PRELIMINARY RESULTS OF A RECREATIONAL USE ATTAINABILITY ANALYSIS OF 31 STREAMS IN THE BRAZOS RIVER BASIN

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Introduction

Section 101(a)(2) of the Federal Water Pollution Control Amendments of 1972 or the Clean Water Act (the Act) states it is the national goal, wherever attainable, to provide for the protection and propagation of fish, shellfish, and wildlife and provide for recreation in and on the waters of the United States. Under section 131.10(j) of the Water Quality Standards Regulation of the United States Environmental Protection Agency (EPA), States are required to conduct a use attainability analysis (UAA) whenever the State designates uses of water bodies that do not include the uses specified in section 101(a)(2) of the Act, removes one of these designated uses, or adopts subcategories of these uses that require less stringent criteria.

A UAA (or RUAA) is a structured scientific assessment of the factors affecting the attainment of a use on a water body. The overall purpose of a RUAA is to make sure streams have the correct recreational use classification following the guidelines established in the Act. A properly carried out RUAA can lead to changes in use that lead to either more or less protective criteria. The ultimate goal is that the new designated use classification is more accurate.

RUAAs generally include physical, chemical, and biological evaluations to determine what factors impair attainment of designated uses and provide information to determine what uses are appropriate and feasible for the water body in question. Important factors in such analyses include naturally occurring pollutant concentrations, anthropogenic sources of pollution, water depth, hydrological modifications, and natural physical characteristics of streams that could impair the use. In addition, RUAAs typically assess the current uses (recreation and otherwise) of the water bodies under evaluation.

States use the information collected in a RUAA to demonstrate to the EPA that attaining the uses in section 101(a)(2) are not feasible because:

1. naturally occurring pollutant concentrations prevent the attainment of the use;
2. natural, ephemeral, intermittent, or low- flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge

of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met;

3. human-caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place;
4. hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use;
5. physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to [chemical] water quality, preclude attainment of aquatic life protection uses; or
6. controls more stringent than those required by sections 30l(b)(l)(A) and (B) and 306 of the Act would result in substantial and widespread economic and social impact.

On May 23 through August 30, 2009, a team from Texas AgriLife Research, Texas A&M University System, assisted the Texas Commission on Environmental Quality (TCEQ) by conducting RUAAs for 31 streams in the Brazos River Basin (Appendix 1). Following the methodology in TCEQ's 2009 Recreational Use Attainability Analysis Procedures, team members talked with landowners on these streams, interviewed recreational users, and collected data. This information will be used by the Water Quality Standards Group within the TCEQ to potentially classify or reclassify streams in the categories of Primary Contact Recreation, Secondary Contact Recreation 1, Secondary Contact Recreation 2, and Noncontact Recreation.

Description of the Study Area

Texas AgriLife Research conducted RUAAs for 31 streams in the Brazos River Basin in Central Texas. These streams are located in the vicinity of Stephenville, De Leon, Comanche, Hamilton, Crawford, Gatesville, Killeen, Granger, College Station, Caldwell, and Seally, Texas. The streams in this RUAA included Nolan Creek/South Nolan Creek (1218) (Classified), Leon River Below Proctor Lake (1221) (Classified), Leon River Below Leon Reservoir (1223), Upper North Bosque River (1255), Allens Creek (1202H), Davidson Creek (1211A), Resley Creek (1221A), South Leon River (1221B), Pecan Creek (1221C), Indian Creek (1221D), Plum Creek (1221E), Walnut Creek (1221F), Duncan Creek (1222A), Sweetwater Creek (1222E), Armstrong Creek (1223A), Indian Creek (1226E), Sims Creek (1226F), Little Duffau Creek (1226K), Cottonwood Branch (1242B), Still Creek (1242C), Thompson Creek (1242D), Big Creek (1242P), Wasp Creek (1246E), Willis Creek (1247A), Mankins Branch (1248C), Goose Creek (1255A), North Fork Upper North Bosque River (1255B), Scarborough Creek (1255C), Tributary of Goose Branch (1255E), Tributary of Scarborough Creek (1255F), and Woodhollow Branch (1255G).

Historical Information Review of Classified Streams
The Leon River (1221), Nolan Creek (1218), and the Upper North Bosque River (1255)

General Information

Portions of the format and general information provided below for the three classified streams are based on the proposed report *One Total Maximum Daily Load for Bacteria in the Leon River Below Proctor Lake For Segment 1221* by the Texas Commission on Environmental Quality (TCEQ 2008). That proposed report in turn is based largely on the report *Final Modeling Report for Fecal Coliform TMDL Development for Leon River Below Proctor Lake, Segment 1221* by James Miertschin & Associates, Inc (JMA 2006).

North Central Texas Climate

The Leon River (Segment 1221), Nolan Creek/South Nolan Creek (Segment 1218), and the Upper North Bosque River (Segment 1255)are located within the North Central Texas climatic division (division 3, NOAA 2005). The climate of the region is classified as subtropical, subhumid. Summers are usually hot and humid, while winters are often mild and dry. The hot weather is rather persistent from late May through September (Fig. 1), accompanied by prevailing southeasterly winds. There is little change in the day-to-day summer weather except for the occasional thunderstorm, which produces much of the annual precipitation within the region. The cool season (November—March) is typically the driest season of the year as well. Winters are typically short and mild, with most of the precipitation falling as drizzle or light rain.

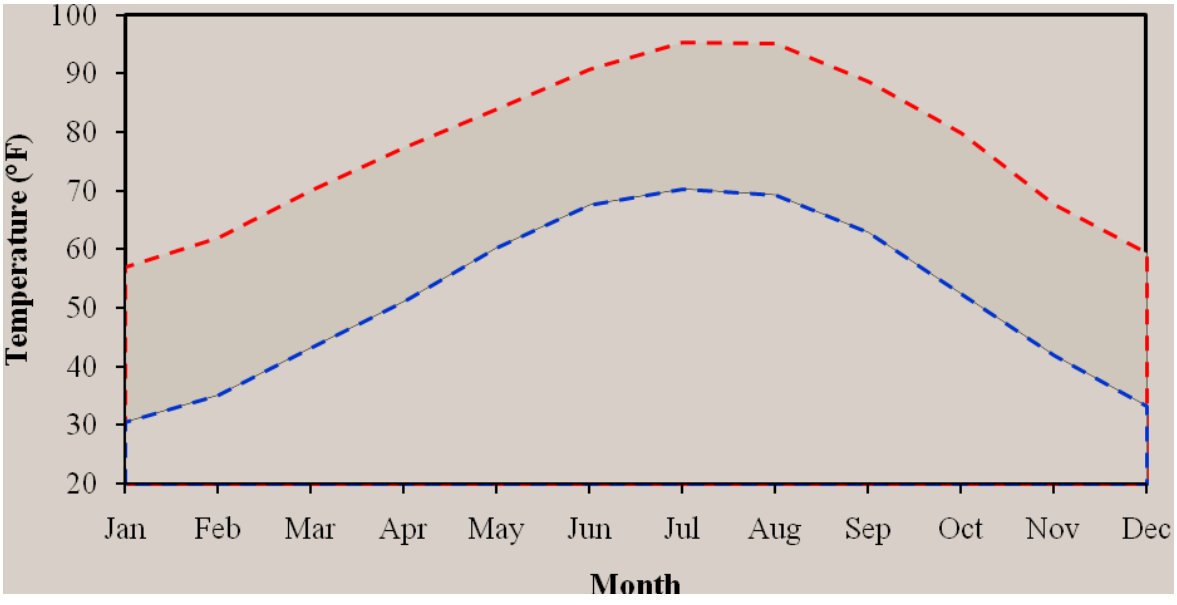


Figure 41. Monthly average normal minimum and maximum temperatures (dashed lines) and range (grey area) for Proctor Reservoir, Comanche County, Texas (1971—2000; Data from NOAA 2002).

As with the rest of the interior of Texas, maximum precipitation periods in the study area are typically late spring (April—June) and early autumn (September—October; Fig. 2). Winter and summer periods are typically low precipitation periods. The maximum precipitation period in May is driven by the buildup of water vapor from the Gulf of Mexico from the prevailing winds from the south. Precipitation is caused by late season cold air migrations, warm season thunderstorms, and spring low-pressure troughs. In September, cold air converges with moisture laden southerly winds and late season convective thunderstorms drive the precipitation. It is not unusual for hurricanes to affect rainfall in the early autumn period. Summer drought conditions are common in the study area, due to strong high-pressure cells that result in lengthy dry spells. Mean annual precipitation in the watershed ranges from 27 to 32 inches per year.

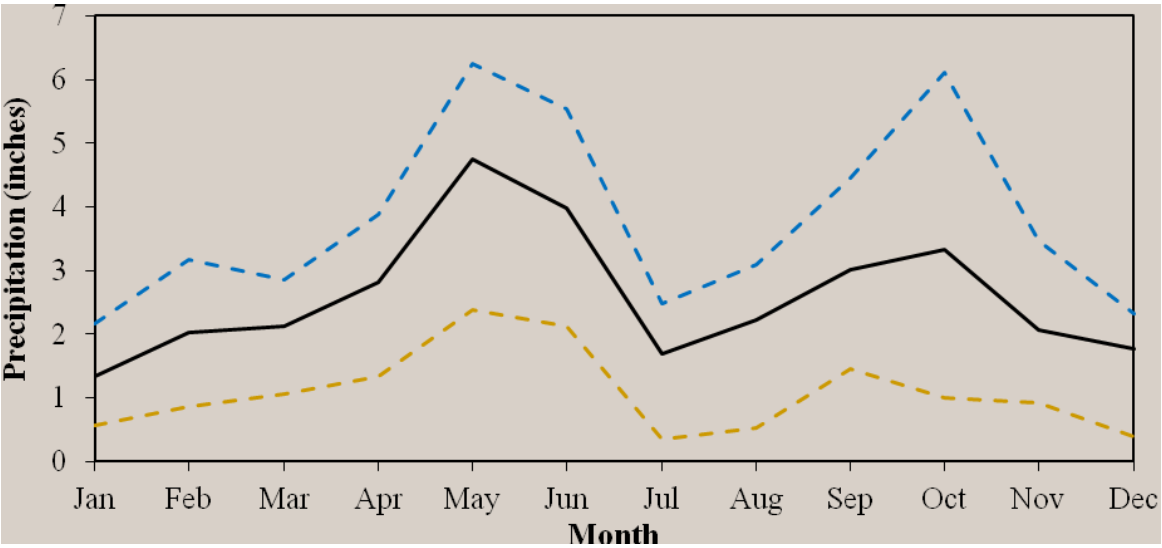


Figure 42. Monthly average 25th-percentile (lower dashed line), mean (solid line), and 75th-percentile (upper dashed line) precipitation for Proctor Reservoir, Comanche County, Texas (1971—2000; Data from NOAA 2009*a*).

Drought indices estimate moisture conditions over different time scales (NOAA 2009*b*). Two drought indices for the North Central Texas climatic region have been included as a general reference to historical short-term "weather spells" and long-term conditions for the area (Figs. 3 & 4, NOAA 2009*c*). Palmer Z Index (PZI) measures short-term drought on a monthly scale. Palmer Hydrological Drought Index (PHDI) estimates long-term conditions by taking into account the hydrological effects of previous and current surface and groundwater levels. As a result, PHDI values respond more slowly to changing weather conditions (NOAA 2009*b*, Weber 1998). Both indices center on zero as "normal" conditions. The relative wetness (positive values) or dryness (negative values) of a monthly time period is proportional to the distance away from zero (NOAA 2007).

Historically (1971—2000), monthly short-term moisture conditions (Fig. 3) have regularly fluctuated between wet and dry spells on average every 2 to 3 months with the longest short-term spells (wet and dry spells) lasting 10 to 11 months. The longest short-term wet spells occurred in

1986—1987 and 1991—1992 while the longest short-term dry spells occurred in 1995—1996 and 1999—2000.

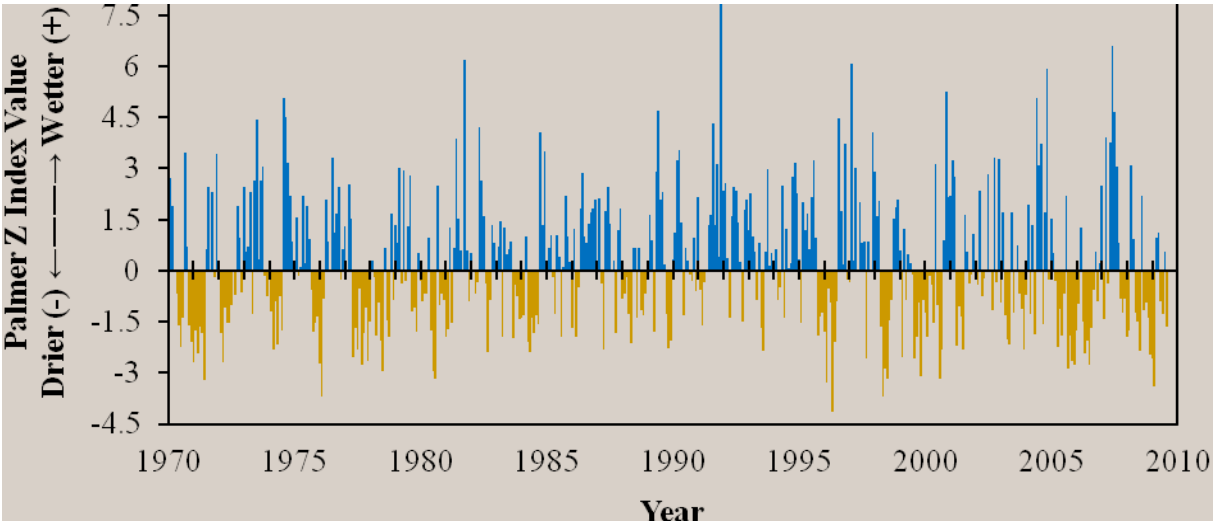


Figure 43. Short-term moisture departures from normal (Palmer Z Index Values) for the North Central Texas Climatic Region (1970—Aug 2009; Data from NOAA 2009*c*).

Long-term moisture conditions (Fig. 4) showed greater duration variability. Although there were equal numbers of long-term wet and dry periods, wet periods tended to last longer. The average duration of long-term wet periods was 22 months but ranged from 3 to 83 months. The longest long-term wet period (83 months) occurred in 1989—1996. Long-term dry periods averaged 10 months and ranged from 2 to 20 months. The longest long-term dry periods (20 months) occurred in 1977—1978 and 2005—2007.

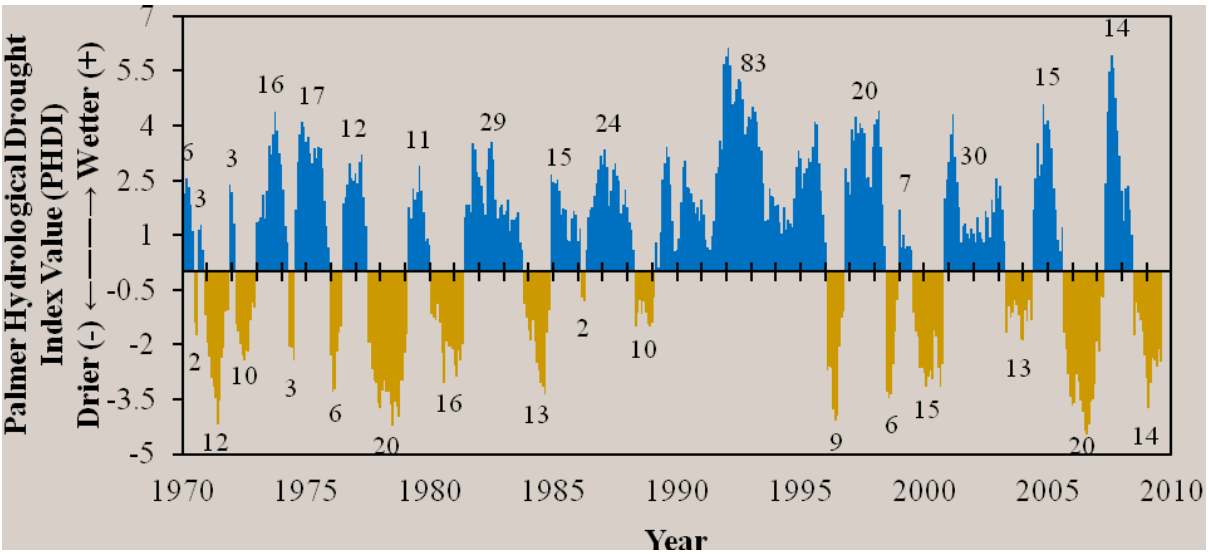


Figure 44. Long-term moisture conditions (Palmer Hydrological Drought Index Values, PHDI) and duration in months (numbers) for the North Central Texas Climatic Region (1970—Aug 2009; Data from NOAA 2009*c*).

Classified Stream Segment 1221 (Leon River Below Proctor Lake): From a point 100 meters (110 yards) upstream of FM 236 in Coryell County to Proctor Dam in Comanche County, Texas.

The Leon River as a whole is located within the USGS Hydrologic Unit 12070201: Texas-Gulf Region > Lower Brazos Subregion > Little River Basin > Leon River (USGS 2009*a*). The Leon River hydrologic unit, or watershed, encompasses approximately 3,000 square miles of several counties in North Central Texas (Fig. 5).

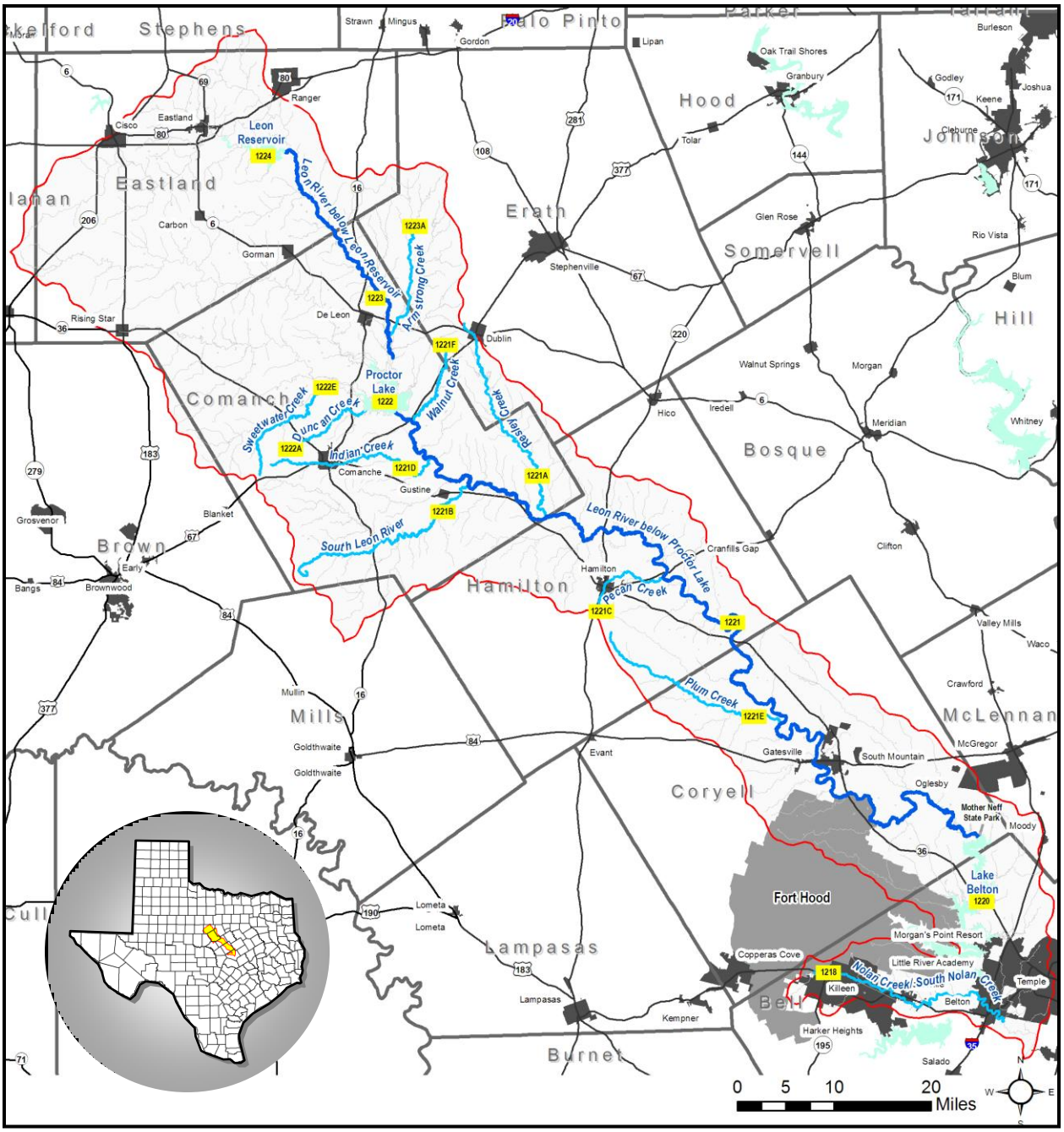


Figure 45. Leon River Hydrologic Unit (12070201) with associated 2009 TCEQ Recreational Use Attainability Analysis Study streams highlighted, North Central Texas.

Segment 1221 (Leon River Below Proctor Lake) is 173 miles long and flows in a southeasterly direction from an elevation of 1,128 feet at Proctor Lake (Segment 1222) to 594 feet at Belton Lake (Segment 1220). Average stream gradient is 3.25 feet per mile (USACE 1949).

Leon River (Segment 1221) Problem History

The Leon River (Segment 1221) was first listed on the Texas 303(d) list of impaired waterways for exceeding the safe bacteria criterion for contact recreation in 1996. This report is meant to provide data to better categorize the current recreational uses of the Leon River (Segment 1221).

Leon River (Segment 1221) Local Population

The Leon River (Segment 1221) flows through three counties. Originating in Comanche County, Segment 1221 passes through Hamilton County and ends in Coryell County. General descriptions of local county populations follow with data from the United States Census Bureau (Census 2009).

Comanche County

Comanche County covers 948 square miles, and had an estimated population of 14,026 (14.8 persons/mi^2) in 2000. The population has increased by about 18 percent since 1970 (Fig. 6). Approximately 50 percent of the population lives in urban areas. The largest urban area is the city of Comanche with a population of 4,482. Smaller urban areas include De Leon (2,433 residents) and Gustine (457 residents). The Leon River (Segment 1221) does not pass through any urban areas in Comanche County (Fig. 5). The closest urban area in Comanche County to the Leon River (Segment 1221) is Gustine, 1.6 miles from the river (Fig. 7).

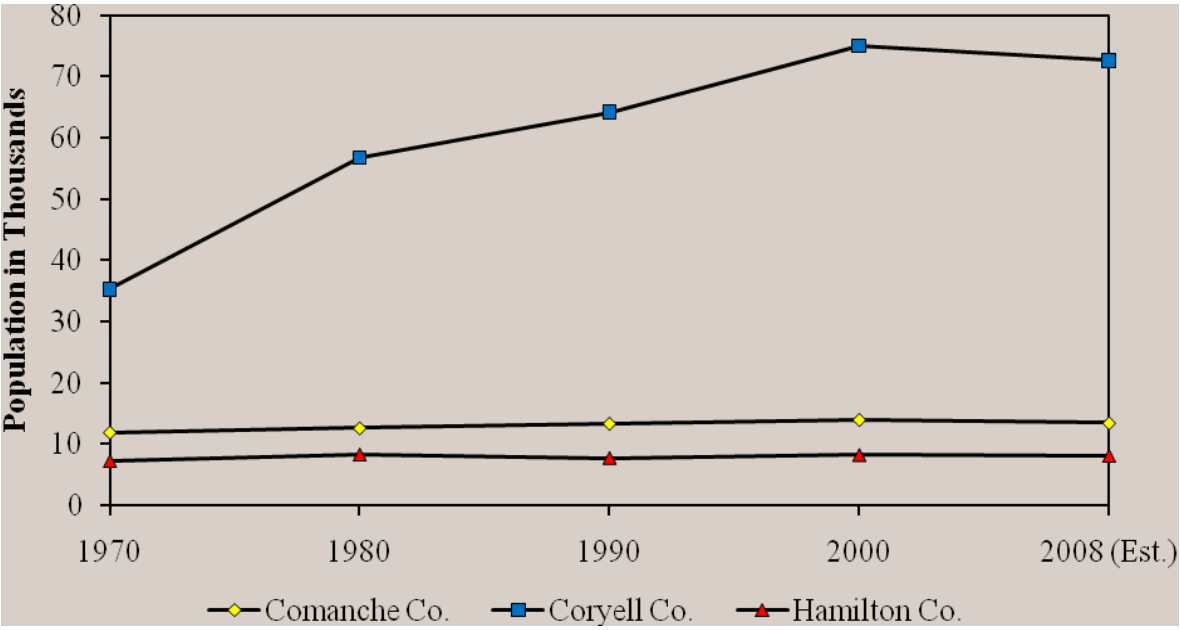


Figure 46. Decennial U.S. Census population values for Comanche, Coryell, and Hamilton Counties, Texas (1970—2000; Census 2009). Note: Year 2008 population values are preliminary estimates.

Hamilton County

Hamilton County covers 837 square miles, and had an estimated population of 8,229 (9.8 persons/mi^2) in 2000. The population has increased by 14 percent since 1970 (Fig. 6). Approximately 52 percent of the population lives in urban areas. The largest urban area is the

city of Hamilton with a population of 2,977. The smaller urban area of Hico has 1,341 residents. The Leon River (Segment 1221) does not pass through any urban areas in Hamilton County (Fig. 5). The closest urban area in Hamilton County to the Leon River (Segment 1221) is Hamilton, 5.9 miles from the river (Fig. 7).

Coryell County

Coryell County covers 1,052 square miles, and has an estimated population of 74,978 (71.3 persons/mi^2) in 2000. The population has increased by about 112 percent since 1970 (Fig. 6). Approximately 85 percent of the population lives in urban areas. The largest urban area is the city of Copperas Cove with a population of 29,971. The City of Gatesville is the second largest city with a population of 15,775. Fort Hood, the largest active duty armored post in the U.S. Armed Forces, occupies portions of Coryell and Bell County. The portion of Fort Hood in Coryell County is estimated to house 16,562 residents. Smaller urban areas include Oglesby (458 residents), Evant (444 residents), and South Mountain (372 residents). The Leon River (Segment 1221) passes through the urban area of Gatesville in Coryell County (Figs. 5 & 7).

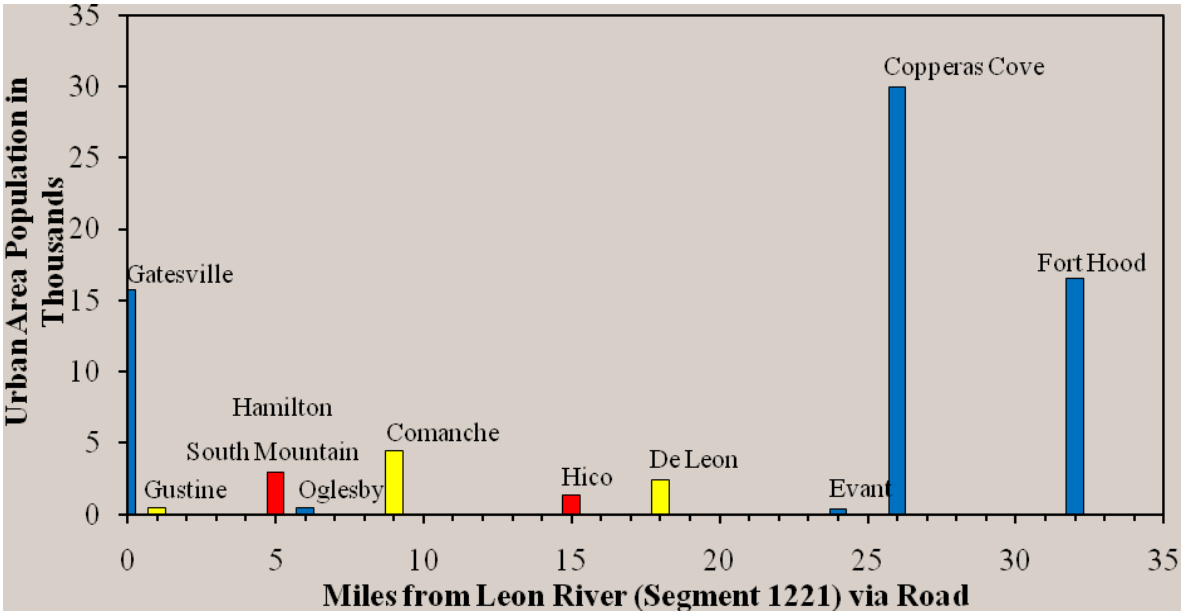


Figure 47. U.S. Census population estimates and distances of urban areas from the Leon River (Segment 1221) in Comanche (yellow bars), Hamilton (red bars), and Coryell (blue bars) Counties, Texas (2000). Note: Distances estimated using ©Google Maps (Google 2009).

Leon River (Segment 1221) Land Use

Land use data for the watershed were based on the United States Geological Survey (USGS) National Land Cover Dataset (NLCD) 1992—2001 Land Cover Retrofit Change Product (Fry et

al. 2009). Derived from Land-sat Thematic Mapper satellite data, the NLCD is a classification scheme for land cover applied consistently over the United States. The spatial resolution of the dataset is 30 meters. Land uses were grouped into seven Anderson Level I land use classifier categories (Fry et al. 2009). Current (i.e., 2001) land uses for the Leon River Hydrologic Unit are shown in Figure 8. Total area by land use and percentages are shown in Figure 9.

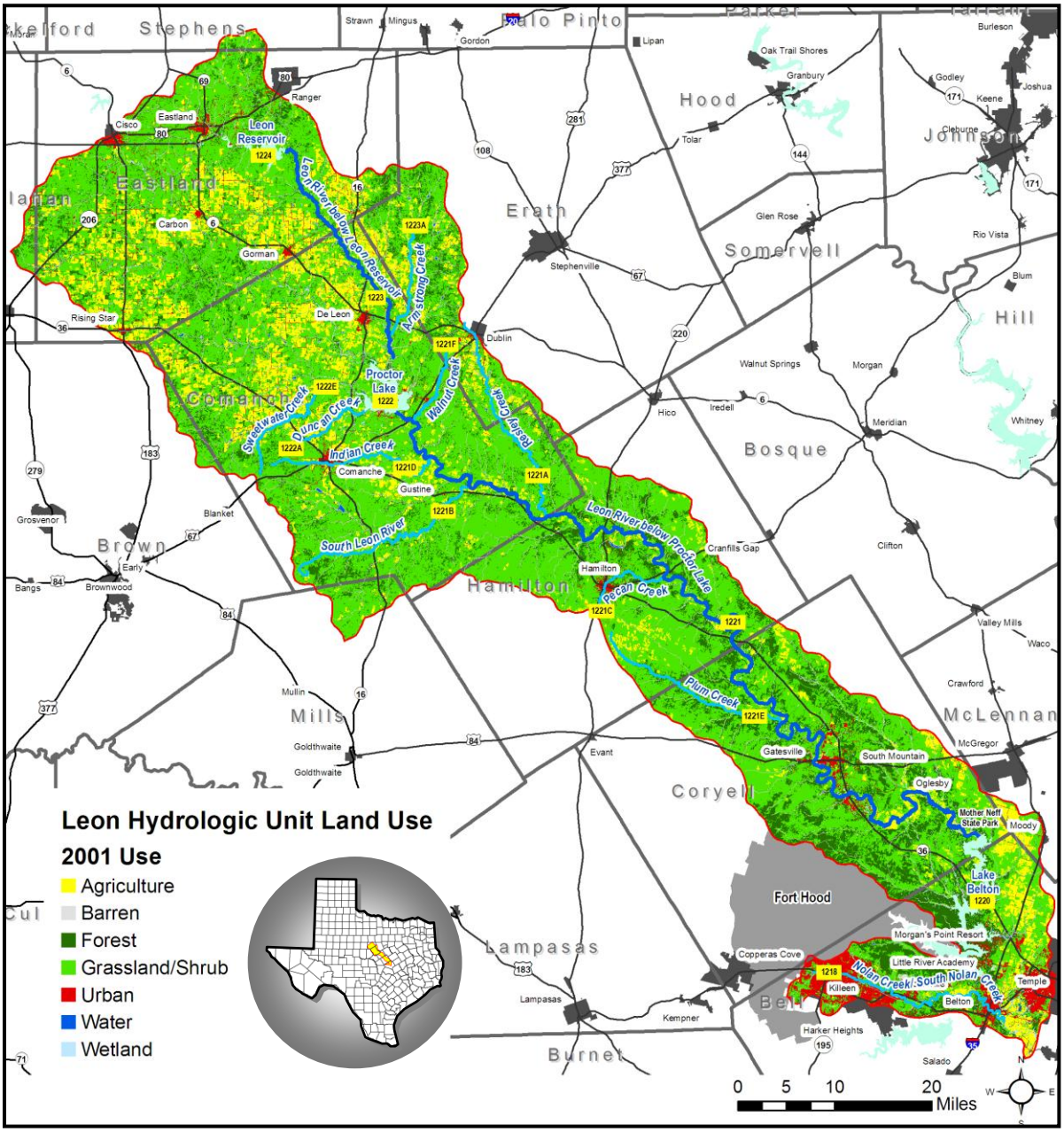


Figure 48. 2001 Anderson Level I land uses for the Leon Hydrologic Unit (12070201) based on the 1992—2001 Land Cover Retrofit Change Product (Fry et al. 2009).

Currently (i.e., 2001), approximately 64 percent of the Leon River watershed's land use is classified as Grassland/Shrub that is distributed throughout the watershed (Figs. 8 & 9). Forest accounts for approximately 16 percent of land use and occupies small patches throughout the

watershed. Larger Forest patches are located in the lower half of the Leon River watershed in Hamilton, Coryell, and Bell Counties. Agriculture (≈ 13% of land use) can be found in small patches along the flood plains of most of the creeks throughout the watershed. Large areas of Agriculture are concentrated in the upper half of the watershed (Eastland and Comanche Counties) and the southeastern end of the watershed in Bell County. Urban land use covers approximately 4 percent of the watershed and has its highest concentration in Bell County. Water, Wetland, and Barren comprise less than 2 percent of land use each.

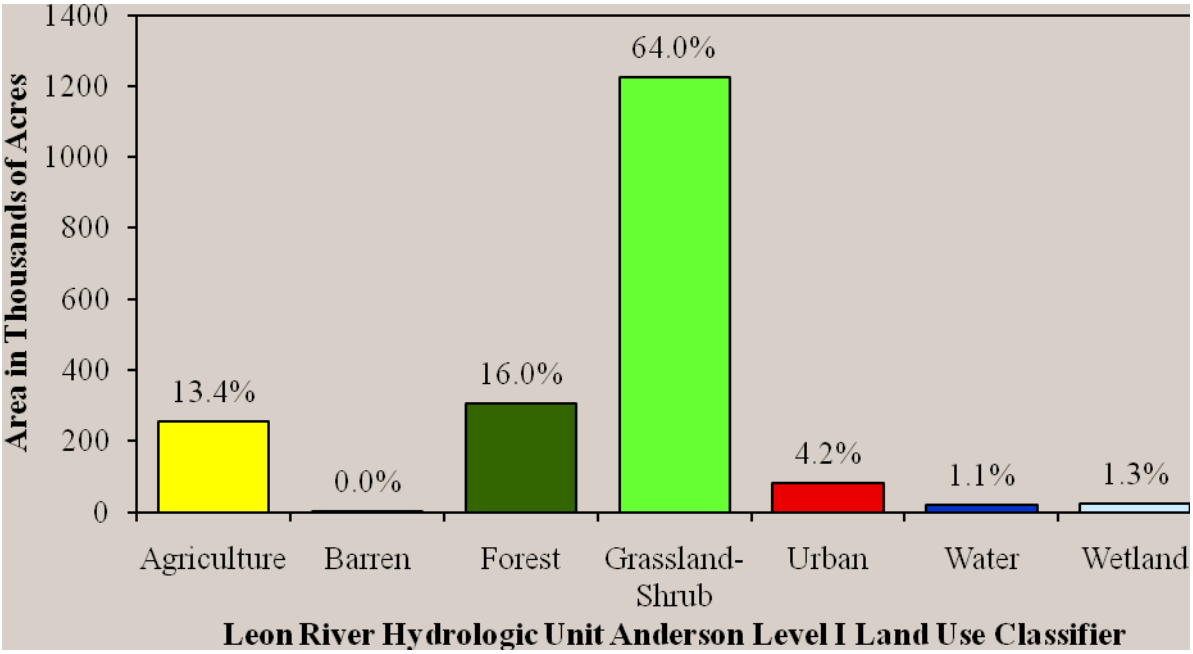


Figure 49. 2001 Land use areas and percentages for the Leon Hydrologic Unit (12070201; data from Frey et al. 2009).

Leon River (Segment 1221) Land Use Changes

Land Use Change Data for the watershed were based on the United States Geological Survey (USGS) 1992—2001 Land Cover Retrofit Change Product (LCRCP; Fry et al. 2009). Derived from the 1992 National Land Cover Dataset (captured in the late 1980s to early 1990s) and the 2001 National Land Cover Dataset (captured in the early 2000s), the LCRCP is a reclassification of both the 1992 and 2001 dataset so that direct comparisons can be made use the Anderson Level I land use classifiers (Fry et al. 2009). The spatial resolution of the dataset is 30 meters. Pixels that changed land use from the 1992 dataset to the 2001 dataset for the Leon River Hydrologic Unit are shown in Figure 10 with the current (i.e., 2001) land use represented. Losses, gains, and net change in land use acres and percentages are shown in Figure 11.

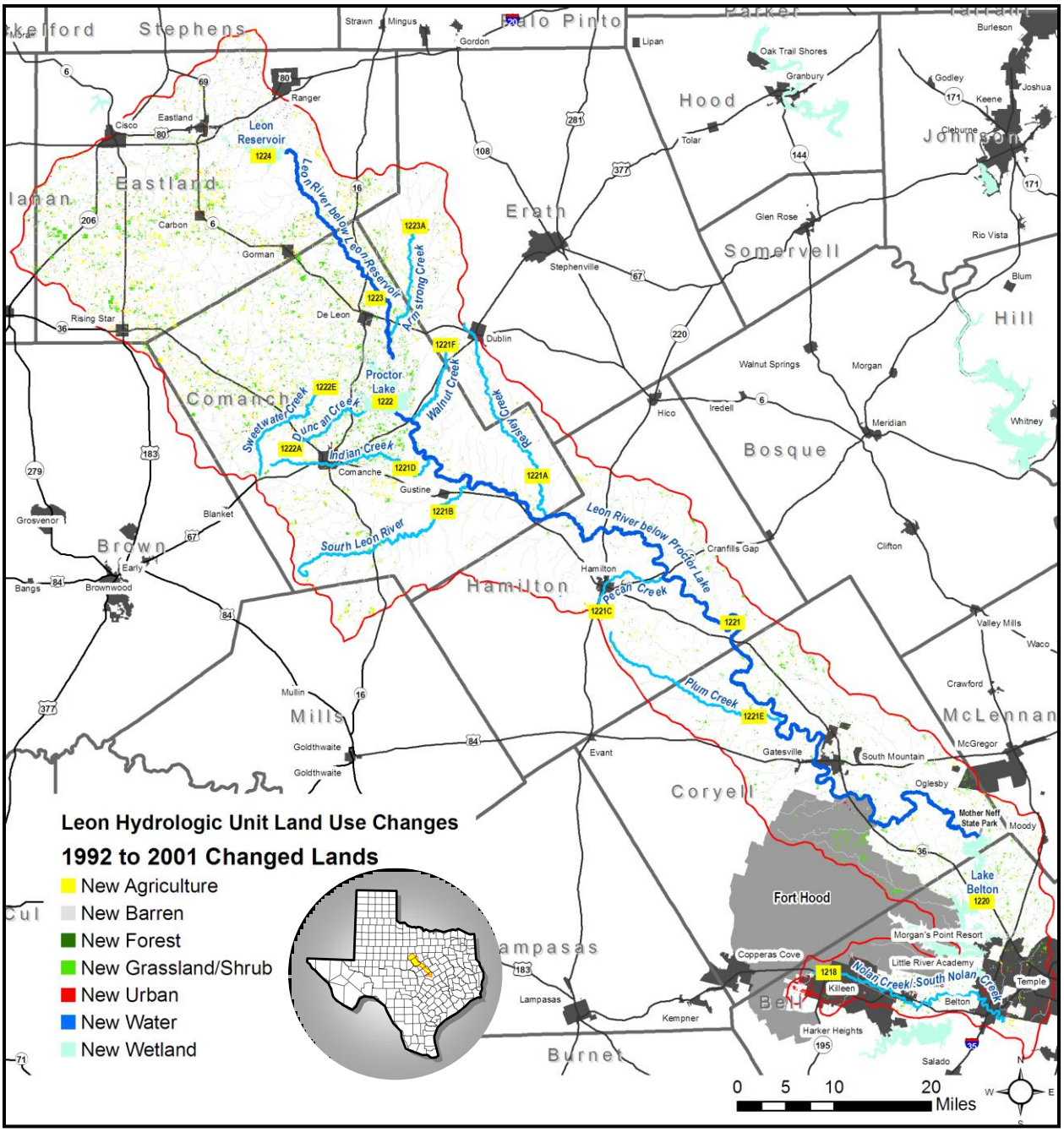


Figure 50. 1992—2001 changes in Anderson Level I land uses for the Leon Hydrologic Unit (12070201) based on the 1992—2001 Land Cover Change Retrofit Product (Frey et al. 2009). 2001 land uses are shown.

