Bacteria Characterization in Segment 2302_01 of the Rio Grande near Brownsville, Texas

A Texas Clean Rivers Program Special Study: FINAL REPORT

Field Work March and April 2010; Final Report June 2011

International Boundary and Water Commission, U.S. Section, Texas Clean Rivers Program
and
the University of Texas at Brownsville, Chemistry and Environmental Sciences Department

AUTHORITY

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 above Brownsville, Texas taken by Kati Carberry during the March 2010 sampling event for this study.

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EXECUTIVE SUMMARY

Rio Grande Segment 2302_01, which runs through the border sister cities of Brownsville, Texas and Matamoros, Tamaulipas, has been listed on the Clean Water Act Section 303(d) Impairment List for bacteria since the State of Texas began listing impairments in 1996. The International Boundary and Water Commission, U.S. Section Texas Clean Rivers Program (USIBWC CRP) and the Chemistry and Environmental Science Department at the University of Texas at Brownsville (UTB) conducted a special study in March and April of 2010 to characterize the bacteria contamination in this 20-mile section of the Rio Grande.

The special study included intensive bacteria monitoring at variable intervals of either one-half or one mile from station to station, for a total of 33 stations over the 20 miles from River Bend upstream of Brownsville to the El Jardin Pump Station below Brownsville. A total of 63 bacteria samples were collected over three days in March and April of 2010. In addition, field crews conducted a survey of all features on both the U.S. and Mexican banks. A total of 37 features, such as drains, pumps, boat ramps, and outfalls, as well as other potential sources of contamination (trash dumps, goat trails, etc), were documented on both banks of the river.

Analysis of data included a correlation of surveyed features to permitted or other legal discharges (including agriculture, wastewater, and stormwater) in both countries. There was relatively little available information on structures in both countries, limiting correlation of surveyed features to permitted discharges.

The bacteria counts collected during both sampling events were very low, and did not approach historically high spikes. Only one of 63 samples exceeded the single-sample maximum for contract recreation set in the 2000 Texas Surface Water Quality Standards. The special study data was compared with routine monitoring data for the last ten years; historical data indicate that bacteria values dropped significantly in between September and October 2008 and have remained low throughout 2009, 2010 and 2011, with the exception of one spike in May of 2010.

The likely reason for improvements in water quality is the completion of the first wastewater treatment plant in Matamoros, which was funded by NADBank beginning in 2003. Construction was completed in 2008, and the plant began operations in late 2008 and was inaugurated in late 2009. The drastic change in bacteria in the Rio Grande coincides roughly with the beginning of operation of this plant and is likely the reason why low bacteria values were collected during sampling events for this bacteria study as well as subsequent routine monitoring.

USIBWC CRP will continue to monitor the bacteria in this section of river to verify if bacteria values remain low. A continued trend of low bacteria may eventually result in a de-listing of this section of river in future assessments by the State of Texas.

PROBLEM DEFINITION

Introduction

Rio Grande Segment 2302_01[a] has been listed on the Clean Water Act Section 303(d) Impairment List for bacteria since the State of Texas began listing impairments in 1996. Due to the binational nature of the Rio Grande, implementing enforcement actions, such as Total Maximum Daily Loads (TMDL), has not been possible. The International Boundary and Water Commission, U.S. Section Texas Clean Rivers Program (USIBWC CRP) and the Texas Commission on Environmental Quality (TCEQ) have conducted routine water quality monitoring in the area for over ten years; however, bacteria data are still sporadic, incomplete and limited in the ability to identify the origin of bacterial contamination.

The USIBWC-CRP and the Chemistry and Environmental Science Department at the University of Texas at Brownsville (UTB) conducted a special study to address the bacteria impairment in Segment 2302_01. The objectives of the special study were:

a) evaluate and identify possible sources of bacteria contamination through a field survey and spatial analysis, and

b) characterize the bacteria contamination through intensive bacteria monitoring.

The information and data collected from the special study provide the information necessary for enforcement entities in both countries to begin steps to reduce pollutant loads and ultimately delist the impairment.

Study Area

Rio Grande Segment 2302 stretches from Falcon Dam downstream to the tidal section about 40 miles from the Gulf of Mexico. This study examines an assessment unit (AU) within Segment 2302 called 2302_01[a] from the El Jardín Pump Station upstream to the Rancho Viejo Floodway. According to the *2010 Texas Water Quality Inventory Water Bodies Evaluated*, Rio Grande AU 2302_01 extends approximately 20 miles from TCEQ Station 13177 upstream to 13179. Within the study area are two additional routine monitoring stations, the Brownsville Public Utilities Board (BPUB) drinking water intake (Station 20449) and the previously inactive TCEQ Station 13178, which was included in the CRP sampling schedule beginning in 2008. Figure 1 shows the study area.

Justification

During the planning phase of the study, participants evaluated existing data to determine what sampling methodologies would be most beneficial to determine the sources and nature of the bacteria contamination. Pre-study data analysis determined that there was limited correlation with flow and precipitation. Limited and sporadic data presented difficulties in ascertaining whether the contamination was point source, nonpoint source, or steady-state. Since graphs show only some bacteria spikes correlate with rain events, a probable explanation for the bacteria contamination is a combination of runoff, point source or nonpoint source pollution. Pre-study graphs can be seen in *Appendix F to the United States Section, International Boundary and Water Commission (USIBWC) Clean Rivers Program FY 2010/2011 QAPP: Bacteria Source Tracking in Segment 2302_07: Phase I,*

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[a] The *2008 Texas Water Quality Inventory Water Bodies Evaluated in the 2008 Assessment* listed this assessment unit as 2302_07; however, assessment units were changed in the Draft 2010 Integrated Report, and 2302_07 was re-named to Segment 2302_01. The spatial extent of the assessment unit was unchanged, and this report uses the new name, 2302_01, to refer to the stretch of river *From the El Jardin Pump Station upstream to the Rancho Viejo Floodway.*

hereafter referred to as "Appendix F."

Based on the pre-study data for CRP routine monitoring Stations 13179, 20449 (BPUB intake), and 13177, the participants determined the source of bacteria is more than likely downstream of the PUB water intake and upstream of 13177. Therefore, the focus area of the study was the 10-mile stretch from 20449 downstream to 13177.

Because the impaired AU is short (20 miles) and the focus area even shorter (10 miles), and because bacteria impairments do not occur immediately upstream or downstream of this AU, there were suspicions that the bacteria was coming from one or more point sources. Participants had heard various rumors of possible discharges that were likely culprits for bacteria contamination. The sampling plan that was agreed upon by TCEQ, IBWC, and UTB would attempt to confirm whether point source pollution was a likely cause and identify possible sources of bacteria contamination through the field survey of features and discharges into the river. This data would create a baseline for evaluating the contamination, resulting in improved understanding of the bacteria contamination and possible solutions.

