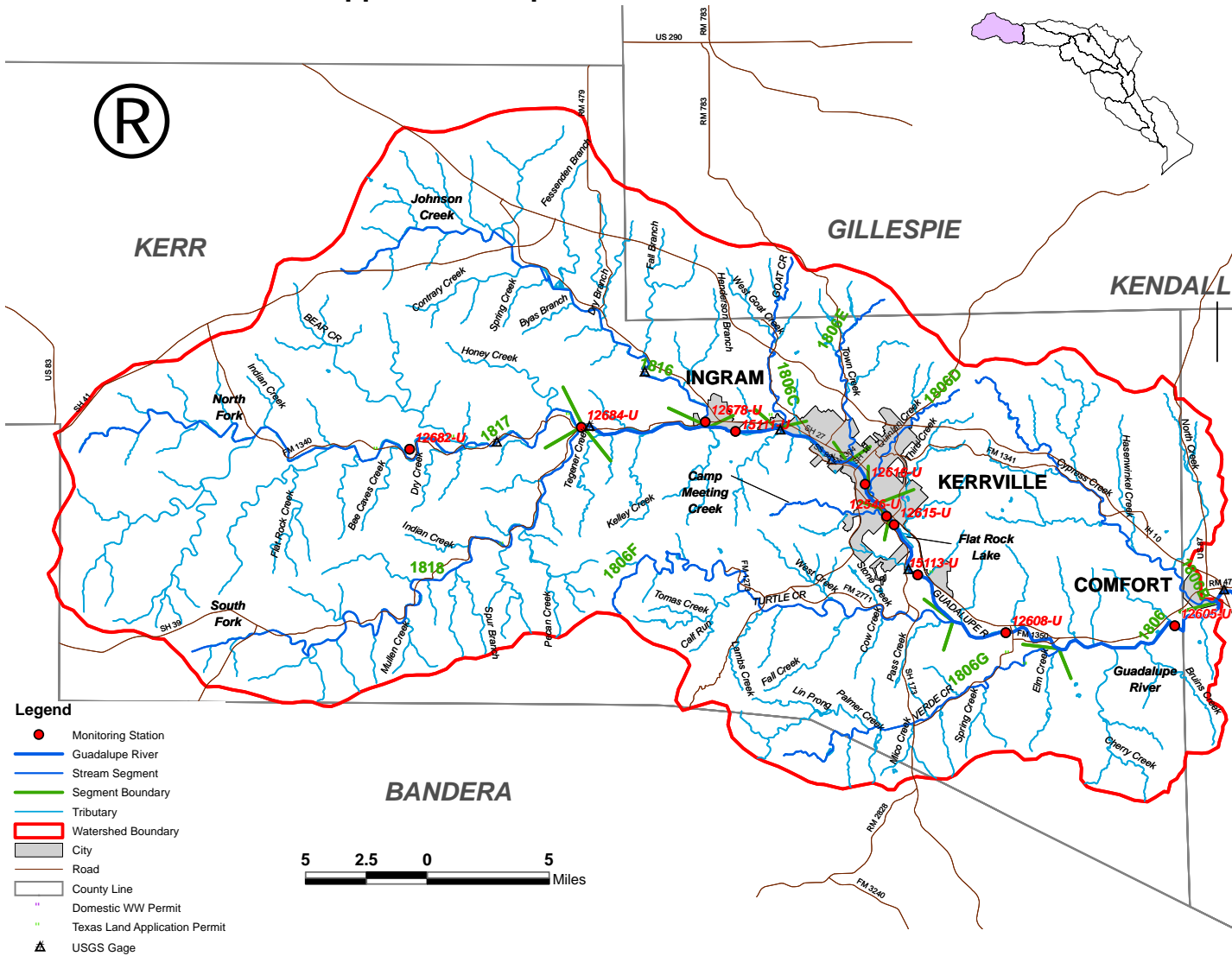


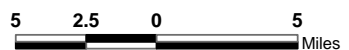
# Upper Guadalupe River Above Comfort



## Current Monitoring Stations – Upper Guadalupe River Above Comfort

- 12682-U North Fork Guadalupe River at Camp Waldemar
- 12684-U South Fork Guadalupe River at Hunt Lions Park
- 12678-U Johnson Creek at SH 39
- 15111-U Guadalupe River at Riverview Road
- 12616-U Guadalupe River at G Street
- 12546-U Camp Meeting Creek
- 12615-U Guadalupe River at Kerrville Schreiner Park
- 15113-U Guadalupe River at Split Rock Road
- 12608-U Guadalupe River at Center Point Lake
- 12605-U Guadalupe River at Hermann Sons Road

- Legend**
- Monitoring Station
  - Guadalupe River
  - Stream Segment
  - Segment Boundary
  - Tributary
  - ▭ Watershed Boundary
  - ▭ City
  - Road
  - ▭ County Line
  - ⬭ Domestic WW Permit
  - ⬭ Texas Land Application Permit
  - ▲ USGS Gage



Sampling sites are labeled in red followed by the letter G (GBRA), T (TCEQ), U (UGRA) or W (Wimberly) indicating who is the monitoring entity.

## Upper Guadalupe above Comfort

**Drainage Area:** 850 square miles

**Streams and Rivers:** North Fork and South Fork of the Guadalupe River, Johnson Creek, Quinlin Creek, Flat Rock Lake, Camp Meeting Creek, Town Creek, Cypress Creek, Goat Creek, Turtle Creek, Verde Creek, Bear Creek

**Aquifer:** Trinity

**River Segments:** 1816, 1817, 1818, 1806, 1806A-G

**Cities:** Center Point, Ingram, Kerrville, Comfort

**Counties:** Kerr, Gillespie, Bandera, Kendall

**EcoRegion:** Edwards Plateau

**Vegetation Cover:**  
 Evergreen Forest - 46.9%    Grass/Herbaceous - 14.4%  
 Shrublands - 28.8%

**Climate:** Average annual rainfall: 30 inches, Average annual temperature: January 32° July 94°

**Land Uses:** Ranching, Farming, Tourism, Light Manufacturing

**Water Body Uses:** Aquatic Life Use, Contact Recreation Use, General Use, Fish Consumption Use, Public Water Supply Use

**Soils:** Dark and loamy over limestone; to the south and east soils are variable with light colored brown to red soils in some areas and dark loamy or loamy soils over clay subsoils elsewhere

**Permitted Wastewater Treatment Facilities:**  
 Domestic: 1    Land Application: 6    Industrial: 0

## Upper Guadalupe River above Comfort

The Upper Guadalupe River watershed above Comfort, Texas drains an area of 850 square miles. The majority of this drainage area is contained within Kerr County, although a small portion of the watershed includes areas in Gillespie, Bandera, and Kendall counties. Major streams and rivers within this drainage area include the North and South Fork of the Guadalupe River, Johnson Creek, Indian Creek, Quinlan Creek, Camp Meeting Creek, Town Creek, Third Creek, Cypress Creek, Goat Creek, Turtle Creek, Verde Creek, and Bear Creek. Cities include Hunt, Ingram, Kerrville, Center Point, and Comfort (Kerr and Kendall County).

Soils are generally dark and loamy over limestone, but are more variable in the southern and eastern portions of the watershed. Vegetation cover is primarily herbaceous and dominated by ash juniper with portions of shrub lands and grass or herbaceous land cover. Average rainfall is 30 inches and average annual temperature is 32 °F in January and 94 °F in July.

Land use in the Upper Guadalupe watershed is defined by ranching, farming, tourism, and light manufacturing. Water bodies are used for aquatic life, contact recreation, fish consumption, and as public water supplies. There is one permitted wastewater treatment facility and six land application facilities in the watershed. The City of Kerrville is permitted to release treated effluent into Third Creek from their wastewater treatment facility. Average annual discharge from this facility is 1.2 million gallons per day (MGD) into Third Creek and 0.91 MGD are reused primarily as irrigation. Quality limits for this facility are a daily average of 5 milligrams per liter (mg/L) carbonaceous biochemical oxygen demand and 5 mg/L total suspended solids.

### Stakeholder Concerns

Stakeholder concerns in this portion of the Guadalupe River basin are focused on preserving the nearly pristine water quality of the area and conserving the water resource of the Guadalupe River. Many are concerned about the predominance of ash juniper in the landscape.

Ash juniper is very efficient at intercepting rain and can capture over ½ inch of rain before it reaches the soil. In a normal year, most rain events produce ½ inch or less of rain. Therefore, rain falling over an area of dense cedar cannot be captured or stored by the watershed. Through brush management, ash juniper can be replaced with other native vegetation that will help enhance and maintain aquifer recharge and spring flow. Approximately 90% of all flow in the Guadalupe River at Kerrville is attributed to spring flow. Therefore, actions that enhance spring flow are crucial to conserving this precious water resource.

Portions of the Guadalupe River in Kerrville have experienced high *E. coli* bacteria levels in recent years. Many stakeholders are concerned that bacteria contamination will affect the recreational use of their favorite swimming holes and that the levels indicate degrading water quality (figure 1). Programs have been initiated to address this concern and are discussed later in the Segment

1806 section of this document. Some Kerr County residents are concerned about a proposed wastewater treatment facility. Recently, a permit application was submitted to the State for a proposed wastewater treatment facility that will discharge treated effluent into a tributary of the Guadalupe River. This proposed facility will not exceed a daily average flow of 25,000 gallons per day with quality limits of 10 mg/L biochemical oxygen demand and 15 mg/L total suspended solids. This permit is currently pending.

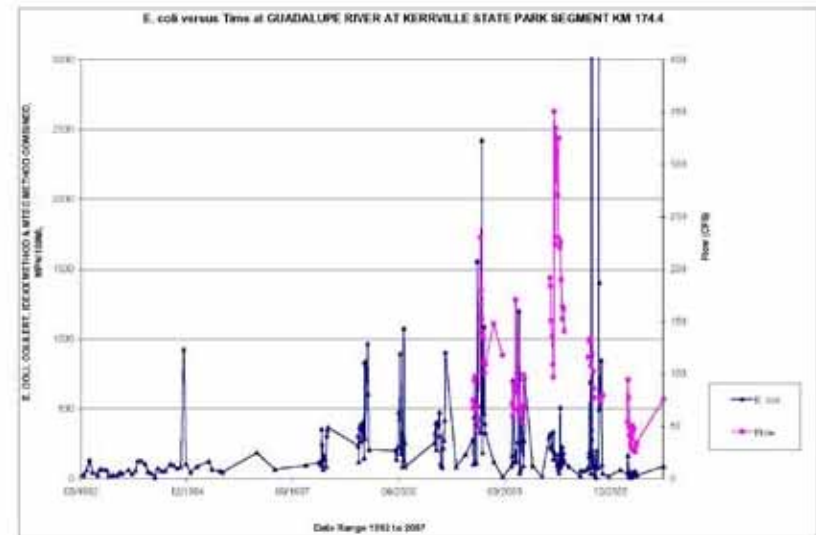


Figure 1. *E. coli* versus time at Kerrville Schreiner Park (12615). In assessment unit 1806\_04.

### Water Quality Monitoring

The designated river segments in The Upper Guadalupe River watershed above Comfort listed under the state of Texas Water Quality Management Plan are segment 1816 (Johnson Creek), segment 1817 (North Fork Guadalupe River), segment 1818 (South Fork Guadalupe River), and segment 1806 (Guadalupe River above Canyon Lake). River segment 1806 can be further divided into segments 1806A thru 1806G to describe specific streams that contribute flows directly to segment 1806.

The Guadalupe-Blanco River Authority (GBRA), together with the Upper Guadalupe River Authority (UGRA), carry out the water quality management efforts in this basin under contract with the Texas Commission on Environmental Quality (TCEQ). Ten sites in Kerr County are monitored on a quarterly basis as part of the Clean Rivers Program (CRP). During each sampling event, the following parameters are monitored: pH, dissolved oxygen, conductivity, temperature, flow, total suspended solids, volatile suspended solids, turbidity, sulfate, chloride, nitrate, total phosphorus, chlorophyll-a, and *E. coli*. In addition to these routine parameters, sampling is also conducted to analyze organics in sediment, metals in sediment, and to assess the biological community. In the past, sediment sampling could not be conducted annually because of unfavorable conditions due to the flash flood

flow regime of the Hill Country. Frequent scouring events and few depositional zones have made sediment collection impossible during some years. Sampling the biological community has also been impacted by flooding because of persistent high flow at the sample sites during some years. In general, the water quality of the Upper Guadalupe River watershed is highly impacted by highly variable flow.

Segment 1806, the Guadalupe River above Canyon Lake, has been identified by the TCEQ as not supporting designated uses due to elevated *E. coli* bacteria concentrations (figure 2). Due to this concern, a Total Maximum Daily Load (TMDL) study was conducted and subsequently adopted by TCEQ. This TMDL, titled *One Total Maximum Daily Load for Bacteria in the Guadalupe River Above Canyon Lake*, is now a part of the state's Water Quality Management Plan.

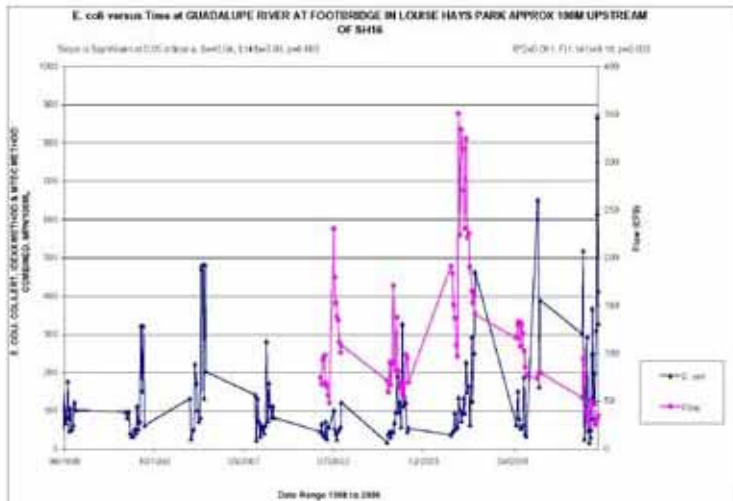


Figure 1. *E. coli* versus time at Louise Hays Park (16243) 100 meters upstream of SH 16, in assessment unit 1806\_06.

Another segment of concern is Camp Meeting Creek, segment 1806A. This stream has been listed as not supporting designated uses when screened against the dissolved oxygen 24-hour average. Additionally, the draft 2008 water quality assessment for the North Fork of the Guadalupe River (segment 1817) found some concern for dissolved oxygen samples at the screening level.

These water quality concerns, as well as the continued urbanization of areas adjoining the Guadalupe River in Kerr County, have focused the attention of the UGRA on a review of the current surface water quality monitoring programs in place in Kerr County. A decision was made to develop a Goal-Based Surface Water Quality Monitoring Plan for Kerr County for 2008.

The Goal-Based Monitoring Plan included a review of available data and recommendations for future water quality monitoring. Trend analyses were conducted by reviewing surface water quality data from the existing Surface Water

Quality Monitoring database (SWQM) maintained by TCEQ. The database covered the time periods from 1972 to 2007. The sites selected for review are located in segment 1806 of the Guadalupe River as well as tributaries of this segment. For the most part, the tributaries are not currently being monitored as part of a routine surface water quality monitoring program. The tributaries drain large areas of the Guadalupe River watershed and have the potential of carrying pollutant loads that could degrade water quality, especially in urbanized areas of Kerr County. As a result, the Goal-Based Monitoring Plan included recommendations to expand water quality monitoring activities on the tributaries of the Upper Guadalupe River.

The key parameters reviewed included specific conductivity, dissolved oxygen, nitrate nitrogen, total phosphorus, chlorides, sulfates, and *E. coli* and preference was given to the most recent data available whenever possible. An explanation of any trends noted at the monitoring sites was also included.

The document developed contains recommendations for a short term surface water quality monitoring program to be conducted by UGRA staff within the watersheds of the Guadalupe River in Kerr County. The primary goals of this monitoring program are to establish baselines of existing and desirable water quality and to identify areas needing more intensive monitoring. Following the initial round of monitoring, the results will be analyzed and used to establish action levels specific to each watershed. These action levels will trigger recommended voluntary Best Management Practices (BMPs) to address any noted downward trends in desirable water quality.

#### Johnson Creek, Segment 1816

Segment 1816, Johnson Creek, extends from the confluence with the Guadalupe River in Kerr County to a point 1.2 km (0.7 miles) upstream of the most upstream crossing of SH 41 in Kerr County. This segment consists of one assessment unit and one monitoring station. UGRA or GBRA has been monitoring Johnson Creek at SH 39 (site 12678) quarterly since 1998 as part of the CRP. This location is also a historical site and has data from the early 1980s to 1997. The Johnson Creek segment is spring fed and approximately 21 miles long. Median flow at site 12678 is 34 cubic feet per second. A USGS gauging station is located in this segment approximately 3.5 miles upstream from site 12678.

The 2008 draft Texas Water Quality Inventory has no impairments or concerns listed for segment 1816. The water quality at site 12678 is consistently good and the segment maintains an exceptional aquatic life use designation. The median concentration for dissolved oxygen is 7.9 milligrams per liter (mg/L), ranging from a minimum of 5.8 mg/L to a maximum of 10.7 mg/L. At no time during the period of 1998 to the present did the dissolved oxygen drop below the state standard (4 mg/L). The **specific conductance** ranged from 360 to 600 micromhos per centimeter ( $\mu\text{mho/cm}$ ), with a median conductivity of 471  $\mu\text{mho/cm}$ .

Water quality is very consistent from year to year. Nitrate values ranged from 0.2 to 3.3 mg/L with most below 3.0 mg/L. This indicates not much nutrient loading is occurring. Total phosphorus ranged from 0.003 to 0.05 mg/L with the bulk of

values being less than or equal to 0.01mg/L. This is a very clean body of water as far as nutrient loading is considered. Chlorides ranged from 1-33 mg/L with most values in the range of 15-30 mg/L. Again, this reinforces the relatively clean nature of this body of water. Sulfates ranged from 1-30 mg/L with most values in the 10-20 mg/L range. There was little variation exhibited annually or from year to year.

#### *Land Use*

The land use in the Johnson Creek watershed is rural with very low density residential development and some camps upstream of Ingram. The scenery and recreational opportunities attract many people to segment 1817. In fact, site 12678 is a very popular swimming hole for local residents. The stream standard for contact recreation is 394 colony forming units (cfu) of *E. coli* bacteria per 100 mL of water for a single grab sample or a geometric mean of 126 cfu. The geometric mean at site 12678 from 2001 to the present is 40 cfu of *E. coli*. During this time period, no sample exceeded the single sample standard of 394 cfu of *E. coli*, but there is an upsurge in the values from June thru September. More data is needed to establish if this trend is consistent with warmer temperatures and/or lower flow in the summer months.

#### North Fork Guadalupe River, Segment 1817

Segment 1817, North Fork Guadalupe River, extends from the confluence with the Guadalupe River in Kerr County to a point 18.2 km (11.3 miles) upstream of Boneyard Draw in Kerr County. This segment consists of one assessment unit and three monitoring stations. UGRA or GBRA has been monitoring the North Fork Guadalupe near Camp Waldemar (site 12682) site quarterly since 1998 as part of the CRP. This location is also a historical site and has data from 1976 to 1997. Two additional sites in this segment were monitored during the summer from 2002 - 2007 for *E. coli* and turbidity only. These sites are North Fork Guadalupe River at FM 1340 (site 12681) and North Fork Guadalupe River at Rock Bottom Road (site 16245). The North Fork Guadalupe River segment is spring fed and approximately 29 miles long. Median flow at site 12682 is 26.5 cubic feet per second. A USGS gauging station is located in this segment approximately 0.5 miles downstream from site 12682.

The 2008 draft Texas Water Quality Inventory lists no impairments for segment 1817, but did find a concern for depressed dissolved oxygen. Overall water quality at site 12682 is very good and the segment maintains an exceptional aquatic life use designation. The median concentration for dissolved oxygen is 7.4 milligrams per liter (mg/L), ranging from a minimum of 5.0 mg/L to a maximum of 9.7 mg/L. At no time during the period of 1998 to the present did the dissolved oxygen drop below the state standard (4 mg/L). The **specific conductance** ranged from 349 to 524 micromhos per centimeter ( $\mu\text{mho/cm}$ ), with a median conductivity of 395  $\mu\text{mho/cm}$ .

A review of the data available for the North Fork of the Guadalupe at this location indicates that consistently good water quality is maintained in this section of the river. Recent nitrate data was scarce but values ranged from <0.1 to 0.74 mg/L.

This indicates not much nutrient loading is occurring. Total phosphorus ranged from 0.002 to 0.022 mg/L with the bulk of values between 0.005 to 0.01 mg/L. This is another indication of very clean body of water as far as nutrient loading is considered. Chlorides ranged from 3-12 mg/L with most values in the range of 6-10 mg/L. Again, this reinforces the relatively clean nature of this body of water. Sulfates ranged from 2-16.5 mg/L. This is also a relatively low value for this parameter.

#### *Land Use*

The land use upstream in the North Fork Guadalupe River is rural with very low density residential development. Many Hill Country summer camps are located in segment 1817 due to the beautiful scenery and numerous recreational opportunities. The stream standard for contact recreation is 394 colony forming units (cfu) of *E. coli* bacteria per 100 mL of water for a single grab sample or a geometric mean of 126 cfu of *E. coli*. The geometric mean at site 12682 from 2001 to the present is 32 cfu of *E. coli*. During this time period, only one sample exceeded the single sample standard of 394 cfu of *E. coli*, but there was some indication of an upward trend in summer months. More data is needed to establish if this trend is consistent.

#### South Fork Guadalupe River, Segment 1818

Segment 1818, South Fork Guadalupe River, extends from the confluence with the Guadalupe River in Kerr County to a point 4.8 km (3.0 miles) upstream of FM 187 in Kerr County. This segment consists of five assessment units and each assessment unit contains one monitoring station. UGRA or GBRA has been monitoring the South Fork Guadalupe River adjacent to Hunt Lions Park (site 12684) quarterly since 1998 as part of the CRP. This site is located in the most downstream assessment unit of the segment. This location is also a historical site and has data from 1976 to 1997. The four additional sites in this segment were monitored during the summer from 2002 - 2007 for *E. coli* and turbidity only. These sites are South Fork Guadalupe Adjacent to Camp Arrowhead (site 12685), South Fork Guadalupe River at Seago Rd (site 16246), South Fork Guadalupe Adjacent to Camp Mystic (site 12686), South Fork Guadalupe Adjacent to Lynxhaven Lodge at SH 39 (site 12688). The South Fork Guadalupe River segment is spring fed and approximately 27 miles long. Median flow at site 12684 is 28 cubic feet per second.

The 2008 draft Texas Water Quality Inventory lists no impairments or concerns in segment 1818. Overall water quality at site 12684 is very good and the segment maintains an exceptional aquatic life use designation. The median concentration for dissolved oxygen is 8.4 milligrams per liter (mg/L), ranging from a minimum of 6.7 mg/L to a maximum of 10.5 mg/L. At no time during the period of 1998 to the present did the dissolved oxygen drop below the state standard for dissolved oxygen (4 mg/L). The **specific conductance** ranged from 360 to 475 micromhos per centimeter ( $\mu\text{mho/cm}$ ), with a median conductivity of 418 $\mu\text{mho/cm}$ .

A review of the data available for this South Fork Guadalupe River station



indicates that consistently good water quality is maintained in this section of the Guadalupe River. Nitrate values ranged from 0.06 to 1.1 mg/L with most below 0.7 mg/L. This indicates not much nutrient loading is occurring. Total phosphorus ranged from 0.003 to 0.067 mg/L with the bulk of values being less than or equal to 0.01 mg/L. Again, this indicates a very clean body of water as far as nutrient loading is considered. Chlorides ranged from 6-21 mg/L with most values in the range of 8-10 mg/L. Sulfates ranged from 0.5-22 mg/L with most values in the 5-15 mg/L range. There was little variation exhibited annually or from year to year.

#### Land Use

The land use in the South Fork Guadalupe River watershed is rural with very low density residential development. Much like the North Fork Guadalupe River, segment 1818 is home to numerous Hill Country summer camps promoting various recreational activities. The stream standard for contact recreation is 394 colony forming units (cfu) of *E. coli* bacteria per 100 mL of water for a single grab sample or a geometric mean of 126 cfu of *E. coli*. The geometric mean at site 12684 from 2001 to the present is 14 cfu of *E. coli*. No samples have ever exceeded the single sample standard of 394 cfu of *E. coli* at this location. The four other monitoring stations in segment 1818 also contain summertime *E. coli* data from 2002 - 2007. The majority of bacteria data during this time indicated *E. coli* levels well below the 394 cfu standard for a single grab sample and only twice did the *E. coli* level exceed the standard. There does appear to be an upsurge in the values from June thru September, but more data is needed to establish if this trend is consistent.

#### Guadalupe River above Canyon Lake, Segment 1806

Segment 1806, Guadalupe River above Canyon Lake, extends from a point (1.7 miles) downstream of Rebecca Creek Road in Comal County to the confluence of the North Fork Guadalupe River and the South Fork Guadalupe River in Kerr County. The segment is approximately 103 miles long. The segment is broken into eight assessment units, however only the following are within the Upper Guadalupe River watershed above Comfort: from confluence with Big Joshua Creek to Flat Rock Dam in Kerrville (1806\_02), from Flat Rock Dam in Kerrville to 1 mile upstream (1806\_03), from 1 mile upstream Flat Rock Dam to confluence with Camp Meeting Creek (1806\_04), from confluence with Camp Meeting Creek to 2 miles upstream (1806\_5), from RR 394 1 mile downstream (1806\_06), and the upper 10 miles of segment (1806\_07). There are five USGS gauging stations located in segment 1806. Median annual **flow** of the Guadalupe River at Hunt is 67 cubic feet per second (ft<sup>3</sup>/s) and median annual flow of the Guadalupe River at Comfort is 186 ft<sup>3</sup>/s.

The assessment units contain six sites which have been monitored by UGRA or GBRA quarterly since 1998 as part of the CRP. Guadalupe River at Hermann Sons Road (site 12605), Guadalupe River at Center Point Lake (site 12608), Guadalupe River at G Street (site 12616), and Guadalupe River at Kerrville Schreiner Park (site 12615) also contain historical data dating back to the mid 1970s and early 1980s. Guadalupe River at Split Rock Road (site 15113) and the Guadalupe River at Riverview Road (site 15111) have been monitored since the beginning of

the CRP only. Several additional sites in this segment were monitored during the summer from 2002 - 2007 for *E. coli* and turbidity only. These sites are Guadalupe River at IH 10 in Comfort (site 12603), Guadalupe River at Louise Hays Park dam (site 16243), Guadalupe River at SH 16 (site 12617), Guadalupe River at Louise Hays Park footbridge (site 16244), Guadalupe River at UGRA Lake (site 12618), Guadalupe River at Bear Creek Road (site 12619), Guadalupe River at Ingram Dam (site 12620), and Guadalupe River at Kelly Creek Road (site 16241).

The 2008 draft Texas Water Quality Inventory lists three impairments and no concerns in segment 1806. Assessment units 1806\_4 (refer to figure 1) and 1806\_6 (refer to figure 2) are impaired for bacteria with geometric mean values exceeding state standards for contact recreation. The TCEQ first identified the impairment to the contact recreation use of segment 1806 in the 2002 Texas Water Quality Inventory and 303(d) List. Due to this concern, a Total Maximum Daily Load (TMDL) study was conducted on the impaired portion of segment 1806 that flows through the City of Kerrville. The impaired reach is defined as the Guadalupe River from its confluence with Town Creek downstream to Flat Rock Lake. The TMDL was adopted by the TCEQ on July 25, 2007 and approved by the Environmental Protection Agency (EPA) on September 25, 2007. This TMDL, titled *One Total Maximum Daily Load for Bacteria in the Guadalupe River Above Canyon Lake*, is now a part of the state's Water Quality Management Plan.

UGRA received a grant from TCEQ for a three-year project aimed at reducing bacteria levels in the impaired reach of the Guadalupe River. The TMDL program also requires the development of an Implementation Plan that identifies pollution reduction strategies to achieve the desired load reductions and provides a detailed plan for implementation. The goal of the TMDL program is to restore and maintain the beneficial uses of the impaired water body.

Though TCEQ is tasked with developing the implementation plan, the state elected to allow UGRA and a local stakeholder group to develop a plan at the local level. UGRA will utilize the TCEQ grant to coordinate and develop an implementation plan for TCEQ's consideration. The grant project includes key assessment activities that are expected to provide better identification of the bacteria sources. Several sites in the impaired reach will be monitored on a routine basis for three years. During the summer, monitoring will increase to include intensive sampling of the impaired region and the tributaries that enter this reach. *E. coli*, temperature, pH, dissolved oxygen, conductivity, and flow data will be collected as well as qualitative information such as the number of swimmers and waterfowl present in the impaired region. Once the sources are identified, potential control measures will be evaluated and implemented over the three-year term of the project.

Despite bacteria concerns, overall water quality in segment 1806 is very good and all assessment units in the segment maintain an exceptional aquatic life use designation. The Guadalupe River at Riverview Road (Station 15111) is sampled quarterly by UGRA staff as part of the CRP. This site is located between the cities of Ingram and Kerrville. A review of the data available for the Guadalupe River at Riverview Road indicates a water body with slightly elevated values for nearly all parameters when compared to the upstream North Fork and South Fork stations.

However, the slight elevations still are not sufficient to lower the water quality below a good rating for this section of the river. **Specific conductivity** ranges from 378-511  $\mu\text{mho/cm}$  with the bulk of values within the 400-500  $\mu\text{mho/cm}$  range. The trends are very consistent year to year. Dissolved oxygen ranges from 5.97-10.5 mg/L with only one value out of 34 readings below 6.0 mg/L. No dissolved oxygen impacts were seen. Nitrate values ranged from 0.1 to 0.79 mg/L. This indicates not much nutrient loading is occurring. Total phosphorus ranged from 0.005 to 0.12 mg/L with the bulk of values being less than 0.02 mg/L. This is still a very clean body of water as far as nutrient loading is considered. Chlorides ranged from 10-24 mg/L with most values in the range of 10-17 mg/L. Again, this reinforces the relatively clean nature of this body of water. Sulfates ranged from 8.6-20 mg/L with most values in the 10-15 mg/L range. There was little variation exhibited annually or from year to year. *E. coli* testing did not result in any values which exceeded the single grab limit of 394 colonies/100 mL but there is an upsurge in the values from June thru September. More data is needed to establish if this is consistent.



Louise Hays Park

The land use in this area of the Guadalupe River is more affected by urbanization from the City of Ingram and the data indicates this increased influence on water quality. However, there does not seem to be any obvious degradation of water quality occurring at this time.

The Guadalupe River at Split Rock Road (Station 15113) is sampled quarterly by UGRA staff as part of the CRP. This site is located between the cities of Kerrville and Center Point. A review of the data

available indicates some effects on water quality by the increased urbanization in this section of the river. However, the available data indicate that the water quality still rates a designation of good. **Specific conductivity** ranges from 390-552  $\mu\text{mho/cm}$  with the bulk of values within the 400-500  $\mu\text{mho/cm}$  range. The trends are very consistent year to year. Dissolved oxygen ranges from 6.8-12.96 mg/L with no values going below 6.0 out of 36 readings. No dissolved oxygen impacts were seen in the data. Nitrate values ranged from 0.17 to 1.1 mg/L. This indicates not much nutrient loading is occurring. Total phosphorus ranged from 0.01 to 0.05 mg/L with the bulk of values being less than 0.025 mg/L. This indicates not much nutrient loading is occurring. Chlorides ranged from 15-32 mg/L, again reinforcing the conclusion that water quality is still relatively good. Sulfates ranged from 13-26 mg/L with not much variation exhibited annually or from year to year. *E. coli* testing did not result in any values which exceeded the single grab limit of 394 colonies/100 mL. This was surprising since this station is downstream of the impacted section of the Guadalupe River that flows through Kerrville. More data is needed to establish if this is consistent.

The land use just upstream of this section of the Guadalupe River is fairly dense residential and commercial urban development on both sides of the river.

## Camp Meeting Creek, Segment 1806A

Segment 1806A, Camp Meeting Creek, is an unclassified water body ranging from the confluence of Flat Rock Lake in southeastern Kerrville to the upstream perennial portion of the stream west of Kerrville. The segment contains two assessment units: the lower 9 miles of the segment (1806A\_02) and the upper 9 miles of the segment (1806A\_03). UGRA or GBRA has been monitoring the Camp Meeting Creek (site 12546) site quarterly since 1998 as part of the CRP. This site is located in the most downstream assessment unit of the segment. This location is also a historical site and has data from 1976 to 1997. The Camp Meeting Creek segment is approximately 27 miles long and median flow at site 12546 is 1.4 cubic feet per second (cfs).

The 2008 draft Texas Water Quality Inventory lists segment 1806A\_03 as impaired for dissolved oxygen because it has failed to meet the dissolved oxygen 24 hour standard. Overall water quality at site 12546 is fair and the segment only maintains a limited aquatic life use designation.

A review of the data available for station 12546 indicates that water quality in this stream is degraded. The median concentration for dissolved oxygen is 7.9 milligrams per liter (mg/L), ranging from a minimum of 2.8 mg/L to a maximum of 14.5 mg/L. On several occasions during the period of 1998 to the present, the dissolved oxygen values have dropped below the state standard for dissolved oxygen (4 mg/L) (figure 3). The **specific conductance** ranged from 435 to 825 micromhos per centimeter ( $\mu\text{mho/cm}$ ), with a median conductivity of 682

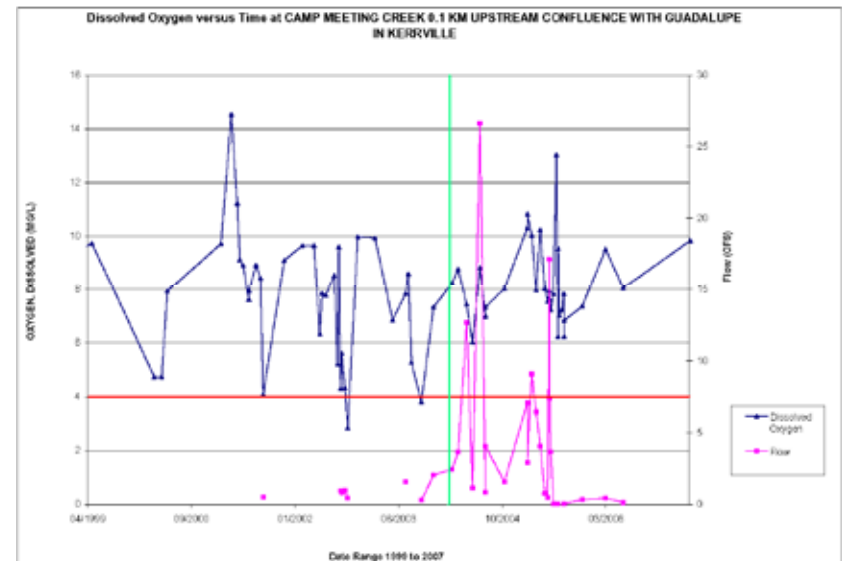


Figure 3. Graph of Dissolved Oxygen versus time at Camp Meeting Creek (12546), 0.1 miles above the confluence with the Guadalupe River. The red horizontal line on the graph represents the single sample standard of 4.0 mg/L of Dissolved Oxygen. The green vertical line on the graph indicates the transition to municipal sewer collection for several of the houses in the upper portion of the watershed.

µmho/cm. There was very little data on nitrates with a range of 0.1 to 17.7 mg/L and most values falling below 3.0 mg/L. More data is needed to see if nutrient enrichment is occurring. Total phosphorus ranged from 0.002 to 0.7 mg/L. When the one extreme value of 0.7 mg/L is removed, the remainder of the data falls within the 0.002 to 0.058 mg/L range. The total phosphorus value of 0.7 mg/L occurred at very low flow (0.4 cfs), but similar low flow events do not coincide with high total phosphorus results; this is an unusually high value that did not reoccur. This does not appear to be a nutrient enrichment issue but more data is needed. Chlorides ranged from 22-60 mg/L with the bulk of values within 30-50 mg/L. There is considerable fluctuation on an annual basis. Sulfates ranged from 9-195 mg/L but the bulk of values fell within 10 to 40 mg/L. Extreme fluctuations were evident but more data is needed to establish any patterns.

The stream standard for contact recreation is 394 colony forming units (cfu) of *E. coli* bacteria per 100 mL of water for a single grab sample or a geometric mean of 126 cfu of *E. coli*. The geometric mean at site 12546 from 2002 to the present is 74 cfu of *E. coli*. Two samples in 2002 and one sample in 2003 exceeded the single sample standard of 394 cfu of *E. coli* at this location.

Camp Meeting Creek travels through a densely populated area occupied by single family residences, a golf course, and mobile home parks. Numerous bridges also cross the creek creating opportunities for non-point source pollutants to enter the creek as runoff. Many residents in the upper section of Camp Meeting Creek rely on private septic systems. In 2004, Kerr County, the City of Kerrville and UGRA partnered to address potential water quality concerns and initiated municipal sewer collection for some homes in this area. Although there are still many more homes on septic systems, since the end of 2003, the single sample contact recreation standard of 394 cfu of *E. coli*, has only been exceeded two times and the dissolved oxygen level has not dropped below the state standard of 4.0 mg/L at this station. The data shown in figures 3 and 4 seems to indicate that the steps taken to address the septic problems in this area are helping to improve the water quality of the Camp Meeting Creek.

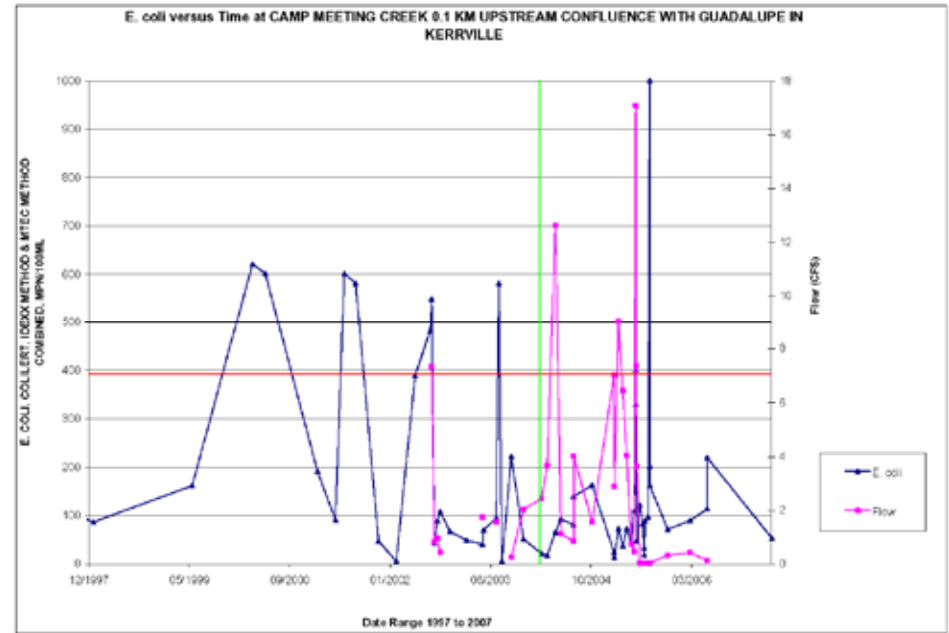
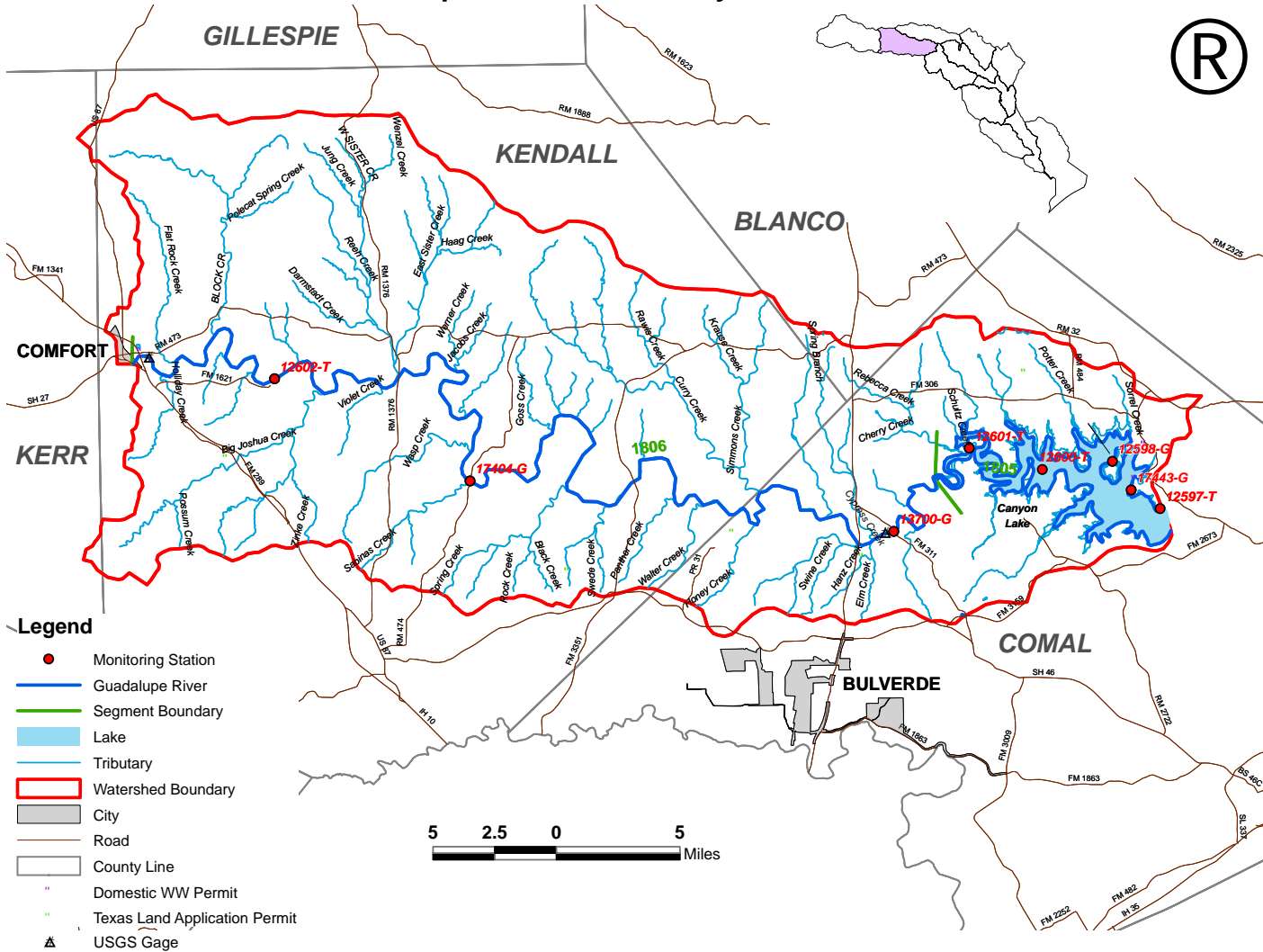


Figure 4. Graph of *E. coli* versus time at Camp Meeting Creek (12546), 0.1 miles above the confluence with the Guadalupe River. The red horizontal line on the graph represents the single sample contact recreation standard of 394 cfu *E. coli*. The green vertical line on the graph indicates the transition to municipal sewer collection for several of the houses in the upper portion of the watershed.

# Guadalupe River Above Canyon Lake



12602-T	Guadalupe River at FM 1621 in Waring
17404-G	Guadalupe River at FM 474
13700-G	Guadalupe River at FM 311 in Spring Branch
12601-T	Canyon Lake at Cranes Mill Park (upper reservoir)
12600-T	Canyon Lake at Potter's Creek Park (mid-reservoir)
12598-G	Canyon Lake near the Canyon Lake Marina
17142-G	Canyon Lake at the Jacob's Creek Park
12567-T	Canyon Lake at the dam (lower reservoir)

Sampling sites are labeled in red followed by the letter G (GBRA), T (TCEQ), U (UGRA) or W (Wimberley) indicating who is the monitoring entity.

## Guadalupe River Above Canyon Lake

**Drainage Area:** 596 square miles

**Streams and Rivers:** Guadalupe River from Comfort to Canyon Lake, Joshua Creek, Flat Rock Creek, Rebecca Creek, Block Creek, West Sister Creek

**Lake:** Canyon Lake

**Aquifer:** Trinity

**River Segments:** 1805, 1806

**Cities:** Comfort, Kandalia, Bergheim, Bulverde, Canyon City, Spring Branch, Startzville

**Counties:** Kerr, Comal, Kendall, Blanco

**EcoRegion:** Edwards Plateau

**Vegetation Cover:**

Evergreen Forest - 43.6%    Shrublands - 11.0%  
 Grass/Herbaceous - 31.3%

**Climate:**

Average annual rainfall: 32 inches  
 Average annual temperature: January 38° July 95°

**Land Uses:** Urban, Unincorporated Suburban Sprawl, Cattle, Goat and Sheep Production, Light and Heavy Industry, and Recreational

**Water Body Uses:** Aquatic Life Use, Contact Recreation Use, General Use, Fish Consumption Use, and Public Water Supply Use

**Soils:** Dark and loamy over limestone to loam with clay subsoils

**Permitted Wastewater Treatment Facilities:** Domestic: 3, Land Application: 1, Industrial: 0



Segment 1806, the Guadalupe River above Canyon Lake, extends from the lake in Comal County, through Kendall County, to the confluence with the north and south forks of the Guadalupe River in Kerr County. For ease in discussing the historical data and understanding the contributing watershed, the segment is separated into two parts in this report. The lower subsegment, which begins below the city of Comfort is separated into three assessment units: the lower 25 miles in Comal County; from the lower 25 miles to the confluence with Big Joshua Creek in Kendall County; and, from the confluence with Big Joshua Creek to the monitoring site near the city of Comfort. (Refer to the Upper Guadalupe River above Comfort for discussion on the water quality of the upper portion of Segment 1806.)

The satellite image (figure 1) of the segment near FM 474 shows the diversity of the land use which is made up of unimproved brush, improved pasture and row crops, and urbanization, in the form of new subdivisions. Some of the large ranches are used for cattle and goat grazing, but many are leased for hunting. Guadalupe River State Park is located in this segment.



Figure 1 is a satellite image of segment near FM 474 (17404).

Several entities have been monitoring the lower portion of Segment 1806 since the 1990s. GBRA has two monitoring sites within the lower subsegment, the Guadalupe River at FM 311 in Spring Branch (13700), which has been monitored monthly since 1996 and the Guadalupe River at FM 474 (17404), in Kendall County, which has been a quarterly monitoring location since October 2001. Each of the monitoring sites is located in the two lower assessment units. TCEQ has a routine site in the upper assessment unit, located at the Guadalupe River at Waring, that they have been monitoring quarterly since 1999. The US Geologic Survey collected water quality data in this subsegment in the 1990s. GBRA added a quarterly, systematic site on the Big Joshua Creek, in 2001 through 2003, in response to concerns of local stakeholders that a shooting range may be having an impact on water quality in the creek. The Upper Guadalupe River Authority sampled the Guadalupe River at the IH10 crossing in Comfort as part of their “swimability” study

from 2002 until 2006. As part of that study, UGRA collected fecal coliform bacteria, and then switched to *E. coli*, along with turbidity, weekly, during the summer months of each year. The median instantaneous **flow** at the Spring Branch site during the historical record of sampling events was 232 cubic feet per second (cfs) and 127 cfs at the FM 474 site. At Waring, the median flow was 154 cfs, slightly higher than at FM 474.

The Kendall County Water Control and Improvement District operates the wastewater treatment plant for the city of Comfort. The plant is the only wastewater discharge to this portion of Segment 1806, and is located at the most upstream part of the subsegment. The permitted discharge is for 0.35 million gallons per day, with high quality effluent standards of 5 milligrams per liter (mg/L) biochemical oxygen demand, 5 mg/L total suspended solids, 2 mg/L ammonia-nitrogen and 1 mg/L total phosphorus. The plant has been operating under a 210 authorization for beneficial reuse of the effluent on a nearby golf course since 2002.

The 2008 draft Texas Water Quality Inventory listed the middle assessment unit as impaired for bacteria because the geometric mean for *E. coli* at the FM 474 site was 140 organisms per 100 milliliters. The stream standard for contact recreation is a geometric mean of 126 organisms per 100 milliliters. Only two sampling events recorded *E. coli* concentrations over the single sample concentration of 394 organisms per 100 milliliters. Further downstream, the geometric mean for *E. coli* at the Spring Branch site was 45 organisms per 100 milliliters, and in the period of record, four samples were collected that exceeded the single sample *E. coli* standard. Upstream of the FM 474 site, at Comfort, the geometric mean for fecal coliform was 100 organisms per 100 milliliters (stream standard = 200 organisms per 100 milliliters) and the geometric mean for *E. coli* was 55 organisms per 100 milliliters. The TCEQ site located at Waring had a geometric mean for *E. coli* of 56 organisms per 100 milliliters and exceeded the single sample grab criteria two times. The only tributary that was monitored between the Waring site and the FM 474 site was the Big Joshua Creek. The geometric mean for *E. coli* during the 2 year systematic sampling project on the Big Joshua Creek was 58 organisms per 100 milliliters, with no single sample concentrations that exceeded the standard. Figure 2 shows the relationship between flow and *E. coli* at the FM 474 site. When

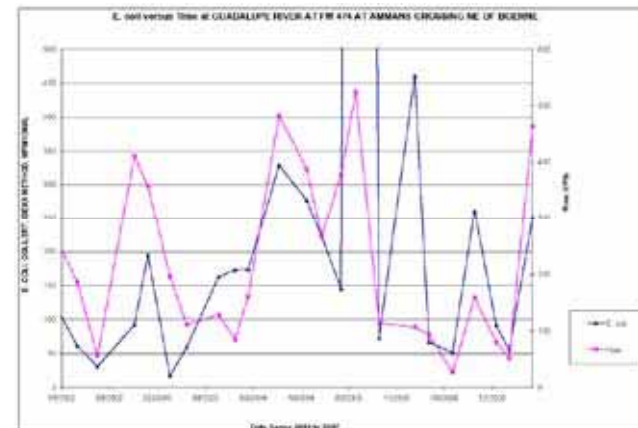


Figure 2. Relationship of *E. coli* and flow at FM 474 (17404).

the site was sampled during high flows there were corresponding elevated bacteria concentrations, pointing to runoff as a source of the contamination. The satellite image of the land use in the area of the sampling site, figure 1, shows that there are improved pastures and land clearing with a thin riparian buffer along the creek and main stem. It is unclear what the land improvements are for but it is apparent that dirt has been moved. Pastures with livestock grazing, land without established grasses (increasing the potential for erosion) and urbanization with impervious cover are possible sources of the nonpoint bacteria loads associated with sediment in runoff.

The median concentrations for dissolved oxygen, beginning at the downstream site at Spring Branch and moving upstream to the Comfort site are 8.9, 9.4 and 9.1 (mg/L), respectively, ranging from a minimum of 6.4 mg/L at the Spring Branch site to a maximum of 13.1 mg/L also at the Spring Branch site. At no time in the period of record did the dissolved oxygen drop below the standard for the minimum dissolved oxygen concentration (4.0 mg/L). The temperature varied between 8.4°C to 31.6°C, with median temperatures of 22°C, 20.9°C and 20.6°C at the three monitoring locations, from downstream to upstream. The **specific conductance** ranged between 178 to 990 micromhos per centimeter, with median conductivities of 500, 545 and 518 micromhos per centimeter. The median pH of the three monitoring sites, from downstream to upstream, were 8.05, 7.92 and 8, ranging from 6.4 to 8.8 standard pH units, falling outside the stream standard range of 6.5 to 9.0 standard units one time at the Spring Branch site (pH of 6.4 measured in June 1993 near median flow). The median concentrations for chloride and sulfate, from downstream to upstream, were 18.6, 18.6 and 21.5 and 21.4, 22.4 and 21.5 mg/L respectively. At no time did the concentration of these dissolved constituents exceed the stream standard of 50 mg/L.

