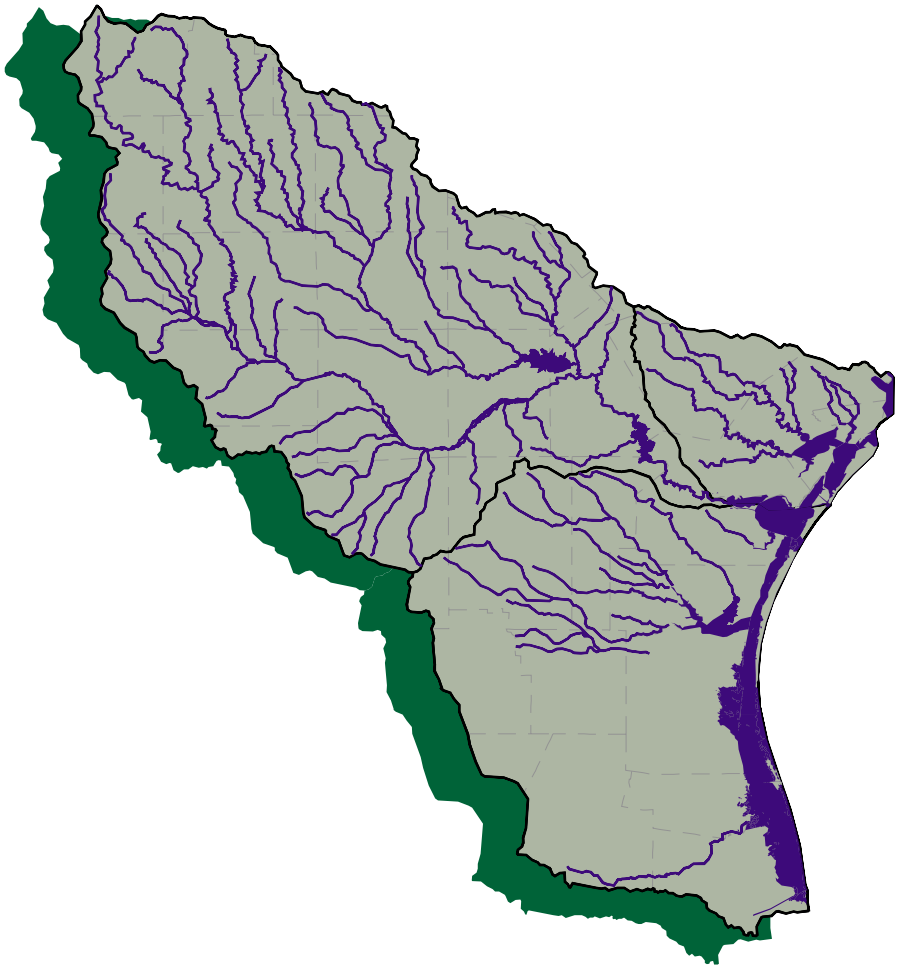
Basin Highlights Report
for the
Nueces River Basin
and the
San Antonio-Nueces and Nueces-Rio Grande Coastal Basins



Nueces River Authority

May 2001

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May 2001

Introduction

In 1991, the Texas Legislature passed the Texas Clean Rivers Act in response to growing concerns that water quality issues were not being addressed in a holistic manner. This legislation requires that basin-wide water quality assessments be conducted for each river basin in Texas using an approach that integrates water quality issues within a river basin or watershed. Basin Summary reports are produced every five years for the basin-wide assessments, and Basin Highlights reports are produced the other four years. The legislation directs the Texas Natural Resource Conservation Commission (TNRCC) to summarize basin-wide assessments into a comprehensive statewide assessment. To fund the program, TNRCC assesses a fee from permit holders for water use and wastewater discharges.

Under the Texas Clean Rivers Act, the Clean Rivers Program (CRP) has developed an effective partnership involving TNRCC, other state agencies, river authorities, local governments, industry, and citizens. Using a watershed management approach, the Nueces River Authority (NRA) and TNRCC work together to identify and evaluate surface water quality issues and to establish priorities for corrective action. NRA is responsible for the Nueces River Basin, the San Antonio – Nueces Coastal Basin, and the Nueces – Rio Grande Coastal Basin with respect to CRP.

Basins Overview

Nueces River Basin

The Nueces River Basin covers approximately 17,000 square miles, encompassing all or part of 23 counties (Figure 1). The basin extends from the hill country of central Texas to the mouth of the Nueces River at Nueces Bay along the coast. The western half of the Edwards Aquifer lies within the basin. The two major reservoirs within the basin are Choke Canyon Reservoir and Lake Corpus Christi. The major rivers of the basin are the Nueces River, Frio River, and Atascosa River. Smaller streams include the Sabinal River, Leona River, Hondo Creek, San Miguel Creek, and Seco Creek. There are no major metropolitan areas in the basin (only a small area in the northwestern most portion of Corpus Christi falls within the basin). Some of the larger communities include Uvalde, Pleasanton, George West, and Three Rivers.

Farming and ranching industries are prevalent throughout the basin. A major refinery is located in Three Rivers. The basin is home to Choke Canyon State Park (SP) on the south side of Choke Canyon Reservoir near Three

Rivers, Lake Corpus Christi SP on the southeast bank of Lake Corpus Christi near Mathis, Garner SP north of Concan, Tips State Recreational Area on the Frio River in Three Rivers, Lipantitlan State Historic Park (SHP) near Sandia, Lost Maples State Natural Area (SNA) north of Hondo.

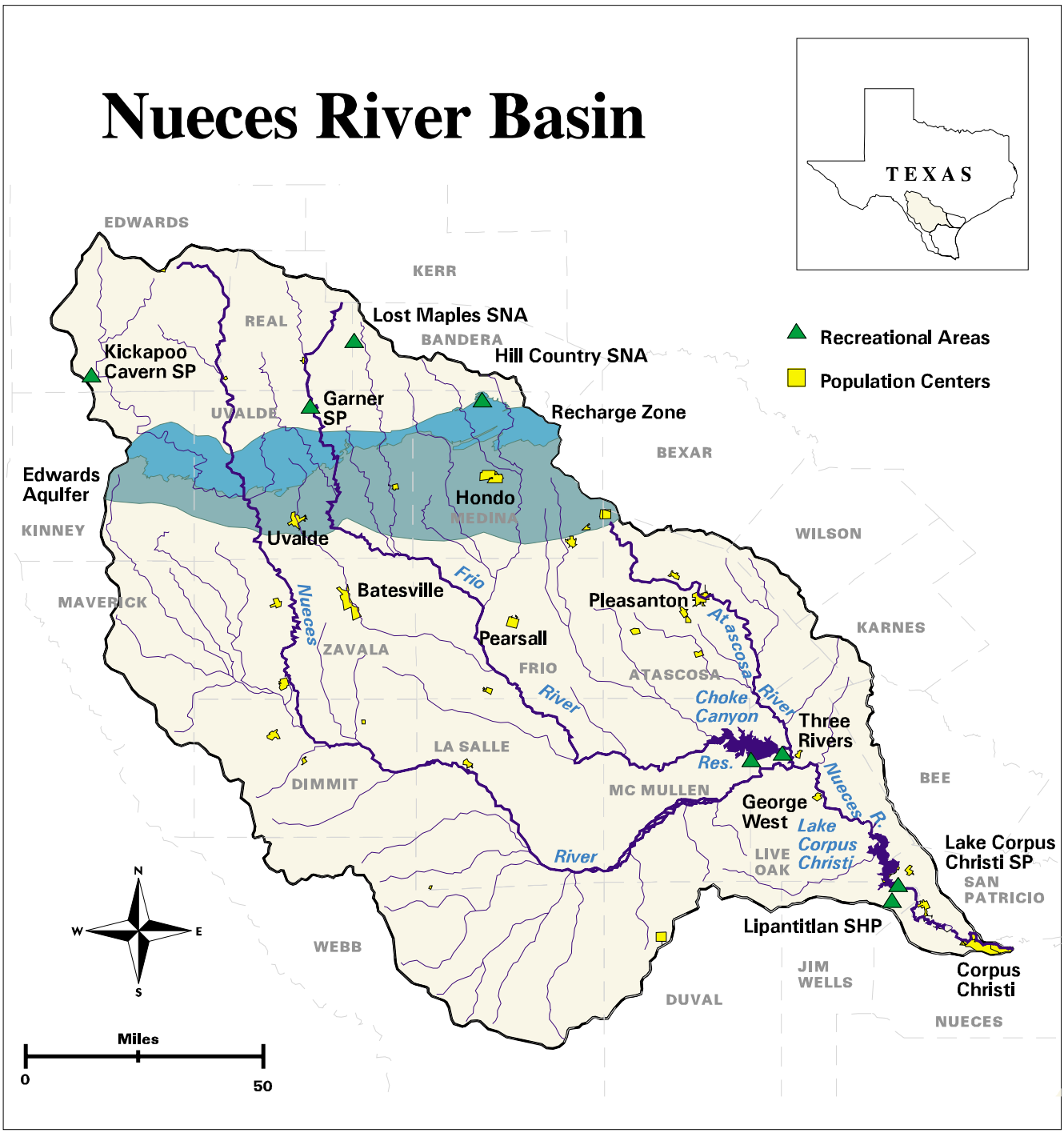


Figure 1 - Nueces River Basin

San Antonio – Nueces Coastal Basin

The San Antonio – Nueces Coastal Basin covers approximately 3,100 square miles, encompassing all or part of seven counties (Figure 2). The basin is predominantly coastal plain, bordering or including Hynes Bay, San Antonio Bay, St. Charles Bay, Copano Bay, Aransas Bay, Mesquite Bay, Redfish Bay, Nueces Bay, and the northern third of Corpus Christi Bay. There are no major reservoirs in the basin. The major rivers of the basin are the Mission River and the Aransas River. There are no major metropolitan areas in the basin; however, some of the larger communities include Beeville, Rockport, Portland, Ingleside, Refugio, and Aransas Pass.

Farming and ranching industries are prevalent throughout the basin. Petrochemical industries are abundant along the northern shoreline of Corpus Christi Bay. The basin is home to Goose Island SP near Rockport, Copano Bay State Fishing Pier along State Highway 35 north of Fulton, Fulton Mansion SHP in Fulton, and the Aransas National Wildlife Refuge in Aransas County.

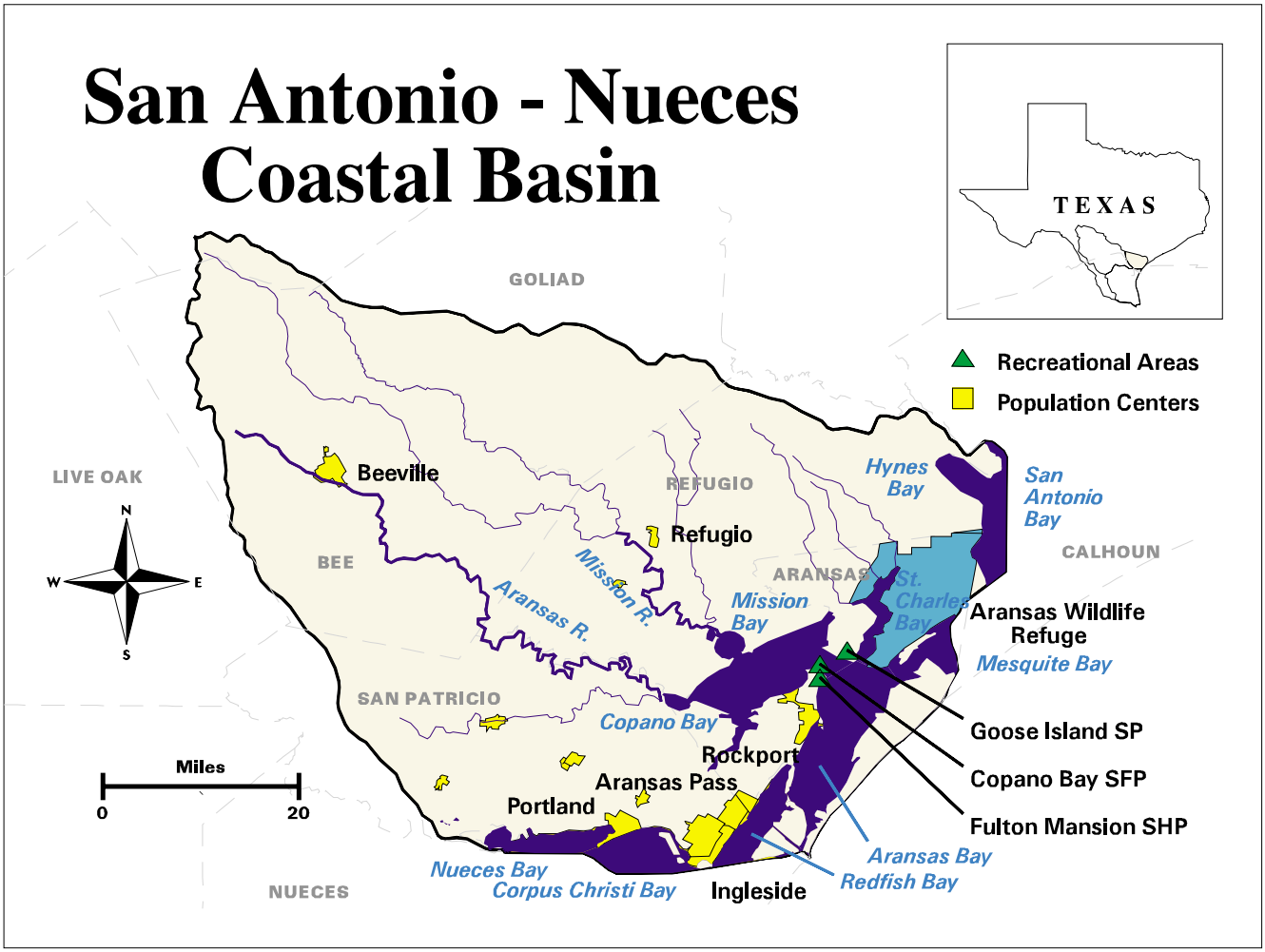


Figure 2 - San Antonio - Nueces Coastal Basin

Nueces – Rio Grande Coastal Basin

The Nueces – Rio Grande Coastal Basin covers approximately 11,400 square miles, encompassing all or part of 12 counties (Figure 3). The basin is predominately brush and coastal plain, bordering or including the southern two-thirds of Corpus Christi Bay, Corpus Christi Ship Channel, Oso Bay, Laguna Madre, and Baffin Bay. There are no major reservoirs or rivers in the basin. However, Petronila Creek, Arroyo Colorado, and the Brownsville Ship Channel are classified stream segments. The tidal portion of Oso Creek is included in the Oso Bay segment. Corpus Christi, Kingsville, Harlingen, Brownsville, and McAllen are the larger cities within the basin. Other communities include Port Aransas, Alice, Falfurrias, and Hebbronville.

