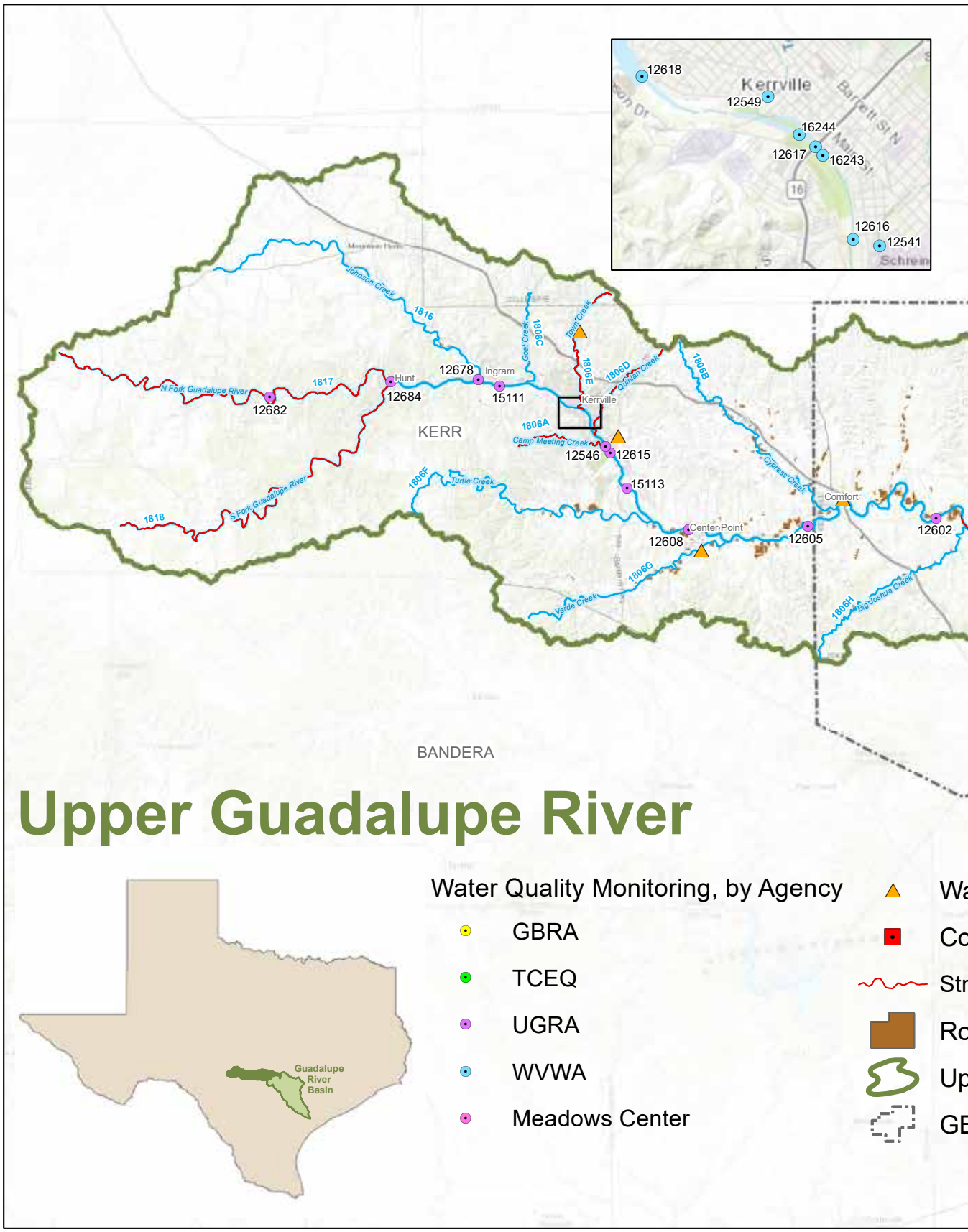
2021
Basin Highlights
REPORT

CLEAN RIVERS PROGRAM

Guadalupe River and Lavaca-Guadalupe Coastal Basins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Quinlan Creek
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Big Joshua Creek
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Upper Guadalupe River
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Water Quality Monitoring, by Agency
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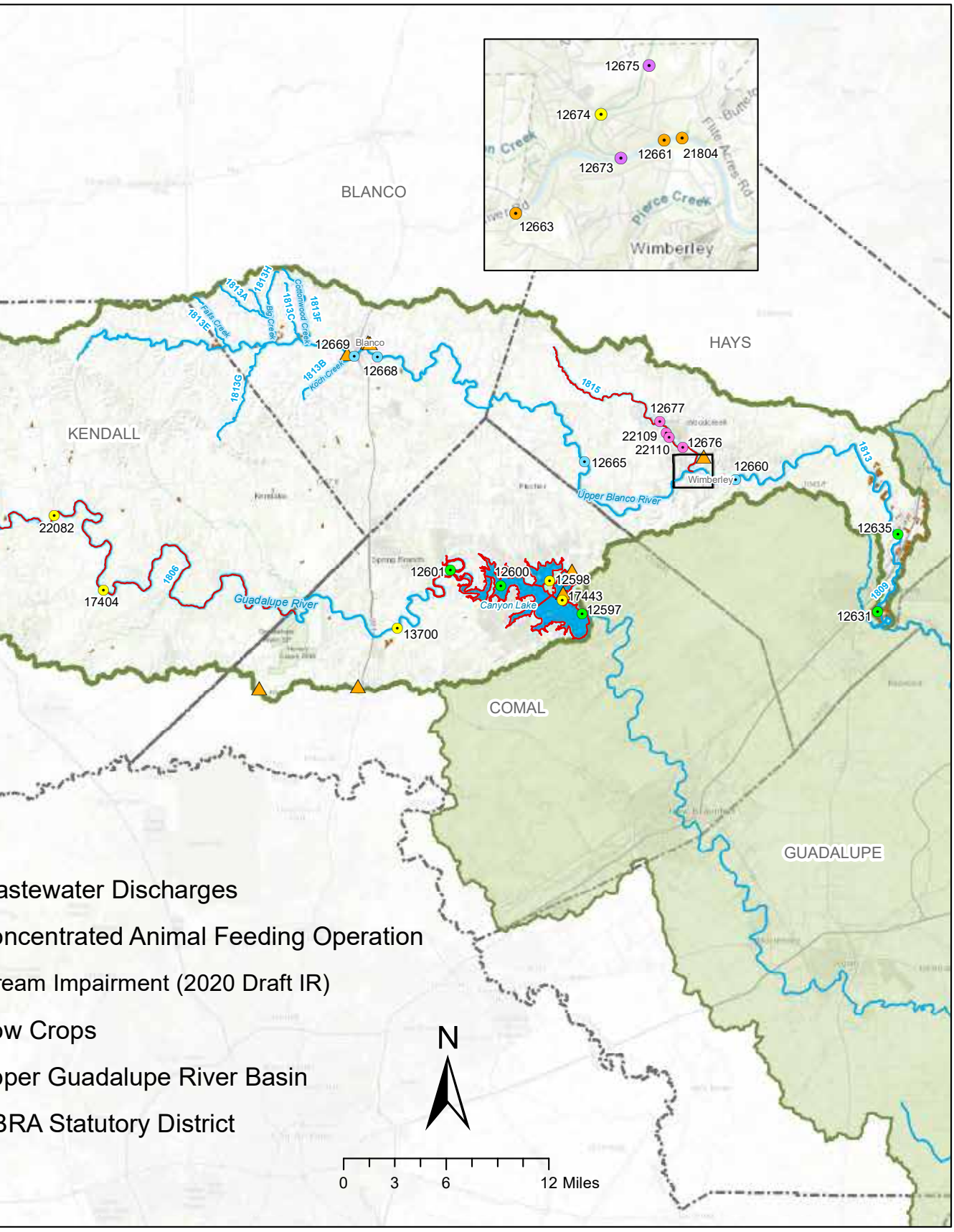
TCEQ
UGRA
WVWA
Meadows Center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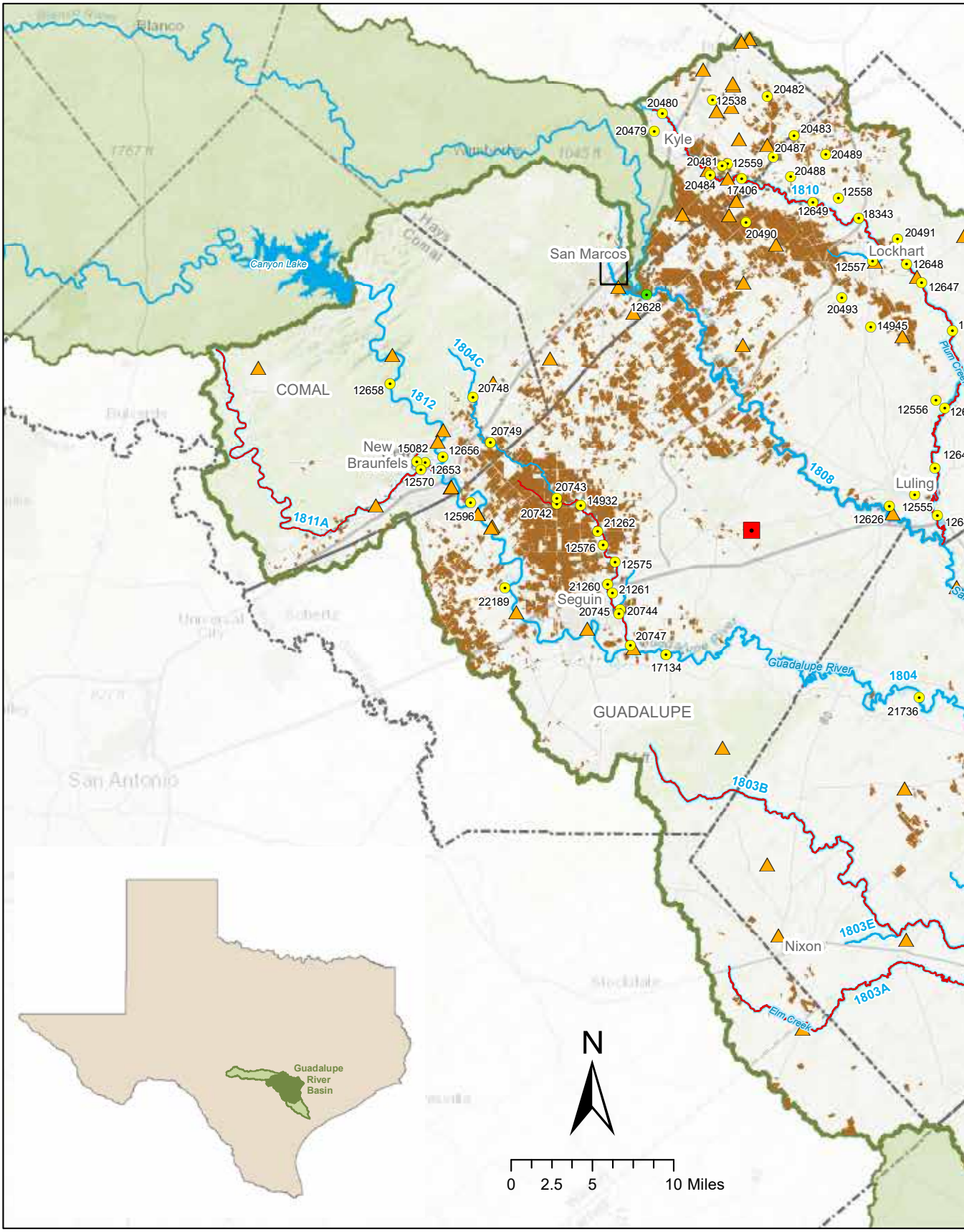
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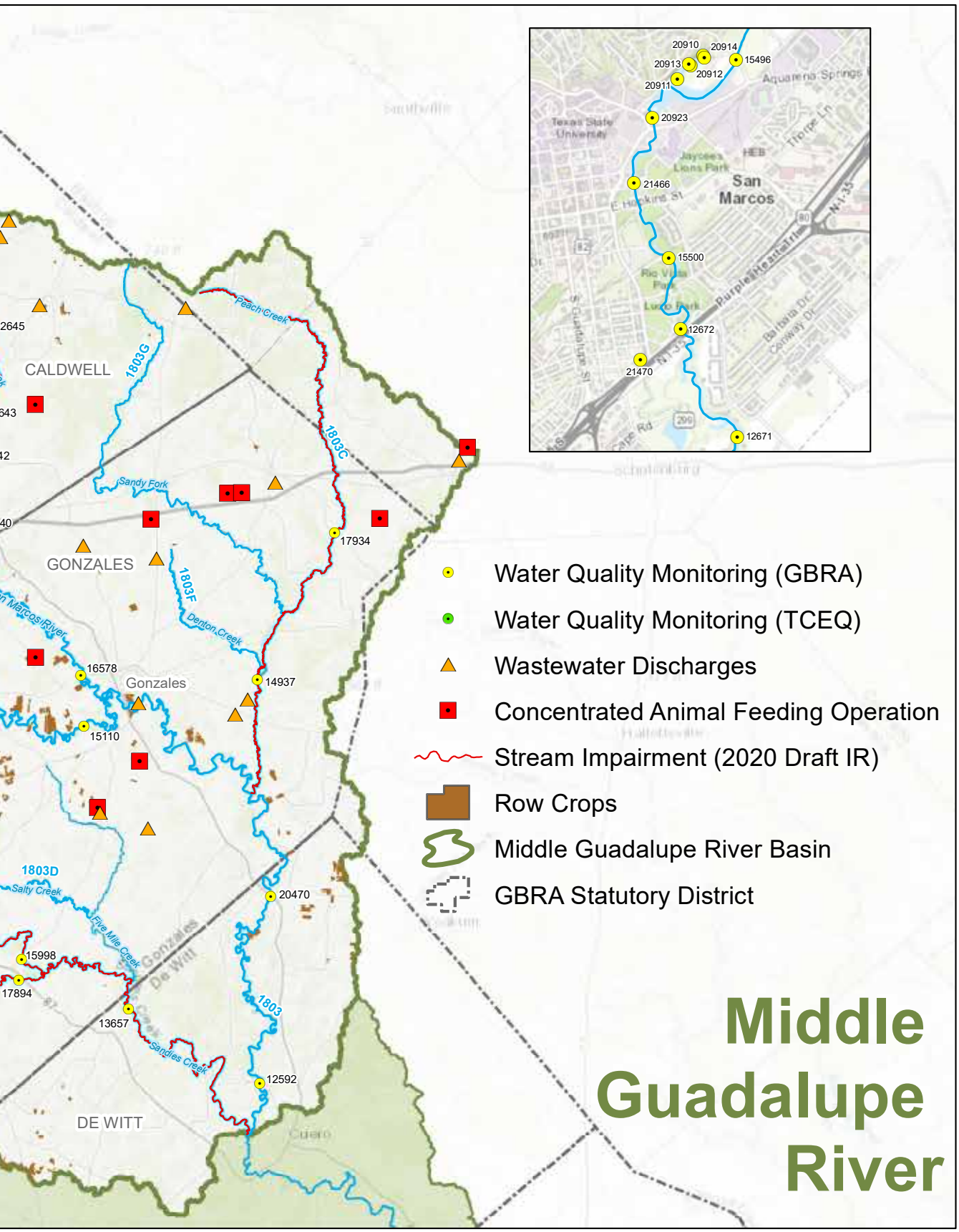
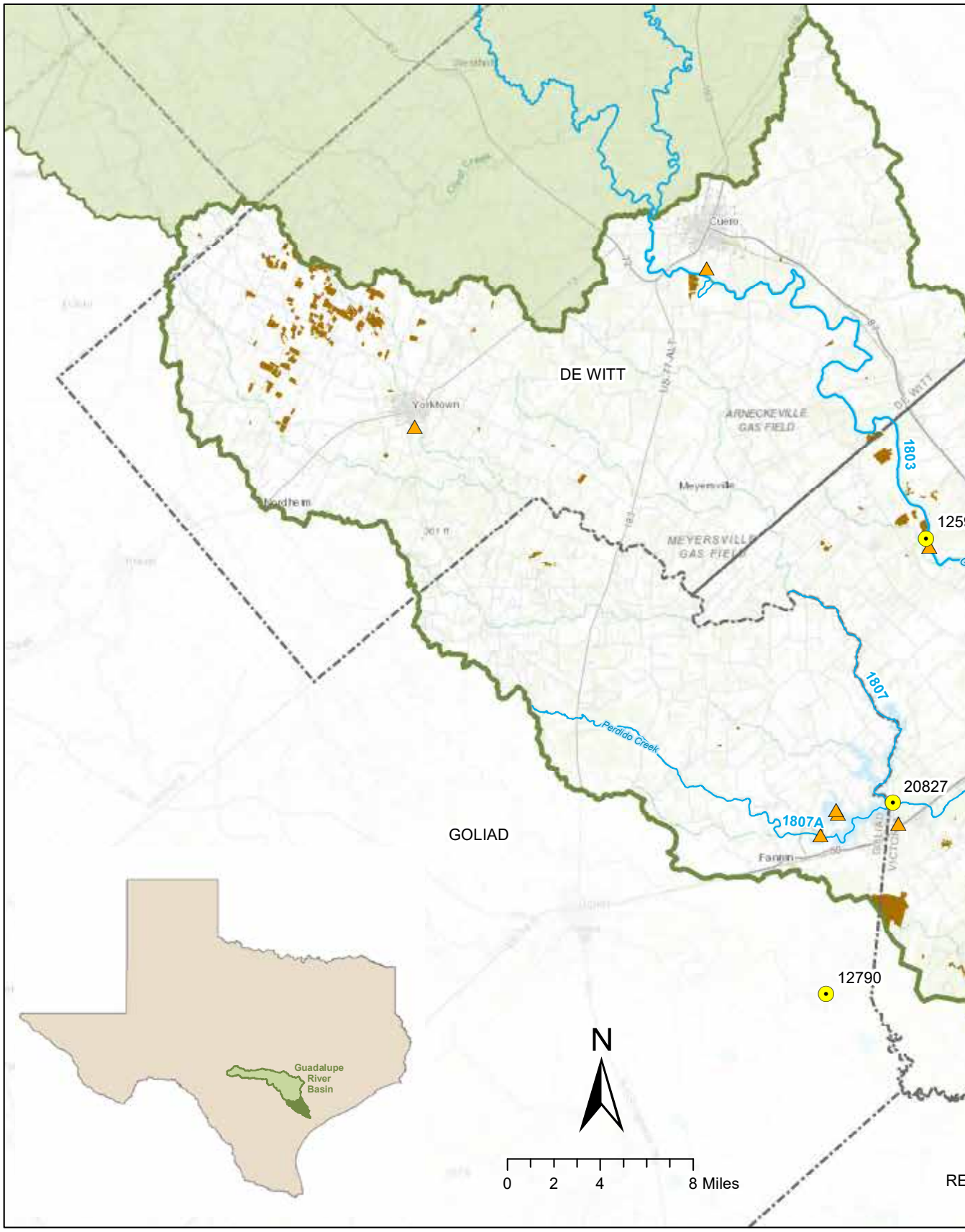


