

Segment 1804 represents the middle portion of the Guadalupe River that transitions between the rapidly urbanizing Texas Hill Country and the ranchlands of the Blackland Prairie. This portion of the river is used extensively for recreational swimming and boating on the small hydroelectric power generating lakes scattered along its length. The middle portion of the Guadalupe River is one of the most ecologically diverse, due to the significant hydrological and geomorphological changes that occur along its length.

Segment 1804 represents the 101 mile stretch of the Guadalupe River between the confluence of the Comal River in the City of New Braunfels and the confluence with the San Marcos River near the City of Gonzales. The majority of the stream flow in this segment comes from releases of water from Canyon Dam and spring flows from the Comal River. The segment also receives additional stream flow from several wastewater treatment discharges located along its length. The river in this segment experiences a drop in elevation of over 300 feet (585 msl to 266 msl) from

the Comal River confluence to the San Marcos River. The significant changes in elevation along this reach have provided ideal locations for the construction of 7 hydroelectric dams. These dams are all operated by GBRA and are much smaller in size than Canyon Dam. The water quality of the river in the impounded portions of the segment is significantly different than in larger reservoirs. The relatively high velocities in these impoundments keep the lakes from stratifying on a regular basis as is seen in Canyon Lake. These hydroelectric plants operate by diverting water into

canals that run parallel to the river in order to turn hydroelectric turbines to generate power. Hydroelectricity is only generated in times when stream flow at the Dunlap power plant is at least 528 cubic feet per second (cfs). The largest canal in the segment is located above the Lake Dunlap hydroelectric power plant, where the City of San Marcos pulls water to supply a surface water treatment plant. The San Marcos plant also supplies water to the cities of Kyle and Buda. Many other water purveyors draw on water from this segment as well: Canyon Regional Water Authority, Springs Hills Water Supply Corporation and Gonzales County Water Supply. The upper portions of the segment are primarily dominated by Lake Dunlap (TP-1 Dam), Lake McQueeney (McQueeney Dam), Lake Placid (TP-4 Dam), and Meadow Lake (Nolte Dam). These impoundments located in the upper portions of the segment are extensively used for recreational boating, swimming, public water supply and fishing. The land use in these areas is primarily urban with houses built along most

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Guadalupe River below Comal River

Drainage Area: 939 square miles

Length: 101 miles

Tributaries: Comal River (1811), Long Creek, Youngs Creek, Deadman Creek, Walnut Branch, Cottonwood Creek, Krams Creek, Geronimo Creek (1804A), Cantau Creek, Saul Creek, Cordell Creek, Polecat Creek, Salt Creek, Mill Creek, Sawlog Creek, Darst Creek, Nash Creek, Burroughs Creek, Foster Branch, Watson Creek, Clemens Creek, Answorth Branch, Stevens Creek, Pecan Branch

Aquifer: Edwards Balcones Fault Zone, Carrizo Wilcox

River Segments: 1804, 1803

Cities and Communities: New Braunfels, Seguin, Belmont, Gonzales

Counties: Comal, Guadalupe, Dewitt

EcoRegion: Edwards Plateau, Texas Blackland Prairie, Post Oak Savannah

Climate: Average annual rainfall 34.99 inches, Average annual temperature 20.28°C

Vegetation Cover: Evergreen Forest 16.79%, Deciduous Forest 11.54%, Shrubland 25.38%; Grassland 8.93%; Woody Wetlands: 3.05% Cultivated Crops 10.78% ; Pasture Hay 12.23%

Land Uses: urban, suburban sprawl, light industry, and recreational. Development: Low Intensity 1.85% ; Medium Intensity 0.76%; High Intensity 0.39%; Open Space 6.22%

Water Body Uses: aquatic life, contract recreation, general use, fish consumption, and public water supply

