Approved by the TCEQ: October 10, 2007

Implementation Plan for Three Total Maximum Daily Loads for Chloride, Sulfate, and Total Dissolved Solids in Petronila Creek Above Tidal

For Segment Number 2204

Prepared by the:
Chief Engineer's Office, Water Programs, TMDL Section

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Distributed by the
Total Maximum Daily Load Program
Texas Commission on Environmental Quality
MC-203
P.O. Box 13087
Austin, Texas 78711-3087

TMDL implementation plans are also available on the TCEQ web site at:
<www.tceq.state.tx.us/implementation/water/tmdl/>.

Contents

Figures

Tables

Implementation Plan for Three Total Maximum Daily Loads for Chloride, Sulfate, and TDS in Petronila Creek Above Tidal

Executive Summary

On January 10, 2007, the Texas Commission on Environmental Quality (TCEQ) adopted *Three Total Maximum Daily Loads for Chloride, Sulfate, and Total Dissolved Solids in Petronila Creek Above Tidal*. The total maximum daily loads (TMDLs) address chloride, sulfate, and total dissolved solids (TDS) in Segment 2204, Petronila Creek Above Tidal. The U.S. Environmental Protection Agency (EPA) approved the TMDLs on March 14, 2007.

This implementation plan, or I-Plan:

- describes the steps the TCEQ and its stakeholders will take to achieve the pollutant reductions identified in the TMDL report, and
- outlines the schedule for implementation activities.

The TCEQ conducted an investigation to identify possible point and nonpoint sources of chloride, sulfate, and TDS, and to quantify the appropriate reductions necessary to comply with established water quality standards. Field investigations identified that concentrations of these parameters exceed criteria in the downstream section of Petronila Creek, southeast of US Hwy 77, in an area where man-made nonpoint sources such as produced water, brine pits, and brine injection wells are numerous (EA, 2006).

Based on the TMDLs for Petronila Creek Above Tidal, the goal of this I-Plan is to reduce concentrations of chloride, sulfate, and TDS to levels that support the general uses of the stream. This will require:

- 100 percent reduction of loading from abandoned brine pits
- 88 percent reduction of loading from produced water
- 88 percent reduction in nonpoint source loadings of chloride
- 78 percent reduction in nonpoint source loadings of sulfate

Several implementation activities were initiated during the TMDL project to achieve pollutant reductions.

- The TCEQ awarded a nonpoint source grant to the Texas Railroad Commission (RRC) to investigate the nature and extent of known salinity contamination associated with oil and gas production, the development of remediation/abatement alternatives or best management practices (BMPs), and the implementation of the BMPs to reduce water pollution.
- The TCEQ Continuous Water Quality Network and Nueces River Authority (NRA) deployed a continuous monitor in December 2006 to measure specific conductivity hourly at water quality station 13093, Petronila Creek at FM 70. A TCEQ web page provides reference to continuous water quality data, and is avail-

able to the RRC to assist in enforcing oil and gas well compliance in the watershed (www.tceq.state.tx.us/compliance/monitoring/water/quality/data/wqm/swqm_realtime_swf.html).

Additional sampling at appropriate locations and frequencies will allow tracking and evaluation of progress toward the interim and final endpoints of the TMDLs.

The project team recognized that communication and comments from stakeholders in the watershed would strengthen the project and its implementation plan. To ensure stakeholders stay informed throughout the implementation phase of this project, the TCEQ will post pertinent material on its web site and schedule meetings as needed. The project information for Petronila Creek Above Tidal is available on the TCEQ's web site at <www.tceq.state.tx.us/implementation/water/tmdl/32-petronila_group.html>.

Introduction

In order to keep Texas' commitment to restore and maintain water quality in impaired rivers, lakes, and bays, the TCEQ will establish implementation plans for each TMDL. The TMDL is a technical analysis that:

- determines the amount of a particular pollutant that a water body can receive and still meet applicable water quality standards, and
- estimates how much the pollutant load must be reduced to comply with water quality standards.

This I-Plan is designed to guide activities that will reduce chloride, sulfate, and TDS in Segment 2204, as defined in the adopted TMDLs. The ultimate goal of the I-Plan is to restore the general uses of Segment 2204 by reducing the annual average concentrations of chloride, sulfate, and TDS to levels that meet the criteria established in the state's water quality standards.