Middle Guadalupe River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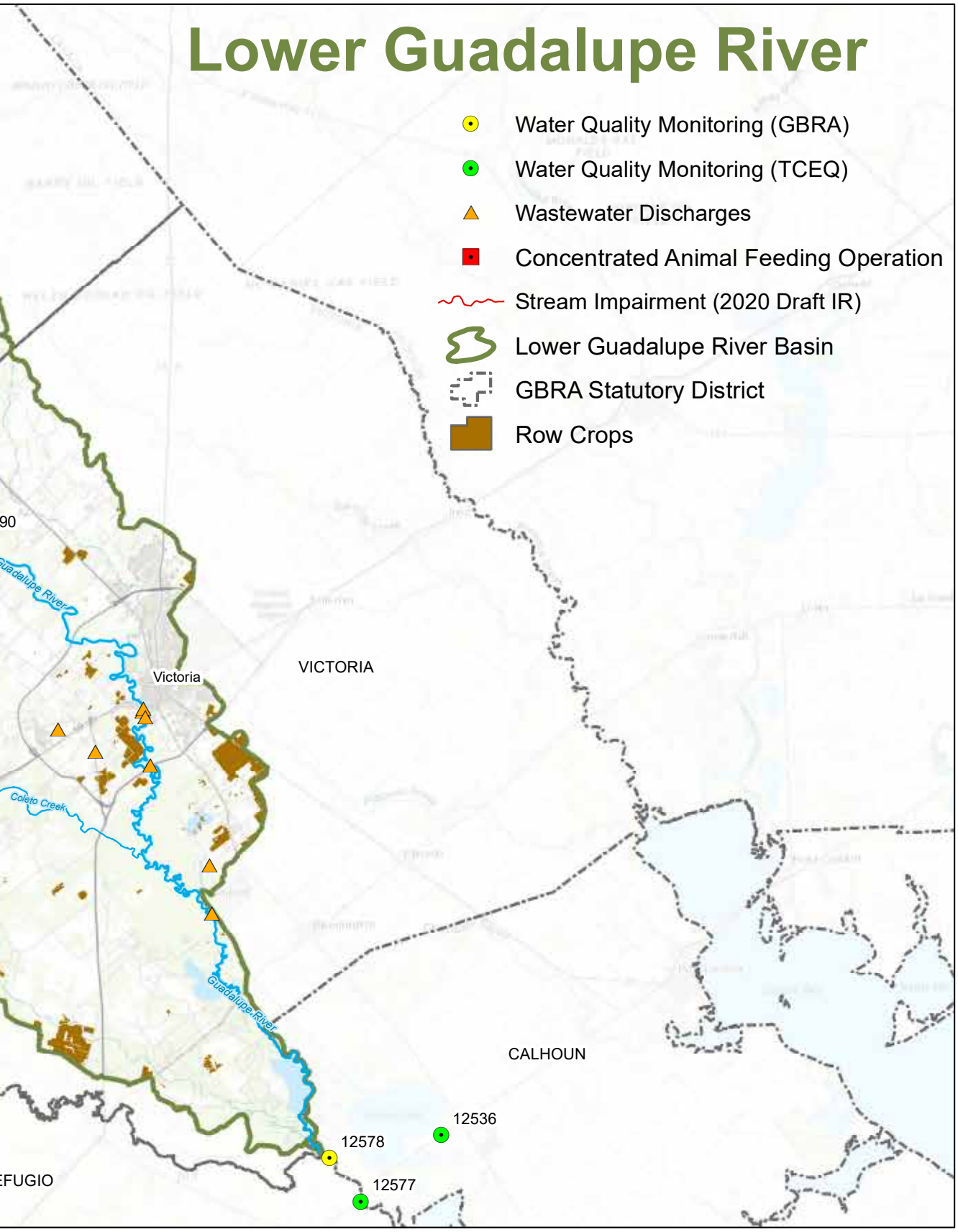
Lower Guadalupe River
Water Quality Monitoring (GBRA)
Water Quality Monitoring (TCEQ)
Wastewater Discharges
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Stream Impairment (2020 Draft IR)
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VICTORIA
Coleto Creek
Guadalupe River
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Cover photo: Foggy morning on the Guadalupe River.
Photo Courtesy of Tara Bushnoe.

2021 BASIN HIGHLIGHTS REPORT INTRODUCTION

By Elizabeth Edgerton, Clean Rivers Program Supervisor

This report highlights activities in the Guadalupe River Basin and the Lavaca-Guadalupe Coastal Basin in the Clean Rivers Program (CRP) in 2020. The CRP is a statewide program managed by the Texas Commission on Environmental Quality (TCEQ), established in 1991 to holistically manage water quality issues throughout the state of Texas. The program is funded by fees assessed to water rights and wastewater discharge permit holders. The objectives of the program are to provide quality assured data to the TCEQ for use in decision making, identify and evaluate water quality issues, promote cooperative watershed planning, recommend management strategies, inform and engage stakeholders, and maintain efficient use of funds.

Upper Guadalupe River in Kerr County.

The Guadalupe-Blanco River Authority (GBRA), along with the Upper Guadalupe River Authority (UGRA), carry out the water quality management efforts in these basins under contract with the TCEQ. The Wimberley Valley Watershed Association (WVWA) and the Meadows Center for Water and the Environment (MCWE) contribute monitoring data collected under the Guadalupe Basin CRP quality assurance project plan from the Blanco River and Cypress Creek watersheds. The majority of funding allocated to this program is used by the partners to carry out monitoring efforts and perform quality assurance and data management.

This report includes watershed characterizations of the waterbodies in the Upper Guadalupe Watershed. Watershed characterizations include segment descriptions, land uses, potential stakeholder issues, descriptions of water quality concerns and impairments, major events, ongoing projects, and maps. The watersheds described in this report are as follows: 1816 – Johnson Creek, 1817 – North Fork Guadalupe River, 1818 – South Fork Guadalupe River, 1806 – Guadalupe River above Canyon Reservoir, 1805 – Canyon Reservoir, 1811 – Comal River, 1811A – Dry Comal River, 1812 – Guadalupe River below Canyon Reservoir, 1815 – Cypress Creek, 1813 – Upper Blanco River, 1809 – Lower Blanco River, and 1808 – Upper San Marcos. This report also includes articles from basin partners and stakeholders that highlight ongoing projects and activities throughout the Blanco River and the upper basin of the Guadalupe River.

2020 HIGHLIGHTS

Adapting Through COVID

It goes without saying that 2020 was a unique and challenging year. Everyone was affected in some way by the rapidly developing situation surrounding the pandemic. In-person meetings were cancelled and clean-up events and other watershed activities were put on hold. The GBRA was no different; many of us quickly adapted to working from home as our office closed temporarily, while others continued work on site with new social distancing guidelines and safety procedures in place. Despite the challenges of this last year, the GBRA was able to maintain its normal sampling schedule and complete all Clean Rivers Program tasks as planned. A huge round of applause goes out to the GBRA water quality team and laboratory staff who worked hard to get the job done on time and in a safe and healthy manner.

GBRA Welcomes New Clean Rivers Program Supervisor

Elizabeth Edgerton
GBRA Clean Rivers Program Supervisor

Also in 2020, the GBRA welcomed Elizabeth Edgerton as the Clean Rivers Program supervisor. Edgerton holds a master's degree with a concentration in Wildlife and Fisheries Sciences from Texas A&M University. Prior to joining GBRA, she worked as a natural resources specialist at the Texas Commission on Environmental Quality, a water quality lab technician in a regional lab, and an aquatic biologist at a private company. Edgerton has a background in water quality analysis, aquatic invasive species management, and field sampling. She oversees the GBRA Clean Rivers Program, as well as the Plum Creek and Geronimo & Alligator Creek Watershed Protection Plans, and all associated monitoring efforts.

GBRA Water Quality Team Electrofishing in the Upper Guadalupe River.

2019 UGRA Large Rainwater System Incentive Program Winner.

UGRA PROMOTES STEWARDSHIP TO PROTECT THE HEALTH OF THE WATERSHED

As the lead water resource-planning agency for the Upper Guadalupe River basin in Kerr County, the Upper Guadalupe River Authority (UGRA) is responsible for preserving and protecting the health of the Upper Guadalupe River watershed. UGRA proactively partners with municipal and county governments, communities, civic groups, schools, and local citizens. Through these partnerships, the Authority leverages resources, facilitates an understanding of water resource issues, and raises awareness of the role everyone in the community can play in maintaining the health of the watershed.

The word “stewardship” embodies an ethic of responsible planning and management. In other words, it means taking responsibility to care for the well-being of something that we value. Our diverse community and downstream users value the Guadalupe River in a variety of ways. Some people spend their weekends soaking in the clear, cool waters, while others enjoy the scenic natural beauty of the river as it weaves through town. Others are thankful for abundant, clean water flowing from their faucet or into their stock tank. Through education, UGRA helps people identify the value of a healthy Guadalupe River. We can then use that shared value to frame discussions about issues and practices that impact the river in positive and negative ways.

Activities that threaten the health of surface water can occur both at the water's edge and far from it. The area of land that rainfall runoff flows across as it rushes downhill to a body of water is called the watershed. The condition of the land and the activities conducted in the watershed have a direct influence on the quality of the receiving body of water. As stewards, we all share the responsibility to protect the health of our land and our rivers. Whether you live on 1,000 acres of ranchland or a small lot in a subdivision, your activities can contribute to the health of the watershed.

Homeowners can conserve water by installing drought tolerant landscaping or by using a rainwater catchment system to collect water for irrigation. Rainwater harvesting is a versatile practice that can be scaled to your budget and space. UGRA incentivizes rainwater harvesting by offering a $200 rebate on equipment purchases and an annual $2,500 competitive award for larger systems. Urban homeowners can trap contaminants and keep pollution from entering waterways by preventing water from flowing off their property and becoming stormwater runoff. Structures like permeable pavers, rain gardens, and terracing are just a few of the features that reduce stormwater runoff and are demonstrated in UGRA's educational landscape called the EduScape.

Terracing and drought tolerant plants demonstrated in the UGRA EduScape.

Streamside Landowner Workshop

Rural landowners have an opportunity to manage their land with watershed stewardship in mind and impact the health of waterways miles downstream. Ranch owners employ different management methods than homeowners on small lots and may focus on maintaining healthy vegetation on their property, which in turn helps capture rainfall. These captured drops soak into the ground and replenish aquifers before being released slowly through seeps and springs, feeding streams and rivers. UGRA promotes landowner practices that have the potential to enhance groundwater and surface water resources by offering assistance to eligible landowners to aid their brush management efforts. Transitioning land dominated by Ashe juniper to more diverse rangeland vegetation can improve range and pastureland productivity while in turn enhancing the ability of the land to capture water.

Landowners along rivers and creeks can improve these waterbodies through stewardship of riparian areas. Riparian areas are dense bands of native vegetation along a waterway that protect water quantity and quality. Sharing information on the importance of these areas to healthy waterways has been an education priority of UGRA for many years and recently, UGRA has established partnerships to implement two landowner assistance programs that focus on riparian areas. Along with Texas Parks and Wildlife Department in the Healthy Creeks Initiative, UGRA has helped Kerr County landowners treat invasive giant cane on their properties. UGRA also partners with Kerr County to offer a bounty on feral hogs in order to protect riparian areas from their destructive behaviors.

Voluntary stewardship by private landowners is essential to the health of a watershed. UGRA is privileged to support landowner activities that conserve water, prevent pollution, conserve soil, support native flora and fauna, and provide clean water for all those living downstream. UGRA serves the citizens of Kerr County as a resource and advocate for the community on water quality, surface water, and the Guadalupe River. Please contact UGRA with comments, questions, or concerns at (830) 896-5445 or visit www.ugra.org.

NATIVE FISH CONSERVATION IN THE UPPER GUADALUPE RIVER

By Tim Birdsong, Chief of Habitat Conservation
Inland Fisheries Division, Texas Parks and Wildlife Department

Texas harbors 191 species of native freshwater fishes, 89 of which are considered vulnerable, imperiled, or critically imperiled. Five of those species are likely extinct. Another six are considered extirpated from the state, meaning they no longer exist in Texas but still occur in adjacent states or Mexico. Declining freshwater fish diversity is a conservation issue not unique to Texas. Freshwater fishes are threatened throughout North America and currently have the highest extinction rate among vertebrates (7.5 extinctions per decade since the 1950s). Of the 1,213 freshwater fishes found in North America, 39 species and 18 subspecies are considered extinct. Similar to other areas of the continent, the primary cause of fish imperilment in Texas is anthropogenic alteration of freshwater systems (e.g. groundwater extraction and concomitant reductions in spring discharge, river fragmentation, alteration of natural river flow patterns, degradation of water quality, introduction of non-native species), which continues to occur at rates and scales that threaten the long-term persistence of native freshwater fishes.

Texas Parks and Wildlife Department (TPWD) and cooperators in the management and conservation of Texas freshwater fishes (Table 1), have implemented a suite of specific regulatory and voluntary-based conservation measures, many of which are unique to freshwater fish recognized as Species of Greatest Conservation Need (SGCN) or State Threatened or Endangered. Fish recognized as SGCN represent state-level recognition of species with low or declining populations in need of conservation action. This may include species already recognized as State Threatened or Endangered, species at risk due to threats to their life history needs or habitats, species that are rare due to few, small or declining populations, abundance, or distribution, or species with declining trends in their habitats and populations.

Freshwater fish recognized as SGCN are prioritized by TPWD for voluntary based investments in research, monitoring, habitat restoration, and habitat protection. A prime example of such investments is the State Wildlife Grants Program, which was authorized by U.S. Congress to provide a source of funding to state fish and wildlife agencies explicitly for the conservation of SGCN. Since the initial appropriation of funding to the program by U.S. Congress in 2002, TPWD has received annual apportionments totaling $34.3 million to fill critical science needs and implement conservation actions to restore and preserve the more than 1,300 species of fish, wildlife, and plants recognized as SGCN in Texas. Since 2008, approximately 25% of that funding ($8.6 million) has been invested in the conservation and recovery of freshwater fishes, corresponding to average annual investments of approximately $660,000. Meanwhile,

TPWD has identified an annual funding need of over $132 million to adequately address the needs of Texas SGCN (across all taxa within the resource management purview of TPWD), including $6.2 million annually to conserve native freshwater fishes. In recognition of the substantial conservation needs of SGCN in Texas and nationwide, the Recovering America's Wildlife Act has been repeatedly introduced into U.S. Congress. Passage of the Act would result in the apportionment of more than $50 million annually in new funding to TPWD to conserve SGCN.

One of the most noteworthy conservation success stories for freshwater fish SGCN in Texas has occurred within the Upper Guadalupe River, which is home to 38 species of native freshwater fish including nine recognized as SGCN: Plateau Shiner *Cyprinella lepida* (Figure 1), Proserpine Shiner *Cyprinella proserpina* (Figure 2), Guadalupe Roundnose Minnow *Dionda flavipinnis*, Burrhead Chub *Macrhybopsis marconis*, Texas Shiner *Notropis amabilis*, Silverband Shiner *Notropis Shumard*i, Headwater Catfish *Ictalurus lupus*, Guadalupe Bass *Micropterus treculii*, and Guadalupe Darter *Percina apristis* (Figure 3). For a checklist of native and non-native fishes documented to occur in the Upper Guadalupe River, visit the Fishes of Texas website at http://www.fishesoftexas.org/checklists/huc/1357.

Figure 1. Plateau Shiner *Cyprinella lepida*, a freshwater fish native to the Upper Guadalupe River and recognized by Texas Parks and Wildlife Department (TPWD) as a Species of Greatest Conservation Need. Photo courtesy of TPWD.

