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Retrospective Case Study in the Raton Basin, Colorado

STUDY OF THE POTENTIAL IMPACTS OF HYDRAULIC FRACTURING ON DRINKING WATER RESOURCES

United States Environmental Protection Agency
Office of Research and Development

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U.S. Environmental Protection Agency
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Washington, DC

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Disclaimer

Table of Contents

List of Tables

List of Figures

Acronyms and Abbreviations

ADQ	audits of data quality
AOM	anaerobic oxidation of methane
Bcf	billion cubic feet
BTEX	benzene, toluene, ethylbenzene, and *m*- + *p*-, and *o*-xylenes
CBM	coalbed methane
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CH_4	methane
CLP	Contract Laboratory Program
CO_2	carbon dioxide
COGCC	Colorado Oil and Gas Conservation Commission
CRDS	cavity ring-down spectrometry
DIC	dissolved inorganic carbon
DO	dissolved oxygen
DOC	dissolved organic carbon
DRO	diesel-range organics
$\delta^{18}O_{H2O}$	oxygen-18/oxygen-16 isotopic ratio in water
$\delta^{2}H_{H2O}$	deuterium/hydrogen isotopic ratio in water
$\delta^{13}C_{CH4}$	carbon-13/carbon-12 isotopic ratio in methane
$\delta^{2}H_{CH4}$	deuterium/hydrogen isotopic ratio in methane
$\delta^{13}C_{DIC}$	carbon-13/carbon-12 isotopic ratio in DIC
$\delta^{18}O_{SO4}$	oxygen-18/oxygen-16 isotopic ratio in sulfate
$\delta^{34}S_{SO4}$	sulfur-34/sulfur-32 isotopic ratio in sulfate
$\delta^{34}S_{H2S}$	sulfur-34/sulfur-32 isotopic ratio in hydrogen sulfide
EPA	(U.S.) Environmental Protection Agency
EDR	Environmental Data Resources, Inc.
ETBE	ethyl tert-butyl ether
GC/MS	gas chromatography/mass spectrometry
GMWL	global meteoric water line

GPS	global positioning system
GRO	gasoline-range organics
GWERD	Ground Water and Ecosystems Restoration Division
HPLC	high-performance liquid chromatography
ICP-OES	inductively coupled plasma–optical emission spectroscopy
ICP-MS	inductively coupled plasma–mass spectroscopy
IRMS	isotope ratio mass spectrometry
LC-MS-MS	liquid chromatography–tandem mass spectrometry
LMWA	low-molecular-weight acid
LMWL	local meteoric water line
LLNL	Lawrence Livermore National Laboratory
Mcf	thousand cubic feet
Mcfd	thousand cubic feet per day
MCL	maximum contaminant level
MDL	method detection limit
Mmcf	million cubic feet
MTBE	methyl tert-butyl ether
my	million years
µg/L	micrograms per liter
µS/cm	microsiemens per centimeter
mg/L	milligrams per liter
mmol/L	millimoles per liter
mol/L	moles per liter
MS/MSD	matrix spike/matrix spike duplicate
NBS	National Bureau of Standards
NERL	National Exposure Research Laboratory
NIST	National Institute of Standards and Technology
NLCD	National Land Cover Database
NRMRL	National Risk Management Research Laboratory

NTU	nephelometric turbidity unit
NURE	National Uranium Resource Evaluation
NWIS	National Water Information System
ORD	Office of Research and Development
ORP	oxidation-reduction potential
PAH	polycyclic aromatic hydrocarbon
permil	‰, parts per thousand
ppm	parts per million
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QL	quantitation limit
RCRA	Resource Conservation and Recovery Act
RSKERL	Robert S. Kerr Environmental Research Laboratory
SAR	Sodium Adsorption Ratio
SLAP	Standard Light Antarctic Precipitation
SMCL	secondary maximum contaminant level
SPC	specific conductance
STORET	STOrage and RETrieval
SVOC	semivolatile organic compound
TBA	tert-butyl alcohol
TBAc	tert-butyl acetate
TBHP	tert-butyl hydroperoxide
Tcf	trillion cubic feet
TDS	total dissolved solids
TIC	tentatively identified compound
THMs	trihalomethanes
TIMS	thermal ionization mass spectrometry

TSA	Technical System Audits
USDW	Underground Source of Drinking Water
USGS	U.S. Geological Survey
VCDT	Vienna Canyon Diablo Troilite
VOC	volatile organic compound
VPDB	Vienna Pee Dee Belemnite
VSMOW	Vienna Standard Mean Ocean Water

Preface

The U.S. Environmental Protection Agency (EPA) is conducting a study of the potential impacts of hydraulic fracturing for oil and gas on drinking water resources. This study was initiated in Fiscal Year 2010 when Congress urged the EPA to examine the relationship between hydraulic fracturing and drinking water resources in the United States. In response, EPA developed a research plan (*Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources*) that was reviewed by the Agency's Science Advisory Board (SAB) and issued in 2011. A progress report on the study (*Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources: Progress Report)*, detailing the EPA's research approaches and next steps, was released in late 2012 and was followed by a consultation with individual experts convened under the auspices of the SAB.

The EPA's study includes the development of several research projects, extensive review of the literature and technical input from state, industry, and non-governmental organizations as well as the public and other stakeholders. A series of technical roundtables and in-depth technical workshops were held to help address specific research questions and to inform the work of the study. The study is designed to address research questions posed for each stage of the hydraulic fracturing water cycle:

- Water Acquisition: What are the possible impacts of large volume water withdrawals from ground and surface waters on drinking water resources?
- Chemical Mixing: What are the possible impacts of surface spills of hydraulic fracturing fluid on or near well pads on drinking water resources?
- Well Injection: What are the possible impacts of the injection and fracturing process on drinking water resources?
- Flowback and Produced Water: What are the possible impacts of surface spills of flowback and produced water on or near well pads on drinking water resources?
- Wastewater Treatment and Waste Disposal: What are the possible impacts of inadequate treatment of hydraulic fracturing wastewaters on drinking water resources?

This report, *Retrospective Case Study in the Raton Basin, Colorado*, is the product of one of the research projects conducted as part of the EPA's study. It has undergone independent, external peer review in accordance with Agency policy and all of the peer review comments received were considered in the report's development.

The EPA's study will contribute to the understanding of the potential impacts of hydraulic fracturing activities for oil and gas on drinking water resources and the factors that may influence those impacts. The study will help facilitate and inform dialogue among interested stakeholders, including Congress, other Federal agencies, states, tribal government, the international community, industry, non-governmental organizations, academia, and the general public.

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Executive Summary

In December 2009, Congress urged the U.S. Environmental Protection Agency (EPA) to study the relationship between hydraulic fracturing and drinking water resources. This report provides the results of one of five retrospective case studies conducted as a component of EPA's national study on the potential impacts of hydraulic fracturing on drinking water resources (US EPA, 2012). The retrospective case studies focused on investigating reported instances of drinking water contamination in areas where hydraulic fracturing had already occurred. This report describes the retrospective case study that was conducted in the Colorado portion of the Raton Basin, located within Las Animas and Huerfano counties. These locations are the focus of unconventional gas production of coalbed methane (CBM) from several coal-bearing strata in the basin.

CBM development and production within the Raton Basin of southern Colorado and northern New Mexico have increased over the past decade, and the Raton Basin is one of the most productive CBM basins in the United States. Annual production of methane from coal beds within Las Animas and Huerfano counties averaged about 103 billion cubic feet during 2007–2013, or about 20% of Colorado's total natural gas production. Coal beds located within the Raton Formation (Late Cretaceous to Tertiary) and the Vermejo Formation (Cretaceous) are the primary sources of methane within the Raton Basin. Gas production from the coal beds depends upon hydraulic fracturing technologies to enhance and create fracture porosity, permeability, and gas flow. In contrast to shale gas and most conventional energy resource development, recovery of CBM typically occurs at relatively shallow depths, sometimes within or in close proximity to aquifers classified as Underground Sources of Drinking Water (USDW). For example, the Raton and Vermejo formations and the Poison Canyon Formation, which overlies the Raton Formation, are sources of ground water for domestic wells and municipal water supply wells within the Raton Basin.

Water quality samples were collected from 14 domestic wells, five monitoring wells, three production wells, and three surface water bodies during four sampling rounds in October 2011, May 2012, November 2012, and April/May 2013 (see Appendices A and B of this report). The production wells and monitoring wells were maintained and operated by Pioneer Natural Resources (Las Animas County) and Petroglyph Energy, Inc. (Huerfano County). The domestic well locations for this case study were based on homeowner concerns regarding potential adverse impacts on their well water and the potential association with drilling, hydraulic fracturing, and/or CBM development in the vicinity of their homes. Specific sampling locations were selected based on criteria such as well depth, geologic and hydrologic characteristics, and proximity to CBM wells. In order to help differentiate potential impacts from hydraulic fracturing or processes related to hydraulic fracturing from other potential contaminant sources that may have caused or contributed to alleged impacts on water quality, detailed environmental record searches were conducted (see Appendix C of this report).

The sampling locations selected by EPA for this case study focused on three areas: the Little Creek Field area in south-central Huerfano County; the North Fork Ranch area in western Las Animas County; and the Arrowhead Ranchettes area, also located in western Las Animas County. Water samples were analyzed for metals, anions, dissolved organic carbon (DOC), dissolved inorganic carbon (DIC), dissolved gases (e.g., methane and ethane), volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), low-molecular-weight acids (LMWAs), glycol ethers, gasoline-range organics (GRO), diesel-range organics (DRO), dissolved strontium isotope ratios ($^{87}Sr/^{86}Sr$), and stable isotopes of oxygen and hydrogen in water ($\delta^{18}O_{H2O}$, $\delta^{2}H_{H2O}$), carbon and hydrogen in methane ($\delta^{13}C_{CH4}$, $\delta^{2}H_{CH4}$), carbon in dissolved inorganic carbon (DIC; $\delta^{13}C_{DIC}$), sulfur and oxygen in sulfate ($\delta^{34}S_{SO4}$, $\delta^{18}O_{SO4}$), and sulfur in hydrogen sulfide ($\delta^{34}S_{H2S}$). These data were collected in order to evaluate possible scenarios of drinking water impairment that may be related to CBM development, such as: (i) potential interactions between produced water and shallow ground water via fluid migration, spills, and/or infiltration; (ii) potential for migration of chemicals used in hydraulic fracturing formulations into shallow ground water; (iii) potential gas migration from hydraulically fractured zones in the Raton and Vermejo formations into shallow ground water aquifers, including the Poison Canyon Formation and alluvial fill deposits; and (iv) secondary biogeochemical affects related to the migration and reaction of methane in shallow aquifers used for drinking water.

Major ion data collected for this study were compared to historical water quality data obtained from the literature, as well as from state and national databases, including water quality and geochemical surveys conducted by the Colorado Oil and Gas Conservation Commission (COGCC), the U.S. Geological Survey (USGS) National Water Information System (NWIS), and the USGS National Uranium Resource Evaluation (NURE) database. The latter two data sources provide water quality data for samples collected prior to 1990 and, therefore, help establish baseline water quality conditions before significant CBM development occurred within the Raton Basin. Statistical comparisons were made between the data collected for this study and historical data in order to identify possible temporal trends in water quality parameters.

Temporal change in major ion chemistry, or lack thereof, at specific locations provides a reasonable approach for assessing potential ground water impacts related to fluid migration. Water co-produced with natural gas in the Raton Basin has a distinctive geochemical signature: sodium-bicarbonate type water with moderate concentrations of total dissolved solids (TDS); low concentrations of sulfate, calcium, and magnesium; variable chloride concentrations; enriched $^{13}C_{DIC}$; low oxidation-reduction potential (ORP); and elevated concentrations of dissolved methane and ferrous iron. Concentrations of arsenic in produced water did not exceed the Maximum Contaminant Level (MCL) of 10 µg/L. This geochemical signature contrasts with shallower aquifers used for drinking water, including the Poison Canyon Formation and alluvial fill deposits. The geochemical signature in these shallower aquifers includes more variable major ion compositions (calcium-bicarbonate, sodium-bicarbonate, and sodium-sulfate water types); lower specific conductance (SPC); generally lower chloride and higher sulfate concentrations; depleted $^{13}C_{DIC}$; and variable redox conditions. This contrast in geochemistry provides distinguishing characteristics for detecting and quantifying potential fluid mixing. Water quality data collected in the Raton Basin from drinking water aquifers before CBM development show similar ranges in SPC values, and no discernible shifts in major ion chemistry were apparent when compared to data collected during this study. The sampling locations examined in this study also showed consistent major ion patterns over the one-and-a-half-year period of the project. These time-independent trends in major ions suggest that significant water migration from gas-producing zones to shallower aquifers used for drinking water has not occurred.

Over the duration of this study, water samples were analyzed for organic chemicals; these measurements evaluated a total of 133 organic compounds. The purpose of these analyses was to investigate the potential occurrence in ground water and surface water of chemicals generally documented as components of hydraulic fracturing fluids, and specifically the chemicals used in fracturing fluids that have been applied in Colorado (e.g., glycol ethers, ethanol, isopropanol, 2-

butoxyethanol, petroleum distillates, acetic acid). In this study, glycol ethers were not detected in ground water samples collected from domestic wells or monitoring wells; low levels of diethylene glycol and triethylene glycol were detected in one of the production wells during the last sampling event (April/May 2013). Tert-butyl alcohol (TBA), diesel-range, and gasoline-range organics were detected at levels greater than quantitation limits (QL) in some domestic wells, monitoring wells, and production wells; detections varied by study area. Detected concentrations of VOCs were 0.3 to 5.1 orders of magnitude below EPA's drinking water standards (MCLs, where available for benzene, toluene, ethylbenzene, xylenes, methylene chloride, and chloroform). These compounds were typically found in produced water sampled from wells and permitted surface discharge. Almost half of the detected organic compounds (46%) were hydrocarbons commonly, but not solely, associated with petroleum fuel releases. The low-level detection of these compounds, coupled with no documentation of any fuel releases or their use in hydraulic fracturing fluids within the vicinity of the study areas, suggests that the origin of these compounds is derived from interactions between organic matter and ground water. The presence of BTEX (benzene, toluene, ethylbenzenes, and xylenes) compounds and benzene derivatives is consistent with results reported for other areas developing CBM resources and may reflect solubilization of coal material, as a by-product of natural water-rock interactions or enhanced solubilization due to injecting fluid with solvent-like properties into coal seams.

The concentration and geographic distribution of TBA detections collected during this study are unique in an area where no documented anthropogenic sources exist. TBA was detected in ground water samples collected from domestic, monitoring, and production wells in this study; detected concentrations ranged from 6.9 to 1,310 micrograms per liter (μg/L). EPA does not have a MCL for TBA; however, several states have passed drinking water action levels because of its potential human toxicity. While a likely source of TBA in ground water is as a degradation product of the fuel oxygenate compounds methyl tert-butyl ether (MTBE) and/or ethyl tert-butyl ether (ETBE), no gasoline spills were documented within the impacted areas and MTBE was banned from use, as a fuel oxygenate, in the state of Colorado in 2002. However, several non-gasoline-related sources of TBA exist: (i) TBA can be produced as a biochemical and/or chemical breakdown product of tert-butyl acetate (TBAc); (ii) TBA can form through the chemical decomposition of tert-butyl hydroperoxide (TBHP); (iii) TBA can be microbially generated from isobutane; or (iv) TBA can be produced by the reaction of isobutylene and water in the presence of a catalyst. Available data indicate that TBHP, a chemical sometimes used in hydraulic fracturing formulations as a gel breaker, was not used in CBM-related hydraulic fracturing applications within the Raton Basin. Prior to April 1, 2012, operators within the state of Colorado were not required to publically disclose information regarding hydraulic fracturing treatments (COGCC, 2011). Consequently, information is unavailable before that time about whether TBA or chemicals that degrade to TBA were used for hydraulic fracturing near the sampling locations of this study. Due to limited experimental and field data, the formation pathway(s) of TBA and the primary controls on its spatial occurrence are unresolved and both anthropogenic and natural sources are possible.

Methane occurs naturally in ground water in the Raton Basin and is commonly present in Cretaceous- and Tertiary-age coal seams and sedimentary deposits. Methane dissolved in water is odorless and tasteless; at high concentrations, dissolved methane can outgas and produce flammable or explosive environments. Dissolved methane was ubiquitous in ground water samples collected in this study. Methane was detected in every domestic well sampled; mean concentrations ranged widely, from about 0.003 to 12.4 milligrams per liter (mg/L), with a median value of 0.46 mg/L. Six domestic wells sampled in this study had a methane concentration above the COGCC cautionary level of 1.1 mg/L that can lead to buildup of explosive quantities of gases in small enclosed areas. Methane was also detected in all of the production wells and monitoring wells sampled during this study. In addition, methane was detected in surface water, typically at low levels (<0.05 mg/L) at locations down gradient of surface-discharged CBM water. At locations where methane concentrations were sufficient, carbon ($\delta^{13}C_{CH4}$) and hydrogen ($\delta^{2}H_{CH4}$) isotopes of methane were measured to compare the origin of methane in the domestic wells with the methane present in the gas-producing Raton and Vermejo coal-bearing formations. A variety of isotope patterns and potential sources were identified in this study. Methane isotope data collected from domestic wells and monitoring wells in the North Fork Ranch study area indicate that the methane is microbially sourced and distinctive from the thermogenic gas present in the CBM-producing coal beds. In one domestic well from the Arrowhead Ranchettes study area, a large isotopic shift was observed over the course of four sampling events. At this location, the isotopic composition of methane progressively transitioned from a thermogenic signature during the first sampling event to a mixed thermogenic/biogenic signature during the later three rounds. The rapid change in the isotopic composition at this location could be due to gas migration; based on the carbon isotope compositions of methane ($\delta^{13}C_{CH4}$) and dissolved inorganic carbon ($\delta^{13}C_{DIC}$), the isotopic shift in $\delta^{13}C_{CH4}$ relative to $\delta^{13}C_{DIC}$ suggests a transition to an environment characterized by acetate fermentation. Finally, domestic wells in the Little Creek Field area contained methane with a thermogenic signature, similar to gas from deeper CBM-producing coal beds, but with a distinct trend indicative of methane oxidation.

A methane oxidation trend was revealed at the Little Creek Field sampling area, located in Huerfano County. Following a series of hydraulic fracturing applications in 2005, gas and water production in the Little Creek Field began to rapidly increase, and positive production trends continued into 2007. In the spring of 2007, it was discovered that methane was venting into domestic water wells completed in the shallow Poison Canyon aquifer system. During this time, as methane vented into the shallow aquifer used for drinking water, free-phase gas was also present and dissolved gas concentrations increased in water withdrawn from drinking water wells. A remediation system, designed for the Poison Canyon aquifer, appeared to reduce the free-phase gas; however, dissolved methane concentrations showed more variable trends with time. This case study evaluated the intermediate-term response and water quality characteristics of the shallow aquifer several years after the unanticipated methane release. Stable isotope patterns of carbon and hydrogen in methane ($\delta^{13}C_{CH4}$, $\delta^{2}H_{CH4}$), DIC ($\delta^{13}C_{DIC}$), and sulfur in sulfate ($\delta^{34}S_{SO4}$) and hydrogen sulfide ($\delta^{34}S_{H2S}$), indicate that methane has been attenuated in the aquifer via dissimilatory bacterial sulfate reduction under anaerobic conditions. Consequently, concentrations of dissolved sulfate have decreased while dissolved hydrogen sulfide has increased; a maximum dissolved sulfide concentration of 36.6 mg/L was measured at one location during this study. The build-up of significant dissolved sulfide concentrations at some of the sampled domestic water locations suggests a deficiency of reactive iron within the aquifer and/or elevated rates of sulfide production that exceed the intrinsic capacity of the system to remove sulfide via mineral precipitation. Analysis of methane concentrations over time provides no clear answer about the timeframe necessary for dissolved methane levels to decrease to pre-release levels. The persistence of anaerobic methane oxidation within this area is questionable in the long term due to the potential exhaustion of terminal electron acceptor(s) and a lack of electron acceptor replenishment given the inferred slow rates of ground water movement and recharge within the study area. Some domestic wells in this area have been equipped with water treatment units to remove dissolved methane and dissolved sulfide.

Key observations/findings from this study are summarized below.

- Recovery of CBM in the Raton Basin occurs within or in close proximity to resources classified as Underground Sources of Drinking Water. Within the Raton Basin, the estimated vertical separation between CBM production intervals and water-supply wells ranges from <100 feet to more than 2,000 feet.
- The sampling locations examined in this study showed consistent major ion patterns over the one-and-a-half-year period of the project. Time-independent trends in major ions suggest that significant water migration from gas-producing zones to shallower aquifers used for drinking water has not occurred.
- Glycol ethers were not detected in samples from domestic wells, monitoring wells, or surface water. Low levels of diethylene glycol and triethylene glycol were estimated in one of the production wells during the last sampling event. No clear evidence of impacts to homeowner wells from injected hydraulic fracturing fluids was indicated in this study.
- Concentrations of BTEX compounds were 0.7 to 5.1 orders of magnitude below EPA's drinking water standards. The presence of BTEX compounds and benzene derivatives in ground water from the Raton Basin is consistent with results reported for other areas developing CBM resources and may reflect water-rock interactions and solubilization of coal material.
- TBA was detected in ground water samples collected from three domestic wells, two monitoring wells, and one production well at concentrations ranging from 6.9 to 1,310 µg/L. The formation pathway of TBA is unresolved; both anthropogenic and natural sources are possible for the occurrence of TBA documented in this study.
- Methane was ubiquitous in ground water samples collected in this study. In domestic wells, mean concentrations varied widely from about 0.003 to 12.4 mg/L. Methane isotope data collected from domestic wells and monitoring wells in the North Fork Ranch study area indicate that the methane is microbially sourced and distinctive from the thermogenic gas present in the underlying CBM-producing coal beds.
- Approximately two years after the Little Creek Field had been hydraulically fractured, a documented gas migration event occurred in this area. This resulted in thermogenic gas from the Vermejo Formation moving upward into the shallower Poison Canyon Formation. Analysis indicates that sulfate-dependent anaerobic oxidation of methane was occurring, and elevated dissolved sulfide concentrations in ground water reflected secondary biogeochemical changes related to the migration and reaction of methane within a shallow aquifer used for drinking water.

1. Introduction

Recent advances in drilling technologies (horizontal drilling) and well stimulation (hydraulic fracturing) have resulted in large-scale development of unconventional reserves of oil and gas across a wide range of geographic regions and geologic formations in the United States. These reserves are considered unconventional, because they are bound up in low-permeability reservoirs such as shale, tight sands, limestone, and coal beds, and recovery of these reserves was previously uneconomical. While some of this new development is occurring in areas with mature oil and gas fields, areas with little to no previous oil and gas development are now being developed. As a result, there are rising concerns over potential impacts on human health and the environment, including potential effects on drinking water resources. Environmental concerns include the potential for contamination of shallow ground water by stray gases (methane), fracturing chemicals associated with unconventional gas development, and formation waters.

Congress urged the U.S. Environmental Protection Agency (EPA), in December 2009, to study hydraulic fracturing and its relationship to drinking water resources (U.S. House of Representatives, 2009). The study was to be conducted using an approach that relied on the best available science, including independent sources of information, and through a transparent, peer-reviewed process to ensure the validity and accuracy of the data. EPA consulted with other federal agencies and appropriate state and interstate regulatory agencies to carry out the study (US EPA, 2010a). In February 2011, EPA issued the *Draft Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources* (US EPA, 2011a). The final *Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources* was released in November 2011 (US EPA, 2011b).

In 2011, EPA began to research the potential impacts of hydraulic fracturing on drinking water resources, if any, and to identify the driving factors that could affect the severity and frequency of any such impacts. EPA scientists focused primarily on hydraulic fracturing of shale formations, with some study of other oil- and gas-producing formations, including coal beds. EPA designed the scope of the research around five stages of the hydraulic fracturing water cycle (US EPA, 2012).

Each stage of the cycle is associated with a primary research question:

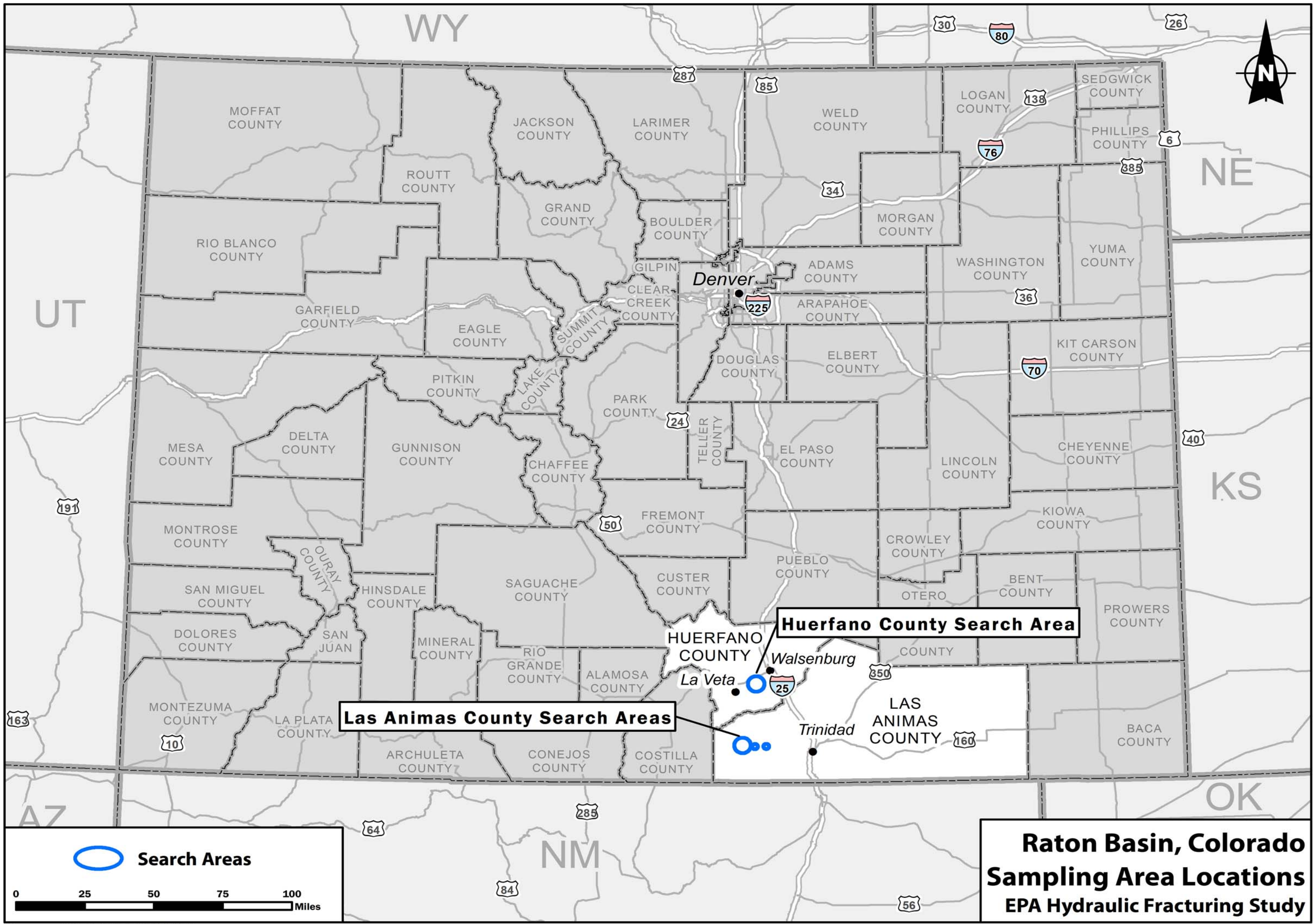
- Water acquisition: What are the potential impacts of large-volume water withdrawals from ground water and surface water on drinking water resources?
- Chemical mixing: What are the potential impacts of hydraulic fracturing fluid surface spills on or near well pads on drinking water resources?
- Well injection: What are the potential impacts of the injection and fracturing process on drinking water resources?
- Flowback and produced water: What are the potential impacts of flowback and produced water (collectively referred to as “hydraulic fracturing wastewater”) surface spills on or near well pads on drinking water resources?
- Wastewater treatment and waste disposal: What are the potential impacts of inadequate treatment of hydraulic fracturing wastewater on drinking water resources?

Prior to the release of the study plan, EPA invited the public to nominate specific regions of the United States for inclusion as potential sites for case studies. The plan identified 41 potential retrospective case study sites. The retrospective case studies were to focus on investigating reported instances of drinking water resource contamination in areas where hydraulic fracturing had already occurred and were intended to inform several of the primary research questions related to chemical mixing, well injection, and flowback and produced water. Of the 41 sites nominated during the stakeholder process, EPA selected five sites across the United States at which to conduct the retrospective case studies. The sites were deemed illustrative of the types of problems that were reported to EPA during stakeholder meetings held in 2010 and 2011. Additional information on site selection can be found in US EPA (2011b). EPA's plan for the retrospective case studies was to determine the presence and extent of drinking water resource contamination, if any, as well as whether hydraulic fracturing, or related processes, contributed to the contamination. Thus, the retrospective sites were expected to provide EPA with information regarding key factors that may be associated with drinking water contamination from hydraulic fracturing activities (US EPA, 2011b).

In 2011, EPA began conducting investigations at the five selected locations: Washington County, Pennsylvania (southwestern Pennsylvania); Bradford County, Pennsylvania (northeastern Pennsylvania); Wise County, Texas; Las Animas and Huerfano counties, Colorado (Raton Basin); and Dunn County, North Dakota (Killdeer). This report discusses the retrospective case study conducted in the Raton Basin, in Colorado, which was selected as an example of a region with coalbed methane (CBM) development.

The Raton Basin Retrospective Case Study was conducted within Huerfano and Las Animas counties, located in southern Colorado (see Figure 1). The general study areas for focused sampling are shown in Figure 1, within the areas defined as "Search Areas." These Search Areas are defined and described in further detail in later sections of this report. Hydraulic fracturing operations within these areas target coal beds, interbedded with sandstones and shales, within the Raton and Vermejo formations. The Raton Basin of northern New Mexico and southern Colorado (see Figure 2) is one of several key basins in the Rocky Mountain region currently producing commercial quantities of CBM; other producing basins include the Greater Green River Basin (Colorado and Wyoming), the Powder River Basin (Montana and Wyoming), and the San Juan Basin (New Mexico and Colorado; US EPA, 2010b).

Coal responds to increasing temperature and pressure over time by changing rank, or thermal maturity. The classification of coal progresses from the lowest rank—lignite—to the highest rank—anthracite. During this maturation process, increased volumes of methane are generated (Kim, 1973). The methane present in coals is either adsorbed onto coal surfaces and within pore spaces, as free gas in pores and fractures, or dissolved in ground water in coal beds (Koenig, 1989). To produce methane from coal, water must be pumped out of fractures and cleats to lower the hydrostatic pressure; this causes methane to desorb from the coal surfaces, move out of the coal, and flow into the well bore (USGS, 2000; Watts, 2006a). Consequently, both water and gas are brought to the land surface during CBM production. The co-produced water can have variable quality, depending on coal rank and characteristics of the subsurface geology and hydrology (e.g., see Dahm et al., 2011). Surface disposal of co-produced water can potentially impact streams that feed into drinking water resources (Batley and Kookana, 2012). Disposal by subsurface reinjection of the water increases production costs and has been linked to seismic activity in some areas (Van der Elst et al., 2013; Keranen et al., 2013). In contrast to shale gas and most conventional oil and gas development, recovery of CBM typically occurs at



Source: *ESRI 2011, EPA ORD*

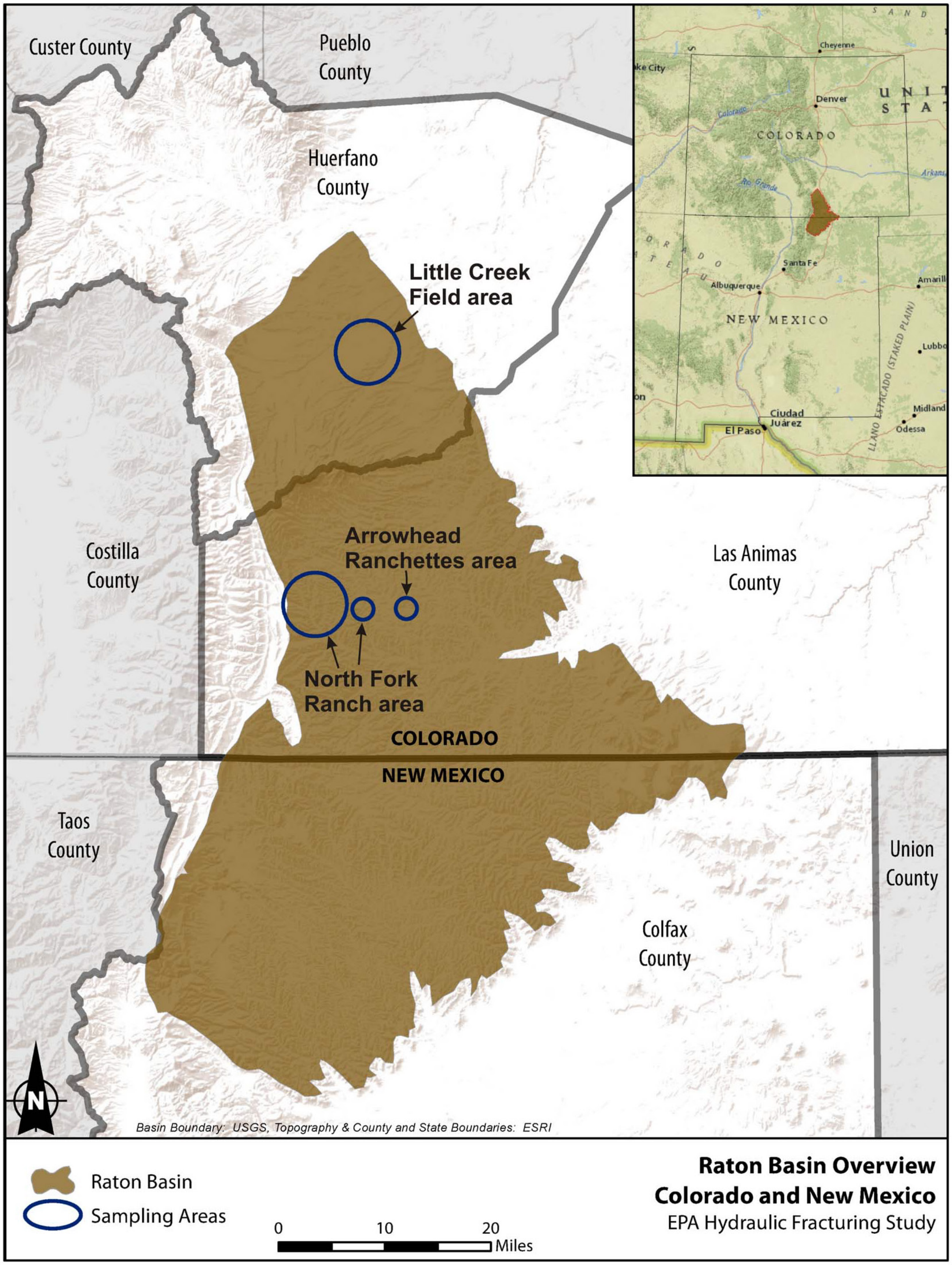
Figure 1. Map showing the location of areas sampled during this case study. The Raton Basin retrospective case study was conducted in Huerfano and Las Animas counties, located within the Colorado portion of the Raton Basin.

relatively shallow depths, sometimes within or in close proximity to resources classified as Underground Sources of Drinking Water (USDW, e.g., US EPA, 2004). Within the Raton Basin, the estimated vertical separation between CBM production intervals and water-supply wells ranges from <100 feet to more than 2,000 feet (Watts, 2006b). Issues regarding water withdrawal and hydraulic fracturing in or near drinking water aquifers have led to public concerns about the application of hydraulic fracturing techniques and potential impacts on the availability and quality of ground water resources.

The sampling locations for this case study were based on homeowner concerns regarding potential adverse impacts on their well water and the potential association with drilling, hydraulic fracturing, and/or CBM development in the vicinity of their homes. Specific sampling locations were selected based on criteria such as well depth, geologic and hydrologic characteristics, and proximity to CBM wells. The Raton Basin study specifically focused on three areas: the Little Creek Field area within south-central Huerfano County, the North Fork Ranch area within western Las Animas County, and the Arrowhead Ranchettes area, also located within western Las Animas County (see Figure 2).

The Little Creek Gas Field is located southwest of Walsenburg, Colorado, and was developed by Petroglyph Energy, Inc. between 1996 and 2007. Hydraulic fracturing was completed in the Little Creek Field in 1998, 2004, and 2005. Following a series of three hydraulic fracturing applications in 2005, gas and water production began to rapidly increase, and positive production trends continued into 2007. In the spring of 2007, it was discovered that potentially explosive levels of methane were venting into domestic water wells completed in the shallow aquifer system of the Poison Canyon Formation (COGCC, 2007a). The methane was tested, and isotopic analyses indicated that the free-flowing gas was the same as the methane that was being produced from coal beds located within the Vermejo Formation; however, no migration pathway was determined (Norwest Questa, 2007a; 2007b). In July 2007, Petroglyph shut-in 52 gas wells in the field at the request of the Colorado Oil and Gas Conservation Commission (COGCC; COGCC, 2008). In January 2008, the COGCC issued Order 1-C6, which outlined a three-phase plan (*Methane Investigation, Monitoring, and Mitigation Program, MIMMP*; see COGCC, 2008) to mitigate the methane migration and potentially allow operations to eventually resume in the field. To help constrain the migration of methane, a hydraulic barrier was created: methane dissolved in the water was removed, and the ground water was then re-injected into the same shallow aquifer. This configuration of extraction and injection wells was expected to create a hydraulic gradient, allowing the methane and ground water to flow toward the pumping capture well and prevent gas migration (Norwest Questa, 2007b).

At the time when methane vented into the shallow aquifer used for drinking water, free-phase gas was present and dissolved gas concentrations increased in the water withdrawn from drinking water wells. Over time, the remediation system for the Poison Canyon aquifer appeared to reduce free-phase gas flow to domestic wells; in September 2011, the remediation system was shut down. Sampling for this retrospective case study was conducted from October 2011 to April/May 2013 and provided an opportunity to evaluate the water quality characteristics, and intermediate-term response, of the shallow aquifer system several years after the unanticipated methane release. It was expected that this aspect of the case study would provide a context for other regions that have experienced gas migration and provide new information about the processes and rates of methane attenuation in a drinking water aquifer after remediation and abatement of the source of methane.



Basin Boundary: USGS, Topography & County and State Boundaries: ESRI

Figure 2. Map showing the location of the Raton Basin, located in southern Colorado and northern New Mexico, and the case study sampling areas.

The North Fork Ranch area within the Raton Basin is located approximately 25 miles west of Trinidad, Colorado. In the summer of 2006, a contractor hired by Pioneer Natural Resources Company began drilling the borehole for the surface casing of the Molokai #13-36 TR CBM well. Shortly thereafter, a mechanical problem occurred with the main air compressor and the drill bit became stuck in the open, uncased borehole. The contractor pressurized the drill pipe in an unsuccessful attempt to remove the drill bit (COGCC, 2010). The following day, residents observed pulsed geysering of water from a domestic well in the vicinity of the drilling activity on the Molokai 13-36 pad (COGCC, 2010). Local residents became concerned that CBM development and drilling activities could potentially have adverse effects on domestic drinking water wells in the area. The COGCC subsequently approved a work plan for Pioneer to install monitoring wells and obtain water quality and water level data prior to, and during, CBM development within an area where drinking water was obtained from the shallow and intermediate aquifers (COGCC, 2010; Norwest Applied Hydrology, 2006). This aspect of the retrospective case study was intended to provide additional follow-up studies and evaluation of ground water and surface water quality in the North Fork Ranch area. The Arrowhead Ranchettes subdivision, located approximately 8.5 miles east of the North Fork Ranch area, was selected as an additional sampling area based on homeowner concerns regarding the quality of water from their domestic wells.

This report provides the Raton Basin Retrospective Case Study data and discussion of results. The following sections of this report provide the purpose and scope of this case study, site background, study methods, historical water quality data, analysis of the study sample data, discussion of site-specific topics, and a summary of the case study findings.

2. Purpose and Scope

As a component of EPA's *National Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources* (US EPA, 2012), five retrospective case studies were conducted to investigate reported instances of drinking water resource contamination in areas of natural gas development and use of hydraulic fracturing technology. These studies were intended to inform primary research questions related to the hydraulic fracturing water cycle (US EPA, 2012).

This report describes the general water quality and geochemistry of ground water in the Raton Basin of Colorado. The selected study sites are located within the Colorado portion of the basin and include parts of Las Animas and Huerfano counties. This region is undergoing increasing development of its CBM resources, and hydraulic fracturing practices within this area focus on recovering gas from CBM formations (Watts, 2006a). The water quality results presented herein are used to evaluate the potential impacts on drinking water resources, if any, from various land-use activities within the region and are not restricted to CBM development, extraction, and production. Ground water wells (which include domestic wells, monitoring wells, and production wells) and surface water locations were sampled over 19 months at three geographic areas within the basin: North Fork Ranch (Las Animas County), Arrowhead Ranchettes (Las Animas County), and the Little Creek Field (Huerfano County).

This report presents analytical data for water samples collected from 26 locations during four sampling rounds: October 2011, May 2012, November 2012, and April/May 2013. The water samples were analyzed for over 235 constituents, including organic compounds, nutrients, major and trace elements, dissolved gases, and selected isotopes. Ground water and surface water quality data, as well as summary statistics, are presented for these analytes. In addition to the chemical data collected specifically for this study, this report incorporates publically available historical water quality datasets collected within the Raton Basin, as well as the results from environmental site assessments of the sampled areas performed as a part of this study.

Each of the retrospective case study sites differs in geologic and hydrologic characteristics; however, generally similar research approaches were followed at the case study locations to assess potential drinking water impacts. As described by US EPA (2012), a tiered approach was followed to guide the progress of the retrospective case studies. The tiered scheme uses the results of successive steps, or tiers, to refine research activities. This report documents progress through the Tier 2 stage and includes the results of water sampling activities and evaluation of water quality impacts. The approach for Tier 2 efforts included a literature review of background geology and hydrology; the choice of sampling locations and the development of a site-specific Quality Assurance Project Plan (QAPP); sampling and analysis of water wells, produced water, and surface water; analysis of historical background data and evaluation of new results against background data; statistical and geochemical evaluation of water quality data; evaluation of potential drinking water contamination; and identification of potential sources of identified contamination, if applicable. Further evaluation of identified contaminant sources and contaminant transport and fate, including the collection of site-specific hydrogeologic information, is not part of the scope of this report.

3. Study Area Background

The Raton Basin is a north-south trending sedimentary and structural depression located along the eastern edge of the Rocky Mountains, between the Sangre de Cristo Mountains to the west and the Apishapa, Las Animas, and Sierra Grande arches to the east (Watts, 2006a). This chevron-shaped basin encompasses roughly 2,200 square miles of southeastern Colorado and northeastern New Mexico (US EPA, 2004) and extends from southern Colfax County, New Mexico, northward into Huerfano County, Colorado (US EPA, 2004; see Figure 2). It is the southernmost of several major coal-bearing basins located along the eastern margin of the Rocky Mountains (Johnson and Finn, 2001). The basin is asymmetrical, with the deep basin axis located along the western margin of the trough, just east of the Sangre de Cristo Mountains (Johnson and Finn, 2001), and the structurally lowest part of the basin is north of the Spanish Peaks, as indicated by structural contours marking the top of the Trinidad Sandstone (see Geldon, 1989).

The sampling points described in this report are located in the Colorado portion of the Raton Basin, including areas in western Las Animas County and south-central Huerfano County (see Figure 2). These areas are bounded by the Great Plain physiographic province on the east, and the Southern Rocky Mountain province on the west. The landscape of the study area is characterized by semi-arid high plains mixed with, in some areas, very steep and rugged terrain. Stream erosion has created numerous canyons and arroyos (Howard, 1982). The average annual total precipitation in Las Animas County is about 14 inches, with the majority of the precipitation occurring from June to September (Colorado Climate Center, 2014a). The average annual total precipitation in Huerfano County is about 15 inches, with the majority of precipitation falling in March and April, and then in July and August (Colorado Climate Center, 2014b). Higher amounts of precipitation occur mainly as snow at upper elevations and near the crests of the Sangre de Cristo Mountains. Snowmelt from the mountains supplies much of the base flow to major streams in the area (McLaughlin, 1966).

3.1. Geology

A thick sequence of Upper Cretaceous and Tertiary coal-bearing clastic sedimentary rocks is preserved within the basin. The sedimentary sequence exposed within the Raton Basin was deposited during the regression of the Cretaceous Interior Seaway, and the stratigraphy reflects well-developed flow-through fluvial systems that contained peat-forming swamps (Cooper et al., 2007; Flores, 1993). Sedimentary rocks in the region (see Figures 3 and 4), from oldest to youngest, include the Pierre Shale, Trinidad Sandstone, and Vermejo Formation of Late Cretaceous age; the Raton Formation of Late Cretaceous and Paleocene age; the Poison Canyon Formation of Paleocene age; and the Cuchara and Huerfano formations of Eocene age (Johnson et al., 1956). Late Upper Cretaceous and lower and middle Tertiary rocks occupy the deepest part of the basin, and the study sites are located within this region.

Numerous discontinuous and thin coal beds are located within the Vermejo and Raton formations, which lie directly above the Trinidad Sandstone. The upper Trinidad intertongues with, and is overlain by, the coal-bearing Vermejo Formation (Topper et al., 2011). This sandstone layer serves as a “marker” for the area because no coals are found below this sandstone (Lewicki, 2001). The Vermejo Formation consists of interbedded buff to gray shale, carbonaceous shale, coal, and slightly arkosic fine- to medium-grained sandstones. These deposits represent channel and channel-margin deposits, including

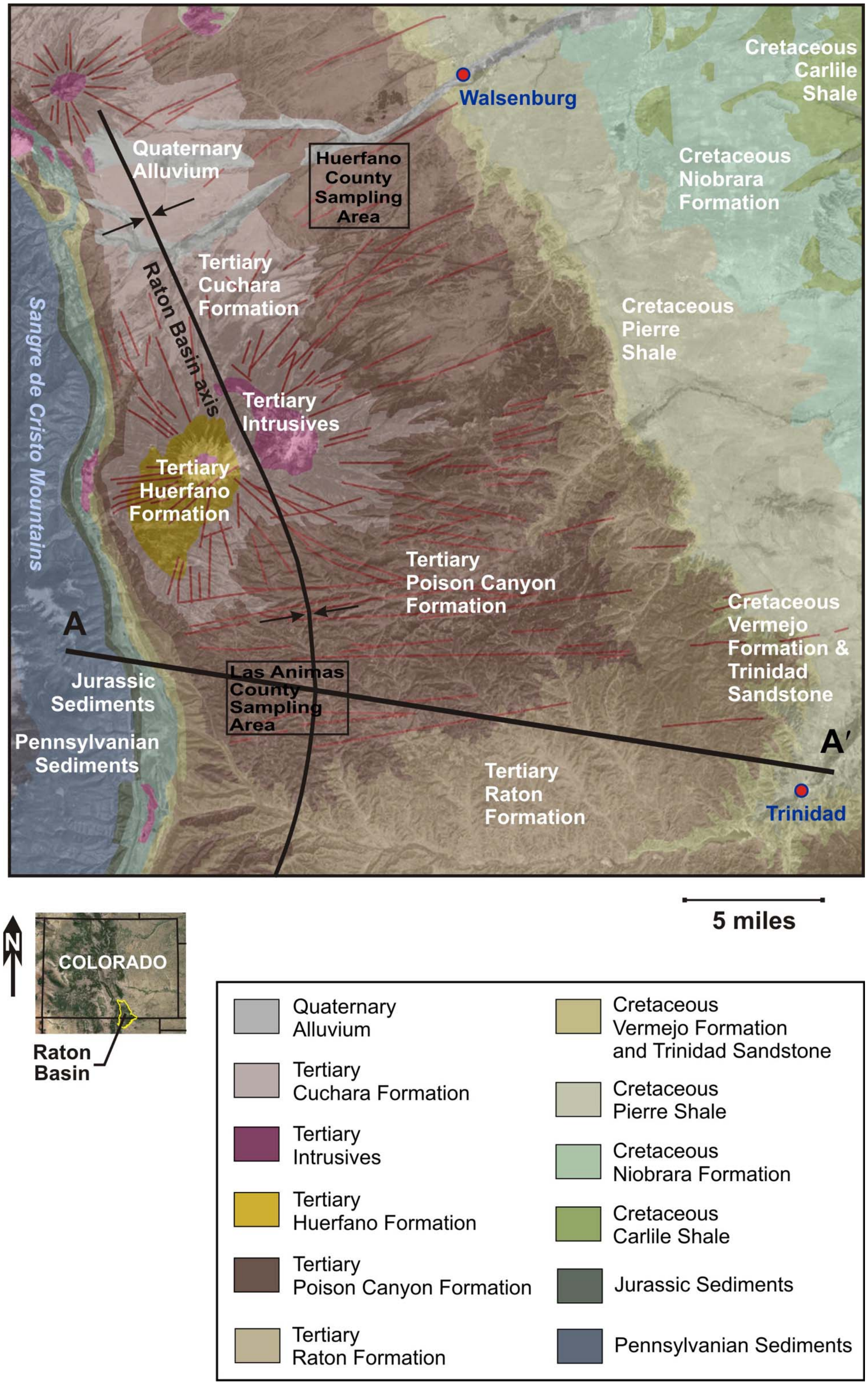
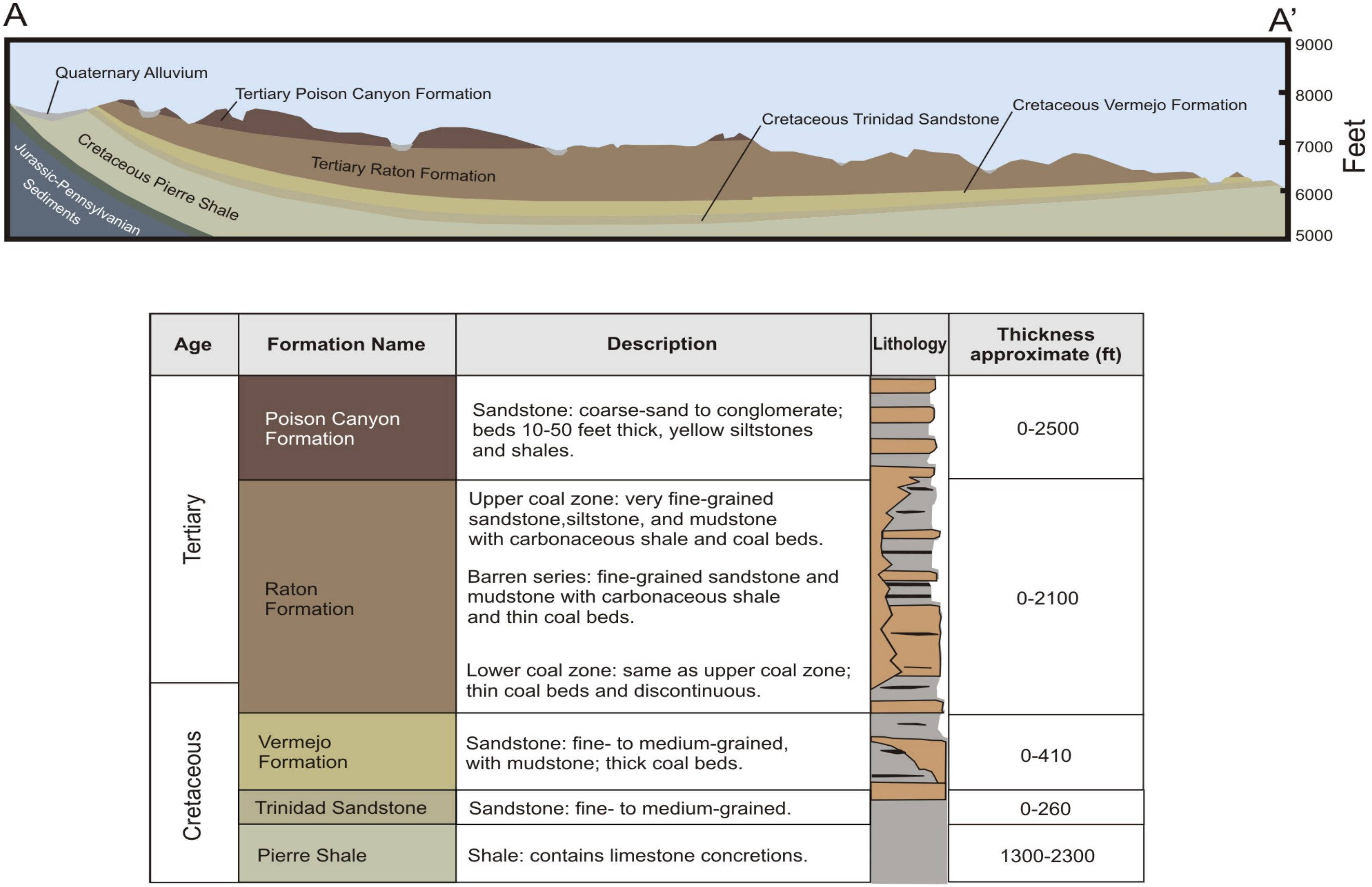


Figure 3. A geologic map of the Raton Basin showing the synclinal axis of the basin and the location of generalized geologic cross-section A-A', which is included in this report as Figure 4.



Age	Formation Name	Description	Lithology	Thickness approximate (ft)
Tertiary	Poison Canyon Formation	Sandstone: coarse-sand to conglomerate; beds 10-50 feet thick, yellow siltstones and shales.		0-2500
	Raton Formation	Upper coal zone: very fine-grained sandstone,siltstone, and mudstone with carbonaceous shale and coal beds. Barren series: fine-grained sandstone and mudstone with carbonaceous shale and thin coal beds. Lower coal zone: same as upper coal zone; thin coal beds and discontinuous.		0-2100
Cretaceous	Vermejo Formation	Sandstone: fine- to medium-grained, with mudstone; thick coal beds.		0-410
	Trinidad Sandstone	Sandstone: fine- to medium-grained.		0-260
	Pierre Shale	Shale: contains limestone concretions.		1300-2300

Figure 4. A generalized geologic cross-section (A-A') and stratigraphic chart (after Abbott et al., 1983; Topper et al., 2011), Raton Basin, CO.

marsh, swamp, lake, and crevasse splay environments (Howard, 1982), and coal formation occurred within channel-margin deposits. When present, the thickness of the Vermejo Formation ranges from about 150 feet within the southern part of the basin to 410 feet within the northern part (Lewicki, 2001). The Vermejo contains 3 to 14 coal beds, over 14 inches thick, over the entire basin, and total coal thickness typically ranges from 5 to 35 feet (US EPA, 2004). The nearshore, fluvial-deltaic deposits of the Vermejo Formation contain the best developed and most laterally extensive coal beds in the basin (Topper et al., 2011). This unit is believed to be the slightly younger equivalent of an identical lithofacies unit represented by the coal-bearing Fruitland Formation of the San Juan Basin (Jurich and Adams, 1984).

The late Cretaceous to Paleocene Raton Formation overlies the Vermejo Formation and is the second coal-bearing formation within the basin. Total thickness of the Raton Formation ranges from 0 to 2,100 feet and is composed of three generally recognizable field divisions: a basal sandstone, conglomeratic throughout most of the western part of the basin; a lower zone, predominantly sandstone, siltstone, and mudstone; and an upper coal zone, consisting of sandstone, siltstone, mudstone and beds of coal (Jurich and Adams, 1984; Johnson and Finn, 2001). The thickest coal-bearing zone of this formation ranges from 0 feet in the western part of the basin to over 1,000 feet in the central part (Jurich and Adams, 1984); individual seams range in thickness from several inches to greater than 10 feet thick (US EPA, 2004). All commercial coal beds, which have been mined extensively and are currently being developed for CBM production, occur in this zone (Lewicki, 2001). These coal units are the likely source of gas found in sandstones within this formation (Johnson and Finn, 2001).

Resting on top of the Raton Formation is the Paleocene-age Poison Canyon Formation, which ranges in thickness from 0 to 2,500 feet (Jurich and Adams, 1984). This unit consists of interbedded coarse-grained conglomeratic, arkosic sandstone, mudstone and siltstone; locally thin, irregular, impure coal beds occur near the base of this formation (Jurich and Adams, 1984). The Poison Canyon lies unconformably over the Raton Formation in the western portion of the basin (Howard, 1982), and becomes finer-grained toward the east (Johnson and Finn, 2001).

Clastic deposits of the Eocene-age Cuchara and Huerfano formations overlie the Poison Canyon Formation within, and northwest of, the Spanish Peaks area (Figure 3; Topper et al., 2011). The Cuchara Formation, which overlies the Poison Canyon with marked unconformity, is composed of beds of red, pink, and white sandstone and thin beds of red and tan shale; where present, they measure up to 5,000 feet in thickness. The Huerfano Formation, consisting of interbedded arkose and greywacke conglomerate, conglomeratic sandstone, siltstone, and minor claystone, appears to lie conformably on the Cuchara Formation on the north and east flanks of West Spanish Peak, but unconformably on the south and west flanks of the peak (Johnson, 1961; Jurich and Adams, 1984).

Quaternary alluvial deposits of limited extent and thickness have been deposited along the present stream and river drainages and consist of gravel, sand, and silt, with minor amounts of cobbles and boulders derived from eroded sedimentary and igneous rocks (Powell, 1952; Topper et al., 2011). These deposits are generally less than 10 feet thick but may be up to 40 feet thick in some locations (Topper et al., 2011).

Epeirogenic movements and orogenic episodes, associated with Laramide deformation, are recorded in the strata and faults and folds that modify the regional structure (Geldon, 1989). The complex structural history is reflected by angular unconformities and lithologic changes within sedimentary rocks located in the basin and characterized by a steeply tilted, overturned, and faulted western limb, a gently sloping eastern limb, and a broad, central portion in which the beds are essentially horizontal (Johnson et al., 1956; Jurich and Adams, 1984). Folds with small amplitude occur throughout the basin (Geldon, 1989). Several small normal faults occur northeast of Weston, Colorado. These nearly vertical faults trend north, east, northeast, and northwest, and have displacements of less than 50 feet (Johnson, 1961).

Miocene and Pliocene igneous dikes, sills, plugs, stocks, and laccoliths, ranging in age from 6.7 to 29.5 million years (my), frequently intrude the coal-bearing Vermejo and Raton formations (Flores and Bader, 1999). The intrusions are composed of basalts, lamprophyres, andesites, and rhyolites (Miggins, 2002). The most prominent igneous features are those related to the Spanish Peaks and their associated radial dike swarm, located in the north-central portion of the basin (Cooper et al., 2007); intrusion probably took place at intervals during the late Eocene or early Oligocene time (Johnson, 1961). These dikes, almost all of which are vertical or nearly so, range from 1 foot to nearly 100 feet in width and extend for a maximum distance of approximately 14 miles (Johnson, 1961; see Figure 3). A separate system of subparallel dikes affects coal seams throughout the entire basin; these intrusions have a roughly east-west orientation, which varies from west-southwest in the northern part of the basin to west-northwest in the southern portion, always trending normal to the Sangre de Cristo Mountains (Cooper et al., 2007; Flores and Bader, 1999; see Figure 3). The dikes vary in thickness from a few inches to more than 100 feet, and are up to 14 miles in length; they are presumed to be intruded into fracture systems that resulted from structural deformation of rock units by intrusive igneous activity (Johnson, 1960; Howard, 1982; Flores and Bader, 1999). The formation of these intrusions altered millions of tons of coal to natural coke and may have played a minor role in generating some of the large CBM resources currently being exploited in this region (Cooper et al., 2007).

3.2. Hydrology

3.2.1. Surface Water

The hydrologic framework of the Raton Basin consists of three main drainages and is part of the larger Arkansas River Basin. Much of the Raton Basin coal-bearing region is deeply incised by two of the three major drainages within the basin, and includes the Purgatoire and Apishapa rivers and their tributaries. The headwaters of these drainages originate in the Culebra Range (Abbott, 1985). The Cucharas River, north of the Spanish Peaks, drains the northern portion of the basin. All three rivers flow east and are tributaries of the Arkansas River. A number of stream segments within each of these drainages are currently found on Colorado's 2012 303(d) list for impairment due to selenium and mercury; it is unclear if the source of the impairments are natural (Colorado Department of Public Health and Environment, 2012).

Annual precipitation in the Raton Basin generally correlates to elevation, ranging from over 30 inches per year in the Spanish Peaks to less than 16 inches per year in eastern portions of the basin (Hathaway and Grigsby, 2008). Distribution of precipitation over time is uneven; much of the precipitation in the plains is from intense summer storms. Precipitation in the mountains results in the formation of a deep snowpack that accumulates during winter months then melts and runs off in the spring and early summer. The Cucharas, Apishapa, and Purgatoire rivers are all sustained by mountain snowpack (Abbott, 1985).

3.2.2. Ground Water

The principal bedrock aquifers in the Raton Basin are the Dakota Sandstone-Purgatoire aquifer (Early Cretaceous), Raton-Vermejo-Trinidad aquifer (Early Tertiary–Late Cretaceous), Cuchara-Poison Canyon aquifer (Eocene), and volcanic rock aquifers (Tertiary; Abbott et al., 1983). The Raton-Vermejo-Trinidad aquifer is confined at depth while the Cuchara-Poison Canyon aquifer is a water table aquifer; alluvial aquifers can be in hydrologic connection between the bedrock aquifer system or perched above the bedrock water table (Howard, 1982). Within these units, sandstone and conglomerate layers transmit most of the water, while shale and coal layers generally retard flow; however, fracture networks within the shales and coals can also transmit water. Talus and alluvium yield small to large quantities of water but are limited in aerial extent, and discharges from these units fluctuate seasonally (Abbott et al., 1983). Sources of recharge for the aquifers include runoff from the Sangre de Cristo Mountains, precipitation infiltration, and infiltration from streams and lakes.

Ground water flow is generally radial from the Spanish Peaks, and regional flow is from west to east, except where it is intercepted by valleys that cut into the rock (Howard, 1982; Oldaker, 1988; Watts, 2006a). Flow is generally lateral and parallel with bedding but also can be downward where fractures connect permeable rock. The depth to ground water depends mostly on topographic position; in all areas but the southeast corner of the basin, water can be encountered at less than 200 feet below land surface (Abott et al., 1983). In stream valleys, ground water is usually less than 100 feet below land surface, and some of this water discharges as springs or flows into stream alluvium. Depth to ground water is also affected by geology: abrupt changes in aquifer permeabilities can result in perched waters, and clusters of springs are often located at or near the contact between the Cuchara-Poison Canyon and Raton-Vermejo-Trinidad aquifers. Aquifer testing within the Raton-Vermejo aquifers reported hydraulic conductivity values that ranged from 0 to 45 feet per day (Abbott et al., 1983), and from 0.06 to 15 feet per day for the Cuchara-Poison Canyon aquifer system (Geldon and Abbott, 1985). Based on static water level data, Howard (1982) concluded that the Raton-Vermejo-Trinidad aquifer and the overlying unconfined Cuchara-Poison Canyon aquifer are separate and under different pressure heads, suggesting that downward movement of shallow(er) ground water to deeper zones may occur. In some areas within the basin, dikes and sills act as barriers to flow and force water to the surface as springs; in other areas, secondary permeability, resulting from fracturing of bedrock during intrusive igneous activity, causes dewatering of the water table (Howard, 1982). Fractures associated with the Spanish Peaks cause dewatering and leakage between aquifer systems; while dewatering the water table aquifers, these fractures are an important source of recharge to the confined units below (Howard, 1982). Alluvial aquifers are recharged by meteoric water and stream channel loss; these aquifers are often perched on top of less permeable bedrock (Howard, 1982). Generally, the alluvium deposited by the Purgatoire and Apishapa rivers transmits water more readily than alluvium deposited in tributary canyons; hydraulic conductivity values ranged between 0.01 and 1,880 feet per day within alluvial deposits (Geldon, 1989).

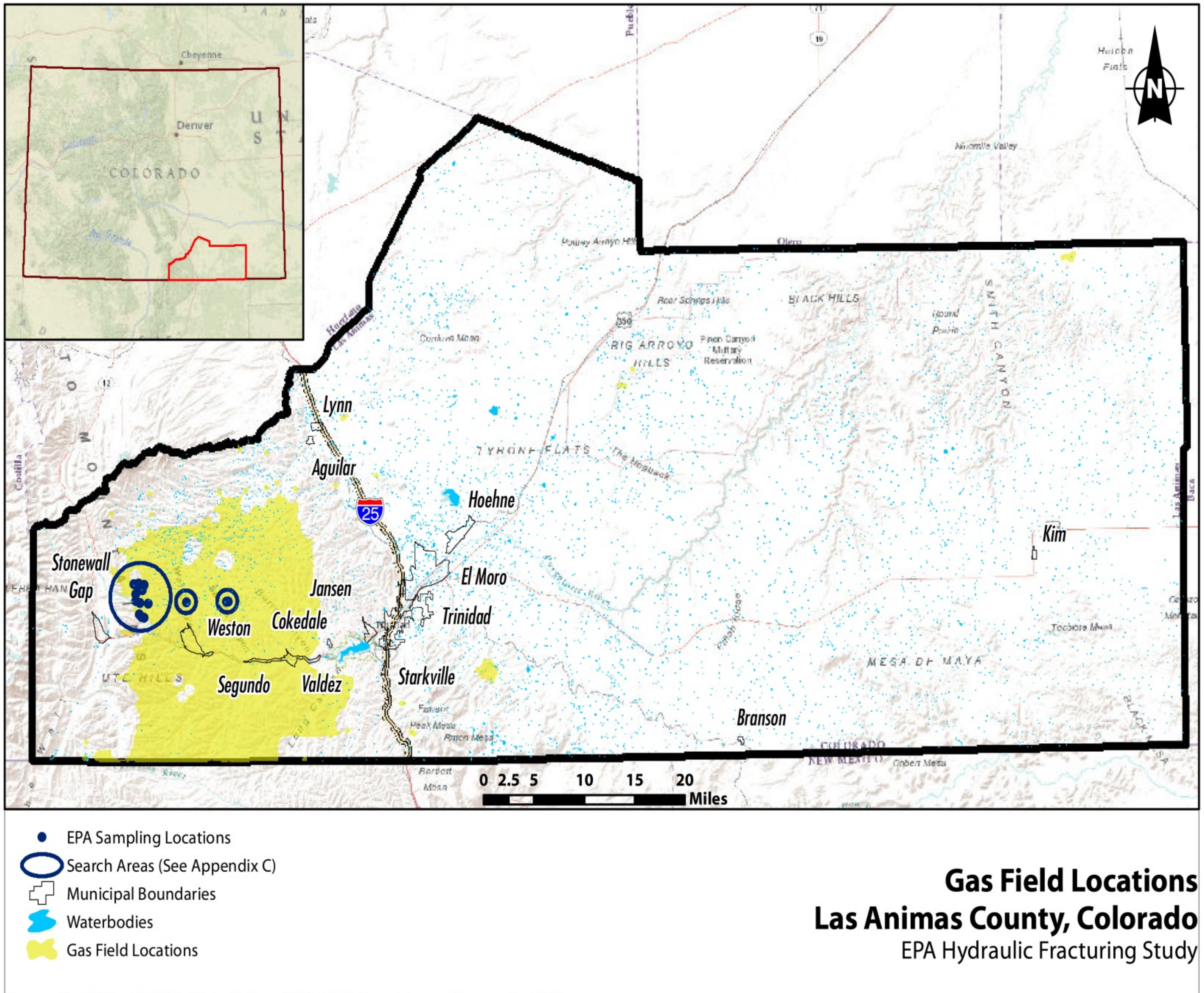
The geologic formations can have distinctive ground water chemistry. The Cuchara-Poison Canyon aquifer is typically calcium-bicarbonate water type, with low total dissolved solids (TDS) concentrations (<500 mg/L). In contrast, the Raton-Vermejo-Trinidad aquifer is generally sodium-bicarbonate water type, with higher average TDS concentrations (<1,500 mg/L). Abbott et al. (1983) noted that concentrations of boron, fluoride, iron, manganese, mercury, nitrate, selenium, and zinc were higher in localized areas due to geologic processes and human activities. High concentrations of fluoride occur within the Poison Canyon and Raton formations, possibly due to dissolution of detrital fluorite. Iron and manganese concentrations can be elevated, particularly in areas where coals are present, partly due to the dissolution of pyrite, siderite, and/or rhodochrosite contained in the coal seams. Nitrate enrichment occurs most often in alluvial aquifers where fertilizers and/or animal wastes add nitrogen (Abbott et al., 1983).

3.3. Coal and Coalbed Methane Production

The Raton Basin contains substantial resources of high- and medium-volatile bituminous coals that extend from outcrops along the periphery to depths of at least 3,000 feet in the deepest parts of the basin (Jurich and Adams, 1984). These coal beds have been extensively mined in the peripheral outcrop belt, along major stream valleys, and within a few structural uplifts within the interior of the basin (Dolly and Meissner, 1977). Commercial mining of the Vermejo and Raton formation coals began in the 1870s (Hemborg, 1998); historically, at least 371 mines have operated within the region (Boreck and Murray, 1979), and the last remaining coal mine closed in 1995. However, in early 2010, the New Elk mine (subsurface coal mine), located in Las Animas County, was reopened for rehabilitation and subsequent coal production; it is currently the only active mine within the Raton Basin.

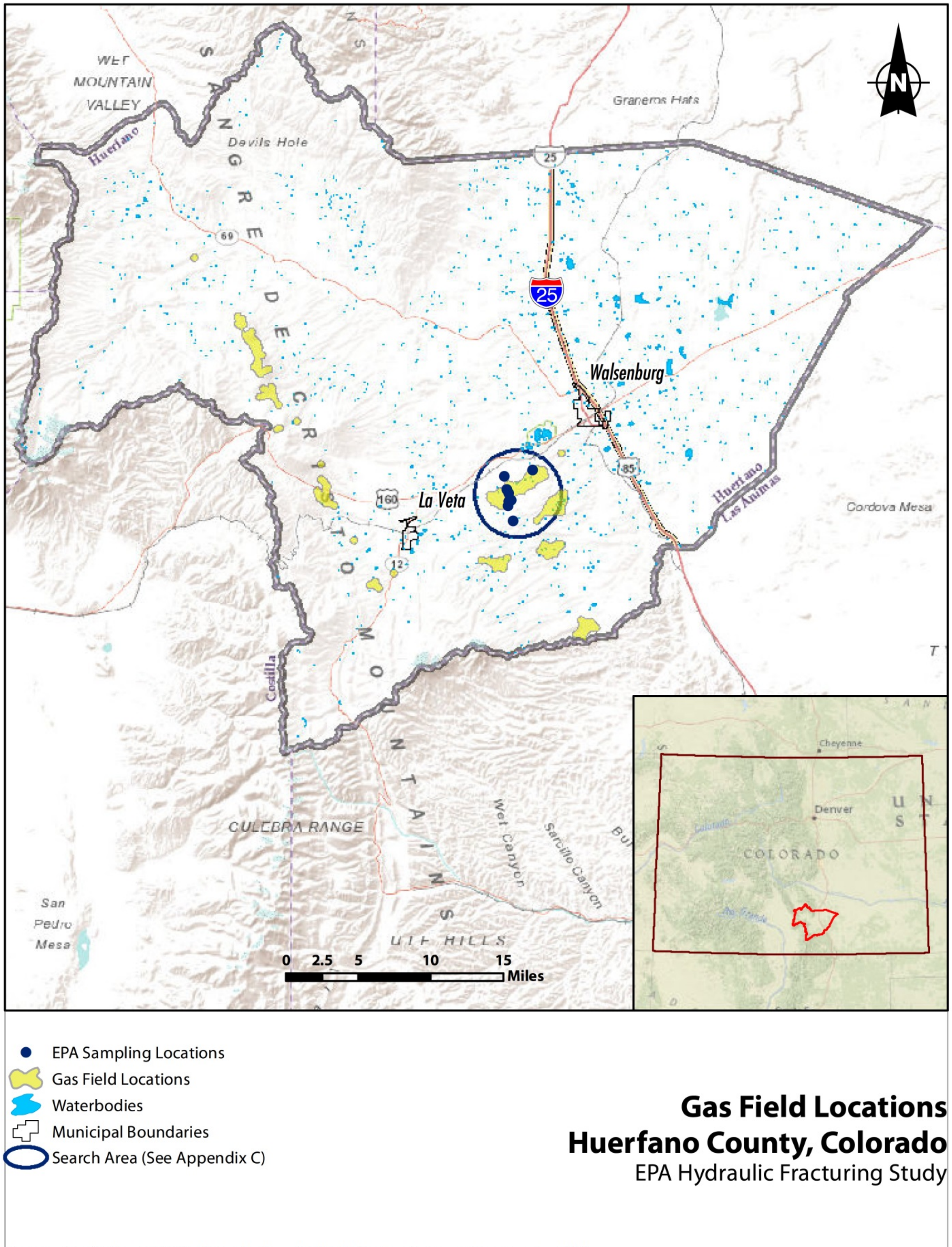
The earliest recorded CBM well in the state of Colorado was drilled in 1951 within the Fruitland Formation of the San Juan Basin. In 1978, the U.S. Geological Survey (USGS) ran tests and discovered that the Raton Basin had high CBM production potential (Danilchik, 1979). Over 500 billion cubic feet (Bcf) of gas has been produced in the Colorado portion of the Raton Basin since initiation of production in the 1980s (Hathaway and Grigsby, 2008); however, major exploration began in the mid-1990s with the development of infrastructure to transport the gas out of the basin (Colorado Geological Survey, 2000). Prior to 1995, there were no gas distribution lines out of the Raton Basin and fewer than 60 wells had been drilled (Flores and Bader, 1999). Most, if not all, wells in the Raton Basin require hydraulic fracture stimulation to attain economic levels of gas production (Flores and Bader, 1999). CBM production involves the dewatering of coal beds, which reduces the pore pressures and allows the methane gas to move freely from the coal. The methane gas is captured through production wells and then sent to market via pipeline. The locations of gas fields developed for CBM in Las Animas and Huerfano counties and the sampling locations of this study are shown in Figures 5 and 6. In 2007, CBM activities temporally ceased within Huerfano County due to uneconomical production of the coal seams.

CBM resources contained in the Vermejo and Raton formations are estimated to be approximately 4.3 trillion cubic feet (Tcf) (U.S. Energy Information Administration, 2007). Expansion of CBM operations has focused on the development of the Vermejo coals, because these coals are thicker and more continuous than those located in the Raton Formation (US EPA, 2004). Annual production of CBM in Colorado has increased from approximately 26 Bcf in 1990 to 486 Bcf in 2012 (U.S. Energy Information Administration, 2013). Since 2002, production has remained relatively stable (U.S. Energy Information Administration, 2013). It was estimated that Colorado's CBM contribution was approximately 3% of the nation's total in 1993, and increased to approximately 7% by the end of 1999 (Colorado Geological Survey, 2000). The Raton Basin has shown annual production increases since 1999, with maximum production occurring in 2008 (115 Bcf; COGCC, 2014a). In 1999, annual production was approximately 30,000 million cubic feet (Mmcf), and production has increased each year since, reaching just under 100,000 Mmcf in 2006, with approximately 2,000 wells in the Raton Basin (see Figure 7; U.S. Energy Information Administration, 2013; COGCC, 2014a). Annual ground water withdrawals for CBM production increased from about 1.45



Source: *Gas Fields, COGCC; Water Bodies, USGS NHD; Boundaries and Topography, ESRI*

Figure 5. Map showing the location of CBM fields and sampling locations in Las Animas County, CO.



Source: *Gas Fields, COGCC; Water Bodies, USGS NHD; Boundaries and Topography, ESRI*

Figure 6. Map showing the location of CBM fields and sampling locations in Huerfano County, CO.

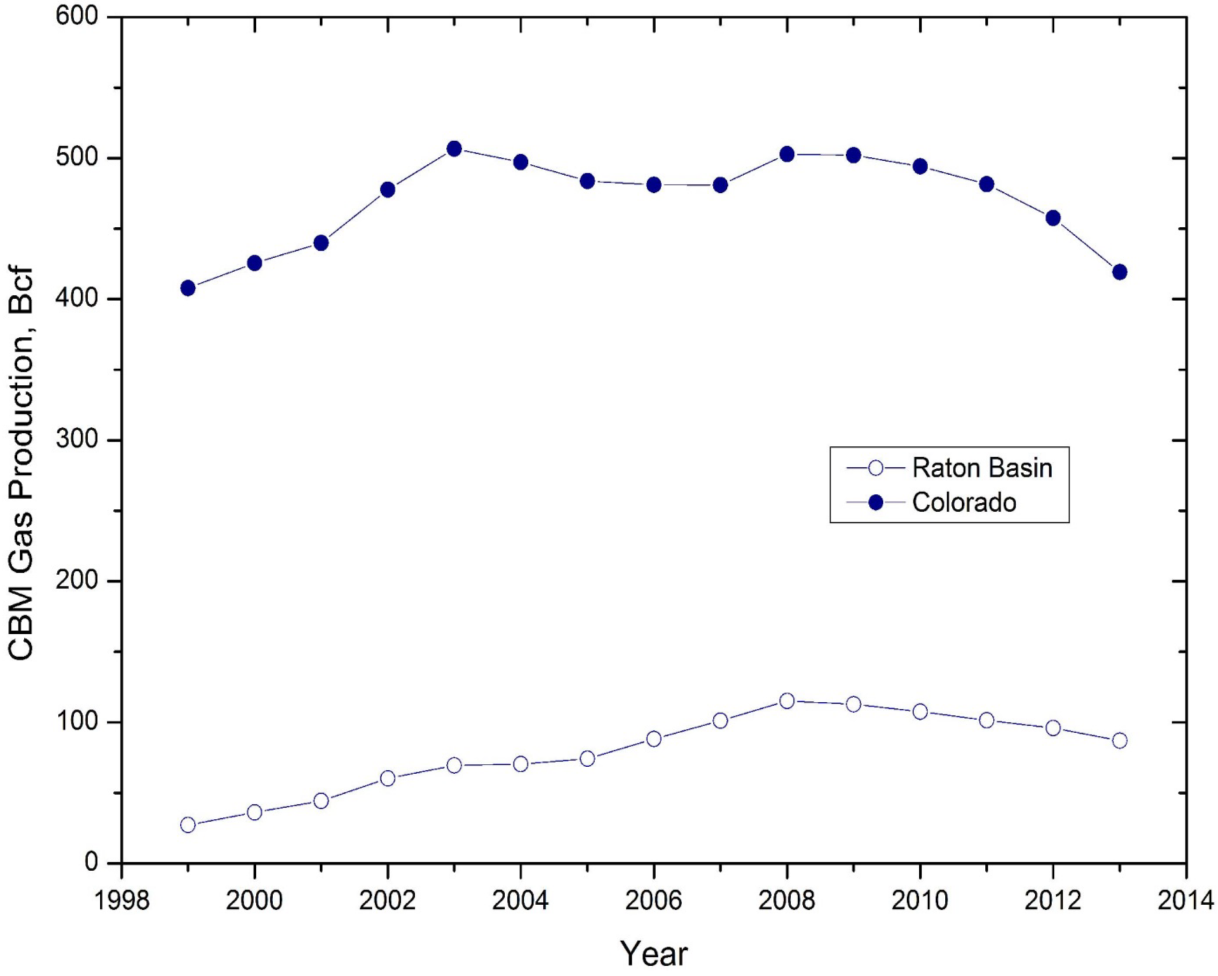


Figure 7. CBM production through time in Colorado and the Raton Basin, 1999—2013 (production in billion cubic feet, Bcf; data from COGCC, 2014a).

billion gallons (from 480 wells) to about 3.64 billion gallons (from 1,568 wells) during 1999–2004 (Watts, 2006b).

Coal beds targeted for development occur within some of the same formations as aquifers used for water supply (Watts, 2006a; 2006b). Oil and gas operations, including the issuing of permits for drilling and operation, well spacing requirements, well bore construction, and well site reclamation, are regulated by the COGCC, under COGCC 100–1200 Series Rules. The COGCC also regulates the abandonment of wells and the treatment and disposal of oil and gas exploration and production waste. Air requirements, water requirements, and hazardous and solid waste requirements (not including oil and gas exploration and production wastes), are regulated by the Colorado Department of Public Health and Environment–Air Pollution Control Division, Water Quality Control Division, and the Hazardous Materials and Waste Management Division, respectively (Colorado Department of Public Health and Environment, 2013).

3.4. Land Use

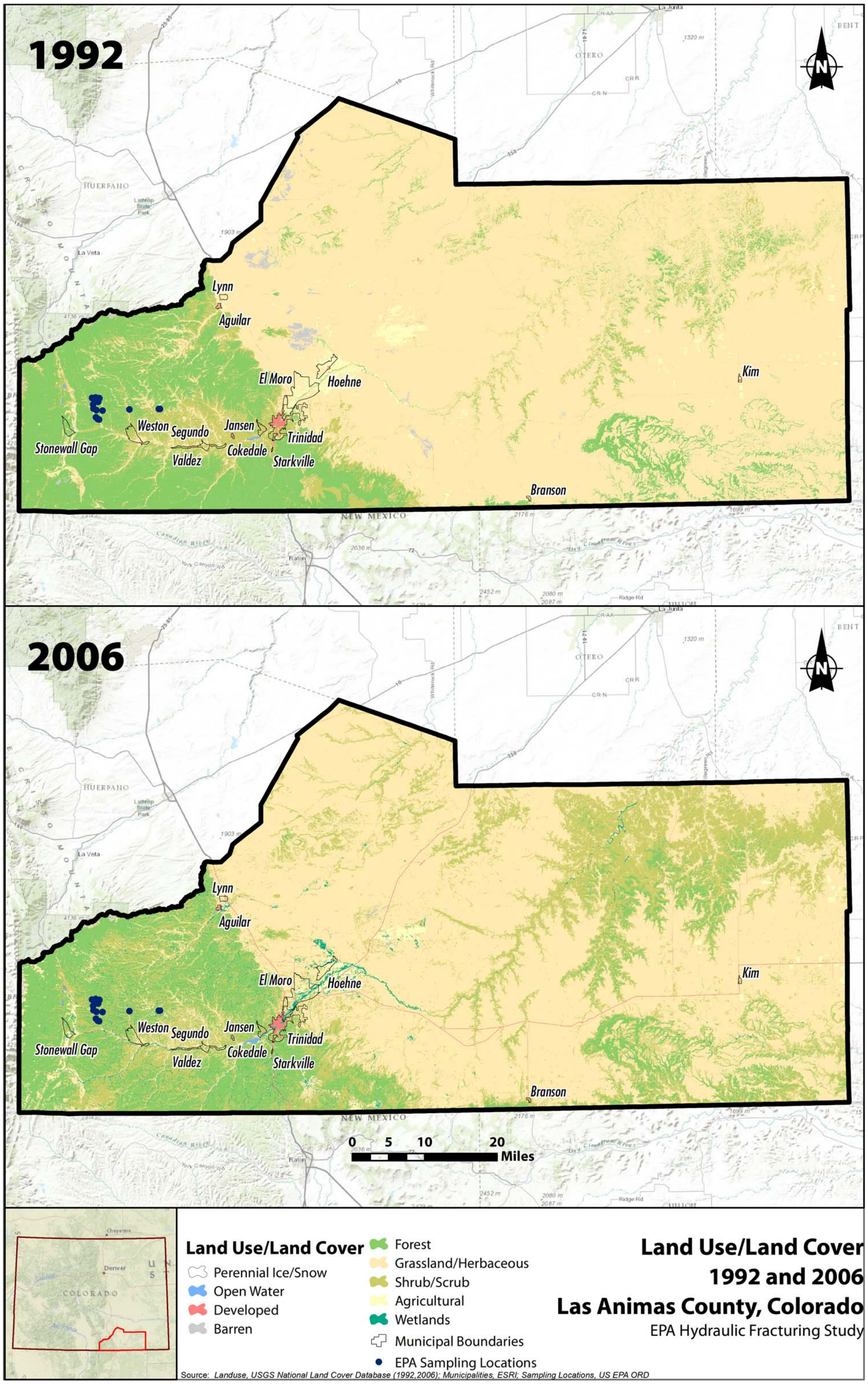
Huerfano and Las Animas counties are sparsely populated, rural counties in Colorado. During the latter part of the nineteenth century, cattle ranching became the first major economic activity within these counties. At the end of the nineteenth century, and during the first part of the twentieth century, coal mining and coke production became major industries in both counties (Murray, 1978). However, the coal mining industry started to decline in the 1920s (Huerfano County Government, 2011). According to Worrall (2003), before 1990 there was little oil and gas development in the northern Raton Basin; more recently CBM development and extraction efforts were renewed in the mid-1990s (US EPA, 2012).

Huerfano County's Comprehensive County Plan describes the county as being "primarily a rural county" (Huerfano County Government, 2011), while Las Animas County government's website describes the county as mostly rural and relying "heavily on farming and ranching as its main economic engine" (Las Animas County Government, 2013). Land use maps for Las Animas and Huerfano counties, presented in Figures 8 and 9, were created using data from the National Land Cover Database (NLCD) and reflect land use activities within Las Animas and Huerfano counties in 1992 and 2006; land use data are also shown in Tables 1 and 2 (USGS, 2012). The NLCD is based upon 30-meter-resolution data from the Landsat satellite, and the 2006 dataset is the most recent available. Although these land use data (1992, 2006) are not quantitatively comparable due to changes in input data and mapping methodologies (see Multi-Resolution Land Characteristics Consortium, 2013), the NLCD data indicate that, in both years, grassland/herbaceous, forests, and shrub/scrub were the largest land use categories in Las Animas and Huerfano counties. Additional analyses of land use and qualitative land use change, with particular focus in the areas adjacent to the sampling locations of this study, are presented in Appendix C.

3.5. Potential Contaminant Sources

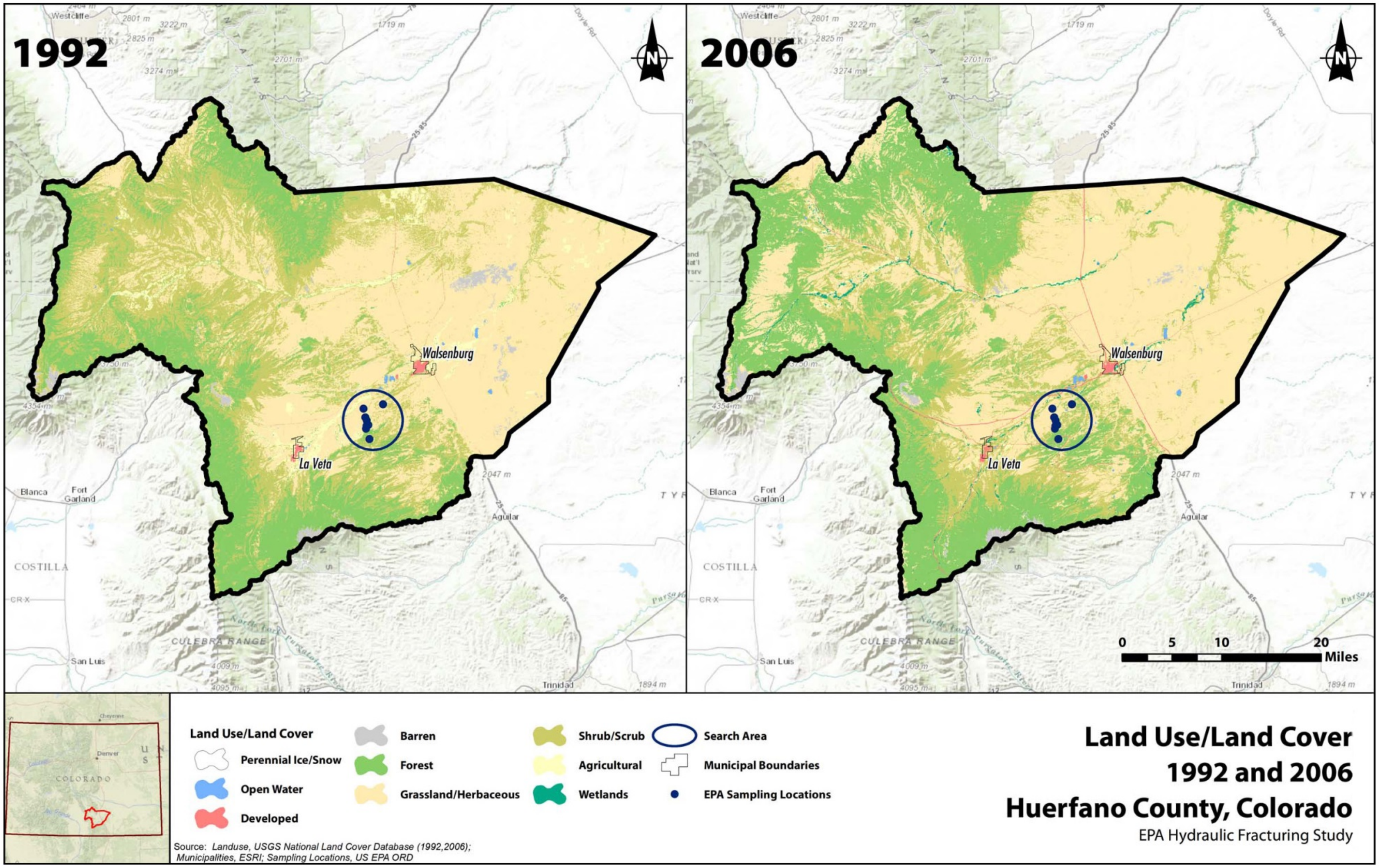
A causal assessment approach was adopted in all of the retrospective case studies to evaluate potential contaminant sources. Causal assessment is defined as the organization and analysis of available evidence to evaluate links between apparent environmental impacts and potential causes, and the assessment of the level of confidence in these causal links.

A list of candidate causes (i.e., hypothesized causes of an environmental impairment that are sufficiently credible to be analyzed; US EPA, 2000a) was developed for this retrospective case study and included the Little Creek Field, North Fork Ranch, and Arrowhead Ranchettes study areas. Environmental stressors were evaluated by examining potential causes and effects. Candidate causes included potential sources that could impact the environment and contribute to any detected levels of surface and/or ground water contamination. Candidate causes were categorized as follows: industrial/commercial land use, historical land use (e.g., farming and mining), current drilling processes/practices, historical drilling practices, and naturally occurring sources. In order to determine whether the presence of other potential sources of contamination existed, unrelated to drilling and hydraulic fracturing processes, a background assessment was conducted; this evaluation is described below and in more detail in Appendix C. Where appropriate, the results of the environmental record assessment are integrated into the analysis of the water quality data in following sections of this report.



Source: *Landuse, USGS National Land Cover Database (1992,2006); Municipalities, ESRI; Sampling Locations, US EPA ORD*

Figure 8. Land use map, Las Animas County, CO, 1992 and 2006 (data from USGS, 2012).


1992

2006

Land Use/Land Cover
1992 and 2006
Huerfano County, Colorado
EPA Hydraulic Fracturing Study

Source: Landuse, USGS National Land Cover Database (1992,2006); Municipalities, ESRI; Sampling Locations, US EPA ORD

Figure 9. Land use map, Huerfano County, CO, 1992 and 2006 (data from USGS, 2012).

The background assessments utilized the following databases:

- Environmental records search: Environmental record searches were performed by obtaining environmental record reports from Environmental Data Resources, Inc. (EDR). EDR provides a service for searching publically available databases, as well as data from their own proprietary databases. Record searches were conducted in defined buffer zones around sampling locations (see search areas in Figures 10 and 11 and in Appendix C).
- Well inventory: Existing oil and gas well inventories were prepared on the same search areas used for the EDR reports using COGCC's oil and gas well database (http://cogcc.state.co.us/cogis).
- State record summary: The COGCC Information System website (http://cogcc.state.co.us/cogis) was used to find up-to-date well records for the study areas. The database provides information on inspection and pollution prevention visits, including a listing of all inspections that have occurred at each well on record, whether violations were noted, and any enforcement that may have resulted. The system provides multiple options to search for records.

Table 1. Land use in Las Animas County in 1992 and 2006.

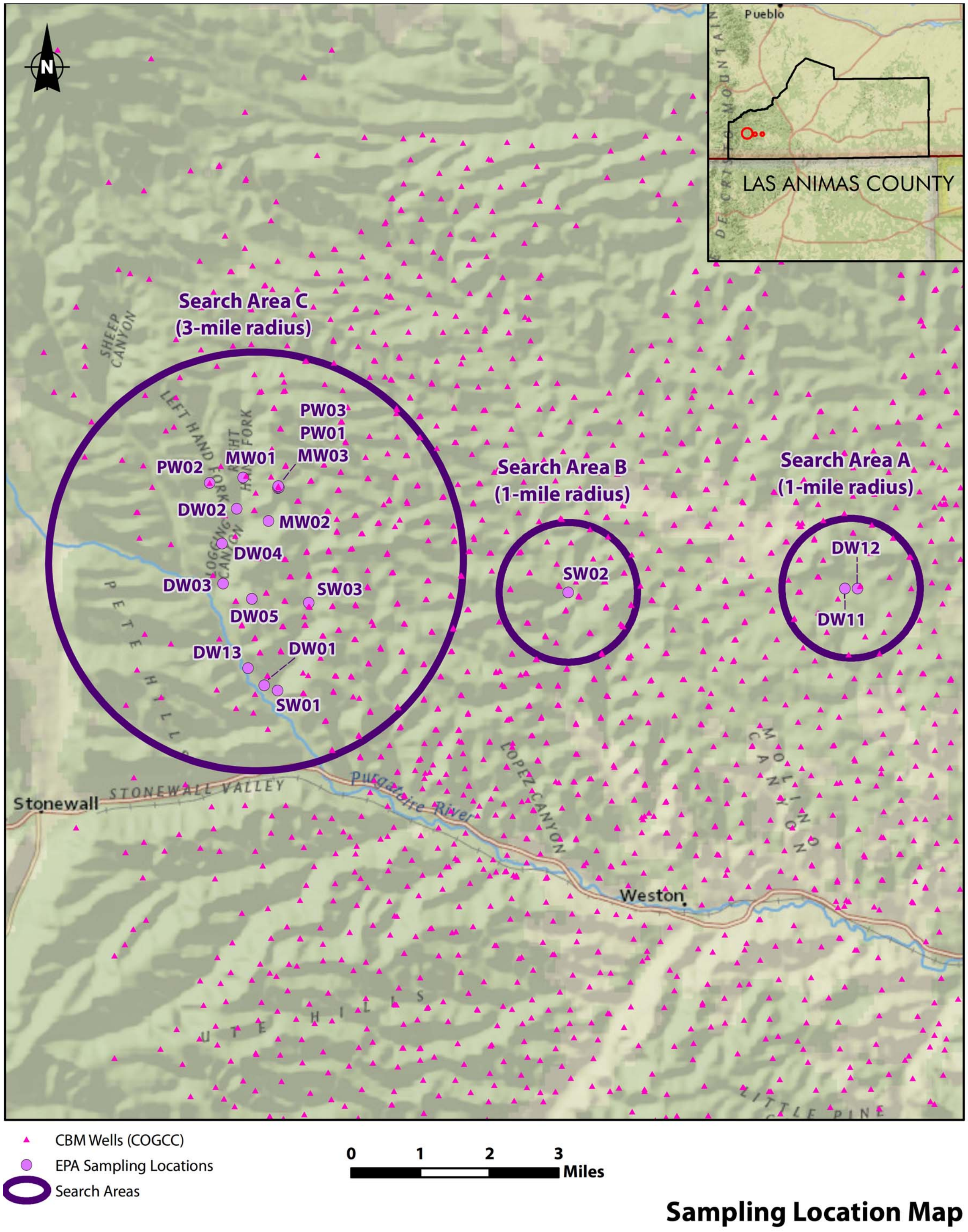
Land Use	1992		2006	
	Square Miles	% of Total	Square Miles	% of Total
Grassland/herbaceous	3,358.5	70.4	2,879.9	60.3
Evergreen forest	691.9	14.5	785.7	16.5
Shrub/scrub	413.0	8.7	875.6	18.3
Deciduous forest	191.6	4.0	97.8	2.0
Row/cultivated crops	47.3	1.0	34.5	0.7
Pasture/hay	26.1	0.5	13.0	0.3
Transitional	19.3	0.4	0.0	0.0
Barren	8.5	0.2	8.1	0.2
Mixed forest	7.9	0.2	19.5	0.4
Developed	7.2	0.2	23.8	0.5
Open water	1.3	0.0	2.4	0.0
Fallow	0.2	0.0	0.0	0.0
Urban/recreational grass	0.0	0.0	0.0	0.0
Perennial ice/snow	0.0	0.0	0.0	0.0
Woody wetlands	0.0	0.0	19.9	0.4
Emergent herbaceous wetlands	0.0	0.0	12.8	0.3
Total	**4,772.8**	**100.0**	**4,773.0**	**100.0**

Source: US Geological Survey (2012).

Table 2. Land use in Huerfano County in 1992 and 2006.

Land Use	1992		2006	
	Square Miles	% of Total	Square Miles	% of Total
Grassland/herbaceous	742.3	46.6	776.9	48.8
Shrub/scrub	394.5	24.8	301.1	18.9
Evergreen forest	253.3	15.9	350.1	22.0
Deciduous forest	118.4	7.4	83.7	5.3
Pasture/hay	34.3	2.2	10.0	0.6
Row/cultivated crops	16.5	1.0	0.7	0.0
Barren	12.5	0.8	15.1	0.9
Transitional	7.9	0.5	0.0	0.0
Mixed forest	6.3	0.4	27.0	1.7
Developed	3.7	0.2	11.1	0.7
Open water	1.8	0.1	2.2	0.1
Urban/recreational grass	0.4	0.0	0.0	0.0
Emergent herbaceous wetlands	0.1	0.0	5.9	0.4
Perennial ice/snow	0.1	0.0	0.0	0.0
Woody wetlands	0.0	0.0	8.3	0.5
Total	**1,592.1**	**100.0**	**1,592.1**	**100.0**

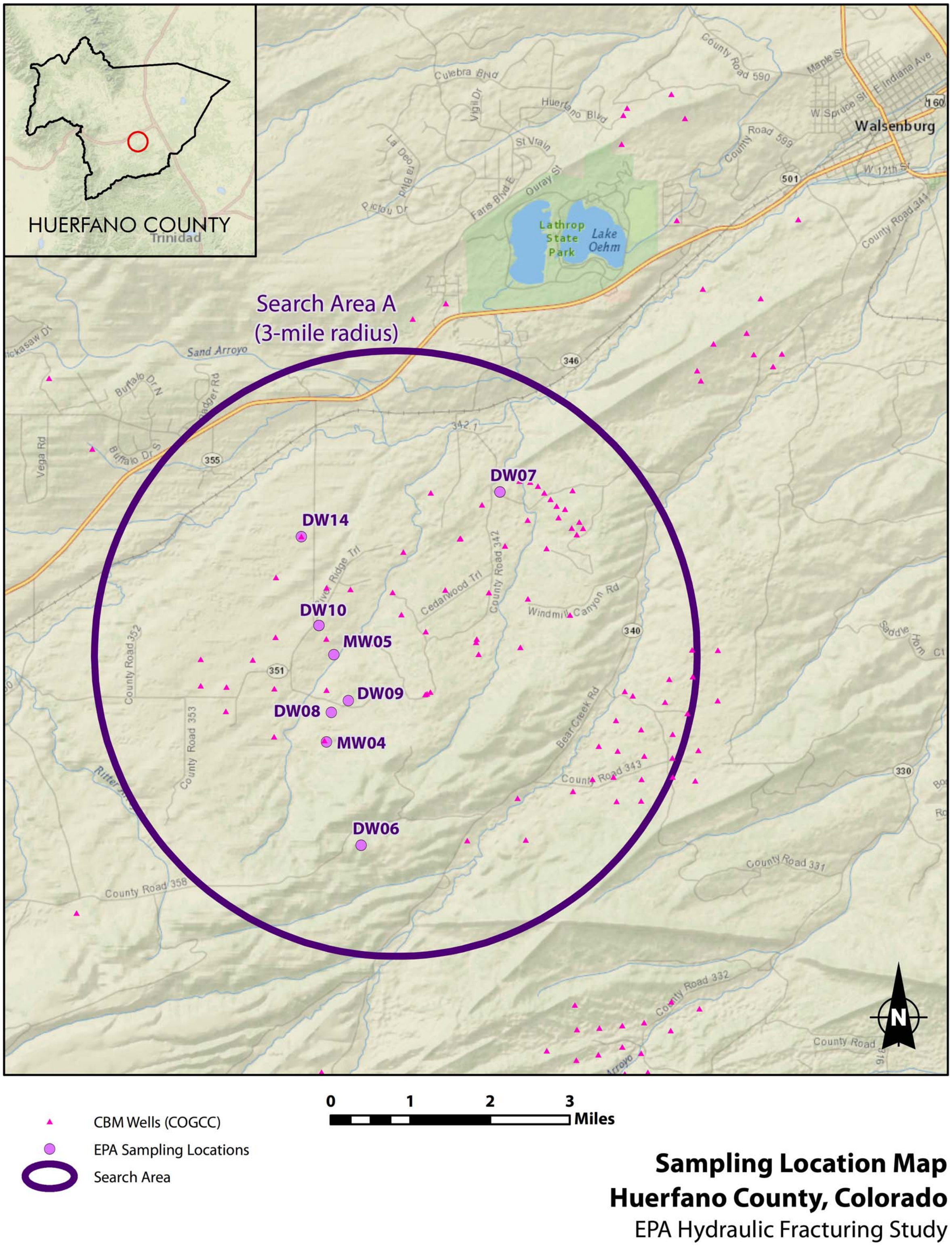
Source: US Geological Survey (2012).



Sampling Location Map
Las Animas County, Colorado
EPA Hydraulic Fracturing Study

Source: *Imagery, ESRI; Wells and Samples: EPA ORD*

Figure 10. Map showing the locations of samples collected, search areas evaluated in the environmental assessments, and CBM wells: Las Animas County, CO. Search Area A contains sampling locations within the Arrowhead Ranchettes study area; sample points within Search Areas B and C are located within the North Fork Ranch study area. See Table 3 for well types.



Source: *Imagery, ESRI; Wells and Samples , EPA ORD, Colorado COGCC*

Figure 11. Map showing the locations of samples collected within the Little Creek Field during this study, the search area evaluated in the environmental assessment, and CBM wells: Huerfano County, CO. See Table 4 for well types.

4. Study Methods

In Las Animas County, the sampled domestic wells and monitoring wells ranged in depth from 60 to 585 feet below land surface. Production wells, located within the Raton and Vermejo coal formations, ranged in depth from 2,405 to 3,040 feet below land surface, respectively. Ground water samples were obtained from production wells to establish the chemical and physical characteristics of ground water associated with CBM-producing coal zones within the study areas; this information was important to evaluate and understand potential interactions between waters from different aquifers, as well as the surface environment. In Huerfano County, domestic wells and monitoring wells ranged in depth from 323 to 706 feet below land surface.

Wherever possible, ancillary data for each well were collected during or near the time of sample collection and included latitude and longitude (recorded with a handheld global positioning system [GPS] device), topographic setting, depth, diameter, screened interval, casing material, and static water level (depth to water). Samples were analyzed for geochemical parameters (pH, specific conductance [SPC], oxidation-reduction potential [ORP], dissolved oxygen [DO], alkalinity, ferrous iron, and dissolved sulfide), major ions, nutrients, trace metals, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), diesel-range organics (DRO), gasoline-range organics (GRO), glycol ethers (diethylene glycol, triethylene glycol, and tetraethylene glycol), low-molecular-weight acids (lactate, formate, acetate, propionate, isobutyrate, and butyrate), dissolved gases (methane, ethane, propane, and butane), strontium isotope ratios ($^{87}Sr/^{86}Sr$), and selected stable isotopes ($\delta^{13}C_{CH4}$, $\delta^{2}H_{CH4}$, $\delta^{13}C_{DIC}$, $\delta^{18}O_{H2O}$, $\delta^{2}H_{H2O}$, $\delta^{34}S_{SO4}$, $\delta^{18}O_{SO4}$, $\delta^{34}S_{H2S}$). A detailed description of the sampling methods, analytical methods, quality assurance (QA), and quality control (QC) is provided in the QAPP for this study (Wilkin, 2013). The laboratories that performed the analyses for each sampling event are listed in Table A1 of Appendix A and analytical results for the sample measurements are tabulated in Appendix B.

4.1. Sampling Locations

Water quality samples were collected from 14 different domestic wells, three production wells, five monitoring wells, and three surface water locations during four sampling rounds in October 2011, May 2012, November 2012, and April/May 2013 (see Tables 3 and 4). The selected study sites are located within the coal-bearing portion of the Raton Basin in Colorado. The first study area is located north-northwest of Trinidad, Colorado, along the western margin of the basin. Figure 10 identifies the sampling locations and the search areas for which environmental record assessments were performed. Search Area A contains two sampling locations in the Arrowhead Ranchettes subdivision; Search Area B includes one surface water sampling location in Wet Canyon; and Search Area C includes 14 sampling locations within the North Fork Ranch subdivision (see Figure 10). The second study area is located south-southwest of Walsenberg, Colorado, in the eastern side of the basin. Figure 11 identifies the sampling locations and the search area in which the environmental assessment was performed. While the stratigraphic sedimentary sequences are similar in the different study areas, the thickness of individual formations, past igneous activity, and the structural history of the sites differ.

Four sampling rounds (rounds 1 through 4) were conducted, commencing in October 2011 and ending in April/May 2013 (see Tables 3 and 4). During round 1 (October 2011), samples were collected from 20 locations, including two production wells, five monitoring wells, 12 domestic wells, and one surface water body. In round 2 (May 2012), round 3 (November 2012), and round 4 (April/May 2013), water samples were collected from two production wells, three monitoring wells, 12 domestic wells, and three surface water locations (20 total locations). In round 3, one domestic well was sampled at the wellhead (RBDW06) and at the kitchen tap (RBDW15) in order to evaluate the effectiveness of a methane/hydrogen sulfide treatment system. The water treatment system appeared to be functioning properly and the concentration of hydrogen sulfide and methane in water collected from the homeowner's kitchen faucet was significantly less than water collected at RBDW06 (see Tables B-1 and B-5). No anomalous results were observed and the location was not sampled in future sampling events. Reasons for including or excluding a location during a sampling round included access issues and QA/QC constraints (e.g., homeowner well function).

Table 3. Information for wells sampled during this study in Las Animas County, CO.

Sample ID	Well Type[1]	Geologic Fm[2]	Sampling Round[3]				Latitude *(°N)*	Longitude *(°W)*	Elevation *(ft)*	Well Depth *(ft BLS)*
			1	2	3	4				
North Fork Ranch										
RBDW01	DW	QA	X	X	NS[4]	NS	37.17826	-104.95889	7530	140
RBDW02	DW	PC-SA	X	X	X	X	37.21538	-104.96784	7897	170
RBDW03	DW	PC-SA	X	X	X	X	37.19978	-104.96972	7664	100
RBDW04	DW	PC-SA	X	NS	X	X	37.20798	-104.97005	7762	507
RBDW05	DW	PC-SA	X	X	X	X	37.19659	-104.96214	8091	450
RBDW13	DW	QA	NS	X	X	X	37.18218	-104.96314	7527	60
RBMW01	MW	PC-SA	X	X	X	X	37.22180	-104.96442	7933	70
RBMW02	MW	PC-SA	X	X	X	X	37.21264	-104.95832	7899	140
RBMW03	MW	PC-SA	X	X	X	X	37.21958	-104.95528	8383	585
RBPW01	PW	RT-CA	X	X	X	X	37.21975	-104.95507	8383	2405
RBPW02	PW	VMJ-CA	X	NS	NS	NS	37.22068	-104.97320	8007	2635
RBPW03	PW	VMJ-CA	NS	X	X	X	37.19850	-104.80655	7270	3040
RBSW01	SW	NA[5]	X	X	X	X	37.17757	-104.95537	7461	NA
RBSW02	SW	NA	NS	X	X	X	37.19778	-104.87917	7316	NA
RBSW03	SW	NA	NS	X	X	X	37.19583	-104.94722	7717	NA
Arrowhead Ranchettes										
RBDW11	DW	RT	X	X	X	X	37.19861	-104.80667	7270	120
RBDW12	DW	--	X	NS	NS	NS	37.19861	-104.80333	7270	--

[1] Well Type: PW = Production Well; MW = Monitoring Well; DW = Domestic Well; SW = Surface Water.

[2] Geologic formation the wells were screened in: QA = Quaternary Alluvium; PC-SA = Poison Canyon sandstone aquifer; RT = Raton Formation; RT-CA = Raton Formation coal aquifer; VMJ-CA = Vermejo Formation coal aquifer.

[3] Sampling Events: round 1 = October 2011; round 2 = May 2012; round 3 = November 2012; and round 4 = April/May 2013.

[4] NS = Not Sampled.

[5] NA = Not Applicable.

Table 4. Information for wells sampled during this study in Huerfano County, CO.

Sample ID	**Well Type[1]**	**Geologic Fm[2]**	**Sampling Round[3]**				**Latitude *(°N)***	**Longitude *(°W)***	**Elevation *(ft)***	**Well Depth *(ft BLS)***
			1	**2**	**3**	**4**				
Little Creek Field										
RBDW06	DW	PC-SA	X	X	X	X	37.52175	-104.87707	7175	323
RBDW07	DW	PC-SA	X	X	X	X	37.57250	-104.85194	6503	345
RBDW08	DW	PC-SA	X	X	X	X	37.54083	-104.88250	6804	607
RBDW09	DW	PC-SA	X	X	X	X	37.54250	-104.87944	6781	706
RBDW10	DW	PC-SA	X	X	X	X	37.55333	-104.88472	6690	615
RBDW14	DW	PC-SA	NS[4]	X	X	X	37.56611	-104.88806	6634	432
RBDW15	Res[5]	NA[6]	NS	NS	X	NS	37.52132	-104.87863	7175	NA
RBMW04	MW	PC-SA	X	NS	NS	NS	37.53658	-104.88336	6838	695
RBMW05	MW	PC-SA	X	NS	NS	NS	37.54911	-104.88207	6656	591

[1] Well Type: PW = Production Well; MW = Monitoring Well; DW = Domestic Well; SW = Surface Water.
[2] Geologic formation the wells were screened in: QA = Quaternary Alluvium; PC-SA = Poison Canyon sandstone aquifer; RT = Raton Formation; RT-CA = Raton Formation coal aquifer; VMJ-CA = Vermejo Formation coal aquifer.
[3] Sampling Events: round 1 = October 2011; round 2 = May 2012; round 3 = November 2012; and round 4 = April/May 2013.
[4] NS = Not Sampled.
[5] Res = Residence. Sample was collected from a kitchen faucet, post-treatment of RBDW06.
[6] NA = Not Applicable.

4.2. Water Collection

Sample bottles for each location were uniquely labeled prior to each sampling round, and all labels were color-coded by analytical parameter. Table A2 of Appendix A identifies the pre-cleaned bottle types and number of sample bottles needed for each laboratory analysis.

Water samples were collected as close to the ground water pump as possible to yield samples that were unaffected by contamination caused during sample collection, and representative of environmental conditions. Teflon-lined polyethylene tubing was connected to the pump output at each sample location; clean tubing was used prior to sampling and filtration and discarded after use. Tubing was not used at sample location RBDW15 (round 3, November 2012); this water sample was collected from the homeowner's kitchen faucet.

Unfiltered samples were collected first for the following parameters: dissolved gases, VOCs, SVOCs, DRO, GRO, glycol ethers, low-molecular-weight acids (LMWAs), total metals, $\delta^{13}C_{CH4}$, and $\delta^{2}H_{CH4}$. Samples for dissolved metals, anions, nutrients, dissolved inorganic carbon (DIC), $\delta^{13}C_{DIC}$, dissolved organic carbon (DOC), $\delta^{18}O_{H2O}$, $\delta^{2}H_{H2O}$, $\delta^{34}S_{SO4}$, $\delta^{18}O_{SO4}$, $\delta^{34}S_{H2S}$, and Sr isotopes were filtered onsite using 0.45-micron pore-size, disposable-capsule filters (Millipore). Approximately 100 milliliters (mL) of ground water were passed through the filter, to waste, prior to filling sample bottles. The date and time of collection and the initials of the sampler were recorded for each location. Sample preservation and holding time requirements for each sample type are described in Table A2 of Appendix A.

4.3. Purging and Sampling at Domestic Wells

A well volume approach, combined with the monitoring of stabilization parameters (pH, SPC, ORP, and DO), was used for purging domestic wells (Yeskis and Zavala, 2002). Domestic wells were sampled using downhole pumps (homeowner), via homeowner taps, or by accessing the well directly using a submersible pump (Proactive Monsoon®) fitted with Teflon-lined polyethylene tubing. When possible, the ground water level was measured using a Solinist® water level indicator and tracked every 10 to 15 minutes during well purging. Most samples (all except RBDW15) were collected directly from the wells before any water treatment. Initial flow rates were obtained at each location; wells were then purged at a flow rate of approximately 0.5 to 10 gallons per minute. The rate of purging was determined by measuring the volume of water collected after a unit of time into a large metered pail or graduated cylinder. Water quality parameters were continuously monitored, and recorded using a YSI 556 multi-parameter probe system to track the stabilization of pH (≤0.02 standard units per minute), ORP (≤2 mV per minute), SPC (≤1% per minute), DO, and temperature. Water flow through the cell housing the multi-parameter probe was maintained at about 0.25 to 0.50 gallons per minute; all excess purge water was valved to waste. Sample collection began after parameter stabilization had occurred, and all samples were stored on ice until processed for shipping.

4.4. Purging and Sampling at Production and Monitoring Wells

Production and monitoring wells were sampled in cooperation with contractors from Pioneer (North Fork Ranch) and Petroglyph (Little Creek Field) using dedicated downhole pumps. Company representatives operated all equipment around the wells.

Production wells were continuously purged. Samples were collected at the wellhead after stable electrode readings for pH, ORP, SPC, DO, and temperature were obtained. Monitoring wells were purged approximately three well volumes prior to sampling, with the exception of RBMW03. Monitoring well RBMW03 was a low-yield well, and continuous ground water pumping and monitoring of parameters to stability was not possible. Therefore, for low-yield well sampling, the recommendations of Yeskis and Zavala (2002) were followed. This method included purging until the well was emptied, recharging the well for about 24 hours, and then collecting representative samples of the fresh recharge to the well. General parameter measurements were made in static mode without continuous flow.

4.5. Sampling at Surface Water Locations

Surface water samples were collected from flowing streams at three locations to establish potential links between observed ground water quality and surface water quality. Measurement of stabilization parameters and sample collection occurred simultaneously; parameters were recorded every 2 minutes for a minimum of 30 minutes at each surface water site, or until electrode readings stabilized. Sample bottles were submerged in the surface water (<0.5 m depth) to just below the surface and filled as grab samples for unfiltered samples. Sampling of surface waters was performed to minimize capture of sediment. Filtered samples were obtained by pumping water from the stream through Teflon-lined polyethylene tubing and a 0.45-micron, high-capacity filter using a peristaltic pump (Pegasus Pump Company Alexis®). Approximately 100 mL of surface water was passed through the filter, to waste, prior to filling the sample bottles. The samples were stored on ice prior to leaving the sampling location.

4.6. Sample Shipping/Handling

At the conclusion of each day, samples were organized by analytical parameter, placed together into sealed Ziploc plastic bags, and transferred to coolers filled with ice. Glass bottles were packed in bubble wrap to prevent breakage. A temperature blank and a chain-of-custody form were placed in each cooler. Coolers were sealed, affixed with a custody seal, and sent to the appropriate lab via express delivery, generally within 24 hours of collection, depending on sample holding time requirements. Sample bottles for $\delta^{13}C_{CH4}$ and $\delta^{2}H_{CH4}$ analyses were placed in an inverted position in coolers and maintained in the inverted position throughout shipment to the analytical laboratory.

4.7. Water Analysis

4.7.1. Field Parameters

Temperature, SPC, pH, ORP, and DO were continuously monitored during well purging using a YSI 556 multi-parameter probe and flow-cell assembly. Electrode measurements of SPC were correlated to the concentration of TDS (Appendix B). YSI electrodes were calibrated every morning prior to sampling following the manufacturer's instructions. A National Institute of Standards and Technology (NIST)-traceable 1,413 microsiemen per centimeter (µS/cm) SPC standard was used for calibration and performance checks. NIST-traceable buffer solutions (4.00, 7.00, and 10.01) were used for pH calibration and performance checks. An Orion ORP standard was used for calibration and performance checks of redox potential measurements. DO sensors were calibrated with air, and low-oxygen measurement performance was tested with a zero-oxygen solution (sodium sulfite). The probe was stored in pH 4.00 buffer solution when not in use.

After well parameters stabilized in each well (except for RBMW03, see above), a 500-mL sample was collected for field determinations of alkalinity, turbidity, ferrous iron, and dissolved sulfide. Duplicate measurements, at a minimum, were collected for each parameter. For all collected samples, alkalinity measurements were determined by titrating ground water samples with 1.6N sulfuric acid (H_2SO_4) to the bromcresol green-methyl red endpoint using a Hach titrator (EPA Method 310.1). Turbidity measurements (EPA Method 180.1) were determined with a Hach 2100Q portable meter. Ferrous iron measurements were collected using the 1,10-phenanthroline colorimetric method (Hach DR/890 colorimeter, Standard Method 3500-FeB for Wastewater). Dissolved sulfide measurements were obtained using the methylene blue colorimetric method (Hach DR/2700 spectrophotometer, Standard Method 4500-S^{2-}D for Wastewater).

Hach spectrophotometers (for ferrous iron and sulfide) and turbidimeters (for turbidity) were inspected before going into the field, and their functionality was verified using performance calibration check solutions. Instrument calibration checks were conducted at least every other day during each sampling round. Ferrous iron accuracy was checked by making duplicate measurements of a 1-mg Fe/L standard solution (Hach Iron Standard solution, using Ferrover reagent); the results ranged from 0.90 to 1.10 mg Fe/L. The accuracy of dissolved sulfide measurements was checked by measuring standard solutions prepared in the laboratory by purging dilute sodium hydroxide solution (0.0001 M) with 1.0% H_2S gas (balance N_2); the results of spectrophotometric measurements were within 20% of expected concentrations. Turbidity was checked against formazin turbidity standards supplied by Hach (10, 20, 100 and 800 NTU). Titrant cartridges used for alkalinity measurements were checked using a 100-mg/L sodium bicarbonate ($NaHCO_3$) solution. Blank solutions (deionized water) for each parameter were measured at the beginning of the day, at midday, and at the end of the day.

4.7.2. Analytical Methods for Ground Water and Surface Water

Water samples were collected and analyzed using the methods identified in Table A2 of Appendix A. The laboratories that performed the analyses, per sampling round, are identified in Table A1. A total of 2,155 samples (not including duplicates of glass containers) were collected and delivered to (up to) 10 laboratories for analyses. Anions, nutrients, DIC, and DOC were analyzed following all sampling events. Quantitative analysis of the major anions bromide (Br^-), chloride (Cl^-), fluoride (F^-), and sulfate (SO_4^{2-}) was determined by capillary ion electrophoresis (EPA Method 6500) using a Waters Quanta 4000 Capillary Ion Analyzer. Nutrients ($NO_3 + NO_2$, NH_3) were measured by flow injection analysis (EPA Method 350.1 and 353.1) on a Lachat QuickChem 8000 Series flow injection analyzer. The carbon concentrations of DIC and DOC in samples were determined via acidification and combustion followed by infrared detection (EPA Method 9060A) on a Shimadzu TOC-VCPH Analyzer.

Dissolved gases (methane, ethane, propane, and butane), LMWAs (lactate, formate, acetate, propionate, isobutyrate, and butyrate), and the stable isotopes of water (δ^2H, $\delta^{18}O$) were analyzed by Shaw Environmental for rounds 1, 2, and 3 and by CB&I for round 4. Dissolved gases were measured using gas chromatography (Agilent Micro 3000 gas chromatograph) following a modification of the method described by Kampbell and Vandegrift (1998). The concentrations of LMWAs were determined using high-performance liquid chromatography (HPLC; Dionex Ics-3000). The hydrogen (δ^2H) and oxygen ($\delta^{18}O$) isotope ratios of water were determined by isotope ratio mass spectrometry (TC/EA, Finnigan Delta Plus XP IRMS) for aqueous samples collected during round 1; cavity ring-down spectrometry was used to measure water isotope ratios in samples collected during rounds 2, 3 and 4 (Picarro L2120i CRDS). The oxygen and hydrogen isotope ratio values are reported in terms of permil (‰, parts per thousand) notation with respect to the Vienna Standard Mean Ocean Water (VSMOW) standard.

The analysis of DRO, GRO, and SVOCs in water samples collected during rounds 1 through 4 was performed by the EPA Region 8 Laboratory. DRO and GRO were determined by gas chromatography, using a gas chromatograph equipped with a flame ionization detector (EPA Method 8015B; Agilent 6890N GC). The concentrations of SVOCs were determined by gas chromatography (GC)/mass spectrometry (MS) (EPA Method 8270D; HP 6890 GC and HP 5975 MS).

VOCs were measured by Shaw Environmental for samples collected during rounds 1, 2 and 3 using automated headspace GC/MS (EPA Methods 5021A and 8260C; Agilent 6890/5973 Quadrupole GC/MS). Samples from rounds 3 and 4 were analyzed by SwRI using purge-and-trap GC/MS (EPA Method 8260B; Agilent 6890N GC/MS). For the round 3 sampling event, a double lab comparison was conducted between Shaw Environmental and SwRI to compare the analytical methods for VOCs, particularly detection capabilities for tert-butyl alcohol (TBA). The results of the double lab comparisons for VOCs, presented in Table A26 of Appendix A, were generally in good agreement, with the exception of toluene which was detected at low levels. The differences in toluene measurements between the two labs are not considered to be significant because of the low concentrations present in the samples compared (0.4-3.2 µg/L; see Appendix A). The double lab comparison verified the occurrence of TBA that was detected at some of the locations included in this case study during every sampling round.

Glycols (2-butoxyethanol, diethylene glycol, triethylene glycol, and tetraethylene glycol) were measured by the EPA Region 3 Laboratory for samples collected during rounds 1, 2, and 4, and by the EPA Office of Research and Development (ORD)/National Exposure Research Laboratory (NERL), Las Vegas, for round 3. Samples were analyzed by HPLC coupled with positive electrospray ionization (ESI+) tandem mass spectrometry (MS/MS; Waters HPLC/MS/MS with a Waters Atlantis dC18 3µm, 2.1×150mm column). Over the course of this case study, the glycol method was in development. A verification study of the method was completed using volunteer federal, state, municipal, and commercial analytical laboratories. The study indicated that the HPLC/MS/MS method was robust, had good accuracy and precision, and exhibited no matrix effects for several water types that were tested (Schumacher and Zintek, 2014).

For samples collected in rounds 1 and 2, major cation and trace metals were determined for filtered (dissolved metals) and unfiltered (total metals) samples by Shaw Environmental. Major cations were analyzed using inductively coupled plasma–optical emission spectroscopy (ICP-OES; EPA Method 200.7; Optima 3300 DV ICP-OES); trace metals were determined by inductively coupled plasma–mass spectroscopy (ICP-MS; EPA Methods 6020A; Thermo X Series II ICP-MS). Unfiltered samples were prepared prior to analysis by microwave digestion (EPA Method 3015A). Total and dissolved trace metals were analyzed through EPA's Contract Laboratory Program (CLP) for round 2. Samples were prepared and analyzed following CLP methodology (Method ISM01.3). Total and dissolved metal analyses for samples collected during rounds 3 and 4 were conducted by SwRI, in accordance with EPA Methods 6020A (ICP-MS) and 200.7 (ICP-OES). Unfiltered samples were digested prior to analysis (EPA Method 200.7). Mercury concentrations were determined by cold-vapor atomic absorption (EPA Method 7470A; PerkinElmer FIMS 400A).

Samples collected during all sampling events were submitted to Isotech Laboratories for stable isotope measurements of DIC ($\delta^{13}C_{DIC}$) and methane ($\delta^{13}C_{CH4}$, $\delta^{2}H_{CH4}$). Samples were also collected for isotope analysis of sulfide ($\delta^{34}S_{H2S}$) and sulfate ($\delta^{34}S_{SO4}$, $\delta^{18}O_{SO4}$) during rounds 2, 3, and 4. The $\delta^{13}C_{DIC}$ was determined using gas stripping and isotope ratio mass spectrometry (IRMS). Elemental analyses, coupled to an isotope ratio mass spectrometer, were used to obtain methane ($\delta^{13}C_{CH4}$, $\delta^{2}H_{CH4}$), sulfide ($\delta^{34}S_{H2S}$), and sulfate ($\delta^{34}S_{SO4}$, $\delta^{18}O_{SO4}$) measurements. The carbon isotope ratio value is reported in terms of permil notation with respect to the Vienna Pee Dee Belemnite (VPDB) standard. The hydrogen and oxygen isotope ratio values are reported in terms of permil notation with respect to the VSMOW standard. The sulfur isotope ratio is reported in terms of permil notation with respect to the Vienna Canyon Diablo Troilite (VCDT) standard.

Strontium isotope ratios ($^{87}Sr/^{86}Sr$) and rubidium (Rb) and strontium (Sr) concentrations were measured by the USGS for samples collected during all sampling events (rounds 1 through 4). High precision ($2\sigma = \pm 0.00002$) strontium isotope ratio results were obtained via thermal ionization mass spectrometry (TIMS; Finnigan Mat 262) using methods described in Peterman et al. (2012).

4.8. QA/QC

Field QC samples for ground water and surface water sampling are summarized in Table A3 of Appendix A and in the QAPP (Wilkin, 2013). QC samples included several types of blanks and duplicate samples. In addition, adequate volumes were collected to allow for laboratory matrix spike samples to be prepared, where applicable. All of the QC sample types were collected, preserved, and analyzed using methodologies identical to those used for water samples collected in the field. Appendix A presents detailed QA practices and the results of QC samples, including discussions of chain of custody, holding times, blank results, field duplicate results, laboratory QA/QC results, data usability, double lab comparisons, performance evaluation samples, QAPP additions and deviations, field QA/QC, application of data qualifiers, tentatively identified compounds (TICs), audits of data quality (ADQ), and field and laboratory Technical System Audits (TSAs). All reported data met project requirements unless otherwise indicated by application of data qualifiers. The application of data qualifiers and data usability is discussed in Appendix A. Detection and reporting limits for all analytes, per sample type, are provided in Tables B1–B6 in Appendix B.

4.9. Data Handling and Analysis

For each sampling location from this study, geochemical parameters and the major ion water quality data collected over the multiple sampling events (n = 4) were averaged in order to compare data from this study with historical data. This approach ensured that more frequently sampled locations were given equivalent weight in the data analyses; however, a shortcoming of this method is that potential temporal variability in concentration data at a single location was not captured. Intra-site variability of the data collected in this study was examined by evaluating time-dependent concentration trends at specific locations. For each sampling location, summary statistics were calculated for selected parameters (e.g., mean, median, standard deviation, and minimum and maximum values). The results of the dissolved (filtered) metals analyses were used for comparison purposes with historical water quality data. Parameters with non-detect values were set at half the minimum detection limit; summary statistics determined for parameters that showed mixed results, both above and below the quantitation limit (QL), were generally determined only when over 50% of the concentration data were above the QL (US EPA, 2000b). In rare cases, concentration values set at half the MDL were used for calculating summary statistics, and these cases are noted in the tabulated data. Organic compounds, detected over the four sampling rounds, were grouped by analyte type, and mean values and concentration ranges were tabulated. Dissolved gas concentrations were treated in a similar manner.

The software package AqQA (version 1.1.1; Standard Methods, 2012) was used to evaluate internal consistency of water compositions by calculating cation/anion balances and by comparing measured and calculated electrical conductivity values (see Appendix A, Table A25). Major ion charge balance was calculated by comparing the summed milliequivalents of major cations (calcium, magnesium, sodium, and potassium) with major anions (chloride, sulfate, bicarbonate, fluoride) using Eqn. 1, where the charge balance error is based on a percentage difference between the total positive charge and the total negative charge:

$$Charge\ balance\ error\ (\%) = \left|\frac{(\sum cations - \sum anions)}{(\sum cations + \sum anions)} \times 100\right| \qquad (1)$$

The calculated charge balance error over the four sampling rounds ranged between 0.0 and 13.2%; 90% of the samples collected for this study had a charge balance error less than 5% (see Appendix A). The saturation index for calcite and fluorite was determined using the Geochemist's Workbench package (version 8; Bethke, 1996). Mineral equilibria calculations were made using temperature and concentrations of base species: major cations (Na^+, K^+, Ca^{2+}, Mg^{2+}), anions (Cl^-, SO_4^{2-}, HCO_3^-, F^-), and pH. Activity corrections were made using the Debye-Hückel equation (Stumm and Morgan, 1996). The Lawrence Livermore National Laboratory (LLNL; EQ3/6) thermodynamic database was selected for use in the calculations (Delany and Lundeen, 1990). For these calculations, charge imbalance was handled by compensating with chloride for samples with an anion deficit or by compensating with sodium for samples with a cation deficit. Only samples with a charge balance error <5% were used for determining saturation indices.

Historical ground water quality data for the Raton Basin in Colorado were gathered from Powell (1952), McLaughlin et al. (1961), Howard (1982), ESN Rocky Mountain (2003), COGCC (2003a), Dahm et al. (2011), the USGS National Water Information System (NWIS) database (USGS, 2013a), and the USGS National Uranium Resource Evaluation (NURE) database (USGS, 2013b). The secondary data obtained from these sources were considered based upon various evaluation criteria, such as:

- Did the organization that collected the data have a quality system in place?
- Were the secondary data collected under an approved QAPP or other similar planning document?
- Were the analytical methods used comparable to those used for the primary data?
- Did the analytical laboratories have demonstrated competency (such as through accreditation) for the analysis they performed?
- Were the data accuracy and precision control limits similar to those for the primary data?
- Were the secondary data source method detection limits (MDLs) and QLs comparable to those associated with the primary data or at least adequate to allow for comparisons?
- Were sampling methods comparable to those used for the primary water quality data collected for this study?

In general, the necessary accompanying metadata were unavailable for the secondary water quality data sources to fully assess these evaluation criteria; thus, the secondary data were used with the understanding that they are of an indeterminable quality relative to the requirements specified for this study (see QAPP; Wilkin, 2013). For the historical datasets, samples with a charge balance error ≤15% were used for water-type analysis and for constructing geochemical plots such as Piper and Schoeller diagrams. In most cases, charge balance errors exceeding the 15% criterion were due to missing concentrations of major cations or anions in the historical datasets. Again, the historical data from locations with multiple sampling events were averaged and summary statistics were determined in order to avoid undue weighting of locations sampled on multiple occasions. Charge balance criteria were not used to screen data for use in summary statistic calculations or for plotting box and whisker diagrams. The EPA STORET (STOrage and RETrieval) data warehouse was not utilized, because these data may be indicative of environmental impact monitoring that could potentially skew background characterization.

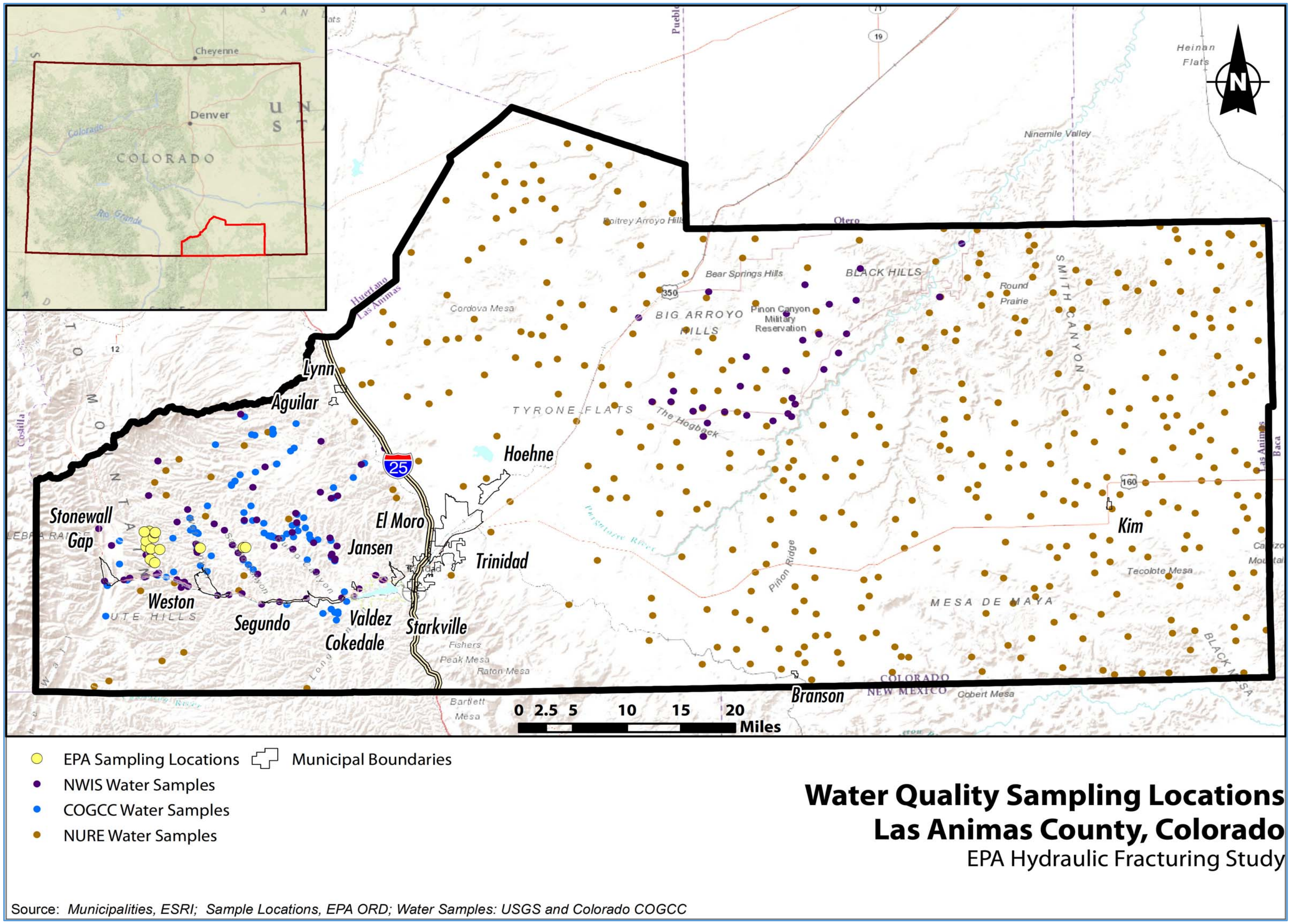
Statistical evaluations were carried out using the ProUCL (US EPA, 2010c) and Statistica (version 12) software packages. Hypothesis testing for the water quality data was performed using nonparametric (Kruskal-Wallis) methods. For the analysis of the major ion trends, average values were used in the statistical tests and were combined with single observations. As noted previously, this approach was used to avoid the undue weighting of locations sampled multiple times, either in the new data collected for this study or in the historical water quality data. *Post hoc* tests were performed using the Kruskal-Wallis multiple comparison test to determine significant differences among water quality datasets for particular analytes. A p-value of less than 0.05 was interpreted as a significant difference between compared datasets. Because a large number of comparisons were made between the data from this study and the historical water quality data that encompass numerous sampling investigations, multiple locations, and extended periods of time, the problem of multiple comparisons is suggested, that is, the increased likelihood of rejecting the null hypothesis and flagging significant differences among datasets. Given the exploratory nature of this study, p-value adjustments (e.g., Bonferroni or Šidák correction factors) were not incorporated and the traditional significance threshold of 0.05 was applied for the data comparisons.

5. Historical Water Quality Data

Comparisons of data from historical sources and collected during this study were conducted for the Colorado portion of the Raton Basin. The historical data are temporally constrained by the availability of information in the various databases, as described below. It is important to point out that the historical water quality data are not taken *a priori* as being representative of the background condition in the study area. The hypothetical background condition is considered here to represent the water quality regime in the absence of all human activities, including unconventional gas development. It is anticipated that data within the historical databases, in fact, contain examples in which the water quality information reflects anthropogenic impact. Thus, for the purposes of this report, the historical data are used as points of reference for screening-level comparisons in order to illustrate regional concentration ranges typical in ground water and for constraining major water composition types that have previously been encountered throughout the study area. The applicability of the historical data for comparison purposes is limited by the parameters for which data have been collected; for example, concentrations of organic compounds, stable isotope ratios, strontium isotope ratios, and dissolved gas concentrations are not typically available in the historical data (Bowen et al., 2015), yet these data types are critical for this study. Subsequent analysis of the historical water quality information, in relation to the new data collected for this study, provides appropriate context regarding: the geologic settings and geochemical environments, the influence of anthropogenic impacts based on environmental record searches (Appendix C), and the recognition of data quality issues (see US EPA, 2013a).

Historical ground water quality data for the Raton Basin in Colorado were gathered from Powell (1952), McLaughlin et al. (1961), Howard (1982), ESN Rocky Mountain (2003), COGCC (2003a), Dahm et al. (2011), the NWIS database (USGS, 2013a), and the NURE database (USGS, 2013b). Data from the USGS databases and the COGCC study were compared with the results from this study; other data sources were used as supporting information for the analysis of water types from the various geologic formations of the Raton Basin. Water quality data from NWIS and NURE are representative of samples collected before any significant CBM development in the Raton Basin (1951–1988); therefore, these datasets allow for aquifer comparisons before and after CBM development. The COGCC data were obtained during a survey conducted in the region from January 9–17, 2002 (COGCC, 2003a). During this survey, 100 private water sources were tested for cations, anions, trace metals, dissolved methane, and selected stable isotopes ($\delta^{13}C_{DIC}$, $\delta^{13}C_{CH4}$). The overall objective of the survey was to collect data that could be used to determine potential impacts from CBM development in the Raton Basin.

The USGS NWIS database for Las Animas County contains entries for 105 ground water locations sampled between 1951 and 1988 (USGS, 2013a). A majority of these sampling points (n = 74) are located in the western part of the county, west of Interstate 25, and are suitable for comparison based on proximity to the sampling locations of this study (see Figure 12). Water quality data mainly include major cations, anions, general parameters (e.g., pH, SPC, and alkalinity), and limited trace metal data. Water quality data are included for alluvial aquifers and for the Poison Canyon, Raton, and Vermejo formations, as well as unspecified aquifers. Ground water samples collected from wells screened in the Poison Canyon and Raton formations ranged in depth from 65 to 200 feet and 75 to 1,780 feet below land surface, respectively. Ground water samples collected from alluvial aquifers were from wells that ranged in depth from 4 to 78 feet below land surface. Seventeen of these locations were sampled more than once, and the results for these locations were averaged. Only 19 of the 74 samples were used for



Water Quality Sampling Locations
Las Animas County, Colorado
EPA Hydraulic Fracturing Study

Source: *Municipalities, ESRI; Sample Locations, EPA ORD; Water Samples: USGS and Colorado COGCC*

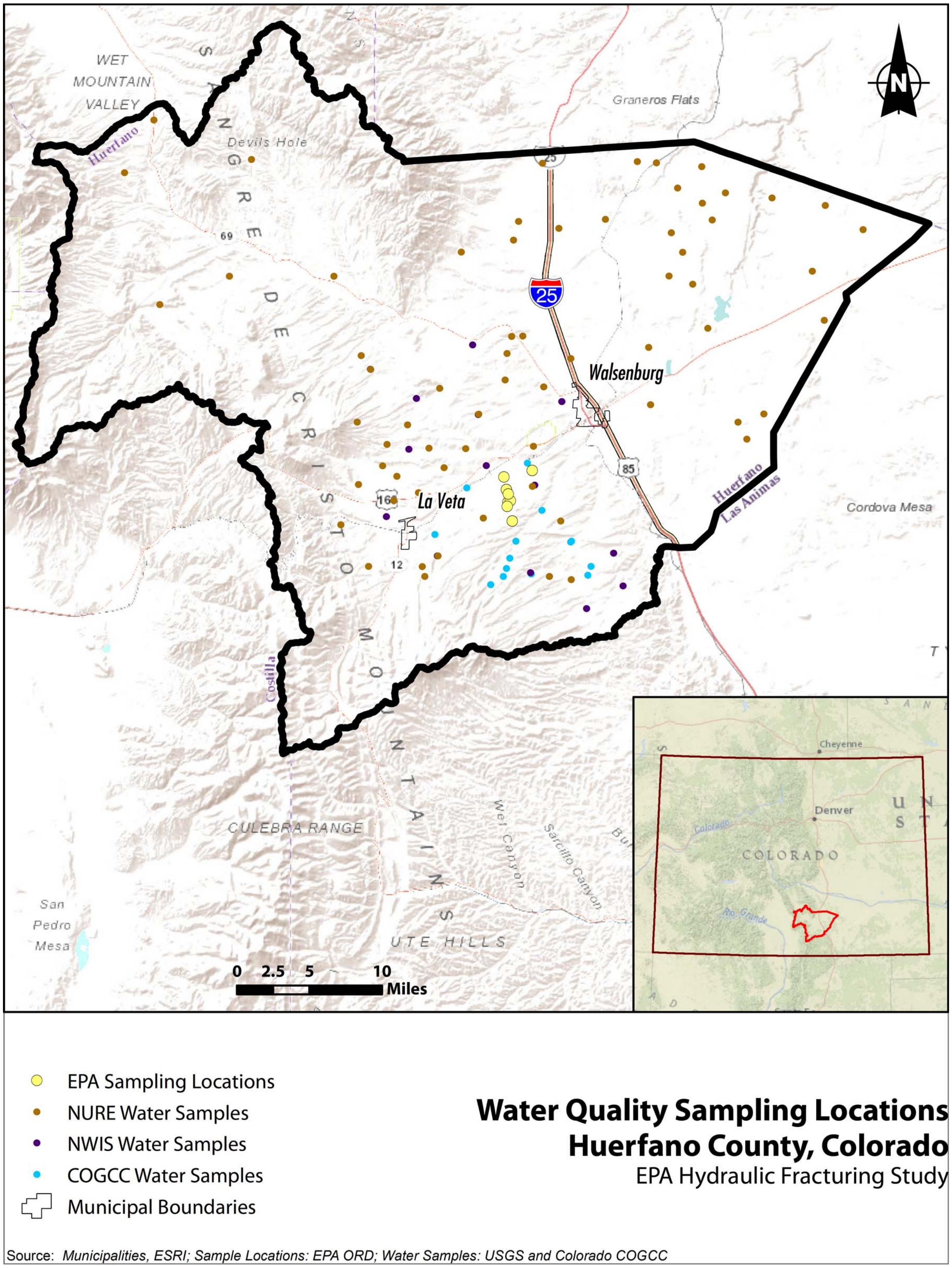
Figure 12. Map showing historical water quality sites and sampling locations from this case study: Las Animas County, CO. Water quality data from NWIS and NURE are representative of samples collected before any significant CBM development in the Raton Basin (1951—1988). The COGCC data were obtained during a survey conducted in 2002.

evaluating water types because their charge balance error was ≤15%; the charge imbalance in the remaining samples is mainly due to missing values for bicarbonate/alkalinity. Data for organic compounds, dissolved gases, and stable isotopes are not available in this dataset.

The USGS NWIS database for Huerfano County contains entries for 14 ground water locations sampled in 1979 (see Figure 13; USGS, 2013a). All of the NWIS sample locations are within 1.7 to 12.5 miles of location RBDW10 of this study. Data are available for the Farista, Cuchara, Poison Canyon, Raton, and Vermejo/Trinidad formations. Ground water samples were collected from wells ranging in depth from 25 to 320 feet below land surface (median = 100 feet). Water quality data mainly include major cations, anions, and general parameters (e.g., pH, SPC, and alkalinity); data for organic compounds, dissolved gases, and stable isotopes are not available in this dataset. All of the samples have a charge balance error ≤15% and were used for evaluating water types. One sample (1/14) was excluded from the comparison of results because of highly anomalous pH and SPC values, indicative of some impact on the water chemistry (i.e., pH=11.5 and specific conductance >8,000 µS/cm).

The USGS NURE database (USGS, 2013b) for Las Animas County includes entries for 419 locations, and a majority of these (398/419) were located in the eastern part of the county, east of Interstate 25 (see Figure 12). These entries were excluded from historical data analyses based on the distance to sampling locations within this study (western part of Las Animas County). Twenty-one locations (21/419) were west of Interstate 25 and located within 5 to 24 miles of location RBDW05 of this study. The only water quality data available from these locations are pH, SPC, and uranium concentrations. For Huerfano County, the NURE database (USGS, 2013b) contains entries for 67 ground water locations that are distributed across the county (see Figure 13). All of the samples were collected in 1976 and 1977. Twelve of the sampling locations (12/67) are within 7 miles of location RBDW10. The only water quality data available from these locations are pH, SPC, and uranium concentrations.

The locations of sampling points from the COGCC study, the NWIS and NURE databases, and this study are identified in Figures 12 (Las Animas County) and 13 (Huerfano County).



Source: *Municipalities, ESRI; Sample Locations: EPA ORD; Water Samples: USGS and Colorado COGCC*

Figure 13. Map showing historical water quality sites and sampling locations from this case study: Huerfano County, CO. Water quality data from NWIS and NURE are representative of samples collected before any significant CBM development in the Raton Basin (1976—1979). The COGCC data were obtained during a survey conducted in 2002.

6. Water Quality Data from This Study

This study was conducted to determine whether drinking water resources have been impacted by various land use activities, including those associated with CBM development and extraction. Some of the broadly framed concerns regarding possible scenarios of drinking water impairment that may be related to CBM development include: (i) potential interactions between produced water and shallow ground water via fluid migration, spills, and/or infiltration; (ii) potential for migration of chemicals used in hydraulic fracturing formulations into shallow ground water; (iii) potential gas migration from hydraulically fractured zones in the Raton and Vermejo formations into shallow ground water aquifers, including the Poison Canyon Formation and alluvial fill deposits; and (iv) secondary biogeochemical affects related to the migration and reaction of methane in shallow aquifers used for drinking water. The following sections describe the results and present interpretations of water quality testing that was completed for this study, including comparisons with, and consideration of, previous water quality data collected in the Colorado portion of the Raton Basin (USGS, 2013a; USGS, 2013b; COGCC, 2003a).

In January 2002, the COGCC conducted a field survey of 100 private wells, located within the Raton Basin, and tested for a suite of inorganic and organic parameters (COGCC, 2003a; see Figures 12 and 13 for sample locations). The overall objective of this study was to gather data that could be used to assess potential water well impacts from current and future CBM development in the Raton Basin. The COGCC study found no discernible distribution patterns among the various parameters evaluated in the survey. Some samples were noted to have elevated levels of sulfate and nitrate, and in some cases, the concentrations of these parameters exceeded drinking-water standards. An assessment of the sources and factors controlling the distribution of these ions was not included in the report. Major ion data from this study indicated that the most common ground water type encountered was the sodium-bicarbonate type (41%), followed by the calcium-bicarbonate (30%), calcium-sulfate (15%), sodium-sulfate (11%), and sodium-chloride water types (3%). These same water types were mapped in the Raton Basin in 1979 by Howard (1982), based on a field survey of 35 sampling locations located within Las Animas and Huerfano counties. Major ion water types are useful for regional characterization of water quality, comparing and evaluating water quality trends from specific geologic/hydrologic units, and for constraining sources of major ions to ground water and surface water.

Major ion trends apparent in the COGCC data are plotted on a trilinear diagram (Piper diagram) and compared to the data from this study (see Figure 14). The sodium-bicarbonate water type predominates in Las Animas County, whereas in Huerfano County, the calcium-bicarbonate and sulfate-types are the most common ground water types. The box diagrams (box plots) shown in Figure 15 compare data for pH, SPC, sodium, calcium, magnesium, barium, chloride, fluoride, sulfate, and bicarbonate from the COGCC survey with the ground water data collected during this study in Las Animas and Huerfano counties. A statistical summary of selected ground water parameters for data collected during this study and the COGCC field survey (COGCC, 2003b) is presented in Table 5. In all cases, the maximum ranges for the parameters shown in Figure 15, from this study, fall within the ranges observed in the COGCC dataset obtained in 2002 (see also Table 5). Statistical analyses using the nonparametric Kruskal-Wallis test indicated significant differences between the two datasets for pH, calcium, magnesium, barium, fluoride, and bicarbonate (p-value <0.05). In most cases, the statistical differences are due to higher mean/median values in the COGCC dataset compared to the data collected for this study. Statistically similar concentration distributions (p-values >0.57) were noted for sodium, chloride, and sulfate.

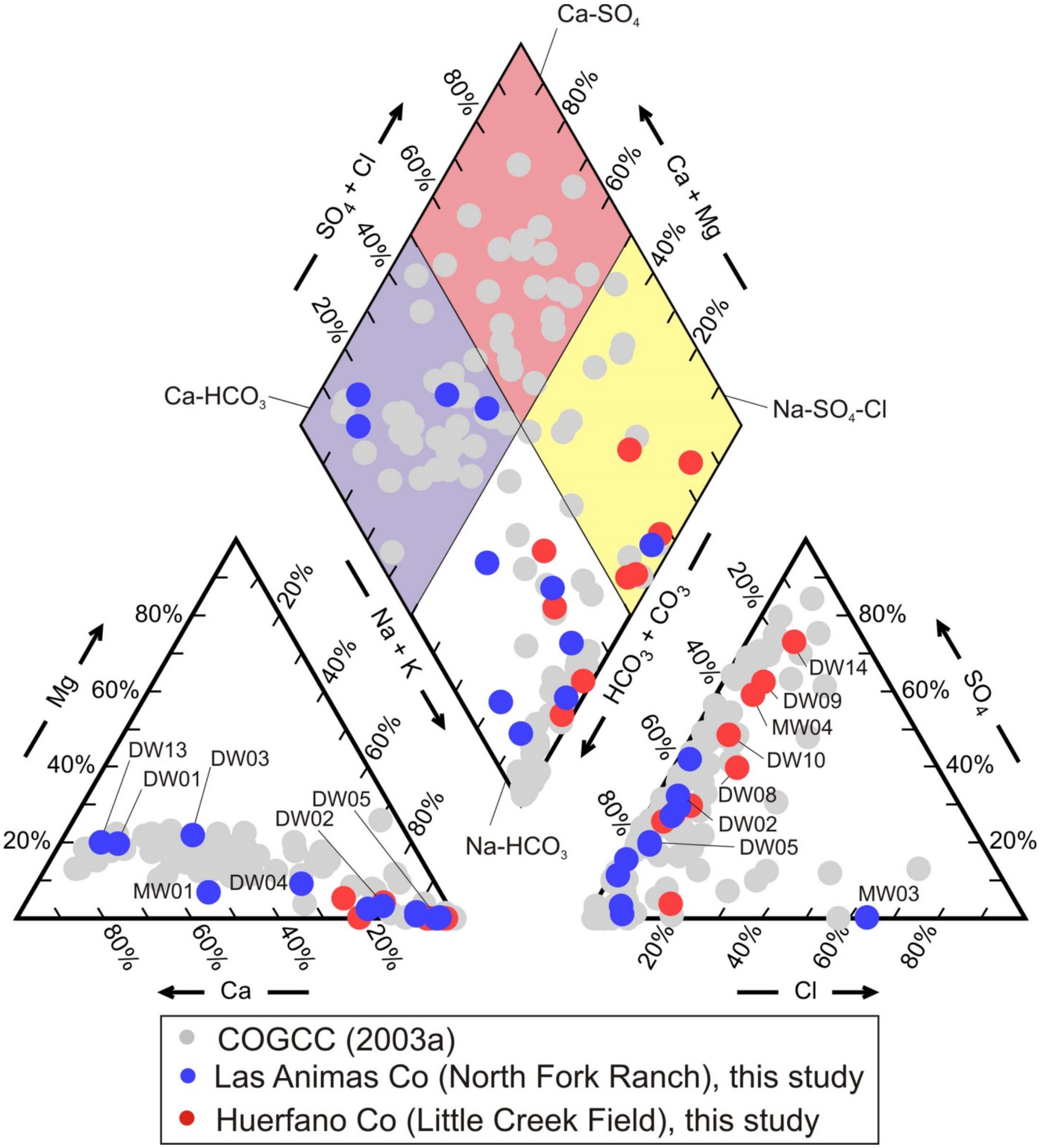


Figure 14. Major ion chemistry of ground water samples collected within the Raton Basin, CO. The trilinear diagram contains data collected during this case study and by the COGCC during a survey conducted in the region in 2002 (COGCC, 2003a).

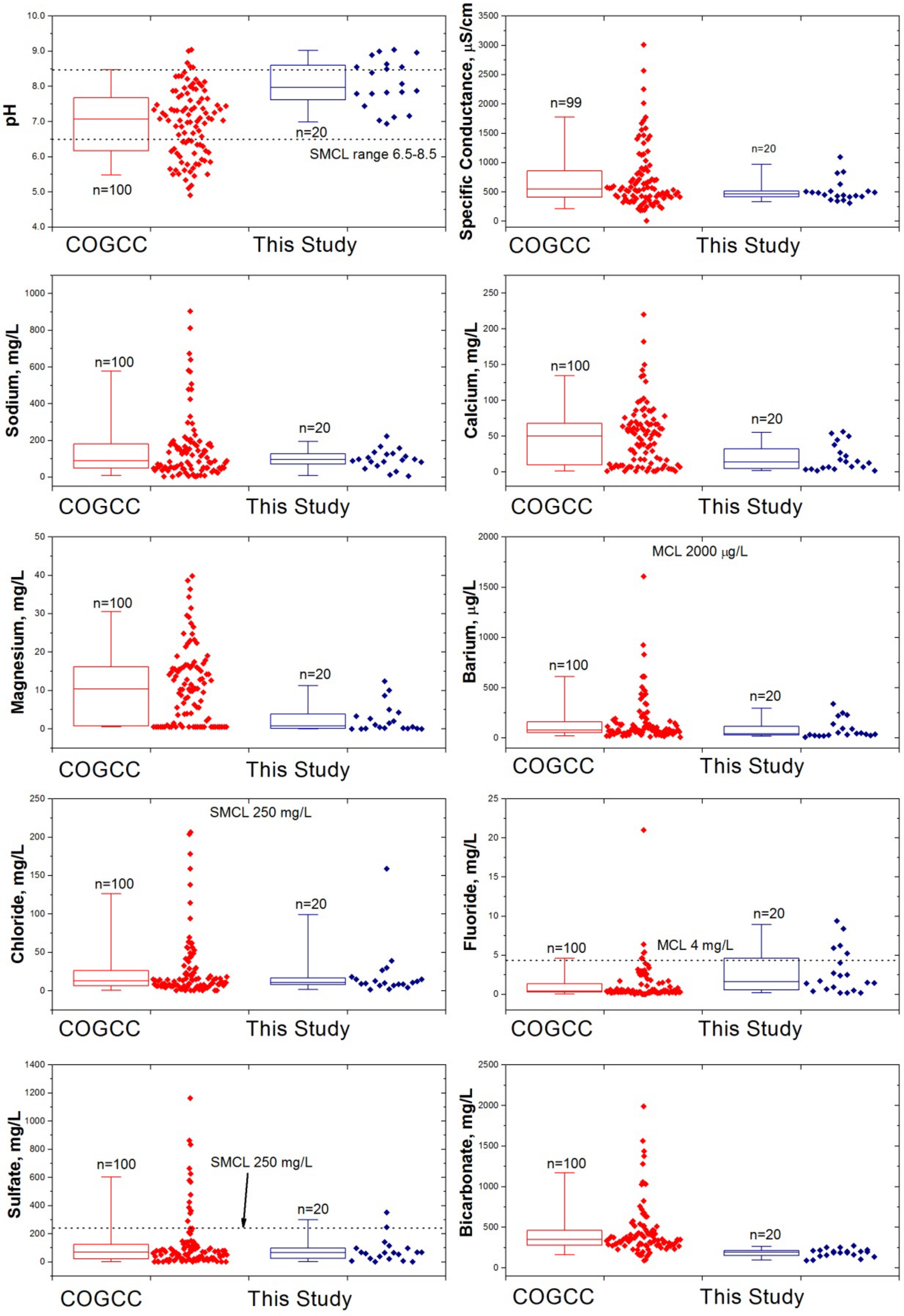


Figure 15. Box diagrams comparing the concentration distributions of selected major cations, anions, and geochemical parameters from water samples collected in Las Animas and Huerfano counties during this study (mean values) to data reported by the COGCC following a survey conducted in 2002 (COGCC, 2003a).