Farming and ranching industries are prevalent throughout the basin, the most notable being the King Ranch and the Kenedy Ranch. Petrochemical industries are abundant along the Corpus Christi Ship Channel, and there are chemical research and development facilities in Bishop and Corpus Christi. Two four-year universities, Texas A&M University-Corpus Christi (TAMUCC) and Texas A&M University-Kingsville, are located within the basin. Graduate degrees are also offered at both schools. The basin is home to Mustang Island SP, Port Isabelle Light House SHP in Port Isabel, and the Padre Island National Seashore.

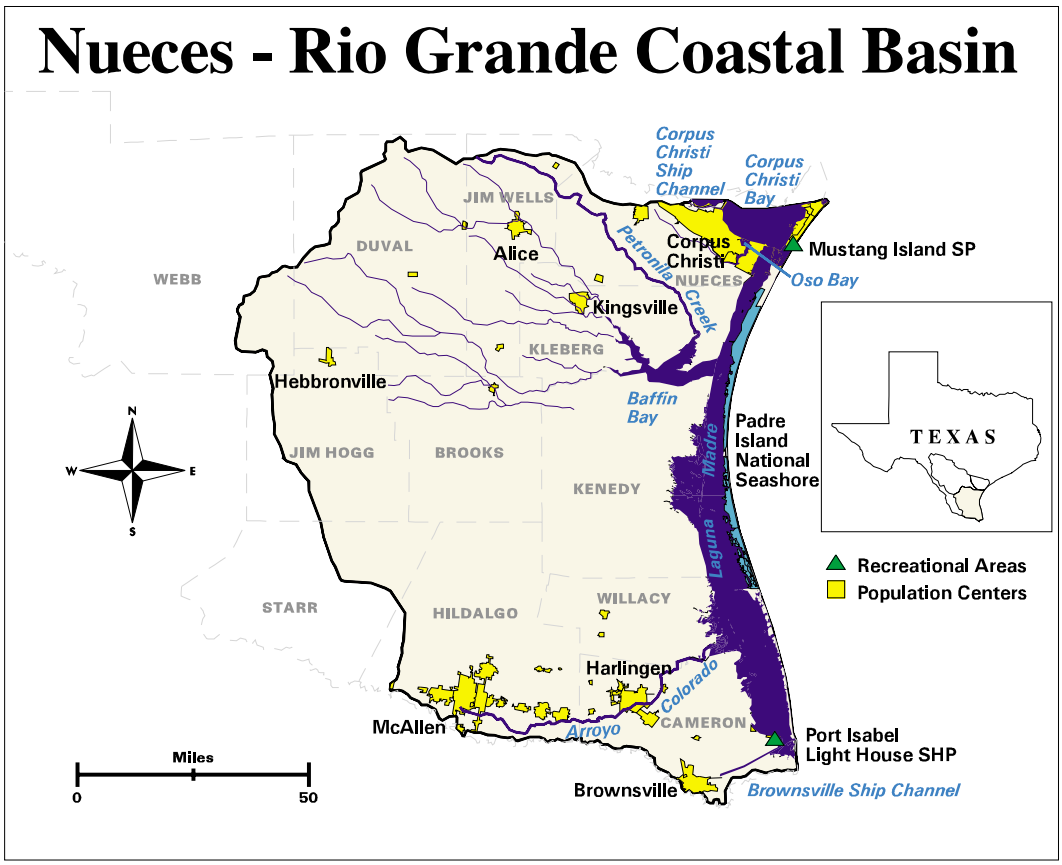


Figure 3 - Nueces - Rio Grande Coastal Basin

Monitoring Activities

Clean Rivers Program / Surface Water Quality Monitoring

NRA is responsible for coordinating the CRP monitoring activities in the Nueces River Basin, the San Antonio-Nueces Coastal Basin, and the Nueces Rio-Grande Coastal Basin for inclusion in TNRCC's Regulatory Activities and Compliance System (TRACS) database. NRA conducts Fixed Station, or Routine, monitoring at a total of 22 stations (10 stations in the Nueces River Basin, 10 stations in the San Antonio-Nueces Coastal Basin, and 2 stations in the Nueces-Rio Grande Coastal Basin) on a quarterly basis (Figure 4). Field measurements include water temperature, dissolved oxygen (DO), pH, conductance, flow (on non-tidal segments), and air temperature. Water samples are taken and analyzed for bacteria, nitrate+nitrite, ammonia, total Kjeldahl nitrogen, phosphorus, phosphate, chloride, sulfate, hardness, alkalinity, total suspended solids, total dissolved solids (TDS), chlorophyll-a, and pheophytin. Benthic samples are collected at the bay stations. Center for Coastal Studies (CCS) at TAMUCC assists NRA with the monitoring. The City of Corpus Christi contributes by providing a boat access to the Lake Corpus Christi site.

NRA coordinates with TNRCC to avoid duplication of efforts between CRP monitoring and the Surface Water Quality Monitoring (SWQM) program conducted by TNRCC regional offices: Region 13 monitors the upper Nueces River Basin, Region 14 monitors the creeks flowing into Baffin Bay and the coastal waters from Baffin Bay to Mesquite Bay, and Region 15 monitors the Arroyo Colorado and the coastal waters south of Baffin Bay.

Tables 1, 2, and 3 list the SWQM stations being monitored in the Nueces River Basin, the San Antonio-Nueces Coastal Basin, and the Nueces Rio-Grande Coastal Basin, respectively, during FY2001. The tables include the segment #, water body, station description, and monitoring agency. Stations located in the bays and estuaries, Basin 24, are included with the adjacent inland basin.

TRACS data are used to assess whether or not stream segments meet water quality standards set forth in TNRCC's *Texas Surface Water Quality Standards*. Many other entities also monitor water quality within the basins, and although their data may not be used directly for official assessments, the information is still very useful in helping to understand the overall system.

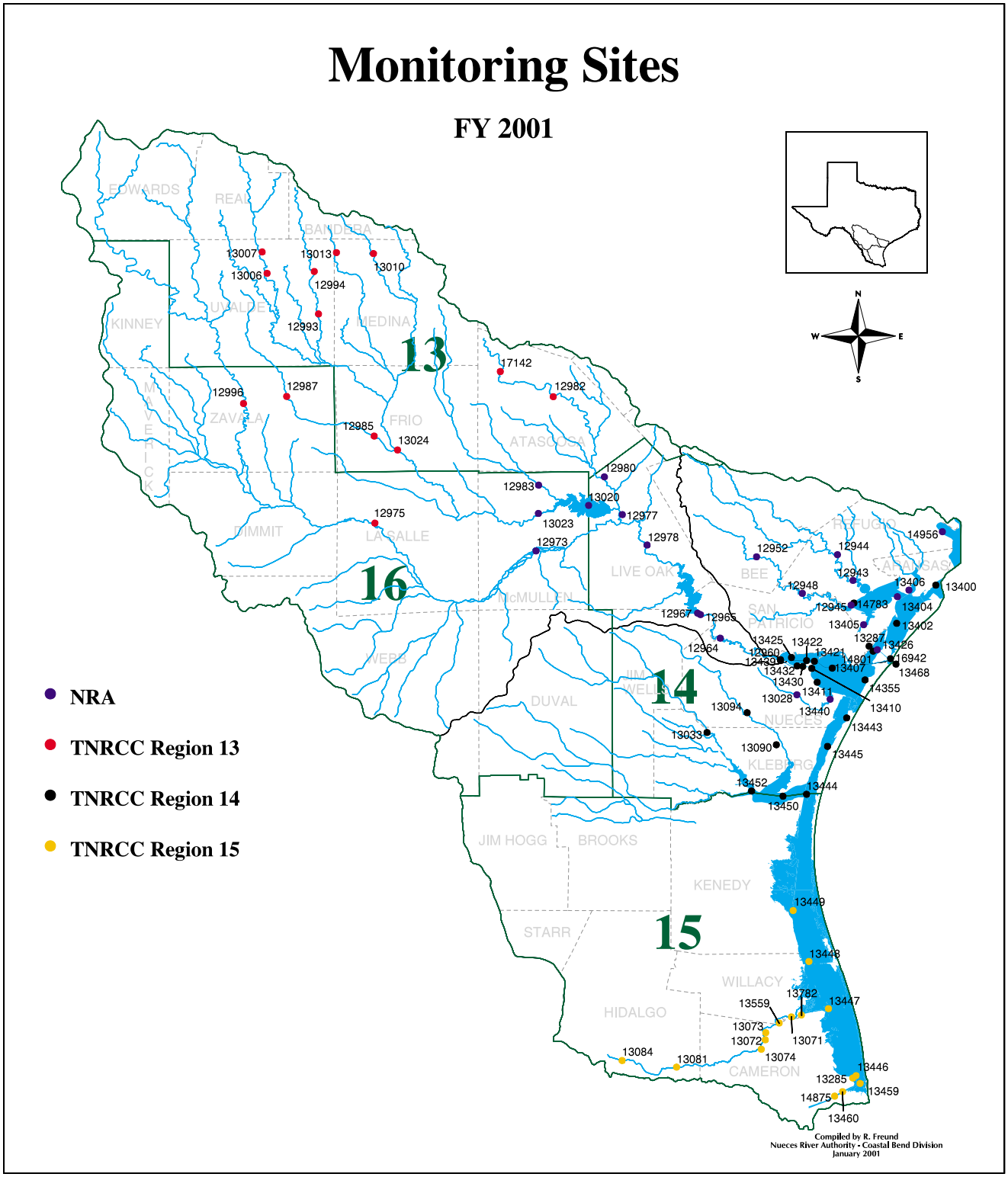


Figure 4 - FY 2001 Monitoring Sites

Table 1. Nueces River Basin

Station	Segment	Water Body	Description	Agency
12960	2101	Nueces River Tidal	N of Viola Turning Basin	Region 14
12964	2102	Nueces River	Bluntzer Bridge on FM 666	NRA
12965	2102	Nueces River	La Fruta Bridge, SH 359	NRA
12967	2103	Lake Corpus Christi	Mid-Lake at Dam	NRA
12973	2104	Nueces River	SH 16 S of Tilden	NRA
12975	2105	Nueces River	IH 35 S of Cotulla	Region 13
12977	2106	Frio River	US 72 in Three Rivers	NRA
12978	2106	Nueces River	US 59 E of George West	NRA
12980	2107	Atascosa River	FM 99 Bridge E of George West	NRA
12982	2107	Atascosa River	US 281 at Pleasanton	Region 13
17142	2107	Atascosa River	FM 2504	Region 13
12983	2108	San Miguel Creek	SH 16 N of Tilden	NRA
12985	2109	Leona River	FM 1581 SW of Pearsall	Region 13
12993	2110	Sabinal River	US 90 Bridge W of Sabinal	Region 13
12994	2110	Sabinal River	12.5 Miles N of Sabinal	Region 13
12996	2112	Nueces River	US 57 S of Uvalde	Region 13
13006	2113	Frio River	SH 127 E of Concan	Region 13
13007	2113	Frio River	Magers Crossing	Region 13
13010	2114	Hondo River	Downstream from bridge on RR 462 near Tarpley	Region 13
13013	2115	Seco River	Miller Ranch near Utopia	Region 13
13020	2116	Choke Canyon Reservoir	Mid-Lake on Live Oak - McMullen County Line	NRA
13023	2117	Frio River	SH 16 in Tilden	NRA
13024	2117	Frio River	US 35 N of Dilley	Region 13

