# Historical Data Review for Tehuacana Creek Segment 1242N in the Brazos River Basin

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| Abbreviation | Definition |
|---|---|
| $BOD_5$ | biochemical oxygen demand (5 day) |
| BRA | Brazos River Authority |
| $CBOD_5$ | carbonaceous biochemical oxygen demand (5 day) |
| DO | dissolved oxygen |
| gpm | gallons per minute |
| lbs/day | pounds per day |
| MGD | million gallons per day |
| mg/L | milligrams per liter |
| MPN | most probable number |
| NPDES | National Pollutant Discharge Elimination System |
| NRCS | Natural Resource Conservation Service |
| RBP | rapid bioassessment protocol |
| RWA | receiving water assessment |
| SH | State Highway |
| s.u. | standard units |
| TAC | Texas Administrative Code |
| TCEQ | Texas Commission on Environmental Quality |
| TMDL | total maximum daily load |
| TPDES | Texas Pollutant Discharge Elimination System |
| TPWD | Texas Parks and Wildlife Department |
| TRACS | Texas Regulatory Activities and Compliance System |
| TSS | total suspended solids |
| US | United States |
| USEPA | United States Environmental Protection Agency |
| USDA | United States Department of Agriculture |
| WCID | Water Control and Improvement District |
| WLE | waste load evaluation |

# Introduction

Tehuacana Creek (Segment 1242N) is an unclassified water body in the Brazos River basin located northeast of Waco. This intermittent stream with perennial pools is the main drainage for the eastern part of McLennan County before joining the Brazos River (Figure 1). Prior to 2007, the stream received permitted wastewater discharges from five sources, each discharging less than 0.5 million gallons per day (MGD). In 2007, Sanderson Farms, Inc. opened a poultry processing plant near the intersection of US 84 and Aviation Parkway in Waco. The plant is permitted by the Texas Commission on Environmental Quality (TCEQ) to discharge 1.7 MGD of treated wastewater into Tehuacana Creek, which will sustain perennial flow in the stream downstream of the discharge.

Texas Parks and Wildlife Department (TPWD) anticipates the 1.7 MGD discharge will significantly change water quality characteristics in the downstream portion of Tehuacana Creek. TPWD is interested in monitoring potential changes to habitat, water quality, and organisms as the stream transitions from intermittent to perennial flow. Additionally, TPWD wants to explore the potential for increased nutrient and total suspended solids loads.

Data for Tehuacana Creek are available from an intensive survey conducted by the TCEQ in 1991, and from station 15771, routinely monitored by the Brazos River Authority (BRA) since 1997. Personnel from the TCEQ Region 9 office in Waco conducted a receiving water assessment (RWA) in 2006 and found the stream to have a high aquatic life use. The downstream portion of the water body is on the 303(d) list as bacterial densities exceed the contact recreation criterion.

# History

The history of Texas is intertwined with Tehuacana Creek. The stream has been a meeting spot for Indian tribes, a place to convene Indian Councils, and a host to students learning about science and their community.

The Handbook of Texas Online (Handbook of Texas 2006b) identifies three Tehuacana Creeks in Texas, as well as a reservoir and state park called Lake Tawakoni (TPWD 2006). The Tehuacana Creek that is the focus of this study originates in Hill County three miles south of Penelope and flows to the Brazos River. Tehuacana Creek in Medina County arises seven miles south of Hondo and flows into Hondo Creek in the Nueces river basin. The third stream is located in northeastern Limestone County and flows forty-two miles to the Trinity River (Handbook of Texas 2006b). Lake Tawakoni, at the headwaters of the Sabine River in Hunt, Rains, and Van Zandt counties, was named after the Tawakoni Indians and serves as a reservoir for municipal and industrial uses. It is one of the most recent state parks added to the system (TPWD 2006).

On March 28, 1843 the Tehuacana Creek Councils convened on Tehuacana Creek in the Brazos River Basin near the Torrey Brothers trading post, which was located south of present-day Waco (Handbook of Texas 2006d). The councils created a peace treaty between the Republic of Texas and the Comanche, Keechi, Waco, Caddo, Anadarko, Ioni, Delaware, Shawnee, Cherokee, Lipan, and Tawakoni tribes. On October 9, 1844 the parties finalized the agreement and made history as the last Indian treaty for the Republic (Handbook of Texas 2006c).

## Project Area

The Tehuacana Creek watershed covers 310 square miles and includes portions of Hill, McLennan, and Limestone counties (Tehuacana Creek Water Control and Improvement District 2005). The stream originates in Hill County and flows 31 miles from Hill to McLennan County and joins the Brazos River south of SH 6, about five miles east of Waco (Figure 1). Several tributaries that drain eastern portions of McLennan County feed into Tehuacana Creek. Little Tehuacana Creek is the largest tributary and starts in West, Texas, joining Tehuacana Creek approximately a mile north of US 84. Tradinghouse Creek Reservoir, located on Tradinghouse Creek in the southeastern portion of the Tehuacana Creek watershed, is the largest reservoir in the watershed. The reservoir provides cooling water to the Luminant Tradinghouse Power Plant.

Located in the Texas Blackland Prairie, Ecoregion 32 (Griffith 2004), the naturally fertile soils consist of rich minerals weathered from limestone, shale, and marl (USDA 1992). These fertile soils provide rangeland for beef and dairy cattle. Corn, wheat, hay, grain sorghums, soybeans, and nursery crops are the main crops grown in McLennan County (Ramos 1999). The flat-to-rolling terrain also supports mesquite, cacti, water-tolerant hardwoods, conifers, and grasses (Handbook of Texas 2006b).

During the 1950's the Tehuacana Creek watershed experienced floods that eroded and damaged farmland, crops, roads, and bridges. As a result of the extensive damage throughout the watershed, Public Law 566 was passed by the 83rd Congress and is known as The Watershed Protection and Flood Prevention Act (USDA 1977). Under Public Law 566, the United States Department of Agriculture (USDA) assisted in building 27 flood control dams along the stream and its tributaries to help eliminate damage during future flood events (NRCS 1998). The USDA also installed 32 grade stabilization structures and did channel work on 10.1 miles of the stream (USDA 1977). The channel work included the enlargement and straightening of Tehuacana Creek from the mouth of Tradinghouse Creek to the mouth of Cottonwood Creek, which enters Tehuacana Creek from the east, upstream from US 84 (USDA 1958). In order to fund the flood control structures, the Tehuacana Creek Water Control and Improvement District 1 was created by Public Law 566.

The final Environmental Impact Statement for the Tehuacana Creek watershed flood control project estimated that the flood control structures would reduce the sediment load for the watershed from 242,000 tons to 112,000 tons annually (USDA 1977).


**Figure 1. Tehuacana Creek special study area location map.**

In 1958, it was noted that the northern part of the watershed had high erosion rates due to steep slopes, a predominance of row-crop farming, and inadequate soil conservation treatment (Figure 2). The southern part of the watershed has lower erosion rates due to more pasture land and bank slopes less than two percent (USDA 1958). The flood control structures and the land treatment plan took into account the differences within the watershed and installed treatments accordingly.

**Figure 2. The right bank at station 18770 on Tehuacana Creek, September 2006.**

## Wastewater Discharges

There are six wastewater discharges, three industrial stormwater discharges, and a varying number of construction stormwater discharges permitted by the TCEQ in the Tehuacana Creek watershed. The wastewater discharges are listed in Table 1 and their locations depicted in Figure 3. Stormwater discharges were not plotted on the map to avoid clutter in the figure.

Discharge monitoring reports for the permitted discharges were obtained from the TCEQ Region 9 office in November 2006 and were reviewed for exceedances. Permit limits, exceedances, and enforcement cases are identified below for each permitted discharge. Data from the Sanderson Farms plant in Bryan, Texas were also reviewed based on the similar designs between the Bryan plant and the newer facility in Waco, and the use of self-report data from the Bryan plant in the Waco permit application.

**Table 1. Permitted discharges in the Tehuacana Creek watershed.**

| Permittee | Permitted Discharge | Effluent (MGD) | TCEQ Permit Number |
|---|---|---|---|
| City of Abbott | Wastewater - Domestic | 0.05 | WQ0011544001 |
| City of West | Wastewater - Domestic | 0.45 | WQ0010544001 |
| McLennan County WCID2 | Wastewater - Domestic | 0.2 | WQ0010344001 |
| Methodist Children's Home | Wastewater - Domestic | 0.0075 | WQ0014464001 |
| Sanderson Farms | Wastewater - Industrial | 1.7 | WQ0004784000 |
| Luminant Tradinghouse Company LP | Wastewater - Industrial | 1056 | WQ0001267000 |
| Acklam Construction Company, Inc. | Stormwater - Construction | - | TXR15CD39 |
| Lacy-Lakeview Recycling and Disposal Facility | Stormwater - Industrial | - | TXR05N599 |
| Lindsey Contractors, Inc. | Stormwater - Construction | - | TXR15DG26 |
| L-3 Communications Integrated Systems, LP | Stormwater - Industrial | - | TXR05P927 |
| Texas State Technical College Airport | Stormwater - Industrial | - | TXR05N893 |