The Big Joshua Creek has comparable pH, temperature, dissolved oxygen and conductivity, with median values that fall in the same range as the three main stem monitoring sites. The creek has slightly lower chloride concentrations but slightly higher sulfate concentrations as compared to the main stem sites.

Nitrate nitrogen, ammonia nitrogen and total phosphorus, were analyzed at the three main stem sites. Over the period of record, nitrate nitrogen was reported under three storet codes, as nitrate nitrogen and in combination with nitrite nitrogen. The median concentrations for all three cited storet codes ranged from 0.38 to 0.83, with the highest median at the upper most main stem site at Waring. Only one monitoring event had a nitrate nitrogen concentration that exceed the screening criteria of 1.95 mg/L. The median ammonia nitrogen concentration at all three sites was below detection limits. The concentration of ammonia nitrogen measured at the main stem sites never exceeded the screening concentration of 0.33 mg/L. The median total phosphorus concentrations were below the limit of quantification for the method at all of the main stem sites. On one occasion, at the Spring Branch site, total phosphorus exceeded the screening concentration of 0.69 mg/L (measured 1.48 mg/L). During that monitoring event the flow was over 12,000 cubic feet per second (median **flow** is approximately 184 cubic feet per second) and the turbidity was 98 nephelometric turbidity units (NTU) (median turbidity is 4.75 NTU). The elevated total phosphorus concentration was most likely due to organically-bound phosphorus in the sediment brought in by rainfall runoff.

The substrate in the main stem transitions from a gravel to bedrock substrate. The water is clear and shallow in the majority of locations along the segment, with very few pools. The suspended solids (TSS) ranged from less than 1 to 278 mg/L, with median concentrations ranging from 3.3 to 10 mg/L at the main stem sites. In most instances, the TSS correlate positively with flow, meaning that the TSS rises when there is elevated flow (figure 3). Since the site is only monitored monthly and is not targeted for stormwater, sampling could have occurred immediately after a rainfall event or several days or weeks after the initial flush of runoff, explaining why there were instances of high flows but no corresponding spike of total suspended solids.

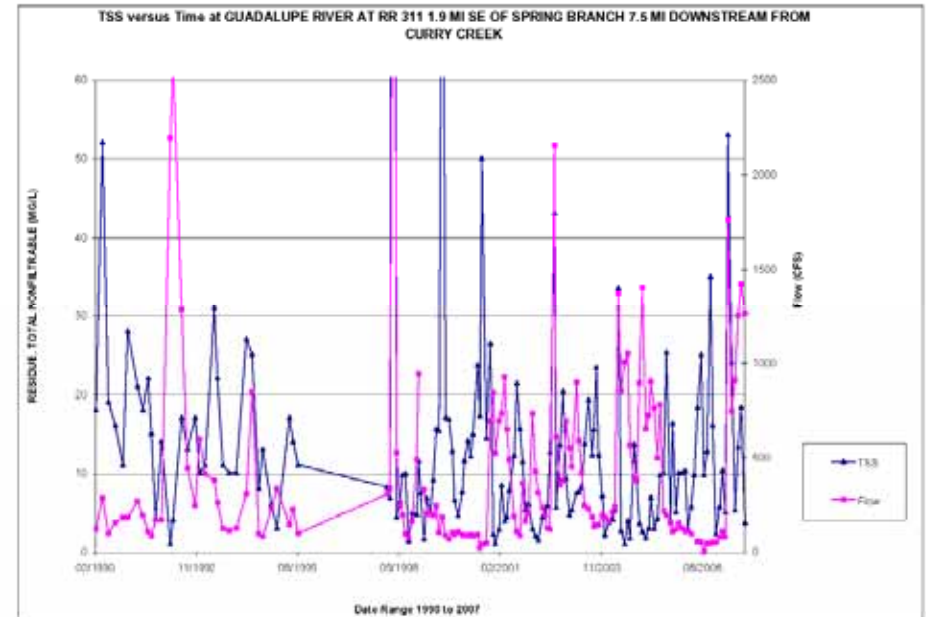
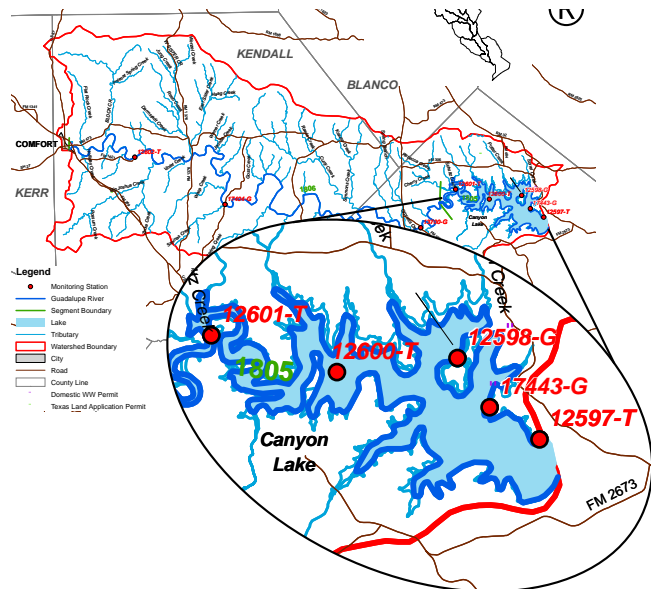


Figure 3. Total suspended solids and flow through the period of historical data collected on the Guadalupe River at Spring Branch.

The median chlorophyll a concentration is less than detection and there was never a measured value above the screening concentration of 14.1 micrograms per liter.



Canyon Reservoir, also known as Canyon Lake, segment 1805, is located in Comal County, west of the city of New Braunfels. The multipurpose reservoir, built by the US Army Corp of Engineers (COE) and the Guadalupe-Blanco River Authority (GBRA) and impounded in the mid-1960's, is designed to serve flood control and water supply functions. It is also used for recreation. Canyon Lake has 8,230 surface acres and over 80 miles of shoreline, seven public parks, two military recreational areas and two marinas. The lake is divided up into four assessment units: the cove around Jacob's Creek Park; the north end of Crane's Mill Park to the south end of Canyon Park; the upper end of the segment; and, the lower end of the reservoir near the dam. The lake has designated uses of contact recreation, exceptional aquatic life use, domestic water supply and aquifer protection.

The reservoir is monomictic, stratifying in the summer and having one turnover per year, usually with the first strong cold front in the fall. The reservoir can be divided into three zones, moving down the reservoir, toward the dam. Those zones include the *riverine zone*, the *transitional zone* and the *lacustrine zone*. The *riverine zone* does not routinely stratify because it is flow-dominated, keeping the waters in this zone mixed. The conditions are often turbid because it is in this zone that sediments carried by stormwater from upstream enter the reservoir. The *transitional zone* is the zone where the river reacts with the reservoir. As the flow from the river slows and spreads, the sediment carried by the stream begins to drop out and settles to the bottom. Studies done on the Canyon Reservoir have found that in years of high runoff and sediment loading, the reservoir's anoxic zone can develop in this transitional zone where the decay of the organic deposition depletes the oxygen. The *lacustrine zone* is located near the dam. The lacustrine zone is clear and deep. It is in this area that thermal stratification occurs, as well as, the development of an anoxic layer. In years of low incoming flow the lake will strongly stratify with "layers" called the *epilimnion* at the surface and the *hypolimnion* at the bottom, separated by a *thermocline* (area of rapid thermal change). In years with heavy spring rains and

incoming flows, the lake will be more weakly stratified because of volume coming into the reservoir, coupled with the release of water from the bottom, used to evacuate the flood pool. In times where the reservoir is strongly stratified the thermocline is strong enough to keep the waters of the epilimnion and hypolimnion from mixing, creating distinctly different density and oxygen differences through the water column.

The reservoir operates as two parts. The lower portion from elevation 800 to 909 mean sea level (msl) is operated by GBRA for conservation storage. GBRA was granted water rights for 90,000 acre-feet of water per year to be made available for customers through water purchase contracts. GBRA releases water from the conservation pool as it is called for by downstream customers.

The upper portion of Canyon Reservoir is referred to as the "flood pool" and is controlled by the COE. This part of the reservoir captures floodwaters that are usually released at rates sufficient to empty the flood pool without contributing to downstream flooding.

#### Land Use

The land use in the watershed is made up of residential and business development, resorts, parks and recreational facilities, and ranches with unimproved brush, used for cattle and hunting. The area has been experiencing a high level of growth, with over 8,690 lots platted in Comal County, and a good number of those in the Canyon Lake watershed. The watershed contains a relatively small amount of urbanized area. The town of Sattler and the city of Bulverde are in the watershed, both of which are not currently served by a domestic wastewater treatment facility. There is one small package plant that serves a strip center in Bulverde but that facility only serves the businesses in the center.

The COE has one development regulation that affects the area immediately around the reservoir. There can be no on-site septic systems or major buildings with plumbing or electricity built within the 948 mean sea level elevation. Any another construction must be reviewed and approved by the COE.

There are two wastewater treatment plants that discharge directly to the reservoir. The Canyon Park Estates Wastewater Treatment Facility (CPE) is operated by GBRA and is being expanded to treat 260,000 gallons per day. The facility must treat the domestic wastewater to high quality standards of 5 milligrams per liter (mg/L) of biochemical oxygen demand, 5 mg/L total suspended solids, 2 mg/L ammonia nitrogen and 1 mg/L total phosphorus. The facility discharges to a cove on the north side of the lake. The other wastewater treatment plant that discharges to the lake is operated by the US Department of Army and serves a small recreational facility available to military personnel. The plant is permitted to discharge 12,500 gallons per day. The remaining area around the reservoir is served by septic tanks, with Comal County being the designated representative for enforcement of septic tank rules.

All four assessment units were listed on the 2008 Draft Water Quality Inventory as impaired due to mercury in fish tissue. The listing came as a result of a fish



consumption advisory issued by the Texas Department of State Health Services (DSHS) in 2006. In 2003, a tier one fish tissue survey was conducted by TCEQ, DSHS and Texas Parks and Wildlife Department. A follow-up tier two survey was conducted in 2005. In the follow-up survey 30 fish were collected and analyzed for heavy metals. The species of fish collected in the survey included striped bass, long-nosed gar, largemouth bass, blue catfish, flathead catfish and white bass. In 2005 the action level for mercury in fish tissue was 0.7 mg/Kg. The two species identified in the advisory were striped bass and long-nosed gar. These two species contained a mean mercury concentration of 1.149 mg/Kg and 0.772 mg/Kg respectively. These species are high end predators that are long-lived and voracious eaters. The mercury bioaccumulated in their tissue as methylmercury, the organometallic form, which is the most toxic form. Because there are very few discharges to the reservoir and these are domestic wastewater, the mostly likely mechanism for mercury to enter the reservoir is by atmospheric deposition. Possible sources of mercury in the area of the reservoir include emissions from coal-fired power plants and cement plants. Other sources include naturally occurring sources, volcanic and industrial emissions. There are 13 other waterbodies in Texas that have fish consumption advisories due to mercury. Most are found in East Texas and the Panhandle. These waterbodies have low pH, high dissolved organic material or are shallow wetlands. It is very unusual for Canyon Reservoir to be included on that list. Canyon Lake has hard water and very low dissolved organic content. In 2006, immediately after the fish consumption advisory was issued, GBRA, along with representatives from the COE, toured the lake by boat looking for illicit discharges. The lake level was down due to drought conditions and would have exposed pipelines to the reservoir. None were found. Additionally, GBRA analyzed the wastewater and sludge produced at the CPE facility and no mercury was detected in either matrix.

In addition to the impairment for mercury in fish tissue, Canyon Reservoir, excluding the cove, was listed with a concern for orthophosphorus and nitrate nitrogen. In the three assessment units that make up the main pool of the reservoir, 41 of the 64 analyses exceeded the screening standard for orthophosphate of 0.05 mg/L. Five of the 68 analyses exceeded the screening standard for nitrate nitrogen. Currently, TCEQ is developing standards for nutrients. Nutrient enrichment from nitrogen and phosphorus can cause excessive growth of macrophytes, algal blooms in the open waters as well as attached to the substrate and floating in mats. The Texas Water Quality Standards have narrative but not numerical nutrient criteria. TCEQ staff are developing and evaluating several alternatives for nutrient standards, one of which, is to express the nutrient criteria in terms of chlorophyll a. Canyon Reservoir is listed on the draft Appendix F (Chapter 301.10) that lists site-specific nutrient criteria for reservoirs and lakes in Texas. The table lists the proposed chlorophyll a concentration and screening concentrations for total phosphorus and total nitrogen for each water body. Criteria formulations were based on selected sampling stations that represent the deep pool near the dam for each reservoir, represent average conditions with an allowance for statistical variability, and are calculated as the upper confidence interval of the mean with the assumption that a sample size of 10 is used. Based on these assumptions, the proposed nutrient criteria for Canyon Reservoir include 3.1 microgram per liter (ug/L) chlorophyll a, a screening concentration of 0.054 mg/L total phosphorus and a screening concentration of 0.841 mg/L total nitrogen. Other alternatives that TCEQ staff are

considering when developing site-specific nutrient criteria include a use-based approach with uses such as aquatic recreation, fishing and drinking water.

In order to review the historical data and look for trends that would indicate changes in water quality, the data was separated into two areas in the reservoir, the main pool stations and the stations located in coves. The main pool sites and the associated depth profiles were reviewed individually and in comparison with other pool monitoring sites.

#### Main Pool - Canyon Reservoir

TCEQ has three monitoring sites located in the reservoir, one in the upper portion of the reservoir, located at Cranes Mill Park (site no. 12601), one in the mid-reservoir at Potter's Creek Park (site no. 12600) and one at the dam (site no. 12597). TCEQ Surface Water Quality Monitoring teams collected water quality data from two to four times per year, beginning in 1990 at the Cranes Mill Park and Potter's Creek Park sites and beginning in 2001 at the dam, and the data sets extend to 2007. The US Geologic Survey monitored sites in the mid-1990s, but have not visited their reservoir sites since 1995. The TCEQ data sets were used in the trend analysis because of the availability of the most recent data.

#### *Canyon Reservoir at Crane's Mill Park (site no. 12601-T)*

The Crane's Mill Park site is located in the upper assessment unit and in the riverine zone of the reservoir. The average depth at the upstream location at Crane's Mill Park was 8.6 meters, ranging from the time it was most shallow of 4.6 meters in 2006 to the time it was at it's deepest at 15 meters in 1990. The reservoir depth fluctuates the most at this location as the flow from the river upstream varies between wet and dry years. The change in temperature from surface to bottom averaged 1.5 °C, ranging from median temperature at the surface of 27.5°C to and a median temperature at the bottom of 24.3°C. There was no thermal stratification at this location. The conductivity changed an average of 30 micromhos per centimeter (umhos/cm) at the surface to bottom profiles. In normal to wet years the conductivity is lower at the surface than at the bottom. In 2006, which was a very dry year, the conductivity was higher at the surface. The surface conductivities at this site ranged from a median of 382 umhos/cm at the surface to a median conductivity of 397 umhos/cm at the bottom.

The difference in dissolved oxygen between the surface to bottom averaged 1.9 mg/L. The median surface dissolved oxygen at the Crane's Mill Park site was 8.1 mg/L and a median bottom dissolved oxygen of 6.3 mg/L. The oxygen was depleted to less than 1.0 mg/L from surface to bottom four times during the period of record at this site, with the most recent being in August 2005.

The difference in pH from surface to bottom at this reservoir location averaged a change of 0.23 pH units. No surface or profile sample fell outside the pH standard range of 6.5 to 9.0.

Nutrients, dissolved constituents, suspended solids and chlorophyll a were analyzed in the surface samples only. Nitrate nitrogen was reported using three



different methods over the period of data collection. Combining the three methods, nitrate nitrogen had a median concentration of 0.05 mg/L, ranging from less than method detection to 0.88. The concentrations measured at the site exceeded the reservoir screening concentration of 0.37 mg/L 8 times or 20% of the time. Ammonia nitrogen had a median concentration of 0.05 mg/L, ranging from less than method detection to 0.23 mg/L, exceeding the reservoir screening concentration of 0.11 mg/L two times. The total phosphorus concentrations ranged from less than method detection to 0.08 mg/L, with a median concentration of less than method detection. Orthophosphate was measured at this site and on the 2008 draft Texas Water Quality Inventory it was noted that there was a concern for this nutrient. One important note to make is that of the 31 measurements of orthophosphate, the method detection level of 0.06 mg/L that was used the majority of the time, was greater than the screening concentration of 0.05 mg/L. It appears that the assessment was done by dropping the less than symbol for the calculations, an accepted practice for data sets containing non-detects, and using that concentration which would make the site appear to exceed the screening concentration.

Chloride and sulfate had median concentrations of 15 and 20 mg/L, respectively and ranged from 9 to 19 mg/L chloride and 12 to 24 mg/L sulfate, both well below the stream standard of 50 mg/L for each. The total suspended solids had a median concentration of 6 mg/L, ranging from 3 mg/L to 123 mg/L, the highest recorded concentrations occurring with high inflows into the reservoir. The high solids content is typical of the riverine zone of the reservoir. The chlorophyll a concentrations were less than 10 ug/L, the method detection limit used by the TCEQ laboratory, and well below the screening concentration of 26.7 ug/L for the assessment unit.

TCEQ also collected metals in water and metals in sediment at this reservoir location. The metals in water had only one to two data points in the data set. However, the analysis of metals in sediment had a data set that included 10 data points. Table 1 gives the median concentrations in milligrams per kilogram or parts per billion of each metal analyzed. The analysis for metals in sediment is important in a reservoir, and especially in those like Canyon Reservoir, because metals will be released from the sediment when the hypolimnion becomes anoxic. The metal oxides that are bound in the sediment then become a source of oxygen for bacteria. The metal ions released diffuse into the water column and can be dispersed throughout the volume of the reservoir as the lake turns over in the fall. As the metals enter the water column, the ions can combine with the available oxygen and become oxides again, be diluted by the large volume in the reservoir, and/or possibly bioaccumulate in the food chain. This source of heavy metals could be an explanation for the mercury in fish tissue impairment in Canyon Reservoir.

Table 1. Metals in Sediment at Canyon Reservoir Sites (1998-2006). Median concentrations in milligrams per kilogram.

Site	Aluminum	Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Manganese	Mercury	Selenium	Silver	Zinc
Crane's Mill Park	25900	5.9	67.6	0.31	16.5	8.4	10.6	295	0.0475	0.474	ND <sup>1</sup>	33.2
Potter's Creek Park <sup>2</sup>	30300	12.1	93.9	ND	21.7	9.1	12.4	351	---	0.63	ND	34.3
At the Dam <sup>2</sup>	31700	<11.9	106	ND	22.1	10.1	15.1	334	---	0.77	ND	35.4

<sup>1</sup> ND = none detected

<sup>2</sup> Only one sample in data set.

<sup>3</sup> Mercury in sediment was not analyzed at this site.

### Canyon Reservoir at Potter's Creek Park (site no. 12600-T)

Moving into the transition zone of the reservoir, the TCEQ samples a site at Potter's Creek Park that has an average depth of 15.2 meters, varying from a shallow depth of 6 meters to a maximum depth of 28 meters. The site weakly stratified in the summer months and was uniform in dissolved oxygen (DO) and temperature in the fall and winter samples. The change in dissolved oxygen in the fall and winter months averaged 1.98 mg/L, with the largest difference of 4.0 mg/L seen in November 2006. In comparison, the spring and summer months averaged 7.1 mg/L change from surface to bottom profiles. Thirteen of the 33 sampling events recorded less than 1.0 mg/L DO at the bottom, more often than the other two reservoir locations. This supports the past studies that show that it is near this site in the reservoir that the solids carried from the river begin to settle out and the oxygen is depleted as the bacteria decompose the organic solids.

As was the case at the Crane's Mill site, the Potter's Creek site profiles had lower conductivities at the surface than at the bottom. In all of the 34 profiles taking at the Potter's Creek site, only three were the inverse. The average difference between the surface and bottom profile samples was 50 umhos/cm. The pH change averaged 0.5 pH units from surface to bottom and no individual sample in the profiles exceeded the 6.0 to 9.5 pH standard.

Nutrients, dissolved constituents, suspended solids and chlorophyll a were analyzed in the surface samples only. Nitrate nitrogen was reported using three different methods over the period of data collection. Combining the three methods, nitrate nitrogen had a median concentration of 0.06 mg/L, ranging from less than method detection to 0.63. The concentrations measured at the site exceeded the reservoir screening concentration of 0.37 mg/L 4 times or less than 10% of the time. Ammonia nitrogen had a median concentration of less than detection, ranging from less than method detection to 0.55 mg/L, exceeding the reservoir screening concentration of 0.11 mg/L two times. The total phosphorus concentration ranged from less than method detection to 0.06 mg/L, with a median concentration of less than method detection. Orthophosphate was measured at this site and, as was mentioned concerning the Crane's Mill site, it was noted on the 2008 Texas Water Quality Inventory that there was a concern for this nutrient. The same observation applies to this site that, of the 35 analyses done for orthophosphate, the method detection level of 0.06 mg/L that was used the majority of the time was greater than the screening concentration of 0.05 mg/L.

Chloride and sulfate had median concentrations of 15 and 20 mg/L, respectively and ranged from 9 to 18 mg/L chloride and 12 to 24 mg/L sulfate, both well below the stream standard of 50 mg/L for each. The total suspended solids had a median concentration of 4 mg/L, ranging from 1 mg/L to 24 mg/L. The high concentrations associated with high inflows into the reservoir seen in the riverine zone on the reservoir are not seen at the Potter's Creek site, located in the transition zone. The chlorophyll a concentrations were less than 10 ug/L, the method detection limit used by the TCEQ laboratory, and well below the screening concentration of 26.7 ug/L for the assessment unit.

TCEQ also collected metals in water and metals in sediment at this reservoir location, but only had one to two data points in the data set. Table 1 gives the measured concentration in milligrams per kilogram or parts per billion of each metal to be used as comparison to the Crane's Mill Park site only and not for assessment.

#### *Canyon Reservoir at the Dam (site no. 12597-T)*

The TCEQ has been monitoring the location at the dam, in the lacustrine zone, since the summer of 2001. The average depth at the dam was 27.4 meters, ranging from its most shallow of 21.3 meters in 2006 to 32 meters. The reservoir depth fluctuates as the volume varies between wet and dry years. The change in temperature from surface to bottom averaged 7.7 °C, ranging from median temperature at the surface of 23.4°C to and a median temperature at the bottom of 15.2°C. Thermal stratification occurred in the summer months in most years. As seen at the upper stations, the conductivity gained an average of 41 micromhos per centimeter (umhos/cm) from surface to bottom profiles. The surface conductivities at this site ranged from a median of 374 umhos/cm at the surface to a median conductivity of 418 umhos/cm at the bottom.

The difference in dissolved oxygen between the surface to bottom averaged 4.9 mg/L. The median surface dissolved oxygen at the dam was 8.7 mg/L and a median bottom dissolved oxygen of 2.4 mg/L. The oxygen was depleted to less than 1.0 mg/L from surface to bottom six times during the period of record at this site (out of 23 sampling events), with the most recent being in July 2007.

The difference in pH from surface to bottom at both reservoir locations averaged a change of 0.52 pH units. The median surface pH was 8.2 and the median pH at the bottom was 7.5. No surface or profile sample fell outside the pH standard range of 6.5 to 9.0.

Nutrients, dissolved constituents, suspended solids and chlorophyll a, were analyzed in the surface samples only. Nitrate nitrogen was reported using two different methods over the period of data collection. Combining the two methods, nitrate nitrogen had a median concentration of 0.085 mg/L, ranging from less than method detection to 0.47. The concentrations measured at the site exceeded the reservoir screening concentration of 0.37 mg/L 2 times. Ammonia nitrogen had a median concentration of less than method detection, never exceeding the reservoir screening concentration of 0.11. The median concentration for total phosphorus was less than method detection. Orthophosphate was measured at this site and on the 2008 Texas Water Quality Inventory it was noted that there was a concern for this nutrient. Again, as at the other two main pool sites, of the 18 measurements made for orthophosphate the method detection level of 0.06 mg/L that was used the majority of the time was greater than the screening concentration of 0.05 mg/L and at this site the reported values were less than 0.06 mg/l 100% of the time. It appears that the assessment was done by dropping the less than symbol and using that concentration in the calculations, which would make the site appear to exceed the screening concentration.

Chloride and sulfate had median concentrations of 15 and 20.5 mg/L, respectively and ranged from 12 to 18 mg/L chloride and 16 to 23 mg/L sulfate, both well below the stream standard of 50 mg/L for each. The total suspended solids had a median concentration of 3 mg/L, ranging from less than method detection to 8 mg/L. The chlorophyll a concentrations were less than 10 ug/L, the method detection limit used by the TCEQ laboratory, and well below the screening concentration of 26.7 ug/L for the assessment unit.

TCEQ also collected metals in water and metals in sediment at their reservoir locations, but only had only one to two data points in the data set for the location at the dam. Table 1 gives the measured concentration in milligrams per kilogram or parts per billion of each metal to be used as comparison to the Crane's Mill Park site only and not for assessment.

The historical data for the main pool of the reservoir was reviewed for trends over time and none were found, or if found, were not indicative of a degradation in water quality.

#### Cove Sites – Canyon Reservoir

GBRA has two monitoring locations in coves on Canyon Reservoir. The first site located near the Canyon Lake Marina (site no. 12598) was established in 1987 as part of the GBRA historical monitoring program aimed at looking at water quality for contact recreation. The parameter list was expanded in 1996 when GBRA joined the Clean Rivers Program. The TCEQ has also monitored at this location and their data is part of this review. GBRA monitors this site monthly and samples are collected from the first third of a meter.

The second monitoring site (GBRA) was established in 2001 at the request of the Comal County Judge. He and the Commissioner's Court were concerned about the wastewater discharge to the cove and wanted a monitoring site closer to the discharge. The site near the Jacob's Creek Park (site no. 17443) is approximately two miles from the discharge. The site is monitored quarterly.

Both coves are relatively shallow as compared to the main pool of the reservoir. The sample sites are located in the assessment unit that refers to the coves around Jacob's Creek Park. There were no concerns noted for this assessment unit other than the mercury in fish tissue impairment previously mentioned.

Looking at the water quality at the Jacob's Creek Park site, the median temperature is 20 °C, ranging from 13.2 to 30.7 °C. The median **specific conductance** was 400 umhos/cm, ranging from 328 to 461 umhos/cm. The dissolved oxygen ranged from 6.79 to 12.5 mg/l, with a median concentration of 10 mg/L and never exceeded the screening concentration of 6.0 mg/L. The pH of the water at the Jacob's Creek Park site ranged from 7.85 to 8.36 pH units, with a median pH of 8.2.

Nitrates, ammonia and total phosphorus were analyzed at the Jacob's Creek Park site. The nitrates were reported using three storet codes, nitrate alone and in combination with nitrite nitrogen. Looking at all three methods, the median

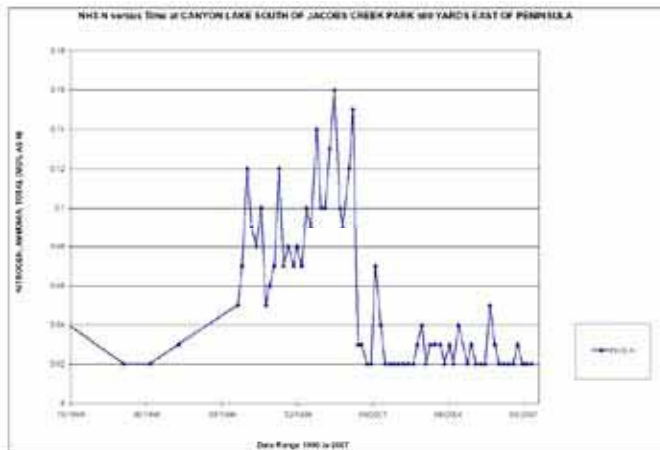
concentration for nitrates was 0.06 mg/L, ranging from less than detection to 0.38 mg/L, exceeding the screening concentration for this assessment unit one time. The ammonia nitrogen was always measured below the screening concentration and the median concentration was below the method detection level. Total phosphorus had a median concentration of less than method detection and did not exceed the screening concentration.

Chlorophyll a concentrations were very low and never approached the screening concentration of 26.7 micrograms per liter (ug/L). The median concentration was 1.5 ug/L, and the highest concentration measured in the historical data set was 10.8 ug/L. *E.coli* concentrations are also very low, with the highest concentration measured being 61 organisms per 100 milliliters. The geometric mean for the site was 3 organisms per 100 milliliters.

The historical data was reviewed for trends over time and none were found, or if found, were not indicative of a degradation in water quality at this location.

The GBRA site in the cove near the Canyon Lake Marina has an extensive historical data set. The median temperature is 24.3 °C, ranging from 10.5 to 32 °C. The median **specific conductance** was 386 umhos/cm, ranging from 306 to 526 umhos/cm. The dissolved oxygen ranged from 6.06 to 12.8 mg/l, with a median concentration of 8.8 mg/L and never exceeded the screening concentration of 6.0 mg/L. The pH of the water at the Jacob's Creek Park site ranged from 7.1 to 8.9 pH units, with a median pH of 8.15.

Nitrates, ammonia and total phosphorus were analyzed at the GBRA marina site. The nitrates were reported using three storet codes, nitrate alone and in combination with nitrite nitrogen. Looking at all three methods, the median concentration for nitrates was 0.12 mg/L, ranging from less than detection to 1.5 mg/L, exceeding the screening concentration of 0.37 mg/L for this assessment unit 26 out of 233 measurements (11.1%). The median concentration for ammonia nitrogen was below the method detection level. Figure 1 shows the concentration of ammonia nitrogen over time. We see a significant drop in concentration in



2001. As mentioned in previous basin highlights and summary reports, the elimination of the distillation step from the analytical procedure for ammonia

Figure 1. Ammonia nitrogen concentrations over time, near the Canyon Lake marina (12598). Drop in concentration in 2001 attributed to the removal of the distillation step from the analytical procedure.

nitrogen removed the contamination of the samples by the laboratory atmosphere and reduced the measured ammonia nitrogen in the samples. After the analytical method was changed, the concentration of ammonia nitrogen at this site does not exceed the screening concentration of 0.11 mg/L, and the median concentration for ammonia nitrogen dropped to 0.02 mg/L.

Chlorophyll a concentrations were very low and exceeded the screening concentration of 26.7 micrograms per liter (ug/L) one time. The median concentration was 2.0 ug/L. The highest concentration measured in the historical data set was 37.3 ug/L which occurred when the reservoir was in the flood pool at 948 msl due to the historic flood of 2002. The reservoir is usually held at 909 msl or less so there was almost 40 feet of inundated land which most likely contributed nutrients and promoted an uncharacteristic spike in algal production (figure 2).

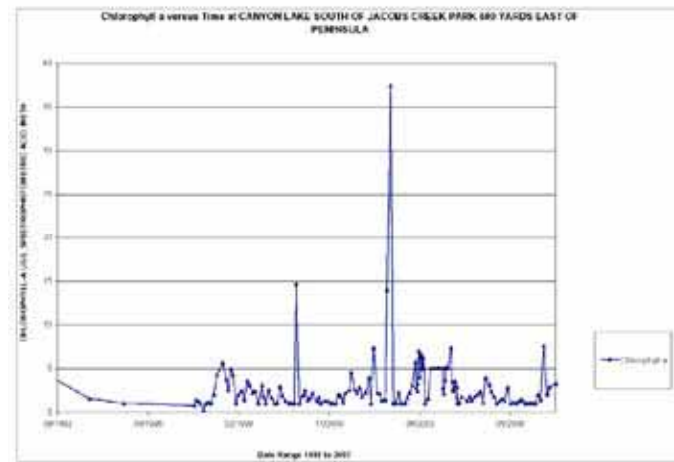
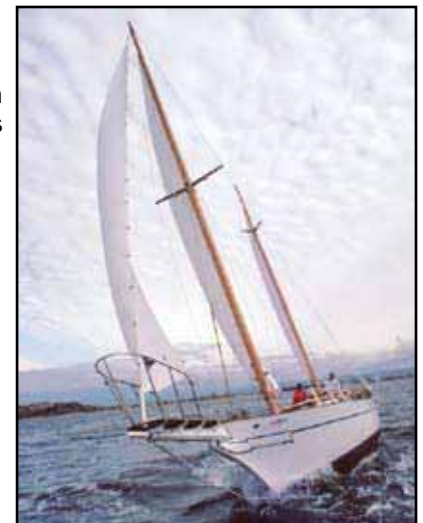
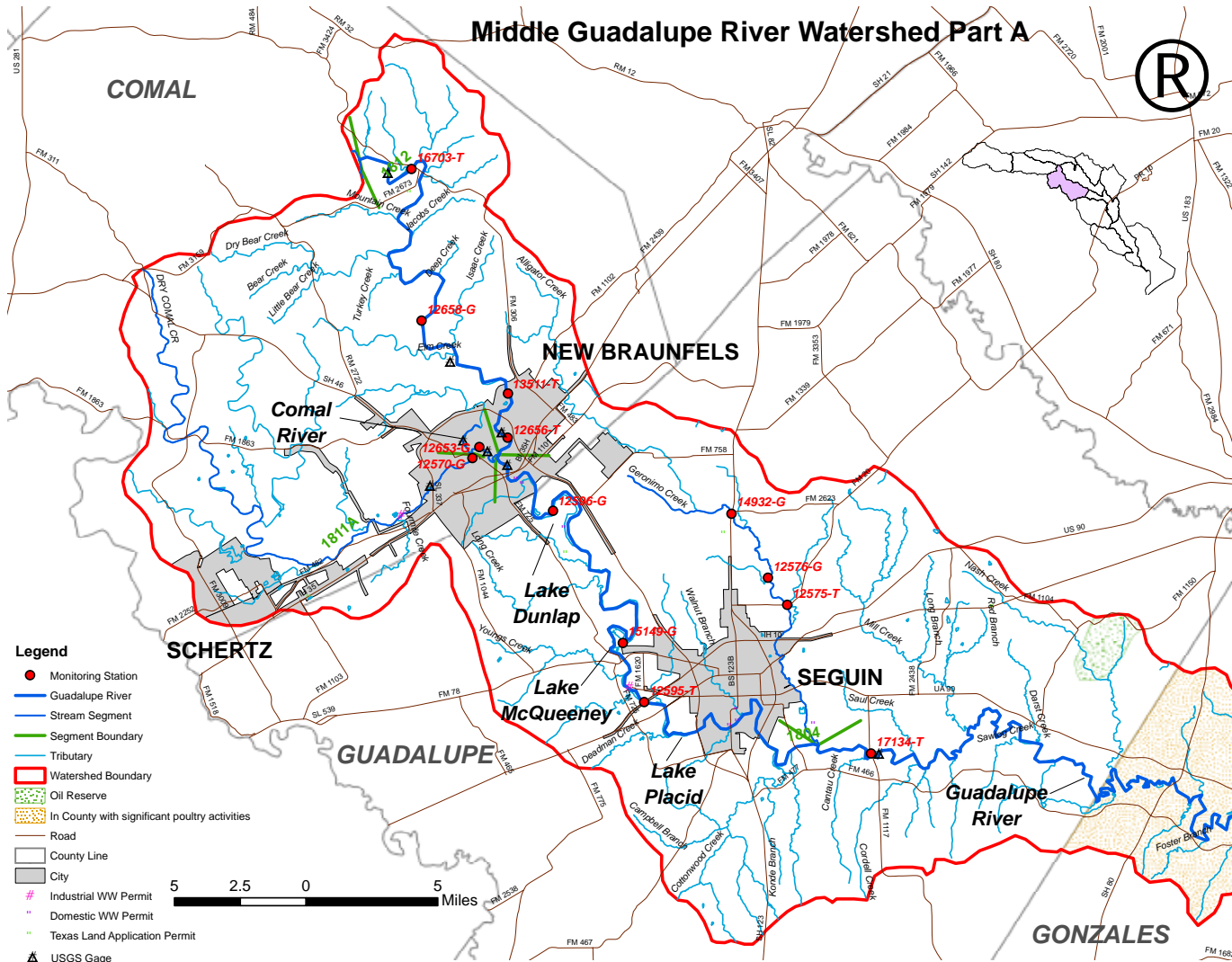


Figure 2. Chlorophyll a over time at the GBRA Canyon Lake Marina site (12598). Spike in chlorophyll a in 2002 due to nutrients from inundated areas that promoted the growth of algae.

The geometric mean for *E. coli* at the GBRA Canyon Lake Marina site was 4 organisms per 100 milliliters, ranging from less than detection to 460 organisms per 100 milliliters. There was only one exceedence of the stream standard for contact recreation of 394 organisms per 100 milliliters which occurred in February 2006. There was no rainfall recorded in close proximity to the sampling location so the spike in *E. coli* was not due to runoff.

The historical data was reviewed for trends over time and none were found, or if found, were not indicative of a degradation in water quality at this location.





**Monitoring Stations – Middle Guadalupe River Watershed Part A**

16703-T	Guadalupe River at FM 306, downstream of Horseshoe Falls
12658-G	Guadalupe River at Second Crossing
13511-T	Guadalupe River at Gruene Bridge
12656-T	Guadalupe River at Cypress Bend Park in New Braunfels
12653-G	Comal River downstream Clemons Dam (Hinman Island)
12570-G	Dry Comal Creek at Missouri-Kansas Railroad Crossing
12596-G	Lake Dunlap at AC's Place
15149-G	Lake McQueeney near the dam at Hot Shots
12595-T	Guadalupe River at IH 10 (Lake Placid)
14932-G	Geronimo Creek at SH 123
12576-G	Geronimo Creek at Haberle Road
12575-T	Geronimo Creek at FM 20
17134-T	Guadalupe River at FM 1117

Sampling sites are labeled in red followed by the letter G (GBRA), T (TCEQ), U (UGRA) or W (Wimberley) indicating who is the monitoring entity.

**Middle Guadalupe Watershed (Part A)**

**Drainage Area:** 939 square miles

**Streams and Rivers:** Guadalupe River below Canyon Dam, Dry Comal Creek, Comal River, Geronimo Creek

**Lakes:** Lake Dunlap, Lake McQueeney, Lake Placid

**Aquifers:** Edwards Trinity, Edwards Balcones Fault Zone, Carrizo Wilcox

**River Segments:** 1804, 1804A, 1811, 1811A, 1812

**Cities:** Sattler, New Braunfels, Schertz, Seguin, Geronimo, Kingsbury

**Counties:** Comal, Guadalupe, Gonzales

**EcoRegions:** Texas Blackland Prairies, Post Oak Savannah

**Vegetation Cover:**

Pasture/Hay - 25.5%	Grass/Herbaceous - 15.1%
Evergreen Forest - 18.0%	Shrublands - 12.0%
Deciduous Forest - 15.5%	Row Crops - 8.1%

**Climate:**

Average annual rainfall: 29 inches

Average annual temperature: January 35° July 95°

**Land Uses:** Urban, Light Manufacturing, Heavy Manufacturing, Farming, Cattle Ranching, Poultry, Petroleum Production, Gravel Mining

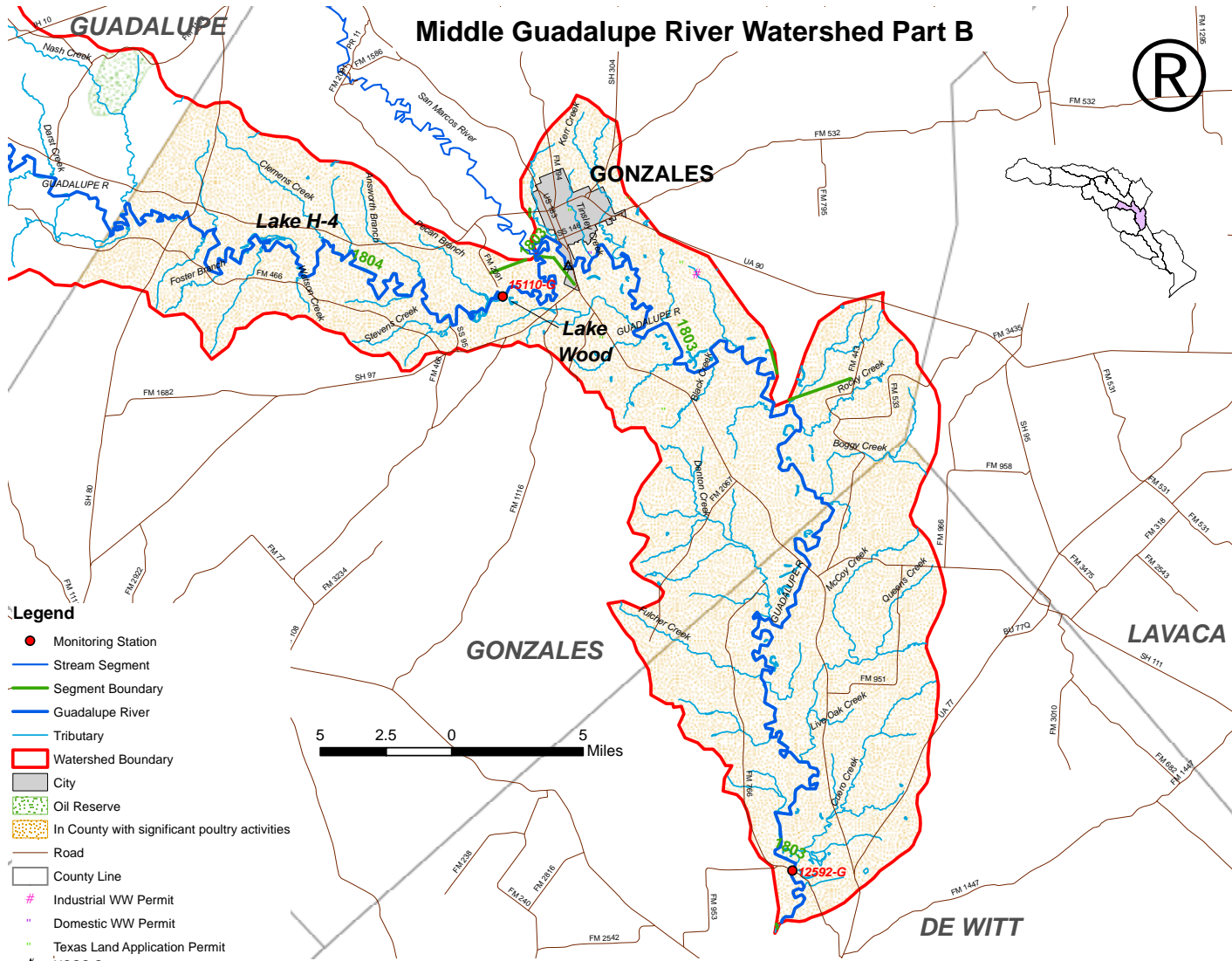
**Water Body Uses:** Aquatic Life, Contact Recreation, Fish Consumption, General, Public Water Supply, Hydroelectricity, Agricultural Crops, Industrial

**Soils:** Dark, calcareous clay, sandy loam, loam with clay subsoils; dark red sandstone, light tan and gray sandstone

**Permitted Wastewater Treatment Facilities:**

Domestic: 8, Land Application: 5, Industrial: 4





**Monitoring Stations – Middle Guadalupe River Watershed Part B**

15110-G Guadalupe River below Lake Wood (H-5) dam  
 12592-G Guadalupe River at FM 766

- Legend**
- Monitoring Station
  - Stream Segment
  - Segment Boundary
  - Guadalupe River
  - Tributary
  - Watershed Boundary
  - City
  - Oil Reserve
  - In County with significant poultry activities
  - Road
  - County Line
  - # Industrial WW Permit
  - “ Domestic WW Permit
  - “ Texas Land Application Permit
  - ▲ USGS Gage

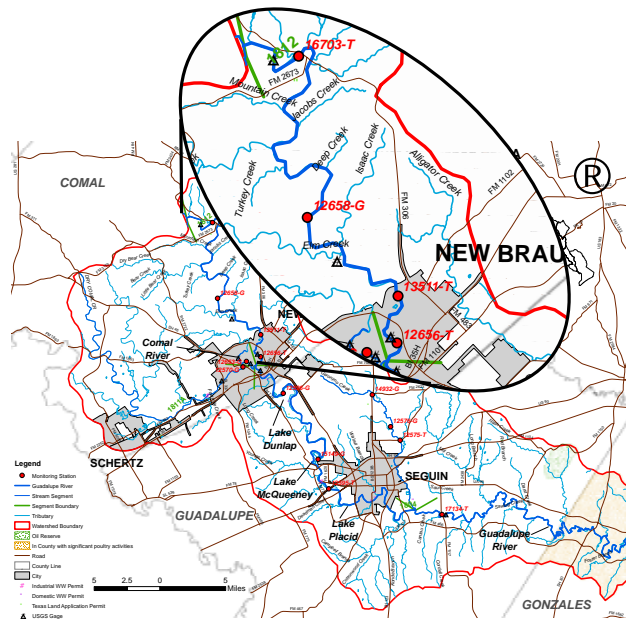
Sampling sites are labeled in red followed by the letter G (GBRA), T (TCEQ), U (UGRA) or W (Wimberley) indicating who is the monitoring entity.

**Middle Guadalupe Watershed (Part B)**

**Drainage Area:** 939 square miles  
**Streams and Rivers:** Guadalupe River below Canyon Dam, Guadalupe River from confluence with the San Marcos River  
**Lakes:** Lake H-4, Lake Wood  
**Aquifers:** Carrizo Wilcox  
**River Segments:** 1803, 1804  
**Cities:** Gonzales  
**Counties:** Guadalupe, Gonzales, Lavaca, DeWitt

**EcoRegions:** Texas Blackland Prairies, Post Oak Savannah  
**Vegetation Cover:**  
 Pasture/Hay - 25.5%      Grass/Herbaceous - 15.1%  
 Evergreen Forest - 18.0%      Shrublands - 12.0%  
 Deciduous Forest - 15.5%      Row Crops - 8.1%  
**Climate:**  
 Average annual rainfall: 29 inches  
 Average annual temperature: January 35° July 95°  
**Land Uses:** Urban, Light Manufacturing, Heavy Manufacturing, Farming, Cattle Ranching, Poultry, Petroleum Production, Gravel Mining

**Water Body Uses:** Aquatic Life, Contact Recreation, Fish Consumption, General, Public Water Supply, Hydroelectricity, Agricultural, Industrial  
**Soils:** Dark, calcareous clay, sandy loam, loam with clay subsoils; dark red sandstone, light tan and gray sandstone  
**Permitted Wastewater Treatment Facilities:**  
 Domestic: 1    Land Application: 4    Industrial: 1



Segment 1812, the **Guadalupe River below Canyon Dam**, extends from the confluence of the Guadalupe and Comal Rivers upstream to the bottom release of Canyon Reservoir. The segment is separated into three assessment units: the lower 4 miles; the upper 9 miles; and, the mid-portion between SH 46 and the confluence with Bear Creek. The entire segment lies within Comal County. GBRA has been monitoring the Guadalupe River at the second crossing (12658) monthly since 1987. The GBRA site is located in the uppermost assessment unit. TCEQ has other historical sites within the segment, one located near the small community of Gruene in the lower portion of the segment, one located in the upper portion near CR 306, one near Horseshoe Falls and one in the city of New Braunfels at Cypress Bend Park. Also, the US Geologic Survey collected water quality data in this segment in the 1990s. The water quality study conducted by New Braunfels Utilities in 2006-07 has monitoring sites within this segment. The study had not been released for public review at the time of this publication.

#### *Land Uses, Discharges and Conditions that Impact Water Quality*

There is one wastewater discharge to the segment, operated by New Braunfels Utilities, located at Gruene. For the majority of the period of historical data, the 1.0 million gallon per day wastewater treatment plant was not discharging to the stream, beneficially reusing the treated effluent on a small golf course. In 2006, the golf course closed and the plant began discharging back to the stream.

The land use in the watershed is mostly private homes and campgrounds, with flows and stream conditions conducive for recreation and very little agricultural use due to the rocky and fractured terrain. The stream segment is heavily influenced by the cold water, bottom releases from Canyon Reservoir. The portion of the stream segment immediately downstream of the release is used for a put-and-take trout

fishery maintained by Trout Unlimited and the Texas Parks and Wildlife Department. It is important to understand how the operation of the Canyon Reservoir impacts the instream flow of the river downstream. Construction on Canyon Dam began in 1958 and began to impound water in 1964. It is a cooperative project jointly managed by GBRA and the U. S. Army Corp of Engineers (COE). The dual-purpose project provides for the storage of water for water supply and for flood protection. The reservoir operates as two parts. The lower portion from elevation 800 to 908 mean sea level (msl) is operated by GBRA for conservation storage. GBRA was granted the original water right for 50,000 acre-feet of water per year to be made available for customers through water purchase contracts. GBRA releases water from the conservation pool as it is called for by downstream customers.

The upper portion of Canyon Reservoir is referred to as the “flood pool” and is controlled by the COE. This part of the reservoir captures floodwaters that are usually released at rates sufficient to empty the flood pool without contributing to downstream flooding. Rates of releases from the flood pool are approximately 5600 cfs. From elevation 911 to elevation 909 msl, the COE releases range up to 1,500 cfs.

Releases out of Canyon Reservoir are governed by several regulatory or contractual requirements. First, the Federal Regulatory Energy Commission stipulated as part of their license agreement with GBRA for hydropower generation at Canyon Dam that GBRA release a minimum of 120 cfs during the months of February through May and 100 cfs other months of the year, except under drought conditions. Second, TCEQ, as part of the Canyon Amendment process added a flow regime that is protective of the instream flow requirements downstream. Third, GBRA has signed an agreement with Trout Unlimited for higher releases during the period of the year (May through September) that is most critical in maintaining a desired thermal regime for stocked rainbow trout downstream of the reservoir. In May, the Trout Unlimited agreement provides for minimum flows that range from 140 to 170 cfs, and in June, the flows range from 210 to 240 cfs. For the months of July, August and September the minimum flow is 200 cfs. Lastly, the base flow of the Guadalupe River coming into the reservoir which would be the amount released from the reservoir under normal flow conditions can be augmented with additional water that is stored under a temporary agreement with the COE and used to enhance flow conditions downstream for recreation use, such as tubing and rafting. The temporary agreement is renewed each year and, most likely, not available in years of drought. Efforts are underway to make this COE agreement permanent.

#### *Water Quality*

The 2008 draft Texas Water Quality Inventory has no impairments or concerns listed for Segment 1812. Looking at the three monitoring locations in the segment with the most consistent data sets, the GBRA station at second crossing (“second crossing site”-12658), the TCEQ site at Gruene (“mid-segment site”-13511), and the TCEQ site at Cypress Bend Park in New Braunfels (“downstream site”-12656), the water quality in the segment is very good. The median concentration for dissolved oxygen at the upstream site was 10 milligrams per liter (mg/L), ranging from a minimum of 6.86 mg/L to a maximum of 13.8 mg/L; at the mid-segment

site the median concentration was 9.4 mg/L, ranging from 7.1 to 11.6 mg/L; at the downstream site the median concentration was 9.0 mg/L, ranging from 6.3 to 14 mg/L. At no time in the period of record did the dissolved oxygen drop below the standard for the minimum dissolved oxygen concentration (4.0 mg/L). The temperature varied between 8.52°C to 30.1°C, with a median temperature of 18.2°C at the second crossing site; varied between 10.7°C to 30.1°C with a median temperature of 18.5°C at the mid-segment site; and, varied between 10.6°C and 29.6°C, with a median temperature of 21.0°C at the downstream site. The **specific** conductance at the second crossing site ranged between 263 and 569 micromhos per centimeter (umhos/cm), with a median conductivity of 425 umhos/cm; ranged from 346 to 503 umhos/cm, with a median 441 umhos/cm at the mid-segment site; and, ranged from 187 to 479 umhos/cm with a median conductivity of 409 umhos/cm at the downstream site. The median pH of the second crossing site was 8.11, ranging from 7.0 to 8.6 standard pH units; at the mid-segment site the median pH was 7.8, ranging from 7.2 to 8.4; and, at the downstream site, the median pH was 8.0, ranging from 6 to 9.7, falling outside the lower stream standard range of 6.5 one time and falling outside the upper standard of 9.0 one time. The median concentrations for chloride and sulfate were 14.2 and 20.2 mg/L respectively. At no time did the concentration of these dissolved constituents exceed the stream standard of 50 mg/L.