Table 2. San Antonio - Nueces Coastal Basin

Station	Segment	Water Body	Description	Agency
12943	2001	Mission River Tidal	FM 2678 Bridge between Refugio and Bayside	NRA
12944	2002	Mission River	US 77 Upstream from Bridge at Refugio	NRA
12945	2003	Aransas River Tidal	FM 136 Bridge S of Bayside	NRA
12948	2004	Aransas River	US 77 Bridge between Woodsboro and Sinton	NRA
12952	2004	Aransas River	County Road E of Skidmore	NRA
14956	2462	Hynes Bay	Austwell at TPWD Public Boat Ramp	NRA
13400	2463	Mesquite Bay	S of GIWW CM 13	Region 14
13402	2471	Aransas Bay	Intersection of GIWW and Lydia Ann Channel S of Rockport	Region 14
16942	2471	Aransas Bay	Lydia Ann Channel Directly W of Aransas Lighthouse	Region 14
13404	2472	Copano Bay	W Side of Fishing Pier alongside SH 35	NRA
13405	2472	Port Bay	FM 881 W of Rockport	NRA
14783	2472	Copano Bay	1 Mile E of Bayside	Region 14
13406	2473	St. Charles Bay	NE of Goose Island SP	NRA
13407	2481	Corpus Christi Bay	CC CM 62	Region 14
13425	2482	Nueces Bay	Near Whites Point	Region 14
13426	2483	Redfish Bay	SH 361 at 3rd Bridge between Aransas Pass and Port Aransas	NRA
14801	2483	Redfish Bay	GIWW at Aransas Pass	Region 14

Table 3. Nueces - Rio Grande Coastal Basin

Station	Segment	Water Body	Description	Agency
13072	2201	Arroyo Colorado Tidal	FM 106 Bridge at Rio Hondo	Region 15
13073	2201	Arroyo Colorado Tidal	Camp Perry	Region 15
13559	2201	Arroyo Colorado Tidal	CM 27 at Boundary between Willacy and Cameron Counties	Region 15
13782	2201	Arroyo Colorado Tidal	Near CM 16 at Arroyo City	Region 15
13074	2202	Arroyo Colorado	Low Water Bridge at Port Harlingen	Region 15
13081	2202	Arroyo Colorado	Main Floodway in Llano Grande at FM 1015 S of Weslaco	Region 15
13084	2202	Arroyo Colorado	US 281 S of Pharr	Region 15
13090	2203	Petronila Creek Tidal	1.2 KM Upstream of Confluence with Tunas Creek	Region 14
13094	2204	Petronila Creek	FM 892 SE of Driscoll	Region 14
13410	2481	Corpus Christi Bay	CC Ship Channel CM 86	Region 14
13411	2481	Corpus Christi Bay	½ Mile off Doddridge Rd.	Region 14
14355	2481	Corpus Christi Bay	Near Shamrock Point	Region 14
13421	2482	Nueces Bay	US 181 Bridge on S side of Causeway	Region 14
13422	2482	Nueces Bay	½ Mile from S Shore at E Overhead Power Line	Region 14
13430	2484	Corpus Christi Inner Harbor	Avery Turning Basin	Region 14
13432	2484	Corpus Christi Inner Harbor	Near Navigation Blvd. Draw Bridge	Region 14
13439	2484	Corpus Christi Inner Harbor	Viola Turning Basin	Region 14
13028	2485	Oso Creek	SH 286 S of CC	NRA
13440	2485	Oso Bay	SH 358	NRA
13443	2491	Laguna Madre	S of Intersection of GIWW and Padre Island Causeway	Region 14
13444	2491	Laguna Madre	Intersection of GIWW at Baffin Bay Marker	Region 14
13445	2491	Laguna Madre	GIWW near Bird Island	Region 14
13447	2491	Laguna Madre	Intersection of GIWW and Arroyo Colorado	Region 14
13448	2491	Laguna Madre	Intersection of GIWW and Port Mansfield Channel	Region 14
13033	2492	San Fernando Creek	US 77 Bypass Bridge at Kingsville	Region 14
13450	2492	Baffin Bay	CM 14	Region 14
13452	2492	Baffin Bay	CM 36	Region 14

Water Quality Data Availability

NRA maintains an online database of surface water quality data for locations within the Nueces River Basin and Nueces Coastal Basins. The data are accessible through the NRA website (http://nueces-ra.tamucc.edu), under the "Clean Rivers Program" then "Surface Water Quality Monitoring Data" links. All historic data from the TRACS database are included in the NRA database.

The user has the option of inputting a SWQM identification number or obtaining a list of stations: (1) sampled within a given date range, (2) within a specific county, (3) within a specific basin, or (4) on a specific segment. The user can then select a station to obtain location information and a list of dates on which the station was sampled. By choosing a specific sampling date, information about the sampling event and the results of analysis are returned. The user also has the option to retrieve all information about a specific parameter for that station. The lists of stations and the analysis information can be retrieved as either HTML pages or ASCII delimited text files.

Questions regarding the use of the online database, or for additional information, should be directed to Rocky Freund, Director of Environmental and Information Programs for NRA. She can be reached via email at rfreund@falcon.tamucc.edu, or by phone at 361-825-3193.

Special Studies

Aransas River Segment Boundary Change

River in segment 2004 (Aransas River Above Tidal) was on the list of impaired water bodies for the state of Texas (Clean Water Act 303(d) list), for TDS. In 1999, TNRCC contracted with CCS to conduct a study to determine the influence of saltwater in and the boundary between this segment and segment 2003, (Aransas River Tidal). This summary of the study and results are taken from a report produced for NRA by Brien Nicolau with CCS.

> The influence of saltwater may have lead to an incorrect ranking of this segment and therefore elevated total dissolved solids concentrations being recorded. CCS conducted sampling to profile conductivity/salinity in an attempt to determine the extent of the tidal influence on this segment and whether the segment was classified correctly. Investigations were also conducted to ascertain whether a fixed saltwater barrier existed along the Aransas River in the past and to what extent this may have affected this stream segment.
>
> To gather sufficient seasonal high tide data with which to accurately assess the situation, CCS planned to conduct two separate sampling events that coincided with the seasonal high tide periods occurring in October 1998 and May 1999. Due to the extreme flooding events in October 1998, the first sampling event was conducted in May 1999, and the second sampling event occurred in October 1999.
>
> Thirteen sampling stations were established on the river from Copano Bay to the bridge at Highway 77 (Figure 5). Field parameters consisting of DO (% saturation and mg/l), water temperature, pH, conductivity, salinity, and water depth were recorded at the surface, mid, and bottom depths at 11 of the 13 stations with a Hydrolab Multi Probe.
>
> The recorded values indicated a slightly higher uniform salinity in the bay that decreased upstream to Station 9 before rising slightly from Station 10 to Station 13. Historical records *(Brune 1981. Springs of Texas. Vol. 1*) do indicate that springs within the area are typically of a sodium chloride type, fresh to slightly saline, which might possibly account for this trend. Personal communications with a resident of the area identified the position of the fixed saltwater barrier to be along the remains of an abandoned road that once crossed the river. Although it could not be verified, it appeared that the road was originally built as a matter of convenience rather than as a saltwater barrier dam.

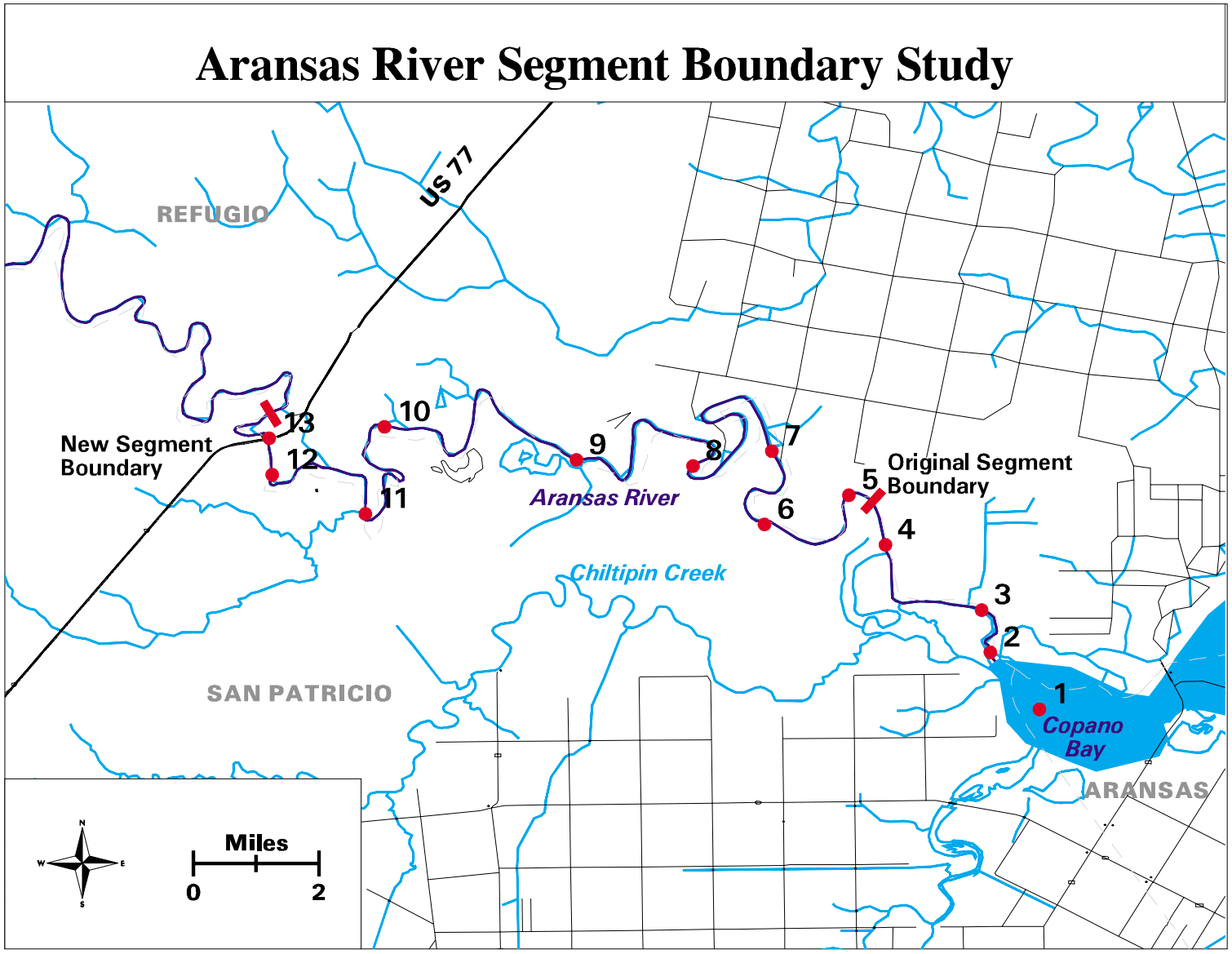


Figure 5 - Aransas River Segment Boundary Study

This study, along with other information, prompted TNRCC to change the segment boundary between segments 2003 and 2004 from "a point 5.3 kilometers (3.3 miles) upstream of Chiltipin Creek in Refugio/San Patricio County" to "a point 1.6 kilometers (1.0 mile) upstream of US 77 in Refugio/San Patricio County." This change became effective August 17, 2000 with the publication of TNRCC's revised *Texas Surface Water Quality Standards*.

Coastal Bend Bays Water Quality Monitoring Project

Even though Corpus Christi Bay has been removed from the 1999 303(d) draft list for dissolved copper, the local stakeholders are still concerned about whether or not there is a dissolved metals problem in the waters of the bay. Therefore, NRA contacted TNRCC and the Environmental Protection Agency (EPA) to help develop a monitoring program to address that concern. With funding through the Coastal Bend Bays and Estuaries Program (CBBEP), this project partnership between NRA, federal and state agencies, and stakeholder entities will provide an intensive, targeted water quality monitoring and assessment of the Coastal Bend Bays system (including Corpus Christi Bay, Nueces Bay, Corpus Christi Inner Harbor, Aransas Bay, Copano Bay, Mission Bay and Oso Bay).

The monitoring plan has incorporated both the Environmental Monitoring and Assessment Program (EMAP) probabilistic sampling design, contributed by the EPA Office of Research and Development, and a targeted monitoring plan. The EMAP sampling design established 30 randomly selected sites per quarter (for a total of 120 random sites) in the study area. Routine field and chemical parameters, and total and dissolved metals are monitored at these sites on a quarterly basis. In addition, six previously established TNRCC monitoring stations were selected for targeted monitoring of the same parameters on a bi-monthly basis. Additional sites are monitored by splitting samples obtained during TNRCC's quarterly SWQM monitoring and by splitting samples collected during the Oso Bay / Oso Creek special study (see below). This unique monitoring design will provide intensive temporal and spatial considerations which are necessary to meet the project objectives of addressing metals concerns in Corpus Christi Bay, characterization of water quality, and development of a screening process for future long-term monitoring in the CBBEP project area.

The project was organized into three phases. Phase I included development, design, and initial implementation of this water quality monitoring project and the partnering efforts of state and federal agencies and stakeholder entities. Phase I of the project has been completed. Phase II of the project encompasses the completion of the first year monitoring program and analysis of the monitoring results. Final sampling for Phase II wascompleted in April of 2001. Although the Nueces River Authority will not be involved, Phase III, if implemented, will be based on the results of Phase II and will be a continuation of the water quality monitoring effort of the Coastal Bend bays system, focusing on water quality of the Upper Laguna Madre and Baffin Bay. Phase III will also include analysis of sediment quality throughout the bays system. The final report should be available in 2003.

Oso Bay / Oso Creek Watershed System Study

TNRCC and the Texas General Land office contracted with CCS to conduct this study to characterize and assess the water quality and biota of the Oso Creek/Oso Bay Watershed System. The primary objective was to assess the watershed for potential water quality problems. A secondary objective was to provide for sampling and data collection during and after several significant rainfall events in an attempt to assess the influence of "pulsed" inputs from potential pollutant sources to the system. In addition, to further define the system, baseline data depicting land usage within the watershed was collected and compiled into basic Geographic Information System (GIS) information layers. The project objectives were also in support of CBBEP's comprehensive conservation and management plan titled the *Coastal Bend Bays Plan*.

