INVESTIGATIONS AND ABATEMENT OF PRODUCED WATER IMPACTS AND SEEPS TO SURFACE WATER

Petronila Creek
Nueces-Rio Grande Coastal Basin (Segment 2204)

Nueces County, Texas

SECTION 319 NONPOINT SOURCE GRANT PROJECT

Railroad Commission of Texas
Heidi Bojes

Section 310 Nonpoint Source Grant

- **In 2006 RRC awarded a Section 310 Nonpoint Source Grant from United States Environmental Protection Agency (US EPA) and Texas Commission on Environmental Quality (TCEQ)**
- **1) Investigate the nature and extent of known salinity contamination thought to be contributing to water quality problems in Petronila Creek (Segment 2204) and**
- **2) Develop remediation/abatement alternatives or Best Management Practices (BMPs)**

Petronila Creek Watershed

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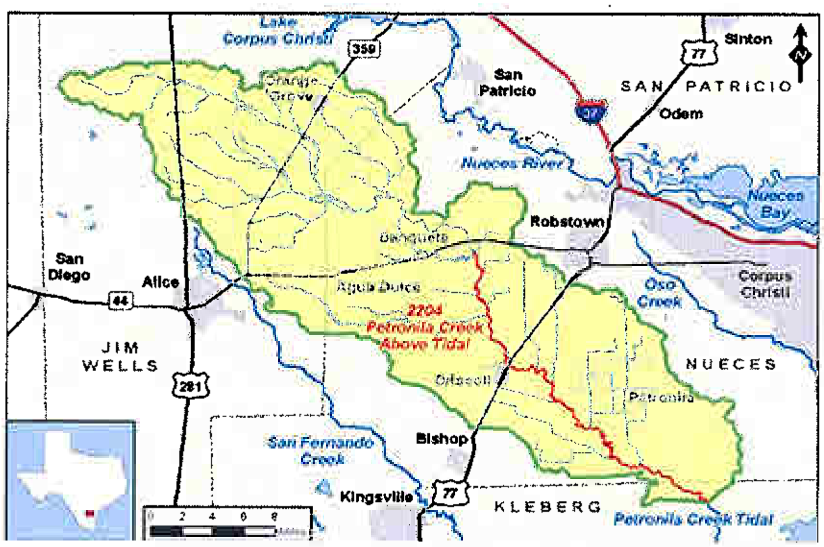


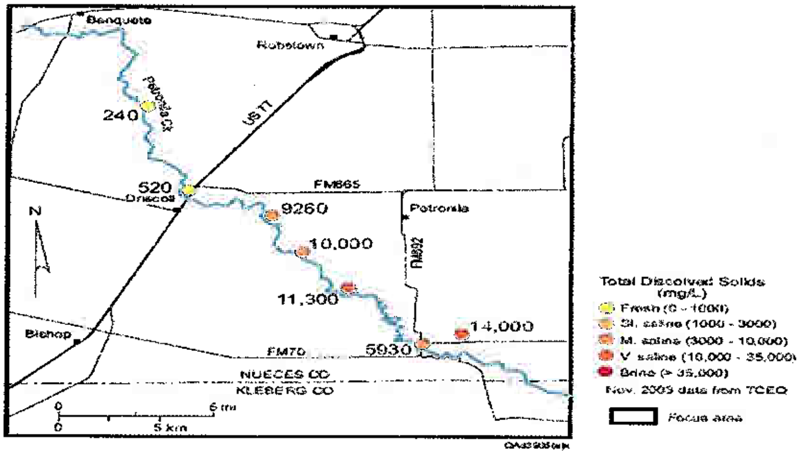
Clean Water Act Section 303(d) list

- In 2000,Petronila Creek (Segment 2204) included on the Section 303(d) list of the Clean Water Act because it did meet applicable water quality standards for chloride, sulfate and total dissolved solids (TDS).
- Current numeric standards to support designated uses: chloride concentration of 1,500 milligrams per liter (mg/L), sulfate of 500 mg/L, and TDS of 4,000 mg/L.
- The designated uses for Petronila Creek above Tidal are contact recreation use and intermediate aquatic life use (30 TAC 307, §307.7). Aquatic life uses recognize the natural variability of aquatic community requirements and local environmental conditions.