Approximately 3.6 percent (68,147 acres) of the Leon River Hydrologic Unit was shown to have changed land use from 1992 to 2001. The greatest land use change was from Agriculture to Grassland/Shrub, which accounted for approximately 39 percent (26,514 acres) of land use changes. However, this was secondly followed by the land use change from Grassland/Shrub to Agriculture (≈ 21% [13,976 acres]). Forest to Grassland/Shrub (≈ 18% [12,188 acres]) and Forest to Agriculture (≈ 6% [4,370 acres]) represented the third and fourth largest changes in land use for the watershed. Grassland/Shrub to Urban and Grassland/Shrub to Forest accounted

for approximately 4 percent (2,431 acres) and 3 percent (2,063 acres) of land use changes, respectively. Combined, the remaining land use changes represented less than 10 percent (6,605 acres) of land use changes.

Grassland/Shrub and Agriculture land use gains appear to be concentrated in the upper half of the watershed in Eastland and Comanche Counties (Fig. 10). Urban land use gains were greatest in Bell County. Forest land use gains were sparsely scattered throughout the watershed.

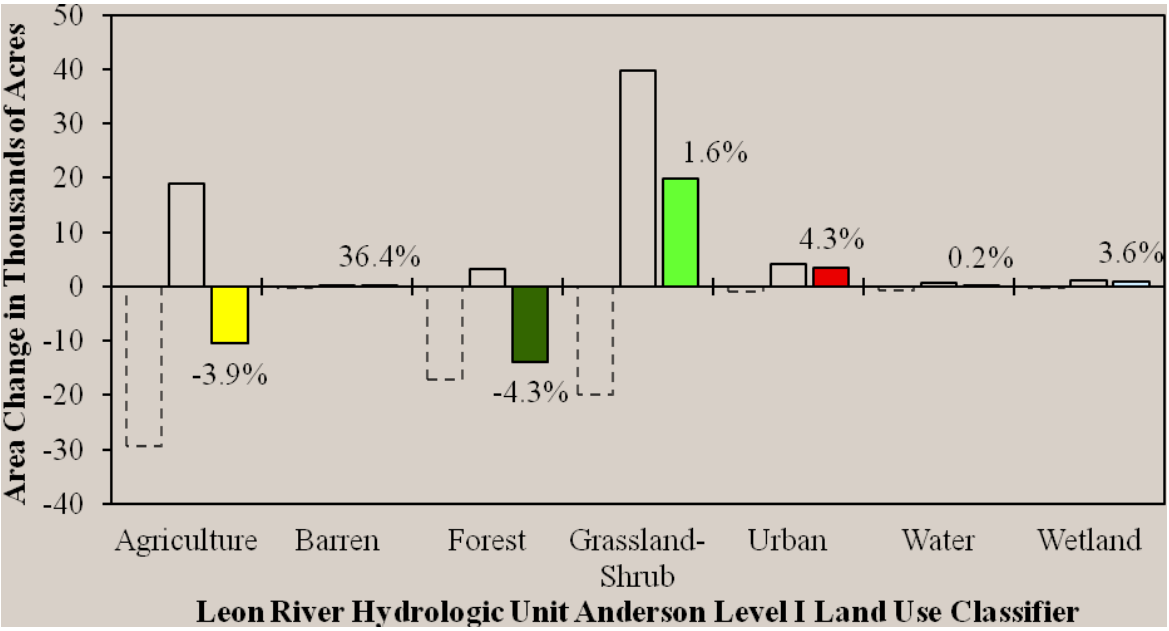


Figure 51. 1992—20001 changes in land use area (gross losses = dashed bars, gross gains = solid white bars, net change = colored bars with percentages) for the Leon Hydrologic Unit (12070201; data from Fry et al. 2009).

One project that began in the early 2000s, known as the Leon River Restoration Project and conducted by Texas A&M University, could influence future land use in portions of the watershed (LRRP 2007). The Leon River Restoration Project is a research brush control program centered in Hamilton and Coryell Counties. The project focuses on the impacts of Ashe Juniper (*Juniperus ashei*) removal, which has become dense in some areas, on water yield and quality, forage production for livestock, and wildlife habitat quality for two federally listed endangered bird species, the golden-cheeked warbler (GCWA, *Vireo atricapillus*) and the black-capped vireo (BCVI, *Dendroica chrysoparia*). Although final results are unavailable, initial findings suggest that juniper removal will increase water yield to the watershed while improving endangered species habitat (Berrios 2004, Greer 2005, LRRP 2007, Wolfe and Hoffman 2005). The positive preliminary findings along with cost sharing programs in place to assist land owners with brush management suggest that the Leon River Restoration Project has the potential to influence future land use change.

Leon River (Segment 1221) Water Availability

The Leon River (Segment 1221) is located downstream from two major reservoirs (Leon Reservoir and Proctor Lake, Fig. 5). Leon Reservoir (Segment 1224) is located at the upper end of the watershed in Eastland County, TX. Leon Reservoir was constructed by the Eastland County Water Supply District in 1954 as a water supply and flood control structure. It has a total conservation volume of 26,420 acre-feet (TWDB 2009). Proctor Lake (Segment 1222) is directly above Segment 1221 in Comanche County, TX. Proctor Lake was constructed by the United States Corps of Engineers primarily as a flood control and water conservation structure in 1963. It has a total conservation volume of 55,457 acre-feet (TWDB 2009).

One to two hundred smaller impoundments (10—5,000 acre-feet) are present in the Leon River Watershed (NID 2007). These impoundments are owned by local governments (e.g., cities, counties, and water conservation boards), private residents, and federal agencies for flood control, water supply, irrigation, and recreation. The majority of these small impoundments were constructed in the 1950s, 1960s, and 1970s. Additionally, there are thousands of privately-owned stock and recreation ponds (<10 acre-feet) throughout the watershed.

The Leon River (Segment 1221) ends by flowing directly into another major reservoir (Lake Belton). Lake Belton (Segment 1220) is located at the lower end of the watershed in Coryell and Bell Counties, TX. Lake Belton was constructed by the United States Corps of Engineers primarily as a flood control and water conservation structure in 1954. It has a total conservation volume of 435,225 acre-feet (TWDB 2009).

Along the Leon River watershed there are numerous diversions for irrigation, municipal supply, industrial uses, and oil field operation as well as wastewater treatment outfalls (TCEQ 2008).

Leon River water availability data were based on the USGS National Water Information System Website daily streamflow values (USGS 2009*b*). The Leon River (Segment 1221) has three monitored streamflow gauges.

Upstream: USGS Gauge 08099500 Leon River near Hasse, Comanche County, TX
Gauge USGS 0809950 has monitored the daily discharge (cubic feet per second) of the upstream portion of the Leon River (Segment 1221), approximately 3.1 river miles below Proctor Lake (Segment 1222), where it crosses United States Highway 67/377 east of Comanche, TX since 1939. The drainage area for this upstream gauge is 1,261 square miles.

Midstream: USGS Gauge 08100000 Leon River near Hamilton, Hamilton County, TX
Gauge USGS 08100000 has monitored the midstream portion of the Leon River (Segment 1221) where it crosses United States Highway 281 north of Hamilton, TX since 1925. Gauge USGS 08100000 is approximately 54.6 river miles below the upstream gauge. The drainage area for this midstream gauge is 1,891 square miles, which is approximately 1.5 times the drainage area of the upstream gauge.

Downstream: USGS Gauge 08100500 Leon River at Gatesville, Coryell County, TX

The downstream portion of the Leon River (Segment 1221) has been monitored by Gauge USGS 08100500 where it crosses Leon Street (just south of United States Highway 84 on the west side of Gatesville, TX) since 1950. Gauge USGS 08100500 is approximately 80.1 river miles below the midstream gauge. The drainage area for this downstream gauge is 2,342 square miles, which is approximately 1.9 times the drainage area of the upstream gauge and 1.2 times the drainage area of the midstream gauge.

Flow duration curves provide a probabilistic description of streamflow at a given location by plotting the percentage of time that flow in a stream is likely to equal or exceed some specified value of interest (OSU 2005). High flow and low flow conditions are categorized as those streamflows that account for the top ten percent and bottom ten percent of recorded daily flows (Cleland 2002*a* and 2002*b*). Mid-range flows present the central 20 percent of recorded daily flows. The flows between high flows and mid-range flows are considered moist conditions, while the flows between mid-range flows and dry conditions are dry conditions. Moist conditions and dry conditions account for 60 percent of recorded daily flows (30% each). Flow duration curves based on 1970—2009 recorded daily median streamflows for the three USGS gauges on the Leon River (Segment 1221) are displayed in Figure 12.

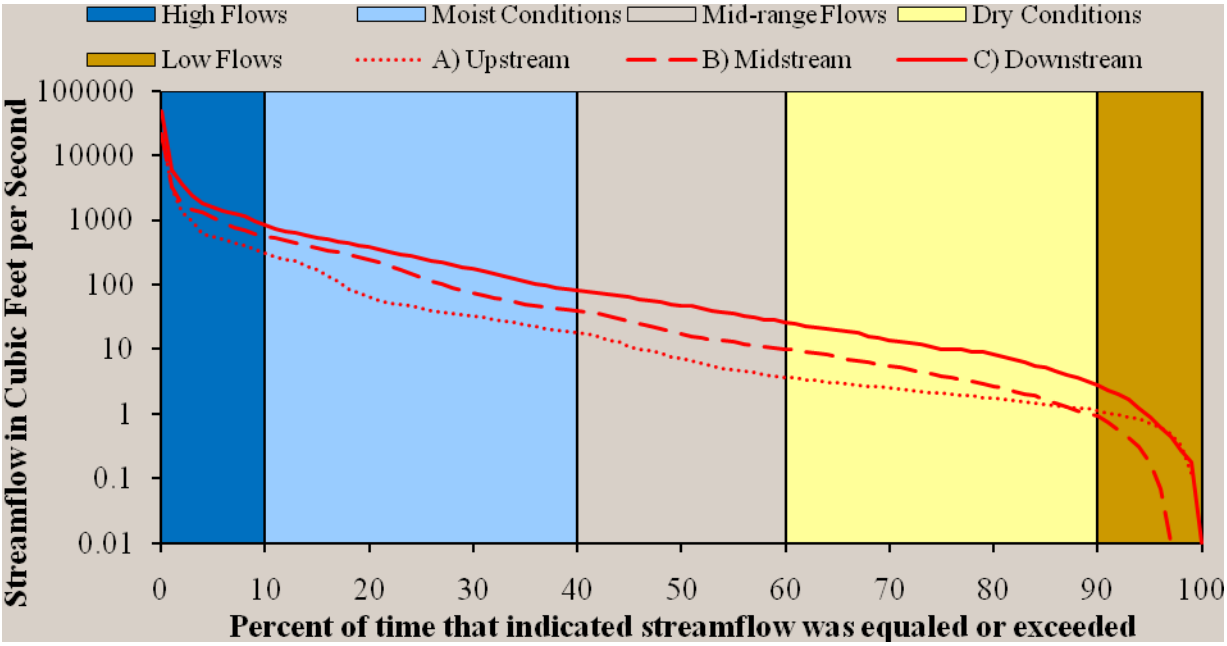


Figure 52. Flow duration curves for the Leon River (Segment 1221) at A) USGS Gauge 08099500 (Upstream), B) USGS Gauge 08100000 (Midstream), and C) USGS Gauge 08100500 (Downstream), 1970—2009. Note: Upstream lacked data in 1991—2007 and Midstream lacked data in 1996—2007.

The highest 1970—2009 daily median streamflow recorded for the Leon River (Segment 1221) was 49,100 cubic feet per second at the downstream gauge. Maximum streamflows at the upstream and midstream gauges were 20,800 and 21,200 cubic feet per second, respectively.

Minimum streamflows were zero cubic feet per second for all three USGS gauges. Midstream gauge, mid-range flows were 2 to 3 times those of the upstream gauge, while the mid-range flows for the downstream gauge were 4 to 7 times those of the upstream gauge. Streamflow boundaries for the various flow duration curve categories are listed in Table 1.

Table 4. Flow duration curve boundaries for the Leon River (Segment 1221) at A) USGS Gauge 08099500 (Upstream), B) USGS Gauge 08100000 (Midstream), and C) USGS Gauge 08100500 (Downstream), 1970—2009.

Flow Duration Curve Category	USGS Gauge Streamflow (Cubic Feet per Second)		
	A) Upstream	B) Midstream	C) Downstream
High Flows	>282	>537	>785
Moist Conditions	18—282	38—537	80—785
Mid-range Flows	3.6—18	9.9—38	26—80
Dry Conditions	1.0—3.6	0.82—9.9	2.6—26
Low Flows	<1.0	<0.82	<2.6

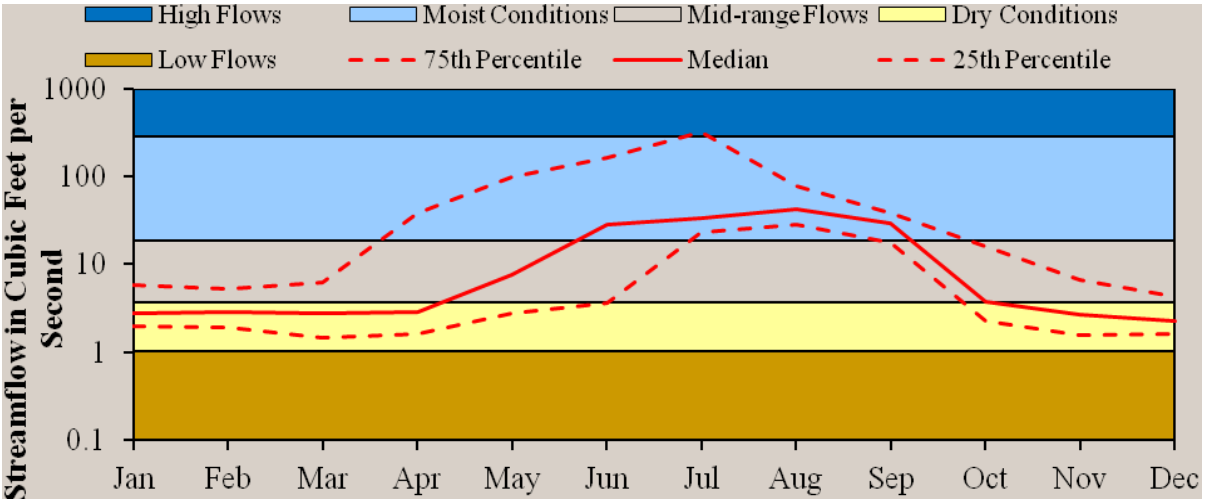
On an annual basis, median monthly streamflows tended to follow North Central Texas precipitation patterns (Fig. 3) for the midstream and downstream gauges with the highest flows occurring during the late spring (April—Jun) and a lesser peak in late Sept—Oct (Fig. 14). Monthly upstream gauge streamflows differed from this pattern, however. This is likely the proximity of the Upstream Gauge to Proctor Lake (Segment 1222) and the resulting influence of Proctor Lake releases to upstream flows.

Historically (1970—2000), median streamflows were relatively stable at the upstream gauge (Fig. 14). The midstream and downstream gauge median streamflows did vary with wet and dry periods with the late 1970s and early 1980s having less streamflows and the late 1980s and 1990s having relatively high streamflows.

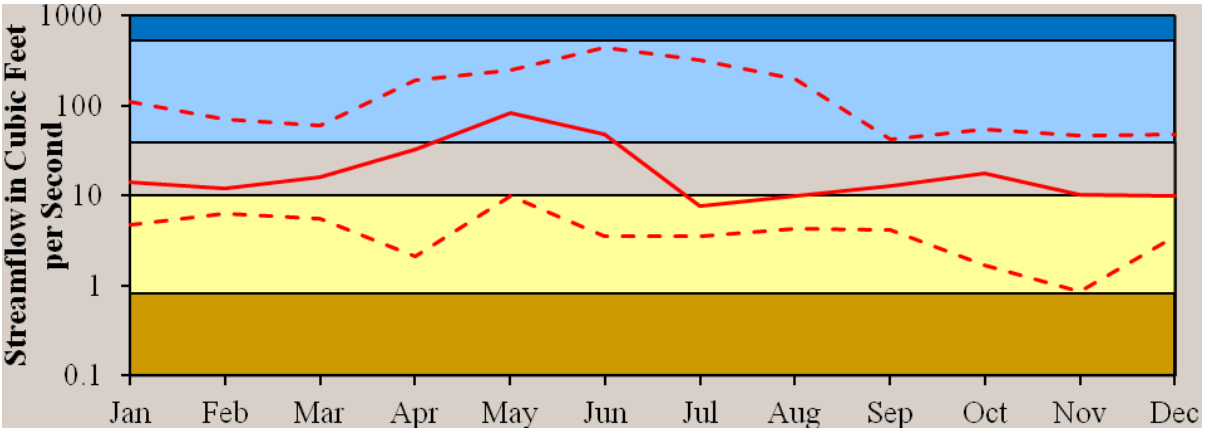
Recreational Access along the Leon River (Segment 1221)

The vast majority of the Leon River (Segment 1221) is surrounded by private property. This limits public access to the approximately 100-ft wide public right-of-way stretches of the Leon River (Segment 1221) that pass underneath United States, State, and County roads for most of the segment. The Leon River intersects public roadways 31 times along the segment. There are 9 public roadway crossings in Comanche County, 11 public roadway crossings in Hamilton County, and 11 public roadway crossings in Coryell County. Public roadway access is the only form of public access in Comanche and Hamilton Counties.

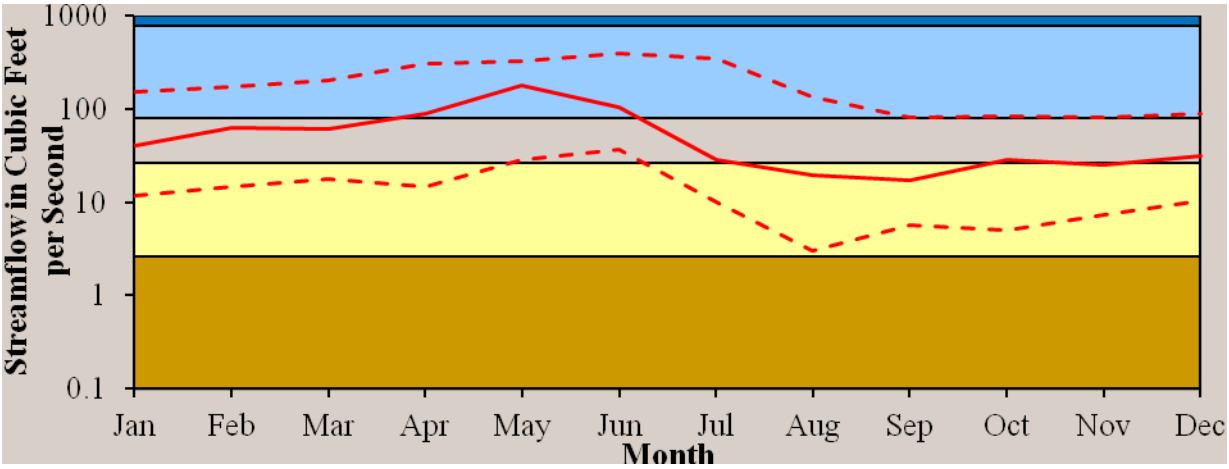
In Coryell County, there are three public access areas in addition to public roadway access points. These public access areas include two Gatesville city parks (Brown Park and Faunt Le Roy Park) and Mother Neff State Park.



A. USGS Gauge 08099500 Leon River near Hasse, Comanche County, TX; Drainage area: 1,261 square miles.

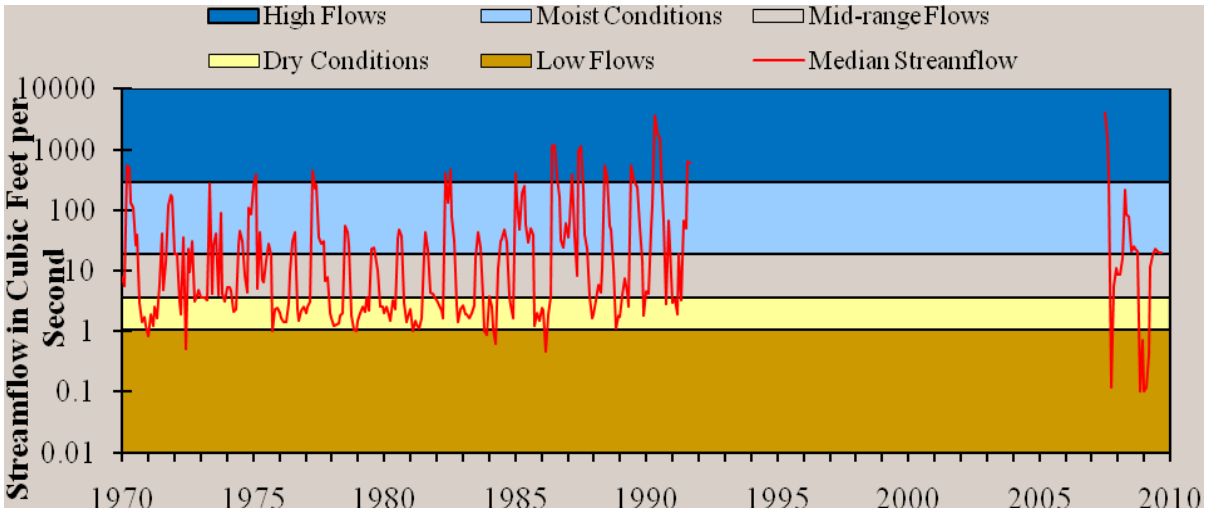


B. USGS Gauge 08100000 Leon River near Hamilton, Hamilton County, TX; Drainage area: 1,891 square miles.

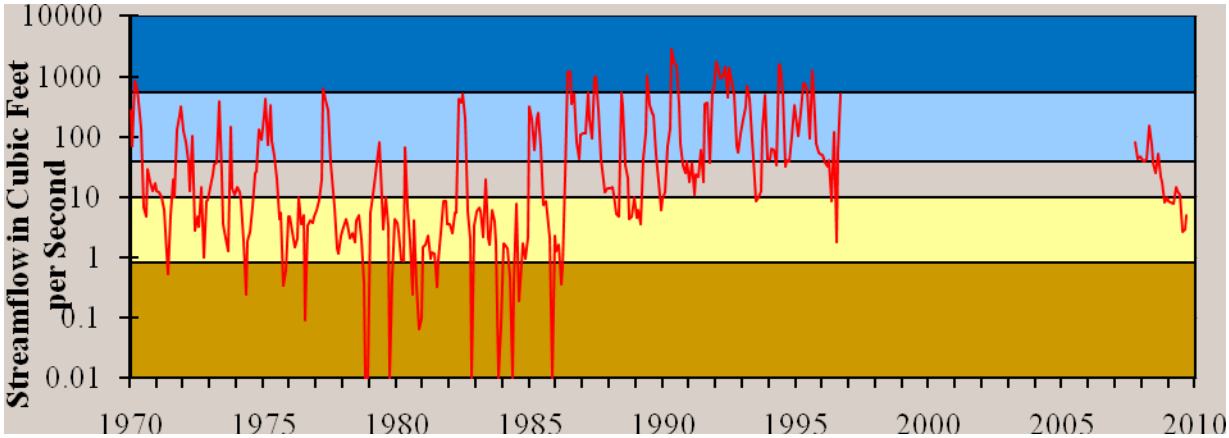


C. USGS Gauge 08100500 Leon River at Gatesville, Coryell County, TX; Drainage area: 2,342 square miles.

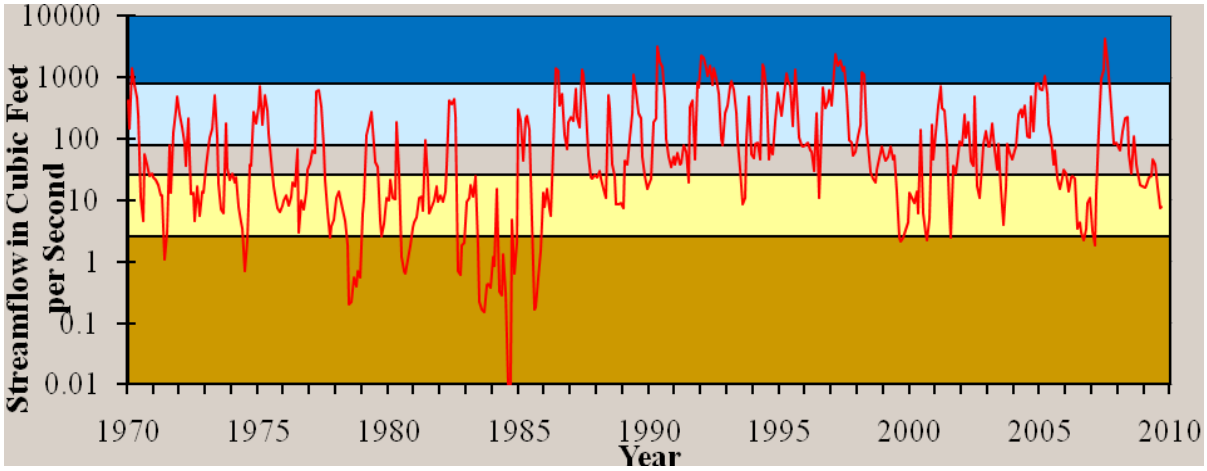
Figure 53. Median, 75th percentile, and 25th percentiles of monthly median streamflows of the Leon River (Segment 1221) at three USGS gauges (A = Upstream, B = Midstream, and C = Downstream) with comparison to their respective flow duration curve values, 1970—2009.



A. USGS Gauge 08099500 Leon River near Hasse, Comanche County, TX; Drainage area: 1,261 square miles.



B. USGS Gauge 08100000 Leon River near Hamilton, Hamilton County, TX; Drainage area: 1,891 square miles.



C. USGS Gauge 08100500 Leon River at Gatesville, Coryell County, TX; Drainage area: 2,342 square miles.

Figure 54. Monthly median streamflows of the Leon River (Segment 1221) at three USGS gauges (A = Upstream, B = Midstream, and C = Downstream) with comparison to their respective flow duration curve values for all dates, 1970—2009. Note: Gauges A and B lacked data for certain periods.

1). **Brown Park, Gatesville, Texas**

Brown Park is located on the eastern side of the Leon River in between United States Highway 84 and East Leon Street in Gatesville, Texas (Fig. 15). Located on five acres, Brown Park is a mowed area underneath tall trees with multiple picnic tables and parking spaces. The historic Leon River Bridge is located at Brown Park where Leon Street crosses the Leon River. Built in 1904, the Leon River Bridge is one of the few remaining steel, Pratt-truss bridges in Texas and became a recorded Texas Historic Landmark in 1996 (THC 2009). Access to the approximately 1,100 feet of the Leon River along the park is unrestricted with somewhat steep banks to the water's edge. It is not known if any organized events take place at Brown Park.

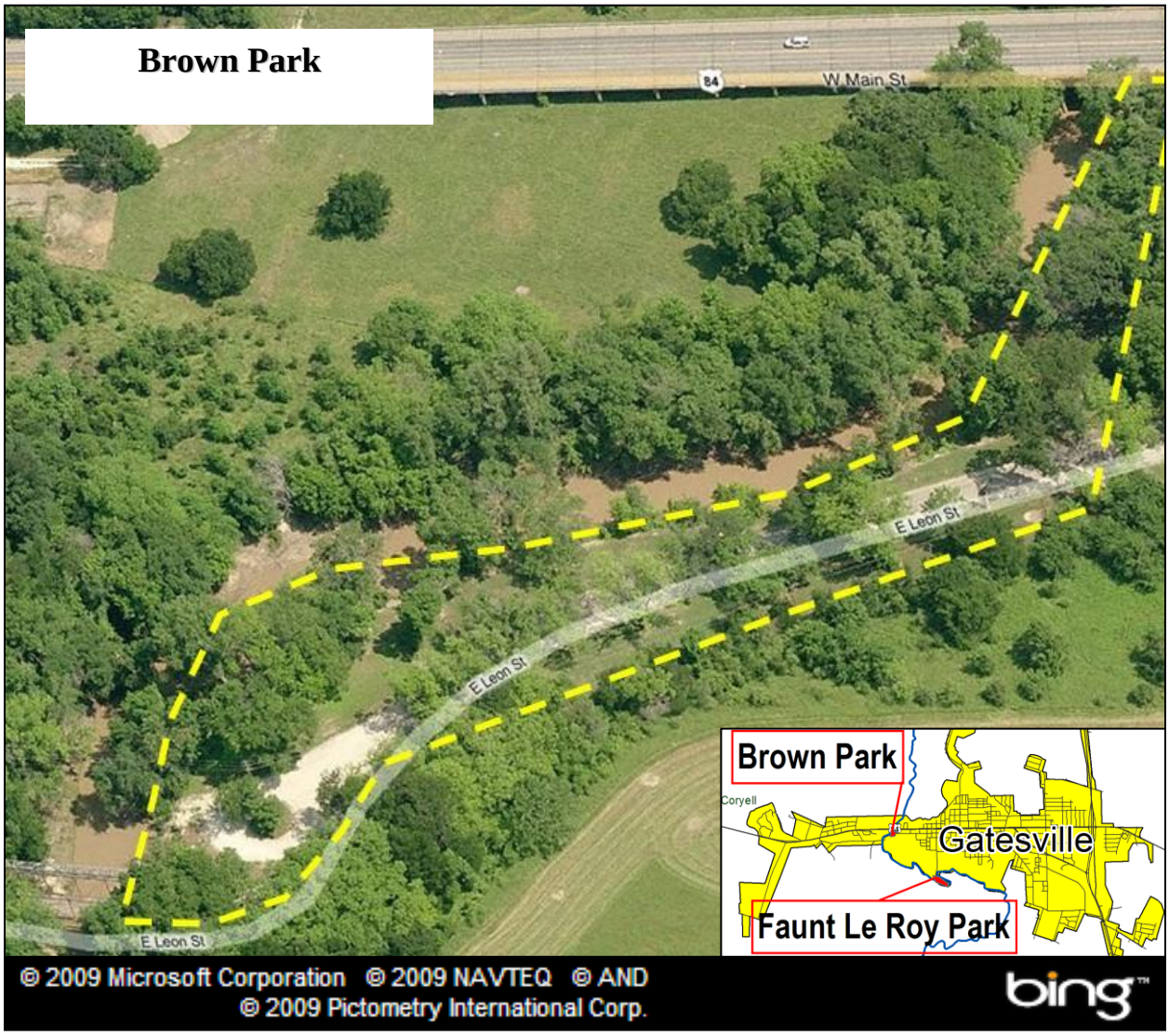


Figure 55. Brown Park (outlined in yellow) along the Leon River in Gatesville, Texas. Note: Aerial image from ©Bing Maps: Bird's eye view (Microsoft 2009).

2). Faunt Le Roy Park, Gatesville, Texas

Faunt Le Roy Park is located at the southern end of South 7th Street in Gatesville, Texas (Fig. 16). Located on nine acres, Faunt Le Roy Park is bordered by the Leon River on three sides and provides access to approximately 2,800 feet of the river. Banks to the water's edge are somewhat steep. Faunt Le Roy has several facilities including a covered pavilion, large barbeque pits, restrooms, playground equipment, a concrete pad for vendors/entertaining/dancing, shaded picnic tables, electric RV hook ups, and hiking and biking trails. The park can also be reserved for family reunions, weddings, and other events.

In addition to day users, Faunt Le Roy Park is used for multiple organized public and private social events annually. The Gatesville Chamber of Commerce has put on a two-day annual arts and crafts festival, known as *Shivaree*, since the early 1970s (GCOC 2009). *Shivaree* typically takes place in June. Events include live music, a car show, arts and craft vendors, food, games, and dancing. In the past, organizers have had a rubber duck race along the portion of the Leon River that surrounds the park but they have not done that in several years.

A three-day family-friendly motorcycle rally, known as *Spring Fling*, put on by the Cen-Tex Road Riders Association has taken place at the park since the early 1980s (CTRRA 2009). Usually held in March, *Spring Fling* offers bike games, bike shows, biking accessory vendors, food, and music.

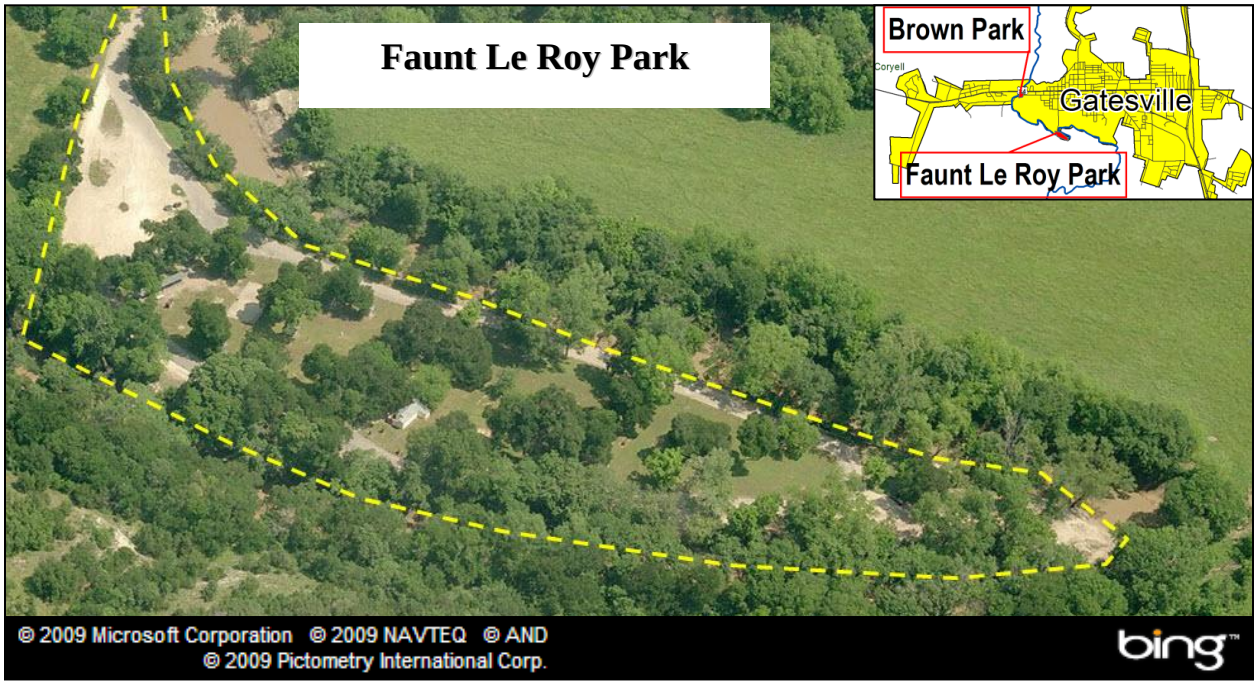


Figure 56. Faunt Le Roy Park (outlined in yellow) along the Leon River in Gatesville, Texas. Note: Aerial image from ©Bing Maps: Bird's eye view (Microsoft 2009).

3). Mother Neff State Park, Coryell County, Texas

Mother Neff State Park is located at 1680 Texas 236 Highway in the southeastern corner of Coryell County Fig. 17). Given to the state in 1916 by Mrs. Isabella E. Neff, Mother Neff State

Park is recognized as the first official state park in Texas (TPWD 2009). Mother Neff State Park was recorded as a Texas Historic Landmark in 1968 for leading to the creation of the Texas State Parks system (THC 2009). The extensive 1930's Civilian Conservation Corps (CCC) buildings and structures constructed at the site led to the park's listing in the National Register of Historic Places in 1992 (NPS 2009). Originally six acres, Mother Neff State Park now includes 259 acres of bottomland hardwoods along the river to mid-grass grasslands on rolling uplands at the northern end of the park (TPWD 1999). Facilities include primitive campsites, campsites with water and electricity, picnic sites, a wooden pavilion, a rock pavilion, air-conditioned recreation hall with kitchen, restrooms with showers, hiking trails, and a playground. An admission fee is required. The Leon River borders the southern edge of the park for approximately 1,500 feet. Since the early 1900s, religious groups have gathered along the river where the park is located today (TPWD 2009). The public at large was allowed access when the area became Mother Neff State Park in 1937. Family reunions, church groups, and wedding receptions are common. Hundreds of thousands of visitors enter the park annually (Crompton et al. 1998). High water levels in Lake Belton can influence Leon River levels at Mother Neff State Park and even further upstream. The proximity of Mother Neff State Park to Lake Belton draws anglers attempting to fish for White bass [*Morone chrysops*] migrating upstream to spawn in spring (March—May) and catfish in the summer (TPWD 2009, Young 1998). Mother Neff State Parks is also recognized as a good location for bird watching (Wauer and Elwonger 1998). Flooding damage in 2007 has reduced some of the facilities in the park. Plans are currently (i.e., 2009) underway to fix the damaged facilities.

Leon River Recreational Use References in Publications

Several publications have attempted to list streams with recreational (e.g., fishing, hunting, or paddling) potential in Texas. The earliest found to specifically reference the Leon River is *Texas: A Guide to the Lone Star State* by the Texas State Highway Commission (TSHC) in 1940. As a precursor to the annual *Texas State Travel Guide* by the Texas Department of Transportation (TXDOT), this publication gives travel distances, short community histories and descriptions of local attractions and activities. In this publication, the Leon River is said to have "fishing for perch, catfish, bass; dove and squirrel hunting." It also says that fossils can be found along the Leon River.

In 1972, *Texas Rivers and Rapids: Canoeing Guide to the Rivers of Texas* by B. M. Nolen and R. E. Narramore was published. The publication has been updated several times (i.e., 1974, 1980, 1983, 1992, and 2000) and has expanded to include surrounding states and information about fishing and backpacking. In the book, Segment 1221 of the Leon River is not mentioned. However, a portion of the Leon River (Segment 1219) below Lake Belton in Bell County from Farm to Market Road 1741 to Farm to Market Road 436 is said to be "a good trip for the beginner, uncomplicated, and navigated easily." A map of the Leon River below Lake Belton is included.

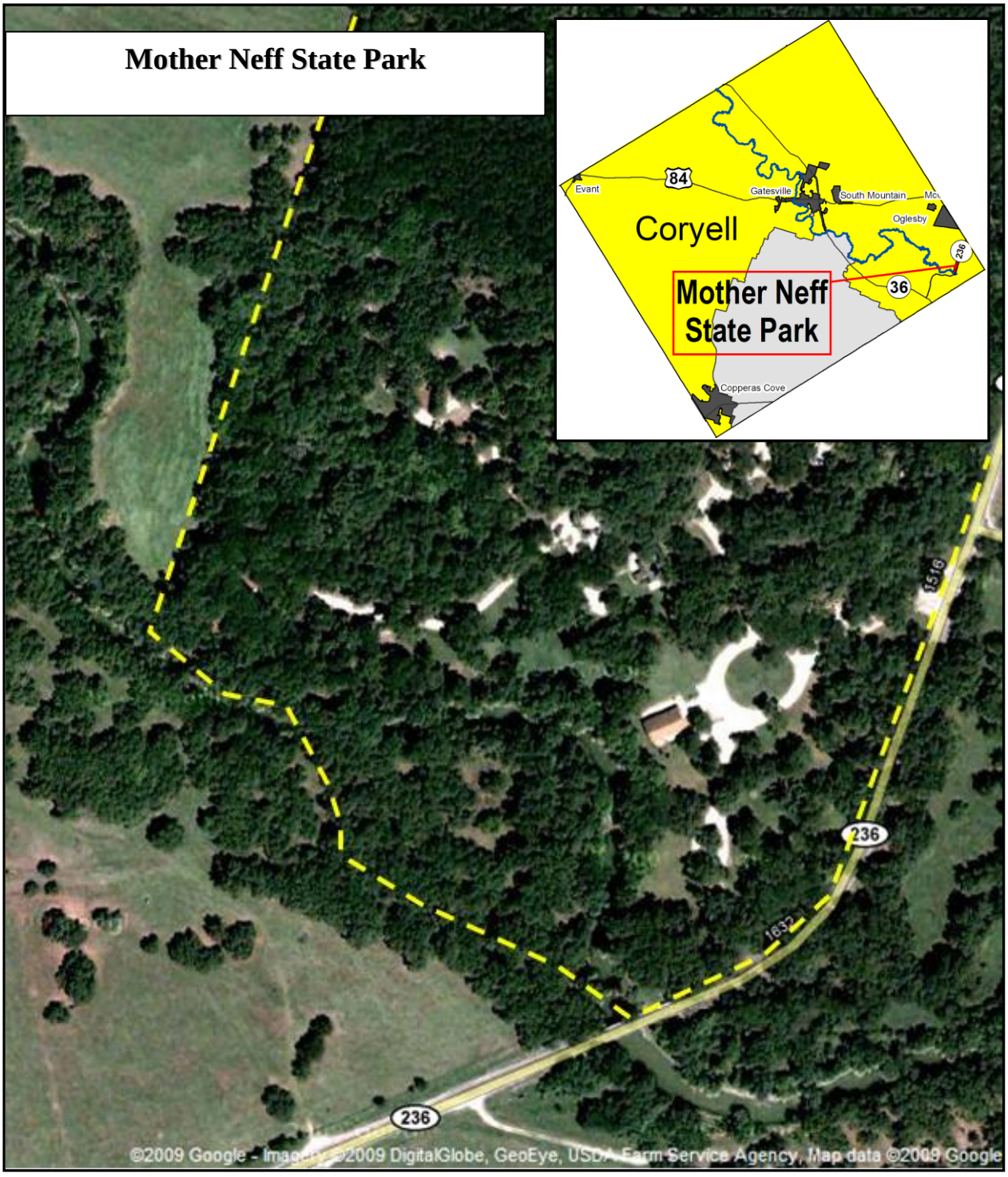


Figure 57. Mother Neff State Park (outlined in yellow) located along the Leon River in Coryell County, Texas. Note: Aerial image from ©Google Maps: Satellite View (Google 2009).