Table 5. Summary statistics for ground water data collected during this study (20 locations) and a survey by the Colorado Oil and Gas Conservation Commission (COGCC) in Las Animas and Huerfano Counties, CO (100 locations; COGCC, 2003a).

Parameter	Data Source	Units	Mean	Median	SD	Min	Max	*n =*
pH	This study[1]		8.1	8.0	0.69	6.9	9.0	20
	COGCC		7.0	7.1	0.97	4.9	9.0	100
SPC	This study	*µS/cm*	521	468	194	314	1100	20
	COGCC	*µS/cm*	725	548	533	7	3008	99
DO	This study	*mg/L*	1.4	1.2	1.1	0.07	3.4	20
	COGCC	*mg/L*	4.3	4.3	2.6	0.7	14.4	98
Sodium, Dissolved	This study	*mg/L*	98	96	53	6.9	223	20
	COGCC	*mg/L*	154	90	175	3.2	904	100
Potassium, Dissolved	This study	*mg/L*	0.7	0.7	0.5	0.2	2.4	20
	COGCC	*mg/L*	1.5	1.3	1.0	<1.0[2]	5.0	100
Calcium, Dissolved	This study	*mg/L*	20	14	19	2.0	56	20
	COGCC	*mg/L*	49	50	42	<3.0	220	100
Magnesium, Dissolved	This study	*mg/L*	2.7	0.8	3.7	<0.03	12	20
	COGCC	*mg/L*	11	10	9.9	<1.0	40	100
Barium, Dissolved	This study	*µg/L*	90	43	95	11	340	20
	COGCC	*µg/L*	165	81	228	10	1610	100
Chloride, Dissolved	This study	*mg/L*	20	11	34	1.6	159	20
	COGCC	*mg/L*	27	13	41	<1.0	207	100
Sulfate, Dissolved	This study	*mg/L*	80	66	86	0.9	351	20
	COGCC	*mg/L*	133	69	203	<1.0	1164	100
Fluoride, Dissolved	This study	*mg/L*	2.8	1.6	2.8	0.2	9.4	20
	COGCC	*mg/L*	1.3	0.4	2.4	<0.1	21	100
Bicarbonate, Dissolved	This study	*mg/L*	185	193	51	94	276	20
	COGCC	*mg/L*	441	348	314	93	1943	100

[1] Statistical data from this study include all domestic wells and monitoring wells screened in alluvium and the Poison Canyon Formation; excluded are surface water and produced water collected from the Raton Formation and the Vermejo Formation.

[2] Summary statistics were computed by setting non-detect values to one half of the reporting limit. For this study, left-censored data were used for magnesium for one sample (1/20). For the COGCC (2003a) dataset, this was done for potassium (33/100), calcium (7/100), magnesium (25/100), chloride (7/100), sulfate (6/100), and fluoride (1/100); thus, left-censored values account for <50% of the data for these elements.

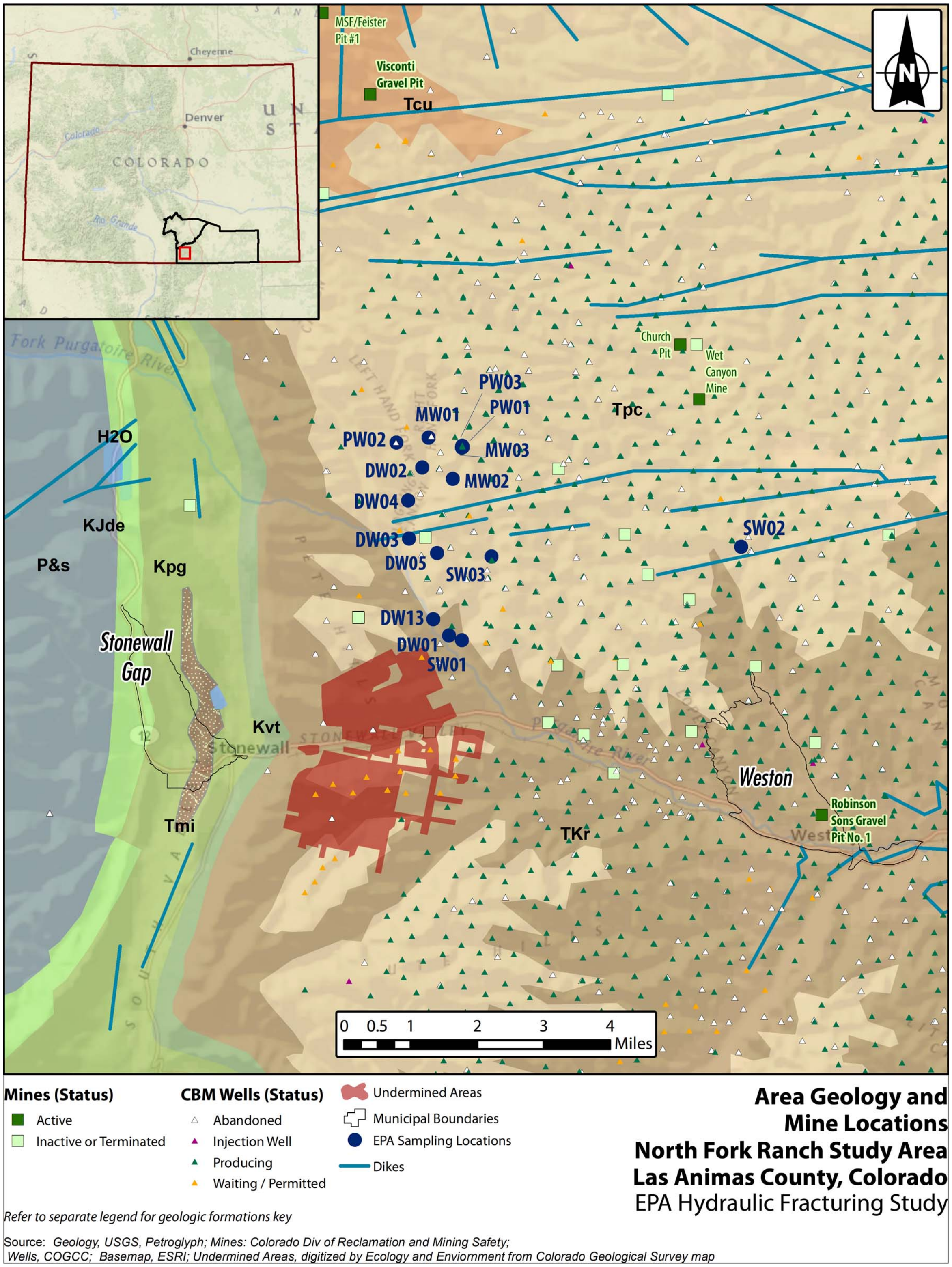
The following sections describe the results for water quality samples collected during this study in Las Animas and Huerfano counties in more detail, including a discussion of literature data and water quality data collected prior to CBM development in the Raton Basin.

6.1. CBM Produced Water

Formation waters associated with CBM in the Rocky Mountain region have distinct geochemical signatures: CBM water is typically the sodium-bicarbonate type, with variable chloride concentrations, and low sulfate, calcium, and magnesium (e.g., Van Voast, 2003; Dahm et al., 2011). When compared to produced water from conventional oil and gas resources, CBM produced water tends to be low in TDS, with values ranging from 370 to 43,000 mg/L; conventional oil and gas formation water has TDS values ranging from 1,000 to 400,000 mg/L (Dahm et al., 2011). During this study, formation water was collected from three production wells, representing the Raton Formation (RBPW01, Sanchinator #11-36TR) and Vermejo Formation (RBPW02, Keystone #11-35; RBPW03, Sanchinator #11-36). These production wells, operated by Pioneer Natural Resources, are located within the North Fork Ranch study area in Las Animas County (see Figure 16A and 16B). A summary of key results for the production wells sampled in this study is provided in Table 6. In addition, major cation and anion data for these production wells are plotted on a Schoeller diagram in Figure 17 and compared to the compositional range (minimum, maximum, and average) reported for CBM waters from the Raton Basin, as compiled by Dahm et al. (2011).

The water quality syntheses of Dahm et al. (2011) included 2,116 well entries from the Raton Basin; a majority of the samples showed diagnostic sodium-bicarbonate type composition. Comparatively, the production wells sampled during this study show major ion concentrations that were below average for Raton Basin CBM water (see Figure 17). These wells show particularly low sulfate concentrations, relative to mean sulfate concentrations in produced water from the Raton Basin (Dahm et al., 2011), which is typical for waters associated with CBM production (Van Voast, 2003). The major ion pattern displayed in Figure 17 is considered to be the result of biochemical sulfate reduction; consequent enrichment of bicarbonate; and precipitation of calcium carbonate, magnesium carbonate, and/or gypsum (Van Voast, 2003; Rice et al., 2008). Ground water from both the Raton and Vermejo formations has a geochemical signature consistent with reducing environments, including low dissolved oxygen concentration (<1 mg/L); low uranium concentration (<0.2 µg/L); low ORP (<-225 mV); and elevated concentrations of methane, iron, and manganese (see Table 6). Arsenic concentrations in the produced water from this study were low, below 0.5 µg/L (see Table 6). Lithium concentrations were notably higher in the produced water (>30 µg/L) compared to the levels detected in shallower aquifers (<10 µg/L). The gas composition was also characteristically dry, with a molar [CH_4/C_2H_6] ratio ranging from about 310 to 5,930.

Constituents and parameters in CBM water that sometimes exceed standards for drinking, livestock, and irrigation water applications included TDS, sodium adsorption ratio (SAR), temperature, pH, iron, and fluoride (Dahm et al., 2011). The production wells sampled in this study had TDS values generally >500 mg/L (estimated from SPC); mean fluoride concentrations that ranged from 2.6 to 3.6 mg/L; pH that ranged from 8.0 to 8.5; and SAR values that ranged from 33 to 66 $(\text{mequiv/L})^{½}$ (see Table 6). High SAR values are a potential concern for water discharged at the surface because Na^+-enriched water in soil can cause cation exchange by replacing Ca^{2+} with Na^+, which impacts properties of clay minerals in soil (McBeth et al., 2003; Engle et al., 2011). SAR values <13 are recommended for irrigation water purposes (Fipps, 2003; Dahm et al., 2011).



Refer to separate legend for geologic formations key

Source: *Geology, USGS, Petroglyph; Mines: Colorado Div of Reclamation and Mining Safety; Wells, COGCC; Basemap, ESRI; Undermined Areas, digitized by Ecology and Enviornment from Colorado Geological Survey map*

Figure 16A. Map of the North Fork Ranch study area (Las Animas County, CO) showing bedrock geology, historic coal mine locations, coalbed methane well locations, and sample locations from this study. See Figure 16B for geology legend.

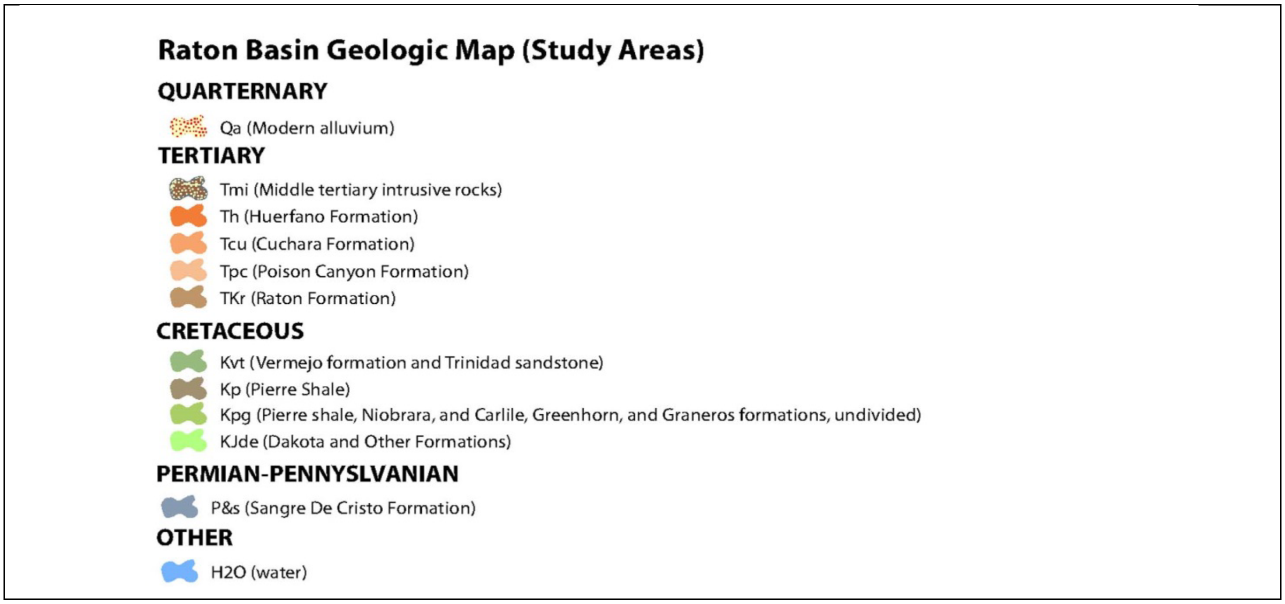


Figure 16B. Geology map legend.

Table 6. Summary of selected results for production wells sampled during this study (North Fork Ranch, Las Animas County).

Parameter	Units	RBPW01 Sanchinator #11-36TR		RBPW02 Keystone #11-35		RBPW03 Sanchinator #11-36	
Round[1]		1,2,3,4		1		2,3,4	
pH		8.40	(0.15)[2]	8.49		7.96	(0.32)[2]
SPC	*µS/cm*	1744	(362)	666		1294	(147)
DO	*mg/L*	0.9	(0.6)	0.2		0.4	(0.3)
ORP	*mV*	-229	(79)	-353		-268	(87)
TDS	*mg/L*	1134	(236)	434		841	(97)
Alkalinity	*mg/L*	893	(45)	478		542	(49)
Sodium[3]	*mg/L*	467	(48)	240	J[4]	332	(23)
Potassium	*mg/L*	2.7	(0.48)	0.43	J	1.0	(0.31)
Lithium[5a]	*µg/L*	33		NM[5b]		47	
Calcium	*mg/L*	2.6	(0.15)	3.3		7.2	(0.59)
Magnesium	*mg/L*	0.74	(0.09)	0.07	J	0.31	(0.02)
Strontium	*µg/L*	360	(37)	270		741	(31)
Barium	*µg/L*	578	(71)	53	J	215	(101)
Chloride	*mg/L*	112	(25)	27.5		161	(26)
Sulfate	*mg/L*	<1.0		<1.0		0.51	(0.42)[6]
Fluoride	*mg/L*	3.6	(0.74)	2.6		3.0	(0.36)
Bromide	*mg/L*	<1.0		<1.0		<1.0	

Table 6. Summary of selected results for production wells sampled during this study (North Fork Ranch, Las Animas County).

Parameter	Units	RBPW01 Sanchinator #11-36TR		RBPW02 Keystone #11-35		RBPW03 Sanchinator #11-36	
Nitrate+Nitrite	*mg - N/L*	<0.10		<0.05		<0.10	
Ammonium	*mg - N/L*	0.61	(0.08)	0.31		0.44	(0.07)
DOC	*mg/L*	1.1	(0.12)	0.97		1.2	(0.18)
Silicon	*mg/L*	6.9	(0.44)	10.3	J	10.9	(0.35)
Iron	*µg/L*	2000	(94)	2690		7700	(4962)
Manganese	*µg/L*	30	(2.3)	38		121	(20)
Arsenic	*µg/L*	0.33	(0.25)	--		0.36	(0.26)
Uranium	*µg/L*	<0.20		--		<0.20	
CH_4	*mg/L*	20.88	(4.94)	14.80		21.87	(6.22)
C_2H_6	*mg/L*	0.0066	(0.0007)	0.0893		0.0141	(0.0037)
$\delta^{13}C_{CH4}$	*‰*	-52.30	(0.31)	-47.67		-45.99	(0.61)
$\delta^{2}H_{CH4}$	*‰*	-234.2	(3.3)	-233.1		-222.1	(1.1)
$\delta^{13}C_{DIC}$	*‰*	16.8	(0.8)	1.2		9.7	(3.1)
SAR (mean)[7]	*(mequiv/L)*$^{\frac{1}{2}}$	66		36		33	

[1] Sampling round: 1 = October 2011; 2 = May 2012; 3 = November 2012; 4 = April/May 2013.
[2] Mean values are tabulated; values in parentheses are 1 standard deviation.
[3] Results for filtered (dissolved) samples are provided.
[4] J = The analyte was positively identified; the associated numerical value is the approximate concentration. See Table A28, Appendix A, for more detailed descriptions.
[5a] Lithium was determined in samples collected during the November 2012 and April/May 2013 events only.
[5b] NM = Not measured.
[6] Left-censored data were used for one sample (1/3).
[7] SAR = Sodium Adsorption Ratio, calculated using the equation: $[Na/(0.5[Ca+Mg])^{0.5}]$, with concentrations in mequiv/L.

Geochemical modeling indicates that ground water from the production wells sampled during this study is close to equilibrium with respect to calcium carbonate, i.e., the calcite saturation index ranged from -0.11 (RBPW03) to 0.08 (RBPW02). Calcite saturation indices that are 0.0 ± 0.1 are typically representative of equilibrium conditions (Langmuir, 1997). The $\delta^{13}C_{DIC}$ values from the produced water indicate ^{13}C enrichment (1.2‰ to 16.8‰; see Table 6), which results from evolved water-rock interactions and bicarbonate generated from the mineralization of organic carbon (Sharma and Frost, 2008; Golding et al., 2013), as discussed in a following section. The methane isotopic signature of the produced gas is also discussed in a later section ("Molecular and Isotopic Composition of Coalbed Methane") and compared to the methane signatures detected in samples collected from shallow aquifers used for drinking water.

Compositional data from the three production wells sampled in this study are plotted on a trilinear diagram and compared to compositions of ground water in the Raton Basin determined in the COGCC survey (see Figure 18). Compositional data for the production wells plot close to the sodium and bicarbonate vertices of the cation and anion ternary plots, respectively.

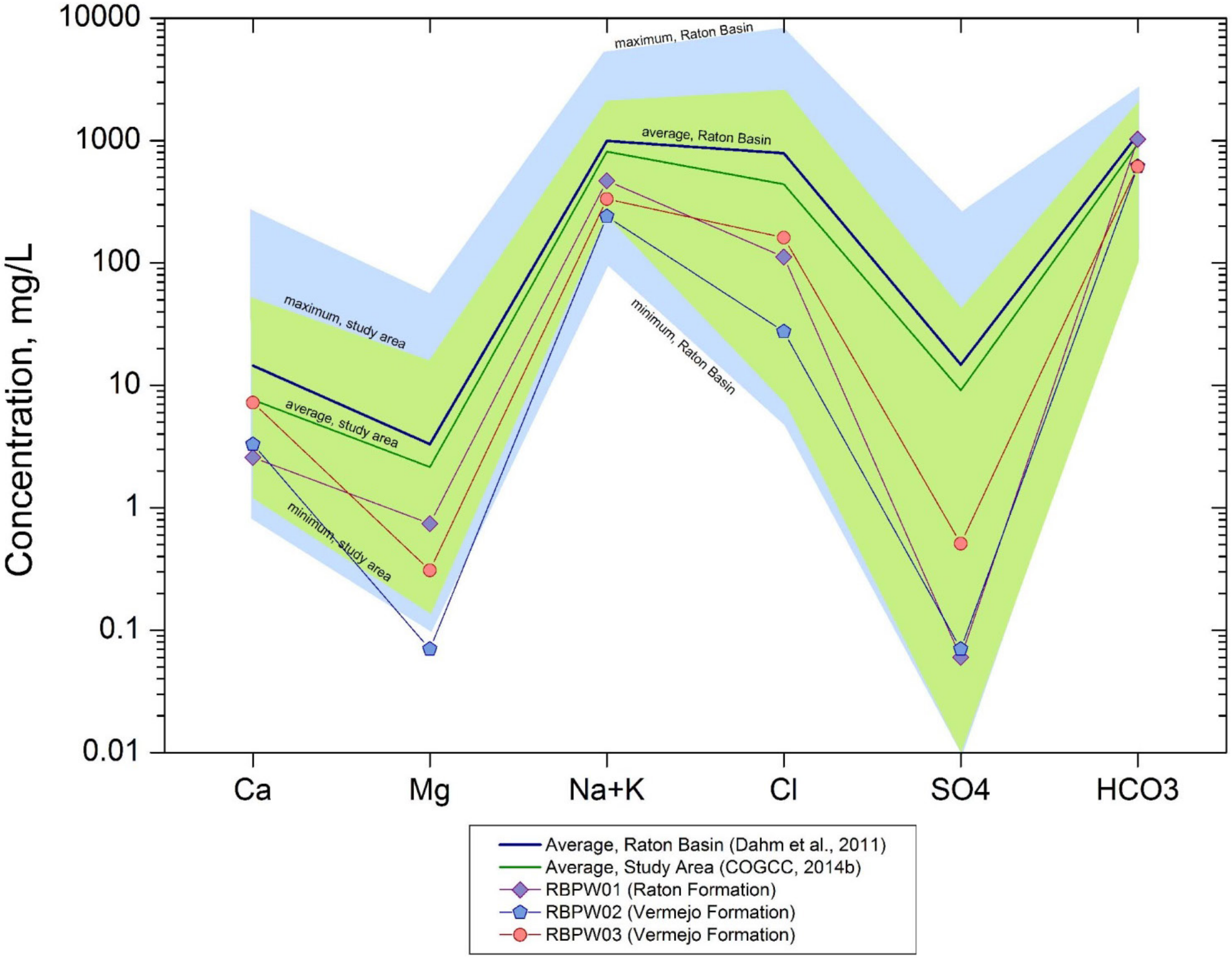


Figure 17. Schoeller diagram showing major cation and anion compositions measured in formation water collected from three CBM production wells (RBPW01, RBPW02, RBPW03; mean values) during this case study, compared to the compositional range (minimum, maximum, and average) reported for CBM waters from the Raton Basin (blue; Las Animas and Huerfano counties), as compiled by Dahm et al. (2011), and within a 3-mile radius of sampling locations in Las Animas County (green; COGCC, 2014b).

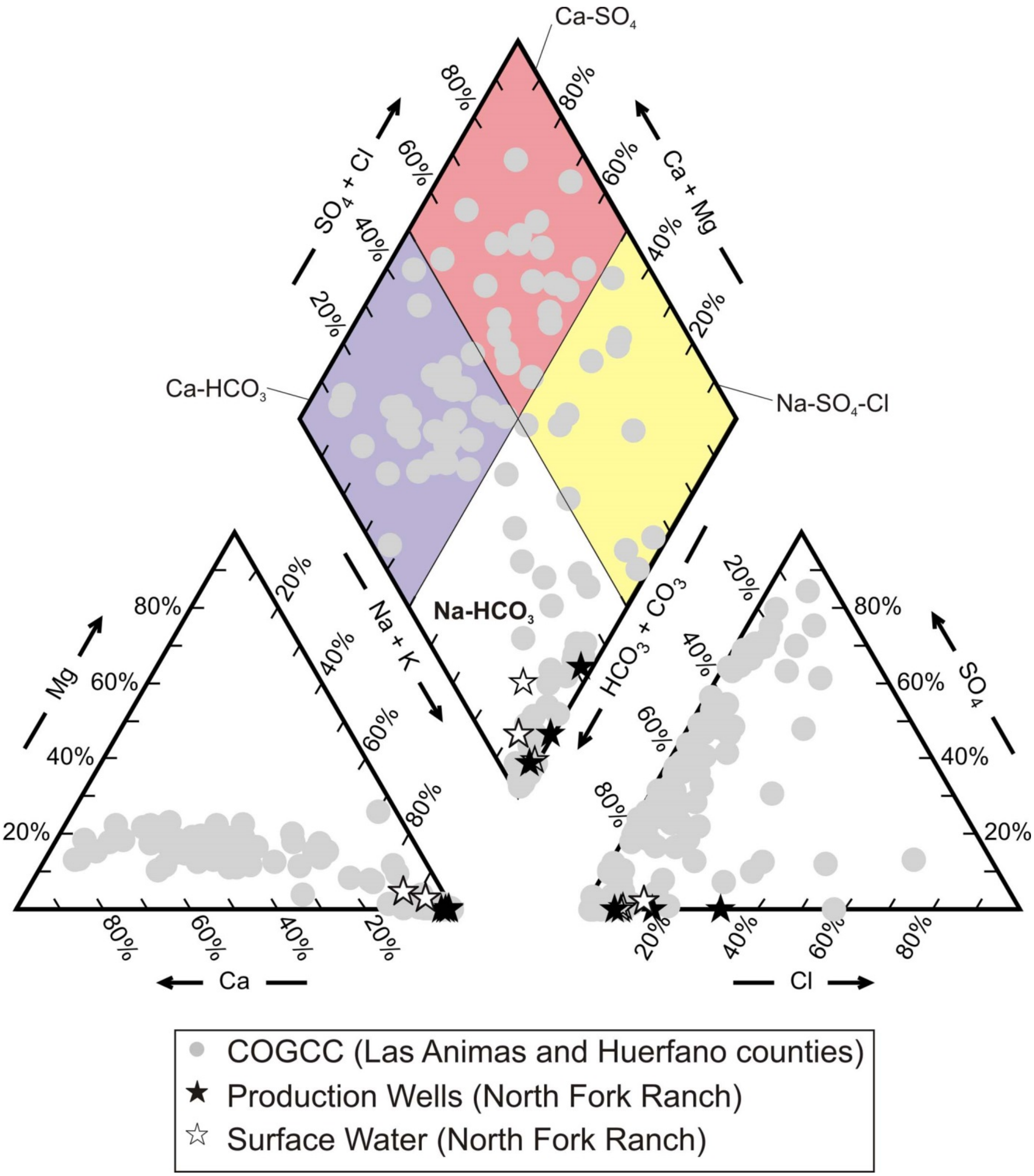


Figure 18. Major ion chemistry of ground water samples collected from CBM production wells (RBPW01, RBPW02, and RBPW03) and surface water locations (RBSW01, RBSW02, and RBSW03) within the North Fork Ranch study area (Las Animas County, CO) during this case study. The trilinear diagram also includes data obtained by the COGCC during a survey conducted in the region in 2002 (COGCC, 2003a).

6.2. Surface Water

Surface waters were sampled in part to establish potential linkages, if any, between observed ground water quality and nearby surface water quality. The streams sampled in this study receive significant discharges of produced water. Surface water location RBSW03 was, in fact, at a point of produced water collection and permitted discharge; surface water locations RBSW01 and RBSW02 were positioned further downstream from discharge points. Location RBSW01 is within the same drainage system as RBSW03. The compositions of the surface water and production well samples are also shown on a trilinear diagram (see Figure 18), with comparison to compositions of ground water in the Raton Basin determined in the COGCC survey (COGCC, 2003a). The surface water samples show sodium-bicarbonate type compositions similar to the produced water, as was expected since produced water is discharged to the stream. Mean SPC values from the three surface water locations ranged from 1,252 to 1,585 µS/cm (see Table 7). Dissolved oxygen concentrations ranged from 0.2 mg/L at the point of discharge to 8.2 mg/L further downstream at location RBSW01. Surface water at the discharge point (RBSW03) showed a reducing signature: low oxygen, low oxidation-reduction potential, low sulfate, and elevated concentrations of iron and methane (see Table 7). Low levels of dissolved methane persisted further down gradient at locations RBSW01 and RBSW02. Values of $\delta^{13}C_{DIC}$ were positive at all locations, indicating that the DIC was predominantly derived from produced water. In addition, lithium concentrations were similar to levels detected in the produced water (24-66 µg/L; see Table 7). Sodium concentrations at the three surface water locations were comparable; however, the concentrations of calcium and magnesium increased further down gradient, and the SAR showed corresponding decreases to mean values of 19 and 14 at locations RBSW01 and RBSW02, respectively (see Table 7).

Table 7. Summary of selected results for surface water locations sampled during this study (North Fork Ranch, Las Animas County).

Parameter	Units	RBSW01		RBSW02		RBSW03	
Round[1]		1,2,3,4		2,3,4		2,3,4	
pH		8.78	(0.39)[2]	8.05	(0.24)	8.31	(0.11)
SPC	*µS/cm*	1252	(108)	1585	(123)	1345	(184)
DO	*mg/L*	8.2	(1.5)	5.5	(0.5)	0.2	(0.2)
ORP	*mV*	177	(111)	69	(12)	-306	(23)
TDS	*mg/L*	814	(75.5)	1030	(80.3)	874	(121)
Alkalinity	*mg/L*	659	(27)	763	(42)	704	(20)
Sodium[3]	*mg/L*	315	(27)	356	(40)	361	(31)
Potassium	*mg/L*	1.7	(0.26)	2.5	(0.23)	1.9	(0.25)
Lithium[4]	*µg/L*	40		24		66	
Calcium	*mg/L*	12.7	(2.4)	30.7	(4.2)	2.6	(0.27)
Magnesium	*mg/L*	5.1	(0.62)	11.7	(0.70)	0.32	(0.01)
Strontium	*µg/L*	333	(40)	640	(65)	282	(7.5)
Barium	*µg/L*	94	(26)	120	(4)	299	(47)
Chloride	*mg/L*	45.4	(4.8)	87.4	(5.0)	47.0	(5.0)

Table 7. Summary of selected results for surface water locations sampled during this study (North Fork Ranch, Las Animas County).

Parameter	Units	RBSW01		RBSW02		RBSW03	
Sulfate	*mg/L*	3.6	(1.5)	21.2	(2.1)	0.2 [5]	
Fluoride	*mg/L*	3.1	(0.1)	2.5	(0.1)	4.2	(0.4)
Bromide	*mg/L*	<1.0		<1.0		<1.0	
Nitrate + Nitrite	*mg - N/L*	0.07	(0.10)[5]	0.05	(0.08)[5]	<0.01	
Ammonium	*mg - N/L*	<0.02		<0.02		0.35	(0.07)
DOC	*mg/L*	2.0	(0.5)	2.6	(0.6)	1.4	(0.5)
Silicon	*mg/L*	6.7	(0.41)	5.7	(0.24)	8.5	(0.50)
Iron[6]	*µg/L*	--		--		555	(117)
Manganese	*µg/L*	1.6	(0.51)	60	(26)	14	(3)
Arsenic	*µg/L*	0.32	(0.20)[5]	0.28	(0.18)[5]	0.91	(1.0)
Uranium	*µg/L*	1.5	(0.15)	3.4	(0.61)	<0.15	
CH_4	*mg/L*	0.0012		0.0144	(0.0067)	15.57	(0.87)
C_2H_6	*mg/L*	<0.0027		<0.0027		0.0069	(0.0005)
$\delta^{13}C_{CH4}$	*‰*	--		--		-52.64	(1.35)
$\delta^{2}H_{CH4}$	*‰*	--		--		-232.8	(3.5)
$\delta^{13}C_{DIC}$	*‰*	4.46	(0.31)	8.13	(0.69)	9.00	(1.19)
SAR (mean)[7]	$(mequiv/L)^{1/2}$	19		14		56	

[1] Sampling round: 1 = October, 2011; 2 = May, 2012; 3 = November, 2012; 4 = April/May, 2013.

[2] Mean values are tabulated; values in parentheses are 1 standard deviation.

[3] Results for filtered (dissolved) samples are provided.

[4] Lithium was determined in samples collected during the November 2012 and April/May 2013 events only.

[5] Use of left-censored data: sulfate in RBSW03 (2/3); nitrate + nitrite in RBSW01 (1/3) and RBSW02 (1/3); and arsenic in RBSW01 (1/3) and RBSW03 (1/3).

[6] Dissolved iron was detected in fewer than 50% of the samples collected at locations RBSW01 and RBSW02.

[7] SAR = Sodium Adsorption Ratio, calculated using the equation: $[Na/(0.5[Ca+Mg])^{0.5}]$, with concentrations in mequiv/L.

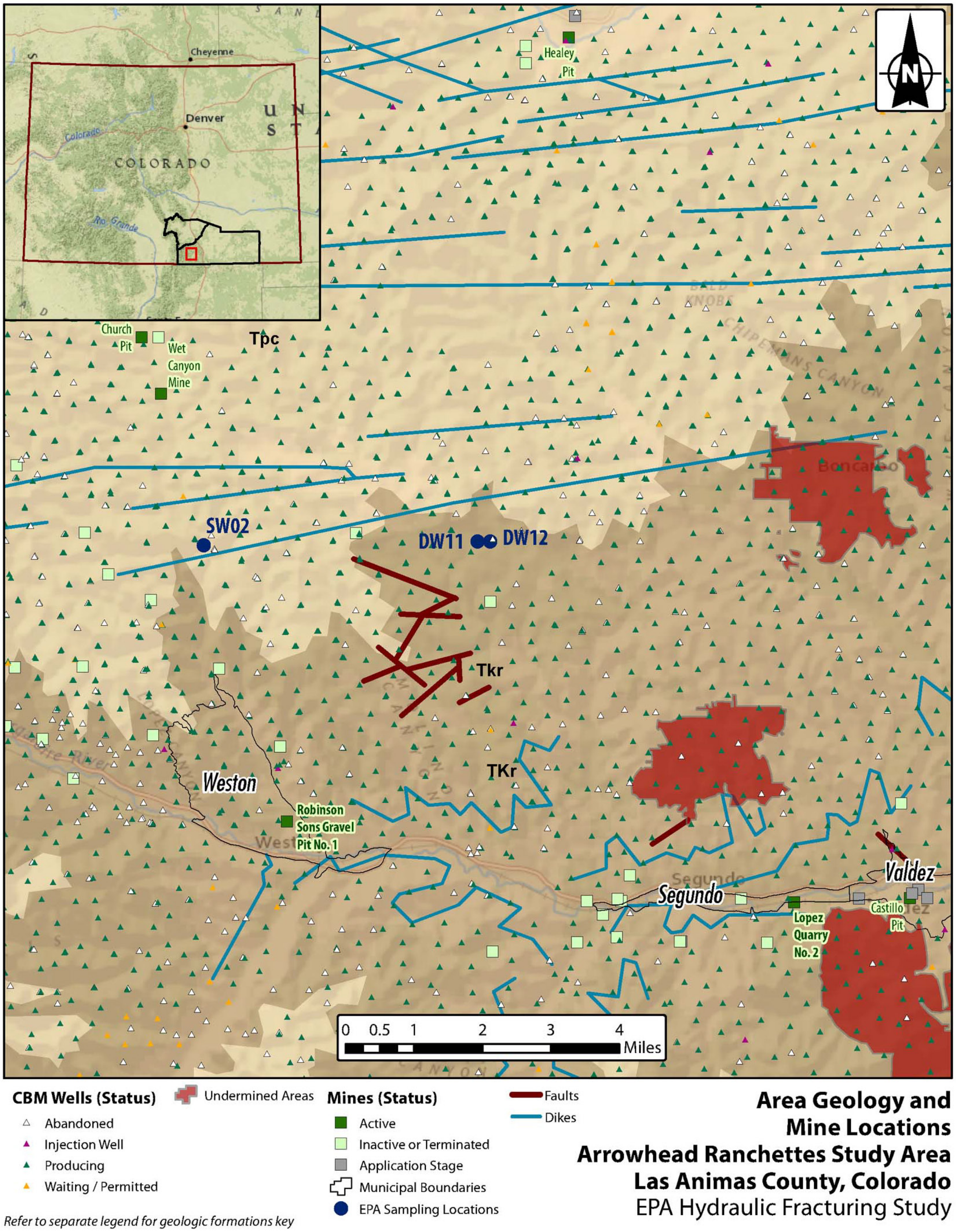
6.3. Las Animas County: Poison Canyon Formation and Alluvial Aquifers

Water wells sampled in the North Fork Ranch and Arrowhead Ranchette areas ranged in depth from 60 to 585 feet below land surface, with a median depth of 140 feet (see Figures 16A, 16B, and 19). Elevations of the bottom of production wells and domestic wells in the North Fork Ranch sampling area (within Search Area C; Figure 10) are compared in Figure 20. Most of the production wells in this area are completed to a total depth between 4,800 and 6,200 feet above mean sea level; whereas, domestic wells are completed to a total depth >7,000 feet above mean sea level. The mean separation distance between gas-producing intervals and domestic water-supply use was 2,360 feet, which generally agrees with the evaluation of vertical separation between production intervals and water-supply wells in this area of Las Animas County (Watts, 2006b). The domestic wells and monitoring wells were screened in alluvial deposits or in the Poison Canyon/Raton Formation (see Table 3). Turbidity, dissolved oxygen, pH, SPC, and ORP were measured in the field during the collection of water samples. The mean temperature of well water from the four sampling rounds ranged from 8.9 to 15.5 degrees Celsius (°C), with a median temperature of 12.2 °C (see Table 8). Turbidity ranged from 0.7 to 22 nephelometric turbidity units (NTU), with a median of 1.3 NTU, a turbidity value representative of very clear water. Dissolved oxygen concentrations were generally suboxic, ranging from 0.1 to 3.4 mg/L, with a median of 1.2 mg/L. The shallower alluvial aquifer tended to have higher levels of dissolved oxygen (3.2 ± 0.4 mg/L; n = 2) compared to the Poison Canyon and Raton formations (1.1 ± 1.0 mg/L; n = 9).

The mean SPC value of well water ranged from 314 to 846 µS/cm, with a median value of 433 µS/cm. The alluvial aquifers had lower and less variable SPC values (339 ± 35 µS/cm; n = 2) compared to the Poison Canyon and Raton formations (480 ± 144 µS/cm; n = 9). Note that the SPC of water from alluvium and the Poison Canyon Formation was typically lower than the produced water from the Raton and Vermejo formations (1,235 ± 542 µS/cm; n = 3). Figure 21 presents a series of histograms of SPC data collected in this study and pre-CBM values from the NURE and NWIS datasets for Las Animas County. The NURE data cannot be differentiated based on geologic formation. Data collected from this study are within the ranges apparent in historical data, indicating that no significant shifts in major ion compositions can be discerned. Statistical analysis reveals that SPC values in the Poison Canyon Formation, as determined in this study and in the pre-CBM NWIS dataset, are not significantly different (p-value = 0.30; Kruskal-Wallis).

Additional comparisons between data collected in this study and pre-CBM data (NWIS; USGS, 2013a) for pH and selected major ions (chloride, sulfate, fluoride, sodium, calcium) are shown in Figure 22. Major ion concentration data and pH data are plotted with respect to the dataset origin (i.e., NWIS or this study), and further categorized by aquifer formation. Note that for all the parameters shown, the range of data collected from alluvial aquifers was similar while results for ground water samples obtained from the Poison Canyon aquifer showed greater variability. There were no apparent differences in the range of sulfate concentrations between data from this study and the pre-CBM NWIS data (p-value = 0.96; Kruskal-Wallis). The NWIS dataset for the Poison Canyon Formation shows wider ranges of concentrations of chloride, sodium, and calcium, as compared to data from this study, with no statistical similarities (p-values <0.05; Kruskal-Wallis). Data from this study showed pH values in the Poison Canyon Formation that ranged from 6.9 to 8.6, with a median of 7.8; in comparison, the NWIS data show a lower range (6.6 to 7.8; median 7.3).

One monitoring well sampled in this study (RBMW03) had elevated levels of fluoride and chloride. Monitoring well RBMW03 is a low-yielding well and represents a stagnant or very slow-moving ground water environment. Enrichment of univalent anions and cations such as Cl^-, F^-, and Na^+ sometimes occurs in such environments due to membrane effects that result in the enrichment of univalent anions and the preferential uptake of divalent cations by clay minerals (Howard, 1982). The water composition of RBMW03 was consistently sodium-chloride type (see Figure 14), which was unique in this study and rare when compared to previous data collected in the Raton Basin. For example, only 3% of the samples from the COGCC survey (COGCC, 2003a) study had the sodium-chloride water type. Other aspects of the ground water composition from this well are discussed in following sections.



Source: *Geology, USGS, Petroglyph; Mines: Colorado Div of Reclamation and Mining Safety; Wells, COGCC; Basemap, ESRI*

Figure 19. Map of the Arrowhead Ranchettes study area (Las Animas County, CO) showing bedrock geology, historic coal mine locations, coalbed methane well locations, and sample locations (RBDW11, RBDW12) from this study. See Figure 16B for the geology legend.

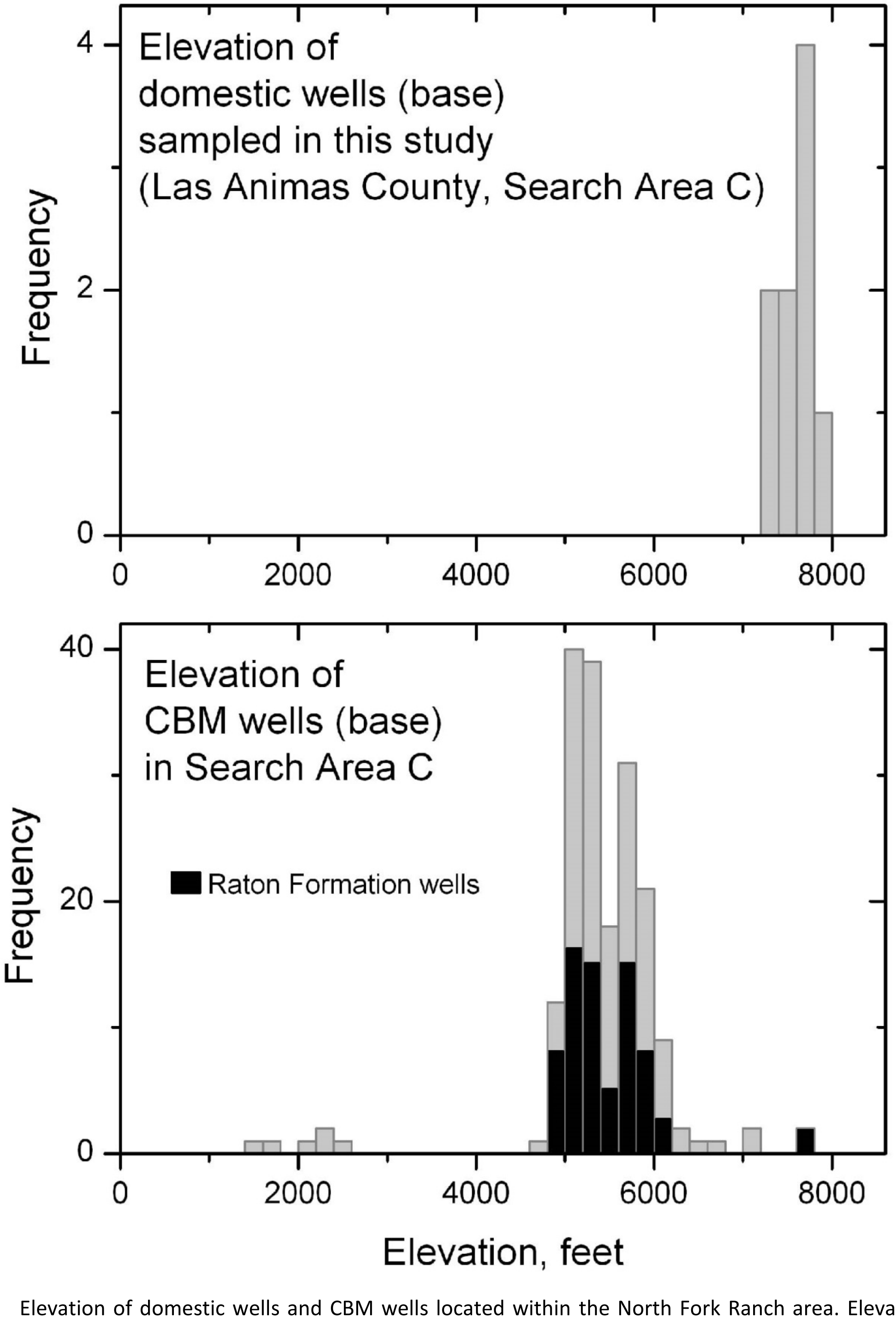


Figure 20. Elevation of domestic wells and CBM wells located within the North Fork Ranch area. Elevations are the height of well bases above mean sea level. The histograms show the vertical separation, in feet, between drinking water aquifers and gas producing zones.

Table 8. Summary statistics for ground water data collected during this study (11 locations) and historical data from the NWIS database for Las Animas County, CO (18 locations; USGS, 2013a).

Parameter	**Data Source**	**Units**	**Mean**	**Median**	**SD**	**Min**	**Max**	***n =***
pH	This study[1]		7.7	7.8	0.61	6.9	8.6	11
	NWIS		7.2	7.3	0.32	6.6	7.8	18
SPC	This study	*µS/cm*	454	433	141	314	846	11
	NWIS	*µS/cm*	802	510	787	280	3380	18
DO	This study	*mg/L*	1.7	1.2	1.2	0.1	3.4	11
Temperature	This study	*°C*	12.2	12.2	2.1	8.9	15.5	11
Turbidity	This study	*NTU*	4.6	1.3	6.8	0.7	22	11
Alkalinity	This study	*mg/L*	174	160	28	144	228	11
	NWIS	*mg/L*	256	214	140	143	522	6
Sodium, Dissolved	This study	*mg/L*	74	86	49	6.9	167	11
	NWIS	*mg/L*	93	36	137	9.8	530	15
Potassium, Dissolved	This study	*mg/L*	0.8	0.7	0.3	0.5	1.3	11
	NWIS	*mg/L*	2.4	2.0	1.7	0.8	6.5	15
Calcium, Dissolved	This study	*mg/L*	26	18	21	3.8	56	11
	NWIS	*mg/L*	71	62	50	5.7	240	17
Magnesium, Dissolved	This study	*mg/L*	4.1	2.1	4.4	0.2	12.4	11
	NWIS	*mg/L*	14	13	13	0.2	58	17
Chloride, Dissolved	This study	*mg/L*	21	8.5	46	1.6	159	11
	NWIS	*mg/L*	92	6.8	265	1.1	1100	17
Sulfate, Dissolved	This study	*mg/L*	40	41	32	1.0	99	11
	NWIS	*mg/L*	56	33	53	1.0	198	17
Fluoride, Dissolved	This study	*mg/L*	1.7	0.7	2.4	0.2	8.4	11
	NWIS	*mg/L*	0.8	0.3	1.0	0.2	2.9	17

[1] Data from this study include all domestic wells and monitoring wells screened in alluvium and the Poison Canyon Formation; excluded are surface water locations and produced water collected from the Raton Formation and the Vermejo Formation. Summary statistics include no use of left-censored data.

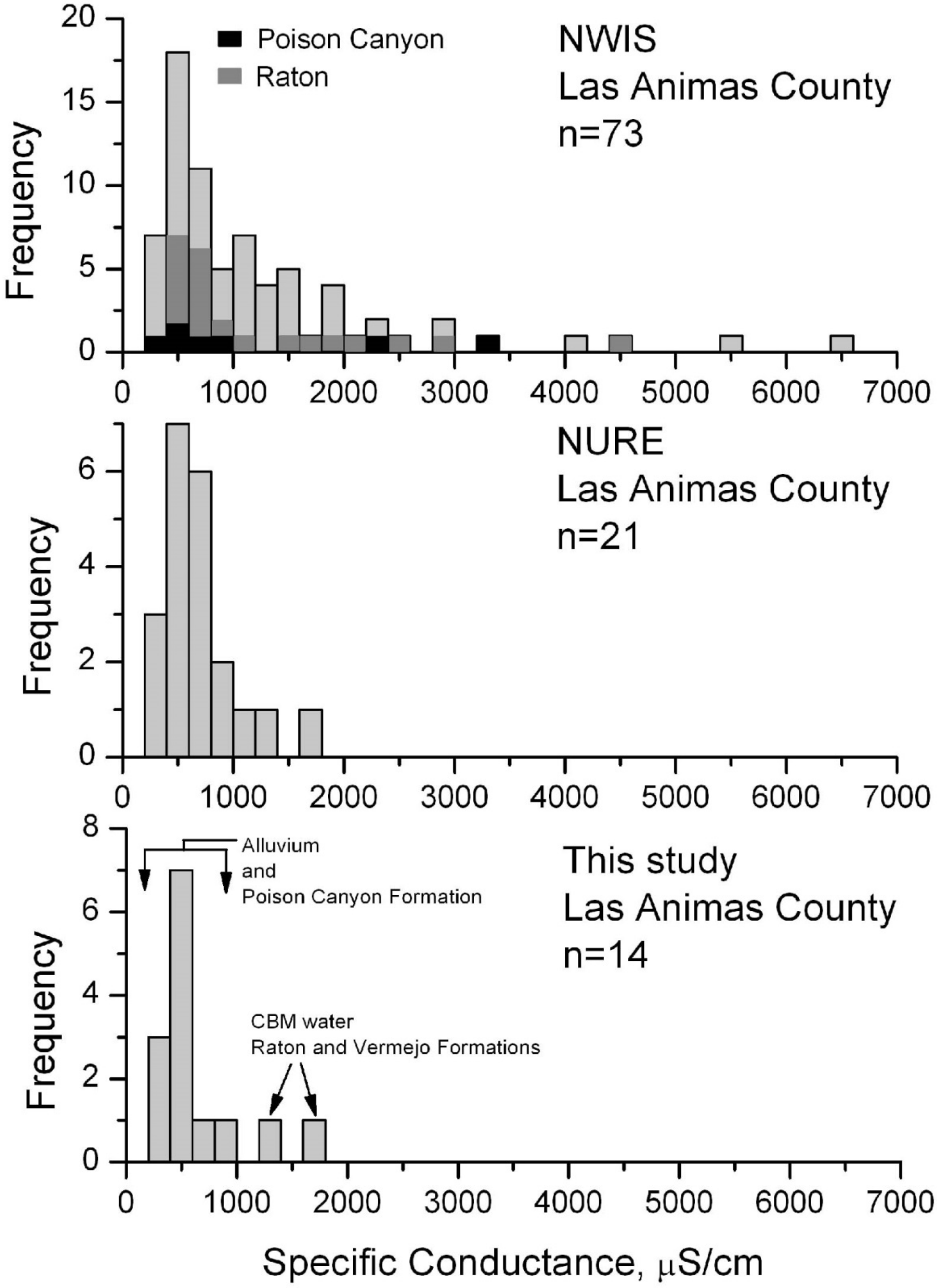


Figure 21. Frequency diagram showing specific conductance in ground water collected during this study, relative to historical water quality datasets (Las Animas County, CO).

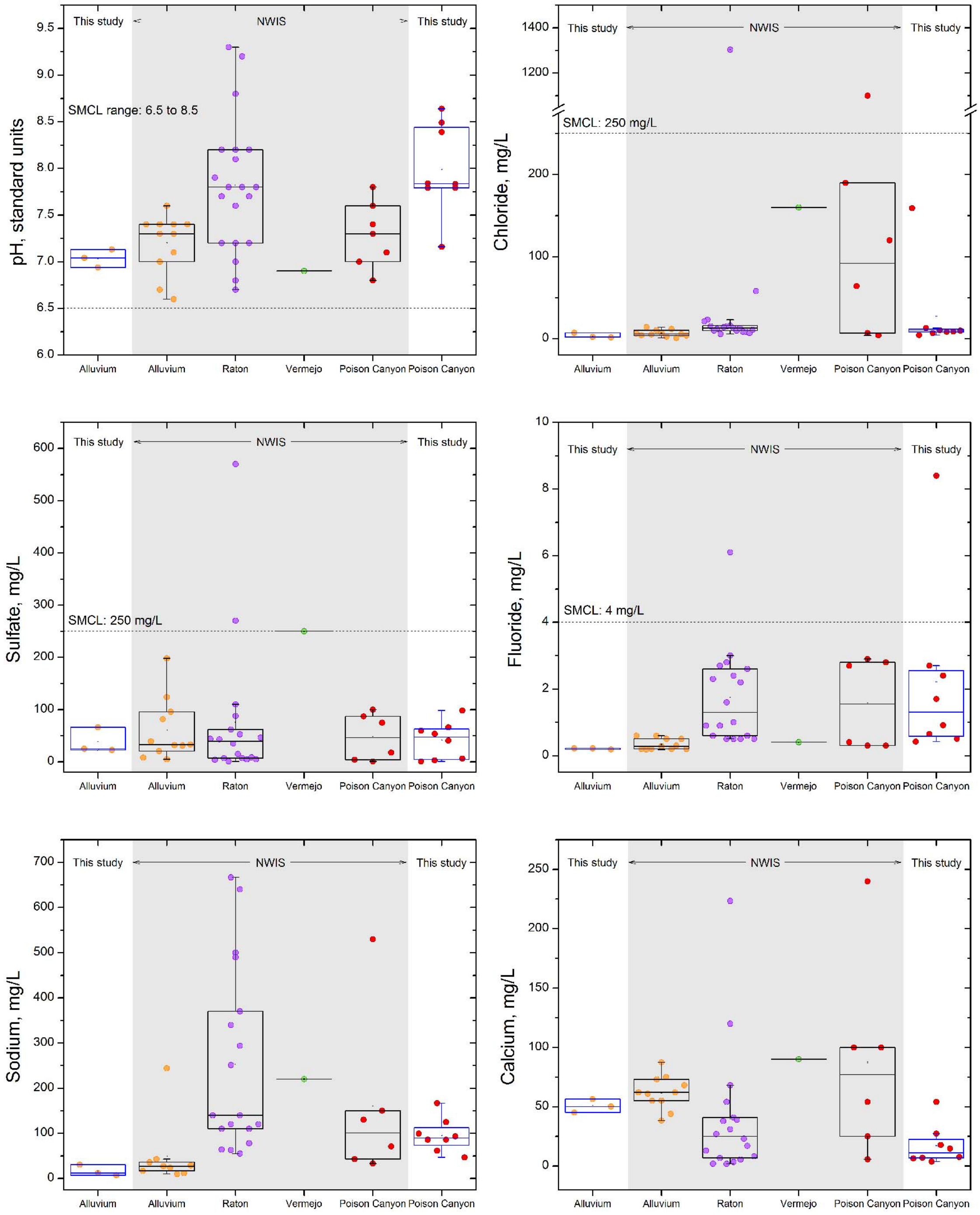


Figure 22. A comparison of pH and major ion data in ground water samples collected from domestic and monitoring wells within Las Animas County during this study, relative to USGS NWIS historical water quality data (USGS, 2013a). Data are plotted with respect to the dataset origin and aquifer formations. NWIS water quality data (in grey shaded area; black box plots) are representative of samples collected prior to any significant CBM development in this area (1951—1988).

In some cases, concentrations of total aluminum (RBDW05, RBDW08, RBDW09, RBDW10, RBDW13, RBDW14), total iron (RBDW09, RBDW11, RBDW13), and total manganese (RBDW02, RBDW09, RBDW11) exceeded secondary drinking-water standards in domestic wells sampled for this study (secondary maximum contaminant levels [SMCLs]; 50 to 200 µg/L, 300 µg/L, and 50 µg/L, respectively). For example, the maximum concentrations of total aluminum, iron, and manganese in domestic well waters observed in this study were 361 µg/L (J; RBDW09), 8,190 µg/L (RBDW13), and 226 µg/L (J; RBDW02), respectively (Appendix B). Secondary drinking water standards are based on aesthetic qualities of water, such as taste, odor, and staining properties. Iron and manganese concentrations are influenced by oxidation-reduction (redox) processes, and these elements are generally expected to be more soluble and mobile under low dissolved oxygen conditions that favor anaerobic microbial processes (Chapelle et al., 1995). Elevated concentrations of dissolved and total iron and manganese are also observed in the pre-CBM NWIS data for the Poison Canyon Formation and alluvial fill deposits. Howard (1982) suggested the dissolution of the minerals pyrite (FeS_2) and siderite ($FeCO_3$) as potential sources of iron in ground water within this region. Potential sources of manganese include dissolution of rhodochrosite ($MnCO_3$) and other aluminosilicates that contain manganese as a minor structurally-substituted component (e.g., biotite and hornblende). Aluminum is generally not soluble at near-neutral pH; acidic or alkaline water may sometimes contain greater concentrations of aluminum due to pH-dependent solubility behavior. Particulate aluminum in ground water is typically considered to be composed of fine-grained aluminum hydroxide or aluminosilicate minerals (Hem, 1985).

Wells screened in alluvial sediments (locations RBDW01 and RBDW13) show calcium-bicarbonate type compositions (see Figure 14). Wells screened in the Poison Canyon are sodium-bicarbonate type. Powell (1952) and Howard (1982) previously noted the predominance of the calcium-bicarbonate type composition in alluvial deposits of the Raton Basin. This water type develops during infiltration as recharge water interacts with the calcium carbonate and/or calcic plagioclase present in soils (Howard, 1982). Howard (1982) noted that water compositions in the Raton Basin changed from dominantly calcium-bicarbonate type in areas of recharge to more evolved, higher TDS, and sodium-bicarbonate type compositions in areas of discharge. The sodium-bicarbonate type water at domestic well locations RBDW02 and RBDW05 contrasts with the sodium-bicarbonate type water present in the Raton and Vermejo formations (see Table 6). The domestic wells (RBDW02 and RBDW05) have lower SPC (e.g., lower sodium, bicarbonate, and chloride) and higher sulfate concentrations. There was little variability observed in SPC values, and calcium, sodium, and chloride concentrations in ground water sampled from domestic wells and monitoring wells within the North Fork Ranch and Arrowhead Ranchettes sampling areas (see Figure 23), suggesting that, over the timescale of this study, the domestic wells were not impacted by fluid migrations from other aquifer systems.

6.4. Huerfano County: Poison Canyon Formation

In the Little Creek Field sampling area in Huerfano County, six domestic wells and two monitoring wells were examined during this study (see Figure 24). The wells ranged in depth from 323 to 706 feet below land surface and were screened in portions of the Poison Canyon Formation. Elevations of production wells and domestic wells in the Little Creek Field sampling area (within Search Area A; Figure 11) are compared in Figure 25. Most of the production wells in this area are completed to a total depth between 4,000 and 5,500 feet above mean sea level; whereas, domestic wells are completed to a total depth of about 6,000 feet above mean sea level. The mean separation distance between gas-producing intervals and domestic water-supply use was 1,250 feet, which generally agrees with the evaluation of vertical separation between production intervals and water-supply wells in this area of Huerfano County (Watts, 2006b). Dissolved oxygen concentrations were low, ranging from 0.2 to 2.6 mg/L (median 0.6 mg/L). Turbidity ranged from 0.7 to 19 NTU, with a median of 5.0 NTU (see Table 9). Values of pH ranged from 7.4 to 9.0, with a median of 8.6. Measurable levels of dissolved sulfide were common in wells from this area, with mean sulfide concentrations ranging from <0.01 to 29 mg/L (J; see Appendix A for descriptions of data qualifiers); the median dissolved sulfide concentration was 1.9 mg/L (J).

SPC values (a surrogate measure of TDS) for data collected in this study (356 to 1,098 µS/cm; median 506 µS/cm) are shown in Figure 26 and compared to historical pre-CBM data contained in the NURE and NWIS datasets for Huerfano County. The number of data points is limited; however, pre-CBM data and data collected in this study show SPC values that are <1,850 µS/cm (see Figure 26). Statistical analysis of the SPC values from the different datasets reveals no significant differences (p-value >0.05; Kruskal-Wallis). Historical NWIS data for pH, chloride, bicarbonate, sodium, calcium, and sulfate are compared with data from this study in Figure 27. Generally similar ranges are apparent within the two datasets for chloride, bicarbonate, and sodium in the Poison Canyon Formation; statistical analysis provides p-values >0.64 for these elements, indicating no significant differences between the datasets for the Poison Canyon Formation. Somewhat lower concentration values are observed in data from this study for calcium and sulfate (p-value ≤ 0.05), and higher pH values are apparent in this study compared to historical data (p-value = 0.01). Unfortunately, the historical datasets do not include information on dissolved gases, in particular data related to dissolved methane concentrations, and therefore comparisons cannot be made. In this study, all samples that had pH>8.5 also had methane concentrations in excess of 5.8 mg/L. Samples with pH values near 9 were from locations RBDW10 (mean pH = 9.04), RBMW04 (pH = 8.96), and RBMW05 (pH = 9.00), and these locations had the highest methane concentrations, typically >10 mg/L. Off-gassing of methane gas can cause elevations in pH by driving off carbon dioxide (CO_2) gas, which leads to positive shifts in pH (e.g., Taulis and Milke, 2013). Methane concentrations and isotope data for this area are discussed in a later section ("Molecular and Isotopic Composition of Coalbed Methane").

Fluoride concentrations in the Little Creek Field area ranged from 1.4 to 9.4 mg/L (see Table 9), with a median concentration of 4.0 mg/L, which is at the primary MCL for fluoride. Elevated fluoride concentrations in ground water of the Raton Basin were noted previously by Howard (1982) and Abbott et al. (1983) and were considered to be due to the dissolution of detrital fluorite (CaF_2) derived from weathering of hydrothermal deposits. Geochemical modeling results indicate that ground water from this area is generally undersaturated with respect to fluorite (saturation index ranging from -0.22 to -2.7), but the saturation index increases toward 0 (equilibrium) with increasing fluoride concentration; these trends are consistent with fluorite dissolution in the aquifer. Mean concentrations of sulfate were also above the SMCL (250 mg/L) in one well (RBDW14) and approached the SMCL in another (RBDW09; see Figure 27).

Wells sampled in this area are all dominated by sodium-bicarbonate or sodium-sulfate type water compositions (see Figure 14). Geochemical data, collected between 1949 and 1951 (McLaughlin et al., 1961), aid in predicting water quality conditions that are likely to be encountered when drilling new wells in Huerfano County. Information was provided for 10 wells, screened in the Poison Canyon Formation. Water types from these wells included calcium-bicarbonate-sulfate and sodium-bicarbonate-sulfate compositions. Values for TDS ranged from 284 to 2,630 mg/L, with corresponding

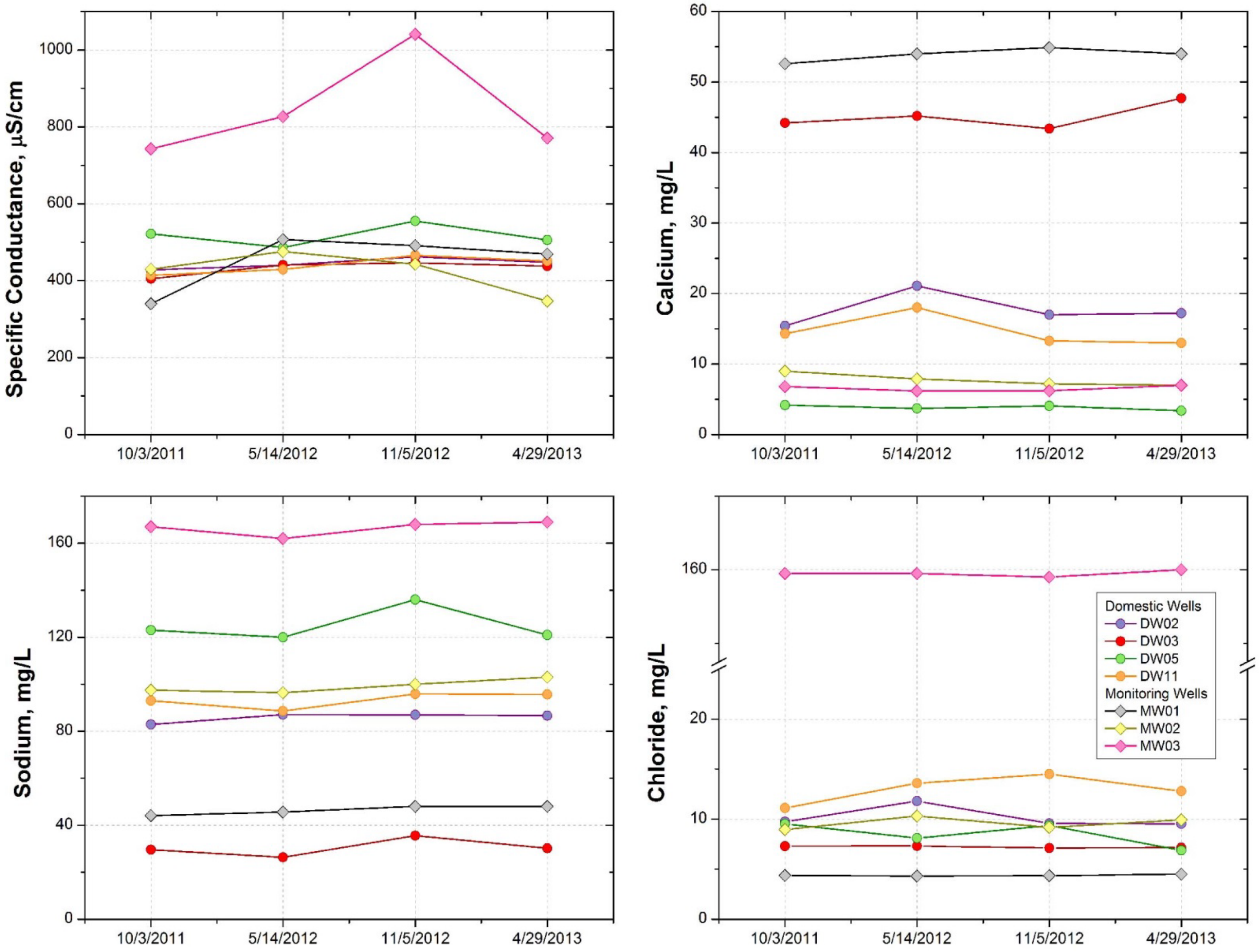
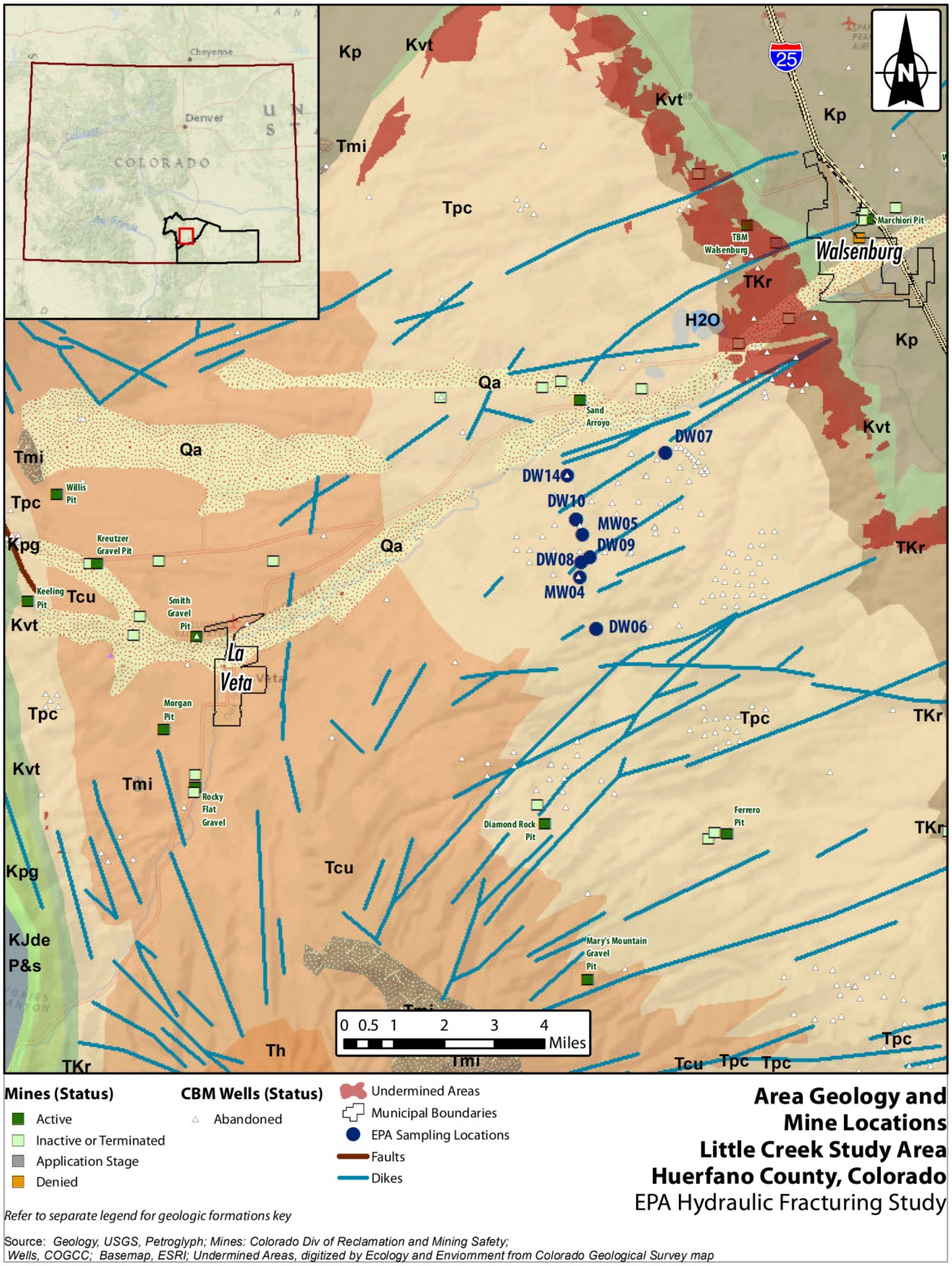


Figure 23. Changes in specific conductance values and calcium, sodium, and chloride concentrations observed in ground water collected from domestic wells and monitoring wells within the North Fork Ranch and Arrowhead Ranchettes sampling areas (Las Animas County, CO), over four sampling events (this case study).



Source: Geology, USGS, Petroglyph; Mines: Colorado Div of Reclamation and Mining Safety; Wells, COGCC; Basemap, ESRI; Undermined Areas, digitized by Ecology and Enviomment from Colorado Geological Survey map

Figure 24. Map of the Little Creek Field study area (Huerfano County, CO) showing bedrock geology, coal mine locations, coalbed methane well locations, and sample locations from this study. See Figure 16B for the geology legend.

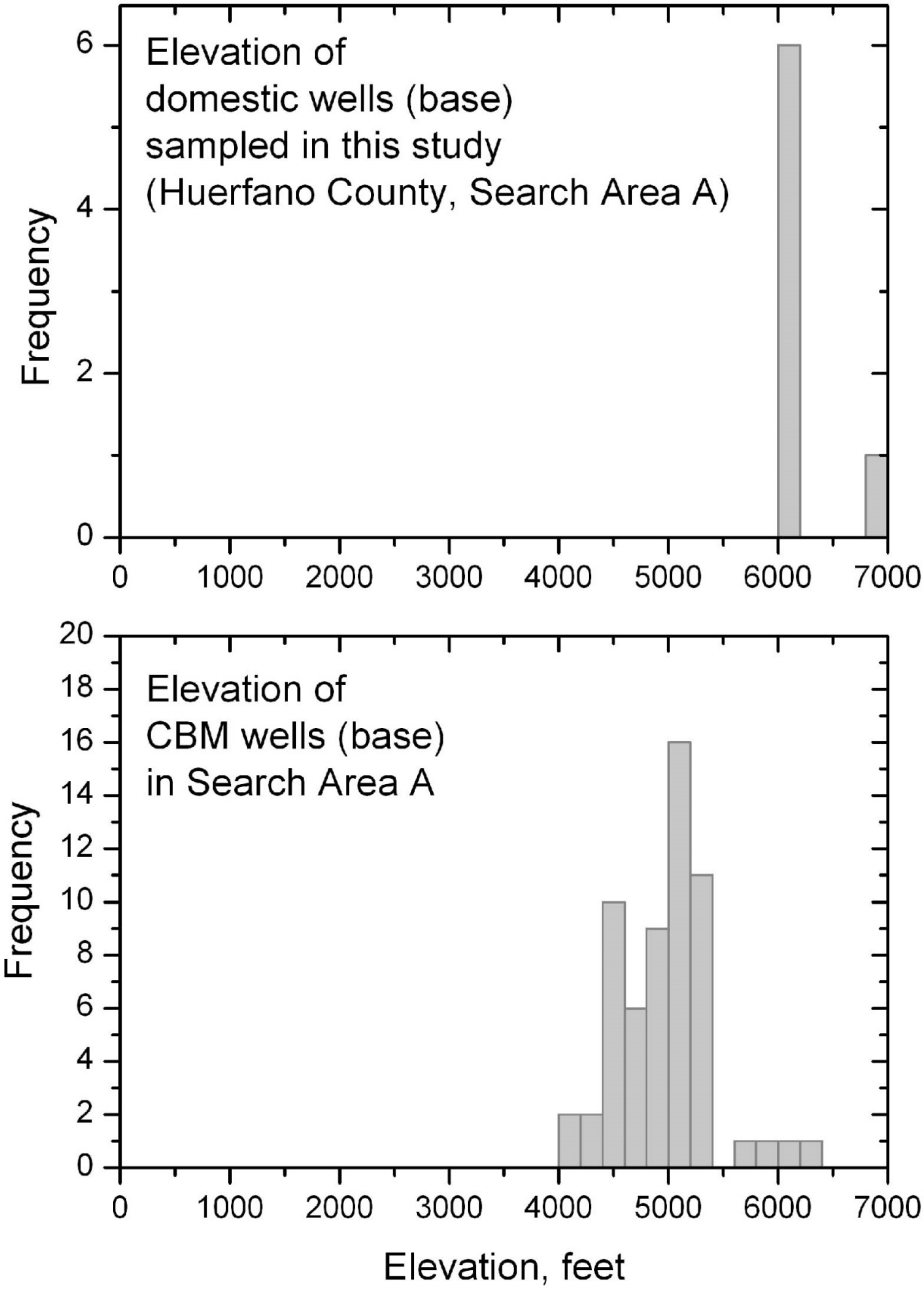


Figure 25. Elevation of domestic wells and CBM wells located within the Little Creek Field study area (Huerfano County, CO). Elevations are the height of well bases above mean sea level. The histograms show the vertical separation, in feet, between drinking water aquifers and gas producing zones.

Table 9. Summary statistics for ground water data collected during this study (9 locations) and historical data from the NWIS database for Huerfano County, CO (3 locations; USGS, 2013a).

Parameter	Data Source	Units	Mean	Median	SD	Min	Max	n =
pH	This study[1]		8.5	8.6	0.57	7.4	9.0	9
	NWIS[2]		6.6	6.7	0.21	6.4	6.8	3
SPC	This study	*µS/cm*	600	506	227	356	1098	9
	NWIS	*µS/cm*	1240	1180	552	720	1820	3
DO	This study	*mg/L*	0.9	0.6	0.8	0.2	2.6	9
Temperature	This study	*°C*	15.6	14.8	2.2	12.4	18.6	9
Turbidity	This study	*NTU*	7.5	5.0	6.9	0.7	19	9
Sulfide[3], Dissolved	This study	*mg/L*	6.3	1.9	9.8	<0.01	29	9
Alkalinity	This study	*mg/L*	146	154	43	84	215	9
	NWIS	*mg/L*	130	150	81	41	200	3
Sodium, Dissolved	This study	*mg/L*	127	115	44	82	223	9
	NWIS	*mg/L*	155	200	79	64	200	3
Potassium, Dissolved	This study	*mg/L*	0.6	0.5	0.7	0.2	2.4	9
	NWIS	*mg/L*	2.0	1.8	0.4	1.8	2.5	3
Calcium, Dissolved	This study	*mg/L*	12	7.1	12	2.0	38	9
	NWIS	*mg/L*	88	58	63	46	160	3
Magnesium[3], Dissolved	This study	*mg/L*	0.8	0.12	1.3	<0.03	3.4	9
	NWIS	*mg/L*	8.8	12	6.5	1.3	13	3
Chloride, Dissolved	This study	*mg/L*	20	15	10	9.1	39	9
	NWIS	*mg/L*	20	21	11	8.6	31	3
Sulfate, Dissolved	This study	*mg/L*	129	98	106	5.9	351	9
	NWIS	*mg/L*	413	430	285	120	690	3
Fluoride, Dissolved	This study	*mg/L*	4.2	4.0	2.8	1.4	9.4	9
	NWIS	*mg/L*	2.0	1.0	2.0	0.6	4.3	3

[1] Data from this study include all domestic wells and monitoring wells screened in the Poison Canyon Formation.

[2] NWIS data include wells screened in the Poison Canyon Formation.

[3] Use of left-censored data, this study: sulfide (1/9) and magnesium (1/9).

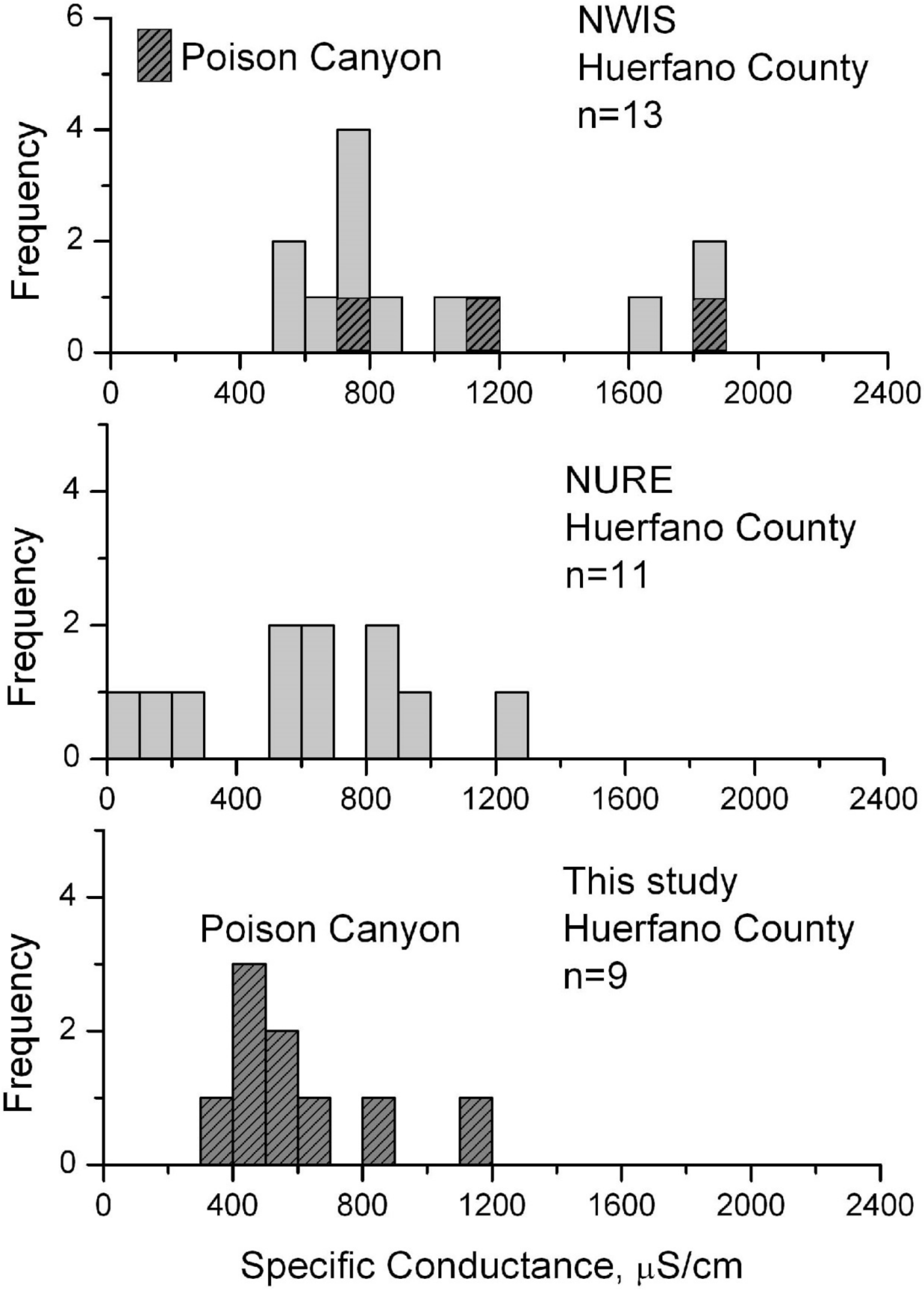


Figure 26. Frequency diagram showing specific conductance in ground water samples collected from domestic and monitoring wells in Huerfano County, CO (Little Creek Field study area) during this study, relative to USGS historical water quality datasets.

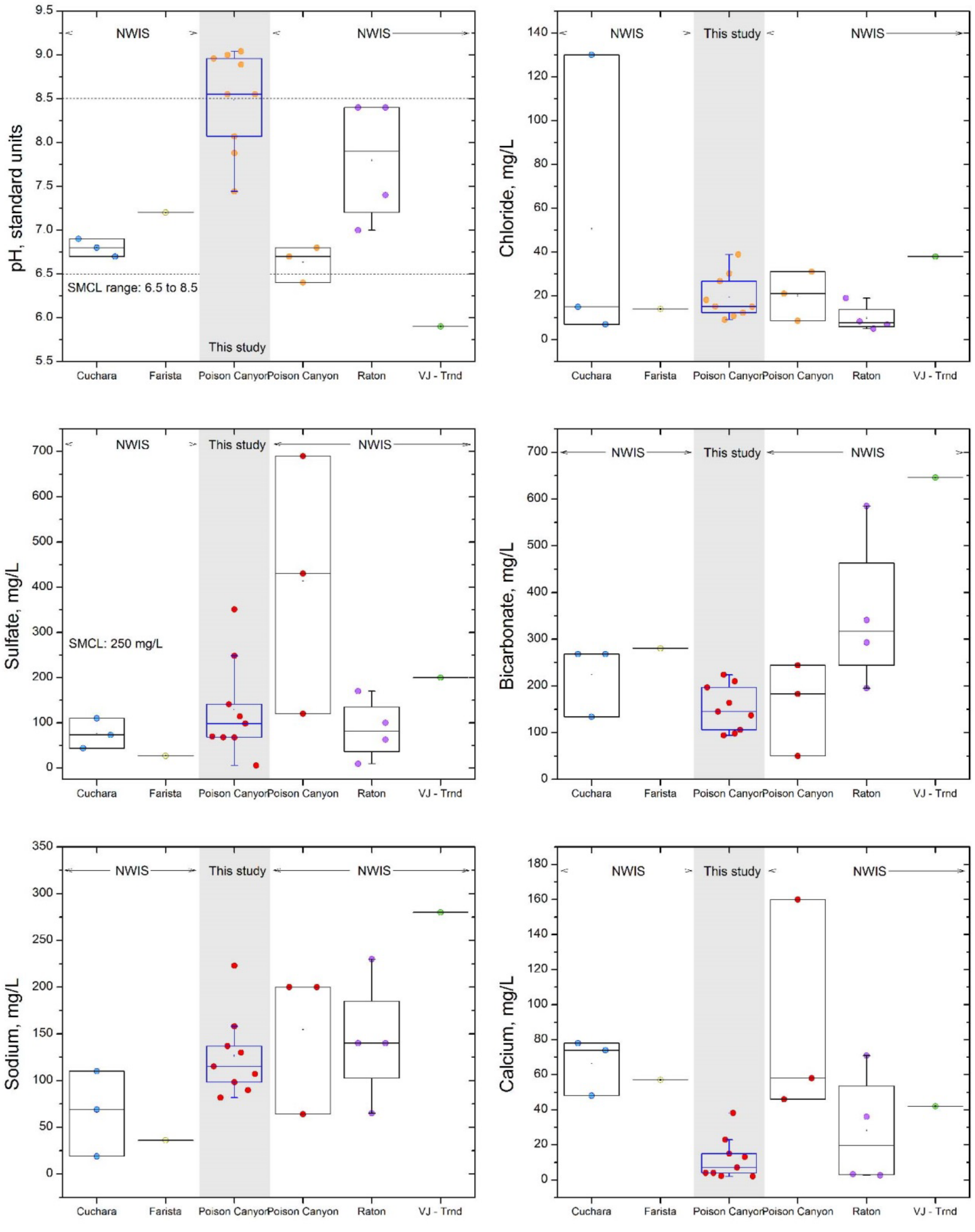


Figure 27. A comparison of pH and major ion data in ground water samples collected from domestic and monitoring wells within Huerfano County during this study, relative to USGS NWIS historical water quality data (USGS, 2013a). Data are plotted with respect to the dataset origin and aquifer formations. NWIS water quality data for the Cuchara, Farista, Raton and Vermejo-Trinidad formations are representative of samples collected prior to any significant CBM development in this area (1979). VJ–Trnd = Vermejo–Trinidad Formation.

SPC values ranging from 298 to 2,970 µS/cm; this range encompasses data collected during this study. Furthermore, a sub-region located west of Walsenburg, Colorado, was mapped by Howard (1982) and showed characteristic sodium-sulfate type water compositions. Elevated sodium and sulfate levels were hypothesized to be derived from the dissolution of thenardite (Na_2SO_4) and/or mirabillite ($Na_2SO_4 \cdot 10H_2O$), secondary minerals formed through evaporative processes in arid regions (Howard, 1982). These minerals—present within sandstone, shale, and coal—could provide a source for sodium-sulfate type ground water compositions. Time trends for SPC, calcium, sodium, and chloride in domestic wells sampled during all four events are shown in Figure 28. With the exception of location RBDW09, major ions show little variability over time. Major ion variability in domestic well RBDW09 is mainly due to changes in specific conductance and the concentrations of calcium and sodium; the cause of this variability is uncertain but may be related to well usage prior to sampling and/or behavior (drawdown and incomplete recovery) of the well during purging.

6.5. Summary of Major Ion Data

As noted earlier, mixing of produced water and shallow ground water used for drinking water via fluid migration, spills, or infiltration are potential scenarios of drinking water impairment related to CBM development where hydraulic fracturing is used. Previous studies of ground water chemistry and hydrology in the Raton Basin, including assessments conducted before CBM development, have revealed variable water quality characteristics throughout the basin that appear to be broadly related to geology and hydrologic setting (e.g., Powell, 1952; McLaughlin, 1966; Howard, 1982; COGCC, 2003a; see Table 5). Water quality data collected in the Raton Basin from drinking water aquifers prior to CBM development show similar ranges in specific conductance when compared to more recent data, including the data from this study. Specific constituents that sometimes exceed established primary and secondary standards for drinking water use include TDS, pH, fluoride, nitrate, iron, manganese, and sulfate. Similar features in water quality characteristics were detected at some of the locations examined in this study. Water co-produced with natural gas in the Raton Basin (see Figure 17) has a distinctive geochemical signature: sodium-bicarbonate type water with moderate TDS concentrations; low concentrations of sulfate, calcium, and magnesium; variable chloride concentrations; low ORP values; and elevated concentrations of lithium, dissolved methane, and ferrous iron (see Table 6). This CBM signature provides useful guiding criteria for detecting and quantifying potential fluid mixing using general measures of water quality, and contrasts with shallower aquifers used for drinking water, including the Poison Canyon Formation and alluvial fill deposits. The geochemical signature in these shallower aquifers (see Tables 5, 8 and 9) includes more variable major ion compositions (calcium-bicarbonate, sodium-bicarbonate, and sodium-sulfate), lower TDS, generally lower chloride and lithium, higher sulfate, and variable redox conditions. Observing changes in major ion chemistry, or lack thereof, through time at specific locations provides one line of reasoning for assessing potential impacts. The sampling locations selected for this study showed consistent major ion patterns over the one-and-half-year study period. These time-independent trends in major ions suggest that no demonstrable water quality impacts have occurred due to water migration at the selected sampling locations of this study (see Figure 23 and Figure 28). Application of other potentially more sensitive isotopic techniques is discussed in a following section. Finally, surface-discharged produced water could potentially infiltrate and impact ground water quality, particularly in areas where flowing streams lose water to ground water; it is possible that wells used for drinking water could be impacted in such hydrologically vulnerable settings. No direct evidence of this process was observed in this study; however, no

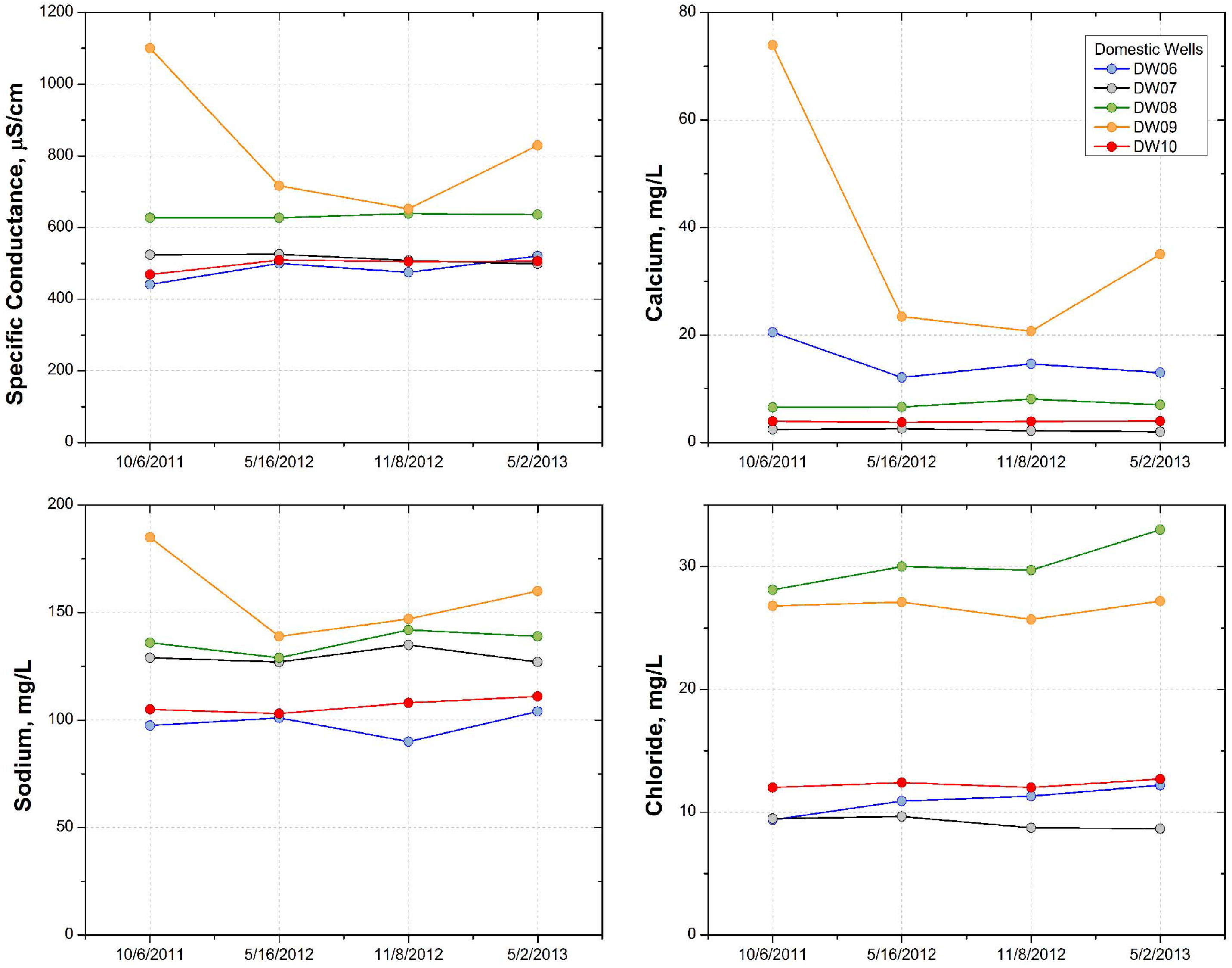


Figure 28. Changes in specific conductance values and calcium, sodium, and chloride concentrations observed in ground water collected from domestic wells within the Little Creek Field sampling area (Huerfano County, CO), over four sampling events (this case study).

monitoring locations were explicitly established to test whether surface-discharge produced water is impacting ground water.

6.6. Organic Compounds

Ground and surface water samples were analyzed for a suite of up to 133 organic compounds, including VOCs, SVOCs, glycol ethers, petroleum hydrocarbons (DRO and GRO), and LMWAs (see Tables B-4, B-5, and B-6 for a list of analytes). The purpose of these analyses was to examine the potential occurrence in ground and surface water of chemicals generally documented to be components of hydraulic fracturing fluids (e.g., Ely, 1989; Veatch et al., 1989; Vidic et al., 2013; U.S. House of Representatives, 2011) and, more specifically, of the chemicals in fracturing fluids that have been used in Colorado (see Table 10; FracFocus, 2013). Water-based fracturing fluids, including nitrogen (N_2 foam), are the predominant type of fracturing fluids used to extract CBM (US EPA, 2004). In Colorado, approximately 96 to 98% of the fracturing fluid is water and sand; potassium chloride (KCl) is a common additive and can constitute 2 to 4%. The remaining fluid is composed of 10 or more chemical additives that are generally complex organic compounds (COGCC, 2013a). Over 2 million gallons of water were used in hydraulic fracturing operations within Las Animas County in 2011 (average = ~88,500 gallons; FracFocus, 2013), which corresponds to approximately 2,000 to 20,000 gallons of chemical compounds for fluids containing 0.1–1% (by volume) chemical additives.

Although CBM-produced water is likely to have unique organic matter signatures due to contact with the coal formation and potential microbial activity related to secondary biogenic methane production (Dahm et al., 2012; Orem et al., 2007), many of the chemicals used in hydraulic fracturing fluids are not naturally found in ground water. For example, glycols (diethylene glycol, triethylene glycol, tetraethylene glycol) and 2-butoxyethanol do not occur in nature, and their presence in water samples could serve as indicators of water resource contamination from hydraulic fracturing activities. These chemicals, in addition to other frequently used hydraulic fracturing chemicals, are covered, in part, by the analytical methods used in this study. The analytical method used for glycols for this study is an improved liquid chromatography–tandem mass spectrometry (LC-MS-MS) method developed to increase the sensitivity and resolution of glycol analyses over existing methods (EPA Method 8015; US EPA, 2012; Schumacher and Zintek, 2014).

A summary of all organic compounds detected in this study, for each study site, is provided in Tables 11 through 13; organic compounds are organized by analytical grouping. VOCs are further categorized on the basis of their primary usage, or origin; this is the same classification scheme used in the National Assessment of VOCs by the USGS National Water-Quality Assessment Program (Zogorski et al., 2006). In summary, bis-(2-ethylhexyl) phthalate was detected in domestic wells, monitoring wells, and production wells at levels that exceeded EPA's drinking water standards (MCL = 6 µg/L). TBA, DRO, and GRO were consistently detected at levels >QL in ground water and/or surface water; detections varied by study site. VOCs were detected in surface water and ground water collected from domestic wells, monitoring wells, and production wells. Glycol ethers were not detected in domestic or monitoring wells; however, low levels (<QL) of diethylene glycol and triethylene glycol were detected in production well RBPW03 during the last sampling event. The detection of low-level concentrations of glycols in the production well might be related to the presence of residual chemicals used as foaming agents during hydraulic fracturing. Historical water-quality data do not provide information on the comprehensive suite of organic analytes evaluated in this study; thus, meaningful comparisons between organic compound data

for this study and data collected prior to CBM development in the Colorado portion of the Raton Basin are not possible. Furthermore, while detections of these compounds could provide strong evidence of impacts related to fluid migration, the absence of organic analyte detections does not necessarily mean that impacts have not occurred.

Table 10. Disclosed chemical additives in hydraulic fracturing fluids used within the Raton Basin, CO (FracFocus, 2013).

Additive type	Compound	Purpose
Acid	*Hydrochloric acid* [1]; Acetic acid	Clean out the wellbore, dissolve minerals, and initiate cracks in rock
Activator	*Methanol;* Ethoxylated nonylphenol	Help bond curable resin proppants together
Biocide	2-Monobromo-2-nitrilopropionamide; 2,2 Dibromo-3-nitrilopropionamide; 2-Bromo-2-nitro-1,3-propanediol; Tetrakis (Hydroxymethyl) phosphonium sulfate	Control bacteria
Breakers	Ammonium persulfate; Carbohydrates; *Ethylene Glycol*; Hemicellulase enzyme; Quartz; Sodium Chloride; Sucrose; Tryptone; Walnut hulls; Yeast extract	Promote delayed breakdown of gel polymers
Buffer	Acetic acid; Acetic anhydride; Sodium hydroxide	Maintain effectiveness of other compounds (such as crosslinker)
Chemical Tracer	Proprietary aromatic hydrocarbon; Tracerco 160c, 161b, 163a, 163b, 164b, 164c, 165b, 165c, 166c, 168a, 718, 731[2]	Establish water movement over an extended time period
Clay Stabilizer	Choline chloride; Oxyalkylated amine quaternary compound	Create a brine carrier fluid
Conductivity Enhancer	Dipropylene glycol monomethyl ether	Protect against proppant diagenesis; improves permeability of proppant pack; enhances fracture conductivity
Crosslinker	Boric acid; Ethanol; *Ethylene glycol; Methanol*; Methyl Borate; Monoethanolamine borate; Petroleum distillates, Terpenes and terpenoids (sweet orange oil)	Maximize fluid viscosity at high temperatures
Foaming Agent	2-butoxyethanol; *Ethylene glycol*; *Methanol*	Used to transport and place proppant into fractures
Friction Reducer	Petroleum distallates (COGCC, 2013a)	Minimize friction between the fluid and the pipe
Gelling Agent	1-butoxy-2-propanol; Guar gum; Ethoxylated isotridecanol; Petroleum distillates; Paraffinic petroleum distillates; Quartz	Thicken water to suspend sand
Inhibitor	Aldehyde; Chloromethylnaphthalene quinoline quaternary amine; Isopropanol; *Methanol*; Propargyl alcohol	Prevent corrosion of pipe by diluted acid; reduce deposition of scales on pipes
Iron Control	Acetic acid; Acetic anhydride; Citric acid	Prevent precipitation of metal oxides
Nitrogen Foam	Nitrogen	Carry proppant
Non-emulsifier	Oxyalkylated alcohol	Trade secret
Other[3]	2-butoxy-1-propanol; Boric oxide*;* *Formaldehyde*; Glycerol; Lactose; Polyethlylene glycol; Organic sulfonic acid; Sodium chloride; Soy	Not provided[2]

Table 10. Disclosed chemical additives in hydraulic fracturing fluids used within the Raton Basin, CO (FracFocus, 2013).

Additive type	Compound	Purpose
	Alkoxylated amine; Alkylene oxide block polymer; Antifoam; Organophilic clay; Polymeric suspending agent; Polyquaternary amine; Surfactant	Trade secret
Oxygen Scavenger	[Ammonium bisulfate (Vidic et al., 2013)]	Remove oxygen from fluid to reduce pipe corrosion
Proppant	Hexamethylenetetramine; *Phenol - Formaldehyde* Resin; Quartz	Keep fractures open
Surfactant	2-Butoxyethanol; Amphoteric surfactant[2]; Essential oils; Ethanol; Secondary alcohol; Terpenes and terpenoids (sweet orange-oil)	Decrease surface tension to allow water recovery

[1] Compounds that are known or possible human carcinogens, regulated under the Safe Drinking Water Act for their risks to human health, or listed as hazardous air pollutants under the Clean Air Act (U.S. House of Representatives, 2011) are in italics.

[2] All listed compounds are proprietary.

[3] Compounds listed are designated “Non-MSDS” by the operator; additional information, other than CAS#, was not provided (FracFocus, 2013).

The results for organic compounds detected during this study are organized by study site and discussed below. An additional discussion of the organic chemicals detected in this study and their distribution is presented in topical sections on “Tert-Butyl Alcohol” and “Coal-Water Interactions.”

6.6.1. North Fork Ranch

Volatile Organic Compounds

VOCs are a subset of organic compounds with inherent physical and chemical properties (i.e., high vapor pressure, low to medium water solubilities, low molecular weights) that allow these compounds to move from water and (preferentially) into air. Some VOCs occur naturally, while others occur as a result of human activities, and some VOCs have both origins (Zogorski et al., 2006). Twelve VOCs were detected in surface water and ground water samples from domestic wells, monitoring wells, and production wells over the four sampling rounds in the North Fork Ranch area (see Table 11). The VOCs are categorized into five groups: gasoline hydrocarbons, gasoline oxygenates, solvents, trihalomethanes (THMs, chlorination by-products), and other.

- Gasoline hydrocarbons—Gasoline hydrocarbons comprise aromatic hydrocarbons or alkyl benzenes and are among the most intensively and widely used VOCs; their predominant use is in gasoline (Zogorski et al., 2006). A majority of the VOC detections (7/12) were relatively water-soluble monoaromatic hydrocarbons collectively designated BTEX compounds (benzene, toluene, ethylbenzene, and m- + p-, and o-xylene), and benzene derivatives. Benzene, benzene derivatives (1,2,3-trimethylbenzene, and 1,2,4-trimethylbenzene), and ethylbenzene were present in ground water collected from production wells and surface water. Benzene was detected at low levels in all production wells (RBPW01, rounds 1, 2, and 4; RBPW02, round 1; and RBPW03, rounds 2, 3, and 4), one domestic well (RBDW03, round 2), and one surface water location (RBSW03, rounds 2, 3 and 4). The maximum benzene concentration was measured in surface water sample RBSW03 during round 2 (1.03 µg/L); furthermore, this location was the only sampling location where ethylbenzene was detected (rounds 2 and 3). Toluene was detected in one domestic well (RBDW05, round 4), two monitoring wells (RBMW02, round 1; RBMW03, rounds 3 and 4), one production well (RBPW03, round 3), and one surface water location (RBSW03, round 3). As noted previously, produced water is disposed of via surface discharge from several production wells located near surface water location RBSW03, and the surface water sample composition reflects a dominant CBM component. Most toluene detections were below the QL but above the MDL, with the exception of RBMW02 during round 1 (0.53 µg/L). Benzene derivatives and xylene (*m*- + *p*-, and *o*-) were detected in two locations: RBPW03 (1,2,3-trimethylbenzene and *o*-xylene, round 3) and RBSW03 (1,2,3-trimethylbenzene, round 3; 1,2,4-trimethylbenzene and *m*- + *p*-xylene, rounds 2 and 3; *o*-xylene, round 3). Concentrations of gasoline hydrocarbons were, in all cases, below MCLs or applicable drinking water standards. The source of these compounds is discussed in a later topical section ("Coal-Water Interactions").

Table 11. Detection of organic compounds in ground and surface water: North Fork Ranch study site.

Analyte/Well ID		Sampling Round[1]				Result *µg/L*	Average *µg/L*	Range *µg/L*
		1	2	3	4			
Volatile Organic Compounds								
† 1,2,3-trimethylbenzene								
	RBPW03	NS[2]		x, J[3]		0.16		
	RBSW03	NS		x, J		0.13		
† 1,2,4-trimethylbenzene								
	RBSW03	NS	x	x, J			1.05	0.13–1.96
† Acetone [4]								
	RBDW03		x, J-			62.3		
	RBPW03	NS		x, J		0.65		
	RBSW01				x, J	0.30		
† Benzene (MCL = 5 µg/L)								
	RBDW03		x			0.66		
	RBPW01	x, J	x		x, J		0.47	0.25–0.77
	RBPW02	x	NS	NS	NS	0.98		
	RBPW03	NS	x	x, J	x, J		0.59	0.43–0.87
	RBSW03	NS	x	x	x, J		0.72	0.29–1.03
Carbon Disulfide								
	RBMW03			x, J		0.12		

Table 11. Detection of organic compounds in ground and surface water: North Fork Ranch study site.

Analyte/Well ID		Sampling Round[1]				Result *µg/L*	Average *µg/L*	Range *µg/L*
		1	2	3	4			
Chloroform (MCL = 80 µg/L)								
	RBDW02				x, J	0.09		
	RBDW05	x			x, J		0.35	0.14–0.56
	RBMW03	x	x	x	x		5.58	1.93–14.0
† Ethylbenzene (MCL = 700 µg/L)								
	RBSW03	NS	x	x, J			0.87	0.06–1.67
† m + p xylene (MCL, ΣXylenes = 10,000 µg/L)								
	RBSW03	NS	x	x, J			1.57	0.20–2.94
Methylene Chloride (MCL = 5 µg/L)								
	RBMW03			x, J	x, J		0.18	0.12–0.23
o–xylene (MCL, ΣXylenes = 10,000 µg/L)								
	RBPW03	NS		x, J		0.08		
	RBSW03	NS		x, J		0.10		
Tert-Butyl Alcohol [5]								
	RBDW03		x, J-[3]			51.3		
	RBMW02	x	x, J-	x	x		30.4	27.2–37.4
	RBMW03	x	x, J-	x, J	x, H		1059	960–1310
	RBPW01				x, J	6.90		
† Toluene (MCL = 1000 µg/L)								
	RBDW05				x, J	0.12		
	RBMW02	x				0.53		
	RBMW03			x, J	x, J		0.15	0.11–0.18
	RBPW03	NS		x, J		0.08		
	RBSW03	NS		x, J		0.08		
Semivolatile Organic Compounds								
† 2-Butoxyethanol								
	RBDW05	x				0.65		
	RBMW03	x				1.45		
2-Butoxyethanol Phosphate								
	RBDW02	x				1.22		
	RBDW13	NS			x, J	1.05		

Table 11. Detection of organic compounds in ground and surface water: North Fork Ranch study site.

Analyte/Well ID		Sampling Round[1]				Result µg/L	Average µg/L	Range µg/L
		1	2	3	4			
Bis-(2-ethylhexyl) Phthalate[6] (MCL = 6 µg/L)								
	RBDW01		x	NS	NS	4.27		
	RBDW02				x, J-	9.56		
	RBDW04		NS	x, J		53.6		
	RBDW13	NS			x	9.66		
	RBMW01				x, J-	5.28		
	RBMW03	x	x, J, H	x	x, J		177	135–291
	RBPW01			x, B	x, J-	47.6		
	RBPW03	NS		x, B	x, J-	22.6		
	RBSW01	x				1.39		
Di-n-octyl Phthalate								
	RBMW03	x			x		7.50	7.35–7.65
Isophorone[7]								
	RBMW03	x	x, J, H		x		1.41	1.11–1.86
Nitrobenzene								
	RBMW03	x				0.63		
† Phenol								
	RBMW03	x				0.52		
Squalene								
	RBDW01	x		NS	NS	1.87		
	RBMW03	x				1.62		
Glycol ethers[8]								
† Diethylene Glycol								
	RBPW03	NS			x, J	1.1		
† Triethylene Glycol								
	RBPW03	NS			x, J+[3]	2.6		
Total Petroleum Hydrocarbons								
Diesel-Range Organics [9]								
	RBDW02	x		x	x		29.5	21.3–39.0
	RBDW03	x				20.0		
	RBDW05				x	21.9		
	RBMW01	x		x	x		27.2	21.7–30.2

Table 11. Detection of organic compounds in ground and surface water: North Fork Ranch study site.

Analyte/Well ID		**Sampling Round**[1]				**Result** ***µg/L***	**Average** ***µg/L***	**Range** ***µg/L***
		1	**2**	**3**	**4**			
	RBMW03	x, J	x, J	x	x		1413	874–1940
	RBPW01	x	x	x	x		56.8	31.9–77.0
	RBPW02	x	NS	NS	NS	40.1		
	RBPW03	NS	x	x, J-, *[3]	x		90.4	73.6–118
	RBSW01	x	x	x, B	x		40.7	34.2–46.9
	RBSW02	NS	x	x	x		27.8	23.6–30.3
	RBSW03	NS	x	x	x		27.8	26.6–28.7
Gasoline-Range Organics								
	RBMW03	x, B	x				30.7	30.1–31.3
Low-molecular-weight acids								
† Acetate								
	RBDW04	R		x, J		60		
	RBDW05	R	x, J			50		
	RBMW01	R		x, J		50		
	RBMW02	R		x		240		
	RBMW03	R	x	x			335	200–470
	RBPW01	R	x, J	x, J			90	90
	RBPW03	NS	x			170		
	RBSW02	NS		x		130		
	RBSW03	NS		x, J		60		

The sampling round in which the analyte was detected is designated using an “x” and qualified results are indicated using the appropriate flag. Average values reflect the mean of the detected results; range is equivalent to the minimum and maximum values detected for an analyte, at a given location. MCLs are provided where available. Analytes prefaced with a † are known constituents of hydraulic fracturing fluids (U.S. House of Representatives, 2011; FracFocus, 2013).

[1] Sampling events: round 1 = October 2011; round 2 = May 2012; round 3 = November 2012; and round 4 = April/May 2013.
[2] NS = Not sampled.
[3] J = The analyte was positively identified, and the associated numerical value is the approximate concentration; J- = Result may be biased low; J+ = Result may be biased high; * = Relative percent difference of lab or field duplicate is outside acceptance criteria; B = Analyte was detected in a blank sample above the QL. See Table A28, Appendix A, for more detailed descriptions.
[4] Acetone—RBSW01, round 4: analyte was present in primary sample, but not in field duplicate.
[5] Tert-Butyl Alcohol—“H” round 4 (RBMW03): analyte concentration was greater than the calibration range; re-analysis of diluted sample missed holding time.
[6] Bis-(2-ethylhexyl) Phthalate—RBDW02, round 4: analyte present in primary sample, but not in field duplicate.
[7] Isophorone—“H”, round 2 (RBMW03): sample foamed during prep and was lost; sample was re-extracted past its holding time.
[8] Glycol ethers: the method used for glycol analysis was under development.
[9] Diesel-Range Organics—RBDW02, round 4: DRO present in primary sample, but not in field duplicate.

- **Gasoline Oxygenates**—Gasoline oxygenates are compounds that contain oxygen as part of their chemical structure and are added to gasoline to improve combustion and reduce emissions. Commonly used oxygenates include alcohols (e.g., methanol, ethanol, isopropyl alcohol, butanol) and/or ethers (e.g., methyl-tert-butyl ether (MTBE), tert-amyl methyl ether (TAME), diisopropyl ether (DIPE), ethyl tert-butyl ether (ETBE)). These compounds, as well as their chemical intermediates (e.g., TBA), were routinely analyzed as part of this study and were not detected in any of the samples, with the exception of TBA. TBA, which is discussed in more detail in a later topical section ("Tert-Butyl Alcohol"), was detected in one domestic well (RBDW03, round 2), one production well (RBPW01, round 4), and consistently detected in rounds 1 through 4 in two monitoring wells, RBMW02 and RBMW03, at concentrations up to 1,310 µg/L (J-). The source and formation pathway(s) of TBA within this area are currently unresolved, and both anthropogenic and natural sources are possible for the documented occurrences of TBA (see the "Tert-Butyl Alcohol" topical section for more information).

- **Solvents**—Solvents are compounds that are used to dissolve other substances. Acetone ($(CH_3)_2CO$) was detected in one domestic well (RBDW03, round 2), one production well (RBPW03, round 3), and one surface water site (RBSW01, round 4). Methylene chloride (CH_2Cl_2; also known as dichloromethane (DCM)) was detected in monitoring well RBMW03 during sampling events 3 and 4. Both compounds were detected at levels below the QL but above the MDL.

  It is important to note that acetone can be produced microbially by solvent-producing strains of *Clostridium* (Jones and Woods, 1986; Häggström, 1985). Most recently, *Clostridium* (sp. Maddingley) was isolated from a brown coal-seam formation water sample collected from Victoria, Australia, and products released by this bacterium during substrate fermentation may support growth of certain methanogens (Rosewarne et al., 2013). Although these microbes lack the solventogenesis genes found in closely-related *Clostridium* strains, this does not preclude the existence of other solventogenesis *Clostridium* strains that may be associated with coal-seam gas formation water, and could explain the low levels of acetone detected in these samples.

- **Trihalomethanes**—Trihalomethanes (THMs) are chemical compounds in which three of the four hydrogen atoms in methane (CH_4) are replaced by halogen atoms—i.e., bromine (Br), chlorine (Cl), fluorine (F), and/or iodine (I). Chloroform ($CHCl_3$) was detected at low levels (<1 µg/L) in two domestic wells (RBDW02, round 4; RBDW05, rounds 1 and 4). This analyte was consistently measured in ground water collected from monitoring well RBMW03 (rounds 1 through 4); however, the concentration steadily decreased over the course of the four sampling events, from 14.0 µg/L (round 1) to 2.3 µg/L (round 4).

  Water that has been chlorinated, or exposed to products containing chlorine, is an important source of chloroform. Both hydrochloric acid (HCl) and potassium chloride (KCl) are components of hydraulic fracturing fluids used for CBM development in the Raton Basin (FracFocus, 2013; COGCC, 2013a); however, chloroform was not detected in any production wells. Both domestic wells (RBDW02 and RBDW05) are located west of monitoring well RBMW03. Given the low, intermittent levels of this analyte detected in RBDW02 and RBDW05 and the steadily decreasing concentration in RBMW03, the presence of chloroform may be due to disinfection of these wells; no well disinfection documentation was available. However, transformations of chloroform linked to microbial activity have been observed in methanogenic environments, and transformation products range from methylene chloride and chloromethane through to carbon dioxide, carbon monoxide, and volatile fatty acids (Chan et al., 2012; Lee et al., 2012). The decreasing concentrations of chloroform in monitoring well RBMW03, coupled with the appearance of methylene chloride in this well during later rounds, could be attributed to microbial activity.

- **Other**—Carbon disulfide (CS_2), a sulfur compound, was detected below the QL but above the MDL in monitoring well RBMW03 during round 3.

Semivolatile Organic Compounds

Eight SVOCs were detected over the four sampling events (see Table 11). SVOCs are typically hydrophobic organic compounds that have a moderate tendency to volatilize; consequently, SVOCs are released slowly from their source and have a propensity to preferentially distribute into organic phases, such as tissue (i.e., bioaccumulation) and/or sediments containing organic carbon (Lopes and Dionne, 1998; Smith et al., 1988).

During round 1, 2-butoxyethanol (2BE), nitrobenzene ($C_6H_5NO_2$), phenol (C_6H_6O), and/or squalene ($C_{30}H_{50}$) were detected in ground water samples from three locations: RBDW01, RBDW05, and RBMW03; however, these compounds were not detected at any of these locations during subsequent sampling events. Nitrobenzene, an industrial chemical, and phenol, a compound widely distributed in coal, were detected at low levels (<1 µg/L) in monitoring well RBMW03. Squalene, a common hydrocarbon biomarker in fossil fuel environments (Peters et al., 2005), was detected in RBDW01 and RBMW03. 2-butoxyethanol, a chemical commonly used in hydraulic fracturing fluids, was detected at low levels (<1.5 µg/L) in domestic well RBDW05 and monitoring well RBMW03. (Note: the method QL for 2-butoxyethanol increased in later rounds due to method updates at the EPA Region 8 Laboratory resulting from annual MDL studies.) The detections of 2-butoxyethanol should be viewed with caution: detections were not repeated beyond the first sampling event, and there were no supportive detections of 2-butoxyethanol using the LC-MS-MS method (developed by Region 3 for 2-butoxyethanol, diethylene glycol, triethylene glycol, and tetraethylene glycol).

SVOCs with the some of the highest observed concentrations included phthalates and 2-butoxyethanol phosphate (TnBP), the tributyl ester of phosphoric acid. These are manufactured chemicals used primarily in the production of coatings, resins, and plastics (Orem et al., 2007). Bis-(2-ethylhexyl) phthalate (DEHP) and di-n-octyl phthalate (DnOP), were detected in several water samples over the four sampling rounds. Although detections were irregular, bis-(2-ethylhexyl) phthalate concentrations exceeded the federally regulated MCL of 6 µg/L (US EPA, 2013b) in three domestic wells (RBDW02, round 4; RBDW04, round 3; and RBDW13, round 4), one monitoring well (RBMW03, rounds 1 through 4), and two production wells (RBPW01 and RBPW03, round 4). The highest concentrations were consistently measured (rounds 1 through 4) in ground water samples from RBMW03 (mean = 177 µg/L). Bis-(2-ethylhexyl) phthalate was detected at concentrations less than the MCL in ground water collected from RBDW01 (round 2) and RBMW01 (round 4), and from surface water location RBSW01 (round 1). Di-n-octyl phthalate was also detected in RBMW03 (mean = 7.50 µg/L) during rounds 1 and 4. Phthalates are not common in nature, and their presence likely represents a contaminant from processing of the samples and/or from leaching of plastic components in well materials (Orem et al., 2007). Phthalates are not listed in Table 10 as components of chemical additives in hydraulic fracturing fluids in the Raton Basin. 2-butoxyethanol phosphate was detected at low levels in ground water collected from RBDW02 (round 1) and RBDW13 (round 4). Low levels of isophorone (mean = 1.41 µg/L), a widely used solvent (US EPA, 2013c), were measured in ground water collected from RBMW03 during rounds 1, 2, and 4; this is the only well in which isophorone was measured within the Las Animas County study areas. This compound is not a documented chemical additive of hydraulic fracturing fluid within this study area, and the source is unknown.

Glycol ethers

Glycol ethers, a class of high-production-volume chemicals with widespread industrial applications as solvents and chemical intermediates (Dieter, 1993), are commonly used chemical components of hydraulic fracturing fluid (U.S. House of Representatives, 2011). These compounds are highly water soluble, with high boiling points and low vapor pressures. Glycols are not normally detected in ground and surface water, and because of their miscibility with water, they are difficult to separate for analytical purposes (Fischer and Hahn, 2005).

Diethylene and triethylene glycol were detected at low levels (<QL) in production well RBPW03 during round 4 (see Table 11). Glycol ethers are degraded rapidly in the environment by microorganisms (Howard et al., 1991; Dwyer and Tiedje, 1983; Mrklas et al., 2004).

Diesel- and Gasoline-Range Organic Compounds

The determination of total petroleum hydrocarbons (TPH) in water is an important means of monitoring for fuel contamination arising from spills or leaking storage tanks (Stahl and Tilotta, 1999). Typically, petroleum contamination in water is divided into two classes: DRO and GRO. DRO are composed of mid-range petroleum products with hydrocarbon compositions of C_{10}–C_{28}; examples include diesel fuel, home heating oil, gas oil, jet fuel, mineral spirits, and kerosene (Restek Corporation, 1994). GRO (C_6–C_{10}) arise from fuels such as gasoline, aviation fuel, and petroleum naphtha; GROs are considered more environmentally malignant because they are composed of a larger percentage of the potentially more toxic aromatic BTEX compounds (benzene, toluene, ethylbenzene, and xylene isomers; Stahl and Tilotta, 1999). Of these two groups, detections of DRO in the North Fork Ranch area exceeded those for GRO (see Table 11).

- **DRO compounds**—DRO compounds were intermittently detected in ground water collected from three domestic wells (RBDW02, rounds 1, 3, and 4; RBDW03, round 1; RBDW05, round 4) and one monitoring well (RBMW01, rounds 1, 3, and 4). Concentrations of DRO in the domestic wells and RBMW01 ranged from 20.0 to 39.0 µg/L; the highest concentrations were collected from RBDW02 (39.0 µg/L) and RBMW01 (30.2 µg/L) during the first sampling event. DRO results in water collected from these two locations during subsequent sampling events mirrored each other: concentrations decreased during rounds 2 (undetected) and 3 (21.3 µg/L and 21.7 µg/L, respectively), but increased in round 4 (28.3 µg/L and 29.8 µg/L, respectively).

  DRO was consistently detected in monitoring well RBMW03, all production well sampling locations (RBPW01, RBPW02, and RBPW03), and all surface water sampling locations (RBSW01, RBSW02, and RBSW03). The highest concentrations were obtained in ground water collected from RBMW03 (874 µg/L to 1940 (J) µg/L). DRO results in production well water ranged from 31.9 µg/L to 118 µg/L; compound concentrations decreased in RBPW03, from 118 µg/L (round

2) to 73.6 µg/L (round 4), but increased in RBPW01, from 31.9 µg/L (round 1) to 77.0 µg/L (round 4). DRO was detected in water collected from all surface water locations, and analyte concentrations were greater, per round and on average, in RBSW01 (mean = 40.7 µg/L) than in samples collected from RBSW02 (mean = 27.8 µg/L) and RBSW03 (mean = 27.8 µg/L). Water within the sampled streams is predominantly sourced from surface discharges of production water and reflects a dominant CBM component.

It is important to point out that the analytical methods used to analyze DRO in aqueous samples measure a wide range of organics in the sample and are not specific to hydrocarbon compounds that originate, for example, from a fuel release (Mohler et al., 2013). Well construction logs for these locations indicate that many of these wells are screened in organic-rich layers, such as shale, siltstone and coal, and this may be the source of these compounds. Non-targeted organic compounds, such as pesticides, phenols, phthalates, and other hydrocarbons, can be captured in the chromatographic integration window and reported as DRO; consequently, analytical methods may actually overestimate the concentration of dissolved DRO (as fuel) in ground water. Some of these compounds (e.g., phenols, phthalates, etc.) were detected in the semivolatile scans previously described. Therefore, it is often helpful to view the DRO chromatograms directly, as shown in Figure 29, for selected ground water wells and surface water locations containing DRO detections. The chromatograms available for production wells RBPW01 and PBPW03 (see Figure 29c) show a broad feature with a peak at about 27 minutes; this pattern implies the presence of longer, alkane-series carbon chains that have undergone weathering and/or biodegradation (Wang and Fingas, 1997; Grossi et al., 2002). The distinct peaks located at about 27.5 minutes in the chromatograms for monitoring well RBMW03 (see Figure 29a) and surface water RBSW01 (see Figure 29b) are consistent with chromatograms depicting chemical composition changes of aromatic hydrocarbons by biodegradation (Wang et al., 1998). However, it is important to note that compounds that originate in hydrocarbon deposits, such as coal, may be mobilized by anthropogenic processes and/or natural water-rock interactions. This is discussed in more detail in the “Coal-Water Interactions” topical section.

- **GRO compounds**—GRO were detected in one monitoring well sample (RBMW03; see Table 11) during rounds 1 and 2.

Low-Molecular-Weight Acids (LMWAs)

LMWAs, predominantly acetate, were detected at low levels in several surface and ground water samples collected within the North Fork Ranch study area (see Table 11). Acetate concentrations ranged from 50 to 465 µg/L, and maximum concentrations were measured in ground water samples obtained from monitoring wells (Table 11). Acetate is one of the most important intermediates produced during the degradation of hydrocarbons, including compounds like DRO, GRO, and/or BTEX, in anaerobic environments (Cozzarelli et al., 1994; Jakobsen and Cold, 2007; Cozzarelli et al., 2010 and references therein). Furthermore, certain microbial species are capable of synthesizing acetate by CO_2 reduction with H_2 or by fermentation of organic compounds (Westermann et al., 1989), and acetate is an important precursor in biogenic methane production (i.e., Whiticar et al., 1986). Acetate was detected in all surface and ground water samples where sufficient concentrations of methane were present to obtain C and H isotope ratios ($\delta^{13}C_{CH4}$; sample locations RBDW04, RBMW02, RBMW03, RBPW01, RBPW03, and RBSW03); the carbon isotope results of methane ($\delta^{13}C_{CH4}$) and dissolved

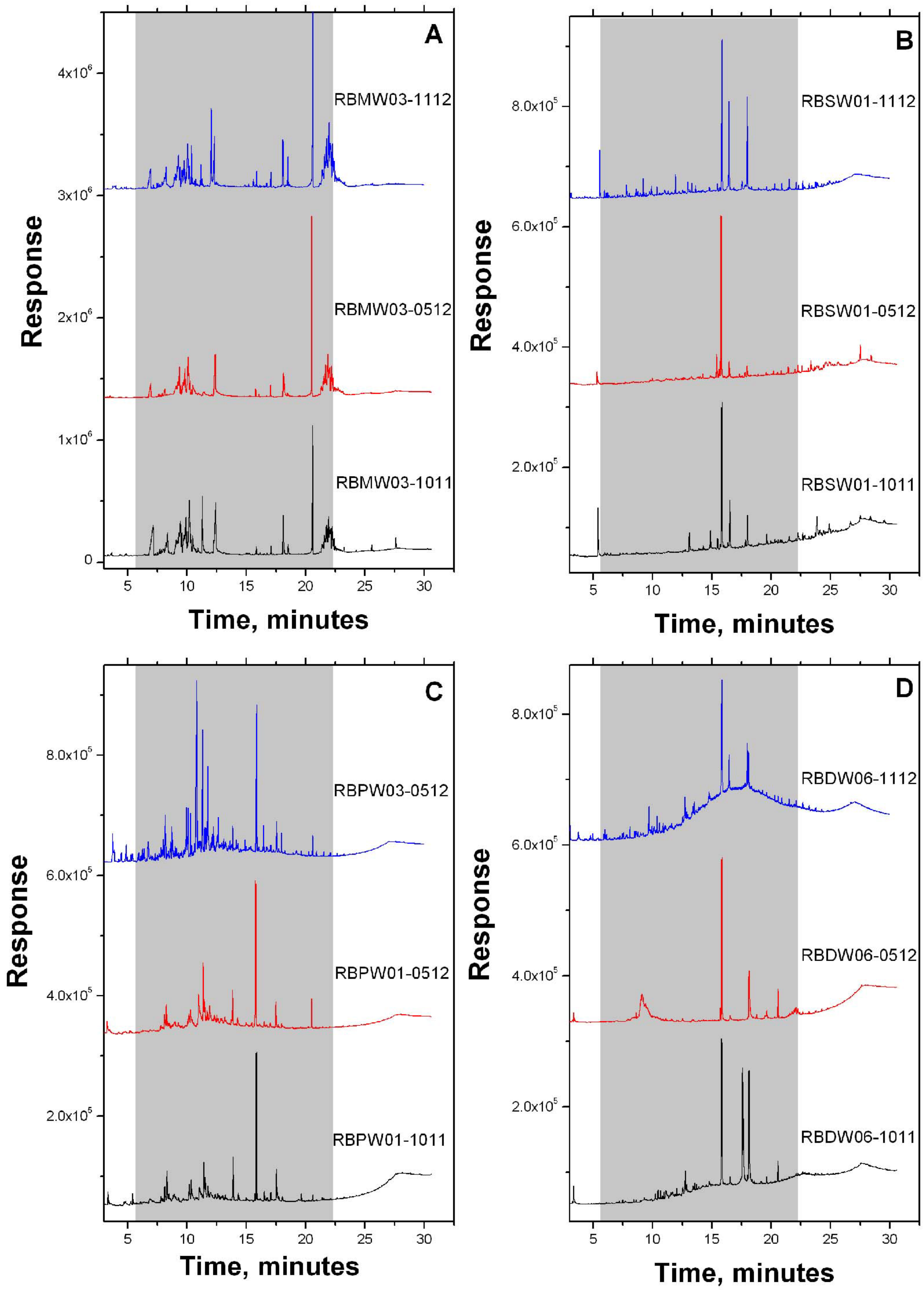


Figure 29. Diesel-range organics (DRO) chromatograms for selected sampling locations. Samples shown in A, B, and C were collected within the North Fork Ranch study area (Las Animas County); sample RBDW06, shown in D, was collected from the Little Creek Field study area (Huerfano County). The grey shaded area represents the integration window for DRO compounds. The peak at ~16 minutes is the surrogate compound, o-terphenyl.

inorganic carbon ($\delta^{13}C_{DIC}$) are consistent with biochemical fractionation of gas due to linked microbial methane generation and hydrocarbon degradation (see "Origin of Methane in Domestic Wells" section—North Fork Ranch).

6.6.2. Arrowhead Ranchettes

Volatile Organic Compounds

Three VOCs were detected in water samples collected from domestic well RBDW11 during the four sampling events (see Table 12): TBA (gasoline oxygenate), chloroform (trihalomethane), and carbon disulfide. Chloroform (rounds 3 and 4) and carbon disulfide (rounds 3 and 4) were detected at levels below the QL but above the MDL. Both hydrochloric acid (HCl) and potassium chloride (KCl) are components of hydraulic fracturing fluids used for CBM development in the Raton Basin (FracFocus, 2013; COGCC, 2013a); however, chloroform was not detected in any production wells within the immediate area (COGCC, 2014b). The presence of chloroform may be due to disinfection of these wells; no well disinfection documentation was available.

TBA was consistently detected (rounds 1 through 4) in water samples collected from RBDW11. The concentration increased from 11.7 µg/L to 32 µg/L over rounds 1, 2 and 3 and then decreased to (12 µg/L) in round 4, mirroring the round 1 result. The source and formation pathway(s) of TBA within this area are currently unresolved, and both anthropogenic and natural sources are possible for the documented occurrences of TBA (see the "Tert-Butyl Alcohol" topical section for more information).

Semivolatile Organic Compounds

Three SVOCs were detected over the four sampling events: bis-(2-ethylhexyl) adipate (DEHA), bis-(2-ethylhexyl) phthalate, and squalene (see Table 12). Bis-(2-ethylhexyl) adipate was detected in ground water collected from RBDW11 and RBDW12 during the first sampling event; however, these results are likely due to lab contamination. Adipate is known to leach from tubing made of PVC plastic (US EPA, 2013d) and was measured in lab blanks during round 1. Bis-(2-ethylhexyl) phthalate was detected during rounds 3 and 4 in ground water samples from RBDW11; the concentration increased from 3.84 µg/L in round 3 to 18.1 µg/L (J-) in round 4. Levels detected in sampling round 4 exceed the federally regulated MCL of 6 µg/L. Squalene, a naturally occurring hydrocarbon, was detected at 3.13 µg/L (J-) in RBDW11 during round 4; however, this compound was measured in the field blank sample at a similar concentration of 3.12 µg/L (J-).

Diesel- and Gasoline-Range Organic Compounds

DRO compounds (see Table 12), described in the North Fork DRO/GRO section (above), were detected in ground water collected from RBDW12 during round 1 (54.7 µg/L) and RBDW11 (22.5 µg/L) during round 4. GRO compounds were not detected at this site.

6.6.3. Little Creek Field

Volatile Organic Compounds

One or more of nine different VOCs were detected in ground water samples during at least one of the four sampling events (see Table 13) and are categorized into five groups: gasoline hydrocarbons, gasoline oxygenates, solvents, trihalomethanes (THMs), and other. These groups were introduced and described in the North Fork Ranch VOC section above.

Table 12. Detection of organic compounds in ground water: Arrowhead Ranchettes study site.

Analyte/Well ID		Sampling Round[1]				Result µg/L	Average µg/L	Range µg/L
		1	2	3	4			
Volatile Organic Compounds								
Carbon Disulfide								
	RBDW11			x, J[2]	x, J		0.18	0.14–0.22
Chloroform (MCL = 80 µg/L)								
	RBDW11			x, J	x, J		0.27	0.22–0.31
Tert-Butyl Alcohol								
	RBDW11	x	x, J-[2]	x	x		19.0	11.7–32
Semivolatile Organic Compounds								
Bis-(2-ethylhexyl) Adipate[3] (MCL = 400 µg/L)								
	RBDW11	x, B				2.61		
	RBDW12	x, B	NS[4]	NS	NS	2.37		
Bis-(2-ethylhexyl) Phthalate (MCL = 6 µg/L)								
	RBDW11			x	x, J-		11.0	3.84–18.1
Squalene[5]								
	RBDW11				x, B, J-	3.13		
Total Petroleum Hydrocarbons								
Diesel-Range Organics								
	RBDW11				x	22.5		
	RBDW12	x	NS	NS	NS	54.7		

The sampling round in which the analyte was detected is designated using an "x" and qualified results are indicated using the appropriate flag. Average values reflect the mean of the detected results; range is equivalent to the minimum and maximum values detected for an analyte, at a given location. MCLs are provided where available. Analytes prefaced with a † are known constituents of hydraulic fracturing fluids (U.S. House of Representatives, 2011; FracFocus, 2013).

[1] Sampling events: round 1 = October 2011; round 2 = May 2012; round 3 = November 2012; and round 4 = April/May 2013.

[2] J = The analyte was positively identified, and the associated numerical value is the approximate concentration; J- = Result may be biased low; B = Analyte was detected in a blank sample above the QL. See Table A28, Appendix A, for more detailed descriptions.

[3] Bis-(2-ethylhexyl) Adipate—"B" round 1: lab blank detection at 1.10 µg/L.

[4] NS = Not sampled.

[5] Squalene—"B" round 4: field blank detection at 3.12 µg/L (J-); concentration data for RBDW11 are suspect.

Table 13. Detection of organic compounds in ground water: Little Creek Field study site.

Analyte/Well ID		**Sampling Round[1]**				**Result** *µg/L*	**Average** *µg/L*	**Range** *µg/L*
		1	**2**	**3**	**4**			
Volatile Organic Compounds								
1,2-dichlorobenzene (MCL = 5 µg/L)								
	RBDW09			x, J[2]		0.08		
† 1,2,3-trimethylbenzene								
	RBDW08			x, J		0.10		
	RBDW09			x, J-[2]		0.08		
† Acetone								
	RBDW06			x, J-		1.6		
	RBDW08			x	x, J		0.58	0.16–1.0
Carbon Disulfide								
	RBDW06			x, J-		0.54		
	RBDW08			x, J	x, J		0.31	0.17–0.45
	RBDW09			x, J-		0.56		
	RBDW10			x, J-		0.71		
	RBDW14	NS[3]		x, J-		0.22		
	RBDW15	NS	NS	x, J-	NS	0.16		
Chloroform (MCL = 80 µg/L)								
	RBDW06	x		x, J-	x, J		1.2	0.08–3.0
	RBDW08			x, J	x		0.54	0.41–0.66
	RBDW14	NS	x	x, J-	x, J		13	0.16–39
	RBDW15	NS	NS	x, J-	NS	1.3		
Methylene Chloride (MCL = 5 µg/L)								
	RBDW06			x, J-		2.1		
	RBDW15	NS	NS	x, J-	NS	0.11		
† Naphthalene								
	RBDW08			x		0.73		
	RBDW09			x, J-		0.78		
Tert-Butyl Alcohol								
	RBDW15	NS	NS	x, J-	NS	9.1		
† Toluene (MCL = 1000 µg/L)								
	RBDW06	x, B	x	x, J-	x, J		0.94	0.21–1.96
	RBDW10	x	x	x, J-	x, J		3.09	0.50–5.91

Table 13. Detection of organic compounds in ground water: Little Creek Field study site.

Analyte/Well ID		**Sampling Round[1]**				**Result** *µg/L*	**Average** *µg/L*	**Range** *µg/L*
		1	**2**	**3**	**4**			
Semivolatile Organic Compounds								
Bis-(2-ethylhexyl) Adipate[4] (MCL = 400 µg/L)								
	RBDW06	x, B				1.46		
	RBDW07	x, B				2.28		
	RBDW08	x, B				2.21		
	RBDW09	x, B				2.33		
	RBDW10	x, B				2.31		
	RBMW04	x, B	NS	NS	NS	3.07		
	RBMW05	x, B	NS	NS	NS	2.56		
Bis-(2-ethylhexyl) Phthalate (MCL = 6 µg/L)								
	RBDW06	x				2.17		
	RBDW08		x			9.33		
	RBDW09				x	11.5		
	RBDW14	NS			x	5.71		
	RBMW05	x	NS	NS	NS	1.03		
Di-n-butyl Phthalate								
	RBMW05	x	NS	NS	NS	5.68		
† Phenol								
	RBDW07	x				1.08		
Total Petroleum Hydrocarbons								
Diesel-Range Organics[5]								
	RBDW06	x	x	x	x		117	81.4–148
	RBDW07	x		x			22.3	21.5–23.0
	RBDW08	x		x, B	x, B		40.0	21.1–52.3
	RBDW09	x	x	x	x, B		56.1	40.5–79.3
	RBDW10	x				21.1		
	RBDW14	NS	x, J	x	x, B		420	24.1–1200[6]
	RBMW05	x	NS	NS	NS	52.5		
Gasoline-Range Organics								
	RBDW06	x	x				22.0	21.5–22.5
	RBDW09		x			31.8		
	RBDW10	x	x	x			29.8	20.6–44.8

Table 13. Detection of organic compounds in ground water: Little Creek Field study site.

Analyte/Well ID		Sampling Round[1]				Result µg/L	Average µg/L	Range µg/L
		1	2	3	4			
	RBDW14	NS	x, J-			49.8		
	RBDW15	NS	NS	x	NS	29.6		

The sampling round in which the analyte was detected is designated using an "x" and qualified results are indicated using the appropriate flag. Average values reflect the mean of the detected results; range is equivalent to the minimum and maximum values detected for an analyte, at a given location. MCLs are provided where available. Analytes prefaced with a † are known constituents of hydraulic fracturing fluids (U.S. House of Representatives, 2011; FracFocus, 2013).

[1] Sampling Events: round 1 = October 2011; round 2 = May 2012; round 3 = November 2012; and round 4 = April/May 2013.
[2] J = The analyte was positively identified, and the associated numerical value is the approximate concentration; J- = Result may be biased low; B = Analyte was detected in a blank sample above the QL. See Table A28, Appendix A, for more detailed descriptions.
[3] NS = Not sampled.
[4] Bis-(2-ethylhexyl) Adipate—"B" round 1: lab blank detection at 1.10 µg/L.
[5] Diesel Range Organics—RBDW10, round 1: DRO present in primary sample, but not in field duplicate.
[6] The high concentration of DRO at location RBDW14 during round 2 is likely related to residual chemicals from well treatment.

- **Gasoline hydrocarbons**—While the full suite of BTEX compounds dominated VOC detections in the North Fork Ranch study site, only three gasoline hydrocarbon analytes were measured in ground water samples collected in the Little Creek Field study area. Benzene derivative 1,2,3-trimethylbenzene was detected at low levels (<QL) at two domestic wells, RBDW08 and RBDW09, during round 2. Similarly, these were the only two sites where low levels of naphthalene (<1 µg/L) were detected (round 3). Toluene was consistently detected (rounds 1 through 4) in two domestic wells: RBDW06 and RBDW10. The highest toluene concentrations were detected in samples collected during round 2 (RBDW06 = 1.96 µg/L; RBDW10 = 5.91 µg/L), and the levels decreased to below the QL by round 4. Many of these wells are screened in organic-rich layers, such as shale, siltstone and coal, and this may be the source of these compounds; compounds that originate in hydrocarbon deposits, such as coal, may be mobilized by anthropogenic processes and/or natural water-rock interactions. The source of gasoline hydrocarbons is discussed in a later topical section ("Coal-Water Interactions").

- **Gasoline Oxygenate**—TBA, discussed in more detail in a later topical section ("Tert-Butyl Alcohol"), was detected during round 3 in one sample from RBDW15 (9.1 µg/L, J-). This was the only time this location was sampled.

- **Solvents**—Three analytes were detected during rounds 3 and 4: 1,2-dichlorobenzene, acetone, and methylene chloride. 1,2-dichlorobenzene, a chemical intermediate used for making herbicides and insecticides (Zogorski et al., 2006), was detected at low levels (<QL) in RBDW09 during round 3. Acetone was measured above the quantitation limit (QL = 1.0 µg/L) in water samples RBDW06 and RBDW08 during round 3. Acetone was detected again, at very low levels (<QL), in RBDW08 during round 4; sources of acetone are discussed above. Methylene chloride was detected in two samples (RBDW06 and RBDW15) during round 3; these samples were collected from one location (i.e., a residential property). RBDW06 was collected from a

domestic well, and RBDW15 was collected from the homeowner's kitchen faucet and reflects post-treatment of ground water.

- **Trihalomethanes**—Chloroform was detected in samples collected from three locations during the four sampling events: RBDW06/RBDW15, RBDW08, and RBDW14. The analyte was detected in water collected from RBDW06 during rounds 1, 3, and 4. Low levels were detected in sample RBDW15 during round 3 (1.3 µg/L, J-), and in water samples collected from RBDW08 during rounds 3 and 4 (<1 µg/L). The highest concentration was obtained during round 2 from RBDW14 (39.0 µg/L); however, the concentration decreased dramatically by round 3 (0.19 µg/L, J-) and remained low (0.16 µg/L, J) through round 4. The presence of chloroform is most likely due to disinfection of the wells, and was the source of the high chloroform concentration detected at location RBDW14 during round 2 (see Table 13; disinfection confirmed by homeowner).
- **Other**—Carbon disulfide was not detected in any wells during the first or second sampling events. It was detected at low levels (<1 µg/L) in water samples collected from all domestic wells sampled during round 3, except for sample RBDW07 (undetected). Carbon disulfide was detected only in water sample RBDW08 during round 4.

Semivolatile Organic Compounds

Four SVOCs were detected over the four sampling events: bis-(2-ethylhexyl) adipate (DEHA), bis-(2-ethylhexyl phthalate), di-n-butyl phthalate, and phenol (see Table 13). Bis-(2-ethylhexyl) adipate was detected at low levels (1.46 µg/L to 3.07 µg/L) in all wells sampled during round 1; however, these results are likely due to lab contamination because adipate was measured in a lab blank following the first sampling event. Bis-(2-ethylhexyl) phthalate and di-n-butyl phthalate were sporadically detected in several water samples over four sampling rounds. Bis-(2-ethylhexyl) phthalate concentrations exceeded the federal MCL of 6 µg/L (US EPA, 2013b) in two domestic wells RBDW08 (round 2, 9.33 µg/L) and RBDW09 (round 4, 11.5 µg/L). The compound was detected at concentrations less than the MCL in ground water collected from RBDW06 (round 1), RBDW14 (round 4), and RBMW05 (round 1). Di-n-butyl phthalate was also detected in RBMW05 (5.68 µg/L) during round 1. Phthalates are discussed in more detail in the North Fork Ranch "Semivolatile Organic Compounds" section, above. Phenol was detected at low levels in one well, RBDW07, during round 1. Phenols present in ground water are linked to lower rank coal deposits (Orem et al., 2007) and are discussed in a later topical section ("Coal-Water Interactions").

Diesel- and Gasoline-Range Organic Compounds

GRO and DRO were introduced and described in the North Fork Ranch DRO/GRO section above. DRO and GRO were detected in several water samples collected in the Little Creek Field study area (see Table 13).

- **DRO compounds**—DRO were detected in all domestic wells in at least one sampling event, as well as in one monitoring well (RBMW05) during round 1. DRO were consistently detected in ground water collected from RBDW06 (mean = 117 µg/L), RBDW09 (mean = 56.1 µg/L), and RBDW14 (mean = 420 µg/L; the high mean concentration at this location is affected by residual chemicals used for well disinfection, see Table 13). These compounds were intermittently detected in ground water sampled from RBDW07 (rounds 1 and 3), RBDW08 (rounds 1, 3, and

4), and RBDW10 (round 1). The chromatogram available for domestic well RBDW06 (see Figure 29d) shows a broad feature with a peak at about 27 minutes; this pattern implies the presence of longer, alkane-series carbon chains that have undergone weathering and/or biodegradation (Wang and Fingas, 1997; Grossi et al., 2002). This is discussed in more detail in the "Coal-Water Interactions" topical section.

- **GRO compounds**—GRO were detected above the QL in ground water collected at four domestic well locations. The highest concentration was detected during round 2 from a sample collected at RBDW14 (49.8 µg/L, J-); however, this was the only sampling event where GRO was detected, and the result may have been affected by the sample matrix. Upon receipt, the EPA Region 8 Laboratory noted the sample smelled strongly of acid or chlorine and that the spike compounds, added to an additional sample for matrix spike/matrix spike duplicate (MS/MSD) analysis, were degraded by the sample matrix. GRO were detected during rounds 1 and 2 in ground water collected from RBDW06, and from RBDW15 (kitchen faucet at location RBDW06) during round 3. The result obtained in the water sample collected at RBDW15 reflected the highest concentration detected at this location (29.6 µg/L). GRO were also detected in ground water collected from RBDW09 during round 2, and from RBDW10 during rounds 1, 2, and 3.

  GRO were not detected in any water samples collected in the Little Creek Field site during the last sampling event (round 4).

6.7. Water Isotopes

Stable isotopes of hydrogen (δ^2H) and oxygen (δ^{18}O) were measured for all ground and surface water samples collected in rounds 1 through 4. These environmental isotopes are suitable tools for hydrogeological investigations because (i) they are part of the water molecules and follow their behavior through hydrological cycles, and (ii) they behave conservatively as long as the relative amount of water involved in chemical reactions remains limited (IAEA, 1983). As such, δ^2H and δ^{18}O serve as useful tracers of water flows, and information can be obtained about the recharge environments and geochemical evolution of dissolved constituents in water (IAEA, 1983).

Isotope results are reported in standard delta (δ) notation, in units of permil relative to the VSMOW reference water, on scales normalized to the δ^2H and δ^{18}O values of the Standard Light Antarctic Precipitation (SLAP) reference water: -428‰ and -55.5‰, respectively (Kendall and Coplen, 2001). For stable hydrogen and oxygen ratios:

$$\delta\,^{2}H = \left[\frac{(\,^{2}H/\,^{1}H)_{sample}}{(\,^{2}H/\,^{1}H)_{standard}} - 1\right] \times 1000 \tag{2}$$

and

$$\delta\,^{18}O = \left[\frac{(^{18}O/^{16}O)_{sample}}{(^{18}O/^{16}O)_{standard}} - 1\right] \times 1000 \tag{3}$$

The δ notation expresses the isotope ratios of hydrogen (Eqn. 2) and oxygen (Eqn. 3) of water in a given sample, relative to the same isotope ratios in an isotopic standard. A positive δ value means that the sample is more enriched in the heavy isotope than the standard; a negative δ value indicates that the sample is depleted in the heavy isotope relative to the standard.

Oxygen and hydrogen isotope compositions for water samples collected at each study site are represented in Figures 30 and 31, together with the global meteoric water line (GMWL; Craig, 1961) and the local meteoric water line (LMWL) for the state of Colorado. The GMWL defines the relationship between $\delta^{18}O$ and $\delta^{2}H$ in worldwide fresh surface waters, based on global precipitation data, and is used as a reference line when local or nearby precipitation data are not available for comparison (Mayo et al., 2007). LMWLs may differ from the GMWL, where $\delta^{18}O$ and $\delta^{2}H$ values reflect the imprint of seasonal variations in precipitation, and evaporative loss from rivers, reservoirs, and lakes, on a regional scale (see Figure 30A, inset; Gat, 1971). As seen in Figure 30A (inset), seasonal changes and/or changes in relative altitude within a given area can influence the signature of water stable isotopes. Precipitation is the ultimate source of ground water in nearly all systems. On average, seasonal variations in the $\delta^{18}O$ and $\delta^{2}H$ composition of precipitation remain fairly constant from year to year due to the constancy in the annual range and sequence of climatic conditions experienced within a geographic region (e.g., temperature, vapor source, direction of air movement, etc.). Through selective recharge and infiltration processes within saturated and unsaturated zones, ground water attains a uniform isotopic character that normally closely approaches a damped reflection of precipitation over a period of years (Sklash et al., 1976).

6.7.1. North Fork Ranch

The oxygen and hydrogen isotope compositions for water samples collected in the North Fork Ranch area are presented in Figure 30. The water isotope values ranged from -14.3 to -8.7‰ for $\delta^{18}O$, and from -101.7 to -65.7‰ for $\delta^{2}H$. The range in $\delta^{18}O$ and $\delta^{2}H$ values was greatest for domestic well samples, ranging from -14.3 to -8.7‰ for $\delta^{18}O$, and from -101.7 to -67.1‰ for $\delta^{2}H$. The isotopic values at each sample location remained fairly constant over the four sampling events, and total variability was <0.8‰ for $\delta^{18}O$ and <2‰ for $\delta^{2}H$. Isotope results for samples collected from monitoring wells, production wells, and surface water bodies ranged from -10.9 to -10.3‰ for $\delta^{18}O$, and from -76.4 to -65.7‰ for $\delta^{2}H$. The total isotopic variability over the four sampling events was: <0.7‰ for $\delta^{18}O$ and <0.9‰ for $\delta^{2}H$ at monitoring well sites, <1‰ for $\delta^{18}O$ and <0.7‰ for $\delta^{2}H$ at production wells, and <0.7‰ for $\delta^{18}O$ and <3.1‰ for $\delta^{2}H$ at surface water locations.

Water isotope data collected in the North Fork Ranch study area fall into two distinct groups, designated as “A” and “B,” relative to the GMWL (see Figure 30A). Group A represents data collected from two domestic well sampling locations: RBDW01 and RBDW13. The range of $\delta^{18}O$ and $\delta^{2}H$ measurements from ground water collected at these locations was from -14.3 to -13.7‰ for $\delta^{18}O$, and from -101.7 to -100.4‰ for $\delta^{2}H$. Both wells are located in Quaternary alluvial aquifers, along the North Fork of the Purgatoire River; RBDW01 is less than 1,800 feet down gradient from RBDW13. The alluvium consists of sand- and gravel-containing clay, with minor amounts of boulders and cobbles, derived from the Sangre de Cristo Mountains along the western margin of the basin. The sand and gravel were predominantly sourced from sedimentary rocks and also include igneous and metamorphic grains (Powell, 1952; Howard, 1982). Isotopic results for $\delta^{2}H$ and $\delta^{18}O$ from these wells fall along the GMWL (see Figure 30A), indicating that precipitation is the predominant source of recharge to these wells. Alluvial wells receive water primarily by downward drainage from the surface and stream channel loss; the alluvium stores and transmits water infiltrating from precipitation, storm, and snowmelt runoff (Howard, 1982). Temporal trends in the isotopic composition of ground water collected from these wells fall within the range observed in precipitation sourced from high-altitude areas to the west and local precipitation.

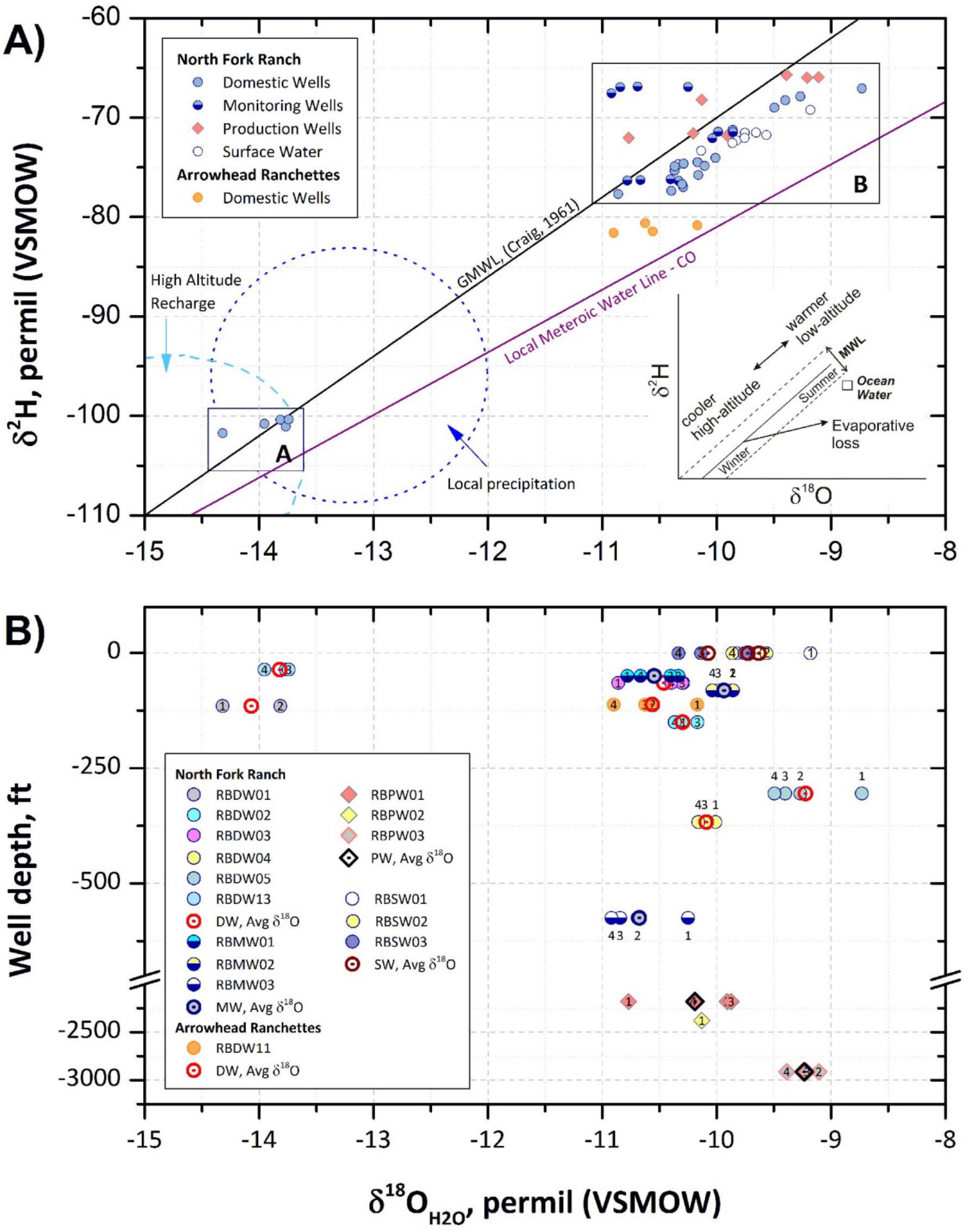


Figure 30. Isotopic trends in δ^{18}O and δ^{2}H in ground water and surface water samples A) and depth trends, relative to the δ^{18}O composition of water B), for samples collected from the North Fork Ranch and Arrowhead Ranchettes study areas (Las Animas County, CO). The inset diagram (top) summarizes how hydrologic processes affect the δ^{18}O and δ^{2}H composition of water. Numbers, located next to symbols, refer to sampling rounds.

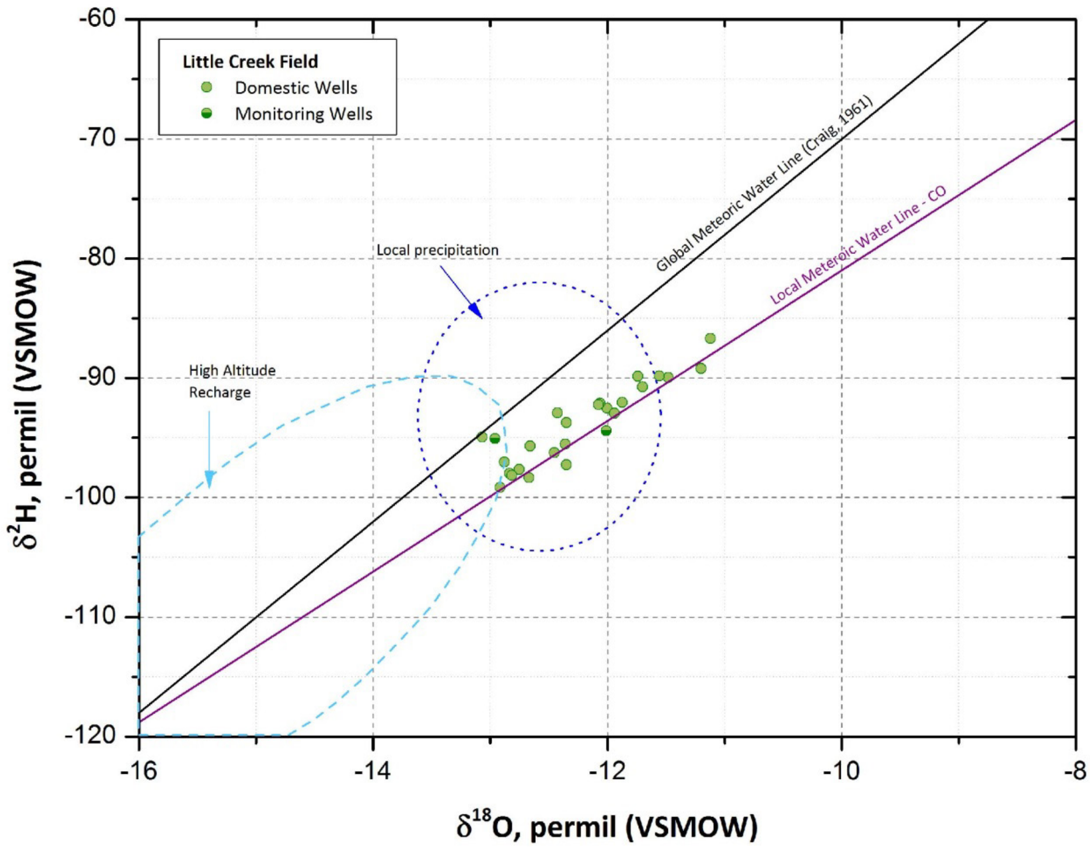


Figure 31. Isotopic trends in δ^{18}O and δ^2H for ground water samples collected from the Little Creek Field study area (Huerfano County, CO).

