, 2015, the San Marcos Environmental Health Department had registration records for 599 septic systems within COSM jurisdiction. Since January 1, 2015, three new septic systems were added into service bringing the total number up to 602 to date. These systems have been permitted and evaluated to prevent subsurface pollutant loadings into the Edwards Aquifer or the San Marcos River.
Minimizing Impacts of Contaminated Runoff (EAHCP §5.7.4; AR Section 3.3.12)	The EAHCP calls for the design and construction of two water quality best management practices (BMPs) to be located at Veramendi and Hopkins Street bridge for the purpose of capturing stormwater runoff before it enters the San Marcos River. The concept design report has been completed and the project has been submitted for funding through the U.S. Environmental Protection Agency (EPA) 319 grant. Awards will be announced early in 2016.

Measure (EAHCP Reference; 2015 Annual Report Section Reference)	Activities Undertaken in 2015
City of San Marcos (COSM)	
Management of HHW (EAHCP §5.7.5; AR Section 3.3.13)	The COSM operates a free HHW collection program available to all San Marcos and Hays County residents in an effort to reduce the risk of pollution to local water resources. The annual outreach goal for HHW is 1,400 total participants. In 2015, this goal was exceeded by 89 percent with an annual total of 2,646 participants. The average number of participants from drop-offs and reuse for 2015 was 221 participants per month, consisting of an average of 150 drop-off program participants per month, and 71 reuse program participants per month. The HHW program collected approximately 59,630 kilograms (kg) of household hazardous waste in 2015. The amount of household hazardous waste diverted from the waste stream and distributed by the reuse program totaled 5,769 kg.
Impervious Cover and Water Quality Protection (EAHCP §5.7.6; AR Section 3.3.14)	In support of the 2015 Water Quality Protection Plan (WQPP), the COSM undertook a variety of activities, including (but not limited to): updating the 2014 WQPP with revisions based on stakeholder feedback; completing City Park BMP design and specifications; providing review of several public and private projects for BMP inclusion; presenting the WQPP at the CodeSMTX environmental workshop; submitting BMP projects for funding through the EPA 319 grant process; modifying recharge zone water quality code, cluster incentives and landscape ordinances; and beginning development of a land conservation program.
Measure (EAHCP Reference; 2015 Annual Report Section Reference)	**Activities Undertaken in 2015**
Texas State University (Texas State)	
Texas wild-rice Enhancement and Restoration (EAHCP §5.4.1; AR Section 3.4.1)	Non-native aquatic vegetation was removed in areas suggested as optimal Texas wild-rice habitat. Non-native vegetation was also removed in mixed stands of Texas wild-rice, and the original Texas wild-rice stand was monitored for expansion. Similarly, for Texas wild-rice stands occupying optimal areas with adjacent non-native vegetation, the non-native vegetation was removed. Texas wild-rice was not planted in the San Marcos River from Spring Lake Dam downstream through Sewell Park from November 2014 through October 2015. Instead, area maintenance was performed through the removal of non-native species and continued monitoring of existing Texas wild-rice stands. In November 2015, the coverage of Texas wild-rice within MCWE sites in the San Marcos River from Spring Lake Dam downstream through Sewell Park was estimated at 1,774.28 m^2, which is an estimated increase of 575.39 m^2, or 48 percent, from 2014. Areas of the Sewell Park reach were scoured during the October 30, 2015 flood event resulting in loss of Texas wild-rice areal coverage.
Management of Recreation in Key Areas (EAHCP §5.4.2; AR Section 3.4.2)	For a discussion related to Texas State's Activities Undertaken in 2015 related to this Conservation Measure, please refer to the summary located under the COSM heading, in the *Management of Recreation in Key Areas (EAHCP §5.3.2; AR Section 3.3.2)* in this table.

Measure (EAHCP Reference; 2015 Annual Report Section Reference)	Activities Undertaken in 2015
Texas State University (Texas State)	
Management of Vegetation (EAHCP §5.4.3; AR Section 3.4.3)	Texas State undertook efforts to manage the aquatic vegetation in Spring Lake through the following measures: • Spring Orifice Maintenance: accumulated sediment was removed where necessary from target springs in Spring Lake by finning the substrate away. In addition, aquatic vegetation was removed from an approximately 1.5-meter radius of each target spring with a machete. • Harvester Boat: Management of submerged and floating aquatic vegetation followed the protocols outlined in the EAHCP (EAHCP §5.4.3.1) and the approved Spring Lake Management Plan. The total estimated harvest was approximately 1,112.5 cubic yards for the year. Texas State also collaborated with the COSM to control aquatic vegetation mats entrained on Texas wild-rice stands below Spring Lake Dam to the end of Sewell Park.
Sediment Removal in Spring Lake and Sewell Park (EAHCP §5.4.4; AR Section 3.4.4)	No dredging occurred from the San Marcos River in Spring Lake through Sewell Park during 2015.
Diversion of Surface Water (EAHCP § 5.4.5; AR Section 3.4.5)	Texas State did not reduce permitted pumping in 2015 to meet EAHCP requirements, since total San Marcos River flows did not reach trigger points (e.g., < 80 cfs). Texas State did, however, continue to voluntarily suspend pumping from the San Marcos River at Sewell Park (Certificate 18-3866). The total volume of surface water diversions from Spring Lake was 38 ac-ft/year for 2015, below the permitted 100 ac-ft/year. Maximum instantaneous diversion rates did not exceed the permitted amount of 1.33 cfs. Texas State continued to use a 0.25-inch mesh screen to cover the intake for surface water diversions. No fountain darters were observed when the screens were cleaned.
Restoration of Native Riparian Vegetation (EAHCP § 5.7.1; AR Section 3.4.6)	For a discussion related to Texas State's Activities Undertaken in 2015 related to this Conservation Measure, please refer to the summary located under the COSM heading, in the *Native Riparian Habitat Restoration (EAHCP §5.7.1; AR Section 3.3.10)* in this table.
Sessom Creek Sand Bar Removal (EAHCP §5.4.6; AR Section 3.4.7)	The Adaptive Hydraulics Modeling System was utilized to model existing conditions and three alternative scenarios that ranged from full sediment bar removal versus differential channel configurations. The report recommended removal using backhoe and was approved by the SC and the IC. The removal is planned for December 2015 or early 2016.
Diving Classes in Spring Lake (EAHCP §5.4.7; AR Section 3.4.8)	The MCWE updated the Spring Lake Management Plan to reflect all the requirements under the ITP and EAHCP. MCWE implemented a Diving Program Control Board that reviews all diving activities within Spring Lake to ensure they comply with the Spring Lake Management Plan and the EAHCP. These efforts also include the development of the Spring Lake Dive Accident Management Plan and revisions to the Diving for Science Program (D4S), which has implemented a more rigorous training program that includes expanded training and orientation on the endangered species. A total of 4,322 dives were recorded from January 2015 through the time of this report preparation.

Measure (EAHCP Reference; 2015 Annual Report Section Reference)	Activities Undertaken in 2015
Texas State University (Texas State)	
Research Programs in Spring Lake (EAHCP §5.4.8; AR Section 3.4.9)	MCWE developed an online access request form in order to oversee access to Spring Lake. Each request is reviewed by an eight-member committee, and if a vertebrate animal is the target of research, the Institutional Animal Care and Use Committee is also consulted for approval. In the event that the proposed research involves diving, the application and methods are reviewed by the Spring Lake Diving Control Board and if necessary, Scientific Diving training is required prior to access. Nineteen research and/or access activities were recorded in Spring Lake in 2015.
Management of Golf Course and Grounds (EAHCP §5.4.9; AR Section 3.4.10)	Texas State golf course operations followed the 2015 Golf Course Management Plan and IPMP guidelines based on both the EAHCP (EAHCP §5.4.9) and the Spring Lake Management Plan.
Boating in Spring Lake and Sewell Park (EAHCP §5.4.10; AR Section 3.4.11)	The Spring Lake Management Plan was modified to ensure consistency with the EAHCP measures outlined in EAHCP (EAHCP §5.4.10) for activities in Spring Lake. A total of 6,943 glass-bottom boat tours and 149 glass-bottom kayak tours were conducted in 2015. Canoeing/kayak classes in Sewell Park were limited to the region between Sewell Park and Rio Vista Dam as specified in the EAHCP. The October 30, 2015 flood caused closure of all Spring Lake programs.
Reduction of Non-Native Species Introduction (EAHCP §5.4.11; AR Section 3.4.12)	For a discussion related to Texas State's Activities Undertaken in 2015 related to this Conservation Measure, please refer to the summary located under the COSM heading, in the *Reduction of Non-Native Species Introduction (EAHCP §5.3.5; AR Section 3.3.5)* in this table.
Control of Non-Native Plant Species (EAHCP §5.4.12; AR Section 3.4.13)	Non-native aquatic vegetation removal focused on *Hydrilla verticillata*, *Hygrophila polysperma*, and *Nasturtium officinale* as these species are the most actively invasive. Denuded areas were targeted for Texas wild-rice or selected native aquatic species planting based on habitat preferences for each native species. Texas wild-rice and native species were obtained from the SMARC or from raceways located at the FAB. An estimated 133.48 m^2 of non-native aquatic vegetation was removed in the San Marcos River from Spring Lake Dam downstream through Sewell Park from December 2014 - October 2015 Reduction of non-native vegetation from 2014-2015 among MCWE work sites in Sewell Park was estimated at 334 m^2. The October 30, 2015 flood event scoured certain areas of the river, and in some instances, helped remove areas of non-native vegetation.
Control of Harmful Non-Native and Predator Species (EAHCP §5.4.13; AR Section 3.4.14)	For a discussion related to Texas State's Activities Undertaken in 2015 related to this Conservation Measure, please refer to the summary located under the COSM heading, in the *Control of Harmful Non-Native and Predator Species (EAHCP §5.3.9; AR Section 3.3.9)* in this table.

Measure (EAHCP Reference; 2015 Annual Report Section Reference)	Activities Undertaken in 2015
City of San Antonio through the San Antonio Water System (SAWS)	
Use of the SAWS ASR for Springflow Protection (EAHCP §5.5.1 and §5.5.2; AR Section 3.5.1)	Under an interlocal contract (ILC) between the EAA and SAWS, SAWS is required to credit to the EAA as being in storage any permitted Edwards Aquifer water for which it receives a Notice of Availability (NOA) from the EAA by certain dates detailed further in the ILC, or based on metered recharge for NOAs received by SAWS after certain dates. The ASR leasing program satisfied 89.1 percent of its enrollment goal for Tier 1 in 2015. Enrollment is on-going, and the program will continue to be adjusted to respond to the dynamics of the market. Of the total 14,849.516 ac-ft available to the EAA in 2015, EAA made available 11,575.016 ac-ft, withholding 22.1 percent to meet expected CPMP permit reductions. The EAA issued twelve NOAs to SAWS during the months ASR leases were accepted by the EAA Board of Directors. Eight NOAs were issued to SAWS authorizing 11,575.016 ac-ft for injection into the ASR before June 30, 2015, and four NOAs were issued to SAWS authorizing 0 ac-ft for injection into the ASR after June 30, 2015. The widespread and regular rains in 2015 led to a dramatic increase in ASR leasing activities.

Measure (EAHCP Reference; 2015 Annual Report Section Reference)	Activities Undertaken in 2015
Texas Parks & Wildlife Department (TPWD)	
State Scientific Areas (SSA) (EAHCP §5.6.1; AR Section 3.6.1)	TPWD designated a two-mile segment of the San Marcos River as an SSA, in conformance with 30 Texas Administrative Code (TAC) 57.910. This scientific area is designed to protect Texas wild-rice by restricting recreation in these areas during flow conditions below 120 cfs. The TPWD, COSM and Texas State designed, produced and installed signs and information kiosks during the summer of 2013, and maintained them during 2014. In 2015, the TPWD began efforts to produce Spanish language versions of the signs and kiosks.

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ACRONYMS AND ABBREVIATIONS

ac-ft	acre-foot/acre-feet
AMP	Adaptive Management Process
AR	Annual Report
ARWG	Applied Research Work Group
ASR	Aquifer Storage and Recovery
ASRPP	Aquifer Storage and Recovery Pooling Program
Atlas	Atlas Environmental
BIO-WEST	BIO-WEST, Inc.
BMP(s)	best management practice(s)
CC	Conservation Crew
cfs	cubic feet per second
cm	centimeter
COI	Certificate of Inclusion
CONB	City of New Braunfels
COSM	City of San Marcos
CPMP	Critical Period Management Program
CPS Energy	City Public Service Energy
CSRB	Comal Springs Riffle Beetle
yd^3	cubic yards
°C	degrees Celsius
DEHP	Bis(2-ethylhexyl) phthalate
D4S	Diving for Science
DoD	U.S. Department of Defense
DO	dissolved oxygen
EAA	Edwards Aquifer Authority
EAHCP	Edwards Aquifer Habitat Conservation Plan
EARDC	Edwards Aquifer Research and Data Center
EARIP	Edwards Aquifer Recovery Implementation Program
EBR	EBR Enterprises
EPA	U.S. Environmental Protection Agency
ERPA	Environmental Restoration and Protection Area
ESA	federal Endangered Species Act of 1973
FAB	Freeman Aquatic Building
FMA	Funding and Management Agreement
F&N	Freese & Nichols, Inc.
ft	foot/feet
ft^3	cubic feet
GBC	Guadalupe Basin Coalition
GFI	ground fault interrupter
GBRA	Guadalupe-Blanco River Authority
HAZMAT	Hazardous Material
HCP	Habitat Conservation Plan
HDR	HDR Engineering, Inc.

Acronyms and Abbreviations (Continued)

HHW	Household Hazardous Waste
IA	Implementing Agreement
IC	Implementing Committee
IH	Interstate Highway
ILA	Interlocal Agreement
ILC	Interlocal Contract
IPMP	Integrated Pest Management Plan
ITP	Incidental Take Permit
lbs	pounds
LID	Low Impact Development
LL	Landa Lake
m^2	square meters
m^3	cubic meters
MCL	maximum contaminant level
MCWE	Meadows Center for Water and the Environment
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
MS4	Municipal Separate Storm Sewer System
msl	mean sea level
µS/cm	micro-Siemens per centimeter
NAS	National Academy of Sciences
NAS *Report 1*	*National Academy of Sciences – Review of the Edwards Aquifer Habitat Conservation Plan: Report 1*
NAS RRWG	NAS Recommendations Review Work Group: Report 1
NBU	New Braunfels Utilities
NCR	New Channel Reach
No.	Number
NOA	Notice of Availability
NRA	Nueces River Authority
NRHM	Non-Radioactive Hazardous Material
NTU	nephelometric turbidity units
NWF	National Wildlife Federation
OCR	Old Channel Reach
oz.	ounce
PAH	non-polycyclic or polycyclic aromatic hydrocarbon
PAR	Photosynthetically Available Radiation
PDS	Passive Diffusion Samplers
PEC	probable effect concentration
PTR	Pristine Texas Rivers, Inc.
RFP(s)	Request for Proposal(s)
RTI	Real Time Instrumentation
RWCP	Regional Water Conservation Program
SARA	San Antonio River Authority
SAV	submerged aquatic vegetation
SAWS	San Antonio Water System

Acronyms and Abbreviations (Continued)

SC	Adaptive Management Science Committee
scfm	standard cubic feet per minute
SCUBA	Self Contained Underwater Breathing Apparatus
SCTWAC	South Central Texas Water Advisory Committee
Service	U.S. Fish & Wildlife Service
SH	Adaptive Management Stakeholder Committee
SMARC	San Marcos Aquatic Research Center
SMRF	San Marcos River Foundation
SOP	Standard Operating Procedure
sp./spp.	species (singular)/species (plural)
SRP	Science Review Panel
SRP/NAS	Science Review Panel/National Academy of Sciences
SSA	State Scientific Area
SWCA	SWCA Environmental Consultants
SWMP	Stormwater Management Plan
TAC	Texas Administrative Code
TACA	Texas Aggregate and Concrete Association
TCEQ	Texas Commission on Environmental Quality
TDA	Texas Department of Agriculture
Texas State	Texas State University
TTU	Texas Tech University
THC	Texas Historical Commission
TPW	Texas Parks & Wildlife
TPWD	Texas Parks & Wildlife Department
TWDB	Texas Water Development Board
TxDOT	Texas Department of Transportation
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish & Wildlife Service
USGS	U.S. Geological Survey
USR	Upper Spring Run
UTSA	University of Texas at San Antonio
VISPO	Voluntary Irrigation Suspension Program Option
WPP	watershed protection plan
WQPP	Water Quality Protection Plan

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1.0 BACKGROUND AND 2015 EDWARDS AQUIFER CONDITIONS, MANAGEMENT, AND NOTABLE CHALLENGES – FLOOD, EAHCP OVERSIGHT, AND COORDINATION

The Edwards Aquifer Habitat Conservation Plan (EAHCP)[3] was approved by the U.S. Fish & Wildlife Service (Service or USFWS) as a regional plan to protect the Edwards Aquifer and the federally-listed species associated therewith while helping to ensure stability of the Edwards Aquifer as a water supply for the region (RECON et al. 2012). After approval of the EAHCP, the Service issued an Incidental Take Permit (ITP) under the federal Endangered Species Act of 1973 (ESA), with an effective date of March 18, 2013.

The permit is ITP No. TE-63663A-1 issued to five cooperating Permittees: the Edwards Aquifer Authority (EAA); the City of New Braunfels (CONB); the City of San Marcos (COSM); Texas State University (Texas State); and the City of San Antonio acting by and through its San Antonio Water System (SAWS) Board of Trustees. The permit authorizes certain "Covered Activities" (EAHCP Chapter 2.0), even under circumstances where the activities may incidentally cause "take" of a covered species. The EAHCP identifies four categories of activities that may result in incidental take: "(1) the regulation and use of the Edwards Aquifer; (2) recreational activities in the Comal and San Marcos springs and river ecosystems; (3) other activities in, and related to, the Comal and San Marcos springs and river ecosystems; and (4) activities involved in and related to the implementation of the minimization and mitigation measures in these ecosystems" (EAHCP §2.1). The Adaptive Management Process (AMP) may also result in incidental take (EAHCP §2.8). Condition K of the ITP was amended in January 2015 to allow the EAA to contract with parties others than the Service for the off-site refugia (EAHCP §6.4), while continuing to support and coordinate with the Service on this effort. A copy of the amended ITP is contained in **Appendix A1** of this report.

The ITP provides incidental take coverage for authorized activities in Uvalde, Medina, Atascosa, Bexar, Comal, Guadalupe, Hays, and Caldwell counties, Texas, within the area in which pumping from the Edwards Aquifer is regulated by the EAA (**Figure 1.0-1**).

The species covered under the EAHCP are listed in **Table 1.0-1**.

Table 1.0-1. Covered Species under the EAHCP ITP

Common Name	Scientific Name	Federal Status	Associated Springs in the EAHCP
Fountain Darter	*Etheostoma fonticola*	Endangered	Comal & San Marcos
San Marcos Gambusia	*Gambusia georgei*	Endangered	San Marcos
Comal Springs Dryopid Beetle	*Stygoparnus comalensis*	Endangered	Comal
Comal Springs Riffle Beetle	*Heterelmis comalensis*	Endangered	Comal & San Marcos
Peck's Cave Amphipod	*Stygobromus pecki*	Endangered	Comal & San Marcos
Texas Wild-Rice	*Zizania texana*	Endangered	San Marcos
Texas Blind Salamander	*Eurycea (+Typhlomolge) rathbuni*	Endangered	San Marcos
San Marcos Salamander	*Eurycea nana*	Threatened	San Marcos
Texas Cave Diving Beetle*	*Haideoporus texanus*	Petitioned	Comal & San Marcos
Comal Springs Salamander	*Eurycea sp.*	Petitioned	Comal & San Marcos
Texas Troglobitic Water Slater	*Lirceolus smithii*	Petitioned	San Marcos

* Also known as the "Edwards Aquifer Diving Beetle."

[3] All acronyms and abbreviations in this Annual Report are defined in the list of ACRONYMS AND ABBREVIATIONS located on pages xxxii-xxxiv of this Annual Report.

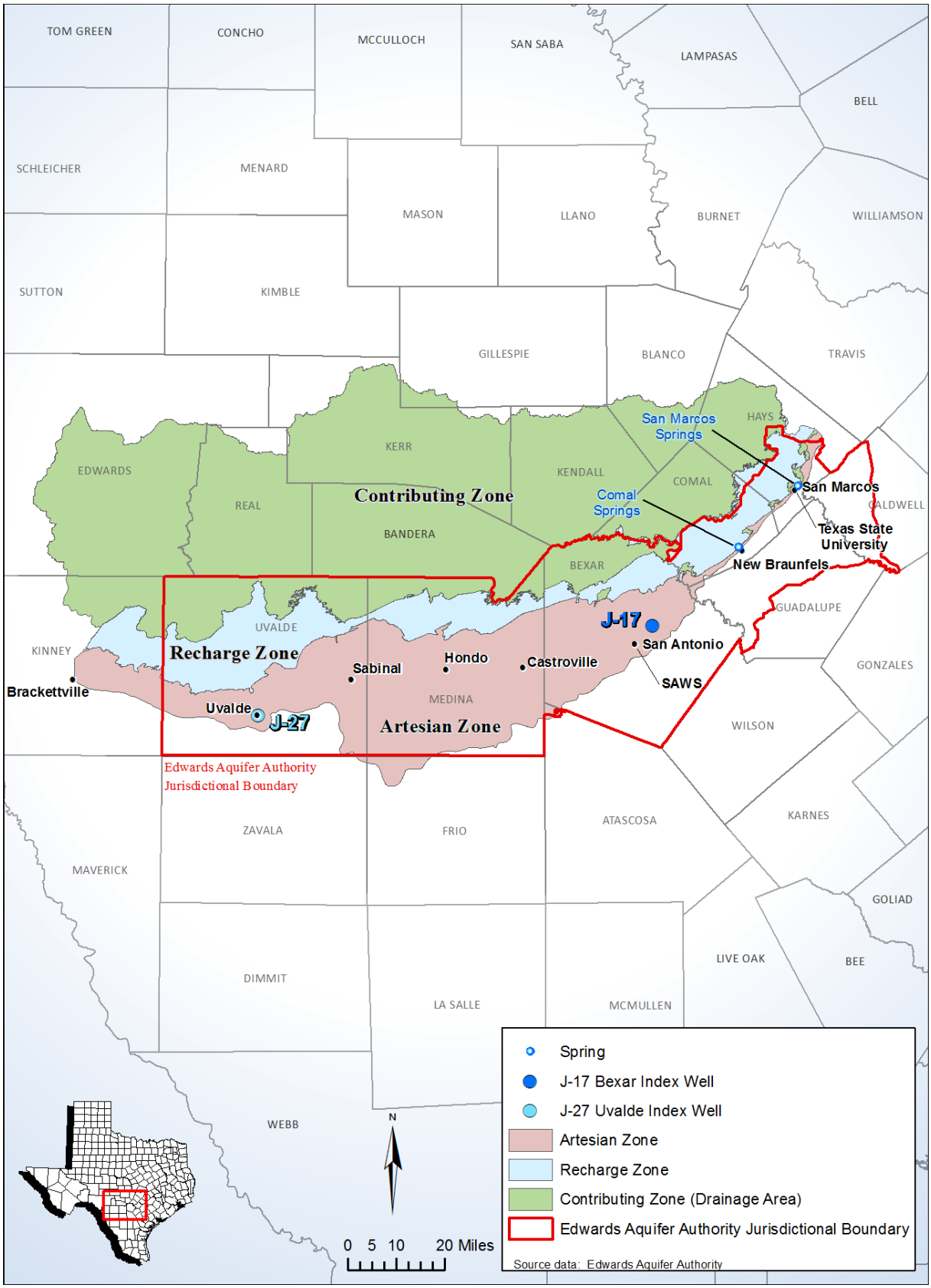

Figure 1.0-1. Incidental Take Coverage Area for ITP No. TE-63663A-1 (EAA Jurisdictional Boundary).

1.1 Incidental Take Permit Requirements

The ITP lists many requirements and conditions, among which are the elements to be included in an Annual Report. The ITP requires an Annual Report be submitted to the USFWS Austin Ecological Services Office and to the USFWS Albuquerque Region 2 Office by March 31 of each year. As specified by Condition U of the ITP (see **Appendix A1**), "The report will document the Permittees' activities and permit compliance for the previous year, thus documenting progress toward the goals and objectives of the Edwards Aquifer Recovery Implementation Program (EARIP) Habitat Conservation Plan (HCP) and demonstrating compliance with the terms and conditions of this incidental take permit."

A condition of the ITP, the Annual Report or its appendices will include the following:

- EAA permitted withdrawals;
- Reference well levels;
- Springflows at Comal and San Marcos springs;
- Aquifer recharge;
- Aquifer discharge from wells and springflow;
- Critical period management reductions;
- Water quality data;
- Location of sampling sites;
- Methods for data collection and variables measured;
- Frequency, timing, and duration of sampling for these variables; and
- Description of the data analysis and who conducted the analysis.

The ITP additionally requires documentation of the following management activities:

- Adaptive management undertaken during the year;
- Expenditures by the EAA on implementation activities;
- Proposed activities for the next year;
- Report on the status of implementation of minimization and mitigation measures and their effectiveness;
- Interim updates and final copies of any research, thesis or dissertation, or published studies accomplished in association with the EARIP or EAHCP;
- Description of species-specific research and management actions undertaken with specific reference to the biological goals and objectives identified for each species;
- Any changes to the Biological Goals and Key Management and Flow-related Objectives of the EAHCP and the reasons for such changes;
- Any changes to the objectives for the monitoring program;
- Effects on the Covered Species or Permit Area;
- Evaluation of progress towards achieving the Biological Goals and Objectives; and
- Any recommendations regarding actions to be taken.

Table 1.1-1 identifies each condition of the ITP as it is stated in the ITP, and provides a reference for the EAHCP Permittees' efforts in 2015 as documented in this Annual Report to comply with these conditions.

Table 1.1-1. ITP Conditions and EAHCP 2015 Annual Report Section References Documenting Permittee Compliance Efforts

ITP Condition	ITP Condition Subsection	ITP Condition Title	Annual Report Section Reference
D.		Acceptance of the permit serves as evidence that the Permittees agree to abide by all conditions stated. Terms and conditions or the permit are inclusive. Any activity not specifically permitted is prohibited. Please read through these conditions carefully as violations of permit terms and conditions could result in your permit being suspended or revoked. Violations of your permit terms and conditions that contribute to a violation of the Endangered Species Act (ESA or Act) could also subject Permittees to criminal or civil penalties.	1.0
E.		The authorization granted by this Permit will be subject to full and complete compliance with and implementation of the EARIP HCP and all specific conditions contained herein. The Permit terms and conditions shall supersede and take precedence over any inconsistent provisions in the HCP or other program documents.	1.0
F.		This permit does not include incidental take coverage for any federal facility which withdraws groundwater from the Edwards Aquifer.	1.0
G.		COVERED SPECIES: This permit only authorizes incidental take of animal species, or impacts to plant species of the following 11 species: 1) Fountain Darter, 2) San Marcos Gambusia, 3) Comal Springs Dryopid Beetle, 4) Comal Springs Riffle Beetle, 5) Peck's Cave Amphipod, 6) Texas Wild Rice, 7) Texas Blind Salamander, 8) San Marcos Salamander, 9) Texas cave diving beetle, 10) Comal Springs Salamander, 11) Texas Troglobitic Water Slater	1.0 (Table 1.1-1)
H.		INCIDENTAL TAKE AUTHORIZATION: The following amount of incidental take is authorized by this permit over the 15 year permit term.	5.0 (Table 5.0-1)
	1.	No more than 797,000 fountain darters in Comal Springs, Landa Lake and the Comal River, and no more than 549,129 fountain darters in the San Marcos Springs, Spring Lake, and San Marcos River.	5.0 (Table 5.0-1)
	2.	No more than 11,179 Comal Springs riffle beetles.	5.0 (Table 5.0-1)
	3.	No more than 1,543 Comal Springs dryopid beetles.	5.0 (Table 5.0-1)
	4.	No more than 18,224 Peck's cave amphipod.	5.0 (Table 5.0-1)
	5.	No more than 10 Texas Blind salamanders.	5.0 (Table 5.0-1)
	6.	No more than 263,857 San Marcos salamanders.	5.0 (Table 5.0-1)
	7.	Incidental take of the Texas cave diving beetle will be provided for individuals of the species killed, harmed, or harassed by springflows with monthly averages above 50.5 cfs (1.43 cms) during HCP Phase I; and by springflows with monthly averages above 51.2 cfs (1.45 cms) during Phase II at San Marcos Springs, if and when this species is listed as threatened or endangered and as long as the HCP is fully implemented. Take limits will be exceeded if these minimum flow rates are not met.	Not applicable, as species not listed during report period.

Table 1.1-1. ITP Conditions and EAHCP 2015 Annual Report Section References Documenting Permittee Compliance Efforts

ITP Condition	ITP Condition Subsection	ITP Condition Title	Annual Report Section Reference
	8.	Incidental take of the Texas troglobitic water slater will be provided for individuals of the species killed, harmed, or harassed by springflows with monthly averages above 50.5 cfs (1.43 cms) during HCP Phase I; and by springflows with monthly averages above 51.2 cfs (1.45 cms) during Phase II at San Marcos Springs, if and when this species is listed as threatened or endangered and as long as the HCP is fully implemented. Take limits will be exceeded if these minimum flow rates are not met.	Not applicable, as species not listed during report period.
	9.	Incidental take of the Comal Springs salamander will be provided for individuals of the species killed, harmed, or harassed by springflows with monthly averages above 27 cfs (0.76 cms) during HCP Phase I and by continuous springflows to 45 cfs (1.27 cms) during Phase II at Comal Springs if and when this species is listed as threatened or endangered, as long as the HCP is fully implemented. Take limits will be exceeded if these minimum flow rates are not met.	Not applicable, as species not listed during report period.
I.		The endangered San Marcos gambusia has not been collected since 1982 and may no longer exist in the wild, but the Service will provide incidental take coverage for individuals of this species resulting from the covered activities if the species is located or becomes established within the Permit Area, as long as the HCP is fully implemented.	Not applicable, as species neither located nor established during report period.
J.		COVERED AREA: This permit only authorizes incidental take of covered species within all of Bexar, Medina, and Uvalde counties, and parts of Atascosa, Comal, Caldwell, Hays, and Guadalupe counties (Permit Area).	1.0
K.		The EAA will support and coordinate with the U.S. Fish and Wildlife Service (Service) on the work relating to the San Marcos Aquatic Resource Center's operation and maintenance of a series of off-site refugia at the Service's San Marcos, Uvalde, and Inks Dam facilities (Section 6.4 of the HCP). The support of the refugia will augment the existing financial and physical resources of these facilities, and provide supplementary resources for appropriate research activities, as necessary, to house and protect adequate popUlations of Covered Species and expanded knowledge of their biology, life histories, and effective reintroduction techniques. The use of this support will be limited to the Covered Species in the EARIP HCP.	3.1.2
L.		COVERED ACTIVITIES FOR WHICH THE INCIDENTAL TAKE IS AUTHORIZED - BY PERMITTEE	3.0
	1.	Edwards Aquifer Authority (EAA)	3.1
	2.	City of New Braunfels (CONB)	3.2
	3.	City of San Marcos (COSM)	3.3
	4.	Texas State University (TXSTATE)	3.4

Table 1.1-1. ITP Conditions and EAHCP 2015 Annual Report Section References Documenting Permittee Compliance Efforts

ITP Condition	ITP Condition Subsection	ITP Condition Title	Annual Report Section Reference
	5.	San Antonio Water System (SAWS)	3.5
M.		The Permittees are jointly responsible for the following measures that specifically contribute to recovery and for which incidental take is authorized:	3.0
	1.	Comal Springs, Landa Lake, and the Comal River:	3.2
	2.	San Marcos Springs, Spring Lake, and the San Marcos River:	3.3 - 3.4
N.		Upon locating a dead, injured, or sick individual of the covered species, or any other endangered or threatened species, the Permittee is required to contact the Service's Law Enforcement Office in Austin, Texas, (512) 490-0948 for care and disposition instructions. Extreme care should be taken in handling sick or injured individuals to ensure effective and proper treatment. Care should also be taken in handling dead specimens to preserve biological materials in the best possible state for analysis of cause of death. In conjunction with the care of sick or injured endangered/threatened species, or preservation of biological materials from a dead specimen, the Permittee and any contractor/subcontractor has the responsibility to ensure that evidence intrinsic to the specimen is not unnecessarily disturbed.	No events meeting this description were reported for 2015.
O.		Conditions of the permit shall be binding on, and for the benefit of, the Permittees and any successors and/or assignees. If the permit requires an amendment because of change of ownership, the Service will process it in accordance with regulations (50 CFR 13.23). Any new Permittee must meet issuance criteria per regulations at 50 CFR 13.25. The covered activities proposed or in progress under the original permit may not be interrupted, provided the conditions of the permit are being followed.	No changes in ownership, or interruptions in Covered Activities, to report.
P.		If, during the tenure of the permit, the project design and/or the extent of the habitat impacts is altered, such that there may be an increase in the anticipated take of covered species, the Permittees are required to contact the Service's Austin Ecological Services Office (ESFO) and obtain an amendment to this permit before commencing any construction or other activities that might result in take beyond that authorized by this permit. If authorized take is exceeded, all activities that are shown to cause take must immediately cease and any take above that authorized shall be reported to the Austin Ecological Services Field Office (505/490-0057) within 48 hours.	No increases in anticipated take, or exceedance of authorized take, to report.
Q.		If actions associated with implementation of the EARIP HCP are shown to result in incidental take of listed species not covered by this permit, those activities that are shown to cause take must immediately cease and any take that has occurred shall be reported to the Austin Ecological Services Field Office (505/490-0057) within 48 hours.	No events meeting this description were reported for 2015.
R.		CHANGED CIRCUMSTANCES	4.0
T.		MONITORING REQUIREMENTS	3.0

Table 1.1-1. ITP Conditions and EAHCP 2015 Annual Report Section References Documenting Permittee Compliance Efforts

ITP Condition	ITP Condition Subsection	ITP Condition Title	Annual Report Section Reference
	1.	The Permittees will monitor compliance with the HCP and provide an annual report as described below.	1.1
	2.	The Permittees will develop a monitoring program to determine whether progress is being made toward meeting the long-term biological goals and objectives.	3.1.7
	3.	The Permittees will develop and oversee a monitoring program to identify and assess potential impacts, including incidental take, from Covered Activities and provide a better understanding and knowledge of the species' life cycles and desirable water quality- and springflow-related habitat requirements of the Covered Species (section 6.3 of the HCP).	3.1.6
U.		Annual Reporting:	
	1.	The EARIP Applicants will provide an annual report, due on March 31 of each year	1.1
	2.	The report will document the Permittees' activities and permit compliance for the previous year, thus documenting progress toward the goals and objectives of the EARIP HCP and demonstrating compliance with the terms and conditions of this incidental take permit. The annual report will include:	1.1
	a.	EAA Permitted withdrawals	Appendix E
	b.	Reference well levels	Appendix D
	c.	Springflows at Comal and San Marcos Springs	Appendix D
	d.	Aquifer recharge	Appendix D
	e.	Aquifer discharge from wells and springflow	Appendix D
	f.	Critical period management reductions	3.1.5
	g.	Water quality data	Appendix C
	h.	Location of sampling sites	Appendix C
	i.	Methods for data collection and variables measured	Appendix C
	j.	Frequency, timing, and duration of sampling for the variables	Appendix C
	k.	Description of the data analysis and who conducted the analysis	Appendix C
	3.	The report will document HCP Management activities, including:	
	a.	Adaptive management activities undertaken during the year	4.0
	b.	Expenditures by the EAA on implementation activities	1.3
	c.	Proposed activities for the next year	Appendix J
	d.	Report on the status of implementation of minimization and mitigation measures and their effectiveness	3.0
	e.	Interim updates and final copies of any research, thesis or dissertation, or published studies accomplished in association with the EARIP or HCP	3.1.1, 7.0
	f.	Description of species-specific research and management actions undertaken with specific reference to the biological goals and objectives identified for each species	3.1.1

Table 1.1-1. ITP Conditions and EAHCP 2015 Annual Report Section References Documenting Permittee Compliance Efforts

ITP Condition	ITP Condition Subsection	ITP Condition Title	Annual Report Section Reference
	g.	Any changes to the Biological Goals and Key Management and Flow-related Objectives of the HCP and the reasons for such changes	No changes during report period.
	h.	Any changes to the objectives for the monitoring program	No changes during report period.
	i.	Effects on the Covered Species or Permit Area	No effects documented during report period.
	j.	Evaluation of progress toward achieving the Biological Goals and Objectives.	2.0
	k.	Any recommendations regarding actions to be taken	6.0
	4.	Information provided in the annual report will be used to determine what, if any, adaptive management strategies should be implemented to most effectively implement the conservation program outlined in the EARIP HCP and to ensure that management changes in response to new, appropriate data are implemented in a timely fashion.	6.0

This document serves as the Annual Report for the calendar year 2015. The comments received on earlier drafts of the 2015 Annual Report are included in **Appendix B**.

1.2 2015 Edwards Aquifer Conditions, Management and Notable Conditions - Flood

Springflow, well discharge, and recharge data are included in the 2014 Hydrological Report (**Appendix D**). **Appendix E** contains a listing of all EAA permitted wells.

In 2015, the Edwards Aquifer Region experienced two major storm events – May 23-25, 2015, and October 30, 2015. In terms of the EAHCP mitigation measures and Covered Species habitat, the October flood was the more detrimental due to increased streamflow, specifically in the San Marcos River (**Figure 1.2-1**). During this event the instantaneous peak stream flow was 20,900 cubic feet per second (cfs) in the San Marcos River and 14,100 cfs in the Comal River. The recorded rainfall was 10 to 16 inches throughout the San Marcos River watershed and 4 to 7 inches in the Comal River watershed.

Figure 1.2-1. Image of flooding on the San Marcos River after the October 2015 rainfall event.

Negative Impacts on EAHCP Mitigation Measures

During the May event, flow along the San Marcos River was largely impeded by floodwaters from the Blanco River with high velocity floodwaters limited to the area of the San Marcos River below the Interstate Highway (IH)-35 crossover. The October event had a wider impact as tributaries within the San Marcos River watershed became inundated from heavy rainfall that caused high velocities along the entire length of the San Marcos River from the headwaters to the confluence with the Blanco River. This inundation of both the main stem river and tributaries caused changes upon the aquatic plant community.

In terms of the specific restoration activities, the COSM and Texas State experienced extensive damage to the riparian restoration fencing that assisted in the continued growth of newly planted vegetation. Additionally, some scouring was recorded throughout the system.

Post flood mapping and observations of the aquatic vegetation indicated significant scouring effects in many locations along the stream bottom in the San Marcos River system. Cover of *Hydrilla verticillata* and *Hygrophila polysperma* were both reduced in many places, but most specifically between the Spring Lake Dam and Aquarena Springs Drive Bridge, where little aquatic vegetation remains except Texas wild-rice (*Zizania texana*). In the City Park reach, cover of *Hydrilla verticillata* was reduced approximately 60 percent, although root masses of *Hydrilla verticillat*a were observed to remain intact in most locations. Here, *Hygrophila polysperma* seemed to remain intact along the western stream edge. Native species, such as *Potamogeton illinoensis* and *Heteranthera dubia* and *Sagittaria platyphylla*, remain intact along the river, while *Cabomba caroliniana* was reduced in the few locations.

In some locations, stream bed scour uprooted Texas wild-rice, forming deep divots and pools and sometimes leaving nothing but bare bedrock where Texas wild-rice once flourished (**Figure 1.2-2**). This was the case especially downstream of Rio Vista Dam, which lost a significant portion of historical Texas wild-rice cover as a result of river bed scour. In other areas, sediment deposition buried Texas wild-rice plants. However, most restored Texas wild-rice planted as part of the EAHCP in City Park and other areas remained intact, albeit severely thinned, during post-flood evaluation. Below Sewell Park, while large clumps of Texas wild-rice were uprooted, a majority of the plantings with root systems remain intact.

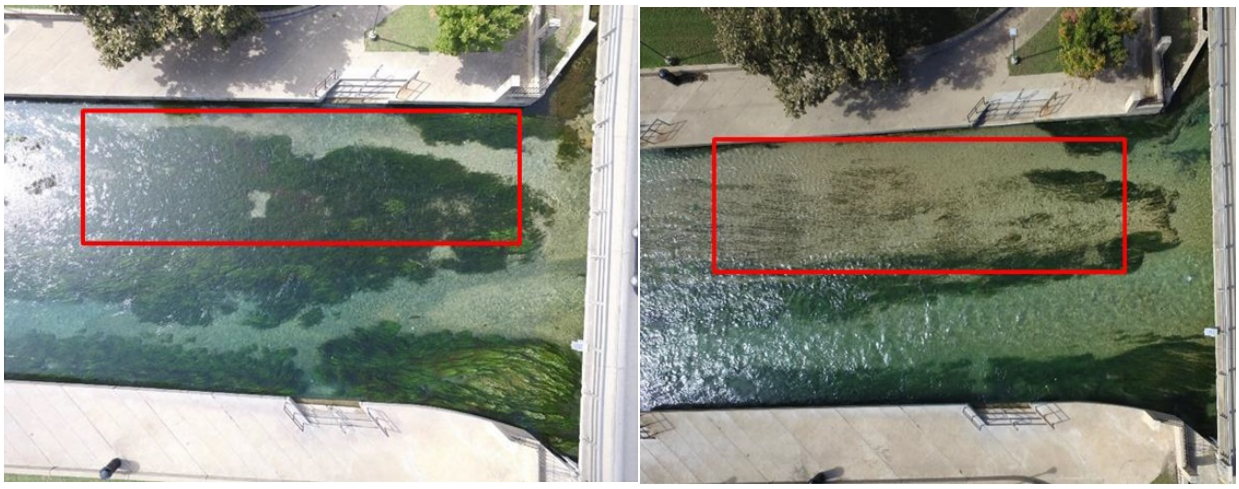

Figure 1.2-2. Images of aquatic vegetation coverage in San Marcos before (left) and after (right) the October 2015 flooding event.

Unlike the San Marcos River, the Comal River did not experience any major flooding in May. In October 2015, the Comal River saw a significant flooding event along its entire length, from Bleiders Creek to its confluence with the Guadalupe River. During this event, Landa Lake (LL) overflowed both the spillway and overtopped the Landa Lake Dam, allowing flood waters into the Old Channel restored areas. Very high waters were witnessed at the CONB Golf Course where the Old Channel completely inundated the golf course parking area, as well as the Elizabeth Street Bridge.

While this high-water event was significant, it caused only localized damage to restored native aquatic plantings. Most plantings in LL and the Old Channel remained with roots intact but with thinned top growth. These locations have been in place for a year or longer and are well established. In more recently planted

locations below Elizabeth Street, deposited gravel and sediment buried restored plantings of *Ludwigia repens*, while cover of *Cabomba caroliniana* was reduced approximately 30 percent from river bed scour (**Figure 1.2-3**). Plantings of *Sagittaria platyphylla* remained intact in this area. *Ludwigia repens*, *Hygrophila polysperma* and *Cabomba caroliniana* were all still observed in the New Channel post-flood, but were significantly reduced in cover, especially in the portion of river channel immediately below the Dry Comal Creek confluence.

Figure 1.2-3. Images of the Comal Old Channel during the October 2015 flooding event.

In the Comal River system, scouring of restored native aquatic vegetation (approximately 10 to 15 percent coverage loss) was recorded shortly after the rain event. The storm brought debris into the Old Channel and was deposited around aquatic restoration areas. Partial removal of channel debris has already occurred. The only native vegetation type significantly impacted systemwide by the flooding was bryophytes, which is to be expected as bryophytes are non-rooted plants that loosely congregate along the stream bottom. After the flood, approximately 80 percent of bryophytes in the Old Channel were removed, while some patches still persisted in LL. It is unknown how long it will take for bryophytes to recover to pre-flood cover, but recovery will likely be slow until the growing season of 2016 begins in spring.

In order to assess any ecological damage, BIO-WEST, Inc. (BIO-WEST) conducted a second round of critical period biological monitoring on both systems (**Appendix F** and **Appendix G**). The EAA's Biological Monitoring Program triggered additional monitoring due to both the May and October flood events. These significant events provided an opportunity for biologists to monitor the systems before and after flood events. Such data is useful in understanding how both systems responded and how the Covered Species and their habitat are affected.

Positive Impacts on EAHCP Mitigation Measures

Recharge to the Edwards Aquifer from the May event had significant impact on both the San Antonio Pool and Uvalde Pool index wells. This positive impact was associated with the proportion of rain that fell on the Recharge and Contributing zones. The increase seen in the J-27 index well (Uvalde Pool) is the most telling. Over a period of about three months, the Uvalde index well experienced an approximate rise of 25 feet (ft).

The amount and timing of rainfall in 2015 was particularly beneficial to irrigators in that most irrigation wells were not put into service until July. Critical Period Management Program (CPMP) – Stage V restrictions were in place in Uvalde County since approval of the EAHCP in March of 2013. Beneficial rains in the area increased aquifer levels such that CPMP restrictions in Uvalde County were completely eliminated. The remaining portions of the EAA's jurisdiction also experienced dramatic increases in water levels during the first six months of 2015 that lessened CPMP restrictions. With the fall rains, CPMP restrictions were eliminated.

Also in 2015, widespread and regular rains led to a dramatic increase in Aquifer Storage and Recovery (ASR) leasing activity. The EAA began 2015 with 4,821 acre-feet (ac-ft) of ASR leases. During the year, increased rainfall resulted in much lower water demands; therefore, the EAA acquired approximately 14,850 ac-ft in the ASR Program leases and 500 ac-ft of pooling leases. In 2016, the EAA began the year with 9,849 ac-ft of leases. EAHCP staff anticipates, that due to the lack of CPMP reductions throughout the region and the fact that VISPO will not be triggering in 2016, ASR leasing opportunities could experience increased popularity.

1.3 2015 Financial Report

As specified in Section 4.6 of the Funding and Management Agreement (FMA), each year the EAA Board of Directors approves each Permittee's Program Funding Application's budget. The Program Funding Applications are the mechanism by which the Permittees request funding to implement the Conservation Measures or other EAHCP Program-related activities. The EAA Board of Directors approved the 2015 Program Funding Applications budgets for each of the Permittees during at their meeting on November 12, 2014.

Throughout the course of 2015, the EAA Board of Directors approved two amendments to the EAHCP budget to meet the needs of the program. Specifically, the items amended were the following: 1) the Program Administration and the Regional Municipal Water Conservation Program budgets on February 10, 2015 and, 2) the Science Review Panel/National Academy of Sciences (SRP/NAS) budget on December 8, 2015. Other budget transfers were made during the year on the Expanded Water Quality Monitoring Program, and the Sediment Removal Program. These transfers are identified in the footnotes in the EAHCP Expense Report located in **Appendix H** of this Annual Report.

The EAHCP Expense Report shows Table 7.1 of the EAHCP funding amounts for 2015 totaling $18,362,597. These amounts can be compared to the EAA Board-approved 2015 Program Funding Applications totaling $24,729,152. A significant increase in the VISPO budget accounts for the large

variation between EAHCP Table 7.1 and the approved budget. **Figure 1.3-1** reflects the 2015 EAA Board-approved 2015 Program Fund Applications, by budget and EAHCP activity.

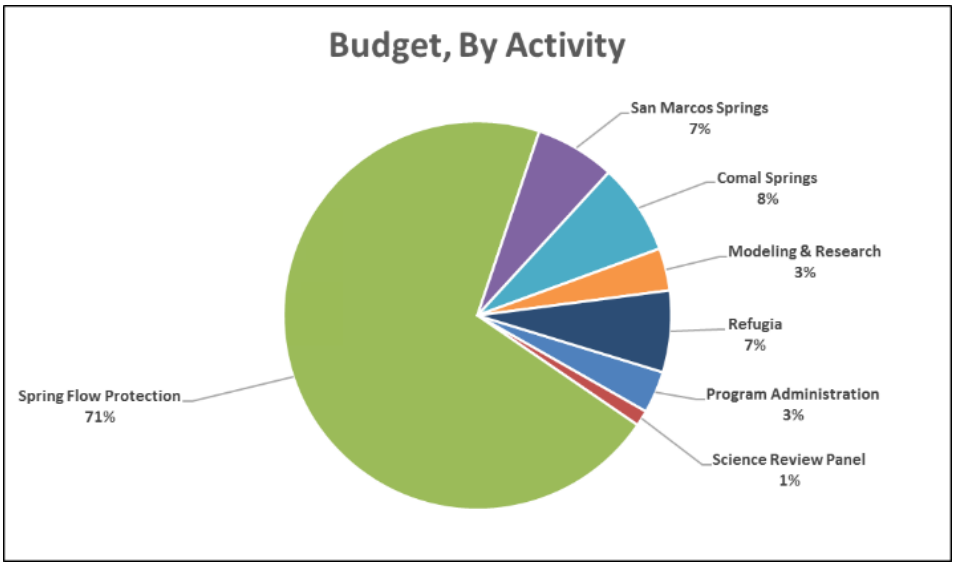

Figure 1.3-1. 2015 EAA Board-approved 2015 Program Fund Applications, by budget and EAHCP activity.

The 2015 actual expenses were $16,397,097. A significant amount of unspent funds in the ASR leasing, ASR Operations and Maintenance, and Regional Water Conservation Program (RWCP) budgets accounts for the difference between total approved budget and actual expenses. **Figure 1.3-2** shows the 2015 actual expenses by each EAHCP activity.

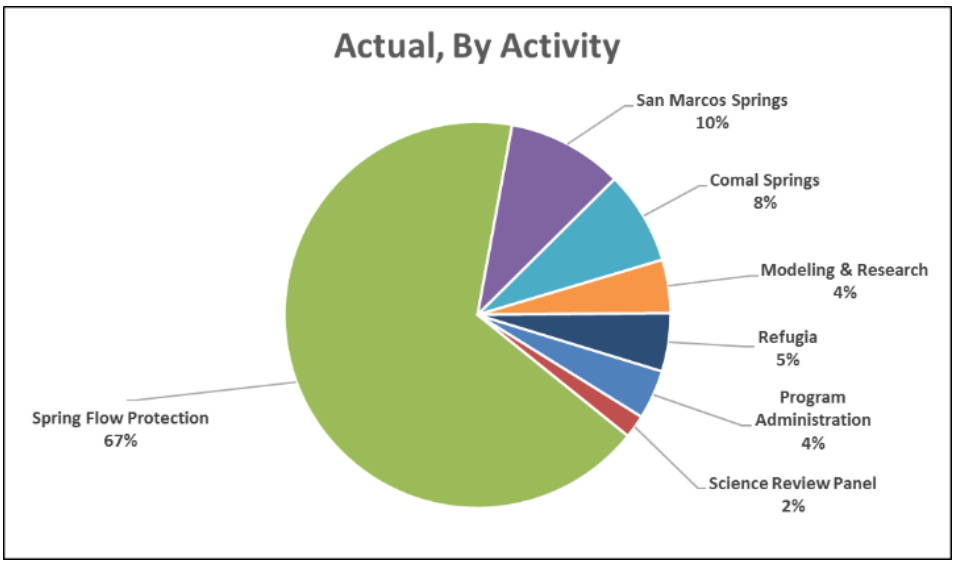

Figure 1.3-2. 2015 actual expenses by EAHCP activity.

The report also breaks down the adopted budget, Program Funding Applications budget and actual expenses. Approximately 34 percent of the approved 2015 Program Funding Applications budget and 11 percent of the adopted budget amounts remained at the end of the December 2015. These amounts were

due primarily to balances resulting from unexpended funds in the RWCP, ASR, and Refugia programs. By the end of 2015, the reserve balance for the EAHCP was $37,346,135, which includes unspent funds accumulated since the inception of the EAHCP (**Figure 1.3-3**).

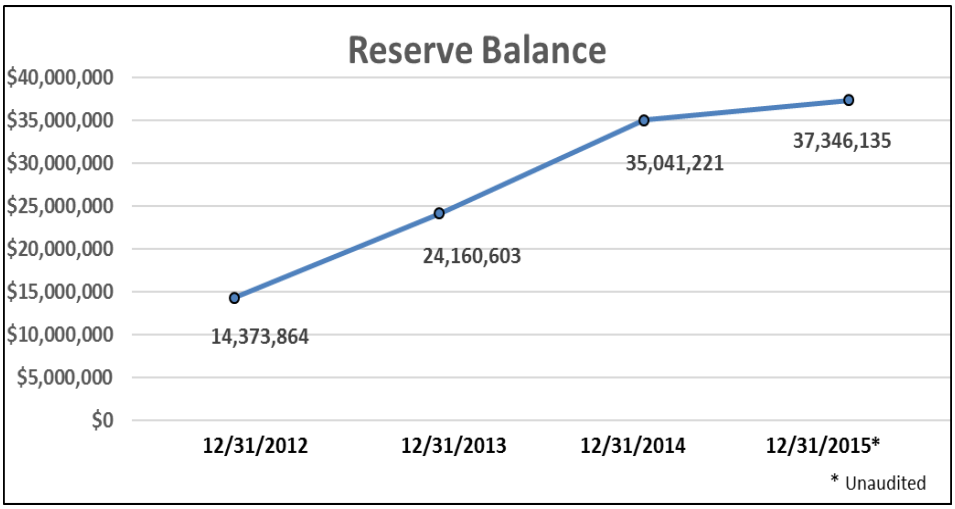

Figure 1.3-3. Reserve balances for EAHCP since program inception.

The EAHCP Expense Report also shows the actual revenue for 2015 of $18,805,257 compared to the budgeted revenue of $18,466,976, which is a variance of only $338,281. Approximately 95 percent of the actual revenue comes from Aquifer Management Fees. It is anticipated that revenue acquired in 2016 will be similar to the revenue acquired in previous years.

1.4 2015 EAHCP Committee Activities

Article Seven of the FMA establishes the roles of four committees for the EAHCP: the Implementing Committee (IC); the Adaptive Management Stakeholder Committee (SH); the Adaptive Management Science Committee (SC); and the SRP/NAS (EAA et al. 2012a). The activities of these four committees and their work groups in 2015 are described in the following subsections.

1.4.1 Activities of the Implementing Committee

The IC supervises implementation of the EAHCP and ensures compliance with documents such as the ITP, EAHCP and FMA. There are five voting members of the IC who represent the five Permittees, and one representative of the Guadalupe-Blanco River Authority (GBRA) who serves as a non-voting member. **Table 1.4-1** lists the members of the IC for 2015. The IC met ten times in 2015, and the agendas and minutes for those meetings are provided in **Appendix I1**.

Table 1.4-1. Members of the Implementing Committee for 2015

Member	Entity	Alternate
Steve Ramsey	CONB	Robert Camareno
Chuck Ahrens/Darren Thompson	SAWS	Darren Thompson/Donovan Burton
Andrew Sansom	Texas State	Juan Guerra
Tom Taggart*	COSM	Melani Howard
Roland Ruiz**	EAA	Rick Illgner
Todd H. Votteler, Ph.D.	GBRA	Charlie Hickman

* Committee Chair
** Committee Vice Chair

Highlights of the IC meetings in 2015 are listed below.

- January 15, 2015:
  - Presentation and authorization to conduct hydrological modeling with HDR Engineering, Inc. (HDR);
  - Presentation of the *2014 Net Disturbance and Take Estimate Report*;
  - Presentation and approval of the amended 2015 Program Management Work Plan, 2015 EAA RWCP Work Plan, and the 2015 EAA Funding Application;
  - Presentation of the *Regional Water Conservation Program Work Group Report*, which represented the work group's efforts conducted and concluded in 2014, and approval to recommend the report to the EAA for implementation consideration; and
  - Presentation and approval of a process and timeline for implementing the *National Academy of Sciences – Review of the Edwards Aquifer Habitat Conservation Plan: Report 1* (NAS *Report 1*).
- February 19, 2015:
  - Discussion and presentation of the budget analysis of the ASR/Voluntary Irrigation Suspension Program Option (VISPO) Work Group's recommendation to increase prices for ASR leases;
  - Presentation and adoption of the *2014 Net Disturbance and Take Estimate Report* as recommended by the SC; and
  - Presentation and approval of the amended 2015 CONB Old Channel Restoration Work Plan.
- March 19, 2015:
  - Presentation and approval of the 2015/2016 Ecological Model Scope of Work as recommended by the SC and presentation on capabilities of the ecological model;
  - Presentation and approval of the *EAHCP 2014 Annual Report* for submittal to USFWS;
  - Discussion and approval to begin creating a Report 1 Recommendations Review Work Group, and appointment of work group members; and
  - Presentation of the NAS *Report 1* by Danny Reible, Ph.D., Chairman – NAS/National Research Council Committee to review the EAHCP[4].
- April 16, 2015:
  - Presentation of rainfall deficits across the Edwards Aquifer region, and discussion of the 2014 U.S. Geological Survey (USGS) Recharge Estimate;

[4] The NAS/National Research Council Committee is serving as the EAHCP SRP.

- Presentation and approval of the NAS Review Recommendations Work Group (NAS RRWG): Report 1 charge; and
- Presentation and discussion of the EAHCP Staff Analysis of the NAS Recommendations from the NAS *Report 1*.

- May 21, 2015:
  - Presentation of a report on the SH and SC Workshop on the NAS *Report 1*;
  - Presentation and discussion of the draft Implementation Plan for the NAS *Report 1*;
  - Presentation of the EAA 2016 Work Plan;
  - Presentation of the Texas State and COSM 2016 Work Plans;
  - Presentation of the design plans for the Comal Springs Conservation Center by New Braunfels Utilities (NBU); and
  - Presentation of the CONB 2016 Work Plan.
- June 18, 2015:
  - Presentation of the Scope of Work in the EAA's Salvage Refugia Contract with SWCA Environmental Consultants (SWCA);
  - Presentation of the Refugia Technical Report, *Refugia Review*;
  - Presentation of the Technical Memorandum regarding ASR/VISPO modeling efforts by HDR;
  - Approval of the 2016 CONB Work Plan;
  - Approval of the 2016 EAA Work Plan; and
  - Approval of the 2016 COSM and Texas State Work Plans.
- August 20, 2015:
  - Presentation and discussion regarding Phase II Strategic Adaptive Management Decision Making;
  - Presentation and adoption of the *National Academy of Sciences - Review of the Edwards Aquifer Habitat Conservation Plan: Report 1 Implementation Plan* recommended by the NAS RRWG;
  - Creation of the Applied Research Work Group (ARWG), appointment of members, and approval of the Work Group's charge; and
  - Presentation and approval to amend the 2015 COSM and Texas State Permanent Access Points/Bank Stabilization Work Plan.
- October 15, 2015:
  - Presentation and approval of the amended 2016 EAA Work Plan.
  - Presentation and approval of the amended 2016 CONB Work Plan.
  - Presentation and approval of the amended 2016 COSM and Texas State Work Plans; and
  - Presentation and approval of the 2016 Funding Applications to be submitted to the EAA Board of Directors.
- November 19, 2015:
  - Presentation and discussion of the EAA's summary of well permitting and pumping history from 2008 to 2014;
  - Presentation and approval of a scope of work to evaluate methodologies and develop timelines for the EAHCP restoration of native vegetation in the San Marcos and Comal ecosystems to achieve the Biological Goals;

- Presentation and approval authorizing the EAHCP Program Manager to submit a letter to the USFWS regarding operational issues and future plans related to the evaluation of native aquatic vegetation restoration, the source of data for calculating the compliance of Texas wild-rice coverage, and the delay in implementing the flow manipulation in the Old Channel of the Comal River;
- Presentation and discussion of a strategic approach for optimizing EAHCP research programs;
- Presentation and adoption of the *2015 Applied Research Work Group Report* for implementation;
- Presentation and authorization for the EAHCP Program Manager to initiate a phased approach for procuring a database for EAHCP data and for conducting a statistical analysis of EAHCP data; and
- Presentation and approval of the amended 2015 EAA Funding Application to be submitted to the EAA Board of Directors.

- December 17, 2015:
  - Joint meeting of the IC, SH and SC.

1.4.1.1 National Academy of Sciences Recommendations Review Work Group: Report 1

The IC undertook a thoughtful process to review and consider the recommendations contained in the NAS *Report 1* as it related to all EAHCP programs. That process began with creating the NAS Recommendations Review Work Group: Report 1 (NAS RRWG) on March 19, 2015. At this meeting, the IC also appointed Cindy Loeffler (Texas Parks & Wildlife Department [TPWD]), Melani Howard (COSM and Texas State), Roger Biggers (NBU), Darren Thompson (SAWS), and Mark Hamilton (EAA) to serve as members of the NAS RRWG. In April 2015, the IC charged the NAS RRWG with, while operating on a consensus-basis, reviewing the EAHCP staff's draft of the *Report 1 Implementation Plan*, modifying it as necessary, and, if appropriate, recommending the plan to the IC for adoption and implementation. On April 22, 2015, the SH and SC held a joint workshop on the NAS *Report 1*. As mentioned previously, a report on the joint committee workshop was presented to the IC on May 21, 2015.

The NAS RRWG met three times during June and July 2015. At their final meeting on July 10, 2015, the NAS RRWG, by consensus, approved the "Summary" section of the draft *Report 1 Implementation Plan* and a budget-based prioritization of these recommendations, and voted to recommend the IC approve and adopt the *Report 1 Implementation Plan*. On August 20, 2015, the IC adopted the *National Academy of Sciences - Review of the Edwards Aquifer Habitat Conservation Plan: Report 1 Implementation Plan* recommended by the NAS RRWG. Copies of the NAS RRWG's charge, meeting agendas and minutes, and final report can be found in **Appendix I2**. A copy of the report on the SH and SC joint workshop can also be found in **Appendix I4**.

For additional discussion related to the NAS *Report 1*, please refer to **subsection 1.4.4**, Activities of the SRP/NAS, below.

1.4.1.2 Applied Research Work Group

For the NAS *Report 1* recommendations related to the EAHCP's Applied Research Program, the NAS RRWG recommended creating an Applied Research Work Group (ARWG) to establish a research project schedule for the remainder of Phase I of the EAHCP (2013 through 2019). On August 20, 2015, the IC subsequently established the ARWG, approved the ARWG's charge, and appointed the following individuals to serve as members: Tom Arsuffi, Ph.D. (Texas Tech University [TTU]); Janis Bush, Ph.D. (University of Texas at San Antonio [UTSA]); Bob Hall, M.S. (EAA); Chad Norris, M.S. (TPWD); and Kenneth Ostrand, Ph.D. (USFWS). Dr. Arsuffi was elected as the ARWG Chair. The ARWG met three times during September and October 2015.

On October 16, 2015, the ARWG unanimously approved their final report, titled *Report of the 2015 Applied Research Work Group*, including the *2016 -2019 Applied Research Project Schedule* and the *2016-2019 Applied Research Project Prioritization Matrix*. Copies of the ARWG's charge, meeting agendas and minutes, and final report can be found in **Appendix I3**.

The presentations of the Regional Water Conservation Program (RWCP) Work Group, NAS RRWG, and ARWG final reports to the IC and the IC's actions on these final reports as noted previously, completed the charges for these work groups. These work groups did not continue to function in 2015 after IC action on their final reports.

1.4.2 Activities of the Adaptive Management Stakeholder Committee

Table 1.4-2 lists the 27 SH representatives, their affiliations, the interests they represented, and their alternates for 2015.

Table 1.4-2. Members of the Adaptive Management Stakeholder Committee in 2015

Member	Affiliation	Representing	Alternate
Carl Adkins	Texas BASS Federation Nation	Recreational interest in the Guadalupe River Basin	Tim Cook
Bruce Alexander	East Medina County Special Utility District	Holder of an initial regular permit issued to a retail public utility located west of Bexar County	No alternate named
Buck Benson	Alamo Cement/Pulman Law	Holder of an initial regular permit issued by the EAA for industrial purposes	Shanna Castro
Cindy Hooper	Texas Commission on Environmental Quality (TCEQ)	TCEQ	Cary Betz
Roger Biggers	NBU	Retail public utility in whose service area the Comal Springs or San Marcos Springs is located	Paula DiFonzo
Jim Bower	City of Garden Ridge	Holder of an EAA initial regular permit issued to a small municipality located east of San Antonio	No alternate named
Doris Cooksey	City Public Service (CPS) Energy	CPS Energy	Louisa Eclarinal
Member to be appointed	Texas Department of Agriculture (TDA)	TDA	No alternate named
Rader Gilleland	Gilleland Farms	Holder of an initial regular permit issued by the EAA for irrigation	Adam Yablonski
Renee Green	Bexar County	Bexar County	Kerim Jacaman
Juan Guerra	Texas State	Texas State	Sheri Lara and Andy Sansom
Myron Hess**	National Wildlife Federation (NWF)	Environmental Interest from the Texas Living Waters Project	No alternate named
Melani Howard	COSM	COSM	Laurie Moyer
Rick Illgner	EAA	EAA	Elizabeth Woody

Table 1.4-2. Members of the Adaptive Management Stakeholder Committee in 2015

Member	Affiliation	Representing	Alternate
Jerry James	City of Victoria	Holder of a municipal surface water right in the Guadalupe River Basin	James Dodson
Glenn Lord	DOW Chemical	Holder of an industrial surface water right in the Guadalupe River Basin	Dwaine Schoppe
Cindy Loeffler	TPWD	TPWD	Colette Barron
Gary Middleton	South Central Texas Water Advisory Committee (SCTWAC)	SCTWAC	No alternate named
Con Mims	Nueces River Authority (NRA)	NRA	Sky Lewey
Kirk Patterson	Regional Clean Air and Water	Edwards Aquifer Region municipal ratepayers/general public	Carol Patterson
Ray Joy Pfannstiel	Guadalupe County Farm Bureau	Agricultural producer from the Edwards Aquifer Region	Gary Schlather
Steve Raabe*	San Antonio River Authority (SARA)	SARA	Allison Elder
Steven Ramsey	CONB	CONB	Zac Martin
Patrick Shriver	SAWS	SAWS	Steven Bereyso
Gary Spence	Guadalupe Basin Coalition (GBC)	Guadalupe River Basin municipal ratepayers/general public	Mike Dussere
Todd Votteler	GBRA	GBRA	Charlie Hickman
Dianne Wassenich	San Marcos River Foundation (SMRF)	Conservation organization	Annalisa Peace

* Committee Chair
** Committee Vice Chair

The SH met in March 2015, and the agenda and minutes for that meeting are attached as **Appendix I4**. The SH also met jointly with the SC on April 22, 2015, for a workshop on the NAS *Report 1*, and with the IC and SC on December 17, 2015. A copy of the agenda for the April 22, 2015 joint workshop and the report to the IC resulting from that workshop can be found in **Appendix I4**.

Highlights of the SH meetings are noted below.

- March 19, 2015:
  - Presentation of the *2014 Net Disturbance and Take Assessment Report*; and
  - Receive report on the adopted process by the IC for implementation of the NAS *Report 1*.
- April 22, 2015:
  - Joint workshop of the SH and SC regarding the NAS *Report 1*.
- December 17, 2015:
  - Joint meeting of the IC, SH and SC.

1.4.3 Activities of the Adaptive Management Science Committee

The SC consists of seven to eleven experts who have technical expertise in one or more of the following areas: (a) the Edwards Aquifer or its management; (b) the Comal Springs and River; (c) the San Marcos Springs and River; or (d) the Covered Species. The SC serves as an independent scientific panel to advise, consult, and provide recommendations to the SH and IC (**Table 1.4-3**). The SC met nine times in 2015, and the agendas and minutes from those meetings are provided in **Appendix I5**.

Table 1.4-3. Members of the Adaptive Management Science Committee in 2015

Member	Affiliation	Expertise	Nominating Entity
Tom Arsuffi, Ph.D.**	TTU	Aquatic Biology Stream Ecology	Implementing
Janis Bush, Ph.D.	UTSA	Plant Ecology Experimental Design	Stakeholder

Table 1.4-3. Members of the Adaptive Management Science Committee in 2015

Member	Affiliation	Expertise	Nominating Entity
Jacquelyn Duke, Ph.D.	Baylor University	Stream Ecology Riparian Ecohydrology	Implementing
Charlie Kreitler, Ph.D.	LBG-Guyton Associates (Retired)	Hydrogeology Groundwater Science	Implementing
Conrad Lamon, Ph.D.	Statistical Ecology Associates LLC	Ecological Modeling	Implementing
Glenn Longley, Ph.D.	Edwards Aquifer Research and Data Center (EARDC) (Retired)	Biologist Edwards Aquifer Specialist	Stakeholder
Robert Mace, Ph.D.	Texas Water Development Board (TWDB)	Hydrology Hydrogeology	Joint Nomination
Doyle Mosier, M.S.*	TPWD (Retired)	Instream Flows Aquatic Habitats	Implementing
Chad Norris, M.S.	TPWD	Aquatic Biology Aquatic Invertebrate Specialist	Stakeholder
Jackie Poole, M.A.	TPWD (Retired)	Botany/Taxonomy Texas wild-rice Specialist	Stakeholder
Floyd Weckerly, Ph.D.	Texas State	Population Ecology Experimental Design	Stakeholder

* Committee Chair
** Committee Vice Chair

Highlights of the 2015 SC meetings are listed below.

- February 11, 2015:
  - Presentations of the 2014 Applied Research Results – *Fountain Darter Movement Under Low-Flow Conditions in the Comal Springs/River Ecosystem; Effects of Low-Flow on Fountain Darter Reproductive Effort; and Effects of Predation on Fountain Darters Study*;
  - Presentation of results of the *2014 Net Disturbance and Take Assessment Report*, and committee action to recommend the IC adopt the report;
  - Presentation on the proposed *2015 Sediment Impacts on Texas wild-rice Applied Research Methods*, and committee input received;
  - Presentation of the *2014 Water Quality Monitoring Report*; and
  - Presentation of details on the development of the Ecological Model.
- March 11, 2015:
  - Presentation of *2014 Report on: Borehole Colonization Traps within Spring Run 1 of the Comal River*;
  - Presentations of the 2014 Applied Research Results – *Comal Springs Riffle Beetle (CSRB) Plastron Use During Low-Flow*; and *Effects of Low-Flow on CSRB Survival*;
  - Presentation on the development of the Finite Element and MODFLOW hydrologic models;
  - Presentation of the 2015/2016 Ecological Model Scope of Work and committee action to recommend the IC approve the Scope of Work, and presentation on the Ecological Model's capabilities;
  - Presentation of the *2014 Biological Monitoring Reports*;
  - Presentations on the proposed 2015 Applied Research methods – Ludwigia repens *Interference Plant Competition Study* and *CSRB Habitat Connectivity Study*, and committee input received; and
  - Presentation of the Process to Select Applied Research Studies, and committee input received.