Nitrate nitrogen, ammonia nitrogen and total phosphorus, were analyzed at the GBRA monitoring location at the second crossing. Over the period of record, nitrate nitrogen was reported under three storet codes, as nitrate nitrogen and in combination with nitrite nitrogen. The median concentrations at the second crossing for all three cited storet codes were 0.21, 0.20, and 0.26 mg/L, ranging from 0.03 to 1.78 mg/L. At no time did the nitrate nitrogen concentration, regardless of storet citing, exceed the screening criteria of 1.95 mg/L. The median concentration for nitrate nitrogen at the mid-segment and downstream sites were 0.4 and 0.36 mg/L respectively, about 2 times higher than the median concentration at the second crossing site, but the range was much tighter, from 0.15 to 0.42 mg/L. The median flow at TCEQ's mid-segment site was 356 cubic feet per second as compared to the median flow of 254 cfs at the second crossing site, the difference most likely due to contributions of flow from small creeks and springs between the sites. The groundwater coming from the springs is influenced by the nitrate nitrogen that is naturally occurring in the geology of the area. The median ammonia nitrogen concentration was 0.21 mg/L, ranging from 0.03 to 0.54 mg/L. Only one time did the concentration of ammonia nitrogen exceed the screening concentration of 0.33 mg/L. The measurement was taken in the winter and during a low flow period (105 cfs) but low flow is not necessarily an explanation for the high concentration because at other times low flows did not result in elevated ammonia concentrations. The median total phosphorus concentration at the second crossing site was below the limit of quantification for the method and when total phosphorus was detected in a sample it did not exceed the screening concentration of 0.69 mg/L. Total phosphorus and ammonia nitrogen concentrations had median concentrations below detection at the TCEQ sites and no measurement at either site exceeded the screening concentrations for either constituent.

Segment 1812 is known for its recreational opportunities. Flows create conditions that range from a slow meandering stream to swift rapids, providing excellent conditions for tubing and rafting. The stream standard for contact recreation is a geometric mean of 126 organisms per 100 milliliters, and the single sample concentration of 394 organisms per 100 milliliters. The geometric mean for *E. coli* bacteria at the second crossing site was 34 organisms per 100 milliliters. In the period of record only one sample was collected at the GBRA site that exceeded the single sample *E. coli* standard of 394 organisms per 100 milliliters. Figure 1 shows the historical *E. coli* concentrations, along with flow. Something interesting to note is that where high flow events explain some spikes in *E. coli* concentrations, there are times where the spikes in bacterial numbers are during low flow periods (summer months in 1999 and 2006). Sources of *E. coli*, such as septic tanks, portable johns and recreationists carrying in and contributing bacteria to the stream, have greater impacts during low flows when there is less dilution and more disruption of stream and bank sediments.

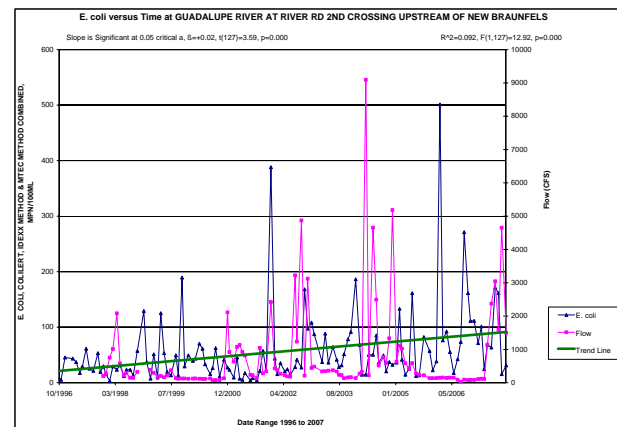


Figure 1. Guadalupe River at 2nd crossing (12658) - *E. coli* verses time all methods.

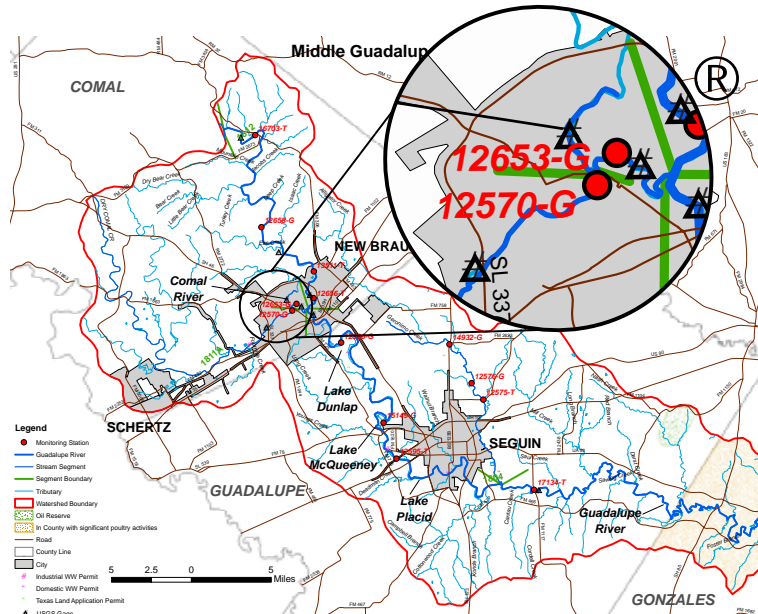
The substrate at the GBRA monitoring location downstream of Canyon Dam is rocky and the limestone hills that surround the stream segment contribute very little suspended solids during localized rain events. The water is clear and shallow in the majority of locations along the segment, with very few pools. The second crossing sampling site is one of the deepest locations in the segment. The suspended solids ranged from 1 to 87.7 mg/L, with a median of 5.1 mg/L. The TCEQ sites had median concentrations of 5.5 and 5.0 mg/L suspended solids at the mid-segment and downstream sites respectively. The median chlorophyll a concentrations at all three sites was less than detection and there was never a measured value above the screening concentration of 14.1 microgram per liter.

The historical data from the three monitoring sites was reviewed for trends, comparing constituents over time and flow regimes. Statistically significant trends that were noted, either positive or negative, were not indicative of degrading water quality conditions.

### Stakeholder Concerns

Stakeholders have voiced concerns for the impacts from recreational use, such as trash, improper or lack of wastewater treatment and the sheer number of persons in the water, have on the water quality, but these concerns are not supported by routinely high bacteria numbers or poor water quality in this segment.





Segment 1811, the Comal River, extends from the confluence of the Guadalupe River to its headwaters springs coming from the Edwards Aquifer, located in and near Landa Lake. The entire segment lies within the city of New Braunfels. GBRA maintains a monitoring location in the Comal River at Hinman Island (12653) and has been monitoring at this site monthly since late 1994. A major tributary to the Comal River is the Dry Comal Creek. GBRA has maintained a monitoring site located on the Dry Comal very near its confluence with the Comal River in New Braunfels since 1996. TCEQ and the US Geological Survey have monitored the Comal River as well but GBRA assumed consistent monitoring of the Comal River when it joined the Clean Rivers Program in 1996.

### Stakeholder Concerns

The Comal River is the shortest river in the State of Texas. It is home to the fountain darter, a federally-listed endangered species. The river is spring-fed, making it a consistent temperature and clarity. Landa Park and its spring-fed pool are located at the headwaters. Landa Lake, located in the park, is the home of ducks, native fish and a healthy stand of rooted, aquatic plants. A concern of stakeholders is the introduction of non-native species such as hygrophylla (aquatic plant), ram's horn snail, and loricarids (aquarium algae eaters) that without natural predators can out-compete the native species and upset the ecological balance in the river. A source of the non-native species is improper disposal of aquarium populations by local residents.

The Comal River is heavily recreated, especially in times when the flow from Canyon Reservoir is reduced due to drought, making the flow in the Guadalupe River too low for tubing and rafting. With increased recreation pressure, comes increased stress and pollution loading (trash) on the Comal River.

### Land Use

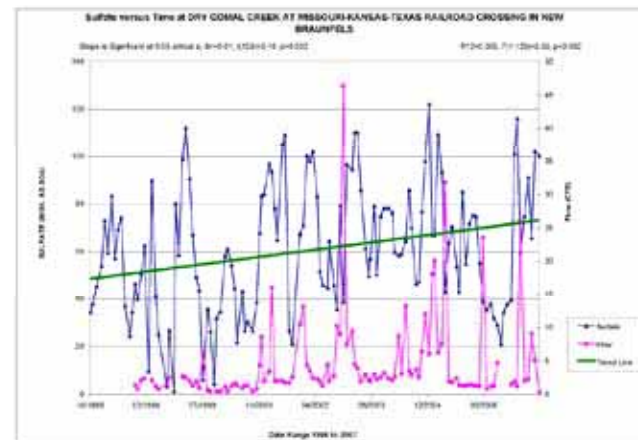
The land use in the watershed of the river proper is entirely urban. Residential property with manicured lawns and impervious cover associated with urban land uses, including roads, roof tops and parking lots can be sources of pollutant loading to the river. Pollutants that might be captured and bio-degraded by soils are instead readily washed over the cement and pavement and directly into the surface water.

The Dry Comal Creek is a small creek with a mean instantaneous flow of 4 cubic feet per second that flows through a large watershed that is currently more rural than urban. As in other areas in the Austin-San Antonio IH 35 corridor, there are new subdivisions being planned in the watershed that will, over time, reverse the dominance of land use from rural to urban. There are sand and gravel operations in the watershed. There are no wastewater or industrial plants that discharge to either the Comal River or Dry Comal Creek.

### Water Quality

The 2008 draft Texas Water Quality Inventory does not list the Comal River or the Dry Comal Creek with any impairments or concerns. Looking at the available historical data on the Comal River (site no. 12653), the temperature varied between 14°C to 28°C, with a median temperature of 23.6°C. The **specific** conductance ranged between 359 and 684 micromhos per centimeter, with a median conductivity of 557 micromhos per centimeter. The median pH of the site was 7.66, ranging from 6.93 to 8.28. The median concentrations for chloride and sulfate in the Comal River were 17 and 24.1 milligrams per liter (mg/L) respectively. All data points for chloride were lower than the stream standard of 50 mg/L except for one point (92.2. mg/L) that appears to be a one-time occurrence. Only three data points for sulfate concentration fell outside of the stream standard of 50 mg/L.

However, in the historical data set for the Dry Comal Creek (site no. 12570), there have been exceedences of the stream standard for sulfate. The Dry Comal Creek is not a classified stream segment so it is assessed using the stream



standards of the Comal River. More than half of the samples analyzed for sulfate exceeded the stream standard of 50 mg/L. Figure 1 shows an upward trend in the sulfate concentration over time. Removing the data

Figure 1. The Dry Comal (12570) is exhibiting a slight upward trend in the monthly concentration of sulfate. The stream standard is 50 mg/L.



associated with high flows, we still see the same upward trend, suggesting that the sulfate is associated with base flows and not rainfall runoff. The source of base flow at the Dry Comal monitoring station are springs located mainly in the city, with no contributions from point source discharges. The majority of the upper watershed is dry a high percentage of the time.

Nitrate nitrogen, ammonia nitrogen and total phosphorus were analyzed at the monitoring locations on both water bodies. Over the period of record, nitrate nitrogen was reported under three storet codes, as nitrate nitrogen and in combination with nitrite nitrogen. The source of the Comal River is the Edwards Aquifer which has historically exhibited elevated nitrate nitrogen. The median concentration for the locations on the Comal River ranged from 0.02 mg/L to 2.7 mg/L. Looking at the historical data set for the Comal, the nitrate nitrogen concentration exceeded the screening criteria of 1.95 milligrams per liter 20 times out of 215 analyses (9.3%). Figure 2 shows the consistent input of nitrogen from the springs coming from the Edwards Aquifer. The exception was during the period of high flows that contributed flow to the stream as well as recharge to the Edwards Aquifer possibly diluting the naturally-occurring nitrate nitrogen in the base flow.

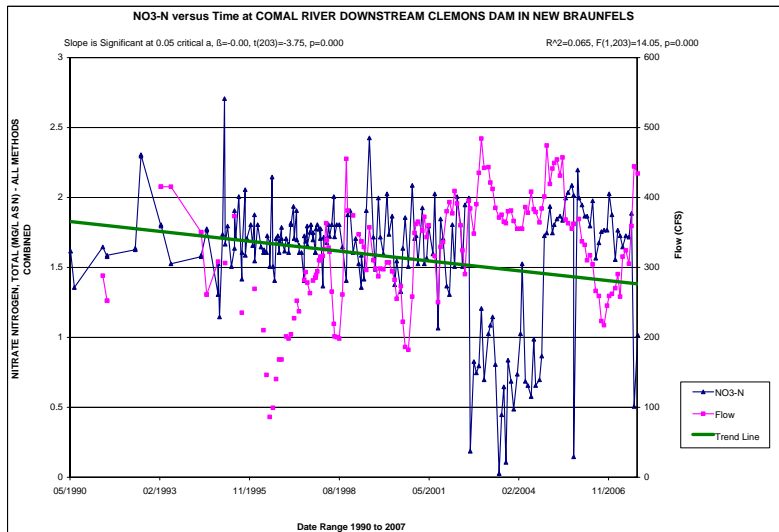


Figure 2. The Hinman Island site (12653) is exhibiting a consistent input of nitrate nitrogen from base flow.

The source of the Dry Comal Creek is primarily ground water and rainfall runoff off of pasture and farmland. The median concentration for nitrate nitrogen in the Dry Comal Creek is lower than the Comal River, ranging from 0.22 mg/L to 0.85 mg/L, and during the period of record, did not exceed the screening concentration. The median ammonia nitrogen concentration for the Comal River was 0.03 mg/L and 0.045 mg/L for the Dry Comal Creek. The median total phosphorus concentration for the Comal River was below the limit of quantification for the method and slightly higher than the limit of quantification in the Dry Comal Creek. When total phosphorus was detected in a sample from either water body it did not exceed the screening concentration of 0.69 milligrams per liter.

Looking at the concentration of nitrate nitrogen over time in the Dry Comal Creek, we see a slight downward trend (Figure 3). In other words, we see a slight decrease in the concentration for the nutrient. Over the same time period, we see an increase in chlorophyll a concentration in the Dry Comal Creek (Figure 4) which could explain the decrease in nitrate concentration as the nutrients are taken up by algae and macrophytes. The median chlorophyll a

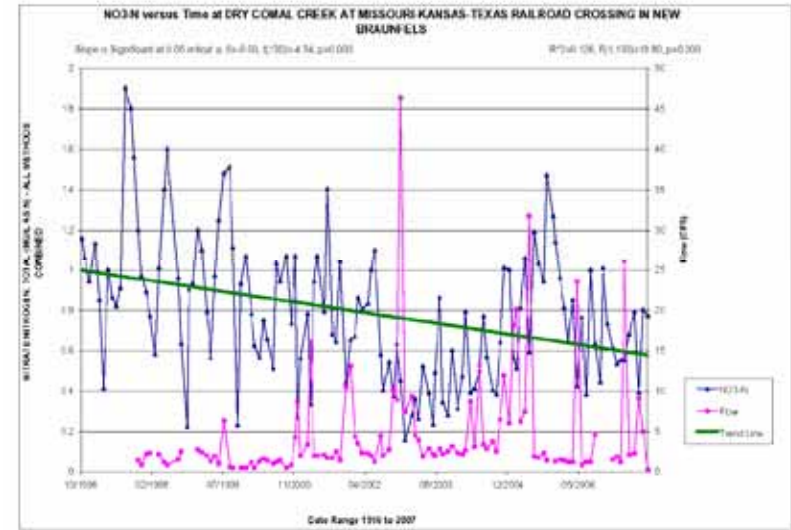


Figure 3. The Dry Comal Creek (12570) is exhibiting a downward trend in nitrate nitrogen.

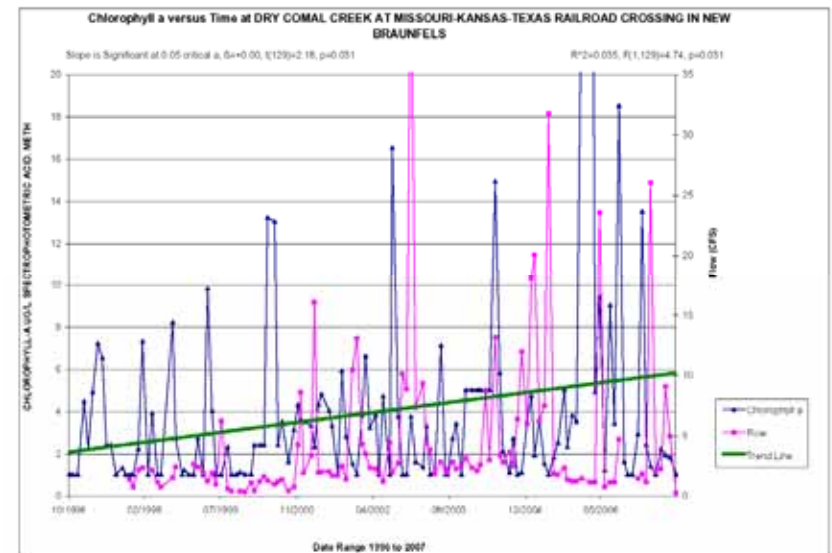


Figure 4. The Dry Comal Creek (12570) is exhibiting an upward trend in Chlorophyll a concentration.

concentration on the Comal River is less than detection and there was never a measured value above the screening concentration of 14.1 microgram per liter. Whereas, the median concentration for chlorophyll a on the Dry Comal Creek is 2.4 micrograms per liter and exceeded the screening concentration five times over the period of record.

An explanation for the upward trend in the concentration of chlorophyll a in the Dry Comal Creek may be the predominant low flow conditions that have defined the creek since 2005. Low flow conditions give the stream more time to assimilate the nutrients, resulting in an increase in algal and macrophyte growth. 2005 and 2006 had prolonged dry periods. Regardless of meteorological conditions, reduction in recharge due to impervious cover in the Dry Comal Creek watershed will continue to result in a corresponding reduction in base flow with more frequent and prolonged low flow conditions, making low base flow the norm rather than the exception.

The Comal River is a slow, meandering stream with a silt substrate that supports large stands of rooted aquatic macrophytes. The stream standard for contact recreation for *E. coli* is a geometric mean of 126 organisms per 100 milliliters, and the single sample concentration of 394 organisms per 100 milliliters. The geometric mean for *E. coli* at the Comal River at Hinman Island site is 52 organisms per 100 milliliters, well below the stream standard. In the period of record seven of the 132 measurements exceeded the single sample *E. coli* standard of 394 organisms per 100 milliliters. There is a slight upward trend in the *E. coli* concentration seen in the data, but it is only statistically significant when both the IDEXX and MTEC laboratory data sets are combined. Often, *E. coli* concentrations increase with rises in flow due to storm water runoff as shown in Figure 5.

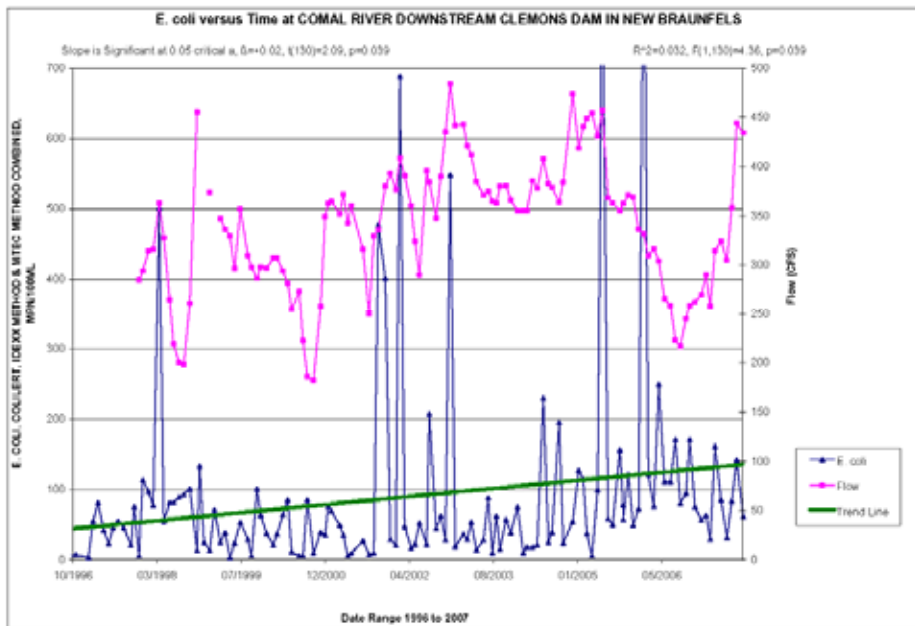


Figure 5. The Hinman Island site (12653) is exhibiting an upward trend in *E. coli* concentration.

The Dry Comal Creek exhibits typical concentrations of *E. coli* bacteria for a stream that receives the majority of its flow from a rural watershed with agricultural bacterial loading. The geometric mean for *E. coli* is 153 organisms per 100 milliliters in the data set that begins in 2002, exceeding the stream standard of 126 organisms per 100 milliliters. 21 out of 134 sampling events (15.7%) exceeded the single sample grab standard of 394 organisms per 100 milliliters for *E. coli* (Figure 6).

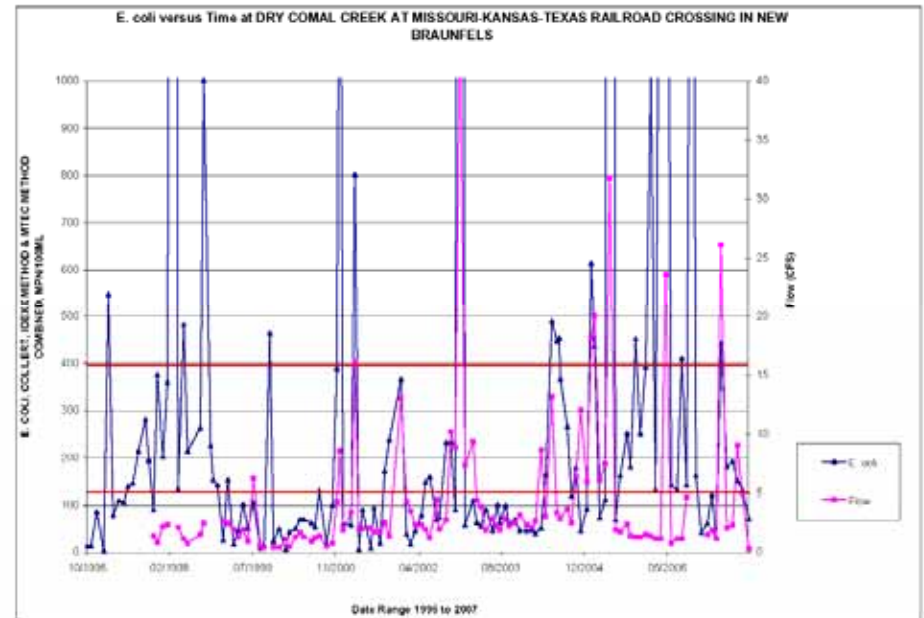
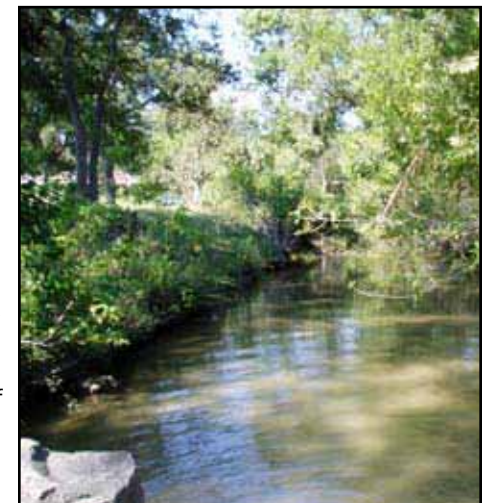


Figure 6. The Dry Comal Creek (12570) exceeded the stream standard for *E. coli* on several occasions (The red lines indicate the stream standards for geometric mean of 126 MPN and grab sample concentration of 394 MPN).

The suspended solids in the Comal River ranged from 1 to 18.3 milligrams per liter, with a median of 1.9 milligrams per liter, and ranged from 1.7 to 78.8 mg/L, with a median of 6 mg/L for the Dry Comal Creek. Non-point pollution in the form of rainfall runoff carries in suspended solids and associated bacteria and oxygen-depleting organic material. Pairing figure 6 with figures 7 and 8 it is evident that the storm events in the Dry Comal Creek watershed carry in high levels of bacteria and suspended material. Possibly due the smaller size of the watershed, the correlation between flow and suspended material is not significant in the Comal River watershed.





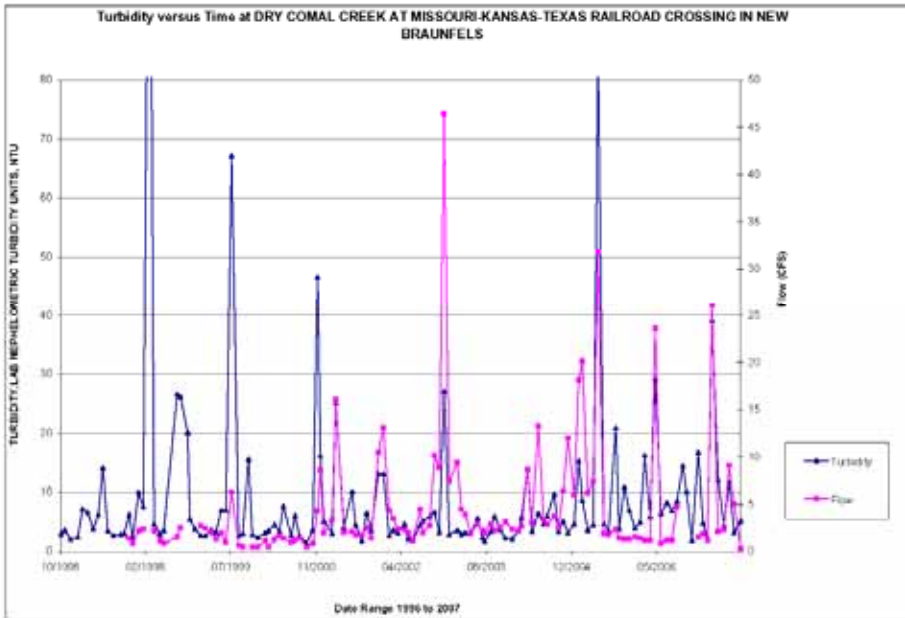


Figure 7. Turbidity versus time at Dry Comal Creek (12570).



Dry Comal Creek at Seguin Street in New Braunfels (site no. 12570).

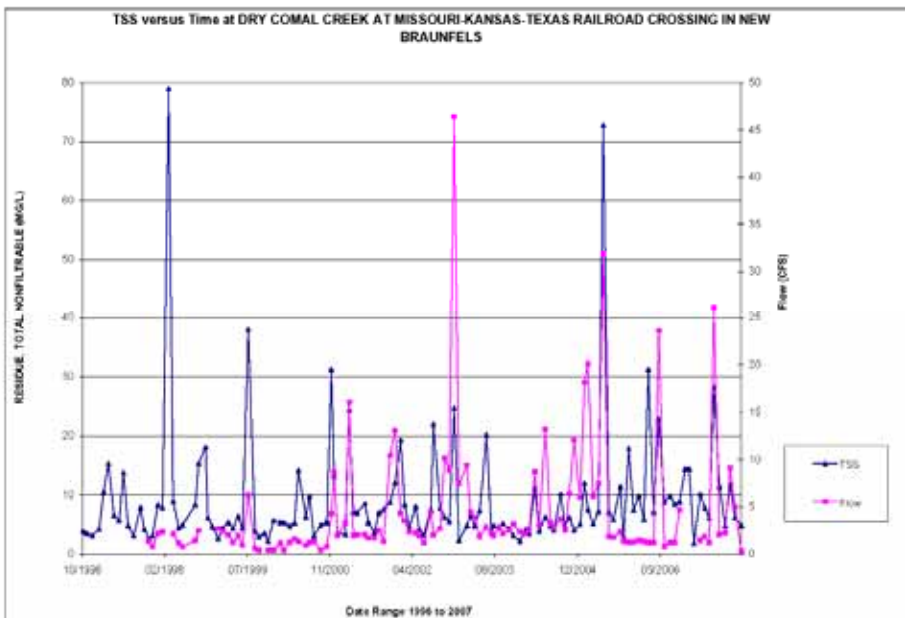


Figure 8. Total suspended solids versus time at Dry Comal Creek (12570).



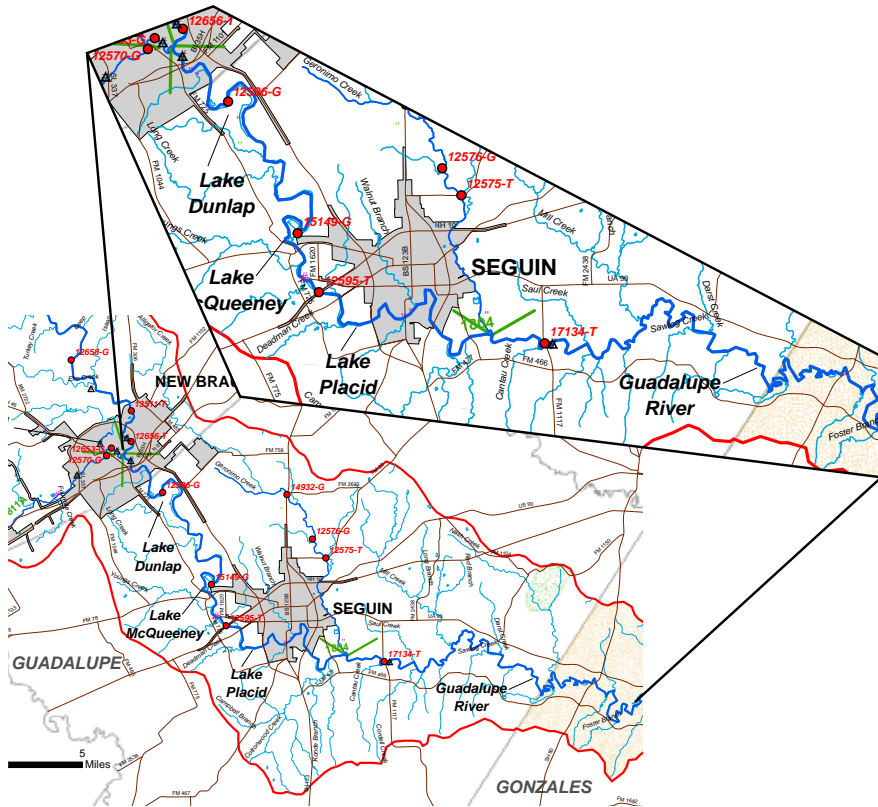
Dry Comal Creek at Seguin Street in New Braunfels 100 meters upstream (site no. 12570).

Guadalupe River from a special study by GBRA during 2004 and 2005 to address nutrient concerns on the power plant lakes. Espy Consultants has also submitted data to TCEQ from a study funded by New Braunfels Utilities in this segment, but the study and its findings has not yet been released. The 2008 Texas Water Quality Inventory Report has no impairments or concerns listed for Segment 1804.

The upper portion of segment 1804 is heavily influenced by the Comal River tributary. The Comal River maintains a fairly consistent annual stream flow from its springs, which often makes up a majority of the water entering the segment, especially during times of dry weather or drought. The upper portion of the segment often exhibits many of the water quality properties of the Comal River. As the water moves downstream it is impounded by a series of six dams, which are operated by the GBRA to generate hydroelectric power. The river must initially pass through the Dunlap Dam, which impounds Lake Dunlap; followed by the McQueeney Dam, which impounds Lake McQueeney; TP4 Dam, which impounds Lake Placid; Nolte Dam, which impounds Meadow Lake; H-4 Dam, which impounds Lake Gonzales; and the H-5 Dam, which impounds Lake Wood. The water impounded in these series of hydroelectric lakes does not take on many of the properties of a reservoir and maintains the attributes of a flowing stream segment, due to the shallow depths and lower retention time of the water in these structures. The river must support approximately 528 cubic feet per second (cfs) discharge at the Lake Dunlap power plant in order for the power plants to generate power. When a discharge of this level cannot be supported, the water is allowed to pass directly through the turbines of the plant without the generation of power. The flow from the Guadalupe is diverted through a water canal above the Dunlap Dam to the hydroelectric turbines. It is from this canal that a pipeline takes raw water to the city of San Marcos Water Treatment Plant. Two additional tributaries contribute to the base flow near the city of Seguin, the Walnut Branch and the Geronimo Creek. The Geronimo Creek tributary of segment 1804 is heavily spring flow dominated and is discussed in a separate section of this report.

Each hydroelectric impoundment has its own unique structure and associated water quality characteristics. Historical data has shown that four out of five years these run-of-river impoundments function as rivers with short residence times. In those years with low flows in the Guadalupe River, longer water residence times in the impoundment will create more “reservoir-like” conditions. The impoundments will weakly stratify in the deep portions. Additionally, the longer residence times allow for nutrient uptake by algae and aquatic plants, promoting blooms and nuisance aquatic infestations.

These impoundments are subject to localized flooding and extended periods of high releases from Canyon Reservoir needed to evacuate the flood pool. Runoff carries in sediment and the prolonged high flows keep sediment suspended. An example of the effect of flow on suspended sediments can be seen in figure 1. The total suspended solids measured at the GBRA sampling location in Lake Dunlap increase with high flows and there are times when the flows are sufficient enough to keep the solids in suspension. In addition to adding organic oxygen-demanding material, suspended solids create turbid conditions that shade out the sunlight and can have the potential bringing in and maintaining elevated bacteria concentrations.



Segment 1804, the **Guadalupe River below the Comal River**, extends from the confluence of the Guadalupe and Comal Rivers, in New Braunfels, 103 miles downstream to the confluence with the San Marcos River. The segment is separated into four assessment units. Assessment unit 1804\_01 consists of the lower 25 miles of the segment from the confluence with the San Marcos River to approximately 8 miles downstream of the FM1117 crossing in Gonzales County. Assessment unit 1804\_02 consists of the area approximately 8 miles upstream of the FM1117 crossing to 58 miles upstream at Lake McQueeney Dam. Assessment unit 1804\_03 consists of the 7 mile portion of the river upstream of Lake McQueeney Dam. Assessment unit 1804\_04 consists of the upper 13 miles of the segment from 7 miles upstream of Lake McQueeney Dam to the confluence with the Comal River in Comal County. The segment is found in three Texas counties: Comal County, Guadalupe County and Gonzales County. GBRA has routinely monitored the Guadalupe River at AC's Place, on the north bank of Lake Dunlap (site no.12596), monthly since 1990. GBRA has routinely monitored the Guadalupe River at Hot Shot's on the Southeast bank of Lake McQueeney (site no. 15149), monthly since 1997. GBRA has routinely monitored the Guadalupe River, below H-5 Dam, before the San Marcos River confluence (site no.15110), monthly since 1996. TCEQ has monitored the Guadalupe River at IH10 (site no. 12595) on a quarterly basis since 1998. TCEQ has also monitored the Guadalupe River at FM 1117 (site no. 17134) on a quarterly basis since 1999. There is additional data on this segment of the



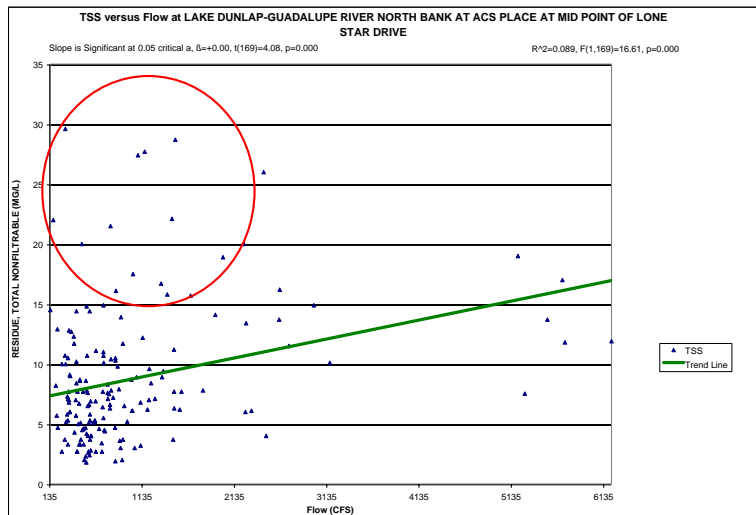


Figure 1. Relationship of flow and suspended solids at the GBRA Lake Dunlap site (12596). Runoff during storm events bring in sediments with the high flows. Prolonged high flows from reservoir releases upstream keep those sediments suspended in the water column (red circle).

## Lake Dunlap

The most upstream run-of-river impoundment, Lake Dunlap begins at the city of New Braunfels and its banks are almost completely lined with residences. The impoundment is narrow and shallow. It has a plunge point midway down the reservoir. Here, in years of low flow, inflow that is cooler because of the temperature of the springs and bottom release of the upstream reservoir, will dip down and flow along the bottom of the impoundment, creating a warm strata of water along the surface. It is at this plunge point that the impoundment will begin to weakly stratify. In years of normal to high river flows, inflows are sufficient enough to keep the water mixed and prevent this stratification from occurring. Figure 2 shows how the temperature of the surface water is impacted by the inflows.

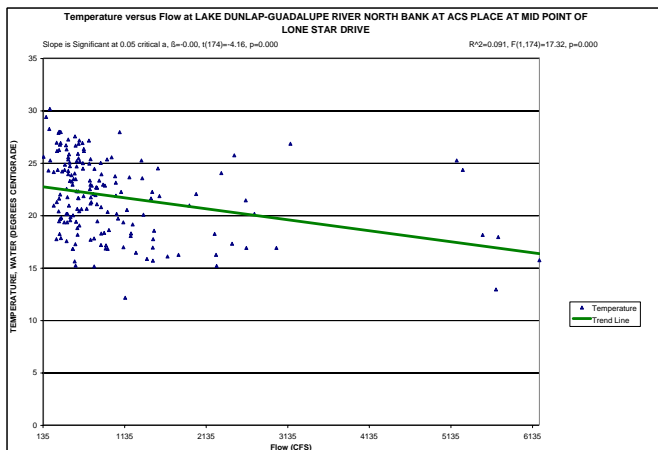


Figure 2. Relationship of temperature and flow at the GBRA monitoring location on Lake Dunlap (12596).

Reviewing the data over the last 10 years at the GBRA station on Lake Dunlap, the dissolved oxygen concentrations ranged from 6.43 to 18.3 milligrams per liter (mg/L), with a median concentration of 9.1 mg/L and not falling below the dissolved oxygen requirement of 5.0 mg/L. The temperature at the surface ranged from 11°C to 30.9°C, with a median temperature of 22°C. The pH never fell outside of the standard range of 6.5 to 9.0 units. The **specific conductance** is showing a very slight rise over time, with a median concentration of 521 micromhos per centimeter (umhos/cm), ranging from 233 umhos/cm to 705 umhos/cm. Lower conductivities occur with elevated flows due to localized rainfall.

The total suspended solids ranged from 1.8 to 201 mg/L, with a median concentration of 7.5 mg/L. Hardness is impacted by the hard water coming from the Comal River and its springs from the Edwards Aquifer. It ranged from 152 mg/L to 353 mg/L, with a median concentration of 248 mg/L. Chloride and sulfate concentrations did not exceed the stream standard of 50 mg/L through historical period of data, ranging from 6 to 41 mg/L chloride (median = 18 mg/L) and 2 to 33 mg/L sulfate (median = 24.4 mg/L).

Nitrate nitrogen, ammonia nitrogen and total phosphorus was measured at the GBRA location on Lake Dunlap. The nitrate concentration was reported alone and in combination with nitrite nitrogen. The Edwards Aquifer contributed to the nitrate concentrations in the Comal River. The median concentration for nitrate nitrogen was 1.0 mg/L, ranging from 0.08 to 3.0 mg/L, exceeding the screening concentration of 1.95 mg/L five out of 260 monitoring events. The ammonia nitrogen concentrations ranged from less than method detection to 0.35 mg/L, exceeding the screening concentration only one time. The median concentration for total phosphorus was 0.08 mg/L, ranging from less than method detection to 0.4 mg/L and never exceeded the screening concentration of 0.69 mg/L. There was limited data available for orthophosphate but the concentrations in the data set never exceeded the screening concentration of 0.37 mg/L.

Chlorophyll a concentrations exceeded the screening criteria of 14.1 micrograms per liter (ug/L) three times. These exceedences occurred when the flow in the impoundment was extremely low. The bacteria concentrations, as fecal coliform or as *E. coli*, exceeded the associated stream standard for contact recreation 33 times (11.8%) over the historical period of record of sixteen years.

## Lake McQueeney

Lake McQueeney has the largest open water area of all of the hydroelectric impoundments. Its banks, like Lake Dunlap, are lined with residences with large yards. Along this open area is the area referred to as Treasure Island, a residential subdivision with greater than 80 high-end homes. Because of the high water table on the island, the effectiveness of the septic tanks that serve the residences here is highly suspect. Failing septic tanks or septic tanks that drain to the lake rather than a drain field can be sources of bacteria and nutrients. GBRA's sampling location is directly across the open area of the impoundment from Treasure Island. The location has seen spikes in chlorophyll a associated with low flow conditions. Figure 3 shows the negative correlation of chlorophyll a and flow. Low flow

conditions create longer residence times, allowing for uptake of nutrients and blooms to occur. Sources of the nutrients for the algae are both point and non-point sources, such as the upstream wastewater discharges, septic tanks that have direct connection with the surface water and excess fertilizers used by residences along the banks and carried in by runoff. Historically, Lake McQueeney's chlorophyll a concentrations show a slight downward trend. The median concentration for chlorophyll a over the period of record was 3.4 ug/L.

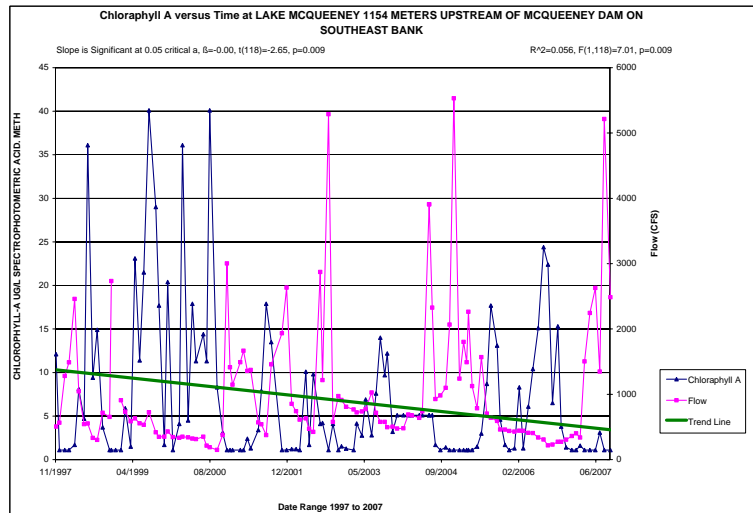


Figure 3. Inverse relationship of chlorophyll a concentration and flow at the GBRA monitoring site on Lake McQueeney (15149).

Reviewing the other historical data on Lake McQueeney at the GBRA monitoring location, the temperature ranged from 12.1°C to 32.4°C, with a median temperature of 23°C. The pH ranged from 7.1 to 8.38 pH units, not falling outside the standard range of 6.5 to 9.0. The conductivity ranged from 293 to 600 umhos/cm, with a median conductivity of 516 umhos/cm. The median dissolved oxygen concentration was 9.23 mg/L, ranging from 5.8 to 13.78 mg/L, not falling below the stream standard of 5.0 mg/L.

Nitrate nitrogen, ammonia nitrogen and total phosphorus were measured at the GBRA location. Nitrate nitrogen ranged from 0.13 to 1.6 mg/L, with a median concentration of 0.78 mg/L. The ammonia nitrogen concentrations ranged from less than method detection to 0.21 mg/L, with a median concentration of 0.04 mg/L. The total phosphorus concentrations ranged from less than method detection to 0.98 mg/L, exceeding the screening concentration of 0.69 mg/L two times. Referring to figure 4, there appears to be a slight correlation between spikes in total phosphorus and spikes in flow, but there are times when the total phosphorus spikes are associated with low flows. Because the phosphorus is measured as total phosphorus, the concentration of the nutrient could be in the organic form, such as in algal cells. A review of the chlorophyll a concentrations during those periods shows a period of higher than normal concentrations. The historical data shows a slight downward trend in total phosphorus concentrations over time.

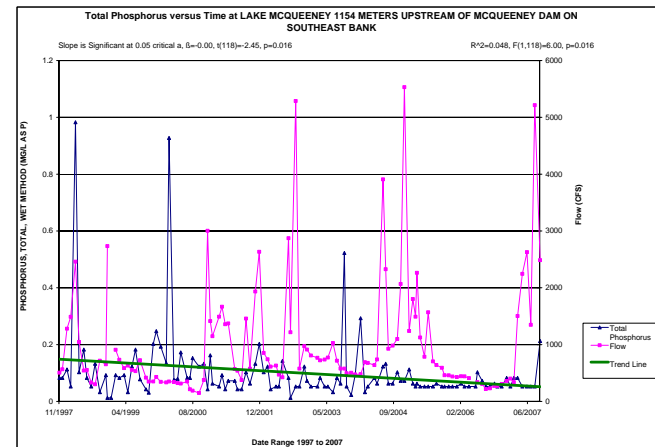


Figure 4. Total phosphorus is correlated with flow at Lake McQueeney (15149) monitoring and showing a slight downward trend over time.

Median chloride and sulfate concentrations were 17.6 and 24.5 mg/L, never exceeding the stream standard concentration of 50 mg/L. The total suspended solids ranged from 1.7 to 43.7 mg/L, with a median concentration of 9.2 mg/L. The median hardness concentration was 245 mg/L.

The bacteria concentrations, either as fecal coliform or *E. coli*, exceeded the associated stream standard for contact recreation only four times over the period of record. The number of exceedences was considerably less than the GBRA Lake Dunlap location. This is most likely due, more to the location of the GBRA site in Lake McQueeney being in an open water area with available sunlight and ultraviolet disinfection than to a source of contamination of fecal bacteria in Lake Dunlap.

#### Lake Placid and Meadow Lake

Lake Placid and **Meadow Lake** are shallow and narrow. Both these impoundments and the riverine portion that connects the two, referred to as Lake Seguin, are susceptible to impacts by urbanization. They received non-point source pollution from runoff from homes and streets. As seen in other urbanized areas, impervious cover created by streets, parking lots and roof tops, allow the pollutants that might be captured and bio-degraded by soils, to instead readily wash over cement and pavement, directly into the surface water bodies.

The TCEQ maintains a monitoring location on Lake Placid at IH 10, downstream of the Commercial Metals steel mill. The list of parameters includes field, nutrient, and inorganics. The temperature, pH, dissolved oxygen and conductivity median concentrations and ranges were comparable to the monitoring locations that GBRA maintains in Lakes Dunlap and McQueeney. The similarity applies to the ammonia nitrogen, nitrate nitrogen, total phosphorus, chloride and sulfate between these impoundments. At this location there were no sampling events that exceeded the screening concentrations or stream standards for these parameters. The median concentration for total suspended solids was higher at the TCEQ site as compared to the upper impoundments but the range was similar to Lake McQueeney. The median chlorophyll a concentration was less than the method detection.

Where the Lake Placid site differed the most from the upstream impoundment sites was in the *E. coli* concentrations. The monitoring site in Lake McQueeney had a geometric mean of 14 organisms per 100 milliliters over the historical period, and Lake Dunlap had a geometric mean of 44 organisms over the same period. The TCEQ Lake Placid site had a geometric mean of 139 organisms per 100 milliliters, exceeding the contact recreation standard of 126 organisms per 100 milliliters. Looking for explanations for the differences, one must consider that there were only 19 sampling events on Lake Placid as compared to 135 monitoring events for *E. coli* on Lakes Dunlap and McQueeney. Also, the site on Lake Placid is located under a bridge that not only shades the site, but has a population of birds that roost above the monitoring location.

TCEQ also monitors the Lake Placid location for heavy metals, both in the water and in the sediment. Table 1 gives the metals concentrations in the TCEQ data set, that begins in late 2004. There were 10 sampling events for total and dissolved metals in water and six sampling events for metals in sediment.

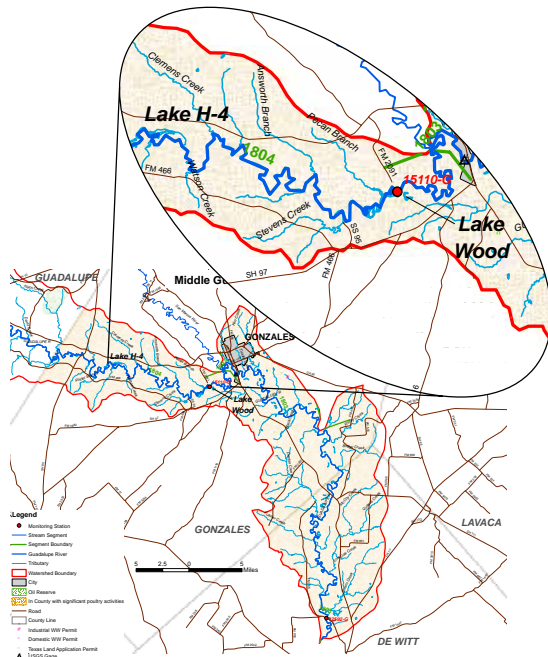
Table 1. Metals in water and sediment as measured at the TCEQ monitoring location on Lake Placid at IH 10 near Seguin.

	Metal (median concentrations)										
	Arsenic	Barium	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Nickel	Silver	Zinc
Water, total (ug/L)	<MD*	---	<MD*	<MD*	0.81	148	<MD*	7.9	<MD*	<MD*	<MD*
Water, dissolved (ug/L)	<MD*	---	<MD*	<MD*	<MD*	<MD*	1.0	2.0	<MD*	<MD*	<MD*
Sediment, total (ug/kg)	5.99	108	0.36	33.8	10.9	---	18.1	410	13.5	<MD*	71.5

\*MD = method detection

Additional information can be found in the section on “metals in water.”

### Lake Gonzales and Lake Wood



Lake Gonzales and Lake Wood are very long and narrow. Lake Gonzales has very limited residential development along its banks. Lake Wood has some development but it, like Lake Gonzales, flows through agricultural lands, dominated by row crops and pastureland. Lake Wood has been severely impacted by sediment loading. The sediment that is picked up by flood waters from upstream has been deposited in the area directly in front of the dam that impounds the lake, reducing the depth at this location to less than four feet.

TCEQ maintains a quarterly monitoring site in the riverine portion above Lake Gonzales and downstream of the city of Seguin. The site located at FM 1117 has a parameter list that includes the same parameters that GBRA monitors at their locations. Comparing the TCEQ site that is downstream of the city and its wastewater treatment plants, we see no significant changes in water quality. The median concentrations for pH, dissolved oxygen, conductivity and temperature are comparable to the other upstream sites and none fall outside of the stream standards. The total suspended solids, chloride and sulfate are comparable as well.

Nitrate nitrogen had a median concentration of 1.44 mg/L, ranging between 0.64 to 2.75 mg/L, slightly higher than the upstream locations. Three of the data points were higher than the screening concentration for nitrates of 1.95 mg/L (10.5%). Ammonia nitrogen had a median concentration of less than method detection and never exceeded the screening concentration of 0.33 mg/L. The median concentration for total phosphorus was slightly higher at the FM1117 location (0.11 mg/L) as compared to the median concentrations upstream (0.08, 0.06, <0.06 mg/L moving from upstream to downstream). Figure 5 shows that there is downward trend in the concentration of total phosphorus over time.