Figure 2. Proserpine Shiner *Cyprinella proserpina*, a freshwater fish native to the Upper Guadalupe River and recognized by Texas Parks and Wildlife Department (TPWD) as a Species of Greatest Conservation Need. Photo courtesy of TPWD.

Figure 3. Guadalupe Darter *Percina apristis*, a freshwater fish native to the Upper Guadalupe River and recognized by Texas Parks and Wildlife Department (TPWD) as a Species of Greatest Conservation Need. Photo courtesy of TPWD.

As with several of the native freshwater fishes that occur in the Guadalupe River, the river is the namesake of the official state fish, Guadalupe Bass (Figure 4). In addition to being recognized as a SGCN, Guadalupe Bass is a prized sport fish of central Texas river anglers. The economic value of Central Texas river fishing was recently estimated to be $71 million over a 16-month period and nearly half of anglers reported specifically targeting Guadalupe Bass. Guadalupe Bass are endemic to the clear, spring-fed rivers of central Texas (including portions of the Brazos, Colorado, Guadalupe, and San Antonio river basins), where populations are threatened with local extirpation from habitat degradation, flow alteration, and hybridization with non-native Smallmouth Bass *Micropterus dolomieu*. These threats are enormously challenging to address, but through the actions of TPWD and an extensive network of committed partners (i.e., fly fishing clubs, conservation non-profits, private landowners, river authorities, universities, and other state and federal agencies), progress continues to be made in achieving the range-wide goal of restoring and maintaining 10 genetically pure, self-sustaining, fishable populations of this native sport fish.

Since establishing the initial range-wide conservation plan for Guadalupe Bass in 1991, TPWD has made concerted efforts to restore and preserve the species in the Upper Guadalupe River, with a recent emphasis on the Blanco River. Stockings of non-native Smallmouth Bass in the Blanco River in 1977 and 1980 resulted in hybridization and

Figure 4. Guadalupe Bass *Micropterus treculii*, the official state fish of Texas and recognized by Texas Parks and Wildlife Department as a Species of Greatest Conservation Need. Photo courtesy of Living Waters Fly Fishing.

genetic introgression with Guadalupe Bass. By 1991, 30% of black bass in the Blanco River were genetically identified as hybrids. Supplemental stockings of 80,014 genetically pure Guadalupe Bass fingerlings occurred in 1994 and 1995, a conservation strategy that was initiated in the Guadalupe River headwaters (i.e., North Fork, South Fork, Johnson Creek) in 1992 intended to reduce hybridization and genetic introgression of wild populations of Guadalupe Bass; however, due to state fish hatchery resource constraints, supplemental stocking of Guadalupe Bass in the Blanco River was abandoned after 1995, and the extirpation of the species from the Blanco River was subsequently documented in 2005. In 2011, Texas experienced exceptional drought conditions and from June through August, record high temperatures combined with minimal precipitation contributed to record low stream flows throughout the State. The Blanco River was reduced to a series of disconnected enduring pools, conditions that offered an opportunity for the targeted removal of Smallmouth Bass and hybrids.

From 2011–2019, a project was conceived and implemented to remove Smallmouth Bass and hybrids from enduring pools during drought conditions and to repatriate Guadalupe Bass to the river once optimal flow conditions returned. The primary objective of the project was to secure a genetically pure, self-sustaining, fishable population of Guadalupe Bass in the Blanco River. The reach selected for removal of Smallmouth Bass and repatriation of Guadalupe Bass was the upper 38 miles of the Blanco River, from the headwaters downstream to an instream feature referred to as The Narrows, a 0.25-mile long in-channel gorge containing a series of five consecutive waterfalls ranging from 2–11 feet in height. The waterfalls were expected to serve as an effective barrier to upstream movement of Smallmouth Bass, which was observed in past studies that examined distribution patterns of native fishes in the Blanco River.

During the peak of drought conditions, seines and electrofishing (by boat, barge, and backpack) were used to remove Smallmouth Bass and hybrids from enduring pools located within the repatriation area. By spring 2012, drought conditions had subsided and normal river flows returned. From spring 2012–2017, 316,016 Guadalupe Bass were stocked in the repatriation area. Genetic monitoring of the reintroduced Guadalupe Bass population was performed in fall 2014–2019. Initial genetic monitoring conducted in fall 2014 identified all 68 black bass recovered from the repatriation area as Guadalupe Bass. Most of the Guadalupe Bass were wild-produced young-of-the-year offspring from Guadalupe Bass stocked in 2012, which was confirmed through genetic analysis. Furthermore, Guadalupe Bass become sexually mature at two years old and no hatchery stocking of Guadalupe Bass occurred in spring 2014. In fall 2015, 59 black bass were collected from the repatriation area for genetic monitoring. This collection occurred after a large flood event in May 2015 during which floodwaters spread onto the floodplain at The Narrows, potentially making the waterfalls passible by Smallmouth Bass or hybrids that persisted downstream. However, similar to 2014, all fish recovered from the repatriation area were confirmed through genetic analysis to be pure Guadalupe Bass, with the exception of one fish that contained a small percentage (1%) of Smallmouth Bass genetics. In 2017, natural reproduction of Guadalupe Bass was again documented in the repatriation area.

In fall 2019, geographically comprehensive genetics surveys were performed throughout the Blanco River, including reaches downstream of the repatriation area. Multiple age classes of wild-produced, genetically pure Guadalupe Bass were documented in the repatriation area, indicating a self-sustaining population has been successfully established. In an area directly downstream of the waterfalls (not stocked), 74% (14 of 19) of the black bass collected were confirmed to be genetically pure Guadalupe Bass. Downstream movement of Guadalupe Bass from the repatriation area was surmised to be responsible for the occurrence of genetically pure Guadalupe Bass downstream of the waterfalls. It is now theorized that the Guadalupe Bass population repatriated upstream of the waterfalls will contribute offspring into the below-barrier population and suppress the frequency of hybrids in downstream reaches by occupying available niches and providing resource competition.

The repatriation of Guadalupe Bass to the Blanco River garnered considerable interest and enthusiasm from local riparian landowners, communities, conservation non-profits, and other stakeholders who partnered to restore and preserve habitats for Guadalupe Bass and other native fishes. During the Guadalupe Bass repatriation project, TPWD performed site visits to 48 ranches (totaling 2,211 acres) to consult with riparian landowners on best management practices for conserving habitats for Guadalupe Bass and other native fishes in the Blanco River. Additionally, TPWD and partners hosted 23 river conservation workshops attended by 877 local landowners and other stakeholders, which covered topics such as the Guadalupe Bass repatriation, best practices for stream and riparian management, and riparian invasive species management. Working days events were also organized to implement riparian restoration on cooperating private lands. One hundred and five volunteers who contributed 433 volunteer hours supported those events. TPWD also collaborated with The Nature Conservancy and over 100 cooperating landowners to control invasive giant reed Arundo donax and restore native riparian vegetation along the Blanco River, an effort that continued in 2020.

Efforts to restore and preserve Guadalupe Bass are also underway in other portions of the Upper Guadalupe River. In 2020, a new TPWD research project was initiated to investigate efficiency and efficacy of new stocking strategies for reducing hybridization and introgression between Guadalupe Bass and Smallmouth Bass. As a component of the study, approximately 22,000 Guadalupe Bass were stocked into the mainstream Guadalupe River and tributaries upstream of Kerrville. TPWD also continued to collaborate with the Upper Guadalupe River Authority, Kerr County, the Water Oriented Recreation District of Comal County, the City of New Braunfels, and over 60 cooperating landowners to restore healthy riverscapes and habitats for Guadalupe Bass in the Upper and Middle Guadalupe River by controlling invasive giant reed.

Similar efforts to conserve other SGCN are being implemented by TPWD and partners throughout the state. To learn more or to get involved, please contact Timothy Birdsong (TPWD Inland Fisheries Division) at (512) 389-4744 or Timothy.Birdsong@tpwd.texas.gov.

TABLE 1. Examples of voluntary and regulatory-based conservation programs that support the conservation of native freshwater fishes recognized as State Threatened or Endangered (STE) or as Species of Greatest Conservation Need (SGCN) in Texas.

Conservation Program	Responsible Organization(s)	Type of Authority	Program Description
National Fish Habitat Partnership	Desert Fish Habitat Partnership, Southeast Aquatic Resources Partnership, Texas Parks and Wildlife Department	Voluntary	Since 2008, nearly 60 fish habitat restoration projects have been supported in Texas through the Desert Fish Habitat Partnership and Southeast Aquatic Resources Partnership; projects restored more than 9,884 acres of fish habitats in ciénegas, creeks, and rivers; the habitat restoration projects were primarily implemented to conserve, restore, or repatriate freshwater fish SGCN
Crucial Habitat Assessment Tool (CHAT)	Western Association of Fish and Wildlife Agencies	Voluntary	This GIS-based tool developed for the western USA informs consideration of fish and wildlife habitats in land-use planning, zoning, and development decisions; areas recognized as crucial freshwater habitats in Texas correspond to the native ranges of freshwater fishes recognized as STE or SGCN
Southeast Conservation Blueprint	Southeastern Association of Fish and Wildlife Agencies	Voluntary	Serves as a living, spatial plan that identifies important areas for fish and wildlife conservation across the southeastern USA and Caribbean; priority freshwater conservation areas identified within Texas correspond to the native ranges of freshwater fishes recognized as STE or SGCN
Texas Aquatic Gap Sampling Program	Texas Parks and Wildlife Department, University of Texas at Austin	Voluntary	Fills gaps in distributional occurrence data for freshwater fishes and mussels recognized as STE or SGCN; surveys are primarily conducted within riverscapes recognized by Texas Parks and Wildlife Department as Native Fish Conservation Areas

TABLE 1 - continued

Conservation Program	Responsible Organization(s)	Type of Authority	Program Description
Cooperative Endangered Species Conservation Fund (Endangered Species Act, Section 6)	Texas Parks and Wildlife Department, U.S. Fish and Wildlife Service	Voluntary	Provides cost-share funding to cooperating universities, non-governmental organizations, and other partners to fill critical science needs and implement conservation measures to conserve federally listed species, which are typically also listed as STE
State Wildlife Grants Program	Texas Parks and Wildlife Department, U.S. Fish and Wildlife Service	Voluntary	Provides cost-share funding to cooperating universities, non-governmental organizations, and other partners to fill critical science needs and implement conservation measures to conserve freshwater fishes recognized as STE or SGCN
Landowner Incentive Program	Texas Parks and Wildlife Department, U.S. Fish and Wildlife Service Partners for Fish and Wildlife Program, and numerous local cooperators	Voluntary	Provides cost-share funding to cooperating landowners to implement fish and wildlife habitat restoration projects on private lands; since 2010, the program has cooperated with approximately 140 landowners to support 160 projects that restored over 59,000 acres; priority landscapes for this program have included riverscapes and watersheds valued in the conservation of freshwater fishes recognized as STE or SGCN
Texas Farm and Ranch Lands Conservation Program	Texas Parks and Wildlife Department	Voluntary	Provides cost-share funding to cooperating land trusts for the purchase of conservation easements on private lands; preservation of riverscapes and watersheds valued in the conservation of STE freshwater fishes or SGCN have been explicitly prioritized by the program
Texas Instream Flow Program	Texas Parks and Wildlife Department, Texas Water Development Board, and Texas Commission on Environmental Quality	Voluntary	Performs studies to identify instream flow regimes needed to maintain sound ecological environments in Texas rivers and streams; studies use SGCN and STE freshwater fishes as focal species

TABLE 1 - continued

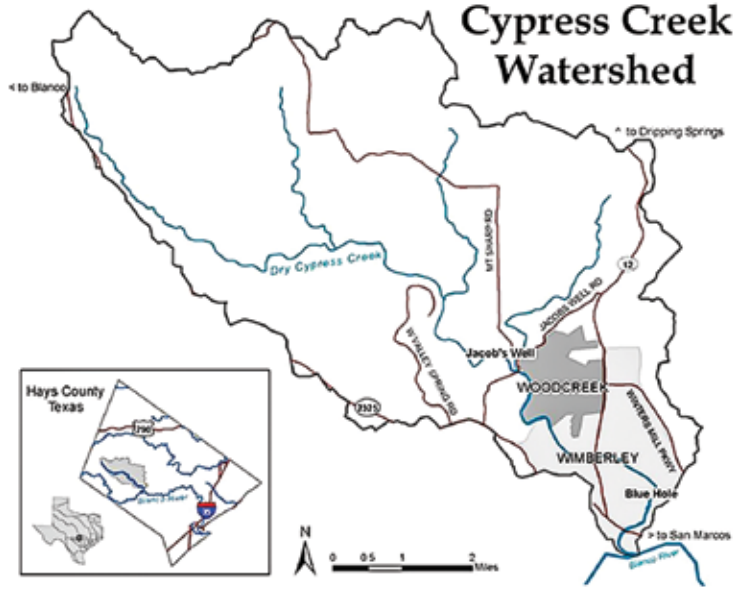
Conservation Program	Responsible Organization(s)	Type of Authority	Program Description
Collaborative Conservation Agreements	Texas Parks and Wildlife Department and numerous cooperators	Voluntary	Through multi-agency conservation plans, Texas Parks and Wildlife Department cooperates with partners to implement interjurisdictional, watershed-scale, and range-wide conservation efforts for focal species, many of which are recognized as SGCN and STE
Texas Native Fish Conservation Areas	Texas Parks and Wildlife Department	Voluntary	Consists of a network of 20 watershed-based management units that serve as strongholds for freshwater fish SGCN and STE freshwater fishes; the conservation areas are recognized as priority areas by Texas Parks and Wildlife Department and partners for investments in habitat preservation, habitat restoration, aquatic invasive species management, research, monitoring, and other conservation investments
Texas Parks & Wildlife Code, §§ 67.001–67.0041, Nongame Species	Texas Parks and Wildlife Department	Regulatory	Provides authorities and mandates for conservation of non-game freshwater fishes, including the need for Texas Parks and Wildlife Department to conduct ecological research, species propagation, survey and monitoring, habitat restoration, habitat protection, and other actions to ensure the continued ability of non-game fishes "to perpetuate themselves"
Texas Parks & Wildlife Code, § 12.0011, Resource Protection	Texas Parks and Wildlife Department	Regulatory	Provides authorization to seek full restitution or restoration of fish and habitat losses occurring as a result of anthropogenic activities; this authority applies to any freshwater fish considered public trust resources that are unlawfully killed, caught, taken, possessed, or injured, regardless of their listing status
Texas Parks & Wildlife Code, § 69.23, Fish and Wildlife Values	Texas Parks and Wildlife Department	Regulatory	Authorizes a substantial increase in the restitution value of STE species, with each State Endangered fish valued at US $1,000 per individual and each State Threatened fish valued at $500 per individual

TABLE 1 - continued

Conservation Program	Responsible Organization(s)	Type of Authority	Program Description
Texas Administrative Code, §§ 69.301–69.311, Scientific, Educational, and Zoological Permits	Texas Parks and Wildlife Department	Regulatory	Authorizes regulatory oversight by Texas Parks and Wildlife Department of scientific and zoological collection of freshwater fishes; listing as STE prohibits the take, possession, transport, or sale of a species in the absence of a Scientific Permit for Research
Texas Parks & Wildlife Code, §§ 52.101–52.401, Introduction of Fish, Shellfish, and Aquatic Plants	Texas Parks and Wildlife Department	Regulatory	Authorizes regulatory oversight by Texas Parks and Wildlife Department of stocking of fishes into public waters, ensuring that no adverse impacts to occur to STE freshwater fishes
Texas Parks & Wildlife Code, sections §§ 57.377–57.386, Permits to Possess or Sell Nongame Fish Taken from Public Freshwater	Texas Parks and Wildlife Department	Regulatory	Authorizes regulatory oversight by Texas Parks and Wildlife Department of commercial fishing activities in public waters, ensuring that no adverse impacts occur to STE freshwater fishes
Texas Parks & Wildlife Code, §§ 57.111–57.137, Harmful or Potentially Harmful Fish, Shellfish, and Aquatic Plants	Texas Parks and Wildlife Department	Regulatory	Authorizes regulatory oversight by Texas Parks and Wildlife Department for management of aquatic invasive species, ensuring that no adverse impacts occur to STE freshwater fishes
Texas Parks & Wildlife Code, §§ 69.101–69.121, Issuance of Marl, Sand, and Gravel Permits	Texas Parks and Wildlife Department	Regulatory	Regulates disturbance of instream habitats within state-owned streambeds; projects that disrupt or remove stream bed materials may only be permitted if determined to not damage or injuriously affect the river or freshwater fishes, not significantly or injuriously change the hydrology of the river, and not significantly accelerate erosion upstream or downstream

WATER QUALITY ORDINANCES ENHANCE WATER QUALITY PROTECTION AND PROMOTE AQUATIC HEALTH FOR THE CYPRESS CREEK WATERSHED

By Nick Dornak, Director of Watershed Services
The Meadows Center for Water and the Environment
and
By Tom Hegemier, P.E., D.WRE, CFM
Doucet and Associates, Inc.



Cypress Creek is a major tributary of the Blanco River located in the central Texas Hill Country in southern Hays County. The Cypress Creek watershed rises from Jacob's Well and flows through the city of Woodcreek and into the Blanco River at Wimberley. Cypress Creek joins the Blanco River on the south side of Wimberley just upstream of Ranch Road 12.

