Upper Frio River Basin Bioassessment: Dry Frio and Frio Rivers in Real and Uvalde Counties, Texas

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EXECUTIVE SUMMARY

Four sites were selected for the upper Frio River Basin Bioassessement, which occurred in March 2014 in Real and Uvalde counties, Texas at two sites on the Dry Frio River and two sites on the Frio River. All four sites were sampled to assess the fish assemblage and to provide updated information for the Fishes of Texas database (Hendrickson and Cohen 2012). The site on the Frio River located at Garner State Park was selected for an additional comprehensive bioassessment to provide data on instream physical habitat, water quality, mussel and macroinvertebrate assemblages, invasive species, riparian habitat, and public access. While the Texas Commission on Environmental Quality (TCEQ) has completed some biological and water quality studies on the upper Frio (Walher and Palma 2004; TCEQ 2012), this report is the first published comprehensive aquatic bioassessment of the Frio River at Garner State Park. Little biological information for the Dry Frio River is publically available, with the most recent records in the Fishes of Texas database occurring in 1968.

Fish communities were similar between the Dry Frio and Frio Rivers, with the main distinction being a lack of catfish species and Texas Shiners in the Dry Frio River. Fish species occurrences were similar to historic fish collection records for the upper Frio and Dry Frio Rivers dating back to 1951 (Hendrickson and Cohen 2012). High fish diversity, low percentage of non-native species, and the presence of four species classified as species of greatest conservation need by the Texas Parks and Wildlife Department (TPWD; TPWD 2012) indicates a high quality fish assemblage in both rivers.

This bioassessment indicated the reach of the Frio River studied at Garner State Park had a high aquatic life use for instream physical habitat, fish, and aquatic macroinvertebrates. This reach received a fair stream health score using a Stream Visual Assessment Protocol modified for Texas streams (SVAP2; Appendix A). This score was lowered due to impacts on the riparian corridor and reduced aquatic connectivity caused by a low-water dam. While it is likely not feasible to remove the dam at the south end of the park, access to the river throughout the park could be managed to allow sections of the riparian zone to recover from high public use.

While bank angling access is not a limiting factor in Garner State Park, few sport fish were collected. The only sport fish species collected was Largemouth Bass (*Micropterus salmoides*) and of those collected only one was over the legal length limit. Lack of instream cover throughout this reach and harvest by park visitors is likely decreasing the abundance of this species. Enhancing instream habitat with anchored large woody debris and encouraging catch-and-release angling are recommended to improve the Largemouth Bass population. Stocking of catfish as an additional sport fishing opportunity is not recommended due to the likelihood of hybridization with the imperiled Headwater Catfish (*Ictalurus lupus*). Other angling opportunities include various sunfish species. Signage or brochures could be made available to the public to promote fishing opportunities and encourage catch-and-release angling.

The Frio River at Garner State Park provides recreational opportunities to the public while maintaining a diverse, functioning ecosystem. A few steps could be taken to improve the riparian area, instream habitat, and overall stream health. The primary recommendation is to continue regular aquatic monitoring to document trends and make recommendations for maintaining the ecosystem.

INTRODUCTION

Site Description

Frio River: The Frio River is part of the Nueces River Basin and falls within the Edwards Plateau ecoregion. The river originates in Real County, Texas from the joining of the East and West Frio Rivers. It continues approximately 200 miles until it joins the Nueces River just south of the City of Three Rivers, Texas. Numerous springs originating from the Edwards and Glen Rose limestone formations feed the Frio River and its tributaries (Brune 1981). Spring flows are important to sustain fish, wildlife, and plant species in this semi-arid region, and provide a substantial economic benefit to surrounding communities (Combs 2008). The Frio River has been listed as a Texas Natural Rivers System nominee by the National Park Service (NPS) based on its exceptional scenery, recreational value, wildlife, and historical significance (NPS 2010). The upper Frio River has also been designated an ecologically significant stream segment in all categories by TPWD: biological function, hydrologic function, riparian conservation area, high water quality and aesthetic value, and unique communities (Norris et al. 2005).

> Garner State Park: Garner State Park is located between Leaky and Concan, Texas on U.S. Highway 83. The park covers 1,774 acres and contains 2.9 miles of Frio River frontage. It has consistently been the most visited state park in the Texas Parks and Wildlife System, annually receiving between 300,000 and 400,000 visitors. The park offers many recreational activities including fishing, swimming, tubing, hiking, boating, biking, miniature golfing, and camping. Garner State Park has a large economic impact on Uvalde County, generating approximately 2 to 3 million dollars a year in revenue and contributing approximately 7.8 million dollars in sales to the county (Combs 2008). With many of the recreational activities in the park centered around the Frio River, it is important to maintain this natural resource for future use.

Dry Frio River: The Dry Frio River is an intermittent tributary of the Frio River that arises in Real County, Texas and confluences with the Frio River approximately 20 miles southeast of Garner State Park. The Dry Frio River is bordered by private property and is fed by several off-channel springs.

Management History

Biological Surveys: TCEQ has surveyed fish and invertebrate communities on the upper Frio River (stream segment 2113) at sites above and below Garner State Park. The reach of the upper Frio River downstream of its confluence with Bear Creek, approximately 7 miles downstream from Garner State Park, is currently listed on TCEQ's 303d list as having an impaired fish and aquatic invertebrate community (TCEQ 2012). This impairment listing was derived from data collected in 2006 and comes with the disclaimer that more data should be collected before mitigation strategies are implemented. TCEQ is currently in the process of collecting more data at their monitoring stations on the Frio River.

Fish Harvest Regulations: Sport fishes in the Frio River are currently managed under statewide freshwater fishing regulations.

Fish Stockings: Channel Catfish (*Ictalurus punctatus*) were stocked in the Frio River within Garner State Park in 1991. Stockings in the Frio River outside of Garner State Park occurred in 2004 for Channel Catfish and in 1994 for Rainbow Trout (TPWD 2014a).

Riparian Vegetation and Habitat: Previous assessments of the upper Frio River report that the riparian corridor is comprised mostly of mesquite (*Prosopis glandulosa*), Texas red bud (*Cercis Canadensis*), Ashe juniper (*Juniperus ashei*), lacey oak (*Quercus laceyi*), cedar elm (*Ulmus crassifolia*), bald cypress (*Taxodium distichm*), pecan (*Carya illinoensis*), willow (*Salix nigra*), sycamore (*Platanus occidentalis*), and Spanish oak (*Quercus buckleyi*) (Norris et al. 2005). Within Garner State Park, there remains an intact riparian corridor for most of the 3 miles of river it borders.

Instream Aquatic Vegetation and Habitat: No studies have been published describing instream aquatic vegetation or habitat. No management actions have been used to control aquatic vegetation or enhance instream habitats.