The plan is a flexible tool that governmental and nongovernmental organizations involved in implementation use to guide their program management. The participating organizations may accomplish the activities described in this I-Plan through rule, order, guidance, or other appropriate formal or informal action.

This I-Plan contains the following components:

1) a description of control actions and management measures[1] that will be implemented to achieve the water quality target.
2) a schedule for implementing activities to achieve TMDL objectives.
3) the legal authority under which the participating agencies may require implementation of the control actions.

[1] Control actions refer to pollutant reduction strategies for regulated point sources, generally TPDES permits. Management measures refer to nonpoint source pollutant reduction strategies, generally voluntary best management practices.

4) a follow-up tracking and monitoring plan to determine the effectiveness of the control actions and management measures undertaken.
5) identification of measurable outcomes and other considerations the TCEQ will use to determine whether the I-Plan has been properly executed, water quality standards are being achieved, or the plan needs to be modified.
6) identification of the communication strategies the TCEQ will use to disseminate information to stakeholders and other interested parties.

This I-Plan also includes all of the nine key elements (Table 1) for watershed-based plans as prescribed in the *FY 2004 Guidelines for the Award of Section 319 Nonpoint Source Grants to States and Territories* (USEPA, 2004). Consequently, projects developed to implement nonpoint source elements of this plan that meet the grant program conditions are eligible for funding under the EPA's Section 319(h) incremental grant program.

The commission approved this I-Plan on October 10, 2007. The TCEQ has primary responsibility for ensuring that water quality standards are restored in impaired water bodies and that these standards are subsequently maintained.

Summary of TMDLs

This section will summarize key elements from the TMDL report *Three Total Maximum Daily Loads for Chloride, Sulfate, and Total Dissolved Solids in Petronila Creek Above Tidal, For Segment 2204*, including a description of the watershed, a summary of the problem, analysis of the sources, and the load reductions. The TMDL report is available on the TCEQ's web site at <www.tceq.state.tx.us/implementation/water/tmdl/32-colorado_petronila.html>.

Watershed Location

Petronila Creek is a freshwater stream, 44 miles in length, located within the Nueces-Rio Grande Coastal Basin (Figure 1). It is formed by the confluence of Agua Dulce and Banquete creeks one mile southeast of the town of Banquete in western Nueces County, and is located southwest of the city of Corpus Christi, Texas. General water quality uses were first identified as impaired by chloride, sulfate, and TDS in the *2000 Texas Water Quality Inventory and 303(d) List*.

Concentrations of chloride, sulfate, and TDS are among the numeric criteria used to evaluate the support of general uses. The criteria for chloride (Cl), sulfate (SO_4), and TDS are average annual concentrations of 1,500 milligrams per liter (mg/L), 500 mg/L, and 4,000 mg/L, respectively (Table 2).

The Nueces-Rio Grande Coastal Basin has a drainage area of about 10,442 square miles. Petronila Creek drains approximately 543 square miles of this basin, and is part of the Baffin Bay watershed. Petronila Creek runs southeast to its outlet on Alazan Bay, 16 miles northeast of Riviera Beach in eastern Kleberg County (at 27° 28' N, 97° 32' W). The surrounding terrain varies from flat, with local shallow depressions, to some rolling areas. Surface features include clay and sandy loams that support grasses, scrub brush, and cacti.

Table 1: Summary of nine key elements

Summary Table for Nine Key Elements of Proposed Control Measures for I-Plan Study Area									
(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**	**(i)**	**(j)**
Causes/Sources of Impairment **Targeted Critical Areas**	**Management Measures**	**Estimated Potential Load Reduction (lbs/Year)**	**Technical and Financial Assistance Needed for Each Measure**	**Education Component for Each Measure (and Other Education)**	**Schedule of Implementation for Each Measure**	**Interim, Measurable Milestones for Each Measure**	**Indicators to Measure Progress**	**Monitoring Component**	**Responsible Entity**
1) Historic Produced Water Disposal in the Clara Driscoll Oil Field 2) Petronila Creek between US 77 and the estuarine influenced tidal zone	Records search and review; field reconnaissance; site survey assessment	Chloride: 4.43E+07 Sulfate: 1.95E+07 TDS: 8.87E+07	Funded (Section 319 Nonpoint Source Grant Project)	Investigative report available electronically via the project web page	2007	n/a	Records review, site reconnaissance results, and recommendations final report	Routine basin monitoring	RRC
	a) Seasonal and probe hole sampling of groundwater b) Implementation of BMPs		Funded (Section 319 Nonpoint Source Grant Project)	Project reports available electronically via the project web page	2008 - 2009	n/a	Reduction in TDS-related concentrations from strategic deployment of BMPs	Routine basin monitoring	RRC
1) Produced Water Disposal 2) Petronila Creek between US 77 and the estuarine influenced tidal zone	Deployment and maintenance of continuous water quality monitor at water quality station 13093, Petronila Creek at FM 70	n/a	Funded (Section 106 Water Pollution Control Program Grant)	TCEQ web page and NRA basin highlights report	2007	n/a	Reduction in TDS-related concentrations	Continuous monitoring and routine basin monitoring	TCEQ & NRA