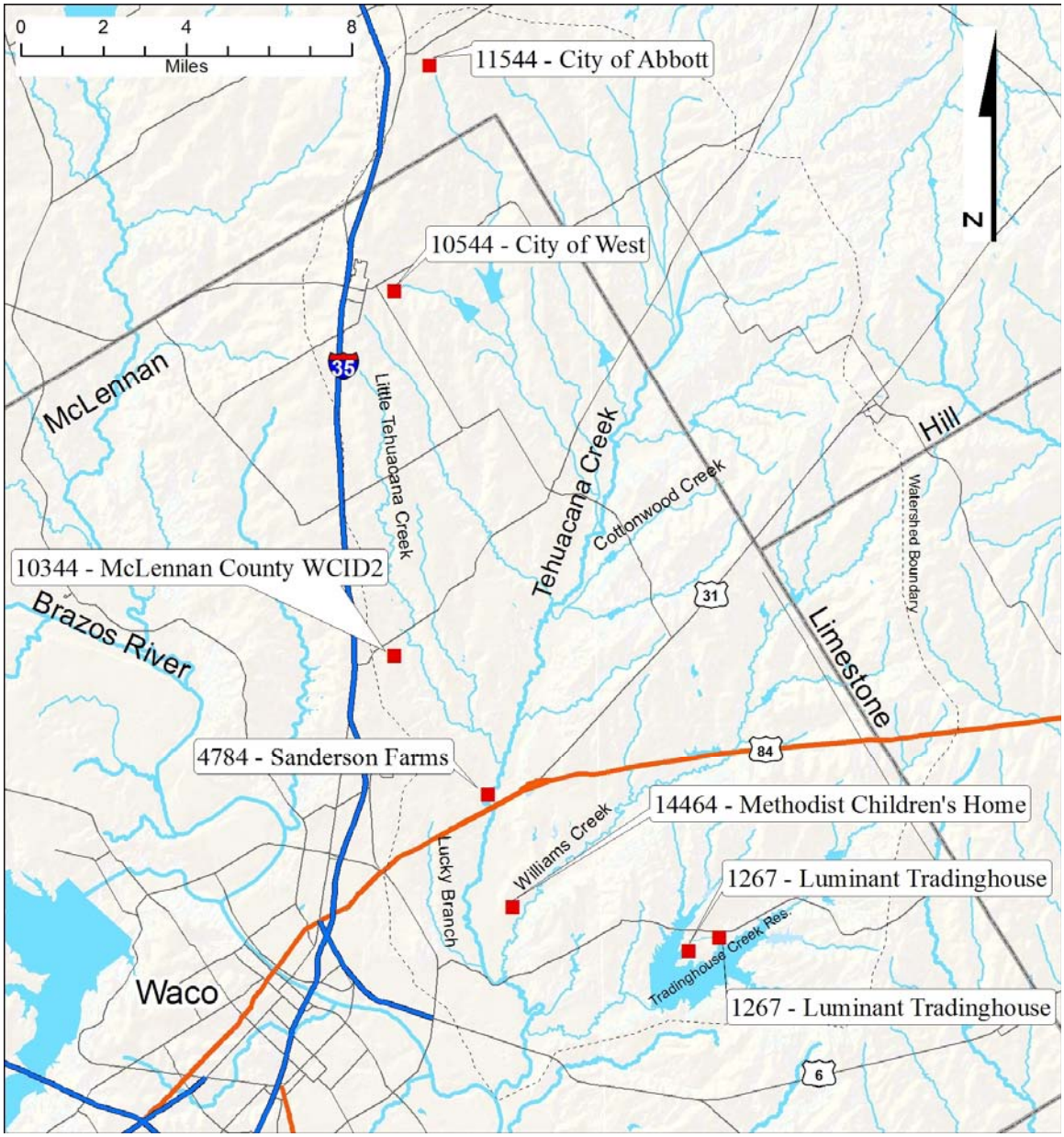


**Figure 3. Locations of permitted wastewater outfalls in the Tehuacana Creek watershed.**

The City of Abbott (TPDES permit number 11544-001) discharges treated municipal wastewater into Cottonwood Creek (a different Cottonwood Creek than mentioned above; there are several in the watershed), which flows into Rice Creek and then enters Tehuacana Creek from the west. The permit authorizes a daily average flow of 0.05 MGD and the effluent limitations include daily average 5-day biochemical oxygen demand ($BOD_5$) of 30 mg/L and total suspended solids (TSS) of 90 mg/L. The treated wastewater must have a residence time of 21 days in the oxidation pond, a pH value between 6.0 and 9.0 standard units, and minimum dissolved oxygen (DO) concentration of 4.0 mg/L.

Discharge monitoring data for the City of Abbott from 2000 to 2006 was reviewed for exceedances. The data indicate that 18 of 74 DO measurements were less than the 4.0 mg/L minimum criteria. Of the 18 measurements, eight occurred in 2002 from March to October and seven in 2003 from March to September. pH values were greater than 9.0 standard units (s.u.) 17 times, with a maximum value of 9.7 s.u. TSS exceeded the 90 mg/L daily average limit five times (twice in 2005 and three times in 2006). Daily average flow ranged from 0.00019 to 0.1825 MGD, with 16 of 74 values greater than 0.05 MGD.

In an enforcement case dated February 25, 2005, the City of Abbott was cited for failing to comply with permit limits for daily average $BOD_5$, daily average TSS, and other effluent limits. During an on-site investigation on January 3, 2006 by the TCEQ, an unauthorized discharge from a manhole was discovered. The TCEQ did not receive prior notice of the overflow. The city was required to clean up the overflow, cited for the unauthorized discharge, and for failure to notify the TCEQ regarding the incident.

The City of West (TPDES permit number 10544-001) discharges treated municipal wastewater into an unnamed tributary then into Rice Creek before reaching Tehuacana Creek. The average permitted flow is 0.45 MGD. The daily average permitted effluent limits are as follows: 20 mg/L for 5-day carbonaceous biochemical oxygen demand ($CBOD_5$); 20 mg/L for TSS; and 2 mg/L for ammonia nitrogen. In addition, chlorine residual must be between 1.0 mg/L and 4.0 mg/L; pH between 6.0 and 9.0 s.u.; and DO must be a minimum of 6.0 mg/L.

Discharge monitoring data for the City of West from 2000 to 2006 shows values outside permitted limits. Twenty-five of 82 DO measurements were less than 6.0 mg/L; one grab TSS value was 84 mg/L in 2002 (the grab sample maximum limit is 65 mg/L); the highest average flow value was 0.72 MGD with 12 averaged events over 0.45 MGD; and the chlorine residual exceeded 4.0 mg/L three consecutive times in 2001 with a maximum value of 5.1 mg/L. Ammonia, pH, and $CBOD_5$ were compliant with permitted values.

The McLennan County Water Control and Improvement District 2 is permitted to discharge 0.20 MGD of treated municipal wastewater into an unnamed tributary which runs into Little Tehuacana Creek and then into Tehuacana Creek (TPDES permit number 10344-001). The effluent limitations for the discharge are: daily average $CBOD_5$ of 10 mg/L; daily average TSS of 15 mg/L; daily average ammonia nitrogen of 3 mg/L; chlorine residual between 1.0 and 4.0 mg/L; pH between 6.0 and 9.0 s.u.; and DO a minimum of 4.0 mg/L.

The McLennan County Water Control and Improvement District 2 discharge monitoring report data summary for 2000 to 2006 is as follows: DO ranged from 2.4 to 9.7 mg/L with eight of 78 measurements less than 4.0 mg/L; daily average TSS ranged from 2.5 to 42.5 mg/L with six values above 15 mg/L; ammonia nitrogen ranged from 0.1 to 19.4 mg/L with eight exceedances; flow data ranged from 0.027 to 0.423 MGD with one exceedance (0.423 MGD in April 2002); chlorine residual levels were below the

minimum twice (0.7 mg/L and 0.9 mg/L in June and July 2001); $CBOD_5$ ranged from 2.5 to 15.25 mg/L with six exceedances (all but one in 2002); and pH ranged from 6.5 to 9.1 s.u. with one exceedance (9.1 s.u.). No enforcement actions were found for the McLennan County Water Control and Improvement District Number 2.

The Methodist Children's Home Ranch (TPDES permit number 14464-001) is authorized to discharge 0.0075 MGD of treated municipal wastewater into an unnamed tributary that flows into Williams Creek then into Tehuacana Creek. The permitted effluent limits are: daily average $BOD_5$ of 20 mg/L; daily average TSS of 20 mg/L; chlorine residual between 1.0 and 4.0 mg/L; pH values between 6.0 and 9.0 s.u.; and a 2.0 mg/L minimum DO level.

Discharge monitoring data for the Methodist Children's Home Ranch are available for 2004 to 2006. DO, flow, pH, and chlorine values were all within permit limits. $BOD_5$ was elevated once (24 mg/L) in June 2005, and three TSS values were greater than the daily average limit of 20 mg/L. The highest daily average TSS value (173 mg/L) was recorded in May 2004.

The Methodist Children's Home Ranch was cited for discharging municipal waste into or adjacent to waters of the state without a permit on August 26, 2002. A permit application was submitted in 2003 and the permit was issued in March 2004.

Luminant Generation Company LP (TPDES permit number 01267) is permitted to discharge treated industrial wastewater via five outfalls into Tradinghouse Creek Reservoir. Tradinghouse Creek Reservoir drains via Tradinghouse Creek, which joins Tehuacana Creek just north of SH 6. The authorized discharges include once-through cooling water, low volume wastes, stormwater runoff, and metal cleaning wastes. The discharge monitoring reports did not have any exceedances except for one pH value of 9.1 s.u. for outfall 201 in July 2005.

The Sanderson Farms, Inc. new poultry processing plant, located on Aviation Parkway in Waco, Texas, is permitted by the TCEQ to discharge 1.7 MGD of treated wastewater into Tehuacana Creek (TPDES permit number 04784). Permitted effluent limits are: 15 mg/L daily average TSS; 10 mg/L daily average $CBOD_5$; 3 mg/L daily average ammonia nitrogen; 200 colonies/100 mL fecal coliform (disinfection will be by ultraviolet light); pH from 6.0 to 9.0 s.u.; and minimum DO concentration 5.0 mg/L.

Sanderson Farms, Inc. has indicated that the wastewater treatment facility in Waco will be similar in design to their Bryan, Texas (Brazos County) plant (TCEQ 2006a). In addition, both streams receiving wastewater are intermittent with perennial pools above the respective discharges. Based on similarities between the Bryan and Waco plants, self-report data from the Bryan plant were used to estimate waste loads from the new Waco facility for the permit application. The Bryan facility discharged an average nitrate-nitrogen concentration of 77.5 mg/L and average total phosphorus concentration of 9.78 mg/L. This nitrate-nitrogen concentration is much higher than expected for freshwater streams. Although industrial wastewater can have different constituents than domestic wastewater, some domestic permits have phosphorus limits of 0.5 or 1 mg/L to protect receiving waters. Screening values are not normally compared directly to effluent

values, but do provide some perspective on these high nutrient levels. The 2004 85th percentile values used for screening freshwater streams for nitrate-nitrogen and total phosphorus are 2.76 and 0.8 mg/L, respectively (Table 2).

