

Bacteria Characterization in Rio Grande Segment 2304 near Laredo, Texas/ Nuevo Laredo, Tamaulipas

**A Texas Clean Rivers Program Special Study
FINAL REPORT**



Field Work May and August 2011; Final Report November 2012

International Boundary and Water Commission, U.S. Section, Texas Clean Rivers Program

with:

City of Laredo Health Department Laboratory,

Laredo Community College,

Rio Grande International Study Center,

Texas A&M International University, and

Texas Commission on Environmental Quality Region 16 Office, Laredo

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This study was conducted with funds from the Texas Commission on Environmental Quality (TCEQ) through the Texas Clean Rivers Program (CRP) for the Rio Grande Basin, administered by the U.S. Section of the International Boundary and Water Commission (USIBWC).

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Cover photo: The Rio Grande below the railroad bridge in Laredo/Nuevo Laredo, August 15, 2011.

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EXECUTIVE SUMMARY

Bacteria levels in the Laredo/ Nuevo Laredo stretch of the Rio Grande have been high for decades. On the U.S. side, the Laredo area has four major wastewater treatment facilities with increasing efforts for infrastructure expansion and improvements. On the Mexican side, Nuevo Laredo also has several wastewater treatment facilities, including the Nuevo Laredo International Wastewater Treatment Plant constructed in the 1990s, made possible with the signing of International Boundary and Water Commission (IBWC) Minute No. 279. The combined infrastructure on both sides of the border has decreased bacteria levels in the river; however, bacteria levels still remain above U.S. and Mexican standards. Historical U.S.-collected data show that bacteria levels spike between routine monitoring Station 13202 at the Jefferson Plant Intake and Station 15814 at the International Bridge #2. The Texas Clean Rivers Program of IBWC's U.S. Section (USIBWC CRP), along with participating U.S. entities (City of Laredo Health Department Laboratory, Texas A&M International University, Rio Grande International Study Center, Laredo Community College, and Texas Commission on Environmental Quality Laredo Regional Office) conducted a special investigation of the bacteria levels. The study objectives were to characterize the bacteria contamination through intensive monitoring and to survey possible sources of contamination. The Target Area was between Station 13202 and Station 15814 where bacteria levels spike.

Monitoring was conducted in May and August of 2011. A total of 118 water samples were collected and tested for *E. coli* and fecal coliform bacteria at 49 stations along a 27-mile stretch of the river. The May sampling included 80 bacteria samples taken from the center of the river at 40 stations along that stretch. Results confirmed that bacteria values spike between Stations 13202 and 15814. Almost all samples in the Target Area were above both U.S. and Mexican standards, with the highest measured count in the river from the May sampling of 14,200 colony forming units/100ml (#/100ml) at the bend in the river. The survey in May documented 115 features such as intakes, discharges, structures, trash piles, tributaries, and animal paths. Of these, 10 features in the Target Area, which we call "features of concern," were selected for further analysis during the second sampling event in August. Six are features of concern in Mexico, 2 are tributaries in Mexico, and 2 are drains in the U.S. The August sampling included 19 sites of 38 bacteria samples and 12 selected sites for analysis of a set of water chemistry parameters. Samples were collected at or near the point of discharge for features of concern, or at the confluence of tributaries with the Rio Grande; in addition, some samples that were not focusing on features of concern were taken in the center of the river. The highest count of fecal coliform from the features of concern was 3,800,000 #/100ml occurring at a drain below Bridge II. The two sites in the U.S. did not have high bacteria counts. Water chemistry analysis shows the drains have varying concentrations of parameters tested, but many have high levels of Biological Oxygen Demand, Chemical Oxygen Demand, Total Dissolved Solids, and nutrients.

This study documents the following possible sources of bacteria: six documented drains in Mexico with high bacteria counts and 2 tributaries in Mexico with high bacteria counts. In addition, some sections of the Mexican bank were not sampled due to inaccessibility beyond islands where bacteria levels in the island inlets spiked. The study also identified four drains or features in Mexico where bacteria samples were not collected because they were located downstream of the Target Area.

There are sanitation infrastructure projects underway in the U.S. and Mexico that should improve river conditions. The U.S. is upgrading wastewater treatment plants and Mexico is disconnecting untreated wastewater from stormwater drains, including 3 of the 6 drains documented in this study. The study research team recommends continued monitoring and evaluation of these infrastructure projects to measure impacts and possible improvements to the bacteria values of the river. In addition, this was a U.S. study, not a joint IBWC binational study; therefore, there is a need for binational discussions and joint U.S.-Mexico studies and monitoring for future resolution to the bacteria contamination in the Rio Grande in the Laredo/Nuevo Laredo area.

1. PROBLEM DEFINITION

1.1 Introduction

Bacteria levels in the Rio Grande in the Laredo/Nuevo Laredo area have been high for decades^[1,2,3,4]. Laredo, Texas has four major wastewater treatment plants: North Laredo Wastewater Treatment Plant (WWTP), Laredo Southside WWTP, Zacate Creek WWTP, and Regional WWTP, along with a handful of minor treatment facilities^[1]. The City of Laredo expanded the North plant in 2011 and is planning future expansions for the South plant in 2012. Several of the plants have had effluent violations in the past 6 years for *E. coli* bacteria^[1]. On the Mexican side in Nuevo Laredo, Tamaulipas, there are several treatment plants, including the Nuevo Laredo International Wastewater Treatment Plant (NLIWTP). In 1989, the International Boundary and Water Commission (IBWC) signed a formal international agreement, IBWC Minute No. 279, “Joint Measures to Improve the Quality of Waters of the Rio Grande at Laredo, Texas/ Nuevo Laredo, Tamaulipas.”^[5] This Minute led to the construction of the NLIWTP, as well as the sewage conveyance system to carry the wastewater to the plant. The plant and collectors were constructed with funding from both the U.S. and Mexican governments. NLIWTP began operations in 1996 with remaining construction finalized within the next several years. Water quality data from the Rio Grande basin shows that bacteria levels in the river downstream of the plant drastically improved in the years following the operation of the plant. Despite the sanitation infrastructure on both sides of the border, high levels of bacteria continue to persist in waters throughout the Laredo/Nuevo Laredo stretch of the river.

The August 25, 1989 IBWC “Joint Report of Principal Engineers Concerning Measures that Should be Undertaken to Improve the Quality of the Waters of the Rio Grande at Laredo, Texas/Nuevo Laredo, Tamaulipas,” which led to Minute No. 279, published fecal coliform levels upstream and downstream of the Laredo/Nuevo Laredo urban area from 1982 to 1989. Data from Station 13196 8.6 miles below Laredo show that fecal coliform values typically ranged from 8,000 to 30,000 colony forming units per 100 ml (#/100ml)^a, with a maximum of 102,000 #/100ml measured in the summer of 1982. After the NLIWTP went online in 1996, bacteria values dropped significantly. At Station 13196 below the NLIWTP, for example, fecal bacteria values ranging from 10,000 to 76,000 #/100ml dropped to about

^a Fecal coliform bacteria values are measured in colonies per 100 ml, also referred to as colony forming units or CFUs per 100ml. *E. coli* values are measured as Most Probable Number per 100 ml. For the purpose of ease of reading for this report, we abbreviate and refer to both fecal coliform and *E. coli* units as #/100ml.

1,000 #/100ml, with some spikes at higher values ^[5]. However, despite the improvement, bacteria levels in the urban areas remain above U.S. and Mexican standards. Figure 1 shows historical data from Station 13202 above Laredo and Station 13196 below Laredo, clearly indicating bacteria values have historically been high below the urban area ^[2, 3]. A 2000 binational IBWC study on the water quality in Laredo and Nuevo Laredo also documented an increase in bacteriological concentrations as the river flows through both communities and recommended monitoring to identify the sources of contamination ^[2].

The Texas Surface Water Quality Standards (TSWQS) for contact recreation are measured in *E. coli* bacteria. Mexico uses different indicator bacteria, fecal coliform, for its standard. Table 1 compares the TSWQS and the Mexican standard for bacteria for the study area of the Rio Grande ^[6, 7].

The standard for *E. coli* for Rio Grande Segment 2304 from Amistad Dam to Falcon Reservoir is 126 #/100ml, using a geometric mean. The Clean Water Act Section 303(d) Impairment List, part of the *Texas Integrated Report* completed by the Texas Commission on Environmental Quality (TCEQ) and submitted to the U.S. Environmental Protection Agency (EPA) every two years, has listed Rio Grande Segment 2304 since 1996 for not meeting the contact recreation standard. The State of Texas divides river segments into smaller stretches called Assessment Units (AUs) for the purpose of the Integrated Reports. In the Laredo area, 2010 AUs 2304_03 to 2304_01 (from the City of Laredo water treatment plant intake downstream to the Arroyo Salado confluence) are impaired for bacteria, according to the *2010 Texas Integrated Report* ^[4]. States are required to take action to address impaired water bodies, but no enforcement or voluntary actions have been implemented in this area because the exact causes of the bacteria have not been known and because of the complexities of the binational nature of the Rio Grande.

Table 1. Bacteria Standards in the U.S. and Mexico

Country	Segment	Uses	Parameter Criteria		
			<i>E. coli</i> bacteria (geometric mean)	Fecal Coliform bacteria (monthly average)	Fecal Coliform bacteria (daily average)
U.S.	Segment 2304 Rio Grande below Amistad Dam	Primary Contact Recreation	126 #/100ml	NA	NA
Mexico	NA	NA	NA	1,000 #/100ml	2,000 #/100ml

The U.S. Section of the IBWC administers the Texas Clean Rivers Program (USIBWC CRP) for the Rio Grande Basin, which is responsible for collecting water quality information in the Rio Grande Basin in Texas. USIBWC CRP routinely collects both fecal coliform and *E. coli* data at 10 stations in the Laredo area, spanning 40 miles upstream of downtown Laredo to 30 miles downstream of Laredo. Data from

the Rio Grande in Segment 2304 show that values of bacteria upstream of Laredo/Nuevo Laredo are extremely low and have been for the past 30 years ^[3]. Bacteria counts increase in the downtown section of Laredo and Nuevo Laredo, somewhere between the City of Laredo water treatment plant on Jefferson Street (Station 13202) and International Bridge #2 (Station 15814). Bacteria counts remain high through Laredo/Nuevo Laredo and past the NLIWTP plant. Figure 2 shows that values exceed TSWQS at Stations 15814, 13200, 15815, 13196 and 15816. Figure 2 also shows that bacteria values spike between Stations 13202 and 15814.

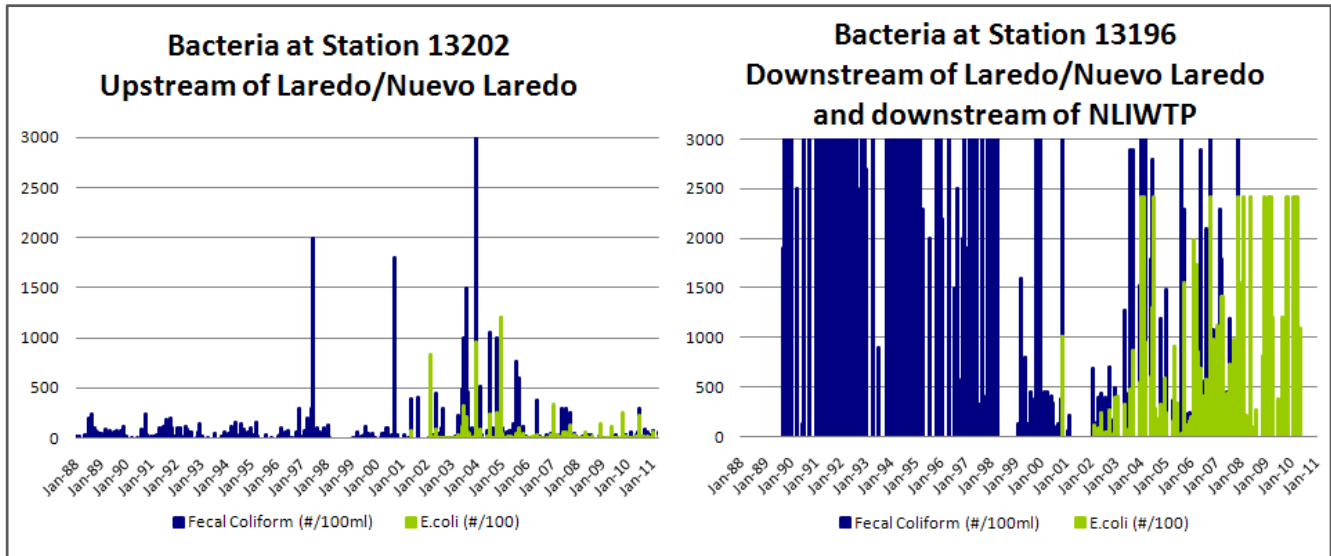


Figure 1 Historical bacteria values above and below Laredo/ Nuevo Laredo

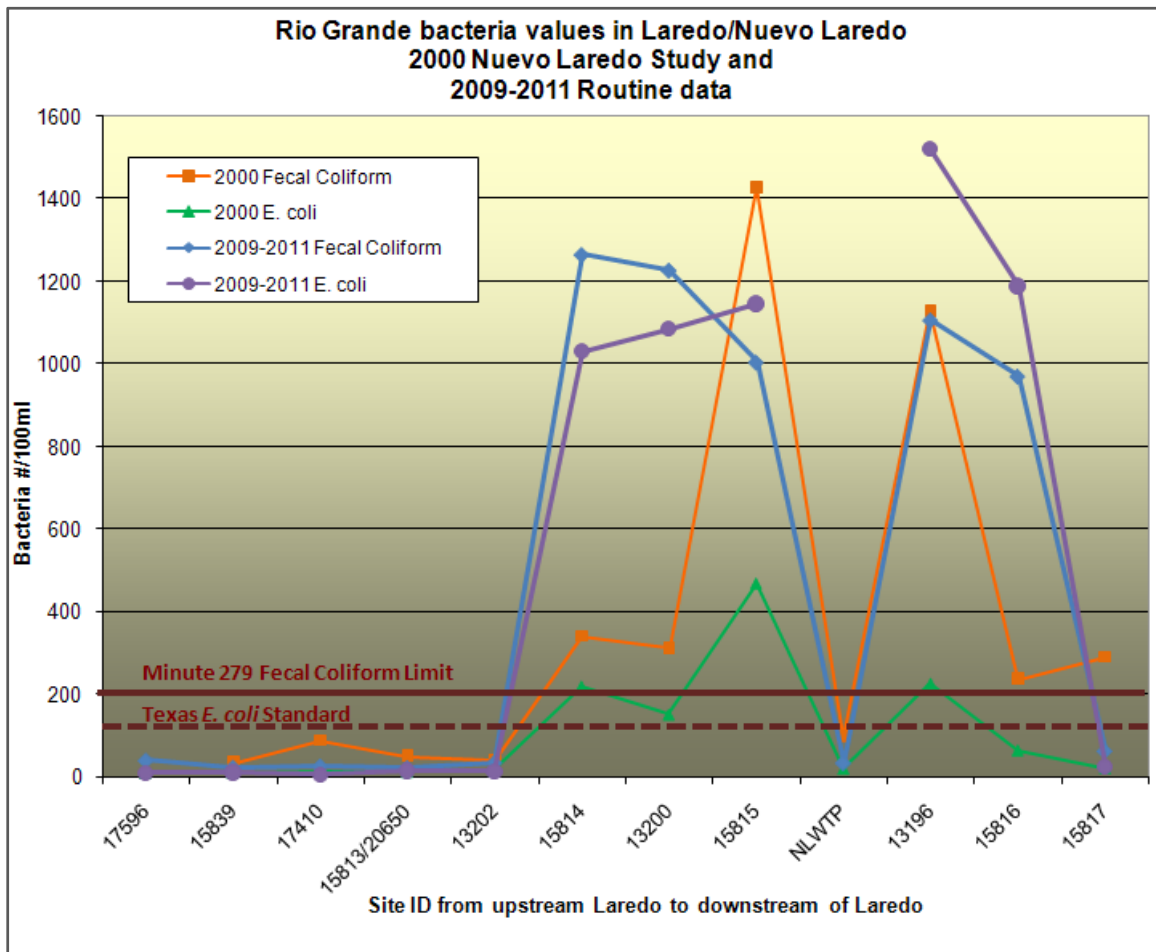


Figure 2 Bacteria Values in Laredo/Nuevo Laredo - upstream to downstream

Note: Station numbers are assigned on a historical basis and are not in numerical order from upstream to downstream

1.2 Study Objectives

The USIBWC CRP, in conjunction with the Rio Grande International Study Center (RGISC), Texas A&M International University (TAMIU), Laredo Community College (LCC), the TCEQ Region 16 office, and the City of Laredo Health Department Laboratory, conducted a special study to address the Rio Grande bacteria impairment in the Laredo area of Segment 2304. The goals of this special study were to:

- evaluate and identify possible sources of bacterial contamination through a field survey (via boat) and spatial analysis of field survey results, and
- characterize the bacteria contamination through intensive bacteria monitoring, with a particular emphasis on the spike of bacteria values occurring below Station 13202.

The information and data collected from the special study was intended to provide information necessary to begin steps to reduce pollutant loads and ultimately delist the impairment.

It is important to note that this study is a United States study and not a joint U.S.-Mexico study. The objectives and results of this domestic study are not supported by the two countries' governments through the International Boundary and Water Commission.

1.3 Study Area

According to the 2010 *Texas Water Quality Inventory Water Bodies Evaluated*, TCEQ used Stations 15814, 13200, 15815, 13196, 15816, and 15817, six of the 10 routine stations in the Laredo area ^[4], to assess impaired Assessment Units 2304_01 to 2304_03. Sampling for this study focused on these impaired AUs as well as a portion of the upstream AU of 2304_04, which included Station 13202. The study area encompassed the reach of the Rio Grande extending approximately 27 miles from TCEQ Station 13202 in AU 2304_04 downstream to Station 15817 in AU 2304_01. Figure 3 shows the stations and the extent of the study area.

The “Target Area” is defined where bacteria values initially spike (see Figure 2) from the downtown area from the City of Laredo intake (Station 13202) through the International Bridge #2 (Station 15814) and downstream to the confluence of Zacate Creek (Station 13200). The Target Area covered only the first four miles of the study area, and the entire stretch down past the NLIWTP was surveyed for study completeness. The Target Area is noted on Figure 3.

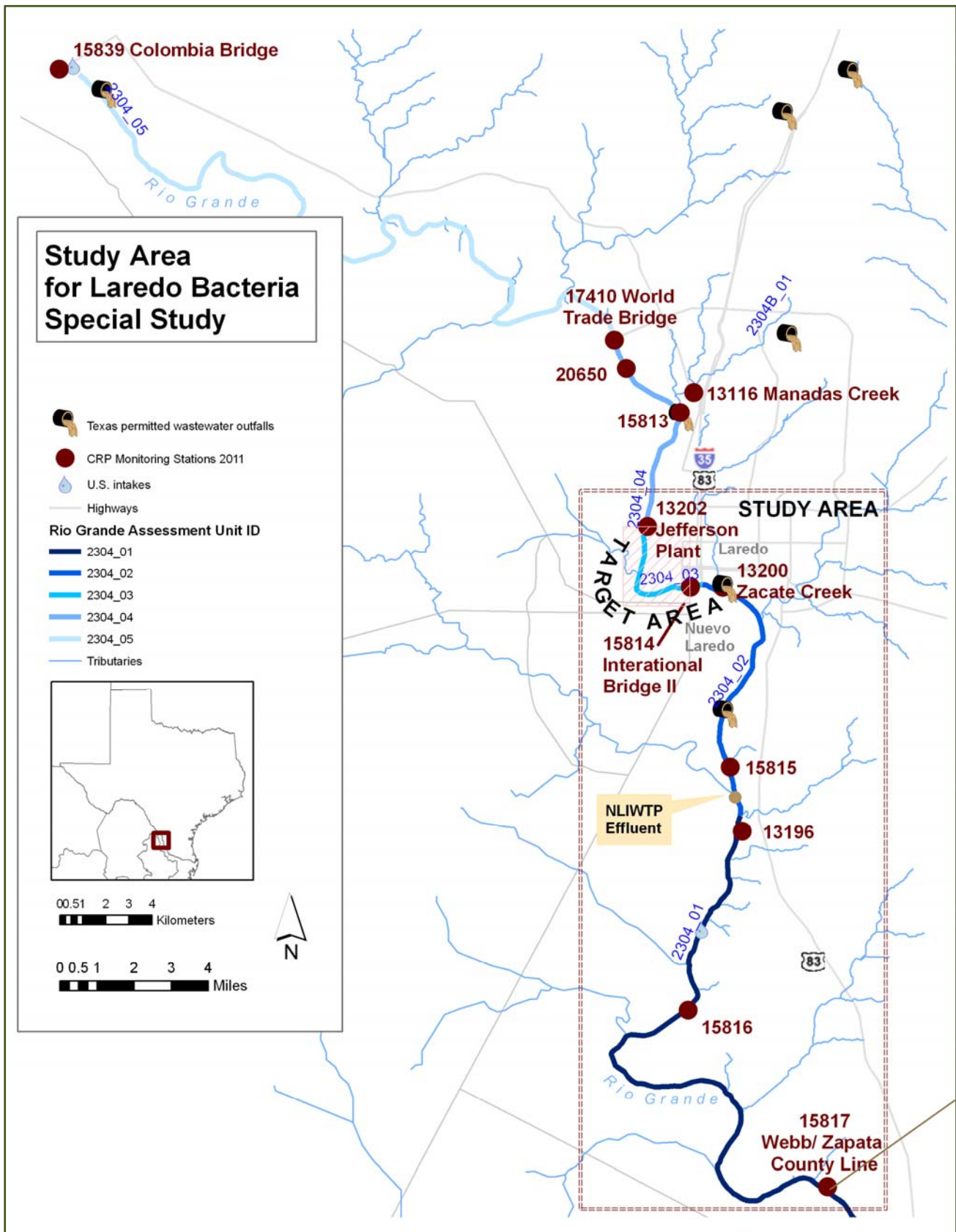


Figure 3 Map of Study Area for this Project

2. SAMPLING

2.1 Proposed Sampling Plan

Forty sampling sites were proposed for this study, shown in Figure 4. These sites were selected to get representative data throughout the study area, and were either historical stations in the TCEQ Surface Water Quality Information System or new sites in between existing historical stations. Sixteen of the 40 stations were within the Target Area. The original plan recommended two sampling events for all 40 stations.