Non-Native Species: One of the most common non-native, invasive species affecting the upper Frio River Basin is *Arundo donax*, commonly known as giant reed or river cane. Giant reed is commonly found in riparian areas throughout rivers of Texas and has the potential to significantly alter stream ecosystems by using large amounts of water, crowding out native riparian species, and altering a streams flow path (Billings 2006). A landowner-driven project, Pull-Kill-Plant, is addressing the giant reed problem in the Sabinal and Nueces River basins through removal, chemical treatment, and replanting of native species (www.pullkillplant.org). To date, this project has removed or treated 4.5 acres of giant reed on the Dry Frio River and 0.5 acres on the Frio River (Sky Lewey, Nueces River Authority, personal communication).

Anecdotal evidence suggests that other non-native species are present in the Frio River and its riparian area; however, no formal surveys have been conducted documenting these species, and no other eradication efforts are currently taking place.

Species of Greatest Conservation Need: Historic fish occurrence records from the Fishes of Texas database (Hendrickson and Cohen 2012) contain records of four species of greatest conservation need (TPWD 2012) collected previously from the Frio River (Headwater Catfish, Plateau Shiner (*Cyprinella lepida)*, Texas Shiner (*Notropis amabilis)* and the Nueces Roundnose Minnow (*Dionda serena*)) and, three species collected previously from the Dry Frio River (Plateau Shiner, Texas Shiner, and the Nueces Roundnose Minnow).

METHODS

Sites: Fish were collected at two sites on the Frio River (Garner State Park (Site A) and private property one mile upstream of Garner State Park (Site B)) and two sites on the Dry Frio River (private property 1.4 miles north of the Real-Uvalde county line (Site C) and the FM 1051 road crossing (Site D)) (See Figure 1). The comprehensive bioassessment was conducted at Site A (Figure 2) within the bounds of Garner State Park.

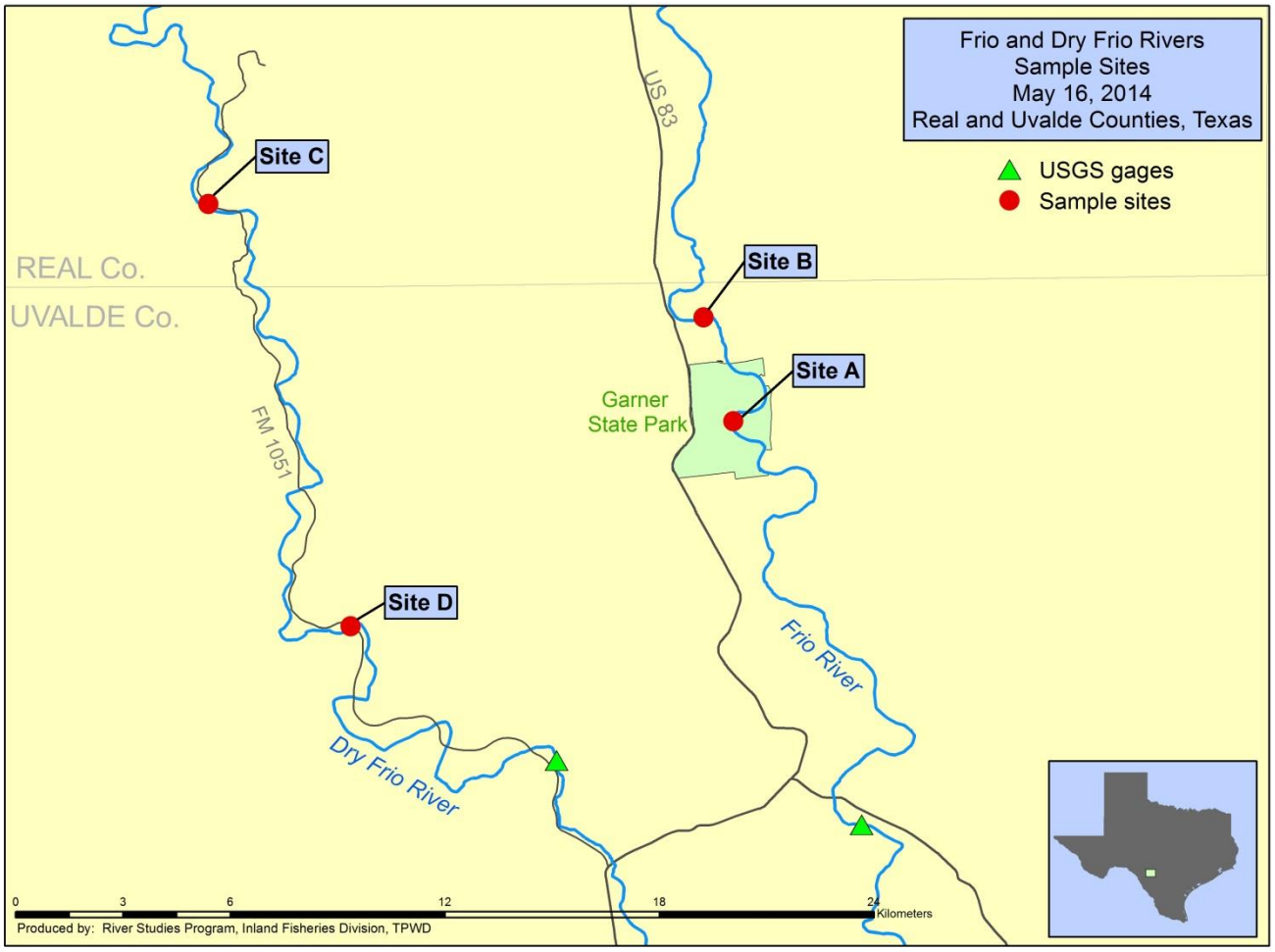


Figure 1. Map of sample sites on the Frio and Dry Frio Rivers in Real and Uvalde counties, Texas, May 2014.