Total Maximum Daily Loads (TMDLs)

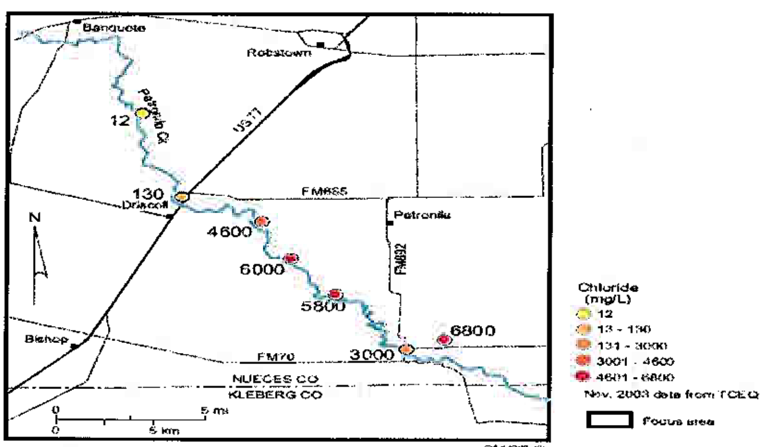
- The state must develop a total maximum daily load (TMDL) for each pollutant that contributes to the impairment of the water.
  - Texas Commission on Environmental Quality (TCEQ) is responsible for developing TMDLs for impaired waters in Texas. (http://tceq.state.tx.us/implementation/water/tmdl/ and http://www.epa.gov/OWOW/tmdl/)
- TMDL is a calculation of the maximum amount of a pollutant(s) that a waterbody can receive and still safely meet water quality standards.
- TMDL is an estimate of how much pollutant load must be reduced from current levels in order to achieve water quality standards.
- TMDL process requires the identification of pollutant sources.

Total Dissolved Solids (TDS) Concentration in Surface Water Samples from Petronila Creek (Nov. 2003)



(Paine et al, 2005, Geophysical Investigations of Salinization along Petronila Creek, Nueces and Kleberg Counties: Bureau of Economic Geology, University of Texas at Austin)

Chloride Concentrations in Surface Water Samples Along the Creek in November 2003



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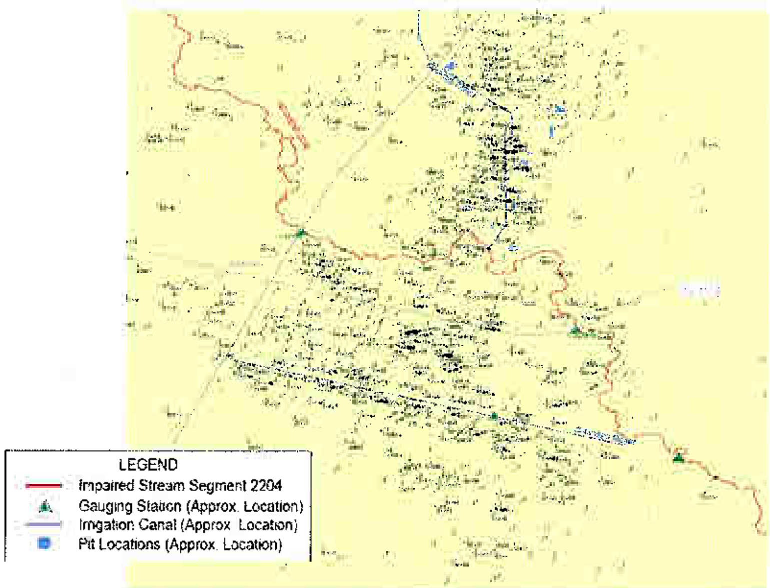
Map of North Clara Driscoll and Clara Driscoll Oilfields