Figure 1: Watershed of Petronila Creek Above Tidal

Table 2: Numeric criteria for Petronila Creek Above Tidal

Segment	Criteria						
	Cl (mg/L)	SO_4 (mg/L)	TDS (mg/L)	Dissolved Oxygen (mg/L)	pH Range (Standard Units)	Indicator Bacteria #/100ml (E. coli)	Temperature (°F)
2204: Petronila Creek Above Tidal	1,500*	500*	4,000*	4.0	6.5-9.0	126+/ 394++	95

* expressed as annual average values

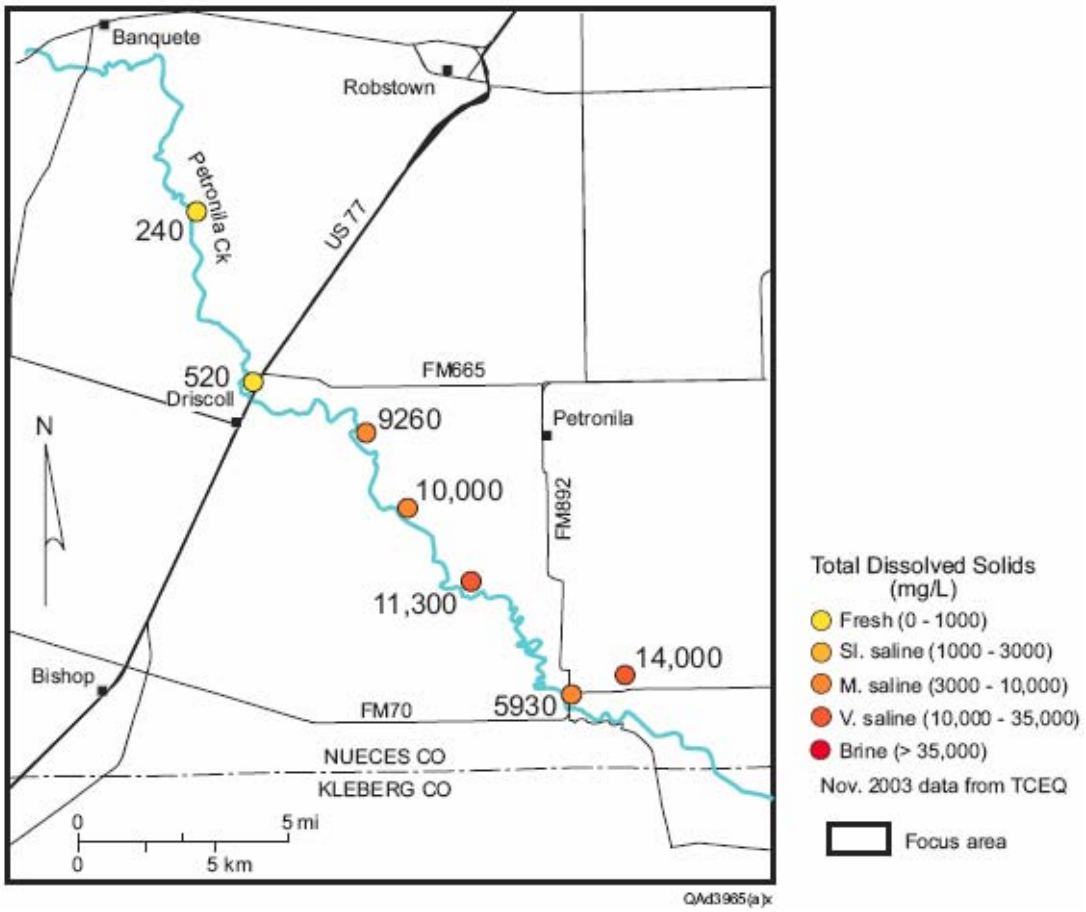
\+ expressed as a geometric mean

++ expressed as an instantaneous grab sample

Problem Definition

General water quality uses were identified as impaired in the *2000 Texas Water Quality Inventory and 303(d) List*. A TMDL project was initiated to identify possible point and nonpoint sources of chloride, sulfate, and TDS, and to quantify appropriate reductions necessary to comply with established water quality standards of 1,500 mg/L, 500 mg/L, and 4,000 mg/L respectively.