**Table 2. 2004 85th percentile values for nutrients and chlorophyll *a* in freshwater streams (TCEQ 2003).**

| Parameter | Screening Levels |
|---|---|
| Ammonia-nitrogen (mg/L) | 0.17 |
| Nitrite-nitrogen (mg/L) | - |
| Nitrate-nitrogen (mg/L) | 2.76 |
| Orthophosphate-phosphorus (mg/L) | 0.5 |
| Total phosphorus (mg/L) | 0.8 |
| Chlorophyll *a* (µg/L) | 11.6 |

Review of discharge monitoring reports for the Sanderson Farms facility in Bryan from 2000 – 2006 provides information on current effluent levels for a similar operation. Reported DO values range from 6.0 to 8.34 mg/L and all 79 values are within effluent limits. However, there were effluent limit exceedances by TSS and ammonia-nitrogen. TSS ranges from 5 to 7,029 mg/L, and daily average ammonia-nitrogen ranges from 1 to 639 mg/L. In April 2001 and July 2004, maximum daily average values for TSS were in the thousands compared to the daily average permit limits (210 mg/L for TSS and 42 mg/L for ammonia-nitrogen), and ammonia-nitrogen exceeded permit limits seven times from May 2001 to November 2001. The high TSS value in July 2004 was the only exceedance that year. Sanderson Farms, Inc. has indicated the Bryan facility experienced problems with wastewater treatment in 2001 which have been resolved (Brenda Flick, Sanderson Farms, Inc., personal communication). Nitrate-nitrogen and total phosphorus do not have established permit limits. Reported daily average values for nitrate-nitrogen ranged from 0.07 to 135 mg/L, and for total phosphorus from 1.99 to 15 mg/L. Sanderson Farms has indicated that dissolved nutrient concentrations in wastewater may be reduced by addition of tertiary treatment.

## Water Quality Standards

The TCEQ sets water quality standards for the state with final approval needed from the United States Environmental Protection Agency (USEPA). Significant water bodies in Texas are called classified segments. The TCEQ assigns water quality standards to each of these classified segments consisting of designated uses, with associated numerical and narrative criteria. Smaller, unclassified water bodies like Tehuacana Creek (1242N) do not have criteria explicitly established. In order to facilitate analysis of Tehuacana Creek historical data, the specific criteria for Brazos River segment 1242 were used (Table 3).

**Table 3. Water quality standards and criteria for Segment 1242 (TCEQ 2000).**

| Use | Parameter | Criteria |
|---|---|---|
| General | Chloride (mg/L), annual average | 350 |
| | Sulfate (mg/L), annual average | 200 |
| | Total Dissolved Solids (mg/L), annual average | 1000 |
| | pH range (standard units) | 6.5-9.0 |
| | Temperature (°F), maximum | 95 |
| High Aquatic Life Use | Dissolved oxygen (mg/L), 24-hour average | 5.0 |
| | Dissolved oxygen (mg/L), minimum | 3.0 |
| Contact Recreation | Escherichia coli (E. coli) (most probable number of colonies per 100 mL), geometric mean | 126 |
| | E. coli (most probable number of colonies per 100 mL), single sample | 394 |

A receiving water assessment in January 2006 by the TCEQ found that Tehuacana Creek supports a high aquatic life use. The dissolved oxygen criteria for high aquatic life use are 24-hour average of 5.0 mg/L and a minimum of 3.0 mg/L. Since it was done recently, this site-specific receiving water assessment has not yet been adopted in the surface water quality standards.

### *Texas Water Quality Inventory and 303(d) List*

For the Texas Water Quality Inventory, Tehuacana Creek is separated into assessment units by the TCEQ; the upstream portion of the stream runs from the confluence of Little Tehuacana Creek upstream to the headwaters, and the downstream portion extends from confluence with the Brazos River upstream to the confluence of Little Tehuacana Creek. The downstream portion is included on the 2002 through the 2008 Texas 303(d) lists for nonattainment of the contact recreation use due to high bacterial densities, with both point and nonpoint sources contributing. TCEQ concluded that more data needs to be collected before a Total Maximum Daily Load (TMDL) will be scheduled (TCEQ 2005).

The upstream portion of Tehuacana Creek has not been assessed due to lack of sufficient data, probably due to the intermittent nature of that portion of the stream. The downstream portion of the stream fully supports the high aquatic life use, but as noted above does not support the contact recreation use (TCEQ 2005).

## Review of Previous Studies

### *Receiving Water Assessment (RWA)*

In January 2006, personnel from the TCEQ Region 9 office in Waco conducted a receiving water assessment (RWA) in response to an industrial permit application from Sanderson Farms, Inc. to discharge poultry processing wastewater into Tehuacana Creek. The discharge enters Tehuacana Creek just downstream from Kirkland Branch, which is 877 meters upstream of US 84 in TCEQ's downstream assessment unit of the creek. The RWA sampling reach started at the proposed discharge location and extended downstream for 268 meters. It is noted in Figure 4 as station 18812.

The TCEQ collected information on habitat, fish, and instantaneous and 24-hour physicochemical parameters from two perennial pools. Typically the RWA data are collected above and below the discharge point in order to compare habitat and document changes above and below the discharge. Due to the dry conditions at the time of the RWA aquatic habitat was not available above the discharge site and two pools were sampled below. The larger pool was used as a reference. The RWA habitat assessment rated the smaller pool as limited and the larger pool as intermediate, noting moderately unstable banks, available instream cover as absent, and bottom substrate as unstable. The perennial pools were sampled during an extended dry period that lasted through the summer of 2006.

The 24-hour physicochemical measurements showed low DO concentration levels during the deployment period. The TCEQ noted that sampling disturbed the substrate in the pools causing a release of gases and increasing turbidity, lowering DO levels for more than 24 hours for both deployments. It is noted that initial instantaneous DO readings from an undisturbed pool showed DO levels at 5.0 mg/L (TCEQ 2006b).

Of the twelve species of fish collected, the western mosquitofish was the most abundant, followed by bluegill and longear sunfish (see Table 4). The fish assemblage scored high using the regionalized index of biotic integrity for ecoregion 32 (Linam et al. 2002). As a result this portion of Tehuacana Creek was assigned a high aquatic life use and DO 24-hour average criteria of 5.0 mg/L (3.0 mg/L minimum).

**Table 4. Fish species collected during the receiving water assessment for Tehuacana Creek, January 2006 (TCEQ 2006b).**

| Genus species | Common Name | Number Caught |
|---|---|---|
| *Gambusia affinis* | Western mosquitofish | 75 |
| *Lepomis macrochirus* | Bluegill | 62 |
| *Lepomis megalotis* | Longear sunfish | 35 |
| *Lepomis cyanellus* | Green sunfish | 8 |
| *Lepomis gulosus* | Warmouth | 7 |
| *Lepomis auritus* | Redbreast sunfish | 2 |
| *Lepomis microlophus* | Redear sunfish | 1 |
| *Pomoxis annularis* | White crappie | 1 |
| *Pimephales vigilax* | Bullhead minnow | 1 |
| *Etheostoma gracile* | Slough darter | 1 |
| *Etheostoma chlorosomum* | Bluntnose darter | 1 |
| *Ameiurus natalis* | Yellow bullhead | 1 |

## *Intensive Survey*

The TCEQ Central Office staff conducted an Intensive Survey in March and June 1991 on segment 1242, which included Tehuacana Creek. Sampling on Tehuacana Creek took place at seven stations located along the entire length of the stream and its main tributaries (Figure 4). The report for the Intensive Survey has not been located, but data from the survey is available from the TCEQ's online database (TCEQ 2006c). Instantaneous physicochemical parameters and routine water chemistry data from the survey are shown in Table 5.

**Table 5. Instantaneous physicochemical and routine water chemistry mean, maximum and minimum measurements for stations 11609, 11610, 11612, 11613, 11614, 11615, and 11616, March and June 1991 (TCEQ 2006c).**

| Parameter Name | Mean | Maximum | Minimum | N |
|---|---|---|---|---|
| DO (mg/L) | 7.1 | 11.0 | 2.0 | 34 |
| Nitrate-nitrogen (mg/L) | 3.50 | 15.21 | 0.03 | 10 |
| Nitrite-nitrogen (mg/L) | 0.11 | 0.43 | 0.01 | 10 |
| Orthophosphate-phosphorus (mg/L) | 2.33 | 8.70 | 0.01 | 9 |
| pH | 7.8 [a] | 8.3 | 7.4 | 33 |
| Specific conductance (µmhos/cm) | 980 | 1562 | 153 | 33 |
| Total dissolved solids (mg/L)[b] | 636.7 | 1015.3 | 99.5 | 33 |
| Sulfate (mg/L) | 178.7 | 363.0 | 93.0 | 10 |
| TSS (mg/L) | 30.8 | 54.0 | 10.0 | 10 |
| Water temperature, ºC | 22.7 | 30.6 | 18.6 | 34 |

[a]Median value for pH

[b] Total dissolved solids were calculated from specific conductance using the equation, TDS (mg/L) = Conductivity (µmhos/cm) x 0.65.

## *Other Studies*

The TCEQ established a routine monitoring station and a special metals study on Tradinghouse Creek Reservoir in November 2004. Station 18457 is located at the lower end of the reservoir (Figure 4). Data are available for station 18457 from November 2004 to present and summarized in Table 6 and Table 7.

Inorganic substance concentrations from Tradinghouse Creek Reservoir (Table 6) were compared with freshwater acute and chronic water quality standards, where such standards exist (TCEQ 2000). Metal-in-tissue values (Table 7) were compared with Table 21 in the *Guidance for Assessing Texas Surface and Finished Water Quality Data* (TCEQ 2003). All average water column values were less than the water quality standards. However, metal-in-tissue values for arsenic, cadmium, lead, and selenium exceed the screening levels.

