Guadalupe River and Lavaca-Guadalupe Coastal Basins
Clean Rivers Program

Nutrient Study of Lakes Dunlap and McQueeney

Prepared by the Guadalupe-Blanco River Authority

In Cooperation with the Texas Commission on Environmental Quality (TCEQ)

January 1, 2004 – August 31, 2005

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<u>**Executive Summary**</u>

Purposes of Study

The purposes of the nutrient study on Lakes Dunlap and McQueeney performed by the Guadalupe-Blanco River Authority (GBRA) and the Clean Rivers Program (CRP) were to collect surface water quality data that characterized water quality conditions in the river and lakes between New Braunfels and Seguin, to look for possible nutrient sources and to determine if there is a relationship between flow and chlorophyll *a*. The water quality conditions were characterized using Texas Commission on Environmental Quality (TCEQ) nutrient screening protocols, and spatial analysis of the data to determine how water quality differs from site to site and from upstream to downstream, and how the differences relate to potential nutrient sources. The relationship between chlorophyll *a* and flow was evaluated by conducting simple linear regression analyses and by reviewing graphs of data to determine how chlorophyll *a* responded during various flow conditions.

Background

Data collected during twelve sampling events conducted beginning in April 2004 and extending until August 2005 were used to characterize water quality conditions in the study area. Sampling was conducted monthly April through October 2004, except in June 2004 due to severe weather and flooding conditions in the study area. Sampling resumed in March 2005 and continued monthly until August 2005. The Comal River, and the Guadalupe River above the confluence with the Comal River combine to create the flow through Lakes Dunlap and McQueeney. The flows from the contributing stream segments are important to consider individually because the Comal River is a significant contributor of nutrients, such as nitrate-nitrogen to the study area and because the flow on the Guadalupe River below Canyon Reservoir can vary based on the releases from Canyon Reservoir.

The annual average flow for the study area through Lakes Dunlap and McQueeney was 793 cubic feet per second (cfs). The flow in the study period was normal to high, with only four of the twelve sampling events below that mean. The spring-fed Comal River exhibited a relatively stable flow throughout the study period, ranging from 356 to 467 cfs. Conversely, the monthly average flow from the contributing segment below Canyon Reservoir ranged from 225 to 2170 cfs.

The list of possible sources of nutrients to the system includes the Comal Springs, the bottom release from Canyon Reservoir, urban and rural runoff, including a golf course and residential lawns, upstream recreational activities, discharges from wastewater treatment plants, septic tanks, nutrient-rich sediments, lake recreation and waterfowl. Phosphorus is a particularly important nutrient to review due to the fact that it is typically the limiting nutrient controlling plant growth, so small increases and decreases in phosphorus can have a significant impact on plant growth. The response of the system to these inputs of phosphorus concentrations as seen in plant growth (measured as chlorophyll *a*) can vary greatly from location to location depending on stream flow, turbidity, time of year (temperature and sunlight), and other factors. The role of nitrate-nitrogen in this relationship is relatively constant and does not have a significant impact on the growth of aquatic plants since phosphorus appears to be the limiting nutrient in this system.

Findings

The graphs of the concentrations of nutrients and chlorophyll *a* over time show very little fluctuation in total phosphorus during the period of the study (monthly samples taken between April 2004 and August 2005), with one exception. During the study, a high-flow event was sampled in July 2004. During the 40 days prior to sampling in July, the releases from Canyon Reservoir fluctuated from approximately 600 cfs to the maximum release of 5,000 cfs. The COE fluctuated the releases from Canyon Reservoir in order to evacuate the flood pool created by an upper basin flood event in June 2004. The data from this event showed a two-to-four fold increase in the concentration of total phosphorus, causing the concentration of phosphorus to exceed the reservoir secondary concerns screening level (0.18 mg/L) set by the TCEQ at two out of the three designated reservoir locations. According to TCEQ, the site at the upper end of Lake McQueeney (Station 15516) and all sites in Lake Dunlap, see figures 2-4, are considered to be riverine and are assessed using the stream screening level of 0.8 mg/L.

The high flow event that occurred in July 2004 showed how concentrations of total phosphorus change from upstream to downstream during or just following a period of high release rates from Canyon Reservoir. One possible explanation for this rise in phosphorus could be the suspension of dissolved phosphorus associated with sediments by the increased flows. The lack of an associated rise in suspended solids and turbidity would indicate that the phosphorus would be in the dissolved form. A possible source of the dissolved phosphorus could be its release in the low oxygen conditions at the sediment/water interface. The increase in phosphorus as you move downstream is substantiated by a previous study performed by GBRA and PBS&J that found that the phosphorus content of the sediments increased as you move downstream from upper Lake Dunlap through Lake McQueeney.

Considering the rise in phosphorus during a high flow event that occurred in July 2004 and the limited data available from the rest of the study period, nutrients trapped in sediments have the greatest potential to increase the concentration of total phosphorus in the system under certain high flow conditions. Throughout the study period typical background concentrations of phosphorus were present most of the time and consistent inputs from wastewater treatment plants upstream do not appear to be elevating the concentration of phosphorus in the stream under most stream flow conditions.

The spatial distribution of chlorophyll *a* in the system is dependent on two factors, concentrations of phosphorus and flow. Typically, there is a lag time after an increase in phosphorus before chlorophyll *a* concentrations increase due to the assimilation of the phosphorus by the available algae and their subsequent reproduction. In addition, there is a negative relationship between flow and chlorophyll *a* due to the dynamics caused by the "flushing effect", where it is difficult for algae to assimilate the phosphorus when everything is moving and the increased concentration of phosphorus is being flushed downstream.

The data collected in the twelve-month period was analyzed for correlations between flow and nutrient concentrations and flow and chlorophyll *a*. The chlorophyll *a* increases as you move down reservoir toward the deeper, warmer, more quiescent water. The secchi disc depths show the effects of increasing chlorophyll *a* concentrations as you move downstream. As the water leaves Lake Dunlap, the surface water thoroughly mixes throughout the water column, combines with spring flow from the old river channel and enters upper Lake McQueeney with an increase in assimilable nutrient concentrations. The reservoir response to nutrient contributions appears at the downstream sites in each impoundment, in the form of chlorophyll *a* and the nutrient concentrations may be reduced by the photosynthetic activity.

The high flows experienced during the study period prevented the correlation between chlorophyll *a* and flow seen in the historical data set. Although there were no strong correlations observed in this small data set, the highest chlorophyll *a* concentrations were seen in July and August 2005, two of the months with the lowest flows in the study period, evidence of the inverse relationship between flow and chlorophyll *a* seen in the historical data set. The correlations may be more pronounced in a larger data set.

Future Considerations

TCEQ nutrient and chlorophyll *a* screening levels and future considerations of criteria should take into consideration the unique conditions of these run-of-the river impoundments. Current screening levels for streams may allow too much algae to grow and current screening levels for reservoirs may be too restrictive considering the ability of these impoundments to act more like slow moving streams. The relationship between algae growth, nutrient concentrations, and flow in these impoundments should be used to develop screening levels and future criteria in deference to statewide percentages based on all reservoirs in Texas.

Residents living on the lakes have found that their use(s) of the lakes have been restricted in the past due to growth of rooted aquatic plants and other macrophytes. This study, and historical studies have attempted to quantify the relationship between nutrients and plant growth (albeit algae). This study has shown that there are many mitigating factors that increase and decrease plant growth, but the source of nutrients from the New Braunfels area, both from point and non-point sources can, in some low flow periods, exacerbate the plant growth. It would be advantageous to investigate wastewater management practices that could be put in place to divert wastewater flows to irrigation during periods of low flow. In addition, certain stormwater controls could be put in place to reduce the loading associated with storm flows. This would also help reduce the effect of stormwater runoff during possible flood conditions.

In order to verify the extent of contributions from area septic tanks, a dye study of different types, ages, and sizes of septic tanks could be done. This study would require differing weather conditions and possibly weekend study due to the increased use of homes during those time periods. This study could be coordinated with the area homeowners associations to ensure their involvement in and cooperation with the study.

The anthropogenic impacts on these water bodies cannot be minimized. As populations grow in the area, the impact of that growth will continue to be felt in several ways. Not only will the failing septic tank impacts need to be addressed, as well as the need for nutrient limitations in wastewater permits, the pressure that will be exerted from the growing population on the water resources, as the cities call upon more and more ground and surface water, will increase the frequency of lower flow conditions. Couple the increase in demand on water sources with the increase in impervious cover that reduces ground water recharge, and the base flow of these impoundments will diminish, causing greater impact from pollutants.

Introduction

The intensive monitoring project on Lakes Dunlap and McQueeney was conducted to collect surface water quality data to characterize lake conditions, look for possible nutrient sources, and determine if there is a relationship between flow and chlorophyll *a*. Data was screened using TCEQ screening protocols and with spatial analyses at the monitoring sites within and between the water bodies.

Segment 1804, the Guadalupe River below the Comal River, is made up primarily of run-of-river impoundments. The water bodies are narrow, shallow and have short residence times. Lakes Dunlap and McQueeney are the first two of these types of impoundments in the series of six. The flow in these water bodies is used to generate hydroelectric power. See the following section, *Guadalupe Valley Hydroelectric System and Canyon Reservoir Operations,* for a description of the hydroelectric power generation system.

Lake Dunlap

Lake Dunlap is the first in the series of low-head run-of-river impoundments. The lake has a surface area of 371 acres, with a volume of 5,130 acre-feet and a mean depth of 4.4 meters. The median residence time is 5.10 days (GBRA-PBS&J, 2001). Lake Dunlap receives treated wastewater effluent from New Braunfels Utilities (NBU)'s two wastewater treatment plants (WWTPs). The North Kuehler plant is permitted to discharge up to 3.1 million gallons per day (MGD) which equates to a discharge of 4.5 cubic feet per second (cfs). The NBU South Kuehler plant is permitted to discharge up to 4.2 MGD (6.5 cfs). Neither of these permits have nutrient limitations. The NBU Gruene plant is permitted for 1.1 MGD (1.7 cfs) but it does not discharge its effluent to the Guadalupe River; 100% of its treated effluent is used to irrigate a nearby golf course. The Mission Valley Mills textile plant is located slightly upstream of Lake Dunlap and is permitted to discharge up to 3 MGD (4.6 cfs). The GBRA Dunlap Wastewater Treatment Plant is permitted to discharge up to 0.16 MGD (0.25 cfs) and has a 210 authorization for the reuse of the effluent as cooling water for the Guadalupe Power Partners (GPP) electric plant. The effluent is pumped along with surface water purchased by GPP to the facility located in Marion, Texas. The reuse of the effluent began in October 2000 and was in operation throughout the study. The population growth and land development in the service area for the Dunlap WWTP have resulted in the need for the expansion of the wastewater plant. GBRA, because of its dual role in resource protection and utility management, voluntarily requested nutrient limitations (total phosphorus <1.0 mg/L, and ammonia-nitrogen <2.0 mg/L) in the amended permit expanding its discharge to 0.95 MGD (1.5 cfs), regardless of the continued reuse of the effluent as cooling water.

The predominant aquatic vegetation found in Lake Dunlap currently are beds of elephant ear (*Colocasia spp.*), and waterlillies (*Nuphar and Nymphae spp.*). Historically, Lake Dunlap has had infestations of non-native species such as waterhyacinth, waterlettuce and hydrilla, but these species were not present during the study period due to vegetation treatments in the mid-1990s and the floods of 1998 and 2000 scouring the lakes.

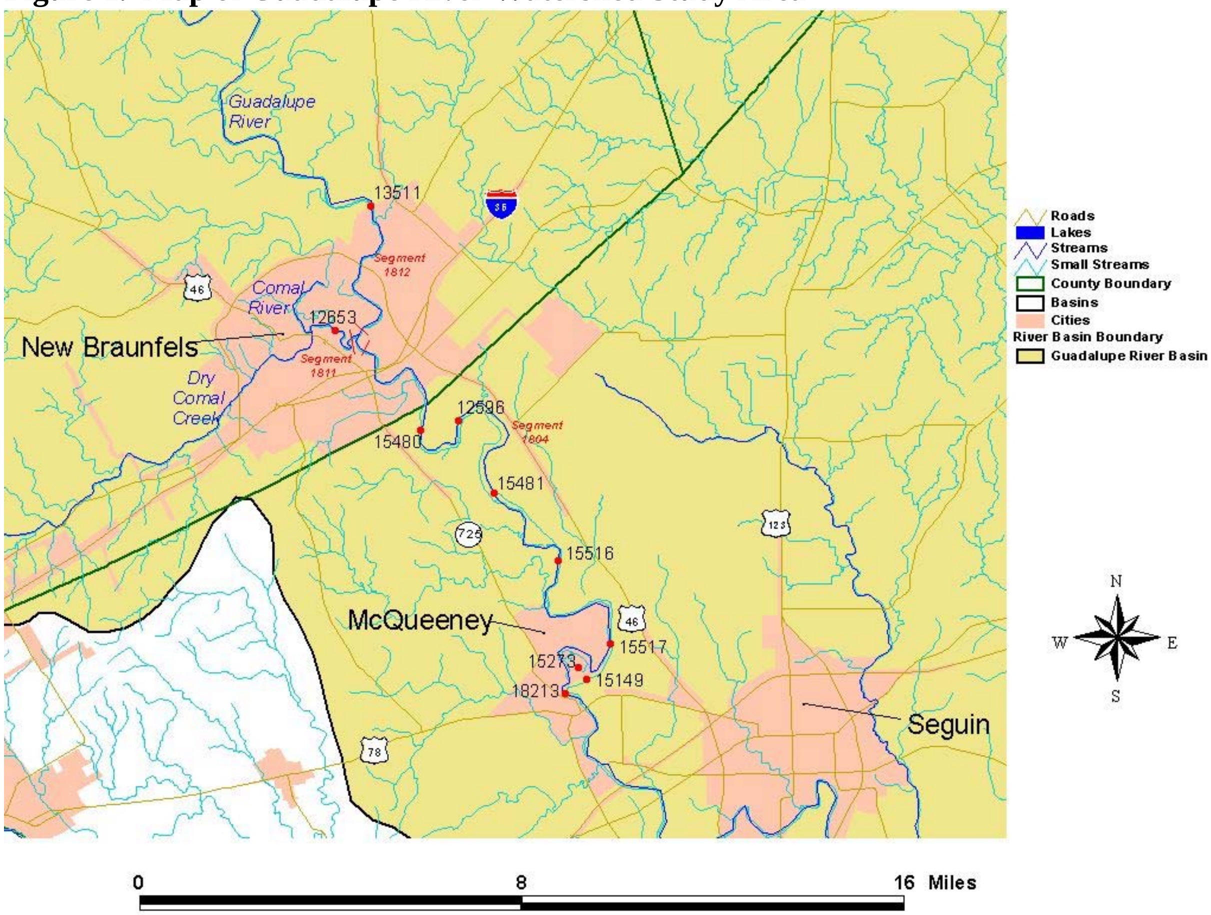
Lake McQueeney

Lake McQueeney is the second of the hydroelectric lakes and receives the majority of its flow from Lake Dunlap. The lake has a surface area of 392 surface acres, with a volume of 4,950 acre-feet and a mean depth of 3.8 meters. The median residence time is 4.37 days (GBRA-PBS&J, 2001). Lake McQueeney receives no point source discharges.

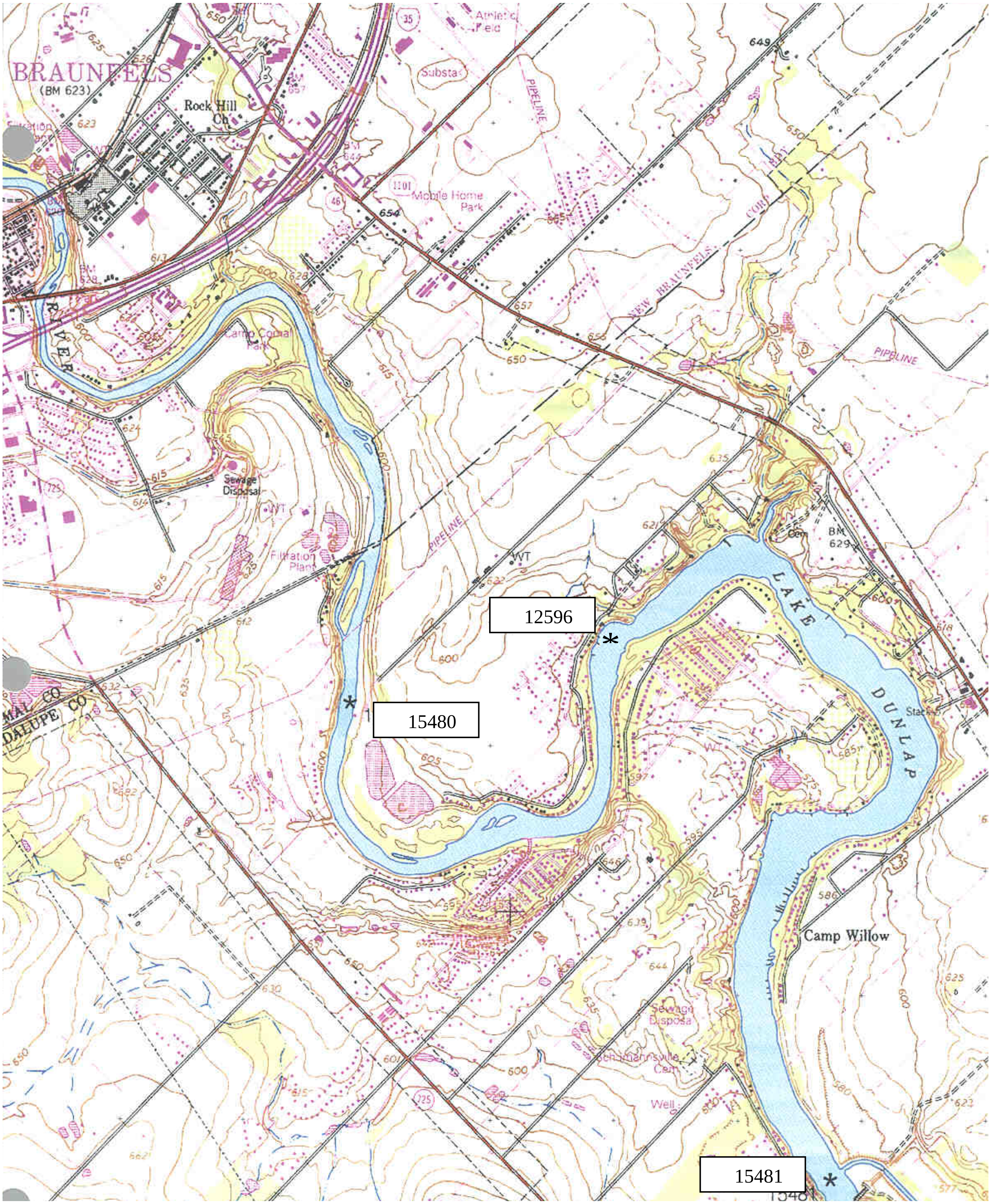
As in Lake Dunlap, the predominant aquatic vegetation found in Lake McQueeney currently are beds of elephant ear (*Colocasia spp.*), and waterlillies (*Nuphar and Nymphae spp.*). Historically, Lake McQueeney has had infestations of non-native species such as waterhyacinth, waterlettuce and hydrilla, but these species were not present during the study period due to vegetation treatments in the mid-1990s and the floods of 1998 and 2000 scouring the lakes.

Figure 1 is a map of the project area. Lakes Dunlap and McQueeney are found primarily in Ecoregion 30, the South Central Plains, with a small portion in Ecoregion 32, Texas Blackland Prairies.

Figure 1. Map of Guadalupe River Watershed Study Area



Three sampling locations are located on Lake Dunlap. Figure 2 is the map of the Lake Dunlap and the locations of the sampling sites. The most upstream station, the Guadalupe River upstream of Lake Dunlap (15480), is above the impoundment and approximately one mile downstream of the combined outfall of the New Braunfels North and South Kuehler Wastewater Plants. Flow at this site is a combination of the Guadalupe River below Canyon Reservoir and the Comal River. At this site the stream is narrow and approximately 1.5 meters deep, with sandy sediments, and currently devoid of any significant beds of macrophytes. Land use in the area includes both rural and urban activities. Homes located in the area are on the NBU municipal sewage system. Possible impacts to this site include nutrient contributions from the Comal Springs, the bottom release from Canyon Reservoir, urban and rural runoff, upstream recreational activities, discharges from the Mission Valley Mills wastewater treatment plant and the New Braunfels Utilities wastewater treatment plants.



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Date: 2/6/04
Scale: 1 inch equals 2000 feet

Figure 2: Nutrient Study Sampling Locations

The CRP routine monitoring site in Lake Dunlap, the Guadalupe River at the upper end of Lake Dunlap, AC's Place (12596), has been monitored by GBRA since spring 1987. The stream is narrow and approximately 1.0 meter deep, with mixed sediment of silt and sand and currently devoid of any significant beds of macrophytes. The banks are lined with homes on septic tanks. In addition to the aforementioned impacts, the water quality at this site can be affected by septic tanks, lake recreation and waterfowl.

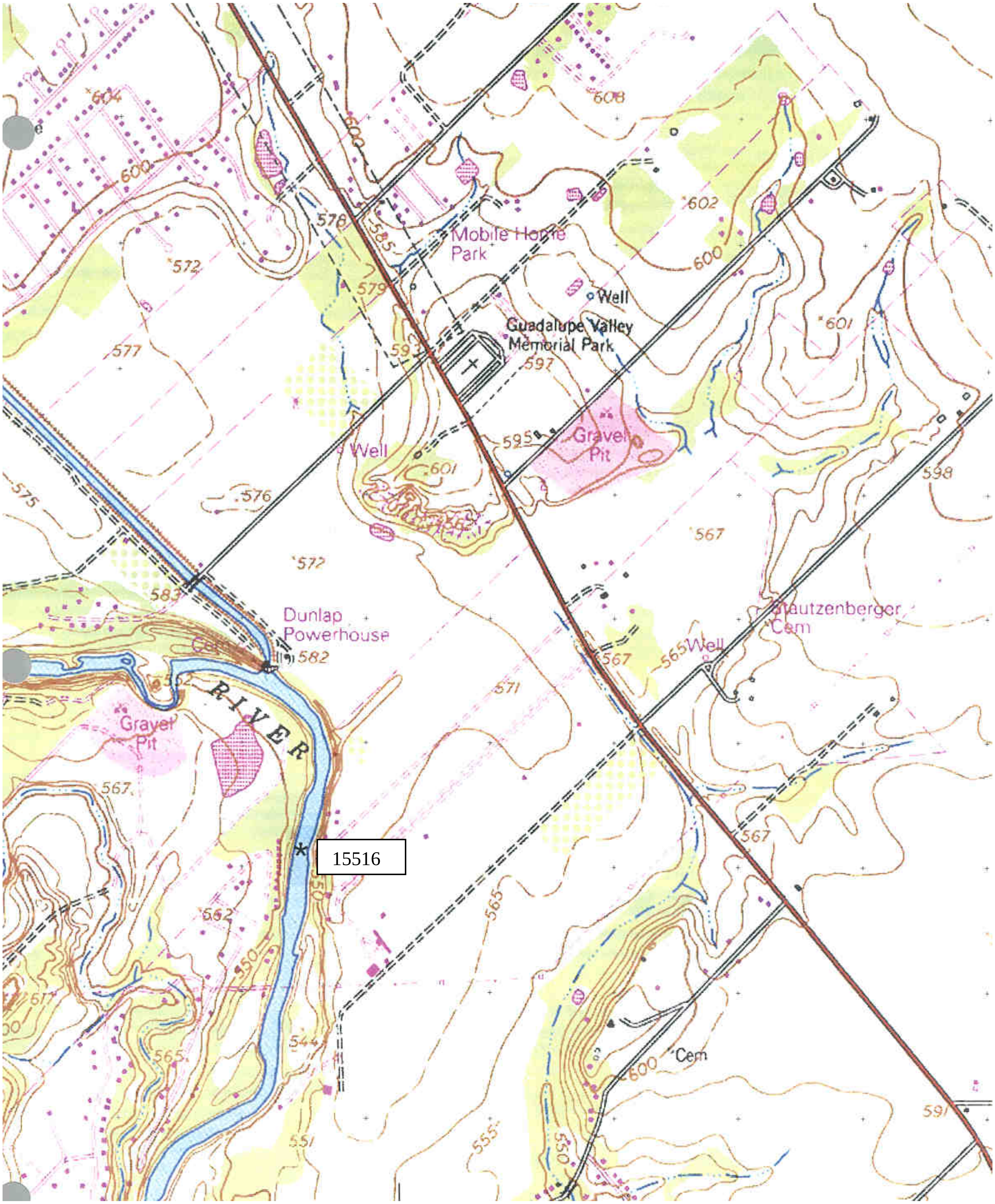
The downstream site on Lake Dunlap, Lake Dunlap at the dam (15481), is located just upstream of the Dunlap Dam and near the mouth of the canal that moves the flow between the reservoirs and through the turbines located at the hydroelectric plant. This is the deepest site on the lake, approximately 8 meters, with primarily silty sediment. The water quality at this site can be impacted by the aforementioned factors, as well as the occasional discharge from the Dunlap Wastewater Treatment Plant when the GPP power plant is down for repairs.

Five sites are located on Lake McQueeney. Figures 3 and 4 are the maps of the lake and the sampling locations. Station 15516, the Guadalupe River between Lake Dunlap and Lake McQueeney, is located just downstream of the discharge from the Dunlap hydroelectric plant. The flow through this site is from the upper reservoir into Lake McQueeney. Flows less than 1300 cubic feet per second (cfs) are passed through the hydroelectric turbines. Flows greater than 1300 cfs are spilled over the gates at the dam through the old river channel and its isolated pools. The old river channel is approximately 2 river miles in length with standing pools, and at most times, fed only by springs, resulting in a small flow of approximately 40 cfs. Station 15516 is approximately 3 meters deep with silty sediment. The land use in the area is recently developed residential with large lawns. The development includes an 18-hole golf course. Runoff from the development flows into Long Branch, a tributary of Lake McQueeney, and/or into the old river channel below Dunlap Dam. There are no significant stands of macrophytes in the area or immediately upstream of the site.

Moving downstream, the next site in Lake McQueeney, the Guadalupe River in the upper end of Lake McQueeney (Station 15517) is located equidistance from the main pool of the reservoir and the headwaters at the Dunlap powerstation. The river channel is narrow, 2 meters deep, with silty sediments and no significant beds of macrophytes in the immediate area. The banks are lined with residences on septic tanks.

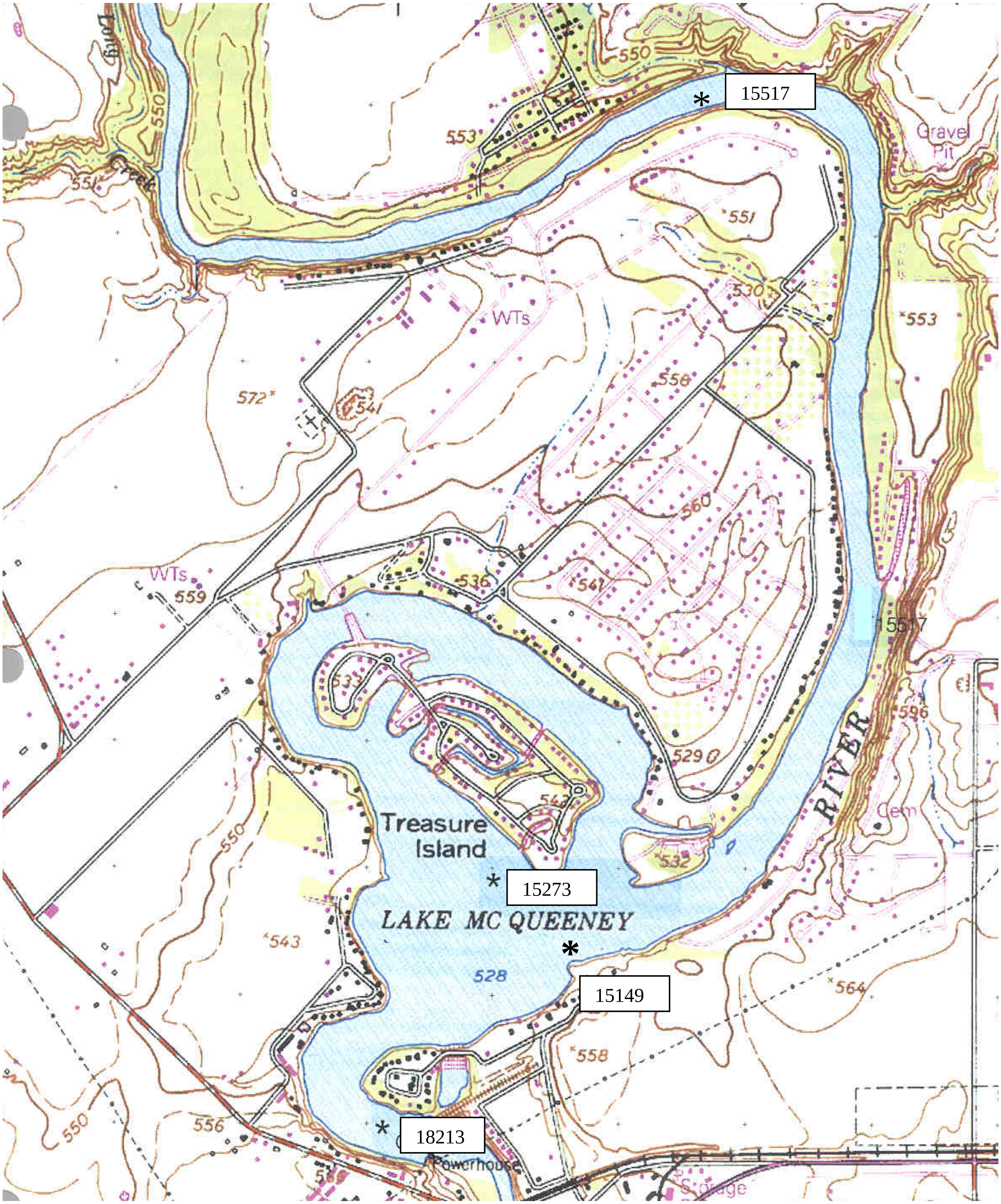
The next downstream site is Station 15149, Lake McQueeney Main Pool in the Old Stream Channel (Hot Shots.) This location has been monitored by GBRA/CRP since spring 1996. The site is approximately 1.5 meters deep, with silty sediment and currently one of the only sites with any significant beds of macrophytes within 10 meters, primarily made up of elephant ear (*Colocasia spp.*), and waterlillies (*Nuphar and Nymphae spp.*). The banks are lined with homes on septic tanks.