The geometric mean for the *E. coli* concentrations was 27 organisms per 100

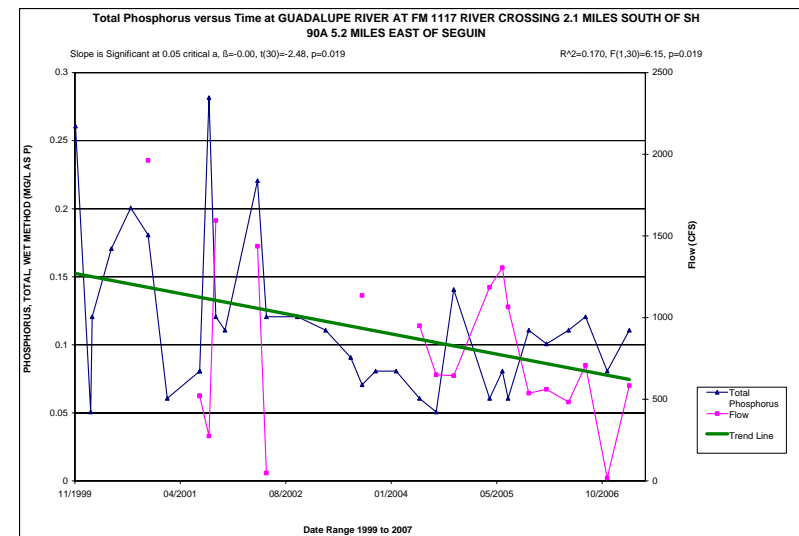


Figure 5. Downward trend in total phosphorus concentration over time at the TCEQ monitoring site located on the Guadalupe River at FM 1117 (17134).

milliliters and only exceeded the stream standard for contact recreation one time.

### Guadalupe River downstream of the H-5 dam

GBRA's last monitoring site in this segment, the **Guadalupe River downstream of the H-5 dam**, is downstream of Lake Wood. Flow at this location is impacted by hydroelectric generation. Although the site is not located in an impoundment it can be compared to the upstream locations because those sites are similar in flow and exhibit riverine characteristics the majority of the time. The median concentrations for pH, dissolved oxygen, conductivity and temperature are comparable to the upstream sites, and none fall outside of the stream standards. The total suspended solids, chloride and sulfate are comparable as well. As shown in figure 6, there is a significant negative correlation of chloride with flow, and the same is seen with conductivity and sulfates, indicating that as flows increase the background concentration of chloride and other dissolved constituents, are diluted. In figures 7 and 8, total suspended solids and turbidity are directly correlated with flow, increasing as flow increases.

Nitrate nitrogen had a median concentration of 0.79 mg/L, ranging between

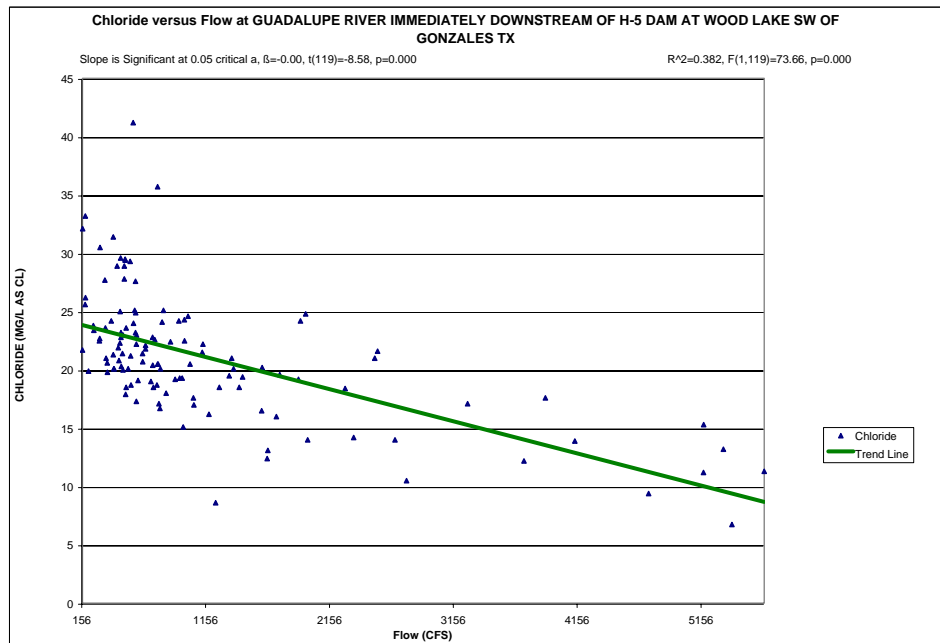


Figure 6. Background chloride concentrations at the GBRA monitoring site located at the Guadalupe River at H-5 (15110) are diluted with high river flows.

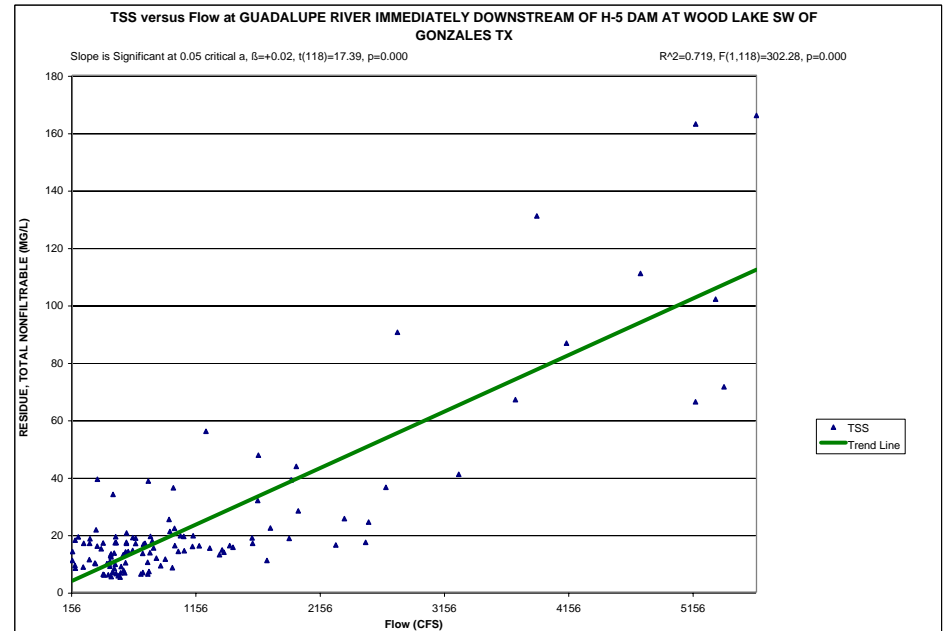


Figure 7. Positive relationship between flow and total suspended solids contributed by stormwater runoff at the Guadalupe River at H-5 monitoring location (15110).

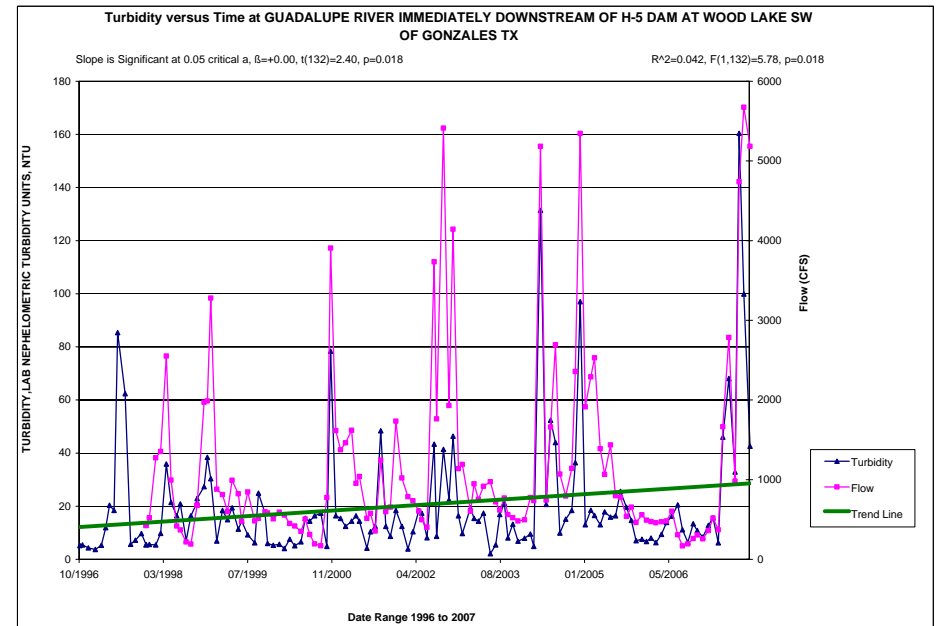


Figure 8. Positive relationship between flow and turbidity contributed by stormwater runoff at the Guadalupe River at H-5 monitoring location (15110).



0.02 to 1.9 mg/L, slightly lower than the locations in Lake Dunlap and Lake Placid, and more comparable to the Lake McQueeney site. None of the data points were higher than the screening concentration for nitrates of 1.95 mg/L. Ammonia nitrogen had a median concentration of 0.04 mg/L and never exceeded the screening concentration of 0.33 mg/L. The median concentration for total phosphorus was comparable to the FM1117 location (0.10 mg/L).

The geometric mean for fecal coliform and *E. coli* were 38 and 31 organisms per 100 milliliters, respectively. Out of the 200 measurements combined, 13 sampling events exceeded the respective stream standard for contact recreation, or 6.5% of the time. The median concentration for chlorophyll a was 3.0 ug/L, exceeding the screening concentration of 14.1 ug/L two times.

#### Stakeholder Concerns

Stakeholder issues in this portion of the Guadalupe River basin include concerns of the impacts of trash that comes from upstream and the impacts of nutrient loading from the New Braunfels wastewater discharges. The river downstream of Canyon Reservoir and the Comal River are highly recreated. The residents that live along the hydro lakes downstream see the impacts of the recreational pressure in the form of trash and vegetation as this material floats down and collects along bulkheads and piers. Aquatic vegetation is broken off and floats downstream as people are tubing or canoeing in areas of submerged plants such as hygrophylla and vallisneria (eelgrass). The plant mass collects in low flow areas and when a large mass builds up it breaks free and floats further downstream, eventually arriving in Lake Dunlap in amounts that impede boat traffic and swimming, collecting floating trash, and creating aesthetically unappealing conditions.

There are seven domestic wastewater discharge permits and one industrial wastewater discharge permit issued in segment 1804. The city of New Braunfels has two wastewater facilities that combine to discharge to Lake Dunlap. The Kuehler plants combined have a permitted discharge volume of 7.3 million gallons per day (MGD), with quality limits of 10 mg/L biochemical oxygen demand and 15 mg/L total suspended solids. The residents along Lakes Dunlap and McQueeney have raised concerns that these facilities impact the water quality of the impoundments by discharging nutrients that promote the growth of algae and aquatic macrophytes. Considering the history of infestations of aquatic vegetation in these hydroelectric impoundments it is a valid concern. The TCEQ renewed the discharge permits without nutrient limitations but required that the city perform a study to determine the appropriate amount of nutrient limitations that should be required by the wastewater plants. The results of the study have not been released to date.

Other large permitted discharges are from the city of Seguin. One plant is permitted to discharge up to an annual daily average of 4.9 MGD of treated domestic wastewater to the Guadalupe River. The second wastewater treatment plant is permitted to discharge up to an annual daily discharge rate of 2.13 MGD of treated domestic wastewater into the Geronimo Creek, 190 feet upstream of the confluence with the Guadalupe River. Both Seguin wastewater treatment plants must meet a 7 day average biochemical oxygen demand of 20 mg/L and a 7 day average total suspended solids level of 20 mg/L. The Walnut Branch plant has an ammonia limitation of 3 milligrams per liter.

A concern of residents along Lake Placid just upstream of the city of Seguin is the dis-

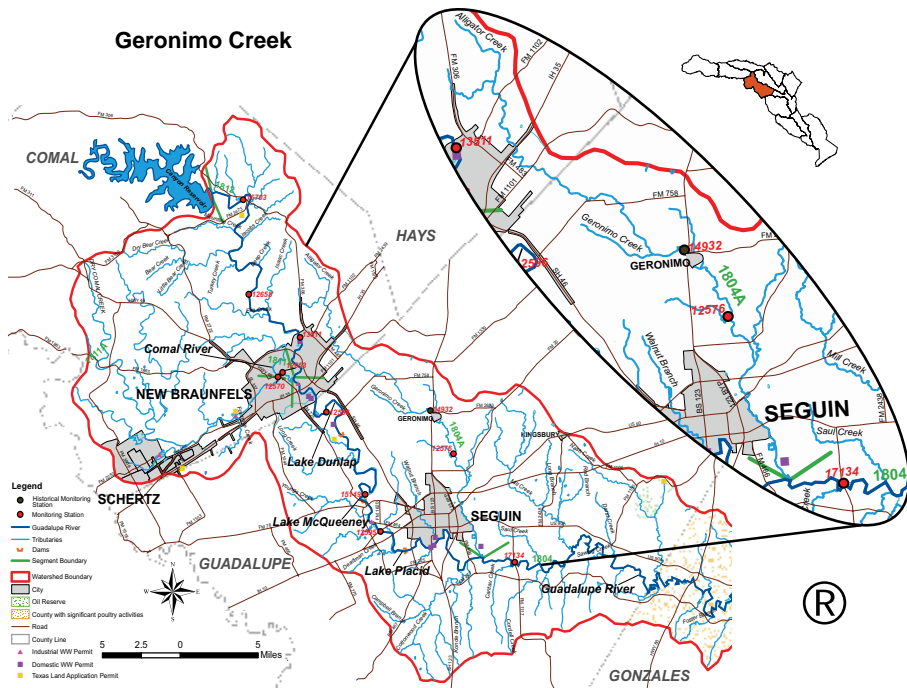
charges and nonpoint source pollution associated with the steel mill that is located on the east banks of the impoundments. In the 1980s the steel mill was linked to contamination of nearby wells with chromium. Since that time, the facility has implemented a progressive environmental program on site that includes reuse of process water and extensive treatment of stormwater before it leaves the facility grounds. Also, TCEQ has a monitoring location downstream of the facility previously discussed in this section.

Segment 1804 of the Guadalupe River has had a number of problems with invasive plant species. The aquatic species include blooms of filamentous algae referred to as “witch’s hair”, waterhyacinth, hydrilla and water lettuce. It is because of the infestation of the upper lakes by hydrilla in the mid-90s that the residents along Lakes Dunlap, McQueeney and Placid organized into homeowner associations. These groups are very active, expanding their areas of concern outside of aquatic vegetation to include water safety, quality and quantity issues. It is members of these groups that make up a large part of the active membership of the Guadalupe River Basin Clean Rivers Program Stakeholders Committee.

The upper lakes are not alone in their battle with aquatic weed infestations. The waterhyacinth, *Eichhornia crassipes*, has dominated the impoundments at Lake Gonzales and Lake Wood. This invasive plant covers the surface of the lakes, which prevents mixing and oxygen exchange, and shades out sunlight, reducing native plant habitat. This plant also impedes recreational activities such as swimming and canoeing, while generally reducing the aesthetic quality of the lakes. In order to combat this nuisance, in 2008, the GBRA and the Texas Park and Wildlife Department have funded a treatment program that includes mechanical shredding and chemical treatment. The shredding process was followed by a chemical treatment with 2, 4-D in Lake Gonzales and glyphosphate in the Lake Wood area. Treatment of aquatic vegetation is not new to this portion of the river basin. In the 1990’s, infestations of hydrilla, *Hydrilla verticillata*, in Lake McQueeney and Lake Dunlap were treated by introducing sterile, triploid grass carp, into these lakes as a biological control, as well as chemical treatments with aquatic herbicides.



Surface of cove in Lake Wood completely covered with Water-Hyacinth.



Geronimo Creek, Segment 1804A, has been monitored by GBRA as part of the Clean Rivers Program since late 1996. The creek was monitored at the SH 123 crossing until August 2003, at which time the routine monitoring site was moved to the Haberle Road crossing. The new site was a past TCEQ monitoring site and an ecoregion reference site. Reviewing the historical data at the Haberle Road site, the median dissolved oxygen (DO) is 9.21 milligrams per liter (mg/L), ranging from 6.9 to 13 mg/L. The stream meets its designated uses, never dropping below the screening level of 5.0 mg/L for dissolved oxygen. The 2008 draft Texas Water Quality Inventory has Geronimo Creek listed with a concern due to elevated nitrate-nitrogen concentrations because 11 of the 60 measurements exceeded the screening level of 1.95 mg/L. In addition, the stream is listed as impaired because the geometric mean for *E. coli* bacteria (162 organisms per 100 milliliters) exceeded the contact recreation stream standard of 394 organisms per 100 milliliters.

### Water Quality

The median **specific conductance** at the Haberle Road site is 875 micromhos per centimeter (umhos/cm), ranging from 485 to 982 umhos/cm. Temperature fluctuations correspond with season, with a median temperature of 22.9°C and ranging from a minimum of 11.9°C to a maximum of 27°C. Total suspended solids and turbidity have median values of 1 and 6.2mg/L respectively and exhibit fluctuations that correspond to storm water runoff.

The historical site on Geronimo Creek, located at SH 123 (site #14932, referred to as “SH123 site”), is approximately 3.6 miles upstream from the current monitoring site located at Haberle Road (site #12576, referred to as “Haberle Road site”). In order to provide the most continuous temporal analysis of this creek, the data from the two sites was combined into a single dataset. Additionally, the data was modified to remove four data points in 1990 collected at the Haberle Road site, due to the large time gap between these points and any subsequent collections. Several statistical differences between these two stations immediately became apparent.

The average **flow** (based on instantaneous flow data taken at time of sampling) of the SH123 site was 5.73 cubic feet per second (cfs) with a standard deviation of 3.21 cfs for the 72 data points collected between November 1997 and August 2003. The average flow of the Haberle Road site was 14.2 cfs with a standard deviation of 8.43 cfs for the 47 data points collected between September 2003 and September 2007. The combined average flow for these two stations was 9.09 cfs with a standard deviation of 7.17 cfs over the entire 119 data points. The GBRA attributes the large differences in average flow and variability between these two stations to the 3.6 mile distance between the stations and the influence of springs and intermittent creeks in the drainage basin.

The pH data of the 85 events collected at the SH123 site from October 1996 through August 2003 showed a median value of 7.65 standard units (S.U.) and a standard deviation of 0.27 S.U. The pH data of the 53 events collected at the Haberle Road site from September 2003 to September 2007 showed a median value of 7.75 S.U. and a standard deviation of 0.09 S.U. As seen in Figure 1, the pH levels appeared to stabilize when the sampling location was changed to Haberle Road. The SH123 site is approximately 1.5 miles removed from the headwater springs that feed the creek and much more likely to experience data variability due to groundwater influences. The new station at Haberle Road is located approximately 5 miles downstream of the headwater springs and appears to exhibit much less variability in pH readings, which may be the result of the stabilizing effects of increased flows and water volume at the downstream station. The average pH over the entire 138 point dataset was 7.69 S.U. with a standard



Figure 1. pH versus Time at the combined Geronimo Creek at SH 123 (14932) and Haberle Road (12576) Stations. The vertical line in the middle of the chart represents the transition from the station at SH 123 to the station at Haberle Road.

deviation of 0.23 S.U.

Five selenium analyses were performed on Geronimo Creek from May 2001 to April 2007. The first four analyses were performed at the SH 123 site, ending with a collection in June of 2003. The final data point was collected at the Haberle Road site, downstream from the previous station (Figure 2). The mean selenium concentration across all data five Geronimo Creek data points was 2.11 parts per billion (ppb) with a standard deviation of 0.22 ppb. The final data point at the Haberle Road site exhibited the highest observed value of 2.42 ppb, which could indicate a temporally or spatially increasing trend in this watershed. Although this level is well below the drinking water maximum contaminant level (MCL) of 50 ppb, and below the acute and chronic concentrations set by US EPA (20 ppb and 5 ppb respectively), the GBRA believes that these levels should be monitored closely due to the close ties between groundwater and surface water in this water body and the

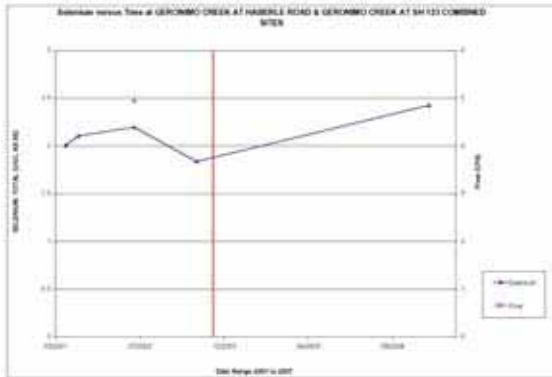


Figure 2. Selenium versus time at the combined Geronimo Creek at SH 123 (14932) and Haberle Road (12576) stations. The vertical red line represents the transition from the SH 123 station to the Haberle Road station.

general absence of selenium in other parts of the Guadalupe watershed.

Initially, phosphorus concentrations in Figure 3 appear to show a shift to a lower and more stable concentration after the transition to the Haberle Road site on 06/2003. However, the statistics show very little change between these two sites and the variability has actually increased at the Haberle Road site. The data collected from the SH123 site has a mean value of 0.076 milligrams per liter (mg/L) with a standard deviation of 0.054 mg/L for the 84 data points collected, while the data from the Haberle Road site has a value of 0.073 mg/L with a



Figure 3. Total Phosphorus versus time at the combined Geronimo Creek at SH 123 (14932) and Haberle Road (12576) stations. The vertical red line represents the transition from the SH 123 station to the Haberle Road station.

standard deviation of 0.088 mg/L for the 49 data points collected. Removing the outlying data point of 0.66 mg/L collected on 09/16/2003, the mean for the Haberle Road site is reduced to 0.060 mg/L with a standard deviation of 0.020 for 50 data points. The change in concentration and variability between these two sites is most likely due to the diluting effects of a higher average flow at Haberle Road site. The least squares trend line for this monitoring parameter, seen in Figure 4,

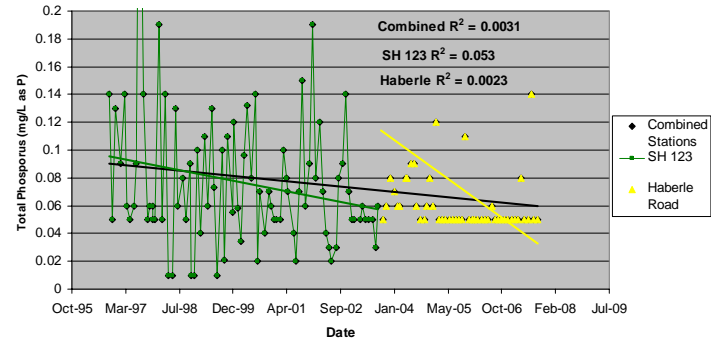


Figure 4. Total phosphorus versus time at the combined Geronimo Creek at SH 123 (14932) and Haberle Road (12576) station.

appears to show a downward trend in overall phosphorus levels.

Chloride also shows a significant decrease in average concentration and variability with the change of site locations. The SH 123 site has an average chloride concentration of 60.6 mg/L with a standard deviation of 12.1 mg/L for the 85 data points collected, while the Haberle Road site has an mean chloride concentration of 40.0 mg/L with a standard deviation of 5.45 mg/L over the 51 data points measured. The mean chloride concentration of the combined sites over the entire 133 point dataset was 53.2 mg/L with a 14.2 mg/L standard deviation. The least squares trend line for this monitoring parameter seen in Figure 5, appears to show a downward trend in chlorides overall and at each station individually.

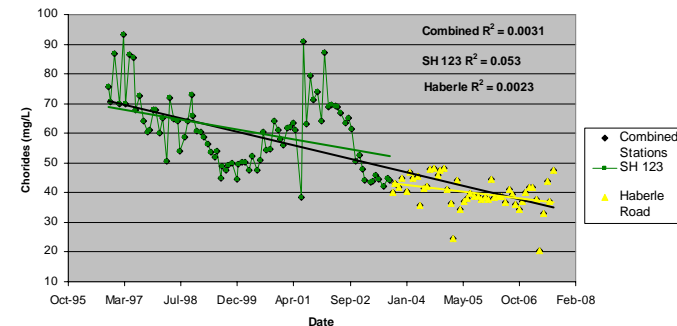


Figure 5. Chloride versus time at the combined Geronimo Creek at SH 123 (14932) and Haberle Road (12576) station.

The nitrate concentrations for Geronimo Creek appear to be fairly consistent despite two changes in test method and a change in station location (Figure 6). Over the entire 137 data points collected on Geronimo Creek the average nitrate observed was 11.07 mg/L with a standard deviation of 2.91 mg/L. The minimum value observed was 5.2 mg/L and the maximum value observed was 18.2 mg/L. The mean concentration for nitrates is over 1 mg/L higher than the MCL of 10.0 mg/L suggested by the EPA for drinking water. The maximum concentration measured is nearly twice the MCL. There is a significant amount of groundwater



influence on Geronimo Creek and many drinking water wells in this watershed are known to share nitrate values similar to or even higher than the creek itself. The GBRA is very concerned about the potential effects of these nitrate levels on the water supply for this region, especially as this particular watershed appears ready for explosive growth over the next decade. The radical deviation of the nitrate concentrations in Geronimo Creek from similar streams in the Guadalupe basin present an interesting question about the source of this contamination.

The Geronimo Creek has exceeded the water quality standard for contact recreation (measurement of the indicator bacteria, *E. coli*, in a grab sample) of 394

colony forming units (CFU) in sixteen, or 1.29%, of the 129 data points collected. The mean *E. coli* concentration observed on Geronimo Creek is 262 CFU with a standard deviation of 493 CFU. The large amounts of variability in the *E. coli* measurements for the stream do not always appear to have an obvious explanation (Figure 7). At least two of the points that display values greater than the water quality standard correlate closely with high flow events. However, the majority of the other abnormalities had average or below average flows. The unexplained values in question could conceivably be attributed to upstream groundwater influences or the dominance of agricultural land use that occurs in this watershed.



Figure 6. Nitrate nitrogen versus time at the combined Geronimo Creek at SH 123 (14932) and Haberle Road (12576) stations. The vertical red line represents the transition from the SH 123 (14932) and Haberle Road (12576) station.

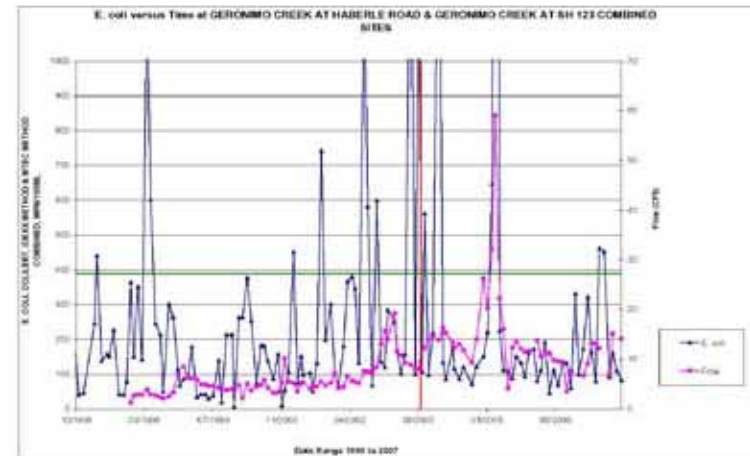


Figure 7. *E. coli* versus time at the combined Geronimo Creek at SH 123 (14932) and Haberle Road (12576) stations. The vertical red line represents the transition from the SH 123 (14932) and Haberle Road (12576) station.

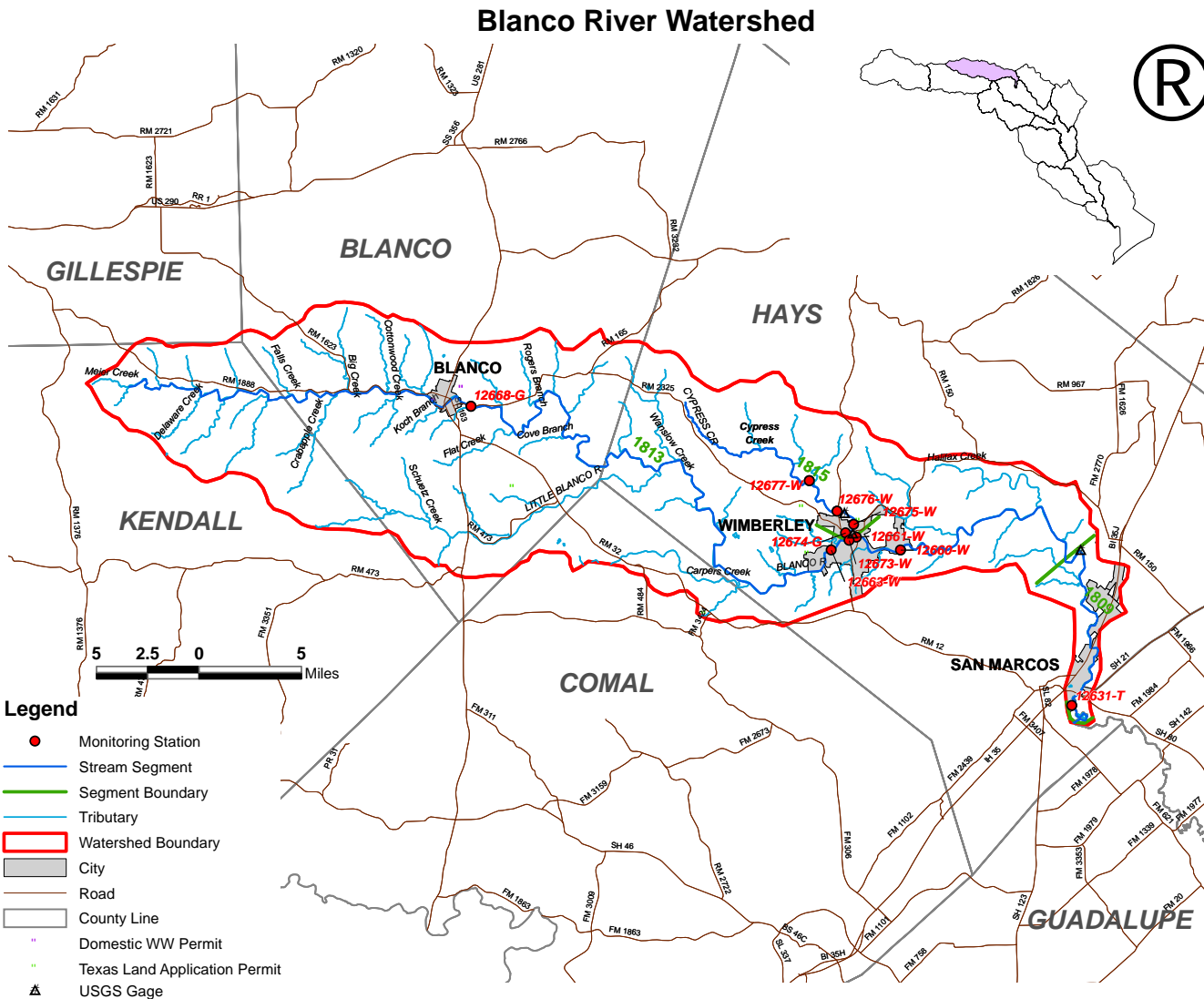


Geronimo Creek at SH 123 (site no. 14932).



Geronimo Creek at Haberle Road (site no. 12576).





**Monitoring Stations – Blanco River and Cypress Creek Watersheds**

12668-G	Blanco River at FM 165
12660-W	Blanco River at FM 174
12661-W	Blanco River at FM 21, downstream of confluence with Cypress Creek
12663-W	Blanco River at Pioneer Town (7A)
12677-W	Cypress Creek at Jacob's Well (headwaters)
12676-W	Cypress Creek at FM 12, north of Wimberley
12675-W	Cypress Creek at Blue Hole
12673-W	Cypress Creek, upstream of confluence with Blanco River
12674-G	Cypress Creek at FM 12, in Wimberley
12637-T	Blanco River 6.3 miles upstream of IH 35
12631-T	Blanco River at Old Martindale Road

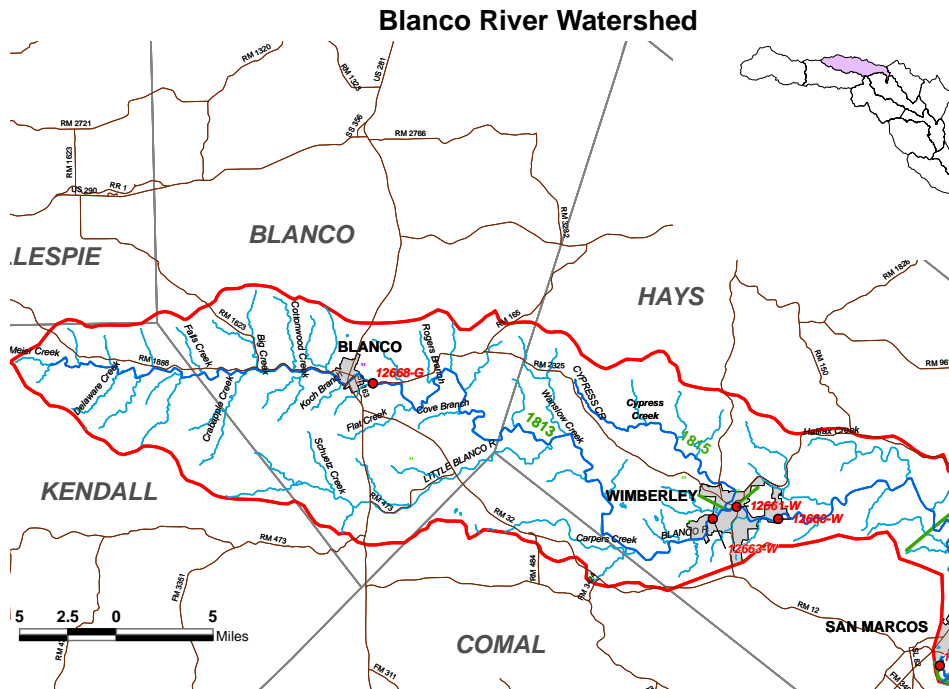
**Blanco River Watershed**

**Drainage Area:** 440 square miles  
**Streams and Rivers:** Guadalupe River, Lower Blanco River, Upper Blanco River, Cypress Creek, Meier Creek, and Sycamore Creek  
**Aquifers:** Edwards-Trinity, Trinity  
**River Segments:** 1813, 1815, 1809  
**Cities:** Blanco, Fisher, Wimberley, Kyle, San Marcos  
**Counties:** Kendall, Comal, Blanco and Hays

**EcoRegion:** Edwards Plateau  
**Vegetation Cover:**  
 Evergreen Forest - 42.9%    Shrublands - 11.0%  
 Grass/Herbaceous - 32.2%    Deciduous Forest - 7.7%  
**Climate:** Average annual rainfall: 31 inches  
 Average annual temperature: January 34° July 94°  
**Land Uses:** Urban, Agricultural Crops (wheat, hay, oats, peaches & pecans), Sheep, Cattle, Goats and Turkey Productions; Light Manufacturing and Recreation

**Water Body Uses:** Aquatic Life Use, Contact Recreation Use, General Use, Fish Consumption Use, and Public Water Supply Use  
**Soils:** Varies from thin limestone to black, waxy, chocolate, and grey loam, calcareous, stony, and clay loams  
**Permitted Wastewater Treatment Facilities:**  
 Domestic: 2    Land Application: 3  
 Industrial: 0

Sampling sites are labeled in red followed by the letter G (GBRA), T (TCEQ), U (UGRA) or W (Wimberley) indicating who is the monitoring entity.



The Blanco River is divided into two classified stream segments. Segment 1813, the upper Blanco River, extends for 71 miles from Lime Kiln Road in Hays County, through Blanco County, to the spring-fed headwaters in northern Kendall County. Segment 1813 consists of 355 square miles of drainage basin that is separated into five assessment units. Assessment unit 1813\_01 evaluates the 14.2 mile lower section of the segment, between Lime Kiln Road and Hays CR 314. Unit 1813\_02 assesses the 3.5 mile section below the City of Wimberley, between Hays CR 314 and Hays CR 1492. Unit 1813\_03 evaluates the 6.5 mile section, below the City of Blanco, between Blanco CR 406 and Highway 281 in Blanco County. Unit 1813\_04 assesses the 17.3 mile section between Highway 281 and the headwaters of the segment. Unit 1813\_05 assesses the 29.5 mile section between Hays CR 1492 and Blanco CR 406. This segment also receives the Cypress Creek tributary below the city of Wimberley. Cypress Creek has been designated as a separate segment 1815 and is discussed in a later section of this document. Segment 1809, the lower Blanco River, is described in the following section. GBRA has routinely monitored one site in segment 1813 (Station #12668), monthly, since October of 1996. The GBRA monitoring site is located at FM 165, ½ mile east of the City and 2 miles below the city's wastewater treatment plant discharge.

The Wimberley Valley Watershed Association recognized the need for more assessment data in this segment of the Blanco and partnered with the GBRA to initiate routine monitoring of three stations (#12660, #12661, and #12663) on the Blanco River, in February of 2003. The data collected by the Wimberley Valley Watershed Association (WVWA) is quality assured by the GBRA and submitted to the

TCEQ under the GBRA quality assurance project plan. The WVWA Station #12660 is an historical site originally monitored by TCEQ and located 3.1 miles downstream of the Cypress Creek confluence at the Fulton Ranch Road crossing. The WVWA Station #12661 was initially sampled by the USGS in May of 1990 and is located 0.4 miles downstream of the Cypress Creek confluence, just below the Ranch Road 12 crossing. WVWA Station #12663 is a new station, located 1.2 miles upstream of the Cypress Creek confluence, at CR 1492, in the upper end of assessment unit 1813\_02. Additional monitoring was conducted by the GBRA in assessment units 1813\_03 and 1813\_04, as part of a special study, between January 2002 and July of 2003.

### *Geology and Water Quality Concerns*

Segment 1813 is spring-fed stream, on the Edwards Plateau. The majority of the segment exhibits limestone substrate with occasional gravel, silt, or clay strata. The limestone is known to contain gypsum deposits, which can contribute to high sulfate concentrations in groundwater. The stream has historically displayed exceptional water quality and usually exhibits extremely clear water. In general, most water quality concerns in this segment of the Blanco River are linked to highly variable stream flow. The upper portions of the river have been known to go dry during prolonged periods of drought and the banks and substrate of the entire segment exhibit significant scouring during extended wet periods. The 2008 Texas Water Quality Inventory and 303(d) list do not list any impairments or concerns for general water use throughout the entire segment. The Texas Water Quality Inventory Report lists a dissolved oxygen concern for aquatic life use in assessment unit 1813\_05, but this is most likely due to low base flow conditions during portions of the assessment period. The increasing population in this area has raised concerns about strains on the available water supply and increased stream erosion potential. The United States Census Bureau estimates a 9.9% increase in the population of Blanco County between April of 2000 and July of 2006. As the population in this area continues to climb, so does the importance of maintaining the water quality of available surface water.

There are currently two domestic treatment plants that are permitted to discharge to the upper Blanco River. Both discharges occur just outside of the city of Blanco, in assessment unit 1813\_03. The city of Blanco wastewater treatment plant is situated ½ mile east of central Blanco and discharges the majority of its effluent into irrigation ponds for fields of coastal bermuda. This plant is permitted to discharge excess effluent into the Blanco River at an average rate of 0.90 million gallons per day. The permitted discharge to the Blanco rarely occurs, except during periods when the coastal bermuda irrigation fields are being harvested. The municipal effluent must meet water quality standards of 30 milligrams per liter (mg/L) of biochemical oxygen demand, 30 mg/L of total suspended solids, 1.0 mg/L of chlorine residual, and a pH between 6.0 and 9.0 standard units. The second plant is the city of Blanco Water Treatment plant is permitted for an average discharge of 0.050 million gallons per day, in the form of backwash water and settling sludge supernatant. The water treatment plant discharge is permitted to have a total suspended solids level of 20 mg/L and a pH of between 6.0 and 9.0 standard units.

## Special Study on the Blanco River

Between September of 1999 and November of 2000 eight of the thirteen sulfate samples collected at the GBRA routine monitoring station, on the Blanco River at FM165 (Station #12668), returned values greater than the stream standard of 50 milligrams per liter (mg/L). GBRA initiated a special study in the upper portions of this segment, in order to identify the reason for the high sulfate values. During the first phase of the study, 13 monitoring locations were sampled for sulfate and conductivity concentrations from January to December of 2002. The phase one study locations included a site on the Blanco River at Cox Road, which was 4.9 miles downstream of the GBRA routine monitoring station at FM165. Phase one of the special study also monitored 11 additional stations, up to 10.8 miles upstream of the GBRA monitoring station at FM165. The phase one study stations upstream of the GBRA monitoring site included 4 main stem sites and 6 tributaries, as well as the City of Blanco wastewater discharge, which was located 2 miles upstream of the GBRA FM 165 station. The first phase of the sulfate study revealed that only the samples from the Big Creek tributary and the city of Blanco WWTP discharge contained sulfate concentrations exceeding the stream standard, as seen in Figure 1. The city of Blanco WWTP discharge was eliminated as a cause for high sulfate concentrations because it was utilizing its permitted discharge water for crop irrigation during the study sampling dates, as well as during the initial period of high sulfate concentrations in 1999 and 2000. The second phase of the study investigated 4 sites on the Big Creek tributary, a well in the Big Creek drainage basin, and a station on the Blanco River 2 miles downstream of the Big Creek confluence, as seen in Figure 2. The analysis of the data from this study showed that the groundwater in this portion of the river basin significantly contributed to high sulfate concentrations, especially during times of low flow.

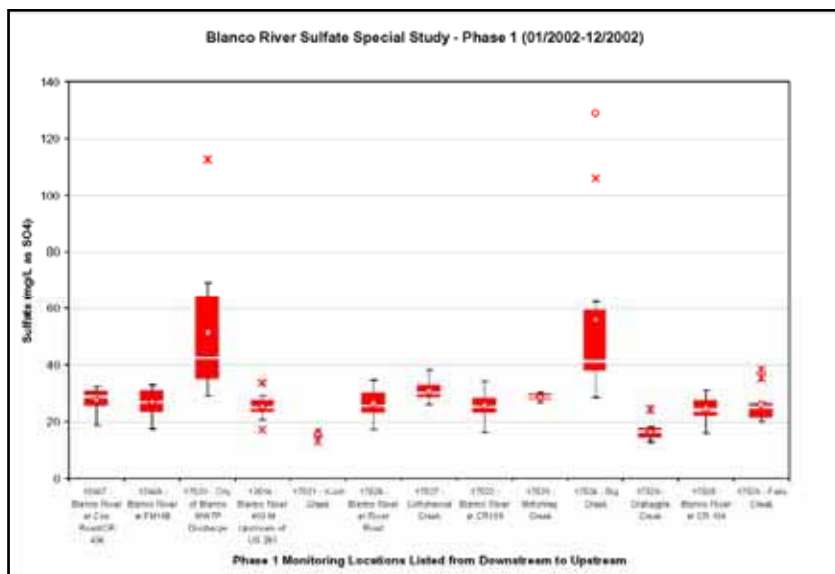


Figure 1. Box and whisker plot of sulfate concentrations at the 13 locations monitored during the first phase of the special sulfate study on the Upper Blanco River.

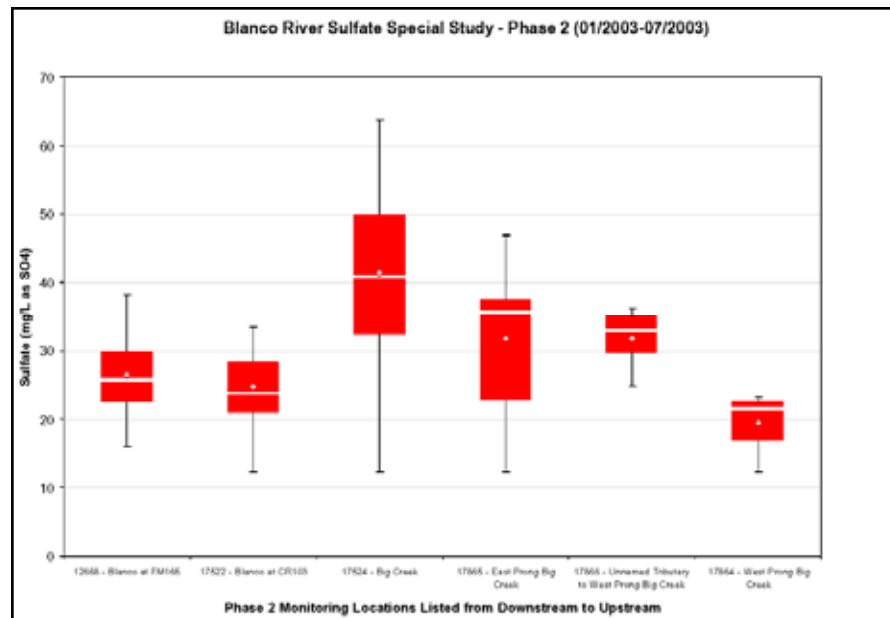


Figure 2. Box and whisker plot of sulfate concentrations at the 6 locations monitored during the second phase of the special sulfate study on the Blanco River.

## Water Quality of the Stream

Over the period of record, the sulfate concentration at the *Blanco at FM 165* site (#12668) had a median value of 28.8 mg/L with a maximum value of 162 mg/L and a minimum value of 5.0 mg/L. The sulfate levels at this site exceeded the stream screening criteria of 50 mg/L 14 times over the period of record, as seen in Figure 3. The sulfate concentration at this site appears to be exhibiting a significant downward trend with time at the 0.05 critical  $\alpha$ ,  $\beta = -0.01$ ,  $t(130) = -2.72$ ,  $p = 0.007$ . A significant portion of the variance in sulfate levels at this site appears to be explained by stream flow,  $R^2 = 0.114$ ,  $F(1,85) = 10.89$ ,  $p = 0.001$ , and over the period of record there appears to be an inverse relationship between sulfate concentration and flow at the 0.05 critical  $\alpha$ , as a rise in flow results in a decrease in sulfate,  $\beta = -0.11$ ,  $t(85) = -3.30$ ,  $p = 0.001$ , as seen in Figure 4. Nitrate nitrogen, ammonia nitrogen, total phosphorus, and chlorophyll a were also analyzed at this monitoring location. Nitrate Nitrogen was reported under three different STORET codes at this location. Combining the results of all three STORET codes, the median nitrate concentration was 0.27 mg/L, with a maximum value of 1.78 mg/L and a minimum value of <0.01 mg/L. None of the samples exceeded the nitrate nitrogen screening criteria of 1.95 mg/L. The median ammonia nitrogen concentration of the GBRA monitoring location at FM 165 was 0.04 mg/L, with a maximum value of 0.34 mg/L and a minimum value of <0.02 mg/L. This station exceeded the ammonia screening concentration of 0.33 mg/L one time, in April of 2000, during a prolonged period of low stream flow. The median total phosphorus concentration was below the limit of quantification for the method and when total phosphorus was detected in a sample it did not exceed the screening concentration of 0.69 mg/L. The



median chlorophyll a concentration was less than detection and there was never a measured value above the screening concentration of 14.1 microgram per liter.

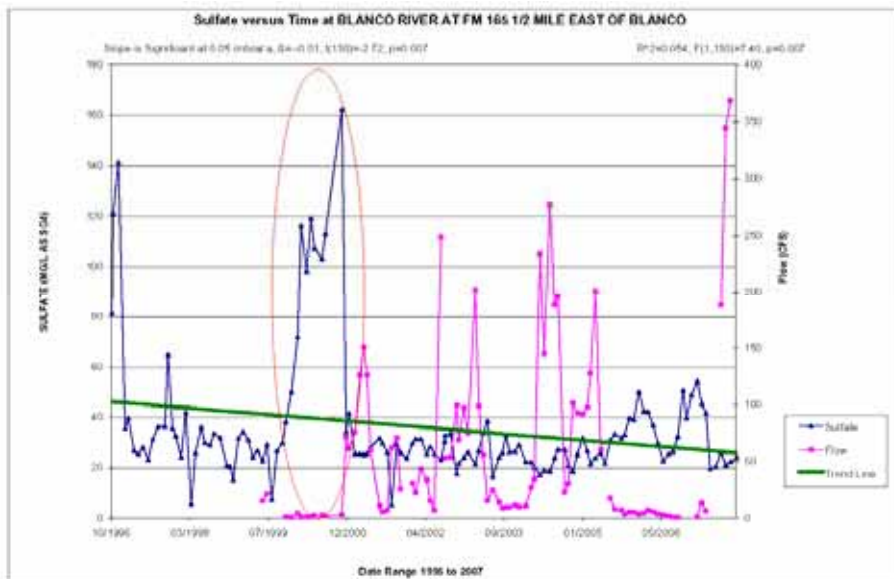


Figure 3. Sulfate concentration versus time at the Blanco River at FM 165 (12668) GBRA monitoring station (period of time that prompted sulfate special study is circled in red).

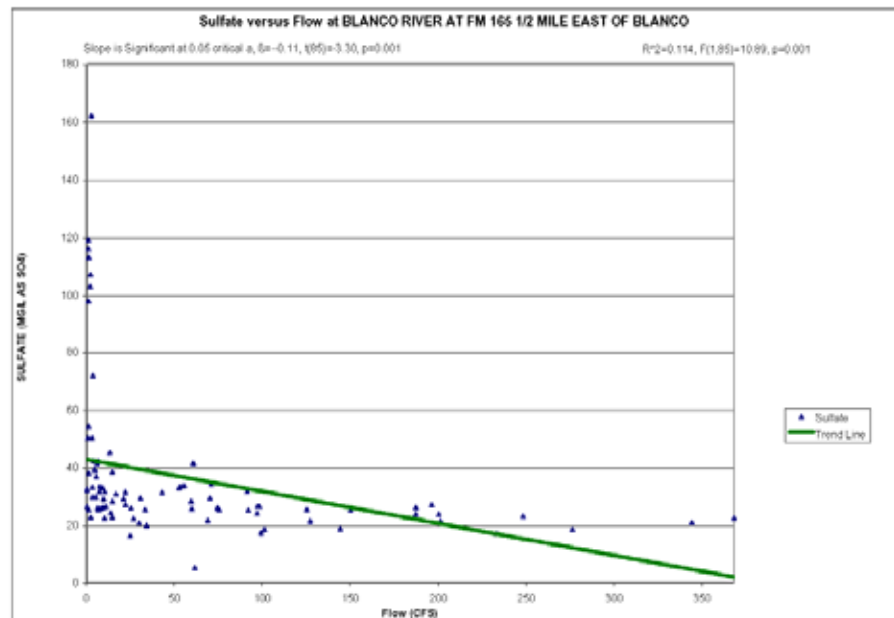


Figure 4. Sulfate concentration versus Flow at the Blanco River at FM 165 (12668) GBRA Monitoring Station. An inverse relationship was found to exist between sulfate and flow.

Nitrate nitrogen, ammonia nitrogen total phosphorus, and chlorophyll a were analyzed at the WWA station on *Blanco River at RR12* (station #12661). Nitrate Nitrogen was reported under two different STORET codes at this location. Combining the results of both STORET codes, the median nitrate concentration was 0.28 mg/L, with a maximum value of 1.9 mg/L and a minimum value of 0.02 mg/L. None of the samples exceeded the nitrate nitrogen screening criteria of 1.95 mg/L. The median ammonia nitrogen concentration of the WWA monitoring location at RR12 was <0.02 mg/L, with a maximum value of 0.5 mg/L and a minimum value of less than the quantification limit for the method. This station exceeded the ammonia screening concentration of 0.33 mg/L one time, in February of 1992, during a prolonged high stream flow event. The median total phosphorus concentration was below the limit of quantification for the method and when total phosphorus was detected in a sample it did not exceed the screening concentration of 0.69 mg/L. The median chlorophyll a concentration was less than detection, however, there were two sample events with measured values above the screening concentration of 14.1 microgram per liter, in November of 1995 and July of 2003. Chlorophyll a has not been monitored at this location since August of 2003 when the WWA took over monitoring duties from the TCEQ.

Nitrate nitrogen, ammonia nitrogen and total phosphorus were analyzed at the WWA station on the *Blanco River at CR 1492* (station #12663). Nitrate Nitrogen was reported under two different STORET codes at this location. Combining the results of both STORET codes, the median nitrate concentration was 0.22 mg/L, with a maximum value of 0.78 mg/L and minimum value of 0.03 mg/L. None of the samples exceeded the nitrate nitrogen screening criteria of 1.95 mg/L. The median ammonia nitrogen concentration of the WWA monitoring location at CR 1492 was less than the method detection limit, with a maximum value of 0.07 mg/L. This station never exceeded the ammonia screening concentration of 0.33 mg/L. The median total phosphorus concentration was below the limit of quantification for the method and when total phosphorus was detected in a sample it did not exceed the screening concentration of 0.69 mg/L. The median chlorophyll a concentration was less than detection, however, there were two sample events with measured values above the screening concentration of 14.1 microgram per liter, in November of 1995 and July of 2003. Chlorophyll a has not been monitored at this location since August of 2003, when the WWA took over monitoring duties from the TCEQ.