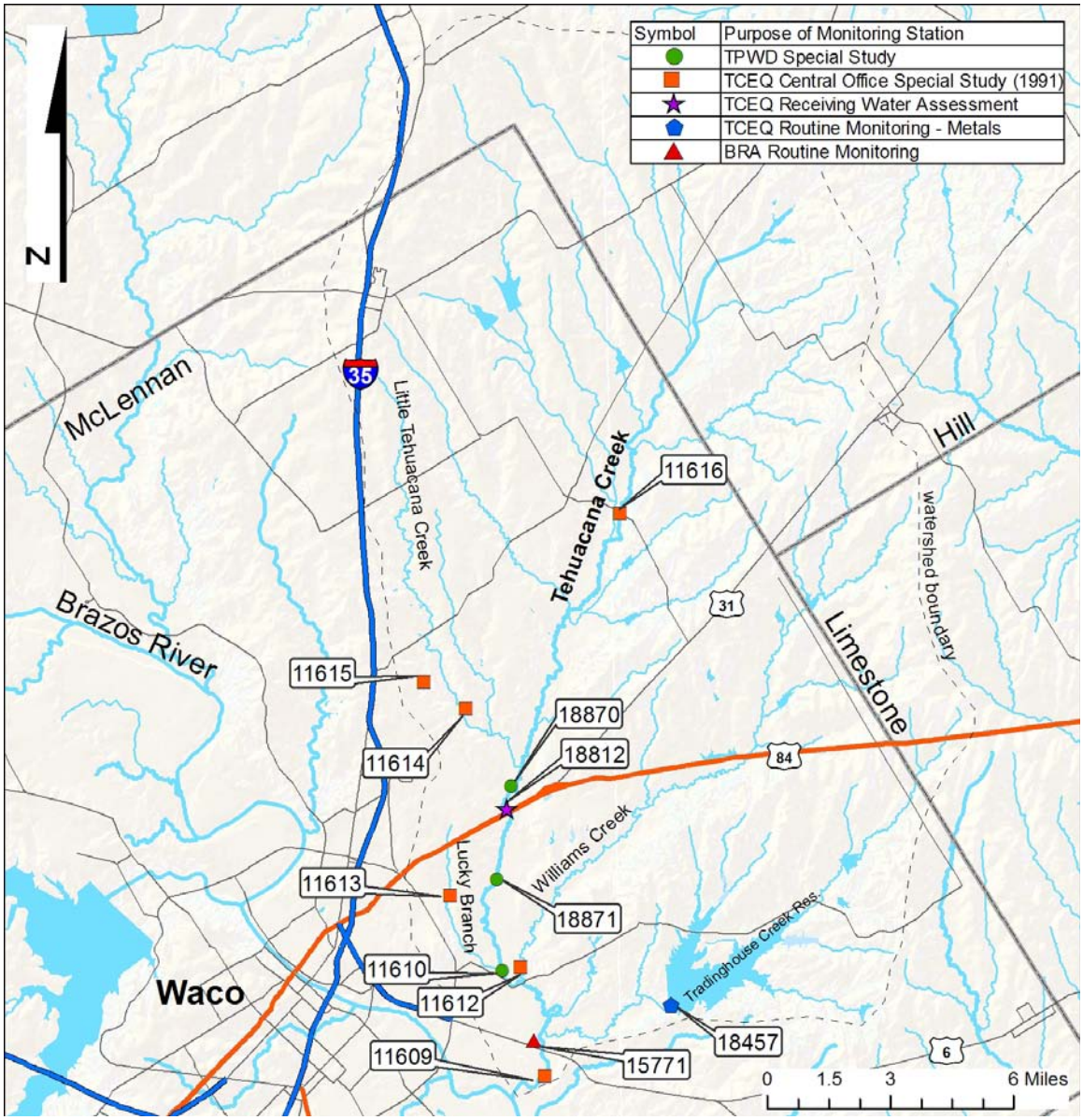


**Figure 4. Map of station locations in the Tehuacana Creek watershed.**

**Table 6. Inorganic substance concentrations for TCEQ station 18457 on Tradinghouse Creek Reservoir (TCEQ 2006d) and screening levels calculated from water quality standards (TCEQ 2000).** [a]

| Parameter Name | Mean | Minimum | Maximum | N | Screening Level[b] |
|---|---|---|---|---|---|
| Alkalinity, total (mg/L) | 134 | 118 | 144 | 6 | NA |
| Aluminum, dissolved (µg/L) | <100 | <100 | <100 | 4 | 991[c] |
| Arsenic, dissolved (µg/L) | 2.8 | <2.5 | 3.3 | 4 | 190 |
| Cadmium, dissolved (µg/L) | <0.1 | <0.1 | <0.1 | 4 | 1.5 |
| Calcium, dissolved (mg/L) | 33.5 | 26.3 | 37.6 | 4 | NA |
| Chromium, dissolved | <4 | <4 | <4 | 4 | NA |
| Chromium (trivalent), (µg/L) | - | - | - | - | 261.6 |
| Chromium (hexavalent), (µg/L) | - | - | - | - | 10.6 |
| Copper, dissolved (µg/L) | 2 | 1 | <3 | 3 | 18.4 |
| Fluoride, total (mg/L) | 0.5 | 0.4 | 0.7 | 6 | NA |
| Iron, dissolved (µg/L) | <10 | <10 | <10 | 3 | NA |
| Lead, dissolved (µg/L) | 0.7 | <0.1 | 1.6 | 4 | 4.6 |
| Magnesium, dissolved (mg/L) | 9.2 | 8.5 | 9.9 | 4 | NA |
| Manganese, dissolved (µg/L) | <0.4 | <0.4 | <0.4 | 4 | NA |
| Mercury, total (µg/L) | <0 | <0 | <0 | 4 | 1.3 |
| Nickel, dissolved (µg/L) | <5 | <5 | <5 | 4 | 234.0 |
| Potassium, dissolved (mg/L) | 9.4 | 8.8 | 9.8 | 4 | NA |
| Selenium, dissolved (µg/L) | <0.4 | <0.1 | <0.5 | 4 | NA |
| Selenium, total (µg/L) | 0.2 | 0.2 | <0.3 | 4 | 5 |
| Silver, dissolved (µg/L) | <0.4 | <0.4 | <0.5 | 3 | 0.8[d] |
| Sodium, dissolved (mg/L) | 59.8 | 55.8 | 62.1 | 3 | NA |
| Zinc, dissolved (µg/L) | <4 | <4 | <4 | 4 | 155.6 |

[a] "<" indicates that some values are at or below the detection limit. When values were averaged to obtain the mean, the detection limit was used in the calculations.
[b] Chronic freshwater criteria unless otherwise noted
[c] Acute freshwater criteria
[d] Standard for silver is for free ion
Brazos Basin hardness value was used (160 mg/L).

**Table 7. Metal concentrations in tissue for TCEQ station 18457 on Tradinghouse Creek Reservoir (TCEQ 2006d) and screening levels (TCEQ 2003).**[a]

| Parameter Name | Mean | Minimum | Maximum | N | Screening Levels |
|---|---|---|---|---|---|
| Arsenic in fish or animal, total (mg/kg) | <4.1 | <4.0 | <4.3 | 4 | 3.0 |
| Cadmium in fish or animal, total (mg/kg) | <1.0 | <1.0 | <1.1 | 4 | 0.5 |
| Chromium in fish or animal, total (mg/kg) | <2.0 | <2.0 | <2.1 | 4 | 100.0 |
| Copper in fish or animal, total (mg/kg) | <1.6 | <1.5 | <1.6 | 4 | 40.0 |
| Lead in fish or animal, total (mg/kg) | <4.1 | <4.0 | <4.3 | 4 | 1.25 |
| Mercury in fish or animal, total (mg/kg) | <0.07 | <0.05 | 0.13 | 4 | 0.7 |
| Selenium in fish or animal, total (mg/kg) | <10.3 | <10.0 | <10.6 | 4 | 2.0 |

[a] "<"indicates that some values are at or below the detection limit. When values were averaged to obtain the mean, the detection limit was used in the calculations.

Baylor University Environmental Studies students conducted a study on Tehuacana and Aquilla creeks (Baylor Leadership Science Project 2000). The students collected instantaneous physicochemical parameters, fecal coliform, E. coli, nitrate, phosphate, and

total suspended solids data in February and March 2000. The project description and some data are available on the internet. There is no mention of quality control checks or quality assurance. In the absence of quality assurance information, these data were not reviewed for this report.

The Brazos River Authority conducted a Rapid Bioassessment Protocol (RBP) Workshop May 25-27, 1993 (Bothwell et al. 1993). The workshop focused on introducing the participants to EPA RBP for evaluating water and habitat quality. Several streams in McLennan County were sampled to provide the participants with hands-on training in sampling and identification of benthic invertebrates and conducting habitat assessments.

The RBP Protocols provide a method for initial screening of water quality in a stream or river. The protocols compare habitat, following EPA's assessment methodology, with benthic species variability using a computer template provided by EPA Region 6. Metric scores for habitat quality and biological condition are plotted and compared to a reference site. The percent comparison between the stream and the reference site provides the amount of impairment for that particular stream.

In 1993, comparison between Tehuacana Creek and the reference stream, Childress Creek (located in the Texas-Oklahoma Plains off FM 2490 in McLennan County), showed Tehuacana Creek as slightly nutrient enriched. The nutrient enrichment conclusion was based on different habitat for the two streams, which may be due to the streams being located in two different ecoregions.

No data or reports from Texas Parks and Wildlife Department have been found for the Tehuacana Creek watershed.

## Water Quality Data

Data are available through TCEQ's Texas Regulatory Activities and Compliance System (TRACS) database. The TRACS Sampling Data Query available on the TCEQ website was accessed on July 2006 for data in Segment 1242, Brazos River above Navasota River (TCEQ 2006c). All records for the segment were downloaded from the database then sorted for stations within the Tehuacana Creek watershed and summarized in this report (Table 8). Additional data are found in Appendix A.

Limited data are available for both the upstream and downstream portions of Tehuacana Creek. The TRACS query identified 12 stations in the Tehuacana Creek watershed (Figure 4). Seven stations are on the main stem, four on tributaries, and one on a reservoir. The stations included one which has been monitored regularly since 1997, seven which correspond to the intensive survey conducted in 1991, one from the 2006 receiving water assessment, one on the reservoir which is a routine monitoring station and part of an ongoing special study, and three from the TPWD study which is in progress.

**Table 8. Stations sampled in the Tehuacana Creek watershed. Stations are listed upstream to downstream.**

| Station ID | Location | Dates Sampled | No. of Sampling Events | Sampling Entity | Purpose of Study |
|---|---|---|---|---|---|
| 11616 | Tehuacana Creek at FM 2311, 2.5 mi. NW of Axtell | 1991 | 1 | TCEQ Central Office | Special Study |
| 11615 | Little Tehuacana Creek at County Rd. East of Elm Mott | 1991 | 10 | TCEQ Central Office | Special Study |
| 11614 | Little Tehuacana Creek at County Rd. NE of Airport in Waco | 1991 | 5 | TCEQ Central Office | Special Study |
| 18870 | Tehuacana Creek 1.39 km upstream of US 84 520 M upstream of Kirland Branch and approximately 5.1 km East of Lacy-Lakeview | 2006 | 1 | Texas Parks and Wildlife Department | Special Study |
| 18812 | Tehuacana Creek at 877 M upstream of US 84 and 30 M downstream of Kirkland Branch confluence approximately 6 km East of Bellmead | 2006 | 1 | TCEQ Regional Office | Receiving Water Assessment |
| 18871 | Tehuacana Creek at Old Mexia Rd. 2.71 km downstream of US 84 and approximately 4.57 km East of Bellmead | 2006 | 1 | Texas Parks and Wildlife Department | Special Study |
| 11613 | Lucky Branch at Camp Ground Rd. East of Bellmead | 1991 | 10 | TCEQ Central Office | Special Study |
| 11612 | Williams Creek at FM 2941 SE of Waco | 1991 | 2 | TCEQ Central Office | Special Study |
| 11610 | Tehuacana Creek at FM 2491 SE of Waco | 1991 | 5 | TCEQ Central Office | Special Study |
| 11610 | Tehuacana Creek at FM 2491 SE of Waco | 2006 | 1 | Texas Parks and Wildlife Department | Special Study |
| 18457 | Tradinghouse Creek Reservoir 195 M East and 445 M North of center of dam spillway approximately 13 km East of Waco | 2005 | 1 | TCEQ Regional Office | Special Study |
| 18457 | Tradinghouse Creek Reservoir 195 M East and 445 M North of center of dam spillway approximately 13 km East of Waco | 2004 - Present | 6 | TCEQ Regional Office | Routine Monitoring |
| 15771 | Tehuacana Creek at SH6, 4 mi. North of Riesel | 1997 - Present | 78 | Brazos River Authority | Routine Monitoring |
| 11609 | Tehuacana Creek at Spur 484 SE of Waco | 1991 | 10 | TCEQ Central Office | Special Study |

Routine monitoring at station 15771 constitutes 78 of the 115 sampling events from Tehuacana Creek. Samples were collected monthly starting in 1997 then reduced to quarterly in 2003. This station is currently included on the Clean Rivers Program sampling list for the BRA. The oldest data found for Tehuacana Creek date from 1991 and consist of 30 sampling events distributed among tributaries and the main stem. A new station was added to the Tehuacana Creek watershed in late 2004 on Tradinghouse Creek Reservoir. The reservoir station serves as a routine monitoring site and a special study site for metals. Personnel from the TCEQ Region 9 office sample the station quarterly and seven sampling events exist for this station. No sampling events for any station were found between 1991 and 1997.