Field parameters to be collected were:

- pH
- DO (in milligrams per liter)
- Specific Conductivity (in micromhos per cm)
- Water temperature in degrees Celsius
- Instantaneous Flow at gage station 15814
- Days since last significant rainfall and other ambient conditions
- Detailed observational data such as water appearance, unusual odors, and recreational activities.

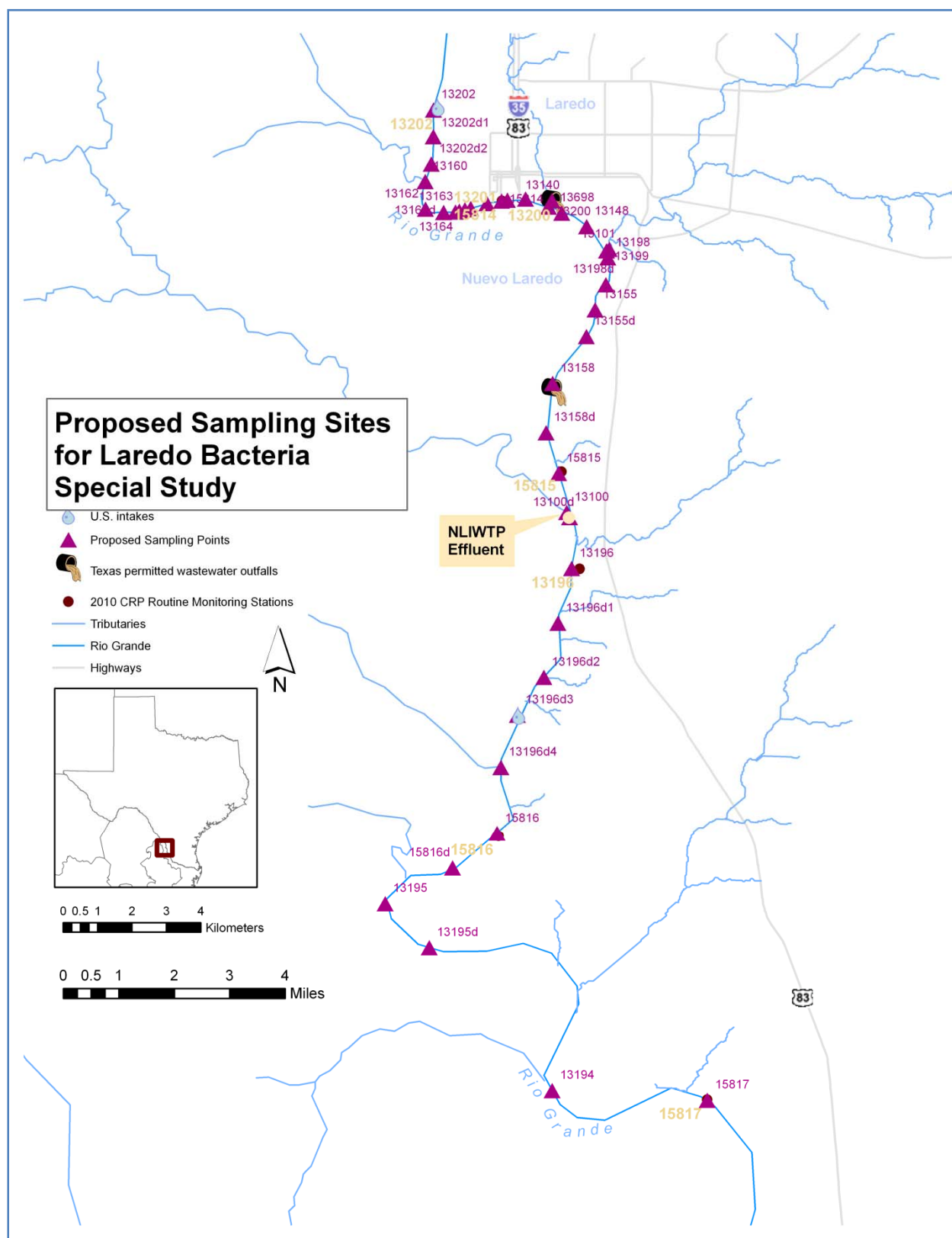
Laboratory parameters to be analyzed were:

- *E. coli*, IDEXX Colilert (in Most Probable Number per 100 ml)
- Fecal coliform (in colonies per 100ml)

Bacteria samples were analyzed by the City of Laredo Health Department Laboratory, which is accredited by National Environmental Laboratory Accreditation Conference.

Details of the original sampling plan, as well as data quality objectives, quality assurance requirements, laboratory measurement performance specifications, proposed sampling plan justification, and pre-study graphs can be found in the supplemental document *Appendix G to the United States Section, International Boundary and Water Commission (USIBWC) Clean Rivers Program FY 2010/2011 QAPP: Bacteria Characterization in Segment 2304 near Laredo, Texas* [9], hereafter referred to as "QAPP Appendix G."

As stated previously, the study objectives were driven by U.S. entities, not by Mexico or joint discussions. However, throughout the planning phase, Mexico was included in correspondence and informal discussions regarding the study. A copy of the QAPP Appendix G was submitted to Mexico in April 2011 as well as an invitation to participate in the sampling activities. Prior to the May sampling event, Mexico indicated their interest in and support of the study.



2.2 Actual Sampling

2.2.1 Bacteria Sampling

Two sampling events were conducted under this study, in May and August of 2011. The first sampling event was conducted May 19 and 20, 2011 and continued May 25, 2011. A total of 40 samples were collected by canoe, from the middle of the river. The second sampling event was conducted on August 15, 2011, when 19 samples were taken with a change in the original sampling plan, as discussed later in this section.

On May 19, eleven participants in 2 canoes, 2 kayaks and a jon boat began sampling at the Jefferson intake (Station 13202). Crews sampled the first 25 stations through Station 13158. A “runner” from TAMU met crews at Bridge I and shuttled the first batch of samples to the lab in order to meet the holding time of 6 hours. Prior to sampling, the USIBWC coordinated with local Border Patrol agents to inform them of the monitoring activities.

On May 20, the crew put in canoes at Masterson, collected 10 samples starting at Station 13158d through Station 15816, and took canoes out at El Cenizo. A runner met the crew at Chacon Creek to deliver the first batch of samples to the lab. A smaller crew continued sampling on May 25 to complete the last 5 stations through the Webb/Zapata County line.

After results of the first sampling event were compiled, the study participants revised the original sampling plan in order to collect additional samples where there were high bacteria values during the May sampling. The original plan called for an identical second sampling event, but study participants felt that targeted monitoring would provide more information on possible sources and narrow the study scope. The study participants also modified the sampling plan to address surveyed drains that were suspected to be causing issues. The IBWC Mexican Section was notified of the changes and gave authorization prior to the August sampling event to sample at the mouth of discharges or tributaries entering the Rio Grande.

The second sampling event was conducted on August 15, 2011 and included 19 bacteria samples and 12 water chemistry samples, at 9 new stations within the Target Area and 10 stations repeated from the May sampling. Chemical analysis included parameters that USIBWC CRP collects at routine monitoring stations, such as nutrients, salts, Biological Oxygen Demand (BOD), chlorophyll-a, as well as a non-routine parameter Chemical Oxygen Demand (COD). Chemical analysis, which was added to the second sampling event after the sampling crew noticed unusual smells and colors in discharges surveyed in May, was intended to provide additional information about possible constituents of discharges, in addition to bacteria.

2.2.2 Survey of Structures

As Figure 2 shows, bacterial contamination has historically spiked between two routine sampling stations, a strong indicator that the contamination is resulting from one or more point discharges.

Therefore one of the study objectives was to conduct a survey of all features and structures along both banks of the river. The survey was conducted during the May 19 and 20 sampling days, and verified in August. The survey team worked on the survey via kayak for better maneuverability. The team documented features along both U.S. and Mexican banks, such as pipes, discharges, stormdrains, intakes, trash piles, animal paths, and structures. The survey team documented a description of the features, GPS locations, pictures and video, and any other noteworthy information such as whether a structure was discharging at the time and whether there were any odors or discoloration in the water nearby.

3. RESULTS

3.1 Bacteria Results from First Sampling Event in May 2011

Results from the May 2011 sampling event are listed in Table A.1 in Appendix A. *E. coli* bacteria values ranged from 13.2 to greater than 2,420 #/100ml and fecal coliform values ranged from 60 to 14,200 #/100ml. Results are shown in Figures 5 and 6. These figures indicate that bacteria values upstream of the Target Area were low and began to increase at the bend in the river. Specifically, both fecal coliform and *E. coli* values spike between Stations 13161 and 13162. Figure 5 shows a graph of the values from the May sampling events. *E. coli* values at Station 13162 were greater than 2,420 #/100ml and remained at that level through the entire Target Area until the U.S. tributary Zacate Creek (Station 13200). Both fecal coliform and *E. coli* values remained high almost to the end of the study area; bacteria values did not decrease until downstream of Rio Bravo (Station 15816d), about 15 miles downstream of Laredo. The dip in *E. coli* values at 13101 was measured at the U.S. tributary Chacon Creek.

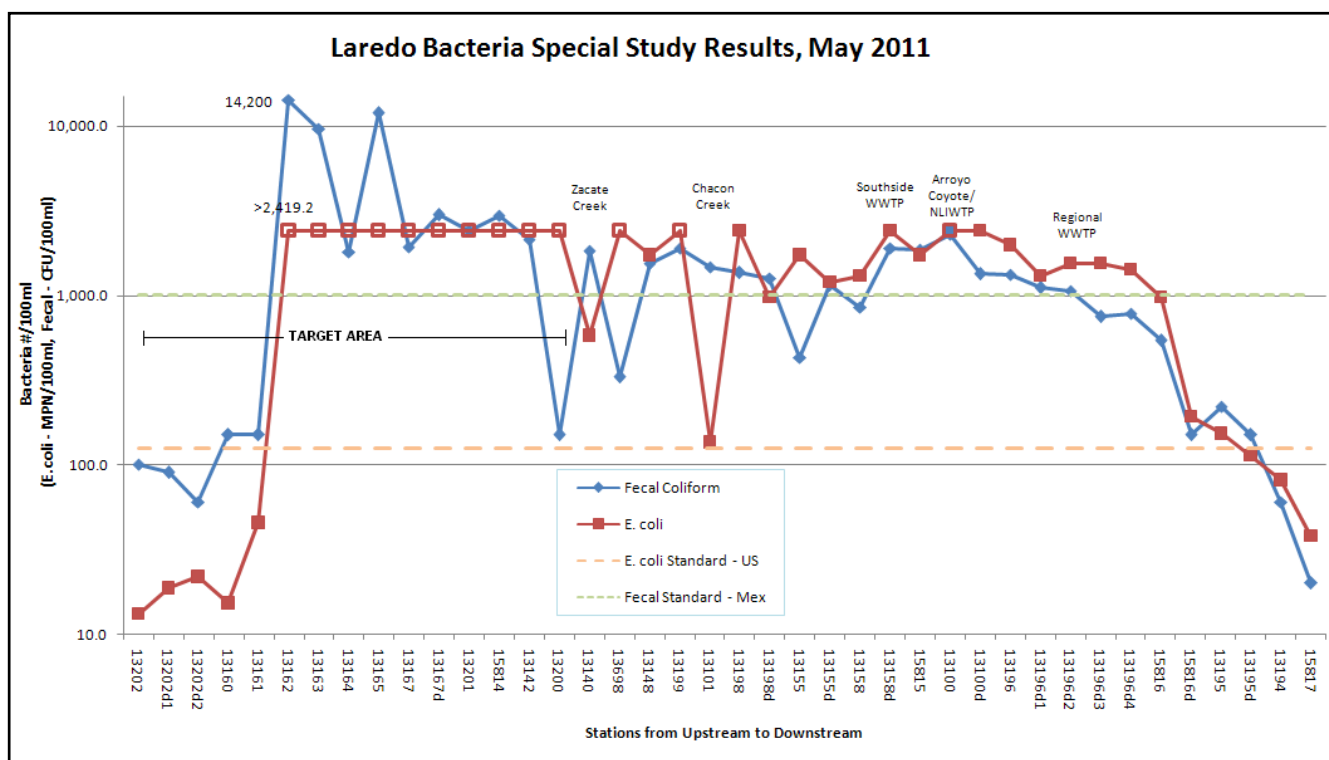


Figure 5 Bacteria Results from May sampling events, from upstream to downstream

(Shown larger as Figure B.1)

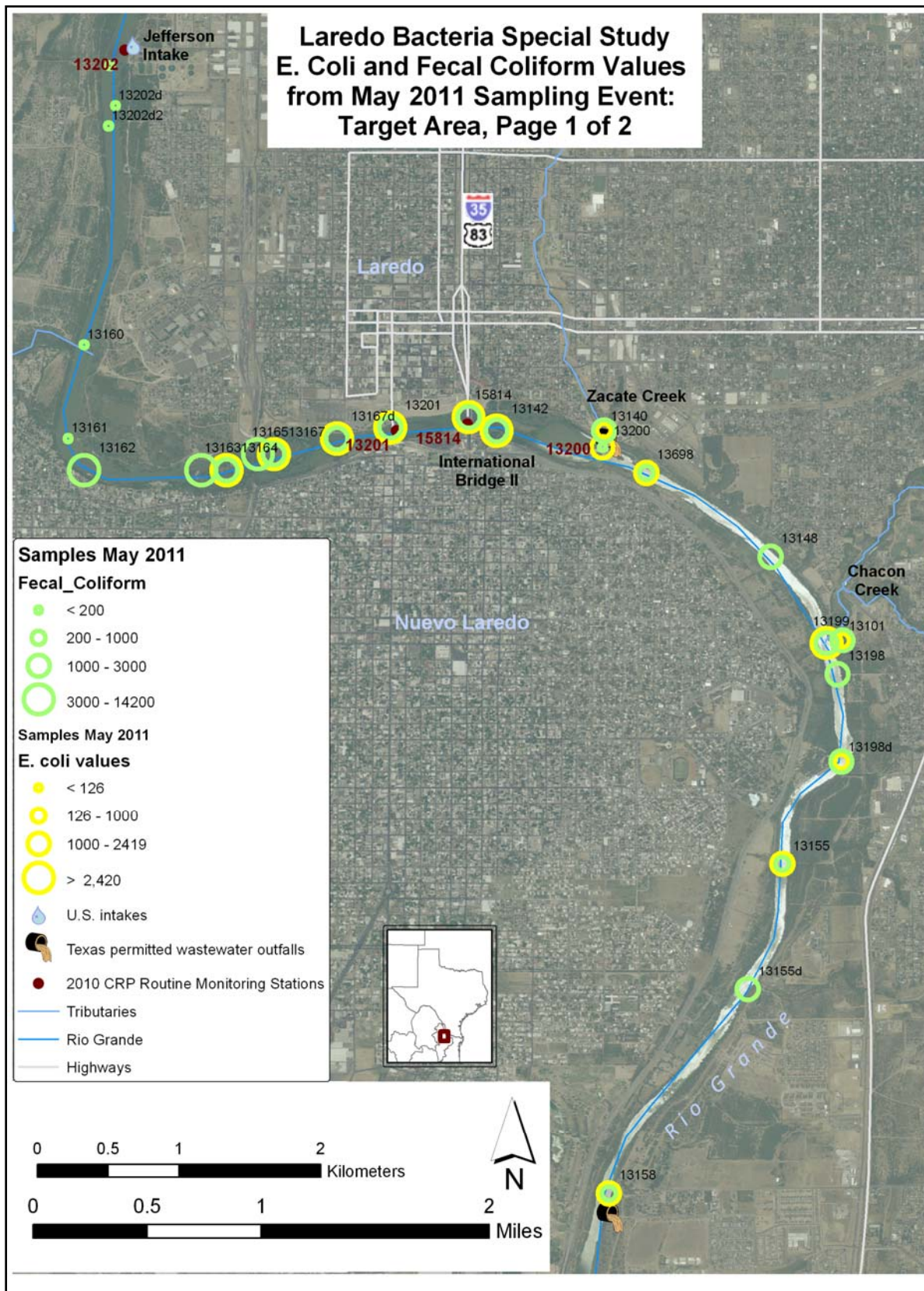


Figure 6 Map 1 of 2 of the highest fecal coliform and *E. coli* bacteria values from the May sampling event.

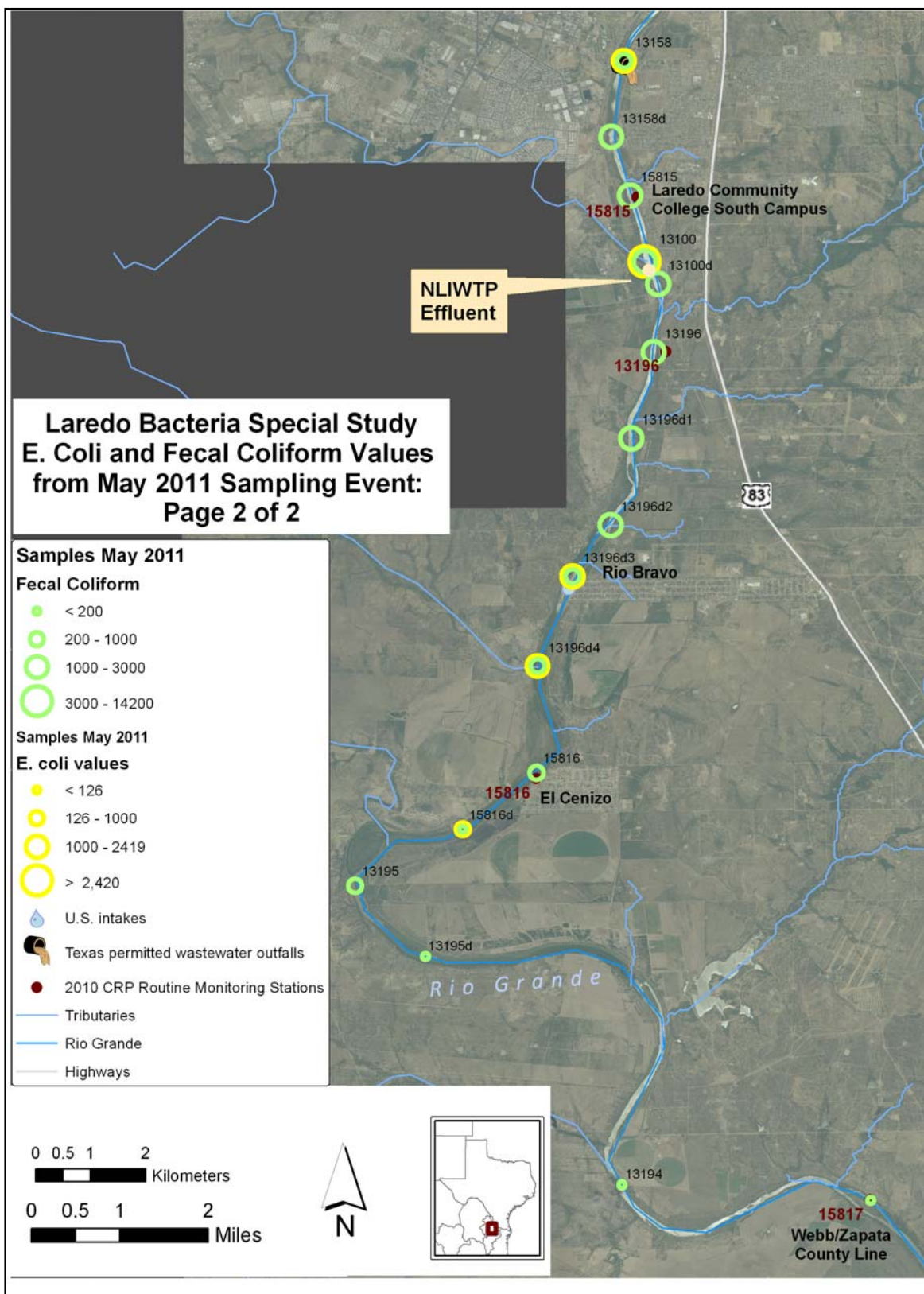


Figure 7 Map 2 of 2 of the highest fecal coliform and *E. coli* bacteria values from the May sampling event

3.2 Results of Survey of Features

On May 19 and 20, the crew surveyed features on both U.S. and Mexican banks from Station 13202 downstream about 16 miles to Station 15816. One-hundred fifteen features were surveyed and are listed in their entirety from upstream to downstream in Appendix C. The list of features includes boat ramps, intake pipes, structures, animal paths, trash piles, pump structures, tributaries, and visible or audible discharges. Not all 27 miles of study were surveyed because of the quantity of features documented in the first 16 miles and because it was not deemed necessary to survey the furthest stretch from the Target Area. Surveyed features are shown with both May and August sampling site locations for the Target Area in Figure 8.