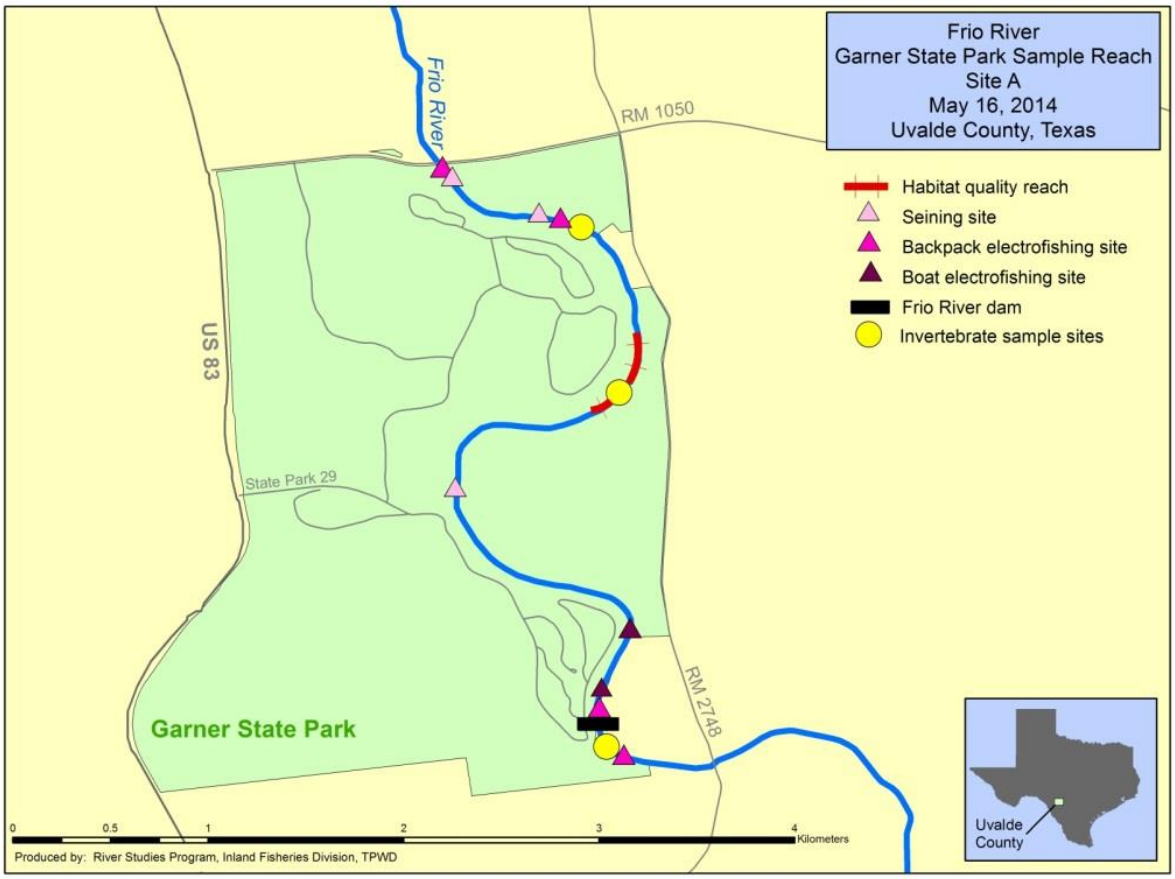


Figure 2. Map of the bioassessment site, Site A, located within the bounds of Garner State Park, Uvalde County, Texas, May 2014.

Habitat Quality: Habitat quality was assessed at our primary bioassessment site, Site A, within the boundaries of Garner State Park according to TCEQ's surface water quality monitoring procedures handbook (TCEQ 2007). Six equidistant habitat transects were assessed over a 500-m reach (Figure 2). At each transect, instream and riparian variables were quantified, summarized using nine habitat metrics, and summed to determine a habitat quality index score.

Water Quality: Water temperature, specific conductance, dissolved oxygen, and pH were recorded for a 29-hour period at the upstream end of Site A using a YSI brand multi-parameter water quality sonde. Data were verified using TCEQ quality assurance/quality control procedures, (TCEQ 2007). Means and standard deviations were calculated for each verified parameter.

Fish Assemblage: Fish were collected from all four sites using a combination of boat and backpack electrofishing and seining techniques following TCEQ protocol (TCEQ 2007). For large fish, total lengths were recorded and a voucher photograph was taken before release. All other fish captured were preserved in 10% formalin and taken to the laboratory for enumeration and species identification. For fish collected at Garner State Park, specific locations of fish sampling by gear type (Figure 2) and effort were documented. These data were used to calculate catch per-unit-effort (CPUE) and a regional index of biotic integrity (Linam et al. 2002). All vouchered specimens will be permanently housed at the University of Texas at Austin Biodiversity Collections facility in Austin, Texas. These data will also be available online through the Fishes of Texas Project website (http://www.fishesoftexas.org/).

Mussel Assemblage: Mussels were surveyed for two person hours along the length of Site A using timed snorkel surveys in multiple mesohabitat types (Strayer and Smith 2003).

Macroinvertebrate Assemblage: Aquatic macroinvertebrates were collected from three locations within Site A (Figure 2). Macroinvertebrates were collected using a D-frame kick net following procedures in TCEQ's surface water quality monitoring procedures handbook (TCEQ 2007). A minimum of 175 macroinvertebrates were collected per location. Macroinvertebrates were preserved in 70% ethanol and transported back to the lab where they were identified to the lowest possible taxonomic group. The macroinvertebrate community was assessed using 12 metrics (TCEQ 2007). These metrics were scored and summed to determine the aquatic life use score.

Riparian Assemblage: A qualitative visual assessment of the riparian area was conducted at Site A. Dominant species present and general health of the riparian corridor were noted.

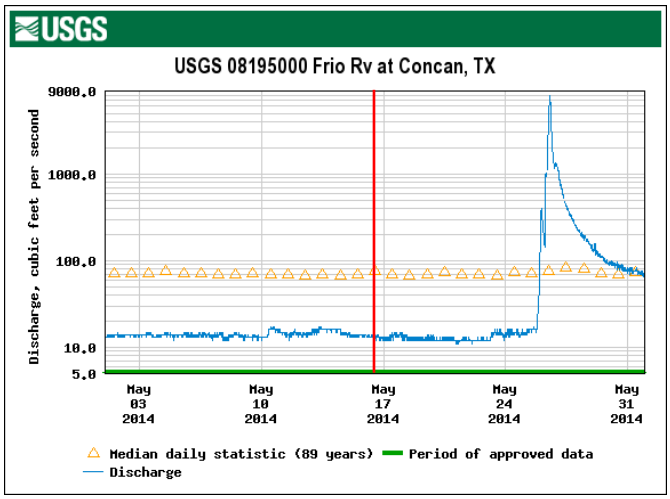
Non-native Species: Two teams surveyed the entire extent of Site A to document the distribution of riparian and aquatic plant non-native species and provide management recommendations. Surveyors used GPS-enabled cameras to document the location of individual plants or patches of plants.

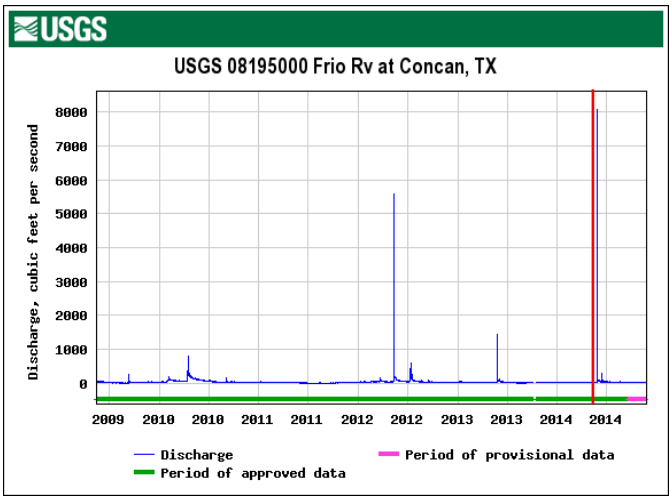
Stream Health: To obtain a snapshot of riparian habitat and overall stream condition, a modified Stream Visual Assessment Protocol (SVAP2; Appendix A) was conducted on Site A. The SVAP2 is based on the SVAP protocol created by the Natural Resources Conservation Service (NRCS 2009), but includes updates to make it more relevant to Texas streams. This protocol allows for a basic level of ecological assessment to qualitatively evaluate the condition of aquatic ecosystems associated with wadeable streams. The SVAP2 utilizes scores from thirteen major scoring elements including: channel condition, hydrological alteration, bank stability, riparian area quantity, riparian area quality, water appearance, nutrient enrichment, barriers to aquatic species movement, stream habitat complexity, pools, aquatic invertebrate community, riffle embeddedness, and salinity. Descriptions of these scoring elements are included in Appendix A. After scoring each element, scores are summed and divided by the number of elements to provide an overall SVAP2 score. Scores are graded as follows: 1-2.9 = Severely Degraded, 3-4.9 = Poor, 5 to 6.9 = Fair, 7 to 8.9 = Good, 9 to 10 = Excellent.