Group B includes water isotope data from all other (non-alluvial) domestic wells, monitoring wells, production wells, and surface water bodies in the North Fork Ranch study area. The data in Group B are isotopically enriched relative to Group A, and there is a similarity in the isotopic composition of ground water samples, regardless of geologic formation. Non-alluvial domestic wells (RBDW02, RBDW03, RBDW04, and RBDW05) and monitoring wells are located in the Cuchara-Poison Canyon aquifer, whereas production wells are screened in the coal-bearing Raton and Vermejo formations. The δ^{18}O and δ^2H measurements for ground water samples collected from the Poison Canyon aquifer ranged from -10.9 to -8.7‰ for δ^{18}O, and from -77.7 to -66.9‰ for δ^2H. The isotopic composition of ground water sampled from the Raton-Vermejo aquifers ranged from -10.8 to -9.1‰ for δ^{18}O, and from -72.1 to -65.7‰ for δ^2H. Samples collected from production well RBPW03, located in the Vermejo Formation, were the most isotopically enriched of all ground water samples collected in the North Fork Ranch study area.

With the exception of monitoring well RBMW03, the isotopic composition of water collected from Poison Canyon domestic and monitoring wells (RBMW01 and RBMW02) plots slightly below the meteoric water lines, indicating isotopic fractionation. The Vermejo-Raton aquifer is unconfined within the vicinity of their outcrop locations, but confined when overlain by other units at depth; the Poison Canyon aquifer is a water-table aquifer (Howard, 1982). It is important to note the heterogeneity and anisotropic nature of these aquifers: the Cuchara-Poison Canyon and Raton-Vermejo aquifers consist of thick sequences of interbedded and discontinuous sandstones, shales, and coals, in which hydraulic and storage properties vary spatially (Watts, 2006a). If it is assumed that ground water collected from the production wells represents meteoric water trending from the late Cretaceous-Paleocene period (because water penetrating deep confined aquifers responds less to precipitation cycles), then the isotopic composition of the domestic and monitoring wells could indicate that there was intermixing of the waters within the aquifer (i.e., since the Poison Canyon formation is unconfined, the isotopic composition of ground water should reflect a precipitation imprint).

Alternatively, deviation from the GMWL could indicate that the different aquifers were subject to similar recharge and/or evolutional paths for the water, so that the net difference in the δ^2H and δ^{18}O was minimal (Bartos and Ogle, 2002). A plot of δ^{18}O versus well depth (see Figure 30B) shows little variability in the isotopic composition of oxygen: isotope values for Poison Canyon domestic and monitoring wells fall, for the most part, within the range measured in ground water from production wells. Furthermore, temporal trends (at each sampling location) in isotopic composition indicate similar ranges of oxygen isotope values but different deuterium values. Trends observed in the δ^{18}O values of formation waters in deep basins can be explained by isotopic exchange between water and minerals, which almost always results in an increase in the δ^{18}O value of the water (Kharaka and Thordsen, 1992).

Ground water sampled from monitoring well RBMW03 fell above the GMWL, indicating excess deuterium. This is likely a result of methanogenesis via a CO_2 reduction pathway, which is discussed in more detail in a later section ("Molecular and Isotopic Composition of Coalbed Methane").

The water isotope results of surface water samples suggest that water within the sampled tributaries is composed predominantly of production water discharged to the surface with minor contributions from precipitation, and the resulting isotopic composition of the water reflects an evaporative imprint (see Figure 30A). A linear fit of surface water data yields a regression line ($\delta^2H = 4.37 * \delta^{18}O - 29.27$, $R^2 = 0.94$) that intersects the GMWL slightly below the isotopic composition of the production wells but far above the annual isotopic composition of precipitation. The location of these data suggests that water within the sampled streams is predominantly sourced from surface discharges of production water, with minor contributions from seasonal precipitation events: if the δ^2H and δ^{18}O isotopic values were significantly influenced by precipitation, then the data would plot along the GMWL, somewhere between production well values and the isotopic values observed in alluvial aquifers and/or local precipitation events. Further, the enrichment of δ^{18}O, relative to the GMWL and production well water isotope values, occurs as a result of evaporation processes; the slope of the regression line (4.37) is consistent with evaporation trends observed in arid regions (slope <5; Kendall and Coplen, 2001).

6.7.2. Arrowhead Ranchettes

Water isotope results for samples collected from domestic well RBDW11 ranged from -10.9 to -10.2‰ for δ^{18}O, and from -81.6 to -80.6‰ for δ^2H; these data are shown in Figure 30. Domestic well RBDW12 was sampled only during round 1; the measured isotopic values for this sample were -10.2 and -80.3‰ for oxygen and hydrogen, respectively.

Ground water collected from RBDW11, located in the Raton Formation, is enriched in δ^{18}O but depleted in δ^2H relative to the GMWL, and surface and ground water samples collected from non-alluvial domestic wells, monitoring wells, and production wells in North Fork Ranch area; the isotopic composition steadily shifts towards the GMWL during rounds 2–4 (Group B, Figure 30A). A comparative ground water sample from the Raton Formation is sample RBPW01, obtained from a production well in North Fork Ranch; the isotope composition of the ground water sample collected from domestic well RBDW11 is isotopically heavier than sample RBPW01. This difference is not unexpected because both the (subsurface) geology and weather patterns shift moving from west to east within the basin. Ground water composition within the Arrowhead Ranchettes study area is modified to a greater extent, relative to RBPW01, by precipitation events because the Raton Formation is exposed at the surface, and not overlain by the Poison Canyon Formation. Furthermore, the central part of the basin receives less precipitation than the western margin, where the North Fork Ranch study area is located (Powell, 1952), so evaporative imprints are much stronger.

6.7.3. Little Creek Field

The oxygen and hydrogen isotope compositions for water samples collected in the Little Creek Field area are represented in Figure 31. The water isotope results for samples collected from domestic wells (excluding RBDW15, collected from a kitchen faucet) in this area ranged from -13.1 to -11.1‰ for δ^{18}O, and from -99.1 to -86.7‰ for δ^{2}H. The total isotopic variability over the four sampling events, at each domestic well, was <0.80‰ for δ^{18}O and <2.2‰ for δ^{2}H, with the exception of the water sample collected at RBDW06 during round 1. Mean isotopic values in ground water collected from this location, -11.8 ± 0.52‰ for δ^{18}O and -91.3 ± 3.1‰ for δ^{2}H, were the heaviest (i.e., isotopically enriched) of all water isotope values collected in the Little Creek study area during all sampling events. The results for samples collected from monitoring wells (round 1) fell within the isotopic range observed in the domestic wells.

Domestic wells within the Little Creek study site are screened within the Cuchara-Poison Canyon aquifer, a confined aquifer that is recharged principally from precipitation falling on the Culebra Range (Abbott et al., 1983; Abbott, 1985), a subrange of the Sangre de Cristo Mountains. The water isotope data collected from this area indicate that ground water recharge is predominantly controlled by precipitation events and evaporative processes, which occur in high areas west of the study area. The results for all samples trend along the LMWL for Colorado; minor deviations are due to regional and seasonal variations in the δ^{18}O and δ^{2}H of precipitation. The distinctive slope of the Colorado LMWL relative to the GMWL reflects the effect of regional evaporative processes on precipitation. The intersection of the Colorado LMWL and the GMWL coincides with the annual average δ^{18}O and δ^{2}H values for peaks within the Sangre de Cristo Mountains (Bowen and Wilkinson, 2002; Bowen and Ravenaugh, 2003; Bowen et al., 2005), which are located west of the study area. Confined aquifers tend to respond less to precipitation cycles (Abbott et al., 1983). The annual average δ^{18}O and δ^{2}H values for precipitation falling on the study site (Bowen and Wilkinson, 2002; Bowen and Ravenaugh, 2003; Bowen et al., 2005) are shown in Figure 31 as a dark blue, dashed circle. If localized precipitation events significantly contributed to ground water recharge within this area, then the data points would trend along a line that intersected the GMWL closer to the annual precipitation values.

6.8. Dissolved Gases

Coals serve as both sources and reservoirs of substantial quantities of hydrocarbon and CO_2 gases (Clayton, 1998). Methane is predominantly a product of the conversion of organic matter in different temperature regimes, and gas produced from bituminous and sub-bituminous coals is typically generated by two distinct processes: biogenic and thermogenic. Biogenic gas, primarily methane and CO_2, is produced via anaerobic decomposition of organic matter by microorganisms (Rice, 1993; Johnson and Flores, 1998). Microbial methane reservoirs are typically located at shallow depths in thermally immature shales and coals (McIntosh et al., 2008). Under favorable conditions, large amounts of biogenic methane can be generated over a period of tens of thousands of years (Johnson and Flores, 1998). In contrast, thermogenic gas is generated over geologic timescales in organic-rich formations that were subject to high temperature and/or pressures, and are typically located at depth in sedimentary basins (McIntosh et al., 2008). Methane is usually the major component; hydrocarbon gases, including ethane (C_2H_6), propane (C_3H_8), and butane (C_4H_{10}) are produced during thermal decomposition of organic matter in the subsurface and accumulate with methane in subsurface reservoirs (Rice, 1993; Quistad and Valentine, 2011). In the Raton Basin, Raton and Vermejo coalbed gases are dry (90 to 95% CH_4), very low in CO_2 (~1%) and higher chain (C_{2+}) hydrocarbons (<0.1%), and contain ~5% nitrogen.

Ground water movement is an important mechanism by which methane migrates from its source, in solution, and accumulates in suitable traps (Edwards, 1991). The production of methane is a concern because it can migrate in the subsurface and reach indoor or confined spaces (e.g., basements, underground piping systems), where it can accumulate to explosive levels (lower explosive limit (LEL) = 5 to 15%; Eltschlager et al., 2001). The concentration of methane within ground water that can lead to an explosive hazard depends on the confined space properties; a potential hazard exists if the partial pressure of methane is greater than 0.05 bars, which is equivalent to 1.6 mg/L (Goody and Darling, 2005). The COGCC identifies 1.1 mg/L as the threshold level at which water well systems have the potential to accumulate explosive vapors in confined spaces (LT Environmental, Inc., 2007).

Methane is widely distributed in shallow aquifers within the Raton Basin, and concentrations of dissolved methane ranging from about 0.0003 mg/L to 38 mg/L were reported for water wells in a baseline study conducted by the COGCC (2003b). The major paths for the vertical migration of gas are formed by natural faults and fractures in the rock; the volume of gas migrating toward the surface is directly related to the type and width of the path along which it migrates. Additional avenues of migration may be created by drilling operations, which not only creates a hole through the strata but also causes fracturing around the wellbore (Gurevich et al., 1993; Van Stempvoort et al., 2005).

The distribution of methane and ethane (C_2H_6) in ground water and surface water samples collected from each study site is shown in Figures 32 through 34 and summarized in Tables 14 through 17.

6.8.1. North Fork Ranch

Dissolved methane was detected above the MDL in ground water and surface water samples (n = 46) collected during sampling rounds 1 through 4; mean concentrations at these sampling locations ranged up to 21.87 mg/L (see Table 14). The distribution of methane concentrations observed in this area, as well as dissolved methane data obtained from private water wells in 2002 from the COGCC study (COGCC, 2003a), is shown in Figure 33A.

Dissolved methane concentrations were greatest in the samples collected from production wells (RBPW01 and RBPW03), with average values >20 mg/L. The methane concentration measured in ground water collected from RBPW02 was 14.8 mg/L; this location was sampled only during round 1. Average methane values obtained from monitoring wells (RBMW01, RBMW02, and RBMW03) ranged from 0.29 mg/L to 10.4 mg/L; all monitoring wells are located within ~0.5 miles of the production wells. Dissolved methane concentrations in five of the six domestic wells were consistently <0.1 mg/L, with the exception of domestic well RBDW04. The concentration of methane in this well increased from 10.0 mg/L in round 1 to 14.4 mg/L in round 4, with an average concentration of 12.4 mg/L (n = 3). Methane was consistently detected in rounds 2, 3 and 4 at surface water locations RBSW02 (mean = 0.014 mg/L, n = 3) and RBSW03 (mean = 15.6 mg/L, n = 3). Methane was also detected at low levels (<QL) during round 3 at RBSW01.

The distribution of ethane concentrations observed in this area is shown in Figure 34A and summarized in Table 15. In the North Fork Ranch study area, dissolved ethane was detected above the QL during all sampling events in production wells (RBPW01, RBPW02, RBPW03), in domestic well RBDW04 (mean = 0.0081 mg/L, n = 2), and at surface water body RBSW03 (mean = 0.0069 mg/L, n = 3). Dissolved ethane concentrations were highest in ground water collected from the production wells and ranged from 0.0061 mg/L to 0.0893 mg/L. Dissolved ethane was detected at low levels in ground water collected from monitoring well RBMW02 during rounds 2 and 4 (mean = 0.0011 mg/L, n = 2) and from RBMW03 during rounds 2 and 3 (mean = 0.0173 mg/L, n = 2); it was not detected in samples from RBMW01 during any sampling event.

Detections of higher chain hydrocarbons (>$C_{2;}$ e.g., propane and butane), were not observed in any ground water or surface water sample during any sampling event.

6.8.2. Arrowhead Ranchettes

Dissolved methane was detected above the QL in domestic well RBDW11 during all sampling events; methane concentrations increased from 0.573 mg/L in round 1 to >2 mg/L in round 4, with an average of 1.57 mg/L (n = 4; see Table 14). Dissolved ethane (see Table 15) was detected at low levels in this well during three of the four sampling events (rounds 1, 2, and 3); the average concentration was 0.0018 mg/L (n = 3). Methane was also detected in ground water collected from domestic well RBDW12 during round 1 (0.832 mg/L); this location was sampled only during round 1. Higher chain hydrocarbons (>C_2; e.g., propane and butane) were not detected in any ground water samples, during any sampling round.

6.8.3. Little Creek Field

The distribution of methane concentrations observed in this area is shown in Figure 33B, and the data are summarized in Table 16. Dissolved methane was detected above the QL in all ground water wells during all sampling events, with the exception of domestic well RBDW14 during round 4: no methane was detected in this well at that time. Average concentration values in domestic wells ranged from 0.001 mg/L to 13.5 mg/L and exhibited a bimodal distribution that correlates to geographic location: methane concentrations were <0.02 mg/L in samples from domestic wells in the northern part of the study area (RBDW07, RBDW14; see Figure 24), but exceeded ~4 mg/L, during each sampling event, in samples from wells south of RBDW07 and RBDW14. Methane was detected in both monitoring wells (RBMW04 and RBMW05) during round 1 (results = 15.1 mg/L and 17.5 mg/L, respectively); this was the only sampling round in which ground water was obtained from these wells. Methane was detected above the QL in water collected from sample RBDW15 during round 3 (0.0817 mg/L). This sample was obtained from the kitchen faucet at location RBDW06, and water chemistry reflects post-treatment ground water. The pre-treatment methane concentration at the well head was 10.40 mg/L.

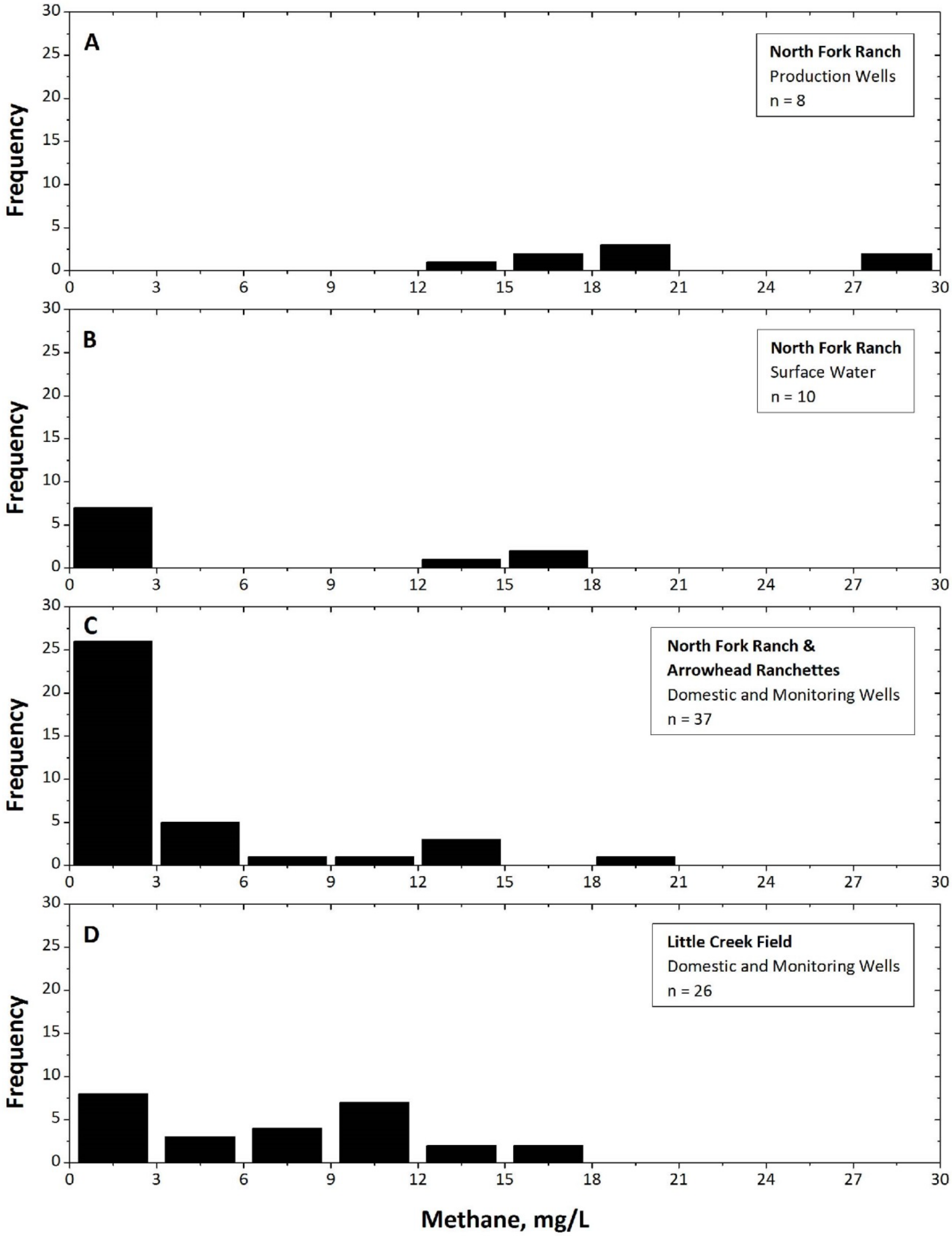


Figure 32. Frequency diagrams showing methane concentrations in production water, surface water, domestic wells, and monitoring wells: all study areas (Raton Basin, CO).

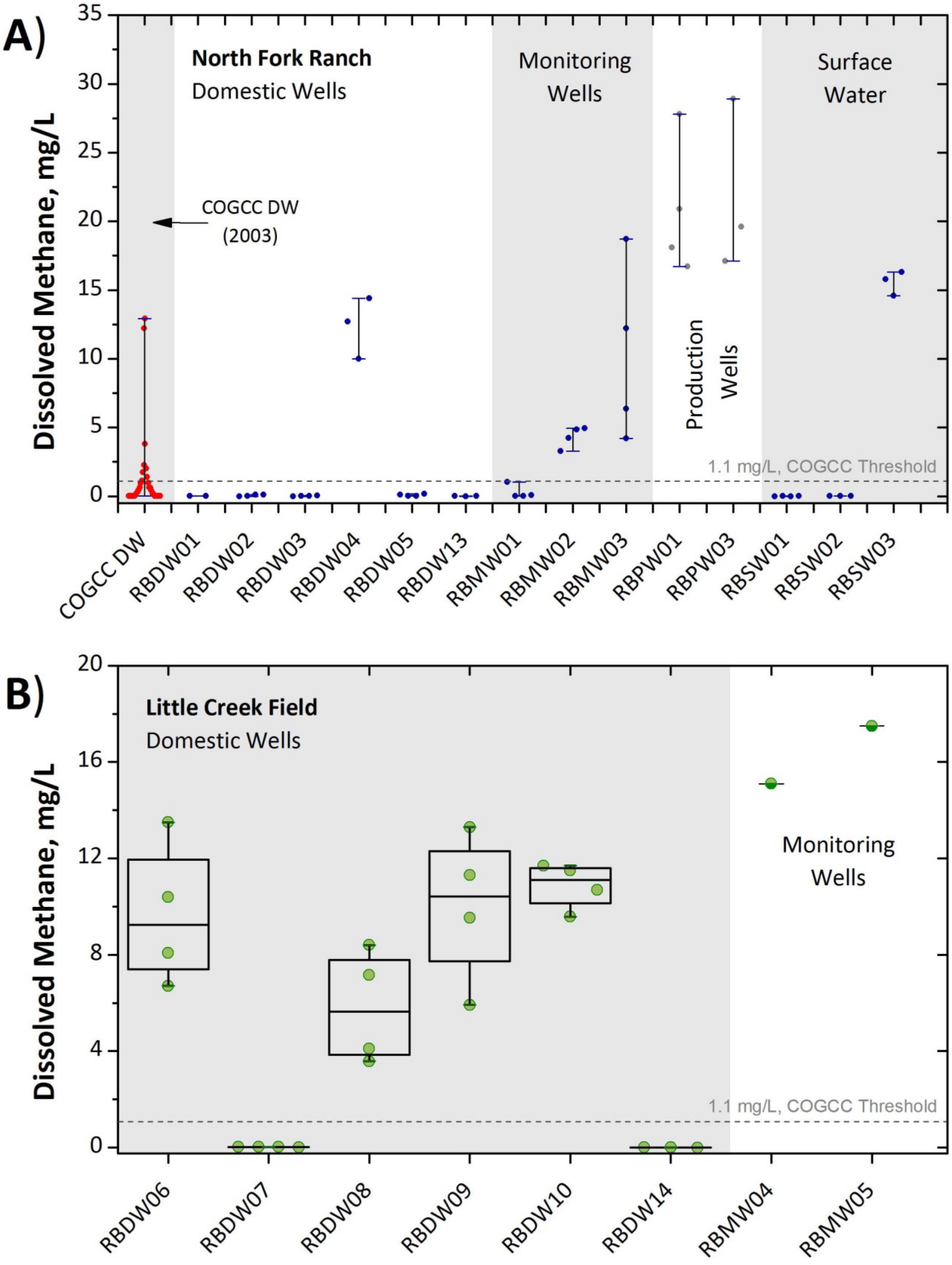
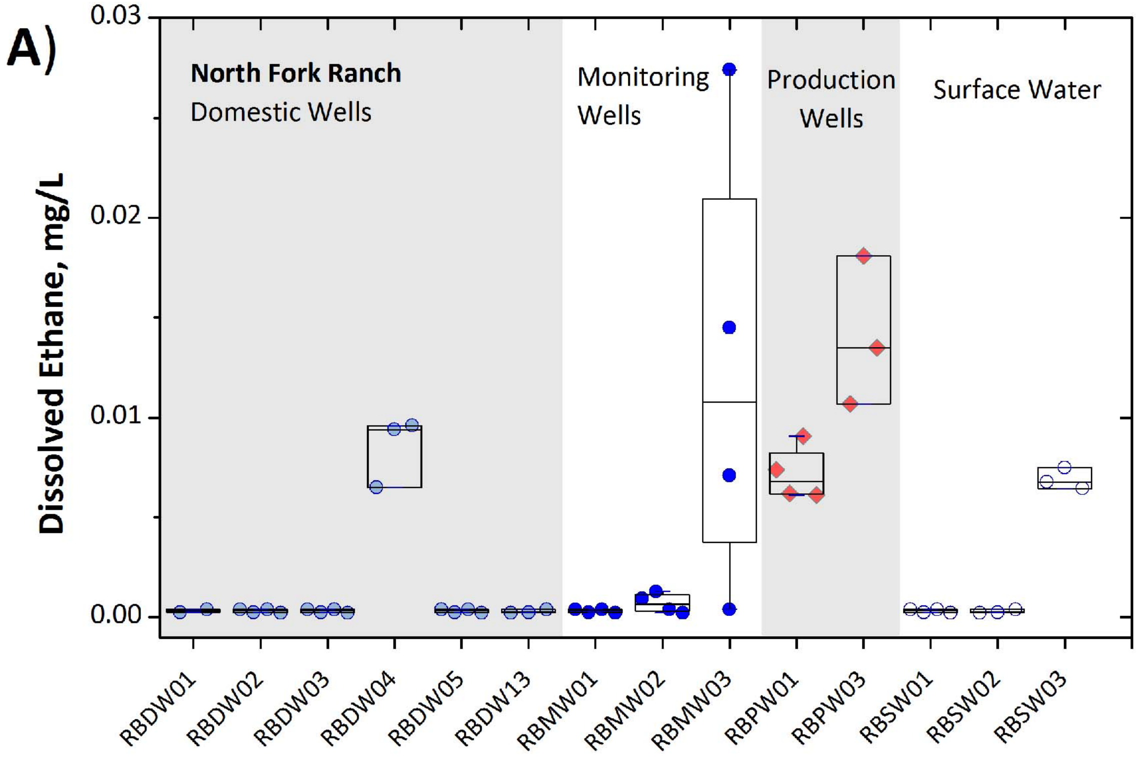


Figure 33. Box diagrams for dissolved methane (mg/L) in water samples collected within the A) North Fork Ranch (Las Animas County) and B) Little Creek Field (Huerfano County) study areas; results obtained from North Fork Ranch, this study, are compared (top) to dissolved methane data reported by the COGCC following a survey conducted in the region in 2002.



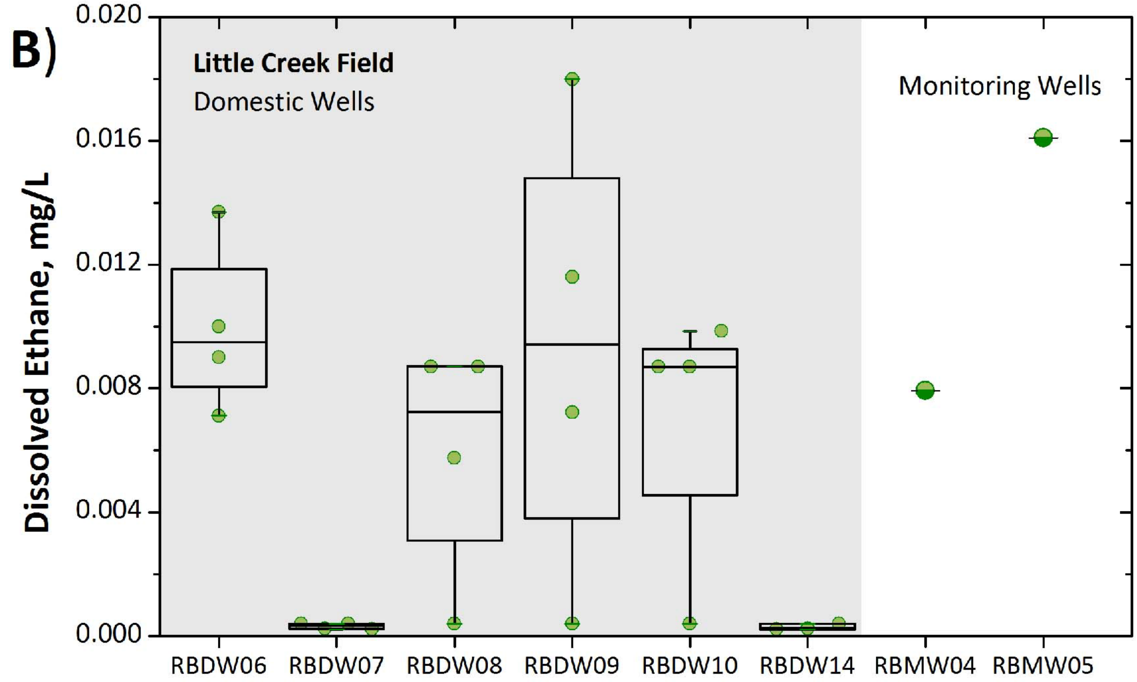


Figure 34. Box diagrams for dissolved ethane (mg/L) in water samples collected within the A) North Fork Ranch (Las Animas County) and B) Little Creek Field (Huerfano County) study areas.

Table 14. Detection of methane in ground and surface water: North Fork Ranch and Arrowhead Ranchettes study sites.

Sample ID	Sampling Round[1]				Result mg/L	Average mg/L	Range mg/L
	1	2	3	4			
North Fork Ranch							
RBDW01	x,B[2]	x	NS[3]	NS		0.0113	0.0069–0.0157
RBDW02	x	x	x			0.0697	<0.0013–0.1010
RBDW03	x, B	x, J[2]	x, *[2]			0.0156	<0.0013–0.0328
RBDW04	x	NS	x	x		12.37	10.00–14.40
RBDW05	x, B	x	x	x, *		0.0952	0.0069–0.1820
RBDW13	NS	x	x	x		0.0185	0.0005–0.0306
RBMW01	x, B	x	x	x, *		0.2906	0.0134–1.04
RBMW02	x	x	x	x		4.32	3.27–4.93
RBMW03	x	x	x	x		10.37	4.21–18.70
RBPW01	x	x	x	x, *		20.88	16.70–27.80
RBPW02	x	NS	NS	NS	14.80		
RBPW03	NS	x	x	x, *		21.87	17.10–28.90
RBSW01		x, J			0.0012		
RBSW02	NS	x	x	x		0.0144	0.0078–0.0212
RBSW03	NS	x	x	x		15.57	14.60–16.30
Arrowhead Ranchettes							
RBDW11	x	x	x	x, *		1.57	0.550–2.87
RBDW12	x	NS	NS	NS	0.8320		

The sampling round in which the analyte was detected is designated using an “x” and qualified results are indicated using the appropriate flag. Average values reflect the mean of the detected results; range is equivalent to the minimum and maximum values detected for an analyte, at a given location.

[1] Sampling Events: round 1 = October 2011; round 2 = May 2012; round 3 = November 2012; and round 4 = April/May 2013.

[2] B = Analyte was detected in a blank sample; J = The analyte was positively identified, and the associated numerical value is the approximate concentration; * = Relative percent difference of lab or field duplicate is outside acceptance criteria. See Table A28, Appendix A, for more detailed descriptions. Data determined to be unusable due to unacceptable blank levels were not used in this table (see Table A25, Appendix A).

[3] NS = Not sampled.

Table 15. Detection of ethane in ground and surface water: North Fork Ranch and Arrowhead Ranchettes study sites.

Sample ID	Sampling Round[1]				Result mg/L	Average mg/L	Range mg/L
	1	2	3	4			
North Fork Ranch							
RBDW01			NS[2]	NS		ND[3]	
RBDW02						ND	
RBDW03						ND	
RBDW04	x, B[4]	NS	x	x		0.0081	0.0065–0.0096
RBDW05						ND	
RBDW13	NS					ND	
RBMW01						ND	
RBMW02		x, J[4]		x, J		0.0011	<0.0027–0.0013
RBMW03	x, B	x	x			0.0173	<0.0027–0.0274
RBPW01	x, B	x	x	x		0.0066	0.0061–0.0074
RBPW02	x	NS	NS	NS	0.0893		
RBPW03	NS	x	x	x		0.0141	0.0107–0.0181
RBSW01						ND	
RBSW02	NS					ND	
RBSW03	NS	x	x	x		0.0069	0.0065–0.0075
Arrowhead Ranchettes							
RBDW11	x, J	x, J	x, J			0.0018	0.0009–0.0027
RBDW12		NS	NS	NS	ND		

The sampling round in which the analyte was detected is designated using an "x" and qualified results are indicated using the appropriate flag. Average values reflect the mean of the detected results; range is equivalent to the minimum and maximum values detected for an analyte, at a given location.

[1] Sampling Events: round 1 = October 2011; round 2 = May 2012; round 3 = November 2012; and round 4 = April/May 2013.
[2] NS = Not sampled.
[3] ND = Not detected.
[4] B = Analyte was detected in a blank sample; J = The analyte was positively identified, and the associated numerical value is the approximate concentration. See Table A28, Appendix A, for more detailed descriptions. Data determined to be unusable due to unacceptable blank levels were not used in this table (see Table A25, Appendix A).

Table 16. Detection of methane in ground water: Little Creek Field study site.

Sample ID	Sampling Round[1]				Result mg/L	Average mg/L	Range mg/L
	1	2	3	4			
Little Creek Field							
RBDW06	x	x	x	x		9.67	6.71–13.50
RBDW07	x	x	x	x		0.0209	0.0178–0.0241
RBDW08	x	x	x	x		5.81	3.58–8.40
RBDW09	x	x	x	x		10.01	5.92–13.30
RBDW10	x	x	x	x		10.87	9.58–11.70
RBDW14	NS[2]	x, J[3]	x			0.0027	<0.0013–0.0044
RBDW15	NS	NS	x	NS	0.0817		
RBMW04	x	NS	NS	NS	15.10		
RBMW05	x	NS	NS	NS	17.50		

The sampling round in which the analyte was detected is designated using an "x" and qualified results are indicated using the appropriate flag. Average values reflect the mean of the detected results; range is equivalent to the minimum and maximum values detected for an analyte, at a given location.

[1] Sampling Events: round 1 = October 2011; round 2 = May 2012; round 3 = November 2012; and round 4 = April/May 2013.
[2] NS = Not sampled.
[3] J = The analyte was positively identified, and the associated numerical value is the approximate concentration. See Table A28, Appendix A, for more detailed descriptions.

Dissolved ethane was detected above the QL in four of six domestic wells, and average concentrations ranged from 0.006 mg/L to 0.018 mg/L. Ethane was detected in both monitoring wells during round 1 (RBMW04 = 0.008 mg/L, RBMW05 = 0.016 mg/L). The distribution of ethane concentrations observed in this area is shown in Figure 34B, and the data are summarized in Table 17. This analyte was never detected in wells located in the northern part of the Little Creek Field study area (RBDW07 and RBDW14).

Propane was not detected in any ground water samples during rounds 1 through 4. Butane was detected in ground water collected from domestic well RBDW08 during round 1 (0.0072 mg/L). Butane was not detected in any samples during subsequent sampling events.

6.9. Molecular and Isotopic Composition of Coalbed Methane

Hydrocarbons in coalbed gas are derived from either thermal breakdown of kerogen or microbial generation via demethylation of organic molecules or CO_2 reduction (Clayton, 1998). Gases can be generated from coal beds during three stages (Johnson and Flores, 1998):

- Early biogenic gas, formed by microbes in the early stages of coalification.
- Thermogenic gas, formed by thermal processes during the main stages of coalification.
- Late-stage biogenic gas, which can form in coal of any rank if the right conditions are met for methane-producing microbes to flourish.

Table 17. Detection of ethane in ground water: Little Creek Field study site.

Sample ID	Sampling Round[1]				Result mg/L	Average mg/L	Range mg/L
	1	2	3	4			
Little Creek Field							
RBDW06	x	x	x	x		0.0100	0.0071–0.0137
RBDW07						ND[2]	
RBDW08	x	x	x			0.0077	<0.0027–0.0087
RBDW09	x	x	x			0.0123	<0.0027–0.0180
RBDW10	x	x	x			0.0091	<0.0027–0.0099
RBDW14	NS[3]					ND	
RBDW15	NS	NS		NS	ND		
RBMW04	x	NS	NS	NS	0.0079		
RBMW05	x	NS	NS	NS	0.0161		

The sampling round in which the analyte was detected is designated using an “x” and qualified results are indicated using the appropriate flag. Average values reflect the mean of the detected results; range is equivalent to the minimum and maximum values detected for an analyte, at a given location.

[1] Sampling Events: round 1 = October 2011; round 2 = May 2012; round 3 = November 2012; and round 4 = April/May 2013.
[2] NS = Not sampled.
[3] J = The analyte was positively identified, and the associated numerical value is the approximate concentration. See Table A28, Appendix A, for more detailed descriptions.

Three categories of geochemical tools are commonly used to correlate natural gas to their sources: gas concentration, molecular composition, and stable isotope ratios (Whiticar, 1996). The relative proportions of CH_4 and higher carbon-number hydrocarbons indicate the dryness of the gas (i.e., C_1/C_{2+}), and depends mainly on (Clayton, 1998):

- The mechanism of gas generation (microbial versus thermogenic).
- Elemental composition of organic material in the coal (i.e., hydrogen/carbon ratio).
- Thermal maturity of the coal.
- Possible retention of higher chain hydrocarbons ($>C_1$) in the coal matrix at low thermal maturities.

Coalbed gas contains the greatest proportions of methane (most “dry”) at high and low ranks, with variable hydrocarbon compositions at intermediate ranks (Clayton, 1998). Gas composition may be used as a first-order approximation for distinguishing between microbial and thermogenic gas; however, multiple post-genetic processes, such as microbial oxidation and migration, may alter gas contents (Osborn and McIntosh, 2010). Empirically defined interpretative diagrams that combine molecular and isotope compositional fields can be used to identify not only primary gases, but also those that have been altered by secondary effects such as microbial oxidation or mixing (Whiticar, 1996).

The stable isotopes of carbon and hydrogen are natural tracers in organic matter, and isotopic variations can be used to elucidate conditions during their formation and/or establish genetic relationships between them, specifically between source and product (Schoell, 1984). Important genetic and post-genetic information (i.e., organic matter source, thermal maturation of source rock, post-generation alteration, reservoir accumulation/loss history) can be obtained from stable carbon and hydrogen isotope compositions of hydrocarbons and fixed gases (Zou et al., 2007, and references therein). The isotopic composition of methane produced by a particular pathway depends on the $\delta^{13}C$ of the methane precursor and the isotope fractionation associated with the production process (Alperin et al., 1992). Biogenic methane is an ultimate dissimilation product of microbially mediated reaction of organic molecules, and methane production rates are related to microbial activity, organic content, and temperature (Bernard et al., 1978; Whiticar et al., 1986). Two pathways have been identified for methane generation via microbial activity, and competitive substrates include CO_2 (reduced by hydrogen) and acetate. The first one, the "CO_2 reduction pathway" (Eqn. 4), uses CO_2 as a substrate, and is represented by the general reaction:

$$\text{CO}_2\text{ reduction:} \qquad CO_2 + 4H_2 \Rightarrow CH_4 + 2H_2O \qquad (4)$$

The net reaction for the "acetate fermentation" pathway is shown in Eqn. 5, where the "*" indicates the intact transfer of the methyl position to methane (CH_4; Whiticar, 1999):

$$\text{Acetate fermentation:} \qquad {}^{*}CH_3COOH \Rightarrow {}^{*}CH_4 + CO_2 \qquad (5)$$

Biogenic methane has a wide range of carbon and hydrogen isotope ratios, and there are coincidental shifts in the $\delta^{13}C$ and $\delta^{2}H$ values of methane relative to the methane production pathway (Chanton et al., 2005): the isotopic composition of carbon ($\delta^{13}C_{CH4}$) ranges from -110 to -50‰, and in hydrogen ($\delta^{2}H_{CH4}$), from -400 to -150‰. Microbial methane generated via a CO_2 reduction pathway (Eqn. 4) in closed reservoir systems can have $\delta^{13}C_{CH4}$ values similar to those of thermogenic methane: ~-55 to -40‰ (Martini et al., 1998). Fermentation of acetate (Eqn. 5) will result in methane that is enriched in $\delta^{13}C_{CH4}$ and depleted in $\delta^{2}H_{CH4}$ relative to methane produced via the CO_2 reduction pathway (Chanton et al., 2005). The separation of the two microbial CH_4 fields, when $\delta^{13}C_{CH4}$ and $\delta^{2}H_{CH4}$ are plotted, is located at approximate boundaries of -60‰ for $\delta^{13}C_{CH4}$ and -250‰ for $\delta^{2}H_{CH4}$ (Whiticar, 1999).

Thermogenic methane is generally enriched in ^{13}C compared to microbial methane, and $\delta^{13}C_{CH4}$ roughly ranges from -50 to -20‰ (Whiticar, 1999). Methane, and to a minor extent ethane and other gaseous hydrocarbons that emerge from thermally stressed organic matter, are at first enriched in the light C isotope and then become isotopically heavier during the maturation process (Stahl, 1977). Eventually, the $\delta^{13}C_{CH4}$ will approach the $^{13}C/^{12}C$ of the original organic matter or kerogen (Whiticar, 1999). The hydrogen isotope ratios of thermogenic methane range from $\delta^{2}H_{CH4}$ values of approximately -275 to -100‰ (Whiticar, 1999).

Additionally, carbon isotopic differences between methane ($\delta^{13}C_{CH4}$) and CO_2 ($\delta^{13}C_{CO2}$), $\Delta^{13}C_{CO2\text{-}CH4,}$ can aid in deciphering gas origin. Thermogenic processes are characterized by low $\Delta^{13}C_{CO2\text{-}CH4}$ values due to high pressures, whereas, low-temperature microbial enzymatic processes lead to ^{13}C enrichment in residual CO_2 (Strąpoć et al., 2011). Within ground water systems, the production of highly ^{13}C-depleted methane, via CO_2 reduction or acetate fermentation, supplies ^{13}C-enriched CO_2 to the system, resulting in increasing $\delta^{13}C$ values within the formation water (Sharma and Frost, 2008).

6.9.1. Gas Characterization: Raton Basin

Molecular and gas composition data are presented first, and then linked to isotope data in a later section. Gas concentrations are generally reported as volume percent. Isotope data for the stable isotopes of carbon and hydrogen in methane ($\delta^{13}C_{CH4}$, $\delta^{2}H_{CH4}$), and carbon in dissolved inorganic carbon ($\delta^{13}C_{DIC}$), are reported in standard delta (δ) notation, in units of permil. For stable hydrogen and carbon ratios:

$$\delta\,^{2}H = \left[\frac{(\,^{2}H/\,^{1}H)_{sample}}{(\,^{2}H/\,^{1}H)_{standard}} - 1\right] \times 1000 \qquad (6)$$

and

$$\delta\,^{13}C = \left[\frac{(^{13}C/^{12}C)_{sample}}{(^{13}C/^{12}C)_{standard}} - 1\right] \times 1000 \qquad (7)$$

The δ notation expresses the isotope ratios of hydrogen (Eqn. 6) and carbon (Eqn. 7) of methane in a given sample, relative to the same isotope ratios in an isotopic standard. Hydrogen isotope ratios are relative to the VSMOW reference water, where the H isotopic value of SLAP is -428‰ (Gonfiantini, 1978). Stable carbon isotopes are relative to the VPBD standard, which is defined by assigning a value of +1.95‰ to National Bureau of Standards (NBS) reference material: NBS19-$CaCO_3$. A positive δ value means that the sample is more enriched in the heavy isotope than the standard; a negative δ value indicates that the sample is depleted in the heavy isotope relative to the standard.

6.9.2. Characterization of Raton- and Vermejo-Produced Gas in the Raton Basin

To evaluate the source of methane in ground water and the potential impact on ground water resources in the Ration Basin due to CBM development, the Raton and Vermejo formations were first characterized using historical compositional and isotopic analyses of gas in ground water samples collected from production wells. The molecular composition of CBM gas and isotopic signatures for each formation were determined using data collected in 2001 by ESN Rocky Mountain (2003) for the COGCC. The COGCC contracted ESN Rocky Mountain to collect and analyze gas and water samples from 50 selected CBM gas wells in Huerfano and Las Animas counties (ESN Rocky Mountain, 2003). Gas samples were analyzed for gas hydrocarbon and fixed gas composition, including isotopic ratios. Two criteria were used to evaluate the applicability of these data for use in this study: (i) molecular compositional analyses: data points containing statistical outliers were eliminated (>±3SD from the mean); and (ii) geographic location: sampled production wells were located within a 3-mile radius of all wells sampled during this case study. These secondary data are summarized in Table 18 and are organized by the producing coal formation: Raton (RT), Vermejo (VJ), or both (RT-VJ).

In Las Animas County, compositional analyses were available for 44 wells: three from Raton coal, 33 from Vermejo coal, and eight from wells producing Raton-Vermejo coals. After applying the criteria above, data from nine wells remained: one from Raton coal, four from the Vermejo coal, and four from Raton-Vermejo coals. It is difficult to fully characterize the gas composition of the coal-bearing Raton Formation based on a single sample. In general, the molecular composition of the gases was similar, regardless of the formation of origin. CBM gas within the case study area was predominantly composed of methane (93 to 95%) and nitrogen (3 to 5%), and higher-chain hydrocarbons (>C_2) were only measured in Raton-Vermejo and Vermejo gas samples. The hydrocarbon composition of Raton-Vermejo coalbed gas was composed of methane and ethane, and one sample also contained minor propane. Detectable concentrations of butane (C_4), pentane (C_5), or hexanes (C_6) were not measured in any of the gas samples.

Table 18. Molecular composition (%) of coalbed methane gas and isotopic signatures (‰) of coalbed-methane-producing formations in the Raton Basin, compiled from selected data in 2001 by ESN Rocky Mountain (ESN Rocky Mountain, 2003; see text). Results are organized by the producing coal formation: Raton (RT), Vermejo (VJ), or both (RT-VJ). Average values reflect the mean of the detected results; range is equivalent to the minimum and maximum values detected for an analyte, at a given location.

Producing Fm:	**Las Animas County**					**Huerfano County**	
	Raton Fm. (RT; 1 well)	**Raton – Vermejo Fm. (RT-VJ; 4 wells)**		**Vermejo Fm. (VJ; 4 wells)**		**Vermejo Fm. (VJ; 3 wells)**	
Analyte	**Result**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Molecular composition							
He	ND[1]	ND	NA[2]	ND	NA	0.0038	0.00–0.0083
H_2	ND	ND	NA	ND	NA	0.02	(n=1)
Ar	0.040	0.040	0.030–0.050	0.040	0.030–0.050	0.123	0.110–0.140
O_2	0.920	0.980	0.810–1.22	0.970	0.084–1.15	1.23	1.11–1.32
CO_2	0.570	0.490	0.080–0.810	0.713	0.520–1.18	1.35	0.100–3.78
N_2	3.56	4.23	3.78–4.84	3.89	3.25–4.44	8.50	7.47–9.19
CO	ND	ND	NA	ND	NA	ND	NA
C_1	94.9	94.2	93.2–95.3	94.4	93.8–95.3	88.8	86.0–91.1
C_2	0.010	0.014	0.007–0.020	0.025	0.010–0.030	0.0059	0.005–0.007
C_2H_4	ND	ND	NA	ND	NA	ND	NA
C_3	ND	0.0014	(n=1)	0.0024	0.001–0.004	ND	NA
iC_4	ND	ND	NA	ND	NA	ND	NA
nC_4	ND	ND	NA	ND	NA	ND	NA
iC_5	ND	ND	NA	ND	NA	ND	NA
nC_5	ND	ND	NA	ND	NA	ND	NA
C_6+	ND	ND	NA	ND	NA	ND	NA
Isotopes: Methane ($\delta^{13}C_{CH4}$, $\delta^{2}H_{CH4}$) and CO_2 ($\delta^{13}C_{C02}$)							
$\delta^{13}C_{CO2}$	12.9	14.3	11.3–19.1	19.6	17.7–21.1	-35.9	(n=1)
$\delta^{13}C_{CH4}$	-43.7	-47.4	-54.7 to -42.5	-41.2	-42.1 to -40.5	-56.1	-58.5 to -53.3
$\delta^{2}H_{CH4}$	-218	-230	-243 to -215	-214	-225 to -210	-247	-254 to -244
$\Delta^{13}C_{(CO2\text{-}CH4)}$	56.6	58.3	54.7–61.6	60.8	58.6–62.1	17.5	(n=1)
***n* =**	1	4		4		3	

[1] ND = Not detected.

[2] NA = Not applicable.

The isotopic composition of headspace gases in the nine samples shows $\delta^{13}C_{CH4}$ and $\delta^{2}H_{CH4}$ values ranging from -54.7 to -40.5‰, and from -243.3 to -209.6‰, respectively. Raton-Vermejo gas was slightly depleted in $\delta^{13}C_{CH4}$ and $\delta^{2}H_{CH4}$, relative to the Raton and Vermejo coal gas samples (see Figure 35; all sample data plotted). When plotted, these values correspond to a thermogenic methane source (see Figure 35). Values for $\delta^{13}C_{CO2}$ were positive, where $\delta^{13}C_{CO2, RT} < \delta^{13}C_{CO2, RT, VJ} < \delta^{13}C_{CO2, VJ}$; only one $\delta^{13}C_{CO2}$ value was available for Raton gas. These enriched CO_2 carbon isotope signatures, when plotted against $\delta^{13}C_{CH4}$, are consistent with biochemical fractionation of gas (Pallasser, 2000; Jones et al., 2008; Golding et al., 2013) due to linked microbial methane generation and hydrocarbon degradation. Coalbed gases collected from the Las Animas portion of the Raton Basin likely contain secondary microbial methane generated during CO_2 reduction (James and Burns, 1984; Zhang et al., 2011) wherein microbes metabolize wet gas components (C_{2+}), *n*-alkanes, and other organic compounds at relatively low temperatures (generally less than 150°F, or 56°C) to generate methane and CO_2 (Scott et al., 1994). Microbial consumption of CO_2 during methane production is supported by the low CO_2 concentration measured in these gases (range = 0.08 to 1.2%). Furthermore, the presence of heavier hydrocarbons (C_{2+}) with biogenic methane indicates the overprint of late-stage biogenic methane in coals that have already generated thermogenic hydrocarbons (Rice, 1993).

Of the six wells sampled in Huerfano County (ESN Rocky Mountain, 2003), only three samples remained after applying the criteria described above; all samples were screened in the coal-bearing Vermejo Formation. Relative to Vermejo gas collected in Las Animas County, samples collected in Huerfano County contained a lower volume % of methane (mean = 88.8%) and more nitrogen (mean = 8.5%). The hydrocarbon composition of these samples was composed only of methane and ethane; propane, butane, pentane, and hexane were not detected. The isotopic compositions of these samples (see Figure 35) were depleted in $\delta^{13}C_{CH4}$ and $\delta^{2}H_{CH4}$ relative to samples collected in Las Animas County. When the carbon and hydrogen isotope composition of methane are plotted on a discriminate diagram, the values fall between the thermogenic and microbial fields, into a “transitional” isotopic composition field. The overlap is related to the combined effect of (i) kinetic isotope fractionation by methanogens, (ii) mixtures of various pathways and/or CH_4 types (e.g., migration/diffusion), and/or (iii) variations in C- and H-isotope composition of precursor organic matter (Whiticar, 1999). None of these samples contained enough CO_2 for isotopic analyses ($\delta^{13}C_{CO2}$), so further interpretation of the processes modifying the isotopic and chemical compositional of these gases is difficult.

6.9.3. Characterization of Gases in the Raton Basin: This Study

All water samples were analyzed for molecular gas composition and the stable isotope ratios of DIC and methane ($\delta^{13}C_{DIC}$, $\delta^{13}C_{CH4}$, $\delta^{2}H_{CH4}$). The data obtained from gas analyses, coupled with the isotopic composition of carbon and hydrogen in methane, and carbon in DIC, indicate that different biogeochemical processes are occurring within each study site. Molecular and gas composition data are presented first and then linked to isotope data in a later section.

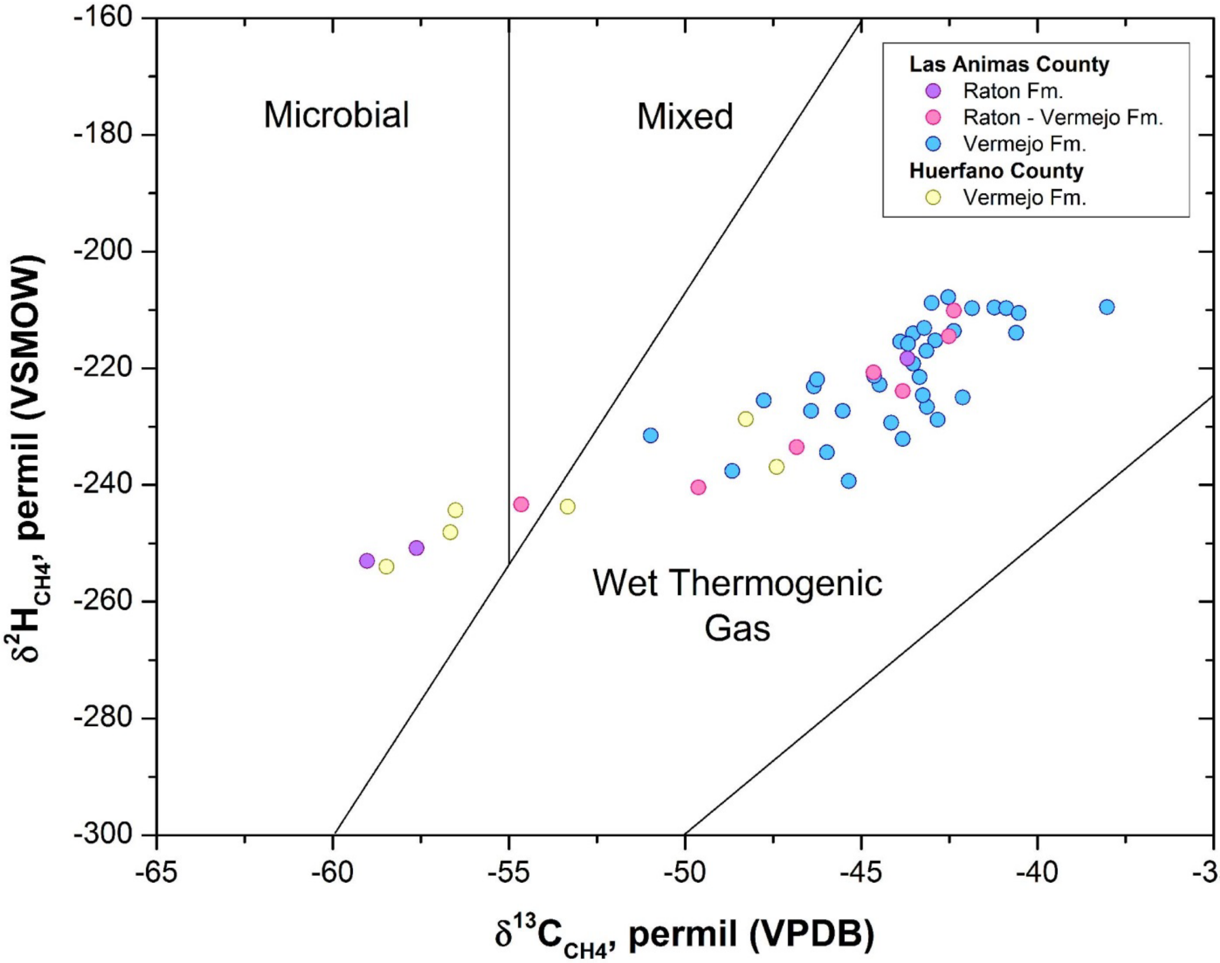


Figure 35. The stable C and H isotopic composition of methane in samples collected from CBM gas wells (n = 50), located throughout the Raton Basin, in 2001 (ESN Rocky Mountain, 2003); data are organized by location (Las Animas/Huerfano County) and the producing coal formation. Zonation is after Jackson et al. (2013).

6.9.4. Molecular Composition: Study Sites

North Fork Ranch

Three production wells were sampled in the North Fork Ranch study site over the four sampling rounds: RBPW01 is producing gas from Raton coals, while RBPW02 and RBPW03 are producing gas from the deeper, Vermejo coals. The molecular composition and gas concentrations, measured in ground water collected from these production wells were nearly identical to the samples collected by ESN Rocky Mountain in 2001. The only difference was that ground water samples collected from the Vermejo formation (RBPW02, RBPW03) contained more propane (C_3), isobutane (iC_4) and n-butane (nC_4) than samples obtained from the Raton-Vermejo and Vermejo coals in 2001. Hexanes were detected in RBPW02 during round 1 and in RBPW03 during round 4; none of the samples in the comparative 2001 dataset contained pentane or hexane. It is important to note that no samples were collected within the vicinity of the North Fork Ranch study site during the 2001 sampling event, so the apparent differences in hydrocarbon distribution and concentration could be a result of geographic location.

All monitoring wells are screened in the Poison Canyon Formation; however, there was variability among the molecular and gas compositions. The molecular and gas composition of samples collected from monitoring well RBMW01 was composed predominantly of nitrogen (mean = 92%), oxygen (mean = 3.4%), and carbon dioxide (mean = 2.5%); hydrocarbon composition (C_{1+}) was <0.2%. The molecular and gas composition of samples collected from monitoring wells RBMW02 and RBMW03 are quite similar with respect to their fixed gas composition: composition is dominated by nitrogen (mean = 58%; n = 8), but to a lesser extent than in RBMW01. However, RBMW02 and RBMW03 differ with respect to their hydrocarbon composition. Methane and ethane were consistently detected, over all sampling rounds, in RBMW02 and RBMW03; however, ethylene (C_2H_4), and propane (C_3) were also consistently detected in RBMW03. These analytes were never detected in ground water samples obtained from RBMW01 or RBMW02. Furthermore, isobutane (rounds 1, 3, and 4), n-butane (rounds 1 and 3), and isopentane (round 1) were detected in monitoring well RBMW03; when detected, concentrations exceeded those found in production wells during the same sampling round.

Dissolved gases in ground water samples collected from alluvial domestic wells (RBDW01, RBDW13) were composed predominantly of nitrogen (range 76.7-87.7%), oxygen (range 5.4-16.9%), and minor amounts of CO_2 (range 4.9-5.2%). Low levels of methane (<0.05%) were consistently detected in water from these wells. During round 1, hexanes (C_{6+}) were measured in ground water sampled from RBDW01 (0.0004%).

The molecular and gas composition in ground water collected from three of the four domestic wells located in the Poison Canyon Formation mirrored the results obtained in the alluvial aquifer samples. The most abundant gas in water from RBDW02, RBDW03, and RBDW05 was nitrogen (range 70 to 93%), followed by oxygen (range 4.7 to 27.7%), and carbon dioxide (range 0.28 to 7.7%). Methane concentrations in these wells (<0.55%) were higher than the results obtained from alluvial aquifer wells. Higher-chain hydrocarbons (C_{2+}) were sporadically detected over the four sampling events: during round 1, ethane (C_2), propane (C_3), and *n*-butane (n-C_4) were detected in ground water obtained from RBDW03; hexane was detected in two wells during round 1 (RBDW02, RBDW03), and in RBDW05 during round 4 (range 0.0004 to 0.0012%).

In contrast, gas and molecular composition results collected from RBDW04, also screened in the Poison Canyon Formation, contained mostly methane (mean = 74.3%; n = 3), nitrogen (mean = 18.8%; n = 3), and oxygen (mean = 5.8%; n = 3). In addition, ethane (C_2) was consistently detected in ground water obtained from this well, as was ethylene (round 1), propane (rounds 1 and 4), and isobutane (round 1).

The molecular and gas composition of surface water collected from RBSW01 and RBSW02 was dominated by nitrogen (range 67.3 to 74.5%), followed by oxygen (range 21.9 to 30.7%), and carbon dioxide (range 0.45 to 2.2%). Low levels of methane (<0.06%) were consistently detected in these surface waters during all sampling rounds; no higher-chain hydrocarbons (C_{2+}) were ever detected. The molecular and gas composition of water obtained from RBSW03 was strongly influenced by surface discharges of produced water. Methane (mean = 83.4%; n = 2) was the predominant gas component; nitrogen (mean = 11.4%; n = 2), oxygen (mean = 4.0%; n = 2), and a minor amount of carbon dioxide (0.94%; n = 2) was also present. The volume % of methane and ethane increased between rounds 3 and 4; propane was detected during rounds 3 and 4, and hexanes were detected during round 3.

Arrowhead Ranchettes

Domestic wells within this area (RBDW11 and RBDW12) are screened within the Raton Formation; ground water was obtained from domestic well RBDW11 during rounds 1–4, and from RBDW12 during round 1. The headspace gas composition of water collected from location RBDW11 is composed mostly of nitrogen (mean = 76.6%), followed by methane (12.0%), and oxygen (8.4%); the volume % of methane increased from 4 to 21%, over the four sampling events. Ethane was consistently detected at low levels during all sampling rounds (mean = 0.0030%; n = 4), and hexanes (C_{6+}) were detected in this well during round 4 (0.0005%). The composition of RBDW12 was similar to that of RBDW11, where $N_2 > C_1 \approx O_2$; however, ethylene, propane, and n-butane were detected in this well during round 1, but never in RBDW11.

Little Creek Field

Total compositional variability in the gas and molecular composition of ground water collected in the Little Creek field is broadly correlated with spatial location: samples located in the northern part of the study area (RBDW07, RBDW14) contained very little methane (<0.2%), while all other wells south of RBDW07 and RBDW14 contained abundant methane (range 37 to 68%; see Figure 36). The dissolved gases in ground water samples collected from domestic wells RBDW07 and RBDW14 were predominantly composed of nitrogen (mean = 89.3% and 82.3%, respectively; n = 3) and oxygen (mean = 8.7% and 15.4%, respectively; n = 3). Methane concentrations were slightly higher in samples from RBDW07 than from RBDW14 (mean = 0.15% versus 0.02%, respectively), and samples from both contained minor levels of carbon dioxide. Ethylene (C_2H_4) was detected in ground water collected from RBDW14 during the last sampling event (0.0009%); however, this was the only hydrocarbon detection ($>C_1$), other than methane, during the four sampling rounds.

For ground water collected from the other domestic and monitoring wells (south of RBDW07 and RBDW14), the gas was composed predominantly of methane and nitrogen. In water obtained from domestic wells RBDW06 and RBDW10 and monitoring wells RBMW04 and RBMW05, methane was the dominant gas present. The highest methane concentration was collected from monitoring well RBMW05 during round 1 (81%). On average, nitrogen was the most abundant gas in water collected from RBDW08 and RBDW09; however, during some sampling rounds, methane % exceeded nitrogen %. Ethane (C_2) and propane (C_3) were consistently detected in domestic and monitoring wells located in the southern part of the study area; however, at most domestic well locations, propane decreased over the four sampling rounds. During round 1, ethylene (C_2H_4) was detected in all domestic wells in the southern portion of the study area (RBDW06, RBDW08, RBDW09, and RBDW10), but not in the monitoring wells. Higher-chain hydrocarbons ($>C_3$) were inconsistently detected at RBDW06, RBDW09, and RBDW10 during the four sampling events, but not at domestic well RBDW08. Iso- and n-butane (iC_4, nC_4) were detected at low levels during round 1 in RBDW06, RBDW09, RBDW10, and RBMW05; only isobutane was detected in water obtained from RBMW04. Butane was also detected in later sampling rounds in ground water collected from RBDW06 (iC_4 and nC_4, round 3), RBDW09 (iC_4, round 4), and RBDW10 (nC_4, rounds 2 and 3). Low levels of pentane (iC_5 and nC_5) were detected during round 1 in domestic well RBDW06.

Figure 36. Gas exsolution in ground water collected from domestic well RBDW09, located within the Little Creek Field study area (Huerfano County), during the November 2012 sampling event. The bubbles reflect a mixture of dissolved gases: results from headspace gas analyses (Appendix B, Table B-8) indicated the presence of methane (44.3%), nitrogen (54.3%), argon (0.99%), carbon dioxide (0.31%), and ethane (0.03%). (Vial diameter = 2.4 cm).

Gas and molecular composition analyses of ground water collected from three production wells located within the Vermejo Formation in 2001 (ESN Rocky Mountain, 2003) showed abundant methane (mean = 88.8%), nitrogen (mean = 8.5%), and minor oxygen (mean = 1.2%). The hydrocarbon composition of these samples was composed only of methane and ethane; propane, butane, pentane, and hexane were not detected. This is in contrast to the hydrocarbon composition measured in ground water collected from domestic wells within the southern part of the Little Creek Field study area, where propane, butane, and pentane were detected over four sampling events.

In summary, historical molecular and gas composition results of ground water samples obtained from CBM wells producing within the Raton, Raton-Vermejo, and Vermejo formations (ESN Rocky Mountain, 2003) in Las Animas and Huerfano counties indicated that these gases were predominantly composed of methane. Higher-chain hydrocarbons ($>C_{2+}$) were restricted to Vermejo-produced gas within Las Animas County, which contained propane (C_3). Headspace gas analyses of ground water collected from production wells during this case study, screened within the Raton and Vermejo formations (North Fork Ranch), were also dominated by methane. Butane (iC_4, nC_4), pentane (iC_5, nC_5), and hexanes ($>C_{6+}$) were absent in the 2001 dataset; however, these compounds were detected in a number of ground water samples—regardless of study area, well type, or geologic formation—over the four sampling events. The presence of these compounds suggests that coalbed methane resources have been modified through biogeochemical reactions and microbial activity (i.e., Oremland, 1988) and corroborates results from isotope measurements of methane ($\delta^{13}C_{CH4}$, $\delta^{2}H_{CH4}$) and DIC ($\delta^{13}C_{DIC}$), which are discussed in a later topical section (“Methane Oxidation: Little Creek Field”).

6.9.5. Origin of Methane in Wells

North Fork Ranch

Water samples collected from seven of 15 locations in the North Fork Ranch study site contained sufficient amounts of methane for isotopic analyses ($\delta^{13}C_{CH4}$, $\delta^{2}H_{CH4}$): one domestic well (RBDW04), two monitoring wells (RBMW02 and RBMW03), all production wells (RBPW01, RBPW02, and RBPW03), and a single surface water site (RBSW03).

Figure 37 shows a methane C and H isotope diagram, with genetic zonation as indicated by Jackson et al. (2013). The isotopic composition of headspace gases in the production wells shows $\delta^{13}C_{CH4}$ and $\delta^{2}H_{CH4}$ ranging from -52.7 to -45.6‰ and -238.4 to -220.8‰, respectively; these values correspond to a thermogenic source. Water collected from the producing Raton Formation is isotopically depleted relative to produced water from the Vermejo Formation. Comparing average $\delta^{13}C_{CH4}$ and $\delta^{2}H_{CH4}$ results in samples collected from RBPW01 to the results for the single Raton sample in the 2001 dataset revealed similar gas and methane isotopic compositions; however, the $\delta^{13}C_{DIC}$ composition was isotopically enriched in water collected from RBPW01. Ground water samples collected from the Vermejo Formation over four sampling rounds were isotopically depleted in both methane and DIC relative to the data obtained in the 2001 study (ESN Rocky Mountain, 2003); however, fixed gas and methane concentrations were similar.

The $\delta^{13}C_{DIC}$ values in ground water collected from all production wells (this study) ranged from 1.2 to 18‰ (n = 8), with a mean value of 16.8 ± 0.82‰ (n = 4) for Raton-produced water and 7.6 ± 4.9‰ for Vermejo-produced water (n = 4). In general, a positive correlation was observed between DIC concentrations and $\delta^{13}C_{DIC}$ ($R^2 = 0.69$). The enriched $\delta^{13}C_{DIC}$ carbon isotope signatures (relative to $\delta^{13}C_{CH4}$ results obtained at these locations) are consistent with biochemical fractionation of gas (Pallasser, 2000; Jones et al., 2008; Golding et al., 2013) due to linked microbial methane generation and hydrocarbon degradation.

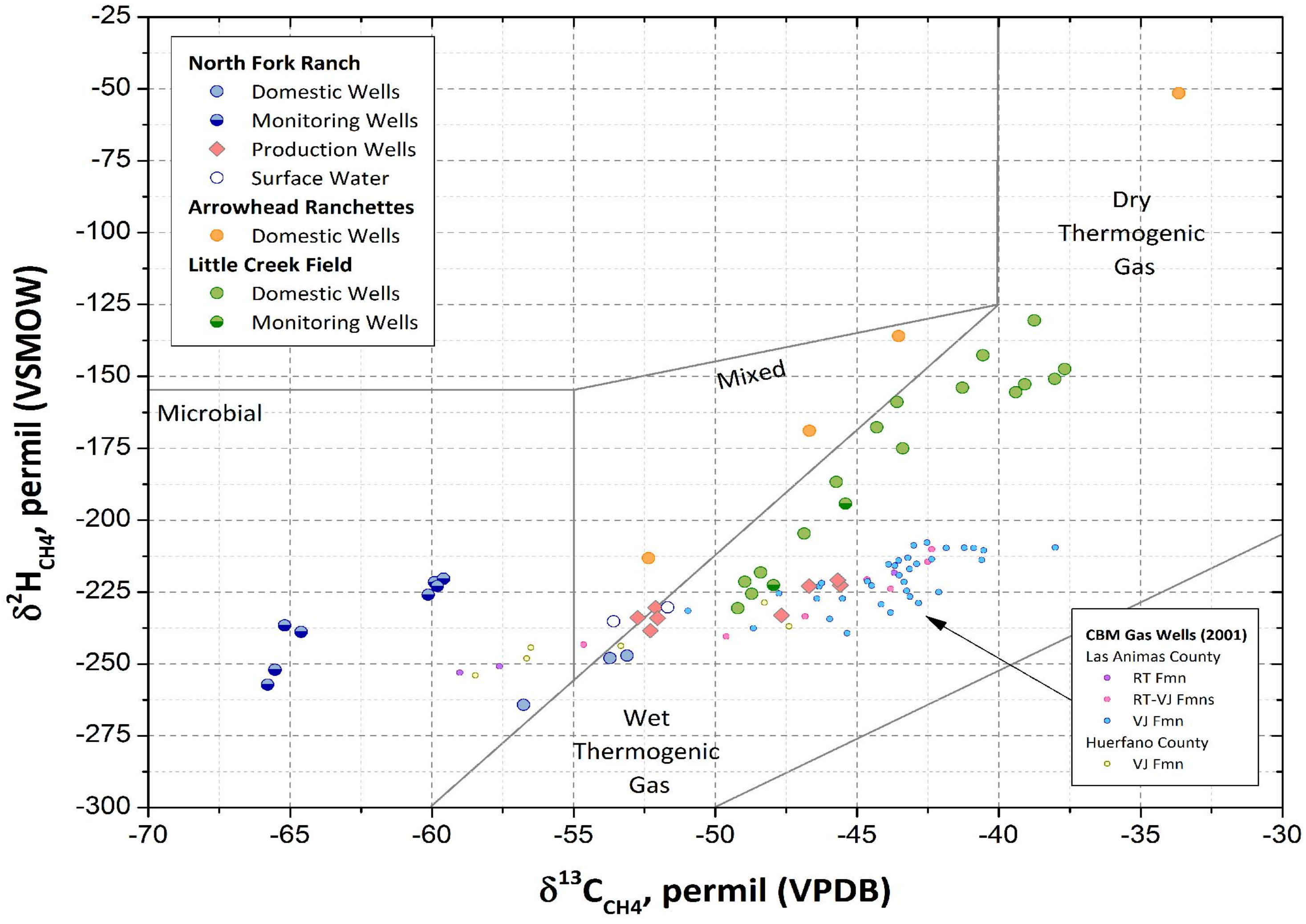


Figure 37. The isotopic composition of dissolved methane in water samples collected during four sampling events, this study. Data points (this study) represent isotopic results per sampling round (i.e., they are not averages; see Table B-8). Historical methane isotope data, obtained from CBM wells (n = 50) in 2001, are also shown (ESN Rocky Mountain, 2003); these data are organized by the producing coal formation (RT = Raton Formation; RT-VJ = Raton–Vermejo Formations (co-mingled); VJ = Vermejo Formation). Zonation is after Jackson et al. (2013).

Isotopic data collected from monitoring wells RBMW02 and RBMW03 indicate that methane is microbially sourced (see Figure 37). The isotopic composition of headspace gases in monitoring wells show $\delta^{13}C_{CH4}$ and $\delta^{2}H_{CH4}$ ranging from -65.8 to -59.6‰ and -257.2 to -220.4‰, respectively. $\delta^{13}C_{DIC}$ values in ground water collected from RBMW02 and RBMW03 ranged from -15.7 to -1.06‰, with a mean value of -15.3 ± 0.31‰ (n = 4) for RBMW02 and -1.52 ± 0.59‰ (n = 4) for RBMW03. In domestic well RBDW04, the mean isotopic (n = 3) compositions of $\delta^{13}C_{CH4}$, $\delta^{2}H_{CH4}$, and $\delta^{13}C_{DIC}$ were -54.5 ± 2.0‰, -253.1 ± 9.6‰, and -11.0 ± 2.5‰, respectively. The isotopic composition of methane transitions from the microbial region during round 1, into the "wet thermogenic" region during rounds 2 and 4, and these data are similar to trends observed in the isotopic composition of Raton and Raton-Vermejo-produced gas (see Figure 37). The well construction log indicates that this well (RBDW04) is screened in carbonaceous material, including coals, and a similarity in coal composition could explain the complementary isotope compositions. There was a good correlation between DIC concentrations and $\delta^{13}C_{DIC}$ (R^2 = 0.62, n = 11) for these samples (RBMW02, RBMW03, RBDW04), which were obtained from wells screened within the Poison Canyon Formation.

The isotopic composition of headspace gases in surface water collected from RBSW03 shows a mean (n = 2) $\delta^{13}C_{CH4}$, $\delta^{2}H_{CH4}$, and $\delta^{13}C_{DIC}$ composition of -52.6 ± 1.4‰, -232.8 ± 3.5‰, and 9.0 ± 1.2‰, respectively. Methane isotope data straddle the boundary between thermogenic and microbially sourced methane (see Figure 37); when combined with the positive $\delta^{13}C_{DIC}$ value (slightly less than the mean $\delta^{13}C_{DIC}$ for Vermejo produced water), these data are consistent with surface discharge of produced water in this area.

The carbon isotope approach for distinguishing metabolic pathways considers fractionation values between carbon sources. The processes that control the stable isotope composition of inorganic carbon ($\delta^{13}C_{DIC}$) in ground water include breakdown of organic matter, carbonate mineral dissolution and precipitation, microbially mediated processes that oxidize reduced carbon and generate CO_2, microbially mediated processes that reduce CO_2 and generate CH_4, and mixing of waters with different $\delta^{13}C_{DIC}$ values (e.g., Deines et al., 1974; Botz et al., 1996; Alperin et al., 1992). Fractionation factors are usually compared between CO_2 and CH_4, where the fractionation factor α is defined as the ratio of carbon isotopes in CO_2 divided by the corresponding carbon isotope ratio in CH_4. This relationship is shown in Eqn. 8:

$$\alpha^{13}C_{CO2-CH4} = \frac{(\delta^{13}C_{CO2} + 1000)}{(\delta^{13}C_{CH4} + 1000)} \tag{8}$$

Since DIC reflects dissolved ΣCO_2 sources, $\delta^{13}C_{DIC}$ is used in place of $\delta^{13}C_{CO2}$ (e.g., Alperin et al., 1992; Cheung et al., 2010). Whiticar et al. (1986) proposed that $\alpha^{13}C_{CO2\text{-}CH4} > 1.06$ are representative of methanogenic environments dominated by CO_2 reduction, while $\alpha^{13}C_{CO2\text{-}CH4} < 1.06$ are characteristic of acetate fermentation. The fractionation factors between DIC and CH_4, $\Delta^{13}C(DIC\text{-}CH_4)$, commonly featured in coal seam gases (Sharma and Frost, 2008; Golding et al., 2013), are illustrated in Figure 38. Included in this figure are lines representing calculated isotopic fractionations of 1.09, 1.06, and 1.03, which correspond to $\Delta^{13}C(DIC\text{-}CH_4)$ values of 90, 60, and 30‰, respectively. The $\Delta^{13}C(DIC\text{-}CH_4)$ of ground water collected from monitoring well RBMW03 is 63.8‰, indicating that methane is being produced via the CO_2 pathway. The $\Delta^{13}C(DIC\text{-}CH_4)$ value for RBMW02 is 44.6‰, and the value for RBDW04 is 43.6‰, each of which corresponds to $\alpha^{13}C_{DIC\text{-}CH4} < 1.06$, characteristic of acetate fermentation.

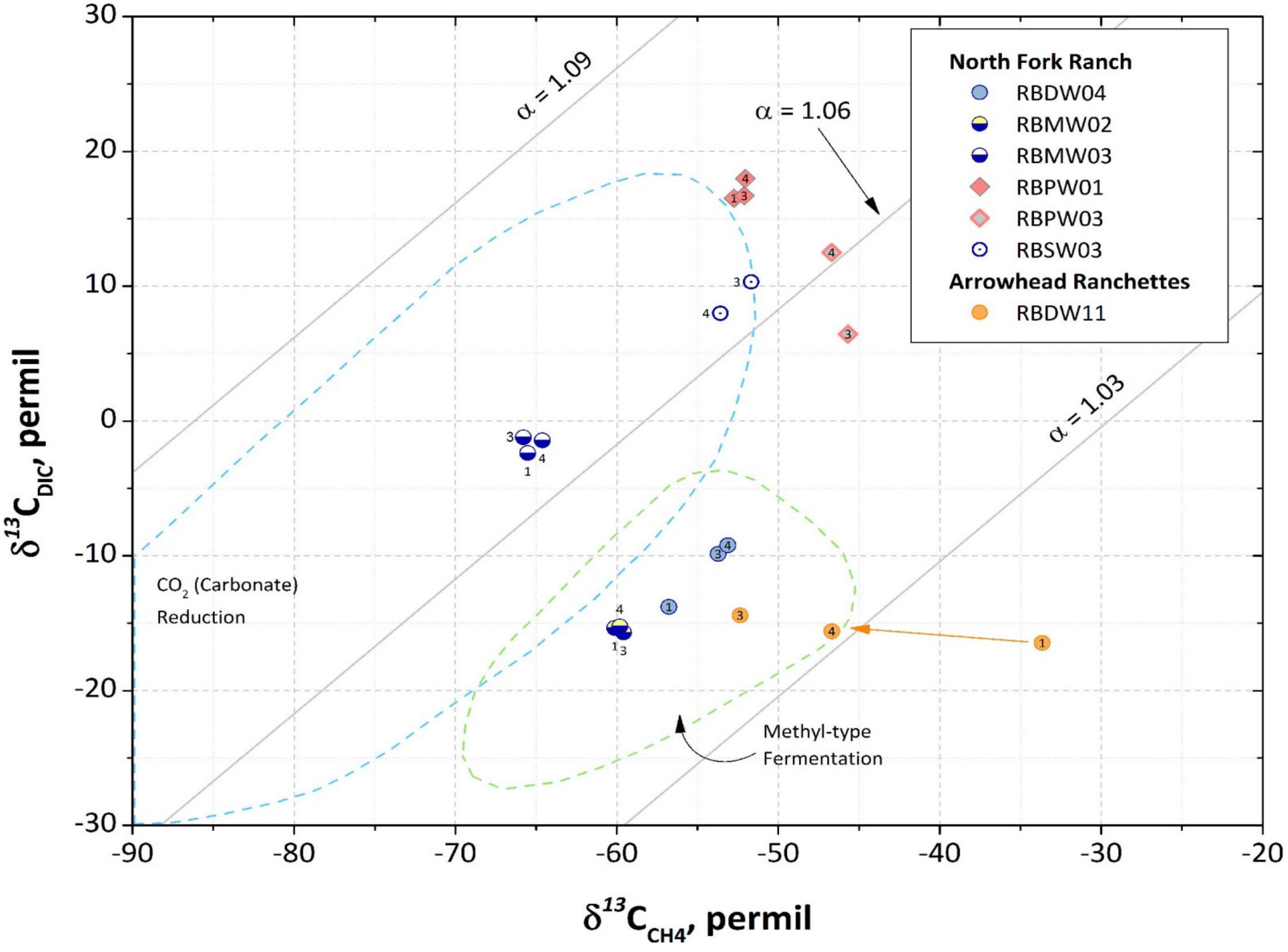


Figure 38. A combination plot of $\delta^{13}C_{CH4}$ and $\delta^{13}C_{DIC}$ with isotope fractionation lines $\alpha^{13}C_{DIC\text{-}CH4}$ (see Eqn. 8) for samples collected within the North Fork Ranch study area (Las Animas County), where α = 1.09, 1.06, and 1.03. Data that plot above the α = 1.06 line (i.e., $\alpha\ ^{13}C_{DIC\text{-}CH4} > 1.06$) are representative of methanogenic environments dominated by CO_2 reduction, while those that plot below (i.e., $\alpha\ ^{13}C_{DIC\text{-}CH4} < 1.06$) are characteristic of acetate fermentation (Whiticar et al., 1986). Numbers located inside of, or next to, symbols indicate the sampling round.

Hydrogen isotope compositions of CH_4 also differentiate between gas origins and can identify secondary processes such as migration or mixing; when gas and water are sampled from the same well, hydrogen isotope compositions of the H_2O-CH_4 system provide a constraint on methanogenesis independent of the carbon isotope system (Schoell, 1980; Whiticar et al., 1986; Martini et al., 1998; Golding et al., 2013). When gases are microbially derived, as indicated by the hydrogen isotope compositions seen in Figure 39, the product δ^2H_{CH4} reflects that of the formation water (Smith et al., 1993, and references therein). In CO_2 reduction (i.e., Eqn. 4), all the hydrogen in the methane produced is derived from the formation water, and the hydrogen isotope composition of the produced methane can be calculated using Eqn. 9:

$$\delta^2H_{CH4} = \delta^2H_{H2O} - 180‰ \text{ (VSMOW)} \tag{9}$$

In contrast, when methane is a product of acetate fermentation (i.e., Eqn. 5), only one hydrogen in the methane is obtained from the formation water; the hydrogen isotope composition of the produced methane can be calculated using Eqn. 10:

$$\delta^2H_{CH4} = 0.25 * \delta^2H_{H2O} - 321‰ \text{ (VSMOW)} \tag{10}$$

The expected δ^2H_{CH4} composition rising from each pathway was calculated using Equations 9 and 10 for all locations in the North Fork Ranch study site where methane isotope data were obtained, and the data are shown in Figure 39. A comparison of calculated δ^2H_{CH4} values with the measured value of δ^2H_{CH4} indicates that CO_2 reduction is the dominant methane-generating process at domestic well RBDW04 and both monitoring wells (RBMW02 and RBMW03). This conclusion is different from the methanogenic pathways determined using the DIC-CH_4 system; the discrepancy could be due to changes in the organic source as carbon is metabolized. Microbes preferentially utilize $^{12}CO_2$ (^{12}C–^{12}C bonds are easier to break than ^{12}C–^{13}C bonds), causing residual CO_2 to become ^{13}C-enriched (Figure 38; e.g., Milkov, 2011; Strąpoć et al., 2007).

Arrowhead Ranchettes

The isotopic composition of headspace gases in domestic well RBDW11 show $\delta^{13}C_{CH4}$ and δ^2H_{CH4} ranging from -52.4 to -33.7‰ (mean = -44.1‰) and -213.2 to -51.5‰ (mean = -142.4‰), respectively (n = 4). Over the course of four sampling events, the isotopic composition of methane transitioned from a thermogenic source during round 1, into a “mixed” source in rounds 2, 3, and 4. This isotopic transition was accompanied by an increase in dissolved methane, from 0.573 mg/L in round 1 to >2 mg/L in round 4. The $\delta^{13}C_{DIC}$ values showed far less variability, ranging from -16.5 to -14.4‰, with a mean value of -15.6 ± 0.87‰ (n = 4); however, $\Delta^{13}C$(DIC-CH_4) increased from 17.2‰ in round 1 to 31.1‰ in round 4. There was good correlation between DIC concentration and the carbon isotope ratio: $R^2 = 0.89$.

The rapid changes in the isotopic composition could be due to gas migration. Based on the carbon isotope compositions of the DIC-CH_4 system, the isotopic shift in $\delta^{13}C_{CH4}$, relative to $\delta^{13}C_{DIC}$ (see Figure 38) is trending toward a region characterized by acetate fermentation. Furthermore, as δ^2H_{CH4} becomes isotopically depleted, the hydrogen composition of the water remains stable (mean = -81.1 ± 0.47‰; n = 4), suggesting the hydrogen composition in methane has not had time to equilibrate with ground water (see Figure 39). The source of the contributing end-member is unclear.

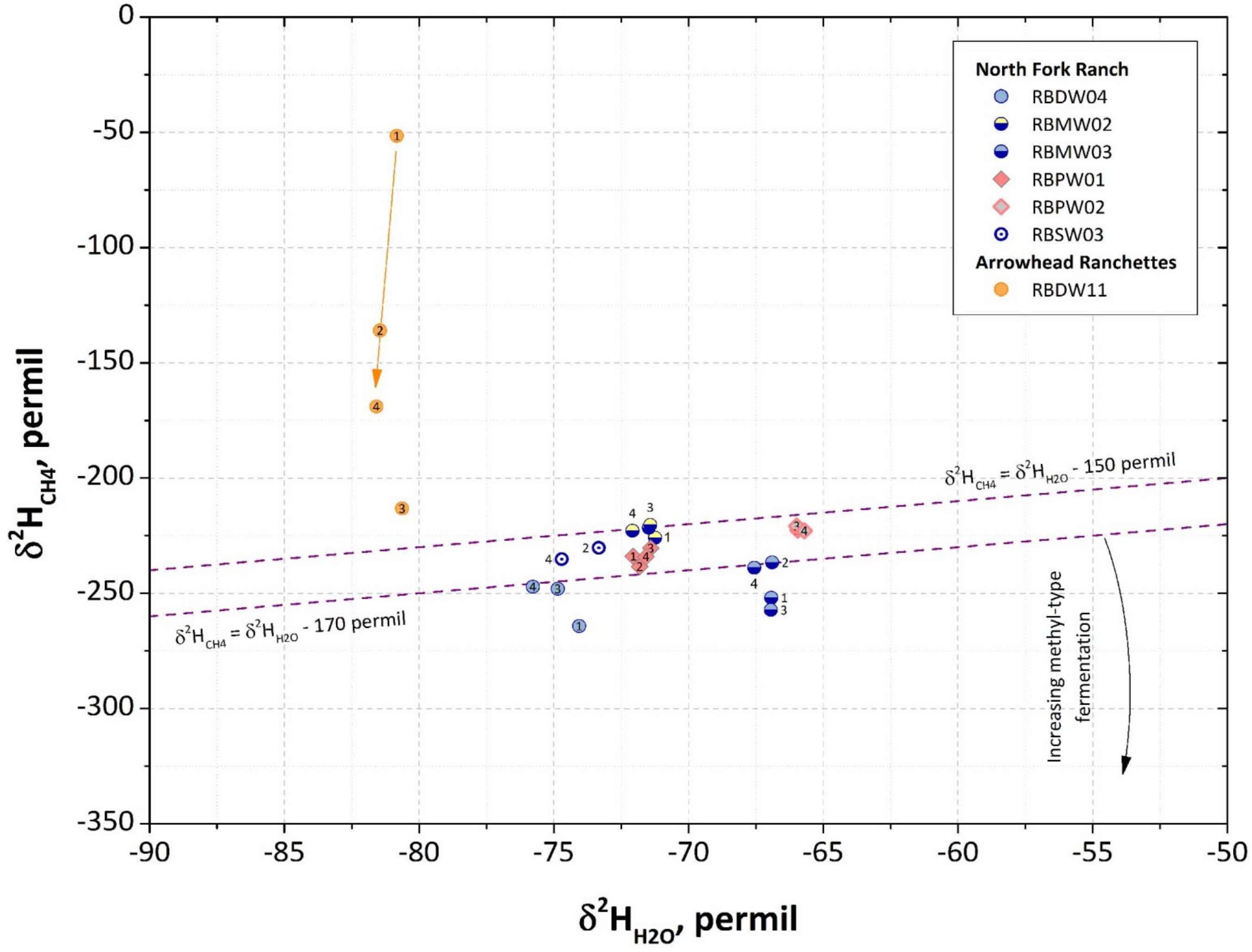


Figure 39. A combination plot of δ^2H_{CH4} and δ^2H_{H2O} for samples collected within the North Fork Ranch study area (Las Animas County)**.** Dashed lines represent the dependence of δ^2H_{CH4} composition as a function of the co-existing formation water (δ^2H_{H2O}); data points that fall between the dashed lines are consistent with methanogenesis dominated by CO_2 reduction. Numbers located inside of, or next to, symbols indicate the sampling round.

Little Creek Field

The isotopic composition of headspace gases in ground water collected from four domestic wells (RBDW06, RBDW08, RBDW09, and RBDW10) and two monitoring wells (RBMW04 and RBMW05), all of which are located in the Poison Canyon Formation, shows $\delta^{13}C_{CH4}$ and $\delta^{2}H_{CH4}$ ranging from -49.2 to -37.7‰ and -230.6 to -130.5‰, respectively; these values correspond to a thermogenic source (see Figure 37). Ground water collected from domestic wells RBDW07 and RBDW14 did not contain a sufficient concentration of methane to obtain C and H isotope ratios, and monitoring wells were only sampled during round 1. The $\delta^{13}C_{DIC}$ values in ground water collected from all domestic and monitoring wells within the Little Creek Field area ranged from -40.9 to -12.0‰, with a mean value of -27.1 ± 10.3‰ ($n = 25$). The correlation between the DIC concentration and $\delta^{13}C_{DIC}$ composition was better in domestic wells located in the northern part of the study area (RBDW07, RBDW14) than in the southern area (RBDW06, RBDW08, RBDW09, RBDW10): $R^2 = 0.93$ ($n = 7$) versus $R^2 = 0.73$ ($n = 16$), respectively.

The coincident enrichment of $\delta^{13}C_{DIC}$, coupled with $\delta^{13}C_{CH4}$ depletion, is consistent with anaerobic methane oxidation. During anaerobic methane oxidation, methane is oxidized with different terminal electron acceptors such as sulfate, nitrate, nitrite, and metals; microorganisms preferentially consume $^{12}CH_4$, resulting in ^{13}C depletion in the CO_2 produced and ^{13}C enrichment in the residual methane (Grossman et al., 2002). Methane attenuation within the Little Creek Field is discussed in more detail in a later topical section (“Methane Oxidation: Little Creek Field”).

6.10. Summary of Dissolved Gases

Dissolved methane was ubiquitous in domestic well samples; mean concentrations ranged widely from about 0.003 to 12.4 mg/L, with a median value of 0.46 mg/L. Methane was also detected in all of the production wells and monitoring wells sampled as a part of this study. In addition, methane was detected in flowing streams, typically at low levels (<0.05 mg/L) at locations downstream (RBSW01 and RBSW02) of surface discharged CBM water (RBSW03). At locations where methane concentrations were sufficient, measurements of the carbon ($\delta^{13}C_{CH4}$) and hydrogen isotope ($\delta^{2}H_{CH4}$) signature were made to compare methane in the domestic wells and monitoring wells with methane present in the gas-producing Raton and Vermejo formations. A variety of isotope patterns and potential sources were identified in this study. Methane isotope data collected from some of the domestic wells and monitoring wells indicate that the methane is microbially sourced and distinctive from thermogenic gas present in the deeper coal beds. In another domestic well, a large isotopic shift was observed over the course of four sampling events; at this location (RBDW11) the isotopic composition of methane progressively transitioned from a thermogenic signature during the first sampling event to a mixed thermogenic/biogenic signature in the later three rounds. The rapid change in the isotopic composition at this location could be due to gas migration, and based on the carbon isotope compositions of DIC and methane, the isotopic shift in $\delta^{13}C_{CH4}$ relative to $\delta^{13}C_{DIC}$ suggests a transition to an environment characterized by acetate fermentation. Finally, domestic wells in the Little Creek Field area contained methane with a thermogenic signature, similar to gas from deeper coal beds (discussed in more detail in a later topical section, “Methane Oxidation: Little Creek Field”), but with a distinctive trend indicative of methane oxidation.

6.11. Strontium Isotopes

Samples were collected during each of the four field events for strontium isotope analysis by thermal ionization mass spectrometry. The strontium isotopic composition of water is dependent only upon dissolution of minerals and ion exchange reactions; as water flows through an aquifer, it progressively acquires a $^{87}Sr/^{86}Sr$ ratio from the rocks with which it interacts (Frost and Toner, 2004). The chemical evolution of ground water is a function of a variety of factors that include, but are not limited to, residence time, initial water composition, and differences in the distribution and reactivity of individual minerals (Gosselin et al., 2004). As such, the Sr isotopic composition of ground water records an integrated signal of water-rock interaction along a flow path and can be used as a dynamic tracer to constrain subsurface flow patterns (Graustein, 1990; Gosselin et al., 2004).

The precision of the strontium isotopic tracer allows for the detection of small variations in ground water strontium isotope composition (Frost and Toner, 2004). Studies have shown that fluid mixing behavior can be understood by a combined evaluation of strontium concentrations and strontium isotope signatures ($^{87}Sr/^{86}Sr$). This technique is highly sensitive, especially in cases where end-member fluids differ significantly in both concentration and isotope ratio (e.g., Capo et al., 1998; Shand et al., 2009; Peterman et al., 2012; Chapman et al., 2012). In this case study, the practical problem is applying strontium isotopes and concentrations to evaluate whether or not shallow ground water has been impacted by the development of CBM gas.

North Fork Ranch

Strontium concentrations and the isotopic composition of strontium ($^{87}Sr/^{86}Sr$) were determined for ground water and surface water samples collected in the North Fork Ranch study site (see Table 19). Strontium concentrations were highest in ground water samples collected from the Vermejo Formation coal aquifers (RBPW02, RBPW03; mean = 597 µg/L), and lowest in ground water samples obtained from domestic wells in alluvial aquifers (RBDW01, RBDW13; mean = 308 µg/L); however, the range in strontium concentration was greatest for domestic and monitoring well samples screened within the Poison Canyon Formation (66.0 to 1,260 µg/L; mean = 473 µg/L). Samples collected from RBPW01 (Raton Formation) showed the least variability over the four sampling rounds (311 to 382 µg/L; mean = 357 µg/L). Strontium concentrations obtained from surface water locations ranged from 254 to 694 µg/L (mean = 425 µg/L).

Table 19. Strontium isotope and concentration data from coal, sandstone, and alluvial aquifers in the Raton Basin, CO. Mean values are shown.

Water Sample ID	Well Type[1]	Study Area[2]	*n*	$^{87}Sr/^{86}Sr$	Sr, µg/L[3]
Quaternary Alluvium					
RBDW01	DW	NFR	2	0.712372	365
RBDW13	DW	NFR	3	0.712304	270
Poison Canyon Sandstone Aquifer					
RBDW02	DW	NFR	4	0.713102	394
RBDW03	DW	NFR	4	0.713333	538
RBDW04	DW	NFR	3	0.712908	869
RBDW05	DW	NFR	4	0.713399	88

Table 19. Strontium isotope and concentration data from coal, sandstone, and alluvial aquifers in the Raton Basin, CO. Mean values are shown.

Water Sample ID	Well Type[1]	Study Area[2]	*n*	^{87}Sr/^{86}Sr	Sr, µg/L[3]
RBMW01	MW	NFR	4	0.712916	1223
RBMW02	MW	NFR	4	0.712910	154
RBMW03	MW	NFR	4	0.712585	143
RBDW06	DW	LCF	4	0.707301	489
RBDW07	DW	LCF	4	0.707787	84
RBDW08	DW	LCF	4	0.707608	170
RBDW09	DW	LCF	4	0.707686	911
RBDW10	DW	LCF	4	0.707841	88
RBDW14	DW	LCF	3	0.707829	284
RBMW04	MW	LCF	1	0.707833	95
RBMW05	MW	LCF	1	0.707932	40
Raton Formation					
RBDW11	DW	AR	4	0.711247	475
RBDW12	DW	AR	1	0.711218	212
RBPW014	PW	NFR	4	0.711783	357
Vermejo Formation Coal Aquifers					
RBPW02	PW	NFR	1	0.708331	268
RBPW03	PW	NFR	3	0.708965	706
Surface Water					
RBSW01	NA[5]	NFR	4	0.712136	308
RBSW02	NA	NFR	3	0.712641	630
RBSW03	NA	NFR	3	0.711122	375

[1] Well Type: DW = Domestic Well; MW = Monitoring Well; PW = Production Well.

[2] Study Area: NFR = North Fork Ranch; LCF = Little Creek Field; AR = Arrowhead Ranchettes.

[3] Sr concentrations from USGS results; these may differ from previous tables that reported metals data from SwRI and Shaw. Of the 90 paired results for strontium (filtered), 96% agreed to within 15%, indicating good agreement in the reproducibility of strontium concentrations between different laboratories.

[4] RBPW01 = Raton Formation coal aquifer.

[5] NA = Not applicable (surface water location).

The strontium isotope ratios for all samples ranged from 0.708331 to 0.713420. The isotopic values at each well location remained constant over the four sampling events; furthermore, differences in the ^{87}Sr/^{86}Sr ratio appear to be constrained with respect to the geologic formation from which the water sample was sourced (see Figure 40A). Strontium isotope ratios for domestic and monitoring wells exhibit the highest strontium isotope values (mean = 0.712917); however, domestic wells located within alluvial aquifers (RBDW01 and RBDW13) are isotopically depleted (mean = 0.712331) relative to domestic and monitoring wells screened within the Poison Canyon Formation (mean = 0.713026). Figure 40B shows a semilog plot of strontium concentrations versus $^{87}Sr/^{86}Sr$ values for samples collected in this study area. Strontium isotope data obtained from Fort Union Formation coal aquifers in the Powder River Basin of Wyoming (Frost et al., 2002) are included in Figure 40B. Both the Fort Union Formation and the Poison Canyon Formation (Raton Basin) were deposited during the Paleocene period. The similarity in both strontium concentration and isotope composition suggests that the source of strontium to these geologic units is the same and likely due to weathering of radiogenic Precambrian rocks uplifted during the Laramide orogeny.

Ground water samples collected from production wells RBPW02 and RBPW03, screened within the Vermejo Formation, reflect the most depleted $^{87}Sr/^{86}Sr$ values (mean = 0.708806). This value is consistent with $^{87}Sr/^{86}Sr$ ratios obtained from leaching experiments on igneous rocks emplaced during the Tertiary period and is discussed in more detail in the "Little Creek Field" section below. Strontium isotope values measured in ground water samples collected from production well RBPW01, which is screened within the Raton Formation, reflected higher $^{87}Sr/^{86}Sr$ ratios relative to Vermejo samples, and lower Sr ratios relative to domestic and monitoring well samples (mean = 0.711783).

The greatest variability in strontium isotope composition was observed in water samples collected from surface water locations (range=0.710440-0.712673). The range of $^{87}Sr/^{86}Sr$ ratios in surface water samples, coupled with temporal changes in concentration (254 to 694 µg/L), indicates that water within the sampled tributaries is composed predominantly of production water discharged to the surface, with minor contributions from precipitation.

Arrowhead Ranchettes

Strontium concentrations ranged from 377 to 604 µg/L (mean = 475 µg/L) in samples collected from RBDW11, screened within the Raton Formation (see Table 19). The average strontium isotope composition, over four sampling rounds, was 0.711247. This value is lower than that for production well RBPW01 (Raton Formation), located in the North Fork Ranch study area (see Figure 40). Domestic well RBDW12 was sampled only during round 1; the measured strontium concentration and isotopic composition for this sample were 212 µg/L and 0.711218, respectively.

Little Creek Field

Strontium concentrations and the isotopic composition of strontium ($^{87}Sr/^{86}Sr$) were determined for ground water collected from domestic and monitoring wells over four sampling events (see Table 19). All sampled wells within the Little Creek study area are screened within the Poison Canyon Formation.

Strontium concentrations ranged from 40 to 1,790 µg/L (mean = 318 µg/L); these values are typically less than those measured for ground water collected from the Poison Canyon Formation in the North Fork Ranch area. The lowest values were consistently measured in ground water from domestic well RBDW10 (mean = 88.3 µg/L), and the highest values were measured in domestic well RBDW09 (mean = 911.3 µg/L). There is no apparent trend in the spatial distribution of strontium concentrations.

The isotopic values at each well location remained constant over the four sampling events; furthermore, differences in $^{87}Sr/^{86}Sr$ ratios appear to be constrained with respect to the geologic formation from which the water sample was sourced (see Figure 41A). All samples are isotopically depleted in strontium (mean = 0.707686) relative to the samples collected in the North Fork Ranch and Arrowhead Ranchettes

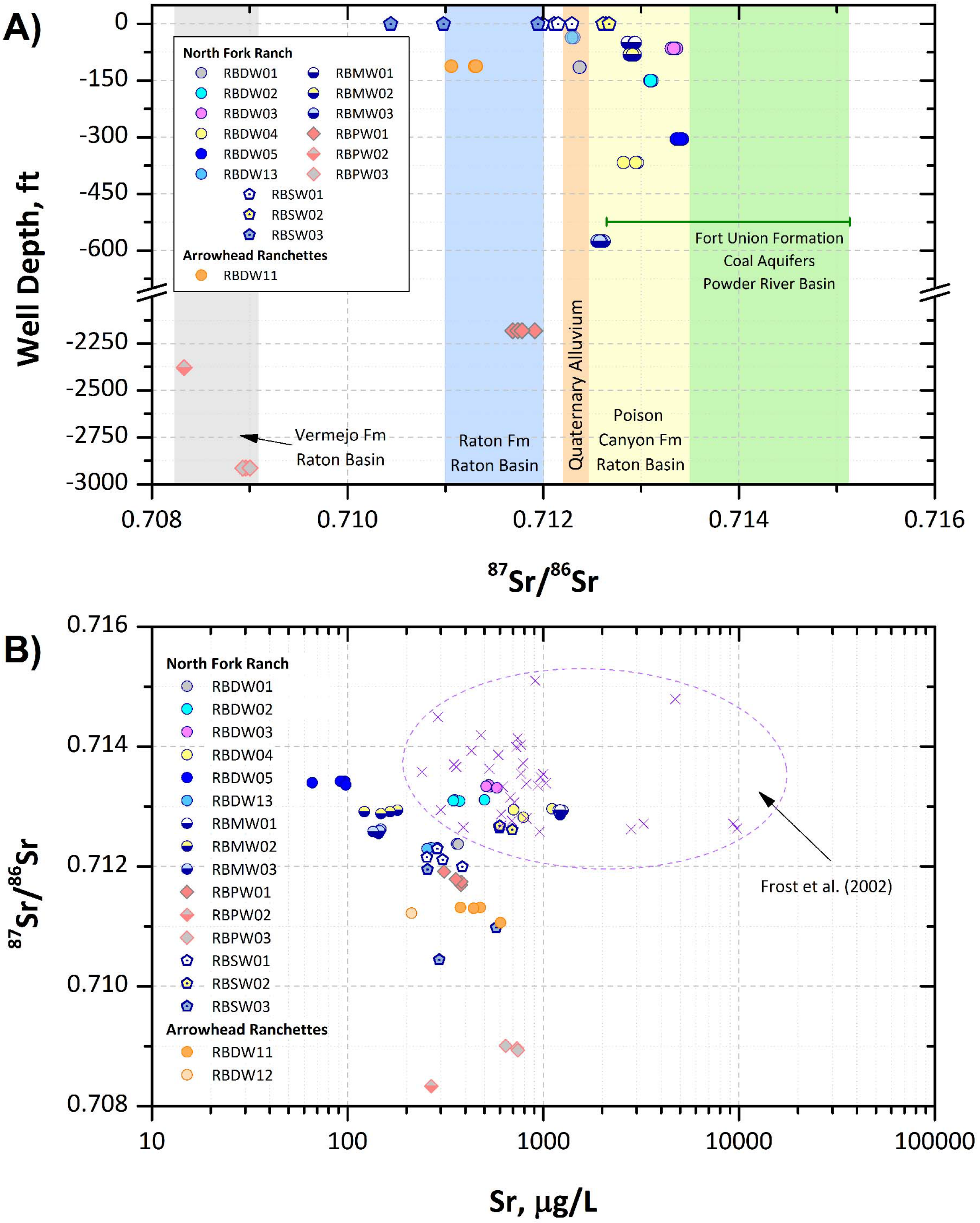


Figure 40. A) Strontium isotope ratios relative to well depth, in feet, for the North Fork Ranch and Arrowhead Ranchettes study areas (Las Animas County, CO). Colored blocks represent the range of Sr ratios observed in water samples, with respect to the geologic unit the well was screened in. B) Sr isotope data obtained from Fort Union Formation coal aquifers in the Powder River Basin of Wyoming (Frost et al., 2002) are superimposed on a semilog plot of Sr concentrations versus $^{87}Sr/^{86}Sr$ values for samples collected during this study.

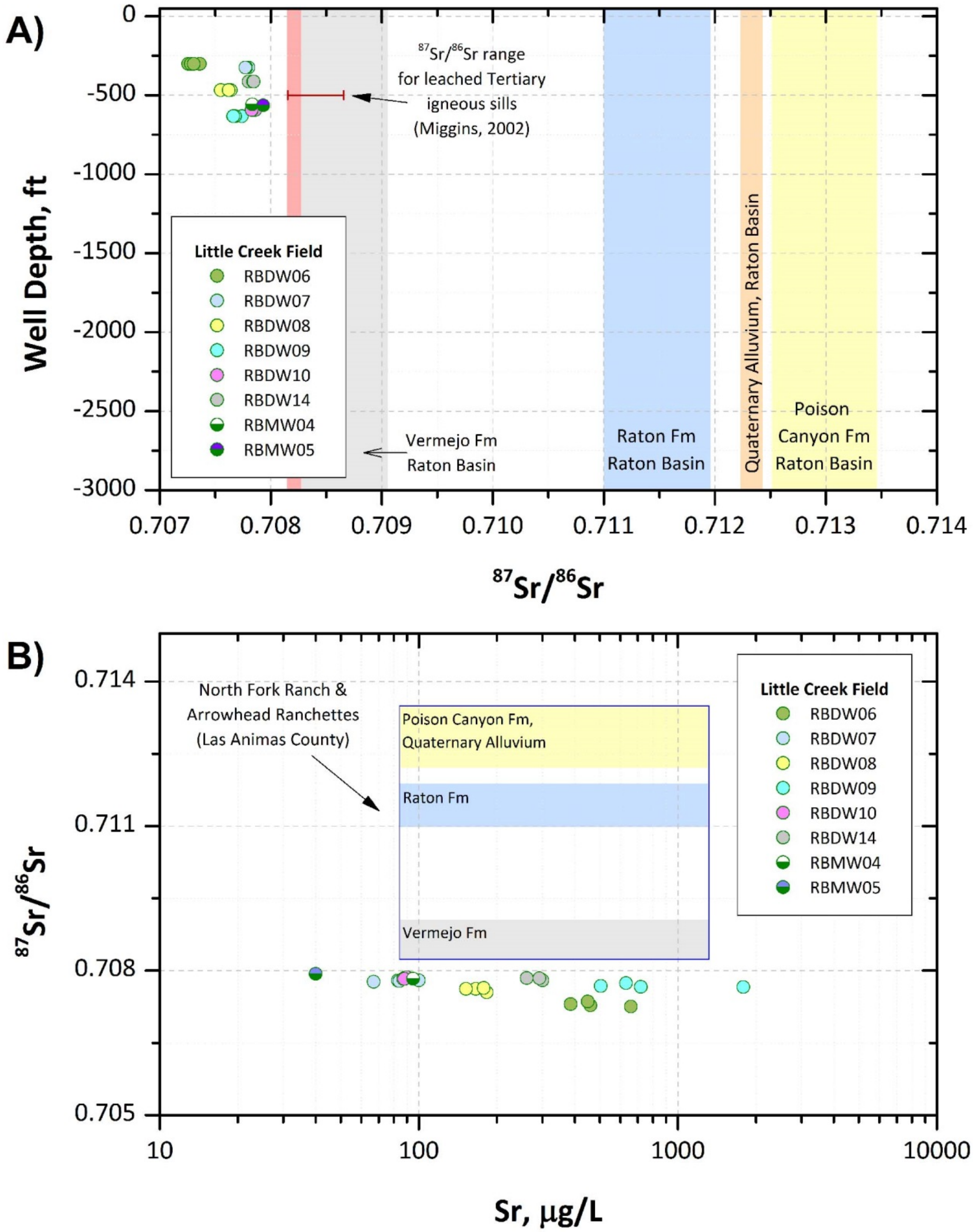


Figure 41. Strontium isotope ratios relative to well depth, in feet (A), and strontium concentrations (B) for the Little Creek Field study area (Huerfano County, CO). Colored blocks represent the range of Sr ratios and concentrations observed in samples collected from Las Animas County, with respect to the geologic units the well was screened in (see Figure 40).

study areas (see Figure 40). Figure 41B shows a semilog plot of strontium concentrations versus $^{87}Sr/^{86}Sr$ values for samples collected in this study area. The isotopic composition of strontium in ground water in this area is similar to the strontium isotope values obtained during leaching experiments of Tertiary igneous rocks (lamprophyres and basalt) collected along the western margin of the Raton Basin (Miggins, 2002). This isotopic similarity suggests that ground water in the Little Creek Field study area has been extensively modified via water-rock interactions, and fluid is near equilibrium with surrounding aquifer materials, including stocks, plugs, and sills emplaced during the Tertiary and into the Quaternary period. This large-scale igneous activity also produced extensive fractures and faults. Igneous activity within the northern Raton Basin is largely associated with the Spanish Peak Mountains, which are located southwest of the Little Creek study site. The Spanish Peaks represent two igneous stocks that injected no fewer than 500 radial and sub-parallel dikes throughout the Raton Basin (Cavness, 2009; Miggins, 2002).

Experimental results from leaching experiments of lamprophyre sills (n = 5) and basalt (n = 1), indicated that, for some of the rocks in the study (particularly lamprophyres), there was a significant difference in the isotopic compositions between the leachate, the silicate residue, and the whole-rock without leaching (Miggins, 2002). Initial whole rock values for two of these samples ranged from 0.706216 to 0.707408; however, the leachate produced a mean value of 0.708401 (±0.000267). In addition, analyses of leached secondary calcium carbonate contained significant amounts of Sr that increased the $^{87}Sr/^{86}Sr$; this has important implications for ground water in carbonate or carbonate-cemented aquifers that acquire their strontium signatures within a relatively short period of time (Frost and Toner, 2004). The invariant strontium isotope ratios measured in ground water obtained from domestic and monitoring wells in the Little Creek Field suggests that the fluid is near equilibrium with surrounding aquifer materials.

In summary, within the Las Animas portion of the Raton Basin, differences in the isotopic composition of strontium appear to be constrained with respect to the geologic formation from which the well water was sourced. Despite similar strontium concentrations, produced water from the Vermejo and Raton formations in the North Fork Ranch area is easily distinguished from ground water collected from the alluvial and Poison Canyon aquifers by its $^{87}Sr/^{86}Sr$ ratio; however, to better access the utility of strontium isotopes tracers, additional strontium isotope data are needed from CBM-producing formations. The strontium isotope composition of ground water in the Little Creek Field has probably been modified from water interactions with igneous bodies emplaced during the Tertiary period. Ground water was collected from water within the Poison Canyon Formation; without strontium isotope data from producing formations in the area, it is unclear as to whether strontium isotopes can be used to trace mixing of water from different geologic units within the Little Creek Field area.

6.12. Sulfur Isotopes

Samples were collected for measurements of $\delta^{34}S$ of sulfide and $\delta^{34}S/\delta^{18}O$ of sulfate in the last three rounds of sampling (May 2012, November 2012, and April/May 2013). These data were collected in order to follow up on observations made during the first sampling event related to increased concentrations of sulfate and wide-ranging sulfide concentrations in some of the ground water samples collected within the Little Creek Field study area in Huerfano County. Sulfate isotope data are presented in this section, and the combined carbon-sulfur isotope data are discussed later in a section on biogeochemical methane attenuation in ground water.

Figure 42 is a plot of $\delta^{34}S_{SO4}$ versus $\delta^{18}O_{SO4}$ for samples collected within Las Animas and Huerfano counties during rounds 2, 3, and 4. Data from the North Fork Ranch area (Las Animas County) show a steep linear trend defined by a narrow range of $\delta^{34}S_{SO4}$ values, from -10.4 to -1.7‰, and $\delta^{18}O_{SO4}$ values, from -0.2 to 7.6‰. The negative $\delta^{34}S$ values suggest that dissolution of pyrite is the probable source for the moderate levels of sulfate in the ground water of this area (sulfate = 0.95 to 98.5 mg/L; median = 40.6 mg/L). Data from location RBDW11, also in Las Animas County, show a parallel and more restricted trend that is offset to positive $\delta^{34}S_{SO4}$ values, perhaps resulting from oxidation of more ^{34}S-enriched pyrite (see Figure 42). When pyrite is oxidized under predominantly anaerobic conditions, the oxygen molecules in sulfate are derived from water (e.g., Pellicori et al., 2005). Because the $\delta^{18}O$ values of sulfate and ground water differ significantly (see Figure 42), pyrite dissolution under anaerobic conditions cannot be the only process controlling the $\delta^{34}S$-$\delta^{18}O$ trend for sulfate. The linear trend for $\delta^{34}S$ and $\delta^{18}O$ of sulfate displayed by samples from the North Fork Ranch area may be controlled by mixing of a sulfate reservoir derived from pyrite dissolution with a sulfate reservoir derived from dissolution of sulfate enriched in ^{34}S. Dissolution of gypsum and/or anhydrite is a possibility for the ^{34}S-enriched sulfate. The $\delta^{34}S_{SO4}$ values of Cretaceous to Paleocene sulfate are expected to be ~17 ± 2‰ (e.g., Claypool et al., 1980; Strauss, 1997); dissolution of sulfate minerals with this isotopic composition could provide an end-member composition to explain the data trends for the North Fork Ranch area observed in Figure 42. Additional data are needed regarding the sulfur isotopic composition of sulfate and sulfide minerals within sedimentary rocks in order to further understand these data.

In contrast to the North Fork Ranch area, data from the Little Creek Field area show a wider range in $\delta^{34}S_{SO4}$ values, from -2.2 to 39.5‰. The positive correlation of $\delta^{34}S_{SO4}$ and $\delta^{18}O_{SO4}$, enrichment of ^{34}S in sulfate, the ratio of ^{18}O to ^{34}S of ~1:5 (0.19), and the presence of dissolved sulfide provide evidence for microbial sulfate reduction (Van Stempvoort et al., 2005; Spence et al., 2005; Fritz et al., 1989). Sulfate-reducing bacteria preferentially respire ^{32}S-enriched sulfate; consequently, residual sulfate becomes progressively enriched in ^{34}S and $\delta^{34}S_{SO4}$ values increase (Harrison and Thode, 1957). The significance of microbial sulfate reduction in the Little Creek Field area is discussed in a later topical section ("Methane Oxidation: Little Creek Field").

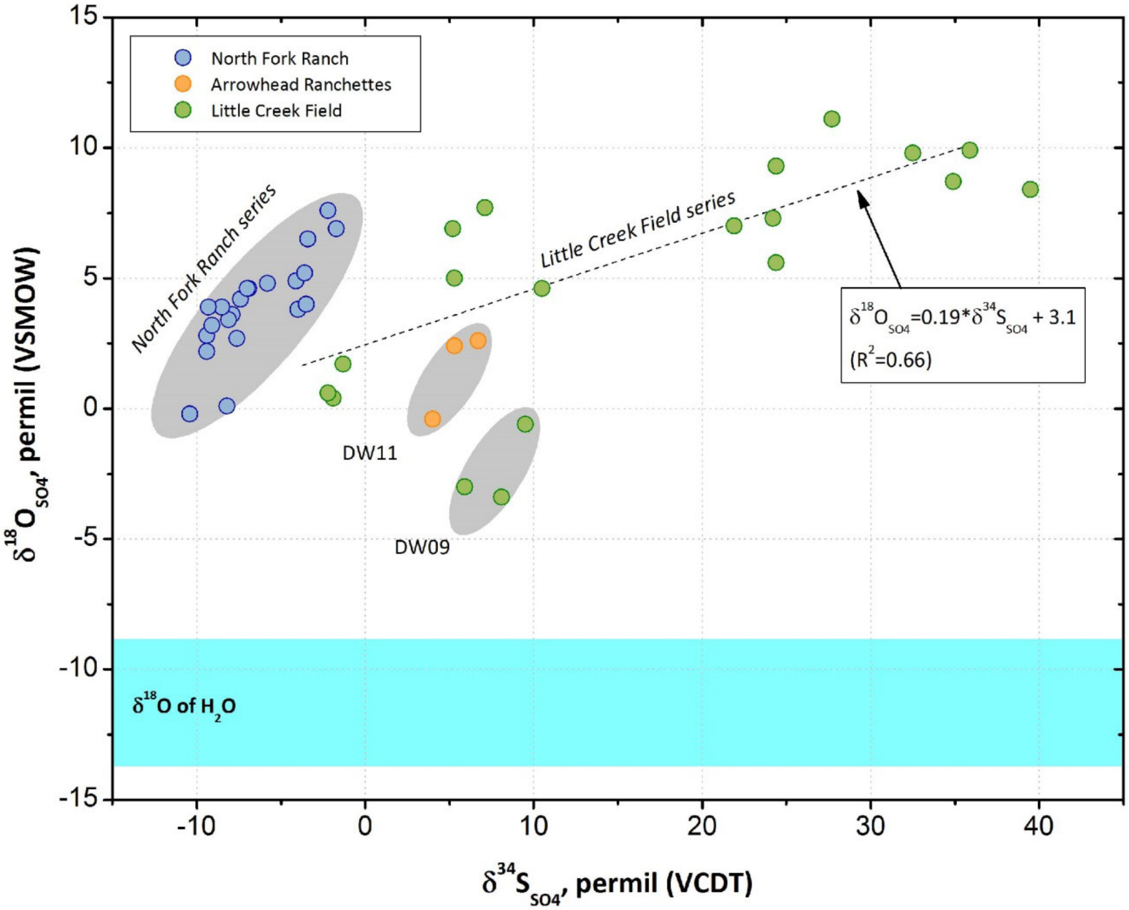


Figure 42. Relationship of stable oxygen and sulfur isotope ratios for dissolved sulfate measured in water samples collected during this study in Las Animas and Huerfano counties during rounds 2, 3, and 4. The aqua box shows the range of the $\delta^{18}O$ values of water ($\delta^{18}O_{H2O}$) obtained for these samples.

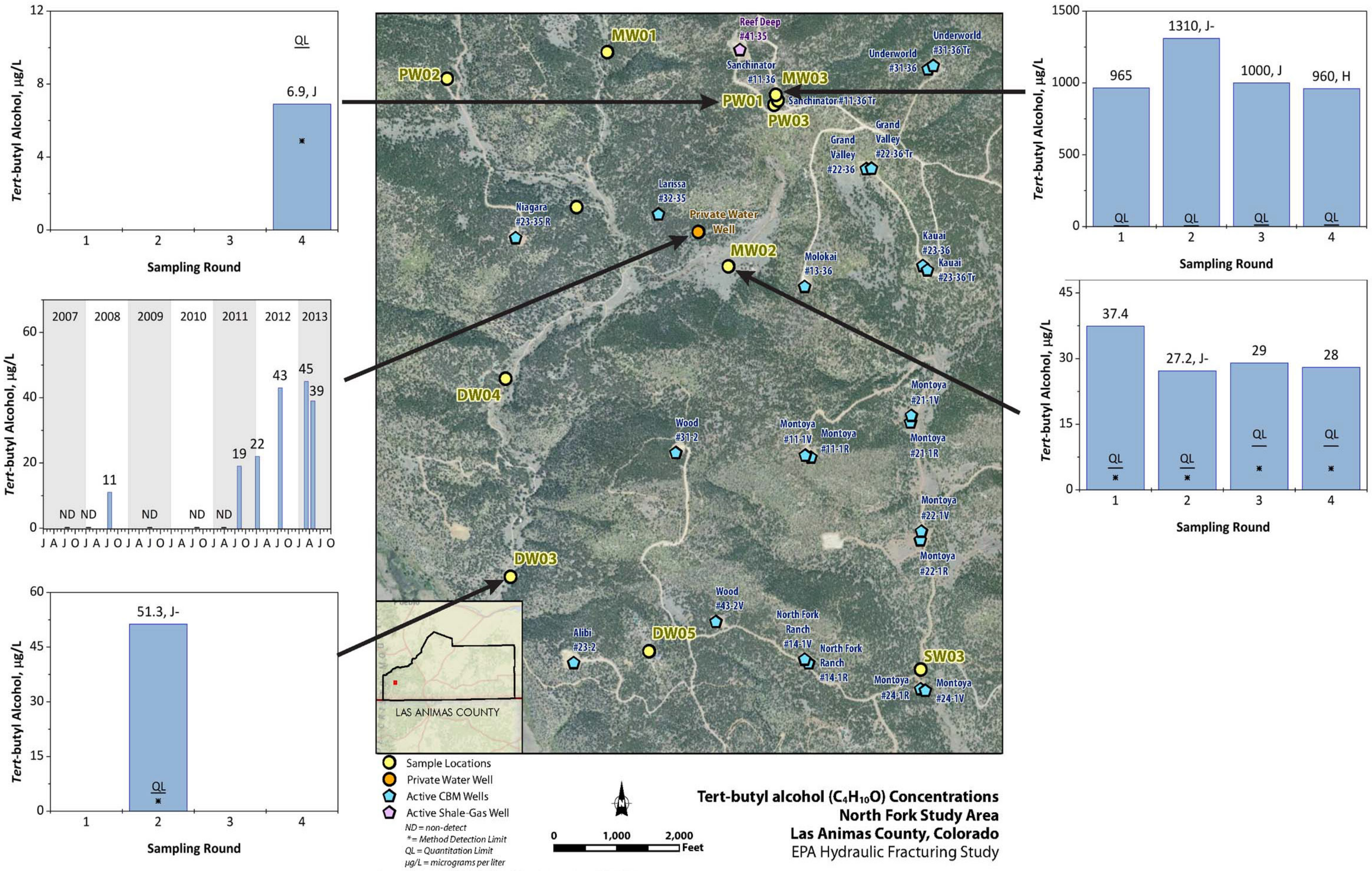
7. Tert-Butyl Alcohol

The concentration data and geographic distribution of TBA detections observed in this study have not been observed or documented in previous studies in the Raton Basin. TBA is the simplest tertiary alcohol, with the structural formula $(CH_3)_3COH$, and is one of four butanol isomers (C_4H_9OH). TBA is miscible in gasoline, ethers, other alcohols, and water, has a low Henry's Law constant (i.e., it does not easily partition from water to air), and weakly sorbs to organic material (Schmidt, 2003). These physico-chemical properties enable TBA to easily partition into water, and once dissolved, TBA can travel at almost the same velocity as ground water (Somsamak et al., 2005). TBA is a significant potential ground water contaminant because of its mobility, recalcitrant nature, and potential toxicity (Clark, 2002). Nevertheless, there is limited research regarding the environmental behavior and fate of TBA in ground water environments. EPA does not have an MCL for TBA; however, several states have passed drinking water action levels because of its potential human toxicity (Cirvello et al., 1995; Kane et al., 2001; Sgambato et al., 2009). For instance, in California and Wisconsin, the primary (health-based) drinking water standard is 12 µg/L (CA-OEHHA, 1999; NEIWPCC, 2006; WI DNR, 2011).

TBA is broadly classified as a gasoline oxygenate (Zogorski et al., 2006). TBA is also a widely used solvent and an intermediate chemical in industrial processes (Schmidt et al., 2004; Wei and Finneran, 2011). Gasoline oxygenates are compounds that contain oxygen as part of their chemical structure and are added to gasoline to improve combustion and reduce emissions. Commonly used oxygenates include alcohols (e.g., methanol, ethanol, isopropyl alcohol, butanol) and ethers (e.g., MTBE, tert-amyl methyl ether (TAME), diisopropyl ether (DIPE), and ETBE). These compounds, as well as their chemical intermediates (e.g., TBA), were routinely analyzed as part of this study but were not detected in any of the samples, with the exception of TBA.

TBA was detected in ground water samples collected from domestic, monitoring, and production wells in the North Fork Ranch study area, as well as a domestic well located in the Arrowhead Ranchettes study area. Within the North Fork Ranch area, TBA was detected in ground water collected from domestic well RBDW03, monitoring wells RBMW02 and RBMW03, and production well RBPW01; concentrations ranged from 6.9 µg/L to 1,310 µg/L (J-). TBA was consistently (rounds 1 through 4) detected in RBMW02 and RBMW03; during each sampling round, the TBA concentration was highest, by an order of magnitude, in monitoring well RBMW03 (range = 960 µg/L to 1,310 µg/L, J-), compared to monitoring well RBMW02 (range = 27.2 µg/L to 37.4 µg/L). The lowest concentration, which was below the QL but above the MDL, was measured in ground water sampled from production well RBPW01 during round 4 (6.9 µg/L, J). TBA was also detected in a water sample collected from domestic well RBDW03 during round 2 (51.3 µg/L, J-).

Figure 43 shows the spatial distribution of TBA detections in the North Fork Ranch area over the four sampling rounds. This figure incorporates data from a private water well (Glibota Environmental, 2013) where TBA has been detected using appropriate analytical methods (GC-MS; concentration range = 11 µg/L to 45 µg/L. Note: TBA data collected from this location were not evaluated during the ADQ). Water chemistry has been privately monitored at this location since 2007. Although this domestic well was not included as a sample location in this case study, ground water samples were collected at a former domestic well (see COGCC, 2010) at a nearby location, designated as monitoring well RBMW02



Source: *Imagery, ESRI; Well and Sample Locations, EPA ORD*

Figure 43. Map showing the spatial distribution of TBA detections and concentrations in the North Fork Ranch sampling area over the four sampling events. Water chemistry has been privately monitored at the "Private Water Well" location (orange symbol) since 2007 (Glibota Environmental, 2013), but it was not sampled during this study. Histograms show TBA concentration (µg/L), quantitation limit (QL), method detection limit (MDL), and the date/round sampled.

(this study), during rounds 1 through 4. There is good agreement within these datasets: the results collected in April 2013 (same day) are similar (private water well = 39 µg/L; RBMW02 = 28 µg/L).

TBA was also consistently detected in domestic well RBDW11, located within the Arrowhead Ranchettes study area. Concentrations ranged from 12 to 32 µg/L (mean = 19 µg/L) over the four sampling rounds. TBA was not detected at nearby location RBDW12 during the first round of sampling (see Figure 44).

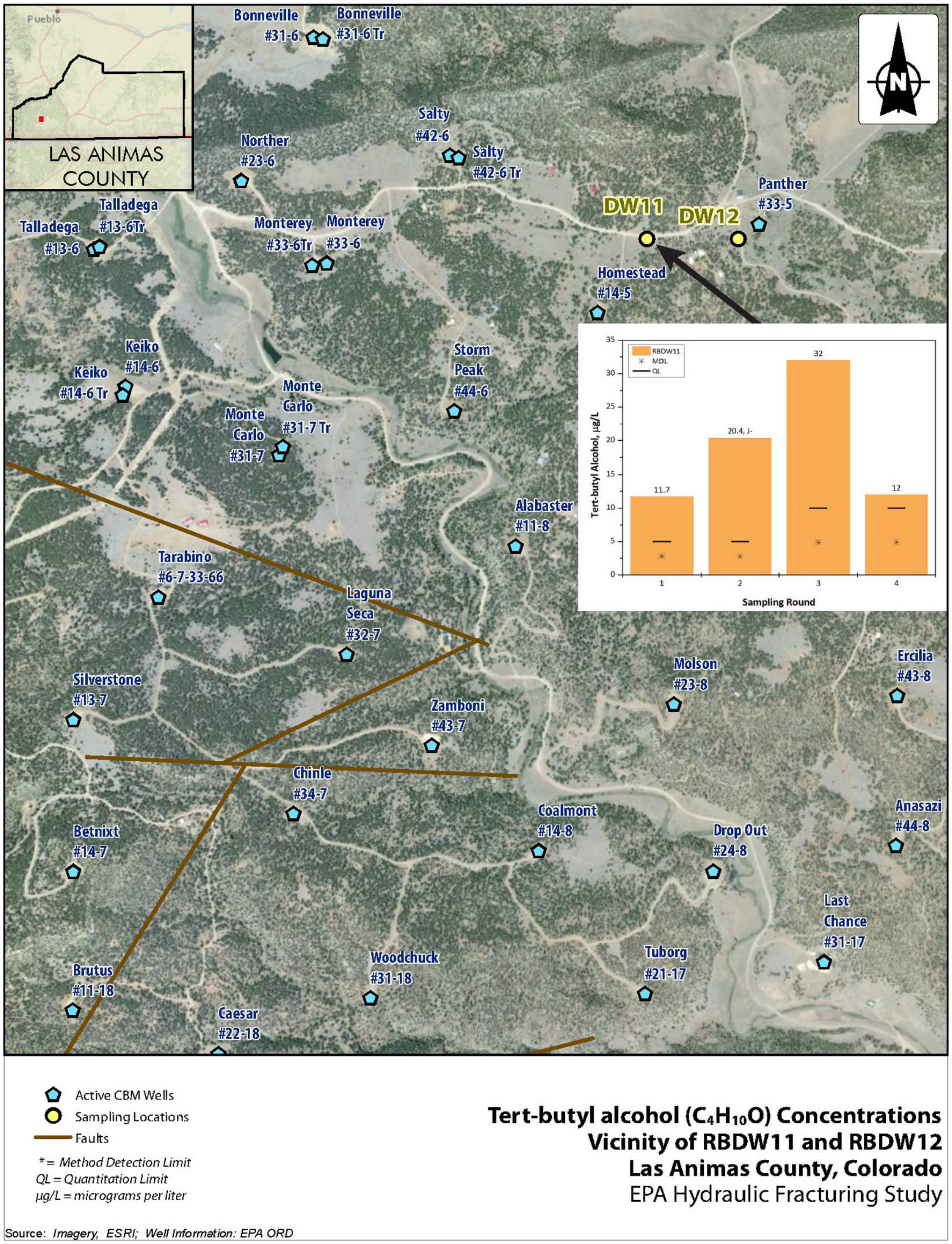
While the typical source of TBA in ground water is usually as a degradation product of the fuel oxygenate compounds MTBE and/or ETBE, several non-gasoline-related sources of TBA exist: (i) TBA can be generated as a biochemical and/or chemical breakdown product of tert-butyl acetate; (ii) TBA can be produced through the chemical decomposition of tert-butyl hydroperoxide; (iii) TBA can be microbially generated from isobutane; or (iv) TBA can be produced by the reaction of isobutylene and water in the presence of a catalyst. Each of these pathways represents a possible source of TBA within the North Fork Ranch and Arrowhead Ranchettes study sites, and each pathway is considered below.

7.1. Degradation of Methyl Tert-Butyl Ether (MTBE)/Ethyl Tert-Butyl Ether (ETBE)

TBA is one of the most widely distributed organic contaminants in ground water at gasoline spill sites (Wilson and Adair, 2007). TBA is the key intermediate in the degradation of several dialkyl ethers used as fuel oxygenates, (i.e., MTBE, ETBE); however, TBA is also an impurity in commercial MTBE (Schmidt, 2003; Wilson et al., 2005) and a fuel additive in its own right (US EPA, 2000c). MTBE degradation has been reported in the presence of all environmentally relevant terminal electron acceptors (i.e., oxygen, nitrate, sulfate, and iron(III)); however, except for oxic conditions, the interpretations of results are controversial within the literature or very limited studies have been conducted (Schmidt et al., 2004). During aerobic MTBE biodegradation, the initial transformation is believed to be carried out by a mono-oxygenase enzyme; these enzymes insert one oxygen atom from molecular oxygen into the organic compound being metabolized, and the other oxygen atom is reduced to form water. The first stable products are TBA and either formaldehyde or formic acid, the latter of which is readily degraded (Wilson et al., 2005).

Degradation of fuel oxygenates under anoxic conditions also yields TBA, possibly by enzymes that cleave the ether bond (- C – O – C -) in the absence of molecular oxygen (Kolhatkar et al., 2002). Anaerobic biodegradation of MTBE is dependent on the predominant terminal electron-accepting conditions, and MTBE degradation can be substantial under relatively oxidized, denitrifying, or humics-amended iron(III)-reducing conditions. In the presence of substantial methanogenic activity, significant accumulations of TBA can occur (Bradley et al., 2001; Finneran and Lovley, 2001; Bradley et al., 2002). Lastly, abiotic transformations of MTBE may occur due to acid hydrolysis of MTBE to TBA during sample preservation or analysis (O'Reilly et al., 2001; Lin et al., 2003).

It is unlikely that the presence of TBA collected from the selected ground water wells in the North Fork Ranch and Arrowhead Ranchettes study areas is the result of MTBE degradation. The following gasoline oxygenate compounds were routinely analyzed as part of this study, but never detected: MTBE, TAME, DIPE, ETBE, and ethanol. There were no documented gasoline spills in this area within a 1-mile radius (see Appendix C), and MTBE was completely banned in the state of Colorado as of April 30, 2002 (US EPA, 2008). Lastly, aerobic biodegradation of MTBE/ETBE by most known bacterial strains produces TBA



Tert-butyl alcohol ($C_4H_{10}O$) Concentrations
Vicinity of RBDW11 and RBDW12
Las Animas County, Colorado
EPA Hydraulic Fracturing Study

Source: *Imagery, ESRI; Well Information: EPA ORD*

Figure 44. Tert-butyl alcohol (TBA) concentrations in ground water collected from location RBDW11 (Arrowhead Ranchettes, Las Animas County), over four sampling rounds. The histogram shows TBA concentration (µg/L), quantitation limit (QL), method detection limit (MDL), and the round sampled.

as a metabolite; therefore, the presence/absence of TBA monooxygenase enzyme can be monitored and used as a proxy for continued biodegradation at a particular location. Microbial analyses conducted on ground water collected from production well RBPW01 in April 2013 (COGCC, 2013b) did not indicate the presence of the "TBA Monooxygenase Functional Gene"; this gene catalyses biodegradation of gasoline oxygenates to TBA (Microbial Insights, 2013).

7.2. Degradation Product of Tert-Butyl Acetate (TBAc)

TBAc ($C_6H_{12}O_2$) is a natural gas-derived oxygenated-ester solvent originally utilized in the 1950s as a fuel additive to improve the combustion quality of diesel fuel and reduce harmful exhaust emissions; however, it was never commercialized for that purpose (Ziegler, 2010). More recently, TBAc has been developed for use in industrial coatings, adhesives, inks, and degreasers, and is a potential substitute for a variety of hazardous air pollutant (HAP) solvents and VOCs, as well as ozone-depleting solvents (Lyondell Chemical Co., 2006). Based on publically available data, TBAc has not been used in hydraulic fracturing processes (US EPA, 2011b; FracFocus, 2013). There are limited environmental studies regarding the impact and fate of this compound; however, TBAc is known to hydrolyze to TBA in chemical and mammalian studies (Groth and Freundt, 1994). The half-life ($t_{½}$) for abiotic hydrolysis of TBAc is dependent upon pH: at 20°C, hydrolysis to TBA at pH 7, 8, and 9 is 135 years, 14.6 years, and 1.5 years, respectively (Lyondell Chemical Co., 2006; Hyman, 2012). The chemical transformation of TBAc with water, resulting in the formation of TBA, is summarized in Eqn. 11:

$$C_6H_{12}O_2 + H_2O \Rightarrow CH_3COO^- + (CH_3)_3COH + H^+ \tag{11}$$

Experimental results from short-term microcosm laboratory studies suggest that TBAc is readily or inherently biodegradable depending on the microorganisms present (Lyondell Chemical Co., 2006; Hyman, 2012); however, neither the mechanism, nor reaction products, were provided in previous reports. Research regarding the kinetics of TBAc biodegradation in natural systems has not been conducted; however, the postulated reaction biodegradation pathway involves cleavage of the acetate group from the tert-butyl alkyl group (Hyman, 2012). This has important implications as to the environmental fate of this compound within aqueous systems; for example, the produced tert-butyl group could participate in a number of reactions (i.e., hydrolysis, substitution reactions, etc.), that could lead to the formation of TBA. If the environment does not contain appropriate TBA-degrading microorganisms (i.e., Nava et al., 2007), TBA can accumulate and, at high concentrations, may inhibit microorganism growth (North et al., 2012).

It is doubtful that the presence of TBA within the North Fork Ranch study area is due to the direct addition of this solvent (TBAc) to hydraulic fracturing fluids because there is no documented use of this chemical in hydraulic fracturing operations within the Raton Basin (FracFocus, 2013). In addition, analysis of environmental records indicated no spills of this chemical in areas around the sampling locations of this study (Appendix C).

7.3. Decomposition of Tert-Butyl Hydroperoxide (TBHP)

TBHP ($C_4H_{10}O_2$) is an alkyl hydroperoxide utilized in commercial and industrial applications. In the petrochemical industry, it is used as an initiator for the emulsion and suspension polymerization of ethylene, vinyl acetate, acrylates, and polyvinyl chloride (PVC), and as a curing agent for unsaturated polyesters (Wang et al., 2007). It is also used as a gel breaker in hydraulic fracturing fluids. The thermal decomposition of TBHP in either liquid phase or inert solvents results in the liberation of oxygen and the formulation of TBA (Wang et al., 2007). Under conditions where thermal decomposition is negligible (<45°C), induced decomposition may occur from the attack of radicals produced by the hydroperoxide on itself (Hiatt et al., 1964). Organic hydroperoxides, such as TBHP, can be destroyed by a variety of reagents, including acids, bases, phenols, and catalytic amounts of various metal ions (Hiatt et al., 1964, and references therein; Stepovik and Potkina, 2013) into TBA and oxygen (Denney and Rosen, 1964). The decomposition of TBHP into TBA and oxygen (Denney and Rosen, 1964) is represented by Eqn. 12:

$$2(CH_3)_3COOH \Rightarrow 2(CH_3)_3COH + O_2 \qquad (12)$$

On December 13, 2011, Colorado passed a Hydraulic Fracturing Disclosure Rule that requires comprehensive public disclosure of the chemicals used in hydraulic fracturing treatments (COGA, 2013); the COGCC requires oil and gas generators to post the disclosure of chemicals on FracFocus.org, the national hydraulic fracturing chemical disclosure registry (COGCC, 2011). The database does not contain proprietary chemical information and/or the chemical ingredients of many additives. The FracFocus.org database is searchable by company, well location, and type of chemical used. According to the database, none of the hydraulic fracturing fluids used in Las Animas County, Colorado, since January 1, 2011, contained TBHP as a component.

7.4. Microbial Oxidation of Isobutane

TBA can be produced by microbial oxidation of isobutane (C_4H_{10}), shown in Eqn. 13 (Mason, 1957), where:

$$C_4H_{10} + O_2 + 2e^- \Rightarrow (CH_3)_3COH + O^{2-}\ (H_2O) \qquad (13)$$

Typically, microorganisms will use short-chain gaseous hydrocarbons as a growth substrate, and then initiate metabolism of gaseous alkanes by inserting one atom from molecular oxygen into the hydrocarbon through the action of broad-spectrum mono-oxygenase enzymes (Shennan, 2006). Hyman (2012) observed TBA production, under both carbon- and oxygen-limited conditions, in over 20 isobutane-utilizing isolates. Under carbon-limited conditions, TBA was consumed, whereas the concentration of TBA remained stable under oxygen-limited conditions.

The equation above implies oxidation. Ground water examined in this study was generally not oxidizing; thus, for this reaction to proceed (in nearly anaerobic conditions), the organisms would need an enzymatic mechanism that involved the addition of water, rather than molecular oxygen, to oxidize isobutane (Atlas, 1981; Parekh et al., 1977). Neither dissolved butane nor propane were detected in any ground water or surface water samples collected from the North Fork Ranch or Arrowhead Ranchette study areas; nevertheless, iC_4 was frequently found in the gas phase in monitoring well RBMW03 (rounds 1, 3, and 4), which also had the highest TBA concentrations. Yet other wells (including RBMW04, RBMW05, RBDW04, RBDW06, RBDW09, and RBDW10) showed iC_4 detections in the headspace gas analysis, but TBA was not detected in samples collected from these locations. Furthermore, other sampling locations that showed consistent detections of TBA (e.g., RBMW02, RBDW11) did not show headspace concentrations of iC_4.

7.5. Formation via an Isobutylene Precursor

Both TBA and TBAc are formed by the reaction of isobutylene (C_4H_8), a component of natural gas, and water in the presence of a catalyst. Liquid phases are formed by water and isobutylene when a solvent is used. Delion et al. (1986) reported the production of TBA and TBAc in the presence of the following solvents: butyl cellosolve (2-butoxyethanol), isopropyl alcohol, cyclohexanol, tetrahydrofurfurylic alcohol, and acetic acid; TBA yield was greatest when acetic acid was used.

The equilibrium reaction in the liquid phase (water) is shown in Eqn. 14:

$$C_4H_8 + H_2O \Leftrightarrow (CH_3)_3COH \tag{14}$$

Isobutylene can be a component of natural gas. Historical headspace gas results of ground water samples obtained from CBM wells producing within the Raton, Raton-Vermejo, and Vermejo formations (ESN Rocky Mountain, 2003) in Las Animas and Huerfano counties indicated that higher-chain hydrocarbons ($>C_{2+}$) were largely restricted to Vermejo-produced gas within Las Animas County, which contained only propane (C_3). Under these circumstances, i.e., in the absence of C_4 compounds, this reaction could not proceed. However, higher molecular weight gaseous alkanes ($\geq C_{4+}$) were detected in a number of ground water samples during this case study, and the presence of these compounds indicates that CBM resources have been modified through microbial activity (i.e., Oremland, 1988). Furthermore, in three of the four wells where TBA was detected, isobutane compounds (iC_4) were measured in the gas phase during headspace gas analyses. Acetic acid, isopropyl alcohol, and 2-butoxyethanol are reported chemical additives within hydraulic fracturing fluids used in Las Animas County (FracFocus, 2013). However, anaerobic microbial oxidation of hydrocarbons can also generate these compounds (e.g., acetic acid (LMWAs), alcohols) as metabolic intermediates (Alperin et al., 1994; Cozzarelli et al., 1994; Cozzarelli et al., 2010). Consequently, the microbial production of low levels of C_4 compounds through time, coupled with the addition of solvents, may favor TBA production into slow moving or stagnant ground water.

The persistent occurrence of TBA through time in the area shown in Figure 43 suggests the presence of a migrating plume. Furthermore, the trends observed at the private water well, with no detections before January 2008 and with increasing levels afterward, are also consistent with leading-edge plume behavior. It is important to note that, prior to April 1, 2012, operators within the state of Colorado were not required to publically disclose information regarding hydraulic fracturing treatments (COGCC, 2011); given that many of the CBM wells located within the study sites were drilled prior to that time, hydraulic fracturing fluid, as the source of TBA within the North Fork Ranch and Arrowhead Ranchettes sampling areas, cannot be completely discounted. It is also possible that the TBA present within the two study areas is from TBA production via microbially mediated processes. Due to limited experimental and field data, a definite pathway could not be determined.

In a recent study, the COGCC examined the occurrence and distribution of TBA from 49 sites in the Raton Basin (Las Animas and Huerfano counties; COGCC, 2015). Samples were collected from CBM and domestic wells. TBA was present in ground water samples from 24% of the domestic wells and from 22% of the CBM wells sampled in the study (COGCC, 2015). COGCC found no evidence that the occurrences of TBA were related to contaminants from hydraulic fracturing fluids; anthropogenic and natural sources of TBA were suggested, but definitive sources of TBA were not identified (COGCC, 2015).

8. Coal-Water Interactions

The Raton Basin contains substantial resources of high- and medium-volatile bituminous coals that extend from outcrops along the periphery of the basin to depths of at least 3,000 feet in the deepest parts of the region (Jurich and Adams, 1984). Extensive commercial mining of coal in the Vermejo and Raton formations began in 1873; however, production started decreasing after 1920, and the last remaining coal mine was closed in 1995 (Flores and Bader, 1999). Coal mining has gradually been replaced by development of CBM: the Raton Basin's CBM contribution was approximately 3% of the nation's total in 2006, with proved reserves estimated at 14.2% (U.S. Energy Information Administration, 2007). Most of the coal-bearing formations targeted for development in Colorado, many of which occur within some of the same formations as aquifers used for water supply, have low porosity and permeability, and hydraulic fracturing operations are needed to produce economic quantities of CBM (COGCC, 2013a). In Colorado, approximately 96% to 98% of the fracturing volume is water and sand, and the remaining volume comprises 10 or more chemical additives that are generally complex organic compounds (COGCC, 2013a); these compounds are difficult to identify in waters that naturally contain complex organics such as those in CBM-producing formations (Dahm et al., 2012).

Ground water and surface water samples were analyzed for a suite of 133 organic compounds, including VOCs, SVOCs, glycol ethers, petroleum hydrocarbons (DRO and GRO), and LMWAs. The purpose of these analyses was to examine the potential occurrence in ground and surface water of chemicals generally documented to be components of hydraulic fracturing fluids (e.g., Ely, 1989; Veatch et al., 1989; Vidic et al., 2013; U.S. House of Representatives, 2011) and, more specifically, of the chemicals in fracturing fluids that have been used in Colorado (see Table 10; FracFocus, 2013). A total of 28 compounds were identified in ground water and surface water samples collected within the three study areas. These data were categorized by the presumed origin of the compounds (i.e., source): anthropogenic, natural, and undetermined; these groupings are organized by study site in Figure 45. It is important to note that compounds that originate in hydrocarbon deposits, such as coal, may be mobilized by anthropogenic processes and/or natural water-rock interactions. A detailed summary of all organic compounds detected in this study, for each study area, is provided in Tables 11, 12, and 13. It is unlikely that the presence of these compounds is related to past mining operations within the region: (i) mining operations were largely confined to the peripheral outcrop belt (eastern margin of the basin), located east of the study areas; (ii) while abandoned underground mines in this area often became filled with water after mining operations ceased, water quality is largely derived from filtration of stream flow and does not reflect interaction with ground water (McLaughlin, 1966); and (iii) abrupt changes in the permeabilities of the Poison Canyon and Raton formations can result in Poison Canyon waters being perched over the less permeable units of the Raton Formation, thus limiting hydrogeologic interactions such as mixing (Howard, 1982).

At least 13 of the detected analytes (1,2-dichlorobenzene, 2-butoxyethanol phosphate, 2-butoxyethanol, bis-(2-ethylhexyl) adipate, bis-(2-ethylhexyl) phthalate, chloroform, diethylene glycol, di-n-butyl phthalate, di-n-octyl phthalate, isophorone, methylene chloride, nitrobenzene, and triethylene glycol) do not occur naturally and are, therefore, considered organic compounds of anthropogenic origin. The source of two analytes, acetone and TBA, is undetermined (see "Organic Compounds" and "Tert-Butyl Alcohol" sections). The remaining 12 detected compounds, which will be collectively referred to as "Petroleum Hydrocarbons," included BTEX compounds and benzene

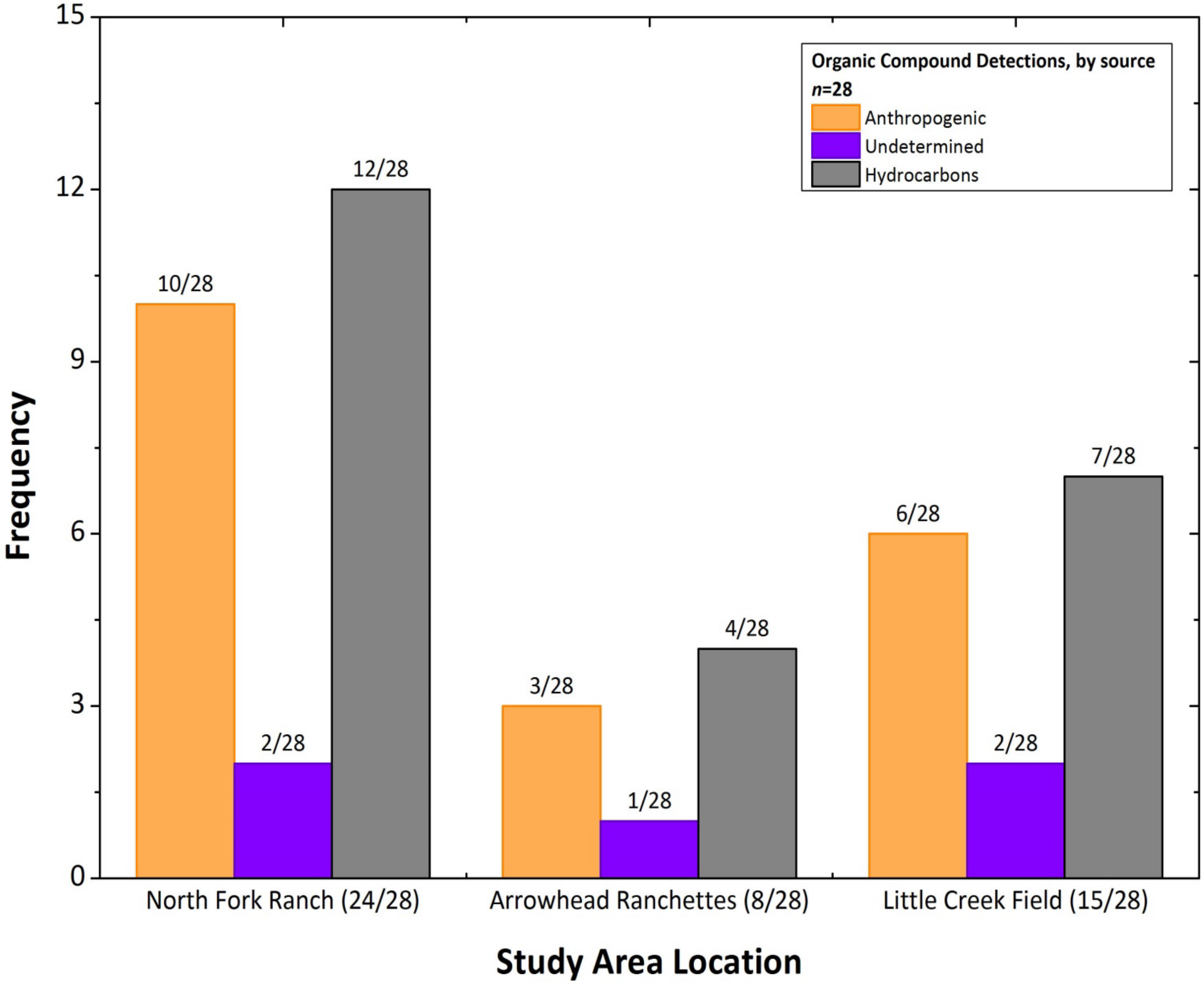


Figure 45. Twenty-eight organic compounds (see Tables 11-13), categorized by compound origin, were detected in ground water and surface water samples collected from the three study areas. The sources of anthropogenic and undetermined compounds are discussed in the text (see "Organic Compounds"); hydrocarbon compounds, which may be mobilized by anthropogenic processes, are likely derived from coal-water interactions within the study areas.

derivatives (1,2,3-trimethylbenzene and 1,2,4-trimethylbenzene), DRO, GRO, carbon disulfide, naphthalene, phenol, and squalene (see Tables 11, 12, and 13). There are no records of fuel spills or leaking storage tanks/pipelines (see Appendix C) or documented use of petroleum distillates in hydraulic fracturing fluid that could account for the presence of these compounds within the three study areas (discussed in more detail below).

8.1. Petroleum Hydrocarbons: Origin

Organic compound speciation and characterization in coalbed-produced water has not been widely studied. The geochemical composition of produced water reflects the contributions of at least two sources: the original fracturing fluid, altered through interactions with the coal seam, and water associated with the coal deposits that becomes mobilized as part of the drilling operation (Batley and Kookana, 2012; Gordalla et al., 2013). Research to date indicates that extractable hydrocarbons show a surprisingly consistent pattern in CBM-produced water from different CBM plays (Dahm et al., 2011; Dahm et al., 2012; Orem et al., 2014). Polycyclic aromatic hydrocarbons (PAHs), the dominant compound class identified in most samples, are primarily composed of lower-molecular-weight (2-ring) compounds and their alkyl derivatives (Orem et al., 2007; Orem et al., 2014); the presence of these compounds reflects a signal derived from interactions between the coal and the aquifer (Dahm et al., 2012).

Within coal seams, the injection of fluid under high pressure causes cracking that extends for distances typically up to 30 meters (Batley and Kookana, 2012). Upon the penetration of the fluid into the coal structure, coal molecules dissociate as weak bonds are broken and rearrange and reassociate in lower free energy formations, macropores are created in the coal structure, and new reactive sites are formed (Pinto et al., 1999; Makitra and Bryk, 2008). The physical alteration of the coal structure increases the available surface area for fluid to penetrate and react with (Takarada et al., 2003), causing the structure to “swell”: there is an overall increase in the volume of the coal as a result of adsorbing the liquid, and the structure becomes distorted (Green et al., 1982; Spears et al., 1993; Van Niekerk et al., 2010, and references therein). Pre-swollen coals are inherently “more reactive” than the original coal (Larsen et al., 1981; Larsen et al., 2001; Kawashima and Saito, 2004), as previously inaccessible reactive sites become available and generate higher yields of solubilized (extracted) matter (Marzec, 1986; Kamieński et al., 1987; Makitra and Bryk, 2008 and references therein). The mechanism of coal extraction seems to occur by substitution reactions, wherein electron-donating solvent molecules replace the coal electron-donor participants. The higher the electron-donor capability of the solvents, the more coal electron-donor centers are replaced by solvent molecules and, therefore, the higher the extraction yields (Marzec, 2002). Additionally, an increase in the nitrogen content of the solvent is reported to enhance extraction yield (Rivolta, 2012), and this may have important implications for areas where coal seams are fractured using nitrogen foams.

Hydraulic fracturing processes within the Raton Basin are relatively short (lasting <1 week, maximum), which limits the amount of time the coal is exposed to the solvent; however, experimental work of coal extraction in both inorganic and organic solvents has revealed that swelling/extraction can occur over short time periods (<1 week; Hombach, 1980; Iino and Matsuda, 1984; Pinto et al., 1999; Sakanishi et al., 2002; Takarada et al., 2003). The rates of solvent uptake and the kinetics of swelling are strongly influenced by factors such as the nature of the coal, the size of the coal particles, the nature of the solvent, the size and shape of the solvent molecules, the accessibility of solvents to coal macromolecules, solvent sorption and diffusion processes in coals, temperature, and moisture content (Krzesińska, 2001). Additionally, modification of the physical structure ultimately promotes chemical dissolution of the coal matrix (Marzec et al., 1979; Szeliga and Marzec, 1983; Marzec and Kisielow, 1983; Iino and Matsuda, 1984; Charlesworth, 1987; Chawla and Davis, 1989). Although some of the hydraulic fracturing fluid is withdrawn after the fracturing event, a portion remains; chemical additives react under the conditions of the fracturing process and form degradation and reaction products (Choi et al., 1989; Gordalla et al., 2013), and continued contact with ground water (a polar solvent) will generate low-molecular-weight hydrocarbons (Iino et al., 2007).