The remaining two sites in Lake McQueeney are located in the main pool, Lake McQueeney at Treasure Island (Station 15273) and Lake McQueeeney at the dam (Station 18213). The site located just south of Treasure Island, an area of large homes on septic tanks, exhibits a lake-like environment, out of the main flow of the river. The site is approximately 2 meters deep, with silty sediments.



Name: NEW BRAUNFELS EAST
Date: 2/6/04
Scale: 1 inch equals 1250 feet

Figure 3: Nutrient Study Sampling Locations



Name: MCQUEENEY
Date: 2/6/04
Scale: 1 inch equals 1250 feet

Figure 4: Nutrient Study Sampling Locations

The site located at the dam is approximately 8 meters deep with silty sediments, and with small stands of macrophytes seen along the banks, but over 70 meters from the sampling location. This site exhibits attenuated flow but also experiences greater mixing than the more quiescent portion of the main pool located near Treasure Island.

Background/Upstream Sites for Comparison

Historical data from two additional sites were included in the spatial analyses. The Guadalupe River at Gruene (Station 13511) is located at the upstream boundary of the study area (Figure 1). The flow at this location is released from the bottom of Canyon Reservoir. The site is characterized by cold, shallow, swift-flowing water, hard bedrock substrate, and cypress trees along the banks and in mid-stream. Factors impacting water quality in this area would be bottom releases from Canyon Reservoir, significant recreational pressure and urban and rural runoff. No point source discharges are upstream of this location.

The Comal River at Clemmons Dam, Hinman Island (Station 12653) has been monitored by GBRA/CRP since 1994. The Comal River at this site, spring fed from the Edwards Aquifer, is a clear, flowing stream, with a consistent temperature year round. The substrate is a mixture of cobble and silt. No point source discharges are upstream of this site but the site can be affected by non-point source impacts such as urban run-off and recreation.

Monitoring Regime for the Study Period

The monitoring of the two impoundments occurred monthly, April through October in 1994 and March through August in 1995. The list of parameters for analysis included: pH, temperature, dissolved oxygen, specific conductance, total phosphorus, nitrate-nitrogen, turbidity, total suspended solids, ammonia-nitrogen, chlorophyll *a*, pheophytin, sulfate, chloride, hardness, *E. coli*, flow, flow severity, total kjeldahl nitrogen, and secchi disk.

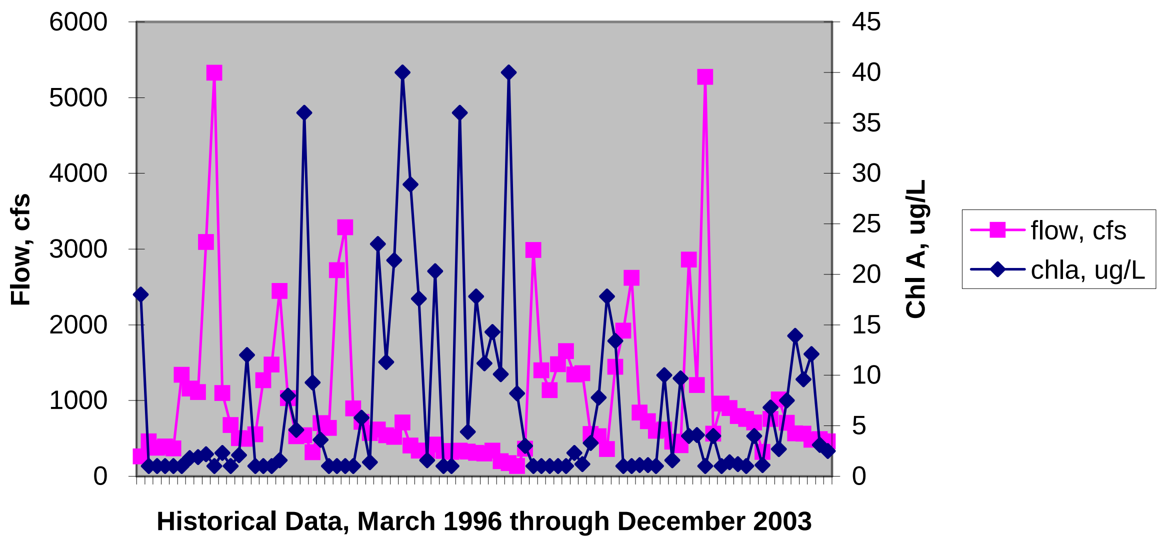
Data was screened using TCEQ screening protocols. There was also a spatial analysis of the data within the two water bodies to determine the sources of nutrient contributions as well as the water bodies' response to the sources.

Project Significance and Background

GBRA has been sampling the Guadalupe River Segment 1804 (below the confluence with the Comal River) since 1987. Chlorophyll *a* was added to the list of analyses in 1996. In the 2002 Clean Water Act (CWA) 305(b) assessment, the sampling location in Lake McQueeney was listed as a concern due to elevated chlorophyll *a* concentrations. The chlorophyll *a* concentration at this site averages approximately 7 ug/L over the historical database, but 25% of the data points fall in the range of 10-40 ug/L. Factors contributing to elevated chlorophyll *a* could include contributions of nutrients from non-point sources such as natural background concentrations from the Comal Springs, septic tanks, and fertilizer use along the banks by homeowners and farms, as well as, point source dischargers into and upstream of Lake Dunlap. It is not fully defined as to which sources cause nutrient levels to increase under varying conditions and the water bodies' response to those increases, so this study will attempt to provide further information to help answer that question.

A review of historical data at the location in Lake McQueeney (Station 15149) shows an inverse relationship between chlorophyll *a* concentrations and flow (Figure 5); meaning as flows increase chlorophyll *a* concentrations decrease. This site is in the primary flow pathway in the main body of the impoundment (e.g., old stream channel), and therefore, experiences greater influence from flow fluctuations than a location in the center of the impoundment away from the old stream channel. This study will attempt to further define the relationship between flow and chlorophyll *a* levels at various river and lake locations to provide additional information to characterize water quality conditions throughout the study area.

Figure 5. Chl *a* vs. Flow, Lake McQueeney



Guadalupe Valley Hydroelectric System and Canyon Reservoir Operations

The Guadalupe Valley Hydroelectric System (GVHS) operates six low-head hydroelectric plants in Guadalupe and Gonzales counties. Lake Dunlap has the highest head at 46 feet. The other five range from 27 – 31 feet. These power plants and dams were constructed in the late 1920's and early 1930's. GBRA purchased the facilities in 1963 from the Texas Power Corporation and the Texas Hydroelectric Corporation. The nameplate output of these six plants is 16,000 kilowatts of electricity. The historical annual generation for the system is approximately 63 million kilowatts, equivalent to about 25,000 – 30,000 average homes on a monthly usage of 2,000 – 2,500 kWHs. The power is sold to the Guadalupe Valley Electric Cooperative. Along with the concrete and steel structures came one of the oldest water rights on the Guadalupe River. The Hydroelectric Division water right is one of the most "senior" water rights in the basin and is a non-consumptive right to generate electricity from the natural flow of the river.

Hydroelectric power is produced using the flow coming into Lake Dunlap. This flow is made up of the flow released from Canyon Reservoir and the flow from the Comal Springs. At each hydro dam, gates are maintained in the up position to impound the flow and direct it through turbines to generate hydropower. The turbines in the GVHS impoundments operate in the flow range of 528 to 1,300 cfs. If the river flow is 528 cfs or greater, each plant can operate all the generators continuously. However, if the flow is less than 528 cfs, operating all generators on each lake continuously will lower the level of the lake. When these conditions occur the hydro plant reduces the number of generators in service. These dams and gates are built for electrical power generation, not flood control. If the flow is greater than 1,300 cfs, the flow is released through the spillways by lowering the gates on each dam. The spillway at each dam is the structure that allows the controlled release of water from the lake. All plants downstream of the Dunlap hydroelectric plant follow the same operating procedure.

Canyon Reservoir is located upstream of the GVHS impoundments and it is important to understand how the operation of the Canyon Reservoir impacts the flow of the river downstream and the operation of the lower hydroelectric plants. 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 – 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 release to empty the flood pool (between 943 and 911 msl) are a function of the head pressure provided by the reservoir and friction, and range from 5,000 cfs at elevation 909 and 5,600 cfs at elevation 943 (Groeger, 2002). From elevation 911 to elevation 909 msl, the COE releases range up to 1,500 cfs.

In the late 1990s, GBRA applied to the TCEQ, then the Texas Natural Resource Conservation Commission, to amend the Canyon Reservoir permit to increase the yield of Canyon Reservoir. The increase in yield was accomplished through the subordination of the GBRA hydropower water rights to Canyon Lake (the hydroelectric rights are now "junior" to the Canyon Reservoir rights). Subordination of the hydropower rights allows GBRA to store in Canyon Lake, some of the Guadalupe River water that would have gone on to the hydroelectric plants downstream (BBC Research, 2003).

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.

Methods and Materials

The methods and materials used to conduct this study are described in detail in Appendix E of the GBRA's CRP FY 2004-2005 Quality Assurance Project Plan, available on the GBRA CRP webpage (http://www.gbra.org/?datapage=crp.asp). Originally, the GBRA was going to analyze the samples for TKN, but because of equipment problems, the GBRA laboratory was unable to reach the minimum analytical limit that was necessary for the study. The LCRA laboratory was used in its place. The analytical methods and data quality objectives are listed in Appendix A. The authority for analysis methodologies under the CRP is derived from the TSWQS (307.1-307.10) in that data generally are generated for comparison to those standards and/or criteria. Copies of laboratory SOPs are retained by GBRA and are available for review by the TCEQ. Laboratory SOPs are consistent with EPA requirements as specified in the method.

The list of parameters includes: pH, temperature, dissolved oxygen, specific conductance, total phosphorus, nitrate-nitrogen, turbidity, total suspended solids, ammonia-nitrogen, chlorophyll *a*, sulfate, chloride, hardness, *E. coli*, flow, and flow severity. In addition to the routine analyses, total kjeldahl nitrogen and secchi disk were reported. The monitoring of the two impoundments occurred monthly, April through October in 2004 and March through August 2005. Sampling was preempted by flooding conditions during the months of June 2004 and November 2004. A total of 12 sampling events were conducted over the study period. According to the study design, the sampling was to occur bimonthly during the months of November through February, but because of a flood event that occurred in late November 2004, flows made sampling hazardous in December through January 2005. Sampling resumed in March 2005 as scheduled. Each sampling event began midmorning in Lake McQueeney at the most upstream site and ended at the most downstream site on Lake Dunlap, taking approximately 4-5 hours. The flow data for each event was obtained from the GBRA hydroelectric department and was based on the flow through the generators at the Lake Dunlap and Lake McQueeney hydroelectric plants at each dam at the time of sampling.

The statistical analyses of the data included comparison of event data and averages between sites, upstream to downstream; with the TCEQ screening levels for streams and reservoirs; and linear regressions of nutrients and chlorophyll *a* with flow at each site as well as at historical sites. Where data was less than the reporting limit, one half of the reporting limit was used in the statistical analyses.

Results and Observations

Sampling was conducted monthly April through October 2004, except in June 2004 and November through January 2005, due to severe weather and flooding conditions in the study area. Sampling resumed in March 2005 and continued monthly until August 2005. Table 1 lists the flow conditions during each sampling event. Data collected for the water quality conditions is tabulated in Appendix B. Appendix F contains graphs showing the data collected over the study period as well as some historical data where available. The graphs show that the total phosphorus levels remained at or below detection levels for most of the study period. A discussion of some of the slight elevations in total phosphorus is provided later in this section on a site-by-site basis. The graphs also show elevated nitrate-nitrogen levels which are greatly influenced by the input from the Comal River whose main source is the Comal Springs from the Edwards Aquifer. Chlorophyll *a* concentrations also remained consistently low for most of the study period. A discussion of some of the slight elevations in chlorophyll *a* is provided later in this section. As you are reading the sections describing the water quality results for specific locations, it may be helpful to reference the graphs in Appendix F.

Table 1. Flow conditions during study period.

Date	Comal River	Guadalupe River Above Confluence With Comal River	Guadalupe River through Lakes Dunlap and McQueeney	Residence Time in Lake Dunlap	Residence Time in Lake McQueeney
4/27/05	360	304	664	3.9	3.8
5/17/05	356	405	761	3.4	3.3
7/20/05	371	2170	2541	1.0	1.0
8/9/05	377	637	1014	2.6	2.5
9/10/05	359	602	961	2.7	2.6
10/15/05	391	655	1046	2.5	2.4
3/11/05	467	1590	2057	1.3	1.2
4/4/05	454	740	1194	2.2	2.1
5/6/05	428	495	923	2.8	2.7
6/3/05	423	1080	1503	1.7	1.7
7/8/05	364	361	725	3.6	3.4
8/3/05	362	225	587	4.4	4.3

Appendix C has the minimum and maximum daily flow conditions for the Comal River, the Guadalupe River above the confluence with the Comal River and the combined flow of the two river systems as they flow through Lakes Dunlap and McQueeney. Appendix D gives the historical annual average for the three stream segments going back as far as 1933. The flows from the contributing stream segments are important to consider individually because the Comal River is a significant contributor of nutrients, such as nitrate-nitrogen to the study area and because the flow on the Guadalupe River below Canyon Reservoir can vary based on the release requirements described in the *Guadalupe Valley Hydroelectric System and Canyon Reservoir Operations.*

The annual average flow for the study area through Lakes Dunlap and McQueeney is 793 cubic feet per second (cfs). The flow in the study period was normal to high, with only four of the twelve sampling events below that mean. The spring-fed Comal River exhibited a relatively stable flow throughout the study period, ranging from 356 to 467 cfs. Conversely, the flow from the contributing segment below Canyon Reservoir ranged from 225 cfs (July 2005) to 21,000 cfs (November 2004), based on flows measured at the USGS gage, Guadalupe River above New Braunfels. During the flood event that occurred in June 2004, flows peaked at 12,000 cfs, on June 9. From June 14 through June 25, the COE released 5,000 cfs from Canyon Reservoir in order to vacate the flood pool. Flows from Canyon Reservoir were reduced slightly (3000-4000 cfs) from June 28 to June 30. Before the COE could complete the evacuation of the flood pool, the flows were reduced to less than 800 cfs in order to create safer recreational flows below Canyon Reservoir over the July 4th holiday weekend. The flows were then increased to 5,000 cfs to resume the evacuation of the flood pool in the reservoir. The sampling event on July 20, 2004 occurred during that period of time that the COE was evacuating the flood pool.

During November 2004, another flood event was recorded. Flows below Canyon Reservoir peaked at 21,000 cfs. Beginning at the end of November and through December 21, flows through the hydro lakes were in excess of 5000 cfs. During the period in January when the sampling would have resumed the flows were still above 1000 cfs and small boat warnings were issued for area lakes, so sampling was not conducted until the scheduled March event.

Review of Nutrients and Possible Sources

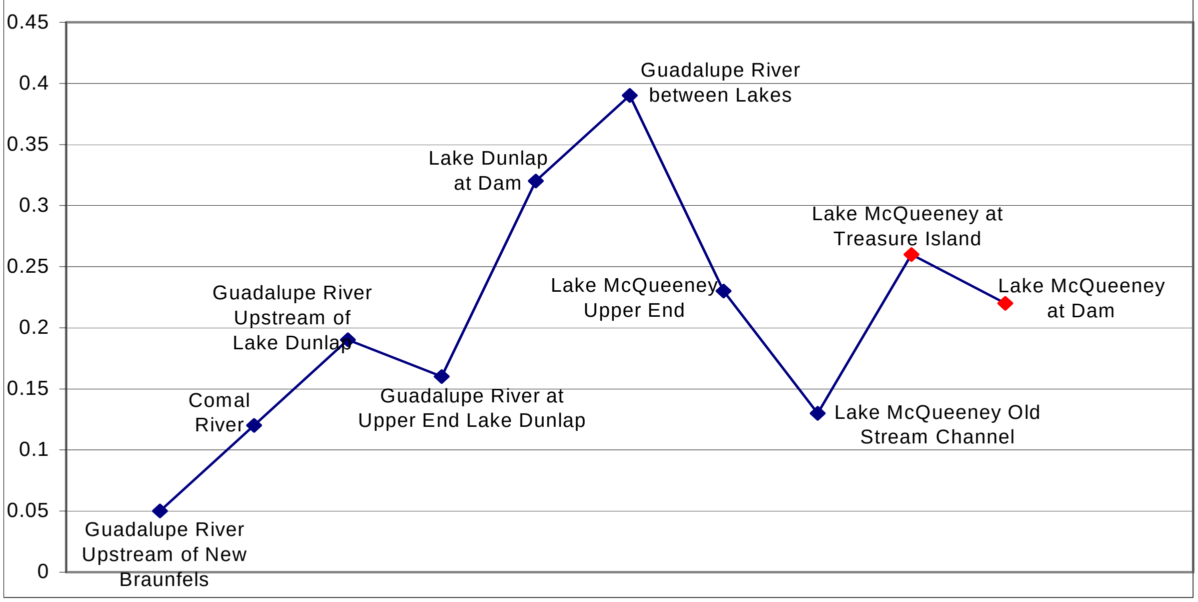
Phosphorus is a particularly important nutrient to review due to the fact that it is typically the limiting nutrient controlling plant growth, so small increases and decreases in phosphorus can have a significant impact on plant growth. The relationship between phosphorus concentrations and plant growth (measured as chlorophyll *a*) can vary greatly from location to location depending on stream flow, turbidity, time of year (temperature and sunlight), and other factors. On a side note, the role of nitrate-nitrogen in this relationship is relatively constant and does not have a significant impact on the growth of aquatic plants since phosphorus appears to be the limiting nutrient in this system.

The graphs showing concentrations of nutrients and chlorophyll *a* over time (Appendix F) show very little fluctuation in total phosphorus during the period of the study (monthly samples taken between April 2004 and August 2005), with one exception.

During the study, a high-flow event was sampled in July 2004. During the 40 days prior to the sampling in July, the releases from Canyon Reservoir fluctuated from approximately 600 cfs to the maximum release of 5,000 cfs. As described previously, the COE fluctuated the releases from Canyon Reservoir in order to evacuate the flood pool created by a flood event in June 2004. The data from this event showed a two-to-four fold increase in the concentration of total phosphorus, causing the concentrations to exceed the reservoir secondary concerns screening level (0.18 mg/L) set by the TCEQ at two out of the three designated reservoir locations (see red dots in Figure 6). According to TCEQ, the site at the upper end of Lake McQueeney and all sites in Lake Dunlap are considered to be riverine and are assessed using the stream screening level of 0.8 mg/L.

The concentrations of total phosphorus at each station from upstream to downstream during this high flow event are shown in Figure 6.

Figure 6. Total Phosphorus (mg/L) from Upstream to Downstream During/After a High Flow Event



Station #:	13511	12653	15480	12596	15481	15516	15517	15149	15273	18213
Tot P (mg/L):	0.05	0.12	0.19	0.16	0.32	0.39	0.23	0.13	0.26	0.22

The high flow event shows how concentrations of total phosphorus change from upstream to downstream during or just following a period of high release rates from Canyon Reservoir. One possible explanation for this rise in phosphorus could be the suspension of dissolved phosphorus associated with sediments by the increased flows. The lack of an associated rise in suspended solids and turbidity would indicate that the phosphorus would be in the dissolved form. A possible source of the dissolved phosphorus could be its release in the low oxygen conditions at the sediment/water interface. The increase in phosphorus as you move downstream is substantiated by a previous study performed by GBRA and PBS&J that found that the phosphorus content of the sediments increased as you move downstream from upper Lake Dunlap through Lake McQueeney.

The two rain events during the study period (March and June 2005) did not show a substantial rise in total phosphorus concentrations. The differences between the July 2004 high flow event and other high flow events are the period of time, the base flows and reservoir releases between events. Only in June and July 2004 did the flow through the system exceed 5,000 cfs for an extended period of time (greater than two days) preceding a sampling event.

The following is a discussion of the data at each station describing the elevated total phosphorus values during the July 2004 high flow event (see graph in Figure 6) to get a better understanding of the sources and causes of elevated total phosphorus throughout the study area. The first two stations on the graph (moving left to right and upstream to downstream) are upstream of the study area and have been included as background sites for comparison purposes.

The sampling site on the Guadalupe River upstream of Lake Dunlap (15480) is the closest downstream station to the New Braunfels Utility's wastewater treatment plant outfalls. The concentration of phosphorus at this station during the July 2004 high flow event is elevated two to three times the typical background concentration of 0.05 to 0.08 mg/L (total phosphorus = 0.19 mg/L). The background concentrations of 0.05 to 0.08 mg/L can be considered indicative of steady-state when wastewater treatment plant effluent is more likely to have an effect on water quality. As the "unimpacted" upstream stations show in the graphs in Appendix F, the concentrations of phosphorus at this location are not any higher than those upstream stations during normal stream flow conditions.

The next sampling site downstream is the Guadalupe River upstream of Lake Dunlap (12596). The concentration of phosphorus actually goes down at this location before it goes up again at the next three downstream sites. This is likely due to the mixing of the load of phosphorus as it moves downstream.

Of greatest interest are the next two downstream sampling sites, which exhibited the greatest concentrations found during the high flow event. These occurred in the Guadalupe River at the Lake Dunlap Dam (15481) and the Guadalupe River between Lakes Dunlap and McQueeney (15516). The dam could be providing a reduction in flow thereby "mixing/ concentrating" the phosphorus load. During the high flow event, river flow went over the dam, flushing the old river channel. A portion of the flow also went through the canal that ends just upstream of the sampling station (15516). It is at this site where the flow from both channels combine and where the highest phosphorus concentrations were found during the study period. The only known point source in the area is the GBRA's Dunlap wastewater treatment plant (2000 feet upstream of Station 15481 and 3800 feet upstream of Station 15516) whose effluent is sent to the power plant for reuse. It does not seem likely that this is the cause of the increased concentrations of phosphorus since this increase only occurred during a high flow event, which is more likely to reduce the concentration of consistent point source flows. The non-point sources in the area are limited to some small residential developments on septic tanks.

A scenario that could explain the spike in phosphorus at these two locations could be the contributions of dissolved phosphorus from decaying organic materials and sediments. After the storm event in June, organic materials associated with stormwater deposited in the reservoirs began to decay and deplete oxygen at the sediment/water interface. The development of the anoxic layer at the sediment surface developed more quickly during the warm summer month and caused a release of dissolved phosphorus from the sediments. The phosphorus released from the sediments then mixed into the water column when the high flows in July passed through the reservoirs. Additionally, the area downstream of Dunlap Dam, in the old river channel, received flows in July that flushed nutrients released in a similar manner into Lake McQueeney.

The concentration of total phosphorus in the Guadalupe River as it enters Lake McQueeney is substantially lower (approximately 40% lower) than the next upstream station in the Guadalupe, possibly due to the uptake of phosphorus by aquatic plants, and/or attenuation over space, similar to the same reaction seen at station 12596 in Lake Dunlap. The concentration of phosphorus continues to decline in the old stream channel in the main body of Lake McQueeney (15149). This is likely due to continued attenuation over space from the upstream elevated levels, as well as the separation between the flow through the lake and the more quiescent waters away from the old stream channel.

The concentration of total phosphorus goes up again at Treasure Island possibly due to inputs coming from the mixing of nutrients in areas routinely out of the normal river flows. In addition to nutrient released from sediments in this location, contributions of phosphorus from septic tanks located in close proximity to the area are likely. The mixing between this quiescent portion of the lake and the main flow of the old stream channel may be somewhat exacerbated during a high flow event. The concentration goes down again slightly at the Lake McQueeney dam possibly due to attenuation of the sources from the stream channel and the main body of the lake.

Considering the response of phosphorus during this high flow event and the limited data available from the rest of the study period, it appears that nutrients trapped in the sediments have the greatest potential to increase the concentration of total phosphorus in the system, under certain flow conditions. Typical background concentrations of phosphorus are present most of the time; therefore, consistent inputs from wastewater treatment plants upstream do not appear to be elevating the concentration of phosphorus in the stream under most stream flow conditions.

Review of Chlorophyll a and the Effect of Phosphorus & Flow

In reviewing chlorophyll *a*, two factors were considered, concentrations of phosphorus and flow. Typically, there is a lag time after an increase in phosphorus before chlorophyll *a* concentrations increase due to the assimilation of the phosphorus by the available algae and their subsequent reproduction. In addition, there is a negative relationship between flow and chlorophyll *a* due to the dynamics caused by the "flushing effect", where it is difficult for algae to assimilate the phosphorus when everything is moving and the increased concentration of phosphorus is being flushed downstream. The following discussions describe the data at each station from upstream to downstream and examine the relationship between chlorophyll *a* and phosphorus.

Guadalupe River in Gruene (Station 13511): This location has been sampled relatively consistently since late 1999 and was chosen to provide background information as a substantial source of flow to the Guadalupe River downstream. This is the most upstream station in this study area and has little to no significant sources of phosphorus from either urban run-off or wastewater treatment plant discharges in its watershed. This section of the stream in Gruene, Texas is free-flowing and does not lend itself to the growth of algae; however, one sample taken on Feb. 7, 2000 showed a concentration of 17 ug/L of chlorophyll *a*, which occurred during a period of very low flows. The rest of the historical data show no concentrations of chlorophyll *a* above the detection limit. There was one event in the historical record when phosphorus was recorded at 0.11 mg/L (May 9, 2001), which followed a period of relatively high flows. The concentration of chlorophyll *a* did not increase during this event leading to the general conclusion that flow is the major factor determining the growth of algae in the stream. All other samples showed concentrations of total phosphorus below the detection limit.

Although this location was not sampled during the high flow event of July 2004, a location downstream of Canyon Reservoir was sampled (Station 12658 Guadalupe River at Second Crossing) and the concentration of phosphorus measured was 0.07 mg/L, indicating that the phosphorus leaving Canyon Reservoir during the high flow event did not exhibit the same spikes in phosphorus concentrations seen downstream in Lakes Dunlap and McQueeney.

Comal River below Clemmons Dam in New Braunfels (Station 12653): This location has been sampled relatively consistently since 1972 and was chosen to provide background information as a substantial source of flow to the Guadalupe River downstream. This section of the river is free-flowing and does not lend itself to the growth of algae. There are beds of macrophytes present at the site. Whereas, the rooted vegetation would not impact the chlorophyll *a* concentrations, these green plants would take up nutrients from both the water column and the sediments. The historical data show 5 samples out of 202 with chlorophyll *a* concentrations greater than the typical reporting limit of 3 ug/L. Those samples were between 3 and 7 ug/L. Total phosphorus levels typically fall between 0.01 and 0.09 mg/L. The relationship between concentrations of chlorophyll *a* and total phosphorus is not apparent from the graph (Appendix F), and other factors such as flow may be masking any possible relationship. There are elevated background concentrations of nitrate-nitrogen that persist (average 1.5 mg/L). The groundwater source, along with non-point sources, add to the nutrient loads in the study area.

