Guadalupe Blanco River Authority
And
Upper Guadalupe River Authority
Clean Rivers Program
FY 2002-03

Investigation of impacts of oil field activities on the San Marcos River and Plum Creek in Caldwell County

Report

Prepared in Cooperation with the Guadalupe-Blanco River Authority and the Texas Commission on Environmental Quality Under the Authorization of the Texas Clean Rivers Act

Guadalupe-Blanco River Authority
933 E. Court St.
Seguin, TX 78155

Clean Rivers Program
Technical Analysis Division
Texas Commission on Environmental Quality
P.O. Box 13087, MC 147
Austin, TX 78711-3087

Questions concerning this report should be directed to:

Debbie Magin
Director of Water Quality Services
Guadalupe-Blanco River Authority
933 E. Court St.
Seguin, TX 78155
(830) 379-5822
dmagin@gbra.org

August 1, 2003

TABLE OF CONTENTS

LIST OF ACRONYMS

BTEX	**Benzene, Toluene, Ethyl Benzene, and Xylene**
CFR	**Code of Federal Regulations**
COC	**Chain-of Custody**
CRP	**Clean Rivers Program**
DQO	**Data Quality Objective**
EPA	**US Environmental Protection Agency**
FY	**Fiscal Year**
GBRA	**Guadalupe-Blanco River Authority**
LCRA	**Lower Colorado River Authority**
PAH	**Polynuclear Aromatic Hydrocarbon**
QA	**Quality Assurance**
QAPP	**Quality Assurance Project Plan**
SOP	**Standard Operating Procedure**
SWQM	**Surface Water Quality Monitoring**
TCEQ	**Texas Commission on Environmental Quality**
TNRCC	**Texas Natural Resource Conservation Commission**
TPH	**Total Petroleum Hydrocarbons**
TRACS	**Texas Regulatory and Compliance System**
TSWQS	**Texas Surface Water Quality Standards**
VOA	**Volatile Organic Analytes**

EXECUTIVE SUMMARY

A special study was conducted to investigate the impact of oil field activities on the water quality of the San Marcos River and Plum Creek in Caldwell County. Active oil wells and storage tanks are heavily concentrated in Caldwell County. According to the Railroad Commission of Texas, there are 4450 wells in Caldwell County that in 2001, produced 956,305 barrels of crude oil. In the study area, there are 996 permitted wells. Additionally, the county is dissected by a network of pipelines that support the oil industry and carry the crude and gas to production facilities outside of the county.

These oil tanks and wells are often unmanned and leaks may go for extended periods of time without detection. Rainfall events can carry contaminated soil and oil deposits to the tributaries that feed the San Marcos River and Plum Creek. The City of Luling is at the greatest risk. The city uses the San Marcos River as the raw water source for their surface water treatment plant located in Luling. GBRA has two routine monitoring sites, one on the San Marcos River and one on the Plum Creek. Total petroleum hydrocarbons (TPH), BTEX and polynuclear aromatic hydrocarbons (PAH) were added quarterly to the list of routine chemical analysis at these sites. In addition, samples were collected for the organic compounds after three rainfall events that occurred during the study period. Sites were monitored upstream of the existing sites to establish background concentrations of the organic compounds.

TPH is a term used to describe a large group of chemical compounds that originate from crude oil. Because there are so many different chemicals in crude oil, it is not practical to measure each one separately. The BTEX chemicals are Benzene, Toluene, Ethylbenzene, and Xylenes. These compounds are volatile, monoaromatic hydrocarbons that are commonly found together in crude petroleum. They are considered one of the major causes of environmental pollution because of widespread occurrences of leakage from underground petroleum storage tanks and spills at petroleum production wells, refineries, pipelines, and distribution terminals (Fries et al., 1994).

The analyses resulted in no detection of BTEX or TPHs, thus no PAH analyses were performed. Whereas, it was good to learn that there were no organic compounds detected in the San Marcos River or Plum Creek, it is apparent by the number and concentration of oil wells in the area that the potential for contamination from oil field activities still exists. Because this was a very limited study of only seven sampling events, additional monitoring may be warranted. It is recommended that the work plan for 2005, and all subsequent work plans, include monitoring for the organic compounds on an annual basis.

INTRODUCTION

GBRA, in conjunction with UGRA, have been monitoring water quality since the mid-1980s and have been actively involved in water quality planning since the early 1970s. Through the Clean Rivers Program's Surface Water Quality Monitoring Project, the river authorities have enhanced and modified their existing programs. The expansion of the existing monitoring efforts has allowed the river authorities' staffs to gather data to characterize water quality conditions in areas not previously monitored. In addition to those monitoring efforts, a special study was conducted to investigate the impact of oil field activities on the water quality of the San Marcos River and Plum Creek in Caldwell County. Active oil wells and storage tanks are heavily concentrated in Caldwell County. These tanks and wells are often unmanned and leaks may go for extended periods of time without detection. Rainfall events can carry contaminated soil and oil deposits to the tributaries that feed the San Marcos River and Plum Creek. In January 2001, an oil field storage tank was found to be leaking and slowly seeping into a small tributary of the San Marcos River in Caldwell County, and in May 1999, a TNRCC (TCEQ) enforcement order required the removal of contaminated soil surrounding a petroleum transmission line near Plum Creek (TCEQ site no. 12640). The City of Luling is at the greatest risk. The city uses the San Marcos River as the raw water source for their surface water treatment plant located in Luling.