Its rugged terrain, narrow canyons, and cool, clear springs define the landscape. The watershed is home to a unique set of rural and urban communities, habitats, and ecosystems that rely on groundwater from the Trinity Aquifer. Used primarily for residential and commercial water supplies in the area, this groundwater supports the thriving economy of the valley. As a significant source of surface water base flows, it also provides valuable riparian habitat to a wide diversity of species, including fishes, waterfowl, reptiles and amphibians, mammals, and insects. A healthy, diverse riparian system in turn helps maintain water quality and quantity.

Cypress Creek Watershed Protection Plan aims to ensure that the long-term integrity and sustainability of the Cypress Creek watershed is preserved and that water quality standards are maintained for present and future generations.

With great effort and support from watershed stakeholders, in 2020, the cities of Wimberley and Woodcreek revised their water quality ordinances to enhance water quality protection and promote aquatic health. The ordinance updates created a set of rules and criteria that are consistent with the TCEQ Optional Enhanced Measures that were determined by the United States Fish and Wildlife Service (USFWS) to be protective of threatened and endangered species. These updated ordinances are protective of water quality during and after the development process, essentially achieving a non-degradation standard through the cumulative treatment effect of multiple measure. From that perspective, the lower one-third of the watershed in a full-build out 2040 condition will essentially experience the same pollutant loads as the existing condition. This is accomplished through the following measures:

- Water quality best management practices that must remove at least 80% of the increase in TSS load through the TCEQ Edwards Aquifer Protection program or city requirements;
- Water quality measure inspection and maintenance requirements that are enforced by the local government to ensure pollutant treatment performance;
- Creek buffer zones, that function similarly to filter strips as they are designed so that upstream runoff is converted to sheet flow. Filter strips are noted as providing 85% TSS management;
- Water quality education materials and workshops that can reduce the use of landscape chemicals, and
- Construction sediment controls that significantly reduce sediment loads during the construction period.

Permeable pavers installed in Downtown Wimberley along a sensitive reach of Cypress Creek.

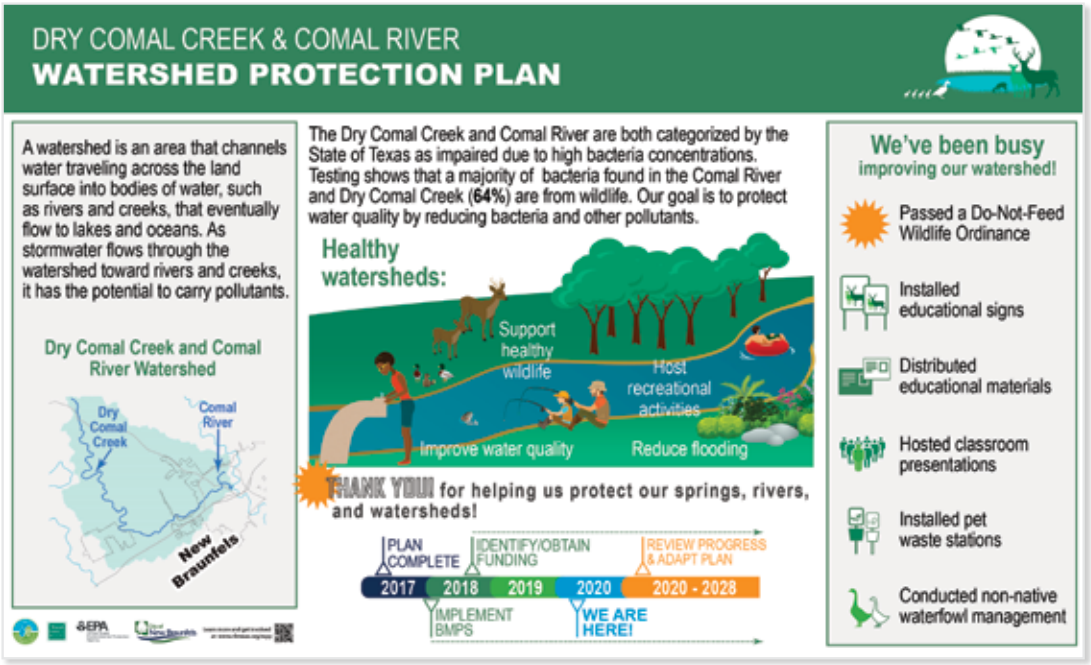
The above approach mimics the TCEQ “Optional Enhanced Measures for the Protection of Water Quality in the Edwards Aquifer”, RG-348A that were noted by the USFWS as protecting threatened and endangered species from impacts due to water quality degradation.

Thus, the water quality ordinance revisions are the single most important measure enacted by this project to date to provide long-term protection of water quality and aquatic habitat. The ordinance revisions, applied to a large land area, manage pollutant loads for generations and place the maintenance burden on the development community and not local and state government operations.

WATERSHED PROTECTION EFFORTS IN NEW BRAUNFELS

By Mark Enders, Watershed Program Manager
City of New Braunfels

The City of New Braunfels continues to take strides towards protecting and improving the rivers and creeks within the portion of the Guadalupe River watershed located in and around New Braunfels. The City's water quality and watershed protection efforts are primarily associated with the Dry Comal Creek and Comal River Watershed Protection Plan (WPP), the City's Stormwater Management Program (aka the MS4 stormwater program) and the Edwards Aquifer Habitat Conservation Plan.



As part of the Dry Comal Creek and Comal River WPP, the City continues to implement bacteria management measures in an effort to reduce bacteria loading to both of these waterbodies. These efforts include, but are not limited to, management of urban and non-native wildlife, pet waste management and outreach/education. Specific activities that have been conducted as part of the WPP include:

- Implementation and enforcement of a wildlife feeding ordinance;
- Installation of "No-feed" educational signage at strategic locations to educate residents and visitors on the negative impacts of wildlife feeding and overabundant urban wildlife;
- Trapping, removal and management of non-native waterfowl populations in Landa Park;

WPP Pet Waste Educational Signage at Puppy Playland Park.

WPP Watershed Education at New Braunfels Middle School.

- Installation of pet waste management signage at key locations;
- Installation of pet waste dispenser stations in City Parks, neighborhood green spaces and multi-family units;
- Education and outreach regarding the WPP and bacteria pollution prevention. Includes publication of education materials in local newspapers, classroom presentations and a part-time watershed educator staffed at the Headwaters at the Comal facility.
- The production of a watershed educational video to air at local movie theatres and on social media platforms.

The City intends to continue efforts to implement the Dry Comal Creek and Comal River WPP and further minimize bacteria loading to these waterbodies. More information on the Dry Comal Creek and Comal River WPP can be found on the City of New Braunfels webpage: www.nbtexas.org/wpp.

The City continues to mitigate stormwater pollution through the implementation of the City of New Braunfels Stormwater Management Plan (SWMP) and MS4 Program. Per the SWMP the City conducts stormwater pollution prevention activities that include but are not limited to:

- Annual screening of stormwater outfalls to identify possible pollutant discharges to the City's storm drain system and local waterways;
- Investigation of pollutant releases and pollution concerns;
- Oversight of active construction activities to ensure contractors are implementing appropriate erosion control and pollution prevention measures;
- Oversight of requirements for new developments that are intended to mitigate stormwater pollution from added impervious cover;
- Oversight of City operations to prevent and minimize stormwater pollution;
- Education and outreach.

More information of the City's MS4 program and Stormwater Management Plan activities can be found on the City's website at www.nbtexas.org/ms4.

EAHCP-Non-Native Species (Tilapia) Removal.

The City also continues to participate in the Edwards Aquifer Habitat Conservation Plan (EAHCP) that includes the implementation of springflow and habitat protection measures intended to protect the habitat of several federally listed endangered species in the Comal and San Marcos River systems. As part of the EAHCP, the City has been performing habitat restoration activities that include:

- Removal of non-native aquatic vegetation and planting of native aquatic vegetation within Landa Lake and the Comal River;
- Extensive removal of non-native riparian vegetation (i.e. elephant ears, Ligustrum, Chinese tallow, etc.) along Landa Lake and the Comal River;
- Planting of native plants within the riparian zone of Landa Lake and the Comal River;
- Removal of non-native fish and animal species from the Comal River system that includes removal of tilapia, suckermouth catfish (Plecostamus sp.) and nutria;
- Design and construction of stormwater treatment facilities (i.e. bioretention basins) within the Comal River watershed.

The City also has recently partnered with the Texas Parks and Wildlife Department (TPWD) on their Healthy Creeks Initiative, which is aimed at managing the highly invasive, non-native Arundo Cane (*Arundo donax*) along streams and rivers in the Texas Hill Country. The City worked with TPWD to identify and treat Arundo cane along portions of the Guadalupe River, Dry Comal Creek and Comal River within the New Braunfels city limits. The City intends to continue working with TPWD on this program to combat and minimize the spread of Arundo cane in our local rivers and creeks.

The City continues to coordinate the annual Dos Rios Watershed Cleanup event to collect litter from local rivers, creeks and contributing watershed areas within New Braunfels. The 2020 Dos Rios Watershed Cleanup event was held as a "do-it-yourself" clean-up challenge where participants led their own clean-up efforts and reported on their efforts. The stats for the 2020 Dos Rios Watershed Cleanup Challenge are listed below:

- Total Number of participants: 240
- Total estimated weight of litter collected: 2,400 lbs.
- Total estimated weight of recyclables collected: 260 lbs.

Since the initiation of the Dos Rios Watershed Cleanup in 2017, approximately 690 volunteers have helped to collect and remove over 6,400 lbs. of litter as part of this event.

The City looks forwards to continuing many of these activities that ultimately help to protect and preserve local streams and river and the Guadalupe River as a whole.

Dos RIos CleanUp Participants

Dos RIos Watershed Cleanup Participants - The Guadfathers

THE HEALTHY CREEKS INITIATIVE: PROTECTING WATER QUALITY AND QUANTITY BY MANAGING ARUNDO IN THE HILL COUNTRY

By Angela England
Texas Parks and Wildlife Dept., Inland Fisheries Division

Arundo (*Arundo donax*) is a large, invasive grass that has increasingly become a problem in Texas in recent decades. It is sometimes also called Giant Reed or Carrizo Cane.

Arundo is a game changer for sensitive riparian areas (extremely important habitats alongside our creeks and rivers). It reduces biodiversity by crowding out the diverse, native plants that are important for wildlife. Native vegetation with strong, deep root systems helps the riparian soil absorb water like a sponge, which sustains spring flow and reduces runoff of pollutants and bacteria into our waterways. Native plants also are key components in native food webs that sustain healthy fish and wildlife populations.

Arundo can resprout from human activities such as cutting, mowing, tilling, and movement of contaminated fill dirt.

Arundo consumes large quantities of water, reducing river flow, and worsens flooding by lessening the floodplain's ability to dissipate flood energy. Arundo's comparatively shallow, weak roots can increase bank erosion, which causes property damage, reduces water quality, and degrades instream habitat for native aquatic life. Arundo stands may harbor pests such as cattle ticks, feral hogs, and nutria. Arundo is highly flammable, which increases wildfire danger, intensity, and frequency.

Arundo doesn't produce fertile seed, instead relying on vegetative reproduction by means of sprouting from stalks and rhizomes (horizontal underground stems). Fragments of these can easily be carried downstream during flooding and start new infestations wherever they take root. Unfortunately, spread also occurs from human activities such as cutting, mowing, tilling, and movement of contaminated fill dirt. Prevention of these is crucial to prevent introduction to new areas, because once Arundo is established, it is difficult to control.

The Healthy Creeks Initiative is a broad partnership among a variety of government and nonprofit agencies as well as private landowners in a seven-county area of the Hill Country. This project provides no-cost treatment of Arundo to participating landowners.

Spraying herbicide is the most effective method of controlling Arundo.

Herbicide treated Arundo on the left, versus untreated on the right.

Chemical treatment is the most effective method of controlling Arundo and can minimize the impact of control efforts on the riparian habitat. We use low concentrations of aquatic-labeled, EPA-approved herbicides that have been rigorously tested to ensure minimal risk of harm to aquatic life, in addition to the standard testing required for all pesticides to ensure they will not harm humans or other wildlife. Treated canes and roots are left in place for at least two years after they appear completely dead. This provides stability to the soil and helps reduce erosion while native plants regrow. The dead canes create a nursery area that protects the new generation of young, native plants.

Within the Guadalupe River Basin, Healthy Creeks Initiative activities began in 2016 in the Blanco watershed in Blanco and Hays counties, in partnership with The Nature Conservancy and the Hill Country Alliance. In 2018, the project was able to expand to Kerr County in the Upper Guadalupe due to a new partnership with the Upper Guadalupe River Authority. In 2019, a new collaboration with the City of New Braunfels and the Water Oriented Recreation District (WORD) of Comal County allowed us to add the Middle Guadalupe watershed from downstream of Canyon Dam to New Braunfels.

Texas Parks and Wildlife Department provides coordination, outreach, and funding for the project, but we rely on partner organizations such as UGRA, WORD, and the City of New Braunfels for accurate and timely data collection and one-on-one relationships with the participating landowners in their regions.

Involvement in the Healthy Creeks Initiative is voluntary, and its success is due in no small part to landowners spreading the word to their neighbors about its success. As of the end of the 2020, over 300 landowners are enrolled as active participants in the program. Visit http://tpwd.texas.gov/healthycreeks for more information and to get involved.

INVASIVE ZEBRA MUSSELS IN THE GUADALUPE RIVER BASIN

By Lee Gudgell, Aquatic Biologist
Guadalupe-Blanco River Authority

In June of 2017, Canyon Lake Marina employees discovered several suspicious organisms attached to a boat stored at Crane's Mill Marina on the southwest side of Canyon Reservoir. On June 8, 2017, Texas Parks and Wildlife (TPWD) fisheries biologists and game wardens confirmed the presence of adult, juvenile and larval zebra mussels (Dreissena polymorpha) in the 8,320-acre water supply reservoir. The discovery of multiple mussel life stages at more than one location indicated the existence of an established, reproducing population. Shortly after this discovery, TPWD classified Canyon Reservoir as the 10th lake in Texas infested by zebra mussels. Zebra mussels have a propensity to colonize the hard surfaces of infested water bodies with dense mats of shells and selectively filter food particles from large volumes of water. This behavior poses significant threats to the aquatic ecosystem, infrastructure and recreational usage of the Guadalupe River Basin.

Adult zebra mussels are freshwater organisms with two hard, hinged shells that enclose soft internal tissue. The shells protect organs such as a muscular foot for movement, reproductive organs, gills and a siphon for filtering food out of the water column. The outer shell is identifiable by its flattened bottom that contains a permanent opening, which releases multiple adhesive "byssal threads". The mussel uses these threads to cling tightly to hard surfaces, which makes it difficult to dislodge. This behavior is in contrast to the majority of other mussels and clams that tend to bury themselves in soft sediments. An enlarged area near the hinge line of the shell helps the mussel to stand upright from the surface to which it attaches. The front of the shells taper up from the bottom like a tent, which helps deter predators like fish from removing it, but also presents sharp edges capable of cutting the skin of recreational swimmers and waders. The outside of the shells can contain a large variety of color patterns such as solid white, brown, or black and often contain a dark striped pattern that evokes the coat of the zebra referenced in its common name.

Zebra mussels are native to drainages of the Black and Caspian seas in Eurasia, but have proven to be one of the most successful ecological invaders of modern times. The short life span, prolific early reproduction, rapid growth rates, and survival of early life stages have proven to be exceptional characteristics to facilitate the rapid expansion of the species. Due to unintentional introductions from shipping traffic during the industrial revolution, occupation of almost every river drainage in Europe occurred in the 19th century.

Invasions of Texas waterbodies have been a growing concern since the first zebra mussel detections occurred in the Great Lakes of North America in 1988. Following infestation of lakes Huron, Erie, and Michigan, the mussels quickly spread into the northeastern United States in the Hudson River and began a rapid expansion to the south through the Illinois River and into the drainages of the Lower Mississippi by 1991. In 2008, they had spread to within 200 miles of the Texas border on the Arkansas River in Oklahoma and the Mississippi River in Louisiana. In 2009, Lake Texoma in the Red River Basin, documented the first zebra mussel observations in Texas. The mussels continued to spread south into the Trinity River at Ray Roberts Lake in 2012 and Lake Lewisville in June of 2013. In September of 2013, zebra mussel sightings occurred at Belton Lake in the Brazos River basin. In June of 2017, zebra mussels infested the Lower Colorado River Basin at Lake Travis and the Guadalupe River Basin at Canyon Lake. By the end of 2020, TPWD has confirmed the detection in five Texas river basins and at least 31 Texas lakes, with 23 designated as infested with an established, reproducing population.

TPWD identified trailered boats as the most likely mechanism for the introduction of this invasive species into new waterways. In 2011, the agency launched its "Clean, Drain, Dry" initiative to educate boaters about the dangers zebra mussels pose to the aquatic ecosystems and infrastructure in Texas. This campaign focused on watercraft cleaning techniques that would minimize the chance of transporting and spreading zebra mussels into new locations. The cleaning regimen prescribed by the program included three steps. Prior to leaving or entering a freshwater river or lake, a boater should remove all visible mud, debris and vegetation from the boat or trailer and all water should be drained from boat compartments such as the motor, live well, and bait buckets. The boat should then dry for a minimum of 7 to 10 days during hotter portions of the year (May through October) and 15 to 20 days during cooler periods (November through April). Alternatively, the entire boat can be power washed with 140°F water to remove the mussels. TPWD intended for these procedures to be effective for short-term exposures to infested waters, but acknowledged that boats with extended contact periods would likely require more intense cleaning techniques. In 2014, TPWD regulations began to mandate the cleaning and draining of watercraft in public waters by imposing statutory fines of up to $500 for noncompliance. The Guadalupe-Blanco River Authority (GBRA) has cooperatively collaborated with TPWD for this education effort by funding the purchase and placement of notifications and signage that elevate public awareness of these rules in the Guadalupe River Basin.