Recent chemical analysis and field investigations of surface water in Petronila Creek, its tributaries, and in local drainage ditches indicate that TDS and chloride concentrations are low upstream from the US 77 bridge at Driscoll, but increase to levels that fail to meet the criteria downstream from US 77, where man-made nonpoint sources such as produced water, brine pits, and brine injection wells are more numerous, as shown in Figures 2 and 3.



Graduated circles, from yellow to red, represent increased concentration of total dissolved solids.

Figure 2: Map of the Segment 2204 study area, depicting TDS concentrations measured in November 2003. (Paine et al, 2005)

Chemical and biological conditions in Petronila Creek were dominated for more than 50 years by oilfield brine discharges of about 50 times the stream salinity (Shipley 1991). In 1969, the Texas Legislature passed a law prohibiting open pit disposal of oilfield brine. Direct brine discharges to Petronila Creek ceased in January 1987.

Source Analysis

Pollutants come from several sources, both point and nonpoint. The sources of salinity in Petronila Creek Above Tidal are:

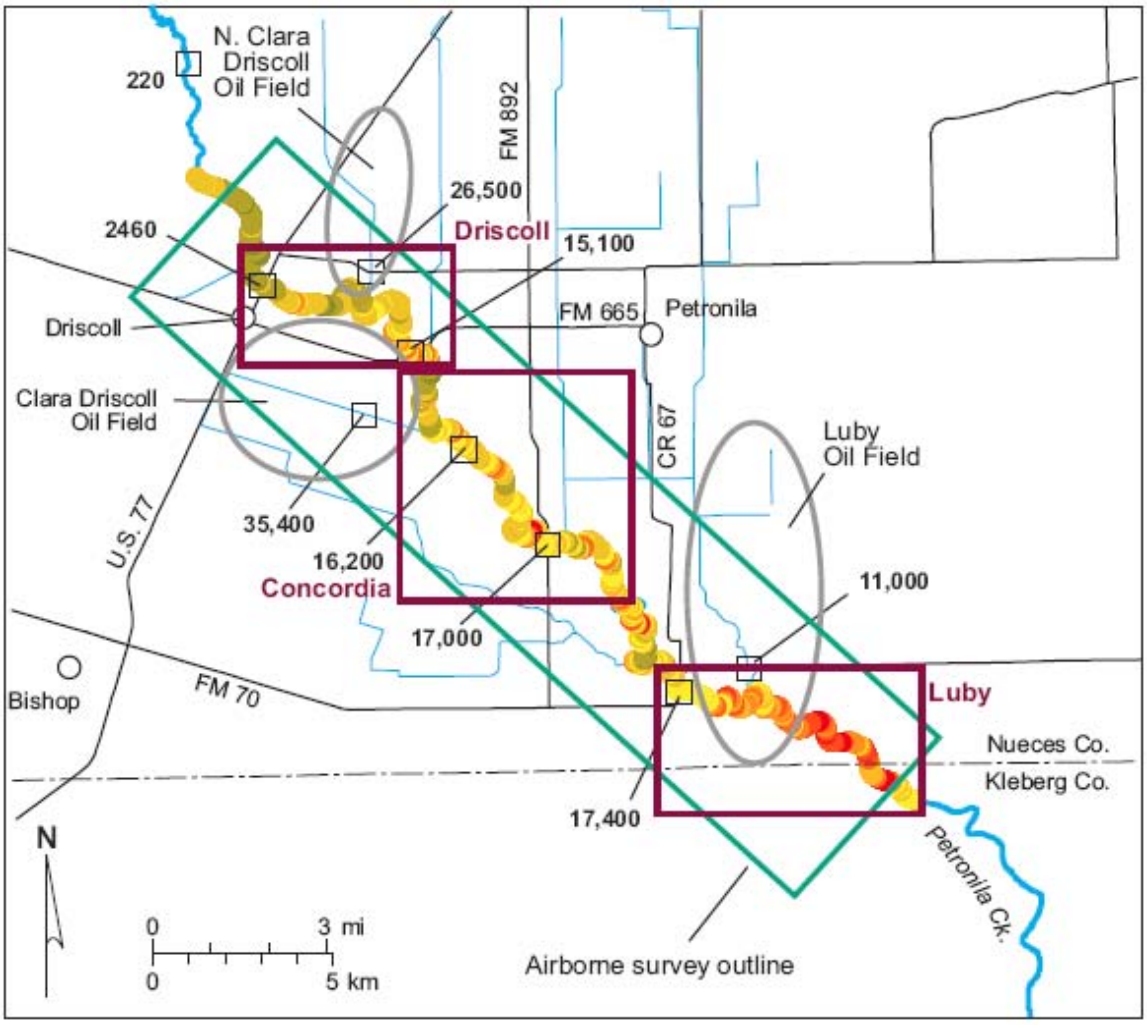


Figure 3: Areas of elevated conductivity measured at 1,350 Hz along the axis of Petronila Creek Above Tidal

- produced water, the primary/largest source, generated as a by-product of petroleum production from documented orphaned and noncompliant oil and gas wells in Nueces and Kleberg Counties. Produced water is brine originating from the same strata as oil that is brought to the surface during production. Produced water typically contains petroleum hydrocarbons and can be toxic to aquatic life.

- six permitted domestic wastewater discharges located within the watershed of Segment 2204 (Table 3).
- brine disposal into large, shallow, unlined pits where water is lost due to evaporation and seepage. When brine evaporates, dissolved solids are left behind as salt crusts that can cause infiltration to the shallow subsurface and local groundwater.

Table 3: Permitted dischargers in the watershed of Petronila Creek Above Tidal

Permit Number	Name of Facility	Flow (MGD)