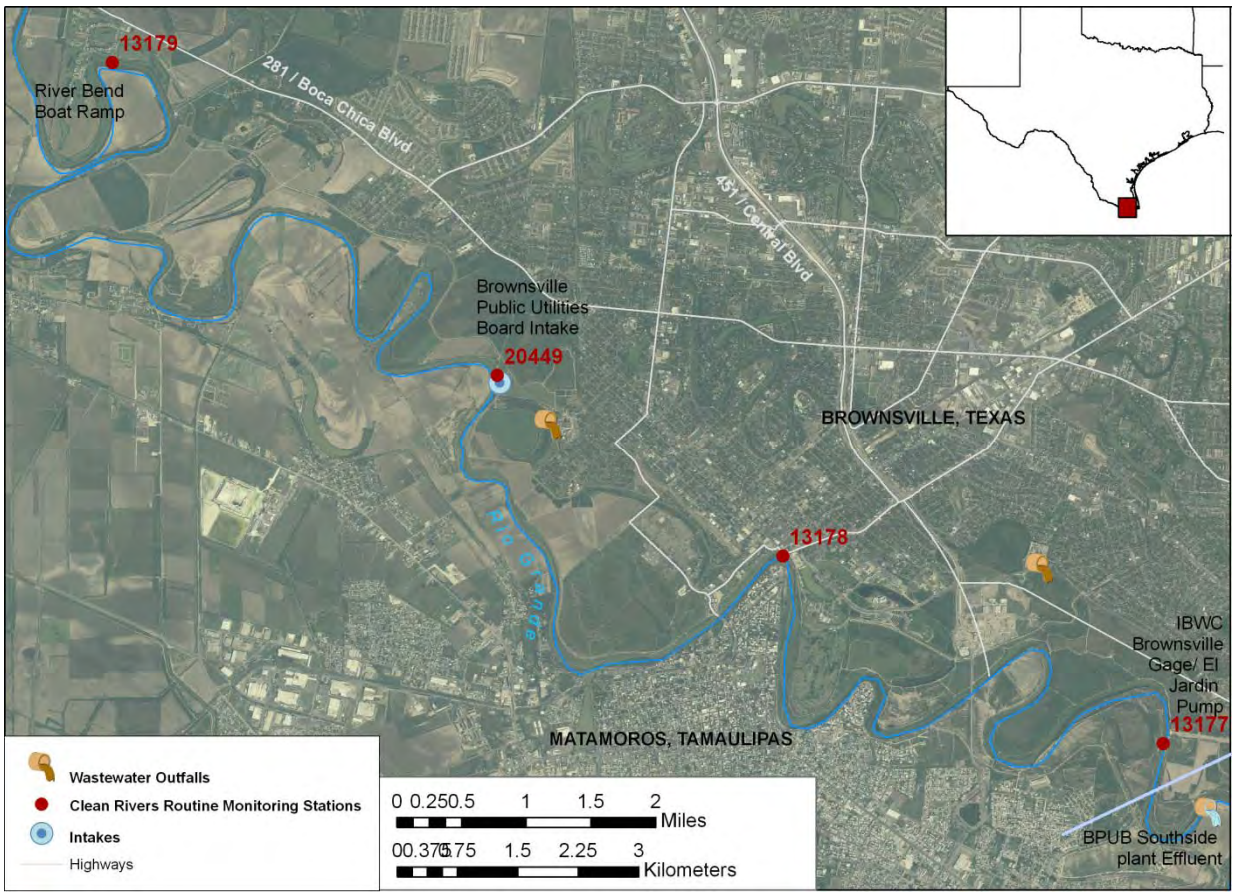


Figure 1. Site Map of Study Area for this Project

SAMPLING

Sampling Plan and Methods

The sample design rationale is based on the intent of the study to characterize the spatial distribution of the bacteria impairment in Segment 2302_01 by sampling at half-mile intervals between stations that have historically picked up high bacterial counts. To this end, 34 sites were selected based on distance from beginning station 13177, with the intent to assess the progressive contamination along the water body and the impact of anthropogenic point sources (i.e., wastewater and agricultural discharges). Figure 2 shows the approximate planned sampling locations. Two sampling events were planned, with 34 samples (plus Quality Control (QC) samples) collected at each sampling event for a total of 68 (plus QC). Sampling events were intended to be collected during low flow conditions so that field crews could conduct visual assessments of features along the banks.

Original Sampling Plan:

- From Station 13177 to 13178, collect 14 samples at approximately half-mile intervals, including at starting Station 13177;
- From 13178 to 20449, collect 10 samples at approximately half-mile intervals including at Stations 13178 and 20449;
- From 20449 to 13179, collect 10 samples at approximately one-mile intervals, including at ending Station 13179.

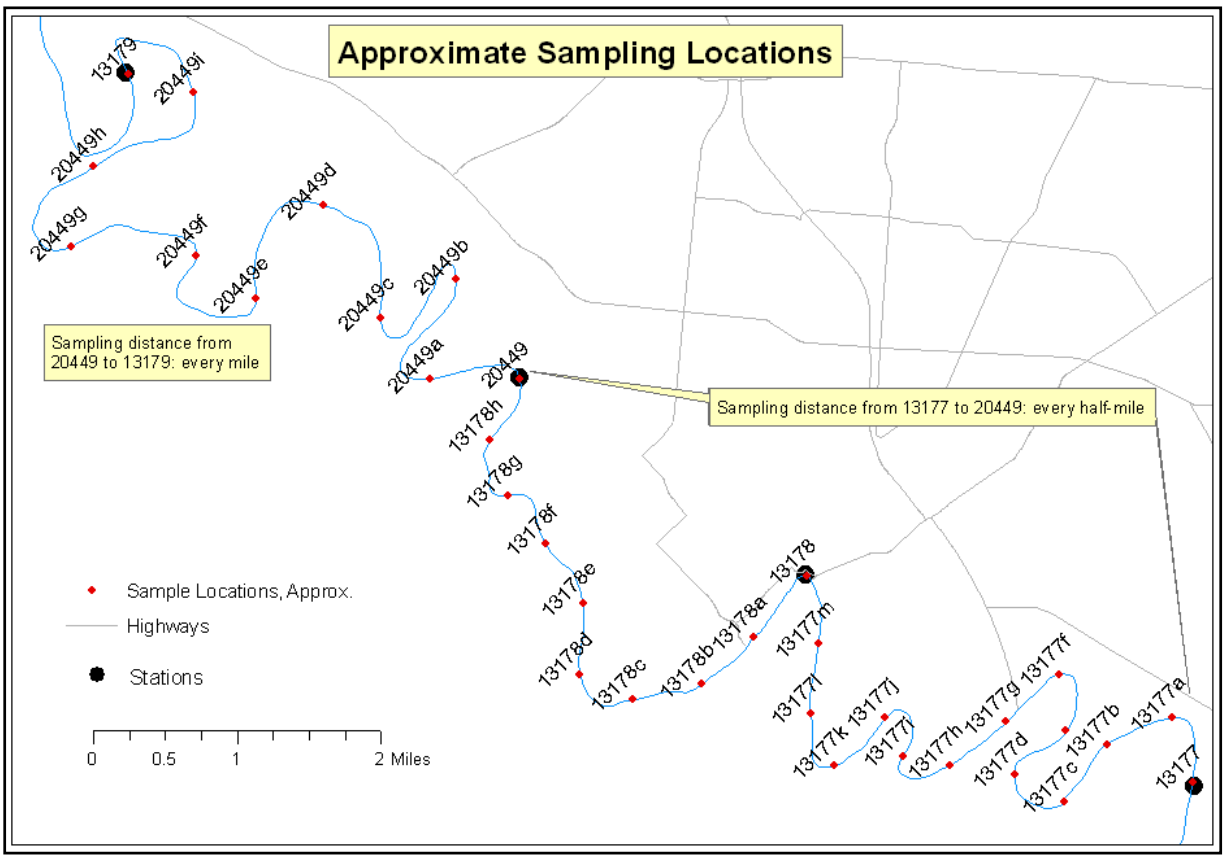


Figure 2. Approximate sampling locations for study

Field parameters to be collected were:

- pH
- DO (in milligrams per liter)
- Specific Conductivity (in micromhos per cm)
- Water temperature in degrees Celsius
- Flow estimate or flow (if possible) at the four routine stations (in cubic feet per second)
- Days since last significant rainfall and other ambient conditions
- Detailed observational data such as water appearance, unusual odors, recreational activities.