The Oso Creek/Oso Bay Watershed System was sampled at eight locations monthly, for a six-month period. The analysis included routine field and chemical parameters, macroinvertebrate organisms, and microbial indicator organisms. Routine field and chemical parameters, and microbiological organisms were collected and analyzed

during and after four significant rainfall events and through the collection and compilation of baseline land use data.

The project was organized into three phases. Phase I included the development of the Quality Assurance Project Plan and sampling plan design, which was approved in September 1999. Phase II encompassed the sampling program, which began in October 1999 and concluded in March 2000, and the analyses of data collection results as well as the collection and compilation of the baseline data for creating the GIS information layers. Phase III included the development of the comprehensive final report which was due originally in July 2000. However, the sampling program was continued for an additional six months. The final report is currently under review by the Total Maximum Daily Load (TMDL) team at TNRCC.

Fecal Coliforms, Enterococci, *Escherichia Coli*, and Total Coliforms as Indicators of Water Quality in Oso Bay, Corpus Christi, Texas

NRA, through the CRP partnership with the TNRCC, contracted CCS to evaluate total and fecal coliform, *Escherichia coli*, and enterococci to address the issue of which is the most appropriate indicator for marine recreational waters in this region. The study was conducted in the Oso Bay area and completed in March 2000.

The distribution of fecal coliform densities imply that the effect of the outfall from the Oso Wastewater Treatment Plant is not as significant as thought. Most of the extremely high levels of bacteria in Oso Bay occurred during or after significant rainfall events. High bacterial numbers may not be directly correlated to the sewage disposal plant, but rather to non-point source sources. Turbidity, sediment, algal blooms, and aquatic birds (shorebirds, waterfowl, and colonial waterbirds) also contributed to high bacterial densities in Oso Bay. Sediment and birds appear to have played a major role in bacterial contamination.

The final report (CCS publication TAMU-CC-0001-CCS) was written by Sara L. Heilman and Dr. Joanna B. Mott with the Department of Physical and Life Sciences at TAMUCC, and Brien A. Nicolau with CCS. The Executive Summary of the report is included as Attachment A.

Total Maximum Daily Load Projects

TNRCC implements a statewide approach for watershed management in Texas to improve the efficiency, effectiveness, and continuity of water quality management programs. It focuses on assessing watershed conditions for all waters of the state and implementing solutions where improvement is necessary. The TMDL Program, a major component of the approach, addresses impaired or threatened streams, lakes, and estuaries (water bodies). The primary objective of the TMDL Program is to restore and maintain the beneficial uses of impaired or threatened water bodies.

When a segment of a water body does not conform to surface water quality standards, it is included on the 303(d) list. Once on the list, a TMDL is required to be performed on that segment for the nonconforming parameter. A TMDL is the total amount of a pollutant that a water body can assimilate and still meet state water quality standards. The term also refers to the assessment process necessary to establish an acceptable pollutant load for an impaired water body and to allocate the load between contributing point, non-point, and natural background sources of pollutants in the watershed. Thus, water quality monitoring and other assessment activities are an integral part of a TMDL.

Arroyo Colorado

Segments 2201, 2202, and 2202A in the Arroyo Colorado watershed are on the 199 303(d) list because of low DO and elevated levels of pollutants, including pesticides, polychlorinated biphenyls (PCBs), and other organic compounds. TNRCC, in conjunction with the Texas State Soil and Water Conservation Board, is currently leading an effort to establish a TMDL for substances identified as causing or contributing to low DO in the Arroyo Colorado. Currently, Texas State Technical College (TSTC), located in Harlingen, is performing a

TMDL Verification Sampling Project in an effort to provide data necessary to evaluate the effectiveness of specified pollution control measures in a load allocation agreement that would be established for the Arroyo Colorado. NRA is providing support to TSTC in return for updates on their results as well as use of the data collected for our CRP requirement in that area.

Basin Groups D and E Combined Studies

In August 2000, the TNRCC TMDL Program announced that it was initiating TMDL projects in basin groups D and E during fiscal year 2001 (Figure 6) for segments listed on the 1999 303 (d) list. There are two projects; one for DO and bacteria, and the other for dissolved solids. The objectives of these projects are: first, determine if existing Surface Water Quality Standards applicable to each of the stream segments are appropriate and, if not, develop designated use and/or criteria adjustment information; second, determine if appropriate water quality standards and criteria are being met in each stream segment; and third, develop information necessary to support modeling and assessment activities required to allocate pollutant loadings in each of the stream segments.

Figure 6 - Basin Planning Groups

The projects will be split into two two-year phases. Phase I of each project will consist of monitoring activities and data analyses in order to meet the defined project objectives. If necessary, Phase I will also include an assessment of data to determine load allocation. Phase II of each project is initiated if Phase I has concluded that an impairment exists and defines and initiates strategies to restore the impaired stream segment. Figure 7 shows

the sampling sites for those stations used in the following discussions of the segments included in the TMDL projects.

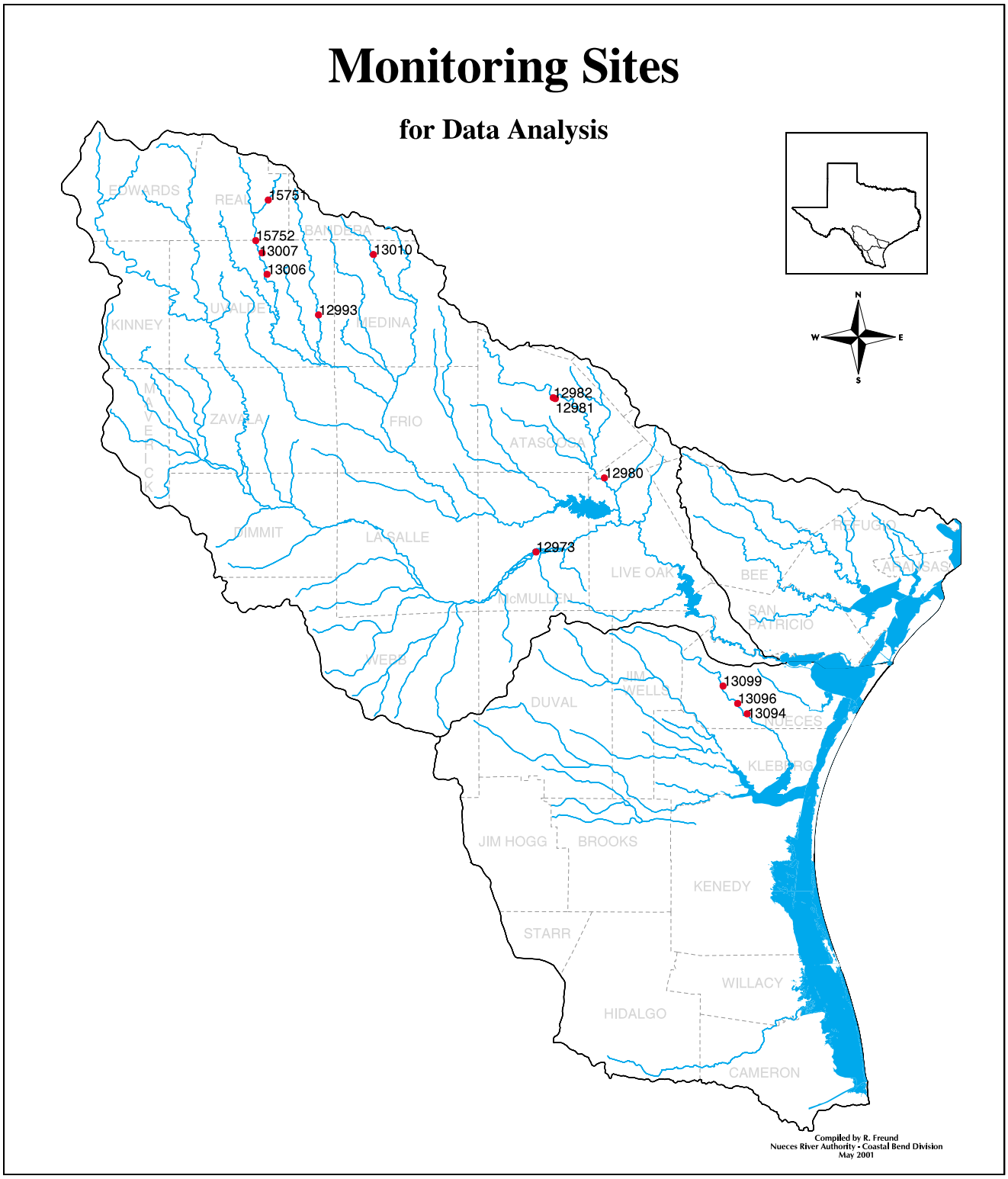


Figure 7 - Monitoring sites for Data Analysis

Inland Dissolved Oxygen / Bacteria

There are a total of 16 segments grouped under this proposed TMDL: four located in the Nueces River Basin; six in the Guadalupe River Basin; four in the San Antonio River Basin; and one in the Lower Colorado River Basin. The parameters of concern for each of the four segments in the Nueces River Basin, 2104 – Nueces River Above Frio River, 2107 – Atascoas River, 2110 – Lower Sabinal River, and 2113 – Upper Frio River, are discussed below. In each of the graphs showing the sampling event results for the parameters of concern, the red horizontal line(s) indicates the criteria established for that particular segment as listed in the *Texas Surface Water Quality Standards*.

2104 – Nueces River Above Frio River: The 303(d) list states that in the lower 25 miles downstream of FM 624 in McMullen County, DO concentrations are occasionally lower than the standard established to provide optimum conditions for aquatic life. SWQM station 12973, Nueces River at SH 16 south of Tilden, is the only station on this segment that has been monitored since 1995.

Figure 8 shows the 18 routine sampling results and the one 24-hour average for DO since 1995 for this location. For the 1999 assessment, two out of 15 samples (13.3%) exceed the criteria, indicating that the segment is partially supporting of aquatic life use. However, an assessment using 1996 – 2000 data would show that only one out of 16 samples (6.7%) exceed the criteria and is therefore fully supporting of aquatic life use. The 24-hour DO meets the criteria.

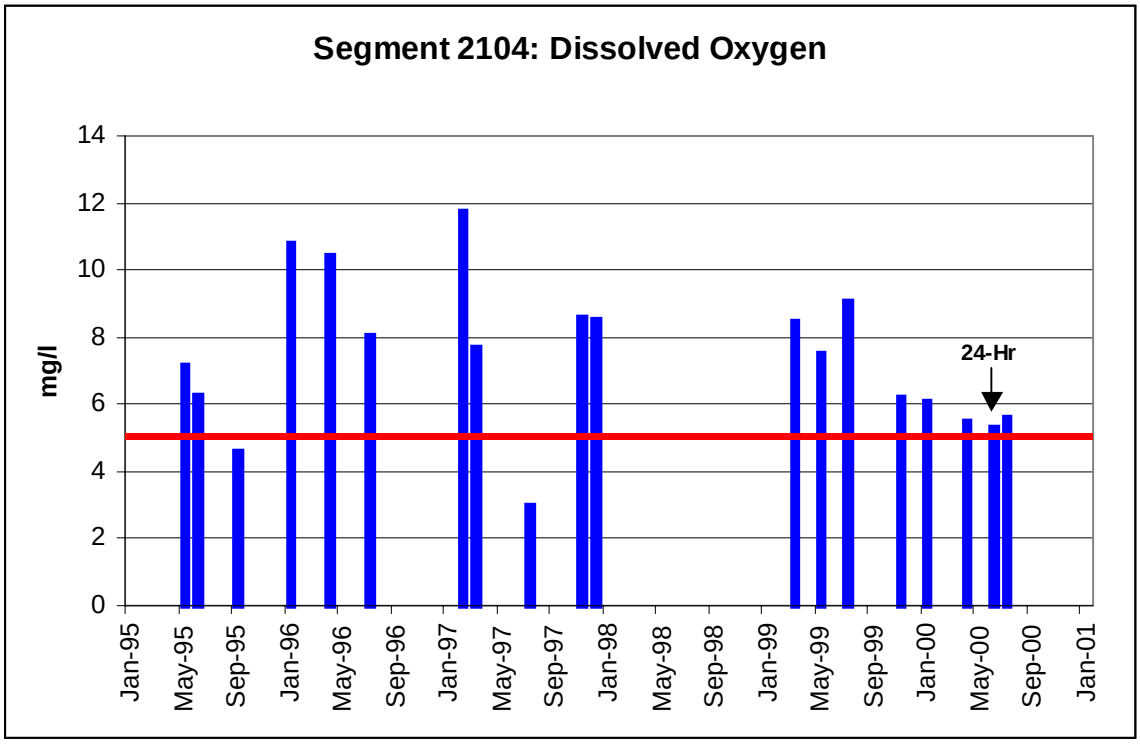


Figure 8 -Segment 2104: Dissolved Oxygen

The 303(d) list also states that measured pH values occasionally higher than the criterion established to safeguard general water quality uses. Figure 9 shows the 19 routine sampling results since 1995 for station 12973. For the 1999 assessment, two out of 16 samples (12.5%) exceed the criteria, indicating that the segment is partially supporting of aquatic life use. An assessment using 1996 – 2000 data would have the same results.