- April 7, 2015:
  - Presentation of the 2014 Applied Research Results – *CSRB Occupancy Modeling and Population Estimate within the Comal Springs System, New Braunfels, Texas*;
  - Presentation on the proposed 2015 Applied Research methods – Algae Dynamics, and committee input received;
  - Presentation on the summary of the NAS *Report 1*;
  - Presentation on the San Marcos Water Quality Protection Plan (WQPP) and Sessom Creek Erosion Remediation Plan;
  - Open Committee Discussion: Applied Research;
  - Presentation and prioritization of potential 2016 Applied Research Fundamental Questions;
  - Staff Reports – Next Steps on the 2016 Applied Research Process, and 2016 Work Plan approval process; and
  - Presentation of the EAA Work Plans, and committee action to recommend them to the IC.
- April 22, 2015:
  - Joint workshop of the SH and SC regarding the NAS *Report 1*.
- May 6, 2015:
  - Presentation on the proposed methods for the *Refugia Captive Propagation Research Study*, and committee input received;
  - Presentation of the proposed 2016 Applied Research Program Scopes of Work;
  - Discussion on the potential next steps in developing an EAHCP Data Analysis effort; and
  - Presentations on the 2016 CONB, COSM and Texas State Work Plans.
- June 10, 2015:
  - Presentation and discussion of the Re-vegetation plan of the Old Channel Bank Stabilization Project, and on-site visit to the Bank Stabilization Project location; and
  - Discussion of questions for an EAHCP Data Analysis effort.
- September 9, 2015:
  - Presentation and discussion of the procedure for SC review of proposals received for the 2016 Applied Research Requests For Proposals – *Evaluation Of The Long-Term Elevated Temperature And Low Dissolved Oxygen Tolerances Of Larvae And Adult Comal Springs Riffle Beetle*; *Evaluation Of The Trophic Level Status And Functional Feeding Group Categorization of Larvae And Adult Comal Springs Riffle Beetle*; and *Evaluation of The Life History of The Comal Springs Riffle Beetle From Egg to Adult*;
  - Discussion on a statistical analysis project that evaluates progress towards accomplishing EAHCP Biological Goals; and
  - Presentation on EAHCP Phase II Strategic Adaptive Management Decision Making.
- November 10, 2015:
  - Presentation and recommendation to delay implementation of the flow manipulation in the Old Channel of the Comal River per EAHCP Table 5-3;
  - Presentation and discussion on the concept for a proposed scope of work to evaluate methodologies and timelines for native vegetation restoration in the San Marcos and Comal ecosystems;
  - Presentation on and endorsement of the *2015 Applied Research Work Group Report*;

- Presentation on a proposed scope of work for a 2016 Applied Research project on the CSRB quantitative sampling methods;
- Presentation and discussion of concept for a proposed scope of work for the creation of an integrated database for the EAHCP;
- Presentation on the Research Plan for the Salvage Refugia Program; and
- Presentation and update on the Ecological Model.

- December 17, 2015:
  - Joint meeting of the IC, SH, and SC.

1.4.4 Activities of the Science Review Panel/National Academy of Sciences

In December 2013, the EAA entered into a contract with the NAS to create an independent Science Review Panel (SRP) as defined in the EAHCP. The purpose of the SRP/NAS is to provide scientific advice in support of the EAHCP on four scientific initiatives: 1) ecological modeling; 2) hydrologic modeling; 3) biological and water quality monitoring; and 4) applied research. The twelve SRP/NAS members are selected by the NAS.

Table 1.4-4 lists the SRP/NAS members for 2015. In 2015, the SRP/NAS met once from October 28 – October 30, 2015, at the EAA's offices in San Antonio, Texas. The agenda for that meeting is provided in **Appendix I6**.

Table 1.4-4. Science Review Panel/National Academy of Sciences Members

Member	Affiliation	Area of Expertise
Jonathan Arthur, Ph.D.	Florida Geological Survey	Hydrogeology and Hydrochemistry
M. Eric Benbow, Ph.D.	Michigan State University	Entomology of Aquatic Ecosystems
Robin K. Craig, Ph.D., J.D.	University of Utah	Water Law
K. David Hambright, Ph.D.	University of Oklahoma	Biology and Water Quality
Lora Harris, Ph.D.	University of Maryland	Aquatic Ecosystems, with expertise in Ecological Modeling
Timothy K. Kratz, Ph.D.	University of Wisconsin—Madison	Aquatic Ecology
Andrew J. Long, Ph.D.	USGS	Hydrology
Jayanthan Obeysekera, Ph.D.	South Florida Water Management District	Hydrologic Modeling
Danny Reible, Ph.D.*	TTU	Chemical Engineering
Kenneth A. Rose, Ph.D.	Louisiana State University	Population Modeling
Laura Toran, Ph.D.	Temple University	Groundwater Monitoring and Modeling
Greg D. Woodside, P.G., C.HG.	Orange County Water District	Watershed Management and Planning

* Committee Chair

The SRP/NAS is conducting a multi-year, formal review process in three distinct phases. The final deliverable for each phase consists of a published report. Phase 1 was completed in March 2015 with the publication of the first report, titled *Review of the Edwards Aquifer Habitat Conservation Plan: Report 1*. This review focused on the EAHCP's hydrologic and ecological models, water quality and biological

monitoring, and applied research programs. In this report, the SRP/NAS identified that overall the EAA and the other Permittees are doing an excellent job implementing many aspects of the EAHCP, and that addressing several overarching scientific and modeling issues would further strengthen the plan. A copy of this report is provided in **Appendix O1.**

The second phase is underway at the time of writing this report, with the NAS' issuance of the September 2015 *Study Announcement – Review of the Edwards Aquifer Habitat Conservation Program – Phase 2* (see **Appendix O2**). For this second report, the SRP/NAS is focusing on the adequacy of information to inform assessments of the EAHCP's scientific initiatives to ensure they are based on the best available science. The SRP/NAS will evaluate relationships among the EAHCP's Conservation Measures, Biological Objectives and Biological Goals. Phase 2 is scheduled to be completed in late 2016 with the delivery of *Report 2*.

Details regarding Phase 3 will be made available after the publication of *Report 2*.

1.4.5 Committee and Work Group Support

During 2015, EAHCP staff successfully facilitated ten IC meetings, nine SC meetings, and three SH meetings (some of which were joint meetings), and organized the meetings of two Work Groups.

Public accountability and the transparency of the EAHCP process are important guiding principles for EAHCP program management and continued to be so in 2015. Committee meetings represent an important opportunity to ensure that this public commitment is met. Accordingly, staff responsibilities for meeting facilitation included ensuring that committee meetings were conducted in accordance with the EAHCP, using the Texas Open Meetings Act as a guide to best practices for providing notice, holding open sessions, and providing records of meetings. Also, EAHCP staff hosted a kayak tour of the Comal and San Marcos spring systems in 2015. Agendas and notices for all meetings were posted a minimum of one week in advance of the meeting date, meetings were held publicly with opportunities for public comment, and minutes were posted publicly.

Facilitating meetings by EAHCP staff also included coordinating meeting logistics, such as reserving venues for meetings, preparing and providing meeting materials, and providing refreshments. For meeting venues, EAHCP Permittees and other regional Partners played an important role by providing courtesy meeting facilities and assisting with other accommodations as needed. Through the cooperation of the EAHCP Permittees and Partners in 2015, SC meetings were held at the San Marcos Activity Center, the San Marcos Recreation Hall, and the New Braunfels Landa Haus. IC meetings were held at the EAA, GBRA, and the New Braunfels Civic Center.

In addition to their work involving standing EAHCP committees, in 2015 staff facilitated and executed the development of two *ad hoc* work groups – the NAS RRWG and the AWRG. Between these two work groups, staff organized and facilitated six additional public meetings.

2.0 BIOLOGICAL GOALS AND OBJECTIVES FOR COVERED SPECIES

The Biological Goals and Objectives of the EAHCP are set out in Section 4.1 of the EAHCP. The identification of biological goals and objectives is one of five components outlined in the HCP Handbook Addendum (USFWS and NMFS 2000), referred to as the "5-Point Policy." Long-term biological goals are the rationale behind the minimization and mitigation strategies and, conversely, minimization and mitigation measures are the means for achieving the long-term biological goals and objectives.

Section 4.1 of the EAHCP includes details for all Covered Species in sections covering the long-term biological goals, key management objectives, flow-related objectives, historical and present day perspective, and methods and discussion. All long-term biological goals, accompanying management objectives, and flow-related objectives are subject to change under limited circumstances set out in the FMA. Any such change will be based solely on the best scientific and commercial data available.

3.0 PLAN IMPLEMENTATION IN 2015

Communication and cooperation among and between all stakeholders in the Edwards Aquifer Region were critical in developing the EARIP HCP. These two factors continue to play a significant role in guiding operation of the EAHCP by the Permittees, Partners, stakeholders and the USFWS. Continual communications with the USFWS has proven to be valuable and both parties are committed.

Section 10(a)(2)(A) of the ESA requires that any application for an ITP be accompanied by an HCP. HCPs must include "measures the applicant will undertake to monitor, minimize, and mitigate such impacts [of the covered activities]" (USFWS HCP Planning Handbook, 3-10). This chapter of the Annual Report discusses the progress achieved in 2015 towards meeting the measures outlined in the EAHCP, and efforts to comply with the ITP requirements.

The following sections describe the activities implemented in 2015 pursuant to the ITP and its conditions, as described in **Appendix A1** of this report. All measures have been implemented according to the reviewed and approved 2015 Work Plans. The latest versions of the 2015 Work Plans and the 2016 Work Plans are included in this Annual Report as **Appendices J1** through **J6**.

3.1 Edwards Aquifer Authority

The EAA is a special regional management district established by the 73rd Texas Legislature in May 1993, with the passage of the EAA Act to preserve and protect the Edwards Aquifer. As established by the Legislature, the EAA is governed by a 15-member elected board of directors representing stakeholder interests within an eight-county area, including all or parts of Uvalde, Medina, Atascosa, Bexar, Comal, Guadalupe, Hays, and Caldwell counties, plus two appointed members – one from Medina or Uvalde counties, and one from the SCTWAC. The SCTWAC also provides regular input to the EAA and, as directed by statute, provides a status report biennially in even-numbered years.

Geologists, hydrogeologists, environmental scientists, biologists, environmental technicians, educators, and administrative staff collaborate daily to fulfill the EAA's statutory mission of managing and protecting the Edwards Aquifer to the benefit of approximately two million South Texans who rely on the Aquifer as their primary source of water.

The EAA is responsible for the following measures under the EAHCP:

- Applied Research (EAHCP §6.3.4)
- Refugia (EAHCP §5.1.1, §6.4.2, §6.4.3, and §6.4.4)
- Voluntary Irrigation Suspension Program Option (EAHCP §5.1.2)
- Regional Water Conservation Program (EAHCP §5.1.3)
- Critical Period Management Program – Stage V (EAHCP §5.1.4)
- Expanded Water Quality Monitoring (EAHCP §5.7.2)
- Biological Monitoring (EAHCP §6.3.1, §6.4.3, and §6.4.4)
- Groundwater Modeling (EAHCP §6.3.2)
- Ecological Modeling (EAHCP §6.3.3)
- Impervious Cover and Water Quality Protection (EAHCP §5.7.6)

3.1.1 Applied Research (EAHCP §6.3.4)

EAHCP Obligations:

The Applied Research Program of the EAHCP is one of the contributing components of the AMP that is part of the administration of the EAHCP. The AMP proactively addresses the level of uncertainty that often exists in the management of natural resources through a process of experimentation and verification. Specifically, the AMP envisioned in the EAHCP is a process for examining alternative strategies for meeting the Biological Goals and Objectives, and then, if necessary, adjusting the minimization and mitigation measures in Chapter 5 of the EAHCP according to what was learned through the AMP.

Pursuant to its role informing AMP deliberations, the primary focus of the EAHCP applied research program is evaluating effects and effectiveness monitoring. Through applied research studies evaluating effects and effectiveness, the Applied Research Program enhances understanding of the ecology of the Comal and San Marcos ecosystems, supports the development of the Ecological Model, and provides scientifically-rigorous information to program management concerning the EAHCP's success in meeting its stated Biological Goals and Objectives.

To carry out the Applied Research Program, at minimum, the EAHCP is obligated to evaluate each of the study topics set out in **Table 3.1-1** below through the design and implementation of targeted studies. As presented in the table, the three tiers of targeted research, coupled with a category of additional studies, were expected to fill critical gaps in data. As additional applied research questions come to light that contribute to compliance with the EAHCP's requirements, other studies beyond those identified in **Table 3.1-1** will be conducted as necessary (please refer to related discussions under subsections ***2015 Compliance Activities*** and ***Proposed Activities for 2016*** below).

Table 3.1-1. Applied Research as Outlined in §6.3.4.2 and §6.3.4.3 of the EAHCP

Tier	Research Activity
Tier A – Fountain Darter Habitat and Food Supply/Comal Springs Riffle Beetle Habitat Associations and Movement	Low-flow Effects on Native Aquatic Vegetation
	Low-flow Effects on Macroinvertebrates
	Effects of Low-flows on CSRB Movement
	Extended Low-flow Period Effects on CSRB
	Test Spring Run Connectivity
Tier B – Direct Impacts to Covered Species	Low-flow Effects on Fountain Darter Movement, Survival, and Reproduction
	Low-flow Effects on CSRB Survival and Reproduction
Tier C – Testing Repeat Occurrences of Low-flows or a Combination of Effects	System Memory
	Ecological Model Validation

Table 3.1-1. Applied Research as Outlined in §6.3.4.2 and §6.3.4.3 of the EAHCP

Tier	Research Activity
Additional Studies	Aquatic Vegetation and Restoration and Non-native Plant Removal • Evaluate transplant methodologies for various types of native aquatic vegetation • Evaluate the success of transplants over extended time periods • Evaluate methodologies for removal of non-native plants • Track maintenance required to keep non-native species from re-establishing
	Old Channel Environmental Restoration and Protection Area (ERPA) • Evaluate the need for channel manipulation for the enhancement of fountain darter habitat in the Old Channel (§5.2.2.1 of the EAHCP)

2015 Compliance Actions:

2015 Studies

In 2015, the following applied research studies were conducted:

Tier A

- ("Test Spring Run Connectivity"): *CSRB Connectivity Study*
  Rationale and role of this study in the EAHCP process: Very little is known about the ecology of the CSRB. While it is known that drought and subsequent low flows may have an impact on the CSRB spring run habitat, the impact to the various components of that habitat is not known. Spring run connectivity will be tested to evaluate the importance of the surface habitat, riparian detritus, and the subsurface habitat to the CSRB. This effort may involve simulating subsurface habitats that are in contact with surface habitat and riparian detritus, those that are isolated from surface habitat and riparian detritus, and subsurface habitats that are connected to surface habitats via trickling water across the surface habitat. This study will gather and evaluate data that may be useful in management decisions and may be necessary for the development of a CSRB component of the Ecological Model.

  The *Comal Springs Riffle Beetle Habitat Connectivity Study Final Report* can be found in **Appendix K1**.

Additional Studies

- Ludwigia repens *Interference Plant Competition Study*
  Rationale and role of this study in the EAHCP process: The aquatic vegetation in the Comal and San Marcos rivers provide habitat. Understanding the plant community composition and progression is essential for understanding habitat changes that may impact listed species. *Ludwigia repens* is a beneficial native species that is a preferred habitat for fountain darters and is currently used in native aquatic plant restoration efforts. Previous studies (not conducted in the Comal or San Marcos rivers) have shown *L. repens* to be a poor competitor compared to *Hygrophila polysperma*, an exotic species now common in both rivers. The ability of *L. repens* to compete with *Hydrilla*, another exotic species, is unknown. However, the flowing water environments of the Comal and

San Marcos rivers may significantly impact the outcome of such competitive interactions. Understanding aquatic vegetation growth, dispersal and re-colonization following stresses on the system (low-flow, high-flow, recreation, etc.), or relative to EAHCP restoration activities is paramount to maintaining fountain darter habitat in both systems. The data collected from the study of *L. repens* interference competition will be directly incorporated in the EAHCP ecological model to refine plant interactions for predictions of change in fountain darter habitat, as well as to be used to guide EAHCP mitigation/restoration efforts in both systems.

The *Final Report for Ludwigia repens Competition Study* can be found in **Appendix K2**.

- *Suspended Sediment Impacts on Texas wild-rice and other Aquatic Plant Growth Characteristics and Aquatic Macroinvertebrates Study*
  Rationale and role of this study in the EAHCP process: Suspended sediment impacts the aquatic vegetation and macroinvertebrate community composition and densities. Data on suspended sediment within the San Marcos River collected at 15-minute intervals, in association with hourly water contact recreation counts shows a longitudinal pattern of increasing turbidity, as well as strong diel, weekly and seasonal patterns. Light attenuation (photosynthetically available radiation, or PAR) is a known factor in affecting plant growth that may be affected by suspended sediments. It is not known to what extent extended diel, weekly, and seasonal impacts of reduced PAR associated with suspended sediments have on the productivity or biomass of Texas wild-rice or other aquatic plants within the San Marcos River. A reduction in aquatic vegetation productivity or biomass may result in a loss of food for the macroinvertebrates. In addition, sediments may directly affect the invertebrate community. This study will evaluate the impacts of suspended sediments in the San Marcos River on a daily, weekly, and seasonal a basis, and their impact on the aquatic vegetation and macroinvertebrate communities for use in the EAHCP Ecological Model.

- The *Suspended Sediment Impacts on Texas wild-rice and other Aquatic Plant Growth Characteristics and Aquatic Macroinvertebrates Study Scope of Work* can be found in **Appendix K3**. The final report for the study was delayed due to the flood events in 2015 (see related discussion under "***Any Modifications or Activities Due to Weather Conditions.***"

- *Algae Dynamics and Dissolved Oxygen (DO) Depletion Study*
  Rationale and role of this study in the EAHCP process: Observations in the Upper Spring Run (USR) and LL sections of the Comal River, as well as in Spring Lake of the San Marcos system, have documented periodic algae blooms that can cover fountain darter and/or San Marcos salamander habitat. In addition, excessive algae blooms were observed during laboratory and pond studies conducted during EAHCP Applied Research studies in 2013. In some instances during the 2013 EAHCP Applied Research laboratory and pond studies, algae completely covered or replaced most of the *Riccia* biomass. There is considerable literature on algae growth and water quality parameters; however, there is limited information specific to the Comal and San Marcos aquatic ecosystems. Results from the 2013 EAHCP Applied Research *Vegetation Tolerance* study demonstrated that the rooted aquatic vegetation types tested were quite resilient to low-flow and resulting reduced water quality conditions (high temperatures, low CO_2, etc.). As shown in

laboratory and pond studies, rooted vegetation, in the absence of algae, can survive low-flow conditions and reduced water quality. It is less understood what happens when that rooted vegetation is covered in algae as sometimes occurs *in-situ*. Aquatic vegetation as habitat continues to be the key variable relative to supporting fountain darters. Accordingly, understanding the changes and effects caused by algae build-up on rooted aquatic vegetation, especially under low-flow conditions, will directly support the refinement of threshold functions in the aquatic vegetation module of the EAHCP Ecological Model.

The final report on *Algae and Dissolved Oxygen Dynamics of Landa Lake and the Upper Spring Run* can be found in **Appendix K4**.

Research Conducted Through Other EAHCP Programs

- *Development of Husbandry and Captive Propagation Techniques for EAHCP Covered Invertebrate Species*
  Rationale and role of this study in the EAHCP process: The purpose for this study is to implement a portion of the EAHCP refugia program by developing a successful captive propagation program for the invertebrate species covered under the EAHCP, including captive rearing, life history, and environmental requirement needs.

  The final report on *Refugia Research: Development of Husbandry and Captive Propagation Techniques for Invertebrates Covered Under the Edwards Aquifer Habitat Conservation Plan* can be found in **Appendix K5**.

EAHCP applied research studies may also be conducted by other Permittees besides the EAA. For information concerning other applied research studies (e.g., gill parasite), please refer to the other Permittees' sections in this report.

Science Committee Role in Applied Research Planning and Procurement

In addition to carrying out the above studies, a new process for planning associated with the 2016 Applied Research Program was implemented in 2015. This process, informed by the recommendation of the NAS *Report 1*, involved incorporating greater scientific review for the Applied Research Program through the role of the SC.

The new process included soliciting SC input concerning the 2016 applied research schedule, resulting in the identification of four projects to be undertaken in 2016 (please refer to related discussion under subsection ***Proposed Activities for 2016*** below). Also as part of the new process, the SC provided input on scientific aspects of scopes of work to be included in request for proposals (RFPs) for applied research projects. In addition, the SC provided a technical assessment of proposals received to support EAHCP selection of the most scientifically-rigorous proposals. This assessment was valuable to EAHCP staff.

Development of an Applied Research Project Schedule for 2016-2019

The ARWG convened meetings in September and October 2015, to recommend a holistic applied research project schedule that would take into account currently identifiable research necessary to better understand the Covered Species in order to achieve the EAHCP's Biological Goals and Objectives. This schedule will be used to develop, review, and assess work plans for the Applied Research Program in 2016 through 2019.

At their final meeting on October 16, 2015, the ARWG unanimously approved a draft *Report of the 2015 Applied Research Work Group*, including appended draft versions of the *2016-2019 Applied Research Project Schedule* and the *2016-2019 Applied Research Project Prioritization Matrix*, which it recommended to the IC as its final deliverables for approval and adoption. The IC adopted the *Report of the 2015 Applied Research Work Group* at its November 19, 2015 meeting. The final, approved report is attached in **Appendix I3**.

Freeman Aquatic Building Update

As discussed in the *EAHCP 2014 Annual Report*, rather than constructing a facility at the San Marcos Aquatic Research Center (SMARC), formerly the USFWS National Fish Hatchery and Technology Center, as was envisioned in the EAHCP, it was decided that appropriate facilities could be obtained through the use of the Freeman Aquatic Building (FAB) on the campus of Texas State. The infrastructure with modifications, provided a more cost-effective option than making the modifications that would be necessary to retrofit the SMARC as a suitable applied research facility for the needs of the EAHCP Applied Research Program.

In 2015 all laboratory experiments conducted under the Applied Research Program were housed in the FAB. Of these, research on the CSRB experienced unexpected mortality. The mortality events were considered to be the result of the facility's water quality. Once the issue was discovered, EAHCP researchers moved their project to the SMARC to mitigate any further losses. For the remainder of 2015, faculty at Texas State partnered with EAHCP staff to determine possible causes and solutions in order to resume conducting research on the CSRB and its surrogate species inside the FAB, as the designated applied research facility for the EAHCP.

In order to determine possible causes of water quality contamination, three rounds of Passive Diffusion Samplers (PDS) were placed throughout the facility. In addition to the water quality sampling, additional surrogate species of the CSRB were collected and placed in experimental units inside the facility. No issues with the FAB's water supply are believed to remain. It is the opinion of both Texas State and EAHCP staff that further CSRB and surrogate species research can be conducted in the FAB as long as the water is run through inline charcoal filters, which have now been installed.

Any Modifications or Activities Due to Weather Conditions:

Flood and/or drought conditions during 2015 did not require any modifications to the applied research projects, with the exception of the "Suspended Sediment Impacts" study, which required a no-cost extension to May 31, 2016 due to flood-related disruption impacts on *in-situ* elements. In addition, the applied

research facilities at the FAB were heavily impacted by the October 2015 flooding event of the San Marcos River. During the flood, the FAB raceway facility and the FAB pond structures along with associated electrical infrastructure became inundated. Following the flood, electrical receptacles and ground fault interrupters (GFIs) were replaced, and pond conduits drained, by Texas State to restore the FAB applied research facilities to working order. See **Figure 3.1-1** and **Figure 3.1-2** for images taken during this flooding event.

Figure 3.1-1. Image of the Freeman Aquatic Building at Texas State University inundated by the October 2015 flooding event.

As shown in **Figure 3.1-1**, the raceway facility is located under the bridge in the foreground of the image and is completely underwater.

Figure 3.1-2. Freeman Aquatic Building pond structures following the October 2015 flooding event.

All conduits were drained and receptacles replaced to restore the facility to working order following the flood.

Proposed Activities for 2016:

The Applied Research Program is a dynamic process in which existing research and data gaps are evaluated by EAA staff, the SC, and additional subject-matter experts. As reported above, the *2016-2019 Applied Research Project Schedule* was developed to provide a guideline for future applied research studies to be conducted. Additional applied research activities may be conducted as deemed necessary and appropriate through the AMP. The SC is integral in the development of research methodologies, and helping to resolve unforeseen conditions or challenges that may arise during applied research activities.

In 2016, the following applied research projects will be conducted:

- Evaluation of the long-term elevated temperature and low DO tolerances of CSRB;
- Evaluation of the life history of the CSRB;
- Evaluation of the trophic level status and functional feeding group categorization of the CSRB;
- Evaluation of quantitative sampling methods for the CSRB; and
- Creation of a comprehensive database for data collected in support of the EAHCP.

Other than *in-situ* studies and the project for the creation of an EAHCP database, all 2016 EAHCP applied research projects will utilize the FAB facility for their experimentation components.

3.1.2 Refugia (EAHCP §5.1.1, §6.4.2, §6.4.3, and §6.4.4)

EAHCP Obligations:

Pursuant to Sections 5.1.1, 6.4.2, 6.4.3, and 6.4.4 of the EAHCP, the EAA will support and coordinate with the USFWS on the work relating to the SMARC fish hatchery operation and maintenance of a series of off-site refugia. ITP Condition K requires that "the support of the refugia will augment the existing financial and physical resources of these facilities, and provide supplementary resources for appropriate research activities, as necessary, to house and protect adequate populations of Covered Species and expand knowledge of their biology, life histories, and effective reintroduction techniques."

2015 Compliance Actions:

As discussed in the 2014 EAHCP Annual Report, State Representative Douglas R. Miller, Chairman of the Edwards Aquifer Legislative Oversight Committee, Texas House of Representatives, requested a formal opinion from the Texas State Attorney General's Office to obtain clarification to ensure that all legal requirements had been met. Chairman Miller's letter to the Texas State Attorney General's Office, dated September 3, 2014 is located in **Appendix K6**. On March 9, 2015, the Attorney General's Office issued an opinion letter, which can be found in **Appendix K7**.

Given the importance of breaking ground on refugia facilities before a salvage recovery operation was triggered, as well as the delay caused by seeking the Attorney General's Opinion, EAHCP staff determined it would be prudent to pursue obtaining a minor administrative amendment to both the EAHCP and the ITP to allow the EAA to contract with entities other than the USFWS to procure a functioning refugia program for the EAHCP's Covered Species. A letter requesting USFWS approval for this amendment was submitted in December 2014. After reviewing the amendment request, the USFWS approved this change to the HCP, and issued an amended ITP on January 21, 2015.

Once approval from USFWS was received, EAHCP staff recommended to phase refugia operations into a *salvage* refugia program, aimed at providing refugia capabilities over the short-term to insure against the imminent threat of salvage triggers, and a long-term refugia program to provide a long-term facility and refugium for the Covered Species for the duration of the ITP. Procurement processes proceeded accordingly as described below.

***Salvage* Refugia Operations**

On March 30, 2015, the EAA issued an RFP titled *Salvage Refugia Operations* (located in **Appendix K8**). This RFP requested proposals from qualified vendors capable of providing a short-term salvage refugia operation intended to maintain compliance with the ITP until a long-term refugia could be built and become fully operational.

The Salvage Refugia Project has two primary objectives: 1) establish short-term refugia for Covered Species; and 2) perform research on species husbandry. For the first objective, salvage refugia will consist of captive populations, in secure facilities, for nine of the eleven threatened, endangered, or candidate species covered by the ITP in accordance with the EAHCP. Because of their limited geographic

distributions, the aquifer-dependent species are vulnerable to extirpation in all or parts of their range due to natural or human-induced habitat impacts (e.g., drought-induced reductions in springflows or catastrophic events, such as a chemical spill). Establishing refugia for the Covered Species is necessary to provide back-up populations that can be used to re-establish endemic populations of the species in the event of population loss or depletion in the wild.

The second objective of the EAA Salvage Refugia Project is to perform research to expand current knowledge of the Covered Species' biology, natural histories, husbandry techniques, and effective re-introduction strategies. This research will build on previous research and experience of the USFWS SMARC, Texas State and other researchers, and will focus on testing and/or refining husbandry techniques for the species in a captive environment.

The EAA received two proposals – one proposal from Texas State and the USFWS at SMARC, and another one from SWCA, the San Antonio Zoo and SeaWorld of San Antonio.

Both proposers were interviewed, and the SWCA proposal was selected to provide Salvage Refugia Operations under an 18-month contract beginning June 10, 2015, and ending on December 31, 2016.

Permitting and construction of the Salvage Refugia Project took approximately six months. At the time of writing this report, the Salvage Refugia Project is nearing completion and will be operational in early 2016. Photos of the early stages of construction of the Salvage Refugia Facility can be seen in **Figure 3.1-3** and **Figure 3.1-4**.

A mandate for the Salvage Refugia Program was to develop a *Salvage Refugia Research Plan* laying out the various research topics and proposed methods that the refugium team would undertake to build knowledge necessary for the effective operation of the Salvage Refugia Facility, such as determining best collection methods for obtaining salvage stock of species, such as the Comal Springs Dryopid Beetle and the Texas blind salamander, that are difficult to obtain in numbers. The final *Salvage Refugia Research Plan* can be viewed under **Appendix K9**.

Long-Term **Refugia Operations**

Efforts toward ITP compliance regarding refugia continued and on September 21, 2015, the EAA issued an RFP titled *Long Term Refugia Operations* (located in **Appendix K10**) seeking proposals to provide long-term refugia operations for the remainder of the ITP term.

Refugia operations were defined in the RFP as:

- One main off-site refugia facility and one redundant off-site refugia facility. Refugia facilities should provide for, at a minimum, the space requirements and infrastructure specifications presented in the conceptual layout (see Attachment C of **Appendix K10**), as well as all requirements in the "Additional Information for Proposers" section of the RFP.
- Refugia program staffed with qualified and permitted individuals to work with all Covered Species.
- Collection, establishment, and maintenance of standing stock, refugia stock, and salvage stock for the Covered Species.
- Development and refinement of animal rearing methods and captive propagation techniques.

Figure 3.1-3. Fresh concrete slab poured for the site of the Salvage Refugia Facility on the grounds of the San Antonio Zoo.

Figure 3.1-4. Delivery of a shipping container from Houston, Texas, retrofitted for the purpose of serving as refugium in the Salvage Refugia Facility at the San Antonio Zoo.

- Preparation of a Research Plan to be used for the duration of the ITP, with specific goals and milestones.
- Conduct research, as defined in the Research Plan, to further refine refugia operations.
- Preparation of a Re-introduction Plan for each Covered Species.
- Re-introduction of affected species, as defined in the Re-introduction Plan, if triggered.
- Refugia program permitting and reporting, as required by: the ITP, USFWS, TPWD, EAHCP Annual Report, EAHCP Annual Work Plans, and compliance meetings with regulators.

The EAA is still reviewing proposals received, and a contractor will be selected in early 2016 to provide Long-Term Refugia Operations.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications to this program due to flood and/or drought conditions; however, it should be noted that due to persistent sufficient flow conditions, no salvage events triggered in 2015.

Proposed Activities for 2016:

Consistent with the intent of ITP Condition K of the ITP, start-up operations for the long-term refugia should be underway. It is expected for permitting, construction, staffing, and other development activities to take approximately twelve months. Beginning in 2017, the refugia will be fully operational.

3.1.3 Voluntary Irrigation Suspension Program Option (EAHCP §5.1.2)

EAHCP Obligations:

The VISPO is a voluntary springflow protection program designed to compensate irrigation permit holders for not pumping from the Edwards Aquifer during certain drought conditions. Participants may enroll in a five-year or ten-year program participation option. Enrollment commits the permit holder to suspend pumping of enrolled water for one calendar year if, on the previous October 1 trigger date, the aquifer level at the J-17 index well is at or below 635 feet mean sea level (ft msl). At all other times, a participant's use of enrolled water is not restricted. Participants are paid an annual stand-by fee for their enrollment in the program, and are provided an additional forbearance payment in years where water use suspension is mandated by the terms of their VISPO forbearance agreements.

Pursuant to Section 5.1.2 of the EAHCP, the EAA is responsible for administering the VISPO. The goal for this program is 40,000 ac-ft of enrolled EAA-issued irrigation permits. The target distribution for enrollment is 10,000 ac-ft/year in Atascosa, Bexar, Comal, and Hays counties, and 15,000 ac-ft/year each in Medina and Uvalde counties. This program accepts both "Base Irrigation Groundwater" and "Unrestricted Irrigation Groundwater" withdrawal rights. Unrestricted Irrigation Groundwater is not restricted as to its place or purpose of use, while base water is restricted to irrigation use.

2015 Compliance Actions:

In 2015, existing VISPO enrollees were monitored for groundwater withdrawals, and no compliance problems were reported. No new enrollment occurred in 2015 because VISPO program enrollment goals were attained in 2014, with a total combined enrollment of 40,921 ac-ft as shown in **Table 3.1-2** below. All VISPO participants were paid a higher amount in 2015, with combined total VISPO payments amounting to $8,677,263 as presented in the table below.

Table 3.1-2. VISPO Total Enrollment (in ac-ft)

Enrollment Option	Atascosa	Bexar	Comal	Hays	Medina	Uvalde	Total
5-Year Base	354	829	0	67	2,920	14,532	18,702
5-Year Unrestricted	0	55	0	56	773	5,885	6,769
Subtotal	354	884	0	123	3,693	20,417	25,471
10-Year Base	0	1,451	0	0	6,152	4,183	11,786
10-Year Unrestricted	0	122	0	0	1,651	1,891	3,664
Subtotal	0	1,573	0	0	7,803	6,074	15,450
Totals	354	2,457	0	123	11,496	26,491	40,921
Payments	$70,880	$538,870	$0	$25,010	$2,538,839	$5,503,664	$8,677,263

During the first two years of EAHCP implementation, the VISPO program achieved complete success while ASR participation lagged. Consequently, HDR was commissioned in 2015 to evaluate the effect on the EAHCP of increasing VISPO enrollment and decreasing ASR participation. The modeled simulations indicated that once the ASR contained the expected volume to initiate a drought of record scenario, ASR leases could be decreased by approximately 95 ac-ft for every 100 ac-ft of VISPO enrollment, while maintaining the baseline minimum Comal Springs discharge of 28 cfs.

Any Modifications or Activities Due to Weather Conditions:

On October 1, 2015, the aquifer level at the J-17 index well was 645.2 ft msl; accordingly VISPO enrollees were informed that VISPO would not be implemented in 2016.

Proposed Activities for 2016:

No new program enrollment will occur as the 40,000 ac-ft goal has been met. Since 2016 is not a trigger year, stand-by payments will be made by March 2016 to all participants. In addition, because over 10,000 ac-ft of Unrestricted Irrigation Groundwater is enrolled in VISPO, these enrollees will be contacted to determine their interest in signing a one-year ASR lease.

3.1.4 Regional Water Conservation Program (EAHCP §5.1.3)

EAHCP Obligations:

The RWCP was included in the EAHCP to provide an opportunity for permit holders not currently engaged in conservation programs to be provided a mechanism for implementing water conservation to offset their current levels of pumping. This program includes municipal and industrial use permit holders, as well as exempt well owners.

The RWCP includes the following elements:

- Lost water and leak detection
- High-efficiency plumbing fixtures and toilet distribution
- Commercial/industrial retrofit rebate
- Water reclamation

Pursuant to Section 5.1.3 of the EAHCP, the goal of the RWCP is to conserve 20,000 ac-ft of permitted or exempt Edwards Aquifer water. Of this amount, 10,000 ac-ft will be held by the EAA in the Groundwater Trust where it will remain un-pumped for the term of the ITP to reduce stress on the Aquifer. The other 10,000 ac-ft of conserved groundwater will remain available for withdrawal by the participating entity.

As a first step to fulfilling this measure, the EAA's goal was to obtain 'initial commitments' in the amount of 10,000 ac-ft/year in 2013. As conserved water is committed to the Groundwater Trust, the initial commitment water is to be returned to the committing entity. At present, SAWS, Texas State and COSM have made initial commitments in the amount of 8,400 ac-ft.

2015 Compliance Actions:

The goal for 2015 was to fully develop and begin implementation of the recommendations from the RWCP Work Group (see 2014 EAHCP Annual Report for more information), as well as the required four individual elements of the RWCP: lost water and leak detection; high efficiency plumbing fixtures and toilet distribution; commercial/industrial retrofit rebate; and water reclamation for efficient water use.

Due to the lack of progress in the RWCP, the EAA terminated the Interlocal Agreement (ILA) with Texas AgriLife as the acting representative for the RWCP on January 31, 2015. With the contract termination, funding was re-allocated to hiring two new EAHCP staff positions – an HCP Coordinator (position filled in June 2015), and a Senior HCP Coordinator (position to be filled in early 2016).

As part of the implementation of the RWCP, the EAA continued to meet the obligations described in the U.S. Bureau of Reclamation's WaterSMART Grant. In September 2015, the grant expired concluding 2015 with over $260,000 expended to reimburse participating entities for high efficiency/low flow toilets and plumbing kits, and leak detection/water loss programs.

The EAA has continued to assist the City of Uvalde with implementation of their water conservation measures (primarily the distribution of high efficiency/low flow toilets and plumbing kits). In 2015, the

installation of high-efficiency toilets and plumbing kits resulted in an estimated savings of 17.72 ac-ft; one-half of that amount (8.86 ac-ft) was transferred into the EAA's Groundwater Trust. At the writing of this report, the City of Uvalde had distributed approximately 1,000 high efficiency/low flow toilets and plumbing kits to city residents.

As previously mentioned in **Section 1.4** – 2015 EAHCP Committee Activities, **subsection 1.4.1** – Activities of the IC, of this Annual Report, in 2014 the IC appointed the RWCP Work Group to develop recommendations to the IC on methods to secure the remaining balance of the 10,000 ac-ft of Edwards Aquifer water to be placed in the Groundwater Trust to meet this ITP requirement. The RWCP Work Group developed nine recommendations. Their final report was presented to the IC on January 15, 2015, and the IC voted to recommend the report to the EAA for implementation. In 2015, EAA staff continued to implement these recommendations, including conversations with the region's industrial users through the Texas Aggregate and Concrete Association's (TACA) Annual Environmental and Sustainability Seminar. There, staff was able to cultivate new relationships and help build a dialogue to benefit conservation efforts with Edwards Aquifer industrial permit holders.

Through conversations with the City of Natalia in late 2014, the EAA committed to providing professional services to analyze their municipal water supply system. In the summer of 2015, the EAA successfully executed a contract with an engineering consulting firm to perform a water audit. The final results were presented to the Natalia City Council. The final report was published in late 2015 (**Appendix K11**).

At the end of 2015, the EAA and SAWS developed an agreement that satisfied the remaining goal for water committed into the Groundwater Trust for the remainder of the ITP. The contract enabled SAWS to initiate a five-year leak detection and repair program within SAWS' existing infrastructure.

The estimated savings are shown in **Table 3.1-3** with a total savings of 19,612 ac-ft of conserved water. One-half of the conserved water (9,806 ac-ft) will be placed in the Groundwater Trust through the RWCP to remain un-pumped until 2028.

Table 3.1-3. Estimated Savings (in ac-ft) of Conserved Water

Water	2016	2017	2018	2019	2020	Total
Estimated Savings (ac-ft)	4,745.00	4,745.00	4,745.00	4,745.00	632.00	19,612.00
Groundwater Trust (ac-ft)	2,372.50	2,372.50	2,372.50	2,372.50	316.00	9,806.00

Any Modifications or Activities Due to Weather Conditions:

There were no modifications to this program due to flood and/or drought conditions in 2015.

Proposed Activities for 2016:

In 2016, the EAA will continue to support the implementation of Conservation Measures that will be designed to to conserve 20,000 ac-ft of Edwards Aquifer withdrawals and commit 10,000 ac-ft to the Groundwater Trust.

Specifically, EAA staff will:

- Continue to work with the City of Uvalde to find additional opportunities for reducing their use of the Edwards Aquifer;
- Find a more efficient means of coordinating with the U.S. Department of Defense (DoD);
- Continue conversations with industrial users including, but not limited to, the concrete and aggregate companies in the region;
- Contact large municipalities to discuss participating in a high-efficiency, low-flow plumbing program;
- Continue to reach out to communities in the EAA's jurisdictional area to determine their willingness to participate in the RWCP; and
- Identify other opportunities to place groundwater in the trust.

3.1.4.1 Regional Water Conservation Program Monitoring Committee

The EAA is responsible for coordinating the activities of the RWCP Monitoring Committee. Representation on the Monitoring Committee includes one representative each from SAWS, the CONB, the COSM, and a small water purveyor that uses the Edwards Aquifer. It is the responsibility of this committee to provide technical input and expertise, seek additional funding, advise the EAA on the efficiency and significance of RWCP activities, consider each activity in the context of achieving the overall EAHCP goal for the RWCP, rank proposed activities, comment on the potential of each activity, consult with the EAA board regarding conserved water determinations, make specific recommendations regarding program implementation, and develop periodic updates tracking the program's progress.

The RWCP Monitoring Committee did not meet during 2015.

3.1.5 Critical Period Management Program – Stage V (EAHCP §5.1.4)

EAHCP Obligations:

Stage V of the EAA CPMP mandates a 44 percent reduction in water use, and is applicable to permit holders in both the San Antonio and Uvalde pools. For the San Antonio Pool, Stage V is triggered when the 10-day average aquifer level at the J-17 index well drops below 625 ft msl, or if the springflows at Comal Springs decline below 45 cfs, based on a ten-day rolling average or below 40 cfs, based on a three-day rolling average. In the Uvalde Pool, Stage V is triggered when the Uvalde County Index Well J-27 aquifer level drops below 840 ft msl.

2015 Compliance Actions:

In 2015, Stage V was in effect in the Uvalde Pool for a total of 154 days. San Antonio, however, did not enter Stage V in 2015. **Table 3.1-4** and **Table 3.1-5** below show the requirements for Stage V reductions in relationship to the first four CPMP stages for both the San Antonio and Uvalde pools, respectively.

Table 3.1-4. CPMP Triggers, Stages, and Reductions for the San Antonio Pool of the Edwards Aquifer

Wells/Springs	Critical Period Stage I*	Critical Period Stage II*	Critical Period Stage III*	Critical Period Stage IV*	Critical Period Stage V**
J-17 Index Well Level (msl)	<660	<650	<640	<630	<625
San Marcos Springs Flow rate (cfs)	<96	<80	N/A	N/A	N/A
Comal Springs Flow rate (cfs)	<225	<200	<150	<100	<45** or <40**
Withdrawal Reduction	20%	30%	35%	40%	44%

* A change to a critical period stage with higher withdrawal reduction percentages, including initially into Stage I for the San Antonio Pool and Stage II for the Uvalde Pool, is triggered if the 10-day average of daily springflows at the Comal Springs or the San Marcos Springs, or the 10-day average of daily Aquifer levels at the J-17 or J-27 Index Wells, as applicable, drop below the lowest number of any of the trigger levels for that stage. A change from any critical period stage to a critical period stage with a lower withdrawal reduction percentage, including exiting from Stage I for the San Antonio Pool, and Stage II for the Uvalde Pool, is triggered only when the 10-day average of daily springflows at the Comal Springs and the San Marcos Springs, and the 10-day average of daily Aquifer levels at the J-17 or J-27 Index Wells, as applicable, are all above the same stage trigger level.

** In order to enter into Critical Period Stage V, the applicable springflow trigger is either less than 45 cfs based on a ten-day rolling average, or less than 40 cfs, based on a three-day rolling average. Expiration of Critical Period Stage V is based on a ten-day rolling average of 45 cfs or greater.

Table 3.1-5. CPMP Triggers, Stages, and Reductions for the Uvalde Pool of the Edwards Aquifer

Wells/Springs	Critical Period Stage I*	Critical Period Stage II*	Critical Period Stage III*	Critical Period Stage IV*	Critical Period Stage V**
J-27 Index Well Level (msl)	N/A	<850	<845	<842	<840
San Marcos Springs Flow rate (cfs)	N/A	N/A	N/A	N/A	N/A
Comal Springs Flow rate (cfs)	N/A	N/A	N/A	N/A	N/A
Withdrawal Reductions	N/A	5%	20%	35%	44%

* A change to a critical period stage with higher withdrawal reduction percentages, including initially into Stage I for the San Antonio Pool and Stage II for the Uvalde Pool, is triggered if the 10-day average of daily springflows at the Comal Springs or the San Marcos Springs, or the 10-day average of daily Aquifer levels at the J-17 or J-27 Index Wells, as applicable, drop below the lowest number of any of the trigger levels for that stage. A change from any critical period stage to a critical period stage with a lower withdrawal reduction percentage, including exiting from Stage I for the San Antonio Pool, and Stage II for the Uvalde Pool, is triggered only when the 10-day average of daily springflows at the Comal Springs and the San Marcos Springs, and the 10-day average of daily Aquifer levels at the J-17 or J-27 Index Wells, as applicable, are all above the same stage trigger level.

** In order to enter into Critical Period Stage V, the applicable springflow trigger is either less than 45 cfs based on a ten-day rolling average, or less than 40 cfs, based on a three-day rolling average. Expiration of Critical Period Stage V is based on a ten-day rolling average of 45 cfs or greater.

Any Modification or Activities Due to Weather Conditions:

Due to the drought conditions in early 2015, the EAA enforced CPMP restrictions in both pools of the Edwards Aquifer. In 2015, the San Antonio Pool began the year in Stage III and the Uvalde Pool began the year in Stage V. While the Uvalde Pool aquifer level increased beginning in June, the San Antonio Pool aquifer level fluctuated up and down throughout the year. Effective August 4, 2015, the Uvalde Pool was

no longer in any stage of CPMP, and on November 9, 2015, the EAA declared expiration of Stage I of the CPMP for the San Antonio Pool. For the remainder of 2015, the EAA did not declare any stages of CPMP restrictions for either pool. **Table 3.1-6** shows the number of days each pool was in a CPMP stage with water use restrictions in 2015.

Table 3.1-6. 2015 CPMP Enforced Reductions – Number of Days Per Pool

CPM Stage	Total Days in Uvalde Pool	Total Days in San Antonio Pool
No CPM reduction	150	114
Stage I	0	47
Stage II	43	177
Stage III	14	27
Stage IV	4	0
Stage V	154	0
Total Reduction	**20.4%**	**19.7%**

Proposed Activities for 2016:

In 2016, the EAA will continue to enforce CPMP restrictions, consistent with the agency's rules, and as discussed in the EAHCP.

3.1.6 Expanded Water Quality Monitoring (EAHCP §5.7.2)

EAHCP Obligations:

The EAA will continue its historical groundwater and surface water quality monitoring programs. In addition to historical monitoring, the EAA will expand its water quality monitoring efforts to include groundwater, surface water, stormwater, sediment, and PDS sampling in LL, the Comal River, Spring Lake, and the San Marcos River.

2015 Compliance Actions:

The EAA continued the Expanded Water Quality Monitoring Program (EAHCP §5.7.2), collecting additional samples and sample types to detect early signs of water quality impairments to the Comal and San Marcos river and spring systems. An overview of the associated data collected and sampling events for 2015, along with analytical parameters by sample type, can be seen in **Table 3.1-7** and **Table 3.1-8** below.

Table 3.1-7. Summary of Data Types and Water Quality Sampling Events for 2015

San Marcos River	Sample Dates
Surface Water/Base Flow	03/25/2015, 09/17/2015
Sediment	06/05/2015
Stormwater	05/05/2015 through 05/06/2015, 10/23/2015
Universal Passive Samplers	02/2015, 04/2015, 06/2015, 08/2015, 10/2015, 12/2015
Comal River	**Sample Dates**
Surface Water/Base Flow	03/16/2015, 09/09/2015
Sediment	06/04/2015
Stormwater	01/22/2015 through 01/23/2015, 10/23/2015
Universal Passive Samplers	02/2015, 04/2015, 06/2015, 08/2015, 10/2015, 12/2015

Table 3.1-8. Analytical Parameters by Sample Type

Analytical Parameter	Surface Water (Base Flow) Samples	Sediment Samples	Stormwater Samples	Passive Diffusion Sampling
Volatile Organic Compounds (VOCs)	Yes	Yes	Yes	No
Semi-volatile Organic Compounds (SVOCs)	Yes	Yes	Yes	No
Organochlorine Pesticides	Yes	Yes	Yes	No
Polychlorinated Biphenyls (PCBs)	Yes	Yes	Yes	No
Herbicides	Yes	Yes	Yes	No
Metals (Al, Sb, As, Ba, Be, Cd, Cr (total), Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, Tl, and Zn)	Yes	Yes	Yes	No
General Water Quality Parameters (GWQP; Total Alkalinity (as $CaCO_3$), Bicarbonate Alkalinity (as $CaCO_3$), Carbonate Alkalinity (as $CaCO_3$); Cl, Br, NO_3, SO4, Fl, pH, TDS, TSS, Ca, Mg, Na, K, Si, Sr, CO_3,)	Yes	No TDS or TSS	Yes	No
Phosphorus (total)	Yes	Yes	Yes	No
Total Organic Carbon (TOC)	Yes	Yes	Yes	No
Dissolved Organic Carbon (DOC)	Yes	Yes	Yes	No
Total Kjeldahl Nitrogen (TKN)	Yes	No	Yes	No
Bacteria (*E. coli*)	Yes	No	Yes	No
Field Parameters (DO, pH, Conductivity, Turbidity, Temperature)	Yes	No	Yes	No
TPH, BTEX, 1,3,5 and 1,2,4- trimethylbenzene, MTBE, phenanthrene, naphthalene1-methyl naphthalene, octane, cis and trans-1,2,-dichloroethene, 1,1-dichloroethane, chloroform, 1,1,1-trichloroethane, 1,2-dichloroethane, carbon tetrachloride, trichloroethene, tetrachloroethene, chlorobenzene, 1,4-dichlorobenzene, 1,1,2-trichloroethane, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, 1,3-dichlorobenzene, and 1,2-dichlorobenzene.	No	No	No	Yes
Caffeine	Yes	No	Yes	No

Summary of 2015 Results

SWCA staff collected surface water (base flow), stormwater, sediment, and passive diffusion samples from the Comal and San Marcos systems. The sampling events met the requirements of the EAHCP and provided background data for these two systems. The limited number of detections above comparative standards is indicative of generally high water quality. However, the total non-polycyclic and polycyclic aromatic hydrocarbons (PAH) and selenium results that exceeded comparative standards were of concern.

Specific detections of interest, such as compounds detected above a maximum contaminant level (MCL), for water, or probable effect concentration (PEC), for sediment, are listed below:

San Marcos Sediment:
HSM340[5]: Total PAH 62.64 milligrams per kilogram (mg/kg) (PEC = 22.8)
HSM320[6]: Selenium 4.20 J[7] mg/kg (Bioaccumulation Toxicity = 4.0)

PAHs in Sediment
PAHs are a group of semi-volatile organic compounds common in urban runoff (Mahler et al., 2005) that can have adverse effects on aquatic life including plants, invertebrates, and fish. The effects of exposure vary but can include organ damage, reproductive harm, or immune system weakening (Mahler et al. 2005). Coal-tar parking lot sealants have been identified as a significant source of PAHs in urban waterways and were banned from use in areas surrounding the Recharge Zone of the Edwards Aquifer within Comal and Hays counties by the EAA in 2012. In each sample year thus far, levels of total PAH in sediment samples have exceeded threshold effect concentrations and PECs at several sites, especially in the San Marcos Springs complex. Further investigation may be warranted to identify the extent of PAH presence in the sediment and to identify potential sources of PAHs.

Selenium in Sediment
The selenium concentration in sediment sample HSM320 of 4.20 J mg/kg is below the laboratory reporting and quantification limit. The concentration in sample HSM320 is above the Texas-specific background concentration level of 0.3 mg/kg. Sediment studies of selenium concentrations have shown that levels of 4 mg/kg or less are not likely to bioaccumulate in the food chain, or have adverse impacts on the reproduction of fish or aquatic birds (Lemly 1995; Moore et al. 1990; Van Derveer and Canton 1996). Selenium detections did exceed this amount at HSM320, with a detected concentration of 4.20 J mg/kg.

DEHP in Sediment
Bis(2-ethylhexyl) phthalate (DEHP) was detected in the majority of sediment samples from the Comal and San Marcos springs complexes in 2013, but was considered by EAA to likely be a laboratory or sampling equipment artifact. DEHP was again detected in some samples from the San Marcos Springs complex in

[5] Site located north of the E. Hopkins St. Bridge, south of the footbridge, close to the western bank of the San Marcos River.
[6] Site located towards the southwest corner of Spring Lake, near the bank adjacent to the Saltgrass Steakhouse parking lot on 221 Sessoms Drive.
[7] "J" signifies detections above the method detection limit, but below the reporting limit.

2014 at HSM320, HSM330[8], and HSM350[9]. Because other plasticizers were not present and different laboratories were used in 2014, it was concluded that DEHP may be present in sediments in the San Marcos system. In 2015, equipment used to collect sediment samples did not contain plasticizers with the exception of one sample collected in the Comal River (HCS330). DEHP was again detected in some of the same San Marcos system samples (HSM330, HSM340, and HSM350). The continued detections of DEHP indicate that it may be present in the middle reaches of the San Marcos system.

The final 2015 Expanded Water Quality Monitoring Report, including water quality data, is included in **Appendix C1**.

Real Time Instrumentation

The objective for implementing the use of Real Time Instrumentation (RTI) was to measure changes in basic water quality parameters in near real time. The RTIs record data at 15-minute intervals, or nearly continuous basis, depending on the parameters. As such, the instrumentation provides a mechanism for recording water quality changes related to season, time of day, weather, and various other influences. The instrumentation measures the following parameters:

- DO in milligram(s) per liter (mg/L)
- pH (no units)
- Conductivity in micro-Siemens per centimeter (µS/cm)
- Turbidity in nephelometric turbidity units (NTU)
- Temperature in degrees Celsius (°C)

The resulting data are included in **Appendix C2** of this Annual Report.

Any Modifications or Activities Due to Weather Conditions:

Sampling activities were minimally affected by on-going drought conditions in the area. No extreme low-flow sampling was initiated at wells (EAHCP §§6.4.3.3 and 6.4.4.3) as flows at Comal Springs did not drop below 30 cfs, or below 50 cfs at San Marcos Springs. Significant rainfall occurred during the first half of 2015, in contrast to the severe drought conditions experienced in previous years. However, rainfall was sparse from July 2015 through October 2015. Rain events were generally scattered in nature, and often too small in magnitude to generate sufficient runoff to sample. However, on October 23, 2015, the New Braunfels area received approximately 2.5 inches of rain and SWCA was able to safely obtain stormwater samples from the Comal River. On October 23-24, 2015, the San Marcos area received approximately 4.0 inches of rain. SWCA was able to safely obtain stormwater samples on October 23, 2015, from the San Marcos River.

[8] Sessoms Creek segment running past the Texas State FAB parking lot.
[9] The east bank of Cypress Island in the San Marcos River, north of Rio Vista Park.

Proposed Activities for 2016:

In 2016, the EAA will continue the Expanded Water Quality Monitoring Program consistent with the requirements outlined in the EAHCP.

3.1.7 Biological Monitoring (EAHCP §6.3.1, §6.4.3, and §6.4.4)

EAHCP Obligations:

The Biological Monitoring Program represents the continuation of the EAA's Variable Flow Study, initiated in 2000, amended to include critical period and EAHCP-specific monitoring to provide a means of monitoring changes to habitat availability and population abundance of the Covered Species that may result from the Covered Activities included in the EAHCP, and natural events.

Pursuant to Section 6.3.1 of the EAHCP, the EAA will continue the Biological Monitoring Program (as amended), including additional sampling during CPMP stages, additional nutrient testing, and additional sampling to include the Edwards Aquifer diving beetle and the Texas troglobitic water slater. The Biological Monitoring Program also includes additional sampling as required by the EAHCP to monitor natural changes occurring in the system as determined to be appropriate through the AMP.

In addition, the Biological Monitoring Program includes triggered monitoring activities as outlined in Sections 6.4.3 and 6.4.4 of the EAHCP. Triggered monitoring requires additional sampling and vegetation mapping activities not included in the Variable Flow Critical Period Sampling Program.

2015 Compliance Actions:

It is important to recognize that many different sampling components are included in the EAHCP Biological Monitoring Program, and that several sampling location strategies are employed. The sampling locations selected are designed to cover a representative extent of Covered Species habitats in both systems, and are a subset that is used for ecological interpretation of the systems, while maximizing resources where practical, and when applicable. As such, the current design employed the following six basic sampling location strategies for the Comal and/or San Marcos systems, with associated sampling components:

1. System-wide sampling
    - Texas wild-rice full-system mapping—annually (San Marcos only)
    - Full system aquatic vegetation mapping—once every five years (will not be performed until 2018)
2. Select longitudinal locations
    - Temperature monitoring—thermistors
    - Water quality sampling—during critical period sampling
    - Fixed-station photography
    - Discharge measurements (Comal system only)
3. Reach Sampling (four reaches)
    - Aquatic vegetation mapping

- Fountain darter drop netting
- Fountain darter presence/absence dip netting
- Macroinvertebrate community sampling (San Marcos)

4. Springs Sampling
   - Endangered Comal invertebrate sampling
   - Comal Springs salamander sampling
   - San Marcos salamander sampling
5. River Section/Segment Sampling
   - Fountain darter timed dip net surveys
   - Macroinvertebrate community sampling (Comal system)
   - Fish community sampling
6. Critical Period (High-flow) Sampling
   - Both systems

The 2015 Biological Monitoring Reports for both the Comal and San Marcos systems are included in **Appendix F** and **Appendix G,** which each include discussion relating to the high-flow, critical period sampling event that took place following the late October 2015 flood in November and December of 2015.

Any Modifications or Activities Due to Weather Conditions:

Rainfall in January 2015 ended critical period monitoring by January 30, 2015, in the Comal system. Rainfall over October 28-29, 2015 was intense enough to create flooding conditions in both the San Marcos and Comal rivers, which triggered high-flow, critical period sampling. The timing of the high-flow occurred shortly after the fall comprehensive sampling event and will now provide the best "before, after, and recovery" data to date for evaluating system memory.

Proposed Activities for 2016:

In 2016, the EAA will continue the Biological Monitoring Program consistent with the requirements outlined in the EAHCP.

3.1.8 Groundwater Modeling (EAHCP §6.3.2)

EAHCP Obligations:

By December 31, 2014, the EAA will: (1) take appropriate steps to reduce the level of uncertainty in the MODFLOW model by filling in data gaps to the extent practicable and by reducing the number of structural limitations in the model; and (2) create a new finite-element model to reduce uncertainty in the model results for use during the AMP and to provide assurance/confirmation that modeling results for the Edwards Aquifer and springflows are more reliable and defensible.

2015 Compliance Actions:

MODFLOW Model

A major update and recalibration of the MODFLOW groundwater flow model was completed in 2014. During 2015, this updated model was used to develop an initial drought-of-record scenario using recharge and pumping estimates for years 1947 through 1958. The model was able to reasonably reproduce water levels in the San Antonio index well J-17 and spring flows at Comal and San Marcos springs during the 1950s drought, but generally underestimated water levels in the Uvalde index well J-27. An analysis of recharge estimation methods and an analysis of model sensitivity to recharge input suggests that the amount and spatial distribution of recharge are key uncertainties that affect the model's ability to reproduce observed water levels and springflows for the drought-of-record.

Following recommendations from the NAS *Report 1*, EAA staff began to develop a set of MODFLOW model scenarios to be used in a comprehensive analysis of the effects of model uncertainty on the modeled response of the aquifer to the various EAHCP Conservation Measures. The set of models developed for this uncertainty analysis is intended to reflect a range of uncertainties for model inputs and parameters, such as the spatial distribution of recharge, aquifer storage capacity, and hydraulic conductivity. A set of models that reasonably reproduce observed water levels and springflows for years 2001 through 2011 will be set up to run drought-of-record scenarios and to evaluate the effects of Conservation Measures under modern pumping demands. This uncertainty analysis is scheduled to be completed by December 2016.

Finite-Element Model

The new finite-element model of the Edwards Aquifer was evaluated by EAA modeling staff during 2015. Overall, this model is not quite as effective as the updated MODFLOW model in matching observed water levels and springflows for the 2001–2011 calibration period. However, because this model includes explicit representation of three hydrogeologic layers (Edwards, Upper Glen Rose, and Lower Glen Rose formations) and the Contributing Zone to the north of the Edwards Aquifer, it can be useful as a tool to evaluate conceptual models for inter-formational movement of water between the Glen Rose and Edwards formations. The NAS *Report 1* provided feedback that there is no significant advantage to having two separate groundwater models and recommended that lessons learned from development of the new finite-element model and the updated MODFLOW model should eventually be combined into a single model during the next major model update. The EAA's current five-year plan for model development calls for planning of the next major model update to begin in 2017.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications to this program due to weather conditions.

Proposed Activities for 2016:

A main focus of 2016 groundwater modeling activities will be to complete a series of uncertainty analyses using an ensemble set of MODFLOW models to evaluate the effects of EAHCP Conservation Measures on

sustaining springflows for a range of model scenarios intended to represent uncertainties in recharge and aquifer hydraulic properties.

3.1.9 Ecological Modeling (EAHCP §6.3.3)

EAHCP Obligations:

The EAA oversees the development of a predictive mechanistic ecological simulation model that will be used to identify and describe ecological responses, and to predict and quantify impacts.

2015 Compliance Actions:

Four main efforts led by BIO-WEST took place in 2015. The first one, continued since 2014, was the development of a model for the principal categories of submerged aquatic vegetation (SAV) in the Comal and San Marcos systems. The modeling team determined that a model combining the key metabolic processes from the ERDC and MEGAPLANT models, with additional capabilities specific to the Comal and San Marcos systems, was most suitable for the EAHCP. This required substantial new model coding. The present version of the model now includes temperature, light penetration into the water with attenuation due to turbidity, photosynthetic increase in biomass both above-ground and below-ground, respiration, and mortality. Plant dispersal has been included in the model to address re-vegetation after scour events, recreational impacts, and impacts associated with low-flow conditions.

For its second effort in 2015, the project team researchers conducted several observational studies to better quantify the behavior of the vegetation communities. These studies included laboratory and field determinations of the relationships between the fraction of area covered (which is the measurement of the extent of each species of SAV in the field) to biomass (which is the parameter modeled), and a literature survey of scour behavior of the dominant SAV species in the two rivers.

The third main modeling effort addressed the fountain darter population. NETLOGO was selected to be the model-development platform for the darter model, because (1) it is a widely accepted, freely distributed software platform for individual-based models, (2) it can represent the spatially varying environments of the two rivers, (3) it can accommodate a wide range of behavioral and physiological "rules", and (4) it employs a versatile, high-level scripting capability, which will facilitate programming. The team developed a strategy for handling the outputs from the 2-D hydraulic model and the 1-D temperature model, already developed in previous studies, and converting these into appropriate input files for the NETLOGO model.

For its fourth effort and in response to an SRP/NAS concern with NETLOGO, in 2015 the project team also developed an alternative model in C++ that has an order-of-magnitude increase in running time.

The fountain darter module of the Ecological Model has a mortality component to account for fountain darter death constructed utilizing the best available data, generated under laboratory conditions with assumptions to estimate fountain darter mortality due to the lack of "real" data. To more effectively calibrate the model, an *in-situ* study to measure fountain darter mortality was conducted. In addition, validation

studies of the Ecological Model began in 2015, with one study designed to collect fountain darter data from randomly selected sampling sites beginning in 2015 and ending in 2016.

A detailed presentation on the Ecological Model was provided at the February 11, 2015 meeting of the SC. This presentation has been included in **Appendix K12**. In addition, BIO-WEST prepared an interim report detailing progress to date on the *Predictive Ecological Model for the Comal and San Marcos Ecosystems Project* on December 31, 2015. This report is included as **Appendix K13**.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications to this program due to weather conditions.

Proposed Activities for 2016:

The current activities related to the Ecological Model will extend into 2016. The goal is to finish calibrating working models for SAV and fountain darters for the study reaches in both the Comal and San Marcos systems in spring 2016. Once calibration and validation studies have been completed and results incorporated into the model for refinement, the completed model is to be delivered to the EAA by December 31, 2016.

Concurrent with model validation in 2016, BIO-WEST will provide on-site training to EAHCP staff on the use of the Ecological Model. In addition to on-site training, BIO-WEST will develop a "User Guide" to assist EAA staff in becoming familiar with the user interface and to serve as a reference in developing model runs. It is anticipated that this training and user guide development will occur in the latter part of 2016. A final report will be submitted by BIO-WEST for Year 3 by December 31, 2016.

3.1.10 Impervious Cover and Water Quality Protection (EAHCP §5.7.6)

EAHCP Obligations:

The EAA will put together materials regarding the value of a ban on the use of coal tar sealants and work with local governments to explore and encourage their consideration of such a ban.

2015 Compliance Actions:

Actions required under the EAHCP were accomplished during 2012-2013 when the EAA collected, analyzed, and shared information regarding the value of a ban on the use of coal tar sealants during a water quality-related rulemaking. Background information regarding those actions is provided below.

Following a presentation from the USGS to the EAA Research and Technology Committee regarding findings on the impact of polycyclic aromatic hydrocarbons (PAHs), the constituent of concern contained in coal tar pavement sealants, EAA staff was directed by the EAA Board of Directors to include a prohibition of coal tar sealants to the list of items that were, at that time, being considered to be included as possible amendments to the EAA Water Quality Protection Rules. The prohibition was subsequently included in the EAA Water Quality Rules Concept Memorandum that was approved and distributed in

2011, following review from a Water Quality Advisory Taskforce that included representation from stakeholders throughout the region.

In 2012, during the rulemaking process and in consideration of the EARIP HCP, EAA staff collected and reviewed numerous studies on the matter provided by the USGS and members of the coal tar industry. A copy of the bibliography is included as **Appendix K14**. The primary concern of the EAA with coal tar pavement sealants was the potential they present for sediment contamination from PAHs in the Edwards Aquifer. This concern stemmed from the hydrogeologic characteristics of the Edwards Aquifer, which has the ability to accept and transport sediment in turbulent flow regimes, into aquatic ecosystems associated with the major Edwards Aquifer springs. The EAA acknowledged that PAH detections in water samples were rare because of their hydrophobic nature (naphthalene, the most soluble PAH, is about the only PAH detected in water samples). Therefore, the EAA would expect there to be PAH compounds in stormwater and related sediment, but not in samples of drinking water. Based on these facts, while there was disagreement on the source of PAHs in sediment, after reviewing all relevant literature and hearing from all interested parties, the EAA believed a focused regulatory approach that restricted the use of coal tar pavement sealants was warranted.

Ultimately, EAA staff concluded that the major concern under the EAA's mission was the threat PAHs posed to aquatic life. Therefore, staff developed a series of recommendations for consideration by the EAA Board of Directors. The recommendation chosen was a narrow approach to the prohibition that isolated areas having the greatest potential to negatively impact the endangered species living in Comal and San Marcos springs ecosystems.

The approved ban prohibits the application of coal tar pavement sealant products over the Recharge Zone and portions of the Contributing Zone of the Edwards Aquifer in Hays and Comal counties. It is important to note that the ban only applies to coal tar pavement sealant products – not all products containing coal tar – such as creosote on telephone poles.

The rulemaking including the prohibition became effective in 2012. The specific language of the prohibition is as follows (EAA 2015):

> **Chapter 713 (Water Quality), Subchapter H (Prohibitions)**
>
> **§ 713.703 Prohibition on the Use of Coal Tar-Based Pavement Sealant Products**
>
> (a) The use of coal tar-based pavement sealant products is prohibited after December 31, 2012.
>
> (b) This section applies to actions located within Comal and Hays Counties on, above, or within:
>
> (1) the recharge zone of the Aquifer, including the area identified on the official maps of the Authority;
>
> or

(2) the contributing zone of the Aquifer five miles up-gradient of the recharge zone, or to the limit of the five-mile water quality buffer zone, whichever is less, including the area identified on the official maps of the Authority.

Information regarding the prohibition was shared with area users and local governments. To the EAA's knowledge, no local governments, other than the City of San Antonio, have explored or considered a ban on the use of coal tar sealants.

Any Modifications or Activities Due to Weather Conditions:

This section is not applicable to the required actions because flood or drought conditions do not impact the collection and sharing of information.

Proposed Activities for 2016:

The EAA has already collected and shared materials regarding the value of a ban on the use of coal tar sealants and has worked with local governments to explore and encourage their consideration of such a ban. The EAA is available to serve as a resource for any local government that concludes future regulatory action is necessary.

3.1.11 Program Management

EAHCP Obligations:

Pursuant to Section 2.2 of the FMA, the EAA is responsible for the general management and oversight of the program, including the duties and responsibilities of the other ITP Permittees, in accordance with the ITP, EAHCP, FMA and other program documents. Section 5.6.5 of the FMA allows for use of EAHCP funds to fund EAA administrative costs and employee salaries, so long as all incurred costs and salaries are 100 percent related to "general management and oversight" of the EAHCP.

Part of the EAA's responsibility includes facilitating the employment of the Program Manager, who is responsible for managing the EAHCP program and ensuring compliance with all relevant program documents. Although referred in the FMA as the "Program Manager," the title for this position under the EAA organizational structure is "Executive Director – Habitat Conservation Plan."

2015 Actions:

In 2015, three positions were added to the EAHCP staff team – Director of Refugia and Covered Species (an EAA-funded position), Senior HCP Program Coordinator, and HCP Program Coordinator. The Senior HCP and HCP Program Coordinator positions were intended to assist in program administration activities, committee and work group meeting coordination, and in the implementation of the RWCP activities. The Director of Refugia and Covered Species Programs position was added to manage EAA's required Salvage and Long-Term Refugia programs as well as EAA's implementation of the Applied Research, Ecological Modeling, and the Biological and Water Quality Monitoring programs. See **Figure 3.1-5** for the EAHCP staff organizational chart.