WQ0010140-001	City of Agua Dulce	0.16
WQ0010592-001	City of Orange Grove	0.2
WQ0011541-001	Driscoll Plant, City of Driscoll	0.1
WQ0011583-001	Banquete Plant, Nueces CO WCID 5	0.1
WQ0011689-001	City of Coastal Bend Youth City	0.015
WQ0011754-001	Petronila Elementary	0.008

Linkage

The past oil industry practice of discharging highly saline produced water into drainage ditches, pits, and Petronila Creek degraded surface water quality and affected aquatic species in Petronila Creek (Shipley, 1991). The salinity of water is strongly correlated to its electrical conductivity. To define the sources of chloride and sulfate, the University of Texas Bureau of Economic Geology (BEG) conducted a TCEQ-sponsored airborne geophysical survey using a multi-frequency electromagnetic induction (EM) instrument to delineate the extent and intensity of salinization and identify salinity sources that degrade surface water quality in Segment 2204.

TMDL Expressions

A summary of allocation loads for Petronila Creek Above Tidal is presented in Table 4. The total load allocations, wasteload allocations, and margins of safety for chloride, sulfate, and TDS are summarized in Tables 5, 6, and 7. The background chloride, sulfate, and TDS loads are included in groundwater and surface runoff contributions and explicitly considered in LA allocations. The sum of WLA and LA is divided by 0.95 to obtain the TMDL. The margin of safety (MOS) is calculated by subtracting WLA and LA from the TMDL.

Table 4: TDS, chloride, and sulfate TMDL allocation load distributions by source

Source	Annual Average Loads (lbs/Year)					
	Chlorides	% Total	Sulfates	% Total	TDS	% Total
Abandoned Brine Pits	0.00E+00	0.00%	0.00E+00	0.00%	0.00E+00	0.00%
Produced Water	37.8E+06	85.25%	8.98E+06	46.09%	80.4E+06	90.69%
Groundwater	0.05E+06	0.12%	0.85E+06	4.39%	0.11E+06	0.12%
Other Background Sources	1.74E+06	3.92%	8.67E+06	44.50%	3.70E+06	4.17%
Point Sources	2.53E+06	5.71%	0.002E+06	0.01%	0.02E+06	0.02%
Margin of Safety	2.22E+06	5.00%	0.97E+06	5.00%	4.43E+06	5.00%
Total	**44.3E+06**	**100%**	**19.5E+06**	**100%**	**88.7E+06**	**100%**

Table 5: Chloride TMDL (10^6 lbs/yr)