Guadalupe River Upstream of Lake Dunlap (Station 15480): This site which was added for the study period, exhibited a two-fold increase in total phosphorus during the July 2004 high flow event; however the concentration of chlorophyll *a* did not change during or after this event. This is likely due to the free-flowing nature of the river at this location. There were no elevated concentrations of chlorophyll *a* for the entire study period. There were no other concentrations of total phosphorus substantially above the detection limit (0.05 mg/L) during the study period.

Guadalupe River at the upper end of Lake Dunlap (Station 12596): This site exhibited a two-fold increase in total phosphorus during the aforementioned high flow event; however the concentration of chlorophyll *a* did not change during or after this event. This is likely due to the somewhat free-flowing nature of the river at this location. In addition to the study period, there is historical data from 1980 available at this location. The regression of chlorophyll *a* to flow showed no significant relationship; however, the highest values were found to occur during the low flow periods and no high values were found during high flow periods, lending support to the generally understood negative relationship between flow and chlorophyll *a*. A regression was also run for chlorophyll *a* and total phosphorus, which did not show any appreciable relationship, likely due to the lag time algae needs to respond to increased concentrations of phosphorus, and the likelihood that flow overrides the ability for algae to accumulate and grow at this location.

Historical Review of Total Phosphorus: A review of historical data (Feb. 1980 through Aug. 2005) at this long-term sampling location on Lake Dunlap in the upstream end of the lake, showed total phosphorus concentrations typically range between 0.05 and 0.11 mg/L. There were 11 samples out of 289 total samples for the period of record that exceeded the TCEQ established reservoir screening level of 0.18 mg/L, resulting in a percent exceedence of 3.8%. There was only one sample that exceeded the TCEQ established stream screening level of 0.8 mg/L. Overall, there were 14 "non-detect" measurements (4.8%) at reporting levels of between 0.01 and 0.05 mg/L in the data set.

For the 2006 assessment of water quality conducted by the TCEQ, samples collected between 12/01/1999 through 11/30/2004 will be used to determine whether a secondary concern exists for phosphorus. Of these 60 samples, 1 exceeded the reservoir screening level, resulting in a percent exceedance of 1.7% and no samples exceed the stream screening level. In the past, the TCEQ has required at least 25% exceedance to consider a nutrient such as phosphorus to indicate a secondary concern; however, recent revisions to the assessment methodology suggest this may change to a greater than 10% exceedance.

Regression Analysis: A regression was done of the historical total phosphorus data and flow, and there was no viable correlation found, and in fact, if there were any relationship at all, it would be a negative one. When the same regression was run for the study period (Apr. 2004 thru Aug. 2005, n = 17), there was a very slight positive correlation (r^2 = 4.2%); however, it was not a significant relationship. The historical regression results do not support the information gleaned from the July 2004 high flow event described above; however, the study period regression results somewhat support the results of that event.

What these two different views of the data tell us is that the dynamics of this system are very complex and cannot be easily identified. One run-off or high flow event may result in a significant increase in concentrations of phosphorus and another may not, depending on a variety of factors including, but not limited to preceding climatic conditions, amount of rainfall & run-off, location of rainfall, reservoir releases and timing of sampling efforts. The statistical methods available and data limitations do not adequately address all of these factors, so our limited view of the data cannot adequately describe this very complex natural process. The unique environmental and flow conditions of each event make it difficult to compare findings from different months, unless the environmental and flow conditions are very well defined and understood.

Lake Dunlap at the Dam (Station 15481): This site exhibited a significant four-fold increase in total phosphorus during the July 2004 high flow event; however, the concentration of chlorophyll *a* did not change during or after this event, possibly due to the consistently high flows even though the flows are somewhat restricted at this location due to the back-up from the dam. We would expect to see some increase in chlorophyll *a* at this location due to the flow dynamics and the increase in total phosphorus, but the levels do not appear to have increased. The only time chlorophyll *a* concentrations were elevated above the detection limit was in July and August of 2005 when flows were greatly reduced and growing conditions were favorable in the warm summer months; however, phosphorus concentrations were not elevated above the detection limit of 0.05 mg/L preceding or during this period.

Guadalupe River between Lake Dunlap and Lake McQueeney (Station 15516) and Guadalupe River in the upper end of Lake McQueeney (Station 15517): These two sites, which were added to the study, exhibited significant increases (six-fold and three-fold, respectively) in total phosphorus during the July 2004 high flow event; however, the concentration of chlorophyll *a* did not change during or after this event, possibly due to the consistently high flows. A slight increase in chlorophyll *a* occurred during a slight increase in total phosphorus in September 2004 when flows had been reduced for one month, showing the influence that reduced flows and small increases in phosphorus have on algae growth. The only other time chlorophyll *a* concentrations were elevated (above the detection limit) during the study period was in July and August of 2005 when flows were greatly reduced and growing conditions were favorable in the warm summer months; however, phosphorus concentrations were not elevated above the detection limit of 0.05 mg/L for the four months preceding, or during this period.

Lake McQueeney Main Pool in Old Stream Channel (Station 15149): This site which has been sampled consistently since 1998, exhibited a two-fold increase in total phosphorus during the July 2004 high flow event, and the concentration of chlorophyll *a* increased slightly in the following month's sample. This sampling location experiences more flow than the other two reservoir locations and gets a majority of it's influence from inflows from upstream. It is not as influenced by the reservoir itself as the other two Lake McQueeney reservoir sampling locations, although flows are much more attenuated at this location than at the upstream riverine sites. This attenuation provides more favorable conditions for algae to grow and therefore, the slight increase in chlorophyll *a* is seen. The other increase in chlorophyll *a* seen for the study period are 3 values from June, July, and August of 2005 when flows receded rapidly and seasonal conditions encouraged algae growth. The concentration of total phosphorus preceding and during these three months remained at or below the detection limit of 0.05 mg/L. It is possible that during these low flow periods, this location is more influenced by the surrounding waters of the lake.

Historical Review of Total Phosphorus: A review of historical total phosphorus data (Nov. 1997 through Aug. 2005) at a long-term sampling location, Lake McQueeney in main body in the old stream channel, showed total phosphorus concentrations typically range between 0.05 and 0.09 mg/L. There were 6 samples out of 95 total samples for the period of record that exceeded the TCEQ established reservoir screening level of 0.18 mg/L, resulting in a percent exceedance of 6.3%. Overall, there were 10 "non-detect" measurements (10.5%) at the level of 0.05 mg/L in the data set.

For the 2006 assessment of water quality conducted by the TCEQ, samples collected between 12/01/1999 through 11/30/2004 will be used to determine whether a secondary concern exists for phosphorus. Of these 60 samples, 5 exceeded the reservoir screening level, resulting in a percent exceedance of 8.3%. In the past, the TCEQ has required greater than 25% of the samples to exceed the screening level to consider a nutrient such as phosphorus a secondary concern; however, recent revisions to the assessment methodology suggest this may change to a greater than 10% exceedance.

Total Phosphorus vs. Flow Regression Results: A regression was done of the historical total phosphorus data and flow, and there was no viable correlation found. When the same regression was run for the study period (Apr. 2004 thru Aug. 2005, n = 18), there was a better correlation ($r^2 = 11.4\%$); however, it was not a significant relationship.

The historical regression results do not support the information gleaned from the July 2004 high flow event described above; however, the study period regression results somewhat support the results of the July 2004 event.

What these two different views of the data tell us is that the dynamics of this system are very complex and cannot be easily identified. One run-off or high flow event may result in a significant increase in concentrations of phosphorus and another may not, depending on a variety of factors including, but not limited to preceding climatic conditions, amount of rainfall & run-off, location of rainfall, reservoir releases, and timing of sampling efforts. The statistical methods available and data limitations do not adequately address all of these factors, so our limited view of the data cannot adequately describe this very complex natural process. The unique environmental and flow conditions of each event make it difficult to compare findings from different months, unless the environmental and flow conditions are very well defined and understood.

Historical Review of Chlorophyll a: A review of historical chlorophyll *a* data shows 16 values out of 94 (17%) that exceeded the reservoir screening level for chlorophyll *a* (11.6 ug/L). Every one of these values, except one, occurred during a period of low flow, somewhat regardless of concentrations of total phosphorus; although, there are some increased concentrations of total phosphorus that either coincide with or precede an increase in chlorophyll *a*. The one exception to the negative flow relationship to chlorophyll *a* occurred right after a three-month period of low flows and was immediately followed by at least one low-flow month.

For the 2006 assessment of water quality conducted by the TCEQ, samples collected between 12/01/1999 through 11/30/2004 will be used to determine whether a secondary concern exists for chlorophyll *a*. Of these 59 samples, 8 exceeded the reservoir screening level, resulting in a percent exceedance of 13.6%. In the past, the TCEQ has required greater than 25% of the samples to exceed the screening level to consider chlorophyll *a* a secondary concern; however, recent revisions to the assessment methodology suggest this may change to a greater than 10% exceedance.

Lake McQueeney at Treasure Island (Station 15273): This site is located just south of Treasure Island in the main pool of the lake and exhibits a more lake-like environment as it is off to the side of the main channel of flow through the lake. With a more quiescent nature, this location provides more favorable conditions for algae to grow. The samples taken from this location showed a significant three-fold increase in total phosphorus during the July 2004 high flow event, and the concentration of chlorophyll *a* increased to 4 ug/L in the following month's sample. The other rise in chlorophyll *a* seen for the study period occurred between March and August 2005 with values between 2 and 5 ug/L. The increase in the concentration of chlorophyll *a* can be attributed to receding flows and seasonal conditions that encouraged algae growth. The concentration of total phosphorus preceding and during these three months remained at or below the detection limit of 0.05 mg/L.

Lake McQueeney at the Dam (Station 18213): This site is just upstream of the dam and exhibits attenuated flow but also experiences greater mixing than the more quiescent portions of the lake that are not in the flow of the main stream channel. The samples taken from this location showed a significant three-fold increase in total phosphorus during the July 2004 high flow event followed by an increase in chlorophyll *a* which rapidly dropped back down to the detection limit as flows began to increase. The relationship between flow and chlorophyll *a* at this location is very apparent. An upward trend in the concentrations of chlorophyll *a* was evident during the corresponding downward trend in flow. None of the chlorophyll *a* concentrations were above the reservoir screening level of 11.6 ug/L.

Discussion

When evaluating conditions for secondary concerns, TCEQ divides freshwater water bodies into two types, streams and reservoirs. It is here that evaluators of Lakes Dunlap and McQueeney are thrown into a quandary. Are these run-of-river impoundments, streams or reservoirs? The residence times in Lake Dunlap during the study period ranged from one day to 4.4 days. The residence times in Lake McQueeney during the study period ranged from one day to 4.3 days. A true reservoir like Canyon Reservoir has a residence time of greater than 400 days. Based on historical flows, you would expect low flows approximately every five years (Groeger, 2002), creating longer residence times in the run-of-river impoundments and more reservoir-like conditions.

Using the screening levels for reservoirs, the nutrient and chlorophyll *a* concentrations exceeded the level less than 10% of the time, except for nitrate-nitrogen. For nitrate-nitrogen in reservoirs, the screening level is 0.32 milligrams per liter (mg/L). At all eight sites, the nitrate-nitrogen concentrations exceeded this level more than 85% of the time, with three of the eight exceeding 0.32 mg/L 100% of the time.

Figures 7 – 10 show the water quality conditions spatially as the water flows through Lake Dunlap and then through Lake McQueeney. The chlorophyll *a* increases as you move down reservoir toward the deeper, warmer, more quiescent water. The secchi disc depths show the effects of increasing chlorophyll *a* concentrations as you move downstream. As the water leaves Lake Dunlap by way of the shallow canal leading to the hydroelectric turbines, the surface water thoroughly mixes throughout and enters upper Lake McQueeney with more assimilable nutrient concentrations. The reservoir response to nutrient contributions appears at the downstream sites in each impoundment, in the form of chlorophyll *a* and the nutrient concentrations may be reduced by the photosynthetic activity.

Figure 7. Spatial distribution of the mean chlorophyll *a* concentrations in the study area.

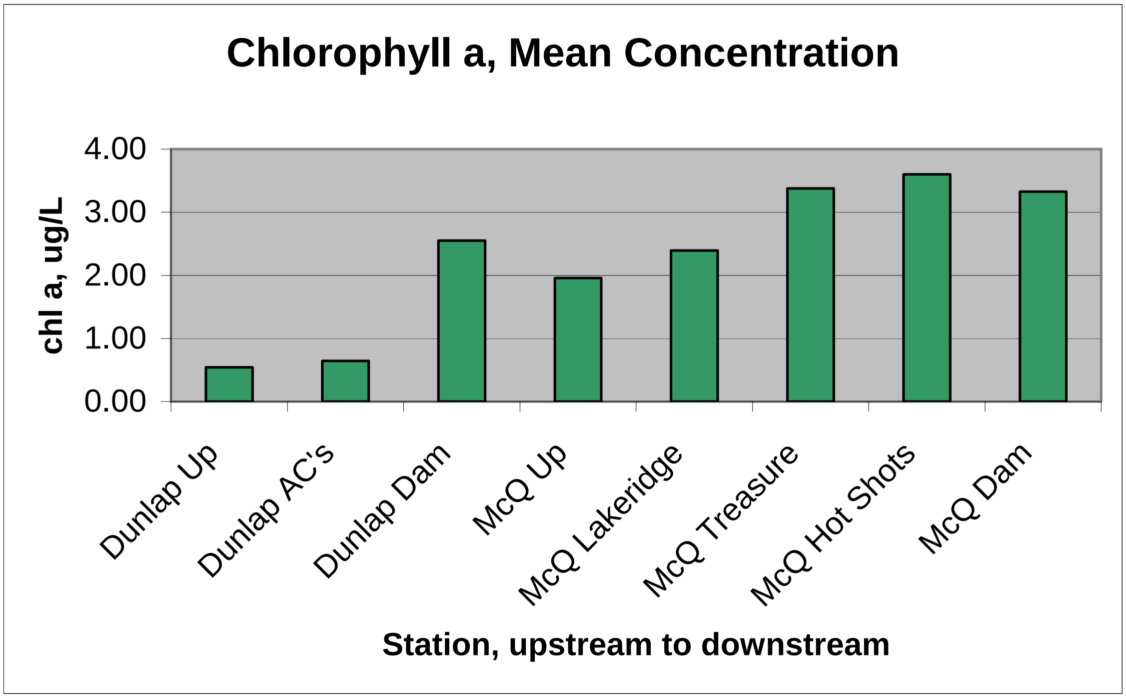


Figure 8. Spatial distribution of secchi disc, mean depth in the study area.

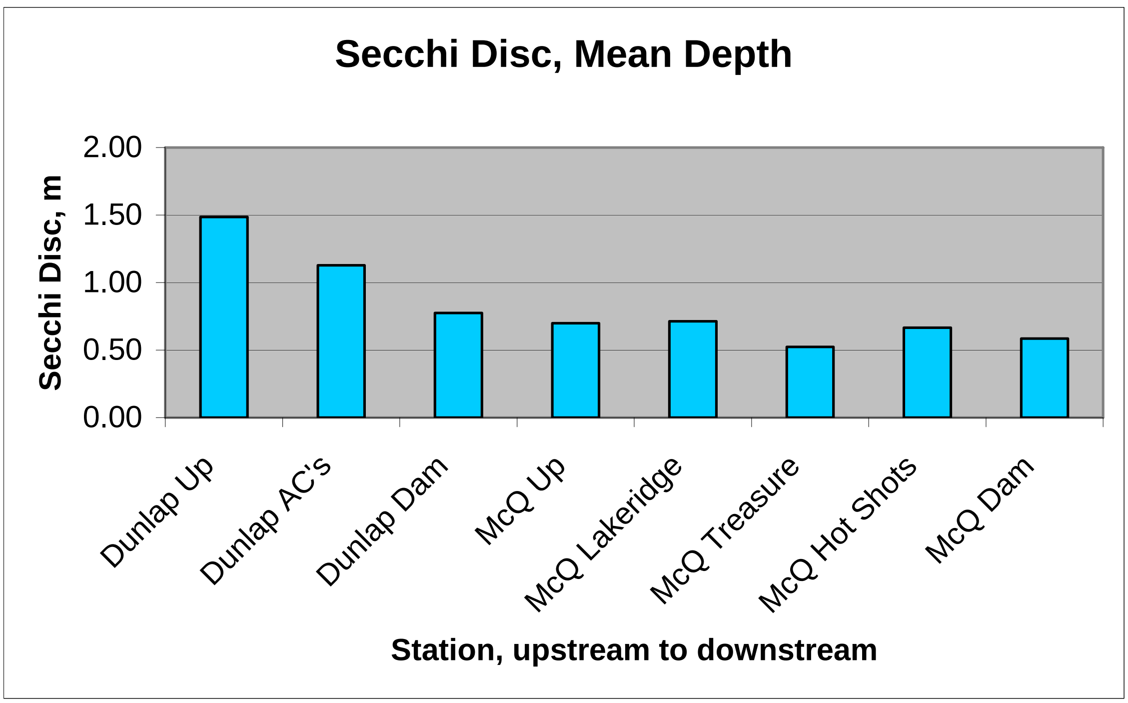


Figure 9. Spatial distribution of the total phosphorus concentrations in the study area.

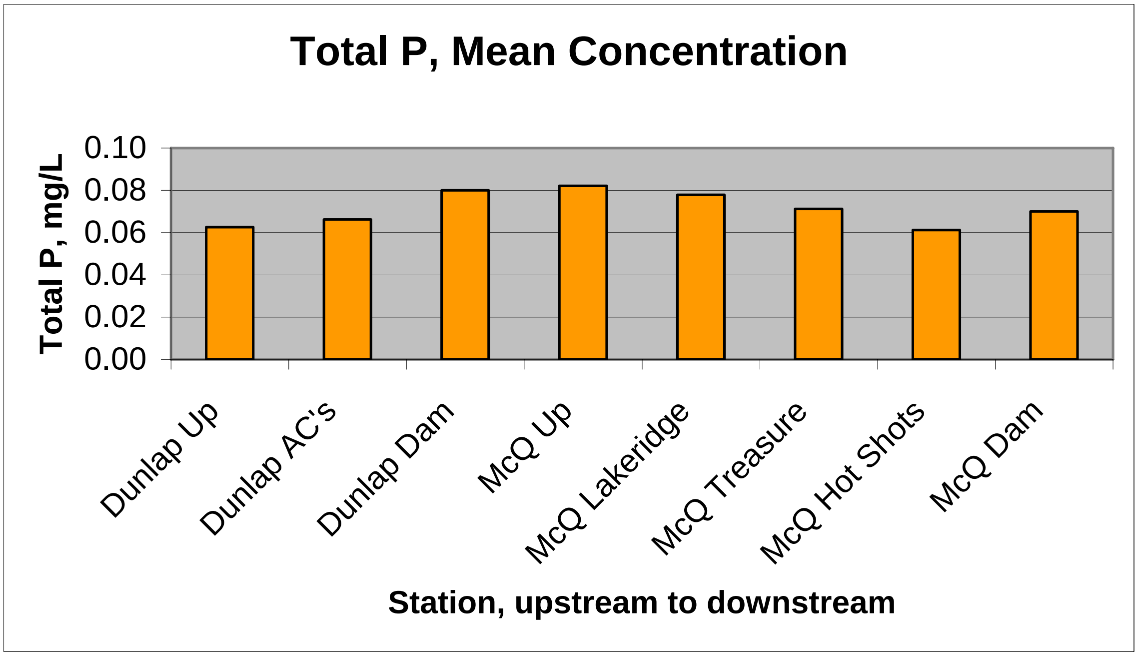
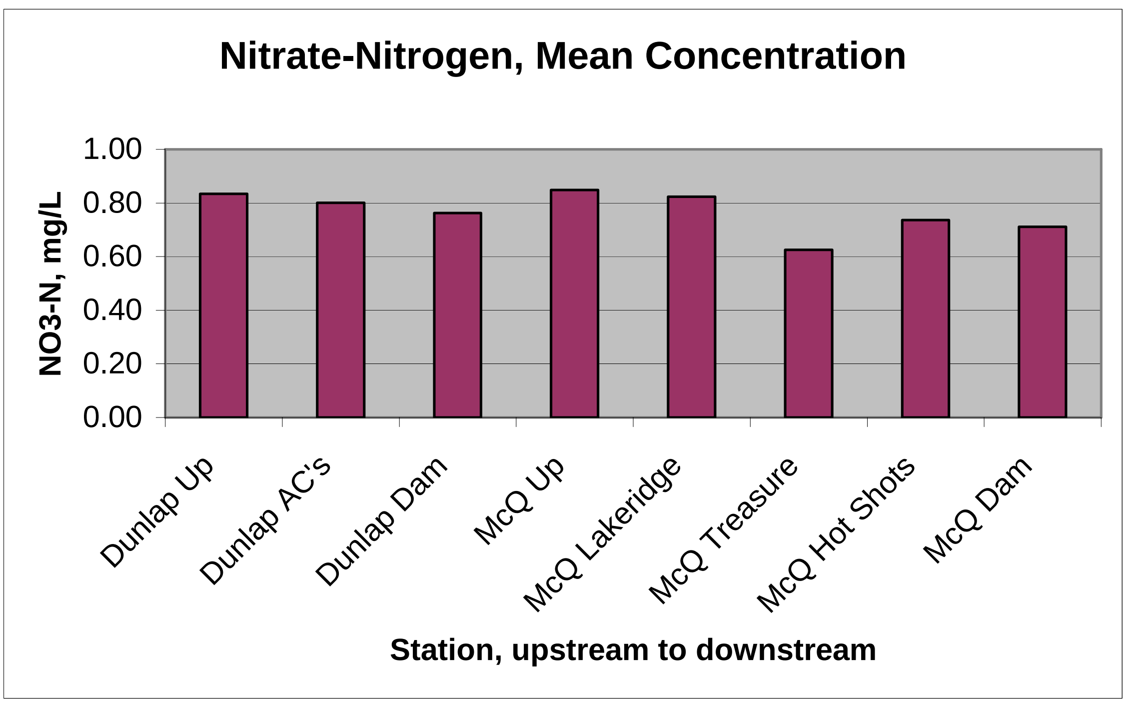


Figure 10. Spatial distribution of the nitrate-nitrogen concentrations in the study area.



The data collected in the twelve-month period was analyzed for correlations between flow and nutrient concentrations and flow and chlorophyll *a*. The high flows experienced during the study period prevented the correlation between chlorophyll *a* and flow seen in the historical data set. Although there were no strong correlations observed in this small data set, the highest chlorophyll *a* concentrations were seen in July and August 2005, two of the months with the lowest flows in the study period, evidence of the inverse relationship between flow and chlorophyll *a* seen in the historical data set. The highest correlation coefficients observed were between flow and total phosphorus, but they were in the range of 0.3 and 0.57. The correlations may be more pronounced in a larger data set.

There have been numerous studies done on these hydroelectric impoundments that have looked at sources and impacts of nutrient loading, from both point and non-point sources. The land use along the two impoundments is similar, comprised primarily residential land activities. The majority of the homes along the banks of both impoundments are on septic tanks. The water quality in the systems may be impacted by old, failing septic systems or septic systems that are located in areas of shallow ground water that can provide a conduit to the surface water nearby. Many have said that the wastewater treatment plants in the study area should have nutrient limitations. A study done in the early 1980's evaluated the removal of phosphorus from the wastewater discharges and stated that the removal would likely reduce aquatic plant levels but at a very high price (Glass Environmental Consultants, 1981).

Previous studies have determined that total phosphorus is most likely the limiting nutrient in the system. Nitrogen exists in relatively consistent concentrations in the Comal Springs but phosphorus tends to be low. There are numerous sources of phosphorus available in the system. In addition to the phosphorus contributions from the wastewater discharges, and failing septic systems, there can be a rise in phosphorus levels in the anoxic discharge from the bottom-draining Canyon Reservoir (GBRA-EH&A, 1998). A study performed by GBRA and the Clean Rivers Program found that total phosphorus levels in lake sediments appear to increase slightly going downstream, and appear to show very substantial differences that might be associated with wastewater discharge (GBRA-PBS&J, 2001).

In addition to the identifiable sources of nutrients, stormwater and sediments play important roles in nutrient dynamics in the system. There is evidence found in this study that nutrients trapped in sediments have potential to increase the concentration of total phosphorus in the system under certain high flow conditions resulting directly or indirectly from stormwater events. Population projections for the Lake Dunlap watershed are proposed to increase by 45% by 2020. With impervious cover that comes with development in the watershed expected to rise to 55%, higher runoff coefficients and loading is expected.

According to Dr. Allen Groeger (Groeger, 2002), Lake Dunlap experiences advective stratification, caused by the cold inflowing water from the Comal River plunging beneath the downstream waters in the lake. In dry years, this stratification can increase the residence time of the surface layer of Lake Dunlap. In wet years, the high flows released from Canyon Reservoir weaken the density differences and little or no stratification occurs. The variability of system's potential for stratification described by Dr. Groeger adds more complexity to the nutrient/productivity dynamics.

Summary

This study was undertaken to determine if there is a spatial relationship as the water moves downstream through Lakes Dunlap and McQueeney. Additionally, it was to determine if the relationship between flow and chlorophyll *a* seen in the historical data was supported in the study period. The study did not clearly identify sources of nutrients, but the spatial analysis of the water quality conditions moving downstream did show nutrient concentrations sufficient to promote algal photosynthetic activity in both reservoirs. Most notably, during the two months that had the most prolonged period of low flow conditions, there was a definite spike in chlorophyll *a* at downstream stations in each impoundment.

Most studies on the hydro lakes and the results of the current study have one aspect in common; water quality conditions are contingent on flow in the system. The flow creates conditions, i.e. temperature regime, stratification, and residence times that impact the productivity of the impoundments. Conversely, high flows or storm water inflows contribute solids and nutrients to the system.

At which time that the development of nutrient standards are considered for streams, one of the challenges will be to address the functionality of run-of-river impoundments because of the high variability in flow conditions. It should be recognized that in most years of normal to high flow, the impoundments are streams with constant throughput of nutrient and sediment loads. But, during years of low flow, drought conditions, the water bodies will respond to nutrient contributions as would a reservoir. TCEQ nutrient and chlorophyll *a* screening levels and future considerations of criteria should take into consideration the unique conditions of these run-of-the river impoundments. Current screening levels for streams may allow too much algae to grow and current screening levels for reservoirs may be too restrictive considering the ability of these impoundments to act more like slow moving streams. The relationship between algae growth, nutrient concentrations, and flow in these impoundments should be used to develop screening levels and future criteria in deference to statewide percentages based on all reservoirs in Texas.

Residents living on the lakes have found that their use(s) of the lakes have been restricted in the past due to growth of rooted aquatic plants and other macrophytes. This study, and historical studies have attempted to quantify the relationship between nutrients and plant growth (albeit algae). This study has shown that there are many mitigating factors that increase and decrease plant growth, but the source of nutrients from the New Braunfels area, both from point and non-point sources can, in some low flow periods, exacerbate the plant growth. It would be advantageous to investigate wastewater management practices that could be put in place to divert wastewater flows to irrigation during periods of low flow. In addition, certain stormwater controls could be put in place to reduce the loading associated with storm flows. This would also help reduce the effect of stormwater runoff during possible flood conditions.

In order to verify the extent of contributions from area septic tanks, a dye study of different types, ages, and sizes of septic tanks could be done. This study would require differing weather conditions and possibly weekend study due to the increased use of homes during those time periods. This study could be coordinated with the area homeowners associations to ensure their involvement in and cooperation with the study.

The anthropogenic impacts on these water bodies cannot be minimized. As populations grow in the area, the impact of that growth will continue to be felt in several ways. Not only will the failing septic tank impacts need to be addressed, as well as the need for nutrient limitations in wastewater permits, the pressure that will be exerted from the growing population on the water resources, as the cities call upon more and more ground and surface water, will increase the frequency of lower flow conditions. Couple the increase in demand on water sources with the increase in impervious cover that reduces ground water recharge, and the base flow of these impoundments will diminish.