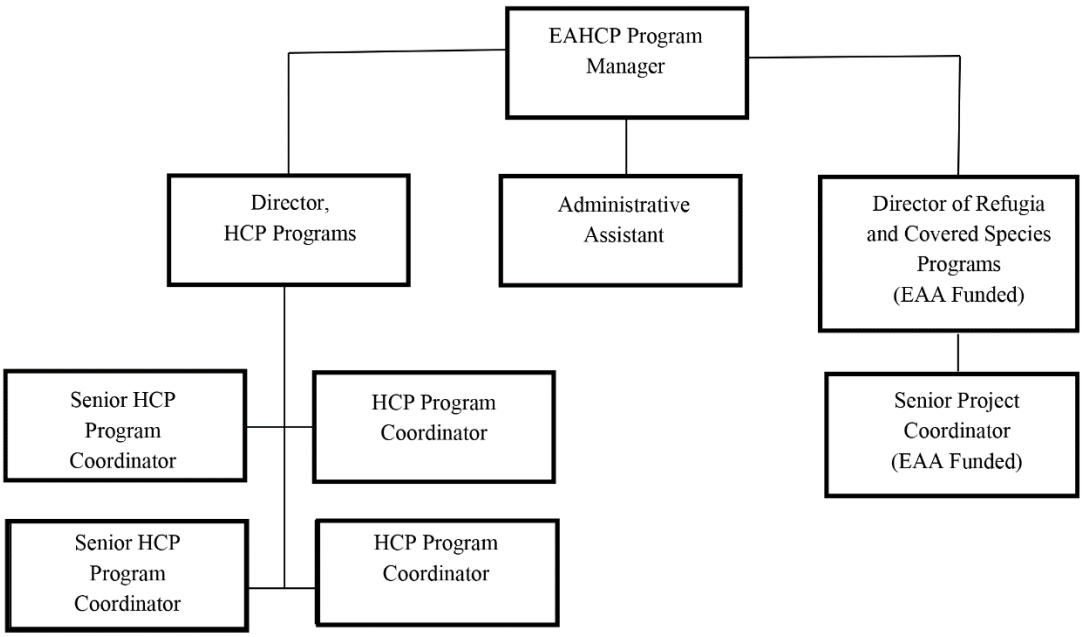

Figure 3.1-5. EAHCP staff organizational chart.

Selected Program Management activities completed in 2015 are listed below:

1. EAHCP staff facilitated the budgeting process and financial duties as assigned by the FMA. Staff tracked the budget throughout 2015, providing monthly updates to the IC and timely reimbursement to the Permittees. This process included managing and tracking more than 30 contracts.

2. EAHCP staff coordinated the 2015 budget process, including the timely approval of: 1) 2016 Work Plans from all Permittees; 2) Program Funding Applications from the EAA, CONB, COSM, and Texas State; and 3) and implementation of the Interlocal Funding Contracts for reimbursement with the CONB, COSM, and Texas State. Additionally, EAHCP staff assisted EAA staff with getting all necessary budget items approved by the EAA Board of Directors.

3. During 2015, EAHCP staff successfully facilitated ten IC, nine SC meetings, three SH meetings, a two-day public meeting for the SRP/NAS, and a SC and SH workshop on the NAS *Report 1*. Additionally, EAHCP staff facilitated and executed the development of two Work Groups, including:

    - The NAS RRWG: In March, the IC received the first report on the NAS, *Report 1*. Subsequently, the IC created the NAS RRWG to provide staff with direction and guidance related to the development of an implementation plan for the recommendations made in NAS *Report 1*. The NAS RRWG met three times and produced a report and a recommendation implementation plan. The IC adopted the NAS RRWG report at its meeting on August 20, 2015.
    - The ARWG: As recommended by the NAS RRWG, the IC created the ARWG to recommend a holistic Applied Research Project Schedule that would take into account all possible research

necessary to better understand the Covered Species in order to achieve the EAHCP's Biological Goals and Objectives. The ARWG met three times and produced a report, with a project schedule and a prioritized project matrix. The IC adopted the ARWG's report at its meeting on November 19, 2015.

4. During the last week of October, EAHCP staff coordinated and hosted a three-day meeting of the SRP/NAS. This meeting initiated the second cycle of the SRP/NAS's review. During this cycle, the SRP/NAS will:
   - Evaluate progress and modifications implemented as a result of its first report;
   - Continue to assess the methods of data collected through the monitoring programs;
   - Identify those questions related to achieving compliance with the Biological Goals and Objects that the models should be used to answer; and
   - Provide an evaluation of how the Phase I Conservation Measures are being implemented and monitored.

   The October meeting included a kayak tour of the San Marcos and Comal springs systems that provided the SPR/NAS a first-hand look at the implementation of the Phase I HCP Conservation Measures. As part of this three-day meeting, staff hosted two days of open public meetings where the SRP/NAS received a status report on the implementation of *Report 1* and updates on the development of the Hydrologic and Ecological Models. The SRP/NAS will produce its second report in late 2016.

5. In 2015, EAHCP staff continued to photograph the progress of the restoration activities in the San Marcos and Comal springs systems, including annual baseline photos for future years.

6. To facilitate communication and coordination among the Permittees, in 2015, EAHCP staff and the IC members from the COSM and Texas State initiated regular monthly meetings to discuss topics relevant to the San Marcos springs. The EAHCP Program Manager and Director held similar dialogues with the CONB on an as-needed basis. Also, the EAHCP staff held bi-weekly conference calls with the CONB, COSM and Texas State staff to discuss any issues or problems with current projects. Also continued this year, the EAHCP Program Manager and the Chair of the IC, and the EAHCP Director and the Chair of the SC, held monthly meetings in preparation for upcoming committee meetings.

7. For better program transparency, the EAA executed a contract with a local public relations firm to design and publish bi-monthly newsletters for the EAHCP during 2015. The *EAHCP Steward* newsletter was intended to inform community members in the region of the progress being made to implement the required Conservation Measures. Additionally, the newsletters provided notices of upcoming meetings and events within the program. Each newsletter contained photos and at least one audio interview with Permittees, Committee Members, or contractors. The *EAHCP Steward* newsletter targeted about 400 committee members, partners, elected officials, and interested citizens. A sample issue of the *EAHCP Steward* newsletter is included in **Appendix K15**.

- In 2015, the EAA published five regular newsletters and two special edition newsletters. The newsletter articles covered a variety of subjects that included stories on the following topics: a 2014 drought recovery and 2015 flood impacts; expected projects for 2015; EAHCP Conservation Measures, such as the Flow-Split Management and Non-native Animal Species Removal in New Braunfels; Recreation Management in San Marcos; the SRP/NAS reports and meetings; FAB Renovations; ASR; Salvage Refugia Program; and the City of Uvalde water scarcity solutions.
- Plans for 2016 are to continue current goals of six regular newsletters and one special edition article to better engage members of the community concerning the work being done in the Edwards Aquifer Region to protect the Covered Species of the EAHCP.

8. For additional outreach efforts in 2015, EAHCP staff gave multiple presentations to describe in detail the current implementation of EAHCP measures as well as to educate students, teachers and others on the fundamental background of the EAHCP. Presentations included the following organizations:
   - San Antonio College;
   - University of the Incarnate Word;
   - Various high schools;
   - Rotary Clubs;
   - GBRA Clean Rivers Program;
   - New Braunfels Chamber of Commerce; and
   - SCTWAC.

3.1.11.1 Permit Oversight

EAHCP staff is committed to maintain all regulatory permits necessary for the implementation of projects in the San Marcos and Comal systems to ensure compliance with the ITP. This does not include permits required for contractors to perform their specific tasks identified in the scope of work of a contract. The purpose of the permit oversight effort is to ensure current compliance with all Federal and State regulatory permits needed for current and future projects. A permit tracking matrix was developed from the information gathered to assist EAHCP staff and Permittees in identifying additional permits needed.

In 2015, EAHCP staff assisted the COSM, Texas State and CONB in completing and submitting all permit applications and coordination letters appropriate for full compliance. These projects include the sand bar removal and fine sediment removal for the San Marcos River, and bank stabilization and sediment removal in the Comal River. For the remainder of 2015, EAHCP staff with the assistance of HDR assisted in fully permitting the San Marcos' Permanent Access Point projects and the Comal's Flow-Split Management Project.

In 2015, HDR provided technical assistance to the EAHCP staff in developing permit applications for various State and Federal agencies that included the TPWD, TCEQ, U.S. Army Corps of Engineers (USACE) and USFWS. Additionally, AmaTerra Environmental, Inc., was retained to provide archeological services and professional assistance regarding the EAHCP's Cultural Resources Permit with the Texas

Historical Commission (THC). This permit is necessary to maintain compliance with the various Federal and State regulatory agencies, which exercise jurisdiction over the activities carried out in the San Marcos and Comal springs systems.

3.1.11.2 Amendments, Informational Memoranda and Clarifications

Pursuant to Section 9.2 of the EAHCP, from time to time, it may be necessary to clarify or make amendments to the EAHCP, Implementing Agreement (IA) (EAA et al. 2013), FMA, or ITP to deal with issues that arise during implementation. In 2015, the Program Manager did not submit any requests for clarifications or amendments to the EAHCP, IA, FMA or ITP. However, as discussed in **Section 3.1.2,** Refugia, of this Annual Report, the Permittees received a response (dated January 21, 2015) from the USFWS amending the ITP with language that would allow the EAA to develop a Refugia Program with entities other than the USFWS. **Appendix A1** includes the response letter from USFWS and the amended ITP. The Program Manager, on behalf of the Permittees, submitted this request to the USFWS on December 4, 2014.

On November 30, 2015, the EAHCP submitted an informational memorandum to the USFWS regarding vegetation in the Comal and San Marcos springs systems. On January 15, 2016, the USFWS responded. A copy of both the EAHCP informational memorandum and USFWS letter response are located in **Appendix A2**.

3.1.12 Challenges Observed and Identified Solutions

For 2015, the EAA observed the following challenges: increasing participation in the ASR Program; implementing the Refugia Program; improving competition in the Applied Research Program; and preparing the EAHCP Committees for the AMP.

Increasing Participation in the ASR Program

As discussed later in **Section 3.5** – San Antonio Water System, **subsection 3.5.1.4 –** Groundwater Rights Pooling Program for Aquifer Storage and Recover, of this Annual Report, the ASR mitigation measure is based on the EAA leasing a total of 50,000 ac-ft of EAA groundwater rights in three 16,666 ac-ft tiers, and transferring use of those rights to SAWS for storage and use during a severe drought. As of December 31, 2015, the EAA enrolled a total of 14,849 ac-ft in the program. While the EAA acquired more leases in 2015 than in 2014, the program still faces challenges in meeting the program goals.

To solve this challenge, in 2015 the EAA contracted with HDR to model the tradeoff and benefit between a VISPO enrollment versus an ASR acquisition. The study concluded that ASR lease acquisitions could be decreased by 0.95 ac-ft, for every 1 ac-ft increase in VISPO enrollment and still maintain the minimum Comal Springs discharge. In 2016, the EAA will continue to evaluate the significance of these results.

Also, as referenced later in **Section 3.5 –** San Antonio Water System, of this Annual Report, the EAA implemented a new program to increase regional contribution – *The Master Pooling Agreement for Aquifer Storage and Recovery.* The program was debuted to a limited number of volunteer permit holders. In 2016,

the EAA expects to expand participation in the pooling program to all interested permit holders to increase participation in the ASR Program. Additionally, EAA will continue to market the ASR Program to permit holders by hosting regular outreach events, publishing the monthly ASR newsletter and distributing other educational information.

Implementing the Refugia Program

As stated earlier in **Section 3.1 –** Edwards Aquifer Authority, **subsection 3.1.2** – Refugia, of this Annual Report, before receiving a formal opinion from the Texas State Attorney General regarding a contract with the USFWS for a refugia system, the EAHCP program requested a minor administrative amendment to both the EAHCP and the ITP to allow the EAA to contract with other entities. Given the importance of the refugia program, once approval was received, the EAA decided to procure refugia services in two phases – salvage and long-term. With the concern of triggering salvage collection, in 2015, the EAA procured services for a Salvage Refugia Program immediately. With the facilities for the salvage refugia underway, in 2016 the EAA will procure long-term refugia facilities that will incorporate the existing salvage refugia facilities, and provide fully-operational refugia facilities through the remainder of the term of the ITP.

Improving Competition in the Applied Research Program

As recommended in the NAS *Report 1* (**Appendix O1**), "the Applied Research Program would benefit from greater competition and collaboration with outside scientific experts through open and widely disseminated solicitations for research." By diversifying thought, understanding, and perspective, the SRP/NAS believed the EAHCP would be strengthened and its goals would be met.

Following this advice, in 2015, the EAA instituted a new process for planning projects for the Applied Research Program. This process also included expanding the list of potential firms. While the RFPs were distributed to more than 225 firms, only one or two proposals were received for the slated list of 2016 projects. For the 2017 Applied Research Program, the EAA will distribute the RFPs again to this expanded list of interested firms, in addition to exploring other means of notifying potential researchers, such as through academic electronic mailing lists.

Preparing Committees for the AMP

At the Joint IC, SH, and SC meeting in December 2015, the EAHCP Program Manager gave a presentation on the AMP for making nonroutine and strategic decisions. Included in this presentation was an overview of the responsibilities of the IC, SH, and SC that are defined in the FMA. This AMP process not only requires an understanding of a complex administrative process, but also requires an understanding of complex scientific information. To ensure that the Committees are informed, the EAHCP Program Manager will continue to plan meetings with the assistance of the Committee chairs and co-chairs, and will develop one-page fact sheets summarizing the technical aspects of the issue at hand.

3.2 City of New Braunfels

The CONB is responsible for implementation of the following measures under the EAHCP:

- Flow-Split Management in the Old and New Channel (EAHCP §5.2.1)
- Native Aquatic Vegetation Restoration and Maintenance (EAHCP §5.2.2)
- Management of Public Recreational Use of Comal Springs and River Ecosystems (EAHCP §5.2.3)
- Decaying Vegetation Removal and Dissolved Oxygen Management (EAHCP §5.2.4)
- Control of Harmful Non-Native Animal Species (EAHCP §5.2.5)
- Monitoring and Reduction of Gill Parasites (EAHCP §5.2.6 and §6.3.6)
- Prohibition of Hazardous Materials Transport Across the Comal River and its Tributaries (EAHCP §5.2.7)
- Native Riparian Habitat Restoration (Riffle Beetle) (EAHCP §5.2.8)
- Reduction of Non-Native Species Introduction and Live Bait Prohibition (EAHCP §5.2.9)
- Litter Collection and Floating Vegetation Management (EAHCP §5.2.10)
- Management of Golf Course Diversions and Operations (EAHCP §5.2.11)
- Native Riparian Habitat Restoration (Old Channel Improvements) (EAHCP §5.7.1)
- Management of Household Hazardous Wastes (EAHCP §5.7.5)
- Impervious Cover and Water Quality Protection (EAHCP §5.7.6)

This report section also includes information regarding public outreach initiatives and non-EAHCP activities conducted by the CONB that are not specifically required by the EAHCP, but support and/or supplement, efforts to protect the Covered Species within the Comal River system.

3.2.1 Flow-Split Management in the Old and New Channels of the Comal River (EAHCP §5.2.1)

EAHCP Obligations:

The CONB will control flow entering the Old and New channels of the Comal River from LL using the culverts and flow-control structure located between LL and the Old Channel of the Comal River. The purpose of this activity is to maintain optimal habitat conditions for the listed species under varying total flow conditions in the system per the Flow-Split Management Plan and Flow-Split Goals described in the EAHCP and summarized in **Table 3.2-1** below.

2015 Compliance Actions:

CONB staff routinely monitored stream flow conditions in the Comal River system, per USGS streamflow gauging stations, and for the first nine months of 2015 adjusted the flow-control gate in order to maintain flow rates stipulated in **Table 3.2-1**. The CONB staff developed and finalized a Standard Operating Procedure (SOP) (**Appendix L1**) to provide guidance on the operation of the flow-control gate and overall flow-split management.

Table 3.2-1. Flow-split Management for Old and New Channels

Total Comal Springflow (cfs)	Old Channel (cfs)		New Channel (cfs)	
	Fall, Winter	Spring, Summer	Fall, Winter	Spring, Summer
350+	80	60	270+	290+
300	80	60	220	240
250	80	60	170	190
200	70	60	130	140
150	60		90	
100	60		40	
80	50		30	
70	50		20	
60	40		20	
50	40		10	
40	30		10	
30	20		10	

As flow conditions continued to remain above 200 cfs going into the fall of 2015, it became apparent that adjustments to comply with the fall/winter flow guidelines included in **Table 3.2-1** could create adverse impacts to aquatic vegetation restoration work completed in the Old Channel. The concern was that higher velocities associated with flow rates in the Old Channel exceeding 65 cfs may erode and scour previous aquatic restoration work and of submerged aquatic vegetation. As supported by the SC, flows were not adjusted beyond 65 cfs in October, November, and December 2015, to allow for further analysis to determine whether sustained flow rates greater than 65 cfs would cause adverse impacts to habitat areas and whether potential revisions to **Table 3.2-1** might be necessary. This deviation from **Table 3.2-1** was communicated to the USFWS in the EAHCP informational memorandum dated November 30, 2015 (**Appendix A2**).

In late 2014 and early 2015, floating vegetative materials in LL were observed accumulating in the area surrounding the intake to the 48-inch culvert (**Figure 3.2-1**). At times, the vegetative material formed dense mats on the screen situated directly in front of the flow-control gate and culvert intake. The CONB began a program to manually remove accumulated vegetative material from the 48-inch culvert intake and adjacent areas on a weekly basis in order to minimize the potential for flow-restrictions associated with vegetation blockage. CONB staff explored options for floating vegetation barrier booms to minimize the amount of vegetative material accumulation on the culvert intake screen.

Figure 3.2-1. Photo of the 48-inch culvert intake screen and flow-control gate.

The photo above illustrates accumulated floating vegetative material at the intake area.

Activities in 2015 included the weekly manual removal of accumulated vegetative material from the culvert area to prevent flow restrictions from LL to the Old Channel.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

The CONB will continue to monitor USGS streamflow gauges in the Comal system and manipulate the flow control gate structure, per the established SOP, to achieve the goals described in Table 5.3 of the EAHCP.

The CONB is proposing to install two additional flow-control gates at the two 24-inch culverts (**Figure 3.2-2**), currently closed with threaded caps, to be utilized as a back-up to the primary 48-inch culvert and control gate. The additional flow-control gates and culverts will allow for controlled flow into the Old Channel during any long-term maintenance activity. The additional flow-control gates and culverts will also be used to divert flow into the Old Channel during emergency situations in which the primary 48-inch culvert is unable to convey adequate flow.

Figure 3.2-2. Location of flow control structures from Landa Lake to the Old Channel.

In addition, the CONB is proposing the installation of two separate floating vegetation booms, with proper anchoring systems, in front of the existing 48-inch culvert control gate and 24-inch culverts. The floating vegetation booms will provide an effective barrier to floating vegetation and debris, thus minimizing the potential for flow restrictions associated with vegetation and debris blockages.

3.2.2 Native Aquatic Vegetation Restoration and Maintenance (EAHCP §5.2.2)

EAHCP Obligations:

The CONB will implement the Aquatic Vegetation Restoration Program within key, sustainable reaches of the Comal River. Restoration activities include the removal of non-native aquatic plant species, planting of target native aquatic plant species, and maintenance of restored areas. The overall goal of the Aquatic Vegetation Restoration Program is to improve habitat conditions for the fountain darter by increasing the amount of usable habitat, and by improving the quality of existing habitat in the Comal River system.

2015 Compliance Actions:

Aquatic vegetation restoration activities in 2015 included removal of non-native aquatic plant species, planting of target native aquatic plant species, and maintenance of restored areas within LL and the Old Channel of the Comal River (**Figure 3.2-3**). **Figure 3.2-3** indicates the extent of target aquatic vegetation restoration areas within the Comal River system. **Figure 3.2-4** and **Figure 3.2-5** indicate the locations of the 2015 restoration plots in LL and the Old Channel, respectively.

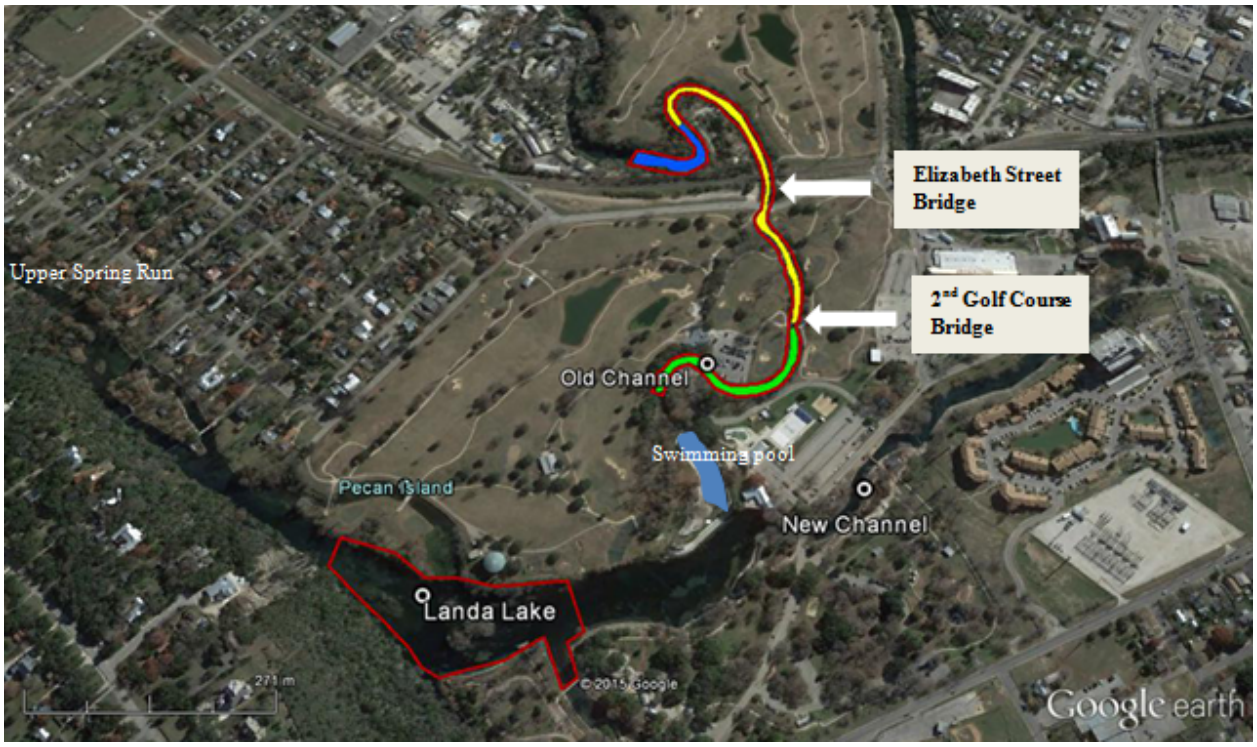

Figure 3.2-3. Location of the Landa Lake and Old Channel restoration areas (outlined in red).

The green area indicates the extent of 2013, 2014 and continued 2015 Old Channel restoration activities. The yellow area represents the new 2015 Old Channel activities, and the dark blue one indicates the area of future removal and restoration.

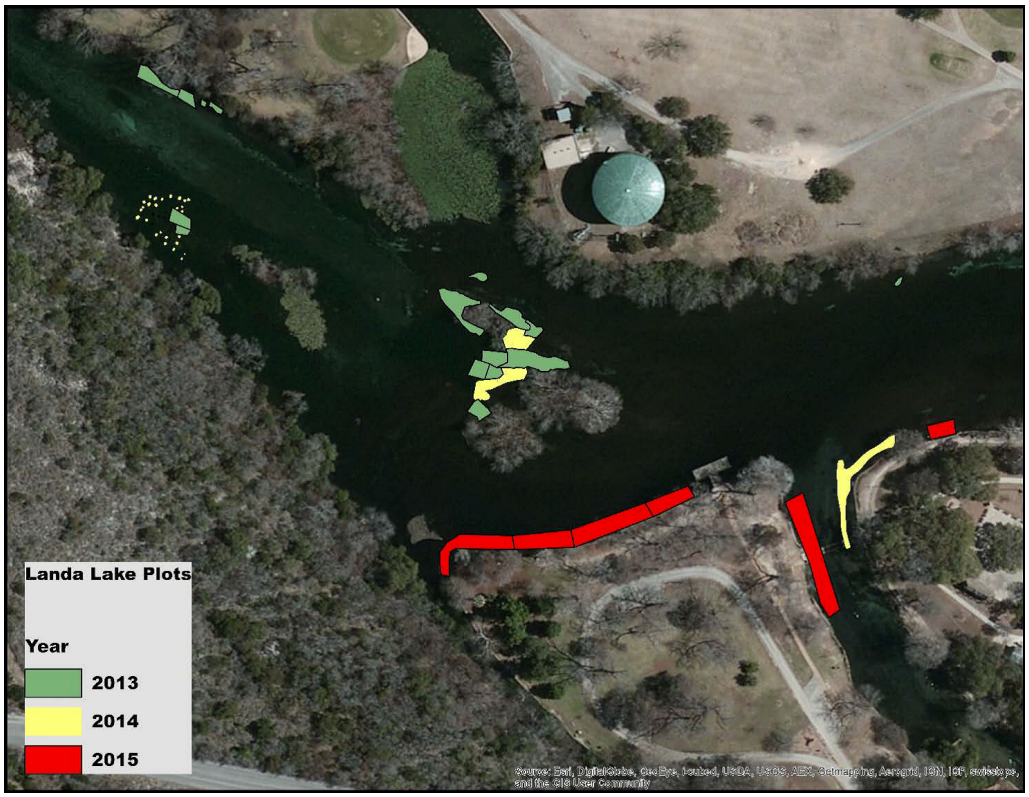

Figure 3.2-4. Map of 2013, 2014, and 2015 aquatic plant restoration plots in Landa Lake.

Figure 3.2-5. Map of 2013, 2014, and 2015 aquatic plant restoration plots in the Old Channel of the Comal River.

Table 3.2-2 summarizes the amount of *Hygrophila* removed in target areas during 2015. *Hygrophila* removal was achieved under Exotic Species Removal Permit AVR 01 15-016 issued by the TPWD. In LL, one small patch of *Hygrophila* remaining from 2014 activities was removed in March 2015, effectively eliminating *Hygrophila* from the LL restoration area. Two additional patches, one near the LL dam and one in the Pecan Island slough, outside of the initial LL restoration area, were removed as well, but were less than 1 square meters (m^2) each. The Old Channel Restoration area included much more *Hygrophila* cover, some of which re-colonized from the previous year when restoration work halted in accordance with the implementation of Condition M of the ITP. Condition M of the ITP stipulates that when Comal Springs flows decline to 130 cfs or lower, and when San Marcos Springs flows decline to 120 cfs of lower, all habitat mitigation and restoration activities that might result in disturbance of the (a) substrate, (b) water quality, (c) plants, and (d) animals or invertebrates in the systems, must be suspended. In the Old Channel restoration area, work for 2015 began above the second golf course bridge (**Figure 3.2-5**). In this location, *Hygrophila* re-colonized in previously treated areas and had to be removed a second time. Some *Hygrophila* stands within this reach were not removed in 2014 and were, therefore, targeted and removed in 2015. In May 2015, *Hygrophila* removal in the Old Channel proceeded downstream of Elizabeth Street for the first time since the inception of the EAHCP Restoration Program.

Table 3.2-2. Amount of *Hygrophila* Removed in Target Areas in 2015

Location/ Section	Area Removed (m^2)	Period of Removal Work (2015)
Landa Lake Restoration Area	20	March
Old Channel Restoration Area	1,894	January-October
Spring-fed Swimming Pool	970	April
Upper Spring Run	539	April-August
Total	**3,423**	January-October

In 2015, *Hygrophila* removal was expanded into two locations outside of the initial restoration areas in an effort to control spreading and re-colonization of the plant. In past years it has been observed that fragments of *Hygrophila* from the USR routinely move into the LL restoration area and collect on native vegetation or in floating vegetation mats. Therefore, *Hygrophila* stands were removed in the USR in order to prevent re-colonization of *Hygrophila* in the project area. In mid-2014 it was observed that the bottom of the spring-fed swimming pool located upstream of the Old Channel restoration area was approximately 80 percent covered with *Hygrophila* and provided large amounts of fragments into the Old Channel. Therefore, removal was deemed necessary to prevent re-colonization downstream. Mechanical removal of approximately 970 m^2 of *Hygrophila* from the spring-fed pool was conducted in 2015. Photos of the spring-fed pool prior to and following the *Hygrophila* removal effort are shown in **Figure 3.2-6**.

Figure 3.2-6. Spring-fed pool prior to (left) and following (right) *Hygrophila* removal.

Removal of *Hygrophila* was accomplished following the same methods as in previous years. Top growth was removed by raking the area while removal of roots and fragments was carried out by raking or tilling sediment. Work was conducted in shallow areas by wading or snorkeling, and in deeper areas the use of multiple divers and a hookah air system was employed. Removed biomass was allowed to float downstream into a floating net, collected and removed. Removal of *Hygrophila* and associated gravel material in the swimming pool occurred via excavator machinery.

Native aquatic plant restoration was conducted again in 2015 within both the LL and Old Channel restoration areas. As in years past, this involved propagation of native plants *in situ,* as well as utilization of transplants and stem sprigs collected from mother colonies located within the Comal River. Expansion and density of planted aquatic plants was monitored by vegetation mapping that occurred four times (January, April, August, and October). Vegetation mapping of the restored areas is an essential element to monitor the progression or success, or lack thereof, of the restoration project. Native aquatic plant coverage has increased considerably in the immediate restoration areas since pre-restoration, although certain factors such as water flow, competition, light availability and seasonality, cause aquatic plant species cover to vary.

Old Channel Restoration Results

In 2015, 1,130 m² of area was planted in eight restoration plots bringing the three-year total of area planted in the Old Channel to 2,673 m². A total of 11,438 plants were planted in the Old Channel restoration area in 2015 with a majority of those planted in new plots (**Table 3.2-3**). **Figure 3.2-7** shows the locations of the Old Channel restoration plots discussed in **Table 3.2-3**. Although overall cover of native vegetation increased over the year, cover of *Ludwigia* experienced a slight decrease from January to August (**Table 3.2-4**). *Cabomba* showed a steady increase in cover, while *Sagittaria* maintained existing cover. Due to the variability of stream habitat and the multitude of factors that can cause decline in plant cover, it is hard to ascertain why *Ludwigia* experienced a decrease in overall cover through August 2015. Regardless of the decrease experienced through summer 2015, *Ludwigia* cover through August 2015 (505 m^2) is still over four times the pre restoration cover (123 m²) for this native species in the Old Channel restoration area. By October, cover of *Ludwigia* increased to 651 m², the highest amount observed all year.

Table 3.2-3. Planting Dates and Number of Native Specimens Planted Within Individual Old Channel Reach Restoration Plots in 2015

Date Planted	Plot	Ludwigia	Sagittaria	Cabomba	Vallisneria
3/23/2015	R		575		
3/23/2015	S		562	617	
3/25/2015	Q*	370			
5/11/2015	S, R	376			
5/11/2015	N,O,Q*	200			
6/16-17/2015	R		2,030	240	
6/23/2015	T			200	
7/7/2015	Sed. Isld*	192			
7/14-15/2015	U	624	1,800	90	650
8/24/2015	V 1-4	912			
9/30/2015	U			600	
9/30/2015	V1-4	1,000			
10/01/2015	V1-4	400			
Totals		**4,074**	**4,967**	**1,747**	**650**

Table 3.2-4. Seasonal Cover (m^2), per Target Vegetation Type, in 2015 Within Old Channel Restoration Area (as indicated by GIS mapping)

Species	January	April	August	October
*Ludwigia**	649	448	505	651
*Sagittaria**	340	386	386	504
*Cabomba**	104	139	177	170
Bryophyte	353	665	934	1,051
Hygrophila	2,602	2,526	1,105	944

*Includes naturally occurring and planted areas in the Old Channel.

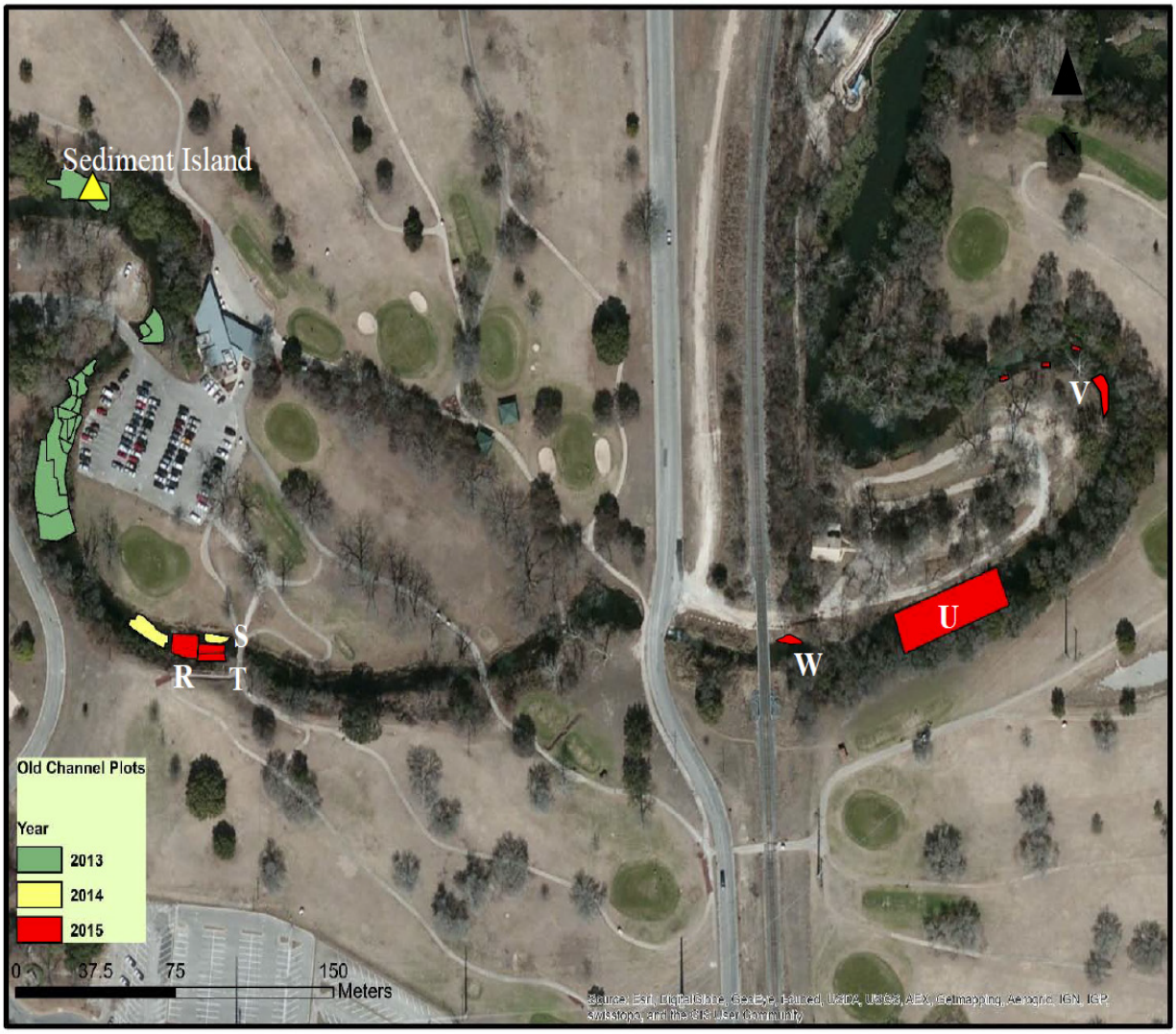

Figure 3.2-7. Locations of the Old Channel restoration plots.

Landa Lake Restoration Results

In 2015, 926 m² of area was planted in seven restoration plots in LL bringing the three-year total of area planted in the lake to 2,694 m². A total of 9,989 plants were planted into the LL restoration area in 2015. The majority of these plants were installed in new plots for 2015 with a large portion of the native aquatic vegetation being planted in areas left bare from the LL Wall Construction Project carried out in 2013 to 2014 **(Figure 3.2-8)**. These large bare areas provided quality conditions for deep water (>4 ft) plantings which will be valuable in providing fountain darter habitat when LL water depths decrease during drought conditions. **Table 3.2-5** summarizes the 2015 restoration work conducted in the LL project area. **Figure 3.2-9** illustrates the locations of the LL plots discussed in **Table 3.2-5**.

Figure 3.2-8. Landa Lake restoration plantings.

These photos show individual *Ludwigia* and *Sagittaria* plantings along recently completed LL walls taken soon after planting in spring 2015. As indicated in **Figure 3.2-8**, by mid-summer the vegetation coverage in these areas had substantially increased.

Table 3.2-5. Planting Dates and Number of Native Specimens Planted Within Individual Landa Lake Restoration Plots in 2015

Date Planted	Plot	Ludwigia	Cabomba	Sagittaria	Vallisneria
12/8/2014	M*	280			
12/9/2014	S2	145			
1/26/2015	T		50		
2/4-6/2015	T		950		
2/18/2015	T		600		
2/25/2015	T		400		
3/11/2015	S2	800			
3/12/2015	U1	200			
3/30/2015	U2	600		125	25
4/6-8/2015	U3	1,400		1,750	1,200
5/12/2015	U4	384			
6/10/2015	U4	480			
6/15/2015	V	200			
10/1/2015	U2	200			
10/1/2015	U3	200			
Totals		**4,889**	**2,000**	**1,875**	**1,225**

* Supplemental plantings in pre-existing restoration plot

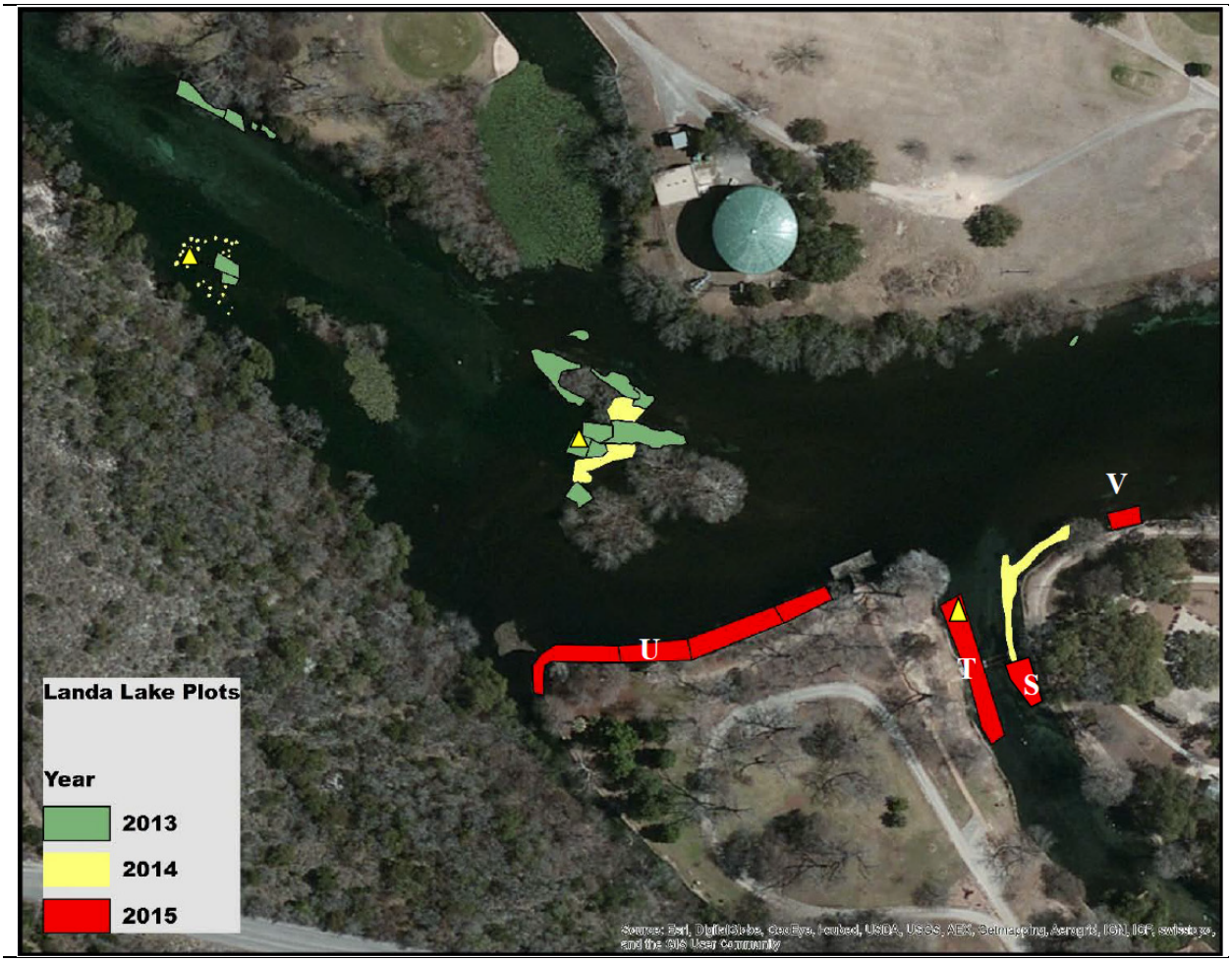

Figure 3.2-9. Locations of the Landa Lake restoration plots.

Table 3.2-6 provides seasonal cover of target aquatic plant species in the LL restoration area in 2015. In general, cover of target species in LL was highest in April. *Ludwigia* and *Cabomba* both experienced large increases in cover between the January and April mapping. During this time *Ludwigia* cover increased 34 percent and *Cabomba* increased nearly 50 percent. However, by August, cover of these two plant species reduced substantially, but both species remained above January totals. Coverage in October also showed a slight decline for these two native species. Again, due to the variability in aquatic habitat, it is difficult to ascertain why aquatic plant cover decreased during the growing period. While floating vegetation mats typically form in LL and have been observed to smother native plants as documented in 2014, these mats did not develop extensively over restoration plots in 2015. Thus, unlike 2014, these mats did not directly contribute to the summertime decline observed in native aquatic plant cover in 2015. The *2015 Native Aquatic Vegetation Restoration in Landa Lake and Old Channel of the Comal River* Report is included as **Appendix L2** of this Annual Report.

Table 3.2-6. Seasonal Cover (m^2), per Target Vegetation Type, in 2015 Within Landa Lake Restoration Area (as indicated by GIS mapping)

Species	January	April	August	October
*Ludwigia**	460	701	486	476
*Sagittaria**	2,423	2,854	2,346	2,644
*Cabomba**	260	511	392	306
Bryophyte	1,723	2,412	N/A	2,109
Hygrophila	20	0	0	0
Vallisneria	15,524	14,991	14,911	13,556

*Includes naturally occurring and planted areas in Landa Lake

Table 3.2-7 depicts a snapshot of EAHCP progress attained by late 2015 through the Native Aquatic Vegetation Restoration and Maintenance Program (EAHCP §5.2.2) towards meeting Biological Goals in the representative reaches associated with establishing fountain darter habitat by vegetation-type in the Comal system. Fountain darter habitat goals in the Comal system are located in Table 4-6 of the EAHCP.

Table 3.2-7. Fountain Darter Habitat (Aquatic Vegetation) in m^2, Comal System, October 2015 Mapping Event

Study Reach	Bryophytes	Hygrophila	Ludwigia	Cabomba	Fil. Algae	Sagittaria	Vallisneria
Upper Spring Run Reach	281	0	6	10	575	898	0
Landa Lake	1,692	0	437	287	221	2,621	12,255
Old Channel	214	920	26	0	0	0	0
New Channel	214	796	79	3,511	0	0	0
Totals	**2,401**	**1,716**	**548**	**3,808**	**796**	**3,519**	**12,255**

Any Modifications or Activities Due to Weather Conditions:

The flood event that occurred on October 30, 2015 did have negative impacts on SAV and aquatic vegetation restoration areas in the Old Channel and LL. It is estimated that approximately 5-10 percent of restored vegetation in LL and 10-15 percent of restored vegetation in the Old Channel was scoured by high flow velocities associated with the flood event. In addition, large colonies of bryophytes in the USR area of LL and within the Old Channel were removed by high flow velocities. Flood debris such as large trees, vegetation, and litter were deposited in and around aquatic vegetation restoration areas in both LL and the Old Channel. A majority of the debris was immediately removed from within the restoration areas following the flood event.

Proposed Activities for 2016:

Aquatic vegetation maintenance, monitoring, and restoration activities will continue in 2016 in compliance with the EAHCP. *Hygrophila* removal will continue below Elizabeth Street and restoration planting is planned to continue in LL as well as the Old Channel. Proposed activities include expanding restoration plantings into the USR area from Bleider's Creek to Spring Island and in select locations (to be determined) of the New Channel of the Comal River. Riparian improvements are also proposed along the Old Channel project area in order to increase light availability necessary to enhance native aquatic vegetation survival and expansion.

3.2.3 Management of Public Recreational Use of Comal Springs and River Ecosystems (EAHCP §5.2.3)

EAHCP Obligations:

The CONB will continue to enforce recreation restrictions on the Comal River that were in place at the time of EAHCP development through the duration of the ITP. This restriction specifically applies to regulations limiting recreation on LL, the spring runs in Landa Park, and the Old Channel of the Comal River. The CONB will additionally extend its take protection to commercial outfitting businesses willing to meet the conditions of such protection through a Certificate of Inclusion (COI) Program to be developed by the CONB.

2015 Compliance Actions:

The CONB continued to enforce City Ordinance Section 142-5, which restricts access to LL, the spring runs, and portions of the Comal River. The CONB Parks Department utilized trained park rangers who routinely patrolled Landa Lake Park to prevent access to these water bodies. The CONB continued to develop outreach strategies regarding the COI Program, including identifying targets for initial contact.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

The CONB will continue to enforce City Ordinance Section 142-5 and provide patrol by park rangers to restrict access to LL, the spring runs, and portions of the Comal River. The CONB will also continue outreach to river recreation outfitters on EAHCP educational activities, and promotion of the voluntary COI program.

3.2.4 Decaying Vegetation Removal and Dissolved Oxygen Management (EAHCP §5.2.4)

EAHCP Obligations:

The CONB will continue to implement a DO management program in LL. The program will be focused on monitoring DO concentrations and related water quality parameters in LL and mitigating for depressed DO levels (<4 mg/L), regardless of the initiating circumstances. Specific program elements include water quality data collection in LL, maintenance of water quality equipment, and operation and maintenance of the existing aeration system. The CONB will also explore options for optimizing the DO management program.

2015 Compliance Actions:

In 2015, the CONB contracted with SWCA to operate and maintain the existing water quality sonde and aeration system in LL (**Figure 3.2-10**). Water quality data including water temperature, DO, pH, conductivity, and turbidity was collected at the water quality sonde at 30-minute intervals throughout 2015.

Water quality data was only recorded intermittently between January and early September 2015, due to technical difficulties with the water quality sonde. Water quality data was continuously recorded from mid-September to October 30, 2015. A detailed report including the 2015 water quality monitoring results is included as **Appendix L3**. The existing aeration system in LL was inspected and maintained throughout 2015 to ensure continued operation and an SOP was developed. The aeration system was operated throughout the summer and fall of 2015 to supplement DO in LL.

The CONB also contracted with BIO-WEST, Baylor University, and AquaStrategies in 2015 to conduct additional DO research in LL in response to concerns associated with the DO data collected during low-flow conditions in the summer and fall of 2014. DO monitoring was conducted in 2015 to further define spatial and temporal DO patterns within LL. In addition, the efficiency of the existing aerators in LL to support DO conditions (> 4.0 mg/L), as specified in the EAHCP, was indirectly tested. Recommendations regarding the feasibility of DO supplementation in select locations within LL were also provided. A full project report describing these activities and results is provided as **Appendix L4** of this report. A summary of these activities is presented below.

Figure 3.2-10. Location of existing water quality monitoring sonde and aeration system in LL.

Spatial DO Evaluation

A one-week spatial evaluation of DO was conducted within LL and the USR reach. The additional DO data was also collected to determine whether DO data collected at the data sonde located at the center of LL is consistent with DO concentrations at various locations throughout LL. Fourteen MiniDOT DO sensors were installed throughout LL in late July and set to record measurements at ten-minute intervals. **Figure 3.2-11** below shows a MiniDOT DO sensor deployed at a mid-column location in LL. **Table 3.2-8** provides a description of each MiniDOT sensor location corresponding with **Figure 3.2-12**.

Figure 3.2-11. MiniDOT DO sensor deployed during spatial expansion study.

Table 3.2-8. Description of 14 MiniDOT DO Sensor Locations in Landa Lake

Site #	Description
1	Downstream buoy in Landa Lake
2	Adjacent to paddleboat rental area
3	At existing DO probe for Aerator Project
4	Adjacent to fishing pier in Vallisneria
5	Adjacent to gazebo at the outflow of Spring Run 3
6	Top of Island 1 in three islands area
7	Upstream of Island 3 in three islands area
8	Lower Pecan Island backwater area
9	Northwest shore across from Pecan Island
10	Mid-channel location near MUPPT Nursery
11	Northwest shore near cable
12	Adjacent to golf course in Pecan Island backwater
13	Upstream of Spring Island
14	Adjacent to Heidelberg Lodge

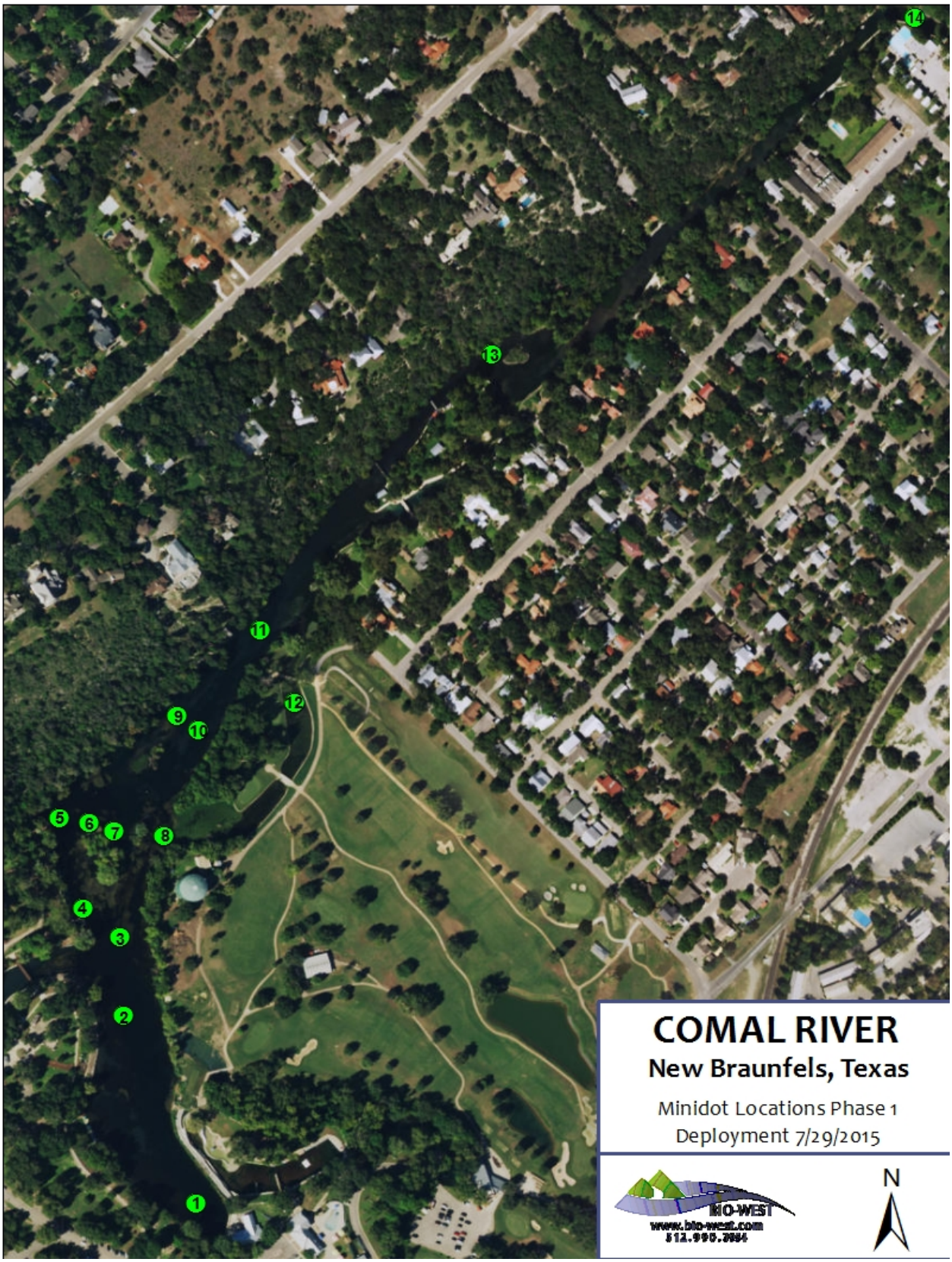

Figure 3.2-12. Location of 14 MiniDOT DO sensors used during the spatial DO evaluation study.

Measurement sites were located throughout the main portion of LL in differing habitat types (deep or shallow, current or stagnant, vegetated or non-vegetated, etc.) to capture the wide range of conditions experienced throughout LL and the USR reach. The spatial evaluation study was initiated on July 28, 2015 and continued for one week with data from the sensors being downloaded on August 5, 2015. During this time period, total system discharge in the Comal system ranged from approximately 300 to 340 cfs. From a historical perspective, this amount represents total system discharge conditions slightly above the long-term historical average, but considerably higher than the 65 cfs total system discharge conditions experienced during summer of 2014. Although lower flow conditions were not available in summer 2015 to test, the data does represent what is to be expected during average total system discharge conditions.

Results from the week-long spatial study are presented in **Figure 3.2-13**. A solid red line is placed on each chart representing the EAHCP management objective for DO (4.0 mg/L). In general, DO conditions ranged between approximately 4.0 and 9.0 mg/L on a daily cycle at most stations (**Figure 3.2-14**). The exception to this was sites located in the more stagnant areas (Sites 8, 12, and 14). DO conditions at Site 8 dipped down to approximately 3.0 mg/L on Day 2 and continued to dip below 4.0 mg/L each subsequent morning of the study. Considering the location of this sonde within a slow moving area surrounded by *Nuphar*, this was not unexpected. In fact, this likely provides a glimpse of what might be expected when total system discharge conditions are considerably lower, causing pockets of considerably lower velocity fields.

Sites 12 and 14 were also located in areas with considerably lower velocities and would likely have experienced DO conditions less than 4.0 mg/L similar to Site 8 on a daily basis. Although these conditions were experienced, biofouling of the probes at these locations rapidly caused both extremely high and low measurements of DO at these locations (**Figure 3.2-12**). As such, we are not confident in the DO measurements reported in **Figure 3.2-14** for these two sites during the one-week study. During continued investigations, it was not uncommon for biofouling to occur within a day of installation, requiring frequent cleaning to obtain accurate measurements. It was evident during the studies that when the sensors started to record over 12-15 mg/L DO during the late afternoon, those sensors were starting to accumulate biofilms that were directly influencing the DO measurements. During these times, extremely low DO conditions were measured the subsequent morning, as expected. These results were pointed out because during preliminary evaluations of the existing DO database for the EAHCP Aeration Project, considerable DO measurements in excess of 15 mg/L were noted in the late afternoon, followed by extreme declines the next morning. Those subsequent declines triggered the activation of the aerators in LL. At this time, it is uncertain how many of the low DO measurements that have triggered the aerators over the implementation period might be an artifact of biofouling.

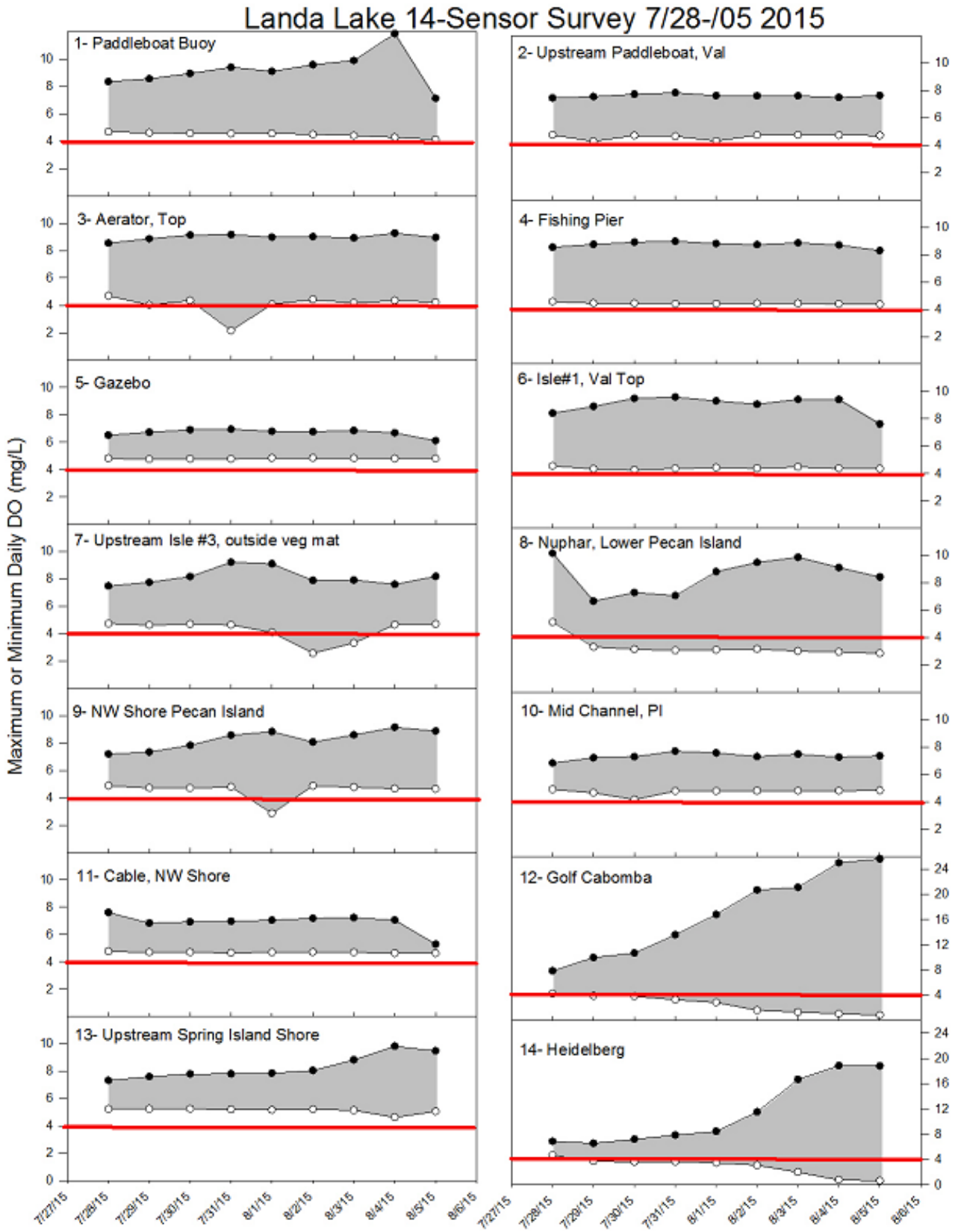

Figure 3.2-13. Maximum or minimum DO results (mg/L) from 14 MiniDOT sensors during spatial evaluation study.

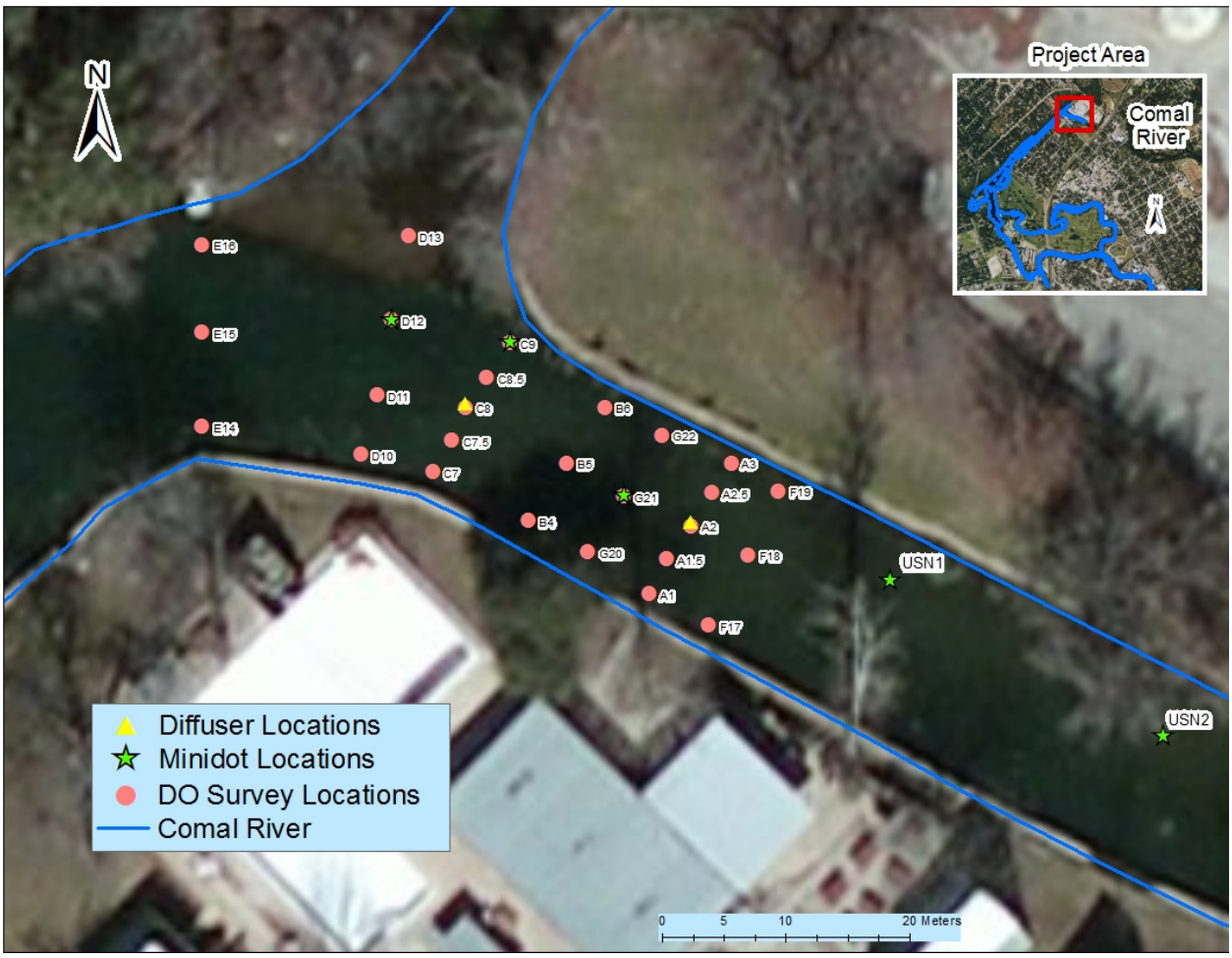

Figure 3.2-14. Sampling transects, diffuser and MiniDOT sensor locations for formal diffuser trial on September 17-18, 2015.

Oxygen Diffuser Trial Study

A diffuser trial study in LL aimed at evaluating the efficacy of the current aeration system was also conducted in 2015. Due to moderate flow-conditions observed in LL in 2015, DO levels were not declining to levels low enough to conduct a meaningful test of the existing aeration system. Therefore, an indirect study was conducted at the mouth of Blieders Creek at Site 14 (**Figure 3.2-12** and **Figure 3.2-13**). DO conditions at Site 14 (Heidelberg Lodge) were experiencing nightly declines in DO that warranted further investigation and provided a location to conduct a DO supplementation efficacy study. A preliminary investigation of DO conditions was conducted at this location during the late afternoon (September 9, 2015) and early morning (September 10, 2015) hours to assess whether a diffuser study in this area might be applicable. DO measurements during this investigation ranged from approximately 2.9 to 9.5 mg/L with a noticeable decline from late afternoon to the following morning. Following the collection of background DO data at this location, a diffuser trial study in the USR Reach/Blieders Creek area was conducted.

The study involved establishing DO monitoring transects through the main study area in Blieders Creek (**Figure 3.2-14**). Two air diffusers were installed at Sites C8 and A2 (**Figure 3.2-15**). DO and temperature

were monitored at each location at the top and bottom of the water column with a hand-held portable meter (HACH® HQ40d multi-parameter meter) using a luminescent optical DO probe (HACH® IntelliCAL™ LDO101 probe). Several near-continuous MiniDOT DO sensors were also deployed in the study area. DO and temperature concentrations were collected throughout the night on September 17, 2015 and into the morning of September 18, 2015, as the diffusers were turned off and on.

To estimate the effectiveness of diffusers for adding oxygen to the water column, a limited experiment was conducted in Blieders Creek as described above. This area was considered a good control area since flow and velocity through this area at the time of the experiment was negligible, and the area was experiencing a bloom of algae. DO measurements leading up to the experiment showed an increase in DO during the day corresponding to algal and plant photosynthesis, and a decrease in DO during the early morning hours corresponding to algal and plant respiration. This pattern allowed for testing the hypothesis that the diffusers could increase the DO content of waters during the early-morning hours.

The immediate project area during the experiment exhibited DO content ranging from approximately 4.6 to 8.6 mg/L on average in the near-vicinity of the diffusers (**Figure 3.2-15**). The overall trend was for DO to steadily decrease from the high in the late afternoon (5:30 p.m.) to a minimum during the next early morning (4:30 a.m.) and remain constant at the minimum until the last measurement after daylight (7:00 a.m.). This ambient control DO condition can be considered to be based upon observations at the location marked "L-DSN" in **Figure 3.2-15**, located at the downstream edge of the test zone ("D-12" in **Figure 3.2-15**). The trend in DO content in the vicinity of the diffusers (sonde observation data at "I-Cinderblock" and "N-C9") was slightly higher compared to the DO trend in downstream areas ("L-DSN") over that timeframe (**Figure 3.2-15**). The upstream areas ("M-USN1" and "H-USN2") exhibited a larger DO swing as a result of increased algae activity.

Point measurements surrounding the diffuser were less conclusive than the MiniDOT sensor data time-series (**Figure 3.2-16**). DO concentration did not appear to significantly vary whether diffusers were turned on or off between the initial morning measurement (4:30 a.m. with the diffusers turned off, average 4.6 mg/L) and the second morning measurement (7:00 a.m. with the diffusers turned on 4.6 mg/L); however, measurements at most observation locations resulted in an increase in the DO while diffusers were turned on, compared to DO reductions or random DO changes while diffusers were turned off. The ambient oxygen concentration of 4.5 to 5.0 mg/L reduced the effectiveness of the diffusers as the moderate oxygen content hampered absorption of additional oxygen into the water column from the diffusers. Greater impact resulting from the diffusers was anticipated and may have been measureable if ambient oxygen concentrations had been lower (e.g., closer to 2 mg/L).

For the Blieders Creek experiment, two sets of two-disc diffuser units were deployed. The spacing between each unit was approximately 60 ft, or one and one-half channel widths (**Figure 3.2-14**). The green line labeled "pred G21_noDiffuser" represents an approximated average trend of DO at the G21 MiniDOT sensor location, assuming no diffuser, and based upon the general trend of reduced DO at the downstream

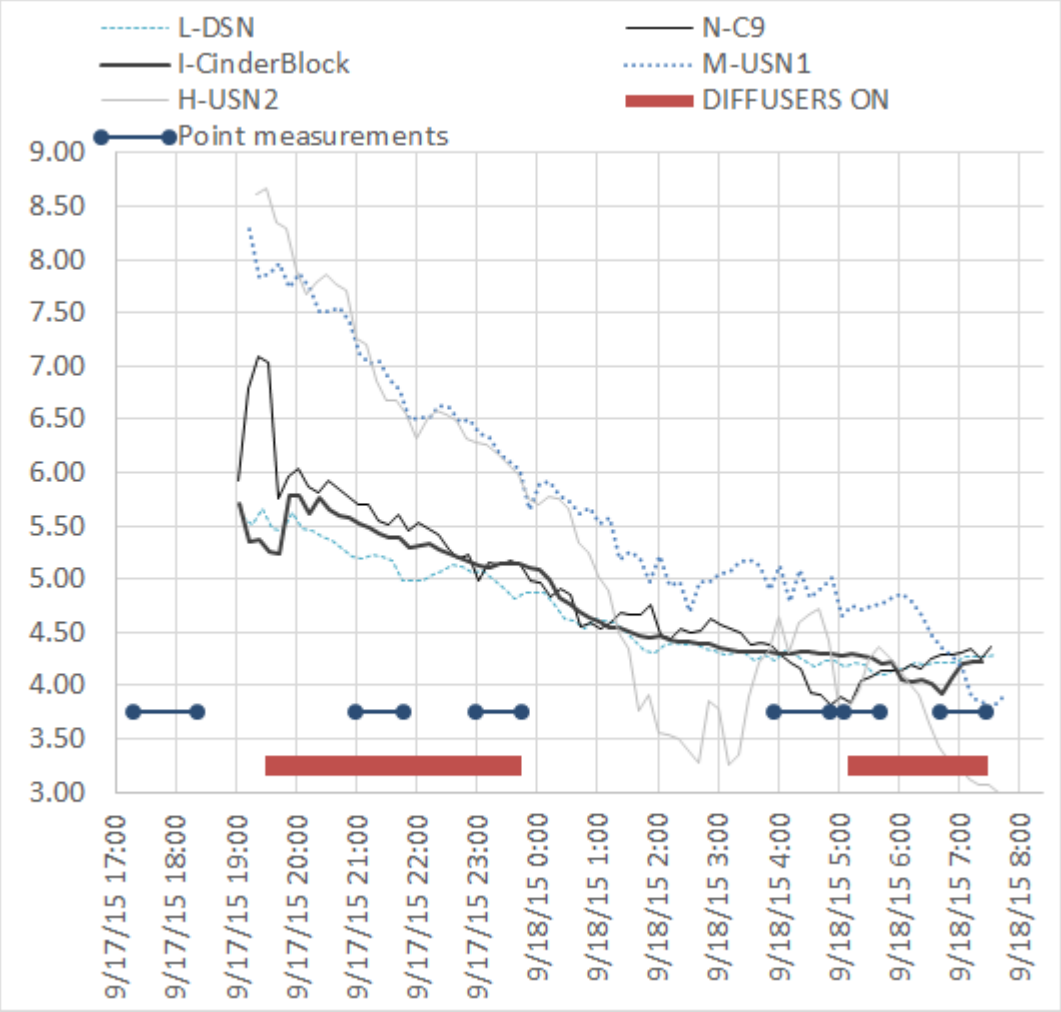

Figure 3.2-15. Blieders Creek DO MiniDot sonde data (DO, mg/L), and time of diffuser experiment activities.