PROJECT SIGNIFICANCE AND BACKGROUND

The study consisted of routine and rainfall event sampling at four sites, two on the San Marcos River and two on the Plum Creek. One site on each water body (referred to as "background site") was chosen to represent the natural background concentrations of the organic compounds and was located upstream of the area where the oil-related activities are concentrated. Two GBRA routine monitoring locations, one on each water body (referred to as "study site"), were chosen because they are existing monitoring locations and they are located within the area of heaviest oil field activities. Total petroleum hydrocarbons (TPH), BTEX and polynuclear aromatic hydrocarbons (PAH) (collectively referred to as "organic compounds") were added quarterly to the list of routine chemical analyses at the two routine monitoring sites. The organic compounds were sampled once per quarter at all four sites. These routine sampling events were made after at least seven days of dry weather conditions in the respective watersheds. In addition to routine monitoring for the organic compounds, samples were collected for the organic compounds after three rainfall events that occur during the study period. The rainfall events that were monitored were of the intensity to cause measurable runoff.

Figure 1 is a map of the monitoring sites within the study area. The study site located on the Plum Creek is at CR 135 southeast of Luling, (12640). The background site on Plum Creek is located at the GBRA systematic site, Plum Creek at Plum Creek Road (17406). The study site located on the San Marcos River is located at the Luling Water Treatment Plant intake (12626). The background site on the San Marcos River is a TCEQ monitoring location, Lower San Marcos River at the county road immediately below the confluence of the San Marcos and Blanco Rivers (12628).

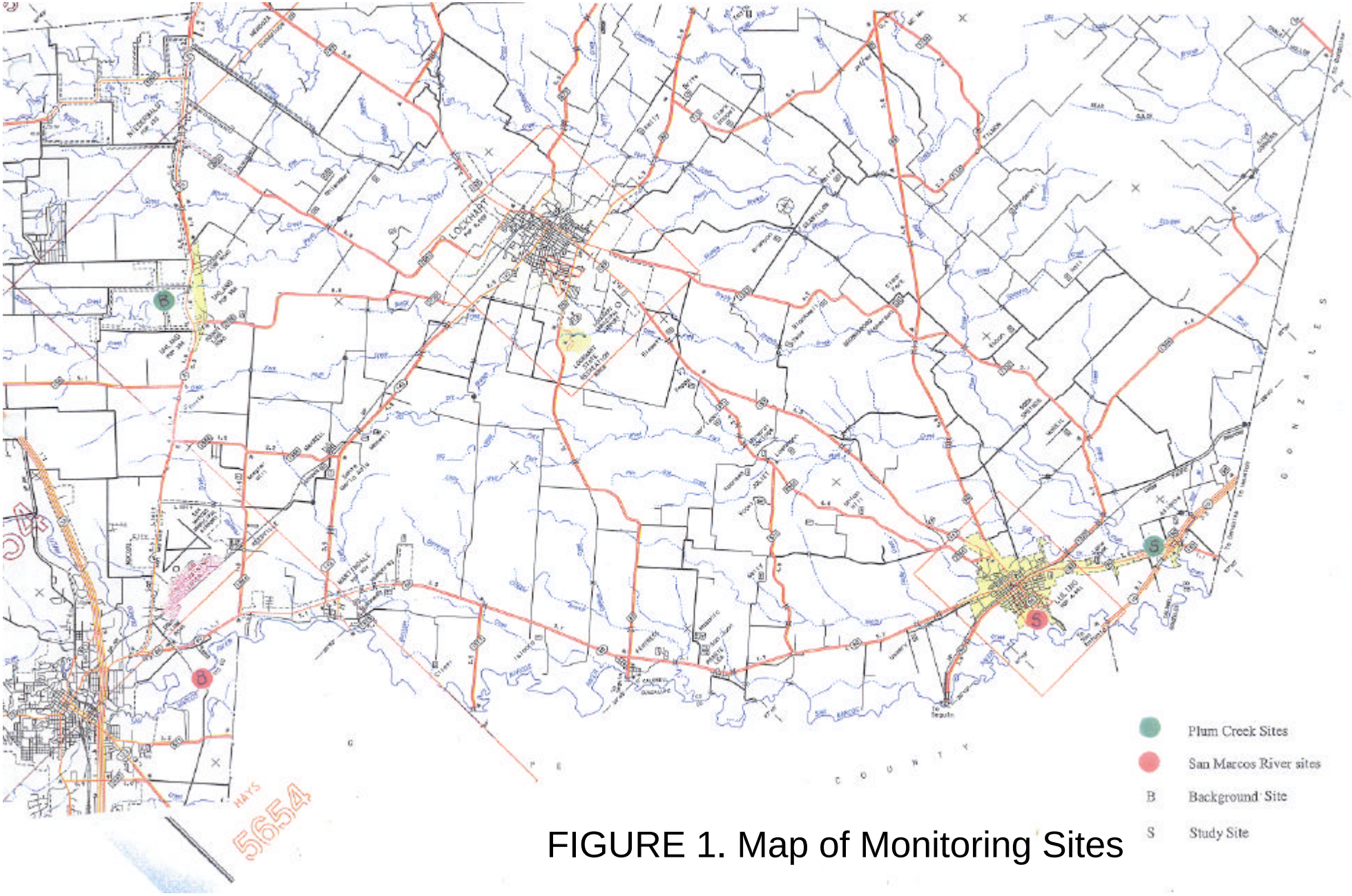


FIGURE 1. Map of Monitoring Sites

Study Area

Caldwell County, in south-central Texas, is in the West Gulf Coastal Plain. It has an area of 544 square miles. The economy depends chiefly on livestock, farming, small industries, and oil production. The land surface ranges from nearly flat to hilly. Figure 2 is a land use map of the county. The study area is dominated by pastureland, with some deciduous forest and row crops. The minimum elevation is at the southern tip of the county where Plum Creek joins the San Marcos River. The surface rises from southeast to northwest. The southwestern portion of the county is drained by the San Marcos River. Plum Creek, a tributary of the San Marcos River, drains approximately 310 square miles, about 60% of the county. Caldwell County has a sub-humid climate coupled with mild winters and hot summers. Rainfall averages thirty-five inches per year.