Physicochemical instantaneous measurements made up the bulk of available data. Parameters collected were water temperature, specific conductance, dissolved oxygen (mg/L), dissolved oxygen saturation (%), pH, and salinity.

Data for stations sampled in the 1991 intensive survey are summarized in Table 5, data from routine monitoring at station 15771 are summarized in Table 9, and data from the station on Tradinghouse Creek Reservoir are shown in Table 6 and Table 7.

Instantaneous DO measurements for station 15771 ranged from 1 to 13.79 mg/L with an average of 8.16 mg/L. All but one of 74 DO measurements exceeded the 3.0 mg/L minimum for instantaneous measurements. The only reading less than 3.0 mg/L at station 15771 occurred in October 1998 and was the only parameter recorded for the October event. While instantaneous DO measurements can not be directly compared to the 24-hour criterion, it can be used as a yardstick to gage general water quality. Six of 74 instantaneous readings were less than 5.0 mg/L, with four of the six occurrences observed in September or October, showing some seasonal trend in depressed values. In 2003, monitoring at station 15771 changed to quarterly and summer and winter sampling changed to July and November. These months are outside the historical period of low DO readings.

Data from seven stations sampled in March and June 1991 included two DO readings below the minimum criterion of 3.0 mg/L and four DO readings less than 5.0 mg/L, out of a total of 34 readings (Table 5). The low DO readings during the March and June sampling events occurred between 8:00 am and noon. The low DO readings occurred during peak respiration time for aquatic plants (macro and micro), presumably causing the lower DO readings.

**Table 9. Instantaneous physicochemical and routine water chemistry measurements for station 15771 on Tehuacana Creek from 1997 to 2006 (TCEQ 2006c) and screening levels (TCEQ 2003). [b]**

| Parameter Name | Mean | Maximum | Minimum | N |
|---|---|---|---|---|
| DO (mg/L) | 8.2 | 13.8 | 1.0 | 74 |
| DO % saturation | 92.2 | 137.6 | 36.7 | 73 |
| E. coli (colonies per 100 mL) | 492 | >2419[a] | 8 | 31 |
| Fecal coliform (colonies per 100 mL) | 372 | 1420 | 4 | 51 |
| Nitrate-nitrogen (mg/L) | 1.00 | 13.07 | <0.02 | 64 |
| Nitrite-nitrogen (mg/L) | 0.09 | 0.78 | <0.02 | 67 |
| Orthophosphate-phosphorus (mg/L) | 0.06 | 0.50 | <0.04 | 57 |
| pH | 7.8[c] | 8.4 | 7.3 | 73 |
| Specific conductance (µmhos/cm) | 854 | 1967 | 189 | 74 |
| Total dissolved solids (mg/L)[d] | 555.4 | 1278.6 | 122.9 | 74 |
| Sulfate (mg/L) | 126.4 | 373.2 | 9.6 | 69 |
| TSS (mg/L) | 67.6 | 557.0 | 6.0 | 81 |
| Water temperature, ºC | 21.0 | 31.2 | 3.2 | 74 |

[a]">" indicates that some values exceed the detection limit. When values were averaged to obtain the mean, the detection limit was used in the calculations.
[b]"<" indicates that some values are at or below the detection limit. When values were averaged to obtain the mean, the detection limit was used in the calculations.
[c]Median value for pH
[d]Total dissolved solids were converted from specific conductance using the equation TDS (mg/L) = Conductivity (µmhos/cm) x 0.65.

Numeric criteria for nutrient parameters such as nitrate, nitrite, orthophosphate-phosphorus, total phosphorus, and chlorophyll *a* have not been established. In conducting assessments, the TCEQ compares observed nutrient levels with statewide 85$^{th}$ percentile screening levels for freshwater streams as listed in Table 18 of *Guidance for Assessing Texas Surface and Finished Water Quality Data* (TCEQ 2003).

For station 15771, orthophosphate-phosphorus has been monitored on 57 events. All but three concentrations were reported at less than the detection limit of 0.05 mg/L. The three concentrations reported above the detection limit were less than the screening level of 0.5 mg/L. Data from the 1991 intensive survey consists of nine data points, four of which exceeded the screening level. The four elevated data points were from two stations, both on tributaries. Station 11615, on Little Tehuacana Creek downstream of the McLennan County WCID 2 outfall, had readings of 6.97 and 8.70 mg/L. Station 11613, located on Lucky Branch, had readings of 3.48 and 1.68 mg/L. All four values were well above the 85$^{th}$ percentile value of 0.5 mg/L.

For station 15771, the maximum nitrate-nitrogen value was 13.07 mg/L, with a minimum of 0.02 mg/L, and an average of 1.00 mg/L (Figure 5). Four of 64 values exceeded the 2004 screening level of 2.76 mg/L. Data from 1991, analyzed using the 2004 screening level, showed three exceedances out of ten measurements. The two highest readings were from station 11615 located on Little Tehuacana Creek, and the third highest was from station 11613 located on Lucky Branch. These data from the 1991 study suggest a concern for nitrate-nitrogen. Comparatively, starting in 2003 there appears to be a declining trend for nitrates at station 15771, but more data are needed to verify this.

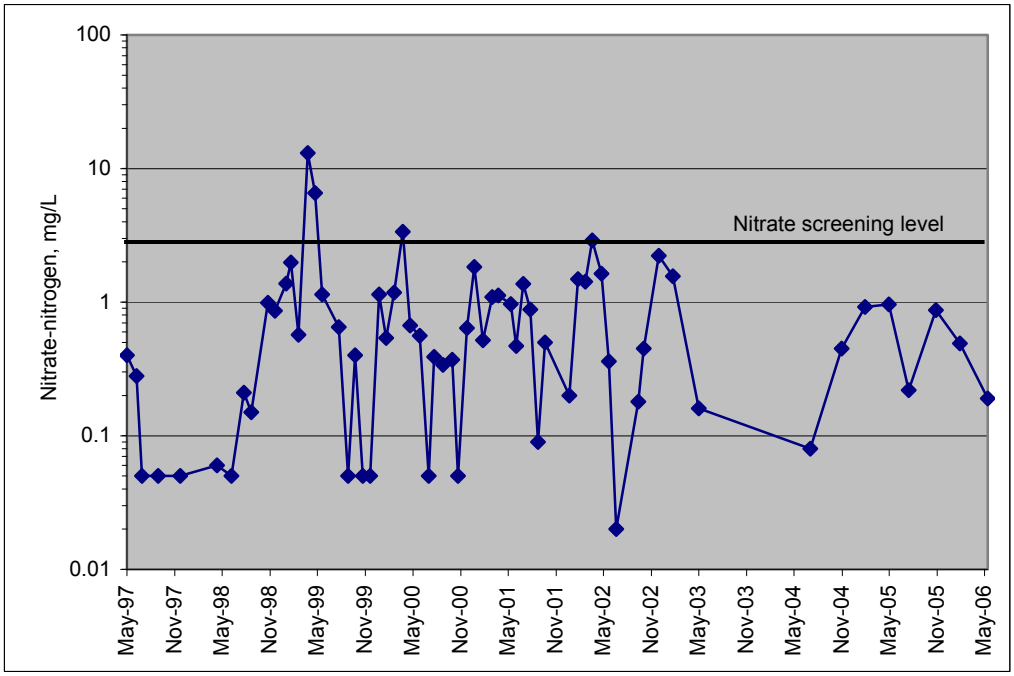


**Figure 5. Nitrate-nitrogen data for station 15771 on Tehuacana Creek from 1997 to 2006.**

Black line depicts the 2004 screening level (2.76 mg/L) for nitrate-nitrogen in freshwater streams.
Lines between data points are drawn to aid visualization and do not represent continuous data collection.

TSS data were difficult to interpret since there are no available criteria or a statewide 85th percentile screening value. However, enough data have been collected from station 15771 (71 measurements, May 1997 to May 2006) to calculate a site-specific 85th percentile value. The data ranged from 6 to 557 mg/L, with a mean of 68 mg/L (Figure 6). The 85th percentile for these 71 measurements is 119 mg/L. The magnitude of this rather high value appears to be driven by the 11 measurements over 150 mg/L. Recalculation excluding the 11 measurements over 150 mg/L provides an 85th percentile value of 43 mg/L.