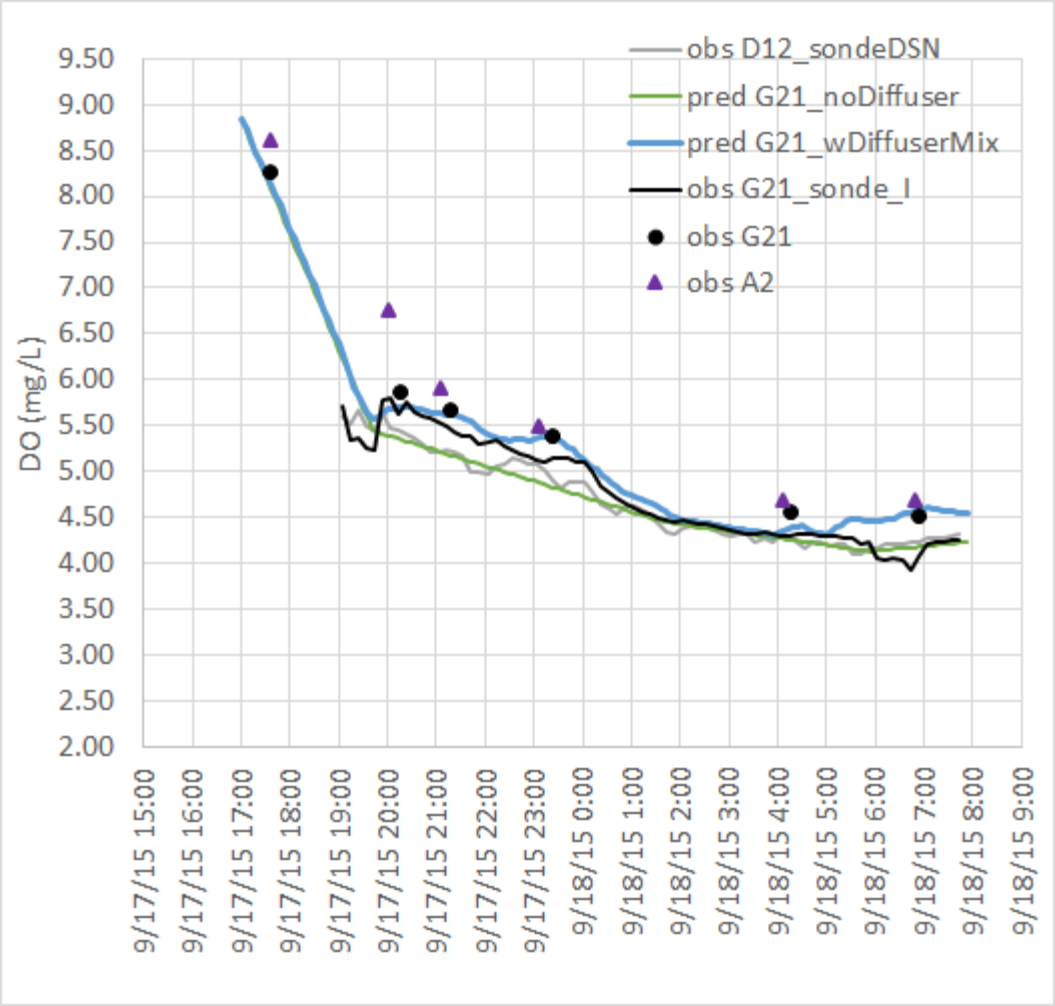

Figure 3.2-16. Blieders Creek – comparison of DO time series at MiniDOT sensor location G12, near diffuser A2.

observation location ("obs D12_sondeDSN") (**Figure 3.2-16**). The blue line labeled "pred G21_wDiffuserMix" represents the addition of the diffusers to the site area, as well as the addition of increased mixing and circulation resulting from movement of the kayak within sites during measurement and diffuser periods (see **Figure 3.2-15** for the time periods). The predicted blue line (with diffuser) generally represents the trend in DO exhibited in this location's sonde data ("obs G21_sonde_I") and point observations ("obs G21" black dots and "obs A2" purple triangles). At these DO concentration levels, i.e., concentration between 4 and 5 mg/L, the combination of the diffuser and the increased circulation appeared to cause an increase in DO of approximately 0.5 mg/L.

Pertinent site characteristics influencing DO concentration at this site are the shallow depths (2.5 ft to 4 ft), lack of flow velocity and mixing with upstream/downstream areas. The zone of influence of each double-disc diffuser unit was estimated to be reduced after 20 ft (distance from diffuser to "I_Cinderblock" sonde).

DO Supplementation in Landa Lake

Based on the work developed using Blieders Creek data, the effectiveness of diffusers in specific locations within LL (**Figure 3.2-17**) was also estimated. When compared to the Blieders Creek/headwaters experiment site, the focus area (EAHCP Aeration Project) for increasing DO during low-flow times in LL exhibits much larger volume, deeper depths, greater footprint area, increased flow-through, and significant SAV.

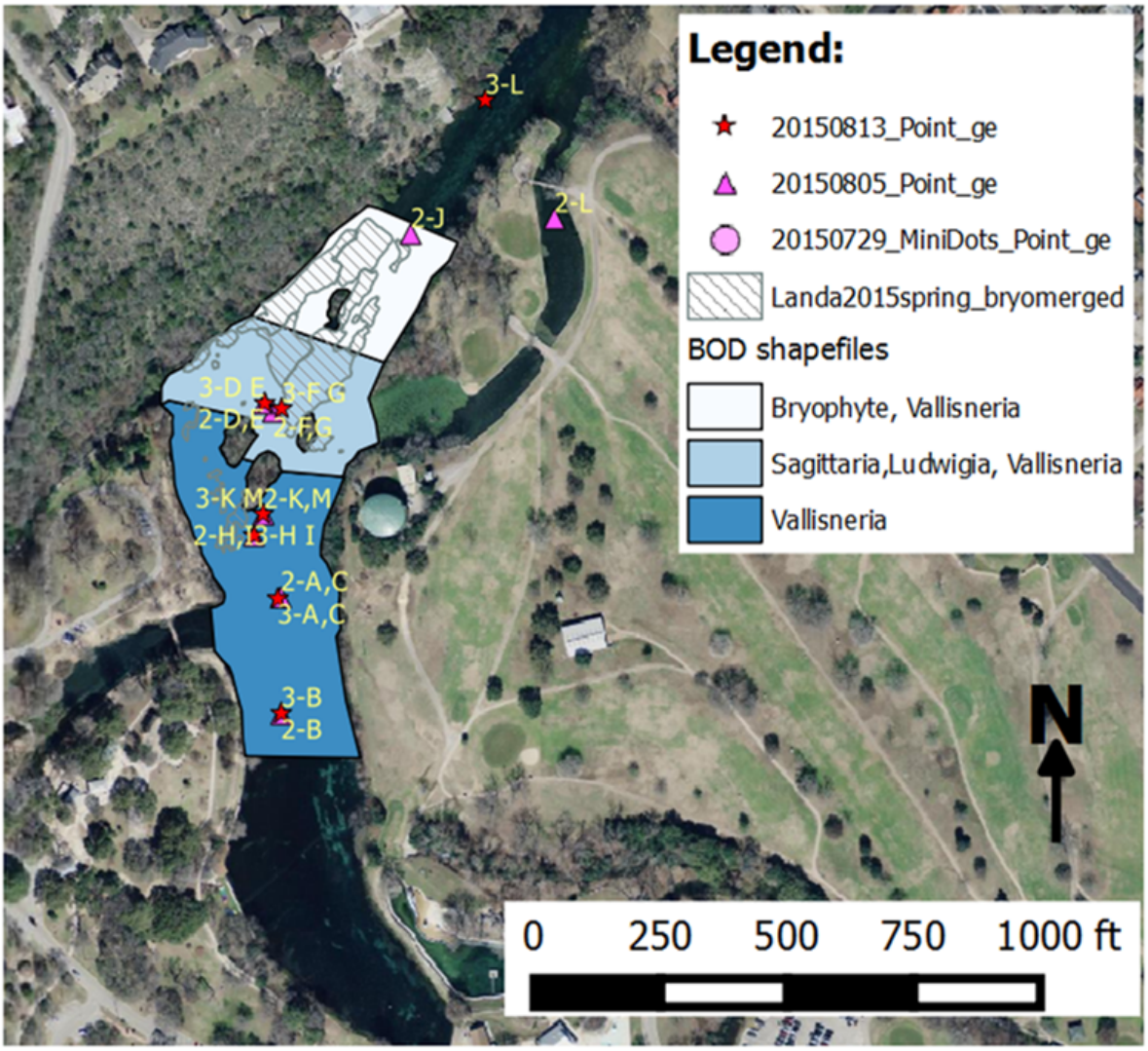

Figure 3.2-17. Map of Landa Lake vegetation zones and 2015 vegetation mat MiniDOT sensor locations.

The one-night period of observed DO concentrations measured in LL for this project in summer 2015 was used to characterize a baseline test condition. Since the existing data observations are being used as the baseline, the diel trend of DO concentration caused by biological activity (algae) already accounts for circulation, wind re-aeration, and chemical, biological and sediment oxygen demand.

With noted assumptions, the impact of installing 160 diffusers at approximately 30-ft spacing is to increase the ambient DO concentration by 1 mg/L. For the conditions tested, this spacing maintains a minimum DO

concentration of 4.5 mg/L throughout the entire area and a return to 5.0 mg/L within six hours (blue line "pred L1_wDiffuser16," **Figure 3.2-18**). This result is an improvement over the minimum DO concentration of 3.3 mg/L in the ambient waters. Use of 160 diffusers requires a considerable compressor with capacity of supplying 208 standard cubic feet per minute (scfm).

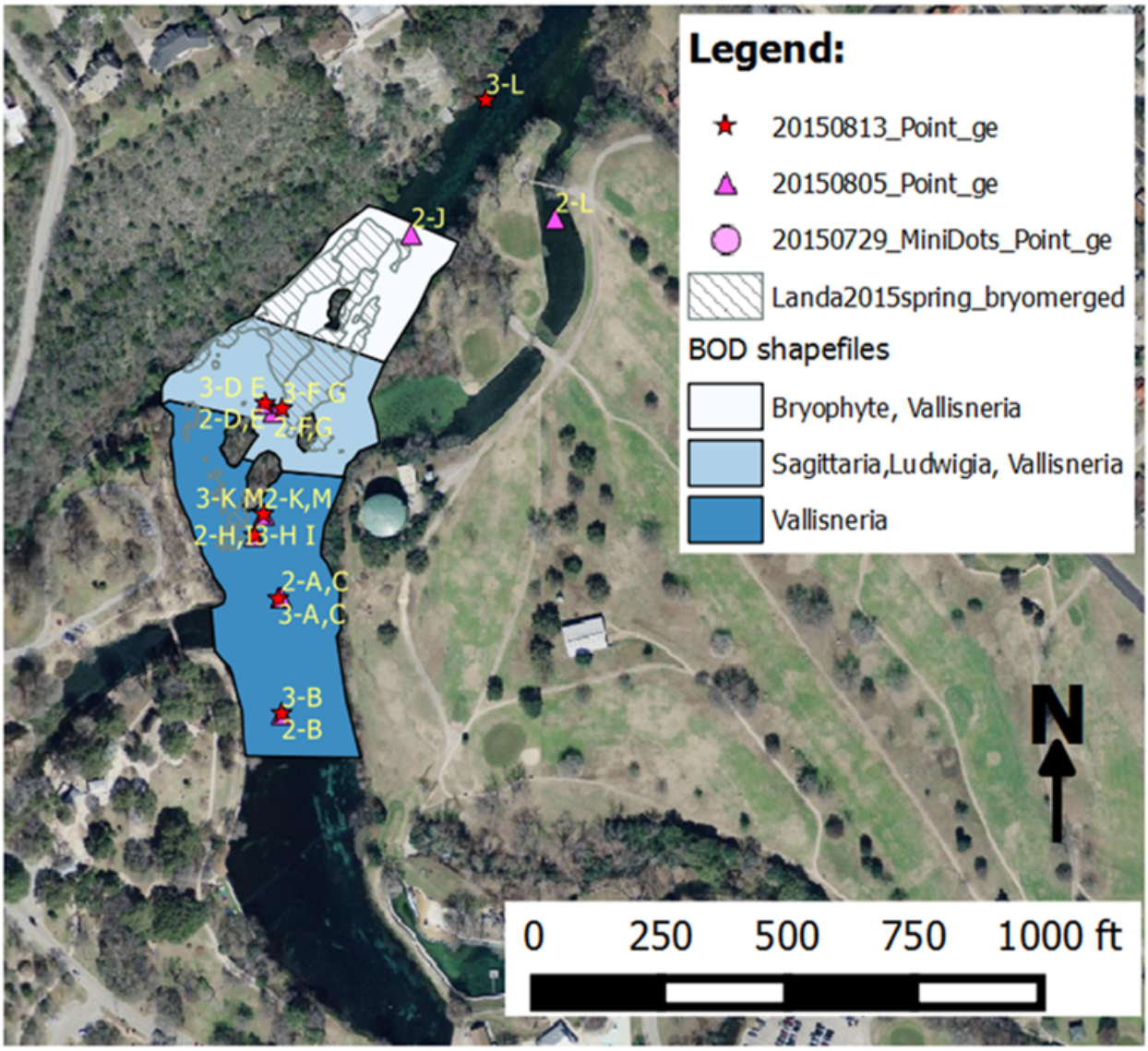

Figure 3.2-18. Landa Lake DO measurements, with predicted effect of 16 and 160 diffusers.

Placing 16 diffusers throughout the same area at approximately 100-ft spacing does little to increase the DO concentrations (green line "pred L1_wDiffuser16," **Figure 3.2-18**) in comparison to ambient waters.

As an alternate, the 16 diffusers could be placed at 30-ft spacing intervals. This spacing would generally maintain a higher DO concentration consistent with the blue line (i.e., 160 diffusers), although the "protection zone" of higher DO would be approximately 8,100 square ft (0.19 acres), much smaller than the overall 3.4-acre area.

Based on the preliminary calculations and observations made for this project, additional work should be conducted to more narrowly focus future diffuser deployments towards specific management objectives and to determine the most efficient mechanical technology capable of accomplishing objectives. Additional resolution on the footprint of the protection area can help reduce the number of disc diffusers. In particular, if a different protection zone is more relevant to the target species, such as the white area indicated in **Figure 3.2-18**, then the depths and surface area of that area may exhibit different DO characteristics. The range of protective ambient DO concentrations necessary for target species also plays a major role. If the minimum protective DO concentration is on the order of 3.0 mg/L, then this generally entails lower costs (less compressor power and fewer diffusers), compared to a minimum protective DO concentration of 4.0 to 5.0 mg/L. Aside from membrane disc diffusers tested as part of this project, there are other means for increasing DO. Alternate methods that may meet management objectives that have not been evaluated are those that can improve circulation (pumps, Solar Bees fans, external air columns, etc.), and are recommended for further investigation. Because of the lake's large surface area, the natural reaeration processes combined with increased exchange of shallow and deep waters may be an effective method to increase overall DO conditions.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

The CONB will continue to monitor water quality parameters, including DO concentrations, within LL. This effort may involve the expansion of DO monitoring efforts in LL during potential low-flow periods to better assess DO conditions spatially throughout LL. The CONB will continue to operate and maintain aerators and associated equipment to mitigate low DO levels as needed based on observed DO concentrations. The CONB will continue to evaluate the effectiveness of the program and the need for additional DO management strategies to meet DO objectives.

3.2.5 Control of Harmful Non-Native Animal Species (EAHCP §5.2.5)

EAHCP Obligations:

The CONB will implement a non-native species control program that targets suckermouth armored catfish (Loricariidae), tilapia (*Oreochromis* spp.), nutria (*Myocastor coypus*), and giant ramshorn snail (*Marisa cornuarietis*). The CONB will conduct annual monitoring and maintenance activities to ensure continued control of the invasive population within the Comal system.

2015 Compliance Actions:

In 2015, the CONB contracted with SWCA to implement non-native removal efforts for the targeted species. SWCA's efforts in 2015 involved six removal sessions, each three days in length, in February, March, April, May, June, and July. SWCA staff utilized gill nets, fyke nets, and spears to capture fish species (**Figure 3.2-19**) and baited box traps for nutria. Ramshorn snails were collected primarily by hand-

Figure 3.2-19. Photos of non-native species removal methods.

In the top photo, a fyke net is set in the Pecan Island area in LL. In the bottom photo, SWCA set out gill nets in LL.

picking. Over the six sessions, SWCA removed a total of 1,308.83 pounds (lbs) of biomass from LL. This volume included 113 vermiculated sailfin catfish, 516 tilapia, 8 nutria, and 411 ramshorn snails removed from LL. **Table 3.2-9** presents the results of each sampling session completed from February 2015 to July 2015. The total biomass, average length, and sex ratios are reported for each species. The total amounts do not include data that is shown as not available (N/A) in the tables.

Table 3.2-9. Non-Native Species Removal Biometrics

Session 1, February 2015

Species	Number Removed	Biomass (kg)	Biomass (lbs)	Avg. Length (cm)	Sex Ratio
Vermiculated sailfin catfish	9	11.89	26.21	45.70	0.33:1 Female bias
Tilapia	93	75.86	16.24	35.00	0.40:1 Female Bias
Nutria	2	5.36	11.81	N/A	Both Male
Giant Ramshorn Snail	103	N/A	N/A	3.41	N/A
Totals	**207**	**93.11**	**205.27**	**N/A**	**N/A**

Session 2, March 2015

Species	Number Removed	Biomass (kg)	Biomass (lbs)	Avg. Length (cm)	Sex Ratio
Vermiculated sailfin catfish	22	23.85	52.58	44.30	1.10:1
Tilapia	93	81.88	180.51	36.20	0.45:1 Female Bias
Nutria	1	2.18	4.80	N/A	Female
Giant Ramshorn Snail	98	N/A	N/A	3.29	N/A
Totals	**214**	**107.91**	**237.90**	**N/A**	**N/A**

Session 3, April 2015

Species	Number Removed	Biomass (kg)	Biomass (lbs)	Avg. Length (cm)	Sex Ratio
Vermiculated sailfin catfish	6	6.86	15.12	46.10	0.33:1 Female bias
Tilapia	109	101.40	223.54	36.60	0.40:1 Female Bias
Nutria	2	6.00	13.20	N/A	Both Male
Giant Ramshorn Snail	0	0	0	N/A	N/A
Totals	**117**	**114.26**	**251.90**	**N/A**	**N/A**

Table 3.2-9. Non-Native Species Removal Biometrics

Session 4, May 2015

Species	Number Removed	Biomass (kg)	Biomass (lbs)	Avg. Length (cm)	Sex Ratio
Vermiculated sailfin catfish	19	20.56	45.32	45.80	1.10:1
Tilapia	106	88.12	194.27	39.30	0.15:1 Ext-Male Bias
Nutria	2	7.30	17.00	N/A	1:1
Giant Ramshorn Snail	0	0	0	N/A	N/A
Totals	**127**	**115.98**	**255.69**	**N/A**	**N/A**

Session 5, June 2015

Species	Number Removed	Biomass (kg)	Biomass (lbs)	Avg. Length (cm)	Sex Ratio
Vermiculated sailfin catfish	45	44.73	98.61	45.40	0.25:1 Male bias
Tilapia	84	77.98	171.90	37.00	0.25:1 Male Bias
Nutria	1	2.29	5.04	N/A	Male
Giant Ramshorn Snail	156	0.92	2.02	3.26	N/A
Totals	**286**	**125.92**	**277.57**	**N/A**	**N/A**

Session 6, July 2015

Species	Number Removed	Biomass (kg)	Biomass (lbs)	Avg. Length (cm)	Sex Ratio
Vermiculated sailfin catfish	12	11.79	26.00	44.90	1:1
Tilapia	30	24.76	54.58	35.90	0.25:1 Male Bias
Nutria	0	N/A	N/A	N/A	N/A
Giant Ramshorn Snail	0	N/A	N/A	N/A	N/A
Totals	**42**	**36.55**	**80.57**	**N/A**	**N/A**

Comparing the three years of removal efforts, there were several key shifts in the data. Most striking is the lack of nutria in the system during 2015. During the entirety of 2015, only eight nutria were captured within the system, as compared to 2013 and 2014, when biologists captured 50 individuals. Importantly, of the eight individual nutria lethally removed from the Comal system, five were male and three were female. This strongly suggests that the breeding population of the nutria in the area has declined below the amount to sustain a population.

SWCA biologists were also able to capture and remove both tilapia and vermiculated sailfin catfish in far fewer numbers as compared to the previous two removal years. In 2013, SWCA removed 391 individual vermiculated sailfin catfish and 2,143 tilapia from the Comal system, comparable to the 308 and 1,646 respective captures in 2014. SWCA was able to remove 112 vermiculated sailfin catfish and 515 tilapia from the lake in 2015. A noticeable shift occurred in the sizes of the removed fish. Each species showed a significant decrease in average length and weight when compared between the first two capture years. This

difference in size strongly implies that removal efforts are suppressing the population's ability to breed and to gain adult mass. A huge shift in smaller body size was noticed this year.

Additionally, throughout the duration of the project SWCA paired with Ms. Luci Cook-Hildreth, TPWD, on a breeding and age study for the vermiculated sailfin catfish. SWCA biologists captured and donated several hundred catfish to the TPWD for analysis. In 2013, all of the female vermiculated sailfin catfish removed during the breeding season (late spring and early summer) had viable egg sacs. During the same time period in 2014, TPWD did not find any females containing egg sacs. This trend continued with the 2015 removal effort, and demonstrates the decreased ability of the vermiculated sailfin catfish to breed within LL.

During the 2013 to 2015 removal efforts, representing a total of 63 field days, SWCA biologists removed approximately 11,300 lbs (five tons) of invasive biomass. In the three years of removal efforts, noticeable impacts have already been observed on both the nutria and vermiculated sailfin catfish populations. Subsequent removal efforts must be made every year for the foreseeable future in order to fully remove or to significantly impact these species' breeding populations. With regard to the tilapia population within the lake, SWCA believes the statistical analysis detailed above shows the desired trend of the reduction in overall body size. SWCA has removed approximately 4,260 tilapia, and suspects there could still be several hundred left in the lake. Giant ramshorn snail removal, while on-going, may only see a lasting decrease through an increase in natural predation. A full report including additional information regarding characteristics of the removed species (i.e., length, weight, and sex ratios) is included as **Appendix L5** of this report.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

The CONB will continue the existing program to remove non-native invasive species from the Comal River system utilizing removal methods proven successful in previous years. Capture methods may be modified slightly to adjust to changing patterns of the target species. The CONB will also to continue to record counts and biomass of removed species.

3.2.6 Monitoring and Reduction of Gill Parasites (EAHCP §5.2.6 and §6.3.6)

EAHCP Obligations:

The CONB will retain a contractor to establish a monitoring and reduction program associated with the gill parasite, *Centrocestus formosanus* and its intermediate host snail, *Melanoides tuberculatus*. Obligated work activities in 2015 include the continuation of gill parasite cercariae water column density monitoring, host snail distribution and density monitoring, host snail infection prevalence monitoring, and fountain darter infection prevalence analysis. Additional research will be conducted through the AMP to determine the most appropriate strategy for gill parasite control in the system.

2015 Compliance Actions:

An identified concern for the fountain darter in the Comal Springs ecosystem is the continued presence of an Asian trematode, *Centrocestus formosanus*. This parasite attaches to the fish's gill filaments, causing extensive gill damage (Mitchell et al. 2000) and eventually mortality, as discussed on page 5-18, Section 5.2.6 of the EAHCP. A non-native snail, *Melanoides tuberculatus*, has been confirmed as the first intermediate host for *C. formosanus* in central Texas (Mitchell et al. 2000). Beginning in 2013, the CONB retained contractors to further investigate this gill parasite, and to explore potential management techniques aimed at minimizing and mitigating for the impact of the parasite under low flows. Key objectives of these efforts were to obtain a better understanding of the potential impacts of the gill parasite on the fountain darter; to investigate appropriate means and methods to alleviate concerns; and to establish a long-term monitoring program. The underlying goal was to enhance the protection of the fountain darter, especially under future low-flow scenarios.

Based on the initial literature review it was evident that one of the most critical gaps in knowledge was system-wide information on the distribution and abundance of both the parasite and snail host. A stratified host snail monitoring system was developed in 2013 to provide analysis of snail populations on multiple scales, using a system-wide survey to determine areas of high snail abundance and then investigating these areas with additional refined sampling to estimate snail densities. A system-wide snail survey was first conducted in 2013 to document the distribution of *M. tuberculatus* throughout the Comal River system, and then repeated in 2014 and 2015 to investigate temporal changes in distribution, such as potential local colonization or extinction events (**Figure 3.2-20**). The results of all three annual surveys show the snail to be extremely abundant in areas of LL, the New Channel above the old power plant, and parts of the USR near Spring Island.

Density sampling was conducted to quantify the density of *M. tuberculatus* both in areas sampled previously in 2013 and 2014 (providing for detection of trends), as well as new hot spot areas identified in the 2015 survey. In 2013, average densities of *M. tuberculatus* in these areas ranged from 179/m^2 to over 1,000/m^2, in 2014 densities observed ranged from 50/m^2 to 850/m^2, and in 2015 densities ranged from 33/m^2 to 936/m^2. The highest observed densities in 2013 were observed in the New Channel Reach (NCR) between LL and the power plant, while in 2014 and 2015 the highest observed densities were in the USR. When reach average densities are compared among years, and their variation (standard error) considered, density estimates are relatively static across years (**Table 3.2-10**), with the exception of 2015 values in LL and NCR, which were lower largely as a consequence of new construction removing previously sampled high density sites in those reaches. Density estimates were first made for the Old Channel Reach (OCR) in 2014 and continued during 2015 (**Table 3.2-10**).

Figure 3.2-20. Points sampled for snails (*M. tuberculatus*) during 2015 comprehensive snail surveys.

Table 3.2-10. Yearly Snail Density Estimates (Mean ± SE) Averaged Over Samples Within Each Reach

	USR	LL	NCR	OCR
2013	371.7 (±115.6)	399.3 (±70.9)	607.1 (±221.2)	---
2014	426.9 (±114)	350 (±103.3)	343.7 (±37.8)	146.2 (±32.6)
2015	480.2(±127.7)	185.3(±55.8)	147.1(±55.9)	62(±6)

USR = Upper Spring Run, LL = Landa Lake, NCR = New Channel Reach, OCR = Old Channel Reach
Please note: no density samples were taken in the Old Channel in 2013.

To monitor temporal changes in the distribution and abundance of *C. formosanus* cercariae in the Comal River, three of the 2013 and 2014 cercariometry sites (LL, OCR, and RV Park [RVP]) (**Figure 3.2-21**) were chosen to continue monitoring.

Cercariae density estimates exhibited interesting variation among sites and in relation to season and discharge in 2014, but not in 2015 for comparable sites (**Figure 3.2-22**). Overall, observed 2015 densities were lower and more stable over time than in 2014, especially in the NCR and RVP, where large spikes in density observed in summer 2014 were lacking in 2015. One explanation for this outcome is that higher flows in 2015 resulted in shorter residency time of cercariae (faster flushing of the system), preventing the cercariae from amassing in high concentrations as observed in 2014 under lower flows. The data suggests that most cercariae production occurs upstream of the OCR in LL and few, if any, cercariae are likely produced from snails occupying the OCR. The USR, though it exhibited much higher snail host infection than the OCR, had much lower infection rates for fountain darters. These data, therefore, suggest that the OCR and the USR may represent areas of management opportunity for the gill parasite.

An initial investigation into the infection rates of snail hosts in the wild was conducted in 2014, and additional data was collected in 2015 to compare to this baseline data, as well as contribute to the 2015 host snail morph investigations described later in this report. The method developed in 2014 to investigate infection rates involving cutting of the snail shells, excising the digestive gland, and processing it under a microscope, was again used in 2015. This method proved highly effective for detection of *C. formosanus* infection. Two other species of parasite known from the system were also detected (*Haplorchis* sp. and *Philopthalmus* sp.), and two additional novel parasites previously unknown in the Comal system have now also been discovered (one in each year). *Centrocestus* infection rates per sampling area ranged from 0 to 42.9 percent, with an overall mean of all areas sampled of 19 percent. The maximum sample area mean observed in BIO-WEST 2014 infection data was 24.9 percent with an overall mean of 13.7 percent, however, in some sub-samples much higher rates were observed. The silty areas of the southern end of LL were found to have some of the highest infection rates in both years (**LLB** in **Figure 3.2-21** and **Table 3.2-11**). Extremely high infection rates were fairly isolated, and spatial aggregation of infected snails was apparent.

Figure 3.2-21. Location of cross sections used for monitoring of drifting cercariae in the water column.

Cercariometry sites are shown in red (SI was not sampled in 2015). The blue areas are sampling regions for parasite infection prevalence, labeled with the three-letter area designation, percent of snails infected by *Centrocestus formosanus*, and the sample size in parentheses from 2014 initial sampling.

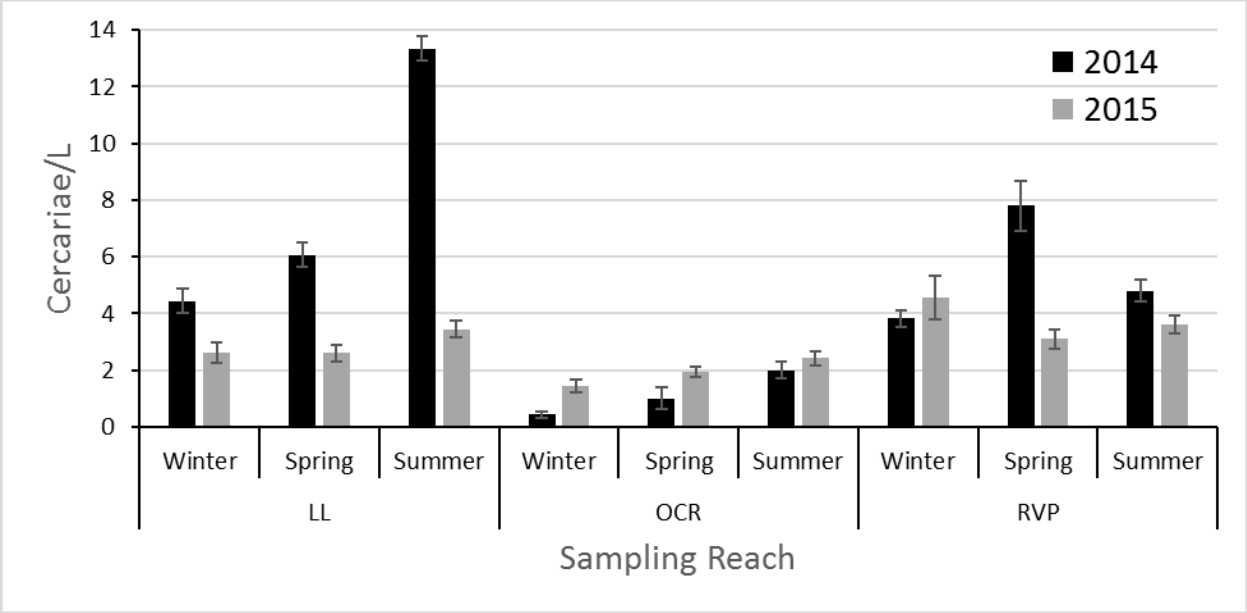

Figure 3.2-22. Density (cercariae/L) of gill parasite (*Centrocestus formosanus*) cercariae in samples taken from the water column at three sites during 2014 and 2015.

The error bars indicated above represent standard errors. The transects sampled included LL outflow, OCR at Elizabeth Avenue, and NCR at Landa RV Park (RVP).

Table 3.2-11. Sample Size (*n*) and Infection Rates (percent) of Host Snails (*Melanoides tuberculatus*) by *Centrocestus formosanus* and other Detected Parasites at High-Host Density Areas in the Comal System

Area*	*N*	Percent Uninfected	Percent *C. Formosanus*	Percent Other Parasites
LLA	21 (643)	42.9 (70.3)	42.9 (14.5)	14.3 (14.8)
LLB	50 (599)	26.0 (35.9)	14.0 (24.9)	60.0 (38.4)
NCA	40 (1,138)	37.5 (67.8)	12.5 (13.1)	50.0 (19.2)
OCR	22 (95)	100.0 (100.0)	0.0 (0.0)	0.0 (0.0)
SID	18 (968)	88.9 (89.8)	5.6 (6.5)	5.6 (3.5)
SIU	71 (771)	69.0 (88.7)	26.8 (6.7)	4.2 (4.5)
USR	52 (530)	69.2 (79.2)	21.1 (13.2)	9.6 (7.5)

* LLA, -B=Lake Landa sample areas A and B; NCA=New Channel Reach area A; OCR=Old Channel Reach; SID= Spring Island Downstream, SIU=Spring Island Upstream, USR=Upper Spring Run

Note: data from the two study years is presented as: 2015 value (2014 value).

Investigations into the underlying mechanisms of the aggregation of infected snails began in 2015 with the development of laboratory methods for assessing genetic and morphological differences in snail populations with higher infection rates. Snail hosts such as *M. tuberculatus* are known to evolve and adapt rapidly, due in part to parthenogenetic reproduction, which results in their existence in the form of one or more genetic clones, each from a different geographic source. BIO-WEST's infection prevalence data has shown the distribution of highly infected snails occurs in patches, which could be caused by different clones preferring different microhabitats, and varying from other clones in their susceptibility to parasite infection. In population and evolutionary biology, different lineages and subpopulations are identified by their

genetics (DNA analysis) or by morphometrics analysis (the measurement of physical traits often augmented by the calculation of ratios and other metrics). Development and testing of these methods was initiated in 2015, with the goal of allowing BIO-WEST to separate genotypically distinct clones of live snails by simple morphometric features or measurements to assess differences in parasite susceptibility for possible management application. DNA markers and morphological characters tested on preliminary 2015 data show the presence of variation and the existence of groups of snails in the data. Morphological analysis will be completed in early 2016.

In addition to studies on the host snails and drifting parasites, an effort was begun in 2014 and continued in 2015 to quantify parasite concentrations in the gills of wild fountain darters. To do this with minimal impact, gills of fountain darters previously collected for EAA applied research fecundity studies were examined under microscopes and recently encysted *C. formosanus* metacercariae were counted. Only darters collected from the New Channel (RVP) and OCR sites were used in 2014, however, darters from the USR were examined in 2015. Parasite counts ranged from 0 to 52 per fish in the New Channel, 0 to 96 per fish in the Old Channel, and 0 to 36 per fish in the USR. Previous studies have concluded that approximately 800 or more encysted metacercariae are necessary to cause mortality in fountain darters (Mitchell et al. 2000), and laboratory experiments show that adult fountain darters can survive accumulation of more than 600 during an eight-hour trial, while over 1,000 caused mortality in the same time period (McDonald et al. 2006). It should be noted, however, that McDonald et al. (2006) also found that the lethal effects of metacercariae were correlated positively with fish length, and that an average of only 60.2 metacercariae caused mortality in larval fountain darters. It is also likely that this is a biased sample, as darters with infection rates at or approaching lethal conditions would be less likely to be observed when sampling.

Gill parasite activities conducted in 2015 are in full compliance with the EAHCP and ITP. Since on the ground field activities were conducted, the associated project footprints and net disturbance assessments are described in **Chapter 5.0**, 2015 Annual Take Estimates, of this Annual Report. A full project report describing 2015 gill parasite activities can be found in **Appendix L6**.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

Based on results of 2015 work, continued monitoring of the distribution and density of both host snail and drifting cercariae is scheduled for 2016, as is continued monitoring of parasite prevalence in the host snail. Further data will aid in monitoring temporal trends of both species within the system, and provide additional insight into the mechanisms behind such trends.

3.2.7 Prohibition of Hazardous Materials Transport Across the Comal River and Tributaries (EAHCP §5.2.7)

EAHCP Obligations:

The CONB will continue efforts to prohibit the transport of hazardous materials on routes crossing the Comal River and its tributaries.

2015 Compliance Actions:

CONB staff finalized a map of proposed routes crossing the Comal River and its tributaries on which hazardous material (HAZMAT) transport has been proposed to be prohibited (**Figure 3.2-23**). The map was were presented to the CONB Transportation and Traffic Advisory Board on October 8, 2015, to gather input on the proposed route prohibitions.

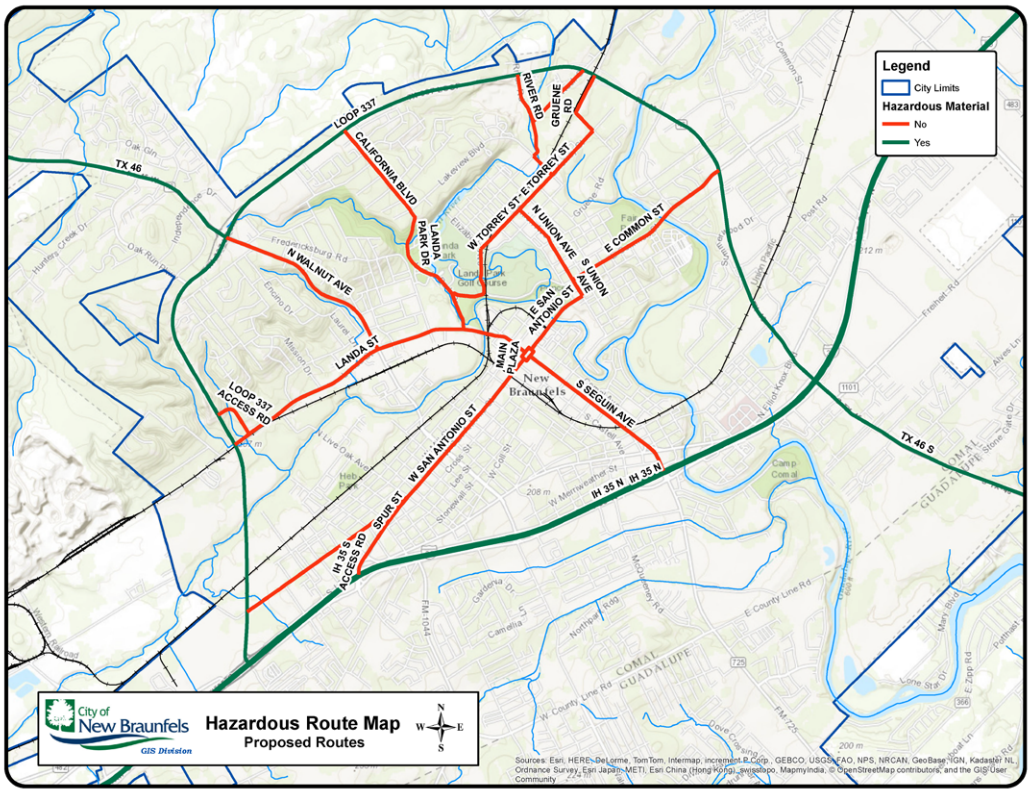

Figure 3.2-23. Map of proposed routes on which hazardous material transport may be prohibited by CONB ordinance.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

A CONB ordinance specifying routes on which hazardous materials may be transported will be drafted and presented to the CONB City Council in early 2016 for consideration.

3.2.8 Native Riparian Habitat Restoration (Riffle Beetle) (EAHCP §5.2.8)

EAHCP Obligations:

In order to improve CSRB habitat, the CONB will implement a restoration program to improve the riparian zone along Spring Run 3 and the western shoreline of LL, and to minimize sedimentation impacts. The program will involve removal of non-native vegetation and revegetation with native species. Restoration efforts will target plants and trees with extensive root systems to provide the greatest opportunity for riffle beetle habitat.

2015 Compliance Actions:

RPS Espey accomplished riparian restoration tasks in 2015 along the northwestern banks of Spring Run 3 and along approximately 600 ft of the western shoreline of LL. The total length of the project area was approximately 1,105 ft, extending from the head of Spring Run 3 to a private property fence line on the western shoreline of LL. **Figure 3.2-23** and **Figure 3.2-24** depict the general location of the project area and the specific work areas, respectively. Restoration planting and erosion control activities extended from the shoreline to approximately 15 yards up the hillside. A summary of 2015 riparian restoration activities is presented below. A full detailed report is included as **Appendix L7** of this report.

Restoration activities in 2015 included: (1) removal and/or treatment of exotic vegetation; (2) construction and maintenance of erosion control structures; (3) revegetation utilizing native vegetation; and (4) sediment and vegetation monitoring.

Non-native plant species within the project area were largely removed in 2013 and 2014, and in 2015 remaining or re-emergent non-native plant species, primarily elephant ear (*Colocasia* spp.*)* and Japanese ligustrum (*Ligustrum japonicum*), were removed using mechanical means. The areal extent of elephant ears in 2015 was very small, therefore, mechanical removal methods (by pulling plant and roots) were employed in lieu of herbicide application. Ligustrum trees ranging between two-inches and six-inches in diameter were cut six-inches to twelve-inches from the ground in order to keep the root structure intact, and to provide an anchor for installed erosion control structures. The remaining stump was manually treated using a "brush on" technique to prevent re-growth. Limited re-growth was also observed from stumps left from the 2014 removals, which were also re-treated. Larger diameter portions of each tree, the main trunk and

Figure 3.2-24. General location of the riparian restoration project area.

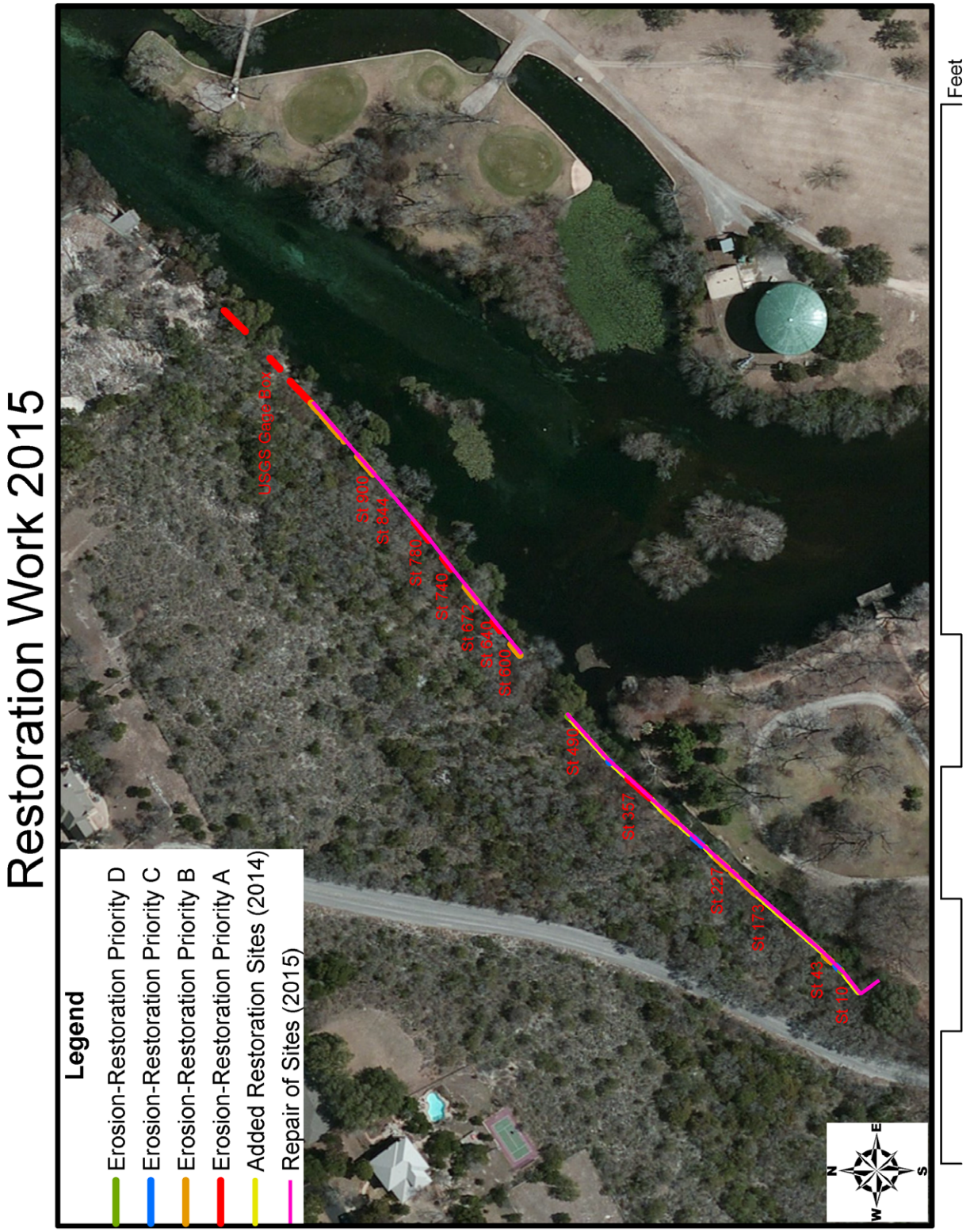

Figure 3.2-25. Locations of riparian restoration activities in 2015.

large branches, were utilized to construct and repair erosion control structures. The smaller ligustrum branches and twigs were used to form erosion prevention mats between the larger branches. Sediment capture devices installed in 2014 were maintained and monitored for structural integrity and sediment capture throughout 2015. To monitor depth of captured sediment, a steel pin was driven just inside the erosion control structure approximately at the midway point along the structure length. Change in exposed height of the steel pin was used to calculate deposited material. Seven monitoring events were conducted to measure erosion pin height at 16 sediment capture devices in 2015. To quantify captured sediment runoff, a series of measurements were taken by dividing the selected control structures into equal segments. Cross-sectional area was calculated for each segment by assuming measured cross sections were parallel to each other, and the control structure was roughly triangular in shape. This assumption is conservative and likely under-estimates sediment accumulation behind the erosion control structures. Captured sediment was estimated for the sampling period from February 18, 2015 to September 3, 2015 (**Table 3.2-12**). Total estimated sediment retained over this time period is estimated to be 5.40 cubic yards (yd^3).

Table 3.2-12. Soil Capture Volume by Site

Location	Total Soil captured behind structure (yd^3)
10	0.21
43	0.08
49	0.65
88	0.16
173	0.15
208	0.27
227	0.55
276	0.83
335	0.58
341	0.00
357	0.77
640	0.18
672	0.46
740	0.18
780	0.21
987	0.12
Total Capture Volume (yd^3)	**5.40**

Native riparian restoration planting was completed during four site visits between February 18, 2015 and March 13, 2015. A summary of species planted per site in 2015 is shown in **Table 3.2-13**. An additional reseeding was conducted on May 29, 2015. Trees were planted on April 20, 2015 and July 16, 2015. All plantings were sprayed with an egg and cayenne solution (one dozen eggs, three teaspoons cayenne to one gallon of water) to discourage deer, squirrels, and rodents, and the spraying was continued during visits for three months to allow establishment of plant roots. Protective fencing was installed around planted trees and consisted of four-ft tall metal fencing surrounding each tree. Sample photos of riparian restoration along Spring Run 3 are shown in **Figure 3.2-26**.

Table 3.2-13. 2015 Riparian Plantings (by site)

	Frost-weed	Canada Wildrye	Virginia Wildrye	Switch-grass	Bristle-grass	Green Sprangle-top	Cedar Sedge	Indian Grass	Meadow Sedge	Big Muhly
	Seed	Seed	Seed	Seed	Seed	Seed	Plug	Plug	Plug	Plug
Site Name	Shade	Shade	Shade	Partial Shade	Partial Shade	Partial Shade	Shade	Shade/ Partial	Partial/ Full Sun	Full Sun
10	X	X	X				X			
43	X	X	X				X			
49	X	X	X				X	X		
88	X	X	X				X	X		
135	X	X	X	X	X	X	X	X		
173	X	X	X	X	X	X	X	X	X	
208	X	X	X	X	X	X	X	X		
227	X	X	X	X	X	X	X	X	X	
253	X	X	X	X	X	X	X	X	X	
276	X	X	X	X	X	X	X	X		
335	X	X	X	X	X	X	X	X	X	
341	X	X	X	X	X	X		X	X	
434	X	X	X	X	X	X				
490	X			X	X	X		X		X
600	X	X	X	X	X	X		X		
640	X	X	X	X	X	X	X	X	X	
672	X	X	X	X	X	X		X	X	X
740	X	X	X	X	X	X		X		
780	X	X	X	X	X	X		X	X	X
844	X	X	X	X	X	X		X	X	X
896	X	X	X	X	X	X	X			
903	X	X	X	X	X	X				
941	X	X	X	X	X	X	X			

See **Appendix L7** for the GPS coordinates to site names identified in **Table 3.2-13**.

Figure 3.2-26. Photos of enhanced riparian zone and erosion control structures along Spring Run 3.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

The CONB will continue to maintain existing riparian restoration coverage and monitor recently restored areas for stability and established vegetative growth. The CONB will continue to increase riparian plant coverage and remove non-native vegetation.

3.2.9 Reduction of Non-Native Species Introduction and Live Bait Prohibition (EAHCP §5.2.9)

EAHCP Obligations:

The CONB will take action to prohibit the introduction of domestic and non-native aquatic organisms, targeting specifically bait species and aquarium trade species into the Comal River system. In addition, the CONB will continue to educate and promote awareness on the adverse impacts of aquarium dumping and use of non-native bait species to the Comal River ecosystem.

2015 Compliance Actions:

The CONB developed educational materials designed to inform the public of invasive species issues and the negative impacts of aquarium dumping. A non-native species introduction educational piece was included in the CONB's *Making the Most of Our Resources* newsletter that was distributed as an insert in 10,000 copies of the Sunday, July 5, 2015 edition of the local *New Braunfels Herald-Zeitung* newspaper (**Figure 3.2-27**). An educational piece was also included in the spring 2015 edition of the CONB's Parks and Recreation Program Guide referred to as *The Fun Things in Life* (**Figure 3.2-28**).

CONB also communicated with TPWD representatives regarding potential live bait restrictions and aquarium dumping prohibitions in LL.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

The CONB will continue to educate and promote awareness on the adverse impacts of aquarium dumping and use of non-native bait species to the Comal River ecosystem. The CONB will continue communications with TPWD regarding the development and implementation of potential CONB ordinances associated with the restriction of live bait species and prohibition of aquatic aquarium dumping. The CONB will also seek opportunities to install signage at key locations within Landa Park to inform residents of the implications of live bait usage and aquarium dumping.

Prevent further introduction of invasive aquatic species into Landa Lake and the Comal River.

> Never dump aquarium fish, snails and plants into natural bodies of water, including Landa Lake and the Comal River!

>Aquariums may contain fish, such as suckermouth catfish, plecostomus (algae eaters), goldfish and koi, as well as exotic snails and plants. These harmful, invasive species are able to thrive in Landa Lake and the Comal River due to stable, year-round water temperatures and availability of food sources.

> Non-native species can cause disruption of native habitats and may cause harm to endangered species that live in Landa Lake and the Comal River.

> Avoid using non-native aquatic species, such as koi and goldfish, for fishing bait.

Ayude a prevenir la invasión de especies acuáticas en el Lago Landa y en el Río Comal.

> Jamás eche peces de acuarios, caracoles o plantas en depósitos naturales de agua, los cuales incluyen al Lago Landa y al Río Comal.

> Los acuarios a veces incluyen peces como bagre ventosa, plecostomus (comedores de algas), peces de colores y koi, así como caracoles y plantas exóticas. Estas especies dañinas e invasivas pueden expandirse en el Lago Landa y en el Río Comal debido a las condiciones y temperaturas estables que ambos ofrecen a lo largo del año, ofreciendo con ello disponibilidad de recursos de alimentación.

> Las especies que no son nativas al sitio pueden causar ruptura en los hábitats naturales y causar daños que ponen en peligro a las especies que viven en el Lago Landa y en el Río Comal.

> Evite a toda costa introducir y usar como cebo de pesca especies acuáticas no nativas, tales como koi y peces de colores.

Figure 3.2-27. Non-native and invasive species introduction educational piece included in the *Making the Most of Our Resources* newsletter distributed in the July 5, 2015 edition of the *New Braunfels Herald-Zeitung* newspaper.

PROTECT YOUR ENVIRONMENT

Prevent further introduction of invasive aquatic species into Landa Lake and the Comal River.

- Never dump aquarium fish, snails and plants into natural bodies of water, including Landa Lake and the Comal River.
- Aquariums may contain fish, such as Suckermouth Catfish, Plecostomus (algae eaters) and Koi, as well as exotic snails and plants. These harmful, invasive species are able to thrive in Landa Lake and the Comal River due to stable, year-round water temperatures and availability of food sources.
- Non-native species can cause disruption of native habitats and may cause harm to endangered species that live in Landa Lake and the Comal River.
- Avoid using non-native aquatic species, such as koi and goldfish, for fishing bait.

City of New Braunfels

HABITAT CONSERVATION PLAN EDWARDS AQUIFER

Figure 3.2-28. Non-native and invasive species introduction educational piece included in the spring 2015 edition of *The Fun Things in Life* guide distributed by the CONB Parks and Recreation Department.

3.2.10 Litter Collection and Floating Vegetation Management (EAHCP §5.2.10)

EAHCP Obligations:

The CONB will perform activities to manage floating vegetation and litter removal to enhance habitat for Covered Species. Management activities will include dislodging of vegetation mats that form on top of the water surface, particularly during low flows, to allow continued movement downstream, and removal of litter from the littoral zone and stream bottom. The CONB will manage floating vegetation mats in LL by removing floating materials entrained on the flow control structures, fishing piers, Three Island area, Landa Park Drive Bridge and other areas where mats collect. Litter removal in LL and the Comal River will continue under the existing CONB program.

2015 Compliance Actions:

The CONB continued to implement a program to remove litter and dislodge floating vegetation mats from LL and portions of the Comal River where Covered Species habitat is present. Management of floating vegetation mats in key areas in LL and portions of the Comal River (**Figure 3.2-29**) prevents shading of restored aquatic vegetation areas, minimizes entrainment of material in the 48-inch culvert screen and control gate to the Old Channel, and reduces oxygen consumption in LL associated with decaying vegetation.

Litter collection efforts in 2015 consisted of litter removal from the surface of LL and the Spring Runs. Litter collection efforts also included removal of litter from select portions of the Old Channel and from the bottom of LL utilizing Self-Contained Underwater Breathing Apparatus (SCUBA) equipment.

Any Modifications or Activities Due to Weather Conditions:

The flood event that occurred on October 30, 2015 resulted in the deposition of large trees, litter, vegetation, and other flood debris within LL and the Old Channel. The CONB utilized a contractor as well as internal CONB staff to remove flood debris from key habitat and previously restored areas.

Proposed Activities for 2016:

The CONB will continue efforts to remove litter and dislodge floating vegetation mats from applicable portions of the Comal River system to prevent negative impacts to flow control structures, aquatic restoration areas, and Covered Species habitat. Targeted areas for litter and floating vegetation mat management may be adjusted slightly based on field observations of where litter and mats accumulate and have the potential to influence Covered Species habitat.

Figure 3.2-29. Location of target floating vegetation mat management areas.

3.2.11 Management of Golf Course Diversions and Operations (EAHCP §5.2.11)

EAHCP Obligations:

The CONB will develop and implement a Golf Course Management Plan that will include an Integrated Pest Management Plan (IPMP) designed to target techniques to protect water quality and minimize potential negative effects to Covered Species.

2015 Compliance Actions:

The CONB continued to update the IPMP, as needed, and maintain a vegetative buffer between the golf course and LL and the Old Channel of the Comal River in order to provide increased water quality protection. The *2016 Landa Lake Golf Course Integrated Pest Management Plan* is located in **Appendix L8** of this Annual Report.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

The CONB will continue to update the IPMP and maintain a vegetative buffer between the golf course and LL and the Old Channel of the Comal River. The IPMP will be revised, as needed, to address any operational changes associated with the management of the golf course grounds.

3.2.12 Native Riparian Habitat Restoration (Old Channel Improvements) (EAHCP §5.7.1)

EAHCP Obligations:

The CONB will initiate a riparian restoration program to enhance the riparian zone along the Old Channel, the golf course, and in the vicinity of Clemens Dam. The CONB will implement bank stabilization and riparian restoration activities in the Old Channel adjacent to where the sediment island was removed.

2015 Compliance Actions:

The design for the Old Channel Bank Stabilization Project and associated Native Riparian Habitat Restoration was accomplished in 2013 and 2014. Design work was completed by Freese and Nichols, Inc. (F&N) and included improvements to the initial riparian restoration concepts to address input from the SC. The CONB again presented the modified plan to the SC on June 10, 2015, to satisfy a request for the SC to be able to offer final comments and suggestions prior to project implementation. The plan was accepted by the SC. Bids for the project were received in 2015, and F&N was selected to provide bid-phase services. F&N processed the CONB floodplain permit, which included applicable hydrologic and hydraulic information. Bank stabilization was originally anticipated for construction in 2014. Construction was delayed, however, due to work restrictions associated with low springflow as discussed in Condition M of the ITP.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

The 2016 EAHCP budget includes funding for construction and F&N's construction phase services. The CONB will proceed with construction of the Bank Stabilization Project and associated riparian restoration. Construction of the project is expected to commence in Spring 2016 with substantial completion of the project expected in Summer 2016.

3.2.13 Management of Household Hazardous Wastes (EAHCP §5.7.5)

EAHCP Obligations:

The CONB will continue to implement a Household Hazardous Waste (HHW) program. The CONB will continue to enhance its HHW program to generate additional participation by the general public.

2015 Compliance Actions:

The CONB held three HHW collection events in 2015. The HHW collection events were held in February, June and October. Overall, 483 car-visits were recorded, and a total of 54,595 lbs of hazardous waste collected. The statistics for each collection event are presented in **Figure 3.2-30**. A photo of the 2015 HHW collection events is shown in **Figure 3.2-31**. The CONB produced educational materials to increase awareness of the HHW program and the EAHCP (e.g., oil funnels, including web links to the CONB's EAHCP and HHW website).

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

The CONB will continue a HHW program, which will include HHW collection events and public outreach efforts. The CONB will not utilize EAHCP funding in 2016 to support HHW collection events as funding has been re-allocated to support the Bank Stabilization and Riparian Restoration Project along the Old Channel of the Comal River. CONB will sponsor and hold at least two HHW collection events in 2016 and will seek opportunities for additional events.[10]

[10] The IC approved these Work Plans and budget amendments at their January 2016 meeting.

3.2.14 Impervious Cover and Water Quality Protection (EAHCP §5.7.6)

EAHCP Obligations:

The CONB will expand criteria related to desired impervious cover, provide incentives to reduce existing impervious cover on public and private property in New Braunfels, and implement best management practices (BMPs) associated with stormwater runoff in the area of LL and the spring runs.

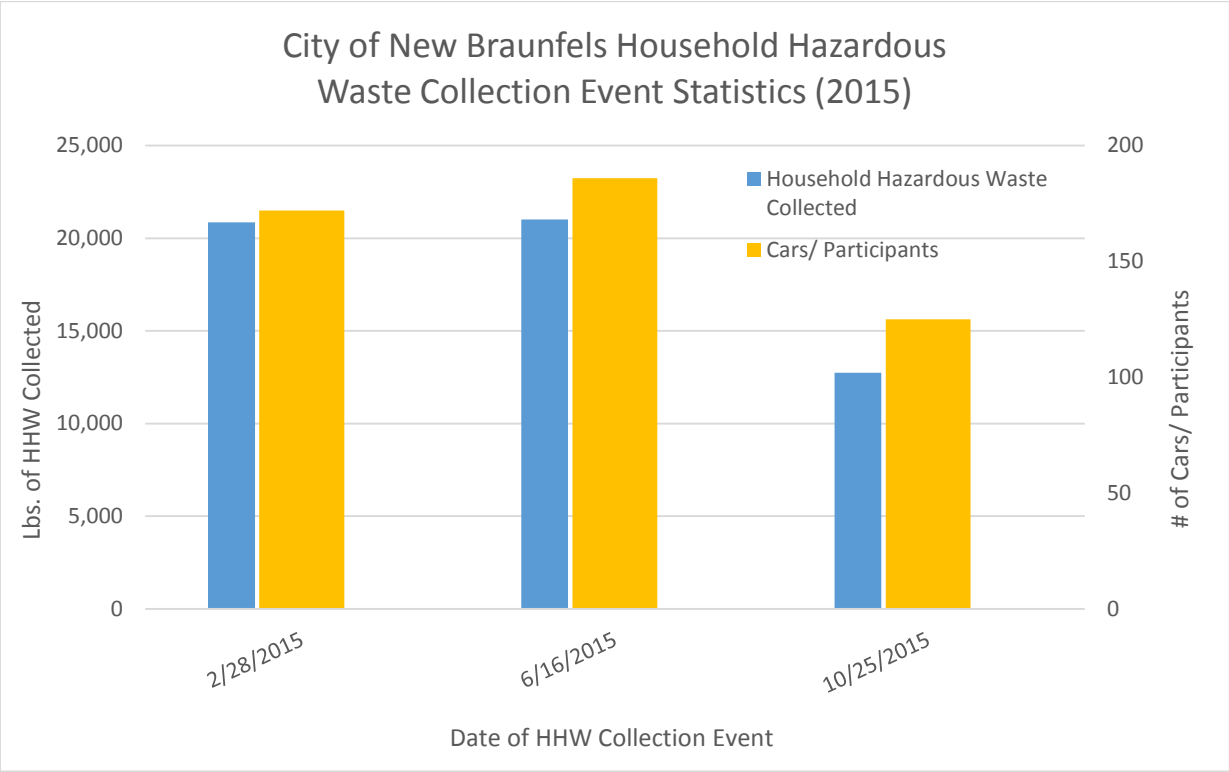

Figure 3.2-30. Statistics for CONB HHW collection events in 2015.

Figure 3.2-31. Photo of the February 2015 CONB HHW collection event.

2015 Compliance Actions:

The CONB continued the development of a Low Impact Development (LID) rebate program aimed at providing funding to homeowners, commercial business, and other property owners within the Comal River watershed to implement LID/water quality improvement projects on their properties. The LID rebate program will offer rebates specifically for impervious cover removal (and subsequent replacement with pervious concrete/paving), as well as for the installation of rain gardens and rainwater harvesting systems all of which will assist in removing potential pollutants from stormwater runoff and/ or decrease the volume of stormwater runoff. The target area for the rebates is for properties located within 1/2 mile of LL and the upper Comal River, and also within the Comal River watershed (**Figure 3.2-32**). In 2015, the CONB developed guidelines for the rebate program, a map of the rebate area, a rebate program application, and associated advertising materials. In addition, the CONB developed a guide to be distributed to local residents to inform them of ways in which they can prevent potential pollutants from reaching endangered species habitat within the Comal system by adopting good lawn care, vehicle maintenance, and landscaping practices.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

The CONB will implement a LID and impervious cover reduction rebate/incentive program targeted at residential and commercial properties contributing stormwater runoff to endangered species habitat within the Comal River system. The CONB will begin efforts to advertise for the LID rebate program in 2016. Advertising methods will include mail-outs to property owners within the eligible rebate area shown in **Figure 3.2-32**. CONB will prioritize LID and water quality improvement projects based on overall participation, project size, and project location. Preference for LID rebates will be given to properties containing large impervious cover areas and those located nearer to LL and the Comal River. BMPs developed as part of this program will include measures directly benefiting the Comal River system that exceed the features of the CONB's standard Municipal Separate Storm Sewer System (MS4) Program. Efforts in 2016 will include collaboration with NBU to fund the removal of impervious cover immediately adjacent to LL at the proposed Comal Springs Conservation Center (**Figure 3.2-33**). The removal of impervious cover and subsequent native plant restoration will increase infiltration, minimize stormwater runoff, and decrease the volume of sediment and pollutants entering LL.

3.2.15 Non-EAHCP: Voluntary Public Outreach Initiatives

2015 Actions:

In addition to the EAHCP requirements discussed in the preceding sections, the CONB voluntarily conducts public education and outreach associated with the EAHCP in order to increase program awareness and maintain community support for the EAHCP.

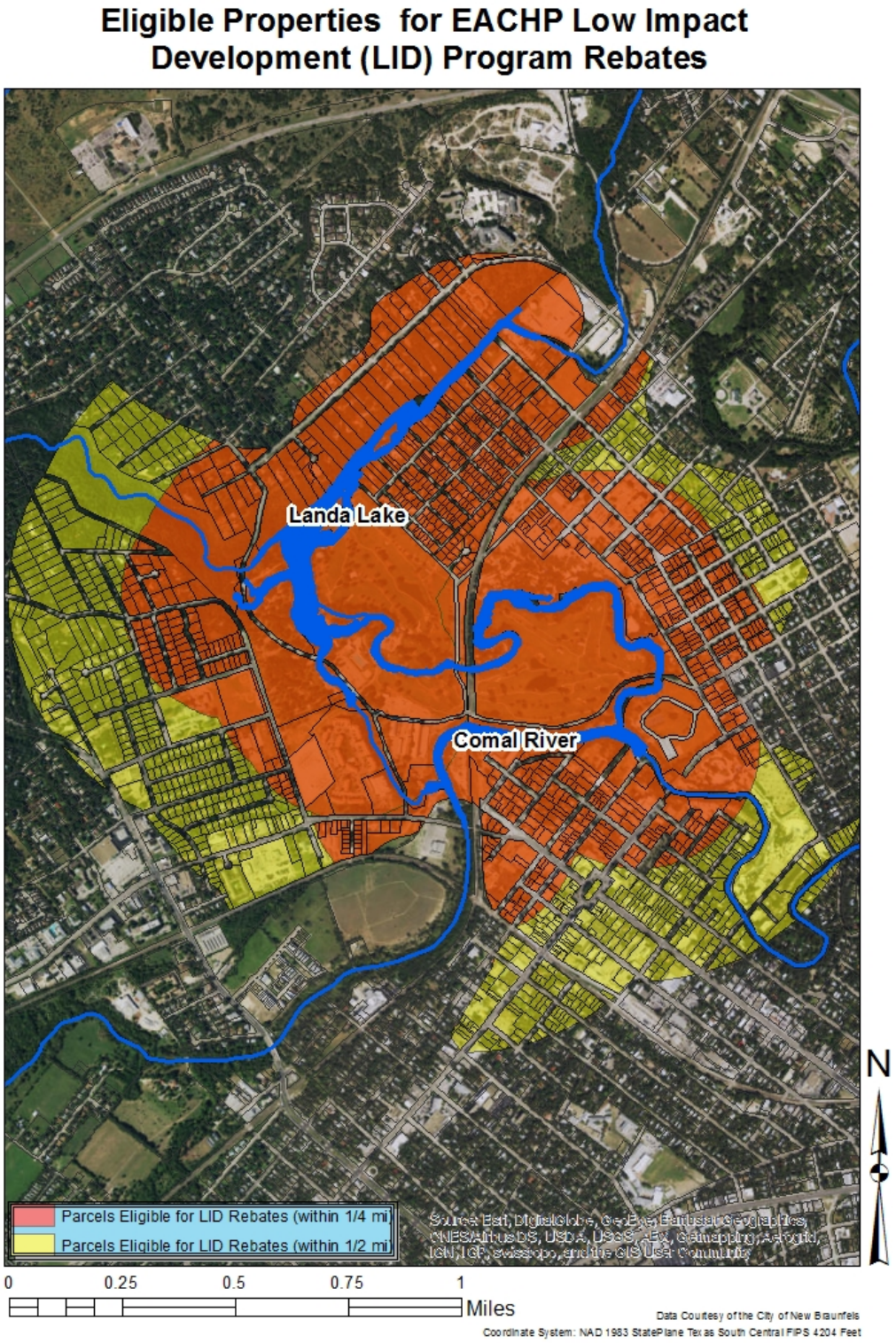

Figure 3.2-32. Map indicating extent of area in which individual property owners will be eligible for LID rebates.

Figure 3.2-33. Proposed Comal Conservation Center (prior to restoration-left; and proposed restoration-right).

CONB staff incorporated an EAHCP education component into all public outreach efforts and educational materials associated with overall water quality and watershed management initiatives in the CONB. Outreach efforts in 2015 included presentations to Boy Scout Troops (**Figure 3.2-34**), local schools, conference attendees (i.e., StormCon 2015 and American Society of Engineers Environmental & Water Resources Institute Conference) (**Figure 3.2-35**), and local civic organizations (i.e., The Friends of Landa Park and Kiwanis Club). CONB staff also presented EAHCP information at the annual Earth Day event (**Figure 3.2-36**). EAHCP outreach and education efforts include discussion of the individual Covered Species, purpose of the EAHCP, and details of individual mitigation and minimization measures currently being implemented within the Comal River system. Outreach materials developed to support educational initiatives include brochures and table displays. The CONB also re-designed and improved the city's EAHCP website that can be found at www.nbtexas.org/EAHCP. The CONB website contains pertinent information regarding the EAHCP and individual mitigation and minimization measures being implemented in New Braunfels.

Proposed Activities for 2016:

The CONB will continue to conduct public education and outreach associated with the EAHCP in order to increase program awareness and maintain community support for the EAHCP.

Figure 3.2-34. Photo of Boy Scout Troop #133 on endangered species field trip led by CONB staff.

Figure 3.2-35. CONB staff presentation on the EAHCP LID and water quality initiatives at the 2015 American Society of Civil Engineers' Environmental and Water Resources Institute Conference.

Figure 3.2-36. CONB Watershed Management display at the 2015 Earth Day event.

3.2.16 Non-EAHCP Activities: Watershed Protection Plan

2015 Actions:

The CONB has been proactively working towards the development of a watershed protection plan (WPP) and program for the Comal River/Dry Comal Creek watershed to address elevated bacteria (e.g., *Escherichia coli*) concentrations. In 2010, the Dry Comal Creek, which is routinely monitored by GBRA as part of the Texas Clean Rivers Program, was identified as being impaired for elevated bacteria concentrations. In response, the CONB applied for and received grant funding from the TCEQ to support the development of Phase One of a WPP. Phase One of the WPP will characterize potential pollutant sources and establish a stakeholder-based framework for informing the public and addressing water quality issues. An application has been submitted for grant funding to support the development of Phase Two, but has yet to be officially approved. The WPP will result in proposed water quality BMPs designed to improve water quality within the Comal and Dry Comal watersheds (**Figure 3.2-37**) to ultimately benefit the Covered Species.