Public Access: Public access to the Frio River was assessed during a site visit prior to the bioassessment. A subsample of access points were assessed for accessibility, parking capacity, and bank fishing potential.

RESULTS AND DISCUSSION

Water Quantity: During the week of sampling, drought maps produced by the U.S. Drought Monitor showed that Real and Uvalde counties were in severe to exceptional drought conditions (USDM 2014). This was reflected in the condition of the Frio River, which according to the nearest United States Geologic Survey (USGS) gage, located approximately 9 miles downstream of Site A (Figure 1), was flowing at only 14 cubic feet per second (cfs) (Figure 3). USGS reports this flow as 20% of the historical daily median flow (Figure 3); however, this low flow is consistent with the recent flow record (Figure 4). The USGS gage on the Dry Frio River, located approximately 7.5 miles downstream of Site D, showed that the flow during sampling was less than 1 cfs or 7% of the historical daily mean flow (Figure 5).





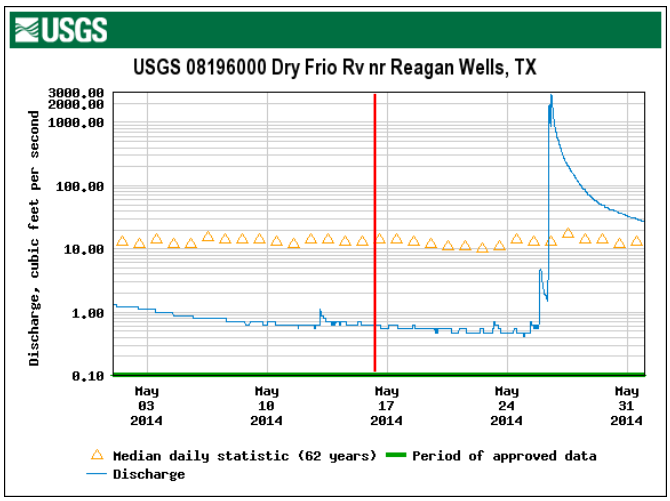


Figure 3 (top): Frio River discharge at Concan, Texas for the period of May 1-31, 2014 provided by USGS. The red line indicates the date of the bioassessment, May 16, 2014.

Figure 4 (middle): Frio River discharge at Concan, Texas for the period of May 2009 – November 2014 provided by USGS. The red line indicates the date of the bioassessment, May, 16, 2014.

Figure 5 (bottom). Dry Frio River discharge near Reagan Wells, Texas for the period of May1 – 31, 2014 provided by USGS. The red line indicates the date of the bioassessment, May 16, 2014.

Habitat Quality: The upper Frio River (Sites A and B) is dominated by shallow water habitats over limestone bedrock and gravel substrates (Figure 6). Habitat quality was directly assessed at Site A using the habitat quality index score (Table 1; TCEQ 2007). Overall this reach received a high habitat quality index score of 21. Riparian buffer and aesthetics of the reach scored low due to development and human impacts, such as the high number of foot trails cutting through the riparian corridor to the river. The mean stream depth was 0.31 m with a mean stream width of 18.6 m. Despite the low flow of the system, the functionality of mesohabitats (riffles, runs, backwaters, and pools) remained intact and received a high score. Instream cover was found in approximately 20% of the reach and was primarily boulder and large cobble. Aquatic macrophytes were present where silt had accumulated in pools. Thirty percent of the reach was shaded, primarily by large cypress trees growing along the stream bank. Most of the stream bank had little other overhanging canopy, most likely due to bedrock substrate and scouring events.

Figure 6. The upper two photographs are typical of habitat found in the Frio River, which is dominated by shallow, flowing habitats over bedrock and gravel substrates. The lower photograph shows the low-water dam on the Frio River near the downstream boundary of Garner State Park.

Table 1. Physical habitat quality index scores for the Frio River within Garner State Park, Site A, May 2014. Categories are scored from low quality to high quality on a scale of 1-4 for the first four metrics and 0-3 for the remaining metrics.

Habitat Quality Category	Index Score
Available instream cover	2
Bottom substrate stability	4
Number of riffles	3
Dimensions of largest pool	4
Channel flow status	3
Bank stability	2
Channel sinuosity	1
Riparian buffer vegetation	1
Aesthetics of reach	1
Total score	**21**
Habitat Quality Category	**High**

Anthropogenic changes in instream habitat were evident throughout the state park. Rock-wall structures of varying sizes had been constructed in the stream channel by park visitors, diverting flow and constricting the channel in some areas (Figure 7). Some of these structures created small pools and velocity shelters in areas that would have otherwise been run habitats. While these structures do alter the flow, the predominately bedrock bottom resists any permanent changes to stream morphology. There is no evidence that these structures are detrimental to the river or aquatic communities as long as the river is not completely dammed. It appears that some of these structures act as velocity shelters that are utilized by some fish species. While these structures do not appear permanent, a site visit on June 6, 2014, less than two weeks after an 8,000 cfs flood pulse, showed that many of the structures remained intact (Figure 7). Given the potential long-lasting effects of these structures, any that span the entire river channel and significantly alter flow should be removed.

Figure 7. Aerial imagery from 2012 (left photograph) shows the Frio River below the dam at Garner State Park with extensive man-made rock walls diverting flow within the streambed. The right image was taken in June 2014, less than two weeks after an 8,000 cfs flood pulse moved through the system. The rock walls remained largely intact after this flood event.

Although not quantitatively assessed, habitats on the Dry Frio River appeared to be dominated by stagnant pool habitats with little flowing water during the period of study (Figure 8). This is not surprising given the extremely low flow conditions experienced in May 2014 (Figure 5).

Figure 8. These photographs are typical of habitats found in the Dry Frio under low flow conditions, which consist of vegetated, slow moving, or stagnant pools.

Water Quality: Water clarity was good throughout the reach. Water temperature varied a little more than 7°C during the sampling period (Table 2), reaching peak temperature of 24.32 ºC at 4 pm the day prior to sampling. Specific conductance and pH did not vary much during the 29-hour period, most likely an artifact of the homogenous spring water found in the upper Frio River. Dissolved oxygen showed a diurnal trend, peaking at 10.70 mg/L at 12:30 pm on May 15, 2014. Water quality results are summarized in Table 2.

Table 2. Water quality summary over a 29-hour period from the Frio River at Site A, May 2014.