The study research team reviewed the bacteria data results from the May sampling and compared the data with locations of the surveyed features. There were 11 features of concern in the Target Area, listed in Table 2. The information in Table 2 is duplicated in Appendix C but is listed in Table 2 to highlight the most probable sources of bacteria in the Target Area based on the data. Two of the discharges were in the U.S., and the rest originated in Mexico. Some of the features had discolored water being discharged into the Rio Grande, and others had foul smells, biomass, foam, or trash.

Based on a combination of the results of bacteria data and the results of the feature survey from May, the research team decided to modify the plan for the second sampling event and focus on these drains and tributaries with poor water and site conditions combined with high bacteria values during the May sampling. Six drains and 2 tributaries in Mexico as well as 2 drains in the U.S. were selected for further analysis. These are: Feature (F) 15, F16b, F18, F20, F22, F23, F29, F34b, F35, and F39. In addition, chemical analysis of other water quality parameters was also added to have a better understanding of the contamination from these discharges of concern.

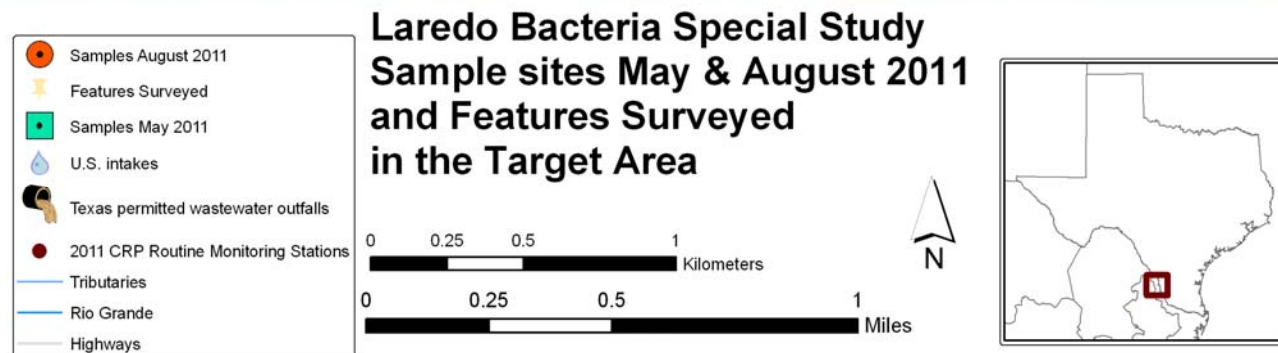
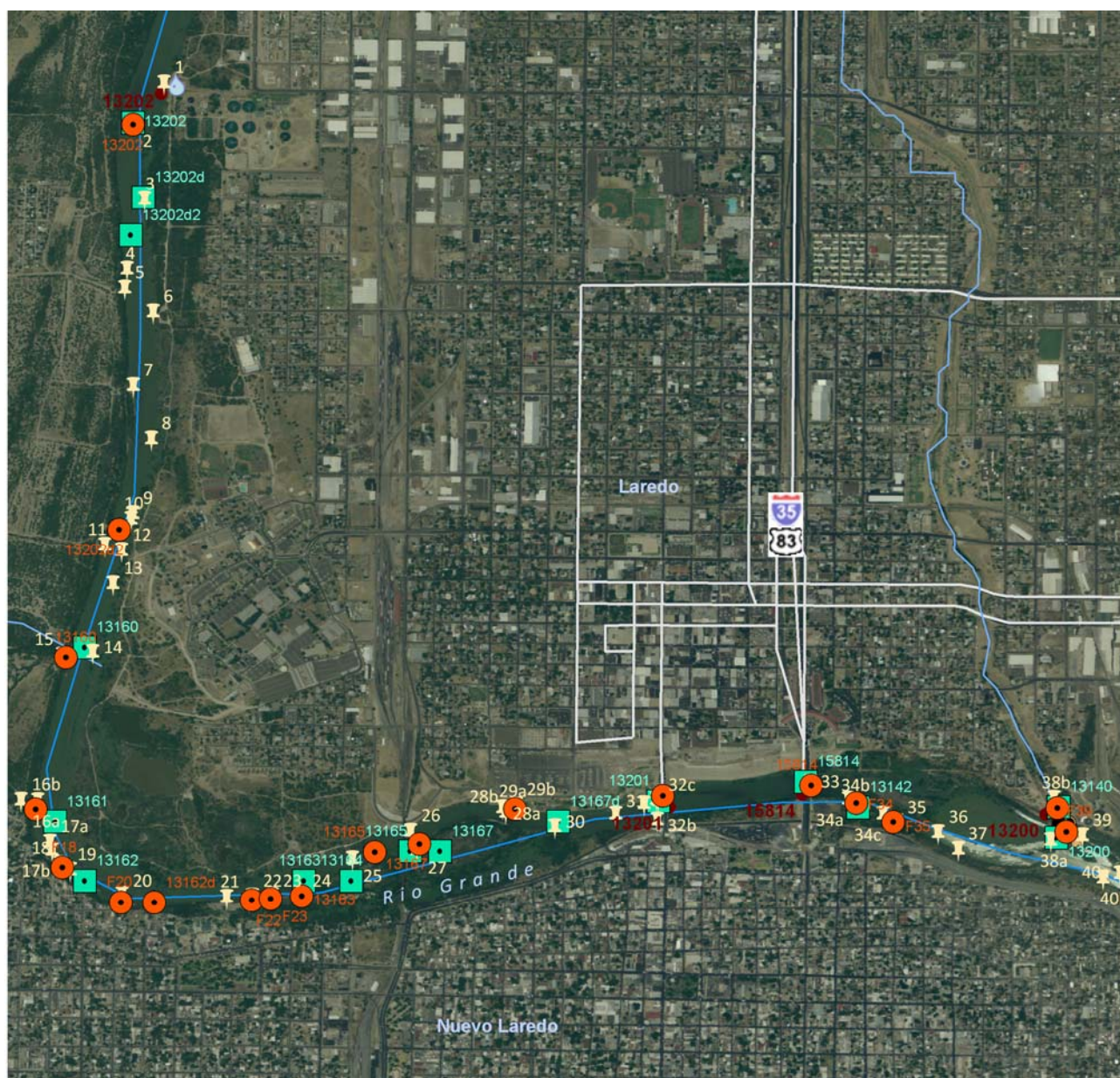
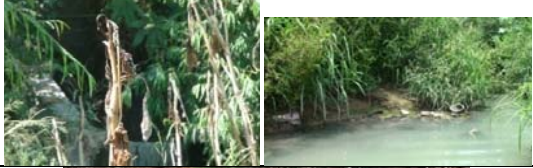


Figure 8 Surveyed Features in the Target Area

Table 2. Features of Concern from Feature Survey in Target Area selected for focused analysis in August

Feature ID	Coordinates	Country	Confirmed Drain?	Description/ Field Notes	Photo	Bacteria Counts from August (#/100ml)
Feature 15	27.50458, -99.52774	Mexico	Not confirmed Mexican tributary	Tributary (Arroyo La Joya). Extremely foul smelling with lots of trash and biofilm. No visible drains.		120,000 (FC) > 9,680 (<i>E. coli</i>)
Feature 16b	27.49966, -99.52914	Mexico	Not confirmed Mexican tributary	Tributary (Arroyo Las Alazanas) Foul smelling. Trash piles on banks, seems to be used as landfill.	 	8,000 (FC) 4,840 (<i>E. coli</i>)
Feature 18	27.49752, -99.52784	Mexico	Confirmed discharge Drain not confirmed	Drain on stone, discharging into a waterfall on river bank. Discharge audible before sighting. Foul smell. Biofilm and trash.		2,900 (FC) 4,840 (<i>E. coli</i>) (sample diluted with river water and is likely biased low)
Feature 20	27.49648, -99.52573	Mexico	Confirmed drain Confirmed discharge	Large cement structure. Wet during May sampling, and discharging small trickle of clear water during August sampling.		14,600 (FC) > 9,680 (<i>E. coli</i>)

Feature 22	27.49641, -99.52133	Mexico	Confirmed discharge Drain not confirmed	Small drain or tributary in Mexico. Trash and foam or biofilm. Milky, foul smelling discharge in August.		13,000 (FC) > 9,680 (<i>E. coli</i>)
Feature 23	27.49644, -99.52066	Mexico	Confirmed drain Confirmed discharge	Cement chute on bank with murky green/white discharge visible as it enters river. Large volume of discolored water discharging. Foul smell. Same as observed in April 2009 during U.S. cane removal projects. August crews noted foam.		336,000 (FC) > 9,680 (<i>E. coli</i>)
Feature 24 near 13163	27.49647, -99.5197	Mexico	No feature confirmed; However, this was one of the highest bacteria counts, but crew could not confirm a drain or feature on other side of island.	Entrance to island splitting river. Mexican side impassible. Raw sewage observed on Mexican side by May sampling crews. Crews were looking for drains on Mexican side which have been documented in the past.		1,300,000 (FC) > 9,680 (<i>E. coli</i>)
Feature 29	27.49944, -99.512499	U.S.	Confirmed drain No discharge	Large cement structure, appears to be stormwater drain, labeled R9		2,600 (FC) 1,450 (<i>E. coli</i>)
Feature 34b	27.49964, -99.50098	Mexico	Confirmed discharge Drain not confirmed	Discharge on Mexican bank, no pipe visible. Discharge has a white stringy material that looks like taffy or plastic consistency. Foul smell. Suds in water samples.		1,080,000 (FC) > 9,680 (<i>E. coli</i>)

Feature 35	27.49895, -99.49957	Mexico	Confirmed drain Confirmed discharge	Cement structure and pipe high on bank. Discharging is audible and visible. Discharge is a blue green murky color. Suds in sample bottles.		3,800,000 (FC) > 9,680 (<i>E. coli</i>)
Feature 39	27.49846, -99.4933	U.S.	Confirmed drain Confirmed discharge	Zacate Creek Outfall		256 (FC) 10 (<i>E. coli</i>)

3.3 Bacteria Results from Second Sampling Event in August 2011

The August sampling included samples from the center of the river as well as focused samples from features of concern from Table 2 which were collected at or near the point of discharge or confluence with the Rio Grande. As discussed in the previous section, due to the fact that bacteria spiked so drastically at the bend in the river during the May sampling, the second sampling was modified to collect bacteria at the surveyed point discharges in the Target Area which caused concern for the research team and merited further investigation.

Results from the August 2011 sampling event are listed in Table A.2 in Appendix A. *E. coli* bacteria values ranged from 10 to greater than 9,676.8 #/100ml and fecal coliform values ranged from 256.2 to 3,800,000 #/100ml. Figure 9 shows a map and Figure 10 shows a graph of the bacteria values from the August sampling events. Table 2 also lists the bacteria counts at the features of concern collected in August. All discharges had extremely high bacteria values above both U.S. and Mexican standards with the exception of the effluent discharge from the Zacate Creek WWTP in the U.S., which had the lowest *E. Coli* count of any sample collected in the entire study. Three discharges (F24, F34b, and F35), all in Mexico, had fecal coliform counts above one million.

Figure 11 shows the results from both the May and August sampling events, arranged in order from upstream to downstream. The data is also listed in Table A.3 in Appendix A.

3.4 Results of Chemical Analysis from Second Sampling Event in August 2011

Many of the features or discharges of concern surveyed in May had unnatural colors and foul odors, and sampling crews were unable to visually identify what kind of contaminants were present or what kind of discharge was being put into the river. Therefore, additional chemical analysis was added to the August sampling.

Parameters analyzed included: Hardness, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Volatile Suspended Solids (VSS), Calcium, Magnesium, Potassium, Sodium, Chloride, Fluoride, Sulfate, Nitrate + Nitrite, Alkalinity, Ammonia, Total Kjeldahl Nitrogen (TKN), Total Phosphorus, Silica, Total Organic Carbon (TOC), Chlorophyll-a, Phaeophytin, Biological Oxygen Demand (BOD), and Chemical Oxygen Demand (COD).^b

Only one site had TSS values above 100 mg/l and VSS about 50 mg/l (F22). Four sites had BOD values above 50 mg/l and COD above 80 mg/l (F15, F18, F23, and F39). Six sites had high nutrient levels (TKN

^b A revision to the QAPP Appendix G was not completed to add the additional parameters to the special study prior to the August sampling; however, the parameters analyzed (with the exception of four parameters: COD, VSS, BOD, and TOC) are included in the overall quality assurance project plan (in Table A7.1) for the USIBWC CRP effective September 1, 2011, and the analyses for this study follow the quality guidelines in the overall QAPP.

above 10 mg/l and ammonia above 5 mg/l (F15, F18, F23, F34, F35, F39). One site had high salinity levels, with TDS above 9,000 mg/l (F20). These results are discussed in Section 4.4. Results of the chemical analysis are listed in Appendix A, Table A.4 and graphed in Appendix B.

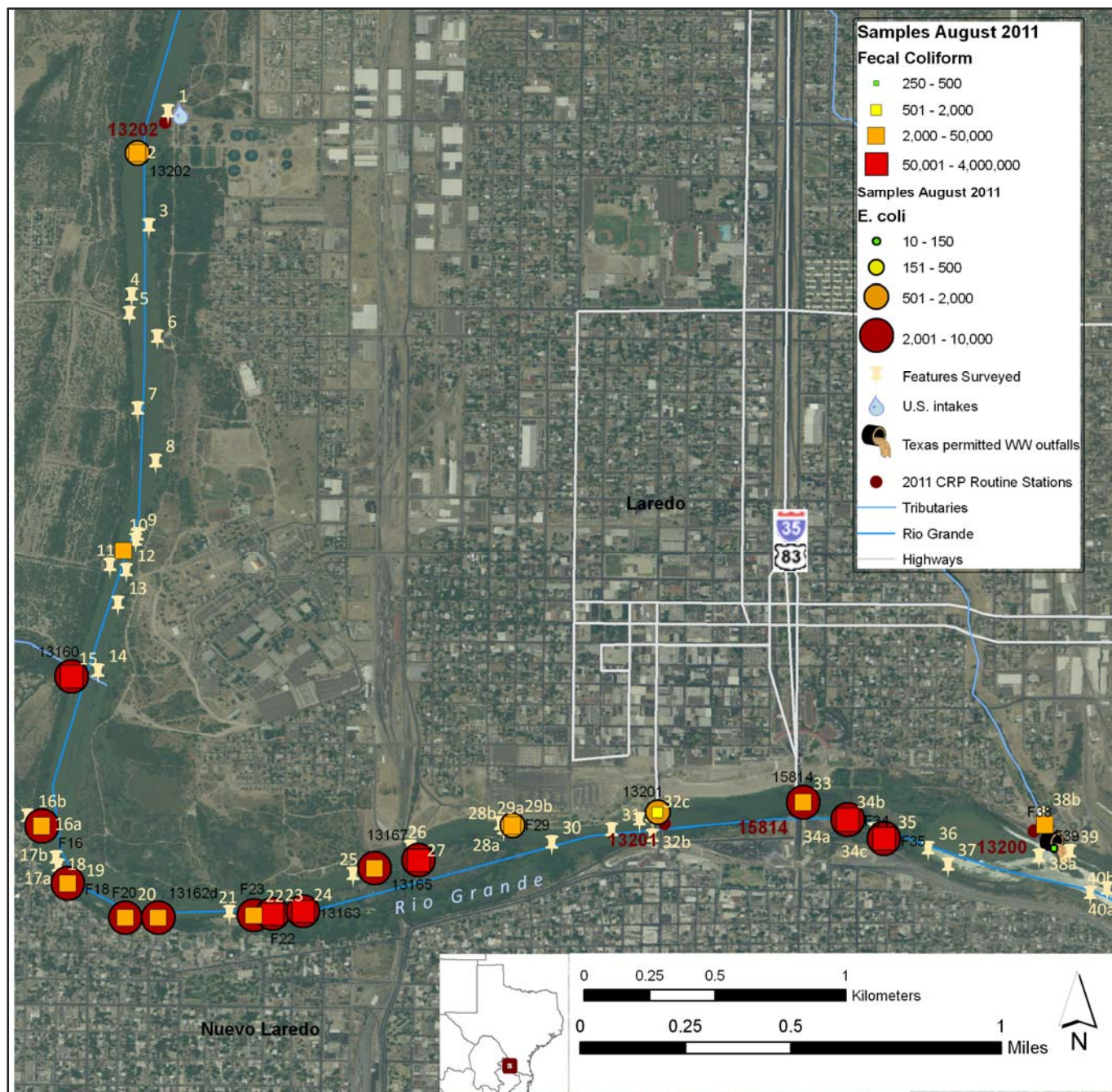


Figure 9 Bacteria values from August sampling

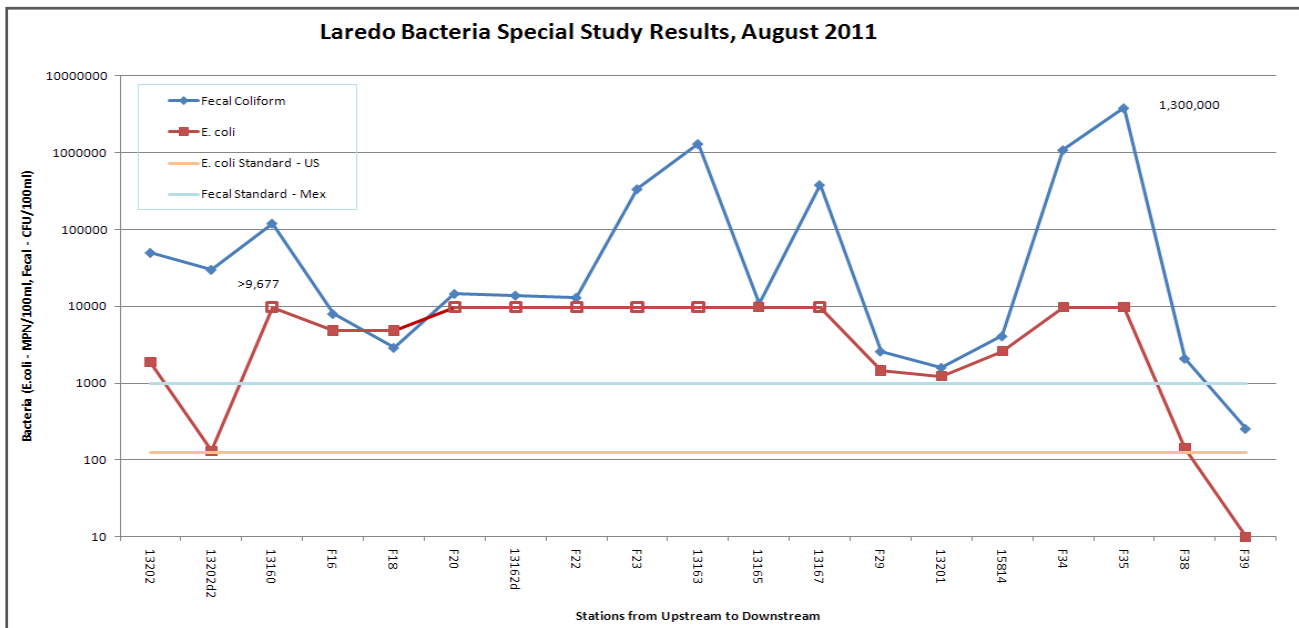


Figure 10 Bacteria Results from August sampling events, from upstream to downstream