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Appendix A. Analytical methods and data quality objectives

PARAMETER	UNITS	MATRIX	METHOD	STORET	AWRL	Lab Reporting Limit (RL)	RECOVERY AT RLs	PRECISION (RPD of LCS/LCS dup)	BIAS (%Rec. of LCS)	Lab
Field Parameters										
pH	pH/ units	water	SM 4500-H^+ B. and TCEQ SOP	00400	NA[1]	NA	NA	NA	NA	Field
DO	mg/L	water	SM 4500-O G. and TCEQ SOP	00300	NA[1]	NA	NA	NA	NA	Field
Conductivity	umhos/cm	water	SM 2510 and TCEQ SOP	00094	NA[1]	NA	NA	NA	NA	Field
Conductivity	umhos/cm	water	SM 2510	00095	NA[1]	NA	NA	NA	NA	GBRA
Temperature	^oC	water	SM 2550 and TCEQ SOP	00010	NA[1]	NA	NA	NA	NA	Field
Flow	cfs	water	TCEQ SOP	00061	NA[1]	NA	NA	NA	NA	Field
Flow measurement method	1-gage 2-electric 3-mechanical 4-weir/flume 5-doppler	water	TCEQ SOP	89835	NA[1]	NA	NA	NA	NA	Field
Flow severity	1-no flow, 2-low, 3-normal, 4-flood, 5-high, 6-dry	water	TCEQ SOP	01351	NA[1]	NA	NA	NA	NA	Field
Secchi Disk	m	water	TCEQ SOP	00078	NA[1]	NA	NA	NA	NA	Field
Days since last significant rainfall	days	water	TCEQ SOP	72053	NA[1]	NA	NA	NA	NA	Field
Conventional Parameters										
TSS	mg/L	water	SM 2540 D.	00530	4	1	NA	20	NA	GBRA
Turbidity	NTU	water	SM 2130 B	82079	0.5	0.5	NA	20	NA	GBRA
Sulfate	mg/L	water	EPA 300.0	00945	10	1	75-125	20	80-120	GBRA
Sulfate[3]	mg/L	water	SM 4500-SO_4 E.	00945	10	1	75-125	20	80-120	GBRA
Chloride	mg/L	water	EPA 300.0	00940	10	1	75-125	20	80-120	GBRA
Chloride[3]	mg/L	water	SM 4500-Cl C.	00940	10	1	75-125	20	80-120	GBRA
Chlorophyll-a, spectrophotometric method	ug/L	water	SM 10200-H	32211	5	1	75-125	20	NA	GBRA
Pheophytin, spectrophotometric method	ug/L	water	SM 10200-H	32218	3	3	75-125	20	NA	GBRA

Conventional Parameters (cont.)										
E. coli, IDEXX Colilert	MPN/100 mL	water	SM 9223-B	31699	1	1	NA	0.5[2]	NA	GBRA
Ammonia-N, total	mg/L	water	SM 4500-NH_3 E.	00610	0.02	0.02	75-125	20	80-120	GBRA
Hardness, total (as CaC03)	mg/L	water	SM 2340 C.	00900	5	5	NA	20	80-120	GBRA
Nitrate-N, total	mg/L	water	EPA 300.0	00620	0.02	0.02	75-125	20	80-120	GBRA
Nitrate/nitrite-N, total[3]	mg/L	water	SM 4500-NO_3 E. + NO_2 B.	00630	0.04	0.02	75-125	20	80-120	GBRA
Total phosphorus	mg/L	water	SM 4500-P B. + E.	00665	0.06	0.05	75-125	20	80-120	GBRA
Total Kjeldahl Nitrogen	mg/L	water	SM 4500-N D.	00625	0.2	1.0[4]	75-125	20	80-120	LCRA

References:

1 Reporting to be consistent with SWQM guidance and based on measurement capability.

2 Based on range statistic as described in Standard Methods, 20th Edition, Section 9020-B, " Quality Assurance/Quality Control – Intralaboratory Quality Control Guidelines."

3 Secondary method listed. To be used in the event that the primary method cannot be used or needs to be confirmed, i.e. automated method cannot be used due to instrument failure.

4 GBRA Regional Laboratory is working to bring the reporting limit more in line with the AWRL by performing MDL studies at 0.2 mg/L. If the reporting limit is lowered based on valid MDL studies the appendix will be amended to reflect new RL.

Appendix B. Water quality data by station.

River Segment 1804
Station Id. No. 15480
Station Name Lake Dunlap Upstream
Longitude 98/05/28 Latitude 29/40/48

Parameter	Parameter Code	4/27/2004 1017	5/17/2004 1155	7/20/2004 1054	8/9/2004 1125	9/10/2004 1342	10/15/2004 1215	3/11/05 1437	4/4/2005 1122	5/6/2005 1125	6/3/2005 1205	7/8/2005 1351	8/3/2005 1042
Flow (cfs)	00060	625	726	2314	913	969	1085	2249	1112	772	1556	691	628
E. coli (org/100mL)	31648	63	64	56	NA[2]	72	210	27	30	33	65	340	82
Suspended Solids (mg/L)	00530	3.9	3	5.6	3.2	6.8	7.3	4.6	3.3	4.8	7.3	4.7	5.0
Turbidity (NTU)	82079	4.12	4.06	4.94	3.6	3.1	4	4.3	3.5	2.9	6.7	4.3	2.9
pH	00400	7.97	7.73	7.8	7.74	NA[1]	7.8	7.96	7.76	7.7	7.84	7.72	7.64
Temperature (C)	00010	21.2	22.1	23.4	24.6	NA[1]	20.1	16.3	19.2	21.5	21	25.1	24.6
Dissolved Oxygen (mg/L)	00300	9	8.02	8.51	8.15	NA[1]	9.01	12	10.02	9.6	8.53	9.24	8.91
Conductivity (umhos/cm)	00094	539	502	457	517	NA[1]	500	492	531	557	465	545	543
Total Phosphorus (mg/L)	00665	0.08	0.07	0.19	<0.05	0.07	0.08	0.05	0.05	<0.05	<0.05	<0.05	0.06
Nitrate-N (mg/L as N)	00630	0.49	0.55	0.66	0.33	0.49	0.6	0.8	1.07	1.24	0.98	1.36	1.38
Chloride (mg/L)	00940	17.6	16.6	13.1	14.2	14.7	15.4	13.1	14.7	15.4	14.8	17.1	16.5
Sulfate (mg/L)	00945	23.8	24.6	17.9	19.6	19.4	20.8	20.3	21.7	23.3	21.3	22.8	22.7
Total Hardness (mg/L)	00900	257	243	208	240	245	243	249	257	262	242	253	264
Ammonia-N (mg/L)	00610	0.03	0.06	0.03	0.04	0.19	0.04	0.02	0.02	0.02	0.02	0.03	0.02
Chlorophyll *a* (mg/m^3)	32211	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	<1	<1
Total Kjeldahl Nitrogen (mg/L)	00625	<1.0	<1	0.38	0.23	0.25	0.29	NA[3]	<0.2	<0.2	0.15	0.27	<0.2
Secchi Disk (m)	00078	1.4	1.15	1.3	1.6	2.0	1.2	1.8	2.1	1.7	1.1	1.5	1.1

1 – Probe malfunction. 2 – Incubator malfunction. 3 – Samples were not delivered to LCRA within holding time. 4 – No data available.

River Segment 1804
Station Id. No. 12596
Station Name Lake Dunlap at AC's Place
Longitude 98/04/48 Latitude 29/40/15

Parameter	Parameter Code	4/27/2004 1017	5/17/2004 1155	7/20/2004 1054	8/9/2004 1125	9/10/2004 1342	10/15/2004 1215	3/11/05 1437	4/4/2005 1122	5/6/2005 1125	6/3/2005 1205	7/8/2005 1351	8/3/2005 1042
Flow (cfs)	00060	625	726	2314	913	969	1085	2249	1112	772	1556	691	628
E. coli (org/100mL)	31648	33	36	72	NA[2]	63	222	68	31	36	80	55	36
Suspended Solids (mg/L)	00530	6.9	4.4	6.1	2	5.2	27.4	6	6.8	7.5	7.7	3.4	4.7
Turbidity (NTU)	82079	7.57	7.04	6.14	7	4.5	16.5	5.9	7.1	6	7.8	4.4	3.5
pH	00400	7.96	7.87	7.66	7.83	7.79	7.74	7.93	7.74	7.71	7.82	7.82	7.74
Temperature (C)	00010	21.8	22.8	24	25.3	25.5	22.2	16.2	19.3	21.9	21.8	27.1	26.3
Dissolved Oxygen (mg/L)	00300	10	7.92	8.02	8.22	7.73	8.51	11.7	9.76	9.51	7.9	9.46	9.41
Conductivity (umhos/cm)	00094	535	501	458	516	507	500	494	540	555	496	546	541
Total Phosphorus (mg/L)	00665	0.08	0.05	0.16	0.07	0.06	0.11	<0.05	0.08	<0.05	0.06	<0.05	0.05
Nitrate-N (mg/L as N)	00630	0.38	0.34	0.73	0.42	0.62	0.29	0.84	1.16	1.18	0.97	1.29	1.39
Chloride (mg/L)	00940	18.5	16.7	13.1	14.5	14.5	41.3	13.3	15.1	15.3	14.9	17.7	17.5
Sulfate (mg/L)	00945	24.9	24.4	17.9	19.7	19.6	28.2	20.5	22.4	22.9	21.6	23.6	23.2
Total Hardness (mg/L)	00900	256	243	210	244	246	248	249	261	260	241	252	262
Ammonia-N (mg/L)	00610	0.04	0.05	0.02	0.03	0.03	0.06	0.03	0.05	0.02	0.04	0.04	0.02
Chlorophyll *a* (mg/m^3)	32211	<1	<1	2.1	<1	<1	<1	<1	<1	<1	<1	1.1	<1.0
Total Kjeldahl Nitrogen (mg/L)	00625	<1	<1.0	0.31	0.25	0.14	0.4	NA[3]	0.262	<0.2	<0.2	<3	0.244
Secchi Disk (m)	00078	NA[4]	0.8	1.1	0.9	1	0.4	1.3	1.2	1.4	0.9	1.4	2

1 – Probe malfunction. 2 – Incubator malfunction. 3 – Samples were not delivered to LCRA within holding time. 4 – No data available.

River Segment 1804
Station Id. No. 15481
Station Name Lake Dunlap at Dam
Longitude 98/04/05 Latitude 29/39/36

Parameter	Parameter Code	4/27/2004 1017	5/17/2004 1155	7/20/2004 1054	8/9/2004 1125	9/10/2004 1342	10/15/2004 1215	3/11/05 1437	4/4/2005 1122	5/6/2005 1125	6/3/2005 1205	7/8/2005 1351	8/3/2005 1042
Flow (cfs)	00060	625	726	2314	913	969	1085	2249	1112	772	1556	691	628
E. coli (org/100mL)	31648	12	38	64	NA[2]	27	1203	33	37	29	26	11	<1
Suspended Solids (mg/L)	00530	6.3	8.5	1.1	8.3	7.6	17.3	6.9	6.8	5	5.6	8.4	7.0
Turbidity (NTU)	82079	7.01	11.8	9.38	8.4	6.7	20.3	8.4	9.7	5.8	6.1	4.3	3.8
pH	00400	7.93	7.97	7.8	7.84	7.79	7.8	8.02	7.81	7.81	7.84	7.86	7.81
Temperature (C)	00010	21.9	23.9	25.6	27	26	21.8	17.6	19.3	22.3	24.6	28.9	28.3
Dissolved Oxygen (mg/L)	00300	9.08	7.54	8.25	8.13	7.92	7.83	11.2	10.01	9.73	7.87	12.57	12.11
Conductivity (umhos/cm)	00094	520	501	526	513	509	390	491	530	546	495	516	518
Total Phosphorus (mg/L)	00665	0.1	0.08	0.32	<0.05	0.05	0.12	0.06	0.08	0.05	<0.05	<0.05	<0.05
Nitrate-N (mg/L as N)	00630	0.35	0.36	1.12	0.28	0.26	0.48	0.81	1.07	1.13	1.1	1.06	1.11
Chloride (mg/L)	00940	18.1	17.3	16.2	14.2	15	12	13.3	14.8	14.8	15.8	17.7	17.6
Sulfate (mg/L)	00945	25.1	25.4	22.2	19.7	20.1	17	20.9	22.3	22	23.4	25.5	23.2
Total Hardness (mg/L)	00900	249	242	240	244	249	186	251	257	258	238	236	240
Ammonia-N (mg/L)	00610	0.05	0.04	0.02	0.02	0.04	0.1	0.02	0.04	0.02	0.04	0.02	<0.02
Chlorophyll *a* (mg/m^3)	32211	<1	<1	<1	4.4	<1	<1	<1	<1	<1	1.1	8.9	12.2
Total Kjeldahl Nitrogen (mg/L)	00625	<1	<1.0	<0.2	<0.2	0.2	0.49	NA[3]	<0.2	<0.2	<0.2	0.68	<0.2
Secchi Disk (m)	00078	0.8	0.55	0.9	0.7	1.0	0.4	1	0.7	1.1	0.6	1	1.5

1 – Probe malfunction. 2 – Incubator malfunction. 3 – Samples were not delivered to LCRA within holding time. 4 – No data available.

River Segment 1804
Station Id. No. 15516
Station Name Lake McQueeney at Dunlap Dam
Longitude 98/02/38 Latitude 29/38/24

Parameter	Parameter	4/27/2004	5/17/2004	7/20/2004	8/9/2004	9/10/2004	10/15/2004	3/11/05	4/4/2005	5/6/2005	6/3/2005	7/8/2005	8/3/2005
	Code	1017	1155	1054	1125	1342	1215	1437	1122	1125	1205	1130	1042
Flow (cfs)	00060	625	726	2314	913	969	1085	2249	1112	772	1556	691	628
E. coli (org/100mL)	31648	16	35	38	NA[2]	44	1300	48	30	11	28	59	15
Suspended Solids (mg/L)	00530	8.2	15.8	15.5	11.5	7.7	26.8	6.9	7	7.7	11.9	9.6	11.78
Turbidity (NTU)	82079	7.91	15.8	11.7	10.2	7.4	25.7	8.7	9.3	7.2	11.8	6	7.8
pH	00400	7.93	7.95	7.94	7.8	7.88	7.89	7.92	7.73	7.62	7.87	7.81	7.72
Temperature (C)	00010	21.9	23.6	25.6	26.1	24.8	21.8	16.7	19.3	21.6	24	27.8	26.7
Dissolved Oxygen (mg/L)	00300	9.29	7.72	8.13	7.37	7.67	7.45	12.1	9.81	9.34	8.22	10.2	9.38
Conductivity (umhos/cm)	00094	520	500	535	511	510	397	494	533	547	512	531	535
Total Phosphorus (mg/L)	00665	0.08	0.06	0.39	0.07	0.05	0.16	<0.05	0.05	<0.05	0.07	<0.05	<0.05
Nitrate-N (mg/L as N)	00630	0.33	0.33	1.41	0.69	0.35	0.41	0.8	1.12	1.15	1.11	1.17	1.31
Chloride (mg/L)	00940	18.2	17.3	16.8	14.5	15.3	12.2	13.4	14.9	14.9	15.8	17.8	17.4
Sulfate (mg/L)	00945	25.5	25.4	22.9	19.9	20.1	17.2	20.7	22.4	22.3	23.6	23.2	24.2
Total Hardness (mg/L)	00900	245	243	250	248	249	198	249	257	260	246	246	260
Ammonia-N (mg/L)	00610	0.04	0.04	0.03	0.03	0.03	0.11	0.02	0.04	0.02	0.04	0.02	0.02
Chlorophyll *a* (mg/m^3)	32211	<1	<1	<1	1.5	<1	2.7	<1	<1	<1	1.1	8.4	6.9
Total Kjeldahl Nitrogen (mg/L)	00625	1.09	<1.0	0.08	0.29	0.22	0.56	NA[3]	<0.2	<0.2	0.42	0.233	<0.2
Secchi Disk (m)	00078	0.9	0.5	0.6	0.6	1	0.3	0.9	0.6	0.7	0.6	1	0.7

1 – Probe malfunction. 2 – Incubator malfunction. 3 – Samples were not delivered to LCRA within holding time. 4 – No data available.

River Segment 1804
Station Id. No. 15517
Station Name Lake McQueeney at Lakeridge
Longitude 98/01/40 Latitude 29/37/12

Parameter	Parameter Code	4/27/2004 1017	5/17/2004 1155	7/20/2004 1054	8/9/2004 1125	9/10/2004 1342	10/15/2004 1215	3/11/05 1437	4/4/2005 1122	5/6/2005 1125	6/3/2005 1205	7/8/2005 1138	8/3/2005 1042
Flow (cfs)	00060	625	726	2314	913	969	1085	2249	1112	772	1556	691	628
E. coli (org/100mL)	31648	3	23	51	NA[2]	29	1046	34	38	19	33	34	13
Suspended Solids (mg/L)	00530	4.7	7.8	14.6	7.2	6.6	25.3	8.5	8.7	9.4	8.4	8.9	9.3
Turbidity (NTU)	82079	5.18	10.9	11.6	6.9	7.2	24.6	8.3	9.9	7.6	10.3	6.1	6.9
pH	00400	8.01	7.87	7.99	7.81	7.88	7.83	8.01	7.72	7.65	7.87	7.83	7.69
Temperature (C)	00010	23	24.3	26	26.5	25.4	21.9	17	19.3	21.5	24.1	28.2	26.8
Dissolved Oxygen (mg/L)	00300	10	7.39	7.6	7.15	7.42	8.19	12.3	9.69	9.37	8.23	10.64	9.08
Conductivity (umhos/cm)	00094	526	503	540	512	513	411	494	533	549	512	525	533
Total Phosphorus (mg/L)	00665	0.08	0.07	0.23	0.06	0.09	0.14	<0.05	0.07	<0.05	0.06	<0.05	0.06
Nitrate-N (mg/L as N)	00630	0.33	0.34	0.92	0.64	0.57	0.42	0.85	1.11	1.17	1.13	1.15	1.25
Chloride (mg/L)	00940	18.1	18.1	17.3	14.3	15.1	12.5	13.4	14.9	14.9	15.9	17.4	17.2
Sulfate (mg/L)	00945	25.4	27	23.3	19.9	20.5	17.1	20.9	22.5	22.1	23.6	23	23.0
Total Hardness (mg/L)	00900	245	238	242	243	249	200	253	260	263	252	242	271
Ammonia-N (mg/L)	00610	0.04	0.05	0.03	0.02	0.02	0.05	0.02	0.04	0.02	0.04	0.03	0.02
Chlorophyll *a* (mg/m^3)	32211	<1	1.1	1.4	2.5	<1.0	3.4	<1	1.2	1.7	1.2	7.5	7.2
Total Kjeldahl Nitrogen (mg/L)	00625	<1	<1	<0.2	0.2	0.25	0.45	NA[3]	<0.2	<0.2	0.49	<0.2	<0.2
Secchi Disk (m)	00078	0.95	0.5	0.4	0.8	1	0.3	1	0.6	0.6	0.7	1	0.7

1 – Probe malfunction. 2 – Incubator malfunction. 3 – Samples were not delivered to LCRA within holding time. 4 – No data available.

River Segment 1804
Station Id. No. 15273
Station Name Lake McQueeney, south of Treasure Island
Longitude 98/02/20 Latitude 29/36/00

Parameter	Parameter Code	4/27/2004 1017	5/17/2004 1155	7/20/2004 1054	8/9/2004 1125	9/10/2004 1342	10/15/2004 1215	3/11/05 1437	4/4/2005 1122	5/6/2005 1125	6/3/2005 1205	7/8/2005 1149	8/3/2005 1042
Flow (cfs)	00060	625	726	2314	913	969	1085	2249	1112	772	1556	691	628
E. coli (org/100mL)	31648	1	5	1	NA[2]	<1	148	15	4	6	23	4	17
Suspended Solids (mg/L)	00530	12.4	11.5	2.7	10.2	10.5	13.6	12	11.1	10.1	11.4	8.8	7.7
Turbidity (NTU)	82079	15.8	16.3	8.24	11.4	10.9	13.8	14.9	14.6	11.9	13.3	9.4	9.1
pH	00400	7.89	7.79	8.01	7.92	7.9	7.89	7.87	8.93	7.78	7.92	7.82	7.77
Temperature (C)	00010	23.3	25.4	25.8	28	25.7	22.2	17.7	19.4	22.5	26.7	30.1	29.8
Dissolved Oxygen (mg/L)	00300	8.86	7	7.66	7.48	7.44	8.1	11.4	8.93	9.64	8.18	8.25	8.23
Conductivity (umhos/cm)	00094	510	496	482	511	507	494	501	535	531	502	517	521
Total Phosphorus (mg/L)	00665	0.11	0.1	0.26	<0.05	<0.05	0.06	0.06	0.09	<0.05	<0.05	<0.05	0.05
Nitrate-N (mg/L as N)	00630	0.36	0.38	0.47	0.57	0.27	0.5	0.75	0.97	0.79	1.02	0.69	0.74
Chloride (mg/L)	00940	17.4	17.5	14.9	14.4	15.2	15	14.6	15.4	15.3	16.5	17.9	17.6
Sulfate (mg/L)	00945	23.1	25.3	20.3	20.1	20.3	19.9	21.5	23	22.9	24.4	24.4	23.6
Total Hardness (mg/L)	00900	246	236	211	242	249	246	251	261	250	244	240	256
Ammonia-N (mg/L)	00610	<0.02	0.04	0.03	0.02	0.02	0.1	0.02	0.03	<0.02	0.03	0.03	0.02
Chlorophyll *a* (mg/m^3)	32211	3.3	2	4	3.9	3.7	1.3	4.7	2	3.3	4.7	4.5	3.1
Total Kjeldahl Nitrogen (mg/L)	00625	<1	<1.0	0.18	0.05	0.26	0.27	NA[3]	0.27	0.219	0.344	<0.2	<0.2
Secchi Disk (m)	00078	0.45	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6

1 – Probe malfunction. 2 – Incubator malfunction. 3 – Samples were not delivered to LCRA within holding time. 4 – No data available.

River Segment 1804
Station Id. No. 15149
Station Name Lake McQueeney, 0.5 mile upstream of McQueeney Dam on Southeast bank (Hot Shots)
Longitude 98/02/10 Latitude 29/26/34

Parameter	Parameter Code	4/27/2004 1017	5/17/2004 1155	7/20/2004 1054	8/9/2004 1125	9/10/2004 1342	10/15/2004 1215	3/11/05 1437	4/4/2005 1122	5/6/2005 1125	6/3/2005 1205	7/8/2005 1351	8/3/2005 1042
Flow (cfs)	00060	625	726	2314	913	969	1085	2249	1112	772	1556	691	628
E. coli (org/100mL)	31648	4	7	29	NA[2]	20	133	29	37	8	328	42	1
Suspended Solids (mg/L)	00530	6.4	9.6	6.8	4.1	4.8	17.3	11.1	9.5	8.8	7.6	10	11
Turbidity (NTU)	82079	6.77	14	9.9	6.4	5.7	14	15	10.1	8.5	7.6	8.3	12
pH	00400	7.97	7.99	8.01	7.84	7.94	7.84	7.9	7.61	7.75	7.83	7.88	7.8
Temperature (C)	00010	23.1	25.2	26.5	27	25.2	22.4	17.3	19.1	21.5	25.6	29.6	29.3
Dissolved Oxygen (mg/L)	00300	9.3	7.24	7.48	7.43	7.87	8.17	11.3	9.35	9.45	8.28	8.79	9.22
Conductivity (umhos/cm)	00094	530	490	538	511	511	489	495	533	548	501	519	521
Total Phosphorus (mg/L)	00665	0.08	0.06	0.13	0.06	0.06	0.1	0.06	0.05	<0.05	<0.05	<0.05	0.06
Nitrate-N (mg/L as N)	00630	0.4	0.38	0.78	0.47	0.56	0.2	0.83	1.06	1.16	1.2	0.87	0.93
Chloride (mg/L)	00940	17.4	17.4	17.2	14.4	15.4	15.1	13.6	15.2	15	16.5	17.7	17.6
Sulfate (mg/L)	00945	24.1	25.1	23.3	19.5	20.7	19.9	20.7	22.9	22.4	24.4	24	23.4
Total Hardness (mg/L)	00900	259	237	252	240	249	245	250	260	252	246	240	256
Ammonia-N (mg/L)	00610	0.04	0.04	0.03	0.03	0.03	0.06	0.02	0.04	0.02	0.05	0.05	<0.02
Chlorophyll *a* (mg/m^3)	32211	<1	4	3.8	1.6	<1	1.3	<1	<1	1.4	2.9	8.6	17.6
Total Kjeldahl Nitrogen (mg/L)	00625	<1	1.2	0.15	0.14	0.2	0.31	NA[3]	0.235	<0.2	0.301	0.25	<0.2
Secchi Disk (m)	00078	NA[4]	0.5	0.6	0.8	1	0.5	0.7	0.6	0.6	0.6	0.6	0.5

1 – Probe malfunction. 2 – Incubator malfunction. 3 – Samples were not delivered to LCRA within holding time. 4 – No data available.

River Segment 1804
Station Id. No. 18213
Station Name Lake McQueeney at Dam
Longitude 98/02/35 Latitude 29/36/00

Parameter	Parameter Code	4/27/2004 1017	5/17/2004 1155	7/20/2004 1054	8/9/2004 1125	9/10/2004 1342	10/15/2004 1215	3/11/05 1437	4/4/2005 1122	5/6/2005 1125	6/3/2005 1205	7/8/2005 1158	8/3/2005 1042
Flow (cfs)	00060	625	726	2314	913	969	1085	2249	1112	772	1556	691	628
E. coli (org/100mL)	31648	3	2	32	NA[2]	6	56	24	5	5	17	1	4
Suspended Solids (mg/L)	00530	6	8.1	9	7.8	10.9	13.4	8.7	6.1	7.3	9.3	9.5	7.0
Turbidity (NTU)	82079	7.94	12.5	9.84	8.8	8.3	12.9	10.7	9	8.6	11.1	9.2	5.4
pH	00400	8.01	7.91	8.02	7.87	7.97	7.87	8.03	7.82	7.76	7.87	7.88	7.73
Temperature (C)	00010	23.3	25.5	27.5	27.6	25.7	22.6	18	19.7	21.7	25.8	30	29.6
Dissolved Oxygen (mg/L)	00300	8.63	7.05	7.32	7.24	8.2	8.11	11.8	10.03	9.2		9.92	9.5
Conductivity (umhos/cm)	00094	535	498	519	511	508	496	496	535	547	516	520	515
Total Phosphorus (mg/L)	00665	0.11	0.11	0.22	<0.05	0.05	0.08	<0.05	0.05	0.05	<0.05	<0.05	0.07
Nitrate-N (mg/L as N)	00630	0.34	0.33	0.47	0.27	0.47	0.34	0.84	1.08	1.12	1.24	1.04	0.99
Chloride (mg/L)	00940	18.1	17.4	16.2	14.4	15.1	15.1	13.4	15.2	15.2	16.4	17.7	17.7
Sulfate (mg/L)	00945	24.3	25.1	22.1	20	20.4	19.8	20.8	23.1	22.7	23.5	23.8	23.5
Total Hardness (mg/L)	00900	258	239	228	243	249	244	246	260	263	247	238	242
Ammonia-N (mg/L)	00610	0.02	0.03	0.03	<0.02	0.02	0.05	0.02	0.04	<0.02	0.03	0.02	<0.02
Chlorophyll *a* (mg/m^3)	32211	4.2	5.5	3.1	3.3	4.8	<1	<1	<1	2.3	3.1	5.8	6.3
Total Kjeldahl Nitrogen (mg/L)	00625	<1.0	<1.0	0.16	0.14	0.26	0.28	NA[3]	<0.2	<0.2	0.2	0.292	<0.2
Secchi Disk (m)	00078	0.75	0.5	0.4	0.6	1.0	0.5	0.6	0.6	0.6	0.6	0.7	0.6

1 – Probe malfunction. 2 – Incubator malfunction. 3 – Samples were not delivered to LCRA within holding time. 4 – No data available.