The county is bisected from southwest to northeast by the Luling-Darst Creek fault zone. According to the Railroad Commission of Texas, there are 4450 wells in Caldwell County that in 2001, produced 956,305 barrels of crude oil (Appendix A). In the study area, there are 996 permitted wells. Figure 3, Map of Oil Field Activities in San Marcos River and Plum Creek Watersheds, shows the location of the wells and the sampling locations. Figure 4, Map of Oil Field Activities in the Middle San Marcos River Watershed, Figure 5, Map of Oil Field Activities in the Lower San Marcos River Watershed, and Figure 6, Map of Oil Field Activities in the Plum Creek Watershed are maps of expanded portions of the county so that the locations of oil wells are discernable. The county is dissected by a network of pipelines that support the oil industry and carry the crude and gas to production facilities outside of the county. Figure 7 is a map of the various pipelines in the county.

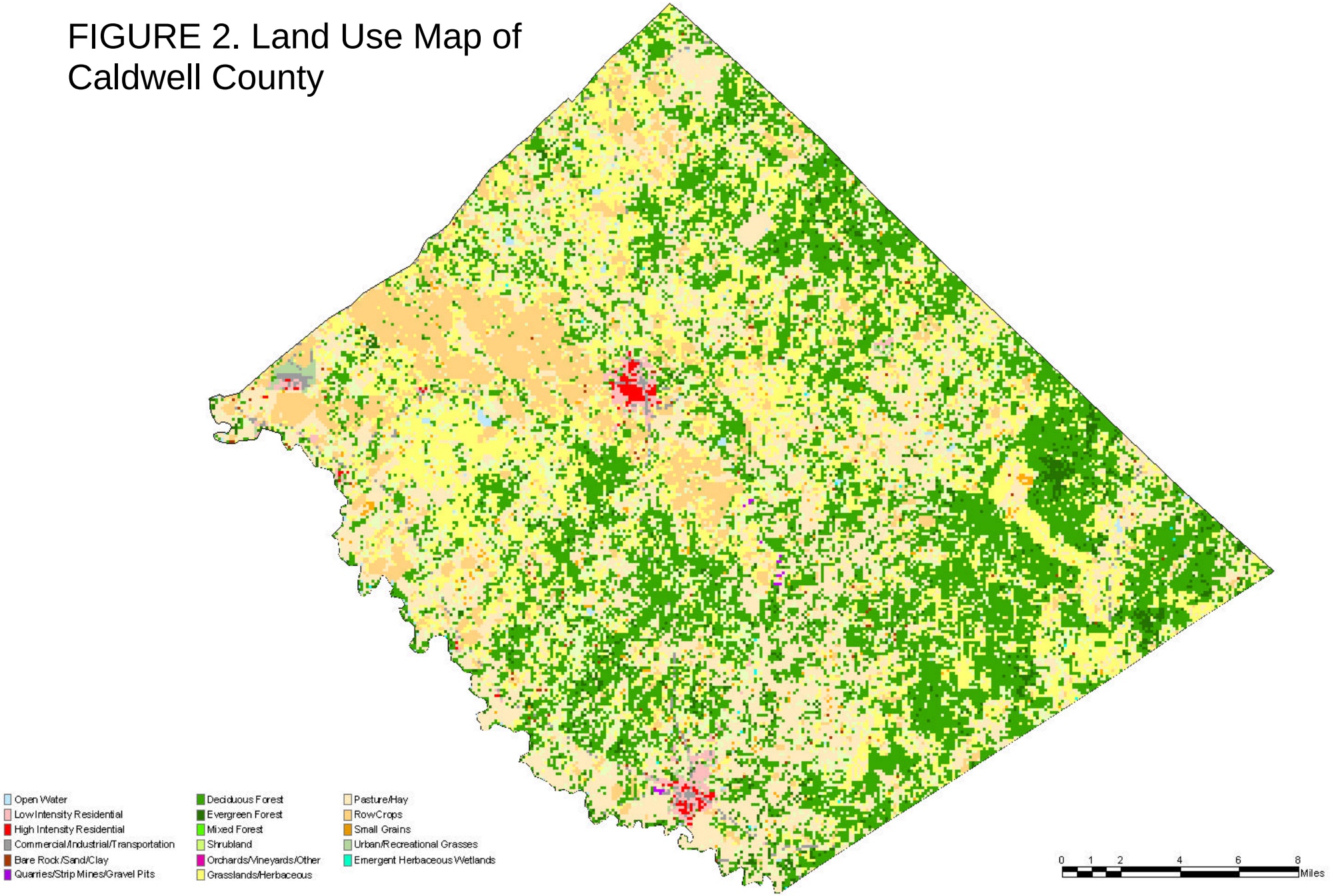
Compounds of Interest

Total petroleum hydrocarbons (TPH), BTEX and polynuclear aromatic hydrocarbons (PAH) (collectively referred to as “organic compounds”) were analyzed on the stream samples. TPH is a term used to describe a large group of chemical compounds that originate from crude oil. Crude oil is used to make petroleum products. Because there are so many different chemicals in crude oil, it is not practical to measure each one separately. Some chemicals that may be a portion of TPHs include benzene, toluene, hexane, xylenes, and naphthalene.