The CONB has also developed, and is currently implementing, a Stormwater Management Plan (SWMP) to meet the requirements of the CONB's MS4 Permit issued by TCEQ in December 2014. The SWMP identifies methods for improving stormwater quality within the CONB's limits that include public education, illicit discharge investigations, construction stormwater management, implementation of post-development stormwater BMPs, and management of municipal operations. All of the elements identified in the SWMP will help to improve water quality within the Comal River system to ultimately benefit the Covered Species.

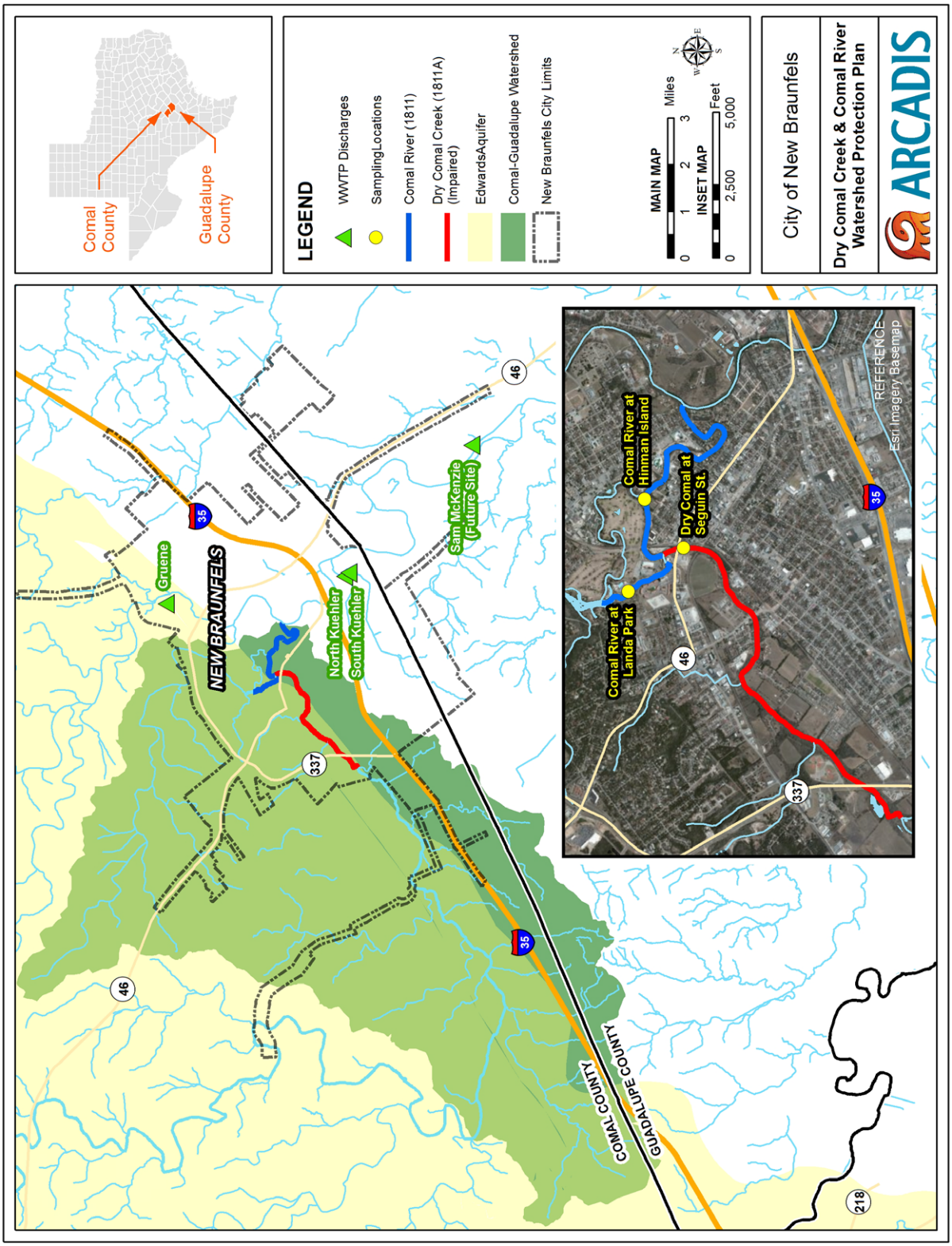

Figure 3.2-37. Dry Comal Creek/Comal River watershed protection plan map.

Proposed Activities for 2016:

The CONB will continue to implement its SWMP associated with the CONB's MS4 Permit. The CONB will also continue development of Phase One of the WPP through a stakeholder-based process. Phase One of the WPP is scheduled to be finalized in 2016 after which Phase Two will be initiated upon approval of grant funding.

3.2.17 Challenges Observed and Identified Solutions

As previously discussed in **Section 3.2 –** City of New Braunfels, **subsection 3.2.2** – Native Aquatic Vegetation Restoration and Maintenance, of this Annual Report, restoration work is progressing below Elizabeth Street in the Old Channel, where the large volume of *Hygrophila* present has been a major challenge. This section of the Old Channel is deeper and wider compared to areas upstream, and presented a challenge as to how effectively and efficiently the team could progress. To overcome this challenge, the BIO-WEST team utilized a much longer and sturdier net that could reach bank to bank and be left in one position instead of relocating every work day, as had been previously done. This method allowed BIO-WEST to clear sections of *Hygrophila* across the entire width of the channel in a more efficient manner. In addition, the BIO-WEST dive team proved instrumental in efforts to remove *Hygrophila* in deeper locations in the Old Channel and in USR. Diving provides prolonged access to the river bottom and allows workers to more thoroughly observe where *Hygrophila* is rooted and garden those specific areas. De-rooting *Hygrophila* is essential to the success of the removal program and can effectively eliminate *Hygrophila* in working locations.

Another challenge continually present along the Old Channel restoration area is the amount of riparian canopy cover. Many large sections of the Old Channel restoration area are currently too shady for native aquatic plant establishment and expansion. Although these large areas may not be suitable for planting, they do not necessarily remain bare. Bryophyte species, which tend to be more shade tolerant, have been observed to colonize bare areas producing thick turf. This habitat is quite suitable for the fountain darter and bryophyte colonization will be promoted by installing natural velocity shelters, such as logs and boulders.

3.3 City of San Marcos

The COSM is responsible for the following measures under the EAHCP:

- Texas wild-rice Enhancement and Restoration (EAHCP §5.3.1 and §6.3.5)
- Management of Recreation in Key Areas (EAHCP §5.3.2)
- Management of Aquatic Vegetation and Litter Below Sewell Park (EAHCP §5.3.3)
- Prohibition of Hazardous Materials Transport Across the San Marcos River and Its Tributaries (EAHCP §5.3.4)
- Reduction of Non-Native Species Introduction (EAHCP §5.3.5)
- Sediment Removal Below Sewell Park (EAHCP §5.3.6)
- Designation of Permanent Access Points and Bank Stabilization (EAHCP §5.3.7)
- Control of Non-Native Plant Species (EAHCP §5.3.8)

- Control of Harmful Non-Native and Predator Species (EAHCP §5.3.9)
- Native Riparian Habitat Restoration (EAHCP §5.7.1)
- Septic System Registration and Permitting Program (EAHCP §5.7.3)
- Minimizing Impacts of Contaminated Runoff (EAHCP §5.7.4)
- Management of Household Hazardous Wastes (EAHCP §5.7.5)
- Impervious Cover and Water Quality Protection (EAHCP §5.7.6)

Implementation of these measures has been accomplished in partnership with Texas State, as specified in the EAHCP. Any measures specified above that were modified in response to drought conditions or any other changes are noted under each EAHCP measure. The COSM extended its EAHCP obligations in partnership with Texas State to maintain consistency in implementation of EAHCP measures that jointly affect the Covered Species and their habitats in the San Marcos River.

3.3.1 Texas wild-rice Enhancement and Restoration (EAHCP §5.3.1 and §6.3.5)

EAHCP Obligations:

The COSM, in partnership with Texas State, will identify optimal habitat areas for Texas wild-rice and target those areas for restoration. Restoration will involve the removal of non-native plant species, propagation of new Texas wild-rice plants, and continued monitoring of the new stands. The COSM will use modeling results from Texas State to determine appropriate sites for restoration to ensure the highest possible success rate.

2015 Compliance Actions:

Non-native aquatic vegetation was removed in areas suggested as optimal Texas wild-rice habitat based on modeling results from Hardy et al. 2010. Non-native vegetation was also removed in mixed stands of Texas wild-rice, and original Texas wild-rice stands were monitored for expansion. Similarly, for Texas wild-rice stands occupying optimal areas with adjacent non-native vegetation, the non-native vegetation was removed and Texas wild-rice monitored for expansion. Non-native vegetation was fanned to displace fountain darters (*Etheostoma fonticola*) prior to uprooting the vegetation. After removal, all non-native vegetation was sorted, and any fountain darters that remained in the piles were salvaged and returned to the river. The non-native vegetation was disposed at the COSM composting facility or the Spring Lake composting facility. Portions of the denuded areas were planted with Texas wild-rice obtained from the SMARC (seed-derived) or from raceways (tiller-derived) located at the FAB. Polygons of areas planted with Texas wild-rice were developed in ArcMap with number of individual plants recorded and densities calculated. Areal coverage of Texas wild-rice for 2015 was assessed using geo-referenced aerial imagery collected with a quadcopter in conjunction with ground-truthed data collected using Trimble GPS units. The Meadows Center for Water and the Environment (MCWE) work sites were separated into reaches to assess changes among and within reaches**.**

The estimated (based on an average number of individuals per pot) number of Texas wild-rice individuals planted November 2014 – November 2015 in the San Marcos River downstream of Sewell Park was 17,741. These individuals covered 20 to 50 percent of the denuded area. Estimated area planted for Texas wild-rice

was 1,150 m^2 (rounded) (**Table 3.3-1**). **Figure 3.3-1** through **Figure 3.3-3** illustrate planting density (plants/m^2) as well as planting locations of Texas wild-rice and other native species in the San Marcos River downstream of Sewell Park.

Table 3.3-1. Date, Estimated Number (n), Area Planted (m^2), and Density Planted of Texas wild-rice in the San Marcos River Downstream of Sewell Park (November 2014 – October 2015)

Date	Estimated Number (n)	Area planted (m^2)	Density Planted (n/m^2)
11/14/2014	320	73.28	4.37
12/15/2014	972	110.03	8.83
1/6/2015	279	48.52	5.75
1/16/2015	678	48.52	13.97
1/20/2015	798	78.66	10.14
1/29/2015	588	38.00	15.47
2/10/2015	876	44.26	19.79
3/12/2015	324	60.08	5.39
3/19/2015	351	16.32	21.51
3/24/2015	880	47.14	18.67
4/7/2015	279	19.08	14.62
4/7/2015	279	13.63	20.47
4/22/2015	474	25.90	18.30
4/23/2015	150	10.25	14.63
4/23/2015	150	16.17	9.28
5/7/2015	639	19.45	32.85
5/19/2015	459	25.50	18.00
6/1/2015	306	29.23	10.47
6/1/2015	612	25.03	24.45
6/11/2015	630	50.16	12.56
6/23/2015	388	12.06	32.16
6/23/2015	776	19.22	40.38
6/25/2015	162	4.19	38.69
6/25/2015	162	2.32	69.88
7/20/2015	105	4.71	22.31
7/20/2015	392	5.78	67.84
7/20/2015	150	6.43	23.34
7/20/2015	100	3.45	29.02
7/20/2015	200	6.59	30.34
7/22/2015	350	9.50	36.86
7/22/2015	250	7.54	33.15
7/22/2015	155	3.86	40.16
7/22/2015	155	3.47	44.63
8/4/2015	320	13.20	24.24
8/4/2015	283	30.61	9.25
8/10/2015	750	73.87	10.15
8/12/2015	510	17.52	29.11
8/19/2015	200	5.10	39.23
8/19/2015	200	11.12	17.99
8/19/2015	200	10.89	18.36
8/26/2015	330	14.25	23.15
9/9/2015	76	3.16	24.07
9/9/2015	152	5.80	26.21
9/16/2015	828	36.10	22.94
10/21/2015	408	18.39	22.19

Table 3.3-1. Date, Estimated Number (n), Area Planted (m^2), and Density Planted of Texas wild-rice in the San Marcos River Downstream of Sewell Park (November 2014 – October 2015)

Date	Estimated Number (n)	Area planted (m^2)	Density Planted (n/m^2)
10/28/2015	95	8.68	10.95
Totals	**17,741**	**1,137.03**	**492**

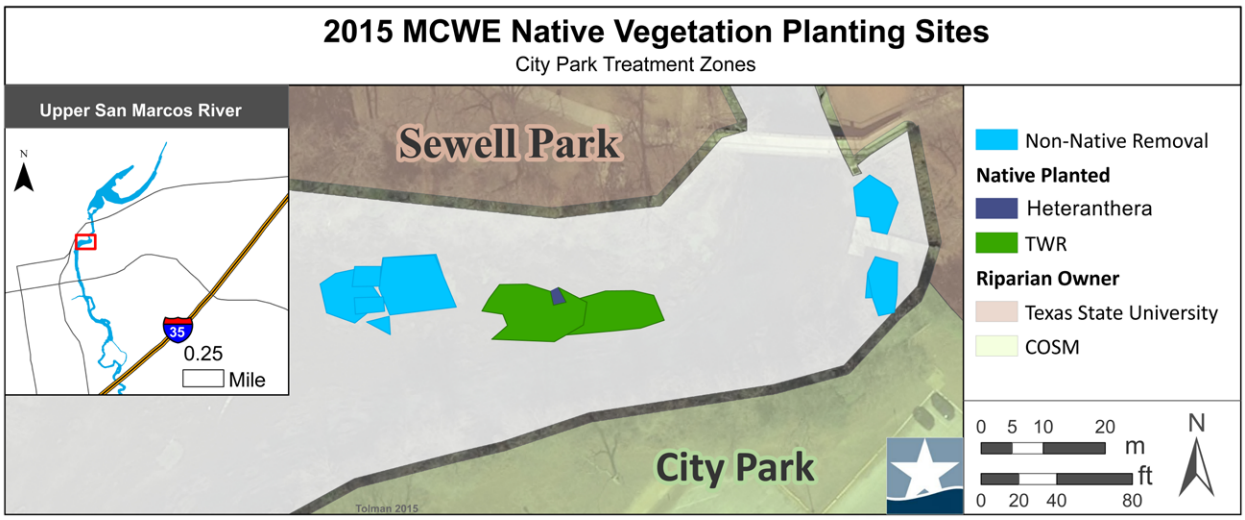

Figure 3.3-1. Planting locations of Texas wild-rice and other native species just downstream of Sewell Park.

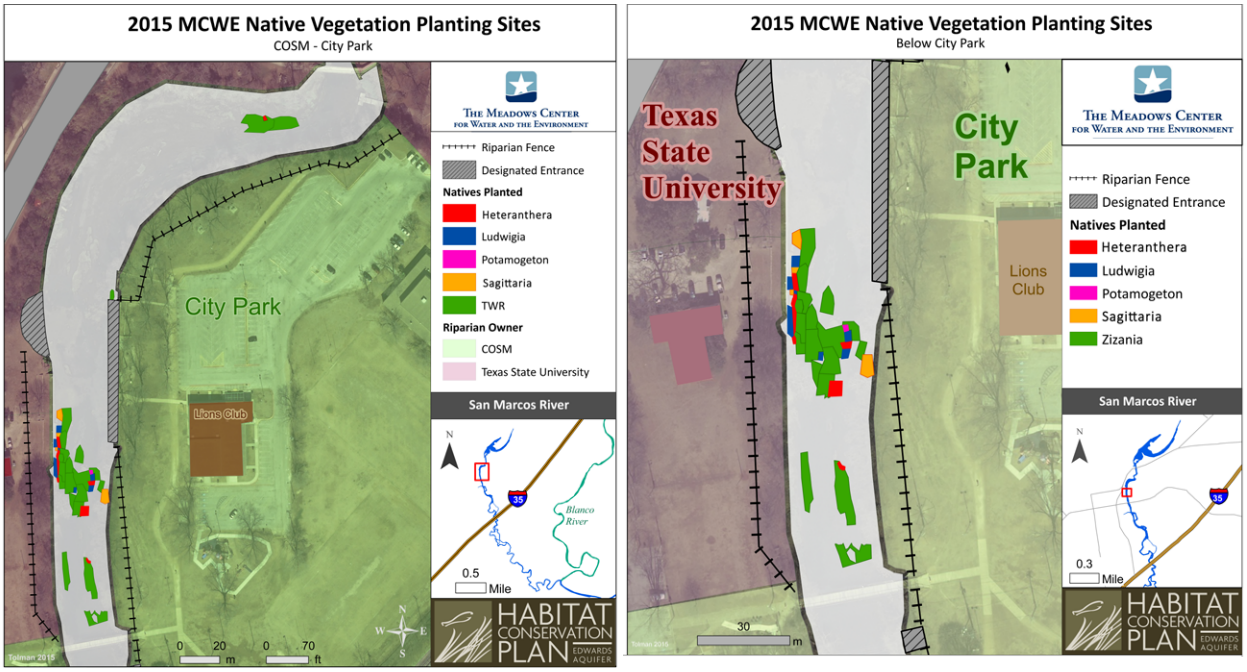

Figure 3.3-2. Planting locations of Texas wild-rice and other native species in upper and lower City Park.

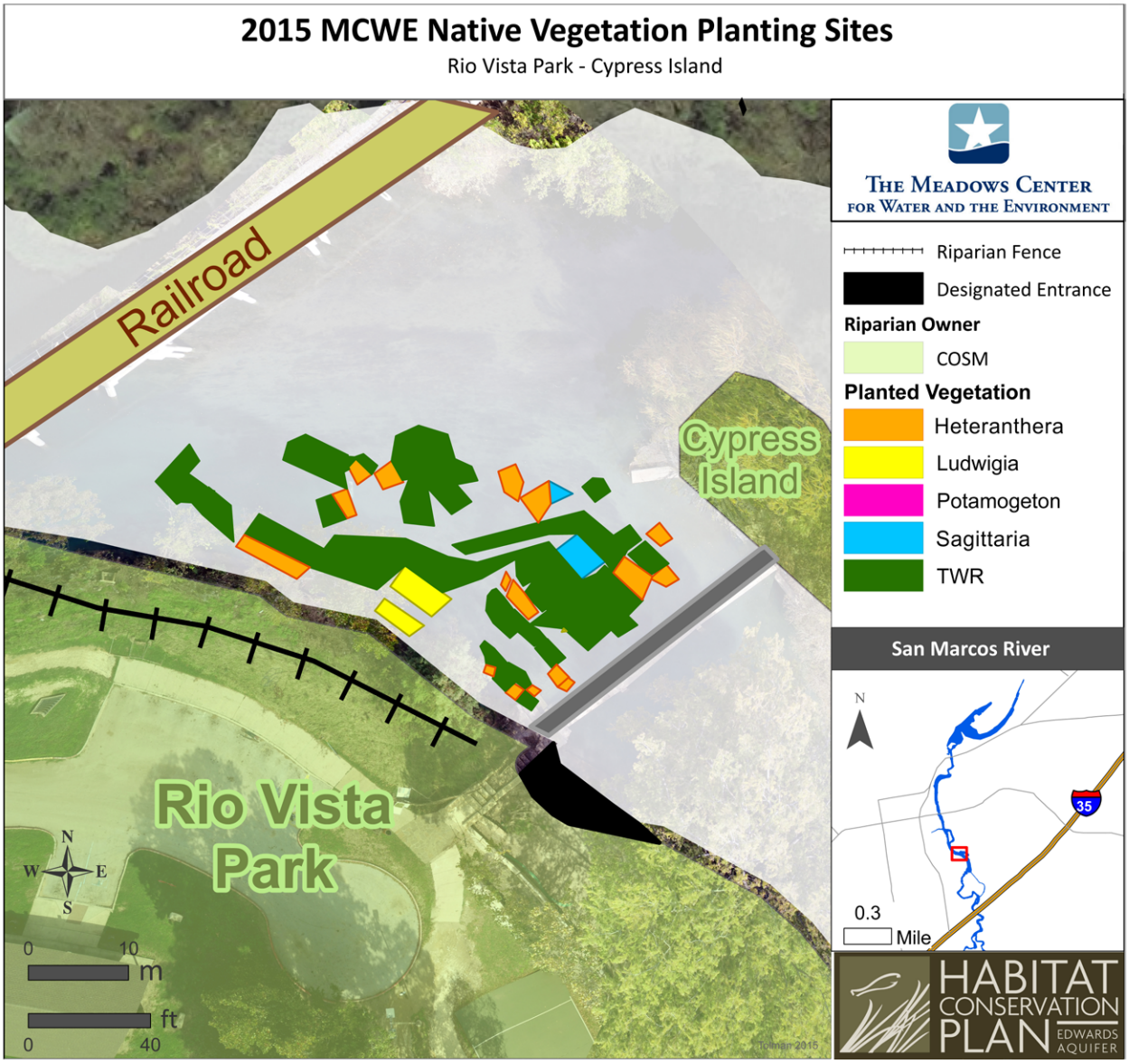

Figure 3.3-3. Planting locations of Texas wild-rice and other native species at Cypress Island above Rio Vista Falls.

Texas wild-rice coverage within MCWE work sites downstream of Sewell Park (i.e., above City Park – Rio Vista-Cypress Island) in the San Marcos River for November 2015 was estimated at 3,737 m^2 (**Table 3.3-2**). The total amounts do not include data that is shown as not available (N/A) in the table.

Area calculations for Texas wild-rice was assessed on two different time scales in the City Park reach of the San Marcos River. Method 1 quantified changes in Texas wild-rice coverage at City Park A (San Marcos Lions Club downstream to first walking bridge below City Park) from 2013 to 2015. Method 2 quantified changes in Texas wild-rice coverage at City Park B, a subset of City Park A, from November 2014 to November 2015. Since 2013, Texas wild-rice has increased through plantings and natural expansion an estimated 2,140 m^2 within MCWE work sites (i.e., above City Park to Rio-Vista Cypress Island). Since 2014, Texas wild-rice has expanded by an estimated 633 m^2 within MCWE work sites.

Table 3.3-2. Estimated Areal Coverage (m^2) of Texas wild-rice (2013-2015) and Changes in Texas wild-rice Coverage (2013-2015 and 2014-2015) Within MCWE Work Sites in Reaches of the San Marcos River Downstream of Sewell Park

Area Calculations (m^2) for Texas wild rice					
Reach	**2013**	**2014**	**2015**	**Change 2013-2015**	**Change 2014-2015**
Above City Park	1,212.26	1,963.40	2,253.01	1,040.75	289.61
City Park A	384.26	N/A	1,348.25	963.99	N/A
City Park B	N/A	602.73	945.63	N/A	342.90
Bicentennial Park – Purgatory Creek	0	N/A	12.58	12.58	N/A
Rio Vista – Cypress Island	0	N/A	122.96	122.96	N/A
Totals	**1,596.52**	**2,566.13**	**4,682.43**	**2,140.28**	**632.51**

N/A applies to area calculations that are undetermined or unavailable.

Table 3.3-3 depicts a snapshot of EAHCP progress attained by late 2015 through Texas wild-rice Enhancement and Restoration efforts (EAHCP §5.3.1 and §5.4.1) towards meeting the Biological Goals associated with establishing Texas wild-rice coverage in the San Marcos Springs system. The long-term Biological Goal for Texas wild-rice in the San Marcos Springs system is listed in Table 4-10 of the EAHCP.

Table 3.3-3. Texas wild-rice Areal Coverage per Segment in m^2, San Marcos System, August 2015 Mapping Event

River Segment	Areal Coverage (m^2)
Spring Lake	26
Spring Lake Dam to Rio Vista Dam	7030
Rio Vista Dam to IH-35	386
Downstream of IH-35	28

Any Modifications or Activities Due to Weather Conditions:

Texas wild-rice plantings were shifted to areas of greater depth to prevent the stand from becoming emergent with any further decrease in flow.

Areas of the San Marcos River downstream of Sewell Park reaches scoured during the October 30, 2015 flood event resulting in loss of Texas wild-rice areal coverage. Areas of scour and Texas wild-rice loss can be observed in **Appendix M1** with images of the October 2015 flood event.

Proposed Activities for 2016:

In 2016, the COSM and Texas State will continue to maintain existing Texas wild-rice stands and plant stands in areas where new habitat has been created through sediment removal and aquatic vegetation restoration. As calculated in the 2015 Work Plan to meet the biological goals for areal coverage of Texas wild-rice, the 2016 goal is to add 1,100 m^2 of additional Texas wild-rice to the system.

3.3.2 Management of Recreation in Key Areas (EAHCP §5.3.2)

EAHCP Obligations:

The COSM will continue to implement recreation mitigation measures approved by the San Marcos City Council on February 1, 2011 (Resolution 2011-21). These include, but are not limited to, trespassing enforcement on private riverfront property, implementation of buffer zones around designated recreation areas, a robust river education program, removal of silt to restore the river to more natural conditions, increasing enforcement measures for violators of river-related recreation management restrictions, and the issuance of COI to river outfitters to extend the protections of the ITP to those entities.

2015 Compliance Actions:

Several strategies were used by the COSM to manage recreation in key areas:

1. Access control: A strategy using hardened access points with a dense riparian buffer between all access points was implemented in 2013 and 2014. These objectives are discussed in detail as part of two other EAHCP measures (see related discussion under **Section 3.3 –** City of San Marcos, **subsections 3.3.6** – Designation of Permanent Access Points and Bank Stabilization, and **3.3.8** – Native Riparian Habitat Restoration, of this Annual Report). In 2014, temporary repairs were made to the upper access point at Ramon Lucio Park with a metal retaining wall. This wall was added as a result of unsafe conditions due to the undermining and dislodging of limestone blocks caused by increased stream flow. In 2015, repairs were made to a number of access points including the addition of concrete bags and mortar. Concrete bags and rebar were added under the limestone blocks of Hopkins and upper Rio Vista access points to address the damage caused by undermining. Large gaps between limestone blocks were filled with mortar at all access points.
2. Signage: In 2013, the COSM used the EAHCP sign template created by the EAA to produce ten signs discussing each EAHCP project, Covered Species and the uniqueness of the San Marcos River, and placed them at each of the fence sites. In 2014, the COSM added six bank stabilization signs, and replaced fading riparian signs. The five bank access signs/kiosks were completed in 2015, but installation was delayed due to flooding. Additionally, the three display signs produced by TPWD, two of which are located in Sewell Park and one in Bicentennial Park, were refurbished. One Sewell Park kiosk was removed because it was redundant. The other kiosk had a TPWD sign and roof replaced. Signage was added at each of the four Texas wild-rice exclosures to inform the public of the purpose. No new signage was added in 2015, but all kiosk signs were completed (**Figure 3.3-4** and **Figure 3.3-5**).
3. Conservation Crew (CC): This work team was developed to educate the public about the EAHCP and to monitor and protect Texas wild-rice stands in high recreation areas. In 2015, the CC was composed of 14 university students. These students were paid by both EAHCP and COSM funding. They began work on May 21, 2015, working Wednesday through Sunday, and worked through the Labor Day weekend. Four to six crew members worked in teams of two to three each day from 11:00 a.m. – 7:00 p.m., with one group kayaking the river and the other group walking the banks in an effort to maximize river user contact.

Figure 3.3-4. EAHCP Covered Species signage.

Figure 3.3-5. EAHCP restoration activities signage.

4. The CC accomplished many tasks under the EAHCP, such as education, protection of endangered species and their habitats (primarily Texas wild-rice, monitoring, volunteer planting events, project maintenance, and litter removal) (**Figure 3.3-6**).
5. Education was accomplished through the creation and installation of signage and speaking with river users about the importance of EAHCP projects and listed species habitat protection. Additionally, CC hosted a three-day four-grade fieldtrip where students visited the GBRA Surface Water Treatment Plant, SMARC and a series of five stations along the San Marcos River covering litter, Texas wild-rice, invasive species, and the unique characteristics of the San Marcos River (**Figure 3.3-7**). CC assisted with a thesis study by surveying river users about their perception and values of the San Marcos River. The CC participated in a number of public events to discuss the EAHCP. The involvement of university students is an added benefit. These students leave the CC Program with a deep understanding of endangered species and the unique nature of the San Marcos River. Additionally, the EAHCP is advertised through these students and the COSM's intern program for the EAHCP is becoming increasingly popular.
6. The CC also removed floating vegetation mats (consisting of mostly *Hydrilla verticillata* and *Hygrophila polysperma*) from four Texas wild-rice exclosures and other Texas wild-rice stands to ensure their health. They also accomplished regular maintenance of the exclosure that protects Texas wild-rice stands by restricting access from river users. The full exclosures were not installed in 2015 due to the stream flows greater than the 120 cfs trigger point.
7. The CC assisted with other projects including the Texas wild-rice survey with USFWS, a graduate student study on Texas wild-rice, exotic invasive removal, tiller collection and native plantings. Areas with an abundance of people such as Rio Vista, City Park and upper Sewell Park are frequently monitored in an effort to reduce negative impacts to the river and to ensure park and university rules are observed. Riparian fences and signs are inspected for damage or graffiti, and any problem areas along the river are reported.
8. Over 1,063 ft^3 of litter and mixed recyclables were removed from the river substrate, litter boats, and parks along the river. The three litter boats in the river are emptied by kayak three to four times a day, helping to prevent litter from entering the river by providing a convenient receptacle for disposal. For a complete list of accomplished tasks and public outreach, see **Appendix M2**.
9. State Scientific Area (SSA): In support of the SSA, the CC provided barriers, signage, and informational kiosks as described in the CC report (**Appendix M2**).
10. Buffer Zones: Rio Vista Falls has a 100-ft buffer zone on the east side of the river that excludes picnic tables, pop-up tents, shelters, and portable grills. The riparian restoration efforts continue to increase the amount of riverside buffers from upper Sewell Park to IH-35.

Figure 3.3-6. Conservation Crew participating in public education events.

Figure 3.3-7. Non-native invasive species education.

11. Overall Interpretation Plan: In 2015, a Master Interpretation Plan was begun, documenting all existing signage by photo and GPS location. Recommendations have been discussed to remove, relocate, repair, or replace each individual sign along the San Marcos River to ensure a uniform and effective interpretation effort. The plan shows the type and location for signage in and along the river corridor with each individual park assigned a theme that best represents the message associated with that park:
    - five English riparian signs;
    - two Spanish riparian signs;
    - one invasive removal sign;
    - one WQPP sign;

- seven bank access point kiosks;
- one Edwards Aquifer sign;
- one archaeological sign at Ramon Lucio; and
- twelve EAHCP background/all-project signs distributed along all riparian fences.

12. Stencil on rented tubes: Applied stencils rubbed off over time, so this action was eliminated. The video loop at City Park and signage while tube renters are queuing will replace this action. This video loop is being developed by the COSM Public Relations Department in partnership with MCWE.
13. Reduce turbidity through watershed management strategies: This action is fully covered as discussed in Section 1.2.17 of the COSM and Texas State WQPP.
14. Partnership between the COSM and Texas State: The CC monitors both COSM and Texas State property and is supported by COSM Park Rangers and Texas State Police. A pre-recreation season meeting is held with Texas State and COSM law enforcement to ensure a cohesive approach to recreation management. Additionally, the COSM Habitat Conservation Plan Manager is funded equally by Texas State and COSM to ensure a unified approach.

Any Modifications or Activities Due to Weather Conditions:

In early 2015, the drought continued to cause lower flow rates in the San Marcos River, which results in increased accumulation of floating vegetation on Texas wild-rice stands and litter on the substrate. Therefore, removal of vegetation mats from Texas wild-rice stands as well as litter removal frequency increased as flows decreased to minimize potential impacts. During flood, litter remained an issue. Floods scoured the watershed, bringing household and commercial litter (**Figure 3.3-8**) into the river. In 2015, both EAHCP and COSM contractors worked to remove the tons of flood-borne litter. Floods also offer opportunities to advance native aquatic habitat by scouring large amounts of *Hydrilla* from the river bottom. EAHCP contractors will respond by intensifying their native aquatic planting efforts.

Proposed Activities for 2016:

In 2016, the COSM will continue to implement education programs targeting river users about sustainable river use and the Covered Species. The CC will continue to educate the public and conduct a diversity of clean-up and restoration efforts in and along the San Marcos River. The COSM EAHCP Manager, CC, and interns will increase time spent on riparian maintenance in an effort to keep up with the growing riparian buffer.

3.3.3 Management of Aquatic Vegetation and Litter Below Sewell Park (EAHCP §5.3.3)

EAHCP Obligations:

The COSM will dislodge floating vegetation mats on the river's surface to facilitate their movement downstream. The COSM will additionally remove inorganic litter regularly during the recreation season.

Figure 3.3-8. Dumpster deposited into the San Marcos River downstream of IH-35 after October 2015 flood.

2015 Compliance Actions:

Pristine Texas Rivers, Inc. (PTR) removed inorganic litter from upper Sewell Park to City Park, and from Rio Vista to Stokes Island. PTR used SCUBA equipment to remove underwater litter from the substrate and surface as well as removing floating vegetation mats (**Figure 3.3-9** through **Figure 3.3-14**).

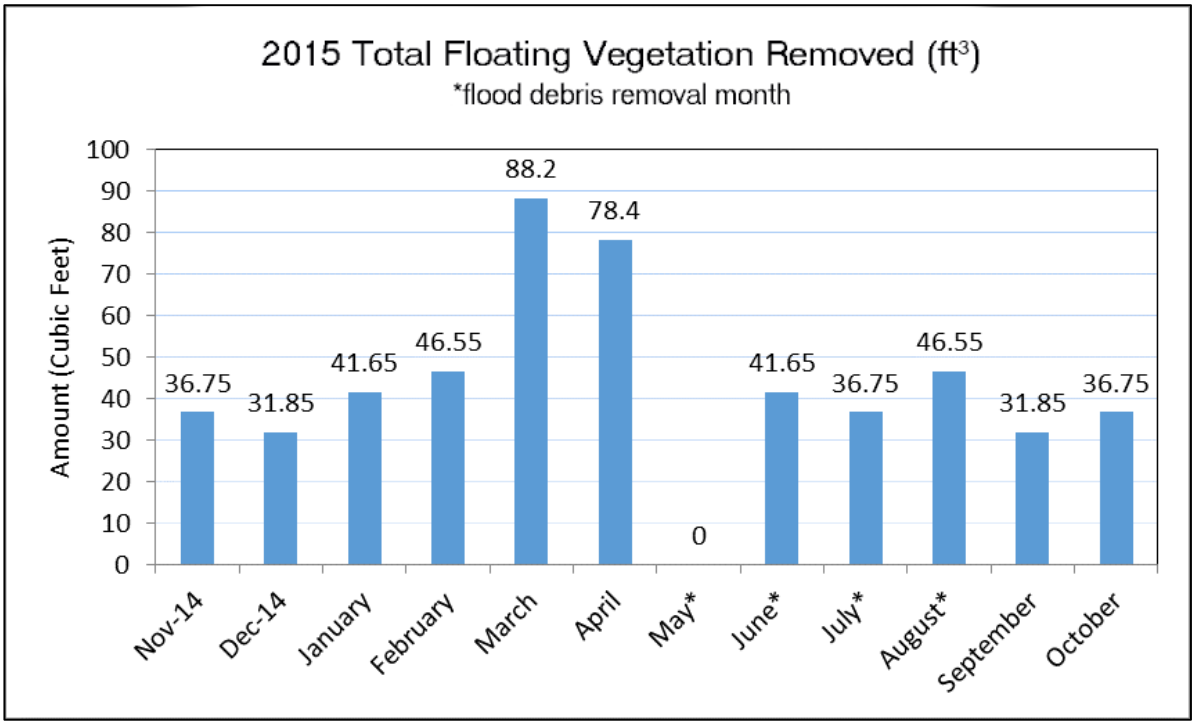

Figure 3.3-9. Total floating vegetation mat removed from November 2014 to October 2015.

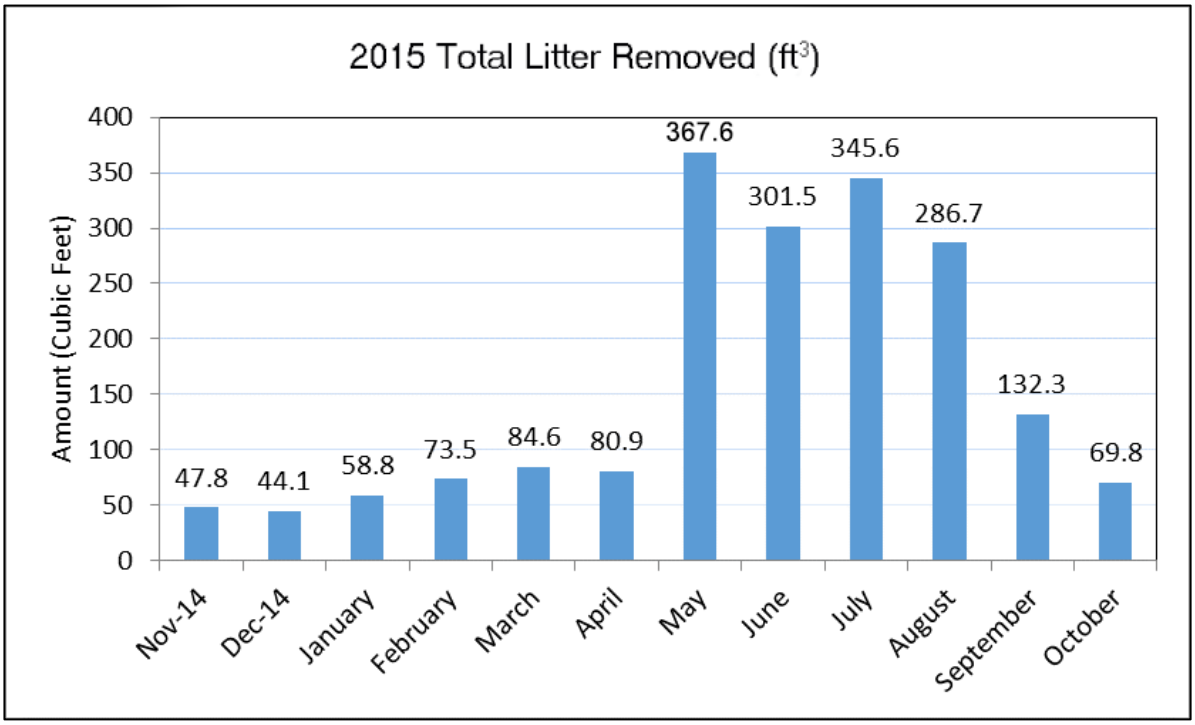

Figure 3.3-10. Total amount of litter removed from November 2014 to October 2015.

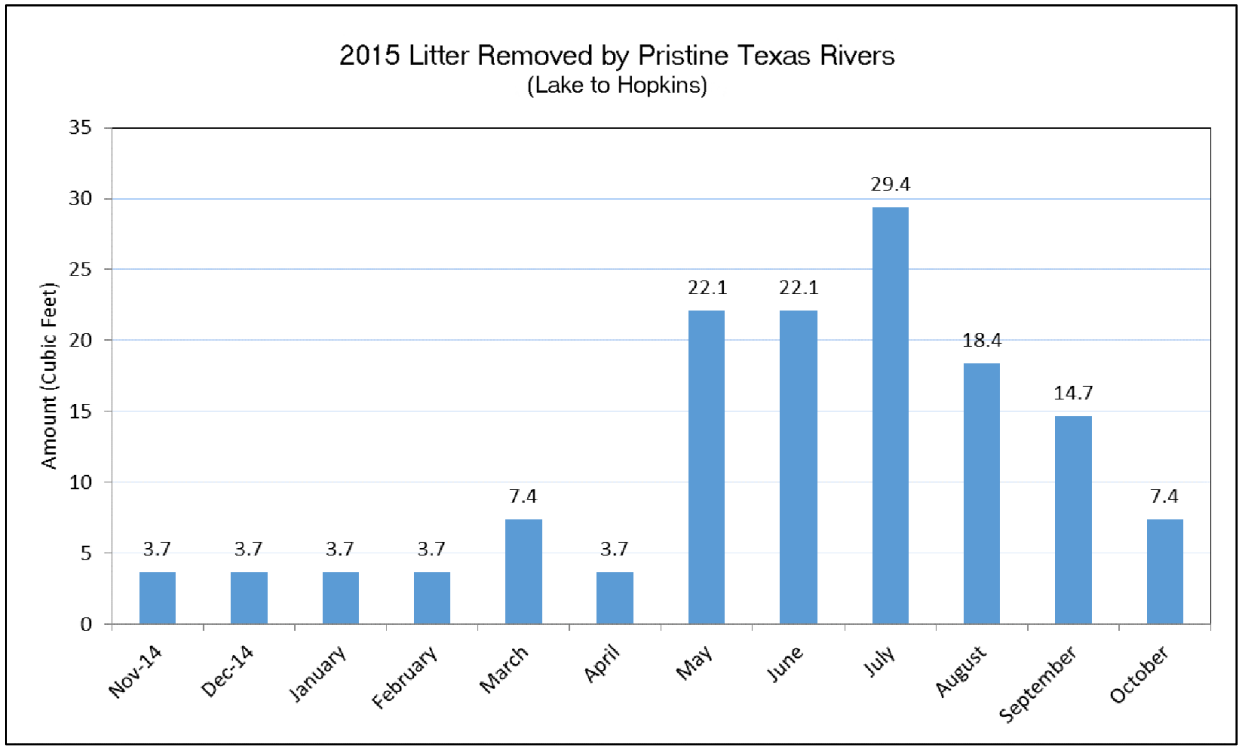

Figure 3.3-11. Amount of litter removal from Spring Lake to Hopkins Road from November 2014 to October 2015.

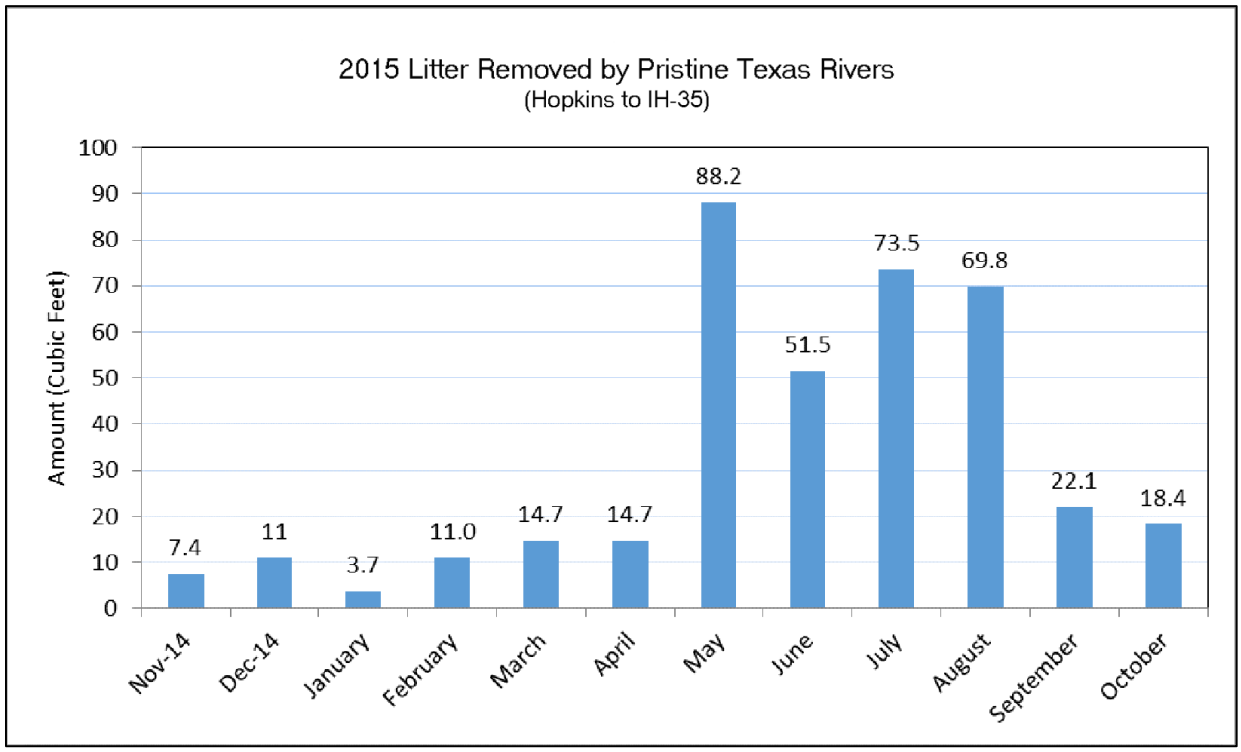

Figure 3.3-12. Amount of litter removal from Hopkins Road to IH-35 from November 2014 to October 2015.

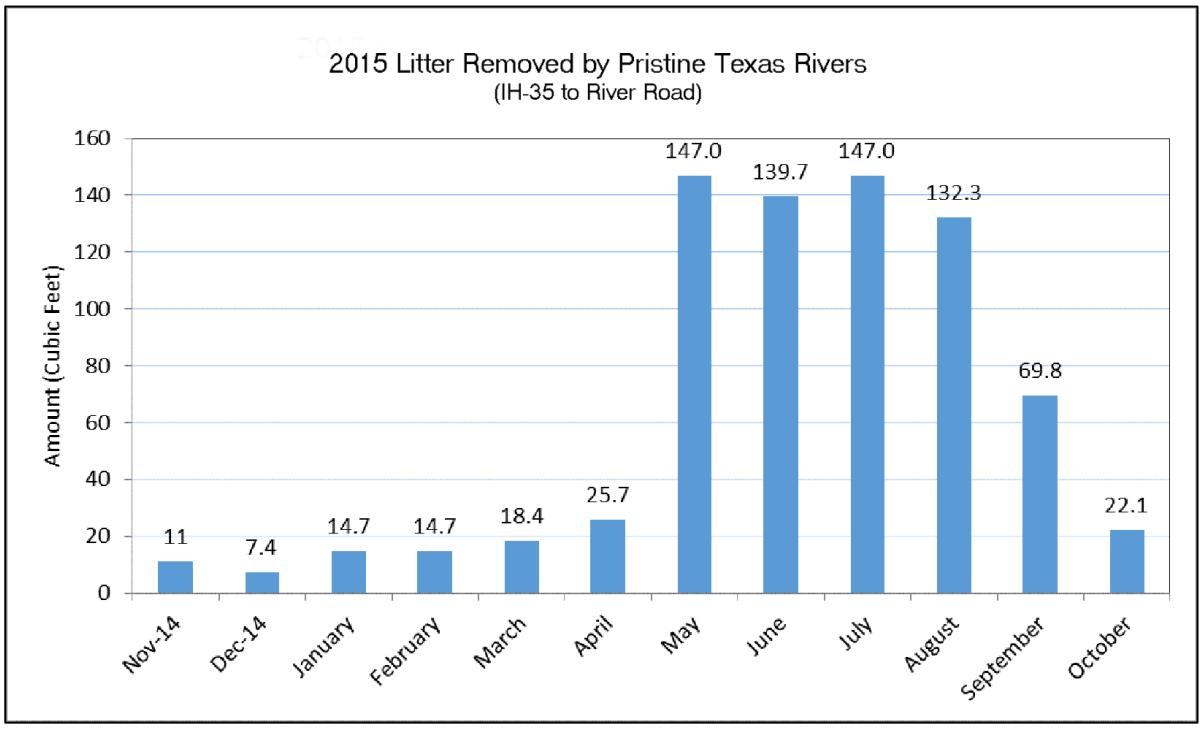

Figure 3.3-13. Amount of litter removal from IH-35 to River Road from November 2014 to October 2015.

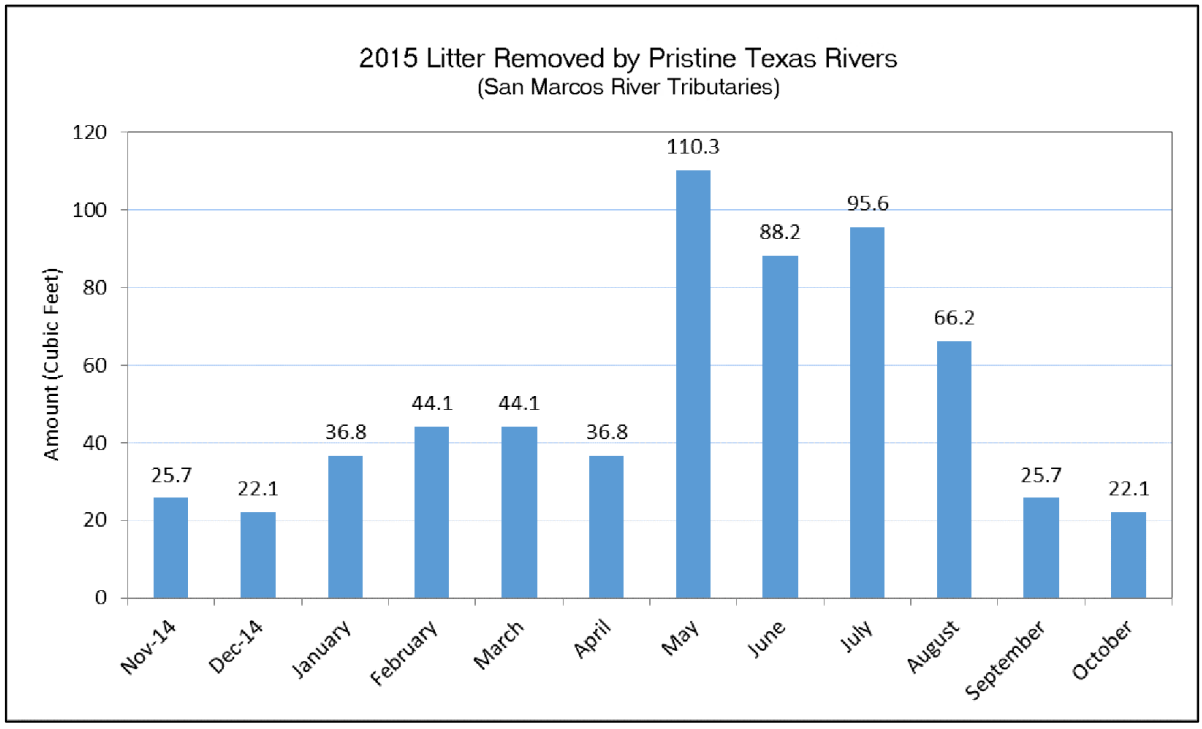

Figure 3.3-14. Amount of litter removal from tributaries from November 2014 to October 2015.

PTR walked the four San Marcos River tributaries (**Figure 3.3-15** and **Figure 3.3-16**) and collected litter in mesh bags. The monthly totals of litter removed exhibits the importance of focusing on areas downstream of IH-35 and the tributaries. Due to the low amounts of litter collected in Spring Lake during the first year of implementation (2013), this location will be accomplished by Texas State as needed under the Spring Lake Management Plan.

PTR continued to find old debris uncovered by river flows mainly below Rio Vista to Stokes parks. The larger flood debris removed from the river includes trashcans, picnic tables, decking, fencing, building debris, tires and other trash. Larger items were torn apart or cut up with chainsaws to facilitate removal. The flood debris was primarily found from Rio Vista to Stokes Island, with the majority caught amidst the islands above IH-35 and downstream on Thompson Island. These area have limited access, making flood debris removal difficult and time consuming.

Any Modifications or Activities Due to Weather Conditions:

During drought, PTR increases time spent removing floating vegetation mats, particularly from Texas wild-rice stands, to prevent the loss of native macrophytes. The rapid accumulation of vegetation mats on stands of Texas wild-rice requires assistance in its removal from both the CC and MCWE personnel.

The two 2015 floods deposited large amounts of litter, particularly below IH-35 as previously discussed. PTR shifted focus from the upstream section to the lower reaches to respond to these events.

Proposed Activities for 2016:

In 2016, the COSM will continue to implement floating vegetation mat and litter removal consistent with protocols established in the EAHCP and in the 2016 Work Plan.

Figure 3.3-15. Litter found in tributaries of the San Marcos River.

Figure 3.3-16. Litter found in tributaries of the San Marcos River (additional photos).

3.3.4 Prohibition of Hazardous Materials Transport Across the San Marcos River and its Tributaries (EAHCP §5.3.4)

EAHCP Obligations:

The COSM will coordinate with Texas Department of Transportation (TxDOT) to designate routes for the transportation of hazardous materials that will minimize the potential for impacts to the San Marcos River and its tributaries.

2015 Compliance Actions:

In 2013, the COSM initiated the process required by TxDOT to designate Wonder World Drive from IH-35 to Ranch Road 12 as a HAZMAT Route. This process is based on the document titled *Traffic Operations Manual*, Chapter 5, Regulatory Signs, Section 7 Non-Radioactive Hazardous Materials Routing. The COSM Fire Marshall was contacted to obtain previous work accomplished on a HAZMAT route. COSM staff reviewed extensive materials, and contacted TxDOT to request a meeting to determine the extent of materials that would be necessary. The COSM has not, as of the time of writing this report, received a response from TxDOT.

As detailed in the 2014 EAHCP Annual Report, the COSM has an understanding of the requirements, process and responsibilities to establish Non-Radioactive Hazardous Materials (NRHM) routing.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

The COSM in 2016 will attempt again to coordinate with TxDOT to determine actions needed to progress on this measure.

3.3.5 Reduction of Non-Native Species Introduction (EAHCP §5.3.5)

EAHCP Obligations:

The COSM will partner with Texas State and other groups to establish an education campaign targeted at reducing the introduction of non-native species into the river system. The COSM will also provide opportunities for people to dispose of unwanted aquatic animals and plants to deter aquarium dumps into the river system.

2015 Compliance Actions:

The following outline to reduce aquaria dumping was developed based on data gathered in 2013 through pet store visits and meetings with Residential Life at Texas State. This plan will continue to be implemented by Atlas Environmental (Atlas), CC, and student interns.

Purpose: To increase public awareness regarding the harms of releasing non-native fish into the San Marcos River.

- Flyer(s)
  - Distributed to all San Marcos pet stores and posted in Texas State dorms near the end of each semester
- State the harms of releasing non-native fish into our river
  - Included in access point kiosk signage, presentations and EAHCP video
- Advertise through:
  - Local pet stores (accomplished in 2014 & 2015)
  - Local schools (not yet accomplished)
  - Texas State campus (accomplished every semester 2014 & 2015)
  - On social media websites (not yet accomplished)
- Donation Centers
  - Earth Angels
  - Discovery Center (not yet formally set up – working to obtain grant funding for ponds)
  - Campus pond (in discussion with Texas State)
  - Educational Booth for Events (Texas wild-rice Festival and City events 2014 & 2015)

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

The COSM, in partnership with Texas State and contractors, will continue to implement the plan described above.

3.3.6 Sediment Removal Below Sewell Park (EAHCP §5.3.6)

EAHCP Obligations:

The COSM will remove sediment from areas along the river between City Park and IH-35. Sediment removal efforts will specifically target potential Texas wild-rice habitat.

2015 Compliance Actions:

A three-inch hydrosuction hose was used to remove accumulations of fine sediment within the San Marcos River. Divers were trained on equipment operations, diving safety protocols, and recognition of all stages of Covered Species from larval to adult prior to any sediment removal. Before dredging, vegetation was removed and the area was fanned to encourage fountain darters and other biota to move out of the area. **Figure 3.3-17** illustrates the dredge in operation and the de-watering bag used to collect dredged sediment. In 2015, the COSM and Texas State obtained a TPWD Sand, Shell, and Gravel and Marl Permit (Permit No. 2015-I003).

Texas State continued to remove fine sediment in the San Marcos River near the confluence with Purgatory Creek. Approximately 284 m^2 (i.e., 85 cubic meters [m^3]) of fine sediment was removed in the San Marcos River from November 2014 – November 2015 (**Table 3.3-4**). **Figure 3.3-18** illustrates the change from fine substrate prior to dredging (red polygon) to coarser substrate post dredging (green polygon).

Figure 3.3-17. Texas State removing fine sediment near the confluence with Purgatory Creek.

The above photo shows Texas State dredge arrangement with one person diving while another is monitoring the dredge equipment (above) and dredged fined sediment is collected in a de-watering tube (below).

Table 3.3-4. Date and Estimates for Fine Sediment Removed (m^2) in the San Marcos River

Date	Area Dredged (m^2)
6/9/2015	37.93
7/14/2015	27.19
7/15/2015	19.37
7/28/2015	10.84
7/28/2015	24.49
7/28/2015	14.24
7/30/2015	10.56
7/30/2015	13.95
8/6/2015	12.48
8/28/2015	58.08
9/2/2015	11.71
9/14/2015	12.28
9/30/2015	26.15
10/7/2015	4.78
Total	**284.04**

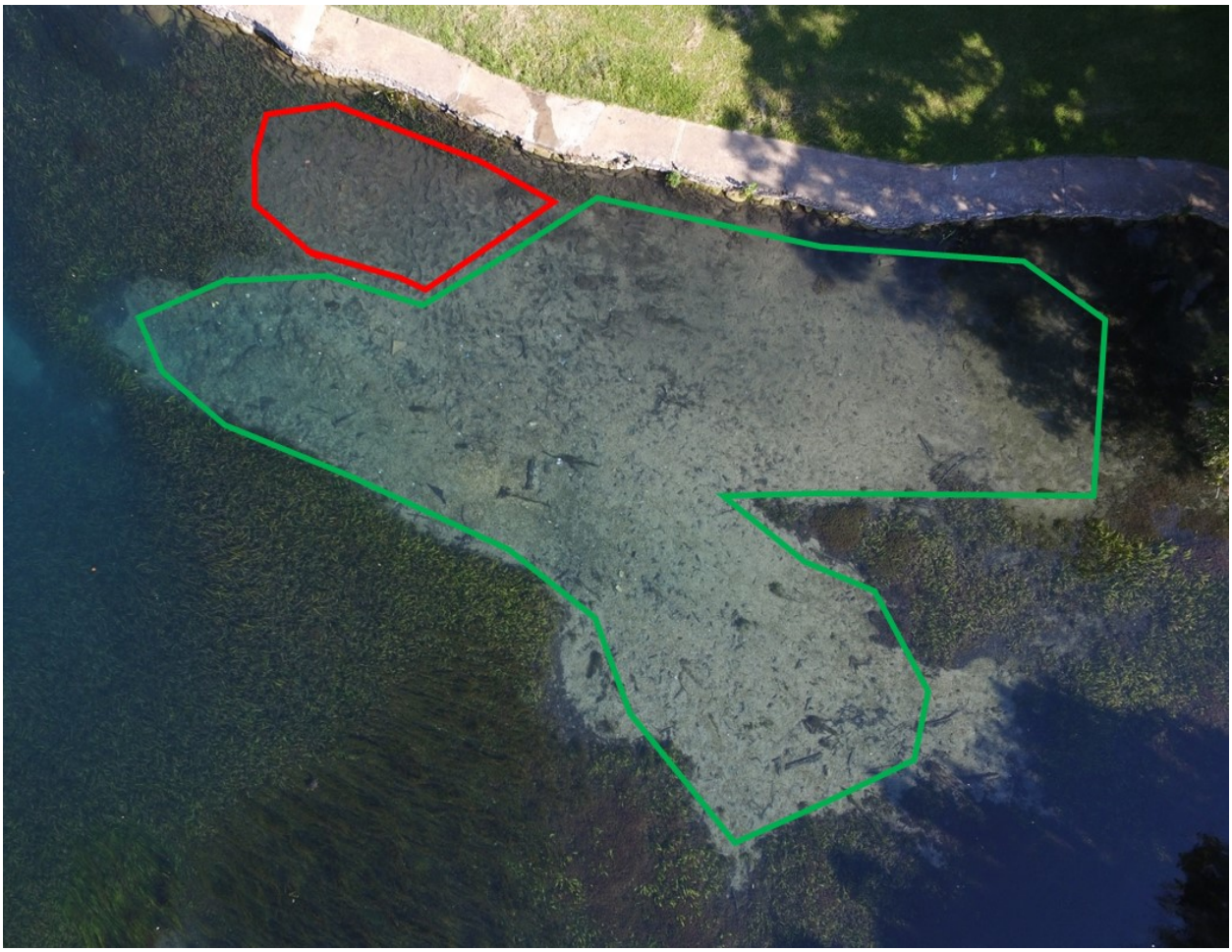

Figure 3.3-18. Example of substrate prior to dredging (red polygon) and post dredging (green polygon).

Any Modifications or Activities Due to Weather Conditions:

The San Marcos River bottom was scoured at the confluence of Purgatory Creek during the October 30, 2015 flood event, resulting in loss of Texas wild-rice areal coverage planted within 2014 dredged areas. Areas of scour can be observed in **Appendix M1** with images of the October 2015 flood event.

Proposed Activities for 2016:

In 2016, the COSM will target removal of approximately 1,000 m^2 of fine sediment from the river bottom. However, due to the intense labor required in the performance of sediment removal, this goal has not been achieved to date. Additional monitoring will occur in 2016, after targeted depth of fine sediment removal has been achieved, the bed elevation will be measured from existing benchmarks and the sediment composition delineated (i.e., sand, gravel, etc.). The measure of success will be determined by the volume of sediment removed. In 2015, the EAA obtained the necessary permitting to address a more widespread area in the San Marcos River, so areas outside City Park and Purgatory confluence will be addressed.

3.3.7 Designation of Permanent Access Points and Bank Stabilization (EAHCP §5.3.7)

EAHCP Obligations:

The COSM will stabilize banks in City Park, at the Hopkins Street underpass, Bicentennial Park, Rio Vista Park, Ramon Lucio Park, and at the Cheatham Street underpass. Bank stabilization will be conducted using stone terraces and native vegetation along the riparian zone. The COSM will incorporate permanent access points to facilitate river entrance by recreationists that is more protective to the species and their habitats. The COSM will maintain all access points in perpetuity. All bank stabilization/access points were heavily eroded areas that experienced intense use by the public through river access. This strategy of providing access points and enhancing riparian zones provides a balance between recreation and maintaining a healthy riparian buffer and river bank.

2015 Compliance Actions:

One of the access points (Ramon Lucio) was undermined during spring of 2014, and two limestone blocks rolled off into the river in the summer. As a result, a team of COSM, TPWD, and EAHCP personnel surveyed all the access points and made recommendations for changes to strengthen the access points. **Figure 3.3-19** through **Figure 3.3-24** illustrate the repairs accomplished or to be accomplished on each access point. TPWD recommended the rows of rock should overlap at least eight-inches.

Figure 3.3-19. Install an anchor rock in structure.

Figure 3.3-20. Install anchor rock in structure extending upstream to Hopkins bridge.

Figure 3.3-21. Pull back structure and extended it further upstream. Key access point into the bank using stabilizing vegetation such as bald cypress/switchgrass.

Figure 3.3-22. Install lift and anchor rock in access to existing concrete bridge at Rio Vista Park. Rock should be keyed into bank and not disruptive to flow (no eddies).

Figure 3.3-23. Re-construct upper access point at Ramon Lucio Park as part of the city river trail construction.

Figure 3.3-24. Add anchor rock to Lower Ramon Lucio Park access point.

Any Modifications or Activities Due to Weather Conditions:

Access points are in need of repair due to flood conditions in 2015. However, until permanent repairs can be accomplished, temporary repairs were made in 2015 using concrete bags to stabilize the access points.

Proposed Activities for 2016:

The COSM will begin modifying the existing access points in accordance with the approved design specifications.

3.3.8 Control of Non-Native Plant Species (EAHCP §5.3.8)

EAHCP Obligations:

The COSM will partner with Texas State to develop and implement a non-native plant removal program reaching from Spring Lake downstream to the city boundary. Aquatic, littoral, and riparian non-native plant species will be removed and replaced with native species. The riparian zone will be re-planted to cover 15 meters in width where possible. The COSM will install fencing to protect the new plantings while they mature. Divers conducting sediment control will first remove non-native aquatic plant species from the area. All removed non-native plants will be bagged and disposed of in accordance with state laws.

2015 Compliance Actions:

Non-Native Aquatic Plant Removal

Non-native aquatic vegetation removal focused on *Hydrilla verticillata, Hygrophila polysperma,* and *Nasturtium officinale*, as these species were the most actively invasive. Prior to non-native vegetation removal, the area was fanned to minimize incidental take of fountain darters and other native species. The non-native aquatic vegetation was removed, shaken, and bagged for disposal at the COSM or Spring Lake composting facility. MCWE's progress for non-native vegetation removal was tracked with polygons containing the date, species removed, estimated area (m^2) and percent removed. A composite map depicting the routine maintenance required to remove large areas of non-native aquatic vegetation was also generated using weekly polygons. The map illustrating the degree of effort was created by overlaying all the weekly polygons, rasterizing the spatial units, assigning a value of one for the treated area, and combining the layers with a raster calculator. As a result, the layers capture the degree of overlap between 99 work sites and identify areas that required repeated removal efforts.

Denuded areas were targeted for Texas wild-rice or selected native aquatic species planting based on habitat preferences for each native species. Texas wild-rice and native species were obtained from the USFWS SMARC or from raceways located at the FAB. Initial efforts for restoration of Texas wild-rice or native vegetation were targeted at planting approximately 20 percent of the surface area restored. MCWE planting efforts was tracked with polygons containing the date, number of individuals, estimated area (m^2), and estimated density planted (individuals/m^2). A map illustrating planting locations and densities was generated using weekly polygons. Aquatic vegetation in MCWE work sites was mapped using geo-

referenced imagery collected using a quadcopter in conjunction with Trimble GPS units prior to and post non-native vegetation removal and native planting to assess changes in the vegetation community through time. MCWE work sites were separated into reaches to assess changes among and within reaches of the San Marcos River (**Figure 3.3-25** through **Figure 3.3-28**).

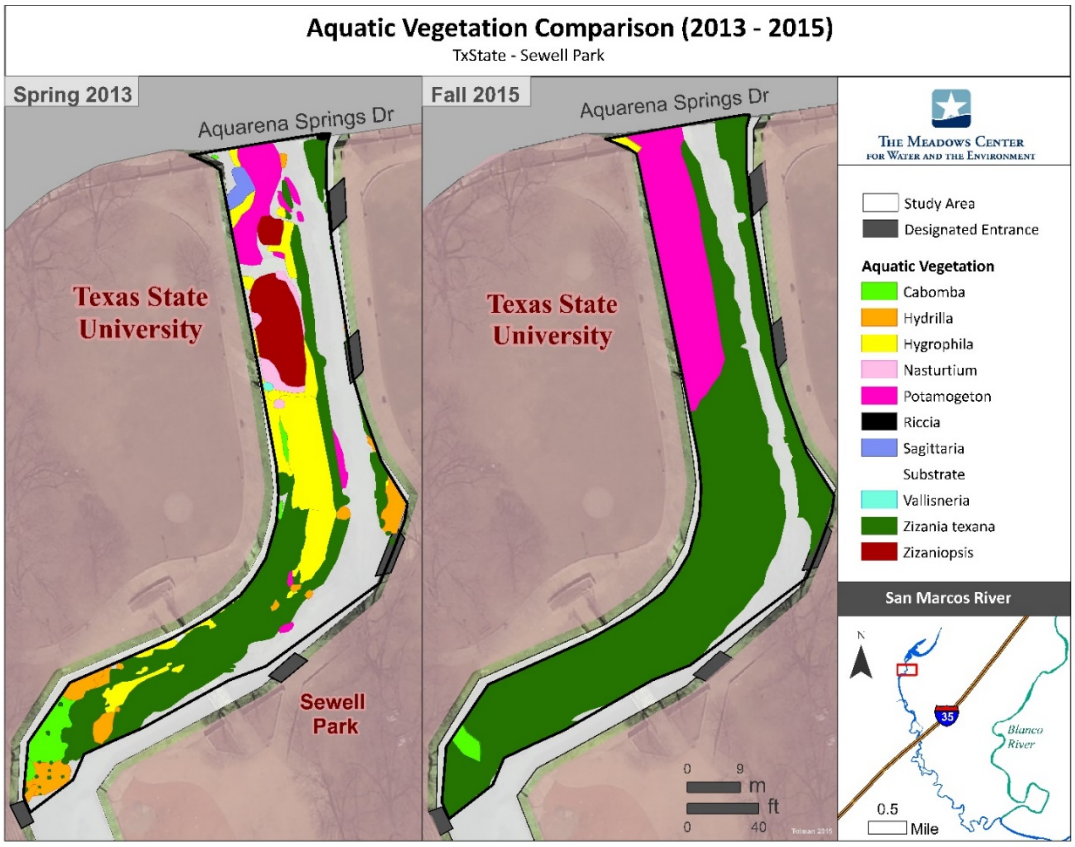

Figure 3.3-25. Sewell Park aquatic vegetation restoration coverage comparison (2013-2015).

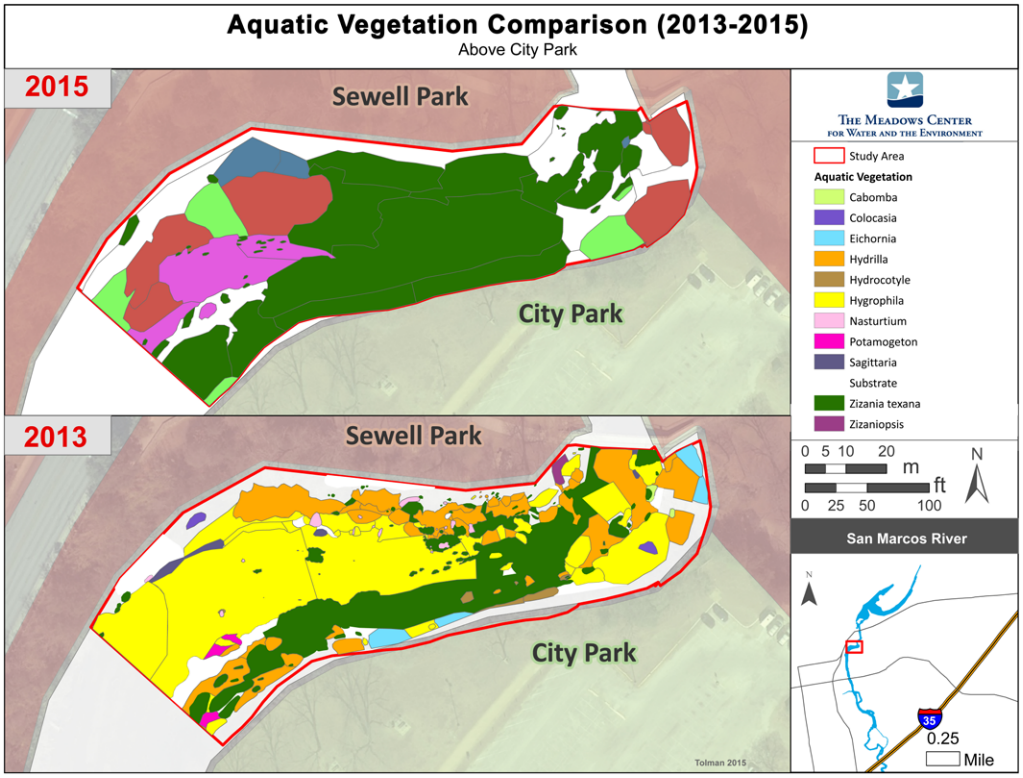

Figure 3.3-26. City Park aquatic vegetation restoration coverage comparison (2013-2015).