	Temperature (C)	**Specific Cond.** Us/cm	**Dissolved Oxygen** Mg/L	**pH**
Mean	20.74	452	9.85	8.0
Minimum	17.06	445	8.87	7.7
Maximum	24.32	456	10.70	8.15
Standard dev.	2.07	3.35	0.67	0.08

Fish Assemblage: A total of 1,093 fish, representing 16 species were collected from two sites on the Frio River (Site A and Site B: Table 3). Fish species collected were similar to historical records of fish collected from the Frio River in Uvalde County dating back to 1951 (Hendrickson and Cohen 2012). Species collected most notably included six native cyprinid, four sunfish, and two catfish species. Insectivores made up the largest trophic guild, comprising over 85% of the fish collected from Site A. Two intolerant species were collected in low numbers from the Frio River: Greenthroat Darter (*Etheostoma lepidum)* and Nueces Roundnose Minnow. Total catch per unit effort from Site A was 0.018 individuals per minute of boat electrofishing time (total effort = 17.9 minutes), 0.088 individuals per minute of backpack electrofishing time (total effort = 20.9 minutes), and 0.41 individuals per seine haul (total effort = 10 seine hauls). Based on species composition and catch per unit effort, a regionalized index of biotic integrity (IBI) score was calculated using data from Site A. Site A received an IBI score of 49, placing it into the high aquatic life use category (Table 4).

Table 3. Fish species collected by site on the Frio River (Sites A and B) and the Dry Frio River (Sites C and D) in May 2014. Trophic guild abbreviations are as follows: Invertivore (IF), Omnivore (O), Herbivore (H), and Piscivore (P).

Scientific name	**Common name**	**Trophic guild**	**Site A**	**Site B**	**Site C**	**Site D**
Ameiurus natalis	Yellow Bullhead	O	1	2		
Campostoma anomalum	Central Stoneroller	H	10	3	5	
Cyprinella lepida	Plateau Shiner	IF	35	25	20	
Cyprinella venusta	Blacktail Shiner	IF	146	162	2	46
Dionda serena	Nueces Roundnose Minnow	O	3	29	27	7
Etheostoma lepidum	Greenthroat Darter	IF	4	5	1	
Gambusia affinis	Western Mosquitofish	IF	29	122	80	14
Herichthys cyanoguttatus	Rio Grande Cichlid	IF		13		
Ictalurus lupus	Headwater Catfish	O	14	7		
Lepomis auritus	Redbreast Sunfish	IF	47	30		5
Lepomis cyanellus	Green Sunfish	P	15	2	2	2
Lepomis macrochirus	Bluegill	IF	5			4
Lepomis megalotis	Longear Sunfish	IF	14	57	29	8
Lepomis miniatus	Redspotted Sunfish	IF				8
Micropterus salmoides	Largemouth Bass	P	9	22		12
Notropis amabilis	Texas Shiner	IF	9	226		
Notropis stramineus	Sand Shiner	IF	34	13	21	
Total			**375**	**718**	**187**	**106**

Table 4. Fish assemblage data and metric scores for fish collected from Site A on the Frio River, May 2014. IBI scores range from low to high on a scale of 1-5.

Metric Category	Intermediate Totals for Metrics		Metric Name	Raw Value	IBI Score
	Drainage Basin Size (km^2)	1,007			
Species Richness and Composition	Number of Fish Species	15	Number of Fish Species	15	5
	Number of Native Cyprinid Species	6	Number of Native Cyprinid Species	6	5
	Number of Benthic Invertivore Species	1	Number of Benthic Invertivore Species	1	3
	Number of Sunfish Species	4	Number of Sunfish Species	4	5
	Number of Intolerant Species	2	Number of Intolerant Species	2	5
	Number of Individuals as Tolerants[a]	55	% of Individuals as Tolerant Species[a]	14.7	5
Trophic Composition	Number of Individuals as Omnivores	15	% of Individuals as Omnivores	4.0	5
	Number of Individuals as Invertivores	326	% of Individuals as Invertivores	86.9	5
	Number of Individuals as Piscivores	24	% of Individuals as Piscivores	6.4	3
Fish Abundance and Condition	Number of Individuals (Seine)	246	Number of Individuals in Sample		2
	Number of Individuals (Shock)	129	Number of Individuals/seine haul	24.6	1
	Number of Individuals in Sample	375	Number of Individuals/min electrofishing	3.25	3
	# of Individuals as Non-native species	47	% of Individuals as Non-native Species	12.5	1
	# of Individuals With Disease/Anomaly	1	% of Individuals With Disease/Anomaly	0.3	5
				Index of Biotic Integrity Numeric Score:	**49**
				Aquatic Life Use:	**High**

[a] Excluding western mosquitofish

A total of 293 fish, representing 13 species were collected from two sites on the Dry Frio River (Site C and Site D: Table 3). These species most notably included 5 native cyprinid and 5 sunfish species. The largest trophic guild present were insectivores and two intolerant species were collected, Nueces Roundnose Minnow and Greenthroat Darter.

Largemouth Bass were collected from sites A and B on the Frio River and from Site D on the Dry Frio River and were the only sport fish collected. Largemouth Bass made up only 2.8% of the total catch on the Frio River and 4.1% of the catch on the Dry Frio River. Despite the low sample size, length frequency data at Site A indicates at least two year classes of Largemouth Bass were present (Figure 9). No Channel Catfish were collected despite previous stockings in this reach of the Frio River. The absence of Channel Catfish is likely due to high fishing pressure, or possible hybridization with the Headwater Catfish, which were collected in the reach. High water clarity limited electrofishing effectiveness for adult sport fish and abundance may be higher than reported.

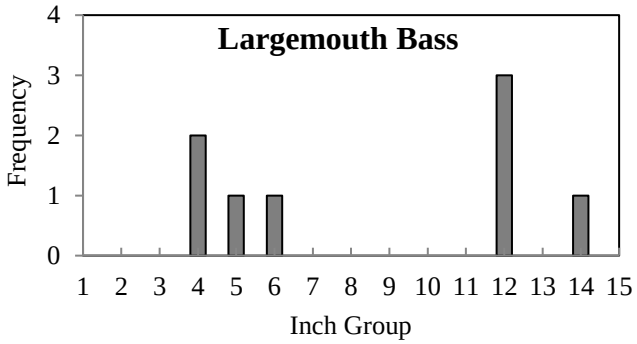


Figure 9. Number of Largemouth Bass caught by inch group combining catch from all gear types at Site A. Largemouth Bass were also collected from sites B and D, but lengths were not recorded.

Four SGCN species were collected from the Frio River: Nueces Roundnose Minnow, Texas Shiner, Headwater Catfish, and Plateau Shiner. Two of these species were also collected on the Dry Frio River: Nueces Roundnose Minnow and Plateau Shiner. There are records of Texas Shiners collected in 1968 on the Dry Frio River downstream of the two sites in this study (Hendrickson and Cohen 2012). Due to the lack of fish data from the Dry Frio, it is not clear if Texas Shiners have been extirpated from this area, or if the sites sampled for this study contained unsuitable habitat.