The BTEX chemicals are Benzene, Toluene, Ethylbenzene, and Xylenes. These compounds are volatile, monoaromatic hydrocarbons that are commonly found together in crude petroleum. They are considered one of the major causes of environmental pollution because of widespread occurrences of leakage from underground petroleum storage tanks and spills at petroleum production wells, refineries, pipelines, and distribution terminals (Fries et al., 1994).

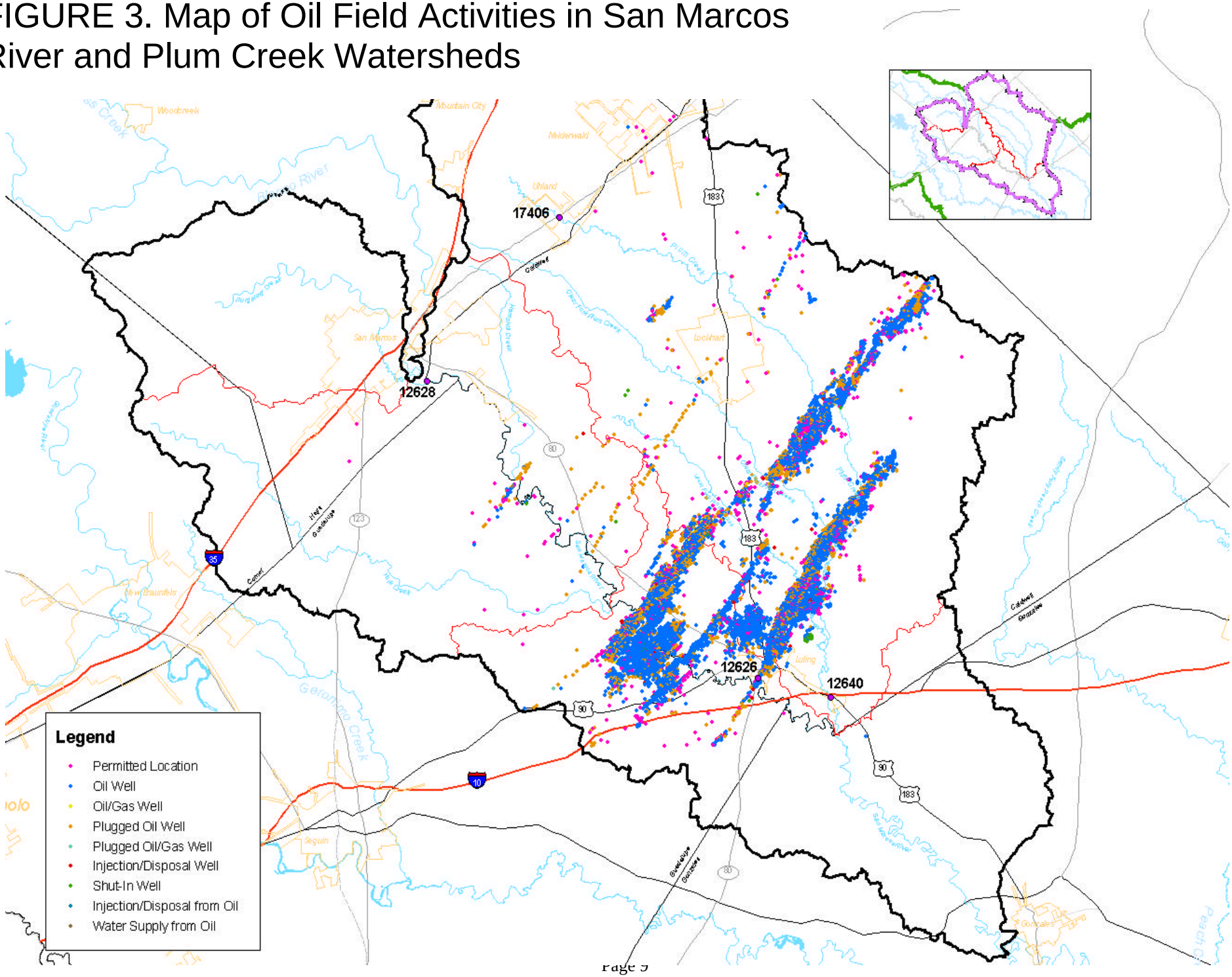
PAHs are a group of organic compounds that are formed during the incomplete burning of coal, oil, gas and wood and are also found in crude oil. There are more than 100 different PAHs that normally occur in mixtures rather than as single compounds.