Laboratory parameters to be analyzed were:

- E. coli, IDEXX Colilert (in Most Probable Number per 100 ml)
- holding time (in hours), E. coli, IDEXX Colilert

Bacteria samples were sent to USIBWC CRP's contract laboratory, Environmental Testing and Consulting, Inc. (ETC), which is accredited by NELAC. Measurement Performance Specifications and data quality objectives are listed in Table A7 in Appendix F.

UTB students collected samples as part of a volunteer research project led by Dr. Elizabeth Heise. Students used a UTB motorboat to collect samples during two periods of intensive sampling in the study area. In addition, the field work included a survey of all features and discharges to the river, including drains and outfalls. The survey included GPS coordinates, photographs, video, and descriptions of all features observed while traveling upstream.

Sampling

The field crew encountered various delays and obstacles to sampling that resulted in deviations from the original sampling plan. Sampling was postponed twice due to heavy rain events immediately prior to scheduled sampling that could bias the results. The first sampling event was conducted over two days, March 8 and 9 of 2010, instead of one day due to extra time for conducting the feature survey as well as conditions on the river, multi-probe calibration issues, encountering unexpected weirs, and locating boat-ramps. The samples from March 8 and 9 followed the original sampling plan, and the crew collected 34 bacteria samples. The second sampling event occurred on April 26, 2010, during which the river had much higher flows than in the first sampling event. The crew collected 29 samples at the same locations as the March event, omitting 5 stations upstream of the focus area because of access issues.

Flow measurements were not collected during either sampling event due to logistics with flow equipment. However, flow data is available from IBWC stream gages at 13177 within the study area, and upstream of the study area in Benito.

The photographs below show sampling on March 8, 2010. Right – filling bacteria containers on the boat, and left – operating the boat and taking coordinates of survey points.

Field work photographs from March sampling event.

RESULTS

Bacteria Results

Results from the March and April sampling events are shown in Appendix A Table 1 and Table 2, respectively. Bacteria values collected during the special study were nowhere near historical spikes. The State of Texas uses E.coli as the bacteria indicator for contact recreation in water bodies in Texas, and the Texas Surface Water Quality Standard for bacteria in Segment 2302 of the Rio Grande is 126 Most Probable Number per 100 ml (MPN/100ml), geometric mean. Prior to the 2010 revisions of the Standards, there was also a single sample maximum standard of 394 MPN/100ml. Only one of all 63 samples exceeded the single sample maximum level. All values above the geometric mean standard are bolded in Tables 1 and 2.

Figure 3 shows where higher values of bacteria were collected in March. The highest bacteria results were between stations 13178e and 13177f. The sites with the highest values were 13177f with 160 MPN/100ml and 13177m with 225 MPN/100ml.

Figure 4 shows where higher values were collected in April. Bacteria counts were higher in general during the second sampling event. The highest bacteria results were collected between stations 13177i and 13177. The sites with the highest values were 13177f and 13177.

The lowest bacteria counts for both sampling events occurred between 13179 and 20449. This stretch had fewer features surveyed and is upstream of most of the urban areas of Brownsville and Matamoros.

Figure 5 graphs the bacteria results for both sampling events. Figure 6 shows the E.coli data from the study together with all data available from the four stations in the study area, from 2001 to 2010. Apart from one spike in 2010, data show that there have not been high bacteria counts at Station 13177 since 2008 when the planning for this special study began, and peak values of >2400 MPN/100ml have not been analyzed since 2007. In addition, a linear trendline for Station 13177 shows bacteria values have been steadily decreasing in the last ten years.

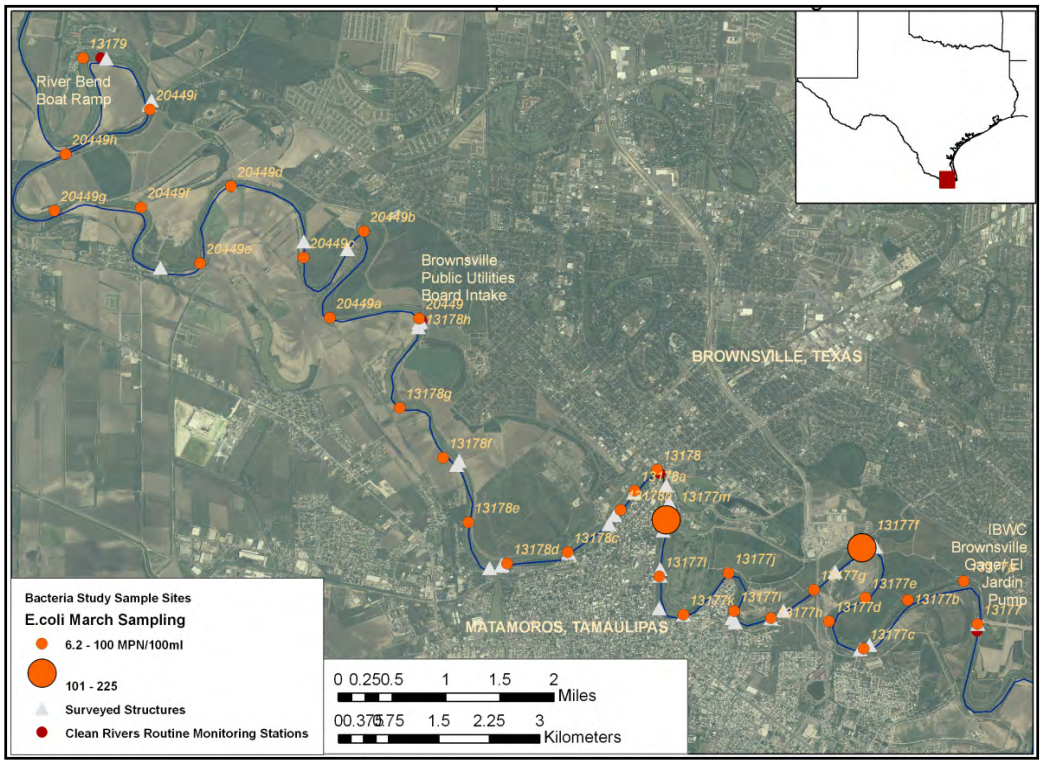


Figure 3. Map of the highest bacteria values from the March sampling event.