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

Permitted Wastewater Treatment Facilities: Domestic 7, Land Application 2, Industrial 2

available shoreline. Due to proximity of this segment to the recent zebra mussel finding in Canyon Lake, the Texas Parks and Wildlife Department (TPWD) and the GBRA have partnered to proactively perform early detection monitoring for zebra mussel larvae in the hydroelectric lakes. As of the winter of 2018, no live zebra mussel larvae have been found in any of the hydro lakes, but TPWD DNA detections in Lake Dunlap and Lake McQueeney reinforce the need for vigilant monitoring in this area. The river surrounding these impoundments is wide and straight with minimal changes in direction. The portion of the segment downstream of the City of Seguin is less channelized and much more sinuous. The river in this segment experiences more frequent changes in direction and the water clarity decreases as the river transitions from the limestone substrates of the Edwards Plateau to the dark clays and silts of the Texas Blackland Prairie Ecoregion. This portion of the watershed



is more sparsely inhabited and much of the land use in the area is associated with farming and ranching. The river also flows into the two hydroelectric impoundments of Lake Gonzales (H-4) and Lake Wood (H-5 Dam), which have are used for recreational fishing and boating.

WATER QUALITY

River segment 1804 has been divided by the TCEO into five assessment units (AUs) that are each represented by one active monitoring station. The latest approved 2014 Texas Integrated Report of Surface Water Quality does not identify any water quality impairments or concerns in this segment. The historical data from all three active TCEO monitoring stations were reviewed for statistical trends, comparing each monitoring parameter against time and stream flow for the period between December of 2002 and November of 2016. The stream flows for segment 1804 appeared to be significantly decreasing over time at three of the stations analyzed. The geometric mean of E. coli in all five assessment units of this segment was well below the contact recreation limit of 126 MPN/100 mL, but no statistical trends were observed. The observed geometric means of 51 MPN/100 mL at station 12596, 24 MPN/100 mL at station 15149, 27 MPN/100 mL at station 17134, 41 MPN/100 mL at station 21736 and 27 MPN/100 mL at station 15110, are all below the standard for the designated contact recreational use.

AU 1804 04 comprises the 8.1 mile portion of the River from the confluence with the Comal River to Lake Dunlap Dam. There are three domestic wastewater discharges that contribute to the water quality in this portion of the river. The New Braunfels Utilities (NBU) operates two wastewater treatment facilities (WWTFs) located off Kuehler Avenue in the City of New Braunfels. Both treatment plants discharge into an unnamed tributary that flows into the Guadalupe River approximately 1.2 miles downstream of IH 35. The NBU North Kuehler WWTF is permitted to treat up to 3.1 million gallons per day (MGD). The NBU South Kuehler WWTF is permitted to discharge up to 4.2 MGD. Both wastewater facilities treat the effluent to ensure that the daily average for biochemical oxygen demand (BOD) does not exceed 10 mg/L, total suspended solids (TSS) does not exceed 15 mg/L, total phosphorus does not exceed 3 mg/L and E. coli does not exceed 126 MPN/100 mL. The North Kuehler WWTF also confirms that free cvanide concentrations do not exceed a daily average of 0.018 mg/L. In March of 2016 NBU performed a 60 day shutdown of the North Kuehler WWTF in order to construct new dissolved oxygen control system and replace older parts. The South Kuehler plant was temporarily retrofitted with a more powerful aeration system in order to handle any additional loading from the plant. NBU also

performed daily effluent monitoring to ensure effective treatment of the effluent into Lake Dunlap. The GBRA also operates one WWTF facility off Farm to Market 725 in this AU. The GBRA facility is permitted to discharge up to 0.95 MGD of effluent into Lake Dunlap approximately 0.7 miles upstream of the Dunlap Dam. The effluent from this plant is treated to ensure that water quality parameters of the discharge do not exceed average daily concentration of 10 mg/L of BOD, 15 mg/L of TSS, 2 mg/L of ammonia nitrogen, 1 mg/L of total phosphorus, and 126 MPN/100 mL of E. coli. The GBRA routinely samples one surface water quality monitoring station in each TCEO assessment unit. Station 12596 is located on the most upstream assessment unit (AU) 1804 04 on the northwest bank of Lake Dunlap. This station was monitored by the TCEO from 1980 until 1990, when the GBRA began its current monthly monitoring regime. This segment has an E. coli geometric mean of 51 MPN/100 mL for the data analyzed from December of 2002 to November of 2016, which is below the standard for the current contact recreational use. The only long term trend in water quality that was observed at this station was a significant increase in nitrate nitrogen over time (Figure 1). This increase in nitrate nitrogen concentrations is most likely due to influence from wastewater treatment in this segment as effluent loads rise as a result of population growth. An efficient wastewater treatment facility