FIGURE 2. Land Use Map of Caldwell County



Data Source: http://landcover.usgs.gov/natllandcover.html

FIGURE 3. Map of Oil Field Activities in San Marcos River and Plum Creek Watersheds



figure

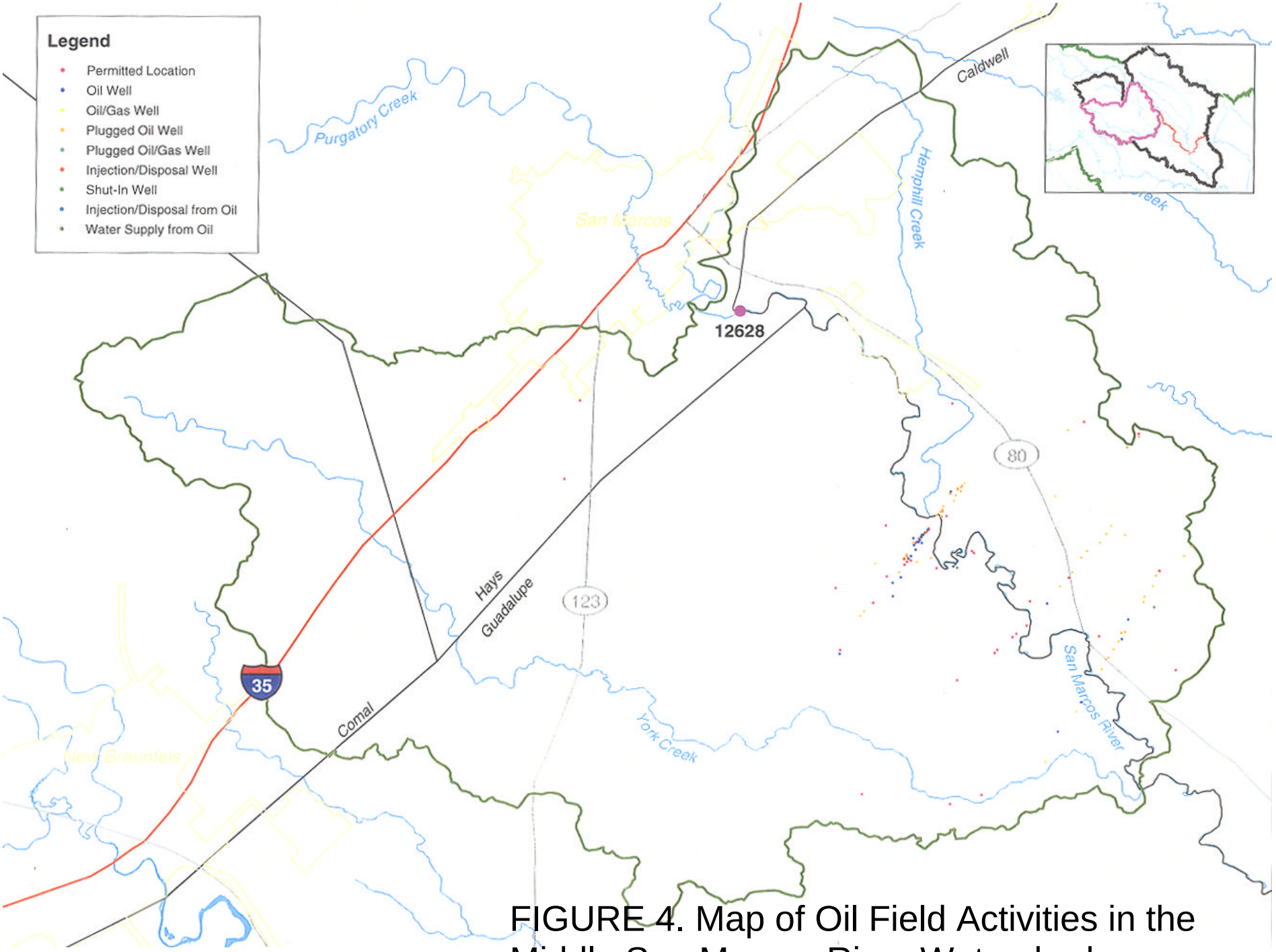


FIGURE 4. Map of Oil Field Activities in the Middle San Marcos River Watershed

figure 5

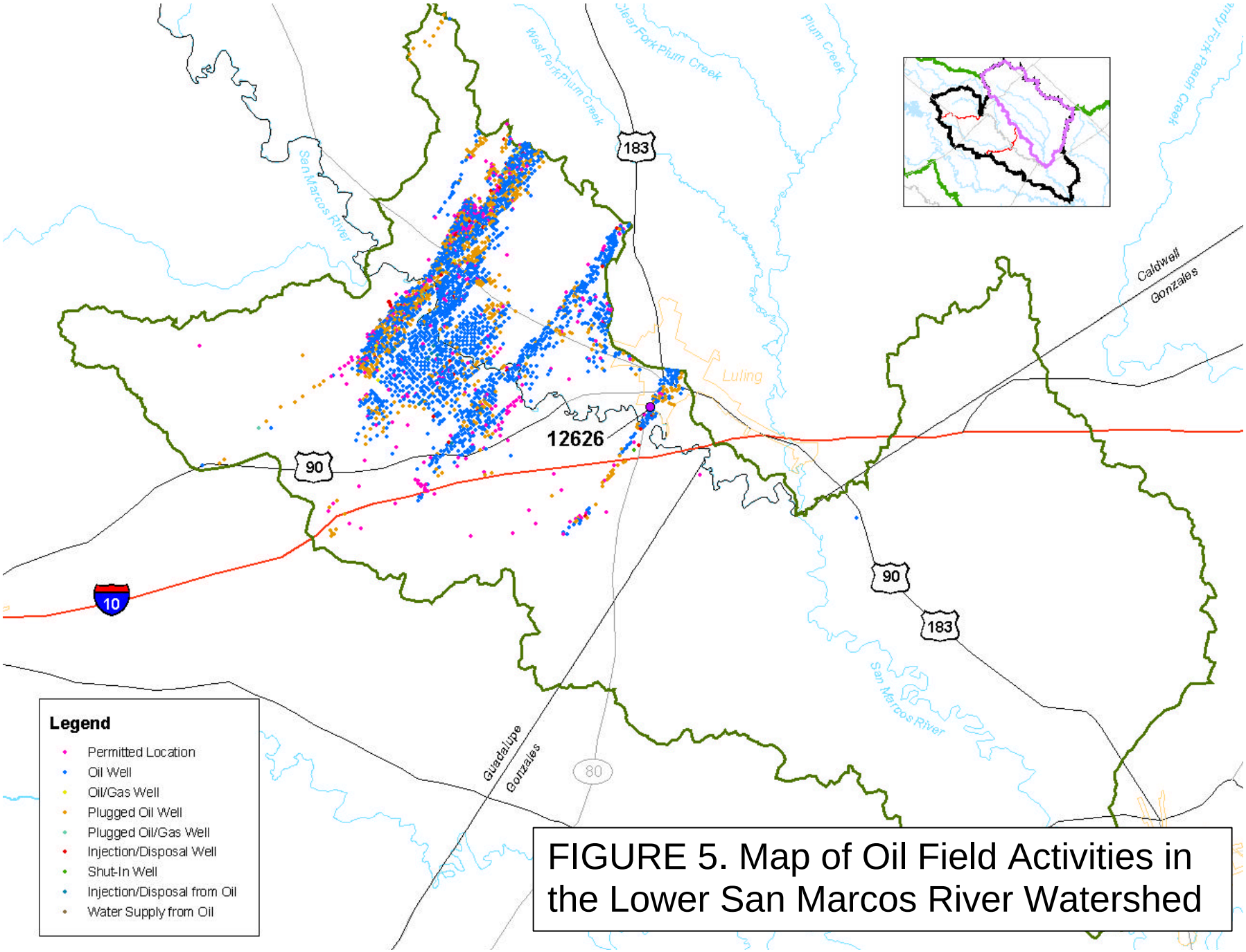
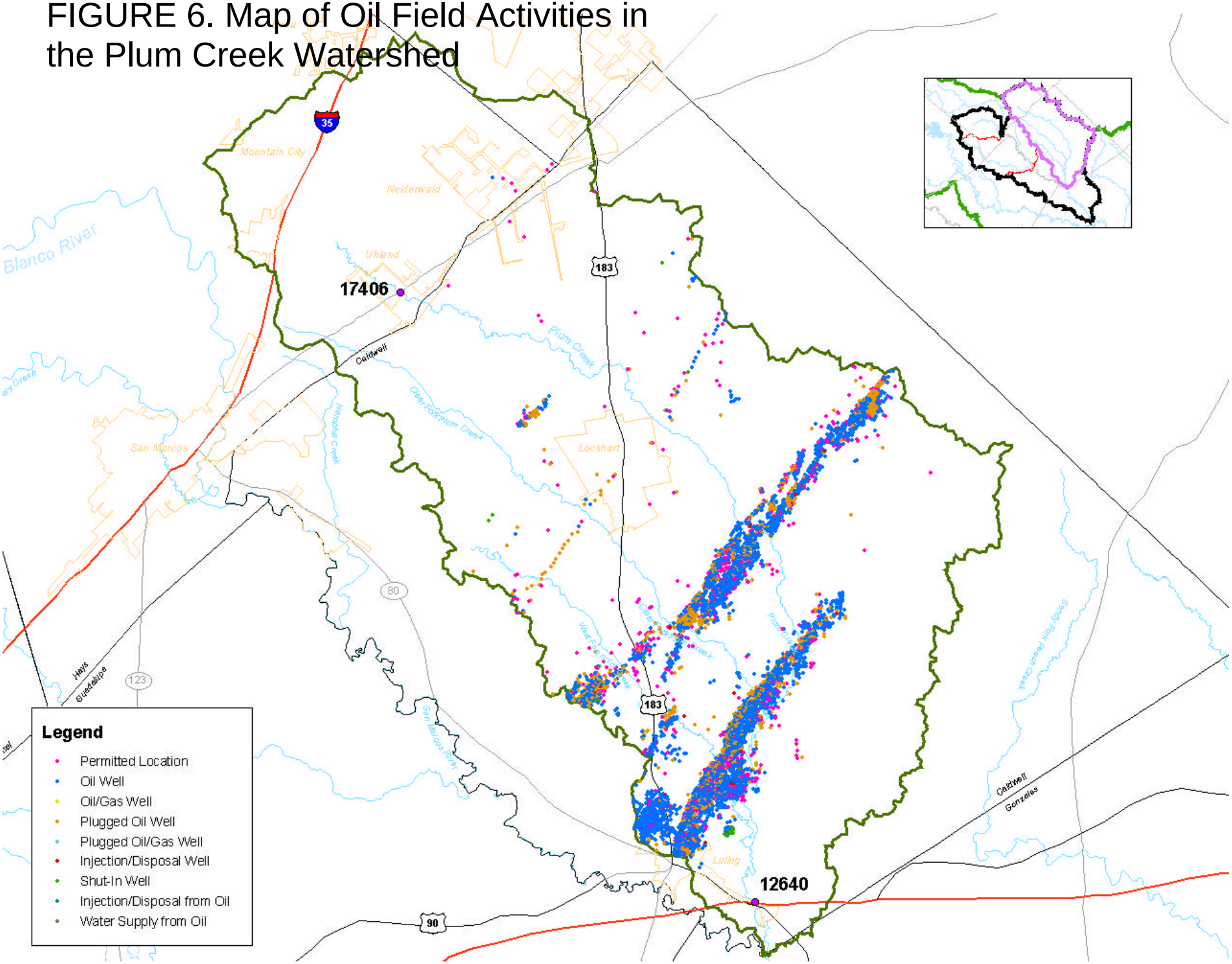