8.2. Discussion

In CBM gas wells, water production is necessary to facilitate the lowering of hydrostatic pressure in the coal seam, allowing gas desorption and production (Dahm et al., 2012). The injection of fluid with solvent-like properties into coal seams may have a secondary impact: the eventual solubilization of the coal matrix, by swelling and solvation, ultimately yielding hydrocarbons with lower molecular weights (Rivolta, 2012; Gordalla et al., 2013). Benzene (and derivatives), ethylbenzene, phenol, squalene, toluene, and xylenes have been reported in analyses of organic compounds in formation fluids associated with shale and coal, as well as produced water (Orem et al., 1999; Orem et al., 2007; Dahm et al., 2011; Dahm et al., 2012; Schlegel et al., 2013).

BTEX compounds were consistently detected in production wells and surface water locations within the North Fork Ranch study area. The BTEX suite of organic compounds was not consistently detected in domestic or monitoring wells in any of the study areas, with the exception of low levels of benzene (RBDW03, round 2) and toluene (RBDW05, round 4; RBMW03, rounds 3 and 4) in North Fork Ranch. Geochemical and isotopic analyses of surface water indicate that water within the sampled tributaries is composed predominantly of production water discharged to the surface, and production wells are producing from the Raton coal (RBPW01) and Vermejo coal (RBPW02, RBPW03) formations. Many of these compounds are commonly associated with the unintended release of petroleum fuel, which can occur as large, discrete events or as chronic, slow leakage from storage tanks and pipelines (Peters et al., 2005). However, there are no records of fuel spills or leaking storage tanks/pipelines occurring in the vicinity of the three study areas within a 1-mile radius (see Appendix C). Alternatively, the COGCC (2013b) has reported that these compounds may be added to hydraulic fracturing fluids, as petroleum distillates, during hydraulic fracturing operations within the state of Colorado. Petroleum distillates were documented as a hydraulic fracturing fluid additive by one operator in Huerfano County; however, this record is limited to a single fracturing job, which occurred in August 2013, located over 14 miles northwest of the Little Creek Field study area. There are no records of petroleum distillates being used, by any operator, in Las Animas County (FracFocus, 2013), where the suite of BTEX compounds was detected (see Tables 11, 12, and 13).

DRO compounds were detected at all three study sites, and detections were not limited to a particular well type. GRO compounds were detected in a single monitoring well in North Fork Ranch study area (RBMW03) during rounds 1 and 2 and in four domestic wells in the Little Creek Field study area. The methods used to analyze DRO/GRO in aqueous samples measure all organics in the sample and are not specific to hydrocarbon compounds that originate, for example, from a fuel release (Mohler et al., 2013). As such, non-targeted organic compounds, such as pesticides, phenols, phthalates, and other hydrocarbons can be captured in the chromatographic integration window and reported as DRO/GRO.

Chromatogram patterns (see Figure 29), determined in ground and surface water samples collected during this case study, are consistent with chromatograms documenting the presence of longer, alkane-series carbon chains and/or aromatic hydrocarbons that have undergone weathering and/or biodegradation (Wang and Fingas, 1997; Wang et al., 1998; Grossi et al., 2002).

Phenol, squalene, naphthalene, and carbon disulfide were detected in ground water collected from domestic and monitoring wells, and detections varied by study area. Note that these compounds were not observed in any production well or surface water samples. Most of the domestic and monitoring wells are screened within organic-rich units (i.e., predominantly shale and/or siltstone), and these compounds can be generated as ground water interacts with algal-derived shale-type organic matter, compared to the more aromatic character of vascular plant-derived organic matter found in coal (Stuermer et al., 1982; Scott et al., 2009; Orem et al., 1999; Orem et al., 2007; Schlegel et al., 2013; Orem et al., 2014).

8.3. Summary

The suite of organic compounds analyzed in this study was selected in order to evaluate the potential occurrence of chemicals generally documented as components of hydraulic fracturing fluids (e.g., Ely, 1989; Veatch et al., 1989; Vidic et al., 2013; U.S. House of Representatives, 2011), and more specifically of the chemicals in fracturing fluids that have been used in Colorado, within ground water and surface water. In addition, results from these analyses will contribute to our understanding of organic matter mobilization and composition in water (i.e., produced, formation) related to hydraulic fracturing activities. Coal is known to contain a number of potentially toxic organic substances, including PAHs, heterocyclic compounds, and aromatic amines (Orem et al., 2007). Environmental impacts due to the mobilization of organic compounds in coal, by ground or surface water, are largely unknown, and few studies have been published on organic substances present in produced and formation water related to CBM extraction activities (Orem et al., 2014, and references therein).

Almost half of the detected compounds (46%; 13 of 28) were hydrocarbons commonly associated with petroleum fuel releases. The presence of BTEX compounds and benzene derivatives is consistent with results reported for other areas developing CBM resources and may reflect solubilization of coal material, either as a by-product of natural water-rock interactions or the injection of fluid with solvent-like properties into coal seams. While experimental research demonstrates the effects of solvents on the coal matrix, very little research has been reported regarding compound-specific products generated during solvent-coal interactions. Nonetheless, these findings have important implications for areas undergoing extensive CBM development where, due to the lack of baseline data, water quality conditions must be estimated after hydraulic fracturing has already begun.

9. Methane Oxidation: Little Creek Field

The Little Creek Field (see Figure 11) is located southwest of Walsenburg, Colorado, and was operated by Petroglyph. In the spring of 2007, potentially explosive levels of methane vented into shallow domestic water wells completed in the Poison Canyon Formation; the first report of gas within a water well occurred on May 22, 2007 (COGCC, 2007b). The release of methane gas from the Vermejo Formation coalbed production zone into the shallower Poison Canyon aquifer system led to elevated dissolved methane concentrations in an aquifer used for drinking water (Norwest Corporation 2011a, 2011b). The purpose of ground water analyses collected within this study area was to examine potential drinking water well contamination (methane and/or other contaminants) and secondary water quality impacts related to methane migration.

Hydraulic fracturing was completed in the Little Creek Field in 1998 (five wells), 2004 (one well), and 2005 (three wells). Following a series of hydraulic fracturing applications in August 2005 (one well) and November 2005 (two wells), gas and water production within the Little Creek Field began to rapidly increase. By January 2006, daily gas volume had increased from ~10 thousand cubic feet (Mcf; daily gas volume mean, 2002–2005) to 60 Mcf (Petroglyph, 2012). Positive production trends continued into 2007. In June 2007, daily mean gas volume had increased to 200 Mcf (Petroglyph, 2012), when it was discovered that high—and potentially explosive—levels of methane were venting into domestic water wells screened within the shallow aquifer system of the Poison Canyon Formation (COGCC, 2007a). At this time, free-phase gas was present and dissolved gas concentrations began to increase in water withdrawn from drinking water wells. Petroglyph, in conjunction with COGCC, began to actively monitor the shallow aquifer water wells and CBM wells in July 2007 (COGCC, 2008). Initial measurements of gas flow collected at some domestic water well heads exceeded 50 thousand cubic feet per day (Mcfd), and a maximum gas flow rate, >100 Mcfd, was measured at one location in September 2007 (Norwest Corporation, 2011b). Cumulative gas production of up to 5,000 Mcfd was reported in several domestic water and CBM wells located *east* of the Little Creek Field (Norwest Questa, 2007b) and southeast of the hydraulic barrier location (described below), indicating that methane migration was occurring on a regional level, instead of locally. Shortly thereafter, Petroglyph and, through contract, Norwest Questa Engineering and Norwest Applied Hydrology (Norwest), began reviewing, analyzing, and evaluating available data to determine the origins of the methane found in the shallow ground water aquifers (Norwest Questa, 2007b). The methane isotope composition indicated methane migration from the Vermejo Formation coals (Norwest Questa, 2007a). The size and nature of the migration pathway between the shallow Poison Canyon aquifer and the Vermejo Formation coals is unknown (Norwest Applied Hydrology, 2008); however, results from numerical simulations suggested that: (i) methane was migrating vertically along localized dikes, which trend southwest-northeast across the Little Creek Field, through buoyancy effects; and/or (ii) the conduit existed within the vicinity of one of the CBM wells (Lively #03-10; Norwest Questa, 2007a).

On July 20, 2007, Petroglyph shut-in 52 gas wells in the field at the request of COGCC. In January 2008, COGCC issued Order 1-C6, which outlined a three-phase plan (*Methane Investigation, Monitoring, and Mitigation Program, MIMMP*; see COGCC, 2008) to mitigate the methane migration and potentially allow operations to eventually resume in the field. The goals of this program were to: (i) determine the extent of the methane-impacted ground water, its origins, and migration using scientific and engineering data; and (ii) to develop: (a) a remediation strategy for affected aquifers, (b) an ongoing strategy for continued CBM operations, and (c) a strategy for degassing Vermejo coals in a controlled manner for future public utilization of a large, fresh water aquifer (Norwest Questa, 2007b).

In March 2008, Petroglyph initiated Phase I of their mitigation program and recovery wells began passively venting; this reduced, and in some cases eliminated, venting methane at private well locations (Petroglyph, 2009). Mitigation efforts focused on removing methane from the produced water stream at the affected wells, with the preferred outcome being the identification and plugging of the conduit; however, identifying the specific conduit was not possible because this would have required reactivation of CBM wells (Norwest Questa, 2007a). Instead, a hydraulic barrier was created by installing water injection wells every 3,000 feet around the migration hot zone to help contain the migration of methane. Methane dissolved in the water was removed, and the ground water was then re-injected into the same shallow aquifer. This configuration of extraction and injection wells was designed to create a hydraulic gradient for the methane and ground water to flow toward the pumping capture well and prevent gas migration (Norwest Questa, 2007b). Landowner issues were addressed by installing methane monitors (10 landowners), supplying water (seven land owners), or installing methane vent systems on water wells (five wells) (Norwest Questa, 2007a). Over time, the remediation system for the Poison Canyon aquifer appeared to reduce free-phase gas and dissolved gas concentrations (Norwest Corporation 2011a, 2011b), and in September 2011 the remediation system was shut down. It is important to note that the significant reduction in domestic well gas flows, after installation of the recovery wells, was interpreted to mean that the mitigation system was removing gas from the Poison Canyon Formation, and that a hydraulic barrier would contain gas migration (Norwest Applied Hydrology, 2008).

9.1. Methane Attenuation

The release of methane gas from the Vermejo Formation coalbed production zone into the shallower Poison Canyon aquifer system led to elevated methane concentrations in an aquifer used for drinking water. The gas migration event occurred in the spring of 2007, approximately two years after hydraulic fracturing occurred in the Little Creek Field.

Sampling for this retrospective case study was conducted from October 2011 to April/May 2013. Changes in the concentrations and isotopic compositions of dissolved gases were tracked over four sampling events and used to evaluate the intermediate-term response and water quality characteristics of the shallow aquifer several years after the methane release. Geochemical and isotopic data indicate that methane in the aquifer has undergone anaerobic oxidation of methane (AOM), which provides a sink for upwardly diffusing methane (e.g., Pohlman et al., 2013 and references therein). AOM is a microbially mediated process where methane is oxidized with different terminal electron acceptors; known pathways include: (i) AOM coupled to sulfate reduction; (ii) AOM coupled to metal-oxide reduction (i.e., iron and manganese; Beal et al., 2009; Riedinger et al., 2014); (iii) AOM by nitrite dismutation (Ettwig et al., 2010); and (iv) AOM and disulfide disproportionation (Milucka et al., 2012). The most thoroughly investigated biochemical hypothesis for AOM involves the oxidation of methane to CO_2 using sulfate (SO_4^{2-}) as the terminal electron acceptor (pathway (i); see Hoehler et al., 1994; Caldwell et al., 2008). This interaction is a cooperative metabolic process mediated by associations between anaerobic methanotrophic archaea (ANMEs; single-celled organisms) and sulfate-reducing bacteria (Hinrichs et al., 1999; Boetius et al., 2000). The coupled reaction is proposed to proceed according to Eqn. 15 (Reeburgh, 1977), where methane is oxidized to CO_2 using sulfate (SO_4^{2-}) and the end products of this microbially mediated reaction are bicarbonate (HCO_3^-) and bisulfide (HS^-):

$$CH_4 + SO_4^{2-} \Rightarrow HCO_3^- + HS^- + H_2O \qquad (15)$$

Time-related changes in the geochemical and isotopic composition of ground water collected from impacted domestic wells within the Little Creek Field area are consistent with sulfate-dependent AOM. Multiple lines of evidence, discussed in detail below, suggest that AOM is occurring; these include:

- Consumption of dissolved methane and sulfate and production of dissolved sulfide and bicarbonate.
- CH_4 loss coupled to production of higher-molecular-weight (C_{2+}) gaseous hydrocarbons.
- A distinct pattern of $\delta^{13}C$ in dissolved inorganic carbon.
- A systematic shift in sulfur and oxygen isotope ratios of SO_4, indicative of microbial sulfate reduction.

9.1.1. Dissolved Methane and Sulfate Coupled with the Production of Dissolved Sulfide and Bicarbonate

The initial, explosive gas venting incident occurred south of the mitigation area, at domestic well RBDW06 (see Figure 11), and subsequent incidents of venting methane trended northward from this location, which is in the same direction as the hydraulic gradient from the Spanish Peaks. Table 20 summarizes the observed average changes in methane, sulfate, sulfide, and bicarbonate concentrations measured in ground water collected from all domestic wells within the Little Creek Field study area; data are organized with respect to water type. Domestic wells RBDW07 and RBDW14, located north of the hydraulic barrier (Norwest Questa, 2007b), contained very low concentrations of methane (<0.05 mg/L) compared to other wells and may reflect an area of undisturbed ground water. These wells were used as “control wells,” and concentrations observed in these wells are used as baseline data, representative of an impact-free Poison Canyon aquifer. Baseline values for RBDW07 (sodium-bicarbonate type) and RBDW14 (sodium-sulfate type) are provided for comparative purposes (see Table 20). Historical water quality data, collected during Petroglyph’s monitoring program (2008–2011), were available for domestic wells RBDW08, RBDW09, and RBDW10; these data were compiled with results obtained during this case study. Historical data were not available for domestic well RBDW06, and the data shown were collected over four sampling events during this case study. It is important to note that wells were sampled only once in 2013, and the value shown for 2013 may not capture the seasonal variation in methane oxidation observed in previous sampling rounds (Chanton et al., 2005; Smemo and Yavitt, 2007).

Observed concentration trends for bicarbonate and dissolved sulfide and sulfate in the methane-impacted domestic wells are consistent with the CH_4 oxidation reaction stated above (Eqn. 15). Dissolved oxygen, nitrate, and iron do not appear to be important electron acceptors in this aquifer. Dissolved oxygen was generally <1.0 mg/L in the ground water, indicating anaerobic conditions. Nitrate plus nitrite were not detected in any of the impacted well locations, with the exception of RBDW09, during round 3 (0.16 mg-N/L); iron was not detected above the QL in ground water collected from any

Table 20. Annual (mean) methane, sulfate, sulfide and bicarbonate concentrations in ground water collected from domestic wells within the Little Creek Field study area**.** Data are organized with respect to water type, sodium-bicarbonate and sodium-sulfate; concentrations observed in domestic wells RBDW07 and RBDW14 are used as baseline (background) data, representative of an impact-free Poison Canyon aquifer.

Sample ID	***(sample size)***	**Methane**	**Sulfate**	**Bicarbonate**	**ΣH_2S[1]**
		mg/L	**mg/L**	**mg/L**	**mg – S/L**
Sodium-Bicarbonate					
RBDW07	***(n = 4)***	**0.021**	**67.9**	**262**	**0.047**
RBDW06					
2011	*(n = 1)*	13.5	80.9	243	5.90
2012	*(n = 2)*	8.56	61.8	218	1.64
2013	*(n = 1)*	8.08	65.5	232	3.00
RBDW08					
2009	*(n = 1[†])*	4.20	99.4	168	0.60
2010	*(n = 1[†])*	6.60	120	171	NA[2]
2011	*(n = 4[‡A])*	6.12	113	174	3.80
2012	*(n = 2)*	5.64	107	182	1.58
2013	*(n = 1)*	8.40	118	203	0.44
Sodium-Sulfate					
RBDW14	***(n = 4[‡B])***	**0.003**	**347**	**99.3**	**0.072**
RBDW09					
2011	*(n = 2[‡A])*	13.8	271	121	1.23
2012	*(n = 2)*	8.61	161	187	10.8
2013	*(n = 1)*	13.3	224	168	8.00
RBDW10					
2010	*(n = 2[†])*	13.7	110	99	20.4[†A]
2011	*(n = 4[‡])*	18.6	123	108	36.6
2012	*(n = 2)*	11.6	94.8	155	28.3
2013	*(n = 1)*	10.7	110	139	24.5

[1] ΣH_2S = Mean dissolved sulfide results were calculated using only data collected during this case study.

[2] NA = Not available.

[†] = Historical data, collected during Petroglyph's monitoring program (2007–2011; Petroglyph, 2013).

[†A] = Historical data; sulfide value is based on 1 sample (n = 1) for RBDW10 (Petroglyph, 2013).

[‡A] = Mean values were calculated using historical data† (Petroglyph) and data from round 1, this case study.

[‡B] = Mean values were calculated using historical data† (Petroglyph) and data from rounds 2–4, this case study.

domestic well. Dissolved sulfate concentrations ranged from 68 to 352 mg/L in the control wells (RBDW07, RBDW14), and from 61 to 445 mg/L in the four impacted domestic wells. Sulfate is apparently the most readily available electron acceptor in the aquifer; thus, the principal reaction involved in CH_4 oxidation appears to be SO_4^{2-} reduction, shown in Eqn. 16, where the end product of this bacterially mediated reaction is bisulfide:

$$SO_4^{2-} + 4H_2 + H^+ \Rightarrow HS^- + 4H_2O \qquad (16)$$

Dissolved sulfide concentrations within ground water collected from the impacted domestic wells (range = 0.44–36.6 mg-S/L, J) were consistently several orders of magnitude higher than those obtained from the control wells (mean <0.05 mg-S/L), indicating sulfide production. Further, dissolved sulfide production was greatest in wells with sodium-sulfate water type (RBDW09, RBDW10), which is expected given the presence of abundant sulfate (see Table 20).

Figures 46, 47, and 48 show the concentration of dissolved methane measured in ground water collected from RBDW08, RBDW09, and RBDW10. At each of these locations, dissolved methane concentrations slowly increased, peaked between late 2010 (RBDW09; see Figure 47) and early 2011 (RBDW08, see Figure 46; and RBDW10, see Figure 48), and then started decreasing. The decrease in dissolved methane concentrations in late 2010/early 2011 was likely due to a combination of methane removal via the remediation system and natural attenuation. Temporal trends observed in data collected after September 2011, when the remediation program ended and shortly before sampling began as part of this case study, are inferred to represent methane attenuation via biochemical processes only. Dissolved methane concentrations obtained in October 2011 during round 1 of this study were lower than the last measurement collected by Petroglyph in July 2011 (see Figures 46, 47, and 48); however, over the course of the four sampling events, considerable fluctuation in methane concentration was observed, especially in sodium-bicarbonate type ground water (i.e., RBDW06, RBDW08), where sulfate is less abundant.

9.1.2. Loss of CH_4, Coupled with Production of C_{2+} Gaseous Alkanes

Following the release of methane gas from the Vermejo Formation coalbed production zone into the shallower Poison Canyon aquifer system in 2007, the concentration of methane gas dissolved in the water samples began increasing, as the released gas equilibrated with the aqueous phase (e.g., Stolaroff et al., 2012). The volume % methane measured in samples collected from RBDW08, RBDW10, and RBDW14 by Petroglyph in 2009, was 38.0%, 33.7%, and 0.047%, respectively. Figure 49 (column A) shows the temporal changes in the volume % methane measured in the headspace gas of ground water collected from the impacted domestic well sites. Maximum methane gas concentrations were observed in ground water collected from RBDW06 (67.4%), RBDW09 (57.9%), and RBDW10 (68.4%) during round 1 of this case study, and during round 2 at RBDW08 (49.3%). Concentrations decreased during subsequent sampling rounds, and the % volume obtained during the last sampling event (round 4) was less than the maximum concentration obtained at any given sample location. The reduction of CH_4 measured in the headspace of ground water obtained from the impacted domestic well locations is attributed to the microbial consumption of methane (Whiticar, 1999).

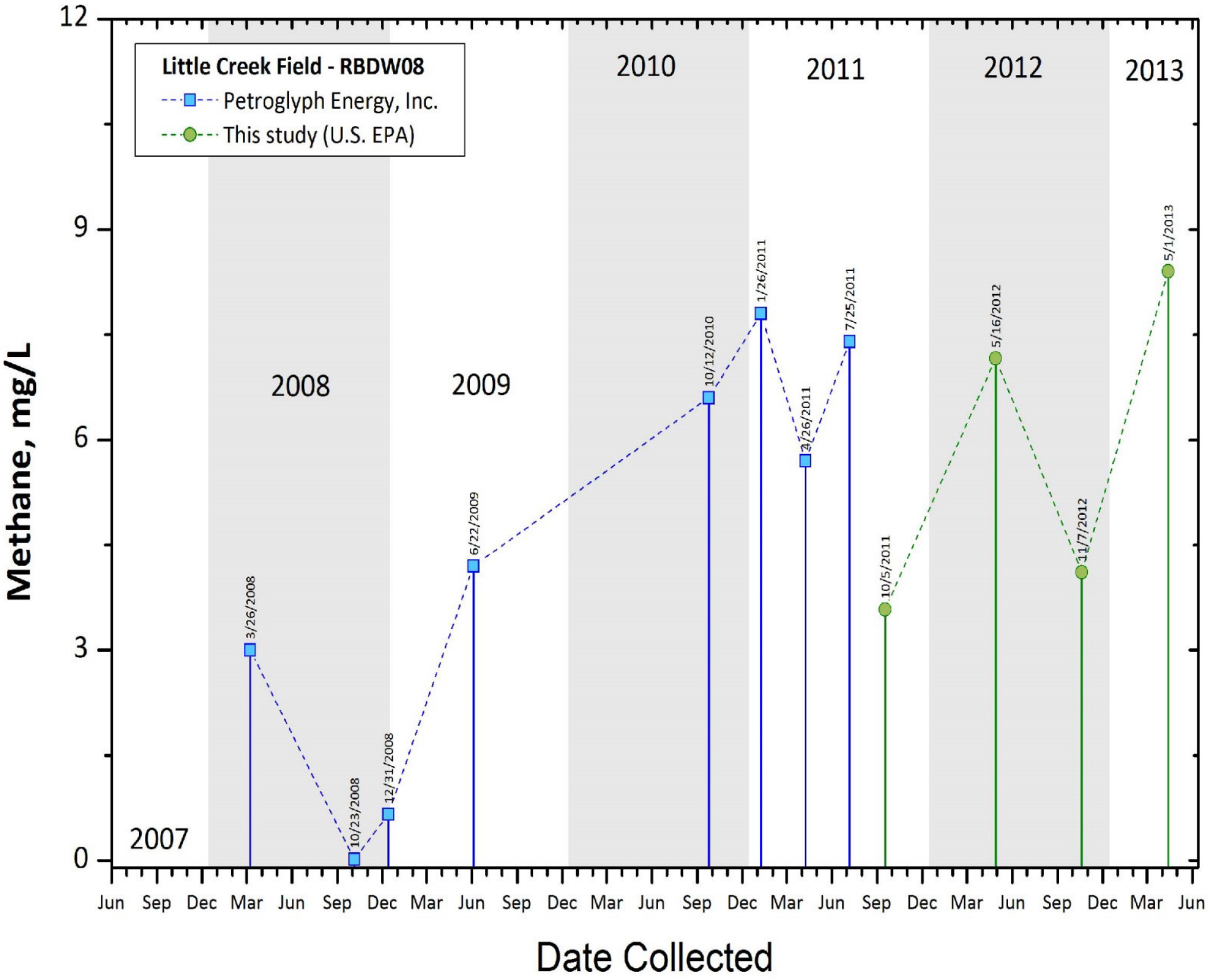


Figure 46. Temporal trends in dissolved methane concentration (mg/L) in ground water samples collected from RBDW08. Historical data, collected by Petroglyph Energy, Inc., are shown in blue (Norwest Corporation, 2011a); data collected during this case study are green.

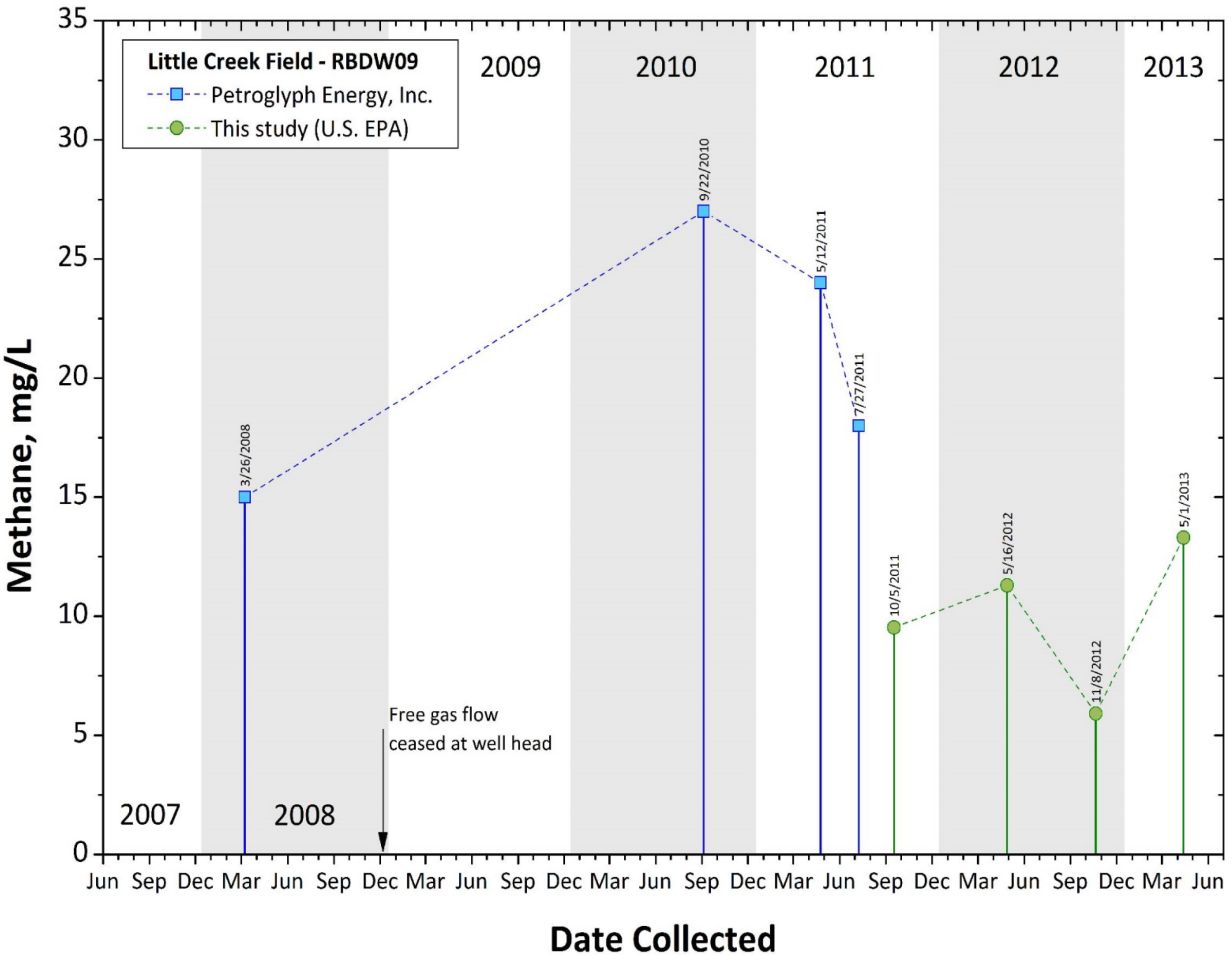


Figure 47. Temporal trends in dissolved methane concentration (mg/L) in ground water samples collected from RBDW09. Historical data, collected by Petroglyph Energy, Inc., are shown in blue (Norwest Corporation, 2011a); data collected during this case study are green. The date where free gas flow ceased at the well head is indicated with an arrow (Norwest Corporation, 2011b).

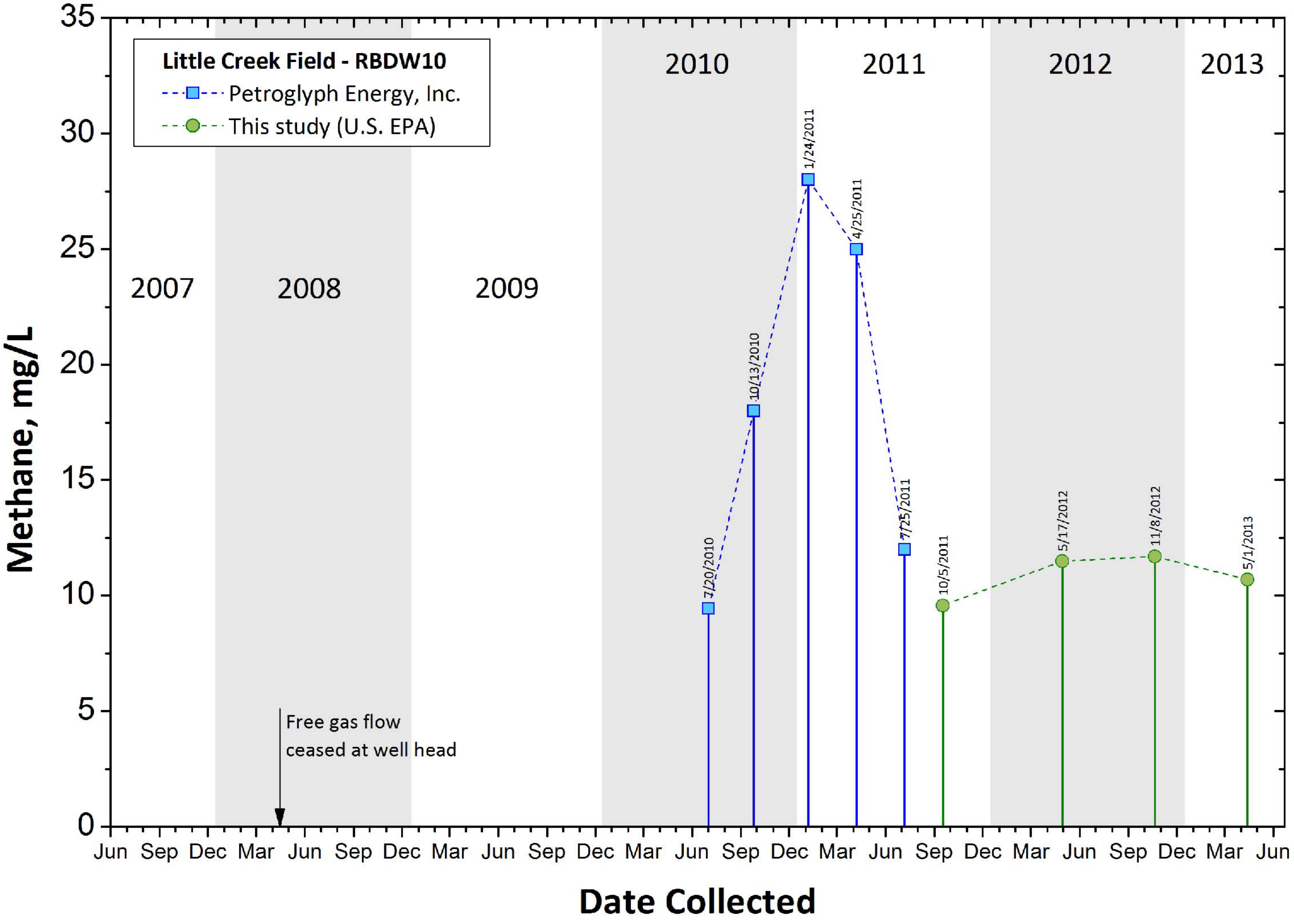


Figure 48. Temporal trends in dissolved methane concentration (mg/L) in ground water samples collected from RBDW10. Historical data, collected by Petroglyph Energy, Inc., are shown in blue (Norwest Corporation, 2011a); data collected during this case study are green. The date where free gas flow ceased at the well head is indicated with an arrow (Norwest Corporation, 2011b).

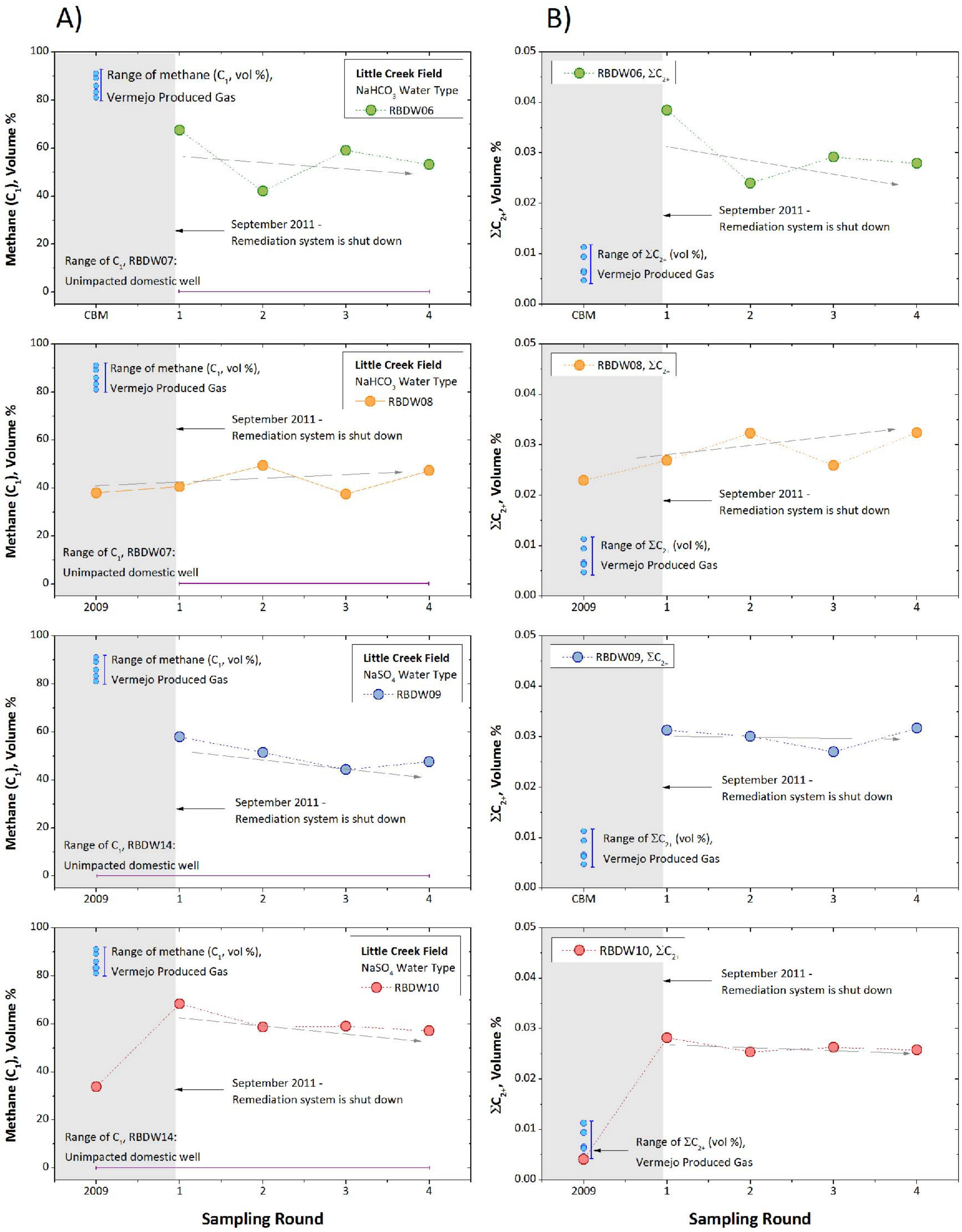


Figure 49. Temporal trends in gas composition (C_1, column A; ΣC_{2+}, column B) for selected locations within the Little Creek Field study area (Huerfano County, CO). Additional data sources: Norwest Corporation, 2009; ESN Rocky Mountain, 2003; Norwest Corporation, 2011c.

Gas and molecular composition analyses of ground water collected from domestic wells in the Little Creek Field area during this case study indicated the presence of higher chained hydrocarbons (>C_3), which are uncharacteristic of Poison Canyon ground water (i.e., RBDW07, RBDW14), and Vermejo-produced water (see "Dissolved Gases" section for more information). Further, these higher chain hydrocarbons were detected only in wells impacted by the methane release; these data are shown in Figure 49 (column B). The appearance of higher molecular-weight (C_{2+}) gaseous alkanes suggests that gaseous hydrocarbons are being produced via biologically mediated pathways (Hunt et al., 1980; Vogel et al., 1982; Oremland et al., 1988; Hinrichs et al., 2006; Xie et al., 2013 and references therein). Significant concentrations of dissolved ethane, propane, and butanes have been detected in a variety of anaerobic aquatic environments that contain active methanogenic flora, and there is evidence that bacterial production of C_{2+} alkanes accompanies methanogenic activity within these environments (Oremland, 1988). Furthermore, the addition of alkanes (>C_1) stimulates sulfate reduction and rates of C_2–C_4 consumption, for example, are comparable to methane consumption, though their stoichiometric impacts on the sulfate pool vary (e.g., Kniemeyer et al., 2007; Adams et al., 2013; Bose et al., 2013).

9.1.3. Distinct Patterns of $\delta^{13}C$ in Dissolved Inorganic Carbon and Methane

The carbon and hydrogen isotopes of methane, in conjunction with coexisting isotope information for CO_2 and H_2O, provide tracers of the processes of bacterial formation and consumption of methane (Whiticar, 1999). Methane oxidation is associated with a carbon isotope effect that results in the enrichment of ^{13}C in the remaining methane (Whiticar and Faber, 1986): microorganisms preferentially consume $^{12}CH_4$, resulting in ^{13}C depletion in the CO_2 produced and ^{13}C enrichment in the residual methane (Grossman et al., 2002). The net reaction for the oxidation of methane to CO_2 is shown in Eqn. 17, where:

$$CH_4 + 2H_2O \Rightarrow CO_2 + 4H_2 \quad (17)$$

Figure 50A shows a methane C and H diagram, with genetic zonation as indicated in Jackson et al. (2013), for ground water collected from the four impacted domestic wells in the Little Creek Field study area; ground water collected from domestic wells RBDW07 and RBDW14 did not contain a sufficient concentration of methane to obtain C and H isotope ratios. The slope of the oxidation trend is 7.5, indicating that every permil (1‰) change in the $\delta^{13}C_{CH4}$ results in a change of approximately 7.5‰ in the $\delta^{2}H_{CH4}$ value ($R^2 = 0.89$).

The greatest change in $\delta^{13}C_{CH4}$ (i.e., $\delta^{13}C_{CH4,\,ini}$ - $\delta^{13}C_{CH4,\,fnl}$), 4.8‰, occurred at well RBDW09, followed by RBDW08 (4.6‰), and RBDW10 (1.4‰); these three wells were located within the hydraulic barrier system. At location RBDW06, the carbon isotopic composition obtained during round 4 (-49‰) was slightly depleted relative to the first isotope measurement obtained during round 1 of this case study (-48.7‰). This well, located south of the hydraulic barrier, is also situated at a higher elevation than the other wells in this area. Lower rates of methane oxidation at this location could be due to continuing, low levels of methane migration, coupled with lower levels of available sulfate for sulfate-reduction; the water type at this location is sodium-bicarbonate.

The stable carbon isotopic compositions of methane and DIC (ΣCO_2) are determined by the various environmental pathways of biogenic methane formation and consumption (Botz et al., 1996; Cheung et al., 2010). Carbon isotopic compositions of DIC ($\delta^{13}C_{DIC}$) in ground water collected from domestic and monitoring wells in the Little Creek Field study area ranged from -40.9 to -12.0‰ and had a mean value

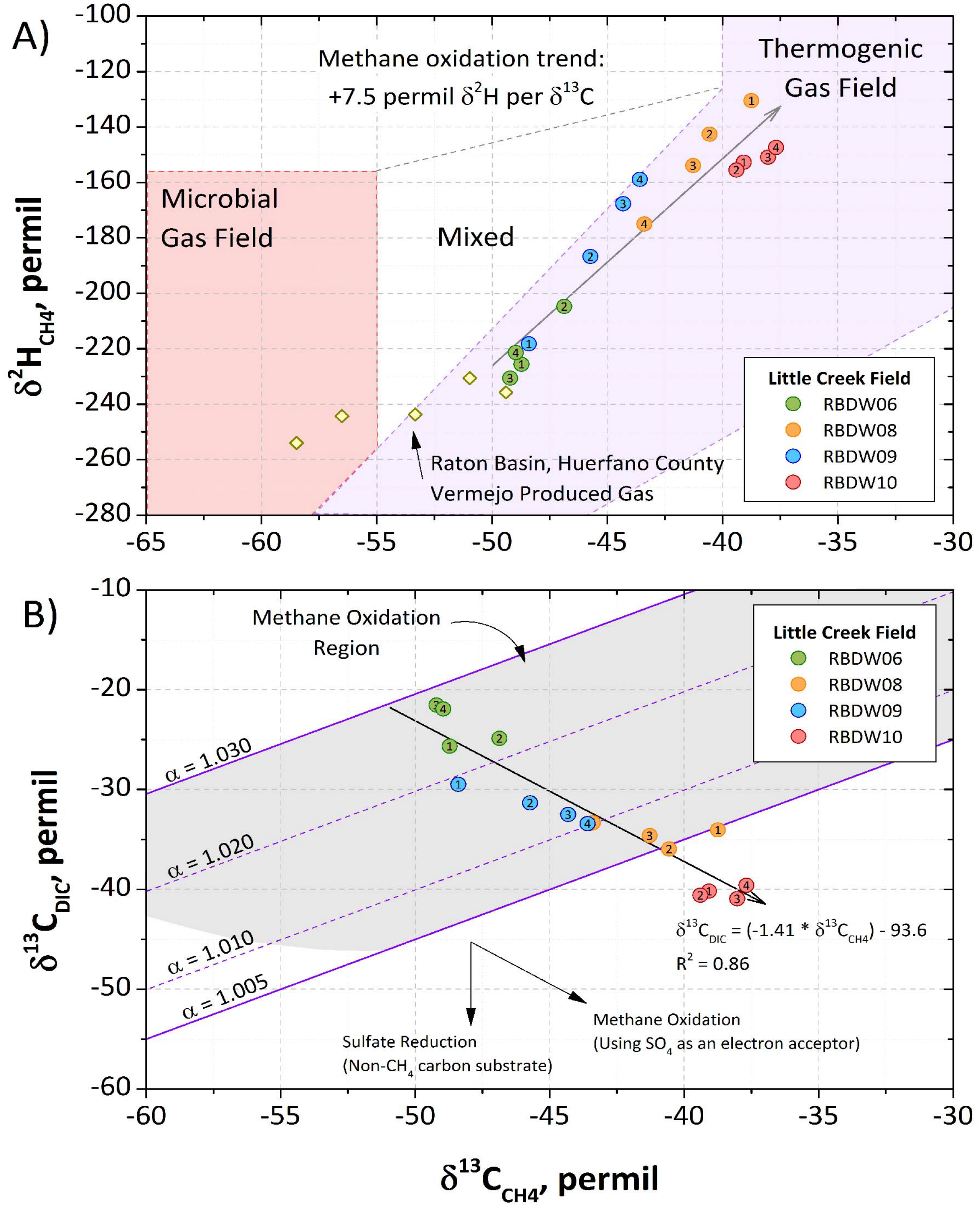


Figure 50. A) Characterization of dissolved methane sources in the Little Creek Field study area (Huerfano County, CO), using stable C and H ratios of methane; historical isotope data were reported by ESN Rocky Mountain (2003). Genetic zonation is after Jackson et al. (2013). B) Methane oxidation trends are shown using the relationship between the stable carbon isotopes of methane ($\delta^{13}C_{CH4}$) and dissolved inorganic carbon ($\delta^{13}C_{DIC}$). Lines represent calculated isotopic fractionation factors of 1.005, 1.01, 1.02, and 1.03, which correspond to $\Delta^{13}C_{DIC-CH4}$ values of 5, 10, 20, and 30‰, respectively; values >1 indicate heavy isotope enrichment in the residual methane. Numbers located inside of, or next to, symbols indicate the sampling round.

of -27.3 ± 10.3‰ (n=25). The highest $\delta^{13}C_{DIC}$ values were obtained from ground water collected at domestic wells RBDW14 (mean = -12.3 ± 0.3‰) and RBDW07 (mean = -13.8 ± 0.2‰); these wells were unaffected by the release of methane gas from the Vermejo Formation coalbed production zone into the shallower Poison Canyon aquifer system. The lowest $\delta^{13}C_{DIC}$ values were measured in ground water collected from RBDW10 (mean = -40.3 ± 0.6‰); this is not surprising given the large enrichment in $\delta^{13}C_{CH4}$, relative to the other well locations, attributed to methane oxidation.

There is a distinct relationship between methane and the coexisting carbon dioxide in the biogenic methane oxidation system: methane oxidation causes a clear, decrease in carbon isotope separation, i.e., $\delta^{13}C_{CO2}$ - $\delta^{13}C_{CH4}$ (Whiticar, 1999). Fractionation factors are usually compared between CO_2 and CH_4, and written as $\alpha^{13}C_{CO2\text{-}CH4} = (\delta^{13}C_{CO2} + 1000)/(\delta^{13}C_{CH4} + 1000)$. The carbon isotope fractionation factors ($\alpha^{13}C_{CO2\text{-}CH4}$) associated with methane oxidation range from 1.0052 to 1.0313 (Whiticar and Faber, 1986), where values >1 indicate heavy isotope enrichment in the residual methane. A carbon isotope plot of $\delta^{13}C_{CH4}$ versus $\delta^{13}C_{DIC}$ for ground water collected from impacted domestic wells is shown in Figure 50B. This figure includes lines representing calculated isotopic fractionation factors of 1.005, 1.01, 1.02, and 1.03, which correspond to $\Delta^{13}C(DIC\text{-}CH_4)$ values of 5, 10, 20, and 30‰, respectively. Calculated fractionation factors ($\alpha^{13}C_{DIC\text{-}CH4}$) for the impacted domestic well locations ranged from 0.997 to 1.03. The mean fractionation factor values for RBDW06 (mean = 1.025 ± 0.003), RBDW08 (mean = 1.006 ± 0.003), and RBDW09 (mean = 1.014 ± 0.004) fell within the range associated with methane oxidation (Whiticar and Faber, 1986); however, the fractionation factor calculated for RBDW10 did not (mean = 0.998 ± 0.0008). The low $\alpha^{13}C_{DIC\text{-}CH4}$ result and depleted $\delta^{13}C_{DIC}$ values (mean = -40.3‰, n = 4) measured in ground water sampled at RBDW10 are likely due to sulfate reduction coupled with methane oxidation. Sulfate reduction will decrease the $\delta^{13}C_{DIC}$ without affecting the $\delta^{13}C_{CH4}$, whereas methane oxidation will decrease the $\delta^{13}C_{DIC}$ and increase the $\delta^{13}C_{CH4}$ (Schlegel et al., 2011; Coleman et al., 1981).

While hydrogen isotope compositions of the $H_2O\text{-}CH_4$ system provide a constraint on methane production, independent of the carbon isotope system (Schoell, 1980; Whiticar et al., 1986; Martini et al., 1998), few studies have examined hydrogen isotope fractionation during methane oxidation. As with carbon, methane-oxidizing bacteria preferentially consume the lighter isotope (^1H), resulting in ^2H enrichment in the residual methane; further, the change in δ^2H_{CH4} that has been oxidized by bacteria is three to 14 times greater than the change observed in the $\delta^{13}C_{CH4}$ value (Liptay et al., 1998). Fractionation factors between δ^2H_{CH4} and δ^2H_{H2O}, where $\alpha^2H_{H2O\text{-}CH4} = (\delta^2H_{H2O} + 1000)/(\delta^2H_{CH4} + 1000)$, were determined for impacted domestic well locations sampled during this case study; mean values ranged from 1.055 to 1.138, which fell within the range of experimentally determined results (experimental range = 1.050 to 1.325; Coleman et al., 1981; Happell et al., 1994). Hydrogen isotope fractionation was greatest in water collected from domestic well RBDW06 ($\alpha^2H_{H2O\text{-}CH4\ avg}$ = 1.138), with little variability between sampling events (range = 0.030). The mean calculated hydrogen fractionation factors ($\alpha^2H_{H2O\text{-}CH4\ avg}$) for RBDW08, RBDW09, and RBDW10 were 1.060, 1.091, and 1.055, respectively. There was little variability in the hydrogen isotope composition of water and methane during rounds 1 through 4 at RBDW10 (range = 0.010); however, $\alpha^2H_{H2O\text{-}CH4}$ increased from 1.041 (round 1) to 1.086 (round 4) at RBDW08, and decreased from 1.131 (round 1) to 1.064 (round 4) at RBDW09. Fluctuations in $\alpha^2H_{H2O\text{-}CH4}$ at RBDW08 and RBDW09 mimic temporal trends observed for $\alpha^{13}C_{DIC\text{-}CH4}$ and may indicate changes in the pathway of methane oxidation, possibly caused by the accumulation or depletion of some other component in the system (Coleman et al., 1981; Bose et al., 2013).

9.1.4. Systematic Shift in Sulfur and Oxygen Isotope Ratios of SO_4–Microbial Sulfate Reduction

As noted previously in this report, sulfate isotope data for dissolved sulfate in ground water from the Little Creek Field study area showed a wide range of $\delta^{34}S$ values, from -2.2 to 39.5‰. In addition, the positive correlation of $\delta^{34}S_{SO4}$ and $\delta^{18}O_{SO4}$, enrichment of ^{34}S in sulfate, the ratio of ^{18}O to ^{34}S of ~1:5, and the presence of dissolved sulfide in ground water of this area are all evidence of microbial sulfate reduction. The sulfur isotopic composition of dissolved sulfide ranged from -17.2 to -6.0‰, and the $\delta^{34}S$ of coexisting dissolved sulfate ranged from -3.4 to 11.1‰. The isotopic separation between coexisting sulfate and sulfide, $\delta^{34}S_{SO4}$-$\delta^{34}S_{H2S}$, ranged from 11.9 to 48.5‰ and shows a marked trend with the concentration of sulfate (see Figure 51A). Assuming a closed system with uniform concentration and isotopic composition, the isotopic separation between dissolved sulfide and dissolved sulfate can be modeled using the Rayleigh isotope fractionation equation:

$$\delta^{34}S_{SO4}-\delta^{34}S_{H2S} = \varepsilon \ln (C/C_0) \qquad (18)$$

where ε is the instantaneous fractionation factor, C_0 is the initial sulfate concentration, and C is the residual sulfate concentration. Fractionation factors ranging from -20 to -40‰ are plotted in Figure 51A. An initial concentration value (C_0) of 350 mg/L, the sulfate concentration at location RBDW14, is assumed to represent unimpacted ground water containing no methane or dissolved sulfide. This observed range of isotopic separation is indicative of microbial sulfate reduction and/or possibly of bacterial disproportionation of intermediate sulfur compounds such as elemental sulfur and thiosulfate (e.g., Habicht et al., 1998; Canfield, 2001; Sørensen and Canfield, 2004). Recent work indicates that zero-valent sulfur is an important intermediate in anaerobic methane oxidation in marine systems (Milucka et al., 2012).

Dissolved sulfide concentrations were elevated at locations RBDW06, RBDW08, RBDW09, and RBDW10, and were as high as 36.6 mg/L (J) at location RBDW10 during round 1 (approximately 1 millimole [mM] sulfide). Dissolved sulfide often does not persist in systems with active sulfate reduction because it tends to react with iron minerals and precipitate as iron sulfide (FeS, e.g., Spence et al. 2005; Van Stempvoort et al., 2005). The build-up of significant dissolved sulfide concentrations at some locations of this study suggests a deficiency of reactive iron in the aquifer solids and/or elevated rates of sulfide production that exceed the intrinsic capacity of the system to remove sulfide via mineral precipitation. Precipitation of FeS is not expected to produce an isotope effect of fractionation, so the dissolved sulfide isotopic composition should be a reliable indicator of the instantaneous isotope fractionation associated with the microbially mediated reduction of sulfate to sulfide.

Further evidence that bacterial sulfate reduction is occurring within a region of the Little Creek Field aquifer is linked to oxidation of organic carbon, as revealed by carbon isotope data. Figure 51B shows that well waters that contained dissolved sulfate also had ^{13}C-depleted DIC ($\delta^{13}C_{DIC}$). Similar to the findings of Van Stempvoort et al. (2005; see also Grossman et al., 2002), this correlation suggests a direct link between bacterial reduction of sulfate and the production of DIC by the oxidation of ^{13}C-depleted organic carbon. Note that the ground water compositions that showed the most significant depletion of $^{13}C_{DIC}$ were sodium-sulfate type, which had $\delta^{13}C_{DIC}$ values that were up to 30‰ more negative than the $\delta^{13}C_{DIC}$ value at location RBDW14, a location that displayed sodium-sulfate type composition but no significant methane or dissolved sulfide (see Figure 51B). In contrast, location

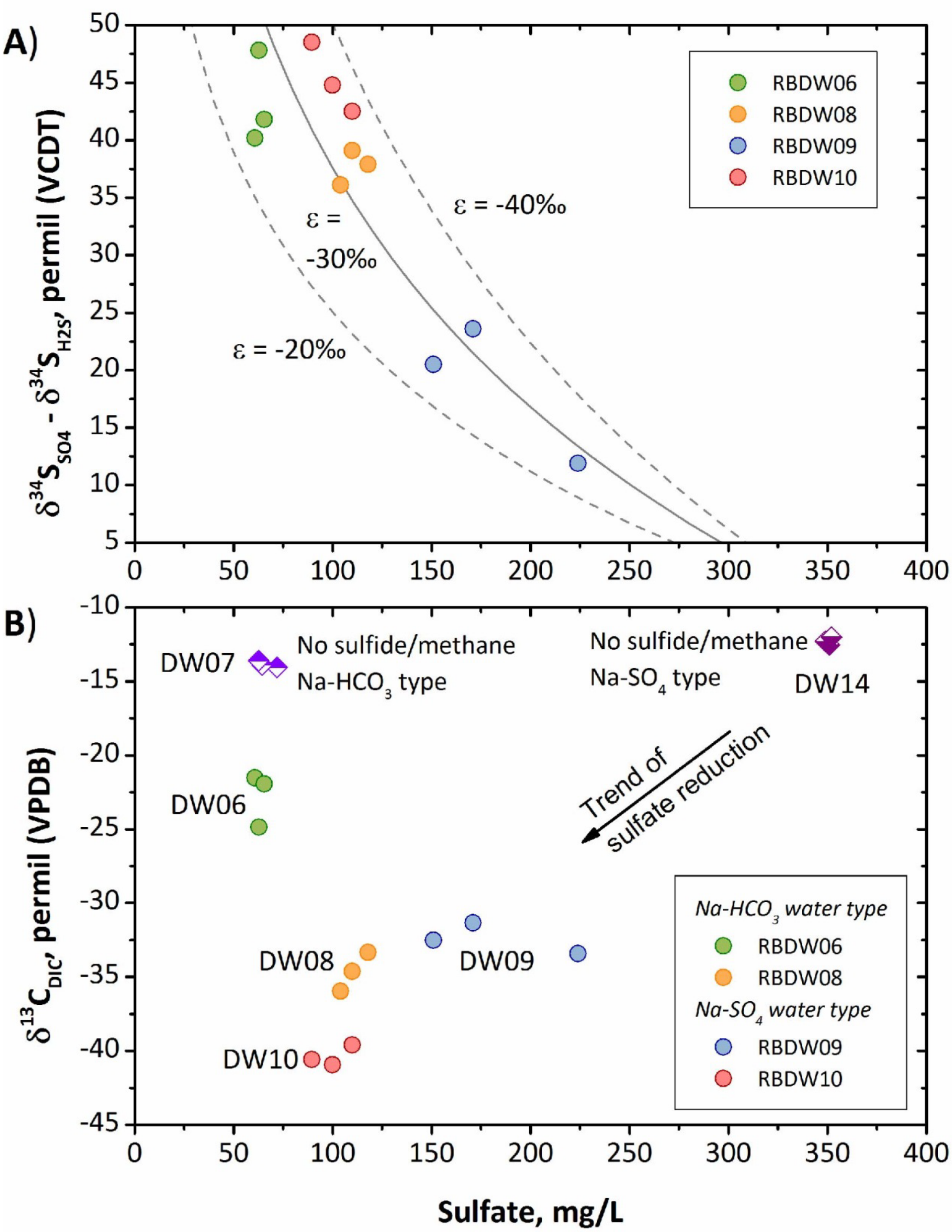


Figure 51. A) Sulfate-sulfide fractionation ($\delta^{34}S_{SO4}$-$\delta^{34}S_{H2S}$) versus sulfate concentration (mg/L). Lines represent modeled (Eqn. 18) fractionation factor values, ranging from -20 to -40‰, where ε is the fractionation factor between dissolved sulfate ($\delta^{34}S_{SO4}$) and dissolved sulfide ($\delta^{34}S_{H2S}$). B) The isotopic composition of DIC ($\delta^{13}C_{DIC}$) versus sulfate concentration. Background values for RBDW07 (sodium-bicarbonate type) and RBDW14 (sodium-sulfate type), representative of an impact-free Poison Canyon aquifer, are provided for comparative purposes.

RBDW06 showed consistent sodium-bicarbonate type composition, and $\delta^{13}C_{DIC}$ values that were consistently less ^{13}C-depleted compared to locations with sodium-sulfate type compositions (i.e., RBDW09 and RBDW10). Therefore, the addition of mineralized carbon at location RBDW06 has not reduced the $\delta^{13}C_{DIC}$ value to the same extent observed at locations RBDW08, RBDW09, and RBDW10. Location RBDW08 has likely transitioned to sodium-bicarbonate from sodium-sulfate type composition due to consumption of sulfate and production of bicarbonate.

9.1.5. Little Creek Field: Impacts

It was expected that this case study would provide a context for other regions that have experienced gas migration and provide new information about the processes and rates of methane attenuation in a drinking water aquifer after remediation and abatement of the source of methane. These results are unique in showing system behavior after a methane release and provide information about a biogeochemical response to methane intrusion.

Geochemical and isotopic compositional trends reflect sulfate-dependent anaerobic methane oxidation processes, resulting in the consumption of dissolved methane and sulfate and production of dissolved sulfide and bicarbonate. The appearance of higher molecular-weight gaseous alkanes (C_{2+}), enrichment of $\delta^{13}C_{DIC}$ coupled with $\delta^{13}C_{CH4}$ depletion, and systematic shifts in the sulfur and oxygen isotope ratios of sulfate are consistent with anaerobic methane oxidation via sulfate reduction. Furthermore, temporal trends in these data show that oxidation rates and mechanisms differ by location. The high $\delta^{34}S$ of sulfate, and low(er) sulfate concentrations in domestic wells RBDW06 and RBDW08 are consistent with microbial sulfate reduction; however, the large carbon and hydrogen fractionation factors ($\alpha^{13}C_{CO2\text{-}CH4}$ and $\alpha^{2}H_{H2O\text{-}CH4}$, respectively) suggest that methane oxidation rates are low and/or a continuous supply of methane has overwhelmed methane-oxidizing bacteria. There was little variability in the $\delta^{13}C_{CH4}$ at RBDW06 (mean = -48.4 ± 1.07‰, n = 4), and this isotopic composition is similar to the isotopic composition of Vermejo produced gas (range = -51.0 to -48.2‰, n = 6; Norwest Questa, 2007b; Norwest Corporation, 2011a). The $\delta^{13}C_{CH4}$ of ground water collected from RBDW08 is becoming depleted over time (-38.75 to -43.39‰, round 1 to round 4, respectively) approaching the $\delta^{13}C_{CH4}$ of Vermejo CBM, while $\delta^{13}C_{DIC}$ is becoming enriched (-34.05 to -33.33‰, round 1 to round 4, respectively) relative to the measured $\delta^{13}C_{CH4}$ values for this location. The strong correlation between $\delta^{13}C_{CH4}$ and sulfate concentration ($R^2 = 0.91$), large $\delta^{34}S_{SO4}$ values, and small carbon and hydrogen fractionation factors in ground water collected from RBDW10 demonstrate that significant methane oxidation via sulfate reduction has occurred at this location. The occurrence of a higher sulfate concentration, lower $\delta^{34}S_{SO4}$, and enriched $\delta^{13}C_{CH4}$ value at RBDW09 may indicate that sulfate reducers are not dominant at this location, and that methane may be oxidized by additional pathways. Additionally, the extent to which simultaneous production and anaerobic oxidation of longer chain alkanes (C_{2+}) affects sulfate reduction rates may have significant, localized (i.e., site-specific) impacts; however, more data are needed to evaluate this relationship (Adams et al., 2013; Bose et al., 2013 and references therein). It is possible that alkane degradation is a significant process that co-occurs with AOM, and may compete for a common oxidant, such as sulfate.

The purpose of the recovery wells was to create a hydraulic gradient for the flow of ground water and associated methane toward the pumping wells (Norwest Applied Hydrology, 2008), and this differential could account for the immediate decrease in free-flowing gas. However, the elimination of free-flowing methane at the well head is not a successful indicator of subsurface conditions: at two domestic well locations (RBDW09, RBDW10), although methane was no longer measurably venting from the well head (gas flow = 0 Mcfd, early 2008), dissolved methane concentrations increased to potentially harmful levels (i.e., 1.1 mg/L). Increasing levels of dissolved methane during the period when methane was being removed from the system suggests that methane continued to migrate along pathways from the lower Vermejo Formation into the Poison Canyon Formation. The initial, explosive gas venting incident occurred south of the mitigation area, at domestic well RBDW06, and subsequent incidents of venting methane trended northward, from this location, which is in the same direction as the hydraulic gradient from the Spanish Peaks. Still, the well head at this location (RBDW06) and at the location where the second incident was reported ("Well C," not sampled as part of this study and located 2,000 feet to the north of location RBDW06) continued to vent methane (into late 2010), long after gas flow had ceased at wells located within the hydraulic barrier (see Figure 52). Cumulative gas production of up to 5,000 Mcfd was reported in several domestic water and CBM wells located *east* of RBDW06 (Norwest Questa, 2007b) and southeast of the hydraulic barrier location—further evidence that methane migration was occurring on a regional level, instead of locally.

The decrease in dissolved methane concentrations in late 2010/early 2011 was likely due to a combination of methane removal via the remediation system and natural attenuation. Temporal trends observed in data collected after September 2011, when the Petroglyph remediation program ended and shortly before sampling began as part of this case study, are inferred to represent methane attenuation via biochemical processes. While these results are unique in showing system behavior after a methane release—and provide information about biogeochemical response to methane intrusion, attenuation rates, and capacity—the persistence of AOM within this area is questionable in the long term due to a potential "exhaustion" of terminal electron acceptor(s) and a lack of electron acceptor "replenishment" given the slow rates of ground water movement and recharge within the study area. Ongoing reducing conditions, coupled with decreasing concentrations of inorganic electron acceptors often linked to AMO and little geochemical and atmospheric input, may impose thermodynamic constraints on methane oxidation rates that could significantly impact the long-term sustainability of natural attenuation within the Little Creek Field area (Smemo and Yavitt, 2007).

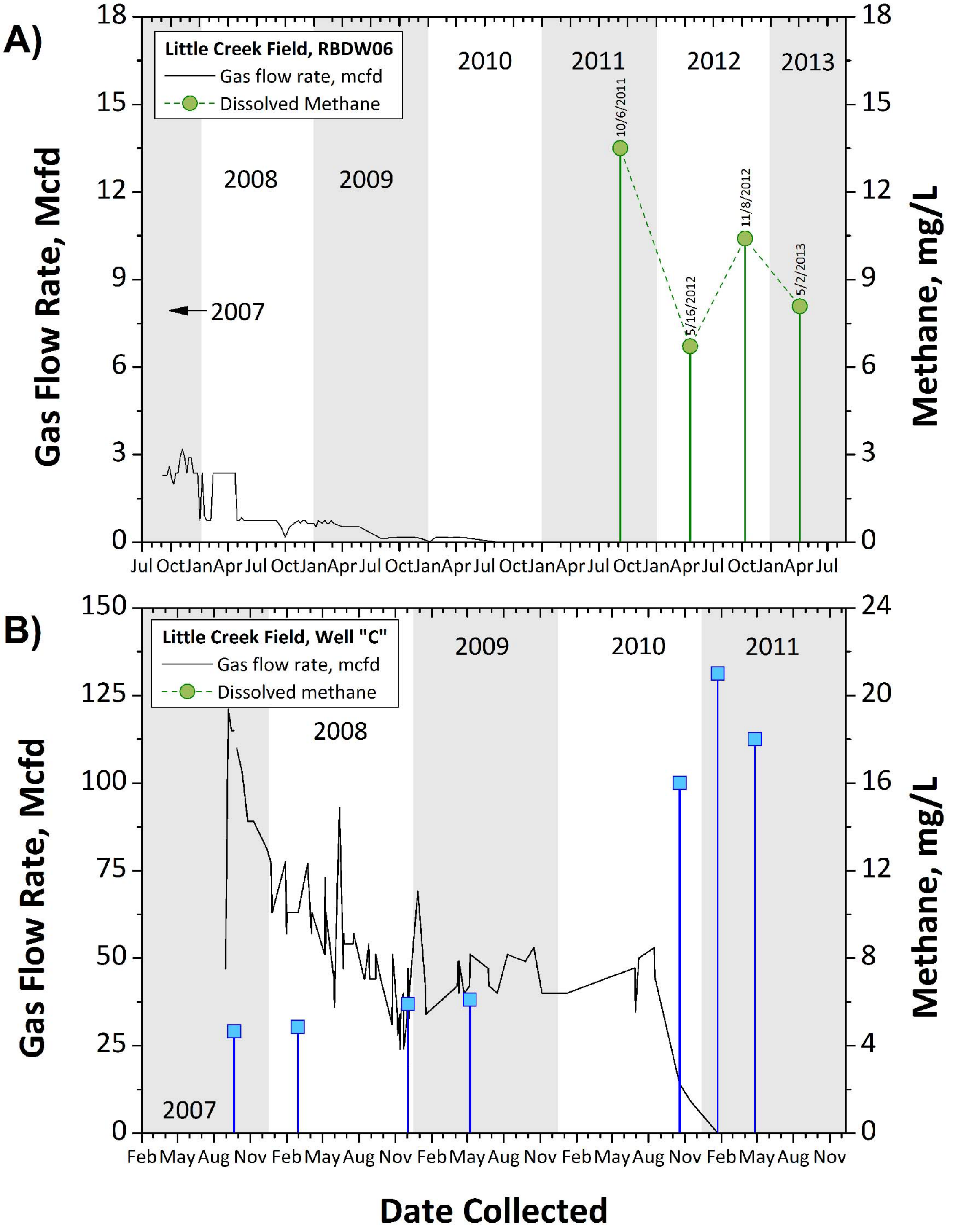


Figure 52. Temporal trends in gas flow measurements and dissolved methane concentrations (mg/L) at domestic well locations A) RBDW06 and B) Well “C”, located within the Little Creek Field study area (Huerfano County, CO). Historical dissolved methane data, collected by Petroglyph Energy, Inc., are shown in blue (Norwest Corporation, 2011b); data collected during this case study are green.

10. Summary of Case Study Results

The Colorado portion of the Raton Basin was selected for a retrospective case study to address reported instances of decreased water quality in domestic wells related to issues such as high dissolved methane and dissolved sulfide concentrations, appearance, odor, and taste. CBM development and production in the Raton Basin, located in southern Colorado and northern New Mexico, has increased over the past decade. Annual production of methane from coal beds in Las Animas and Huerfano counties averaged about 103 Bcf during 2007–2013, or about 20% of Colorado's total natural gas production. Coal beds in the Raton Formation (Late Cretaceous to Tertiary) and the Vermejo Formation (Cretaceous) are the primary sources of methane in the Raton Basin. Gas production from these coal beds depends upon hydraulic fracturing technologies to enhance and create fracture porosity, permeability, and gas flow. This study was prompted by concerns about potential impacts on drinking water resources, such as: (i) potential interactions between CBM-produced water and shallow ground water via fluid migration, spills, and/or infiltration; (ii) potential for migration of chemicals used in hydraulic fracturing formulations into shallow ground water; (iii) potential gas migration from hydraulically fractured zones in the gas-producing coal beds into shallow ground water aquifers; and (iv) secondary biogeochemical affects related to the migration and reaction of methane in shallow aquifers used for drinking water.

The sampling locations selected by EPA for this case study focused on three areas: the Little Creek Field area in south-central Huerfano County, the North Fork Ranch area in western Las Animas County, and the Arrowhead Ranchettes area, also located in western Las Animas County. Water quality samples were collected from a maximum of 14 domestic wells, five monitoring wells, three surface water locations, and three production wells in Las Animas and Huerfano counties during four rounds in October 2011, May 2012, November 2012, and April/May 2013. The water samples collected were analyzed for geochemical parameters (temperature, pH, SPC, ORP, dissolved oxygen, and turbidity), major cations and anions, nutrients, trace metals, VOCs, SVOCs, DRO, GRO, glycol ethers, low-molecular-weight acids, strontium isotope ratios, and selected stable isotopes ($\delta^{18}O_{H2O}$, $\delta^{2}H_{H2O}$, $\delta^{13}C_{DIC}$, $\delta^{13}C_{CH4}$, $\delta^{2}H_{CH4}$, $\delta^{18}O_{SO4}$, $\delta^{34}S_{SO4}$, and $\delta^{34}S_{H2S}$). The data collected for this case study include a range of compounds and chemical indicators that are potentially linked to hydraulic fracturing activities and aid in providing a conceptual framework for evaluating potential impacts. In order to help determine whether hydraulic fracturing or processes related to hydraulic fracturing caused or contributed to alleged impacts on water quality, environmental record searches were conducted to identify other potential contaminant sources. Candidate causes of water quality impairment included potential sources that could contribute to any detected levels of surface and/or ground water contamination. For this case study, candidate causes were categorized as follows: industrial/commercial land use, historical land use (e.g., farming and mining), current drilling processes/practices, historical drilling practices, and naturally occurring sources. Table 21 summarizes the potential ground water and surface water impacts identified during this study.

In contrast to shale gas and most conventional oil and gas development, recovery of CBM typically occurs at relatively shallow depths, sometimes within or in close proximity to drinking water aquifers (Watts, 2006b). Within the areas examined for this case study, the vertical separation between the gas-producing zones and the domestic wells sampled ranged from about 1,250 to 2,360 feet. The evaluation of potential impacts from unconventional CBM gas development included an analysis of CBM water geochemistry in relation to shallow ground water geochemistry, analysis of historical ground water quality in Las Animas and Huerfano counties, consideration of the chemicals used in hydraulic fracturing, and analysis of dissolved gases and their isotopic compositions. Historical water quality data were obtained from literature sources and state and federal water quality databases. In some cases, these historical data were used to examine water quality trends in the Raton Basin aquifers before CBM development. Water co-produced with natural gas in the Raton Basin has a distinct geochemical signature: sodium-bicarbonate type water with moderate concentrations of TDS; low sulfate, calcium, and magnesium concentrations; variable chloride concentration; enriched $^{13}C_{DIC}$ values; low ORP values; and elevated concentrations of dissolved methane and ferrous iron. This geochemical pattern is generally considered to be the result of biochemical sulfate reduction, consequent enrichment of bicarbonate, and precipitation of calcium carbonate, magnesium carbonate, and/or gypsum. The gas composition is also characteristically dry, with a molar $[CH_4/C_2H_6]$ ratio >300. Constituents and parameters in CBM water that sometimes exceed standards for drinking, livestock, and irrigation water applications include TDS, SAR, pH, iron, and fluoride. The production wells sampled in this study had TDS values generally >500 mg/L; mean fluoride concentrations that ranged from 2.6 to 3.6 mg/L; pH that ranged from 8.0 to 8.5; and SAR values that ranged from 33 to 66 $(\text{mequiv/L})^{½}$. High SAR values are a potential concern for water discharged at the surface because Na^+-enriched water in soil can cause cation exchange by replacing Ca^{2+} with Na^+, which impacts properties of clay minerals in soil. Surface-discharged CBM water could potentially infiltrate and impact ground water quality, particularly in areas where flowing streams lose water to ground water. The possibility exists that wells used for drinking water could be impacted in such hydrologically vulnerable settings, although no direct evidence of this process was documented in this study.

Table 21. Potential ground water and surface water impacts identified during the Raton Basin, CO, retrospective case study.

Impacted Parameters	Study Area	Locations	Sample Type	Description	Potential Sources
Dissolved Methane	North Fork Ranch	All	Ground water and surface water	0.003 to 20.9 mg/L, including all well types and surface water. Widely distributed; multiple isotopic signatures	Thermogenic and biogenic processes; gas migration from coal beds
	Arrowhead Ranchettes	All			
	Little Creek Field	All			
Tert-Butyl Alcohol	North Fork Ranch	RBDW03 RBMW02 RBMW03 RBPW01	Ground water	6.9 to 1,310 µg/L; detected in domestic wells, monitoring wells, and a production well	Microbial; anthropogenic
	Arrowhead Ranchettes	RBDW11			
	Little Creek Field	RBDW15			
Volatile Organic Compounds	North Fork Ranch	RBDW02 RBDW03 RBDW05 RBMW02 RBMW03 RBPW01 RBPW02 RBPW03 RBSW01 RBSW03	Ground water and surface water	BTEX compounds, chloroform, petroleum hydrocarbons; low concentration levels, below MCLs	Coal-water interactions; well disinfection; surface discharge; well components
	Arrowhead Ranchettes	RBDW11			
	Little Creek Field	RBDW06 RBDW08 RBDW09 RBDW10 RBDW14 RBDW15			

Table 21. Potential ground water and surface water impacts identified during the Raton Basin, CO, retrospective case study.

Impacted Parameters	Study Area	Locations	Sample Type	Description	Potential Sources
Semivolatile Organic Compounds	North Fork Ranch	RBDW01 RBDW02 RBDW04 RBDW05 RBDW13 RBMW01 RBMW03 RBPW01 RBPW03 RBSW01	Ground water and surface water	Phthalates, adipates, phenol, squalene; MCL exceedances for bis-(2-ethylhexyl) phthalate	Coal-water interactions; well components; lab contamination
	Arrowhead Ranchettes	All			
	Little Creek Field	All			
Fluoride	North Fork Ranch	RBMW03 RBPW01 RBSW03	Ground water and surface water	Widely distributed; locations noted with fluoride levels exceeding the primary MCL (4 mg/L)	Dissolution of aquifer solids (fluorite)
	Arrowhead Ranchettes	none			
	Little Creek Field	RBDW08 RBDW09 RBDW10 RBMW04 RBMW05			
Sulfate	North Fork Ranch	none	Ground water and surface water	Widely distributed; one location exceeded the secondary MCL (250 mg/L)	Dissolution of sulfates and/or sulfides
	Arrowhead Ranchettes	none			
	Little Creek Field	RBDW14			
Iron and Manganese	North Fork Ranch	RBDW02 RBDW13 RBMW01 RBPW03 RBSW02	Ground water and surface water	Regionally variable; linked to moderate and low oxidation-reduction potential environments	Dissolution of aquifer solids (carbonates, sulfides)
	Arrowhead Ranchettes	RBDW11			
	Little Creek Field	RBDW09			
pH	North Fork Ranch	RBDW05 RBSW01	Ground water and surface water	Some locations exceeded the secondary MCL pH range (6.5-8.5)	Natural buffering of pH; gas exsolution causing pH to increase
	Arrowhead Ranchettes	RBDW12			
	Little Creek Field	RBDW07 RBDW08 RBDW10 RBDW14 RBMW04 RBMW05			
Sodium Adsorption Ratio	North Fork Ranch	RBSW01 RBSW02 RBSW03	Surface water	Mean SAR values in surface waters ranged from 14 to 56 (mequiv/L)^{½}	Permitted discharge of Na-HCO_3 type CBM water
	Arrowhead Ranchettes	--			
	Little Creek Field	--			

Previous studies of ground water chemistry and hydrology in the Raton Basin, including assessments conducted prior to CBM development, revealed variable water quality characteristics throughout the basin that appear to be broadly related to geology and hydrologic setting (e.g., Powell, 1952; McLaughlin, 1966; Howard, 1982; COGCC, 2003a). Specific ground water constituents that sometimes exceed established primary and secondary standards for drinking water use include TDS, pH, fluoride, nitrate, iron, manganese, and sulfate. Similar trends in water quality characteristics (e.g., elevated pH, fluoride, iron, manganese, and sulfate) were detected at some of the locations examined in this study. Compared to CBM water, the geochemical signature in shallower aquifers used for drinking water, including the Poison Canyon Formation and alluvial fill deposits, includes more variable major ion compositions (calcium-bicarbonate, sodium-bicarbonate, and sodium-sulfate), lower TDS, generally lower chloride and lithium, higher sulfate, depleted $^{13}C_{DIC}$, and variable redox conditions. The contrast in geochemistry between producing formations and shallower aquifers used for domestic water can be used to assess potential fluid mixing. Water quality data collected in the Raton Basin from drinking water aquifers prior to CBM development show similar ranges in specific conductance when compared to more recent data, and no discernible shifts in major ion chemistry are apparent. Furthermore, the sampling locations selected for this study showed consistent major ion patterns over the one-and-a-half-year period of this study. These time-independent trends in major ions provide no evidence of water quality impairment due to ground water migration at the selected sampling locations of this study.

Water isotope studies show that the ground water in alluvial deposits is sourced from local precipitation and precipitation in high-altitude areas. Deeper ground water in the Cuchara-Poison Canyon aquifer and the Raton-Vermejo aquifer is enriched in ^{18}O and ^{2}H compared to shallower ground water present in the alluvium, suggesting a source of meteoric water sourced under warmer climatic conditions. Surface water within the sampled tributaries is composed predominantly of production water discharged at the surface, with relatively minor contributions from local precipitation. Differences in the isotopic composition of strontium in ground water appear be constrained with respect to the geologic formation. Despite similar strontium concentrations, produced waters from the Vermejo and Raton formations in the North Fork Ranch study area are easily distinguished from ground water collected from the alluvial and Poison Canyon aquifers by using the $^{87}Sr/^{86}Sr$ ratio. The strontium isotope composition of ground water within the Little Creek Field has probably been modified from water-interactions with igneous bodies emplaced during the Tertiary period. In this area, ground water was collected only from the Poison Canyon Formation; without strontium isotope data from deeper producing formations, it is unclear as to whether strontium isotopes can be used to trace mixing of water from different geologic units within this area.

The purpose of the extensive analysis of organic chemicals was to evaluate the potential occurrence in ground water and surface water of chemicals generally documented as components of hydraulic fracturing fluids. In summary, bis-(2-ethylhexyl) phthalate was detected in some ground water wells at levels that exceeded EPA's drinking water standards (MCL=6 µg/L). TBA, DRO, and GRO were consistently detected at levels above limits of quantitation at some locations; detections varied by study site. BTEX compounds were detected at some locations on an inconsistent basis. There were no detections of glycol ethers in samples from domestic wells; diethylene glycol and triethylene glycol were detected in one sample collected from a production well in the last sampling round. The detection of low-level concentrations of glycols in the production well is possibly related to the presence of residual chemicals used as foaming agents during hydraulic fracturing. Almost half of the detected compounds

(46%) were hydrocarbons commonly associated with petroleum fuel releases. Detection of these compounds at low levels, coupled with the lack of documentation of any fuel releases or their use in hydraulic fracturing fluids within the vicinity of the study areas, suggests that these compounds are sourced from the organic-rich deposits they are screened in. Furthermore, the presence of BTEX compounds and benzene derivatives is consistent with results reported for other areas developing CBM resources and may reflect solubilization of coal material, as a by-product of natural water-rock interactions or enhanced solubilization due to injecting fluid with solvent-like properties into coal seams. While experimental research demonstrates the effects of solvents on the coal matrix, very little research has been reported regarding compound-specific products generated during solvent-coal interactions, and additional experimental work is needed. Nonetheless, these findings have important implications for areas undergoing extensive CBM development where, due to the lack of baseline data, water quality conditions often must be estimated after hydraulic fracturing has already begun.

In this study, TBA was detected in ground water samples collected from domestic, monitoring, and production wells at concentrations ranging from 6.9 to 1,310 µg/L. When detected in ground water, the usual source of TBA is as a degradation product of fuel oxygenate compounds, such as MTBE and/or ETBE. However, several non-gasoline-related sources of TBA are also possible, such as TBA production via chemical decomposition of TBHP or TBAc, microbial production of TBA by isobutane oxidation, and/or generation via the reaction of isobutylene and water in the presence of a catalyst. The formation pathway of TBA is unresolved, and both anthropogenic and natural sources are possible for the occurrence of TBA documented in this study. There are no documented gasoline spills that occurred within these areas and MTBE was banned in the state of Colorado in 2002, suggesting that MTBE/ETBE degradation would not be able to account for the TBA detections present within ground water in two areas examined during this case study. Available data indicate that TBHP, a chemical sometimes used in hydraulic fracturing formulations as a gel breaker, was not used in nearby hydraulic fracturing applications to develop CBM. It is possible that the TBA present within the study areas is from TBA production via microbially mediated processes; however, due to limited experimental and field data, the pathway has yet to be determined.

Dissolved methane was detected in all of the ground water samples collected from domestic wells; mean concentrations ranged widely, from about 0.003 to 12.4 mg/L. The high frequency of methane detections points to the widespread occurrence of methane in ground water of the Raton Basin. A variety of stable isotope patterns and potential sources of methane were identified in this study, including microbially sourced methane that is distinctive from thermogenic methane present in the deeper coal beds, mixed thermogenic/biogenic sources, and thermogenic methane undergoing oxidation. One of the key findings of the study is evidence that sulfate-reducing processes control the natural attenuation of methane, which was previously released into, and impacted, a drinking water aquifer in Huerfano County, Colorado. Multiple lines of evidence indicate that anaerobic oxidation of methane is occurring; these include consumption of dissolved methane and sulfate and production of dissolved sulfide and bicarbonate, methane loss coupled to production of higher-molecular-weight (C_{2+}) gaseous hydrocarbons, a distinct pattern of $\delta^{13}C$ in DIC, and a systematic shift in sulfur and oxygen isotope ratios of SO_4, indicative of microbial sulfate reduction. Time-trends of methane concentrations, however, suggest that the overall process of methane attenuation is slow, and available data trends provide no indication of the necessary timeframe required to reduce dissolved methane concentrations to low levels. The persistence of anaerobic methane oxidation within this area is questionable in the long term due to the potential exhaustion of terminal electron acceptor(s) and a lack of electron acceptor replenishment, given the inferred slow rates of ground water movement and recharge within the study area.

Data collected over the 19-month sampling period of this study provide insight into temporal and spatial variations in water quality within a structurally complex region experiencing CBM development. Few geochemical parameters can unambiguously distinguish between all possible contaminant sources, and previous studies of ground water chemistry and hydrology in the Raton Basin, including assessments conducted prior to CBM development, have revealed variable water quality characteristics throughout the basin that appear to be broadly related to geology and hydrologic setting. It is important to acknowledge that the rate of development and production of unconventional energy resources, such as CBM, outpaces the time frame in which ecosystems respond and the rate that geological processes occur; cause-effect relationships therefore may not be immediate and evidence of water quality impairment may not occur until much later.

Key observations/findings from this study are summarized below.

- Recovery of CBM in the Raton Basin occurs within or in close proximity to resources classified as Underground Sources of Drinking Water. Within the Raton Basin, the estimated vertical separation between CBM production intervals and water-supply wells ranges from <100 feet to more than 2,000 feet.
- The sampling locations examined in this study showed consistent major ion patterns over the one-and-a-half-year period of the project. Time-independent trends in major ions suggest that significant water migration from gas-producing zones to shallower aquifers used for drinking water has not occurred.
- Previous studies of ground water chemistry and hydrology in the Raton Basin, including assessments conducted before CBM development, have revealed variable water quality characteristics throughout the basin that appear to be related to geology and hydrologic setting. Specific constituents that sometimes exceed established primary and secondary standards for drinking water use include TDS, pH, fluoride, nitrate, iron, manganese, and sulfate. Similar water quality characteristics were detected at locations examined in this study.
- Streams sampled in this study received permitted discharges of produced water. When compared to the composition of produced water, surface water showed consistent sodium-bicarbonate type composition, organic compound detections, and isotopic patterns for inorganic carbon, strontium, and water.
- Glycol ethers were not detected in samples from domestic wells, monitoring wells, or surface water. Low levels of diethylene glycol and triethylene glycol were estimated in one of the production wells during the last sampling event. No clear evidence of impacts to homeowner wells from injected hydraulic fracturing fluids was indicated in this study.
- Concentrations of BTEX compounds were 0.7 to 5.1 orders of magnitude below EPA's drinking water standards. The presence of BTEX compounds and benzene derivatives in ground water from the Raton Basin is consistent with results reported for other areas developing CBM resources and may reflect water-rock interactions and solubilization of coal material.

- TBA was detected in ground water samples collected from three domestic wells, two monitoring wells, and one production well at concentrations ranging from 6.9 to 1,310 µg/L. The formation pathway of TBA is unresolved; both anthropogenic and natural sources are possible for the occurrence of TBA documented in this study.
- Methane was ubiquitous in ground water samples collected in this study. In domestic wells, mean concentrations varied widely from about 0.003 to 12.4 mg/L. Methane isotope data collected from domestic wells and monitoring wells in the North Fork Ranch study area indicate that the methane is microbially sourced and distinctive from the thermogenic gas present in the underlying CBM-producing coal beds.
- Approximately two years after the Little Creek Field had been hydraulically fractured, a documented gas migration event occurred in this area and resulted in thermogenic gas from the Vermejo Formation moving upward into the shallower Poison Canyon Formation. Analysis indicates that sulfate-dependent anaerobic oxidation of methane was occurring, and elevated dissolved sulfide concentrations in ground water reflected secondary biogeochemical changes related to the migration and reaction of methane within a shallow aquifer used for drinking water.

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Appendix A
QA/QC Summary
Retrospective Case Study in the Raton Basin, Colorado

U.S. Environmental Protection Agency
Office of Research and Development
Washington, DC

May 2015
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Table of Contents

List of Tables

List of Figures

A.1. Introduction

This appendix describes general Quality Assurance (QA) and the results of Quality Control (QC) samples, including discussion of chain of custody, holding times, blank results, field duplicate results, laboratory QA/QC results, data usability, double lab comparisons, performance evaluation samples, Quality Assurance Project Plan (QAPP) additions and deviations, field QA/QC, application of data qualifiers, tentatively identified compounds (TICs), Audits of Data Quality (ADQ), and field and laboratory Technical System Audits (TSAs). All reported data for the Raton Basin Retrospective Case Study met project requirements unless otherwise indicated by the application of data qualifiers in the final data summaries (see Appendix B). In rare cases, data were rejected as unusable and not reported.

A.1.1. October 2011 Sampling Event

The sampling and analytical activities for the October 2011 sampling event were conducted under a QAPP titled “Hydraulic Fracturing Retrospective Case Study, Raton Basin, CO,” version 0, approved on September 20, 2011. Any deviations from this QAPP are described in Section A9. Twelve domestic wells, five monitoring wells, two production wells, and one surface water location were sampled during this event. A total of 468 samples were collected and delivered to six laboratories for analysis: Shaw Environmental, Ada, OK; EPA ORD/NRMRL, Ada, OK; EPA Region 8, Golden, CO; EPA Region 3, Fort Meade, MD; Isotech Laboratories, Inc., Champaigne, IL; and USGS Laboratory, Denver, CO (see Table A1). Measurements were made for over 240 analytes per sample location. Of the 468 samples, 128 samples (27%) were QC samples, including blanks, field duplicates, matrix spikes, and matrix spike duplicates.

A.1.2. May 2012 Sampling Event

The sampling and analytical activities for the May 2012 sampling event were conducted under a QAPP titled “Hydraulic Fracturing Retrospective Case Study, Raton Basin, CO,” version 1, approved on April 30, 2012. Specific changes made to the QA documentation are described in the revised QAPP. An Addendum to version 1 (approved on December 12, 2012) was prepared to document QC acceptance criteria for the reanalysis of samples for metals collected during the May 2012 sampling event. Any deviations from this QAPP are described in Section A9. Twelve domestic wells, three monitoring wells, two production wells, and three surface water locations were sampled during this event. A total of 508 samples were collected and delivered to six laboratories for analysis: Shaw Environmental, Ada, OK; EPA ORD/NRMRL, Ada, OK; EPA Region 8, Golden, CO; EPA Region 3, Fort Meade, MD; Isotech Laboratories, Inc., Champaigne, IL; and USGS Laboratory, Denver, CO (see Table A1). Metals samples were subsequently resubmitted to an EPA Contract Laboratory Program (CLP) lab (Chemtech; Mountain, NJ) for analysis of trace metals by inductively coupled plasma–mass spectrometry (ICP-MS). Measurements were made for over 245 analytes per sample location. Of the 508 samples, 128 samples (25%) were QC samples, including blanks, field duplicates, matrix spikes, and matrix spike duplicates.

A.1.3. November 2012 Sampling Event

The sampling and analytical activities for the November 2012 sampling event were conducted under a QAPP titled “Hydraulic Fracturing Retrospective Case Study, Raton Basin, CO,” version 1, approved on April 30, 2012. Any deviations from this QAPP are described in Section A9. Addendum No. 2 to version

1 (approved on February 25, 2013) was prepared to document QC acceptance criteria for the analysis of samples for metals and Volatile Organic Compounds (VOCs) by an EPA Region 7 contract laboratory for samples collected during the November 2012 event. Thirteen domestic wells, three monitoring wells, two production wells, and three surface water locations were sampled during this event. A total of 606 samples were collected and delivered to seven laboratories for analysis: Shaw Environmental, Ada, OK; EPA ORD/NRMRL, Ada, OK; SWRI, San Antonio, TX; EPA Region 8, Golden, CO; EPA ORD/NERL, Las Vegas, NV; Isotech Laboratories, Inc., Champaigne, IL; and USGS Laboratory, Denver, CO (see Table A1). Measurements were made for over 245 analytes per sample location. Of the 606 samples, 180 samples (30%) were QC samples, including blanks, field duplicates, matrix spikes, and matrix spike duplicates.

A.1.4. April/May 2013 Sampling Event

The sampling and analytical activities for the April/May 2013 sampling event were conducted under an approved QAPP titled “Hydraulic Fracturing Retrospective Case Study, Raton Basin, CO,” version 2, approved on April 12, 2013. Any deviations from this QAPP are described in Section A9. Twelve domestic wells, three monitoring wells, two production wells, and three surface water locations were sampled during this event. A total of 573 samples were collected and delivered to seven laboratories for analysis: CB&I, Ada, OK; EPA ORD/NRMRL, Ada, OK; SWRI, San Antonio, TX; EPA Region 8, Golden, CO; EPA Region 3, Fort Meade, MD; Isotech Laboratories, Inc., Champaigne, IL; and USGS Laboratory, Denver, CO (see Table A1). Measurements were made for over 235 analytes per sample location. Of the 573 samples, 185 samples (32%) were QC samples, including blanks, field duplicates, matrix spikes, and matrix spike duplicates.

A final version of the QAPP titled “Hydraulic Fracturing Retrospective Case Study, Raton Basin, CO,” version 3, was approved on November 5, 2013. The QAPP is available at: http://www2.epa.gov/sites/production/files/documents/qapp-retrospective-case-study-raton-basin.pdf.

A.2. Chain of Custody

Sample types, bottle types, sample preservation methods, analyte holding times, analysis methods, and laboratories receiving samples for analysis are listed in Tables A1 and A2. Samples collected in the field were packed on ice into coolers for shipment by overnight delivery along with completed chain-of-custody (COC) documents and temperature blank containers. In general, all samples collected in the field were successfully delivered to the laboratories responsible for conducting the analyses. The following sections describe any noted issues related to the sample shipments and potential impacts on data quality.

A.2.1. October 2011 Sampling

One cooler sent to the EPA Region 3 Laboratory for glycol analysis of samples RBMW02, RBDW02, RBDW04, RBMW03, RBEqBlk02, RBDW05, RBDW05d, RBSW01, RBFBlk02, RBMW04, RBDW08, RBMW05, RBDW09, RBEqBlk03, RBDW10, RBDW10d, and RBSW01 arrived at the laboratory at a temperature of 15°C due to a delay in shipment. Glycols were not detected in any of the samples, but these samples were qualified with the “J-” qualifier as estimated with a potential low bias. All samples sent to the EPA Region 8 Laboratory for diesel-range organics (DRO) analysis were checked in at a pH of less than 2, with the exception of samples RBFBlk01, RBMW03, and RBFBlk03; these samples arrived with a pH of 3 and were then reduced to pH less than 2 prior to laboratory preparation. There was no suspected impact on data quality for these samples.

A.2.2. May 2012 Sampling

One cooler of samples collected on May 14, 2012 was received at the Robert S. Kerr Environmental Research Center in Ada, Oklahoma with the custody seals broken; the shipping company apparently cut the seals. The analytical suites included: metals, dissolved gases, VOCs, low-molecular-weight acids, anions, nutrients, dissolved inorganic carbon (DIC), dissolved organic carbon (DOC), and water isotopes; however, all sample containers were intact within sealed bags and there was no expected impact on data quality for these parameters and samples. A sample for gas isotopes (RBSW03) was received at Isotech Laboratories with the cap broken off the bottle; thus, analysis of this sample was not possible.

A.2.3. November 2012 Sampling

One cooler sent to the EPA ORD/NERL Laboratory for glycol analysis of samples BFBlk04, RBEqBlk04, RBDW14, RBDW10, RBDW10d, RBDW06, RBDW06, RBDW15, RBMW04, and RBDW09 arrived at the laboratory at a temperature of 19°C due to a delay in shipment. Glycols were not detected in any of the samples, but these samples were qualified with the "J-" qualifier as estimated with a potential low bias. One cooler containing VOC samples was received at 15°C at SWRI. Samples affected were RDW06, RDW09, RDW10, RDW10dup, RDW14, RDW15, RDWFBlk04, RDWEqBlk04, and RDWTripBlk04. These samples were qualified in the final summary spreadsheet with a "J-".

A.2.4. April/May 2013 Sampling

One cooler sent to the EPA Region 8 Laboratory was misdelivered to Test America Laboratories. Test America broke the custody seals and opened the cooler. The shipping company subsequently delivered the cooler to the EPA Region 8 Laboratory; temperature blanks were within acceptance criteria. The cooler contained some of the samples collected on May 1, 2013, and there was no expected impact on data quality for these samples. Two coolers sent to the Robert S. Kerr Environmental Research Center in Ada, Oklahoma, on May 1, 2013, were received at 8.0 and 6.8°C, respectively. These coolers contained samples RBFBlk01, RBEqBlk01, RBTripBlk01, RBPW03, RBPW01, RBMW01, RBMW01d, RBDW11, RBDW02, RBDW02d, and RBDW05, which were analyzed for low-molecular-weight acids, dissolved gases, anions, nutrients, DIC, DOC, and water isotopes. The temperature of the received samples was well below the average ambient temperature of the sampling points (12°C), and most of the sample types contained a preservative. There was no expected impact on data quality for these samples.

A.3. Holding Times

Holding times are the length of time a sample can be stored after collection and prior to analysis without significantly affecting the analytical results. Holding times vary with the analyte, sample matrix, and analytical methodology. Sample holding times for the analyses conducted in this investigation are listed in Table A2; holding times range from 7 days to 6 months. Generally, estimated analyte concentrations for samples with holding time exceedances are considered to be biased low.

A.3.1. October 2011 Sampling

All samples met holding times.

A.3.2. May 2012 Sampling

During analytical preparations at the EPA Region 8 Laboratory, sample RBMW03 foamed during the laboratory extraction procedure and was lost. The sample was re-extracted one day past its holding time. Semivolatile organic compounds (SVOCs) reported for this sample were estimated and given the "H" qualifier. Impact on data quality is considered minimal.

A.3.3. November 2012 Sampling

All samples met holding times.

A.3.4. April/May 2013 Sampling

Sample RBMW03 had a tert-butyl alcohol concentration that exceeded the calibration range. Reanalysis of this sample after a 20x dilution was completed after the holding time expired. Therefore, the tert-butyl alcohol result for this sample was estimated and given the "H" qualifier, although there is no suspected impact on data quality. The concentration of tert-butyl alcohol after dilution was in reasonable agreement with the concentration determined within the specified holding time by extrapolation outside of the calibration range.

A.4. Blank Samples Collected During Sampling

An extensive series of blank samples were collected during all sampling events, including field blanks, equipment blanks, and trip blanks (see Table A3). These QC samples were intended to test for possible bias from potential sources of contamination during field sample collection, equipment cleaning, sample bottle transportation to and from the field, and laboratory procedures. The same water source was used for the preparation of all blank samples (Barnstead NANOpure Diamond UV water). Field blanks were collected to evaluate potential contamination from sample bottles and environmental sources. Equipment blanks were collected to determine whether cleaning procedures or sampling equipment (filters, fittings, tubing) potentially contributed to analyte detections. Trip blanks consisted of serum bottles and VOA vials filled with NANOpure water and sealed in the laboratory. Trip blanks were used to evaluate whether VOA vials and dissolved gas serum bottles were contaminated during sample storage, sampling, or shipment to and from the field. All analyses have associated field and equipment blanks, except for isotope ratio analyses, for which no blank sampling schemes are appropriate. Sample bottle types, preservation, and holding times were applied to blank samples in the same way as they were applied to field samples (see Table A2).

The following criteria were used for qualifying samples with potential blank contamination. Sample contamination was considered significant if analyte concentrations in blanks were above the method Quantitation Limit (QL) and if the analyte was present in an associated field sample at a level <10× the concentration in the blank. In cases where both the sample and its associated laboratory, equipment, field, or trip blank were between the Method Detection Limit (MDL) and the QL, the sample data were reported as less than the QL with a "U" qualifier. Blank samples (i.e., field, equipment, and trip) were associated to field samples by dates of collection; for example, most sample shipments included both field samples and blank samples that were used for blank assessments. Results of blanks analyses are reported in Tables A4-A12. In general, field blank samples were free from detections of a vast majority of analytes. The following sections describe instances where blank detections were noted and there were potential impacts on data quality and usability. Refer to Table A25 for more detail on impacts to data usability from detections in blank samples. As previously stated, a majority of these blanks were free from detections or were less than the QL and, in these cases, the sample data are not affected and are not discussed in the following sections.

A.4.1. October 2011

Nitrate+nitrite, ammonia, and DOC were reported in several blank samples at low levels, which resulted in "B" qualifiers being applied to the results for several samples (see Table A4).

Toluene was detected at low levels in one field blank, one equipment blank, and two trip blanks. As a result of these detections, the "B" qualifier was applied to the results for sample RBDW06 (see Table A7).

For the low-molecular-weight acids, acetate was consistently detected in all blanks and all samples at similar levels; consequently, the acetate data were rejected (see Table A8). The source for acetate contamination was later determined to be the preservative.

Methane, ethane, propane, and butane were detected in two trip blanks above the QL, which resulted in the application of several "B" qualifiers. The detections of these gases were likely related to laboratory contamination because all four gases were detected in the blanks (see Table A9).

For SVOC analyses, bis-(2-ethylhexyl) adipate was detected in several lab blanks and was likely related to laboratory contamination. The compound bis-(2-ethylhexyl) phthalate was detected in one equipment blank; however, this detection did not impact any sample results (see Table A11). Gasoline-range organics (GRO) were detected in an equipment blank and a field blank, resulting in the application of the "B" qualifier to the results for sample RBMW03 (see Table A12).

A.4.2. May 2012

Field and equipment blank samples contained levels of nitrate+nitrite that resulted in the application of the "B" qualifier to the results for several samples (see Table A4). All sample results for nitrate+nitrite were low, less than about 0.5 mg/L.

Field and/or equipment blanks had detectable levels of total copper (Cu). Consequently, "B" qualifiers were added to the total Cu results for several of the field samples. Lab blanks had levels of total and dissolved antimony (Sb) that resulted in the application of the "B" qualifier to the results for sample RBMW03.

For low-molecular-weight acids, there were detectable concentrations of formate and propionate in one or more of the blanks. In the case of formate, all blanks collected had detectable concentrations; consequently, the formate data were rejected (see Table A8). Follow-up studies indicated that the likely source of formate contamination was the sample containers. For this reason, formate was not reported in subsequent sampling rounds. Propionate was not detected in samples, therefore there was no impact on data usability.

A.4.3. November 2012

DOC was detected in an equipment blank above the QL, which resulted in the application of several "B" qualifiers (see Table A4). Nitrate+nitrite were also detected in several field and equipment blanks, resulting in the application of "B" qualifiers. Concentrations of nitrate+nitrite were generally quite low in the field samples, less than <1.2 mg/L. The results for chloride, sulfate, bromide, and fluoride were rejected for sample RBFBlk03; this sample was mistakenly acidified with sulfuric acid in the field.

For metals analyses, blank detections resulted in the application of "B" qualifiers for total aluminum (Al), Cu, iron (Fe), molybdenum (Mo), nickel (Ni), and zinc (Zn), and for dissolved Cu, Mo, and Ni (see Tables A5 and A6).

Several low-level detections of methane in blanks resulted in the application of the "B" qualifier to the results for sample RBSW01 (see Table A9).

For SVOCs, bis-(2-ethylhexyl) phthalate was detected in an equipment blank and a field blank above the QL; these detections resulted in the application of several "B" qualifiers (see Table A11). In addition, squalene was detected in one of the field blanks, but this compound was not detected in any of the field samples. DRO were detected above the QL in one equipment blank collected on November 7, 2012; this resulted in the application of "B" qualifiers to the results for samples collected on that day, RBDW08 and RBSW01 (see Table A12).

A.4.4. April/May 2013

For metals analyses, blank detections resulted in the application of "B" qualifiers for total Al, arsenic (As), chromium (Cr), Cu, thorium (Th), vanadium (V), and Zn, and for dissolved Al, Cu, Ni, and Th. These detections were likely related to laboratory contamination (see Table A5 and A6).

Propionate was detected above the QL in several blank samples; however, because propionate was not detected in any of the field samples, there was no impact on data quality (see Table A8).

For SVOC analytes, there was a single detection of squalene above the QL in a field blank collected on April 29, 2013. This detection resulted in the "B" qualifier being applied to the results for samples RBDW11 and RBMW01d (see Table A11). DRO were detected above the QL in one equipment blank collected on May 1, 2013; this resulted in the "B" qualifier being applied to the results for samples collected on that day, RBDW08, RBDW09, and RBDW14 (see Table A12).

A.5. Field Duplicate Samples

Field duplicate samples were collected to measure the reproducibility and precision of field sampling and analytical procedures. The relative percent difference (RPD) was calculated to compare concentration differences between the primary (sample 1) and duplicate sample (sample 2) using the following equation:

$$\text{RPD (\%)} = ABS\left(\frac{2 \times (\text{sample } 1 - \text{sample } 2)}{(\text{sample } 1 + \text{sample } 2)}\right) \times 100$$

RPDs were calculated when the constituents in both the primary sample and duplicate sample were >5× the method QLs. Sample results were qualified if RPDs were >30% for duplicate field samples. The results of field duplicate analyses are provided in Tables A13-A24. Note that different RPD criteria apply to laboratory duplicate and matrix spike duplicate samples; these QC criteria are described in the QAPP.

A.5.1. All Sampling Events

Parameters that required qualification based on RPDs not meeting applicable criteria for field duplicates were: total Ni and dissolved methane (Round 3, November 2012); and, total manganese (Mn) and dissolved methane (Round 4, April/May 2013). These RPD exceedances have to do with reproducibility of trace metal and dissolved gas concentrations. Overall, reproducibility of the multiple field duplicates was very good, as shown on the cumulative percent diagram below (see Figure A1). RPD values of field duplicates from all of the rounds of sampling followed a similar pattern, with generally >90% of duplicate samples agreeing to within 10%.

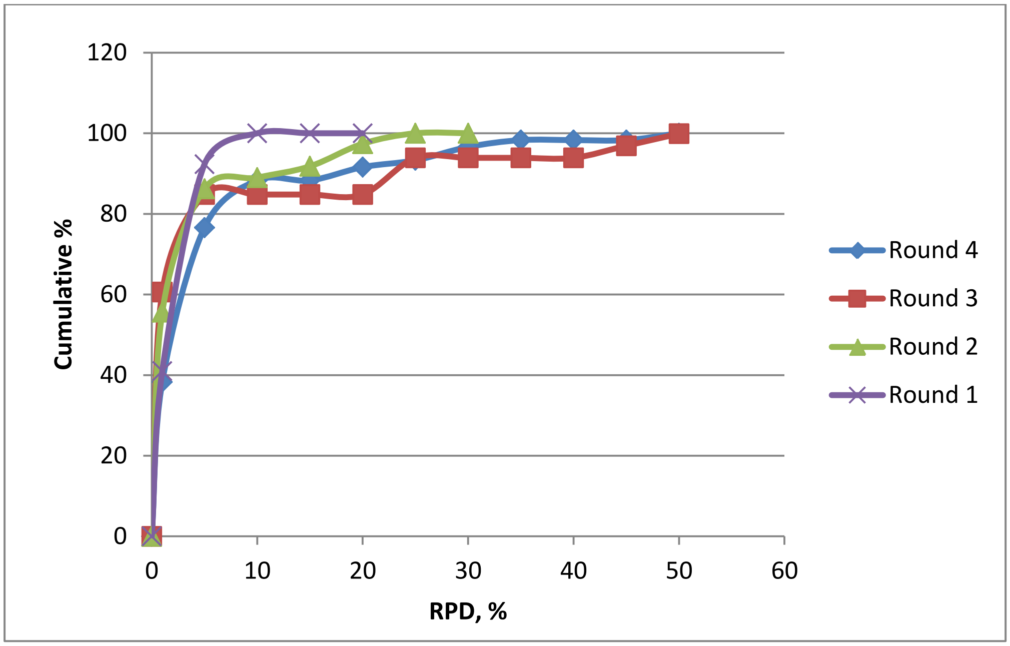

Figure A1. Cumulative % diagram showing the percent agreement of duplicate field samples collected during the four rounds of sampling.

A.6. Laboratory QA/QC Results and Data Usability Summary

The QA/QC requirements for laboratory analyses conducted as part of this case study are provided in the QAPPs. Table A25 summarizes laboratory QA/QC results identified during sample analysis, such as laboratory duplicate analysis, laboratory blank analysis, matrix spike results, calibration and continuing calibration checks, and field QC. Impacts on data quality related to issues noted in the QA/QC results are also presented in Table A25. Data qualifiers and data descriptors are listed in Table A28. Many of the specific QA/QC observations noted in the Audit of Data Quality are summarized in Table A25.

A majority of the reported data met project requirements. Data that did not meet QA/QC requirements specified in the QAPP are indicated by the application of data qualifiers in the final data summaries (see Appendix B). Data determined to be unusable were rejected and qualified with an "R." Depending on the data qualifier, data usability is affected to varying degrees. For example, data qualified with a "B" would not be appropriate to use when the sample concentration is below the blank concentration. But as the sample data increase in concentration and approach 10x the blank concentration, they may be more appropriate to use. Data with a "J" flag are usable with the understanding that the concentration is approximate, but the analyte is positively identified. A "J+" or "J-" qualifier indicates a potential positive or negative bias, respectively. An "H" qualifier, for exceeding sample holding time, is considered a negative bias. An "*" indicates that the data are less precise than project requirements. Each case is evaluated to determine the extent that data are usable or not (see Table A25).

A.7. Double-lab Comparisons

Shaw Environmental and SWRI analyzed samples for VOCs using standard EPA methods in the third round of sampling (November 2012; see Table A26). Shaw Environmental used EPA Method 5021A plus 8260C (gas chromatography–mass spectrometry [GC-MS], equilibrium headspace analysis). SWRI used EPA Method 5035 plus 8260B (GC-MS, closed-system purge-and-trap). The primary dataset used for the data analysis was the set of results from SWRI. The results were compared for common detections of chloroform, tert-butyl alcohol, methylene chloride, benzene, and toluene in Table A26. Overall, the concentration data for these chemicals were highly comparable between the two labs. RPDs range between 4.3 and 134%. The highest RPD values were noted for low-level detections of toluene, and these differences were not considered to be significant because of the low concentrations detected. RPD values for the majority of the constituents were below or equal to 40% (83% of comparisons). The compounds 1,2-dichlorobenzene, 1,2,3-trimethylbenzene, acetone, carbon disulfide, and naphthalene were detected in some samples at low levels by SWRI, but these compounds were not reported by Shaw. In addition, *o*-xylene was detected by Shaw in sample RBSW03, but it was not detected by SWRI. Overall, these results show reasonable agreement and demonstrate accurate identification and quantitation of VOCs that were present above method QLs. In particular, the double-lab comparison verified the occurrence of tert-butyl alcohol that was detected at some of the sampling locations included in this case study during every event.

A.8. Performance Evaluation Samples

A series of performance evaluation (PE) samples were analyzed by the laboratories conducting critical analyses to support the HF Retrospective Case Studies. The PE samples were analyzed as part of the normal QA/QC standard operating procedures, and in the case of certified labs, as part of the certification process to maintain certification for that laboratory. The results of the PE tests are presented in tabular form in the Wise County, Texas, Retrospective Case Study QA/QA Appendix and are not repeated here. These tables show the results of 1,354 tests; 98.6% of the reported values fell within the acceptance range. For the ORD/NRMRL Laboratory, a total of 95 tests were performed, with 96.9% of the reported values falling within the acceptable range. Similarly, for the Shaw Environmental Laboratory, a total of 835 tests were performed, with 98.7% of the reported values falling within the acceptable range. The EPA Region 8 Laboratory had a total of 424 tests performed, with 98.8% of the reported values falling within the acceptable range. These PE sample results demonstrate the high quality of the analytical data reported here. Analytes not falling within the acceptable range were examined, and corrective action was undertaken to ensure data quality in future analysis.

A.9. QAPP Additions and Deviations

A deviation from the QAPP occurred during the October 2011 sampling event. The ICP-MS metals data were not reported from the first sampling event because of concerns about the data quality, and because the samples could not be re-analyzed within the specified sample holding time. Instead, ICP-OES data were reported for the ICP-MS metals As, Cd, Cr, Cu, Ni, Pb, and Se. ICP-MS data were collected for the following three sampling events. In general, the ICP-OES trace metal data from the first round of sampling cannot be compared with the subsequent ICP-MS data due to the large differences in QLs and MDLs for the ICP-OES and ICP-MS methods; therefore, trace metal evaluations only consider data collected during the later three sampling events. Information about the concentrations of As, cadmium (Cd), Cr, Cu, Ni, Pb, and selenium (Se) from the first round was considered to be for screening-level evaluation.

Analysis of the original ICP-MS results for the second sampling event in May 2012 indicated that the laboratory did not analyze interference check solutions (ICSs) as described in EPA Method 6020A. These ICSs would have enabled the laboratory to evaluate the analytical method's ability to appropriately handle known potential interferences and other matrix effects. In ICP-MS analysis, the ICSs are used to verify that interference levels are corrected by the data system within quality control limits. Because of the importance of this missing QC check, it was deemed necessary to reject the data from the original analysis. Because samples were within the method holding time, reanalysis was conducted by the EPA Superfund Analytical Services Contract Laboratory Program (EPA CLP) for Al, As, Cd, Cr, Cu, Ni, Pb, Sb, Se, Th, thallium (Tl), and uranium (U) by ICP-MS. This additional work was completed under an Addendum to revision 1 of the QAPP. The CLP ICP-MS data were reported for both dissolved and total metals for the metals listed above for the May 2012 sampling event.

A.10. Field QA/QC

A YSI Model 556 electrode and flow-cell assembly was used to measure temperature, specific conductance, pH, oxidation-reduction potential (ORP), and dissolved oxygen. YSI electrodes were calibrated in the morning of each sampling day. In general, performance checks were conducted after initial calibration, at midday and at the end of each day. NIST-traceable buffer solutions (4.00, 7.00, and/or 10.01) were used for pH calibration and for continuing checks. Orion ORP standard was used for calibration of redox potential measurements. Oakton conductivity standard was used for calibration of specific conductance measurements. Dissolved oxygen sensors were calibrated with air and checked with zero-oxygen solutions to ensure good performance at low oxygen levels. Table A27 provides the results of initial, midday, and end-of-the-day performance checks. Prior to field deployment, the electrode assembly and meter were checked to confirm good working order. Performance checks for pH were outside of control limits in a few instances during the October 2011 and April/May sampling events, which resulted in the application of "J" qualifiers to some of the pH data. In several cases, performance checks of specific conductance were outside of control limits, but data useability is not considered to be impacted. Also, zero-oxygen solution checks were occasionally above the optimal <0.25 mg/Lcriterion; however, in all cases the performance check results were <1 mg/L for dissolved oxygen and confirmed electrode performance at low oxygen levels. Finally, in some cases performance check measurements for ORP were not recorded. These instances are noted in Table A27; data usability is not considered to be impacted.

Field parameters at this case study location consisted of turbidity, alkalinity, total dissolved sulfide species (ΣH_2S), and ferrous iron. Because field measurements of ferrous iron and dissolved sulfide sometimes required dilution and all sample preparations and measurements were made in an uncontrolled environment (i.e., the field), concentration data for these parameters were qualified in all cases as estimated. The turbidity was measured using a Hach 2100Q Portable Turbimeter and was calibrated using a Hach 2100Q StablCal Calibration Set. The Hach 2100Q StablCal Calibration Set consists of the 20 nephelometric turbidity unit (NTU), 100 NTU, and 800 NTU standards, with a 10 NTU calibration verification standard. For alkalinity measurements, a Hach Model AL-DT Digital Titrator was used. The total dissolved sulfide and ferrous iron measurements were collected using Hach DR2700 and DR890 spectrometers, respectively. The equipment used for measuring alkalinity, total dissolved sulfide, and ferrous iron was tested in the lab prior to field deployment using known standards. In the field, a blank sample was measured to confirm that no cross contamination occurred between the different sampling locations. This was also the case for turbidity; however, a 10 NTU standard was also used to verify the calibration.

A.11. Data Qualifiers

Data qualifiers and their definitions are listed in Table A28. Many factors can impact the quality of data reported for environmental samples, including factors related to sample collection in the field, transport of samples to laboratories, and the analyses conducted by the various laboratories. The list of qualifiers in Table A28 is based on the Data Qualifier Definitions presented in the EPA CLP National Functional Guidelines for Superfund Organic Methods Data Review (USEPA/540/R-01, 2008), and the EPA CLP National Functional Guidelines for Superfund Inorganic Methods Data Review (USEPA/540/R/10/011, 2010), with the addition of data qualifiers "H" and "B", which are necessary for communicating issues that occur during analysis in laboratories not bound by the CLP statement of work. The "R" qualifier was used in cases where it was determined that data needed to be rejected. Data rejection can occur for many reasons, which must be explained in QA/QC narratives. Conditions regarding the application of qualifiers include:

- If the analyte was not detected, then it was reported as <QL and qualified with U.
- If the analyte concentration was between the MDL and QL, then it was qualified with J.
- If the analyte concentration was <QL, then the B qualifier was not applied.

- If both an analyte and an associated blank concentration were between the MDL and QL, then the sample results were reported as <QL and qualified with U.
- For samples associated with high matrix spike recoveries, the J+ qualifier was not applied if the analyte was <QL.
- For samples associated with low matrix spike recoveries, the J- qualifier was applied to the analyte with low recovery regardless of analyte concentration (< or > QL).

A.12. Tentatively Identified Compounds

The EPA Region 8 Laboratory reported tentatively identified compounds (TICs) from SVOC analyses. Several SVOC TICs were identified in samples and blanks (see Table A29). To be identified as a TIC, a peak had to have an area at least 10% as large as the area of the nearest internal standard and a match quality greater than 80. The TIC match quality is based on the number and ratio of the major fragmentation ions. A perfect match has a value of 99. Although the TIC report is essentially a qualitative report, an estimated concentration was calculated based on a response factor of 1.00 and the area of the nearest internal standard. The search for TICs included the whole chromatogram from approximately 3.0 to 41.0 minutes for SVOCs. TICs are compounds that can be detected, but, without the analysis of standards, cannot be confirmed or reliably quantified. Oftentimes, TICs are representative of a class of compounds rather than indicating a specific compound. Only the top TIC was reported for each peak.

A.13. Audits of Data Quality

An Audit of Data Quality (ADQ) was performed for each sampling event per EPA's NRMRL standard operating procedure (SOP), "Performing Audits of Data Quality (ADQs)," to verify that the requirements of the QAPP were properly implemented for the analysis of critical analytes for samples submitted to laboratories identified in the QAPP associated with this project. The ADQs were performed by a QA support contractor, Neptune and Company, Inc., and reviewed by NRMRL QA staff. NRMRL QA staff provided the ADQ results to the project Principal Investigator for response and assisted in the implementation of corrective actions. The ADQ process is an important element of Category I (highest of four levels in EPA ORD) Quality Assurance Projects, which this study operated under for all aspects of ground water sample collection and analysis.

Complete data packages were provided to the auditors for the October 2011, May 2012, November 2012, and April/May 2013 sampling events. A complete data package consisted of the following: sample information; method information; data summary; laboratory reports; raw data, including QC results; and data qualifiers. The QAPP was used to identify data quality indicator requirements and goals, and a checklist was prepared based on the types of data collected. The data packages were reviewed against the checklist by tracing a representative set of the data in detail from raw data and instrument readouts through data transcription or transference through data manipulation (either manually or electronically by commercial or customized software), and through data reduction to summary data, data calculations, and final reported data. All calibration and QA/QC data were reviewed for all available data packages. Data summary spreadsheets prepared by the Principal Investigator were also reviewed to determine whether data had been accurately transcribed from lab summary reports and appropriately qualified based on lab and field QC results.

The critical analytes, as identified in version 3 of the QAPP, are GRO; DRO; VOCs, including alcohols (ethanol, isopropyl alcohol, tert butyl alcohol, naphthalene, benzene, toluene, ethylbenzene, and xylenes); dissolved gases (methane and ethane); trace elements (As, Se, Sr, Ba); major cations (Ca, Mg, Na, K); and major anions (Cl, SO_4).Also included in the ADQs were the following analytes: sVOCs, all metals analyzed, pH in the October 2011 sampling event, and glycols. The non-conformances identified in an ADQ may consist of the following categories: finding (a deficiency that has or may have a significant effect on the quality of the reported results; a corrective action response is required), or observation (a deficiency that does not have a significant effect on the quality of the reported results; a corrective action response is required). The ADQ (three reports) for the October 2011 sampling event noted a series of eleven observations and two findings; the May 2012 sampling event had six observations and two findings; the November 2013 event had 25 observations and one finding; and the April/May 2013 sampling event had 18 observations. In most cases, the ADQ findings and observations are found in Table A25 along with the corrective actions taken and data qualifications. All findings and observations were resolved through corrective actions.

A.14. Laboratory Technical System Audits

Laboratory Technical Systems Audits (TSAs) were conducted early in the project to allow for identification and correction of any issues that may affect data quality. Laboratory TSAs focused on the critical target analytes. Laboratory TSAs were conducted on-site at the ORD/NRMRL Laboratory and Shaw Environmental [both laboratories are located at the Robert S. Kerr Research Center, Ada, OK] and at the EPA Region 8 Laboratory (Golden, CO) which analyzed for SVOCs, DRO and GRO. Detailed checklists, based on the procedures and requirements specified in the QAPP, related SOPs, and EPA Methods, were prepared and used during the TSAs. These audits were conducted with contract support from Neptune and Co., with oversight by NRMRL QA Staff. The QA Manager tracked implementation and completion of any necessary corrective actions. The TSAs took place in July 2011. The TSAs found good QA practices in place at each laboratory. There were no findings and six observations across the three laboratories audited.All observations were resolved through corrective actions. The observations had no impact on the sample data quality.

A.15. Field Technical System Audits

For Category 1 QA projects, TSAs are conducted on both field and laboratory activities. Detailed checklists, based on the procedures and requirements specified in the QAPP, SOPs, and EPA Methods, were prepared and used during the TSAs. The field TSA took place during the first sampling event in October 2011 (audit date: October 4, 2011). The sample collection, documentation, field measurements (and calibration), and sample handling were performed according to the QAPP. No findings and four observations were noted in the field TSA related to analysis of samples in the field, notebook error corrections, YSI calibrations, and a revision to the QAPP regarding dissolved gas sample collection. All observations were resolved through corrective actions. There was no impact on the sample data quality.

Appendix A Tables

Table A1. Laboratories performing the analyses, per sampling round: Raton Basin, CO.

Measurement	Round 1, Oct. 2011	Round 2, May 2012	Round 3, Nov. 2012	Round 4, April/May 2013
Anions	RSKERC General Parameters Lab	RSKERC General Parameters Lab	RSKERC General Parameters Lab	RSKERC General Parameters Lab
Diesel Range Organics (DRO)	EPA Region VIII Laboratory	EPA Region VIII Laboratory	EPA Region VIII Laboratory	EPA Region VIII Laboratory
Dissolved gases	Shaw Environmental	Shaw Environmental	Shaw Environmental	CB&I (name changed from Shaw due to change in ownership)
Gasoline Range Organics (GRO)	EPA Region VIII Laboratory	EPA Region VIII Laboratory	EPA Region VIII Laboratory	EPA Region VIII Laboratory
Low-Molecular-Weight Acids	Shaw Environmental	Shaw Environmental	Shaw Environmental	CB&I
Glycols	EPA Region III Laboratory	EPA Region III Laboratory	EPA NERL, Las Vegas	EPA Region III Laboratory
Metals (filtered and unfiltered)	Shaw Environmental	Shaw Environmental & EPA CLP Lab	Region VII Contract Lab (SwRI)	Region VII Contract Lab (SwRI)
Microbial[1]	ORD-Cincinnati Laboratory	ORD-Cincinnati Laboratory	NR	NR
Semivolatile Organic Compounds (SVOC)	EPA Region VIII Laboratory	EPA Region VIII Laboratory	EPA Region VIII Laboratory	EPA Region VIII Laboratory
Strontium Isotopes, $^{87}Sr/^{86}Sr$	USGS	USGS	USGS	USGS
Volatile Organic Compounds (VOC)	Shaw Environmental	Shaw Environmental	Shaw Environmental/Region VII Contract Lab (SwRI)	Region VII Contract Lab (SwRI)
Water Isotopes	Shaw Environmental	Shaw Environmental	Shaw Environmental	CB&I
$\delta^{13}C$, $\delta^{2}H$, $\delta^{34}S$, $\delta^{18}O$	Isotech Laboratories	Isotech Laboratories	Isotech Laboratories	Isotech Laboratories

[1] Data collected from the microbial samples are not presented in this report.

Table A2. Sample containers, preservation, and holding times for ground water and surface water samples from the Raton Basin, CO.

Sample Type	Analysis Method (Lab Method)	Sample Bottles (# of Bottles[1])	Preservation/Storage	Holding Time(s)	Sampling Round[2]
Anions – Br^-, Cl^-, SO_4^{2-}, F^-	EPA Method 6500 (RSKSOP-276, v3,4)	30 mL, plastic bottle (1)	Refrigerate ≤6°C[4]	28 days	1, 2, 3, 4
Metals, Dissolved (filtered)	EPA Methods 200.7 and 6020A (RSKSOP-213, v4; RSKSOP-257, v3 or -332, v0)	125 mL, plastic bottle (1)	HNO_3, pH<2; Room temperature	6 months (Hg – 28 days)	1
	Method ISM01.3	125 mL, plastic bottle (1)	HNO_3, pH<2; Room temperature	6 months (Hg – 28 days)	2
	EPA Methods 200.7 and 6020A Hg: EPA Method 7470A	1 L, plastic bottle (1)	HNO_3, pH<2; Room temperature	6 months (Hg – 28 days)	3, 4
Metals, Total (unfiltered)	EPA Methods 200.7 and 6020A; Digestion: EPA Method 3015A (RSKSOP-179, v2; -213, v4; RSKSOP-257, v3 or -332, v0)	125 mL, plastic bottle (1)	HNO_3, pH<2; Room temperature	6 months (Hg – 28 days)	1
	Method ISM01.3	125 mL, plastic bottle (1)	HNO_3, pH<2; Room temperature	6 months (Hg – 28 days)	2
	EPA Methods 200.7 and 6020A; Digestion: EPA Method 3015A; Hg: EPA Method 7470A	1 L, plastic bottle (1)	HNO_3, pH<2; Room temperature	6 months (Hg – 28 days)	3, 4

Table A2. Sample containers, preservation, and holding times for ground water and surface water samples from the Raton Basin, CO.

(continued)

Sample Type	Analysis Method (Lab Method)	Sample Bottles (# of Bottles[1])		Preservation/Storage	Holding Time(s)	Sampling Round[2]
Nutrients (as –N), (NO_3^- + NO_2^-), NH_4	EPA Method 353.1 and 350.1 (RSKSOP-214, v5)	30 mL, plastic bottle	(1)	H_2SO_4, pH<2; Refrigerate ≤6°C	28 days	1, 2, 3, 4
Dissolved Inorganic Carbon (DIC)	EPA Method 9060A (RSLSOP-330, v.0)	40 mL, VOA vial (clear glass)	(2)	Refrigerate ≤6°C	14 days	1, 2, 3, 4
Dissolved Organic Carbon (DOC)	EPA Method 9060A (RSLSOP-330, v0)	40 mL, VOA vial (clear glass)	(2)	H_3PO_4, pH<2; Refrigerate ≤6°C	28 days	1, 2, 3, 4
Dissolved Gases	RSKSOP-194, v4 and -175, v5 (No EPA Method)	60 mL, serum bottles	(2)	No Headspace TSP[3], pH>10; Refrigerate ≤6°C[4]	14 days	1, 2, 3, 4
Low-Molecular-Weight Acids	RSKSOP-112, v6 (No EPA Method)	40 mL, VOA vial (amberglass)	(2)	1M NaOH, pH>10; TSP[3] used in Round 1; Refrigerate ≤6°C	30 days	1, 2, 3, 4
Diesel Range Organics (DRO)	EPA Method 8015D (ORGM-508, V1.0)	1 L, glass bottle[5] (amber)	(2)	HCl, pH<2; Refrigerate ≤6°C	7 days until extraction; 40 days after extraction	1, 2, 3, 4
Gasoline Range Organics (GRO)	EPA Method 8015D (ORGM-606, v1.0)	40 mL, VOA vial[5] (amber glass)	(2)	No Headspace HCl, pH<2; Refrigerate ≤6°C	14 days	1, 2, 3, 4

Table A2. Sample containers, preservation, and holding times for ground water and surface water samples from the Raton Basin, CO.
(continued)

Sample Type	Analysis Method (Lab Method)	Sample Bottles (# of Bottles[1])		Preservation/Storage	Holding Time(s)	Sampling Round[2]
Glycols	Region III Method[6] (No EPA Method)	40 mL, VOA vial (amber glass)	(2)	Refrigerate ≤6°C	14 days	1, 2, 3, 4
Semivolatile Organic Compounds (SVOC)	EPA Method 8270D (ORGM-515, V1.1)	1 L, glass bottle[5] (amber)	(2)	Refrigerate ≤6°C	7 days until extraction; 30 days after extraction	1, 2, 3, 4
Volatile Organic Compounds (VOC)	EPA Methods 5021A and 8260B (RSKSOP-299, v1)	40 mL, VOA vial (amber glass)	(4)	No Headspace; TSP[3], pH>10; Refrigerate ≤6°C	14 days	1, 2, 3
	EPA Method 8260B (SwRI TAP-01-0404-043)	40 mL, VOA vial (amber glass)	(4)	No Headspace; HCl, pH<2; Refrigerate ≤6°C	14 days	3, 4
δ^2H, δ^{18}O – Stable isotopes of water (filtered)	RSKSOP-296, v1 (No EPA Method)	20 mL, VOA vial (clear glass)	(1)	Refrigerate ≤6°C	Stable	1
	RSKSOP-334, v0 (No EPA Method)	20 mL, VOA vial (clear glass)	(1)	Refrigerate ≤6°C	Stable	2, 3, 4
δ^{13}C – Inorganic Carbon (filtered)	Isotech SOP-100, v0; -104 (No EPA Method)	60 mL, plastic bottle	(1)	Refrigerate ≤6°C	14 days	1, 2, 3, 4

Table A2. Sample containers, preservation, and holding times for ground water and surface water samples from the Raton Basin, CO.

(continued)

Sample Type	Analysis Method (Lab Method)	Sample Bottles (# of Bottles[1])		Preservation/Storage	Holding Time(s)	Sampling Round[2]
$\delta^{13}C$, $\delta^{2}H$ – Methane	Isotech SOP-120, v0; SOP-103, v0; -104 (No EPA Method)	1 L, plastic bottle	(1)	Caplet of benzalkonium chloride; Refrigerate ≤6°C	3 months	1, 2, 3, 4
$^{87}Sr/^{86}Sr$ – Strontium isotopes (filtered)	Thermal Ionization Mass Spectrometry (TIMS) (No EPA Method)	500 mL, plastic bottle	(1)	Refrigerate ≤6°C	6 months	1, 2, 3, 4
$\delta^{34}S$ – Dissolved sulfide	Isotech SOP-119, v0 (No EPA Method)	1 L, plastic bottle	(1)	Zn acetate to fix $H_2S_{(aq)}$ as ZnS; Refrigerate ≤6°C	6 months	1, 2, 3, 4
$\delta^{34}S$, $\delta^{18}O$ – Dissolved sulfate	Isotech SOP-119, v0; -120, v0 (No EPA Method)	1 L, plastic bottle	(1)	Zn acetate to fix $H_2S_{(aq)}$ as ZnS; Refrigerate ≤6°C	6 months	2, 3, 4
Microbial[7]	PCR Assays	1 L, amber plastic bottle (autoclaved)	(2)	Water: Refrigerate ≤6°C Filters: Dry ice or -15°C	Water: 10 days until filtered; Filters: 45 days	1, 2

[1] Spare bottles were available for laboratory QC samples and for replacement of compromised sample containers (broken bottle, QC failures, etc).

[2] Sampling rounds occurred in October 2011, May 2012, November 2012, and April/May 2013.

[3] Trisodium phosphate (TSP).

[4] Above the freezing point of water.

[5] For every 10 samples add two more bottles for one selected sample, or if <10 samples collected, collect two more bottles for one select sample.

[6] EPA Methods 8000C and 8321 were followed for method development and QA/QC; the method was based on ASTM D773-11.

[7] Microbial data are not presented in this report; these analyses were not performed to support the drinking water study.

Table A3. Field QC samples, and acceptance criteria, for ground water analysis

QC Sample	Purpose	Method	Frequency	Acceptance Criteria[1]/ Corrective Actions
Trip Blanks – (VOCs, dissolved gases, only)	Assesses contamination during transportation.	Fill bottles with reagent water, preserve, take into the field, and return without opening.	One in each ice chest with VOC and dissolved gas samples.	<QL Samples are flagged when the analyte concentration was >QL, but <10X the concentration found in the blank.
Equipment Blanks	Assesses contamination from field equipment, sampling procedures, decontamination procedures, sample containers, preservative, and shipping.	Apply only to samples collected via equipment (i.e., filtered samples)[2]. Reagent water is filtered and collected into bottles and preserved same as filtered samples.	One day per sampling.	
Field Blanks[3]	Assesses contamination introduced from a sample container, with the appropriate preservative.	In the field, reagent water is collected into the sample containers and preserved.	One per day of sampling.	
Field Duplicates	Represents precision of field sampling, analysis, and site heterogeneity.	One or more samples collected immediately after original sample.	One in every 10 samples; if <10 samples were collected for a water type (ground or surface), a duplicate was collected for one sample.	RPD<30% for results > 5X the QL. Affected data were flagged as needed.
Temperature Blanks	Measures the temperature of samples in the cooler.	A bottle was filled with reagent water, placed into a cooler prior to sealing, and transported to the analytical facility.	One per cooler.	The temperature was recorded by the receiving lab upon receipt.[4]

[1] Reporting Limit (RL) or Quantitation Limit (QL).

[2] Reagent water was filtered, collected into bottles, and preserved at the same time as filtered water samples.

[3] Blank samples were not required for isotope measurements, including O, H, C, S, and Sr.

[4] The PI was notified if the samples arrived with no ice and/or if the temperature recorded from the temperature blank was >6°C.

Table A4. Anions, DIC, DOC, and nutrient blanks: Raton Basin, CO.

Sample ID	Date Collected	DOC	DIC	$NO_3^- + NO_2^-$	NH_3	Br^-	Cl^-	SO_4^{2-}	F^-
Units		mg/L	mg/L	mg–N/L	mg–N/L	mg/L	mg/L	mg/L	mg/L
October 2011									
RBEqBlk01-1011	10/3/2011	0.08	<1.00	0.14	<0.05	<1.00	<1.00	<1.00	<0.20
RBEqBlk02-1011	10/4/2011	0.13	<1.00	<0.05	<0.05	<1.00	<1.00	<1.00	<0.20
RBEqBlk03-1011	10/5/2011	0.88	<1.00	0.01	0.07	<1.00	<1.00	<1.00	<0.20
RBFBlk01-1011	10/3/2011	<0.50	<1.00	<0.05	<0.05	<1.00	<1.00	<1.00	<0.20
RBFBlk02-1011	10/4/2011	0.08	<1.00	0.28	0.01	<1.00	<1.00	<1.00	<0.20
RBFBlk03-1011	10/6/2011	<0.50	<1.00	<0.05	<0.05	<1.00	<1.00	<1.00	<0.20
MDL		0.07	0.02	0.01	0.01	0.14	0.07	0.14	0.04
QL		0.50	1.00	0.05	0.05	1.00	1.00	1.00	0.20
Detection in Samples		20/22	22/22	8/22	12/22	0/22	22/22	20/22	22/22
Concentration min		0.49	18.4	0.18	0.01	<1.00	1.80	2.08	0.20
Concentration max		4.63	197	0.37	0.61	<1.00	159	445	9.41

Table A4. Anions, DIC, DOC, and nutrient blanks for Round 2 (May 2012): Raton Basin, CO. *(continued)*

Sample ID	Date Collected	DOC	DIC	$NO_3^- + NO_2^-$	NH_3	Br^-	Cl^-	SO_4^{2-}	F^-
Units		mg/L	mg/L	mg–N/L	mg–N/L	mg/L	mg/L	mg/L	mg/L
May 2012									
RBEqBlk01-0512	5/14/2012	<0.50	<1.00	0.14	<0.10	<1.00	<1.00	<1.00	<0.20
RBEqBlk02-0512	5/15/2012	<0.50	<1.00	0.16	<0.10	<1.00	<1.00	<1.00	<0.20
RBEqBlk03-0512	5/16/2012	<0.50	<1.00	<0.10	<0.10	<1.00	<1.00	<1.00	<0.20
RBFBlk01-0512	5/14/2012	<0.50	<1.00	0.13	<0.10	<1.00	<1.00	<1.00	<0.20
RBFBlk02-0512	5/15/2012	<0.50	<1.00	0.15	<0.10	<1.00	<1.00	<1.00	<0.20
RBFBlk03-0512	5/16/2012	<0.50	<1.00	<0.10	<0.10	<1.00	<1.00	<1.00	<0.20
MDL		0.01	0.04	0.01	0.01	0.13	0.11	0.05	0.03
QL		0.50	1.00	0.10	0.10	1.00	1.00	1.00	0.20
Detection in Samples		20/22	22/22	11/22	6/22	2/22	22/22	20/22	22/22
Concentration min		0.65	17.6	0.14	0.12	0.71	1.85	0.55	0.20
Concentration max		3.18	187	0.33	0.58	0.78	159	351	8.50

Table A4. Anions, DIC, DOC, and nutrient blanks for Round 3 (November 2012): Raton Basin, CO. (continued)

Sample ID	Date Collected	DOC	DIC	NO_3^- + NO_2^-	NH_3	Br^-	Cl^-	SO_4^{2-}	F^-
Units		mg/L	mg/L	mg–N/L	mg–N/L	mg/L	mg/L	mg/L	mg/L
November 2012									
RBEqBlk01-1112	11/5/2012	<0.50	<1.00	0.26	<0.10	<1.00	<1.00	<1.00	<0.20
RBEqBlk02-1112	11/6/2012	<0.50	<1.00	1.23	<0.10	<1.00	<1.00	<1.00	<0.20
RBEqBlk03-1112	11/7/2012	2.46	<1.00	0.87	<0.10	<1.00	<1.00	<1.00	<0.20
RBEqBlk04-1112	11/8/2012	<0.50	<1.00	1.23	<0.10	<1.00	<1.00	<1.00	<0.20
RBFBlk01-1112	11/5/2012	<0.50	<1.00	0.78	<0.10	<1.00	<1.00	<1.00	<0.20
RBFBlk02-1112	11/6/2012	<0.50	<1.00	<0.10	<0.10	<1.00	0.96	<1.00	<0.20
RBFBlk03-1112	11/7/2012	<0.50	<1.00	0.73	<0.10	R	R	R	R
RBFBlk04-1112	11/8/2012	<0.50	<1.00	1.08	<0.10	<1.00	0.15	<1.00	<0.20
MDL		0.01	0.04	0.01	0.01	0.17	0.13	0.16	0.05
QL		0.50	1.00	0.10	0.10	1.00	1.00	1.00	0.20
Detection in Samples		22/23	23/23	10/23	7/23	1/23	23/23	21/23	23/23
Concentration min		0.53	20.7	0.16	0.12	0.21	1.16	0.31	0.15
Concentration max		2.86	209	1.15	0.81	0.21	158	349	8.72

R = data rejected for RBFBlk03-1122 because the sample was mistakenly acidified.

Table A4. Anions, DIC, DOC, and nutrient blanks for Round 4 (April/May 2013): Raton Basin, CO.
(continued)

Sample ID	Date Collected	DOC	DIC	NO_3^- + NO_2^-	NH_3	Br^-	Cl^-	SO_4^{2-}	F^-
Units		mg/L	mg/L	mg–N/L	mg–N/L	mg/L	mg/L	mg/L	mg/L
April/May 2013									
RBEqBlk01-0413	4/29/2013	<0.50	<5.00	0.01	<0.10	<1.00	<1.00	<1.00	<0.20
RBEqBlk02-0413	4/30/2013	<0.50	<5.00	<0.10	<0.10	<1.00	<1.00	<1.00	<0.20
RBEqBlk03-0413	5/1/2013	<0.50	<5.00	<0.10	<0.10	<1.00	<1.00	<1.00	<0.20
RBEqBlk04-0413	5/2/2013	<0.50	<5.00	<0.10	<0.10	<1.00	<1.00	<1.00	<0.20
RBFBlk01-0413	4/29/2013	<0.50	<5.00	0.01	<0.10	<1.00	<1.00	<1.00	<0.20
RBFBlk02-0413	4/30/2013	<0.50	<5.00	<0.10	<0.10	<1.00	<1.00	<1.00	<0.20
RBFBlk03-0413	5/1/2013	<0.50	<5.00	0.01	<0.10	<1.00	<1.00	<1.00	<0.20
RBFBlk04-0413	5/2/2013	<0.50	<5.00	<0.10	<0.10	<1.00	<1.00	<1.00	<0.20
MDL		0.05	0.04	0.01	0.02	0.17	0.13	0.16	0.05
QL		0.50	5.00	0.10	0.10	1.00	1.00	1.00	0.20
Detection in Samples		21/23	23/23	4/23	9/23	7/23	23/23	21/23	23/23
Concentration min		0.64	19.7	0.01	0.02	0.26	1.70	0.56	0.23
Concentration max		3.42	213	0.17	0.53	0.74	190	352	8.29

Table A5. Dissolved metals blanks: Raton Basin, CO.

Sample ID	Date Collected	Ag	Al	As	B	Ba	Be	Ca	Cd	Co
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L
October 2011										
RBEqBlk01-1011	10/3/2011	6	<494	<20	<333	<4	<10	<0.29	<4	<4
RBEqBlk02-1011	10/4/2011	<14	<494	<20	<333	<4	<10	<0.29	<4	<4
RBEqBlk03-1011	10/5/2011	<14	<494	<20	<333	<4	<10	<0.29	<4	<4
RBFBlk01-1011	10/3/2011	9	<494	<20	<333	<4	<10	<0.29	<4	<4
RBFBlk02-1011	10/4/2011	<14	<494	<20	<333	<4	<10	<0.29	<4	<4
RBFBlk03-1011	10/6/2011	<14	<494	<20	<333	<4	<10	<0.29	<4	<4
MDL		4	148	6	100	1	3	0.09	1	1
QL		14	494	20	333	4	10	0.29	4	4
Detection in Samples		0/22	0/22	0/22	2/22	22/22	0/22	22/22	0/22	1/22
Concentration min		<14	<494	<20	135	11	<10	1.99	<4	2
Concentration max		<14	<494	<20	219	485	<10	73.9	<4	2

Table A5. Dissolved metals blanks for Round 1 (October 2011): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Cr	Cu	Fe	Hg	K	Li	Mg	Mn	Mo
Units		µg/L	µg/L	µg/L		mg/L		mg/L	µg/L	µg/L
October 2011										
RBEqBlk01-1011	10/3/2011	<7	<20	<67	NA	<0.35	NA	<0.10	<14	<17
RBEqBlk02-1011	10/4/2011	<7	<20	<67	NA	<0.35	NA	<0.10	<14	<17
RBEqBlk03-1011	10/5/2011	<7	<20	<67	NA	<0.35	NA	<0.10	<14	<17
RBFBlk01-1011	10/3/2011	<7	<20	<67	NA	<0.35	NA	<0.10	<14	<17
RBFBlk02-1011	10/4/2011	<7	<20	<67	NA	<0.35	NA	<0.10	<14	<17
RBFBlk03-1011	10/6/2011	<7	<20	<67	NA	<0.35	NA	<0.10	<14	<17
MDL		2	6	20		0.11		0.030	4	5
QL		7	20	67		0.35		0.10	14	17
Detection in Samples		0/22	2/22	10/22		22/22		20/22	13/22	11/22
Concentration min		<7	16	21		0.21		0.03	6	5
Concentration max		<7	30	2,690		2.25		11.9	281	17

NA = not analyzed.

Table A5. Dissolved metals blanks for Round 1 (October 2011): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Na	Ni	P	Pb	S	Sb	Se	Si	Sr
Units		mg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	mg/L	µg/L
October 2011										
RBEqBlk01-1011	10/3/2011	<1.71	<84	<0.06	<17	<0.46	R	<30	<0.43	<4
RBEqBlk02-1011	10/4/2011	<1.71	<84	<0.06	<17	<0.46	R	<30	<0.43	<4
RBEqBlk03-1011	10/5/2011	<1.71	<84	<0.06	<17	<0.46	R	<30	<0.43	<4
RBFBlk01-1011	10/3/2011	<1.71	<84	<0.06	<17	<0.46	R	<30	<0.43	<4
RBFBlk02-1011	10/4/2011	<1.71	<84	<0.06	<17	<0.46	R	<30	<0.43	<4
RBFBlk03-1011	10/6/2011	<1.71	<84	<0.06	<17	<0.46	R	<30	<0.43	<4
MDL		0.51	25	0.02	5	0.14		9	0.130	1
QL		1.71	84	0.06	17	0.46		30	0.43	4
Detection in Samples		22/22	0/22	2/22	0/22	20/22		7/22	22/22	22/22
Concentration min		12.8	<84	0.10	<17	1.46		10	3.0	41
Concentration max		419	<84	0.39	<17	695		32	10.3	1770

R = data rejected.

Table A5. Dissolved metals blanks for Round 1 (October 2011): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Th	Ti	Tl	U	V	Zn
Units			µg/L	µg/L	µg/L	µg/L	µg/L
October 2011							
RBEqBlk01-1011	10/3/2011	NA	<7	<17	<50	<10	<50
RBEqBlk02-1011	10/4/2011	NA	<7	<17	<50	<10	<50
RBEqBlk03-1011	10/5/2011	NA	<7	<17	<50	<10	<50
RBFBlk01-1011	10/3/2011	NA	<7	<17	<50	<10	<50
RBFBlk02-1011	10/4/2011	NA	<7	<17	<50	<10	<50
RBFBlk03-1011	10/6/2011	NA	<7	<17	<50	<10	<50
MDL			2	5	15	3	15
QL			7	17	50	10	50
Detection in Samples			2/22	0/22	2/22	1/22	4/22
Concentration min			3	<17	16	3	22
Concentration max			3	<17	20	3	156

NA = not analyzed.

Table A5. Dissolved metals blanks for Round 2 (May 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Ag	Al	As	B	Ba	Be	Ca	Cd	Co
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L
May 2012										
RBEqBlk01-0512	5/14/2012	<14	5.1	<1.0	<333	<4	<10	<0.29	<1.0	<4
RBEqBlk02-0512	5/15/2012	<14	4.7	<1.0	<333	<4	<10	<0.29	<1.0	<4
RBEqBlk03-0512	5/16/2012	<14	2.5	<1.0	<333	<4	<10	<0.29	<1.0	<4
RBFBlk01-0512	5/14/2012	<14	<20.0	<1.0	<333	<4	<10	<0.29	<1.0	<4
RBFBlk02-0512	5/15/2012	<14	4.6	<1.0	<333	<4	<10	<0.29	<1.0	<4
RBFBlk03-0512	5/16/2012	<14	<20.0	<1.0	<333	<4	<10	<0.29	<1.0	<4
MDL		4	2.2	0.18	100	1	3	0.09	0.06	1
QL		14	20.0	1.0	333	4	10	0.29	1.0	4
Detection in Samples		0/22	2/22	4/22	3/22	22/22	0/22	22/22	0/22	0/22
Concentration min		<14	69.9	1.2	114	16.9	<10	2.5	<1.0	<4
Concentration max		<14	577	2.1	291	561	<10	58.9	<1.0	<4

Table A5. Dissolved metals blanks for Round 2 (May 2012): Raton Basin, CO. *(continued)*

Sample ID	Date Collected	Cr	Cu	Fe	Hg	K	Li	Mg	Mn	Mo
Units		µg/L	µg/L	µg/L		mg/L		mg/L	µg/L	µg/L
May 2012										
RBEqBlk01-0512	5/14/2012	<2.0	<2.0	<67	NA	<0.35	NA	<0.10	<14	<1.0
RBEqBlk02-0512	5/15/2012	<2.0	<2.0	<67	NA	<0.35	NA	<0.10	<14	<1.0
RBEqBlk03-0512	5/16/2012	<2.0	<2.0	<67	NA	<0.35	NA	<0.10	<14	<1.0
RBFBlk01-0512	5/14/2012	<2.0	<2.0	<67	NA	<0.35	NA	<0.10	<14	<1.0
RBFBlk02-0512	5/15/2012	<2.0	<2.0	<67	NA	<0.35	NA	<0.10	<14	<1.0
RBFBlk03-0512	5/16/2012	<2.0	<2.0	<67	NA	<0.35	NA	<0.10	<14	<1.0
MDL		0.06	0.11	20		0.11		0.03	4	0.14
QL		2.0	2.0	67		0.35		0.10	14	1.0
Detection in Samples		1/22	11/22	9/22		22/22		22/22	12/22	13/22
Concentration min		2.1	2.7	22		0.29		0.04	7	1.2
Concentration max		2.1	19.5	11300		3.4		12.7	282	21.2

NA = not analyzed.

Table A5. Dissolved metals blanks for Round 2 (May 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Na	Ni	P	Pb	S	Sb	Se	Si	Sr
Units		mg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	mg/L	µg/L
May 2012										
RBEqBlk01-0512	5/14/2012	<1.71	<1.0	<0.06	<1.0	<0.46	<2.0	R	<0.43	<4
RBEqBlk02-0512	5/15/2012	<1.71	<1.0	<0.06	<1.0	<0.46	<2.0	R	<0.43	<4
RBEqBlk03-0512	5/16/2012	<1.71	<1.0	<0.06	<1.0	<0.46	<2.0	R	<0.43	<4
RBFBlk01-0512	5/14/2012	<1.71	<1.0	<0.06	<1.0	<0.46	<2.0	R	<0.43	<4
RBFBlk02-0512	5/15/2012	<1.71	<1.0	<0.06	<1.0	<0.46	<2.0	R	<0.43	<4
RBFBlk03-0512	5/16/2012	<1.71	<1.0	<0.06	<1.0	<0.46	<2.0	R	<0.43	<4
MDL		0.51	0.11	0.02	0.03	0.14	0.08		0.13	1
QL		1.71	1.0	0.06	1.0	0.46	2.0		0.43	4
Detection in Samples		22/22	4/22	3/22	3/22	22/22	2/22		22/22	22/22
Concentration min		6.9	1.5	0.02	1.2	0.4	0.16		3.08	82.3
Concentration max		432	6.9	0.09	1.9	471	2.3		11.1	1190

R = data rejected.

Table A5. Dissolved metals blanks for Round 2 (May 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Th	Ti	Tl	U	V	Zn
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
May 2012							
RBEqBlk01-0512	5/14/2012	R	<7	<1.0	R	<10	<50
RBEqBlk02-0512	5/15/2012	R	<7	<1.0	R	<10	<50
RBEqBlk03-0512	5/16/2012	R	<7	<1.0	R	<10	<50
RBFBlk01-0512	5/14/2012	R	<7	<1.0	R	<10	<50
RBFBlk02-0512	5/15/2012	R	<7	<1.0	<1.0	<10	<50
RBFBlk03-0512	5/16/2012	R	<7	<1.0	R	<10	<50
MDL			2	0.04	0.04	3	15
QL			7	1.0	1.0	10	50
Detection in Samples			1/22	0/22	3/16	0/22	3/22
Concentration min			10	<1.0	1.5	<10	16
Concentration max			10	<1.0	2.7	<10	284

R = data rejected.

Table A5. Dissolved metals blanks for Round 3 (November 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Ag	Al	As	B	Ba	Be	Ca	Cd	Co
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L
November 2012										
RBEqBlk01-1112	11/5/2012	<10	<20	<0.2	<40	<5	<5	0.03	<0.2	<5
RBEqBlk02-1112	11/6/2012	<10	<20	<0.2	<40	<5	<5	0.07	<0.2	<5
RBEqBlk03-1112	11/7/2012	<10	<20	<0.2	<40	<5	<5	0.02	<0.2	<5
RBEqBlk04-1112	11/8/2012	<10	<20	<0.2	<40	<5	<5	0.04	<0.2	<5
RBFBlk01-1112	11/5/2012	<10	<20	<0.2	<40	<5	<5	0.01	<0.2	<5
RBFBlk02-1112	11/6/2012	<10	<20	<0.2	<40	<5	<5	<0.1	<0.2	<5
RBFBlk03-1112	11/7/2012	<10	<20	<0.2	<40	0.5	<5	0.05	<0.2	<5
RBFBlk04-1112	11/8/2012	<10	6	<0.2	<40	<5	<5	0.03	<0.2	<5
MDL		2	2.5	0.2	5	0.3	0.1	0.01	0.2	1.6
QL		10	20	0.2	40	5	5	0.1	0.2	5
Detection in Samples		0/23	15/23	8/23	7/23	23/23	1/23	23/23	0/23	5/23
Concentration min		<10	3.1	0.26	50.7	18.6	0.25	2.2	<0.2	1.7
Concentration max		<10	18.8	1.8	290	632	0.25	54.9	<0.2	2.7

Table A5. Dissolved metals blanks for Round 3 (November 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Cr	Cu	Fe	Hg	K	Li	Mg	Mn	Mo
Units		µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L
November 2012										
RBEqBlk01-1112	11/5/2012	<2	0.1	<100	0.02	<0.5	<10	<0.05	<5	<0.5
RBEqBlk02-1112	11/6/2012	<2	0.2	<100	0.02	<0.5	<10	0.02	<5	<0.5
RBEqBlk03-1112	11/7/2012	<2	<0.5	<100	0.01	<0.5	<10	<0.05	<5	<0.5
RBEqBlk04-1112	11/8/2012	<2	0.1	<100	0.04	<0.5	<10	<0.05	<5	<0.5
RBFBlk01-1112	11/5/2012	<2	<0.5	<100	0.01	<0.5	<10	<0.05	<5	<0.5
RBFBlk02-1112	11/6/2012	<2	<0.5	<100	0.02	<0.5	<10	<0.05	<5	0.2
RBFBlk03-1112	11/7/2012	<2	2.8	<100	0.03	<0.5	<10	<0.05	<5	0.1
RBFBlk04-1112	11/8/2012	<2	0.8	<100	0.03	<0.5	<10	<0.05	<5	0.6
MDL		0.25	0.1	40	0.01	0.05	0.8	0.01	0.2	0.05
QL		2	0.5	100	0.2	0.5	10	0.05	5	0.5
Detection in Samples		4/23	11/23	8/23	0/23	23/23	21/23	23/23	22/23	23/23
Concentration min		0.3	0.55	48.5	<0.2	0.23	1.2	0.03	0.3	0.4
Concentration max		0.69	11	9760	<0.2	2.6	50.5	12	287	31

Table A5. Dissolved metals blanks for Round 3 (November 2012): Raton Basin, CO. (continued)

Sample ID	Date Collected	Na	Ni	P	Pb	S	Sb	Se	Si	Sr
Units		mg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	mg/L	µg/L
November 2012										
RBEqBlk01-1112	11/5/2012	0.02	<0.2	<0.05	<0.2	NA	<0.2	<2	<0.10	<2
RBEqBlk02-1112	11/6/2012	0.03	0.45	<0.05	<0.2	NA	<0.2	<2	0.01	<2
RBEqBlk03-1112	11/7/2012	0.06	<0.2	<0.05	<0.2	NA	<0.2	<2	<0.10	<2
RBEqBlk04-1112	11/8/2012	0.18	<0.2	0.02	<0.2	NA	<0.2	<2	<0.10	<2
RBFBlk01-1112	11/5/2012	0.02	<0.2	0.01	<0.2	NA	<0.2	<2	<0.10	<2
RBFBlk02-1112	11/6/2012	0.02	<0.2	<0.05	<0.2	NA	<0.2	<2	0.01	<2
RBFBlk03-1112	11/7/2012	<0.25	0.40	0.02	<0.2	NA	<0.2	<2	<0.10	0.33
RBFBlk04-1112	11/8/2012	0.11	0.12	0.03	<0.2	NA	<0.2	<2	<0.10	<2
MDL		0.01	0.1	0.01	0.05		0.1	0.6	0.01	0.2
QL		0.25	0.2	0.05	0.2		0.2	2	0.10	2
Detection in Samples		23/23	21/23	7/23	11/23		2/23	4/23	23/23	23/23
Concentration min		6.9	0.20	0.02	0.09		0.1	0.68	3.2	79.4
Concentration max		506	4.3	0.19	0.68		2.2	1.9	11.1	1,270

NA = not analyzed.