GBRA has also proactively collaborated with TPWD to provide early detection monitoring of zebra mussel expansion. In June of 2017, GBRA deployed settlement samplers at multiple locations in Canyon Reservoir to track the spread of the invasive mussels throughout the lake. These fixed "McMahan Style" and "Portland Style" samplers consisted of a steel wool pad, affixed to clear plastic clasps or a four inch perforated PVC pipe (Figure 1). This settlement base attaches to a weighted brick on the bottom and a suspension rope on the top. GBRA researchers hung these apparatus four to six meters into the water column in order to provide an optimal location for juvenile zebra mussels to attach during breeding cycles. In November of 2017, GBRA employees documented the spread of zebra mussels to the northeastern side of Canyon Reservoir, including Canyon Park Marina and the Joint Base San Antonio recreational area. In the same month, GBRA staff collaborated with TPWD invasive species biologists to begin collecting planktonic mussels and DNA samples in reservoirs downstream of Canyon. GBRA pulled 12" wide x 36" long plankton nets vertically through the water columns of Lake Dunlap (TP-1 Dam), Lake McQueeney (TP-3 Dam) and Lake Placid (TP-4 Dam) during optimal breeding conditions, as water temperatures reached 16 to 19°C (Figures 2 & 3). GBRA collected plankton net "tows" from one to eight-meter water depths with a 63-micron mesh, and washed the contents into 500 mL containers of preservative. The small mesh size of these plankton nets allowed GBRA researchers to capture the microscopic 97 to 492-micron "veliger" form of zebra mussels that can persist in the water column for a few days

Figure 1 - Colonized McMahan Style Zebra Mussel Sampler at Canyon Lake.

Figure 2 – GBRA Researcher Lee Gudgell performing veliger monitoring.

Figure 3 – GBRA Researcher Jana Gray performing veliger monitoring.

to several months after egg release and fertilization. The TPWD A.E. Wood Fish Hatchery analyzed samples with cross-polarized light microscopy to identify planktonic zebra mussels and confirmed positive samples with polymerase chain reaction (PCR) DNA testing. In May of 2019, GBRA sampling at all three reservoirs resulted in the early discovery of veligers in planktonic samples and adult mussels on deployed settlement samplers. TPWD used this information to reclassify the zebra mussel status of Lakes Dunlap, McQueeney and Placid from "suspect" to "positive". To date, the limited abundance and locations of zebra mussels in these water bodies does not reach a threshold to indicate that they have been "infested" by a sustained reproducing population. Since this discovery, GBRA has continued to expand early detection monitoring efforts throughout the basin. GBRA performs quarterly checks of deployed settlement samplers at 10 locations downstream of Lake Placid, six locations on Coleto Creek Reservoir and five locations on the Guadalupe paddling trail upstream of Canyon Reservoir. To date, GBRA has not detected any zebra mussels outside of the previously confirmed reservoirs.

The destructive effects of zebra mussels introduced into new aquatic environments has been profound. Zebra mussels have devastated native ecosystems by colonizing the shells of native mussels, and increased concentrations of toxins, nutrients and harmful algae. The Guadalupe orb (Cyclonaias necki), False spike (Fusconaias mitchelli), Guadalupe fatmucket (Lampsilis bermanni) are three state threatened mussel species exclusively found in the Guadalupe River basin whose life cycles could be inhibited due to zebra mussels. Zebra mussels also selectively filter planktonic food particles out of the water column, which can change the nutrient cycling of a water body. Non-nutritious suspended particles such phosphorus, ammonia nitrogen, and mats of green and blue-green algae often increase in infested waters because of zebra mussel feeding behavior. The mussels alter the overall transparency of the water body as they remove suspended particles such as plankton and discard undesirable particles through their inhalant siphon. Increasing water clarity can also be detrimental to fish community as reductions of fish such as gizzard and threadfin shad occur due to increased competition for planktonic food sources, which may in turn affect sport fish. In Canyon Reservoir, the noticeable increase in water clarity is already presenting itself by allowing other invasive species such as Hydrilla plants to take hold in larger and deeper portions of the lake than were previously available as result of increased sunlight penetration.

The economic cost of zebra mussels to the people of the United States cannot be understated. The propensity of the mussels to attach to hard surfaces at densities of up to 700,000 organisms per square meter and survive at depths of up to 60 meters has

the potential to affect all manner of submerged public and private property including boats, moorings, and infrastructure of industrial water and power supplies. In 2014, Cornell University estimated the annual economic cost of zebra mussels in the United States was $5 billion per year in direct damages. In the Guadalupe River Basin, GBRA is proactively modifying its operations to protect drinking water infrastructure from zebra mussels. GBRA purchased a robotic camera system to perform regular inspections of freshwater intakes (Figure 4).

Figure 4 – Deep Trekker Robotic CCTV at Western Canyon WTP.

The GBRA Western Canyon WTP is capable of treating up to 21 million gallons per day of drinking water. The plant has three water intakes at 29 feet, 49 feet and 99 feet below normal pool level. The mussels have previously colonized the upper two pipes. In order to protect this vital resource, GBRA anticipates spending ~$200,000 per year to treat infested zebra mussel intakes with copper sulfate pentahydrate. In addition, GBRA plans to replace intake grates on downstream reservoirs with copper grates that are resistant to zebra mussel attachment. The price of combating this species will undoubtedly continue to rise as these mussels spread to new areas. GBRA will continue to steward the natural resources of the basin and ensure the integrity of water supplies to its customers in the face of this growing threat.

UPPER SAN MARCOS RIVER WATERSHED PROTECTION PLAN

By Aspen Navarro,
Watershed Services Coordinator,
The Meadows Center of Water and
the Environment

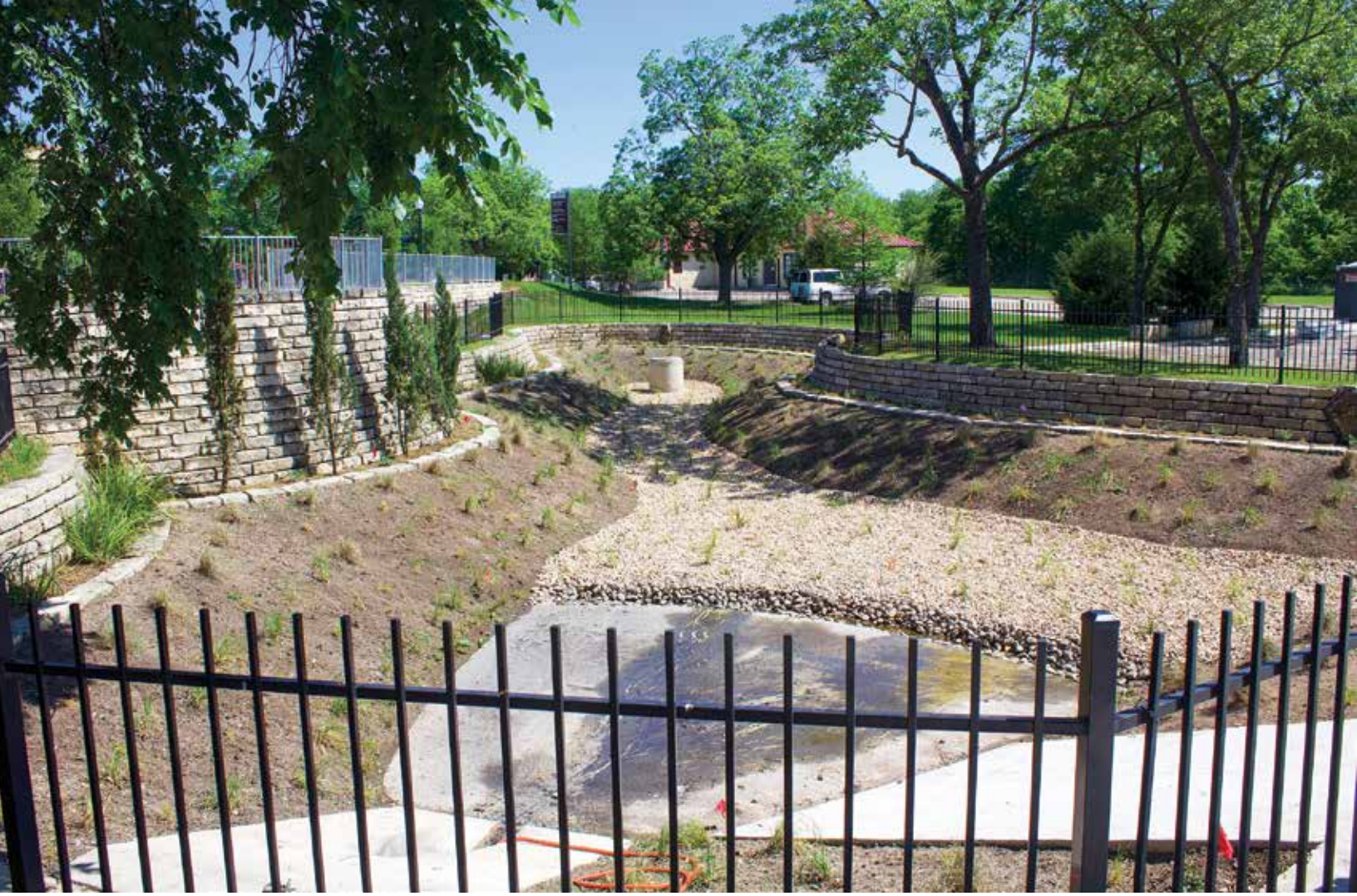
Despite a global pandemic, 2020 was quite a busy year for the Upper San Marcos River (USMR) Watershed Protection Plan (WPP). Implementation Phase I of the WPP concluded in August after two years of hard work. Major aspects of Phase I aimed to enhance public awareness and water quality through education and outreach, as well as demonstration projects. Projects accomplished throughout the course of the implementation timeline include stakeholder meetings, workshops, interpretive bilingual educational signage, a watershed ordinance review, a water quality data summary, and a new StoryMap to highlight the two best management practices (BMPs) completed in April of 2020.

Matthews Street prior to installation of Hogtrap Best Management Practice (BMP). Photo courtesy of Aspen Navarro.

Completed BMPs in Phase I consisted of two retrofits projects working to protect the watershed from pollutants and contaminants by intercepting and filtering stormwater runoff before it enters the San Marcos River during rain events. The first BMP, Matthew's Street "Hogtrap", was completed in collaboration with Texas State University and is working to divert stormwater away from a location on campus known to experience excessive runoff. Improvements included increasing the capacity of a subsurface stormwater pipe along a hillside surface and stabilizing the hillside to prevent further erosion and sediment from depositing into Sessom Creek, a tributary of the USMR. The second retrofit, Hutchison biofiltration pond, was completed with the City of San Marcos. The pond is one amongst a series of smaller biofiltrations ponds along CM Allen Drive that captures and filters stormwater runoff received from downtown San Marcos. The collective CM Allen Project was awarded 2nd place in the Professional Category of the 2020 Outstanding Green Infrastructure and LID Project Competition from Region 6 of the EPA. In their entirety, the two retrofits have the capability of reducing total suspended solids by over 7,900 pounds per year, 19.4 pounds of total phosphorus, and 68 pounds of total nitrogen.

Matthews Street after installation of Hogtrap BMP. Photo courtesy of Aspen Navarro.

Two intensive reports were completed in Phase I. The first report was led by Tom Hegemier, Senior Project Manager at Doucet & Associates, which analyzed development ordinances within the watershed and Edwards Aquifer. The analysis found that the City of San Marcos had some of the best stormwater protection measures and requirements for new developments within their Stormwater Technical Manual and Code SMTX. The protection measures and regulations in place have the potential to make a substantial difference in managing pollutant loads within the watershed and preventing a major increase in impervious cover. The second report consisted of a water quality data summary and analysis compiled from all available data from partners such as the City, Edwards Aquifer Authority, and Texas Stream Team.



Completed Hutchison biofiltration pond. Photo Courtesy of Aspen Navarro.

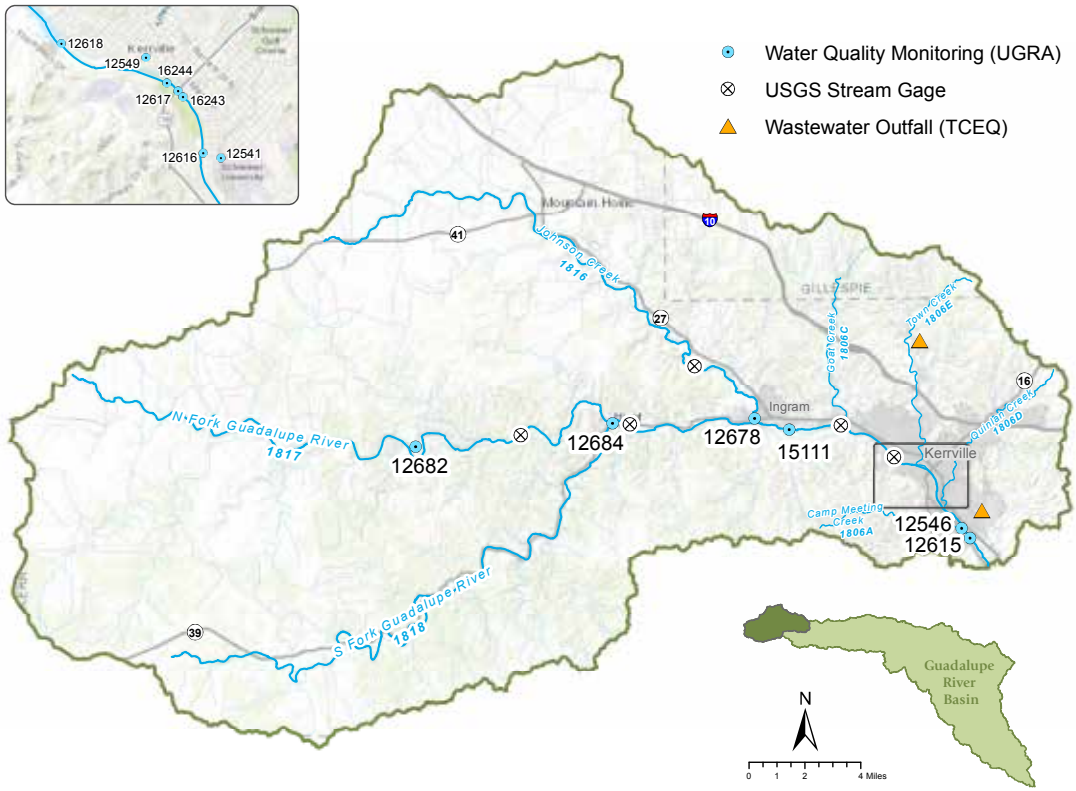
The report displayed that the watershed was meeting the state water quality standards and the more stringent stakeholder established standards. In the coming years, we look forward to seeing how the two new BMPs help improve water quality within the watershed. Both reports can be found on the watershed website UpperSanMarcosRiver.org.

Just before the conclusion of the first Phase I TCEQ contract, a new collaborative 319 funded project kicked off with The Meadows Center, the San Marcos Greenbelt Alliance (SMGA), the City of San Marcos, and the Mermaid Society of Texas. SMGA and the City's portion of the grant includes efforts towards restoration of Sessom Creek Natural Area, which includes in-stream and riparian restoration, construction of vegetated filter strips and brush berms, and development of a community trail plan. The Mermaid Society will be responsible for planning and executing an extensive education and outreach program to distribute amongst local schools and the general public to increase public awareness of nonpoint source pollution. The project kicked off summer of 2020 and will conclude in early 2023. We are excited to continue pursuing new project opportunities, work to protect the watershed, and increase awareness about how individuals can actively participate in making a difference.

SUBWATERSHED DESCRIPTIONS

North Fork Guadalupe River
at Benson Crossing.
Photo Courtesy of Tara Bushnoe.