FIGURE 5. Map of Oil Field Activities in the Lower San Marcos River Watershed

FIGURE 6. Map of Oil Field Activities in the Plum Creek Watershed



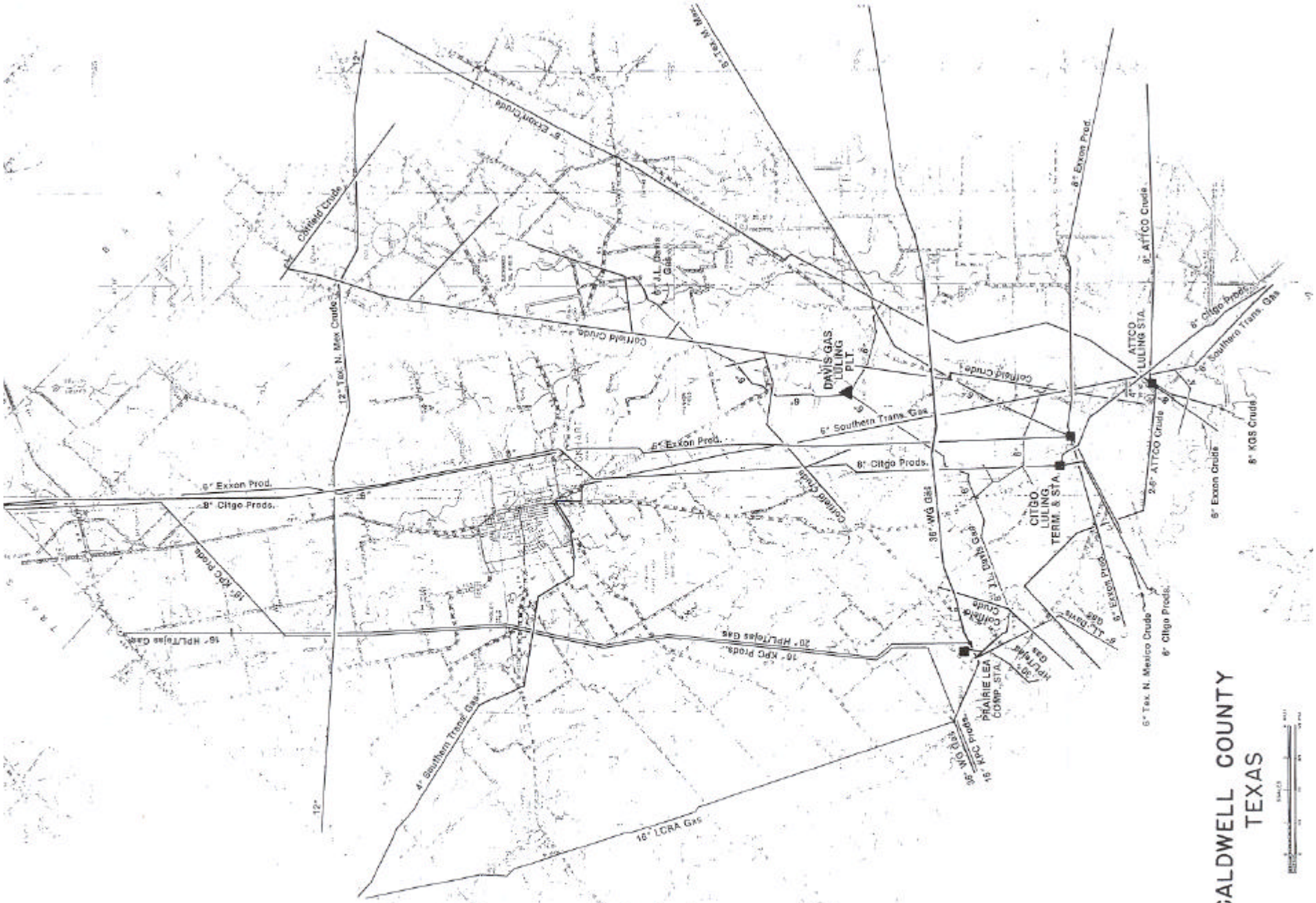


FIGURE 7. Map of Network of Oil Pipelines in Caldwell County

The organic compounds associated with oil production and petroleum products do have adverse health affects. Some of the compounds can affect the central nervous system, others can cause a nerve disorder, and some will have effects on the blood, lungs, skin, eyes and immune system. There are no regulations or advisories specific to TPH or BTEX but there are human health criteria recommendations for some of the TPH, BTEX and PAH compounds. The following table lists examples of the organic compounds included in TPHs, BTEX and PAHs and the associated human health criteria recommended by EPA:

Priority Pollutant	**Human Health Criteria for Consumption of Water and Organism**
Benzene	0.61-2.2 ug/L
Ethyl-benzene	3100 ug/L
Toluene	6800 ug/L
Acenaphthene	670 ug/L
Anthracene	8300 ug/L
Benzo[a]anthracene; Benzo[a]pyrene; benzo[b]fluoranthene	0.0038 ug/L
Chyrsene	0.0038 ug/L
Fluorene	1100 ug/L

METHODS AND MATERIALS

The purpose of the project was to investigate the impact of the activities associated with the oil field industry on the water quality of the San Marcos River and Plum Creek in Caldwell County. The measurement performance criteria to support the project objectives are specified in Table 1. Concentrations of the organic compounds measured at the study sites, at routine flow conditions and after rainfall events, were compared to the concentrations at the respective background sites. The following question and decision rule were used to evaluate the monitoring results.