Mussels: A riffle-run complex and two pools were surveyed for live mussels and the entire reach of Site A was searched for shell material. No live mussels were collected during this study, nor was any shell material from native mussels observed during shoreline searches. One long dead Asian clam (*Corbicula* sp.) shell was found. No evidence was found during this survey that indicated this reach has supported native mussels anytime in the recent past. Populations of native mussels have been found downstream of Garner State Park on the lower Frio River, near the City of Three Rivers, Texas (Clinton Robertson, TPWD, personal communication). The predominantly bedrock substrate of the upper Frio River is not conducive to native mussel colonization. As you move downstream to the lower Frio River, substrates transition to more suitable substrates for colonization, such as sands and gravels.

Macroinvertebrates: A total of 503 macroinvertebrates, representing 8 orders and 19 families (Table 5) were collected and identified from three locations within Site A (Figure 2). Dominant macroinvertebrate taxa present were mayflies (Order Ephemeroptera), amphipods (Order Amphipoda) and caddisflies (Order Trichoptera), making up 35.98%, 20.48%, and 17.30% of the total catch respectively. While no stoneflies were collected, the invertebrate community still contained a high percentage of taxa from the orders Ephemeroptera and Trichoptera (53%), typically an indicator of good water quality. The aquatic life use score as calculated from the rapid bioassessment protocol for benthic macroinvertebrates was 34, placing this site in the high aquatic life use category (Table 6).

Table 5. Macroinvertebrates with their associated abundances and trophic guilds collected from Site A on the Frio River, May 2014. Trophic guilds are abbreviated as follows: collector gatherer (CG), filtering collector (FC), predator (P), scraper (SCR), and shredder (SHR).

Order	Family	Genus	Abundance	Trophic Guild
Amphipoda	Taltridae	*Hyalella*	103	CG/SHR
Coleoptera	Dytiscidae	*Dytiscidae*	3	P
	Elmidae	*Hexacylloepus*	6	SCR/CG
		Macrelmis	1	SCR/CG
		Microcylloepus	18	SCR/CG
		Neoelmis	5	SCR/CG
Diptera	Ceratopogonidae	*Ceratopogonidae*	1	P/CG
	Chironomidae	*Chironomidae*	3	P/CG/FC
	Simuliidae	*Simuliidae*	62	FC
	Tabanidae	*Tabanidae*	1	P
Ephemeroptera	Baetidae	*Baetodes*	1	SCR
		Camelobaetidius	124	SCR/CG
		Fallceon	17	SCR/CG
		Paracloeodes	18	SCR/CG
		Procloeon	1	SCR/CG
	Heptageniidae	*Maccaffertium*	13	SCR/CG
	Oligoneuriidae	*Isonychia*	3	FC
	Tricorythidae	*Tricorythodes*	4	CG
Hemiptera	Gerridae	*Metrobates*	1	P
	Naucoridae	*Ambrysus*	8	P
Megaloptera	Corydalidae	*Corydalus*	1	P
Odonata	Coenagrionidae	*Agria*	13	P
		Enallagma/Coenagrion	7	P
	Coryduliidae	*Neurocordulia*	2	P
Trichoptera	Helicopsychidae	*Cheumatopsyche*	23	FC
		Hydropsyche	10	FC
	Hydroptilidae	*Hydroptilidae*	1	SCR
	Philopotamidae	*Chimarra*	53	FC

*Lowest taxonomic identification available if order was not determined

Table 6. Metrics and scoring criteria for kick samples collected using the rapid bioassessment protocol for benthic macroinvertebrates at Site A on the Frio River, May 2014. Metrics are scored from low to high quality on a scale of 1-4.

Metric	Total	Score
Taxa richness (Genus)	28.00	4
EPT taxa abundance	12.00	4
Biotic index (HBI)	4.90	2
% Chironomidae	0.60	1
% Dominant taxon	24.65	3
% Dominant FFG	31.61	4
% Predators	7.46	4
Intolerant: tolerant taxa	1.92	2
% Trichoptera as Hydropsychidae	37.93	3
# of non-insect taxa	1.00	1
% collector gatherers	31.61	2
% Elmidae	5.96	4
	Total Score	**34**
	Aquatic Life Use	**High**

Riparian Assemblage: Common tree species observed within the riparian area of Site A included: bald cypress (*Taxodium distichum)*, little walnut (*Juglans microcarpa*), pecan (*Carya illioensis*), American sycamore (*Platanus occidentalis*), ligustrum (*Ligustrum japonicum*), hackberry (*Celtis reticulata*), and red mulberry (*Morus rubra*). Common herbaceous species observed included: sawgrass (*Cladium mariscus*), emory sedge (*Carex emoryi*), switchgrass (*Panicum virgatum*), muhly (*Muhlenbergia lindheimeri*), bushy bluestem (*Andropogon glomeratus*), buttonbush (*Cephalanthus occidentalis*), gravelbar brickelbush (*Brickellia dentata*), slender brickelbush (*Brickellia eupatorioides var gracillima*), mullein (*Verbascum sp.*), frostweed (*Verbesina virginica*), baccharis (*Baccharis sp*.), Lindheimer indigo (*Indigofera lindheimeriana*), bog hemp (*Boemeria cylindrical*), senna (*Senna lindheimeriana*), and white-top sedge (*Rhyncospora colorata*). These species were consistent with the riparian community types listed in the Texas Ecological Systems Classification Project (TPWD 2014b), which recorded riparian vegetative community types within the riparian area of Garner State Park. While plant vigor and regeneration were poor, the diversity of species indicate that if public access to the river could be more focused, there are a wide array of riparian plants present to act as seed sources for regeneration and eventual riparian recovery.

Non-Native Species: The location of non-native species found at Site A can be found in Figure 10. The only aquatic invasive plant species found within Site A was parrotfeather watermilfoil (*Myriophyllum aquaticum*) (Figure 11). While this species was limited in distribution at Site A, these sightings are the first record of this species in Uvalde County (EDDMapS 2014).