Table A5. Dissolved metals blanks for Round 3 (November 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Th	Ti	Tl	U	V	Zn
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
November 2012							
RBEqBlk01-1112	11/5/2012	<0.2	<5	<0.2	<0.2	<0.2	<5
RBEqBlk02-1112	11/6/2012	<0.2	<5	<0.2	<0.2	<0.2	2
RBEqBlk03-1112	11/7/2012	<0.2	<5	<0.2	<0.2	<0.2	3
RBEqBlk04-1112	11/8/2012	<0.2	<5	<0.2	<0.2	<0.2	2
RBFBlk01-1112	11/5/2012	<0.2	<5	<0.2	<0.2	<0.2	<5
RBFBlk02-1112	11/6/2012	<0.2	<5	<0.2	<0.2	<0.2	<5
RBFBlk03-1112	11/7/2012	<0.2	<5	0.06	<0.2	<0.2	1
RBFBlk04-1112	11/8/2012	<0.2	<5	<0.2	<0.2	<0.2	2
MDL		0.05	0.5	0.05	0.15	0.02	0.6
QL		0.2	5	0.2	0.2	0.2	5
Detection in Samples		0/23	1/23	0/23	8/23	22/23	10/23
Concentration min		<0.2	0.52	<0.2	0.15	0.02	1.1
Concentration max		<0.2	0.52	<0.2	3.7	2.3	88.6

Table A5. Dissolved metals blanks for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Ag	Al	As	B	Ba	Be	Ca	Cd	Co
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L
April/May 2013										
RBEqBlk01-0413	4/29/2013	<10	49	<0.2	<40	<5	0.1	0.01	<0.2	<5
RBEqBlk02-0413	4/30/2013	<10	34	<0.2	<40	<5	<5	0.01	<0.2	<5
RBEqBlk03-0413	5/1/2013	1.2	38	<0.2	<40	<5	0.1	0.02	<0.2	<5
RBEqBlk04-0413	5/2/2013	<10	36	<0.2	<40	<5	<5	0.02	<0.2	<5
RBFBlk01-0413	4/29/2013	<10	36	<0.2	<40	<5	<5	0.01	<0.2	<5
RBFBlk02-0413	4/30/2013	<10	38	<0.2	<40	<5	<5	0.01	<0.2	<5
RBFBlk03-0413	5/1/2013	<10	37	<0.2	<40	<5	0.1	0.01	<0.2	<5
RBFBlk04-0413	5/2/2013	<10	<20	<0.2	<40	<5	<5	0.04	<0.2	<5
MDL		0.6	4	0.04	4	0.1	0.1	0.009	0.15	1
QL		10	20	0.2	40	5	5	0.1	0.2	5
Detection in Samples		2/23	8/23	19/23	11/23	23/23	1/23	23/23	0/23	1/23
Concentration min		0.98	27.8	0.05	40.4	18.4	0.14	1.98	<0.2	1.2
Concentration max		1.1	46.7	2.2	310	635	0.14	54.4	<0.2	1.2

Table A5. Dissolved metals blanks for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Cr	Cu	Fe	Hg	K	Li	Mg	Mn	Mo
Units		µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L
April/May 2013										
RBEqBlk01-0413	4/29/2013	1.6	2.8	<100	<0.2	<0.50	<10	<0.05	<5	<0.5
RBEqBlk02-0413	4/30/2013	0.6	<0.5	<100	<0.2	<0.50	<10	<0.05	<5	<0.5
RBEqBlk03-0413	5/1/2013	0.8	0.7	<100	<0.2	<0.50	<10	<0.05	<5	<0.5
RBEqBlk04-0413	5/2/2013	0.6	<0.5	<100	<0.2	<0.50	<10	<0.05	<5	<0.5
RBFBlk01-0413	4/29/2013	0.7	<0.5	<100	<0.2	<0.50	<10	<0.05	<5	<0.5
RBFBlk02-0413	4/30/2013	0.7	<0.5	<100	<0.2	<0.50	<10	<0.05	<5	<0.5
RBFBlk03-0413	5/1/2013	0.7	<0.5	<100	<0.2	<0.50	<10	<0.05	<5	<0.5
RBFBlk04-0413	5/2/2013	0.3	<0.5	<100	<0.2	<0.50	<10	<0.05	<5	<0.5
MDL		0.25	0.4	14	0.01	0.05	0.4	0.007	0.2	0.1
QL		2	0.5	100	0.2	0.5	10	0.05	5	0.5
Detection in Samples		0/23	14/23	8/23	0/23	23/23	8/23	23/23	23/23	21/23
Concentration min		<2	0.48	76	<0.2	0.26	12.7	0.04	0.39	0.54
Concentration max		<2	7.6	2040	<0.2	2.6	80.7	13.1	264	14.1

Table A5. Dissolved metals blanks for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Na	Ni	P	Pb	S	Sb	Se	Si	Sr
Units		mg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	mg/L	µg/L
April/May 2013										
RBEqBlk01-0413	4/29/2013	<0.25	0.56	0.01	<0.2	NA	<0.2	<2	<0.10	0.5
RBEqBlk02-0413	4/30/2013	<0.25	<0.2	0.02	<0.2	NA	<0.2	<2	<0.10	0.4
RBEqBlk03-0413	5/1/2013	<0.25	0.29	0.01	<0.2	NA	<0.2	<2	<0.10	0.5
RBEqBlk04-0413	5/2/2013	<0.25	0.15	0.02	<0.2	NA	<0.2	<2	0.02	0.4
RBFBlk01-0413	4/29/2013	<0.25	0.20	0.01	<0.2	NA	<0.2	<2	<0.10	0.4
RBFBlk02-0413	4/30/2013	<0.25	0.18	0.01	<0.2	NA	<0.2	<2	<0.10	0.4
RBFBlk03-0413	5/1/2013	<0.25	0.24	0.02	<0.2	NA	<0.2	<2	<0.10	0.4
RBFBlk04-0413	5/2/2013	<0.25	<0.2	<0.05	<0.2	NA	<0.2	<2	<0.10	<2
MDL		0.01	0.15	0.005	0.15		0.05	0.4	0.005	0.05
QL		0.25	0.2	0.05	0.2		0.2	2	0.10	2
Detection in Samples		23/23	21/23	3/23	7/23		4/23	6/23	23/23	23/23
Concentration min		7.1	0.16	0.06	0.18		0.06	0.41	3.1	69.1
Concentration max		510	8.7	0.15	1.6		2.7	2.2	10.5	1,170

NA = not analyzed.

Table A5. Dissolved metals blanks for Round 4 (April/May 2013): Raton Basin, CO

(continued)

Sample ID	Date Collected	Th	Ti	Tl	U	V	Zn
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
April/May 2013							
RBEqBlk01-0413	4/29/2013	<0.2	<5	<0.2	0.10	<0.2	1.2
RBEqBlk02-0413	4/30/2013	<0.2	<5	<0.2	<0.2	<0.2	1.2
RBEqBlk03-0413	5/1/2013	0.38	<5	<0.2	<0.2	<0.2	1.9
RBEqBlk04-0413	5/2/2013	<0.2	<5	<0.2	<0.2	<0.2	1.2
RBFBlk01-0413	4/29/2013	<0.2	<5	<0.2	<0.2	<0.2	<5
RBFBlk02-0413	4/30/2013	<0.2	<5	<0.2	<0.2	<0.2	0.6
RBFBlk03-0413	5/1/2013	<0.2	<5	<0.2	<0.2	<0.2	<5
RBFBlk04-0413	5/2/2013	<0.2	<5	<0.2	<0.2	<0.2	<5
MDL		0.05	0.2	0.05	0.05	0.02	0.5
QL		0.2	5	0.2	0.2	0.2	5
Detection in Samples		2/23	5/23	0/23	8/23	23/23	9/23
Concentration min		0.32	0.22	<0.2	0.09	0.02	5.4
Concentration max		0.36	0.98	<0.2	3.8	1.1	75.9

Table A6. Total metals blanks: Raton Basin, CO.

Sample ID	Date Collected	Ag	Al	As	B	Ba	Be	Ca	Cd	Co
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L
October 2011										
RBEqBlk01-1011	10/3/2011	<16	<548	<22	<370	<4	<11	0.1	<4	<4
RBEqBlk02-1011	10/4/2011	<16	<548	<22	<370	<4	<11	<0.32	<4	<4
RBEqBlk03-1011	10/5/2011	<16	<548	<22	<370	<4	<11	<0.32	<4	<4
RBFBlk01-1011	10/3/2011	<16	<548	<22	<370	<4	<11	<0.32	<4	<4
RBFBlk02-1011	10/4/2011	<16	<548	<22	<370	<4	<11	<0.32	<4	<4
RBFBlk03-1011	10/6/2011	<16	<548	<22	<370	<4	<11	<0.32	<4	<4
MDL		4	164	7	111	1	3	0.1	1	1
QL		16	548	22	370	4	11	0.32	4	4
Detection in Samples		0/22	4/22	0/22	2/22	22/22	0/22	22/22	2/22	0/22
Concentration min		<16	204	<22	139	20	<11	2.47	1.0	<4
Concentration max		<16	2,290	<22	217	486	<11	75.7	1.0	<4

Table A6. Total metals blanks for Round 1 (October 2011): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Cr	Cu	Fe	Hg	K	Li	Mg	Mn	Mo
Units		µg/L	µg/L	µg/L		mg/L	µg/L	mg/L	µg/L	µg/L
October 2011										
RBEqBlk01-1011	10/3/2011	<8	<22	<74	NA	<0.39	NA	<0.11	<16	<19
RBEqBlk02-1011	10/4/2011	<8	7	<74	NA	<0.39	NA	<0.11	<16	<19
RBEqBlk03-1011	10/5/2011	<8	<22	<74	NA	<0.39	NA	<0.11	<16	<19
RBFBlk01-1011	10/3/2011	<8	<22	<74	NA	<0.39	NA	<0.11	<16	<19
RBFBlk02-1011	10/4/2011	<8	7	<74	NA	<0.39	NA	<0.11	<16	<19
RBFBlk03-1011	10/6/2011	<8	<22	<74	NA	<0.39	NA	<0.11	<16	<19
MDL		2	7	22		0.12		0.03	4	6
QL		8	22	74		0.39		0.11	16	19
Detection in Samples		3/22	9/22	17/22		22/22		22/22	15/22	1/22
Concentration min		3	8	28		0.29		0.04	6	16
Concentration max		5	41	4280		2.36		12	292	16

NA = not analyzed.

Table A6. Total metals blanks for Round 1 (October 2011): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Na	Ni	P	Pb	S	Sb	Se	Si	Sr
Units		mg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	mg/L	µg/L
October 2011										
RBEqBlk01-1011	10/3/2011	<1.90	<93	<0.07	<19	<0.51	R	<33	<0.48	<4
RBEqBlk02-1011	10/4/2011	<1.90	<93	<0.07	<19	<0.51	R	<33	<0.48	<4
RBEqBlk03-1011	10/5/2011	<1.90	<93	<0.07	<19	<0.51	R	<33	<0.48	<4
RBFBlk01-1011	10/3/2011	<1.90	<93	<0.07	<19	<0.51	R	<33	<0.48	<4
RBFBlk02-1011	10/4/2011	<1.90	<93	<0.07	<19	<0.51	R	<33	<0.48	<4
RBFBlk03-1011	10/6/2011	<1.90	<93	<0.07	<19	<0.51	R	<33	<0.48	<4
MDL		0.57	28	0.02	6	0.15		10	0.14	1
QL		1.90	93	0.07	19	0.51		33	0.48	4
Detection in Samples		22/22	0/22	2/22	0/22	21/22		0/22	22/22	22/22
Concentration min		13.4	<93	0.03	<19	0.23		<33	3.19	59
Concentration max		431	<93	0.11	<19	138		<33	10.6	1,890

R = data rejected.

Table A6. Total metals blanks for Round 1 (October 2011): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Th	Ti	Tl	U	V	Zn
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
October 2011							
RBEqBlk01-1011	10/3/2011	NA	<8	<19	<56	<11	<56
RBEqBlk02-1011	10/4/2011	NA	<8	<19	<56	<11	<56
RBEqBlk03-1011	10/5/2011	NA	<8	<19	<56	<11	<56
RBFBlk01-1011	10/3/2011	NA	<8	<19	<56	<11	<56
RBFBlk02-1011	10/4/2011	NA	<8	<19	<56	<11	<56
RBFBlk03-1011	10/6/2011	NA	<8	<19	<56	<11	<56
MDL			2	6	17	3	17
QL			8	19	56	11	56
Detection in Samples			6/22	0/22	0/22	1/22	4/22
Concentration min			2	<19	<56	4	21
Concentration max			74	<19	<56	4	998

NA = not analyzed.

Table A6. Total metals blanks for Round 2 (May 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Ag	Al	As	B	Ba	Be	Ca	Cd	Co
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L
May 2012										
RBEqBlk01-0512	5/14/2012	<16	<20.0	<1.0	<370	<4	<11	<0.32	<1.0	<4
RBEqBlk02-0512	5/15/2012	<16	<20.0	<1.0	<370	<4	<11	<0.32	<1.0	<4
RBEqBlk03-0512	5/16/2012	<16	<20.0	<1.0	<370	<4	<11	<0.32	<1.0	<4
RBFBlk01-0512	5/14/2012	<16	<20.0	<1.0	<370	<4	<11	<0.32	<1.0	<4
RBFBlk02-0512	5/15/2012	<16	<20.0	<1.0	<370	<4	<11	<0.32	<1.0	<4
RBFBlk03-0512	5/16/2012	<16	<20.0	<1.0	<370	<4	<11	<0.32	<1.0	<4
MDL		4	2.2	0.18	111	1	3	0.10	0.06	1
QL		16	20.0	1.0	370	4	11	0.32	1.0	4
Detection in Samples		0/22	10/22	5/22	3/22	22/22	0/22	22/22	0/22	0/22
Concentration min		<16	24.0	1.1	116	18.3	<11	2.55	<1.0	<4
Concentration max		<16	810	1.6	292	589	<11	57.5	<1.0	<4

Table A6. Total metals blanks for Round 2 (May 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Cr	Cu	Fe	Hg	K	Li	Mg	Mn	Mo
Units		µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L
May 2012										
RBEqBlk01-0512	5/14/2012	<2.0	<2.0	<74	NA	<0.39	NA	<0.11	<16	<1.0
RBEqBlk02-0512	5/15/2012	<2.0	<2.0	<74	NA	<0.39	NA	<0.11	<16	<1.0
RBEqBlk03-0512	5/16/2012	<2.0	<2.0	<74	NA	<0.39	NA	<0.11	<16	<1.0
RBFBlk01-0512	5/14/2012	<2.0	<2.0	<74	NA	<0.39	NA	<0.11	<16	<1.0
RBFBlk02-0512	5/15/2012	<2.0	3.0	<74	NA	<0.39	NA	<0.11	<16	<1.0
RBFBlk03-0512	5/16/2012	<2.0	<2.0	<74	NA	<0.39	NA	<0.11	<16	<1.0
MDL		0.06	0.11	22		0.12		0.03	4	0.14
QL		2.0	2.0	74		0.39		0.11	16	1.0
Detection in Samples		3/22	13/22	19/22		22/22		18/22	15/22	13/22
Concentration min		2.4	2.5	25		0.29		0.16	5	1.1
Concentration max		3.8	20.5	12,200		2.97		12.1	286	30.4

NA = not analyzed.

Table A6. Total metals blanks for Round 2 (May 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Na	Ni	P	Pb	S	Sb	Se	Si	Sr
Units		mg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	mg/L	µg/L
May 2012										
RBEqBlk01-0512	5/14/2012	<1.90	<1.0	<0.07	<1.0	<0.51	<2.0	<5.0	<0.48	<4
RBEqBlk02-0512	5/15/2012	<1.90	<1.0	<0.07	<1.0	<0.51	<2.0	<5.0	<0.48	<4
RBEqBlk03-0512	5/16/2012	<1.90	<1.0	<0.07	<1.0	0.18	<2.0	<5.0	<0.48	<4
RBFBlk01-0512	5/14/2012	<1.90	<1.0	<0.07	<1.0	<0.51	<2.0	<5.0	<0.48	<4
RBFBlk02-0512	5/15/2012	<1.90	<1.0	<0.07	<1.0	<0.51	<2.0	<5.0	<0.48	<4
RBFBlk03-0512	5/16/2012	0.78	<1.0	<0.07	<1.0	0.21	<2.0	<5.0	<0.48	<4
MDL		0.57	0.110	0.02	0.03	0.15	0.08	1.2	0.14	1
QL		1.90	1.0	0.07	1.0	0.51	2.0	5.0	0.48	4
Detection in Samples		22/22	4/22	5/22	6/22	19/22	1/22	0/15	22/22	22/22
Concentration min		7.13	1.3	0.02	1.4	0.64	3.5	<5.0	3.1	87
Concentration max		457	8.9	0.10	3.5	104	3.5	<5.0	11.1	1,240

Table A6. Total metals blanks for Round 2 (May 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Th	Ti	Tl	U	V	Zn
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
May 2012							
RBEqBlk01-0512	5/14/2012	<1.0	<8	<1.0	R	<11	<56
RBEqBlk02-0512	5/15/2012	<1.0	<8	<1.0	R	<11	<56
RBEqBlk03-0512	5/16/2012	<1.0	<8	<1.0	R	<11	<56
RBFBlk01-0512	5/14/2012	<1.0	<8	<1.0	R	<11	<56
RBFBlk02-0512	5/15/2012	<1.0	<8	<1.0	R	<11	<56
RBFBlk03-0512	5/16/2012	<1.0	<8	<1.0	R	<11	<56
MDL		0.05	2	0.04		3	17
QL		1.0	8	1.0		11	56
Detection in Samples		11/22	5/22	0/22		1/22	7/22
Concentration min		0.06	5	<1.0		4	17
Concentration max		0.54	67	<1.0		4	196

R = data rejected.

Table A6. Total metals blanks for Round 3 (November 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Ag	Al	As	B	Ba	Be	Ca	Cd	Co
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L
November 2012										
RBEqBlk01-1112	11/5/2012	<10	<20	<0.2	<20	<2.5	<2.5	<0.05	<0.2	<2.5
RBEqBlk02-1112	11/6/2012	<10	<20	<0.2	<20	0.4	<2.5	<0.05	<0.2	<2.5
RBEqBlk03-1112	11/7/2012	<10	<20	<0.2	9	<2.5	<2.5	<0.05	<0.2	<2.5
RBEqBlk04-1112	11/8/2012	<10	34	<0.2	<20	0.6	<2.5	0.03	<0.2	<2.5
RBFBlk01-1112	11/5/2012	<10	<20	<0.2	<20	<2.5	<2.5	<0.05	<0.2	<2.5
RBFBlk02-1112	11/6/2012	<10	<20	<0.2	<20	<2.5	<2.5	<0.05	<0.2	<2.5
RBFBlk03-1112	11/7/2012	<10	100	<0.2	<20	<2.5	<2.5	0.02	<0.2	<2.5
RBFBlk04-1112	11/8/2012	<10	38	<0.2	<20	<2.5	<2.5	0.03	<0.2	<2.5
MDL		2	2.5	0.2	2.7	0.2	0.1	0.01	0.2	1
QL		10	20	0.2	20	2.5	2.5	0.05	0.2	2.5
Detection in Samples		0/23	15/23	10/23	20/23	23/23	0/23	23/23	0/23	2/23
Concentration min		<10	20.1	0.22	6.8	20.3	<2.5	2.16	<0.2	2.1
Concentration max		<10	757	2.0	280	572	<2.5	49.6	<0.2	2.2

Table A6. Total metals blanks for Round 3 (November 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Cr	Cu	Fe	Hg	K	Li	Mg	Mn	Mo
Units		µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L
November 2012										
RBEqBlk01-1112	11/5/2012	<2	0.2	<50	0.05	<0.25	<5	<0.03	<2.5	<0.5
RBEqBlk02-1112	11/6/2012	<2	0.2	<50	0.02	<0.25	<5	<0.03	<2.5	2.0
RBEqBlk03-1112	11/7/2012	<2	0.2	65	0.05	<0.25	<5	<0.03	0.4	<0.5
RBEqBlk04-1112	11/8/2012	<2	0.9	<50	0.06	<0.25	<5	<0.03	0.3	<0.5
RBFBlk01-1112	11/5/2012	<2	0.2	<50	<0.2	<0.25	<5	<0.03	0.3	<0.5
RBFBlk02-1112	11/6/2012	<2	0.2	<50	<0.2	<0.25	<5	<0.03	<2.5	<0.5
RBFBlk03-1112	11/7/2012	<2	1.2	<50	0.05	<0.25	<5	<0.03	<2.5	<0.5
RBFBlk04-1112	11/8/2012	<2	0.9	<50	0.05	<0.25	<5	<0.03	<2.5	<0.5
MDL		0.3	0.1	19	0.01	0.02	0.4	0.01	0.2	0.05
QL		2	0.5	50	0.2	0.25	5	0.03	2.5	0.5
Detection in Samples		7/23	20/23	10/23	0/23	23/23	23/23	23/23	18/23	23/23
Concentration min		0.43	0.5	109	<0.2	0.27	0.7	0.04	1.8	0.38
Concentration max		4.8	16	10,600	<0.2	2.6	54	11.5	260	32.1

Table A6. Total metals blanks for Round 3 (November 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Na	Ni	P	Pb	S	Sb	Se	Si	Sr
Units		mg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	mg/L	µg/L
November 2012										
RBEqBlk01-1112	11/5/2012	<0.13	<0.2	<0.03	<0.2	NA	<0.2	<2	<0.05	<2
RBEqBlk02-1112	11/6/2012	0.04	0.52	<0.03	<0.2	NA	<0.2	<2	<0.05	<2
RBEqBlk03-1112	11/7/2012	0.09	0.11	<0.03	<0.2	NA	<0.2	<2	0.02	<2
RBEqBlk04-1112	11/8/2012	0.22	0.14	0.01	<0.2	NA	<0.2	<2	0.03	<2
RBFBlk01-1112	11/5/2012	<0.13	0.11	<0.03	<0.2	NA	<0.2	<2	<0.05	<2
RBFBlk02-1112	11/6/2012	0.03	0.25	<0.03	<0.2	NA	<0.2	<2	<0.05	<2
RBFBlk03-1112	11/7/2012	0.06	0.18	<0.03	<0.2	NA	<0.2	<2	0.01	<2
RBFBlk04-1112	11/8/2012	0.13	0.15	0.02	<0.2	NA	<0.2	<2	0.01	<2
MDL		0.01	0.1	0.01	0.05		0.1	0.6	0.01	0.2
QL		0.13	0.2	0.03	0.2		0.2	2	0.05	2
Detection in Samples		23/23	23/23	8/23	20/23		2/23	3/23	23/23	23/23
Concentration min		6.8	0.16	0.02	0.06		0.2	0.77	3.31	84.3
Concentration max		530	4.1	0.11	1.8		0.5	2.5	10.4	1,120

NA = not analyzed.

Table A6. Total metals blanks for Round 3 (November 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Th	Ti	Tl	U	V	Zn
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
November 2012							
RBEqBlk01-1112	11/5/2012	<0.2	<2.5	<0.2	<0.2	0.1	<2.5
RBEqBlk02-1112	11/6/2012	<0.2	<2.5	<0.2	<0.2	0.08	4
RBEqBlk03-1112	11/7/2012	<0.2	<2.5	0.24	<0.2	0.1	4
RBEqBlk04-1112	11/8/2012	<0.2	<2.5	<0.2	<0.2	0.2	<2.5
RBFBlk01-1112	11/5/2012	<0.2	<2.5	<0.2	<0.2	0.1	<2.5
RBFBlk02-1112	11/6/2012	<0.2	<2.5	<0.2	<0.2	0.02	<2.5
RBFBlk03-1112	11/7/2012	<0.2	<2.5	0.07	<0.2	0.1	<2.5
RBFBlk04-1112	11/8/2012	<0.2	<2.5	<0.2	<0.2	0.1	<2.5
MDL		0.05	0.25	0.05	0.15	0.02	1.2
QL		0.2	2.5	0.2	0.2	0.2	2.5
Detection in Samples		3/23	12/23	3/23	6/23	21/23	14/23
Concentration min		0.09	0.3	0.08	0.16	0.18	3.1
Concentration max		0.14	7.4	0.15	1.5	2.8	157

Table A6. Total metals blanks for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Ag	Al	As	B	Ba	Be	Ca	Cd	Co
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L
April/May 2013										
RBEqBlk01-0413	4/29/2013	<10	37	0.20	<20	<2.5	<2.5	0.01	<0.2	<2.5
RBEqBlk02-0413	4/30/2013	<10	39	0.22	<20	<2.5	<2.5	<0.05	<0.2	<2.5
RBEqBlk03-0413	5/1/2013	<10	36	<0.2	<20	<2.5	<2.5	<0.05	<0.2	<2.5
RBEqBlk04-0413	5/2/2013	<10	37	0.21	<20	<2.5	<2.5	<0.05	<0.2	<2.5
RBFBlk01-0413	4/29/2013	<10	61	0.21	<20	<2.5	<2.5	<0.05	<0.2	<2.5
RBFBlk02-0413	4/30/2013	<10	35	0.20	<20	<2.5	<2.5	0.01	<0.2	<2.5
RBFBlk03-0413	5/1/2013	<10	37	0.21	<20	<2.5	<2.5	0.01	<0.2	<2.5
RBFBlk04-0413	5/2/2013	<10	36	<0.2	<20	<2.5	<2.5	0.01	<0.2	<2.5
MDL		0.6	4	0.04	2.1	0.2	0.1	0.005	0.15	0.4
QL		10	20	0.2	20	2.5	2.5	0.05	0.2	2.5
Detection in Samples		0/23	16/23	23/23	18/23	23/23	0/23	23/23	1/23	5/23
Concentration min		<10	22.2	0.26	3.3	18.1	<2.5	1.94	0.16	0.65
Concentration max		<10	433	2.4	300	630	<2.5	53.8	0.16	1

Table A6. Total metals blanks for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Cr	Cu	Fe	Hg	K	Li	Mg	Mn	Mo
Units		µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L
April/May 2013										
RBEqBlk01-0413	4/29/2013	<2	<0.5	<50	<0.2	0.03	<5	<0.03	0.18	<0.5
RBEqBlk02-0413	4/30/2013	<2	<0.5	<50	<0.2	<0.25	<5	<0.03	<2.5	<0.5
RBEqBlk03-0413	5/1/2013	0.7	<0.5	<50	<0.2	0.02	<5	<0.03	<2.5	<0.5
RBEqBlk04-0413	5/2/2013	0.6	<0.5	<50	<0.2	0.02	<5	<0.03	<2.5	<0.5
RBFBlk01-0413	4/29/2013	0.4	<0.5	<50	<0.2	<0.25	<5	<0.03	<2.5	<0.5
RBFBlk02-0413	4/30/2013	0.4	<0.5	<50	<0.2	<0.25	<5	<0.03	<2.5	<0.5
RBFBlk03-0413	5/1/2013	0.5	4.7	<50	<0.2	<0.25	<5	<0.03	<2.5	<0.5
RBFBlk04-0413	5/2/2013	0.3	<0.5	<50	<0.2	<0.25	<5	<0.03	<2.5	<0.5
MDL		0.25	0.4	7	0.01	0.02	0.2	0.002	0.1	0.1
QL		2	0.5	50	0.2	0.25	5	0.03	2.5	0.5
Detection in Samples		3/23	19/23	20/23	0/23	23/23	15/23	23/23	20/23	23/23
Concentration min		2.3	0.74	8.1	<0.2	0.33	3.1	0.07	3.5	0.52
Concentration max		78.2	17.9	8,190	<0.2	2.7	46.2	12.9	282	14.8

Table A6. Total metals blanks for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Na	Ni	P	Pb	S	Sb	Se	Si	Sr
Units		mg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	mg/L	µg/L
April/May 2013										
RBEqBlk01-0413	4/29/2013	0.01	<0.2	<0.03	<0.2	NA	<0.2	0.70	0.02	<25
RBEqBlk02-0413	4/30/2013	0.01	<0.2	<0.03	<0.2	NA	<0.2	<2	0.02	<25
RBEqBlk03-0413	5/1/2013	<0.13	<0.2	<0.03	<0.2	NA	<0.2	<2	<0.05	<25
RBEqBlk04-0413	5/2/2013	<0.13	<0.2	<0.03	<0.2	NA	<0.2	<2	<0.05	<25
RBFBlk01-0413	4/29/2013	<0.13	<0.2	<0.03	<0.2	NA	<0.2	<2	0.01	<25
RBFBlk02-0413	4/30/2013	<0.13	<0.2	<0.03	<0.2	NA	<0.2	<2	<0.05	<25
RBFBlk03-0413	5/1/2013	<0.13	<0.2	<0.03	<0.2	NA	<0.2	<2	<0.05	<25
RBFBlk04-0413	5/2/2013	<0.13	<0.2	<0.03	<0.2	NA	<0.2	0.42	<0.05	<25
MDL		0.004	0.15	0.002	0.15		0.05	0.4	0.002	0.05
QL		0.13	0.2	0.03	0.2		0.2	2	0.05	25
Detection in Samples		23/23	23/23	8/23	14/23		7/23	8/23	23/23	23/23
Concentration min		7.8	0.25	0.003	0.15		0.06	0.43	3.1	71.9
Concentration max		500	46	0.105	1.8		3.0	2.5	10.4	1,230

NA = not analyzed.

Table A6. Total metals blanks for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Th	Ti	Tl	U	V	Zn
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
April/May 2013							
RBEqBlk01-0413	4/29/2013	<0.2	<2.5	<0.2	<0.2	0.42	4.4
RBEqBlk02-0413	4/30/2013	<0.2	<2.5	<0.2	<0.2	0.42	2.8
RBEqBlk03-0413	5/1/2013	0.32	<2.5	<0.2	<0.2	0.42	3.8
RBEqBlk04-0413	5/2/2013	<0.2	<2.5	<0.2	<0.2	0.40	3.1
RBFBlk01-0413	4/29/2013	<0.2	<2.5	<0.2	<0.2	0.42	0.5
RBFBlk02-0413	4/30/2013	<0.2	<2.5	<0.2	<0.2	0.39	<2.5
RBFBlk03-0413	5/1/2013	<0.2	<2.5	<0.2	<0.2	0.40	<2.5
RBFBlk04-0413	5/2/2013	<0.2	<2.5	<0.2	<0.2	0.32	0.7
MDL		0.05	0.4	0.05	0.05	0.02	0.4
QL		0.2	2.5	0.2	0.2	0.2	2.5
Detection in Samples		3/23	8/23	0/23	14/23	23/23	13/23
Concentration min		0.28	0.5	<0.2	0.06	0.35	2.7
Concentration max		0.34	12.4	<0.2	3.8	2.1	192

Table A7. Volatile organic compound (VOC) blanks: Raton Basin, CO.

Sample ID	Date Collected	ethanol (64-17-5)	isopropanol (67-63-0)	acrylonitrile (107-13-1)	styrene (100-42-5)	acetone (67-64-1)	tert-butyl alcohol (75-65-0)	methyl tert-butyl ether (1634-04-4)	di-isopropyl ether (108-20-3)	ethyl tert-butyl ether (637-92-3)	tert-amyl methyl ether (994-05-8)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1011	10/3/2011	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBEqBlk02-1011	10/4/2011	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBEqBlk03-1011	10/5/2011	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBFBlk01-1011	10/3/2011	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBFBlk02-1011	10/4/2011	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBFBlk03-1011	10/6/2011	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBTripBlk01-1011	10/3/2011	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBTripBlk02-1011	10/4/2011	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBTripBlk03-1011	10/5/2011	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBTripBlk04-1011	10/6/2011	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
MDL		12.4	6.4	6.8	0.16	0.63	2.8	0.41	0.12	0.17	0.15
QL		100	25	25	0.5	1.0	5.0	1.0	1.0	1.0	1.0
Detection in Samples		0/22	0/22	0/22	0/22	0/22	3/22	0/22	0/22	0/22	0/22
Concentration min		<100	<25	<25	<0.5	<1.0	11.7	<1.0	<1.0	<1.0	<1.0
Concentration max		<100	<25	<25	<0.5	<1.0	965	<1.0	<1.0	<1.0	<1.0

Table A7. VOC blanks for Round 1 (October 2011): Raton Basin, CO.

(continued)

Sample ID	Date Collected	vinyl chloride (75-01-4)	1,1-dichloroethene (75-35-4)	carbon disulfide (75-15-0)	methylene chloride (75-09-2)	trans-1,2-dichloroethene (156-60-5)	1,1-dichloroethane (75-34-3)	cis-1,2-dichloroethene (156-59-2)	chloroform (67-66-3)	1,1,1-trichloroethane (71-55-6)	carbon tetrachloride (56-23-5)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1011	10/3/2011	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk02-1011	10/4/2011	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk03-1011	10/5/2011	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk01-1011	10/3/2011	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk02-1011	10/4/2011	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk03-1011	10/6/2011	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk01-1011	10/3/2011	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk02-1011	10/4/2011	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk03-1011	10/5/2011	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk04-1011	10/6/2011	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MDL		0.18		0.07	0.14	0.11	0.08	0.14	0.07	0.09	0.10
QL		0.5		0.5	1.0	0.5	0.5	0.5	0.5	0.5	0.5
Detection in Samples		0/22		0/22	0/22	0/22	0/22	0/22	4/22	0/22	0/22
Concentration min		<0.5		<0.5	<1.0	<0.5	<0.5	<0.5	0.56	<0.5	<0.5
Concentration max		<0.5		<0.5	<1.0	<0.5	<0.5	<0.5	14	<0.5	<0.5

R = data rejected.

Table A7. VOC blanks for Round 1 (October 2011): Raton Basin, CO.
(continued)

Sample ID	Date Collected	benzene (71-43-2)	1,2-dichloroethane (107-06-2)	trichloroethene (79-01-6)	toluene (108-88-3)	1,1,2-trichloroethane (79-00-5)	tetrachloroethene (127-18-4)	chlorobenzene (108-90-7)	ethylbenzene (100-41-4)	m+p xylene (108-38-3, 106-42-3)	o-xylene (95-47-6)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1011	10/3/2011	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBEqBlk02-1011	10/4/2011	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBEqBlk03-1011	10/5/2011	<0.5	<0.5	<0.5	0.24	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBFBlk01-1011	10/3/2011	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBFBlk02-1011	10/4/2011	<0.5	<0.5	<0.5	0.24	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBFBlk03-1011	10/6/2011	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBTripBlk01-1011	10/3/2011	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBTripBlk02-1011	10/4/2011	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBTripBlk03-1011	10/5/2011	<0.5	<0.5	<0.5	0.40	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBTripBlk04-1011	10/6/2011	<0.5	<0.5	<0.5	0.41	R	<0.5	<0.5	<1.0	<2.0	<0.5
MDL		0.07	0.16	0.15	0.10		0.10	0.09	0.07	0.17	0.06
QL		0.5	0.5	0.5	0.5		0.5	0.5	1.0	2.0	0.5
Detection in Samples		2/22	0/22	0/22	4/22		0/22	0/22	0/22	0/22	0/22
Concentration min		0.38	<0.5	<0.5	0.53		<0.5	<0.5	<1.0	<2.0	<0.5
Concentration max		0.98	<0.5	<0.5	4.16		<0.5	<0.5	<1.0	<2.0	<0.5

R = data rejected.

Table A7. VOC blanks for Round 1 (October 2011): Raton Basin, CO.

(continued)

Sample ID	Date Collected	isopropylbenzene (98-82-8)	1,3,5-trimethylbenzene (108-67-8)	1,2,4-trimethylbenzene (95-63-6)	1,3-dichlorobenzene (541-73-1)	1,4-dichlorobenzene (106-46-7)	1,2,3-trimethylbenzene (526-73-8)	1,2-dichlorobenzene (95-50-1)	naphthalene (91-20-3)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1011	10/3/2011	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk02-1011	10/4/2011	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk03-1011	10/5/2011	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk01-1011	10/3/2011	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk02-1011	10/4/2011	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk03-1011	10/6/2011	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk01-1011	10/3/2011	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk02-1011	10/4/2011	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk03-1011	10/5/2011	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk04-1011	10/6/2011	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MDL		0.06	0.06	0.06	0.10	0.08	0.12	0.13	0.12
QL		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Detection in Samples		1/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22
Concentration min		0.31	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Concentration max		0.31	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Table A7. VOC blanks for Round 2 (May 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	ethanol (64-17-5)	isopropanol (67-63-0)	acrylonitrile (107-13-1)	styrene (100-42-5)	acetone (67-64-1)	tert-butyl alcohol (75-65-0)	methyl tert-butyl ether (1634-04-4)	di-isopropyl ether (108-20-3)	ethyl tert-butyl ether (637-92-3)	tert-amyl methyl ether (994-05-8)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0512	5/14/2012	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBEqBlk02-0512	5/15/2012	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBEqBlk03-0512	5/16/2012	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBFBlk01-0512	5/14/2012	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBFBlk02-0512	5/15/2012	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBFBlk03-0512	5/16/2012	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBTripBlk01-0512	5/14/2012	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBTripBlk02-0512	5/15/2012	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBTripBlk03-0512	5/16/2012	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
MDL		12.4	6.4	6.8	0.16	0.63	2.8	0.41	0.12	0.17	0.15
QL		100	25	25	0.5	1.0	5.0	1.0	1.0	1.0	1.0
Detection in Samples		0/22	0/22	0/22	0/22	1/22	5/22	0/22	0/22	0/22	0/22
Concentration min		<100	<25	<25	<0.5	62.3	19.5	<1.0	<1.0	<1.0	<1.0
Concentration max		<100	<25	<25	<0.5	62.3	1310	<1.0	<1.0	<1.0	<1.0

Table A7. VOC blanks for Round 2 (May 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	vinyl chloride (75-01-4)	1,1-dichloroethene (75-35-4)	carbon disulfide (75-15-0)	methylene chloride (75-09-2)	trans-1,2-dichloroethene (156-60-5)	1,1-dichloroethane (75-34-3)	cis-1,2-dichloroethene (156-59-2)	chloroform (67-66-3)	1,1,1-trichloroethane (71-55-6)	carbon tetrachloride (56-23-5)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0512	5/14/2012	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk02-0512	5/15/2012	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk03-0512	5/16/2012	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk01-0512	5/14/2012	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk02-0512	5/15/2012	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk03-0512	5/16/2012	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk01-0512	5/14/2012	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk02-0512	5/15/2012	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk03-0512	5/16/2012	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MDL		0.18	0.11	0.07	0.14	0.11	0.08	0.14	0.07	0.09	0.10
QL		0.5	0.5	0.5	1.0	0.5	0.5	0.5	0.5	0.5	0.5
Detection in Samples		0/22	0/22	0/22	0/22	0/22	0/22	0/22	2/22	0/22	0/22
Concentration min		<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	1.93	<0.5	<0.5
Concentration max		<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	39.0	<0.5	<0.5

Table A7. VOC blanks for Round 2 (May 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	benzene (71-43-2)	1,2-dichloroethane (107-06-2)	trichloroethene (79-01-6)	toluene (108-88-3)	1,1,2-trichloroethane (79-00-5)	tetrachloroethene (127-18-4)	chlorobenzene (108-90-7)	ethylbenzene (100-41-4)	m+p xylene (108-38-3, 106-42-3)	o-xylene (95-47-6)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0512	5/14/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBEqBlk02-0512	5/15/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBEqBlk03-0512	5/16/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBFBlk01-0512	5/14/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBFBlk02-0512	5/15/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBFBlk03-0512	5/16/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBTripBlk01-0512	5/14/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBTripBlk02-0512	5/15/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBTripBlk03-0512	5/16/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
MDL		0.07	0.16	0.10	0.10		0.100	0.090	0.07	0.17	0.06
QL		0.5	0.5	0.5	0.5		0.5	0.5	1.0	2.0	0.5
Detection in Samples		4/22	0/22	0/22	3/22		0/22	0/22	1/22	1/22	0/22
Concentration min		0.66	<0.5	<0.5	1.96		<0.5	<0.5	1.67	2.94	<0.5
Concentration max		1.03	<0.5	<0.5	5.91		<0.5	<0.5	1.67	2.94	<0.5

R = data rejected.

Table A7. VOC blanks for Round 2 (May 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	isopropylbenzene (98-82-8)	1,3,5-trimethylbenzene (108-67-8)	1,2,4-trimethylbenzene (95-63-6)	1,3-dichlorobenzene (541-73-1)	1,4-dichlorobenzene (106-46-7)	1,2,3-trimethylbenzene (526-73-8)	1,2-dichlorobenzene (95-50-1)	naphthalene (91-20-3)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0512	5/14/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk02-0512	5/15/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk03-0512	5/16/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk01-0512	5/14/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk02-0512	5/15/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk03-0512	5/16/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk01-0512	5/14/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk02-0512	5/15/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk03-0512	5/16/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MDL		0.06	0.06	0.06	0.10	0.08	0.12	0.13	0.12
QL		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Detection in Samples		0/22	0/22	1/22	0/22	0/22	0/22	0/22	0/22
Concentration min		<0.5	<0.5	1.96	<0.5	<0.5	<0.5	<0.5	<0.5
Concentration max		<0.5	<0.5	1.96	<0.5	<0.5	<0.5	<0.5	<0.5

Table A7. SwRI VOC blanks for Round 3 (November 2012): Raton Basin, CO. **Primary data set.The Shaw VOC data are presented for comparison.*

Sample ID	Date Collected	ethanol (64-17-5)	isopropanol (67-63-0)	acrylonitrile (107-13-1)	styrene (100-42-5)	acetone (67-64-1)	tert-butyl alcohol (75-65-0)	methyl tert-butyl ether (1634-04-4)	di-isopropyl ether (108-20-3)	ethyl tert-butyl ether (637-92-3)	tert-amyl methyl ether (994-05-8)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1112	11/5/2012	<100	<10	<1.0	NA	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBEqBlk02-1112	11/6/2012	<100	<10	<1.0	NA	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBEqBlk03-1112	11/7/2012	<100	<10	<1.0	NA	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBEqBlk04-1112	11/8/2012	<100	<10	<1.0	NA	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBFBlk01-1112	11/5/2012	<100	<10	<1.0	NA	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBFBlk02-1112	11/6/2012	<100	<10	<1.0	NA	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBFBlk03-1112	11/7/2012	<100	<10	<1.0	NA	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBFBlk04-1112	11/8/2012	<100	<10	<1.0	NA	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBTripBlk01-1112	11/5/2012	<100	<10	<1.0	NA	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBTripBlk02-1112	11/6/2012	<100	<10	<1.0	NA	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBTripBlk03-1112	11/7/2012	<100	<10	<1.0	NA	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBTripBlk04-1112	11/8/2012	<100	<10	<1.0	NA	<1.0	<10	<0.5	<0.5	<0.5	<0.5
MDL		63	7.4	0.07		0.28	4.9	0.07	0.08	0.11	0.11
QL		100	10	1.0		1.0	10	0.5	0.5	0.5	0.5
Detection in Samples		0/23	0/23	0/23		3/23	4/23	0/23	0/23	0/23	0/23
Concentration min		<100	<10	<1.0		0.65	9.1	<0.5	<0.5	<0.5	<0.5
Concentration max		<100	<10	<1.0		1.6	1000	<0.5	<0.5	<0.5	<0.5

Table A7. SwRI VOC blanks for Round 3 (November 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	vinyl chloride (75-01-4)	1,1-dichloroethene (75-35-4)	carbon disulfide (75-15-0)	methylene chloride (75-09-2)	trans-1,2-dichloroethene (156-60-5)	1,1-dichloroethane (75-34-3)	cis-1,2-dichoroethene (156-59-2)	chloroform (67-66-3)	1,1,1-trichloroethane (71-55-6)	carbon tetrachloride (56-23-5)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk02-1112	11/6/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk03-1112	11/7/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk04-1112	11/8/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk01-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk02-1112	11/6/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk03-1112	11/7/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk04-1112	11/8/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk01-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk02-1112	11/6/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk03-1112	11/7/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk04-1112	11/8/2012	<0.5	<0.5	0.11	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MDL		0.14	0.09	0.10	0.10	0.07	0.06	0.10	0.05	0.09	0.09
QL		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Detection in Samples		0/23	0/23	9/23	3/23	0/23	0/23	0/23	6/23	0/23	0/23
Concentration min		<0.5	<0.5	0.12	0.11	<0.5	<0.5	<0.5	0.19	<0.5	<0.5
Concentration max		<0.5	<0.5	0.71	2.1	<0.5	<0.5	<0.5	4.1	<0.5	<0.5

Table A7. SwRI VOC blanks for Round 3 (November 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	benzene (71-43-2)	1,2-dichloroethane (107-06-2)	trichloroethene (79-01-6)	toluene (108-88-3)	1,1,2-trichloroethane (79-00-5)	tetrachloroethene (127-18-4)	chlorobenzene (108-90-7)	ethylbenzene (100-41-4)	m+p xylene (179601-23-1)	o-xylene (95-47-6)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBEqBlk02-1112	11/6/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBEqBlk03-1112	11/7/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBEqBlk04-1112	11/8/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBFBlk01-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBFBlk02-1112	11/6/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBFBlk03-1112	11/7/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBFBlk04-1112	11/8/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBTripBlk01-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBTripBlk02-1112	11/6/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBTripBlk03-1112	11/7/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBTripBlk04-1112	11/8/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
MDL		0.05	0.04	0.12	0.07	0.07	0.13	0.08	0.06	0.15	0.06
QL		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0	0.5
Detection in Samples		3/23	0/23	0/23	6/23	0/23	0/23	0/23	1/23	1/23	2/23
Concentration min		0.07	<0.5	<0.5	0.08	<0.5	<0.5	<0.5	0.06	0.20	0.08
Concentration max		0.84	<0.5	<0.5	1.8	<0.5	<0.5	<0.5	0.06	0.20	0.10

Table A7. SwRI VOC blanks for Round 3 (November 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	isopropylbenzene (98-82-8)	1,3,5-trimethylbenzene (108-67-8)	1,2,4-trimethylbenzene (95-63-6)	1,3-dichlorobenzene (541-73-1)	1,4-dichlorobenzene (106-46-7)	1,2,3-trimethylbenzene (526-73-8)	1,2-dichlorobenzene (95-50-1)	naphthalene (91-20-3)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk02-1112	11/6/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk03-1112	11/7/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk04-1112	11/8/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk01-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk02-1112	11/6/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk03-1112	11/7/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk04-1112	11/8/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk01-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk02-1112	11/6/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk03-1112	11/7/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk04-1112	11/8/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MDL		0.07	0.08	0.03	0.09	0.07	0.15	0.05	0.08
QL		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Detection in Samples		0/23	0/23	1/23	0/23	0/23	4/23	1/23	2/23
Concentration min		<0.5	<0.5	0.13	<0.5	<0.5	0.08	0.08	0.73
Concentration max		<0.5	<0.5	0.13	<0.5	<0.5	0.16	0.08	0.78

Table A7. Shaw VOC blanks for Round 3 (November 2012): Raton Basin, CO.

**The SwRI VOC data is the primary data set; the Shaw VOC data is presented for comparison.*

Sample ID	Date Collected	ethanol (64-17-5)	isopropanol (67-63-0)	acrylonitrile (107-13-1)	styrene (100-42-5)	acetone (67-64-1)	tert-butyl alcohol (75-65-0)	methyl tert-butyl ether (1634-04-4)	di-isopropyl ether (108-20-3)	ethyl tert-butyl ether (637-92-3)	tert-amyl methyl ether (994-05-8)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1112	11/5/2012	<200	<25	<25	<0.5	<10	<5.0	<1.0	<1.0	<1.0	<1.0
RBEqBlk02-1112	11/6/2012	<200	<25	<25	<0.5	<10	<5.0	<1.0	<1.0	<1.0	<1.0
RBEqBlk03-1112	11/7/2012	<200	<25	<25	<0.5	<10	<5.0	<1.0	<1.0	<1.0	<1.0
RBEqBlk04-1112	11/8/2012	<200	<25	<25	<0.5	<10	<5.0	<1.0	<1.0	<1.0	<1.0
RBFBlk01-1112	11/5/2012	<200	<25	<25	<0.5	<10	<5.0	<1.0	<1.0	<1.0	<1.0
RBFBlk02-1112	11/6/2012	<200	<25	<25	<0.5	<10	<5.0	<1.0	<1.0	<1.0	<1.0
RBFBlk03-1112	11/7/2012	<200	<25	<25	<0.5	<10	<5.0	<1.0	<1.0	<1.0	<1.0
RBFBlk04-1112	11/8/2012	<200	<25	<25	<0.5	<10	<5.0	<1.0	<1.0	<1.0	<1.0
RBTripBlk01-1112	11/5/2012	<200	<25	<25	<0.5	<10	<5.0	<1.0	<1.0	<1.0	<1.0
RBTripBlk02-1112	11/6/2012	<200	<25	<25	<0.5	<10	<5.0	<1.0	<1.0	<1.0	<1.0
RBTripBlk03-1112	11/7/2012	<200	<25	<25	<0.5	<10	<5.0	<1.0	<1.0	<1.0	<1.0
RBTripBlk04-1112	11/8/2012	<200	<25	<25	<0.5	<10	<5.0	<1.0	<1.0	<1.0	<1.0
MDL		35.5	16.8	9.09	0.06	4.35	2.66	0.09	0.15	0.28	0.10
QL		200	25	25	0.5	10	5.0	1.0	1.0	1.0	1.0
Detection in Samples		0/23	0/23	0/23	0/23	0/23	3/23	0/23	0/23	0/23	0/23
Concentration min		<200	<25	<25	<0.5	<10	34.8	<1.0	<1.0	<1.0	<1.0
Concentration max		<200	<25	<25	<0.5	<10	958	<1.0	<1.0	<1.0	<1.0

Table A7. Shaw VOC blanks for Round 3 (November 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	vinyl chloride (75-01-4)	1,1-dichloroethene (75-35-4)	carbon disulfide (75-15-0)	methylene chloride (75-09-2)	trans-1,2-dichloroethene (156-60-5)	1,1-dichloroethane (75-34-3)	cis-1,2-dichloroethene (156-59-2)	chloroform (67-66-3)	1,1,1-trichloroethane (71-55-6)	carbon tetrachloride (56-23-5)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1112	11/5/2012	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk02-1112	11/6/2012	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk03-1112	11/7/2012	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk04-1112	11/8/2012	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk01-1112	11/5/2012	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk02-1112	11/6/2012	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk03-1112	11/7/2012	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk04-1112	11/8/2012	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk01-1112	11/5/2012	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk02-1112	11/6/2012	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk03-1112	11/7/2012	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk04-1112	11/8/2012	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MDL		0.12		0.05	0.17	0.17	0.09	0.15	0.09	0.17	0.12
QL		0.5		0.5	1.0	0.5	0.5	0.5	0.5	0.5	0.5
Detection in Samples		0/23		0/23	1/23	0/23	0/23	0/23	3/23	0/23	0/23
Concentration min		<0.5		<0.5	1.5	<0.5	<0.5	<0.5	0.98	<0.5	<0.5
Concentration max		<0.5		<0.5	1.5	<0.5	<0.5	<0.5	3.56	<0.5	<0.5

R = data rejected.

Table A7. Shaw VOC blanks for Round 3 (November 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	benzene (71-43-2)	1,2-dichloroethane (107-06-2)	trichloroethene (79-01-6)	toluene (108-88-3)	1,1,2-trichloroethane (79-00-5)	tetrachloroethene (127-18-4)	chlorobenzene (108-90-7)	ethylbenzene (100-41-4)	m+p xylene (108-38-3, 106-42-3)	o-xylene (95-47-6)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBEqBlk02-1112	11/6/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBEqBlk03-1112	11/7/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBEqBlk04-1112	11/8/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBFBlk01-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBFBlk02-1112	11/6/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBFBlk03-1112	11/7/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBFBlk04-1112	11/8/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBTripBlk01-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBTripBlk02-1112	11/6/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBTripBlk03-1112	11/7/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBTripBlk04-1112	11/8/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
MDL		0.11	0.21	0.10	0.09		0.10	0.10	0.06	0.14	0.03
QL		0.5	0.5	0.5	0.5		0.5	0.5	1.00	2.0	0.5
Detection in Samples		2/23	0/23	0/23	3/23		0/23	0/23	0/23	0/23	1/23
Concentration min		0.39	<0.5	<0.5	1.83		<0.5	<0.5	<1.0	<2.0	2.18
Concentration max		0.61	<0.5	<0.5	3.17		<0.5	<0.5	<1.0	<2.0	2.18

R = data rejected.

Table A7. Shaw VOC blanks for Round 3 (November 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	isopropylbenzene (98-82-8)	1,3,5-trimethylbenzene (108-67-8)	1,2,4-trimethylbenzene (95-63-6)	1,3-dichlorobenzene (541-73-1)	1,4-dichlorobenzene (106-46-7)	1,2,3-trimethylbenzene (526-73-8)	1,2-dichlorobenzene (95-50-1)	naphthalene (91-20-3)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk02-1112	11/6/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk03-1112	11/7/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk04-1112	11/8/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk01-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk02-1112	11/6/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk03-1112	11/7/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk04-1112	11/8/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk01-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk02-1112	11/6/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk03-1112	11/7/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk04-1112	11/8/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MDL		0.07	0.04	0.07	0.10	0.07	0.06	0.09	0.12
QL		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Detection in Samples		0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23
Concentration min		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Concentration max		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Table A7. VOC blanks for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	ethanol (64-17-5)	isopropanol (67-63-0)	acrylonitrile (107-13-1)	styrene (100-42-5)	acetone (67-64-1)	tert-butyl alcohol (75-65-0)	methyl tert-butyl ether (1634-04-4)	di-isopropyl ether (108-20-3)	ethyl tert-butyl ether (637-92-3)	tert-amyl methyl ether (994-05-8)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0413	4/29/2013	<100	<10	<1.0	<0.5	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBEqBlk02-0413	4/30/2013	<100	<10	<1.0	<0.5	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBEqBlk03-0413	5/1/2013	<100	<10	<1.0	<0.5	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBEqBlk04-0413	5/2/2013	<100	<10	<1.0	<0.5	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBFBlk01-0413	4/29/2013	<100	<10	<1.0	<0.5	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBFBlk02-0413	4/30/2013	<100	<10	<1.0	<0.5	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBFBlk03-0413	5/1/2013	<100	<10	<1.0	<0.5	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBFBlk04-0413	5/2/2013	<100	<10	<1.0	<0.5	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBTripBlk01-0413	4/29/2013	<100	<10	<1.0	<0.5	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBTripBlk02-0413	4/30/2013	<100	<10	<1.0	<0.5	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBTripBlk03-0413	5/1/2013	<100	<10	<1.0	<0.5	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBTripBlk04-0413	5/2/2013	<100	<10	<1.0	<0.5	<1.0	<10	<0.5	<0.5	<0.5	<0.5
MDL		63	7.4	0.07	0.05	0.28	4.9	0.07	0.08	0.11	0.51
QL		100	10	1.0	0.5	1.0	10	0.5	0.5	0.5	0.5
Detection in Samples		0/23	0/23	0/23	0/23	2/23	4/23	0/23	0/23	0/23	0/23
Concentration min		<100	<10	<1.0	<0.5	0.16	6.9	<0.5	<0.5	<0.5	<0.5
Concentration max		<100	<10	<1.0	<0.5	0.30	960	<0.5	<0.5	<0.5	<0.5

Table A7. VOC blanks for Round 4 (April/May 2013): Raton Basin, CO.
(continued)

Sample ID	Date Collected	vinyl chloride (75-01-4)	1,1-dichloroethene (75-35-4)	carbon disulfide (75-15-0)	methylene chloride (75-09-2)	trans-1,2-dichloroethene (156-60-5)	1,1-dichloroethane (75-34-3)	cis-1,2-dichoroethene (156-59-2)	chloroform (67-66-3)	1,1,1-trichloroethane (71-55-6)	carbon tetrachloride (56-23-5)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk02-0413	4/30/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk03-0413	5/1/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk04-0413	5/2/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk01-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk02-0413	4/30/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk03-0413	5/1/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk04-0413	5/2/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk01-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk02-0413	4/30/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk03-0413	5/1/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk04-0413	5/2/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MDL		0.14	0.09	0.10	0.10	0.07	0.06	0.10	0.05	0.09	0.09
QL		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Detection in Samples		0/23	0/23	2/23	1/23	0/23	0/23	0/23	8/23	0/23	0/23
Concentration min		<0.5	<0.5	0.22	0.12	<0.5	<0.5	<0.5	0.08	<0.5	<0.5
Concentration max		<0.5	<0.5	0.45	0.12	<0.5	<0.5	<0.5	2.3	<0.5	<0.5

Table A7. VOC blanks for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	benzene (71-43-2)	1,2-dichloroethane (107-06-2)	trichloroethene (79-01-6)	toluene (108-88-3)	1,1,2-trichloroethane (79-00-5)	tetrachloroethene (127-18-4)	chlorobenzene (108-90-7)	ethylbenzene (100-41-4)	m+p xylene (179601-23-1)	o-xylene (95-47-6)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBEqBlk02-0413	4/30/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBEqBlk03-0413	5/1/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBEqBlk04-0413	5/2/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBFBlk01-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBFBlk02-0413	4/30/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBFBlk03-0413	5/1/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBFBlk04-0413	5/2/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBTripBlk01-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBTripBlk02-0413	4/30/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBTripBlk03-0413	5/1/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBTripBlk04-0413	5/2/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
MDL		0.05	0.04	0.12	0.07	0.07	0.13	0.08	0.06	0.15	0.06
QL		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0	0.5
Detection in Samples		3/23	0/23	0/23	4/23	0/23	0/23	0/23	0/23	0/23	0/23
Concentration min		0.25	<0.5	<0.5	0.11	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
Concentration max		0.43	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5

Table A7. VOC blanks for Round 4 (April/May 2013): Raton Basin, CO.
(continued)

Sample ID	Date Collected	isopropylbenzene (98-82-8)	1,3,5-trimethylbenzene (108-67-8)	1,2,4-trimethylbenzene (95-63-6)	1,3-dichlorobenzene (541-73-1)	1,4-dichlorobenzene (106-46-7)	1,2,3-trimethylbenzene (526-73-8)	1,2-dichlorobenzene (95-50-1)	naphthalene (91-20-3)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk02-0413	4/30/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk03-0413	5/1/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBEqBlk04-0413	5/2/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk01-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk02-0413	4/30/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk03-0413	5/1/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBFBlk04-0413	5/2/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk01-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk02-0413	4/30/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk03-0413	5/1/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBTripBlk04-0413	5/2/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MDL		0.07	0.08	0.08	0.09	0.07	0.15	0.05	0.08
QL		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Detection in Samples		0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23
Concentration min		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Concentration max		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Table A8. Low-molecular-weight acid blanks: Raton Basin, CO.

Sample ID	Date Collected	Lactate (50-21-5)	Formate (64-18-6)	Acetate (64-19-7)	Propionate (79-09-4)	Isobutyrate (79-31-2)	Butyrate (107-92-6)
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
RBEqBlk01-1011	10/3/2011	<0.10	<0.10	R	<0.10	<0.10	<0.10
RBEqBlk02-1011	10/4/2011	<0.10	0.05	R	<0.10	<0.10	<0.10
RBEqBlk03-1011	10/5/2011	<0.10	<0.10	R	<0.10	<0.10	<0.10
RBFBlk01-1011	10/3/2011	<0.10	0.07	R	<0.10	<0.10	<0.10
RBFBlk02-1011	10/4/2011	<0.10	0.09	R	<0.10	<0.10	<0.10
RBFBlk03-1011	10/6/2011	<0.10	<0.10	R	<0.10	<0.10	<0.10
MDL		0.01	0.01		0.02	0.01	0.01
QL		0.10	0.10		0.10	0.10	0.10
Detection in Samples		2/22	4/22		0/22	0/22	0/22
Concentration min		0.09	0.06		<0.10	<0.10	<0.10
Concentration max		0.17	0.18		<0.10	<0.10	<0.10

R = data rejected.

Table A8. Low-molecular-weight acid blanks for Rounds 2 (May 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Lactate (50-21-5)	Formate (64-18-6)	Acetate (64-19-7)	Propionate (79-09-4)	Isobutyrate (79-31-2)	Butyrate (107-92-6)
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
RBEqBlk01-0512	5/14/2012	<0.10	R	<0.10	<0.10	<0.10	<0.10
RBEqBlk02-0512	5/15/2012	<0.10	R	<0.10	<0.10	<0.10	<0.10
RBEqBlk03-0512	5/16/2012	<0.10	R	<0.10	<0.10	<0.10	<0.10
RBFBlk01-0512	5/14/2012	<0.10	R	<0.10	<0.10	<0.10	<0.10
RBFBlk02-0512	5/15/2012	<0.10	R	<0.10	<0.10	<0.10	<0.10
RBFBlk03-0512	5/16/2012	<0.10	R	0.06	0.27	<0.10	<0.10
MDL		0.01		0.01	0.02	0.01	0.01
QL		0.10		0.10	0.10	0.10	0.10
Detection in Samples		0/22		4/22	1/22	0/22	0/22
Concentration min		<0.10		0.05	0.14	<0.10	<0.10
Concentration max		<0.10		0.20	0.14	<0.10	<0.10

R = data rejected.

Table A8. Low-molecular-weight acid blanks for Round 3 (November 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Lactate (50-21-5)	Formate (64-18-6)	Acetate (64-19-7)	Propionate (79-09-4)	Isobutyrate (79-31-2)	Butyrate (107-92-6)
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
RBEqBlk01-1112	11/5/2012	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RBEqBlk02-1112	11/6/2012	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RBEqBlk03-1112	11/7/2012	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RBEqBlk04-1112	11/8/2012	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RBFBlk01-1112	11/5/2012	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RBFBlk02-1112	11/6/2012	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RBFBlk03-1112	11/7/2012	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RBFBlk04-1112	11/8/2012	<0.10	NR	<0.10	<0.10	<0.10	<0.10
MDL		0.10		0.10	0.10	0.10	0.10
QL		0.02		0.01	0.02	0.02	0.02
Detection in Samples		1/23		7/23	0/23	0/23	0/23
Concentration min		0.08		0.05	<0.10	<0.10	<0.10
Concentration max		0.08		0.47	<0.10	<0.10	<0.10

NR = not reported.

Table A8. Low-molecular-weight acid blanks for Round 4 (April/May 2013): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Lactate (50-21-5)	Formate (64-18-6)	Acetate (64-19-7)	Propionate (79-09-4)	Isobutyrate (79-31-2)	Butyrate (107-92-6)
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
RBEqBlk01-0413	4/29/2013	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RBEqBlk02-0413	4/30/2013	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RBEqBlk03-0413	5/1/2013	<0.10	NR	<0.10	1.12	<0.10	<0.10
RBEqBlk04-0413	5/2/2013	<0.10	NR	<0.10	2.01	<0.10	<0.10
RBFBlk01-0413	4/29/2013	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RBFBlk02-0413	4/30/2013	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RBFBlk03-0413	5/1/2013	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RBFBlk04-0413	5/2/2013	<0.10	NR	<0.10	1.00	<0.10	<0.10
MDL		0.10		0.10	0.10	0.10	0.10
QL		0.02		0.01	0.02	0.02	0.02
Detection in Samples		0/23		0/23	0/23	0/23	0/23
Concentration min		<0.10		<0.10	<0.10	<0.10	<0.10
Concentration max		<0.10		<0.10	<0.10	<0.10	<0.10

NR = not reported.

Table A9. Dissolved gas blanks: Raton Basin, CO.

Sample ID	Date Collected	Methane (74-82-8)	Ethane (74-84-0)	Propane (74-98-6)	Butane (106-97-8)
Units		mg/L	mg/L	mg/L	mg/L
RBEqBlk01-1011	10/3/2011	0.0009	0.0010	<0.0040	0.0022
RBEqBlk02-1011	10/4/2011	<0.0014	<0.0029	<0.0040	<0.0051
RBEqBlk03-1011	10/5/2011	<0.0014	<0.0029	<0.0040	<0.0051
RBFBlk01-1011	10/3/2011	<0.0014	<0.0029	<0.0040	<0.0051
RBFBlk02-1011	10/4/2011	<0.0014	0.0022	0.0040	0.0018
RBFBlk03-1011	10/6/2011	<0.0014	<0.0029	<0.0040	<0.0051
RBTripBlk01-1011	10/3/2011	0.0029	0.0049	0.0091	0.0071
RBTripBlk02-1011	10/4/2011	0.0044	0.0066	0.0129	0.0104
RBTripBlk03-1011	10/5/2011	<0.0014	<0.0029	<0.0040	<0.0051
RBTripBlk04-1011	10/6/2011	<0.0014	<0.0029	<0.0040	0.0012
MDL		0.0002	0.0008	0.0008	0.0010
QL		0.0014	0.0029	0.0040	0.0051
Detection in Samples		21/22	12/22	3/22	1/22
Concentration min		0.0026	0.0027	0.0046	0.0072
Concentration max		27.80	0.0893	0.0094	0.0072

Table A9. Dissolved gas blanks for Round 2 (May 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Methane (74-82-8)	Ethane (74-84-0)	Propane (74-98-6)	Butane (106-97-8)
Units		mg/L	mg/L	mg/L	mg/L
RBEqBlk01-0512	5/14/2012	<0.0013	<0.0027	<0.0038	<0.0047
RBEqBlk02-0512	5/15/2012	<0.0013	<0.0027	<0.0038	<0.0047
RBEqBlk03-0512	5/16/2012	<0.0013	<0.0027	<0.0038	<0.0047
RBFBlk01-0512	5/14/2012	<0.0013	<0.0027	<0.0038	<0.0047
RBFBlk02-0512	5/15/2012	<0.0013	<0.0027	<0.0038	<0.0047
RBFBlk03-0512	5/16/2012	<0.0013	<0.0027	<0.0038	<0.0047
RBTripBlk01-0512	5/14/2012	<0.0013	<0.0027	<0.0038	<0.0047
RBTripBlk02-0512	5/15/2012	<0.0013	<0.0027	<0.0038	<0.0047
RBTripBlk03-0512	5/16/2012	<0.0013	<0.0027	<0.0038	<0.0047
MDL		0.0003	0.0005	0.0007	0.0007
QL		0.0013	0.0027	0.0038	0.0047
Detection in Samples		22/22	12/22	0/22	0/22
Concentration min		0.0005	0.0006	<0.0038	<0.0047
Concentration max		19.60	0.0180	<0.0038	<0.0047

Table A9. Dissolved gas blanks for Round 3 (November 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Methane (74-82-8)	Ethane (74-84-0)	Propane (74-98-6)	Butane (106-97-8)
Units		mg/L	mg/L	mg/L	mg/L
RBEqBlk01-1112	11/5/2012	<0.0013	<0.0027	<0.0037	<0.0047
RBEqBlk02-1112	11/6/2012	<0.0013	<0.0027	<0.0037	<0.0047
RBEqBlk03-1112	11/7/2012	0.0105	<0.0027	<0.0037	<0.0047
RBEqBlk04-1112	11/8/2012	<0.0013	<0.0027	<0.0037	<0.0047
RBFBlk01-1112	11/5/2012	<0.0013	<0.0027	<0.0037	<0.0047
RBFBlk02-1112	11/6/2012	<0.0013	<0.0027	<0.0037	<0.0047
RBFBlk03-1112	11/7/2012	0.0138	<0.0027	<0.0037	<0.0047
RBFBlk04-1112	11/8/2012	<0.0013	<0.0027	<0.0037	<0.0047
RBTripBlk01-1112	11/5/2012	<0.0013	<0.0027	<0.0037	<0.0047
RBTripBlk02-1112	11/6/2012	<0.0013	<0.0027	<0.0037	<0.0047
RBTripBlk03-1112	11/7/2012	0.0095	<0.0027	<0.0037	<0.0047
RBTripBlk04-1112	11/8/2012	<0.0013	<0.0027	<0.0037	<0.0047
MDL		0.0003	0.0005	0.0007	0.0007
QL		0.0013	0.0027	0.0037	0.0047
Detection in Samples		23/23	11/23	0/23	0/23
Concentration min		0.0044	0.0017	<0.0037	<0.0047
Concentration max		18.70	0.0274	<0.0037	<0.0047

Table A9. Dissolved gas blanks for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Methane (74-82-8)	Ethane (74-84-0)	Propane (74-98-6)	Butane (106-97-8)
Units		mg/L	mg/L	mg/L	mg/L
RBEqBlk01-0413	4/29/2013	<0.0013	<0.0027	<0.0037	<0.0047
RBEqBlk02-0413	4/30/2013	<0.0013	<0.0027	<0.0037	<0.0047
RBEqBlk03-0413	5/1/2013	<0.0013	<0.0027	<0.0037	<0.0047
RBEqBlk04-0413	5/2/2013	<0.0013	<0.0027	<0.0037	<0.0047
RBFBlk01-0413	4/29/2013	<0.0013	<0.0027	<0.0037	<0.0047
RBFBlk02-0413	4/30/2013	<0.0013	<0.0027	<0.0037	<0.0047
RBFBlk03-0413	5/1/2013	<0.0013	<0.0027	<0.0037	<0.0047
RBFBlk04-0413	5/2/2013	<0.0013	<0.0027	<0.0037	<0.0047
RBTripBlk01-0413	4/29/2013	<0.0013	<0.0027	<0.0037	<0.0047
RBTripBlk02-0413	4/30/2013	<0.0013	<0.0027	<0.0037	<0.0047
RBTripBlk03-0413	5/1/2013	<0.0013	<0.0027	<0.0037	<0.0047
RBTripBlk04-0413	5/2/2013	<0.0013	<0.0027	<0.0037	<0.0047
MDL		0.0002	0.0008	0.0004	0.0003
QL		0.0013	0.0027	0.0037	0.0047
Detection in Samples		18/23	6/23	0/23	0/23
Concentration min		0.0142	0.0009	<0.0037	<0.0047
Concentration max		28.90	0.0181	<0.0037	<0.0047

Table A10. Glycol blanks: Raton Basin, CO.

Sample ID	Date Collected	2-butoxyethanol (111-76-2)	Diethylene glycol (111-46-6)	Triethylene glycol (112-27-6)	Tetraethylene glycol (112-60-7)
Units		µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1011	10/3/2011	<5	<25	<25	<25
RBEqBlk02-1011	10/4/2011	<5	<25	<25	<25
RBEqBlk03-1011	10/5/2011	<5	<25	<25	<25
RBFBlk01-1011	10/3/2011	<5	<25	<25	<25
RBFBlk02-1011	10/4/2011	<5	<25	<25	<25
RBFBlk03-1011	10/6/2011	<5	<25	<25	<25
QL		5	25	25	25
Detection in Samples		0/22	0/22	0/22	0/22
Concentration min		<5	<25	<25	<25
Concentration max		<5	<25	<25	<25

Table A10. Glycol blanks for Round 2 (May 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	2-butoxyethanol (111-76-2)	Diethylene glycol (111-46-6)	Triethylene glycol (112-27-6)	Tetraethylene glycol (112-60-7)
Units		µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0512	5/14/2012	<25	<25	<25	<25
RBEqBlk02-0512	5/15/2012	<25	<25	<25	<25
RBEqBlk03-0512	5/16/2012	<25	<25	<25	<25
RBFBlk01-0512	5/14/2012	<25	<25	<25	<25
RBFBlk02-0512	5/15/2012	<25	<25	<25	<25
RBFBlk03-0512	5/16/2012	<25	<25	<25	<25
QL		25	25	25	25
Detection in Samples		0/22	0/22	0/22	0/22
Concentration min		<25	<25	<25	<25
Concentration max		<25	<25	<25	<25

Table A10. Glycol blanks for Round 3 (November 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	2-butoxyethanol (111-76-2)	Diethylene glycol (111-46-6)	Triethylene glycol (112-27-6)	Tetraethylene glycol (112-60-7)
Units		µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1112	11/5/2012	<25	<10	<10	<10
RBEqBlk02-1112	11/6/2012	<25	<10	<10	<10
RBEqBlk03-1112	11/7/2012	<25	<10	<10	<10
RBEqBlk04-1112	11/8/2012	<25	<10	<10	<10
RBFBlk01-1112	11/5/2012	<25	<10	<10	<10
RBFBlk02-1112	11/6/2012	<25	<10	<10	<10
RBFBlk03-1112	11/7/2012	<25	<10	<10	<10
RBFBlk04-1112	11/8/2012	<25	<10	<10	<10
QL		25	10	10	10
Detection in Samples		0/23	0/23	0/23	0/23
Concentration min		<25	<10	<10	<10
Concentration max		<25	<10	<10	<10

Table A10. Glycol blanks for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	2-butoxyethanol (111-76-2)	Diethylene glycol (111-46-6)	Triethylene glycol (112-27-6)	Tetraethylene glycol (112-60-7)
Units		µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0413	4/29/2013	<10	<10	<10	<10
RBEqBlk02-0413	4/30/2013	<10	<10	<10	<10
RBEqBlk03-0413	5/01/2013	<10	<10	<10	<10
RBEqBlk04-0413	5/02/2013	<10	<10	<10	<10
RBFBlk01-0413	4/29/2013	<10	<10	<10	<10
RBFBlk02-0413	4/30/2013	<10	<10	<10	<10
RBFBlk03-0413	5/01/2013	<10	<10	<10	<10
RBFBlk04-0413	5/02/2013	<10	<10	<10	<10
QL		10	10	10	10
Detection in Samples		0/23	1/23	1/23	0/23
Concentration min		<10	1.1	2.6	<10
Concentration max		<10	1.1	2.6	<10

Table A11. Semivolatile organic compound (SVOC) blanks: Raton Basin, CO.

Sample ID	Date Collected	R-(+)-limonene (5989-27-5)	1,2,4-trichlorobenzene (120-82-1)	1,2-dichlorobenzene (95-50-1)	1,2-dinitrobenzene (528-29-0)	1,3-dichlorobenzene (541-73-1)	1,3-dimethyladamantane (702-79-4)	1,3 –dinitrobenzene (99-65-0)	1,4-dichlorobenzene (106-46-7)	1,4-dinitrobenzene (100-25-4)	1-methylnaphthalene (90-12-0)	2,3,4,6-tetrachlorophenol (58-90-2)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1011	10/3/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBEqBlk02-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBEqBlk03-1011	10/5/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBFBlk01-1011	10/3/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBFBlk02-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBFBlk03-1011	10/6/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
QL		0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Detection in Samples		0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22
Concentration min		<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Concentration max		<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50

Table A11. Semivolatile organic compound (SVOC) blanks for Round 1 (October 2011): Raton Basin, CO.

(continued)

Sample ID	Date Collected	2,3,5,6-tetrachlorophenol (935-95-5)	2,4,5-trichlorophenol (95-95-4)	2,4,6-trichlorophenol (88-06-2)	2,4-dichlorophenol (120-83-2)	2,4-dimethylphenol (105-67-9)	2,4-dinitrophenol (51-28-5)	2,4-dinitrotoluene (121-14-2)	2,6-dinitrotoluene (606-20-2)	2-butoxyethanol (111-76-2)	2-butoxyethyl phosphate (78-51-3)	2-chloronaphthalene (91-58-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1011	10/3/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<1.00	<0.50
RBEqBlk02-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<1.00	<0.50
RBEqBlk03-1011	10/5/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<1.00	<0.50
RBFBlk01-1011	10/3/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<1.00	<0.50
RBFBlk02-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<1.00	<0.50
RBFBlk03-1011	10/6/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<1.00	<0.50
QL		0.50	0.50	0.50	0.50	0.50	5.00	0.50	0.50	0.50	1.00	0.50
Detection in Samples		0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	3/22	1/22	0/22
Concentration min		<0.50	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	0.65	1.22	<0.50
Concentration max		<0.50	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	1.45	1.22	<0.50

Table A11. Semivolatile organic compound (SVOC) blanks for Round 1 (October 2011): Raton Basin, CO.
(continued)

Sample ID	Date Collected	2-chlorophenol (95-57-8)	2-methylnaphthalene (91-57-6)	2-methylphenol (95-48-7)	2-nitroaniline (88-74-4)	2-nitrophenol (88-75-5)	3&4-methylphenol (108-39-4 & 106-44-5)	3,3'-dichlorobenzidine (91-94-1)	3-nitroaniline (99-09-2)	4,6-dinitro-2-methylphenol (534-52-1)	4-bromophenyl phenyl ether (101-55-3)	4-chloro-3-methylphenol (59-50-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1011	10/3/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	NR	<0.50	<0.50	<0.50	<0.50
RBEqBlk02-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	NR	<0.50	<0.50	<0.50	<0.50
RBEqBlk03-1011	10/5/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	NR	<0.50	<0.50	<0.50	<0.50
RBFBlk01-1011	10/3/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	NR	<0.50	<0.50	<0.50	<0.50
RBFBlk02-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	NR	<0.50	<0.50	<0.50	<0.50
RBFBlk03-1011	10/6/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	NR	<0.50	<0.50	<0.50	<0.50
QL		0.50	0.50	0.50	0.50	0.50	0.50		0.50	0.50	0.50	0.50
Detection in Samples		0/22	0/22	0/22	0/22	0/22	0/22		0/22	0/22	0/22	0/22
Concentration min		<0.50	<0.50	<0.50	<0.50	<0.50	<0.50		<0.50	<0.50	<0.50	<0.50
Concentration max		<0.50	<0.50	<0.50	<0.50	<0.50	<0.50		<0.50	<0.50	<0.50	<0.50

NR = not reported.

Table A11. Semivolatile organic compound (SVOC) blanks for Round 1 (October 2011): Raton Basin, CO.

(continued)

Sample ID	Date Collected	4-chloroaniline (106-47-8)	4-chlorophenyl phenyl ether (7005-72-3)	4-nitroaniline (100-01-6)	4-nitrophenol (100-02-7)	Acenaphthene (83-32-9)	Acenaphthylene (208-96-8)	Adamantane (281-23-2)	Aniline (62-53-3)	Anthracene (120-12-7)	Azobenzene (103-33-3)	Benzo(a)anthracene (56-55-3)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1011	10/3/2011	<1.00	<0.50	<0.50	<2.50	<0.50	<0.50	<0.50	<1.00	<0.50	<0.50	<0.50
RBEqBlk02-1011	10/4/2011	<1.00	<0.50	<0.50	<2.50	<0.50	<0.50	<0.50	<1.00	<0.50	<0.50	<0.50
RBEqBlk03-1011	10/5/2011	<1.00	<0.50	<0.50	<2.50	<0.50	<0.50	<0.50	<1.00	<0.50	<0.50	<0.50
RBFBlk01-1011	10/3/2011	<1.00	<0.50	<0.50	<2.50	<0.50	<0.50	<0.50	<1.00	<0.50	<0.50	<0.50
RBFBlk02-1011	10/4/2011	<1.00	<0.50	<0.50	<2.50	<0.50	<0.50	<0.50	<1.00	<0.50	<0.50	<0.50
RBFBlk03-1011	10/6/2011	<1.00	<0.50	<0.50	<2.50	<0.50	<0.50	<0.50	<1.00	<0.50	<0.50	<0.50
QL		1.00	0.50	0.50	2.50	0.50	0.50	0.50	1.00	0.50	0.50	0.50
Detection in Samples		0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22
Concentration min		<1.00	<0.50	<0.50	<2.50	<0.50	<0.50	<0.50	<1.00	<0.50	<0.50	<0.50
Concentration max		<1.00	<0.50	<0.50	<2.50	<0.50	<0.50	<0.50	<1.00	<0.50	<0.50	<0.50

Table A11. Semivolatile organic compound (SVOC) blanks for Round 1 (October 2011): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Benzo(a)pyrene (50-32-3)	Benzo(b)fluoranthene (205-99-2)	Benzo(g,h,i)perylene (191-24-2)	Benzo(k)fluoranthene (207-08-9)	Benzoic Acid (65-85-0)	Benzyl alcohol (100-51-6)	Bis-(2-chloroethoxy)methane (111-91-1)	Bis-(2-chloroethyl)ether (111-44-4)	Bis-(2-chloroisopropyl)ether (108-60-1)	Bis-(2-ethylhexyl) adipate (103-23-1)	Bis-(2-ethylhexyl) phthalate (117-81-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1011	10/3/2011	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<0.50	<1.00	<1.00
RBEqBlk02-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<0.50	<1.00	1.23
RBEqBlk03-1011	10/5/2011	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<0.50	<1.00	<1.00
RBFBlk01-1011	10/3/2011	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<0.50	<1.00	<1.00
RBFBlk02-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<0.50	<1.00	<1.00
RBFBlk03-1011	10/6/2011	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<0.50	<1.00	<1.00
QL		0.50	0.50	0.50	0.50	5.00	0.50	0.50	0.50	0.50	1.00	1.00
Detection in Samples		0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	10/22	5/22
Concentration min		<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<0.50	1.46	1.03
Concentration max		<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<0.50	3.07	143

Table A11. Semivolatile organic compound (SVOC) blanks for Round 1 (October 2011): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Butyl benzyl phthalate (85-68-7)	Carbazole (86-74-8)	Chrysene (218-01-9)	Dibenz(a,h)anthracene (53-70-3)	Dibenzofuran (132-64-9)	Diethyl phthalate (84-66-2)	Dimethyl phthalate (131-11-3)	Di-n-butyl phthalate (84-74-2)	Di-n-octyl phthalate (117-84-0)	Diphenylamine (122-39-4)	Fluoranthene (206-44-0)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1011	10/3/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBEqBlk02-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBEqBlk03-1011	10/5/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBFBlk01-1011	10/3/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBFBlk02-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBFBlk03-1011	10/6/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
QL		0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Detection in Samples		0/22	0/22	0/22	0/22	0/22	0/22	0/22	1/22	1/22	0/22	0/22
Concentration min		<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	5.68	7.64	<0.50	<0.50
Concentration max		<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	5.68	7.64	<0.50	<0.50

Table A11. Semivolatile organic compound (SVOC) blanks for Round 1 (October 2011): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Fluorene (86-73-7)	Hexachlorobenzene (118-74-1)	Hexachlorobutadiene (87-68-3)	Hexachlorocyclopentadiene (77-47-4)	Hexachloroethane (67-72-1)	Indeno(1,2,3-cd)pyrene (193-39-5)	Isophorone (78-59-1)	Naphthalene (91-20-3)	Nitrobenzene (98-95-3)	N-nitrosodimethylamine (62-75-9)	N-nitrosodi-n-propylamine (621-64-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1011	10/3/2011	<0.50	<0.50	< 1.00	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBEqBlk02-1011	10/4/2011	<0.50	<0.50	< 1.00	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBEqBlk03-1011	10/5/2011	<0.50	<0.50	< 1.00	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBFBlk01-1011	10/3/2011	<0.50	<0.50	< 1.00	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBFBlk02-1011	10/4/2011	<0.50	<0.50	< 1.00	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBFBlk03-1011	10/6/2011	<0.50	<0.50	< 1.00	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
QL		0.50	0.50	1.00	0.50	1.0	0.50	0.50	0.50	0.50	0.50	0.50
Detection in Samples		0/22	0/22	0/22	0/22	0/22	0/22	1/22	0/22	1/22	0/22	0/22
Concentration min		<0.50	<0.50	< 1.00	<0.50	<1.0	<0.50	1.26	<0.50	0.63	<0.50	<0.50
Concentration max		<0.50	<0.50	< 1.00	<0.50	<1.0	<0.50	1.26	<0.50	0.63	<0.50	<0.50

Table A11. Semivolatile organic compound (SVOC) blanks for Round 1 (October 2011): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Pentachlorophenol (87-86-5)	Phenanthrene (85-01-8)	Phenol (108-95-2)	Pyrene (129-00-0)	Pyridine (110-86-1)	Squalene (111-02-4)	Terpiniol (98-55-5)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-1011	10/3/2011	<1.00	<0.50	<0.50	<0.50	<0.50	<1.00	<0.50
RBEqBlk02-1011	10/4/2011	<1.00	<0.50	<0.50	<0.50	<0.50	<1.00	<0.50
RBEqBlk03-1011	10/5/2011	<1.00	<0.50	<0.50	<0.50	<0.50	<1.00	<0.50
RBFBlk01-1011	10/3/2011	<1.00	<0.50	<0.50	<0.50	<0.50	<1.00	<0.50
RBFBlk02-1011	10/4/2011	<1.00	<0.50	<0.50	<0.50	<0.50	<1.00	<0.50
RBFBlk03-1011	10/6/2011	<1.00	<0.50	<0.50	<0.50	<0.50	<1.00	<0.50
QL		1.00	0.50	0.50	0.50	0.50	1.00	0.50
Detection in Samples		0/22	0/22	2/22	0/22	0/22	2/22	0/22
Concentration min		<1.00	<0.50	0.52	<0.50	<0.50	1.62	<0.50
Concentration max		<1.00	<0.50	1.08	<0.50	<0.50	1.87	<0.50

Table A11. Semivolatile organic compound (SVOC) blanks for Round 2 (May 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	R-(+)-limonene (5989-27-5)	1,2,4-trichlorobenzene (120-82-1)	1,2-dichlorobenzene (95-50-1)	1,2-dinitrobenzene (528-29-0)	1,3-dichlorobenzene (541-73-1)	1,3-dimethyladamantane (702-79-4)	1,3 -dinitrobenzene (99-65-0)	1,4-dichlorobenzene (106-46-7)	1,4-dinitrobenzene (100-25-4)	1-methylnaphthalene (90-12-0)	2,3,4,6-tetrachlorophenol (58-90-2)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0512	5/14/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBEqBlk02-0512	5/15/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBEqBlk03-0512	5/16/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBlk01-0512	5/14/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBlk02-0512	5/15/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBlk03-0512	5/16/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
QL		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00
Detection in Samples		0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22
Concentration min		<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
Concentration max		<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 2 (May 2012): Raton Basin, CO. *(continued)*

Sample ID	Date Collected	2,3,5,6-tetrachlorophenol (935-95-5)	2,4,5-trichlorophenol (95-95-4)	2,4,6-trichlorophenol (88-06-2)	2,4-dichlorophenol (120-83-2)	2,4-dimethylphenol (105-67-9)	2,4-dinitrophenol (51-28-5)	2,4-dinitrotoluene (121-14-2)	2,6-dinitrotoluene (606-20-2)	2-butoxyethanol (111-76-2)	2-Butoxyethanol phosphate (78-51-3)	2-chloronaphthalene (91-58-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L
RBEqBlk01-0512	5/14/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk02-0512	5/15/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk03-0512	5/16/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk01-0512	5/14/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk02-0512	5/15/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk03-0512	5/16/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
QL		2.00	2.00	2.00	2.00	2.00	3.00	1.00	1.00	1.00	1.00	1.00
Detection in Samples		0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22
Concentration min		<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
Concentration max		<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 2 (May 2012): Raton Basin, CO. *(continued)*

Sample ID	Date Collected	2-chlorophenol (95-57-8)	2-methylnaphthalene (91-57-6)	2-methylphenol (95-48-7)	2-nitroaniline (88-74-4)	2-nitrophenol (88-75-5)	3&4-methylphenol (108-39-4 & 106-44-5)	3,3'-dichlorobenzidine (91-94-1)	3-nitroaniline (99-09-2)	4,6-dinitro-2-methylphenol (534-52-1)	4-bromophenyl phenyl ether (101-55-3)	4-chloro-3-methylphenol (59-50-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0512	5/14/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBEqBlk02-0512	5/15/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBEqBlk03-0512	5/16/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBFBlk01-0512	5/14/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBFBlk02-0512	5/15/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBFBlk03-0512	5/16/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
QL		2.00	1.00	2.00	1.00	2.00	5.00	1.00	3.00	2.00	1.00	2.00
Detection in Samples		0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22
Concentration min		<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
Concentration max		<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 2 (May 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	4-chloroaniline (106-47-8)	4-chlorophenyl phenyl ether (7005-72-3)	4-nitroaniline (100-01-6)	4-nitrophenol (100-02-7)	Acenaphthene (83-32-9)	Acenaphthylene (208-96-8)	Adamantane (281-23-2)	Aniline (62-53-3)	Anthracene (120-12-7)	Azobenzene (103-33-3)	Benzo(a)anthracene (56-55-3)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0512	5/14/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk02-0512	5/15/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk03-0512	5/16/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk01-0512	5/14/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk02-0512	5/15/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk03-0512	5/16/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
QL		3.00	1.00	3.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Detection in Samples		0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22
Concentration min		<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Concentration max		<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 2 (May 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Benzo(a)pyrene (50-32-8)	Benzo(b)fluoranthene (205-99-2)	Benzo(g,h,i)perylene (191-24-2)	Benzo(k)fluoranthene (207-08-9)	Benzoic Acid (65-85-0)	Benzyl alcohol (100-51-6)	Bis-(2-chloroethoxy)methane (111-91-1)	Bis-(2-chloroethyl)ether (111-44-4)	Bis-(2-chloroisopropyl)ether (108-60-1)	Bis-(2-ethylhexyl) adipate (103-23-1)	Bis-(2-ethylhexyl) phthalate (117-81-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0512	5/14/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBEqBlk02-0512	5/15/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBEqBlk03-0512	5/16/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBlk01-0512	5/14/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBlk02-0512	5/15/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBlk03-0512	5/16/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
QL		1.00	1.00	1.00	1.00	3.00	1.00	1.00	1.00	1.00	1.00	2.00
Detection in Samples		0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	3/22
Concentration min		<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	4.27
Concentration max		<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	135

Table A11. Semivolatile organic compound (SVOC) blanks for Round 2 (May 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Butyl benzyl phthalate (85-68-7)	Carbazole (86-74-8)	Chrysene (218-01-9)	Dibenz(a,h)anthracene (53-70-3)	Dibenzofuran (132-64-9)	Diethyl phthalate (84-66-2)	Dimethyl phthalate (131-11-3)	Di-n-butyl phthalate (84-74-2)	Di-n-octyl phthalate (117-84-0)	Diphenylamine (122-39-4)	Fluoranthene (206-44-0)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0512	5/14/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk02-0512	5/15/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk03-0512	5/16/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk01-0512	5/14/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk02-0512	5/15/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk03-0512	5/16/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
QL		1.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Detection in Samples		0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22	0/22
Concentration min		<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Concentration max		<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 2 (May 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Fluorene (86-73-7)	Hexachlorobenzene (118-74-1)	Hexachlorobutadiene (87-68-3)	Hexachlorocyclopentadiene (77-47-4)	Hexachloroethane (67-72-1)	Indeno(1,2,3-cd)pyrene (193-39-5)	Isophorone (78-59-1)	Naphthalene (91-20-3)	Nitrobenzene (98-95-3)	N-nitrosodimethylamine (62-75-9)	N-nitrosodi-n-propylamine (621-64-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0512	5/14/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk02-0512	5/15/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk03-0512	5/16/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk01-0512	5/14/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk02-0512	5/15/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk03-0512	5/16/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
QL		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Detection in Samples		0/22	0/22	0/22	0/22	0/22	0/22	1/22	0/22	0/22	0/22	0/22
Concentration min		<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	1.86	<1.00	<1.00	<1.00	<1.00
Concentration max		<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	1.86	<1.00	<1.00	<1.00	<1.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 2 (May 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Pentachlorophenol (87-86-5)	Phenanthrene (85-01-8)	Phenol (108-95-2)	Pyrene (129-00-0)	Pyridine (110-86-1)	Squalene (111-02-4)	Terpiniol (98-55-5)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0512	5/14/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBEqBlk02-0512	5/15/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBEqBlk03-0512	5/16/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBFBlk01-0512	5/14/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBFBlk02-0512	5/15/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBFBlk03-0512	5/16/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
QL		2.00	1.00	2.00	1.00	1.00	2.00	1.00
Detection in Samples		0/22	0/22	0/22	0/22	0/22	0/22	0/22
Concentration min		<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
Concentration max		<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 3 (November 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	R-(+)-limonene (5989-27-5)	1,2,4-trichlorobenzene (120-82-1)	1,2-dichlorobenzene (95-50-1)	1,2-dinitrobenzene (528-29-0)	1,3-dichlorobenzene (541-73-1)	1,3-dimethyladamantane (702-79-4)	1,3 -dinitrobenzene (99-65-0)	1,4-dichlorobenzene (106-46-7)	1,4-dinitrobenzene (100-25-4)	1-methylnaphthalene (90-12-0)	2,3,4,6-tetrachlorophenol (58-90-2)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEQBLK01-1112	11/5/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBEqBLK02-1112	11/6/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBEqBLK03-1112	11/7/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBEqBLK04-1112	11/8/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBLK01-1112	11/5/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBLK02-1112	11/6/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBLK03-1112	11/7/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBLK04-1112	11/8/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
QL		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00
Detection in Samples		0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23
Concentration min		<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
Concentration max		<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 3 (November 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	2,3,5,6-tetrachlorophenol (935-95-5)	2,4,5-trichlorophenol (95-95-4)	2,4,6-trichlorophenol (88-06-2)	2,4-dichlorophenol (120-83-2)	2,4-dimethylphenol (105-67-9)	2,4-dinitrophenol (51-28-5)	2,4-dinitrotoluene (121-14-2)	2,6-dinitrotoluene (606-20-2)	2-butoxyethanol (111-76-2)	2-Butoxyethanol phosphate (78-51-3)	2-chloronaphthalene (91-58-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEQBLK01-1112	11/5/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBLK02-1112	11/6/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBLK03-1112	11/7/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBLK04-1112	11/8/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBLK01-1112	11/5/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBLK02-1112	11/6/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBLK03-1112	11/7/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBLK04-1112	11/8/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
QL		2.00	2.00	2.00	2.00	2.00	3.00	1.00	1.00	1.00	1.00	1.00
Detection in Samples		0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23
Concentration min		<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
Concentration max		<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 3 (November 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	2-chlorophenol (95-57-8)	2-methylnaphthalene (91-57-6)	2-methylphenol (95-48-7)	2-nitroaniline (88-74-4)	2-nitrophenol (88-75-5)	3&4-methylphenol (108-39-4 & 106-44-5)	3,3'-dichlorobenzidine (91-94-1)	3-nitroaniline (99-09-2)	4,6-dinitro-2-methylphenol (534-52-1)	4-bromophenyl phenyl ether (101-55-3)	4-chloro-3-methylphenol (59-50-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEQBLK01-1112	11/5/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBEqBLK02-1112	11/6/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBEqBLK03-1112	11/7/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBEqBLK04-1112	11/8/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBFBLK01-1112	11/5/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBFBLK02-1112	11/6/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBFBLK03-1112	11/7/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBFBLK04-1112	11/8/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
QL		2.00	1.00	2.00	1.00	2.00	5.00	1.00	3.00	2.00	1.00	2.00
Detection in Samples		0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23
Concentration min		<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
Concentration max		<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 3 (November 2012): Raton Basin, CO. *(continued)*

Sample ID	Date Collected	4-chloroaniline (106-47-8)	4-chlorophenyl phenyl ether (7005-72-3)	4-nitroaniline (100-01-6)	4-nitrophenol (100-02-7)	Acenaphthene (83-32-9)	Acenaphthylene (208-96-8)	Adamantane (281-23-2)	Aniline (62-53-3)	Anthracene (120-12-7)	Azobenzene (103-33-3)	Benzo(a)anthracene (56-55-3)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEQBLK01-1112	11/5/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBLK02-1112	11/6/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBLK03-1112	11/7/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBLK04-1112	11/8/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBLK01-1112	11/5/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBLK02-1112	11/6/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBLK03-1112	11/7/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBLK04-1112	11/8/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
QL		3.00	1.00	3.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Detection in Samples		0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23
Concentration min		<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Concentration max		<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 3 (November 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Benzo(a)pyrene (50-32-8)	Benzo(b)fluoranthene (205-99-2)	Benzo(g,h,i)perylene (191-24-2)	Benzo(k)fluoranthene (207-08-9)	Benzoic Acid (65-85-0)	Benzyl alcohol (100-51-6)	Bis-(2-chloroethoxy)methane (111-91-1)	Bis-(2-chloroethyl)ether (111-44-4)	Bis(2-chloroisopropyl)ether (39638-32-9)	Bis-(2-ethylhexyl) adipate (103-23-1)	Bis-(2-ethylhexyl) phthalate (117-81-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEQBLK01-1112	11/5/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBEqBLK02-1112	11/6/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBEqBLK03-1112	11/7/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBEqBLK04-1112	11/8/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	5.34
RBFBLK01-1112	11/5/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	9.40
RBFBLK02-1112	11/6/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBLK03-1112	11/7/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBLK04-1112	11/8/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
QL		1.00	1.00	1.00	1.00	3.00	1.00	1.00	1.00	1.00	1.00	2.00
Detection in Samples		0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	5/23
Concentration min		<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	2.22
Concentration max		<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	139

Table A11. Semivolatile organic compound (SVOC) blanks for Round 3 (November 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Butyl benzyl phthalate (85-68-7)	Carbazole (86-74-8)	Chrysene (218-01-9)	Dibenz(a,h)anthracene (53-70-3)	Dibenzofuran (132-64-9)	Diethyl phthalate (84-66-2)	Dimethyl phthalate (131-11-3)	Di-n-butyl phthalate (84-74-2)	Di-n-octyl phthalate (117-84-0)	Diphenylamine (122-39-4)	Fluoranthene (206-44-0)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEQBLK01-1112	11/5/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBLK02-1112	11/6/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBLK03-1112	11/7/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBLK04-1112	11/8/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBLK01-1112	11/5/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBLK02-1112	11/6/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBLK03-1112	11/7/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBLK04-1112	11/8/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
QL		1.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Detection in Samples		0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23
Concentration min		<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Concentration max		<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 3 (November 2012): Raton Basin, CO. *(continued)*

Sample ID	Date Collected	Fluorene (86-73-7)	Hexachlorobenzene (118-74-1)	Hexachlorobutadiene (87-68-3)	Hexachloro cyclopentadiene (77-47-4)	Hexachloroethane (67-72-1)	Indeno(1,2,3-cd)pyrene (193-39-5)	Isophorone (78-59-1)	Naphthalene (91-20-3)	Nitrobenzene (98-95-3)	N-nitrosodimethylamine (62-75-9)	N-nitrosodi-n-propylamine (621-64-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEQBLK01-1112	11/5/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBLK02-1112	11/6/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBLK03-1112	11/7/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBLK04-1112	11/8/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBLK01-1112	11/5/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBLK02-1112	11/6/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBLK03-1112	11/7/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBLK04-1112	11/8/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
QL		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Detection in Samples		0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23
Concentration min		<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Concentration max		<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 3 (November 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Pentachlorophenol (87-86-5)	Phenanthrene (85-01-8)	Phenol (108-95-2)	Pyrene (129-00-0)	Pyridine (110-86-1)	Squalene (111-02-4)	Terpiniol (8000-41-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEQBLK01-1112	11/5/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBEqBLK02-1112	11/6/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBEqBLK03-1112	11/7/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBEqBLK04-1112	11/8/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBFBLK01-1112	11/5/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBFBLK02-1112	11/6/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBFBLK03-1112	11/7/2012	<2.00	<1.00	<2.00	<1.00	<1.00	18.0	<1.00
RBFBLK04-1112	11/8/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
QL		2.00	1.00	2.00	1.00	1.00	2.00	1.00
Detection in Samples		0/23	0/23	0/23	0/23	0/23	0/23	0/23
Concentration min		<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
Concentration max		<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	R-(+)-limonene (5989-27-5)	1,2,4-trichlorobenzene (120-82-1)	1,2-dichlorobenzene (95-50-1)	1,2-dinitrobenzene (528-29-0)	1,3-dichlorobenzene (541-73-1)	1,3-dimethyladamantane (702-79-4)	1,3 -dinitrobenzene (99-65-0)	1,4-dichlorobenzene (106-46-7)	1,4-dinitrobenzene (100-25-4)	1-methylnaphthalene (90-12-0)	2,3,4,6-tetrachlorophenol (58-90-2)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0413	4/29/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBEqBlk02-0413	4/30/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBEqBlk03-0413	5/1/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBEqBlk04-0413	5/2/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBlk01-0413	4/29/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBlk02-0413	4/30/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBlk03-0413	5/1/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBlk04-0413	5/2/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
QL		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00
Detection in Samples		0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23
Concentration min		<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
Concentration max		<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	2,3,5,6-tetrachlorophenol (935-95-5)	2,4,5-trichlorophenol (95-95-4)	2,4,6-trichlorophenol (88-06-2)	2,4-dichlorophenol (120-83-2)	2,4-dimethylphenol (105-67-9)	2,4-dinitrophenol (51-28-5)	2,4-dinitrotoluene (121-14-2)	2,6-dinitrotoluene (606-20-2)	2-butoxyethanol (111-76-2)	2-Butoxyethanol phosphate (78-51-3)	2-chloronaphthalene (91-58-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0413	4/29/2013	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk02-0413	4/30/2013	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk03-0413	5/1/2013	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk04-0413	5/2/2013	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk01-0413	4/29/2013	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk02-0413	4/30/2013	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk03-0413	5/1/2013	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk04-0413	5/2/2013	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
QL		2.00	2.00	2.00	2.00	2.00	3.00	1.00	1.00	1.00	1.00	1.00
Detection in Samples		0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	1/23	0/23
Concentration min		<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	1.05	<1.00
Concentration max		<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	1.05	<1.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	2-chlorophenol (95-57-8)	2-methylnaphthalene (91-57-6)	2-methylphenol (95-48-7)	2-nitroaniline (88-74-4)	2-nitrophenol (88-75-5)	3&4-methylphenol (108-39-4 & 106-44-5)	3,3'-dichlorobenzidine (91-94-1)	3-nitroaniline (99-09-2)	4,6-dinitro-2-methylphenol (534-52-1)	4-bromophenyl phenyl ether (101-55-3)	4-chloro-3-methylphenol (59-50-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0413	4/29/2013	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBEqBlk02-0413	4/30/2013	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBEqBlk03-0413	5/1/2013	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBEqBlk04-0413	5/2/2013	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBFBlk01-0413	4/29/2013	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBFBlk02-0413	4/30/2013	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBFBlk03-0413	5/1/2013	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBFBlk04-0413	5/2/2013	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
QL		2.00	1.00	2.00	1.00	2.00	5.00	1.00	3.00	2.00	1.00	2.00
Detection in Samples		0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23
Concentration min		<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
Concentration max		<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	4-chloroaniline (106-47-8)	4-chlorophenyl phenyl ether (7005-72-3)	4-nitroaniline (100-01-6)	4-nitrophenol (100-02-7)	Acenaphthene (83-32-9)	Acenaphthylene (208-96-8)	Adamantane (281-23-2)	Aniline (62-53-3)	Anthracene (120-12-7)	Azobenzene (103-33-3)	Benzo(a)anthracene (56-55-3)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0413	4/29/2013	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk02-0413	4/30/2013	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk03-0413	5/1/2013	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk04-0413	5/2/2013	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk01-0413	4/29/2013	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk02-0413	4/30/2013	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk03-0413	5/1/2013	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk04-0413	5/2/2013	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
QL		3.00	1.00	3.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Detection in Samples		0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23
Concentration min		<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Concentration max		<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Benzo(a)pyrene (50-32-8)	Benzo(b)fluoranthene (205-99-2)	Benzo(g,h,i)perylene (191-24-2)	Benzo(k)fluoranthene (207-08-9)	Benzoic Acid (65-85-0)	Benzyl alcohol (100-51-6)	Bis-(2-chloroethoxy)methane (111-91-1)	Bis-(2-chloroethyl)ether (111-44-4)	Bis(2-chloroisopropyl)ether (39638-32-9)	Bis-(2-ethylhexyl) adipate (103-23-1)	Bis-(2-ethylhexyl) phthalate (117-81-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0413	4/29/2013	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBEqBlk02-0413	4/30/2013	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBEqBlk03-0413	5/1/2013	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBEqBlk04-0413	5/2/2013	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBlk01-0413	4/29/2013	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBlk02-0413	4/30/2013	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBlk03-0413	5/1/2013	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBFBlk04-0413	5/2/2013	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
QL		1.00	1.00	1.00	1.00	3.00	1.00	1.00	1.00	1.00	1.00	2.00
Detection in Samples		0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	10/23
Concentration min		<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	5.28
Concentration max		<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	291

Table A11. Semivolatile organic compound (SVOC) blanks for Round 4 (April/May 2013): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Butyl benzyl phthalate (85-68-7)	Carbazole (86-74-8)	Chrysene (218-01-9)	Dibenz(a,h)anthracene (53-70-3)	Dibenzofuran (132-64-9)	Diethyl phthalate (84-66-2)	Dimethyl phthalate (131-11-3)	Di-n-butyl phthalate (84-74-2)	Di-n-octyl phthalate (117-84-0)	Diphenylamine (122-39-4)	Fluoranthene (206-44-0)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0413	4/29/2013	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk02-0413	4/30/2013	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk03-0413	5/1/2013	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk04-0413	5/2/2013	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk01-0413	4/29/2013	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk02-0413	4/30/2013	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk03-0413	5/1/2013	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk04-0413	5/2/2013	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
QL		1.00	3.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Detection in Samples		0/23	0/23	0/23	0/23	0/23	0/23	0/23	0/23	1/23	0/23	0/23
Concentration min		<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	7.35	<1.00	<1.00
Concentration max		<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	7.35	<1.00	<1.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Fluorene (86-73-7)	Hexachlorobenzene (118-74-1)	Hexachlorobutadiene (87-68-3)	Hexachlorocyclopentadiene (77-47-4)	Hexachloroethane (67-72-1)	Indeno(1,2,3-cd)pyrene (193-39-5)	Isophorone (78-59-1)	Naphthalene (91-20-3)	Nitrobenzene (98-95-3)	N-nitrosodimethylamine (62-75-9)	N-nitrosodi-n-propylamine (621-64-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0413	4/29/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk02-0413	4/30/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk03-0413	5/1/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBEqBlk04-0413	5/2/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk01-0413	4/29/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk02-0413	4/30/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk03-0413	5/1/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBFBlk04-0413	5/2/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
QL		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Detection in Samples		0/23	0/23	0/23	0/23	0/23	0/23	1/23	0/23	0/23	0/23	0/23
Concentration min		<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	1.11	<1.00	<1.00	<1.00	<1.00
Concentration max		<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	1.11	<1.00	<1.00	<1.00	<1.00

Table A11. Semivolatile organic compound (SVOC) blanks for Round 4 (April/May 2013): Raton Basin, CO. *(continued)*

Sample ID	Date Collected	Pentachlorophenol (87-86-5)	Phenanthrene (85-01-8)	Phenol (108-95-2)	Pyrene (129-00-0)	Pyridine (110-86-1)	Squalene (111-02-4)	Terpiniol (8000-41-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
RBEqBlk01-0413	4/29/2013	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBEqBlk02-0413	4/30/2013	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBEqBlk03-0413	5/1/2013	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBEqBlk04-0413	5/2/2013	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBFBlk01-0413	4/29/2013	<2.00	<1.00	<2.00	<1.00	<1.00	3.12	<1.00
RBFBlk02-0413	4/30/2013	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBFBlk03-0413	5/1/2013	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBFBlk04-0413	5/2/2013	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
QL		2.00	1.00	2.00	1.00	1.00	2.00	1.00
Detection in Samples		0/23	0/23	0/23	0/23	0/23	2/23	0/23
Concentration min		<2.00	<1.00	<2.00	<1.00	<1.00	3.13	<1.00
Concentration max		<2.00	<1.00	<2.00	<1.00	<1.00	3.82	<1.00

Table A12. Diesel Range Organics (DRO) & Gasoline Range Organics (GRO) blanks: Raton Basin, CO

Sample ID	Date Collected	GRO/TPH	DRO
Units		µg/L	µg/L
October 2011			
RBEqBlk01-1011	10/3/2011	28.0	< 20.0
RBEqBlk02-1011	10/4/2011	< 20.0	< 20.0
RBEqBlk03-1011	10/5/2011	< 20.0	< 20.0
RBFBlk01-1011	10/3/2011	< 20.0	< 20.0
RBFBlk02-1011	10/4/2011	20.2	< 20.0
RBFBlk03-1011	10/6/2011	< 20.0	< 22.2
QL		20	20
Detection in Samples		4/22	14/22
Concentration min		22.5	20.0
Concentration max		30.1	1940
May 2012			
RBEqBlk01-0512	5/14/2012	< 20.0	< 20.0
RBEqBlk02-0512	5/15/2012	< 20.0	< 20.0
RBEqBlk03-0512	5/16/2012	< 20.0	< 20.0
RBFBlk01-0512	5/14/2012	< 20.0	< 20.0
RBFBlk02-0512	5/15/2012	< 20.0	< 20.0
RBFBlk03-0512	5/16/2012	< 20.0	< 20.0
QL		20.0	20.0
Detection in Samples		6/22	10/22
Concentration min		21.5	26.6
Concentration max		49.8	1310

Table A12. DRO/GRO blanks for Rounds 3 (November 2012) and 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	GRO/TPH	DRO
Units		µg/L	µg/L
November 2012			
RBEQBLK01-1112	11/5/2012	<20.0	<20.0
RBEqBLK02-1112	11/6/2012	<20.0	<20.0
RBEqBLK03-1112	11/7/2012	<20.0	24.7
RBEqBLK04-1112	11/8/2012	<20.0	<20.0
RBFBLK01-1112	11/5/2012	<20.0	<20.0
RBFBLK02-1112	11/6/2012	<20.0	<20.0
RBFBLK03-1112	11/7/2012	<20.0	<20.0
RBFBLK04-1112	11/8/2012	<20.0	<20.0
QL		20.0	20.0
Detection in Samples		3/23	13/23
Concentration min		20.6	21.3
Concentration max		29.6	874
April/May 2013			
RBEqBlk01-0413	4/29/2013	<20.0	<20.0
RBEqBlk02-0413	4/30/2013	<20.0	<20.0
RBEqBlk03-0413	5/1/2013	<20.0	24.8
RBEqBlk04-0413	5/2/2013	<20.0	<20.0
RBFBlk01-0413	4/29/2013	<20.0	<20.0
RBFBlk02-0413	4/30/2013	<20.0	<20.0
RBFBlk03-0413	5/1/2013	<20.0	<20.0
RBFBlk04-0413	5/2/2013	<20.0	<20.0
QL		20.0	20.0
Detection in Samples		0/23	16/23
Concentration min		<20.0	21.9
Concentration max		<20.0	1530

Table A13. DOC, DIC, nutrients, and anion field duplicates: Raton Basin, CO.

Sample ID	Date Collected	DOC	DIC	NO_3^- + NO_2^-	NH_3	Br^-	Cl^-	SO_4^{2-}	F^-
Units		mg/L	mg/L	mg N/L	mg N/L	mg/L	mg/L	mg/L	mg/L
October 2011									
5x QL		2.50	5.00	0.25	0.25	5.00	5.00	5.00	1.00
RBDW05-1011	10/4/2011	<0.50	49.0	0.35	<0.05	<1.00	9.53	55.8	0.57
RBDW05d-1011	10/4/2011	<0.50	49.1	0.37	<0.05	<1.00	9.65	56.8	0.49
RPD%		NC	0.20	5.56	NC	NC	1.25	1.78	NC
RBDW10-1011	10/5/2011	0.58	21.5	<0.05	0.20	<1.00	12.0	93.5	5.95
RBDW10d-1011	10/5/2011	0.57	21.5	<0.05	0.26	<1.00	12.0	94.5	6.06
RPD%		NC	0.00	NC	NC	NC	0.00	1.06	1.83
May 2012									
5X QL		2.5	5.00	0.50	0.50	5.00	5.0	5.0	1.0
RBDW06-0512	5/16/2012	1.16	42.7	<0.10	<0.10	<1.00	10.9	62.8	1.65
RBDW06d-0512	5/16/2012	1.16	42.6	<0.10	<0.10	<1.00	11.0	62.5	1.54
RPD%		NC	0.23	NC	NC	NC	0.91	0.48	6.9
RBDW11-0512	5/15/2012	0.83	54.1	0.17	<0.10	<1.00	13.6	4.37	1.34
RBDW11d-0512	5/15/2012	0.79	54.3	0.16	<0.10	<1.00	13.8	4.38	1.42
RPD%		NC	0.37	NC	NC	NC	1.46	NC	5.80

NC = not calculated.

Table A13. DOC, DIC, nutrients, and anion field duplicates: Raton Basin, CO.

(continued)

Sample ID	Date Collected	DOC	DIC	NO_3^- + NO_2^-	NH_3	Br^-	Cl^-	SO_4^{2-}	F^-
Units		mg/L	mg/L	mg N/L	mg N/L	mg/L	mg/L	mg/L	mg/L
November 2012									
5x QL		2.50	5.00	0.50	0.50	5.00	5.00	5.00	1.00
RBDW03-1112	11/5/2012	0.93	41.0	0.59	<0.10	<1.00	7.11	67.0	0.17
RBDW03-1112 Dup	11/5/2012	0.95	41.0	0.58	<0.10	<1.00	7.18	66.7	0.16
RPD%		NC	0.00	1.71	NC	NC	0.98	0.45	NC
RBDW10-1112	11/8/2012	0.67	20.9	<0.10	0.56	<1.00	12.0	100	6.23
RBDW10-1112 Dup	11/8/2012	0.68	21.0	<0.10	0.64	<1.00	12.2	101	6.27
RPD%		NC	0.48	NC	13.33	NC	1.65	1.00	0.64
April/May 2013									
5x QL		2.50	25.0	0.50	0.50	5.00	5.00	5.00	1.00
RBMW01-0413	4/29/2013	1.48	38.7	<0.10	0.09	0.36	4.50	94.6	0.44
RBMW01d-0413	4/29/2013	1.44	39.4	<0.10	0.09	0.35	4.64	97.1	0.41
RPD%		NC	1.79	NC	NC	NC	NC	2.61	NC
RBDW02-0413	4/29/2013	1.15	37.0	<0.10	<0.10	<1.00	9.54	62.3	1.03
RBDW02d-0413	4/29/2013	1.15	36.5	<0.10	<0.10	<1.00	9.50	62.3	1.04
RPD%		NC	1.36	NC	NC	NC	0.42	0.00	0.97
RBSW01-0413	4/30/2013	2.57	153	0.01	<0.10	0.60	40.1	2.37	3.15
RBSW01d-0413	4/30/2013	2.37	154	<0.10	<0.10	0.56	40.0	2.43	3.17
RPD%		NC	0.65	NC	NC	NC	0.25	NC	0.63

Table A14. Dissolved metal field duplicates: Raton Basin, CO.

Sample ID	Date Collected	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
5x QL		70	2470	100	1665	20	50	1.45	20	20	35	100
RBDW05-1011	10/4/2011	<14	<494	<20	<333	39	<10	4.18	<4	<4	<7	<20
RBDW05d-1011	10/4/2011	<14	<494	<20	<333	39	<10	4.17	<4	<4	<7	<20
RPD%		NC	NC	NC	NC	0.0	NC	0.24	NC	NC	NC	NC
RBDW10-1011	10/5/2011	<14	<494	<20	<333	25	<10	3.94	<4	<4	<7	<20
RBDW10d-1011	10/5/2011	<14	<494	<20	<333	25	<10	3.86	<4	<4	<7	<20
RPD%		NC	NC	NC	NC	0.0	NC	2.05	NC	NC	NC	NC

Sample ID	Date Collected	Fe	Hg	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb
Units		µg/L		mg/L		mg/L	µg/L	µg/L	mg/L	µg/L	mg/L	µg/L
5x QL		335		1.75		0.50	70	85	8.550	420	0.30	85
RBDW05-1011	10/4/2011	<67	NA	0.63	NA	0.27	20	<17	123	<84	<0.060	<17
RBDW05d-1011	10/4/2011	<67	NA	0.58	NA	0.27	20	<17	123	<84	<0.060	<17
RPD%		NC		NC		NC	NC	NC	0.00	NC	NC	NC
RBDW10-1011	10/5/2011	<67	NA	0.22	NA	0.05	<14	12	105	<84	<0.060	<17
RBDW10d-1011	10/5/2011	<67	NA	0.24	NA	0.04	<14	6	103	<84	<0.060	<17
RPD%		NC		NC		NC	NC	NC	1.92	NC	NC	NC

NC = not calculated. NA = not analyzed.

Table A14. Dissolved metal field duplicates for Round 1 (October 2011): Raton Basin, CO

(continued)

Sample ID	Date Collected	S	Sb	Se	Si	Sr	Th	Ti	Tl	U	V	Zn
Units		mg/L	µg/L	µg/L	mg/L	µg/L		µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.30		150	2.15	20		35	85	250	50	250
RBDW05-1011	10/4/2011	19.8	R	<30	4.75	100	NA	<7	<17	<50	<10	<50
RBDW05d-1011	10/4/2011	19.9	R	<30	4.74	99	NA	<7	<17	<50	<10	<50
RPD%		0.50		NC	0.21	1.01		NC	NC	NC	NC	NC
RBDW10-1011	10/5/2011	681	R	18	4.90	90	NA	3	<17	<50	<10	<50
RBDW10d-1011	10/5/2011	695	R	16	4.91	86	NA	<7	<17	<50	<10	<50
RPD%		2.03		NC	0.20	4.55		NC	NC	NC	NC	NC

NC = not calculated. NA = not analyzed.

Table A14. Dissolved metal field duplicates for Round 2 (May 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
5X QL		70	100	5	1665	20	50	1.45	5	20	10	10
RBDW06-0512	5/16/2012	<14	<20.0	<1.0	<333	17.1	<10	12.1	<1.0	<4	<2.0	<2.0
RBDW06d-0512	5/16/2012	<14	<20.0	<1.0	<333	16.9	<10	12.2	<1.0	<4	<2.0	<2.0
RPD%		NC	NC	NC	NC	NC	NC	0.82	NC	NC	NC	NC
RBDW11-0512	5/15/2012	<14	<20.0	<1.0	<333	275	<10	18.0	<1.0	<4	<2.0	3.7
RBDW11d-0512	5/15/2012	<14	<20.0	<1.0	<333	271	<10	17.9	<1.0	<4	<2.0	2.7
RPD%		NC	NC	NC	NC	1.47	NC	0.56	NC	NC	NC	NC

Sample ID	Date Collected	Fe	Hg	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb
Units		µg/L		mg/L		mg/L	µg/L	µg/L	mg/L	µg/L	mg/L	µg/L
5X QL		335		1.77		0.5	70	5	8.55	5	0.30	5
RBDW06-0512	5/16/2012	<67	NA	0.56	NA	2.24	<14	21.2	101	<1.0	<0.06	<1.0
RBDW06d-0512	5/16/2012	<67	NA	0.56	NA	2.25	<14	17.7	102	<1.0	<0.06	<1.0
RPD%		NC		NC		0.45	NC	17.99	0.99	NC	NC	NC
RBDW11-0512	5/15/2012	534	NA	1.13	NA	2.62	25	2.1	88.6	<1.0	<0.06	<1.0
RBDW11d-0512	5/15/2012	556	NA	1.11	NA	2.57	25	2.3	87.7	<1.0	<0.06	<1.0
RPD%		4.04		NC		1.93	NC	NC	1.02	NC	NC	NC

NC = not calculated. NA = not analyzed.

Table A14. Dissolved metal field duplicates for Round 2 (May 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	S	Sb	Se	Si	Sr	Th	Ti	Tl	U	V	Zn
Units		mg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5X QL		2.3	10	25	2.15	20	5	35	5	5	50	250
RBDW06-0512	5/16/2012	143	<2.0	R	9.50	428	R	<7	<1.0	R	<10	<50
RBDW06d-0512	5/16/2012	142	<2.0	R	9.51	431	R	<7	<1.0	R	<10	<50
RPD%		0.70	NC		0.11	0.70		NC	NC		NC	NC
RBDW11-0512	5/15/2012	1.23	<2.0	<5.0	3.81	603	R	<7	<1.0	<1.0	<10	<50
RBDW11d-0512	5/15/2012	1.20	<2.0	R	3.80	594	R	<7	<1.0	<1.0	<10	<50
RPD%		NC	NC	NC	0.26	1.50		NC	NC	NC	NC	NC

NC = not calculated. R = data rejected.

Table A14. Dissolved metal field duplicates for Round 3 (November 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
5X QL		50	100	1	200	25	25	0.5	1	25	10	2.5
RBDW03-1112	11/5/2012	<10	<20	<0.2	<40	60	<5	43.4	<0.2	<5	<2	1.2
RBDW03-1112 Dup	11/5/2012	<10	<20	<0.2	<40	61	<5	43.4	<0.2	<5	<2	1.2
RPD%		NC	NC	NC	NC	0.99	NC	0.00	NC	NC	NC	NC
RBDW10-1112	11/8/2012	<10	8.3	<0.2	<40	20	<5	3.9	<0.2	<5	<2	<0.5
RBDW10-1112 Dup	11/8/2012	<10	4.9	<0.2	<40	20	<5	3.8	<0.2	<5	<2	<0.5
RPD%		NC	NC	NC	NC	NC	NC	1.83	NC	NC	NC	NC

Sample ID	Date Collected	Fe	Hg	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb
Units		µg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	mg/L	µg/L	mg/L	µg/L
5X QL		500	1	2.5	50	0.25	25	2.5	1.25	1	0.25	1
RBDW03-1112	11/5/2012	51	<0.2	1.1	<10	12	0.3	0.5	35.6	1.6	<0.05	0.18
RBDW03-1112 Dup	11/5/2012	49	<0.2	1.1	<10	12	0.3	0.5	35.9	1.4	<0.05	0.16
RPD%		NC	NC	NC	NC	0.00	NC	NC	0.84	13.33	NC	NC
RBDW10-1112	11/8/2012	<100	<0.2	0.23	1.9	0.03	1.8	1.1	108	0.24	<0.05	<0.2
RBDW10-1112 Dup	11/8/2012	<100	<0.2	0.24	2.2	0.03	1.7	1.0	108	<0.2	<0.05	<0.2
RPD%		NC	NC	NC	NC	NC	NC	NC	0.00	NC	NC	NC

Table A14. Dissolved metal field duplicates for Round 3 (November 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	S	Sb	Se	Si	Sr	Th	Ti	Tl	U	V	Zn
Units		mg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5X QL			1	10	0.5	10	1	25	1	1	1	25
RBDW03-1112	11/5/2012	NR	<0.2	1.6	4.4	576	<0.2	<5	<0.2	0.42	0.1	3
RBDW03-1112 Dup	11/5/2012	NR	<0.2	1.9	4.4	581	<0.2	<5	<0.2	0.42	0.1	3
RPD%			NC	NC	0.00	0.86	NC	NC	NC	NC	NC	NC
RBDW10-1112	11/8/2012	NR	<0.2	0.7	4.88	86	<0.2	<5	<0.2	<0.2	0.02	<5
RBDW10-1112 Dup	11/8/2012	NR	<0.2	<2	4.85	89	<0.2	<5	<0.2	<0.2	0.02	<5
RPD%			NC	NC	0.62	3.33	NC	NC	NC	NC	NC	NC

NC = not calculated. NR = not reported.

Table A14. Dissolved metal field duplicates for Round 4 (April/May 2013): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
5x QL		50	100	1	200	25	25	0.5	1	25	10	2.5
RBMW01-0413	4/29/2013	<10	<20	0.07	<40	31.5	<5	54.4	<0.2	<5	<2	<0.5
RBMW01d-0413	4/29/2013	<10	<20	0.08	<40	32.0	<5	54.2	<0.2	<5	<2	0.6
RPD%		NC	NC	NC	NC	1.57	NC	0.37	NC	NC	NC	NC
RBDW02-0413	4/29/2013	<10	<20	0.07	<40	102	<5	17.2	<0.2	<5	<2	1.8
RBDW02d-0413	4/29/2013	<10	<20	0.07	40	101	<5	16.7	<0.2	<5	<2	2.0
RPD%		NC	NC	NC	NC	0.99	NC	2.95	NC	NC	NC	NC
RBSW01-0413	4/30/2013	<10	<20	0.47	117	117	<5	12.7	<0.2	<5	<2	0.5
RBSW01d-0413	4/30/2013	<10	<20	0.50	152	111	<5	11.8	<0.2	<5	<2	0.7
RPD%		NC	NC	NC	NC	5.26	NC	7.35	NC	NC	NC	NC

NC = not calculated.

Table A14. Dissolved metal field duplicates for Round 4 (April/May 2013): Raton Basin, CO *(continued)*

Sample ID	Date Collected	Fe	Hg	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb
Units		µg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	mg/L	µg/L	mg/L	µg/L
5x QL		500	1	2.5	50	0.25	25	2.5	1.25	1	0.25	1
RBMW01-0413	4/29/2013	175	<0.2	1.1	13	4.24	260	0.78	48	1.2	<0.05	<0.2
RBMW01d-0413	4/29/2013	175	<0.2	1.1	13	4.32	264	0.66	49	1.4	<0.05	<0.2
RPD%		NC	NC	NC	NC	1.87	1.53	NC	1.24	15.38	NC	NC
RBDW02-0413	4/29/2013	<100	<0.2	0.67	<10	1.46	2.8	1.5	87	0.77	<0.05	0.25
RBDW02d-0413	4/29/2013	<100	<0.2	0.64	<10	1.42	3.1	1.4	84	0.73	<0.05	0.20
RPD%		NC	NC	NC	NC	2.78	NC	NC	3.53	NC	NC	NC
RBSW01-0413	4/30/2013	76	<0.2	1.5	36	4.68	1.5	1.5	318	0.58	<0.05	<0.2
RBSW01d-0413	4/30/2013	<100	<0.2	1.6	36	4.51	1.3	1.5	319	0.54	<0.05	<0.2
RPD%		NC	NC	NC	NC	3.70	NC	NC	0.31	NC	NC	NC

NC = not calculated.

Table A14. Dissolved metal field duplicates for Round 4 (April/May 2013): Raton Basin, CO.
(continued)

Sample ID	Date Collected	S	Sb	Se	Si	Sr	Th	Ti	Tl	U	V	Zn
Units		mg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL			1	10	0.5	10	1	25	1	1	1	25
RBMW01-0413	4/29/2013	NA	<0.2	<2	4.3	1170	<0.2	0.2	<0.2	<0.2	0.02	<5
RBMW01d-0413	4/29/2013	NA	<0.2	<2	4.3	1170	<0.2	0.3	<0.2	<0.2	0.04	<5
RPD%			NC	NC	0.70	0.00	NC	NC	NC	NC	NC	NC
RBDW02-0413	4/29/2013	NA	0.06	<2	3.18	396	<0.2	<5	<0.2	<0.2	0.23	8.8
RBDW02d-0413	4/29/2013	NA	0.06	0.4	3.10	394	<0.2	<5	<0.2	<0.2	0.26	7.9
RPD%			NC	NC	2.55	0.51	NC	NC	NC	NC	NC	NC
RBSW01-0413	4/30/2013	NA	<0.2	<2	6.10	309	<0.2	0.7	<0.2	1.5	0.94	<5
RBSW01d-0413	4/30/2013	NA	<0.2	<2	6.11	294	0.32	<5	<0.2	1.6	0.96	7.3
RPD%			NC	NC	0.16	4.98	NC	NC	NC	6.45	NC	NC

NC = not calculated. NA = not analyzed.

Table A15. Total metal field duplicates: Raton Basin, CO.

Sample ID	Date Collected	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
5X QL		80	2740	110	1850	20	55	1.60	20	20	40	110
RBDW05-1011	10/4/2011	<16	<548	<22	<370	39	<11	4.27	<4	<4	<8	<22
RBDW05d-1011	10/4/2011	<16	<548	<22	<370	38	<11	4.20	<4	<4	<8	<22
RPD%		NC	NC	NC	NC	2.60	NC	1.65	NC	NC	NC	NC
RBDW10-1011	10/5/2011	<16	<548	<22	<370	26	<11	4.03	<4	<4	<8	<22
RBDW10d-1011	10/5/2011	<16	<548	<22	<370	25	<11	4.01	<4	<4	<8	<22
RPD%		NC	NC	NC	NC	3.92	NC	0.50	NC	NC	NC	NC

Sample ID	Date Collected	Fe	Hg	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb
Units		µg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	mg/L	µg/L	mg/L	µg/L
5X QL		370		1.95		0.55	80	95	9.50	465	0.35	95
RBDW05-1011	10/4/2011	<74	NA	0.68	NA	0.28	22	<19	124	<93	<0.07	<19
RBDW05d-1011	10/4/2011	<74	NA	0.69	NA	0.27	22	<19	124	<93	<0.07	<19
RPD%		NC		NC		NC	NC	NC	0.00	NC	NC	NC
RBDW10-1011	10/5/2011	36	NA	0.29	NA	0.06	<16	<19	106	<93	<0.07	<19
RBDW10d-1011	10/5/2011	36	NA	0.30	NA	0.05	<16	<19	108	<93	<0.07	<19
RPD%		NC		NC		NC	NC	NC	1.87	NC	NC	NC

NC = not calculated. NA = not analyzed.

Table A15. Total metal field duplicates for Round 1 (October 2011): Raton Basin, CO.

(continued)

Sample ID	Date Collected	S	Sb	Se	Si	Sr	Th	Ti	Tl	U	V	Zn
Units		mg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L *L*	µg/L	µg/L	µg/L	µg/L
5X QL		2.55		165	2.4	20		40	95	280	55	280
RBDW05-1011	10/4/2011	17.9	R	<33	5.00	106	NA	<8	<19	<56	<11	<56
RBDW05d-1011	10/4/2011	17.8	R	<33	4.98	104	NA	<8	<19	<56	<11	<56
RPD%		0.560		NC	0.40	1.90		NC	NC	NC	NC	NC
RBDW10-1011	10/5/2011	40.0	R	<33	5.47	93	NA	<8	<19	<56	<11	<56
RBDW10d-1011	10/5/2011	40.6	R	<33	5.52	94	NA	<8	<19	<56	<11	<56
RPD%		1.49		NC	0.91	1.07		NC	NC	NC	NC	NC

NC = not calculated. R = data rejected. NA = not analyzed.

Table A15. Total metal field duplicates for Round 2 (May 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
5x QL		78	100	5.0	1850	22	56	1.6	5.0	20	10	10
RBDW06-0512	5/16/2012	<16	<20.0	<1.0	<370	18.3	<11	12.4	<1.0	<4	<2.0	<2.0
RBDW06d-0512	5/16/2012	<16	<20.0	<1.0	<370	18.8	<11	12.3	<1.0	<4	<2.0	<2.0
RPD%		NC	NC	NC	NC	NC	NC	0.81	NC	NC	NC	NC
RBDW11-0512	5/15/2012	<16	<20.0	<1.0	<370	282	<11	17.7	<1.0	<4	<2.0	4.7
RBDW11d-0512	5/15/2012	<16	<20.0	<1.0	<370	281	<11	17.8	<1.0	<4	<2.0	4.1
RPD%		NC	NC	NC	NC	0.36	NC	0.56	NC	NC	NC	NC

Sample ID	Date Collected	Fe	Hg	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb
Units		µg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	mg/L	µg/L	mg/L	µg/L
5x QL		370		1.97		0.55	80	5.0	9.50	5.0	0.35	5.0
RBDW06-0512	5/16/2012	26	NA	0.56	NA	2.17	<16	30.4	101	<1.0	<0.07	<1.0
RBDW06d-0512	5/16/2012	29	NA	0.53	NA	2.11	<16	29.7	99.7	<1.0	<0.07	<1.0
RPD%		NC		NC		2.80	NC	2.33	1.30	NC	NC	NC
RBDW11-0512	5/15/2012	744	NA	1.03	NA	2.36	27	2.3	88.8	<1.0	<0.07	2.7
RBDW11d-0512	5/15/2012	659	NA	1.02	NA	2.36	26	2.1	88.0	<1.0	<0.07	<1.0
RPD%		12.12		NC		0.00	NC	NC	0.90	NC	NC	NC

NC = not calculated. NA = not analyzed.

Table A15. Total metal field duplicates for Round 2 (May 2012): Raton Basin, CO

(continued)

Sample ID	Date Collected	S	Sb	Se	Si	Sr	Th	Ti	Tl	U	V	Zn
Units		mg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.6	10	25	2.4	20	5.0	40	5.0	5.0	55	280
RBDW06-0512	5/16/2012	18.3	<2.0	<5.0	9.24	450	<1.0	<8	<1.0	R	<11	100
RBDW06d-0512	5/16/2012	19.0	<2.0	R	9.37	449	<1.0	<8	<1.0	R	<11	100
RPD%		3.75	NC	NC	1.40	0.22	NC	NC	NC		NC	NC
RBDW11-0512	5/15/2012	1.01	<2.0	<5.0	3.51	627	0.07	<8	<1.0	<1.0	<11	17
RBDW11d-0512	5/15/2012	1.01	<2.0	<5.0	3.50	626	<1.0	<8	<1.0	<1.0	<11	<56
RPD%		NC	NC	NC	0.29	0.16	NC	NC	NC	NC	NC	NC

NC = not calculated. R = data rejected.

Table A15. Total metal field duplicates for Round 3 (November 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
5x QL		50	100	1.0	100	12.5	12.5	0.25	1	12.5	10	2.5
RBDW03-1112	11/5/2012	<10	25	<0.2	23	55	<2.5	41.1	<0.2	<2.5	<2	2.0
RBDW03-1112 Dup	11/5/2012	<10	46	<0.2	20	56	<2.5	41.5	<0.2	<2.5	<2	1.8
RPD%		NC	NC	NC	NC	1.27	NC	0.97	NC	NC	NC	NC
RBDW10-1112	11/8/2012	<10	24	<0.2	37	23	<2.5	3.8	<0.2	2.2	0.6	<0.5
RBDW10-1112 Dup	11/8/2012	<10	39	<0.2	36	23	<2.5	3.8	<0.2	<2.5	<2	1.9
RPD%		NC	NC	NC	NC	0.44	NC	0.00	NC	NC	NC	NC

Sample ID	Date Collected	Fe	Hg	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb
Units		µg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	mg/L	µg/L	mg/L	µg/L
5x QL		250	1	1.3	25	0.15	12.5	2.5	0.65	1	0.15	1
RBDW03-1112	11/5/2012	<50	<0.2	1.1	0.70	11	<2.5	0.6	33	2.9	<0.03	0.28
RBDW03-1112 Dup	11/5/2012	<50	<0.2	1.1	0.85	12	<2.5	0.9	32	1.7	<0.03	0.26
RPD%		NC	NC	NC	NC	0.87	NC	NC	0.62	52	NC	NC
RBDW10-1112	11/8/2012	<50	<0.2	0.27	2.4	0.05	<2.5	2.6	107	0.26	<0.03	0.07
RBDW10-1112 Dup	11/8/2012	<50	<0.2	0.29	2.6	0.04	<2.5	2.4	104	0.22	<0.03	<0.2
RPD%		NC	NC	NC	NC	NC	NC	NC	2.84	NC	NC	NC

Table A15. Total metal field duplicates for Round 3 (November 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	S	Sb	Se	Si	Sr	Th	Ti	Tl	U	V	Zn
Units		mg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL			1	10	0.25	10	1	12.5	1	1	1	12.5
RBDW03-1112	11/5/2012	NA	<0.2	2.5	4.4	529	<0.2	0.3	0.15	0.43	0.2	5
RBDW03-1112 Dup	11/5/2012	NA	<0.2	1.9	4.4	538	<0.2	0.3	<0.2	0.42	0.3	4
RPD%			NC	NC	0.68	1.69	NC	NC	NC	NC	NC	NC
RBDW10-1112	11/8/2012	NA	<0.2	<2	5.2	104	<0.2	0.3	<0.2	<0.2	0.2	<2.5
RBDW10-1112 Dup	11/8/2012	NA	<0.2	<2	5.2	92	<0.2	0.3	<0.2	<0.2	0.2	<2.5
RPD%			NC	NC	0.77	12.57	NC	NC	NC	NC	NC	NC

NC = not calculated. NA = not analyzed.

Table A15. Total metal field duplicates for Round 4 (April/May 2013): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
5X QL		50	100	1	100	12.5	12.5	0.25	1	12.5	10	2.5
RBMW01-0413	4/29/2013	<10	38.9	0.31	<20	29.8	<2.5	52.6	<0.2	<2.5	<2	<0.5
RBMW01d-0413	4/29/2013	<10	<20	0.29	11.6	30.1	<2.5	53.8	<0.2	<2.5	<2	<0.5
RPD%		NC	NC	NC	NC	1.0	NC	2.3	NC	NC	NC	NC
RBDW02-0413	4/29/2013	<10	22.2	0.36	<20	105	<2.5	16.9	<0.2	<2.5	<2	5.5
RBDW02d-0413	4/29/2013	<10	24.1	0.26	3.50	104	<2.5	16.9	<0.2	<2.5	<2	7.2
RPD%		NC	NC	NC	NC	0.96	NC	0.00	NC	NC	NC	26.8
RBSW01-0413	4/30/2013	<10	329	0.64	118	123	<2.5	12.8	<0.2	<2.5	<2	0.98
RBSW01d-0413	4/30/2013	<10	433	0.77	124	117	<2.5	12.1	<0.2	0.7	<2	1.10
RPD%		NC	27.3	NC	4.96	5.0	NC	5.6	NC	NC	NC	NC

NC = not calculated.

Table A15. Total metal field duplicates for Round 4 (April/May 2013): Raton Basin, CO

(continued)

Sample ID	Date Collected	Fe	Hg	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb
Units		µg/L	µg/L	mg/L	µg/L	mg/L	µg/L	µg/L	mg/L	µg/L	mg/L	µg/L
5X QL		250	1	1.25	25	0.13	12.5	2.5	0.63	1	0.13	1
RBMW01-0413	4/29/2013	143	<0.2	1.0	12.4	4.3	278	0.82	44.8	1.8	<0.03	<0.2
RBMW01d-0413	4/29/2013	161	<0.2	1.1	13.1	4.3	282	1.0	47.2	1.5	<0.03	<0.2
RPD%		NC	NC	NC	NC	0.46	1.43	NC	5.2	18.2	NC	NC
RBDW02-0413	4/29/2013	26.7	<0.2	0.69	<5	1.4	47.3	1.2	84.2	0.68	0.003	0.53
RBDW02d-0413	4/29/2013	54	<0.2	0.69	4.8	1.4	64.8	0.96	84.4	0.76	<0.03	0.72
RPD%		NC	NC	NC	NC	0.0	31.22	NC	0.24	NC	NC	NC
RBSW01-0413	4/30/2013	476	<0.2	1.7	35.6	4.7	14.2	1.8	309	1.0	0.034	0.15
RBSW01d-0413	4/30/2013	467	<0.2	1.7	36.4	4.5	14	1.7	305	1.2	<0.03	0.17
RPD%		1.91	NC	1.18	2.2	3.04	1.42	NC	1.30	NC	NC	NC

NC = not calculated.

Table A15. Total metal field duplicates for Round 4 (April/May 2013): Raton Basin, CO.
(continued)

Sample ID	Date Collected	S	Sb	Se	Si	Sr	Th	Ti	Tl	U	V	Zn
Units		mg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5X QL			1	10	0.25	125	1	12.5	1	1	1	12.5
RBMW01-0413	4/29/2013	NA	<0.2	<2	4.1	1220	<0.2	<2.5	<0.2	<0.2	0.4	<2.5
RBMW01d-0413	4/29/2013	NA	<0.2	<2	4.3	1230	<0.2	<2.5	<0.2	<0.2	0.4	<2.5
RPD%			NC	NC	4.7	0.82	NC	NC	NC	NC	NC	NC
RBDW02-0413	4/29/2013	NA	<0.2	<2	3.1	417	0.29	<2.5	<0.2	0.12	0.66	6.5
RBDW02d-0413	4/29/2013	NA	<0.2	<2	3.1	414	<0.2	<2.5	<0.2	0.13	0.65	7
RPD%			NC	NC	0.97	0.72	NC	NC	NC	NC	NC	NC
RBSW01-0413	4/30/2013	NA	<0.2	0.43	7.0	326	<0.2	12.4	<0.2	1.6	1.6	<2.5
RBSW01d-0413	4/30/2013	NA	0.08	0.92	7.0	306	0.28	11.6	<0.2	1.5	2.0	<2.5
RPD%			NC	NC	0.00	6.33	NC	NC	NC	6.5	22.2	NC

NC = not calculated. NA = not analyzed.

Table A16. Volatile organic compound (VOC) field duplicates: Raton Basin, CO.

Sample ID	Date Collected	ethanol (64-17-5)	isopropanol (67-63-0)	acrylonitrile (107-13-1)	styrene (100-42-5)	acetone (67-64-1)	tert-butyl alcohol (75-65-0)	methyl tert-butyl ether (1634-04-4)	diisopropyl ether (108-20-3)	ethyl tert-butyl ether (637-92-3)	tert-amyl methyl ether (994-05-8)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		500	125	125	2.5	5.0	25	5.0	5.0	5.0	5.0
RBDW05-1011	10/4/2011	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBDW05d-1011	10/4/2011	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1011	10/5/2011	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBDW10d-1011	10/5/2011	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A16. VOC field duplicates for Round 1 (October 2011): Raton Basin, CO

(continued)

Sample ID	Date Collected	vinyl chloride (75-01-4)	1,1-dichloroethene (75-35-4)	carbon disulfide (75-15-0)	methylene chloride (75-09-2)	trans-1,2-dichloroethene (156-60-5)	1,1-dichloroethane (75-34-3)	cis-1,2-dichloroethene (156-59-2)	chloroform (67-66-3)	1,1,1-trichloroethane (71-55-6)	carbon tetrachloride (56-23-5)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5		2.5	5.0	2.5	2.5	2.5	2.5	2.5	2.5
RBDW05-1011	10/4/2011	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	0.56	<0.5	<0.5
RBDW05d-1011	10/4/2011	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	0.58	<0.5	<0.5
RPD%		NC		NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1011	10/5/2011	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBDW10d-1011	10/5/2011	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC		NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated. R = data rejected.

Table A16. VOC field duplicates for Round 1 (October 2011): Raton Basin, CO

(continued)

Sample ID	Date Collected	benzene (71-43-2)	1,2-dichloroethane (107-06-2)	trichloroethene (79-01-6)	toluene (108-88-3)	1,1,2-trichloroethane (79-00-5)	tetrachloroethene (127-18-4)	chlorobenzene (108-90-7)	ethylbenzene (100-41-4)	m+p xylene (108-38-3, 106-42-3)	o-xylene (95-47-6)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	2.5	2.5		2.5	2.5	5.0	10	2.5
RBDW05-1011	10/4/2011	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBDW05d-1011	10/4/2011	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RPD%		NC	NC	NC	NC		NC	NC	NC	NC	NC
RBDW10-1011	10/5/2011	<0.5	<0.5	<0.5	4.16	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBDW10d-1011	10/5/2011	<0.5	<0.5	<0.5	4.14	R	<0.5	<0.5	<1.0	<2.0	<0.5
RPD%		NC	NC	NC	0.48		NC	NC	NC	NC	NC

NC = not calculated. R = data rejected.

Table A16. VOC field duplicates for Round 1 (October 2011): Raton Basin, CO

(continued)

Sample ID	Date Collected	isopropylbenzene (98-82-8)	1,3,5-trimethylbenzene (108-67-8)	1,2,4-trimethylbenzene (95-63-6)	1,3-dichlorobenzene (541-73-1)	1,4-dichlorobenzene (106-46-7)	1,2,3-trimethylbenzene (526-73-8)	1,2-dichlorobenzene (95-50-1)	naphthalene (91-20-3)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
RBDW05-1011	10/4/2011	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBDW05d-1011	10/4/2011	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1011	10/5/2011	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBDW10d-1011	10/5/2011	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A16. VOC field duplicates for Round 2 (May 2012): Raton Basin, CO

(continued)

Sample ID	Date Collected	ethanol (64-17-5)	isopropanol (67-63-0)	acrylonitrile (107-13-1)	styrene (100-42-5)	acetone (67-64-1)	tert-butyl alcohol (75-65-0)	methyl tert-butyl ether (1634-04-4)	diisopropyl ether (108-20-3)	ethyl tert-butyl ether (637-92-3)	tert-amyl methyl ether (994-05-8)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		500	125	125	2.5	5.0	25	5.0	5.0	5.0	5.0
RBDW06-0512	5/16/2012	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RBDW06d-0512	5/16/2012	<100	<25	<25	<0.5	<1.0	<5.0	<1.0	<1.0	<1.0	<1.0
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW11-0512	5/15/2012	<100	<25	<25	<0.5	<1.0	20.4	<1.0	<1.0	<1.0	<1.0
RBDW11d-0512	5/15/2012	<100	<25	<25	<0.5	<1.0	19.5	<1.0	<1.0	<1.0	<1.0
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A16. VOC field duplicates for Round 2 (May 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	vinyl chloride (75-01-4)	1,1-dichloroethene (75-35-4)	carbon disulfide (75-15-0)	methylene chloride (75-09-2)	trans-1,2-dichloroethene (156-60-5)	1,1-dichloroethane (75-34-3)	cis-1,2-dichloroethene (156-59-2)	chloroform (67-66-3)	1,1,1-trichloroethane (71-55-6)	carbon tetrachloride (56-23-5)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	2.5	5.0	2.5	2.5	2.5	2.5	2.5	2.5
RBDW06-0512	5/16/2012	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBDW06d-0512	5/16/2012	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW11-0512	5/15/2012	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBDW11d-0512	5/15/2012	<0.5	<0.5	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A16. VOC field duplicates for Round 2 (May 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	benzene (71-43-2)	1,2-dichloroethane (107-06-2)	trichloroethene (79-01-6)	toluene (108-88-3)	1,1,2-trichloroethane (79-00-5)	tetrachloroethene (127-18-4)	chlorobenzene (108-90-7)	ethylbenzene (100-41-4)	m+p xylene (108-38-3, 106-42-3)	o-xylene (95-47-6)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	2.5	2.5	2.5	2.5	2.5	5.0	10	2.5
RBDW06-0512	5/16/2012	<0.5	<0.5	<0.5	1.96	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBDW06d-0512	5/16/2012	<0.5	<0.5	<0.5	2.08	R	<0.5	<0.5	<1.0	<2.0	<0.5
RPD%		NC	NC	NC	NC		NC	NC	NC	NC	NC
RBDW11-0512	5/15/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBDW11d-0512	5/15/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RPD%		NC	NC	NC	NC		NC	NC	NC	NC	NC

NC = not calculated. R. data rejected.

Table A16. VOC field duplicates for Round 2 (May 2012): Raton Basin, CO

(continued)

Sample ID	Date Collected	isopropylbenzene (98-82-8)	1,3,5-trimethylbenzene (108-67-8)	1,2,4-trimethylbenzene (95-63-6)	1,3-dichlorobenzene (541-73-1)	1,4-dichlorobenzene (106-46-7)	1,2,3-trimethylbenzene (526-73-8)	1,2-dichlorobenzene (95-50-1)	naphthalene (91-20-3)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
RBDW06-0512	5/16/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBDW06d-0512	5/16/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC
RBDW11-0512	5/15/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBDW11d-0512	5/15/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A16. SwRI - VOC field duplicates for Round 3 (November 2012): Raton Basin, CO

**Primary data set.The Shaw VOC data is presented for comparison.*

Sample ID	Date Collected	ethanol (64-17-5)	isopropanol (67-63-0)	acrylonitrile (107-13-1)	styrene (100-42-5)	acetone (67-64-1)	tert-butyl alcohol (75-65-0)	methyl tert-butyl ether (1634-04-4)	di-isopropyl ether (108-20-3)	ethyl tert-butyl ether (637-92-3)	tert-amyl methyl ether (994-05-8)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		500	50	5.0		5.0	50	2.5	2.5	2.5	2.5
RBDW03-1112	11/5/2012	<100	<10	<1.0	NR	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBDW03-1112 Dup	11/5/2012	<100	<10	<1.0	NR	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC		NC	NC	NC	NC	NC	NC
RBDW10-1112	11/8/2012	<100	<10	<1.0	NR	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBDW10-1112 Dup	11/8/2012	<100	<10	<1.0	NR	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC		NC	NC	NC	NC	NC	NC

NC = not calculated. NR = not reported.

Table A16. SwRI - VOC field duplicates for Round 3 (November 2012): Raton Basin, CO

(continued)

Sample ID	Date Collected	vinyl chloride (75-01-4)	1,1-dichloroethene (75-35-4)	carbon disulfide (75-15-0)	methylene chloride (75-09-2)	trans-1,2-dichloroethene (156-60-5)	1,1-dichloroethane (75-34-3)	cis-1,2-dichloroethene (156-59-2)	chloroform (67-66-3)	1,1,1-trichloroethane (71-55-6)	carbon tetrachloride (56-23-5)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
RBDW03-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBDW03-1112 Dup	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1112	11/8/2012	<0.5	<0.5	0.71	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBDW10-1112 Dup	11/8/2012	<0.5	<0.5	0.56	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A16. SwRI - VOC field duplicates for Round 3 (November 2012): Raton Basin, CO

(continued)

Sample ID	Date Collected	benzene (71-43-2)	1,2-dichloroethane (107-06-2)	trichloroethene (79-01-6)	toluene (108-88-3)	1,1,2-trichloroethane (79-00-5)	tetrachloroethene (127-18-4)	chlorobenzene (108-90-7)	ethylbenzene (100-41-4)	m+p xylene (179601-23-1)	o-xylene (95-47-6)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	5.0	2.5
RBDW03-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBDW03-1112 Dup	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1112	11/8/2012	<0.5	<0.5	<0.5	1.8	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBDW10-1112 Dup	11/8/2012	<0.5	<0.5	<0.5	0.66	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A16. SwRI - VOC field duplicates for Round 3 (November 2012): Raton Basin, CO

(continued)

Sample ID	Date Collected	isopropylbenzene (98-82-8)	1,3,5-trimethylbenzene (108-67-8)	1,2,4-trimethylbenzene (95-63-6)	1,3-dichlorobenzene (541-73-1)	1,4-dichlorobenzene (106-46-7)	1,2,3-trimethylbenzene (526-73-8)	1,2-dichlorobenzene (95-50-1)	naphthalene (91-20-3)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
RBDW03-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBDW03-1112 Dup	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1112	11/8/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBDW10-1112 Dup	11/8/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A16. Shaw - VOC field duplicates for Round 3 (November 2012): Raton Basin, CO

***The SwRI VOC data is the primary data set; the Shaw VOC data is presented for comparison.**

Sample ID	Date Collected	ethanol (64-17-5)	isopropanol (67-63-0)	acrylonitrile (107-13-1)	styrene (100-42-5)	acetone (67-64-1)	tert-butyl alcohol (75-65-0)	methyl tert-butyl ether (1634-04-4)	di-isopropyl ether (108-20-3)	ethyl tert-butyl ether (637-92-3)	tert-amyl methyl ether (994-05-8)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		1000	125	125	2.5	50	25	5.0	5.0	5.0	5.0
RBDW03-1112	11/5/2012	<200	<25	<25	<0.5	<10	<5.0	<1.0	<1.0	<1.0	<1.0
RBDW03-1112 Dup	11/5/2012	<200	<25	<25	<0.5	<10	<5.0	<1.0	<1.0	<1.0	<1.0
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1112	11/8/2012	<200	<25	<25	<0.5	<10	<5.0	<1.0	<1.0	<1.0	<1.0
RBDW10-1112 Dup	11/8/2012	<200	<25	<25	<0.5	<10	<5.0	<1.0	<1.0	<1.0	<1.0
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A16. Shaw - VOC field duplicates for Round 3 (November 2012): Raton Basin, CO

(continued)

Sample ID	Date Collected	vinyl chloride (75-01-4)	1,1-dichloroethene (75-35-4)	carbon disulfide (75-15-0)	methylene chloride (75-09-2)	trans-1,2-dichloroethene (156-60-5)	1,1-dichloroethane (75-34-3)	cis-1,2-dichloroethene (156-59-2)	chloroform (67-66-3)	1,1,1-trichloroethane (71-55-6)	carbon tetrachloride (56-23-5)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	2.5	5.0	2.5	2.5	2.5	2.5	2.5	2.5
RBDW03-1112	11/5/2012	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBDW03-1112 Dup	11/5/2012	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC		NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1112	11/8/2012	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBDW10-1112 Dup	11/8/2012	<0.5	R	<0.5	<1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC		NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated. R = data rejected.

Table A16. Shaw - VOC field duplicates for Round 3 (November 2012): Raton Basin, CO

(continued)

Sample ID	Date Collected	benzene (71-43-2)	1,2-dichloroethane (107-06-2)	trichloroethene (79-01-6)	toluene (108-88-3)	1,1,2-trichloroethane (79-00-5)	tetrachloroethene (127-18-4)	chlorobenzene (108-90-7)	ethylbenzene (100-41-4)	m+p xylene (108-38-3, 106-42-3)	o-xylene (95-47-6)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	2.5	2.5	2.5	2.5	2.5	5.0	10	2.5
RBDW03-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBDW03-1112 Dup	11/5/2012	<0.5	<0.5	<0.5	<0.5	R	<0.5	<0.5	<1.0	<2.0	<0.5
RPD%		NC	NC	NC	NC		NC	NC	NC	NC	NC
RBDW10-1112	11/8/2012	<0.5	<0.5	<0.5	2.7	R	<0.5	<0.5	<1.0	<2.0	<0.5
RBDW10-1112 Dup	11/8/2012	<0.5	<0.5	<0.5	3.2	R	<0.5	<0.5	<1.0	<2.0	<0.5
RPD%		NC	NC	NC	15.65		NC	NC	NC	NC	NC

NC = not calculated. R = data rejected.

Table A16. Shaw - VOC field duplicates for Round 3 (November 2012): Raton Basin, CO

(continued)

Sample ID	Date Collected	isopropylbenzene (98-82-8)	1,3,5-trimethylbenzene (108-67-8)	1,2,4-trimethylbenzene (95-63-6)	1,3-dichlorobenzene (541-73-1)	1,4-dichlorobenzene (106-46-7)	1,2,3-trimethylbenzene (526-73-8)	1,2-dichlorobenzene (95-50-1)	naphthalene (91-20-3)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
RBDW03-1112	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBDW03-1112 Dup	11/5/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1112	11/8/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBDW10-1112 Dup	11/8/2012	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A16. VOC field duplicates for Round 4 (April/May 2013): Raton Basin, CO.
(continued)

Sample ID	Date Collected	ethanol (64-17-5)	isopropanol (67-63-0)	acrylonitrile (107-13-1)	styrene (100-42-5)	acetone (67-64-1)	tert-butyl alcohol (75-65-0)	methyl tert-butyl ether (1634-04-4)	di-isopropyl ether (108-20-3)	ethyl tert-butyl ether (637-92-3)	tert-amyl methyl ether (994-05-8)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		500	50	5.0	2.5	5.0	50	2.5	2.5	2.5	2.5
RBMW01-0413	4/29/2013	<100	<10	<1.0	<0.5	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBMW01d-0413	4/29/2013	<100	<10	<1.0	<0.5	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW02-0413	4/29/2013	<100	<10	<1.0	<0.5	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RBDW02d-0413	4/29/2013	<100	<10	<1.0	<0.5	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBSW01-0413	4/30/2013	<100	<10	<1.0	<0.5	0.30	<10	<0.5	<0.5	<0.5	<0.5
RBSW01d-0413	4/30/2013	<100	<10	<1.0	<0.5	<1.0	<10	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A16. VOC field duplicates for Round 4 (April/May 2013): Raton Basin, CO
(continued)

Sample ID	Date Collected	vinyl chloride (75-01-4)	1,1-dichloroethene (75-35-4)	carbon disulfide (75-15-0)	methylene chloride (75-09-2)	trans-1,2-dichloroethene (156-60-5)	1,1-dichloroethane (75-34-3)	cis-1,2-dichloroethene (156-59-2)	chloroform (67-66-3)	1,1,1-trichloroethane (71-55-6)	carbon tetrachloride (56-23-5)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
RBMW01-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBMW01d-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW02-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.09	<0.5	<0.5
RBDW02d-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.08	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBSW01-0413	4/30/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBSW01d-0413	4/30/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A16. VOC field duplicates for Round 4 (April/May 2013): Raton Basin, CO

(continued)

Sample ID	Date Collected	benzene (71-43-2)	1,2-dichloroethane (107-06-2)	trichloroethene (79-01-6)	toluene (108-88-3)	1,1,2-trichloroethane (79-00-5)	tetrachloroethene (127-18-4)	chlorobenzene (108-90-7)	ethylbenzene (100-41-4)	m+p xylene (179601-23-1)	o-xylene (95-47-6)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	5.0	2.5
RBMW01-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBMW01d-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW02-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBDW02d-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBSW01-0413	4/30/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RBSW01d-0413	4/30/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.0	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A16. VOC field duplicates for Round 4 (April/May 2013): Raton Basin, CO.
(continued)

Sample ID	Date Collected	isopropylbenzene (98-82-8)	1,3,5-trimethylbenzene (108-67-8)	1,2,4-trimethylbenzene (95-63-6)	1,3-dichlorobenzene (541-73-1)	1,4-dichlorobenzene (106-46-7)	1,2,3-trimethylbenzene (526-73-8)	1,2-dichlorobenzene (95-50-1)	naphthalene (91-20-3)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
RBMW01-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBMW01d-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC
RBDW02-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBDW02d-0413	4/29/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC
RBSW01-0413	4/30/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RBSW01d-0413	4/30/2013	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
RPD%		NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A17. Low-molecular-weight acid field duplicates: Raton Basin, CO.