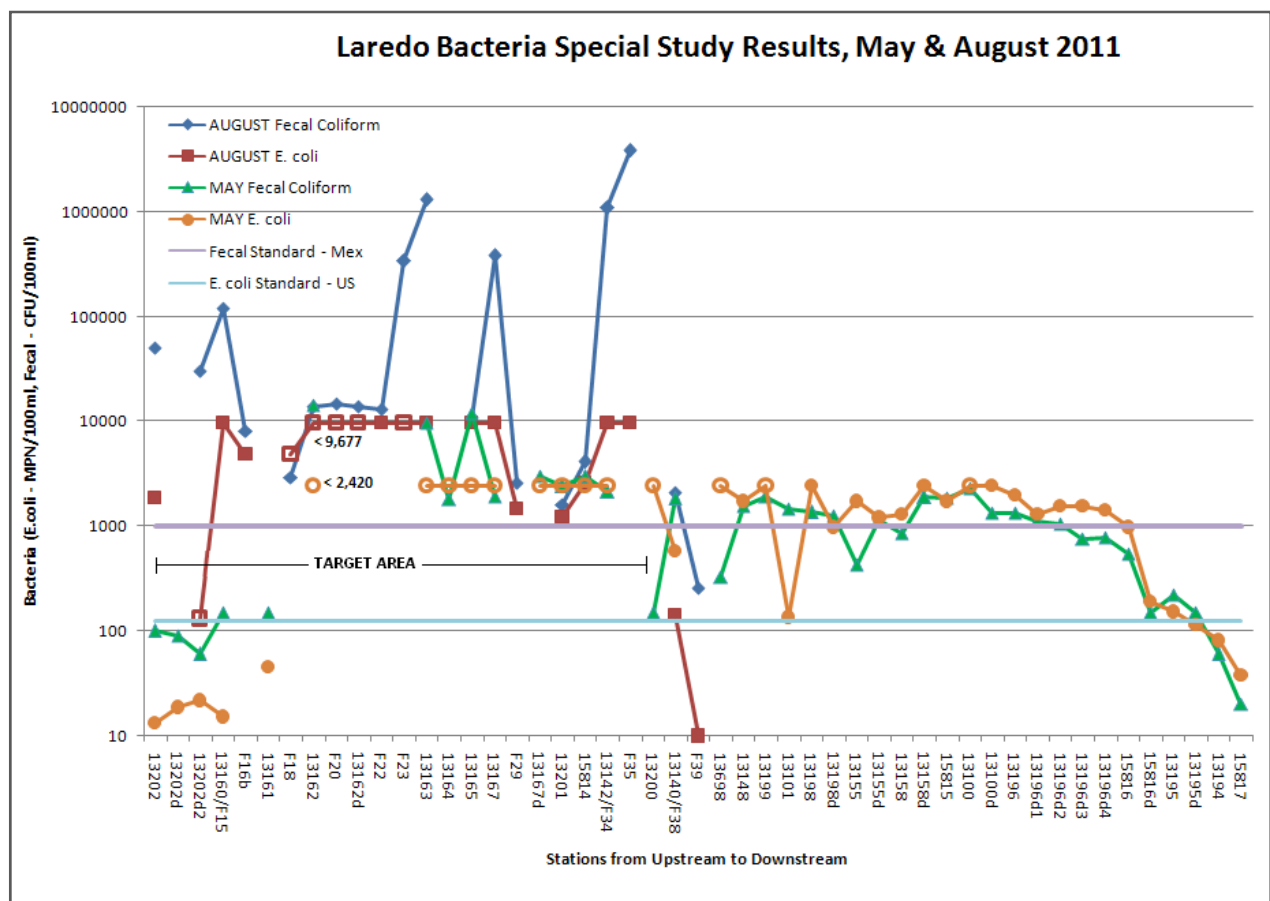


Figure 11 Bacteria Results from both May and August sampling events, from upstream to downstream

(Figures 10 and 11 shown larger as Figures B.2 and B.3)

4. DISCUSSION

4.1 Discussion of Bacteria Values

Table 1 lists the Texas and Mexican standards for bacteria in the Rio Grande. As seen in Figure 6 in the previous section, 80% of *E. coli* values collected in the study from the May samples were above the Texas standard for contact recreation, and 58% of fecal coliform values from May samples were above the Mexican standard for bacteria. In August, 85% of *E. coli* values were above the Texas standard for contact recreation, and 95% of fecal coliform values were above the Mexican standard for bacteria.

The bacteria values for the features of concern, listed in Table 2, show that the Feature 39, the Zacate Creek WWTP outfall, in the U.S., had low bacteria, and this drain is eliminated as a likely cause of bacteria in the river. The other drain in the U.S. (Feature 29) had bacteria levels above both U.S. and Mexican standards, but had much lower bacteria levels than other drains tested. This stormwater drain was not discharging at the time of sampling.

Feature 24 was the beginning of a large set of three islands separating U.S. and Mexican banks. Several sites in the sampling plan were located at historical drains on the Mexican side, but the channel on the Mexican side was impassible. Bacteria values between the islands at F24 and Station 13167 were some of the highest but the bank opposite the islands was not surveyed. Water between the islands is slow-moving and could harbor bacteria, therefore bacteria values at these sites may be biased high; however, with fecal coliform counts of 1,300,000 #/100ml and 380,000 #/100ml, respectively, both island inlets are a hazard to human health and merit further investigation.

Regarding the bacteria values collected in August, one note is that bacteria values from the river samples appear to have been significantly affected by rainfall-runoff from upstream rain events. Figure 12 shows precipitation at the IBWC gages at Del Rio (200 miles upstream of Laredo) and Eagle Pass (136 miles upstream of Laredo) as well as the river flow at Eagle Pass and Laredo gages. Figure 12 indicates that four days prior to the August 15 sampling event, a four-inch rainfall occurred in Del Rio upstream of Laredo which caused the flows to crest in Eagle Pass on August 12 and in Laredo on August 14. There was no recorded rainfall in Laredo. Base bacteria values at the “control point” at the Jefferson intake (Station 13202) were 50,000 #/100 ml; since bacteria values are usually low at this site we can conclude that the Del Rio and Eagle Pass rain events could have affected the bacteria in the river in Laredo, and river samples collected on August 15 appear to impacted by the runoff with higher bacteria values. However, since most of the August samples were collected at point sources, we assume that the runoff in the river did not impact the bacteria measured at discharges since there was no rainfall in Laredo.

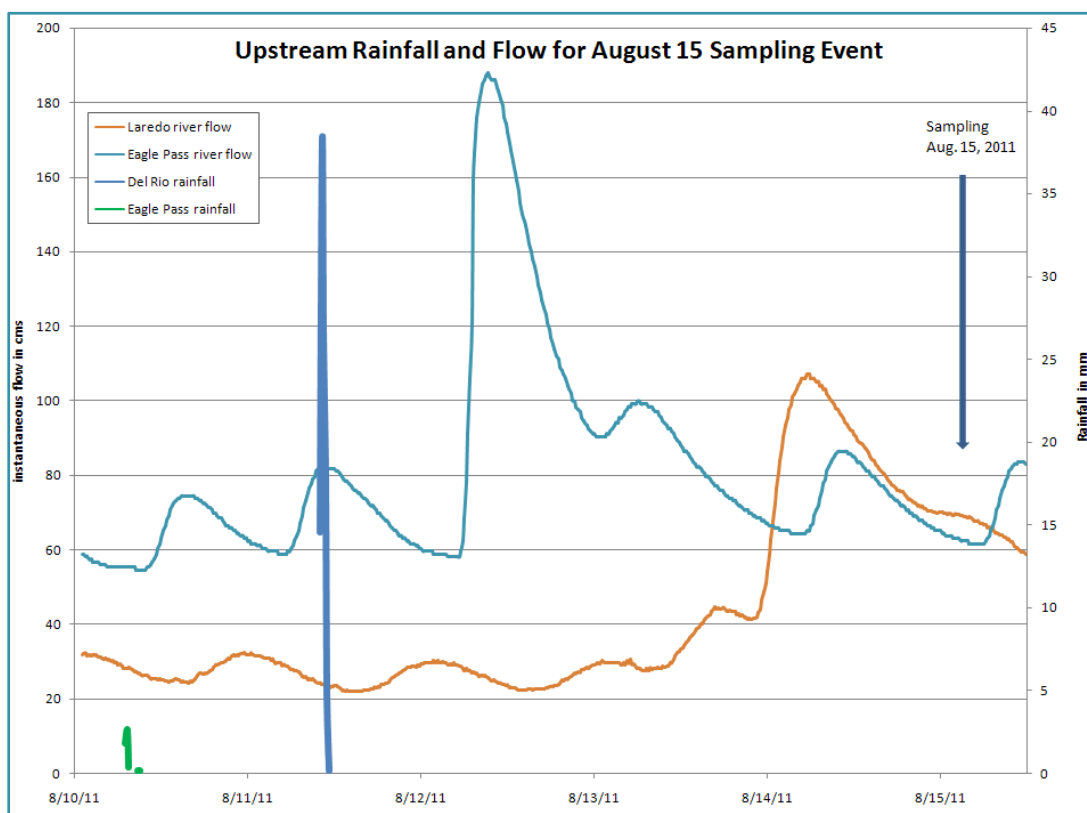


Figure 12 Rainfall and Flow for August 15 Sampling Event

4.2 Discussion of Wastewater Treatment Plants

Three wastewater outfalls from the U.S. enter the Rio Grande in our study area. Zacate Creek WWTP is the only plant in the Target Area. As discussed previously, the Zacate Creek WWTP (F39) had low bacteria counts (10 #/100ml *E. coli* and 256.2 #/100ml fecal coliform) during the August sampling. River samples from the May sampling event were high upstream of the Zacate Creek WWTP. However, it is of note that the Zacate Creek WWTP has had effluent violations in the past two years ^[1].

Alternatively, bacteria counts nearly doubled from above to below the City of Laredo Southside WWTP, with *E. coli* values upstream of the plant at Station 13158 at 1,299.7 #/100ml and values below the plant at Station 13158d at 2,419.2 #/100ml. The Southside WWTP has also had effluent violations in the past two years ^[1].

River samples at and below the Webb County Regional WWTP (Stations 13196d3 and 13196d4) were also high (*E. coli* values of 1553.1 #/100ml and 1413.6 #/100ml, respectively). The Regional WWTP has also had effluent violations in the past two years ^[1].

Although all three plants have had effluent violations in the past two years, because Zacate Creek WWTP had extremely low bacteria values during this study, we can conclude that Zacate Creek WWTP may not be contributing to the bacteria levels in the river, but the Southside and Regional plants may be contributing and should be investigated further. Both the Southside and Regional plants discharge downstream of the Target Area of this study and therefore were not part of the focus of the study.

There is one wastewater treatment plant in Mexico that discharges into our study area, the NLIWTP. IBWC Minute No. 279 sets effluent standards for the NLIWTP, including a limit of 200 #/100ml for fecal coliform. International data exchange shows that the NLIWTP treatment plant is currently meeting all effluent standards set in Minute No. 279 ^[17, 20]. According to data from Mexico, the average fecal coliform count for 2009 to 2011 was 33 #/100ml, well below the limit ^[17, 20]. Figure 2 also shows that NLIWTP effluent is not contributing to high bacteria in the river.

The NLIWTP currently discharges into Arroyo Coyotes downstream of Nuevo Laredo. Samples from this study in the May sampling event indicate that both *E. coli* and fecal coliform bacteria levels are high at the site collected at Station 13100 at the mouth of Arroyo Coyotes (> 2,420 #/100ml *E. coli* and 2,300 #/100ml fecal coliform) as well as at Station 13100d below the treatment plant (2,419.2 #/100ml *E. coli* and 1,340 #/100 ml fecal coliform). Since effluent samples are well below this, the bacteria could be coming from upstream of the plant in the Arroyo Coyote, but this could not be confirmed in this study.

It is important to note that all wastewater treatment plants in this area, both in the U.S. and Mexico, are discharging downstream of the historically measured peaks in bacteria, as well as the spike measured from the August sampling. Although some of the plants could be contributing to bacteria levels of the river, none of the wastewater outfalls are the cause of high bacteria upstream of Bridge II (Station 15814).

4.3 Discussion of IBWC Minute No. 279

Both the feature survey and the results of bacteria from August samples at the drains of concern discussed previously indicate that the contamination in the Rio Grande is likely coming from six drains in Mexico.

IBWC Minute No. 279 and its associated Joint Report of Engineers, both from 1989, documented almost three dozen stormwater drains in Nuevo Laredo which bypass sewage into the Rio Grande ^[5, 10]. These drains were slated to have been disconnected from the stormwater system with the construction of the Riverside Collector in the IBWC Nuevo Laredo Sanitation Project, eliminating untreated discharges into the river. Discussions with Mexico indicate that many of the untreated discharges documented in Minute No. 279 have been eliminated or connected to the sewer system in Nuevo Laredo. However, some drains still exist and could be some of the features surveyed in the May 2011 survey for this study. Table 3 lists the similar features surveyed in May. The names of the

drains, which are listed in Minute No. 279, come from the street in Nuevo Laredo which the drain parallels.

One of the drains that is of most concern for water quality is Feature 23, America Drain, which is discharging a very large flow (visual estimate of 0.1 cubic meters per second) of discolored water with extremely high bacteria (336,000 #/100ml) as well as high nutrients, BOD/COD, and the lowest DO value of all sites measured.

Table 3. Drains Surveyed in Mexico with association to Minute 279 Drains

CRP Study FeatureID	Possible Correlated Drain	Minute 279 Drain Number (page 30)	Fecal Coliform Bacteria Count
Feature 15	Arroyo La Joya	1	120,000 #/100ml Fecal Coliform (FC)
Feature 16b	Arroyo Las Alazanzas	2	8,000 #/100ml FC
Feature 18	Monterrey Drain	3	2,900 #/100ml FC <i>(sample diluted with river water and could be biased low)</i>
Feature 20	NA	NA	14,600 #/100ml FC
Feature 22	NA	NA	13,000 #/100ml FC
Feature 23	America Drain	4	336,000 #/100ml FC
Feature 24	Entrance to island below America Drain	Below 4	1,300,000 #/100ml FC
Station 13167	island inlet below Drain Abasolo	5	380,000 #/100ml FC
Feature 34b	Jesus Carranza Drain	10	1,080,000 #/100ml FC
Feature 35	PJ Mendez Drain	11	3,800,000 #/100ml FC
Feature 37	20 de Noviembre Drain	12	No bacteria collected (below Target Area)
Feature 49	5 de Febrero	21 or 22	No bacteria collected (below Target Area)
Feature 51	Campeche Stormwater Drain	23	No bacteria collected (below Target Area)

Note: Sources for drain names and approximate locations [5], [10], and [16]

4.4 Discussion of Chemical Analysis

Many of the drains that were targeted for additional monitoring during the August sampling event had high values of other parameters in addition to bacteria. Feature 20 appears to be a very large stormwater drain which had a high salt content. Feature 39, the Zacate Creek WWTP outfall in Laredo, had extremely low values of bacteria but nutrient values were the second-highest of all the twelve drains with chemical analysis. In addition, TDS values were slightly above Texas standard

(Table 5). Table 4 lists the drains with values of various parameters that have values exceeding threshold values listed in Tables 5 to 8. The sources of the drains are unknown to the study research team.

Tables 6 and 8 list screening levels and indicators in both countries ^[2, 4, 18]. Seventy-five percent of drains had ammonia levels higher than the Texas screening level and half had total phosphorus above screening levels. Table 7 lists Mexican standards for water quality parameters other than bacteria ^[7].

Table 4. Sites of concern for non-bacteria parameters		
Feature ID	Parameters that exceed threshold values	Country
Feature 15	DO, BOD, COD, ammonia, TKN	Mexico
Feature 18	BOD, COD, ammonia	Mexico
Feature 20	TDS, Sulfate, Chloride	Mexico
Feature 22	TSS	Mexico
Feature 23	DO, TDS, BOD, COD, ammonia	Mexico
13167	DO	River in between islands
Feature 35	DO	Mexico
Feature 39	BOD, COD, TKN, ammonia	U.S.

Table 5. Texas Surface Water Quality Standards for non-bacteria parameters						
Segment	Uses	Parameter Criteria				
		Chloride	Sulfate	Total Dissolved Solids	Dissolved Oxygen	pH
Segment 2304 Rio Grande below Amistad Dam	Primary Contact Recreation High Aquatic Life Public Water Supply General Use (including Irrigation)	200 mg/l	300 mg/l	1,000 mg/l	5.0 mg/l or higher	6.5 to 9.0

Table 6. Texas Screening Levels for Nutrients

Nutrient	Screening Level
Ammonia	0.33 mg/l
Nitrate + Nitrite	1.95 mg/l
Total Phosphate	0.69 mg/l
Chlorophyll-a	14.1 µg/l

Table 7. Mexico's Effluent Standards for National Waters

Parameter (in mg/l)	Rivers					
	Irrigation		Urban Public Use		Aquatic Life	
	Monthly	Daily	M	D	M	D
Total Nitrogen	40	60	40	60	15	25
Total Phosphorus	20	30	20	30	5	10
TSS	150	200	75	125	40	60
BOD	150	200	75	150	30	60
Oil and Grease	15	25	15	25	15	25
Floating Material	absent	absent	absent	absent	absent	absent

Table 8. Mexican Water Quality Indicators for BOD and COD

BOD		COD	
BOD ≤ 3	Excellent	COD ≤ 10	Excellent
3 < BOD ≤ 6	Good	10 < COD ≤ 20	Good
6 < BOD ≤ 30	Acceptable	20 < COD ≤ 40	Acceptable
30 < BOD ≤ 120	Contaminated	40 < COD ≤ 200	Contaminated
BOD > 120	Strongly Contaminated	COD > 200	Strongly Contaminated

4.5 Discussion of Current Projects Improving River Conditions

There are several current projects in both countries, either in planning or construction phases, which will result in improved conditions on the river. These projects are described below and listed in Table 9.

The City of Laredo Utilities Department is improving and expanding both water and wastewater plants in Laredo. The City of Laredo received funds from the American Recovery and Reinvestment Act to upgrade the Jefferson Water Plant as well as several waterline replacements. Grants and bonds are also allowing the city to expand various wastewater treatment plants throughout the city and close the Zacate Creek WWTP by 2015 ^[21].

According to the Municipal Commission for Water and Wastewater (COMAPA) in Nuevo Laredo, the drainage network in Nuevo Laredo dates back to 1923 and integrates stormwater and wastewater. In 1989, Nuevo Laredo had a population of 220,000 inhabitants and the city produced up to 1,000 liters per second (lps) of untreated discharges to the Rio Grande. In 2000, after over \$60 million in improvements, the sanitary system covered 87% of the city and had reduced the untreated flows to 185 lps ^[12]. However, increases in demands on infrastructure increased untreated flows to 400 lps by 2008. Additional \$25 million in infrastructure improvements helped reduced these untreated flows down to 295 lps in 2009 and further down to 165 lps in 2011. Additional planned projects for 2012 will decrease the untreated flows to the Rio Grande to 126 lps ^[12].

There are three projects in Nuevo Laredo and Laredo being funded by the North American Development Bank (NADB) and certified by the Border Environment Cooperation Commission (BECC). These projects are currently addressing many of the untreated discharges entering the Rio Grande from Mexico. In addition, personnel from the BECC stated that a fourth project is in the planning phase, which includes the second phase of the wastewater collection improvement project in Nuevo Laredo and would consist of disconnecting additional drains from stormwater systems; these drains could be features documented in this project and listed in Tables 2 and 3 ^[12-17].

According to Mexican officials, the completion of these projects will have 98% of Nuevo Laredo connected to sanitation infrastructure and eliminate most untreated discharges entering the Rio Grande ^[16].