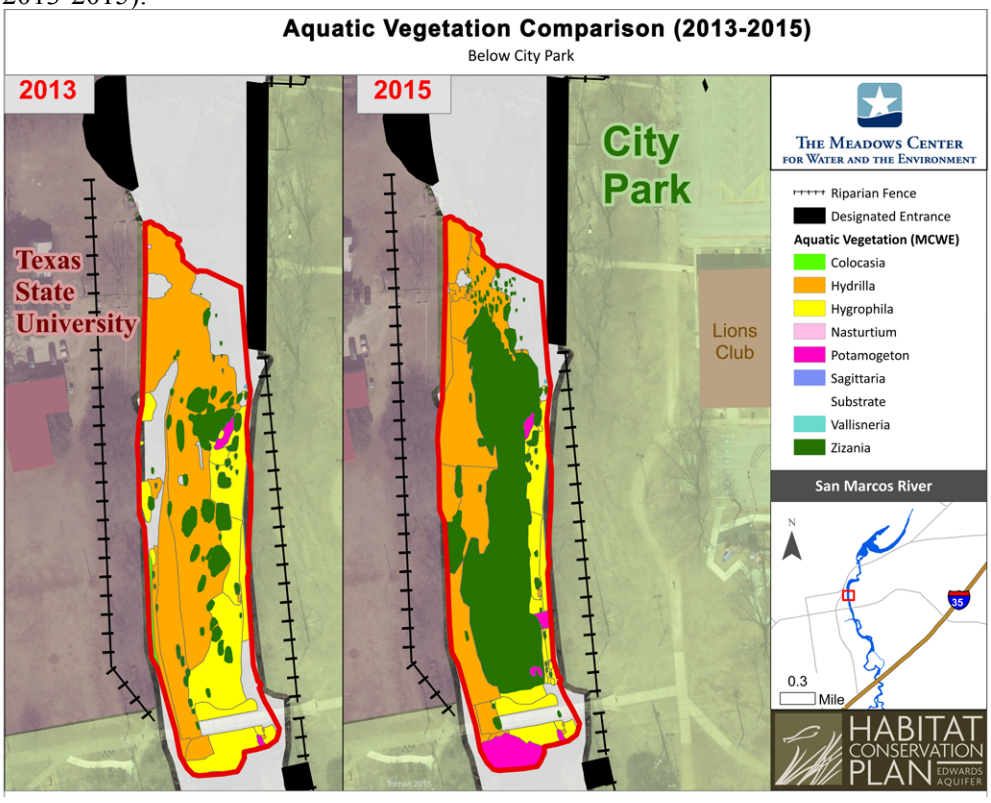

Figure 3.3-27. Below City Park aquatic vegetation restoration coverage comparison (2013-2015).

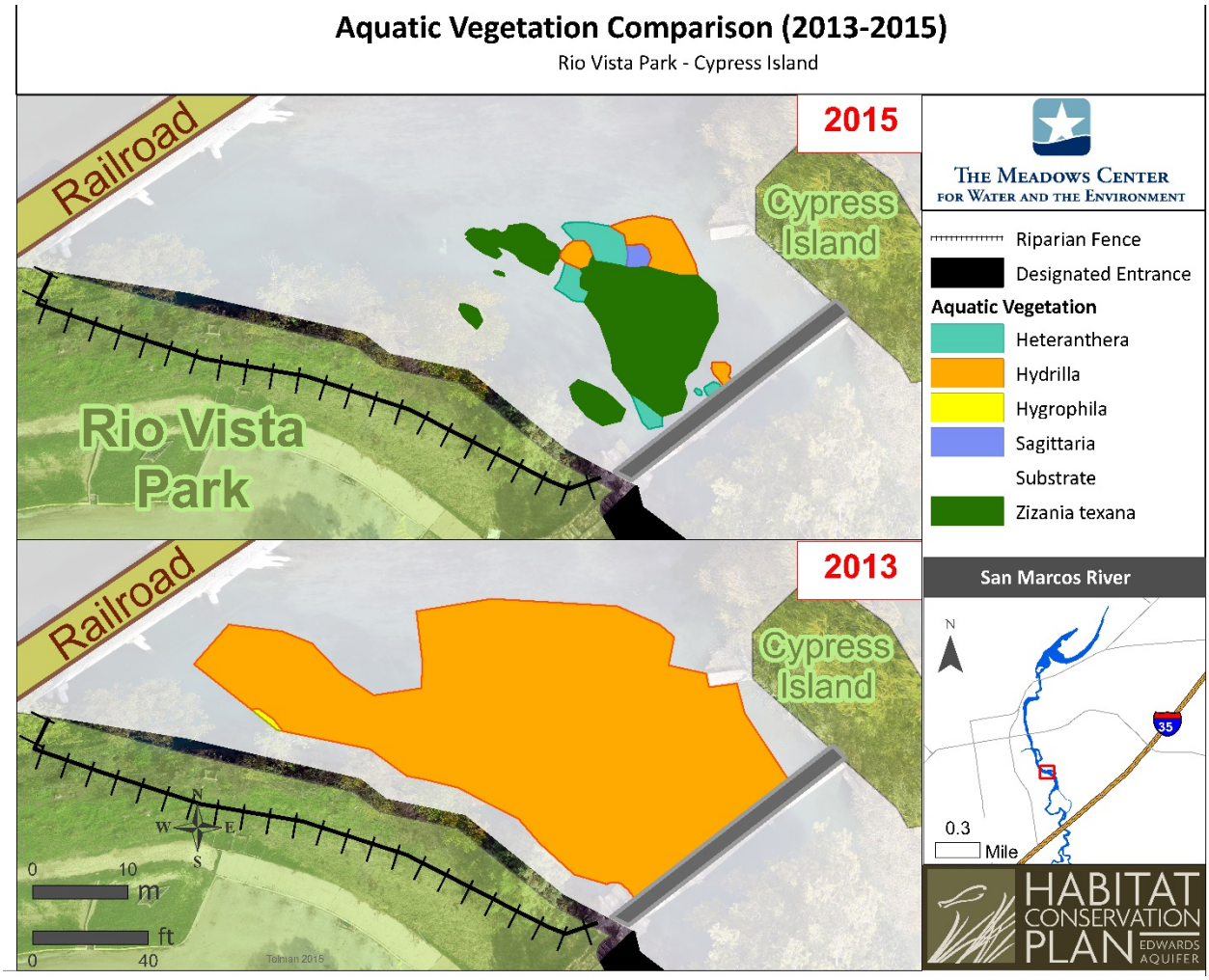

Figure 3.3-28. Rio Vista Park aquatic vegetation restoration coverage comparison (2013-2015).

An estimated 3,017.77 m^2 of non-native aquatic vegetation was removed in the San Marcos River downstream of Sewell Park to IH-35, from December 2014 – October 2015 in areas worked by MCWE staff (**Table 3.3-5**). The non-native vegetation species removed was *Hydrilla verticillata* (estimated area ~1,867 m^2), *Hygrophila polysperma* (~444 m^2), *Hydrilla/Hygrophila* mix (~116 m^2) and *Nasturtium officinale* (~35 m^2). **Figure 3.2-29** illustrates the degree of effort for non-native aquatic vegetation removal by MCWE staff in the San Marcos River for 2015. An average daily removal work site was 33 m^2, but ranged in size from 1.7 m^2 to 281 m^2.

Table 3.3-5. Estimated Area Removed (m^2) of Non-Native Vegetation Species by Date in the San Marcos River Downstream of Sewell Park to IH-35 (December 2014 – October 2015)

Species	Date	Area Removed (m2)
Zizaniopsis miliacea	12/16/2014	16.22
	12/17/2014	31.46
***Zizaniopsis miliacea* total**		**47.67**
Hydrilla verticillata	12/16/2014	59.52
	1/16/2015	22.32
	1/27/2015	32.95
	1/29/2015	86.39
	2/9/2015	45.26
	2/10/2015	30.98
	3/11/2015	21.47
	3/13/2015	15.45
	3/13/2015	34.98
	3/13/2015	15.50
	3/23/2015	17.51
	3/24/2015	31.19
	4/2/2015	10.40
	4/2/2015	13.56
	4/7/2015	15.56
	4/9/2015	25.82
	4/28/2015	11.87
	5/7/2015	25.09
	5/18/2015	37.04
	5/18/2015	28.31
	5/19/2015	33.30
	5/19/2015	43.76
	5/20/2015	52.12
	5/28/2015	26.88
	5/28/2015	28.88
	5/28/2015	1.71
	6/1/2015	23.79
	6/2/2015	25.65
	6/2/2015	15.60
	6/3/2015	136.03
	6/4/2015	85.77
	6/16/2015	66.33
	6/17/2015	128.89
	6/18/2015	73.81
	6/22/2015	32.69
	6/22/2015	9.48
	7/29/2015	26.32
	7/29/2015	12.79
	7/29/2015	8.46
	8/3/2015	35.92
	8/3/2015	14.70
	8/5/2015	58.30
	8/11/2015	19.67
	8/11/2015	4.04
	8/11/2015	6.38
	8/13/2015	22.48
	8/13/2015	35.01

Table 3.3-5. Estimated Area Removed (m^2) of Non-Native Vegetation Species by Date in the San Marcos River Downstream of Sewell Park to IH-35 (December 2014 – October 2015)

Species	Date	Area Removed (m2)
	8/17/2015	33.57
	8/18/2015	36.34
	8/20/2015	26.25
	8/20/2015	33.65
	8/25/2015	8.33
	8/25/2015	7.02
	8/25/2015	3.30
	9/9/2015	6.57
	9/9/2015	7.44
	9/15/2015	57.60
	10/1/2015	8.46
	10/8/2015	19.56
	10/28/2015	8.53
***Hydrilla verticillata* total**		**1,866.54**
Hydrilla/Hygrophila mix	1/16/2015	21.53
	1/20/2015	94.27
***Hydrilla/Hygrophila* mix total**		**115.81**
Hygrophila polysperma	12/16/2014	6.11
	4/2/2015	79.91
	4/7/2015	15.73
	4/29/2015	73.49
	4/30/2015	14.56
	5/5/2015	33.25
	5/28/2015	6.73
	6/3/2015	9.99
	6/22/2015	6.57
	7/13/2015	24.47
	7/15/2015	40.59
	7/21/2015	89.92
	8/11/2015	9.90
	10/27/2015	32.60
***Hygrophila polysperma* total**		**443.82**
Sagittaria platyphylla	7/15/2015	85.42
	7/15/2015	17.55
	7/21/2015	29.49
	8/24/2015	12.79
	8/24/2015	12.72
	9/1/2015	9.90
	9/10/2015	9.94
	9/29/2015	23.54
	10/6/2015	12.65
	10/27/2015	13.75
***Sagittaria platyphylla* total**		**227.75**
Vegetation mat removed	10/5/2015	**281.03**
Nasturtium officinale	5/7/2015	5.42
	5/7/2015	29.73
***Nasturtium officinale* total**		**35.15**
Total estimated area removed of vegetation		**3,017.77**

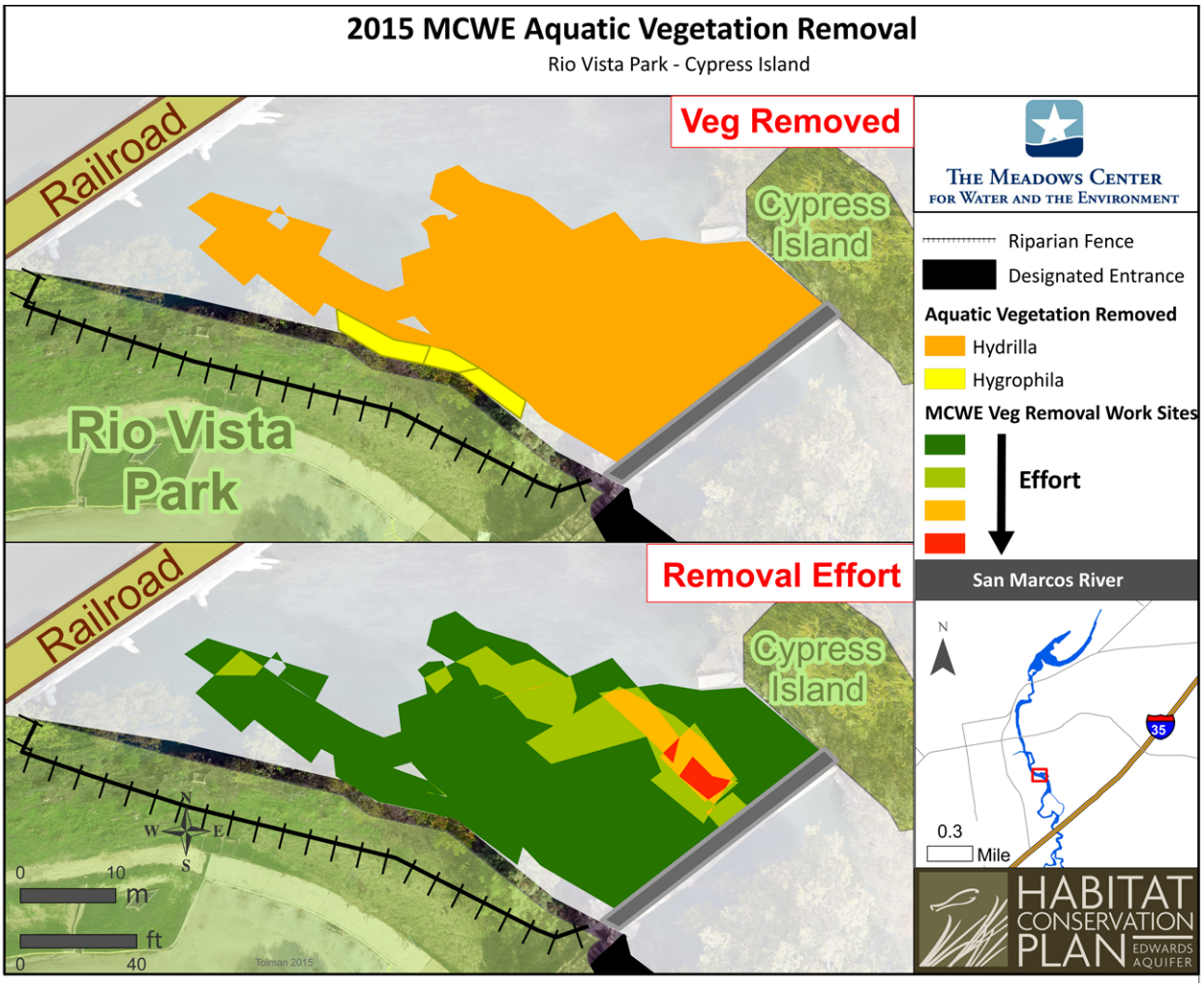

Figure 3.3-29. Non-native aquatic vegetation removal effort in the San Marcos River.

Based upon GPS polygon locations, estimated reduction of non-native vegetation observed from 2013 – November 2015 within MCWE work sites was 4,115 m^2 in the San Marcos River downstream of Sewell Park (**Table 3.3-6**). Estimated reduction of non-native vegetation observed from 2014-2015 with MCWE work sites was 1,796 m^2 (**Figure 3.3-30** through **Figure 3.3-31**). Changes in vegetation outside of the areas worked were not included since differences observed could not be attributed to EAHCP work. Also, area calculations for non-native vegetation was assessed on two different timescales in the City Park reach of the San Marcos River. The first timescale quantified changes in non-native vegetation coverage at City Park A (San Marcos Lions Club downstream to first walking bridge below City Park) from 2013 to 2015. The second timescale quantified changes in non-native vegetation at City Park B, a subset of City Park A, from November 2014 to November 2015. Estimated area reduction per non-native vegetation species within MCWE work sites since 2013 was *Hygrophila polysperma* (~1,377 m^2), *Hydrilla verticillata* (~2,622 m^2), *Nasturtium officinale* (31 m^2), *Vallisneria spiralis* (2 m^2), and *Eichhornia* (~84 m^2). Estimated area reduction per non-native vegetation species within MCWE work sites from 2014-2015 includes *Hygrophila polysperma* (~462 m^2), *Hydrilla verticillata* (~1,205 m^2), *Nasturtium officinale* (112 m^2), and *Eichhornia* (~17 m^2). The October 30, 2015 flood event scoured certain areas of the river, and in some instances, helped remove areas of non-native vegetation (**Appendix M1**).

Table 3.3-6. Difference in Area (m^2) of Non-Native Vegetation Species in the San Marcos River Among Reaches in the San Marcos River Downstream of Sewell Park at Year One (2013), Year Two (November 2014), and Year Three (November 2015) of Removal Activities

Area Calculations (m^2) for Non-Native Species						
Reach	Species	2013	2014	2015	Change 2013-2015	Change 2014-2015
Above City Park	*Hydrilla verticillata*	857.28	1,034.49	236.89	-620.39	-797.6
	Hygrophila polysperma	1,483.73	795.21	530.71	-953.02	-264.5
	Nasturtium officinale	29.84	111.66	0	-29.84	-111.66
	Eichhornia	83.53	17.08	0	-83.53	-17.08
City Park A	*Hydrilla verticillata*	1,466.30	N/A	308.33	-1,157.97	N/A
	Hygrophila polysperma	585.57	N/A	191.77	-393.8	N/A
	Nasturtium officinale	1.55	N/A	0	-1.55	N/A
	Vallisneria spiralis	1.72	N/A	0	-1.72	N/A
City Park B	*Hydrilla verticillata*	N/A	581.30	173.50	N/A	-407.8
	Hygrophila polysperma	N/A	347.95	150.93	N/A	-197.02
Bicentennial Park – Purgatory Creek	*Hydrilla verticillata*	58.57	N/A	65.98	7.41	N/A
	Hygrophila polysperma	27.65	N/A	0	-27.65	N/A
Rio Vista – Cypress Island	*Hydrilla verticillata*	1,006.71	N/A	156.01	-850.7	N/A
	Hygrophila polysperma	2.45	N/A	0	-2.45	N/A

(N/A applies to area calculations that are undetermined or unavailable.)

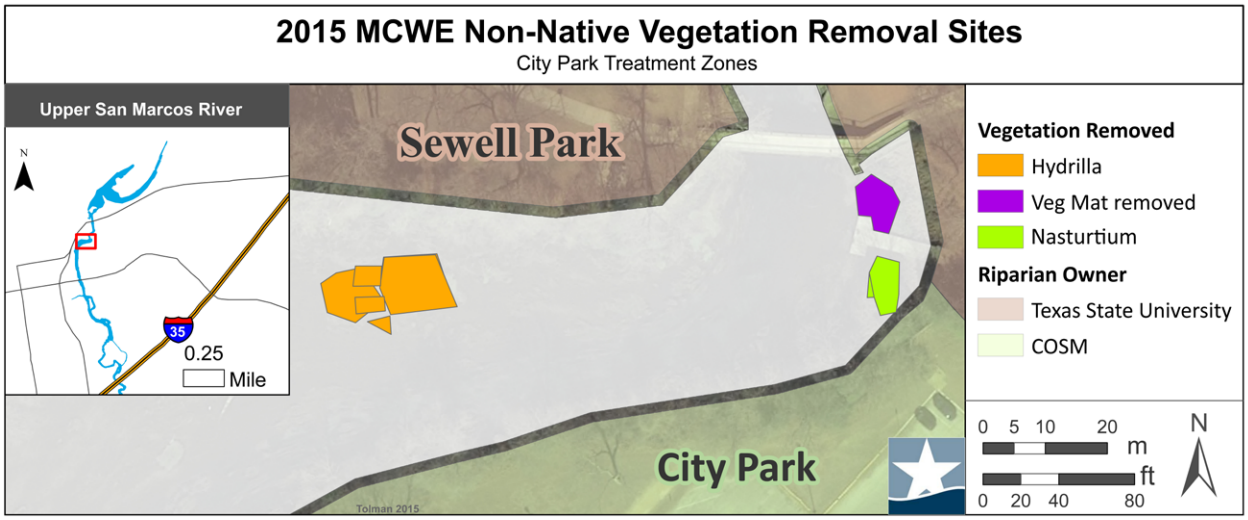

Figure 3.3-30. 2015 Non-native vegetation removal sites at City Park.

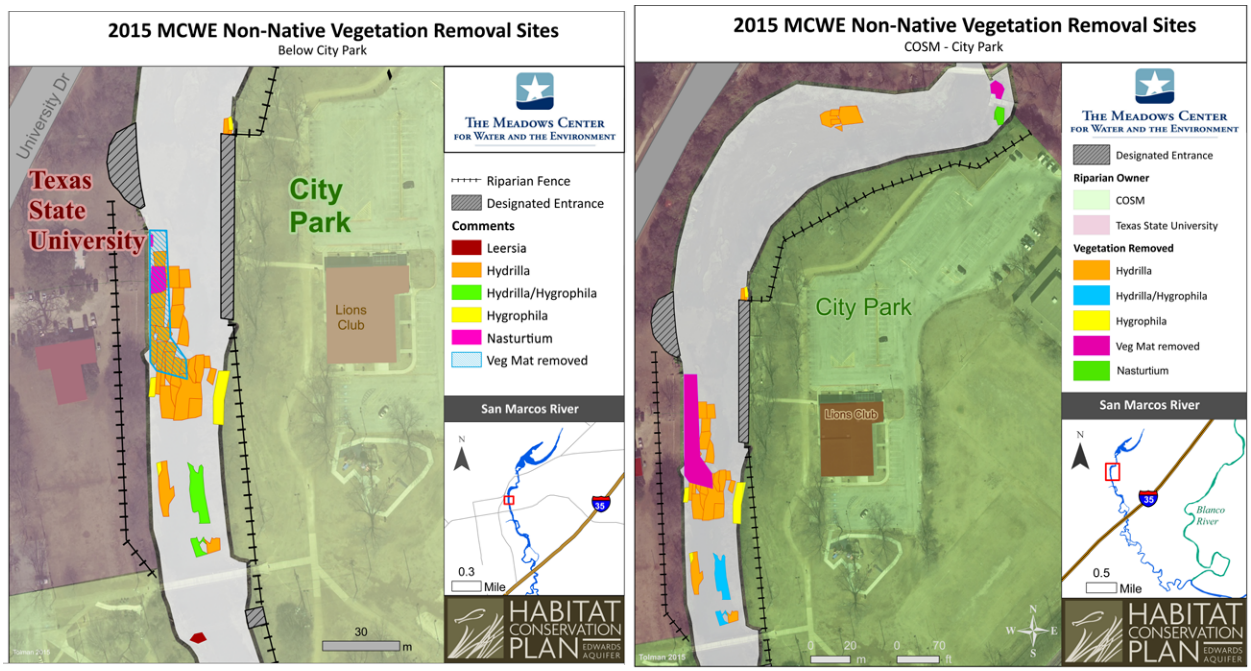

Figure 3.3-31. 2015 Non-native vegetation removal sites below City Park.

Twenty fountain darters were collected during non-native aquatic vegetation removal and returned to the river. Other species collected and returned to the river included crayfish, sunfish species, and mosquito fish (**Table 3.3-7).**

Table 3.3-7. Animal Species Collected and Returned to the San Marcos River During Non-Native Vegetation Removal (November 2014 – October 2015)

Species	Month												
	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Total
Lepomis sp. (sunfishes)	2	-	15	10	4	20	12	12	7	9	6	7	**104**
Etheostoma fonticola (fountain darter)	-	-	4	2	1	-	-	-	1	10	2	-	**20**
Gambusia sp. (mosquito fish)	-	-	5	-	-	-	-	-	-	30	-	-	**35**
Ameiurus sp. (bullhead catfish)	-	-	10	-	-	2	-	-	-	5	-	2	**19**
Poecilia sp. (mollies)	2	-	-	-	-	-	-	-	-	-	-	-	**2**
Micropterus salmoides (largemouth bass)	-	-	-	-	-	-	-	-	1	-	-	-	**1**
Ambloplites rupestris (rockbass)	-	-	2	2	1	9	5	-	2	-	-	5	**26**
Notropis amabilis (Texas shiner)	-	-	-	3	-	-	-	-	-	-	-	-	**3**
Cambaridae (crayfish)	25	-	10	5	36	105	75	25	50	50	35	75	**491**
Testudinata (Turtles)	-	-	-	1	-	1	-	-	-	-	-	-	**2**

Table 3.3-8 denotes the number of each native vegetation species planted once an area was denuded of non-native vegetation. An estimated number of native species planted in the San Marcos River downstream of Sewell Park was 24,552 individuals from December 2014 – October 2015. The greatest number of individuals planted was Texas wild-rice (17,741) followed by *Ludgwigia repens* (2,967), *Heteranthera dubia* (2,916), and S*agittaria platyphylla* (874). Other native species planted were *Potamogeton illinoensis*. Estimated area planted with native species was 1,457 m^2 in the San Marcos River downstream of Sewell Park within areas removed of non-native vegetation. **Figure 3.3-32** through **Figure 3.3-34** illustrate planting density (plants/m^2), as well as planting location of Texas wild-rice and other native species in the San Marcos River downstream of Sewell Park.

Table 3.3-8. Number of Each Native Vegetation Species Planted Monthly in the San Marcos River Downstream of Sewell Park (December 2014 – October 2015)

Species	Date	No.	Area Planted (m^2)	Density Planted (plants/m^2)
Heteranthera dubia	12/15/2014	12	4.32	2.78
	1/20/2015	40	3.57	11.21
	2/6/2015	162	21.46	7.55
	3/12/2015	138	7.07	19.53
	4/23/2015	84	2.68	31.31
	4/23/2015	100	3.17	31.54
	5/7/2015	100	1.96	50.99
	5/19/2015	63	9.35	6.74
	6/1/2015	138	7.07	19.52
	6/23/2015	450	8.90	50.55
	6/23/2015	450	3.17	141.89
	6/25/2015	45	2.39	18.84
	6/25/2015	45	1.59	28.32
	7/20/2015	198	5.25	37.72
	7/20/2015	100	0.81	123.29
	7/20/2015	30	0.88	33.93
	7/20/2015	30	1.13	26.64
	7/20/2015	116	2.99	38.78
	7/22/2015	24	0.95	25.16
	8/12/2015	25	10.85	2.31
	8/12/2015	25	8.12	3.08
	8/12/2015	25	6.69	3.74
	8/26/2015	75	5.66	13.25
	8/26/2015	135	4.51	29.96
	9/9/2015	204	2.96	68.88
	9/9/2015	102	3.54	28.81
***Heteranthera dubia* total**		**2,916**	**131.04**	
Ludwigia repens	2/6/2015	486	21.46	22.64
	3/12/2015	132	7.59	17.38
	3/19/2015	123	7.76	15.86
	3/19/2015	123	4.25	28.94
	5/7/2015	171	1.38	124.18
	5/19/2015	315	7.31	43.08
	6/1/2015	711	17.14	41.48
	6/11/2015	288	9.30	30.96
	6/23/2015	9	0.08	118.06
	8/4/2015	400	13.84	28.90
	8/4/2015	209	7.40	28.25
***Ludwigia repens* total**		**2,967**	**97.51**	
Potamogeton illinoensis	4/7/2015	**54**	**3.32**	16.28
Sagittaria platyphylla	2/6/2015	69	21.46	3.21
	4/7/2015	225	26.59	8.46
	5/19/2015	36	4.15	8.68
	6/9/2015	200	14.42	13.87
	7/28/2015	230	16.60	13.86
	8/12/2015	75	2.62	28.58
	10/28/2015	39	2.01	19.38
***Sagittaria platyphylla* total**		**874**	**87.85**	

Table 3.3-8. Number of Each Native Vegetation Species Planted Monthly in the San Marcos River Downstream of Sewell Park (December 2014 – October 2015)

Species	Date	No.	Area Planted (m^2)	Density Planted (plants/m^2)
Zizania texana	11/14/2014	320	73.28	4.37
	12/15/2014	972	110.03	8.83
	1/6/2015	279	48.52	5.75
	1/16/2015	678	48.52	13.97
	1/20/2015	798	78.66	10.14
	1/29/2015	588	38.00	15.47
	2/10/2015	876	44.26	19.79
	3/12/2015	324	60.08	5.39
	3/19/2015	351	16.32	21.51
	3/24/2015	880	47.14	18.67
	4/7/2015	279	19.08	14.62
	4/7/2015	279	13.63	20.47
	4/22/2015	474	25.90	18.30
	4/23/2015	150	10.25	14.63
	4/23/2015	150	16.17	9.28
	5/7/2015	639	19.45	32.85
	5/19/2015	459	25.50	18.00
	6/1/2015	306	29.23	10.47
	6/1/2015	612	25.03	24.45
	6/11/2015	630	50.16	12.56
	6/23/2015	388	12.06	32.16
	6/23/2015	776	19.22	40.38
	6/25/2015	162	4.19	38.69
	6/25/2015	162	2.32	69.88
	7/20/2015	105	4.71	22.31
	7/20/2015	392	5.78	67.84
	7/20/2015	150	6.43	23.34
	7/20/2015	100	3.45	29.02
	7/20/2015	200	6.59	30.34
	7/22/2015	350	9.50	36.86
	7/22/2015	250	7.54	33.15
	7/22/2015	155	3.86	40.16
	7/22/2015	155	3.47	44.63
	8/4/2015	320	13.20	24.24
	8/4/2015	283	30.61	9.25
	8/10/2015	750	73.87	10.15
	8/12/2015	510	17.52	29.11
	8/19/2015	200	5.10	39.23
	8/19/2015	200	11.12	17.99
	8/19/2015	200	10.89	18.36
	8/26/2015	330	14.25	23.15
	9/9/2015	76	3.16	24.07
	9/9/2015	152	5.80	26.21
	9/16/2015	828	36.10	22.94
	10/21/2015	408	18.39	22.19
	10/28/2015	95	8.68	10.95
***Zizania texana* total**		**17,741**	**1,137.03**	
Total native species plantings		**24,552**	**1,456.75**	

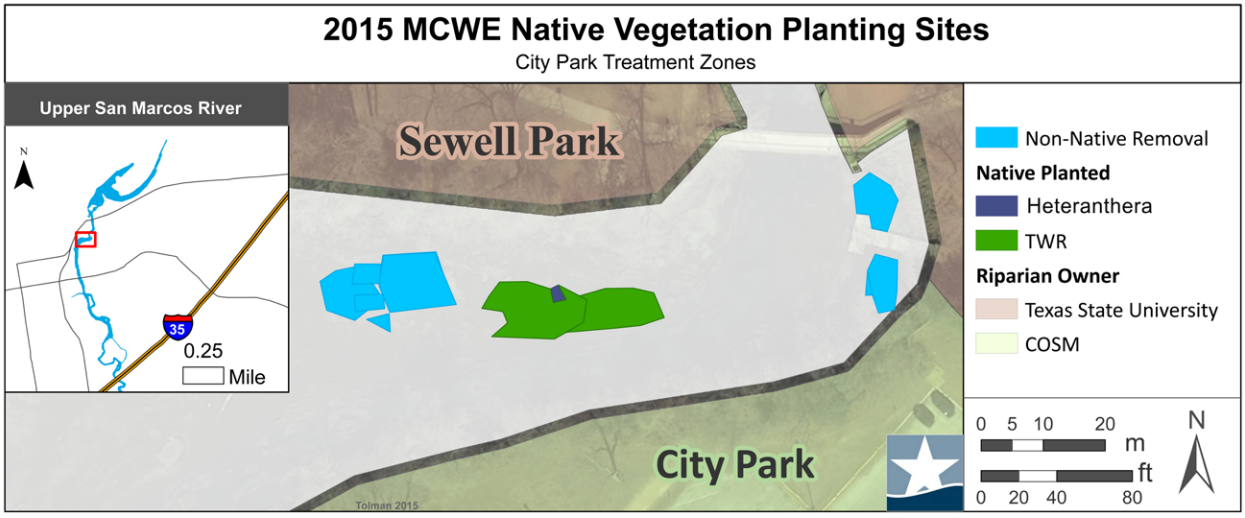

Figure 3.3-32. Planting locations and planted densities of Texas wild-rice and other native species just downstream of Sewell Park.

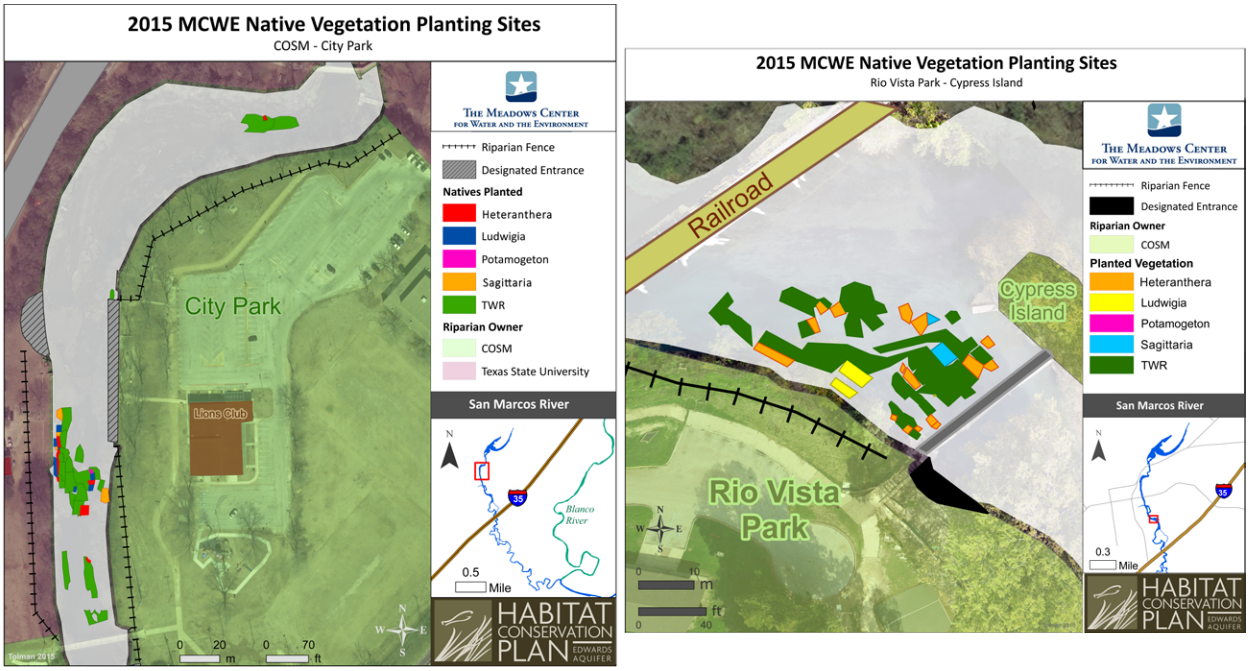

Figure 3.3-33. Planting locations and planted densities of Texas wild-rice and other native species in upper and lower City Park.

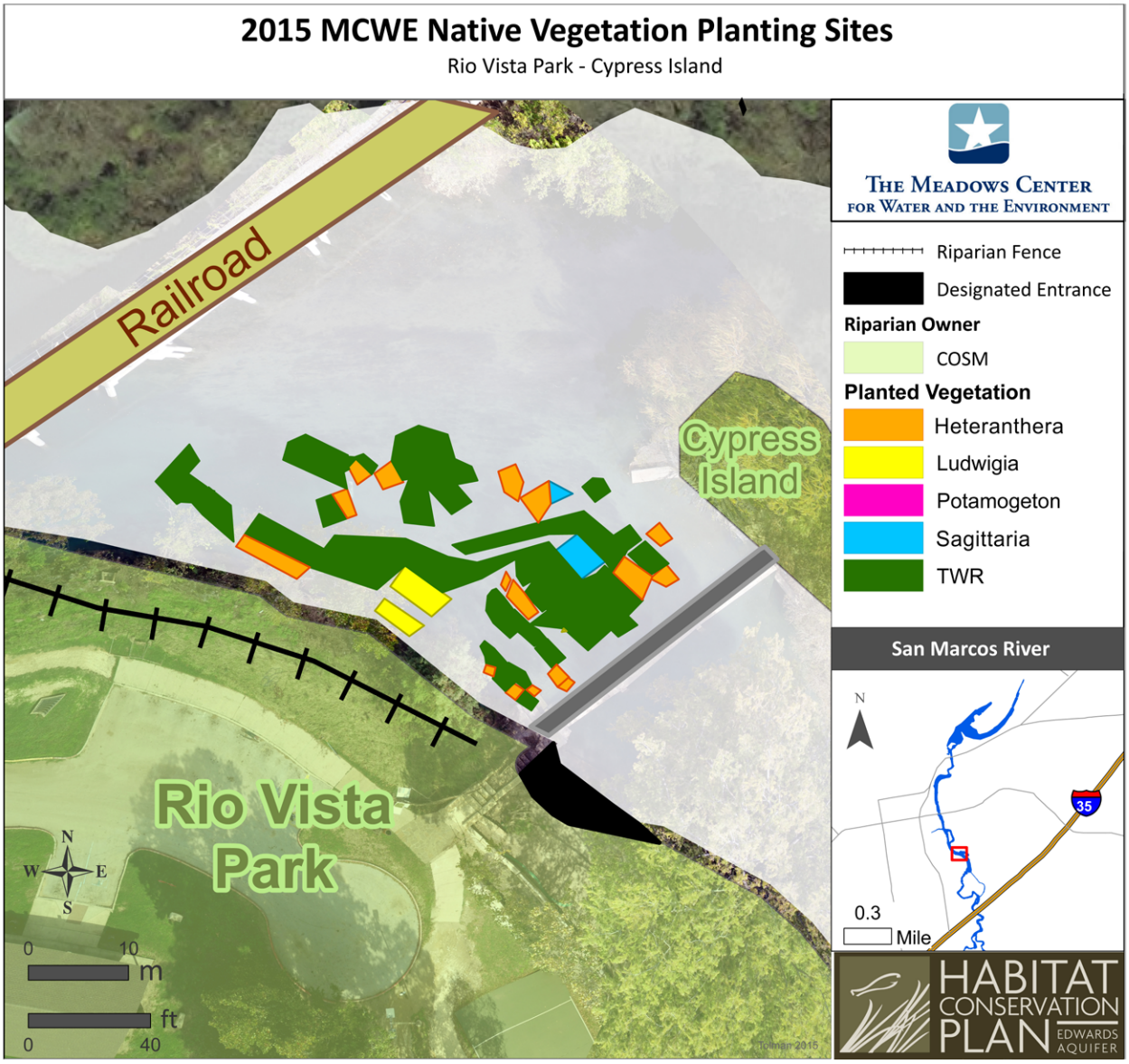

Figure 3.3-34. Planting locations and planted densities of Texas wild-rice and other native species at Cypress Island above Rio Vista Falls.

Table 3.3-9 shows changes in native aquatic vegetation from 2013 to 2015 among reaches of the San Marcos River downstream of Sewell Park. Changes in native vegetation outside of the areas worked were not included, since differences observed could not be attributed to work by the MCWE team. Also, area calculations for native vegetation was assessed on two different time scales in the City Park reach of the San Marcos River. Method 1 quantified changes in native vegetation coverage at City Park A (San Marcos Lions Club downstream to first walking bridge below City Park) from 2013 to 2015. Method 2 quantified changes in native vegetation at City Park B, a subset of City Park A, from November 2014 to November 2015. Among native species, *Zizania texana* increased the most from 2013 to 2015 (3,086 m^2) followed by *Sagittaria platyphylla* (557 m^2), and *Heteranthera dubia* (79 m^2) (**Figure 3.3-34** and **Table 3.3-9**). A report titled *2014-2015 Progression*, located in **Appendix M3** illustrates areas of native aquatic vegetation

expansion and vegetation loss before and after the October 2015 flood event within work areas. Loss in areal coverage was observed for native species including *Potamogeton illinoensis*, *Cabomba caroliniana*, and *Hydrocotyle*, which was attributed to recreation impacts and to riverbed scouring and sediment deposition that occurred during the October 30, 2015 flood event.

Table 3.3-9. Difference in Area (m^2) of Native Vegetation Species Within MCWE Work Sites in Reaches of the San Marcos River Downstream of Sewell Park at Year One (2013), Year Two (November 2014), and Year Three (November 2015) of Removal and Planting Activities.

Area Calculations for Native Species (m^2)						
Reach	**Species**	**2013**	**2014***	**2015**	**Change 2013-2015**	**Change 2014-2015**
Above City Park	*Zizania texana*	1,212.26	1,963.40	2,253.01	1,040.75	289.61
	Sagittaria platyphylla	22.41	375.62	684.85	662.44	309.23
	Heteranthera dubia	0	18.76	0	0	-18.76
	Potamogeton illinoensis	769.81	336.09	169.73	-600.08	-166.36
	Hydrocotyle	23.09	33.59	14.93	-8.16	-18.66
	Cabomba caroliniana	11.01	5.89	0	-11.01	-5.89
	Zizaniopsis	16.04	0	0	-16.04	-16.04
	Ludwigia repens	0	16.37	0	0	-16.37
City Park A	*Zizania texana*	384.26	N/A	1,348.25	963.99	N/A
	Sagittaria platyphylla	17.73	N/A	0	-17.73	N/A
	Heteranthera dubia	0	N/A	0.33	0.33	N/A
	Potamogeton illinoensis	254.01	N/A	180.15	-73.86	N/A
City Park B	*Zizania texana*	N/A	602.73	945.63	N/A	342.90
	Sagittaria platyphylla	N/A	32.25	0	N/A	-32.25
	Heteranthera dubia	N/A	62.51	0	N/A	-62.51
	Potamogeton illinoensis	N/A	106.10	111.90	N/A	-5.80
	Cabomba caroliniana	N/A	9.28	0	N/A	-9.28
	Ludwigia repens	N/A	25.55	0	N/A	-25.55
Bicentennial Park – Purgatory Creek	*Zizania texana*	0	N/A	12.58	12.58	N/A
	Sagittaria platyphylla	100.15	N/A	7.93	-92.22	N/A
	Potamogeton illinoensis	10.31	N/A	0	-10.31	N/A
	Cabomba caroliniana	107.19	N/A	0	-107.19	N/A
Rio Vista – Cypress Island	*Zizania texana*	0	N/A	122.96	122.96	N/A
	Sagittaria platyphylla	0	N/A	4.94	4.94	N/A
	Heteranthera dubia	0	N/A	63.44	63.44	N/A

(N/A applies to area calculations that are undetermined or unavailable.)

Table 3.3-10 depicts a snapshot of EAHCP progress attained by late 2015 through the Control of Non-Native Plant Species program (EAHCP §5.3.8 and §5.4.12) towards meeting the Biological Goals associated with establishing fountain darter habitat by vegetation-type in the San Marcos Springs system. Fountain darter habitat goals in the San Marcos Springs system are listed in Table 4-24 of the EAHCP.

Table 3.3-10. Fountain Darter Habitat (Aquatic Vegetation) in m^2, San Marcos System, October 2015 Mapping Event

Study Reach	Hygrophila	Ludwigia	Cabomba	Hydrilla	Potamogeton	Sagittaria	Vallisneria
Spring Lake Dam	58	1	0	31	6	21	3
City Park	295	2	0	751	59	129	0
IH-35	523	73	252	181	0	271	0
Totals	**876**	**76**	**252**	**963**	**65**	**421**	**3**

Appendix M4 of this Annual Report is a report titled, *Propagation of Texas Wild Rice and Other Native Plants for Habitat Restoration in the San Marcos River*, published in 2015 summarizing efforts by the USFWS at the SMARC to propagate these native species.

Non-Native Littoral Plant Removal

In 2015, removal efforts consisted primarily of removal of regrowth and invasive plants from Spring Lake to Cheatham Street. New effort was placed into removal in the remaining area to Stokes Park as shown in **Figure 3.3-35** and **Figure 3.3-36**. Effort was greater in fall and winter before the elephant ears began their spring growth.

EBR Enterprises (EBR) partnered in the removal of large Chinese tallow trees lining the Texas State golf course and assisted with removal of regrowth and invasive plants at Rio Vista. EBR revisited Bert Brown Road to get the mass back under control. This effort was an attack on the numerous small elephant ears that have resulted from fragments and possible seeds floating in from different spots during the recent floods. EBR found that the bulbs were right at the surface, instead of being subsurface.

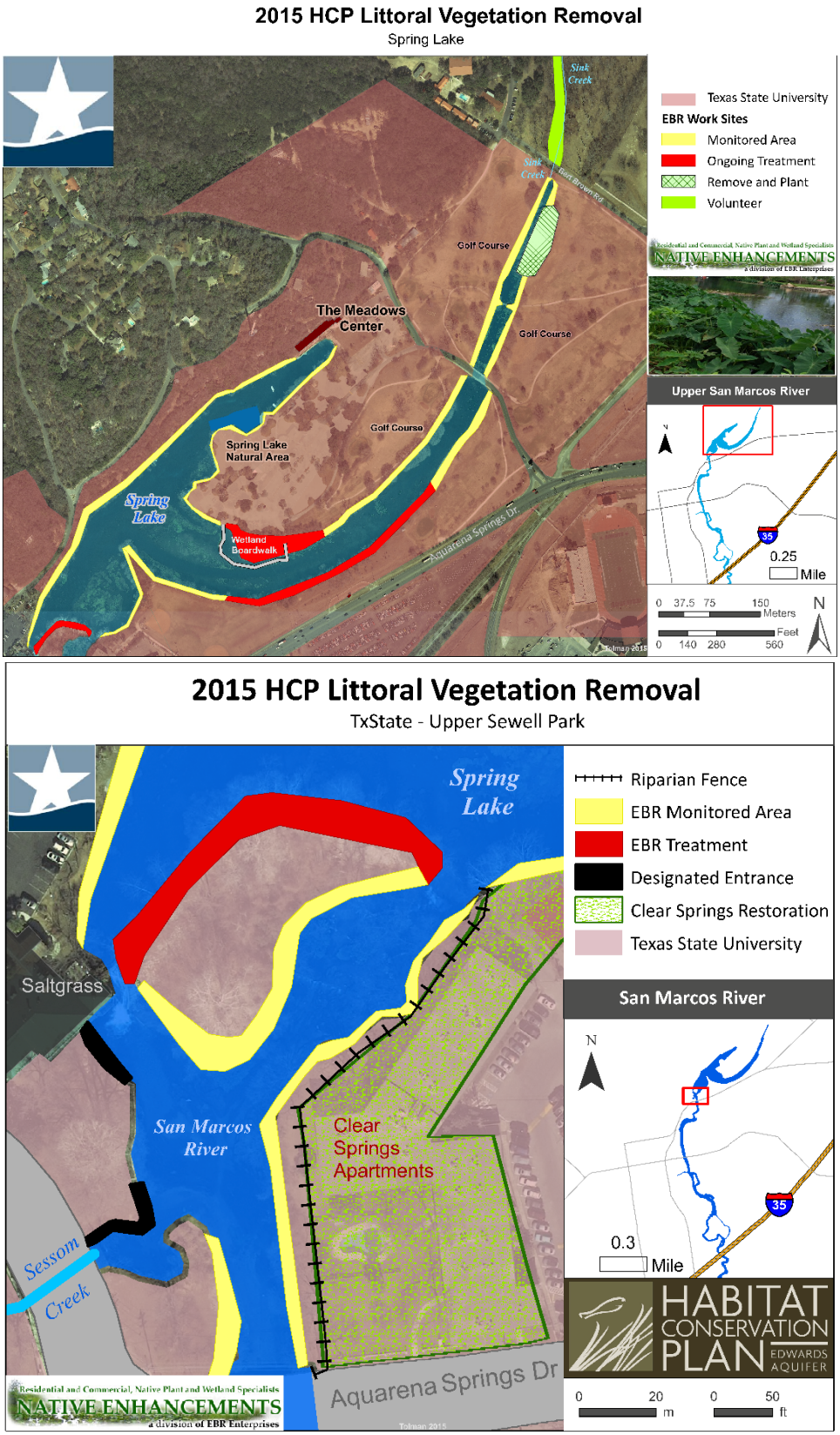

Figure 3.3-35. Areas of removal and replanting at Spring Lake and upper Sewell Park.

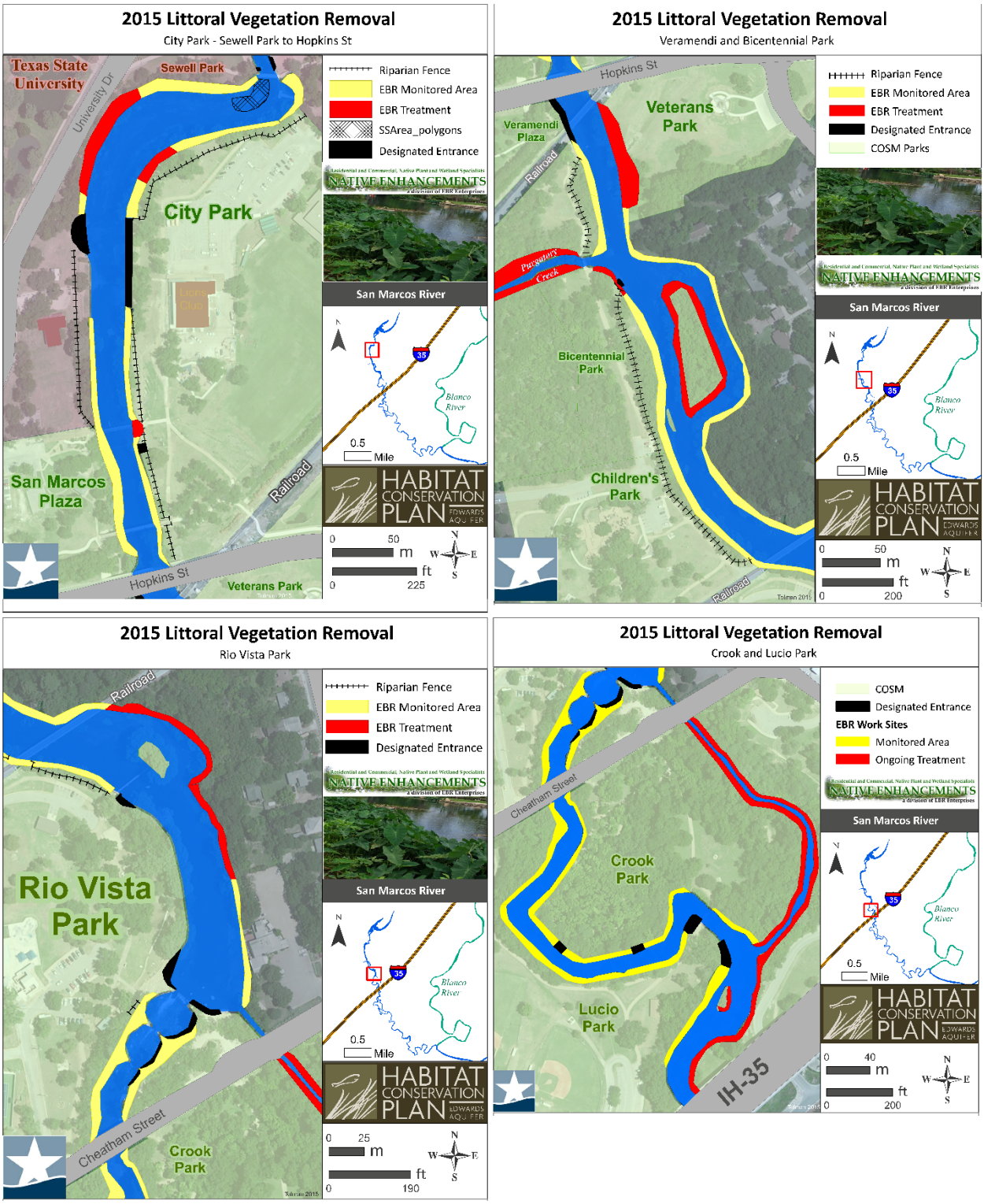

Figure 3.3-36. Treated areas from City Park to IH-35.

EBR used Aquaneat (glyphosate-based herbicide) for elephant ears and other non-native plants encountered in the littoral zone (10.25 ounces (oz.) per gallon maximum). This herbicide was mixed with Aqua King Plus Surfactant (1 oz. per gallon) and Turf Mark Blue, Blue Dye. On the upland tree, shrub stumps and root buttresses, EBR used Relegate **(**Triclopyr-based herbicide) at 10 oz. per gallon. The Relegate was mixed with glyphosate (10.25 oz. per gallon maximum), Drexel Surf Ac 820 Surfactant (1 oz. per gallon) and Turf Mark Blue, a blue dye. **Figure 3.3-37** illustrates non-native littoral plant removal efforts in progress and completed. Chemicals were applied with a one-gallon pump-up sprayer set on a steady stream for a more precise target hit to minimize leaching and non-target plant damage. Roots of woody plants were scarred up with a machete to expose more of the cambium layer and treated with an herbicide mix (**Table 3.3-11**).

Table 3.3-11. Non-Native Species (Less Than Four-Inches in Diameter) Removed From the Littoral Zone of the San Marcos River

Common Name	Scientific Name
Arrowhead vine	*Syngonium podophyllum*
Cat claw vine	*Macfadyena unguis-cati*
Chinaberry tree	*Melia azedarach*
Chinese tallow	*Triadica sebifera*
Chinese privet	*Ligustrum sinense*
Elephant ear	*Colocasia esculenta*
Japanese honeysuckle	*Lonicera japonica*
Loquat	*Eriobotrya japonica*
Ligustrum	*Ligustrum japonicum* and/or *Ligustrum lucidum*
Nandina	*Nandina domestica*
Paper mulberry	*Broussonetia papyrifera*
Umbrella sedge	*Cyperus alternifolius*
Water hyacinth	*Eichhornia crassipes*
Yellow iris	*Iris pseudacorus*

Any Modifications or Activities Due to Weather Conditions:

Non-native littoral removal and native plantings were delayed until the rainy season (October) to avoid the need for weekly watering. Areas of the San Marcos River downstream of the Sewell Park reaches scoured during the October 30, 2015 flood event resulting in loss of Texas wild-rice and other native species within and outside of MCWE work sites. Areas of scour and native vegetation changes can be observed in **Appendix M1** with images of the October 2015 flood event.

Figure 3.3-37. Non-native littoral plant removal in progress (above) and completed (below).

Proposed Activities for 2016:

In 2016, the COSM will remove 1,500 m^2 of non-native aquatic plant material. Stands of elephant ears already treated will continue to be weeded for regrowth, and removal will continue to Stokes with native littorals planted in their place. Riparian invasive species will be removed from the Wildlife Annex and Ramon Lucio.

3.3.9 Control of Harmful Non-Native and Predator Species (EAHCP §5.3.9)

EAHCP Obligations:

The COSM, in partnership with Texas State, will implement a non-native species control program that targets the suckermouth armored catfish (Loricariidae), tilapia (*Oreochromis* spp.), red-rimmed melania (*Melanoides tuberculata*), and the giant ramshorn snail *(Marisa cornuarietis)*. The COSM will conduct annual monitoring and maintenance activities to ensure continued control of the invasive population within the San Marcos system.

2015 Compliance Actions:

Tilapia

The tilapia in Spring Lake spawn from March through June. During this time Atlas focused all efforts on tilapia removal by bowfishing, spearfishing, and using gill nets. A speargun was used for tilapia removal in Spring Lake only. Tilapia were also captured throughout the river along with suckermouth catfish by polespear and seine net. Bowfishing was the most successful method during spawning season (March-June). Outside of spawning season, a speargun was the most successful method for removing tilapia.

Figure 3.3-38 and **Figure 3.3-39** show the locations and number of tilapia captured over time in the San Marcos River.

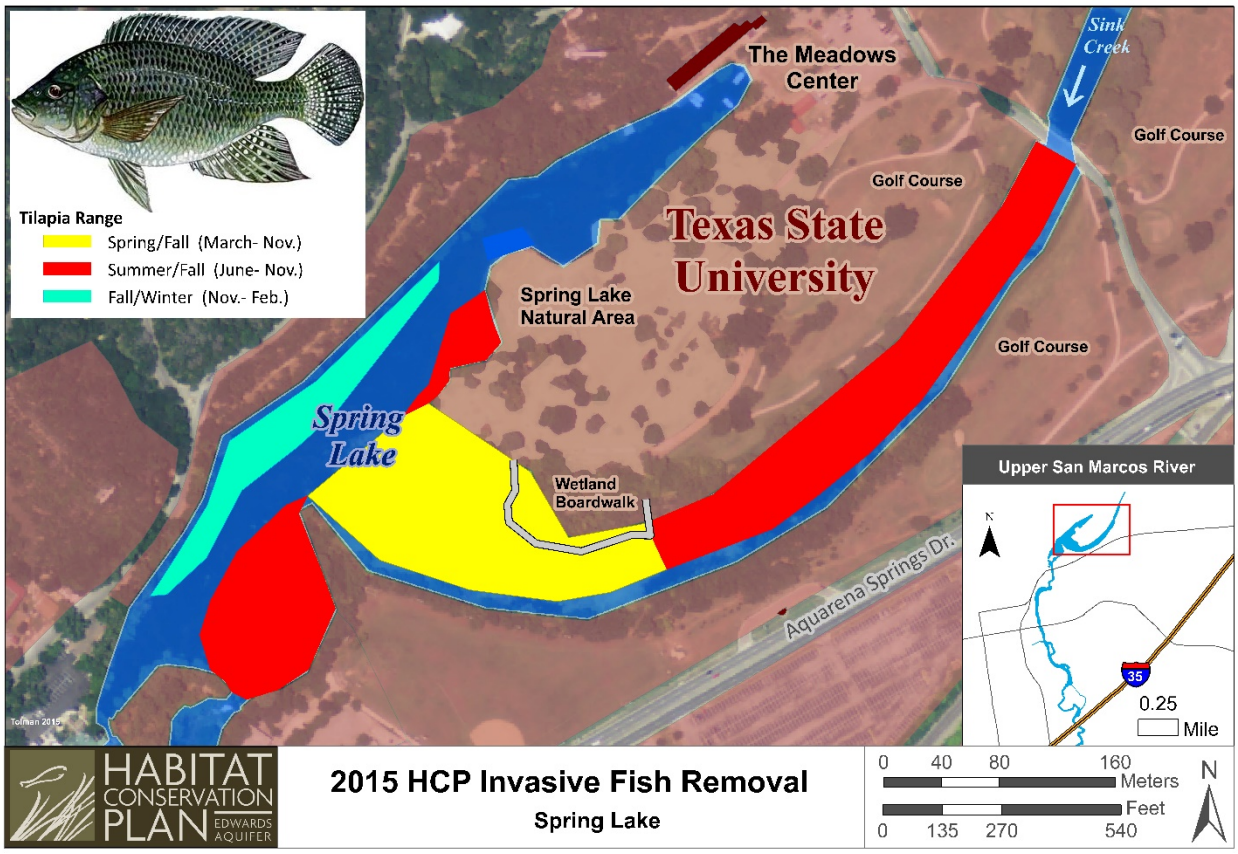

Figure 3.3-38. Area of tilapia removal in Spring Lake.

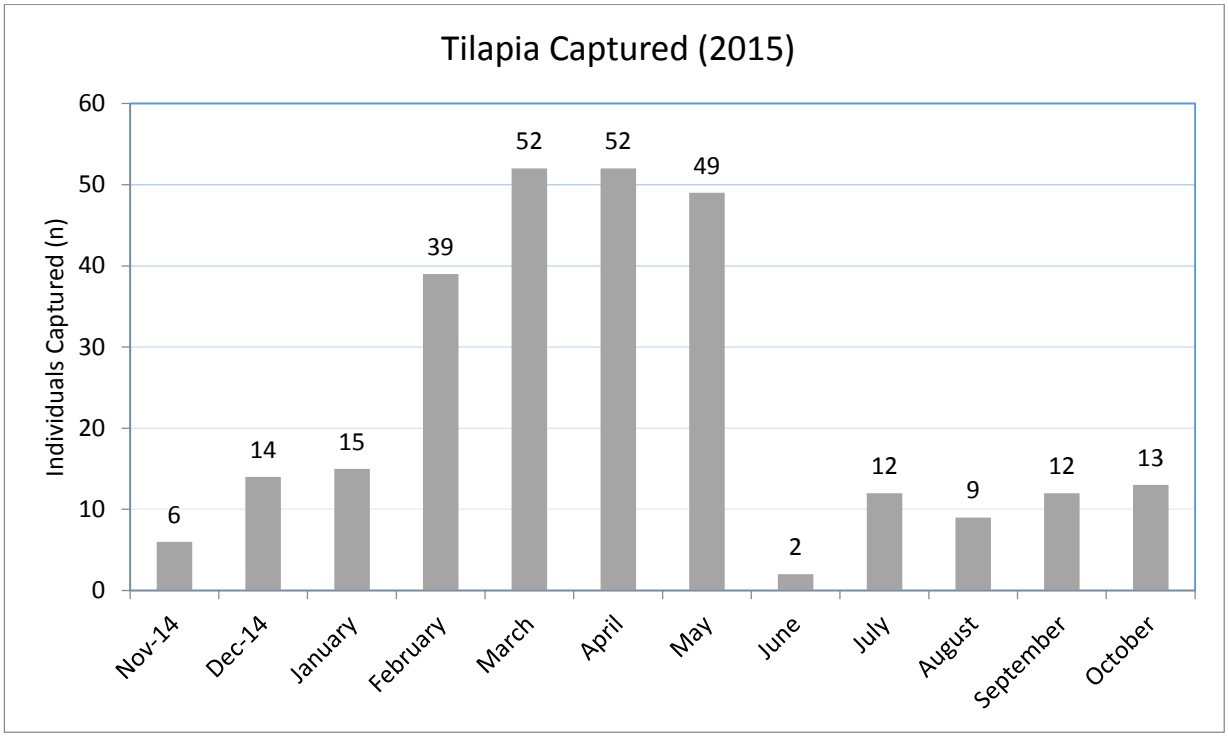

Figure 3.3-39. Number of individual tilapia captured from November 2014 to October 2015.

Suckermouth catfish (*Hypostomus plecostomus*)

Suckermouth catfish were captured from Spring Lake to IH-35 using pole spears and hand collection while snorkeling. Suckermouth catfish were speared at both night and day, but during the recreation season Atlas dives were only conducted at night due to the constant turbidity of the water during the day. The number of suckermouth catfish are reducing in Spring Lake. In 2014, 29 suckermouth catfish were removed from Spring Lake, and in 2015, Atlas only removed three suckermouth catfish from Spring Lake (in January). The highest captures of suckermouth catfish from Spring Lake occur during the spear-fishing tournaments and during the summer. No additional suckermouth catfish were seen for the remainder of 2015.

Figure 3.3-40 and **Figure 3.3-41** show the number and locations of suckermouth catfish captures over time in the San Marcos River.

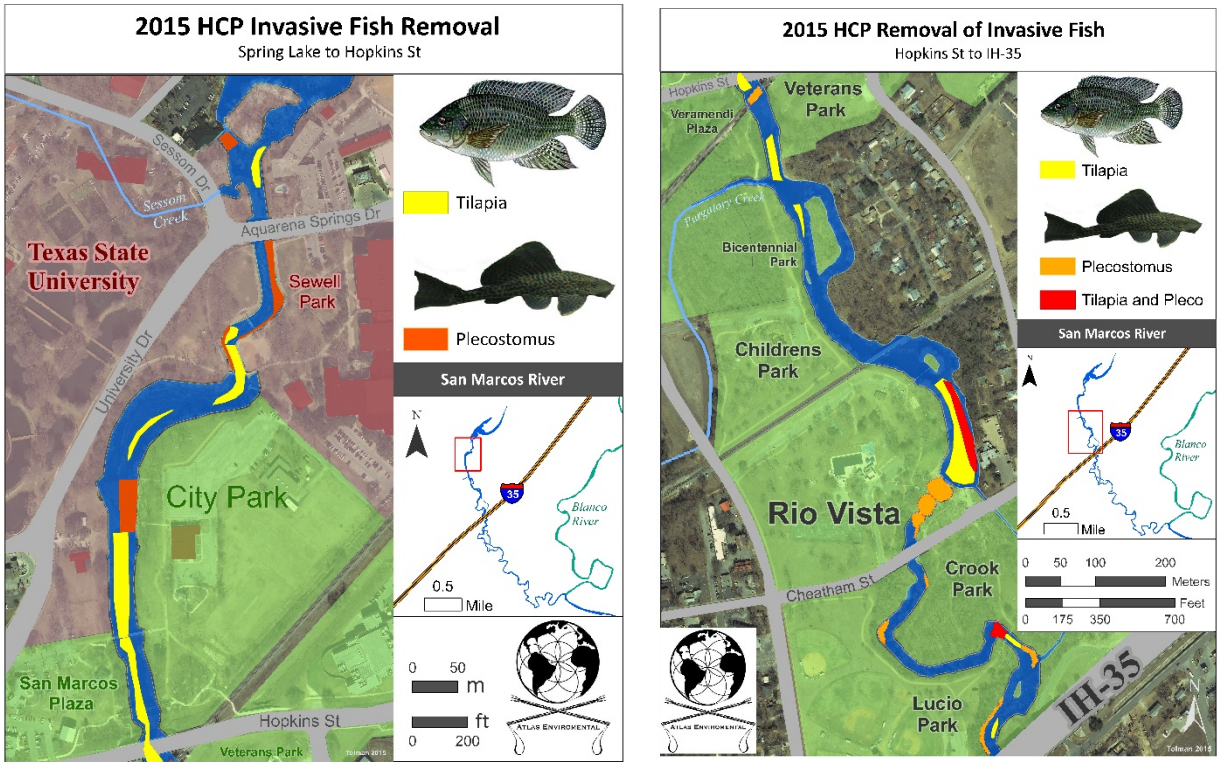

Figure 3.3-40. Treatment areas for suckermouth catfish and tilapia from Spring Lake Dam to IH-35.

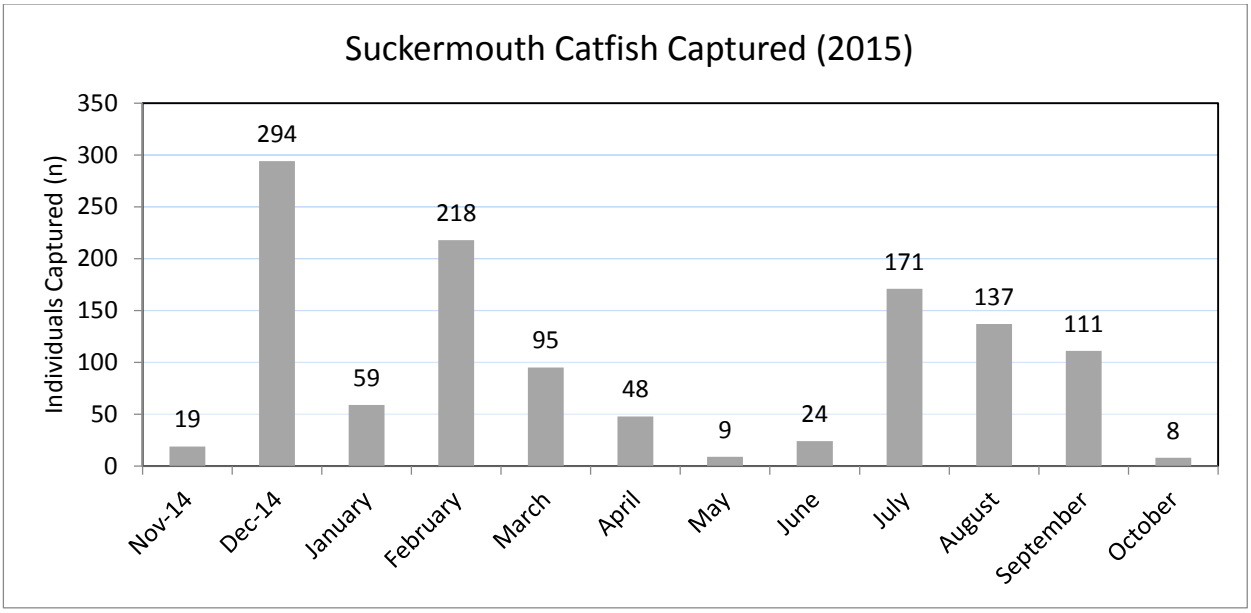

Figure 3.3-41. Number of suckermouth catfish (*Hypostomus plecostomus*) captured from November 2014 to October 2015.

Red-Rimmed Melania and Giant Ramshorn Snail Removal

Early in 2013, Atlas built traps to capture snails in areas of highest concentrations both during the day and at night. However, traps were not as successful or selective as hand-picking snails. Atlas now works areas of large concentrations by hand-collection, and primarily in Spring Lake and by Clear Springs Apartments (**Figure 3.3-42**).

Atlas participated in the EAHCP's public outreach efforts using brochures and posters to inform the public on the impacts of dumping aquaria into rivers. These have been distributed at local pet stores, schools, San Marcos Nature Center and the University. Atlas also set up an educational booth to increase public awareness of non-native invasive fish at the annual Texas wild-rice Festival. With permission from the San Marcos Park Rangers, Atlas programs two week-long pole spear tournaments twice each year to give the community the opportunity to take part in the EAHCP by removing non-native invasive fish.