Appendix C. Flow conditions during study period

Comal Rv at New Braunfels, TX

Date	Stream Flow (ft^3/s) (Mean)	
4/1/2004	345	Maximum Monthly
4/2/2004	364	Stream Flow Mean
4/3/2004	357	433
4/4/2004	366	Minimum Monthly
4/5/2004	406	Stream Flow Mean
4/6/2004	369	345
4/7/2004	360	GBRA Sampling
4/8/2004	356	Event 04/27/04
4/9/2004	360	360
4/10/2004	384	
4/11/2004	433	
4/12/2004	411	
4/13/2004	385	
4/14/2004	382	
4/15/2004	380	
4/16/2004	376	
4/17/2004	370	
4/18/2004	365	
4/19/2004	364	
4/20/2004	361	
4/21/2004	363	
4/22/2004	361	
4/23/2004	366	
4/24/2004	420	
4/25/2004	372	
4/26/2004	378	
4/27/2004	360	
4/28/2004	355	
4/29/2004	355	
4/30/2004	355	

Guadalupe Rv abv Comal Rv at New Braunfels, TX

Date	Stream Flow (ft^3/s) (Max)	Stream Flow (ft^3/s) (Min)	Stream Flow (ft^3/s) (Mean)	
4/1/2004	258	241	247	Maximum Monthly
4/2/2004	241	235	235	Stream Flow Mean
4/3/2004	349	235	334	4260
4/4/2004	379	349	353	Minimum Monthly
4/5/2004	379	300	324	Stream Flow Mean
4/6/2004	300	276	289	235
4/7/2004	276	252	268	GBRA Sampling
4/8/2004	1,390	241	348	Event 04/27/04
4/9/2004	4,240	1,390	2,180	304
4/10/2004	4,380	4,170	4,240	
4/11/2004	4,320	4,210	4,260	
4/12/2004	4,300	4,230	4,260	
4/13/2004	4,290	4,210	4,250	
4/14/2004	4,270	4,200	4,230	
4/15/2004	4,240	4,200	4,220	
4/16/2004	5,110	1,760	3,520	
4/17/2004	1,780	1,750	1,760	
4/18/2004	2,140	1,750	1,840	
4/19/2004	2,140	349	1,630	
4/20/2004	349	320	333	
4/21/2004	320	307	317	
4/22/2004	307	288	298	
4/23/2004	288	276	281	
4/24/2004	519	276	456	
4/25/2004	453	444	446	
4/26/2004	444	313	340	
4/27/2004	313	294	304	
4/28/2004	300	282	294	
4/29/2004	282	276	281	
4/30/2004	2,970	276	738	

Flow – Lakes Dunlap and McQueeney

Date	Stream Flow (ft^3/s) (Mean)	
4/1/2004	592	Maximum Monthly
4/2/2004	599	Stream Flow Mean
4/3/2004	691	4693
4/4/2004	719	Minimum Monthly
4/5/2004	730	Stream Flow Mean
4/6/2004	658	592
4/7/2004	628	GBRA Sampling
4/8/2004	704	Event 04/27/04
4/9/2004	2540	664
4/10/2004	4624	
4/11/2004	4693	
4/12/2004	4671	
4/13/2004	4635	
4/14/2004	4612	
4/15/2004	4600	
4/16/2004	3896	
4/17/2004	2130	
4/18/2004	2205	
4/19/2004	1994	
4/20/2004	694	
4/21/2004	680	
4/22/2004	659	
4/23/2004	647	
4/24/2004	876	
4/25/2004	818	
4/26/2004	718	
4/27/2004	664	
4/28/2004	649	
4/29/2004	636	
4/30/2004	1093	

Comal Rv at New Braunfels, TX

Date	Stream Flow (ft^3/s) (Mean)	
5/1/2004	353	Maximum Monthly
5/2/2004	349	Stream Flow Mean
5/3/2004	356	444
5/4/2004	352	Minimum Monthly
5/5/2004	355	Stream Flow Mean
5/6/2004	353	335
5/7/2004	349	GBRA Sampling
5/8/2004	352	Event 05/17/04
5/9/2004	356	356
5/10/2004	357	
5/11/2004	356	
5/12/2004	355	
5/13/2004	358	
5/14/2004	444	
5/15/2004	379	
5/16/2004	365	
5/17/2004	356	
5/18/2004	350	
5/19/2004	349	
5/20/2004	349	
5/21/2004	345	
5/22/2004	346	
5/23/2004	347	
5/24/2004	345	
5/25/2004	340	
5/26/2004	339	
5/27/2004	338	
5/28/2004	335	
5/29/2004	338	
5/30/2004	344	
5/31/2004	355	

Guadalupe Rv abv Comal Rv at New Braunfels, TX

Date	Stream Flow (ft^3/s) (Max)	Stream Flow (ft^3/s) (Min)	Stream Flow (ft^3/s) (Mean)	
5/1/2004	3,950	2,960	3,410	Maximum Monthly
5/2/2004	3,950	3,840	3,900	Stream Flow Mean
5/3/2004	3,900	3,830	3,860	3900
5/4/2004	3,910	3,830	3,870	Minimum Monthly
5/5/2004	3,910	3,810	3,850	Stream Flow Mean
5/6/2004	3,880	2,190	3,360	313
5/7/2004	2,190	471	1,640	GBRA Sampling
5/8/2004	610	527	566	Event 05/17/04
5/9/2004	559	535	537	405
5/10/2004	535	313	370	
5/11/2004	313	313	313	
5/12/2004	356	313	350	
5/13/2004	363	356	356	
5/14/2004	462	363	410	
5/15/2004	559	387	522	
5/16/2004	543	543	543	
5/17/2004	543	371	405	
5/18/2004	371	363	370	
5/19/2004	363	341	355	
5/20/2004	349	349	349	
5/21/2004	349	349	349	
5/22/2004	519	349	470	
5/23/2004	527	503	506	
5/24/2004	1,250	503	1,140	
5/25/2004	1,250	909	1,210	
5/26/2004	1,250	1,240	1,240	
5/27/2004	1,250	1,240	1,240	
5/28/2004	1,240	495	608	
5/29/2004	495	480	488	
5/30/2004	503	480	489	
5/31/2004	543	480	488	

Flow – Lakes Dunlap and McQueeney

Date	Stream Flow (ft^3/s) (Mean)	
5/1/2004	3763	Maximum Monthly
5/2/2004	4249	Stream Flow Mean
5/3/2004	4216	4249
5/4/2004	4222	Minimum Monthly
5/5/2004	4205	Stream Flow Mean
5/6/2004	3713	669
5/7/2004	1989	GBRA Sampling
5/8/2004	918	Event 05/17/04
5/9/2004	893	761
5/10/2004	727	
5/11/2004	669	
5/12/2004	705	
5/13/2004	714	
5/14/2004	854	
5/15/2004	901	
5/16/2004	908	
5/17/2004	761	
5/18/2004	720	
5/19/2004	704	
5/20/2004	698	
5/21/2004	694	
5/22/2004	816	
5/23/2004	853	
5/24/2004	1485	
5/25/2004	1550	
5/26/2004	1579	
5/27/2004	1578	
5/28/2004	943	
5/29/2004	826	
5/30/2004	833	
5/31/2004	843	

Comal Rv at New Braunfels, TX

Date	Stream Flow (ft³/s) (Mean)	
6/2/2004	347	Maximum Monthly
6/3/2004	348	Stream Flow Mean
6/4/2004	347	3150
6/5/2004	408	Minimum Monthly
6/6/2004	357	Stream Flow Mean
6/7/2004	356	347
6/8/2004	389	GBRA Sampling
6/9/2004	3,150	Event Date
6/10/2004	1,360	No Sample Collected
6/11/2004	521	
6/12/2004	453	
6/13/2004	439	
6/14/2004	430	
6/15/2004	431	
6/16/2004	432	
6/17/2004	437	
6/18/2004	413	
6/19/2004	406	
6/20/2004	399	
6/21/2004	389	
6/22/2004	381	
6/23/2004	372	
6/24/2004	371	
6/25/2004	367	
6/26/2004	367	
6/27/2004	701	
6/28/2004	549	
6/29/2004	768	
6/30/2004	913	

Guadalupe Rv abv Comal Rv at New Braunfels, TX

Date	Stream Flow (ft³/s) (Max)	Stream Flow (ft³/s) (Min)	Stream Flow (ft³/s) (Mean)	
6/2/2004	2,720	2,670	2,690	Maximum Monthly
6/3/2004	2,720	646	2,070	Stream Flow Mean
6/4/2004	1,230	1,070	1,200	5420
6/5/2004	1,210	488	642	Minimum Monthly
6/6/2004	488	471	482	Stream Flow Mean
6/7/2004	576	471	483	482
6/8/2004	748	576	649	GBRA Sampling
6/9/2004	11,900	637	2,830	Event Date
6/10/2004	5,720	756	1,480	No Sample Collected
6/11/2004	839	730	791	
6/12/2004	730	637	685	
6/13/2004	637	593	618	
6/14/2004	2,690	593	1,480	
6/15/2004	4,100	2,680	3,200	
6/16/2004	5,460	3,950	4,340	
6/17/2004	5,520	5,390	5,420	
6/18/2004	5,420	5,380	5,400	
6/19/2004	5,410	5,340	5,380	
6/20/2004	5,390	5,330	5,360	
6/21/2004	5,380	3,060	4,570	
6/22/2004	3,160	2,990	3,070	
6/23/2004	3,090	2,960	3,030	
6/24/2004	3,020	2,960	2,980	
6/25/2004	3,030	839	2,550	
6/26/2004	839	576	610	
6/27/2004	721	576	591	
6/28/2004	3,430	568	1,380	
6/29/2004	5,500	3,400	4,080	
6/30/2004	4,000	1,150	3,060	

Flow – Lakes Dunlap and McQueeney

Date	Stream Flow (ft³/s) (Mean)	
6/2/2004	3037	Maximum Monthly
6/3/2004	2418	Stream Flow Mean
6/4/2004	1547	5980
6/5/2004	1050	Minimum Monthly
6/6/2004	839	Stream Flow Mean
6/7/2004	839	839
6/8/2004	1038	GBRA Sampling
6/9/2004	5980	Event Date
6/10/2004	2840	No Sample Collected
6/11/2004	1312	
6/12/2004	1138	
6/13/2004	1057	
6/14/2004	1910	
6/15/2004	3631	
6/16/2004	4772	
6/17/2004	5857	
6/18/2004	5813	
6/19/2004	5786	
6/20/2004	5759	
6/21/2004	4959	
6/22/2004	3451	
6/23/2004	3402	
6/24/2004	3351	
6/25/2004	2917	
6/26/2004	977	
6/27/2004	1292	
6/28/2004	1929	
6/29/2004	4848	
6/30/2004	3973	

Comal Rv at New Braunfels, TX

Date	Stream Flow (ft^3/s) (Mean)	
7/2/2004	400	Maximum Monthly
7/3/2004	397	Stream Flow Mean
7/4/2004	394	541
7/5/2004	389	Minimum Monthly
7/6/2004	384	Stream Flow Mean
7/7/2004	394	365
7/8/2004	398	GBRA Sampling
7/9/2004	393	Event 07/20/04
7/10/2004	394	371
7/11/2004	389	
7/12/2004	384	
7/13/2004	380	
7/14/2004	381	
7/15/2004	376	
7/16/2004	382	
7/17/2004	375	
7/18/2004	371	
7/19/2004	371	
7/20/2004	371	
7/21/2004	368	
7/22/2004	366	
7/23/2004	365	
7/24/2004	378	
7/25/2004	541	
7/26/2004	509	
7/27/2004	398	
7/28/2004	392	
7/29/2004	390	
7/30/2004	386	
7/31/2004	393	

Guadalupe Rv abv Comal Rv at New Braunfels, TX

Date	Stream Flow (ft^3/s) (Max)	Stream Flow (ft^3/s) (Min)	Stream Flow (ft^3/s) (Mean)	
7/2/2004	797	748	776	Maximum Monthly
7/3/2004	748	692	721	Stream Flow Mean
7/4/2004	711	655	682	5410
7/5/2004	655	637	649	Minimum Monthly
7/6/2004	3,830	427	980	Stream Flow Mean
7/7/2004	5,420	3,830	5,320	511
7/8/2004	5,420	5,380	5,410	GBRA Sampling
7/9/2004	5,420	5,380	5,400	Event 07/20/04
7/10/2004	5,470	5,360	5,390	2170
7/11/2004	5,410	5,360	5,380	
7/12/2004	5,380	5,190	5,360	
7/13/2004	5,190	341	1,560	
7/14/2004	5,330	349	4,680	
7/15/2004	5,330	3,810	5,040	
7/16/2004	3,840	797	3,000	
7/17/2004	797	559	589	
7/18/2004	559	543	553	
7/19/2004	2,140	535	1,000	
7/20/2004	2,170	2,140	2,170	
7/21/2004	2,190	1,750	2,050	
7/22/2004	1,750	480	1,340	
7/23/2004	568	419	511	
7/24/2004	527	480	516	
7/25/2004	721	503	534	
7/26/2004	543	503	517	
7/27/2004	918	503	878	
7/28/2004	918	655	728	
7/29/2004	655	628	646	
7/30/2004	646	637	643	
7/31/2004	673	637	640	

Flow – Lakes Dunlap and McQueeney

Date	Stream Flow (ft^3/s) (Mean)	
7/2/2004	1176	Maximum Monthly
7/3/2004	1118	Stream Flow Mean
7/4/2004	1076	5808
7/5/2004	1038	Minimum Monthly
7/6/2004	1364	Stream Flow Mean
7/7/2004	5714	876
7/8/2004	5808	GBRA Sampling
7/9/2004	5793	Event 07/20/04
7/10/2004	5784	2541
7/11/2004	5769	
7/12/2004	5744	
7/13/2004	1940	
7/14/2004	5061	
7/15/2004	5416	
7/16/2004	3382	
7/17/2004	964	
7/18/2004	924	
7/19/2004	1371	
7/20/2004	2541	
7/21/2004	2418	
7/22/2004	1706	
7/23/2004	876	
7/24/2004	894	
7/25/2004	1075	
7/26/2004	1026	
7/27/2004	1276	
7/28/2004	1120	
7/29/2004	1036	
7/30/2004	1029	
7/31/2004	1033	

Comal Rv at New Braunfels, TX

Date	Stream Flow (ft^3/s) (Mean)	
8/2/2004	383	Maximum Monthly
8/3/2004	382	Stream Flow Mean
8/4/2004	382	397
8/5/2004	378	Minimum Monthly
8/6/2004	378	Stream Flow Mean
8/7/2004	382	364
8/8/2004	378	GBRA Sampling
8/9/2004	377	Event 08/09/04
8/10/2004	377	377
8/11/2004	380	
8/12/2004	376	
8/13/2004	375	
8/14/2004	376	
8/15/2004	376	
8/16/2004	374	
8/17/2004	373	
8/18/2004	374	
8/19/2004	373	
8/20/2004	370	
8/21/2004	367	
8/22/2004	379	
8/23/2004	376	
8/24/2004	374	
8/25/2004	374	
8/26/2004	373	
8/27/2004	372	
8/28/2004	397	
8/29/2004	378	
8/30/2004	364	
8/31/2004	365	

Guadalupe Rv abv Comal Rv at New Braunfels, TX

Date	Stream Flow (ft^3/s) (Max)	Stream Flow (ft^3/s) (Min)	Stream Flow (ft^3/s) (Mean)	
8/2/2004	673	637	638	Maximum Monthly
8/3/2004	772	637	747	Stream Flow Mean
8/4/2004	772	764	772	1550
8/5/2004	772	764	772	Minimum Monthly
8/6/2004	772	764	767	Stream Flow Mean
8/7/2004	772	637	681	480
8/8/2004	673	637	644	GBRA Sampling
8/9/2004	637	637	637	Event 08/09/04
8/10/2004	764	637	736	637
8/11/2004	772	748	757	
8/12/2004	756	748	750	
8/13/2004	756	748	748	
8/14/2004	748	628	664	
8/15/2004	637	628	628	
8/16/2004	1,150	628	1,030	
8/17/2004	1,080	1,070	1,080	
8/18/2004	1,100	1,070	1,080	
8/19/2004	1,070	756	790	
8/20/2004	756	480	511	
8/21/2004	480	471	480	
8/22/2004	593	480	494	
8/23/2004	503	471	492	
8/24/2004	1,160	411	808	
8/25/2004	1,530	1,160	1,360	
8/26/2004	1,560	1,530	1,550	
8/27/2004	1,550	427	1,230	
8/28/2004	559	480	501	
8/29/2004	559	495	508	
8/30/2004	576	488	497	
8/31/2004	610	576	602	

Flow – Lakes Dunlap and McQueeney

Date	Stream Flow (ft^3/s) (Mean)	
8/2/2004	1021	Maximum Monthly
8/3/2004	1129	Stream Flow Mean
8/4/2004	1154	1923
8/5/2004	1150	Minimum Monthly
8/6/2004	1145	Stream Flow Mean
8/7/2004	1063	847
8/8/2004	1022	GBRA Sampling
8/9/2004	1014	Event 08/09/04
8/10/2004	1113	1014
8/11/2004	1137	
8/12/2004	1126	
8/13/2004	1123	
8/14/2004	1040	
8/15/2004	1004	
8/16/2004	1404	
8/17/2004	1453	
8/18/2004	1454	
8/19/2004	1163	
8/20/2004	881	
8/21/2004	847	
8/22/2004	873	
8/23/2004	868	
8/24/2004	1182	
8/25/2004	1734	
8/26/2004	1923	
8/27/2004	1602	
8/28/2004	898	
8/29/2004	886	
8/30/2004	861	
8/31/2004	967	

Comal Rv at New Braunfels, TX

Date	Stream Flow (ft^3/s) (Mean)	
9/2/2004	357	Maximum Monthly
9/3/2004	357	Stream Flow Mean
9/4/2004	363	407
9/5/2004	366	Minimum Monthly
9/6/2004	365	Stream Flow Mean
9/7/2004	365	354
9/8/2004	361	GBRA Sampling
9/9/2004	359	Event 09/10/04
9/10/2004	359	359
9/11/2004	357	
9/12/2004	358	
9/13/2004	374	
9/14/2004	407	
9/15/2004	373	
9/16/2004	365	
9/17/2004	363	
9/18/2004	360	
9/19/2004	361	
9/20/2004	358	
9/21/2004	357	
9/22/2004	357	
9/23/2004	357	
9/24/2004	356	
9/25/2004	357	
9/26/2004	358	
9/27/2004	356	
9/28/2004	356	
9/29/2004	354	

Guadalupe Rv abv Comal Rv at New Braunfels, TX

Date	Stream Flow (ft^3/s) (Max)	Stream Flow (ft^3/s) (Min)	Stream Flow (ft^3/s) (Mean)	
9/2/2004	628	602	611	Maximum Monthly
9/3/2004	628	628	628	Stream Flow Mean
9/4/2004	628	495	526	1030
9/5/2004	503	488	489	Minimum Monthly
9/6/2004	628	480	523	Stream Flow Mean
9/7/2004	602	495	507	313
9/8/2004	628	602	614	GBRA Sampling
9/9/2004	628	610	612	Event 09/10/04
9/10/2004	610	602	602	602
9/11/2004	602	480	518	
9/12/2004	495	480	481	
9/13/2004	692	480	588	
9/14/2004	1,150	637	1,010	
9/15/2004	1,040	1,030	1,030	
9/16/2004	1,040	1,030	1,030	
9/17/2004	1,040	1,030	1,030	
9/18/2004	1,030	341	493	
9/19/2004	480	341	436	
9/20/2004	471	471	471	
9/21/2004	471	471	471	
9/22/2004	480	419	468	
9/23/2004	419	341	346	
9/24/2004	341	334	335	
9/25/2004	334	327	329	
9/26/2004	327	320	326	
9/27/2004	320	320	320	
9/28/2004	320	313	318	
9/29/2004	313	313	313	

Flow – Lakes Dunlap and McQueeney

Date	Stream Flow (ft^3/s) (Mean)	
9/2/2004	968	Maximum Monthly
9/3/2004	985	Stream Flow Mean
9/4/2004	889	1417
9/5/2004	855	Minimum Monthly
9/6/2004	888	Stream Flow Mean
9/7/2004	872	667
9/8/2004	975	GBRA Sampling
9/9/2004	971	Event 09/10/04
9/10/2004	961	961
9/11/2004	875	
9/12/2004	839	
9/13/2004	962	
9/14/2004	1417	
9/15/2004	1403	
9/16/2004	1395	
9/17/2004	1393	
9/18/2004	853	
9/19/2004	797	
9/20/2004	829	
9/21/2004	828	
9/22/2004	825	
9/23/2004	703	
9/24/2004	691	
9/25/2004	686	
9/26/2004	684	
9/27/2004	676	
9/28/2004	674	
9/29/2004	667	

Comal Rv at New Braunfels, TX

Date	Stream Flow (ft³/s) (Mean)	
10/1/2004	355	Maximum Monthly
10/2/2004	769	Stream Flow Mean
10/3/2004	567	1070
10/4/2004	399	Minimum Monthly
10/5/2004	386	Stream Flow Mean
10/6/2004	385	355
10/7/2004	384	GBRA Sampling
10/8/2004	384	Event 10/15/04
10/9/2004	383	391
10/10/2004	383	
10/11/2004	383	
10/12/2004	383	
10/13/2004	411	
10/14/2004	435	
10/15/2004	391	
10/16/2004	385	
10/17/2004	385	
10/18/2004	386	
10/19/2004	385	
10/20/2004	384	
10/21/2004	383	
10/22/2004	381	
10/23/2004	543	
10/24/2004	842	
10/25/2004	1,070	
10/26/2004	433	
10/27/2004	433	
10/28/2004	423	
10/29/2004	410	
10/30/2004	402	
10/31/2004	402	

Guadalupe Rv abv Comal Rv at New Braunfels, TX

Date	Stream Flow (ft³/s) (Max)	Stream Flow (ft³/s) (Min)	Stream Flow (ft³/s) (Mean)	
10/1/2004	307	307	307	Maximum Monthly
10/2/2004	8,510	307	1,790	Stream Flow Mean
10/3/2004	692	535	595	2810
10/4/2004	1,270	387	520	Minimum Monthly
10/5/2004	1,540	1,270	1,530	Stream Flow Mean
10/6/2004	1,540	1,530	1,530	307
10/7/2004	1,530	1,510	1,520	GBRA Sampling
10/8/2004	1,520	527	1,240	Event 10/15/04
10/9/2004	730	711	725	655
10/10/2004	730	721	721	
10/11/2004	721	711	720	
10/12/2004	721	701	714	
10/13/2004	730	673	704	
10/14/2004	721	655	672	
10/15/2004	655	655	655	
10/16/2004	655	655	655	
10/17/2004	655	655	655	
10/18/2004	655	527	641	
10/19/2004	527	495	503	
10/20/2004	495	495	495	
10/21/2004	495	495	495	
10/22/2004	495	495	495	
10/23/2004	1,620	411	879	
10/24/2004	1,040	848	907	
10/25/2004	1,640	559	982	
10/26/2004	2,920	1,630	1,980	
10/27/2004	2,950	2,570	2,810	
10/28/2004	2,590	2,520	2,560	
10/29/2004	2,570	1,900	2,360	
10/30/2004	1,900	1,890	1,900	
10/31/2004	1,890	1,880	1,890	

Flow – Lakes Dunlap and McQueeney

Date	Stream Flow (ft³/s) (Mean)	
10/1/2004	662	Maximum Monthly
10/2/2004	2559	Stream Flow Mean
10/3/2004	1162	3234
10/4/2004	919	Minimum Monthly
10/5/2004	1916	Stream Flow Mean
10/6/2004	1915	662
10/7/2004	1904	GBRA Sampling
10/8/2004	1624	Event 10/15/04
10/9/2004	1108	1046
10/10/2004	1104	
10/11/2004	1103	
10/12/2004	1097	
10/13/2004	1115	
10/14/2004	1107	
10/15/2004	1046	
10/16/2004	1040	
10/17/2004	1040	
10/18/2004	1027	
10/19/2004	888	
10/20/2004	879	
10/21/2004	878	
10/22/2004	876	
10/23/2004	1422	
10/24/2004	1749	
10/25/2004	2052	
10/26/2004	2413	
10/27/2004	3243	
10/28/2004	2983	
10/29/2004	2770	
10/30/2004	2302	
10/31/2004	2292	

Comal Rv at New Braunfels, TX

Date	Stream Flow (ft³/s) (Mean)	
11/2/2004	435	Maximum Monthly
11/3/2004	417	Stream Flow Mean
11/4/2004	415	6860
11/5/2004	411	Minimum Monthly
11/6/2004	410	Stream Flow Mean
11/7/2004	412	408
11/8/2004	412	GBRA Sampling
11/9/2004	411	Event Date
11/10/2004	413	No Sample Collected
11/11/2004	410	
11/12/2004	408	
11/13/2004	410	
11/14/2004	422	
11/15/2004	505	
11/16/2004	491	
11/17/2004	2,600	
11/18/2004	816	
11/19/2004	528	
11/20/2004	587	
11/21/2004	509	
11/22/2004	6,860	
11/23/2004	1,760	
11/24/2004	1,070	
11/25/2004	871	
11/26/2004	810	
11/27/2004	677	
11/28/2004	592	
11/29/2004	539	
11/30/2004	508	

Guadalupe Rv abv Comal Rv at New Braunfels, TX

Date	Stream Flow (ft³/s) (Max)	Stream Flow (ft³/s) (Min)	Stream Flow (ft³/s) (Mean)	
11/2/2004	2,640	2,030	2,130	Maximum Monthly
11/3/2004	2,640	2,600	2,620	Stream Flow Mean
11/4/2004	2,640	2,590	2,610	7720
11/5/2004	2,610	1,640	2,420	Minimum Monthly
11/6/2004	1,650	1,620	1,630	Stream Flow Mean
11/7/2004	1,620	1,610	1,620	961
11/8/2004	1,610	1,590	1,600	GBRA Sampling
11/9/2004	1,600	1,590	1,590	Event Date
11/10/2004	1,590	1,590	1,590	No Sample Collected
11/11/2004	1,590	1,580	1,580	
11/12/2004	1,590	1,580	1,580	
11/13/2004	1,580	1,560	1,570	
11/14/2004	1,630	1,580	1,600	
11/15/2004	1,720	1,630	1,670	
11/16/2004	2,160	1,650	1,680	
11/17/2004	5,990	1,220	2,950	
11/18/2004	1,220	909	1,040	
11/19/2004	2,210	805	987	
11/20/2004	2,380	2,210	2,270	
11/21/2004	2,250	1,700	2,180	
11/22/2004	21,000	1,290	7,720	
11/23/2004	3,590	1,530	1,910	
11/24/2004	1,610	1,190	1,350	
11/25/2004	1,190	1,010	1,090	
11/26/2004	1,010	918	961	
11/27/2004	1,360	848	974	
11/28/2004	1,940	1,330	1,450	
11/29/2004	2,600	1,930	2,060	
11/30/2004	5,440	2,550	3,450	

Flow – Lakes Dunlap and McQueeney

Date	Stream Flow (ft³/s) (Mean)	
11/2/2004	2565	Maximum Monthly
11/3/2004	3037	Stream Flow Mean
11/4/2004	3025	14580
11/5/2004	2831	Minimum Monthly
11/6/2004	2040	Stream Flow Mean
11/7/2004	2032	1515
11/8/2004	2012	GBRA Sampling
11/9/2004	2001	Event Date
11/10/2004	2003	No Sample Collected
11/11/2004	1990	
11/12/2004	1988	
11/13/2004	1980	
11/14/2004	2022	
11/15/2004	2175	
11/16/2004	2171	
11/17/2004	5550	
11/18/2004	1856	
11/19/2004	1515	
11/20/2004	2857	
11/21/2004	2689	
11/22/2004	14580	
11/23/2004	3670	
11/24/2004	2420	
11/25/2004	1961	
11/26/2004	1771	
11/27/2004	1651	
11/28/2004	2042	
11/29/2004	2599	
11/30/2004	3958	

Comal Rv at New Braunfels, TX

Date	Stream Flow (ft³/s) (Mean)	
12/2/2004	503	Maximum Monthly
12/3/2004	496	Stream Flow Mean
12/4/2004	493	503
12/5/2004	490	Minimum Monthly
12/6/2004	486	Stream Flow Mean
12/7/2004	478	441
12/8/2004	476	GBRA Sampling
12/9/2004	473	Event Date
12/10/2004	465	No Sample Collected
12/11/2004	462	
12/12/2004	463	
12/13/2004	457	
12/14/2004	452	
12/15/2004	448	
12/16/2004	447	
12/17/2004	447	
12/18/2004	441	
12/19/2004	442	
12/20/2004	441	
12/21/2004	443	
12/22/2004	442	
12/23/2004	444	
12/24/2004	443	
12/25/2004	444	
12/26/2004	443	
12/27/2004	443	
12/28/2004	443	
12/29/2004	443	
12/30/2004	443	
12/31/2004	442	

Guadalupe Rv abv Comal Rv at New Braunfels, TX

Date	Stream Flow (ft³/s) (Max)	Stream Flow (ft³/s) (Min)	Stream Flow (ft³/s) (Mean)	
12/2/2004				Maximum Monthly
12/3/2004				Stream Flow Mean
12/4/2004	5,410	5,360	5,370	5370
12/5/2004	5,390	5,330	5,360	Minimum Monthly
12/6/2004	5,410	5,330	5,370	Stream Flow Mean
12/7/2004	5,390	5,310	5,350	1100
12/8/2004	5,380	5,280	5,330	GBRA Sampling
12/9/2004	5,340	5,250	5,310	Event Date
12/10/2004	5,330	5,230	5,260	No Sample Collected
12/11/2004	5,270	5,220	5,230	
12/12/2004	5,230	5,170	5,210	
12/13/2004	5,230	5,140	5,170	
12/14/2004	5,190	5,120	5,160	
12/15/2004	5,170	5,120	5,150	
12/16/2004	5,160	5,080	5,120	
12/17/2004	5,120	5,060	5,090	
12/18/2004	5,090	5,030	5,060	
12/19/2004	5,080	5,000	5,030	
12/20/2004	5,050	4,980	5,020	
12/21/2004	5,020	4,950	5,000	
12/22/2004	5,000	1,550	3,810	
12/23/2004	1,550	1,530	1,540	
12/24/2004	1,530	1,530	1,530	
12/25/2004	1,530	1,520	1,530	
12/26/2004	1,530	1,520	1,520	
12/27/2004	1,520	1,500	1,520	
12/28/2004	1,510	1,500	1,510	
12/29/2004	1,510	1,500	1,510	
12/30/2004	1,510	927	1,330	
12/31/2004	1,110	1,100	1,100	