Table 9. Current Projects in the Laredo/Nuevo Laredo area

Location	Project Name	Project Description	Project Cost and Funding Source	Estimated Completion Date
Laredo	City of Laredo Wastewater Infrastructure Improvement	Sewer Rehabilitation & Contingency Sewer Breaks; Manadas Creek WWTP 3 MGD upgrade; South Laredo WWTP 6.0 MGD Expansion (Bond 2008 - \$3,000,000); Sombreretillo Creek WWTP - 3 MGD (Verde Corp & Pico Ranch); Laredo Colombia WWTP - 60,000 gpd expansion; Elimination of Zacate Creek WWTP	\$62 million, various funding sources including Texas Water Development Board and Bonds	2012-2015
Laredo	City of Laredo Water Infrastructure Improvements	Upgrade processes and electrical components at the Jefferson Water Plant, as well as replace waterlines and upgrade pump stations throughout Laredo	\$50 million Funded by American Recovery and Reinvestment Act, Texas Water Development Board, and Bonds	2012 -2015
Laredo	Improvements to the Water and Wastewater Services in 15 Colonias in Laredo and Webb County, Texas	Expansion of the water distribution lines and wastewater collection lines as well as the construction of booster stations and storage facilities to service the 15 colonias surrounding Laredo.	\$21.6 million 36% funded by NADBank	September 2012
Nuevo Laredo	Improvements to the Water and Wastewater Collection and Treatment Systems	First phase water and wastewater system improvements which include expansion of the water treatment plant, construction of a ground water storage tank, and installation of water distribution lines and residential meters, as well as construction of a new wastewater treatment plant, collectors and sewer lines.	\$57.7 million 44% funded by NADBank	August 2010
Nuevo Laredo	Comprehensive Storm Sewer Project	Construction of a new storm drainage system, consisting of six storm sewer collectors and a storm water channel.	\$44.3 million 50% funded by NADBank	Unlisted

Source: [11]

Table 10. COMAPA Stormwater Drains to be Disconnected from Untreated Discharges

Drain to be Disconnected	Possible Study Feature ID addressed	Project Cost	Untreated Flow Eliminated from the Rio Grande
Niños Heroes	Features 23 and 24	\$12.6 million	126 lps
Lincoln Drain	None	\$5.3 million	6 lps
20 de Noviembre	Feature 37	\$2.5 million	2.14 lps
Guatemala	None	\$18.5 million	18
Monterrey	Feature 18	\$7.5 million	73.3 lps
V Carranza/ 5 de Febrero	Feature 49	Not listed	Not listed

Source: [12], [13], and [16]

4.6 Discussion of Top Features of Concern and Which are Being Addressed

The top features of concern which are likely causing the high levels of bacteria in the Rio Grande are listed in Tables 2, 3, and 4. This study documented the following regarding these features of concern:

1. There were 2 U.S. drains in the Target Area (F29 and F39) which were included in the analysis in August. F29 was not discharging so the sample collected at this site was more representative of river water and impacts from upstream features. F39 did not have high bacteria but did have nutrient issues. Neither feature is likely contributing to high bacteria in the river.
2. There were 10 confirmed drains or discharges in Mexico (6 of which have confirmed high bacteria). Only 6 of these 10 drains in Mexico had bacteria samples collected (F18, F20, F22, F23, F34b, and F35). This study confirms that all 6 of those drains in Mexico had high bacteria. Bacteria samples were not collected at the 4 remaining confirmed discharges in Mexico (F37, F49, F51, and F57). Bacteria values in the river below F37 include Station 13200 and 13698, both of which had *E. coli* values > 2,420 #/100ml. Bacteria values in the river doubled from above to below F49 (Station 13198d with an *E. coli* value of 980.4 #/100ml and Station 13155 with an *E. coli* value of 1,733 #/100ml). F51 lies between Station 13155 and Station 13155d, and *E. coli* values in the river below F51 decreased but fecal coliform increased. F57 lies between Station 13155d and Station 13158, but no significant change was detected between. From this data, F37 and F49 may be more significant drains to address of the 4 at which bacteria values were not collected.
3. There were 2 tributaries in Mexico which had high bacteria and should be investigated further (F15 and 16b).
4. An extremely high bacteria sample was collected between islands where crews could not sample on the bank (F24) and should be investigated further.
5. The two U.S. wastewater outfalls beyond the Target Area could have a slight negative impact on the river and should be investigated further. The Southside plant is currently undergoing an expansion project.
6. Possible discharges into Arroyo Coyotes upstream of NLIWTP effluent in Mexico should also be evaluated.

According to Table 10 and the information above, current projects in Mexico are likely addressing 4 of the 10 confirmed discharges (F18, F23, F37, F49), including 3 of the 6 drains with high bacteria discussed in point 2 above. The drain of the biggest concern to the study participants was F23, America Drain, which appears to be addressed by the Niños Heroes drain disconnection. This project will also likely address any drain near F24.

4.7 Additional issues identified during study

The research team documented a large amount of trash throughout the study area on both banks. Arroyos and tributaries were lined with trash. Some debris was clearly from the 2010 floods since it was hanging in trees, but most of the trash was not flood debris. One area of concern is El Cenizo, on

the U.S. side, which has cliffs that are being used for illegal trash dumping. Trash issues are listed in Appendix D from upstream to downstream.

5. CONCLUSION

This project collected a total of 118 bacteria samples and documented 115 features in the 27-mile study area. The study also documented 6 discharges that were probable causes of the high bacteria, all of which originate in Mexican territory. The study documented an additional 7 possible drains or discharges in Mexico and that could also contribute but were not confirmed. The data in this study point to the probable cause of high bacterial contamination in the river as being attributed to untreated wastewater flowing into stormwater systems in Nuevo Laredo. However, many of these point sources are being addressed by current wastewater and stormwater infrastructure projects in Mexico. The area downstream of the Target Area may have additional sources of bacteria but were not investigated fully. Additional areas for future investigation are documented in the previous section under "4.6 Discussion of Top Features of Concern."

6. RECOMMENDATIONS

The International Boundary and Water Commission, U.S. Section is in communications with the Mexican Section regarding the results of this study. IBWC Minute No. 297 recommends that both Sections work together to continue to address sanitation in the Laredo/ Nuevo Laredo area ^[8]. Currently funded projects under construction are already addressing some drains documented in this project and will likely lead to improvements in water quality upon completion.

The study research team recommends continued monitoring of the documented drains of concern to verify that projects slated to eliminate discharges into the Rio Grande will be effective in decreasing bacterial contamination into the Laredo/ Nuevo Laredo stretch of the river. The research team also recommends further analysis, in the form of a binational study, to verify some discharges that could not be verified in this study. Binational studies are particularly important due to the international nature of the discharges. IBWC should be the lead agency on future binational studies in the Laredo/Nuevo Laredo area.

The study research team also recommends that local communities and regulatory entities in both countries pursue the trash issues documented in this study.

Lastly, the research team recommends that results from this study be used to support additional infrastructure projects to address drains that are not in current projects, or in the event that the planned projects are not sufficient to reduce contamination, in order remove this section of river from the Texas list of impairments and ensure the health and safety of recreational users and aquatic life.

7. SOURCES

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Appendix A

Results from May and August 2011 Sampling Events

Table A.1 – Bacteria and Field Results from the May sampling event

Station ID	QAPP ID, if different	Station Name	Station NUM	POINT_X	POINT_Y	Date	Time	Water Temp	pH	D.O.	Spec . Cond	Days since rain	Flow	Flow Method	Weather	G T L T	E. coli	Fecal Coliform	Field Comments	Lab Comment
13202		RG at Jefferson St Plant	1	-99.5254	27.52264	5/19/11	8:50	26.13	8.18	6.75	972	4			3		13.2	100.0		
13202d1		RG 0.5 mile downstream of 13202	2	-99.5225	27.51993	5/19/11	9:01	26.18	8.16	6.91	973	4			3		8.7	90.0	taken too far north	
13202d2		RG 1 mile downstream of 13202	3	-99.5255	27.51883	5/19/11	9:25	26.15	8.15	6.95	974	4			3		21.8	60.0	taken too far north	
13160		RG at Mexican Tributary La Joya	4	-99.527	27.5049	5/19/11	10:00	26.21	8.16	6.99	975	4			3		15.2	150.0		
13161	13162	RG Just below Mexican Tributary Las Alanzas	5	-99.528	27.499	5/19/11	10:10	26.24	8.14	6.97	976	4			3		45.5	150.0	Foul smell, trash clearly visible on banks of drain	
13162	13162d	RG Just below Avenida Monterrey Drain	6	-99.527	27.497	5/19/11	10:22	26.28	8.13	6.86	982	4			3	>	2,420	14,200	slight foul smell, large waterfall coming into river, two large trashpiles right on bank. Large concrete pipe a little downstream.	
13163		RG Below Avenida Americas Drain	7	-99.5196	27.497	5/19/11	10:40	26.38	8.14	7.25	981	4			3	>	2,420	9,600.0		
13164		RG 0.1 mi upstream of railroad bridge	8	-99.518	27.497	5/19/11	10:49	26.37	8.13	7.02	981	4			3	>	2,420	1,800.0	no drain visible. Large land island divides the river. Mex side not visible.	
13165		RG Immediately below Railroad Bridge	9	-99.516	27.498	5/19/11	11:05	26.39	8.13	7.02	981	4			3	>	2,420	11,960.0	no drain visible.	
13167		RG 0.3 miles downstream of 13167	10	-99.515	27.498	5/19/11	11:18	26.46	8.15	7.26	982	4			3	>	2,420	1,930.0	large drain	
13167d		RG 0.2 mi upstream of Bridge 1	11	-99.511	27.499	5/19/11	11:26	26.5	8.14	7.14	983	4			3	>	2,420	2,980.0	drain closely upstream	
13201	13167d	RG at Bridge I	11b	-99.5076	27.49969	5/19/11	12:00	26.88	8.16	7.4	984	4			3	>	2,420	2,390.0	Bridge I	
15814		RG at Bridge II	12	-99.5072	27.49945	5/19/11	12:28	26.81	8.14	7.35	986	4			3	>	2,420	2,970.0	Bridge II	
13142		RG 0.1 mi below Bridge II	13	-99.5009	27.499	5/19/11	12:37	26.86	8.14	7.3	986	4			2	>	2,420	2,140.0	site 13 and 14 too close together. May have sampled at 14.	
13200		RG at Azteca Park dock	15	-99.4942	27.49845	5/19/11	13:00	27	8.2	7.87	979	4			2	>	2,420	150.0	15 and 16 switched	
13140		Zacate Creek 70 m upstream of confluence with Rio Grande	16	-99.4941	27.4995	5/19/11	13:06	27.64	8.22	7.34	1120	4			2		579.4	1,830.0	15 and 16 switched	atypical colonies present in FC plates

13698		RG 0.75 mi below Bridge II	17	-99.4914	27.49683	5/19/11	13:22	27.29	8.18	7.31	1017	4			2	>	2,420	330.0		atypical colonies present in FC plates
13148		RG 1.3 mi below Bridge II	18	-99.483	27.492	5/19/11	13:40	27.39	8.17	7.54	995	4			2		1,732.9	1,550.0		
13199		RG 50 m upstream of confluence with Chacon Creek	19	-99.48	27.486	5/19/11	13:57	27.44	8.16	7.54	1001	4			2	>	2,420	1,910.0		
13101		Chacon Creek	20	-99.479	27.486	5/19/11	14:05	29.01	8.24	7.97	1513	4			2		135.4	1,470.0		verified value with Laredo lab
13198		RG 150 yards downstream of Confluence of Chacon Creek	21	-99.479	27.484	5/19/11	14:30	27.65	8.12	7.68	1007	4			2		2,419.2	1,360.0		
13198d		RG 0.5 mi downstream of 13198	22	-99.478	27.478	5/19/11	14:49	27.83	8.18	7.72	1005	4			1		980.4	1,260.0		
13155		RG 1 mi below Chacon Creek (13101)	23	-99.482	27.472	5/19/11	15:05	27.93	8.21	7.66	1006	4			1		1,732.9	430.0		
13155d		RG 0.5 mi downstream of 13155	24	-99.485	27.464	5/19/11	15:24	28.07	8.22		1005	4			1		1,203.3	1,150.0		
13158		RG 2.6 mi downstream of Chacon Creek	25	-99.493	27.451	5/19/11	16:00	28.34	8.28	7.48	1004	4			1		1,299.7	850.0		
13158d		RG 0.7 mi downstream of Laredo NPDES Permit	26	-99.4958	27.43879	5/20/11	9:16	27.64	8.12	6.15	995	5			3		2,419.2	1,890.0	cloudy. Sampled near Santa Rita soccer field.	
15815		RG at Masterson Road in Laredo	27	-99.4928	27.42918	5/20/11	9:42	27.62	8.04	5.95	999	5			3		1,732.9	1,860.0	cloudy. Irrigation intake E. bank (US)	
13100		Arroyo el Coyote Mexican Tributary 1 meter upstream of the confluence with the Rio Grande	28	-99.4904	27.41834	5/20/11	10:05	28.88	7.84	6.88	1825	5			3	>	2,420	2,300.0	cloudy. At mouth of creek.	atypical colonies present
13100d		Downstream of NLIWTP	29	-99.4882	27.41474	5/20/11	10:53	27.79	8.05	6.16	1004	5			3		2,419.2	1,340.0	cloudy. Couldn't locate NIWTP outfall. Sampled downstream.	atypical colonies present
13196		RG at Pipeline Cross 8.7 mi downstream of Laredo	30	-99.4889	27.40349	5/20/11	11:10	27.72	7.97	6.04	1017	5			3		1,986.3	1,330.0	pipe opening noted on E (US) bank	atypical colonies present
13196d1		RG 1 mile downstream of 13196	31	-99.4926	27.38949	5/20/11	11:33	27.8	7.95	5.87	1030	5			3		1,299.7	1,110.0	just upstream USBP camera tower and a pipe going into river	
13196d2		RG 2 miles downstream of 13196	32	-99.496	27.37527	5/20/11	11:53	27.85	7.93	5.9	1030	5			2		1,553.0	1,060.0	sampled just upstream of large island bifurcating river	atypical colonies present
13196d3		RG at Webb County Water Utilities Intake	33	-99.5022	27.36686	5/20/11	12:34	28.15	7.99	6.06	1032	5			2		1,553.1	750.0	latitude about 27.371 jst upstream of this sample site had ww effluent odor. Probably was outfall	atypical colonies present

																			discharge from webb co WWTP?	
13196d4		RG 1 mile downstream of Webb Intake	34	-99.5079	27.35217	5/20/11	13:00	28.16	7.94	5.98	1031	5			2		1,413.6	780.0		atypical colonies present
15816		RG at Rio Bravo 0.5 km downstream of the Community of El Cenizo	35	-99.5081	27.33477	5/20/11	13:31	28.28	7.93	5.77	1033	5			2		980.4	540.0	sampled near fence and shed on E (US) bank. fire scorched area on w (Mex) bank	atypical colonies present
15816d		RG 1 mile downstream of 15816	36	-99.5201	27.32549	5/24/11	8:28	28	6.82	6.63	1063				2		191.8	150.0	very windy, south winds	atypical colonies present
13195		RG near Isla Mestno at Irrigation Pump 350 meters downstream of Isla Mesteno	37	-99.5377	27.31619	5/24/11	8:59	28.03	7.25	5.68	1065	7			2		152.9	220.0		atypical colonies present in FC plates
13195d		RG 1 mile downstream of 13195	38	-99.5262	27.30469	5/24/11	9:25	28.02	7.41	5.97	1064				2		113.7	150.0		atypical colonies present in FC plates
13194		RG at San Isidro pump Station	39	-99.4941	27.26743	5/24/11	11:22	28.66	7.71	6.7	1066	7			1		81.0	60.0	south wind	atypical colonies present in FC plates
15817		RG at Webb/Zapata County Line	40	-99.4535	27.26492	5/24/11	12:53	29.11	7.74	7.63	1075	7			1		38.9	20.0		atypical colonies present in FC plates

Table A.2 – Bacteria and Field Results from the August sampling event

Lab ID	SiteDesc	SiteID	Date	Time	Latitude	Longitude	Water Temp	pH	D.O.	Spec. Cond.	Days since PPT	Flow	Flow Measurement Method	Weather	GTLT	E. coli	Fecal Coliform
B1	Jefferson Street Intake	13202	8/15/11	8:13 AM	27.52259	-99.5254	29.3	8.2	6.05	985	4			1		1,868	50,000
B2C1	1 mile downstream of 13202	13202d2	8/15/11	8:33 AM	27.50888	-99.5258	29.29	8.24	6.13	986	4			1		131.4	30,000
B3C2	unnamed Mexican tributary	F15	8/15/11	8:44 AM	27.50456	-99.5276	29.58	8.01	3.55	1,240	4			1	>	9,676.8	120,000
B4C3	Mexican tributary	F16	8/15/11	8:54 AM	27.49941	-99.5287	29.41	8.12	4.98	1,113	4			1		4,838.34	8,000
B5C4	Drain on stone with waterfall, Mex	F18	8/15/11	9:03 AM	27.49745	-99.5278	29.34	8.17	5.62	995	4			1		4,838.34	2,900
B7C6	large cement structure drain, Mex	F20	8/15/11	9:18 AM	27.49626	-99.5258	29.67	8.23	5.5	1,439	4			1	>	9,676.8	14,600
B8	0.5 mile downstream of 13162	13162d	8/15/11	9:28 AM	27.49626	-99.5247	29.39	8.19	5.96	996	4			1	>	9,676.8	13,900
B9C7	small tributary or drain, Mex	F22	8/15/11	9:42 AM	27.49634	-99.5214	29.41	8.18	5.77	994	4			1	>	9,676.8	13,000
B10C8	cement chute drain, Mex	F23	8/15/11	9:46 AM	27.49639	-99.5207	32.61	8.2	0.57	1,407	4			1	>	9,676.8	336,000
B11	In island Below NL water treatment plant	F24	8/15/11	9:56 AM	27.49647	-99.5197	29.36	7.95	2.41	1,225	4			1	>	9,676.8	1,300,000
B12	River on other side of island of Avenida Abasolo drain	13165	8/15/11	10:02 AM	27.49797	-99.5172	29.33	8.23	6.14	993	4			1		9,676.68	11,000
B13	Island Inlet on other side of island of Avenida Donato drain	13167	8/15/11	10:07 AM	27.49825	-99.5157	29.13	7.88	3.03	1,102	4			1	>	9,676.8	380,000
B14C9	Stormwater drain, US	F29	8/15/11	10:15 AM	27.49944	-99.5125	29.46	8.15	5.75	997	4			1		1,452	2,600
B15	Bridge I	13201	8/15/11	10:25 AM	27.49988	-99.5075	29.6	8.16	5.92	993	4			1		1,226.2	1,600
B16	Bridge II	15814	8/15/11	10:59 AM	27.50023	-99.5025	29.6	8.15	6.17	991	4	2,324	Gage	1		2,599.3	4,100
B17C10	hidden drain with taffy discharge	F34	8/15/11	11:10 AM	27.49963	-99.5009	29.82	8.15	5.89	1,002	4			1	>	9,676.8	1,080,000
B18C11	hidden drain with murky discharge	F35	8/15/11	11:23 AM	27.49899	-99.4997	30.65	8	4.02	1,107	4			1	>	9,676.8	3,800,000
B19C12	Zacate Creek	F38	8/15/11	11:33 AM	27.49947	-99.4942	29.9	8.16	5.26	1,208	4			1		142.6	2,100
B20C5	Zacate Creek WWTP outfall	F39	8/15/11	11:55 AM	27.4987	-99.4938	33.3	7.6	6.8	1,352	4			1		10	256.2

Table A.3 – Combined Bacteria Results from May and August, from upstream to downstream

Station ID	Date	GTLT	<i>E. coli</i>	Fecal Coliform		GTLT	<i>E. coli</i>	Fecal Coliform
13202	05/19/2011		13.2	100.0	08/15/2011		1,868	50,000
13202d	05/19/2011		18.7	90.0				
13202d2	05/19/2011		21.8	60.0	08/15/2011		131.4	30,000
13160/F15	05/19/2011		15.2	150.0	08/15/2011	>	9,676.8	120,000
F16b					08/15/2011		4,838.34	8,000
13161	05/19/2011		45.5	150.0				
F18					08/15/2011		4,838.34	2,900
13162	05/19/2011	>	2,420.0	14,200	08/15/2011	>	9,676.8	13,900
F20					08/15/2011	>	9,676.8	14,600
13162d					08/15/2011	>	9,676.8	13,900
F22					08/15/2011	>	9,676.8	13,000
F23					08/15/2011	>	9,676.8	336,000
F24					08/15/2011	>	9,676.8	1,300,000
13163	05/19/2011	>	2,420.0	9,600.0				
13164	05/19/2011	>	2,420.0	1,800.0				
13165	05/19/2011	>	2,420.0	11,960.0	08/15/2011		9,676.68	11,000
13167	05/19/2011	>	2,420.0	1,930.0	08/15/2011	>	9,676.8	380,000
F29					08/15/2011		1,452	2,600
13167d	05/19/2011	>	2,420.0	2,980.0				
13201	05/19/2011	>	2,420.0	2,390.0	08/15/2011		1,226.2	1,600
15814	05/19/2011	>	2,420.0	2,970.0	08/15/2011		2,599.3	4,100
13142/F34	05/19/2011	>	2,420.0	2,140.0	08/15/2011	>	9,676.8	1,080,000
F35					08/15/2011	>	9,676.8	3,800,000
13200	05/19/2011	>	2,420.0	150.0				
13140/F38	05/19/2011		579.4	1,830.0	08/15/2011		142.6	2,100
F39					08/15/2011		10	256.2
13698	05/19/2011	>	2,420.0	330.0				
13148	05/19/2011		1,732.9	1,550.0				