Produced Water

- Produced water is water trapped in underground formations that is brought to the surface along with oil or gas.
- Largest volume byproduct or waste stream associated with oil and gas production
- Volume varies throughout the lifetime of a reservoir.
- Chemical and physical characteristics depend on geographic location of the field, the geological formation with which the produced water has been in contact for thousands of years, and the type of hydrocarbon product being produced.
- Produced water salinity (TDS) in the US ranges from 100 mg/L to 400,000 mg/L (seawater is 35,000 mg/L).
- Produced water salinity in Clara Driscoll Oilfield (Vicksburg Formation) averages TDS 49,300 mg/L and chloride 28,904 mg/L.

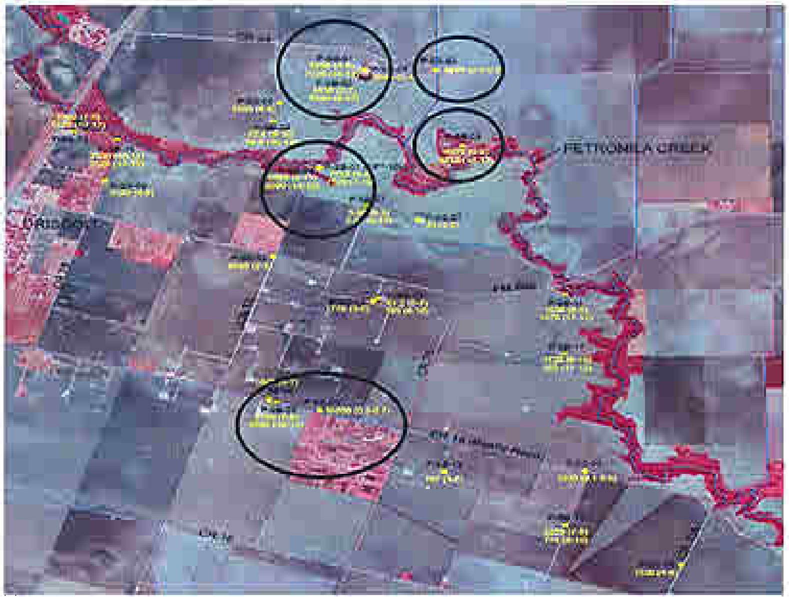
Possible Sources of Pollution

- Tidal discharge
  - In the early 1990s, Railroad Commission banned the discharge of produced water to Petronila Creek.
- Saltwater disposal and storage pits
  - Non-permitted large, shallow, unlined pits where water would be lost due to evaporation and seepage.
  - Railroad Commission's no-pit order in 1969
- Injection wells
  - Injecting brine into subsurface strata is used for both disposal of excess brine and for recovering oil from under-pressurized formations.

RRC Investigation

- Pit location (yellow boxes □)
- Oil-waste land areas (black boxes ■)
- Environmentally impacted areas (red dots ●)
- Oil and gas wells (black dots ●)
- Drainage ditches (green lines —)

Chloride Concentration in Soil



Groundwater Potentiometric Map (Dec. 2007)

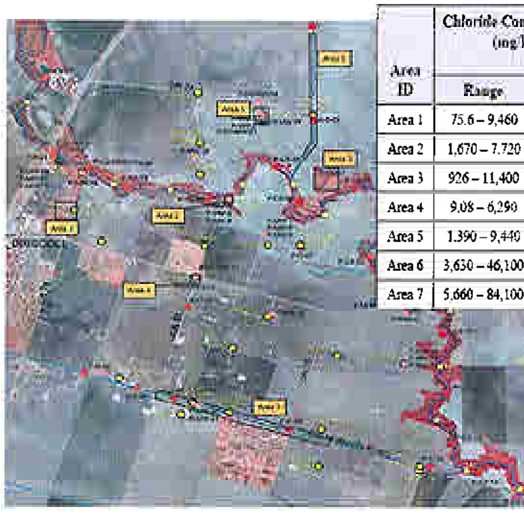
Chloride Concentration in Groundwater Map