Sample ID	Date Collected	Lactate (50-21-5)	Formate (64-18-6)	Acetate (64-19-7)	Propionate (79-09-4)	Isobutyrate (79-31-2)	Butyrate (107-92-6)
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
5x QL		0.50	0.50		0.50	0.50	0.50
RBDW05-1011	10/4/2011	0.09	<0.10	R	<0.10	<0.10	<0.10
RBDW05d-1011	10/4/2011	<0.10	<0.10	R	<0.10	<0.10	<0.10
RPD%		NC	NC		NC	NC	NC
RBDW10-1011	10/5/2011	0.17	0.06	R	<0.10	<0.10	<0.10
RBDW10d-1011	10/5/2011	<0.10	<0.10	R	<0.10	<0.10	<0.10
RPD%		NC	NC		NC	NC	NC

NC = not calculated. R = data rejected.

Table A17. Low-molecular-weight acid field duplicates for Round 2 (May 2012): Raton Basin, CO. *(continued)*

Sample ID	Date Collected	Lactate (50-21-5)	Formate (64-18-6)	Acetate (64-19-7)	Propionate (79-09-4)	Isobutyrate (79-31-2)	Butyrate (107-92-6)
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
5x QL		0.50		0.50	0.50	0.50	0.50
RBDW06-0512	5/16/2012	<0.10	R	<0.10	<0.10	<0.10	<0.10
RBDW06d-0512	5/16/2012	<0.10	R	<0.10	<0.10	<0.10	<0.10
RPD%		NC		NC	NC	NC	NC
RBDW11-0512	5/15/2012	<0.10	R	<0.10	<0.10	<0.10	<0.10
RBDW11d-0512	5/15/2012	<0.10	R	<0.10	<0.10	<0.10	<0.10
RPD%		NC		NC	NC	NC	NC

NC = not calculated. R = data rejected.

Table A17. Low-molecular-weight acid field duplicates for Round 3 (November 2012): Raton Basin, CO. *(continued)*

Sample ID	Date Collected	Lactate (50-21-5)	Formate (64-18-6)	Acetate (64-19-7)	Propionate (79-09-4)	Isobutyrate (79-31-2)	Butyrate (107-92-6)
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
5x QL		0.50		0.50	0.50	0.50	0.50
RBDW03-1112	11/5/2012	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RBDW03-1112 Dup	11/5/2012	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RPD%		NC		NC	NC	NC	NC
RBDW10-1112	11/8/2012	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RBDW10-1112 Dup	11/8/2012	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RPD%		NC		NC	NC	NC	NC

NC = not calculated. NR = not reported.

Table A17. Low-molecular-weight acid field duplicates for Round 4 (April/May 2013): Raton Basin, CO

(continued)

Sample ID	Date Collected	Lactate (867-56-1)	Formate (64-18-6)	Acetate (127-09-3)	Propionate (137-40-6)	Isobutyrate(19455-20-0)	Butyrate (156-54-7)
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
5x QL		0.50		0.50	0.50	0.50	0.50
RBMW01-0413	4/29/2013	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RBMW01d-0413	4/29/2013	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RPD%		NC		NC	NC	NC	NC
RBDW02-0413	4/29/2013	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RBDW02d-0413	4/29/2013	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RPD%		NC		NC	NC	NC	NC
RBSW01-0413	4/30/2013	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RBSW01d-0413	4/30/2013	<0.10	NR	<0.10	<0.10	<0.10	<0.10
RPD%		NC		NC	NC	NC	NC

NC = not calculated. NR = not reported.

Table A18. Dissolved gas field duplicates: Raton Basin, CO

Sample ID	Date Collected	Methane (74-82-8)	Ethane (74-84-0)	Propane (74-98-6)	Butane (106-97-8)
Units		mg/L	mg/L	mg/L	mg/L
October 2011					
5x QL		0.0071	0.0145	0.0200	0.0255
RBDW05-1011	10/4/2011	0.0026	<0.0029	<0.0040	<0.0051
RBDW05d-1011	10/4/2011	0.0052	<0.0029	<0.0040	<0.0051
RPD%		NC	NC	NC	NC
RBDW10-1011	10/5/2011	9.580	0.0087	<0.0040	<0.0051
RBDW10d-1011	10/5/2011	10.40	0.0090	<0.0040	<0.0051
RPD%		8.21	NC	NC	NC
May 2012					
5x QL		0.0065	0.0135	0.0190	0.0235
RBDW06-0512	5/16/2012	6.710	0.0100	<0.0038	<0.0047
RBDW06d-0512	5/16/2012	5.300	0.0074	<0.0038	<0.0047
RPD%		23.48	NC	NC	NC
RBDW11-0512	5/15/2012	0.5500	0.0009	<0.0038	<0.0047
RBDW11d-0512	5/15/2012	0.6410	0.0006	<0.0038	<0.0047
RPD%		15.28	NC	NC	NC
November 2012					
5x QL		0.0065	0.0135	0.0185	0.0235
RBDW03-1112	11/5/2012	0.0328	<0.0027	<0.0037	<0.0047
RBDW03-1112 Dup	11/5/2012	0.0518	<0.0027	<0.0037	<0.0047
RPD%		44.9	NC	NC	NC
RBDW10-1112	11/8/2012	11.70	0.0099	<0.0037	<0.0047
RBDW10-1112 Dup	11/8/2012	12.20	0.0110	<0.0037	<0.0047
RPD%		4.18	NC	NC	NC

NC = not calculated.

Table A18. Dissolved gas field duplicates for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Methane (74-82-8)	Ethane (74-84-0)	Propane (74-98-6)	Butane (106-97-8)
Units		mg/L	mg/L	mg/L	mg/L
April/May 2013					
5x QL		0.0065	0.0135	0.0185	0.0235
RBMW01-0413 A	4/29/2013	1.040	<0.0027	<0.0037	<0.0047
RBMW01d-0413 A	4/29/2013	0.4940	<0.0027	<0.0037	<0.0047
RPD%		71.2	NC	NC	NC
RBDW02-0413 A	4/29/2013	<0.0013	<0.0027	<0.0037	<0.0047
RBDW02d-0413 A	4/29/2013	0.1490	<0.0027	<0.0037	<0.0047
RPD%		NC	NC	NC	NC
RBSW01-0413 A	4/30/2013	<0.0013	<0.0027	<0.0037	<0.0047
RBSW01d-0413 A	4/30/2013	<0.0013	<0.0027	<0.0037	<0.0047
RPD%		NC	NC	NC	NC

NC = not calculated.

Table A19. Glycol field duplicates: Raton Basin, CO.

Sample ID	Date Collected	2-butoxyethanol (111-76-2)	Diethylene glycol (111-46-6)	Triethylene glycol (112-27-6)	Tetraethylene glycol (112-60-7)
Units		µg/L	µg/L	µg/L	µg/L
October 2011					
5x QL		25	125	125	125
RBDW05-1011	10/4/2011	<5	<25	<25	<25
RBDW05d-1011	10/4/2011	<5	<25	<25	<25
RPD%		NC	NC	NC	NC
RBDW10-1011	10/5/2011	<5	<25	<25	<25
RBDW10d-1011	10/5/2011	<5	<25	<25	<25
RPD%		NC	NC	NC	NC
May 2012					
5x QL		125	125	125	125
RBDW06-0512	5/16/2012	<25	<25	<25	<25
RBDW06d-0512	5/16/2012	<25	<25	<25	<25
RPD%		NC	NC	NC	NC
RBDW11-0512	5/15/2012	<25	<25	<25	<25
RBDW11d-0512	5/15/2012	<25	<25	<25	<25
RPD%		NC	NC	NC	NC
November 2012					
5x QL		125	50	50	50
RBDW03-1112	11/5/2012	<25	<10	<10	<10
RBDW03d-1112	11/5/2012	<25	<10	<10	<10
RPD%		NC	NC	NC	NC
RBDW10-1112	11/8/2012	<25	<10	<10	<10
RBDW10d-1112	11/8/2012	<25	<10	<10	<10
RPD%		NC	NC	NC	NC

Table A19. Glycol field duplicates for Round 4 (April/May 2013): Raton Basin, CO. *(continued)*

Sample ID	Date Collected	2-butoxyethanol (111-76-2)	Diethylene glycol (111-46-6)	Triethylene glycol (112-27-6)	Tetraethylene glycol (112-60-7)
Units		µg/L	µg/L	µg/L	µg/L
April/May 2013					
5x QL		50	50	50	50
RBMW01-0413	4/29/2013	<10	<10	<10	<10
RBMW01d-0413	4/29/2013	<10	<10	<10	<10
RPD%		NC	NC	NC	NC
RBDW02-0413	4/29/2013	<10	<10	<10	<10
RBDW02d-0413	4/29/2013	<10	<10	<10	<10
RPD%		NC	NC	NC	NC
RBSW01-0413	4/30/2013	<10	<10	<10	<10
RBSW01d-0413	4/30/2013	<10	<10	<10	<10
RPD%		NC	NC	NC	NC

NC = not calculated.

Table A20. Semivolatile organic compound (SVOC) field duplicates: Raton Basin, CO.

Sample ID	Date Collected	R-(+)-limonene (5989-27-5)	1,2,4-trichlorobenzene (120-82-1)	1,2-dichlorobenzene (95-50-1)	1,2-dinitrobenzene (528-29-0)	1,3-dichlorobenzene (541-73-1)	1,3-dimethyladamantane (702-79-4)	1,3 -dinitrobenzene (99-65-0)	1,4-dichlorobenzene (106-46-7)	1,4-dinitrobenzene (100-25-4)	1-methylnaphthalene (90-12-0)	2,3,4,6-tetrachlorophenol (58-90-2)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
RBDW05-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBDW05d-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1011	10/5/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBDW10d-1011	10/5/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 1 (October 2011): Raton Basin, CO.

(continued)

Sample ID	Date Collected	2,3,5,6-tetrachlorophenol (935-95-5)	2,4,5-trichlorophenol (95-95-4)	2,4,6-trichlorophenol (88-06-2)	2,4-dichlorophenol (120-83-2)	2,4-dimethylphenol (105-67-9)	2,4-dinitrophenol (51-28-5)	2,4-dinitrotoluene (121-14-2)	2,6-dinitrotoluene (606-20-2)	2-butoxyethanol (111-76-2)	2-butoxyethyl phosphate (78-51-3)	2-chloronaphthalene (91-58-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	2.5	2.5	2.5	25.0	2.5	2.5	2.5	5.0	2.5
RBDW05-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	0.65	<1.00	<0.50
RBDW05d-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	0.74	<1.00	<0.50
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1011	10/5/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<1.00	<0.50
RBDW10d-1011	10/5/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<1.00	<0.50
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 1 (October 2011): Raton Basin, CO

(continued)

Sample ID	Date Collected	2-chlorophenol (95-57-8)	2-methylnaphthalene (91-57-6)	2-methylphenol (95-48-7)	2-nitroaniline (88-74-4)	2-nitrophenol (88-75-5)	3&4-methylphenol (108-39-4 & 106-44-5)	3,3'-dichlorobenzidine (91-94-1)	3-nitroaniline (99-09-2)	4,6-dinitro-2-methylphenol (534-52-1)	4-bromophenyl phenyl ether (101-55-3)	4-chloro-3-methylphenol (59-50-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	2.5	2.5	2.5	2.5		2.5	2.5	2.5	2.5
RBDW05-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	NR	<0.50	<0.50	<0.50	<0.50
RBDW05d-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	NR	<0.50	<0.50	<0.50	<0.50
RPD%		NC	NC	NC	NC	NC	NC		NC	NC	NC	NC
RBDW10-1011	10/5/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	NR	<0.50	<0.50	<0.50	<0.50
RBDW10d-1011	10/5/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	NR	<0.50	<0.50	<0.50	<0.50
RPD%		NC	NC	NC	NC	NC	NC		NC	NC	NC	NC

NC = not calculated. NR = not reported.

Table A20. SVOC field duplicates for Round 1 (October 2011): Raton Basin, CO

(continued)

Sample ID	Date Collected	4-chloroaniline (106-47-8)	4-chlorophenyl phenyl ether (7005-72-3)	4-nitroaniline (100-01-6)	4-nitrophenol (100-02-7)	Acenaphthene (83-32-9)	Acenaphthylene (208-96-8)	Adamantane (281-23-2)	Aniline (62-53-3)	Anthracene (120-12-7)	Azobenzene (103-33-3)	Benzo(a)anthracene (56-55-3)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		5.0	2.5	2.5	12.5	2.5	2.5	2.5	5.0	2.5	2.5	2.5
RBDW05-1011	10/4/2011	<1.00	<0.50	<0.50	<2.50	<0.50	<0.50	<0.50	<1.00	<0.50	<0.50	<0.50
RBDW05d-1011	10/4/2011	<1.00	<0.50	<0.50	<2.50	<0.50	<0.50	<0.50	<1.00	<0.50	<0.50	<0.50
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1011	10/5/2011	<1.00	<0.50	<0.50	<2.50	<0.50	<0.50	<0.50	<1.00	<0.50	<0.50	<0.50
RBDW10d-1011	10/5/2011	<1.00	<0.50	<0.50	<2.50	<0.50	<0.50	<0.50	<1.00	<0.50	<0.50	<0.50
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 1 (October 2011): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Benzo(a)pyrene (50-32-3)	Benzo(b)fluoranthene (205-99-2)	Benzo(g,h,i)perylene (191-24-2)	Benzo(k)fluoranthene (207-08-9)	Benzoic Acid (65-85-0)	Benzyl alcohol (100-51-6)	Bis-(2-chloroethoxy)methane (111-91-1)	Bis-(2-chloroethyl)ether (111-44-4)	Bis-(2-chloroisopropyl)ether (108-60-1)	Bis-(2-ethylhexyl) adipate (103-23-1)	Bis-(2-ethylhexyl) phthalate (117-81-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	2.5	2.5	25.0	2.5	2.5	2.5	2.5	5.0	5.0
RBDW05-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<0.50	<1.00	<1.00
RBDW05d-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<0.50	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1011	10/5/2011	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<0.50	2.31	<1.00
RBDW10d-1011	10/5/2011	<0.50	<0.50	<0.50	<0.50	<5.00	<0.50	<0.50	<0.50	<0.50	2.36	2.44
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 1 (October 2011): Raton Basin, CO

(continued)

Sample ID	Date Collected	Butyl benzyl phthalate (85-68-7)	Carbazole (86-74-8)	Chrysene (218-01-9)	Dibenz(a,h)anthracene (53-70-3)	Dibenzofuran (132-64-9)	Diethyl phthalate (84-66-2)	Dimethyl phthalate (131-11-3)	Di-n-butyl phthalate (84-74-2)	Di-n-octyl phthalate (117-84-0)	Diphenylamine (122-39-4)	Fluoranthene (206-44-0)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
RBDW05-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBDW05d-1011	10/4/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1011	10/5/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBDW10d-1011	10/5/2011	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 1 (October 2011): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Fluorene (86-73-7)	Hexachlorobenzene (118-74-1)	Hexachlorobutadiene (87-68-3)	Hexachlorocyclopentadiene (77-47-4)	Hexachloroethane (67-72-1)	Indeno(1,2,3-cd)pyrene (193-39-5)	Isophorone (78-59-1)	Naphthalene (91-20-3)	Nitrobenzene (98-95-3)	N-nitrosodimethylamine (62-75-9)	N-nitrosodi-n-propylamine (621-64-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		2.5	2.5	5.0	2.5	5.0	2.5	2.5	2.5	2.5	2.5	2.5
RBDW05-1011	10/4/2011	<0.50	<0.50	< 1.00	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBDW05d-1011	10/4/2011	<0.50	<0.50	< 1.00	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1011	10/5/2011	<0.50	<0.50	< 1.00	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RBDW10d-1011	10/5/2011	<0.50	<0.50	< 1.00	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20 Semivolatile organic compound (SVOC) field duplicates for Round 1 (October 2011): Raton Basin, CO. *(continued)*

Sample ID	Date Collected	Pentachlorophenol (87-86-5)	Phenanthrene (85-01-8)	Phenol (108-95-2)	Pyrene (129-00-0)	Pyridine (110-86-1)	Squalene (111-02-4)	Terpiniol (98-55-5)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		5.0	2.5	2.5	2.5	2.5	5.0	2.5
RBDW05-1011	10/4/2011	<1.00	<0.50	<0.50	<0.50	<0.50	<1.00	<0.50
RBDW05d-1011	10/4/2011	<1.00	<0.50	<0.50	<0.50	<0.50	<1.00	<0.50
RPD%		NC	NC	NC	NC	NC	NC	NC
RBDW10-1011	10/5/2011	<1.00	<0.50	<0.50	<0.50	<0.50	<1.00	<0.50
RBDW10d-1011	10/5/2011	<1.00	<0.50	<0.50	<0.50	<0.50	<1.00	<0.50
RPD%		NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 2 (May 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	R-(+)-limonene (5989-27-5)	1,2,4-trichlorobenzene (120-82-1)	1,2-dichlorobenzene (95-50-1)	1,2-dinitrobenzene (528-29-0)	1,3-dichlorobenzene (541-73-1)	1,3-dimethyladamantane (702-79-4)	1,3 -dinitrobenzene (99-65-0)	1,4-dichlorobenzene (106-46-7)	1,4-dinitrobenzene (100-25-4)	1-methylnaphthalene (90-12-0)	2,3,4,6-tetrachlorophenol (58-90-2)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	10.0
RBDW06-0512	5/16/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBDW06d-0512	5/16/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW11-0512	5/15/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBDW11d-0512	5/15/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 2 (May 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	2,3,5,6-tetrachlorophenol (935-95-5)	2,4,5-trichlorophenol (95-95-4)	2,4,6-trichlorophenol (88-06-2)	2,4-dichlorophenol (120-83-2)	2,4-dimethylphenol (105-67-9)	2,4-dinitrophenol (51-28-5)	2,4-dinitrotoluene (121-14-2)	2,6-dinitrotoluene (606-20-2)	2-butoxyethanol (111-76-2)	2-Butoxyethanol phosphate (78-51-3)	2-chloronaphthalene (91-58-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		10.0	10.0	10.0	10.0	10.0	15.0	5.0	5.0	5.0	5.0	5.0
RBDW06-0512	5/16/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW06d-0512	5/16/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW11-0512	5/15/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW11d-0512	5/15/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 2 (May 2012): Raton Basin, CO

(continued)

Sample ID	Date Collected	2-chlorophenol (95-57-8)	2-methylnaphthalene (91-57-6)	2-methylphenol (95-48-7)	2-nitroaniline (88-74-4)	2-nitrophenol (88-75-5)	3&4-methylphenol (108-39-4 & 106-44-5)	3,3'-dichlorobenzidine (91-94-1)	3-nitroaniline (99-09-2)	4,6-dinitro-2-methylphenol (534-52-1)	4-bromophenyl phenyl ether (101-55-3)	4-chloro-3-methylphenol (59-50-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		10.0	5.0	10.0	5.0	10.0	25	5.0	15.0	10.0	5.0	10.0
RBDW06-0512	5/16/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBDW06d-0512	5/16/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW11-0512	5/15/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBDW11d-0512	5/15/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 2 (May 2012): Raton Basin, CO

(continued)

Sample ID	Date Collected	4-chloroaniline (106-47-8)	4-chlorophenyl phenyl ether (7005-72-3)	4-nitroaniline (100-01-6)	4-nitrophenol (100-02-7)	Acenaphthene (83-32-9)	Acenaphthylene (208-96-8)	Adamantane (281-23-2)	Aniline (62-53-3)	Anthracene (120-12-7)	Azobenzene (103-33-3)	Benzo(a)anthracene (56-55-3)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		15.0	5.0	15.0	15.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
RBDW06-0512	5/16/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW06d-0512	5/16/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW11-0512	5/15/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW11d-0512	5/15/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 2 (May 2012): Raton Basin, CO

(continued)

Sample ID	Date Collected	Benzo(a)pyrene (50-32-3)	Benzo(b)fluoranthene (205-99-2)	Benzo(g,h,i)perylene (191-24-2)	Benzo(k)fluoranthene (207-08-9)	Benzoic Acid (65-85-0)	Benzyl alcohol (100-51-6)	Bis-(2-chloroethoxy)methane (111-91-1)	Bis-(2-chloroethyl)ether (111-44-4)	Bis-(2-chloroisopropyl)ether (108-60-1)	Bis-(2-ethylhexyl) adipate (103-23-1)	Bis-(2-ethylhexyl) phthalate (117-81-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		5.0	5.0	5.0	5.0	15.0	5.0	5.0	5.0	5.0	5.0	10.0
RBDW06-0512	5/16/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBDW06d-0512	5/16/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW11-0512	5/15/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBDW11d-0512	5/15/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 2 (May 2012): Raton Basin, CO

(continued)

Sample ID	Date Collected	Butyl benzyl phthalate (85-68-7)	Carbazole (86-74-8)	Chrysene (218-01-9)	Dibenz(a,h)anthracene (53-70-3)	Dibenzofuran (132-64-9)	Diethyl phthalate (84-66-2)	Dimethyl phthalate (131-11-3)	Di-n-butyl phthalate (84-74-2)	Di-n-octyl phthalate (117-84-0)	Diphenylamine (122-39-4)	Fluoranthene (206-44-0)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		5.0	15.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
RBDW06-0512	5/16/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW06d-0512	5/16/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW11-0512	5/15/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW11d-0512	5/15/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 2 (May 2012): Raton Basin, CO

(continued)

Sample ID	Date Collected	Fluorene (86-73-7)	Hexachlorobenzene (118-74-1)	Hexachlorobutadiene (87-68-3)	Hexachlorocyclopentadiene (77-47-4)	Hexachloroethane (67-72-1)	Indeno(1,2,3-cd)pyrene (193-39-5)	Isophorone (78-59-1)	Naphthalene (91-20-3)	Nitrobenzene (98-95-3)	N-nitrosodimethylamine (62-75-9)	N-nitrosodi-n-propylamine (621-64-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
RBDW06-0512	5/16/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW06d-0512	5/16/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW11-0512	5/15/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW11d-0512	5/15/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20 Semivolatile organic compound (SVOC) field duplicates for Round 2 (May 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Pentachlorophenol (87-86-5)	Phenanthrene (85-01-8)	Phenol (108-95-2)	Pyrene (129-00-0)	Pyridine (110-86-1)	Squalene (111-02-4)	Terpiniol (98-55-5)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		10.0	5.0	10.0	5.0	5.0	10.0	5.0
RBDW06-0512	5/16/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBDW06d-0512	5/16/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC
RBDW11-0512	5/15/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBDW11d-0512	5/15/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 3 (November 2012): Raton Basin, CO

(continued)

Sample ID	Date Collected	R-(+)-limonene (5989-27-5)	1,2,4-trichlorobenzene (120-82-1)	1,2-dichlorobenzene (95-50-1)	1,2-dinitrobenzene (528-29-0)	1,3-dichlorobenzene (541-73-1)	1,3-dimethyladamantane (702-79-4)	1,3 -dinitrobenzene (99-65-0)	1,4-dichlorobenzene (106-46-7)	1,4-dinitrobenzene (100-25-4)	1-methylnaphthalene (90-12-0)	2,3,4,6-tetrachlorophenol (58-90-2)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	10.0
RBDW03-1112	11/5/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBDW03-1112 Dup	11/5/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1112	11/8/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBDW10-1112 Dup	11/8/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 3 (November 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	2,3,5,6-tetrachlorophenol (935-95-5)	2,4,5-trichlorophenol (95-95-4)	2,4,6-trichlorophenol (88-06-2)	2,4-dichlorophenol (120-83-2)	2,4-dimethylphenol (105-67-9)	2,4-dinitrophenol (51-28-5)	2,4-dinitrotoluene (121-14-2)	2,6-dinitrotoluene (606-20-2)	2-butoxyethanol (111-76-2)	2-Butoxyethanol phosphate (78-51-3)	2-chloronaphthalene (91-58-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		10.0	10.0	10.0	10.0	10.0	15.0	5.0	5.0	5.0	5.0	5.0
RBDW03-1112	11/5/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW03-1112 Dup	11/5/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1112	11/8/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW10-1112 Dup	11/8/2012	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 3 (November 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	2-chlorophenol (95-57-8)	2-methylnaphthalene (91-57-6)	2-methylphenol (95-48-7)	2-nitroaniline (88-74-4)	2-nitrophenol (88-75-5)	3&4-methylphenol (108-39-4 & 106-44-5)	3,3'-dichlorobenzidine (91-94-1)	3-nitroaniline (99-09-2)	4,6-dinitro-2-methylphenol (534-52-1)	4-bromophenyl phenyl ether (101-55-3)	4-chloro-3-methylphenol (59-50-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		10.0	5.0	10.0	5.0	10.0	25	5.0	15.0	10.0	5.0	10.0
RBDW03-1112	11/5/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBDW03-1112 Dup	11/5/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1112	11/8/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBDW10-1112 Dup	11/8/2012	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 3 (November 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	4-chloroaniline (106-47-8)	4-chlorophenyl phenyl ether (7005-72-3)	4-nitroaniline (100-01-6)	4-nitrophenol (100-02-7)	Acenaphthene (83-32-9)	Acenaphthylene (208-96-8)	Adamantane (281-23-2)	Aniline (62-53-3)	Anthracene (120-12-7)	Azobenzene (103-33-3)	Benzo(a)anthracene (56-55-3)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		15.0	5.0	15.0	15.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
RBDW03-1112	11/5/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW03-1112 Dup	11/5/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1112	11/8/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW10-1112 Dup	11/8/2012	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 3 (November 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Benzo(a)pyrene (50-32-8)	Benzo(b)fluoranthene (205-99-2)	Benzo(g,h,i)perylene (191-24-2)	Benzo(k)fluoranthene (207-08-9)	Benzoic Acid (65-85-0)	Benzyl alcohol (100-51-6)	Bis-(2-chloroethoxy)methane (111-91-1)	Bis-(2-chloroethyl)ether (111-44-4)	Bis(2-chloroisopropyl)ether (39638-32-9)	Bis-(2-ethylhexyl) adipate (103-23-1)	Bis-(2-ethylhexyl) phthalate (117-81-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		5.0	5.0	5.0	5.0	15.0	5.0	5.0	5.0	5.0	5.0	10.0
RBDW03-1112	11/5/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBDW03-1112 Dup	11/5/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1112	11/8/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBDW10-1112 Dup	11/8/2012	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 3 (November 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	Butyl benzyl phthalate (85-68-7)	Carbazole (86-74-8)	Chrysene (218-01-9)	Dibenz(a,h)anthracene (53-70-3)	Dibenzofuran (132-64-9)	Diethyl phthalate (84-66-2)	Dimethyl phthalate (131-11-3)	Di-n-butyl phthalate (84-74-2)	Di-n-octyl phthalate (117-84-0)	Diphenylamine (122-39-4)	Fluoranthene (206-44-0)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		5.0	15.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
RBDW03-1112	11/5/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW03-1112 Dup	11/5/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1112	11/8/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW10-1112 Dup	11/8/2012	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 3 (November 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Fluorene (86-73-7)	Hexachlorobenzene (118-74-1)	Hexachlorobutadiene (87-68-3)	Hexachlorocyclopentadiene (77-47-4)	Hexachloroethane (67-72-1)	Indeno(1,2,3-cd)pyrene (193-39-5)	Isophorone (78-59-1)	Naphthalene (91-20-3)	Nitrobenzene (98-95-3)	N-nitrosodimethylamine (62-75-9)	N-nitrosodi-n-propylamine (621-64-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
RBDW03-1112	11/5/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW03-1112 Dup	11/5/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW10-1112	11/8/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW10-1112 Dup	11/8/2012	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 3 (November 2012): Raton Basin, CO

(continued)

Sample ID	Date Collected	Pentachlorophenol (87-86-5)	Phenanthrene (85-01-8)	Phenol (108-95-2)	Pyrene (129-00-0)	Pyridine (110-86-1)	Squalene (111-02-4)	Terpiniol (8000-41-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		10.0	5.0	10.0	5.0	5.0	10.0	5.0
RBDW03-1112	11/5/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBDW03-1112 Dup	11/5/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC
RBDW10-1112	11/8/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBDW10-1112 Dup	11/8/2012	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 4 (April/May 2013): Raton Basin, CO

(continued)

Sample ID	Date Collected	R-(+)-limonene (5989-27-5)	1,2,4-trichlorobenzene (120-82-1)	1,2-dichlorobenzene (95-50-1)	1,2-dinitrobenzene (528-29-0)	1,3-dichlorobenzene (541-73-1)	1,3-dimethyladamantane (702-79-4)	1,3 -dinitrobenzene (99-65-0)	1,4-dichlorobenzene (106-46-7)	1,4-dinitrobenzene (100-25-4)	1-methylnaphthalene (90-12-0)	2,3,4,6-tetrachlorophenol (58-90-2)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	10.0
RBMW01-0413	4/29/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBMW01d-0413	4/29/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW02-0413	4/29/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBDW02d-0413	4/29/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBSW01-0413	4/30/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBSW01d-0413	4/30/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 4 (April/May 2013): Raton Basin, CO

(continued)

Sample ID	Date Collected	2,3,5,6-tetrachlorophenol (935-95-5)	2,4,5-trichlorophenol (95-95-4)	2,4,6-trichlorophenol (88-06-2)	2,4-dichlorophenol (120-83-2)	2,4-dimethylphenol (105-67-9)	2,4-dinitrophenol (51-28-5)	2,4-dinitrotoluene (121-14-2)	2,6-dinitrotoluene (606-20-2)	2-butoxyethanol (111-76-2)	2-butoxyethanol phosphate (78-51-3)	2-chloronaphthalene (91-58-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		10.0	10.0	10.0	10.0	10.0	15.0	5.0	5.0	5.0	5.0	5.0
RBMW01-0413	4/29/2013	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBMW01d-0413	4/29/2013	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW02-0413	4/29/2013	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW02d-0413	4/29/2013	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBSW01-0413	4/30/2013	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBSW01d-0413	4/30/2013	<2.00	<2.00	<2.00	<2.00	<2.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

Table A20. SVOC field duplicates for Round 4 (April/May 2013): Raton Basin, CO

(continued)

Sample ID	Date Collected	2-chlorophenol (95-57-8)	2-methylnaphthalene (91-57-6)	2-methylphenol (95-48-7)	2-nitroaniline (88-74-4)	2-nitrophenol (88-75-5)	3&4-methylphenol (108-39-4 & 106-44-5)	3,3'-dichlorobenzidine (91-94-1)	3-nitroaniline (99-09-2)	4,6-dinitro-2-methylphenol (534-52-1)	4-bromophenyl phenyl ether (101-55-3)	4-chloro-3-methylphenol (59-50-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		10.0	5.0	10.0	5.0	10.0	25.0	5.0	15.0	10.0	5.0	10.0
RBMW01-0413	4/29/2013	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBMW01d-0413	4/29/2013	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW02-0413	4/29/2013	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBDW02d-0413	4/29/2013	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBSW01-0413	4/30/2013	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RBSW01d-0413	4/30/2013	<2.00	<1.00	<2.00	<1.00	<2.00	<5.00	<1.00	<3.00	<2.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

Table A20. SVOC field duplicates for Round 4 (April/May 2013): Raton Basin, CO

(continued)

Sample ID	Date Collected	4-chloroaniline (106-47-8)	4-chlorophenyl phenyl ether (7005-72-3)	4-nitroaniline (100-01-6)	4-nitrophenol (100-02-7)	Acenaphthene (83-32-9)	Acenaphthylene (208-96-8)	Adamantane (281-23-2)	Aniline (62-53-3)	Anthracene (120-12-7)	Azobenzene (103-33-3)	Benzo(a)anthracene (56-55-3)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		15.0	5.0	15.0	15.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
RBMW01-0413	4/29/2013	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBMW01d-0413	4/29/2013	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW02-0413	4/29/2013	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW02d-0413	4/29/2013	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBSW01-0413	4/30/2013	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBSW01d-0413	4/30/2013	<3.00	<1.00	<3.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 4 (April/May 2013): Raton Basin, CO

(continued)

Sample ID	Date Collected	Benzo(a)pyrene (50-32-8)	Benzo(b)fluoranthene (205-99-2)	Benzo(g,h,i)perylene (191-24-2)	Benzo(k)fluoranthene (207-08-9)	Benzoic Acid (65-85-0)	Benzyl alcohol (100-51-6)	Bis-(2-chloroethoxy)methane (111-91-1)	Bis-(2-chloroethyl)ether (111-44-4)	Bis(2-chloroisopropyl)ether (39638-32-9)	Bis-(2-ethylhexyl) adipate (103-23-1)	Bis-(2-ethylhexyl) phthalate (117-81-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		5.0	5.0	5.0	5.0	15.0	5.0	5.0	5.0	5.0	5.0	10.0
RBMW01-0413	4/29/2013	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	5.28
RBMW01d-0413	4/29/2013	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	95.9
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW02-0413	4/29/2013	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	9.56
RBDW02d-0413	4/29/2013	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBSW01-0413	4/30/2013	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RBSW01d-0413	4/30/2013	<1.00	<1.00	<1.00	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<2.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

Table A20. SVOC field duplicates for Round 4 (April/May 2013): Raton Basin, CO

(continued)

Sample ID	Date Collected	Butyl benzyl phthalate (85-68-7)	Carbazole (86-74-8)	Chrysene (218-01-9)	Dibenz(a,h)anthracene (53-70-3)	Dibenzofuran (132-64-9)	Diethyl phthalate (84-66-2)	Dimethyl phthalate (131-11-3)	Di-n-butyl phthalate (84-74-2)	Di-n-octyl phthalate (117-84-0)	Diphenylamine (122-39-4)	Fluoranthene (206-44-0)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		5.0	15.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
RBMW01-0413	4/29/2013	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBMW01d-0413	4/29/2013	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW02-0413	4/29/2013	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW02d-0413	4/29/2013	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBSW01-0413	4/30/2013	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBSW01d-0413	4/30/2013	<1.00	<3.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 4 (April/May 2013): Raton Basin, CO
(continued)

Sample ID	Date Collected	Fluorene (86-73-7)	Hexachlorobenzene (118-74-1)	Hexachlorobutadiene (87-68-3)	Hexachlorocyclopentadiene (77-47-4)	Hexachloroethane (67-72-1)	Indeno(1,2,3-cd)pyrene (193-39-5)	Isophorone (78-59-1)	Naphthalene (91-20-3)	Nitrobenzene (98-95-3)	N-nitrosodimethylamine (62-75-9)	N-nitrosodi-n-propylamine (621-64-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
RBMW01-0413	4/29/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBMW01d-0413	4/29/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBDW02-0413	4/29/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBDW02d-0413	4/29/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
RBSW01-0413	4/30/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RBSW01d-0413	4/30/2013	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC = not calculated.

Table A20. SVOC field duplicates for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Pentachlorophenol (87-86-5)	Phenanthrene (85-01-8)	Phenol (108-95-2)	Pyrene (129-00-0)	Pyridine (110-86-1)	Squalene (111-02-4)	Terpiniol (8000-41-7)
Units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
5x QL		10.0	5.0	10.0	5.0	5.0	10.0	5.0
RBMW01-0413	4/29/2013	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBMW01d-0413	4/29/2013	<2.00	<1.00	<2.00	<1.00	<1.00	3.82	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC
RBDW02-0413	4/29/2013	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBDW02d-0413	4/29/2013	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC
RBSW01-0413	4/30/2013	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RBSW01d-0413	4/30/2013	<2.00	<1.00	<2.00	<1.00	<1.00	<2.00	<1.00
RPD%		NC	NC	NC	NC	NC	NC	NC

NC = not calculated

Table A21. Diesel range organic (DRO) and Gasoline range organic (GRO) field duplicates: Raton Basin, CO.

Sample ID	Date Collected	GRO/TPH	DRO
Units		µg/L	µg/L
October 2011			
5x QL		100	100
RBDW05-1011	10/4/2011	< 20.0	< 20.0
RBDW05d-1011	10/4/2011	< 20.0	< 20.0
RPD%		NC	NC
RBDW10-1011	10/5/2011	23.9	21.1
RBDW10d-1011	10/5/2011	25.2	< 20.0
RPD%		NC	NC
May 2012			
5x QL		100	100
RBDW06-0512	5/16/2012	21.5	89.7
RBDW06d-0512	5/16/2012	22.3	105
RPD%		NC	NC
RBDW11-0512	5/15/2012	< 20.0	< 20.0
RBDW11d-0512	5/15/2012	< 20.0	< 20.0
RPD%		NC	NC
November 2012			
5x QL		100	100
RBDW03-1112	11/5/2012	<20.0	<20.0
RBDW03-1112 Dup	11/5/2012	<20.0	<20.0
RPD%		NC	NC
RBDW10-1112	11/8/2012	20.6	<20.0
RBDW10-1112 Dup	11/8/2012	20.8	<20.0
RPD%		NC	NC

NC = not calculated.

Table A21. Diesel range organic (DRO) and Gasoline range organic (GRO) field duplicates for Round 4 (April/May 2013): Raton Basin, CO.
(continued)

Sample ID	Date Collected	GRO/TPH	DRO
Units		µg/L	µg/L
April/May 2013			
5x QL		100	100
RBMW01-0413	4/29/2013	<20.0	29.8
RBMW01d-0413	4/29/2013	<20.0	45.6
RPD%		NC	NC
RBDW02-0413	4/29/2013	<20.0	28.3
RBDW02d-0413	4/29/2013	<20.0	<20.0
RPD%		NC	NC
RBSW01-0413	4/30/2013	<20.0	46.9
RBSW01d-0413	4/30/2013	<20.0	50.4
RPD%		NC	NC

NC = not calculated.

Table A22. Oxygen and hydrogen stable isotopes of water – field duplicates: Raton Basin, CO.

Sample ID	Date Collected	δ^2H	$\delta^{18}O$
Units		‰	‰
October 2011			
RBDW05-1011	10/4/2011	-67.06	-8.73
RBDW05d-1011	10/4/2011	-66.95	-8.72
RPD%		0.16	0.11
RBDW10-1011	10/5/2011	-97.28	-12.35
RBDW10d-1011	10/5/2011	-97.11	-12.34
RPD%		0.17	0.08
May 2012			
RBDW06-0512	5/16/2012	-92.53	-12.00
RBDW06d-0512	5/16/2012	-92.43	-12.04
RPD%		0.10	0.29
RBDW11-0512	5/15/2012	-81.45	-10.56
RBDW11d-0512	5/15/2012	-81.34	-10.52
RPD%		0.13	0.37
November 2012			
RBDW03-1112	11/5/2012	-76.72	-10.30
RBDW03-1112 Dup	11/5/2012	-76.89	-10.29
RPD%		0.23	0.06
RBDW10-1112	11/8/2012	-98.34	-12.67
RBDW10-1112 Dup	11/8/2012	-98.27	-12.75
RPD%		0.07	0.62
April/May 2013			
RBMW01-0413	4/29/2013	-76.29	-10.67
RBMW01d-0413	4/29/2013	-76.40	-10.58
RPD%		0.15	0.81
RBDW02-0413	4/29/2013	-74.90	-10.37
RBDW02d-0413	4/29/2013	-74.97	-10.28
RPD%		0.08	0.89
RBSW01-0413	4/30/2013	-72.28	-9.83
RBSW01d-0413	4/30/2013	-72.21	-9.82
RPD%		0.10	0.04

Table A23. Strontium isotope field duplicates: Raton Basin, CO.

Sample ID	Date Collected	Sr	Rb	$^{87}Sr/^{86}Sr$	1/Sr	Rb/Sr
Units		µg/L	µg/L	Atom Ratio	L/µg	Wt. Ratio
October 2011						
RBDW05-1011	10/4/2011	97	0.68	0.713416	0.0103	0.0070
RBDW05d-1011	10/4/2011	97	0.69	0.713562	0.0103	0.0071
RPD%		0.00	1.46	0.02	0.00	1.46
RBDW10-1011	10/5/2011	88	0.24	0.707844	0.0114	0.0027
RBDW10d-1011	10/5/2011	87	0.23	0.707843	0.0115	0.0027
RPD%		1.14	2.99	0.00	1.14	1.84
May 2012						
RBDW06-0512	5/16/2012	460	0.5	0.70728	0.0022	0.0011
RBDW06d-0512	5/16/2012	462	0.5	0.70725	0.0022	0.0011
RPD%		0.43	0.00	0.00	0.00	0.00
RBDW11-0512	5/15/2012	604	0.6	0.71106	0.0017	0.0010
RBDW11d-0512	5/15/2012	651	0.7	0.71126	0.0015	0.0011
RPD%		7.49	15.38	0.03	12.50	9.52
November 2012						
RBDW03-1112	11/5/2012	580	0.5	0.71331	0.0017	0.0009
RBDW03-1112 Dup	11/5/2012	581	0.5	0.71331	0.0017	0.0009
RPD%		0.17	0.00	0.00	0.00	0.00
RBDW10-1112	11/8/2012	87	<0.5	0.70783	0.0115	NR
RBDW10-1112 Dup	11/8/2012	86	<0.5	0.70783	0.0116	NR
RPD%		1.16	NC	0.00	0.87	

NC = not calculated. NR = not reported.

Table A23. Strontium isotope field duplicates for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	Sr	Rb	$^{87}Sr/^{86}Sr$	1/Sr	Rb/Sr
Units		µg/L	µg/L	atom ratio	L/µg	Wt. Ratio
April/May 2013						
RBMW01-0413	4/29/2013	1220	0.9	0.712939	0.00082	0.00074
RBMW01d-0413	4/29/2013	1200	0.9	0.712928	0.00083	0.00075
RPD%		1.65	0.00	0.00	1.21	1.34
RBDW02-0413	4/29/2013	347	<0.5	0.713096	0.00288	NR
RBDW02d-0413	4/29/2013	344	<0.5	0.713093	0.00291	NR
RPD%		0.87	NC	0.00	1.04	
RBSW01-0413	4/30/2013	254	1.7	0.712151	0.00394	0.00669
RBSW01d-0413	4/30/2013	257	1.9	0.712058	0.00389	0.00739
RPD%		1.17	11.1	0.01	1.28	9.94

NC = not calculated. NR = not reported.

Table A24. Isotech gas field duplicates: Raton Basin, CO.

Sample ID	Date Collected	He	H_2	Ar	O_2	CO_2	N_2	CO	C_1	C_2	C_2H_4
Units		%	%	%	%	%	%	%	%	%	%
RBDW05-1011	10/4/2011	NR	ND	1.71	13.31	0.34	84.6	0.023	0.0343	ND	ND
RBDW05d-1011	10/4/2011	NR	ND	1.68	12.91	0.35	85.0	0.062	0.0335	ND	ND
RPD%		NC	NC	1.77	3.05	2.90	0.45	91.76	2.36	NC	NC
RBDW10-1011	10/5/2011	NR	ND	0.60	0.013	0.025	30.9	ND	68.41	0.026	0.0002
RBDW10d-1011	10/5/2011	NR	ND	0.61	0.036	0.024	31.5	ND	67.80	0.026	0.0002
RPD%		NC	NC	1.65	93.9	4.08	1.86	NC	0.90	1.14	0.00

Sample ID	Date Collected	C_3	iC_4	nC_4	iC_5	nC_5	C_{6+}	Specific Gravity	BTU	Helium dilution
Units		%	%	%	%	%	%			factor
RBDW05-1011	10/4/2011	ND	ND	ND	ND	ND	ND	0.994	0	0.77
RBDW05d-1011	10/4/2011	ND	ND	ND	ND	ND	ND	0.994	1.00	0.77
RPD%		NC	NC	NC	NC	NC	NC	0.00	NC	0.00
RBDW10-1011	10/5/2011	0.0012	0.0002	0.0002	ND	ND	ND	0.687	694	0.57
RBDW10d-1011	10/5/2011	0.0011	0.0002	0.0002	ND	ND	ND	0.690	687	0.56
RPD%		8.70	0.00	0.00	NC	NC	NC	0.44	1.01	1.77

NC = not calculated. ND = not detected. NR = not reported.

Table A24. Isotech isotope (carbon, hydrogen) field duplicates for Round 1 (October 2011): Raton Basin, CO. *(continued)*

Sample ID	Date Collected	$\delta^{13}C_1$	δDC_1	$\delta^{13}C_2$	$\delta^{13}C$ DIC
Units		‰	‰	‰	‰
RBDW05-1011	10/4/2011	NR	NR	NR	-15.27
RBDW05d-1011	10/4/2011	NR	NR	NR	-15.14
RPD%		NC	NC	NC	0.85
RBDW10-1011	10/5/2011	-39.08	-152.7	NR	-40.18
RBDW10d-1011	10/5/2011	-39.07	-149.3	NR	-40.24
RPD%		0.03	2.25	NC	0.15

NC = not calculated. NR = not reported.

Table A24. Isotech gas field duplicates for Round 2 (May 2012): Raton Basin, CO.
(continued)

Sample ID	Date Collected	He	H_2	Ar	O_2	CO_2	N_2	CO	C_1	C_2	C_2H_4
Units		%	%	%	%	%	%	%	%	%	%
RBDW06-0512	5/16/2012	NR	ND	1.100	0.0700	0.4900	56.30	ND	42.02	0.0225	ND
RBDW06d-0512	5/16/2012	NR	ND	1.100	0.1200	0.4900	55.31	ND	42.96	0.0229	ND
RPD%		NC	NC	0.00	52.63	0.00	1.77	NC	2.21	1.76	NC
RBDW11-0512	5/15/2012	NR	ND	1.600	8.250	1.930	83.59	0.0720	4.560	0.0023	ND
RBDW11d-0512	5/15/2012	NR	ND	1.620	7.580	1.920	84.26	0.0630	4.550	0.0024	ND
RPD%		NC	NC	1.24	8.46	0.52	0.80	13.33	0.22	4.26	NC

Sample ID	Date Collected	C_3	C_3H_6	iC_4	nC_4	iC_5	nC_5	C_{6+}	Specific Gravity	BTU	Helium dilution
Units		%	%	%	%	%	%	%			factor
RBDW06-0512	5/16/2012	0.0015	ND	ND	ND	ND	ND	ND	0.801	426	0.73
RBDW06d-0512	5/16/2012	0.0015	ND	ND	ND	ND	ND	ND	0.797	436	0.73
RPD%		0.00	NC	NC	NC	NC	NC	NC	0.50	2.32	0.00
RBDW11-0512	5/15/2012	ND	ND	ND	ND	ND	ND	ND	0.977	46	0.78
RBDW11d-0512	5/15/2012	ND	ND	ND	ND	ND	ND	ND	0.976	46	0.78
RPD%		NC	NC	NC	NC	NC	NC	NC	0.10	0.00	0.00

NC = not calculated. ND = not detected. NR = not reported.

Table A24. Isotech isotope (carbon, hydrogen, sulfur, oxygen) field duplicates for Round 2 (May 2012): Raton Basin, CO. *(continued)*

Sample ID	Date Collected	$\delta^{13}C_1$	δDC_1	$\delta^{13}C$ DIC	$\delta^{34}S\ SO_4^{2-}$	$\delta^{18}O\ SO_4^{2-}$	$\delta^{34}S\ H_2S$
Units		‰	‰	‰	‰	‰	‰
RBDW06-0512	5/16/2012	-46.87	-204.7	-24.87	35.9	9.9	-11.9
RBDW06d-0512	5/16/2012	-46.90	-206.3	-24.89	36.3	10.2	NR
RPD%		0.06	0.78	0.08	1.11	2.99	NC
RBDW11-0512	5/15/2012	-43.53	-136.0	-15.91	4.0	-0.4	NR
RBDW11d-0512	5/15/2012	-43.60	-138.0	-15.80	4.1	-1.0	NR
RPD%		0.16	1.46	0.69	2.47	85.71	NC

NC = not calculated. NR = not reported.

Table A24. Isotech gas field duplicates for Round 3 (November 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	He	H_2	Ar	O_2	CO_2	N_2	CO	C_1	C_2	C_2H_4
Units		%	%	%	%	%	%	%	%	%	%
RBDW03-1112	11/5/2012	NA	ND	0.735	11.30	3.84	83.96	ND	0.165	ND	ND
RBDW03-1112 Dup	11/5/2012	NA	ND	1.34	14.88	3.55	80.09	ND	0.138	ND	ND
RPD%		NC	NC	58.31	27.35	7.85	4.72	NC	17.82	NC	NC
RBDW10-1112	11/8/2012	NA	ND	0.780	0.077	ND	40.07	ND	59.05	0.0248	ND
RBDW10 -1112 Dup	11/8/2012	NA	ND	0.781	0.038	0.031	39.38	ND	59.74	0.0252	ND
RPD%		NC	NC	0.13	67.83	NC	1.74	NC	1.16	1.60	NC

Sample ID	Date Collected	C_3	C_3H_6	iC_4	nC_4	iC_5	nC_5	C_{6+}	Specific Gravity	BTU	Helium dilution
Units		%	%	%	%	%	%	%			factor
RBDW03-1112	11/5/2012	ND	ND	ND	ND	ND	ND	ND	1.006	2	0.80
RBDW03-1112 Dup	11/5/2012	ND	ND	ND	ND	ND	ND	ND	1.012	1	0.79
RPD%		NC	NC	NC	NC	NC	NC	NC	0.59	NC	1.26
RBDW10-1112	11/8/2012	0.0009	ND	ND	0.0006	ND	ND	ND	0.727	599	0.68
RBDW10 -1112 Dup	11/8/2012	0.0010	ND	ND	ND	ND	ND	ND	0.724	606	0.69
RPD%		10.53	NC	NC	NC	NC	NC	NC	0.41	1.16	1.46

NA = not analyzed. NC = not calculated. ND = not detected.

Table A24. Isotech isotope (carbon, hydrogen, sulfur, oxygen) field duplicates for Round 3 (November 2012): Raton Basin, CO.

(continued)

Sample ID	Date Collected	$\delta^{13}C_1$	δDC_1	$\delta^{13}C$ DIC	$\delta^{34}S\ SO_4^{2-}$	$\delta^{18}O\ SO_4^{2-}$	$\delta^{34}S\ H_2S$
Units		‰	‰	‰	‰	‰	‰
RBDW03-1112	11/5/2012	NR	NR	-13.52	-8.1	3.4	NA
RBDW03-1112 Dup	11/5/2012	NR	NR	-13.85	-8.0	3.2	NA
RPD%		NC	NC	2.41	1.24	6.06	NC
RBDW10-1112	11/8/2012	-38.03	-150.9	-40.94	34.9	8.7	-9.9
RBDW10-1112 Dup	11/8/2012	-38.04	-149.9	-41.00	34.8	8.7	-9.9
RPD%		0.03	0.66	0.15	0.29	0.00	0.00

NA = not analyzed. NC = not calculated. NR = data not reported.

Table A24. Isotech gas field duplicates for Round 4 (April/May 2013): Raton Basin, CO.
(continued)

Sample ID	Date Collected	He	H_2	Ar	O_2	CO_2	N_2	CO	C_1	C_2	C_2H_4
Units		%	%	%	%	%	%	%	%	%	%
RBMW01-0413	4/29/2013	NA	ND	1.74	2.78	2.34	92.93	ND	0.2140	ND	ND
RBMW01d-0413	4/29/2013	NA	ND	1.74	2.80	2.35	92.90	ND	0.2130	ND	ND
RPD%		NC	NC	0.00	0.72	0.43	0.03	NC	0.47	NC	NC
RBDW02-0413	4/29/2013	NA	ND	1.44	27.66	0.71	70.18	ND	0.0145	ND	ND
RBDW02d-0413	4/29/2013	NA	ND	1.45	27.86	0.78	69.89	ND	0.0151	ND	ND
RPD%		NC	NC	0.69	0.72	9.40	0.41	NC	4.05	NC	NC
RBSW01-0413	4/30/2013	NA	ND	1.36	30.70	0.54	67.33	0.060	0.0141	ND	ND
RBSW01d-0413	4/30/2013	NA	ND	1.34	30.56	0.46	67.56	0.066	0.0092	ND	ND
RPD%		NC	NC	1.48	0.46	16.00	0.34	9.52	42.06	NC	NC

NA = not analyzed. NC = not calculated. ND = not detected.

Table A24. Isotech gas field duplicates for Round 4 (April/May 2013): Raton Basin, CO.
(continued)

Sample ID	Date Collected	C_3	C_3H_6	iC_4	nC_4	iC_5	nC_5	C_{6+}	Specific Gravity	BTU	Helium dilution
Units		%	%	%	%	%	%	%			factor
RBMW01-0413	4/29/2013	ND	ND	ND	ND	ND	ND	ND	0.990	2	0.79
RBMW01d-0413	4/29/2013	ND	ND	ND	ND	ND	ND	ND	0.990	2	0.79
RPD%		NC	NC	NC	NC	NC	NC	NC	0.00	0.00	
RBDW02-0413	4/29/2013	ND	ND	ND	ND	ND	ND	ND	1.015	0	0.77
RBDW02d-0413	4/29/2013	ND	ND	ND	ND	ND	ND	ND	1.016	0	0.77
RPD%		NC	NC	NC	NC	NC	NC	NC	0.10	0.00	
RBSW01-0413	4/30/2013	ND	ND	ND	ND	ND	ND	ND	1.018	0	0.79
RBSW01d-0413	4/30/2013	ND	ND	ND	ND	ND	ND	ND	1.017	0	0.79
RPD%		NC	NC	NC	NC	NC	NC	NC	0.10	0.00	

NC = not calculated. ND = not detected.

Table A24. Isotech isotope (carbon, hydrogen, sulfur, oxygen) field duplicates for Round 4 (April/May 2013): Raton Basin, CO.

(continued)

Sample ID	Date Collected	$\delta^{13}C1$	δDC_1	$\delta^{13}C$ DIC	$\delta^{34}S\ SO_4^{2-}$	$\delta^{18}O\ SO_4^{2-}$	$\delta^{34}S\ H_2S$
Units		‰	‰	‰	‰	‰	‰
RBMW01-0413	4/29/2013	NR	NR	-15.19	-8.5	3.9	NA
RBMW01d-0413	4/29/2013	NR	NR	-15.11	-8.8	4.3	NA
RPD%		NC	NC	0.53	3.47	9.76	NC
RBDW02-0413	4/29/2013	NR	NR	-16.02	-6.9	4.6	NA
RBDW02d-0413	4/29/2013	NR	NR	-15.99	-6.7	5.0	NA
RPD%		NC	NC	0.19	2.94	8.33	NC
RBSW01-0413	4/30/2013	NR	NR	4.47	0.5	2.6	NA
RBSW01d-0413	4/30/2013	NR	NR	4.68	0.7	3.0	NA
RPD%		NC	NC	4.59	33.33	14.29	NC

NA = not analyzed. NC = not calculated. NR = not reported.

Table A25. Data Usability Summary[1].

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
October 2011		
Field Parameters/EPA on-site	A midday check of a pH 4.00 performance standard on 10/3/2011 read 4.23, slightly above the control range of 3.8 to 4.2; a pH 7.00 performance standard was 6.96, within the specified acceptance criterion (Table A27). End-of-day pH performance standards on 10/4/2011 were 7.45 and 10.37, respectively, outside of the control ranges (midday pH check was acceptable).	Affected samples (RBPW01, RBPW02, RBSW01, and RBDW01) were qualified “J” for pH as estimated.The performance deviations are minimal and the pH data are considered to be usable.
	An end-of-the-day performance check of specific conductance on 10/3/2011 read low, outside of the specified acceptance criterion. The low value was likely related to cold temperature of the calibration solution. An end-of-the-day check on 10/4/2011 of the zero-oxygen solution was above the optimal <0.25 mg/Lcriterion (0.59 mg/L); the result was still <1 mg/L and confirmed electrode performance at low oxygen levels. In some cases performance check readings for ORP were not recorded and evaluated (see Table A27).	Data usability for specific conductance and dissolved oxygen is considered to be minimally affected. Data usability of ORP measurements for samples RBDW05, RBMW01, RBMW04, and RBMW05 is considered to be minimally impacted.
	Results for ferrous iron and sulfide are considered screening values as they were measured on site with field kits.	All detected results for ferrous iron and sulfide were qualified “J” as estimated. Data usability is unaffected.

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
Dissolved gases/Shaw Environmental	Trip blanks collected on 10/3/2011 and 10/4/2011 had dissolved gas levels above the QL for methane, ethane, propane, and butane, likely due to laboratory contamination.	Affected samples (RBMW01, RBDW01, RBDW03, RBDW05, RBDW05d for methane; RBMW03, RBDW04, RBPW01 for ethane; and RBSW01 for propane) were qualified with "B". Methane data for RBDW05 and RBDW05d were near the blank levels and are unusable but indicative of low concentration levels; other samples exceeded the blank levels by ~3x and are usable with the qualifier. Ethane and propane data in the affected samples are unusable.
DOC/ORD/NRMRL- Ada	An equipment blank had a DOC concentration above the QL.	Affected samples (RBMW04, RBMW05, RBDW08, RBDW09, RBDW10, RBDW10d) were qualified with a "B". Concentration levels in the affected samples RBMW04, RBMW05, RBMW10, and RBMW10d were below the blank level. However, low levels of DOC are indicated in the sample results. RBMW08 and RBMW09 concentrations were above the blank level and are usable with caution.
DIC/ORD/NRMRL- Ada	One matrix spike recovery was outside of control limits at 66.7%. Four other matrix spikes were acceptable and the method blank spike recovery was 96.5%.	All samples were qualified with a "J-", but the data are considered to be usable; the potential low bias is taken into consideration.
Anions/Ammonia ORD/NRMRL- Ada	Nitrate + Nitrite: One field blank and one equipment blank were above the QL.	Nitrate + Nitrite:Affected samples were qualified with a "B." Data for affected samples are usable with caution, for RBDW01, RBDW02, RBDW03 which were 2x the associated equipment blank; RBDW05, and RBDW05d were greater in concentration than in the associated field blank and are usable with caution; RBDW04 was less than the associated blank and is unusable;

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
		low-levels of nitrate in all samples are indicated.
	Ammonia was detected in one equipment blank.	Affected samples (RBDW08, RBDW09, RBDW10, and RBDW10d) were qualified with a "B"; all concentrations are greater than the associated blank. Low levels of ammonia are indicated in the field samples. Ammonia data for affected samples are usable with caution.
Dissolved Metals/Shaw Environmental	ICP-MS:All ICP-MS results were rejected and replaced with ICP-OES results.The reasons stated were potential interferences and that interference check standards were not run.	ICP-MS:The ICP-MS data were replaced with ICP-OES data.Detection and quantitation limits are higher than desirable. The ICP-OES data cannot be compared with the subsequent ICP-MS data for trace metals from the last three sampling events.
	ICP-OES:Dissolved Sb results were rejected due to potential spectralinterference.	ICP-OES: Sb results were qualified with "R" and were rejected as unusable.
	Continuing calibration checks were analyzed at appropriate intervals, however, some metals (B, Ba, K, Na, Ag, Si, S, P, and U) were not always included in the check standards at the required intervals.	All samples with detected quantities for these metals were qualified "J" as estimated. Data for B, Ba, K, Na, Ag, Si, S, P, and U are usable as positive identifications with estimated concentrations.

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
Total Metals/Shaw Environmental	ICP-MS:All ICP-MS results were rejected and replaced with ICP-OES results.The reasons stated were potential interferences and that interference check standards were not run. ICP-OES: Total Sb results were rejected due to potential spectral interference. Continuing calibration checks were being analyzed at appropriate intervals, however, some metals (B, Ba, K, Na, Ag, Si, S, P, and U) were not always included in the check standards at the required intervals. Digestion: it was determined that all parameters were not adhered to in EPA Method 3015A.	ICP-MS: The ICP-MS data were replaced with ICP-OES data. Detection and quantitation limits are higher than desirable. The ICP-OES data cannot be compared with the subsequent ICP-MS data for trace metals from the last three sampling events. ICP-OES:Sb results were qualified with “R” and rejected as unusable. All samples with detected quantities for these metals were qualified “J” as estimated. Data for B, Ba, K, Na, Ag, Si, S, P, and U are usable as positive identifications with estimated concentrations. The “J” qualifier was applied to detections above the QL for digested samples. Data are usable as positive identifications with estimated concentrations.
Charge Balance	The calculated charge balance error ranged from 0 to 7.5%, based on the major cations (dissolved Na, K, Ca, and Mg) and anions (Cl, F, SO_4, and DIC).	Meets project requirements.
Measured versus calculated values of Specific Conductance (SPC)	The error in measured SPC versus calculated SPC ranged from 0.1 to 13.6%.	Meets project requirements.

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
VOC/Shaw Environmental	The matrix spike results for 1,1-dichloroethene and 1,1,2-trichloroethane were significantly outside of the control limits. These compounds are known to be affected by base hydrolysis. The preservative, trisodium phosphate (TSP), is a base and elevated temperatures (heated headspace sample introduction) will accelerate the hydrolysis of 1,1,2-trichloroethane to 1,1-dichloroethene. Toluene was detected in one field blank, one equipment blank, and two trip blanks. Carbon disulfide was outside of control limits in matrix spike samples.	All data for 1,1-dichloroethene and 1,1,2-trichloroethane were qualified with "R" and rejected as unusable. The affected sample (RBDW06) was qualified with a "B" for toluene. The sample data are ~3x the blank level and considered to be usable with caution. All sample results for carbon disulfide were qualified with a "J-" with a potential negative bias.
Low-Molecular-Weight Acids/Shaw Environmental	All field blanks for acetate were greater than the QL. It was later determined that the TSP preservative was the source of the acetate contamination. Low matrix spike recovery (0%) was indicated for isobutyrate.	For acetate, the data were qualified with "R" and rejected as unusable. Due to 0% recovery of the matrix spike, isobutyrate data are unusable.
Glycols/EPA Region 3 Laboratory	The method for glycols was under development.	The QAPP stated that these data are to be considered screening values until the method was validated. Even though the data are considered to be for screening level evaluation, they are usable as on-going QC checks provide

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
		confidence that the method can detect glycols.
	One cooler arrived at the laboratory at a temperature of 15 °C due to a delay in the shipment.	Affected samples (RBMW02, RBDW04, RBMW03, RBeqBlk02, RBDW02, RBDW05, RBDW05d, RBSW01, RBFBlk02, RBMW04, RBDW08, RBMW05, RBDW09, RBEqBlk03, RBDW10,RBDW10d, RBSW01) were qualified with a "J-" due to the temperature exceedance and the potential negative bias is taken into account for data usability.
SVOC/EPA Region 8 Laboratory	Bis-(2-ethylhexyl) adipate was detected in a lab blank (1.1 µg/L) and was likely related to laboratory contamination.	Affected samples (RBMW04, RBMW05, RBDW06, RBDW07, RBDW08, RBDW09, RBDW10, RBDW10d, RBDW11, and RBDW12) were qualified with "B" for bis-(2-ethylhexyl) adipate. Detections were likely due to laboratory contamination and the data are unusable.
	Bis-(2-ethylhexyl) phthalate was detected in an equipment blank.	None of the associated sample results required qualification. RBMW03 was >10x the blank result. RBSW01 was a grab sample and not collected with the sampling equipment; therefore, it was not impacted. Data usability is unaffected.
	Several analytes had low recoveries in a matrix spike/matrix spike duplicate: R-(+)-limonene (49.8% & 40.8%), 1,3-dimethyladamantane (49.8% & 41.2%, adamantane (52.4% & 43.2%), benzo(a)pyrene (73.2%* & 53.6%), and carbazole (0% & 109%*).	Affected samples (RBMW03, RBMW04, RBMW05, RBDW02, RBDW06, RBDW07, RBDW08, RBDW09, RBDW10, RBDW10d, RBDW11, and BRDW12) were qualified with a "J-" and the potential negative bias is taken into account for data usability.

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
	*acceptable	
DRO/GRO/EPA Region 8 Laboratory	DRO: The surrogate recovery in sample RBMW03 was outside of control limits by 3%. GRO was detected in two blank samples above the QL.	DRO: the affected sample was qualified as "J" as estimated. Impact on data usability is minimal. GRO results for sample RBMW03 are used with caution.
O, H Stable Isotopes of Water/Shaw Environmental	All QA/QC criteria were met.	Meets project requirements.
Sr Isotopes/USGS Laboratory - Denver	All QA/QC criteria were met.	Meets project requirements.
Isotech Gas Isotopes	All QA/QC criteria were met.	Meets project requirements.
May 2012		
Field Parameters/EPA on-site	Results for ferrous iron and sulfide are considered screening values as they were measured on site with field kits. In some cases performance check readings for ORP were not recorded and evaluated (see Table A27).	All detected results were qualified "J" as estimated. Data usability is unaffected. Data usability of ORP measurements for samples RBSW02, RBSW03, RBDW03, RBDW05, RBDW09, RBDW11, RBDW13, and RBMW03 is considered to be minimally impacted.
Dissolved gases/Shaw Environmental	All QA/QC criteria were met.	Meets project requirements.
DOC/ORD/NRMRL- Ada	All QA/QC criteria were met.	Meets project requirements.
DIC/ORD/NRMRL- Ada	All QA/QC criteria were met.	Meets project requirements.
Anions/Ammonia ORD/NRMRL- Ada	Nitrate+Nitrite: detected in field and equipment blanks.	Nitrate+Nitrite: affected samples (RBDW01, RBDW02, RBDW03, RBDW05, RBDW11, RBDW11d, RBDW13, RBSW01, and RBSW02) were qualified "B." Sample concentrations were equal to or greater than the blanks and are therefore usable with caution. All sample data are indicative of low levels of Nitrate+Nitrite.

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
Dissolved Metals/Shaw Environmental	ICP-MS: All ICP-MS results were rejected due to potential interferences and because interference check standards were not run. Samples were re-analyzed using a CLP lab.	ICP-MS: CLP lab ICP-MS data were used.
	ICP-OES: continuing calibration checks were analyzed at appropriate intervals, however, these metals (B, Ba, K, Na, Ag, Si, S, and P) were not always included in the check standards at the required intervals.	ICP-OES: All samples with detected quantities for these metals were qualified "J" as estimated. Data for B, Ba, K, Na, Ag, Si, S, P, and U are usable as positive identifications with estimated concentrations.
	Spike recoveries forNa and S were outside of control limits.	All samples were qualified with "J-" and the potential negative bias is taken into account for data usability.
Total Metals/Shaw Environmental	ICP-MS: all ICP-MS results were rejected due to potential interferences and because interference check standards were not run. Samples were re-analyzed using CLP lab.	ICP-MS: CLP ICP-MS data were used.
	Digestion: it was determined that all parameters were not adhered to in EPA Method 3015A.	Digestion: the "J" qualifier was applied to detections above the QL for digested samples. Data are usable as positive identifications with estimated concentrations.
	ICP-OES: continuing calibration checks were analyzed at appropriate intervals, however, these metals (B, Ba, K, Na, Ag, Si, S, and P) were are not always included in the check standards at the required intervals.	ICP-OES: All samples with detected quantities for these metals were qualified "J" as estimated. Data for B, Ba, K, Na, Ag, Si, S, P, and U are usable as positive identifications with estimated concentrations.

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
	Spike recovery for Na was outside of control limits. Spike recovery for Ag on sample RBSW01 was low (5.60%).	All samples for Na were qualified with “J-” and the potential negative bias is taken into account for data usability. Sample RBSW01 was qualified with “J-” for Ag and the potential negative bias is taken into account for data usability.
Total and Dissolved Metals by ICP-MS/CLP	The ICP-MS metal analytes, as identified in the QAPP, that were analyzed by the CLP lab, are total & dissolved: Al, As, Cd, Cr, Cu, Pb, Ni, Mo, Sb, Se, Th, Tl, and U.	
	Field blanks, equipment blanks, or lab blanks had levels above the QL for total Cu, dissolved Sb, and total Sb.	Total Cu: affected samples (RBDW02, RBMW03, RBDW11, RBDW11d, RBDW13, RBSW03) were qualified with a “B”. All sample data were above the blank levels and are usable with caution. Total and dissolved Sb: RBMW03 were qualified with a “B” and results are usable with caution.
	Laboratory duplicate results and matrix spike recoveries were outside of control limits for total Pb.	Total Pb: affected samples (RBMW03, RBDW11, and RBPW03) were qualified with an “*”; data are used with caution and with the understanding there may be a precision issue. Affected samples (RBMW02, RBDW01, RBPW01, RBSW01, RBSW02, EBSW03 and RBFBlk02) were qualified with a “J-”; the potential negative bias is taken into account for data usability.
	The CLP laboratory rejected results for some samples for dissolved and total Se (very low spike recoveries), dissolved Th (interference check standards well outside of control limits), dissolved and total U	Total and dissolved Se, U, and dissolved Th: data for affected samples (see Appendix B) for these parameters were qualified with an “R” and are considered to be unusable.

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
	(interference check standards well outside of control limits and/or continuing calibration check failures). Low spike recovery was indicated for total and dissolved Se, Th, and U .	 Affected samples (see Appendix B) were qualified with a “J-”; the potential negative bias is taken into account for data usability.
Charge Balance	The calculated charge balance error ranged from 0 to 4.2%, based on the major cations (dissolved Na, K, Ca, and Mg) and anions (Cl, F, SO_4, and DIC).	Meets project requirements.
Measured versus calculated values of Specific Conductance (SPC)	The error in measured SPC versus calculated SPC ranged from 0.6 to 13.8%.	Meets project requirements.
VOC/Shaw Environmental	The matrix spike results for 1,1-dichloroethene and 1,1,2-trichloroethane were significantly outside of the control limits. These compounds are known to be affected by base hydrolysis. The preservative, trisodium phosphate (TSP), is a base and elevated temperatures (heated headspace sample introduction) will accelerate the hydrolysis of 1,1,2-trichloroethane to 1,1-dichloroethene. Carbon disulfide, acetone, acrylonitrile, and tert butyl alcohol were outside of control limits in matrix spikes.	All data for 1,1-dichloroethene and 1,1,2-trichloroethane were qualified with “R” and rejected as unusable. For carbon disulfide, acetone, acrylonitrile, and tert butyl alcohol, affected samples were qualified “J-” as a potential negative bias that is taken into account for data usability.

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
Low-Molecular-Weight Acids/Shaw Environmental	Formate: All field and equipment blank samples contained formate above the QL. Formate was determined to be present in sample containers. Propionate was detected above the QL in one blank, but none of the sample data were impacted.	Formate: all results were rejected and qualified with an "R" as unusable. Propionate: associated sample data are unaffected and usable.
Glycols/EPA Region 3 Laboratory	The method for glycols was under development.	The QAPP stated that these data are to be considered screening values until the method was validated. Even though the data are considered to be for screening level evaluation, they are usable as on-going QC checks provide confidence that the method can detect glycols.
SVOC/EPA Region 8 Laboratory	Sample RBMW03 was lost during the initial extraction due to excessive foaming. The sample was re-extracted one day past its holding time. Low matrix spike recoveries were noted for limonene, 1,3-dimethyladamantane, adamantane, and 2-butoxyethanol.	Results for this sample are considered to be estimated and the "H" qualifier was applied. Impact on data usability is considered minimal. Affected samples were qualified with a "J-" as a potential negative bias that is taken into account for data usability.

Table A25.Data Usability Summary
(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
DRO/GRO/EPA Region 8 Laboratory	DRO: There was no recovery of the surrogate in sample RBDW14.	DRO: the affected sample was qualified with a "J" as estimated. This sample likely contained residual chemicals used for well treatment (lab noted it "smelled strongly of acid or chlorine"). All results for organic chemicals for this sample are used with caution, including DRO and GRO.
	The chromatogram for RBMW03 did not specifically match the diesel standard.	RBMW03 was qualified with a "J" and is usable as an estimate.
	GRO: low MS/MSD recovery for sample RBDW14 was indicated (63.3% and 59.7%, respectively).	GRO: the affected sample RBDW14 was qualified with a "J-" as a potential negative bias that is taken into account for data usability.
O, H Stable Isotopes of Water/Shaw Environmental	All QA/QC criteria were met.	Meets project requirements.
Sr Isotopes/USGS Laboratory- Denver	All QA/QC criteria were met.	Meets project requirements.
Isotech Gas Isotopes	Sample RBSW03 was compromised during shipment; no analysis was possible for gas isotopes for this sample.	Samples were collected from this location during the third and fourth rounds of sampling.
November 2012		
Field Parameters/EPA on-site	Results for ferrous iron and sulfide are considered screening values as they were measured on-site with field kits.	All detected results were qualified with "J" as estimated. Data usability is unaffected.
	An end-of-the-day performance check on 11/6/2012 for specific conductance read high by 10%. In some cases performance check readings for ORP were not	Data usability of the specific conductance data is minimally impacted for sample RBDW07. Data usability of ORP measurements for samples RBDW02, RBDW03, and

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
	recorded and evaluated (see Table A27).	RBDW05 is considered to be minimally impacted.
Dissolved gases/Shaw	Methane was detected above the QL in one field blank, one equipment blank, and one trip blank.	The affected sample was qualified with "B" (RBSW01); sample concentration is less than the associated blanks and methane data for this sample are unusable.
	The field duplicate pair RBDW03/RBDW03 exceeded the 30% RPD criterion (RPD = 45%).	The field duplicate pair, RBDW03/RBDW03d, were qualified with an "*". Methane concentrations in these samples were 0.0328 mg/L and 0.0518 mg/L, respectively. Data may be used with caution and with the understanding that they do not meet precision requirements.
DOC/ORD/NRMRL- Ada	DOC was present in an equipment blank above the QL.	Affected samples (RBMW03, RBDW08, RBDW11, and RBSW01) were qualified with a "B." Sample concentrations for RBDW08, RBDW11, and RBSW01 were below the equipment blank concentration and are unusable; however, sample data reflect low concentrations of DOC. RBMW03 sample concentration was slightly greater than the blank and is usable with caution.
DIC/ORD/NRMRL-Ada	All QA/QC criteria were met.	Meets project requirements.
Anions/Ammonia ORD/NRMRL-Ada	Nitrate+Nitrite was detected in most field and equipment blanks above the QL.	Affected samples (RBDW02, RBDW03, RBDW03d, RBDW04, RBDW05, RBDW07, RBDW09, RBDW11, RBDW13, and RBSW01 were qualified with a "B". Qualified sample data for Nitrate+Nitrite for RBDW02 RBDW03, RBDW03d, RBDW04, RBDW07, RBDW09, RBDW13, and RBSW01 were less than their associated blanks and

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
		are considered to be unusable, but are indicative of low level concentrations. RBDW05 and RBDW11 were greater than their associated blanks and are usable with caution.
	Anion data for RBFBlk03 were rejected because the sample was mistakenly acidified in the field.	Data for Br, Cl, SO_4, and Ffor RBFBlk03 were qualified with an "R" and are rejected as unusable. There is no suspected impact on sample data quality; none of the other blank samples showed anion levels above the QL.
Dissolved Metals/ Southwest Research Institute	ICP-MS Dissolved Metals: field and/or equipment blanks showed concentrations above the QL for Cu, Mo, and Ni. Cold vapor AA for Hg: All QA/QC criteria were met.	For Cu, affected samples (RBMW03, RBDW11, RBDW14, RBDW15, and RBSW01) were qualified with a "B". Dissolved Cu data for these samples are considered to be unusable, but are indicative of low concentration levels. For Mo, affected samples (RBDW09, RBDW10, RBDW10dup, RBDW14) were qualified with a "B". Data for RBDW09, RBDW10, RBDW10dup are considered to be usable with caution; data for RBDW14 are usable since the sample concentration is 8.5x the blank detection. For Ni, affected samples (RBMW02, RBMW03, RBDW04, RBDW08, RBDW11, RBDW13, RBSW01, RBSW02, and RBSW03) were qualified with a "B". Data for RBSW01 and RBWM03 are considered to be usable since sample data are >9x blank levels; all other dissolved Ni data are used with caution (RBDW04, RBDW13, and RBSW02 are greater than blanks) or are unusable (RBMW02, RBDW08, RBDW11, and

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
		RBSW03 are less than blanks). Cold vapor AA for Hg:Meets project requirements.
Total Metals/Southwest Research Institute	ICP-MS and ICP-OES Total Metals: field, equipment, and/or lab blanks showed concentrations above the QL for Al, Cu, Fe, Mo, Ni, and Zn. Laboratory and field duplicates were outside of control limits for total Cu and Ni.	For total Al, affected samples (RBMW03, RBDW06, RBDW09, RBDW10, RBDW10dup, RBDW14, RBDW15, RBSW01) were qualified with a "B". Data for samples RBDW06, RBDW10, RBDW10dup, RBDW14, and RBDW15 are considered to be unusable because sample data are close to the blank levels. For total Cu, affected samples (RBMW03, RBDW06, RBDW08, RBDW09, RBDW10dup, RBDW11, RBDW14, RBDW15, and RBSW01) were qualified with a "B". Because of the blank issues and reproducibility issues (qualified with "*"), none of these data for total Cu are usable. For total Fe, sample RBSW01 was qualified with a "B". Data for this sample are usable with caution since the sample data are ~3x the value in the blank. For total Mo, affected samples (RBMW02, RBDW04, RBDW07, RBDW13, RBSW02, and RBSW03) were qualified with a "B". With the exception of sample RBMW02, total Mo data for the affected samples are unusable. For total Ni, all sample data are unusable because of blank issues (qualified with "B") and reproducibility issues (qualified with "*"). For total Zn, affected samples (RBMW03, RBDW04, RBDW08, and

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
	Cold vapor AA for Hg: All QA/QC criteria were met.	RBDW11) were qualified with a "B". All sample data are above the blank levels and these data are used with caution. Cold vapor AA for Hg:Meets project requirements.
Charge Balance	The calculated charge balance error ranged from 0.3 to 4.3%, based on the major cations (dissolved Na, K, Ca, and Mg) and anions (Cl, F, SO_4, and DIC).	Meets project requirements.
Measured versus calculated values of Specific Conductance (SPC)	The error in measured SPC versus calculated SPC ranged from 0.0 to 18.5%.	Sample RBMW03 was outside of the acceptance criterion of 15%; SPC data for this sample are used with caution (may be biased high).
VOC/Southwest Research Institute	One of the shipment coolers was received at 15°C. A double lab comparison of VOC results was conducted in this round between SwRI and Shaw (see section A7). The SwRI data set is used as the primary datasource for VOCs.	Affected samples (RBDW06, RBDW09, RBDW10, RBDW10dup, RBDW14, RBDW15, RBFBlk04, RBEqBlk04, and RBTripBlk04) were qualified with a "J-" and are potentially biased low.
Low-Molecular-Weight Acids/Shaw Environmental	Low matrix spike recovery for butyrate and isobutyrate was noted.	Affected samples were qualified with a "J-" and are potentially biased low.
Glycols/EPA ORD NERL, Las Vegas	The method for glycols was under development. One of the shipment coolers was received at 19°C due to a delayed shipment.	The QAPP stated that these data are to be considered screening values until the method was validated. Even though the data are considered to be for screening level evaluation, they are usable as on-going QC checks provide confidence that the method can detect glycols. Affected samples (RBFBlk04, RBEqBlk04, RBDW10, RBDW10dup, RBDW06, RBDW14, RBDW15, and RBDW09) were qualified with a "J-" for

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
		possible negative bias.
	2-butoxyethanol was low in a LCS and was below control limits in two MS/MSD pairs.	All sample results for 2-butoxyethanol were qualified with a “J-” for possible negative bias. None of the glycol analytes were detected above QLs.
SVOC/EPA Region 8 Laboratory	Matrix spike recoveries were outside of control limits for 3,3’-dichlorobenzidine (0%), and squalene (48.5%).	3,3’-dichlorobenzidine and squalene in all samples were given the “J-” qualifier for potential low bias.
	Bis-(2-ethylhexl) phthalate and squalene were detected in blank samples collected in the field.	Affected samples for bis-(2-ethylhexyl) phthalate were qualified with “B” (RBPW01 and RBPW03); data for these samples are unusable. Data for this compound in sample RBDW11 are usable with caution. Squalene was not detected in any of the sample data and no “B” qualifiers were necessary.
	Bis-(2-ethylhexyl) phthalate in sample RBDW04 was outside the quantitiation range.	Bis-(2-ethylhexl) phthalate in sample RBDW04 was qualified with a “J” as estimated. The data are usable as estimated.

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
DRO/GRO/EPA Region 8 Laboratory	DRO: the MSD for DRO sample RBPW03 was below the recovery control limits of 60-120% (50.1%). The RPD for the MS/MSD pair for this sample was also outside of control limits. DRO was detected in one equipment blank above the QL. GRO: All QA/QC criteria were met.	DRO: sample RBPW03 was given the“J-” and “*” qualifiers; the DRO concentration is considered to be an estimated value with a negative bias. Affected samples (RBDW08 and RBSW01) were given the “B” qualifier. DRO concentration data for these samples are used with caution. GRO: Meets project requirements.
O, H Stable Isotopes of Water/Shaw Environmental	Lab report indicated possible methanol contamination in 4 samples.	Affected samples (RBDW09, RBDW11, RBDW14, and RBSW03) were given the “J” qualifier as estimated, but these data are considered to be usable.
Sr Isotopes/USGS Laboratory- Denver	All QA/QC criteria were met.	Meets project requirements.
Isotech Gas Isotopes	All QA/QC criteria were met.	Meets project requirements.
April/May 2013		
Field Parameters/EPA on-site	End-of-the-day checks of pH 7.00 and pH 10.01 performance standards on 4/29/2013 read 7.41 and 10.31, slightly above the control ranges (the midday check was acceptable). A series of zero-oxygen solution checks were above the optimal <0.25 mg/Lcriterion; the performance check results were still <1 mg/L and confirmed electrode performance at low oxygen levels. Results for ferrous iron and sulfide are considered screening values as they were measured on-site with	pH results for samples RBMW01 and RBMW01d were qualified with a “J” as estimated; data usability is minimally affected. Data usability of DO measurements is considered to be minimally affected. All detected results were qualified with “J” as estimated. Data usability is unaffected.

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
	field kits.	
Dissolved gases/CB&I	Field duplicate pair RBMW01/RBMW01d exceeded the RPD criterion of 30% for methane.	Sample results for RBMW01 and RBMW01d were 1.040 mg/L and 0.4940 mg/L, respectively. These samples, and other samples collected on 4/29/2013 were given the "*" qualifier; the data are considered to be usable with the qualifiers applied indicating some imprecision in the sample results.
DOC/ORD/NRMRL- Ada	Two coolers containing samples for DOC were received at 8.0° and 6.8°C.	The temperature blank readings were below the average ambient ground water temperature of 12°C and samples were acid preserved; data quality are not expected to be impacted.
DIC/ORD/NRMRL-Ada	Two coolers containing samples for DIC were received at 8.0° and 6.8°C.	The temperature blank readings were below the average ambient ground water temperature of 12°C; data quality are not expected to be impacted.
Anions/Ammonia ORD/NRMRL-Ada	Two coolers containing samples for ammonia and nitrate+nitrite were received at 8.0° and 6.8°C.	The temperature blank readings were below the average ambient ground water temperature of 12°C; samples were acid preserved for ammonia and nitrate+nitrite; data quality are not expected to be impacted.
Dissolved Metals/ Southwest Research Institute	ICP-MS Dissolved Metals: field and/or equipment blanks showed concentrations above the QL for Al, Cu, Ni, and Th.	For Al, affected samples were qualified with a "B". Dissolved Al data for these affected samples are considered to be unusable, but are indicative of low concentration levels.With the exception of sample RBDW11, all qualified samples for Cu are considered to be unusable. For Ni, all affected samples were qualified with a "B." Blank issues were not noted for total Ni concentrations;

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
	ICP-OES and Cold vapor AA for Hg: All QA/QC criteria met.	the low concentrations indicated for dissolved Ni and similar concentrations to total Ni suggest that these data are usable with caution. Dissolved Th concentration in RBDW08 was less than the blank and is unusable. In these cases for Al, Cu, Ni, and Th, sample concentrations are low (i.e., near QLs). ICP-OES and Cold vapor AA for Hg: Meets project requirements.
Total Metals/Southwest Research Institute	ICP-MS and ICP-OES Total Metals: field, equipment, and/or lab blanks showed concentrations above the QL for Al, As, Cr, Cu, Th, V, and Zn. Reproducibility issues for lab and field duplicates were noted for total Mn, Cu, and Th. The field duplicate pair for Mn RBDW02/RBDW02d was slightly outside of the 30% criterion (31.2%); however, the field duplicate pair RBMW01/RBMW01d was well within the RPD criterion. The lab duplicate pair for total Mn was above the RPD criterion at 29.5%. The lab duplicate pair for total Cu was above the RPD criterion at 53.4%. The lab duplicate pair for total Th were <5xQL, therefore the control limit of the QL (0.2) is applied, which was exceeded. Total B results were qualified due to exceeded control limits of serial	For total Al, affected samples were qualified with a "B". With the exceptions of samples RBMW03 and RBSW01, that have sample concentrations that exceed blank levels by >7x, qualified sample data are not usable. All qualified sample data for total As are unusable with exception of RBMW03 and RBDW05 which are about 7x and almost 10x their associated blank value, respectively; data for these samples are usable. Total Cr is qualified with a "B" for samples RBDW07 and RBDW10; these sample are usable with caution. Field blank detections (qualified "B") and reproducibility issues (qualified "*") indicate that qualified total Cu results are suspect and they are not usable. The total Th concentration reported for sample RBDW08 is unusable due to a detection with a similar concentration in an equipment blank.

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
	dilution analyses. Cold vapor AA for Hg: All QA/QC criteria were met.	All total V results are unusable. For total Zn, samples RBDW04, RBDW09, RBDW11, and RBDW13, for which sample data are >5x blank levels, are usable with caution. With the exception of RBDW05, which is less than the blank value, all other qualified sample datafor total Zn are greater than blank values and also are usable with caution. Affected data (see Appendix B) for Mn are qualified "*". Data should be used with caution as not meeting precision requirements. For total Th, affected samples (RBDW02 and RBDW08) were qualified with an "*". Data should be used with caution as not meeting precision requirements. Results for total B were qualified with "J" as estimated for some samples due to high % differences for serial dilution analyses. Qualified data are considered to be estimated concentrations. Cold vapor AA for Hg: Meets project requirements.
Charge Balance	The calculated charge balance error ranged from 0.1 to 13.2%, based on the major cations (dissolved Na, K, Ca, and Mg) and anions (Cl, F, SO_4, and DIC).	All samples except RBDW03 and RBDW13 met project requirements. Charge imbalance in sample RBDW03 (13.2%) appears to be due to a deficit of bicarbonate, based on comparisons with concentration data from previous sampling rounds. Data from this well are used with caution. The charge balance error for sample RBDW13

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
		(10.1%) was just outside of the control range (10%); the data for this sample are considered to be usable.
Measured versus calculated values of Specific Conductance (SPC)	The error in measured SPC versus calculated SPC ranged from 0.3 to 11.3%.	Meets project requirements.
VOC/Southwest Research Institute	Sample RBMW03 required re-analysis for tert-butyl alcohol, because the initial analysis was outside of the calibration range. Re-analysis after dilution was performed after the 14-day holding time.	Sample results for RBMW03 were qualified with the "H" qualifier and are potentially biased low. The concentration of tert-butyl alcohol prior to dilution, but determined outside of the calibration range, was in reasonable agreement with the analysis within calibration requirements but after the holding time expired. Data quality are not expected to be impacted.
Low Molecular Weight Acids/Shaw Environmental	Propionate was detected in several blank samples. Low recovery for isobutyrate matrix spikes were noted.	Propionate was not detected in any of the samples, so there are no data usability issues. For isobutyrate, affected samples were qualified with a "J-" with possible negative bias to the data.
Glycols/EPA Region 3 Laboratory	The method for glycols was under development. The LCS recovery for triethylene glycol was high (129%). One sample had a detection of triethylene glycol.	The QAPP stated these data are to be considered screening values until the method was validated. Even though the data are considered to be for screening level evaluation, they are usable as on-going QC checks provide confidence that the method can detect glycols. Sample RBPW03 was qualified with the "J+" due to the high spike recovery. Diethylene glycol in this same sample was detected at a concentration below the QL and was qualified as "J" as an estimated concentration.

Table A25.Data Usability Summary

(continued)

Analysis/Lab	Summary of QA/QC Results	Impact on Data/Usability
SVOC/EPA Region 8 Laboratory	Various analytes were outside of laboratory control limits for matrix spikes. Affected analytes were:1,3-dimethyladamantane, bis-(2-ethylhexl) phthalate, and squalene. Squalene was detected in a field blank.	Affected samples were given the "J-" qualifier for potential low bias. Samples RBDW11 and RBMW01d were qualified with a "B"; sample detections for squalene are suspect but considered usable with caution.
DRO/GRO/EPA Region 8 Laboratory	DRO was detected above the QL in one equipment blank. Low surrogate in RBDW07. GRO: all QA/QC criteria were met.	DRO: affected samples (RBDW08, RBDW09, RBDW14) were given the "B" qualifier and are greater than the blank. DRO concentration data for these samples are usable with caution. RBDW07 was qualified with a "J-" for potential negative bias. GRO: meets project requirements.
O, H Stable Isotopes of Water/Shaw Environmental	All QA/QC criteria were met.	Meets project requirements.
Sr Isotopes/USGS Laboratory- Denver	All QA/QC criteria were met.	Meets project requirements.
Isotech Gas Isotopes	One sample for sulfur isotope analysis of sulfate was outside of the requirement for agreement of laboratory duplicates for $\delta^{18}O$. The control limit is <0.50 permil difference.The difference for the duplicate was 0.57 permil.	Sample RBDW05 was given the "*" qualifier. The exceedance is not significant; the data are usable.

[1] QA/QC criteria and project requirements were met with exceptions as listed.

Table A26. Results of double-lab VOC analyses for November 2012 sampling event.

			Shaw			SWRI			%RPD
Analyte	**CAS #**	**Sample ID**	**MDL**	**QL**	**Result**	**MDL**	**QL**	**Result**	
Chloroform	*67-66-3*	MW03	0.09	0.5	3.56	0.05	0.5	4.1	14.1
		DW06	0.09	0.5	2.85	0.05	0.5	3.0	5.1
		DW15	0.09	0.5	0.98	0.05	0.5	1.3	28.1
Tert-butyl alcohol	*75-65-0*	MW02	2.66	5.0	34.8	4.9	10	29	18.2
		MW03	2.66	5.0	958	4.9	10	1000	4.3
		DW11	2.66	5.0	36.7	4.9	10	32	13.7
Methylene chloride	*75-09-2*	DW06	0.17	1.5	1.5	0.1	0.5	2.1	33.3
Benzene	*71-43-2*	PW03	0.11	0.5	0.39	0.05	0.5	0.48	20.7
		SW03	0.11	0.5	0.61	0.05	0.5	0.84	31.7
Toluene	*108-88-3*	DW06	0.09	0.5	1.83	0.07	0.5	0.36	134.2
		DW10	0.09	0.5	2.71	0.07	0.5	1.8	40.4
		DW10 Dup	0.09	0.5	3.17	0.07	0.5	0.66	131.1

Table A27. Field QC Data for YSI Electrode Measurements.

October 2011		YSI – Unit 1		YSI – Unit 2	
Parameter[1]	Acceptance Range	Electrode Reading	Performance Evaluation[2]	Electrode Reading	Performance Evaluation[2]
October 3, 2011					
Calibration Verification: Start-of-Day					
pH = 4	3.80 – 4.20	4.00	Acceptable	4.01	Acceptable
pH = 7	6.80 – 7.20	7.00	Acceptable	7.00	Acceptable
pH = 10	9.81 – 10.21	9.85	Acceptable	NR[3]	Not evaluated
SPC	1.272 – 1.554	1.413	Acceptable	1.413	Acceptable
ORP	184 - 224	207.9	Acceptable	204.0	Acceptable
Zero-DO	≤ 0.25	0.08	Acceptable	NR	Not evaluated
Midday					
pH = 4	3.80 – 4.20	4.23	Out of range	NR	Not evaluated
pH = 7	6.80 – 7.20	6.96	Acceptable	7.05	Acceptable
pH = 10	9.81 – 10.21	NR	Not Evaluated	NR	Not evaluated
SPC	1.272 – 1.554	NR	Not Evaluated	1.499	Acceptable
ORP	184 - 224	NR	Not Evaluated	NR	Not evaluated
Zero-DO	≤ 0.25	NR	Not Evaluated	NR	Not evaluated
End-of-Day					
pH = 4	3.80 – 4.20	3.81	Acceptable	4.09	Acceptable
pH = 7	6.80 – 7.20	NR	Not Evaluated	7.00	Acceptable
pH = 10	9.81 – 10.21	NR	Not Evaluated	NR	Not evaluated
SPC	1.272 – 1.554	1.043	Out of range	1.370	Acceptable
ORP	184 - 224	NR	Not Evaluated	203.3	Acceptable
Zero-DO	≤ 0.25	NR	Not Evaluated	0.06	Acceptable
October 4, 2011					
Calibration Verification: Start-of-Day					
pH = 7	6.80 – 7.20	7.00	Acceptable	7.00	Acceptable
pH = 10	9.81 – 10.21	10.01	Acceptable	NR	Not evaluated
SPC	1.272 – 1.554	1.413	Acceptable	1.413	Acceptable
ORP	184 - 224	205.0	Acceptable	204.0	Acceptable
Zero-DO	≤ 0.25	0.15	Acceptable	0.04	Acceptable

Table A27. Field QC Data for YSI Electrode Measurements.

(continued)

October 2011		YSI – Unit 1		YSI – Unit 2	
Parameter[1]	Acceptance Range	Electrode Reading	Performance Evaluation[2]	Electrode Reading	Performance Evaluation[2]
October 4, 2011 *(cont'd)*					
Calibration Verification: Midday					
pH = 7	6.80 – 7.20	NR	Not Evaluated	7.02	Acceptable
pH = 10	9.81 – 10.21	10.17	Acceptable	NR	Not evaluated
SPC	1.272 – 1.554	NR	Not Evaluated	1.425	Acceptable
ORP	184 - 224	NR	Not Evaluated	NR	Not evaluated
Zero-DO	≤ 0.25	NR	Not Evaluated	NR	Not evaluated
End-of-Day					
pH = 7	6.80 – 7.20	7.45	Out of range	7.11	Acceptable
pH = 10	9.81 – 10.21	10.37	Out of range	NR	Not evaluated
SPC	1.272 – 1.554	1.369	Acceptable	1.440	Acceptable
ORP	184 - 224	203.0	Acceptable	NR	Not evaluated
Zero-DO	≤ 0.25	0.59	Out of range	0.05	Acceptable
October 5, 2011					
Calibration Verification: Start-of-Day					
pH = 7	6.80 – 7.20	7.00	Acceptable	7.01	Acceptable
pH = 10	9.81 – 10.21	10.01	Acceptable	NR	Not evaluated
SPC	1.272 – 1.554	1.413	Acceptable	1.413	Acceptable
ORP	184 - 224	NR	Not Evaluated	204	Acceptable
Zero-DO	≤ 0.25	0.14	Acceptable	0.04	Acceptable
Midday					
pH = 7	6.80 – 7.20	6.94	Acceptable	7.11	Acceptable
pH = 10	9.81 – 10.21	10.16	Acceptable	NR	Not evaluated
SPC	1.272 – 1.554	NR	Not Evaluated	1.435	Acceptable
ORP	184 - 224	NR	Not Evaluated	NR	Not evaluated
Zero-DO	≤ 0.25	NR	Not Evaluated	NR	Not evaluated
End-of-Day					
pH = 7	6.80 – 7.20	6.99	Acceptable	7.03	Acceptable
pH = 10	9.81 – 10.21	9.98	Acceptable	NR	Not evaluated

Table A27. Field QC Data for YSI Electrode Measurements.

(continued)

October 2011		YSI – Unit 1		YSI – Unit 2	
Parameter	**Acceptance Range**	**Electrode Reading**	**Performance Evaluation**	**Electrode Reading**	**Performance Evaluation**
October 5, 2011					
Calibration Verification: End-of-Day					
SPC	1.272 – 1.554	1.408	Acceptable	1.489	Acceptable
ORP	184 - 224	NR	Not Evaluated	203.3	Acceptable
Zero-DO	≤ 0.25	0.24	Acceptable	0.07	Acceptable
October 6, 2011					
Calibration Verification: Start-of-Day					
pH = 7	6.80 – 7.20	7.00	Acceptable	7.00	Acceptable
pH = 10	9.81 – 10.21	10.01	Acceptable	NR	Not evaluated
SPC	1.272 – 1.554	1.413	Acceptable	1.416	Acceptable
ORP	184 - 224	204.3	Acceptable	204	Acceptable
Zero-DO	≤ 0.25	0.22	Acceptable	0.05	Acceptable
End-of-Day					
pH = 7	6.80 – 7.20	6.95	Acceptable	7.14	Acceptable
pH = 10	9.81 – 10.21	10.09	Acceptable	NR	Not evaluated
SPC	1.272 – 1.554	1.383	Acceptable	1.483	Acceptable
ORP	184 - 224	202.3	Acceptable	198	Acceptable
Zero-DO	≤ 0.25	0.24	Acceptable	0.08	Acceptable

[1] Parameters: SPC = Specific Conductance; ORP = Oxidation – Reduction Potential; DO = Dissolved Oxygen (checked using a Zero-Oxygen solution).

[2] If pH received an “Unacceptable” performance evaluation, all wells sampled between the last passing calibration check and the “failed” calibration check received a “J” qualifier.

[3] NR = Not Recorded

Table 27. Field QC Data for YSI Electrode Measurements.

(continued)

May 2012		YSI – Unit 1		YSI – Unit 2	
Parameter[1]	**Acceptance Range**	**Electrode Reading**	**Performance Evaluation[2]**	**Electrode Reading**	**Performance Evaluation[2]**
May 14, 2012					
Calibration Verification: Start-of-Day					
pH = 7	6.82 – 7.22	7.02	Acceptable	7.02	Acceptable
pH = 10	9.86 – 10.26	10.06	Acceptable	10.06	Acceptable
SPC	1.272 – 1.554	1.413	Acceptable	1.413	Acceptable
ORP	194 - 237	215.0	Acceptable	215.1	Acceptable
Zero-DO	≤ 0.25	0.02	Acceptable	0.02	Acceptable
Mid-day					
pH = 7	6.82 – 7.22	7.04	Acceptable	6.99	Acceptable
pH = 10	9.86 – 10.26	NR[2]	Not Evaluated	NR	Not Evaluated
SPC	7.630 – 8.010	7.878	Acceptable	1.422	Acceptable
ORP	212 - 242	224.9	Acceptable	NR	Not Evaluated
Zero-DO	≤ 0.25	NR	Not Evaluated	NR	Not Evaluated
End-of-Day					
pH = 7	6.82 – 7.22	7.02	Acceptable	7.16	Acceptable
pH = 10	9.81 – 10.21	10.04	Acceptable	NR	Not Evaluated
SPC	1.272 – 1.554	1.418	Acceptable	1.420	Acceptable
ORP	194 - 237	NR	Not Evaluated	NR	Not Evaluated
Zero-DO	≤ 0.25	0.03	Acceptable	NR	Not Evaluated
May 15, 2012					
Calibration Verification: Start-of-Day					
pH = 7	± 0.2 of CAL[3]	7.02	Acceptable	7.03	Acceptable
pH = 10	± 0.2 of CAL	10.06	Acceptable	10.10	Acceptable
SPC	1.272 – 1.554	1.413	Acceptable	1.413	Acceptable
ORP	194 - 237	NR	Not Evaluated	NR	Not Evaluated
Zero-DO	≤ 0.25	NR	Not Evaluated	0.03	Acceptable
Mid-day					
pH = 7	± 0.2 of CAL[5]	7.10	Not Evaluated	7.04	Acceptable
pH = 10	± 0.2 of CAL	NR	Not Evaluated	NR	Not Evaluated

Table A27. Field QC Data for YSI Electrode Measurements.

(continued)

May 2012		**YSI – Unit 1**		**YSI – Unit 2**	
Parameter	**Acceptance Range**	**Electrode Reading**	**Performance Evaluation**	**Electrode Reading**	**Performance Evaluation**
May 15, 2012 *(cont'd)*					
Calibration Verification: Mid-day					
SPC	7.630 – 8.010	7.841	Acceptable	1.402	Acceptable
ORP	212 - 242	227.2	Acceptable	NR	Not Evaluated
Zero-DO	≤ 0.25	0.03	Acceptable	NR	Not Evaluated
End-of-Day					
pH = 7	± 0.2 of CAL	7.07	Acceptable	7.09	Acceptable
pH = 10	± 0.2 of CAL	10.10	Acceptable	NR	Not Evaluated
SPC	1.272 – 1.554	1.437	Acceptable	1.393	Acceptable
ORP	194 - 237	NR	Not Evaluated	NR	Not Evaluated
Zero-DO	≤ 0.25	0.02	Acceptable	NR	Not Evaluated
May 16, 2012					
Calibration Verification: Start-of-Day					
pH = 7	± 0.2 of CAL	7.02	Acceptable	7.03	Acceptable
pH = 10	± 0.2 of CAL	10.06	Acceptable	10.06	Acceptable
SPC	1.272 – 1.554	1.435	Acceptable	1.413	Acceptable
ORP	194 - 237	213.8	Acceptable	NR	Not Evaluated
Zero-DO	≤ 0.25	0.02	Acceptable	0.06	Acceptable
Mid-day					
pH = 7	± 0.2 of CAL	NR	Not Evaluated	7.06	Acceptable
pH = 10	± 0.2 of CAL	NR	Not Evaluated	NR	Not Evaluated
SPC	1.272 – 1.554	NR	Not Evaluated	1.416	Acceptable
ORP	194 - 237	NR	Not Evaluated	NR	Not Evaluated
Zero-DO	≤ 0.25	NR	Not Evaluated	NR	Not Evaluated
End-of-Day					
pH = 7	± 0.2 of CAL	7.04	Acceptable	7.08	Acceptable
pH = 10	± 0.2 of CAL	10.00	Acceptable	NR	Not Evaluated
SPC	1.272 – 1.554	1.409	Acceptable	1.410	Acceptable
ORP	194 - 237	213.3	Acceptable	NR	Not Evaluated
Zero-DO	≤ 0.25	0.02	Acceptable	NR	Not Evaluated

Table A27. Field QC Data for YSI Electrode Measurements.

(continued)

May 2012		YSI – Unit 1		YSI – Unit 2	
Parameter	Acceptance Range	Electrode Reading	Performance Evaluation	Electrode Reading	Performance Evaluation
May 17, 2012					
Calibration Verification: Start-of-Day					
pH = 7	6.82 – 7.22	7.02	Acceptable	NA[4]	—
pH = 10	9.86 – 10.26	10.06	Acceptable	NA	—
SPC	1.272 – 1.554	1.413	Acceptable	NA	—
ORP	194 - 237	NR	Not Evaluated	NA	—
Zero-DO	$\leq$ 0.25	0.05	Acceptable	NA	—
End-of-Day					
pH = 7	6.82 – 7.22	7.03	Acceptable	NA	—
pH = 10	9.86 – 10.26	10.03	Acceptable	NA	—
SPC	1.272 – 1.554	1.433	Acceptable	NA	—
ORP	194 - 237	214.3	Acceptable	NA	—
Zero-DO	$\leq$ 0.25	0.05	Acceptable	NA	—

[1] Parameters: SPC = Specific Conductance; ORP = Oxidation – Reduction Potential; DO = Dissolved Oxygen (checked using a Zero-Oxygen solution).

[2] NR = Not Recorded.

[3] ±0.2 of CAL = Instruments were calibrated on-site; the calibration value of the buffer was adjusted using current temperature values.

[4] NA = Not applicable; the instrument was not used that day.

Table A27. Field QC Data for YSI Electrode Measurements.

(continued)

November 2012		YSI – Unit 1		YSI – Unit 2		YSI – Unit 3	
Parameter[1]	Acceptance Range	Electrode Reading	Performance Evaluation[2]	Electrode Reading	Performance Evaluation[2]	Electrode Reading	Performance Evaluation[2]
November 5, 2012							
Calibration Verification: Start-of-Day							
pH = 7	6.83 – 7.23	NA[3]	—	7.03	Acceptable	7.08	Acceptable
pH = 10	9.89 – 10.29	NA	—	10.08	Acceptable	10.04	Acceptable
SC	1.272 – 1.554	NA	—	1.411	Acceptable	1.533	Acceptable
ORP	197 - 241	NA	—	219.8	Acceptable	NR[4]	Not Evaluated
Zero-DO	$\leq$ 0.25	NA	—	0.10	Acceptable	0.03	Acceptable
Mid-day							
pH = 7	6.83 – 7.23	NA	—	6.94	Acceptable	7.08	Acceptable
pH = 10	9.89 – 10.29	NA	—	10.08	Acceptable	10.09	Acceptable
SC	1.272 – 1.554	NA	—	1.395	Acceptable	1.287	Acceptable
ORP	197 - 241	NA	—	222.8	Acceptable	NR	Not Evaluated
Zero-DO	$\leq$ 0.25	NA	—	0.06	Acceptable	0.08	Acceptable
End-of-Day							
pH = 7	6.83 – 7.23	NA	—	7.07	Acceptable	7.07	Acceptable
pH = 10	9.89 – 10.29	NA	—	10.14	Acceptable	10.02	Acceptable
SC	1.272 – 1.554	NA	—	1.384	Acceptable	1.424	Acceptable
ORP	197 - 241	NA	—	218.4	Acceptable	NR	Not Evaluated
Zero-DO	$\leq$ 0.25	NA	—	0.10	Acceptable	NR	Not Evaluated

Table A27. Field QC Data for YSI Electrode Measurements.

(continued)

November 2012		YSI – Unit 1		YSI – Unit 2		YSI – Unit 3	
Parameter	**Acceptance Range**	**Electrode Reading**	**Performance Evaluation**	**Electrode Reading**	**Performance Evaluation**	**Electrode Reading**	**Performance Evaluation**
November 6, 2012							
Calibration Verification: Start-of-Day							
pH = 7	6.81 – 7.21	NA	—	6.97	Acceptable	7.02	Acceptable
pH = 10	9.86 – 10.26	NA	—	10.06	Acceptable	10.07	Acceptable
SC	1.272 – 1.554	NA	—	1.405	Acceptable	1.406	Acceptable
ORP	197 - 241	NA	—	218.3	Acceptable	220.1	Acceptable
Zero-DO	≤ 0.25	NA	—	0.10	Acceptable	0.04	Acceptable
Mid-day							
pH = 7	6.83 – 7.23	NA	—	NR	Not Evaluated	7.02	Acceptable
pH = 10	9.89 – 10.29	NA	—	NR	Not Evaluated	10.06	Acceptable
SC	1.272 – 1.554	NA	—	NR	Not Evaluated	1.521	Acceptable
ORP	197 - 241	NA	—	NR	Not Evaluated	219.9	Acceptable
Zero-DO	≤ 0.25	NA	—	NR	Not Evaluated	0.06	Acceptable
End-of-Day							
pH = 7	6.83 – 7.23	NA	—	7.00	Acceptable	6.99	Acceptable
pH = 10	9.89 – 10.29	NA	—	10.06	Acceptable	10.00	Acceptable
SC	1.272 – 1.554	NA	—	1.386	Acceptable	1.711	Out of range
ORP	197 - 241	NA	—	218.8	Acceptable	213.5	Acceptable
Zero-DO	≤ 0.25	NA	—	0.05	Acceptable	NR	Not Evaluated

Table A27. Field QC Data for YSI Electrode Measurements.

(continued)

November 2012		YSI – Unit 1		YSI – Unit 2		YSI – Unit 3	
Parameter	Acceptance Range	Electrode Reading	Performance Evaluation	Electrode Reading	Performance Evaluation	Electrode Reading	Performance Evaluation
November 7, 2012							
Calibration Verification: Start-of-Day							
pH = 7	6.81 – 7.21	6.92	Acceptable	6.97	Acceptable	NA	—
pH = 10	9.86 – 10.26	10.04	Acceptable	10.08	Acceptable	NA	—
SC	1.272 – 1.554	1.460	Acceptable	1.407	Acceptable	NA	—
ORP	197 - 241	221.0	Acceptable	220.9	Acceptable	NA	—
Zero-DO	$\leq$ 0.25	0.02	Acceptable	0.08	Acceptable	NA	—
Mid-day							
pH = 7	6.83 – 7.23	7.02	Acceptable	NR	Not Evaluated	NA	—
pH = 10	9.89 – 10.29	10.08	Acceptable	NR	Not Evaluated	NA	—
SC	1.272 – 1.554	1.433	Acceptable	NR	Not Evaluated	NA	—
ORP	197 - 241	NR	Not Evaluated	NR	Not Evaluated	NA	—
Zero-DO	$\leq$ 0.25	0.04	Acceptable	NR	Not Evaluated	NA	—
End-of-Day							
pH = 7	6.83 – 7.23	7.06	Acceptable	6.93	Acceptable	NA	—
pH = 10	9.89 – 10.29	10.08	Acceptable	9.93	Acceptable	NA	—
SC	1.272 – 1.554	1.426	Acceptable	1.417	Acceptable	NA	—
ORP	197 - 241	219.8	Acceptable	221.0	Acceptable	NA	—
Zero-DO	$\leq$ 0.25	0.02	Acceptable	0.04	Acceptable	NA	—

Table A27. Field QC Data for YSI Electrode Measurements.

(continued)

November 2012		YSI – Unit 1		YSI – Unit 2		YSI – Unit 3	
Parameter	**Acceptance Range**	**Electrode Reading**	**Performance Evaluation**	**Electrode Reading**	**Performance Evaluation**	**Electrode Reading**	**Performance Evaluation**
November 8, 2012							
Calibration Verification: Start-of-Day							
pH = 7	6.81 – 7.21	7.02	Acceptable	7.03	Acceptable	NA	—
pH = 10	9.86 – 10.26	10.08	Acceptable	10.05	Acceptable	NA	—
SC	1.272 – 1.554	1.412	Acceptable	1.401	Acceptable	NA	—
ORP	197 - 241	219.0	Acceptable	218.9	Acceptable	NA	—
Zero-DO	≤ 0.25	0.02	Acceptable	0.08	Acceptable	NA	—
Mid-day							
pH = 7	6.83 – 7.23	6.99	Acceptable	NR	Not Evaluated	NA	—
pH = 10	9.89 – 10.29	10.04	Acceptable	NR	Not Evaluated	NA	—
SC	1.272 – 1.554	1.538	Acceptable	NR	Not Evaluated	NA	—
ORP	197 - 241	219.7	Acceptable	NR	Not Evaluated	NA	—
Zero-DO	≤ 0.25	0.10	Acceptable	0.12	Acceptable	NA	—
End-of-Day							
pH = 7	6.83 – 7.23	6.97	Acceptable	7.02	Acceptable	NA	—
pH = 10	9.89 – 10.29	10.06	Acceptable	10.02	Acceptable	NA	—
SC	1.272 – 1.554	1.499	Acceptable	1.422	Acceptable	NA	—
ORP	197 - 241	220.4	Acceptable	220.0	Acceptable	NA	—
Zero-DO	≤ 0.25	0.05	Acceptable	0.10	Acceptable	NA	—

Table A27. Field QC Data for YSI Electrode Measurements.

(continued)

April/May 2013		YSI – Unit 1		YSI – Unit 2		YSI – Unit 3	
Parameter[1]	Acceptance Range	Electrode Reading	Performance Evaluation[2]	Electrode Reading	Performance Evaluation[2]	Electrode Reading	Performance Evaluation[2]
April 29, 2013							
Calibration Verification: Start-of-Day							
pH = 7	6.81 – 7.21	7.01	Acceptable	6.98	Acceptable	NA	—
pH = 10	9.86 – 10.26	NR	Not Evaluated	10.06	Acceptable	NA	—
SC	1.272 – 1.554	1.413	Acceptable	1.492	Acceptable	NA	—
ORP	197 - 241	216.0	Acceptable	219.0	Acceptable	NA	—
Zero-DO	≤ 0.25	0.09	Acceptable	0.43	Out of range	NA	—
Mid-day							
pH = 7	6.81 – 7.21	6.83	Acceptable	7.10	Acceptable	NA	—
pH = 10	9.86 – 10.26	NR	Not Evaluated	10.01	Acceptable	NA	—
SC	1.272 – 1.554	1.395	Acceptable	1.446	Acceptable	NA	—
ORP	197 - 241	215.0	Acceptable	206.8	Acceptable	NA	—
Zero-DO	≤ 0.25	0.15	Acceptable	0.33	Out of range	NA	—
End-of-Day							
pH = 7	6.81 – 7.21	6.98	Acceptable	7.41	Out of range	NA	—
pH = 10	9.86 – 10.26	NR	Not Evaluated	10.31	Out of range	NA	—
SC	1.272 – 1.554	1.400	Acceptable	1.396	Acceptable	NA	—
ORP	197 - 241	216.0	Acceptable	204.3	Acceptable	NA	—
Zero-DO	≤ 0.25	0.15	Acceptable	0.33	Out of range	NA	—

Table A27. Field QC Data for YSI Electrode Measurements.

(continued)

April/May 2013		YSI – Unit 1		YSI – Unit 2		YSI – Unit 3	
Parameter	**Acceptance Range**	**Electrode Reading**	**Performance Evaluation**	**Electrode Reading**	**Performance Evaluation**	**Electrode Reading**	**Performance Evaluation**
April 30, 2013							
Calibration Verification: Start-of-Day							
pH = 7	6.80 – 7.20	7.00	Acceptable	7.08	Acceptable	NA	—
pH = 10	9.86 – 10.26	NR	Not Evaluated	10.13	Acceptable	NA	—
SC	1.272 – 1.554	1.413	Acceptable	1.349	Acceptable	NA	—
ORP	197 - 241	216.0	Acceptable	232.2	Acceptable	NA	—
Zero-DO	≤ 0.25	0.05	Acceptable	0.35	Out of range	NA	—
Mid-day							
pH = 7	6.80 – 7.20	NR	Not Evaluated	7.08	Acceptable	NA	—
pH = 10	9.86 – 10.26	NR	Not Evaluated	10.18	Acceptable	NA	—
SC	1.272 – 1.554	NR	Not Evaluated	1.392	Acceptable	NA	—
ORP	197 - 241	NR	Not Evaluated	NR	Not Evaluated	NA	—
Zero-DO	≤ 0.25	NR	Not Evaluated	0.21	Acceptable	NA	—
End-of-Day							
pH = 7	6.80 – 7.20	7.08	Acceptable	7.16	Acceptable	NA	—
pH = 10	9.86 – 10.26	NR	Not Evaluated	10.19	Acceptable	NA	—
SC	1.272 – 1.554	1.425	Acceptable	1.383	Acceptable	NA	—
ORP	197 - 241	213.0	Acceptable	208.8	Acceptable	NA	—
Zero-DO	≤ 0.25	0.15	Acceptable	0.21	Acceptable	NA	—

Table A27. Field QC Data for YSI Electrode Measurements.
(continued)

April/May 2013		YSI – Unit 1		YSI – Unit 2		YSI – Unit 3	
Parameter	**Acceptance Range**	**Electrode Reading**	**Performance Evaluation**	**Electrode Reading**	**Performance Evaluation**	**Electrode Reading**	**Performance Evaluation**
May 1, 2013							
Calibration Verification: Start-of-Day							
pH = 7	6.81 – 7.21	NA	—	7.01	Acceptable	7.01	Acceptable
pH = 10	9.86 – 10.26	NA	—	9.93	Acceptable	NR	Not Evaluated
SC	1.272 – 1.554	NA	—	1.320	Acceptable	1.413	Acceptable
ORP	197 - 241	NA	—	219.0	Acceptable	214.0	Acceptable
Zero-DO	< 0.25	NA	—	NR	Not Evaluated	0.20	Acceptable
Mid-day							
pH = 7	6.81 – 7.21	NA	—	NR	Not Evaluated	NR	Not Evaluated
pH = 10	9.86 – 10.26	NA	—	10.12	Acceptable	NR	Not Evaluated
SC	1.272 – 1.554	NA	—	1.387	Acceptable	NR	Not Evaluated
ORP	197 - 241	NA	—	NR	Not Evaluated	NR	Not Evaluated
Zero-DO	< 0.25	NA	—	0.58	Out of range	NR	Not Evaluated
End-of-Day							
pH = 7	6.81 – 7.21	NA	—	7.09	Acceptable	7.06	Acceptable
pH = 10	9.86 – 10.26	NA	—	10.19	Acceptable	NR	Not Evaluated
SC	1.272 – 1.554	NA	—	1.417	Acceptable	1.398	Acceptable
ORP	197 - 241	NA	—	216.6	Acceptable	214.0	Acceptable
Zero-DO	< 0.25	NA	—	0.57	Out of range	0.05	Acceptable

Table A27. Field QC Data for YSI Electrode Measurements.

(continued)

April/May 2013		YSI – Unit 1		YSI –Unit 2		YSI – Unit 3	
Parameter	Acceptance Range	Electrode Reading	Performance Evaluation	Electrode Reading	Performance Evaluation	Electrode Reading	Performance Evaluation
May 2, 2013							
Calibration Verification: Start-of-Day							
pH = 7	6.80 – 7.20	NA	—	NA	—	7.00	Acceptable
pH = 10	9.86 – 10.26	NA	—	NA	—	NR	Not Evaluated
SC	1.272 – 1.554	NA	—	NA	—	1.413	Acceptable
ORP	197 - 241	NA	—	NA	—	215.0	Acceptable
Zero-DO	$\leq$ 0.25	NA	—	NA	—	0.09	Acceptable
End-of-Day							
pH = 7	6.81 – 7.21	NA	—	NA	—	NR	Not Evaluated
pH = 10	9.81 – 10.21	NA	—	NA	—	10.03	Acceptable
SC	1.272 – 1.554	NA	—	NA	—	1.461	Acceptable
ORP	197 - 241	NA	—	NA	—	217.0	Acceptable
Zero-DO	$\leq$ 0.25	NA	—	NA	—	0.15	Acceptable

[1] Parameters: SC = Specific Conductance; ORP = Oxidation – Reduction Potential; DO = Dissolved Oxygen (checked using a Zero-Oxygen solution).

[2] If pH received an “Unacceptable” performance evaluation, all wells sampled between the last passing calibration check and the “failed” calibration check received a “J” qualifier.

[3] NA = Not applicable; the instrument was not used that day.

[4] NR = Not Recorded.

Table A28. Data Qualifiers and Data Descriptors.

Qualifier	Definition
U	The analyte was analyzed for, but was not detected above the reported quantitation limit (QL).
J	The analyte was positively identified. The associated numerical value is the approximate concentration of the analyte in the sample (due either to the quality of the data generated because certain quality control criteria were not met, or the concentration of the analyte was below the QL).
J+	The result is an estimated quantity, but the result may be biased high.
J-	For both detected and non-detected results, there may be a low bias due to low spike recoveries or sample preservation issues.
B	The analyte is found in a blank sample above the QL and the concentration found in the sample is less than 10 times the concentration found in the blank.
H	The sample was prepared or analyzed beyond the specified holding time.Sample results may be biased low.
*	Relative percent difference of a field or lab duplicate is outside acceptance criteria.
R	The data are unusable. The sample results are rejected due to serious deficiencies in the ability to analyze the sample and/or meet quality control criteria. Sample results are not reported. The analyte may or may not be present in the sample.

Data Descriptors

Descriptor	Definition
NA	Not Applicable (See QAPP)
NR	Not Reported by Laboratory or Field Sampling Team
ND	Not Detected
NS	Not Sampled

Table A29. Tentatively Identified Compounds (TICs) for SVOCs.

Sample	Compound (CAS Number)	Estimated Concentration (µg/L)
October 2011 Sampling Event		
RBFBlk01-1011	2-Undecanone (112-12-9)	1.16
RBEqBlk01-1011	Toluene (108-88-3)	0.31
	Butanoic acid (107-92-6)	0.39
	2-Nonanone (821-55-6)	0.35
	2-Undecanone (112-12-9)	1.33
	2,4-bis(1,1-dimethylethyl)phenol (96-76-4)	0.66
RBFBlk02-1011	2-Undecanone (112-12-9)	1.71
RBEqBlk02-1011	Carbamic acid, methyl ester (598-55-0)	0.25
	2-Undecanone (112-12-9)	1.35
	Phenol, 2,5-bis(1,1-dimethylethyl) (5875-45-6)	0.50
RBMW03-1011	1 H-benzyltriazole (95-14-7)	0.87
	4-tert-Butylbenzoic acid (98-73-70)	11.72
	6-ethoxy-1,2,3,4-tetrahydro-2,2,4-trimethylquinoline (16489-90-0)	5.06
	Bisphenol A (80-05-7)	13.54
	Bis(3,5,5-trimethylhexyl) phthalate (20548-62-3)	15.85
RBDW01-1011	Mono(2-ethylhexyl) phthalate (4376-20-9)	0.31
RBDW03-1011	P-tert-octylphenol (140-66-9)	0.30
	Phthalic acid isobutyl octyl ester (1000309-04-5)	1.00
RBPW01-1011	2-ethyl-1-hexanol (104-76-7)	0.38
	Naphthalene (91-20-3)	0.31
	4-methyl-benzoic acid (99-94-5)	0.26
	1-methyl-naphthalene (90-12-0)	0.51
	2-methyl-naphthalene (91-57-6)	0.46
	p-tolylacetic acid (622-47-9)	0.75
	(2,4-xylyl)-acetic acid (6331-04-0)	0.60
	2,6-dimethyl-naphthalene (581-42-0)	0.31
	2,5-dimethylphenylacetic acid (1000342-65-5)	0.42
RBPW02-1011	N-methyl-aniline (100-61-8)	0.33
	Sulfur (13798-23-7)	0.46
RBSW01-1011	Bisphenol A (80-05-7)	0.43
RBFBlk03-1011	2-Undecanone (112-12-9)	1.31
RBEqBlk03-1011	2-Undecanone (112-12-9)	1.29
RBDW06-1011	Dibutyl phthalate (84-74-2)	0.28
	Bisphenol A (80-05-7)	2.08
RBDW07-1011	2-ethyl-1-hexanol (104-76-7)	0.77
	Triphenyl phosphate (115-86-6)	0.84
	Mono(2-ethylhexyl) phthalate (4376-20-9)	0.34
RBDW08-1011	3-methyl-2-cyclohexen-1-one (1193-18-6)	0.37
	Cyclic octaatomic sulfur (10544-50-0)	2.03
	Bisphenol A (80-05-7)	1.29

Table A29. Tentatively Identified Compounds (TICs) for SVOCs.

(continued)

Sample	Compound (CAS Number)	Estimated Concentration (µg/L)
RBDW09-1011	Cyclohexanol (108-93-0)	0.42
	Phthalic anhydride (85-44-9)	0.38
	Sulfur (13798-23-7)	0.80
	Bisphenol A (80-05-7)	4.16
RBDW10-1011	Toluene (108-88-3)	2.22
	Sulfur (13798-23-7)	1.50
	Bisphenol A (80-05-7)	1.47
RBDW10d-1011	Toluene (108-88-3)	2.06
	Sulfur (13798-23-7)	2.19
	Bisphenol A (80-05-7)	1.31
	Butyl citrate (77-94-1)	0.30
RBDW11-1011	Bisphenol A (80-05-7)	0.46
RBDW12-1011	2-ethyl-1-hexanol (104-76-7)	0.77
	Diisobutyl phthalate (84-69-5)	0.30
	Bisphenol A (80-05-7)	1.39
	Terephthalic acid, di(4,octyl) e… (1000323-74-2)	3.33
RBMW04-1011	Phthalic acid, decyl isobutyl ester (1000308-94-2)	0.33
RBMW05-1011	Sulfur (13798-23-7)	1.24
	2-mercaptobenzothiazole (149-30-4)	1.17
	Bisphenol A (80-05-7)	0.93
May 2012 Sampling Event		
RBPW01-0512	4-Methyl-Benzoic acid (99-94-5)	0.64
	p-Tolyacetic acid (622-47-9)	2.34
	Tributyl phosphate (126-73-8)	0.87
RBPW03-0512	4-Cyanocyclohexene (100-45-8)	0.67
	N-Formymorpholine (4394-85-8)	0.78
	Benzothiazole (95-16-9)	1.08
	Phthalic anhydride (85-44-9)	2.17
	1,2-Ethanediol, monobenzoate (94-33-7)	6.10
	2-Mercaptobenzothiazole (149-30-4)	0.83
	Cyclic octaatomic sulfur (10544-50-0)	2.26
RBDW05-0512	Cyclic octaatomic sulfur (10544-50-0)	1.17
RBFBlk02-0512	2-Nonanone (821-55-6)	0.59
	2-Undecanone (112-12-9)	1.75
	3,5-Di-tert-butyl-4-hydrtoxybenzaldehyde (1620-98-0)	0.89
RBEqBlk02-0512	2-Undecanone (112-12-9)	1.67
	3,5-Di-tert-butyl-4-hydrtoxybenzaldehyde (1620-98-0)	0.85
RBMW01-0512	n-hexadecanoic acid (57-10-3)	1.34
	Octadecanoic acid (57-11-4)	1.21
	Octacosane (630-02-4)	0.54
RBMW03-0512	Bisphenol A (80-05-7)	31.02
	Hexadecanoic acid, butyl ester (111-06-8)	7.77
	Phthalic acid, bis(7-methyloctyl) (20548-62-3)	>50
RBDW03-0512	Diisobutyl phpthalate (84-69-5)	0.66

Table A29. Tentatively Identified Compounds (TICs) for SVOCs.
(continued)

Sample	Compound (CAS Number)	Estimated Concentration (µg/L)
RBDW06-0512	Cyclic octaatomic sulfur (10544-50-0)	36.07
RBDW06d-0512	Cyclic octaatomic sulfur (10544-50-0)	14.36
RBDW09-0512	Cyclic octaatomic sulfur (10544-50-0)	>>3.4
RBDW10-1512	Toluene (108-88-3)	2.76
	Cyclic octaatomic sulfur (10544-50-0)	Too high
RBDW14-0512	1-Chloro-3-methyl-2-butene (503-60-6)	4.01
	1,2-Dichloro-2-methyl-butane (23010-04-0)	5.16
November 2012		
RBEQBLK01-1112	2-undecanone (112-12-9)	0.64
RBPW01-1112	1-(2-Methoxy-1-methylethyl)... (1000210-02-1)	1.01
	Benzeneacetic acid, .alpha.... (000492-37-5)	1.49
PBPW03-1112	Benzoic acid, 2-methylpropy... (000120-50-3)	2.43
	Phthalic anhydride (000085-44-9)	1.23
RBDW02-1112	1,2-Benzenedicarboxylic aci...(000084-69-5)	0.92
RBFBLK02-1112	2-Undecanone (112-12-9)	0.74
RBEqBLK02-1112	2-Undecanone (112-12-9)	0.61
	Ethane, 1,1,2,2-tetrachloro- (000079-34-5)	0.86
RBMW02-1112	1-Propene, 1,1,2-trichloro- (021400-25-9)	0.52
RBSW03-1112	Cyclic octaatomic sulfur (010544-50-0)	0.99
RBDW04-1112	Ethane, 1,1,2-trichloro- (000079-00-5)	8.11
	Ethane, 1,1,2,2-tetrachloro- (01) (000079-34-5)	103
RBDW07-1112	Phthalic acid, decyl isobut... (1000308-94-2)	0.97
RBFBLK03-1112	2-Undecanone (000112-12-9)	0.71
RBMW03-1112	1H-Benzotriazole (027556-51-0)	6.87
	Benzoic acid, p-tert-butyl- (000098-73-7)	3.89
	Phenol, 4,4'-(1-methylethyl...	13.4
	Phthalic acid, bis(7-methyl... (03) (020548-62-3)	18.6
	Phthalic acid, dodecyl nony... (1000308-92-6)	5.47
RBEqBLK03-1112	1-Propene, 1,2,3-trichloro-... (013116-57-9)	0.91
RBDW08-1112	Phenol, 4,4'-(1-methylethyl... (000080-05-7)	0.60
RBDW10-1112	Toluene (000108-88-3)	0.70
	Phthalic acid, decyl isobut... (1000308-94-2)	2.79
April 2013 Sampling Event		
RBFBlk01-0413	1-Propene, 1,2,3-trichloro- (000096-19-5)	0.78
	3,5-di-tert-Butyl-4-hydroxy... (001620-98-0)	0.69
	2-Undecanone (000112-12-9)	1.32
RBEqBlk01-0413	2-Undecanone (000112-12-9)	1.20
RBPW03-0413	Phthalic anhydride (000085-44-9)	2.73
	2-Mercaptobenzothiazole (000149-30-4)	1.02
	1,4-Benzenediamine, N-(1-me... (000101-72-4)	0.97
RBPW01-0413	p-Tolylacetic acid (000622-47-9)	1.61
	Acetic acid, (2,4-xylyl)- (006331-04-0)	0.89
RBMW01d-0413	Dodecanoic acid (000143-07-7)	1.57
	Di-n-octyl phthalate (000117-84-0)	70.6
RBDW02d-0413	1-Propene, 1,2,3-trichloro-... (013116-57-9)	3.65

Table A29. Tentatively Identified Compounds (TICs) for SVOCs.
(continued)

Sample	Compound (CAS Number)	Estimated Concentration (µg/L)
RBEqBlk02-0413	3,5-di-tert-Butyl-4-hydroxy... (001620-98-0)	0.67
	2-Undecanone (000112-12-9)	1.11
RBFBlk02-0413	3,5-di-tert-Butyl-4-hydroxy... (001620-98-0)	0.56
	2-Undecanone (000112-12-9)	1.35
RBDW04-0413	Propanoic Acid (000079-09-4)	0.62
	2-Propanol, 1,1'-oxybis- (000110-98-5)	1.14
RBDW13-0413	Dodecanoic acid (000143-07-7)	1.12
RBSW03-0413	p-Tolylacetic acid (000622-47-9)	0.57
	2-Propanol, 1,1'-oxybis- (000110-98-5)	0.53
RBEqBlk03-0413	3,5-di-tert-Butyl-4-hydroxy... (001620-98-0)	0.96
	2-Undecanone (000112-12-9)	1.04
RBFBlk03-0413	3,5-di-tert-Butyl-4-hydroxy... (001620-98-0)	1.12
	2-Undecanone (000112-12-9)	1.28
RBDW07-0413	2-Propanol, 1,1'-oxybis- (000110-98-5)	3.07
RBDW09-0413	Sulfur (013798-23-7)	2.19
	Phenol, 4,4'-(1-methylethyl... (000080-05-7)	0.91
RBDW14-0413	Cumarin-3-carboxylic acid, ... (020300-59-8)	0.57
RBMW03-0413	Phthalic acid, bis(7-methyl... (03) (020548-62-3)	18.9
	Phenol, 4,4'-(1-methylethyl... (000080-05-7)	23.7
	1H-Benzotriazole (000095-14-7)	13.2
RBEqBlk04-0413	p-Xylene (000106-42-3)	0.68
	Benzene, 1,3-dimethyl- (000108-38-3)	0.55
	9-Octadecenamide, (Z)- (000301-02-0)	0.91
RBFBlk04-0413	p-Xylene (000106-42-3)	0.98
	o-Xylene (000095-47-6)	0.73
RBDW06-0413	Cyclic octaatomic sulfur (010544-50-0)	0.69
RBDW08-0413	Sulfur (013798-23-7)	2.66
	Methane, tribromo- (000075-25-2)	1.84
	Methane, dibromochloro- (000124-48-1)	0.83
	2(5H)-Furanone (000497-23-4)	0.94

Appendix B
Sample Results
Retrospective Case Study in the Raton Basin, Colorado

U.S. Environmental Protection Agency
Office of Research and Development
Washington, DC

May 2015
EPA/600/R-14/091

Table of Contents

Tables

Appendix B. Sample Results - Legend (Raton Basin, Colorado)

Data Qualifiers

<	The analyte concentration is less than the quantitation limit (QL).
U	The analyte was analyzed for, but was not detected above the reported QL.
J	The analyte was positively identified. The associated numerical value is the approximate concentration of the analyte in the sample (due either to the quality of the data generated because certain quality control criteria were not met, or the concentration of the analyte was below the QL).
J+	The result is an estimated quantity, but the result may be biased high.
J-	For both detected and non-detected results, the result is estimated but may be biased low.
B	The analyte is found in a blank sample above the QL and the concentration found in the sample is less than 10 times the concentration found in the blank.
H	The sample was prepared or analyzed beyond the specified holding time. Sample results may be biased low.
*	Relative percent difference of a field or lab duplicate is outside acceptance criteria.
R	The data are unusable. The sample results are rejected due to serious deficiencies in the ability to analyze the sample and/or meet quality control criteria. Sample results are not reported. The analyte may or may not be present in the sample.

Notes

Table B-1	Total Dissolved Solids (TDS) is estimated based on Specific Conductance (SPC): TDS(mg/L) = SPC(mS/cm) * 650.
	Field-determined concentrations of ferrous iron and hydrogen sulfide are screening values.
	Round 1 and 4 - J flag: pH failed end-of-day calibration check.
Table B-2	Round 3 - R qualifier for RBFBlk03-1112 is applied because the sample was mistakenly acidified, this affects Br, Cl, SO_4, and F.
Table B-3	R. Data rejected. Potential spectral (mass or emission) interference (Sb) or interference check sample problem reported by laboratory.
	Round 2 - R qualifiers for total and dissolved Se are due to matrix spike analyses outside of acceptance criteria.
	Round 2 - R qualifiers for dissolved Th are due to interference check samples outside of acceptance criteria.
	R qualifiers for total and dissolved U are due to interference check samples and/or continuing calibration verification checks outside of acceptance criteria.
Table B-4	R. Data rejected. 1,1,2-trichloroethane is subject to alkaline hydrolysis to 1,1-dichloroethene. This reaction could be supported by the sample preservative (trisodium phosphate). This applies to samples collected in Round 1 and 2.
Table B-5	Round 1 - R. Data rejected. Acetate contamination in samples and blanks is due to the sample preservative (trisodium phosphate).
	Round 2 - R. Data Rejected. Formate contamination in sample vials.
	The method used for glycol analysis is under development.
Table B-6	Round 1 - The method used for analysis of aniline, hexachlorocylcopentadiene, and pyridine is under development.
Table B-8	Round 2 - RBSW03-0512: Dissolved gas bottle compromised in transit.