converts ammonia nitrogen waste into nitrate nitrogen, which is subsequently discharged. Nitrate nitrogen is the form of nitrogen most readily usable by aquatic life. The average nitrate nitrogen concentration for the 164 data points assessed was 1.17 mg/L, which was well below the TCEQ screening criteria of 1.95 mg/L and human health criteria of 10 mg/L.

AU1804_03 is the 7.6 mile portion of segment 1804 located downstream of the Lake Dunlap dam to the Lake McQueeney Dam. This portion of the segment is represented by the routine monitoring station 15149. This station has been monitored monthly by the GBRA since 1997. An analysis of the data from December of 2002 to November of 2016 revealed that chlorophyll a concentrations are significantly increasing over time at this station (Figure 2). Chlorophyll a is a green pigment that is produced by aquatic plants and algae and used by the TCEO as an indicator of nutrient loading. The chlorophyll a levels also appear to have a significant inverse relationship with stream flow (Figure 3). The stream flow in this AU was also noted to be significantly decreasing over time (Figure 4), which may be responsible for the increase in chlorophyll a levels along with the increase in available nitrate nitrogen that was noted in the upstream AU 1804_04. These slower moving waters and available nutrients may be providing conditions that are more conducive to algae growth. This AU will likely experience increased influence from treated wastewater in the future, as a new treatment facility was constructed by the NBU on the hydroelectric diversion canal for Lake Dunlap. This

facility is permitted to discharge up to 4.9 MGD of treated effluent into either the Lake Dunlap hydroelectric diversion canal or the portion or the river channel approximately 0.6 miles downstream of Dunlap Dam. This effluent will be treated to at a daily average of water guality parameter concentrations not to exceed CBOD of 10 mg/L, TSS of 15 mg/L, ammonia nitrogen of 3 mg/L, total phosphorus of 1 mg/L and E. coli of 126 MPN/100 mL. This wastewater facility has been permitted to undergo two future expansions of capacity as demand from population growth in this area continues to increase. Each expansion in treatment capacity will also reduce the average daily permitted total phosphorus concentrations to 0.75 mg/L at 7.5 MGD and 0.5 mg/L at 9.9 MGD.

AU 1804_02 represents the 27 mile



long portion of the segment from Lake McQueeney Dam downstream to the confluence with Mill Creek in Guadalupe County. This AU travels through two hydrological impoundments at Lake Placid (TP-4 Dam) and Meadow Lake (Nolte Dam) as well as a historical impoundment on Max Starcke Reservoir in the City of Seguin. This AU receives the wastewater discharges from two treatment facilities operated by the City of Seguin. The Walnut Branch WWTF discharges into the Walnut Branch tributary that flows into the Guadalupe approximately 0.7 miles downstream of State Highway 123. The WWTF is permitted to discharge up to 4.9 MDG of effluent treated to 10 mg/L of CBOD, 15 mg/L of TSS, 3 mg/L of ammonia nitrogen and 126 MPN/100 mL of E. coli. A second WWTF is permitted to discharge up to 2.13 MGD of effluent to the Geronimo Creek tributary of the Guadalupe (1804A) immediately upstream of the confluence with the Guadalupe River. The Geronimo Creek WWTF is permitted to discharge effluent treated to a BOD of 20 mg/L, TSS of 20 mg/L and E. coli of 126 MPN/100 mL. The only active monitoring station in AU 1804_02 is station 17134, which is located at the Farm to Market Road 1117 crossing of the Guadalupe downstream of the City of Seguin. Station 17134 was monitored by TCEO on a guarterly basis from 1999 to 2015, at which point it monitoring duties were transferred to