TMDL (lbs/year)	WLA (lbs/year)	LA (lbs/year)	MOS (lbs/year)
44	3	39	2

Table 6: Sulfate TMDL (10^6 lbs/yr)

TMDL (lbs/year)	WLA (lbs/year)	LA (lbs/year)	MOS (lbs/year)
20	0.002	19	1

Table 7: TDS TMDL (10^6 lbs/yr)

TMDL (lbs/year)	WLA (lbs/year)	LA (lbs/year)	MOS (lbs/year)
89	0.02	84	5

Implementation Strategy

The implementation strategy describes actions the TCEQ and stakeholders will undertake to achieve water quality standards. It specifies the actions necessary to meet the load al-

locations assigned to all point sources and nonpoint sources identified in the TMDL report. These actions provide reasonable assurance that the regulatory and voluntary activities necessary to achieve the pollutant reductions will be implemented.

Action strategies may be selected from a menu of possible measures, based on an evaluation of feasibility, costs, support, timing, and other factors. Activities may be implemented in phases based on the TCEQ's assessment of progress.

Phased Implementation

The TCEQ and stakeholders have chosen a phased approach for this I-Plan. A phased approach provides time-steps so that monitoring data may be evaluated to verify expected load reductions and determine the effectiveness of BMPs. A TMDL under the phased approach establishes a schedule or timetable for the installation and evaluation of management measures, data collection, assessment for water quality standards attainment, and if needed, additional predictive modeling. If monitoring determines that the measures implemented under a phase are not sufficient to achieve water quality standards, then the next phase of management practices shall be implemented.

The management measures for Petronila Creek Above Tidal will be implemented in three separate phases:

- Phase I begins in 2007, upon approval of the plan by the commission.
- Phase II of the plan will commence after 2010 (three years after approval) if the TCEQ determines that BMPs implemented under Phase I have not sufficiently improved water quality to achieve standards.
- Phase III will begin in 2015 (eight years after approval) if the TCEQ determines that Phase II BMPs have not sufficiently improved water quality.

Control Action 1.0: Investigation and Abatement of Produced Water Impacts and Seeps to Surface Water

In 2006, the RRC was awarded a nonpoint source grant to investigate the nature and extent of known salinity contamination associated with oil and gas production, the development of abatement alternatives or BMPs, and the construction and placement of BMPs to reduce water pollution. This process requires records search and review, site reconnaissance, and data evaluation. The project, "Investigation and Abatement of Produced Water Impacts and Seeps to Surface Water," is directed specifically to the area of the Clara Driscoll oil fields.

The RRC will conduct various activities to achieve the goal of reduced nonpoint source pollutant loading to Petronila Creek:

- review the BEG airborne geophysical survey and land-based confirmation sampling project for the Petronila Creek TMDL project and determine the most effective approach for source investigation.
- determine locations using the geophysical survey data and selected soil borings to install monitoring wells up-gradient and downstream of saltwater seepage into

Petronila Creek, its tributaries, and downstream of known or suspected discharge points.

- select soil-boring locations in abandoned pits and suspected release areas and collect samples for analysis.
- sample newly installed monitoring wells and sample surface water at strategic points along Petronila Creek, its watershed, and hurricane canals that flow into the creek.
- conduct a study to choose and implement BMPs to reduce the TDS loading.

The project management team includes personnel from the RRC's Site Remediation section in Austin and personnel from the District 4 office in South Texas. The project team has contracted with TRC Customer-Focused Solutions (TRC) to investigate the Clara Driscoll oil fields. Identification and evaluation of effective BMPs is isolated to an area of elevated salinity in the Petronila Creek Above Tidal watershed. This control action will focus on the reach of the creek from US Hwy 77 downstream to the upper limit of tidal influence on the creek near FM 70 (Figure 4).