The Leon River also appears in *An Analysis of Texas Waterways: A Report on the Physical Characteristics of Rivers, Streams, and Bayous in Texas* prepared by the Texas Parks and Wildlife Department (TPWD) in 1974. The books focus was to "cover all of the rivers, streams,

and bayous in the State of Texas that are capable of supporting normal waterway recreational activities, such as canoeing, kayaking, and rafting." In the book, the Leon River (Segment 1221) from Proctor Reservoir to Gatesville is said to be "suitable for recreational activities only during periods when water is being released from the dam after heavy rains." From Gatesville to Lake Belton, the Leon River (Segment 1221) is said to "usually have sufficient water for recreational activities" and a map is given for reference. The book suggests United States Highway 84 at Gatesville as a good point to begin recreational use. Occasional log jams are said to occur along the Leon River's length.

A Guide to Texas Rivers and Streams by G. Kirkley was published in 1983. This book appears to be based on *An Analysis of Texas Waterways: A Report on the Physical Characteristics of Rivers, Streams, and Bayous in Texas* by the Texas Parks and Wildlife Department using the same map images and suggesting the same sections of the Leon River for recreational use.

Although fishing along the Leon River is only mentioned in publication as occurring at Mother Neff State Park (Young 1998), there have been studies that looked at fish species within the Leon River watershed (Rose and Echelle 1981, Stanley 2009, TPWD 2007*a* and 2007*b*, USFWS 1998). These studies have found that preferred fish species are found in the Leon River (TPWD 2004). Based on these studies, species known to inhabit the Leon River are catfish (Channel catfish [*Ictalurus punctatus*], Flathead catfish [*Pylodictus olivaris*], and Yellow bullhead [*Ameiurus natalis*], bass (Largemouth bass [*Micropterus salmoides*], White bass [*Morone chrysops*]), crappie (White crappie [*Pomoxis annularis*]), and sunfish (Green sunfish [*Lepomis cyanellus*], Bluegill [*Lepomis macrochirus*], Longear sunfish [*Lepomis megalotis*]).

Historical Accounts of Recreation on the Leon River

With the vast majority of the Leon River located on private property, historical accounts of recreation along the Leon River and its tributaries are limited. *The History of the Baggett Family: The Baggett Family in America Website* (Baggett 2009) describes a picnic held along the Leon River in the late 1800s/early 1900s in which the children "waded the river, and the more adventurous children jumped from the trees to swim in the Leon River." Other personal accounts of swimming in the Leon River and/or its tributaries include the early 1900s (Straight 1988), 1920s (Stephens 2000), 1930s (Dragoo 2008, Mann 2002, and Rowe 2003), and 1940s (Chupp 2006). Fishing along the Leon River has also taken place since the early 1900s (Sitton 2003).

In addition to historical accounts, in excess of 60 local landowners and residents were interviewed about their knowledge of past and present Leon River recreational use for this study in the summer of 2009. Some of these land owners have been familiar with the Leon River for decades (over 50% have been familiar with the Leon River for greater than 20 years) and were willing to share their knowledge of historical Leon River recreational use. Some landowners stated that they and/or people they know have swam, waded, fished, used small water craft (i.e.,

canoes, kayaks, and/or small aluminum boats), hunted, and/or searched for arrowheads at places along the Leon River in the past. Historical Leon River recreational use and frequency appears to have varied by landowner. Some landowners stated that they swam and fished in the river when they and/or their family were younger and continue to do so. Other landowners stated that they do not use the Leon River for recreation and have never seen or heard of anyone using the Leon River for recreation.

Classified Stream Segment 1218 (Nolan Creek/ South Nolan Creek): From confluence with the Leon River (Segment 1219) in Bell County to a point 100 meters (110 yards) upstream to the most upstream crossing of US 190 and Loop 172 in Bell County, Texas.

Nolan Creek/ South Nolan Creek (Segment 1218) is a considered a portion of the Leon River USGS Hydrologic Unit 12070201: Texas-Gulf Region > Lower Brazos Subregion > Little River Basin > Leon River (USGS 2009*a*). The Nolan Creek/ South Nolan Creek portion of the watershed encompasses approximately 135 square miles (Fig. 18).

Segment 1218 (Nolan Creek/ South Nolan Creek) is 29 miles long and flows in a easterly direction from an elevation of 870 feet at its start northwest of Killeen, Texas to 450 feet at the confluence with the Leon River (Segment 1219; TNRIS 2009). Average stream gradient is 13 to 14 feet per mile (Daniel 2004, TNRIS 2009).

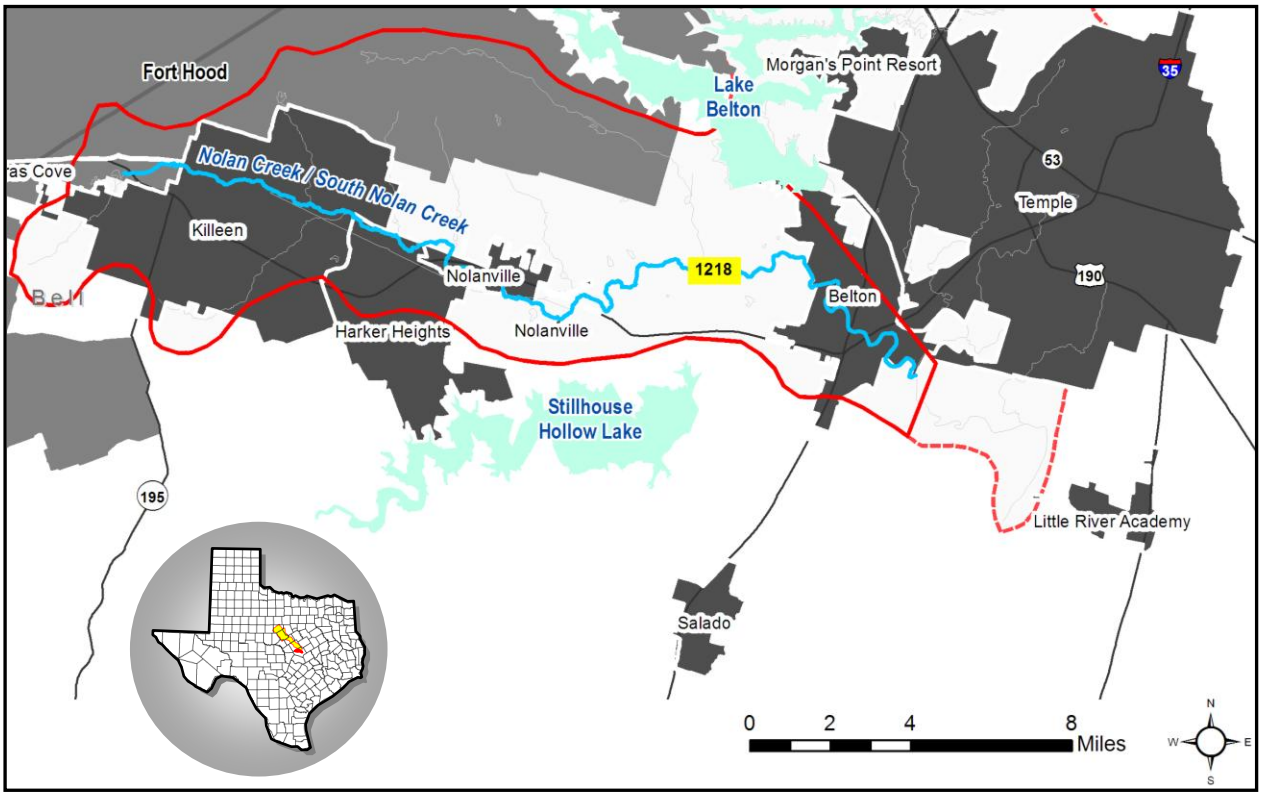


Figure 58. Nolan Creek/ South Nolan Creek (Segment 1218) portion of the Leon River Hydrologic Unit (12070201), Bell County, Texas.

Nolan Creek/ South Nolan Creek (Segment 1218) was first listed on the Texas 303(d) list of impaired waterways for exceeding the safe bacteria criterion for contact recreation in 1998. This report is meant to provide data to better categorize the current recreational uses of Nolan Creek/ South Nolan Creek (Segment 1218).

Nolan Creek/ South Nolan Creek Local Population

Nolan Creek/ South Nolan Creek (Segment 1218) flows through a portion of Bell County, Texas. A general description of the local population follows with data from the United States Census Bureau (Census 2009).

Bell County covers 1,051 square miles and has an estimated population of 237,974 (226.4 persons/mi^2) in 2000. The population has increased by about 91 percent since 1970 (Fig. 19). Approximately 86 percent of the population lives in urban areas. The largest urban area is the city of Killeen with a population of 87,505. The city of Temple is the second largest urban area with a population of 54,533. Harker Heights (17,558) and Fort Hood (17,282) are the third and fourth largest urban areas in the county. The city of Belton has a population of 15,719. Smaller urban areas in Bell County include Morgans Point Resort (2,989 residents), Nolanville (2,150 residents), Barlett (1,675 residents), Little River-Academy (1,645), Troy (1,378), Rogers (1,117), and Holland (1,102). Nolan Creek/ South Nolan Creek (Segment 1218) passes through the four urban areas of Killeen, Harker Heights, Nolanville, and Belton, Texas (Fig. 18).

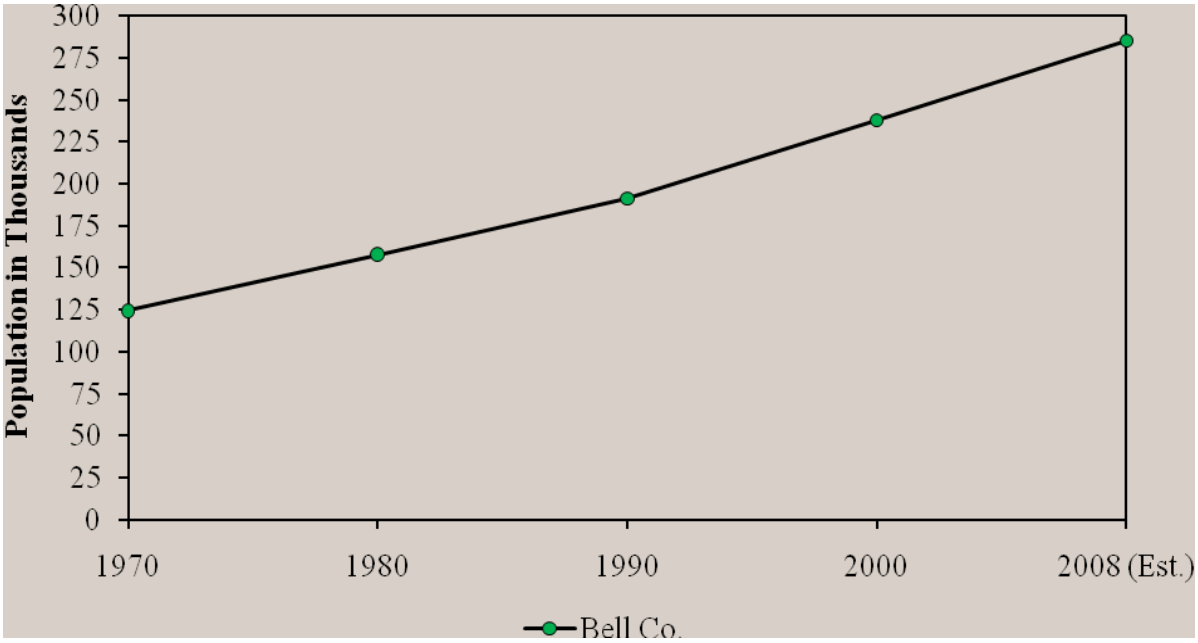


Figure 59. Decennial U.S. Census population values for Bell County, Texas (1970—2000; Census 2009). Note: Year 2008 population values are preliminary estimates.

Nolan Creek/ South Nolan Creek Land Use

Land use data for the Nolan Creek portion of the watershed were based on the United States Geological Survey (USGS) National Land Cover Dataset (NLCD) 1992—2001 Land Cover Retrofit Change Product (LCRCP) (Fry et al. 2009). Derived from Land-sat Thematic Mapper

satellite data, the NLCD is a classification scheme for land cover applied consistently over the United States. Derived from the 1992 National Land Cover Dataset (captured in the late 1980s to early 1990s) and the 2001 National Land Cover Dataset (captured in the early 2000s), the LCRCP is a reclassification of both the 1992 and 2001 dataset so that direct comparisons can be made using the Anderson Level I land use classifiers (Fry et al. 2009). The spatial resolution of the NLCD and the LCRCP is 30 meters. Land uses were grouped into seven Anderson Level I land use classifier categories (Fry et al. 2009). Current (i.e., 2001) land uses for the Nolan Creek/ South Nolan Creek area are shown in Figure 20. Total area by land use and percentages are shown in Figure 21.

Currently (i.e., 2001) approximately 34 percent of the Nolan Creek/ South Nolan Creek's watershed land use is classified as Grassland/Shrub that is concentrated in between the urban areas of Nolanville and Belton along the middle of the segment (Figs. 20 & 21). Urban accounts for approximately 29 percent of land use and is greatest in the urban areas of Killeen-Fort Hood, Harker Heights, and Nolanville along the upper end of the segment and Belton along the lower end of the segment. Forest (≈ 22% of land use) is found in patches in between the urban areas of Nolanville and Belton with portions located in Fort Hood. Water land use covers approximately 9 percent of the watershed and is found at Lake Belton as well as above the several flood control dams found in the watershed. Agriculture (≈ 4% of land use) is found mostly northwest of Belton along the floodplain of Nolan Creek. Wetland accounts for 2 percent of land use while Barren is less than 1 percent of land use.

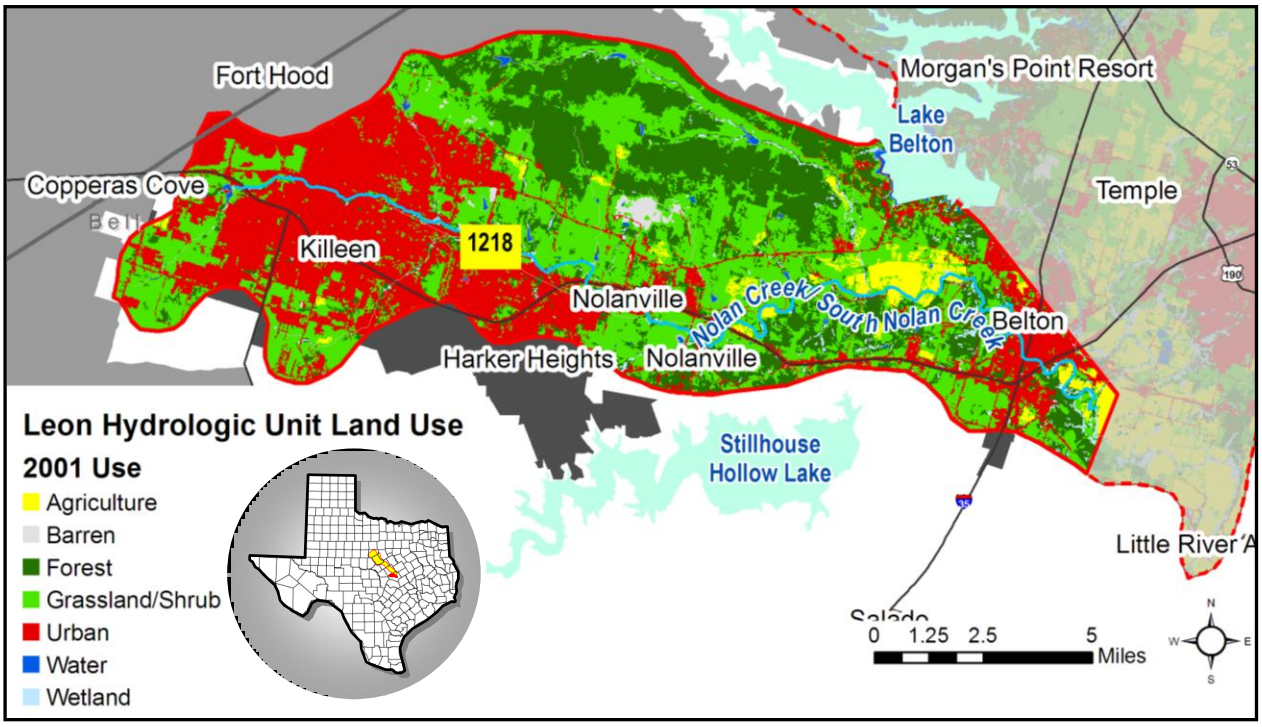


Figure 60. Anderson Level I land uses for Nolan Creek/ South Nolan Creek (Segment 1218) watershed based on the 1992—2001 Land Cover Retrofit Change Product (Fry et al. 2009).

Land Use Change Data for the watershed were based on the United States Geological Survey (

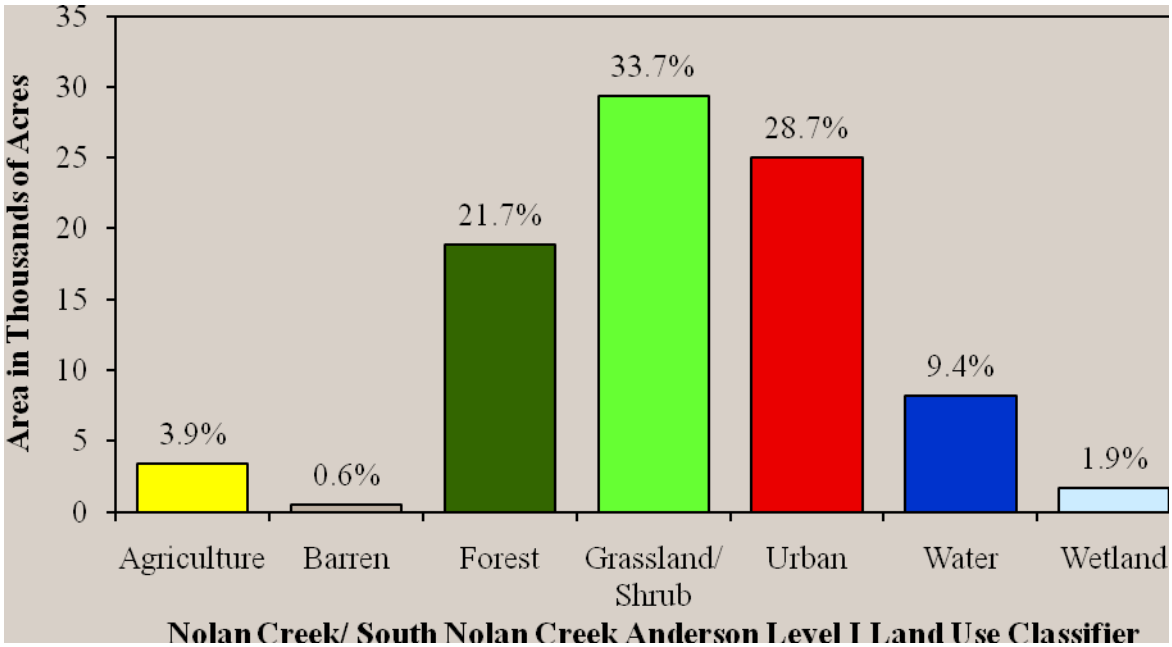


Figure 61. 2001 Land use areas and percentages for the Nolan Creek/ South Nolan Creek watershed; data from Frey et al. 2009.

Approximately 3.1 percent (2,733 acres) of the Nolan Creek/ South Nolan Creek watershed was shown to have changed land use from 1992 to 2001 (Fig. 22 & 23). The greatest land use change was from Grassland/Shrub to Urban, which accounted for approximately 51 percent (1,388 acres) of land use changes. The second greatest land use change was from Forest to Grassland/Shrub (≈24%, 652 acres). Grassland/Shrub to Barren accounted for 7 percent (184 acres) of land use changes while Agriculture to Grassland/Shrub comprised 5 percent (137 acres) of changes. Forest to Urban (≈3%, 92 acres) and Agriculture to Urban (≈3%, 72 acres) were the fifth and sixth greatest land use conversions. Combined, the remaining land use changes accounted for less than 10 percent (208 acres) of land use changes.

Urban land use gains appear to be concentrated in the urban areas of Killeen, Copperas Cove, and Belton (Fig. 22). Pixels that changed land use from the 1992 dataset to the 2001 dataset for the Nolan Creek/ South Nolan Creek watershed are shown in Figure 22 with the current (i.e., 2001) land use represented. Losses, gains, and net change in land use acres and percentages are shown in Figure 23. Grassland/Shrub land use gains were mostly scattered in between Nolanville and Belton. Barren land use gains were sparsely scattered throughout the watershed.

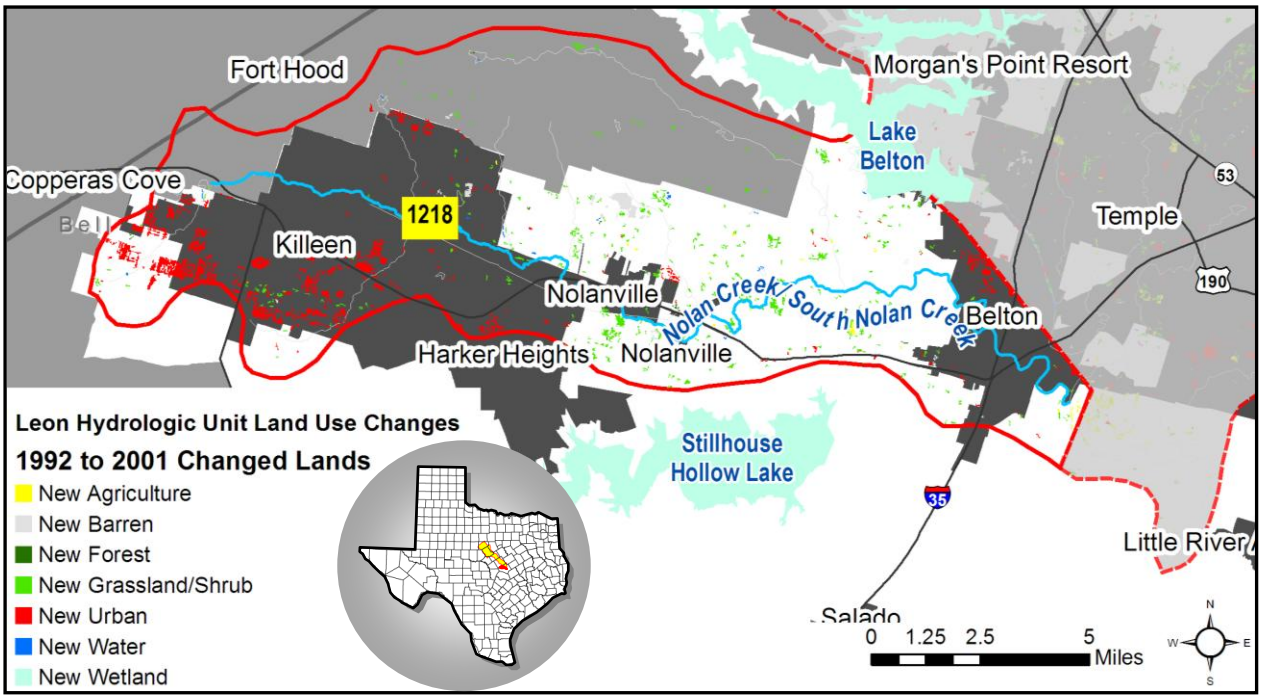


Figure 62. 1992--2001 changes in Anderson Level I land uses for the Nolan Creek/ South Nolan Creek watershed based on the 1992--2001 Land Cover Change Retrofit Product (Frey et al. 2009). 2001 land uses are shown.

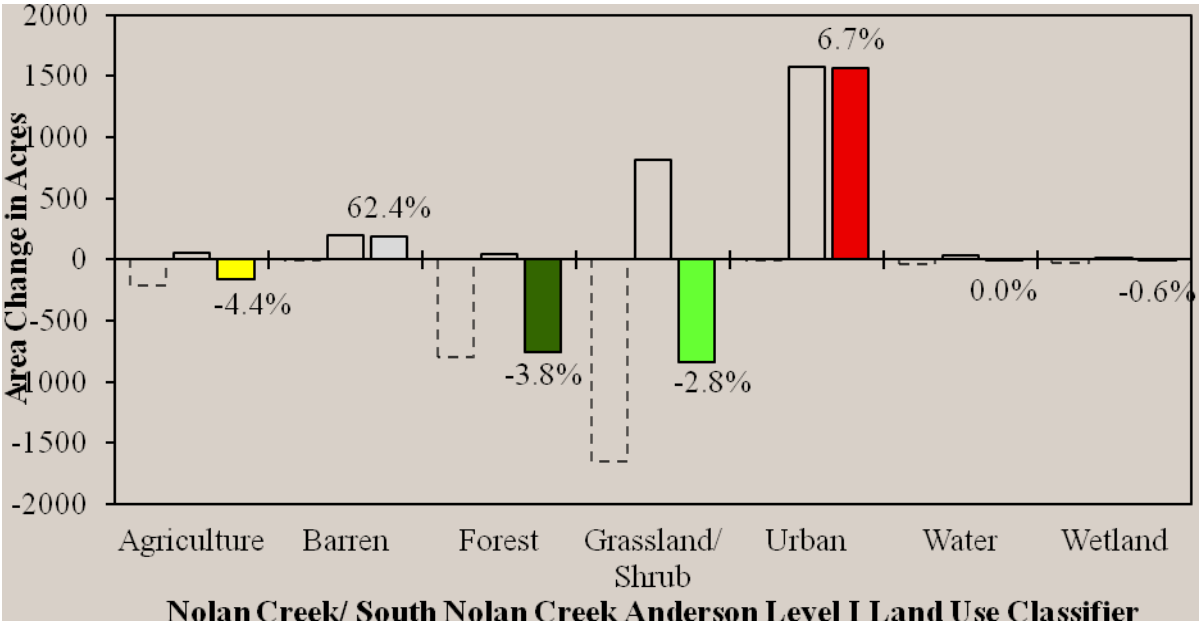


Figure 63. 1992—2001 changes in land use area (gross losses = dashed bars, gross gains = solid white bars, net change = colored bars with percentages) for the Nolan Creek/ South Nolan Creek. Data from Fry et al. 2009.

Nolan Creek/ South Nolan Creek (Segment 1218) Water Availability

The Nolan Creek/ South Nolan Creek (Segment 1218) originates northwest of Killeen in Bell County. No major reservoirs are found upstream of the segment. Severe flooding in the early to mid-1900s has led to several floodwater retarding dams on the tributaries to Segment 1218. There are wastewater treatment outfalls at Killeen, Harker Heights, Nolanville, and Belton along Segment 1218.

Nolan Creek/ South Nolan Creek water availability data were based on the USGS National Water Information System Website daily streamflow values (USGS 2009*b*). Nolan Creek/ South Nolan Creek has one monitored streamflow gauge.

USGS Gauge 08102600 Nolan Creek at Belton, Bell County, TX

Nolan Creek/ South Nolan Creek (Segment 1218) has been monitored by Gauge USGS 08102600 where it crosses Interstate 35/ United States Highway 190 just after is passes along Confederate Park in Belton, TX from 1974—1982. The drainage area for the gauge is 112 square miles (USGS 2009*b*).

Flow duration curves provide a probabilistic description of streamflow at a given location by plotting the percentage of time that flow in a stream is likely to equal or exceed some specified value of interest (OSU 2005). High flow and low flow conditions are categorized as those streamflows that account for the top ten percent and bottom ten percent of recorded daily flows (Cleland 2002*a* and 2002*b*). Mid-range flows present the central 20 percent of recorded daily flows. The flows between high flows and mid-range flows are considered moist conditions, while the flows between mid-range flows and dry conditions are dry conditions. Moist conditions and dry conditions account for 60 percent of recorded daily flows (30% each). Flow duration curves, based on 1974—1982 recorded daily streamflow for the USGS gauge on Nolan Creek/ South Nolan Creek (Segment 1218) are displayed in Figure 24.

The highest 1974—1982 median daily streamflow recorded for Nolan Creek/ South Nolan Creek (Segment 1218) was 8,370 cubic feet per second (Fig. 24). Minimum streamflow was 8.6 cubic feet per second. Streamflow boundaries for the various flow duration curve categories are listed in Table 2.

On an annual basis, 1974—1982 median monthly Nolan Creek streamflows showed a spike in last spring (April—June) likely due to rainfall based on the precipitation of north central Texas (Fig. 2 & 25). Streamflows tended to decrease from July—October. Streamflows tend to stay about the same during the winter and then slowly increase in the late winter/early spring months.

Historical (1970—2000) median Nolan Creek/ South Nolan Creek streamflow data is only available from 1974 to 1982 (Fig. 26). No long-term trends can be seen based on the available data.

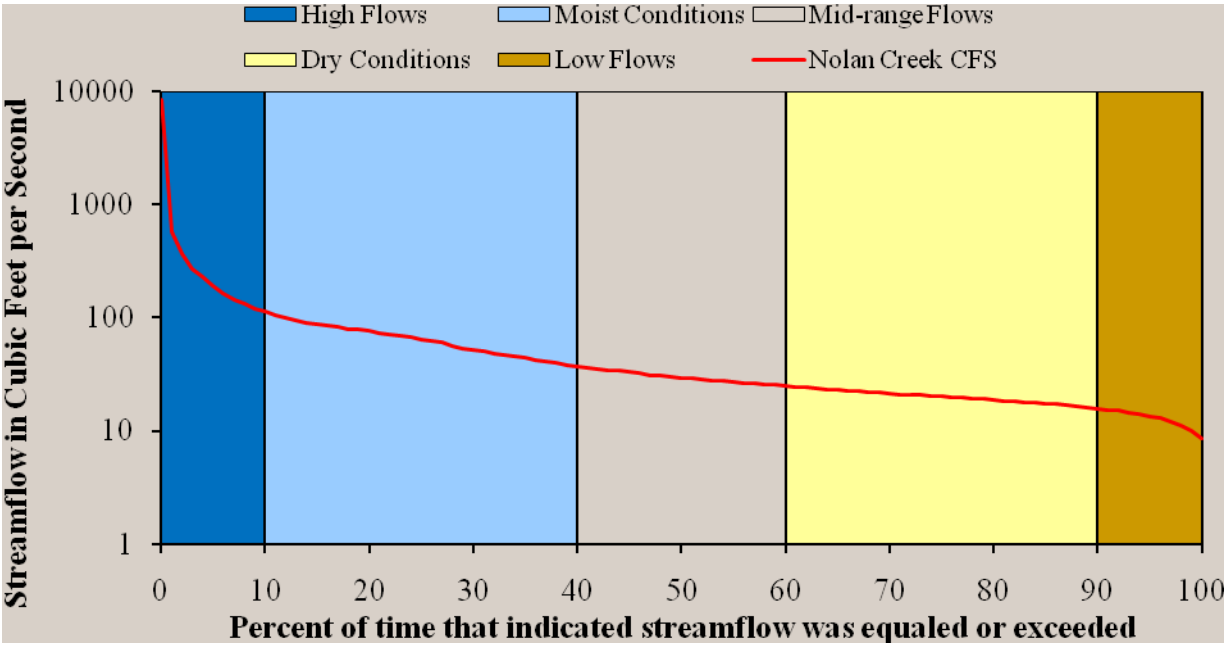


Figure 64. Flow duration curve for Nolan Creek (Segment 1218) at USGS Gauge 08102600 at Belton, Texas. Note: data are from 1974—1982.

Table 5. Flow duration curve boundaries for Nolan Creek (Segment 1218) at USGS Gauge 08102600, 1974—1982.

Flow Duration Curve Category	USGS Gauge Streamflow (Cubic Feet per Second)
	Nolan Creek (USGS Gauge 08102600)
High Flows	>115
Moist Conditions	38—115
Mid-range Flows	25—38
Dry Conditions	16—25
Low Flows	<16

Recreational Access along Nolan Creek/ South Nolan Creek (Segment 1218)

Nolan Creek/ South Nolan Creek (Segment 1218) intersects or passes underneath 30 public right-of-ways along its length. Twelve road crossings are located in Killen city limits, two crossings in Harker Heights city limits, two crossings in Nolanville city limits, eight crossings in Belton city limits, and six crossings outside of city limits in between Nolanville and Belton.

In addition to road crossings, eight public access areas are located along Nolan Creek/ South Nolan Creek. These public access include one Killeen city park (Killen Community Center Complex), three Harker Heights city parks (Nolan Creek Trail, Booker Greenspace, and Summit Soccer Complex), and four Belton city parks (Lions Field, Harris Park, Yettie Polk Park, and Confederate Park). There is also a Nolan Creek Hike and Bike Trail in Belton that runs parallel to Nolan Creek and connects the four Belton parks together.

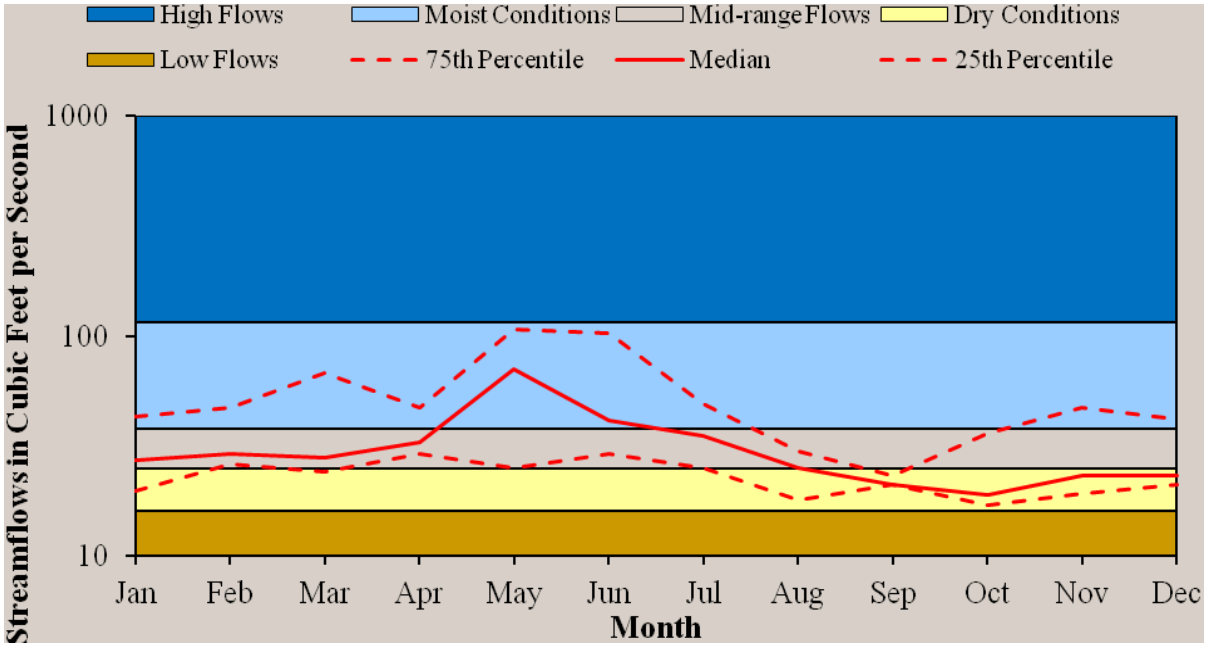


Figure 65. Median, 75th percentile, and 25th percentiles of monthly median streamflow of Nolan Creek/ South Nolan Creek (Segment 1218) at USGS gauge 08102600 with comparison to its flow duration curve values, 1974—1982.

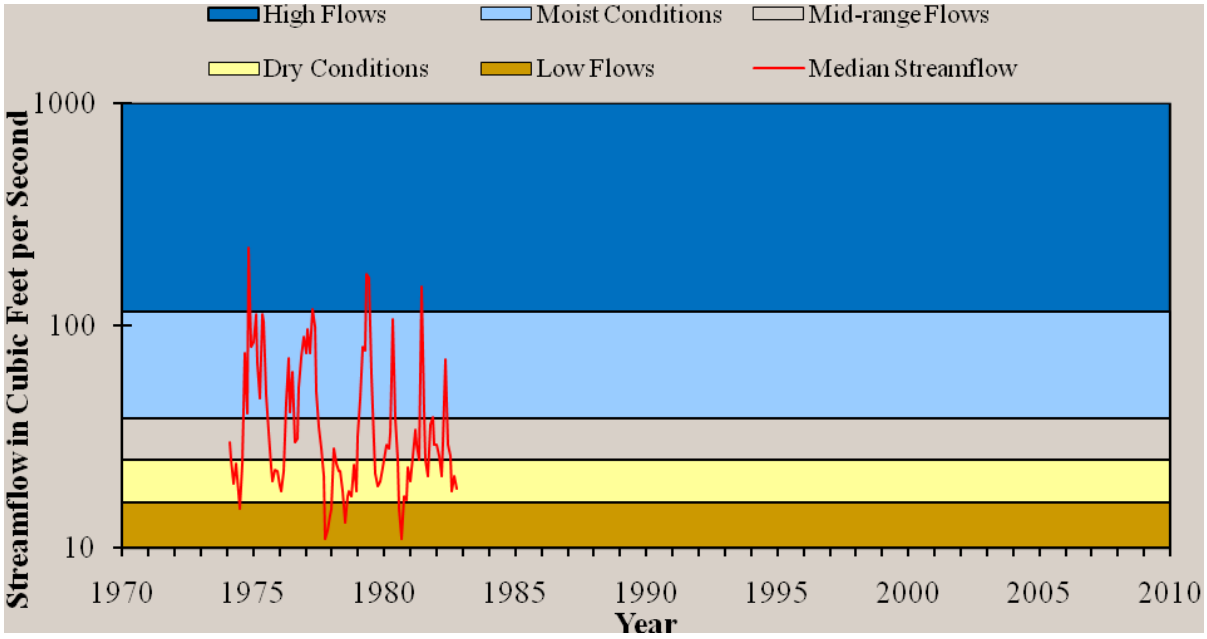


Figure 66. Median monthly streamflow of Nolan Creek/ South Nolan Creek (Segment 1218) at USGS gauges 08102600 with comparison to its respective flow duration curve values, 1974—1982. Note: Data only available for 1974—1982.

1). Killeen Community Center Complex, Killeen, Texas

The Killeen Community Center Complex is located north of Veterans Memorial Boulevard/ Business Highway 190 on the southern side of South Nolan Creek in between WS Young Drive and 38th Street (FM 2410) in Killeen, Texas (Fig. 27). Located on approximately 140 acres, the Killeen Community Center Complex includes the Killeen Community Center, the Killeen Senior Center, an amphitheater, Well's Pavilion, the Rotary Children's Park, nine softball and baseball fields, and the Andy K. Wells Hike and Bike Trail. The Community Center, Senior Center, and amphitheater are located greater than 1,000 feet from South Nolan Creek. The Rotary Children's Park includes a playground and covered area and is located about 125 feet from South Nolan Creek. The ball fields are 100—200 feet from the creek. The recently completed Andy K. Wells Hike and Bike Trail follows along South Nolan Creek for the length of the complex and current long-term plans would like the Hike and Bike Trail to be extended along the creek (KPR 2009). The city of Killeen owns approximately 6,050 feet (1.15 miles) of creek-front property at the complex from South 28th Street to South 38th Street (FM 2410) that is accessible to the public.

Celebrate Killeen Festival is an annual event that takes place at the Killeen Community Center Complex in early spring. Events include children's entertainment, softball tournaments, a car show, hay rides, 5k run, multi-cultural entertainment acts, and concerts at the amphitheater. *Holiday Under the Stars* includes Christmas lights, hot chocolate, holiday tunes, and a Jingle Bell Run at the Killeen Community Center Complex in early December.

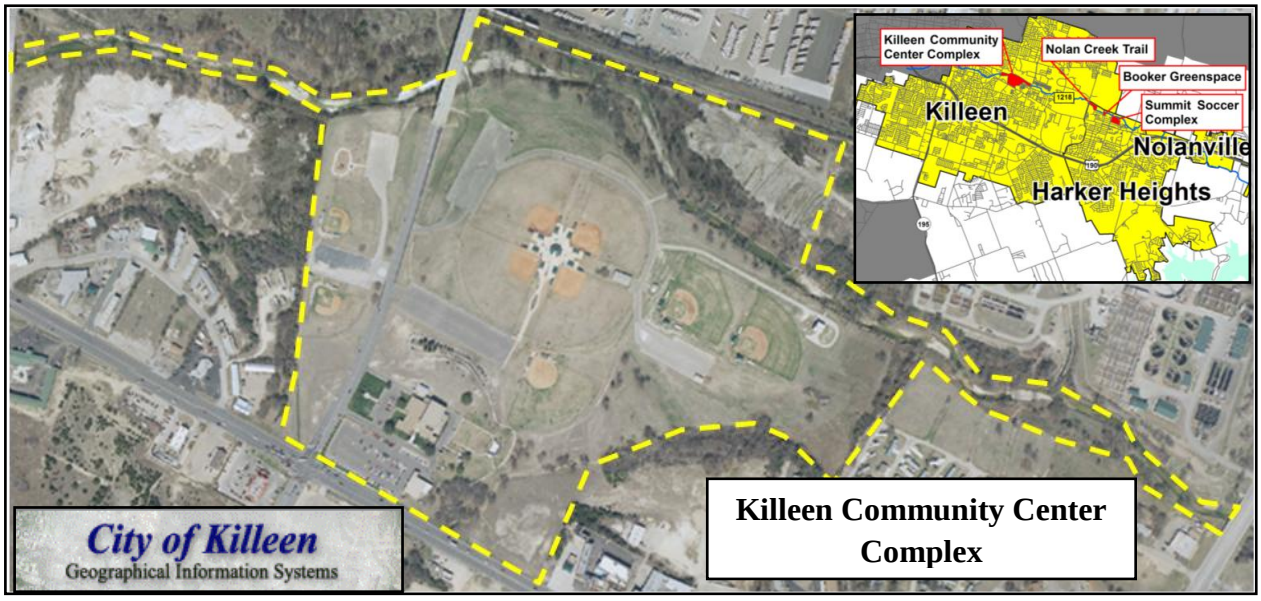


Figure 67. Killeen Community Center Complex (outlined in yellow) along South Nolan Creek (Segment 1218) in Killeen, Texas. Note: Aerial image from City of Killeen Geographical Information Systems (KGIS 2009).