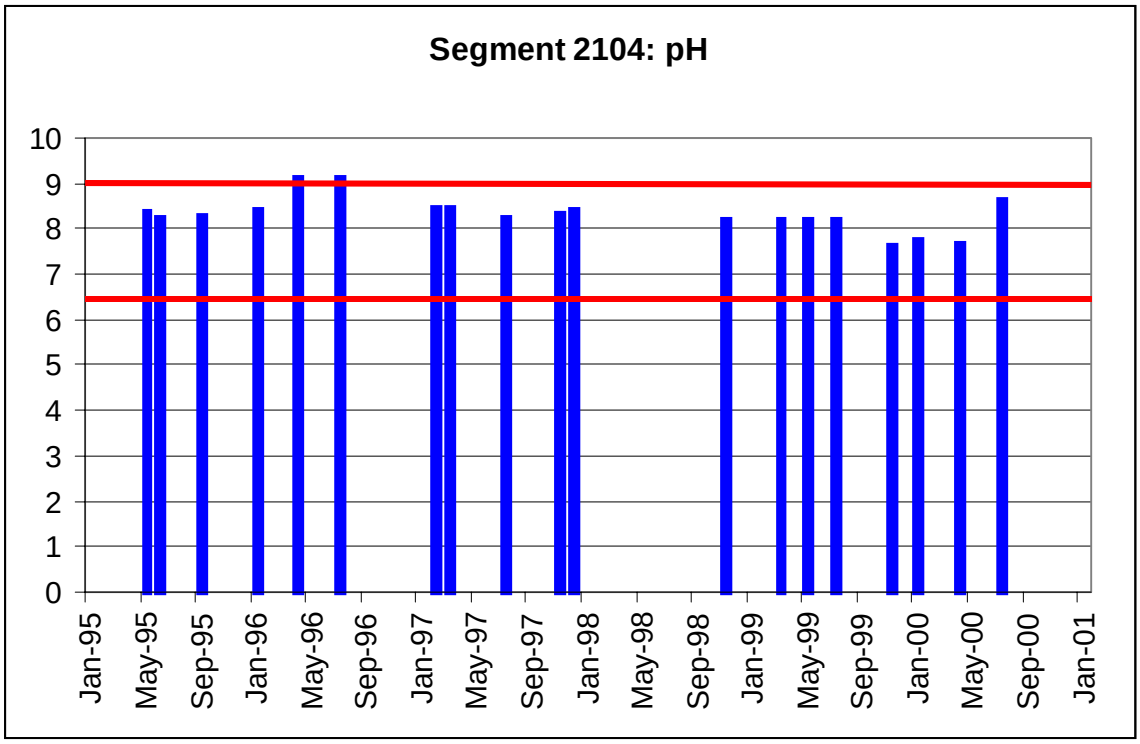


Figure 9 – pH: Segment 2104

2107 – Atascosa River: The 303(d) list states that in the lower 25 miles downstream of SH 16 in Atascosa County, DO concentrations are sometimes lower than the criterion established to ensure optimum conditions for aquatic life. There are three monitoring stations on this segment; 12980, Atascosa River at FM 99 bridge west of Whitsett, 12981, Atascosa River on dirt road directly east of Pleasanton at railroad bridge, and 12982, Atascosa River at US 281 at Pleasanton. Station 12981 has been replaced by station 12982 for monitoring purposes.

Figure 10 shows the 12, 10, and five routine sampling results for DO since 1995 for stations 12980, 12981,and 12982, respectively. For station 12980, the 1999 assessment contains two out of nine samples (22.2%) that exceed the criteria, indicating that the segment is partially supporting of aquatic life use. An assessment using 1996 – 2000 data would also indicated that the segment is partially supporting of aquatic life use with two out of 12 (16.7%) exceeding the criteria. For station 12981, the 1999 assessment contains two out of ten samples (20%) that exceed the criteria, indicating that the segment is partially supporting of aquatic life use. There are not the required minimum number of samples to assess station 12981 using only 1996 – 2000 data, however two of the six samples exceed the criteria. There are not the required minimum number of samples to assess station 12982 for either time period, however one out of one (1995-1999) and one out of five (1996-2000) samples exceed the criteria.

The 303(d) list also states that bacteria levels sometimes exceed the criterion established to assure the safety of contact recreation. Figures 11 shows the five, seven, and one routine sampling results for fecal coliform for stations 12980, 12981,and 12982, respectively. It also contains the four routine sampling results for E. coli for station 12980. Although there are not the required minimum samples for any given station, the combined analysis for fecal coliform for the 1995 – 1999 data indicates that the segment is non-supportive of contact recreation with seven out of 10 samples (70%) exceeding the criteria. The combined analysis for fecal coliform for the 1996 – 2000 data also indicates that the segment is non-supportive of contact recreation with five out of

nine samples (55.6%) exceeding the criteria. There are not the required minimum number of samples to assess station 12980 for E. coli, however four out of four samples exceed the criteria.

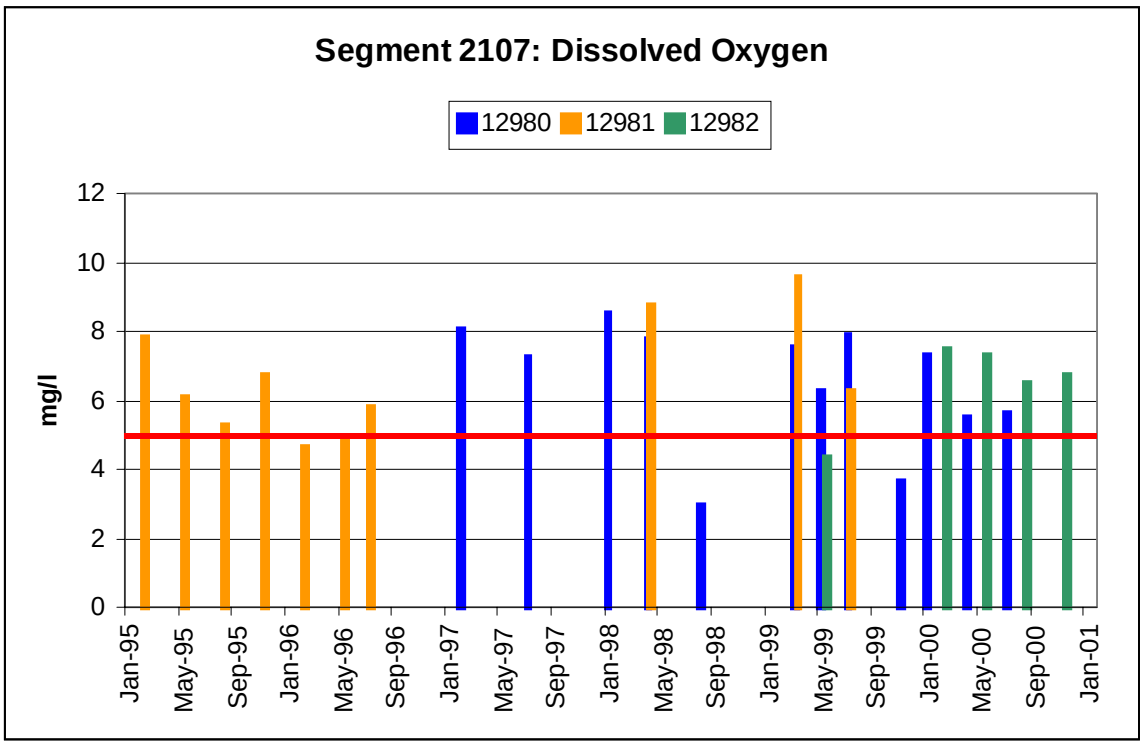


Figure 10 -Segment 2107: Dissolved Oxygen

2110 – Lower Sabinal River: The 303(d) list states that bacteria levels sometimes exceed the criterion established to assure the safety of contact recreation. SWQM station 12993, Sabinal River bridge on US 90 west of Sabinal, is the only station on this segment that has been monitored since 1995.

Figure 12 shows the 13 and eight routine sampling results for fecal coliform and E. coli since 1995 for this location. For the 1999 assessment of fecal coliform, 10 out of 12 samples (83.3%) exceed the criteria, indicating that the segment is not in support of contact recreation. An assessment using 1996 – 2000 data would also indicated that the segment is not in support of contact recreation with 11 out of 13 (84.6%) exceeding the criteria There are not required minimum number of samples to perform an analysis of E. coli, however, six out of eight samples exceed the criteria.

2113 – Upper Frio River: The 303(d) list states that from FM 2748 in Real County to just downstream of SH127 in Uvalde County, DO concentrations are occasionally lower than the standard established to ensure optimum conditions for aquatic life. There are four monitoring stations on this segment; 13006, Frio River at SH 127 east of Concan, 13007, Frio River at Magers Crossing, 15751, East Frio River at Birchfield approximately 800' upstream of Steep Hollow Creek, and 15752, Frio River at Jake's Hole approximately 1000' downstream of FM 1120.

A special study was conducted at these sites April – July 1997 to evaluate the impact of recreational use (primarily in Garner State Park) and land development in the Upper Frio River on the water quality and the aquatic biological community. Station 15751 was the reference station above the primary study area,

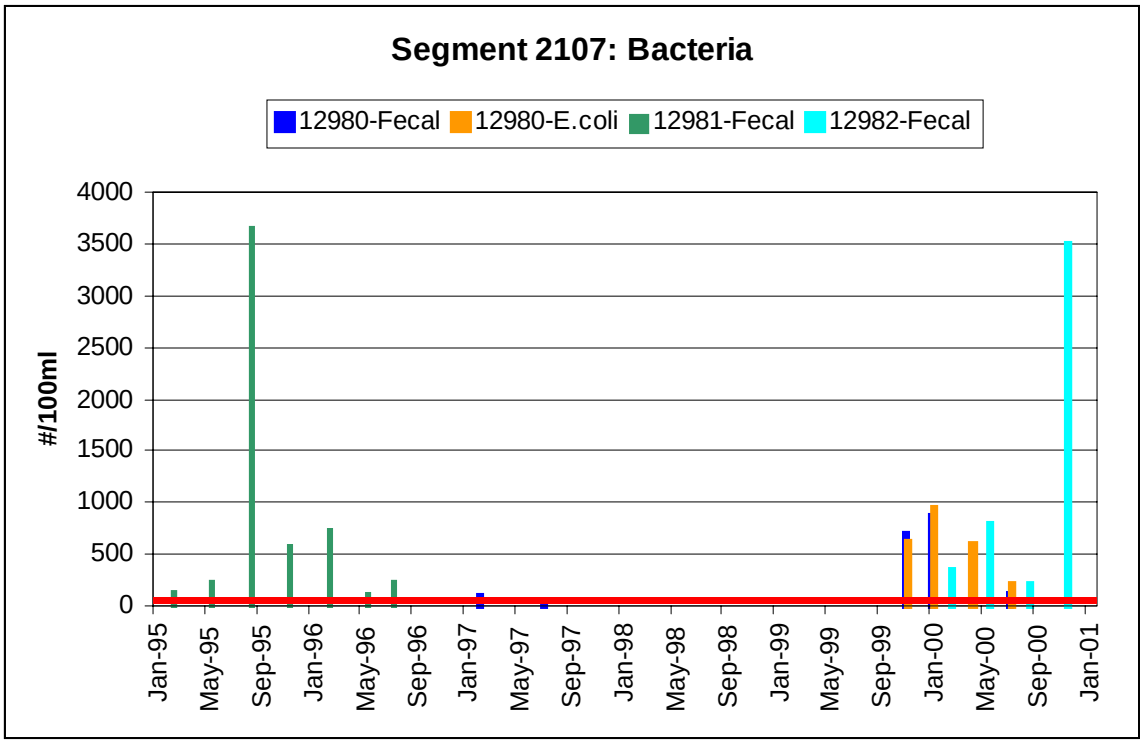


Figure 11 – Segment 2107: Bacteria

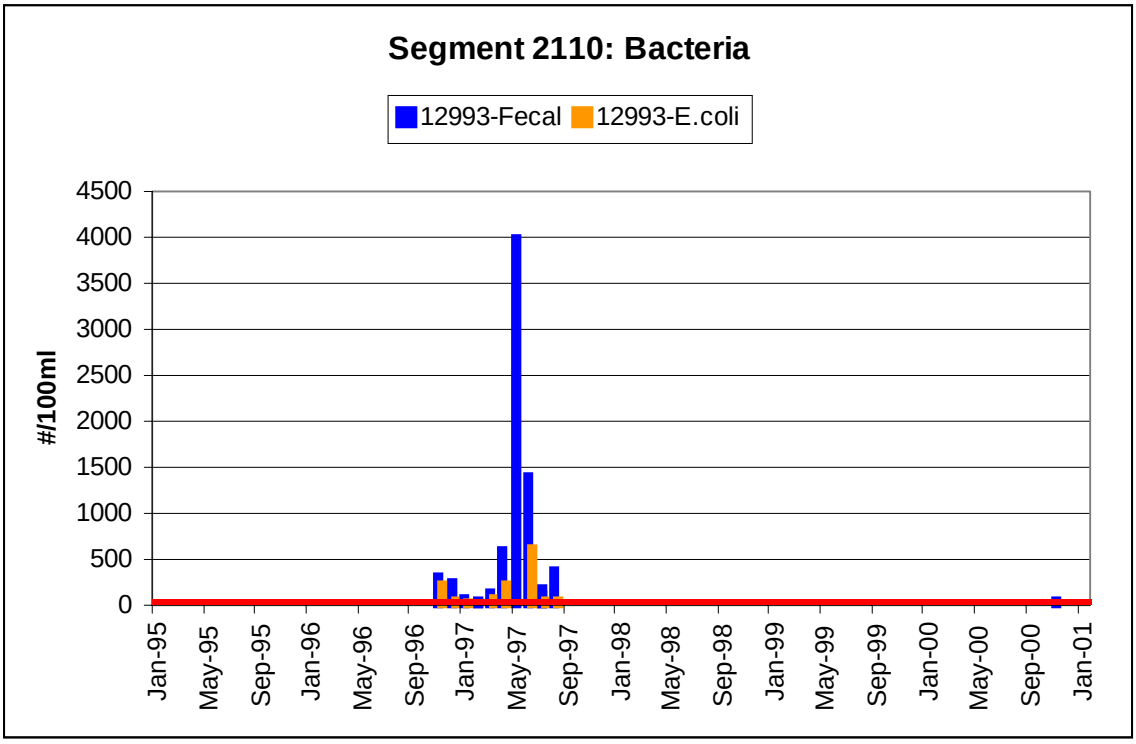


Figure 12 – Segment 2110: Bacteria

15752 was the mid-point of the study area, 13007 was the end of the study area, and 13006 was below the study area. With respect to DO, the final report states that "at Station 3 (13007), DO values were consistently lower than at the other three locations during all four sampling events. This condition may indicate the presence of a continuous source of oxygen demand such as recreational use refuse or septic tank effluent seepage in the reach from Station 2 (15752) to Station 3. Sewage at Garner State Park is treated and disposed by land irrigation with no direct discharge to the river; therefore, park sewage is not a likely source of oxygen demand. No bacteria data were collected as part of this study; these could provide an indication of any septic tank effluent influences." The report goes on to state that "Station 3, below Garner State Park should be investigated to determine the cause of low DO conditions. Monitoring of diurnal DO profile data should be collected with coliform data, nutrient data, and TDS."