Flow – Lakes Dunlap and McQueeney

Date	Stream Flow (ft³/s) (Mean)	
12/2/2004	503	Maximum Monthly
12/3/2004	496	Stream Flow Mean
12/4/2004	5863	5863
12/5/2004	5850	Minimum Monthly
12/6/2004	5856	Stream Flow Mean
12/7/2004	5828	496
12/8/2004	5806	GBRA Sampling
12/9/2004	5783	Event Date
12/10/2004	5725	No Sample Collected
12/11/2004	5692	
12/12/2004	5673	
12/13/2004	5627	
12/14/2004	5612	
12/15/2004	5598	
12/16/2004	5567	
12/17/2004	5537	
12/18/2004	5501	
12/19/2004	5472	
12/20/2004	5461	
12/21/2004	5443	
12/22/2004	4252	
12/23/2004	1984	
12/24/2004	1973	
12/25/2004	1974	
12/26/2004	1963	
12/27/2004	1963	
12/28/2004	1953	
12/29/2004	1953	
12/30/2004	1773	
12/31/2004	1542	

Comal Rv at New Braunfels, TX

Date	Stream Flow (ft^3/s) (Mean)	
1/2/2005	445	Maximum Monthly
1/3/2005	444	Stream Flow Mean
1/4/2005	443	507
1/5/2005	442	Minimum Monthly
1/6/2005	440	Stream Flow Mean
1/7/2005	440	437
1/8/2005	441	GBRA Sampling
1/9/2005	442	Event Date
1/10/2005	442	No Sample Collected
1/11/2005	440	
1/12/2005	440	
1/13/2005	438	
1/14/2005	438	
1/15/2005	442	
1/16/2005	442	
1/17/2005	442	
1/18/2005	442	
1/19/2005	441	
1/20/2005	442	
1/21/2005	441	
1/22/2005	439	
1/23/2005	438	
1/24/2005	438	
1/25/2005	438	
1/26/2005	437	
1/27/2005	503	
1/28/2005	507	
1/29/2005	453	
1/30/2005	446	
1/31/2005	445	

Guadalupe Rv abv Comal Rv at New Braunfels, TX

Date	Stream Flow (ft^3/s) (Max)	Stream Flow (ft^3/s) (Min)	Stream Flow (ft^3/s) (Mean)	
1/2/2005	1,120	1,100	1,110	Maximum Monthly
1/3/2005	1,120	1,100	1,110	Stream Flow Mean
1/4/2005	1,110	1,100	1,110	1110
1/5/2005	1,110	1,090	1,100	Minimum Monthly
1/6/2005	1,100	1,090	1,090	Stream Flow Mean
1/7/2005	1,100	1,090	1,090	512
1/8/2005	1,090	1,090	1,090	GBRA Sampling
1/9/2005	1,090	1,050	1,080	Event Date
1/10/2005	1,050	748	934	No Sample Collected
1/11/2005	748	740	743	
1/12/2005	748	740	743	
1/13/2005	856	730	784	
1/14/2005	848	327	524	
1/15/2005	721	341	512	
1/16/2005	730	701	721	
1/17/2005	730	628	707	
1/18/2005	628	619	627	
1/19/2005	628	619	628	
1/20/2005	628	628	628	
1/21/2005	628	628	628	
1/22/2005	628	610	622	
1/23/2005	619	610	611	
1/24/2005	619	610	614	
1/25/2005	619	610	613	
1/26/2005	619	576	604	
1/27/2005	781	568	638	
1/28/2005	848	730	758	
1/29/2005	865	848	858	
1/30/2005	865	856	857	
1/31/2005	891	848	860	

Flow – Lakes Dunlap and McQueeney

Date	Stream Flow (ft^3/s) (Mean)	
1/2/2005	1555	Maximum Monthly
1/3/2005	1554	Stream Flow Mean
1/4/2005	1553	1555
1/5/2005	1542	Minimum Monthly
1/6/2005	1530	Stream Flow Mean
1/7/2005	1530	954
1/8/2005	1531	GBRA Sampling
1/9/2005	1522	Event Date
1/10/2005	1376	No Sample Collected
1/11/2005	1183	
1/12/2005	1183	
1/13/2005	1222	
1/14/2005	962	
1/15/2005	954	
1/16/2005	1163	
1/17/2005	1149	
1/18/2005	1069	
1/19/2005	1069	
1/20/2005	1070	
1/21/2005	1069	
1/22/2005	1061	
1/23/2005	1049	
1/24/2005	1052	
1/25/2005	1051	
1/26/2005	1041	
1/27/2005	1141	
1/28/2005	1265	
1/29/2005	1311	
1/30/2005	1303	
1/31/2005	1305	

Comal Rv at New Braunfels, TX

Date	Stream Flow (ft³/s) (Mean)	
2/2/2005	480	Maximum Monthly
2/3/2005	451	Stream Flow Mean
2/4/2005	446	504
2/5/2005	446	Minimum Monthly
2/6/2005	452	Stream Flow Mean
2/7/2005	487	443
2/8/2005	468	GBRA Sampling
2/9/2005	453	Event Date
2/10/2005	447	No Sample Collected
2/11/2005	447	
2/12/2005	447	
2/13/2005	448	
2/14/2005	447	
2/15/2005	446	
2/16/2005	445	
2/17/2005	445	
2/18/2005	444	
2/19/2005	445	
2/20/2005	446	
2/21/2005	445	
2/22/2005	443	
2/23/2005	443	
2/24/2005	479	
2/25/2005	456	
2/26/2005	472	
2/27/2005	504	
2/28/2005	457	

Guadalupe Rv abv Comal Rv at New Braunfels, TX

Date	Stream Flow (ft³/s) (Max)	Stream Flow (ft³/s) (Min)	Stream Flow (ft³/s) (Mean)	
2/2/2005	1,120	909	987	Maximum Monthly
2/3/2005	1,140	1,120	1,130	Stream Flow Mean
2/4/2005	1,130	1,120	1,120	1370
2/5/2005	1,130	1,120	1,120	Minimum Monthly
2/6/2005	1,150	1,120	1,140	Stream Flow Mean
2/7/2005			1,220	814
2/8/2005			1,370	GBRA Sampling
2/9/2005	1,170	1,150	1,150	Event Date
2/10/2005	1,150	900	1,060	No Sample Collected
2/11/2005	900	814	867	
2/12/2005	814	814	814	
2/13/2005	814	814	814	
2/14/2005	909	805	827	
2/15/2005	909	900	909	
2/16/2005	900	900	900	
2/17/2005	900	891	893	
2/18/2005	900	891	897	
2/19/2005	900	900	900	
2/20/2005	909	900	900	
2/21/2005	909	891	903	
2/22/2005	900	856	895	
2/23/2005	900	900	900	
2/24/2005	936	865	904	
2/25/2005	909	900	900	
2/26/2005	927	900	913	
2/27/2005	936	918	926	
2/28/2005	1,120	927	976	

Flow – Lakes Dunlap and McQueeney

Date	Stream Flow (ft³/s) (Mean)	
2/2/2005	1467	Maximum Monthly
2/3/2005	1581	Stream Flow Mean
2/4/2005	1566	1838
2/5/2005	1566	Minimum Monthly
2/6/2005	1592	Stream Flow Mean
2/7/2005	1707	1261
2/8/2005	1838	GBRA Sampling
2/9/2005	1603	Event Date
2/10/2005	1507	No Sample Collected
2/11/2005	1314	
2/12/2005	1261	
2/13/2005	1262	
2/14/2005	1274	
2/15/2005	1355	
2/16/2005	1345	
2/17/2005	1338	
2/18/2005	1341	
2/19/2005	1345	
2/20/2005	1346	
2/21/2005	1348	
2/22/2005	1338	
2/23/2005	1343	
2/24/2005	1383	
2/25/2005	1356	
2/26/2005	1385	
2/27/2005	1430	
2/28/2005	1433	

Comal Rv at New Braunfels, TX

Date	Stream Flow (ft³/s) (Mean)	
3/2/2005	534	Maximum Monthly
3/3/2005	479	Stream Flow Mean
3/4/2005	454	739
3/5/2005	567	Minimum Monthly
3/6/2005	739	Stream Flow Mean
3/7/2005	579	454
3/8/2005	507	GBRA Sampling
3/9/2005	472	Event 03/11/05
3/10/2005	470	467
3/11/2005	467	
3/12/2005	466	
3/13/2005	467	
3/14/2005	465	
3/15/2005	464	
3/16/2005	468	
3/17/2005	467	
3/18/2005	465	
3/19/2005	464	
3/20/2005	463	
3/21/2005	463	
3/22/2005	459	
3/23/2005	458	
3/24/2005	457	
3/25/2005	457	
3/26/2005	457	
3/27/2005	457	
3/28/2005	456	
3/29/2005	457	
3/30/2005	455	
3/31/2005	456	

Guadalupe Rv abv Comal Rv at New Braunfels, TX

Date	Stream Flow (ft³/s) (Max)	Stream Flow (ft³/s) (Min)	Stream Flow (ft³/s) (Mean)	
3/2/2005	1,260	1,130	1,180	Maximum Monthly
3/3/2005	1,190	1,110	1,170	Stream Flow Mean
3/4/2005	1,520	495	1,090	1850
3/5/2005	1,650	1,520	1,560	Minimum Monthly
3/6/2005	1,650	1,640	1,650	Stream Flow Mean
3/7/2005	1,710	1,630	1,650	765
3/8/2005	1,630	1,620	1,630	GBRA Sampling
3/9/2005	1,620	1,610	1,620	Event 03/11/05
3/10/2005	1,610	1,600	1,600	1590
3/11/2005	1,600	1,590	1,590	
3/12/2005	1,590	1,580	1,580	
3/13/2005	1,580	1,580	1,580	
3/14/2005	1,860	1,580	1,680	
3/15/2005	1,860	1,850	1,850	
3/16/2005	1,860	1,830	1,850	
3/17/2005	1,850	1,830	1,840	
3/18/2005	1,830	1,830	1,830	
3/19/2005	1,830	1,820	1,830	
3/20/2005	1,830	1,820	1,820	
3/21/2005	1,830	1,820	1,830	
3/22/2005	1,830	1,830	1,830	
3/23/2005	1,830	1,820	1,830	
3/24/2005	1,830	1,820	1,830	
3/25/2005	1,830	1,250	1,620	
3/26/2005			1,250	
3/27/2005			1,100	
3/28/2005			900	
3/29/2005	772	772	772	
3/30/2005	772	772	772	
3/31/2005	772	756	765	

Flow – Lakes Dunlap and McQueeney

Date	Stream Flow (ft³/s) (Mean)	
3/2/2005	1714	Maximum Monthly
3/3/2005	1649	Stream Flow Mean
3/4/2005	1544	2318
3/5/2005	2127	Minimum Monthly
3/6/2005	2389	Stream Flow Mean
3/7/2005	2229	1221
3/8/2005	2137	GBRA Sampling
3/9/2005	2092	Event 03/11/05
3/10/2005	2070	2057
3/11/2005	2057	
3/12/2005	2046	
3/13/2005	2047	
3/14/2005	2145	
3/15/2005	2314	
3/16/2005	2318	
3/17/2005	2307	
3/18/2005	2295	
3/19/2005	2294	
3/20/2005	2283	
3/21/2005	2293	
3/22/2005	2289	
3/23/2005	2288	
3/24/2005	2287	
3/25/2005	2077	
3/26/2005	1707	
3/27/2005	1557	
3/28/2005	1356	
3/29/2005	1229	
3/30/2005	1227	
3/31/2005	1221	

Comal Rv at New Braunfels, TX

Date	Stream Flow (ft³/s) (Mean)
4/2/2005	455
4/3/2005	454
4/4/2005	454
4/5/2005	456
4/6/2005	454
4/7/2005	453
4/8/2005	452
4/9/2005	453
4/10/2005	452
4/11/2005	451
4/12/2005	450
4/13/2005	449
4/14/2005	446
4/15/2005	445
4/16/2005	446
4/17/2005	444
4/18/2005	446
4/19/2005	444
4/20/2005	444
4/21/2005	443
4/22/2005	442
4/23/2005	439
4/24/2005	439
4/25/2005	440
4/26/2005	438
4/27/2005	437
4/28/2005	435
4/29/2005	432
4/30/2005	430

Maximum Monthly Stream Flow Mean: 456

Minimum Monthly Stream Flow Mean: 430

GBRA Sampling Event 04/04/05: 454

Guadalupe Rv abv Comal Rv at New Braunfels, TX

Date	Stream Flow (ft³/s) (Max)	Stream Flow (ft³/s) (Min)	Stream Flow (ft³/s) (Mean)
4/2/2005	756	748	748
4/3/2005	748	740	745
4/4/2005	740	740	740
4/5/2005	740	559	676
4/6/2005	568	551	560
4/7/2005	551	551	551
4/8/2005	551	543	551
4/9/2005	543	444	457
4/10/2005	444	436	441
4/11/2005	436	427	433
4/12/2005	427	427	427
4/13/2005	427	419	425
4/14/2005	427	419	423
4/15/2005	527	419	456
4/16/2005	527	527	527
4/17/2005	527	527	527
4/18/2005	628	527	555
4/19/2005	628	495	610
4/20/2005	628	628	628
4/21/2005	628	628	628
4/22/2005	637	628	628
4/23/2005	628	619	625
4/24/2005	646	619	637
4/25/2005	756	646	650
4/26/2005	814	756	811
4/27/2005	814	721	806
4/28/2005	721	683	684
4/29/2005	683	584	653
4/30/2005	593	584	587

Maximum Monthly Stream Flow Mean: 811

Minimum Monthly Stream Flow Mean: 423

GBRA Sampling Event 04/04/05: 740

Flow – Lakes Dunlap and McQueeney

Date	Stream Flow (ft³/s) (Mean)
4/2/2005	1203
4/3/2005	1199
4/4/2005	1194
4/5/2005	1132
4/6/2005	1014
4/7/2005	1004
4/8/2005	1003
4/9/2005	910
4/10/2005	893
4/11/2005	884
4/12/2005	877
4/13/2005	874
4/14/2005	869
4/15/2005	901
4/16/2005	973
4/17/2005	971
4/18/2005	1001
4/19/2005	1054
4/20/2005	1072
4/21/2005	1071
4/22/2005	1070
4/23/2005	1064
4/24/2005	1076
4/25/2005	1090
4/26/2005	1249
4/27/2005	1243
4/28/2005	1119
4/29/2005	1085
4/30/2005	1017

Maximum Monthly Stream Flow Mean: 1249

Minimum Monthly Stream Flow Mean: 869

GBRA Sampling Event 04/04/05: 1194

Comal Rv at New Braunfels, TX

Date	Stream Flow (ft³/s) (Mean)	
5/2/2005	429	Maximum Monthly
5/3/2005	428	Stream Flow Mean
5/4/2005	430	447
5/5/2005	427	Minimum Monthly
5/6/2005	428	Stream Flow Mean
5/7/2005	427	416
5/8/2005	437	GBRA Sampling
5/9/2005	432	Event 05/06/05
5/10/2005	428	428
5/11/2005	428	
5/12/2005	427	
5/13/2005	428	
5/14/2005	428	
5/15/2005	430	
5/16/2005	431	
5/17/2005	425	
5/18/2005	425	
5/19/2005	425	
5/20/2005	424	
5/21/2005	424	
5/22/2005	423	
5/23/2005	422	
5/24/2005	420	
5/25/2005	416	
5/26/2005	417	
5/27/2005	418	
5/28/2005	421	
5/29/2005	447	
5/30/2005	431	
5/31/2005	420	

Guadalupe Rv abv Comal Rv at New Braunfels, TX

Date	Stream Flow (ft³/s) (Max)	Stream Flow (ft³/s) (Min)	Stream Flow (ft³/s) (Mean)	
5/2/2005	584	576	582	Maximum Monthly
5/3/2005	593	576	582	Stream Flow Mean
5/4/2005	602	519	584	823
5/5/2005	519	495	498	Minimum Monthly
5/6/2005	495	495	495	Stream Flow Mean
5/7/2005	495	495	495	427
5/8/2005	551	495	515	GBRA Sampling
5/9/2005	673	495	522	Event 05/06/05
5/10/2005	764	673	677	495
5/11/2005	814	764	811	
5/12/2005	814	814	814	
5/13/2005	822	814	821	
5/14/2005	831	822	823	
5/15/2005	839	814	820	
5/16/2005	831	814	819	
5/17/2005	822	814	814	
5/18/2005	814	692	800	
5/19/2005	692	683	683	
5/20/2005	692	637	679	
5/21/2005	637	628	631	
5/22/2005	628	619	626	
5/23/2005	619	551	572	
5/24/2005	551	444	459	
5/25/2005	444	444	444	
5/26/2005	444	444	444	
5/27/2005	453	436	442	
5/28/2005	453	427	440	
5/29/2005	480	427	455	
5/30/2005	559	427	470	
5/31/2005	427	427	427	

Flow – Lakes Dunlap and McQueeney

Date	Stream Flow (ft³/s) (Mean)	
5/2/2005	1011	Maximum Monthly
5/3/2005	1010	Stream Flow Mean
5/4/2005	1014	1251
5/5/2005	925	Minimum Monthly
5/6/2005	923	Stream Flow Mean
5/7/2005	922	847
5/8/2005	952	GBRA Sampling
5/9/2005	954	Event 05/06/05
5/10/2005	1105	923
5/11/2005	1239	
5/12/2005	1241	
5/13/2005	1249	
5/14/2005	1251	
5/15/2005	1250	
5/16/2005	1250	
5/17/2005	1239	
5/18/2005	1225	
5/19/2005	1108	
5/20/2005	1103	
5/21/2005	1055	
5/22/2005	1049	
5/23/2005	994	
5/24/2005	879	
5/25/2005	860	
5/26/2005	861	
5/27/2005	860	
5/28/2005	861	
5/29/2005	902	
5/30/2005	901	
5/31/2005	847	

Comal Rv at New Braunfels, TX

Date	Stream Flow (ft^3/s) (Mean)	
6/2/2005	435	Maximum Monthly
6/3/2005	423	Stream Flow Mean
6/4/2005	423	435
6/5/2005	418	Minimum Monthly
6/6/2005	418	Stream Flow Mean
6/7/2005	415	373
6/8/2005	416	GBRA Sampling
6/9/2005	412	Event 06/03/05
6/10/2005	412	423
6/11/2005	410	
6/12/2005	407	
6/13/2005	407	
6/14/2005	405	
6/15/2005	401	
6/16/2005	402	
6/17/2005	401	
6/18/2005	397	
6/19/2005	395	
6/20/2005	391	
6/21/2005	389	
6/22/2005	384	
6/23/2005	383	
6/24/2005	385	
6/25/2005	385	
6/26/2005	385	
6/27/2005	384	
6/28/2005	377	
6/29/2005	373	
6/30/2005	374	

Guadalupe Rv abv Comal Rv at New Braunfels, TX

Date	Stream Flow (ft^3/s) (Max)	Stream Flow (ft^3/s) (Min)	Stream Flow (ft^3/s) (Mean)	
6/2/2005	1,080	673	1,010	Maximum Monthly
6/3/2005	1,090	1,080	1,080	Stream Flow Mean
6/4/2005	1,080	805	861	1080
6/5/2005	805	797	803	Minimum Monthly
6/6/2005	797	511	605	Stream Flow Mean
6/7/2005	511	503	508	339
6/8/2005	503	495	502	GBRA Sampling
6/9/2005	495	349	460	Event 06/03/05
6/10/2005	444	341	418	1080
6/11/2005	427	427	427	
6/12/2005	436	427	428	
6/13/2005	427	419	422	
6/14/2005	419	419	419	
6/15/2005	427	419	419	
6/16/2005	419	363	377	
6/17/2005	363	363	363	
6/18/2005	363	356	363	
6/19/2005	371	356	358	
6/20/2005	356	356	356	
6/21/2005	363	356	356	
6/22/2005	356	349	356	
6/23/2005	356	349	351	
6/24/2005				
6/25/2005				
6/26/2005				
6/27/2005				
6/28/2005				
6/29/2005	363	349	355	
6/30/2005	356	320	339	

Flow – Lakes Dunlap and McQueeney

Date	Stream Flow (ft^3/s) (Mean)	
6/2/2005	1445	Maximum Monthly
6/3/2005	1503	Stream Flow Mean
6/4/2005	1284	1503
6/5/2005	1221	Minimum Monthly
6/6/2005	1023	Stream Flow Mean
6/7/2005	923	384
6/8/2005	918	GBRA Sampling
6/9/2005	872	Event 06/03/05
6/10/2005	830	1503
6/11/2005	837	
6/12/2005	835	
6/13/2005	829	
6/14/2005	824	
6/15/2005	820	
6/16/2005	779	
6/17/2005	764	
6/18/2005	760	
6/19/2005	753	
6/20/2005	747	
6/21/2005	745	
6/22/2005	740	
6/23/2005	734	
6/24/2005	385	
6/25/2005	385	
6/26/2005	385	
6/27/2005	384	
6/28/2005	377	
6/29/2005	728	
6/30/2005	713	

Comal Rv at New Braunfels, TX

Date	Stream Flow (ft³/s) (Mean)	
7/2/2005	371	Maximum Monthly
7/3/2005	370	Stream Flow Mean
7/4/2005	370	379
7/5/2005	367	Minimum Monthly
7/6/2005	361	Stream Flow Mean
7/7/2005	364	349
7/8/2005	364	GBRA Sampling
7/9/2005	364	Event 07/08/05
7/10/2005	365	364
7/11/2005	360	
7/12/2005	356	
7/13/2005	355	
7/14/2005	355	
7/15/2005	349	
7/16/2005	379	
7/17/2005	368	
7/18/2005	371	
7/19/2005	368	
7/20/2005	364	
7/21/2005	364	
7/22/2005	370	
7/23/2005	370	
7/24/2005	372	
7/25/2005	370	
7/26/2005	367	
7/27/2005	366	
7/28/2005	367	
7/29/2005	365	
7/30/2005	369	
7/31/2005	368	

Guadalupe Rv abv Comal Rv at New Braunfels, TX

Date	Stream Flow (ft³/s) (Max)	Stream Flow (ft³/s) (Min)	Stream Flow (ft³/s) (Mean)	
7/2/2005	387	300	328	Maximum Monthly
7/3/2005	427	363	378	Stream Flow Mean
7/4/2005	395	356	371	378
7/5/2005	371	341	351	Minimum Monthly
7/6/2005	341	300	320	Stream Flow Mean
7/7/2005	419	258	293	225
7/8/2005	395	341	361	GBRA Sampling
7/9/2005	363	313	335	Event 07/08/05
7/10/2005	356	334	350	361
7/11/2005	356	288	331	
7/12/2005	288	235	262	
7/13/2005	235	225	229	
7/14/2005	225	225	225	
7/15/2005	225	225	225	
7/16/2005	225	225	225	
7/17/2005	436	225	269	
7/18/2005	371	327	350	
7/19/2005	327	264	300	
7/20/2005	444	241	300	
7/21/2005	371	300	335	
7/22/2005	300	241	269	
7/23/2005	241	225	229	
7/24/2005	225	225	225	
7/25/2005	225	225	225	
7/26/2005	225	225	225	
7/27/2005	225	225	225	
7/28/2005	225	225	225	
7/29/2005	225	225	225	
7/30/2005	225	225	225	
7/31/2005	225	225	225	

Flow – Lakes Dunlap and McQueeney

Date	Stream Flow (ft³/s) (Mean)	
7/2/2005	699	Maximum Monthly
7/3/2005	748	Stream Flow Mean
7/4/2005	741	748
7/5/2005	718	Minimum Monthly
7/6/2005	681	Stream Flow Mean
7/7/2005	657	574
7/8/2005	725	GBRA Sampling
7/9/2005	699	Event 07/08/05
7/10/2005	715	725
7/11/2005	691	
7/12/2005	618	
7/13/2005	584	
7/14/2005	580	
7/15/2005	574	
7/16/2005	604	
7/17/2005	637	
7/18/2005	721	
7/19/2005	668	
7/20/2005	664	
7/21/2005	699	
7/22/2005	639	
7/23/2005	599	
7/24/2005	597	
7/25/2005	595	
7/26/2005	592	
7/27/2005	591	
7/28/2005	592	
7/29/2005	590	
7/30/2005	594	
7/31/2005	593	

Comal Rv at New Braunfels, TX

Date	Stream Flow (ft^3/s) (Mean)	
8/2/2005	362	Event 08/03/05
8/3/2005	362	362

Guadalupe Rv abv Comal Rv at New Braunfels, TX

Date	Stream Flow (ft^3/s) (Max)	Stream Flow (ft^3/s) (Min)	Stream Flow (ft^3/s) (Mean)	
8/2/2005	225	225	225	Event 08/03/05
8/3/2005	225	225	225	225

Flow – Lakes Dunlap and McQueeney

Date	Stream Flow (ft^3/s) (Mean)
8/2/2005	Event 08/03/05
8/3/2005	587

Appendix D. Historical Annual Average Flows for Study Area

	Comal Rv at New Braunfels, TX		Guadalupe Rv abv Comal Rv at New Braunfels, TX		Guadalupe abv Comal + Comal at New Braunfels
Year	Annual mean streamflow, in ft3/s	Year	Annual mean streamflow, in ft3/s	Year	Annual mean streamflow, in ft3/s
1933	312	1933	157	1933	469
1934	318	1934	121	1934	439
1935	338	1935	792	1935	1130
1936	365	1936	953	1936	1318
1937	358	1937	322	1937	680
1938	353	1938	321	1938	674
1939	301	1939	89.2	1939	390.2
1940	287	1940	240	1940	527
1941	360	1941	857	1941	1217
1942	366	1942	439	1942	805
1943	341	1943	188	1943	529
1944	349	1944	620	1944	969
1945	374	1945	581	1945	955
1946	382	1946	522	1946	904
1947	356	1947	414	1947	770
1948	277	1948	90	1948	367
1949	293	1949	236	1949	529
1950	262	1950	101	1950	363
1951	206	1951	61.3	1951	267.3
1952	224	1952	379	1952	603
1953	197	1953	152	1953	349
1954	136	1954	39.9	1954	175.9
1955	92.3	1955	47.6	1955	139.9
1956	38.6	1956	13.6	1956	52.2
1957	192	1957	705	1957	897
1958	323	1958	903	1958	1226
1959	317	1959	441	1959	758
1960	333	1960	654	1960	987
1961	342	1961	540	1961	882
1962	267	1962	116	1962	383
1963	208	1963	73.9	1963	281.9
1964	191	1964	164	1964	355
1965	289	1965	269	1965	558
1966	267	1966	324	1966	591
1968	340	1968	427	1968	767
1969	293	1969	384	1969	677
1970	313	1970	510	1970	823

Year	Comal Rv at New Braunfels, TX Annual mean streamflow, in ft3/s	Year	Guadalupe Rv abv Comal Rv at New Braunfels, TX Annual mean streamflow, in ft3/s	Year	Guadalupe abv Comal + Comal at New Braunfels Annual mean streamflow, in ft3/s
1971	221	**1971**	439	**1971**	660
1972	364	**1972**	545	**1972**	909
1973	406	**1973**	868	**1973**	1274
1974	392	**1974**	501	**1974**	893
1975	408	**1975**	886	**1975**	1294
1976	386	**1976**	530	**1976**	916
1977	400	**1977**	775	**1977**	1175
1978	331	**1978**	651	**1978**	982
1979	404	**1979**	976	**1979**	1380
1980	285	**1980**	244	**1980**	529
1981	324	**1981**	907	**1981**	1231
1982	278	**1982**	248	**1982**	526
1983	238	**1983**	245	**1983**	483
1984	126	**1984**	113	**1984**	239
1985	266	**1985**	799	**1985**	1065
1986	304	**1986**	730	**1986**	1034
1987	375	**1987**	1,613	**1987**	1988
1988	277	**1988**	246	**1988**	523
1989	163	**1989**	159	**1989**	322
1990	179	**1990**	302	**1990**	481
1991	257	**1991**	499	**1991**	756
1992	463	**1992**	1,994	**1992**	2457
1993	398	**1993**	406	**1993**	804
1994	321	**1994**	259	**1994**	580
1995	278	**1995**	323	**1995**	601
1996	174	**1996**	116	**1996**	290
1997	267	**1997**	1,198	**1997**	1465
1998	417	**1998**	908	**1998**	1325
1999	344	**1999**	236	**1999**	580
2000	268	**2000**	364	**2000**	632
2001	357	**2001**	883	**2001**	1240
2002	469	**2002**	1,782	**2002**	2251
2003	394	**2003**	531	**2003**	925

	Comal Rv at New Braunfels, TX	Guadalupe Rv abv Comal Rv at New Braunfels, TX	Guadalupe abv Comal + Comal at New Braunfels
Minimum Annual Mean Streamflow, in ft3/s	38.6	13.6	52.2
Maximum Annual Mean Streamflow, in ft3/s	469	1994	2457
Average Annual Mean Streamflow, in ft3/s	301	482	793