2). Nolan Creek Trail, Harker Heights, Texas

Nolan Creek Trail is located east of Roy Reynolds Drive on the northern side of Nolan Creek in Harker Heights, Texas (Fig. 28). Located on approximately 15 acres, Nolan Creek Trail follows

South Nolan Creek for approximately 2,000 feet along a decomposed granite path. The area is wooded with picnic areas but, the area is not well maintained and there is no parking lot at the site.

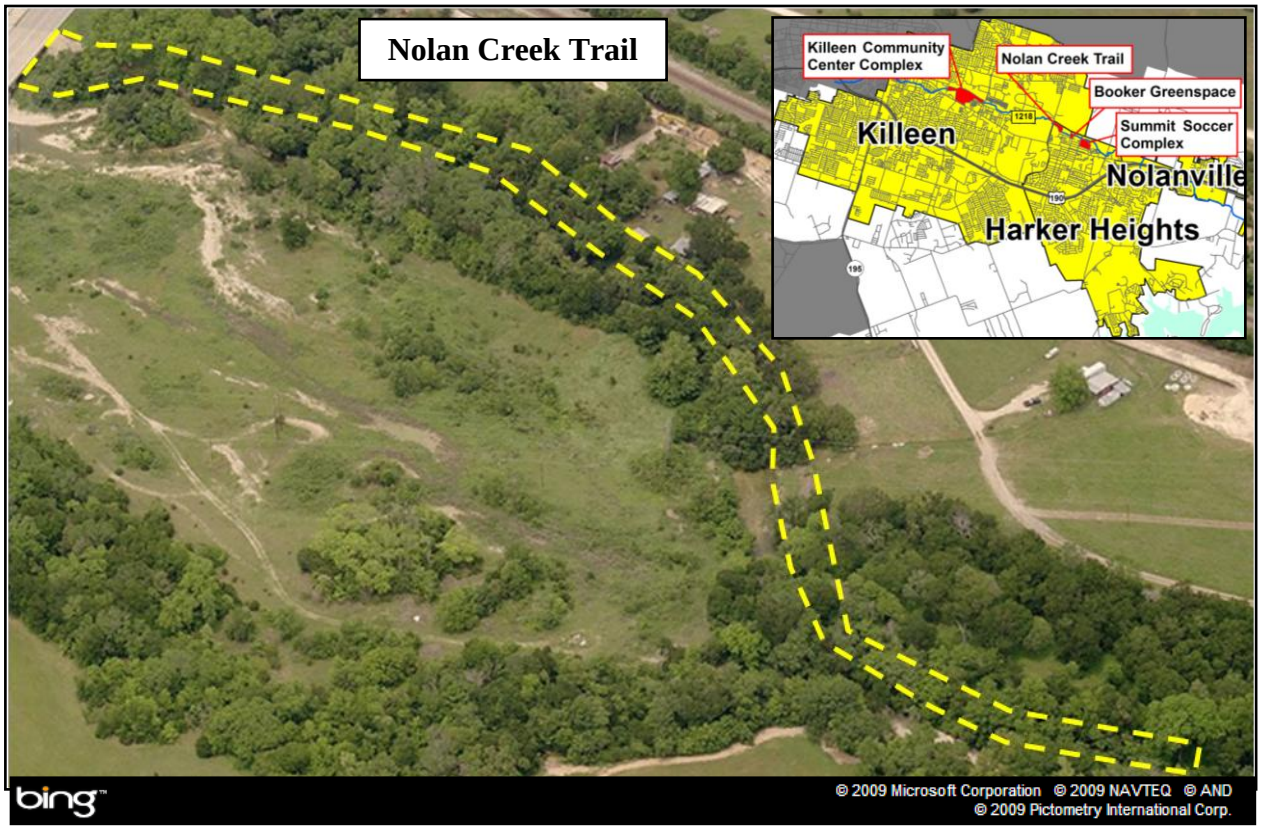


Figure 68. Nolan Creek Trail (outlined in yellow) along South Nolan Creek (Segment 1218) in Harker Heights, Texas. Note: Aerial image from ©Bing Maps: Bird's eye view (Microsoft 2009).

3). Booker Greenspace, Harker Heights, Texas

Booker Greenspace is located at the northwestern end of 504 North Amy Boulevard in Harker Heights, Texas (Fig. 29). Located on approximately one acre, Booker Greenspace is a mowed area under shade trees with picnic units and access to South Nolan Creek for approximately 250 feet.

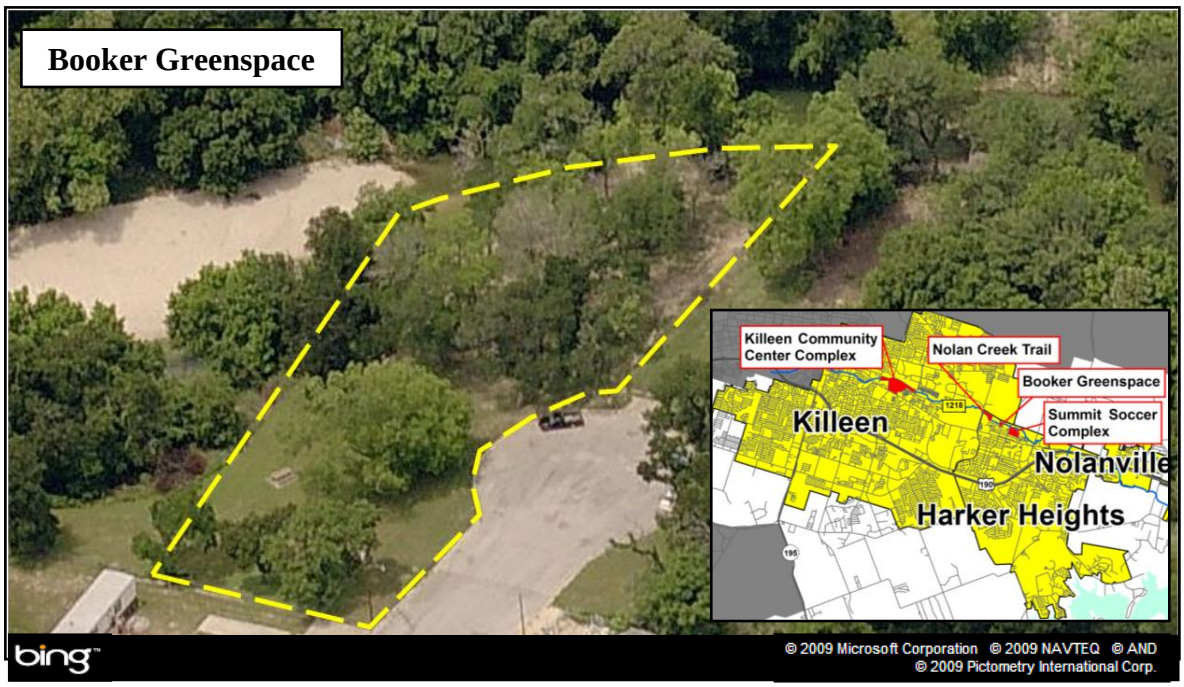


Figure 69. Booker Greenspace (outlined in yellow) along South Nolan Creek (Segment 1218) in Harker Heights, Texas. Note: Aerial image from ©Bing Maps: Bird's eye view (Microsoft 2009).

4). Summit Soccer Complex, Harker Heights, Texas

Summit Soccer Complex is located north of East Turnbo Road at 401 North Amy Lane in Harker Heights, Texas (Fig. 30). Located on approximately 33 acres, Summit Soccer Complex includes 11 soccer fields and restrooms. There is also access to approximately 1,200 feet of South Nolan Creek on the north side of the complex.

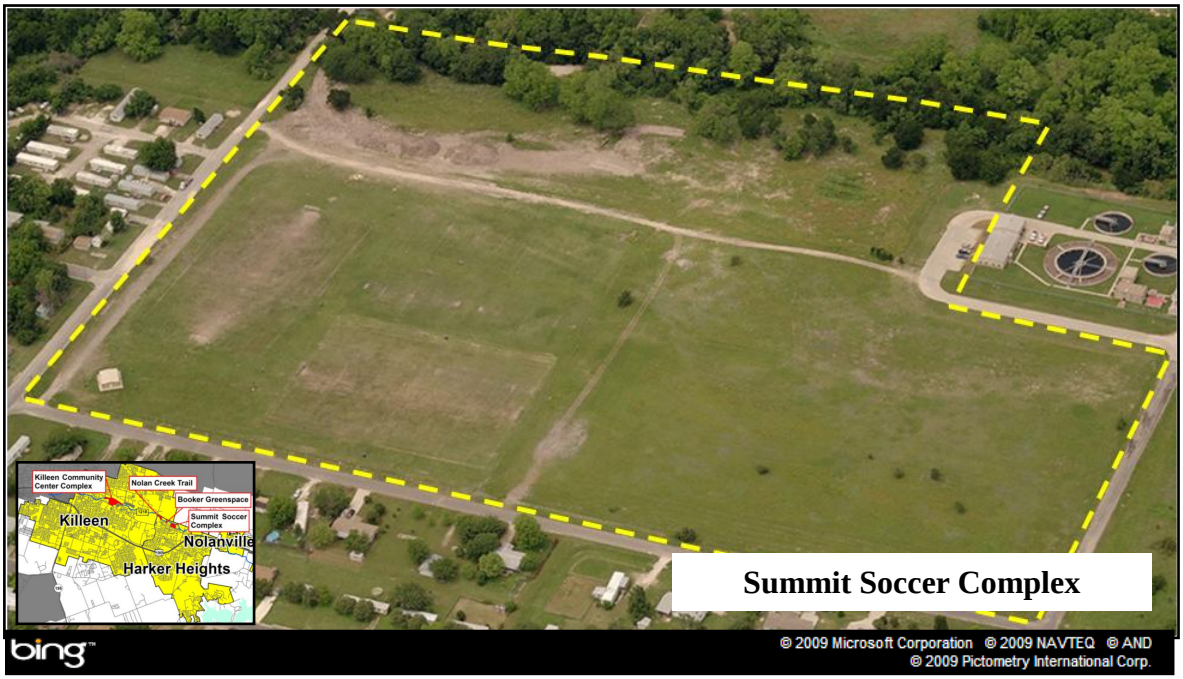


Figure 70. Booker Greenspace (outlined in yellow) along South Nolan Creek (Segment 1218) in Harker Heights, Texas. Note: Aerial image from ©Bing Maps: Bird's eye view (Microsoft 2009).

5). Lions Field, Belton, Texas

Lions Field is located south of Nolan Creek on the north side of West 5th Avenue at Smith Street in Belton, Texas (Fig. 31). Located on approximately two acres, Lions Field is a mowed area with a backstop for softball/baseball practice or unofficial games and a basketball court. Although there is not any parking at the location, there is a bike rake present. Lions Field provides access to Nolan Creek and connects to the Nolan Creek Hike and Bike Trail.

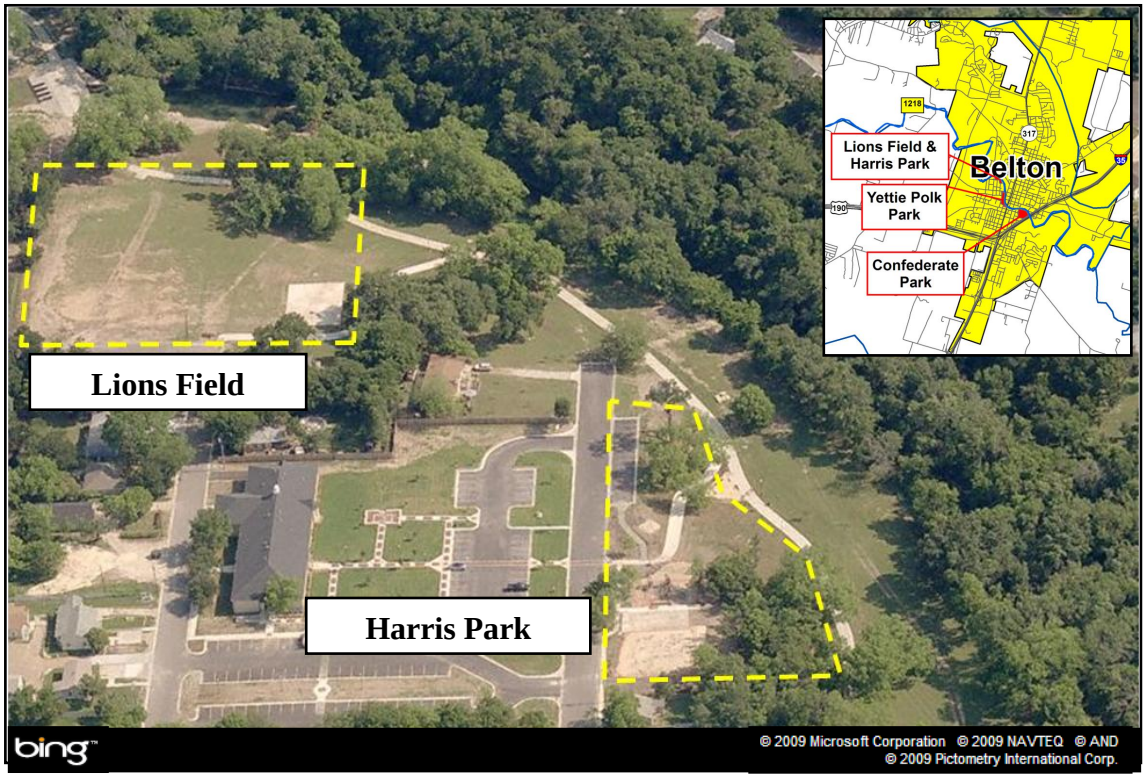


Figure 71. Lions Field and Harris Park (outlined in yellow) along Nolan Creek (Segment 1218) in Belton, Texas. Note: Aerial image from ©Bing Maps: Bird's eye view (Microsoft 2009).

6). Harris Park, Belton, Texas

Harris Park is located west of Nolan Creek on North Alexander Street across from the Harris Community Center at 401 North Alexander Street in Belton, Texas (Fig. 31). Located on approximately 10 acres, Harris Park includes restrooms, a pavilion, a summer-time aquatic splash pad, a playground, covered picnic tables, a drinking fountain, a butterfly sanctuary, and horseshoe throwing pits. Parking spaces are available. Harris Park provides access to Nolan Creek and connects to the Nolan Creek Hike and Bike Trail.

7). Yettie Polk Park, Belton, Texas

Yettie Polk Park is located along the western side of Nolan Creek from West 2nd Street to Main Street (Highway 317) in Belton, Texas (Fig. 32). Located on approximately 9 acres, Yettie Polk

Park is Belton's first city park and was established in the 1800s. Amenities include a 300-seat area with raised bandstand, playgrounds, basketball courts, picnic tables, benches, restrooms, drinking fountains, a barbecue pit area, swing sets, and parking lots. The park provides access to Nolan Creek and connects to the Nolan Creek Hike and Bike Trail.

Thousands of visitors are attracted to Yettie Polk Park and Confederate Park for the annual July 4th Celebration that has taken place for greater than 80 years. As part of the Belton Rodeo, the *Festival on Nolan Creek* includes a fiddler's contest, arts & craft booths, western apparel vendors, kids games, a food court, a parade, patriotic programs, petting zoo, pony rides, and more (BCC 2009). Christmas light events also take place at the park. Texas Parks and Wildlife has annually released Rainbow trout [*Oncorhynchus mykiss*] in the winter for immediate capture into Nolan Creek along Yettie Polk and Confederate parks since the early 1990s (TPWD 2009*b*).

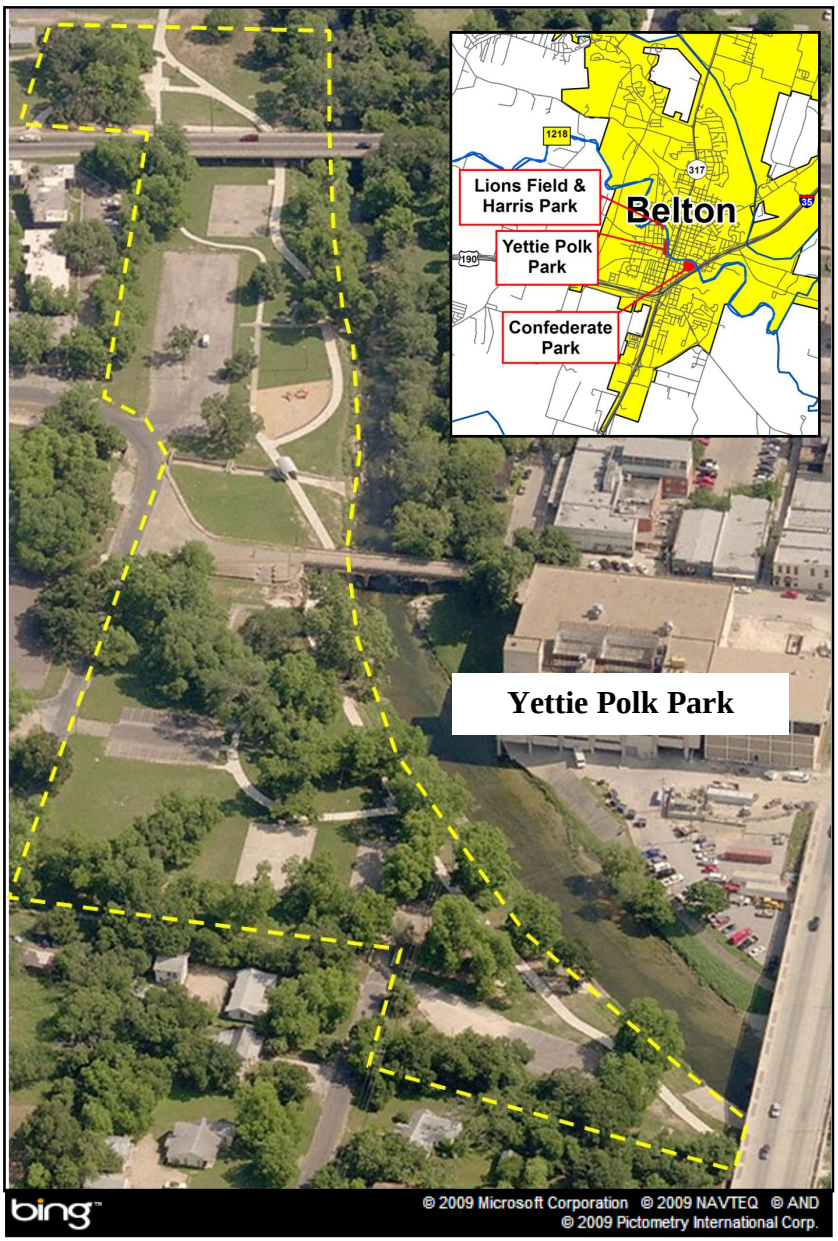


Figure 72. Yettie Polk Park (outlined in yellow) along Nolan Creek (Segment 1218) in Belton, Texas. Note: Aerial image from ©Bing Maps: Bird's eye view (Microsoft 2009).

8). Confederate Park, Belton, Texas

Confederate Park is located along the southern side of Nolan Creek west of Interstate 35 at Confederate Park Drive in Belton, Texas (Fig. 33). Located on 15 acres, Confederate Park was the second park developed in Belton to honor ex-Confederate veterans in the late 1800s. A portion of the park is used as a Park and Ride facility for the Temple, Killeen, and Austin area. Park amenities include a pavilion, a playground, a basketball court, a restroom, a water fountain, and security lighting. The park provides access to Nolan Creek and connects to the Nolan Creek Hike and Bike Trail.

Thousands of visitors are attracted to Yettie Polk Park and Confederate Park for the annual July 4th Celebration that has taken place for greater than 80 years. As part of the Belton Rodeo, the *Festival on Nolan Creek* includes a fiddler's contest, arts & craft booths, western apparel vendors, kids games, a food court, a parade, patriotic programs, petting zoo, pony rides, and more (BCC 2009). Texas Parks and Wildlife has annually released Rainbow trout [*Oncorhynchus mykiss*] in the winter for immediate capture into Nolan Creek along Yettie Polk and Confederate parks since the early 1990s (TPWD 2009*b*).

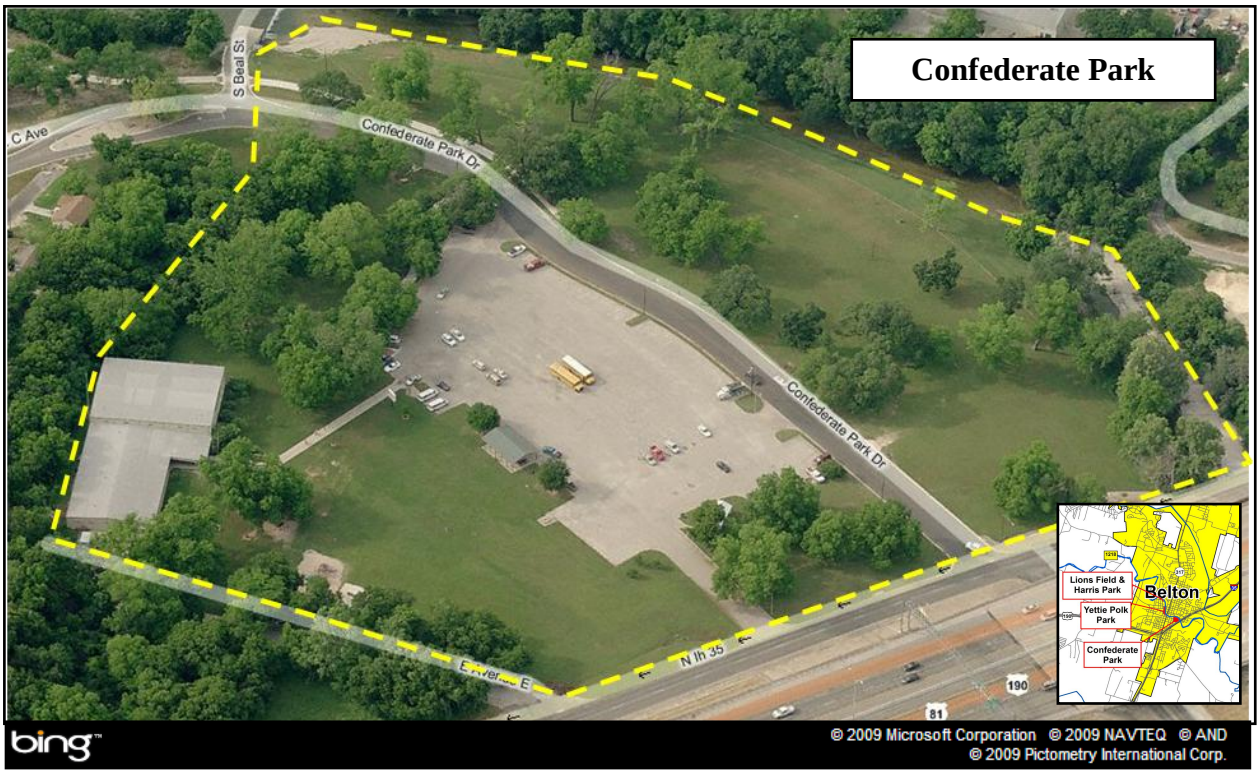


Figure 73. Confederate Park (outlined in yellow) along Nolan Creek (Segment 1218) in Belton, Texas. Note: Aerial image from ©Bing Maps: Bird's eye view (Microsoft 2009).

9). Nolan Creek Hike and Bike Trail, Belton, Texas

The Nolan Creek Hike and Bike Trail is located along Nolan Creek and follows Nolan Creek from North Sparks Street to Interstate 35 (Fig. 34). The Nolan Creek Hike and Bike Trail is a 1.25 mile long, concrete path with multiple pocket parks (i.e., benches, picnic tables, bike racks) that connects Lions Field, Harris Park, Yettie Polk Park, and Confederate Park together. The trail varies in distance from Nolan Creek with open access to the creek for the length of the trail.

At the north end of the trail, there is a low water crossing bridge. The bridge is used by Girl Scouts and Boy Scouts for their bridging ceremonies which recognize the transition of an individual to a higher skill level within the organization. Future plans call for the Nolan Creek Hike and Bike Trail to be extended in both directions along Nolan Creek (Belton 2009).

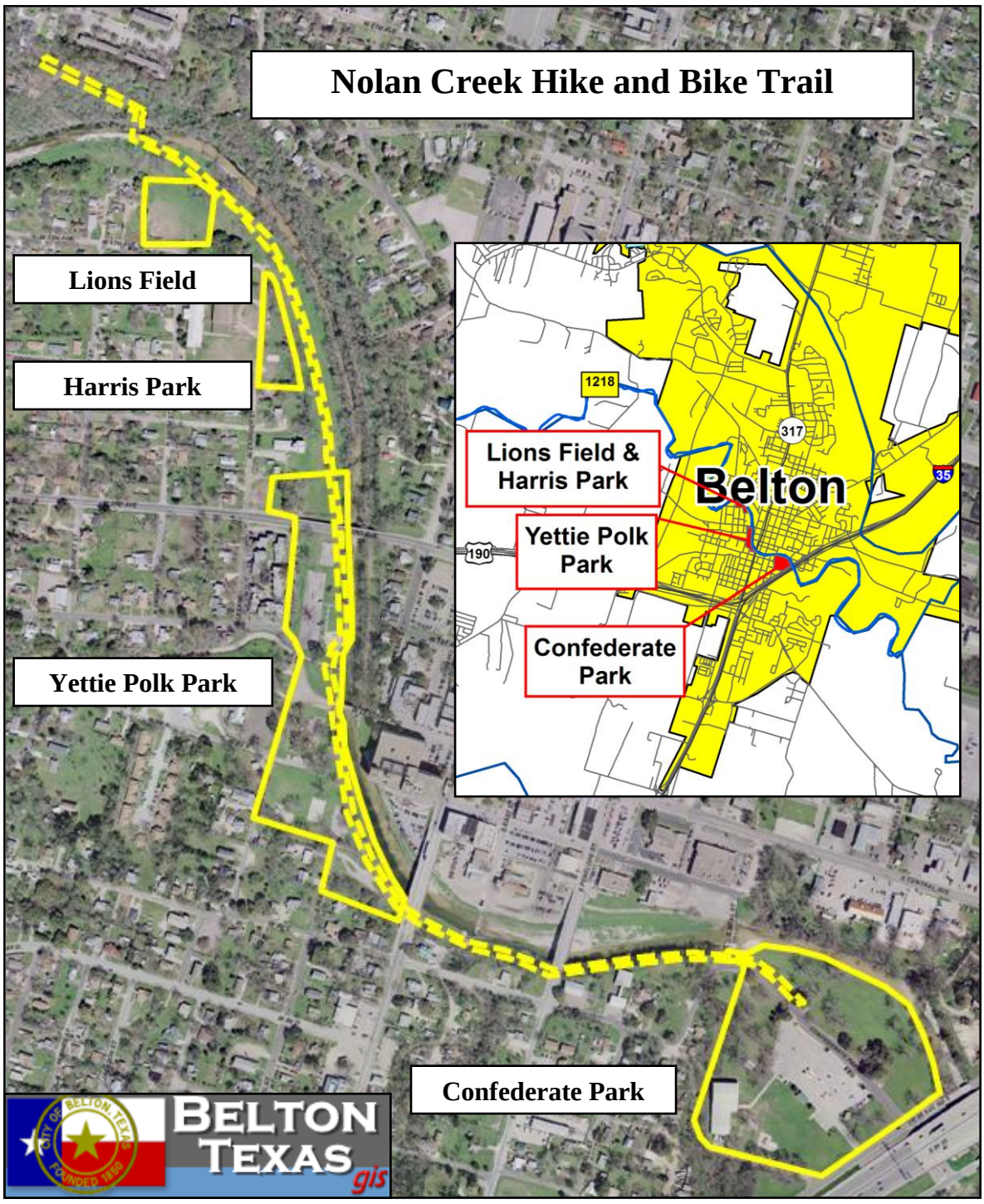


Figure 74. Nolan Creek Hike and Bike Trail (outlined in yellow) along with associated parks in Belton, Texas. Note Aerial image from the Belton Geographic Information Systems (BGIS 2009).

Nolan Creek/ South Nolan Creek (Segment 1218) is described in the 2004 *Texas Whitewater* by S. H. Daniel as a whitewater kayaking destination for a few Class II—III rapids when the creek is up. The author suggests putting in at Backstrom Crossing Road, east of Nolanville, Texas just

upstream from where South Nolan Creek combines with North Nolan Creek. He suggests taking out 7 miles downstream at Interstate 35 in Belton.

Fishing is documented in Nolan Creek with the Texas Parks and Wildlife Department annually stocking Rainbow trout [*Oncorhynchus mykiss*] during the winter months into Nolan Creek near Yettie Polk Park and Confederate Park, in Belton City limits since the early 1990's (TPWD 2009*b*). Several low dams across Nolan Creek keep the trout in the area. There is also evidence of preferred native fish species inhabiting Nolan Creek (Stanley 2009, TPWD 2004, USFWS 1998).

Historical Accounts of Recreation on Nolan Creek/ South Nolan Creek

Accounts of historical recreation along Nolan Creek/ South Nolan Creek are limited. There are photos of row boats for rent at one of the annual July 4th Celebrations at Yettie Polk and Confederate Park in the 1920s (Bowmer 1976). There are also old photos of children sitting and wading into what is believed to be Nolan Creek in Belton city limits in the 1920s as well (FLICKR 2008). The 1938 issue of *The Texas Outlook*, a newsletter by the Texas State Teachers Association states that Nolan Creek is a popular picnic spot (TSTA 1938).

In addition to historical accounts, 17 interviews of local landowners and residents were interviewed about their knowledge of past and present Nolan Creek recreational use for this study in the summer of 2009. Landowner accounts confirm that swimming, wading, kayaking, and fishing have taken place in the past.

Classified Stream Segment 1255 (Upper North Bosque River): From a point immediately above the confluence of Indian Creek in Erath County to the confluence of the North Fork and South Fork of the Bosque River in Erath County.

The Upper North Bosque River (Segment 1255) is located within the USGS Hydrologic Unit 12060204: Texas-Gulf Region > Middle Brazos Subregion > Middle Brazos-Bosque > North Bosque (USGS 2009*a*). The North Bosque hydrologic unit, or watershed, encompasses approximately 1,240 square miles of Bosque, Coryell, Erath, Hamilton, McLennan, and Somervell counties in North Central Texas. The Upper North Bosque River (Segment 1255) portion of the watershed is approximately 116 square miles (Fig. 35).

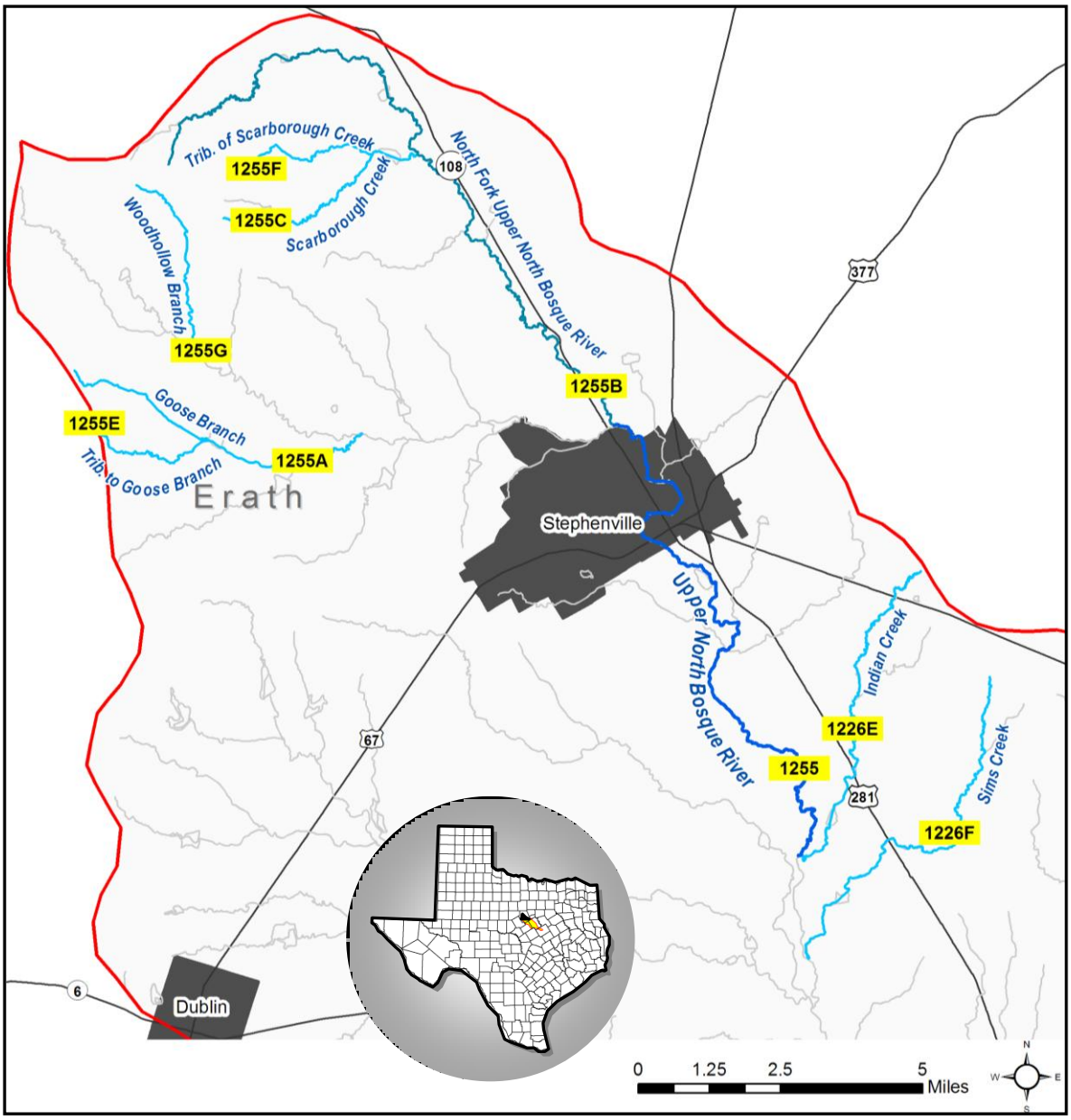


Figure 75. Upper portion of North Bosque Hydrologic Unit (12060204) with associated 2009 TCEQ Recreational Use Attainability Analysis Study streams highlighted, North Central Texas.

Segment 1255 (Upper North Bosque River) is 17.5 miles long and flows in a southeasterly direction from an elevation of 1,250 feet at the confluence of the North Fork Upper North Bosque River (Segment 1255B) and the South Fork North Bosque River (Segment 1255D) just north of Stephenville, Texas to an elevation of 1,140 feet at the confluence with Indian Creek (Segment 1226E) to form the North Bosque River (Segment 1226) in Erath County, Texas (TNRIS 2009). Average stream gradient is approximately 6.3 feet per mile.

Upper North Bosque River (Segment 1255) Problem History

The Upper North Bosque River (Segment 1255) was first listed on the Texas 303(d) list of impaired waterways for exceeding the safe bacteria criterion for contact recreation in 1998. This

report is meant to provide data to better categorize the current recreational uses of the Upper North Bosque River (Segment 1255).

Upper North Bosque River Local Population

The Upper North Bosque River (Segment 1255) flows through a portion of Erath County, Texas. A general description of the local population follows with data from the United States Census Bureau (Census 2009).

Erath County covers 1,090 square miles, and had an estimated population of 33,001 (30.3 persons/mi^2) in 2000. The population has increased by about 82 percent since 1970 (Fig. 36). Approximately 55 percent of the population lives in urban areas. The largest urban area is the city of Stephenville with a population of 14,989. The other urban area in Erath County is Dublin (3,754 residents). The Upper North Bosque River (Segment 1255) passes through the urban area of Stephenville (bordering two public areas). Dublin is approximately 13 miles from the segment.

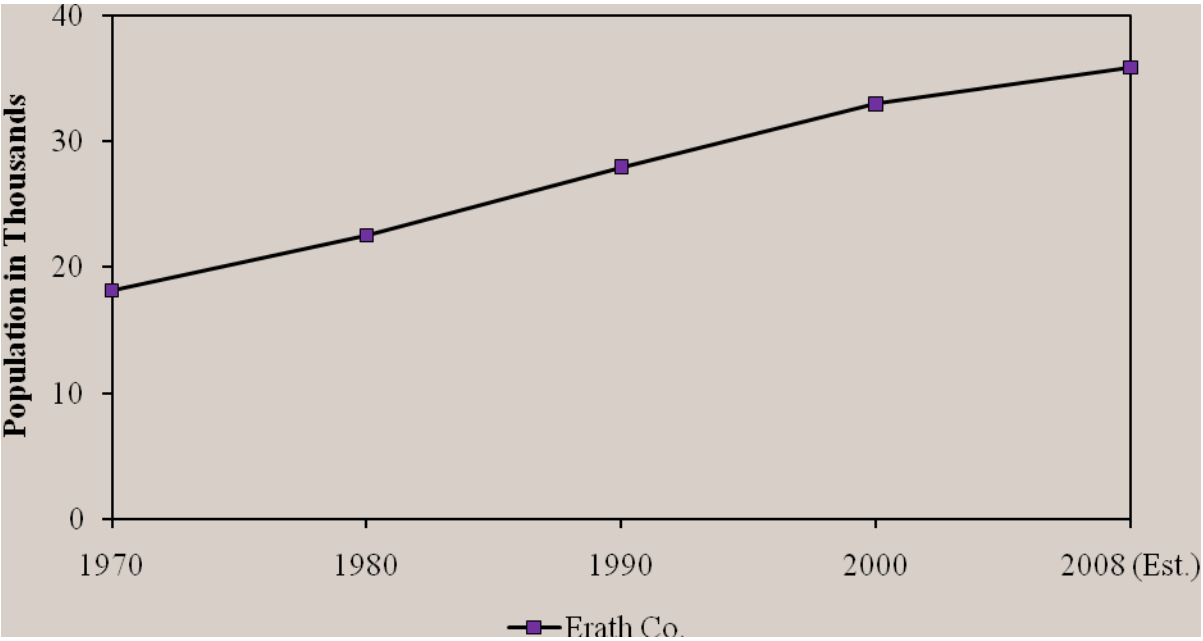


Figure 76. Decennial U.S. Census population values for Erath County, Texas (1970—2000); Census 2009). Note: Year 2008 population values are preliminary estimates.

Upper North Bosque River Land Use

Land use data for the upper portion of the watershed were based on the United States Geological Survey (USGS) National Land Cover Dataset (NLCD) 1992—2001 Land Cover Retrofit Change Product (Fry et al. 2009). Derived from Land-sat Thematic Mapper satellite data, the NLCD is a classification scheme for land cover applied consistently over the United States. The spatial resolution of the dataset is 30 meters. Land uses were grouped into seven Anderson Level I land use classifier categories (Fry et al. 2009). Current (i.e., 2001) land uses for the upstream lands of

North Bosque Hydrologic Unit are shown in Figure 37. Total area by land use and percentages are shown in Figure 38.

Currently (i.e., 2001) approximately 57 percent of the Upper North Bosque River's watershed land use is classified as Grassland/Shrub that is distributed throughout the watershed (Figs. 37 & 38). Agriculture accounts for approximately 20 percent of land use and is concentrated along flood plains of the various small streams throughout the watershed. Forest (≈ 11% of land use) is found in small patches along some streams and higher hills and ridges. Several large patches of Forest are located northwest of Stephenville. Urban land use covers approximately 9 percent of the watershed and is centered at the city of Stephenville. Wetland (≈ 2% of land use) is found along the headwaters of some streams as well as man-made ponds and floodwater retarding structures (dams). Water and Barren comprise less than 1 percent of land use each.