Figure 13 shows the five and one routine sampling results for stations 13006 and 13007, respectively and the four special study results for all stations (three for station 15751 - one sample was lost). There are not enough samples at any one site to perform an analysis on the 1995-1999 data. However the 1996-2000 data for 13006 show that none of the nine samples exceed the criteria. Since all the stations are within a 25 mile stretch of the river, a combined analysis shows that five out of 21 samples (23.8%) exceed the criteria indicating the segment is in partial support for contact recreation.

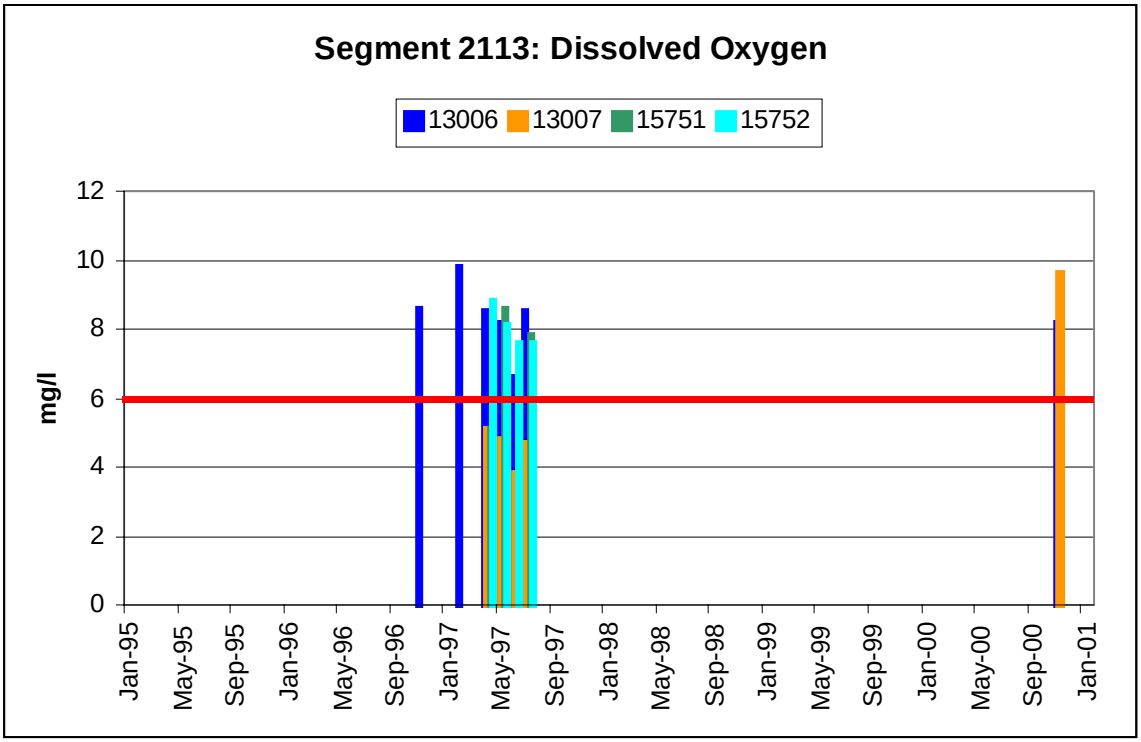


Figure 13 - Segment 2113: Dissolved Oxygen

Total Dissolved Solids

There are a total of four segments grouped under this proposed TMDL; one located in the Nueces River Basin; two in the San Antonio River Basin; and one in the Brazos River Basin. The segment in the Nueces River Basin on the 303(d) list for TDS is 2204 – Petronila Creek Above Tidal. The 303(d) list states that the average concentrations of chloride, sulfate, and TDS exceed the criteria to safeguard general water quality uses. There are three monitoring stations on this segment; 13904, Petronila Creek at FM-892 southeast of Driscoll, 13096, Petronila Creek at FM-665 east of Driscoll, and 13099, Petronila Creek at FM 2826 north of Driscoll.

Figures 14, 15, and 16 show the 19, four, and three routine sampling events for stations 13094, 13096, and 13099, respectively, for TDS, sulfate, and chloride, respectively. The 1999 assessment for station 13094 shows that 14 out of 18 (77.8%) of the TDS samples, 11 out of 18 (61.1%) of the sulfate samples, and 14 out of 18 (77.8%) of the chloride samples exceed the criteria which indicates that this portion of the segment is non-supporting for aquatic life use. An analysis of the 1996 - 2000 data for 13094 as the same results with 12 out of 16 (75.0%)of the TDS samples, nine out of 16 (56.3%) of the sulfate samples, and 12 out of 16 (75.0%) of the chloride samples exceeding the criteria.

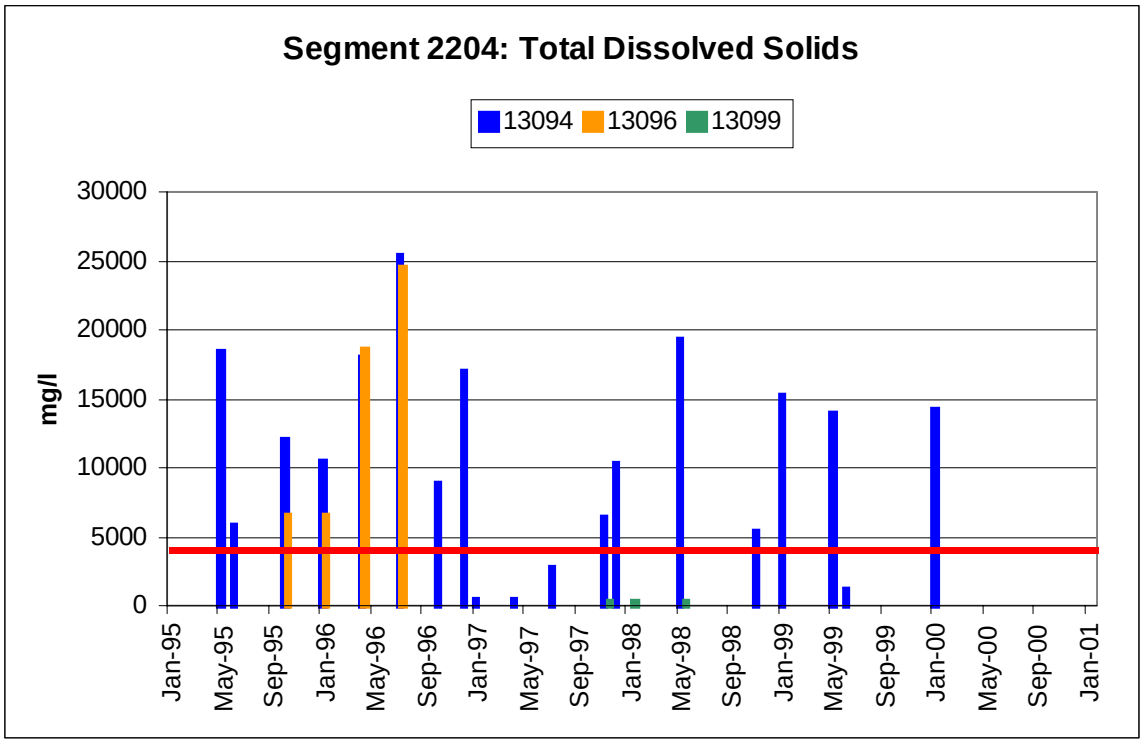


Figure 14 - TDS: Segment 2204

There are not the required minimum number of samples at station 13096 for an analysis, however four out of four (100%) of the TDS samples and four out of four (100%) of the sulfate samples exceed the criteria. None of the four samples for chloride exceed the criteria. There are not the required minimum number of samples at station 13099 for an analysis, however none of the three samples for either TDS, sulfate, or chloride exceed the criteria indicating that the source of the problem is somewhere between stations 13099 and 13096.