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GBRA. An analysis of the data at this station identified two notable trends over time. The stream flow at this location is also declining over time (Figure 5). The chloride concentrations are increasing over time and show a significant inverse correlation with stream flow (Figures 6 & 7). The nitrate nitrogen levels are significantly decreasing over time at this station and no correlation was found between this parameter and stream flow (Figure 8) The decrease in nitrate nitrogen may be due to additional nutrient uptake by invasive aquatic plants such as Hydrilla (Hydrilla verticillata) that have covered large portions of the substrate near this monitoring station.

AU 1804 05 is the longest AU in river segment 1804. This AU flows for 33 miles from the confluence with Mill Creek in Guadalupe County to the Confluence with Clemens Creek in Gonzales County. This portion of the segment is much more riverine than the assessment units upstream with faster moving water and many meandering twists and turns. The only impoundment in this AU is Lake Gonzales (H-4 Dam). The H-4 Dam is located approximately 3.5 miles upstream of the confluence with Clemens Creek. This segment of the Guadalupe River has been colonized by several invasive species of plants including Hydrilla (Hydrilla verticillata), Water Hyacinth (Eichhornia crassips) and Water Lettuce (Pistia Stratiotes). The GBRA has actively attempted to remove these species by lowering lake levels on

H-4 Dam during freezing temperatures in order to kill Water Hyacinth on the surface. The GBRA has also partnered with the TPWD in order to treat these species by releasing triploid Grass Carp and applying aquatic herbicides. These efforts have provided temporary seasonal suppression, but annual treatments are still needed to prevent the growth and spread of these invasive species. The only active monitoring station in the reach of 1804_05 is station 21736, which is located 200 meters downstream of the H-4 Dam. Quarterly routine monitoring was initiated by the GBRA at this station in September of 2015. The current water quality conditions in this AU were difficult to ascertain because the data set available for analysis was limited to 5 data points. The average concentrations of all water quality monitoring parameters analyzed did not indicate any exceedances of TCEQ stream standards.

The most downstream AU in segment 1804 is AU 1804_01, which represents the 25 mile long portion of the river from the confluence with Clemens Creek to the confluence with the San Marcos River (Segment 1808). The hydrology of this AU is very similar to AU 1804_05, with a twisting river channel and one hydroelectric impoundment on Lake Wood (H-5 Dam). The hydrology of this AU was significantly changed in March of 2016, when flood waters caused one of the gates on the dam that impounds Lake Wood (H-5 Dam) to be damaged. As a result of this damage, Lake Wood

drained into the original river channel. Increased velocities were observed in the old channel and previously wetted portions of the lake are now dry. The only active monitoring station in this AU is Station 15110, which is located immediately downstream of the H-5 Dam. Station 15110 has been monitored monthly by GBRA from 1996 till September of 2015 when the sampling interval at this station was decreased to a quarterly basis. This data from station 15110 was analyzed for water quality trends and several changes over time were discovered. The stream flow at this station is significantly decreasing over time (Figure 9). The chloride concentrations at this station are increasing over time and inversely correlate with stream flow (Figures 10 & 11). The dissolved oxygen and nitrate nitrogen concentrations are both decreasing over time (Figures 12 & 13). These parameters are not significantly correlated with stream flow, but are positively correlated with each other (Figure 14). The dissolved oxygen and nitrate nitrogen may both be impacted by the invasive aquatic plants that that have inhabited this AU. The Hydrilla and Water Hyacinth found in Lake Wood may be consuming a portion of the available nitrate nitrogen. Water Hyacinth forms mats on the surface of the water body. which have been documented to block air exchange from the atmosphere and may lead to diminished concentrations in the water column.