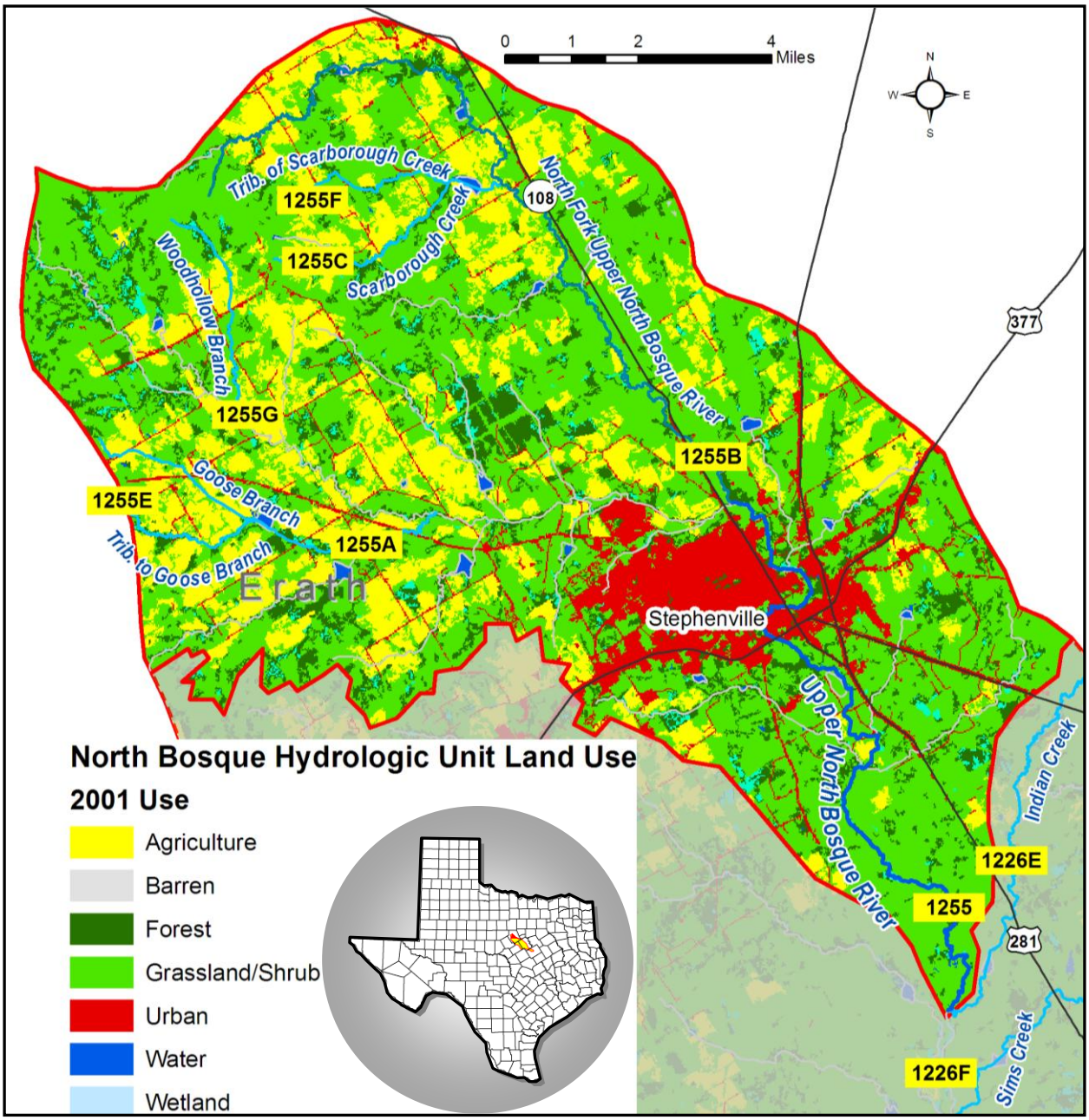


Figure 77. Anderson Level I land uses for the Upper North Bosque River watershed based on the 1992--2001 Land Cover Retrofit Change Product (Frey et al. 2009).

Upper North Bosque River Land Use Changes

Land Use Change Data for the watershed were based on the United States Geological Survey (USGS) 1992—2001 Land Cover Retrofit Change Product (LCRCP; Fry et al. 2009). Derived from the 1992 National Land Cover Dataset (captured in the late 1980s to early 1990s) and the 2001 National Land Cover Dataset (captured in the early 2000s), the LCRCP is a reclassification of both the 1992 and 2001 dataset so that direct comparisons can be made use the Anderson Level I land use classifiers (Fry et al. 2009). The spatial resolution of the dataset is 30 meters.

Pixels that changed land use from the 1992 dataset to the 2001 dataset for the Upper North Bosque River watershed are shown in Figure 39 with the current (i.e., 2001) land use represented. Losses, gains, and net change in land use acres and percentages are shown in Figure 40.

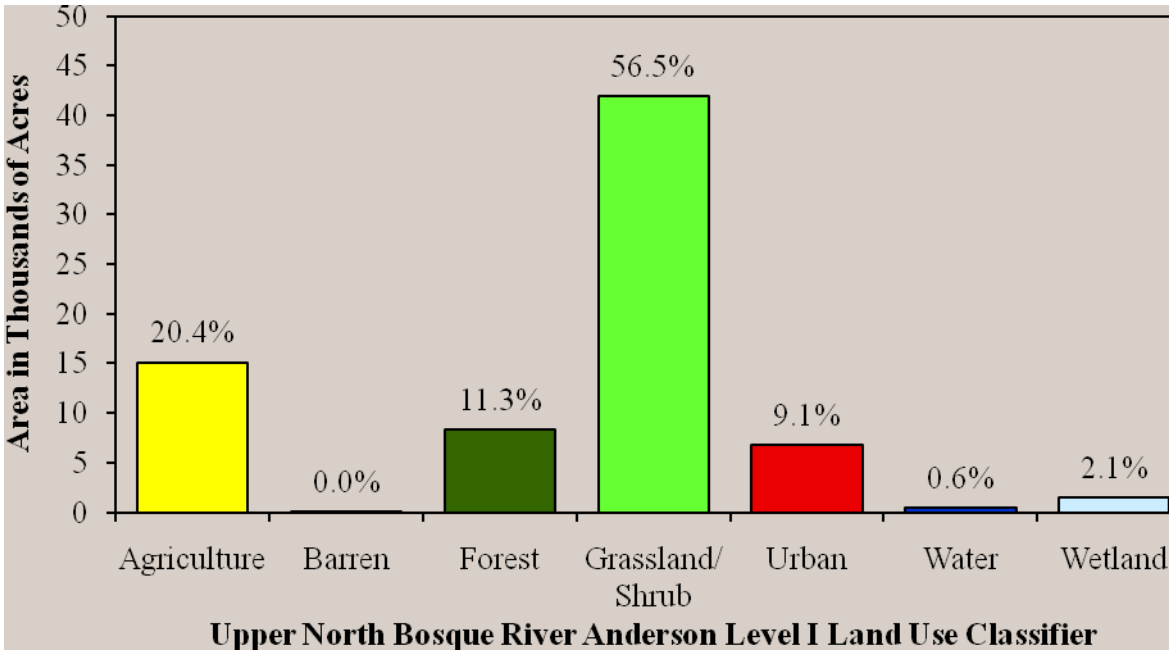


Figure 78. 2001 Land use areas and percentages for the Upper North Bosque River watershed; data from Frey et al. 2009.

Approximately 1.4 percent (1,048 acres) of the Upper North Bosque River watershed was shown to have changed land use from 1992 to 2001 (Fig. 39). The greatest land use change was from Forest to Agriculture, which accounted for approximately 42 percent (436 acres) of land use changes. The second greatest land use change was from Forest to Grassland/Shrub (≈23%, 241 acres). Grassland/Shrub to Urban (≈10%, 105 acres) and Grassland/Shrub to Agriculture (≈9%, 93 acres) represented the third and fourth largest changes in land use for the watershed. Agriculture to Grassland/Shrub accounted for 4 percent (42 acres) of land use changes. Grassland/Shrub to Forest accounted for approximately 3 percent (29 acres) of land use changes. Combined, the remaining land use changes accounted for less than 10 percent (100 acres) of land use changes.

Agriculture land use gains appear to be concentrated along the North Fork Upper North Bosque River watershed and associated tributaries (Fig. 39). Urban land use gains were greatest in Stephenville city limits. Grassland/Shrub and Forest land use gains were sparsely scattered throughout the watershed.

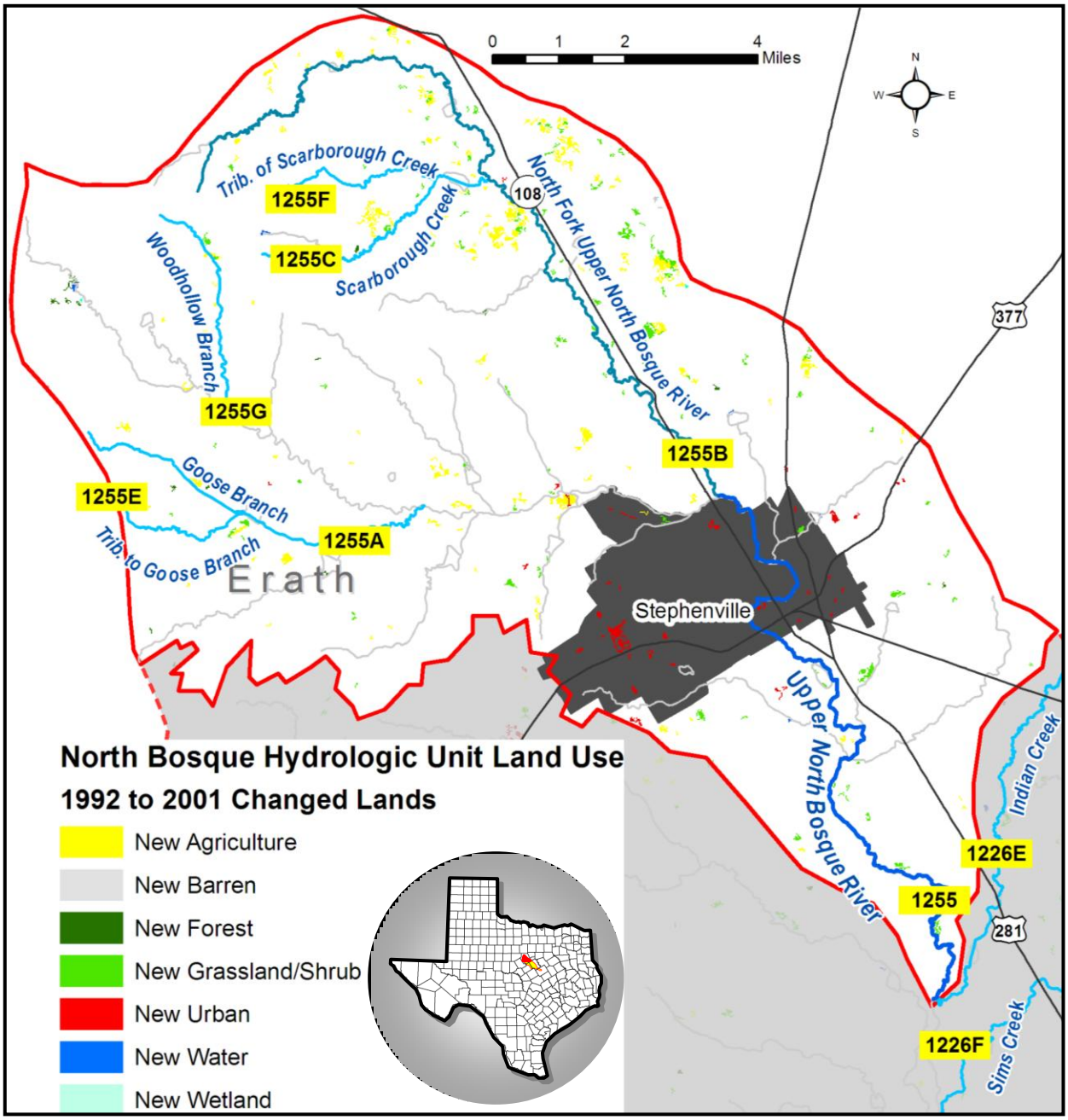


Figure 79. 1992--2001 changes in Anderson Level I land uses for the Upper North Bosque River watershed based on the 1992--2001 Land Cover Change Retrofit Product (Frey et al. 2009). 2001 land uses are shown.

Upper North Bosque (Segment 1255) Water Availability

The Upper North Bosque River (Segment 1255) is close to the headwaters of the North Bosque Hydrologic Unit (12060204) in Erath County. No major reservoirs are found in the Upper North Bosque River portion of the watershed. However, there are numerous floodwater retarding dams on the tributaries of Segment 1255. There is a wastewater treatment outfall at Stephenville along Segment 1255.

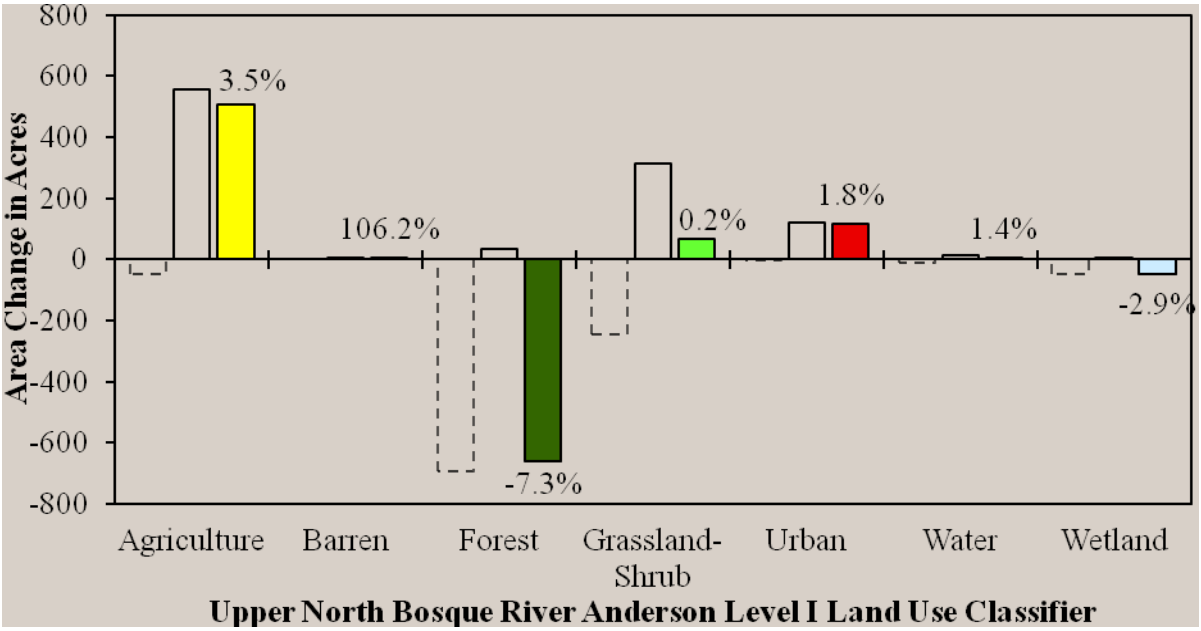


Figure 80. 1992—20001 changes in land use area (gross losses = dashed bars, gross gains = solid white bars, net change = colored bars with percentages) for the Upper North Bosque River. Data from Fry et al. 2009.

Upper North Bosque River water availability data were based on the USGS National Water Information System Website daily streamflow values (USGS 2009*b*). The Upper North Bosque River (Segment 1255) has one monitored streamflow gauge.

USGS Gauge 08093700 North Bosque River at Stephenville, Erath County, TX

The Upper North Bosque River (Segment 1255) has been monitored by Gauge USGS 08093700 where it crosses Texas State Highway 108 (South Graham Avenue) just before it enters Stephenville City Park in Stephenville, TX from 1958—1979. The drainage area for the gauge is 95.9 square miles.

Flow duration curves provide a probabilistic description of streamflow at a given location by plotting the percentage of time that flow in a stream is likely to equal or exceed some specified value of interest (OSU 2005). High flow and low flow conditions are categorized as those streamflows that account for the top ten percent and bottom ten percent of recorded daily flows (Cleland 2002*a* and 2002*b*). Mid-range flows present the central 20 percent of recorded daily flows. The flows between high flows and mid-range flows are considered moist conditions, while the flows between mid-range flows and dry conditions are dry conditions. Moist conditions and dry conditions account for 60 percent of recorded daily flows (30% each). Flow duration curves, based on 1958—1979 recorded daily streamflow for the USGS gauge on the Upper North Bosque River (Segment 1255) are displayed in Figure 41.

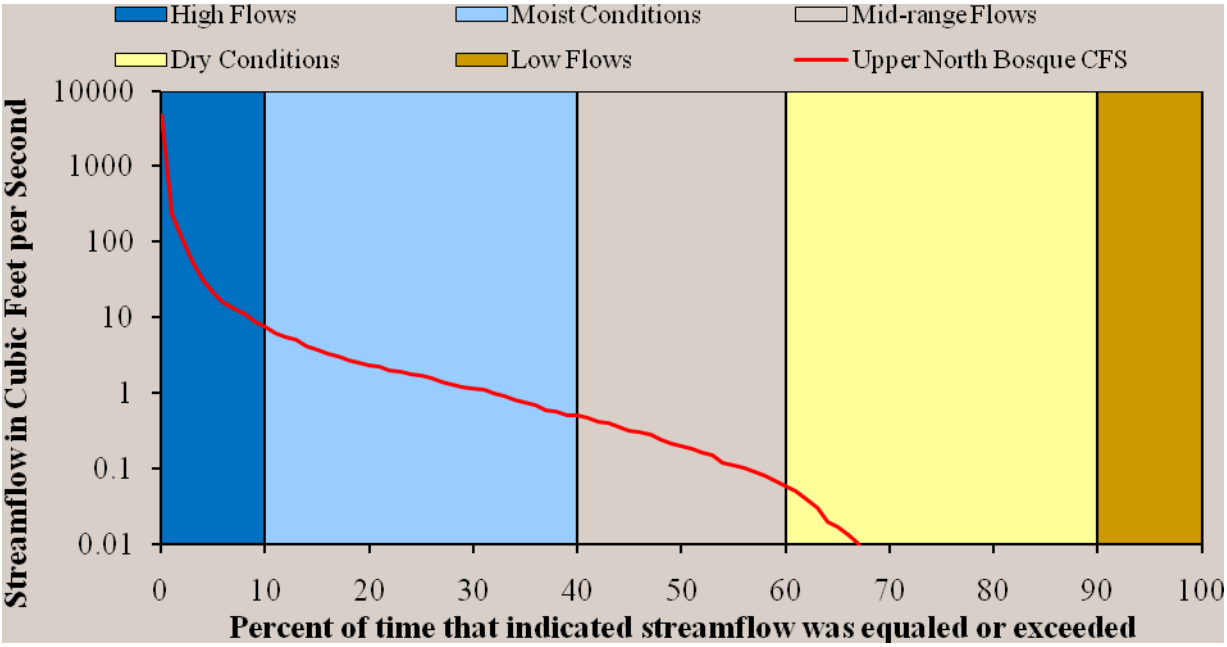


Figure 81. Flow duration curve for the Upper North Bosque River (Segment 1255) at USGS Gauge 08093700 at Stephenville, Texas. Data are from 1958—1979.

The highest 1958—1979 streamflow recorded for the Upper North Bosque River (Segment 1255) was 4,720 cubic feet per second (Fig. 41). Minimum streamflow was zero feet per second. Streamflow boundaries for the various flow duration curve categories are listed in Table 3. Over 30 percent of the time, streamflow was zero cubic feet per second at the gauge.

Table 6. Flow duration curve boundaries for the Upper North Bosque River (Segment 1255) at USGS Gauge 08093700, 1958—1979.

Flow Duration Curve Category	USGS Gauge Streamflow (Cubic Feet per Second)
	Upper North Bosque River (USGS Gauge 08093700)
High Flows	>7.9
Moist Conditions	0.5—7.9
Mid-range Flows	0.06—0.5
Dry Conditions	0—0.06
Low Flows	0

On an annual basis, 1970—1979 median monthly Upper North Bosque River streamflows showed a spike in last spring (April—Jun) likely due to rainfall (Fig. 42). This spike was followed by the hot summer months of July, August, and September having little to no streamflows. Streamflows starts to return in the fall months of October and November.

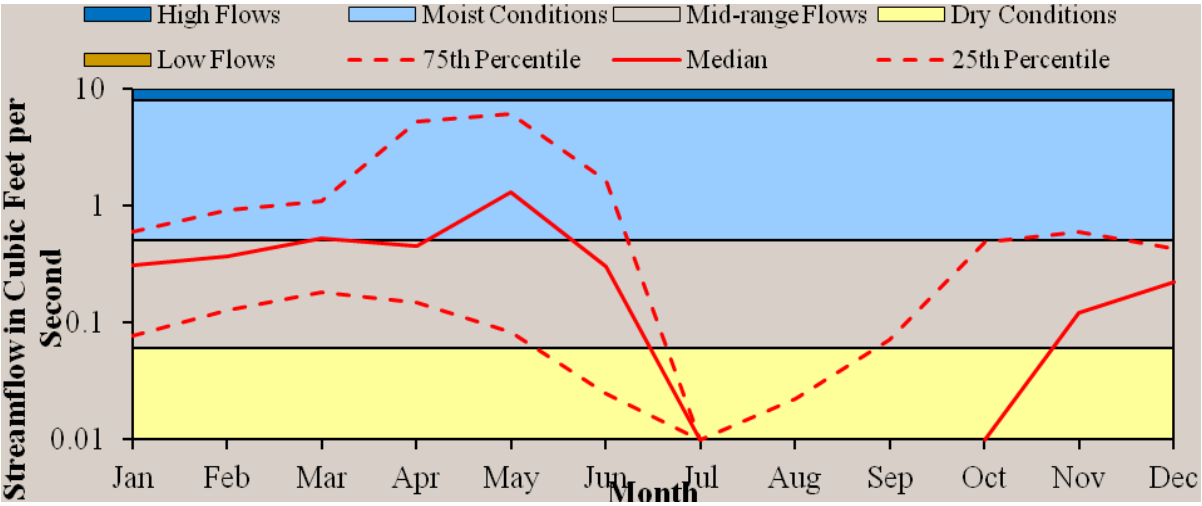


Figure 82. Median, 75th percentile, and 25th percentiles of monthly median streamflow of the Upper North Bosque River (Segment 1255) at USGS gauge 08093700 with comparison to its flow duration curve values, 1970—1979.

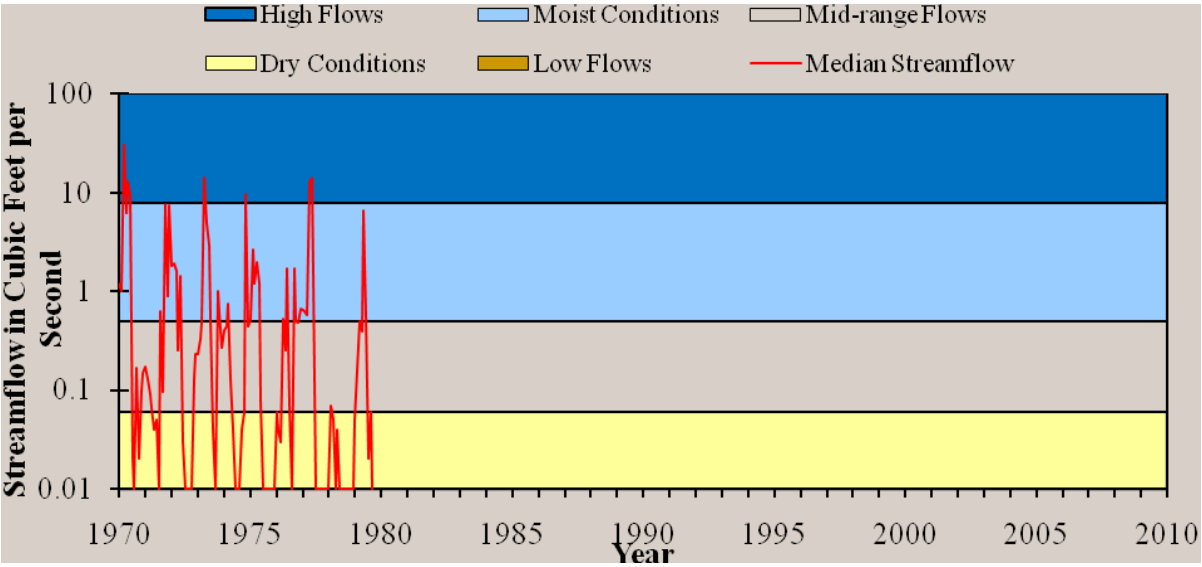


Figure 83. Median streamflow of the Upper North Bosque River (Segment 1255) at USGS gauges 08093700 with comparison to its respective flow duration curve values, 1970—2009. Data only available for 1970—1979.

Historical (1970—2000), median Upper North Bosque River streamflow data is only available from 1970 to 1979 (Fig. 43). Although no long-term trends can be seen from the available data, it can be seen that the stream stopped flowing every year on record.

Recreational Access along the Upper North Bosque River (Segment 1255)

The Upper North Bosque River is a relatively short segment (17.5 miles) mostly surrounded by private property. However, the segment intersects eight public roadways along its length with seven of those roadways inside Stephenville city limits. In addition to the road crossings, there are two public access areas along the segment (Stephenville Historical House Museum and Stephenville City Park).

1). Stephenville Historical House Museum, Stephenville, Erath County, Texas

The Stephenville Historical House Museum is located at 525 East Washington Street (Texas State Highway 195) on the southern side of the Upper North Bosque River in Stephenville, Texas (Fig. 44). Located on approximately four acres, the museum is a collection of nineteenth century structures (currently ten) furnished with period furniture and artifacts. Used as a popular spot for family photos, no admission is charged and the grounds are open all day every day (SHHM 2009). A 1/10th-mile, self-guided nature trail borders the Upper North Bosque River on the property.

Two scheduled one-day events take place at the museum annually. *Bygone Days* is a historical reenactment of nineteenth century living held in October. The *Native & Heirloom Plant Fair* is held in the spring. Both events are free to the public and include concessions.

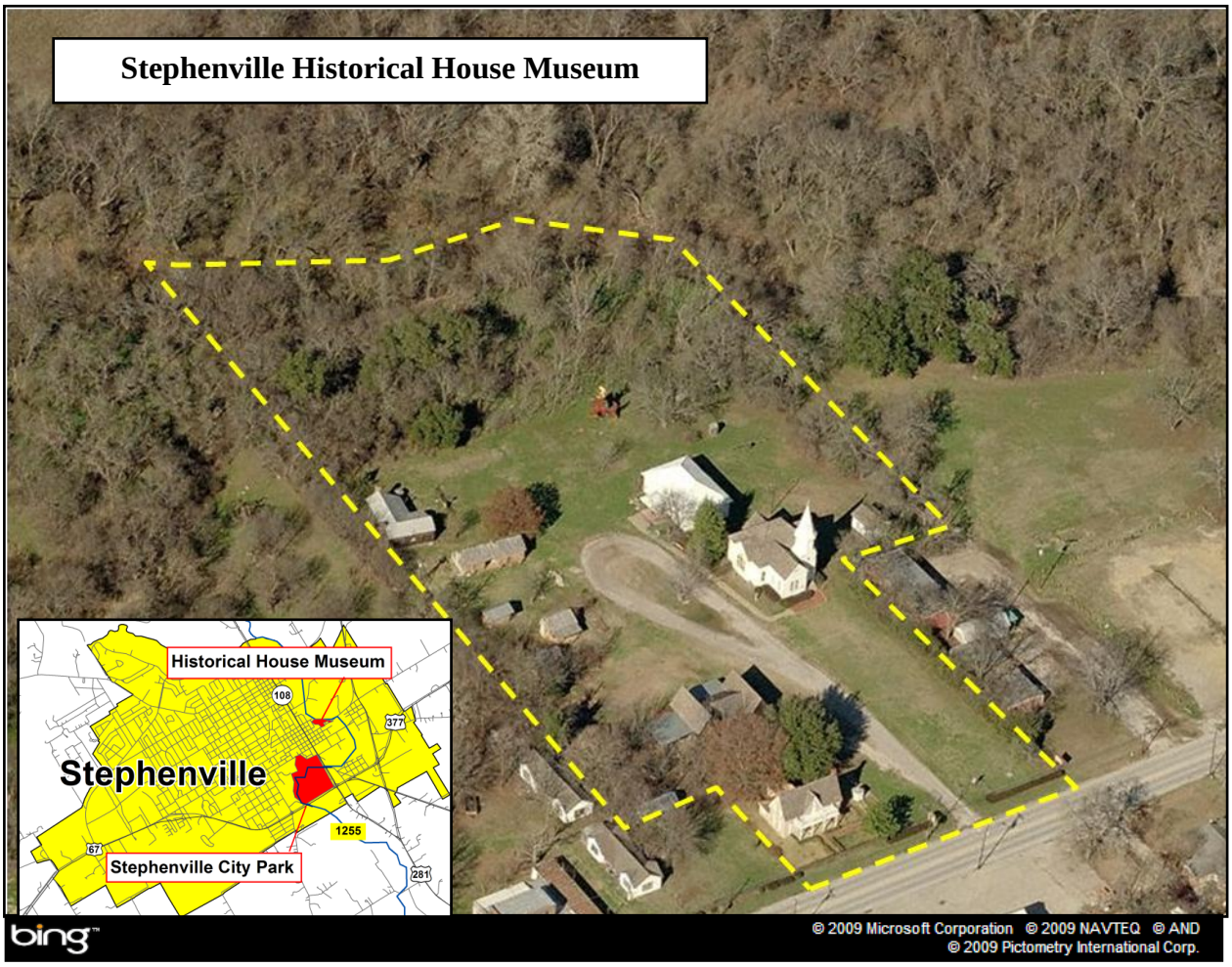


Figure 84. Stephenville Historical House Museum (outlined in yellow) along the Upper North Bosque River (Segment 1255) in Stephenville, Texas. Note: Aerial image from ©Bing Maps: Bird's eye view (Microsoft 2009).

2). Stephenville City Park, Stephenville, Erath County, Texas

Stephenville City Park is located north of United States Highway 67/377, off of South Graham Street (Texas State Highway 108) on the southeastern side of the Upper North Bosque River in Stephenville, Texas (Fig. 45). Located on 120 acres, Stephenville City Park is Stephenville's largest and most popular park. Amenities include 1.3 mile walking trail along the Upper North Bosque River, an outdoor stage, a recreation hall, two pavilions, a riverside gazebo, picnic areas with grills, playgrounds, horseshoe courts, tennis courts, volleyball courts, basketball courts, softball and baseball fields, a soccer field, a water park, a skate park, and RV hook-ups with water and electricity. There is a fishing pier in a deeper pool of the river inside of the park.

The Stephenville Bass Club has sponsored a Stephenville *Fish Day in the Park* for the past eight years at the park. Fish Day draws hundreds of visitors to the park in an attempt to catch newly-released catfish in the deeper pool of the river at the center of the park (SBC 2008).

Daily users, organized sports, weddings, and family reunions take place at the park. *DairyFest* is a one-day festival that takes place in June at the park to promote the influence of the dairy industry in the area with dairy-related food, games, a 5K run, and entertainment (TCAA 2009). Other events held at the park include fourth of July celebrations and Cinco de Mayo.

Upper North Bosque River Recreational Use Reference in Publications

The Upper North Bosque River (Segment 1255) is not referenced directly in any publications but is considered when describing the Bosque River. The Bosque River up to Texas State Highway 108 is mentioned in *An Analysis of Texas Waterways: A Report on the Physical Characteristics of Rivers, Streams, and Bayous in Texas* prepared by the Texas Parks and Wildlife Department (TPWD) in 1974 and *A Guide to Texas Rivers and Streams* by G. Kirkley in 1983. Both books describe the upper reaches of the Bosque River in Erath County as a narrow, free-flowing clear stream that is typically too shallow for recreational use, however; it is said to have the potential to be a good recreational waterway during periods of heavy rain.

The North Bosque River (downstream from segment 1255) is mentioned in *Texas Whitewater* by S. H. Daniel as a whitewater kayaking destination during high flow events between Hico, Texas and Iredell, Texas in Hamilton and Bosque Counties.

Fishing in the Upper North Bosque River is described in *Flyfisher's Guide to Texas* by P. H. Shook as having deeper holes that will hold fish. Below Erath County, the Bosque River is said to be an excellent river for flyfishing. Other studies have also verified the presence of gamefish in the Upper North Bosque River (Segment 1255; TIAER 2000, TPWD 1989).

Figure 85. Stephenville City Park (outlined in yellow) along the Upper North Bosque River (Segment 1255) in Stephenville, Texas. Note: Aerial image from the North Central Texas Council of Governments (NCTCOG 2009).

Historical Accounts of Recreation on the Upper North Bosque River

Personal accounts of historical recreation along the Upper North Bosque River (Segment 1255) are limited. The Bosque River Coalition states that swimming and fishing in the Upper North Bosque River has occurred for generations in Erath and Bosque Counties (BRC 2009).

Local landowner and resident interviews conducted in the summer of 2009 confirmed that the segment has been used for swimming and fishing in the past.

Methods

Creation of a GIS Project

An ESRI ArcMap GIS project was created to acquire the information needed to carry out the RUAA site surveys. Stream shapefiles were obtained from TCEQ. Shapefiles of Texas counties, cities, major roads, and stream point sources (tx_wastewtr outfall) were obtained from TCEQs Atlas of Texas Surface Waters. A watershed shapefile (basinspy) was obtained from Texas Parks and Wildlife. Aerial photographs (2004 NAIP 1m) and street shapefiles were obtained from the Texas Natural Resources Information System. Shapefiles (polygons) of private property parcels were obtained from county property appraiser offices. In many cases these private property parcel polygon shapefiles were created by digitizing the paper maps of the property appraiser offices. A shapefile (Park Lands Combined) containing all known recreation areas in the study area was created. This shapefile includes data from the 2005 TPWD Land and Water Resources Conservation and Recreation Plan Layers, TNRIS StratMap layers, and parks and recreation areas from websites including College Station Parks GIS, Williamson County Open Spaces, and local authorities. The TPWD shapefiles include cityparkspy, countyparkspy, fed_adminbndpy, fed_propbndypy, fed_wildareaspy, nonprofitspy, other_statelandspy, riverauthparkspy, tpw_propbndypy, and tpw_propbndypy_org. The TNRIS shapefiles include StratMapv2_Park_poly and StratMapv2_Cultural_poly.

Sampling Design and Site Selection

Systematic and purposive sampling methods were used to select survey sites on project streams. Using the TCEQ stream shapefiles, survey stations were generally evenly spaced every 1.67 miles or 3 points per 5 mile segment of stream. This methodology ensured that the survey sites provide a representative sample of the conditions that exist along the entire population of streams. In order to ensure that recreational use was targeted for measurement, evenly spaced points were replaced with sites near these points where recreation was most likely to occur. These targeted areas of recreational use included public parks, bridges, and other areas that are accessible to recreational users. In many cases, systematic survey sites were not sampled due to the lack of permission from private property owners.

Collected Data for Each Stream Survey Sites

Field data was collected based on TCEQ's Recreational Use Attainability Analyses Procedures for a Comprehensive RUAA and a Basic RUAA Survey (May 2009). Following these procedures, Contact Information Forms (Appendix 2), RUAA Summaries (Appendix 5), Field Data Sheets (Appendix 3), and Comprehensive RUAA Interview Form (Appendix 4) were completed for each RUAA stream survey site. Weekly Palmer Hydrological Drought Index data was obtained NOAA's National Climatic Data Center's National Environmental Satellite, Data, and Information Service website (http://www.ncdc.noaa.gov/oa/climate/monitoring/drought/). Daily precipitation data was obtained from NOAA's National Climatic Data Center (http://cdo.ncdc.noaa.gov/dly/DLY).

Photograph Naming Convention

In sequence, photograph names (i.e. 1242D.1.30_25Up_08032009_23207) provide the segment identification code for the specific survey site, the location in meters along the stream reach where the photograph was taken, a photo number assigned by the camera, a code which describes the contents, the date, and the time of day to the nearest second. Photographs taken at locations other than 30, 150, or 300 meters along the reach do not have reach location information. The example photograph name above was an upstream photograph, 30 meters along the reach at survey site 1242D.1 with a camera photo number of 25. This example photograph was taken on August 3, 2009 at 2:32 pm and 7 seconds. Content codes include Up (up stream), Dwn (down stream), LB (left bank), RB (right bank), SPA (site/public access), SC (surrounding conditions), CO (channel obstructions), HM (hydrologic modifications), PR (promote recreation), IR (impede recreation), UC (unsafe condition), HP (human presence), IHU (indications of human use), G (garbage), Dam (on channel impoundment), and FPS (flowing point source or NPDES discharge).

Completion of RUAA Summaries

The average thalweg depth, substantial pools deeper than 1 m, and hydrologic conditions based on the Palmer Drought Severity Index (PDSI) were determined based on quantitative methods such as calculating the sum or mean. Both observations on use and the general level of public access were determined by subjective methods. This was necessary due to the multiple sources of information that can be used to answer these questions. In interpreting the results of these, it is important to take into consideration that other alternative subjective methodologies could potentially produce different results. Observations on use including primary contact, secondary contact (1 & 2), and non-contact recreation activities were primarily determined by considering information provided by interviews with land owners surrounding the streams. The second factor considered came from the information recorded by survey teams, and the last factor considered were field observations of indications of human use at survey sites. The general level of public access was determined primarily by survey team's responses to "Describe Access Opportunities" for each survey site and secondarily on "Bank Access", "Surrounding Conditions that Impede Recreation", and the number of recreation areas located for each stream.

Results

General Stream Characteristics

The seven hundred and fifty two miles of Brazos River Basin streams were evaluated with a total of 486 full surveys (Table 4). Three hundred and seventy three sites were surveyed one time and 113 were surveyed twice. Roadside surveys were conducted when access was not permitted or possible.

Based on the Park Lands Combined shapefile, a total of 22 public recreation areas are located on 1218(8), 1221(4), 1255(2), 1221A(1), 1222A(1), 1221D(1), 1246E(1), 1247A(1), 1211A(1), 1242B(1), and 1242C(1) (Appendix 1).

Pasture was the dominant riparian zone recorded for all the streams as a whole (Table 5). Out of a total of 1322 observed left bank and right bank riparian zone types, 384 or 29% were pasture followed by shrub dominated corridors (26%), forest (23%), denuded eroded bank (11%), mowed maintained corridor (4%), and row crops (3%). Eight other bank riparian zone types were recorded, but each represent less than 3% of the total.

Multiple continuous and categorical hydrologic field observations indicate the amount of water present in RUAA streams (Table 6). The North Fork of the Upper Bosque River (1255B) had the widest average width followed by 1221, 1218, 1221E, and 1221C. The Leon River (1221) had the deepest average thalweg followed by 1255, 1242D, 1218, and 1221E. Nolan Creek (1218) had the largest average flow followed by 1221, 1242D, 1242C, and 1255. The Leon River (1221) had the largest perennial stream type classification frequency and positive response for enough water for primary contact followed by 1218.

Based on the tx wastewtr outfall shapefile, 12 permitted domestic sewage outfalls less than 1 million gallons per day total are located on 1255B(1), 1255(1), 1221A(1), 1221D(1), 1221B(1), 1221C(1), 1246E(1), 1218(2), 1242P(1), 1211A(1), and 1202H(1). A total of 10 permitted domestic and wastewater treatment plant outfalls greater than or equal to 1 million gallons per day are located on 1218(5), 1221(2), 1255(1), 1248C(1), and 1242C(1) (Appendix 1).

The RUAA summary analysis for each stream (Table 7) indicates that primary contact, secondary contact (1 & 2), and non-contact recreation activities frequently occur on 1218, 1221,

1211A, 1221A, and 1221E. Primary contact, secondary contact (1 & 2), and non-contact recreation activities seldom occur on 1223, 1221B, 1221C, 1222E, 1242C, 1247A, 1248C, and 1255F. Sixteen streams had substantial pools deeper than 1 meter including 1218, 1221, 1211A, 1221A, and 1221E despite moderate to mid-range drought conditions at the time of the survey. Fifteen streams did not have substantial pools deeper than 1 meter including 1223, 1247A, 1248C, and 1255F. Nineteen of the 31 streams had very limited public access due to the large amount of privately owned land and the lack of public recreation areas surrounding these streams.

Table 4. General RUAA stream characteristics.

Stream	Waterbody Name	Stream Type	Total Stream Miles	# of First Surveys	# of Second Surveys	# of Road-side Surveys
1218	Nolan Creek/South Nolan Cr.	Classified	29.8	19	17	2
1221	Leon River Below Proctor Lake	Classified	190.0	92	83	29
1223	Leon River Below Leon Res.	Perennial	37.5	16		6
1255	Upper North Bosque River	Classified	13.3	11	7	6
1202H	Allens Creek	Intermittent w pools	18.0	7		2
1211A	Davidson Creek	Intermittent w pools	58.5	27		5
1221A	Resley Creek	Intermittent	34.3	18	2	2
1221B	South Leon River	Perennial	39.4	10		5
1221C	Pecan Creek	Perennial	11.9	8		1
1221D	Indian Creek	Perennial	29.9	12	1	5
1221E	Plum Creek	Perennial	26.1	9		7
1221F	Walnut Creek	Intermittent w pools	14.7	8		2
1222A	Duncan Creek	Intermittent	16.1	10		
1222E	Sweetwater Creek	Intermittent	23.9	9		5
1223A	Armstrong Creek	Intermittent	17.0	11		
1226E	Indian Creek	Intermittent	7.9	4		1
1226F	Sims Creek	Intermittent	8.6	3	1	2
1226K	Little Duffau Creek	Intermittent	14.1	7	1	1
1242B	Cottonwood Branch	Intermittent w pools	6.8	4		
1242C	Still Creek	Perennial	8.9	5		
1242D	Thompson Creek	Intermittent w pools	20.7	11		
1242P	Big Creek	Intermittent	47.5	25		4
1246E	Wasp Creek	Intermittent	10.6	7		1
1247A	Willis Creek	Perennial	22.3	13	1	1
1248C	Mankins Branch	Perennial	4.7	3		
1255A	Goose Creek	Intermittent w pools	7.2	3		1
1255B	N Fork Upper N. Bosque River	Intermittent	17.8	12		1
1255C	Scarborough Creek	Intermittent	4.9	2		2
1255E	Trib. of Goose Branch	Intermittent	2.8	1		1
1255F	Trib. of Scarborough Creek	Intermittent	2.9	2		
1255G	Woodhollow Branch	Intermittent	3.8	4		
		Totals	**752.0**	**373**	**113**	**92**

Table 5. Sum of the left bank and right bank riparian zone corridor categorical observations with the percent of the dominant riparian zone categories calculated for each stream.