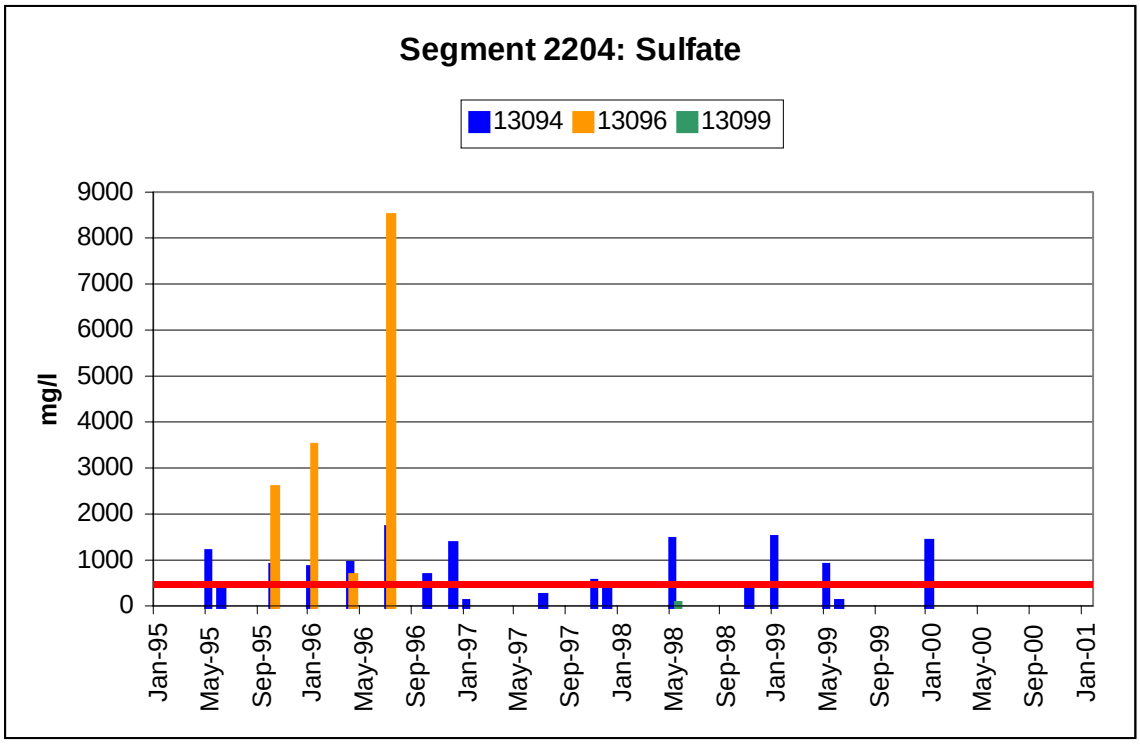


Figure 15 - Segment 2204: Sulfate

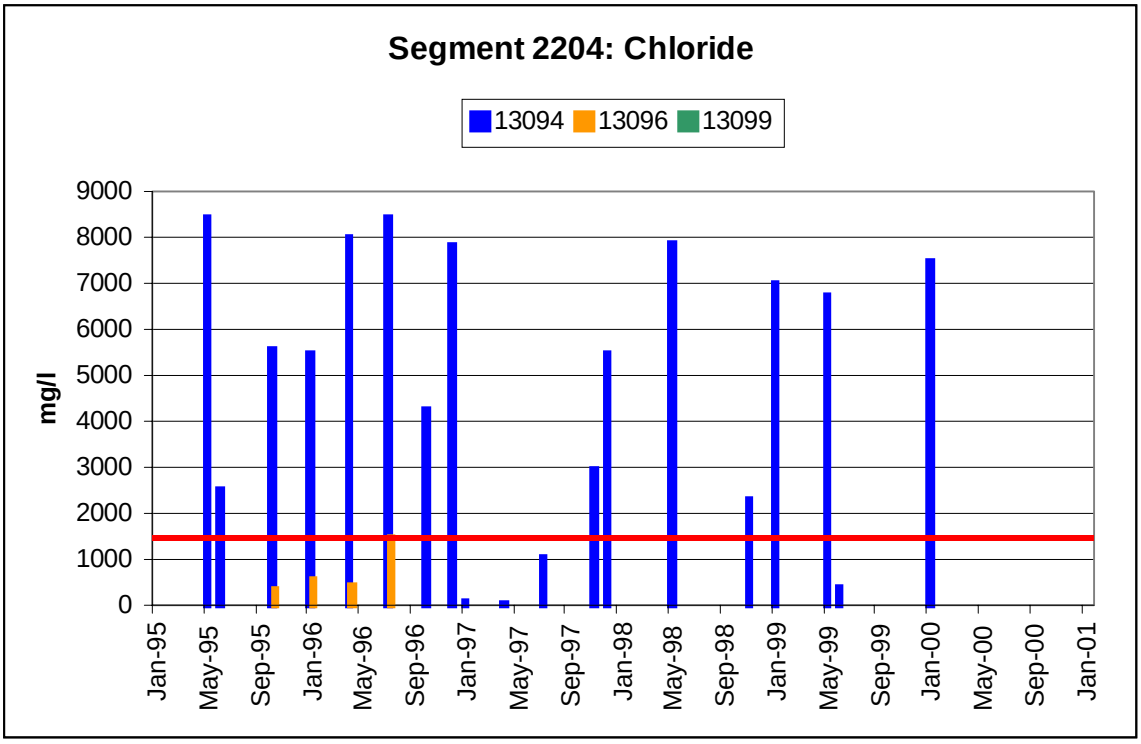


Figure 16 - Segment 2204: Chloride

Public Outreach

Nueces River Forum

The Upper Nueces Basin is noted for its scenic, clear flowing rivers. These rivers are valuable natural resources that strengthen local economies, sustain fish and wildlife, and offer recreational opportunities to local citizens and visitors. Today, litter, trespassing, vandalism, aquatic habitat destruction, poaching and other damages caused by offensive public conduct are threatening the integrity and value of these rivers, especially where access to the rivers is facilitated by the crossing of public roads.

On September 27, 2000, NRA hosted a public forum in Uvalde, Texas to highlight this growing problem. The public and representatives from several state agencies were invited to attend and speak on these issues. Following this initial meeting, a sub-group, representative of all sides concerned, was developed to determine if there was a way to control the public abuse of the rivers that would be acceptable to all users of the rivers. The group has met twice and has decided that further research is needed concerning law enforcement on this subject. At this time, NRA has no enforcement authority on the rivers, however the Texas Legislature is considering an amendment to the NRA's enabling legislation that would allow NRA to adopt and enforce rules to protect the natural condition of the state-owned river beds and banks within the NRA's boundaries.

Currently, NRA is continuing a public awareness campaign regarding these issues of public abuse of the river through CRP. In November 2000, NRA participated in Uvalde's Annual Hunter's Roundup, an event that encourages outdoor activities in the upper Nueces Basin. Brochures and other information were distributed during the event. For more information about this effort, visit our website at http://nueces-ra.tamucc.edu/publicout/preleases.html.

Earth Day / Bay Day

On Earth Day, April 22, 2000, NRA participated in the first annual Earth Day/Bay Day held at Hazel Bazemore Park on the Nueces River. Organized by the Coastal Bend Bays Foundation, and sponsored by various group, this event was an effort towards educating the public about the importance of natural resources and why they need to be protected. State and federal agencies as well as other organizations and clubs were on hand to distribute information and speak to the public. Activities such as kayaking, bird watching, hiking, and (simulated) rock climbing were also available for the day. NRA provided information about their activities related to water quality and water conservation. Staff was on hand to display equipment used for water quality testing and to demonstrate how the equipment is used. The event was a huge success and attracted thousands of people.

Earth Day/Bay Day for 2001 was held on April 22nd at Blucher Park in Corpus Christi. Again, kayaking, bird watching, and rock climbing were be available. Other activities included cycling and kite-making. Through

CRP, NRA helped to sponsor the event and again provided information on water resources protection and planning.

Texas Watch

In an effort to create a more complete database of water quality information for the state of Texas, TNRCC created the Texas Watch Program. This program was developed to "facilitate environmental stewardship by empowering a statewide network of concerned volunteers, partners, and institutions in a collaborative effort to promote a healthy and safe environment through environmental education, data collection, and community action." The Texas Watch Program is managed by Southwest Texas University (SWT) in San Marcos where is it administered through a cooperative partnership of SWT, TNRCC, and EPA. The program is very active in educating the public on water quality standards and issues as well as training their volunteers in proper water quality data collection techniques.

Texas Watch has been a major participant and coordinator of several environmental events. One such event, "Earth Day 2000 - A Day in the Life of Texas Waters," took place on April 18, 2000 statewide. This event was designed to promote Earth Day awareness and celebrate Earth Day's 30th anniversary. During this day, thousands of volunteers associated with Texas Watch performed a statewide sampling initiative. The volunteers sampled several surface and ground water sites and reported their results to the staff at Texas Watch. Professional water quality organizations, including NRA, submitted their sampling information for the day as well.

Texas Watch conducted the "Day in the Life of Texas Waters" again on Earth Day, April 18, 2001. NRA participated by sampling four bay locations and submitting the results to Texas Watch. NRA also demonstrated water quality sampling at the Ingleside Public Works wastewater treatment plant for the Ingleside senior Girl Scouts Troop.

NRA is constantly working towards expanding their relationship with the Texas Watch program. Recently, NRA has become involved with providing support to a volunteer group in Rockport, Texas. The group was created out of concern for a local water body. Little Bay is a highly used contact and non-contact recreational area and the volunteers are concerned about bacteria concentrations in the area. Little Bay is adjacent to Aransas Bay, a segment on the 303(d) list for pathogens, so NRA feels that the volunteer group may have reason to be concerned. After six months of initial volunteer sampling, it has been concluded that long-term monitoring should be continued to better understand the dynamics of the water body.

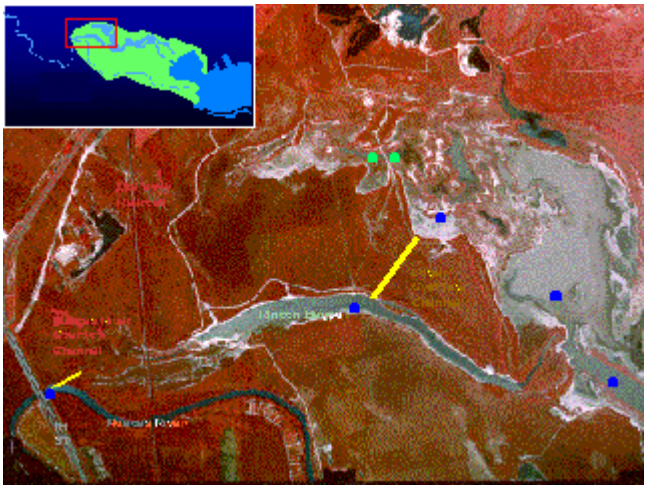
For more information about Texas Watch and their program, visit their website at www.texaswatch.geo.swt.edu. or call their toll-free number 877-506-1401.

Regional News

Rincon Bayou Diversion Project

The following paragraphs are excerpts from the *Executive Summary of the Rincon Bayou Demonstration Project Concluding Report September 2000* published by the United Stated Department of the Interior Bureau of Reclamation in cooperation with University of Texas Marine Science Institute.

In 1993, the U.S. Bureau of Reclamation (Reclamation) initiated a demonstration project with the following objectives: (1) to increase the opportunity for freshwater flow events into the upper Nueces Delta, and (2) to monitor subsequent changes in delta productivity.



The primary features of the Rincon Bayou Demonstration Project were two excavated channels (the Nueces Overflow Channel and the Rincon Overflow Channel), which were completed in October 1995. Monitoring g activities were conducted from October 1994 through December 1999, and were focused on the response of organisms in the water column, sediments, and tidal flats of the delta.

The Rincon Bayou Demonstration Project significantly lowered the minimum flooding threshold of the upper Nueces Delta, thereby increasing the opportunity for larger, more frequent diversions of fresh water from the Nueces River. During the 50-month demonstration period, the amount of fresh water diverted into the upper Nueces Delta was increased by about 732%. Five freshwater inflow events were sufficient to activate the project's Rincon Overflow Channel and inundate, to varying degrees, the tidal flats of the upper delta. These tidal flats would not have otherwise been directly freshened. As a result, in a relatively short period of time (only 4.2 years after the opening the Project's Nueces Overflow Channel), the average salinity gradient in the upper delta reverted to a more natural form, with average salinity concentration in the upper Rincon Bayou becoming the lowest in the Nueces Delta.

The effects of the demonstration project on the ecology of Rincon Bayou and the upper Nueces Delta were positive to the environment. Single-celled plant communities in the water column (phytoplankton) and on the surface of the sediments (microphytobenthos) evidenced increases in primary productivity with the reduction of salinity concentration. Benthic communities (composed of bottom-dwelling organisms) evidenced increased in abundance, biomass and diversity. And, vegetation communities evidenced increases in plant cover and decreases in bare area. In summary, it was observed that freshwater inflow controlled, to a great extent, the ecological function of the upper delta ecosystem by regulating critical biological mechanisms.

A significant degree of ecological function was returned to the Nueces Delta and Nueces Estuary ecosystems by the demonstration project. Prior to the project, persistently high salinity concentrations severely inhibited the function of the Nueces Delta, and the delta's natural contribution to the greater estuary ecosystem was limited to infrequent periods when natural flow events occurred. With the restored regular interaction between the Nueces River and Rincon Bayou, fresh water and nutrients were more consistently introduced into the upper delta. As a result, estuarine habitat in the delta component

of the Nueces Estuary improved in both quality and quantity, and foraging opportunities for many estuarine species were increased.

In late 2000, the Corpus Christi City Council authorized city staff to work with NRA staff to explore whether agreement could be reached among the City, NRA, and other interested parties for the City to re-open the channel as a permanent diversion feature, in return for reduced pass-through requirements from the Lake Corpus Christi / Choke Canyon reservoir system. The Nueces Estuary Advisory Council (NEAC) met on the City/NRA's proposal and appointed a Working Group to evaluate the proposal and develop a plan for implementation. On March 6, 2001, the full NEAC met to discuss and ultimately approve the plan. The plan was approved by the TNRCC on April 5, 2001.

The plan will economically supplement the City's water supply by increasing reservoir system firm yield by 3,200 acre-feet (AF) annually. This will be accomplished by automatically reducing the City's obligation to pass through water to 1,200 AF per month when the system storage is less than 40% of capacity, and suspending the obligation entirely when supplies drop below 30% of capacity. This relief from pass-throughs will remain in effect as long as the City meets the following requirements:

1. Re-open the Rincon Overflow channel by the end of 2001,
2. Construct a pipeline and pumps to deliver up to 3,000 AF per month of pass-throughs to the Upper Nueces Delta by the end of 2002,
3. Implement a monitoring and assessment program to evaluate the benefits,
4. When system supply drops below 50% of capacity, initiate enhanced communications to the public on water conservation and the importance of estuaries,
5. When system supply drops below 40% of capacity, prohibit outdoor watering of vegetation from 10:00am to 6:00pm, and
6. When system supply drops below 30% of capacity, prohibit lawn watering more often than every five days.

The City will continue its present policy of maximum use of Lake Texana water and operating the reservoir system to maximize system yield. Additional benefits to the City include:

1. Increase in firm yield at a reasonable cost per AF,
2. The decision when to implement drought measures is left completely to the judgment of future councils, prudently weighing all economic, human, and other factors at that time,
3. The automatic measures at 50%, 40%, and 30% are targeted for demand reduction in watering grass and plants, and are supportable as good, routine conservation measures, and
4. The health of the Nueces Estuary would be enhanced, with consequent benefits to the area.

Senate Bill 1

Senate Bill 1 (SB1) was enacted by the 75th Session of the Texas Legislature in 1997. It specified that long-term water management plans be developed for all regions of Texas and provided that future regulatory and financing decisions of TNRCC and the Texas Water Development Board (TWDB) be consistent with approved regional water plans. As stated in SB1, the purpose of this region-based planning effort is to:

> "Provide for the orderly development, management, and conservation of water resources and preparation for and response to drought conditions in order that sufficient water will be available at a reasonable cost to ensure public health, safety, and welfare; further economic development; and protect the agricultural and natural resources of that particular region."

Coastal Bend Regional Water Plan

TWDB is the state agency designated to coordinate the overall statewide planning effort. The Coastal Bend Water Planning Region, which is comprised of 11 counties, is one of the State's 16 planning regions established by TWDB. The 19-member Coastal Bend Regional Water Planning Group (RWPG) was appointed by TWDB to represent a wide range of stakeholder interests and act as the steering and decision-making body of the regional planning effort. The Coastal Bend RWPG designated NRA as the administrative agency and principal contractor to receive a grant from the TWDB to develop the water plan. The Coastal Bend RWPG's members represent 12 interests: the public, counties, municipalities, industries, agriculture, the environment, small businesses, electric-generating utilities, port authorities, river authorities, water districts, and water utilities.

The planning horizon used in the first plan is the 50-year period from 2000 to 2050. This planning period allows for long-term forecast of the prospective water situation, sufficiently in advance of needs, to allow for appropriate water management strategies to be implemented. As required in Senate Bill 1, TWDB specified planning rules and guidelines (31 TAC 357.7 and 357.12) to focus the efforts and to provide for general consistency among the regions so that the regional plans can then be aggregated into an overall State Water Plan.