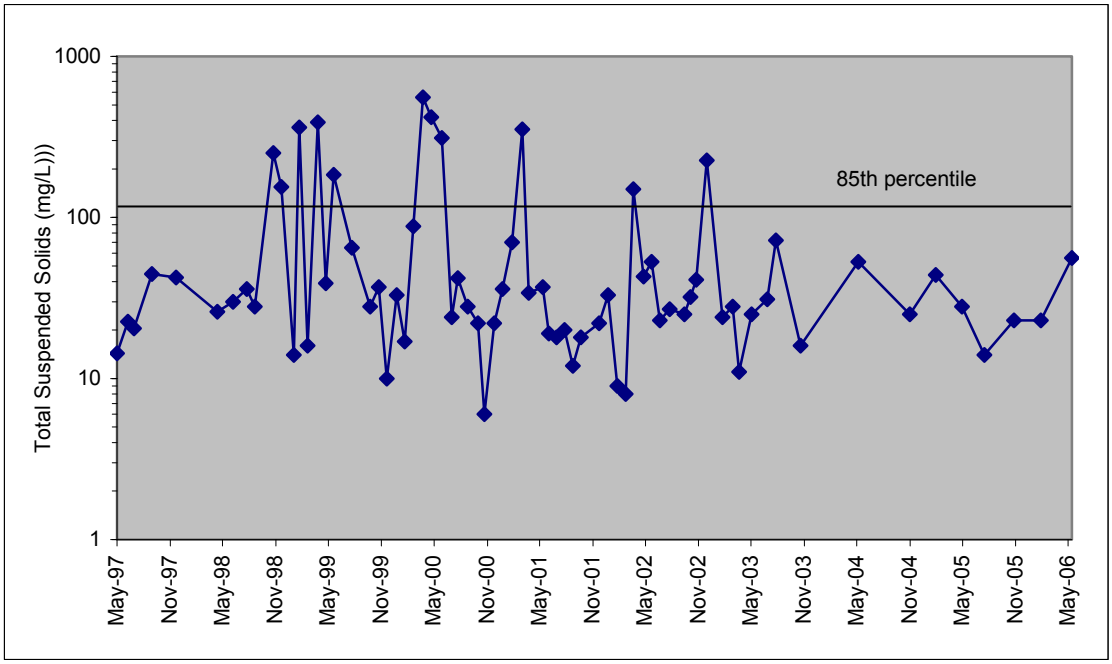


**Figure 6. Total suspended solids data for station 15771 on Tehuacana Creek from 1997 to 2006.**

Lines between data points are drawn to aid visualization and do not represent continuous data collection.

Estimated rainfall data based on NEXRAD radar interpolation from January 1, 2000 to December 9, 2006 for latitude 31.539 and longitude 97.036 (station 15771) (Texas A&M University Spatial Sciences Laboratory 2004) was compared with TSS data from 15771. The comparison of TSS and estimated rainfall shows high TSS readings after multiple days of rain within the watershed, especially if the rainfall total was more than 20 mm within four days preceding a TSS reading (Figure 7). There appear to be high TSS levels with rainfall events over 20 mm, however high TSS values also occur after rainfall events less then 20 mm. Because the size and extent of the watershed differ from the NEXRAD averaging cell, and the NEXRAD data are variable, the correlation of flow severity and TSS values was also examined (Figure 8). The 11 TSS measurements above 150 mg/L were observed by field staff during high flow or flood flow events. High flow severity was also noted when TSS values ranged from 22 to 70 mg/L (November to February).

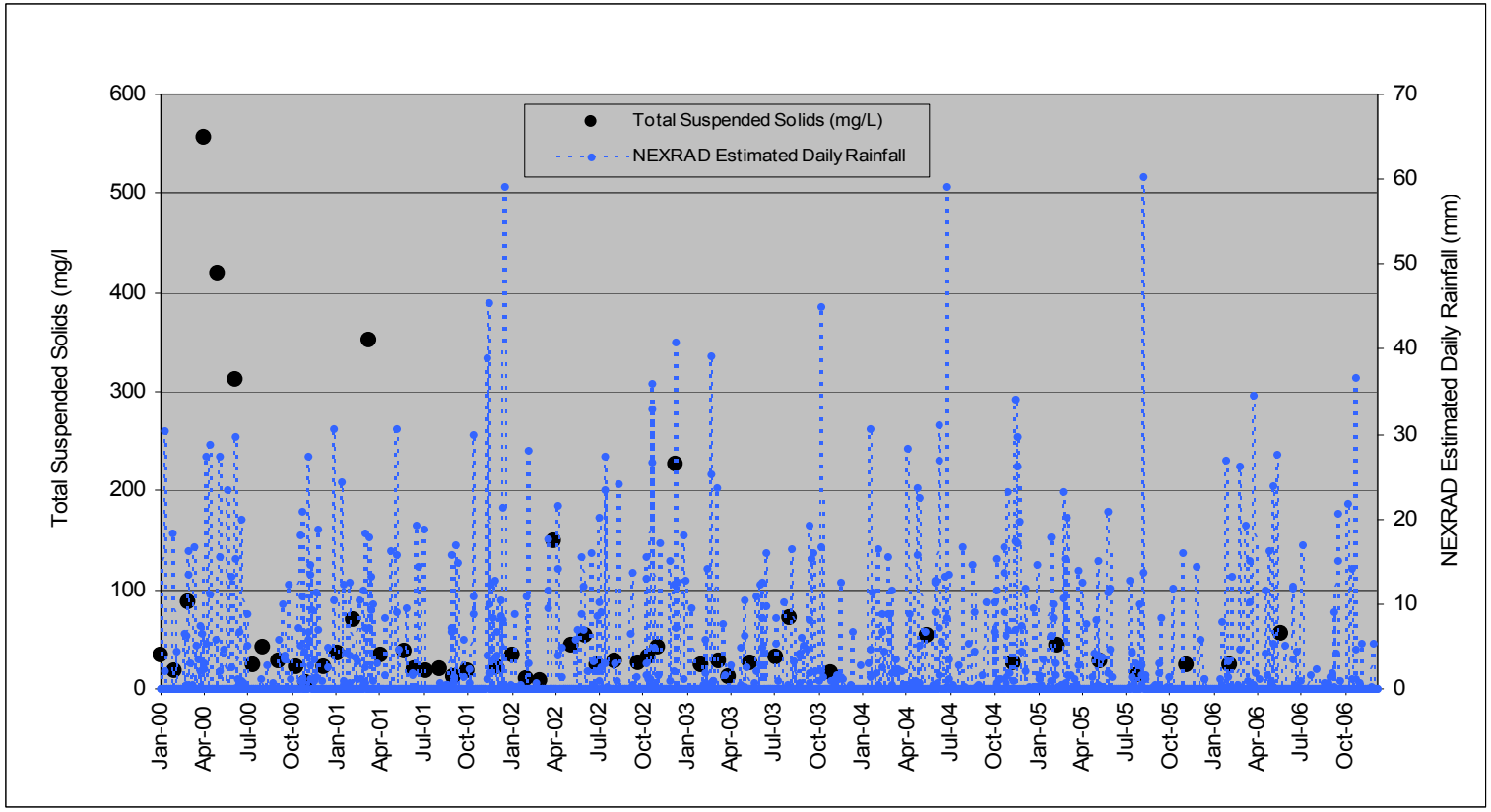


**Figure 7. NEXRAD interpreted daily rainfall and total suspended solids data for station 15771 on Tehuacana Creek from 2000 to 2006.**

TSS and NEXRAD rainfall datasets proved difficult to compare because of limited NEXRAD rainfall data and changes to TSS monitoring frequencies in 2003. NEXRAD rainfall data is available since January 2000, which allows seven years of TSS and NEXRAD rainfall data comparison. To further complicate matters, in August 2003 routine sampling at station 15771 changed from monthly to quarterly, which lowered the number of available TSS measurements. Comparison of historic data shows that quarterly sampling occurred during months with lower rainfall events or months without large rainfall events.

TSS values and NEXRAD estimated annual rainfall totals generally have decreased since 2003 with the exception of the rainfall total in 2004. NEXRAD estimated annual rainfall in 2003 was approximately 200 mm less than that in the previous three years, with 2005 and 2006 also being relatively dry years (Table 10).

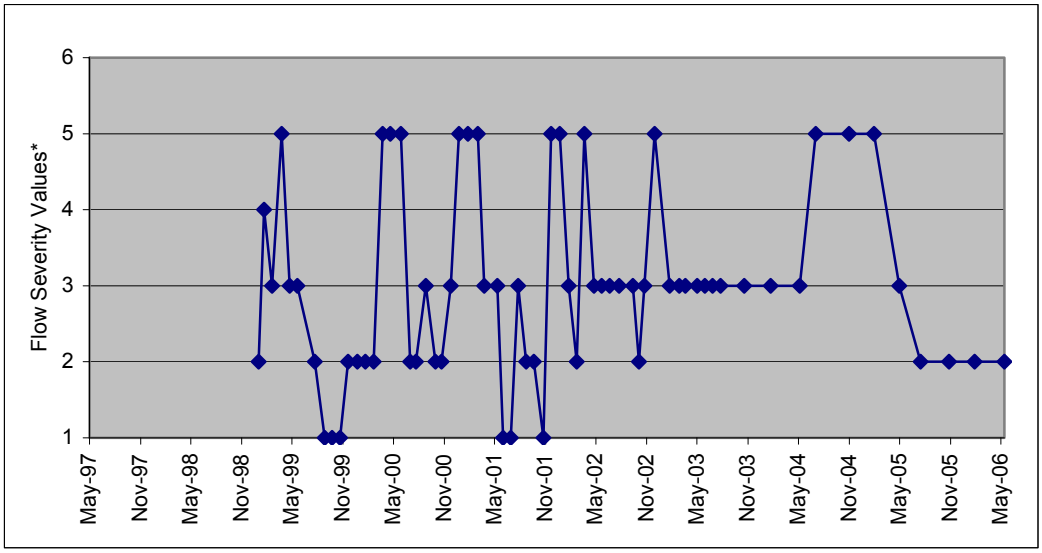


**Figure 8. Flow severity observations for station 15771 on Tehuacana Creek from 1999 to 2006.**

*Flow Severity Values: 1 = No flow, 2 = Low flow, 3 = Normal flow, 4 = Flood flow, 5 = High flow, 6 = Dry conditions.

Lines between data points are drawn to aid visualization and do not represent continuous data collection.

**Table 10. NEXRAD interpreted data estimate of total annual rainfall for station 15771 on Tehuacana Creek from January 2000 to December 9, 2006.**

| Year | Total Rainfall (mm) |
|---|---|
| 2000 | 687 |
| 2001 | 716 |
| 2002 | 655 |
| 2003 | 478 |
| 2004 | 854 |
| 2005 | 460 |
| 2006 | 467* |

* Data for 2006 runs from January 1, 2006 to December 9, 2006.

TSS values from the intensive survey in March and June of 1991 ranged from 10 to 54 mg/L with a mean of 30.8 mg/L (data from tributaries and the main stem). The 1991 data set is consistent with the larger data set from 15771. The ten TSS measurements in the 1991 dataset are inadequate for calculating an 85$^{th}$ percentile, and flow severity values are not available for the 1991 dataset.

Segment 1242, on the main stem of the Brazos River, provides a yardstick for evaluating Tehuacana Creek TSS values. The 85$^{th}$ percentile value for segment 1242 is 17 mg/L (Wilson Snyder, TCEQ, personal communication). This value is much lower than the 85$^{th}$ percentile for Tehuacana Creek (119 mg/L) and the 85th percentile value with high TSS values excluded (43 mg/L). It is beyond the scope of this review to thoroughly analyze differences between the Brazos River main stem and Tehuacana Creek.