Stream	Pasture	% Pasture	Shrub dominated corridor	% Shrub dominated corridor	Forest	% Forest	Denuded eroded bank	% Denuded eroded bank	Mowed maintained corridor	% Mowed maintained corridor
1218	10	11	36	40	18	20	2	2	15	17
1221	159	39	89	22	106	26	33	8	7	2
1223	16	43	5	14	7	19	4	11	0	0
1255	7	13	25	47	8	15	2	4	7	13
1202H	5	20	4	16	4	16	5	20	4	16
1211A	17	22	28	35	27	34	5	6	0	0
1221A	16	25	16	25	11	17	7	11	4	6
1221B	11	33	12	36	5	15	5	15	0	0
1221C	9	53	3	18	4	24	0	0	1	6
1221D	6	22	6	22	8	30	0	0	3	11
1221E	15	44	9	26	3	9	1	3	0	0
1221F	8	38	10	48	0	0	3	14	0	0
1222A	12	40	5	17	9	30	2	7	0	0
1222E	5	19	11	41	6	22	5	19	0	0
1223A	11	26	10	23	10	23	11	26	0	0
1226E	0	0	6	75	2	25	0	0	0	0
1226F	3	21	0	0	5	36	3	21	1	7
1226K	9	39	6	26	0	0	6	26	0	0
1242B	0	0	2	14	4	29	4	29	0	0
1242C	0	0	4	21	8	42	3	16	2	11
1242D	2	4	12	26	14	30	12	26	0	0
1242P	16	23	15	21	16	23	16	23	2	3
1246E	9	41	5	23	1	5	1	5	0	0
1247A	13	31	9	21	7	17	2	5	1	2
1248C	0	0	0	0	4	40	0	0	0	0
1255A	3	38	0	0	3	38	1	13	0	0
1255B	15	47	8	25	5	16	4	13	0	0
1255C	0	0	0	0	3	50	3	50	0	0
1255E	0	0	0	0	2	100	0	0	0	0
1255F	2	50	2	50	0	0	0	0	0	0
1255G	5	29	8	47	4	24	0	0	0	0
Total	**384**	**29**	**346**	**26**	**304**	**23**	**140**	**11**	**47**	**4**

Table 5 (continued).

Stream	Row crops	% Row crops	Rip rap	Urban	Public Park w/ various facilities	Suburban	Herbaceous grassland	Commercial building	Herbaceous marsh	Bedrock	Cemetery	Total
1218	0	0	3	4	1							**89**
1221	9	2	0		2							**405**
1223	1	3	2				2					**37**
1255	0	0	2	1		1						**53**
1202H	0	0	0				1		2			**25**
1211A	0	0	2									**79**
1221A	0	0	4	6								**64**
1221B	0	0	0									**33**
1221C	0	0	0									**17**
1221D	1	4	0		1			2				**27**
1221E	0	0	6									**34**
1221F	0	0	0									**21**
1222A	2	7	0									**30**
1222E	0	0	0									**27**
1223A	0	0	0								1	**43**
1226E	0	0	0									**8**
1226F	0	0	2									**14**
1226K	2	9	0									**23**
1242B	0	0	2	2								**14**
1242C	0	0	0	2								**19**
1242D	0	0	6									**46**
1242P	4	6	2									**71**
1246E	5	23	1									**22**
1247A	10	24	0									**42**
1248C	0	0	2			2				2		**10**
1255A	1	13	0									**8**
1255B	0	0	0									**32**
1255C	0	0	0									**6**
1255E	0	0	0									**2**
1255F	0	0	0									**4**
1255G	0	0	0									**17**
Total	**35**	**3**	**34**	**15**	**4**	**3**	**3**	**2**	**2**	**2**	**1**	**1322**

Table 6. Hydrologic stream characteristics with the frequency of recorded categorical field observations for each stream.

Stream	Avg Width (m)	Avg Thalweg (m)	Avg Flow (ft/s)	Flow Frequency	Stream Type Frequency	Channel Frequency	Water for Primary Contact Frequency
Allens Creek	2.86	0.26	3.35	.57 no flow	.57 Intermittent	1 Wadeable	1 No
1202H				.28 low	.28 Ephemeral		
				.14 normal	.14 Perennial		
Davidson Creek	2.90	0.31	0.3	.37 normal	.37 Ephemeral	1 Wadeable	.70 No
1211A				.30 dry	.30 Intermittent w/ pools		.30 Yes
				.26 no flow	.19 Perennial		
Nolan Creek	11.16	0.43	32.05	.39 normal	.69 Perennial	.94 Wadeable	.61 Yes
1218				.28 low	.14 Ephemeral	.06 Non-wadeable	.39 No
				.11 no flow	.11 Intermittent w/ pools		
Leon River	13.98	0.73	19.18	.4 normal	.91 Perennial	.54 Non-wadeable	.84 Yes
1221				.4 low	.07 Intermittent w/ pools	.45 Wadeable	.13 No
				.11 no flow	.01 Ephemeral		
Resley Creek	5.40	0.22	0.26	.45 dry	.45 Ephemeral	.95 Wadeable	.75 No
1221A				.3 no flow	.3 Intermittent w/ pools	.05 Non-wadeable	.25 Yes
				.2 low	.15 Intermittent		
South Leon River	4.62	0.37	0.99	.5 low	.6 Intermittent w/ pools	1 Wadeable	.5 Yes
1221B				.2 no flow	.3 Perennial		.5 No
				.2 normal	.1 Ephemeral		
Pecan Creek	8.85	0.22	0.33	.38 low	.63 Intermittent w/ pools	.88 Wadeable	.5 Yes
1221C				.25 normal	.25 Ephemeral	.13 Non-wadeable	.5 No
				.25 no flow	.13 Intermittent		
Indian Creek	4.55	0.30	0.36	.46 normal	.38 Intermittent w/ pools	.92 Wadeable	.62 No
1221D				.23 no flow	.31 Ephemeral	.08 Non-wadeable	.38 Yes
				.23 dry	.15 Perennial		
Plum Creek	9.81	0.43	0.05	.67 no flow	.56 Intermittent w/ pools	1 Wadeable	.56 Yes
1221E				.22 low	.22 Perennial		.44 No
				.11 normal	.11 Intermittent		
Walnut Creek	2.37	0.12	0.40	.38 no flow	.5 Intermittent w/ pools	1 Wadeable	.75 No
1221F				.38 dry	.25 Ephemeral		.25 Yes
				.25 low	.125 Intermittent		
Duncan Creek	2.20	0.20	0.10	.4 low	.5 Ephemeral	1 Wadeable	.9 No
1222A				.3 no flow	.5 Intermittent w/ pools		.1 Yes
				.3 dry			

Table 6 (Continued).

Stream	Avg Width (m)	Avg Thalweg (m)	Avg Flow (ft/s)	Flow Frequency	Stream Type Frequency	Channel Frequency	Water for Primary Contact Frequency
Sweetwater Creek 1222E	3.58	0.22	0.03	.33 normal .33 normal .22 no flow	.56 Ephemeral .33 Perennial .11 Intermittent w/ pools	1 Wadeable	.78 No .22 Yes
Leon River 1223	5.75	0.26		.56 no flow .19 dry .13 normal	.44 Ephemeral .31 Intermittent w/ pools .13 Perennial	.94 Wadeable .06 Non-wadeable	.75 No .19 Yes
Armstrong Creek 1223A	4.70	0.10	0.41	.45 low .45 dry .09 normal	.45 Ephemeral .27 Intermittent .18 Intermittent w/pools	1 Wadeable	.90 No .10 Yes
Indian Creek 1226E	3.29	0.03		1 no flow	.75 Intermittent w/ pools .25 Ephemeral	1 Wadeable	1 No
Sims Creek 1226F	2.40	0.29	0.11	.5 high .25 low .25 dry	.75 Intermittent .25 Ephemeral	1 Wadeable	.75 Yes .25 No
Little Duffau Creek 1226K	4.75	0.28	0.27	.5 dry .25 no flow .25 dry	.38 Ephemeral .38 Intermittent .13 Perennial	1 Wadeable	.75 No .25 Yes
Cottonwood Br. 1242B	2.48	0.29		1 no flow	1 Ephemeral	1 Wadeable	1 No
Still Creek 1242C	3.74	0.33	2.62	.6 no flow .4 normal	.6 Ephemeral .2 Intermittent .2 Perennial	1 Wadeable	.8 No .2 Yes
Thompson Creek 1242D	4.33	0.44	5.02	.36 normal .27 no flow .18 high	.36 Perennial .36 Intermittent .18 Ephemeral	.82 Wadeable .09 Non-wadeable	.5 Yes .5 No
Big Creek 1242P	5.34	0.32	0.06	.44 dry .24 no flow .16 normal	.48 Ephemeral .28 Intermittent .12 Intermittent w/ pools	.84 Wadeable .08 Non-wadeable	.72 No .28 Yes
Wasp Creek 1246E	4.46	0.39		.57 normal .43 low	.57 Intermittent w/ pools .43 Intermittent	1 Wadeable	.57 Yes .43 No
Willis Creek 1247A	3.79	0.20	0.07	.79 no flow .21 low	.36 Ephemeral .29 Intermittent .29 Intermittent w/ pools	1 Wadeable	.79 No .14 Yes
Mankins Branch 1248C	3.03	0.30		.33 dry .33 normal .33 low	.33 Ephemeral .33 Perennial .33 Intermittent	1 Wadeable	.67 No .33 Yes

Table 6 (continued).

Stream	Avg Width (m)	Avg Thalweg (m)	Avg Flow (ft/s)	Flow Frequency	Stream Type Frequency	Channel Frequency	Water for Primary Contact Frequency
Up. North Bosque 1255	8.42	0.49	1.10	.44 no flow .39 low .11 dry	.56 Intermittent w/ pools .17 Intermittent .17 Perennial	.72 Wadeable .17 Non-wadeable	.56 No .28 Yes
Goose Creek 1255A	0.00	0.01		1 dry	1 Ephemeral	1 Wadeable	1 No
Up. North Bosque 1255B North Fork	23.46	0.12		.58 dry .42 no flow	.58 Ephemeral .25 Intermittent w/ pools .17 Perennial	.83 Wadeable .17 Non-wadeable	.75 No .25 Yes
Scarborough Cr. 1255C	0.00	0.04		.5 no flow .5 dry	1 Ephemeral	1 Wadeable	1 No
Goose Branch 1255E Tributary of Scarborough Cr.	0.00	0.01		1 dry	1 Ephemeral	1 Wadeable	1 No
1255F Tributary of Woodhollow Br.	0.00	0.00		1 dry	1 Ephemeral	1 Wadeable	1 No
1255G	1.35	0.01		.5 dry .25 no flow .25 normal	.5 Ephemeral .25 Intermittent .25 Perennial	.75 Wadeable .25 Non-wadeable	.75 No .25 Yes

Table 7. RUAA summary for each stream.

Stream Name	Seg No.	Class	Primary Contact	Secondary Contact Rec 1	Secondary Contact 2	Non-contact	Avg Thalw	Subst pools >1m	General Public Access	PDSI
Nolan Creek	1218	Yes	Frequently	Frequently	Frequently	Frequently	0.43	Yes	Easy	Moderate drought
Leon River Below Proctor L.	1221	Yes	Frequently	Frequently	Frequently	Frequently	0.73	Yes	Very limited	Moderate drought
Leon River Below Leon Res.	1223	No	Seldom	Seldom	Seldom	Seldom	0.26	No	Very limited	Moderate drought
Upper North Bosque River	1255	Yes	Unknown	Frequently	Frequently	Frequently	0.49	Yes	Easy	Moderate drought
Allens Creek	1202H	No	Not obs or rep	Frequently	Not obs or rep	Not obs or rep	0.26	No	Moderate	Moderate drought
Davidson Creek	1211A	No	Frequently	Frequently	Frequently	Frequently	0.31	Yes	Moderate	Mid-range
Resley Creek	1221A	No	Frequently	Frequently	Frequently	Frequently	0.22	Yes	Moderate	Moderate drought
South Leon River	1221B	No	Seldom	Seldom	Seldom	Seldom	0.37	Yes	Very limited	Moderate drought
Pecan Creek	1221C	No	Seldom	Seldom	Seldom	Seldom	0.22	Yes	Easy	Moderate drought
Indian Creek	1221D	No	Not obs or rep	Seldom	Not obs or rep	Seldom	0.30	No	Moderate	Moderate drought
Plum Creek	1221E	No	Frequently	Frequently	Unknown	Frequently	0.43	Yes	Very limited	Moderate drought
Walnut Creek	1221F	No	Unknown	Unknown	Frequently	Frequently	0.12	Yes	Very limited	Moderate drought
Duncan Creek	1222A	No	Not obs or rep	Not obs or rep	Not obs or rep	Frequently	0.20	Yes	Very limited	Moderate drought
Sweetwater Creek	1222E	No	Seldom	Seldom	Seldom	Seldom	0.22	Yes	Very limited	Moderate drought
Armstrong Creek	1223A	No	Not obs or rep	Not obs or rep	Not obs or rep	Seldom	0.10	No	Very limited	Moderate drought
Indian Creek	1226E	No	Not obs or rep	Not obs or rep	Not obs or rep	Not obs or rep	0.03	No	Moderate	Moderate drought
Sims Creek	1226F	No	Not obs or rep	Seldom	Not obs or rep	Not obs or rep	0.29	No	Very limited	Moderate drought
Little Duffau Creek	1226K	No	Not obs or rep	Not obs or rep	Not obs or rep	Not obs or rep	0.28	Yes	Very limited	Moderate drought
Cottonwood Branch	1242B	No	Not obs or rep	Not obs or rep	Not obs or rep	Seldom	0.29	Yes	Moderate	Mid-range
Still Creek	1242C	No	Seldom	Seldom	Seldom	Seldom	0.33	Yes	Moderate	Mid-range
Thompson Creek	1242D	No	Not obs or rep	Seldom	Not obs or rep	Not obs or rep	0.44	No	Very limited	Mid-range
Big Creek	1242P	No	Not obs or rep	Not obs or rep	Not obs or rep	Seldom	0.32	Yes	Very limited	Moderate drought
Wasp Creek	1246E	No	Not obs or rep	Not obs or rep	Not obs or rep	Not obs or rep	0.39	Yes	Very limited	Moderate drought
Willis Creek	1247A	No	Seldom	Seldom	Seldom	Seldom	0.20	No	Moderate	Moderate drought
Mankins Branch	1248C	No	Seldom	Seldom	Seldom	Unknown	0.30	No	Easy	Moderate drought
Goose Creek	1255A	No	Unknown	Unknown	Unknown	Unknown	0.01	No	Very limited	Moderate drought
N Fork Upper N. Bosque R.	1255B	No	Not obs or rep	Not obs or rep	Not obs or rep	Seldom	0.12	No	Very limited	Moderate drought
Scarborough Creek	1255C	No	Not obs or rep	Seldom	Unknown	Seldom	0.04	No	Very limited	Moderate drought
Trib. of Goose Branch	1255E	No	Not obs or rep	Not obs or rep	Not obs or rep	Not obs or rep	0.01	No	Very limited	Moderate drought
Trib. of Scarborough Creek	1255F	No	Seldom	Seldom	Seldom	Not obs or rep	0.00	No	Very limited	Moderate drought
Woodhollow Branch	1255G	No	Not obs or rep	Not obs or rep	Not obs or rep	Not obs or rep	0.01	No	Very limited	Moderate drought

Observations and Evidence of Recreational Use and Surrounding Conditions that Promote Recreation

A total of 14 people were observed carrying out primary contact recreation activities on 1218 (11) and 1221 (3) (Table 8). The 3 people observed on 1221 were swimming in the water. Sixty two people were observed carrying out secondary contact recreation activities on 1218 (30), 1221D (3), 1222E (2), 1242C (3), and 1255 (24). The dominant secondary contact recreation activity observed was fishing. Various non-contact activities were recorded on 1211A, 1218, 1221, 1221C, 1221D, 1221F, 1242B, 1242C, 1242D, and 1255.

A total of 183 indications of human use were recorded on all the streams (Table 9). A total of eight rope swings were found on 1221 (5), 1221B (1), 1221E (1), and 1248C (1). Five boats total were found on 1221 (3), 1255B (1), and 1255G (1). Fishing tackle was found 52 separate times total on 1218 (7), 1221 (27), 1223 (2), 1255 (4), 1221A (1), 1221B (1), 1221D (3), 1221E (1), 1242D (2), 1247A (1), 1248C (1), and 1255C (2). Four remnants of kid's play were found on 1221 (2), 1255 (1), and 1242D (1).

Nine hundred and forty surrounding conditions that promote recreational use were found on all the streams combined (Table 10). Based on these observations made in the field, a total of 20 parks were found on 1218 (5), 1221 (4), 1255 (3), 1211A (1), 1221A (1), 1221C (3), 1221D (1), 1226E (1), and 1242C (1). Fifteen playgrounds total were found on 1218 (4), 1221 (4), 1255 (2), 1211A (1), 1221A (1), 1221C (2), and 1242C (1). One school was found on 1202H.

Table 8. Recreation Activities observed during RUAA field surveys.

Seg ID	Date	Primary Contact Recreation Activities	Count
1218.18	7/17/09	Wading-Children	3
1218.19	7/10/09	Wading-Adult and Bathing	1
1221.85	7/18/09	Swimming and Bathing	3
		Total	**14**

Seg ID	Date	Secondary Contact Recreation Activities	Count
1218.3	5/31/09	Fishing	2
1218.14	7/18/09	Wading-Adults	2
1218.16	7/31/09	Fishing	5
1218.17	7/18/09	Fishing and Wading-Adults	10
1218.18	7/10/09	Fishing and feeding ducks	16
1218.18	7/17/09	Fishing	2
1221D.10	7/11/09	Exploring, playing on shoreline	3
1222E.7Alt	7/18/09	Fishing	2
1242C.1	5/23/09	Throwing rocks and playing on shoreline	3
1255.7	8/15/09	Fishing, pets and related contact with water	4
1255.8	6/19/09	Fishing and children playing along water's edge	20
		Total	**62**

Seg ID	Date	Non Contact Activities
1211A.14	7/26/09	Sitting, standing, and walking
1218.14	7/18/09	Sitting
1218.16	7/31/09	Standing, walking, and wildlife watching
1218.17	7/18/09	Picnicking
1218.18	7/10/09	Standing, walking, sitting, and picnicking
1218.18	7/17/09	Basketball, sitting, and walking
1218.19	7/17/09	Standing
1218.2	5/31/09	Walking
1218.3	5/31/09	Weed trimming, standing, and walking
1221.85	7/18/09	Bicycling, jogging, lying down, picnicking, playing on shoreline, sitting, standing, walking
1221C.4	6/12/09	Bicycling
1221C.5	6/12/09	Sitting
1221D.10	7/11/09	Walking, and wildlife watching
1221F.10	6/13/09	Bicycling
1242B.2	5/23/09	Bicycling, and walking
1242C.1	5/23/09	Bicycling, jogging/running, and walking
1242D.8	5/23/09	Woman walking dog over bridge
1255.4	6/6/09	Walking
1255.8	6/19/09	Jogging/running, and walking

Table 9. All indications of human use recorded during field surveys. Values represent the total and average per site for each stream.

Stream	House	Pavilion w/ grills	Play ground	Private Park	Dock or Platform	Stairs	Gates on corridor	Bench	Hammock	Chair	Homemade Bridge	Boat	Rope swing
1218					1		1						
1221					3					1		3	5
1223													
1255					1								
1202H							1				1		
1211A													
1221A			1							1			
1221B						1							
1221C					1		1						
1221D													
1221E		1											1
1221F				1									
1222A													
1222E													
1223A													
1226E													
1226F	1												
1226K													
1242B													
1242C													
1242D					1								
1242P													
1246E													
1247A					1		1	1	1				
1248C													1
1255A													
1255B												1	
1255C													
1255E													
1255F													
1255G					1							1	
Total	**1**	**1**	**1**	**1**	**9**	**1**	**4**	**1**	**1**	**2**	**1**	**5**	**8**

Table 9 (continued).

Stream	Camping sites	Fire pit/ring	Remnant of kid's play	Toy	Fish trap	Fishing tackle	Foot print	RV/ATV tracks	Hunting blind/ feeder	Shotgun shell, arrow, clay bird	Drink bottle	Other	Total	Avg Per Site
1218	1	1		1		7	2	4			2	3	**23**	**0.64**
1221	7	4	2	2		27	2		2	1	1	9	**69**	**0.39**
1223		1				2						1	**4**	**0.25**
1255	2		1			4	1			1		3	**13**	**0.72**
1202H				1			1					1	**5**	**0.71**
1211A							2	2	1			1	**6**	**0.22**
1221A						1						2	**5**	**0.25**
1221B						1	2						**5**	**0.50**
1221C							1						**3**	**0.38**
1221D						3							**3**	**0.23**
1221E						1		1					**4**	**0.44**
1221F											1		**2**	**0.25**
1222A									1	1			**2**	**0.20**
1222E										1			**1**	**0.11**
1223A										2			**2**	**0.18**
1226E													**0**	**0.00**
1226F					1							1	**3**	**0.75**
1226K													**0**	**0.00**
1242B													**0**	**0.00**
1242C												1	**1**	**0.20**
1242D			1	1		2	1					2	**8**	**0.73**
1242P								1				1	**2**	**0.08**
1246E								1					**1**	**0.14**
1247A		1				1	2						**8**	**0.57**
1248C						1	1						**3**	**1.00**
1255A													**0**	**0.00**
1255B										1		1	**3**	**0.25**
1255C				1		2				2			**5**	**2.50**
1255E													**0**	**0.00**
1255F													**0**	**0.00**
1255G													**2**	**0.50**
Total	**10**	**7**	**4**	**6**	**1**	**52**	**15**	**9**	**4**	**9**	**4**	**26**	**183**	**0.38**

Table 10. Characteristics that promote recreation recorded during field surveys. Values represent the total and average per site for each stream.

Stream	Park	Play-ground	Nearby school	Camp-ground	Sports Field	Trail hiking or biking	Public Property	Hist. marker	Parking lot	Stairs or walkway	Gate	Beach	Boat ramp	Dock or raft	Picnic table
1218	5	4			2	4	2		6	2		1			
1221	4	4		4		7	2		6	1		2	2		1
1223									1			1			
1255	3	2		2	1	4	1		1			1		1	
1202H			1		1				1						
1211A	1	1			1	4	1		2						
1221A	1	1		1		1	1	1	1	1	2				
1221B						1									
1221C	3	2			1	1	2		1						1
1221D	1				1	1	1		1						
1221E						2									
1221F							1								
1222A						1									
1222E						1									
1223A						1									
1226E	1					1	1		1						
1226F								1							
1226K						1									
1242B															
1242C	1	1			1										
1242D													1	1	1
1242P															
1246E						3									
1247A						7	1		1					1	
1248C															
1255A															
1255B						3									
1255C															
1255E															
1255F															
1255G						2								1	
Total	**20**	**15**	**1**	**7**	**8**	**45**	**13**	**2**	**22**	**4**	**2**	**5**	**3**	**4**	**3**

Table 10 (continued).

Stream	Cabin, grill, gazebo	Garden grove	Populated area	Residential area	Urban suburban location	Rural area	Bridge	Roads paved and unpaved	Power line corridor	Other	Total	Avg per site
1218			4	11	7	7	22	14	1	1	**93**	**2.6**
1221				1	2	94	53	42	2	1	**228**	**1.3**
1223						8	9	5			**24**	**1.5**
1255			2	4	5	2	12	6	1		**48**	**2.7**
1202H			2	2	1	3	5	5	2		**23**	**3.3**
1211A				2	1	17	10	13		1	**54**	**2.0**
1221A	1	1	1	3	3	11	9	14			**53**	**2.7**
1221B						8	6	6			**21**	**2.1**
1221C			1				3	3	1		**19**	**2.4**
1221D			1		1	2	8	6			**23**	**1.8**
1221E				2		7	8	8			**27**	**3.0**
1221F			1	2		6	5	8	1		**24**	**3.0**
1222A						7	7	8			**23**	**2.3**
1222E						3	5	7			**16**	**1.8**
1223A				1	1	8	3	7			**21**	**1.9**
1226E			1			4	1	4			**14**	**3.5**
1226F					1	1	3	2			**8**	**2.0**
1226K						7	3	6	3		**20**	**2.5**
1242B						1	3	3			**7**	**1.8**
1242C				1	1	1	4	2		1	**13**	**2.6**
1242D				1		5	7	6			**22**	**2.0**
1242P						17	13	15			**45**	**1.8**
1246E				1		5	4	6			**19**	**2.7**
1247A				3		10	8	14	1		**46**	**3.3**
1248C				1	1	1	2	2			**7**	**2.3**
1255A							1	2			**3**	**1.0**
1255B			1	2		7	3	5			**21**	**1.8**
1255C				1				2			**3**	**1.5**
1255E								1			**1**	**1.0**
1255F				1		1	1	1			**4**	**2.0**
1255G						4		3			**10**	**2.5**
Total	**1**	**1**	**14**	**39**	**24**	**247**	**218**	**226**	**12**	**4**	**940**	**1.9**

Surrounding Conditions that Impede Recreation and Channel Obstructions

One thousand three hundred and sixty nine surrounding conditions that impede recreational use were found on all the streams combined (Table 11). Three hundred and sixty four out of the 1369 conditions or 27% were private property. Other dominant conditions were fences (21%), no public access (18%), steep slopes (18%), and no trespass signs (5%).

A total of 580 channel obstructions were observed for all streams (Table 12). Thirty five percent of these were log jams or trees followed by fences (18%), barbed wire (10%), and thick vegetation (7%).

Table 11. Characteristics that impede recreation recorded during field surveys. Values represent the total and average per site for each stream.

Stream	No public access	No trespass sign	Private Property	Electric Fence	Barbed wire	Fence	Gate	No road	No public parking	No water	Construction	Reputed to be contaminated
1218	12	4	16			7		1	1	2		
1221	109	33	140			103		49				
1223	9	1	14			11		2		1		
1255	6		5			5		1		2		
1202H	2	1	6			6		1				
1211A	15	3	17			17		8				
1221A	8	1	14	1	1	12	1	2		1		
1221B	4	1	8			7		1				
1221C	3	2	6			5						
1221D	2		9			3		1		1		1
1221E	6	3	8			8						
1221F	5	1	8			7						
1222A	4	1	10			7						
1222E	1		9			5						
1223A	6	2	8			10		1				
1226E	2		3			4						
1226F	3	1	4			4		1				
1226K	1	2	8			5		1				
1242B			1									
1242C	2		2			4					1	
1242D	7		8			8		2				
1242P	12	4	21		1	19		2	1	2		
1246E	5		6			7						
1247A	5	2	8			9						
1248C			1									
1255A			3			3						
1255B	10	3	12			11		1		1		
1255C	2		2			2						
1255E			1			1						
1255F	1		2									
1255G	2		4			3						

Total	**244**	**65**	**364**	**1**	**2**	**293**	**1**	**74**	**2**	**10**	**1**		**1**	

Table 11 (continued).

Stream	Industrial	Stagnant or foul odor	Steep slope	Thick veg.	Cacti	Wild-life	Mosqu-itoes	Deep mud	Long hike	Trash	Barge ship traffic	Pump or Water testing station	Other	Total	Avg per site
1218	1		8			1						1		**54**	**35**
1221	1		126	1		9	1	2	1		1	3	2	**581**	**10**
1223		1	7	1		1								**48**	**79**
1255			11	2									1	**33**	**72**
1202H			2			1								**19**	**3**
1211A			11			6								**77**	**3**
1221A			7	1		2								**51**	**3**
1221B			6									1		**28**	**3**
1221C														**16**	**2**
1221D			4			2								**23**	**2**
1221E			4											**29**	**3**
1221F			4		2									**27**	**3**
1222A			3											**25**	**3**
1222E			3			2								**20**	**2**
1223A			5			1							1	**34**	**3**
1226E														**9**	**2**
1226F														**13**	**3**
1226K			1											**18**	**2**
1242B		1	1			2				1				**6**	**2**
1242C			2			1							2	**14**	**3**
1242D	1		8			1							2	**37**	**3**
1242P			14	1				1					1	**79**	**3**
1246E			1	1										**20**	**3**
1247A			8											**32**	**2**
1248C						1								**2**	**1**
1255A			2											**8**	**3**
1255B			5											**43**	**4**
1255C			2											**8**	**4**
1255E														**2**	**2**
1255F														**3**	**2**
1255G				1										**10**	**3**

Total	**3**	**2**	**245**	**8**	**2**	**30**	**1**	**3**	**1**	**1**	**1**	**5**	**9**	**1369**	**3**

Table 12. Chanel obstructions recorded during field surveys. Values represent the total and average per site for each stream.

Stream	Barbed wire	Fence	Log jam or tree	Dam	Water contr struct	Dock or raft	Power line or cable	Culvert	Low bridge	Cement column	Garbage	Rip rap	Thick veg.	Utility Pipe	Other	Total	Avg per site
1218		2	2	1	4			1	3	4		3	2	1	1	**24**	**0.7**
1221	1	4	60	2				1	2	3		4	5	1		**83**	**0.5**
1223	5	4	5					0	1	0		1				**16**	**1.0**
1255		2	7		1	1		5	4	0		1	5			**26**	**1.4**
1202H	1	4	2		2			1	2	0		1	2			**15**	**2.1**
1211A	6	7	24	2				3	4	0		1	7	2	1	**57**	**2.1**
1221A	4	5	9					2	3	0			5			**28**	**1.4**
1221B			5					1	1	3		1				**11**	**1.1**
1221C	2	5	1	2				4	3	0			1	1		**19**	**2.4**
1221D		2	4	1				0		0						**7**	**0.5**
1221E	3	5	2	2				4	4	0	1	3				**24**	**2.7**
1221F	2	7	5				1	0		0			1	1		**17**	**2.1**
1222A	1	5	8					0	1	0			1			**16**	**1.6**
1222E	2	4	3					0	1	0		2	3	1		**16**	**1.8**
1223A	5	4	7				1	0		0				1	1	**19**	**1.7**
1226E	3	4	4					2		0		1				**14**	**3.5**
1226F	1	2	2					0		0		2	1			**8**	**2.0**
1226K	1	2	2	1				0		0					1	**7**	**0.9**
1242B	1	1	4		1			0	2	0		1	1	1		**12**	**3.0**
1242C	3	3	4	1	2			1		0		2	2	3		**21**	**4.2**
1242D	3	4	9	2				2	1	0	1	4	3	1	1	**31**	**2.8**
1242P	4	5	16					1	1	0	2	3	1			**33**	**1.3**
1246E	2	2	2					3		0		2	1	1		**13**	**1.9**
1247A	5	7	6	1				2		0			2	1		**24**	**1.7**
1248C			1					0		0						**1**	**0.3**
1255A		2	1					1	1	0						**5**	**1.7**
1255B	1	5	5	2				1		0		4				**18**	**1.5**
1255C		2	1					1		0						**4**	**2.0**
1255E		1	1					0		0						**2**	**2.0**
1255F		1						0	1	0						**2**	**1.0**
1255G		3	3					1		0						**7**	**1.8**

Total	**56**	**104**	**204**	**17**	**10**	**1**	**1**	**37**	**35**	**9**	**3**	**36**	**43**	**15**	**5**	**580**	**1.19**

Summary

Four hundred and eighty six full surveys on 31 streams in the Brazos River Basin were completed in this RUAA to evaluate whether the existing and/or attainable recreational uses of these streams might be different than the presumed or designated recreational uses. Important data collected in this RUAA included general stream characteristics, observations and evidence of recreational use and surrounding conditions that promote recreation, and surrounding conditions that impede recreation including channel obstructions.

Pasture was the dominant riparian zone recorded for all the streams combined (29%), closely followed by shrub dominated corridors, and forest.

Permitted domestic sewage outfalls less than 1 million gallons per day total are located on 1255B(1), 1255(1), 1221A(1), 1221D(1), 1221B(1), 1221C(1), 1246E(1), 1218(2), 1242P(1), 1211A(1), and 1202H(1). Permitted domestic and wastewater treatment plant outfalls greater than or equal to 1 million gallons per day are located on 1218(5), 1221(2), 1255(1), 1248C(1), and 1242C(1).

Multiple continuous and categorical hydrologic field observations indicate that the Leon River below Proctor Lake (1221), Nolan Creek (1218), Plum Creek (1221E), and Upper North Bosque River (1255) had a significant quantity of water at the time of the survey despite moderate to mid-range drought conditions. All of these streams had substantial pools over 1 meter in depth and the RUAA summary analysis generally indicates that primary contact, secondary contact (1 & 2), and non-contact recreation activities frequently occur on them. RUAA summary analysis also indicates that primary contact, secondary contact (1 & 2), and non-contact recreation activities frequently occur on Resley Creek (1221A) and Davidson Creek (1211A).

A total of 14 people were observed carrying out primary contact recreation activities on Nolan Creek 1218 (11) and Leon River below Proctor Lake 1221 (3). The 3 people observed on 1221 were swimming in the water. Sixty two people were observed carrying out secondary contact recreation activities on 1218 (30), 1221D (3), 1222E (2), 1242C (3), and 1255 (24). The dominant secondary contact recreation activity observed was fishing.

Rope swings were found on the Leon River below Proctor Lake 1221 (5), South Leon River 1221B (1), Plum Creek 1221E (1), and Mankins Branch 1248C (1). Five boats total were found on the Leon River 1221 (3), North Fork Upper North Bosque River 1255B (1), and Woodhollow Branch 1255G (1). Fishing tackle was found 52 separate times total on 1218 (7), 1221 (27), 1223 (2), 1255 (4), 1221A (1), 1221B (1), 1221D (3), 1221E (1), 1242D (2), 1247A (1), 1248C (1), and 1255C (2). Four remnants of kid's play were found on 1221 (2), 1255 (1), and 1242D (1).

Based on the Park Lands Combined shapefile, a total of 22 public recreation areas were identified on 1218(8), 1221(4), 1255(2), 1221A(1), 1222A(1), 1221D(1), 1246E(1), 1247A(1), 1211A(1), 1242B(1), and 1242C(1). During the RUAA field work, 20 recreation areas total were identified by field teams on 1218 (5), 1221 (4), 1255 (3), 1211A (1), 1221A (1), 1221C (3), 1221D (1), 1226E (1), and 1242C (1). Fifteen playgrounds total were found on 1218 (4), 1221 (4), 1255 (2), 1211A (1), 1221A (1), 1221C (2), and 1242C (1) and 1 school was found on 1202H.

Twenty seven percent of all surrounding conditions that impede recreational use were private property followed by fences (21%), no public access (18%), steep slopes (18%), and no trespass signs (5%). RUAA summary analysis indicates 19 of the 31 streams had very limited public access due to the large amount of privately owned land surrounding the streams. In addition 35% of all channel obstructions were log jams or trees followed by fences (18%), barbed wire (10%), and thick vegetation (7%).

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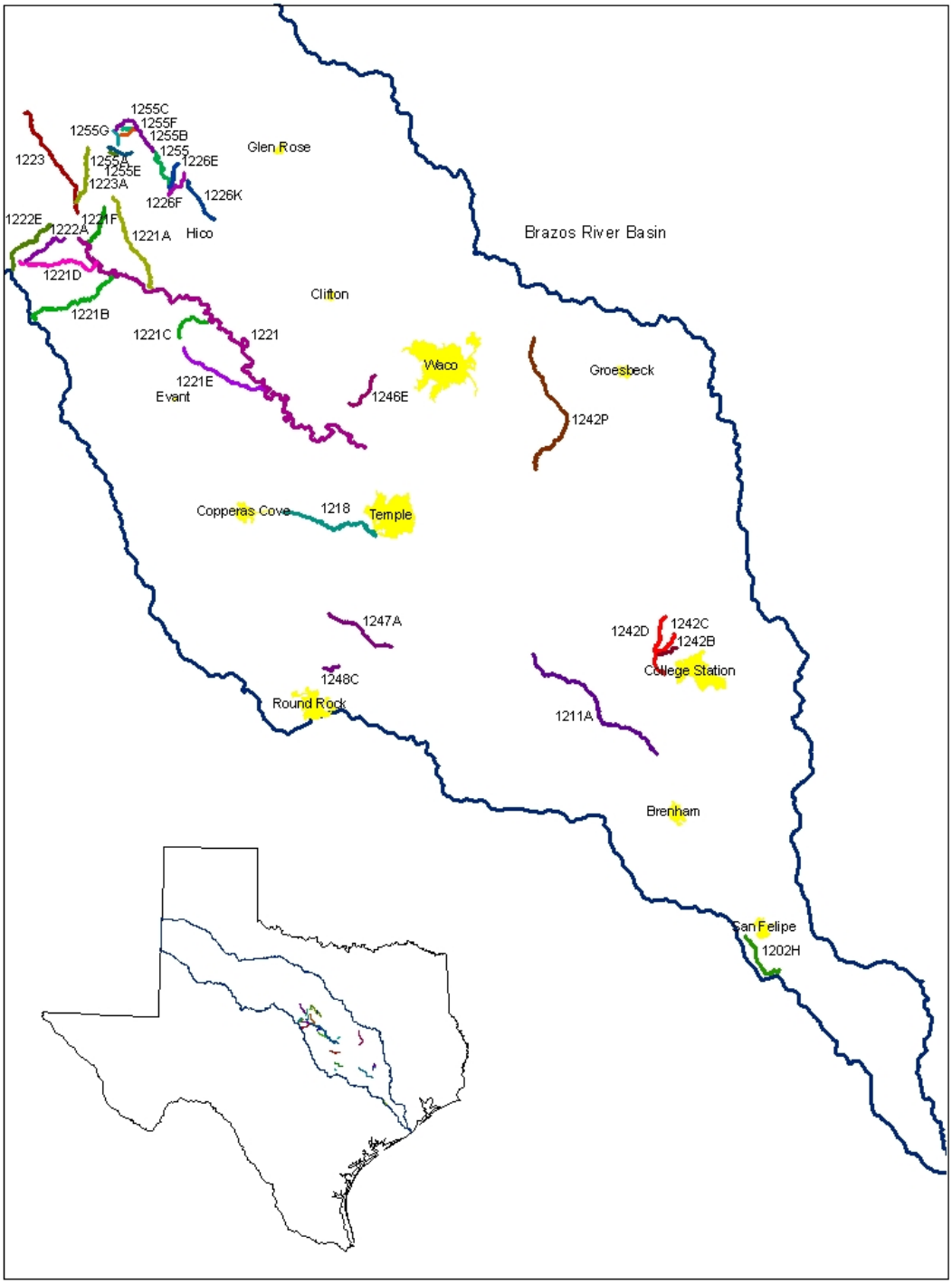
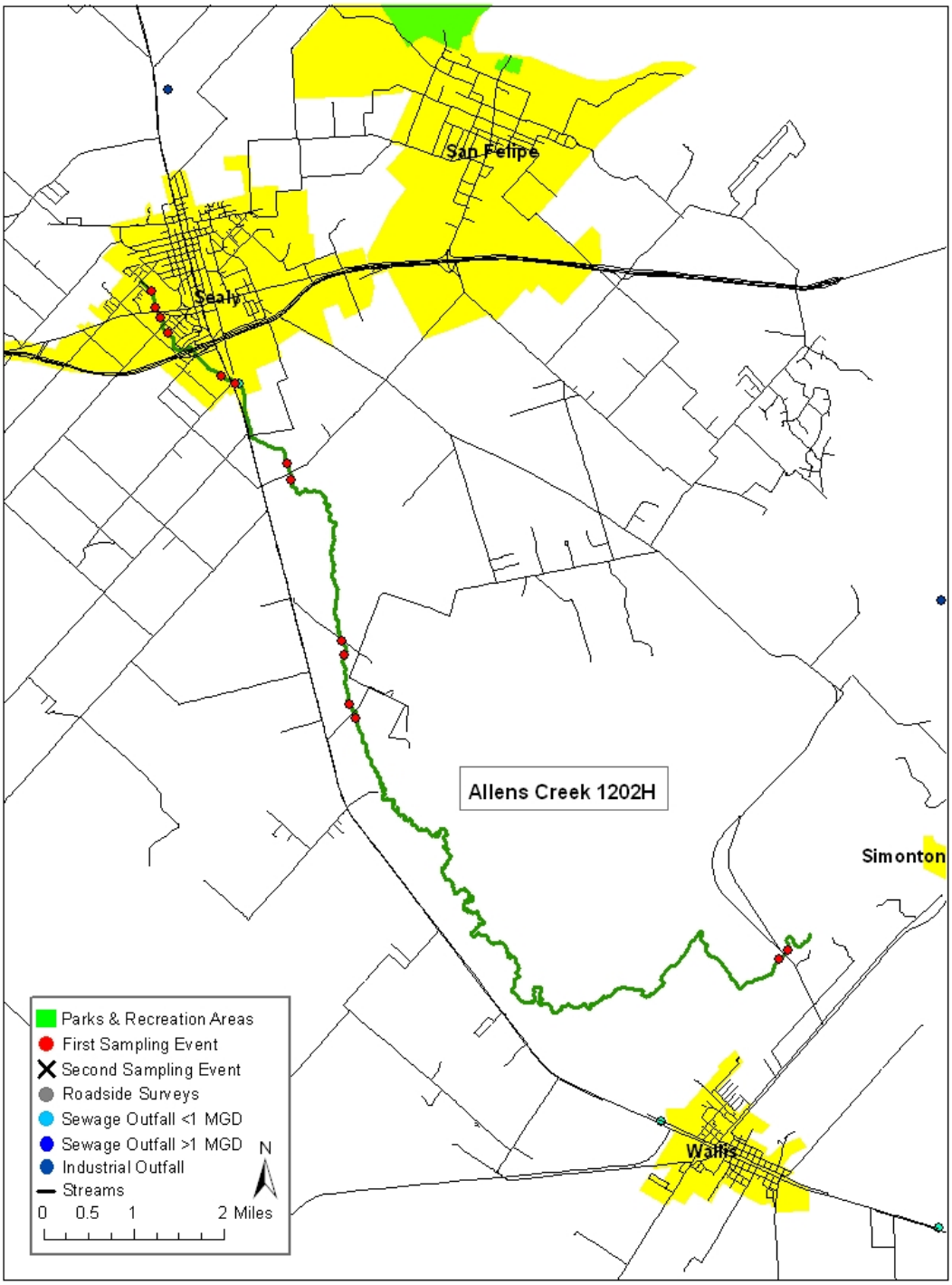
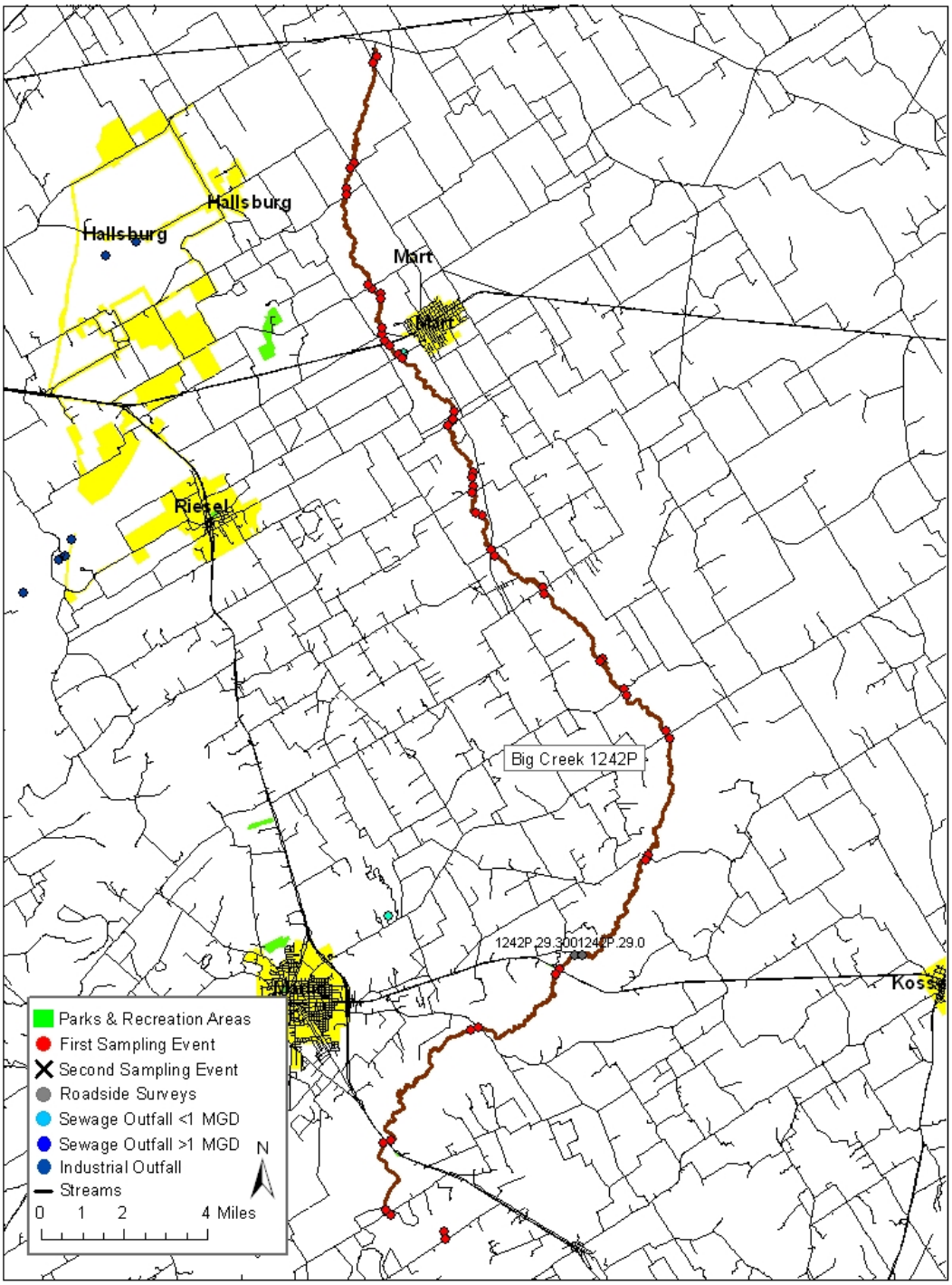
Appendix 1. Maps of study area and 2009 RUAA streams.