The first *Coastal Bend Regional Water Plan* (2001) compares current water supplies with long-term water demands, identifies projected water needs in the region, describes proposed water management strategies for meeting those needs, and reports other findings. The report is provided in two volumes, and electronic versions of the Plan are available through our website at: http://nueces-ra.tamucc.edu/rwpgsite.html.

Lower Nueces River Dissolved Minerals Study

Conducted as part of the SB1 planning program, this particular study focused on segment 2102 of the Nueces River; specifically between the Wesley Seale Dam and the Calallen Saltwater Barrier Dam. The purpose of the study was to analyze the increase of mineral concentrations in the Nueces River and to identify the probable source(s) of the increase. The project began in August 1999 with a preliminary series of samples to determine sampling locations. Monthly samples, taken through June 2000, included both routine field data and lab analyses. Groundwater samples were also taken at various locations along the channel by hand augered sample wells. The same suite of constituents as the surface water samples were analyzed. It was concluded that the increase of mineral concentrations in the Lower Nueces River are likely a result of surface-groundwater interaction. Lab analyses revealed similar mineral concentrations in geographically similar samples. With continued monitoring, possible project goals are aimed towards (1) identifying potential water supply intake modifications and/or river management strategies to minimize further withdrawal of highly mineralized water, and (2) evaluation of blending Nueces River water with other water supplies such as Lake Texana water, Colorado River water, and other sources.

San Patricio Water Municipal Water District: Wastewater Re-Use Project

The San Patricio Municipal Water District (SPMWD), the City of Aransas Pass, Reynolds Metals, and the Sherwin Alumina Co. completed a $3 million wastewater reuse project which was dedicated on March 9, 2001. The following paragraphs are from a press release issued by SPMWD about the project.

> Reclaimed treated wastewater and sewage sludge will be piped from the Aransas Pass Wastewater Treatment Plant to the Reynolds Metals property where it will be used for dust control and to maintain and encourage plant growth on 450 acres of old bauxite tailings.
>
> While some of the water will be consumed in maintaining vegetative cover, most will be "polished" as it moves through the vegetation and will then be used by Sherwin Alumina as manufacturing process water.

This new recycling process allows the same water to be used three times – for municipal purposes, for irrigation and for manufacturing. Startup of the pipeline effectively expands the regional water supply because the recycled water will take the place of Nueces River water that has been used for dust control, irrigation and manufacturing.

The project also addresses the issue of nutrient enrichment of Redfish Bay where water quality is expected to improve because only a small portion of the effluent from the Aransas Pass treatment plant will be discharged to the bay in the future.

A demonstration project to prove that habitat could be created on the bauxite tailings has been underway for almost a decade. Texas A&M University at Kingsville has investigated plant species, soil amendments and planting practices. Completely barren and sterile " red mud" areas have been converted to lush growth that has attracted a variety of local wildlife.

Tom Ballou of Sherwin Alumina managed the reuse demonstration project for Reynolds. "We call this 'serial' water reuse," he said. "This is a project where everyone is a winner. Our water resources are extended, bay water quality is improved, manufacturing needs are met, and we get an alternative way to enhance several hundred acres of tailings that will serve as a wildlife sanctuary."

The water conservation project was built by SPMWD with a loan from TWDB which joined the TNRCC in strongly endorsing the project. Reynolds has received special recognition from the Sierra Club for this innovative water conservation effort.

SPMWD provides water to Odem, Taft, Portland Gregory, Ingleside, Aransas Pass, Naval Station Ingleside, Port Aransas, Rockport, Fulton and two rural water systems. It also serves industries including Sherwin Alumina, Reynolds Metals, Occidental Chemical, OxyMar, DuPont, Air Liquide, Gregory Power Partners, and Ingleside Cogeneration LP.

The district's customers account for approximately 20% of the total demand for water from the regional water supply system managed by the City of Corpus Christi. Much of the region's growth is taking place in the SPMWD's service area. To meet this need the district has completed more that $30 million in system expansion projects in the past three years.

On April 5, 2001, SPMWD received the 2000 Water Conservation and Reuse award for the "small utility direct" category from the Texas Section of the American Water Works Association for this project.

Nueces River Authority News

Board of Directors

The NRA has six new directors, appointed by Governor George W. Bush, effective December 20, 2000 through February 1, 2005:

Steve Beever (Pearsall) replaced Margaret Bowman (San Antonio)
Ernest R. Garza, CPA (Robstown) replaced George A. Finley (Corpus Christi)
Homero Jaime Saenz (Carrizo Springs) filled a position vacated by Alfredo Zamora (Cotulla)
J. R. Schneider (George West) replaced Patricia H. Sugarek (Skidmore)
Roxana Proctor Tom (Campellton) replaced Mary Melissa Ramos (Floresville)
L. B. "Pete" Vaden, DVM (Uvalde) replaced Susan Allen Lynch (Rio Frio)

The continuing directors are:

Ernestine Carson (Barksdale) – President
Thomas Reding, Jr. (Portland) – First Vice President
August Linnartz, Jr. (Carrizo Springs) – Second Vice President
William Dillard (Uvalde) – Secretary-Treasurer
Patty Mueller (Corpus Christi) – Executive Committee
Jimmy Dodson (Robstown)
Ariel Garcia (Corpus Christi)
Hazel Graff (Hondo)
William Howell (Portland)
Leslie Kinsel (Cotulla)
Beth Knolle (Sandia)
Kay Lynn Theek (Sommerville)
Lawrence Warburton, Jr. (Alice)

NRA Staff Changes

In August 2000, Ms. Gabrielle Grunkemeyer, Associate Water Resources Analyst in the Coastal Bend Division office, was awarded a Masters degree at TAMUCC. Ms. Grunkemeyer received a Masters of Science (M.S.) in Environmental Science - emphasizing Water Policy and Management. Due to her academic accomplishment, Ms. Grunkemeyer was promoted to Water Resources Analyst.

In September 2000, the NRA promoted Mr. Sam Sugarek, Graduate Office Assistant, to Field Technician. Along with data entry, his duties now include conducting the sampling and monitoring activities as well as purchasing, inventorying, and maintaining equipment. Mr. Sugarek continues to work on a part-time basis while completing his M.S. in Environmental Science at TAMUCC.

Information and Contacts

Visit the NRA's web site at http://nueces-ra.tamucc.edu.
For additional information, questions, or comments, contact:

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Acknowledgement

The document was prepared in cooperation with the TNRCC under authorization of the Clean Rivers Act.

Appendix A

The TNRCC has conducted periodic baseline monitoring of Oso Bay in Corpus Christi, Texas since April 1972 for fecal coliform bacteria. In 1996, the TNRCC determined that Oso Bay (Segment 2485) did not support the oyster water use and partially supported the contact recreation use due to elevated fecal coliform densities. To further evaluate Oso Bay and to help aid in the design of future projects, NRA, through the CRP partnership with the TNRCC, contracted CCS at TAMUCC to conduct a year-long, targeted monitoring, bacterial indicator study to monitor the recreational water quality of Oso Bay.

Although swimming in Corpus Christi, Texas, occurs mainly on the Gulf of Mexico beaches, wind surfing, wading, and fishing are common recreational activities in the bay systems. One of the major public health issues related to Corpus Christi's estuarine environment is the possibility of contracting a disease or illness through physical contact with contaminated waters. Microbiological parameters are direct measures of pollution by man and other warm-blooded animals and can contribute unique information about water quality and public health risk from waterborne disease. Pathogenic microorganisms from sources such as stormwater runoff, sewage overflows, boating wastes, and malfunctioning septic systems can potentially be transmitted to humans during recreational use involving primary contact with water. Although pathogens would be the ideal microorganisms to isolate from water, they are difficult to detect in the aquatic environment because of their low concentrations. Therefore, indicator bacteria, or non-pathogenic microorganisms, are generally measured in recreational water as indicators of fecal contamination, and thus potential pathogen contamination, because they parallel the survival of at least some pathogens.

This study was conducted to evaluate total and fecal coliform, *Escherichia coli*, and enterococci to address the issue of which is the most appropriate indicator for marine recreational waters in this region. Oso Bay was monitored as a study site to reflect how bacterial parameters may fluctuate in freshwater and saline environments. Overall levels and seasonal fluctuations of enterococci, *E. coli*, total coliform, and fecal coliform were evaluated in Oso Bay, a freshwater influenced shallow bay. In addition, continued monitoring of Oso Bay will help to establish a large indicator bacteria database which would allow for the determination of water quality trends and a more representative characterization of the Oso Bay project area.

Oso Bay, an enclosed bay located in Corpus Christi, Texas, off the southern shore of Corpus Christi Bay was determined to be an ideal bacterial monitoring site due to its ranges in salinity, pollution sources, and recreational uses. Oso Bay exchanges water only with Corpus Christi Bay and receives freshwater inflows from Oso Creek. Documented water quality problems in Oso Bay may partially be a result of discharges from a combination of nine permitted wastewater facilities. Non-point sources of pollution, considered to have high levels of impact on the bay, include urban runoff and upstream sources.

A total of 396 water samples were collected from four nearshore surface locations within Oso Bay. Sampling Sites A and B were located near the treated wastewater discharge from the Oso Wastewater Treatment Plant and Hans Suter Wildlife Refuge. These two sites were characterized as brackish to freshwater. The two saline Sites, C and D, were located at opposite ends of the bay; the Oso Creek tributary into the southern end of the bay (C) and the Corpus Christi Bay inlet on the northern end (D). Sites A, C, and D were previously designated as monitoring stations by the TNRCC (ID # 13441, 13440, and 13442, respectively).

Sampling events were conducted during a 12 month period; weekly for fifteen successive weeks from June through September 1998, and twice a month from October 1998 through June 1999. Field data (water temperature, pH, dissolved oxygen, specific conductance, and salinity) were collected in conjunction with bacterial analysis. Samples were analyzed for concentrations of fecal coliform, enterococci, total coliform, and *E. coli*, after membrane filtration.

Bacterial densities were greatest at Site B with a range of 80-510,000 cfu (colony forming units)/100 ml for fecal coliform, 110-650,000 cfu/100 ml for *E. coli* and 1-560,000 cfu/100 ml for enterococci. For the purpose of this study, Oso Bay was considered a "lightly used" swimming area (upper 90% Confidence Limit) where 400 cfu/100 ml, 409 cfu/100 ml, and 276 cfu/100ml are the EPA single sample water quality standards for fecal coliform, *E. coli*, and enterococci, respectively. Fecal coliform densities were approximately 50 times higher at Site B (downstream from Site A and the sewage outfall) than A, implying that outfall from the wastewater treatment plant was not as significant as thought. High bacterial numbers at Sites A and B may not be directly correlated to the sewage disposal plant, but rather to non-point sources. Most of the extremely high levels of bacteria in Oso Bay occurred during or after significant rainfall events, although the study was not designed to distinguish runoff

or stormwater effects. Turbidity, sediment, algal blooms and aquatic birds (shorebirds, waterfowl, and colonial waterbirds) also contributed to high bacterial densities in Oso Bay. Sediment and birds appear to have played a major role in bacterial contamination particularly at Site B. At Sites B and D, highest bacterial densities were in April 1999 during spring bird migration, while at Sites A and C, counts were highest from September through November during the wet season.

Lowest overall bacterial counts were recorded from Site C (3-2,100 cfu/100ml) followed by Site A (1-2200 cfu/100 ml). The freshwater-influenced site, (A) had the lowest mean enterococci value (148 cfu/100 ml). Mean bacterial numbers at Site D (outflow into Corpus Christi Bay) were almost three times as high as those recorded from Site C (inflow from Oso Creek and Central Power & Light Barney Davis Plant), indicating fecal loading in the bay. Lowest fecal coliform, *E. coli*, and enterococci counts generally occurred during the hot and dry summer months (June-September) of 1998.

Specific sample site differences play a major role in the variability of indicator bacteria numbers. Over 70% of the indicator bacteria samples at Site B were in non-compliance with EPA water quality standards for recreational waters. Although the water at Site B was primarily influenced by waterfowl and sediment, other areas of the bay could be influenced by the extremely high fecal bacteria densities from this site. Bacterial densities at Site A were probably affected by outflow from the Oso Wastewater Treatment Plant. High numbers at Site D correlated with high numbers and tide information at Site B, particularly in March and April, suggesting that numbers at Site D were influenced by Site B. The lowest concentrations of bacteria were detected at Site C, the site with the highest overall mean salinity and furthest from point sources of pollution, but influenced by Oso Creek. This suggests that fecal loading in Oso Bay does not reach Site C (the southern end of the bay).

In conclusion, the results of the present study suggest that the water quality in Oso Bay has not improved compared with historical data. Continued monitoring at additional sites in and adjacent to Oso Bay is recommended in order to establish a large indicator bacteria database which would allow for the determination of water quality trends and could be utilized by the TNRCC for possible Total Maximum Daily Load development, permit decisions, and water quality assessments. A continuous long-term database would also allow for temporal and spatial comparisons of waterbodies with diverse characteristics and be helpful in the construction of predictive closure models for bay area advisories. Evaluation of indicator bacteria in Oso Bay and similar settings should take into account increases in bacterial densities as a result of natural phenomenon such as resuspension of sediments and wildlife fecal inputs, that might cause surface waters to exceed limits. Finally, additional studies on the extent of fecal loading from non point sources is recommended. Extensive knowledge of the watershed and determination of pollution sources is critical to accurately interpret microbiological monitoring results