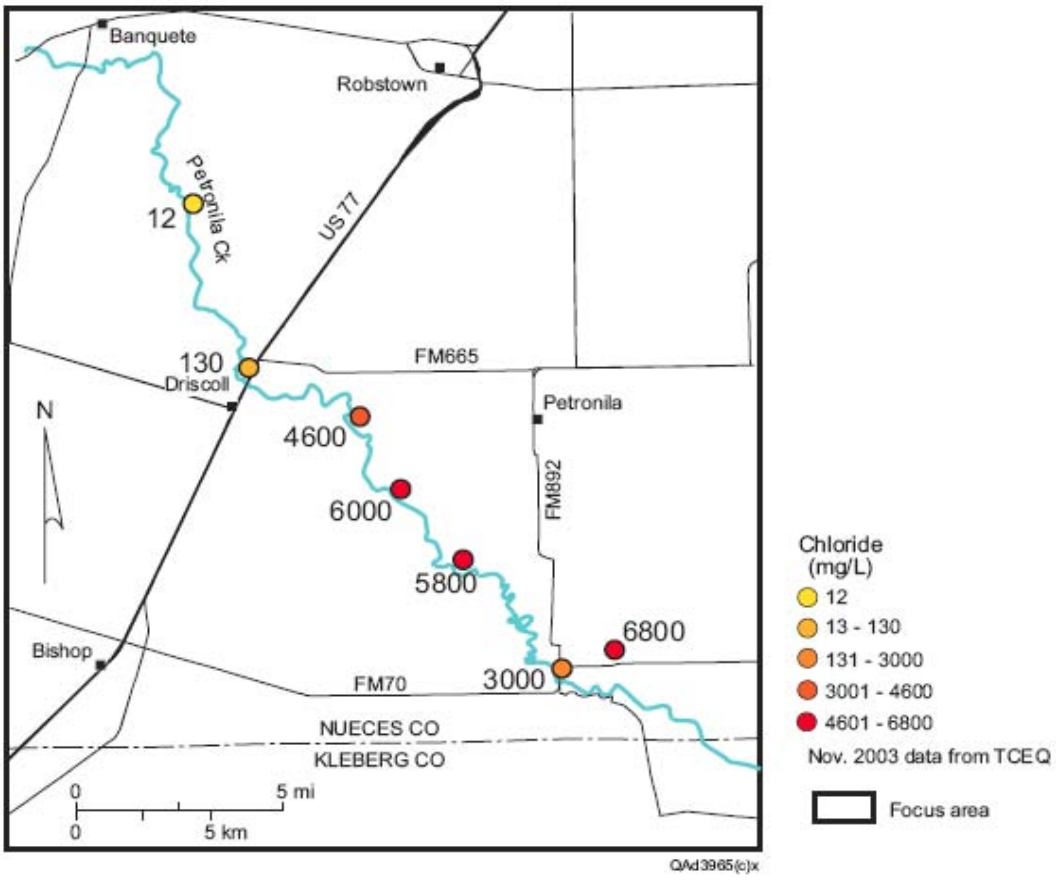


Figure 4: Map of Petronila Creek depicting chloride concentration in surface water samples along the creek in November 2003 (Paine et al, 2005)

Control Action 1.0 will enhance the pollution prevention efforts of the RRC and the TCEQ to restore and maintain water quality in Petronila Creek. The project team will post quarterly status reports on its web site at <www.rrc.state.tx.us/divisions/og/site_rem/nps/petronila/index.html>. The "Preliminary Investigative Report on Petronila Creek," dated August 2006, and available on the web site, is the initial status report for the project.

The RRC has the legal authority and responsibility to protect the state's natural resources, the environment, and public safety through the regulation of the oil and natural gas industry, pipeline transporters, natural gas utilities, rail safety, and surface mining operations. Therefore, implementation of regulatory actions to abate produced water impacts to surface water affecting Petronila Creek lies within the jurisdiction of the RRC.

Control Action 2.0: Routine and Continuous Water Quality Monitoring

Because it has been confirmed that the surface water in the downstream reach of Segment 2204 is more conductive than the reach above US Hwy 77, and contributes a significant saline load to Petronila Creek, the TCEQ and the NRA have deployed a continuous monitor at water quality station 13093 (Petronila Creek at FM 70) to continuously monitor specific conductance and temperature. Its operation is coordinated by the Monitoring Operations Division of the TCEQ, and will be operated and maintained by NRA staff. Implementation of this action is funded through the Water Pollution Control Program Grant under the Clean Water Act, Section 106.

Figure 5: Photograph of site, 13093 – Petronila Creek at FM 70

The data generated from the continuous monitoring station will be used to track changes in salinity (using specific conductance) during all flow conditions, and provide the RRC a means to monitor compliance with its "no pit" order implemented in 1969 and its "no produced-water discharge to tidal streams" order implemented in 1987.