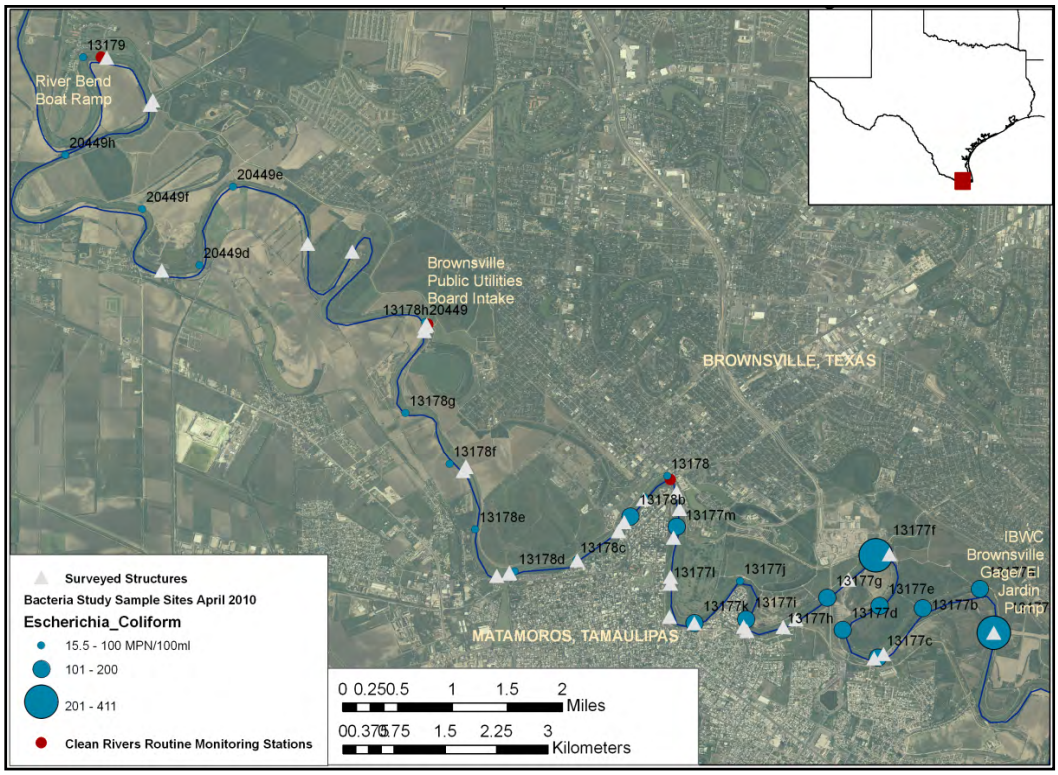


Figure 4. Map of the highest bacteria values from the April sampling event.

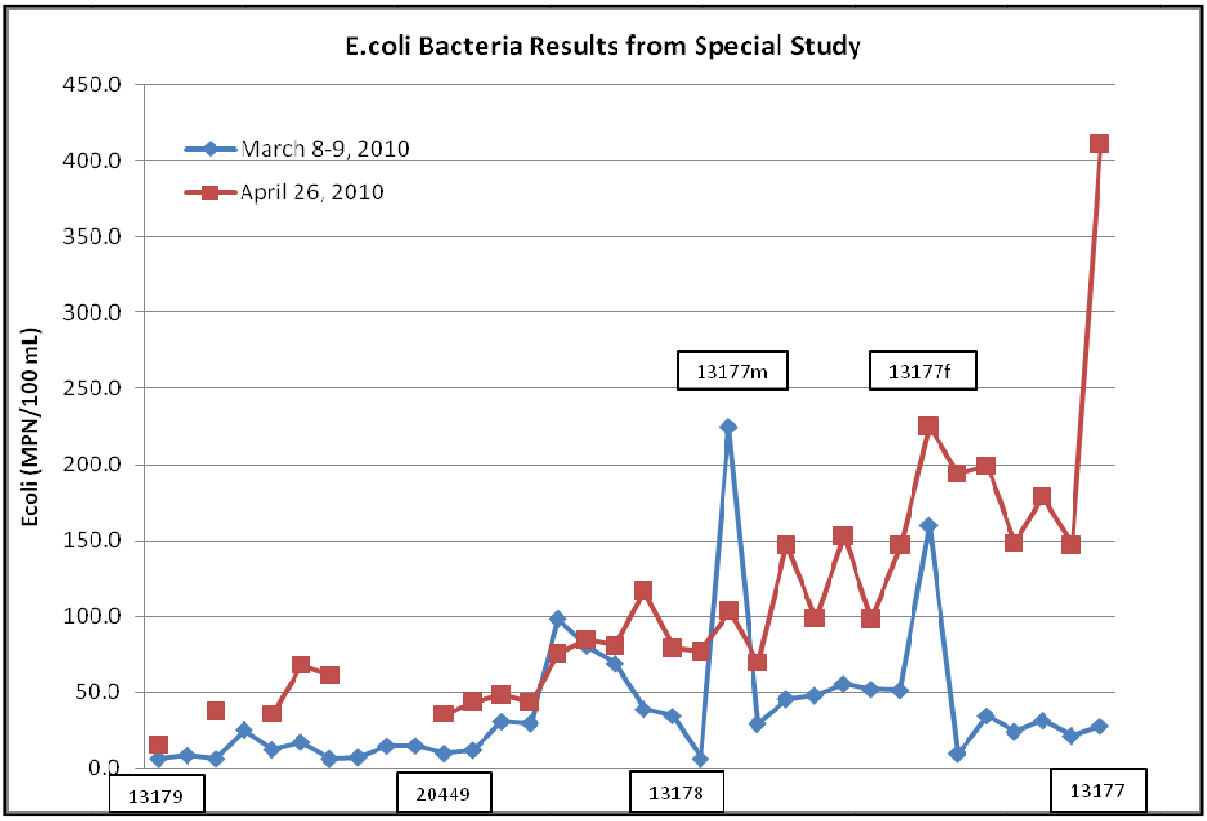


Figure 5. Bacteria Results from both sampling events, from upstream to downstream.

Survey of Features

The field crew originally documented 21 features that could be discharges. However, the crew also took many photographs and video with a GPS camera/camcorder. Review of the video and photos subsequent to field work determined there were actually 37 features. The term "feature" is used to include all semi-permanent or permanent objects and structures along either bank that could potentially cause varying kinds of contamination in the river. The 37 features include: 28 pipes, drains or pumps, as well as 3 boat ramps, 3 weirs, a goat trail, and two trash sites. Results of the survey are shown in Appendix B Table 3 (descriptions) and Appendix B Table 4 (photos), starting from 13177 going upstream to 13179. In addition, Figure 7 shows a map of all the surveyed features, with high bacteria results also emphasized.

The features upstream of the highest bacteria samples collected in March were Feature 17, a small pipe from a residential area on the Mexican bank (upstream of 13177f) and Features 28 and 8 on the U.S. bank (upstream of 13177m) . The features upstream of the highest bacteria samples collected in April were Feature 25 (upstream of 13177) and Feature 18 (upstream of 13177e and 13177d) on the U.S. bank, and Features 19 and 20 (both upstream of 13177b and 13177a) and Feature 16 (upstream of 13177g) on the Mexican bank.