13199	05/19/2011	>	2,420.0	1,910.0				
13101	05/19/2011		135.4	1,470.0				
13198	05/19/2011		2,419.2	1,360.0				
13198d	05/19/2011		980.4	1,260.0				
13155	05/19/2011		1,732.9	430.0				
13155d	05/19/2011		1,203.3	1,150.0				
13158	05/19/2011		1,299.7	850.0				
13158d	05/20/2011		2,419.2	1,890.0				
15815	05/20/2011		1,732.9	1,860.0				
13100	05/20/2011	>	2,420.0	2,300.0				
13100d	05/20/2011		2,419.2	1,340.0				
13196	05/20/2011		1,986.3	1,330.0				
13196d1	05/20/2011		1,299.7	1,110.0				
13196d2	05/20/2011		1,553.0	1,060.0				
13196d3	05/20/2011		1,553.1	750.0				
13196d4	05/20/2011		1,413.6	780.0				
15816	05/20/2011		980.4	540.0				
15816d	05/24/2011		191.8	150.0				
13195	05/24/2011		152.9	220.0				
13195d	05/24/2011		113.7	150.0				
13194	05/24/2011		81.0	60.0				
15817	05/24/2011		38.0	20.0				

Table A.4 – Results of chemical analysis from the August sampling event

August Station Name	Station ID	Hard mg/l	TDS mg/l	TSS mg/l	VSS mg/l	Ca mg/l	Mg mg/l	K mg/l	Na mg/l	Cl mg/l	Fl mg/l	Sulf mg/l	NitNit mg/l	Alk mg/l	NH3 mg/l	TKN mg/l	Phos mg/l	Si mg/l	TOC mg/l	Chloro µg/l	Phae µg/l	BOD mg/l	COD mg/l
B2-C1	13202d2	276	675	68	20	80	18.6	5.55	105	170	0.791	182	<.05	132	0.28	4.76	0.105	8.45	5.68	< 3	< 3	7.94	11.6
B3-C2	13160/ F15	328	1160	19	< 4	93.3	23.1	13.4	169	222	0.898	193	<.05	128	24.6	30	4.42	23.8	61.8	< 3	< 3	83.4	130
B4-C3	F16b	272	720	48	8	77.3	19.1	5.31	110	153	0.793	203	0.232	372	1.4	5.88	0.183	8.75	4.89	< 3	< 3	6.97	12.6
B5-C4	F18	282	850	47	7	79.4	20.4	9.29	187	181	1.07	202	1.02	206	15.7	21	2.5	18.3	46.5	< 3	< 3	69	118
B7-C6	F20	2160	9210	18	< 4	489	229	25.2	2820	2410	4.94	4190	4.18	356	1.68	4.35	0.437	11.8	12	16	12	18	31.7
B9-C7	F22	324	715	370	78	99.4	18.3	4.31	94.8	170	1.07	194	2.17	124	1.68	8.12	0.485	8.81	13.9	< 3	< 3	19.8	34.8
B10-C8	F23	331	1580	11	< 4	103	18.1	5.83	110	391	1.16	312	< .05	308	13.4	17.1	2	23.2	33.9	< 3	< 3	50.8	86.2
B14-C9	F29	284	695	57	10	81.3	19.5	5.27	106	171	0.941	184	0.325	128	0.28	3.92	0.095	9.46	5.59	< 3	< 3	8.29	14.1
B17-C10	13142/ F34	264	720	53	9	74.4	19.1	6.7	112	151	0.935	189	2.96	160	7.28	12	0.797	9.5	8.75	< 3	< 3	13	22.2
B18-C11	F35	328	715	16	< 4	97	20.8	8.37	139	182	0.878	179	0.583	188	9.52	14.8	2.61	10.5	12	< 3	< 3	19	32.3
B19-C12	13140/ F38	342	770	26	< 4	95	25.6	7.07	167	191	0.875	220	0.314	132	0.28	5.04	0.112	8.41	5.94	7	< 3	8.89	15
B20-C5	F39	234	1200	17	< 4	88	25.3	15.3	190	286	0.942	272	0.0528	228	25.2	28.8	0.771	18.6	35.1	< 3	< 3	52.2	89.3

Key:

Hard – Hardness

TDS – Total Dissolved Solids

TSS – Total Suspended Solids

VSS – Volatile Suspended Solids

Ca – Calcium

Mg – Magnesium

K – Potassium

Na – Sodium

Cl – Chloride

Fl – Fluoride

Sulf – Sulfate

NitNit – Nitrate plus Nitrate

Alk – Alkalinity

NH3 – Ammonia

TKN – Total Kjeldahl Nitrogen

Phos – Total Phosphorus

Si – Silica

TOC – Total Organic Carbon

Chloro – Chlorophyll-a

Phae – Phaeophytin

BOD – Biological Oxygen Demand

COD – Chemical Oxygen Demand

Appendix B

Graphs of Data

Laredo Bacteria Special Study Results, May 2011

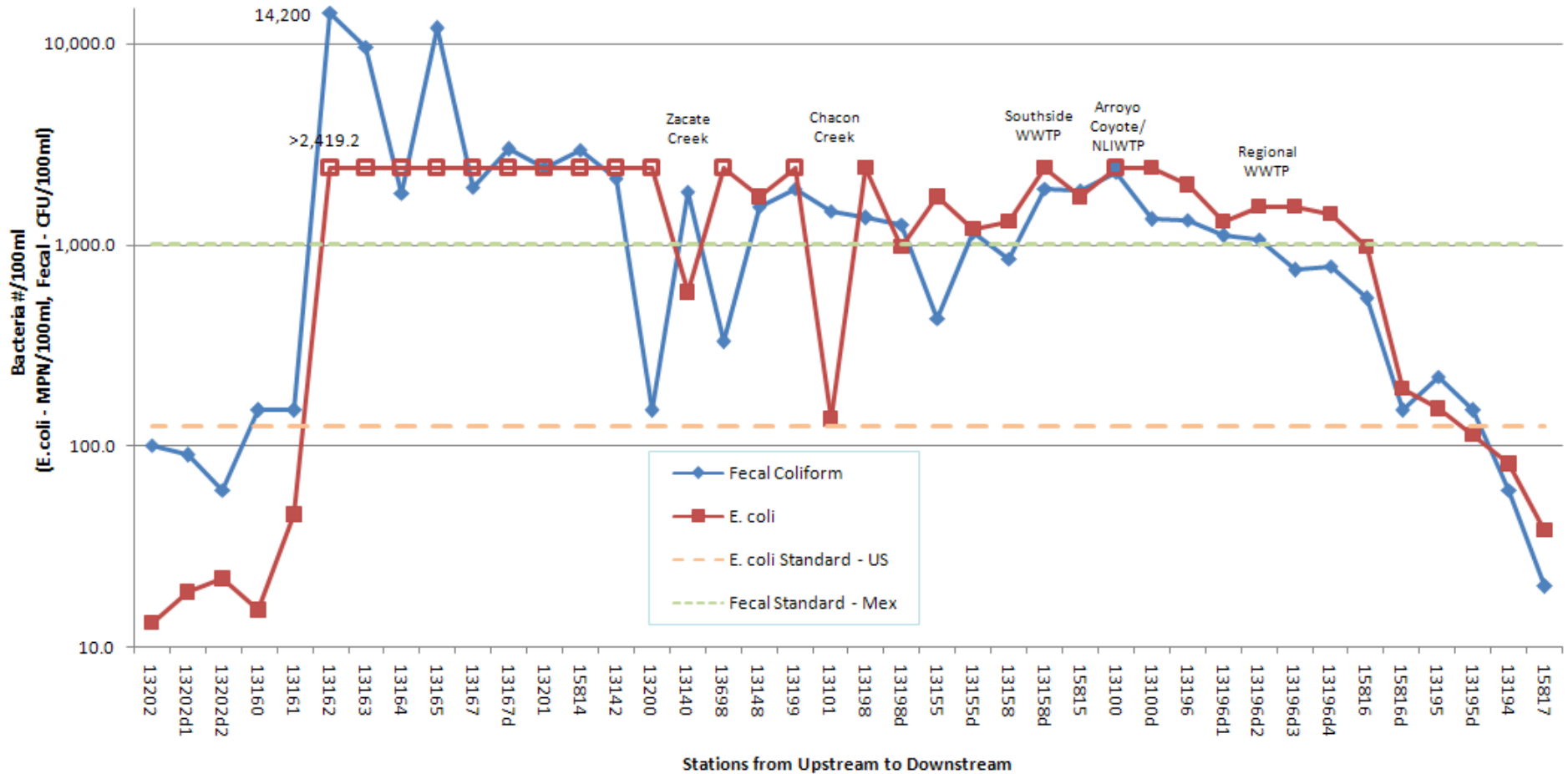


Figure B.1 Graph of Bacteria Results from May 2011 sampling (also Figure 5)

Laredo Bacteria Special Study Results, August 2011

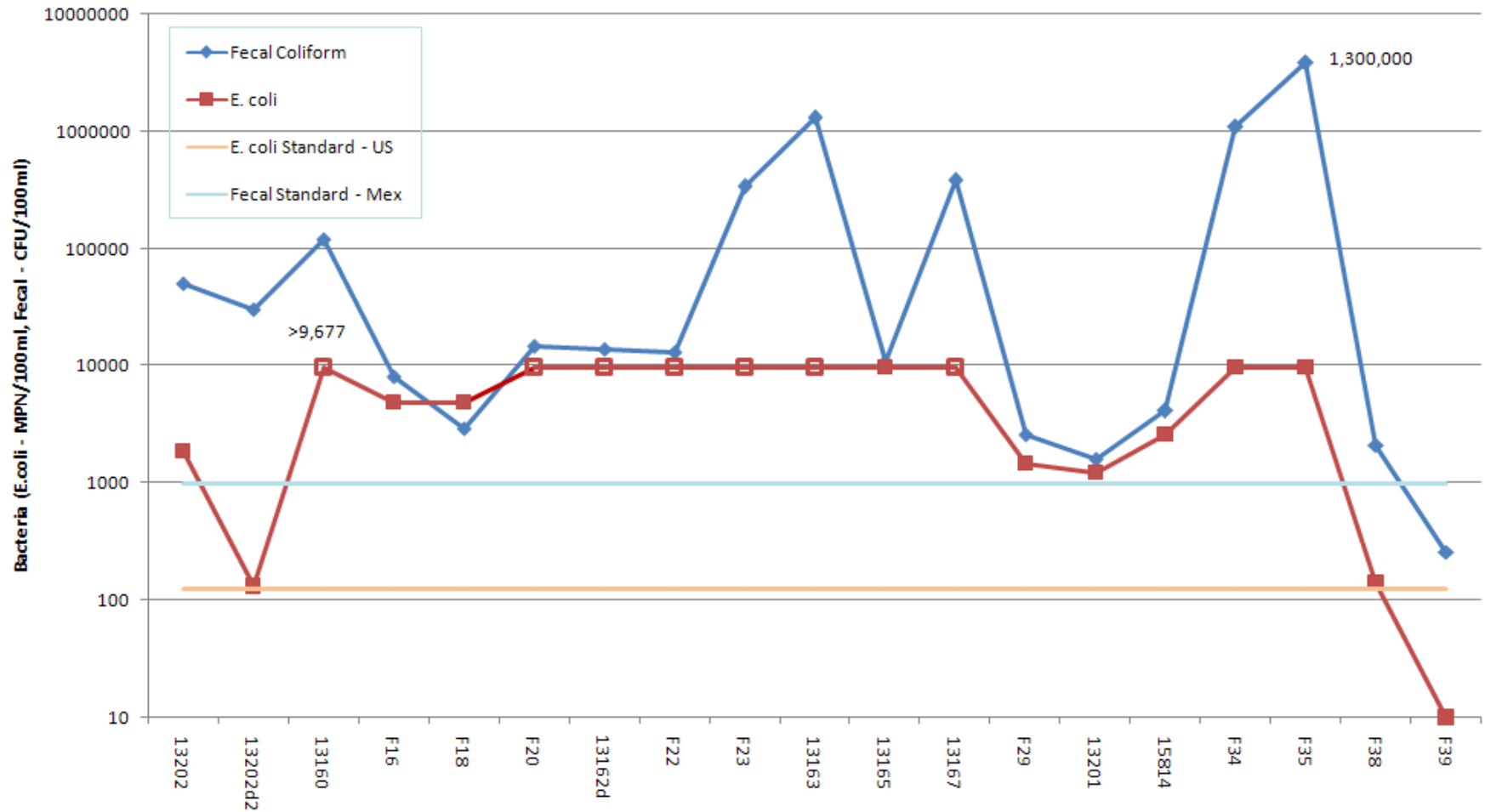


Figure B.2 Graph of Bacteria Results from August 2011 sampling (also Figure 10)

Open square means actual value was greater than that value. Closed square means exact value measured.

Laredo Bacteria Special Study Results, May & August 2011

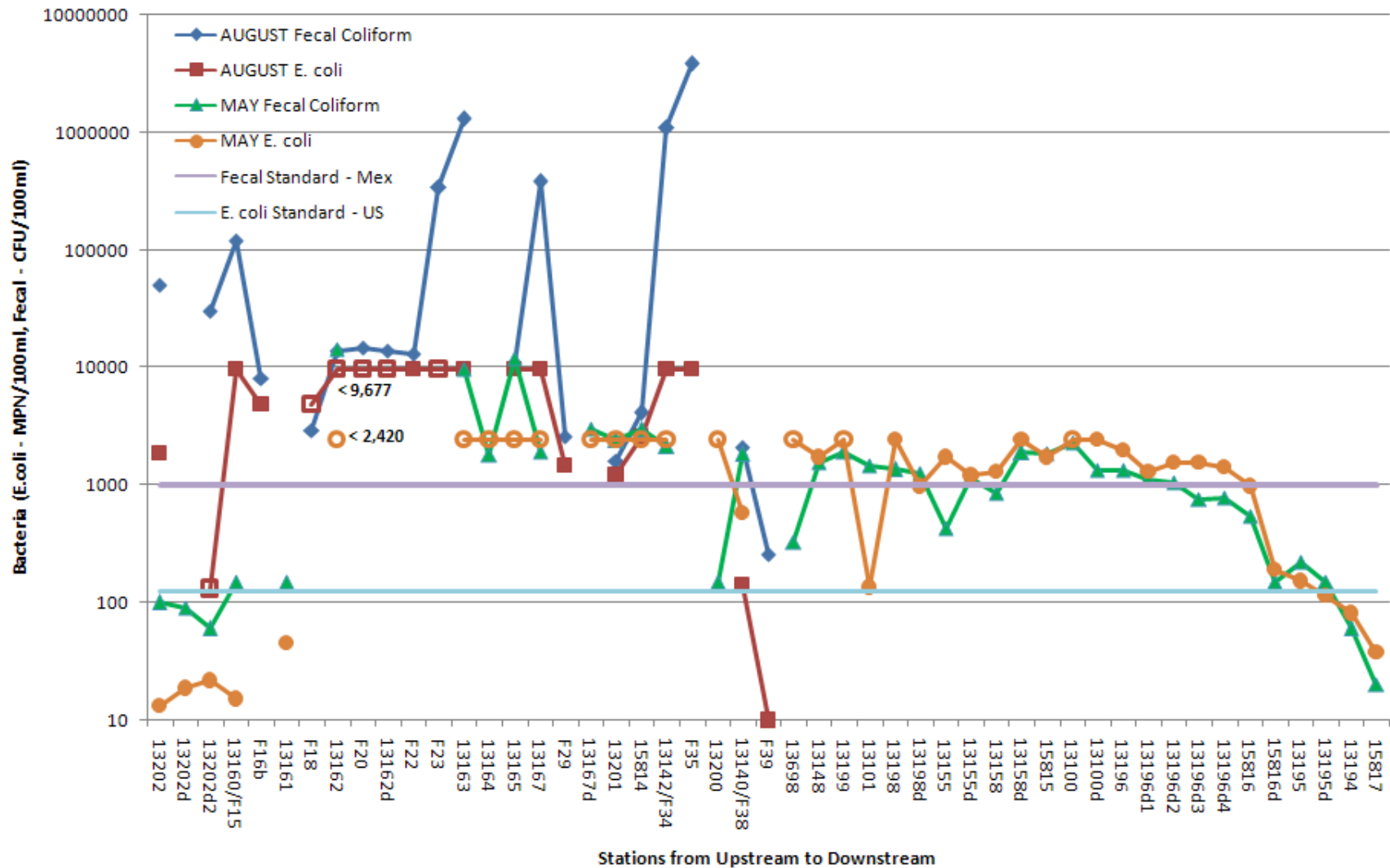


Figure B.3 Graph of Bacteria Results from both May and August 2011 sampling (also Figure 11)