Appendix E. Non-conformance reports for missing or non-reportable data

Data Tables: Reference Footnote #1

GBRA REGIONAL LABORATORY

Deficiency/Nonconformance/Corrective Action Report for CRP

Report #: 193 904	Prepared by: BC	Date: 9-7-05

FIELD DATA FOR 193 904 DUNLAP UP 9-10-04 Description of Deficiency	FIELD PROBE VEENTOUT BAD BATTERY/PROBLEMS/BATTERY RUN SAMPLE IN LAB
Is Deficiency a NONCONFORMANCE Y or N If yes, complete report, if no indicate the date of closure	Y
Cause of Nonconformance	PROBLEM WITH BATTERY HAVING TO CARRY CHARGER IN SURBURBAN BATTERY NOT STAYING CHARGED
Impact of Nonconformance /TRACS	USED LAB DATA TO REPORT NOT FIELD DATA FOR pH+COND. COULD NOT REPORT DO + TEMP
Corrective Action to Nonconformance	GET BATTERY WORKING
Date of proposed action	9-7-05
Person responsible for action	FIELD STAFF
Date completed	
Date closed	

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SURFACE WATER QUALITY MONITORING PROGRAM
FIELD DATA REPORTING FORM

RTAG# | REGION | EMAIL-ID: | COLLECTOR

STATION ID | SEGMENT | SEQUENCE | DATA SOURCE

Station Description PUN LAP UP 9-10-04 1350 BLJT

GRAB SAMPLE

COMPOSITE SAMPLE

133904

00010		WATER TEMP (°C only)	72053		DAYS SINCE LAST SIGNIFICANT PRECIPITATION
00400	—	pH (s.u)	01351	9-9-04 23	FLOW SEV 1-no flow 2-low 3-normal 6-high 4-flood 5-dry
00300		D.O. (mg/L)			
00094	—	SPECIFIC COND (µmhos/cm)	00061	969	INSTANTANEOUS STREAM FLOW (ft³/sec)
00480		SALINITY (ppt, marine only)	89835	|	FLOW MEASUREMENT METHOD 1- Flow Gage Station 2- Electric 3- Mechanical 4- Weir/Flume
50060		CHLORINE RESIDUAL (mg/L)			
00078	2.0	SECCHI DISK (meters)	74069		FLOW ESTIMATE (ft³/sec)
82078		TURBIDITY-FIELD (NTU)	82903		TOTAL WATER DEPTH (meters)
31616		FECAL COLIFORM (#/100 ml)	00055		WATER VELOCITY (maximum)(ft/sec)
31699		E. coli (#/100 ml) (Colilert Method)	89864		MAXIMUM POOL WIDTH (meters)
31701		Enterococci (#/100 ml) (Enterolert Method)	89869		POOL LENGTH (meters)
			89865		MAXIMUM POOL DEPTH (meters)

133904

Measurement Comments and Field Observations:

LAKE LOW PROBE WENT OUT BATTERY FAILED
LOW 1 FOOT MAINTENANCE PH + COND IN LAB

Rev. 10/27/00

Received Dec-07-01 16:04 From-512 239 4410 To-GBRA Page 002

Data Tables: Reference Footnote #2

GBRA REGIONAL LABORATORY

Deficiency/Nonconformance/Corrective Action Report for CRP

Report #: 080 04-01	Prepared by: BL / JL / DM	Date: 8/11/04

Description of Deficiency	E.Coli's for month of Aug. 04' E.Coli's for 8/9/04 were in inc. when - reported to DM immediately 8/10/04	temp was disc to be out of range
Is Deficiency a NONCONFORMANCE Y or N If yes, complete report, if no indicate the date of closure	Nonconformance	
Cause of Nonconformance	Micro incubator turned off	temp out of range
Impact of Nonconformance /TRACS	temp out of range unreportable E.Coli for mth of Aug.	
Corrective Action to Nonconformance	8/11/04 - moved cart from area - taped down on/off switch w/ note "DO NOT TURN OF - Reviewed w/LAB personnel	
Date of proposed action	8/11/04	
Person responsible for action	Josie Lozano	
Date completed	8/11/04	
Date closed	8/11/04	

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Data Tables: Reference Footnote #3

GBRA REGIONAL LABORATORY

Deficiency/Nonconformance/Corrective Action Report for CRP

Report #: 031105-01 TKN | Prepared by: Juan Carmona | Date: 9/7/05

Description of Deficiency	3/11/05 Mcqueeney to Dunlap Nutrient Study TKN's not submi in time to LCRA
Is Deficiency a NONCONFORMANCE (Y) or N If yes, complete report, if no indicate the date of closure	Samples Out of Holding Time.
Cause of Nonconformance	Miscommunication between Field Sampling personnel and Sample custodian.
Impact of Nonconformance /TRACS	No TKN Results for Data Set on 3/11/05.
Corrective Action to Nonconformance	Placed a board on front fridge for send-outs to be written & a place to put samples that need to be send-out. Also splits were pulled upon arrival of samples to lab.
Date of proposed action	4/1/05
Person responsible for action	All lab personnel
Date completed	9/7/05 (JJC) JL.
Date closed	9/7/05 JL.

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– No Results submitted
– Charges zero out

Data Tables: Reference Footnote #4

GBRA REGIONAL LABORATORY

Deficiency/Nonconformance/Corrective Action Report for CRP

Report #: 042704-01	Prepared by: Lee Gadgell	Date: 9-7-05

Description of Deficiency	No secchi disk reading taken at AC's Place + Hot shots on 4-27-04
Is Deficiency a NONCONFORMANCE Y or N If yes, complete report, if no indicate the date of closure	Yes
Cause of Nonconformance	Unknown - Tech forgot to take reading
Impact of Nonconformance /TRACS	secchi depth readings will not be reported for AC's + Hot shots on these days
Corrective Action to Nonconformance	Make sure QAPP is read by field technicians and all parameters collected accordingly
Date of proposed action	4-27-04
Person responsible for action	Mike McCall Entire lab notified
Date completed	9-7-05 (LG)
Date closed	9/7/05

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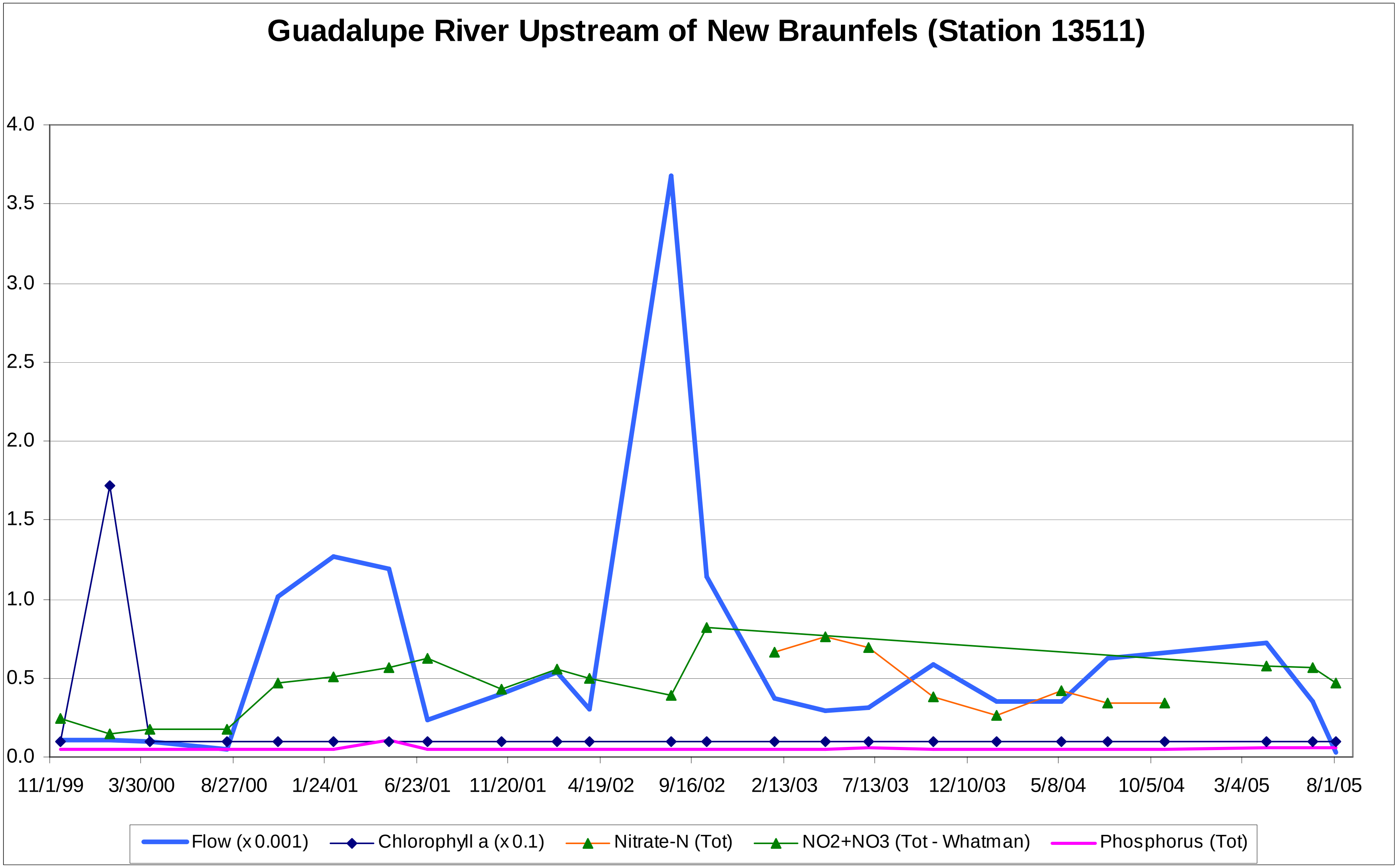
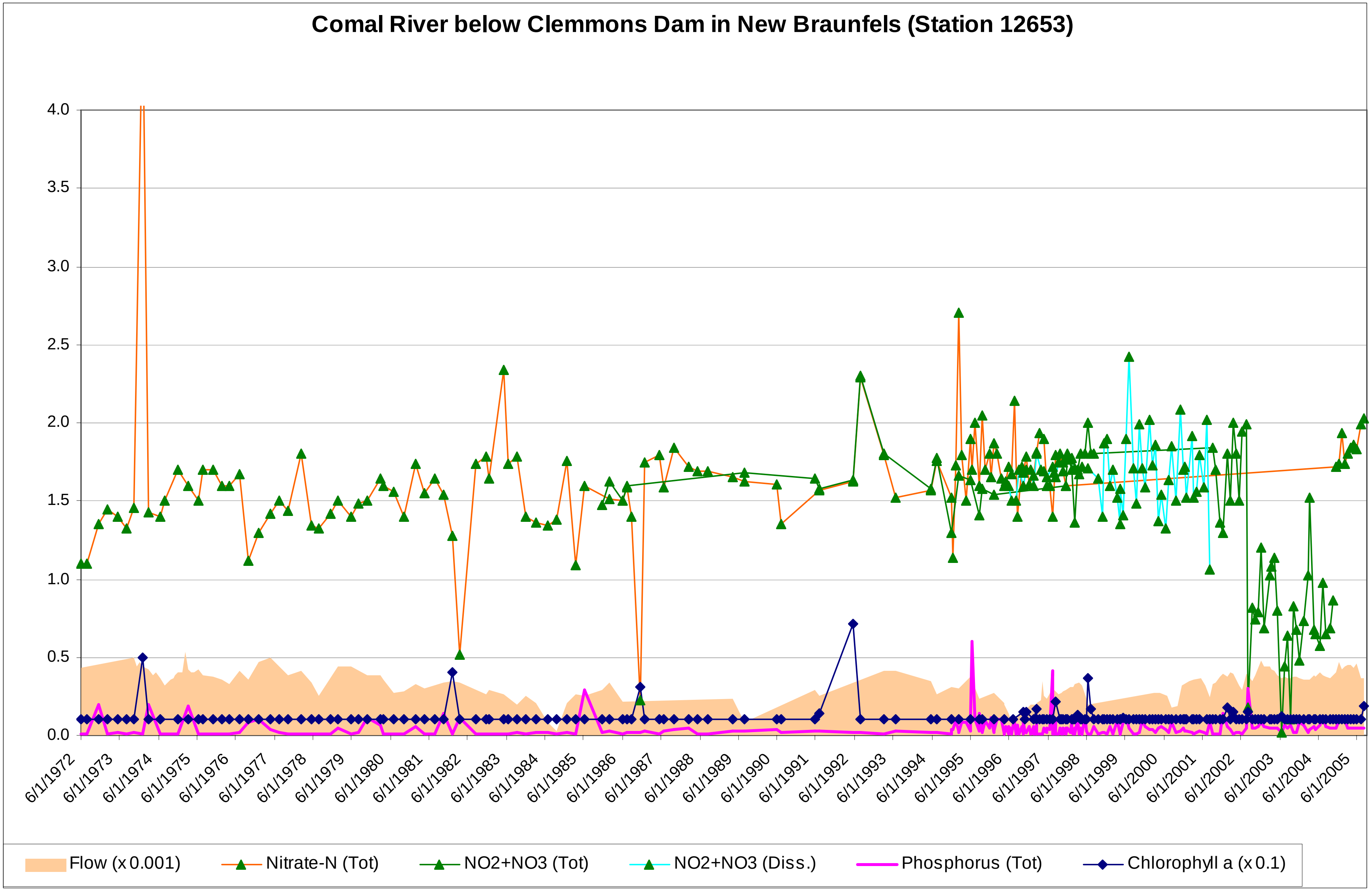
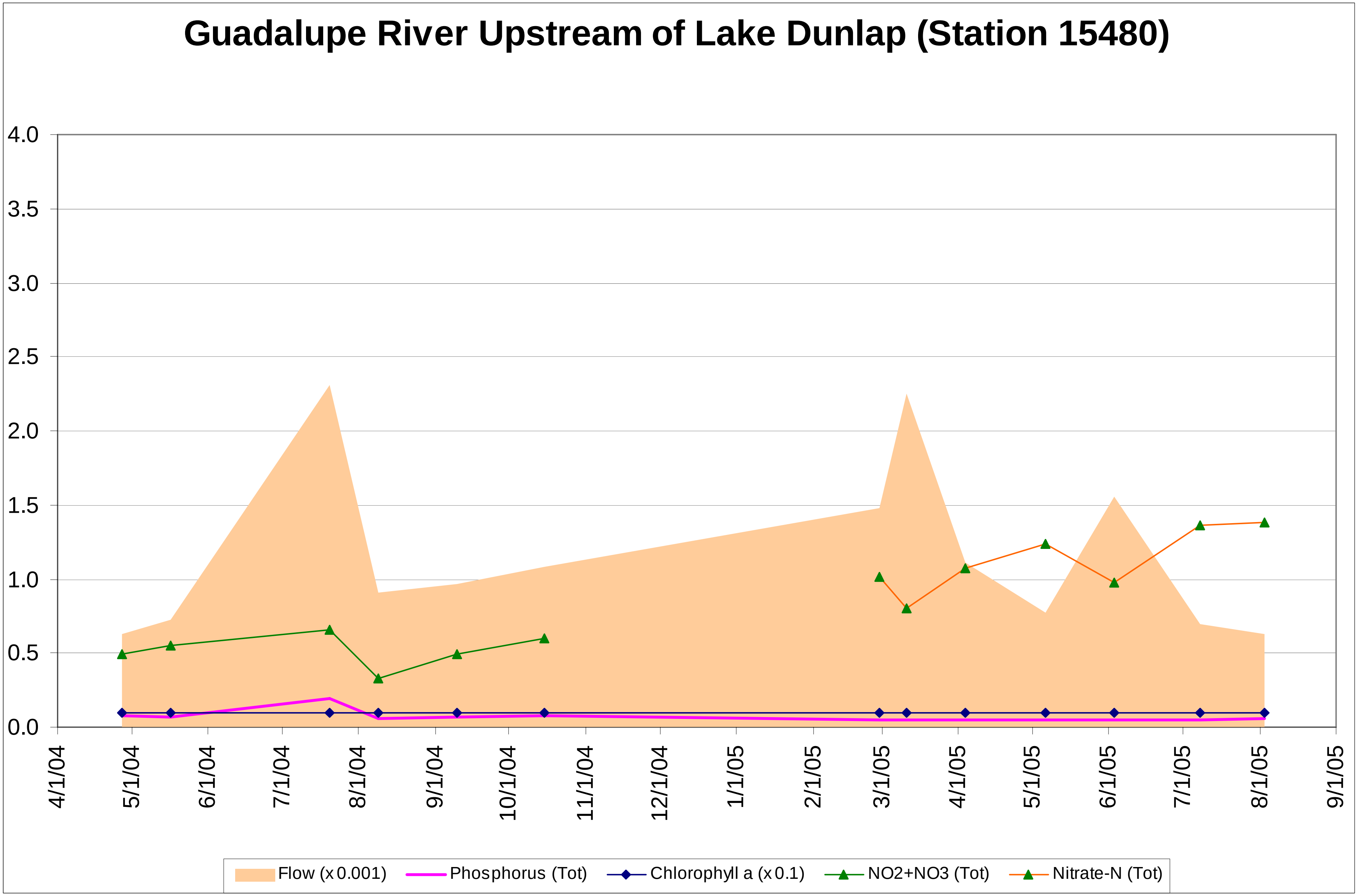
130622 - Dunlap @ AC's place
130618 - McQueeney @ Hot shot
not submitted or changed

Appendix F. Graphs of Historical Water Quality Data from Stations in Study Area

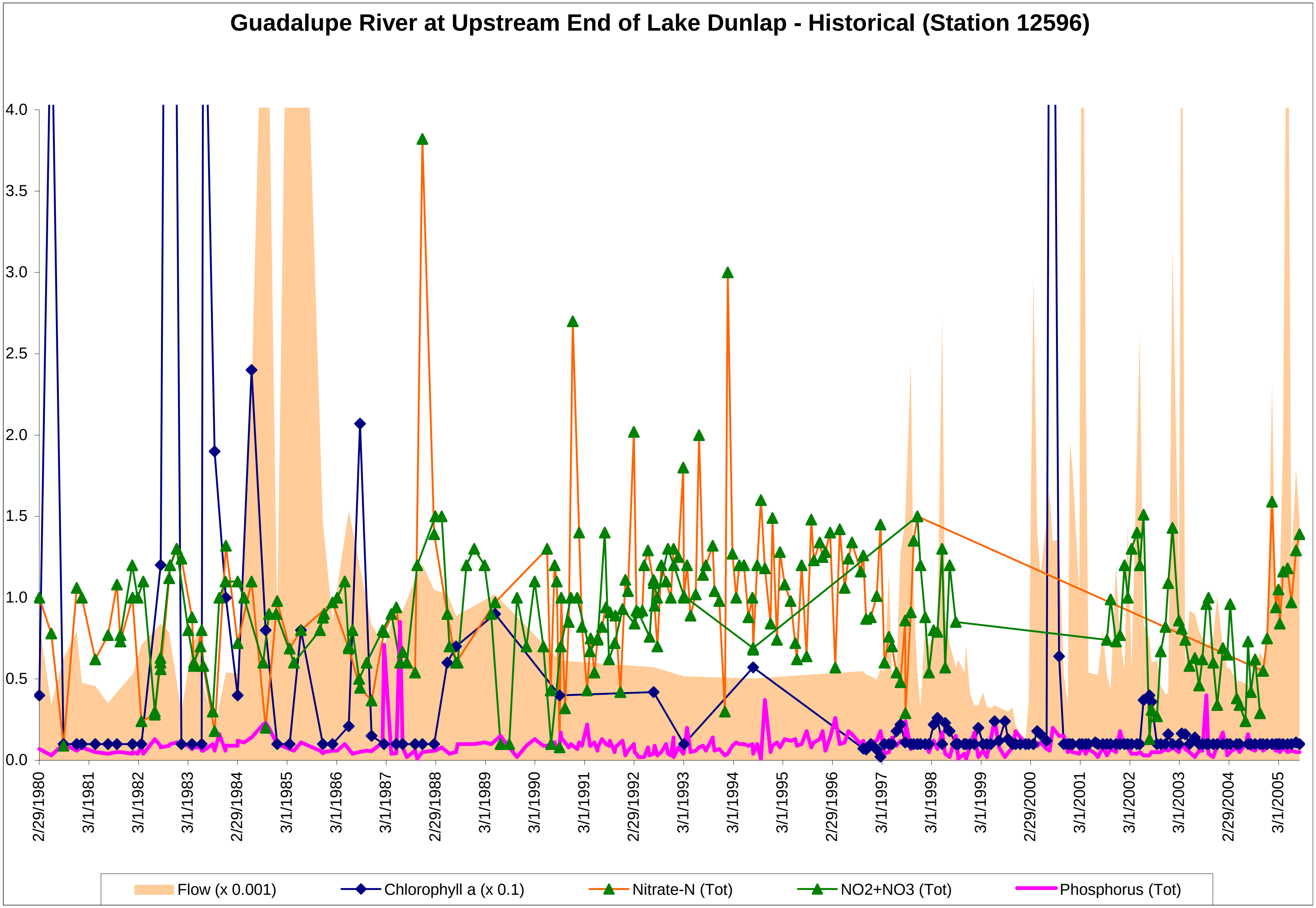


Guadalupe River Upstream of New Braunfels (Station 13511)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
11/1/99
3/30/00
8/27/00
1/24/01
6/23/01
11/20/01
4/19/02
9/16/02
2/13/03
7/13/03
12/10/03
5/8/04
10/5/04
3/4/05
8/1/05
Flow (x 0.001)
Chlorophyll a (x 0.1)
Nitrate-N (Tot)
NO2+NO3 (Tot - Whatman)
Phosphorus (Tot)

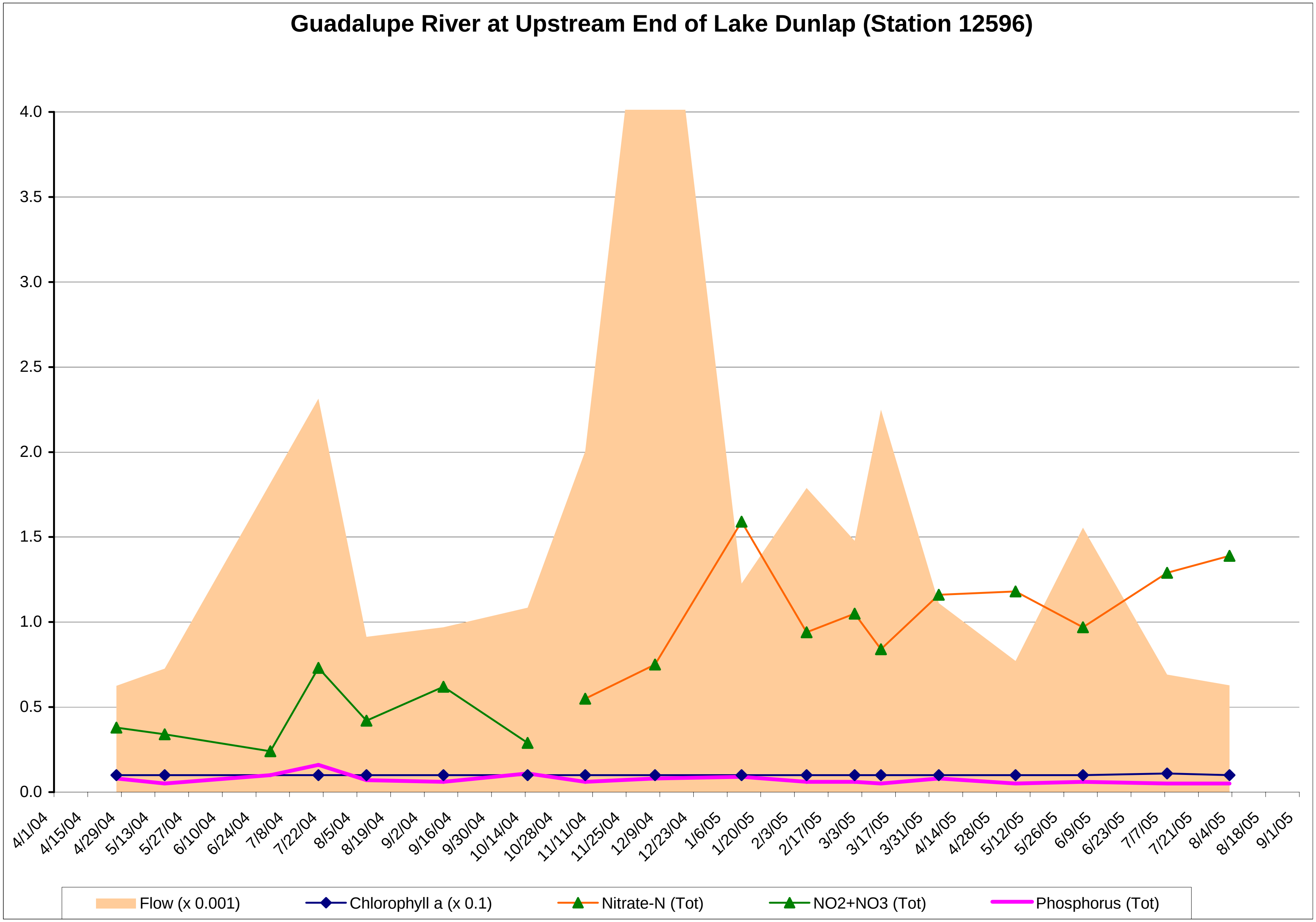

Comal River below Clemmons Dam in New Braunfels (Station 12653)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
6/1/1972
6/1/1973
6/1/1974
6/1/1975
6/1/1976
6/1/1977
6/1/1978
6/1/1979
6/1/1980
6/1/1981
6/1/1982
6/1/1983
6/1/1984
6/1/1985
6/1/1986
6/1/1987
6/1/1988
6/1/1989
6/1/1990
6/1/1991
6/1/1992
6/1/1993
6/1/1994
6/1/1995
6/1/1996
6/1/1997
6/1/1998
6/1/1999
6/1/2000
6/1/2001
6/1/2002
6/1/2003
6/1/2004
6/1/2005
Flow (x 0.001)
Nitrate-N (Tot)
NO2+NO3 (Tot)
NO2+NO3 (Diss.)
Phosphorus (Tot)
Chlorophyll a (x 0.1)



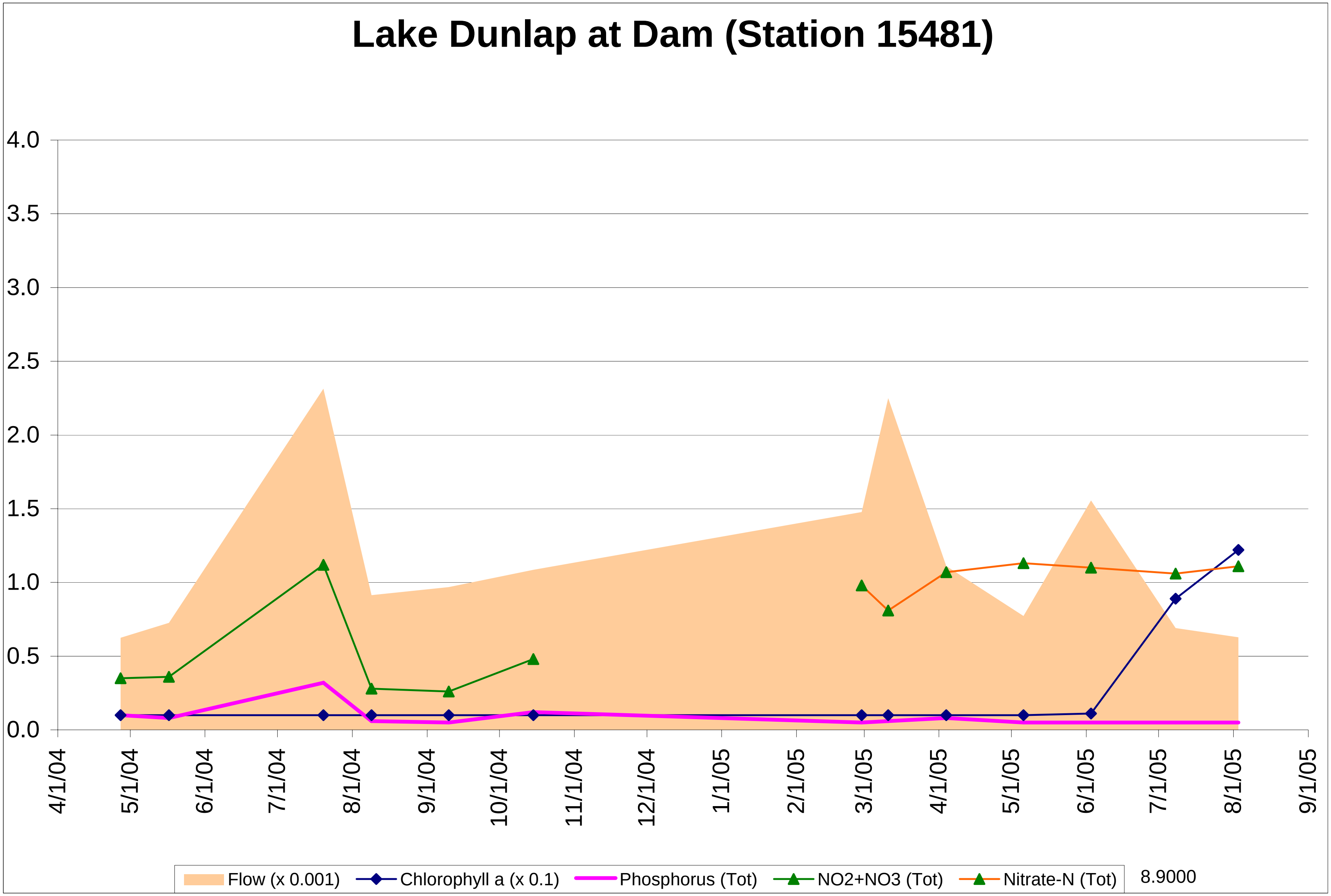
Guadalupe River Upstream of Lake Dunlap (Station 15480)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4/1/04
5/1/04
6/1/04
7/1/04
8/1/04
9/1/04
10/1/04
11/1/04
12/1/04
1/1/05
2/1/05
3/1/05
4/1/05
5/1/05
6/1/05
7/1/05
8/1/05
9/1/05
Flow (x 0.001)
Phosphorus (Tot)
Chlorophyll a (x 0.1)
NO2+NO3 (Tot)
Nitrate-N (Tot)