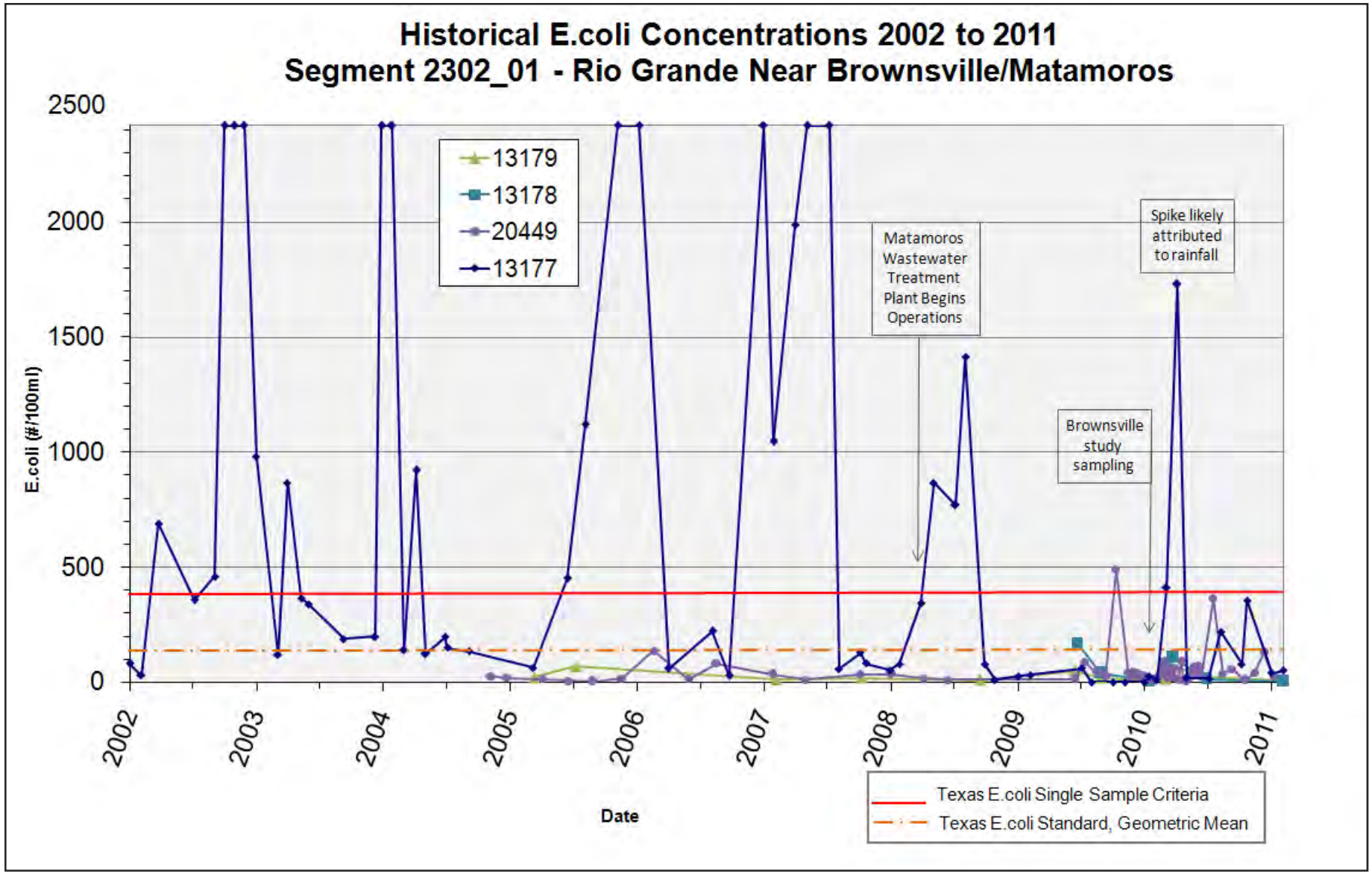


Figure 6. E.Coli concentrations in Segment 2302_01 from 2002 to 2011, including study data

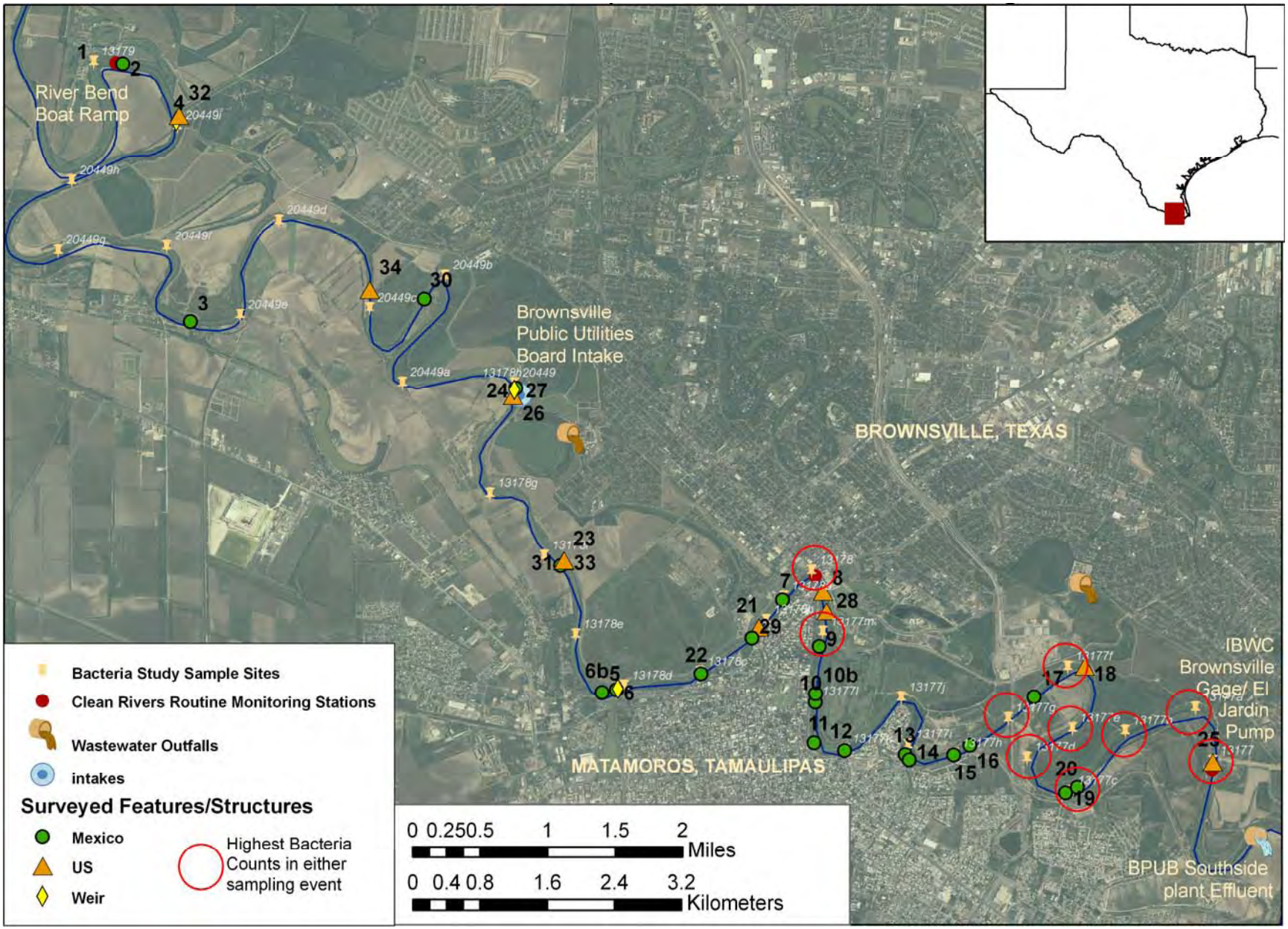


Figure 7. Map of surveyed features.

DISCUSSION AND CONCLUSIONS

Because the planning team suspected that contamination was coming from point sources, ideally the data would show where the possible sources of contamination were located within a narrow spatial range of one or two miles based on peaks in *E. coli* counts. However, bacteria values were all relatively low during both sampling events, with peaks much lower than historical bacteria spike values which had initially caused this stretch of river to be listed as impaired. Based on the study data, as well as historical data, no one feature surveyed can be pointed to as the source of contamination, and further study is needed.

One positive conclusion of this study is that the data has confirmed that the potential cause of the bacteria is between stations 20449 and 13177, and more than likely between 13178 and 13177. This stretch is the most populated and contains the majority of features on both banks. Data also showed that bacteria seems to build up to 13177, where counts are typically high.

The survey of features was extremely valuable. The study team did not anticipate so many features, because most of the permitted facilities in the U.S. in that area discharge either into the Arroyo Colorado or to canals that empty into the Laguna Madre watershed instead of the Rio Grande. The multitude and variety of features surveyed indicate that this type of survey should be conducted in other parts of the Rio Grande Basin.

The study participants attempted to match the surveyed features with permitted facilities in both countries, such as storm water and agricultural drains, wastewater outfalls, and municipal pumps. Limited data is available on some types of drains in both countries, and although the study team has unofficial information regarding possible ownership of the features, very little information is confirmed and therefore not presented in this report.