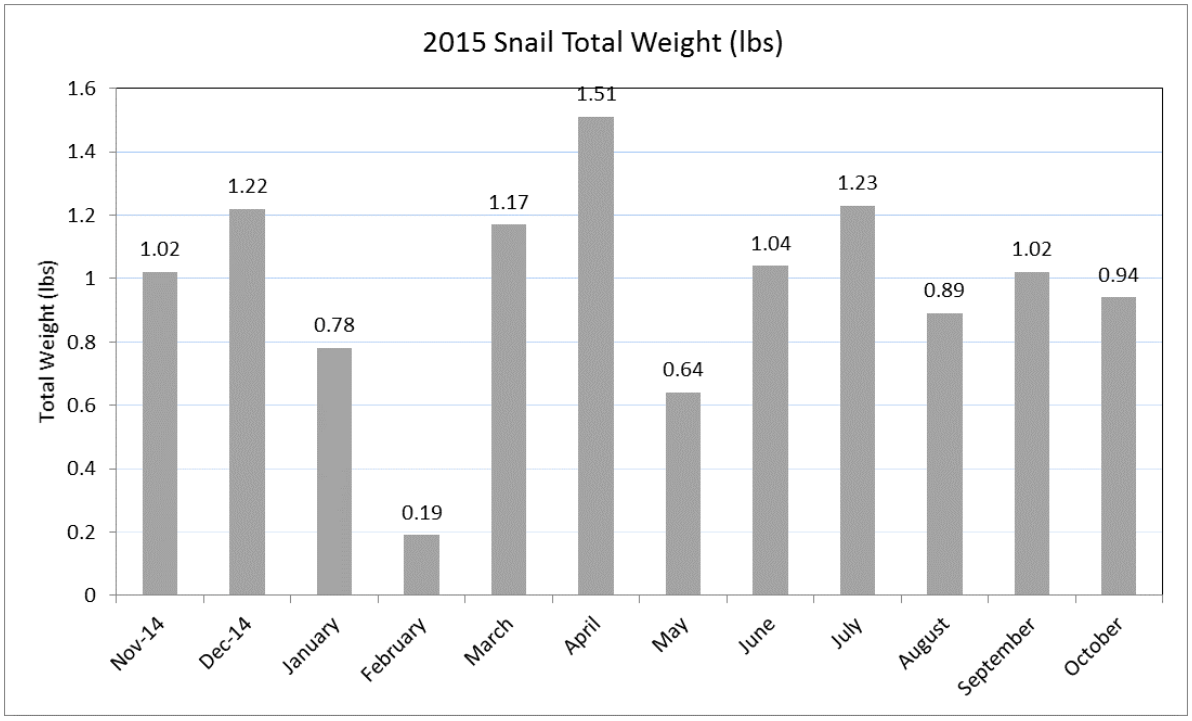

Figure 3.3-42. Number of ramshorn snail removal from November 2014 to October 2015.

Tournaments

Atlas hosts spring and fall spearfishing tournaments that increase the capture of tilapia and suckermouth catfish. Results of the 2015 spring tournament: 23 participants removed 160 suckermouth catfish (104 lbs.) and 29 tilapia (49 lbs.) (**Figure 3.3-43)**. The fall tournament will be held in December 2015 (pushed back by the Halloween flood). The tournament sold out, with 42 participants.

Monitoring Program

Atlas snorkeled in the river from Upper Sewell Park to Rio Vista Falls to perform monthly suckermouth catfish counts. Suckermouth catfish were trending slightly downward in Rio Vista and Sewell Park (**Figure 3.3-44**).

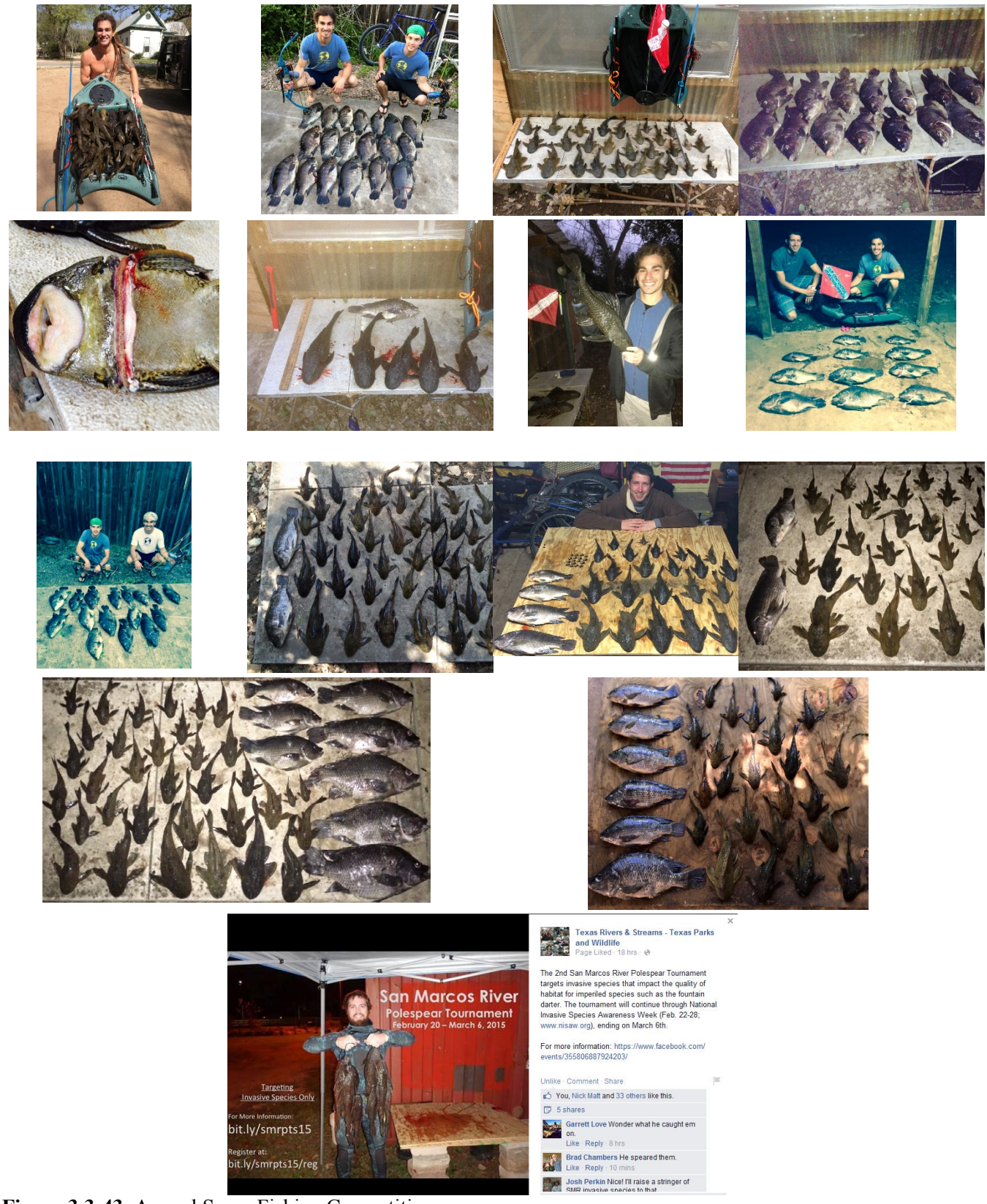

Figure 3.3-43. Annual Spear Fishing Competition.

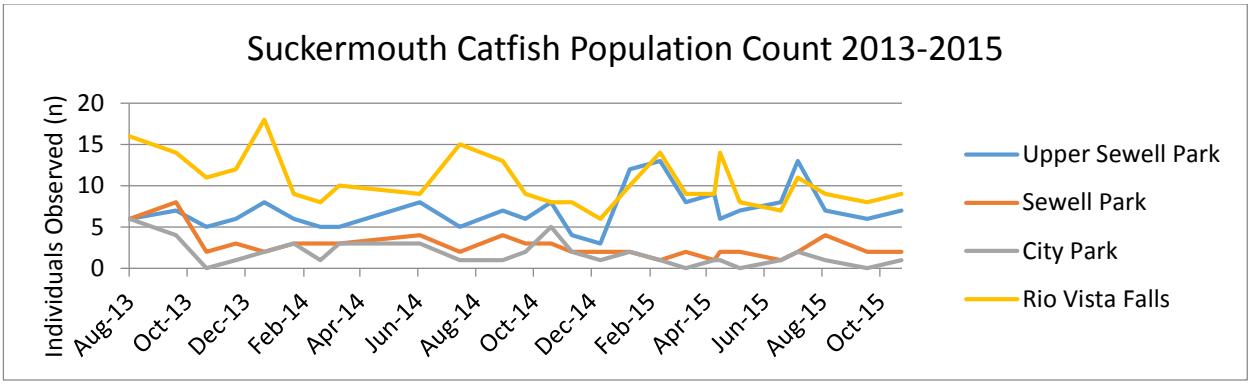

Figure 3.3-44. Suckermouth catfish population count from August 2014 to October 2015.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

In 2016, the COSM will continue regular removal of the tilapia, suckermouth catfish, and snails. Monthly monitoring will continue and include tilapia starting in January 2016. Semiannual tournaments will continue to increase the removal quantities.

To date, the COSM's contractor has not targeted sailfin catfish (*Pterygoplichthys)* in Spring Lake.

3.3.10 Native Riparian Habitat Restoration (EAHCP §5.7.1)

EAHCP Obligations:

The COSM will restore riparian habitats with native species on City property from City Park to Stokes Island. The COSM will establish a program for private landowners to implement riparian restoration on their properties with the opportunity for reimbursement of plant acquisition costs if program criteria are met.

2015 Compliance Actions:

The COSM accomplished non-native tree, shrub and vine removal in Riverhouse, Wildlife Annex and Ramon Lucio parks throughout the spring and autumn of 2015. Plant removal was performed with chainsaws and hand tools. All stumps were treated by EBR and HCP interns. A second removal pass was accomplished in October to capture the regrowth. Erosion control and soil protection practices placed all the straight branches and trunks on contour as well and produced mulch on-site to fill between the contour logs (**Figure 3.3-45**). In Ramon Lucio Park, the logs from the site were not sufficient, so Heritage Tree Care will supplement erosion control with mulch logs. This method has the advantage of creating new germination areas from catching silt and seed in mulch logs and allowed existing seed bank to germinate under the protective layer of mulch. Species removed were Japanese and Chinese privet (*Ligustrum*

Figure 3.3-45. Erosion control and soil protection practices.

japonicum and *L. sinense*), chinaberry (*Melia azedarach*), white mulberry (*Morus alba*), Chinese tallow (*Triadica sebifera*), and Japanese honeysuckle (*Lonicera japonica*). New invasive seedlings were removed in October, mostly by hand-digging or simply pulling.

Most plantings were performed in March-April 2015 and October-November 2015 to take advantage of spring and fall rains. Sites planted included City, Rio Vista, Wildlife Annex, Crooks and Ramon Lucio parks. To reduce costs and involve the community, all plantings were performed by volunteers during scheduled planting days (**Figure 3.3-46**). Plants were sourced from SMARC and Madrone Nursery. Both sources gather seeds from the San Marcos area used to propagate, more specifically, along and adjacent to the San Marcos River, the COSM Nature Center, Ringtail Ridge Natural Area, and Spring Lake Natural Area. In 2015, the COSM implemented a new strategy, as a lesson taken from success of 2014, to combat the drought condition and watering restriction challenges. The COSM has taken a low maintenance approach – planting drought tolerant prohibitive species, littoral species, and relying on the native seed stock to re-populate (**Figure 3.3-47**). In areas of high sun exposure, supplemental watering was required and completed using a temporary TCEQ water permit. Spray irrigation instead of drip was used to allow the entire reclaimed riparian area to start filling in from existing seed stock beyond plantings. Hand-watering with a pitcher from the river was performed in areas without irrigation until plants were established for deep watering efficiency.

Weekly hand watering and weeding were the bulk of the maintenance required in 2015.

Across all sites, a five- to ten-foot buffer zone of access-prohibitive trees, shrubs and vines was planted along the length of the planting zone. This buffer zone of plants was fenced in by the COSM to protect it from trampling. Species were selected as recommended by local plant experts, the U.S. Department of Agriculture (USDA), USFWS, TPWD and TCEQ for riparian restoration projects. The existing plant species composition is very diverse, which will assist the riparian restoration.

Figure 3.3-46. Volunteer native riparian improvement planting.

Figure 3.3-47. COSM use of drought tolerant prohibitive species, littoral species, and native seed stock.

Table 3.3-12 provides a list of species planted at City, Rio Vista, Wildlife Annex, Crooks and Ramon Lucio parks.

Table 3.3-12. List of Species Planted at City, Rio Vista, Wildlife Annex, Crooks and Ramon Lucio Parks

Common Name	Species	Quantity
American elm	*Ulmus americana*	31
Anaqua	*Ehretia anacua*	22
Baby blue eyes	*Nemophila phacelioides*	20
Bald cypress	*Taxodium distichum*	61
Beautyberry	*Callicarpa americana*	8
Black walnut	*Juglans nigra*	19
Black willow	*Salix nigra*	31
Box elder	*Acer negundo*	36
Brushy bluestem	*Andropogon virginicus*	30
Buttonbush	*Cephalanthus occidentalis*	90
Cat claw mimosa	*Mimosa aculeaticarpa*	34
Cedar elm	*Ulmus crassifolia*	28
Chinquapin oak	*Quercus muehlenbergii*	3
Coral vine	*Antigonon leptopus*	7
Cottonwood	*Populus deltoides*	36
Crow-foot sedge	*Carex crus-corvi*	25
Dewberry	*Rubus trivialis*	1
Eastern gamagrass	*Tripsacum dactyloides*	105
Eastern redbud	*Cercis canadensis*	6
Elderberry	*Sambucus canadensis*	57
Emory's sedge	*Carex emoryi*	233
Evergreen sumac	*Rhus virens*	2
Flameleaf sumac	*Rhus lanceolata*	2
Gum bumelia	*Sideroxylon lanuginosum*	1
Honey locust	*Gleditsia triacanthos*	2
Huisache	*Acacia farnesiana*	45

Table 3.3-12. List of Species Planted at City, Rio Vista, Wildlife Annex, Crooks and Ramon Lucio Parks

Common Name	Species	Quantity
Inland sea oats	*Chasmanthium latifolium*	117
Lacey oak	*Quercus laceyi*	13
Lean flatsedge	*Cyperus setigerus*	12
Lindheimer's muhly	*Muhlenbergia lindheimeri*	4
Mexican buckeye	*Ungnadia speciose*	12
Mexican plum	*Prunus mexicana*	14
Osage-orange	*Maclura pomifera*	4
Pecan	*Carya illinoinensis*	25
Pencil cactus	*Opuntia leptocaulis*	40
Pink mimosa	*Mimosa borealis*	97
Possumhaw	*Ilex decidua*	12
Prickly pear cactus	*Opuntia macrorhiza*	25
Red buckeye	*Aesculus pavia*	8
Retama	*Parkinsonia aculeate*	12
Rough-leaf dogwood	*Cornus drummondii*	3
Switchgrass	*Panicum virgatum*	93
Tasajillo	*Cylindropuntia leptocaulis*	40
Sycamore	*Platunus occidntalis*	48
Texas ash	*Fraxinus texensis*	16
Texas mountain laurel	*Sophora secundiflora*	20
Texas red bud	*Cercis canadensis*	2
Texas rush	*Juncus texanus*	60
Trumpet creeper	*Campsis radicans*	4
Vasey oak	*Quercus vaseyana*	6
Western soapberry	*Sapindus saponaria*	15

Figure 3.3-48 through **Figure 3.3-50** depict locations of riparian restoration.

Any Modifications or Activities Due to Weather Conditions:

Low rainfall conditions in combination with planting in April demanded an intense irrigation program throughout the summer. As a result of the Memorial Day and Halloween floods, riparian areas have experienced increased erosion and a general loss of soil and mulch. The loss of riparian plantings was minimal however – estimated at 80 percent survival.

As part of the riparian restoration measure in 2015, the COSM constructed fence for new sites and maintained existing fence line on the upland edge of the riparian plantings to protect them from trampling. Additionally, CC, interns and volunteers installed a number of smaller fences as riparian buffer plantings have expanded in new areas. These fences were intended to be in place for multiple years to allow time for the plants to mature. All of these fences, from upper Sewell Park to Ramon Lucio were flattened by the 2015 Halloween flood.

Figure 3.3-48. River House site (1,000 m^2): invasive removal, and City Park sites (842 m^2): additional native plantings to existing restoration sites.

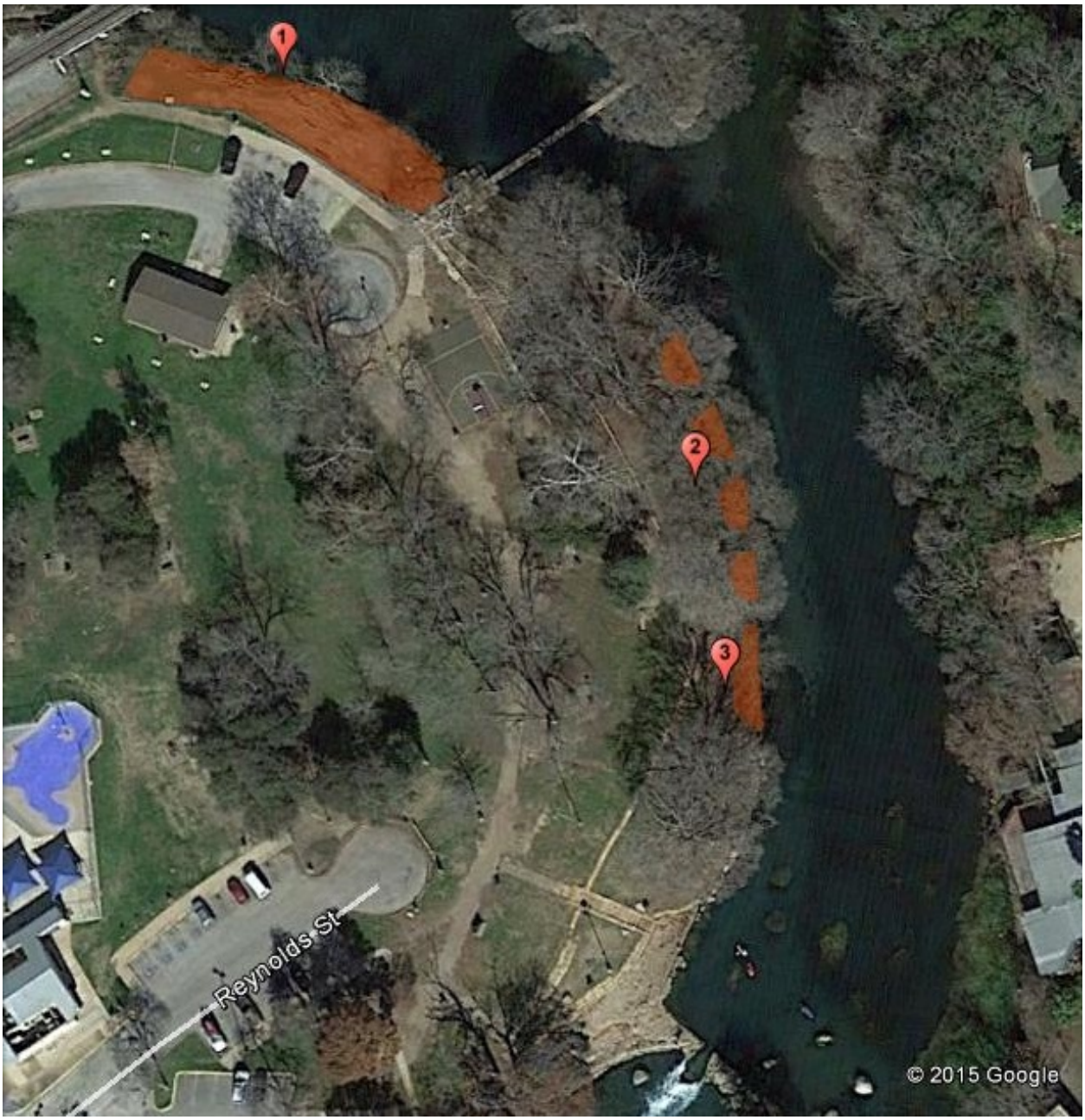

Figure 3.3-49. New riparian restoration at Rio Vista (687 m^2) – Sites 1 & 3: invasive removal and native plantings; and Site 2: native plantings.

Figure 3.3-50. New riparian restoration at Wildlife Annex (6,700 m^2) and Ramon Lucio (3,856 m^2) – Sites 1 & 6: invasive removal and native plantings; Site 4: native plantings; and Sites 2, 3, & 5: invasive removal.

Proposed Activities for 2016:

In 2016, the COSM and Texas State will focus on removal of large invasive species in Ramon Lucio and Wildlife Annex parks and continued removal of invasive regrowth in all previously restored areas. COSM and Texas State will also focus on native plantings that do not require extensive irrigation due to the difficulty of watering new plantings. Restoration efforts will be evaluated for 2016. Fences on COSM property will be repaired prior to recreation season. Texas State will not install new fences, so prohibitive plantings will be densely planted in an effort to deter access to the riparian buffer.

3.3.11 Septic System Registration and Permitting Program (EAHCP §5.7.3)

EAHCP Obligations:

The COSM will establish a registration, evaluation, and permitting program for aerobic and anaerobic septic systems.

2015 Compliance Actions:

As of January 1, 2015, the San Marcos Environmental Health Department had registration records for 599 septic systems within COSM jurisdiction. Since January 1, 2015, three new septic systems were added into service bringing the total number up to 602 to date. These systems have been permitted and evaluated to prevent subsurface pollutant loadings into the Edwards Aquifer or San Marcos River.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

The COSM will continue to implement their septic system registration and permitting program. This program includes the required connection to municipal sewer lines according to COSM Ordinance, Section 86.152.

3.3.12 Minimizing Impacts of Contaminated Runoff (EAHCP §5.7.4)

EAHCP Obligations:

The COSM will excavate and stabilize two areas for the construction of two sedimentation ponds in the vicinity of the San Marcos River. Once funded, construction of these BMPs will be closely monitored for potential impacts to the river system. Upon completion, the COSM will regularly monitor these ponds to remove and properly dispose of accumulated sediments off-site.

2015 Compliance Actions:

The EAHCP calls for the design and construction of two water quality BMPs to be located at Veramendi and Hopkins Street bridge for the purpose of capturing stormwater runoff before it enters the San Marcos River. **Figure 3.3-51** and **Figure 3.3-52** below show the proposed locations of the Hopkins Drainage Channel Pond 1 (near San Marcos Plaza) and Pond 2 (near Veramendi Park). John Gleason, LLC and Complete Watershed Solutions, have completed the concept design report (**Appendix M5**) and this project has been submitted for funding through the U.S. Environmental Protection Agency (EPA) 319 grant. Awards will be announced early in 2016.

Figure 3.3-51. Proposed location for Hopkins Drainage Channel Pond 1 near San Marcos Plaza.

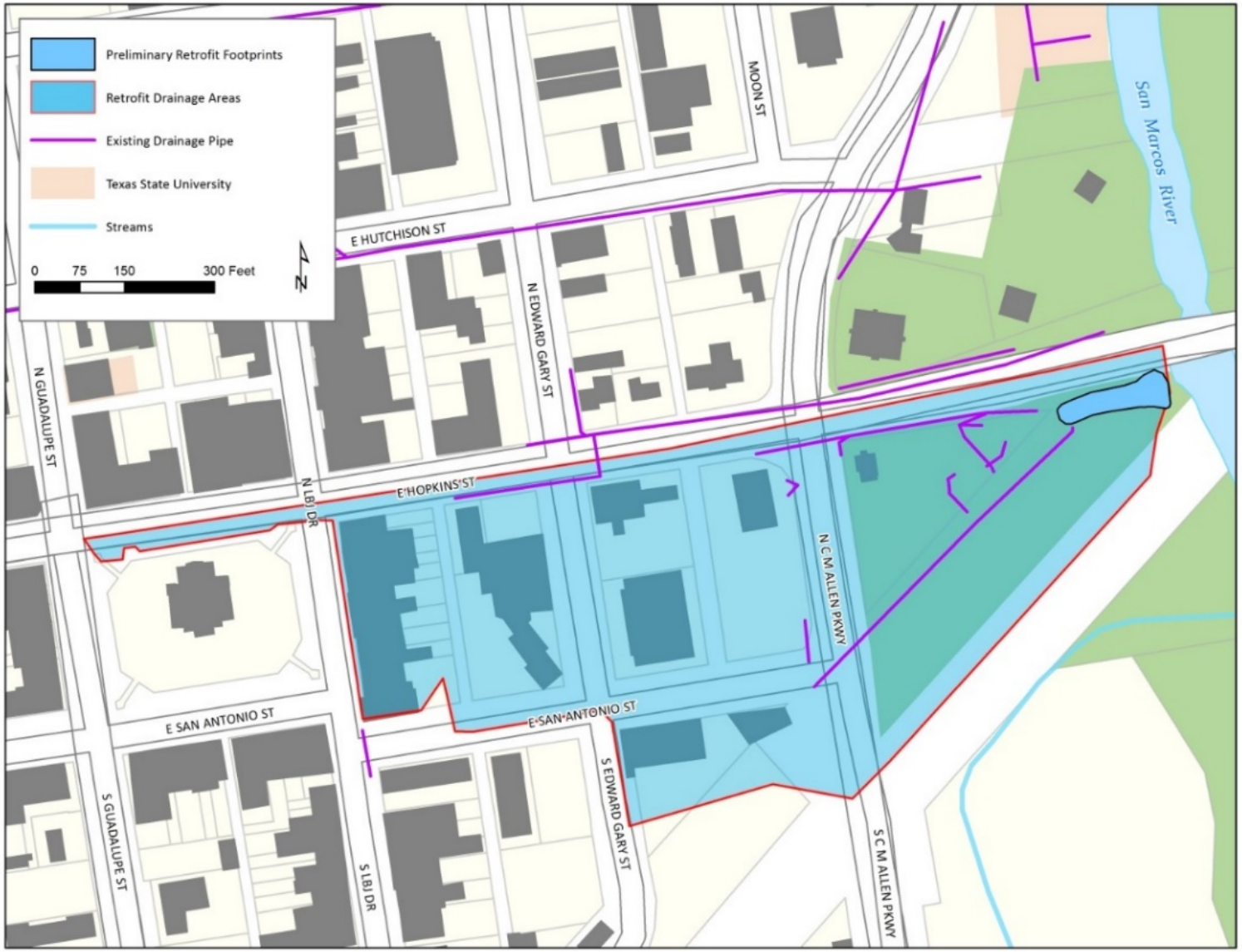

Figure 3.3-52. Proposed location for Hopkins Drainage Channel Pond 2 near Veramendi Park.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

If funded through the EPA 319 grant, the BMPs will be constructed.

3.3.13 Management of Household Hazardous Wastes (EAHCP §5.7.5)

EAHCP Obligations:

The COSM will continue to expand its existing HHW program. This program will include opportunities for collection locations available to the general public.

2015 Compliance Actions:

As a member of the EAHCP, the COSM operates an HHW collection program. This program is available free of charge for all Hays County residents. Visitors are able to drop off household chemicals and paint that are hazardous for the environment. This facility also operates a reuse program for items that are in good condition. Labor for the facility is contracted to Green Guy Recycling. HHW is open to the public every Tuesday and Friday from 12:00 p.m. to 3:30 p.m. It is located at 630 E. Hopkins, San Marcos, TX 78666.

The majority of participants come from the cities of San Marcos, Kyle, Wimberley, and areas outside of the city limits. These areas are home to environmentally sensitive watersheds and the Edwards Aquifer Contributing and Recharge Zones. Offering a safe alternative to improper or illegal dumping of hazardous household chemicals is paramount to improving water quality and regional sustainability.

Drop-Off Center Participation

The primary function of the HHW program is the drop-off center. Residents drive into the unloading area, where they are met by an HHW worker. The participants remain in their vehicle as the worker unloads the containers onto a cart. Each participant fills out a survey and provides their address. From these surveys, monthly participation rates are tracked for each community (**Figure 3.3-53**)

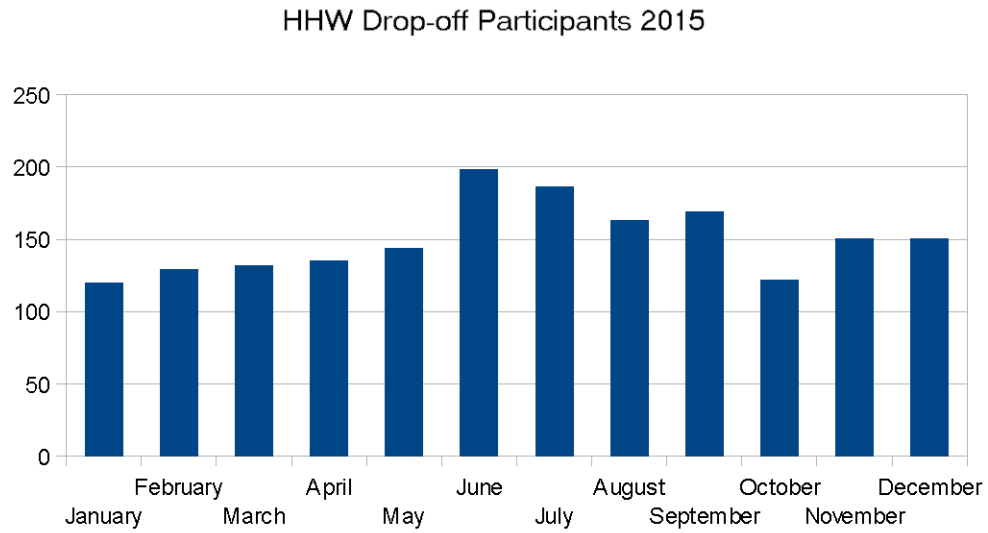

Figure 3.3-53. HHW Drop-off participants in 2015.

The monthly drop-off center participation rates are shown in **Figure 3.3-53**. The data indicates that the summer months are the busiest for traffic to the facility. The average number of participants for 2015 was 150 per month. The average number of participants for 2014 was 122 per month.

The HHW facility is open to all residents of Hays County. As shown in **Figure 3.3-54**, the majority of the residents come from the COSM and areas outside of municipal jurisdictions. The San Marcos region is an environmentally sensitive area for the San Marcos River. Preventing illegal dumping and pollution in this region makes great strides towards improving water quality.

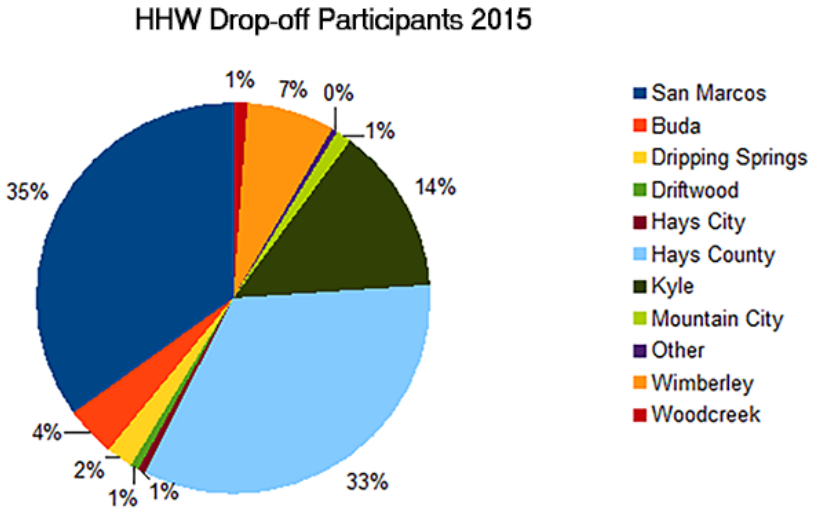

Figure 3.3-54. 2015 Drop-off Center participants by community.

Reuse Program Participation

The reuse program supports the drop-off center by attracting residents and diverting reusable items from the disposal stream. When chemicals are unloaded, the worker segregates new and slightly used containers that are ready for use. Many visitors with items eligible for reuse are in the moving process. Rather than moving all of their cleaning supplies, they have the option to deliver them to the HHW. These items are taken to the reuse building and are sorted on shelves. This building is open to the public during regular operating hours. Reuse participants fill out a form documenting the materials they pick up. This form explains that unused items are to be returned to HHW and not to be thrown into the regular waste stream. Participation for the reuse program has grown over time. The program also serves to educate the public about safe disposal and alternatives to harmful chemicals.

The monthly participation rates for the reuse program in 2015 are shown in **Figure 3.3-55**. The monthly totals range from 45 participants in January, to 95 participants in July. The monthly average is 71 participants. For 2014, the average was 67 participants. This program received many compliments from visitors. Participants save money by collecting reuse items at no cost and the HHW program saves money by reducing disposal expenses.

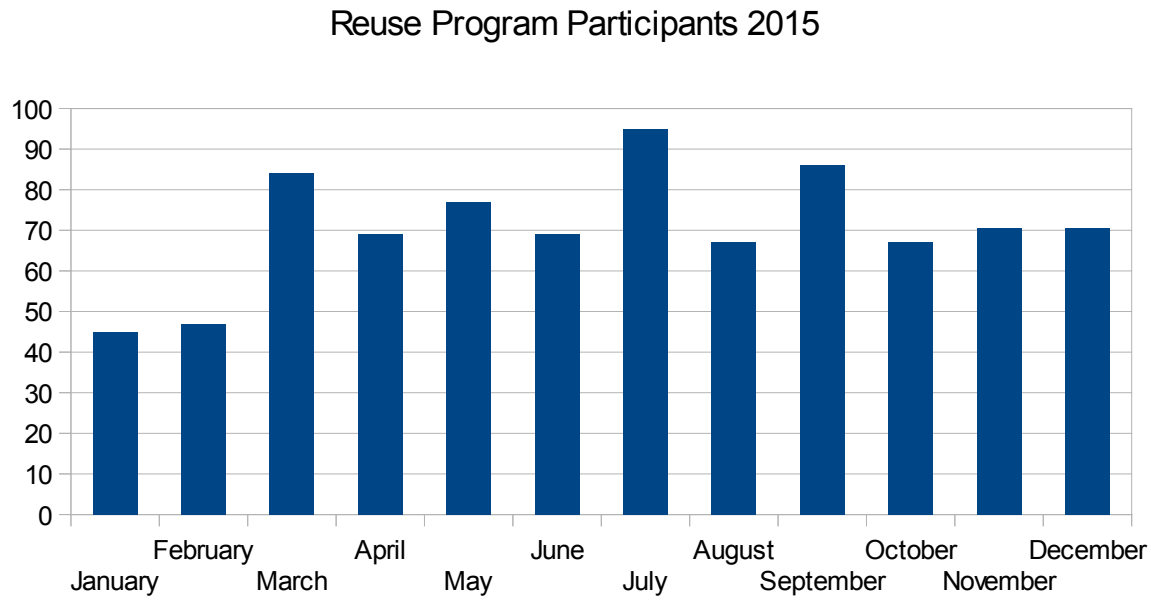

Figure 3.3-55. Reuse Program participants in 2015.

The annual outreach goal for HHW is 1,400 total participants. In 2015, this goal was exceeded by 89 percent with an annual total of 2,646 participants. For 2014, the annual total was 2,462 participants. The popularity of the reuse program and increased exposure through public outreach contributed to the program's success.

The total number of participants from drop-offs and reuse for 2015 are shown in **Figure 3.3-56**. The average was 221 participants per month. The average for 2014 was 205 participants per month. The drop-off center

surveys indicate that the COSM website and word of mouth contributed to the steady program participation. These findings are consistent with the 2014 survey results.

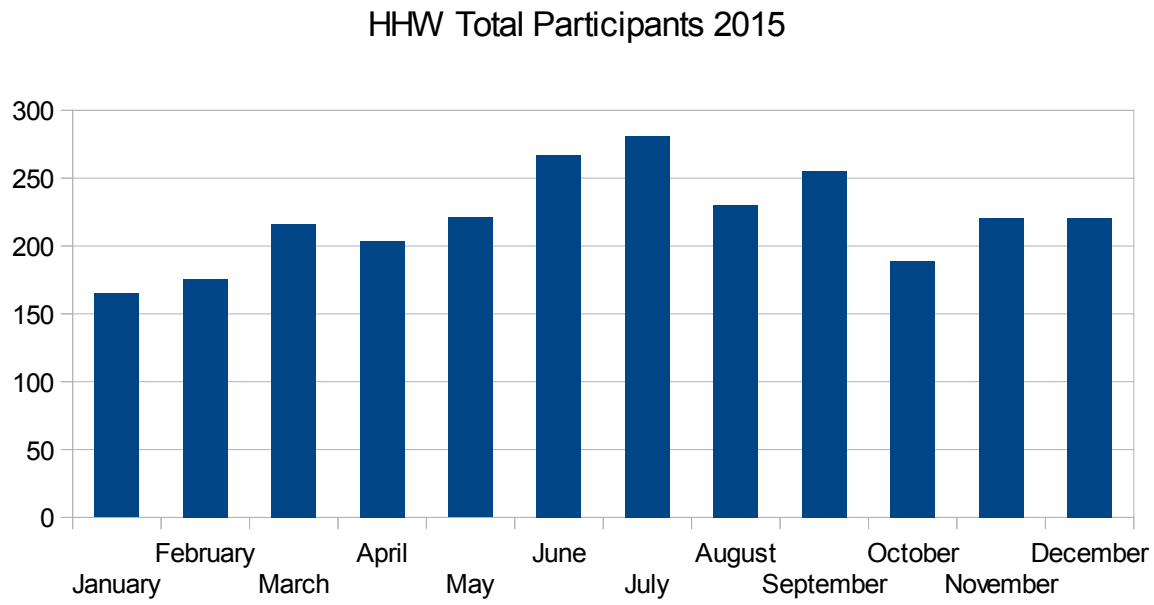

Figure 3.3-56. Drop-off and reuse participants in 2015.

The Chemicals

The household hazardous materials accepted by HHW include a wide-range of common chemicals and waste products. After the household waste is unloaded from the vehicle, the material is sorted and weighed. Each item is sorted based on chemical type. HHW facility workers collaborate with the chemical disposal company to evaluate the waste stream and finding storage and shipping options that reduce the expense. For example, oil based and latex paint, liquid flammables, used motor oil, cooking oil, and anti-freeze are bulked into 55-gallon drums. The remaining chemicals are sorted into either 55-gallon drums or lined gaylord boxes. Each container is stored in a chemical building or under cover until they are shipped to recycling facilities and a chemical landfill.

Figure 3.3-57 includes a complete list of materials accepted at HHW.

Materials Accepted
Latex Paint
Oil Based Paint
Flammable Liquids and Solids
Pesticides
Liquid and Solid “9’s”
Acids
Bases
Oxidizers
Aerosol
Oil and Oil Filters
Anti-Freeze
Cook Oil
CFLS
Fluorescent Bulbs
Mercury Vapor Bulbs
Batteries
Propane
Expandable Foam
Smoke Detectors and Thermostats
Unknown Materials

Figure 3.3-57. Household chemicals accepted at HHW.

HHW disposed of approximately 59,630 kilograms of HHW in 2015. Without this program, much of this waste would have been improperly disposed of in the municipal waste stream or illegally dumped. The monthly totals for HHW disposal are shown in **Figure 3.3-58**. Monthly figures range from 3,703 kilograms in August, to 6,933 kilograms in June. Drop-off disposal weights for 2015 averaged 4,969 kilograms per month.

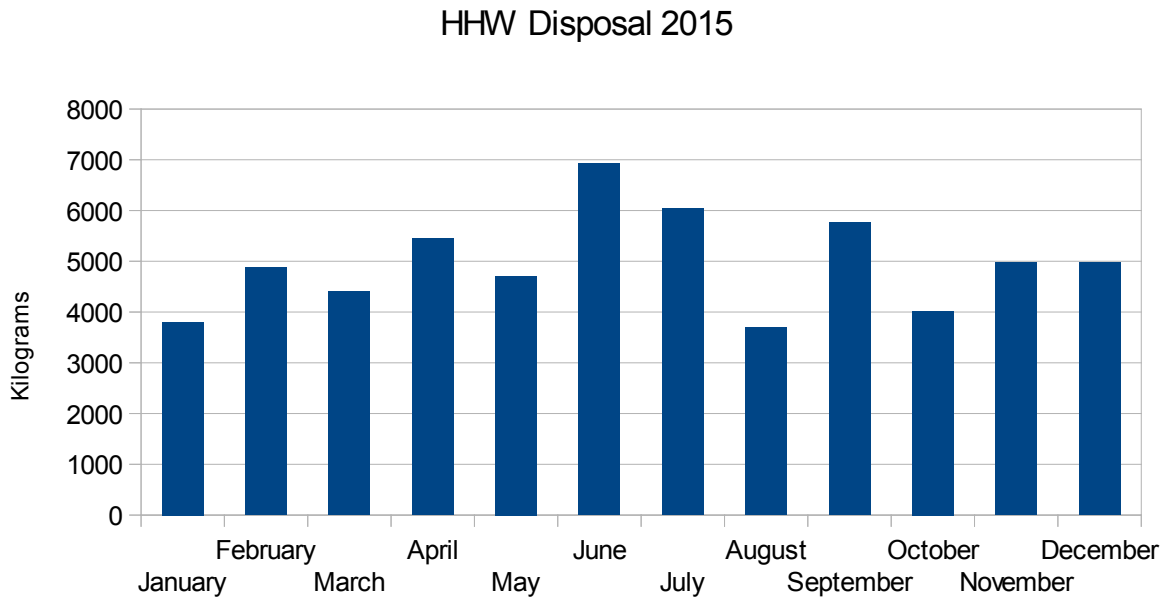

Figure 3.3-58. HHW disposal weights for 2015.

The amount of household hazardous waste diverted from the waste stream and distributed by the Reuse Program totaled 5,769 kilograms. Not only does this save on costs, it also decreases the demand for new products. The program helps with both material reuse and waste reduction.

The monthly quantities of waste distributed by the reuse program are shown in **Figure 3.3-59**. The average amount reused was 481 kilograms per month. The amounts ranged from 155 kilograms in February, to 748 kilograms in July.

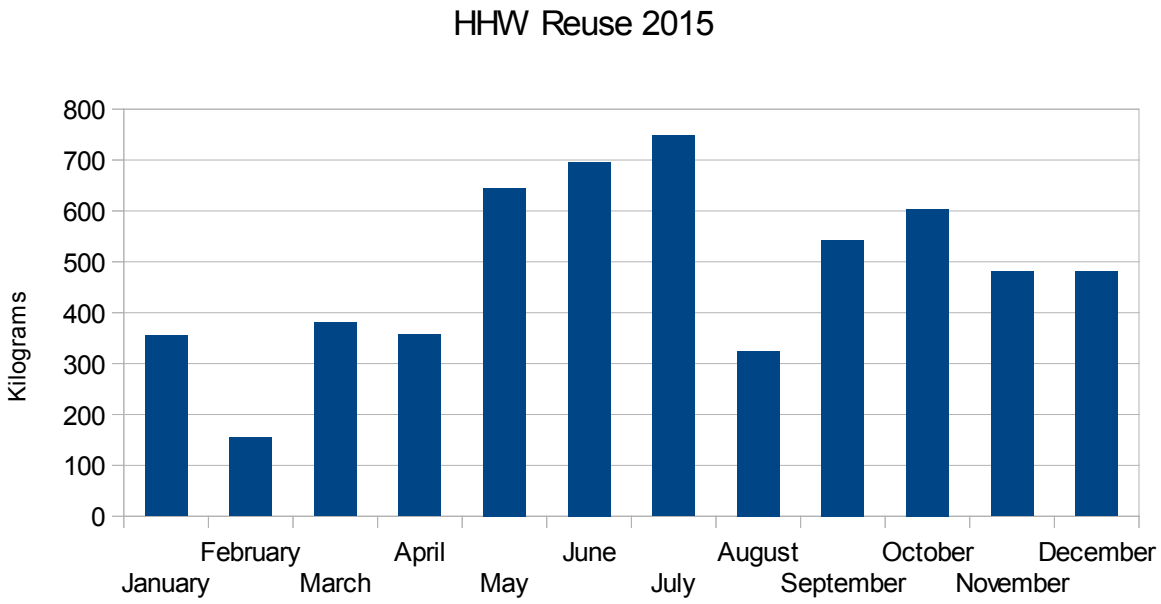

Figure 3.3-59. HHW reuse weights in 2015.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

Moving forward, the COSM's goal for 2016 is to increase participation rates and continue to inspire greater awareness of the impact of HHW on the environment, particularly Covered Species habitat.

3.3.14 Impervious Cover and Water Quality Protection (EAHCP §5.7.6)

EAHCP Obligations:

The COSM will establish a program to protect water quality and reduce the impact of impervious cover. Target programs will be identified consistent with the recommendations of the LID/Water Quality Work Group Report developed during the EARIP and included as Appendix Q to the EAHCP.

The San Marcos WQPP is a locally-developed approach for compliance with the ESA in San Marcos, Texas. The intent of the WQPP is to provide a holistic, integrated approach for Texas State and the COSM in regards to water quality concerns associated with impervious cover and urban development. In addition to protecting habitat for endangered species, the WQPP will help the entities serve the needs of their growing populations and promote responsible economic development, good public infrastructure, and preserve open space.

2015 Compliance Actions:

The following services were performed in support of the 2015 WQPP during this period.

- Completed BMP spreadsheet model
- Updated retrofit geodatabase and costing tool
- Updated the 2014 WQPP with revisions based on stakeholder feedback
- Completed City Park BMP design and specifications
- Provided review of several public and private projects including Veteran's Park skateboard facility for BMP inclusion
- Developed and delivered presentation for staff and consultant BMP workshop
- Presented the WQPP at the CodeSMTX environmental workshop
- Submitted BMP projects for funding through the EPA 319 grant process
- Developed examples of water quality protection strategies for transition zone for city adoption
- Modified recharge zone water quality code, cluster incentives and landscape ordinances are part of the CodeSMTX process
- Landscape design for rain gardens treating the Stagecoach Trail widening project
- Began development of a land conservation program

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

In 2016, the COSM and Texas State will continue implementation of the WQPP, including participation from all jurisdictional watershed areas that directly or indirectly impact the Covered Species. The COSM will continue development of new land development code, BMP design criteria, a land conservation program and an educational program to accompany the roll-out of the Protection Plan. Once adopted by both COSM and Texas State, specific recommendations within the WQPP will be implemented. The WQPP team will continue to design and oversee construction of structural BMPs within the COSM and on the Texas State campus throughout 2016 (including those with potential EPA 319 grant funding).

3.3.15 Challenges Observed and Identified Solutions

In 2015, the COSM experienced the following challenges:

- Recreation on the eastern spillway in upper Sewell Park has significantly increased over the past two years and is causing the same impacts as seen in City Park and Rio Vista, resulting in complete loss of aquatic vegetation, bank compaction, and trails through the planted riparian buffer. To help this situation, the COSM is working with Texas State to fix the riparian fence on river left and establish pathways and plantings on river bank right. Signage will be introduced to educate river users about Covered Species habitat. If the eastern spillway and left bank could be protected zones, this would be the best solution.
- The flood/drought cycle changes the water level, thus making it difficult to keep the t-posts in the Texas wild-rice exclosures safe with regard to river users. All exclosures (with the exception of upper Sewell) will consequently be removed.
- Fine sediment removal is a very slow process, with minimal area treated relative to the labor costs. The 2015 Halloween flood revealed that the largest damage to aquatic plants was the deposition of gravel/cobble from Sessom Creek, not fine silts. Treating sedimentation at the source may be more critical than attempting to recover from poor watershed practices. This challenge requires review by the EAA and the IC.
- The challenge of determining success of the invasive fish removal program is being addressed by a continuous monitoring regime in which suckermouth catfish are counted in the same locations monthly. This program began in August 2013 and shows the locations in which suckermouth catfish are decreasing/increasing. This program needs to be accomplished for tilapia also.
- Riparian and water quality buffer plantings have been 75 percent successful. Water is a limiting factor (no source), so the COSM moved to a different planting regime to avoid long-term watering. Success will be determined by fall of 2016.
- The plants listed in Table 4-21 of the EAHCP have been difficult to establish in all designated segments of the San Marcos River. Consequently, the EAHCP is conducting a study to determine, if appropriate, whether the methodologies and/or vegetative goals need to be modified in order to achieve the Biological Goals of the EAHCP.
- Due to an increase in summer recreational use in the San Marcos River, there was a corresponding increase in litter, which could not be controlled despite the large number of resources working to keep the parks and river clean. The COSM's Parks & Recreation Department is working on various solutions.
- As the COSM continues to work towards a comprehensive solution, the current strategy is to keep working on the low-hanging fruit to make slow progress in watershed protection.
- Limited hours and location are a challenge for the growth of the HHW program. The facility is open from 12:00 p.m. to 3:30 p.m. every Tuesday and Friday. Many participants are unable to access the facility during operating hours because of typical work schedules and the distance from areas within the county. The mobile event in Dripping Springs, Texas, during the summer was successful because it made the facility available to an area that is relatively far from the main facility. This event was also successful because it was held on a Saturday. Moving forward, additional mobile events and extended hours will increase participation for the facility.

3.4 Texas State University

Texas State is responsible for the following measures under the EAHCP:

- Texas wild-rice Enhancement and Restoration (§5.4.1 and §6.3.5)
- Management of Recreation in Key Areas (§5.4.2)
- Management of Vegetation (§5.4.3)
- Sediment Removal in Spring Lake and Sewell Park (§5.4.4)
- Diversion of Surface Water (§5.4.5)
- Restoration of Native Riparian Vegetation (§5.7.1)
- Sessom Creek Sand Bar Removal (§5.4.6)
- Diving Classes in Spring Lake (§5.4.7)
- Research Programs in Spring Lake (§5.4.8)
- Management of Golf Course and Grounds (§5.4.9)
- Boating in Spring Lake and Sewell Park (§5.4.10)
- Reduction of Non-Native Species Introduction (§5.4.11)
- Control of Non-Native Plant Species (§5.4.12)
- Control of Harmful Non-Native and Predator Species (§5.4.13)

Implementation of these measures has been accomplished in partnership with the COSM, as specified in the EAHCP. Modifications due to weather conditions are discussed in the subsections below. Texas State extended its EAHCP obligations in partnership with the COSM to maintain consistency in implementation of EAHCP measures that jointly affect the Covered Species and their habitats in the San Marcos River.

3.4.1 Texas wild-rice Enhancement and Restoration (EAHCP §5.4.1 and §6.3.5)

EAHCP Obligations:

Texas State, in partnership with the COSM, will identify optimal habitat areas for Texas wild-rice and target those areas for restoration. Restoration will involve the removal of non-native plant species, propagation of new wild-rice plants, and continued monitoring of the new stands. The COSM will use modeling results from Texas State and TPWD to determine appropriate sites for restoration to ensure the best possible success rate.

2015 Compliance Actions:

Non-native aquatic vegetation was removed in areas suggested as optimal Texas wild-rice habitat, based on modeling results from Hardy et al. 2010. Non-native vegetation was also removed in mixed stands of Texas wild-rice, and the original Texas wild-rice stand was monitored for expansion. Similarly, for Texas wild-rice stands occupying optimal areas with adjacent non-native vegetation, the non-native vegetation was removed. Non-native vegetation was fanned to displace fountain darters prior to uprooting the vegetation. After removal, all non-native vegetation was sorted and any fountain darters (or other native species) were salvaged and returned to the river. The non-native vegetation was disposed at the COSM composting facility. Texas wild-rice was not planted in the San Marcos River from Spring Lake Dam downstream through Sewell Park from November 2014 through October 2015. Instead, area maintenance

was performed through the removal of non-native species and continued monitoring of existing Texas wild-rice stands. Areal coverage of Texas wild-rice was assessed using geo-referenced aerial imagery collected with a quadcopter in conjunction with ground-truthed data collected using Trimble GPS units.

Texas wild-rice coverage within MCWE work sites in the San Marcos River from Spring Lake Dam downstream through Sewell Park has continued to increase since 2013, when it was measured at an estimated 864.83 m^2 in the upper and lower Sewell reaches. In 2014, the total area increased to approximately 1,198.89 m^2, an increase of 909.45 m^2, or 105 percent, from 2013. In November 2015, the area was estimated at 1,774.28 m^2, which is an estimated increase of 575.39 m^2, or 48 percent, from 2014 (**Table 3.4-1**, **Figure 3.4-1**). **Figure 3.4-1** denotes areal coverage changes in Texas wild-rice and other native species from 2013-2015 among MCWE work sites in the upper and lower Sewell Park reaches of the San Marcos River.

Table 3.4-1. Estimated Areal Coverage (m^2) of Texas wild-rice Within MCWE Work Sites in Texas State Reaches of the San Marcos River (2013-2015)

Area Calculations for Texas wild-rice (m^2)			
Reach	2013	2014	2015
Upper Sewell	198.50	360.22	572.79
Lower Sewell	666.33	838.67	1,201.49
Totals	**864.83**	**1,198.89**	**1,774.28**

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Areas of Sewell Park reaches were scoured during the October 30, 2015 flood event resulting in changes of Texas wild-rice areal coverage. Areas of scour and Texas wild-rice loss can be observed in **Appendix M1** with images of the October 2015 flood event.

Proposed Activities for 2016:

In 2016, Texas State will continue to maintain existing Texas wild-rice stands through selective gardening within and around existing stands and plantings where non-native vegetation and silt is removed. These strategies will target a goal of adding 1,100 m^2 of additional Texas wild-rice to the system.

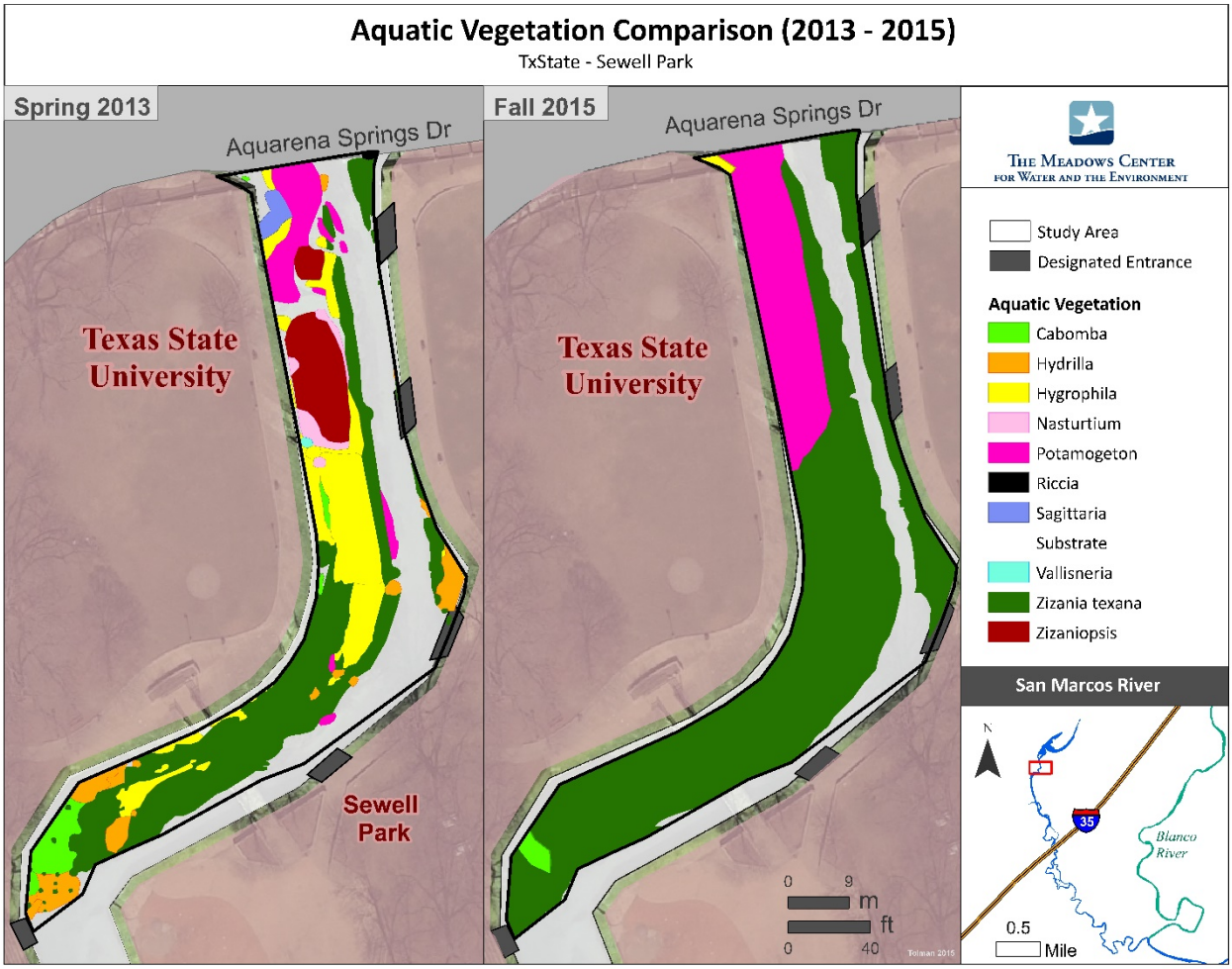

Figure 3.4-1. Difference in areal coverage Texas wild-rice and other native species from 2013-2015 among MCWE work sites in the Sewell Park Reaches of the San Marcos River.

3.4.2 Management of Recreation in Key Areas (EAHCP §5.4.2)

For discussion related to Texas State's *EAHCP Obligations*, *2015 Compliance Actions*, *Any Modifications or Activities Due to Weather Conditions*, and *Proposed Activities for 2016* related to this Conservation Measure, please refer to the discussion under the **Section 3.3** – City of San Marcos, **subsection 3.3.2** – Management of Recreation in Key Areas.

3.4.3 Management of Vegetation (EAHCP §5.4.3)

EAHCP Obligations:

Texas State will utilize hand-cutting and a harvester boat to manage aquatic vegetation in Spring Lake. Related activities include:

- Weekly, floating vegetation mats will be dislodged in five springs; each spring will be addressed every two to three weeks.
- Floating vegetation mats will be dislodged more frequently in the summer.

- Floating vegetation mats will be dislodged from Texas wild-rice stands weekly.
- Algae will be removed regularly in the summer.
- Accumulated sediments around spring orifices will be removed within a 1.5-meter buffer radius.
- From 1.5 to 3.0 meters from spring orifices, vegetation will be sheared to a height of 30 centimeters (cm) and from 3.0 to 6.0 meters from the orifice, vegetation will be sheared to a height of one meter.
- Fifteen to 20 boatloads of plant material will be removed by the harvester boat monthly; including weekly removal from designated zones one, two, and three (EAHCP Figure 5.2).
- Removed vegetation will be inspected for aquatic species that will be returned to the river system immediately.
- Vegetation mats will be removed from zones four and five (EAHCP Figure 5.2) on an as-needed basis.
- Texas State employees or others working with and around Texas wild-rice will be trained by TPWD to recognize and protect the plant while doing work in the San Marcos system.
- All vegetation removal activities on Texas State property will be managed by a full-time staff person responsible for operating the harvester boat, manually removing floating vegetation mats, and ensuring all staff and volunteers involved in vegetation removal are familiar with the aquatic ecosystem and able to recognize Covered Species.

2015 Compliance Actions:

Management of Submerged and Floating Aquatic Vegetation in Spring Lake

- Spring Orifice Maintenance: Texas State personnel at the MCWE in conjunction with qualified Diving for Science (D4S) volunteers removed accumulated sediment where necessary from target springs in Spring Lake by finning the substrate away. In addition, aquatic vegetation was removed from an approximately 1.5 meter radius of each target spring with a machete. The aquatic vegetation within the next 1.5 meter radius area around each target spring was cut to a height of 30 cm and the cut material allowed to flow downstream with the current. Aquatic vegetation within the next three-meter radius of target springs was sheared to height of one-meter and cut vegetation allowed to drift downstream. **Table 3.4-2** provides a summary of work conducted for this EAHCP measure.

Table 3.4-2. Aquatic Vegetation Maintenance Activities Within Spring Lake in 2015

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Totals
Aquatic Maintenance (approximate dives)	15	15	15	15	15	25	25	10	15	15	20	0	**195**
Aquatic Maintenance Dive Hours (average 1.25 hrs/dive)	19	19	19	19	19	31	31	13	19	19	25	0	**244**
D4S Volunteers	71	70	102	46	77	81	149	136	56	122	69	0	**890**
D4S Dive Hours (average 1.25 hrs/dive)	89	88	128	95	96	101	186	170	148	153	86	0	**1,339**

- Harvester Boat: Management of submerged and floating aquatic vegetation followed the protocols outlined in the EAHCP (EAHCP §5.4.3.1) and the approved Spring Lake Management Plan. The harvesting schedule targets three cuts per week, typically on Monday, Wednesday, and Friday mornings. Scheduled harvesting of each zone rotates in order to allow each zone adequate recovery time and ensure that a specific zone is not over cut. This results in each zone being cut two or three times a month. The estimated aquatic vegetation harvest is approximately 10 to 12 yd^3 per cutting. The total estimated harvest is approximately 1,112.5 yd^3 for the year.

Management of Aquatic Vegetation below Spring Lake Dam to City Park

Texas State collaborated with the COSM to control aquatic vegetation mats entrained on Texas wild-rice stands below Spring Lake Dam to the end of Sewell Park. Aquatic vegetation removal was conducted by PTR by pushing floating mats downstream, as specified in the EAHCP. In addition, personnel at the MCWE and COSM's CC supplemented vegetation removal during low flows.

Any Modifications or Activities Due to Weather Conditions:

Drought increased frequency of aquatic vegetation removal activities.

Proposed Activities for 2016:

In 2016, Texas State will continue to implement floating vegetation mat and litter removal consistent with protocols established in the EAHCP and in the 2015 Work Plan.

3.4.4 Sediment Removal in Spring Lake and Sewell Park (EAHCP §5.4.4)

EAHCP Obligations:

Texas State will remove accumulated sediments from Texas wild-rice habitat in Spring Lake and from Spring Lake Dam to City Park. Sediments will be removed using hydrosuction. Protective measures including finning, controlled use of the vacuum hose, and clear boundaries for divers will limit any impacts to the species.

2015 Compliance Actions:

No dredging occurred from the San Marcos River in Spring Lake through Sewell Park during 2015.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

In 2016, areas of sediment accumulation in Spring Lake will be addressed due to the receipt of a TPWD Sand & Gravel Permit recently obtained by the EAA. Sediment in the slough will not be removed due to excessive amount and poor cost/benefit ratio.

3.4.5 Diversion of Surface Water (EAHCP §5.4.5)

EAHCP Obligations:

Texas State will reduce the amount of surface water diverted from the San Marcos River in accordance with the following conditions:

- Reduce diversion by two cfs when the USGS gauge at University Bridge reads 80 cfs (reduction made below Spring Lake Dam).
- Reduce diversion by an additional two cfs (total four cfs) when the USGS gauge at University Bridge reads 60 cfs (reduction made in Spring Lake).
- Reduce diversion by all but one cfs when the USGS gauge at University Bridge reads 49 cfs (reduction made in the Sewell Park reach).
- Cease all surface water diversions when the USGS gauge at University Bridge reads 45 cfs.

Texas State will additionally use, maintain, and monitor 0.25-inch mesh screen covers at the intake for the surface water diversion.

2015 Compliance Actions:

Texas State did not reduce permitted pumping in 2015 to meet EAHCP requirements, since total San Marcos River flows did not reach trigger points (i.e., < 80 cfs). Texas State did, however, continue to voluntarily suspend pumping from the San Marcos River at Sewell Park (Certificate 18-3866). The total volume of surface water diversions from Spring Lake was 38 ac-ft/year for 2015, and below the permitted 100 ac-ft/year. Maximum instantaneous diversion rates did not exceed the permitted amount of 1.33 cfs.

Texas State continued to use a 0.25-inch mesh screen to cover the intake for surface water diversions. The mesh screen prevents the suctioning of fountain darters and other protected biota into the diversion pumps. The screens were routinely inspected and cleaned as part of regular operations. No fountain darters were observed when the screens were cleaned.

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

In 2016, Texas State will reduce or cease the diversion of surface water as required by flow conditions and described in the EAHCP.

3.4.6 Restoration of Native Riparian Vegetation (EAHCP §5.7.1)

For discussion related to Texas State's *EAHCP Obligations*, *2015 Compliance Actions*, *Any Modifications or Activities Due to Weather Conditions* and *Proposed Activities for 2016* related to this Conservation Measure, please refer to the discussion under the **Section 3.3** – City of San Marcos, **subsection 3.3.10 –** Native Riparian Habitat Restoration.

3.4.7 Sessom Creek Sand Bar Removal (EAHCP §5.4.6)

EAHCP Obligations:

Texas State, in partnership with the COSM, completed a study to determine the most appropriate technique for removal of the Sessom Creek Sand Bar. The modeling results and removal method recommendation was reviewed by the SC and approved by the IC.

2015 Compliance Actions:

The Adaptive Hydraulics Modeling System (version 4.31, Berger et al. 2013) was utilized to model existing conditions and three alternative scenarios that ranged from full sediment bar removal to differential channel configurations. The report recommended removal using backhoe and was approved by the SC and the IC.

Any Modifications or Activities Due to Weather Conditions:

The 2015 Halloween flood magnified the deposition at the confluence, so it is unlikely that removal will handle the additional deposition.

Proposed Activities for 2016:

Texas State will review and consider possible removal of the gravel bar at the Sessom Creek confluence.

3.4.8 Diving Classes in Spring Lake (EAHCP §5.4.7)

EAHCP Obligations:

Every diver participating in the Texas State's D4S Program will need to show an understanding of the Covered Species found in Spring Lake and their habitats, as well as the laws and regulations relevant to those species. Divers must exhibit good buoyancy control, have the ability to avoid contact with listed species and critical habitat, and maintain a distance from the lake bottom.

No more than 16 trained divers may be present in Spring Lake at any time. Texas State will conduct training for check-out dives and SCUBA classes no more than three times per day, and classes will include a maximum of twelve students per class.

2015 Compliance Actions:

MCWE updated the Spring Lake Management Plan to reflect all the requirements under the EAHCP and ITP. This includes the following EAHCP measures:

- D4S Program (§5.4.7.1)
- Texas State Continuing Education (§5.4.2)
- Texas State SCUBA Classes (§5.4.7.3)

The revised plan implements the EAHCP requirements with the following restrictions:

- D4S Program – No more than 16 volunteer divers/day and ≤ 8 at one time
- Texas State Continuing Education – 12 divers/class; ≤ 3 classes/day; restricted to the Dive Training Area
- Texas State SCUBA Classes – 12 students/class; ≤ 3 classes/day; restricted to the Dive Training Area

The revised Spring Lake Management Plan was submitted and approved by the President's Cabinet in 2012. As part of this effort, MCWE implemented a Diving Program Control Board that reviews all diving activities within Spring Lake to ensure they comply with the Spring Lake Management Plan and the EAHCP. These efforts also include the development of the Spring Lake Dive Accident Management Plan and revised D4S Program, which has implemented a more rigorous training program that includes expanded training and orientation on the endangered species. Diving activities in Spring Lake are summarized in **Table 3.4-3**.

Table 3.4-3. Diving Activities in Spring Lake in 2015

Activity FY 2015	January	February	March	April	May	June	July	August	September	October	November	December	Reporting Period Totals
Aquatic Maintenance (approximate dives)	15	15	15	15	15	25	25	10	15	15	20	0	185
TXST Student Dives	0	0	38	30	11	50	40	2	0	39	89	0	299
Public Divers	198	254	275	126	409	288	268	212	129	113	188	0	2,460
Volunteer Divers	71	70	102	76	77	81	149	136	118	122	69	0	1,071
SCI Student Dives	0	0	0	0	0	0	0	0	0	0	0	0	0
SCI Class Dives	0	0	0	0	0	0	0	0	0	0	0	0	0
Research Dives	6	6	2	10	2	8	3	6	2	10	4	0	59
External Dives (EAA, FWS, etc.)	8	8	2	2	7	4	0	4	3	3	4	0	45
New volunteers	14	20	35	40	6	16	14	39	9	0	8	0	201
Wounded Warriors (groups not individual #'s)	0	1	0	1	0	0	0	0	0	0	0	0	2
Totals	**312**	**374**	**469**	**300**	**527**	**472**	**499**	**409**	**276**	**302**	**382**	**0**	**4,322**

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

In 2016, Texas State will implement their diving class program consistent with the protocols identified in the EAHCP.

3.4.9 Research Programs in Spring Lake (EAHCP §5.4.8)

EAHCP Obligations:

No research will be conducted in Spring Lake without prior review and approval by the MCWE to assess impacts to the Covered Species. Where take cannot be avoided, Texas State will provide education to researchers regarding the species and their habitats. Independent researchers may need to obtain individual permits from the USFWS.

2015 Compliance Actions:

The Chief Science Officer at the MCWE chairs the Spring Lake Environmental Committee, which oversees all access to Spring Lake. To this end, MCWE developed an online access request form (http://www.aquarena.txstate.edu/Diving-for-Science/Access.html). Each request is reviewed by an eight-member committee, and if a vertebrate animal is the target of research the Institutional Animal Care and Use Committee is also consulted for approval. In the event that the proposed research involves diving, the application and methods are reviewed by the Spring Lake Diving Control Board and, if necessary, Scientific Diving training is required prior to access. **Table 3.4-4** summarizes the research/access activities in Spring Lake for 2015.

Table 3.4-4. Research and/or Access Activities on Spring Lake in 2015

Approved Research Activities FY 2015					
Researcher	**Department/Agency**	**Duration**		**Description**	**Impact +/-**
Nick Menchaca	Atlas	09/01/14	Still Active	Invasive animal removal	Minimal
Eston Loving	EBR	09/01/14	Still Active	Invasive vegetation removal	Minimal
Don Steen	Parking Services	10/21/14	10/22/14	Restripe parking lot	N/A
Sonja Mlenar	MCWE	11/5/14	11/5/14	Nature interpretation	Minimal
Randy Gibson	USFWS	12/5/14	1/29/16	Set/check Diversion trap	Minimal
Seth Hodges	Triathlon Club	4/18/15	4/18/15	Triathlon	Minimal
Maria Rocha	Indigenous Cultures Institute	3/28/15	3/29/15	Powwow	Minimal
Adrienne Correa	Rice University	3/21/15	4/12/15	EBIO 379 Biology class	Minimal
Caitlin Gabor	Texas State Biology	1/31/15	8/31/15	Sailfin Mollie stress/mate choice	Minimal
Mary Wicksten	Texas A&M Biology	2/16/15	5/12/15	Gastrotrich collecting	Moderate
Jeremiah Pizana	Rotary Club	9/25/15	9/26/15	Triathlon	Minimal
Sarah Robertson	TPWD			Collect mosquitofish	Minimal
Jerry Cochran	Texas State Facilities	6/13/15	6/13/15	Texas Water Safari	Minimal
Francis Rose	Texas State Biology	9/1/12	12/31/15	Trapping/monitoring turtle community	Minimal
Edmund Oborny	BIO-WEST	10/28/12	12/31/15	EARDAC salamander survey	Minimal

Table 3.4-4. Research and/or Access Activities on Spring Lake in 2015

Approved Research Activities FY 2015					
Researcher	**Department/Agency**	**Duration**		**Description**	**Impact +/-**
Valentin Cantu	USFWS	09/01/14	Still Active	Collecting wild San Marcos salamanders	Minimal
Andrew Johnston	Halff Engineering	09/01/14	Still Active	Assess Burleson's Dam	Minimal
Kristy Kollaus	MCWE	6/9/15	6/10/15	Collect bass for ichthyology class dissection	Minimal
Michelle Crawford	Texas State Aquatic Biology	7/7/15	10/31/15	Evaluate growth of Texas wild-rice	Minimal

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

In 2016, Texas State will implement their research program consistent with the protocols identified in the EAHCP.