- Isoconcentration contours
  - Blue dashed lines = shallow screen interval
  - Red dashed lines = intermediate screen interval
- Chloride concentration
  - Blue numbers = shallow screen interval
  - Red numbers = intermediate screen interval
  - Green numbers = deep screen interval

Chloride-Sulfate Ratio Map (Oct. 2007)

Potential Areas of Concern

Potential Areas of Concern and Salinity Information



Area ID	Chloride Concentration (mg/kg)		Conductivity Concentration (µmhos/cm)		Area of Elevated Salinity* (ft²)	Depth of Elevated Salinity* (feet)
	Range	Average	Range	Average		
Area 1	75.6 – 9,460	2,421	461 – 11,800	4,995	39,600	9
Area 2	1,670 – 7,720	5,215	2,910 – 12,000	7,347	30,000	10.5
Area 3	926 – 11,400	4,647	1,600 – 25,400	9,271	111,300	9
Area 4	9.08 – 6,290	1,593	1,690 – 7150	3,679	2,900	7
Area 5	1,390 – 9,440	5,242	3,910 – 17,100	9,428	166,000	10.5
Area 6	3,630 – 46,100	15,108	5,920 – 90,200	28,804	91,200	3
Area 7	5,660 – 84,100	39,320	7,800–166,000	74,048	120,000	3

Area	Chloride Mass (kilograms)
1	19,610
2	37,334
3	105,793
4	735
5	207,654
6	79,706
7	318,451

BMP Ranking

BMP Priority	Description	Rationale
1	Area 2	*Close proximity to Petronila Creek (60 feet) * High average salinity concentration (Chloride 5,215 mg/kg; conductivity 7,347 µmhos/cm) * Direct salinity loading into Petronila Creek via runoff and based on visual observation.
	Area 6	*Direct salinity loading via runoff into Petronila Creek. * High average salinity concentration (Chloride 15,108 mg/kg; conductivity 28,804 µmhos/cm)
	Area 7	* Direct salinity loading via runoff into Petronila Creek. * High average salinity concentration (Chloride 39,320 mg/kg; conductivity 74,048 µmhos/cm)
2	Area 3	*Proximity to Petronila Creek (800 feet) * High average salinity concentration (Chloride 4,647 mg/kg; conductivity 9,271 µmhos/cm) * Transport mechanism of salinity to creek mainly via percolation to groundwater then advection.
3	Area 5	*Proximity to Petronila Creek (1,400 feet) * High average salinity concentration (Chloride 5,242 mg/kg; conductivity 9,428 µmhos/cm) * Transport mechanism of salinity to creek mainly via percolation to groundwater then advection.
4	Area 4	*Proximity to Petronila Creek (7,500 feet) * Lowest average salinity concentration (Chloride 1,593 mg/kg; conductivity 3,679 µmhos/cm) * Transport mechanism of salinity to creek mainly via percolation to groundwater then advection.
5	Area 8	*Proximity to Petronila Creek (1,900 feet) * Second lowest average salinity concentration (Chloride 2,421 mg/kg; conductivity 4,995 µmhos/cm) * Transport mechanism of salinity to creek mainly via percolation to groundwater then advection.

BMP Alternatives for Salinity Abatement

- BMP selection is based on effectiveness, ability to be implemented, regulatory agency and stakeholder acceptance, cost
- Areas 1 – 5 (saline-contaminated shallow soils)
  - Cap Installation
  - Excavation and Offsite Disposal
  - In-situ Flushing
  - Immobilization
- Areas 6 and 7 (saline-contaminated drainage ditches)
  - Excavation and Offsite Disposal

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http://www.rrc.state.tx.us/environmental/environsupport/nps/petronila/index.php

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