According to TCEQ, there are no permitted wastewater facilities that discharge into the Rio Grande in this study area in Texas. The only nearby permitted discharge is the Brownsville Public Utilities Board Southside Wastewater Plant (Figure 1); however, this discharge is downstream of the end of the study area (Station 13177) and therefore not a concern. Other permitted wastewater facilities in Brownsville discharge outside of the Rio Grande.

IBWC coordinated with the Mexican Section from the initial phases of the study and requested information on the features in Mexico. Mexico has no official record of the features but Mexican officials stated that the local government of Tamaulipas is working to eliminate all discharges into the Rio Grande in this area through the Comprehensive Water and Sanitation Project for the City of Matamoros, Tamaulipas. Part of that project includes the construction of the first wastewater plant for the City of Matamoros. This wastewater plant was funded by the North American Development Bank (NADBank) and certified by the Border Environment Cooperation Commission (BECC).

The most likely cause of water quality improvement in this stretch of river is the completion of the Matamoros Wastewater Treatment Plant, which was inaugurated on September 29, 2009, between the study planning and implementation stages. Although the plant was inaugurated in 2009, according to Mexican sources, the plant began testing operations in July 2008. With the exception of a spike of bacteria in August and September of 2008, the beginning of the operation of the plant correlates with lower bacteria at Station 13177. Figure 6 shows the historical data of all four routine monitoring sites and indicates that beginning in winter of 2008-2009, bacteria counts fell drastically. Lower bacteria is likely attributed to discharges being diverted away from the Rio Grande, as planned in the Matamoros Comprehensive Water and Sanitation Project.

Figure 6 shows that in the last 3 years from 2008 to 2011, bacteria counts have for the most part stayed below the single sample maximum criteria, with the exception of one spike at 13177 on May 27, 2010, which is likely due to runoff from approximately 2 inches of rainfall that occurred in the Brownsville between May 15 and May 18. USIBWC staff also collected bacteria samples under a separate project of the August 2010 floodwaters of the Lower Rio Grande upstream of the study area, and high bacteria was not found in the floodwaters due to the large volume of water. Routine monitoring has shown that bacteria in the river since late 2008 has not seen historically high spikes since the beginning of operations of the Matamoros plant. The USIBWC concludes that the completion and operation of the needed infrastructure is positively impacting water quality of the Rio Grande in this area.

Future Work

USIBWC CRP and its sampling partners will continue to collect routine monitoring in Brownsville. If future routine monitoring begins to pick up high bacteria counts again, the study team may plan future sampling to focus more on the section from 13178 downstream to 13177 during various flow conditions and seasons to continue to characterize the bacteria contamination and understand possible sources. The study team would evaluate the results presented in this report and plan a possible Phase II to continue evaluating bacteria in Segment 2302_01.

However, if future routine monitoring determines that bacteria counts are continuing to decline in AU 2302_01, low bacteria could potentially lead to delisting of the assessment unit in a future TCEQ assessment.

SOURCES

- *Draft 2010 Texas Integrated Report: Draft 2010 Texas 303(d) List* and *Texas Water Quality Inventory Water Bodies Evaluated* http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/wqm/305_303.html
- USIBWC CRP Monitoring Station Data http://www.ibwc.gov/CRP/monstats.htm
- *United States Section, International Boundary and Water Commission (USIBWC) Clean Rivers Program FY 2010/2011 QAPP (USIBWC QAPP) and its Appendix F: Bacteria Source Tracking in Segment 2302_07: Phase I* http://www.ibwc.gov/CRP/documents/USIBWC10QAPP.pdf
- *Correspondence with the Mexican Section of the International Boundary and Water Commission as well as North American Development Bank*

Appendix A. Results from March and April Sampling Events

Table 1. Results from March 8-9, 2010 sampling event

OBJECTID	Station	Lon	Lat	Date	Time	Water Temp C	pH	DO mg/l	Spec. Cond.	Last Sig Precip (days)	Flow (cfs)	Weather	Comments	Rain	Ecoli Results	Holding_Time
1	13177	-97.45492	25.87861	03/09/10	15:18	21.1	8.2	NR	1978	11	166	Partly Cloudy	Weir Downstream little to no flow.	Rained night before not significant	27.8	23
2	13177a	-97.45678	25.88431	03/09/10	15:08	21.1	8.1	NR	1990	11		Partly Cloudy	Hydrilla downstream	Rained night before not significant	21.3	23
3	13177b	-97.46428	25.88181	03/09/10	14:59	21.4	8.1	NR	1994	11		Partly cloudy	Not as much hydrilla or birds	Rained night before not significant	31.3	23
4	13177c	-97.47019	25.87533	03/09/10	14:43	21.7	8.1	NR	1998	11		Partly Cloudy	Duplicate taken	Rained night before not significant	24.1	24
5	13177d	-97.47481	25.87897	03/09/10	14:37	21.4	8.1	NR	1991	11		Partly Cloudy		Rained night before not significant	34.5	24
6	13177e	-97.46994	25.88208	03/09/10	14:29	21.3	8.1	NR	1997	11		Partly Cloudy		Rained night before not significant	9.6	24
7	13177f	-97.47044	25.88872	03/09/10	14:11	21.0	8.1	NR	1979	11		Partly Cloudy		Rained night before not significant	**160.0**	24
8	13177g	-97.47683	25.88317	03/09/10	14:03	21.1	8.1	NR	1971	11		Partly Cloudy		Rained night before not significant	51.2	24
9	13177h	-97.48258	25.87942	03/09/10	13:52	20.9	8.2	NR	1980	11		Partly Cloudy		Rained night before not significant	52.0	24
10	13177i	-97.48756	25.88033	03/09/10	13:33	20.8	8.2	NR	1967	11		Partly Cloudy		Rained night before not significant	55.6	25
11	13177j	-97.48828	25.88539	03/09/10	13:22	20.5	8.1	NR	1962	11		Partly Cloudy	Lots of birds in area	Rained night before not significant	48.0	25
12	13177k	-97.49433	25.87986	03/09/10	13:14	20.8	8.1	NR	1964	11		Partly Cloudy	Large drain discharging	Rained night before not significant	45.7	25
13	13177l	-97.49758	25.88494	03/09/10	12:54	20.6	8.1	NR	1962	11		Partly Cloudy	Drain pipe and feature	Rained night before not significant	29.2	25
14	13177m	-97.49669	25.89244	03/09/10	12:37	20.6	8.0	NR	1966	11		Cloudy	Border patrol said to look here	Rained night before not significant	**225.0**	26
15	13178	-97.49789	25.89908	03/09/10	12:29	20.5	8.0	NR	1965	11		Partly Cloudy		Rained night before not significant	6.2	26
16	13178a	-97.50086	25.89631	03/09/10	12:24	20.3	8.0	NR	1965	11		Partly Cloudy		Rained night before not significant	34.5	26
17	13178b	-97.50278	25.89378	03/09/10	12:11	20.3	8.0	NR	1964	11		Partly Cloudy	Between B&M Bridge and Gateway	Rained night before not significant	38.9	26
18	13178c	-97.50986	25.88814	03/09/10	11:59	20.3	8.0	NR	1963	11		Cloudy	Upstream of B&M Bridge	Rained night before not significant	68.9	26
19	13178d	-97.51797	25.88664	03/09/10	11:47	20.3	8.0	NR	1963	11		Cloudy	Downstream of sandbag weir	Rained night before not significant	80.9	26
20	13178e	-97.52317	25.89214	03/09/10	11:10	20.4	7.9	NR	1965	11		Cloudy		Rained night before not significant	98.5	27