As the TCEQ's indicator bacteria changed in 2000 from fecal coliform to E. coli, both fecal coliform (Figure 9) and E. coli (Figure 10) data are present in the historical record. Tehuacana Creek was first included on the TCEQ's 303(d) list in 2002 for non-support of the contact recreation use due to fecal coliform exceedances observed from 1997 - 2001. The TCEQ has identified both point and nonpoint sources as contributing to bacterial loads. When fecal coliform and flow severity data (Figure 8) are analyzed together, elevated fecal coliform densities are observed during high flow as well as normal to low flow. Elevated fecal coliform densities during variable flow conditions suggests that both point and nonpoint sources may be contributing.

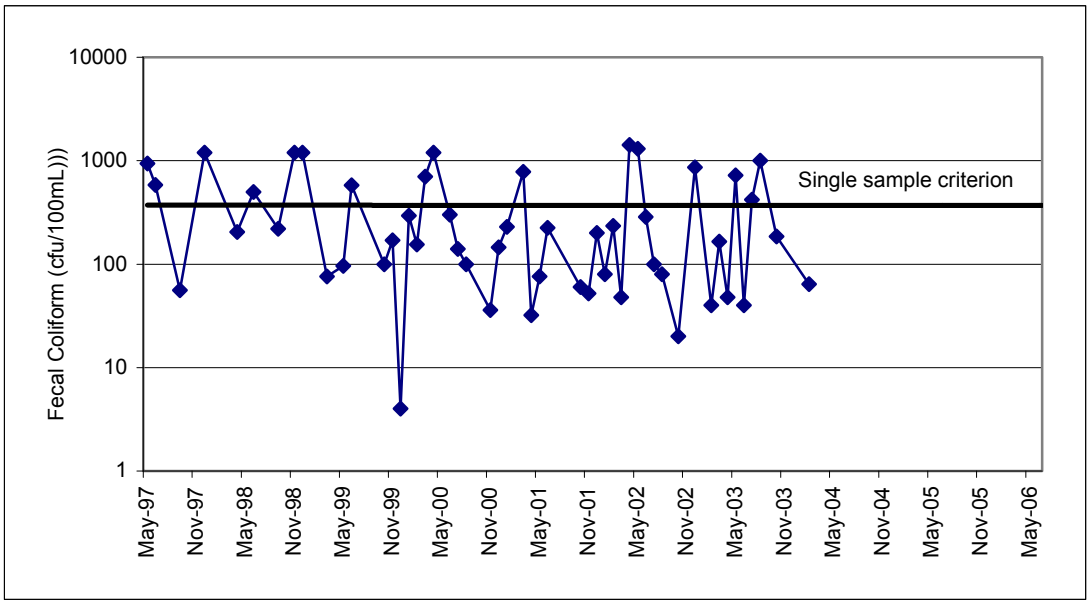


**Figure 9. Single sample Fecal coliform data for station 15771 on Tehuacana Creek from 1997 to 2004.**

Single sample criteria should not exceed 400 colony forming units (cfu) per 100 mL (shown on graph with a horizontal line). Lines between data points are drawn to aid visualization and do not represent continuous data collection.

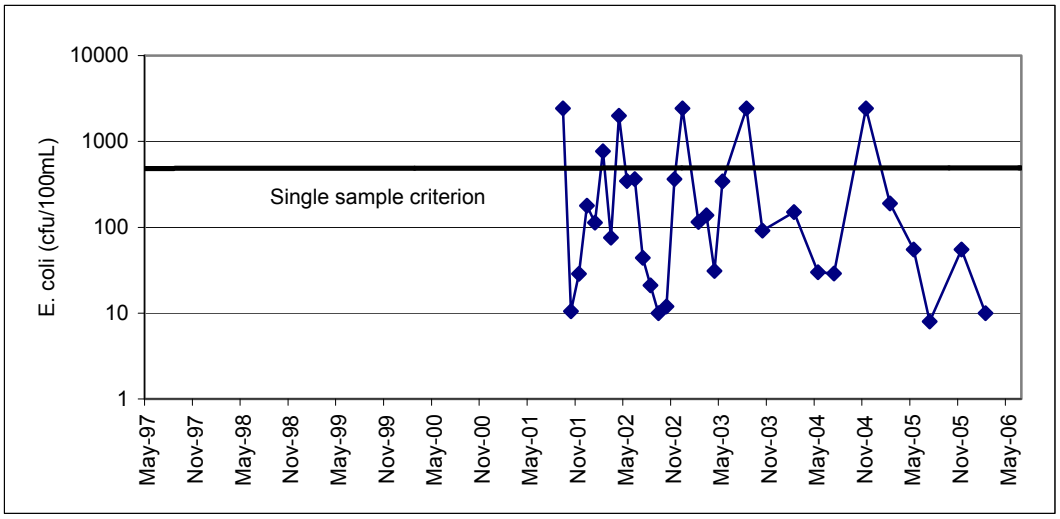


**Figure 10. Single sample E. coli data for station 15771 on Tehuacana Creek from 2001 to 2006.**

Single sample criteria should not exceed 394 colony forming units (cfu) per 100 mL (shown on graph with a horizontal line). Lines between data points are drawn to aid visualization and do not represent continuous data collection.

# Conclusions

Tehuacana Creek is an unclassified intermittent stream with perennial pools. The stream is located in Ecoregion 32, the Texas Blackland Prairies, in Hill and McLennan counties NE of Waco. Sanderson Farms has recently been permitted by the TCEQ to discharge 1.7 MGD of treated wastewater into Tehuacana Creek upstream from US 84, which will sustain perennial flow in the stream downstream from the outfall.

TCEQ conducted a receiving water assessment of Tehuacana Creek in 2006 and found a diverse fish community. The TCEQ established a high aquatic life use for the stream, and a corresponding 24-hour average DO criterion of 5.0 mg/L with a minimum criterion of 3.0 mg/L.

Routine monitoring data from 1997 to 2006 and data from an intensive survey in 1991 were reviewed and compared to Brazos River main stem segment 1242 criteria. The data showed the mean of historical instantaneous DO levels at station 15771 to be 8.16 mg/L, with occasional individual concentrations less than the 3.0 mg/L minimum dissolved oxygen criterion.

Tehuacana Creek proves challenging for stream access and sampling due to a deeply incised channel, and steep banks. The stream has a history of heavy erosion during rainfall events. Erosion has been such a problem that Congress responded with legislation (Public Law 566) which established a reservoir soil control system. Tehuacana Creek was one of many streams to receive flood control dams. A total of 27 flood control dams were constructed on Tehuacana Creek and its tributaries to slow run-

off and retain sediment. NEXRAD estimated rainfall data, and routine monitoring flow severity data, show correlation between high TSS values and increased rainfall and flow severity. With Tehuacana Creek's history of erosion problems, a large continuous wastewater discharge into Tehuacana Creek has the potential to increase erosion within the stream bed resulting in higher TSS values downstream of the new discharge.

Review of historical TSS data provides a baseline for future comparisons. The 85$^{th}$ percentile of the 71 historic TSS measurements for Tehuacana Creek is 119 mg/L. The 85$^{th}$ percentile is comparatively high but is somewhat skewed by 11 TSS values over 150 mg/L. The calculated 85$^{th}$ percentile without the high TSS values is 43 mg/L. TSS conditions should be reevaluated after the permitted discharge is established by comparing new values to the historical database.

The tendency for Tehuacana Creek to exhibit high nitrate concentrations could be exacerbated if the new discharge contributes significant amounts of nitrate. The RBP of Tehuacana Creek in 1993 showed slight nutrient enrichment compared to the reference stream, Childress Creek. In the wastewater discharge application for the Waco, Texas plant, Sanderson Farms, Inc. provided pollutant analysis information that estimates average effluent concentrations of 77.5 mg/L for nitrate-nitrogen and 9.8 mg/L for total phosphorus. Sanderson Farms has indicated that these values may be reduced by addition of tertiary treatment. The estimated concentrations are high compared to TCEQ's 2004 85$^{th}$ percentile screening values (2.76 mg/L for nitrate-nitrogen and 0.8 mg/L for total phosphorus). If the new discharge into Tehuacana Creek does contain high nitrate-nitrogen and phosphorus levels, the increased nutrient load could cause excessive algal growth and proliferation exacerbated by the pooling, low-flow nature of the stream. Increased algal activity may contribute to unstable pH values and DO concentrations. Continued routine and special study monitoring is needed to document water quality change in Tehuacana Creek as the Sanderson Farms plant begins operation and continuous wastewater discharge ensues.

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*"s.v." stands for sub verbo, "under the word."

# Appendix A. Water Quality Data for Tehuacana Creek

For all figures, lines are drawn to aid visualization and do not represent continuous data collection.