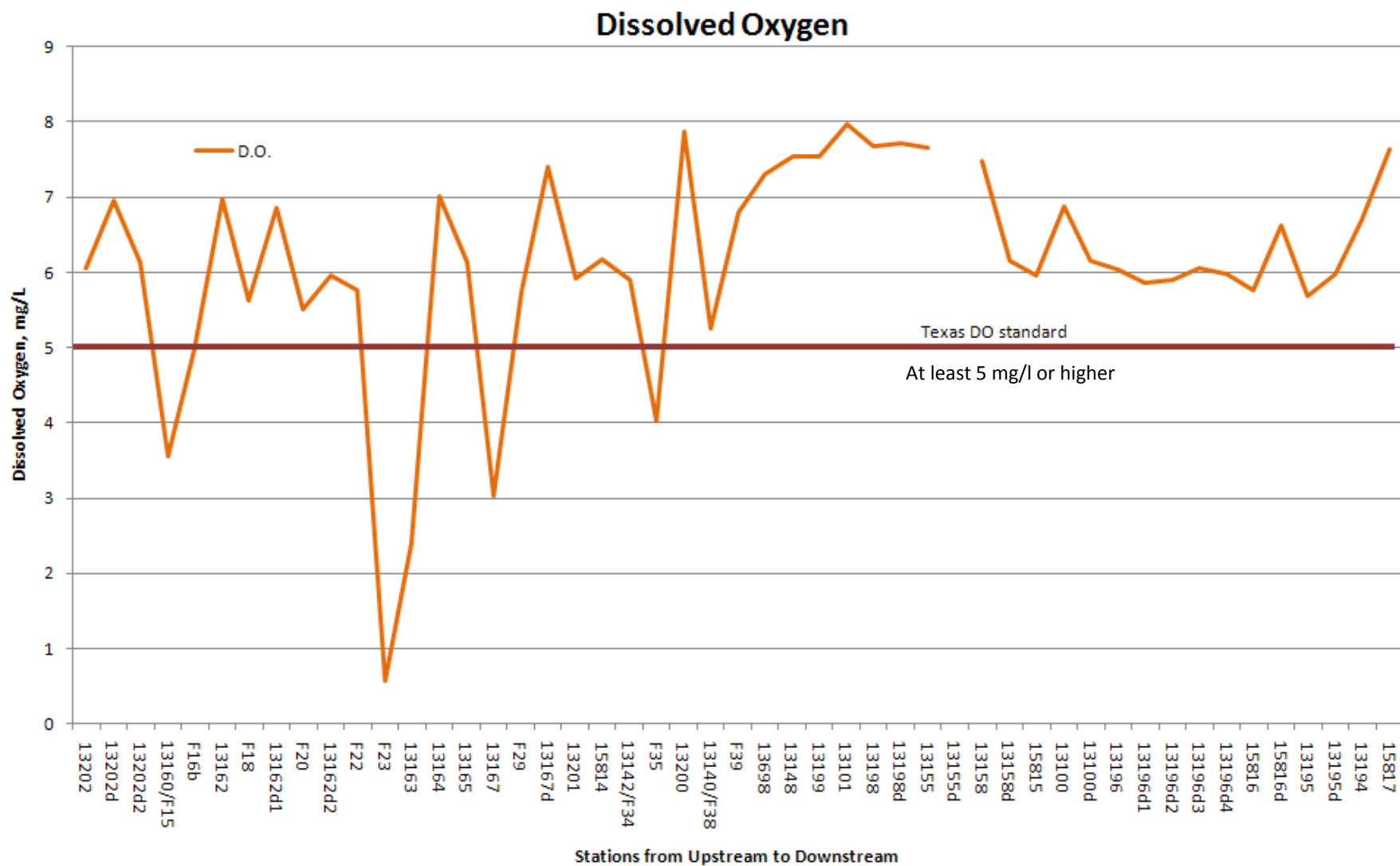


Figure B.4 Graph of Dissolved Oxygen values May and August

Laredo Bacteria Special Study Results, August 2011

TSS and VSS at selected discharges

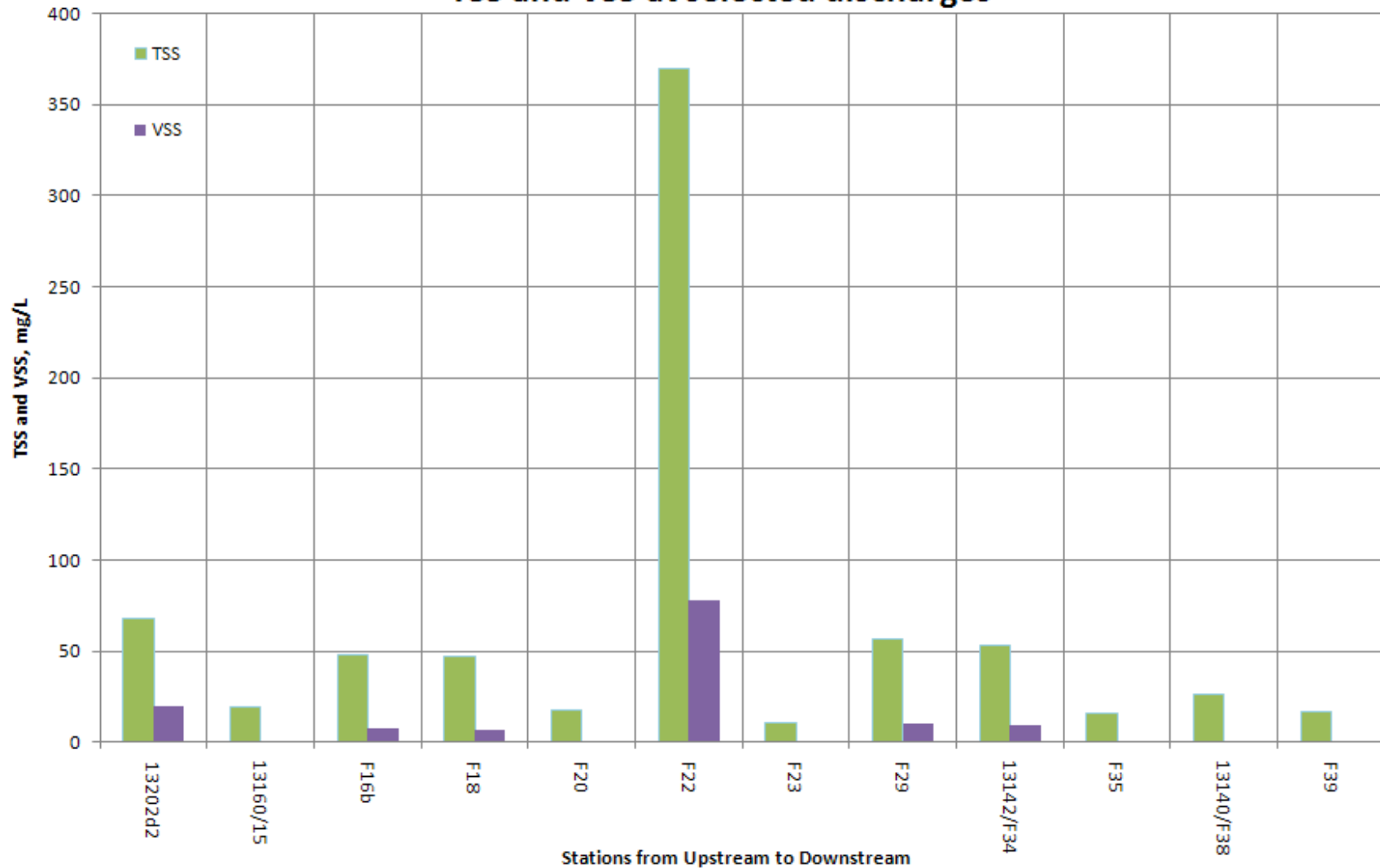


Figure B.5 Graph of TSS and VSS values at discharges from August sampling

Laredo Bacteria Special Study Results, August 2011

BOD and COD at selected discharges

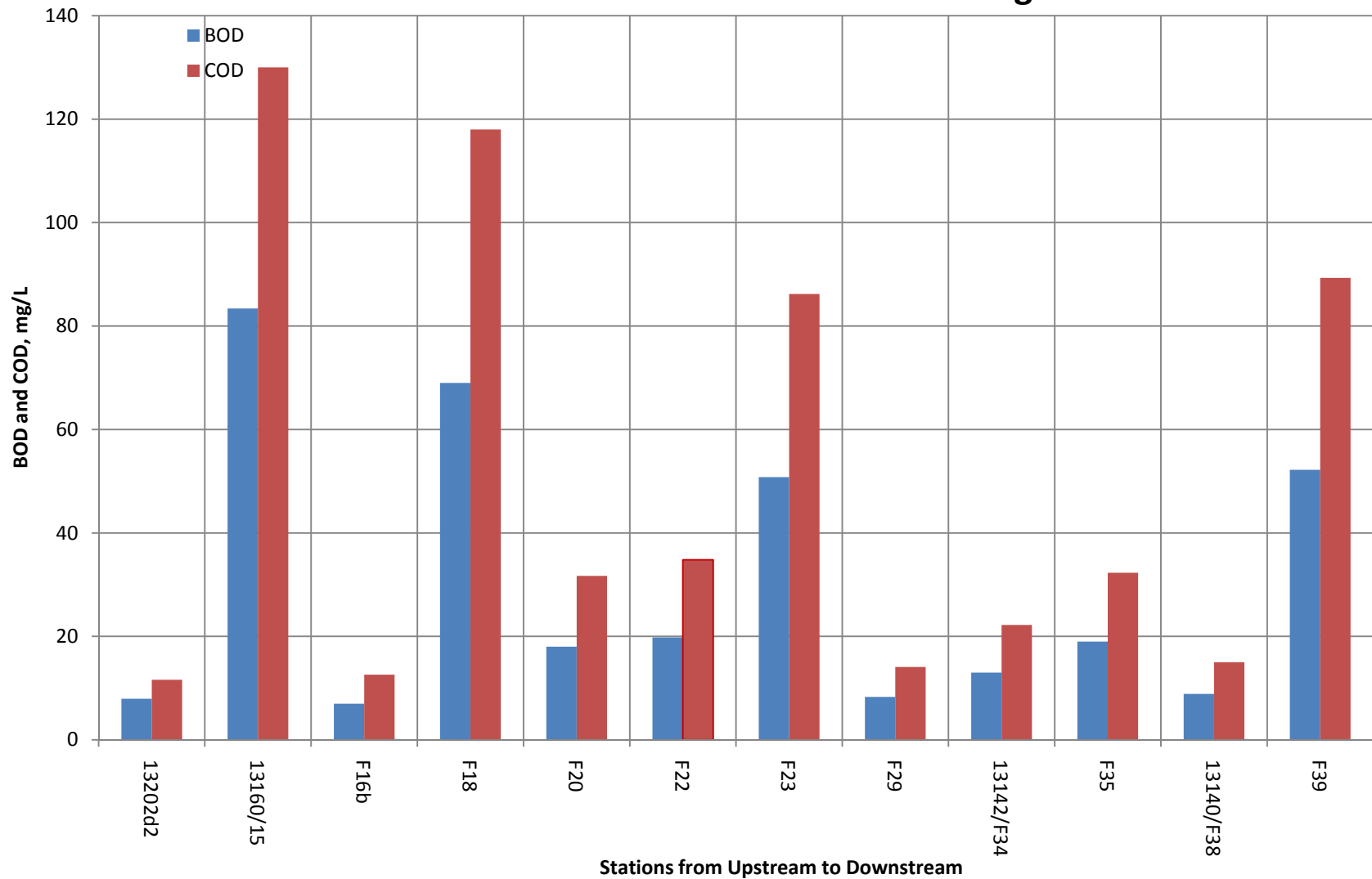


Figure B.6 Graph of BOD and COD values at discharges from August sampling

Laredo Bacteria Special Study Results, August 2011

Nutrients at selected discharges

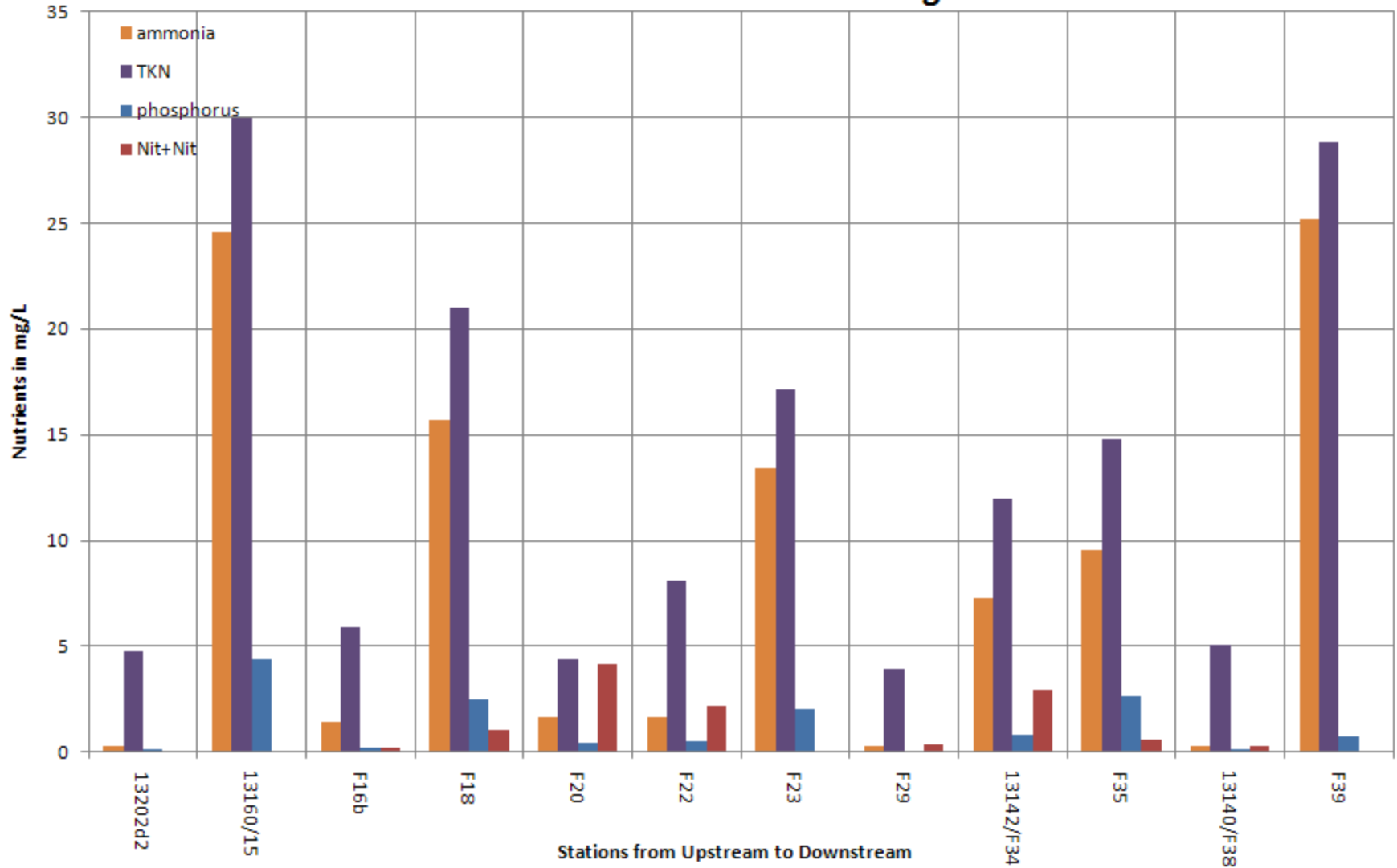


Figure B.7 Graph of nutrient values at discharges from August sampling

Laredo Bacteria Special Study Results, August 2011

Salts at selected discharges

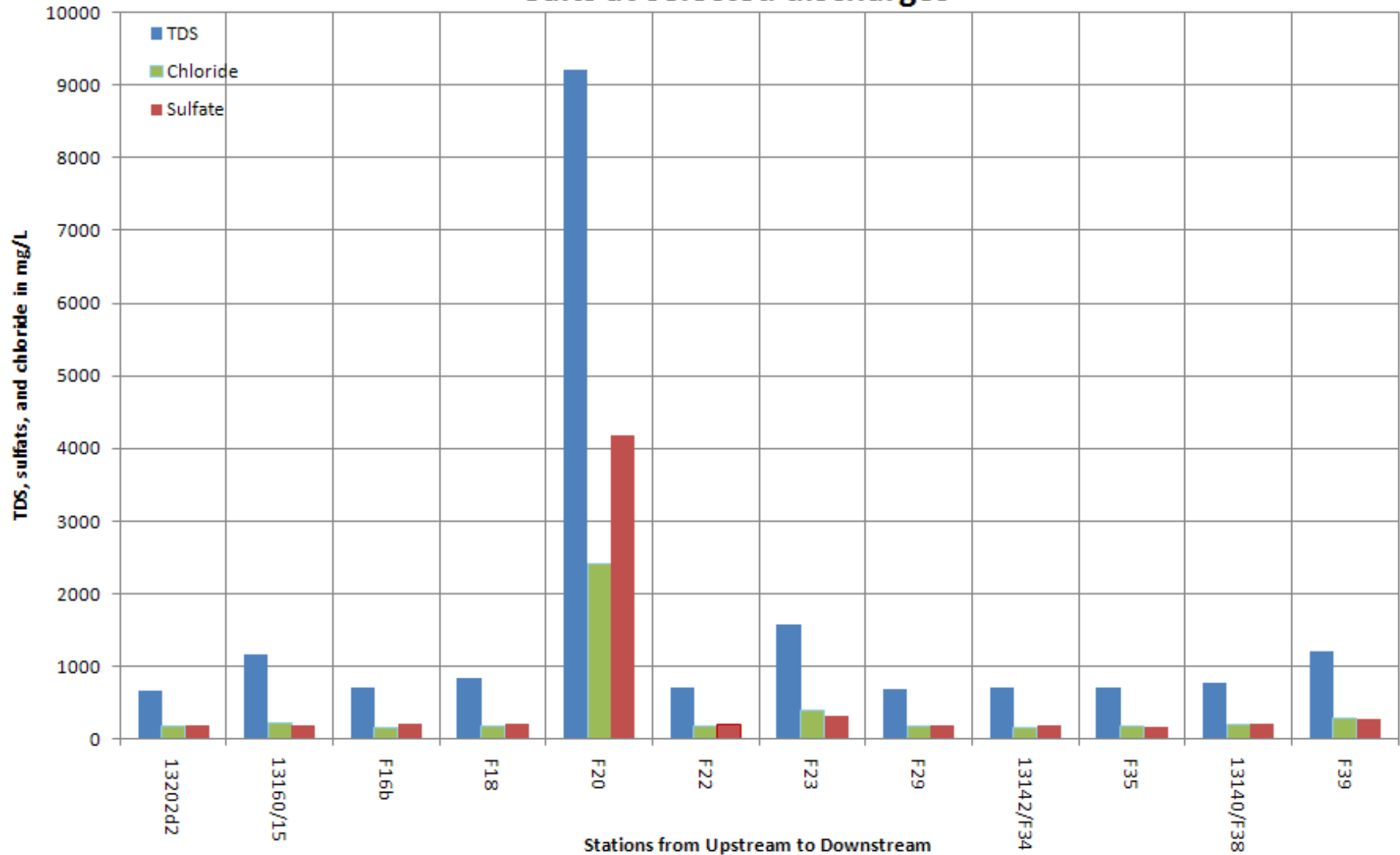


Figure B.8 Graph of TDS, sulfate and chloride values at discharges from August sampling

Appendix C

Results of Survey of Features

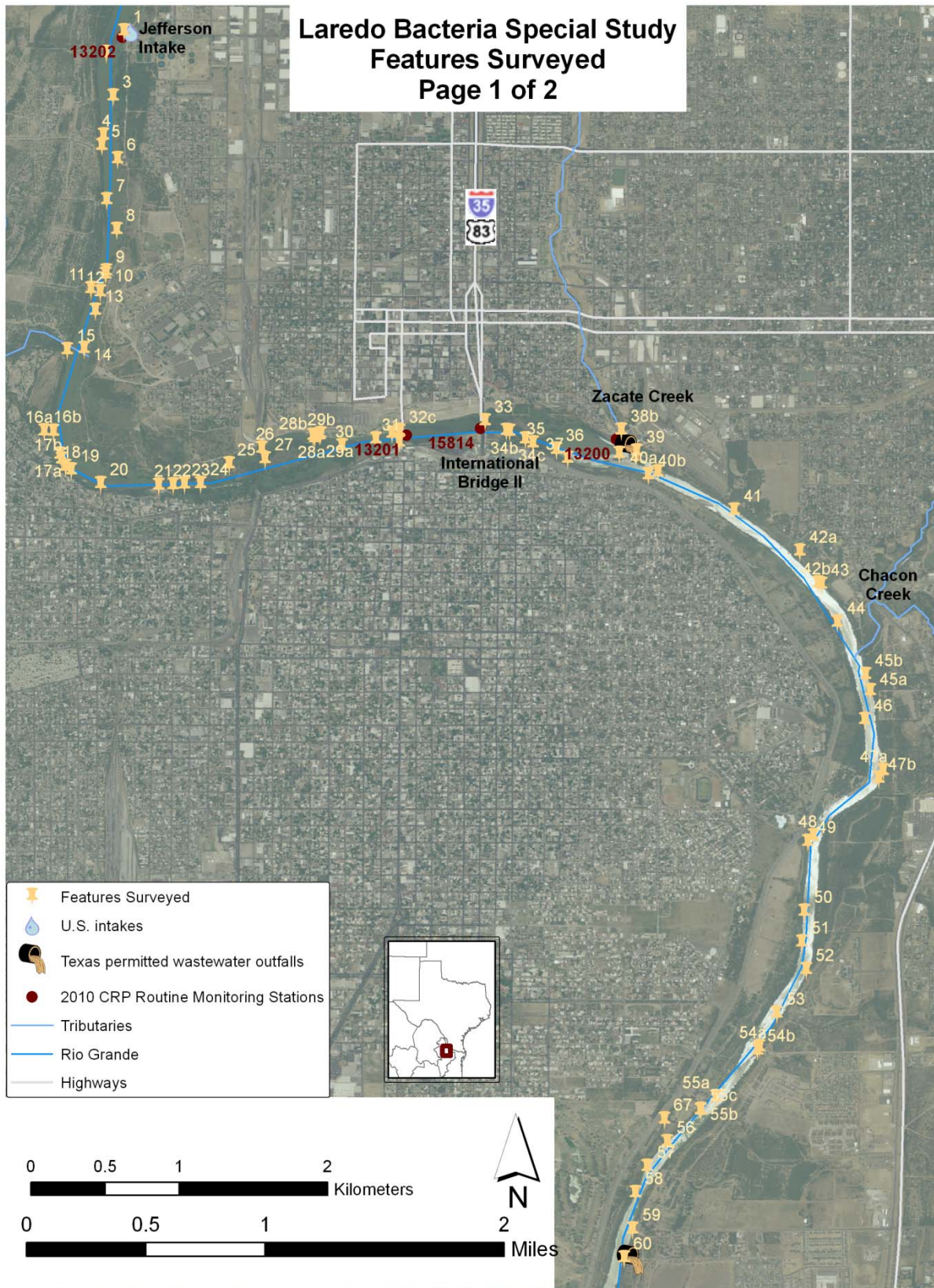


Figure C.1 Map 1 of 2 of the features surveyed in May.