21	13178f	-97.52656	25.90069	03/09/10	10:27	20.2	8.0	NR	1951	11		Cloudy	Duplicate taken	Rained night before not significant	29.5	28
22	13178g	-97.53236	25.90733	03/09/10	10:14	20.2	8.0	NR	1947	11		Cloudy	No flow, goat trail on Mexican side	Rained night before not significant	30.7	28
23	13178h	-97.52975	25.91922	03/09/10	9:40	20.1	8.0	NR	1948	11		Cloudy		Rained night before not significant	11.9	29
24	20449	-97.52975	25.91922	03/08/10	15:06	19.9	7.9	NR	1930	10		Cloudy	Weir, dead animal in water (cow or mule)		9.8	23
25	20449a	-97.54175	25.91928	03/08/10	14:54	20.0	7.9	NR	1936	10		Cloudy			14.8	23
26	20449b	-97.53719	25.93078	03/08/10	14:42	20.1	7.8	NR	1945	10		Cloudy			14.6	23
27	20449c	-97.54525	25.92728	03/08/10	14:30	20.1	7.8	NR	1953	10		Cloudy			7.3	23
28	20449d	-97.55947	25.92661	03/08/10	11:50	19.9	7.4	NR	1953	10		Cloudy	Windy, steep river bank		6.3	26
29	20449e	-97.55930	25.92680	03/08/10	14:13	20.1	7.8	NR	1955	10		Cloudy			17.3	23
30	20449f	-97.56703	25.93394	03/08/10	11:17	19.9	7.6	NR	1954	10		Cloudy	Boat ramp		12.2	27
31	20449g	-97.57864	25.93350	03/08/10	13:56	20.5	7.8	NR	1949	10		Cloudy			25.3	24
32	20449h	-97.57717	25.94103	03/08/10	13:39	20.0	7.7	NR	1943	10		Cloudy			6.2	24
33	20449i	-97.56586	25.94692	03/08/10	13:28	19.9	7.7	NR	1942	10		Cloudy	Took sample just below weir		8.6	24
34	13179	-97.57483	25.95381	03/08/10	8:38	19.7	7.7	NR	1941	10		Cloudy	Very windy, water hyacinth		6.3	30

Table 2. Results from April 26, 2010 sampling event

OBJECTID	Station	Lon	Lat	Date	Time	Water Temp C	pH	DO mg/l	Spec Cond	Last Sig Precip Days	Flow (cfs)	Weather	Comments	Rain	Ecoli Results	Holding_Time
1	13177	-97.45492	25.87861	04/26/10	11:59	26.5	7.8	5.4	1460	5	674	Clear	Intake, pumping station. duplicate sample taken		**411.0**	28
2	13177a	-97.45678	25.88431	04/26/10	11:54	26.4	7.7	5.6	1470	5		Clear			**147.0**	28
3	13177b	-97.46428	25.88181	04/26/10	11:49	26.4	7.7	5.3	1480	5		Clear			**179.0**	28
4	13177c	-97.47019	25.87533	04/26/10	11:43	26.3	7.8	5.6	1480	5		Clear			**148.0**	30
5	13177d	-97.47481	25.87897	04/26/10	11:38	26.3	7.8	5.6	1490	5		Clear	Duplicate taken		**199.0**	28
6	13177e	-97.46994	25.88208	04/26/10	11:33	26.3	7.8	5.6	1490	5		Clear	Downstream of large drainpipe BPUB on US side		**194.0**	28
7	13177f	-97.47044	25.88872	04/26/10	11:21	26.3	7.8	5.6	1490	5		Clear			**225.0**	28
8	13177g	-97.47683	25.88317	04/26/10	11:16	26.2	7.8	5.5	1450	5		Clear	Feature 16 upstream discharging. Site is at Los Tomates Bridge		**147.0**	28
9	13177h	-97.48258	25.87942	04/26/10	11:09	26.2	7.8	5.5	1510	5		Clear			98.7	28
10	13177i	-97.48756	25.88033	04/26/10	11:01	26.2	7.7	6.2	1510	5		Clear	More hyacinth. water color is inconsistent		**153.0**	28
11	13177j	-97.48828	25.88539	04/26/10	10:55	26.1	7.7	5.5	1520	5		Clear			98.8	28
12	13177k	-97.49433	25.87986	04/26/10	10:49	26.1	7.7	5.7	1520	5		Clear	Flowing discharge on Mexican bank. Dup taken		**147.0**	29
13	13177l	-97.49758	25.88494	04/26/10	10:42	26.0	7.8	5.7	1530	5		Clear	Yellow gated outflow with stairs (Feature 10)		69.7	29
14	13177m	-97.49669	25.89244	04/26/10	10:33	26.0	7.7	5.7	1540	5		Clear			104.0	29

15	13178	-97.49789	25.89908	04/26/10	10:26	26.0	7.8	5.7	1550	5		Clear	Swallows under bridge. just downstream of international bridge		77.1	29
16	13178a	-97.50086	25.89631	04/26/10	10:18	26.0	7.8	5.5	1550	5		Clear			79.4	29
17	13178b	-97.50278	25.89378	04/26/10	10:13	26.0	7.8	5.7	1550	5		Clear	Downstream of Band M bridge		117.0	29
18	13178c	-97.50986	25.88814	04/26/10	10:06	26.0	7.7	6.7	1560	5		Clear			80.8	30
19	13178d	-97.51797	25.88664	04/26/10	9:59	26.0	7.8	5.5	1560	5		Clear			84.7	30
20	13178e	-97.52317	25.89214	04/26/10	9:50	26.0	7.7	5.8	1570	5		Clear			75.7	30
21	13178f	-97.52656	25.90069	04/26/10	9:42	26.1	7.7	5.8	1580	5		Clear			43.6	30
22	13178g	-97.53236	25.90733	04/26/10	9:43	7.7	5.6	5.6	1580	5		Clear			48.8	30
23	13178h	-97.52975	25.91922	04/26/10	9:26	26.1	7.8	5.9	1590	5		Clear			43.9	30
24	20449	-97.52975	25.91922	04/26/10	9:00	26.1	7.7	5.6	1590	5		Clear	BPUB weir. March sampled above, April below weir		35.9	31
25	20449a	No Sample Taken in April														
26	20449b	No Sample Taken in April														
27	20449c	No Sample Taken in April														
28	20449d	-97.55947	25.92661	04/26/10	14:28	26.8	7.7	5.8	1660	5		Clear			61.2	25
29	20449e	-97.55930	25.92680	04/26/10	14:21	26.8	7.8	6.1	1660	5		Clear			68.1	25
30	20449f	-97.56703	25.93394	04/26/10	14:09	26.7	7.8	6.2	1660	5		Clear			35.9	25
31	20449g	No Sample Taken in April														
32	20449h	-97.57717	25.94103	04/26/10	13:58	26.7	7.8	6.2	1660	5		Clear			38.0	26
33	20449i	No Sample Taken in April														
34	13179	-97.57483	25.95381	04/26/10	15:15	27.0	7.7	5.6	1680	5		Clear	At boat ramp		15.5	24