Appendix B. Sample Results - Legend (Raton Basin, Colorado)

Acronyms

CAS	Chemical Abstracts Service
DIC	Dissolved Inorganic Carbon
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DRO	Diesel Range Organics
GRO	Gasoline Range Organics
NA	Not Applicable (See QAPP)
ND	Not Detected
NR	Not Reported by Laboratory or Field Sampling Team
NS	Not Sampled
ORP	Oxidation reduction potential
SPC	Specific Conductance
TDS	Total Dissolved Solids
TPH	Total Petroleum Hydrocarbons

Units

BTU	British thermal unit
^{o}C	Degrees Celsius
µg/L	Micrograms per liter
mg/L	Milligrams per liter
mS/cm	Millisiemens per centimeter at 25^{o}C

Key

MW	Monitoring Well sample
PW	Production Well sample
DW	Drinking water sample
SW	Surface water sample
04	Sampling location
d	Field Duplicate

Appendix B. Sample Results - Legend (Raton Basin, Colorado)

Metals and Isotopes

Ag	Silver
Al	Aluminum
As	Arsenic
B	Boron
Ba	Barium
Be	Beryllium
Ca	Calcium
Cd	Cadmium
Co	Cobalt
Cr	Chromium
Cu	Copper
Fe	Iron
K	Potassium
Li	Lithium
Mg	Magnesium
Mn	Manganese
Mo	Molybdenum
Na	Sodium
Ni	Nickel
P	Phosphorus
Pb	Lead
Rb	Rubidium
S	Sulfur
Sb	Antimony
Se	Selenium
Si	Silicon
Sr	Strontium
Th	Thorium
Ti	Titanium
Tl	Thallium
U	Uranium
V	Vanadium
Zn	Zinc

$\delta^{2}H$	$[(^{2}H/H)$ Sample/$(^{2}H/H)$ Standard] * 1000
$\delta^{18}O$	$[(^{18}O/^{16}O)$ Sample/$(^{18}O/^{16}O)$ Standard] * 1000
$\delta^{13}C$	$[(^{13}C/^{12}C)$ Sample/$(^{13}C/^{12}C)$ Standard] * 1000
$\delta^{34}S$	$[^{34}S/^{32}S)$ Sample/$(^{34}S/^{32}S)$ Standard] * 1000

Table B-1 Sample Results - Field Parameters (Raton Basin, Colorado)

	Sample	MW01	MW01	MW01	MW01	MW02	MW02	MW02	MW02
	Sample Date	10/3/11	5/15/12	11/5/12	4/29/13	10/4/11	5/15/12	11/6/12	4/30/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Temperature	°C	8.8	8.8	9.1	9.0	10.6	10.5	10.5	10.7
SPC	mS/cm	0.340	0.507	0.491	0.469	0.430	0.476	0.443	0.347
TDS	mg/L	221	330	319	305	279	309	288	225
DO	mg/L	0.47	0.23	0.19	0.49	1.80	0.96	0.92	1.27
pH		6.71	7.35	7.10	7.47 J	8.39	8.47	8.21	8.50
ORP	mV	-72	-71	-86	-57	52	-138	-160	-122
Turbidity	NTU	1.7	0.47	0.53	0.57	0.8	0.44	0.99	0.76
Alkalinity	mg $CaCO_3$/L	146	161	144	144	162	164	153	160
Ferrous Iron	mg Fe^{2+}/L	0.13 J	0.18 J	0.13 J	0.21 J	0.11 J	<0.03 U	<0.03 U	0.06 J
Hydrogen Sulfide	mg S/L	0.03 J	0.01 J	0.01 J	<0.01 U	0.24 J	0.26 J	0.37 J	0.40 J

Table B-1 Sample Results - Field Parameters (Raton Basin, Colorado)

	Sample	MW03	MW03	MW03	MW03	MW04	MW05	DW01	DW01
	Sample Date	10/4/11	5/15/12	11/7/12	5/1/13	10/5/11	10/5/11	10/3/11	5/15/12
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 1	Round 1	Round 2
Temperature	^{o}C	13.4	14.3	13.2	6.7	18.6	16.9	12.5	17.6
SPC	mS/cm	0.743	0.827	1.041	0.771	0.506	0.356	0.362	0.364
TDS	mg/L	483	538	677	501	329	231	235	237
DO	mg/L	1.83	1.39	0.10	1.51	0.41	0.22	2.73	4.13
pH		8.36	7.70	7.80	7.30	8.96	9.00	7.10 J	7.15
ORP	mV	96	152	-75	194	-5	-268	445	160
Turbidity	NTU	30	37.1	12.4	8.4	0.7	19	0.9	2.90
Alkalinity	mg CaCO$_3$/L	112	212	119	131	84	164	170	198
Ferrous Iron	mg Fe^{2+}/L	0.89 J	0.09 J	0.04 J	0.18 J	0.19 J	0.32 J	<0.03 U	<0.03 U
Hydrogen Sulfide	mg S/L	0.01 J	<0.01 U	0.02 J	0.01 J	0.77 J	13.9 J	0.01 J	0.02 J

Table B-1 Sample Results - Field Parameters (Raton Basin, Colorado)

	Sample	DW02	DW02	DW02	DW02	DW03	DW03	DW03	DW03
	Sample Date	10/3/11	5/14/12	11/5/12	4/29/13	10/3/11	5/15/12	11/5/12	4/30/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Temperature	°C	10.4	9.7	9.7	10.7	11.4	10.0	10.4	10.3
SPC	mS/cm	0.428	0.440	0.462	0.448	0.405	0.441	0.446	0.438
TDS	mg/L	278	288	300	291	264	286	290	285
DO	mg/L	4.77	0.81	0.90	7.21	2.01	3.57	1.22	1.62
pH		7.64	7.91	8.05	7.70	7.11	6.91	7.23	6.51
ORP	mV	218	229	-2	98	-102	125	32	157
Turbidity	NTU	1.6	0.65	0.48	1.40	2.6	17.1	0.67	0.76
Alkalinity	mg CaCO$_3$/L	146	220	185	164	154	163	158	163
Ferrous Iron	mg Fe^{2+}/L	<0.03 U	0.04 J	<0.03 U	<0.03 U	<0.03 U	<0.03 U	<0.03 U	<0.03 U
Hydrogen Sulfide	mg S/L	0.01 J	<0.01 U	<0.01 U	<0.01 U	<0.01 U	<0.01 U	<0.01 U	<0.01 U

Table B-1 Sample Results - Field Parameters (Raton Basin, Colorado)

	Sample	DW04	DW04	DW04	DW05	DW05	DW05	DW05
	Sample Date	10/4/11	11/6/12	4/30/13	10/4/11	5/14/12	11/5/12	4/29/13
Parameter	Unit	Round 1	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Temperature	^{o}C	14.4	10.7	13.5	12.2	11.8	11.6	11.6
SPC	mS/cm	0.413	0.413	0.415	0.522	0.486	0.555	0.506
TDS	mg/L	269	268	270	339	316	361	329
DO	mg/L	1.83	0.50	1.05	1.94	1.39	4.03	0.62
pH		7.76	7.96	7.64	8.46	8.62	8.63	8.26
ORP	mV	-89	-46	125	40	42	-53	35
Turbidity	NTU	0.5	0.20	1.38	0.7	0.59	2.78	0.93
Alkalinity	mg CaCO$_3$/L	156	157	167	196	221	218	208
Ferrous Iron	mg Fe^{2+}/L	<0.03 U	0.03 J	<0.03 U	<0.03 U	0.01 J	0.05 J	<0.03 U
Hydrogen Sulfide	mg S/L	<0.01 U	0.01 J	<0.01 U	0.01 J	<0.01 U	<0.01 U	<0.01 U

Table B-1 Sample Results - Field Parameters (Raton Basin, Colorado)

	Sample	DW06	DW06	DW06	DW06	DW07	DW07	DW07	DW07
	Sample Date	10/6/11	5/16/12	11/8/12	5/2/13	10/6/11	5/16/12	11/6/12	5/1/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Temperature	^{o}C	13.0	14.2	13.7	12.7	14.9	15.1	14.8	14.5
SPC	mS/cm	0.441	0.500	0.475	0.520	0.524	0.525	0.508	0.499
TDS	mg/L	286	325	309	338	340	341	330	324
DO	mg/L	0.35	0.05	3.49	1.27	0.28	0.19	5.71	0.50
pH		7.74	7.99	7.86	7.93	8.52	9.08	9.07	8.90
ORP	mV	-67	-304	-274	-74	85	66	1	-109
Turbidity	NTU	2.7	24.8	1.20	0.84	0.7	18.0	0.39	0.76
Alkalinity	mg $CaCO_3$/L	199	197	160	190	205	214	197	244
Ferrous Iron	mg Fe^{2+}/L	0.06 J	0.06 J	0.03 J	<0.03 U	0.06 J	0.06 J	<0.03 U	<0.03 U
Hydrogen Sulfide	mg S/L	5.90 J	1.79 J	1.50 J	3.00 J	0.02 J	NR	0.06 J	0.06 J

Table B-1 Sample Results - Field Parameters (Raton Basin, Colorado)

	Sample	DW08	DW08	DW08	DW08	DW09	DW09	DW09	DW09
	Sample Date	10/5/11	5/16/12	11/7/12	5/1/13	10/5/11	5/16/12	11/8/12	5/1/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Temperature	°C	16.2	17.2	14.5	10.6	NR	18.6	18.2	17.6
SPC	mS/cm	0.627	0.627	0.639	0.636	1.101	0.717	0.652	0.829
TDS	mg/L	407	408	415	414	715	466	424	540
DO	mg/L	0.04	0.71	0.10	1.19	0.31	0.14	1.15	0.81
pH		8.48	8.50	8.36	8.87	7.41	8.35	8.19	8.31
ORP	mV	-297	-317	-306	-145	-144	-305	-242	-312
Turbidity	NTU	3.1	20.5	6.79	3.71	3.1	2.28	0.55	12.8
Alkalinity	mg $CaCO_3$/L	152	159	140	166	99	147	159	138
Ferrous Iron	mg Fe^{2+}/L	<0.03 U	0.07 J	<0.03 U	0.03 J	<0.03 U	<0.03 U	0.06 J	<0.03 U
Hydrogen Sulfide	mg S/L	3.80 J	2.47 J	0.70 J	0.44 J	1.23 J	6.33 J	15.3 J	8.00 J

Table B-1 Sample Results - Field Parameters (Raton Basin, Colorado)

Parameter	Sample Sample Date Unit	DW10 10/5/11 Round 1	DW10 5/17/12 Round 2	DW10 11/8/12 Round 3	DW10 5/1/13 Round 4	DW11 10/6/11 Round 1	DW11 5/15/12 Round 2	DW11 11/7/12 Round 3	DW11 4/29/13 Round 4	DW12 10/6/11 Round 1
Temperature	^{o}C	16.4	17.7	17.0	16.7	14.0	14.5	16.1	10.4	13.1
SPC	mS/cm	0.469	0.509	0.505	0.506	0.414	0.429	0.466	0.451	0.350
TDS	mg/L	305	331	328	329	269	279	303	293	227
DO	mg/L	0.10	0.06	1.42	0.68	0.45	0.80	2.12	0.82	0.07
pH		8.89	9.01	9.03	9.21	7.71	7.81	8.00	7.83	8.64
ORP	mV	-208	-316	-193	-324	-133	-143	8	132	-62
Turbidity	NTU	1.0	3.72	1.20	4.48	NS	5.67	0.82	1.88	1.1
Alkalinity	mg $CaCO_3$/L	129	131	123	114	NS	209	220	256	196
Ferrous Iron	mg Fe^{2+}/L	<0.03 U	<0.03 U	0.05 J	<0.03 U	NS	0.27 J	<0.03 U	<0.03 U	<0.03 U
Hydrogen Sulfide	mg S/L	36.6 J	33.9 J	22.6 J	24.50 J	NS	<0.01 U	0.01 J	<0.01 U	0.11 J

Table B-1 Sample Results - Field Parameters (Raton Basin, Colorado)

Parameter	Sample Sample Date Unit	DW13 5/15/12 Round 2	DW13 11/6/12 Round 3	DW13 4/30/13 Round 4	DW14 5/17/12 Round 2	DW14 11/8/12 Round 3	DW14 5/1/13 Round 4	DW15 11/8/12 Round 3
Temperature	^{o}C	14.8	12.2	9.5	14.2	13.4	9.6	14.5
SPC	mS/cm	0.314	0.301	0.327	1.214	1.108	0.971	0.491
TDS	mg/L	204	195	213	789	720	631	319
DO	mg/L	2.00	5.02	1.67	5.21	0.10	2.53	0.19
pH		7.17	7.12	6.82	8.82	8.51	8.32	7.44
ORP	mV	126	80	55	710	43	-49	-14
Turbidity	NTU	6.31	11.8	19.7	3.72	0.47	50.9	0.92
Alkalinity	mg $CaCO_3$/L	152	145	148	85	99	78	160
Ferrous Iron	mg Fe^{2+}/L	0.12 J	<0.03 U	0.30 J	<0.03 U	<0.03 U	0.33 J	<0.03 U
Hydrogen Sulfide	mg S/L	0.03 J	<0.01 U	<0.01 U	<0.01 U	<0.01 U	0.03 J	0.14 J

Table B-1 Sample Results - Field Parameters (Raton Basin, Colorado)

	Sample	PW01	PW01	PW01	PW01	PW02	PW03	PW03	PW03
	Sample Date	10/3/11	5/14/12	11/5/12	4/29/13	10/3/11	5/14/12	11/5/12	4/29/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Temperature	^{o}C	15.9	15.7	15.1	15.1	15.3	12.2	14.0	14.4
SPC	mS/cm	1.202	1.929	1.952	1.894	0.666	1.365	1.393	1.125
TDS	mg/L	781	1254	1269	1231	434	887	906	730
DO	mg/L	0.24	1.67	0.96	0.89	0.20	0.02	0.70	0.37
pH		8.34 J	8.55	8.49	8.22	8.49 J	8.32	7.87	7.69
ORP	mV	-338	-160	-183	-234	-353	-368	-226	-211
Turbidity	NTU	3.6	3.67	2.91	3.39	9.0	55.1	94.9	12.3
Alkalinity	mg $CaCO_3$/L	836	887	903	946	478	530	501	596
Ferrous Iron	mg Fe^{2+}/L	0.27 J	0.20 J	0.09 J	0.13 J	0.20 J	1.04 J	1.32 J	0.31 J
Hydrogen Sulfide	mg S/L	0.03 J	0.01 J	0.02 J	<0.01 U	0.04 J	<0.01 U	<0.01 U	<0.01 U

Table B-1 Sample Results - Field Parameters (Raton Basin, Colorado)

	Sample	SW01	SW01	SW01	SW01	SW02	SW02	SW02
	Sample Date	10/4/11	5/14/12	11/7/12	4/30/13	5/14/12	11/6/12	4/30/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
Temperature	^{o}C	14.8	16.7	3.0	18.2	16.8	8.4	13.5
SPC	mS/cm	1.187	1.178	1.409	1.233	1.541	1.724	1.489
TDS	mg/L	772	744	916	801	1002	1121	968
DO	mg/L	7.84	8.33	10.19	6.60	5.65	5.87	4.91
pH		9.26 J	8.86	8.34	8.66	8.33	7.92	7.90
ORP	mV	119	216	313	61	60	82	65
Turbidity	NTU	3.2	20.0	3.70	9.47	16.9	1.62	2.86
Alkalinity	mg CaCO$_3$/L	639	639	697	659	717	799	772
Ferrous Iron	mg Fe^{2+}/L	0.12 J	0.04 J	<0.03 U	0.14 J	0.09 J	<0.03 U	0.05 J
Hydrogen Sulfide	mg S/L	0.02 J	<0.01 U	<0.01 U	0.02 J	<0.01 U	<0.01 U	<0.01 U

Table B-1 Sample Results - Field Parameters (Raton Basin, Colorado)

	Sample	SW03	SW03	SW03
	Sample Date	5/15/12	11/6/12	4/30/13
Parameter	Unit	Round 2	Round 3	Round 4
Temperature	^{o}C	19.1	27.0	22.4
SPC	mS/cm	1.427	1.474	1.135
TDS	mg/L	935	957	738
DO	mg/L	0.03	0.05	0.40
pH		8.42	8.32	8.20
ORP	mV	-292	-332	-294
Turbidity	NTU	2.00	2.68	1.17
Alkalinity	mg $CaCO_3$/L	727	691	694
Ferrous Iron	mg Fe^{2+}/L	0.12 J	0.05 J	0.06 J
Hydrogen Sulfide	mg S/L	0.01 J	0.03 J	0.03 J

Table B-2 Sample Results - Anions and Ammonia (Raton Basin, Colorado)

Parameter	Sample Sample Date Unit	MW01 10/3/11 Round 1	MW01 5/15/12 Round 2	MW01 11/5/12 Round 3	MW01 4/29/13 Round 4	MW02 10/4/11 Round 1	MW02 5/15/12 Round 2	MW02 11/6/12 Round 3	MW02 4/30/13 Round 4
Anion-Cation Balance	%	7.5	0.6	2.7	1.0	1.6	0.8	1.0	2.0
DOC	mg/L	1.54	1.62	1.46	1.48	0.73	0.70	0.67	0.71
DIC	mg/L	36.9 J-	36.3	37.4	38.7	37.1 J-	36.9	36.5	36.7
Nitrate + Nitrite	mg N/L	<0.05 U	<0.10 U	<0.10 U	<0.10 U	<0.05 U	<0.10 U	<0.10 U	<0.10 U
Ammonia	mg N/L	0.09	<0.10 U	<0.10 U	0.09 J	<0.05 U	<0.10 U	<0.10 U	<0.10 U
Bromide	mg/L	<1.00 U	<1.00 U	<1.00 U	0.36 J	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Chloride	mg/L	4.38	4.32	4.36	4.50	8.97	10.3	9.17	9.94
Sulfate	mg/L	94.2	101	104	94.6	62.7	58.6	61.2	56.5
Fluoride	mg/L	0.44	0.45	0.36	0.44	2.79	2.93	2.46	2.48

Table B-2 Sample Results - Anions and Ammonia (Raton Basin, Colorado)

Parameter	Sample Sample Date Unit	MW03 10/4/11 Round 1	MW03 5/15/12 Round 2	MW03 11/7/12 Round 3	MW03 5/1/13 Round 4	MW04 10/5/11 Round 1	MW05 10/5/11 Round 1	DW01 10/3/11 Round 1	DW01 5/15/12 Round 2
Anion-Cation Balance	%	2.8	0.2	1.6	1.5	2.3	6.8	0.3	2.1
DOC	mg/L	4.63	3.18	2.86 B	3.42	0.66 B	0.82 B	0.66	0.65
DIC	mg/L	32.2 J-	30.8	30.7	30.5	18.4 J-	26.9 J-	49.8 J-	50.0
Nitrate + Nitrite	mg N/L	<0.05 U	<0.10 U	<0.10 U	<0.10 U	<0.05 U	<0.05 U	0.33 B	0.24 B
Ammonia	mg N/L	<0.05 U	<0.10 U	<0.10 U	<0.10 U	<0.05 U	<0.05 U	<0.05 U	<0.10 U
Bromide	mg/L	<1.00 U	<1.00 U	<1.00 U	<3.00 U	<1.00 U	<1.00 U	<1.00 U	0.71 J
Chloride	mg/L	159	159	158	160	15.1	18.2	1.80	2.07
Sulfate	mg/L	2.08	0.84 J	0.31 J	0.56 J	141	5.93	21.9	23.2
Fluoride	mg/L	7.91	8.50	8.72	8.29	5.24	9.41	0.20	0.23

Table B-2 Sample Results - Anions and Ammonia (Raton Basin, Colorado)

	Sample	DW02	DW02	DW02	DW02	DW03	DW03	DW03	DW03
	Sample Date	10/3/11	5/14/12	11/5/12	4/29/13	10/3/11	5/15/12	11/5/12	4/30/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Anion-Cation Balance	%	0.7	0.3	1.0	0.7	0.9	4.2	1.2	13.2
DOC	mg/L	1.12	1.25	1.14	1.15	1.11	1.07	0.93	0.92
DIC	mg/L	36.4 J-	37.1	36.5	37.0	40.2 J-	38.4	41.0	41.6
Nitrate + Nitrite	mg N/L	0.32 B	0.18 B	0.24 B	<0.10 U	0.30 B	0.16 B	0.59 B	0.17
Ammonia	mg N/L	<0.05 U	<0.10 U	<0.10 U	<0.10 U	<0.05 U	<0.10 U	<0.10 U	<0.10 U
Bromide	mg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	0.37 J
Chloride	mg/L	9.75	11.8	9.57	9.54	7.31	7.33	7.11	7.15
Sulfate	mg/L	60.9	76.7	64.3	62.3	65.0	66.4	67.0	66.3
Fluoride	mg/L	0.89	0.68	1.03	1.03	0.28	0.21	0.17 J	0.24

Table B-2 Sample Results - Anions and Ammonia (Raton Basin, Colorado)

	Sample	DW04	DW04	DW04	DW05	DW05	DW05	DW05
	Sample Date	10/4/11	11/6/12	4/30/13	10/4/11	5/14/12	11/5/12	4/29/13
Parameter	Unit	Round 1	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Anion-Cation Balance	%	1.0	1.6	1.8	0.4	0.2	3.5	0.1
DOC	mg/L	0.78	0.65	0.64	<0.50 U	<0.50 U	0.53	<0.50 U
DIC	mg/L	42.0 J-	40.0	38.8	49.0 J-	48.7	49.9	49.8
Nitrate + Nitrite	mg N/L	0.25 B	0.96 B	<0.10 U	0.35 B	0.16 B	1.15 B	<0.10 U
Ammonia	mg N/L	0.10	0.12	0.09 J	<0.05 U	<0.10 U	<0.10 U	<0.10 U
Bromide	mg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Chloride	mg/L	7.03	6.51	7.07	9.53	8.10	9.37	6.89
Sulfate	mg/L	39.8	39.4	42.5	55.8	52.2	57.7	48.3
Fluoride	mg/L	0.66	0.59	0.71	0.57	0.44	0.46	0.58

Table B-2 Sample Results - Anions and Ammonia (Raton Basin, Colorado)

	Sample	DW06	DW06	DW06	DW06	DW07	DW07	DW07	DW07
	Sample Date	10/6/11	5/16/12	11/8/12	5/2/13	10/6/11	5/16/12	11/6/12	5/1/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Anion-Cation Balance	%	1.6	0.0	0.3	2.1	2.4	0.5	3.4	1.5
DOC	mg/L	1.22	1.16	1.35	1.05	0.65	0.80	0.56	0.68
DIC	mg/L	43.2 J-	42.7	38.8	40.7	43.9 J-	43.9	44.4	43.9
Nitrate + Nitrite	mg N/L	<0.05 U	<0.10 U	<0.10 U	<0.10 U	<0.05 U	0.14	1.14 B	<0.10 U
Ammonia	mg N/L	0.02 J	<0.10 U	<0.10 U	<0.10 U	0.10	0.12	<0.10 U	0.10
Bromide	mg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Chloride	mg/L	9.37	10.9	11.3	12.2	9.47	9.65	8.73	8.66
Sulfate	mg/L	80.9	62.8	60.8	65.5	72.7	71.9	64.4	62.7
Fluoride	mg/L	1.17	1.65	1.63	1.60	1.39	1.30	1.53	1.49

Table B-2 Sample Results - Anions and Ammonia (Raton Basin, Colorado)

Parameter	Sample Sample Date Unit	DW08 10/5/11 Round 1	DW08 5/16/12 Round 2	DW08 11/7/12 Round 3	DW08 5/1/13 Round 4	DW09 10/5/11 Round 1	DW09 5/16/12 Round 2	DW09 11/8/12 Round 3	DW09 5/1/13 Round 4
Anion-Cation Balance	%	2.2	0.0	4.3	0.5	0.0	1.6	3.6	1.9
DOC	mg/L	0.92 B	1.15	1.05 B	1.17	1.44 B	0.88	0.89	1.07
DIC	mg/L	31.6 J-	32.7	32.4	32.3	23.7 J-	28.3	32.5	29.7
Nitrate + Nitrite	mg N/L	<0.05 U	<0.10 U	<0.10 U	<0.10 U	<0.05 U	<0.10 U	0.16 B	<0.10 U
Ammonia	mg N/L	0.22 B	<0.10 U	<0.10 U	<0.10 U	0.22 B	0.19	0.81	0.02 J
Bromide	mg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	0.26 J
Chloride	mg/L	28.1	30.0	29.7	33.0	26.8	27.1	25.7	27.2
Sulfate	mg/L	122	104	110	118	445	171	151	224
Fluoride	mg/L	4.15	3.74	4.22	3.98	5.26	6.33	7.28	6.06

Table B-2 Sample Results - Anions and Ammonia (Raton Basin, Colorado)

	Sample	DW10	DW10	DW10	DW10	DW11	DW11	DW11	DW11	DW12
	Sample Date	10/5/11	5/17/12	11/8/12	5/1/13	10/6/11	5/15/12	11/7/12	4/29/13	10/6/11
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4	Round 1
Anion-Cation Balance	%	7.0	3.5	3.2	1.9	1.0	0.8	1.2	1.2	2.0
DOC	mg/L	0.58 B	0.66	0.67	0.72	0.59	0.83	0.70 B	0.64	0.49 J
DIC	mg/L	21.5 J-	20.8	20.9	20.1	55.7 J-	54.1	52.7	54.6	42.4 J-
Nitrate + Nitrite	mg N/L	<0.05 U	<0.10 U	<0.10 U	<0.10 U	0.24	0.17 B	0.98 B	<0.10 U	0.18
Ammonia	mg N/L	0.20 B	0.24	0.56	0.04 J	0.01 J	<0.10 U	<0.10 U	<0.10 U	0.12
Bromide	mg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Chloride	mg/L	12.0	12.4	12.0	12.7	11.1	13.6	14.5	12.8	8.68
Sulfate	mg/L	93.5	89.6	100	110	2.80	4.37	2.41	2.08	6.33
Fluoride	mg/L	5.95	5.90	6.23	5.55	1.67	1.34	2.04	1.65	2.36

Table B-2 Sample Results - Anions and Ammonia (Raton Basin, Colorado)

Parameter	Sample Sample Date Unit	DW13 5/15/12 Round 2	DW13 11/6/12 Round 3	DW13 4/30/13 Round 4	DW14 5/17/12 Round 2	DW14 11/8/12 Round 3	DW14 5/1/13 Round 4	DW15 11/8/12 Round 3
Anion-Cation Balance	%	0.2	1.6	10.1	0.1	2.1	0.4	0.8
DOC	mg/L	<0.50 U	<0.50 U	<0.50 U	0.68	0.65	1.82	0.79
DIC	mg/L	40.8	38.1	39.6	17.6	20.7	19.7	38.7
Nitrate + Nitrite	mg N/L	0.20 B	0.82 B	0.08 J	0.33	<0.10 U	<0.10 U	<0.10 U
Ammonia	mg N/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Bromide	mg/L	0.78 J	0.21 J	0.74 J	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Chloride	mg/L	1.85	1.16	1.70	77.8	18.7	20.2	15.2
Sulfate	mg/L	26.0	22.2	26.4	351	349	352	70.1
Fluoride	mg/L	0.20	0.15 J	0.23	2.75	2.34	2.46	1.44

Table B-2 Sample Results - Anions and Ammonia (Raton Basin, Colorado)

Parameter	Sample Sample Date Unit	PW01 10/3/11 Round 1	PW01 5/14/12 Round 2	PW01 11/5/12 Round 3	PW01 4/29/13 Round 4	PW02 10/3/11 Round 1	PW03 5/14/12 Round 2	PW03 11/5/12 Round 3	PW03 4/29/13 Round 4
Anion-Cation Balance	%	0.7	0.1	2.2	0.6	1.6	2.2	3.9	0.2
DOC	mg/L	1.00	1.24	0.98	1.08	0.97	1.30	1.00	1.31
DIC	mg/L	197 J-	187	209	213	121 J-	121	120	120
Nitrate + Nitrite	mg N/L	<0.05 U	<0.10 U	<0.10 U	<0.10 U	<0.05 U	<0.10 U	<0.10 U	<0.10 U
Ammonia	mg N/L	0.61	0.58	0.71	0.53	0.31	0.43	0.51	0.38
Bromide	mg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Chloride	mg/L	79.4	110	122	138	27.5	144	148	190
Sulfate	mg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	0.75 J	0.76 J
Fluoride	mg/L	3.48	3.12	4.63	3.02	2.56	3.03	3.29	2.57

Table B-2 Sample Results - Anions and Ammonia (Raton Basin, Colorado)

Parameter	Sample Sample Date Unit	SW01 10/4/11 Round 1	SW01 5/14/12 Round 2	SW01 11/7/12 Round 3	SW01 4/30/13 Round 4	SW02 5/14/12 Round 2	SW02 11/6/12 Round 3	SW02 4/30/13 Round 4
Anion-Cation Balance	%	2.9	1.1	3.7	0.4	2.3	2.6	0.1
DOC	mg/L	1.52	1.92	1.48 B	2.57	3.14	1.91	2.84
DIC	mg/L	147 J-	145	162	153	166	194	178
Nitrate + Nitrite	mg N/L	<0.05 U	0.19 B	0.51 B	0.01 J	0.14 B	<0.10 U	0.02 J
Ammonia	mg N/L	<0.05 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Bromide	mg/L	<1.00 U	<1.00 U	<1.00 U	0.60 J	<1.00 U	<1.00 U	<1.00 U
Chloride	mg/L	46.5	43.6	51.5	40.1	81.6	89.7	90.8
Sulfate	mg/L	4.33	5.38	2.45	2.37	23.6	20.2	19.7
Fluoride	mg/L	3.03	2.90	3.19	3.15	2.43	2.55	2.46

Table B-2 Sample Results - Anions and Ammonia (Raton Basin, Colorado)

Parameter	Sample Sample Date Unit	SW03 5/15/12 Round 2	SW03 11/6/12 Round 3	SW03 4/30/13 Round 4
Anion-Cation Balance	%	2.1	2.5	5.7
DOC	mg/L	1.54	0.83	1.72
DIC	mg/L	162	166	183
Nitrate + Nitrite	mg N/L	<0.10 U	<0.10 U	<0.10 U
Ammonia	mg N/L	0.36	0.41	0.28
Bromide	mg/L	<1.00 U	<1.00 U	<1.00 U
Chloride	mg/L	41.6	48.0	51.4
Sulfate	mg/L	0.55 J	<1.00 U	<1.00 U
Fluoride	mg/L	4.10	3.82	4.61

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	MW01	MW01	MW01	MW01	MW02	MW02	MW02	MW02
	Sample Date	10/3/11	5/15/12	11/5/2012	4/29/13	10/4/11	5/15/12	11/6/2012	4/30/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved Ag	µg/L	<14 U	<14 U	<10 U	<10 U	<14 U	<14 U	<10 U	<10 U
Total Ag	µg/L	<16 U	<16 U	<10 U	<10 U	<16 U	<16 U	<10 U	<10 U
Dissolved Al	µg/L	<494 U	<20.0 U	<20 U	<20 U	<494 U	<20.0 U	4 J	<20 U
Total Al	µg/L	<548 U	<20.0 U	<20 U	39 B	<548 U	<20.0 U	<20 U	<20 U
Dissolved As	µg/L	<20 U	<1.0 U	<0.2 U	0.07 J	<20 U	1.9	1.6	2.2
Total As	µg/L	<22 U	<1.0 U	<0.2 U	0.31 B	<22 U	1.6	1.7	2.4
Dissolved B	µg/L	<333 U	<333 U	<40 U	<40 U	<333 U	<333 U	<40 U	<40 U
Total B	µg/L	<370 U	<370 U	14 J	<20 U	<370 U	<370 U	7 J	3.3 J
Dissolved Ba	µg/L	29 J	28.5 J	31	32	47 J	42.7 J	46	47
Total Ba	µg/L	30 J	29.0 J	27	30	47 J	44.1 J	42	44
Dissolved Be	µg/L	<10 U	<10 U	<5 U	<5.0 U	<10 U	<10 U	<5 U	<5.0 U
Total Be	µg/L	<11 U	<11 U	<2.5 U	<2.5 U	<11 U	<11 U	<2.5 U	<2.5 U
Dissolved Ca	mg/L	52.6	54.0	54.9	54.4	9.00	7.89	7.2	6.6
Total Ca	mg/L	53.8 J	53.4 J	49.6	52.6	9.18 J	7.83 J	6.8	6.3
Dissolved Cd	µg/L	<4 U	<1.0 U	<0.2 U	<0.20 U	<4 U	<1.0 U	<0.2 U	<0.20 U
Total Cd	µg/L	<4 U	<1.0 U	<0.2 U	<0.20 U	<4 U	<1.0 U	<0.2 U	<0.20 U
Dissolved Co	µg/L	<4 U	<4 U	<5 U	<5.0 U	<4 U	<4 U	<5 U	<5.0 U
Total Co	µg/L	<4 U	<4 U	<2.5 U	<2.5 U	<4 U	<4 U	<2.5 U	1.0 J
Dissolved Cr	µg/L	<7 U	<2.0 U	<2 U	<2.0 U	<7 U	<2.0 U	<2 U	<2.0 U
Total Cr	µg/L	<8 U	<2.0 U	<2 U	<2.0 U	<8 U	<2.0 U	<2 U	<2.0 U
Dissolved Cu	µg/L	<20 U	<2.0 U	<0.5 U	<0.50 U	<20 U	<2.0 U	<0.5 U	<0.50 U
Total Cu	µg/L	13 J	<2.0 U	<0.5 U	<0.50 U	<22 U	<2.0 U	<0.5 U	<0.50 U
Dissolved Fe	µg/L	189	175	180	175	<67 U	<67 U	<100 U	<100 U
Total Fe	µg/L	212 J	184	153	143	39 J	25 J	NR[2]	NR[2]
Dissolved Hg	µg/L	NR	NR	<0.2 U	<0.20 U	NR	NR	<0.2 U	<0.20 U
Total Hg	µg/L	NR	NR	<0.2 U	<0.20 U	NR	NR	<0.2 U	<0.20 U
Dissolved K	mg/L	1.07 J	1.06 J	1.1	1.1	0.48 J	0.51 J	0.44 J	0.44 J
Total K	mg/L	1.08 J	1.05 J	1.1	1.0	0.57 J	0.69 J	0.45	0.45
Dissolved Li	µg/L	NA	NR	13	13	NA	NR	3 J	<10 U
Total Li	µg/L	NA	NR	12	12	NA	NR	3 J	3 J
Dissolved Mg	mg/L	4.24	4.41	4.4	4.2	1.35	1.09	0.91	0.78

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	MW03	MW03	MW03	MW03	MW04	MW05	DW01	DW01
	Sample Date	10/4/11	5/15/12	11/7/2012	5/1/13	10/5/11	10/5/11	10/3/11	5/15/12
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 1	Round 1	Round 2
Dissolved Ag	µg/L	<14 U	<14 U	<10 U	<10 U	<14 U	<14 U	<14 U	<14 U
Total Ag	µg/L	<16 U	<16 U	<10 U	<10 U	<16 U	<16 U	<16 U	<16 U
Dissolved Al	µg/L	<494 U	577	12 J	28 B	<494 U	<494 U	<494 U	<20.0 U
Total Al	µg/L	1350 J	695	757 B	265 B	<548 U	2290 J	<548 U	24.0
Dissolved As	µg/L	<20 U	1.2	1.1	1.3	<20 U	<20 U	<20 U	<1.0 U
Total As	µg/L	<22 U	1.2	1.2	1.4 B	<22 U	<22 U	<22 U	<1.0 U
Dissolved B	µg/L	<333 U	<333 U	<40 U	<40 U	<333 U	<333 U	<333 U	<333 U
Total B	µg/L	<370 U	<370 U	<20 U	7.0 J	<370 U	<370 U	<370 U	<370 U
Dissolved Ba	µg/L	318 J	294 J	383	366	37 J	11 J	274 J	227 J
Total Ba	µg/L	363 J	334 J	323	347	38 J	34 J	283 J	233 J
Dissolved Be	µg/L	<10 U	<10 U	0.3 J	<5.0 U	<10 U	<10 U	<10 U	<10 U
Total Be	µg/L	<11 U	<11 U	<2.5 U	<2.5 U	<11 U	<11 U	<11 U	<11 U
Dissolved Ca	mg/L	6.82	6.17	6.2	6.6	3.89	1.99	53.8	58.9
Total Ca	mg/L	7.19 J	6.55 J	5.8	6.2	4.05 J	2.87 J	54.9 J	57.5 J
Dissolved Cd	µg/L	<4 U	<1.0 U	<0.2 U	<0.20 U	<4 U	<4 U	<4 U	<1.0 U
Total Cd	µg/L	<4 U	<1.0 U	<0.2 U	<0.20 U	<4 U	<4 U	<4 U	<1.0 U
Dissolved Co	µg/L	<4 U	<4 U	<5 U	<5.0 U	<4 U	<4 U	<4 U	<4 U
Total Co	µg/L	<4 U	<4 U	<2.5 U	0.9 J	<4 U	<4 U	<4 U	<4 U
Dissolved Cr	µg/L	<7 U	<2.0 U	0.7 J	<2.0 U	<7 U	<7 U	<7 U	<2.0 U
Total Cr	µg/L	5 J	2.4	2.9	<2.0 U	<8 U	5 J	<8 U	<2.0 U
Dissolved Cu	µg/L	<20 U	19.5 J	0.7 B	1.1 B	<20 U	<20 U	<20 U	<2.0 U
Total Cu	µg/L	41 J	15.3 J, B	14 B	11.4 B	<22 U	8 J	<22 U	<2.0 U
Dissolved Fe	µg/L	60 J	379	<100 U	<100 U	<67 U	32 J	<67 U	<67 U
Total Fe	µg/L	1480 J	516 J	710	270	92 J	4280 J	36 J	37 J
Dissolved Hg	µg/L	NR	NR	<0.2 U	<0.20 U	NR	NR	NR	NR
Total Hg	µg/L	NR	NR	<0.2 U	<0.20 U	NR	NR	NR	NR
Dissolved K	mg/L	0.55 J	0.75 J	0.58	0.53	0.25 J	0.21 J	0.89 J	0.84 J
Total K	mg/L	0.84 J	0.75 J	0.66	0.57	0.32 J	0.60 J	1.05 J	0.93 J
Dissolved Li	µg/L	NA	NR	10	<10 U	NA	NA	NA	NR
Total Li	µg/L	NA	NR	9	9	NA	NA	NA	NR
Dissolved Mg	mg/L	0.19	0.19	0.15	0.15	0.03 J	<0.10 U	9.64	10.6

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW02	DW02	DW02	DW02	DW03	DW03	DW03	DW03
	Sample Date	10/3/11	5/14/12	11/5/2012	4/29/13	10/3/11	5/15/12	11/5/2012	4/30/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved Ag	µg/L	<14 U	<14 U	<10 U	<10 U	<14 U	<14 U	<10 U	<10 U
Total Ag	µg/L	<16 U	<16 U	<10 U	<10 U	<16 U	<16 U	<10 U	<10 U
Dissolved Al	µg/L	<494 U	<20.0 U	<20 U	<20 U	<494 U	<20.0 U	<20 U	<20 U
Total Al	µg/L	<548 U	<20.0 U	<20 U	22 B	<548 U	38.2	25	<20 U
Dissolved As	µg/L	<20 U	<1.0 U	<0.2 U	0.07 J	<20 U	<1.0 U	<0.2 U	0.06 J
Total As	µg/L	<22 U	<1.0 U	<0.2 U	0.36 B	<22 U	<1.0 U	<0.2 U	0.30 B
Dissolved B	µg/L	<333 U	<333 U	<40 U	<40 U	<333 U	<333 U	<40 U	<40 U
Total B	µg/L	<370 U	<370 U	17 J	<20 U	<370 U	<370 U	23	22
Dissolved Ba	µg/L	86 J	106 J	85	102	57 J	41.5 J	60	58
Total Ba	µg/L	96 J	103 J	85	105	57 J	45.7 J	55	53
Dissolved Be	µg/L	<10 U	<10 U	<5 U	<5.0 U	<10 U	<10 U	<5 U	<5.0 U
Total Be	µg/L	<11 U	<11 U	<2.5 U	<2.5 U	<11 U	<11 U	<2.5 U	<2.5 U
Dissolved Ca	mg/L	15.4	21.1	17.0	17.2	44.2	45.2	43.4	47.7
Total Ca	mg/L	17.4 J	19.3 J	17.6	16.9	44.2 J	45.1 J	41.1	45.9
Dissolved Cd	µg/L	<4 U	<1.0 U	<0.2 U	<0.20 U	<4 U	<1.0 U	<0.2 U	<0.20 U
Total Cd	µg/L	<4 U	<1.0 U	<0.2 U	<0.20 U	<4 U	<1.0 U	<0.2 U	<0.20 U
Dissolved Co	µg/L	<4 U	<4 U	<5 U	<5.0 U	<4 U	<4 U	<5 U	<5.0 U
Total Co	µg/L	<4 U	<4 U	<2.5 U	<2.5 U	<4 U	<4 U	<2.5 U	<2.5 U
Dissolved Cr	µg/L	<7 U	<2.0 U	<2 U	<2.0 U	<7 U	<2.0 U	<2 U	<2.0 U
Total Cr	µg/L	<8 U	<2.0 U	<2 U	<2.0 U	<8 U	<2.0 U	<2 U	<2.0 U
Dissolved Cu	µg/L	<20 U	3.7 J	1.9	1.8 B	16 J	11.9 J	1.2	6.9
Total Cu	µg/L	14 J	6.2 J, B	9.2 *	5.5 *	26 J	18.3 J	2.0 *	9.3 *
Dissolved Fe	µg/L	36 J	<67 U	<100 U	<100 U	<67 U	<67 U	51 J	105
Total Fe	µg/L	36 J	30 J	<50 U	27 J	130 J	165 J	<50 U	22 J
Dissolved Hg	µg/L	NR	NR	<0.2 U	<0.20 U	NR	NR	<0.2 U	<0.20 U
Total Hg	µg/L	NR	NR	<0.2 U	<0.20 U	NR	NR	<0.2 U	<0.20 U
Dissolved K	mg/L	0.59 J	0.81 J	0.65	0.67	1.04 J	1.04 J	1.1	1.1
Total K	mg/L	0.67 J	0.75 J	0.66	0.69	1.11 J	1.00 J	1.1	1.1
Dissolved Li	µg/L	NA	NR	5 J	<10 U	NA	NR	<10 U	<10 U
Total Li	µg/L	NA	NR	5	<5 U	NA	NR	0.7 J	<5 U
Dissolved Mg	mg/L	1.36	1.91	1.4	1.5	11.9	12.7	12	13

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW04	DW04	DW04	DW05	DW05	DW05	DW05
	Sample Date	10/4/11	11/6/2012	4/30/13	10/4/11	5/14/12	11/5/2012	4/29/13
Parameter	Unit	Round 1	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved Ag	µg/L	<14 U	<10 U	<10 U	<14 U	<14 U	<10 U	<10 U
Total Ag	µg/L	<16 U	<10 U	<10 U	<16 U	<16 U	<10 U	<10 U
Dissolved Al	µg/L	<494 U	<20 U	<20 U	<494 U	<20.0 U	8 J	44 B
Total Al	µg/L	<548 U	<20 U	<20 U	<548 U	<20.0 U	79	<20 U
Dissolved As	µg/L	<20 U	<0.2 U	0.08 J	<20 U	1.3	1.8	1.6
Total As	µg/L	<22 U	<0.2 U	0.37 B	<22 U	1.3	2.0	2.0 B
Dissolved B	µg/L	<333 U	<40 U	<40 U	<333 U	<333 U	<40 U	<40 U
Total B	µg/L	<370 U	13 J	<20 U	<370 U	<370 U	17 J	9.3 J
Dissolved Ba	µg/L	268 J	195	201	39 J	31.3 J	34	28
Total Ba	µg/L	263 J	173	203	39 J	31.9 J	49	27
Dissolved Be	µg/L	<10 U	<5 U	<5.0 U	<10 U	<10 U	<5 U	<5.0 U
Total Be	µg/L	<11 U	<2.5 U	<2.5 U	<11 U	<11 U	<2.5 U	<2.5 U
Dissolved Ca	mg/L	35.1	22.9	24.0	4.18	3.69	4.1	3.4
Total Ca	mg/L	34.5 J	21.8	24.1	4.27 J	3.63 J	3.8	3.4
Dissolved Cd	µg/L	<4 U	<0.2 U	<0.20 U	<4 U	<1.0 U	<0.2 U	<0.20 U
Total Cd	µg/L	<4 U	<0.2 U	<0.20 U	<4 U	<1.0 U	<0.2 U	<0.20 U
Dissolved Co	µg/L	<4 U	<5 U	<5.0 U	<4 U	<4 U	<5 U	<5.0 U
Total Co	µg/L	<4 U	<2.5 U	<2.5 U	<4 U	<4 U	2.1 J	<2.5 U
Dissolved Cr	µg/L	<7 U	<2 U	<2.0 U	<7 U	<2.0 U	<2 U	<2.0 U
Total Cr	µg/L	<8 U	<2 U	<2.0 U	<8 U	<2.0 U	<2 U	<2.0 U
Dissolved Cu	µg/L	30	11	6.3	<20 U	<2.0 U	<0.5 U	<0.50 U
Total Cu	µg/L	33 J	15 *	18 *	<22 U	2.5 J	14 *	1.0
Dissolved Fe	µg/L	<67 U	<100 U	<100 U	<67 U	<67 U	<100 U	<100 U
Total Fe	µg/L	<74 U	<50 U	<50 U	<74 U	<74 U	109	33 J
Dissolved Hg	µg/L	NR	<0.2 U	<0.20 U	NR	NR	<0.2 U	<0.20 U
Total Hg	µg/L	NR	<0.2 U	<0.20 U	NR	NR	<0.2 U	<0.20 U
Dissolved K	mg/L	1.25 J	1.3	1.3	0.63 J	0.80 J	0.62	0.57
Total K	mg/L	1.27 J	1.3	1.4	0.68 J	0.81 J	0.64	0.64
Dissolved Li	µg/L	NA	5 J	<10 U	NA	NR	5 J	<10 U
Total Li	µg/L	NA	4 J	<5 U	NA	NR	4 J	4 J
Dissolved Mg	mg/L	6.15	4.4	4.7	0.27	0.23	0.25	0.21

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW06	DW06	DW06	DW06	DW07	DW07	DW07	DW07
	Sample Date	10/6/11	5/16/12	11/8/2012	5/2/13	10/6/11	5/16/12	11/6/2012	5/1/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved Ag	µg/L	<14 U	<14 U	<10 U	1.1 J	<14 U	<14 U	<10 U	<10 U
Total Ag	µg/L	<16 U	<16 U	<10 U	<10 U	<16 U	<16 U	<10 U	<10 U
Dissolved Al	µg/L	<494 U	<20.0 U	11 J	<20 U	<494 U	<20.0 U	4 J	<20 U
Total Al	µg/L	<548 U	<20.0 U	49 B	39 B	<548 U	<20.0 U	<20 U	31 B
Dissolved As	µg/L	<20 U	<1.0 U	<0.2 U	<0.20 U	<20 U	<1.0 U	<0.2 U	<0.20 U
Total As	µg/L	<22 U	<1.0 U	<0.2 U	0.29 B	<22 U	<1.0 U	<0.2 U	0.28 B
Dissolved B	µg/L	<333 U	<333 U	51	61	<333 U	<333 U	89	67
Total B	µg/L	<370 U	<370 U	48	54	<370 U	<370 U	59	66
Dissolved Ba	µg/L	41 J	17.1 J	19	18	54 J	54.7 J	50	48
Total Ba	µg/L	31 J	18.3 J	20	18	56 J	56.0 J	45	47
Dissolved Be	µg/L	<10 U	<10 U	<5 U	0.1 J	<10 U	<10 U	<5 U	<5.0 U
Total Be	µg/L	<11 U	<11 U	<2.5 U	<2.5 U	<11 U	<11 U	<2.5 U	<2.5 U
Dissolved Ca	mg/L	20.5	12.1	14.6	12.9	2.43	2.57	2.2	2.0
Total Ca	mg/L	16.1 J	12.4 J	14.1	12.7	2.68 J	2.55 J	2.2	1.9
Dissolved Cd	µg/L	<4 U	<1.0 U	<0.2 U	<0.20 U	<4 U	<1.0 U	<0.2 U	<0.20 U
Total Cd	µg/L	<4 U	<1.0 U	<0.2 U	<0.20 U	1 J	<1.0 U	<0.2 U	<0.20 U
Dissolved Co	µg/L	<4 U	<4 U	<5 U	<5.0 U	<4 U	<4 U	<5 U	<5.0 U
Total Co	µg/L	<4 U	<4 U	<2.5 U	<2.5 U	<4 U	<4 U	<2.5 U	<2.5 U
Dissolved Cr	µg/L	<7 U	<2.0 U	<2 U	<2.0 U	<7 U	<2.0 U	<2 U	<2.0 U
Total Cr	µg/L	<8 U	<2.0 U	<2 U	<2.0 U	<8 U	<2.0 U	<2 U	2.3 B
Dissolved Cu	µg/L	<20 U	<2.0 U	<0.5 U	<0.50 U	<20 U	<2.0 U	<0.5 U	<0.50 U
Total Cu	µg/L	<22 U	<2.0 U	16 B	3.8 *	8 J	<2.0 U	0.5 *	4.4 *, B
Dissolved Fe	µg/L	<67 U	<67 U	<100 U	<100 U	<67 U	<67 U	<100 U	<100 U
Total Fe	µg/L	79 J	26 J	<50 U	31 J	<74 U	<74 U	<50 U	<50 U
Dissolved Hg	µg/L	NR	NR	<0.2 U	<0.20 U	NR	NR	<0.2 U	<0.20 U
Total Hg	µg/L	NR	NR	<0.2 U	<0.20 U	NR	NR	<0.2 U	<0.20 U
Dissolved K	mg/L	0.56 J	0.56 J	0.50	0.49 J	0.50 J	0.60 J	0.49 J	0.46 J
Total K	mg/L	0.55 J	0.56 J	0.54	0.56	0.56 J	0.51 J	0.49	0.52
Dissolved Li	µg/L	NA	NR	6 J	<10 U	NA	NR	1 J	<10 U
Total Li	µg/L	NA	NR	6	7	NA	NR	1 J	<5 U
Dissolved Mg	mg/L	3.85	2.24	2.3	2.4	0.13	0.15	0.11	0.08

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW08	DW08	DW08	DW08	DW09	DW09	DW09	DW09
	Sample Date	10/5/11	5/16/12	11/7/2012	5/1/13	10/5/11	5/16/12	11/8/2012	5/1/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved Ag	µg/L	<14 U	<14 U	<10 U	<10 U	<14 U	<14 U	<10 U	<10 U
Total Ag	µg/L	<16 U	<16 U	<10 U	<10 U	<16 U	<16 U	<10 U	<10 U
Dissolved Al	µg/L	<494 U	<20.0 U	5 J	41 B	<494 U	<20.0 U	9 J	36 B
Total Al	µg/L	<548 U	<20.0 U	<20 U	66 B	361 J	125	101 B	39 B
Dissolved As	µg/L	<20 U	<1.0 U	<0.2 U	0.05 J	<20 U	<1.0 U	<0.2 U	<0.20 U
Total As	µg/L	<22 U	<1.0 U	<0.2 U	0.28 B	<22 U	<1.0 U	<0.2 U	0.31 B
Dissolved B	µg/L	<333 U	<333 U	<40 U	42	<333 U	<333 U	56	52
Total B	µg/L	<370 U	<370 U	<20 U	39	<370 U	<370 U	54	52
Dissolved Ba	µg/L	20 J	23.6 J	22	21	49 J	31.4 J	34	46
Total Ba	µg/L	20 J	23.9 J	20	20	69 J	38.9 J	47	45
Dissolved Be	µg/L	<10 U	<10 U	<5 U	<5.0 U	<10 U	<10 U	<5 U	<5.0 U
Total Be	µg/L	<11 U	<11 U	<2.5 U	<2.5 U	<11 U	<11 U	<2.5 U	<2.5 U
Dissolved Ca	mg/L	6.55	6.63	8.1	6.9	73.9	23.4	20.7	34.7
Total Ca	mg/L	6.52 J	6.54 J	7.7	6.7	75.7 J	23.5 J	22.0	32.8
Dissolved Cd	µg/L	<4 U	<1.0 U	<0.2 U	<0.20 U	<4 U	<1.0 U	<0.2 U	<0.20 U
Total Cd	µg/L	<4 U	<1.0 U	<0.2 U	<0.20 U	<4 U	<1.0 U	<0.2 U	<0.20 U
Dissolved Co	µg/L	<4 U	<4 U	<5 U	<5.0 U	<4 U	<4 U	<5 U	<5.0 U
Total Co	µg/L	<4 U	<4 U	<2.5 U	<2.5 U	<4 U	<4 U	<2.5 U	<2.5 U
Dissolved Cr	µg/L	<7 U	<2.0 U	<2 U	<2.0 U	<7 U	<2.0 U	<2 U	<2.0 U
Total Cr	µg/L	<8 U	<2.0 U	<2 U	<2.0 U	<8 U	<2.0 U	0.4 J	<2.0 U
Dissolved Cu	µg/L	<20 U	<2.0 U	<0.5 U	0.9 B	<20 U	<2.0 U	<0.5 U	0.7 B
Total Cu	µg/L	<22 U	<2.0 U	1.6 *, B	17.3 *, B	<22 U	<2.0 U	0.5 B	2.1 *, B
Dissolved Fe	µg/L	<67 U	<67 U	<100 U	<100 U	21 J	<67 U	<100 U	<100 U
Total Fe	µg/L	<74 U	<74 U	<50 U	8 J	412 J	108 J	120	<50 U
Dissolved Hg	µg/L	NR	NR	<0.2 U	<0.20 U	NR	NR	<0.2 U	<0.20 U
Total Hg	µg/L	NR	NR	<0.2 U	<0.20 U	NR	NR	<0.2 U	<0.20 U
Dissolved K	mg/L	0.26 J	0.29 J	0.56	0.48 J	0.58 J	0.51 J	0.42 J	0.51
Total K	mg/L	0.35 J	0.32 J	0.56	0.54	0.70 J	0.44 J	0.46	0.49
Dissolved Li	µg/L	NA	NR	4 J	<10 U	NA	NR	4 J	<10 U
Total Li	µg/L	NA	NR	4 J	<5 U	NA	NR	5	6
Dissolved Mg	mg/L	0.15	0.15	0.12	0.13	1.07	0.34	0.24	0.48

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW10	DW10	DW10	DW10	DW11	DW11	DW11	DW11
	Sample Date	10/5/11	5/17/12	11/8/2012	5/1/13	10/6/11	5/15/12	11/7/2012	4/29/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved Ag	µg/L	<14 U	<14 U	<10 U	<10 U	<14 U	<14 U	<10 U	<10 U
Total Ag	µg/L	<16 U	<16 U	<10 U	<10 U	<16 U	<16 U	<10 U	<10 U
Dissolved Al	µg/L	<494 U	69.9	8 J	45 B	<494 U	<20.0 U	3 J	47 B
Total Al	µg/L	<548 U	287	24 B	153 B	<548 U	<20.0 U	<20 U	45 B
Dissolved As	µg/L	<20 U	<1.0 U	<0.2 U	0.05 J	<20 U	<1.0 U	<0.2 U	0.09 J
Total As	µg/L	<22 U	<1.0 U	<0.2 U	0.38 B	<22 U	<1.0 U	<0.2 U	0.37 B
Dissolved B	µg/L	<333 U	<333 U	<40 U	<40 U	<333 U	<333 U	<40 U	<40 U
Total B	µg/L	<370 U	<370 U	37	35	<370 U	<370 U	<20 U	<20 U
Dissolved Ba	µg/L	25 J	24.2 J	20	26	224 J	275 J	207	214
Total Ba	µg/L	26 J	27.9 J	23	27	230 J	282 J	191	210
Dissolved Be	µg/L	<10 U	<10 U	<5 U	<5.0 U	<10 U	<10 U	<5 U	<5.0 U
Total Be	µg/L	<11 U	<11 U	<2.5 U	<2.5 U	<11 U	<11 U	<2.5 U	<2.5 U
Dissolved Ca	mg/L	3.94	3.76	3.9	4.2	14.3	18.0	13.3	13.0
Total Ca	mg/L	4.03 J	3.86 J	3.8	4.1	14.8 J	17.7 J	12.7	12.7
Dissolved Cd	µg/L	<4 U	<1.0 U	<0.2 U	<0.20 U	<4 U	<1.0 U	<0.2 U	<0.20 U
Total Cd	µg/L	<4 U	<1.0 U	<0.2 U	<0.20 U	1 J	<1.0 U	<0.2 U	<0.20 U
Dissolved Co	µg/L	<4 U	<4 U	<5 U	<5.0 U	<4 U	<4 U	<5 U	<5.0 U
Total Co	µg/L	<4 U	<4 U	2.2 J	<2.5 U	<4 U	<4 U	<2.5 U	<2.5 U
Dissolved Cr	µg/L	<7 U	<2.0 U	<2 U	<2.0 U	<7 U	<2.0 U	<2 U	<2.0 U
Total Cr	µg/L	<8 U	<2.0 U	0.6 J	2.9 B	<8 U	<2.0 U	<2 U	<2.0 U
Dissolved Cu	µg/L	<20 U	<2.0 U	<0.5 U	<0.50 U	<20 U	3.7 J	2.6 B	7.6 B
Total Cu	µg/L	<22 U	<2.0 U	<0.5 U	15.1 *, B	9 J	4.7 J, B	3.5 *, B	8.5 *
Dissolved Fe	µg/L	<67 U	38 J	<100 U	<100 U	32 J	534	<100 U	<100 U
Total Fe	µg/L	36 J	231 J	<50 U	110	496 J	744 J	<50 U	19 J
Dissolved Hg	µg/L	NR	NR	<0.2 U	<0.20 U	NR	NR	<0.2 U	<0.20 U
Total Hg	µg/L	NR	NR	<0.2 U	<0.20 U	NR	NR	<0.2 U	<0.20 U
Dissolved K	mg/L	0.22 J	0.29 J	0.23 J	0.26 J	0.90 J	1.13 J	0.88	0.89
Total K	mg/L	0.29 J	0.29 J	0.27	0.33	0.98 J	1.03 J	0.87	0.90
Dissolved Li	µg/L	NA	NR	2 J	<10 U	NA	NR	5 J	<10 U
Total Li	µg/L	NA	NR	2 J	<5 U	NA	NR	6	6
Dissolved Mg	mg/L	0.05 J	0.04 J	0.03 J	0.04 J	1.97	2.62	1.8	1.8

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW12	DW13	DW13	DW13	DW14	DW14	DW14
	Sample Date	10/6/11	5/15/12	11/6/2012	4/30/13	5/17/12	11/8/2012	5/1/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
Dissolved Ag	µg/L	<14 U	<14 U	<10 U	1.0 J	<14 U	<10 U	<10 U
Total Ag	µg/L	<16 U	<16 U	<10 U	<10 U	<16 U	<10 U	<10 U
Dissolved Al	µg/L	<494 U	<20.0 U	<20 U	46 B	<20.0 U	7 J	40 B
Total Al	µg/L	<548 U	36.2	46	69 B	29.0	36 B	53 B
Dissolved As	µg/L	<20 U	<1.0 U	<0.2 U	<0.20 U	<1.0 U	<0.2 U	0.12 J
Total As	µg/L	<22 U	<1.0 U	<0.2 U	0.33 B	<1.0 U	0.3	0.44 B
Dissolved B	µg/L	<333 U	<333 U	<40 U	<40 U	<333 U	<40 U	<40 U
Total B	µg/L	<370 U	<370 U	8 J	<20 U	<370 U	34	34
Dissolved Ba	µg/L	140 J	90.1 J	90	94	26.2 J	24	29
Total Ba	µg/L	138 J	93.9 J	85	131	27.5 J	26	29
Dissolved Be	µg/L	<10 U	<10 U	<5 U	<5.0 U	<10 U	<5 U	<5.0 U
Total Be	µg/L	<11 U	<11 U	<2.5 U	<2.5 U	<11 U	<2.5 U	<2.5 U
Dissolved Ca	mg/L	6.94	50.7	47.2	52.7	12.9	13.1	13.2
Total Ca	mg/L	6.93 J	50.2 J	45.4	48.6	12.8 J	12.6	13.2
Dissolved Cd	µg/L	<4 U	<1.0 U	<0.2 U	<0.20 U	<1.0 U	<0.2 U	<0.20 U
Total Cd	µg/L	<4 U	<1.0 U	<0.2 U	<0.20 U	<1.0 U	<0.2 U	<0.20 U
Dissolved Co	µg/L	<4 U	<4 U	1.8 J	1.2 J	<4 U	<5 U	<5.0 U
Total Co	µg/L	<4 U	<4 U	<2.5 U	<2.5 U	<4 U	<2.5 U	<2.5 U
Dissolved Cr	µg/L	<7 U	<2.0 U	<2 U	<2.0 U	2.1	0.5 J	<2.0 U
Total Cr	µg/L	<8 U	<2.0 U	<2 U	78	3.8	1.1 J	<2.0 U
Dissolved Cu	µg/L	<20 U	<2.0 U	0.6	3.5	14.6 J	1.8 B	1.5 B
Total Cu	µg/L	<22 U	6.1 J, B	5.9 *	3.1 *	10.7 J	2.6 B	3.3 *, B
Dissolved Fe	µg/L	28 J	<67 U	102	172	<67 U	<100 U	<100 U
Total Fe	µg/L	28 J	430 J	1400	8190	71 J	<50 U	41 J
Dissolved Hg	µg/L	NR	NR	<0.2 U	<0.20 U	NR	<0.2 U	<0.20 U
Total Hg	µg/L	NR	NR	<0.2 U	<0.20 U	NR	<0.2 U	<0.20 U
Dissolved K	mg/L	0.68 J	0.58 J	0.69	0.67	0.82 J	0.65	0.63
Total K	mg/L	0.73 J	0.65 J	0.69	0.84	0.60 J	0.68	0.63
Dissolved Li	µg/L	NA	NR	1 J	<10 U	NR	4 J	<10 U
Total Li	µg/L	NA	NR	1 J	<5 U	NR	3 J	<5 U
Dissolved Mg	mg/L	0.45	8.88	8.0	9.1	0.08 J	0.07	0.10

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW15	PW01	PW01	PW01	PW01	PW02	PW03	PW03	PW03
	Sample Date	11/8/2012	10/3/11	5/14/12	11/5/2012	4/29/13	10/3/11	5/14/12	11/5/2012	4/29/13
Parameter	Unit	Round 3	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved Ag	µg/L	<10 U	<14 U	<14 U	<10 U	<10 U	<14 U	<14 U	<10 U	<10 U
Total Ag	µg/L	<10 U	<16 U	<16 U	<10 U	<10 U	<16 U	<16 U	<10 U	<10 U
Dissolved Al	µg/L	16 J	<494 U	<20.0 U	<20 U	<20 U	<494 U	<20.0 U	<20 U	<20 U
Total Al	µg/L	26 B	<548 U	<20.0 U	20	25 B	<548 U	<20.0 U	<20	<20 U
Dissolved As	µg/L	<0.2 U	<20 U	<1.0 U	0.3	0.27	<20 U	<1.0 U	0.6	0.38
Total As	µg/L	0.2	<22 U	<1.0 U	0.4	0.63 B	<22 U	1.1	0.8	0.70 B
Dissolved B	µg/L	<40 U	<333 U	<333 U	<40 U	43	219 J	291 J	290	310
Total B	µg/L	26	<370 U	<370 U	37	33 J	217 J	292 J	280	300 J
Dissolved Ba	µg/L	34	485 J	561 J	632	635	53 J	243 J	300	103
Total Ba	µg/L	38	486 J	589 J	572	630	53 J	244 J	281	100
Dissolved Be	µg/L	<5 U	<10 U	<10 U	<5 U	<5.0 U	<10 U	<10 U	<5 U	<5.0 U
Total Be	µg/L	<2.5 U	<11 U	<11 U	<2.5 U	<2.5 U	<11 U	<11 U	<2.5 U	<2.5 U
Dissolved Ca	mg/L	22.9	2.37	2.53	2.7	2.7	3.30	7.50	7.6	6.5
Total Ca	mg/L	22.4	2.47 J	2.56 J	2.5	2.7	3.36 J	7.38 J	7.3	6.5
Dissolved Cd	µg/L	<0.2 U	<4 U	<1.0 U	<0.2 U	<0.20 U	<4 U	<1.0 U	<0.2 U	<0.20 U
Total Cd	µg/L	<0.2 U	<4 U	<1.0 U	<0.2 U	0.16 J	<4 U	<1.0 U	<0.2 U	<0.20 U
Dissolved Co	µg/L	<5 U	<4 U	<4 U	2.3 J	<5.0 U	<4 U	<4 U	1.7 J	<5.0 U
Total Co	µg/L	<2.5 U	<4 U	<4 U	<2.5 U	0.8 J	<4 U	<4 U	<2.5 U	<2.5 U
Dissolved Cr	µg/L	<2 U	<7 U	<2.0 U	<2 U	<2.0 U	<7 U	<2.0 U	<2 U	<2.0 U
Total Cr	µg/L	<2 U	<8 U	<2.0 U	0.9 J	<2.0 U	3 J	3.8	1.1 J	<2.0 U
Dissolved Cu	µg/L	3.1 B	<20 U	5.7 J	<0.5 U	<0.50 U	<20 U	11.5 J	<0.5 U	<0.50 U
Total Cu	µg/L	6.4 B	<22 U	6.4 J	2.2 *	2.5	21 J	20.5 J	6.9	13.9
Dissolved Fe	µg/L	<100 U	2110	2040	1900.00	1950.0	2690	11300	9760.00	2040.00
Total Fe	µg/L	NR[2]	2270 J	2270 J	2070	2180	3820 J	12200 J	NR[2]	2240
Dissolved Hg	µg/L	<0.2 U	NR	NR	<0.2 U	<0.20 U	NR	NR	<0.2 U	<0.20 U
Total Hg	µg/L	<0.2 U	NR	NR	<0.2 U	<0.20 U	NR	NR	<0.2 U	<0.20 U
Dissolved K	mg/L	2.4	2.25 J	3.38 J	2.6	2.6	0.43 J	1.37 J	0.81	0.88
Total K	mg/L	2.4	2.36 J	2.97 J	2.6	2.7	0.54 J	1.32 J	0.81	0.98
Dissolved Li	µg/L	7 J	NA	NR	32	33	NA	NR	49	45
Total Li	µg/L	7	NA	NR	31	33	NA	NR	48	46
Dissolved Mg	mg/L	3.4	<0.10 U	0.75	0.79	0.82	0.07 J	0.32	0.32	0.28

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	SW01	SW01	SW01	SW01	SW02	SW02	SW02
	Sample Date	10/4/11	5/14/12	11/7/2012	4/30/13	5/14/12	11/6/2012	4/30/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
Dissolved Ag	µg/L	<14 U	<14 U	<10 U	<10 U	<14 U	<10 U	<10 U
Total Ag	µg/L	<16 U	<16 U, J-	<10 U	<10 U	<16 U	<10 U	<10 U
Dissolved Al	µg/L	<494 U	<20.0 U	19 J	<20 U	<20.0 U	7 J	<20 U
Total Al	µg/L	204 J	810	144 B	329 B	693	72	57 B
Dissolved As	µg/L	<20 U	<1.0 U	0.4	0.47	<1.0 U	0.3	0.43
Total As	µg/L	<22 U	<1.0 U	0.4	0.64 B	<1.0 U	0.4	0.58 B
Dissolved B	µg/L	135 J	114 J	127	117	<333 U	95	114
Total B	µg/L	139 J	116 J	131	118 J	<370 U	90	98 J
Dissolved Ba	µg/L	58 J	95.9 J	105	117	116 J	121	124
Total Ba	µg/L	60 J	123 J	119	123	135 J	112	118
Dissolved Be	µg/L	<10 U	<10 U	<5 U	<5.0 U	<10 U	<5 U	<5.0 U
Total Be	µg/L	<11 U	<11 U	<2.5 U	<2.5 U	<11 U	<2.5 U	<2.5 U
Dissolved Ca	mg/L	9.42	13.9	14.8	12.7	25.9	33.8	32.3
Total Ca	mg/L	9.58 J	14.7 J	14.5	12.8	27.1 J	31.9	32.3
Dissolved Cd	µg/L	<4 U	<1.0 U	<0.2 U	<0.20 U	<1.0 U	<0.2 U	<0.20 U
Total Cd	µg/L	<4 U	<1.0 U	<0.2 U	<0.20 U	<1.0 U	<0.2 U	<0.20 U
Dissolved Co	µg/L	2 J	<4 U	<5 U	<5.0 U	<4 U	1.7 J	<5.0 U
Total Co	µg/L	<4 U	<4 U	<2.5 U	<2.5 U	<4 U	<2.5 U	<2.5 U
Dissolved Cr	µg/L	<7 U	<2.0 U	0.3 J	<2.0 U	<2.0 U	<2 U	<2.0 U
Total Cr	µg/L	<8 U	<2.0 U	<2 U	<2.0 U	<2.0 U	<2 U	<2.0 U
Dissolved Cu	µg/L	<20 U	7.9 J	1.6 B	0.5	11.0 J	0.6	0.5 J
Total Cu	µg/L	<22 U	5.5 J	0.9 B	0.98	5.3 J	3.5 *	0.74
Dissolved Fe	µg/L	52 J	22 J	<100 U	76 J	<67 U	136	<100 U
Total Fe	µg/L	159 J	1450 J	187 B	476	1020 J	150	163
Dissolved Hg	µg/L	NR	NR	<0.2 U	<0.20 U	NR	<0.2 U	<0.20 U
Total Hg	µg/L	NR	NR	<0.2 U	<0.20 U	NR	<0.2 U	<0.20 U
Dissolved K	mg/L	1.42 J	2.01 J	1.7	1.5	2.73 J	2.4	2.3
Total K	mg/L	1.58 J	2.33 J	1.7	1.7	2.84 J	2.4	2.4
Dissolved Li	µg/L	NA	NR	43	36	NR	26	22
Total Li	µg/L	NA	NR	43	36	NR	25	23
Dissolved Mg	mg/L	5.77	5.37	4.4	4.7	10.9	12	12

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	SW03	SW03	SW03
	Sample Date	5/15/12	11/6/2012	4/30/13
Parameter	Unit	Round 2	Round 3	Round 4
Dissolved Ag	µg/L	<14 U	<10 U	<10 U
Total Ag	µg/L	<16 U	<10 U	<10 U
Dissolved Al	µg/L	<20.0 U	3 J	<20 U
Total Al	µg/L	29.0	31	<20 U
Dissolved As	µg/L	2.1	0.4	0.26
Total As	µg/L	1.5	0.5	0.26 B
Dissolved B	µg/L	176 J	134	176
Total B	µg/L	179 J	138	92 J
Dissolved Ba	µg/L	281 J	264	352
Total Ba	µg/L	287 J	257	249
Dissolved Be	µg/L	<10 U	<5 U	<5.0 U
Total Be	µg/L	<11 U	<2.5 U	<2.5 U
Dissolved Ca	mg/L	2.91	2.4	2.5
Total Ca	mg/L	2.64 J	2.3	2.1
Dissolved Cd	µg/L	<1.0 U	<0.2 U	<0.20 U
Total Cd	µg/L	<1.0 U	<0.2 U	<0.20 U
Dissolved Co	µg/L	<4 U	2.7 J	<5.0 U
Total Co	µg/L	<4 U	<2.5 U	0.8 J
Dissolved Cr	µg/L	<2.0 U	0.4 J	<2.0 U
Total Cr	µg/L	<2.0 U	4.8	<2.0 U
Dissolved Cu	µg/L	7.6 J	<0.5 U	<0.50 U
Total Cu	µg/L	5.7 J, B	1.4 *	<0.50 U
Dissolved Fe	µg/L	647	423.00	594.00
Total Fe	µg/L	645 J	772	413
Dissolved Hg	µg/L	NR	<0.2 U	<0.20 U
Total Hg	µg/L	NR	<0.2 U	<0.20 U
Dissolved K	mg/L	2.05 J	1.6	2.0
Total K	mg/L	1.74 J	1.7	1.9
Dissolved Li	µg/L	NR	51	81
Total Li	µg/L	NR	54	45
Dissolved Mg	mg/L	0.33	0.31	0.34

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	MW01	MW01	MW01	MW01	MW02	MW02	MW02	MW02
	Sample Date	10/3/11	5/15/12	11/5/2012	4/29/13	10/4/11	5/15/12	11/6/2012	4/30/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Total Mg	mg/L	4.34 J	4.40 J	4.0	4.3	1.35 J	1.10 J	0.89	0.76
Dissolved Mn	µg/L	281	282	287	260	26	25	17	16
Total Mn	µg/L	292 J	286	260	278 *	27 J	26 J	17	16
Dissolved Mo	µg/L	5 J	<1.0 U	0.8	0.78	13 J	13.6	14	14
Total Mo	µg/L	<19 U	<1.0 U	0.8	0.82	16 J	13.0	14 B	15
Dissolved Na	mg/L	44 J	45.6 J-	48	48	98 J	96.4 J-	100	103
Total Na	mg/L	45 J	45.6 J-	46	45	95 J	97.6 J-	95	102
Dissolved Ni	µg/L	<84 U	<1.0 U	1.3	1.2 B	<84 U	<1.0 U	0.20 B	0.16 J
Total Ni	µg/L	<93 U	<1.0 U	1.7 *	1.8	<93 U	<1.0 U	0.38 *, B	0.40
Dissolved P	mg/L	<0.06 U	<0.06 U	<0.05 U	<0.05 U	<0.06 U	<0.06 U	<0.05 U	<0.05 U
Total P	mg/L	<0.07 U	<0.07 U	<0.03 U	<0.03 U	<0.07 U	<0.07 U	<0.03 U	<0.03 U
Dissolved Pb	µg/L	<17 U	<1.0 U	<0.2 U	<0.20 U	<17 U	<1.0 U	<0.2 U	<0.20 U
Total Pb	µg/L	<19 U	<1.0 U	<0.2 U	<0.20 U	<19 U	<1.0 U, J-	0.14 J	<0.20 U
Dissolved S	mg/L	34.2 J	33.6 J-	NR	NR	25.1 J	23.4 J-	NR	NR
Total S	mg/L	31.7 J	31.7 J	NR	NR	19.9 J	19.6 J	NR	NR
Dissolved Sb	µg/L	R	<2.0 U	<0.2 U	<0.20 U	R	<2.0 U	<0.2 U	<0.20 U
Total Sb	µg/L	R	<2.0 U	<0.2 U	<0.20 U	R	<2.0 U	<0.2 U	<0.20 U
Dissolved Se	µg/L	<30 U	<5.0 U, J-	<2 U	<2.0 U	<30 U	<5.0 U	<2 U	<2.0 U
Total Se	µg/L	<33 U	R	<2 U	<2.0 U	<33 U	<5.0 U	<2 U	<2.0 U
Dissolved Si	mg/L	4.38 J	4.47 J	4.5	4.3	3.00 J	3.08 J	3.2	3.2
Total Si	mg/L	4.41 J	4.19 J	4.4	4.1	3.19 J	3.11 J	3.3	3.2
Dissolved Sr	µg/L	1160	1190	1270	1170	185	157	150	136
Total Sr	µg/L	1250 J	1240 J	1120	1220	183 J	162 J	151	137
Dissolved Th	µg/L	NA	R	<0.2 U	<0.20 U	NA	<1.0 U	<0.2 U	<0.20 U
Total Th	µg/L	NA	0.06 J	<0.2 U	<0.20 U	NA	0.22 J-	<0.2 U	<0.20 U
Dissolved Ti	µg/L	<7 U	<7 U	<5 U	0.2 J	<7 U	<7 U	<5 U	0.7 J
Total Ti	µg/L	<8 U	<8 U	<2.5 U	<2.5 U	<8 U	<8 U	<2.5 U	1.3 J
Dissolved Tl	µg/L	<17 U	<1.0 U	<0.2 U	<0.20 U	<17 U	<1.0 U	<0.2 U	<0.20 U
Total Tl	µg/L	<19 U	<1.0 U	<0.2 U	<0.20 U	<19 U	<1.0 U	<0.2 U	<0.20 U
Dissolved U	µg/L	<50 U	R	<0.2 U	<0.20 U	<50 U	<1.0 U	0.15 J	0.12 J
Total U	µg/L	<56 U	<1.0 U	<0.2 U	<0.20 U	<56 U	<1.0 U	<0.2 U	0.12 J

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	MW03	MW03	MW03	MW03	MW04	MW05	DW01	DW01
	Sample Date	10/4/11	5/15/12	11/7/2012	5/1/13	10/5/11	10/5/11	10/3/11	5/15/12
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 1	Round 1	Round 2
Total Mg	mg/L	0.36 J	0.23 J	0.23	0.18	0.04 J	0.40 J	9.94 J	10.3 J
Dissolved Mn	µg/L	25	23	19	8.5	6 J	32	<14 U	<14 U
Total Mn	µg/L	50 J	22 J	36	17	9 J	95 J	<16 U	<16 U
Dissolved Mo	µg/L	6 J	2.1	1.8	1.6	<17 U	5 J	<17 U	<1.0 U
Total Mo	µg/L	<19 U	2.1	1.7	1.8	<19 U	<19 U	<19 U	<1.0 U
Dissolved Na	mg/L	167 J	162 J-	168	169	115 J	90 J	13 J	11.5 J-
Total Na	mg/L	164 J	159 J-	175	163	118 J	90 J	13 J	12.0 J-
Dissolved Ni	µg/L	<84 U	6.9	4.3 B	3.8	<84 U	<84 U	<84 U	1.5
Total Ni	µg/L	<93 U	8.9	3.9 *, B	6.2	<93 U	<93 U	<93 U	<1.0 U
Dissolved P	mg/L	0.39 J	<0.06 U	0.09	<0.05 U	<0.06 U	<0.06 U	<0.06 U	<0.06 U
Total P	mg/L	<0.07 U	0.02 J	0.02 J	<0.03 U	<0.07 U	0.03 J	<0.07 U	<0.07 U
Dissolved Pb	µg/L	<17 U	1.9 J	0.14 J	0.24	<17 U	<17 U	<17 U	<1.0 U
Total Pb	µg/L	<19 U	2.7 J, *	1.8	1.6	<19 U	<19 U	<19 U	<1.0 U, J-
Dissolved S	mg/L	1.46 J	0.39 J-	NR	NR	69.6 J	455 J	7.61 J	7.05 J-
Total S	mg/L	1.17 J	0.64 J	NR	NR	44.4 J	16.0 J	6.69 J	6.85 J
Dissolved Sb	µg/L	R	2.3 B	2.2	2.7	R	R	R	<2.0 U
Total Sb	µg/L	R	3.5 B	0.5	3.0	R	R	R	<2.0 U
Dissolved Se	µg/L	<30 U	<5.0 U	<2 U	<2.0 U	<30 U	10 J	<30 U	R
Total Se	µg/L	<33 U	<5.0 U	<2 U	<2.0 U	<33 U	<33 U	<33 U	<5.0 U
Dissolved Si	mg/L	3.99 J	4.63 J	4.0	4.1	4.78 J	4.72 J	4.83 J	4.70 J
Total Si	mg/L	6.57 J	4.83 J	5.6	4.3	5.11 J	9.86 J	4.71 J	4.55 J
Dissolved Sr	µg/L	152	138	141	147	99	41	366	364
Total Sr	µg/L	166 J	146 J	146	152	109 J	59 J	395 J	372 J
Dissolved Th	µg/L	NA	<1.0 U	<0.2 U	<0.20 U	NA	NA	NA	R
Total Th	µg/L	NA	0.25 J-	0.14 J	<0.20 U	NA	NA	NA	<1.0 U, J-
Dissolved Ti	µg/L	<7 U	10	<5 U	1.0 J	<7 U	<7 U	<7 U	<7 U
Total Ti	µg/L	27 J	8 J	7	3.3	<8 U	74 J	<8 U	<8 U
Dissolved Tl	µg/L	<17 U	<1.0 U	<0.2 U	<0.20 U	<17 U	<17 U	<17 U	<1.0 U
Total Tl	µg/L	<19 U	<1.0 U	<0.2 U	<0.20 U	<19 U	<19 U	<19 U	<1.0 U
Dissolved U	µg/L	<50 U	<1.0 U	<0.2 U	0.09 J	<50 U	<50 U	16 J	1.8 J-
Total U	µg/L	<56 U	<1.0 U	<0.2 U	0.10 J	<56 U	<56 U	<56 U	1.5 J-

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW02	DW02	DW02	DW02	DW03	DW03	DW03	DW03
	Sample Date	10/3/11	5/14/12	11/5/2012	4/29/13	10/3/11	5/15/12	11/5/2012	4/30/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Total Mg	mg/L	1.53 J	1.70 J	1.5	1.4	12.0 J	12.1 J	11	13
Dissolved Mn	µg/L	<14 U	<14 U	4 J	2.8 J	<14 U	<14 U	0.3 J	0.4 J
Total Mn	µg/L	191 J	226 J	11	47 *	<16 U	<16 U	<2.5 U	<2.5 U
Dissolved Mo	µg/L	8 J	<1.0 U	1.5	1.5	<17 U	<1.0 U	0.5	<0.50 U
Total Mo	µg/L	<19 U	1.2	1.4	1.2	<19 U	<1.0 U	0.6	0.52
Dissolved Na	mg/L	83 J	87.1 J-	87	87	30 J	26.3 J-	36	30
Total Na	mg/L	84 J	85.0 J-	84	84	30 J	27.4 J-	33	29
Dissolved Ni	µg/L	<84 U	<1.0 U	0.44	0.77 B	<84 U	<1.0 U	1.6	1.4
Total Ni	µg/L	<93 U	<1.0 U	0.70 *	0.68	<93 U	<1.0 U	2.9 *	1.4
Dissolved P	mg/L	<0.06 U	<0.06 U	<0.05 U	<0.05 U	<0.06 U	<0.06 U	<0.05 U	<0.05 U
Total P	mg/L	<0.07 U	<0.07 U	<0.03 U	0.003 J	<0.07 U	<0.07 U	<0.03 U	<0.03 U
Dissolved Pb	µg/L	<17 U	1.6 J	0.48	0.25	<17 U	<1.0 U	0.18 J	1.6
Total Pb	µg/L	<19 U	2.3 J	0.52	0.53	<19 U	<1.0 U	0.28	1.8
Dissolved S	mg/L	21.4 J	25.0 J-	NR	NR	22.1 J	21.2 J-	NR	NR
Total S	mg/L	20.1 J	22.9 J	NR	NR	20.0 J	18.6 J	NR	NR
Dissolved Sb	µg/L	R	<2.0 U	<0.2 U	0.06 J	R	<2.0 U	<0.2 U	<0.20 U
Total Sb	µg/L	R	<2.0 U	<0.2 U	<0.20 U	R	<2.0 U	<0.2 U	0.06 J
Dissolved Se	µg/L	<30 U	R	<2 U	<2.0 U	<30 U	<5.0 U, J-	1.6 J	2.2
Total Se	µg/L	<33 U	R	0.8 J	<2.0 U	<33 U	<5.0 U, J-	2.5	2.5
Dissolved Si	mg/L	3.05 J	3.29 J	3.4	3.2	4.57 J	4.69 J	4.4	4.3
Total Si	mg/L	3.32 J	3.10 J	3.5	3.1	4.54 J	4.43 J	4.4	4.2
Dissolved Sr	µg/L	358	495	399	396	547	534	576	582
Total Sr	µg/L	421 J	468 J	413	417	567 J	569 J	529	564
Dissolved Th	µg/L	NA	R	<0.2 U	<0.20 U	NA	R	<0.2 U	<0.20 U
Total Th	µg/L	NA	<1.0 U	0.09 J	0.29 *	NA	<1.0 U	<0.2 U	<0.20 U
Dissolved Ti	µg/L	<7 U	<7 U	<5 U	<5.0 U	<7 U	<7 U	<5 U	<5.0 U
Total Ti	µg/L	<8 U	<8 U	<2.5 U	<2.5 U	<8 U	<8 U	0.3 J	0.5 J
Dissolved Tl	µg/L	<17 U	<1.0 U	<0.2 U	<0.20 U	<17 U	<1.0 U	<0.2 U	<0.20 U
Total Tl	µg/L	<19 U	<1.0 U	0.08 J	<0.20 U	<19 U	<1.0 U	0.15 J	<0.20 U
Dissolved U	µg/L	<50 U	<1.0 U, J-	<0.2 U	<0.20 U	<50 U	<1.0 U, J-	0.42	0.42
Total U	µg/L	<56 U	<1.0 U	<0.2 U	0.12 J	<56 U	<1.0 U	0.43	0.42

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW04	DW04	DW04	DW05	DW05	DW05	DW05
	Sample Date	10/4/11	11/6/2012	4/30/13	10/4/11	5/14/12	11/5/2012	4/29/13
Parameter	Unit	Round 1	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Total Mg	mg/L	6.01 J	4.2	4.7	0.28 J	0.24 J	0.26	0.21
Dissolved Mn	µg/L	<14 U	3 J	4.8 J	20	8 J	14	7.0
Total Mn	µg/L	<16 U	2.4 J	6.2 *	22 J	8 J	14	7.8 *
Dissolved Mo	µg/L	<17 U	0.5	0.54	<17 U	1.2	1.4	1.2
Total Mo	µg/L	<19 U	0.6 B	0.56	<19 U	1.1	1.3	1.1
Dissolved Na	mg/L	52 J	67	66	123 J	120 J-	136	121
Total Na	mg/L	50 J	63	63	124 J	118 J-	122	119
Dissolved Ni	µg/L	<84 U	0.84 B	2.4	<84 U	<1.0 U	0.28	0.32 B
Total Ni	µg/L	<93 U	2.0 *, B	1.3	<93 U	<1.0 U	0.36 *	0.25
Dissolved P	mg/L	<0.06 U	0.02 J	<0.05 U	<0.06 U	0.02 J	<0.05 U	<0.05 U
Total P	mg/L	<0.07 U	<0.03 U	<0.03 U	<0.07 U	<0.07 U	0.02 J	<0.03 U
Dissolved Pb	µg/L	<17 U	0.68	0.44	<17 U	<1.0 U	<0.2 U	<0.20 U
Total Pb	µg/L	<19 U	0.37	0.90	<19 U	<1.0 U	1.0	<0.20 U
Dissolved S	mg/L	14.0 J	NR	NR	19.8 J	17.3 J-	NR	NR
Total S	mg/L	12.6 J	NR	NR	17.9 J	16.1 J	NR	NR
Dissolved Sb	µg/L	R	<0.2 U	0.06 J	R	<2.0 U	<0.2 U	<0.20 U
Total Sb	µg/L	R	<0.2 U	<0.20 U	R	<2.0 U	<0.2 U	0.06 J
Dissolved Se	µg/L	<30 U	<2 U	<2.0 U	<30 U	R	<2 U	<2.0 U
Total Se	µg/L	<33 U	<2 U	<2.0 U	<33 U	R	<2 U	<2.0 U
Dissolved Si	mg/L	4.78 J	4.7	4.6	4.75 J	4.68 J	5.2	4.7
Total Si	mg/L	4.59 J	4.7	4.4	5.00 J	4.71 J	5.4	4.8
Dissolved Sr	µg/L	1130	797	808	100	86.8	99	81.8
Total Sr	µg/L	1130 J	722	834	106 J	89.3 J	102	82
Dissolved Th	µg/L	NA	<0.2 U	<0.20 U	NA	R	<0.2 U	<0.20 U
Total Th	µg/L	NA	<0.2 U	<0.20 U	NA	<1.0 U	<0.2 U	<0.20 U
Dissolved Ti	µg/L	<7 U	<5 U	<5.0 U	<7 U	<7 U	<5 U	<5.0 U
Total Ti	µg/L	<8 U	<2.5 U	<2.5 U	<8 U	<8 U	1 J	<2.5 U
Dissolved Tl	µg/L	<17 U	<0.2 U	<0.20 U	<17 U	<1.0 U	<0.2 U	<0.20 U
Total Tl	µg/L	<19 U	<0.2 U	<0.20 U	<19 U	<1.0 U	<0.2 U	<0.20 U
Dissolved U	µg/L	<50 U	<0.2 U	<0.20 U	<50 U	<1.0 U, J-	0.17 J	<0.20 U
Total U	µg/L	<56 U	<0.2 U	<0.20 U	<56 U	<1.0 U	0.16 J	0.16 J

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW06	DW06	DW06	DW06	DW07	DW07	DW07	DW07
	Sample Date	10/6/11	5/16/12	11/8/2012	5/2/13	10/6/11	5/16/12	11/6/2012	5/1/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Total Mg	mg/L	3.06 J	2.17 J	2.7	2.3	0.16 J	<0.11 U	0.13	0.08
Dissolved Mn	µg/L	9 J	<14 U	4 J	3.1 J	<14 U	<14 U	2 J	1.4 J
Total Mn	µg/L	8 J	<16 U	5.0	3.5 *	<16 U	<16 U	1.8 J	<2.5 U
Dissolved Mo	µg/L	<17 U	21.2	8.0	0.64	<17 U	1.8	2.3	2.0
Total Mo	µg/L	<19 U	30.4	13	1.6	<19 U	2.3	2.3 B	2.3
Dissolved Na	mg/L	98 J	101 J-	90	104	129 J	127 J-	135	127
Total Na	mg/L	97 J	101 J-	90	103	131 J	126 J-	122	126
Dissolved Ni	µg/L	<84 U	<1.0 U	0.78	0.38	<84 U	<1.0 U	<0.2 U	<0.20 U
Total Ni	µg/L	<93 U	<1.0 U	0.77 B	2.2	<93 U	<1.0 U	0.16 *, J	2.2
Dissolved P	mg/L	<0.06 U	<0.06 U	<0.05 U	<0.05 U	<0.06 U	<0.06 U	<0.05 U	<0.05 U
Total P	mg/L	<0.07 U	<0.07 U	<0.03 U	0.006 J	<0.07 U	<0.07 U	<0.03 U	<0.03 U
Dissolved Pb	µg/L	<17 U	<1.0 U	<0.2 U	<0.20 U	<17 U	<1.0 U	<0.2 U	<0.20 U
Total Pb	µg/L	<19 U	<1.0 U	0.18 J	0.36	<19 U	<1.0 U	0.20	0.30
Dissolved S	mg/L	161 J	143 J-	NR	NR	26.9 J	24.8 J-	NR	NR
Total S	mg/L	20.7 J	18.3 J	NR	NR	23.7 J	21.4 J	NR	NR
Dissolved Sb	µg/L	R	<2.0 U	<0.2 U	<0.20 U	R	<2.0 U	<0.2 U	<0.20 U
Total Sb	µg/L	R	<2.0 U	<0.2 U	<0.20 U	R	<2.0 U	<0.2 U	<0.20 U
Dissolved Se	µg/L	<30 U	R	<2 U	<2.0 U	<30 U	R	<2 U	<2.0 U
Total Se	µg/L	<33 U	<5.0 U, J-	<2 U	<2.0 U	<33 U	R	<2 U	<2.0 U
Dissolved Si	mg/L	9.30 J	9.50 J	8.6	9.6	4.58 J	4.71 J	4.8	4.6
Total Si	mg/L	9.47 J	9.24 J	8.9	9.3	4.91 J	4.71 J	4.9	4.6
Dissolved Sr	µg/L	679	428	464	428	86	89.4	79	69.1
Total Sr	µg/L	567 J	450 J	445	439	96 J	93.8 J	84	72
Dissolved Th	µg/L	NA	R	<0.2 U	<0.20 U	NA	<1.0 U, J-	<0.2 U	<0.20 U
Total Th	µg/L	NA	<1.0 U	<0.2 U	<0.20 U	NA	<1.0 U	<0.2 U	<0.20 U
Dissolved Ti	µg/L	<7 U	<7 U	<5 U	<5.0 U	<7 U	<7 U	<5 U	<5.0 U
Total Ti	µg/L	<8 U	<8 U	2 J	<2.5 U	3 J	<8 U	<2.5 U	<2.5 U
Dissolved Tl	µg/L	<17 U	<1.0 U	<0.2 U	<0.20 U	<17 U	<1.0 U	<0.2 U	<0.20 U
Total Tl	µg/L	<19 U	<1.0 U	<0.2 U	<0.20 U	<19 U	<1.0 U	<0.2 U	<0.20 U
Dissolved U	µg/L	<50 U	R	<0.2 U	<0.20 U	<50 U	R	<0.2 U	<0.20 U
Total U	µg/L	<56 U	R	<0.2 U	0.06 J	<56 U	R	<0.2 U	0.07 J

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW08	DW08	DW08	DW08	DW09	DW09	DW09	DW09
	Sample Date	10/5/11	5/16/12	11/7/2012	5/1/13	10/5/11	5/16/12	11/8/2012	5/1/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Total Mg	mg/L	0.14 J	<0.11 U	0.13	0.12	1.18 J	0.19 J	0.34	0.46
Dissolved Mn	µg/L	<14 U	7 J	7	5.7	54	9 J	7	13
Total Mn	µg/L	6 J	5 J	6.7	5.7 *	65 J	8 J	12	12 *
Dissolved Mo	µg/L	<17 U	<1.0 U	0.4 J	0.82	<17 U	<1.0 U	0.8 B	0.72
Total Mo	µg/L	<19 U	<1.0 U	1.1	1.0	<19 U	<1.0 U	1.4	1.3
Dissolved Na	mg/L	136 J	129 J-	142	139	185 J	139 J-	147	160
Total Na	mg/L	134 J	128 J-	140	137	185 J	140 J-	146	155
Dissolved Ni	µg/L	<84 U	<1.0 U	0.26 B	0.51 B	<84 U	<1.0 U	0.70	1.4 B
Total Ni	µg/L	<93 U	<1.0 U	0.50 *	0.52	<93 U	<1.0 U	1.1 B	1.4
Dissolved P	mg/L	<0.06 U	<0.06 U	<0.05 U	<0.05 U	<0.06 U	<0.06 U	<0.05 U	<0.05 U
Total P	mg/L	<0.07 U	<0.07 U	<0.03 U	<0.03 U	<0.07 U	<0.07 U	<0.03 U	<0.03 U
Dissolved Pb	µg/L	<17 U	<1.0 U	<0.2 U	<0.20 U	<17 U	<1.0 U	<0.2 U	<0.20 U
Total Pb	µg/L	<19 U	<1.0 U	0.06 J	<0.20 U	<19 U	<1.0 U	0.08 J	<0.20 U
Dissolved S	mg/L	151 J	143 J-	NR	NR	206 J	297 J-	NR	NR
Total S	mg/L	40.4 J	31.4 J	NR	NR	138 J	58.3 J	NR	NR
Dissolved Sb	µg/L	R	<2.0 U	<0.2 U	<0.20 U	R	<2.0 U	<0.2 U	<0.20 U
Total Sb	µg/L	R	<2.0 U	<0.2 U	<0.20 U	R	<2.0 U	<0.2 U	<0.20 U
Dissolved Se	µg/L	<30 U	R	<2 U	<2.0 U	<30 U	<5.0 U, J-	<2 U	0.7 J
Total Se	µg/L	<33 U	R	<2 U	0.45 J	<33 U	<5.0 U, J-	<2 U	0.49 J
Dissolved Si	mg/L	6.41 J	6.43 J	6.6	6.5	4.85 J	4.86 J	4.7	4.9
Total Si	mg/L	6.81 J	6.44 J	6.8	6.4	5.60 J	5.12 J	5.3	4.8
Dissolved Sr	µg/L	175	167	175	165	1770	560	499	778
Total Sr	µg/L	180 J	173 J	186	168	1890 J	597 J	524	783
Dissolved Th	µg/L	NA	<1.0 U, J-	<0.2 U	0.36 B	NA	<1.0 U, J-	<0.2 U	<0.20 U
Total Th	µg/L	NA	<1.0 U	<0.2 U	0.34 *, B	NA	<1.0 U	<0.2 U	<0.20 U
Dissolved Ti	µg/L	<7 U	<7 U	<5 U	<5.0 U	<7 U	<7 U	<5 U	<5.0 U
Total Ti	µg/L	<8 U	<8 U	<2.5 U	<2.5 U	10 J	5 J	3	<2.5 U
Dissolved Tl	µg/L	<17 U	<1.0 U	<0.2 U	<0.20 U	<17 U	<1.0 U	<0.2 U	<0.20 U
Total Tl	µg/L	<19 U	<1.0 U	<0.2 U	<0.20 U	<19 U	<1.0 U	<0.2 U	<0.20 U
Dissolved U	µg/L	<50 U	<1.0 U, J-	<0.2 U	<0.20 U	20 J	<1.0 U, J-	<0.2 U	<0.20 U
Total U	µg/L	<56 U	R	<0.2 U	<0.20 U	<56 U	R	<0.2 U	<0.20 U

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW10	DW10	DW10	DW10	DW11	DW11	DW11	DW11
	Sample Date	10/5/11	5/17/12	11/8/2012	5/1/13	10/6/11	5/15/12	11/7/2012	4/29/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Total Mg	mg/L	0.06 J	<0.11 U	0.05	0.07	2.00 J	2.36 J	1.8	1.7
Dissolved Mn	µg/L	<14 U	<14 U	2 J	3.0 J	21	25	3 J	16
Total Mn	µg/L	<16 U	<16 U	<2.5 U	4.9 *	26 J	27 J	22	68 *
Dissolved Mo	µg/L	12 J	<1.0 U	1.1 B	0.76	5 J	2.1	5.1	3.0
Total Mo	µg/L	<19 U	<1.0 U	2.6	1.9	<19 U	2.3	5.1	3.0
Dissolved Na	mg/L	105 J	103 J-	108	111	93 J	88.6 J-	96	96
Total Na	mg/L	106 J	105 J-	107	109	94 J	88.8 J-	93	97
Dissolved Ni	µg/L	<84 U	<1.0 U	0.24	0.30 B	<84 U	<1.0 U	0.34 B	1.2 B
Total Ni	µg/L	<93 U	<1.0 U	0.26 B	1.1	<93 U	<1.0 U	0.68 *	0.74
Dissolved P	mg/L	<0.06 U	<0.06 U	<0.05 U	<0.05 U	<0.06 U	<0.06 U	<0.05 U	<0.05 U
Total P	mg/L	<0.07 U	<0.07 U	<0.03 U	<0.03 U	<0.07 U	<0.07 U	<0.03 U	<0.03 U
Dissolved Pb	µg/L	<17 U	<1.0 U	<0.2 U	<0.20 U	<17 U	<1.0 U	0.09 J	0.38
Total Pb	µg/L	<19 U	<1.0 U	0.07 J	1.1	<19 U	2.7 J, *	0.46	1.0
Dissolved S	mg/L	681 J	471 J-	NR	NR	6.25 J	1.23 J-	NR	NR
Total S	mg/L	40.0 J	36.7 J	NR	NR	0.99 J	1.01 J	NR	NR
Dissolved Sb	µg/L	R	<2.0 U	<0.2 U	<0.20 U	R	<2.0 U	<0.2 U	<0.20 U
Total Sb	µg/L	R	<2.0 U	<0.2 U	<0.20 U	R	<2.0 U	<0.2 U	<0.20 U
Dissolved Se	µg/L	18 J	<5.0 U, J-	0.7 J	<2.0 U	13 J	<5.0 U	0.7 J	0.9 J
Total Se	µg/L	<33 U	<5.0 U, J-	<2 U	<2.0 U	<33 U	<5.0 U	<2 U	<2.0 U
Dissolved Si	mg/L	4.90 J	5.08 J	4.9	4.9	3.46 J	3.81 J	3.7	3.6
Total Si	mg/L	5.47 J	5.84 J	5.2	5.0	3.36 J	3.51 J	3.7	3.5
Dissolved Sr	µg/L	90	82.3	86	94.2	484	603	460	431
Total Sr	µg/L	93 J	87.0 J	104	95	519 J	627 J	417	437
Dissolved Th	µg/L	NA	R	<0.2 U	<0.20 U	NA	R	<0.2 U	<0.20 U
Total Th	µg/L	NA	0.07 J	<0.2 U	<0.20 U	NA	0.07 J-	<0.2 U	<0.20 U
Dissolved Ti	µg/L	3 J	<7 U	<5 U	<5.0 U	<7 U	<7 U	<5 U	<5.0 U
Total Ti	µg/L	<8 U	8 J	0.3 J	5.0	2 J	<8 U	<2.5 U	<2.5 U
Dissolved Tl	µg/L	<17 U	<1.0 U	<0.2 U	<0.20 U	<17 U	<1.0 U	<0.2 U	<0.20 U
Total Tl	µg/L	<19 U	<1.0 U	<0.2 U	<0.20 U	<19 U	<1.0 U	<0.2 U	<0.20 U
Dissolved U	µg/L	<50 U	R	<0.2 U	<0.20 U	<50 U	<1.0 U	<0.2 U	<0.20 U
Total U	µg/L	<56 U	R	<0.2 U	<0.20 U	<56 U	<1.0 U	<0.2 U	0.09 J

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW12	DW13	DW13	DW13	DW14	DW14	DW14
	Sample Date	10/6/11	5/15/12	11/6/2012	4/30/13	5/17/12	11/8/2012	5/1/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
Total Mg	mg/L	0.44 J	8.64 J	7.8	8.6	<0.11 U	0.09	0.11
Dissolved Mn	µg/L	27	<14 U	5 J	5.2	<14 U	<5 U	8.5
Total Mn	µg/L	28 J	6 J	12	37 *	<16 U	<2.5 U	<2.5 U
Dissolved Mo	µg/L	<17 U	<1.0 U	0.4 J	<0.5 U	5.5	5.1 B	5.1
Total Mo	µg/L	<19 U	<1.0 U	0.4 B	0.71	5.4	5.3	8.6
Dissolved Na	mg/L	86 J	6.88 J-	6.9	7	242 J-	216	212
Total Na	mg/L	86 J	7.13 J-	6.8	8	244 J-	220	205
Dissolved Ni	µg/L	<84 U	<1.0 U	1.4 B	2.1	1.9	1.7	8.7
Total Ni	µg/L	<93 U	<1.0 U	2.6 *, B	46	2.0	4.1 B	2.3
Dissolved P	mg/L	<0.06 U	<0.06 U	<0.05 U	<0.05 U	<0.06 U	0.13	<0.05 U
Total P	mg/L	<0.07 U	<0.07 U	<0.03 U	0.006 J	<0.07 U	0.08	<0.03 U
Dissolved Pb	µg/L	<17 U	<1.0 U	0.30	0.18 J	1.2 J	0.18 J	<0.20 U
Total Pb	µg/L	<19 U	1.4 J	1.4	0.47	3.5 J	0.50	1.4
Dissolved S	mg/L	6.28 J	7.88 J-	NR	NR	116 J-	NR	NR
Total S	mg/L	2.13 J	7.74 J	NR	NR	104 J	NR	NR
Dissolved Sb	µg/L	R	<2.0 U	<0.2 U	<0.20 U	0.16 J	<0.2 U	<0.20 U
Total Sb	µg/L	R	<2.0 U	<0.2 U	0.06 J	<2.0 U	<0.2 U	<0.20 U
Dissolved Se	µg/L	<30 U	R	<2 U	0.6 J	R	<2 U	0.5 J
Total Se	µg/L	<33 U	R	<2 U	0.62 J	<5.0 U, J-	<2 U	<2.0 U
Dissolved Si	mg/L	3.61 J	4.72 J	4.3	4.1	4.14 J	4.0	4.0
Total Si	mg/L	3.68 J	4.52 J	4.5	4.5	4.24 J	4.4	4.1
Dissolved Sr	µg/L	229	279	265	281	274	288	294
Total Sr	µg/L	230 J	284 J	258	382	292 J	270	299
Dissolved Th	µg/L	NA	R	<0.2 U	<0.20 U	<1.0 U, J-	<0.2 U	<0.20 U
Total Th	µg/L	NA	<1.0 U	<0.2 U	<0.20 U	0.29 J	<0.2 U	<0.20 U
Dissolved Ti	µg/L	<7 U	<7 U	<5 U	<5.0 U	<7 U	<5 U	<5.0 U
Total Ti	µg/L	<8 U	<8 U	2 J	<2.5 U	<8 U	<2.5 U	<2.5 U
Dissolved Tl	µg/L	<17 U	<1.0 U	<0.2 U	<0.20 U	<1.0 U	<0.2 U	<0.20 U
Total Tl	µg/L	<19 U	<1.0 U	<0.2 U	<0.20 U	<1.0 U	<0.2 U	<0.20 U
Dissolved U	µg/L	<50 U	<1.0 U, J-	0.93	1.2	<1.0 U, J-	<0.2 U	0.14 J
Total U	µg/L	<56 U	1.1 J-	0.94	1.1	<1.0 U	<0.2 U	0.12 J

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW15	PW01	PW01	PW01	PW01	PW02	PW03	PW03	PW03
	Sample Date	11/8/2012	10/3/11	5/14/12	11/5/2012	4/29/13	10/3/11	5/14/12	11/5/2012	4/29/13
Parameter	Unit	Round 3	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Total Mg	mg/L	3.8	0.64 J	0.76 J	0.77	0.83	0.08 J	0.32 J	0.31	0.28
Dissolved Mn	µg/L	5	33	31	30	28	38	138	125	99
Total Mn	µg/L	6.8	36 J	35 J	31	36 *	53 J	157 J	139	110 *
Dissolved Mo	µg/L	31	9 J	<1.0 U	0.9	0.72	17	1.4	1.5	2.2
Total Mo	µg/L	32	<19 U	<1.0 U	0.9	1.0	<19 U	1.2	1.6	2.3
Dissolved Na	mg/L	82	419 J	432 J-	506	510	240 J	305 J-	341	349
Total Na	mg/L	81	431 J	457 J-	530	500	243 J	310 J-	342	340
Dissolved Ni	µg/L	1.5	<84 U	<1.0 U	0.22	0.20 B	<84 U	2.6	0.56	1.8 B
Total Ni	µg/L	2.2 B	<93 U	<1.0 U	1.4 *	1.6	<93 U	6.6	2.4 *, B	3.6
Dissolved P	mg/L	<0.05 U	0.10 J	0.09 J	0.19	0.15	<0.06 U	<0.06 U	0.16	0.12
Total P	mg/L	<0.03 U	0.11 J	0.10 J	0.11	0.105	<0.07 U	0.02 J	0.03	0.028
Dissolved Pb	µg/L	0.54	<17 U	<1.0 U	<0.2 U	<0.20 U	<17 U	<1.0 U	0.09 J	<0.20 U
Total Pb	µg/L	0.72	<19 U	<1.0 U, J-	0.06 J	<0.20 U	<19 U	1.4 J, *	0.72	1.3
Dissolved S	mg/L	NR	<0.46 U	0.78 J-	NR	NR	<0.46 U	0.76 J-	NR	NR
Total S	mg/L	NR	<0.51 U	<0.51 U	NR	NR	0.23 J	<0.51 U	NR	NR
Dissolved Sb	µg/L	<0.2 U	R	<2.0 U	<0.2 U	<0.20 U	R	<2.0 U	0.1 J	<0.20 U
Total Sb	µg/L	<0.2 U	R	<2.0 U	<0.2 U	<0.20 U	R	<2.0 U	0.2	0.16 J
Dissolved Se	µg/L	<2 U	32	R	<2 U	<2.0 U	20 J	<5.0 U, J-	<2 U	<2.0 U
Total Se	µg/L	<2 U	<33 U	<5.0 U	<2 U	<2.0 U	<33 U	<5.0 U, J-	<2 U	<2.0 U
Dissolved Si	mg/L	8.1	6.31 J	6.75 J	7.3	7.1	10.3 J	11.1 J	11.1	10.5
Total Si	mg/L	8.5	6.54 J	6.75 J	7.3	7.1	10.6 J	11.1 J	10.4	10.4
Dissolved Sr	µg/L	516	312	349	385	393	270	732	776	716
Total Sr	µg/L	585	328 J	365 J	354	414	287 J	753 J	721	733
Dissolved Th	µg/L	<0.2 U	NA	<1.0 U	<0.2 U	<0.20 U	NA	<1.0 U	<0.2 U	<0.20 U
Total Th	µg/L	<0.2 U	NA	0.08 J-	<0.2 U	<0.20 U	NA	0.08 J-	0.10 J	<0.20 U
Dissolved Ti	µg/L	<5 U	<7 U	<7 U	<5 U	<5.0 U	3 J	<7 U	<5 U	<5.0 U
Total Ti	µg/L	<2.5 U	<8 U	<8 U	<2.5 U	1.0 J	<8 U	<8 U	<2.5 U	<2.5 U
Dissolved Tl	µg/L	<0.2 U	<17 U	<1.0 U	<0.2 U	<0.20 U	<17 U	<1.0 U	<0.2 U	<0.20 U
Total Tl	µg/L	<0.2 U	<19 U	<1.0 U	<0.2 U	<0.20 U	<19 U	<1.0 U	0.11 J	<0.20 U
Dissolved U	µg/L	0.18 J	<50 U	<1.0 U	<0.2 U	<0.20 U	<50 U	R	<0.2 U	<0.20 U
Total U	µg/L	0.16 J	<56 U	R	<0.2 U	<0.20 U	<56 U	R	<0.2 U	<0.20 U

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	SW01	SW01	SW01	SW01	SW02	SW02	SW02
	Sample Date	10/4/11	5/14/12	11/7/2012	4/30/13	5/14/12	11/6/2012	4/30/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
Total Mg	mg/L	5.86 J	5.60 J	5.1	4.67	10.9 J	12	12
Dissolved Mn	µg/L	<14 U	<14 U	0.9 J	1.5 J	50	90	40
Total Mn	µg/L	<16 U	29 J	3.6	14	78 J	92	44
Dissolved Mo	µg/L	6 J	1.4	1.6	1.5	1.9	2.0	1.9
Total Mo	µg/L	<19 U	<1.0 U	1.6	1.8	1.1	5.2 B	2.2
Dissolved Na	mg/L	301 J	289 J-	350	318	317 J-	396	356
Total Na	mg/L	305 J	295 J-	352	309	323 J-	398	344
Dissolved Ni	µg/L	<84 U	<1.0 U	4.2 B	0.58	<1.0 U	1.2 B	1.2
Total Ni	µg/L	<93 U	<1.0 U	0.83 *, B	1.0	1.3	0.68 *, B	1.6
Dissolved P	mg/L	<0.06 U	<0.06 U	<0.05 U	<0.05 U	<0.06 U	0.04 J	<0.05 U
Total P	mg/L	<0.07 U	0.04 J	0.02 J	0.034	0.04 J	0.03	0.026
Dissolved Pb	µg/L	<17 U	<1.0 U	0.24	<0.20 U	<1.0 U	<0.2 U	<0.20 U
Total Pb	µg/L	<19 U	<1.0 U, J-	0.16 J	0.15 J	<1.0 U, J-	<0.2 U	<0.20 U
Dissolved S	mg/L	1.61 J	1.46 J-	NR	NR	7.28 J-	NR	NR
Total S	mg/L	1.49 J	1.58 J	NR	NR	7.60 J	NR	NR
Dissolved Sb	µg/L	R	<2.0 U	<0.2 U	<0.20 U	<2.0 U	<0.2 U	<0.20 U
Total Sb	µg/L	R	<2.0 U	<0.2 U	<0.20 U	<2.0 U	<0.2 U	0.07 J
Dissolved Se	µg/L	14 J	<5.0 U	<2 U	<2.0 U	<5.0 U	<2 U	<2.0 U
Total Se	µg/L	<33 U	<5.0 U	<2 U	0.43 J	<5.0 U	<2 U	0.64 J
Dissolved Si	mg/L	6.86 J	6.69 J	7.0	6.1	5.78 J	5.9	5.4
Total Si	mg/L	6.89 J	10.5 J	7.6	7.0	8.04 J	6.1	5.4
Dissolved Sr	µg/L	296	342	386	309	571	701	649
Total Sr	µg/L	316 J	368 J	368	326	603 J	639	679
Dissolved Th	µg/L	NA	<1.0 U	<0.2 U	<0.20 U	<1.0 U	<0.2 U	<0.20 U
Total Th	µg/L	NA	0.06 J-	<0.2 U	<0.20 U	0.10 J-	<0.2 U	<0.20 U
Dissolved Ti	µg/L	<7 U	<7 U	0.5 J	0.7 J	<7 U	<5 U	<5.0 U
Total Ti	µg/L	3 J	67 J	3	12	35 J	0.8 J	1.1 J
Dissolved Tl	µg/L	<17 U	<1.0 U	<0.2 U	<0.20 U	<1.0 U	<0.2 U	<0.20 U
Total Tl	µg/L	<19 U	<1.0 U	<0.2 U	<0.20 U	<1.0 U	<0.2 U	<0.20 U
Dissolved U	µg/L	<50 U	1.5 J-	1.4	1.5	2.7 J-	3.7	3.8
Total U	µg/L	<56 U	1.6 J-	1.5	1.6	2.6 J-	<0.2 U	3.8

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	SW03	SW03	SW03
	Sample Date	5/15/12	11/6/2012	4/30/13
Parameter	Unit	Round 2	Round 3	Round 4
Total Mg	mg/L	0.16 J	0.31	0.31
Dissolved Mn	µg/L	17	11	13
Total Mn	µg/L	12 J	13	10
Dissolved Mo	µg/L	1.5	1.3	0.94
Total Mo	µg/L	1.4	1.5 B	1.1
Dissolved Na	mg/L	326 J-	369	387
Total Na	mg/L	347 J-	382	341
Dissolved Ni	µg/L	<1.0 U	0.36 B	<0.20 U
Total Ni	µg/L	<1.0 U	1.9 *, B	0.66
Dissolved P	mg/L	0.03 J	0.10	0.06
Total P	mg/L	<0.07 U	0.05	0.060
Dissolved Pb	µg/L	<1.0 U	<0.2 U	<0.20 U
Total Pb	µg/L	<1.0 U, J-	0.14 J	<0.20 U
Dissolved S	mg/L	0.95 J-	NR	NR
Total S	mg/L	<0.51 U	NR	NR
Dissolved Sb	µg/L	<2.0 U	<0.2 U	<0.20 U
Total Sb	µg/L	<2.0 U	<0.2 U	<0.20 U
Dissolved Se	µg/L	<5.0 U	<2 U	<2.0 U
Total Se	µg/L	<5.0 U	<2 U	0.55 J
Dissolved Si	mg/L	7.90 J	8.8	8.8
Total Si	mg/L	8.18 J	9.1	8.4
Dissolved Sr	µg/L	282	290	275
Total Sr	µg/L	279 J	278	223
Dissolved Th	µg/L	<1.0 U	<0.2 U	<0.20 U
Total Th	µg/L	0.54 J-	<0.2 U	<0.20 U
Dissolved Ti	µg/L	<7 U	<5 U	<5.0 U
Total Ti	µg/L	<8 U	0.5 J	<2.5 U
Dissolved Tl	µg/L	<1.0 U	<0.2 U	<0.20 U
Total Tl	µg/L	<1.0 U	<0.2 U	<0.20 U
Dissolved U	µg/L	<1.0 U	<0.2 U	<0.20 U
Total U	µg/L	<1.0 U	<0.2 U	<0.20 U

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	MW01	MW01	MW01	MW01	MW02	MW02	MW02	MW02
	Sample Date	10/3/11	5/15/12	11/5/2012	4/29/13	10/4/11	5/15/12	11/6/2012	4/30/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved V	µg/L	<10 U	<10 U	<0.2 U	0.02 J	<10 U	<10 U	0.4	0.31
Total V	µg/L	<11 U	<11 U	<0.2 U	0.40 B	<11 U	<11 U	0.4	0.77 B
Dissolved Zn	µg/L	<50 U	<50 U	<5 U	<5.0 U	<50 U	<50 U	<5 U	<5.0 U
Total Zn	µg/L	<56 U	<56 U	<2.5 U	<2.5 U	<56 U	<56 U	<2.5 U	<2.5 U

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	MW03	MW03	MW03	MW03	MW04	MW05	DW01	DW01
	Sample Date	10/4/11	5/15/12	11/7/2012	5/1/13	10/5/11	10/5/11	10/3/11	5/15/12
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 1	Round 1	Round 2
Dissolved V	µg/L	<10 U	<10 U	0.3	0.41	<10 U	<10 U	<10 U	<10 U
Total V	µg/L	<11 U	<11 U	1.5	1.40 B	<11 U	4 J	<11 U	<11 U
Dissolved Zn	µg/L	<50 U	<50 U	<5 U	5.4	<50 U	<50 U	<50 U	<50 U
Total Zn	µg/L	24 J	<56 U	12 B	6.4 B	<56 U	<56 U	<56 U	<56 U

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW02	DW02	DW02	DW02	DW03	DW03	DW03	DW03
	Sample Date	10/3/11	5/14/12	11/5/2012	4/29/13	10/3/11	5/15/12	11/5/2012	4/30/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved V	µg/L	<10 U	<10 U	0.2	0.23	<10 U	<10 U	0.1 J	0.12 J
Total V	µg/L	<11 U	<11 U	0.2	0.66 B	<11 U	<11 U	0.2	0.55 B
Dissolved Zn	µg/L	<50 U	<50 U	6	8.8	33 J	16 J	3 J	34
Total Zn	µg/L	<56 U	<56 U	7	6.5 B	21 J	23 J	5	37

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW04	DW04	DW04	DW05	DW05	DW05	DW05
	Sample Date	10/4/11	11/6/2012	4/30/13	10/4/11	5/14/12	11/5/2012	4/29/13
Parameter	Unit	Round 1	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved V	µg/L	<10 U	0.07 J	0.09 J	<10 U	<10 U	0.5	0.50
Total V	µg/L	<11 U	<0.2 U	0.54 B	<11 U	<11 U	0.8	0.88 B
Dissolved Zn	µg/L	22 J	14	20	<50 U	<50 U	1 J	<5.0 U
Total Zn	µg/L	<56 U	14 B	24 B	<56 U	<56 U	3	2.7 B

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW06	DW06	DW06	DW06	DW07	DW07	DW07	DW07
	Sample Date	10/6/11	5/16/12	11/8/2012	5/2/13	10/6/11	5/16/12	11/6/2012	5/1/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved V	µg/L	<10 U	<10 U	0.09 J	0.05 J	<10 U	<10 U	0.02 J	0.02 J
Total V	µg/L	<11 U	<11 U	0.4	0.56 B	<11 U	<11 U	0.2	0.43 B
Dissolved Zn	µg/L	<50 U	<50 U	82	76	<50 U	<50 U	<5 U	<5.0 U
Total Zn	µg/L	<56 U	100 J	157	192	<56 U	<56 U	<2.5 U	<2.5 U

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW08	DW08	DW08	DW08	DW09	DW09	DW09	DW09
	Sample Date	10/5/11	5/16/12	11/7/2012	5/1/13	10/5/11	5/16/12	11/8/2012	5/1/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved V	µg/L	<10 U	<10 U	0.06 J	0.07 J	<10 U	<10 U	0.1 J	0.04 J
Total V	µg/L	<11 U	<11 U	0.2	0.47 B	<11 U	<11 U	0.4	0.54 B
Dissolved Zn	µg/L	156 U	72	<5 U	<5.0 U	31 J	<50 U	<5 U	<5.0 U
Total Zn	µg/L	998 J	196 J	11 B	12 B	327 J	24 J	11	26 B

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW10	DW10	DW10	DW10	DW11	DW11	DW11	DW11
	Sample Date	10/5/11	5/17/12	11/8/2012	5/1/13	10/6/11	5/15/12	11/7/2012	4/29/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved V	µg/L	<10 U	<10 U	0.02 J	0.08 J	3 J	<10 U	0.06 J	0.07 J
Total V	µg/L	<11 U	<11 U	0.2	0.80 B	<11 U	<11 U	0.2	0.60 B
Dissolved Zn	µg/L	<50 U	<50 U	<5 U	<5.0 U	<50 U	<50 U	5	22
Total Zn	µg/L	<56 U	<56 U	<2.5 U	5.3 B	<56 U	17 J	8 B	27 B

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW12	DW13	DW13	DW13	DW14	DW14	DW14
	Sample Date	10/6/11	5/15/12	11/6/2012	4/30/13	5/17/12	11/8/2012	5/1/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
Dissolved V	µg/L	<10 U	<10 U	0.1 J	0.10 J	<10 U	2.3	1.10
Total V	µg/L	<11 U	<11 U	0.4	1.20 B	<11 U	2.8	2.10 B
Dissolved Zn	µg/L	<50 U	284	89	35	<50 U	<5 U	<5.0 U
Total Zn	µg/L	<56 U	97 J	141	27 B	<56 U	3	14 B

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	DW15	PW01	PW01	PW01	PW01	PW02	PW03	PW03	PW03
	Sample Date	11/8/2012	10/3/11	5/14/12	11/5/2012	4/29/13	10/3/11	5/14/12	11/5/2012	4/29/13
Parameter	Unit	Round 3	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved V	µg/L	0.7	<10 U	<10 U	0.04 J	0.03 J	<10 U	<10 U	0.03 J	0.13 J
Total V	µg/L	0.9	<11 U	<11 U	0.5	0.89 B	<11 U	<11 U	0.4	0.75 B
Dissolved Zn	µg/L	23	<50 U	<50 U	<5 U	<5.0 U	<50 U	<50 U	2 J	<5.0 U
Total Zn	µg/L	30	<56 U	<56 U	<2.5 U	<2.5 U	<56 U	<56 U	6	<2.5 U

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	SW01	SW01	SW01	SW01	SW02	SW02	SW02
	Sample Date	10/4/11	5/14/12	11/7/2012	4/30/13	5/14/12	11/6/2012	4/30/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
Dissolved V	µg/L	<10 U	<10 U	0.7	0.94	<10 U	0.8	1.00
Total V	µg/L	<11 U	4 J	1.1	1.60 B	<11 U	0.9	1.40 B
Dissolved Zn	µg/L	<50 U	<50 U	<5 U	<5.0 U	<50 U	<5 U	<5.0 U
Total Zn	µg/L	<56 U	<56 U	<2.5 U	<2.5 U	<56 U	<2.5 U	<2.5 U

Table B-3 Sample Results - Dissolved and Total Metals (Raton Basin, Colorado)

	Sample	SW03	SW03	SW03
	Sample Date	5/15/12	11/6/2012	4/30/13
Parameter	Unit	Round 2	Round 3	Round 4
Dissolved V	µg/L	<10 U	0.03 J	0.03 J
Total V	µg/L	<11 U	0.3	0.35 B
Dissolved Zn	µg/L	<50 U	<5 U	<5.0 U
Total Zn	µg/L	<56 U	<2.5 U	<2.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample	MW01	MW01	MW01	MW01	MW02	MW02	MW02	MW02
	Sample Date	10/3/11	5/15/12	11/5/12	4/29/13	10/4/11	5/15/12	11/6/12	4/30/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
ethanol (64-17-5)	µg/L	<100 U	<100 U	<100 U	<100 U	<100 U	<100 U	<100 U	<100 U
isopropanol (67-63-0)	µg/L	<25 U	<25 U	<10 U	<10 U	<25 U	<25 U	<10 U	<10 U
acrylonitrile (107-13-1)	µg/L	<25 U	<25 U, J-	<1.0 U	<1.0 U	<25 U	<25 U, J-	<1.0 U	<1.0 U
styrene (100-42-5)	µg/L	<0.5 U	<0.5 U	NR	<0.5 U	<0.5 U	<0.5 U	NR	<0.5 U
acetone (67-64-1)	µg/L	<1.0 U	<1.0 U, J-	<1.0 U	<1.0 U	<1.0 U	<1.0 U, J-	<1.0 U	<1.0 U
tert-butyl alcohol (75-65-0)	µg/L	<5.0 U	<5.0 U, J-	<10 U	<10 U	37.4	27.2 J-	29	28
methyl tert-butyl ether (1634-04-4)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
diisopropyl ether (108-20-3)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
ethyl tert-butyl ether (637-92-3)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
tert-amyl methyl ether (994-05-8)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
vinyl chloride (75-01-4)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1-dichloroethene (75-35-4)	µg/L	R	R	<0.5 U	<0.5 U	R	R	<0.5 U	<0.5 U
carbon disulfide (75-15-0)	µg/L	<0.5 U, J-	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U, J-	<0.5 U	<0.5 U
methylene chloride (75-09-2)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
trans-1,2-dichloroethene (156-60-5)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1-dichloroethane (75-34-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
cis-1,2-dichoroethene (156-59-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
chloroform (67-66-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1,1-trichloroethane (71-55-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
carbon tetrachloride (56-23-5)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
benzene (71-43-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2-dichloroethane (107-06-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
trichloroethene (79-01-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
toluene (108-88-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	0.53	<0.5 U	<0.5 U	NR[2]
1,1,2-trichloroethane (79-00-5)	µg/L	R	R	<0.5 U	<0.5 U	R	R	<0.5 U	<0.5 U
tetrachloroethene (127-18-4)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
chlorobenzene (108-90-7)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
ethylbenzene (100-41-4)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
m+p xylene (108-38-3, 106-42-3)	µg/L	<2.0 U	<2.0 U	<1.0 U	<1.0 U	<2.0 U	<2.0 U	<1.0 U	<1.0 U
o-xylene (95-47-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
isopropylbenzene (98-82-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,3,5-trimethylbenzene (108-67-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample	MW03	MW03	MW03	MW03	MW04	MW05	DW01	DW01
	Sample Date	10/4/11	5/15/12	11/7/12	5/1/13	10/5/11	10/5/11	10/3/11	5/15/12
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 1	Round 1	Round 2
ethanol (64-17-5)	µg/L	<100 U	<100 U	<100 U	<100 U	<100 U	<100 U	<100 U	<100 U
isopropanol (67-63-0)	µg/L	<25 U	<25 U	<10 U	<10 U	<25 U	<25 U	<25 U	<25 U
acrylonitrile (107-13-1)	µg/L	<25 U	<25 U, J-	<1.0 U	<1.0 U	<25 U	<25 U	<25 U	<25 U, J-
styrene (100-42-5)	µg/L	<0.5 U	<0.5 U	NR	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
acetone (67-64-1)	µg/L	<1.0 U	<1.0 U, J-	<1.0 U	<1.0 U	<1.0 U	<1.0 U	<1.0 U	<1.0 U, J-
tert-butyl alcohol (75-65-0)	µg/L	965	1310 J-	1000 J	960 H	<5.0 U	<5.0 U	<5.0 U	<5.0 U, J-
methyl tert-butyl ether (1634-04-4)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<1.0 U	<1.0 U
diisopropyl ether (108-20-3)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<1.0 U	<1.0 U
ethyl tert-butyl ether (637-92-3)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<1.0 U	<1.0 U
tert-amyl methyl ether (994-05-8)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<1.0 U	<1.0 U
vinyl chloride (75-01-4)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1-dichloroethene (75-35-4)	µg/L	R	R	<0.5 U	<0.5 U	R	R	R	R
carbon disulfide (75-15-0)	µg/L	<0.5 U, J-	<0.5 U, J-	0.12 J	<0.5 U	<0.5 U, J-	<0.5 U, J-	<0.5 U, J-	<0.5 U, J-
methylene chloride (75-09-2)	µg/L	<1.0 U	<1.0 U	0.23 J	0.12 J	<1.0 U	<1.0 U	<1.0 U	<1.0 U
trans-1,2-dichloroethene (156-60-5)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1-dichloroethane (75-34-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
cis-1,2-dichoroethene (156-59-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
chloroform (67-66-3)	µg/L	14.0	1.93	4.1	2.3	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1,1-trichloroethane (71-55-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
carbon tetrachloride (56-23-5)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
benzene (71-43-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2-dichloroethane (107-06-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
trichloroethene (79-01-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
toluene (108-88-3)	µg/L	NR[2]	<0.5 U	0.18 J	0.11 J	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1,2-trichloroethane (79-00-5)	µg/L	R	R	<0.5 U	<0.5 U	R	R	R	R
tetrachloroethene (127-18-4)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
chlorobenzene (108-90-7)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
ethylbenzene (100-41-4)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<1.0 U	<1.0 U
m+p xylene (108-38-3, 106-42-3)	µg/L	<2.0 U	<2.0 U	<1.0 U	<1.0 U	<2.0 U	<2.0 U	<2.0 U	<2.0 U
o-xylene (95-47-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
isopropylbenzene (98-82-8)	µg/L	0.31 J	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,3,5-trimethylbenzene (108-67-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW02	DW02	DW02	DW02	DW03	DW03	DW03	DW03
	Sample Date	10/3/11	5/14/12	11/5/12	4/29/13	10/3/11	5/15/12	11/5/12	4/30/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
ethanol (64-17-5)	µg/L	<100 U	<100 U	<100 U	<100 U	<100 U	<100 U	<100 U	<100 U
isopropanol (67-63-0)	µg/L	<25 U	<25 U	<10 U	<10 U	<25 U	<25 U	<10 U	<10 U
acrylonitrile (107-13-1)	µg/L	<25 U	<25 U, J-	<1.0 U	<1.0 U	<25 U	<25 U, J-	<1.0 U	<1.0 U
styrene (100-42-5)	µg/L	<0.5 U	<0.5 U	NR	<0.5 U	<0.5 U	<0.5 U	NR	<0.5 U
acetone (67-64-1)	µg/L	<1.0 U	<1.0 U, J-	<1.0 U	<1.0 U	<1.0 U	62.3 J-	<1.0 U	<1.0 U
tert-butyl alcohol (75-65-0)	µg/L	<5.0 U	<5.0 U, J-	<10 U	<10 U	<5.0 U	51.3 J-	<10 U	<10 U
methyl tert-butyl ether (1634-04-4)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
diisopropyl ether (108-20-3)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
ethyl tert-butyl ether (637-92-3)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
tert-amyl methyl ether (994-05-8)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
vinyl chloride (75-01-4)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1-dichloroethene (75-35-4)	µg/L	R	R	<0.5 U	<0.5 U	R	R	<0.5 U	<0.5 U
carbon disulfide (75-15-0)	µg/L	<0.5 U, J-	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U, J-	<0.5 U	<0.5 U
methylene chloride (75-09-2)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
trans-1,2-dichloroethene (156-60-5)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1-dichloroethane (75-34-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
cis-1,2-dichoroethene (156-59-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
chloroform (67-66-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	0.09 J	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1,1-trichloroethane (71-55-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
carbon tetrachloride (56-23-5)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
benzene (71-43-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	0.66	<0.5 U	<0.5 U
1,2-dichloroethane (107-06-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
trichloroethene (79-01-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
toluene (108-88-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1,2-trichloroethane (79-00-5)	µg/L	R	R	<0.5 U	<0.5 U	R	R	<0.5 U	<0.5 U
tetrachloroethene (127-18-4)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
chlorobenzene (108-90-7)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
ethylbenzene (100-41-4)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
m+p xylene (108-38-3, 106-42-3)	µg/L	<2.0 U	<2.0 U	<1.0 U	<1.0 U	<2.0 U	<2.0 U	<1.0 U	<1.0 U
o-xylene (95-47-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
isopropylbenzene (98-82-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,3,5-trimethylbenzene (108-67-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW04	DW04	DW04	DW05	DW05	DW05	DW05
	Sample Date	10/4/11	11/6/12	4/30/13	10/4/11	5/14/12	11/5/12	4/29/13
Parameter (CAS Number)	Unit	Round 1	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
ethanol (64-17-5)	µg/L	<100 U	<100 U	<100 U	<100 U	<100 U	<100 U	<100 U
isopropanol (67-63-0)	µg/L	<25 U	<10 U	<10 U	<25 U	<25 U	<10 U	<10 U
acrylonitrile (107-13-1)	µg/L	<25 U	<1.0 U	<1.0 U	<25 U	<25 U, J-	<1.0 U	<1.0 U
styrene (100-42-5)	µg/L	<0.5 U	NR	<0.5 U	<0.5 U	<0.5 U	NR	<0.5 U
acetone (67-64-1)	µg/L	<1.0 U	<1.0 U	<1.0 U	<1.0 U	<1.0 U, J-	<1.0 U	<1.0 U
tert-butyl alcohol (75-65-0)	µg/L	<5.0 U	<10 U	<10 U	<5.0 U	<5.0 U, J-	<10 U	<10 U
methyl tert-butyl ether (1634-04-4)	µg/L	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
diisopropyl ether (108-20-3)	µg/L	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
ethyl tert-butyl ether (637-92-3)	µg/L	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
tert-amyl methyl ether (994-05-8)	µg/L	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
vinyl chloride (75-01-4)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1-dichloroethene (75-35-4)	µg/L	R	<0.5 U	<0.5 U	R	R	<0.5 U	<0.5 U
carbon disulfide (75-15-0)	µg/L	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U, J-	<0.5 U	<0.5 U
methylene chloride (75-09-2)	µg/L	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
trans-1,2-dichloroethene (156-60-5)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1-dichloroethane (75-34-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
cis-1,2-dichoroethene (156-59-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
chloroform (67-66-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	0.56	<0.5 U	<0.5 U	0.14 J
1,1,1-trichloroethane (71-55-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
carbon tetrachloride (56-23-5)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
benzene (71-43-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2-dichloroethane (107-06-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
trichloroethene (79-01-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
toluene (108-88-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	0.12 J
1,1,2-trichloroethane (79-00-5)	µg/L	R	<0.5 U	<0.5 U	R	R	<0.5 U	<0.5 U
tetrachloroethene (127-18-4)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
chlorobenzene (108-90-7)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
ethylbenzene (100-41-4)	µg/L	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
m+p xylene (108-38-3, 106-42-3)	µg/L	<2.0 U	<1.0 U	<1.0 U	<2.0 U	<2.0 U	<1.0 U	<1.0 U
o-xylene (95-47-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
isopropylbenzene (98-82-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,3,5-trimethylbenzene (108-67-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW06	DW06	DW06	DW06	DW07	DW07	DW07	DW07
	Sample Date	10/6/11	5/16/12	11/8/12	5/2/13	10/6/11	5/16/12	11/6/12	5/1/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
ethanol (64-17-5)	µg/L	<100 U	<100 U	<100 U, J-	<100 U	<100 U	<100 U	<100 U	<100 U
isopropanol (67-63-0)	µg/L	<25 U	<25 U	<10 U, J-	<10 U	<25 U	<25 U	<10 U	<10 U
acrylonitrile (107-13-1)	µg/L	<25 U	<25 U, J-	<1.0 U, J-	<1.0 U	<25 U	<25 U, J-	<1.0 U	<1.0 U
styrene (100-42-5)	µg/L	<0.5 U	<0.5 U	NR	<0.5 U	<0.5 U	<0.5 U	NR	<0.5 U
acetone (67-64-1)	µg/L	<1.0 U	<1.0 U	1.6 J-	<1.0 U	<1.0 U	<1.0 U	<1.0 U	<1.0 U
tert-butyl alcohol (75-65-0)	µg/L	<5.0 U	<5.0 U	<10 U, J-	<10 U	<5.0 U	<5.0 U	<10 U	<10 U
methyl tert-butyl ether (1634-04-4)	µg/L	<1.0 U	<1.0 U	<0.5 U, J-	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
diisopropyl ether (108-20-3)	µg/L	<1.0 U	<1.0 U	<0.5 U, J-	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
ethyl tert-butyl ether (637-92-3)	µg/L	<1.0 U	<1.0 U	<0.5 U, J-	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
tert-amyl methyl ether (994-05-8)	µg/L	<1.0 U	<1.0 U	<0.5 U, J-	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
vinyl chloride (75-01-4)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1-dichloroethene (75-35-4)	µg/L	R	R	<0.5 U, J-	<0.5 U	R	R	<0.5 U	<0.5 U
carbon disulfide (75-15-0)	µg/L	<0.5 U, J-	<0.5 U, J-	0.54 J-	<0.5 U	<0.5 U, J-	<0.5 U, J-	<0.5 U	<0.5 U
methylene chloride (75-09-2)	µg/L	<1.0 U	<1.0 U	2.1 J-	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
trans-1,2-dichloroethene (156-60-5)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1-dichloroethane (75-34-3)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
cis-1,2-dichoroethene (156-59-2)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
chloroform (67-66-3)	µg/L	0.58	<0.5 U	3.0 J-	0.08 J	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1,1-trichloroethane (71-55-6)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
carbon tetrachloride (56-23-5)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
benzene (71-43-2)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2-dichloroethane (107-06-2)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
trichloroethene (79-01-6)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
toluene (108-88-3)	µg/L	1.23 B	1.96	0.36 J-	0.21 J	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1,2-trichloroethane (79-00-5)	µg/L	R	R	<0.5 U, J-	<0.5 U	R	R	<0.5 U	<0.5 U
tetrachloroethene (127-18-4)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
chlorobenzene (108-90-7)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
ethylbenzene (100-41-4)	µg/L	<1.0 U	<1.0 U	<0.5 U, J-	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
m+p xylene (108-38-3, 106-42-3)	µg/L	<2.0 U	<2.0 U	<1.0 U, J-	<1.0 U	<2.0 U	<2.0 U	<1.0 U	<1.0 U
o-xylene (95-47-6)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
isopropylbenzene (98-82-8)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,3,5-trimethylbenzene (108-67-8)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW08	DW08	DW08	DW08	DW09	DW09	DW09	DW09
	Sample Date	10/5/11	5/16/12	11/7/12	5/1/13	10/5/11	5/16/12	11/8/12	5/1/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
ethanol (64-17-5)	µg/L	<100 U	<100 U	<100 U	<100 U	<100 U	<100 U	<100 U, J-	<100 U
isopropanol (67-63-0)	µg/L	<25 U	<25 U	<10 U	<10 U	<25 U	<25 U	<10 U, J-	<10 U
acrylonitrile (107-13-1)	µg/L	<25 U	<25 U, J-	<1.0 U	<1.0 U	<25 U	<25 U, J-	<1.0 U, J-	<1.0 U
styrene (100-42-5)	µg/L	<0.5 U	<0.5 U	NR	<0.5 U	<0.5 U	<0.5 U	NR	<0.5 U
acetone (67-64-1)	µg/L	<1.0 U	<1.0 U	1.0	0.16 J	<1.0 U	<1.0 U	<1.0 U, J-	<1.0 U
tert-butyl alcohol (75-65-0)	µg/L	<5.0 U	<5.0 U	<10 U	<10 U	<5.0 U	<5.0 U	<10 U, J-	<10 U
methyl tert-butyl ether (1634-04-4)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U, J-	<0.5 U
diisopropyl ether (108-20-3)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U, J-	<0.5 U
ethyl tert-butyl ether (637-92-3)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U, J-	<0.5 U
tert-amyl methyl ether (994-05-8)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U, J-	<0.5 U
vinyl chloride (75-01-4)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U
1,1-dichloroethene (75-35-4)	µg/L	R	R	<0.5 U	<0.5 U	R	R	<0.5 U, J-	<0.5 U
carbon disulfide (75-15-0)	µg/L	<0.5 U, J-	<0.5 U, J-	0.17 J	0.45 J	<0.5 U, J-	<0.5 U, J-	0.56 J-	<0.5 U
methylene chloride (75-09-2)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U, J-	<0.5 U
trans-1,2-dichloroethene (156-60-5)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U
1,1-dichloroethane (75-34-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U
cis-1,2-dichoroethene (156-59-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U
chloroform (67-66-3)	µg/L	<0.5 U	<0.5 U	0.41 J	0.66	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U
1,1,1-trichloroethane (71-55-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U
carbon tetrachloride (56-23-5)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U
benzene (71-43-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U
1,2-dichloroethane (107-06-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U
trichloroethene (79-01-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U
toluene (108-88-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U
1,1,2-trichloroethane (79-00-5)	µg/L	R	R	<0.5 U	<0.5 U	R	R	<0.5 U, J-	<0.5 U
tetrachloroethene (127-18-4)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U
chlorobenzene (108-90-7)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U
ethylbenzene (100-41-4)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U, J-	<0.5 U
m+p xylene (108-38-3, 106-42-3)	µg/L	<2.0 U	<2.0 U	<1.0 U	<1.0 U	<2.0 U	<2.0 U	<1.0 U, J-	<1.0 U
o-xylene (95-47-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U
isopropylbenzene (98-82-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U
1,3,5-trimethylbenzene (108-67-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW10	DW10	DW10	DW10	DW11	DW11	DW11	DW11
	Sample Date	10/5/11	5/17/12	11/8/12	5/1/13	10/6/11	5/15/12	11/7/12	4/29/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
ethanol (64-17-5)	µg/L	<100 U	<100 U	<100 U, J-	<100 U	<100 U	<100 U	<100 U	<100 U
isopropanol (67-63-0)	µg/L	<25 U	<25 U	<10 U, J-	<10 U	<25 U	<25 U	<10 U	<10 U
acrylonitrile (107-13-1)	µg/L	<25 U	<25 U, J-	<1.0 U, J-	<1.0 U	<25 U	<25 U, J-	<1.0 U	<1.0 U
styrene (100-42-5)	µg/L	<0.5 U	<0.5 U	NR	<0.5 U	<0.5 U	<0.5 U	NR	<0.5 U
acetone (67-64-1)	µg/L	<1.0 U	<1.0 U	<1.0 U, J-	<1.0 U	<1.0 U	<1.0 U, J-	<1.0 U	<1.0 U
tert-butyl alcohol (75-65-0)	µg/L	<5.0 U	<5.0 U	<10 U, J-	<10 U	11.7	20.4 J-	32	12
methyl tert-butyl ether (1634-04-4)	µg/L	<1.0 U	<1.0 U	<0.5 U, J-	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
diisopropyl ether (108-20-3)	µg/L	<1.0 U	<1.0 U	<0.5 U, J-	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
ethyl tert-butyl ether (637-92-3)	µg/L	<1.0 U	<1.0 U	<0.5 U, J-	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
tert-amyl methyl ether (994-05-8)	µg/L	<1.0 U	<1.0 U	<0.5 U, J-	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
vinyl chloride (75-01-4)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1-dichloroethene (75-35-4)	µg/L	R	R	<0.5 U, J-	<0.5 U	R	R	<0.5 U	<0.5 U
carbon disulfide (75-15-0)	µg/L	<0.5 U, J-	<0.5 U, J-	0.71 J-	<0.5 U	<0.5 U, J-	<0.5 U, J-	0.14 J	0.22 J
methylene chloride (75-09-2)	µg/L	<1.0 U	<1.0 U	<0.5 U, J-	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
trans-1,2-dichloroethene (156-60-5)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1-dichloroethane (75-34-3)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
cis-1,2-dichoroethene (156-59-2)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
chloroform (67-66-3)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	0.31 J	0.22 J
1,1,1-trichloroethane (71-55-6)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
carbon tetrachloride (56-23-5)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
benzene (71-43-2)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	0.07 J	<0.5 U
1,2-dichloroethane (107-06-2)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
trichloroethene (79-01-6)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
toluene (108-88-3)	µg/L	4.16	5.91	1.8 J-	0.50 J	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1,2-trichloroethane (79-00-5)	µg/L	R	R	<0.5 U, J-	<0.5 U	R	R	<0.5 U	<0.5 U
tetrachloroethene (127-18-4)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
chlorobenzene (108-90-7)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
ethylbenzene (100-41-4)	µg/L	<1.0 U	<1.0 U	<0.5 U, J-	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
m+p xylene (108-38-3, 106-42-3)	µg/L	<2.0 U	<2.0 U	<1.0 U, J-	<1.0 U	<2.0 U	<2.0 U	<1.0 U	<1.0 U
o-xylene (95-47-6)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
isopropylbenzene (98-82-8)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,3,5-trimethylbenzene (108-67-8)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW12	DW13	DW13	DW13	DW14	DW14	DW14	DW15
	Sample Date	10/6/11	5/15/12	11/6/12	4/30/13	5/17/12	11/8/12	5/1/13	11/8/12
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4	Round 3
ethanol (64-17-5)	µg/L	<100 U	<100 U	<100 U	<100 U	<100 U	<100 U, J-	<100 U	<100 U, J-
isopropanol (67-63-0)	µg/L	<25 U	<25 U	<10 U	<10 U	<25 U	<10 U, J-	<10 U	<10 U, J-
acrylonitrile (107-13-1)	µg/L	<25 U	<25 U, J-	<1.0 U	<1.0 U	<25 U, J-	<1.0 U, J-	<1.0 U	<1.0 U, J-
styrene (100-42-5)	µg/L	<0.5 U	<0.5 U	NR	<0.5 U	<0.5 U	NR	<0.5 U	NR
acetone (67-64-1)	µg/L	<1.0 U	<1.0 U, J-	<1.0 U	<1.0 U	<1.0 U	<1.0 U, J-	<1.0 U	<1.0 U, J-
tert-butyl alcohol (75-65-0)	µg/L	<5.0 U	<5.0 U, J-	<10 U	<10 U	<5.0 U	<10 U, J-	<10 U	9.1 J-
methyl tert-butyl ether (1634-04-4)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
diisopropyl ether (108-20-3)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
ethyl tert-butyl ether (637-92-3)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
tert-amyl methyl ether (994-05-8)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
vinyl chloride (75-01-4)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
1,1-dichloroethene (75-35-4)	µg/L	R	R	<0.5 U	<0.5 U	R	<0.5 U, J-	<0.5 U	<0.5 U, J-
carbon disulfide (75-15-0)	µg/L	<0.5 U, J-	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U, J-	0.22 J-	<0.5 U	0.16 J-
methylene chloride (75-09-2)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<0.5 U, J-	<0.5 U	0.11 J-
trans-1,2-dichloroethene (156-60-5)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
1,1-dichloroethane (75-34-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
cis-1,2-dichoroethene (156-59-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
chloroform (67-66-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	39.0	0.19 J-	0.16 J	1.3 J-
1,1,1-trichloroethane (71-55-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
carbon tetrachloride (56-23-5)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
benzene (71-43-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
1,2-dichloroethane (107-06-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
trichloroethene (79-01-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
toluene (108-88-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
1,1,2-trichloroethane (79-00-5)	µg/L	R	R	<0.5 U	<0.5 U	R	<0.5 U, J-	<0.5 U	<0.5 U, J-
tetrachloroethene (127-18-4)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
chlorobenzene (108-90-7)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
ethylbenzene (100-41-4)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
m+p xylene (108-38-3, 106-42-3)	µg/L	<2.0 U	<2.0 U	<1.0 U	<1.0 U	<2.0 U	<1.0 U, J-	<1.0 U	<1.0 U, J-
o-xylene (95-47-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
isopropylbenzene (98-82-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
1,3,5-trimethylbenzene (108-67-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample	PW01	PW01	PW01	PW01	PW02	PW03	PW03	PW03
	Sample Date	10/3/11	5/14/12	11/5/12	4/29/13	10/3/11	5/14/12	11/5/12	4/29/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
ethanol (64-17-5)	µg/L	<100 U	<100 U	<100 U	<100 U	<100 U	<100 U	<100 U	<100 U
isopropanol (67-63-0)	µg/L	<25 U	<25 U	<10 U	<10 U	<25 U	<25 U	<10 U	<10 U
acrylonitrile (107-13-1)	µg/L	<25 U	<25 U, J-	<1.0 U	<1.0 U	<25 U	<25 U, J-	<1.0 U	<1.0 U
styrene (100-42-5)	µg/L	<0.5 U	<0.5 U	NR	<0.5 U	<0.5 U	<0.5 U	NR	<0.5 U
acetone (67-64-1)	µg/L	<1.0 U	<1.0 U, J-	<1.0 U	<1.0 U	<1.0 U	<1.0 U, J-	0.65 J	<1.0 U
tert-butyl alcohol (75-65-0)	µg/L	<5.0 U	<5.0 U, J-	<10 U	6.9 J	<5.0 U	<5.0 U, J-	<10 U	<10 U
methyl tert-butyl ether (1634-04-4)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
diisopropyl ether (108-20-3)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
ethyl tert-butyl ether (637-92-3)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
tert-amyl methyl ether (994-05-8)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
vinyl chloride (75-01-4)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1-dichloroethene (75-35-4)	µg/L	R	R	<0.5 U	<0.5 U	R	R	<0.5 U	<0.5 U
carbon disulfide (75-15-0)	µg/L	<0.5 U, J-	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U, J-	<0.5 U	<0.5 U
methylene chloride (75-09-2)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
trans-1,2-dichloroethene (156-60-5)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1-dichloroethane (75-34-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
cis-1,2-dichoroethene (156-59-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
chloroform (67-66-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1,1-trichloroethane (71-55-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
carbon tetrachloride (56-23-5)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
benzene (71-43-2)	µg/L	0.38 J	0.77	<0.5 U	0.25 J	0.98	0.87	0.48 J	0.43 J
1,2-dichloroethane (107-06-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
trichloroethene (79-01-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
toluene (108-88-3)	µg/L	NR[2]	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	0.08 J	NR[2]
1,1,2-trichloroethane (79-00-5)	µg/L	R	R	<0.5 U	<0.5 U	R	R	<0.5 U	<0.5 U
tetrachloroethene (127-18-4)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
chlorobenzene (108-90-7)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
ethylbenzene (100-41-4)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<1.0 U	<0.5 U	<0.5 U
m+p xylene (108-38-3, 106-42-3)	µg/L	<2.0 U	<2.0 U	<1.0 U	<1.0 U	<2.0 U	<2.0 U	<1.0 U	<1.0 U
o-xylene (95-47-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	0.08 J	<0.5 U
isopropylbenzene (98-82-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,3,5-trimethylbenzene (108-67-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample	SW01	SW01	SW01	SW01	SW02	SW02	SW02
	Sample Date	10/4/11	5/14/12	11/7/12	4/30/13	5/14/12	11/6/12	4/30/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
ethanol (64-17-5)	µg/L	<100 U	<100 U	<100 U	<100 U	<100 U	<100 U	<100 U
isopropanol (67-63-0)	µg/L	<25 U	<25 U	<10 U	<10 U	<25 U	<10 U	<10 U
acrylonitrile (107-13-1)	µg/L	<25 U	<25 U, J-	<1.0 U	<1.0 U	<25 U, J-	<1.0 U	<1.0 U
styrene (100-42-5)	µg/L	<0.5 U	<0.5 U	NR	<0.5 U	<0.5 U	NR	<0.5 U
acetone (67-64-1)	µg/L	<1.0 U	<1.0 U, J-	<1.0 U	0.30 J	<1.0 U, J-	<1.0 U	<1.0 U
tert-butyl alcohol (75-65-0)	µg/L	<5.0 U	<5.0 U, J-	<10 U	<10 U	<5.0 U, J-	<10 U	<10 U
methyl tert-butyl ether (1634-04-4)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<0.5 U	<0.5 U
diisopropyl ether (108-20-3)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<0.5 U	<0.5 U
ethyl tert-butyl ether (637-92-3)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<0.5 U	<0.5 U
tert-amyl methyl ether (994-05-8)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<0.5 U	<0.5 U
vinyl chloride (75-01-4)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1-dichloroethene (75-35-4)	µg/L	R	R	<0.5 U	<0.5 U	R	<0.5 U	<0.5 U
carbon disulfide (75-15-0)	µg/L	<0.5 U, J-	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U
methylene chloride (75-09-2)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<0.5 U	<0.5 U
trans-1,2-dichloroethene (156-60-5)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1-dichloroethane (75-34-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
cis-1,2-dichoroethene (156-59-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
chloroform (67-66-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1,1-trichloroethane (71-55-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
carbon tetrachloride (56-23-5)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
benzene (71-43-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2-dichloroethane (107-06-2)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
trichloroethene (79-01-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
toluene (108-88-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,1,2-trichloroethane (79-00-5)	µg/L	R	R	<0.5 U	<0.5 U	R	<0.5 U	<0.5 U
tetrachloroethene (127-18-4)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
chlorobenzene (108-90-7)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
ethylbenzene (100-41-4)	µg/L	<1.0 U	<1.0 U	<0.5 U	<0.5 U	<1.0 U	<0.5 U	<0.5 U
m+p xylene (108-38-3, 106-42-3)	µg/L	<2.0 U	<2.0 U	<1.0 U	<1.0 U	<2.0 U	<1.0 U	<1.0 U
o-xylene (95-47-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
isopropylbenzene (98-82-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,3,5-trimethylbenzene (108-67-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample	SW03	SW03	SW03
	Sample Date	5/15/12	11/6/12	4/30/13
Parameter (CAS Number)	Unit	Round 2	Round 3	Round 4
ethanol (64-17-5)	µg/L	<100 U	<100 U	<100 U
isopropanol (67-63-0)	µg/L	<25 U	<10 U	<10 U
acrylonitrile (107-13-1)	µg/L	<25 U, J-	<1.0 U	<1.0 U
styrene (100-42-5)	µg/L	<0.5 U	NR	<0.5 U
acetone (67-64-1)	µg/L	<1.0 U, J-	<1.0 U	<1.0 U
tert-butyl alcohol (75-65-0)	µg/L	<5.0 U, J-	<10 U	<10 U
methyl tert-butyl ether (1634-04-4)	µg/L	<1.0 U	<0.5 U	<0.5 U
diisopropyl ether (108-20-3)	µg/L	<1.0 U	<0.5 U	<0.5 U
ethyl tert-butyl ether (637-92-3)	µg/L	<1.0 U	<0.5 U	<0.5 U
tert-amyl methyl ether (994-05-8)	µg/L	<1.0 U	<0.5 U	<0.5 U
vinyl chloride (75-01-4)	µg/L	<0.5 U	<0.5 U	<0.5 U
1,1-dichloroethene (75-35-4)	µg/L	R	<0.5 U	<0.5 U
carbon disulfide (75-15-0)	µg/L	<0.5 U, J-	<0.5 U	<0.5 U
methylene chloride (75-09-2)	µg/L	<1.0 U	<0.5 U	<0.5 U
trans-1,2-dichloroethene (156-60-5)	µg/L	<0.5 U	<0.5 U	<0.5 U
1,1-dichloroethane (75-34-3)	µg/L	<0.5 U	<0.5 U	<0.5 U
cis-1,2-dichoroethene (156-59-2)	µg/L	<0.5 U	<0.5 U	<0.5 U
chloroform (67-66-3)	µg/L	<0.5 U	<0.5 U	<0.5 U
1,1,1-trichloroethane (71-55-6)	µg/L	<0.5 U	<0.5 U	<0.5 U
carbon tetrachloride (56-23-5)	µg/L	<0.5 U	<0.5 U	<0.5 U
benzene (71-43-2)	µg/L	1.03	0.84	0.29 J
1,2-dichloroethane (107-06-2)	µg/L	<0.5 U	<0.5 U	<0.5 U
trichloroethene (79-01-6)	µg/L	<0.5 U	<0.5 U	<0.5 U
toluene (108-88-3)	µg/L	<0.5 U	0.08 J	<0.5 U
1,1,2-trichloroethane (79-00-5)	µg/L	R	<0.5 U	<0.5 U
tetrachloroethene (127-18-4)	µg/L	<0.5 U	<0.5 U	<0.5 U
chlorobenzene (108-90-7)	µg/L	<0.5 U	<0.5 U	<0.5 U
ethylbenzene (100-41-4)	µg/L	1.67	0.06 J	<0.5 U
m+p xylene (108-38-3, 106-42-3)	µg/L	2.94	0.20 J	<1.0 U
o-xylene (95-47-6)	µg/L	<0.5 U	0.10 J	<0.5 U
isopropylbenzene (98-82-8)	µg/L	<0.5 U	<0.5 U	<0.5 U
1,3,5-trimethylbenzene (108-67-8)	µg/L	<0.5 U	<0.5 U	<0.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample	MW01	MW01	MW01	MW01	MW02	MW02	MW02	MW02
	Sample Date	10/3/11	5/15/12	11/5/12	4/29/13	10/4/11	5/15/12	11/6/12	4/30/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
1,2,4-trimethylbenzene (95-63-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2,3-trimethylbenzene (526-73-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
naphthalene (91-20-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample	MW03	MW03	MW03	MW03	MW04	MW05	DW01	DW01
	Sample Date	10/4/11	5/15/12	11/7/12	5/1/13	10/5/11	10/5/11	10/3/11	5/15/12
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 1	Round 1	Round 2
1,2,4-trimethylbenzene (95-63-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2,3-trimethylbenzene (526-73-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
naphthalene (91-20-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW02	DW02	DW02	DW02	DW03	DW03	DW03	DW03
	Sample Date	10/3/11	5/14/12	11/5/12	4/29/13	10/3/11	5/15/12	11/5/12	4/30/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
1,2,4-trimethylbenzene (95-63-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2,3-trimethylbenzene (526-73-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
naphthalene (91-20-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW04	DW04	DW04	DW05	DW05	DW05	DW05
	Sample Date	10/4/11	11/6/12	4/30/13	10/4/11	5/14/12	11/5/12	4/29/13
Parameter (CAS Number)	Unit	Round 1	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
1,2,4-trimethylbenzene (95-63-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2,3-trimethylbenzene (526-73-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
naphthalene (91-20-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample Sample Date	DW06 10/6/11	DW06 5/16/12	DW06 11/8/12	DW06 5/2/13	DW07 10/6/11	DW07 5/16/12	DW07 11/6/12	DW07 5/1/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
1,2,4-trimethylbenzene (95-63-6)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2,3-trimethylbenzene (526-73-8)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
naphthalene (91-20-3)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW08	DW08	DW08	DW08	DW09	DW09	DW09	DW09
	Sample Date	10/5/11	5/16/12	11/7/12	5/1/13	10/5/11	5/16/12	11/8/12	5/1/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
1,2,4-trimethylbenzene (95-63-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U
1,2,3-trimethylbenzene (526-73-8)	µg/L	<0.5 U	<0.5 U	0.10 J	<0.5 U	<0.5 U	<0.5 U	0.08 J-	<0.5 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	0.08 J-	<0.5 U
naphthalene (91-20-3)	µg/L	<0.5 U	<0.5 U	0.73	<0.5 U	<0.5 U	<0.5 U	0.78 J-	<0.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW10	DW10	DW10	DW10	DW11	DW11	DW11	DW11
	Sample Date	10/5/11	5/17/12	11/8/12	5/1/13	10/6/11	5/15/12	11/7/12	4/29/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
1,2,4-trimethylbenzene (95-63-6)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2,3-trimethylbenzene (526-73-8)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
naphthalene (91-20-3)	µg/L	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

Parameter (CAS Number)	Sample Sample Date Unit	DW12 10/6/11 Round 1	DW13 5/15/12 Round 2	DW13 11/6/12 Round 3	DW13 4/30/13 Round 4	DW14 5/17/12 Round 2	DW14 11/8/12 Round 3	DW14 5/1/13 Round 4	DW15 11/8/12 Round 3
1,2,4-trimethylbenzene (95-63-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
1,3-dichlorobenzene (541-73-1)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
1,4-dichlorobenzene (106-46-7)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
1,2,3-trimethylbenzene (526-73-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
1,2-dichlorobenzene (95-50-1)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-
naphthalene (91-20-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U, J-	<0.5 U	<0.5 U, J-

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

Parameter (CAS Number)	Sample Sample Date Unit	PW01 10/3/11 Round 1	PW01 5/14/12 Round 2	PW01 11/5/12 Round 3	PW01 4/29/13 Round 4	PW02 10/3/11 Round 1	PW03 5/14/12 Round 2	PW03 11/5/12 Round 3	PW03 4/29/13 Round 4
1,2,4-trimethylbenzene (95-63-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2,3-trimethylbenzene (526-73-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	0.16 J	<0.5 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
naphthalene (91-20-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample	SW01	SW01	SW01	SW01	SW02	SW02	SW02
	Sample Date	10/4/11	5/14/12	11/7/12	4/30/13	5/14/12	11/6/12	4/30/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
1,2,4-trimethylbenzene (95-63-6)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2,3-trimethylbenzene (526-73-8)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U
naphthalene (91-20-3)	µg/L	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U	<0.5 U

Table B-4 Sample Results - Volatile Organic Compounds (Raton Basin, Colorado)

	Sample	SW03	SW03	SW03
	Sample Date	5/15/12	11/6/12	4/30/13
Parameter (CAS Number)	Unit	Round 2	Round 3	Round 4
1,2,4-trimethylbenzene (95-63-6)	µg/L	1.96	0.13 J	<0.5 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.5 U	<0.5 U	<0.5 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.5 U	<0.5 U	<0.5 U
1,2,3-trimethylbenzene (526-73-8)	µg/L	<0.5 U	0.13 J	<0.5 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.5 U	<0.5 U	<0.5 U
naphthalene (91-20-3)	µg/L	<0.5 U	<0.5 U	<0.5 U

Table B-5 Sample Results - Dissolved Gases, Diesel and Gasoline Range Organics, Glycols, and Low Molecular Weight Acids (Raton Basin, Colorado)

	Sample	MW01	MW01	MW01	MW01	MW02	MW02	MW02	MW02
	Sample Date	10/3/11	5/15/12	11/5/12	4/29/13	10/4/11	5/15/12	11/6/12	4/30/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved Gases									
Methane (74-82-8)	mg/L	0.0134 B	0.0191	0.0900	1.040 *	4.840	4.250	4.930	3.270
Ethane (74-84-0)	mg/L	<0.0029 U	<0.0027 U	<0.0027 U	<0.0027 U	<0.0029 U	0.0013 J	<0.0027 U	0.0009 J
Propane (74-98-6)	mg/L	<0.0040 U	<0.0038 U	<0.0037 U	<0.0037 U	<0.0040 U	<0.0038 U	<0.0037 U	<0.0037 U
Butane (106-97-8)	mg/L	<0.0051 U	<0.0047 U	<0.0047 U	<0.0047 U	<0.0051 U	<0.0047 U	<0.0047 U	<0.0047 U
Diesel and Gas Range Organics									
GRO/TPH	µg/L	< 20.0 U	< 20.0 U	<20.0 U	<20.0 U	< 20.0 U	< 20.0 U	<20.0 U	<20.0 U
DRO	µg/L	30.2	< 20.0 U	21.7	29.8	< 20.0 U	< 20.0 U	<20.0 U	<20.0 U
Glycols									
2-butoxyethanol (111-76-2)	µg/L	<5 U	<25 U	<25 U, J-	<10 U	<5 U, J-	<25 U	<25 U, J-	<10 U
Diethylene glycol (111-46-6)	µg/L	<25 U	<25 U	<10 U	<10 U	<25 U, J-	<25 U	<10 U	<10 U
Triethylene glycol (112-27-6)	µg/L	<25 U	<25 U	<10 U	<10 U	<25 U, J-	<25 U	<10 U	<10 U
Tetraethylene glycol (112-60-7)	µg/L	<25 U	<25 U	<10 U	<10 U	<25 U, J-	<25 U	<10 U	<10 U
Low Molecular Weight Acids									
Lactate (50-21-5)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	0.08 J	<0.10 U
Formate (64-18-6)	mg/L	<0.10 U	R	NR	NR	<0.10 U	R	NR	NR
Acetate (64-19-7)	mg/L	R	<0.10 U	0.05 J	<0.10 U	R	<0.10 U	0.24	NR[2]
Propionate (79-09-4)	mg/L	<0.10 U	0.14	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Isobutyrate (79-31-2)	mg/L	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U, J-	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U, J-
Butyrate (107-92-6)	mg/L	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U

Table B-5 Sample Results - Dissolved Gases, Diesel and Gasoline Range Organics, Glycols, and Low Molecular Weight Acids (Raton Basin, Colorado)

	Sample	MW03	MW03	MW03	MW03	MW04	MW05	DW01	DW01
	Sample Date	10/4/11	5/15/12	11/7/12	5/1/13	10/5/11	10/5/11	10/3/11	5/15/12
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 1	Round 1	Round 2
Dissolved Gases									
Methane (74-82-8)	mg/L	6.370	4.210	18.70	12.20	15.10	17.50	0.0157 B	0.0069
Ethane (74-84-0)	mg/L	0.0145 B	0.0071	0.0274	<0.0027 U	0.0079	0.0161	<0.0029 U	<0.0027 U
Propane (74-98-6)	mg/L	<0.0040 U	<0.0038 U	<0.0037 U	<0.0037 U	<0.0040 U	<0.0040 U	<0.0040 U	<0.0038 U
Butane (106-97-8)	mg/L	<0.0051 U	<0.0047 U	<0.0047 U	<0.0047 U	<0.0051 U	<0.0051 U	<0.0051 U	<0.0047 U
Diesel and Gas Range Organics									
GRO/TPH	µg/L	30.1 B	31.3	<20.0 U	<20.0 U	< 20.0 U	< 20.0 U	< 20.0 U	< 20.0 U
DRO	µg/L	1940 J	1310 J	874	1530	< 20.0 U	52.5	< 20.0 U	< 20.0 U
Glycols									
2-butoxyethanol (111-76-2)	µg/L	<5 U, J-	<25 U	<25 U, J-	<10 U	<5 U, J-	<5 U, J-	<5 U	<25 U
Diethylene glycol (111-46-6)	µg/L	<25 U, J-	<25 U	<10 U	<10 U	<25 U, J-	<25 U, J-	<25 U	<25 U
Triethylene glycol (112-27-6)	µg/L	<25 U, J-	<25 U	<10 U	<10 U	<25 U, J-	<25 U, J-	<25 U	<25 U
Tetraethylene glycol (112-60-7)	µg/L	<25 U, J-	<25 U	<10 U	<10 U	<25 U, J-	<25 U, J-	<25 U	<25 U
Low Molecular Weight Acids									
Lactate (50-21-5)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Formate (64-18-6)	mg/L	<0.10 U	R	NR	NR	<0.10 U	<0.10 U	0.18	R
Acetate (64-19-7)	mg/L	NR[2]	0.20	0.47	<0.10 U	R	R	R	<0.10 U
Propionate (79-09-4)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Isobutyrate (79-31-2)	mg/L	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U, J-	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Butyrate (107-92-6)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U

Table B-5 Sample Results - Dissolved Gases, Diesel and Gasoline Range Organics, Glycols, and Low Molecular Weight Acids (Raton Basin, Colorado)

	Sample	DW02	DW02	DW02	DW02	DW03	DW03	DW03	DW03
	Sample Date	10/3/11	5/14/12	11/5/12	4/29/13	10/3/11	5/15/12	11/5/12	4/30/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved Gases									
Methane (74-82-8)	mg/L	0.1010	0.0141	0.0939	<0.0013 U	0.0129 B	0.0012 J	0.0328 *	<0.0013 U
Ethane (74-84-0)	mg/L	<0.0029 U	<0.0027 U	<0.0027 U	<0.0027 U	<0.0029 U	<0.0027 U	<0.0027 U	<0.0027 U
Propane (74-98-6)	mg/L	<0.0040 U	<0.0038 U	<0.0037 U	<0.0037 U	<0.0040 U	<0.0038 U	<0.0037 U	<0.0037 U
Butane (106-97-8)	mg/L	<0.0051 U	<0.0047 U	<0.0047 U	<0.0047 U	<0.0051 U	<0.0047 U	<0.0047 U	<0.0047 U
Diesel and Gas Range Organics									
GRO/TPH	µg/L	< 20.0 U	< 20.0 U	<20.0 U	<20.0 U	< 20.0 U	< 20.0 U	<20.0 U	<20.0 U
DRO	µg/L	39.0	< 20.0 U	21.3	28.3	20.0	< 20.0 U	<20.0 U	<20.0 U
Glycols									
2-butoxyethanol (111-76-2)	µg/L	<5 U, J-	<25 U	<25 U, J-	<10 U	<5 U	<25 U	<25 U, J-	<10 U
Diethylene glycol (111-46-6)	µg/L	<25 U, J-	<25 U	<10 U	<10 U	<25 U	<25 U	<10 U	<10 U
Triethylene glycol (112-27-6)	µg/L	<25 U, J-	<25 U	<10 U	<10 U	<25 U	<25 U	<10 U	<10 U
Tetraethylene glycol (112-60-7)	µg/L	<25 U, J-	<25 U	<10 U	<10 U	<25 U	<25 U	<10 U	<10 U
Low Molecular Weight Acids									
Lactate (50-21-5)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Formate (64-18-6)	mg/L	<0.10 U	R	NR	NR	<0.10 U	R	NR	NR
Acetate (64-19-7)	mg/L	R	<0.10 U	<0.10 U	<0.10 U	R	<0.10 U	<0.10 U	<0.10 U
Propionate (79-09-4)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Isobutyrate (79-31-2)	mg/L	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U, J-	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U, J-
Butyrate (107-92-6)	mg/L	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U

Table B-5 Sample Results - Dissolved Gases, Diesel and Gasoline Range Organics, Glycols, and Low Molecular Weight Acids (Raton Basin, Colorado)

	Sample	DW04	DW04	DW04	DW05	DW05	DW05	DW05
	Sample Date	10/4/11	11/6/12	4/30/13	10/4/11	5/14/12	11/5/12	4/29/13
Parameter (CAS Number)	Unit	Round 1	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved Gases								
Methane (74-82-8)	mg/L	10.00	12.70	14.40	0.0026 B	0.0069	0.1820	0.0966 *
Ethane (74-84-0)	mg/L	0.0094 B	0.0065	0.0096	<0.0029 U	<0.0027 U	<0.0027 U	<0.0027 U
Propane (74-98-6)	mg/L	<0.0040 U	<0.0037 U	<0.0037 U	<0.0040 U	<0.0038 U	<0.0037 U	<0.0037 U
Butane (106-97-8)	mg/L	<0.0051 U	<0.0047 U	<0.0047 U	<0.0051 U	<0.0047 U	<0.0047 U	<0.0047 U
Diesel and Gas Range Organics								
GRO/TPH	µg/L	< 20.0 U	<20.0 U	<20.0 U	< 20.0 U	< 20.0 U	<20.0 U	<20.0 U
DRO	µg/L	< 20.0 U	<20.0 U	<20.0 U	< 20.0 U	< 20.0 U	<20.0 U	21.9
Glycols								
2-butoxyethanol (111-76-2)	µg/L	<5 U, J-	<25 U, J-	<10 U	<5 U, J-	<25 U	<25 U, J-	<10 U
Diethylene glycol (111-46-6)	µg/L	<25 U, J-	<10 U	<10 U	<25 U, J-	<25 U	<10 U	<10 U
Triethylene glycol (112-27-6)	µg/L	<25 U, J-	<10 U	<10 U	<25 U, J-	<25 U	<10 U	<10 U
Tetraethylene glycol (112-60-7)	µg/L	<25 U, J-	<10 U	<10 U	<25 U, J-	<25 U	<10 U	<10 U
Low Molecular Weight Acids								
Lactate (50-21-5)	mg/L	<0.10 U	<0.10 U	<0.10 U	0.09 J	<0.10 U	<0.10 U	<0.10 U
Formate (64-18-6)	mg/L	<0.10 U	NR	NR	<0.10 U	R	NR	NR
Acetate (64-19-7)	mg/L	R	0.06 J	<0.10 U	R	0.05 J	<0.10 U	<0.10 U
Propionate (79-09-4)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Isobutyrate (79-31-2)	mg/L	<0.10 U	<0.10 U, J-	<0.10 U, J-	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U, J-
Butyrate (107-92-6)	mg/L	<0.10 U	<0.10 U, J-	<0.10 U	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U

Table B-5 Sample Results - Dissolved Gases, Diesel and Gasoline Range Organics, Glycols, and Low Molecular Weight Acids (Raton Basin, Colorado)

	Sample	DW06	DW06	DW06	DW06	DW07	DW07	DW07	DW07
	Sample Date	10/6/11	5/16/12	11/8/12	5/2/13	10/6/11	5/16/12	11/6/12	5/1/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved Gases									
Methane (74-82-8)	mg/L	13.50	6.710	10.40	8.080	0.021	0.0206	0.0178	0.0241
Ethane (74-84-0)	mg/L	0.0137	0.0100	0.0090	0.0071	<0.0029 U	<0.0027 U	<0.0027 U	<0.0027 U
Propane (74-98-6)	mg/L	<0.0040 U	<0.0038 U	<0.0037 U	<0.0037 U	<0.0040 U	<0.0038 U	<0.0037 U	<0.0037 U
Butane (106-97-8)	mg/L	<0.0051 U	<0.0047 U	<0.0047 U	<0.0047 U	<0.0051 U	<0.0047 U	<0.0047 U	<0.0047 U
Diesel and Gas Range Organics									
GRO/TPH	µg/L	22.5	21.5	<20.0 U	<20.0 U	< 20.0 U	< 20.0 U	<20.0 U	<20.0 U
DRO	µg/L	81.4	89.7	147	148	23.0	< 20.0 U	21.5	<20.0 U, J-
Glycols									
2-butoxyethanol (111-76-2)	µg/L	<5 U	<25 U	<25 U, J-	<10 U	<5 U	<25 U	<25 U, J-	<10 U
Diethylene glycol (111-46-6)	µg/L	<25 U	<25 U	<10 U, J-	<10 U	<25 U	<25 U	<10 U	<10 U
Triethylene glycol (112-27-6)	µg/L	<25 U	<25 U	<10 U, J-	<10 U	<25 U	<25 U	<10 U	<10 U
Tetraethylene glycol (112-60-7)	µg/L	<25 U	<25 U	<10 U, J-	<10 U	<25 U	<25 U	<10 U	<10 U
Low Molecular Weight Acids									
Lactate (50-21-5)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Formate (64-18-6)	mg/L	<0.10 U	R	NR	NR	<0.10 U	R	NR	NR
Acetate (64-19-7)	mg/L	R	<0.10 U	<0.10 U	<0.10 U	R	<0.10 U	<0.10 U	<0.10 U
Propionate (79-09-4)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Isobutyrate (79-31-2)	mg/L	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U, J-	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U, J-
Butyrate (107-92-6)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U

Table B-5 Sample Results - Dissolved Gases, Diesel and Gasoline Range Organics, Glycols, and Low Molecular Weight Acids (Raton Basin, Colorado)

	Sample	DW08	DW08	DW08	DW08	DW09	DW09	DW09	DW09
	Sample Date	10/5/11	5/16/12	11/7/12	5/1/13	10/5/11	5/16/12	11/8/12	5/1/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved Gases									
Methane (74-82-8)	mg/L	3.580	7.160	4.110	8.400	9.530	11.30	5.920	13.30
Ethane (74-84-0)	mg/L	0.0087	0.0087	0.0058	<0.0027 U	0.0116	0.0180	0.0072	<0.0027 U
Propane (74-98-6)	mg/L	0.0094	<0.0038 U	<0.0037 U	<0.0037 U	<0.0040 U	<0.0038 U	<0.0037 U	<0.0037 U
Butane (106-97-8)	mg/L	0.0072	<0.0047 U	<0.0047 U	<0.0047 U	<0.0051 U	<0.0047 U	<0.0047 U	<0.0047 U
Diesel and Gas Range Organics									
GRO/TPH	µg/L	< 20.0 U	< 20.0 U	<20.0 U	<20.0 U	< 20.0 U	31.8	<20.0 U	<20.0 U
DRO	µg/L	21.1	< 20.0 U	46.5 B	52.3 B	79.3	40.5	53.8	50.9 B
Glycols									
2-butoxyethanol (111-76-2)	µg/L	<5 U, J-	<25 U	<25 U, J-	<10 U	<5 U, J-	<25 U	<25 U, J-	<10 U
Diethylene glycol (111-46-6)	µg/L	<25 U, J-	<25 U	<10 U	<10 U	<25 U, J-	<25 U	<10 U, J-	<10 U
Triethylene glycol (112-27-6)	µg/L	<25 U, J-	<25 U	<10 U	<10 U	<25 U, J-	<25 U	<10 U, J-	<10 U
Tetraethylene glycol (112-60-7)	µg/L	<25 U, J-	<25 U	<10 U	<10 U	<25 U, J-	<25 U	<10 U, J-	<10 U
Low Molecular Weight Acids									
Lactate (50-21-5)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Formate (64-18-6)	mg/L	0.10	R	NR	NR	0.07 J	R	NR	NR
Acetate (64-19-7)	mg/L	R	<0.10 U	<0.10 U	<0.10 U	R	<0.10 U	<0.10 U	<0.10 U
Propionate (79-09-4)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Isobutyrate (79-31-2)	mg/L	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U, J-	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U, J-
Butyrate (107-92-6)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U

Table B-5 Sample Results - Dissolved Gases, Diesel and Gasoline Range Organics, Glycols, and Low Molecular Weight Acids (Raton Basin, Colorado)