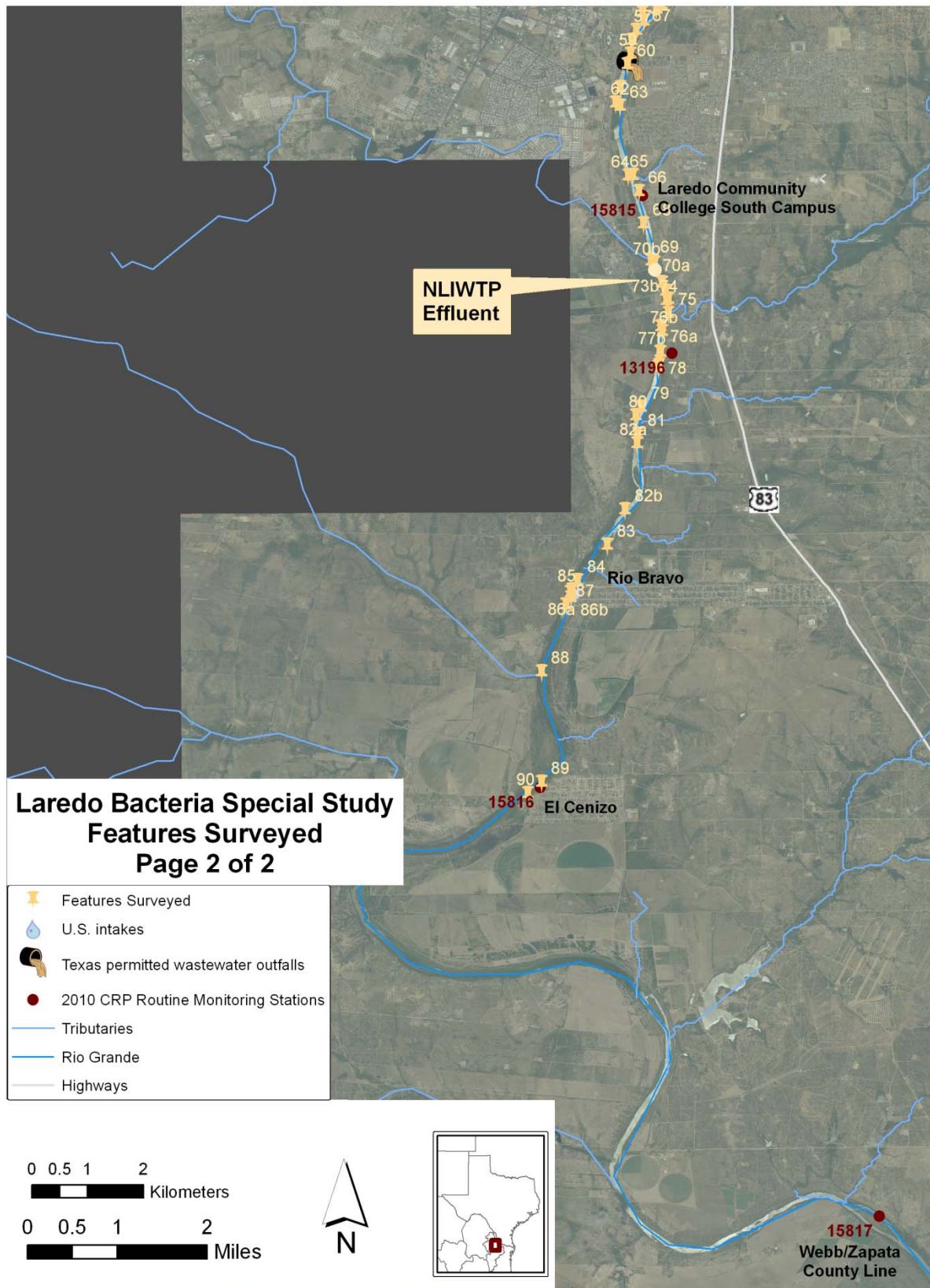


Figure C.2 Map 2 of 2 of the features surveyed in May.

Table C.1 Results of Survey of Features: USIBWC CRP Laredo Bacteria Special Study

Photo	Coun try	Feature ID and Field Description	Coord inates
	U.S	Feature 1 – Jefferson Street drinking plant intake.	27.52392, -99.52431
	MEX	Feature 2 – Road on bank with trash. Electric lines, suspected intake, but no pipes visible.	27.52261, -99.52539

	U.S.	Feature 3 – Erosion channel on U.S. side with some trash (tire in water). Trash downstream.	27.51997, -99.52497
	U.S.	Feature 4 – Footpath down to river on US side.	27.51761, -99.52556
	MEX	Feature 5 – Side channel with sediment bar, lots of trash and some foam. Footpath down to river beside side channel.	27.51697, -99.52565

	U.S.	Feature 6 – Footpath to river with trash and tires.	27.51618 -99.52469
	MEX	Feature 7 – Old brick building, (perhaps old pump house).	27.51367, -99.52536
	U.S.	Feature 8 – Stormwater drain on U.S. bank labeled R-10. Probably old Laredo Community College stormwater drain constructed in the 1930s WPA. Some trash.	27.51187 -99.52475

	U.S.	Feature 9 – Intake pipe, small and hidden on bank. Probably part of old farm project that ran on wind turbines.	27.50936, -99.52537
	U.S.	Feature 10 – Drain, hard to see on bank. Probably old drainage ditch from WPA.	27.50918, -99.52543
	MEX	Feature 11 – Road to the river across from Laredo Community College.	27.50829 -99.52631

	U.S.	Feature 12 – Steps to river on LCC campus directly across from Feature 11.	27.50811, -99.52575
 	U.S.	Feature 13 – Corroded metal pipe in river. Structure for possible old intake with metal building at top of bank (red arrow).	27.50698, -99.52604

	U.S.	Feature 14 – Possible drain. Not visible or accessible. Crew thought there was a second old WPA drain in this area.	27.50467, -99.52673
	MEX	Feature 15 – Tributary in Mexico. Extremely foul smelling with lots of trash and biofilm.	27.50458, -99.52774

	MEX	Feature 16a – Clearing on bank, unsure if this is footpath or possible dry arroyo?	27.49964, -99.52858
	MEX	Feature 16b – Tributary with trash/landfill on banks. Foul smell. Later referenced to “Arroyo Las Alazanas”	27.49966 -99.52914

	MEX	Feature 17a – Path to river and small building/tower on bank.	27.49825, -99.52817
 	MEX	Feature 17b – Large residential buildings at top of bank, lots of trash. Appears to be a Colonia. Fishermen on bank.	27.49797, -99.52809

 	MEX	Feature 18 – Discharging drain on stone, waterfall on bank to river (red arrow). Foul smell. Later identified as “Dren Monterrey”	27.49752, -99.52784
	MEX	Feature 19 – Trash pile on bank.	27.4973, -99.52749

	MEX	Feature 20 – Large cement structure. In May, not discharging but wet. In August, this drain was discharging a trickle of clear water during, and crews collected a sample of the discharge.	27.49648, -99.52573
	MEX	Feature 21 – COMAPA intake. Several intake structures on bank.	27.49638, -99.52221
	MEX	Feature 22 – Small tributary in Mexico, or possible small drain. Trash and foam or biofilm. Milky, foul smelling discharge noted in August sampling.	27.49641, -99.52133

				
	MEX	Feature 23 – Cement chute on bank with murky green/white discharge visible entering river. Foul smell. Same as USIBWC CRP staff observed in April 2009 during U.S. cane removal projects. August sampling crews noted foam. Visual estimate flow is 100 lps. Later identified as “Dren America”	27.49644, -99.52066	

	MEX	Feature 24 – Entrance to island splitting river. Raw sewage observed on Mexican side by members of field crew during May sampling. Impassable with canoes. Sampling plan had sites named after historic Mexican drains on the other side of the island.	27.49647, -99.51967
	U.S.	Feature 25 – Stormwater drain labeled R10. Cement debris in water.	27.49767, -99.51795
	Both U.S. and MEX	Feature 26 – Railroad bridge. In August the bridge was freshly painted on the Mexican side.	27.49861, -99.51598

	Both U.S. and MEX	Feature 27 – Channel between islands. Lots of birds, including kingfishers.	27.49798, -99.51578
	U.S.	Feature 28a – Trash pile at base of bank.	27.4994, -99.51289
	U.S.	Feature 28b – Cement blocks falling off U.S. banks, just downstream of Feature 28. Construction on bank after floods, loose sediment.	27.49925, -99.51278

				
	U.S.	Feature 29a – Stormwater drain labeled R-9. Large drain with grating.	27.49944, -99.5125	
	U.S.	Feature 29b – Small pipe directly to the right of Feature 29.	27.4995, -99.51242	

	U.S.	Feature 30 – Stormwater drain, large round pipe on bank in dirt.	27.49877, -99.51111
	U.S.	Feature 31 – White stormwater plastic pipe.	27.49919, -99.50906
	U.S.	Feature 31b – Second white stormwater plastic pipe.	27.49953, -99.5081

	U.S.	Feature 32a – Boat ramp at Bridge I.	27.49969, -99.50769
	MEX	Feature 32b – Cement drain on Mexican side of Bridge I.	27.49899, -99.50766
	Both U.S. and MEX	Feature 32c – International Bridge I	27.49965, -99.50763

	Both U.S. and MEX	Feature 33 – International Bridge II.	27.50028, -99.50248
	MEX	Feature 34a – Trash and clearing on Mexican bank just upstream of 34a. Fishermen here.	27.49969, -99.50119
	MEX	Feature 34b – Discharge on Mexican bank, no pipe visible. Discharge also has a white stringy material that looks like a taffy or plastic consistency. Foul smell, foam. Suds in the sample bottles in August.	27.49964, -99.50098

				
	MEX	Feature 34c – Clearing on bank and possible arroyo with some trash, possibly a tent.	27.49919, -99.50044	
	MEX	Feature 35 – Drain in bank. Discharging is audible. Discharge is a blue/green murky. Cement structure with pipe high on bank seen during August sampling (bottom photo). Suds in the sample bottles.	27.49895, -99.49957	

				
	MEX	Feature 36 – Makeshift rest-stop on bank. Men on bank, trash in river.	27.49856, -99.49817	
	MEX	Feature 37 – Small tributary or drain. No pipe visible. Lots of trash.	27.498, -99.49748	

	U.S.	Feature 38a – Zacate Creek. Lots of trash (bottom photo).	27.49831, -99.49436
			
	U.S.	Feature 38b – Metal pipe in Zacate Creek.	27.49972, -99.49425

	U.S.	Feature 39 – Zacate Creek WWTP outfall. Discharging large volume. Island between outfall and river creates a fast flow with lots of foam (second photograph). Fishermen have set up large nets at end of this island and outfall flow.	27.49846, -99.4933
	MEX	Feature 40a – Cattle path leading up to a building on the bank. Lots of fishermen nearby.	27.49718, -99.49201

	MEX	Feature 40b – Cement blocks in river. On opposite side of outfall island in 39b. Unable to survey exact coordinates or get closer photo	27.49702, -99.4926
	U.S.	Feature 41 – Tower and metal structure on U.S. bank with antenna. Possible old intake? No pipe visible on bank.	27.49486, -99.48757
	U.S.	Feature 42a – Dirt road down to river	27.49239, -99.48344

	U.S.	Feature 42b – Dirt boat ramp. No photo taken. GPS estimated from Google Earth based on field notes (screenshot shown on left).	27.49045, -99.48235
	U.S.	Feature 43 – Small arroyo. Outlet not clearly visible.	27.49039, -99.48214
	MEX ?	Feature 44 – Historical drain at Station 13148; however crew was unable to locate drain. Instead, crew saw a round piece of cement pipe just downstream of target drain location.	27.48808, -99.48117

 	U.S.	Feature 45a – Chacon Creek and lots of trash in the creek.	27.48394, -99.47919
	U.S.	Feature 45b – Tower with metal fence or stair rail structure on bank. Difficult to see. May be an intake or other structure.	27.48490, -99.47948

	MEX	Feature 46 – Tributary or erosion channel? Review of aerial photography does not seem to show any arroyos in the area.	27.48217, -99.47953
	U.S.	Feature 47a – Small tributary or erosion channel. Slight indication of structure behind vegetation but difficult to see. No structure seen in Google Earth. Just upstream of F47b.	27.47909, -99.4784
	U.S.	Feature 47b – Large cement block with metal pipes dislodged on bank, appears to be old sump. Piece of block is in center of river. Immediately upstream of block are two metal pipes that appear to be intake pipes.	27.47862, -99.47867

					
			MEX	Feature 48 – Old blue building on Mexican bank just upstream of F49.	27.47514, -99.48261
			MEX	Feature 49 – Cement drain with pipe and murky grey/white discolored discharge. Lots of trash and foul smell.	27.47479, -99.48296

	MEX	Feature 50 – Crew looked for historical drain in Mexico at Station 13155; crew did not find drain, but did find cement structure debris in river below target drain location.	27.47053, -99.48317
	MEX	Feature 51 – Audible discharge. Crew heard water flowing here but could not find a drain opening or pipe behind the cane.	27.46868, -99.48333
	U.S.	Feature 52 – Small pipe with white elbow, probably intake. Border Patrol agents standing here. Trash in river.	27.46702, -99.48306

	U.S.	Feature 53 – Creek with cement debris at confluence.	27.46439, -99.48483
	U.S.	Feature 54a – Old black pipe in bank with cement debris in river. Downstream of large house on bank.	27.46237, -99.48589
	U.S.	Feature 54b – Large house on bank with large retaining wall on bank. Border Patrol vehicle parked here. Antenna.	27.46217, -99.48599

	MEX	Feature 55a – Pump equipment on bank, not permanent pipe. Residential, possibly animal structures at top of bank.	27.45934, -99.48855
	MEX	Feature 55b – Rusted pipe directly upstream of 55c.	27.45854, -99.48943
	MEX	Feature 55c – Small blue intake pipe, not permanent pipe. Animal fences and grazing evidence. Just downstream of F55b.	27.45858, -99.48944

	MEX	Feature 56 – Pathway to river and lots of trash in water.	27.45664, -99.49147
 	MEX	Feature 57 – Small discharge. No pipe visible but flowing water (red arrow) is visible and audible. Trash.	27.45516, -99.49267

	MEX	Feature 58 – Large brown rusted pipe, appears to be intake.	27.45358, -99.4934
	U.S.	Feature 59 – Rusted pipe with metal frame, appears to be intake.	27.45137, -99.49356
	U.S.	Feature 60 – Old broken rusted pipe at Masterson station 15815, appears to be intake not being used.	27.44965, -99.49408

Day 2 Below Masterson

	U.S.	Feature 61 – Laredo outfall, permitted facility. Discharging.	27.44599, -99.49519
	MEX	Feature 62 – Small side channel with dead cane and some trash and a path down to river next to it.	27.44355, -99.49599
	U.S.	Feature 63 – Arroyo with freshly cut logs clearing channel.	27.44304, -99.49527

				
	MEX	Feature 64 – Blue green pipe arching into river, looks broken and unused.	27.43184, -99.49399	
	U.S.	Feature 65 – Dry arroyo across from F64.	27.43188, -99.49322	

	U.S.	Feature 66 – Metal pipe and cement structure on top of U.S. bank. End of pipe near river not visible due to heavy cane. Structure appears to be pumping equipment.	27.42931, -99.49224
	MEX	Feature 67 – Large circular structure on bank, looks like pump, with drain and a grate covering the drain or intake. Crew heard water draining in to grate.	27.458, -99.49164

	MEX	Feature 68 – Grazing along bank. Fence separates grazed and non-grazed sections.	27.42414, -99.49153
	MEX	Feature 69 – Arroyo El Coyote. Crew was unable to find NLIWTP effluent location near here; Mexican entities confirmed via phone while crews were out that the NLIWTP discharges into Arroyo El Coyote.	27.41817, -99.4903
	MEX	Feature 70a – Cement square structure on bank.	27.41811, -99.48997

	U.S.	Feature 70b – Island with cows. Grazed.	27.41783, -99.48969
	MEX	Feature 71a – Metal pipes and metal circular structure, appears to be well and pumping equipment. Crew thought this was ranch below NLIWTP effluent/ Arroyo El Coyote.	27.4146 -99.48856
	MEX	Feature 71b – Cement structure on bank directly downstream of F70a.	27.41469, -99.48856

	MEX	Feature 71c – Fishermen's path down to river with fire burning. Fishermen present.	27.41333, -99.48797
No photo. Field crew could not find a discharge from coordinates. No effluent visible, no discharge heard. Fishermen said plant discharged upstream. Field crew called USIBWC who called CILA who confirmed that the plant is discharging, but that the discharge is into Arroyo El Coyote. Conclusion drawn that coordinates were incorrect.	N/A	Feature 72 – Supposed location of NLIWTP outfall but incorrect; see F69.	N/A
	U.S.	Feature 73a – Long metal pipe, appears to be intake.	27.41203, -99.48752

	U.S.	Feature 73b – A second metal pipe next to F73.	27.41203, -99.4875
	MEX	Feature 74 – 3 Small blue-gray pipes with small red-framed building at top of bank.	27.41182, -99.48784
	U.S.	Feature 75 – Arroyo with trash at mouth.	27.40977, -99.48747

 	MEX	Feature 76a – Metal structure on bank and metal pipe almost hidden under water.	27.40761, -99.48875
	U.S.	Feature 76b – Path down to river with clearing on bank.	27.40681, -99.48847

	U.S.	Feature 77a – Small rusty pipe.	27.40353, -99.48883
	U.S.	Feature 77b – Small metal pipe just below 77a.	27.40344, -99.48872
	U.S.	Feature 77c – Path to river with fishermen just below F77b.	27.40144, -99.48897

	U.S.	Feature 78 – Metal in water, appears to be a fence or old dock.	27.40111, -99.4891
	MEX	Feature 79 – Metal structure visible on floodplain; however, no pipe or structure visible on bank due to vegetation.	27.39468, -99.49191
	U.S.	Feature 80 – Arroyo. Electric lines visible on Mexican side directly across from arroyo but no pipe or pump visible.	27.39329, -99.49273

	U.S.	Feature 81 – Plastic blue intake pipe.	27.39035, -99.49242
 	U.S.	Feature 82a – Metal intake pipe. Above it is a pump structure with yellow pole and stairs. Above that is a tall tower, probably a Border Patrol lookout tower.	27.38886, -99.49258

	MEX	Feature 82b – Livestock path to river.	27.37822, -99.49447
	U.S.	Feature 83 – Round building on US bank. Appears residential or agricultural.	27.37253, -99.49734
	U.S.	Feature 84 – Intake for Webb County.	27.36685, -99.5021

	U.S.	Feature 85 – Metal pipe and fence on bank.	27.36533, -99.50295
	U.S.	Feature 86a – WWTP outfall for Webb County. Discharging. Sudsy water.	27.36494, -99.50322

	U.S.	Feature 86b – Clearing on bank below tower.	27.36411, -99.50317
	U.S.	Feature 87 – Concrete pile with trash.	27.36294, -99.50391

	MEX	Feature 88 – Dry arroyo with cow path (shown small in vertical photo) and tire trash. Several native mussel species found on this arroyo's sandbar.	27.3522, -99.50791
 			
	U.S.	Feature 89 – Huge trash pile on cliffs at El Cenizo. Appears community dump trash over cliffs regularly.	27.33449, -99.5079

	U.S.	Feature 90 – Arroyo at bottom of cliffs at El Cenizo park. Arroyo has lots of trash.	27.33268, -99.51008
			

Appendix D

Trash Issues Documented During Survey

USIBWC CRP Laredo Bacteria Special Study, May 19-20, 2011 and August 15, 2011

Photos shown from upstream to downstream

Table D.1 Trash issues documented during Survey	
Photo of Trash	Trash description/ location
	Makeshift landfill on banks of Mexican Tributary, Feature 16
	Tires lining bank of tributary in Mexico Feature 16

	Trash in river on sediment island above river bend, below Mexican tributary Feature 16 27.4989, -99.5284
	Trash on Mexican bank, Feature 19
	Trash on U.S. bank, Feature 28, 27.4994, -99.5129

 A photograph showing a riverbank on the US side. The bank is composed of a mix of natural rocks and large, rectangular concrete blocks, likely construction debris. Some green grass is growing between the rocks. The river water is visible in the foreground.	Construction debris on the US side at Feature 28b below river bend above international bridges 27.4992, -99.5128
 A photograph of a riverbank on the Mexican side. The bank is covered with dense green vegetation, including tall grasses and some yellow flowers. Several old, discarded tires are visible, some partially buried in the soil and others floating in the water. A piece of driftwood is also visible on the bank.	Tires and trash on Mexican bank, Feature 34b 27.4997, -99.50119
 A photograph showing a riverbank with significant trash accumulation. The bank is covered with dense, dark vegetation. In the foreground, there is a large pile of debris in the water and along the shore, including a white styrofoam cup, a green plastic bottle, and various sticks and branches.	Trash in Zacate Creek at Feature 38

	Trash on U.S. bank between Features 40 and 41 27.4949, -99.4876
	Trash in river near Feature 40 27.4949, -99.4876
	Tires and trash below Feature 56 27.4566, -99.4915

	Trash in Mexican arroyo at Feature 57
	Trash on U.S. bank upstream of Chacon Creek
	Trash in Chacon Creek on the U.S. side 27.48394 -99.4792

	Trash in Chacon Creek on the U.S. side
	Trash in US arroyo 27.4098 -99.4878
	Trash on Mexican bank near Laredo Community College South

	Inner tube floating in river below Feature 68
	Old tire in river at Feature 88
	Tires piled on US bank upstream of El Cenizo

	Trash on cliffs near El Cenizo at Feature 89 27.33449 -99.5079
	Trash on cliffs near El Cenizo at Feature 89
	Trash in U.S. arroyo near El Cenizo at Feature 90