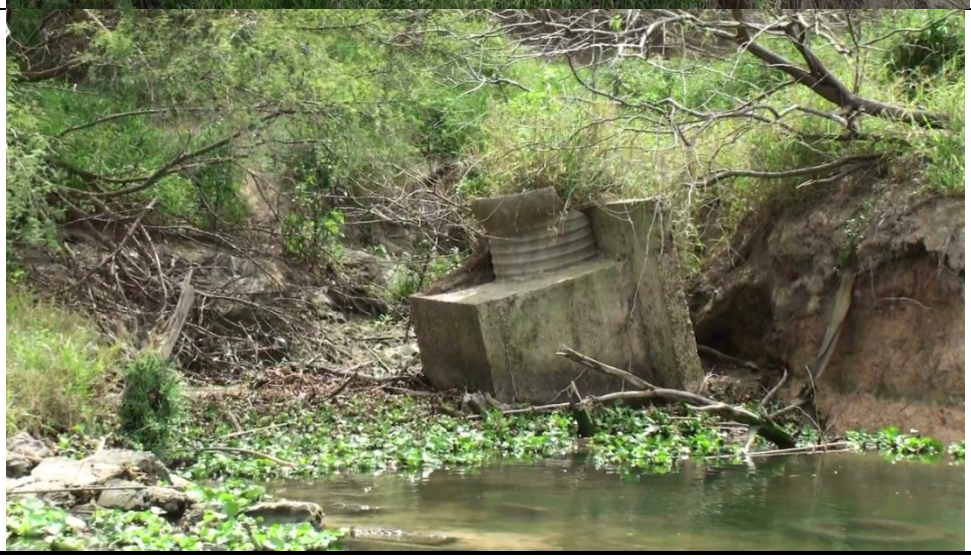
Appendix B. Results of Survey of Features

Table 3. Description of Surveyed "Features" from 13177 upstream to 13179

Feature	Country	LON	LAT	Description
25	US	-97.4549	25.8786	El Jardin pump (Station 13177, IBWC gage site)
20	Mexico	-97.46941	25.875846	Metal pipe off of the Mexican bank. Looked dry
19	Mexico	-97.470682	25.875263	Cement drain feature on the Mexican bank
17	Mexico	-97.474036	25.885566	Small blue pipe coming down from homes on the Mexican side, and possibly a chicken coup
16	Mexico	-97.480947	25.880387	4 large drain pipes on Mexican side. Border patrol mentioned this has "green stuff" discharging at night. Ends of pipes have fallen off. 2 on far right hand side (when facing pipes) were discharging; 2 on left were wet
15	Mexico	-97.48265	25.879367	Large cement drain pipe, 10 feet high, on Mexican bank
14	Mexico	-97.487423	25.878825	Large cement drain pipe on Mexican bank. Washed out and upside down in river
13	Mexico	-97.487854	25.879413	large drain on Mexican bank, metal pipe is not wet
12	Mexico	-97.494349	25.879843	Large drain, discharging. Door has a permanent hole where is has rusted near the bottom of the gate
11	Mexico	-97.497627	25.880673	Cement feature with big drain and staircase leading down to a gate. Not wet
10	Mexico	-97.497488	25.885012	Large drain pipe about four feet wide. Next to Feature 10b
10b	Mexico	-97.4975	25.885	Yellow feature with staircase.
9	Mexico	-97.497081	25.891005	Area of cut-out landscape, appears to be a possible discharge on Mexican bank. Yellow feature behind vegetation
28	US	-97.496322	25.894461	Upright metal pipe downstream of US Feature 8. Coordinates approximate.
8	US	-97.496678	25.896969	Pumping station
7	Mexico	-97.501025	25.896045	Drain pipe - cement feature with blue pipe
21	US	-97.503555	25.893033	Metal pipe and cement feature on US side. Hidden behind vegetation, no discharge
29	Mexico	-97.504304	25.891873	Drain under Puente Viejo on Mexican bank
22	Mexico	-97.509756	25.888052	Cement chute going into the river on the Mexican bank. Green on top
5	Mexico	-97.52	25.886	Large landfill trash dump on Mexican side. Coordinates estimated from field sheet notes; lies upstream of pump 6.
6	Mexico	-97.51857	25.88641	Pumping station
6b	Weir	-97.518445	25.886515	Sandbag weir just downstream of Feature 6
31	Mexico	-97.5247	25.9	Goat trails on Mexican bank
23	US	-97.524387	25.900261	Pipe on the US side at the boat ramp.
33	US	-97.524387	25.900261	Boat ramp with pipe (Feature 23)
26	Mexico	-97.530019	25.918438	Large cement feature with two drains just downstream of Feature 27
27	Weir	-97.531	25.918	Weir of large rocks and debris at BPUB intake
26b	Mexico	-97.529888	25.918936	Gate and bridge upstream of weir and Feature 26
24	Mexico	-97.5296	25.9188	Brownsville Public Utilities Board intake (Station 20449)
30	Mexico	-97.5394	25.9284	Tire levee/landfill
34	US			Boat ramp
3	Mexico	-97.56446	25.925906	Water pump/irrigation
4	Weir	-97.565989	25.947542	Trash/debris weir
32	US	-97.565675	25.948109	Pumping station
2	Mexico	-97.571721	25.953692	Pumping station
1	US	-97.54525	25.929389	River Bend boat ramp (Station 13179)

Table 4. Photos of Surveyed "Feature" from 13177 upstream to 13179	
	U.S. Feature **25**. El Jardin pump station, CRP Station 13177
	Mexico Feature **20**. Metal, or brown plastic, pipe off the bank. Dry.
	Mexico Feature **19.** Cement drain feature. Wet.

	U.S. Feature **18.** Large drain. Waterfall at the end of the tunnel falling into foam.
 	Mexico Feature **17**. Small blue pipe coming down from residential area (and possibly chicken coup above)

	Mexico Feature **16**. Four large drain pipes on bank. Border Patrol mentioned this has “green stuff”” discharging at night. Parts of pipes have fallen off. Two pipes discharging, the other 2 wet.
	Mexico Feature **15**. Cement pipe about 10 feet high or more.
	**Mexico** Feature **14**. Large cement drain pipe, washed out and upside down in river. Trash in water nearby.

	Mexico Feature **13**. Large metal drain pipe high on bank with riprap below. Appeared dry.
	Mexico Feature **12**. Large drain cement feature with metal gates, which have a permanent rusted hole at bottom. Discharging.
	Mexico Feature **11**. Large cement feature with big drain and staircase leading down to a gate. Dry.

	Mexico Feature **10**. Large drain pipe about four feet wide. About 100 feet away is a yellow feature with staircase (10b).
	Mexico Feature **10b**. Yellow feature with staircase.
	Mexico Feature **9**. Area of cut-out landscape with yellow feature hidden behind bank vegetation. Below is a cement base, a gray pool, and trash.

	U.S. Feature **28**. Upright metal pipe downstream of US Feature 8.
	U.S. Feature **8**. Pumping station with blue and yellow railing.
	Mexico Feature **7**. Cement drain feature with blue pipe. Wet.

	U.S. Feature **21**. Metal pipe and cement feature hidden behind vegetation on bank.
	Mexico Feature **29**. Drain under Puente Viejo on Mexican bank.
	Mexico Feature **22**. Cement chute going into the river on the Mexican bank. Green on top.

	Mexico Feature **5**. Landfill
	Mexico Feature **6**. Pumping station.
	Weir Feature **6b.** Sandbag weir just downstream of Feature 6.

	Mexico Feature **31.** Goat trails on Mexican bank.
	US Feature **23.** Pipe on US side at Border Patrol boat ramp.
	US Feature **33.** Boat Ramp

	Mexico Feature **26.** Large cement feature with two drains just downstream of weir near PUB intake.
	Weir Feature **27.** Weir of large rocks and debris at PUB intake.
	Mexico Feature **26b.** Gate upstream of weir and Feature 26.

	US Feature **24.** Brownsville Public Utilities Board intake.
	Mexico Feature **30.** Tires lining Mexican bank at residential area. Trash.
	US Feature **34.** Boat Ramp

	Mexico Feature **3.** Water pump and drain.
	Weir Feature **4.** Trash/debris weir .

	US Feature **32.** Pump Station
	Mexico Feature **2.** Pump Station downstream of 13179 and upstream of Feature 32.
	US Feature **1.** River Bend boat ramp (Station 13179)