Nitrate nitrogen, ammonia nitrogen and total phosphorus were analyzed at the WWA station on the *Blanco River at CR 173* (station #12660). Nitrate nitrogen was reported under three different STORET codes at this location. Combining the results of all three STORET codes, the median nitrate concentration was 0.22 mg/L with maximum value of 0.75 mg/L and minimum value of 0.02 mg/L. None of the samples exceeded the nitrate nitrogen screening criteria of 1.95 mg/L. The median ammonia nitrogen concentration of the WWA monitoring location at CR 173 was less than the method detection limit. This station never exceeded the ammonia screening concentration of 0.33 mg/L. The median total phosphorus concentration was below the limit of quantification for the method and when total phosphorus was detected in a sample it did not exceed the screening concentration of 0.69 mg/L. The median chlorophyll a concentration was less than detection,



however, there were two sample events with measured values above the screening concentration of 14.1 microgram per liter, in November of 1995 and July of 2003. Chlorophyll a has not been monitored at this location since May of 2002 when the TCEQ discontinued monitoring.

Segment 1813 provides clear, spring water for contact recreational opportunities. The low base flows in the river often prevent canoeing and tubing, but many dammed pools exist in the segment, which attract campers and swimmers. The stream standard for contact recreation is a geometric mean of 126 organisms per 100 milliliters, and a single sample concentration of 394 organisms per 100 milliliters. The geometric mean for *E. coli* at the GBRA FM165 site (station #12668) is 24 organisms per 100 milliliters. In the period of record, only six grab samples at the FM 165 site have exceeded the single sample *E. coli* standard of 394 organisms per 100 milliliters and all but one of these events occurred during periods of extremely high flow. The geometric mean for *E. coli* at the WVWA CR1492 site (station #12663) is 98 organisms per 100 milliliters. In the period of record, only six grab samples at the CR1492 site have exceeded the single sample *E. coli* standard of 394 organisms per 100 milliliters and all of these events occurred during periods of extremely high flow. The geometric mean for *E. coli* at the WVWA RR12 site (station #12661) is 80 organisms per 100 milliliters. In the period of record, only six grab samples at the RR12 site have exceeded the single sample *E. coli* standard of 394 organisms per 100 milliliters and all of these events occurred during periods of extremely high flow. The geometric means for *E. coli* in the monitoring stations of this segment appear to be lowest in the upper reaches of the segment, highest before the Cypress Creek confluence in the city of Wimberley and begin declining after the confluence, as the water leaves the city.

#### Land Uses

The land use in the segment consists of increasingly urbanized areas above or near the city of Blanco and the city of Wimberley. In the long stretches above and below these two cities farm and ranch land is prevalent. Many family farms are being sold and subdivided, and this area is expected to continue to increase its residential land use over the next few years. The impervious cover that is created by residential land use and subdivisions, i.e. streets, rooftops and parking lots, can be a source of nonpoint source pollution. The impervious cover forces water that could be captured by the soil to run off directly into the creeks and streams. This runoff can increase erosion and suspended sediment loading in the water bodies as well as carry other organic pollutants. The median total suspended solids (TSS) value at the Blanco River at FM165 monitoring station is 3.4 mg/L with a maximum value of 20 mg/L and a minimum value below the limit of quantification for the method. The WVWA monitoring sites exhibited median TSS values of 1.7 mg/L with a maximum value of 43.3 mg/L at the CR1492 site, 1.7 mg/L with a maximum value of 40.2 mg/L at the RR12 site and 1.6 mg/L with a maximum value of 49.7 mg/L at the CR173 site.

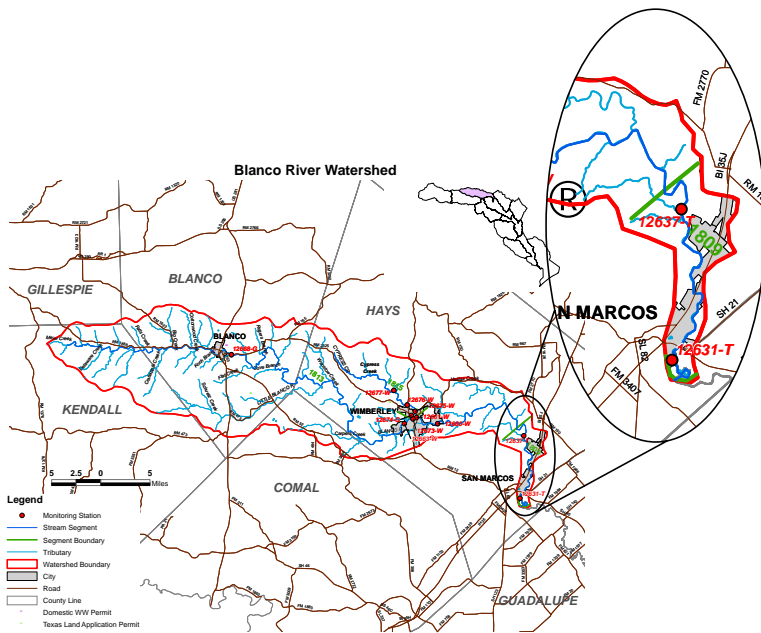
The historical data from the two monitoring sites was reviewed for trends, comparing constituents over time and flow regimes. Statistically significant trends that were noted, either positive or negative, were not indicative of degrading water quality conditions.



The Blanco River at FM 165 (site no. 12668) during the drought of 2006.



Blanco River at FM 165 (site no. 12668) during normal to low flow.



The Blanco River is divided into two classified stream segments. Segment 1809, **the lower Blanco River**, extends from the confluence of the Blanco and San Marcos Rivers, just outside the city of San Marcos, upstream to the Lime Kiln Road crossing in Hays County. The segment is 15 miles long and is separated into two assessment units. Assessment unit 1809\_01 consists of the segment from the confluence with the San Marcos River to 7 miles upstream. Assessment unit 1809\_02 consists of the upper 8 miles of the segment from 7 miles upstream of the San Marcos River confluence, to Lime Kiln Road. The upper Blanco River, segment 1813, includes the area upstream of Lime Kiln Road and is described in the preceding section. TCEQ has been monitoring the Blanco River at Hays CR 295/Old Martindale Road, east of San Marcos (site no. 12631) quarterly since May of 1994. The TCEQ monitoring site is located in the lower half of the segment, in assessment unit 1809\_01. TCEQ monitors this site four times per year. There is another TCEQ site in the second assessment unit of the segment, 6.3 miles upstream of the IH 35 bridge (site no. 12637), but this monitoring location only contained a very limited data set from 10 monitoring events and is not currently being monitored. The statistical review of the data in this segment focused on the CR 295 monitoring location.

#### Land Uses and Water Quality Concerns

The 85 square mile drainage area of the lower Blanco River is primarily located on the Edwards Plateau, but enters the Blackland Prairies on the eastern edge of Hays County. This segment consists of limestone substrate with occasional stony and clay loams. The changes in elevation as the river crosses the Balcones fault increase the streamflow, but there are also several slow moving stretches throughout the segment. The water is primarily used for aquatic life, contact

recreation and fish consumption. The land in the basin is used for farming, ranching, recreation, light manufacturing and urban development. The urban development of this segment is increasing at a rapid pace due to the rivers location in the middle of the IH 35 corridor and its close proximity to the rapidly expanding cities of San Marcos and Kyle. The United States Census Bureau estimates that there was a 33% increase in the population of Hays County from April of 2000 to July of 2006. The rapidly increasing population in this area raises concerns about the growing amount of impervious cover and subsequent potential for non-point source pollution.

#### Water Quality of the Stream

The lower Blanco River has no major tributaries to contribute to flow and sediment loading of the stream. High flow events are almost exclusively associated with flow contributions from segment 1813 or runoff from dry creeks within the segment. The median instantaneous **flow** of the CR 295 monitoring station, in segment 1809, was 66 cubic feet per second (cfs). However, the stream experienced wide swings in flow, from 18 cfs to 1270 cfs, throughout the period of record. Due to the bedrock substrate of the lower Blanco, total suspended solid (TSS) values are relatively low in this segment of the river. The median TSS value for the CR 295 station is 4.0 milligrams per liter (mg/L), with a maximum value of 83 mg/L during a high flow event. Sediment loading during high flows is often indicative of bacteria in the water column (figure 1) because storm water brings in bacteria and the high flows keep solids suspended in the water, which keep ultraviolet light from the sun from penetrating the water and killing the bacteria. The stream standard for contact recreation is a geometric mean of 126 organisms per 100 milliliters, and a single sample concentration of 394 organisms per 100 milliliters. The CR 295 monitoring location has a geometric mean *E. coli* concentration of 50 organisms per 100 ml (MPN/100 mL). This site exceeded

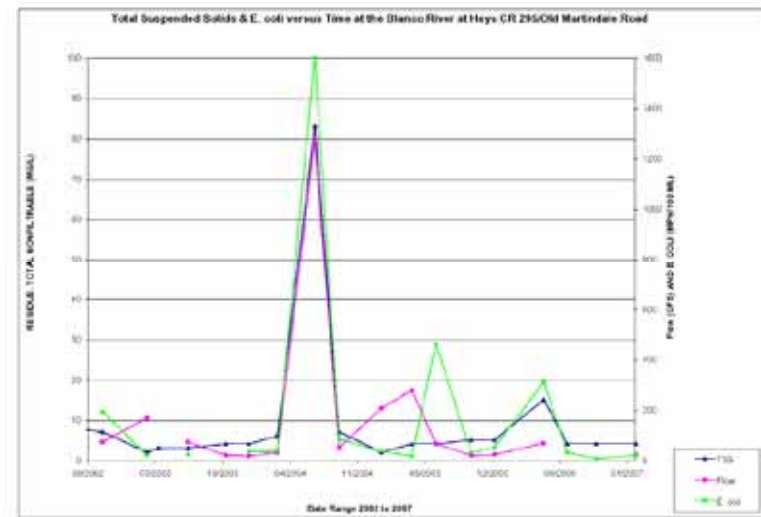


Figure 1. - Total suspended solids and *E. coli* over time at the TCEQ Blanco River at CR 295 (12631) monitoring location.



the stream contact recreation grab standard for *E. coli* two times throughout the period of record. Both events occurred during periods of high flows and the highest recorded *E. coli* number at this site, 1600 MPN/100ml, was recorded at the same time as the highest recorded total suspended solid concentration.

There are no permitted dischargers in segment 1809 of the Blanco River. The 2008 draft Texas Water Quality Inventory Report had no impairments or concerns listed for Segment 1809. The TCEQ CR295 monitoring site had median concentrations of conductivity, chloride and sulfate of 448 micromhos per centimeter, 13.0 milligrams per liter and 27.0 milligrams per liter respectively. The TCEQ site never exceeded the stream standard for chlorides or sulfates of 50 milligrams per liter (mg/L). The median concentration for dissolved oxygen is 8.6 mg/L, ranging from a minimum of 5.0 mg/L to a maximum of 11.1 mg/L at the TCEQ site at CR 295. The median pH value at this site was 7.8 and ranged from a low of 7.10 to a high of 8.30, never falling outside the stream standard range of 6.5 to 9 standard pH units.

Nitrate nitrogen, ammonia nitrogen and total phosphorus, were analyzed at the TCEQ CR 295 location. Over the period of record, nitrate nitrogen was reported under three STORET codes, as nitrate nitrogen and in combination with nitrite nitrogen. At the TCEQ site in the upper part of the segment, the median concentrations of nitrate for all three methods was 0.31 mg/L, ranging from 0.05 to 1.75 mg/L and never falling outside of the screening concentration of 1.95 mg/L. The median concentration for ammonia nitrogen was below the limit of quantification for the method and the maximum ammonia nitrogen value recorded at this site was 0.08 mg/L, which was well below the screening concentration of 0.33 mg/L. The median total phosphorus concentration at the TCEQ CR 295 site was below the limit of quantification for the method and had a maximum value of 0.12 mg/L, which was well below the screening concentration of 0.69 mg/L. The data from this monitoring station indicates that the quality of the water at this monitoring station is of excellent quality.

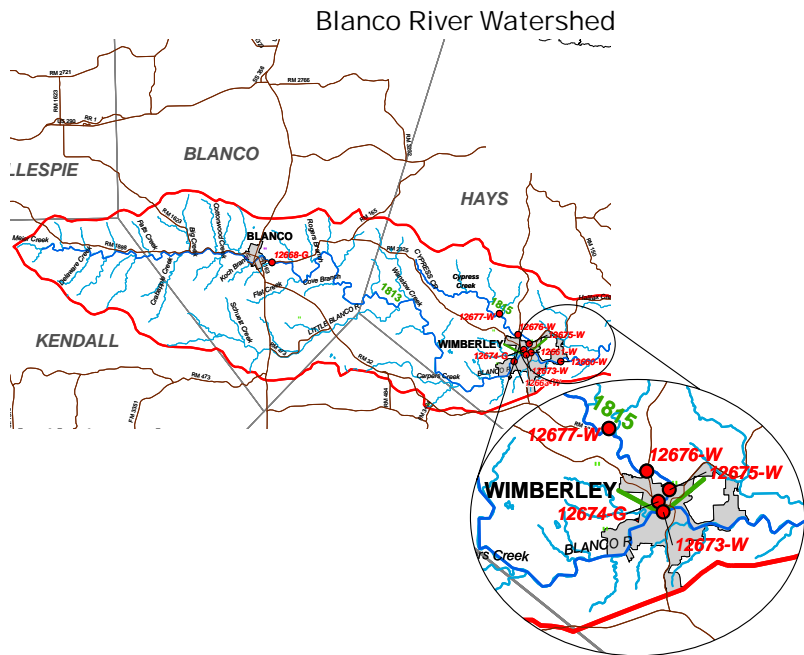
A trend analysis of all the data available in segment 1809 showed no significant changes over time. Although there are no signs to indicate diminishing water quality in this segment, it will be watched closely in the future, as urbanization continues to grow and more information becomes available to supplement the limited data set that is currently available.



Blanco River at SH 21 in San Marcos (upstream view).



Blanco River at SH 21 in San Marcos (downstream view).



Segment 1815, the Cypress Creek, extends from the confluence of the Cypress Creek and the Blanco River in the city of Wimberley, to the Jacob's Well, its headwaters, north of the city. The entire segment lies within Hays County. GBRA monitors the Cypress Creek at Ranch Road 12 ("RR 12"; Site no. 12674) quarterly. TCEQ monitored the RR 12 site quarterly from 1991 until GBRA assumed the quarterly monitoring in 1998. The Wimberley Valley Watershed Association (WVWA), with funding from the city of Wimberley, established a monitoring program on the Cypress Creek in 2003. The WVWA established their monitoring guidelines to comply with the Guadalupe River Basin Quality Assurance Project Plan so that the data that they collected could be submitted to the TCEQ database and used for stream assessments. More on the WVWA and the goals of their monitoring project can be found in the *Coordination and Cooperation* section of this report. The sites in the WVWA monitoring project include the Cypress Creek at Jacob's Well, the headwaters of the Cypress Creek; the Cypress Creek at Ranch Road 12, one mile north of the city of Wimberley; and the Cypress Creek at the confluence with the Blanco River. They added a new site, the Cypress Creek near the Blue Hole recreational area, in late 2005.

### Stakeholder Concerns

Stakeholders in the Cypress Creek watershed have raised three issues that they feel are impacting water quality. The issues include the small, overloaded septic tanks used by the businesses along the creek in the city which could be contributing bacteria to the stream. Another issue is the increased urbanization of previously unused areas which can bring in a variety of pollutants such as nutrients and suspended solids that can decrease oxygen in the stream, especially during periods

of low flow. Finally, the stakeholders are concerned by the increasing demand on the groundwater resources in the area which reduces the flows from Jacob's well which in turn reduces the oxygen in the stream as well as the water becomes more stagnant during times of low flow. These concerns are not unfounded as the limited data set on Cypress Creek (dissolved oxygen, *E. coli* and nutrients) shows later in this section.

### Wastewater Contributions

There is one wastewater plant in the watershed of the Cypress Creek. The Blue Hole wastewater plant is permitted to the city of Wimberley and GBRA, and is operated by GBRA. The facility disposes of the treated waste by subsurface irrigation at a volume not to exceed 15,000 gallons per day and at a rate that does not exceed 0.16 gallons per square foot. The permit allows for surface irrigation when the plant is expanded to 50,000 gallons per day. There is no permitted discharge to the waters of the Cypress Creek in either phase of operation. The Blue Hole plant has only one customer, a 122 -bed rehabilitation facility. The wastewater plant has been cited for being out of compliance due to biochemical oxygen demand concentrations that exceed the permitted amount. GBRA has been working to bring the plant into compliance. GBRA attributes the poor performance to the imhoff tank treatment process that is inadequate to treat the high organic waste being discharged by the rehabilitation hospital/nursing home. Because of the subsurface disposal method the high biochemical oxygen demand does not pose a threat to the water quality of the Cypress Creek. Some of the operating options that GBRA has been working on to bring the plant into compliance include working with the rehab hospital to lower the organic load by training their employees about what should be disposed of down the drains, pretreating the waste before it enters the imhoff tank and working with the city to build a new facility that would serve not only the rehab center but bring the area onto wastewater treatment. This final option would have the added benefit of taking downtown businesses along the creek off their failing septic tanks.

### Water Quality

The 2008 draft Texas Water Quality Inventory lists Cypress Creek with a concern for depressed dissolved oxygen. Out of 161 measurements, 35 fell below the screening criteria of 6.0 milligrams per liter (mg/L). The station located at Jacob's Well which is the headwaters of the creek has a median dissolved oxygen concentration of 5.9 mg/L, ranging from 3.8 to 7.9 mg/L. The water leaving the well, as expected for ground water, is low in dissolved oxygen, but over the period of time that data has been collected at the well we see a degrading trend in dissolved oxygen (figure 1).

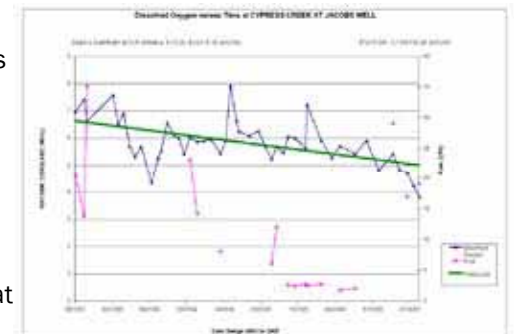


Figure 1. Dissolved oxygen over time at Jacob's Well (12677) on the Cypress Creek.



The WVWA site that is on RR12 has a median dissolved oxygen concentration of 6.9 mg/L, ranging from 3.0 to 9.13 mg/L. As the water in the creek travels downstream through the watershed it is aerated and the median concentration for dissolved oxygen goes up. The median concentration for dissolved oxygen at the GBRA RR12, further downstream, is 8.4 mg/L, ranging from 4.3 to 11.97 mg/L. Even though the median concentrations rise as the creek flows downstream, there is similar downward trend in dissolved oxygen over time at each site on the Cypress Creek as seen at Jacob's Well and may be linked with reduced flows from the well due to increased pressure on the groundwater.

The new monitoring site located near the Blue Hole recreational facility on Cypress Creek has a median dissolved oxygen concentration of 5.9 mg/L, ranging from 3.6 and 8.1 mg/L, but it has a very small data set compared to the other two sites downstream of Jacob's Well. This site was added by the WVWA in late 2005 after the park was purchased by the city of Wimberley. It is a location that is very important to the residents in the area, with historical, sentimental and ecological significance and warrants continued monitoring.

Considering all of the monitoring locations on the segment, the temperature varied between 11.1°C to 26.8°C, with a median temperature of 20.8°C. The **specific conductance** ranged between 376 and 712 micromhos per centimeter (umhos/cm), with a median conductivity of 542 umhos/cm. The median pH of the site was 7.61, ranging from 6.94 at the Jacob's Well site, to 9.0 at the GBRA RR12 location. The median concentrations for chloride and sulfate at the GBRA RR12 location were 14.2 and 17.3 respectively. At no time did the concentration of these dissolved constituents exceed the stream standard of 50 milligrams per liter.

Nitrate nitrogen, ammonia nitrogen and total phosphorus, were analyzed at all of the monitoring locations on the segment. Over the period of record, nitrate nitrogen was reported under three storet codes, as nitrate nitrogen and in combination with nitrite nitrogen. The median concentrations for all the locations ranged from 0.06 mg/L at the Blue Hole site, to 0.45 mg/L at the Jacob's Well location. When looking at the nitrate nitrogen concentrations over time, combining all methods, we see a slight upward trend and a positive correlation with flow. At no time did the nitrate nitrogen concentration, regardless of storet citing, exceed the screening criteria of 1.95 milligrams per liter. The median ammonia nitrogen concentration was below detection at all monitoring locations. The median total phosphorus concentration was below the limit of quantification for the method and when total phosphorus was detected in a sample, it did not exceed the screening concentration of 0.69 milligrams per liter.

Segment 1815 is a slow meandering stream with a bedrock substrate. The contact recreation stream standard, using *E. coli*, is a geometric mean of 126 organisms per 100 milliliters, and the single sample concentration of 394 organisms per 100 milliliters. The geometric mean for *E. coli* at the GBRA RR12 site is 125 organisms per 100 milliliters, just below the stream standard. In the period of record only two of the 40 measurements exceeded the single sample *E. coli* standard of 394 organisms per 100 milliliters. Often, *E. coli* concentrations rise with rises in flow due to storm water runoff. At the GBRA RR12 site, there are

periods where the inverse appears to be true (Figure 2). A possible explanation for this phenomenon could be that the contributions of *E. coli* from failing septic tanks in the city are more easily detected when the baseflow is not sufficient enough to dilute the bacteria.

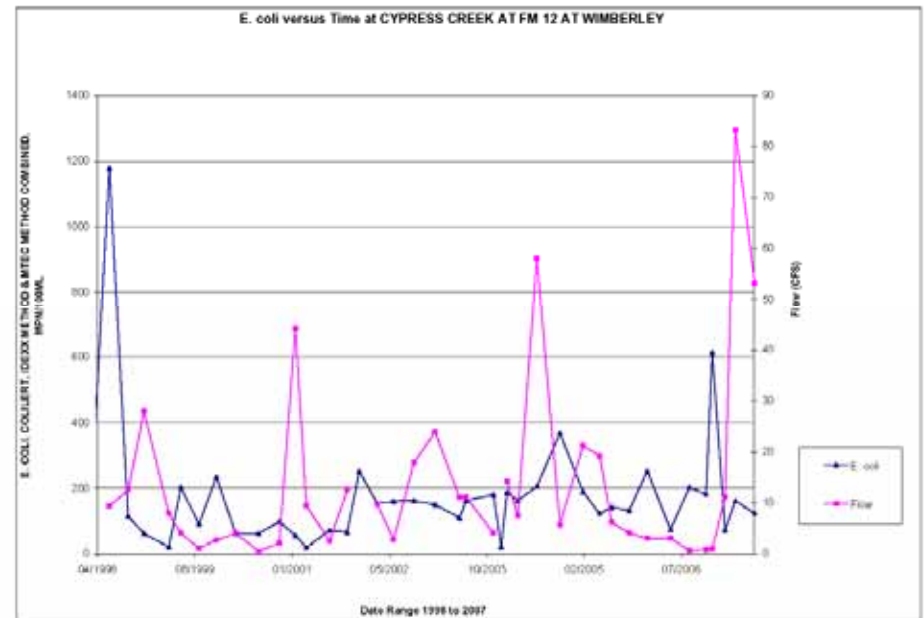


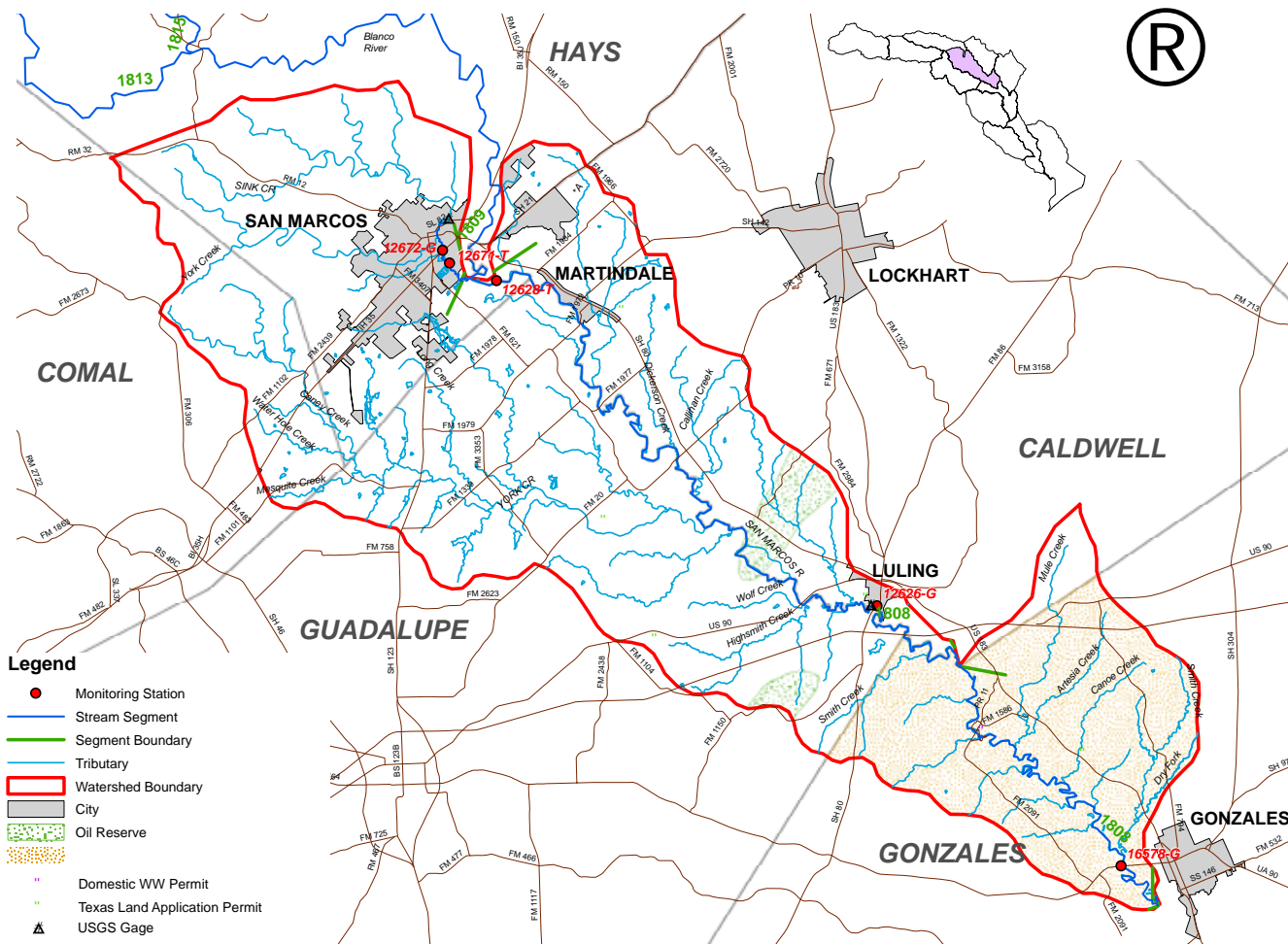
Figure 2. *E. coli* concentrations and flow over time at the Cypress Creek at FM 12 site (12674).

The suspended solids ranged from 1 to 35 milligrams per liter, with a median of 1.7 milligrams per liter. The median chlorophyll a concentration was less than detection and there was never a measured value above the screening concentration of 14.1 microgram per liter.



Cypress Creek at RR 12 in Wimberley (site no. 12674).

## San Marcos River Watershed



- Legend**
- Monitoring Station
  - Stream Segment
  - Segment Boundary
  - Tributary
  - ▭ Watershed Boundary
  - ▭ City
  - ▭ Oil Reserve
  - ▭ Domestic WW Permit
  - ▭ Texas Land Application Permit
  - ▭ USGS Gage

- Monitoring Stations – San Marcos River**
- 12672-G San Marcos River at IH 35 in San Marcos
  - 12671-T San Marcos River 0.7 m downstream of IH 35 in San Marcos
  - 12628-T San Marcos River downstream of confluence with Blanco River
  - 12626-G San Marcos River at Luling
  - 16578-G San Marcos River at SH 90A, near Gonzales

Sampling sites are labeled in red followed by the letter G (GBRA), T (TCEQ), U (UGRA) or W (Wimberley) indicating who is the monitoring entity.

### San Marcos River Watershed

**Drainage Area:** 522 square miles

**Streams and Rivers:** Lower San Marcos River, Upper San Marcos River, Sink Creek, York Creek

**Aquifers:** Edwards-Balcones Fault Zone, Carrizo-Wilcox

**River Segments:** 1814, 1808

**Cities:** San Marcos, Maxwell, Martindale, Fentress, Prairie Lea, Luling, Ottine, Gonzales

**Counties:** Hays, Guadalupe, Caldwell, Gonzales

**EcoRegion:** Edwards Plateau, Post Oak Savannah, Texas Blackland Prairies

### Vegetation Cover:

- Pasture/Hay - 27.0%
- Grass/Herbaceous - 16.3%
- Deciduous Forest - 19.0%
- Evergreen Forest - 12.8%
- Shrublands - 12.2%
- Row Crops - 8.6%

### Climate:

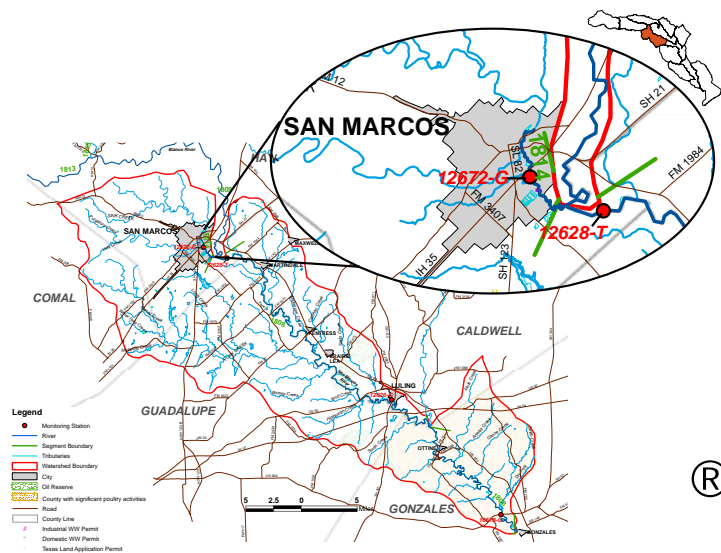
- Average annual rainfall: 33 inches
- Average annual temperature: January 40° July 96°

**Land Uses:** Urban, Industry, Agricultural Crops (corn, sorghum, hay, cotton, wheat, pecans), Cattle & Hog Production, Poultry Production, Oil Production, and Recreation

**Water Body Uses:** Aquatic Life Use, Contact Recreation Use, General Use, Fish Consumption Use, and Public Water Supply Use

**Soils:** Varies from thin limestone to black, waxy, chocolate, and grey loam

**Permitted Wastewater Treatment Facilities:**  
Domestic: 4, Land Application: 2, Industrial: 0



The San Marcos River is divided into two classified stream segments. Segment 1814, the upper San Marcos River, extends from the confluence of the San Marcos and Blanco Rivers, just outside the city of San Marcos, to the headwaters of the river in and around Spring Lake within the city. The segment is 4.5 miles long and is separated into four assessment units: the lower 1.5 miles; from that point to IH 35; from IH 35 to Spring Lake; and, the remaining portion of the segment to the headwaters. The lower San Marcos, segment 1808, is described in the following section. GBRA has been monitoring the San Marcos River at IH 35 (site no. 12672) quarterly since 1998. The GBRA site is located in the upper half of the segment, above the discharge of the city's wastewater treatment plant but below the city's downtown and business district. TCEQ has one historical site less than one mile downstream of the GBRA site that has data from 1991 to 1997. TCEQ monitored this site two to four times per year. There are other TCEQ sites in this segment but with very limited data sets.

#### Stakeholder Concerns

The stakeholders, primarily the San Marcos River Foundation, have asked that TCEQ locate a monitoring site downstream of the city's discharge. The closest monitoring station downstream of the discharge is at site no. 12629 (approximately 0.5 miles) but only four sampling events were conducted in 1999-2000. When asked at a basin steering committee meeting, representatives of the TCEQ Region 11 office explained the difficulty of getting public access for a monitoring site in close proximity and downstream of the wastewater treatment plant. The San Marcos River Foundation offered to assist in locating a landowner that could grant public access to the regional Surface Water Quality Monitoring team. TCEQ has a quarterly monitoring site that is 3 miles downstream of the city's discharge. The 44 data points span 1990 to 2007. Data from this site will be discussed in the next section on segment 1808.

#### Wastewater Contributions

In addition to the city of San Marcos's Wastewater Treatment Plant (WWTP), there is one other wastewater discharge to the segment. The Texas Parks and Wildlife Department's A.E. Wood Fish Hatchery manages a concentrated aquatic animal production general permit. The General Permit (TXG130005) requires measuring and reporting flow once daily; daily maximum total suspended solids of 90 milligrams per liter (mg/L) monitored once per month; dissolved oxygen of 5.0 mg/L monitored once per week; carbonaceous oxygen demand of 250 pounds per day maximum reported once per month and an ammonia daily maximum of 2.0 mg/L. The city of San Marcos wastewater plant is permitted to discharge 9 million gallons per day. After a lengthy court battle, the San Marcos River Foundation was successful in getting the city's effluent treated to a higher quality. The effluent must meet high quality standards of 5 mg/L biochemical oxygen demand, 5 mg/L total suspended solids, 2 mg/L ammonia-nitrogen and 1 mg/L total phosphorus. The wastewater plant utilizes ultraviolet light for disinfection and is allowed to discharge up to 200 organisms per 100 milliliter of fecal coliform bacteria. The wastewater plant has received authorization from the TCEQ to reuse the effluent for irrigation on golf courses and dust control, when possible. The Gary Job Corps Center (GJCC), located along this segment, no longer discharges treated wastewater to the San Marcos River. The GJCC discontinued its treatment of wastewater in 2000 and sends its raw wastewater to the San Marcos WWTP.

#### Endangered Species

The San Marcos River is home to the Texas Wild Rice and fountain darter, both endangered species. The constant temperature and consistent flow make the conditions conducive to these unique species as well as other native and non-native, aquatic flora and fauna. The Texas Wild Rice is in danger of being out-competed by an invasive non-native aquatic plant, cryptocoryne, also known as water trumpet. Water trumpet is a fast-growing rooted aquatic plant with no natural predators. In addition to the damage it poses to Texas Wild Rice, water trumpet is replacing the habitat that the fountain darter relies on. Removal or control of this invasive plant is difficult because it is found commingled with the wild rice. Gentle removal techniques, that are very labor intensive, have been employed so as to not uproot or damage the wild rice. The cryptocoryne is an example of the damage that can come from introduction of non-native species, in this case, most likely introduced by people disposing of the contents of their aquariums. Other species that are associated with the improper disposal of aquarium populations include looricarids (algae eaters), hydrilla and the giant ram's horn snail.

#### Water Quality

The stream segment is heavily influenced by springs from the Edwards Aquifer, located in the hills above the city and in Spring Lake. The springs discharge a median flow of 164 cubic feet per second. The flow from these springs keeps the temperature in the upper San Marcos River stable, at a median temperature of 22.8°C, ranging from 19.2 °C to 25.2°C. Figure 1 shows how stable the temperature of the upper San Marcos River is. The exception is during times of



prolonged drought as seen in 2006 where, in the data set collected by GBRA, the site experienced its historical maximum temperature and minimum flow. The inverse relationship between temperature and flow would not be unusual or alarming at most sites, but with the existence of the endangered species that live in this segment and rely on the consistency of temperature and flow, maintaining the flow from San Marcos Springs is critical to maintaining their habitat.

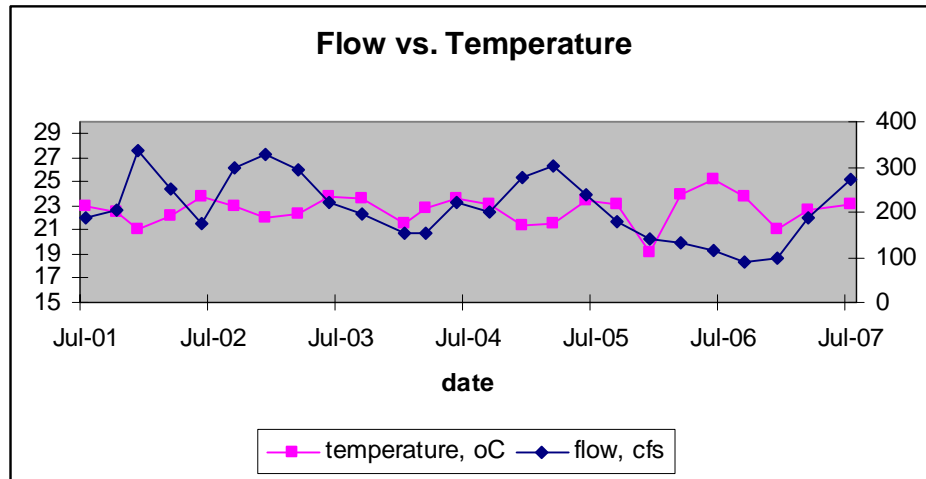


Figure 1. Flow and temperature collected by GBRA at the IH 35 site on the upper San Marcos River (12672).

The 2008 draft Texas Water Quality Inventory has no impairments or concerns listed for Segment 1814. The water quality at the GBRA and TCEQ monitoring sites is very good. The median concentration for dissolved oxygen is 9.35 mg/L, ranging from a minimum of 7.0 mg/L to a maximum of 13.0 mg/L. At no time in the period of record did the dissolved oxygen drop below the minimum dissolved oxygen standard (4.0 mg/L). The **specific conductance** ranged between 263 and 569 micromhos per centimeter, with a median conductivity of 425 micromhos per centimeter. The median pH was 7.67, ranging from 6.9 to 8.06 standard units, never falling outside the stream standard range of 6.5 to 9 standard pH units. The median concentrations for chloride and sulfate were 19.2 and 25.3 mg/L respectively. At no time did the concentration of these dissolved constituents exceed the stream standard of 50 mg/L.

Nitrate nitrogen, ammonia nitrogen and total phosphorus were analyzed at the GBRA and TCEQ locations. Over the period of record, nitrate nitrogen was reported under three storet codes, as nitrate nitrogen and in combination with nitrite nitrogen. The median concentrations for all three methods were 1.18, 1.13, and 1.23 mg/L, ranging from 0.29 to 2.26 mg/L. Regardless of storet code citing, only two samples exceeded the nitrate nitrogen screening criteria of 1.95 mg/L. The median ammonia nitrogen concentration, combining the GBRA and TCEQ sites, was 0.03 mg/L, ranging from 0.03 to 0.14 mg/L; never exceeding the screening concentration of 0.33 mg/L. The median total phosphorus concentration was below the limit of quantification for the method and when total

phosphorus was detected in a sample it did not exceed the screening concentration of 0.69 mg/L. The median chlorophyll a concentration is less than detection and there was never a measured value above the screening concentration of 14.1 microgram per liter.

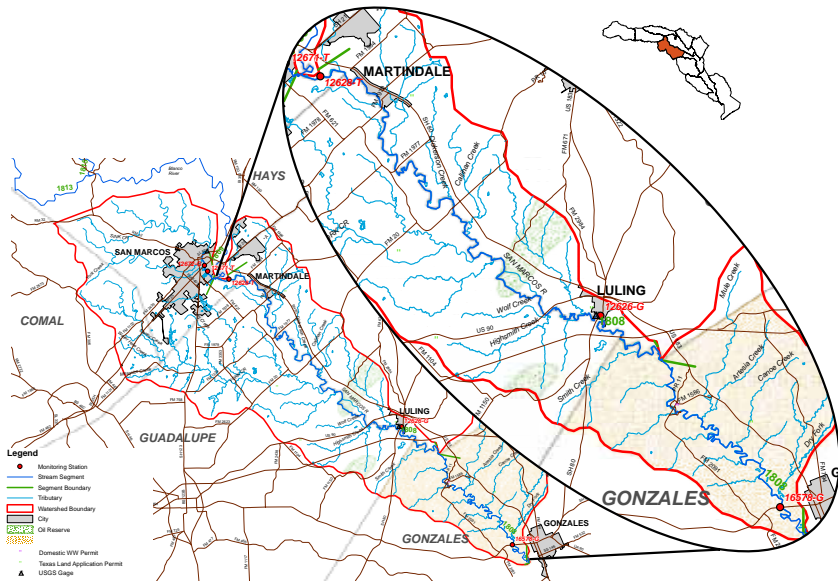
#### Water and Land Uses

Segment 1814 is known for its contact recreational opportunities. The clear, cool spring water attracts recreationists. The flows from the springs create excellent conditions for snorkeling, tubing and canoeing. The San Marcos River is home to the Texas Water Safari, one of the world's largest canoe races. The race attracts over 150 canoeing teams each June. The stream standard for contact recreation is a geometric mean of 126 organisms per 100 milliliters, and a single sample concentration of 394 organisms per 100 milliliters. The geometric mean for *E. coli* at the GBRA IH 35 site is 34 organisms per 100 milliliters. In the period of record no sample collected exceeded the single sample *E. coli* standard of 394 organisms per 100 milliliters. The TCEQ monitored their site for fecal coliform bacteria before a contact recreation standard was established for *E. coli*. The geometric mean for fecal coliform bacteria at the TCEQ site was 39 organisms per 100 milliliter (contact recreation standard for fecal coliform is a geometric mean of 200 organisms per 100 milliliters), with only one sample exceeding the single sample standard of 400 organisms per 100 milliliters.



The land use in the segment consists of a highly urbanized area above the two monitoring locations and urban area to large tracts of farmland below the two monitoring sites. Many of these family farms are being sold and subdivided, so you are beginning to see more roof tops in the watershed than cows. The impervious cover created by these urbanized areas and subdivisions, i.e. streets, rooftops and parking lots, can be a source of nonpoint source pollution. Because of the impervious cover, the pollutants that might be captured and bio-degraded by soils, are instead readily washed over cement and pavement, directly into the surface water bodies. The suspended solids at the two monitoring sites ranged from 1 to 32 mg/L, with a median of 3 mg/L. The sediment at the GBRA monitoring location in this segment is slated for organics analysis in 2008-09, specifically looking for the constituents associated with urban environments, such as polyaromatic hydrocarbons.

The historical data from the two monitoring sites was reviewed for trends, comparing constituents over time and flow regimes. Statistically significant trends that were noted, either positive or negative, were not indicative of degrading water quality conditions.



The San Marcos River is divided into two classified stream segments. Segment 1808, the **lower San Marcos River**, extends from the confluence of the San Marcos and Guadalupe Rivers, just outside the city of Gonzales, upstream to the confluence with the lower Blanco River near the city of San Marcos in Hays County. The segment is 75 miles long and is separated into four assessment units: the lower 18 miles; from the confluence with Mile Creek to the confluence with Plum Creek; from the confluence with Plum Creek to the Guadalupe County Road 239; and, the remaining portion of the segment to the confluence with the Blanco River. The upper San Marcos, segment 1814, is described in the preceding section. GBRA has been monitoring the San Marcos River at Luling (site no. 12626) monthly since 1987 and at the San Marcos at SH 90A (site no. 16578) quarterly since 1999. The GBRA Luling site is located in the upper half of the segment, in the third assessment unit. The GBRA 90A site is in the lowest most assessment unit, just upstream of the confluence with the Guadalupe River. TCEQ has one historical site located just downstream of the confluence with the Blanco River in Hays County (site no. 12628). TCEQ monitors this site two to four times per year. There are other TCEQ sites in this segment but with very limited data sets. The statistical review of the data covered the three historical sites described above.

#### Stakeholder Concerns

At a Guadalupe River Basin Steering Committee meeting the stakeholders, primarily the San Marcos River Foundation, asked that TCEQ locate a monitoring site downstream of the city of San Marcos' discharge. Representatives from the TCEQ Region 11 office explained the difficulty of getting public access for a monitoring site in close proximity and downstream of the wastewater treatment plant. The San Marcos River Foundation offered to assist in locating a landowner that could grant public access to the regional Surface Water Quality Monitoring team. The TCEQ's monitoring site in segment 1808 is 3 miles downstream of the city's discharge.

In addition to the city of San Marcos's Wastewater Treatment Plant (WWTP) located in the upper segment, there is one other wastewater discharge to the segment. The city of Luling's south plant discharges to the San Marcos River and is permitted to discharge up to 500,000 gallons per day. The facility is permitted to discharge total suspended solids of 20 milligrams per liter (mg/L), 20 mg/L biochemical oxygen demand, and ammonia-nitrogen of 2.0 mg/L.

The lower San Marcos River has two major tributaries that contribute flow and loading to the stream, the Blanco River and Plum Creek. The lower segment does not have the endangered species that are found in the upper segment. The median **instantaneous flow** of the uppermost station in segment 1808 was 226 cubic



feet per second (cfs) which is made up of the combined flow of the San Marcos River and the Blanco River as measured at the USGS gages. There are very little contributions of flow downstream of the Blanco to Luling so the concentrations of dissolved constituents remain relatively unchanged. The median concentrations for conductivity, chloride and sulfate are 553 micromhos per centimeter, 18.5 milligrams per liter and 26 milligrams per liter respectively at the TCEQ site just downstream of the Blanco River. The GBRA Luling site had median concentrations

of conductivity, chloride and sulfate of 552 micromhos per centimeter, 24.6 milligrams per liter and 28.7 milligrams per liter respectively.

Moving downstream, comparing the GBRA site at 90A to the GBRA Luling site, there is evidence of impacts to water quality by Plum Creek. The median instantaneous flow at the GBRA site at SH 90A was 415 cfs, made up of the combined flows of the San Marcos River and Plum Creek, increasing the median flow upstream at the Luling site. The city of Luling's wastewater treatment plant contributes less than 1.5 cfs to the San Marcos River. The GBRA 90A site had median concentrations of conductivity, chloride and sulfate of 610 micromhos per centimeter, 43.4 milligrams per liter and 35.1 milligrams per liter respectively. The GBRA Luling site exceeded the stream standards for both dissolved constituents only once as well (Cl - 56.5 mg/L and SO4 - 63.8 mg/L). But, at the GBRA 90A site downstream of the confluence with Plum Creek, the standard for chlorides was exceeded 20% of the time, ranging from 18.4 to 135 mg/L. The stream exceeded the standard for sulfate two times in the period of record. Plum Creek contributes nutrients and bacteria to the San Marcos River as well. A more detailed discussion of the water quality can be found in the section on Plum Creek.

Looking at each site individually and reviewing the data for trends, the conductivity shows a positive trend over time at the uppermost site as well as the GBRA Luling site (figures 1 and 2). Although there was statistically significant data for more than one dissolved constituent that explained the slight rise over time in the conductivity at the uppermost site, the rise in conductivity at the Luling site is most likely due to a rise in sulfate (figure 3).

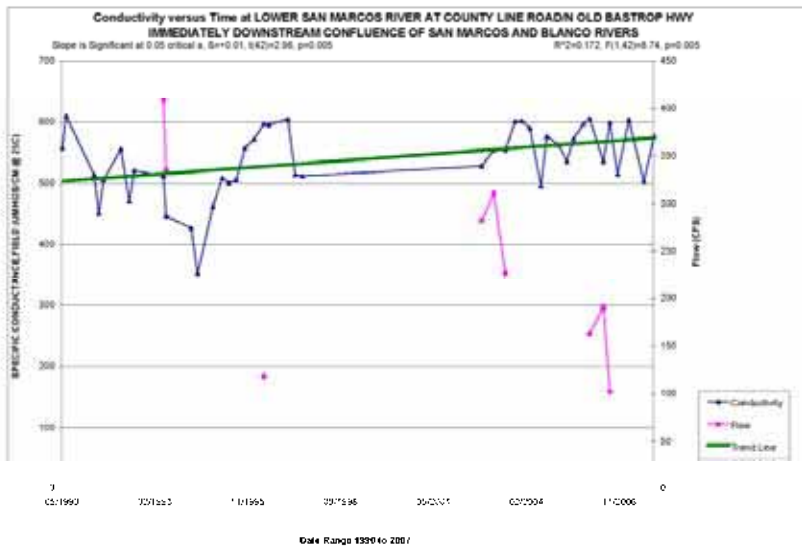


Figure 1. Rise in conductivity at the uppermost monitoring location on the lower San Marcos River (12628).

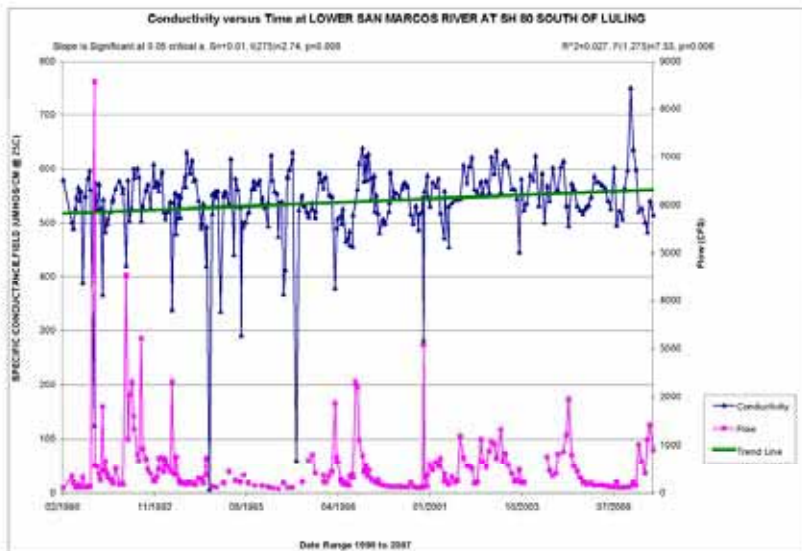


Figure 2. Rise in conductivity over time at the GBRA Luling site on the San Marcos River (12626).

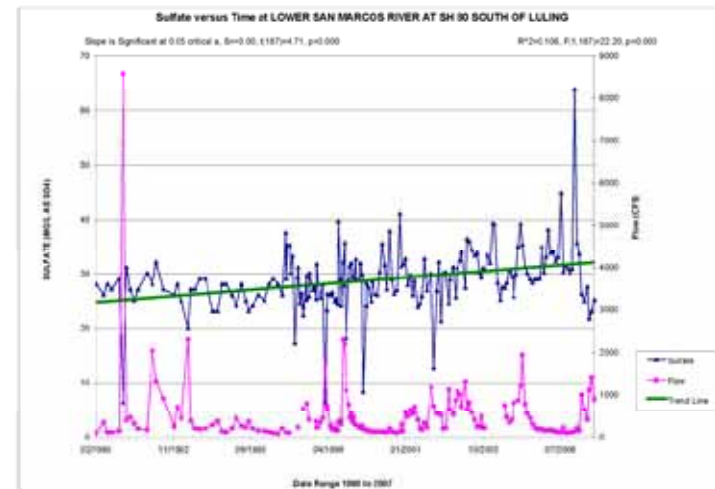


Figure 3. Rise in sulfate concentration over time at the San Marcos River at Luling (12626).

The 2008 draft Texas Water Quality Inventory has no impairments or concerns listed for Segment 1808. The median concentration for dissolved oxygen is 9.0 mg/L, ranging from a minimum of 7.4 mg/L to a maximum of 10.8 mg/L at the TCEQ site below the confluence with the Blanco River. At the GBRA Luling site, the median concentration for dissolved oxygen was slightly lower at 7.99 mg/L, ranging from a minimum of 5.2 mg/L to a maximum of 21.0 mg/L. The median concentration for dissolved oxygen was 8.81 mg/L, ranging from a minimum of 5.8 mg/L to a maximum of 11.7 mg/L at the GBRA 90A site. At no time in the data sets of all three monitoring locations did the dissolved oxygen drop below the minimum dissolved oxygen standard (3.0 mg/L). The median pH values at the three sites were 7.8, 7.8 and 7.99, upstream to downstream, and ranged from a low of 7.13 to a high of 9.34, falling outside the stream standard range of 6.5 to 9 standard pH units one time at the GBRA Luling site.