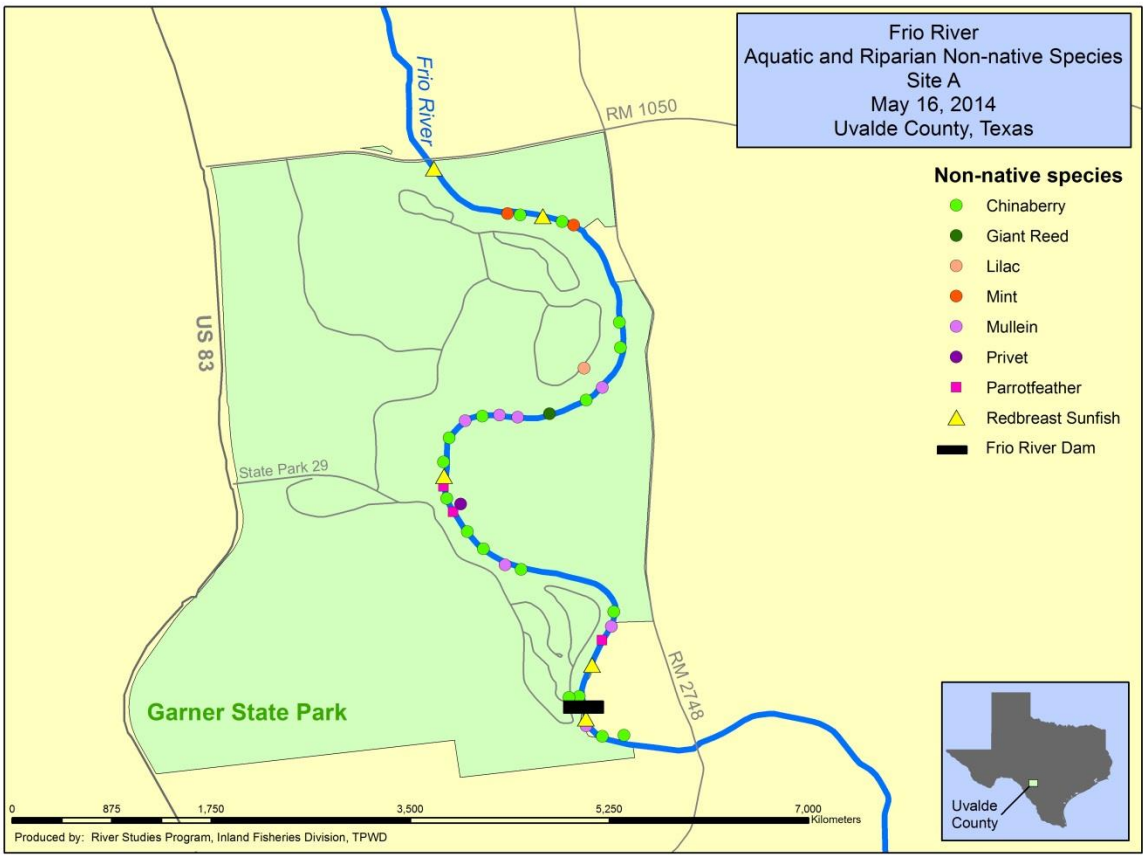


Figure 10. Non-native species locations in the Frio River and riparian corridor at Garner State Park, May 2014. Aquatic plant species are represented by squares, riparian plant species are represented by circles, and fish species are represented by triangles.

Figure 11. Photos of parrotfeather, a non-native, aquatic macrophyte, located in the Frio River at Garner State Park, May 2014.

Riparian invasive plant species encountered during the survey of Site A included chinaberry (*Melia azaderach*), wooly mullien *(Verbascum thapsus*), mint *(Mentha* sp.), privet *(Ligustrum sp.)*, lilac chaste tree *(Vitex agnus-castus)*, and Japanese honeysuckle *(Lonicera japonica*), with chinaberry being the only widely spread of these (Figure 12). Chinaberry was found throughout Site A; however, it was only found as isolated trees and chinaberry thickets had not yet formed. Similarly, only one privet and one lilac chaste tree were mapped throughout the reach of Site A. The other non-native species encountered were present in low densities and numbers. A small bundle of dead, uprooted giant reed was found within Site A and was likely washed downstream from treated areas.

Figure 12. Photos of the most prevalent non-native species found throughout the riparian corridor of the Frio River at Garner State Park, May 2014. From left to right: Chinaberry, wooly mullein, and mint.

Only one species of non-native fish, Redbreast Sunfish (*Lepomis auritus*), was collected in the Dry Frio and Frio Rivers (Table 3). This species made up 7% of the total catch from the Frio River and less than 2% of the total catch from the Dry Frio River. The only other non-native fish collected during this sampling effort was the Rio Grande Cichlid (*Herichthys cyanoguttatus)*, which was only collected from Site B on the Frio River in very low numbers (n = 13; < 2% of total catch).

Stream Health: Overall stream health fell into the fair category (SVAP2 score = 6.7; Table 7). This site scored high for having good water appearance, low riffle embededness, moderately high riparian area quantity, and moderately low nutrient enrichment. Two of the elements that scored the lowest were bank condition and riparian area quality. Within the park, these low scores can be attributed to the high volume of foot traffic on the banks, which hampers vegetative regeneration and the maintenance of healthy root systems to help stabilize soils. Barriers to aquatic species movement also scored low, which was attributed to the presence of the low-water dam at the downstream end of Site A which impedes fish movement except under high flow conditions.

Table 7. Element scores from the Stream Visual Assessment Protocol (SVAP) conducted on the Frio River at Site A in March 2014. Element scores are rated from 1 (severely degraded) to 10 (excellent). The average of the element scores is listed as the stream health score.

Element	Score
Channel condition	6
Hydrologic alteration	7
Bank condition	4.5
Riparian area quantity	8
Riparian area quality	5
Water appearance	9
Nutrient enrichment	8
Barriers to aquatic sp. movement	4
Stream habitat complexity	6
Pools	6
Aquatic invertebrate community	8
Riffle embeddedness	9
Salinity	N/A
Stream Health Score	6.7

Public Access: Site A was qualitatively evaluated for stream public access using satellite imagery and a site visit conducted prior to the bioassessment. Due to the high number of stream access points found throughout the state park, it was determined that access is not a limiting factor for the public, therefore no formal access survey was conducted. Garner State Park has both formal (i.e. paved canoe put-ins) and informal (i.e. foot paths connecting campsites to the river) river access. While most stream access paths traverse rocky terrain leading through the riparian area down to the river, the shoreline around the dam is concreted and provides some accessibility for the physically challenged.

SUMMARY AND RECOMMENDATIONS

Garner State Park Reach (Frio River Site A): The reach of the Frio River within Garner State Park was classified as having a high aquatic life use rating for instream physical habitat, fish, and aquatic macroinvertebrates. These scores in conjunction with good water quality and a diverse riparian plant assemblage are indicative of a healthy, functioning ecosystem. While fish diversity was high, few adult sport fish were collected, likely due to the lack of instream cover, harvest, and/or sampling limitations due to the clear water. No mussels were found; however, there was no evidence this section of the Frio River ever supported a mussel population. This is typical of many clear, bedrock streams in Texas. Despite a high level of public use, the Frio River at Garner State Park maintains diverse assemblages of fish, macroinvertebrates, and riparian vegetation. Impacts from public use did lower the overall stream health score to fair, but this reach still maintains a functioning ecosystem.

To enhance sport fishing potential for Largemouth Bass within the state park, instream cover such as large woody debris (Rosgen 1996) could be added to pools, most notably to the pool just upstream of the dam. Park staff should encourage catch-and-release angling for this species. Stocking of Channel Catfish (even for special fishing events) is not recommended within this reach of Garner State Park or in the upper Frio River, due to the high likelihood of hybridization with the imperiled Headwater Catfish. Sunfish species offer another angling opportunity. Signage or brochures could be made available to park guests to make them aware of sport fishing opportunities and to encourage catch-and-release angling.

Redbreast Sunfish made up approximately 12.5% of the total catch at Site A. While this is a non-native species, in this highly recreational environment, benefits of the species as an angling opportunity outweigh any negative impacts on the fish community. Green Sunfish, Bluegill, and Longear Sunfish were collected throughout the reach indicating Redbreast Sunfish are not outcompeting native sunfish species, but abundance of this species should be monitored.