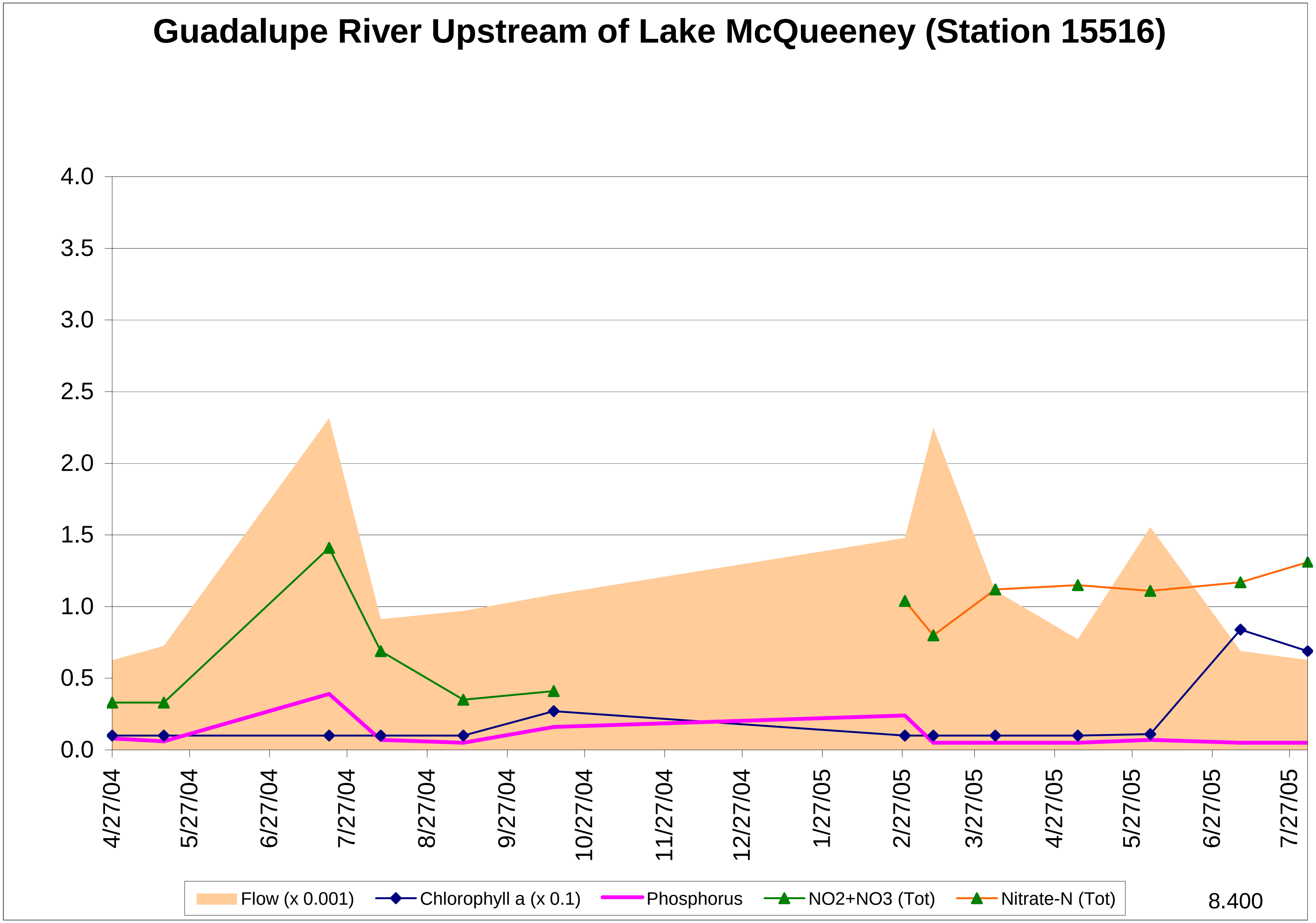
Guadalupe River at Upstream End of Lake Dunlap - Historical (Station 12596)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2/29/1980
3/1/1981
3/1/1982
3/1/1983
2/29/1984
3/1/1985
3/1/1986
3/1/1987
2/29/1988
3/1/1989
3/1/1990
3/1/1991
2/29/1992
3/1/1993
3/1/1994
3/1/1995
2/29/1996
3/1/1997
3/1/1998
3/1/1999
2/29/2000
3/1/2001
3/1/2002
3/1/2003
2/29/2004
3/1/2005
Flow (x 0.001)
Chlorophyll a (x 0.1)
Nitrate-N (Tot)
NO2+NO3 (Tot)
Phosphorus (Tot)

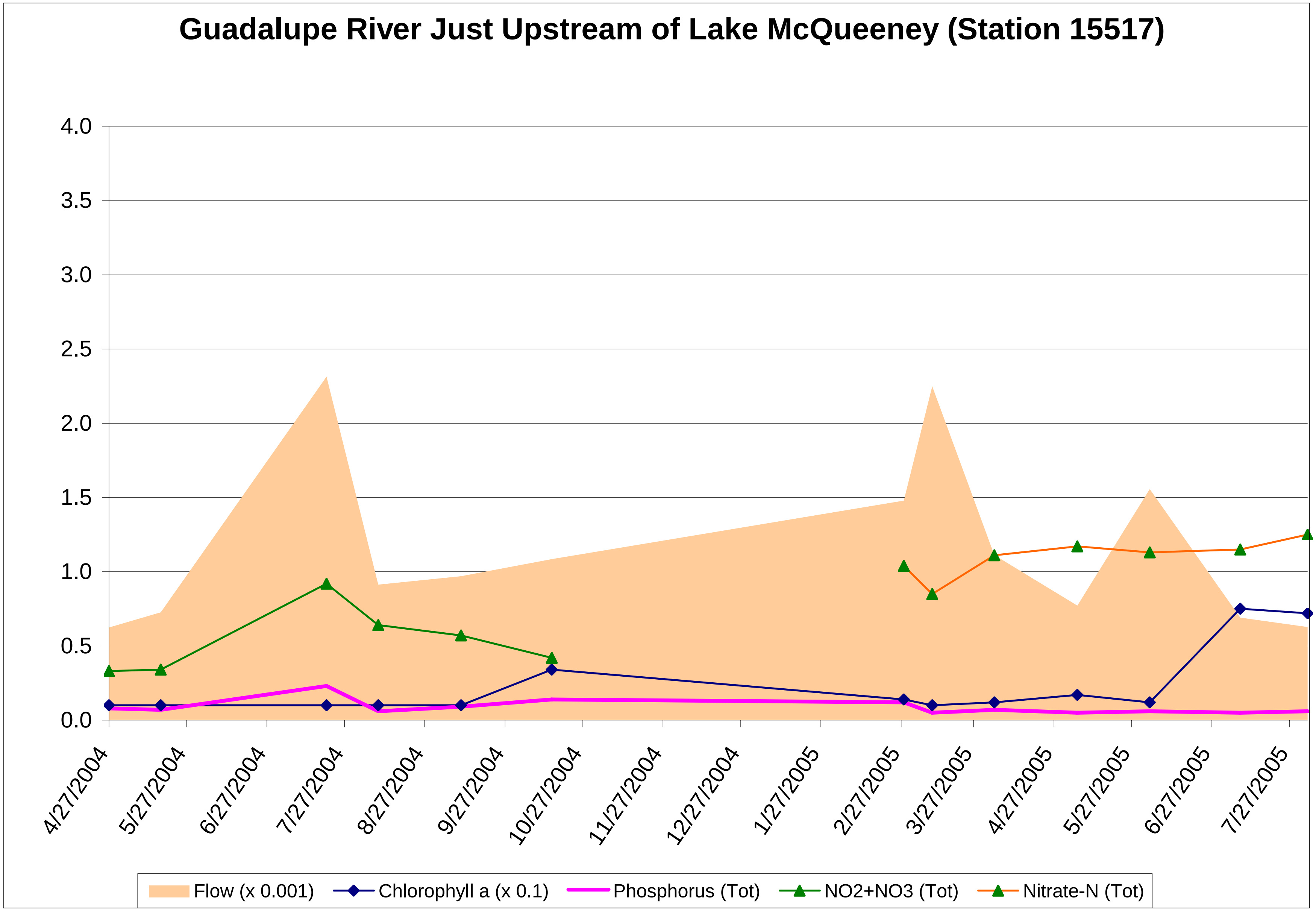


Guadalupe River at Upstream End of Lake Dunlap (Station 12596)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4/1/04
4/15/04
4/29/04
5/13/04
5/27/04
6/10/04
6/24/04
7/8/04
7/22/04
8/5/04
8/19/04
9/2/04
9/16/04
9/30/04
10/14/04
10/28/04
11/11/04
11/25/04
12/9/04
12/23/04
1/6/05
1/20/05
2/3/05
2/17/05
3/3/05
3/17/05
3/31/05
4/14/05
4/28/05
5/12/05
5/26/05
6/9/05
6/23/05
7/7/05
7/21/05
8/4/05
8/18/05
9/1/05
Flow (x 0.001)
Chlorophyll a (x 0.1)
Nitrate-N (Tot)
NO2+NO3 (Tot)
Phosphorus (Tot)

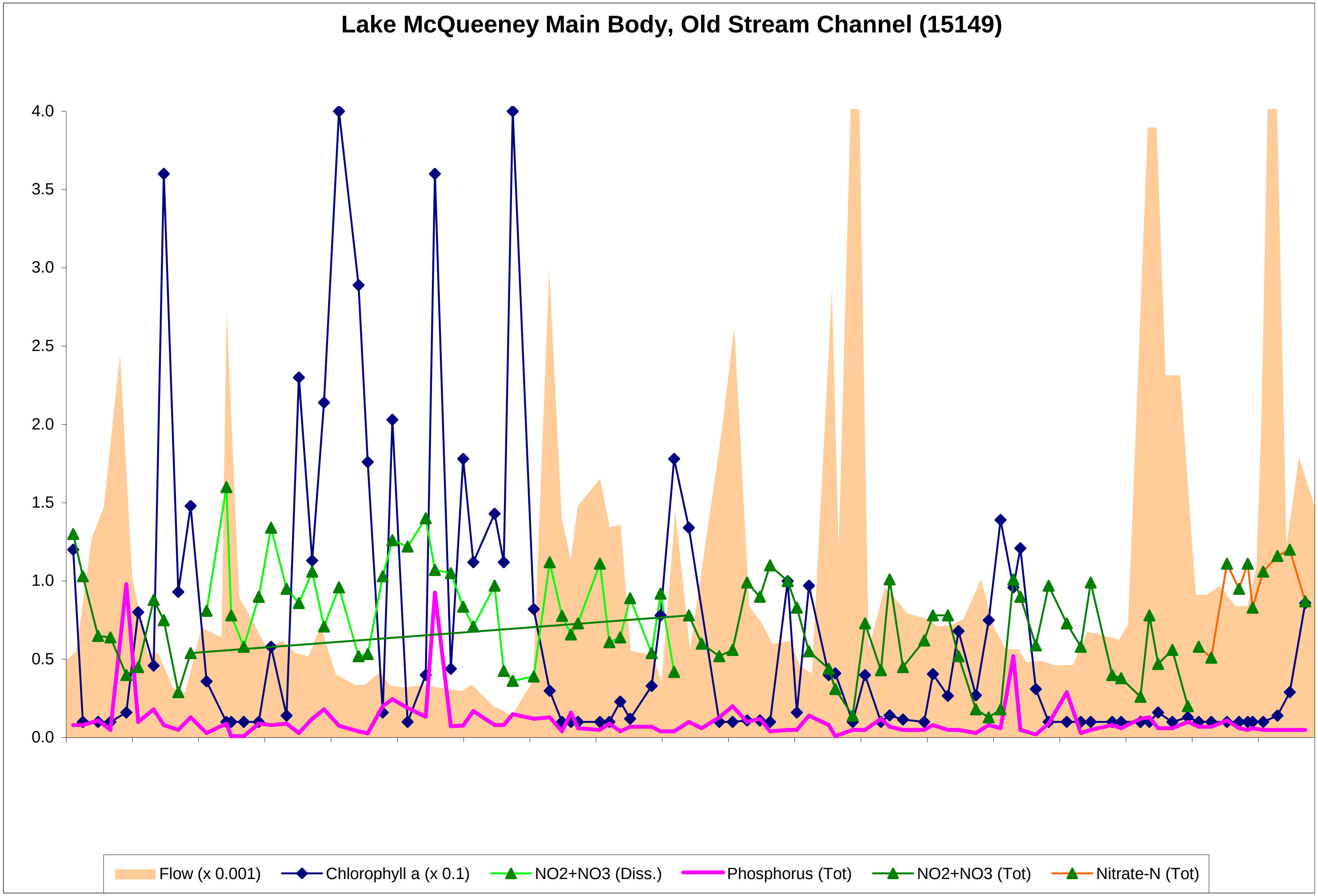


Lake Dunlap at Dam (Station 15481)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4/1/04
5/1/04
6/1/04
7/1/04
8/1/04
9/1/04
10/1/04
11/1/04
12/1/04
1/1/05
2/1/05
3/1/05
4/1/05
5/1/05
6/1/05
7/1/05
8/1/05
9/1/05
Flow (x 0.001)
Chlorophyll a (x 0.1)
Phosphorus (Tot)
NO2+NO3 (Tot)
Nitrate-N (Tot)
8.9000

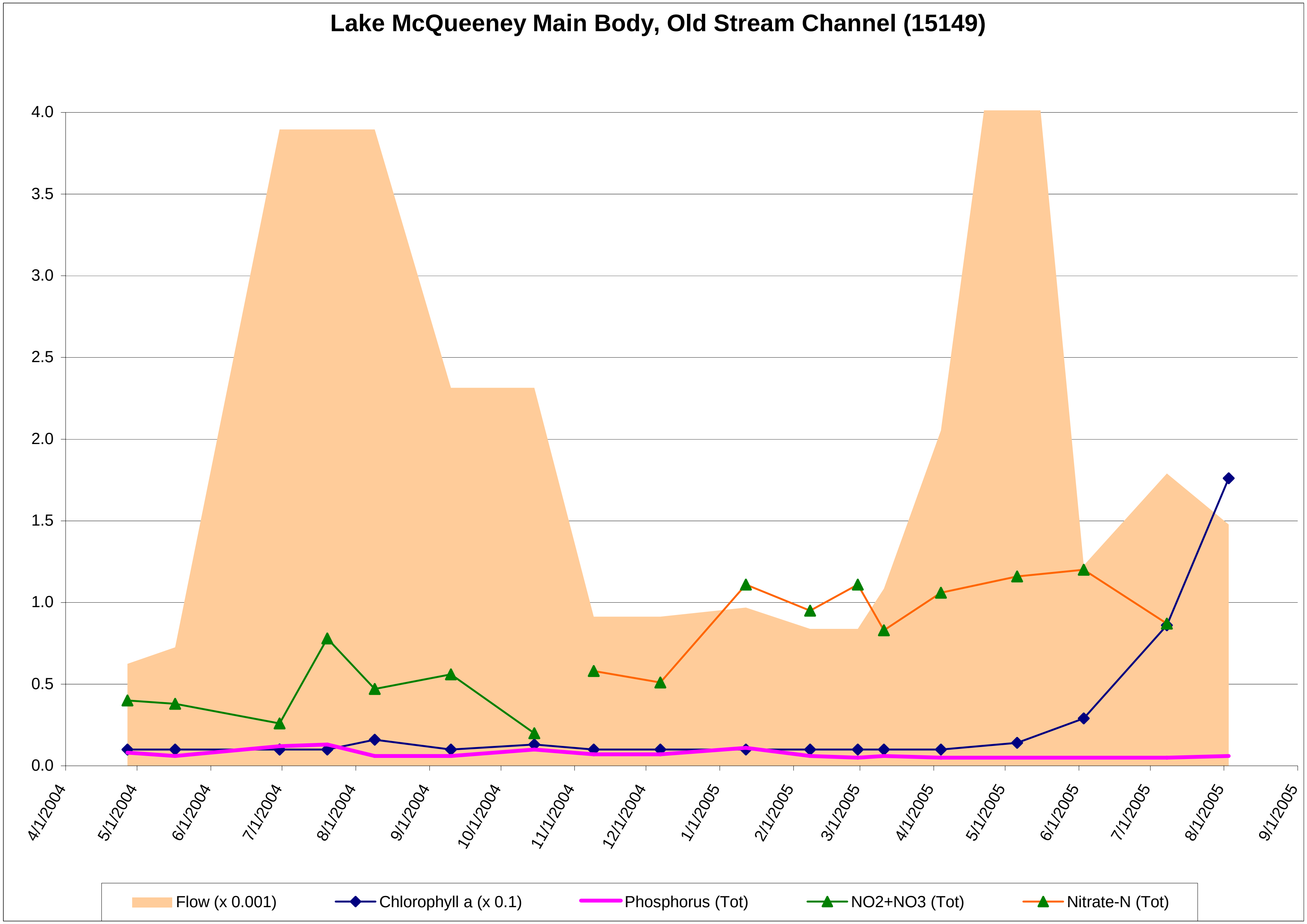

Guadalupe River Upstream of Lake McQueeney (Station 15516)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4/27/04
5/27/04
6/27/04
7/27/04
8/27/04
9/27/04
10/27/04
11/27/04
12/27/04
1/27/05
2/27/05
3/27/05
4/27/05
5/27/05
6/27/05
7/27/05
Flow (x 0.001)
Chlorophyll a (x 0.1)
Phosphorus
NO2+NO3 (Tot)
Nitrate-N (Tot)
8.400



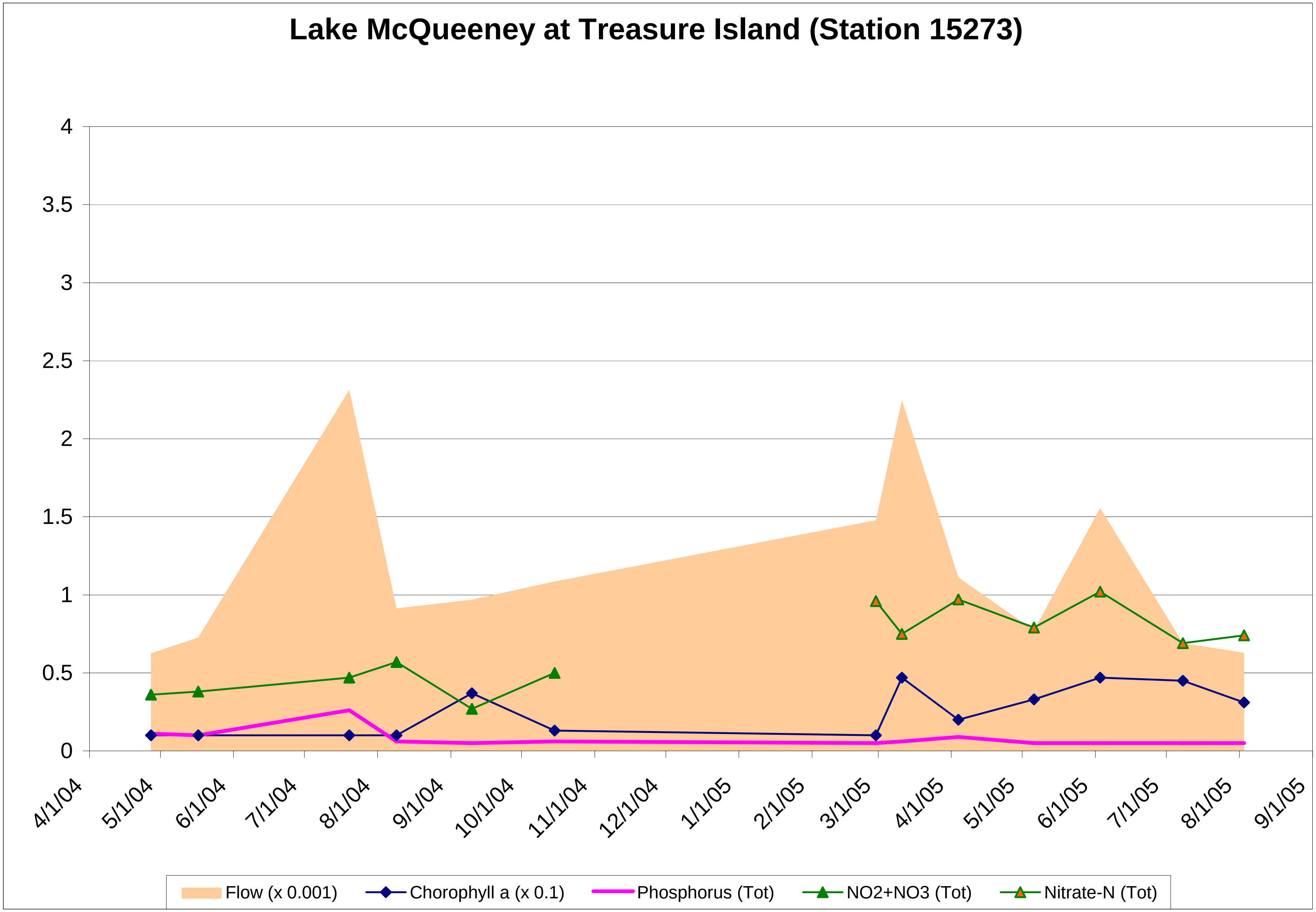
Guadalupe River Just Upstream of Lake McQueeney (Station 15517)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4/27/2004
5/27/2004
6/27/2004
7/27/2004
8/27/2004
9/27/2004
10/27/2004
11/27/2004
12/27/2004
1/27/2005
2/27/2005
3/27/2005
4/27/2005
5/27/2005
6/27/2005
7/27/2005
Flow (x 0.001)
Chlorophyll a (x 0.1)
Phosphorus (Tot)
NO2+NO3 (Tot)
Nitrate-N (Tot)



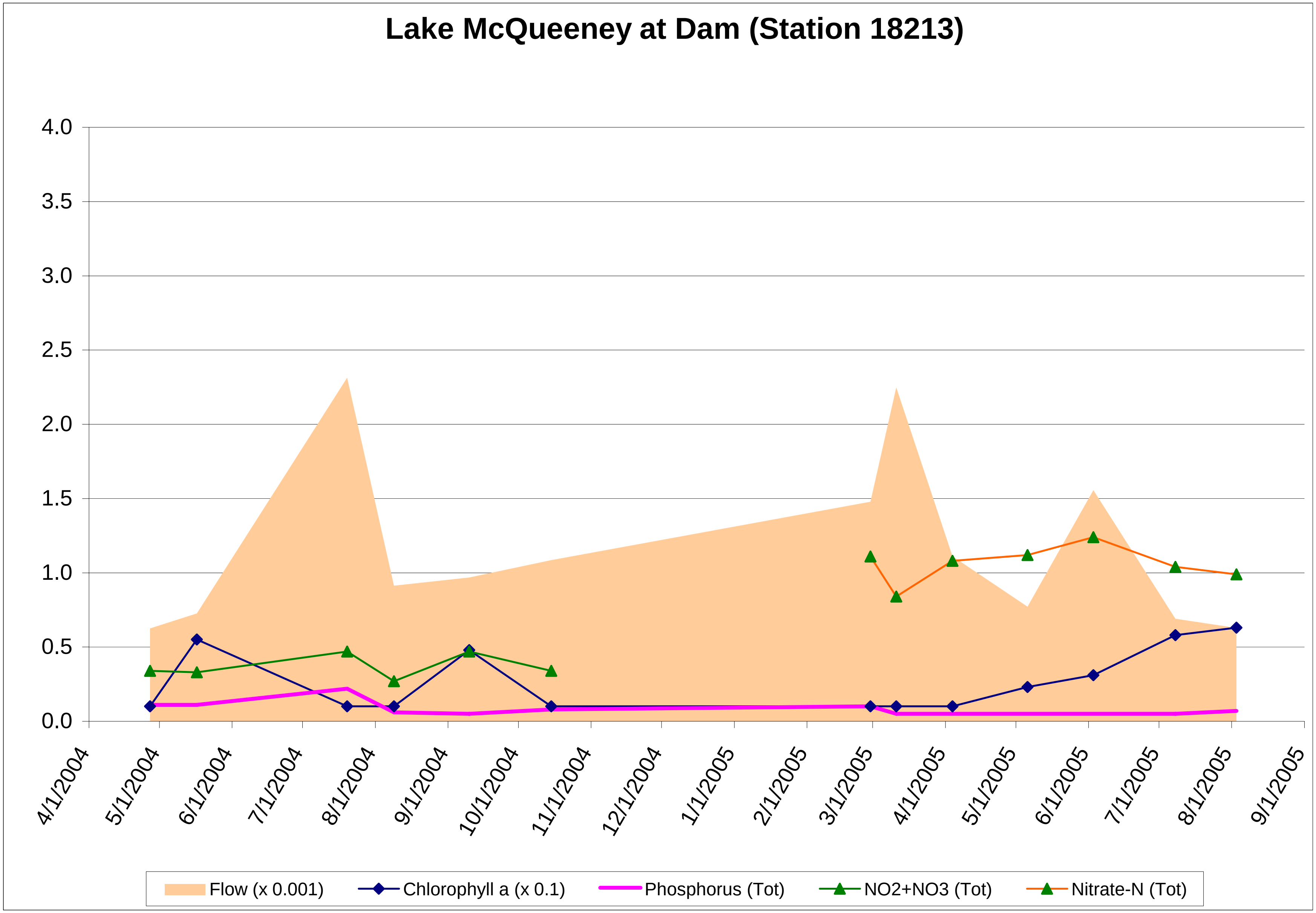
Lake McQueeney Main Body, Old Stream Channel (15149)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Flow (x 0.001)
Chlorophyll a (x 0.1)
NO2+NO3 (Diss.)
Phosphorus (Tot)
NO2+NO3 (Tot)
Nitrate-N (Tot)



Lake McQueeney Main Body, Old Stream Channel (15149)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4/1/2004
5/1/2004
6/1/2004
7/1/2004
8/1/2004
9/1/2004
10/1/2004
11/1/2004
12/1/2004
1/1/2005
2/1/2005
3/1/2005
4/1/2005
5/1/2005
6/1/2005
7/1/2005
8/1/2005
9/1/2005
Flow (x 0.001)
Chlorophyll a (x 0.1)
Phosphorus (Tot)
NO2+NO3 (Tot)
Nitrate-N (Tot)



Lake McQueeney at Treasure Island (Station 15273)
4
3.5
3
2.5
2
1.5
1
0.5
0
4/1/04
5/1/04
6/1/04
7/1/04
8/1/04
9/1/04
10/1/04
11/1/04
12/1/04
1/1/05
2/1/05
3/1/05
4/1/05
5/1/05
6/1/05
7/1/05
8/1/05
9/1/05
Flow (x 0.001)
Chorophyll a (x 0.1)
Phosphorus (Tot)
NO2+NO3 (Tot)
Nitrate-N (Tot)



Lake McQueeney at Dam (Station 18213)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
4/1/2004
5/1/2004
6/1/2004
7/1/2004
8/1/2004
9/1/2004
10/1/2004
11/1/2004
12/1/2004
1/1/2005
2/1/2005
3/1/2005
4/1/2005
5/1/2005
6/1/2005
7/1/2005
8/1/2005
9/1/2005
Flow (x 0.001)
Chlorophyll a (x 0.1)
Phosphorus (Tot)
NO2+NO3 (Tot)
Nitrate-N (Tot)