Question: Do any of the study site samples, routine or rainfall, exhibit higher concentrations of BTEX, TPH or PAH than the respective background site samples?

Decision Rule 1: If the concentration of any of the organic compounds monitored at a study site quarterly under routine conditions or collected after a rainfall event is greater than 25% relative percent difference of the upstream respective background site, then there may be a significant impact from oil field activities in that reach of the stream and will necessitate consideration of additional monitoring in the next biennium. If the organic compound has a drinking water standard, that concentration will be used as a screening concentration as well. Both the city of Luling and the Railroad Commission of Texas will be notified of the results of the study in order to increase the attention and inspection of the oil field operations in Caldwell County and initiate better communications between the Railroad Commission and city of Luling's potable water operations.

Table 1 Data Quality Objectives for Special Study for Oil Field Impacts

PARAMETER	UNITS	MATRIX	METHOD	STORET	RL	PRECISION	ACCURACY at RLS (% REC)	ACCURACY of lab matrix spikes (%REC)	LABORATORY PERFORMING ANALYSIS
Organics									
BTEX	ug/L	water	EPA 624	04721	5	30	70-130	70-130	LCRA
TPH	mg/L	water	TX 1005	04720	5	30	70-130	70-130	LCRA
PAH	ug/L	water	EPA 625	04722	5-10	30	70-130	70-130	LCRA
Flow Severity	1-no flow, 2-low, 3-normal, 4-flood, 5-high, 6-dry	water	TCEQ SOP	01351	NA[1]	NA	NA	NA	GBRA
Rainfall past 24 hours	inches	water	TCEQ SOP	82553	NA	NA	NA	NA	GBRA
Rainfall past 7 days	inches	water	TCEQ SOP	82554	NA	NA	NA	NA	GBRA
Days since last significant rainfall	days	water	TCEQ SOP	70253	NA	NA	NA	NA	GBRA

1 Reporting to be consistent with the SWQM guidance and based on measurement capability.

The monitoring during routine conditions was tied to the routine monitoring done at the study sites currently. Rainfall monitoring was done when the laboratory was notified of significant rainfall in the study area by either the National Weather Service or the city of Luling water plant personnel.

RESULTS AND OBSERVATIONS

The results of the sample analyses are tabulated in Table 2 Monitoring Results of Oil Field Impact Study. The analyses resulted in no detection of BTEX or TPHs, thus no PAH analyses were performed. Appendix C contains all laboratory reports and chains of custody. Four quarterly samples were analyzed as well as three rainfall samples.

RECOMMENDATIONS

Whereas, it is good to learn that there were no organic compounds detected in the San Marcos River or in the Plum Creek, it is apparent by the number and concentration of oil wells in the area that the potential for contamination from oil field activities still exists. Because this was a very limited study of only seven sampling events, additional monitoring may be warranted. It is recommended that the work plan for 2005, and all subsequent work plans, include monitoring for the organic compounds on an annual basis.

Table 2. Monitoring Results of Oil Field Impact Study

		BTEX							TPH						
Site Description (Number)	Event	10/9/02	11/18/02	12/3/02	2/28/03	4/30/03	7/7/03	8/13/03	10/9/02	11/18/02	12/3/02	2/28/03	4/30/03	7/7/03	8/13/03
PLUM CREEK AT CR 135 SE OF LULING (12640)	Back-ground	---	ND	---	ND	ND	---	ND	---	ND	---	ND	ND	---	ND
	Rainfall	ND	---	ND	---	---	ND	---	ND	---	ND	---	---	ND	---
SAN MARCOS RIVER AT LULING WATER TREATMENT PLANT (12626)	Back-ground	---	ND	---	ND	ND	---	ND	---	ND	---	ND	ND	---	ND
	Rainfall	ND	---	ND	---	---	ND	---	ND	---	ND	---	---	ND	---
LOWER SAN MARCOS RIVER AT COUNTY ROAD IMMEDIATELY BELOW CONFLUENCE OF SAN MARCOS AND BLANCO RIVERS (12628)	Back-ground	---	ND	---	ND	ND	---	ND	---	ND	---	ND	ND	---	ND
	Rainfall	ND	---	ND	---	---	ND	---	ND	---	ND	---	---	ND	---
PLUM CREEK AT PLUM CREEK ROAD NORTH OF UHLAND IN HAYS COUNTY (17406)	Back-ground	---	ND		ND	ND	---	ND	---	ND		ND	ND	---	ND
	Rainfall	ND	---	ND	---	---	ND	---	ND	---	ND	---	---	ND	---

ND = Not detected; no PAH analysis run.

REFERENCES

Agency for Toxic Substances and Disease Registry. http://www.atsdr.cdc.gov/tfacts123.html.

Dallas Morning News. 1999. Texas Almanac, 2000-2001. Caldwell County.

Fries MR, Zhou J, Chee-Sanford J, Tiedje JM. Isolation, characterization, and distribution of denitrifying toluene degraders from a variety of habitats. 1994. Appl Environ Microbiol. Aug;60(8):2802-10.

Railroad Commission of Texas. http://www.rrc.state.tx.us/divisions/og/information-data.

Railroad Commission of Texas. Pipeline maps by County.

Texas Water Development Board. 1966. Ground-Water Resources of Caldwell County, Texas.

US Environmental Protection Agency. 2002. National Recommended Water Quality Criteria: 2002. Human Health Criteria Calculation Matrix.

USGS. National Land Use Data Set. http://landcover.usgs.gov/natllandcover.html.