Guadalupe River Above Flat Rock Dam



FACTS AND FEATURES

Drainage Area	537 square miles
Length	17 miles
Tributaries	Kelly Creek, Indian Creek, Goat Creek (1806C), Bear Creek, Town Creek(1806E), Quinlan Creek (1806D), Camp Meeting Creek (1806A), Third Creek
Aquifer	Trinity, Edwards Plateau
River Segments	1816, 1817, 1818, 1806, 1806A, 1806C, 1806D, 1806E
Cities and Communities	Hunt, Ingram, Kerrville
Counties	Kerr, Gillespie
EcoRegion	Edwards Plateau
Climate	Average annual rainfall 32.08 inches, Average annual temperature 65.1°F
Land Uses	Ranching, farming, tourism, light manufacturing
Water Body Uses	Aquatic life, contact recreation, general use, fish consumption, and public water supply
Soils	Dark and loamy over limestone to loam with clay subsoils
Permitted Wastewater Treatment Facilities	Domestic 2, Land Application 6, Industrial 0

Guadalupe River Above Flat Rock Dam

RIVER SEGMENT, DESCRIPTION, AND CONCERNS

Segment	Description	Concerns and Recommendations
1816	Segment 1816, Johnson Creek, begins near SH 41 in western Kerr County and extends to the confluence with the Guadalupe River in Ingram, TX, and is approximately 21 miles long. This segment contains one assessment unit, 1816_01, and one routine monitoring station, 12678, which is located immediately upstream of the SH 39 crossing in Ingram and is monitored by UGRA. There is also one USGS gage in this AU, located approximately 3.5 miles north of the routine monitoring site. Johnson Creek watershed is rural with a very low population density. The scenery and numerous recreational activates in this segment attract many visitors to the area, and it is a popular swimming hole for local residents. Stakeholders in this area include rural landowners, agricultural producers, river outfitters, and UGRA.	The 2020 Texas Integrated Report (IR) lists no impairments for this segment, however it has one concern for impaired habitat. This concern stems from data collected during a 2016 aquatic life monitoring event (ALM). A regression analysis of data collected between 2003 and 2016 showed several water quality trends at this station. Stream flow at this station averaged 41 cfs with a decreasing trend over time. Additionally, there was an increase in E. coli, turbidity, total suspended solids, and chlorides over the study period. There was also a decreasing trend in nitrates. All of the observed changes, with the exception of E. coli, showed a significant correlation with stream flow and were likely the result of the pervasive drought conditions experienced during that time frame. GBRA plans to reassess conditions at this site in the future as it is thought that low flow conditions that may have impacted the habitat parameters that were assessed.
1817	Segment 1817, North Fork Guadalupe River, begins near Boneyard Draw in western Kerr County and extends to the confluence with the Guadalupe River in Hunt, TX, and is roughly 29 miles long. The segment contains one assessment unit (1817_01) and one routine monitoring station that is monitored by UGRA (12682) located at the Weldemar Crossing on FM 1340, approximately 6 miles upstream from the confluence. There is also one USGS gage located in the AU, approximately 0.5 miles downstream from site 12682. The North Fork Guadalupe River watershed is rural, with a very low population density. This rural area contains agricultural farming including Concentrated Animal Feeding Operations. Multiple hill country summer camps area located in this segment due to the beautiful scenery and numerous recreational activates available. In additional to the hill country summer camps, stakeholders in this area include rural landowners, agricultural producers, river outfitters, and UGRA.	The 2020 IR has North Fork Guadalupe River listed for impaired fish community and impaired macrobenthic community, as well as a concern for impaired habitat. This stream currently has an “exceptional” aquatic life use rating however a use attainability analysis (UAA) may be required to determine if this rating is appropriate. A regression analysis of data collected between 2003 and 2016 showed several water quality trends at this station. Stream flow at this station averaged 22 cfs with a decreasing trend over time. Additionally, there was a decrease in volatile suspended solids, specific conductance, and nitrate over the study period. There was also an increase in chloride and pH. All of the observed changes showed a significant correlation with stream flow and were likely the result of the pervasive drought conditions experienced during that time frame. GBRA plans to reevaluate this segment in the future to determine if the uncharacteristic low flow conditions impacted the habitat parameters that were assessed.

Guadalupe River Above Flat Rock Dam - continued

Segment	Description	Concerns and Recommendations
1818	Segment 1818, South Fork Guadalupe River, begins upstream of FM 187 in western Kerr County and extends to the confluence with the Guadalupe River in Hunt, TX, and is approximately 27 miles long. The segment contains five assessment units (1818_01 – 1818_05), however only the most downstream AU (1818_01) contains a routine monitoring station (12684) which is monitored by UGRA. Station 12684 is located at the SH 39 crossing in Hunt just upstream from the confluence with the North Fork Guadalupe River adjacent to Hunt Lion's Park. There are no USGS gages in this segment. Similar to South Fork Guadalupe River, this segment is rural with low population and minimal urban development, is home to many Hill Country summer camps, and is a popular destination for outdoor recreation enthusiasts. In additional to the hill country summer camps, stakeholders in this area include rural landowners, agricultural producers, river outfitters, and UGRA.	The 2014 IR identified a concern for depressed dissolved oxygen for this segment. It was thought that this concern would not persist into the next assessment period, as stream flows returned to normal following several years of drought conditions. The 2020 IR removes the concern for depressed dissolved oxygen, however it adds impairments for fish community and macrobenthic community, as well as a concern for impaired habitat. Like the North Fork Guadalupe River, this stream currently has an "exceptional" aquatic life use rating however a use attainability analysis (UAA) may be required to determine if this rating is appropriate.
1806	Segment 1806 begins at the confluence of the North and South Forks of the Guadalupe River in Kerr County and extends 105 miles to Canyon Reservoir in Comal County. In this report we will discuss 1806 as two separate sub-watershed: from the confluence of the North and South Forks to Flat Rock Dam in the City of Kerrville, and from Flat Rock Dam to Canyon Reservoir. Segment 1806 has seven assessment units, four of which are located above Flat Rock Dam. Those four AUs are described here. AU 1806_09 flows from Flat Rock Dam Upstream to the confluence of Cam Meeting Creek in Kerrville. 1806_10 runs from the confluence of Camp Meeting Creek to the confluence of Town Creek in Kerrville. 1806_11 runs from the confluence of Town Creek upstream to the confluence of Goat Creek in Kerrville. 1806_12 is the portion that runs from Goat Creek upstream to the confluence of the North and South Forks of the Guadalupe River in Kerr County. UGRA performs routine sampling at 10 stations within the portion of 1806 above Flat Rock Lake. There are three USGS gages within this portion of 1806, one just below the confluence of the North and South Forks in Hunt, one near the Bear Creek Road Crossing immediately west of Kerrville, and one just downstream of Nimitz Dam in Kerrville.	This stream segment was added to the 303(d) list of impairments in 2020 for bacteria; this listing was a result of geometric mean of bacteria concentrations exceeding the contact recreation standard. Previously, this AU had an impairment for bacteria that was removed in the 2016 IR, when average conditions fell below the contact recreation standard. In the 2018 IR, this AU had concerns listed for bacteria and dissolved oxygen grab minimum.

Upper Guadalupe River in Kerr County.

Guadalupe River Below Flat Rock Dam

- Water Quality Monitoring (GBRA)
- Water Quality Monitoring (UGRA)
- USGS Stream Gage
- Wastewater Outfall (TCEQ)

N

0 1 2 4 Miles

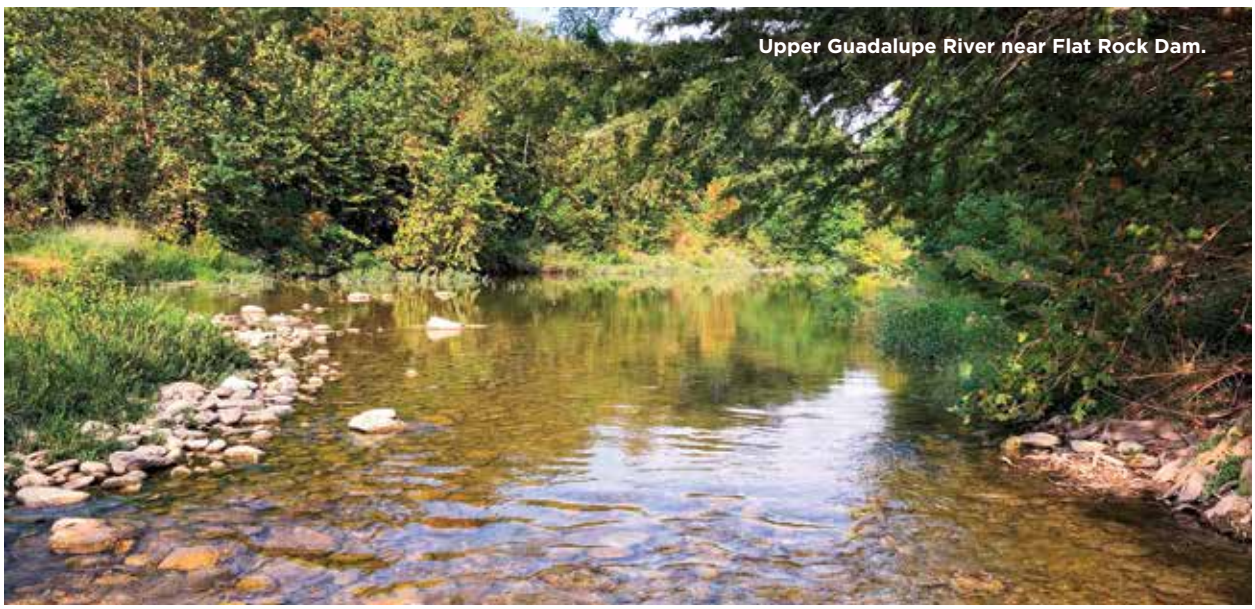
FACTS AND FEATURES

Drainage Area	827 square miles
Streams and Rivers from Flat Rock Dam to Canyon Lake	Silver Creek, Turtle Creek, Steel Creek, Verde Creek (1806G), Bluff Creek, Cherry Creek, Bruins Creek, Wilson Creek, Cypress Creek (1806B), Holliday Creek, Flat Rock Creek, Block Creek, Joshua Creek (1806H), Violet Creek, Sister Creek, Jacobs Creek, Wasp Creek, Bear Creek, Sabinas Creek, Goss Creek, Spring Creek, Swede Creek, Panther Creek, Walter Creek, Honey Creek, Curry Creek, Spring Branch, Swine Creek, Elm Creek, Cypress Creek, Miller Creek
Aquifer	Trinity, Edwards Plateau
River Segments	1806
Cities	Center Point, Comfort, Kendalia, Bergheim, Bulverde, Spring Branch
Counties	Kerr, Comal, Kendall, Blanco
EcoRegion	Edwards Plateau
Climate	Average annual rainfall 31.68 inches, Average annual temperature January 38°, July 95°
Land Uses	Urban, unincorporated suburban sprawl, cattle, goat and sheep production, light and heavy industry, and recreational
Water Body Uses	Aquatic life, contact recreation, general use, fish consumption, and public water supply
Soils	Dark and loamy over limestone to loam with clay subsoils
Permitted Wastewater Treatment Facilities	Land Application 6, Domestic 1

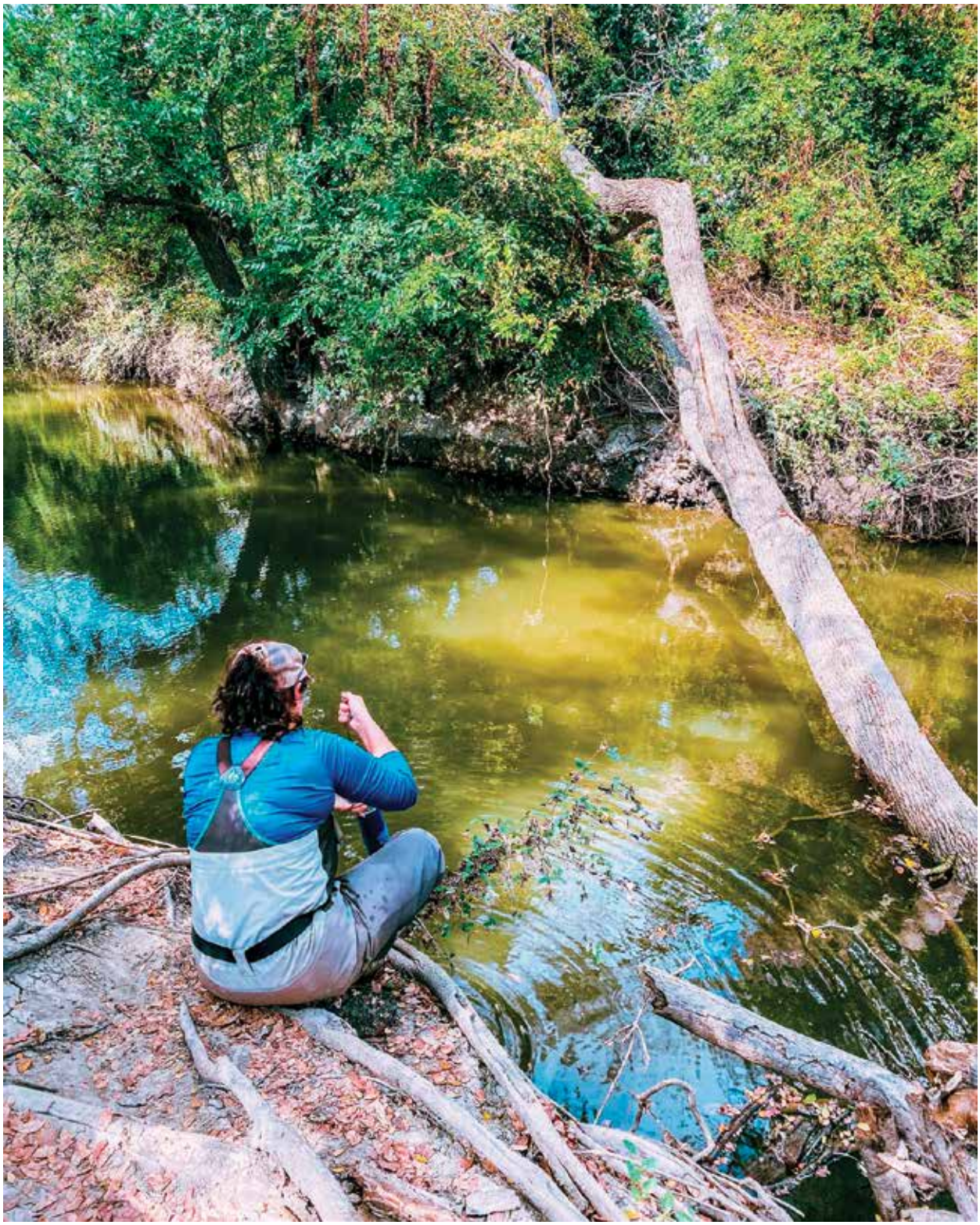
Guadalupe River Below Flat Rock Dam

RIVER SEGMENT, DESCRIPTION, AND CONCERNS

Segment	Description	Concerns and Recommendations
1806	Segment 1806 comprises the 105 mile portion of the Guadalupe River that flows from the headwaters in Kerr County to Canyon Reservoir in Comal County. This section will focus on 1806 from below Flat Rock Dam to above Canyon Reservoir. This portion of 1806 contains three assessment units, which are described here. These three AUs represent over 93% of the total river reach for segment 1806. 1806_02 flows approximately 32 miles from Flat Rock Dam to the confluence with Big Joshua Creek. This segment contains four routine monitoring stations that are monitored by UGRA: 15113, located off Split Rock Road near SH27, 12608, located at Center Point Lake, 12605, located at the Hermann Sons Road crossing of the Guadalupe River just upstream of the Kerr County line, and 12602, located near the FM 1621 bridge in Waring, TX. 1806_08 flows from the confluence with Honey Creek upstream to the confluence with Big Joshua Creek and contains one monitoring station, 17404, which is located upstream of the FM 474 Bridge on the Guadalupe River in Kendall County. 17404 is a routine monitoring station that is monitored monthly by the GBRA. This AU is commonly used for contact recreation and fishing, and is in an area that is much more rural than the other AUs upstream in the city of Kerrville, making this AU much more likely to be influenced by agricultural runoff than industrial or urban runoff. 1806_01 is a 25 mile stretch of the river that flows from the confluence with Honey Creek to 1.7 miles upstream of Rebecca Creek, just north of Canyon Dam. This AU contains one monitoring station, 13700, located upstream of the FM 311 Bridge on the Guadalupe River, near the USGS gaging station in Spring Branch. 13700 is a routine monitoring station that is monitored monthly by the GBRA. This AU is part of the Guadalupe Paddling Trail and is known for clear water and heavy contact recreation use. This large stretch of river has both rural and densely populated areas and is a popular destination for outdoor enthusiasts. Stakeholders in the area range from agricultural producers, to river outfitters, to municipalities.	Segment 1806 is on the 303(d) list of impaired water bodies with an impairment for bacteria, and concerns for impaired fish community and impaired habitat. Bacteria samples for this AU were collected at station 17404, upstream of the FM 474 Bridge in Kendall County. The assessed bacteria geometric mean at this station (177 MPS/100 mL) is considerably higher than values collected at the nearest upstream (12602) and downstream (13700) stations (55 MPN/100 mL and 68 MPN/100 mL), respectively). GBRA added a new sampling station upstream of 174041 in order to better characterize this AU: station 22082, located above the FM 1376 Bridge. Station 22082 has shown significantly lower bacteria concentrations compared to 17404. The source of the bacteria at station 17404 is unknown, however the high values may be associated with failing onsite sewage facilities (OSSFs) upstream of the station. Further investigation would need to be conducted to try to identify the source of the bacteria.