Routine monitoring will occur within the watershed throughout the implementation schedule. The monitoring strategy for Petronila Creek will consider the spatial and temporal aspects sufficient to characterize trends in water quality due to management practices in the implementation plan.

Both continuous and routine monitoring will provide water quality data for evaluation of standards attainment. A web page will allow users to review, customize, and generate a data report <www.tceq.state.tx.us/cgi-bin/compliance/monops/select_water_daily? basin22.gif>.

Implementation Tracking

This I-Plan includes provisions to track the progress of the plan using both programmatic and water quality indicators. These terms are further defined as:

- **Programmatic Indicator** – A measure of administrative actions undertaken that result in an improvement in water quality.
- **Water Quality Indicator** – A measure of water quality conditions for comparison to pre-existing conditions, constituent loadings, and water quality standards.

Implementation tracking provides information that can be used to determine if progress is being made toward meeting goals. Tracking also allows stakeholders to evaluate actions taken, identify those which may not be working, and make any changes that may be necessary to get the plan back on target. The RRC, NRA, and TCEQ will work collaboratively to ensure monitoring data are assessed to track progress.

Programmatic Indicators

Several monitoring and remediation projects are planned or underway as part of this implementation plan. Additional details of the various monitoring efforts are described in the "Water Quality Indicators" section of this document.

The TCEQ and the EPA will further evaluate the need for, and effectiveness of, the various mitigation and remediation options based on periodic evaluation of monitoring results. Timetables for additional monitoring and/or implementation of any BMPs, and estimates of the time necessary for restoration of the general uses, will be further developed as the results of the ongoing monitoring become known. Interim evaluations will be made as appropriate, with final evaluations to be performed following completion of all scheduled efforts.

Water Quality Indicators

Verification that designated uses have been restored requires the measurement of applicable water quality indicators. The measurable outcome of all phases of this I-Plan shall be the attainment of the TMDL endpoints for chloride, sulfate, and TDS in Petronila Creek Above Tidal.

Throughout the implementation schedule, the TCEQ will monitor chloride, sulfate, and TDS quarterly, and conductivity continuously. Continuous monitoring will occur at water quality station 13093, Petronila Creek at FM 70. Achievement of the endpoints will be measured through the analysis of data collected by the NRA and the TCEQ. Updates on progress toward the endpoints will be provided to stakeholders via the project web page and the NRA's annual assessment report.

Review Strategy

The TCEQ and stakeholders in TMDL implementation projects periodically assess the results of the planned activities and other sources of information to evaluate the adequacy of the I-Plan. Stakeholders evaluate several factors, such as the pace of implementation, the effectiveness of best management practices, load reductions, and progress toward meeting water quality standards. The TCEQ will document the results of these evaluations and its rationale for maintaining or revising elements of the I-Plan, and will present them as part of the state's normal reporting process summarized in the following section.

Communication Strategy

Communication is necessary to ensure that stakeholders understand the I-Plan and its progress in restoring water quality conditions. The TCEQ will disseminate the information derived from tracking I-Plan activities to interested parties, including watershed stakeholders, state leadership, government agencies, nongovernmental organizations, and individuals.

Throughout the implementation process, general updates will be provided to the stakeholders in the basin via the project web page. The TCEQ also publishes a report every two years that summarizes the status of TMDL program in the state, including the implementation of individual TMDL projects. Work plans for the project include a commitment to provide appropriate information to the TCEQ to update these progress assessments.

References

EA Engineering, Science, and Technology, Inc., the Louis Berger Group, Inc., 2006. "Petronila Creek Above Tidal (Segment 2204) Total Maximum Daily Load for Chloride, Sulfate, and Total Dissolved Solids: Final Report prepared for Texas Commission on Environmental Quality," Total Maximum Daily Load Requisition No. 582-1-30480.

Paine, Jeffrey G., Nance, H.S., Collins, Edward W., 2005. "Geophysical Investigations of Salinization along Petronila Creek, Nueces and Kleburg Counties, Texas: Bureau of Economic Geology," University of Texas at Austin.

Shipley, F.S., 1991. "Oil Field-Produced Brines in a Coastal Stream: Water Quality and Fish Community Recovery Following Long Term Impacts," Texas Journal of Science, v. 43, no. 1, p. 51-64.

USEPA 2003. "Nonpoint Source Program and Grants Guidelines for States and Territories." <www.epa.gov/fedrgstr/EPA-WATER/2003/October/Day-23/w26755.htm>. Accessed December 28, 2006.