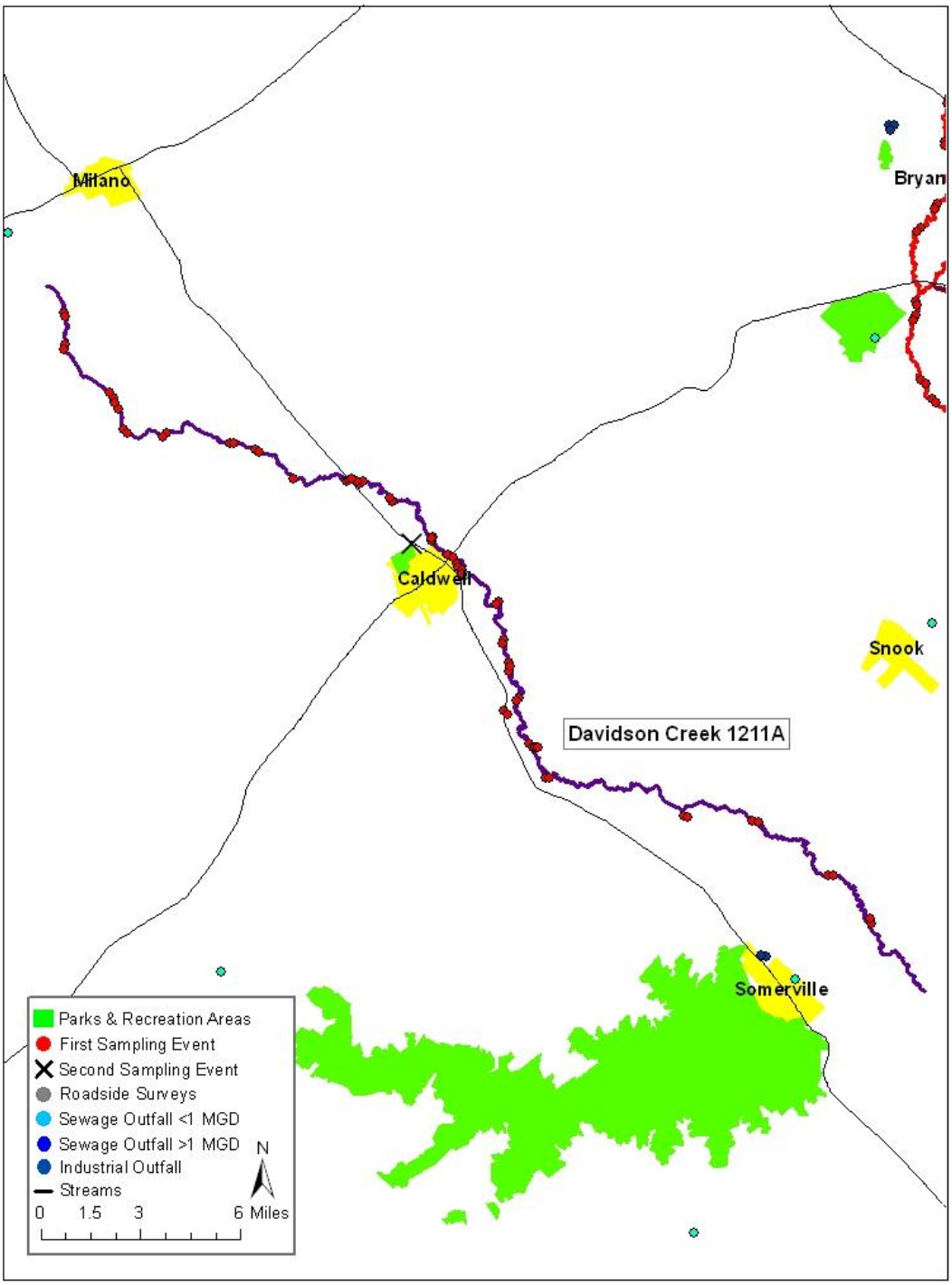
Map of the 31 2009 RUAA Streams in the Brazos River Basin, Texas.



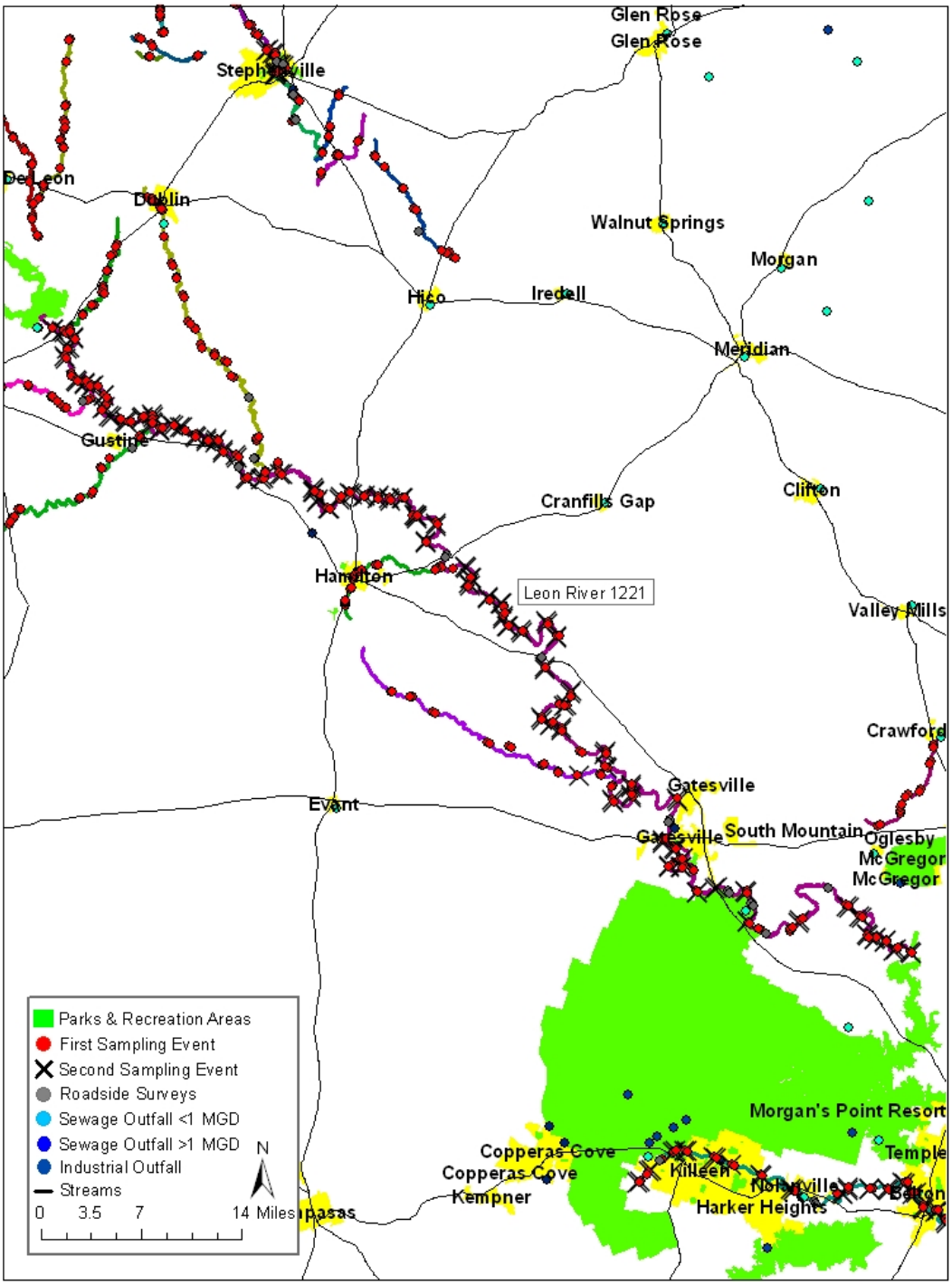
Map of survey sites, recreation areas, and wastewater outfalls along Allens Creek 1202H.



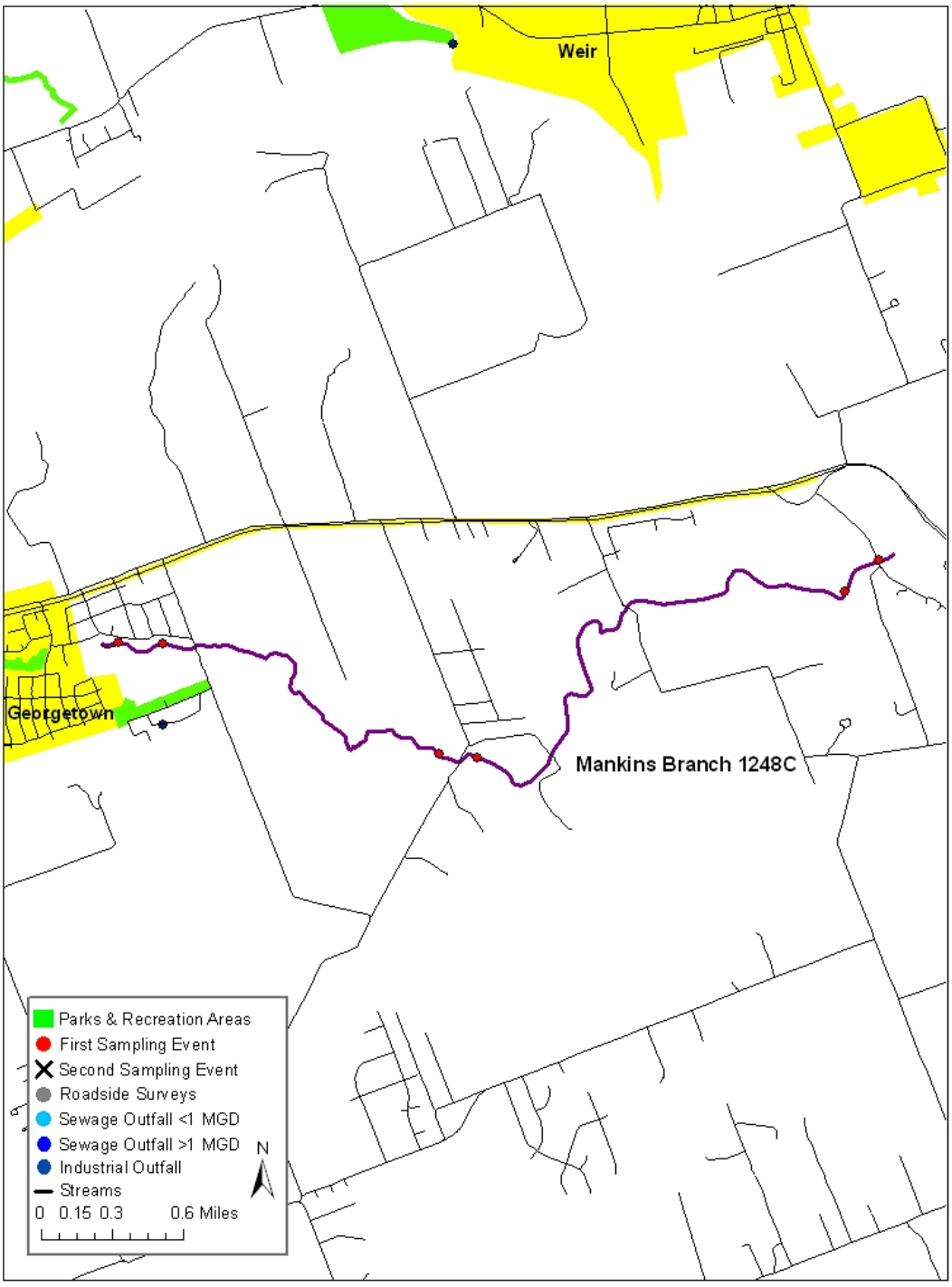
Map of survey sites, recreation areas, and wastewater outfalls along Big Creek 1242P.



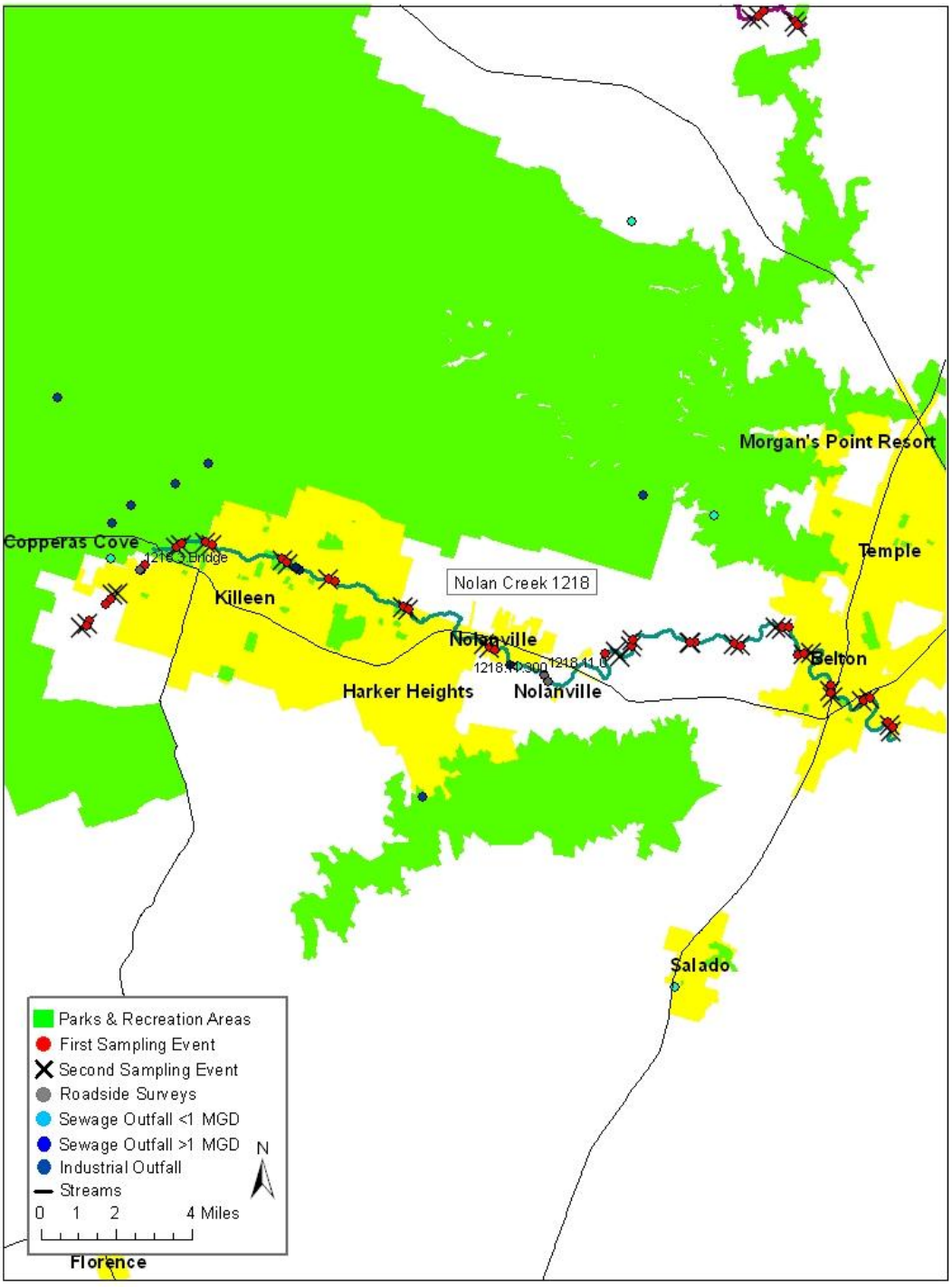
Map of survey sites, recreation areas, and wastewater outfalls along Davidson Creek 1211A.



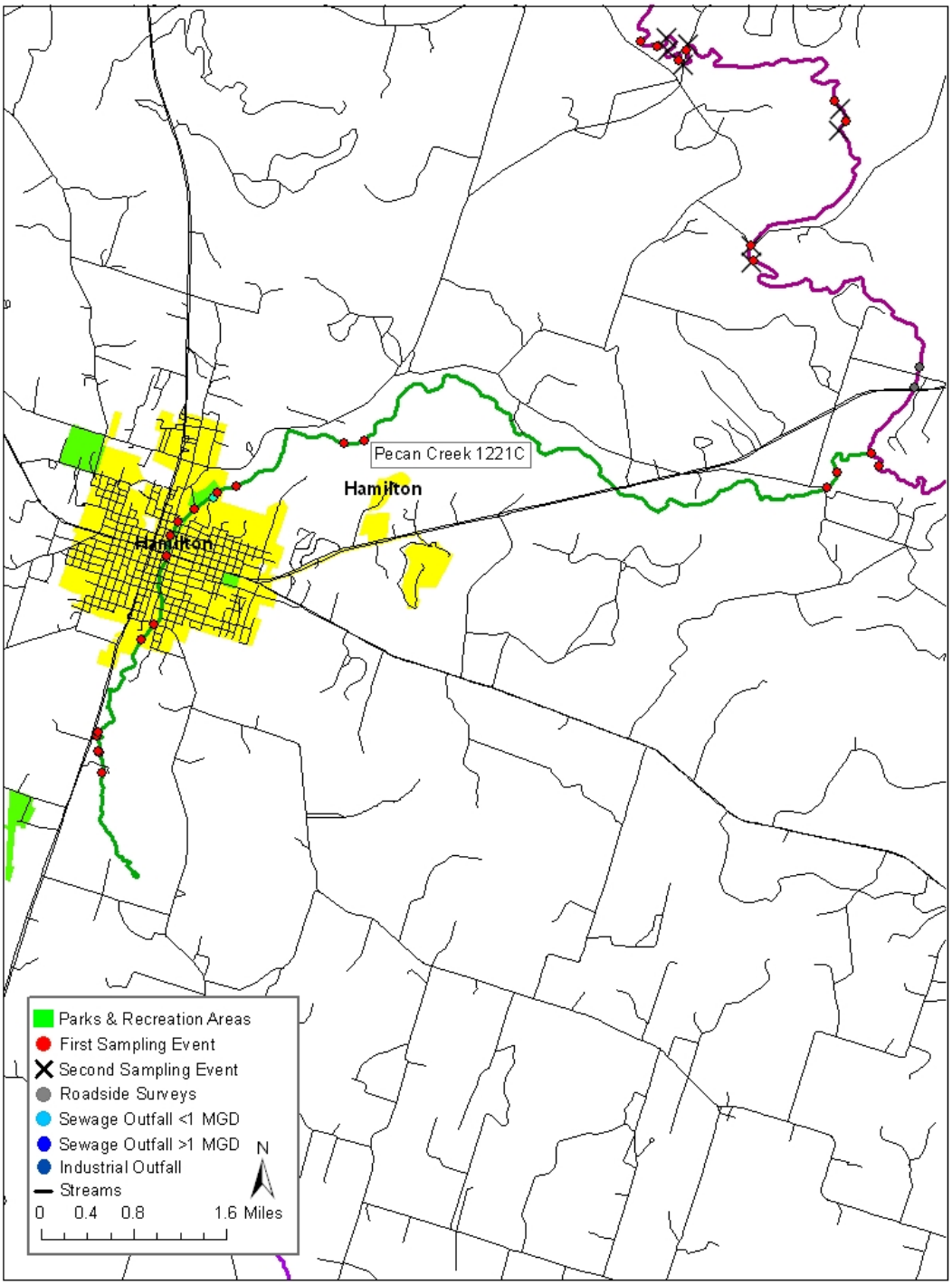
Map of survey sites, recreation areas, and wastewater outfalls along the Leon River 1221.



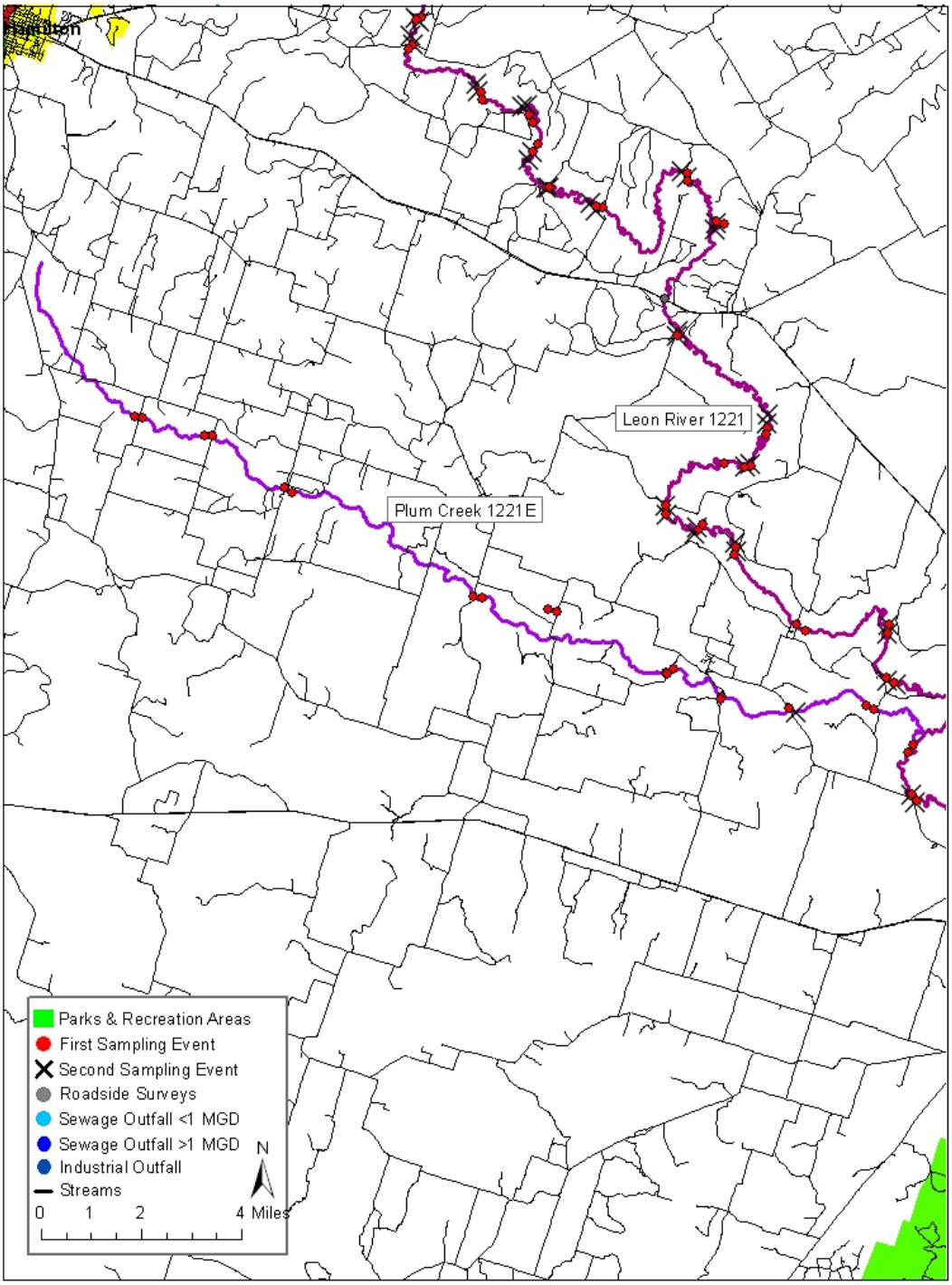
Map of survey sites, recreation areas, and wastewater outfalls along Mankins Branch 1248C.



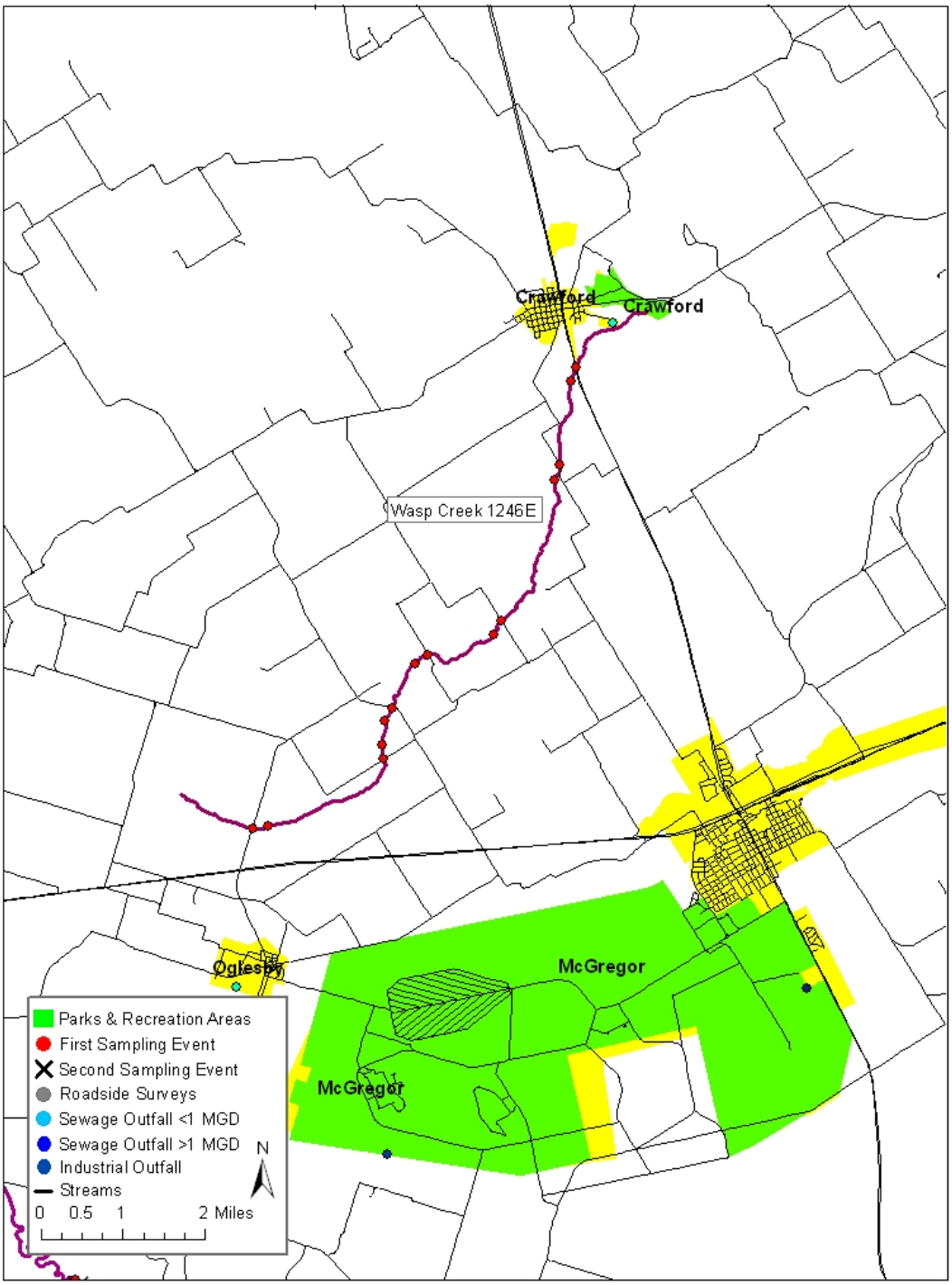
Map of survey sites, recreation areas, and wastewater outfalls along Nolan Creek 1218.



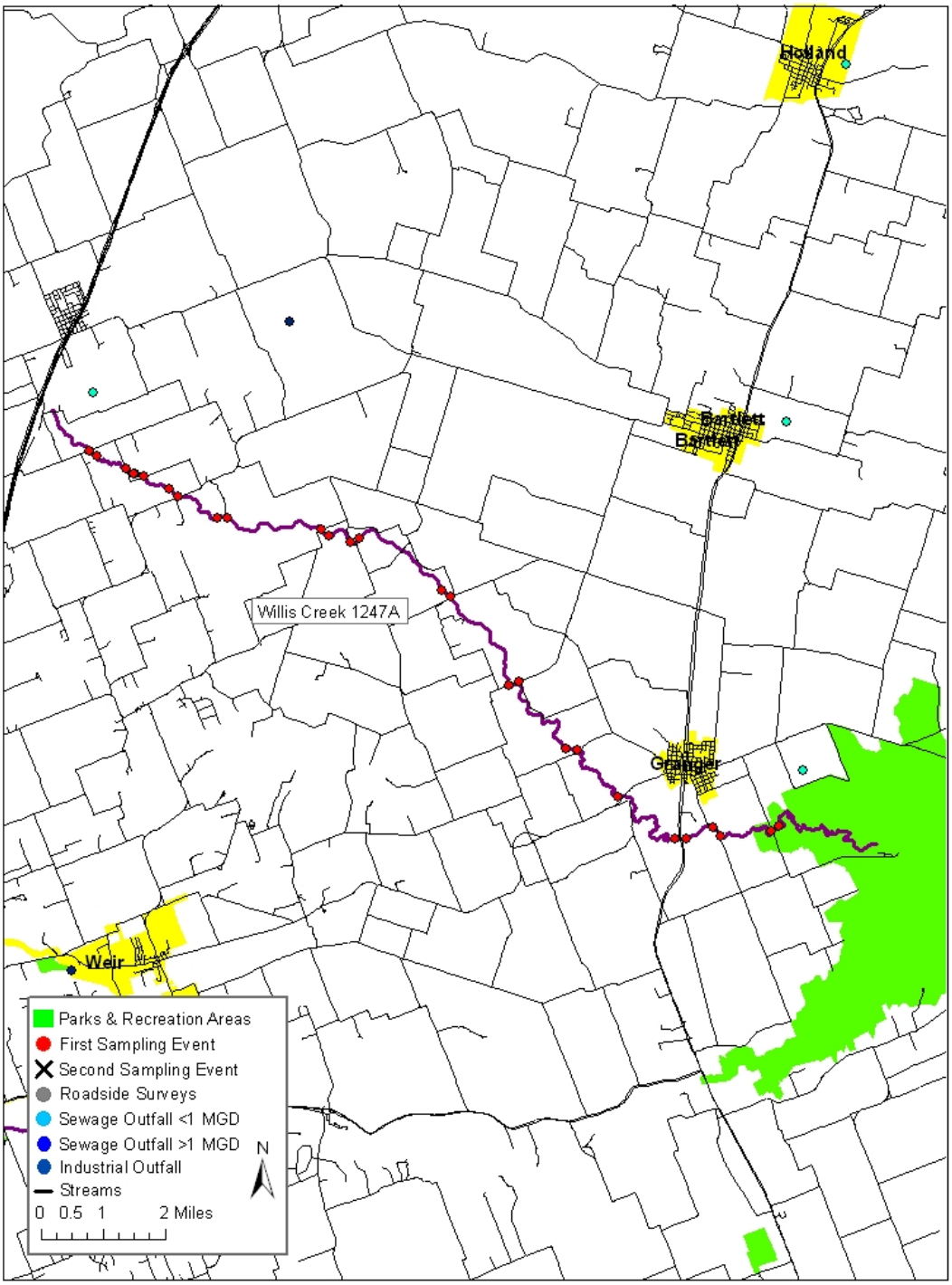
Map of survey sites, recreation areas, and wastewater outfalls along Pecan Creek 1221C.



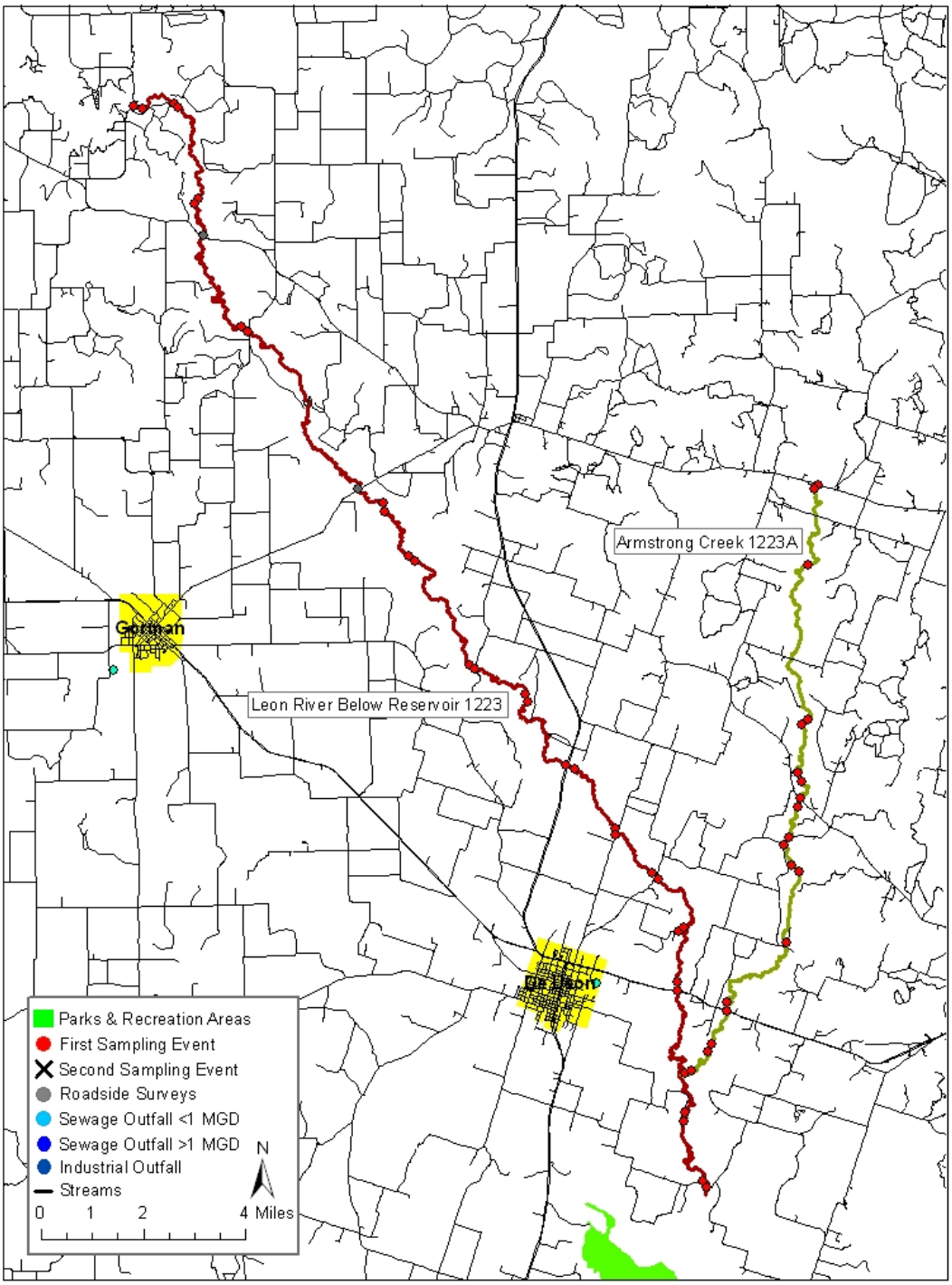
Map of survey sites, recreation areas, and wastewater outfalls along Plum Creek 1221E.



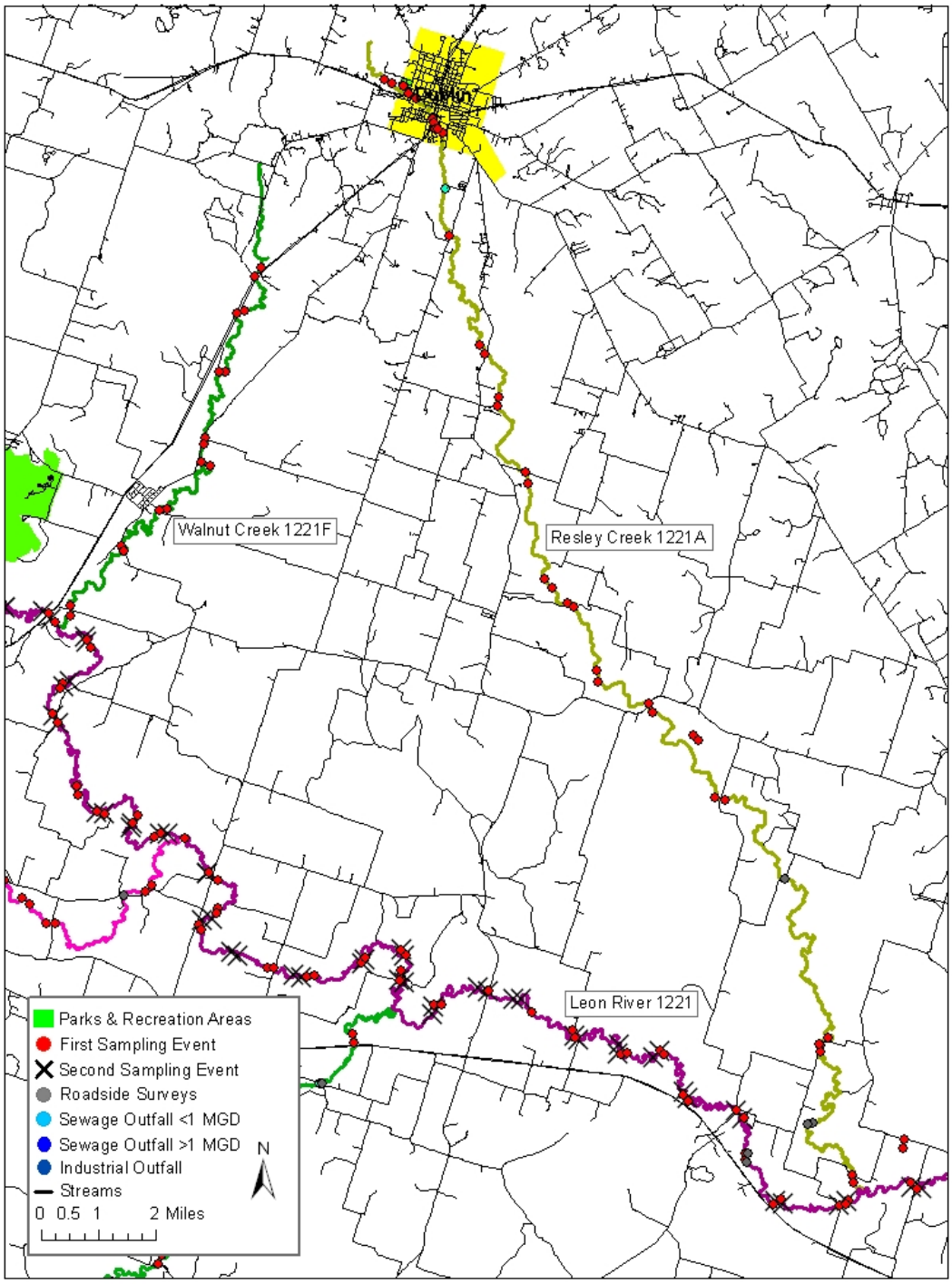
Map of survey sites, recreation areas, and wastewater outfalls along Wasp Creek 1246E.