The moderating effect of the San Marcos Springs on water temperature in the upper segment is lost as the stream flows downstream through the watershed. The median temperature of the TCEQ site downstream of the Blanco was 23°C, ranging from 17.6°C to 27.7°C. The median temperature at the GBRA Luling site was 22.8°C, ranging from 8.4°C to 31.5°C, and the median temperature at the GBRA 90A site was 22.2°C, ranging from 12.1°C to 30.3°C.

Nitrate nitrogen, ammonia nitrogen and total phosphorus, were analyzed at the GBRA and TCEQ locations. Over the period of record, nitrate nitrogen was reported under three storet codes, as nitrate nitrogen and in combination with nitrite nitrogen. At the TCEQ site in the upper part of the segment, the median concentrations for all three methods were 0.9, 1.1, and 1.28 mg/L, ranging from 0.42 to 1.88 mg/L. Moving downstream to the GBRA Luling site, the median concentrations for all three methods were 0.71, 1.06, and 1.25 mg/L, ranging from 0.18 to 8.51 mg/L, falling outside of the screening concentration of 1.95 mg/L three times. In the lower portion of the segment, the median concentrations for all three methods were 0.66, 1.02, and 1.03 mg/L, ranging from 0.38 to 1.83 mg/L. The median ammonia nitrogen concentration, at both GBRA sites, was 0.04 mg/L,



ranging from less than detection to 0.30 mg/L; never exceeding the screening concentration of 0.33 mg/L. The median concentration for ammonia nitrogen of 0.07 mg/L at the TCEQ site was slightly higher than the downstream stations, and exceeded the screening concentration of 0.33 mg/L one time. The difference in the median concentrations may be from contributions from the wastewater treatment plant discharge 3 miles upstream, though the impact is not significant enough to cause the stream to exceed the screening concentration of 0.33 mg/L more than one time. The median total phosphorus concentrations were 0.06, 0.09 and 0.10 mg/L, from upstream to downstream respectively, and ranged from below the limit of quantification for the method to 1.38 mg/L. The concentration of total phosphorus exceeded the screening concentration of 0.69 mg/L five times at the TCEQ site. Again, the source of the nutrient may be coming from the wastewater discharge that is within 3 miles of the sampling site. Other possible sources of the nutrients can be from nonpoint sources such as stormwater off of fertilized fields.

A review of the nutrient data for trends over time at the TCEQ site show statistically significant downward trends in total kjeldahl nitrogen (TKN) and total phosphorus (figures 4 and 5). TKN is a combination of organic nitrogen and ammonia nitrogen. TKN and total phosphorus are both nutrients that are constituents of wastewater

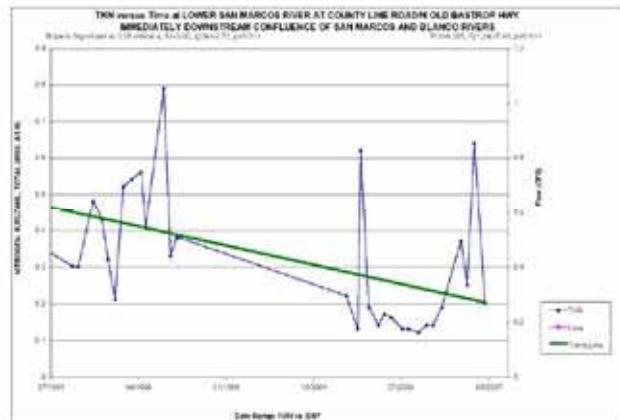


Figure 4. Total Kjeldahl Nitrogen versus time at the San Marcos River at Old Bastrop Highway (12628) (No flow data was available for this data set).

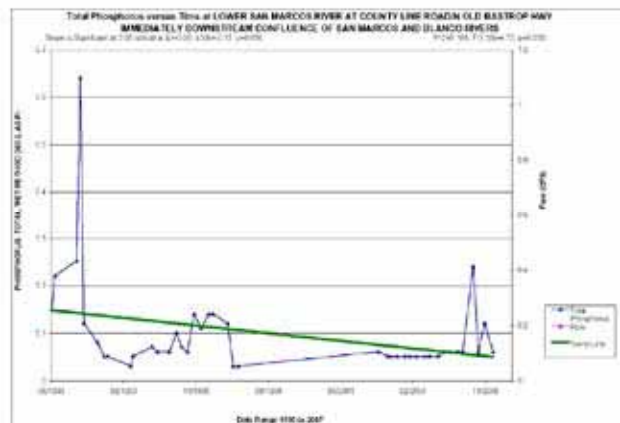


Figure 5. Total Phosphorus versus time at the San Marcos River at Old Bastrop Highway (12628) (No flow data was available for this data set).

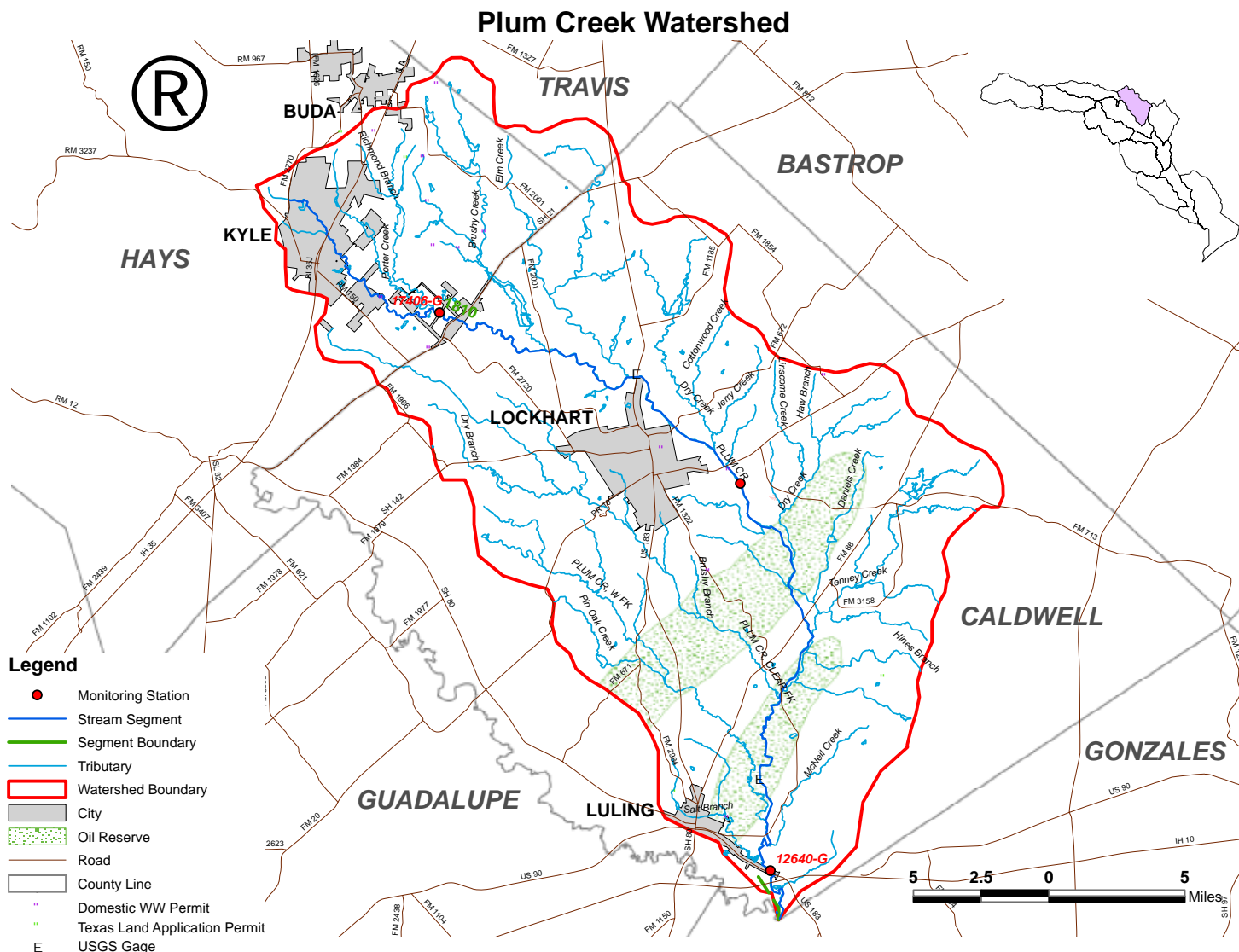
effluent. The downward trend in these nutrients could be a result of the improved level of wastewater treatment by the city of San Marcos plant or it could just be the result of a change in detection level for each method in 1997.

Segment 1808 is known for its contact recreational opportunities. The flows in the river create excellent conditions for snorkeling, tubing and canoeing. The San Marcos River is home to the Texas Water Safari, one of the world's largest canoe races. The race attracts over 150 canoeing teams each June. Additionally, it was in this segment that the Texas Parks and Wildlife Department opened their first Paddling Trail. The Luling Paddling Trail begins at the river crossing at SH 90 west of Luling and ends at the Zedler Mill in the city. The stream standard for contact recreation is a geometric mean of 126 organisms per 100 milliliters, and a single sample concentration of 394 organisms per 100 milliliters. The TCEQ monitored for fecal coliform bacteria at their site before a contact recreation standard was established for *E. coli*. The geometric mean for fecal coliform in the small data set was 89 organisms per 100 milliliters (contact recreation standard for fecal coliform is a geometric mean of 200 organisms per 100 milliliters), and the geometric mean for *E. coli* was 101 organisms per 100 milliliter after the parameter was changed. Two samples exceeded the single sample standard of 400 organisms per 100 milliliters for fecal coliforms and exceeded the single sample standard for *E. coli* three times. At the GBRA Luling site, the geometric mean for *E. coli* was 55 organisms per 100 milliliters, exceeding the single sample standard 8 times. At the lower portion of the segment, the geometric mean for *E. coli* was 98 organisms per 100 milliliters, exceeding the single sample standard four times, all of which were during high flow events. The higher concentration of bacteria at high flows is not unusual because storm water brings in bacteria and for a period of time after the storm event, the high flows keep solids in suspension and shade ultraviolet light from the sun from penetrating the water and killing the bacteria.

The land use in watershed that drains to the segment consists of mostly large farms and ranch land. The contributions of bacteria from agricultural activities that have been recognized in other parts of the state as being a significant source of the load in impaired streams are not seen in segment 1808 but this may be because the median flow in the San Marcos River can assimilate those contributions. But, as with other areas in the basin as well as the state, these family farms are being sold and subdivided, so you will begin to see more roof tops in the watershed than cattle, and those cattle in much more concentrated areas. With urban sprawl comes more impervious cover, more runoff and more pollutant loading.

A review of the data for suspended solids at each location shows no significant trend over time, or, if there was a slight trend, it was negative, i.e. a reduction in total suspended solids, over time. Looking at the segment as a whole, the median concentration of suspended solids increases as you move downstream, beginning at 8 mg/L at the uppermost site, going to 17.2 mg/L at the GBRA Luling site and then to 31.6 mg/L at the downstream site at SH 90A.

The median chlorophyll a concentration is less than detection and there was never a measured value above the screening concentration of 14.1 microgram per liter.



Monitoring Stations – Plum Creek	
17406-G	Plum Creek at Plum Creek Road near Uhland
12647-T	Plum Creek at CR 202, Old McMahon Bridge, downstream of Lockhart
12640-G	Plum Creek at FM 135, near Luling

- Legend**
- Monitoring Station
  - Stream Segment
  - Segment Boundary
  - Tributary
  - ▭ Watershed Boundary
  - ▭ City
  - ▭ Oil Reserve
  - Road
  - County Line
  - Domestic WW Permit
  - Texas Land Application Permit
  - USGS Gage
  - E

Sampling sites are labeled in red followed by the letter G (GBRA), T (TCEQ), U (UGRA) or W (Wimberley) indicating who is the monitoring entity.

**Plum Creek Watershed**

**Drainage Area:** 397 square miles

**Streams and Rivers:** San Marcos River, Plum Creek, Clear Fork Creek

**Aquifers:** Edwards-Balcones Fault Zone, Carrizo Wilcox

**River Segments:** 1810

**Cities:** Kyle, Buda, Uhland, Luling, Lockhart

**Counties:** Hays, Travis, Caldwell

**EcoRegion:** Texas Blackland Prairies, Post Oak Savannah

**Vegetation Cover:**

- Deciduous Forest - 23.6%
- Pasture/Hay- 22.9%
- Grass/Herbaceous - 22.4%
- Row Crops - 14.4%
- Shrublands - 11.4%

**Climate:**

- Average annual rainfall: 33 inches
- Average annual temperature: January 40° July 95°

**Land Uses:** Industry, Urban, Oil & Gas Production, Cattle, Hog and Poultry Productions, Agriculture Crops (sorghum, hay, cotton, wheat and corn)

**Water Body Uses:** Aquatic Life Use, Contact Recreation Use, General Use, Fish Consumption Use

**Soils:** Black, waxy soil to sandy soil, limestone to black waxy chocolate and grey loam

**Permitted Wastewater Treatment Facilities:**

- Domestic: 10
- Land Application: 0
- Industrial: 0

Plum Creek, Segment 1810, has its headwaters in Hays County near the city of Kyle. The creek travels through Hays and Caldwell Counties and confluences with the San Marcos River near the city of Luling. The stream has been assessed by TCEQ and is listed on the 2008 draft Texas Water Quality Inventory as impaired for bacteria, with concerns for nutrients, including nitrate nitrogen, ammonia nitrogen, orthophosphate and total phosphorus. Additionally, it is listed with a concern for dissolved oxygen at the minimum grab concentration of 3.0 milligram per liter (mg/L). The stream is broken into three assessment units: from the confluence with the San Marcos River to 2.5 miles upstream of the confluence with Clear Fork Plum Creek; from that point to 0.5 mile upstream of the crossing with SH 21; and, from that point to the upper end of the segment.

### The Upper Plum Creek watershed



The stream begins in an area of rapid development along the IH 35 corridor, between the cities of Kyle and Buda. The stream is made up of flow from several tributaries such as Andrews Branch, Porters Creek and Bunton's Branch. These streams receive wastewater discharges from the city of Kyle's wastewater plant (WWTP), the city of Buda's wastewater plant and several smaller plants that serve new subdivisions just beginning to develop. In

the upper portion of the watershed, there are eight wastewater plants that are constructed and currently permitted to discharge a total of over three million gallons per day, the largest facility of which is the city of Kyle's WWTP at 1.5 MGD. Most of these facilities are permitted with future phases that when all the plants reach their final capacity will total over 10 MGD. The permit limits for the majority of the facilities in the upper portion of the watershed are 10 mg/L biochemical oxygen demand, 15 mg/L total suspended solids and 3 mg/L ammonia-nitrogen. The effluents of the city of Buda, and the Sunfield and Shadow Creek developments have limits for total phosphorus of 1.2 mg/L, 1.0 mg/L and 1.0 mg/L respectively. These facilities all utilize chlorine for disinfection.

In addition to urban areas, this portion of the watershed includes agricultural land and areas that have been known to have old, failing or inappropriately built septic tanks, according to the Hays County Environmental Health Office. In addition to these sources of nonpoint source contributions of bacteria, pet waste is considered a source of *E. coli* as well.

GBRA maintains a routine monitoring location in the upper assessment unit located at the crossing of the creek at Plum Creek Road near the community of Uhland. Uhland is not served by a municipal wastewater system at this time. A

review of the historical data from the Plum Creek at Plum Creek Road site (site no. 17406) shows trends of diminishing water quality. The most prominent water quality concerns are for nutrient and bacteria concentrations. Figure 1 shows the upward trend in total phosphorus concentrations over time. In this figure the inverse relationship between flow and phosphorus can also be seen.

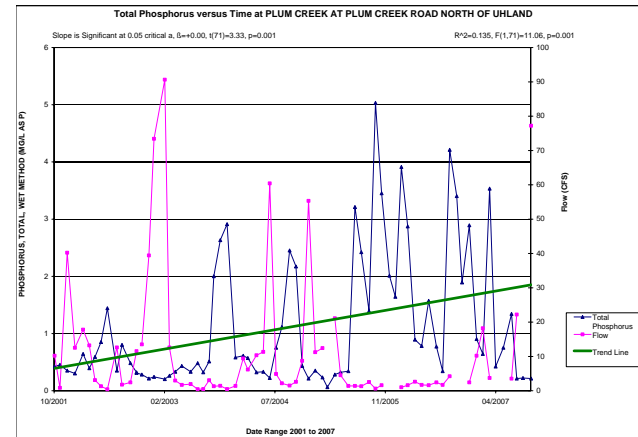


Figure 1. At the GBRA monitoring location at Plum Creek at Plum Creek Road (17406) near Uhland, there is an inverse relationship between flow and total phosphorus.

This relationship exists because the stream is effluent dominated and as more wastewater effluent is added to the creek the phosphorus will continue to rise. The median concentration of total phosphorus was 0.56 mg/L, ranging from less than method detection to 5.02 mg/L. 42% of the time the data for total phosphorus fell above the screening concentration of 0.69 mg/L. Nitrate nitrogen shows an increasing trend over time (figure 2). The median concentration for nitrate nitrogen was 2.28 mg/L, ranging from 0.22 to 19.8 mg/L, exceeding the screening concentration 50% of the time. Spikes in nitrate concentrations appear to be linked to low flow periods when the stream is effluent dominated. Total phosphorus and nitrate nitrogen are of concern because of the potential for promoting nuisance algal blooms that can deplete oxygen in the stream, especially in the early morning hours, degrading the habitat for fish and aquatic invertebrates.

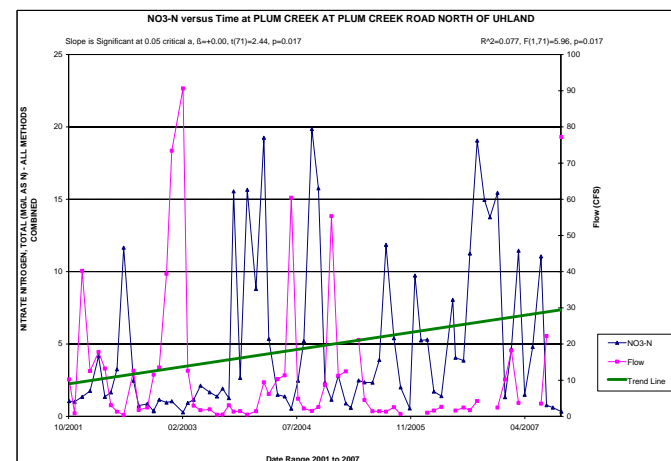


Figure 2. Concentration of nitrate nitrogen showing an increasing trend over time at the Plum Creek at Plum Creek Road (17406). Spikes attributed to periods of low flow when the stream becomes dominated by wastewater effluent.

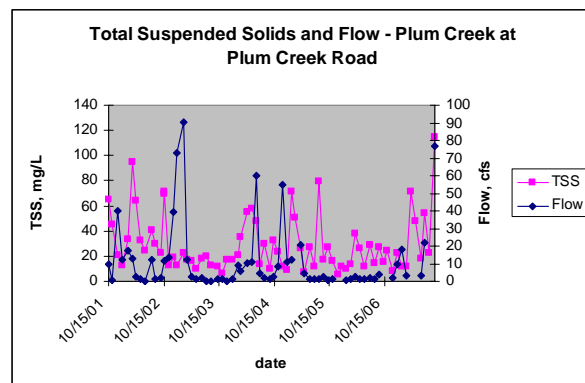


Ammonia nitrogen exceeded the screening concentration 13% of the time but of more concern was the magnitude of the exceedences. Three of the five sampling events that exceeded the 0.33 mg/L screening concentration for ammonia nitrogen were greater than 10 mg/L. Ammonia nitrogen is a concern because of its toxicity to fish. Because of the effluent dominance of the stream, the most logical source of these nutrients is wastewater discharge but other sources of nutrients should be considered such as runoff carrying fertilizers from agricultural fields and lawns and organic wastes from animals such as livestock, pets and wildlife.

This portion of the stream is impaired by fecal bacteria, including *E. coli*. The geometric mean of the *E. coli* concentrations was 239 organisms per 100 milliliters which exceeds the stream standard for contact recreation of 126 organisms per 100 milliliters. 18 of the 72 sampling events for *E. coli* exceeded the single sample grab standard of 394 organisms per 100 milliliters. The concern for these violations of the stream standard for contact recreation is there but reduced, recognizing the low potential for contact recreation at the site.

The temperature ranged from 6°C to 28.1°C at the Plum Creek Road site, with a median temperature of 20.8°C. The pH ranged from 7.0 to 8.18, with a median value of 7.81. The median dissolved oxygen concentration was 7.27 mg/L, ranging from 2.2 to 14.1 mg/L. The stream standard for dissolved oxygen for this segment is 5.0 mg/L and the minimum dissolved oxygen standard is 3.0 mg/L. The stream was at or below 5.0 mg/L eight times out of 75 sampling events and below 3.0 mg/L four times.

Total suspended solids (TSS) and turbidity have an atypical inverse relationship with flow at the Plum Creek Road location (figure 3). TSS can be suspended materials that includes algal cells, organic material and sediment brought in by rainfall runoff from fields and construction sites. A possible explanation for the elevated solids concentrations during the lowest period of flow in 2005 through 2006 could be the increased density of the water due to high dissolved solids which would cause the lighter particles to remain in suspension, to be measured as turbidity and TSS. The median conductivity during this period was 1136 umhos/cm. The median conductivity for the entire period of record was 836 umhos/cm, ranging from 404 to 1315 umhos/cm. The increase in dissolved solids during low flows can be attributed to contributions from groundwater sources



that have elevated dissolved solids or from wastewater effluent.

Figure 3. Total suspended solids at the GBRA site located at Plum Creek at Plum Creek Road (17406). Lightweight particles remain in suspension during low flows, possibly due to increase water density with increase in concentration of dissolved solids during these periods.

### The Middle Plum Creek Watershed

The water quality of the middle portion of segment 1810, Plum Creek, is represented by the data collected by TCEQ at their quarterly monitoring site at CR 202 (site no. 12657), southeast of the city of Lockhart. The middle portion of the creek flows through agricultural cropland, pastureland and the urbanized areas in and around the city of Lockhart. There is some ground water recharge by the stream near the Hwy 183 north of Lockhart. Additionally, it is near this area that oil and gas production begins to become a dominant land use.

The city of Lockhart, as well as Caldwell County, are primed for growth over the next few years as construction of the SH 130 tollway and its spur 45, bring traffic into the area. The Texas Department of Transportation is constructing a mitigation wetland near the creek and Hwy 183. The area will include walking and bike trails, learning kiosks and birding trails. The area is strictly to mitigate lost wetlands during construction of SH130. Water quality was not considered in the design though it will capture flood waters that would normally inundate Plum Creek, and slow water down as it travels through weirs. There is no way to pump water from Plum Creek to supplement the wetlands in times of drought.

The creek receives wastewater effluent discharged from the city of Lockhart's two WWTP, whose combine permitted volume is 2.6 MGD. Neither plant have effluent limits for phosphorus but do have an effluent limit for ammonia nitrogen of 3.0 mg/L. The effluents must meet a carbonaceous oxygen demand of 10 mg/L and total suspended solids of 15 mg/L. The Lockhart Larremore facility, located in the city, uses chlorine to disinfect the effluent. The Lockhart FM 20 facility, located outside the city and upstream of the TCEQ monitoring location, uses ultraviolet light to disinfect the effluent and must analyze the effluent for fecal coliform bacteria daily.

The median **flow** at the TCEQ site at CR 202 (23.2 cubic feet per second) is approximately two times the flow at the upstream site that is monitored by GBRA. Even though there is loss of flow to recharge upstream of Lockhart, the additional flow from groundwater springs that are located in and near the city are sufficient and consistent enough to double the flow at the TCEQ site. These springs, according to local citizens, are not known to go dry, even in driest periods. The springs are thought to originate from the Leona formation that is known for elevated nitrate nitrogen.

The median conductivity at the TCEQ CR202 site is 868 umhos/cm, ranging from 43.9 to 1030 umhos/cm. There was a period of six months in late 2001 (3 sampling events ranging from 43.9 to 96.2 umhos/cm) that had unusually low conductivities. There are no recorded flows for those sampling events that can be reviewed to see if stormwater may have diluted background salt concentrations. The median temperature at the TCEQ site was 23.2°C, ranging from 11.8°C to 28.3°C. The median pH was 7.9, ranging from 7.33 to 8.2, not falling outside the range of the pH stream standard.

The median concentration for total suspended solids was 19 mg/L, ranging from 5 to 502 mg/L. There is limited flow data available but what information

is available shows that the TSS increases with increases in flow associated with storm events. The inorganic constituents, chloride and sulfate, had median concentrations of 82 mg/L and 78 mg/L respectively, never exceeding the stream standard for these constituents of 350 mg/L and 150 mg/L.

Nitrate nitrogen, ammonia nitrogen, orthophosphate and total phosphorus were measured at the TCEQ site at CR202. The nitrate nitrogen was analyzed alone and in combination with nitrite nitrogen. The median concentration was 7.43 mg/L, ranging from 0.49 to 14.2 mg/L and exceeding the stream screening criteria of 1.95 mg/L 24 out of 27 measurements. The sources of the nitrates at this location are most likely the springs that originate from the Leona formation as well as wastewater effluent. Ammonia nitrogen ranged from less than method detection to 0.1 mg/L, with a median concentration that was less than method detection. The concentrations that were measured never exceeded the stream screening criteria of 0.33 mg/L.

Figure 4 shows that 50% of the total phosphorus measurements were at or above the screening concentration of 0.69 mg/L. The median concentration was 0.685 mg/L, ranging from 0.14 to 1.33 mg/L. The TCEQ also included orthophosphate, which is phosphorus in the dissolved form, in their list of analytes measured at their quarterly site. 17 of the 24 sampling events for orthophosphate exceeded the screening criteria of 0.37 mg/L. The median concentration was 0.64 mg/L, ranging from less than method detection to 1.25 mg/L. Comparing the total and orthophosphate concentration in Figure 4, it appears that in almost every case the majority of the total phosphorus was in the dissolved form, pointing to wastewater effluent or fertilizer, rather than phosphorus associated with algal cells or suspended sediment. Sources of dissolved and total phosphorus include wastewater effluent, storm water that carries in fertilizers and organic material, and failing septic tanks.

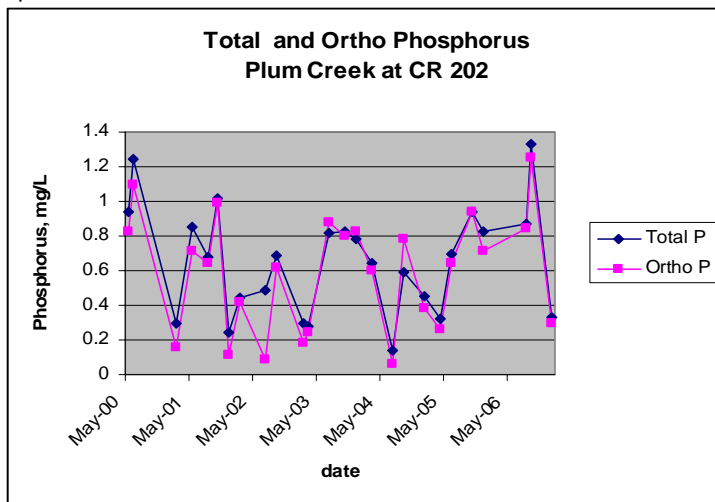


Figure 4. Phosphorus, as total and in the dissolved form, over time at the Plum Creek at CR 202 site (12647). The majority of the phosphorus was in the dissolved form.

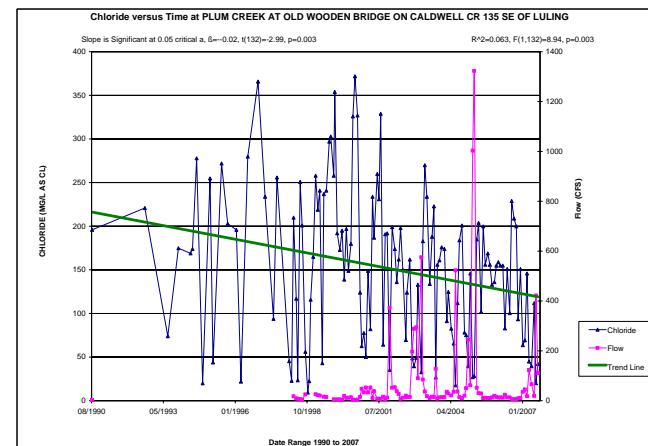
Confirming the bacterial impairment identified in the 2008 draft Texas Water Quality Inventory, the geometric mean for fecal coliform at the TCEQ site was 231 organisms per 100 milliliters (org/100mL), exceeding the contact recreation standard for fecal coliform of 200 org/100mL. *E. coli* was also quantified and the geometric mean (117 org/100mL) came close but did not exceed the standard of 126 org/100mL. Two sampling events for each group of bacteria exceeded the single sample grab standard for the respective parameter.

No sampling events measured chlorophyll a greater than the method detection used by the TCEQ laboratory.

#### The Lower Plum Creek

The land use in the lower Plum Creek watershed is primarily agricultural crop and pastureland, forests, with a heavy concentration of oil and gas production activities. The only urbanized area is the city of Luling where the creek confluences with the San Marcos River. The city of Luling discharges wastewater to a tributary of the lower Plum Creek. The plant is designed to discharge up to 0.9 MGD, with quality limits of 10 mg/L carbonaceous biochemical oxygen demand, 15 mg/L total suspended solids and 3.0 mg/L ammonia nitrogen. GBRA has had a monthly monitoring site in this portion of the watershed located at CR 135 since 1998. TCEQ has monitored this site and their data was included in the historical review. The 2008 draft Texas Water Quality Inventory listed the lowest assessment unit of the Plum Creek as impaired for bacteria, with a concern for nitrate nitrogen.

The baseflow in the lower portion of the watershed is impacted by saline groundwater. As the stream flow is increased with stormwater and runoff, the concentration of dissolved salts goes down. For example, figure 5 shows the



inverse relationship of chloride and flow, with a decreasing trend over time.

Figure 5. Chloride concentration has an inverse relationship with flow, as storm flows dilute the naturally saline base flow of the lower portion of Plum Creek (12640).

The median **flow** (12 cfs) in the lower portion of the creek is three times the flow at the TCEQ site in the middle Plum Creek, due to the contribution of flow from the West Fork and Clear Fork tributaries that confluence with the Plum Creek in the lower portion of the watershed.

The median temperature at the GBRA CR135 site is 22.3°C, ranging from 6.9°C to 28.9°C. The conductivity ranged from 146 to 2061 umhos/cm, with a median conductivity of 1233 umhos/cm, 45% higher than the lower two monitoring stations. The pH ranged from 7.1 to 8.52, with a median pH of 7.86. The dissolved oxygen ranged from 2.5 mg/L to 14.6 mg/L, with a median concentration of 7.24 mg/L. The dissolved oxygen fell below the stream standard of 5.0 mg/L 12 times out of 137 measurements in the historical record, and one time below the screening concentration of 3.0 mg/L. The stream dipped down to 2.5 mg/L dissolved oxygen during one of the lowest flows recorded in the data set.

Total suspended solids ranged from 4 mg/L to 1930 mg/L, with a median concentration of 24.6 mg/L. The highest concentrations of solids are associated with high flows, following storm events as the runoff carries in sediments. The water is hard with a median hardness concentration of 313 mg/L, ranging from 65.8 mg/L to 502 mg/L. Chloride and sulfate concentrations were higher at this site than the other two monitoring sites. The median chloride concentration was 155 mg/L, ranging from 8.5 to 371 mg/L, exceeding the stream standard for chloride two times. Sulfate ranged from 1 to 1030 mg/L, with a median concentration of 81.3 mg/L, exceeding the stream standard for sulfate of 150 mg/L five times.

Nitrate nitrogen, ammonia nitrogen and total phosphorus were analyzed at the GBRA site in the lower Plum Creek. Nitrate nitrogen was analyzed alone or in combination with nitrite nitrogen. The median concentration for nitrate nitrogen was 1.59 mg/L, ranging from 0.08 mg/L to 7.69 mg/L, and exceeding the screening concentration of 1.95 mg/L 59 times out of 142 measurements, or 42% of the time. The ammonia nitrogen concentration ranged from less than method detection to 0.3 mg/L, with a median concentration of 0.06 mg/L, never exceeding the screening concentration of 0.33 mg/L. Looking at the concentration of ammonia nitrogen over time, we see a significant drop in concentration in 2001. As mentioned in previous basin highlights and summary reports, the elimination of the distillation step from the ammonia nitrogen analytical procedure removed the contamination of the samples by the laboratory atmosphere and reduced the measured ammonia nitrogen in the samples (Figure 6).

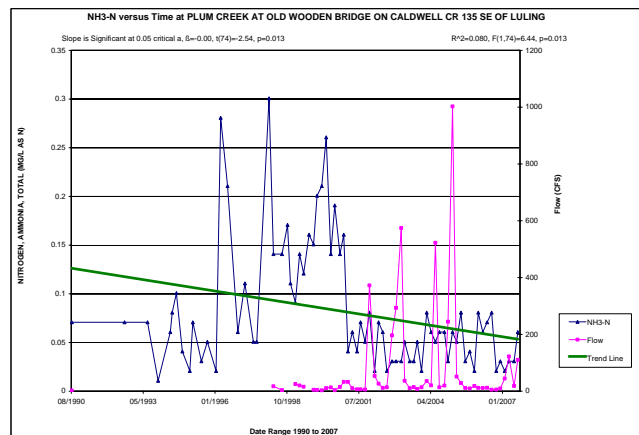


Figure 6. Ammonia nitrogen over time measured at the GBRA monitoring site on Plum Creek at CR 135 (12640). Drop in concentration in 2001 attributed to the removal of the distillation step from the analytical procedure.

Total phosphorus concentrations show a slight downward trend or improvement over time (figure 7). The median concentration of total phosphorus was 0.36 mg/L, ranging from less than method detection to 1.24 mg/L. Ten of the 133 measurements were higher than the screening concentration of 0.69 mg/L, or 7.5% of the time. A possible explanation for the trend could be the increased frequency of analysis in the later years of the historical record.

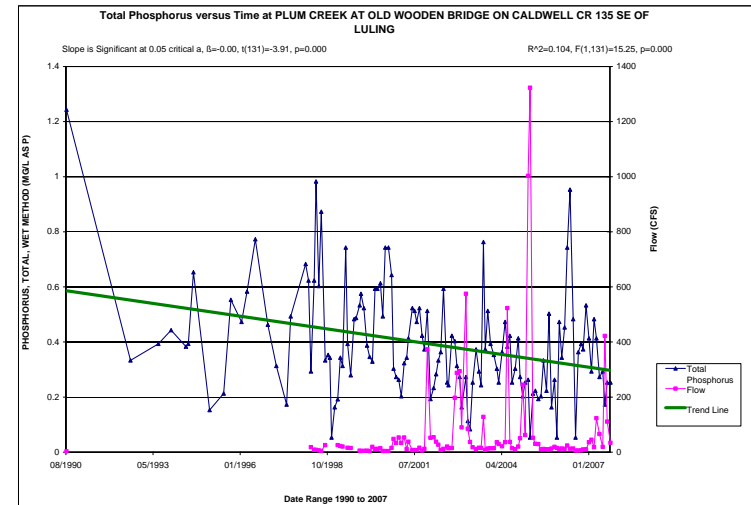


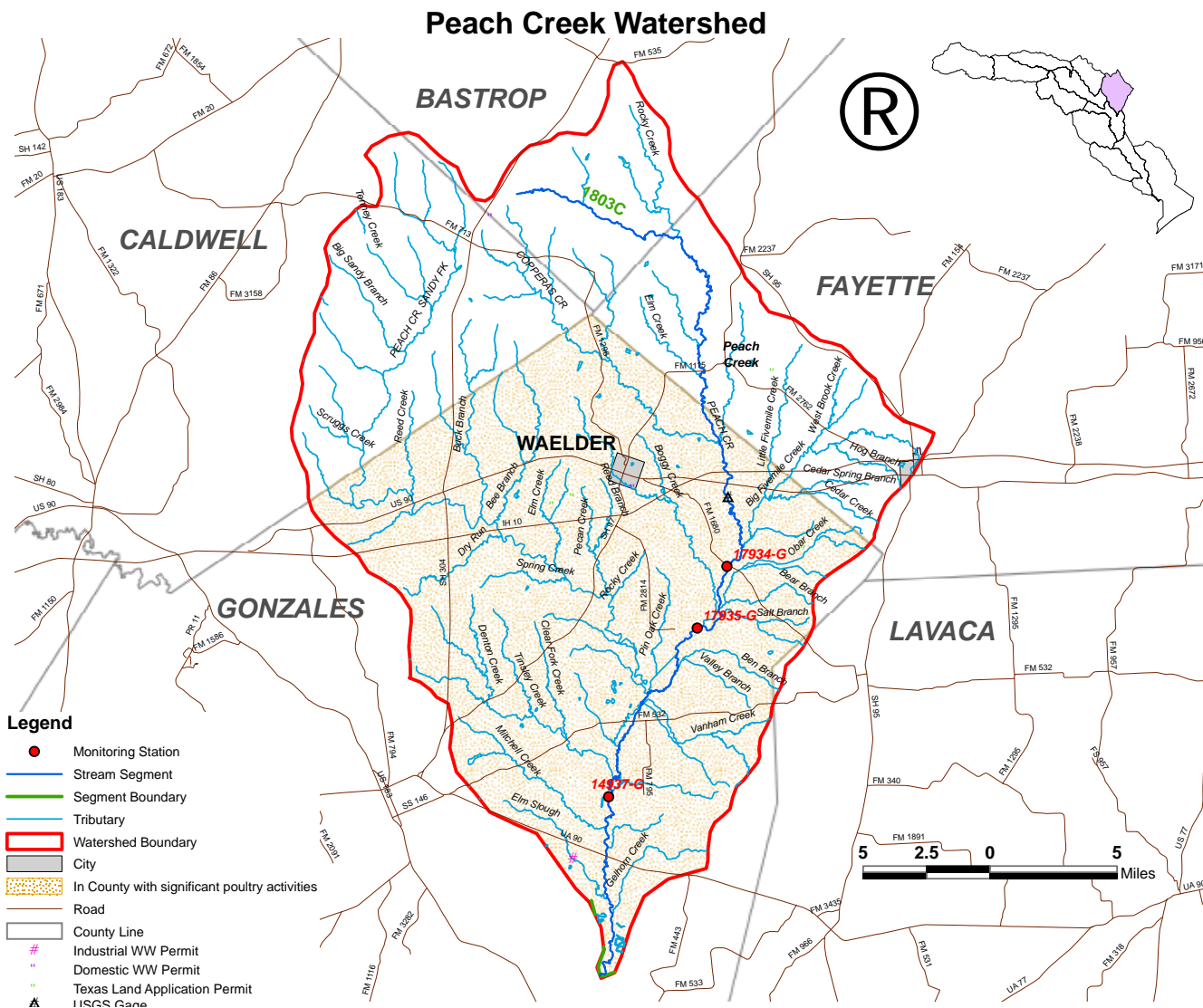
Figure 7. Data at the GBRA monitoring site at CR 135 (12640) shows a significant downward trend in total phosphorus over time that could be explained by an increase in frequency in analyses in the later years of historical monitoring.

During the period of historical data, fecal coliform was analyzed and then replaced by *E. coli*. The respective stream contact recreation standard was exceeded 26 times. The geometric mean for fecal coliform was 168 org/100mL and the geometric mean for *E. coli* was 108 org/100mL. As expected there is a rise bacteria concentrations with storm flows.

### Stakeholder Concerns

The stakeholders that have attended the annual meetings for the Clean Rivers Program Steering Committee as well as those that have commented at other Plum Creek watershed meetings, are concerned about several issues. The issues include the impacts from wastewater effluents, the potential for contamination and spills from unattended oil and gas production facilities, excessive illegal trash dumping in the creek and poorly functioning or failing septic tanks. The Plum Creek Watershed Partnership has recently completed the development of a watershed protection plan that is under consideration by the US EPA. As part of the plan, the members recommended that a compact be entered into by governmental entities and interested parties in the watershed, promoting regionalization of wastewater facilities rather than package plants, the utilization of wastewater for reuse and the increased level of wastewater treatment that includes reduction in nutrient concentrations.





**Monitoring Stations – Peach Creek**

17934-G Peach Creek at FM 1680  
 17935-G Peach Creek at FM 397  
 14937-G Peach Creek at FM 353

Sampling sites are labeled in red followed by the letter G (GBRA), T (TCEQ), U (UGRA) or W (Wimberley) indicating who is the monitoring entity.

**Peach Creek Watershed**

**Drainage Area:** 480 square miles  
**Streams and Rivers:** Guadalupe River, Peach Creek, Copperas Creek  
**Aquifers:** Carrizo-Wilcox  
**River Segments:** 1803C  
**Cities:** Waelder, Flatonia  
**Counties:** Caldwell, Bastrop, Fayette, Gonzales

**EcoRegion:** Texas Blackland Prairies, Post Oak Savannah  
**Vegetation Cover:**  
 Pasture/Hay - 21.1%      Shrublands - 13.9%  
 Grass/Herbaceous - 23.4%      Deciduous Forest - 34.1%  
**Climate:**  
 Average annual rainfall: 31 inches  
 Average annual temperature: January 39° July 94°  
**Land Uses:** Recreation, Extensive Cattle and Poultry Productions, Light Industry, Agricultural Crops

**Water Body Uses:** Aquatic Life Use, Contact Recreation Use, Fish Consumption Use  
**Soils:** Dark red sandstone and tan and grey sandstone  
**Permitted Wastewater Treatment Facilities:**  
 Domestic: 3  
 Land Application: 2  
 Industrial: 1

Peach Creek, a tributary of segment 1803, the Guadalupe River below the San Marcos River, extends from its confluence with the Guadalupe River in Gonzales County, northward, with portions of the watershed in Fayette, Bastrop and Caldwell counties. The segment is separated into three assessment units: the lower 25 miles; the portion that extends from FM 1680 in Gonzales County to the confluence with Elm Creek in Fayette County; and, the remainder of the water body. GBRA has been monitoring Peach Creek (14937) monthly since 1996. The GBRA site is located in the lower assessment unit. Peach Creek was listed as impaired for bacteria in 2000. A Total Maximum Daily Load Study (TMDL) performed by TCEQ confirmed the impairment in the lower two assessments units and found that the upper assessment unit is not impaired for bacteria. The TMDL that is up for adoption in late 2008 modeled the watershed to determine the amount of load reduction that would be necessary to bring the stream back into compliance with stream standards. After looking into the operation of the wastewater plants discharging to the creek, it was determined that the sources of bacterial loading are most likely from non-point sources, such as failing septic tanks, livestock and wildlife. The study determined there needs to be a 47 to 100 percent reduction in non-point source bacterial loading to Peach Creek. However, TCEQ recognizes the potential for bacterial contributions from these wastewater facilities so there are waste load allocations assigned to the wastewater plants that require that they maintain adequate disinfection. To assure that there is a reduction of bacteria in the waste, the cities have bacterial monitoring requirements in their permits.

#### Wastewater Discharges

There are five point sources that have permits to discharge treated water to the segment, two of which could potentially contribute to the bacterial impairment. The cities of Waelder and Flatonia operate wastewater plants that are facultative lagoon systems that do not include chemical disinfection. TCEQ believes that the lagoon process holds the wastewater with sufficient time for reduction in bacteria by solar radiation and other natural processes.

The proposed Total Maximum Daily Load for Bacteria in Peach Creek report can be accessed at <http://www.tceq.state.tx.us/implementation/water/tmdl/34-peachcreekbacteria.html>. The Texas State Soil and Water Conservation Board, along with the Gonzales County Soil and Water Conservation District, have funds available to provide technical and financial assistance to landowners for the development of water quality management plans (WQMPs). The WQMPs are written specifically for each landowner's property and uses, with the goal to reduce the bacterial loading to Peach Creek. The funding includes cost sharing for water quality management practices that give livestock alternatives to watering directly in the creek or work to retain storm water off pastureland. These practices include fencing, stock ponds, troughs and water wells, as well as brush management, riparian herbaceous cover and forest buffers. To get additional information on these opportunities, contact the Gonzales County Soil and Water Conservation District at (830) 672-8371, ext.3.

#### Water Quality

The GBRA routine monitoring site at CR 353 exhibits wide swings in water quality. The median concentration for dissolved oxygen is 6.8 milligrams per liter (mg/L), ranging from a minimum of 2.1 mg/L to a maximum of 13.5 mg/L. During the period of record the dissolved oxygen dropped below the standard for the minimum dissolved oxygen concentration (4.0 mg/L) three times. The temperature varied between 5.5°C to 29.8°C, with a median temperature of 22.4°C. The **specific** conductance ranged between 101 and 1680 micromhos per centimeter, with a median conductivity of 602 micromhos per centimeter. The median pH of the site was 7.84, ranging from 6.68 to 8.76 standard pH units, never falling outside the stream standard range of 6.5 to 9.0 standard units.

The median concentration for chloride was 46.1 mg/L, ranging from 4.2 to 230 mg/L, falling outside the stream standard used for assessment 64 times out of 136 data measurements. Peach Creek exhibited a wide range in sulfate concentrations, ranging between 0.5 and 327 mg/L, with a median concentration of 20.1 mg/L. The sulfate concentrations fell outside the stream standard of 50 mg/L 48 times. The same wide range in concentrations is seen with total hardness. As seen in figure 1, the ionic constituents, represented by conductivity, are negatively correlated with flow. The constituents that make up the majority of the dissolved solids also correlate with each other, meaning that when the hardness and chloride are elevated, the sulfate follows the same pattern. Two of the other three permitted dischargers in the watershed are from clay mining operations and may be linked to the wide swings in the dissolved constituents. These discharges are intermittent and while within the permitted allowances could explain the wide swings in concentrations.

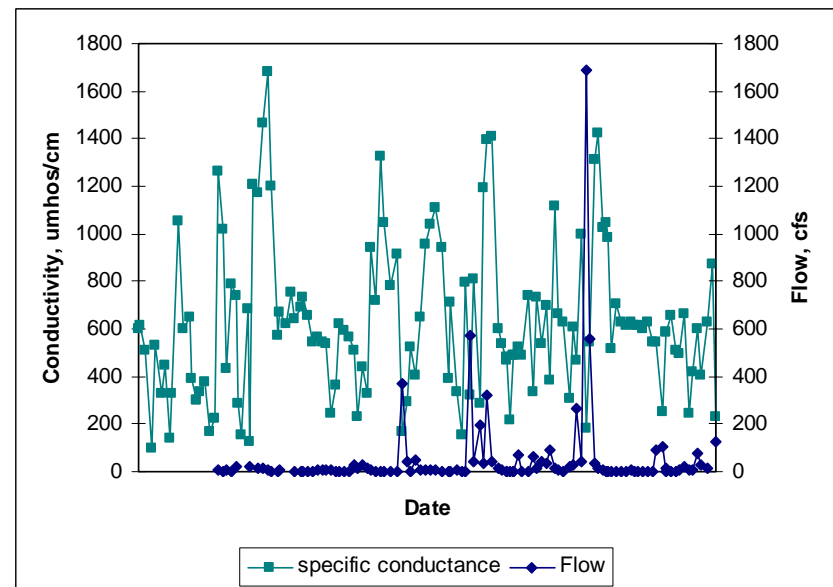


Figure 1. Specific conductance verses flow over the period of historical data at the GBRA monitoring site at CR 353 (14937).

Most locations in the Guadalupe River basin have relatively high hardness concentrations with one exception, Peach Creek. The toxicity of certain metals is dependent on the hardness of the stream. The metals toxicity criteria that are hardness dependent are cadmium, chromium, copper, nickel, lead and zinc. The hardness concentration at the 15<sup>th</sup> percentile is 39 milligrams per liter in Peach Creek as compared to an average of 221 mg/L in other parts of the basin. It is at this percentile that the toxicity criteria for Peach Creek are calculated. The acute and chronic toxicity criteria are considerably lower for Peach Creek than at other locations in the river basin. Also, the highest concentrations of aluminum, arsenic, chromium, nickel and zinc in the basin are found at the CR 353 site. Currently, Peach Creek does not exceed the standards for acute and chronic toxicity but the concentrations that have been found do warrant continued monitoring. Refer to the "Metals in Water" section of this document for the metals concentrations measured at the CR 353 site from 1999 to 2007.

Nitrate nitrogen, ammonia nitrogen and total phosphorus, were analyzed at the GBRA monitoring location on Peach Creek. Over the period of record, nitrate nitrogen was reported under three storet codes, as nitrate nitrogen and in combination with nitrite nitrogen. The median concentrations for all three cited storet codes were 0.15, 0.20, and 0.23 mg/L, ranging from less than detection to 1.94 mg/L. At no time did the nitrate nitrogen concentration, regardless of storet citing, exceed the screening criteria of 1.95 mg/L. The median ammonia nitrogen concentration was 0.09 mg/L, ranging from 0.02 to 6.3 mg/L which was a one-time occurrence in the data. Four sampling events showed the concentration of ammonia nitrogen over the screening concentration of 0.33 mg/L. The median total phosphorus concentration was 0.29 mg/L, and ranged from less than the limit of quantification for the method to 1.08 mg/L which was the only data point that exceeded the screening concentration of 0.69 mg/L. Also, there is a slight downward trend in phosphorus concentrations over time as seen in figure 2. Time significantly predicted total phosphorus values,  $\beta = -0.00$ ,  $t(132) = -4.49$ ,  $p < 0.01$ . Time also explained a significant proportion of variance in total phosphorus values,  $R^2 = 0.13$ ,  $F(1,132) = 20.16$ ,  $p < 0.01$ .

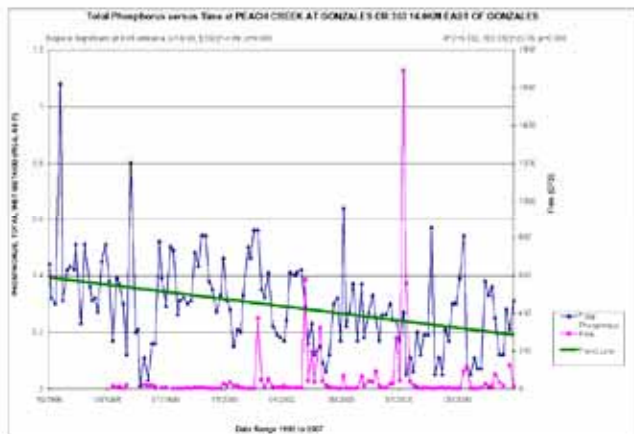


Figure 2. Total Phosphorus and Flow over the period of historical data at the GBRA monitoring site at CR 353 (14937).

Peach Creek is a slow, meandering stream with pools. The median **flow** at the GBRA site at FM 353 is 4.3 cubic feet per second (cfs), ranging from 0.75 to 1690 cfs. Over the period of record the flow was less than 30 cfs about 80% of the time. The approximate depth at the sampling location is 2.5-3.0 feet, but many stream reaches in the upper part of the watershed are known to go dry. The pools are typically 2-5 feet in depth.

Regardless of the lack of access conducive to contact recreation, streams like Peach Creek, are assessed using the water quality standard for contact recreation. The stream standard for contact recreation is a geometric mean of 126 organisms per 100 milliliters, and the single sample concentration of 394 organisms per 100 milliliters. The geometric mean for *E. coli* bacteria at CR 353 is 162 organisms per 100 milliliters, with over 25% of the data points exceeding the grab standard.

The substrate at the GBRA monitoring location on Peach Creek ranges from sandy to small cobble. The water is turbid (median = 22 nephelometric turbidity units) and can have a slight brown tint from tannins that leach from decaying plant material. The suspended solids ranged from 1.7 to 394 mg/L, with a median of 13.2 mg/L. The median chlorophyll a concentration is 2.0 micrograms per liter (ug/L) and ranged from less than detection to 19.2 ug/L. There were three monitoring events that were above the screening concentration of 14.1 ug/L. Reviewing the data to look for links between turbidity and flow or chlorophyll a, no significant correlations were found. The periods circled in figure 3 show that the turbidity can stay elevated with no corresponding peaks in flow. The data was reviewed and there were no elevated chlorophyll a values associated with algal blooms during these periods. One possible link to the turbidity could be the extreme flood events prior to each time period highlighted on the graph. The inundation of the banks causes loss of grasses along the shoreline that would provide stabilization and prevent or minimize erosion and loss of sediment.