Table 1

	Station 12596	- Lake Dunlap at	AC's Place 12/2	002 - 11/2016		
AU 1804_04 General Use						
Parameter	Mean	Maximum	Minimum	# of	Screening Criteria	
				Measurements		
Temperature (°C)	22.5	30.6	14.6	164	32.2	
pH	7.9	8.4	7.5	164	6.5 - 9.0	
Chloride (mg/L)	19.3	41.3	9.42	164	100.00	
Sulfate (mg/L)	25.8	35.1	9.7	164	50.00	
Total Dissolved Solids	351	458	255	164	400.00	
(mg/L)						
NH3-N (mg/L)	<0.10	0.38	<0.02	93	0.33	
Total Phosphorus (mg/L)	<0.05	0.40	<0.02	164	0.69	
Chlorophyll-a (µg/L)	2.7	27.5	<1.0	163	14.1	
Nitrate Nitrogen (mg/L)	1.17	2.04	0.15	164	1.95	
TKN (mg/L)	0.33	1.00	<0.20	77	N/A	
AU 1804_04 Recreational Use						
<i>E. coli</i> (MPN/100 mL)	51 Geomean	2400	3	163	126 Geomean	
AU 1804_04 Aquatic Life Use						
Dissolved Oxygen (mg/L)	9.5	15.3	6.3	163	≥3.0 Minimum & ≥5.0	
					Average	

Station 17134 - Guadalupe River at FM 1117 02/2003 - 10/2016							
AU 1804_02 General Use							
Parameter	Mean	Maximum	Minimum	# of	Screening Criteria		
				Measurements			
Temperature (°C)	23.2	31.1	10.5	53	32.20		
pH	8.1	8.4	7.5	52	6.5 - 9.0		
Chloride (mg/L)	19.8	27.0	11.0	54	100.00		
Sulfate (mg/L)	27.0	33.0	15.0	54	50.00		
Total Dissolved Solids	330	394	124	53	400.00		
(mg/L)							
NH3-N (mg/L)	<0.10	0.21	<0.05	53	0.33		
Total Phosphorus (mg/L)	0.09	0.19	<0.02	50	0.69		
Chlorophyll-a (µg/L)	6.0	15.8	1.0	40	14.1		
Nitrate Nitrogen (mg/L)	1.27	2.13	<0.04	53	1.95		
TKN (mg/L)	0.35	1.02	<0.2	52	N/A		
AU 1804_02 Recreational Use							
<i>E. coli</i> (MPN/100 mL)	27 Geomean	920	3	48	126 Geomean		
AU 1804_02 Aquatic Life Use							
Dissolved Oxygen (mg/L)	9.3	14.8	6.7	53	≥3.0 Minimum & ≥5.0		
					Average		

Station 21736 - Guadalupe River at H-4 Dam 09/2015 - 09/2016

Table 2

Station 15149 – Lake McQueeney at Hot Shot's 12/2002 - 11/2016						
AU 1804_03 General Use						
Parameter	Mean	Maximum	Minimum	# of	Screening Criteria	
				Measurements		
Temperature (°C)	23.0	33.0	11.8	169	32.2	
pH	7.9	13.5	4.9	169	6.5 - 9.0	
Chloride (mg/L)	19.1	33.5	5.6	165	100.00	
Sulfate (mg/L)	25.6	35.3	11.2	165	50.00	
Total Dissolved Solids	336	389	174	169	400.00	
(mg/L)						
NH3-N (mg/L)	<0.10	0.70	<0.02	90	0.33	
Total Phosphorus (mg/L)	<0.05	0.52	<0.02	164	0.69	
Chlorophyll-a (µg/L)	7.3	43.4	<1.0	164	14.1	
Nitrate Nitrogen (mg/L)	0.88	1.82	0.05	164	1.95	
TKN (mg/L)	0.4	1.2	<0.2	77	N/A	
AU 1818_03 Recreational Use						
<i>E. coli</i> (MPN/100 mL)	24 Geomean	43.4	<1	164	126 Geomean	
AU 1818_03 Aquatic Life Use						
Dissolved Oxygen (mg/L)	9.2	13.5	4.9	168	≥3.0 Minimum & ≥5.0	
					Average	