3.4.10 Management of Golf Course and Grounds (EAHCP §5.4.9)

EAHCP Obligations:

Texas State will develop and implement a Golf Course Management Plan, including an IPMP. These plans will consider the appropriate application of environmentally-sensitive chemicals to reduce negative impacts to neighboring ecosystems. Any significant changes in the management protocol will be addressed through the AMP.

2015 Compliance Actions:

Texas State golf course operations followed the 2015 Golf Course Management Plan and IPMP guidelines based on both the EAHCP (EAHCP §5.4.9) and the Spring Lake Management Plan (**Appendix M6**).

Any Modifications or Activities Due to Weather Conditions:

There were no modifications or activities due to weather conditions.

Proposed Activities for 2016:

In 2016, Texas State will continue to implement its Golf Course Management Plan and IPMP.

3.4.11 Boating in Spring Lake and Sewell Park (EAHCP §5.4.10)

EAHCP Obligations:

Boating at Spring Lake will be restricted to areas treated with the harvester, operators will enter and exit boats at designated access points, and all boats will follow USFWS standards for proper cleaning.

2015 Compliance Actions:

The Spring Lake Management Plan was modified to ensure consistency with the EAHCP measures outlined in EAHCP (EAHCP §5.4.10) for activities in Spring Lake. This modification included limiting canoe/kayak classes to no more than two classes per day with a maximum duration of one hour and limited to 20 students in ten canoes. In addition, the glass-bottom boats are restricted to areas in Spring Lake that are mowed for aquatic vegetation control. Boat access into Spring Lake must follow the USFWS de-contamination process as outlined in the Spring Lake Management Plan and only enter at specific controlled locations that minimize potential impacts to listed species or their habitats. A total of 6,943 glass-bottom boat tours and 149 glass-bottom kayaks were conducted in 2015.

Canoeing/kayak classes in Sewell Park were limited to the region between Sewell Park and Rio Vista Dam as specified in the EAHCP. Access to the river was confined to the floating boat dock adjacent to the recreation center downstream of the walking bridge in Sewell Park. No more than three classes/day with a maximum of 20 students in ten canoes are permitted and not to exceed two hours in duration.

Any Modifications or Activities Due to Weather Conditions:

The 2015 Halloween flood caused closure of all Spring Lake programs.

Proposed Activities for 2016:

In 2016, Texas State will continue to implement the boating program in Spring Lake and Sewell Park consistent with the protocols identified in the EAHCP.

3.4.12 Reduction of Non-Native Species Introduction (EAHCP §5.4.11)

For discussion related to Texas State's *EAHCP Obligations*, *2015 Compliance Actions*, *Any Modifications or Activities Due to Weather Conditions* and *Proposed Activities for 2016* related to this Conservation Measure, please refer to the discussion under the **Section 3.3 –** City of San Marcos, **subsection 3.3.5** – Reduction of Non-Native Species Introduction.

3.4.13 Control of Non-Native Plant Species (EAHCP §5.4.12)

EAHCP Obligations:

Texas State, in partnership with the COSM, will develop a non-native plant species removal program within university boundaries.

2015 Compliance Actions:

Non-native aquatic vegetation removal focused on *Hydrilla verticillata, Hygrophila polysperma,* and *Nasturtium officinale* as these species are the most actively invasive. Prior to non-native vegetation removal, the area was fanned to minimize incidental take of fountain darters and other native species. The non-native aquatic vegetation was removed, shaken, native aquatic species salvaged and returned to the

river (including egg masses) and then bagged for disposal at the COSM or Spring Lake compositing facility. MCWE's progress for non-native vegetation removal was tracked with polygons containing the date, species removed, estimated area (m^2) and percent removed. A composite map depicting the routine maintenance required to remove large areas of non-native aquatic vegetation was generated using weekly polygons. The map illustrating the degree of effort was created by overlaying all the weekly polygons, rasterizing the spatial units, assigning a value of one for the treated area, and combining the layers with raster calculator. As a result, the layers capture the degree of overlap between 99 work sites and identify areas that required repeated removal efforts.

Denuded areas were targeted for Texas wild-rice or selected native aquatic species planting based on habitat preferences for each native species. Texas wild-rice and native species were obtained from the SMARC or from raceways located at the FAB. Initial efforts for restoration of Texas wild-rice or native vegetation were targeted at planting approximately 20 percent of the surface area restored. MCWE planting efforts was tracked with polygons containing the date, number of individuals, estimated area (m^2), and estimated density planted (individuals/m^2). A map illustrating planting location and planted densities was generated using weekly polygons. Aquatic vegetation was mapped using geo-referenced imagery captured with a quadcopter in conjunction with Trimble GPS units in work areas prior to non-native vegetation removal and native planting to assess changes in the vegetation community through time.

An estimated 133.48 m^2 of non-native aquatic vegetation was removed in the San Marcos River from Spring Lake Dam downstream through Sewell Park from December 2014 - October 2015 among areas worked by Texas State staff (**Table 3.4-5**). The non-native vegetation species removed were *Hygrophila polysperma* (estimated area ~18.58 m^2) and *Nasturtium officinale* (~75.11 m^2). **Figure 3.4-2** illustrates the non-native aquatic vegetation removal areas by MCWE staff in the San Marcos River for 2015.

Table 3.4-5. Estimated Area Removed (m^2) of Non-Native Vegetation Species by Date in the San Marcos River from Spring Lake Dam through Sewell Park (December 2014 – October 2015)

Species	Date	Area Removed (m^2)
Zizaniopsis miliacea	12/16/2014	2.53
Hygrophila polysperma	1/5/2105	18.58
Nasturtium officinale	3/3/2015	17.27
	3/3/2015	8.77
	3/3/2015	7.87
	4/28/2015	34.12
	4/28/2015	7.07
***Nasturtium officinale* total**		**75.11**
Vegetation mat removed	4/28/2015	37.26
Total Area Aquatic Plants Removed		**133.48**

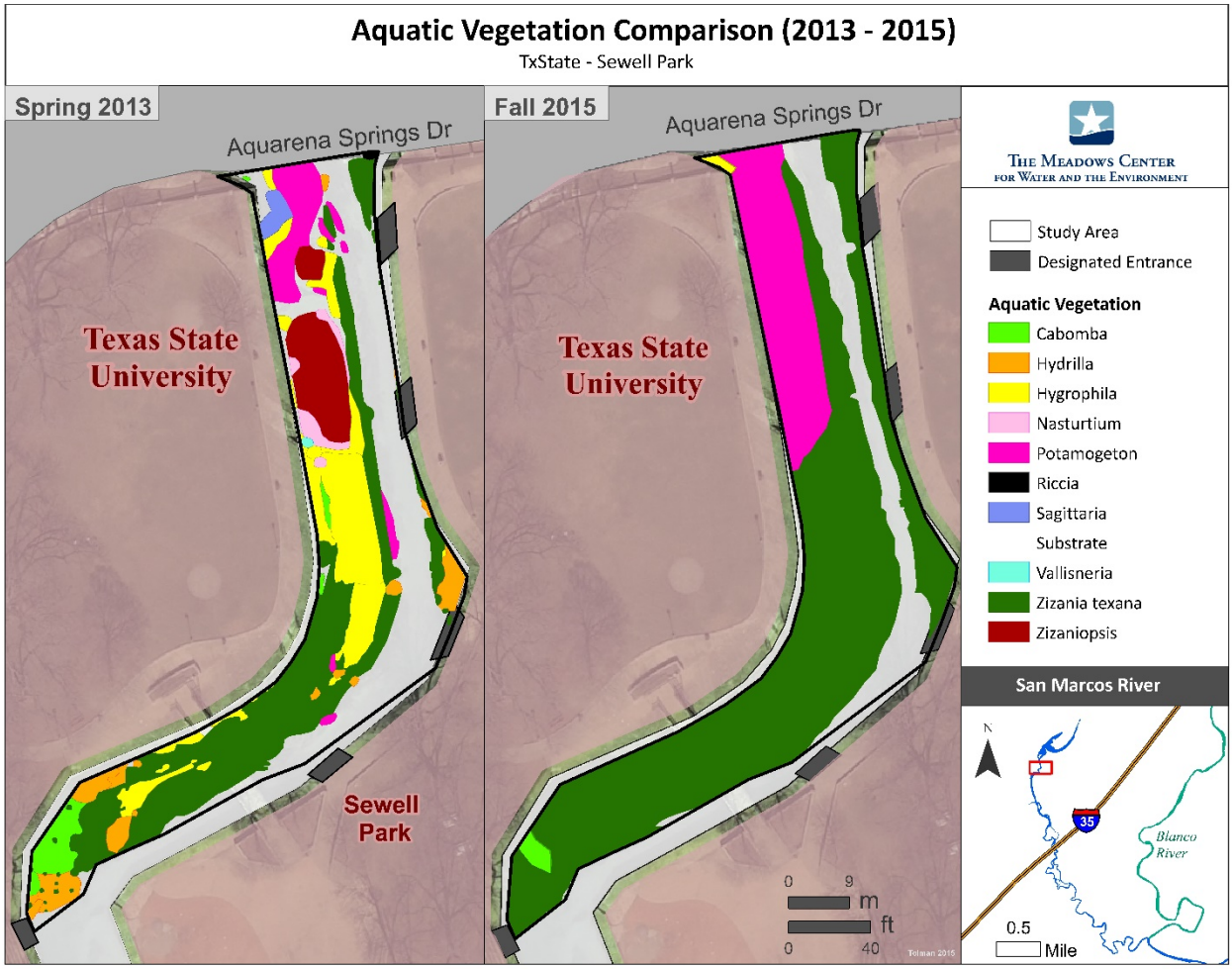

Figure 3.4-2. Non-native aquatic vegetation removal by MWCE staff in the San Marcos River comparison (2013–2015).

Based upon GPS polygons, estimated reduction of non-native vegetation observed from 2013 to November 2015 was 621.21 m^2 in the San Marcos River downstream of Spring Lake Dam through Sewell Park (**Figure 3.4-2**). Changes in vegetation outside of the areas worked were not included because differences observed could not be attributed to our work. Estimated area reduction per non-native vegetation species since 2013 was *Hygrophila polysperma* (~ 291 m^2), *Nasturtium officinale* (~32 m^2), and *Hydrilla verticillata* (~299 m^2). Reduction of non-native vegetation from 2014-2015 among MCWE work sites in Sewell Park was estimated at 334 m^2. The October 30, 2015 flood event scoured certain areas of the river, and in some instances, helped remove areas of non-native vegetation (**Appendix M1** and **Table 3.4-6**).

Table 3.4-6. Difference in Area (m^2) of Non-Native Vegetation Species in the San Marcos River in Sewell Park Reaches at Year One (2013), Year Two (November 2014), and Year Three (November 2015) of Removal Activities

Area Calculations for Non-Native Species (m^2)				
Reach	**Species**	**2013**	**2014**	**2015**
Upper Sewell	*Hydrilla verticillata*	257.70	115.52	36.52
	Hygrophila polysperma	63.89	38.12	8.95
	Vallisneria spiralis	-	10.09	
Lower Sewell	*Hydrilla verticillata*	133.52	72.80	55.39
	Hygrophila polysperma	242.09	201.27	6.40
	Nasturtium officinale	31.80	-	-
	Vallisneria spiralis	2.38	3.04	

Twenty fountain darters were captured during non-native aquatic vegetation removal and returned to the river. Other species captured and released included crayfish, sunfish species, and mosquito fish (**Table 3.4-7**).

Table 3.4-7. Animal Species Collected and Returned to the San Marcos River During Non-Native Vegetation Removal (November 2014 – October 2015)

	Month												
Species	**Nov-14**	**Dec-14**	**Jan-15**	**Feb-15**	**Mar-15**	**Apr-15**	**May-15**	**Jun-15**	**Jul-15**	**Aug-15**	**Sep-15**	**Oct-15**	**Total**
Lepomis sp. (sunfishes)	2	-	15	10	4	20	12	12	7	9	6	7	**104**
Etheostoma fonticola (fountain darter)	-	-	4	2	1	-	-	-	1	10	2	-	**20**
Gambusia sp. (mosquito fish)	-	-	5	-	-	-	-	-	-	30	-	-	**35**
Ameiurus sp. (bullhead catfish)	-	-	10	-	-	2	-	-	-	5	-	2	**19**
Poecilia sp. (mollies)	2	-	-	-	-	-	-	-	-	-	-	-	**2**
Micropterus salmoides (largemouth bass)	-	-	-	-	-	-	-	-	1	-	-	-	**1**
Ambloplites rupestris (rockbass)	-	-	2	2	1	9	5	-	2	-	-	5	**26**
Notropis amabilis (Texas Shiner)	-	-	-	3	-	-	-	-	-	-	-	-	**3**
Cambaridae (crayfish)	25	-	10	5	36	105	75	25	50	50	35	75	**491**
Testudinata (Turtle)	-	-	-	1	-	1	-	-	-	-	-	-	**2**

Table 3.4-8 and **Figure 3.4-2** denote changes in native aquatic vegetation from 2013-2015 among reaches of the San Marcos River from Spring Lake Dam downstream through Sewell Park. Changes in native vegetation outside of the areas worked were not included, because differences observed could not be attributed to MCWE's work. Among native species, *Zizania texana* increased from 2013-2015 (~909 m^2).

A report titled, *2014-2015 Progression*, located in **Appendix M3**, illustrates areas of native aquatic vegetation expansion within work areas. Loss in areal coverage was observed for native species including *Potamogeton illinoensis*, *Cabomba caroliniana*, *Heteranthera dubia*, *Sagittaria platyphylla* and *Ludwigia repens*, which we attribute to recreation effects and to riverbed scouring and sediment deposition that

occurred during the October 30, 2015 flood event. **Appendix M1** illustrates areas of loss in work areas before and after the October 2015 flood event.

Table 3.4-8 denotes the area of native vegetation species prior to non-native vegetation removal and native planting activities, after one year of non-native vegetation removal and native planting activities, after two years of non-native vegetation removal and native planting activities, and the third year of non-native vegetation removal and native planting activities in the San Marcos River from Spring Lake Dam through Sewell Park.

Table 3.4-8. Difference in Area (m^2) of Native Vegetation Species Prior to Non-Native Vegetation Removal and Native Planting Activities After Year 1 (2013), After Year 2 (2014), and After Year 3 (2015) in the San Marcos River from Spring Lake through Sewell Park

Area Calculations for Native Species (m^2)				
Reach	**Species**	**2013**	**2014**	**2015**
Upper Sewell	*Zizania texana*	198.50	360.22	572.79
	Sagittaria platyphylla	2.68	7.01	9.90
	Potamogeton illinoensis	164.36	127.15	-
	Hydrocotyle	55.07	97.78	10.34
Lower Sewell	*Zizania texana*	666.33	838.67	1,201.49
	Sagittaria platyphylla	21.35	37.62	1.60
	Heteranthera dubia	-	71.49	-
	Potamogeton illinoensis	207.99	193.35	87.95
	Cabomba caroliniana	44.75	21.42	13.76
	Ludwigia repens	-	31.42	-
	Zizaniopsis	154.31	-	-

Any Modifications or Activities Due to Weather Conditions:

Areas of Sewell Park were scoured during the October 30, 2015 flood event resulting in area loss of Texas wild-rice and other native species. Areas of scour and native species loss can be observed in **Appendix M1** with images of the October 2015 flood event.

Proposed Activities for 2016:

Non-native aquatic plant removal will occur in conjunction with sediment removal within and around Texas wild-rice stands. Therefore, Texas State will aim to remove 1,500 m^2 of non-native aquatic plants.

3.4.14 Control of Harmful Non-Native and Predator Species (EAHCP §5.4.13)

For discussion related to Texas State's *EAHCP Obligations*, *2015 Compliance Actions*, *Any Modifications or Activities Due to Weather Conditions* and *Proposed Activities for 2016* related to this Conservation Measure, please refer to the discussion under the **Section 3.3** – City of San Marcos, **subsection 3.3.9** – Control of Harmful Non-Native and Predator Species.

3.4.15 Challenges Observed and Identified Solutions

For discussion of challenges observed and identified solutions by Texas State, please refer to the discussion under the **Section 3.3** – City of San Marcos, **subsection 3.3.15** – Challenges Observed and Identified Solutions.

3.5 San Antonio Water System

SAWS is one of the largest water and wastewater systems in the United States and serves most of Bexar County, as well as portions of three adjacent counties. The municipally-owned utility serves a customer base of over 1.7 million customers that grows an additional two percent each year, as San Antonio is one of the fastest growing cities in the country. SAWS' Twin Oaks ASR Project in southern Bexar County is a key conservation measure for the EAHCP. This conservation measure uses the injection and storage of EAA-issued Edwards Aquifer groundwater withdrawal permits leased by the EAA. Under certain conditions more fully described in the EAHCP and the ASR contract entered into with the EAA, this water is recovered from storage to serve SAWS customers during certain drought conditions as specified in the contract. The day-to-day operation of the ASR is managed by SAWS. A twelve-person Regional Advisory Group composed of diverse stakeholders meets to advise SAWS on the implementation of the Conservation Measure.

The EAHCP broadly outlines how SAWS, with the assistance of the Regional Advisory Group, will describe in the Annual Report the storage and recovery activities (EAHCP §5.5.1, page 5-38).

SAWS is responsible for the following measure under the EAHCP:

- Use of the San Antonio Water System Aquifer Storage and Recovery for Springflow Protection (EAHCP §5.5.1 and §5.5.2)

3.5.1 Use of the San Antonio Water System Aquifer Storage and Recovery for Springflow Protection (EAHCP §5.5.1 and §5.5.2)

EAHCP Obligations:

SAWS will utilize the Twin Oaks ASR Facility as a springflow protection measure during times of certain extreme drought. When the level of well J-17 is less than 630 ft-msl and the ten-year rolling recharge to the Aquifer is less than or equal to 500,000 ac-ft/year, SAWS may return water from the ASR facility to its distribution system. Additionally, when these conditions are met, SAWS will forbear making withdrawals from the Aquifer from designated wells on the northeast side of its service area equivalent to certain forbearance schedules prescribed in the ASR contract.

SAWS will make every effort to simulate the return patterns identified in modeling by HDR during the development of the EAHCP; however, the EAHCP recognizes that future droughts may not exactly mimic the drought of record, so flexibility will be afforded to SAWS.

Section 5.5.2 of the EAHCP includes a discussion on the use of the SAWS Water Resources Integration Program as the Phase II presumptive action for the EAHCP. To date, Phase II is not yet in effect and has not yet been discussed by the committees of the EAHCP, so it is not discussed at length in this report.

2015 Compliance Actions:

In 2013, an Interlocal Contract (ILC) was developed between the EAA and SAWS during a seven-month period. The ILC translates the conceptual elements of SAWS ASR commitment in Section 5.5.1 of the EAHCP into measurable activities related to both parties' responsibilities.

SAWS is responsible for organizing and facilitating an ASR Advisory Group. The ILC also required formation of a Staff Work Group. This subject will also be discussed further in this section of the Annual Report.

Under the ILC, SAWS is required to credit to the EAA as being in storage any permitted Edwards Aquifer water for which it receives a Notice of Availability (NOA) from the EAA by certain dates detailed further in the ILC, or based on metered recharge for NOAs received by SAWS after certain dates.

3.5.1.1 San Antonio Water System Aquifer Storage and Recovery Regional Advisory Committee

Per the requirement on page 5-39 of the EAHCP, a twelve-person Regional Advisory Group consisting of four representatives of SAWS, the EAHCP Program Manager, and one representative each from the EAA, an EAA permit holder for irrigation purposes, a representative of small municipal pumpers, a representative of the spring cities, an environmental representative (including TPWD), a representative of industrial aquifer users, and downstream interests, will provide advice to SAWS regarding the implementation of the program.

The EAHCP and SAWS ASR ILC provide for continued dialog and interaction. Under the ILC, SAWS has the responsibility for facilitating two groups. The first is SAWS Aquifer Storage and Recovery Regional Advisory Group as described in the EAHCP and immediately above. The second is a Staff Work Group whose membership and general descriptions are described in the ILC. These groups each met in compliance with EAHCP and ILC. The SAWS Aquifer Storage and Recovery Regional Advisory Group met quarterly in 2015 (on March 31, 2015, June 26, 2015, September 29, 2015, and December 7, 2015). Topics of these meetings included:

- 1st Quarter – presentations by SAWS and the EAA on drought outlook and SAWS production statistics.
- 2nd Quarter – presentations on historic recharge and recharge triggers as it relates to the ASR in the EAHCP, drought and aquifer level forecasts by SAWS and the EAA, and selected SAWS production statistics.
- 3rd Quarter – discussion of El Niño development, aquifer level and drought outlooks, and SAWS production activities.
- 4th Quarter – presentations by SAWS and the EAA on drought outlook and SAWS production statistics, as well as a presentation and discussion about the Water Resources Integration Pipeline.

3.5.1.2 Status of San Antonio Water System Aquifer Storage and Recovery Lease Acquisition

The EAA will acquire 50,000 ac-ft of Edwards Aquifer permitted water through leases and options for use in the SAWS ASR Program. Acquisition will be accomplished in three tiers (**Table 3.5-1**).

Table 3.5-1. SAWS Aquifer Storage and Recovery Lease and Structure Option as Identified in the EAHCP

Tier	Ac-ft	Description
I	16,667	Leased for immediate storage in the ASR
II	16,667	Acquired as options; exercised when the 10-year rolling recharge for the previous year falls below 572,000 ac-ft/year
III	16,667	Acquired as options; exercised when the 10-year rolling recharge for the previous year falls below 472,000 ac-ft/year

The ASR leasing program satisfied 89.1 percent of its enrollment goal for Tier 1 in 2015. Enrollment is on-going and the program will continue to be adjusted to respond to the dynamics of the market.

3.5.1.3 Edwards Aquifer Authority Notices of Availability to San Antonio Water System

Of the total 14,849.516 ac-ft available to the EAA in 2015, EAA made available 11,575.016 ac-ft, withholding 22.1 percent to meet expected CPMP permit reductions (**Table 3.5-2**). The EAA issued twelve NOAs to SAWS during the months ASR leases were accepted by the EAA Board of Directors. Eight NOAs were issued to SAWS authorizing 11,575.016 ac-ft for injection into the ASR before June 30, 2015, and four NOAs were issued to SAWS authorizing 0 ac-ft for injection into the ASR after June 30, 2015. EAA must account for expected CPMP permit reductions for the San Antonio Pool in making groundwater available to SAWS for injection into the ASR facility, and EAA withheld pumping rights to cover a maximum 22.1 percent reduction for 2015.

Table 3.5-2. SAWS Aquifer Storage and Recovery Notices of Availability in 2015

NOA #	Date Effective (through December 31, 2014)	Total Ac-ft Acquired	Total Ac-ft Authorized
2015 NOA #1	January 7, 2015	4,811.418	3,031.193
2015 NOA #2	February 10, 2015	2.500	2.500
2015 NOA #3	March 11, 2015	70.000	70.000
2015 NOA #4	April 15, 2015	179.700	179.700
2015 NOA #5	May 13, 2015	171.000	171.000
2015 NOA #6	June 30, 2015	10.000	1,790.225
2015 NOA #7	June 30, 2015	6,330.398	6,330.398
2015 NOA #8	June 30, 2015	N/A*	500.000
2015 NOA #9	July 15, 2015	850.000	0.000
2015 NOA #10	August 12, 2015	530.500	0.000
2015 NOA #11	September 9, 2015	477.500	0.000
2015 NOA #12	October 14, 2015	1,416.500	0.000
	Totals	**14,849.516**	**12,075.016****

* See subsection 3.5.1.4 below.

** EAA withheld pumping rights to cover a maximum 22.1% reduction for 2015.

3.5.1.4 Groundwater Rights Pooling Program for Aquifer Storage and Recovery

In May 2015, the EAA Board of Directors authorized staff to implement a new program designed to increase regional contributions in the ASR in support of the EAHCP. To further encourage participation, the EAA also implemented the Aquifer Storage and Recover Pooling Program (ASRPP). *The Master Pooling Agreement for Aquifer Storage and Recovery* outlined this new offering to EAA permit holders that allows them to participate in the "pooling" of their un-pumped groundwater withdrawal rights remaining at the end of the year. These un-pumped rights are pooled together with remaining rights from other participants to collectively offset same-year pumping authorized by the EAA for regional contributions to the ASR. This program is open to municipal, industrial, and unrestricted irrigation use permit holders. EAA uses a proportional ratio calculation to administer payments to all pool participants. The total pool of un-pumped authorization is compared against the amounts of groundwater authorized for ASR contributions during that same year and determines a "utilization ratio." That utilization ratio is then applied to the amounts contributed by each participant to determine that portion eligible for reimbursement at a rate of $50 per ac-ft.

For example, the EAA totals the average unpumped water for each permit holder enrolled in the Pooling Program. In this scenario the EAA uses an average unpumped volume of 1,000 ac-ft. This number supports the EAA to authorize a pre-determined conservative portion of 500 ac-ft. to be injected into the ASR against the projected Groundwater Pool. After the year is over, all pooling participants' unpumped rights are calculated and contributed. For this example, the unpumped rights at the end of the year equaled the average at 1,000 ac-ft. This volume is then used to produce the pool utilization ratio for that year, which would then be equal to 500/1,000 or 50%.

The EAA debuted this new program in a 2015 pilot study to a limited number of volunteer permit holders representing municipal, industrial and irrigation users. EAA staff enrolled 14 permit holders in the 2015 groundwater rights pooling program and issued an NOA of 500 ac-ft in June 2015. The 500 ac-ft volume issued in 2015 was determined by averaging the previous two years of unpumped water and making a conservative calculation for injection. Reconciliation of the pool and payment to program participants will occur by April 2016. EAA staff expects to expand participation in the pooling program to all interested permit holders in 2016, and will issue the NOA for the 2016 pooling effort before June 30, 2016.

Any Modifications or Activities Due to Weather Conditions:

No modifications to the use of SAWS' ASR due to drought conditions occurred in 2015. Trigger levels were not reached during this time period, so SAWS ASR use for EAHCP springflow protection was not implemented. However, the weather pattern in 2015 had a dramatic effect on ASR leases. The amount and timing of rainfall in 2015 was particularly beneficial to irrigators in that most irrigation wells were not put into service until July. Stage V CPMP restrictions (44 percent mandatory reductions) had been in place in Uvalde County since approval of the EAHCP in March of 2013. Beneficial rains in the area increased Edwards Aquifer levels such that CPMP restrictions in Uvalde County were completely eliminated. The remaining portion of the EAA jurisdictional area also experienced dramatic increases in water levels in the first six months and elimination of CPMP restrictions; followed by four months of Stage I and II restrictions, and finished the year out of CPMP restrictions with the fall rains. The widespread and regular rains in 2015

led to a dramatic increase in ASR leasing activities. The year began with 4,821 ac-ft of ASR leases. During the year, increased rainfall resulted in much lower water demands; therefore, the EAA acquired approximately 14,850 ac-ft of ASR leases and 500 ac-ft of pooling leases. In 2016, the year will begin with 9,849 ac-ft of leases.

Proposed Activities for 2016:

In 2016, SAWS will continue to manage the ASR Program as described in the EAHCP and consistent with the terms identified in the ILC with the EAA.

3.5.2 Challenges Observed and Identified Solutions

The SAWS Twin Oaks ASR facility is gated, fenced, and patrolled, and SAWS is unaware of any unauthorized activities by the public at the ASR.

3.6 Texas Parks & Wildlife Department

The TPWD serves as the state agency with primary responsibility for conserving, protecting and enhancing the state's fish and wildlife resources. In this role, TPWD has the authority to establish state "scientific areas" for the purposes of education, scientific research, and preservation of flora and fauna of scientific or educational value (TPW Code § 81.501). To minimize the impacts of recreation, TPWD has created a two-mile segment of the public waters of the San Marcos River as an SSA in the San Marcos Springs ecosystem (30 Texas Administrative Code (TAC) 57.910).

In order to protect existing and restored fountain darter habitat, TPWD will pursue creation of state scientific areas in the Comal Springs ecosystem. The goal of the regulations will be to minimize impacts to habitat from recreation activities.

3.6.1 State Scientific Areas (EAHCP §5.6.1)

EAHCP Obligations:

The TPWD will pursue the establishment of an SSA in the San Marcos Springs ecosystem for expanded protection of Texas wild-rice within a two-mile segment. TPWD will pursue an ILA with the COSM and Texas State regarding enforcement of the SSA.

To protect extensive aquatic and riparian restoration, TPWD, in coordination with the CONB, will pursue an SSA within the Old Channel of the Comal River. Once an SSA is established, TPWD will pursue an ILA with the CONB regarding enforcement of the area.

2015 Compliance Actions:

The EAHCP requires that TPWD pursue creation of SSAs in the San Marcos and Comal River. TPWD has the authority to establish SSAs for the purposes of education, scientific research, and preservation of flora and fauna of scientific or educational value (TPW Code § 81.501). To preserve Texas wild-rice during low

flows and to minimize the impacts of recreation, TPWD created a two-mile segment of the public waters of the San Marcos River as an SSA in the San Marcos Springs ecosystem (31 TAC 57.910). This scientific area is designed to protect Texas wild-rice by restricting recreation in these areas during flow conditions below 120 cfs. The rule makes it unlawful for any person to: (1) move, deface, alter, or destroy any sign, buoy, boom, or other such marking delineating the boundaries of the area; (2) uproot Texas wild-rice within the area; and (3) enter an area that is marked. The regulations are intended to preserve at least 1,000 m^2 of Texas wild-rice (**Appendix M7**).

In cooperation with the COSM and Texas State, signs and information kiosks were designed, produced, and installed during the summer of 2013. The purpose of the signs and information kiosks is to educate the public about protecting the San Marcos River and its endangered biota, especially during prime recreational season. In 2015, the TPWD began efforts to produce Spanish language versions of the signs and kiosks.

Figure 3.6-1. Biologist removing detritus from area of Texas wild-rice.

Any Modifications or Activities Due to Weather Conditions:

When the flows within the San Marcos River SSA are 120 cfs or less, physical barriers may be placed within the SSA to help recreational users avoid vulnerable stands of Texas wild-rice while enjoying the river and to protect areas where habitat has been restored. Flows in the San Marcos River were above 120 cfs during the summer of 2015.

Proposed Activities for 2016:

In 2016, TPWD will work to expand their public education efforts to include signage in Spanish. In addition, TPWD will pursue an ILA with the COSM and Texas State regarding enforcement of the SSA.

3.6.2 Challenges Observed and Identified Solutions

Efforts to expand education outreach by translating SSA signage into Spanish were delayed due to TPWD staff retirement, but will continue in 2016. A formal ILA between TPWD, the COSM, and Texas State regarding enforcement of the SSA was not completed, but the three entities were in communication throughout the year.

4.0 ADAPTIVE MANAGEMENT PROCESS ACTIVITIES FOR 2015

Article 7 of the FMA outlines the procedural steps and responsibilities of the Permittees for making AMP decisions. It also identifies three different AMP decisions the Permittees may make – Routine, Nonroutine, and Strategic AMP decisions.

Routine decisions are decisions involving ongoing, day-to-day matters related to the management and administration of existing Conservation Measures[11] and Phase II Conservation Measures implemented through the Strategic AMP that do not require an amendment to the ITP. Nonroutine AMP decisions are decisions relating to existing Conservation Measures, which are not Routine or Strategic AMP decisions. Strategic AMP decisions are decisions that relate to the selection of Phase II Conservation Measures that are to be implemented by the Permittees in Phase II.

Strategic AMP decisions will not be made until 2018, but in 2015, the Permittees continued to implement monitoring, research and modeling activities to provide information that will be necessary to support later Strategic AMP decisions. These activities are summarized in **Section 3.1**, Edwards Aquifer Authority, of this Annual Report. Additionally, the EAHCP evaluated approximately 70 recommendations from the NAS *Report 1* related to both monitoring programs, the Applied Research Program, and hydrologic and ecological modeling activities. Also in 2015, the SRP/NAS met to begin work on its second report, which will focus on an evaluation of the Phase I Conservation Measures.

The Permittees have implemented adaptive management in the form of learning from implementation experiences and then modifying annual work plans (Routine Decisions). However, no formal AMPs, as defined by the FMA, were initiated in 2015.

4.1 Routine Decisions

In 2015, the Permittees made a variety of Routine AMP decisions, as improvements to methodologies came to light and other circumstances presented themselves requiring minor adjustments to the implementation of Conservation Measures.

4.2 Nonroutine Decisions

In 2015, the Permittees made preliminary steps towards undertaking possible future Nonroutine AMP decisions. At the time of this writing, this work is in an information and data gathering stage for the issues regarding the following Conservation Measures:

- Native Aquatic Vegetation Restoration and Non-native Species Control (EAHCP §5.2.2, §5.3.1, §5.3.3, §5.3.8, §5.4.1, and §5.4.3)
- Flow-Split Management in the Old and New Channels (EAHCP §5.2.1)

The following summarizes the background, rationale, and process for evaluating these Conservation Measures:

[11] In this Annual Report, a Conservation Measure means a measure identified in Chapter 5 of the EAHCP, as such measure may be modified pursuant to the AMP.

Native Aquatic Vegetation Restoration and Non-native Species Control – Since 2013, the CONB, COSM and Texas State have been removing non-native aquatic vegetation and replacing it with native aquatic vegetation with mixed results. To ensure the goals established in the EAHCP for fountain darter habitat for both the Comal and San Marcos springs systems are achieved, in 2015, EAHCP procured the services of BIO-WEST, with Watershed Systems Group, Inc., to evaluate and document removal and planting methodologies in both systems. As a result of this assessment in 2016, the contractors will draft a schedule that accomplishes the Biological Goals established in EAHCP Table 4-1 (Comal Springs) and EAHCP Table 4-21 (San Marcos Springs) or, if warranted and justified, will recommend a clarification to the EAHCP.

Flow-Split Management in the Old and New Channels of the Comal River – Since the development of EAHCP Table 5-3 (Flow-Split Management for Old and New Channels), the CONB has collected data on habitat and fountain darters that indicates increases in flow above 65 cfs via the flow-split will not benefit the endangered species habitat in the Old Channel, but conversely, cause the destruction of significant amounts of existing habitat. It is believed that increasing flows to 70 or 80 cfs in the Old Channel, as prescribed by Table 5-3, will be detrimental to fountain darter habitat, especially in the highly restored areas above Elizabeth Street.

For the reasons outlined above, and with the support and recommendation of the SC, in 2015, the Permittees resolved to deviate from EAHCP Table 5-3 by not increasing the flows in the Old Channel above 65 cfs, until an evaluation of the results of the flow manipulations in the Old Channel is documented. If needed, this evaluation may recommend a flow-split regime for the Old Channel and New Channel that will lead to the development of a new Table 5-3, modified to achieve the maximum benefit possible to the Covered Species and their habitat. This evaluation will be completed in 2016. This decision was reported to the USFWS in a November 30, 2015 letter which is included here for reference in **Appendix A2**.

4.3 Strategic AMP Decisions

As stated above, Strategic AMP decisions will not be made until 2018.

5.0 2015 ANNUAL TAKE ESTIMATES

The ITP requires a Net Disturbance and Incidental Take assessment be conducted at the conclusion of each year for incorporation into the ITP Annual Report. Condition M (1a and 2a) of the ITP specifically addresses minimization and mitigation activities associated with the EAHCP. This requirement stipulates that over the course of any given year no more than 10 percent of a Covered Species occupied habitat can be affected by EAHCP mitigation and restoration activities. Following quantification of net disturbance specific to these activities, incidental take was calculated for the disturbed areas. However, that is only part of the overall incidental take assessment. Incidental take associated with implementation of all other applicable EAHCP Covered Activities was then characterized and quantified to the degree practical. For a more detailed description of methodologies and species specific results, please refer to the Item M Net Disturbance and Incidental Take assessments (**Appendix N**). As in previous years, all 2015 assessments were performed in accordance with ITP requirements.

Table 5.0-1 provides an overview of net disturbance percentages and a summary of incidental take for 2015. As shown in **Table 5.0-1**, only the fountain darter in the Comal System had a net disturbance when considering the project footprint for EAHCP mitigation and restoration activities overlaid on occupied habitat. The net disturbance was 3.4 percent of the total occupied habitat for the fountain darter. As shown in **Table 5.0-1**, there were no project footprints that overlapped with any of the known occupied habitat for the endangered Comal invertebrates. In the San Marcos system, both the fountain darter and San Marcos salamander had a net disturbance per this assessment. The fountain darter had 3.1 percent of its total occupied habitat disturbed whereas the San Marcos salamander amount was less than 1 percent. For the Texas blind salamander and CSRB, there were no activities conducted in 2015 that directly impacted any of the orifices where collections have routinely been made over the years. In summary, the 10 percent disturbance rule (Item M [a]) was in compliance for 2015.

While average monthly discharge in both systems began the year below the historic average, both minor and major precipitation events quickly increased discharge resulting in above average total system discharge for the majority of 2015. A severe flooding event occurred on the San Marcos system over the Memorial Day weekend timeframe when record precipitation fell over the San Marcos and Blanco rivers basins. Most of the severe flooding affected the Blanco River, but its historic discharge caused the San Marcos River to back up from IH-35 all the way to Spring Lake Dam. The nature of this flooding (backwater inundation effect) resulted in very minor damage to the biota and habitat in the San Marcos river upstream of IH-35. This is an important consideration as all three reaches used in the take calculation for the San Marcos system are above this boundary. As such, the late May flooding on the San Marcos River did not affect take calculations per established methodologies for this report. Another more devastating flooding event occurred in both the Comal and San Marcos rivers at the end of October 2015. Unlike the Memorial Day weekend flood, this flood in the San Marcos system occurred when precipitation swelled the Sink and Purgatory creek drainages. With Sink Creek flowing into Spring Lake, and Purgatory Creek coming in upstream of Rio Vista Park, flooding effects on habitat (i.e., aquatic vegetation) were magnified throughout the system. However, as the comprehensive fall biological monitoring was conducted prior to this flooding event, and those aquatic vegetation maps are used for the spring to fall aquatic vegetation change

calculations, this flooding event did not affect take calculations per established methodologies for this report.

An evaluation of **Table 5.0-1** shows that calculated incidental take on the Comal system with respect to the surface dwelling organisms (CSRB and fountain darter) was considerably less in 2015 than observed during the drought conditions experienced in both 2013 and 2014. The primary cause for this decrease was the above average discharge conditions throughout most of 2015 that resulted in full inundation of surface habitats within CSRB occupied habitat and inundated habitat and constant water temperatures relative to the fountain darter. For the San Marcos system, incidental take went up slightly in 2015. This slight increase was due to a combination of more EAHCP restoration measures being implemented in 2015 because Condition M was not triggered, and because of increases in recreational impacts in the Spring Lake Dam reach of the river.

When examining 2015 impacts, conditions are in line with those characterized in the Biological Opinion as an average year. As such, the incidental take numbers summarized in **Table 5.0-1** and documented in this report continue to justify the data sets used and methodologies employed in 2015 relative to performing an incidental take assessment within the context of the Biological Opinion. It is understood that adjustments to data sets and/or methodologies may be employed based on feedback from the USFWS, SC, EAHCP participants, or others as deemed appropriate by the EAHCP.

Table 5.0-1. Summary of Impacted Habitat (m^2) and Net Disturbance and Incidental Take for EAHCP Covered Species Compared Against ITP Maximum Permit Amounts

Covered Species Per System	HCP Mitigation / Restoration		HCP Measures / Drought	Combined Impacted Habitat 2015 Total (m^2)	Incidental Take		2015 Incidental Take Total	ITP Maximum Permit Amount	ITP Permit Maximum Minus (Combined First Three Years)
	Impacted Habitat (m^2)	Net Disturbance % Of Total Occupied Habitat	Impacted Habitat (m^2)		HCP Mitigation / Restoration	HCP Measures/ Drought			
Comal System									
Fountain Darter	3,217	3.4%	193	3,410	4,826	290	5,115	797,000	758,344
Comal Springs Riffle Beetle	0	0.0%	0	0	0	0	0	11,179	8,933
Comal Springs Dryopid Beetle	0	0.0%	0	0	0	0	0	1,543	1,528
Peck's Cave Amphipod	0	0.0%	0	0	0	0	0	18,224	18,060
San Marcos System									
Fountain Darter	3,474	3.1%	5,389	8,863	5,211	8,084	13,295	549,129	507,213
San Marcos Salamander	16	0.6%	337	353	48	1,011	1,059	263,857	261,264
Texas Blind Salamander	0	0.0%	0	0	0	0	0	10	10
Comal Springs Riffle Beetle	0	0.0%	0	0	0	0	0	N/A	N/A

6.0 RECOMMENDATIONS MOVING FORWARD

The Permittees are now in their third year of implementing the EAHCP. With the benefit of experience—including during wide-ranging weather conditions—and time, the Permittees continue to gain perspective and practical insights into implementation of the EAHCP. Based upon this knowledge and experience, the Permittees recommend the following as priorities for 2016.

6.1 Aquifer Storage and Recovery

As discussed in **Section 3.5** – San Antonio Water System, **subsection 3.5.1.4**, Groundwater Rights Pooling Program for Aquifer Storage and Recovery, of this Annual Report, the ASR Conservation Measure is based on the EAA leasing a total of 50,000 ac-ft of EAA groundwater rights in three 16,666 ac-ft tiers, and transferring use of those rights to SAWS for storage and use during severe drought. In 2015, the EAA continued working with challenges related to implementing this ITP requirement, but nevertheless was able to increase enrollment to 14,849 ac-ft, or 89 percent of the goal for Tier 1. Enrollment was ongoing, and the program continued to be adjusted to respond to water market conditions.

To further encourage participation, the EAA also implemented the Aquifer Storage and Recovery Pooling Program (ASRPP) as a new element designed to increase program contributions. This new offering to EAA municipal, industrial, and unrestricted irrigation use permit holders allows them to participate by "pooling" their un-pumped groundwater withdrawal rights remaining at the end of the year. These un-pumped rights are pooled together with remaining rights from other participants to collectively offset same-year pumping authorized by the EAA for regional contributions to the ASR. With the pool participants, the EAA calculates a "utilization ratio" (proportional ratio) to calculate payments to be made to each participant to determine that portion eligible for reimbursement at a rate of $50 per ac-ft.

The EAA debuted this new program in a 2015 pilot study and enrolled 14 permit holders. In response to these efforts, in June 2015, the EAA issued a notice to SAWS to inject 500 ac-ft in 2016 for regional contributions against the pool. As a result, those 14 ASRPP participants will be paid according to the proportional ratio calculations. At the time of this writing (early 2016), the EAA is recruiting interested permit holders with unrestricted water rights to expand participation in the pooling program.

Recruitment performance going into 2016 is promising. ASR leasing rates began accelerating towards the end of 2015, and the Permittees are hopeful to be able to continue to support this forward momentum for 2016. Overall, depending upon the success of both the ASR Leasing and the ASRPP programs, throughout 2016, the Permittees will continue to explore other ways to achieve the goals of ASR.

For 2016, the Permittees recommend continued concerted effort to build on and learn from what works for ASR participation, and look for innovative ways to improve the program in support of meeting ASR recruitment goals.

6.2 Refugia

As previously discussed in **Section 3.1** – Edwards Aquifer Authority, **subsection 3.1.2**, Refugia, of this Annual Report, in 2014, the EAA requested an opinion from the Texas State Attorney General's Office regarding the legal authority to enter into a contract with USFWS for refugia operations. On March 9, 2015, the Attorney General's Office issued an opinion letter in which the Attorney General did not find any compelling reason that the EAA could not enter into a contract with the USFWS given the circumstances indicated in the letter.

Given the threat of drought conditions, the Permittees determined it would be prudent to structure refugia operations according to a staggered, two-phase process, with the first step consisting of establishing a *Salvage* Refugia Program aimed at quickly providing refuge capabilities to protect the Covered Species over the short-term, ensuring against imminent salvage triggers threats; and the second step consisting of establishing a *Long-Term* Refugia Program to provide a long-term facility and refugium for the Covered Species for the duration of the ITP. The Salvage Refugia Project is nearing completion, and is expected to be operational in early 2016.

For the Long-Term Refugia Program, in 2015, the EAA issued an RFP, with carefully defined specifications and requirements for long-term refugia operations to carry the program through the remainder of the term of the ITP. In early 2016, the EAA will select a contractor meeting these requirements. For the Refugia Program in 2016, the Permittees recommend securing a strong, qualified candidate for this contract to fulfill the requirements for long-term refugia operations.

6.3 New Braunfels Springs System: Bank Stabilization Project in the Old Channel

In order to decrease the potential for further erosion of a large cut bank along the Old Channel of the Comal River, the CONB will implement a large-scale Bank Stabilization Project, accompanied by riparian restoration that will minimize sedimentation within the river channel.

Initial design of the Bank Stabilization Project was completed in 2014, and subsequent modifications to the design plan were made in 2015. The project entails re-grading the existing cut bank, installing slope protection, anchoring the slope, installing slope drains, and establishing native riparian vegetation. The project will provide long-term stability to the existing eroded bank, and will provide benefit to restored fountain darter habitat within the Old Channel.

The project was previously scheduled to be constructed in 2015, but was delayed due to several factors, including: 1) riparian restoration design modifications to address concerns raised by the SC; 2) waiting until weather conditions provided assurance that Comal spring flow conditions would remain well above the 130 cfs trigger for Condition M of the ITP restrictions for the duration of the project; and 3) floodplain permit acquisition. The project was bid in late 2015, and is expected to commence in early 2016. The Permittees recommend that a concerted effort be made to ensure that this important project is finished in 2016, according to construction timelines.

6.4 San Marcos Springs System: Water Quality Protection Plan

The WQPP, a locally developed approach for compliance with the ESA in San Marcos, will be a priority for the COSM and Texas State. The intent of the WQPP is to provide a holistic, integrated approach in regards to water quality concerns associated with impervious cover and urban development. In addition to protecting habitat for endangered species, the WQPP will help the Permittees serve the needs of their growing populations and promote responsible economic development, good public infrastructure, and preserve open space. A final draft of the WQPP is complete and will now be updated annually as knowledge grows and techniques change. In 2016, the WQPP team will be focusing on Sessom Creek watershed for restoration as well as BMP implementation on Texas State campus as approved. The Permittees hope to address erosion problems in the Sessom Creek watershed through grants for implementation.

7.0 LITERATURE REVIEW

The following list of articles and reports represents a review of literature related to the protected species, aquatic features, and management actions associated with the EAHCP and the EARIP. This review includes journal articles, study reports, and theses and dissertations published or approved during late 2014 and 2015. The literature search was accomplished by conducting online searches of the JSTOR digital library, Google Scholar, Texas State University Dissertations and Theses, and the EAA document library.

7.1 Literature from 2014

Bartenstein, C. S. 2014. The historic and present use of habitat conservation plans for the protection of aquatic species. Thesis, University of Georgia, Athens, Georgia, USA.

This thesis summarized the use of habitat conservation plans for endangered aquatic species and outlined their characteristics. The thesis also presented three HCPs as case studies, including the EAHCP, and outlined the social and political context associated with the development of each plan.

BIO-WEST, Inc. 2014. Fountain darter movement under low-flow conditions in the Comal Springs/River ecosystem. Final Report. October 30, 2014. Prepared for Edwards Aquifer Authority. 29 pages.

This report described the results of a field study to examine wild fountain darter movement in a stressed environment caused by low-flow conditions. Fountain darters from the headwaters of the Comal River were captured and marked with fluorescent visual implant elastomers. During the study period, total system discharge in Comal Springs declined, causing spring flow within the study area to be essentially zero. Of the 2,000 marked individuals, 149 fountain darters were recaptured. In general, the recaptured fountain darters were found to be relatively sedentary, moving an average of 20.9 meters, though two individuals were found to move approximately 130 meters toward a more spring-influenced area. Different utilization of available habitat by fountain darters was also observed when the low-flow conditions caused degradation of the aquatic vegetation in the study area.

BIO-WEST Project Team. 2014. Effect of low-flow on riffle beetle survival in laboratory conditions. Final Report. November 14, 2014. Prepared for Edwards Aquifer Authority. 30 pages.

This research report described a series of experiments examining the effects of extended low-flow periods on riffle beetle survival and water quality under laboratory conditions in a custom-built Riffle Beetle Aquifer Simulation System (RBASS), which allowed controlled experimentation in an upwelling environment. Three riffle beetle species, including the Comal Springs riffle beetle, were used during the experiments. Pilot and experimental studies described in the report provided information on substrate use, handling stress, water temperature acclimation, surrogate suitability, and beetle responses to environmental stimuli.

Craig, C. A. 2014. Relationship between base flow magnitude and spring fish communities. Thesis, Texas State University, San Marcos, Texas, USA.

This thesis examined species richness, relative abundance, and densities of fishes associated with spring complexes across a gradient of base flow magnitudes within the karst terrains of the Edwards Plateau Region of central Texas. The six spring complexes and associated river reaches studied included the Upper San Marcos-San Marcos River. The study found that while there were differences across the flow gradient in spring-associated species richness compared to riverine-associated fishes, as well as differences in relative abundance and densities, only species density was found to be linearly related to base flow.

Huston, D. C., M. D. Worsham, D. G. Huffman, and K. G. Ostrand. 2014. Infection of fishes, including threatened and endangered species by the trematode parasite *Haplorchis pumilio* (Looss, 1986) (Trematoda: Heterophyidae). BioInvasions Records 3: 189-194.

This journal article discussed the life history of an exotic trematode (Haplorchis pumilio) and infection of a common cyprinid artificially exposed to high densities of cercaria from infected snails. The study looked for metacercariae infection in several endangered fishes, including the Fountain Darter. The study found that wild-caught Fountain Darter specimens showed evidence of infection with H. pumilio.

Hutchins, B. T., B. F. Schwartz, and W. H. Nowlin. 2014. Morphological and trophic specialization in a subterranean amphipod assemblage. Freshwater Biology 59: 2447-2461.

This journal article examined an assemblage of seven amphipod species from the Edwards Aquifer for similarities and differences in trophic structure and mouthpart morphology. Trophic characteristics, including food resource type and trophic position within the food chain, were measured based on carbon and nitrogen isotope analysis. The results suggested that each amphipod occupied a different trophic position, and that trophic position showed some correlation with the size and shape of mouthparts.

Nichols, H. 2014. Borehole colonization traps within Spring Run One of the Comal River. Presented as a final project for Karst Hydrology and Geomorphology, Bio 7405, Fall 2014. Texas State University, San Marcos, Texas, USA.

This report described a research project in which borehole colonization trap designs were tested and used to sample the interstitial environment for fauna associated with Spring Run One in the Landa Lake area of the Comal River. Cotton lures were placed in different configurations within the borehole traps and water quality data was collected throughout the study. The study found that while siltation was an issue affecting performance of the traps, lures within the borehole traps did attract riffle beetles and other fauna.

Puig-Williams, V. 2014. The endangered *Springflow* act: How the Endangered Species Act influences groundwater law and protects springflow in Texas, Research Paper No. 2014-03, December 2014.

The Center for Global Energy, International Arbitration and Environmental Law. The University of Texas at Austin School of Law. 17 pages.

This research paper identified issues associated with protecting species that rely on springs or springflow. The requirements and protection mechanisms available under the Endangered Species Act were examined, as well as the regulatory tools available to groundwater conservation districts, which have the authority to regulate groundwater pumping in Texas. The paper outlined and provided examples of the relationship between endangered species protection and groundwater management. Desired future conditions, minimum springflow requirements, and habitat conservation plans were discussed. The paper also included a summary table that listed the springs in Texas with listed species and/or minimum flow requirements.

Puig-Williams, V., and M. E. Taylor. 2014. The conflict between endangered species and the State Water Plan: Will new listing under the Endangered Species Act thwart the state water planning process? Research Paper No. 2014-01, April 2015. The Center for Global Energy, International Arbitration and Environmental Law. The University of Texas at Austin School of Law. 29 pages.

This research paper examined the potential impacts to water planning activities in Texas by future actions of the USFWS to list certain aquatic species under a settlement agreement work plan. In addition to a discussion of Central Texas salamanders, West Texas invertebrates, two Brazos River shiners, and Texas Mussels, the paper described the recent history of actions related to the Comal Springs species. For the Comal Springs species, the authors noted that it was unlikely that water management strategies outlined in the State Water Plan would impact the critical habitat for the Comal Springs species, as there were no groundwater projects planned in the Edwards Aquifer and the species were included in the EAHCP.

Texas State University and BIO-WEST, Inc. 2014. Effects of low flow on fountain darter reproductive effort. Habitat Conservation Plan (HCP) 2014 applied research. Final Report. October 2014. Prepared for Edwards Aquifer Authority. 28 pages.

This report examined the effects of low flow conditions on fountain darter fecundity by comparing measures of reproductive readiness in the fountain darter across a gradient of flow regimes and vegetation types in the San Marcos River and upper spring run reaches of the Comal River. The study found that reproductive effort across all sites was not constant through time and generally decreased from January through August. Reproductive effort as measured by ovary stage was greater within higher flow environments, though spawning differences among flow gradients were not detected. The study reported that reproductive effort was greater on tall vegetation compared to short vegetation at some sites, but that at the Comal Upper Spring Run, bare substrates had the greatest reproductive effort, likely due to the limited available vegetation.

Texas State University and BIO-WEST, Inc. 2014. Effects of predation on fountain darters study. Habitat Conservation Plan (HCP) 2014 applied research. Final Report. October 2014. Prepared for Edwards Aquifer Authority. 11 pages.

This report described a predation study designed to test whether the removal of piscine predators (bass) from fountain darter habitat would have unintended consequences, such as a trophic cascade that would cause an increase in crayfish populations and subsequent decrease in fountain darter populations. Experimental treatments in a laboratory setting involved combinations of fountain darter, bass, and crayfish, both with and without vegetation. The study found that the observed trophic effects of predation by bass and crayfish on the fountain darter were additive and not interactive or cascading.

7.2 Literature from 2015

Adams, W. G., R. D. Blanchard, and R. A. Earl. 2015. Edwards Aquifer Region stakeholder frame analysis. Papers in Applied Geography 3: 235-242.

This journal article described a qualitative study, using interactional frame theory, of the issues surrounding the use of water in the Edwards Aquifer Region. The research used framing to shape, organize, and focus on the current concerns of stakeholders and to revisit a previous case study that had examined the stakeholder conflicts over the Edwards Aquifer from 1980 through 1997. The study also identified current issues including implementation of the EAHCP and unresolved issues from previous conflicts.

Bilbo, J. N. 2015. The effects of water velocity and sediment composition on competitive interactions between native and invasive macrophyte species in a spring fed river. Thesis, Texas State University, San Marcos, Texas, USA.

This thesis examined competitive interactions between two aquatic macrophytes, native Illinois pondweed and the non-native hydrilla, in Spring Lake at the headwaters of the San Marcos River. Experimental treatments varied by growth type (monoculture or mixture), substrate (sand or silt sediment) and water velocity (low or high). The study found that while the native pondweed had higher growth rates than hydrilla across all treatments, both species produced more biomasss when planted in monoculture and there was a non-significant trend toward more growth in both sand and high velocity treatments.

Committee to Review the Edwards Aquifer Habitat Conservation Plan, Water Science and Technology Board, Division on Earth and Life Studies, National Research Council of the National Academies. 2015. Review of the Edwards Aquifer Habitat Conservation Plan, Report 1. Washington, D.C: The National Academies Press. 173 pages.

This published report presents a review of activities by the EAA and its partners to implement the HCP. The report was part of a three-stage study and focused on a review of four scientific initiatives within the HCP: hydrologic modeling, ecological modeling, water quality and biological

monitoring, and the Applied Research program. This report summarized the current status of each initiative and provided conclusions and recommendations related to aspects of the programs that were working well or could be more efficient. Finally, the report identified several overarching concerns that should be addressed for the long-term benefit of the HCP.

Cooke, M., G. Longley, and R. Gibson. 2015. Spring association and microhabitat preferences of the Comal Springs riffle beetle (*Heterelmis comalensis*). The Southwestern Naturalist 60: 110-121.

This journal article examined habitat factors related to the Comal Springs riffle beetle's association with springs of the Edwards Aquifer. The study found that adult and larval beetle abundance in cotton lure traps placed near spring outlets was highest within 20 centimeters of the spring outlet and decreased gradually away from the spring openings. The riffle beetle's preferences for well water, CO_2 concentrations, temperature, and light were compared to a more widespread riffle beetle species. While both species of riffle beetles showed a preference for low flow, elevated CO_2 concentrations, and temperatures near 23ºC, the Comal Springs riffle beetle preferred well water conditions.

Crow, J. C. 2015. Effects of temperature and nitrogenous wastes on survival and growth of the Barton Springs salamander *Eurycea sosorum*. Thesis, Texas State University, San Marcos, Texas, USA.

This thesis examined the physiological responses of the Barton Springs salamander to thermal manipulations and three common aquatic nitrogenous toxins. The thermal study found that an optimal growth temperature of 18.3ºC resulted in an approximately 60 percent increase in total length in tested salamanders. The temperature that showed loss-of-righting response effects for 50 percent of the experimental population was approximately 32.6ºC. The nitrogenous waste study also reported 96-hour median lethal concentrations for ammonia, nitrite, and nitrate.

Dame, K. K., and J. F. Westerlund. 2015. Blind Salamanders beneath and resident scientists within our science classrooms: Secondary study attitudes in a NSF GK-12 program. Electronic Journal of Science Education 19. 28 pages. Retrieved from http://ejse.southwestern.edu/

This journal article discussed the results of a survey of student attitudes toward science during and after an NSF-funded educational partnership between resident scientists and grades K-12 science teachers. During the "Project Flowing Waters" program, students learned about the San Marcos River and endangered species, such as the blind salamander, from interactions with the resident scientists.

Datri, C. W., C. L. Pray, Y. Zhang, and W. H. Nowlin. 2015. Nutrient enrichment scarcely affects ecosystem impacts of a non-native herbivore in a spring-fed river. Freshwater Biology 60:551-562.

This journal article examined the role of nutrient enrichment and herbivorous armoured catfish on ecosystem processes in the San Marcos River using a replicated stream channel experiment. While the presence of armoured catfish reduced periphyton biomass, altered detrital decomposition rates,

decreased periphyton N:P, and increased the severity of periphyton P-limitation, the study found little evidence that adding nutrients altered the effects on armoured catfish on ecosystem dynamics.

Davis, D. R., and C. R. Gabor. 2015. Behavioral and physiological antipredator responses of the San Marcos salamander, *Eurycea nana*. Physiology & Behavior 139:145-149.

This journal article examined antipredator responses in the San Marcos salamander by recording antipredator behavior (reduced activity) and corticosterone release rates (physiological response) when salamanders were exposed to chemical cues associated with two fish species. The study found that the San Marcos salamander showed a decreased antipredator response and no physiological response when exposed to chemical cues associated with a high encounter frequency predator (redbreast sunfish) as compared to chemical cues associated with a low encounter frequency predator (largemouth bass).

DeColo, S. L., A. S. Aspbury, K. G. Ostrand, and C. R. Gabor. 2015. Male-male interactions and their influence on the mating behavior and success in the fountain darter, *Etheostoma fonticola*. Acta Ethologica. Advance online publication. doi: 10.1007/s10211-015-0216-x

This journal article examined the effects of male-male interactions on female mating choice in the fountain darter. The study found that while larger males exhibited higher rates of aggressive behaviors and smaller males exhibited more defensive behaviors, these differences did not lead to differences in spawning success.

Diaz, P. H., J. N. Fries, T. H. Bonner, M. L. Alexander, and W. H Nowlin. 2015. Mesohabitat associations of the threatened San Marcos salamander (*Eurycea nana*) across its geographic range. Aquatic Conservation: Marine and Freshwater Ecosystems 25:307-321.

This journal article described the results of a year-long study of the mesohabitats, or visually distinct habitat areas within a stream, associated with the San Marcos salamander within its designated critical habitat in the San Marcos River. The study also looked for patterns of co-occurrence with macrophytes and benthic invertebrates. The results indicated that salamanders were almost exclusively found in mesohabitats characterized by cobble and gravel substrates that were covered in filamentous algae and Amblystegium sp., an aquatic moss. Because no consistent co-occurrence with specific invertebrates or macrophytes was observed, the authors indicated that salamanders were likely selecting mesohabitats based on benthic substrate rather than biotic communities.

Gou, S., S. Gonzales, and G. R. Miller. Mapping potential groundwater-dependent ecosystems for sustainable management. Ground Water 53:99-110.

This journal article described a geospatial information system (GIS) analysis of climate, topography, hydrology, and ecology data used to calculate an index of groundwater-dependent ecosystems in Texas. In the potential groundwater-dependent ecosystems identified during the analysis, 75 percent were located in areas with soil depths averaging 45 cm. Dominant vegetation

types within these areas were identified as live oak, Ashe juniper, and mesquite. A more detailed GIS analysis of the Edwards Aquifer region using satellite imagery found that 8 percent of natural vegetation was likely using groundwater.

Gulley, R. L. 2015. Heads above water: the inside story of the Edwards Aquifer Recovery Implementation Program. College Station: Texas A&M University Press. 234 pages.

This book tells the story of the EARIP, including a discussion of the water issues in the Edwards Aquifer Region, the history of the EARIP process, and how consensus was reached among the thirty-nine diverse stakeholders.

Hardy, T., K. Kollaus, K. Tolman, T. Heard, and M. Howard. 2015. Ecohydraulics in applied river restoration: a case study in the San Marcos River, Texas, USA. Journal of Applied Water Engineering and Research. Advance online publication. doi: 10.1080/23249676.2015.1090352.

This journal article described a study that used a hydraulic model to predict optimal locations for replacement of non-native aquatic plants with Texas wild rice. After the non-native plants were manually removed and Texas wild rice was planted within the exposed areas, a year-long monitoring effort showed a high success rate for Texas wild rice expansion and reductions in non-native species within the restored areas.

HDR, Inc. 2015. Final Refugia Review, Edwards Aquifer Habitat Conservation Program, Edwards Aquifer Authority, Comal and San Marcos Springs, Texas. Report dated May 2015.

This report identified and described the preliminary infrastructure, space, water, and species expertise necessary for the EAA Refugia Program. Proposed target and trigger values for standing and refugia stock populations were identified. The report also provided summaries of the current state of knowledge regarding known habitat and life histories for each of the eleven species in the EAHCP.

Huston, D. C. and J. R. Gibson. 2015. Underwater pupation by the Comal Springs riffle beetle, *Heterelmis comalensis* Bosse, Tuff, and Brown, 1988 (Coleoptera: Elmidae), with an update on culture techniques. The Coleopterists Bulletin 69: 521-524.

This journal report presented recent laboratory observations of underwater pupation by the Comal Springs riffle beetle, which was unusual since it was previously thought that all riffle beetles pupated above the water line. The report also described the culture container system, consisting of flow-through aquaria, that was used during the study.

Huston, D. C., J. R. Gibson, K. G. Ostrand, C. W. Norris, and P. H. Diaz.. 2015. Monitoring and marking techniques for the endangered Comal Springs riffle beetle, *Heterelmis comalensis* Bosse, Tuff, and Brown, 1988 (Coleoptera: Elmidae). The Coleopterists Bulletin 69: 793-798.

This journal article discussed monitoring methods for the Comal Springs riffle beetle. The article reported success using pleated cotton lures within steel screen box cages over a 17-week sampling effort, with beetle density peaking at nine to ten weeks. Other spring-associated aquatic species were found on the lures, including Peck's cave amphipod and the Comal Springs dryopid beetle. Laboratory evaluation of marks made with oil-based paint pens indicated no mortality in a surrogate riffle beetle species, though the method is time consuming and labor intensive due to the small size of the beetle. A combination of the two monitoring methods for a mark-recapture study recovered two out of the 100 beetles returned to monitored spring sites, with one individual recovered at the same release site and the other 1.7 meters away from its release site.

Hutchison, J. T. 2015. Propagation of Texas wild rice and other native plants for habitat restoration in the San Marcos River. 2015 Final Report. City of San Marcos grant. November 3, 2015. 16 pages.

This project report described operations at the San Marcos Aquatic Resources Center in which Texas wild rice, native aquatic plants, and native riparian and terrestrial plants were propagated and maintained for replanting in the San Marcos River. Data and observations were presented on plant growth, propagation success rates, and recommended timing of replanting operations for the various species grown during the project. The report also provided a brief update on a research project to evaluate Texas wild rice planting patterns in the San Marcos River.

Hutchison, J. T., D. C. Huston, and J. R. Gibson. 2015. Defoliation of cultured creeping primrose willow (*Ludwigia repens*) and other aquatic plants by *Parapoynx obscuralis* (Lepidoptera: Crambidae). Southwestern Entomologist 40: 227-232.

This journal article reported observations on plant preferences, larval damage estimates, and other life history traits of P. obscuralis, a *moth associated with aquatic and wetland plants. The moth species was observed feeding, and at times defoliating, several plants propagated at the San Marcos Aquatic Resources Center, including the endangered Texas wild rice, over three growing seasons.*

Hutchison, J. T. and K. G. Ostrand. 2015. Texas wildrice (*Zizania texana* Hitchc.) propagule production and survival in outdoor ponds as influenced by water depth and velocity. Native Plants Journal 16: 234-241.

This journal article described growth and propagation of Texas wild rice in an outdoor pond at the San Marcos Aquatic Resources Center, where the plants are grown to support restoration efforts. Experimental factors recorded for the pond study included water depth, current velocity, initial root length, and number of initial tillers per pot. Evaluation of survival, emergence, and flowering after one growing season indicated that plant survival was greater in higher current velocity or deeper water levels, but that plant emergence and flowering rates were greater at lower current

velocities (≤ 0.10 meters per second) and shallower depths (≤0.35 meters). Potting a minimum of three tillers with a combined total root length of > 0.6 meters also showed higher survival rates. No clear pattern on tiller production was observed based on water depth or current velocity.

Kollaus, K. A., K. P. K. Behen, T. C. Heard, T. B. Hardy, and T. H. Bonner. 2015. Influence of urbanization on a karst terrain stream and fish community. Urban Ecosystems 18: 293-320.

This journal article examined the effects of catchment urbanization on the San Marcos River through comparison of historical fish community changes recorded from 1880 to 2011. The upper San Marcos River supported a persistent fish community over time, with changes that could not be solely attributed to urbanization of its watershed. The authors indicated that the upper San Marcos River was an exception to the predictions associated with urban stream syndrome because it represented a dynamic stream system with decreasing stream flow and increasing water temperatures over time and also because the water quantity of the river was greater than other headwater streams typically used to assess urban stream syndrome.

Nichols, H., T. H. Bonner, and K. G. Ostrand. 2015. Discharge and habitat mediated effects on fountain darter *Etheostoma fonticola* reproduction. Oral Presentation. American Fisheries Society, 145th Annual Meeting, August 16-20, 2015, Portland Oregon.

This presentation described a study to assess the effects of reduced surface flow and changes in aquatic vegetation on reproduction in the fountain darter in the Comal and San Marcos Rivers. The preliminary results found that measures of reproductive potential were similar among the flow environments and microhabitat types examined.

Nowlin, W. H., B. Schwartz, T. Hardy, and R. Gibson. 2015. Determination of limitations of Comal Springs riffle beetle plastron use during low-flow study. Edwards Aquifer Authority Study No. 14-14-697-HCP. Final Report. 23 pages.

This report described the results of a series of experiments that examined the effects of temperature and dissolved oxygen changes on fitness in three riffle beetle species, including the Comal Springs riffle beetle. Low-flow spring conditions were presumed to increase daily average water temperature and lower dissolved oxygen concentrations, which in turn would affect plastron function and potential survival and fitness in the beetles. Changes in temperature or dissolved oxygen were adjusted in the laboratory over a short or long period of time until the beetles stopped responding to a stimulus. The study found that the Comal Springs riffle beetle was able to tolerate high temperatures and low dissolved oxygen concentrations over the short term, though the temperature thresholds for stress behaviors was lower when compared to the other spring-associated beetle species. Observations also indicated that long-term exposure to higher temperatures may have substantial negative effects on riffle beetle fitness.

Sanchez, B. 2015. The San Marcos River, a community river: Threats, impacts, and strategies. Honors Thesis, Texas State University, San Marcos, Texas, USA.

This undergraduate honors thesis described the history of development along the San Marcos River, some of the current threats to the river due to urbanization, and strategies to reduce the impacts of these threats.

Scanes, C., D. Ruppel, B. Littrell, and T. H. Bonner. 2015. Fish community and habitat assessments within an urbanized spring-fed stream of the Edwards Plateau. Poster Presentation. American Fisheries Society, 145th Annual Meeting, August 16-20, 2015, Portland Oregon.

This poster presentation described a study to examine the relationship between spring flow and biotic integrity in the Comal River system using fish community densities, fish-habitat associations, and spring flow. Preliminary results, conducted during a region-wide drought, found that densities of spring fishes, including the endangered fountain darter, decreased during declining spring flow, though seasonal reproductive effects could not be excluded as a possible mechanism in the decline.

Xu, X., J. Wu, M. Qi, Q. Lu, P. F. Lee, S. Lutz, S. Ge, and J. Wen. 2015. Comparative phylogeography of the wild-rice genus *Zizania* (Poaceae) in eastern Asia and North America. American Journal of Botany 105:239-247.

This journal article compared the genetic diversity of several closely-related species of the wild rice genus Zizania from North America and eastern Asia. The study found that Zizania from North American populations were much more diverse compared to the eastern Asian populations and proposed that diversification and evolution of the North American species may have been driven by different climate histories (i.e., glaciation) relative to eastern Asia.

Zara Environmental, LLC. 2015. Comal Springs riffle beetle occupancy modeling and population estimate within the Comal Springs system, New Braunfels, Texas. Report dated 23 March 2015. Prepared for Edwards Aquifer Authority, San Antonio, Texas, USA. 20 pages.

This report described the results of population modeling estimates based on lure-based survey efforts for the Comal Spring riffle beetle in the Comal Springs complex during a period of extreme low flow in October 2014. Data on covariates thought to impact occupancy or detection, such as spring type, spring location, substrate types, flow, and shade, were also collected. A total of 137 Comal Springs riffle beetles were observed, including 101 beetles and 36 larvae in 22 out of the 95 sampled spring outlets. Modeling results indicated that Comal Springs riffle beetle occupancy was positively correlated with spring orifices and the presence of roots and/or detritus. The Comal Springs dryopid beetle and the Peck's Cave amphipod were also observed during the survey.

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