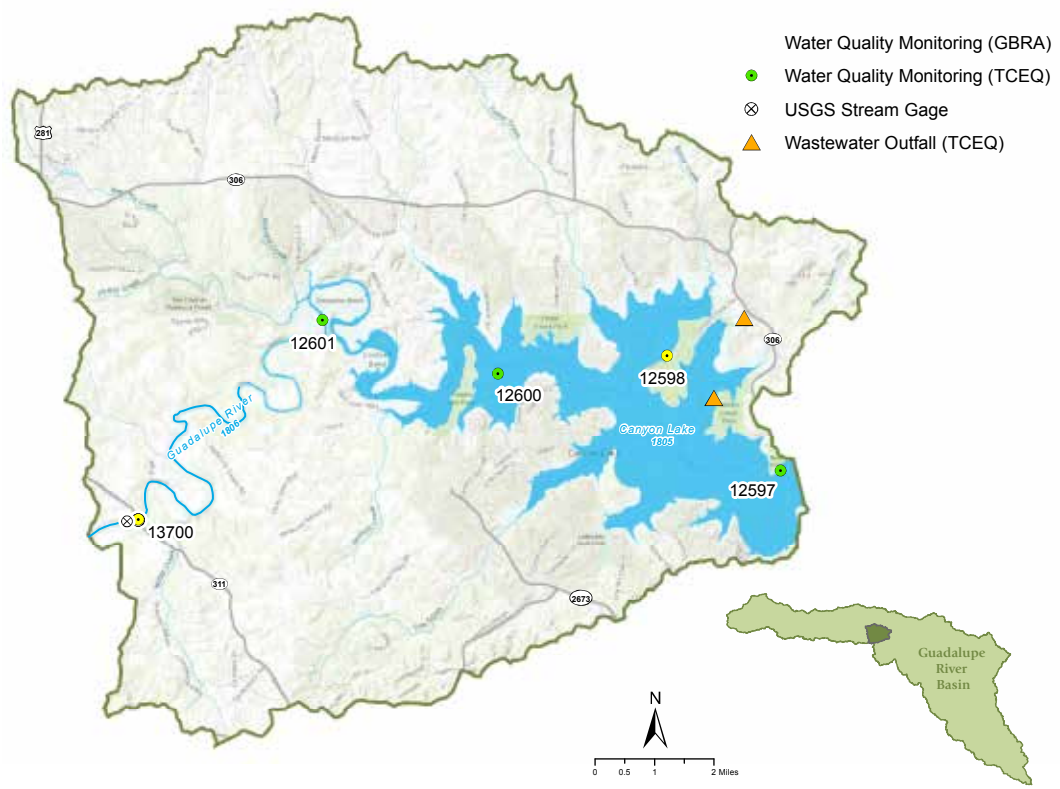


Upper Guadalupe River near Flat Rock Dam.



GBRA Water Quality Technician Jana Gray collecting water quality data.

Canyon Reservoir



FACTS AND FEATURES

Drainage Area	1,432 square miles
Reservoir Surface Area	8,240 acres
Reservoir Conservation Capacity	378,781 acre-ft
Tributaries of Canyon Lake	Rebecca Creek, Shultz Creek, Jentsch Creek, Tom Creek, Potter Creek, Sorrel Creek, Jacobs Creek Aquifer: Trinity, Edwards Plateau
River Segments	1805
Cities and Communities	Sattler, Startzville, Cranes Mill, Hancock
Counties	Comal
EcoRegion	Edwards Plateau
Climate	Average annual rainfall 37.43 inches, Average annual temperature 19.36°C
Land Uses	Unincorporated suburban sprawl, cattle, goat and sheep production, light industry, and recreational
Water Body Uses	Aquatic life, contract recreation, general use, fish consumption, and public water supply
Soils	Dark and loamy over limestone to loam with clay subsoils
Permitted Wastewater Treatment Facilities	Land Application 1, Domestic 2

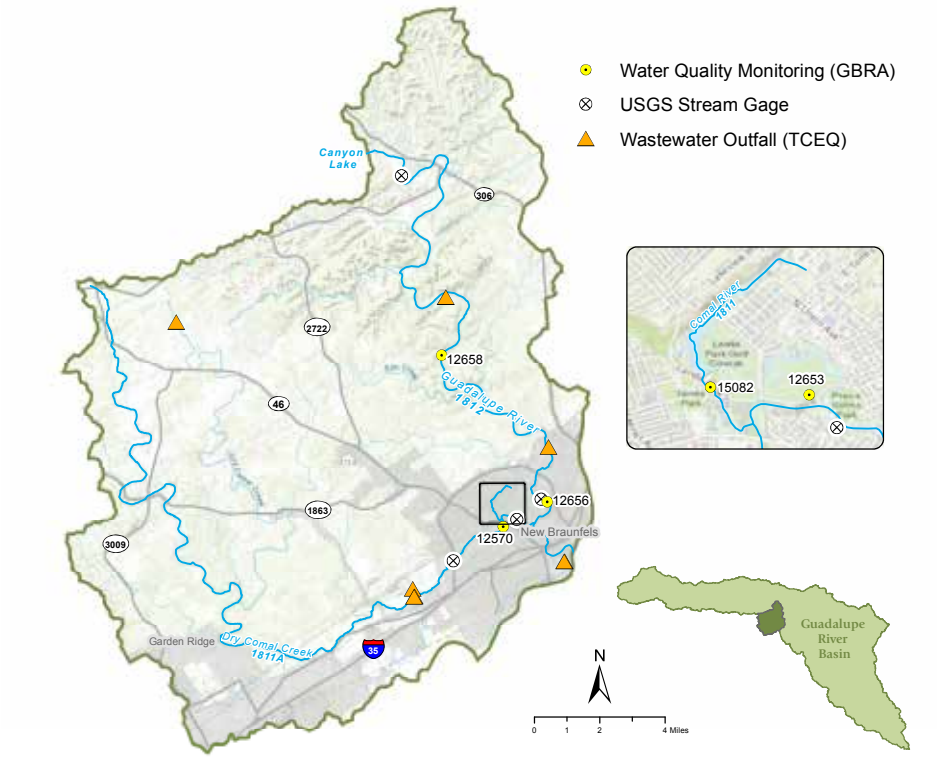
Aerial View of Canyon Reservoir Spillway.

Canyon Reservoir

RIVER SEGMENT, DESCRIPTION, AND CONCERNS

Segment	Description	Concerns and Recommendations
1805	Segment 1805 represents the section of the Guadalupe River that is impounded within Canyon Reservoir, and includes the area from upstream of Canyon Dam down to a point 1.7 miles downstream of Rebecca Creek Road in Comal County. Impoundment began in 1964; the reservoir is used for conservation of water and flood control, and is a popular recreational area. The reservoir has 80 miles of shoreline and a conservation storage capacity of 382,000 acre-feet. Segment 1805 is divided into four AUs: 1805_1, the cove around Jacob's Creek Park, 1805_02, near the center of the lake from the north end of Crane's Mill Park peninsula to the south end of Canyon Park, 1805_03, the upstream portion of the segment, and 1805_04, the area between Canyon Dam and Canyon Park. Each AU within the lake has one monitoring station that is monitored regularly by either the TCEQ or GBRA. The reservoir is known for clear water and heavy contact recreation use. Canyon Reservoir is a highly developed area with numerous homesites and subdivisions along its shores. Additionally, the lake is a popular destination for boating, swimming, and fishing. Homeowners, businesses, the US Army Corps or Engineers, and local municipalities are all key stakeholders of this area.	1805 has been listed on the 303(d) impairment list since 2005 for mercury in edible fish tissue. This listing occurred as a result of fish tissue sampling performed by the Department of State Health Services (DSHS). In 2005, the DSHS collected 30 fish samples from 3 locations across the reservoir. All fish samples collected from the reservoir contained detectable levels of mercury. Mean concentrations in longnose gar and striped bass (0.772 mg/kg and 1.149 mg/kg respectively) exceeded the chronic ingestion minimal risk level if more than two 8 ounce portions of these fish were consumed per month by adults, or two 4 ounce portions were consumed by children under the age of 12. No direct sources of mercury have been identified around the reservoir, however atmospheric deposition from coal fired power plants and other industrial uses is a likely source. For this impairment to be removed, additional sampling by the DSHS would need to occur. Zebra mussels (Dreissena polymorpha) were first discovered in Texas in April 2009, and were discovered at Canyon Reservoir on a boat hull at Crane's Mill Marina on June 8, 2017. A subsequent investigation by Texas Parks and Wildlife, which included plankton monitoring at multiple locations across the reservoir, identified both adult mussels and microscopic larvae confirming that the reservoir has an established reproducing population. Zebra mussels can attach to nearly any surface, forming large clusters that smother native mussels and clog water intake pipes, causing significant environmental and economic damage. Water bodies surrounding Canyon Reservoir are now at significant risk of infestation, as zebra mussels are easily transported between water bodies on boat hulls, and in live wells. Because of this, decontamination procedures are strictly enforced on boats and other watercraft that are transported between reservoirs in the state, in an attempt to prevent further spread. The TPWD and the GBRA have partnered to monitor reservoirs downstream of Canyon Reservoir for the presence of zebra mussels.

Guadalupe River below Canyon Reservoir, Comal River, and Dry Comal Creek



FACTS AND FEATURES

Drainage Area	217.79 square miles
Length	25.6 miles
Tributaries	Mountain Creek, Jacob's Creek, Bear Creek, Turkey Creek, Isaac Creek, Deep Creek, Elm Creek, Blieders Creek
Aquifer	Trinity, Edwards Trinity River, Edward Balcones Fault Zone
Segments	1811, 1811A, 1812
Cities	New Braunfels, Gruene, Canyon City
Counties	Comal
EcoRegion	Edwards Plateau, Blackland Prairie
Climate	Average annual rainfall 34.48 inches, Average annual temperature 19.58°C
Land Uses	Urban, suburban sprawl, light industry, and recreational.
Water Body Uses	Aquatic life, contract recreation, general use, fish consumption, and public water supply.
Soils	Dark and loamy over limestone to loam with clay subsoils. Permitted Wastewater Treatment
Permitted Wastewater Treatment Facilities	1 Domestic

Upper Spring Run of Landa Lake.
Photo Courtesy Mark Enders.

Winter at Comal Springs in Landa Park.

Guadalupe River below Canyon Reservoir, Comal River, and Dry Comal Creek

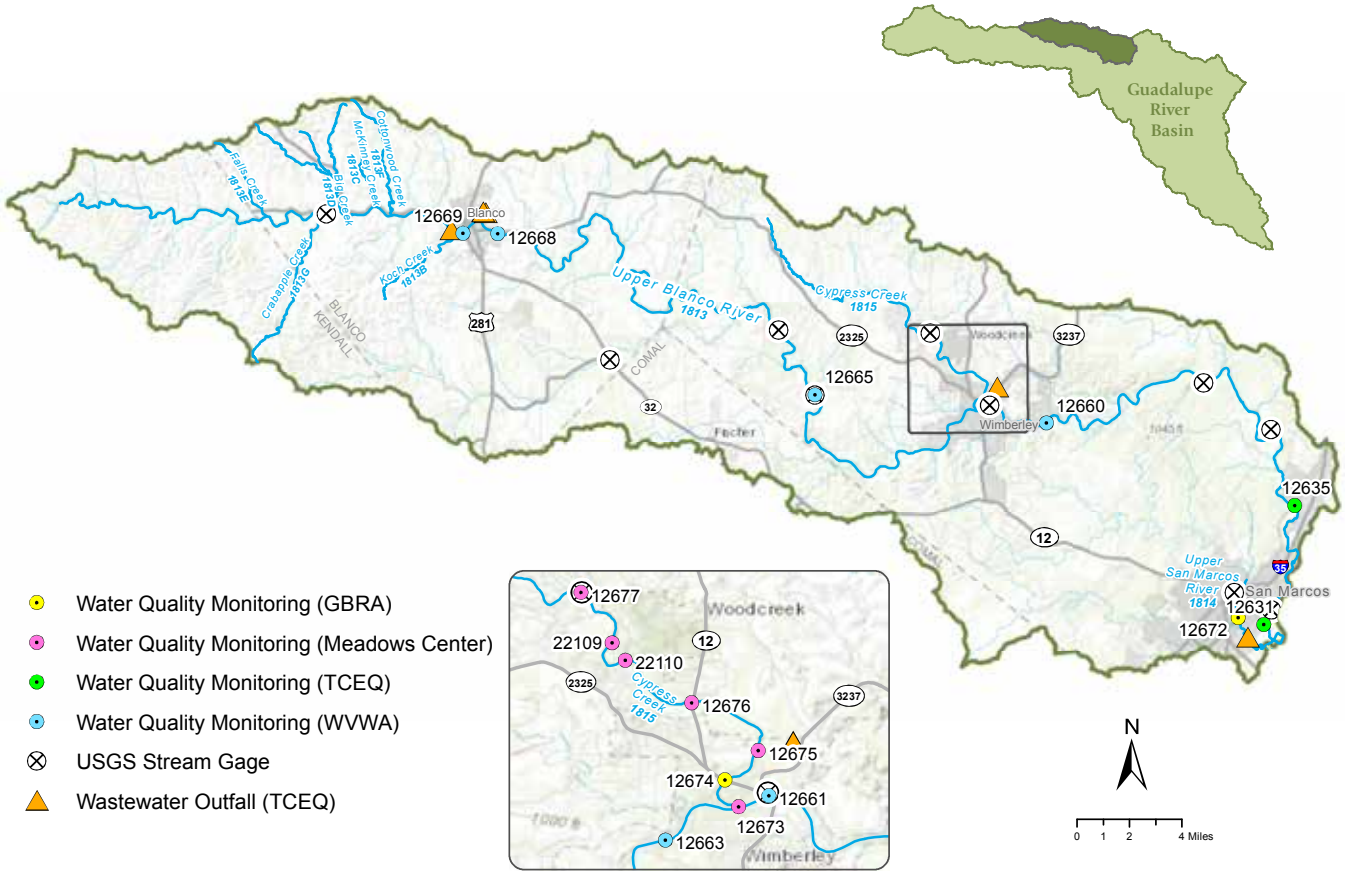
RIVER SEGMENT, DESCRIPTION, AND CONCERNS

Segment	Description	Concerns and Recommendations
1812	Segment 1812 includes a 23.1 mile long section of the Guadalupe River from below Canyon Reservoir to the confluence with the Comal River. Several underground springs from the Edwards Aquifer contribute to this section of the Guadalupe River, however the majority of the stream flow comes from regulated discharges from the bottom of Canyon Dam. The cold water that is released from the bottom of Canyon Dam, coupled with a limestone substrate create a cool, clear, and slow-flowing river with intermittent whitewater rapids. The segment is a very popular recreational area, drawing tubers, rafter, kayakers, and swimmers. Additionally, the cold, clear water provides excellent conditions for sport fishing. Texas Parks and Wildlife and Trout Unlimited regularly release rainbow and brown trout below Canyon Dam throughout the year. Due to the rocky soils and limestone hills in this area, there is very little agricultural land use. Instead, land use is mostly made up of recreational businesses, campgrounds, and private homes. Stakeholders include landowners and homeowners, river outfitters and other recreational businesses, and municipalities such as Canyon City. The TCEQ has divided 1812 into three Assessment Units (AUs). 1812_03 is the 9 mile section of 1812 that flows from Canyon Dam to the confluence with Bear Creek. This AU includes one monitoring station, 16703, which is located off FM 306 immediately below Canyon Dam. It is monitored quarterly by the GBRA. 1812_02 is the middle portion of 1812, flowing from the confluence of Bear Creek downstream to the confluence with Elm Creek. This AU contains one monthly monitoring station (12658) that is monitored by the GBRA, located at the second river crossing on River Road upstream of the City of New Braunfels. 1812_01 is the lowermost section of 1812, flowing four miles from the confluence with Elm Creek down to the confluence with the Comal River. This AU also currently contains one monitoring station, 12656, which is monitored quarterly by the GBRA and located at Cypress Bend Park in New Braunfels, TX.	As of the 2020 Texas Integrated Report, 1812 has no know impairments or concerns. This segment has dissolved oxygen levels that are consistently above the average life standard of 6 mg/l, indicative of strong support for aquatic life uses.