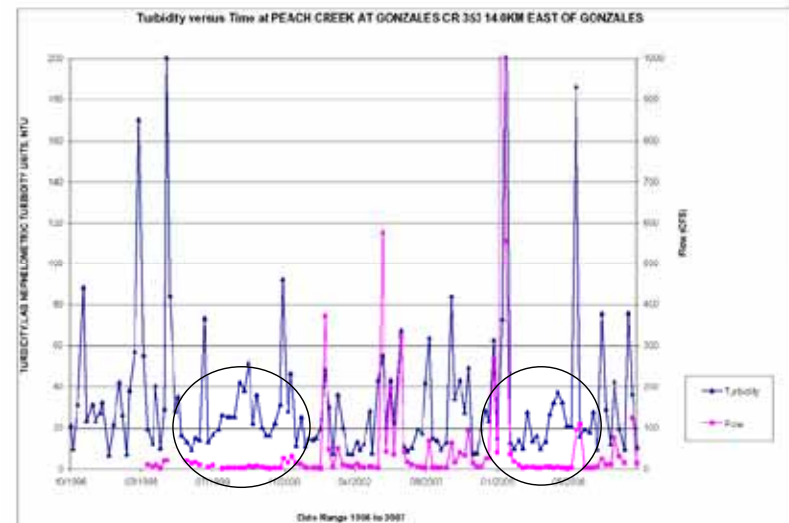


Figure 3. Turbidity and Flow over the period of historical data at the GBRA monitoring site at CR 353 (14937).



GBRA has two additional monitoring sites in the watershed. One site, located at the crossing of FM 1680, was monitored bimonthly for three years beginning in FY2004. The site is located upstream of GBRA's historical routine site and at the midpoint of the watershed. It was added in response to concerns by the Texas Parks and Wildlife Department that there was a possible link between an



Peach Creek at CR 353 downstream view (site no. 14937)

agricultural producer and a fish kill on the stream. To date, there has been no further investigation noted by the TPWD that GBRA is aware of. A site at the crossing of CR 397 that was monitored during the TMDL project has been added to the GBRA monitoring program in order to assess any changes in water quality as best

management practices are installed during the implementation phase that would follow the adoption of the TMDL. The site at CR397 is downstream of the site located at FM 1680, and midway between FM 1680 site and the CR 353 site. Both sites are located in the assessment units that were listed as impaired for bacteria, and both are located downstream of the cities of Waelder and Flatonia's wastewater discharges. In comparison with the CR 353 site, these two sites show similar ranges in dissolved constituents. The more substantial differences are seen in chlorophyll a and dissolved oxygen. The higher median chlorophyll a (only FM 1680 chlorophyll a data available) and lower median dissolved oxygen at the two new sites (Figures 4 and 5) as compared to the historical site at CR 353 are most likely due to more frequent low flow to no flow conditions (median flow at FM 1680 is less than one cubic foot per second) and available nutrients at these two locations. The



Peach Creek at CR 353 uownstream view (site no. 14937)

median phosphorus concentration (0.36 mg/L) and the median nitrate nitrogen concentration (0.23 mg/L) are slightly higher at the upstream location (FM 1680). The higher nutrient concentrations may be a result of the site's proximity to the wastewater discharges.

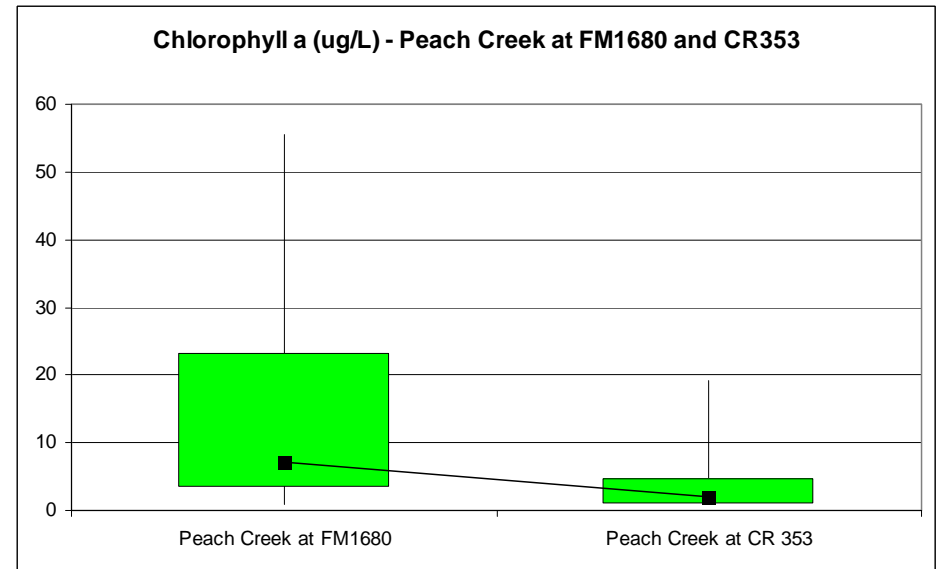


Figure 4. Chlorophyll a concentrations at the FM1680 (17934) and CR 353 (14937) monitoring sites on Peach Creek. The boxes represent the range of concentrations that fall between 25 to 50 % of the historical data set; the whiskers represent the complete range of concentrations; and the black square is the median concentration for historical data sets.

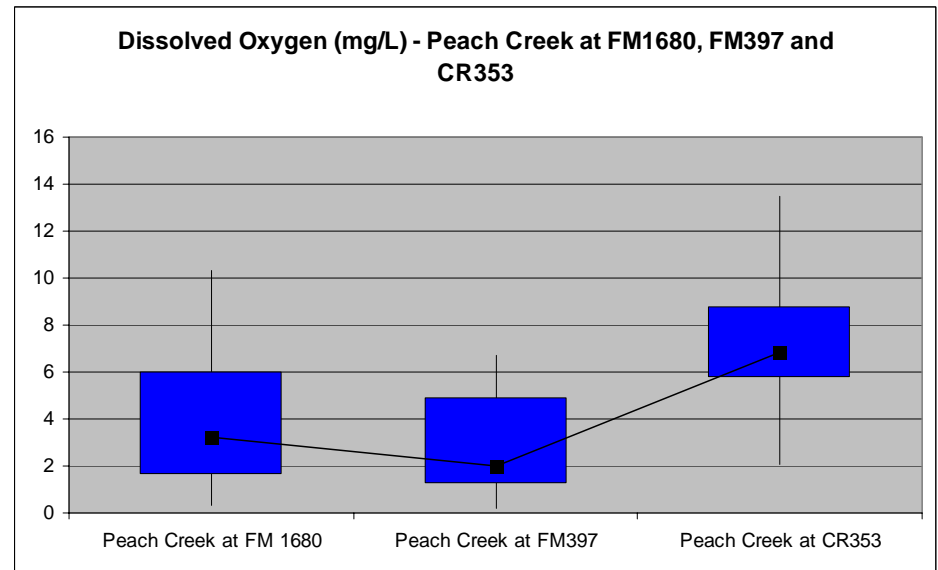
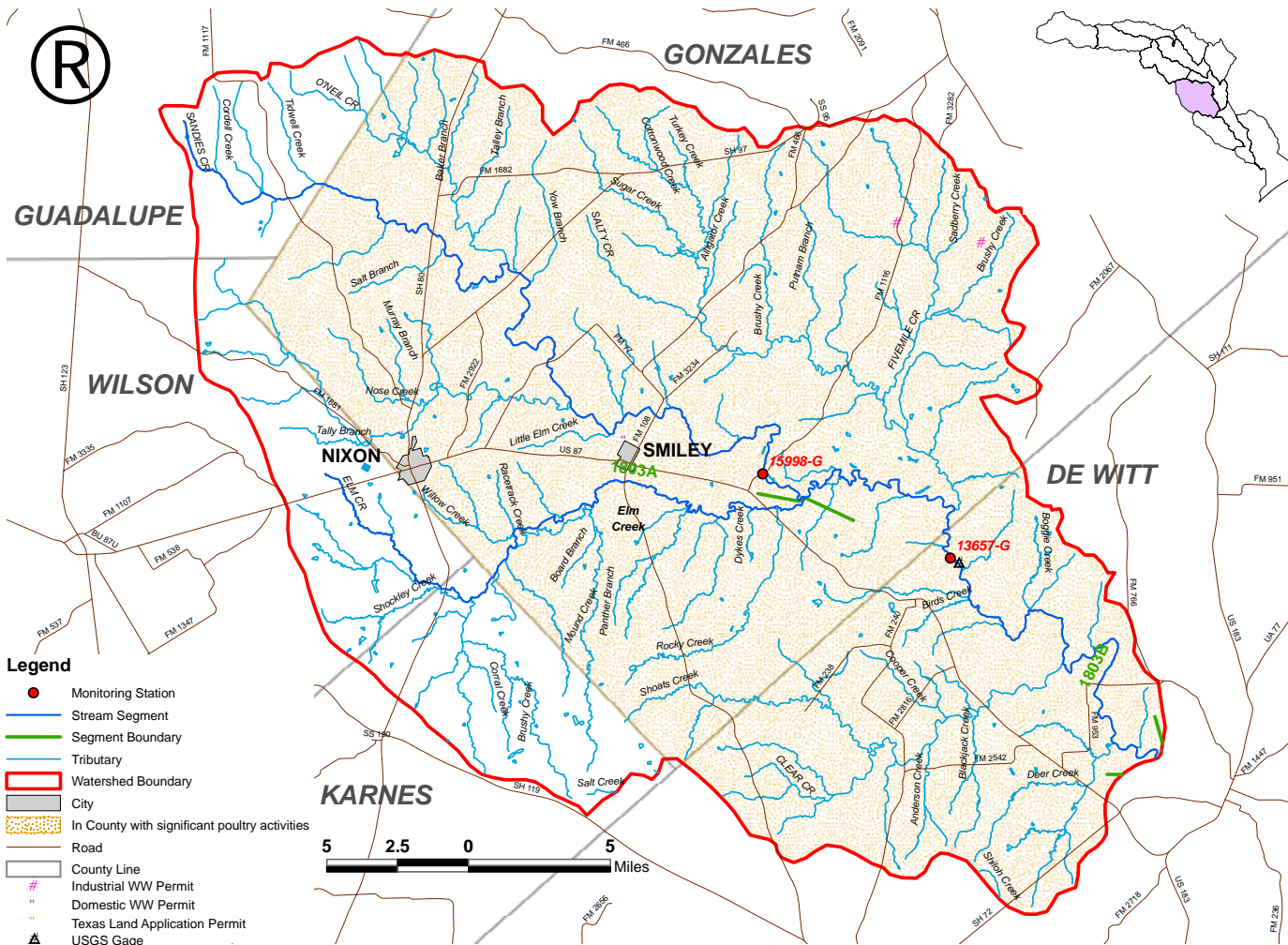


Figure 5. Dissolved oxygen concentrations in the FM1680 (17934), FM397 (17935) and CR 353 (14937) monitoring sites on Peach Creek. The boxes represent the range of concentrations that fall between 25 to 50 % of the historical data set; the whiskers represent the complete range of concentrations; and the black square is the median concentration for historical data sets.

# Sandies Creek Watershed



**Monitoring Stations – Sandies Creek**

15998-G Sandies Creek at FM 1116  
 13657-G Sandies Creek near Westhoff

Sampling sites are labeled in red followed by the letter G (GBRA), T (TCEQ), U (UGRA) or W (Wimberley) indicating who is the monitoring entity.

## Sandies Creek Watershed

**Drainage Area:** 711 square miles

**Streams and Rivers:** Guadalupe River, Elm Creek, and Sandies Creek, Five Mile Creek, Salty Creek, Clear Creek, O’Neil Creek

**Aquifers:** Carrizo-Wilcox, Gulf Coast

**River Segments:** 1803A, 1803B

**Cities:** Smiley, Nixon

**Counties:** Guadalupe, Karnes, Wilson, Gonzales, DeWitt

**EcoRegion:** Texas Blackland Prairies, Post Oak Savannah

### Vegetation Cover:

Pasture/Hay - 24.9%	Deciduous Forest - 19.6%
Grass/Herbaceous - 24.3%	Evergreen Forest - 5.3%
Shrublands - 21.1%	Row Crops - 3.4%

**Climate:** Average annual rainfall: 31 inches  
 Average annual temperature: January 39°  
 July 94°

**Land Uses:** Light Manufacturing, Extensive Cattle Production and Poultry Production; Agricultural Crops (hay, sorghum, etc.)

**Water Body Uses:** Aquatic Life Use, Contact Recreation Use, Fish Consumption Use

**Soils:** Dark red sandstone, light tan and gray sandstone

### Permitted Wastewater Treatment Facilities:

Domestic: 3  
 Land Application: 1  
 Industrial: 1



Sandies Creek, Segment 1803B, extends approximately 65 miles, from its confluence with the Guadalupe River in DeWitt County, near the city of Cuero, upstream, through Gonzales County, to its headwaters in Guadalupe County. The creek flows through a watershed that is made up of hardwoods, pines, mesquites and a variety of grasses. Elm Creek, 1803A, is a tributary of Sandies Creek that flows from its headwaters in Wilson County through Gonzales County to converge with Sandies Creek, downstream of the city of Smiley. Elm Creek is approximately 24 miles long, in a watershed that is rural, and characterized by flat to rolling terrain, dominated by hardwoods, pines, mesquite and a variety of grasses. Both creeks are unclassified stream segments that were assessed as one assessment unit each, using the stream standards for the main stem Guadalupe River that receives their combined flow. GBRA has historical monitoring sites on Sandies Creek since 1996. The current site, monitored since 2000, is located at Westhoff (site no. 13657). The original site, located at FM 1116, was moved to the Westhoff site in order to more accurately record flow by using the USGS gaging station nearby. Also, there were safety considerations that made the Westhoff site a better long term site. GBRA does not maintain a routine site on Elm Creek. There was not enough long term data on Elm Creek to look for trends in water quality. Other sites on Sandies and Elm Creeks have been monitored for short periods of time for special studies, one of which was to determine, if any, the impacts of poultry operations on watersheds. The study collected monthly data from each creek from November 1997 to August 1998. It was because of this limited study that the creeks were suspected of being impaired. Other data collected in the watershed were for the TCEQ total maximum daily load study started in 2002.

#### Land uses

The land use is primarily agricultural with row crops and poultry and livestock production. There are two wastewater treatment plants in the watershed, one for the city of Nixon and one for the city of Smiley. Both plants are permitted to discharge to small tributaries of Sandies Creek. The city of Nixon facility is



Sandies Creek at FM 1116 (15998).

permitted to discharge up to 0.45 million gallons per day, with quality limits of 10 milligrams per liter (mg/L) carbonaceous oxygen demand, 15 mg/L total suspended solids and 3 mg/L ammonia-nitrogen. The facility uses chlorine to disinfect the effluent. The city of Smiley treats its wastewater in an facultation lagoon and is authorized to use their effluent to irrigate a hay field in lieu of discharge.

#### Water Quality

Sandies and Elm Creeks were both listed on the 2006 Texas Water Quality Inventory as impaired for depressed dissolved oxygen and for exceedence of the bacteria standard for contact recreation. Currently, a total maximum daily load (TMDL) study is being conducted by the TCEQ. Data was collected on the two tributaries in 2002 and 2004. TCEQ is analyzing the data to develop TMDLs for dissolved oxygen and for bacteria. The goal of the TMDL study is to determine the amount of a pollutant that a body of water can receive and still support its designated uses. The allowable load is then allocated among the potential sources of pollution within the watershed. Potential sources of pollutants include point sources such as wastewater discharges, and non-point sources, including agricultural land use activities, wildlife and septic tanks.

In Sandies and Elm Creeks, low dissolved oxygen levels indicate that existing conditions are not optimal for aquatic life support. To meet the aquatic life support standards, the creek must have better than a 5.0 mg/L median dissolved oxygen concentration. Also, the creek should not fall below 3.0 mg/L more than 25% of the time. Reviewing the historical data at the GBRA site at Westhoff on Sandies Creek, the median dissolved oxygen was 6.4 mg/L, ranging from 0.8 to 13.5 mg/L. The stream dropped below 3.0 mg/L 9 times out of 133 measurements, or 6.8%. As seen in figure 1, there is a wide range of measured dissolved oxygen concentrations over the period of record. The variation in dissolved oxygen can be due to several factors, including time of day when photosynthesis adds oxygen during the sunlit hours, time of year when the colder water can hold more saturated dissolved oxygen, or early morning hours when dissolved oxygen drops due to respiration of algal cells overnight. Additionally, if the sediment load of the stream increases due to runoff, decomposition and bacterial respiration can cause a drop in the dissolved oxygen concentration. All of these factors are possible in Sandies Creek.

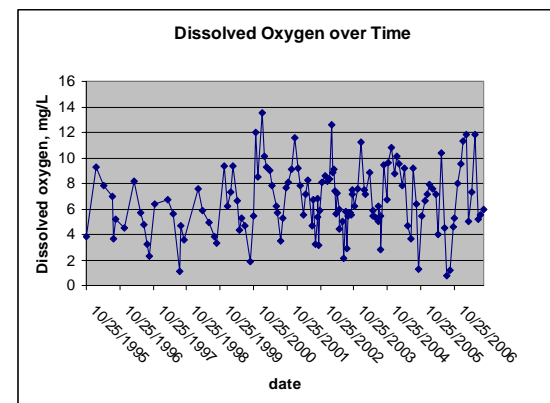


Figure 1. Dissolved oxygen concentrations measured over time in Sandies Creek at Westhoff (13657).



The temperature in Sandies Creek ranged from 8.64 to 30.40C, with a median temperature of 23.20C. The median pH was 7.9, ranging from 6.8 to 8.91, and never exceeded the stream standards of 6.5 to 9.0. The conductivity and dissolved constituents of Sandies Creek are also highly variable, as seen in figure 2.

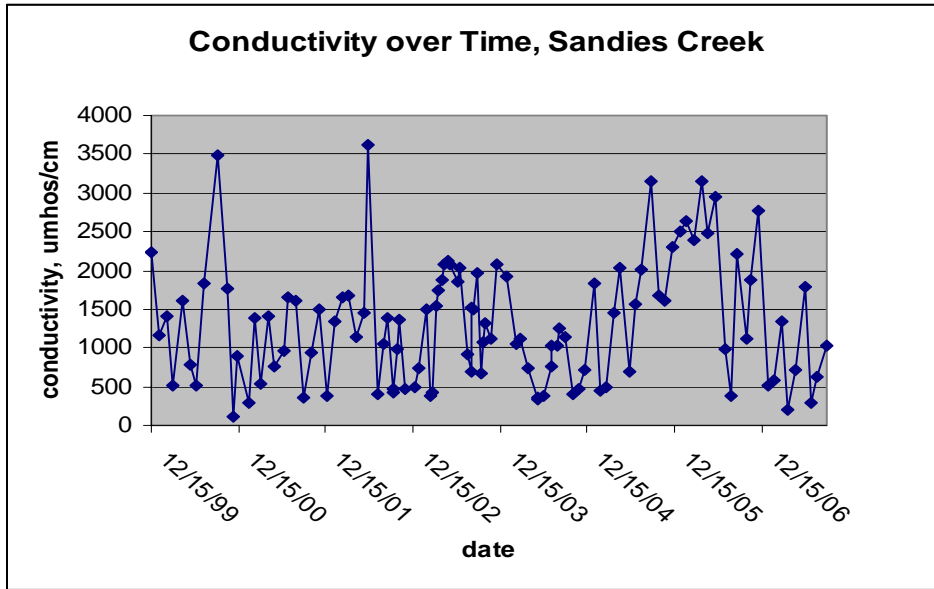


Figure 2. Variability in conductivity, or dissolved solids, over time in Sandies Creek at Westhoff (13657).

The stream is high in dissolved solids in comparison to the lower Guadalupe River. The dissolved solids in Sandies Creek, based on conductivity, are approximately 852 mg/L, as compared to 358 mg/L in the lower Guadalupe River. In figure 3, increases in flow see corresponding decreases in the chloride concentration, and the majority of time the concentration of chlorides remain elevated at low flows, indicating that the base flow is high in dissolved salts.

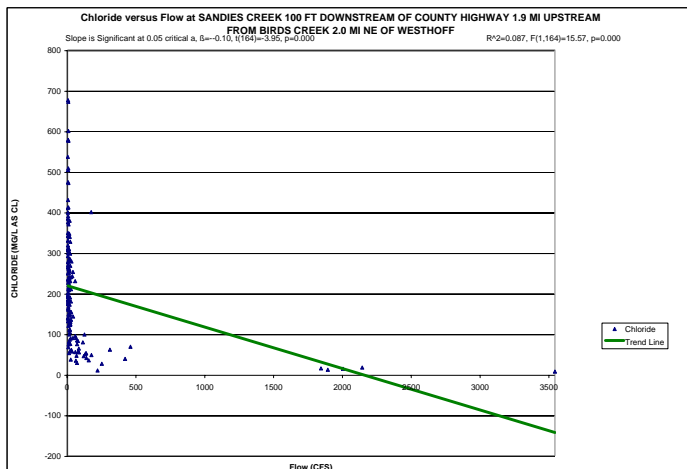


Figure 3 - Sandies at Westhoff (13657) chloride verses flow.

Chloride and sulfate concentrations ranged from 7.1 to 676 mg/L and 1 to 429 mg/L, respectively, with median concentrations of 190 mg/L and 47 mg/L. The hardness of the creek ranged from 45.4 to 395 mg/L, with a median concentration of 142 mg/L. The median concentration of total suspended solids was 39.8 mg/L, ranging from 12.2 to 510 mg/L.

Chlorophyll a concentrations have spiked in Sandies Creek and those spikes are associated with low flow periods, as seen in Figure 4. The median concentration is 4.45, ranging from 0.25 ug/L to 125 ug/L. Nineteen of the 108 sampling events had chlorophyll a concentrations that exceeded the screening concentration of 14.4 ug/L. 2006 was very dry year and the most consistently high values are seen in that time period.

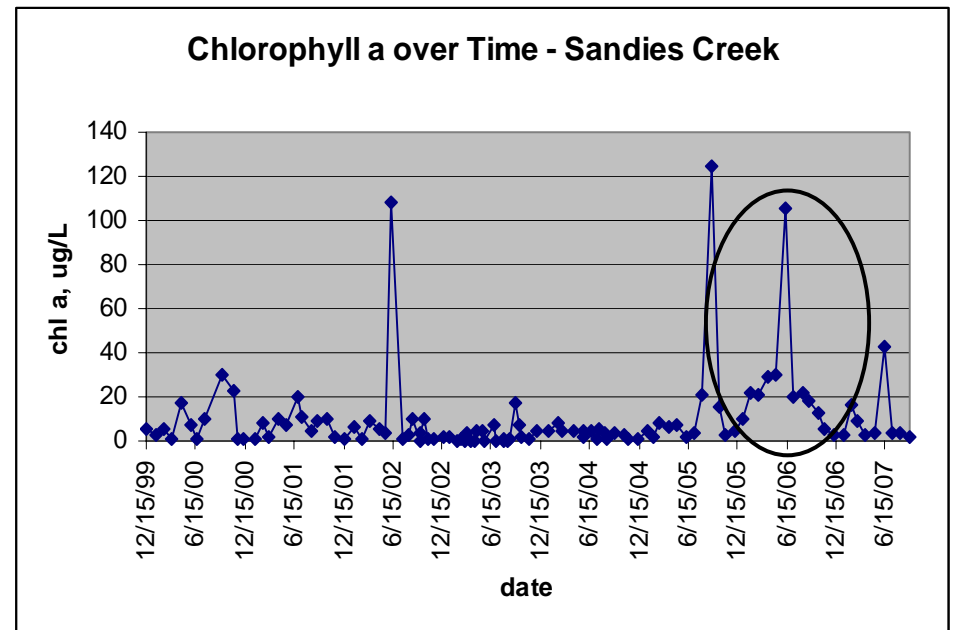


Figure 4. Chlorophyll a concentrations increase during low flow periods at the Sandies Creek at Westhoff (13657) as seen in 2006.

Nitrogen and phosphorus were analyzed at the GBRA Sandies Creek location. Ammonia nitrogen concentrations did not exceed the screening concentration of 0.33 mg/L during the period of record and had a median concentration of 0.06 mg/L, ranging from less than detection to 0.27 mg/L. Nitrate nitrogen was analyzed as nitrate and in combination with nitrite. The median concentration for nitrate nitrogen, combining all methods was 0.26 mg/L, ranging from 0.02 to 2.0 mg/L, exceeding the screening concentration of 1.95 mg/L one time out of 108 measurements. The median concentration of total phosphorus was 0.38 mg/L, ranging from less than method detection to 1.4 mg/L, exceeding the screening concentration 11 times out of 105 measurements (10.4%). There was no correlation with rises in flow to explain the spikes in phosphorus concentration so the most likely source of the phosphorus is wastewater effluent, although, of

the median flow in the creek of 9.9 cubic feet per second, the contribution of wastewater is less than 0.5 cubic feet per second on a daily basis. None of the nutrients showed any significant trends, improving or degrading, over time.

*E. coli* was analyzed and the bacterial impairment noted in the assessment was confirmed over the period of time that GBRA has monitored at the Westhoff location. The geometric mean for *E. coli*, 182 organisms per 100 milliliters, exceeded the stream standard for contact recreation of 126 organisms per 100 milliliters. 27 of the 108 measurements exceeded the single grab standard of 394 organisms per 100 milliliters, or 25% of the time.

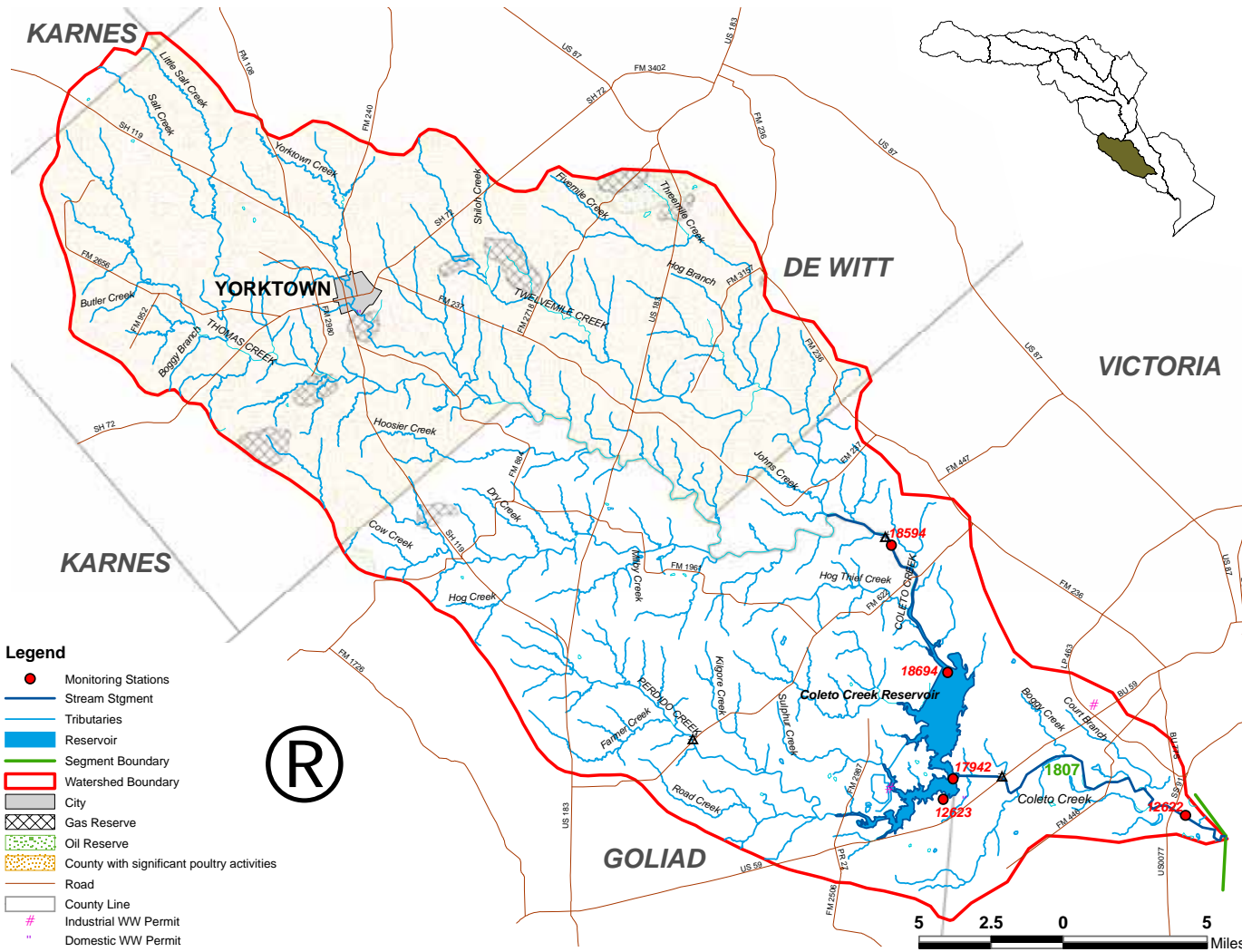
#### *Stakeholders concerns*

Stakeholders in the watershed are concerned that an inappropriate amount of emphasis is being placed on the necessity of the stream to meet standards for contact recreation because of the low amount of contact recreation use in Sandies and Elm Creeks. Most of the stakeholders are land owners with agricultural interests, on large farms that have been in their families for generations, and they feel the activities on their property have not changed over the years. It should be noted that the conditions in Sandies Creek and the lack of public access for contact recreation reduce the potential of human exposure to bacteria during contact recreation.



Sandies Creek at FM 1116 (15998).

# Coletto Creek Watershed



12622-T	Coletto Creek at US 77, downstream of reservoir
12623-G	Coletto Creek Reservoir at boat ramp in park
17942-T	Coletto Creek Reservoir in main pool at dam
18694-T	Coletto Creek Reservoir in arm of reservoir
18594-G	Coletto Creek at Arnold Road
18595-G	Perdido Creek at FM 622 near Fannin

Sampling sites are labeled in red followed by the letter G (GBRA), T (TCEQ), U (UGRA) or W (Wimberley) indicating who is the monitoring entity.

- Legend**
- Monitoring Stations
  - Stream Segment
  - Tributaries
  - Reservoir
  - Segment Boundary
  - ▭ Watershed Boundary
  - ▭ City
  - ▭ Gas Reserve
  - ▭ Oil Reserve
  - ▭ County with significant poultry activities
  - Road
  - County Line
  - # Industrial WW Permit
  - Domestic WW Permit
  - ▲ USGS Gage

## Coletto Creek Watershed

**Drainage Area:** 558 square miles

**Streams and Rivers:** Guadalupe River, Coletto Creek, Perdido Creek, Twelve Mile Creek, Thomas Creek

**Aquifer:** Gulf Coast

**River Segments:** 1807

**Cities:** Yorktown

**Counties:** DeWitt, Goliad, Victoria

**EcoRegion:** Texas Blackland Prairies  
Gulf Coastal Plains

**Vegetation Cover:**  
 Pasture/Hay - 15.3%      Shrublands - 9.7%,  
 Grass/Herbaceous - 33.2%      Deciduous Forest - 18.7%  
 Row Crops - 5.0%

**Climate:**  
 Average annual rainfall: 30 inches  
 Average annual temperature: January 41° July 95°

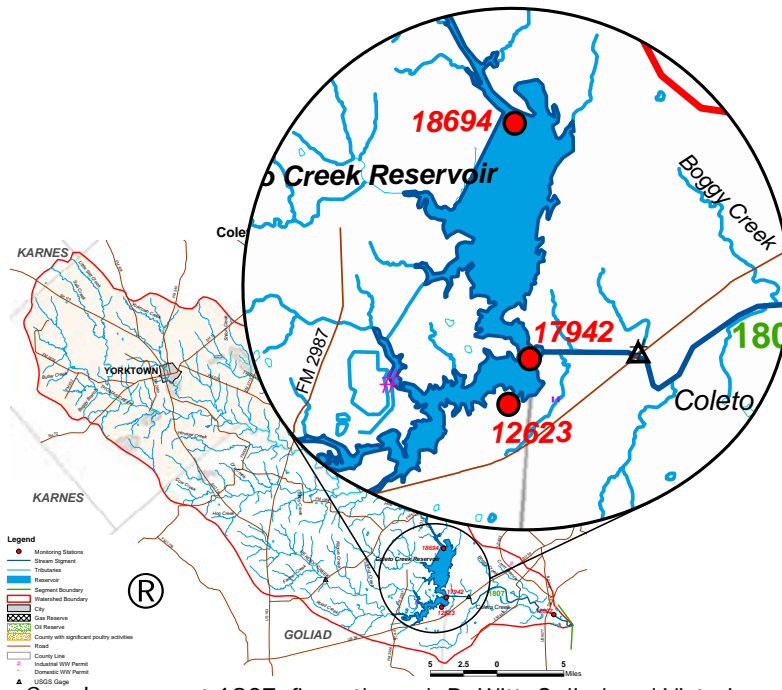
**Land Uses:** Agricultural Crops (sorghum, rice, cotton and corn), Beef, Hogs and Poultry Productions and Oil and Gas Production

**Water Body Uses:** Aquatic Life Use, Contact Recreation Use, Fish Consumption Use, Public Water Supply Use and Power Plant Cooling

**Soils:** Sandy, sandy loam and clay loam

**Permitted Wastewater Treatment Facilities:**  
 Domestic: 2  
 Industrial: 2





The Coletto Creek, segment 1807, flows through DeWitt, Goliad and Victoria counties. The land uses in the watershed include farming and ranching, oil and gas production and recently, in-situ uranium mining. The only urbanized area is the small community of Yorktown located in DeWitt County in the upper watershed. The segment is divided into two assessment units: from the confluence with the Guadalupe River to the Coletto Creek Reservoir Dam; and, the remaining portion of the segment. The upper part of the segment includes Coletto Creek Reservoir. The segment summary will be separated into two sections, the reservoir and the creek.

### Coletto Creek Reservoir

Coletto Creek Reservoir began impounding water in 1980, and is primarily used as a cooling pond for the coal-fired Coletto Creek power plant located in Goliad County. The power plant discharges 360,000 gallons per minute of water per year to the reservoir, after it has been pumped from the reservoir, through the facility for cooling. The temperature of the discharge cannot exceed 108°F. In addition to cooling capacity, the 3,100 surface acre reservoir is used for recreation, including swimming, boating, skiing and fishing. The reservoir is one of the best fishing sites in the Guadalupe River Basin because of the warm water and excellent fish habitat. The Texas Parks and Wildlife Department (TPWD) utilizes the reservoir as part of their fish stocking program. The reservoir has 61 miles of shoreline, with a sandy substrate and an average depth of eleven feet (2.5 meters).

The reservoir is fed by four major creeks, Coletto Creek, Perdido Creek, Turkey Creek and Sulphur Creek. The reservoir is maintained at a constant level. In times of drought, water can be pumped from the Guadalupe River to maintain

lake levels, under a water right permit held by the power company. The last time the water right was called upon to bring water from the Guadalupe River was in 2006. The warm water creates ideal conditions for the growth of several species of aquatic vegetation, including non-native stands of Eurasian milfoil, waterhyacinth and the dominant species, hydrilla. These aquatic plants provide excellent fish habitat but have been known to grow to excessive amounts that can restrict cooling water flow and public access in several areas of the reservoir. GBRA, partnering with the TPWD and the US Corps of Engineers, has a program to maintain the appropriate level of vegetation by controlling the plants with biological, chemical and mechanical means. The park staff has established a lake stakeholder group that is consulted each year that a vegetation management treatment program is needed. The stakeholder group includes TPWD, fishermen, members of local landowner associations and representatives of the recreation industry.

GBRA has one historical monitoring station which is located at the park on the Coletto Creek Reservoir (site no. 12623). The surface water site was established in 1987 as part of the GBRA contact recreation water quality index. The nine parameter list was expanded in 1996 when the GBRA joined the Clean Rivers Program, and includes field parameters, *E. coli*, suspended solids, dissolved constituents, chlorophyll a and nutrients.

TCEQ has two quarterly monitoring sites located in the reservoir, one in the main pool near the dam (site no. 17942) and one in an arm of the reservoir (site no. 18694). The monitoring program includes depth profile samples but, since the sites were established in 2005 and were monitored only quarterly, the data set is very limited.

The depth at each location was approximately six (6) meters. Reviewing the limited data set that profiles the two sites on the reservoir, there was no thermal stratification at the dam or in the arm of the reservoir. The temperature change through the depth profile averaged less than 1°C change from surface to bottom at either sampling location. The conductivity changed less than 10 micromhos per centimeter from surface to bottom and, between sites, the median conductivities were different by less than 10 umhos/cm. One note to make was a 200 umhos/cm drop in the reservoir conductivity in March 2007, seen at both sampling locations, that was due to the large volume of rainfall runoff coming into the reservoir.

The difference in dissolved oxygen between the surface to bottom averaged 1.2 milligrams per liter (mg/L) at the dam and 1.5 mg/L in the reservoir arm. The greatest change in dissolved oxygen seen in the depth profile was during August 2006, a very dry year, at both locations, with 5.8 mg/L at the surface and dropping to 1.4 mg/L at the bottom at the dam, and going from 7.7 mg/L at the surface and dropping to 4.6 mg/L at the bottom in the reservoir arm. In the limited historical data set, there were no surface sites that dropped below the stream standard of 4.0 mg/L, and no depth samples except in August 2006, dropped below that standard.

The difference in pH from surface to bottom at both reservoir locations averaged a change of 0.15 pH units. No surface or profile sample fell outside the pH standard range of 6.5 to 9.0.

The TCEQ collected nutrients and dissolved constituents at the surface in both reservoir locations. The data set was too small to do trend analyses but the median concentrations can be calculated and compared between reservoir sites. The dissolved constituents' median concentrations for chloride and sulfate, were not significantly different between the sites, (chloride: dam – 93.5 mg/L and arm – 94.5 mg/L; sulfate: dam – 31 mg/L and arm – 32 mg/L). The median concentration of ammonia nitrogen and nitrate nitrogen were less than the method detection level, with no values in the very limited data set that exceeded the screening values of 0.11 mg/L and 0.37 mg/L, respectively.

The data set for chlorophyll a on Coletto Creek is very limited with only two data points at each reservoir location. The mean chlorophyll a values were high in comparison to sites in other parts of the river basin (14.4 micrograms per liter (ug/L) at the dam and 13.4 ug/L). Currently, TCEQ is developing standards for nutrients. Nutrient enrichment from nitrogen and phosphorus can cause excessive growth of macrophytes, algal blooms in the open waters as well as attached to the substrate and floating in mats. The Texas Water Quality Standards have narrative but not numerical nutrient criteria. TCEQ staff are developing and evaluating several alternatives for nutrient standards, one of which, is to express the nutrient criteria in terms of chlorophyll a. Coletto Creek is not listed on the draft Appendix F (Chapter 301.10) that lists site-specific nutrient criteria for reservoirs and lakes in Texas. The table lists the proposed chlorophyll a, total phosphorus and total nitrogen for each water body. Criteria formulations were based on selected sampling stations that represent the deep pool near the dam for each reservoir, represent average conditions with an allowance for statistical variability, and are calculated as the upper confidence interval of the mean with the assumption that a sample size of 10 is used. Based on these criteria, a nutrient standard cannot be calculated on Coletto Creek Reservoir because the data set collected at the TCEQ sampling station at the dam is not large enough. The GBRA site on the reservoir would have a sufficient amount of data but the site is not located in the main pool. The GBRA site is located at the boat ramp in a cove, very near a swimming site on the reservoir. The site was originally established to assess the water quality for contact recreation. The median chlorophyll a concentration at the GBRA site on the reservoir is 5.0 ug/L, with 5 data points that exceed the screening concentration. Other alternatives that TCEQ staff are considering when developing site-specific nutrient criteria include a use-based approach with uses such as aquatic recreation, fishing and drinking water. Another factor that may play into the development of nutrient criteria for Coletto Creek Reservoir will be if the reservoir will be designated as “impacted” due to the warm water discharge from the power plant that utilizes the water body for cooling purpose. There are no other domestic or industrial discharges to the reservoir or upstream tributaries.

The GBRA Coletto Creek Reservoir site at the boat ramp had a median temperature of 24.2°C, ranging from 11°C to 33°C; and, a median **specific** conductance of 401, ranging from 147 to 690 umhos/cm. At the GBRA site, the change in conductivity over time shows a positive trend (Figure 1). In addition to the positive trend in conductivity, possible fluctuations seen in Figure 1 may be attributable to both changes in season as well as periods of wet and dry weather conditions. An example of the impact of meteorological conditions can be seen

in 2006. The reservoir received very little fresh water inflows, reaching one of its lowest elevation, and recording the highest conductivities in the data set. Seasonally, the evaporation rate on the reservoir, impacted by water temperature, wind and sunlight, increases during the warm summer months, causing the dissolved constituents to become more concentrated in the reservoir, showing an upward change in conductivity.

Substantiating both of these explanations for the upward trend in conductivity, are the changes in chloride concentrations over the same time period (Figure 2). The median chloride concentration during the period of record was 80.8 mg/L, ranging from 3.9 to 104 mg/L. Exacerbating the concentration of dissolved constituents is the level of chloride coming into the reservoir from the feeder streams. The GBRA monitoring site on the Coletto Creek at Arnold Road, located upstream of the reservoir, has a median concentration of chloride of 125.5 mg/L, ranging from 62.7 to 149 mg/L. The GBRA site on Perdido Creek, also a tributary to the reservoir, has a median chloride concentration of 170 mg/L, ranging from 55.7 to 216 mg/L. Without fresh water inflows of rain or water pumped from the Guadalupe River, the baseflow from the salty creeks, combined with the high evaporation rates, cause the chlorides in the reservoir to be elevated. Sulfates show a similar pattern but the concentrations in both the reservoir and in the tributaries are much lower. TCEQ has established a stream standard for chlorides of 250 mg/L and 100 mg/L for sulfates, for this segment, rather than the 50 mg/L seen in other parts of the Guadalupe River basin.

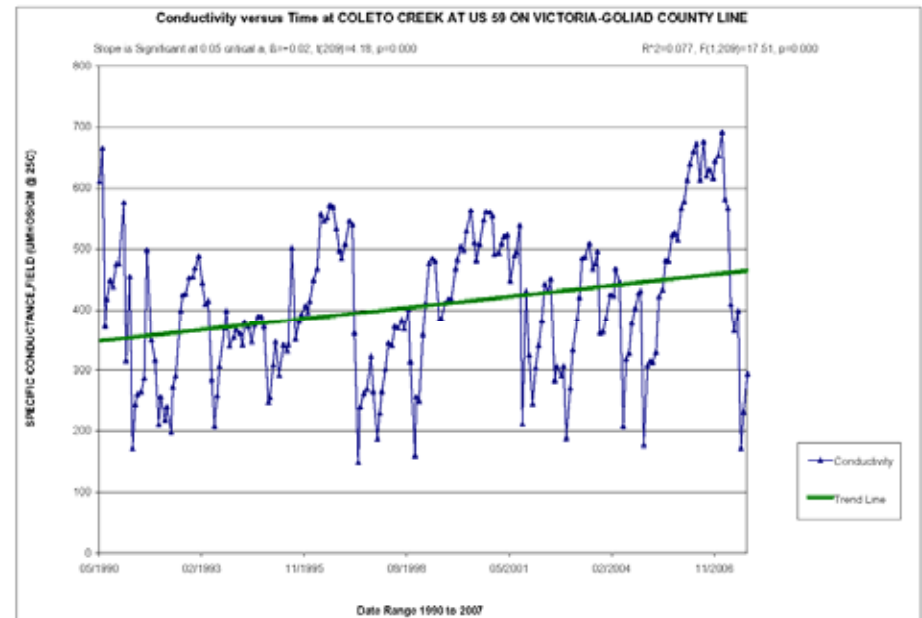


Figure 1. Specific conductance over time at the GBRA Coletto Creek Reservoir sampling site located at the boat ramp in the park (12623).



Figure 2. Chloride concentrations at the GBRA Coletto Creek Reservoir location (12623).

The dissolved oxygen ranged from 4.23 to 11.9 mg/L, with a median concentration of 8.25 mg/L. The site had no data points that fell below the dissolved oxygen grab minimum concentration of 4.0 mg/L and 14 out of 210 data points (6.7%) that fell below the dissolved oxygen grab screening level of 6.0 mg/L.

Ammonia nitrogen, nitrate nitrogen and total phosphorus were analyzed at the GBRA site at the boat ramp to the reservoir. The median concentration for ammonia nitrogen was 0.04 mg/L, ranging from less than the method detection to 0.34 mg/L. Looking at the trend in ammonia nitrogen over time, we see a significant drop in concentration in 2001. As mentioned in previous basin highlights

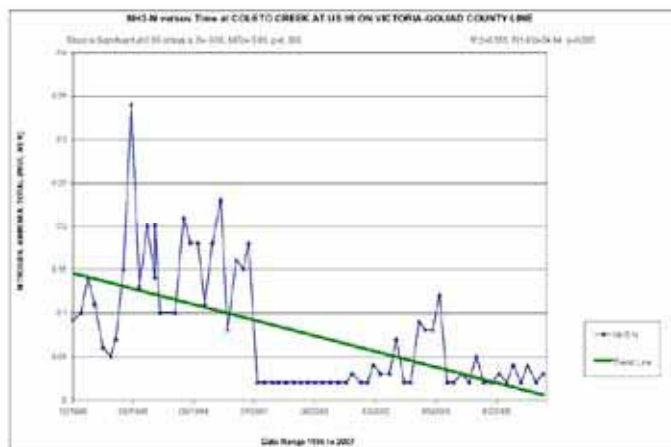


Figure 3. Ammonia nitrogen over time measured at the Coletto Creek Reservoir site at the boat ramp (12623). Drop in concentration in 2001 attributed to the removal of the distillation step from the analytical procedure.

and summary reports, the elimination of the distillation step from the ammonia nitrogen analytical procedure removed the contamination of the samples by the laboratory atmosphere and reduced the measured ammonia nitrogen in the samples (Figure 3).

This drop in ammonia concentration in 2001 is seen at the majority of other sites in the river basin but it is worthy of mention especially when looking at the Coletto Creek Reservoir data set because the concentrations prior to 2001 exceeded the screening concentration of 0.11 mg/L over 66% of the time and only one time out of 39 data points after 2001.

Nitrate nitrogen was analyzed and reported under three storet codes, alone and in combination with nitrite nitrogen. Nitrate nitrogen, combining all methods, had a median concentration of 0.09 and ranged from less than method detection to 0.94 mg/L, exceeding the screening concentration of 0.33 mg/L fourteen times out of 214 data points (6.5%). Total phosphorus concentrations ranged from less than method detection to 1.15 mg/L, with a median concentration of 0.074 mg/L. The historical data showed that the site only exceeded the screening concentration for total phosphorus three times, one being 1.15 mg/L which is atypical of the historical data for the site, being fifteen-fold higher than the median, and may be due to sample contamination.

### Coletto Creek

The lower assessment unit is approximately 15 miles in length with a median flow of 5.6 cubic feet per second. Because very little of the watershed is below the Coletto Creek Reservoir, the flow in the lower assessment unit is dependent on releases from the reservoir. The upper assessment unit has the majority of the watershed for the Coletto Creek and its tributaries. Guadalupe River Basin stakeholders have voiced concerns about the impacts from oil and gas production and most recently, the possible impacts from the exploration and in-situ mining for uranium on the water quality in the Coletto Creek, upstream of the reservoir. In response to this concern GBRA established two stream sites upstream of the reservoir on Coletto Creek (site no. 18594) and Perdido Creek (site no. 18595) and sampled bimonthly for two years. The data sets for each site are very limited and not appropriate for trends over time analyses but the systematic monitoring does record baseline conditions for comparison in future years. Additionally, in 2007 and 2008, radiological samples are being collected at the Arnold Road site. The TCEQ has a stream monitoring location (site no. 12622) downstream of the reservoir that they have monitored two to four times per year since 1990.



Coletto Creek at Arnold Road (site no. 18594).



The median flow in the Perdido Creek is very low, only 0.2 cubic feet per second. The median flow in the Coletto Creek is 8 cubic feet per second. Looking at the small data set for Perdido Creek the only water quality parameters that raise concern is the elevated conductivity which is due to the elevated chloride concentration (median conductivity = 1066 umhos/cm; chloride = 170 mg/L). In the Coletto Creek at Arnold Road, the same is true. Again, it must be noted that these data sets are very small and not appropriate for use in stream assessments.

The TCEQ site below the reservoir has a very extensive data set, from 1991 to 2007. The median flow was 5.7 cubic feet per second. The median temperature was 25.3°C, ranging from 13°C to 33.7°C. The dissolved oxygen ranged from 4.8 mg/L to 12.5 mg/L, with a median concentration of 8.29 mg/L.

The conductivity was elevated, similar to the reservoir and upstream tributaries. The median specific conductance was 784 umhos/cm, ranging from 294 to 1354 umhos/cm. As seen upstream, the chloride contributes the most to the conductivity, with a median concentration of 115 mg/L but the stream did not exceed the stream standard of 250 mg/L in the historical data set. Where conductivity and chloride showed a positive, or increasing trend, at the GBRA site in the reservoir, these constituents showed the opposite trend or reducing concentrations downstream of the reservoir. Figures 5 and 6 show a negative trend which may be due to the contributions from tributaries to the Coletto Creek that are downstream of the reservoir.

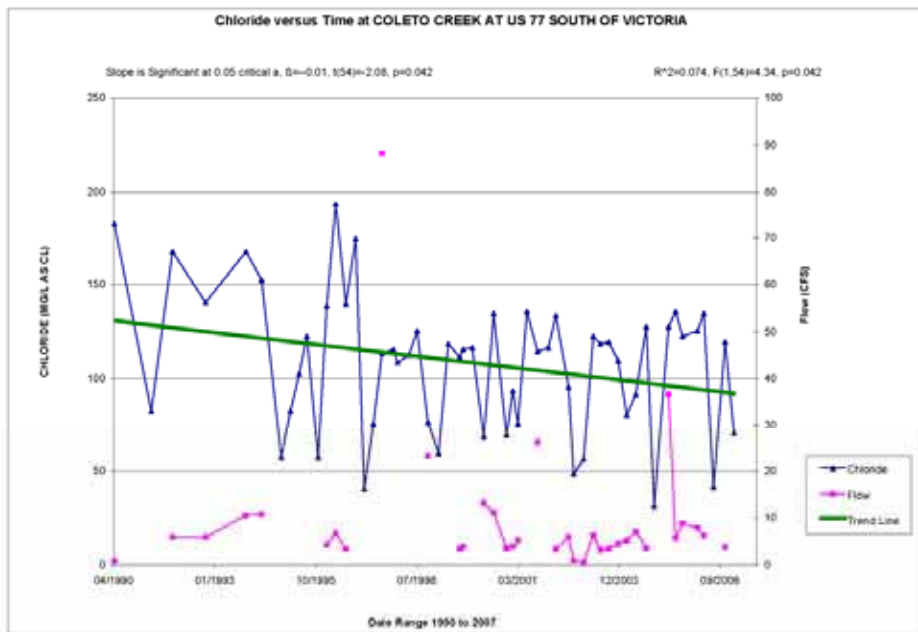


Figure 4. Negative trend in chloride concentration seen at the TCEQ site on Coletto Creek downstream of the reservoir (12622).