To combat the non-native aquatic parrotfeather patches within Site A, we recommend immediate treatment with a herbicide while the infestation is limited and controllable, followed by monitoring and additional treatments should new infestations appear. Parrotfeather spreads through fragmentation, and attempts to remove infestations—mechanically or manually—often result in further spread and are not recommended. Several herbicides have proven effective for eliminating parrotfeather, including triclopyr or byspiribac-sodium (Texas A&M Agrilife Extension 2014; DiTomaso et al. 2013).

All riparian non-native species documented were present in low numbers, or present a low risk of spreading. The primary recommendation for all terrestrial non-native plant species is monitoring. If spreading of any of these species is detected, manual removal or the use of species-specific herbicides is recommended. While living giant reed was not found within Site A, it should be considered a priority watch species for Garner State Park due to its occurrence in other areas of the basin and potential negative impacts to natural ecosystems and public use of the park. Any stands of giant reed found in the future should be treated or removed immediately.

High public use has impacted the riparian corridor and instream habitats of the Frio River throughout the length of the park. A management option to address the negative impacts of foot paths through the riparian corridor may be to open up “pocket access” sites for park visitors to utilize, while closing off other areas to

allow for re-establishment for riparian vegetation. To protect seedlings from herbivory, fenced exclosures could be implemented to serve as nurseries for young plants while they are establishing. These exclosures could be removed once the new vegetation is established or relocated to another site to allow for continued vegetative recovery throughout the riparian area.

Man-made rock structures within the stream bed that divert flow, while semi-permanent, are likely not a concern unless they impound a section of river and significantly alter flow. In that case it is recommended the structure be removed.

Frio (Site B) and Dry Frio Rivers (Sites C and D): Assessments of Sites B, C, and D were limited to fish collections. Fish assemblages were similar between the two rivers with the exception of the catfish species (Headwater Catfish and Bullhead Catfish) and Texas Shiners only occurring in the Frio River, and Redspotted Sunfish only occurring in the Dry Frio River. Redbreast Sunfish and Rio Grande Cichlids were the only non-native species collected at these sites. These species were collected in low numbers and are likely not detrimental to the fish assemblage. Increasing the geographical scope of future fish sampling efforts in the Dry Frio could help determine if Texas Shiners have been extirpated from this river. Texas Shiners were previously collected downstream of Sites C and D at the crossing of US Hwy 83 (Hendrickson and Cohen 2012). It is possible this species is still present in the Dry Frio River, but is restricted to reaches adjacent to spring outflows, such as the reach upstream of US Hwy 83.

While no riparian or non-native plant species assessments were conducted at these sites, there is a high probability that the non-native plant species documented at Site A are present. Monitoring of all non-native species is recommended to prevent spreading. Focal species for monitoring, removal, and herbicide treatment are giant reed (due to its potential impacts on stream hydrology) and chinaberry (due to its widespread distribution in this area).

Conclusions: Despite high public use and drought, the Frio and Dry Frio Rivers appeared to be healthy, functioning aquatic ecosystems at the time of the bioassessment. While only a few recommendations were made to improve aquatic and riparian habitats, it is important to routinely monitor these areas. Ecosystem stressors such as drought, increased domestic and agricultural demands for water, and climate change could have a negative impact on these systems in the future.

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APPENDIX A

Stream Visual Assessment Protocol 2 Field Worksheets

Stream Visual Assessment Protocol 2
Summary Sheet

Owner/Site Location: _____ Evaluator's name(s):_____
Date and time of assessment: _____ Weather Conditions: _____
Stream name_____ Tributary to: _____ HUC: _____
Reach location (UTM or lat/long) Upstream_____/_____ _____
Downstream_____/_____

Part B. Stream/Reach Description:

Stream Gage Location/Discharge: _____/_____cfs
Watershed conditions[1]:_____
_____
Stream Source (check one): _____ surface, precipitation, alluvial _____ groundwater, spring-fed

Bart B.2 Field Assessment:

A. Preliminary Field Data:

Bankfull channel width_____ Reach length_____ Bankfull depth_____ Floodplain width[2]_____
Avg. riparian zone width[3]_____ Method used (e.g., rangefinder, aerial photos):_____
Channel type/classification (Rosgen): _____ Floodplain wetlands (if present): _____acres/reach
Gradient (check one): ____low (0-2%) ____ moderate (>2 <4%) ____high (>4%)
Riparian cover (check one for each type):
Tree[4]: ___ 0-20% ___20-40% ___40-60% ___60-80% ___80-100%

List common species: _____
Shrub[4]: ___ 0-20% ___20-40% ___40-60% ___60-80% ___80-100%

List common species: _____
Herbaceous: ___ 0-20% ___20-40% ___40-60% ___60-80% ___80-100%

List common species: _____
Aquatic Vegetation: ___ 0-20% ___20-40% ___40-60% ___60-80% ___80-100%

List common species: _____
Bare: ___ 0-20% ___20-40% ___40-60% ___60-80% ___80-100%

Substrates (100% total): _____bedrock _____boulder _____cobble _____gravel _____sand _____fines
(>250mm) (60-250mm) (2-60mm) (2-0.6mm) (<0.6mm)

Take 4 photos at the upstream end of the reach, and 4 photos at the downstream end of the reach

Photo description	Reach location	Photo #	Photo description	Reach location	Photo #
upstream	upstream		upstream	downstream	
downstream	upstream		downstream	downstream	
riparian zone left bank	upstream		riparian zone left bank	downstream	
riparian zone right bank	upstream		riparian zone right bank	downstream	

B. Element Scores:

[1]Use aerial photos, topo maps and other resources to determine ecoregion, evaluate presence of road crossings, impoundments/dams, mining, agriculture, urbanization, corridor condition, etc. in the watershed

[2]Multiply bankfull depth by 2, and trace that elevation in a horizontal plane out from the stream channel until you hit a slope to determine the approximate width of the floodplain (Rosgen's floodplain width calculation)

[3]Only include zone that is actually functioning as a buffer in this measurement; determined by subtracting the channel width from the floodplain width and dividing by 2

[4]Woody vegetation 16 feet or taller classified as trees, woody vegetation less than 16 feet classified as shrubs

Element	Score	
1. Channel Condition		
2. Hydrologic Alteration		
3. Bank Condition		A = Sum of all elements scored
4. Riparian Area Quantity		B = Number of elements scored
5. Riparian Area Quality		
6. Water Appearance		Score (A/B) = _____
7. Nutrient Enrichment		
8. Barriers to Aquatic Sp. Movement		1 to 2.9 Severely Degraded
9. Stream Habitat Complexity		3 to 4.9 Poor
10. Pools		5 to 6.9 Fair
11. Aquatic Invertebrate Community		7 to 8.9 Good
12. Riffle Embeddedness		9 to 10 Excellent
13. Salinity		

Suspected causes of SVAP scores less than 5 (does not meet quality criteria for stream species):_____

_____

_____

_____

Recommendations for further assessment or actions: _____

_____

_____

_____

Riparian wildlife habitat recommendations: _____

_____

_____

Other comments: _____

_____

_____

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