Guadalupe River below Canyon Reservoir, Comal River, and Dry Comal Creek – continued

Segment	Description	Concerns and Recommendations
1811	Segment 1811 includes the Comal River. The shortest river in the state at approximately 2.5 miles long, the Comal River flows from the headwaters to its confluence with the Guadalupe River and is located entirely within the city limits of New Braunfels, TX. 1811 is fed by underground springs from the Edwards Aquifer; seven major springs and dozens of smaller springs occur within the first mile of the segment. These springs are the largest in Texas and the American Southwest. Segment 1811 has been divided in to two Assessment Units (AUs) by the TCEQ. 1811_01 is the portion from the confluence with the Guadalupe River to just upstream of the confluence with the Dry Comal Creek (segment 1811A). 1811_01 contains one monitoring station, 12653, located on the Comal River at Hinman Island, which is monitored monthly by GBRA. This monitoring station is a historical monitoring site that was first monitored by the Texas Water Quality Board in 1968. 1811_02 is the portion of the stream upstream of the confluence with the Dry Comal Creek, to Klingemann Street in New Braunfels, TX. 1811_02 contains one monitoring station, 15082, located on the new river channel upstream of Dry Comal Creek. This site is monitored monthly by GBRA. The Comal River maintains consistent water temperature and high water clarity throughout the year, unique water quality conditions created by the springs that feed the river. Despite being the shortest river in the state, the Comal River is an extremely popular tourist destination for recreational swimming and tubing. Stakeholders include landowners and homeowners, river outfitters and other recreational businesses, and City of New Braunfels. Additionally, the river is home to several federally endangered species, including the Fountain Darter (Etheostoma fonticola), Comal Springs Riffle Beetle (Heterelmis comalensis), Comal Springs Dryopid Beetle (Stygoparnus comalensis) and the Peck's Cave Amphipod (Stygobromus pecki).	1811 continues to be listed on the 303(d) list for an impairment for bacteria levels. The TCEQ only assessed the impairment on the section of the Comal River downstream of the confluence with Dry Comal Creek (1811A). 1811A (which will be discussed in detail in the next section) is impaired for bacteria, likely stemming from rural and agricultural nonpoint source runoff. The City of New Braunfels, as part of a watershed protection plan (WPP), is working with stakeholders to actively reduce bacteria loads entering the river. New Braunfels and the surrounding area is experiencing high rates of development and a steady increase in population. Multiple developments have been constructed in the watershed more are planned for the future. Construction continues for a 2,430 development called Veramendi, which includes 1,200 acres of schools, roads, and over 5,000 homes. It also includes 380 acres of non-residential development including hotels and businesses. This property, which drains into Blieder's Creek, includes a dam that can hold approximately 20 million cubic feet of water during storm events. This dam could reduce runoff by up to 1000 cubic feet per second (CFS) into the Comal watershed. Increased development and population could also contribute to increased levels on nonpoint source runoff in the future. Stream flow and pollution levels are of particular concern for this segment because of its unique recreational and aquatic life uses.
1811A	The Dry Comal Creek is a 34.8 mile long tributary of the Comal River with a 110.7 square mile drainage area, much larger than the Comal River, and is dry for the majority of the year in the portions of the watershed upstream of the City of New Braunfels. This creek is more heavily influenced by rainwater runoff than underground spring flow, due to the substantially larger drainage area and relatively few springs. The Dry Comal Creek watershed is heavily influenced by surrounding agricultural land use, however urban development continues to increase in the area. The GBRA has one routine monitoring station located on the Dry Comal Creek, 12570, located near the confluence with the Comal River. Stakeholders include landowners and homeowners, river outfitters and other recreational businesses, and City of New Braunfels.	1811A continues to carry an impairment for bacteria that was first assessed by TCEQ in 2010. The City of New Braunfels is working with local stakeholders to reduce bacteria loading in the watershed, through the implementation of a watershed protection plan (WPP) for the Comal River and Dry Comal Creek. Bacterial Source Tracking was conducted in the watershed as part of this WPP to help guide the implementation of best management practices (BMPs). The largest sources of bacteria were determined to be non-avian wildlife such as deer and raccoons, avian wildlife including non-native species, livestock, and pets. As a result, the City implemented a "do not feed urban wildlife" ordinance in March of 2019, has actively managed avian populations through oil-coating non-native duck eggs and trapping and relocating waterfowl at Landa Park to reduce overpopulation, and installed pet waste stations.

Blanco River, Upper San Marcos River, and Cypress Creek



Blanco River Watershed

FACTS AND FEATURES

Drainage Area	435 square miles
Length	89 miles
Tributaries	Meier Creek, Blackberry Creek, Delaware Creek, South Fork Blanco River, Falls Creek (1813E), Crabapple Creek (1813G), West Prong Big Creek (1813A), Clear Creek (1813I), East Prong Big Creek (1813H), McKinney Creek (1813C), Cottonwood Creek (1813F), Blasingame Creek, Hinds Branch, Koch Branch (1813B), Durham Branch, Flat Creek, Rogers Branch, Boardhouse Creek, Cove Branch, Rocky Creek, Little Blanco River, Wanslow Creek, Cedar Fork, Carpers Creek, Dutch Branch, Elm Creek, Pinoak Creek, Cypress Creek (1815), Deer Creek, Pierce Creek, Sycamore Creek, Lone Man Creek
Aquifer	Edwards Plateau River
Segments	1809, 1813, 1815
Cities and Communities	Blanco, Fischer, Wimberley, Kyle, San Marcos
Counties	Kendall, Comal, Blanco, Hays
EcoRegion	Edwards Plateau, Texas Blackland Prairies
Climate	Average annual rainfall 34.83 inches, Average annual temperature 65.35°F
Land Uses	Urban, agricultural crops (wheat, hay, oats, peaches and pecans), sheep, cattle, goat and turkey production; light manufacturing and recreation
Water Body Uses	Aquatic life, contact recreation, general use, fish consumption, and public water supply
Soils	Thin limestone to black waxy, chocolate, and grey loam, calcareous, stony, and clay loams
Permitted Wastewater Treatment Facilities	Domestic 3, Land Application 0, Industrial 0

Upper San Marcos River Watershed

FACTS AND FEATURES

Drainage Area	94.6 square miles
Length	4.5 miles
Tributaries	Sink Creek, Sessom Creek, Purgatory Creek, Willow Springs Creek
Aquifer	Edwards-Balcones Fault Zone
Segments	1814
Cities and Communities	San Marcos
Counties	Hays, Guadalupe
EcoRegion	Edwards Plateau, Texas Blackland Prairies
Climate	Average annual rainfall 35.75 inches, Average annual temperature 68.45°F
Land Uses	Urban, suburban sprawl, agricultural crops, cattle, hog and poultry production, oil production, and recreation
Water Body Uses	Aquatic life, contact recreation, general use, fish consumption, and public water supply
Soils	Thin limestone to black, waxy, chocolate and grey loam
Permitted Wastewater Treatment Facilities	Domestic 4, Land Application 0, Industrial 0

Blanco River, Upper San Marcos River, and Cypress Creek

RIVER SEGMENT, DESCRIPTION, AND CONCERNS

Segment	Description	Concerns and Recommendations
1813	Segment 1813 represents the Upper Blanco River, a 71 mile stretch that flows from Kendall County, through the City of Blanco, and down to the City of San Marcos where it joins up with the San Marcos River. Located entirely within the Edwards Plateau, this spring-fed stream flows along limestone substrate with the occasional gravel, silt, and clay strata. Water quality in this segment is typically classified as exceptional 1813 has numerous classified and unclassified tributaries, including Cypress Creek (segment 1815) which will be described later in this section. 1813 is divided into five Assessment Units (AUs) by the TCEQ. AU 1813_01 represents the portion of the Upper Blanco from a point 0.2 miles upstream of Lime Kiln Road in Hays County, to the confluence with Spoke Creek. This AU contains one monitoring station, 12660, which is located on the Blanco River at Hay CR 174 and is monitored by the Wimberley Valley Watershed Association (WVWA). AU 1813_02 runs from the confluence with Spoke Pile Creek, up to the confluence with Cypress Creek. This AU contains one monitoring station, 12661, which is located at the Ranch Road 12 Crossing in Wimberley and is monitored quarterly by WVWA. AU 1813_05 covers the portion of the Upper Blanco River from the confluence with Cypress Creek to the confluence with Rogers Branch in Hays County. This AU contains one monitoring station, 12663, located on FM 165 east of the City of Blanco and monitored quarterly by the TCEQ. 1813_04 is the uppermost portion of the segment, from Hinds Branch in Blanco County to Meier Creek in Kendall County. There are no active monitoring stations in this AU. This segment is a mix of rural and urbanized areas, with increased urbanization occurring in and around the City of Blanco. Stakeholders in the Upper Blanco include the City of Blanco, WVWA, and City of San Marcos.	As of the most recently published 2020 Texas Integrated Report, segment 1813 has no listed water quality impairments or concerns. The Upper Blanco River has run dry in the past, during periods of drought. In general, any possible concerns for water quality for this segment are tied to changes in stream flow. An analysis of data conducted by GBRA from the four monitoring stations in this segment revealed significant changes occurring over time. At station 12668, the most upstream monitoring location, significant changes in pH over time were found, and a significant increase in chlorides and sulfates were also noted. Station 12661 showed an increase in both pH and temperature. At station 12660, upstream of Cypress Creek, an increase in both pH was noted. Station 12663, the most downstream station in the segment, showed a significant increase in dissolved oxygen (DO) concentrations. All of the changes found in this segment are likely due to slower moving water as a result of several years of drought in the area. This slower moving water, coupled with higher water temperatures resulted in higher than normal levels of green algae growing in the Upper Blanco River. As a result, increased photosynthetic activity in the river likely caused the increase in DO and pH levels, as carbonic acid was removed from the water column and DO was released.
1809	Segment 1809 includes the Lower Blanco River, which runs 15 miles from the confluence with the San Marcos River to Lime Kiln Road in Hays County. The TCEQ has divided this segment into two Assessment Units (AUs). AU 1809_01 covers the lower seven mile portion, from the confluence with the San Marcos River to IH 35. AU1809_02 covers the upper eight miles from IH 35 to Lime Kiln Road. This AU contains one monitoring station, 12631, located in at the Hays County Road 295 crossing. This station is monitored quarterly by the TCEQ. Stakeholders include City of San Marcos, City of Wimberley, MCWE, and WVWA.	As of the 2020 Integrated Report, there are no listed concerns or impairments for this segment. This segment is heavily influenced by rainfall runoff and is prone to drastically reduced flows during periods of heavy drought conditions which has the potential to affect water quality. It is thought that the Golden Orb (Quadrula aurea), and endangered mussel species endemic to Texas, may exist in this segment though it has not been confirmed to date. In 2021 the GBRA plans to conduct an Aquatic Life Monitoring Event in this segment. A mussel survey will be conducted to look for evidence of this rare species.

Blanco River, Upper San Marcos River, and Cypress Creek - continued

Segment	Description	Concerns and Recommendations
1815	Segment 1815 represents Cypress Creek. This 15.7 mile spring fed creek flows southeast through the City of Wimberley until it joins up with the Upper Blanco River. Cypress Creek contains multiple swimming holes and is well known for its exceptional water quality, making it a popular contact recreation area. 1815 is divided into two AUs. AU 1815_02 describes the upper seven miles of the creek which is comprised of intermittent stream flows. There are no monitoring stations in this AU. 1815_01 is the flowing portion of the Creek downstream of the headwater springs. All five monitoring stations in segment 1815 are located in this AU. Station 12673 is the most downstream station, located at the confluence of the Blanco River and monitored by WVWA. Station 12674 is the next upstream station, located at Ranch Road Crossing 12 and monitored by GBRA. Station 12675 is located in the Blue Hole Campground in the City of Wimberley and is monitored by WVWA. Station 12677 is located at Jacob's Well Spring near the headwaters of Cypress Creek and is monitored by WVWA. Stakeholders in this area include WVWA, The Meadows Center for Water and the Environment (MCWE), City of Wimberley, local outfitters, and businesses.	Segment 1815 is listed on the 2020 Integrated Report for impairments for depressed dissolved oxygen 24 hour average, impaired fish community, and impaired macrobenthic community. It also has concerns listed for impaired habitat. Following a series of Aquatic Life Monitoring Events (ALMs) performed from 2011 through 2013, the 2014 Texas Integrated Report of Surface Water Quality identified aquatic life use concerns for depressed oxygen and impaired biological habitat for this segment. These ALMs were performed during a period of heavy drought when the segment experienced several periods of intermittent flow, conditions that do not accurately represent typical conditions in this segment. The impairments and concerns listed for 1815 in the 2020 Integrated Report are directly influenced by the data collected during these previous ALMs. In 2021 the TCEQ will perform a round of ALMs on this segment, which may result in changes to the listed impairments and concerns for 1815 in the future. Aside from the impairments and concerns listed for this segment, there are water quality concerns in the Cypress Creek Watershed related to the rapid urbanization and development that is occurring in Hays County. As a result of this, a watershed protection plan was developed by the Meadows Center for Water and the Environment and local stakeholders, outlining plans to improve and maintain water quantity and quality standards in the watershed. The plan was approved in 2016 by the EPA and became immediately eligible for Clean Water Act Section 319 Grants. In 2017, a 1.34 million dollar 3-year implementation plan began, with the intent to decrease nonpoint source pollution in the watershed. Modeling and data collection performed under this project revealed that many homes and businesses in the watershed are served by aging septic systems, raising concerns about possible influence on the creek as these systems begin to fail.

Blanco River, Upper San Marcos River, and Cypress Creek - continued

Segment	Description	Concerns and Recommendations
1814	Segment 1814 represents the upper portion of the San Marcos River. This 4.5 mile long stretch is a spring fed stream that flows through the limestone substrates of the Edwards Plateau, from the headwaters of the river to the confluence with the Blanco River. The Upper San Marcos is a unique ecosystem that is home to a number of endangered species, including the Fountain Darter (Etheostoma fonticola), Texas Blind Salamander (Typhlomolge rathbuni), Texas Wild Rice (Zizania texana) which is found only in the San Marcos River, and the likely extinct San Marcos Gambusia (Gambusia georgei). The San Marcos Salamander (Eurycea nana) is also found within this reach and is considered a threatened species. These endangered species are heavily dependent on the continued consistency and purity of the springs that feed this river. The Upper San Marcos River is an urbanized area that is experiencing rapid growth. The area is a popular destination for outdoor enthusiasts. Additionally, this segment runs through Texas State University; the river is a popular spot for students. Stakeholders in this segment include City of San Marcos, MCWE, Texas State University, and many local outfitters and businesses who rely on the river. Segment 1814 is divided in four Assessment Units (AUs). 1814_01 is the 1.5 mile section of the river from 0.6 miles upstream of the Blanco River. This section contains no monitoring stations. 1814_02 includes the section from 1814_01 to IH 35. This section contains no monitoring stations. 1814_03 runs from IH 35 to Spring Lake and contains one monitoring station, 12672, located just upstream of the IH 35 crossing. This station is monitored by the GBRA. 1814_04 includes the portion of the river from Spring Lake to the headwaters.	1814 has been listed in previous Integrated Reports (2010 and 2012) for total dissolved solids, however this listing was removed in 2014 and this segment has not been listed on an Integrated Report since. Like many watersheds in the Guadalupe River basin, the Upper San Marcos is experiencing rapid growth population increase. With this progress comes concerns of increased nonpoint source pollution. To protect the sensitive and unique endangered species that inhabit this river system, a number of efforts are being made to preserve the spring flows that feed the San Marcos River. Those efforts include the development and approval of the Edwards Aquifer Habitat Conservation Plan (EAHCP) in 2013. The EAHCP introduced minimization and mitigation activities designed to protect the endangered species in the Upper San Marcos River. Conservation efforts within this plan include a focus on water conservation, alternative water supply, and removal of non-native riparian species such as elephant ear and water hyacinth, as well as recreational use limitations in State Scientific Areas as designated by the Texas Park and Wildlife Department. These efforts have noticeably improved the outlook for species including Texas Wild Rice and the San Marcos Fountain Darter.

Yellow Bellied Slider in Sping Lake.
Photo Courtesy of Jennifer Idol.

WATERSHED COORDINATORS' BIOGRAPHIES

Stephen Risinger

As a watershed coordinator for the Plum Creek Watershed, Stephen Risinger assists stakeholders with development and implementation of their watershed protection plans. He is responsible for coordinating educational programs and events, and increasing the implementation of agricultural and urban BMPs with the goal of restoring and protecting water quality in the creeks. Before becoming a watershed coordinator in 2018, Stephen spent nearly a decade working as an Intelligence Mission Supervisor for various classified programs in the United States Airforce, Stephen knows what truly drives operational programs and that is the support of dedicated individuals and networks. It's how well you connect with the community you're trying to help and communicate your understanding back to them. In addition to his extensive networking and management abilities, Stephen possesses his certification in water policy. Stephen holds a BS in environmental studies and resource management from Texas State University.

Nick Dornack

Nick Dornak is the Director of Watershed Services at The Meadows Center for Water and the Environment in San Marcos, TX. With 20 years of experience in watershed planning, research and stakeholder engagement, Nick operates at the nexus of science and policy to inform decisions and advance best practices for protecting water resources. Nick has previously served as Watershed Coordinator for the Plum Creek and Upper San Marcos watersheds and has been coordinating efforts for the Cypress Creek watershed since he joined the Meadows Center in early 2018. Nick received his B.S. in Agricultural Development/Animal Science from Texas A&M University and an M.S. in Rangeland Ecology and Watershed Management from the University of Wyoming. He lives with his wife, Carrie, three children, Aiden, Emery and Townes Edward and a variety of other critters on the banks of the Blanco River in Wimberley, TX.

Dr. Evgenia Spears

Hi! I'm the new Watershed Coordinator for the Geronimo and Alligator Creeks Watershed. Prior to joining Texas A&M AgriLife Extension Service, I completed a doctorate program at Texas A&M University, where I studied the relationship between humans and nature. Being a proponent of community-based approaches to conservation, I strongly believe that stakeholder engagement is essential for effective and sustainable management of natural resources. I am excited to share my passion for stewardship with everyone who lives, works, and recreates in the Geronimo and Alligator Creeks Watershed!

Phillip Quast

Phillip Quast is the Watershed Coordinator for the City of New Braunfels and has held this position for over two years. His academic background includes a Master of Applied Geography degree from Texas State University with a focus on Environmental Resource Management and Geographic Information Systems and a Bachelor of Science degree in Computer Science, also from Texas State University. Phillip has worked in the field of land conservation and habitat restoration for 12 years and enjoys working to develop and implement programs that are designed to improve the habitats for wildlife to thrive in.

Aspen Navarro

Aspen Navarro serves as the Program Coordinator for The Meadows Center for Water and the Environment's Watershed Services division. Mrs. Navarro has been with the Meadows Center for over five years, but a major role of hers the past year and a half includes serving as the Watershed Coordinator for the Upper San Marcos River Watershed Protection Plan. Additionally, Mrs. Navarro coordinates the Texas Stream Team Citizen Science Program, which strives to efficiently fill in the gaps of state water quality monitoring with citizen scientist monitoring throughout Texas, especially in areas with implementing or developing watershed protection plans.

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