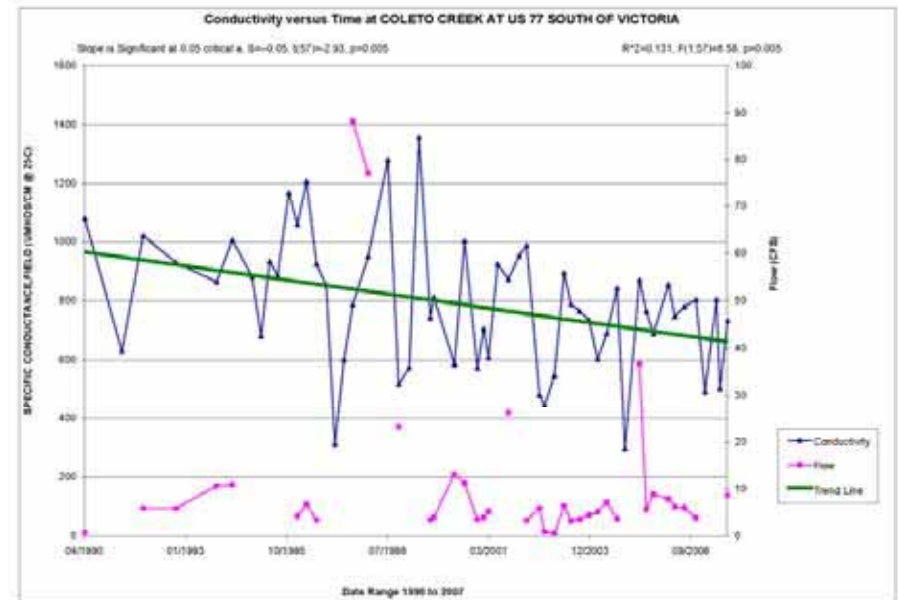
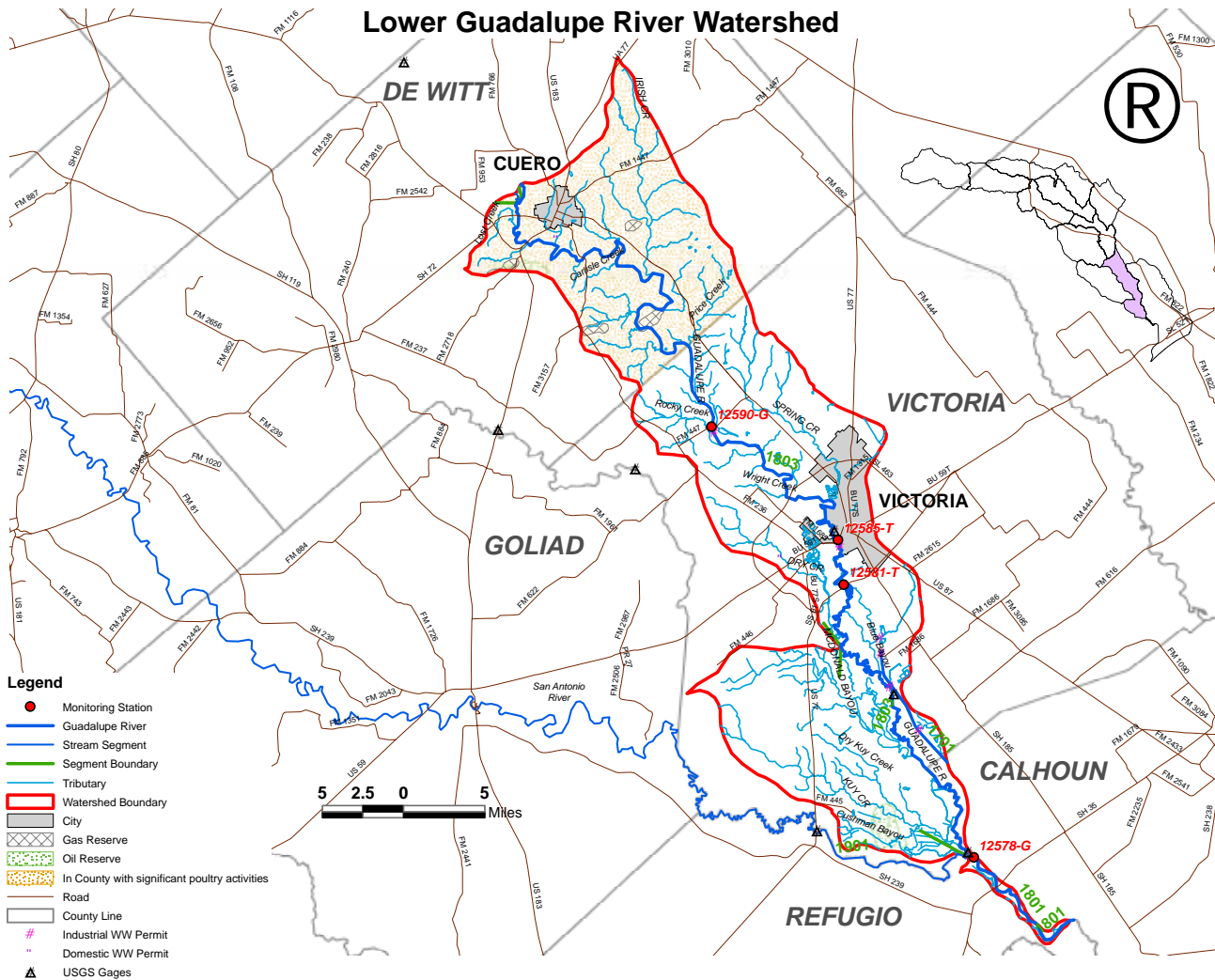


Figure 5. Negative trend in conductance seen at the TCEQ site on Coletto Creek downstream of the reservoir (12622).

*E. coli* and fecal coliform concentrations exceeded the respective contact recreation standard only two times in the historical data set. The nutrient concentrations, ammonia nitrogen, nitrate nitrogen and total phosphorus, never exceeded the stream screening concentrations for each respective nutrient.



Perdido Creek at FM 622 (site no. 18595).



**Monitoring Stations – Lower Guadalupe**

12595-G Guadalupe River at FM 766 west of Cuero  
 12590-G Guadalupe River at Nursery  
 12578-G Guadalupe River at Salt Water Barrier  
 12577-T Guadalupe River at Tidal Bridge

Sampling sites are labeled in red followed by the letter G (GBRA), T (TCEQ), U (UGRA) or W (Wimberley) indicating who is the monitoring entity.

**Lower Guadalupe River Watershed**

**Drainage Area:** 488 square miles  
**Streams and Rivers:** Guadalupe River Tidal, Guadalupe River Below San Antonio River, and Guadalupe River Below San Marcos River, Sandies Creek, Elm Creek, Coletto Creek, Spring Creek, McDonald Bayou  
**Aquifers:** Carrizo-Wilcox, Gulf Coast  
**River Segments:** part of 1803, 1802, 1801, 1701  
**Cities:** Cuero, Victoria, Tivoli  
**Counties:** Calhoun, Refugio, Victoria, DeWitt  
**EcoRegion:** Gulf Coastal Plains, East Central Texas Plains

**Vegetation Cover:**  
 Pasture/Hay - 14.8%      Shrublands - 21.1%  
 Grass/Herbaceous - 22.6%      Evergreen Forest - 5.7%  
 Row Crops - 4.2%      Wetlands - 10.2%  
 Deciduous Forest 14.8%

**Climate:**  
 Average annual rainfall: 37.4 inches  
 Average annual temperature: January 53° July 84°

**Land Uses:** Urban, Agricultural Crops (cotton, corn, wheat, rice, hay, grain sorghum), Cattle and Hog Productions, Industrial (plastics, chemicals, petrochemicals)

**Water Body Uses:** Aquatic Life Use, Contact Recreation Use, General Use, Fish Consumption Use, Heavy Industrial Use, Public Water Supply Use  
**Soils:** Cracking clay subsoil, sandy, sandy and clay loam  
**Permitted Wastewater Treatment Facilities:**  
 Domestic: 4  
 Industrial: 5

The **Lower Guadalupe** is made up of three river segments. Segment 1801, Guadalupe Tidal; Segment 1802, Guadalupe River below the San Antonio River; and, Segment 1803, the Guadalupe River below the confluence with the San Marcos River. Additional discussion on Segment 1701, the Victoria Barge Canal, is included in this section.

### Guadalupe Tidal

Segment 1801, Guadalupe Tidal, extends from one-half mile downstream of the GBRA Salt Water Dam to where the river enters Guadalupe Bay in Calhoun County. This eleven mile stretch is a typical marshy, tidal river. (The Salt Water Dam is a set of two inflatable fabric dams, used during times of low river flow to prevent salt water intrusion by tides.) The TCEQ Region 14 office has monitored at the tidal bridge over the Guadalupe River two to four times per year since 1990. Unfortunately, the data set did not include flow data with each constituent, so it is difficult to attribute extremes in water quality to extremes in flow. Compounding the problem with relating flow to parameter data is the fact that before August 2000 the US Geologic Survey reported flow as gage height rather than as cubic feet per second (cfs). After that date, the flow is given as cubic feet per second. Wherever possible, historical knowledge of flow and comparison of gage heights during those periods to gage heights that have corresponding flow in cfs were considered when looking at extremes in data. An example can be seen in the data taken in September 2002. One of the highest values reported for total phosphorus, enterococcus, *E. coli* and total suspended solids were recorded at the TCEQ tidal bridge site in September 2002. Although the flow that the USGS reported during the September sampling event did not seem unusually high, in July 2002, the upper Guadalupe River experienced one of its most devastating floods. The USGS gage in this segment does not accurately reflect true flows when flows are greater than 2,500 cfs. The September data set was most likely still influenced by flood flows coming from upstream.

### Water Quality

Segment 1801 is made up of one assessment unit. The segment was listed with concerns on the 2008 draft Texas Water Quality Inventory for depressed dissolved oxygen and nitrate nitrogen. The inventory cites that the segment exceeded the dissolved oxygen grab criteria of 5.0 milligrams per liter (mg/L) 6 times out of the 37 data points assessed. The median concentration for dissolved oxygen was 6.53 mg/L, ranging from 3.9 mg/L to 12.3 mg/L.

Nitrate nitrogen exceeded the screening concentration of 1.1 mg/L 26 out of 28 sampling events. The median concentration was 1.98 mg/L, ranging from less than detection to 4.72 mg/L. The exceedence of the nitrate screening criteria is due to the concentration of nitrate nitrogen coming from the San Antonio River. GBRA established a monitoring site on the lower San Antonio River at Fannin in 1987, in part, to help explain impacts of flows coming from this “tributary” of the Guadalupe River. The GBRA San Antonio River site had a median concentration of 5.15 mg/L over the period of historical monitoring performed by GBRA from 1987 to 2007. The San Antonio River is effluent-dominated with the city of San Antonio

and other smaller cities downstream discharging to the stream. Prior to major upgrades to the wastewater plants that serve the city of San Antonio, the stream routinely violated the drinking water standard of 10 mg/L nitrate nitrogen. Since the upgrade of the city of San Antonio’s Dos Rios Wastewater plant and the installation of a major water reuse program that diverts some of the city’s wastewater effluent to industrial users, concentration of nitrate nitrogen in the San Antonio River has been reduced. However, the San Antonio River still enters the Guadalupe River above the screening concentration for nitrate nitrogen (1.1 mg/L). The nitrate nitrogen concentration upstream, in segment 1803, ranged from 0.85 mg/L at the Guadalupe River at FM 766 in DeWitt County to 0.7 mg/L at the Hwy 59 Bridge in downstream of Victoria (very limited data set collected by USGS.) Figure 1 shows that there is no trend, increasing or decreasing, in the nitrate nitrogen concentration over time.

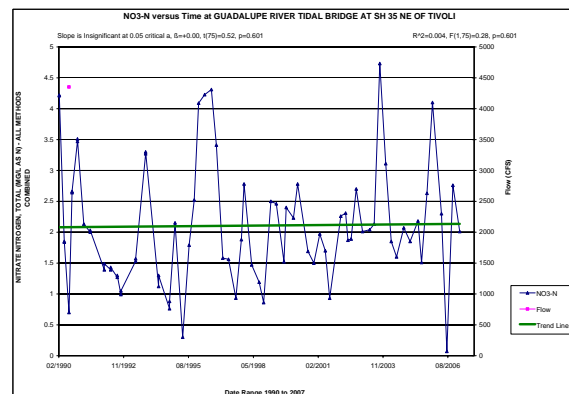


Figure 1. Guadalupe River at Tidal Bridge (12577)- nitrate nitrogen over time.

Surprisingly, segment 1801 only exceeded the screening concentration of 0.66 mg/L for total phosphorus one time (0.92 mg/L) in the data set used by the TCEQ assessment team. Figure 2 shows that conditions are improving in respect to the phosphorus concentration that is mostly due to the upgrade of the city of San Antonio’s Dos Rios Wastewater plant and the installation of a major water reuse program that diverts the majority of the city’s wastewater effluent to industrial users.

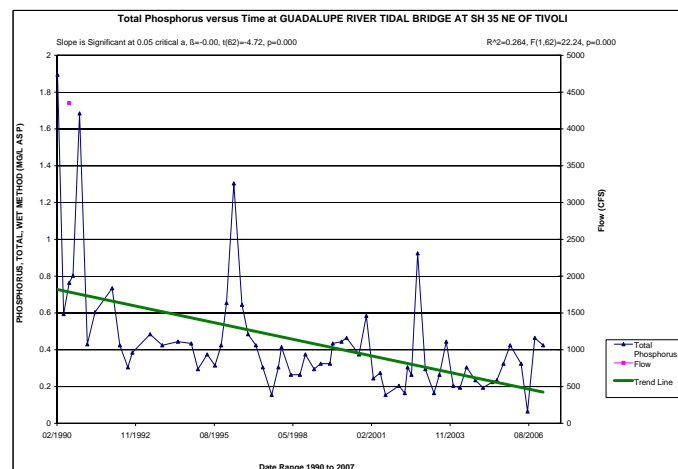


Figure 2. Guadalupe River at Tidal Bridge (12577) – phosphorus concentrations showing slight decline over time.



The median concentration for the **specific conductance** was 714 micromhos per centimeter (umhos/cm), ranging from 371 to 8062 umhos/cm. The extreme high conductance was recorded in January 2002 and there was no known associated flow extremes, high or low, during that time. The next highest values are a series of three measurements in the low 1000 umhos/cm that occurred in 1996. 1996 was one of the driest years during the period of record. These higher conductivity results are most likely due to the higher ratio of wastewater to baseflow in the river because these concentrations are too low to be from tidal influence.

The median pH was 7.99, ranging from 7.5 to 8.9. The temperature ranged from 8.9 °C to 31.9 °C, with a median temperature of 25.6 °C. The total suspended solids ranged from 4 to 774 mg/L, with a median concentration of 74 mg/L. Ammonia nitrogen did not exceed the screening concentration during the period of record. Chloride concentrations ranged from 28 to 147 mg/L, with a median concentration of 64 mg/L. Sulfate concentrations ranged from 23 to 93 mg/L, with a median concentration of 51 mg/L. The monitoring site was monitored for fecal coliform in the early years and then converted to *E. coli* and enterococcus in the 2001. The concentrations of all bacteria groups only exceeded the stream standard one time each, in the data set in September 2002 when the river was experiencing the effects of flooding upstream.

#### Stakeholder Concerns

No specific stakeholders concerns have been voiced at Clean Rivers Program meetings but issues that impact this segment include reduction in fresh water flows due to upstream demands and wastewater reuse, impacting the bay and estuary and threatening the habitat of the whooping crane, an endangered species that winters near San Antonio Bay; and log jams that create impedances that force the rivers and streams in the segment to leave their channels and flow across property.

#### Guadalupe River Below the San Antonio River

Segment 1802, **Guadalupe River below the San Antonio River**, is a 0.4 mile section of river that extends from the confluence of the Guadalupe River and the San Antonio River in Refugio County to 0.5 mile downstream of the Salt Water Barrier. In this stretch, the Guadalupe River is a slow moving coastal river that is characterized by log jams and fractured flow patterns. Currently, the flow from the San Antonio River may be entering the Guadalupe River in a different location due to past log jams that have created cuts over to Elms Bayou. GBRA, along with other entities in the area, including the Refugio and Calhoun counties, the US Corp of Engineers, and NRCS, will be investigating the area and the flow patterns to determine if the actual confluence of the two rivers has changed.

#### Water Quality

Segment 1802 is made up of one assessment unit. GBRA has one historical monitoring site in Segment 1802. The “Salt Water Barrier” site (GBRA SWB), site number 12578, has been sampled monthly since 1987. The flow was recorded as gage height until the year 2000, where mean daily flow or instantaneous flow in

cubic feet per second is now being recorded for each sampling event.

The segment was listed with concerns on the 2008 draft Texas Water Quality Inventory for nitrate nitrogen, with 30 out of 83 measurements exceeding the screening concentration of 1.95 mg/L. In the GBRA data set and combining all methods reported, the median concentration for nitrate nitrogen was 1.9 mg/L, ranging from 0.18 to 16.9 mg/L. As described in the summary for Segment 1801, segment 1802 is also highly influenced by the contributions of the effluent-dominated stream, the San Antonio River, during low flows and by dilution when there are high flows from flood events upstream (figure 3).

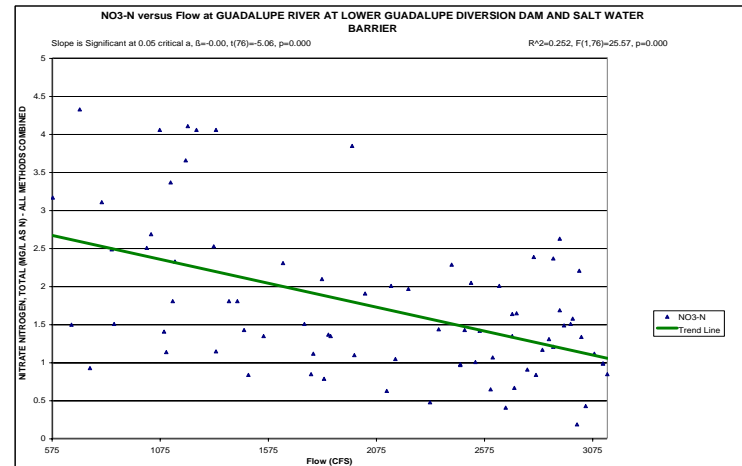
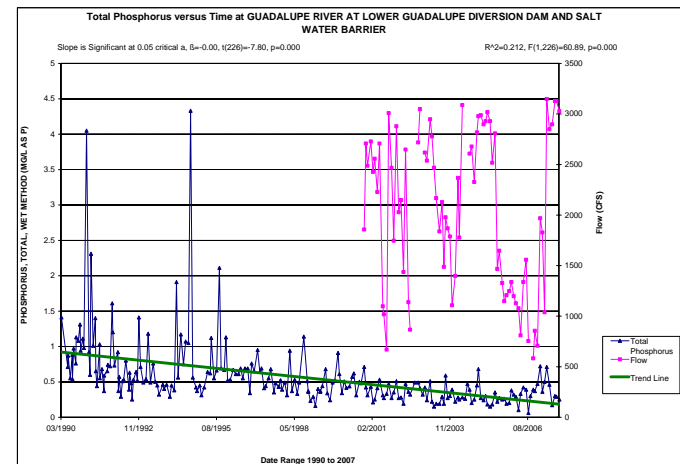


Figure 3. Fluctuations in nitrate concentrations at the GBRA site at the Salt Water Barrier (12578), due in part to contributions from the San Antonio River and to dilution during high flow events.

Figure 4 shows a decreasing trend in total phosphorus, similar to the downward trend seen in Segment 1801. The decreasing concentrations may be associated with an improvement in wastewater treatment in both watersheds over time. There



is no correlation with flow. The median concentration was 0.46 mg/L, ranging from less than method detection to 4.32 mg/L.

Figure 4. Decreasing trend in phosphorus concentration over time at the GBRA SWB site on the Lower Guadalupe (12578).

The water quality at the GBRA SWB site was very similar to the TCEQ monitoring location at the Tidal Bridge in Segment 1801, since both are downstream of the San Antonio River, the largest influence to the water quality in this portion of the river. The temperature ranged from 9.97°C to 32°C, with a median temperature of 23.1°C. The pH ranged from 7.5 to 8.9, with a median pH of 7.99. The total suspended solids had a median concentration of 76 mg/L, ranging from 7.1 to 1572 mg/L. The chloride and sulfate concentrations had median concentrations of 59.2 and 50.7 mg/L, ranging from 7.4 to 140 mg/L and 0.5 to 107 mg/L respectively.

The bacterial analysis of Segment 1802 included fecal coliform and *E. coli*, but not enterococcus. The *E. coli* concentrations ranged from 2 to 3300 organisms per 100 milliliters, with higher concentrations correlated with higher flow events. The chlorophyll a ranged from less than method detection to 38.3 micrograms per liter, exceeding the screening concentration of 14.1 ug/L 19 times out of 135 sampling events. There was no statistical correlation with flow.

Metals in water were analyzed at the GBRA SWB site. The data can be reviewed in the *Metals in Water* section of this document. The SWB site, the most downstream site, monitored by GBRA for metals in water, has one of the highest concentrations of each metal detected in the river basin, usually slightly less than those detected at Peach Creek. The concentrations at the SWB are not near the acute or chronic metals criteria because the hardness of the water reduces the toxic nature of the heavy metals. The concentrations at this site are not unexpected because being at the farthest end of the basin we would see the cumulative contributions of all tributaries and discharges to the river. One note to make, based on concerns by others across the state, the concentration of aluminum in April 2007 may be due to questionable field equipment and laboratory analyses provided by the contractor.

#### *Stakeholder Concerns*

No specific stakeholders concerns have been voiced at Clean Rivers Program meetings for segment 1802 but issues that have been raised over the years include reduction in fresh water flows due to upstream demands and wastewater reuse, impacting the bay and estuary and threatening the habitat of the whooping crane, an endangered species that winters near San Antonio Bay, and log jams that create dams that force the rivers and streams in the segment to leave their channels and flow across property.



Three mile log jam on lower San Antonio River.

### **Guadalupe River below the confluence with the San Marcos River**

The **Guadalupe River below the confluence with the San Marcos River**, Segment 1803, begins in Gonzales County, flowing downstream to the confluence with the San Antonio River in Refugio County. The river flows through Gonzales, DeWitt, Victoria, Refugio and Calhoun counties. This portion of the Guadalupe River is a slow-moving, coastal river with a silty substrate, and lined with pecan bottoms. Because of the change in elevation, the upper reaches of the Guadalupe River located in the hill country are shallow and turbulent. Conversely, the lower Guadalupe River flows through low hills and flat plains, with very little turbulence. Segment 1803 is subject to flooding during which the river often leaves its banks and inundates the riparian areas along the river. While high flows during flooding events scour the inundated areas in the upper segments of the river, the flood waters in the lower basin, spread out over the land that is along the river, deposits silt and carries material, such as logs, downriver.

Segment 1803 is divided into five assessment units: the lower 25 miles (1803\_01); from the confluence with the Coletto Creek 25 miles upstream (1803\_02); from the confluence with the Sandies Creek upstream 25 miles (1803\_03); from 25 miles upstream of the confluence with Coletto Creek to the confluence with Sandies Creek (1803\_4); from 25 miles upstream of the confluence with Sandies Creek to the upper end of the segment (confluence with the San Marcos River) (1803\_05).

#### *Land Use and Wastewater Discharges*

GBRA has an historical site near Cuero ("FM 766"; Site no. 12595) in Segment 1803. GBRA has monitored this site monthly since 1990. The FM 766 site is located in assessment unit 1803\_03, approximately at the halfway point down the segment. Also in Segment 1803, in assessment unit 1803\_02, GBRA maintains a quarterly monitoring site upstream of the city of Victoria, near the community of Nursery. The site at Nursery (site no. 12590) has been monitored since late 1999. GBRA has recently discontinued monitoring at a quarterly site on the Guadalupe located near the Invista (formerly I.E. Dupont deNemours, Inc.) industrial site. After reviewing the flow, it was determined that the sampling location was in the mixing zone of the industrial discharge and not representative of the flow and water quality of the segment. The site has not been replaced because of the lack of public access locations in the area. The area downstream of the industrial plant is in large tracts of private land with no public access points. The next closest monitoring site was a site maintained in the early 1990s by the US Geological Survey located downstream of the city of Victoria at Hwy 59.

The land use in the upper portion of Segment 1803 is primarily agricultural, with row crops, pastures, hog, chicken and cattle operations. The cities of Gonzales and Cuero are located in the upper portion, both of which have wastewater plants that discharge into the segment. The city of Gonzales operates a wastewater facility that is permitted to discharge 1.5 million gallons per day (MGD), with limitations of 10 milligrams per liter (mg/L) biochemical oxygen demand, 15 mg/L total suspended solids and utilizes ultraviolet light for disinfection of the effluent. The city of

Cuero plant is designed and permitted to treat 1.5 MGD. The facility has permit limitations of 20 mg/L biochemical oxygen demand and 20 mg/L total suspended solids. The city of Victoria is located further downstream and is the largest city in the watershed, with a population of greater than 60,000. The city is served by two wastewater treatment plants operated by GBRA. The Victoria Willow Street plant is designed and permitted to treat 2.5 MGD. The facility is a combination trickling filter/activated sludge facility, with permit limitations of 20 mg/L biochemical oxygen demand and 20 mg/L total suspended solids. The Victoria Regional plant is designed and permitted to treat 9.6 MGD. Its effluent limitations include 20 mg/L carbonaceous biochemical oxygen demand and 20 mg/L total suspended solids.

In addition to the municipal wastewater systems, there are industrial discharge permits issued in the segment. There are two power plants that serve the city of Victoria and surrounding area that use flow from the Guadalupe River as once-through cooling, discharging warm water back to the mainstem. The power plant located in the city of Victoria must monitor and record the daily maximum flow, temperature and rise in river temperature, along with river stage. The second facility is located upstream of the city and near the community of Nursery. Invista has discharge permits, in addition to injection wells and a wetlands area, that treat and dispose of different waste streams on their plant site.

### Water Quality

There are two sites on Segment 1803 with sufficient historical data for trends analyses and review, the GBRA's monthly site near Cuero ("FM766") and the GBRA site upstream of the city of Victoria near Nursery ("Nursery"). The Nursery site is only monitored quarterly and was established in late 1999. The USGS monitoring location at Hwy 59 downstream of Victoria has a very limited data set from the early to mid-90s. The data can be used for comparison to the upstream locations but not for trend analysis.

The median **flow** that was recorded during the historical monitoring at the FM766 site in the upper portion of the segment was 2487 cubic feet per second (cfs) and at Nursery, the median flow during sampling was 1610 cfs. This difference in flow is not due to a loss in water but mostly due to difference in the size of the data sets. The temperature ranged from 9.8°C to 33.7°C, with a median temperature of 23°C at the FM766 site. The range of temperature measured at the Nursery site was similar, 9.7°C to 31.7°C. The median pH for the FM766 site was 8.03, and 7.91 at Nursery. Neither sites exceeded the stream standard range of 6.5 to 9.0. The conductivity at the FM766 ranged from 205 to 691 micromhos per centimeter (umhos/cm), and ranged from 302 to 688 umhos/cm at the Nursery site, with medians of 539 and 558 respectively.

There is very little change in nutrient concentrations between the two stations. Neither station exceeded the screening concentration for ammonia nitrogen of 0.33 milligrams per liter (mg/L), and had very similar ranges in concentration. The median concentration for nitrate nitrogen was the same at both locations. The FM766 site exceeded the screening concentration for nitrates 2 times out of 208 measurements and the Nursery site exceeded the screening concentration

only once. There is very little correlation of nitrate concentration with flow. Figure 5 shows the change in nitrate and flow over time at the FM766 site. Where higher than normal flow events can explain some peaks in nitrate, there are more times where the nitrate fluctuates without changes in flow. The same fluctuations in nitrates are seen at the Nursery site as well.

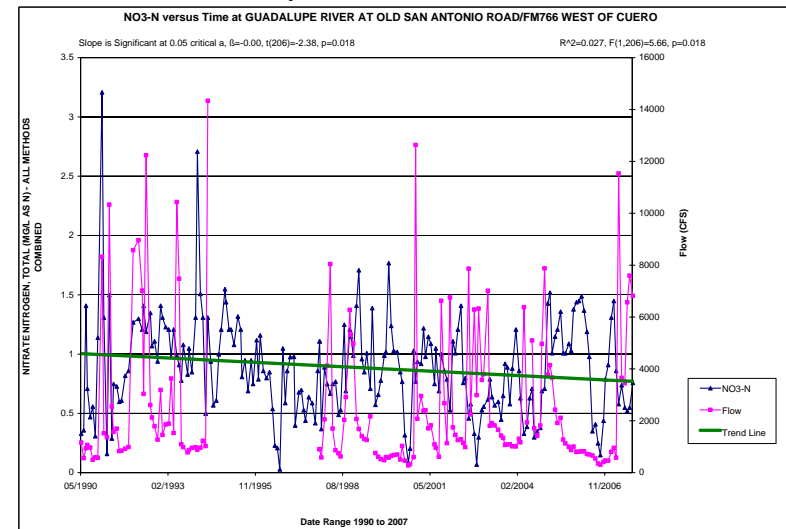


Figure 5. Fluctuations in nitrate nitrogen concentrations at the GBRA site at FM 766 (12592) are not easily explained by flow.

Total phosphorus has a positive correlation with higher flows at the FM766 site as seen in figure 6. The source of the total phosphorus is most likely the suspended

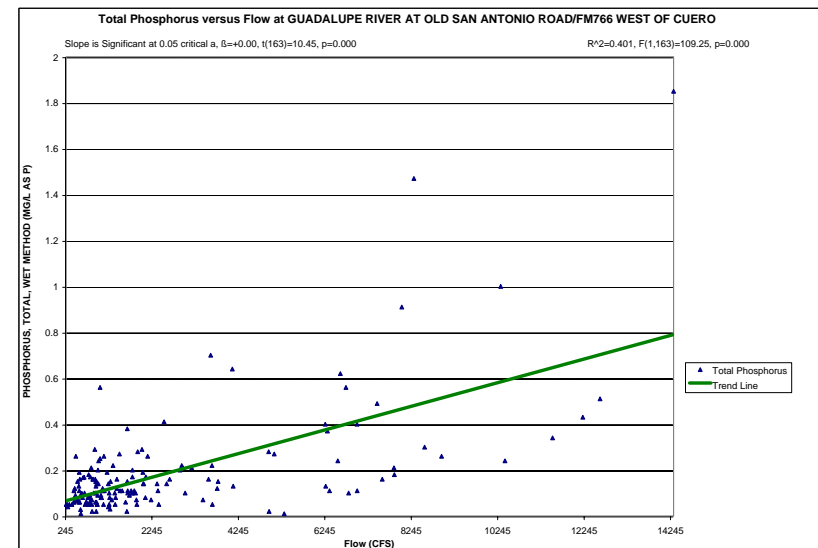


Figure 6. Total phosphorus positively correlates with high flow events at the GBRA FM766 (12592) monitoring location.



material that is carried in during high runoff events. To support this likelihood, figure 7 shows the statistical correlation between suspended solids and flow. The suspended material is made up of sediment and organic material which contains phosphorus, in the form of inorganic phosphates that are added to the fields as fertilizer and organic phosphorus, bound in plant material and soil. The same relationships are seen at the Nursery site as well. The median total suspended solids concentration at the FM766 site was 24 mg/L, ranging from 3.7 to 1036 mg/L. The Nursery site had a median concentration of 30.8 mg/L, ranging from 8.3 to 948 mg/L.

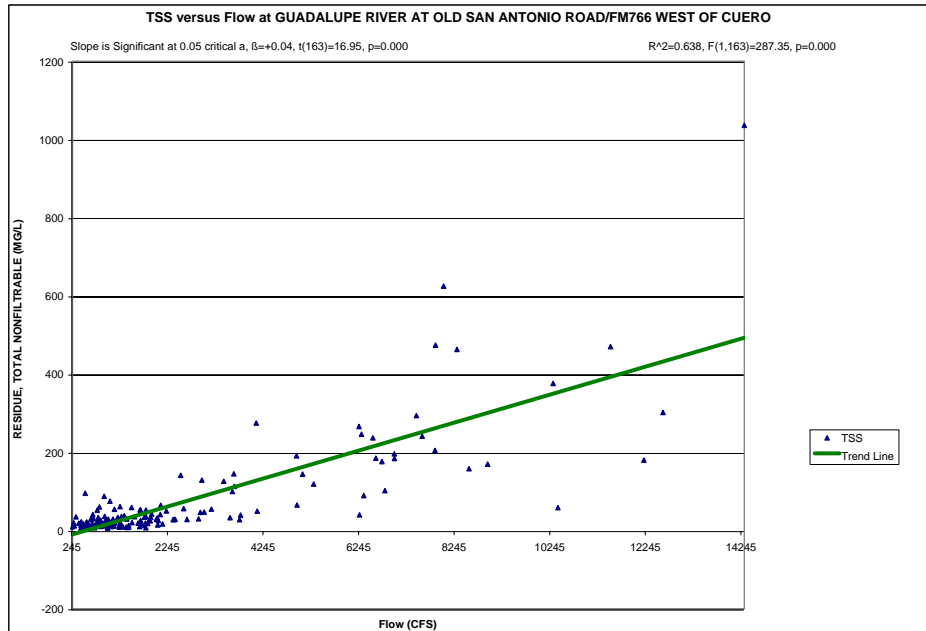


Figure 7. Total suspended solids correlates with flow at the GBRA FM 766 site (12592), bringing in phosphorus in the form of phosphates from fertilizers and as organic phosphorus in silt and organic material.

Flow has the opposite effect on dissolved constituents, diluting the natural background concentrations of chloride and sulfate (figure 8). The median concentrations of chloride at the FM766 site was 27.8 mg/L, ranging from 7.2 to 64 mg/L, and never exceeding the stream standard of 100 mg/L. The median concentration for sulfate at the FM 766 was 30.4 mg/L, ranging from 3.4 to 45.8 mg/L. The concentrations for these dissolved constituents were similar at the Nursery site.

The *E. coli* geometric mean at the FM766 was 44 organisms per 100 milliliters. Exceedences of the stream standard for contact recreation occurred 14 out of 134 measurements, or 10.4% of the time. The *E. coli* geometric mean at the Nursery site was slightly higher, at 87 organisms per 100 milliliters, and exceedences of the stream standard for contact recreation occurred 7 out of 33 sampling events. The difference between sites is most likely due to the differences in the

small size of the data set for the Nursery site and not to a consistent source of bacteria. Chlorophyll a concentrations at both sites were the same, with median concentrations of 2.7 micrograms per liter. The ranges differed slightly, with a higher concentrations occurring at the FM766 site. The site exceeded the screening concentration for chlorophyll a 3 out of 133 measurements. The Nursery site did not exceed the screening concentration in the period of record. As with other constituents monitored, the differences between sites are most likely due to the smaller size of the data set.

### Stakeholder Concerns

Stakeholder concerns in this segment include impacts of poultry operations, primarily in the Sandies and Elm Creek watersheds; impacts from bacterial and nutrient contributions from non-point source runoff, ranging from small cow/calf operations to confined animal feed lots; potential for spills and leaks from the many chemical pipelines that cross the river; impacts from in-situ uranium mining; and, impacts of endocrine disrupting chemicals associated with agricultural operations, such as synthetic growth hormones and antibiotics, as well as those that fall in the group of chemicals referred to as “personal care products”, such as lotions, pain relievers and insect repellents. The bacterial impairments on Sandies and Elm Creeks are being investigated in the total maximum daily load project that is finishing up in 2008. The potential for spills and leaks is difficult to address. TCEQ regional offices are responsible for responding to spills, as well as the Texas Parks and Wildlife Department’s Spills and Kills Team. Specific to the Guadalupe Basin, GBRA sends letters each year to the fire and emergency management offices of each county, requesting that GBRA be notified if there is spill or leak response required in their county. Our field crew will respond in order to offer assistance in monitoring the stream, to provide historical water quality information as well as gather current information that can be relayed to operations and water users downstream of the spill and to keep the events inventory up to date for future reference. In-situ uranium mining is discussed in the section on the Coletto Creek watershed, segment 1807.

Investigation into the potential for endocrine disrupting chemicals in the watershed is very costly and there are very few laboratories available to analyze for that large suite of compounds. As technology improves, the compounds are more easily detected, but there is little known as to what concentrations in surface water should raise a red flag. In the future, CRP and GBRA will discuss the need for these analyses and whether the funding for those analyses is available.

## Victoria Barge Canal

Segment 1701, the Victoria Barge Canal, extends from the turning basin downstream to the confluence with the San Antonio Bay. The TCEQ Region 14 has one monitoring location in the Barge Canal. The site has been monitored from 1990 through 1997, discontinued for a period of 4 years and reinstated in 2001. The regional office crew monitored the site quarterly.

The barge canal is used by industries for barge traffic. Additionally, several industries, such as Union Carbide and BP Chemical, discharge permitted waste to the waterbody. The water body has been listed with concern for nitrate nitrogen and chlorophyll a concentrations on the 2008 draft Texas Water Quality Inventory. The designated use is listed as non-recreational. The impairment for aquatic life support because of dissolved oxygen concentrations was lifted after diurnal monitoring collected additional data and showed sufficient dissolved oxygen to support aquatic life use.

### Water Quality Monitoring

Field parameters were collected over the period of record, and through the water column, at depths of 0.3 meter (m) through 5 m. The following table shows the median values for each field parameter by depth, measured over the period of record:

Depth	Conductivity	pH	Dissolved Oxygen	Temperature	Salinity
0.3 m (surface)	6500	8.1	7.6	26	3.6
0.31 – 1.0 m	6232	8	7.52	28.6	3.4
1.1 – 2.0 m	6201	8	7.15	27.5	3.4
2.1 – 3.0 m	3365	8.25	7.75	27.7	2.4
3.1 – 5.0 m	2485	8.25	7.2	29	1.8

The canal is brackish, uniform in pH, temperature and dissolved oxygen through the water column, and showing some density stratification from surface to bottom.

Conventional parameters were collected at the surface, within 0.3 meters. The total suspended solids ranged from 4 to 186 milligrams per liter (mg/L), with a median concentration of 42 mg/L. The suspended solids appeared to be increasing through 1997, but after the site was reinstated the solids appear to have stabilized (Figure 1).

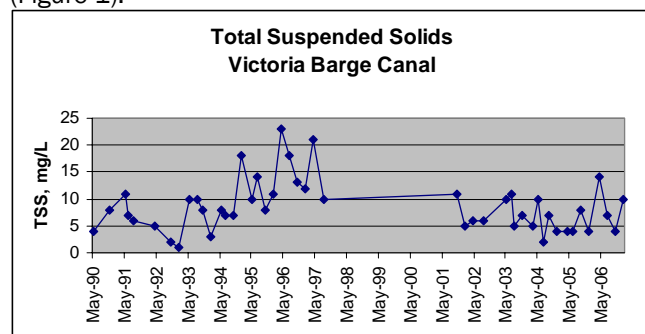
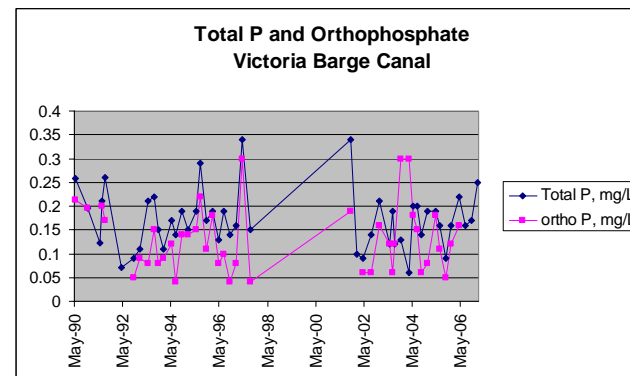


Figure 1. Total suspended solids in the Victoria Barge Canal (12536).

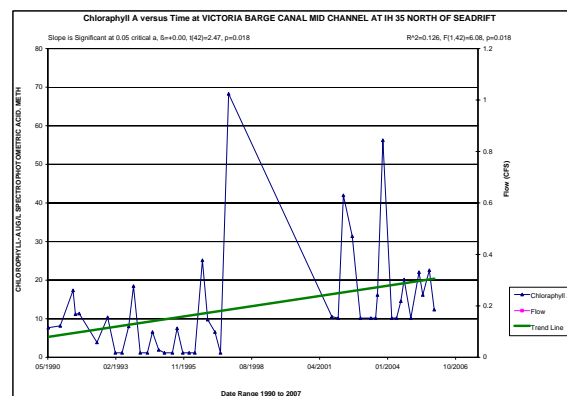
In 2006 the Texas Water Quality Inventory listed the barge canal with concerns for nitrate nitrogen. The nitrate nitrogen concentrations ranged between 0.01 to 1.4 mg/L, with a median concentration of 0.18 mg/L. The ammonia nitrogen concentrations ranged from below method detection to 10.11 mg/L, with a median concentration of 0.065 mg/L. The site exceeded the screening concentration three times, one being 10.11 mg/L in May 1994. This value appears to be a one time occurrence. Total phosphorus concentrations ranged from 0.06 to 0.34 mg/L, with a median concentration of 0.16 mg/L. The majority of the total phosphorus was in the orthophosphate (dissolved) form. The median concentration of the orthophosphate over the same period of record was 0.12 mg/L. Over the 14 years worth of quarterly data, there is very little change in the phosphorus concentrations and no significant trend is indicating a degrading water quality (figure 2).



concentrations and no significant trend is indicating a degrading water quality (figure 2).

Figure 2. Total and orthophosphate concentrations in Victoria Barge Canal (12536).

Chlorophyll a concentrations ranged from less than detection to 68.1 micrograms per liter. Ten measurements fell outside the screening concentration of 14.4 micrograms per liter, or 22% of the time. In figure 3, there appears to be a slight upward trend in the chlorophyll a.

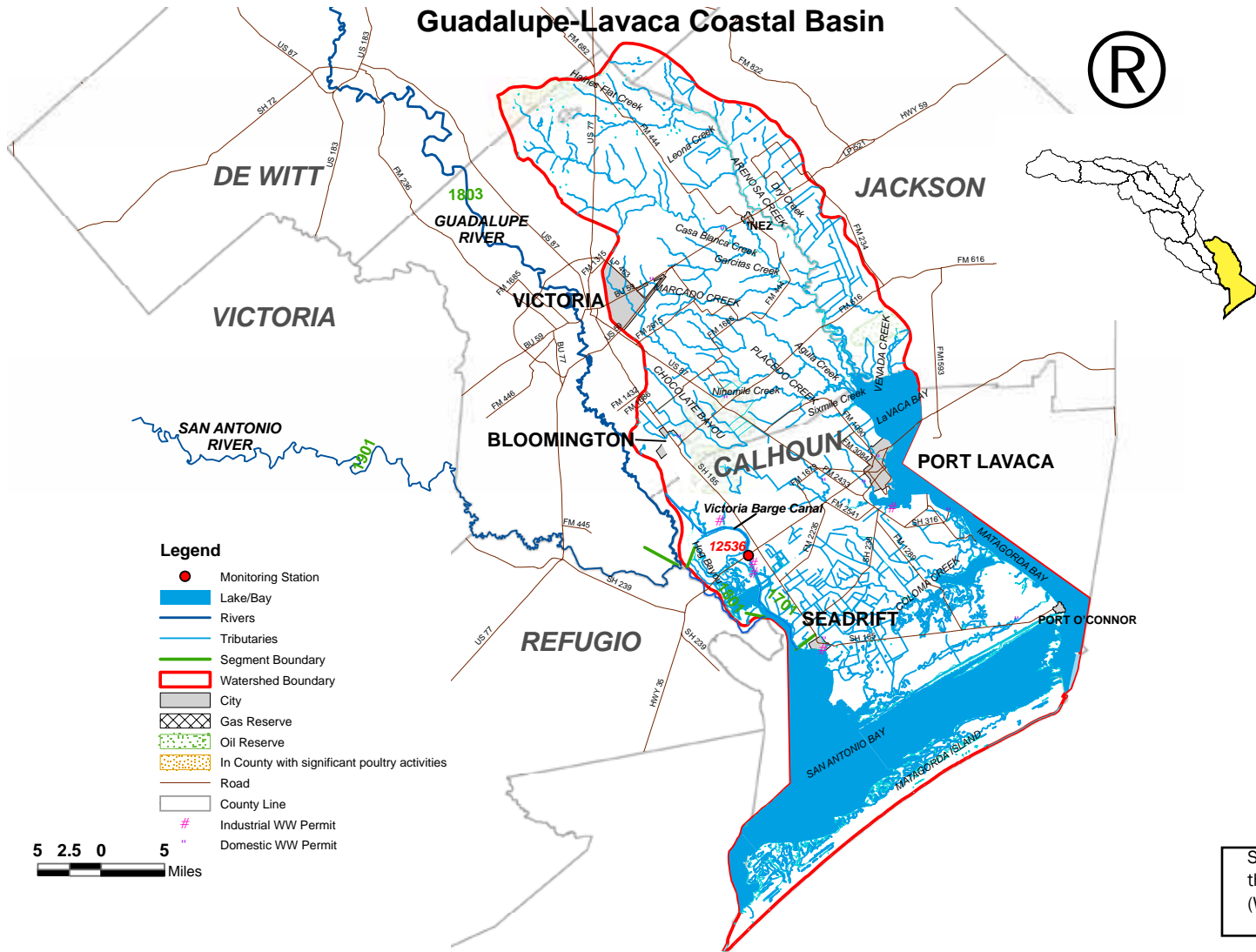


Data collected before the site was discontinued in 1997 had a lower detection limit of 1.0 microgram per liter. After the site was reinstated the detection limit for the chlorophyll a method was raised to 10 micrograms per liter.

Figure 3. Data shows a slight upward trend in chlorophyll a concentrations over time at the Victoria Barge Canal site (12536).

### Stakeholder Concerns

No stakeholders have voiced concerns with the Barge Canal. General concerns for water quality and the impact of barge traffic, chemical pipelines and industrial discharge quality would apply.



**Monitoring Stations –  
Guadalupe-Lavaca Coastal Basin**  
12536-T Victoria Barge Canal

Sampling sites are labeled in red followed by the letter G (GBRA), T (TCEQ), U (UGRA) or W (Wimberley) indicating who is the monitoring entity.

**Guadalupe-Lavaca Coastal Basin**

**Drainage Area:** 998 square miles

**Streams and Rivers:** Guadalupe River, Garcitas Creek, Victoria Barge Canal, Mercado Creek, Arenosa Creek

**Aquifer:** Gulf Coast

**River Segments:** 2453

**Cities:** Victoria, Seadrift, Bloomington, Inez, Port O’Connor, Port Lavaca

**Counties:** Calhoun, Victoria, Jackson

**EcoRegion:** Gulf Coastal Plains

**Vegetation Cover:**

- Pasture/Hay - 15.1%
- Grass/Herbaceous - 13.7%
- Row Crops - 21.4%
- Shrublands - 16.9%
- Deciduous Forest - 8.4%
- Wetlands - 17.2%

**Climate:** Average annual rainfall: 42 inches  
Average annual temperature: January 44° July 93°

**Land Uses:** Agriculture Row Crops (cotton, corn, rice and grain sorghum), Urban, Recreation, Oil & Gas Production, Cattle, Hog and Poultry Production, Industry (plastics, chemicals, petrochemicals)

**Water Body Uses:** Aquatic Life Use, Non-contact Recreation Use, Fish Consumption Use, Industrial Cooling

**Soils:** Clay subsoils, deep black soil, sandy clay, dark clay loam, clay

**Permitted Wastewater Treatment Facilities:**  
Domestic: 10  
Industrial: 5



The Guadalupe-Lavaca Coastal Basin has a drainage basin of 998 square miles. It receives flow from the Guadalupe River, Garcitas Creek, Arenosa Creek and the Victoria Barge Canal, along with other smaller tributaries and bayous. The bay and estuary system is made up of Chocolate Bay, Lavaca Bay, Matagorda Bay and San Antonio Bay. Within the drainage basin are the cities of Inez, Port Lavaca, Port O'Connor and Seadrift.

The area is home to the Whooping Crane, a migratory bird whose population had dwindled to dangerously low numbers, but is making a come back. The cranes are on the federally protected endangered species list. The Aransas Wildlife Refuge is their winter home. Studies are underway that are looking into impacts of reduced fresh water inflows on the bird's habitat and food supply.

### Land use

The land use in the watershed is made up of urban, rural, farming (rice and row crops) and industrial. The industrial plants include facilities for Union Carbide, BP Chemical, Formosa Plastics and Seadrift Coke. These industries manufacture a number of organic chemicals, which produce varying waste streams. These facilities maintain a number of wastewater and stormwater outfalls that discharge to the Victoria Barge Canal. Additionally, the Calhoun County Navigation District operates a Marine Loading facility in Point Comfort.

The area has come to the attention of land developers, looking to build large subdivisions made up of both summer residences and permanent homes. The area will need to increase water and wastewater infrastructure to order to support the growth.



Formosa

### Stakeholder Concerns

Stakeholders have voiced concern for a beneficial land application site in the upper portion of the watershed, near the city of Ines, and Arenosa Creek. The site has been permitted to land apply Class B wastewater sludge at a rate not to exceed 8 dry tons per acre per year on 793.4 acres located within approximately

2,881 acres. The stakeholders' fear is mismanagement that would allow pollutants to leave the property in the runoff. At the request of stakeholders and under CRP, samples of Arenosa Creek were collected prior to the issuance of the permit in order to establish background conditions. Samples were collected monthly from December 2000 to August 2003. The data collected showed that the creek was intermittent with high bacterial concentrations (geometric mean for *E. coli* = 198 organisms per 100 milliliters). The median total phosphorus concentration was 0.22 milligrams per liter.

Another concern of area stakeholders is the reduction of freshwater inflows to the bay and estuary system because of increased demands from upstream. There are additional studies underway looking into the fluctuations in salinity and impacts of reduced freshwater on the biological communities in and living along the bays.

A future concern that will become more important as populations in South Texas rise is the demand to develop desalination as a source of potable water. These facilities will introduce a new waste stream that will need to be handled.

### San Antonio Bay Studies

Two studies were initiated in 2003 to look at the importance and impacts of instream flows into San Antonio Bay and its ecosystem. The studies were to be funded by the partners working to develop the Lower Guadalupe Water Supply Project that would supply water from the lower Guadalupe Basin to the metropolitan areas of Bexar County and the Hill Country. Shortly after the studies were inaugurated funding was pulled by the largest partner, the San Antonio Water System. Recognizing the importance of the studies and that the need for water for the area was not going away, the GBRA and the San Antonio River Authority, continued to fund the two studies. The following is an overview of the objectives and status of the studies.

### The San Antonio Guadalupe Estuarine System (SAGES) Project

The SAGES project, Linking Freshwater Inflows and Marsh Community Dynamics in San Antonio Bay to Whooping Cranes, will help to provide a comprehensive understanding of the relationships between the nature of instream flows and Whooping Crane health along the Texas Gulf Coast, thus allowing state water managers to optimize diversions of freshwater while minimizing impact to this endangered species. The objectives of the study are to quantify patterns of habitat use by the cranes in relation to changes in Blue Crab availability, temperature, and human-induced disturbances; evaluate relationships between changes in water temperature, salinity and dissolved oxygen and the blue crabs; quantify macrophytic responses in marshes to annual variability in inflows and water chemistry; and, develop a model of relationships of inflows into bay to the whooping cranes in the marshes of Aransas Wildlife Refuge. The study is being conducted by teams from Texas A&M University, led by Dr. Douglas Slack, Dr. William Grant and Dr. Stephen Davis, and has completed four years of the six-year study. Project status is available at <http://sages.tamu.edu>.

### Estuarine Responses Project (ERP)

The overall focus of the ERP is the ecological health of the San Antonio Bay estuary, with the objective to assess the effects of instream freshwater inflows on that health. The health of the estuary will be measured by a complex of variables, both inorganic and organic, whose average values and distribution within the bay are characteristic of the estuary. The ERP will address hydrography (physical processes and variables, including morphology, hydrology, internal circulations, tides and other exchanges with the sea, stratification, and sedimentary processes), water quality and biology of the bay. Central to the project is the development and application of models capable of depicting the large-scale variations in key ecosystem parameters and their dependence upon external factors, one of the most important being the fresh water inflows into the bay. Phase I of the project, to gather and inventory historical data on San Antonio Bay, is critical to the development of these models. Because of the loss of the original funding the progress on the project has slowed somewhat. As funding is available the project will proceed in smaller phases. The project team is led by George Ward of the University of Texas at Austin.