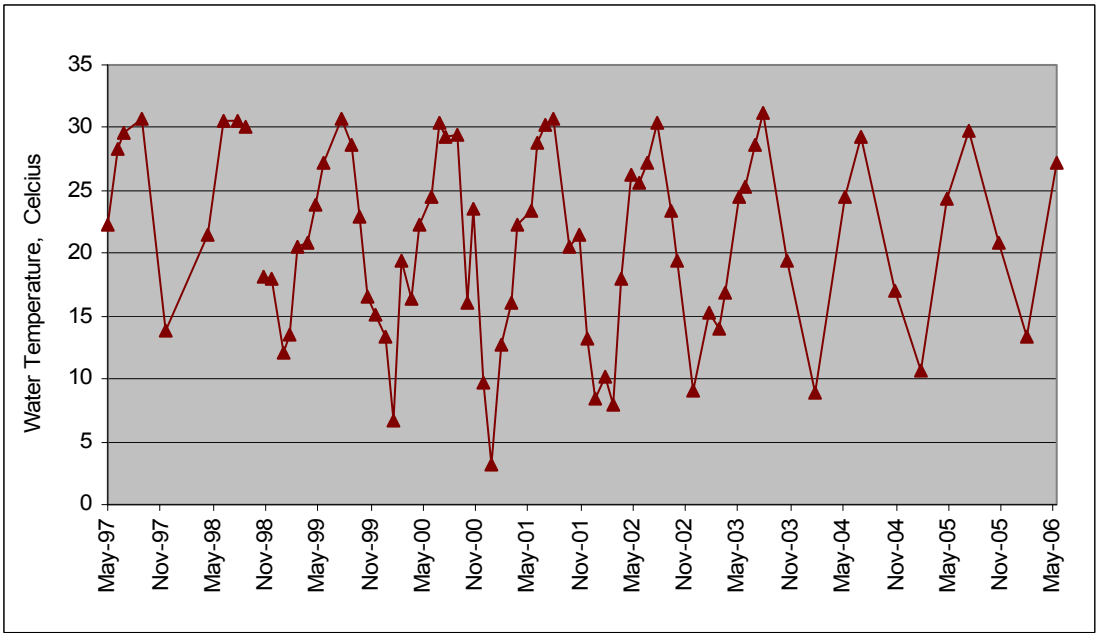


**Figure A 1. Water temperature data for station 15771 on Tehuacana Creek from 1997 to 2006.**

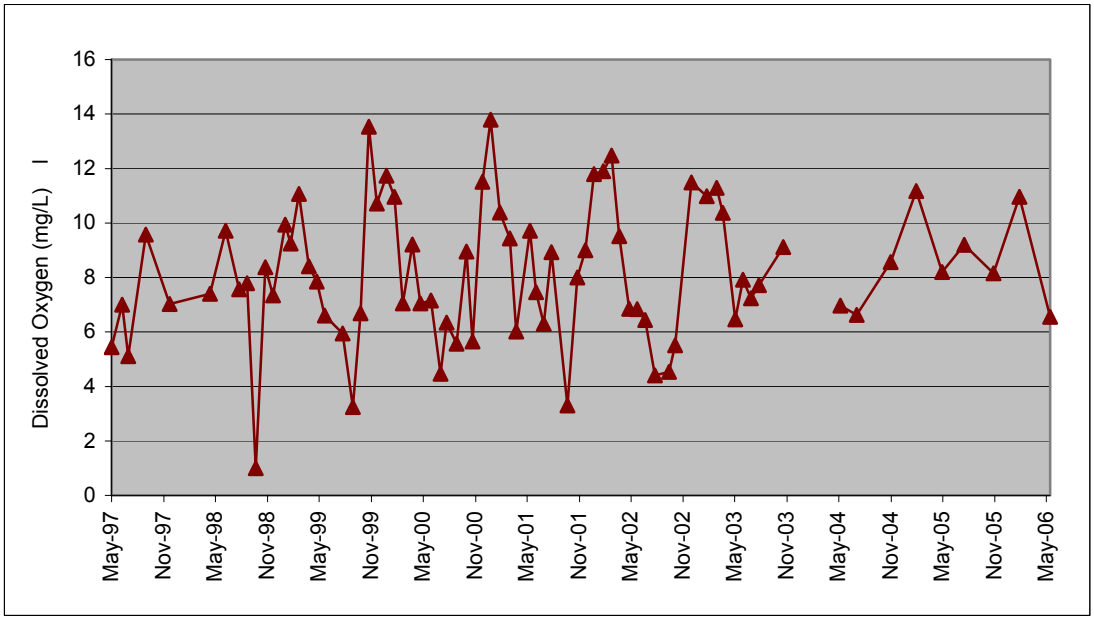


**Figure A 2. Instantaneous dissolved oxygen data for station 15771 on Tehuacana Creek from 1997 to 2006.**

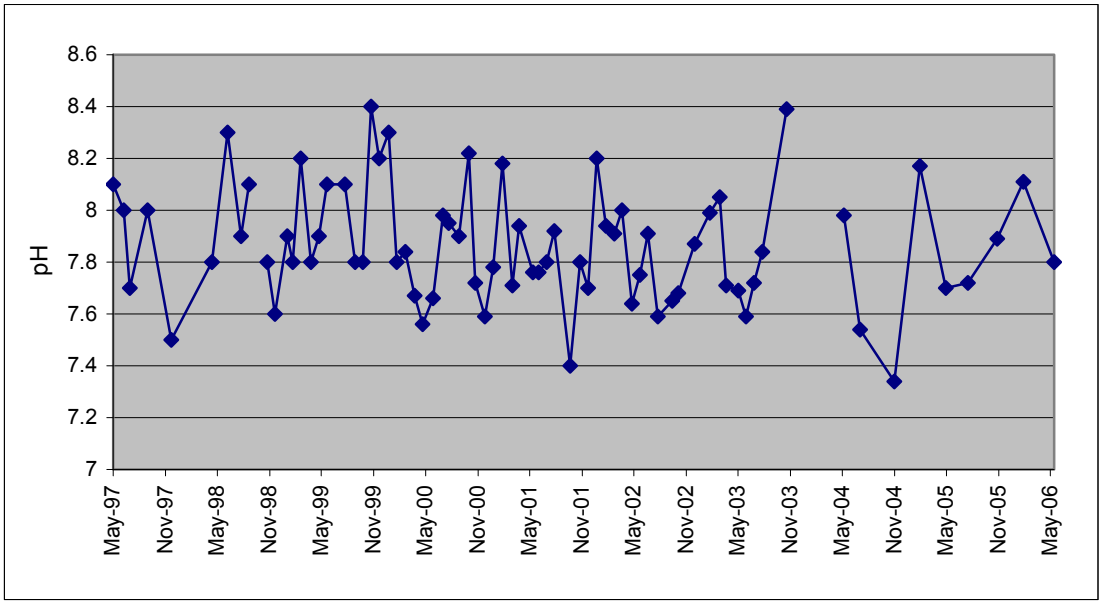


**Figure A 3. pH data for station 15771 on Tehuacana Creek from 1997 to 2006.**

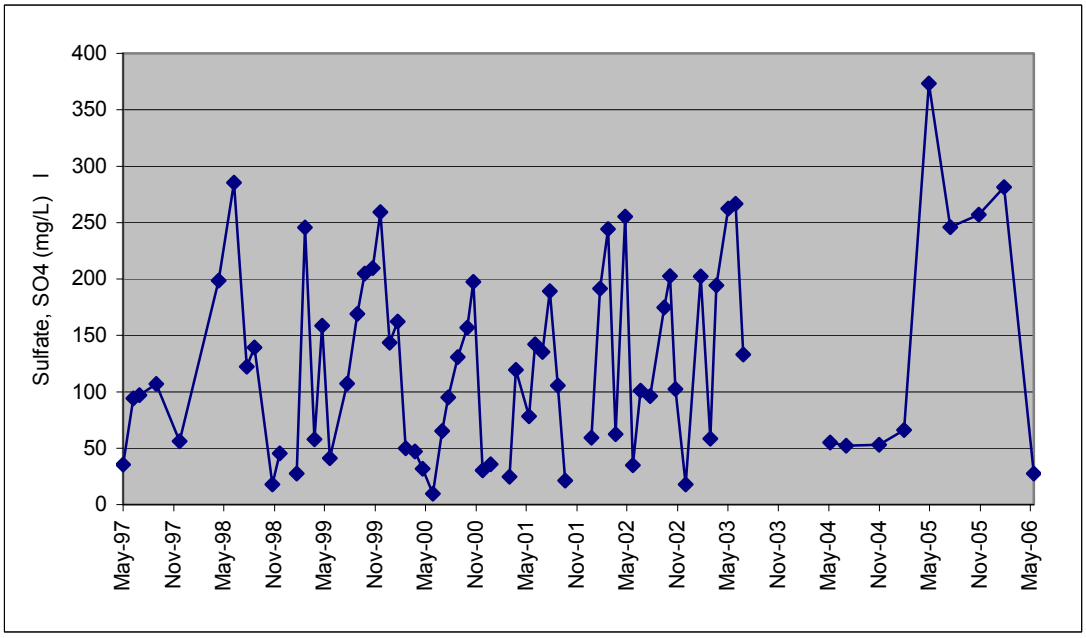


**Figure A 4. Sulfate data for station 15771 on Tehuacana Creek from 1997 to 2006.**

The numerical sulfate criterion for Segment 1242, the Brazos River above the Navasota River, is 200 mg/L annual average.

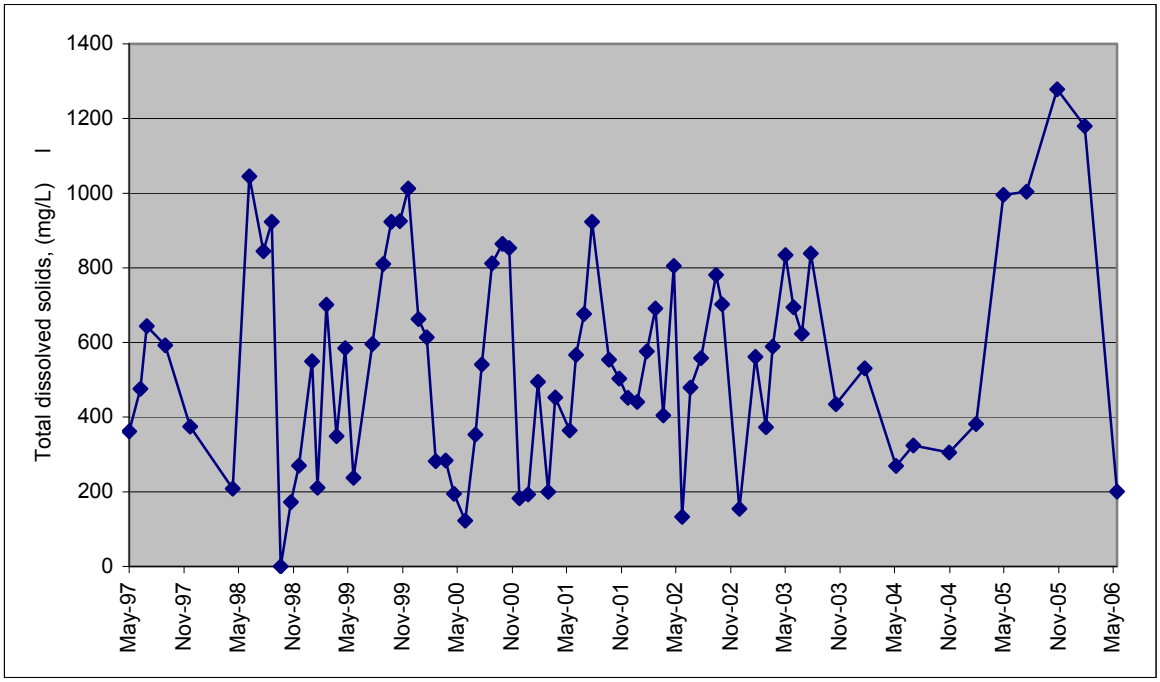


**Figure A 5. Total dissolved solids data for station 15771 on Tehuacana Creek from 1997 to 2006.**

Total dissolved solids were converted from specific conductance using the equation, TDS (mg/L) = Conductivity (µmhos/cm) x 0.65.