		AU 1804_05	General Use			
Parameter	Mean	Maximum	Minimum	# of	Screening Criteria	
				Measurements		
Temperature (°C)	22.7	28.4	15.2	5	32.20	
pH	8.0	8.0	7.9	5	6.5 - 9.0	
Chloride (mg/L)	20.1	24.8	15.8	5	100.00	
Sulfate (mg/L)	25.0	31.4	19.5	5	50.00	
Total Dissolved Solids	332	357	284	5	400.00	
(mg/L)						
NH3-N (mg/L)	<010	<0.10	<0.10	5	0.33	
Total Phosphorus (mg/L)	<0.05	0.10	<0.04	5	0.69	
Chlorophyll-a (µg/L)	4.7	14.5	1.5	5	14.1	
Nitrate Nitrogen (mg/L)	0.99	1.34	0.53	5	1.95	
TKN (mg/L)	0.43	0.62	0.34	5	N/A	
AU 1804_05 Recreational Use						
<i>E. coli</i> (MPN/100 mL)	41 Geomean	100	11	5	126 Geomean	
AU 1804_05 Aquatic Life Use						
Dissolved Oxygen (mg/L)	8.1	9.2	6.5	5	≥3.0 Minimum & ≥5.0	
					Average	

Table 3

Table 4

Table 5

Station 1511	LO - Guadalupe Ri	ver Downstream o	of H-5 Dam SW of	Gonzales 12/2002 - (09/2016	
AU 1804_01 General Use						
Parameter	Mean	Maximum	Minimum	# of	Screening Criteria	
				Measurements		
Temperature (°C)	22.3	31.5	9.1	153	32.20	
pH	7.9	8.4	7.2	152	6.5 - 9.0	
Chloride (mg/L)	21.6	36.3	8.6	153	100.00	
Sulfate (mg/L)	28.6	38.0	14.8	153	50.00	
Total Dissolved Solids	326	395	200	152	400.00	
(mg/L)						
NH3-N (mg/L)	<0.10	0.33	<0.02	82	0.33	
Total Phosphorus (mg/L)	<0.05	0.70	<0.02	152	0.69	
Chlorophyll-a (µg/L)	3.8	13.5	<1.0	152	14.1	
Nitrate Nitrogen (mg/L)	0.78	1.83	<0.05	153	1.95	
TKN (mg/L)	0.38	1.97	<0.2	64	N/A	
AU 1804_01 Recreational Use						
<i>E. coli</i> (MPN/100 mL)	27 Geomean	4100	<1	151	126 Geomean	
AU 1804_01 Aquatic Life Use						
Dissolved Oxygen (mg/L)	8.6	12.9	5.2	152	≥3.0 Minimum & ≥5.0	
					Average	

Figure 1



Figure 2





Figure 3





Figure 5







Figure 7



Figure 8



Figure 9



03/2011

Date Range 2002 to 2016

11/2013

Ω

08/2016

Trend Line

71

FLOW

n

12/2002

09/2005

06/2008



Figure 11

CHLORIDE VERSUS FLOW AT STATION 15110 - GUADALUPE RIVER IMMEDIATELY DOWNSTREAM OF H-5 DAM AT WOOD LAKE SW OF GONZALES Slope is Significant at 0.05 critical α, β=0.00, t(151)=-9.39, p=0.000 R^2=0.369, F(1,151)=88.20, p=0.000 40 CHLORIDE (MG/L AS CL) 35 30 25 20 15 CHLORIDE 10 Trend Line 5 0 32 1032 2032 3032 4032 5032 6032 Flow (CFS)

Figure 12



Figure 13



Figure 14