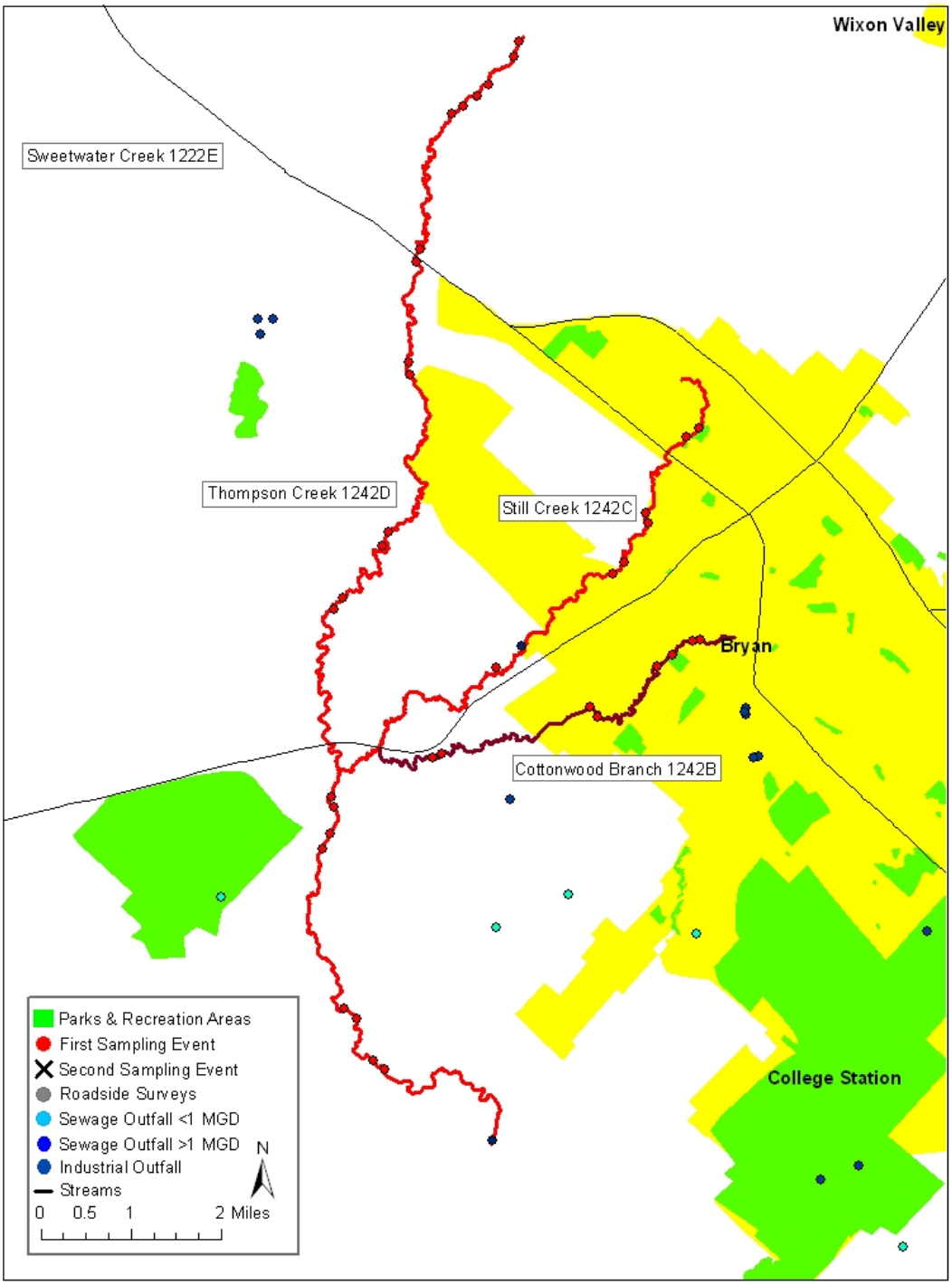
Map of survey sites, recreation areas, and wastewater outfalls along Willis Creek 1247A.



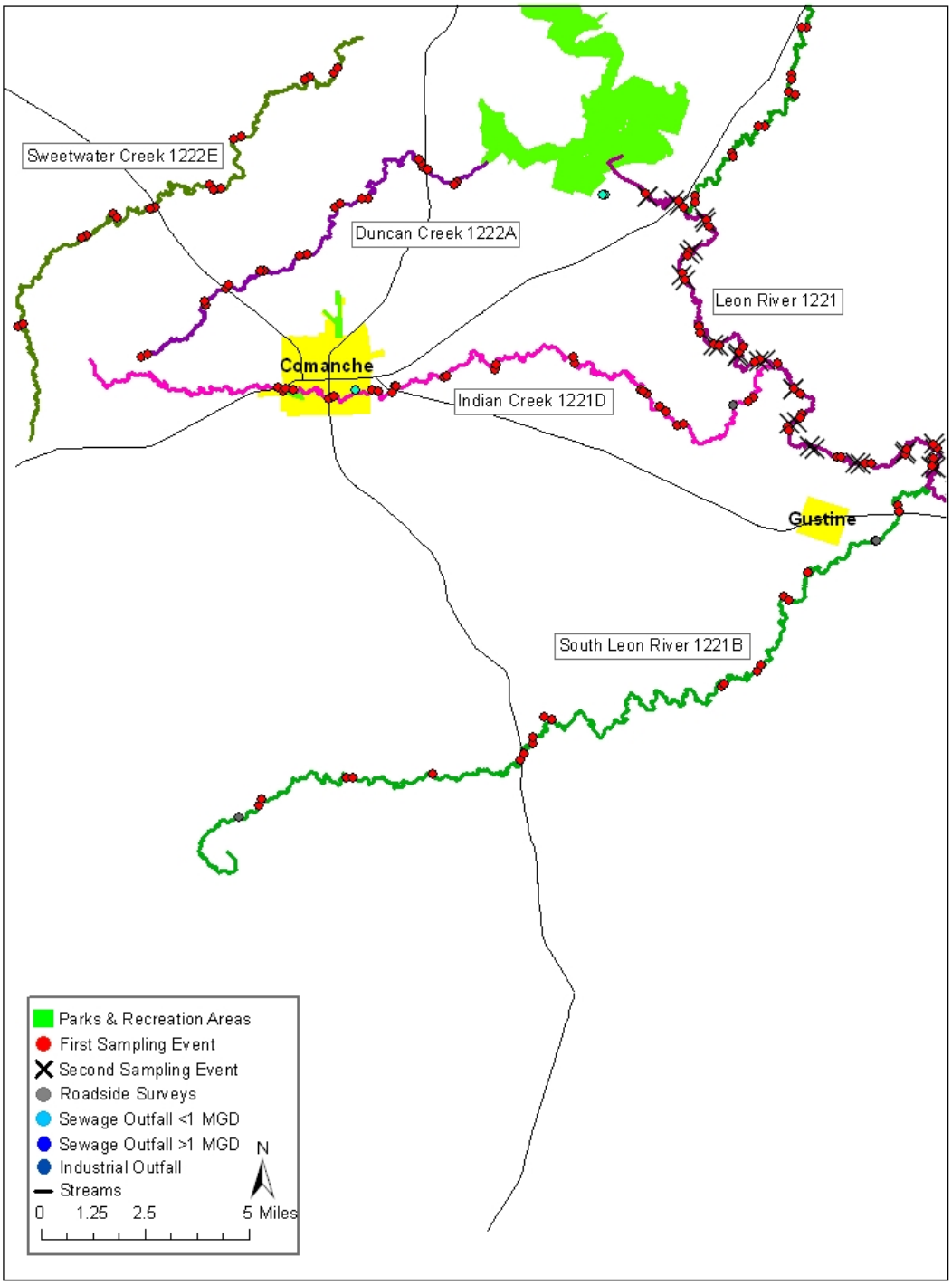
Map of survey sites, recreation areas, and wastewater outfalls along Armstrong Creek 1223A and the Leon River Below the Reservoir 1223.



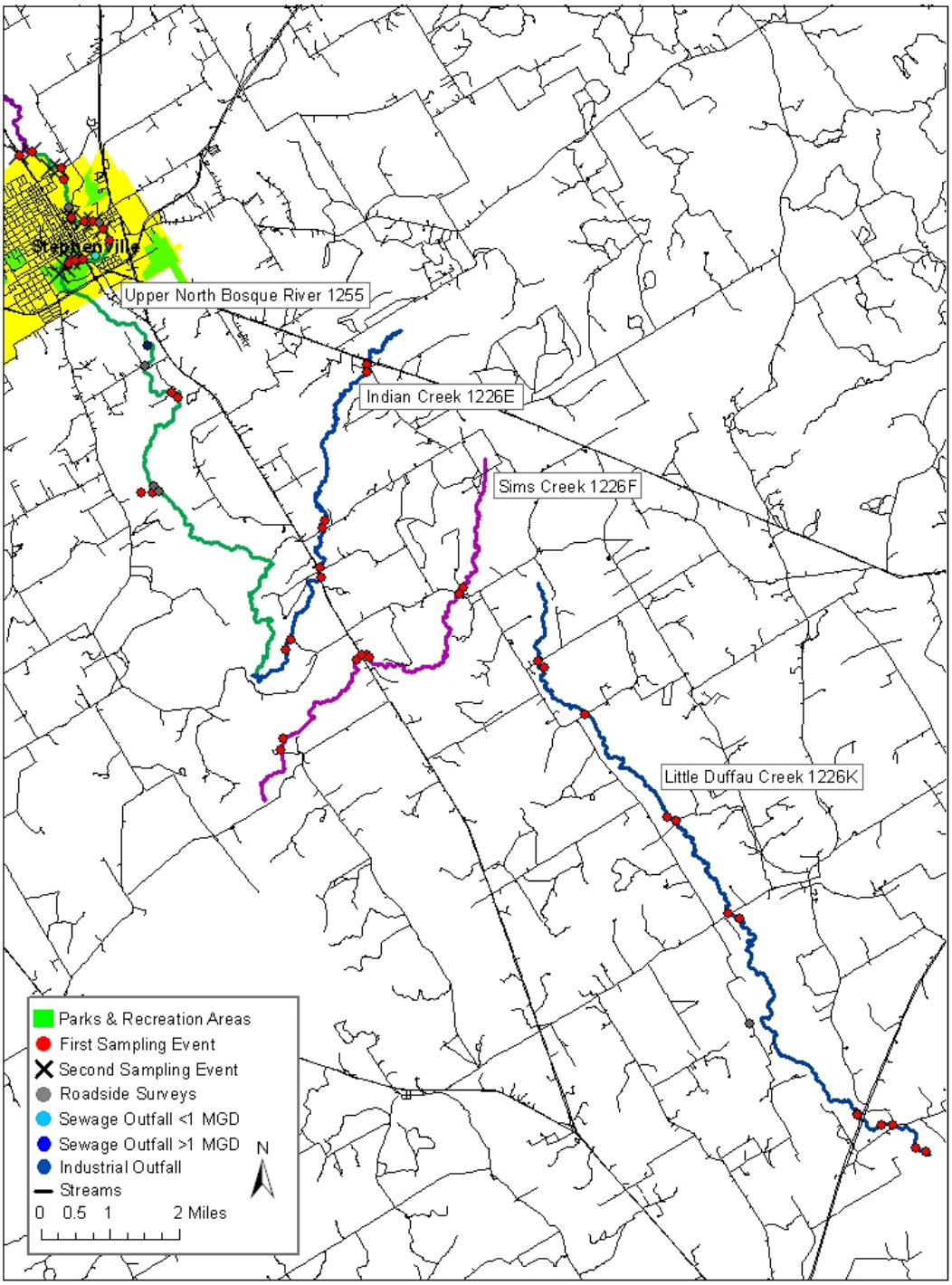
Map of survey sites, recreation areas, and wastewater outfalls along Resley Creek 1221A and Walnut Creek 1221F.



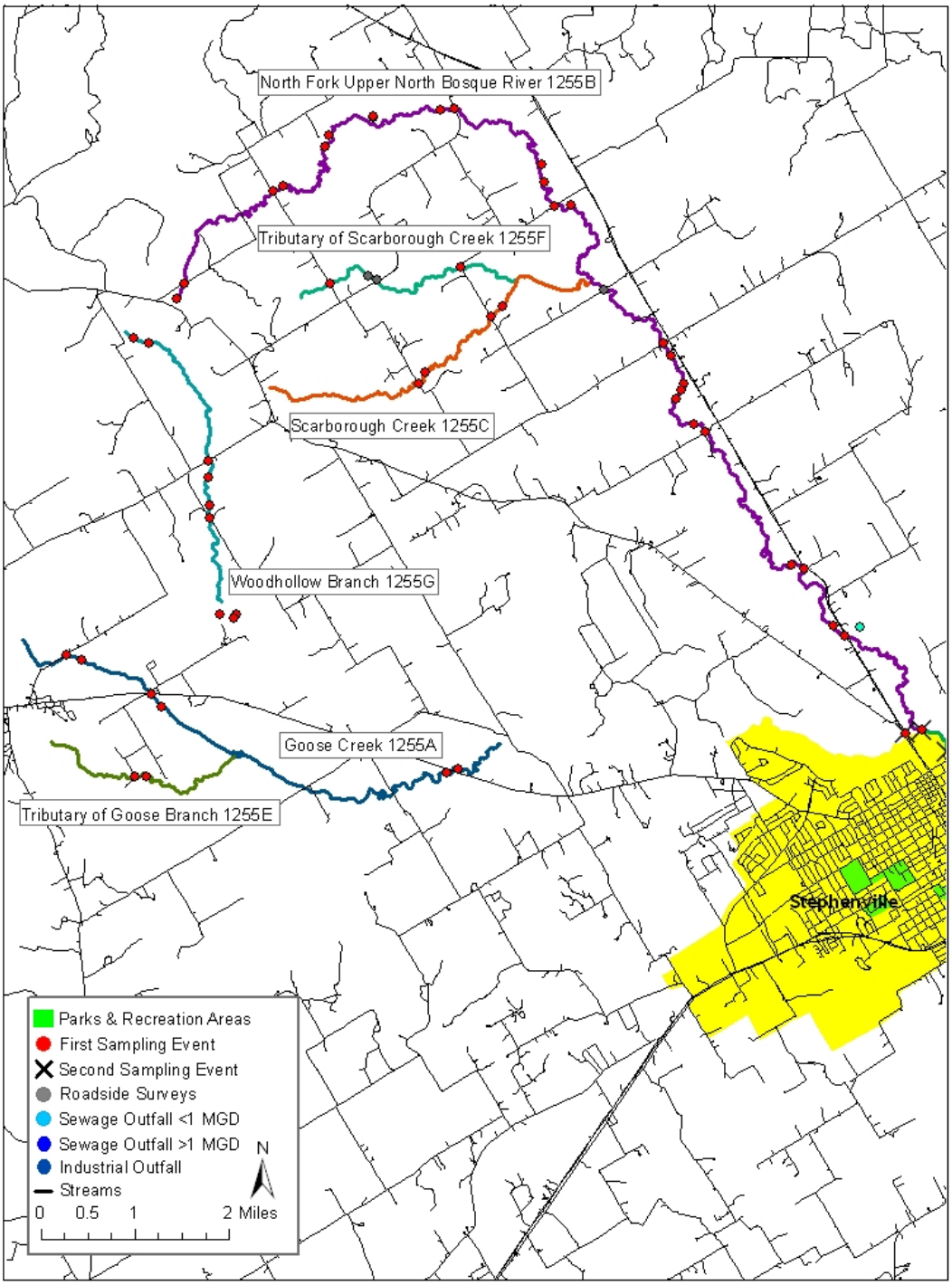
Map of survey sites, recreation areas, and wastewater outfalls along Cottonwood Branch 1242B, Still Creek 1242C, and Thompson Creek 1242D.



Map of survey sites, recreation areas, and wastewater outfalls along Duncan Creek 1222A, Indian Creek 1221D, the South Leon River 1221B, and Sweetwater Creek 1222E.



Map of survey sites, recreation areas, and wastewater outfalls along Indian Creek 1226E, Little Duffau Creek 1226K, Sims Creek 1226F, and Upper North Bosque River 1255.



Map of survey sites, recreation areas, and wastewater outfalls along Goose Creek 1255A, the Tributary of Goose Creek 1255E, the North Fork of the Upper North Bosque River 1255B, Scarborough Creek 1255C, the Tributary of Scarborough Creek 1255F, and Woodhollow Branch 1255G.

Appendix 2

Contact Information Form

(This form should be completed prior to conducting a Basic RUAA Survey and/or Comprehensive RUAA. *The TCEQ Water Quality Standards Group will not consider or review a RUAA unless the appropriate entities listed below have been notified prior to the beginning of a RUAA. A RUAA should not be conducted until you have received a Notice to Proceed from the TCEQ Water Quality Standards Group.)*

River or stream name: _____

Ask the contacts if a recreational use-attainability analysis is appropriate for the river or stream and check Yes or No below. Document the name of the person contacted and the date they were notified about the proposed RUAA project.

Required Local Contacts:

Clean Rivers Partners (River Authority and other local partners)	□ Yes □ No	Date Notified: _____ Name: _____
Texas Parks and Wildlife Department region staff	□ Yes □ No	Date Notified: _____ Name: _____
TCEQ region staff	□ Yes □ No	Date Notified: _____ Name: _____
TSSWCB	□ Yes □ No	Date Notified: _____ Name: _____

Suggested Additional Local Contacts (*Ask the contacts if a recreational use-attainability analysis is appropriate for the river or stream and check Yes or No below. If contacted, include information regarding notification date and person contacted on a separate page and attach it to this form*):

Local Parks and Recreation Departments	□ Yes □ No
Local Government/Jurisdiction	□ Yes □ No
Local Recreation Groups	□ Yes □ No
Conservation Groups	□ Yes □ No
Local County Extension Agent	□ Yes □ No
Watershed Groups	□ Yes □ No
Long-term Landowners/Adjacent Landowners	□ Yes □ No
Texas Stream Team	□ Yes □ No
Canoe Clubs	□ Yes □ No
City Commissioners Office	□ Yes □ No
Real estate agents	□ Yes □ No

Contact Information Form

Local non-profits □ Yes □ No

City/county offices (Engineer, Health, Law Enforcement) □ Yes □ No

Flood control districts □ Yes □ No

Councils of Government □ Yes □ No

TPWD Game Warden □ Yes □ No

Other:_____ □ Yes □ No

(should be completed prior to conducting a Basic RUAA Survey and/or Comprehensive RUAA)

Draft Definitions (2010 TSWQS Revision)

- Primary contact recreation: Water recreation activities, such as wading by children, swimming, water skiing, diving, tubing, surfing, and whitewater kayaking, canoeing, and rafting, involving a significant risk of ingestion of water.

- Secondary contact recreation 1: Water recreation activities, such as fishing, commercial and recreational boating, and limited body contact incidental to shoreline activity, not involving a significant risk of water ingestion and that commonly occur.

- Secondary contact recreation 2: Water recreation activities, such as fishing, commercial and recreational boating, and limited body contact incidental to shoreline activity, not involving a significant risk of water ingestion but that occur less frequently than for secondary contact recreation 1 due to (1) physical characteristics of the water body and/or (2) limited public access.

- Noncontact recreation: Activities, such as ship and barge traffic, birding, and using hike and bike trails near a water body, not involving a significant risk of water ingestion, and where primary and secondary contact recreation should not occur because of unsafe conditions.

Information from Local Contacts:

1. If any entity answered no, please have them list the reason(s) why:

_____

_____

_____

2. Did the local entities confirm that primary contact recreation activities frequently occur? □ Yes □ No

Please describe how often the activities occur? □ Unknown □ Never □ Daily □ Monthly □ Yearly

If no, explain: _____

3. Did the local entities confirm that secondary contact recreation 1 activities frequently occur? □ Yes □ No

Please describe how often the activities occur? □ Unknown □ Never □ Daily □ Monthly □ Yearly

If no, explain: _____

4. Did the local entities confirm that secondary contact recreation 2 activities frequently occur? □ Yes □ No

Please describe how often the activities occur? □ Unknown □ Never □ Daily □ Monthly □ Yearly

If no, explain: _____

5. Did the local entities confirm that noncontact recreation activities frequently occur? □ Yes □ No

Please describe how often the activities occur? □ Unknown □ Never □ Daily □ Monthly □ Yearly

If no, explain: _____

6. Do the local entities know if this water body provides substantial flow to a water body with primary contact recreation activities (e.g. swimming in a state/local park) or a bathing beach that is located immediately downstream? □ Yes □ No □ Unknown

If yes, have the local entities provide the name of the water body and a description of the location of the primary contact recreation uses or bathing beach.

_____
_____

Notify TCEQ Water Quality Standards Group (required):

Send an e-mail notification to the TCEQ Water Quality Standards Group at standards@tceq.state.tx.us.

Notified: □ Yes □ No

Date Notified by e-mail: _____

Date TCEQ WQS E-mail Response Received: _____

WQS Group Contact Person Providing Response: _____

Did the WQS Group provide a Notice to Proceed with the RUAA? □ Yes □ No

Appendix 3

Field Data Sheets – Basic RUAA Survey

(should be completed for each site)

Data Collectors & Contact Information:
Date & Time: County Name:
Stream Name:
Segment No. or nearest downstream Segment No.:
Description of Site:

At any point during the Basic RUAA Survey it becomes apparent that primary contact recreation is clearly the use for the water body the investigator should stop conducting the UAA.

A. Stream Characteristics:

1. Check the following channel flow status that applies.

□ dry □ no flow □ low □ normal □ high □ flooded

2. Check the following stream type that applies on the day of the survey:

□ Ephemeral: A stream which flows only during or immediately after a rainfall event, and contains no refuge pools capable of sustaining a viable community of aquatic organisms.

□ Intermittent: A stream which has a period of zero flow for at least one week during most years. Where flow records are available, a stream with a 7Q2 flow of less than 0.1 cubic feet per second is considered intermittent.

□ Intermittent w/ perennial pools: An intermittent stream which maintains persistent pools even when flow in the stream is less than 0.1 cubic feet per second.

□ Perennial: A stream which flows continuously throughout the year. Perennial streams have a 7Q2 equal to or greater than 0.1 cubic feet per second.

□ Designated or unclassified tidal stream: A stream that is tidally influenced. If you checked this box, you will need to contact the Water Quality Standards Group and evaluate whether or not a bathing beach is located along the tidal stream and whether or not a bathing beach is located along the estuary, bay or Gulf water that the tidal stream flows into.

3. Streamflow

Use USGS gage data (if a gage is located at a site or within a quarter mile of a site) or use the Stream Flow (Discharge) Measurement Form and follow the procedures outlined in the most recent TCEQ Surface Water Quality Monitoring Procedures, Volume 1, RG-415. If USGS gage data is used for a site, include that information as an attachment and list the streamflow on the sampling date below. If the stream flow taken at one site is representative of the flow at another site(s), then that flow can be used as the observed flow and should be documented below. If the stream flow measured at one site is different from another site, then stream flow should be taken at both sites. _____ cfs

4. Water Quality Data (Field Parameters)

Field parameters should be collected in accordance with the procedures outlined in the most recent TCEQ Surface Water Quality Monitoring Procedures, Volume 1.

Air Temp _____º C Water Temp _____º C

Stream Name_____ Site: _____

Date: _____ Time: _____

5. Riparian Zone (Mark dominant categori l R (Right Bank). Bank orientation is determined by the investigator facing downstream.)

_____ Forest _____ Urban _____ Rip rap

_____ Shrub dominated corridor _____ Pasture _____ Concrete

_____ Herbaceous marsh _____ Row crops Other (specify): _____

_____ Mowed/maintained corridor _____ Denuded/Eroded bank

6. Ease of bank access to the water body: □ Easy □ Moderately easy □ Moderately difficult □ Difficult

7. Please describe access opportunities or explain why the site is not easily accessible (Attach photos for documentation):

_____

_____

8. Dominant Primary Substrate

□Cobble □Sand □Silt □Mud/Clay □Gravel □Bedrock □Rip rap □ Concrete

B. Primary Contact Water Recreation

- Primary contact recreation draft definition: Water recreation activities, such as wading by children, swimming, water skiing, diving, tubing, surfing, and whitewater kayaking, canoeing, and rafting, involving a significant risk of ingestion of water.

1. Were water recreation activities that involve a significant risk of ingestion (full body immersion) observed at this site?

□ Yes □ No primary contact recreation activities were observed

a. Check the following boxes of primary contact recreation activities observed at the time of the sampling event at the site (Attach photos of the activities or lack of activities).

□ Wading-Children □ Tubing □ No primary contact activities that

□ Wading-Adults □ Surfing commonly occur were observed

□ Swimming □ Whitewater-kayaking, canoeing, rafting

□ Water skiing □ Other: _____

□ Diving □ frequent public swimming-created by publicly owned land or commercial operations

b. Check the number of individuals observed at the site: □ None □ 1-10 □ 11-20 □ 20-50 □ greater than 50

Stream Name_____ Site: _____

Date: _____ Time: _____

c. Check the following that apply regarding to the water body.

□ Water in mouth or nose of the individual □ Primary touch: Individual's body (or portion) immersed in water

□ Secondary touch: fishing, pets and related contact with water □ Individual is in a boat touching water

□ Individual is on shore near water within 8 meters (25ft) of water □ Individual is well away from water between 8 and 30 meters (100 ft) □ Not applicable

2. If primary contact recreation activities are not observed, describe the physical characteristics of the water body that may hinder the frequency of primary contact (depth, etc.) (Attach photos, etc. for documentation).

_____

_____

3. Describe if there is public access (e.g. parks, roads, etc.) (Attach photos, maps, etc. for documentation).

_____

_____

4. Is an area with primary contact recreation activities or a bathing beach (e.g. state/local parks with swimming, etc.) located near (e.g. within 5 miles upstream and downstream) this site?

C. Secondary Contact Water Recreation Evaluation:

- Secondary contact recreation 1: Water recreation activities, such as fishing, commercial and recreational boating, and limited body contact incidental to shoreline activity, not involving a significant risk of water ingestion and that commonly occur.

- Secondary contact recreation 2: Water recreation activities, such as fishing, commercial and recreational boating, and limited body contact incidental to shoreline activity, not involving a significant risk of water ingestion but that occur less frequently than for secondary contact recreation 1 due to (1) physical characteristics of the water body and/or (2) limited public access.

1. Were water recreation activities observed at the site, but the nature of the recreation does not involve a significant risk of ingestion (e.g. secondary contact recreation activities)? □ Yes □ No secondary contact recreation activities were observed

a. Check the following boxes of secondary contact recreation activities that were observed at the time of the sampling event at the site (Attach photos of activities or lack of activities).

□ Fishing

□ Boating-commercial, recreational

□ Non-whitewater-kayaking, rafting, canoeing

□ No secondary contact recreation activities were observed

□ Other secondary contact activities: _____

Stream Name_____ Site: _____

Date: _____ Time: _____

b. Check the number of individuals observe

□ None □ 1-10 □ 11-20 □ 20-50 □ greater than 50

c. Check the following that apply regarding the individuals proximity to the water body.

□ Secondary touch: fishing, pets and related contact with water □ In a boat touching water

□ Body on shore near water within 8 meters (25ft) of water □ Body well away from water between 8 and 30 meters (100 ft)

2. If secondary contact recreation activities are not observed, describe the physical characteristics of the water body that may hinder the frequency of secondary contact (Attach photos, etc. for documentation).
_____
_____

3. If secondary contact recreation activities are observed, how often do water recreational activities occur that do not involve a significant risk of water ingestion? □ frequently □ infrequently

Please describe how often the activities occur? □ Unknown □ Never □ Daily □ Monthly □ Yearly

4. If infrequently, what is the reason? □ physical characteristics of the water body □ limited public access □ other

If other, list reasons: _____

5. Describe the physical characteristics of the water body that hinders the frequency of secondary contact recreation (depth, etc.) (Attach photos or depth measurements, etc. for documentation).
_____
_____
_____

6. Describe why there is limited public access (e.g. lack of roads, river or stream banks overgrown, etc.) (Attach photos, maps, etc. for documentation).

_____
_____
_____

D. Noncontact Recreation Evaluation

Noncontact recreation applies to water bodies where recreation activities do not involve a significant risk of water ingestion, and where primary and secondary contact recreation uses do not occur because of unsafe conditions, such as barge traffic.

1. Provide site-specific information and documentation (including photographs) regarding unsafe conditions, recreation activities, and presence or absence of water recreation activities.

Stream Name_____ Site: _____

Date: _____ Time: _____

E. Stream Channel and Substantial Pools

Please check the following which best describes the river or stream: □ Wadeable □ Non-wadeable

1. Wadeable Streams

Determine whether or not the average depth at the thalweg is greater than 0.5 meters and if there are substantial pools with a depth of 1 meter or greater. Walk an approximately 300 meter reach (total) at the site and take the following measurements within the 300 meter reach. Measurements should be taken during base flow conditions (sustained or typical dry, warm-weather flows between rainfall events, excluding unusual antecedent conditions of drought or wet weather

Also, take photos facing upstream, downstream, left bank, and right bank at the 30 meters, 150 meters, and 300 meters.

Photos #s (30 meters) Upstream____ Downstream____ Left Bank ____ Right Bank____

Photos #s (150 meters) Upstream____ Downstream____ Left Bank ____ Right Bank____

Photos #s (300 meters) Upstream____ Downstream____ Left Bank ____ Right Bank____

a) Substantial pools - Measure the length of each pool (if > 10 pools only measure 10 pools), the width (at the widest point), and the deepest depth. A substantial pool is considered a pool greater than 10 meters in length for the purposes of a Basic RUAA Survey. If depth and/or width measurements were not attainable, explain why.

	Length (meters)	**Width (meters)**	**Depth (meters)**
Pool 1			
Pool 2			
Pool 3			
Pool 4			
Pool 5			
Pool 6			
Pool 7			
Pool 8			
Pool 9			
Pool 10			

b)Average depth at the thalweg –Take depth measurements approximately every 30 meters to calculate an average depth at the thalweg (at least 10 measurements needed). If depth and/or width measurements were not attainable, explain why.

Distance	**Depth (meters)**
30 meters	
60 meters	
90 meters	
120 meters	
150 meters	
180 meters	
210 meters	
240 meters	
270 meters	
300 meters	
Average	

Stream Name_____ Site: _____

Date: _____ Time: _____

c) Stream width - Measure (1) the width at (s the typical average width of the 300 meter reach; (2) the width at the narrowest point of the stream within the 300 meter reach; and (3) the width at the widest point of the stream within the 300 meter reach.

Measurement Type	Width (meters)
Typical Average Width of 300 meter reach	
Width at narrowest point of the stream within 300 meter reach	
Width at the widest point of the stream within 300 meter reach	

d) Is there sufficient water within a 300 meter stream reach during base flow conditions to support primary contact recreation? □ Yes □ No

COMMENTS:

_____

_____

2. Non-wadeable Streams

If accessible, take 10 width measurements which represent typical widths of the 300 meter reach. If the water is too deep and not accessible record the estimated average width of the water body.

Also, take photos facing upstream, downstream, left bank, and right bank at .

Photos #s (30 meters) Upstream____ Downstream____ Left Bank ____ Right Bank____

Photos #s (150 meters) Upstream____ Downstream____ Left Bank ____ Right Bank____

Photos #s (300 meters) Upstream____ Downstream____ Left Bank ____ Right Bank____

# Measurements	Width (meters)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Stream Name_____ Site: _____

Date: _____ Time: _____

F. Additional RUAA Information

1. Check the following activities observed over the site reach.

□ Drinking or water in mouth □ Playing on shoreline

□ Bathing □ Picnicking

□ Walking □ Motorcycle/ATV

□ Jogging/running □ Hunting/Trapping

□ Bicycling □ Wildlife watching

□ Standing □ None

□ Sitting □ Other: _____

□ Lying down/sleeping

2. Are there permanent or long-term hydrologic modifications that are constructed and operated in a way that affects the recreational uses? □ Yes □ No (If yes, please provide supporting documentation and photos.)

Comments: _____

_____

3. Check any channel obstructions that apply (Attach photos).

□ Culverts □ Fences □ Log jams □ Rip rap □ Water control structure
□ Barbed wire □ Dams □ Thick vegetation □ Low bridges □ None

□ Utility pipe □ Other (specify):_____

4. Check all surrounding conditions that promote recreational activities (Attach photos of evidence or unusual items of interest).

□ Campgrounds □ Stairs/walkway □ Roads (paved/unpaved)□
Other:_____

□ Playgrounds □ Boating access (ramps) □ Populated area □ None of the Above

□ Rural area □ Beach □ Docks or rafts

□ Residential □ Bridge crossing □ Commercial outfitter

□ National forests □ Commercial boating □ Nearby school

□ Urban/suburban location □ Trails/paths (hiking/biking) □ Power Line Corridor

□ Golf Course □ Paved parking lot □ Parks (national/city/county/state)

□ Sports Field □ Unimproved parking lot □ Public Property

Stream Name_____ Site: _____

Date: _____ Time: _____

Comments:_____ _____

_____

5. Check all surrounding conditions that impede recreational activities (Attach photos of evidence or unusual items of interest).

□ Private Property □ Fence

□ No trespass sign □ Barge/ship traffic

□ Wildlife □ Industrial

□ Steep slopes □ None of the Above

□ No public access □ Other:_____

□ No roads

Comments:_____

_____

6. Check any indications of human use (Attach photos).

□ Roads □ RV/ATV Tracks □ NPDES Discharge □ Organized event

□ Rope swings □ Camping Sites □ Gates on corridor □ No Human Presence

□ Dock/platform □ Fire pit/ring □ Children's toys

□ Foot paths/prints □ Fishing Tackle □ Remnant's of Kid's play

□ Other: _____

Comments:_____

_____

7. Check all water characteristics that apply (Attach photos).

Aquatic Vegetation: □ absent □ rare □common □abundant

Algae Cover: □ absent □ rare □common □abundant

Odor: □ none □ rare □common □abundant

Color: □ clear □ green □red □ brown □ black

Bottom Deposit: □ sludge □ solids □ fine sediments □none □other

Water Surface: □ clear □ scum □ foam □ debris □ oil

Other:

_____

_____

Stream Name_____ Site: _____

Date: _____ Time: _____

8. Vertebrates Observed within 300 meter r

Snakes □ None □ slight presence □ moderate presence □ large presence

Water Dependent Birds □ None □ slight presence □ moderate presence □ large presence

Alligators □ None □ slight presence □ moderate presence □ large presence

Comments: _____

9. Mammals Observed within 300 meter reach

Wild □ None □ slight presence □ moderate presence □ large presence

Domesticated Pets □ None □ slight presence □ moderate presence □ large presence

Livestock □ None □ slight presence □ moderate presence □ large presence

Feral Hogs □ None □ slight presence □ moderate presence □ large presence

Comments: _____

10. Evidence of wild animals or evidence of birds, cattle, hogs, etc.

□ Tracks □ Fecal droppings □ Bird nests

11. Garbage Observed

Large garbage in the channel □ None □ Rare □ Common □ Abundant

Small garbage in the channel □ None □ Rare □ Common □ Abundant

Bank Garbage □ None □ Rare □ Common □ Abundant

Briefly describe the kinds of garbage observed: _____

_____

_____

12. Is the site located in a wildlife preserve with large wildlife (i.e waterfowl) population? □ Yes □ No

13. Please document any other relevant information regarding recreational activities and the water body in general (for example, area outside of the stream reach evaluated).

_____

_____

_____

_____

_____

Stream:_____ Date:_____

Site:_____ FDS Page 7 of 8 _____ Site Description:_____ _____

Time Begin:_____ Time End:_____ Meter Type:_____

Observers:_____ Stream Width*:_____ Section Width (W):_____

Observations:_____

Section Midpoint **(ft) (m)**	**Section Depth** **(ft) (m) (cm)** **(D)**	**Observational Depth**** **(ft)(m)**	**Velocity (V)**		**Flow (Q)**
			At Point **(ft/s)(m/s)**	**Average** **(ft/s)(m/s)**	**(m^3/s) (ft^3/s)** **Q = (W)(D)(V)**

Appendix 4

Comprehensive RUAA Interview Form

Stream Name: _____ Segment #: _____ Site: _____

Interviewer's Name: _____

Date & Time (include AM or PM): _____

Interviewed: □ In person □ By phone □ By mail

□ No interviews were conducted

If no interviews were conducted, please provide an explanation:

_____

_____

*Are you willing to respond to a short survey about this stream? □ Yes □ No

If yes, complete contact information for the interviewee below. Do not collect name or contact information if interviewee is a minor. The contact information portion is not required if the interviewee does not want to provide this information.

Legal name: _____ Daytime phone number: _____

Mailing address: _____

Interviewee selected because (e.g., house adjacent to stream; standing by stream, etc.)

_____

_____

Questions:

1. Are you familiar with this stream? □ Yes □ No If yes, how many years? _____

   If yes, proceed to #2. If no, stop here and do not conduct an interview.

2. Describe the location(s) of the stream reach the interviewee is familiar with:
_____

_____

Stream Name_____ Site: _____

Date: _____ Time: _____

3. Have the interviewer characterize the interviewer may not be familiar with TCEQ's definitions or distinction between the different water bodies, please refer to the definitions listed below when asking this question.

□ Ephemeral: A stream which flows only during or immediately after a rainfall event, and contains no refuge pools capable of sustaining a viable community of aquatic organisms.

□ Intermittent: A stream which has a period of zero flow for at least one week during most years. Where flow records are available, a stream with a 7Q2 flow of less than 0.1 cubic feet per second is considered intermittent. (Channel contains flowing water for only a portion of the year and surface water may be absent at times.)

□ Intermittent w/ perennial pools: An intermittent stream which maintains persistent pools even when flow in the stream is less than 0.1 cubic feet per second. (When not flowing, the water may remain in isolated pools.)

□ Perennial: A stream which flows continuously throughout the year. Perennial streams have 7Q2equal to or greater than 0.1 cubic feet per second.

4. Have you or your family personally used the stream for recreation? □ Yes □ No

If yes, proceed to #6. If no, proceed to #5.

5(a). List reasons stream not used. _____

5(b). Proceed to #7.

6.) How do you use the stream? When did these uses occur (e.g. year(s); season) and how often (times/year)? What location did these uses occur (get specific location and mark on a map)?

□ Swimming □ Skin Diving □ Water Skiing □ Wind surfing □ Hunting □ Wading-Adults

□ Tubing □ Kayaking □ Rafting □ Trapping □ SCUBA diving

□ Snorkeling □ Fishing □ Boating □ Canoeing □ Wading-Children

_____

_____

7. Have you observed others using this stream for recreation? □ Yes □ No

If yes, proceed to #8. If no, proceed to #9.

Stream Name_____ Site: _____

Date: _____ Time: _____

8. What kinds of uses have you witnesse ss these uses occurring (e.g. year(s); season) and how often (times/year)? What location did these uses occur (get specific location and mark on a map)?

□ Swimming □ Skin Diving □ Water Skiing □ Wind surfing □ Hunting □ Wading-Adults

□ Tubing □ Kayaking □ Rafting □ Trapping □ SCUBA diving

□ Snorkeling □ Fishing □ Boating □ Canoeing □ Wading-Children

_____

_____

9. Have you heard about anyone using this stream for recreation? □ Yes □ No

If yes, proceed to #10. If no, conclude the interview.

10. What kind of uses have you heard about? When did you hear that these uses occur (e.g. year(s); season) and how often (times/year)? What location did these uses occur (get specific location and mark on a map)?

□ Swimming □ Skin Diving □ Water Skiing □ Wind surfing □ Hunting □ Wading-Adults

□ Tubing □ Kayaking □ Rafting □ Trapping □ SCUBA diving

□ Snorkeling □ Fishing □ Boating □ Canoeing □ Wading-Children

_____

_____

11. Can you recommend someone else we could contact that knows the stream? □ Yes □ No

If yes, list person's contact information: _____

_____

12. Additional comments (from the interviewee or interviewer):

_____

Appendix 5

RUAA Summary

(Not part of the Field Data Sheet)

This form should be filled out after RUAA data collection is completed. Use the Contact Information Form, Field Data Sheets from all sites, Historical Information Review, and other relevant information to answer the following questions on the water body.

Name of water body: _____

Segment No. or Nearest Downstream Segment No.: _____

Classified?: _____

County: _____

1. Observations on Use

a. Do primary contact recreation activities occur on the water body?

□ frequently □ seldom □ not observed or reported □ unknown

b. Do secondary contact recreation 1 activities occur on the water body?

□ frequently □ seldom □ not observed or reported □ unknown

c. Do secondary contact recreation 2 activities occur on the water body?

□ frequently □ seldom □ not observed or reported □ unknown

d. Do noncontact recreation activities occur on the water body?

□ frequently □ seldom □ not observed or reported □ unknown

2. Physical Characteristics of Water Body

a. What is the average thalweg depth? _____ meters

b. Are there substantial pools deeper than 1 meter? □ yes □ no

c. What is the general level of public access?

□ easy □ moderate □ very limited

3. Hydrological Conditions (Based on Palmer Drought Severity Index)

□ Mild-Extreme Drought □ Incipient dry spell □ Near Normal □ Incipient wet spell □ Mild-Extreme Wet