	Sample	DW10	DW10	DW10	DW10	DW11	DW11	DW11	DW11
	Sample Date	10/5/11	5/17/12	11/8/12	5/1/13	10/6/11	5/15/12	11/7/12	4/29/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved Gases									
Methane (74-82-8)	mg/L	9.580	11.50	11.70	10.70	0.573	0.5500	2.870	2.300 *
Ethane (74-84-0)	mg/L	0.0087	0.0087	0.0099	<0.0027 U	0.0027 J	0.0009 J	0.0017 J	<0.0027 U
Propane (74-98-6)	mg/L	<0.0040 U	<0.0038 U	<0.0037 U	<0.0037 U	0.0057	<0.0038 U	<0.0037 U	<0.0037 U
Butane (106-97-8)	mg/L	<0.0051 U	<0.0047 U	<0.0047 U	<0.0047 U	<0.0051 U	<0.0047 U	<0.0047 U	<0.0047 U
Diesel and Gas Range Organics									
GRO/TPH	µg/L	23.9	44.8	20.6	<20.0 U	< 20.0 U	< 20.0 U	<20.0 U	<20.0 U
DRO	µg/L	21.1	< 20.0 U	<20.0 U	<20.0 U	< 23.3 U	< 20.0 U	<20.0 U	22.5
Glycols									
2-butoxyethanol (111-76-2)	µg/L	<5 U, J-	<25 U	<25 U, J-	<10 U	<5 U	<25 U	<25 U, J-	<10 U
Diethylene glycol (111-46-6)	µg/L	<25 U, J-	<25 U	<10 U, J-	<10 U	<25 U	<25 U	<10 U	<10 U
Triethylene glycol (112-27-6)	µg/L	<25 U, J-	<25 U	<10 U, J-	<10 U	<25 U	<25 U	<10 U	<10 U
Tetraethylene glycol (112-60-7)	µg/L	<25 U, J-	<25 U	<10 U, J-	<10 U	<25 U	<25 U	<10 U	<10 U
Low Molecular Weight Acids									
Lactate (50-21-5)	mg/L	0.17	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Formate (64-18-6)	mg/L	0.06 J	R	NR	NR	<0.10 U	R	NR	NR
Acetate (64-19-7)	mg/L	R	<0.10 U	<0.10 U	<0.10 U	R	<0.10 U	<0.10 U	<0.10 U
Propionate (79-09-4)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Isobutyrate (79-31-2)	mg/L	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U, J-	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U, J-
Butyrate (107-92-6)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U

Table B-5 Sample Results - Dissolved Gases, Diesel and Gasoline Range Organics, Glycols, and Low Molecular Weight Acids (Raton Basin, Colorado)

	Sample	DW12	DW13	DW13	DW13	DW14	DW14	DW14	DW15
	Sample Date	10/6/11	5/15/12	11/6/12	4/30/13	5/17/12	11/8/12	5/1/13	11/8/12
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4	Round 3
Dissolved Gases									
Methane (74-82-8)	mg/L	0.832	0.0005 J	0.0306	0.0244	0.0010 J	0.0044	<0.0013 U	0.0817
Ethane (74-84-0)	mg/L	<0.0029 U	<0.0027 U	<0.0027 U	<0.0027 U	<0.0027 U	<0.0027 U	<0.0027 U	<0.0027 U
Propane (74-98-6)	mg/L	<0.0040 U	<0.0038 U	<0.0037 U	<0.0037 U	<0.0038 U	<0.0037 U	<0.0037 U	<0.0037 U
Butane (106-97-8)	mg/L	<0.0051 U	<0.0047 U	<0.0047 U	<0.0047 U	<0.0047 U	<0.0047 U	<0.0047 U	<0.0047 U
Diesel and Gas Range Organics									
GRO/TPH	µg/L	< 20.0 U	< 20.0 U	<20.0 U	<20.0 U	49.8 J-	<20.0 U	<20.0 U	29.60
DRO	µg/L	54.7	< 20.0 U	<20.0 U	<20.0 U	1200 J	24.1	34.6 B	<20.0 U
Glycols									
2-butoxyethanol (111-76-2)	µg/L	<5 U	<25 U	<25 U, J-	<10 U	<25 U	<25 U, J-	<10 U	<25 U, J-
Diethylene glycol (111-46-6)	µg/L	<25 U	<25 U	<10 U	<10 U	<25 U	<10 U, J-	<10 U	<10 U, J-
Triethylene glycol (112-27-6)	µg/L	<25 U	<25 U	<10 U	<10 U	<25 U	<10 U, J-	<10 U	<10 U, J-
Tetraethylene glycol (112-60-7)	µg/L	<25 U	<25 U	<10 U	<10 U	<25 U	<10 U, J-	<10 U	<10 U, J-
Low Molecular Weight Acids									
Lactate (50-21-5)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Formate (64-18-6)	mg/L	<0.10 U	R	NR	NR	R	NR	NR	NR
Acetate (64-19-7)	mg/L	R	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Propionate (79-09-4)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Isobutyrate (79-31-2)	mg/L	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U, J-	<0.10 U	<0.10 U, J-	<0.10 U, J-	<0.10 U, J-
Butyrate (107-92-6)	mg/L	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U

Table B-5 Sample Results - Dissolved Gases, Diesel and Gasoline Range Organics, Glycols, and Low Molecular Weight Acids (Raton Basin, Colorado)

	Sample	PW01	PW01	PW01	PW01	PW02	PW03	PW03	PW03
	Sample Date	10/3/11	5/14/12	11/5/12	4/29/13	10/3/11	5/14/12	11/5/12	4/29/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Dissolved Gases									
Methane (74-82-8)	mg/L	27.80	16.70	18.10	20.90 *	14.80	19.60	17.10	28.90 *
Ethane (74-84-0)	mg/L	0.0091 B	0.0062	0.0061	0.0074	0.0893	0.0135	0.0107	0.0181
Propane (74-98-6)	mg/L	<0.0040 U	<0.0038 U	<0.0037 U	<0.0037 U	<0.0040 U	<0.0038 U	<0.0037 U	<0.0037 U
Butane (106-97-8)	mg/L	<0.0051 U	<0.0047 U	<0.0047 U	<0.0047 U	<0.0051 U	<0.0047 U	<0.0047 U	<0.0047 U
Diesel and Gas Range Organics									
GRO/TPH	µg/L	< 20.0 U	< 20.0 U	<20.0 U	<20.0 U	< 20.0 U	< 20.0 U	<20.0 U	<20.0 U
DRO	µg/L	31.9	48.0	70.1	77.0000	40.1	118	79.7 J-, *	73.6
Glycols									
2-butoxyethanol (111-76-2)	µg/L	<5 U	<25 U	<25 U, J-	<10 U	<5 U	<25 U	<25 U, J-	<10 U
Diethylene glycol (111-46-6)	µg/L	<25 U	<25 U	<10 U	<10 U	<25 U	<25 U	<10 U	1.1 J
Triethylene glycol (112-27-6)	µg/L	<25 U	<25 U	<10 U	<10 U	<25 U	<25 U	<10 U	2.6 J+
Tetraethylene glycol (112-60-7)	µg/L	<25 U	<25 U	<10 U	<10 U	<25 U	<25 U	<10 U	<10 U
Low Molecular Weight Acids									
Lactate (50-21-5)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Formate (64-18-6)	mg/L	<0.10 U	R	NR	NR	<0.10 U	R	NR	NR
Acetate (64-19-7)	mg/L	NR[2]	0.09 J	0.09 J	<0.10 U	R	0.17	<0.10 U	NR[2]
Propionate (79-09-4)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Isobutyrate (79-31-2)	mg/L	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U, J-	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U, J-
Butyrate (107-92-6)	mg/L	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U

Table B-5 Sample Results - Dissolved Gases, Diesel and Gasoline Range Organics, Glycols, and Low Molecular Weight Acids (Raton Basin, Colorado)

	Sample	SW01	SW01	SW01	SW01	SW02	SW02	SW02
	Sample Date	10/4/11	5/14/12	11/7/12	4/30/13	5/14/12	11/6/12	4/30/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
Dissolved Gases								
Methane (74-82-8)	mg/L	<0.0014 U	0.0012 J	0.0049 B	<0.0013 U	0.0078	0.0212	0.0142
Ethane (74-84-0)	mg/L	<0.0029 U	<0.0027 U	<0.0027 U	<0.0027 U	<0.0027 U	<0.0027 U	<0.0027 U
Propane (74-98-6)	mg/L	0.0046 B	<0.0038 U	<0.0037 U	<0.0037 U	<0.0038 U	<0.0037 U	<0.0037 U
Butane (106-97-8)	mg/L	<0.0051 U	<0.0047 U	<0.0047 U	<0.0047 U	<0.0047 U	<0.0047 U	<0.0047 U
Diesel and Gas Range Organics								
GRO/TPH	µg/L	< 20.0 U	< 20.0 U	<20.0 U	<20.0 U	< 20.0 U	<20.0 U	<20.0 U
DRO	µg/L	41.8	34.2	39.8 B	46.9	30.3	23.6	29.4
Glycols								
2-butoxyethanol (111-76-2)	µg/L	<5 U, J-	<25 U	<25 U, J-	<10 U	<25 U	<25 U, J-	<10 U
Diethylene glycol (111-46-6)	µg/L	<25 U, J-	<25 U	<10 U	<10 U	<25 U	<10 U	<10 U
Triethylene glycol (112-27-6)	µg/L	<25 U, J-	<25 U	<10 U	<10 U	<25 U	<10 U	<10 U
Tetraethylene glycol (112-60-7)	µg/L	<25 U, J-	<25 U	<10 U	<10 U	<25 U	<10 U	<10 U
Low Molecular Weight Acids								
Lactate (50-21-5)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Formate (64-18-6)	mg/L	<0.10 U	R	NR	NR	R	NR	NR
Acetate (64-19-7)	mg/L	R	<0.10 U	<0.10 U	<0.10 U	<0.10 U	0.13	<0.10 U
Propionate (79-09-4)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U
Isobutyrate (79-31-2)	mg/L	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U, J-	<0.10 U	<0.10 U, J-	<0.10 U, J-
Butyrate (107-92-6)	mg/L	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U	<0.10 U, J-	<0.10 U

Table B-5 Sample Results - Dissolved Gases, Diesel and Gasoline Range Organics, Glycols, and Low Molecular Weight Acids (Raton Basin, Colorado)

Parameter (CAS Number)	Sample Sample Date Unit	SW03 5/15/12 Round 2	SW03 11/6/12 Round 3	SW03 4/30/13 Round 4
Dissolved Gases				
Methane (74-82-8)	mg/L	14.60	16.30	15.80
Ethane (74-84-0)	mg/L	0.0075	0.0068	0.0065
Propane (74-98-6)	mg/L	<0.0038 U	<0.0037 U	<0.0037 U
Butane (106-97-8)	mg/L	<0.0047 U	<0.0047 U	<0.0047 U
Diesel and Gas Range Organics				
GRO/TPH	µg/L	< 20.0 U	<20.0 U	<20.0 U
DRO	µg/L	26.6	28.2	28.7
Glycols				
2-butoxyethanol (111-76-2)	µg/L	<25 U	<25 U, J-	<10 U
Diethylene glycol (111-46-6)	µg/L	<25 U	<10 U	<10 U
Triethylene glycol (112-27-6)	µg/L	<25 U	<10 U	<10 U
Tetraethylene glycol (112-60-7)	µg/L	<25 U	<10 U	<10 U
Low Molecular Weight Acids				
Lactate (50-21-5)	mg/L	<0.10 U	<0.10 U	<0.10 U
Formate (64-18-6)	mg/L	R	NR	NR
Acetate (64-19-7)	mg/L	<0.10 U	0.06 J	<0.10 U
Propionate (79-09-4)	mg/L	<0.10 U	<0.10 U	<0.10 U
Isobutyrate (79-31-2)	mg/L	<0.10 U	<0.10 U, J-	<0.10 U, J-
Butyrate (107-92-6)	mg/L	<0.10 U	<0.10 U, J-	<0.10 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	MW01	MW01	MW01	MW01	MW02	MW02	MW02	MW02
	Sample Date	10/3/11	5/15/12	11/5/12	4/29/13	10/4/11	5/15/12	11/6/12	4/30/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
R-(+)-limonene (5989-27-5)	µg/L	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U
1,2,4-trichlorobenzene (120-82-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,2-dinitrobenzene (528-29-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,3-dimethyladamantane (702-79-4)	µg/L	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U, J-
1,3 -dinitrobenzene (99-65-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,4-dinitrobenzene (100-25-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1-methylnaphthalene (90-12-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2,3,4,6-tetrachlorophenol (58-90-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,3,5,6-tetrachlorophenol (935-95-5)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4,5-trichlorophenol (95-95-4)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4,6-trichlorophenol (88-06-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dichlorophenol (120-83-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dimethylphenol (105-67-9)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dinitrophenol (51-28-5)	µg/L	<5.00 U	<3.00 U	<3.00 U	<3.00 U	<5.00 U	<3.00 U	<3.00 U	<3.00 U
2,4-dinitrotoluene (121-14-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2,6-dinitrotoluene (606-20-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-butoxyethanol (111-76-2)	µg/L	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U
2-chloronaphthalene (91-58-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-chlorophenol (95-57-8)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2-methylnaphthalene (91-57-6)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-methylphenol (95-48-7)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	NR[2]
2-nitroaniline (88-74-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-nitrophenol (88-75-5)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
3&4-methylphenol (108-39-4 & 106-44-5)	µg/L	<0.50 U	<5.00 U	<5.00 U	<5.00 U	<0.50 U	<5.00 U	<5.00 U	<5.00 U
3,3'-dichlorobenzidine (91-94-1)	µg/L	NR	<1.00 U	<1.00 U, J-	<1.00 U	NR	<1.00 U	<1.00 U, J-	<1.00 U
3-nitroaniline (99-09-2)	µg/L	<0.50 U	<3.00 U	<3.00 U	<3.00 U	<0.50 U	<3.00 U	<3.00 U	<3.00 U
4,6-dinitro-2-methylphenol (534-52-1)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
4-bromophenyl phenyl ether (101-55-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
4-chloro-3-methylphenol (59-50-7)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	MW03	MW03	MW03	MW03	MW04	MW05	DW01	DW01
	Sample Date	10/4/11	5/15/12	11/7/12	5/1/13	10/5/11	10/5/11	10/3/11	5/15/12
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 1	Round 1	Round 2
R-(+)-limonene (5989-27-5)	µg/L	<0.50 U, J-	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U, J-	<0.50 U, J-	<0.50 U	<1.00 U, J-
1,2,4-trichlorobenzene (120-82-1)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
1,2-dinitrobenzene (528-29-0)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
1,3-dimethyladamantane (702-79-4)	µg/L	<0.50 U, J-	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U, J-	<0.50 U, J-	<0.50 U	<1.00 U, J-
1,3 -dinitrobenzene (99-65-0)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
1,4-dinitrobenzene (100-25-4)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
1-methylnaphthalene (90-12-0)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
2,3,4,6-tetrachlorophenol (58-90-2)	µg/L	<0.50 U	<2.00 H, U	<2.00 U	<2.00 U	<0.50 U	<0.50 U	<0.50 U	<2.00 U
2,3,5,6-tetrachlorophenol (935-95-5)	µg/L	<0.50 U	<2.00 H, U	<2.00 U	<2.00 U	<0.50 U	<0.50 U	<0.50 U	<2.00 U
2,4,5-trichlorophenol (95-95-4)	µg/L	<0.50 U	<2.00 H, U	<2.00 U	<2.00 U	<0.50 U	<0.50 U	<0.50 U	<2.00 U
2,4,6-trichlorophenol (88-06-2)	µg/L	<0.50 U	<2.00 H, U	<2.00 U	<2.00 U	<0.50 U	<0.50 U	<0.50 U	<2.00 U
2,4-dichlorophenol (120-83-2)	µg/L	<0.50 U	<2.00 H, U	<2.00 U	<2.00 U	<0.50 U	<0.50 U	<0.50 U	<2.00 U
2,4-dimethylphenol (105-67-9)	µg/L	<0.50 U	<2.00 H, U	<2.00 U	<2.00 U	<0.50 U	<0.50 U	<0.50 U	<2.00 U
2,4-dinitrophenol (51-28-5)	µg/L	<5.00 U	<3.00 H, U	<3.00 U	<3.00 U	<5.00 U	<5.00 U	<5.00 U	<3.00 U
2,4-dinitrotoluene (121-14-2)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
2,6-dinitrotoluene (606-20-2)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
2-butoxyethanol (111-76-2)	µg/L	1.45	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U, J-
2-chloronaphthalene (91-58-7)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
2-chlorophenol (95-57-8)	µg/L	<0.50 U	<2.00 H, U	<2.00 U	<2.00 U	<0.50 U	<0.50 U	<0.50 U	<2.00 U
2-methylnaphthalene (91-57-6)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
2-methylphenol (95-48-7)	µg/L	NR^2	<2.00 H, U	<2.00 U	<2.00 U	<0.50 U	<0.50 U	<0.50 U	<2.00 U
2-nitroaniline (88-74-4)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
2-nitrophenol (88-75-5)	µg/L	<0.50 U	<2.00 H, U	<2.00 U	<2.00 U	<0.50 U	<0.50 U	<0.50 U	<2.00 U
3&4-methylphenol (108-39-4 & 106-44-5)	µg/L	<0.50 U	<5.00 H, U	<5.00 U	<5.00 U	<0.50 U	<0.50 U	<0.50 U	<5.00 U
3,3'-dichlorobenzidine (91-94-1)	µg/L	NR	<1.00 H, U	<1.00 U, J-	<1.00 U	NR	NR	NR	<1.00 U
3-nitroaniline (99-09-2)	µg/L	<0.50 U	<3.00 H, U	<3.00 U	<3.00 U	<0.50 U	<0.50 U	<0.50 U	<3.00 U
4,6-dinitro-2-methylphenol (534-52-1)	µg/L	<0.50 U	<2.00 H, U	<2.00 U	<2.00 U	<0.50 U	<0.50 U	<0.50 U	<2.00 U
4-bromophenyl phenyl ether (101-55-3)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
4-chloro-3-methylphenol (59-50-7)	µg/L	<0.50 U	<2.00 H, U	<2.00 U	<2.00 U	<0.50 U	<0.50 U	<0.50 U	<2.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW02	DW02	DW02	DW02	DW03	DW03	DW03	DW03
	Sample Date	10/3/11	5/14/12	11/5/12	4/29/13	10/3/11	5/15/12	11/5/12	4/30/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
R-(+)-limonene (5989-27-5)	µg/L	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U
1,2,4-trichlorobenzene (120-82-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,2-dinitrobenzene (528-29-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,3-dimethyladamantane (702-79-4)	µg/L	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U, J-
1,3 -dinitrobenzene (99-65-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,4-dinitrobenzene (100-25-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1-methylnaphthalene (90-12-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2,3,4,6-tetrachlorophenol (58-90-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,3,5,6-tetrachlorophenol (935-95-5)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4,5-trichlorophenol (95-95-4)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4,6-trichlorophenol (88-06-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dichlorophenol (120-83-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dimethylphenol (105-67-9)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dinitrophenol (51-28-5)	µg/L	<5.00 U	<3.00 U	<3.00 U	<3.00 U	<5.00 U	<3.00 U	<3.00 U	<3.00 U
2,4-dinitrotoluene (121-14-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2,6-dinitrotoluene (606-20-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-butoxyethanol (111-76-2)	µg/L	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U
2-chloronaphthalene (91-58-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-chlorophenol (95-57-8)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2-methylnaphthalene (91-57-6)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-methylphenol (95-48-7)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2-nitroaniline (88-74-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-nitrophenol (88-75-5)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
3&4-methylphenol (108-39-4 & 106-44-5)	µg/L	<0.50 U	<5.00 U	<5.00 U	<5.00 U	<0.50 U	<5.00 U	<5.00 U	<5.00 U
3,3'-dichlorobenzidine (91-94-1)	µg/L	NR	<1.00 U	<1.00 U, J-	<1.00 U	NR	<1.00 U	<1.00 U, J-	<1.00 U
3-nitroaniline (99-09-2)	µg/L	<0.50 U	<3.00 U	<3.00 U	<3.00 U	<0.50 U	<3.00 U	<3.00 U	<3.00 U
4,6-dinitro-2-methylphenol (534-52-1)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
4-bromophenyl phenyl ether (101-55-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
4-chloro-3-methylphenol (59-50-7)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW04	DW04	DW04	DW05	DW05	DW05	DW05
	Sample Date	10/4/11	11/6/12	4/30/13	10/4/11	5/14/12	11/5/12	4/29/13
Parameter (CAS Number)	Unit	Round 1	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
R-(+)-limonene (5989-27-5)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U
1,2,4-trichlorobenzene (120-82-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,2-dinitrobenzene (528-29-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,3-dimethyladamantane (702-79-4)	µg/L	<0.50 U	<1.00 U	<1.00 U, J-	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U
1,3 -dinitrobenzene (99-65-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,4-dinitrobenzene (100-25-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1-methylnaphthalene (90-12-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2,3,4,6-tetrachlorophenol (58-90-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,3,5,6-tetrachlorophenol (935-95-5)	µg/L	<0.50 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4,5-trichlorophenol (95-95-4)	µg/L	<0.50 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4,6-trichlorophenol (88-06-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dichlorophenol (120-83-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dimethylphenol (105-67-9)	µg/L	<0.50 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dinitrophenol (51-28-5)	µg/L	<5.00 U	<3.00 U	<3.00 U	<5.00 U	<3.00 U	<3.00 U	<3.00 U
2,4-dinitrotoluene (121-14-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2,6-dinitrotoluene (606-20-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-butoxyethanol (111-76-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	0.65	<1.00 U, J-	<1.00 U	<1.00 U
2-chloronaphthalene (91-58-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-chlorophenol (95-57-8)	µg/L	<0.50 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2-methylnaphthalene (91-57-6)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-methylphenol (95-48-7)	µg/L	<0.50 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2-nitroaniline (88-74-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-nitrophenol (88-75-5)	µg/L	<0.50 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
3&4-methylphenol (108-39-4 & 106-44-5)	µg/L	<0.50 U	<5.00 U	<5.00 U	<0.50 U	<5.00 U	<5.00 U	<5.00 U
3,3'-dichlorobenzidine (91-94-1)	µg/L	NR	<1.00 U, J-	<1.00 U	NR	<1.00 U	<1.00 U, J-	<1.00 U
3-nitroaniline (99-09-2)	µg/L	<0.50 U	<3.00 U	<3.00 U	<0.50 U	<3.00 U	<3.00 U	<3.00 U
4,6-dinitro-2-methylphenol (534-52-1)	µg/L	<0.50 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
4-bromophenyl phenyl ether (101-55-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
4-chloro-3-methylphenol (59-50-7)	µg/L	<0.50 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW06	DW06	DW06	DW06	DW07	DW07	DW07	DW07
	Sample Date	10/6/11	5/16/12	11/8/12	5/2/13	10/6/11	5/16/12	11/6/12	5/1/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
R-(+)-limonene (5989-27-5)	µg/L	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U
1,2,4-trichlorobenzene (120-82-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,2-dinitrobenzene (528-29-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,3-dimethyladamantane (702-79-4)	µg/L	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U
1,3 -dinitrobenzene (99-65-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,4-dinitrobenzene (100-25-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1-methylnaphthalene (90-12-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2,3,4,6-tetrachlorophenol (58-90-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,3,5,6-tetrachlorophenol (935-95-5)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4,5-trichlorophenol (95-95-4)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4,6-trichlorophenol (88-06-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dichlorophenol (120-83-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dimethylphenol (105-67-9)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dinitrophenol (51-28-5)	µg/L	<5.00 U	<3.00 U	<3.00 U	<3.00 U	<5.00 U	<3.00 U	<3.00 U	<3.00 U
2,4-dinitrotoluene (121-14-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2,6-dinitrotoluene (606-20-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-butoxyethanol (111-76-2)	µg/L	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U
2-chloronaphthalene (91-58-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-chlorophenol (95-57-8)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2-methylnaphthalene (91-57-6)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-methylphenol (95-48-7)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2-nitroaniline (88-74-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-nitrophenol (88-75-5)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
3&4-methylphenol (108-39-4 & 106-44-5)	µg/L	<0.50 U	<5.00 U	<5.00 U	<5.00 U	<0.50 U	<5.00 U	<5.00 U	<5.00 U
3,3'-dichlorobenzidine (91-94-1)	µg/L	NR	<1.00 U	<1.00 U, J-	<1.00 U	NR	<1.00 U	<1.00 U, J-	<1.00 U
3-nitroaniline (99-09-2)	µg/L	<0.50 U	<3.00 U	<3.00 U	<3.00 U	<0.50 U	<3.00 U	<3.00 U	<3.00 U
4,6-dinitro-2-methylphenol (534-52-1)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
4-bromophenyl phenyl ether (101-55-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
4-chloro-3-methylphenol (59-50-7)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW08	DW08	DW08	DW08	DW09	DW09	DW09	DW09
	Sample Date	10/5/11	5/16/12	11/7/12	5/1/13	10/5/11	5/16/12	11/8/12	5/1/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
R-(+)-limonene (5989-27-5)	µg/L	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U
1,2,4-trichlorobenzene (120-82-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,2-dinitrobenzene (528-29-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,3-dimethyladamantane (702-79-4)	µg/L	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U
1,3 -dinitrobenzene (99-65-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,4-dinitrobenzene (100-25-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1-methylnaphthalene (90-12-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2,3,4,6-tetrachlorophenol (58-90-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,3,5,6-tetrachlorophenol (935-95-5)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4,5-trichlorophenol (95-95-4)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4,6-trichlorophenol (88-06-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dichlorophenol (120-83-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dimethylphenol (105-67-9)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dinitrophenol (51-28-5)	µg/L	<5.00 U	<3.00 U	<3.00 U	<3.00 U	<5.00 U	<3.00 U	<3.00 U	<3.00 U
2,4-dinitrotoluene (121-14-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2,6-dinitrotoluene (606-20-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-butoxyethanol (111-76-2)	µg/L	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U
2-chloronaphthalene (91-58-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-chlorophenol (95-57-8)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2-methylnaphthalene (91-57-6)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-methylphenol (95-48-7)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2-nitroaniline (88-74-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-nitrophenol (88-75-5)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
3&4-methylphenol (108-39-4 & 106-44-5)	µg/L	<0.50 U	<5.00 U	<5.00 U	<5.00 U	<0.50 U	<5.00 U	<5.00 U	<5.00 U
3,3'-dichlorobenzidine (91-94-1)	µg/L	NR	<1.00 U	<1.00 U, J-	<1.00 U	NR	<1.00 U	<1.00 U, J-	<1.00 U
3-nitroaniline (99-09-2)	µg/L	<0.50 U	<3.00 U	<3.00 U	<3.00 U	<0.50 U	<3.00 U	<3.00 U	<3.00 U
4,6-dinitro-2-methylphenol (534-52-1)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
4-bromophenyl phenyl ether (101-55-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
4-chloro-3-methylphenol (59-50-7)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW10	DW10	DW10	DW10	DW11	DW11	DW11	DW11
	Sample Date	10/5/11	5/17/12	11/8/12	5/1/13	10/6/11	5/15/12	11/7/12	4/29/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
R-(+)-limonene (5989-27-5)	µg/L	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U
1,2,4-trichlorobenzene (120-82-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,2-dinitrobenzene (528-29-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,3-dimethyladamantane (702-79-4)	µg/L	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U
1,3 -dinitrobenzene (99-65-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,4-dinitrobenzene (100-25-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1-methylnaphthalene (90-12-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2,3,4,6-tetrachlorophenol (58-90-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,3,5,6-tetrachlorophenol (935-95-5)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4,5-trichlorophenol (95-95-4)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4,6-trichlorophenol (88-06-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dichlorophenol (120-83-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dimethylphenol (105-67-9)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dinitrophenol (51-28-5)	µg/L	<5.00 U	<3.00 U	<3.00 U	<3.00 U	<5.00 U	<3.00 U	<3.00 U	<3.00 U
2,4-dinitrotoluene (121-14-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2,6-dinitrotoluene (606-20-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-butoxyethanol (111-76-2)	µg/L	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U
2-chloronaphthalene (91-58-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-chlorophenol (95-57-8)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2-methylnaphthalene (91-57-6)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-methylphenol (95-48-7)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2-nitroaniline (88-74-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-nitrophenol (88-75-5)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
3&4-methylphenol (108-39-4 & 106-44-5)	µg/L	<0.50 U	<5.00 U	<5.00 U	<5.00 U	<0.50 U	<5.00 U	<5.00 U	<5.00 U
3,3'-dichlorobenzidine (91-94-1)	µg/L	NR	<1.00 U	<1.00 U, J-	<1.00 U	NR	<1.00 U	<1.00 U, J-	<1.00 U
3-nitroaniline (99-09-2)	µg/L	<0.50 U	<3.00 U	<3.00 U	<3.00 U	<0.50 U	<3.00 U	<3.00 U	<3.00 U
4,6-dinitro-2-methylphenol (534-52-1)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
4-bromophenyl phenyl ether (101-55-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
4-chloro-3-methylphenol (59-50-7)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW12	DW13	DW13	DW13	DW14	DW14	DW14	DW15
	Sample Date	10/6/11	5/15/12	11/6/12	4/30/13	5/17/12	11/8/12	5/1/13	11/8/12
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4	Round 3
R-(+)-limonene (5989-27-5)	µg/L	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U	<1.00 U, J-	<1.00 U	<1.00 U	<1.00 U
1,2,4-trichlorobenzene (120-82-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
1,2-dinitrobenzene (528-29-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
1,3-dimethyladamantane (702-79-4)	µg/L	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U, J-	<1.00 U, J-	<1.00 U	<1.00 U	<1.00 U
1,3 -dinitrobenzene (99-65-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
1,4-dinitrobenzene (100-25-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
1-methylnaphthalene (90-12-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
2,3,4,6-tetrachlorophenol (58-90-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
2,3,5,6-tetrachlorophenol (935-95-5)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
2,4,5-trichlorophenol (95-95-4)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
2,4,6-trichlorophenol (88-06-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
2,4-dichlorophenol (120-83-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
2,4-dimethylphenol (105-67-9)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
2,4-dinitrophenol (51-28-5)	µg/L	<5.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U
2,4-dinitrotoluene (121-14-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
2,6-dinitrotoluene (606-20-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
2-butoxyethanol (111-76-2)	µg/L	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U	<1.00 U, J-	<1.00 U	<1.00 U	<1.00 U
2-chloronaphthalene (91-58-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
2-chlorophenol (95-57-8)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
2-methylnaphthalene (91-57-6)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
2-methylphenol (95-48-7)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
2-nitroaniline (88-74-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
2-nitrophenol (88-75-5)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
3&4-methylphenol (108-39-4 & 106-44-5)	µg/L	<0.50 U	<5.00 U	<5.00 U	<5.00 U	<5.00 U	<5.00 U	<5.00 U	<5.00 U
3,3'-dichlorobenzidine (91-94-1)	µg/L	NR	<1.00 U	<1.00 U, J-	<1.00 U	<1.00 U	<1.00 U, J-	<1.00 U	<1.00 U, J-
3-nitroaniline (99-09-2)	µg/L	<0.50 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U
4,6-dinitro-2-methylphenol (534-52-1)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
4-bromophenyl phenyl ether (101-55-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
4-chloro-3-methylphenol (59-50-7)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	PW01	PW01	PW01	PW01	PW02	PW03	PW03	PW03
	Sample Date	10/3/11	5/14/12	11/5/12	4/29/13	10/3/11	5/14/12	11/5/12	4/29/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
R-(+)-limonene (5989-27-5)	µg/L	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U
1,2,4-trichlorobenzene (120-82-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,2-dinitrobenzene (528-29-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,3-dimethyladamantane (702-79-4)	µg/L	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U
1,3 -dinitrobenzene (99-65-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1,4-dinitrobenzene (100-25-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
1-methylnaphthalene (90-12-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2,3,4,6-tetrachlorophenol (58-90-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,3,5,6-tetrachlorophenol (935-95-5)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4,5-trichlorophenol (95-95-4)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4,6-trichlorophenol (88-06-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dichlorophenol (120-83-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dimethylphenol (105-67-9)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2,4-dinitrophenol (51-28-5)	µg/L	<5.00 U	<3.00 U	<3.00 U	<3.00 U	<5.00 U	<3.00 U	<3.00 U	<3.00 U
2,4-dinitrotoluene (121-14-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2,6-dinitrotoluene (606-20-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-butoxyethanol (111-76-2)	µg/L	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U
2-chloronaphthalene (91-58-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-chlorophenol (95-57-8)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
2-methylnaphthalene (91-57-6)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-methylphenol (95-48-7)	µg/L	NR[2]	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	NR[2]
2-nitroaniline (88-74-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
2-nitrophenol (88-75-5)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
3&4-methylphenol (108-39-4 & 106-44-5)	µg/L	<0.50 U	<5.00 U	<5.00 U	<5.00 U	<0.50 U	<5.00 U	<5.00 U	<5.00 U
3,3'-dichlorobenzidine (91-94-1)	µg/L	NR	<1.00 U	<1.00 U, J-	<1.00 U	NR	<1.00 U	<1.00 U, J-	<1.00 U
3-nitroaniline (99-09-2)	µg/L	<0.50 U	<3.00 U	<3.00 U	<3.00 U	<0.50 U	<3.00 U	<3.00 U	<3.00 U
4,6-dinitro-2-methylphenol (534-52-1)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
4-bromophenyl phenyl ether (101-55-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
4-chloro-3-methylphenol (59-50-7)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	SW01	SW01	SW01	SW01	SW02	SW02	SW02
	Sample Date	10/4/11	5/14/12	11/7/12	4/30/13	5/14/12	11/6/12	4/30/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
R-(+)-limonene (5989-27-5)	µg/L	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U	<1.00 U, J-	<1.00 U	<1.00 U
1,2,4-trichlorobenzene (120-82-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
1,2-dichlorobenzene (95-50-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
1,2-dinitrobenzene (528-29-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
1,3-dichlorobenzene (541-73-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
1,3-dimethyladamantane (702-79-4)	µg/L	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U, J-	<1.00 U, J-	<1.00 U	<1.00 U, J-
1,3 -dinitrobenzene (99-65-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
1,4-dichlorobenzene (106-46-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
1,4-dinitrobenzene (100-25-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
1-methylnaphthalene (90-12-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
2,3,4,6-tetrachlorophenol (58-90-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
2,3,5,6-tetrachlorophenol (935-95-5)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
2,4,5-trichlorophenol (95-95-4)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
2,4,6-trichlorophenol (88-06-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
2,4-dichlorophenol (120-83-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
2,4-dimethylphenol (105-67-9)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
2,4-dinitrophenol (51-28-5)	µg/L	<5.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U
2,4-dinitrotoluene (121-14-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
2,6-dinitrotoluene (606-20-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
2-butoxyethanol (111-76-2)	µg/L	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U	<1.00 U, J-	<1.00 U	<1.00 U
2-chloronaphthalene (91-58-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
2-chlorophenol (95-57-8)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
2-methylnaphthalene (91-57-6)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
2-methylphenol (95-48-7)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
2-nitroaniline (88-74-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
2-nitrophenol (88-75-5)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
3&4-methylphenol (108-39-4 & 106-44-5)	µg/L	<0.50 U	<5.00 U	<5.00 U	<5.00 U	<5.00 U	<5.00 U	<5.00 U
3,3'-dichlorobenzidine (91-94-1)	µg/L	NR	<1.00 U	<1.00 U, J-	<1.00 U	<1.00 U	<1.00 U, J-	<1.00 U
3-nitroaniline (99-09-2)	µg/L	<0.50 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U
4,6-dinitro-2-methylphenol (534-52-1)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
4-bromophenyl phenyl ether (101-55-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
4-chloro-3-methylphenol (59-50-7)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

Parameter (CAS Number)	Sample Sample Date Unit	SW03 5/15/12 Round 2	SW03 11/6/12 Round 3	SW03 4/30/13 Round 4
R-(+)-limonene (5989-27-5)	µg/L	<1.00 U, J-	<1.00 U	<1.00 U
1,2,4-trichlorobenzene (120-82-1)	µg/L	<1.00 U	<1.00 U	<1.00 U
1,2-dichlorobenzene (95-50-1)	µg/L	<1.00 U	<1.00 U	<1.00 U
1,2-dinitrobenzene (528-29-0)	µg/L	<1.00 U	<1.00 U	<1.00 U
1,3-dichlorobenzene (541-73-1)	µg/L	<1.00 U	<1.00 U	<1.00 U
1,3-dimethyladamantane (702-79-4)	µg/L	<1.00 U, J-	<1.00 U	<1.00 U, J-
1,3 -dinitrobenzene (99-65-0)	µg/L	<1.00 U	<1.00 U	<1.00 U
1,4-dichlorobenzene (106-46-7)	µg/L	<1.00 U	<1.00 U	<1.00 U
1,4-dinitrobenzene (100-25-4)	µg/L	<1.00 U	<1.00 U	<1.00 U
1-methylnaphthalene (90-12-0)	µg/L	<1.00 U	<1.00 U	<1.00 U
2,3,4,6-tetrachlorophenol (58-90-2)	µg/L	<2.00 U	<2.00 U	<2.00 U
2,3,5,6-tetrachlorophenol (935-95-5)	µg/L	<2.00 U	<2.00 U	<2.00 U
2,4,5-trichlorophenol (95-95-4)	µg/L	<2.00 U	<2.00 U	<2.00 U
2,4,6-trichlorophenol (88-06-2)	µg/L	<2.00 U	<2.00 U	<2.00 U
2,4-dichlorophenol (120-83-2)	µg/L	<2.00 U	<2.00 U	<2.00 U
2,4-dimethylphenol (105-67-9)	µg/L	<2.00 U	<2.00 U	<2.00 U
2,4-dinitrophenol (51-28-5)	µg/L	<3.00 U	<3.00 U	<3.00 U
2,4-dinitrotoluene (121-14-2)	µg/L	<1.00 U	<1.00 U	<1.00 U
2,6-dinitrotoluene (606-20-2)	µg/L	<1.00 U	<1.00 U	<1.00 U
2-butoxyethanol (111-76-2)	µg/L	<1.00 U, J-	<1.00 U	<1.00 U
2-chloronaphthalene (91-58-7)	µg/L	<1.00 U	<1.00 U	<1.00 U
2-chlorophenol (95-57-8)	µg/L	<2.00 U	<2.00 U	<2.00 U
2-methylnaphthalene (91-57-6)	µg/L	<1.00 U	<1.00 U	<1.00 U
2-methylphenol (95-48-7)	µg/L	<2.00 U	<2.00 U	<2.00 U
2-nitroaniline (88-74-4)	µg/L	<1.00 U	<1.00 U	<1.00 U
2-nitrophenol (88-75-5)	µg/L	<2.00 U	<2.00 U	<2.00 U
3&4-methylphenol (108-39-4 & 106-44-5)	µg/L	<5.00 U	<5.00 U	<5.00 U
3,3'-dichlorobenzidine (91-94-1)	µg/L	<1.00 U	<1.00 U, J-	<1.00 U
3-nitroaniline (99-09-2)	µg/L	<3.00 U	<3.00 U	<3.00 U
4,6-dinitro-2-methylphenol (534-52-1)	µg/L	<2.00 U	<2.00 U	<2.00 U
4-bromophenyl phenyl ether (101-55-3)	µg/L	<1.00 U	<1.00 U	<1.00 U
4-chloro-3-methylphenol (59-50-7)	µg/L	<2.00 U	<2.00 U	<2.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	MW01	MW01	MW01	MW01	MW02	MW02	MW02	MW02
	Sample Date	10/3/11	5/15/12	11/5/12	4/29/13	10/4/11	5/15/12	11/6/12	4/30/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
4-chloroaniline (106-47-8)	µg/L	<1.00 U	<3.00 U	<3.00 U	<3.00 U	<1.00 U	<3.00 U	<3.00 U	<3.00 U
4-chlorophenyl phenyl ether (7005-72-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
4-nitroaniline (100-01-6)	µg/L	<0.50 U	<3.00 U	<3.00 U	<3.00 U	<0.50 U	<3.00 U	<3.00 U	<3.00 U
4-nitrophenol (100-02-7)	µg/L	<2.50 U	<3.00 U	<3.00 U	<3.00 U	<2.50 U	<3.00 U	<3.00 U	<3.00 U
Acenaphthene (83-32-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Acenaphthylene (208-96-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Adamantane (281-23-2)	µg/L	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U
Aniline (62-53-3)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Anthracene (120-12-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Azobenzene (103-33-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(a)anthracene (56-55-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(a)pyrene (50-32-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(b)fluoranthene (205-99-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(g,h,i)perylene (191-24-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(k)fluoranthene (207-08-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzoic Acid (65-85-0)	µg/L	<5.00 U	<3.00 U	<3.00 U	<3.00 U	<5.00 U	<3.00 U	<3.00 U	<3.00 U
Benzyl alcohol (100-51-6)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethoxy)methane (111-91-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethyl)ether (111-44-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroisopropyl)ether (108-60-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) adipate (103-23-1)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) phthalate (117-81-7)	µg/L	<1.00 U	<2.00 U	<2.00 U	5.28 J-	<1.00 U	<2.00 U	<2.00 U	<2.00 U
Butyl benzyl phthalate (85-68-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Carbazole (86-74-8)	µg/L	<0.50 U	<3.00 U	<3.00 U	<3.00 U	<0.50 U	<3.00 U	<3.00 U	<3.00 U
Chrysene (218-01-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dibenz(a,h)anthracene (53-70-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dibenzofuran (132-64-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Diethyl phthalate (84-66-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dimethyl phthalate (131-11-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Di-n-butyl phthalate (84-74-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Di-n-octyl phthalate (117-84-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Diphenylamine (122-39-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	MW03	MW03	MW03	MW03	MW04	MW05	DW01	DW01
	Sample Date	10/4/11	5/15/12	11/7/12	5/1/13	10/5/11	10/5/11	10/3/11	5/15/12
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 1	Round 1	Round 2
4-chloroaniline (106-47-8)	µg/L	<1.00 U	<3.00 H, U	<3.00 U	<3.00 U	<1.00 U	<1.00 U	<1.00 U	<3.00 U
4-chlorophenyl phenyl ether (7005-72-3)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
4-nitroaniline (100-01-6)	µg/L	<0.50 U	<3.00 H, U	<3.00 U	<3.00 U	<0.50 U	<0.50 U	<0.50 U	<3.00 U
4-nitrophenol (100-02-7)	µg/L	<2.50 U	<3.00 H, U	<3.00 U	<3.00 U	<2.50 U	<2.50 U	<2.50 U	<3.00 U
Acenaphthene (83-32-9)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Acenaphthylene (208-96-8)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Adamantane (281-23-2)	µg/L	<0.50 U, J-	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U, J-	<0.50 U, J-	<0.50 U	<1.00 U, J-
Aniline (62-53-3)	µg/L	<1.00 U	<1.00 H, U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Anthracene (120-12-7)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Azobenzene (103-33-3)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Benzo(a)anthracene (56-55-3)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Benzo(a)pyrene (50-32-8)	µg/L	<0.50 U, J-	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U, J-	<0.50 U, J-	<0.50 U	<1.00 U
Benzo(b)fluoranthene (205-99-2)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Benzo(g,h,i)perylene (191-24-2)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Benzo(k)fluoranthene (207-08-9)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Benzoic Acid (65-85-0)	µg/L	<5.00 U	<3.00 H, U	<3.00 U	<3.00 U	<5.00 U	<5.00 U	<5.00 U	<3.00 U
Benzyl alcohol (100-51-6)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Bis-(2-chloroethoxy)methane (111-91-1)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Bis-(2-chloroethyl)ether (111-44-4)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Bis-(2-chloroisopropyl)ether (108-60-1)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Bis-(2-ethylhexyl) adipate (103-23-1)	µg/L	<1.00 U	<1.00 H, U	<1.00 U	<1.00 U	3.07 B	2.56 B	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) phthalate (117-81-7)	µg/L	143	135 J, H	139	291 J	<1.00 U	1.03	<1.00 U	4.27
Butyl benzyl phthalate (85-68-7)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Carbazole (86-74-8)	µg/L	<0.50 U, J-	<3.00 H, U	<3.00 U	<3.00 U	<0.50 U, J-	<0.50 U, J-	<0.50 U	<3.00 U
Chrysene (218-01-9)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Dibenz(a,h)anthracene (53-70-3)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Dibenzofuran (132-64-9)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Diethyl phthalate (84-66-2)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Dimethyl phthalate (131-11-3)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Di-n-butyl phthalate (84-74-2)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	5.68	<0.50 U	<1.00 U
Di-n-octyl phthalate (117-84-0)	µg/L	7.64	<1.00 H, U	<1.00 U	7.35	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Diphenylamine (122-39-4)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW02	DW02	DW02	DW02	DW03	DW03	DW03	DW03
	Sample Date	10/3/11	5/14/12	11/5/12	4/29/13	10/3/11	5/15/12	11/5/12	4/30/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
4-chloroaniline (106-47-8)	µg/L	<1.00 U	<3.00 U	<3.00 U	<3.00 U	<1.00 U	<3.00 U	<3.00 U	<3.00 U
4-chlorophenyl phenyl ether (7005-72-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
4-nitroaniline (100-01-6)	µg/L	<0.50 U	<3.00 U	<3.00 U	<3.00 U	<0.50 U	<3.00 U	<3.00 U	<3.00 U
4-nitrophenol (100-02-7)	µg/L	<2.50 U	<3.00 U	<3.00 U	<3.00 U	<2.50 U	<3.00 U	<3.00 U	<3.00 U
Acenaphthene (83-32-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Acenaphthylene (208-96-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Adamantane (281-23-2)	µg/L	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U
Aniline (62-53-3)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Anthracene (120-12-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Azobenzene (103-33-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(a)anthracene (56-55-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(a)pyrene (50-32-8)	µg/L	<0.50 U, J-	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(b)fluoranthene (205-99-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(g,h,i)perylene (191-24-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(k)fluoranthene (207-08-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzoic Acid (65-85-0)	µg/L	<5.00 U	<3.00 U	<3.00 U	<3.00 U	<5.00 U	<3.00 U	<3.00 U	<3.00 U
Benzyl alcohol (100-51-6)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethoxy)methane (111-91-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethyl)ether (111-44-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroisopropyl)ether (108-60-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) adipate (103-23-1)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) phthalate (117-81-7)	µg/L	<1.00 U	<2.00 U	<2.00 U	9.56 J-	<1.00 U	<2.00 U	<2.00 U	<2.00 U
Butyl benzyl phthalate (85-68-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Carbazole (86-74-8)	µg/L	<0.50 U, J-	<3.00 U	<3.00 U	<3.00 U	<0.50 U	<3.00 U	<3.00 U	<3.00 U
Chrysene (218-01-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dibenz(a,h)anthracene (53-70-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dibenzofuran (132-64-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Diethyl phthalate (84-66-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dimethyl phthalate (131-11-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Di-n-butyl phthalate (84-74-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Di-n-octyl phthalate (117-84-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Diphenylamine (122-39-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW04	DW04	DW04	DW05	DW05	DW05	DW05
	Sample Date	10/4/11	11/6/12	4/30/13	10/4/11	5/14/12	11/5/12	4/29/13
Parameter (CAS Number)	Unit	Round 1	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
4-chloroaniline (106-47-8)	µg/L	<1.00 U	<3.00 U	<3.00 U	<1.00 U	<3.00 U	<3.00 U	<3.00 U
4-chlorophenyl phenyl ether (7005-72-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
4-nitroaniline (100-01-6)	µg/L	<0.50 U	<3.00 U	<3.00 U	<0.50 U	<3.00 U	<3.00 U	<3.00 U
4-nitrophenol (100-02-7)	µg/L	<2.50 U	<3.00 U	<3.00 U	<2.50 U	<3.00 U	<3.00 U	<3.00 U
Acenaphthene (83-32-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Acenaphthylene (208-96-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Adamantane (281-23-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U
Aniline (62-53-3)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Anthracene (120-12-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Azobenzene (103-33-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(a)anthracene (56-55-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(a)pyrene (50-32-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(b)fluoranthene (205-99-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(g,h,i)perylene (191-24-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(k)fluoranthene (207-08-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzoic Acid (65-85-0)	µg/L	<5.00 U	<3.00 U	<3.00 U	<5.00 U	<3.00 U	<3.00 U	<3.00 U
Benzyl alcohol (100-51-6)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethoxy)methane (111-91-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethyl)ether (111-44-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroisopropyl)ether (108-60-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) adipate (103-23-1)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) phthalate (117-81-7)	µg/L	<1.00 U	53.6 J	<2.00 U	<1.00 U	<2.00 U	<2.00 U	<2.00 U, J-
Butyl benzyl phthalate (85-68-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Carbazole (86-74-8)	µg/L	<0.50 U	<3.00 U	<3.00 U	<0.50 U	<3.00 U	<3.00 U	<3.00 U
Chrysene (218-01-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dibenz(a,h)anthracene (53-70-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dibenzofuran (132-64-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Diethyl phthalate (84-66-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dimethyl phthalate (131-11-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Di-n-butyl phthalate (84-74-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Di-n-octyl phthalate (117-84-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Diphenylamine (122-39-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW06	DW06	DW06	DW06	DW07	DW07	DW07	DW07
	Sample Date	10/6/11	5/16/12	11/8/12	5/2/13	10/6/11	5/16/12	11/6/12	5/1/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
4-chloroaniline (106-47-8)	µg/L	<1.00 U	<3.00 U	<3.00 U	<3.00 U	<1.00 U	<3.00 U	<3.00 U	<3.00 U
4-chlorophenyl phenyl ether (7005-72-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
4-nitroaniline (100-01-6)	µg/L	<0.50 U	<3.00 U	<3.00 U	<3.00 U	<0.50 U	<3.00 U	<3.00 U	<3.00 U
4-nitrophenol (100-02-7)	µg/L	<2.50 U	<3.00 U	<3.00 U	<3.00 U	<2.50 U	<3.00 U	<3.00 U	<3.00 U
Acenaphthene (83-32-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Acenaphthylene (208-96-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Adamantane (281-23-2)	µg/L	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U
Aniline (62-53-3)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Anthracene (120-12-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Azobenzene (103-33-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(a)anthracene (56-55-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(a)pyrene (50-32-8)	µg/L	<0.50 U, J-	<1.00 U	<1.00 U	<1.00 U	<0.50 U, J-	<1.00 U	<1.00 U	<1.00 U
Benzo(b)fluoranthene (205-99-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(g,h,i)perylene (191-24-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(k)fluoranthene (207-08-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzoic Acid (65-85-0)	µg/L	<5.00 U	<3.00 U	<3.00 U	<3.00 U	<5.00 U	<3.00 U	<3.00 U	<3.00 U
Benzyl alcohol (100-51-6)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethoxy)methane (111-91-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethyl)ether (111-44-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroisopropyl)ether (108-60-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) adipate (103-23-1)	µg/L	1.46 B	<1.00 U	<1.00 U	<1.00 U	2.28 B	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) phthalate (117-81-7)	µg/L	2.17	<2.00 U	<2.00 U	<2.00 U	<1.00 U	<2.00 U	<2.00 U	<2.00 U
Butyl benzyl phthalate (85-68-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Carbazole (86-74-8)	µg/L	<0.50 U, J-	<3.00 U	<3.00 U	<3.00 U	<0.50 U, J-	<3.00 U	<3.00 U	<3.00 U
Chrysene (218-01-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dibenz(a,h)anthracene (53-70-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dibenzofuran (132-64-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Diethyl phthalate (84-66-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dimethyl phthalate (131-11-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Di-n-butyl phthalate (84-74-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Di-n-octyl phthalate (117-84-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Diphenylamine (122-39-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW08	DW08	DW08	DW08	DW09	DW09	DW09	DW09
	Sample Date	10/5/11	5/16/12	11/7/12	5/1/13	10/5/11	5/16/12	11/8/12	5/1/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
4-chloroaniline (106-47-8)	µg/L	<1.00 U	<3.00 U	<3.00 U	<3.00 U	<1.00 U	<3.00 U	<3.00 U	<3.00 U
4-chlorophenyl phenyl ether (7005-72-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
4-nitroaniline (100-01-6)	µg/L	<0.50 U	<3.00 U	<3.00 U	<3.00 U	<0.50 U	<3.00 U	<3.00 U	<3.00 U
4-nitrophenol (100-02-7)	µg/L	<2.50 U	<3.00 U	<3.00 U	<3.00 U	<2.50 U	<3.00 U	<3.00 U	<3.00 U
Acenaphthene (83-32-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Acenaphthylene (208-96-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Adamantane (281-23-2)	µg/L	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U
Aniline (62-53-3)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Anthracene (120-12-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Azobenzene (103-33-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(a)anthracene (56-55-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(a)pyrene (50-32-8)	µg/L	<0.50 U, J-	<1.00 U	<1.00 U	<1.00 U	<0.50 U, J-	<1.00 U	<1.00 U	<1.00 U
Benzo(b)fluoranthene (205-99-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(g,h,i)perylene (191-24-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(k)fluoranthene (207-08-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzoic Acid (65-85-0)	µg/L	<5.00 U	<3.00 U	<3.00 U	<3.00 U	<5.00 U	<3.00 U	<3.00 U	<3.00 U
Benzyl alcohol (100-51-6)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethoxy)methane (111-91-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethyl)ether (111-44-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroisopropyl)ether (108-60-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) adipate (103-23-1)	µg/L	2.21 B	<1.00 U	<1.00 U	<1.00 U	2.33 B	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) phthalate (117-81-7)	µg/L	<1.00 U	9.33	<2.00 U	<2.00 U	<1.00 U	<2.00 U	<2.00 U	11.5
Butyl benzyl phthalate (85-68-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Carbazole (86-74-8)	µg/L	<0.50 U, J-	<3.00 U	<3.00 U	<3.00 U	<0.50 U, J-	<3.00 U	<3.00 U	<3.00 U
Chrysene (218-01-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dibenz(a,h)anthracene (53-70-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dibenzofuran (132-64-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Diethyl phthalate (84-66-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dimethyl phthalate (131-11-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Di-n-butyl phthalate (84-74-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Di-n-octyl phthalate (117-84-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Diphenylamine (122-39-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW10	DW10	DW10	DW10	DW11	DW11	DW11	DW11
	Sample Date	10/5/11	5/17/12	11/8/12	5/1/13	10/6/11	5/15/12	11/7/12	4/29/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
4-chloroaniline (106-47-8)	µg/L	<1.00 U	<3.00 U	<3.00 U	<3.00 U	<1.00 U	<3.00 U	<3.00 U	<3.00 U
4-chlorophenyl phenyl ether (7005-72-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
4-nitroaniline (100-01-6)	µg/L	<0.50 U	<3.00 U	<3.00 U	<3.00 U	<0.50 U	<3.00 U	<3.00 U	<3.00 U
4-nitrophenol (100-02-7)	µg/L	<2.50 U	<3.00 U	<3.00 U	<3.00 U	<2.50 U	<3.00 U	<3.00 U	<3.00 U
Acenaphthene (83-32-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Acenaphthylene (208-96-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Adamantane (281-23-2)	µg/L	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U
Aniline (62-53-3)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Anthracene (120-12-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Azobenzene (103-33-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(a)anthracene (56-55-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(a)pyrene (50-32-8)	µg/L	<0.50 U, J-	<1.00 U	<1.00 U	<1.00 U	<0.50 U, J-	<1.00 U	<1.00 U	<1.00 U
Benzo(b)fluoranthene (205-99-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(g,h,i)perylene (191-24-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(k)fluoranthene (207-08-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzoic Acid (65-85-0)	µg/L	<5.00 U	<3.00 U	<3.00 U	<3.00 U	<5.00 U	<3.00 U	<3.00 U	<3.00 U
Benzyl alcohol (100-51-6)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethoxy)methane (111-91-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethyl)ether (111-44-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroisopropyl)ether (108-60-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) adipate (103-23-1)	µg/L	2.31 B	<1.00 U	<1.00 U	<1.00 U	2.61 B	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) phthalate (117-81-7)	µg/L	<1.00 U	<2.00 U	<2.00 U	<2.00 U	<1.00 U	<2.00 U	3.84	18.1 J-
Butyl benzyl phthalate (85-68-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Carbazole (86-74-8)	µg/L	<0.50 U, J-	<3.00 U	<3.00 U	<3.00 U	<0.50 U, J-	<3.00 U	<3.00 U	<3.00 U
Chrysene (218-01-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dibenz(a,h)anthracene (53-70-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dibenzofuran (132-64-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Diethyl phthalate (84-66-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dimethyl phthalate (131-11-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Di-n-butyl phthalate (84-74-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Di-n-octyl phthalate (117-84-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Diphenylamine (122-39-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW12	DW13	DW13	DW13	DW14	DW14	DW14	DW15
	Sample Date	10/6/11	5/15/12	11/6/12	4/30/13	5/17/12	11/8/12	5/1/13	11/8/12
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4	Round 3
4-chloroaniline (106-47-8)	µg/L	<1.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U
4-chlorophenyl phenyl ether (7005-72-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
4-nitroaniline (100-01-6)	µg/L	<0.50 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U
4-nitrophenol (100-02-7)	µg/L	<2.50 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U
Acenaphthene (83-32-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Acenaphthylene (208-96-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Adamantane (281-23-2)	µg/L	<0.50 U, J-	<1.00 U, J-	<1.00 U	<1.00 U	<1.00 U, J-	<1.00 U	<1.00 U	<1.00 U
Aniline (62-53-3)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Anthracene (120-12-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Azobenzene (103-33-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Benzo(a)anthracene (56-55-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Benzo(a)pyrene (50-32-8)	µg/L	<0.50 U, J-	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Benzo(b)fluoranthene (205-99-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Benzo(g,h,i)perylene (191-24-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Benzo(k)fluoranthene (207-08-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Benzoic Acid (65-85-0)	µg/L	<5.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U
Benzyl alcohol (100-51-6)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethoxy)methane (111-91-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethyl)ether (111-44-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroisopropyl)ether (108-60-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) adipate (103-23-1)	µg/L	2.37 B	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) phthalate (117-81-7)	µg/L	<1.00 U	<2.00 U	<2.00 U	9.66	<2.00 U	<2.00 U	5.71	<2.00 U
Butyl benzyl phthalate (85-68-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Carbazole (86-74-8)	µg/L	<0.50 U, J-	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U
Chrysene (218-01-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Dibenz(a,h)anthracene (53-70-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Dibenzofuran (132-64-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Diethyl phthalate (84-66-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Dimethyl phthalate (131-11-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Di-n-butyl phthalate (84-74-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Di-n-octyl phthalate (117-84-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Diphenylamine (122-39-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	PW01	PW01	PW01	PW01	PW02	PW03	PW03	PW03
	Sample Date	10/3/11	5/14/12	11/5/12	4/29/13	10/3/11	5/14/12	11/5/12	4/29/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
4-chloroaniline (106-47-8)	µg/L	<1.00 U	<3.00 U	<3.00 U	<3.00 U	<1.00 U	<3.00 U	<3.00 U	<3.00 U
4-chlorophenyl phenyl ether (7005-72-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
4-nitroaniline (100-01-6)	µg/L	<0.50 U	<3.00 U	<3.00 U	<3.00 U	<0.50 U	<3.00 U	<3.00 U	<3.00 U
4-nitrophenol (100-02-7)	µg/L	<2.50 U	<3.00 U	<3.00 U	<3.00 U	<2.50 U	<3.00 U	<3.00 U	<3.00 U
Acenaphthene (83-32-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Acenaphthylene (208-96-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Adamantane (281-23-2)	µg/L	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U
Aniline (62-53-3)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Anthracene (120-12-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Azobenzene (103-33-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(a)anthracene (56-55-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(a)pyrene (50-32-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(b)fluoranthene (205-99-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(g,h,i)perylene (191-24-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzo(k)fluoranthene (207-08-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Benzoic Acid (65-85-0)	µg/L	<5.00 U	<3.00 U	<3.00 U	<3.00 U	<5.00 U	<3.00 U	<3.00 U	<3.00 U
Benzyl alcohol (100-51-6)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethoxy)methane (111-91-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethyl)ether (111-44-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroisopropyl)ether (108-60-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) adipate (103-23-1)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) phthalate (117-81-7)	µg/L	<1.00 U	<2.00 U	2.36 B	47.6 J-	<1.00 U	<2.00 U	2.22 B	22.6 J-
Butyl benzyl phthalate (85-68-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Carbazole (86-74-8)	µg/L	<0.50 U	<3.00 U	<3.00 U	<3.00 U	<0.50 U	<3.00 U	<3.00 U	<3.00 U
Chrysene (218-01-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dibenz(a,h)anthracene (53-70-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dibenzofuran (132-64-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Diethyl phthalate (84-66-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Dimethyl phthalate (131-11-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Di-n-butyl phthalate (84-74-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Di-n-octyl phthalate (117-84-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Diphenylamine (122-39-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	SW01	SW01	SW01	SW01	SW02	SW02	SW02
	Sample Date	10/4/11	5/14/12	11/7/12	4/30/13	5/14/12	11/6/12	4/30/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
4-chloroaniline (106-47-8)	µg/L	<1.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U
4-chlorophenyl phenyl ether (7005-72-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
4-nitroaniline (100-01-6)	µg/L	<0.50 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U
4-nitrophenol (100-02-7)	µg/L	<2.50 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U
Acenaphthene (83-32-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Acenaphthylene (208-96-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Adamantane (281-23-2)	µg/L	<0.50 U	<1.00 U, J-	<1.00 U	<1.00 U	<1.00 U, J-	<1.00 U	<1.00 U
Aniline (62-53-3)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Anthracene (120-12-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Azobenzene (103-33-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Benzo(a)anthracene (56-55-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Benzo(a)pyrene (50-32-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Benzo(b)fluoranthene (205-99-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Benzo(g,h,i)perylene (191-24-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Benzo(k)fluoranthene (207-08-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Benzoic Acid (65-85-0)	µg/L	<5.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U
Benzyl alcohol (100-51-6)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethoxy)methane (111-91-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethyl)ether (111-44-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroisopropyl)ether (108-60-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) adipate (103-23-1)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) phthalate (117-81-7)	µg/L	1.39	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
Butyl benzyl phthalate (85-68-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Carbazole (86-74-8)	µg/L	<0.50 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U	<3.00 U
Chrysene (218-01-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Dibenz(a,h)anthracene (53-70-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Dibenzofuran (132-64-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Diethyl phthalate (84-66-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Dimethyl phthalate (131-11-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Di-n-butyl phthalate (84-74-2)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Di-n-octyl phthalate (117-84-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Diphenylamine (122-39-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	SW03	SW03	SW03
	Sample Date	5/15/12	11/6/12	4/30/13
Parameter (CAS Number)	Unit	Round 2	Round 3	Round 4
4-chloroaniline (106-47-8)	µg/L	<3.00 U	<3.00 U	<3.00 U
4-chlorophenyl phenyl ether (7005-72-3)	µg/L	<1.00 U	<1.00 U	<1.00 U
4-nitroaniline (100-01-6)	µg/L	<3.00 U	<3.00 U	<3.00 U
4-nitrophenol (100-02-7)	µg/L	<3.00 U	<3.00 U	<3.00 U
Acenaphthene (83-32-9)	µg/L	<1.00 U	<1.00 U	<1.00 U
Acenaphthylene (208-96-8)	µg/L	<1.00 U	<1.00 U	<1.00 U
Adamantane (281-23-2)	µg/L	<1.00 U, J-	<1.00 U	<1.00 U
Aniline (62-53-3)	µg/L	<1.00 U	<1.00 U	<1.00 U
Anthracene (120-12-7)	µg/L	<1.00 U	<1.00 U	<1.00 U
Azobenzene (103-33-3)	µg/L	<1.00 U	<1.00 U	<1.00 U
Benzo(a)anthracene (56-55-3)	µg/L	<1.00 U	<1.00 U	<1.00 U
Benzo(a)pyrene (50-32-8)	µg/L	<1.00 U	<1.00 U	<1.00 U
Benzo(b)fluoranthene (205-99-2)	µg/L	<1.00 U	<1.00 U	<1.00 U
Benzo(g,h,i)perylene (191-24-2)	µg/L	<1.00 U	<1.00 U	<1.00 U
Benzo(k)fluoranthene (207-08-9)	µg/L	<1.00 U	<1.00 U	<1.00 U
Benzoic Acid (65-85-0)	µg/L	<3.00 U	<3.00 U	<3.00 U
Benzyl alcohol (100-51-6)	µg/L	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethoxy)methane (111-91-1)	µg/L	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroethyl)ether (111-44-4)	µg/L	<1.00 U	<1.00 U	<1.00 U
Bis-(2-chloroisopropyl)ether (108-60-1)	µg/L	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) adipate (103-23-1)	µg/L	<1.00 U	<1.00 U	<1.00 U
Bis-(2-ethylhexyl) phthalate (117-81-7)	µg/L	<2.00 U	<2.00 U	<2.00 U
Butyl benzyl phthalate (85-68-7)	µg/L	<1.00 U	<1.00 U	<1.00 U
Carbazole (86-74-8)	µg/L	<3.00 U	<3.00 U	<3.00 U
Chrysene (218-01-9)	µg/L	<1.00 U	<1.00 U	<1.00 U
Dibenz(a,h)anthracene (53-70-3)	µg/L	<1.00 U	<1.00 U	<1.00 U
Dibenzofuran (132-64-9)	µg/L	<1.00 U	<1.00 U	<1.00 U
Diethyl phthalate (84-66-2)	µg/L	<1.00 U	<1.00 U	<1.00 U
Dimethyl phthalate (131-11-3)	µg/L	<1.00 U	<1.00 U	<1.00 U
Di-n-butyl phthalate (84-74-2)	µg/L	<1.00 U	<1.00 U	<1.00 U
Di-n-octyl phthalate (117-84-0)	µg/L	<1.00 U	<1.00 U	<1.00 U
Diphenylamine (122-39-4)	µg/L	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	MW01	MW01	MW01	MW01	MW02	MW02	MW02	MW02
	Sample Date	10/3/11	5/15/12	11/5/12	4/29/13	10/4/11	5/15/12	11/6/12	4/30/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Fluoranthene (206-44-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Fluorene (86-73-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorobenzene (118-74-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorobutadiene (87-68-3)	µg/L	< 1.00 U	<1.00 U	<1.00 U	<1.00 U	< 1.00 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorocyclopentadiene (77-47-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachloroethane (67-72-1)	µg/L	<1.0 U	<1.00 U	<1.00 U	<1.00 U	<1.0 U	<1.00 U	<1.00 U	<1.00 U
Indeno(1,2,3-cd)pyrene (193-39-5)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Isophorone (78-59-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Naphthalene (91-20-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Nitrobenzene (98-95-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
N-nitrosodimethylamine (62-75-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
N-nitrosodi-n-propylamine (621-64-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Pentachlorophenol (87-86-5)	µg/L	<1.00 U	<2.00 U	<2.00 U	<2.00 U	<1.00 U	<2.00 U	<2.00 U	<2.00 U
Phenanthrene (85-01-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Phenol (108-95-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
Pyrene (129-00-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Pyridine (110-86-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Squalene (111-02-4)	µg/L	<1.00 U	<2.00 U	<2.00 U, J-	<2.00 U, J-	<1.00 U	<2.00 U	<2.00 U, J-	<2.00 U
Terpiniol (98-55-5)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
tri-(2-butoxyethyl) phosphate (78-51-3)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	MW03	MW03	MW03	MW03	MW04	MW05	DW01	DW01
	Sample Date	10/4/11	5/15/12	11/7/12	5/1/13	10/5/11	10/5/11	10/3/11	5/15/12
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 1	Round 1	Round 2
Fluoranthene (206-44-0)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Fluorene (86-73-7)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Hexachlorobenzene (118-74-1)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Hexachlorobutadiene (87-68-3)	µg/L	< 1.00 U	<1.00 H, U	<1.00 U	<1.00 U	< 1.00 U	< 1.00 U	< 1.00 U	<1.00 U
Hexachlorocyclopentadiene (77-47-4)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Hexachloroethane (67-72-1)	µg/L	<1.0 U	<1.00 H, U	<1.00 U	<1.00 U	<1.0 U	<1.0 U	<1.0 U	<1.00 U
Indeno(1,2,3-cd)pyrene (193-39-5)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Isophorone (78-59-1)	µg/L	1.26	1.86 J, H	<1.00 U	1.11	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Naphthalene (91-20-3)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Nitrobenzene (98-95-3)	µg/L	0.63	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
N-nitrosodimethylamine (62-75-9)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
N-nitrosodi-n-propylamine (621-64-7)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Pentachlorophenol (87-86-5)	µg/L	<1.00 U	<2.00 H, U	<2.00 U	<2.00 U	<1.00 U	<1.00 U	<1.00 U	<2.00 U
Phenanthrene (85-01-8)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Phenol (108-95-2)	µg/L	0.52	<2.00 H, U	<2.00 U	<2.00 U	<0.50 U	<0.50 U	<0.50 U	<2.00 U
Pyrene (129-00-0)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Pyridine (110-86-1)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
Squalene (111-02-4)	µg/L	1.62	<2.00 H, U	<2.00 U, J-	<2.00 U	<1.00 U	<1.00 U	1.87	<2.00 U
Terpiniol (98-55-5)	µg/L	<0.50 U	<1.00 H, U	<1.00 U	<1.00 U	<0.50 U	<0.50 U	<0.50 U	<1.00 U
tri-(2-butoxyethyl) phosphate (78-51-3)	µg/L	<1.00 U	<1.00 H, U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

Sample		DW02	DW02	DW02	DW02	DW03	DW03	DW03	DW03
	Sample Date	10/3/11	5/14/12	11/5/12	4/29/13	10/3/11	5/15/12	11/5/12	4/30/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Fluoranthene (206-44-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Fluorene (86-73-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorobenzene (118-74-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorobutadiene (87-68-3)	µg/L	< 1.00 U	<1.00 U	<1.00 U	<1.00 U	< 1.00 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorocyclopentadiene (77-47-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachloroethane (67-72-1)	µg/L	<1.0 U	<1.00 U	<1.00 U	<1.00 U	<1.0 U	<1.00 U	<1.00 U	<1.00 U
Indeno(1,2,3-cd)pyrene (193-39-5)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Isophorone (78-59-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Naphthalene (91-20-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Nitrobenzene (98-95-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
N-nitrosodimethylamine (62-75-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
N-nitrosodi-n-propylamine (621-64-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Pentachlorophenol (87-86-5)	µg/L	<1.00 U	<2.00 U	<2.00 U	<2.00 U	<1.00 U	<2.00 U	<2.00 U	<2.00 U
Phenanthrene (85-01-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Phenol (108-95-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
Pyrene (129-00-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Pyridine (110-86-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Squalene (111-02-4)	µg/L	<1.00 U	<2.00 U	<2.00 U, J-	<2.00 U, J-	<1.00 U	<2.00 U	<2.00 U, J-	<2.00 U
Terpiniol (98-55-5)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
tri-(2-butoxyethyl) phosphate (78-51-3)	µg/L	1.22	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW04	DW04	DW04	DW05	DW05	DW05	DW05
	Sample Date	10/4/11	11/6/12	4/30/13	10/4/11	5/14/12	11/5/12	4/29/13
Parameter (CAS Number)	Unit	Round 1	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Fluoranthene (206-44-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Fluorene (86-73-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorobenzene (118-74-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorobutadiene (87-68-3)	µg/L	< 1.00 U	<1.00 U	<1.00 U	< 1.00 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorocyclopentadiene (77-47-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachloroethane (67-72-1)	µg/L	<1.0 U	<1.00 U	<1.00 U	<1.0 U	<1.00 U	<1.00 U	<1.00 U
Indeno(1,2,3-cd)pyrene (193-39-5)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Isophorone (78-59-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Naphthalene (91-20-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Nitrobenzene (98-95-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
N-nitrosodimethylamine (62-75-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
N-nitrosodi-n-propylamine (621-64-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Pentachlorophenol (87-86-5)	µg/L	<1.00 U	<2.00 U	<2.00 U	<1.00 U	<2.00 U	<2.00 U	<2.00 U
Phenanthrene (85-01-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Phenol (108-95-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
Pyrene (129-00-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Pyridine (110-86-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Squalene (111-02-4)	µg/L	<1.00 U	<2.00 U, J-	<2.00 U	<1.00 U	<2.00 U	<2.00 U, J-	<2.00 U, J-
Terpiniol (98-55-5)	µg/L	<0.50 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
tri-(2-butoxyethyl) phosphate (78-51-3)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW06	DW06	DW06	DW06	DW07	DW07	DW07	DW07
	Sample Date	10/6/11	5/16/12	11/8/12	5/2/13	10/6/11	5/16/12	11/6/12	5/1/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Fluoranthene (206-44-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Fluorene (86-73-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorobenzene (118-74-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorobutadiene (87-68-3)	µg/L	< 1.00 U	<1.00 U	<1.00 U	<1.00 U	< 1.00 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorocyclopentadiene (77-47-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachloroethane (67-72-1)	µg/L	<1.0 U	<1.00 U	<1.00 U	<1.00 U	<1.0 U	<1.00 U	<1.00 U	<1.00 U
Indeno(1,2,3-cd)pyrene (193-39-5)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Isophorone (78-59-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Naphthalene (91-20-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Nitrobenzene (98-95-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
N-nitrosodimethylamine (62-75-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
N-nitrosodi-n-propylamine (621-64-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Pentachlorophenol (87-86-5)	µg/L	<1.00 U	<2.00 U	<2.00 U	<2.00 U	<1.00 U	<2.00 U	<2.00 U	<2.00 U
Phenanthrene (85-01-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Phenol (108-95-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	1.08	<2.00 U	<2.00 U	<2.00 U
Pyrene (129-00-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Pyridine (110-86-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Squalene (111-02-4)	µg/L	<1.00 U	<2.00 U	<2.00 U, J-	<2.00 U	<1.00 U	<2.00 U	<2.00 U, J-	<2.00 U
Terpiniol (98-55-5)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
tri-(2-butoxyethyl) phosphate (78-51-3)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW08	DW08	DW08	DW08	DW09	DW09	DW09	DW09
	Sample Date	10/5/11	5/16/12	11/7/12	5/1/13	10/5/11	5/16/12	11/8/12	5/1/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Fluoranthene (206-44-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Fluorene (86-73-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorobenzene (118-74-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorobutadiene (87-68-3)	µg/L	< 1.00 U	<1.00 U	<1.00 U	<1.00 U	< 1.00 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorocyclopentadiene (77-47-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachloroethane (67-72-1)	µg/L	<1.0 U	<1.00 U	<1.00 U	<1.00 U	<1.0 U	<1.00 U	<1.00 U	<1.00 U
Indeno(1,2,3-cd)pyrene (193-39-5)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Isophorone (78-59-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Naphthalene (91-20-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Nitrobenzene (98-95-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
N-nitrosodimethylamine (62-75-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
N-nitrosodi-n-propylamine (621-64-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Pentachlorophenol (87-86-5)	µg/L	<1.00 U	<2.00 U	<2.00 U	<2.00 U	<1.00 U	<2.00 U	<2.00 U	<2.00 U
Phenanthrene (85-01-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Phenol (108-95-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
Pyrene (129-00-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Pyridine (110-86-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Squalene (111-02-4)	µg/L	<1.00 U	<2.00 U	<2.00 U, J-	<2.00 U	<1.00 U	<2.00 U	<2.00 U, J-	<2.00 U
Terpiniol (98-55-5)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
tri-(2-butoxyethyl) phosphate (78-51-3)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

Parameter (CAS Number)	Sample Sample Date Unit	DW10 10/5/11 Round 1	DW10 5/17/12 Round 2	DW10 11/8/12 Round 3	DW10 5/1/13 Round 4	DW11 10/6/11 Round 1	DW11 5/15/12 Round 2	DW11 11/7/12 Round 3	DW11 4/29/13 Round 4
Fluoranthene (206-44-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Fluorene (86-73-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorobenzene (118-74-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorobutadiene (87-68-3)	µg/L	< 1.00 U	<1.00 U	<1.00 U	<1.00 U	< 1.00 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorocyclopentadiene (77-47-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachloroethane (67-72-1)	µg/L	<1.0 U	<1.00 U	<1.00 U	<1.00 U	<1.0 U	<1.00 U	<1.00 U	<1.00 U
Indeno(1,2,3-cd)pyrene (193-39-5)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Isophorone (78-59-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Naphthalene (91-20-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Nitrobenzene (98-95-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
N-nitrosodimethylamine (62-75-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
N-nitrosodi-n-propylamine (621-64-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Pentachlorophenol (87-86-5)	µg/L	<1.00 U	<2.00 U	<2.00 U	<2.00 U	<1.00 U	<2.00 U	<2.00 U	<2.00 U
Phenanthrene (85-01-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Phenol (108-95-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
Pyrene (129-00-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Pyridine (110-86-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Squalene (111-02-4)	µg/L	<1.00 U	<2.00 U	<2.00 U, J-	<2.00 U	<1.00 U	<2.00 U	<2.00 U, J-	3.13 B, J-
Terpiniol (98-55-5)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
tri-(2-butoxyethyl) phosphate (78-51-3)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	DW12	DW13	DW13	DW13	DW14	DW14	DW14	DW15
	Sample Date	10/6/11	5/15/12	11/6/12	4/30/13	5/17/12	11/8/12	5/1/13	11/8/12
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4	Round 3
Fluoranthene (206-44-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Fluorene (86-73-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorobenzene (118-74-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorobutadiene (87-68-3)	µg/L	< 1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorocyclopentadiene (77-47-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Hexachloroethane (67-72-1)	µg/L	<1.0 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Indeno(1,2,3-cd)pyrene (193-39-5)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Isophorone (78-59-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Naphthalene (91-20-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Nitrobenzene (98-95-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
N-nitrosodimethylamine (62-75-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
N-nitrosodi-n-propylamine (621-64-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Pentachlorophenol (87-86-5)	µg/L	<1.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
Phenanthrene (85-01-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Phenol (108-95-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
Pyrene (129-00-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Pyridine (110-86-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Squalene (111-02-4)	µg/L	<1.00 U	<2.00 U	<2.00 U, J-	<2.00 U	<2.00 U	<2.00 U, J-	<2.00 U	<2.00 U, J-
Terpiniol (98-55-5)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
tri-(2-butoxyethyl) phosphate (78-51-3)	µg/L	<1.00 U	<1.00 U	<1.00 U	1.05 J	<1.00 U	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	PW01	PW01	PW01	PW01	PW02	PW03	PW03	PW03
	Sample Date	10/3/11	5/14/12	11/5/12	4/29/13	10/3/11	5/14/12	11/5/12	4/29/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Fluoranthene (206-44-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Fluorene (86-73-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorobenzene (118-74-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorobutadiene (87-68-3)	µg/L	< 1.00 U	<1.00 U	<1.00 U	<1.00 U	< 1.00 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorocyclopentadiene (77-47-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Hexachloroethane (67-72-1)	µg/L	<1.0 U	<1.00 U	<1.00 U	<1.00 U	<1.0 U	<1.00 U	<1.00 U	<1.00 U
Indeno(1,2,3-cd)pyrene (193-39-5)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Isophorone (78-59-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Naphthalene (91-20-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Nitrobenzene (98-95-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
N-nitrosodimethylamine (62-75-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
N-nitrosodi-n-propylamine (621-64-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Pentachlorophenol (87-86-5)	µg/L	<1.00 U	<2.00 U	<2.00 U	<2.00 U	<1.00 U	<2.00 U	<2.00 U	<2.00 U
Phenanthrene (85-01-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Phenol (108-95-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<0.50 U	<2.00 U	<2.00 U	<2.00 U
Pyrene (129-00-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Pyridine (110-86-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
Squalene (111-02-4)	µg/L	<1.00 U	<2.00 U	<2.00 U, J-	<2.00 U, J-	<1.00 U	<2.00 U	<2.00 U, J-	<2.00 U, J-
Terpiniol (98-55-5)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<0.50 U	<1.00 U	<1.00 U	<1.00 U
tri-(2-butoxyethyl) phosphate (78-51-3)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	SW01	SW01	SW01	SW01	SW02	SW02	SW02
	Sample Date	10/4/11	5/14/12	11/7/12	4/30/13	5/14/12	11/6/12	4/30/13
Parameter (CAS Number)	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
Fluoranthene (206-44-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Fluorene (86-73-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorobenzene (118-74-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorobutadiene (87-68-3)	µg/L	< 1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Hexachlorocyclopentadiene (77-47-4)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Hexachloroethane (67-72-1)	µg/L	<1.0 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Indeno(1,2,3-cd)pyrene (193-39-5)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Isophorone (78-59-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Naphthalene (91-20-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Nitrobenzene (98-95-3)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
N-nitrosodimethylamine (62-75-9)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
N-nitrosodi-n-propylamine (621-64-7)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Pentachlorophenol (87-86-5)	µg/L	<1.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
Phenanthrene (85-01-8)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Phenol (108-95-2)	µg/L	<0.50 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U	<2.00 U
Pyrene (129-00-0)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Pyridine (110-86-1)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
Squalene (111-02-4)	µg/L	<1.00 U	<2.00 U	<2.00 U, J-	<2.00 U	<2.00 U	<2.00 U, J-	<2.00 U
Terpiniol (98-55-5)	µg/L	<0.50 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U
tri-(2-butoxyethyl) phosphate (78-51-3)	µg/L	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U	<1.00 U

Table B-6 Sample Results - Semivolatile Organic Compounds (Raton Basin, Colorado)

	Sample	SW03	SW03	SW03
	Sample Date	5/15/12	11/6/12	4/30/13
Parameter (CAS Number)	Unit	Round 2	Round 3	Round 4
Fluoranthene (206-44-0)	µg/L	<1.00 U	<1.00 U	<1.00 U
Fluorene (86-73-7)	µg/L	<1.00 U	<1.00 U	<1.00 U
Hexachlorobenzene (118-74-1)	µg/L	<1.00 U	<1.00 U	<1.00 U
Hexachlorobutadiene (87-68-3)	µg/L	<1.00 U	<1.00 U	<1.00 U
Hexachlorocyclopentadiene (77-47-4)	µg/L	<1.00 U	<1.00 U	<1.00 U
Hexachloroethane (67-72-1)	µg/L	<1.00 U	<1.00 U	<1.00 U
Indeno(1,2,3-cd)pyrene (193-39-5)	µg/L	<1.00 U	<1.00 U	<1.00 U
Isophorone (78-59-1)	µg/L	<1.00 U	<1.00 U	<1.00 U
Naphthalene (91-20-3)	µg/L	<1.00 U	<1.00 U	<1.00 U
Nitrobenzene (98-95-3)	µg/L	<1.00 U	<1.00 U	<1.00 U
N-nitrosodimethylamine (62-75-9)	µg/L	<1.00 U	<1.00 U	<1.00 U
N-nitrosodi-n-propylamine (621-64-7)	µg/L	<1.00 U	<1.00 U	<1.00 U
Pentachlorophenol (87-86-5)	µg/L	<2.00 U	<2.00 U	<2.00 U
Phenanthrene (85-01-8)	µg/L	<1.00 U	<1.00 U	<1.00 U
Phenol (108-95-2)	µg/L	<2.00 U	<2.00 U	<2.00 U
Pyrene (129-00-0)	µg/L	<1.00 U	<1.00 U	<1.00 U
Pyridine (110-86-1)	µg/L	<1.00 U	<1.00 U	<1.00 U
Squalene (111-02-4)	µg/L	<2.00 U	<2.00 U, J-	<2.00 U
Terpiniol (98-55-5)	µg/L	<1.00 U	<1.00 U	<1.00 U
tri-(2-butoxyethyl) phosphate (78-51-3)	µg/L	<1.00 U	<1.00 U	<1.00 U

Table B-7 Sample Results - Water Isotopes and Strontium Isotopes (Raton Basin, Colorado)

	Sample	MW01	MW01	MW01	MW01	MW02	MW02	MW02	MW02
	Sample Date	10/3/11	5/15/12	11/5/12	4/29/13	10/4/11	5/15/12	11/6/12	4/30/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Water Isotopes									
δ^{2}H	‰	-76.34	-76.37	-76.22	-76.29	-71.24	-71.48	-71.42	-72.08
δ^{18}O	‰	-10.78	-10.33	-10.40	-10.67	-9.86	-9.86	-9.99	-10.04
Strontium Isotopes									
Sr	µg/L	1190	1220	1260	1220	180	165	148	122
Rb	µg/L	0.83	0.9	1.0	0.9	0.38	0.4	<0.5	<0.5
^{87}Sr/^{86}Sr	Atom Ratio	0.712933	0.71286	0.71293	0.712939	0.712937	0.71291	0.71288	0.712913
1/Sr	L/µg	0.0008	0.0008	0.0008	0.00082	0.0056	0.0061	0.0068	0.00820
Rb/Sr	Weight Ratio	0.0007	0.0007	0.0008	0.00074	0.0021	0.0024	NR	NR

Table B-7 Sample Results - Water Isotopes and Strontium Isotopes (Raton Basin, Colorado)

	Sample	MW03	MW03	MW03	MW03	MW04	MW05	DW01	DW01
	Sample Date	10/4/11	5/15/12	11/7/12	5/1/13	10/5/11	10/5/11	10/3/11	5/15/12
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 1	Round 1	Round 2
Water Isotopes									
δ^{2}H	‰	-66.93	-66.89	-66.95	-67.56	-94.43	-95.08	-101.74	-100.38
δ^{18}O	‰	-10.25	-10.69	-10.84	-10.92	-12.01	-12.96	-14.32	-13.81
Strontium Isotopes									
Sr	µg/L	148	144	146	135	95	40	361	368
Rb	µg/L	0.58	0.9	0.5	0.5	0.27	0.20	0.85	0.8
^{87}Sr/^{86}Sr	Atom Ratio	0.712620	0.71255	0.71259	0.712578	0.707833	0.707932	0.712374	0.71237
1/Sr	L/µg	0.0068	0.0069	0.0068	0.00741	0.0105	0.0250	0.0028	0.0027
Rb/Sr	Weight Ratio	0.0039	0.0063	0.0034	0.00370	0.0028	0.0050	0.0023	0.0022

Table B-7 Sample Results - Water Isotopes and Strontium Isotopes (Raton Basin, Colorado)

	Sample	DW02	DW02	DW02	DW02	DW03	DW03	DW03	DW03	DW04	DW04	DW04
	Sample Date	10/3/11	5/14/12	11/5/12	4/29/13	10/3/11	5/15/12	11/5/12	4/30/13	10/4/11	11/6/12	4/30/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4	Round 1	Round 3	Round 4
Water Isotopes												
$\delta^{2}H$	‰	-74.64	-75.33	-74.48	-74.90	-77.69	-77.00	-76.72	-77.37	-74.06	-74.85	-75.78
$\delta^{18}O$	‰	-10.29	-10.37	-10.17	-10.37	-10.86	-10.29	-10.30	-10.40	-10.01	-10.10	-10.16
Strontium Isotopes												
Sr	µg/L	352	501	374	347	532	528	580	510	1110	791	705
Rb	µg/L	0.36	0.4	<0.5	<0.5	0.40	0.3	0.5	<0.5	1.32	1.6	1.4
$^{87}Sr/^{86}Sr$	Atom Ratio	0.713111	0.71311	0.71309	0.713096	0.713329	0.71336	0.71331	0.713334	0.712960	0.71282	0.712945
1/Sr	L/µg	0.0028	0.0020	0.0027	0.00288	0.0019	0.0019	0.0017	0.00196	0.0009	0.0013	0.00142
Rb/Sr	Weight Ratio	0.0010	0.0008	NR	NR	0.0008	0.0006	0.0009	NR	0.0012	0.0020	0.00199

Table B-7 Sample Results - Water Isotopes and Strontium Isotopes (Raton Basin, Colorado)

	Sample	DW05	DW05	DW05	DW05	DW06	DW06	DW06	DW06
	Sample Date	10/4/11	5/14/12	11/5/12	4/29/13	10/6/11	5/16/12	11/8/12	5/2/13
Parameter	**Unit**	**Round 1**	**Round 2**	**Round 3**	**Round 4**	**Round 1**	**Round 2**	**Round 3**	**Round 4**
Water Isotopes									
δ^{2}H	‰	-67.06	-67.87	-68.26	-69.00	-86.68	-92.53	-92.05	-93.72
δ^{18}O	‰	-8.73	-9.27	-9.40	-9.49	-11.12	-12.00	-11.87	-12.35
Strontium Isotopes									
Sr	µg/L	97	92	98	66	659	460	449	386
Rb	µg/L	0.68	0.7	0.8	0.6	0.49	0.5	<0.5	<0.5
^{87}Sr/^{86}Sr	Atom Ratio	0.713416	0.71342	0.71336	0.713398	0.707256	0.70728	0.70736	0.707306
1/Sr	L/µg	0.0103	0.0109	0.0102	0.01515	0.0015	0.0022	0.0022	0.00259
Rb/Sr	Weight Ratio	0.0070	0.0076	0.0082	0.00909	0.0007	0.0011	NR	NR

Table B-7 Sample Results - Water Isotopes and Strontium Isotopes (Raton Basin, Colorado)

	Sample	DW07	DW07	DW07	DW07	DW08	DW08	DW08	DW08
	Sample Date	10/6/11	5/16/12	11/6/12	5/1/13	10/5/11	5/16/12	11/7/12	5/1/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Water Isotopes									
δ^2H	‰	-89.19	-89.97	-89.81	-89.86	-90.72	-92.10	-92.23	-92.91
$\delta^{18}O$	‰	-11.20	-11.48	-11.56	-11.74	-11.70	-12.06	-12.08	-12.43
Strontium Isotopes									
Sr	µg/L	83	100	84	67	166	183	178	152
Rb	µg/L	0.52	0.6	0.6	0.6	0.26	0.3	1.1	0.8
$^{87}Sr/^{86}Sr$	Atom Ratio	0.707795	0.70780	0.70778	0.707771	0.707623	0.70755	0.70764	0.707620
1/Sr	L/µg	0.0120	0.0100	0.0119	0.01493	0.0060	0.0055	0.0056	0.00658
Rb/Sr	Weight Ratio	0.0063	0.0060	0.0071	0.00896	0.0016	0.0016	0.0062	0.00526

Table B-7 Sample Results - Water Isotopes and Strontium Isotopes (Raton Basin, Colorado)

	Sample	DW09	DW09	DW09	DW09	DW10	DW10	DW10	DW10
	Sample Date	10/5/11	5/16/12	11/8/12	5/1/13	10/5/11	5/17/12	11/8/12	5/1/13
Parameter	**Unit**	**Round 1**	**Round 2**	**Round 3**	**Round 4**	**Round 1**	**Round 2**	**Round 3**	**Round 4**
Water Isotopes									
δ^{2}H	‰	-94.95	-95.70	-95.55 J	-97.04	-97.28	-97.66	-98.34	-99.15
δ^{18}O	‰	-13.07	-12.66	-12.36 J	-12.88	-12.35	-12.75	-12.67	-12.92
Strontium Isotopes									
Sr	µg/L	1790	631	504	720	88	90	87	88
Rb	µg/L	0.64	0.5	0.5	0.5	0.24	0.3	<0.5	<0.5
^{87}Sr/^{86}Sr	Atom Ratio	0.707661	0.70774	0.70768	0.707663	0.707844	0.70786	0.70783	0.707828
1/Sr	L/µg	0.0006	0.0016	0.0020	0.00139	0.0114	0.0111	0.0115	0.01136
Rb/Sr	Weight Ratio	0.0004	0.0008	0.0010	0.00069	0.0027	0.0033	NR	NR

Table B-7 Sample Results - Water Isotopes and Strontium Isotopes (Raton Basin, Colorado)

	Sample	DW11	DW11	DW11	DW11	DW12	DW13	DW13	DW13	DW14	DW14	DW14
	Sample Date	10/6/11	5/15/12	11/7/12	4/29/13	10/6/11	5/15/12	11/6/12	4/30/13	5/17/12	11/8/12	5/1/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
Water Isotopes												
$\delta^{2}H$	‰	-80.83	-81.45	-80.63 J	-81.59	-80.33	-101.07	-100.37	-100.80	-98.14	-96.25 J	-97.99
$\delta^{18}O$	‰	-10.17	-10.56	-10.62 J	-10.90	-10.21	-13.77	-13.74	-13.95	-12.82	-12.46 J	-12.84
Strontium Isotopes												
Sr	µg/L	476	604	441	377	212	287	267	255	300	292	261
Rb	µg/L	0.56	0.6	0.6	0.6	0.51	0.2	<0.5	<0.5	<0.5	<1.0	<0.5
$^{87}Sr/^{86}Sr$	Atom Ratio	0.711314	0.71106	0.71130	0.711313	0.711218	0.71231	0.71231	0.712291	0.70780	0.70784	0.707847
1/Sr	L/µg	0.0021	0.0017	0.0023	0.00265	0.0047	0.0035	0.0037	0.00392	0.0033	0.0034	0.00383
Rb/Sr	Weight Ratio	0.0012	0.0010	0.0014	0.00159	0.0024	0.0007	NR	NR	NR	NR	NR

Table B-7 Sample Results - Water Isotopes and Strontium Isotopes (Raton Basin, Colorado)

	Sample	DW15	PW01	PW01	PW01	PW01	PW02	PW03	PW03	PW03
	Sample Date	11/8/12	10/3/11	5/14/12	11/5/12	4/29/13	10/3/11	5/14/12	11/5/12	4/29/13
Parameter	Unit	Round 3	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Water Isotopes										
δ^{2}H	‰	-92.95	-72.05	-71.82	-71.40	-71.58	-68.20	-65.94	-65.98	-65.70
δ^{18}O	‰	-11.94	-10.77	-9.91	-9.87	-10.21	-10.13	-9.11	-9.21	-9.39
Strontium Isotopes										
Sr	µg/L	625	311	379	382	357	268	734	742	643
Rb	µg/L	7.4	3.75	4.3	4.2	4.4	0.94	2.0	2.1	2.3
^{87}Sr/^{86}Sr	Atom Ratio	0.70751	0.711915	0.71169	0.71174	0.711785	0.708331	0.70896	0.70893	0.709004
1/Sr	L/µg	0.0016	0.0032	0.0026	0.0026	0.00280	0.0037	0.0014	0.0013	0.00156
Rb/Sr	Weight Ratio	0.0118	0.0121	0.0113	0.0110	0.01232	0.0035	0.0027	0.0028	0.00358

Table B-7 Sample Results - Water Isotopes and Strontium Isotopes (Raton Basin, Colorado)

	Sample	SW01	SW01	SW01	SW01	SW02	SW02	SW02	SW03	SW03	SW03
	Sample Date	10/4/11	5/14/12	11/7/12	4/30/13	5/14/12	11/6/12	4/30/13	5/15/12	11/6/12	4/30/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
Water Isotopes											
$\delta^{2}H$	‰	-69.22	-71.50	-71.97	-72.28	-71.76	-71.52	-72.56	-72.04	-73.33 J	-74.70
$\delta^{18}O$	‰	-9.18	-9.66	-9.86	-9.83	-9.56	-9.75	-9.86	-9.76	-10.14 J	-10.33
Strontium Isotopes											
Sr	µg/L	287	306	386	254	598	694	599	575	294	256
Rb	µg/L	0.55	0.9	1.1	1.7	1.1	<1.0	<1	6.6	3.6	4.4
$^{87}Sr/^{86}Sr$	Atom Ratio	0.712293	0.71211	0.71199	0.712151	0.71264	0.71261	0.712673	0.71098	0.71044	0.711946
1/Sr	L/µg	0.0035	0.0033	0.0026	0.00394	0.0017	0.0014	0.00167	0.0017	0.0034	0.00391
Rb/Sr	Weight Ratio	0.0019	0.0029	0.0028	0.00669	0.0018	NR	NR	0.0115	0.0122	0.01719

Table B-8 Sample Results - Isotech Gas Isotopes (Raton Basin, Colorado)

	Sample	MW01	MW01	MW01	MW01	MW02	MW02	MW02	MW02
	Sample Date	10/3/11	5/15/12	11/5/12	4/29/13	10/4/11	5/15/12	11/6/12	4/30/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Helium	%	NR	NR	NA	NA	NR	NR	NA	NA
Hydrogen	%	NR	ND	ND	ND	ND	ND	ND	ND
Argon	%	1.80	1.830	0.809	1.74	1.15	1.270	0.941	1.17
Oxygen	%	5.08	4.600	1.14	2.78	2.69	3.800	2.15	2.71
Carbon dioxide	%	2.51	2.410	2.55	2.34	0.24	0.1400	0.16	0.12
Nitrogen	%	90.4	90.99	95.33	92.93	66.6	70.47	70.97	68.48
Carbon monoxide	%	0.020	ND	ND	ND	ND	ND	ND	ND
Methane	%	0.16	0.1680	0.175	0.2140	29.31	24.32	25.77	27.52
Ethane	%	ND	ND	ND	ND	0.005	0.0037	0.0043	0.0042
Ethene	%	ND	ND	ND	ND	ND	ND	ND	ND
Propane	%	ND	ND	ND	ND	ND	ND	ND	ND
Propylene	%	NR	ND	ND	ND	NR	ND	ND	ND
Isobutane	%	ND	ND	ND	ND	ND	ND	ND	ND
Normal Butane	%	ND	ND	ND	ND	ND	ND	ND	ND
Isopentane	%	ND	ND	ND	ND	ND	ND	ND	ND
Normal Pentane	%	ND	ND	ND	ND	ND	ND	ND	ND
Hexane Plus	%	0.0008	ND	ND	ND	ND	ND	ND	ND
$\delta^{13}C_1$	‰	NR	NR	NR	NR	-60.13	-59.91	-59.59	-59.81
δDC_1	‰	NR	NR	NR	NR	-225.9	-221.6	-220.4	-222.9
$\delta^{13}C_2$	‰	NR	NR	NR	NR	NR	NR	NR	NR
$\delta^{13}C$ DIC	‰	-15.56	-15.65	-15.47	-15.19	-15.36	-14.94	-15.69	-15.25
$\delta^{34}S\ SO4^{2-}$	‰	NR	-9.1	-9.3	-8.5	NR	-3.5	-3.6	-1.7
$\delta^{18}O\ SO4^{2-}$	‰	NR	3.2	3.9	3.9	NR	4.0	5.2	6.9
$\delta^{34}S$ H2S	‰	NR	NR	NA	NA	NR	NR	NR[2]	NR[2]
Specific Gravity		0.995	0.994	0.986	0.990	0.856	0.878	0.868	0.863
BTU		2.00	2	2	2	297	246	261	279
Helium dilution	factor	0.76	0.77	0.80	0.79	0.64	0.64	0.72	0.64

Table B-8 Sample Results - Isotech Gas Isotopes (Raton Basin, Colorado)

	Sample	MW03	MW03	MW03	MW03	MW04	MW05	DW01	DW01
	Sample Date	10/4/11	5/15/12	11/7/12	5/1/13	10/5/11	10/5/11	10/3/11	5/15/12
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 1	Round 1	Round 2
Helium	%	NR	NR	NA	NA	NR	NR	NR	NR
Hydrogen	%	ND	ND	ND	ND	ND	ND	NR	ND
Argon	%	0.89	1.210	0.361	1.02	0.70	0.39	1.55	1.550
Oxygen	%	7.28	11.32	1.73	6.67	2.53	0.01	16.88	16.29
Carbon dioxide	%	0.62	0.6000	0.34	0.66	0.02	0.02	4.87	4.900
Nitrogen	%	52.2	62.91	19.00	54.23	34.9	18.7	76.7	77.21
Carbon monoxide	%	0.011	0.0260	ND	ND	0.007	ND	0.047	ND
Methane	%	38.93	23.92	78.51	37.40	61.82	80.85	0.00	0.0513
Ethane	%	0.041	0.0171	0.0556	0.0206	0.015	0.034	ND	ND
Ethene	%	0.0020	0.0012	0.0014	0.0012	ND	ND	ND	ND
Propane	%	0.0045	0.0004	0.0028	0.0004	0.0009	0.0019	ND	ND
Propylene	%	NR	ND	ND	ND	NR	NR	NR	ND
Isobutane	%	0.0017	ND	0.0014	0.0004	0.0002	0.0002	ND	ND
Normal Butane	%	0.0008	ND	0.0006	ND	ND	0.0002	ND	ND
Isopentane	%	0.0003	ND	ND	ND	ND	ND	ND	ND
Normal Pentane	%	ND	ND	ND	ND	ND	ND	ND	ND
Hexane Plus	%	ND	ND	ND	ND	ND	ND	0.0004	ND
$\delta^{13}C_1$	‰	-65.53	-65.20	-65.79	-64.62	-47.95	-45.41	NR	NR
δDC_1	‰	-252.0	-236.6	-257.2	-238.9	-222.6	-194.3	NR	NR
$\delta^{13}C_2$	‰	NR	NR	NR	NR	NR	NR	NR	NR
δ^{13}C DIC	‰	-2.38	-1.06	-1.21	-1.44	-27.36	-37.86	-13.11	-13.11
δ^{34}S SO4^{2-}	‰	NR	NR	NR[1]	NR[1]	NR	NR	NR	-4.0
δ^{18}O SO4^{2-}	‰	NR	NR	NR[1]	NR[1]	NR	NR	NR	3.8
δ^{34}S H2S	‰	NR	NR	NA	NA	NR	NR	NR	NR
Specific Gravity		0.824	0.892	0.649	0.830	0.718	0.635	1.024	1.023
BTU		395	243	797	379	627	820	0	1
Helium dilution	factor	0.65	0.75	0.64	0.75	0.57	0.52	0.75	0.72

Table B-8 Sample Results - Isotech Gas Isotopes (Raton Basin, Colorado)

	Sample	DW02	DW02	DW02	DW02	DW03	DW03	DW03	DW03
	Sample Date	10/3/11	5/14/12	11/5/12	4/29/13	10/3/11	5/15/12	11/5/12	4/30/13
Parameter	**Unit**	**Round 1**	**Round 2**	**Round 3**	**Round 4**	**Round 1**	**Round 2**	**Round 3**	**Round 4**
Helium	%	NR	NR	NA	NA	NR	NR	NA	NA
Hydrogen	%	NR	ND	ND	ND	NR	ND	ND	ND
Argon	%	1.60	1.750	1.06	1.44	1.64	1.640	0.735	1.65
Oxygen	%	17.32	5.120	8.02	27.66	13.50	15.80	11.30	8.28
Carbon dioxide	%	0.33	1.070	1.38	0.71	4.03	4.270	3.84	4.65
Nitrogen	%	80.5	91.86	88.99	70.18	80.6	78.25	83.96	85.37
Carbon monoxide	%	0.073	0.0980	ND	ND	0.100	0.0370	ND	ND
Methane	%	0.20	0.1070	0.547	0.0145	0.08	0.0013	0.165	0.0507
Ethane	%	ND	ND	ND	ND	0.000	ND	ND	ND
Ethene	%	ND	ND	ND	ND	ND	ND	ND	ND
Propane	%	ND	ND	ND	ND	0.0004	ND	ND	ND
Propylene	%	NR	ND	ND	ND	NR	ND	ND	ND
Isobutane	%	ND	ND	ND	ND	ND	ND	ND	ND
Normal Butane	%	ND	ND	ND	ND	0.0004	ND	ND	ND
Isopentane	%	ND	ND	ND	ND	ND	ND	ND	ND
Normal Pentane	%	ND	ND	ND	ND	ND	ND	ND	ND
Hexane Plus	%	0.0008	ND	ND	ND	0.0012	ND	ND	ND
$\delta^{13}C_1$	‰	NR	NR	NR	NR	NR	NR	NR	NR
δDC_1	‰	NR	NR	NR	NR	NR	NR	NR	NR
$\delta^{13}C_2$	‰	NR	NR	NR	NR	NR	NR	NR	NR
$\delta^{13}C$ DIC	‰	-16.09	-16.02	-16.03	-16.02	-13.72	-13.63	-13.52	-12.94
$\delta^{34}S$ $SO4^{2-}$	‰	NR	-9.4	-7.9	-6.9	NR	-7.6	-8.1	-7.4
$\delta^{18}O$ $SO4^{2-}$	‰	NR	2.8	3.6	4.6	NR	2.7	3.4	4.2
$\delta^{34}S$ H2S	‰	NR	NR	NA	NA	NR	NR	NA	NA
Specific Gravity		0.999	0.987	0.988	1.015	1.014	1.019	1.006	1.011
BTU		2.00	1	6	0	1.00	0	2	1
Helium dilution	factor	0.75	0.78	0.79	0.77	0.75	0.77	0.80	0.79

Table B-8 Sample Results - Isotech Gas Isotopes (Raton Basin, Colorado)

	Sample	DW04	DW04	DW04	DW05	DW05	DW05	DW05
	Sample Date	10/4/11	11/6/12	4/30/13	10/4/11	5/14/12	11/5/12	4/29/13
Parameter	Unit	Round 1	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Helium	%	NR	NA	NA	NR	NR	NA	NA
Hydrogen	%	ND	ND	ND	ND	ND	ND	ND
Argon	%	0.45	0.403	0.248	1.71	1.800	0.834	1.73
Oxygen	%	6.81	6.68	3.79	13.31	8.060	8.42	4.72
Carbon dioxide	%	0.83	0.65	0.56	0.34	0.2900	0.28	0.30
Nitrogen	%	21.7	21.29	13.63	84.6	89.79	89.95	93.07
Carbon monoxide	%	0.047	ND	ND	0.023	ND	ND	ND
Methane	%	70.14	70.96	81.74	0.03	0.0632	0.514	0.1780
Ethane	%	0.030	0.0190	0.0308	ND	ND	ND	ND
Ethene	%	0.0004	ND	ND	ND	ND	ND	ND
Propane	%	0.0007	ND	0.0003	ND	ND	ND	ND
Propylene	%	NR	ND	ND	NR	ND	ND	ND
Isobutane	%	0.0007	ND	ND	ND	ND	ND	ND
Normal Butane	%	ND	ND	ND	ND	ND	ND	ND
Isopentane	%	ND	ND	ND	ND	ND	ND	ND
Normal Pentane	%	ND	ND	ND	ND	ND	ND	ND
Hexane Plus	%	ND	ND	ND	ND	ND	ND	0.0004
$\delta^{13}C_1$	‰	-56.77	-53.72	-53.12	NR	NR	NR	NR
δDC_1	‰	-264.2	-248.0	-247.1	NR	NR	NR	NR
$\delta^{13}C_2$	‰	NR	NR	NR	NR	NR	NR	NR
$\delta^{13}C$ DIC	‰	-13.80	-9.87	-9.23	-15.27	-15.77	-15.05	-15.46
$\delta^{34}S\ SO4^{2-}$	‰	NR	-7.0	-5.8	NR	-4.1	-3.4	-2.2
$\delta^{18}O\ SO4^{2-}$	‰	NR	4.6	4.8	NR	4.9	6.5	7.6 *
$\delta^{34}S\ H2S$	‰	NR	NA	NA	NR	NR	NA	NA
Specific Gravity		0.693	0.688	0.639	0.994	0.987	0.982	0.982
BTU		711	719	829	0	1	5	2
Helium dilution	factor	0.71	0.72	0.67	0.77	0.78	0.79	0.76

Table B-8 Sample Results - Isotech Gas Isotopes (Raton Basin, Colorado)

	Sample	DW06	DW06	DW06	DW06	DW07	DW07	DW07	DW07
	Sample Date	10/6/11	5/16/12	11/8/12	5/2/13	10/6/11	5/16/12	11/6/12	5/1/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Helium	%	NR	NR	NA	NA	NR	NR	NA	NA
Hydrogen	%	ND	ND	ND	ND	ND	ND	ND	ND
Argon	%	0.65	1.100	0.753	0.889	1.80	1.690	1.62	1.77
Oxygen	%	0.09	0.0700	0.044	0.15	6.35	12.31	13.09	3.03
Carbon dioxide	%	0.40	0.4900	0.36	0.40	0.08	0.0750	0.082	0.086
Nitrogen	%	31.4	56.30	39.77	45.41	91.6	85.81	85.08	94.91
Carbon monoxide	%	ND	ND	ND	ND	0.046	ND	ND	ND
Methane	%	67.44	42.02	59.04	53.12	0.15	0.1140	0.124	0.2010
Ethane	%	0.034	0.0225	0.0270	0.0264	ND	ND	ND	ND
Ethene	%	0.0004	ND	ND	ND	ND	ND	ND	ND
Propane	%	0.0025	0.0015	0.0016	0.0015	ND	ND	ND	ND
Propylene	%	NR	ND	ND	ND	NR	ND	ND	ND
Isobutane	%	0.0004	ND	0.0003	ND	ND	ND	ND	ND
Normal Butane	%	0.0004	ND	0.0003	ND	ND	ND	ND	ND
Isopentane	%	0.0004	ND	ND	ND	ND	ND	ND	ND
Normal Pentane	%	0.0004	ND	ND	ND	ND	ND	ND	ND
Hexane Plus	%	ND	ND	ND	ND	ND	ND	ND	ND
$\delta^{13}C_1$	‰	-48.72	-46.87	-49.21	-48.96	NR	NR	NR	NR
δDC_1	‰	-225.6	-204.7	-230.6	-221.4	NR	NR	NR	NR
$\delta^{13}C_2$	‰	NR	NR	NR	NR	NR	NR	NR	NR
δ^{13}C DIC	‰	-25.66	-24.87	-21.53	-21.93	-13.81	-14.04	-13.88	-13.61
δ^{34}S SO4^{2-}	‰	NR	35.9	24.4	27.7	NR	5.3	5.2	7.1
δ^{18}O SO4^{2-}	‰	NR	9.9	9.3	11.1	NR	5.0	6.9	7.7
δ^{34}S H2S	‰	NR	-11.9	-15.8	-14.1	NR	NR	NA	NA
Specific Gravity		0.694	0.801	0.728	0.754	0.983	0.991	0.992	0.978
BTU		684	426	599	539	2.00	1	1	2
Helium dilution	factor	0.71	0.73	0.68	0.73	0.75	0.77	0.78	0.77

Table B-8 Sample Results - Isotech Gas Isotopes (Raton Basin, Colorado)

	Sample	DW08	DW08	DW08	DW08	DW09	DW09	DW09	DW09
	Sample Date	10/5/11	5/16/12	11/7/12	5/1/13	10/5/11	5/16/12	11/8/12	5/1/13
Parameter	**Unit**	**Round 1**	**Round 2**	**Round 3**	**Round 4**	**Round 1**	**Round 2**	**Round 3**	**Round 4**
Helium	%	NR	NR	NA	NA	NR	NR	NA	NA
Hydrogen	%	ND	ND	ND	ND	ND	ND	ND	ND
Argon	%	1.19	1.030	1.20	1.03	0.80	0.9460	0.993	0.819
Oxygen	%	0.02	0.1400	0.045	1.06	2.06	0.053	0.025	0.073
Carbon dioxide	%	0.17	0.1400	0.15	0.18	1.12	0.1800	0.31	0.22
Nitrogen	%	58.0	49.29	61.13	50.42	38.1	47.28	54.31	51.18
Carbon monoxide	%	ND	ND	ND	ND	0.009	ND	ND	ND
Methane	%	40.56	49.37	37.45	47.28	57.91	51.51	44.34	47.68
Ethane	%	0.026	0.0311	0.0251	0.0313	0.029	0.0292	0.0261	0.0305
Ethene	%	0.0004	ND	ND	ND	0.0003	ND	ND	ND
Propane	%	0.0008	0.0012	0.0008	0.0011	0.0013	0.0009	0.0009	0.0010
Propylene	%	NR	ND	ND	ND	NR	ND	ND	ND
Isobutane	%	ND	ND	ND	ND	0.0003	ND	ND	0.0002
Normal Butane	%	ND	ND	ND	ND	0.0003	ND	ND	ND
Isopentane	%	ND	ND	ND	ND	ND	ND	ND	ND
Normal Pentane	%	ND	ND	ND	ND	ND	ND	ND	ND
Hexane Plus	%	ND	ND	ND	ND	ND	ND	ND	ND
$\delta^{13}C_1$	‰	-38.75	-40.56	-41.28	-43.39	-48.40	-45.73	-44.31	-43.59
δDC_1	‰	-130.5	-142.6	-153.9	-175.0	-218.2	-186.7	-167.7	-158.9
$\delta^{13}C_2$	‰	NR	NR	NR	NR	NR	NR	NR	NR
δ^{13}C DIC	‰	-34.05	-35.96	-34.61	-33.33	-29.49	-31.33	-32.51	-33.42
δ^{34}S SO4^{2-}	‰	NR	24.4	21.9	24.2	NR	8.1	9.5	5.9
δ^{18}O SO4^{2-}	‰	NR	5.6	7.0	7.3	NR	-3.4	-0.6	-3.0
δ^{34}S H2S	‰	NR	-11.7	-17.2	-13.7	NR	-15.5	-11.0	-6.0
Specific Gravity		0.806	0.768	0.818	0.779	0.740	0.759	0.790	0.775
BTU		411	501	380	479	587	522	450	484
Helium dilution	factor	0.75	0.74	0.76	0.73	0.62	0.68	0.67	0.50

Table B-8 Sample Results - Isotech Gas Isotopes (Raton Basin, Colorado)

	Sample	DW10	DW10	DW10	DW10	DW11	DW11	DW11	DW11	DW12
	Sample Date	10/5/11	5/17/12	11/8/12	5/1/13	10/6/11	5/15/12	11/7/12	4/29/13	10/6/11
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4	Round 1
Helium	%	NR	NR	NA	NA	NR	NR	NA	NA	NR
Hydrogen	%	ND	ND	ND	ND	ND	ND	ND	ND	ND
Argon	%	0.60	0.8290	0.780	0.807	1.60	1.600	1.32	1.50	1.63
Oxygen	%	0.01	0.084	0.077	0.093	8.53	8.250	13.47	3.30	6.92
Carbon dioxide	%	0.03	0.0280	ND	0.04	1.49	1.930	0.85	1.48	0.19
Nitrogen	%	30.9	40.28	40.07	41.97	84.4	83.59	65.22	73.20	84.0
Carbon monoxide	%	ND	ND	ND	ND	0.044	0.0720	ND	ND	ND
Methane	%	68.41	58.75	59.05	57.07	3.96	4.560	19.13	20.52	7.24
Ethane	%	0.026	0.0240	0.0248	0.0251	0.001	0.0023	0.0055	0.0034	0.003
Ethene	%	0.0002	ND	ND	ND	ND	ND	ND	ND	0.0004
Propane	%	0.0012	0.0007	0.0009	0.0007	ND	ND	ND	ND	0.0004
Propylene	%	NR	ND	ND	ND	NR	ND	ND	ND	NR
Isobutane	%	0.0002	ND	ND	ND	ND	ND	ND	ND	ND
Normal Butane	%	0.0002	0.0007	0.0006	ND	ND	ND	ND	ND	0.0004
Isopentane	%	ND	ND	ND	ND	ND	ND	ND	ND	ND
Normal Pentane	%	ND	ND	ND	ND	ND	ND	ND	ND	ND
Hexane Plus	%	ND	ND	ND	ND	ND	ND	ND	0.0005	ND
$\delta^{13}C_1$	‰	-39.08	-39.40	-38.03	-37.68	-33.66	-43.53††	-52.36	-46.68	-60.83
δDC_1	‰	-152.7	-155.5	-150.9	-147.4	-51.5	-136††	-213.2	-168.9	-227.4
$\delta^{13}C_2$	‰	NR	NR	NR	NR	NR	NR	NR	NR	NR
$\delta^{13}C$ DIC	‰	-40.18	-40.59	-40.94	-39.59	-16.47	-15.91	-14.42	-15.60	-14.96
$\delta^{34}S\ SO4^{2-}$	‰	NR	39.5	34.9	32.5	NR	4.0	5.3	6.7	NR
$\delta^{18}O\ SO4^{2-}$	‰	NR	8.4	8.7	9.8	NR	-0.4	2.4	2.6	NR
$\delta^{34}S\ H2S$	‰	NR	-9.0	-9.9	-10.0	NR	NR	NA	NA	NR
Specific Gravity		0.687	0.728	0.727	0.735	0.977	0.977	0.917	0.901	0.955
BTU		694	596	599	579	40.0	46	194	208	73.0
Helium dilution	factor	0.57	0.71	0.68	0.71	0.77	0.78	0.76	0.79	0.73

Table B-8 Sample Results - Isotech Gas Isotopes (Raton Basin, Colorado)

	Sample	DW13	DW13	DW13	DW14	DW14	DW14	DW15
	Sample Date	5/15/12	11/6/12	4/30/13	5/17/12	11/8/12	5/1/13	11/8/12
Parameter	Unit	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4	Round 3
Helium	%	NR	NA	NA	NR	NA	NA	NA
Hydrogen	%	ND	ND	ND	ND	ND	ND	ND
Argon	%	1.700	1.68	1.70	1.580	1.59	1.59	1.78
Oxygen	%	10.04	5.42	8.86	17.05	13.32	15.93	3.14
Carbon dioxide	%	5.210	5.21	5.03	1.470	0.087	0.16	1.49
Nitrogen	%	83.01	87.68	84.40	79.71	84.97	82.30	93.58
Carbon monoxide	%	0.0370	ND	ND	0.1800	ND	ND	ND
Methane	%	0.0045	0.0092	0.0150	0.0093	0.0344	0.0192	0.0058
Ethane	%	ND	ND	ND	ND	ND	ND	ND
Ethene	%	ND	ND	ND	ND	ND	0.0009	ND
Propane	%	ND	ND	ND	ND	ND	ND	ND
Propylene	%	ND	ND	ND	ND	ND	ND	ND
Isobutane	%	ND	ND	ND	ND	ND	ND	ND
Normal Butane	%	ND	ND	ND	ND	ND	ND	ND
Isopentane	%	ND	ND	ND	ND	ND	ND	ND
Normal Pentane	%	ND	ND	ND	ND	ND	ND	ND
Hexane Plus	%	ND	ND	ND	ND	ND	ND	ND
$\delta^{13}C_1$	‰	NR	NR	NR	NR	NR	NR	NR
δDC_1	‰	NR	NR	NR	NR	NR	NR	NR
$\delta^{13}C_2$	‰	NR	NR	NR	NR	NR	NR	NR
$\delta^{13}C$ DIC	‰	-12.76	-11.65	-11.12	-12.54	-12.30	-12.01	-20.24
$\delta^{34}S$ $SO4^{2-}$	‰	-8.2	-10.4	-9.4	-1.9	-2.2	-1.3	10.5
$\delta^{18}O$ $SO4^{2-}$	‰	0.1	-0.2	2.2	0.4	0.6	1.7	4.6
$\delta^{34}S$ H2S	‰	NR	NA	NA	NR	NA	NA	NR[2]
Specific Gravity		1.017	1.010	1.014	1.005	0.992	0.997	0.987
BTU		0	0	0	1	0	0	0
Helium dilution	factor	0.77	0.80	0.76	0.78	0.77	0.77	0.79

Table B-8 Sample Results - Isotech Gas Isotopes (Raton Basin, Colorado)

	Sample	PW01	PW01	PW01	PW01	PW02	PW03	PW03	PW03
	Sample Date	10/3/11	5/14/12	11/5/12	4/29/13	10/3/11	5/14/12	11/5/12	4/29/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Helium	%	0.0058	NR	NA	NA	NR	NR	NA	NA
Hydrogen	%	ND	ND	ND	ND	NR	ND	ND	ND
Argon	%	0.05	0.1640	0.054	0.067	0.12	0.1300	0.106	0.049
Oxygen	%	0.99	3.200	0.22	0.94	1.90	0.3500	0.049	0.58
Carbon dioxide	%	0.26	0.6900	0.70	0.69	0.53	2.050	2.01	0.89
Nitrogen	%	2.2	6.950	2.39	2.83	5.7	5.860	5.61	2.11
Carbon monoxide	%	ND	ND	ND	ND	ND	ND	ND	ND
Methane	%	96.46	88.98	96.62	95.45	91.53	91.58	92.19	96.34
Ethane	%	0.015	0.0175	0.0197	0.0199	0.261	0.0295	0.0300	0.0293
Ethene	%	ND	ND	ND	ND	ND	ND	ND	ND
Propane	%	0.0003	0.0004	0.0003	0.0003	0.0069	0.0010	0.0011	0.0011
Propylene	%	NR	ND	ND	ND	NR	ND	ND	ND
Isobutane	%	0.0001	ND	ND	ND	0.0010	ND	ND	0.0004
Normal Butane	%	ND	ND	ND	ND	0.0005	ND	ND	0.0004
Isopentane	%	ND	ND	ND	ND	ND	ND	ND	0.0002
Normal Pentane	%	ND	ND	ND	ND	ND	ND	ND	ND
Hexane Plus	%	0.0001	ND	ND	ND	0.0005	ND	ND	0.0002
$\delta^{13}C_1$	‰	-52.74	-52.29	-52.11	-52.04	-47.67	-45.59	-45.68	-46.69
δDC_1	‰	-233.9	-238.4	-230.4	-234.1	-233.1	-222.6	-220.8	-222.9
$\delta^{13}C_2$	‰	NR	NR	NR	NR	-22.1	NR	NR	NR
$\delta^{13}C$ DIC	‰	16.53	16.05	16.71	17.98	1.23	10.16	6.45	12.50
$\delta^{34}S\ SO4^{2-}$	‰	NR	NR	NR[1]	NR[1]	NR	NR	NR[1]	NR[1]
$\delta^{18}O\ SO4^{2-}$	‰	NR	NR	NR[1]	NR[1]	NR	NR	NR[1]	NR[1]
$\delta^{34}S\ H2S$	‰	NR	NR	NA	NA	NR	NR	NR[2]	NA
Specific Gravity		0.572	0.608	0.572	0.578	0.595	0.601	0.598	0.575
BTU		978	902	980	968	933	929	935	977
Helium dilution	factor	NR	0.72	0.70	0.69	0.59	0.69	0.71	0.45

Table B-8 Sample Results - Isotech Gas Isotopes (Raton Basin, Colorado)

	Sample	SW01	SW01	SW01	SW01	SW02	SW02	SW02
	Sample Date	10/4/11	5/14/12	11/7/12	4/30/13	5/14/12	11/6/12	4/30/13
Parameter	Unit	Round 1	Round 2	Round 3	Round 4	Round 2	Round 3	Round 4
Helium	%	NR	NR	NA	NA	NR	NA	NA
Hydrogen	%	ND	ND	ND	ND	ND	ND	ND
Argon	%	1.44	1.410	1.39	1.36	1.530	1.05	1.48
Oxygen	%	30.17	30.59	29.04	30.70	23.21	22.58	21.92
Carbon dioxide	%	0.45	0.5400	0.56	0.54	1.640	2.20	2.14
Nitrogen	%	67.9	67.34	69.01	67.33	73.39	74.14	74.45
Carbon monoxide	%	0.069	0.1100	ND	0.060	0.1700	ND	ND
Methane	%	0.00	0.0055	0.0011	0.0141	0.0598	0.0301	0.0108
Ethane	%	ND	ND	ND	ND	ND	ND	ND
Ethene	%	ND	ND	ND	ND	ND	ND	ND
Propane	%	ND	ND	ND	ND	ND	ND	ND
Propylene	%	NR	ND	ND	ND	ND	ND	ND
Isobutane	%	ND	ND	ND	ND	ND	ND	ND
Normal Butane	%	ND	ND	ND	ND	ND	ND	ND
Isopentane	%	ND	ND	ND	ND	ND	ND	ND
Normal Pentane	%	ND	ND	ND	ND	ND	ND	ND
Hexane Plus	%	ND	ND	ND	ND	ND	ND	ND
$\delta^{13}C_1$	‰	NR	NR	NR	NR	NR	NR	NR
δDC_1	‰	NR	NR	NR	NR	NR	NR	NR
$\delta^{13}C_2$	‰	NR	NR	NR	NR	NR	NR	NR
δ^{13}C DIC	‰	4.83	4.55	3.97	4.47	7.34	8.64	8.41
δ^{34}S SO4^{2-}	‰	NR	-3.4	-0.4	0.5	-4.3	-6.0	-3.7
δ^{18}O SO4^{2-}	‰	NR	4.1	2.8	2.6	7.6	9.4	9.4
δ^{34}S H2S	‰	NR	NR	NA	NA	NR	NA	NA
Specific Gravity		1.017	1.018	1.016	1.018	1.014	1.015	1.015
BTU		0	0	0	0	1	0	0
Helium dilution	factor	0.78	0.77	0.72	0.79	0.78	0.77	0.77

Table B-8 Sample Results - Isotech Gas Isotopes (Raton Basin, Colorado)

	Sample	SW03	SW03	SW03
	Sample Date	5/15/12	11/6/12	4/30/13
Parameter	Unit	Round 2	Round 3	Round 4
Helium	%	NR	NA	NA
Hydrogen	%	NR	ND	ND
Argon	%	NR	0.236	0.187
Oxygen	%	NR	4.40	3.58
Carbon dioxide	%	NR	0.93	0.95
Nitrogen	%	NR	13.00	9.83
Carbon monoxide	%	NR	ND	ND
Methane	%	NR	81.41	85.43
Ethane	%	NR	0.0184	0.0227
Ethene	%	NR	ND	ND
Propane	%	NR	0.0011	0.0006
Propylene	%	NR	ND	ND
Isobutane	%	NR	ND	ND
Normal Butane	%	NR	ND	ND
Isopentane	%	NR	ND	ND
Normal Pentane	%	NR	ND	ND
Hexane Plus	%	NR	0.0004	ND
$\delta^{13}C_1$	‰	NR	-51.68	-53.59
δDC_1	‰	NR	-230.3	-235.2
$\delta^{13}C_2$	‰	NR	NR	NR
$\delta^{13}C$ DIC	‰	8.71	10.31	7.98
$\delta^{34}S$ $SO4^{2-}$	‰	NR	NR[1]	NR[1]
$\delta^{18}O$ $SO4^{2-}$	‰	NR	NR[1]	NR[1]
$\delta^{34}S$ H2S	‰	NR	NA	NA
Specific Gravity		NR	0.643	0.625
BTU		NR	826	866
Helium dilution	factor	NR	0.72	0.68

Appendix C
Background Data
Retrospective Case Study in the Raton Basin, Colorado

U.S. Environmental Protection Agency
Office of Research and Development
Washington, DC

May 2015
EPA/600/R-14/091

Table of Contents

List of Tables

List of Figures

C.1. Land Use

This section presents descriptions of land uses in Huerfano and Las Animas counties as a whole, followed by descriptions of land uses in and around the sampling points of this study. Building on information provided in the Background section of this report, information on the use of agricultural land was obtained from the Cropland Data Layer produced by the National Agricultural Statistics Service (U.S. Department of Agriculture, 2012), which contains data on agricultural uses of land based on satellite imagery and extensive agricultural ground checking of the imagery. Figures C-1a and C-1b show land uses, including agricultural uses, in Huerfano and Las Animas counties, respectively, in 2012. Tables C-1a and C-1b show the percentages of each county's land devoted to the largest agricultural uses. Grassland herbaceous was the largest agricultural land use in both counties, accounting for approximately 50% and 62%, respectively, of the land in Huerfano and Las Animas counties.

Land use change data from the U.S. Geological Survey's National Land Cover Database for 1992 and 2006 are not directly comparable (U.S. Geological Survey, 2012). However, it is possible to compare data from 1992 with data from 2001 and to then compare data from 2001 with that from 2006 to identify land use changes in the 1992 to 2001 and 2001 to 2006 sub-periods (Multi-Resolution Land Characteristics Consortium, 2013). Figures C-2a and C-2b show land use changes in Huerfano and Las Animas counties, respectively, between 1992 and 2001 and between 2001 and 2006. Tables C-2a and C-2b present data on the changes in land use in the counties in the same two sub-periods. It can be seen from the tables that only a very small proportion (i.e., less than 1%) of the land in the counties changed use during either sub-period.

The populations in both counties (an indicator of the intensity of land use) were declining until 1990, before increasing between 1990 and 2010 by approximately 12% in Huerfano County and approximately 13% in Las Animas County (see Figure C-3) (U.S. Census Bureau, 2013a-d). In 2011, the population density was approximately 4 persons per square mile in Huerfano County and approximately 3 persons per square mile in Las Animas County. The state as a whole has a population density of approximately 49 persons per square mile (U.S. Census Bureau, 2012a).

In 2010, 0.1% of the land area in both Huerfano and Las Animas counties was taken up by urban areas (another indicator of the intensity of land use), whereas 1.5% of the land in the entire state was taken up by urban areas (U.S. Census Bureau, 2012b).

Employment is another broad indicator of land use in a county. Table C-3 identifies the largest industries, by employment, in Huerfano and Las Animas counties. The service industry categories of health care and social assistance, retail trade, and accommodation and food services accounted for a majority of employment in both counties.

C.2. Search Areas

C.2.1. Land Use

Figures C-4 through C-7, which were created using data from the National Land Cover Database, present land use maps for the search area in 1992 and 2006. The search area in Huerfano County and Search

Area C in Las Animas County encompass a 3-mile search radius around the sampling points in the counties, whereas Search Areas A and B in Las Animas County encompass a 1-mile search radius around the sampling points in the county. The search areas are used to focus the analysis of land use patterns and the environmental records searches. Tables C-4 through C-7 present data on land use in the search areas in 1992 and 2006. In both years, grassland/herbaceous, shrub/scrub, and evergreen forest were the largest land use categories in the search area in Huerfano County, and evergreen forest and shrub/scrub were the largest land use categories in the search areas in Las Animas County.

C.2.2. Crop Land

Figures C-8 through C-11 show land uses, including agricultural land uses, in the search areas in 2012. Tables C-8 through C-11 show the percentages of land devoted to the largest agricultural uses in the search areas. Grassland herbaceous comprised the largest agricultural land use in all of the search areas.

C.2.3. Land Use Changes

Figures C-12 through C-15 show land use changes in the search areas between 1992 and 2001 and between 2001 and 2006. Tables C-12 through C-15 show the changes in land use in the search areas during the two sub-periods. The tables show that, in general, there was either no change or extremely small changes (less than 1%) in land use in the search areas during the sub-periods.

C.3. Environmental Records Search

Environmental record searches of the North Fork Ranch and Arrowhead Ranchette in Las Animas County and Little Creek Field in Huerfano County were performed by Environmental Data Resources, Inc. (EDR). EDR provides a service for searching publically available databases and also provides data from their own proprietary databases. The database searches included records reviews of several federal, state, and tribal environmental databases and proprietary EDR environmental databases for the two study areas. The searches identified the documented use, storage, and release of hazardous materials and petroleum products (see Attachment 1).[1] Record dates varied based on the particular database from which the record was obtained. EDR began collecting a majority of the records in 1991 from the standard databases (State Hazardous Sites Cleanup Act Site Lists [SHWS]; Landfills [LF]; Leaking Underground Storage Tanks [LUST]; Underground Storage Tanks [UST]; Resource Conservation and Recovery Act [RCRA]; National Priority List [NPL]; Comprehensive Environmental Response, Compensation and Liability Information System [CERCLIS]; etc.). However, some databases (e.g., Spills) may have records dating back to the 1980s.

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[1] Environmental Data Resources, Inc. (EDR) does not search the EnviroFacts and its associated EnviroMapper databases but searches 19 of the 20 environmental databases covered by EnviroFacts, either as standalone databases (such as CERCLIS, RCRA, TSCA, etc.) or as databases searched as part of the Facility Index System/Facility Registry System (FINDS) database. The only EnviroFacts database that is not reviewed as part of an EDR search is the Cleanups in My Community (Cleanup) database, which maps and lists areas where hazardous waste is being or has been cleaned up throughout the United States. However, it is likely the information in the Cleanup database is also found in other databases that are part of EDR searches.

The record search areas were based on 1- and 3-mile-radii search areas centered around a single sampling point or a cluster of EPA sampling points. These search areas were chosen based on professional judgment considering the large size of the two study areas.

The identified records include historically contaminated properties; businesses that use, generate, transport, or dispose of hazardous materials or petroleum products in their operations; active contaminated sites that are currently under assessment and/or remediation; sites with NPDES and SPDES permits; and active and abandoned mines and landfills. All of the properties listed on the Environmental Records Search Report were reviewed and screened based on the EDR record search findings to determine whether they are potential candidate causes. The criteria used for the screening include relevant environmental information (including, but not limited to, notices of violations, current and historical use of the site, materials and wastes at the site, releases and/or spills), and distance from the sampling locations.

Sites that EDR could not automatically map due to poor or inadequate address information in the searched databases were not included on the EDR radius map. However, EDR determined that, based on the limited address information available, it is possible that these sites could be located within the stated search radius (e.g., zip code listed within searched radius) and are, therefore, listed on the Environmental Records Search Report as “orphan” sites. All orphan sites were screened to the extent possible based on limited site information available through additional searches of the databases listed above and information obtained through internet searches (i.e., on the EPA website and state websites). Additionally, through a more extensive review of the available records (including EnviroFacts, business listings, etc.), a location was determined for most orphan sites, and their approximate distance from the sampling points was measured on a map.

C.3.1. Oil and Gas Well Inventory

Well inventories were prepared for the same search areas described above for the EDR reports. All oil and gas wells identified within the search areas were selected for review. Specific focus was placed on wells within 1 mile of EPA sampling locations. Information was obtained from desktop surveys performed using searchable state agency databases. The oldest well spud date identified in this study was March 1973.

C.3.2. State Record Summary

The Colorado Oil and Gas Conservation Commission (COGCC) Information System website (http://cogcc.state.co.us/cogis) was used to find up-to-date well records for the study areas (see Tables C-16 and C-17). This database provides information on inspection and pollution prevention visits, including a listing of all inspections that have occurred at each well on record, whether violations were noted, and any enforcement that may have resulted. The system provides multiple options to search for records. Not all of the state’s records may be included in the state’s electronic database. Access to additional paper records can be obtained by appointment only from the particular state regional office. The oldest violation identified by the desktop survey for this investigation is from August 1995.

C.4. Evaluation of Data for the North Fork Ranch and Arrowhead Ranchette in Las Animas County

C.4.1. EDR Search Results for North Fork Ranch in Las Animas County

Three separate search areas were established for the EDR database searches to capture the Las Animas County sampling locations (see Figure C-16). The radii of these search areas were either 1 mile (search areas A and B, Arrowhead Ranchette) or 3 miles (Search Area C, North Fork Ranch). The database search identified 17 mapped sites/records within these search areas. An additional 20 orphan sites were identified during the searches. Orphan sites are those sites with poor locational information in the databases that may or may not exist outside the actual search radius. An attempt to locate these sites with information available in the reports and through internet searches was performed to aid in determining the potential for these sites to be candidate causes. Orphan sites often appear on more than one database (e.g., UST, LUST). The evaluations of the sites are summarized in Table C-18.

Of the 37 sites identified in the EDR reports, only 17 incidents/records/sites were retained as potential candidate causes. These sites were identified in the databases as described below:

- **Mines:** Twelve mine sites are or were located between 0.28 and 2.87 miles from the EPA Study sampling locations. Most of these mines were coal mines, but the resources extracted from some of them are unknown. Coal mines are potential sources of methane and other impacts on water quality (e.g., metals, pH, turbidity, and TDS); therefore, these sites were retained as potential candidate causes.
- **Leaking underground storage tanks (LUST):** Two LUST sites (1.3 miles and 1.6 miles from EPA Study sampling locations) were retained as potential candidate causes because the tanks contained gasoline and diesel, and some of the EPA Study samples contained gasoline-related volatile organic compounds (VOCs).
- **FINDS:** One site was retained as a potential candidate cause. This site, located 4.1 miles from RBSW01, was determined to be a coal mine listed under RCRA as a CESQG.
- **NPDES:** One site was retained as a potential candidate cause. This site was a potential mining operation located 1.9 miles from RBSW01.
- **RCRA CESQG:** One site listed on the RCRA CESQG database was retained as a potential candidate cause. The site was reported to be a source of ground water contamination and is located about 1.1 miles from RBSW01.

C.4.2. Oil and Gas Well Inventory Summary

As described above, the EPA determined the distances of their sampling locations from the wells identified in the COGCC database files (see Table C-16).

Three hundred and nine oil and gas wells are located in Las Animas County Search Areas A through C. Of these wells, 191 are located within 1 mile of an EPA Study sampling location (see Table C-17 and Figure C-16).

In summary, numerous oil and gas production wells are located in the study area. The presence of numerous oil and gas wells increase the probability of one or more of these features being a potential candidate cause for methane migration.

C.4.3. State Record Summary

Notice of Violations. Notices of violations (NOVs) were researched for all oil and gas wells within a 1-mile radius of the EPA Study sampling locations (see Table C-19). A total of 117 records were identified. Forty-three wells within 1 mile of an EPA Study sampling location were retained because they had notable violations that could be linked to candidate causes (see Table C-20). Each of these wells has one or more notable violations, including the following:

- Improper casing cementing,
- Erosion control resulting in migration of silt into waterways,
- Numerous spills of drill water and produced water from pits,
- Improper waste disposal, and
- Complaints about methane in domestic well water.

C.5. Evaluation of Data for Little Creek Field in Huerfano County

C.5.1. EDR Search Results for Little Creek Field in Huerfano County

Beginning in 1998, Petroglyph, Inc., began operating in the Little Creek Field to recover coalbed methane from coal within the Vermejo Formation. This process involves dewatering of the coal seams to allow release and eventual recovery of methane gas. In mid-2005, pumping rates were increased, lowering the water table within the Vermejo Formation. As a result of this activity, methane gas escaped into the overlying Poison Canyon Formation and was detected in domestic drinking water wells. Petroglyph shut in all gas wells in July 2007 and began a program in conjunction with COGCC to investigate, monitor, and mitigate methane within the Poison Canyon Formation. EPA sampling efforts were designed based on the detections of methane within selected drinking water wells.

One 3-mile-radius search area was established for the EDR database searches to capture all of the EPA sampling locations (see Figure C-17). The database search located two mapped sites/records within this search area, as well as an additional 27 orphan sites. Orphan sites are those sites with poor locational information in the databases that may or may not exist outside the actual search radius. An attempt to locate these sites with information available in the reports and through internet searches was performed to aid in determining the potential for these sites to be candidate causes. Orphan sites often appear on more than one database (e.g., UST, LUST). The evaluations of the sites are summarized in Table C-21.

Of the 29 sites identified in the EDR reports for Huerfano County, the incidents, records, and sites represented sand and gravel mines, several solid waste facilities, several hazardous waste handlers, and leaky underground storage tanks (USTs) and aboveground storage tanks (ASTs) containing gasoline, diesel, propane, and liquefied petroleum gas. However, none of these sites was retained as a potential candidate cause because of excessive distance (i.e., several miles) from the EPA Study sampling locations, the nature of site operations, or a lack of documented releases.

C.5.2. Oil and Gas Well Inventory Summary

As described above, the EPA determined the distances of their sampling locations from the wells identified in the COGCC database files (see Table C-16).

Seventy-five oil and gas wells are located within the Huerfano County 3-mile-radius search area, and 39 of these wells are located within 1 mile of an EPA Study sampling location (see Table C-17).

In summary, the numerous oil and gas production wells in the study area increase the probability that one or more of these features is the cause of the methane migration. However, it is likely that the regional effort to develop coalbed methane, rather than a single well, is the potential candidate cause that allowed the escape of methane gas into the overlying formation.

C.5.3. State Record Summary

Notice of Violations. NOVs were researched for all oil and gas wells within a 1-mile radius of the EPA Study sampling locations (see Table C-22). A total of six records were identified, including violations for the discharge of fluids from machinery; the need to produce, plug, or pass a mechanical integrity test; not properly restoring a site; and administrative issues. One NOV for a well within 1 mile of an EPA Study sampling location was retained as a notable violation that could be linked to candidate causes. This violation was for a minor oil leak from machinery (see Table C-23).

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Appendix C Tables

Table C-1a Major Agricultural Land Uses in Huerfano County in 2012

Agricultural Land Use	% of County Land
Grassland herbaceous	50.2
Alfalfa	0.7
Other hay/non-alfalfa	0.3

Source: U.S. Department of Agriculture, 2012.

Table C-1b Major Agricultural Land Uses in Las Animas County in 2012

Agricultural Land Use	% of County Land
Grassland herbaceous	62.2
Alfalfa	0.4
Fallow/idle cropland	0.3
Winter wheat	0.1

Source: U.S. Department of Agriculture, 2012.

Table C-2a Changes in Land Use, 1992 to 2001 and 2001 to 2006, in Huerfano County

Change in Land Use	% of County Land Area	
	1992 to 2001	2001 to 2006
No change	99.1	99.7
Change in land use	0.9	0.3
- to grassland/shrub	0.6	0.0
- to agriculture	0.1	0.0
- to wetlands	0.1	0.0
- to herbaceous	0.0	0.1
- to shrub/scrub	0.0	0.1
- to hay/pasture	0.0	0.1

Source: U.S. Geological Survey, 2012.

Note: Excluded from the table are land use categories for which the area that changed use represent less than one thousandth of the total county area. Consequently, the percentages in the columns may not sum to 100%.

Table C-2b Changes in Land Use, 1992 to 2001 and 2001 to 2006, in Las Animas County

Change in Land Use	% of County Land Area	
	1992 to 2001	2001 to 2006
No change	99.6	99.4
Change in land use	0.4	0.6
- to agriculture	0.2	0.0
- to grassland/shrub	0.1	0.0
- to herbaceous	0.0	0.2
- to shrub/scrub	0.0	0.4

Source: U.S. Geological Survey, 2012.
Note: Excluded from the table are land use categories for which the area that changed use represent less than one thousandth of the total county area. Consequently, the percentages in the columns may not sum to 100%.

Table C-3 Largest Industries, by Employment, in Huerfano and Las Animas Counties in 2011

Industry	Huerfano County			Las Animas County		
	Number of Paid Employees	Rank	% of Total Paid Employees	Number of Paid Employees	Rank	% of Total Paid Employees
Health care and social assistance	456	1	35.5	783	1	23.4
Retail trade	264	2	20.6	685	2	20.4
Accommodation and food services	187	3	14.6	598	3	17.8
Professional, scientific, and technical services	67	4	5.2	111	6	3.3
Other services (except public administration)	49	5	3.8	181	5	5.4
Finance and insurance	27	6	2.1	0	0	0
Information	20	7	1.6	41	11	1.2
Construction	0	N/A	0.0	299	4	8.9
Manufacturing	0	N/A	0.0	73	7	2.2
Wholesale trade	0	N/A	0.0	63	8	1.9
Real estate and rental and leasing	0	N/A	0.0	60	9	1.8
Administrative and support, and waste management and remediation services	0	N/A	0.0	48	10	1.4

Sources: US Census Bureau, 2011a, 2011b.
Note: N/A = Not applicable.

Table C-4 Land Use in Search Area A, Huerfano County, in 1992 and 2006

Land Use	1992		2006	
	Square Miles	% of Total	Square Miles	% of Total
Grassland/herbaceous	17.8	63.2	12.6	44.8
Shrub/scrub	5.2	18.3	8.4	29.8
Evergreen forest	2.6	9.2	6.4	22.8
Pasture/hay	1.4	5.0	0.1	0.5
Deciduous forest	1.0	3.6	0.0	0.0
Row/cultivated crops	0.2	0.6	0.0	0.0
Barren	0.0	0.1	0.0	0.0
Developed	0.0	0.1	0.4	1.3
Open water	0.0	0.0	0.0	0.2
Woody wetlands	0.0	0.0	0.1	0.2
Emergent herbaceous wetlands	0.0	0.0	0.1	0.5
Total	**28.2**	**100.0**	**28.2**	**100.0**

Source: US Geological Survey, 2012.
Note: Totals may not sum exactly due to rounding.

Table C-5 Land Use in Search Area A, Las Animas County, in 1992 and 2006

Land Use	1992		2006	
	Square Miles	% of Total	Square Miles	% of Total
Shrub/scrub	1.5	49.3	0.6	19.2
Evergreen forest	1.0	32.7	1.9	61.9
Grassland/herbaceous	0.5	14.7	0.5	17.0
Deciduous forest	0.1	3.3	0.0	0.3
Woody wetlands	0.0	0.0	0.1	1.7
Total	**3.1**	**100.0**	**3.1**	**100.0**

Source: US Geological Survey, 2012.
Note: Totals may not sum exactly due to rounding.

Table C-6 Land Use in Search Area B, Las Animas County, in 1992 and 2006

Land Use	1992		2006	
	Square Miles	% of Total	Square Miles	% of Total
Evergreen forest	1.8	56.8	2.0	64.3
Shrub/scrub	1.0	33.0	0.9	27.6
Grassland/herbaceous	0.2	7.8	0.1	4.3
Deciduous forest	0.1	2.4	0.0	1.6
Woody wetlands	0.0	0.0	0.1	2.2
Emergent herbaceous wetlands	0.0	0.0	0.0	0.1
Total	**3.1**	**100.0**	**3.1**	**100.0**

Source: US Geological Survey, 2012.
Note: Totals may not sum exactly due to rounding.

Table C-7 Land Use in Search Area C, Las Animas County, in 1992 and 2006

Land Use	1992		2006	
	Square Miles	% of Total	Square Miles	% of Total
Evergreen forest	20.5	72.5	17.7	62.6
Shrub/scrub	4.3	15.1	7.8	27.5
Grassland/herbaceous	1.6	5.6	0.4	1.4
Deciduous forest	1.5	5.5	1.5	5.2
Pasture/hay	0.4	1.3	0.5	1.8
Emergent herbaceous wetlands	0.0	0.0	0.0	0.1
Woody wetlands	0.0	0.0	0.4	1.4
Total	**28.2**	**100.0**	**28.2**	**100.0**

Source: US Geological Survey, 2012.
Note: Totals may not sum exactly due to rounding.

Table C-8 Major Agricultural Land Uses in Search Area A, Huerfano County, in 2012

Use	% of Land
Grassland herbaceous	45.4
Alfalfa	0.9
Other hay/non-alfalfa	0.3

Source: US Department of Agriculture, 2012.

Table C-9 Major Agricultural Land Uses in Search Area A, Las Animas County, in 2012

Use	% of Land
Grassland herbaceous	11.8

Source: US Department of Agriculture, 2012.

Table C-10 Major Agricultural Land Uses in Search Area B, Las Animas County, in 2012

Use	% of Land
Grassland herbaceous	4.7

Source: US Department of Agriculture, 2012.

Table C-11 Major Agricultural Land Uses in Search Area C, Las Animas County, in 2012

Use	% of Land
Grassland herbaceous	1.3
Alfalfa	0.2
Other hay/non-alfalfa	0.1

Source: US Department of Agriculture, 2012.

Table C-12 Changes in Land Use, 1992 to 2001 and 2001 to 2006, in Search Area A, Huerfano County

Change in Land Use	% of Land	
	1992 to 2001	2001 to 2006
No change	99.3	99.9
Change in land use	0.7	0.1
- to grassland/shrub	0.3	0.0
- to agriculture	0.2	0.0
- to open water	0.1	0.0
- to wetlands	0.1	0.0
- to hay/pasture	0.0	0.1

Source: US Geological Survey, 2012.

Table C-13 Changes in Land Use, 1992 to 2001 and 2001 to 2006, in Search Area A, Las Animas County

Change in Land Use	% of Land	
	1992 to 2001	2001 to 2006
No change	100.0	100.0

Source: US Geological Survey, 2012.

Table C-14 Changes in Land Use, 1992 to 2001 and 2001 to 2006, in Search Area B, Las Animas County

Change in Land Use	% of Land	
	1992 to 2001	2001 to 2006
No change	100.0	99.9
Change in land use	0.0	0.1
- to shrub/scrub	0.0	0.1

Source: US Geological Survey, 2012.

Table C-15 Changes in Land Use, 1992 to 2001 and 2001 to 2006, in Search Area C, Las Animas County

	% of Land	
Change in Land Use	**1992 to 2001**	**2001 to 2006**
No change	99.8	99.7
Change in land use	0.2	0.3
- to agriculture	0.2	0.0
- to shrub/scrub	0.0	0.2
- to herbaceous	0.0	0.1

Source: US Geological Survey, 2012.

Table C-16 Well Inventory Summary, Raton Basin, Colorado, Retrospective Case Study

API Number	Operator	Well Name	Facility ID	Status	Operator Number	Field Code	Distance N/S of Section Line	Direction from Section Line	Distance E/W of Section Line	Direction Section Line	Quarter	Section	Township	Range	Latitude	Longitude	Ground Elevation	Location Quality	Field Name	Location ID	County	Search Area
05-055-06191	PETROGLYPH ENERGY INC	MCCONNELL 01-04	89076	AL	8667	99999	1020	N	727	W	NWNW	1	29S	67W	37.557115	-104.846871	6615	Planned LatLong	Wildcat	383613	Huerfano	A
05-055-05012	PAN AMERICAN PETROLEUM CORP	FERDINAND B ROHR 1	211730	DA	66802	99999	672	N	2031	E	NWNE	9	29S	67W	37.544215	-104.892833	6754	Planned LatLong	Wildcat	383461	Huerfano	A
05-055-05027	PETROGLYPH ENERGY INC	DICK REALTY & INV CO 1	211737	DA	8667	99999	2000	N	660	E	SENE	3	29S	67W	37.554845	-104.869809	6666	Actual LatLong	Wildcat	383467	Huerfano	A
05-055-06004	CLARK, E.B. SR.	GOEMMER LAND CO 1	211769	DA	17538	99999	660	N	660	W	NWNW	11	29S	67W	37.543361	-104.865472	6826	Actual LatLong	Wildcat	383496	Huerfano	A
05-055-06023	MINERALS MANAGEMENT INC	GOLDEN CYCLE 1	211788	DA	100806	99999	660	N	760	W	NWNW	11	29S	67W	37.543526	-104.865192	6830	Planned LatLong	Wildcat	383513	Huerfano	A
05-055-06024	FILON EXPLORATION CORP	GOLDEN CYCLE 2	211789	DA	100018	99999	2180	S	1955	E	NWSE	2	29S	67W	37.551315	-104.856182	6670	Planned LatLong	Wildcat	383514	Huerfano	A
05-055-06034	JORDAN, TOM	GOLDEN CYCLE 2-A	211799	DA	45006	99999	1397	S	1843	E	NWSE	2	29S	67W	37.549165	-104.855812	6684	Planned LatLong	Wildcat	383521	Huerfano	A
05-055-06038	AMOCO PRODUCTION CO.	GOLDEN CYCLE LAND CO 1	211803	DA	2500	99999	592	N	948	W	NWNW	11	29S	67W	37.543716	-104.864552	6835	Planned LatLong	Wildcat	383522	Huerfano	A
05-055-06060	ALAMOSA DRILLING INC	STAN SEARLE 1	211823	DA	900	99999	2020	S	650	E	NESE	33	28S	67W	37.566083	-104.887917	6645	Actual LatLong	Wildcat	383540	Huerfano	A
05-055-06086	PETROGLYPH ENERGY INC	LIVELY 03-03	211849	DA	8667	99999	698	N	1914	W	NENW	3	29S	67W	37.558475	-104.879052	6647	Planned LatLong	Wildcat	383546	Huerfano	A
05-055-06146	PETROGLYPH ENERGY INC	LIVELY 3-10	211908	PA	8667	70830	1885	S	2123	E	NWSE	3	29S	67W	37.550699	-104.875072	6659	Actual LatLong	Purgatoire River	324511	Huerfano	A
05-055-06147	PETROGLYPH ENERGY INC	LIVELY 3-12	211909	PA	8667	70830	1993	S	661	W	NWSW	3	29S	67W	37.551379	-104.883431	6678	Actual LatLong	Purgatoire River	324512	Huerfano	A
05-055-06148	PETROGLYPH ENERGY INC	LIVELY 10-02	211910	PA	8667	99999	648	N	1983	E	NWNE	10	29S	67W	37.543755	-104.874341	6767	Actual LatLong	Wildcat	383592	Huerfano	A
05-055-06149	PETROGLYPH ENERGY INC	LIVELY 10-04	211911	PA	8667	70830	664	N	660	W	NWNW	10	29S	67W	37.544001	-104.883368	6737	Actual LatLong	Purgatoire River	324513	Huerfano	A
05-055-06150	PETROGLYPH ENERGY INC	LIVELY 10-12	211912	PA	8667	70830	1982	S	660	W	NWSW	10	29S	67W	37.536750	-104.883793	6825	Actual LatLong	Purgatoire River	324514	Huerfano	A
05-055-06151	PETROGLYPH ENERGY INC	LIVELY 2-12	211913	PA	8667	70830	2637	S	660	W	NWSW	2	29S	67W	37.552411	-104.865375	6702	Actual LatLong	Purgatoire River	324515	Huerfano	A
05-055-06152	PETROGLYPH ENERGY INC	LIVELY 34-09	211914	AL	8667	99999	1414	S	527	E	NESE	34	28S	67W	37.563875	-104.869452	6562	Planned LatLong	Wildcat	383593	Huerfano	A
05-055-06153	PETROGLYPH ENERGY INC	LIVELY 35-07	211915	PA	8667	70830	1551	N	1613	E	SWNE	35	28S	67W	37.570621	-104.855188	6526	Actual LatLong	Purgatoire River	324516	Huerfano	A
05-055-06154	PETROGLYPH ENERGY INC	LIVELY 35-09	211916	PA	8667	70830	1667	S	507	E	NESE	35	28S	67W	37.564717	-104.851035	6557	Actual LatLong	Purgatoire River	324517	Huerfano	A
05-055-06155	PETROGLYPH ENERGY INC	STATE 36-11	211917	PA	8667	70830	1648	S	1691	W	NESW	36	28S	67W	37.564380	-104.843494	6579	Actual LatLong	Purgatoire River	324518	Huerfano	A
05-055-06156	PETROGLYPH ENERGY INC	LIVELY 02-02	211918	PA	8667	70830	772	N	1373	E	NWNE	2	29S	67W	37.558017	-104.853967	6598	Actual LatLong	Purgatoire River	324519	Huerfano	A
05-055-06157	PETROGLYPH ENERGY INC	LIVELY 02-03	211919	PA	8667	70830	618	N	1652	W	NENW	2	29S	67W	37.558371	-104.861890	6603	Actual LatLong	Purgatoire River	324520	Huerfano	A
05-055-06158	PETROGLYPH ENERGY INC	LIVELY 03-04	211920	PA	8667	70830	981	N	821	W	NWNW	3	29S	67W	37.558692	-104.883385	6665	Actual LatLong	Purgatoire River	324521	Huerfano	A
05-055-06159	PETROGLYPH ENERGY INC	LIVELY 35-11	211921	DA	8667	99999	2106	S	2426	W	NESW	35	28S	67W	37.565765	-104.859242	6541	Planned LatLong	Wildcat	324532	Huerfano	A
05-055-06160	PETROGLYPH ENERGY INC	LIVELY 03-01	211922	PA	8667	70830	748	N	1109	E	NENE	3	29S	67W	37.558077	-104.871393	6588	Actual LatLong	Purgatoire River	324522	Huerfano	A
05-055-06161	PETROGLYPH ENERGY INC	STATE 36-05	211923	PA	8667	70830	2239	N	675	W	SWNW	36	28S	67W	37.568427	-104.846902	6527	Actual LatLong	Purgatoire River	324523	Huerfano	A
05-055-06162	PETROGLYPH ENERGY INC	MARTINEZ 07-04	211924	DA	8667	99999	214	N	1163	W	NWNW	7	29S	66W	37.543816	-104.829281	6639	Planned LatLong	Wildcat	383594	Huerfano	A
05-055-06163	PETROGLYPH ENERGY INC	MARTINEZ 07-02	211925	PA	8667	70830	788	N	2123	E	NWNE	7	29S	66W	37.542310	-104.822021	6744	Actual LatLong	Purgatoire River	324524	Huerfano	A
05-055-06165	PETROGLYPH ENERGY INC	ROHR 09-10	211927	PA	8667	70830	2071	S	2087	E	NWSE	9	29S	67W	37.537311	-104.892921	6803	Actual LatLong	Purgatoire River	324526	Huerfano	A
05-055-06166	PETROGLYPH ENERGY INC	ROHR 04-10	211928	PA	8667	70830	1987	S	2022	E	NWSE	4	29S	67W	37.551583	-104.892615	6700	Actual LatLong	Purgatoire River	324527	Huerfano	A
05-055-06167	PETROGLYPH ENERGY INC	MARTINEZ 12-09	211929	PA	8667	70830	2165	S	292	E	NESE	12	29S	67W	37.535956	-104.834059	6704	Actual LatLong	Purgatoire River	324528	Huerfano	A
05-055-06168	PETROGLYPH ENERGY INC	HURTADO 13-04	211930	PA	8667	99999	864	N	241	W	NWNW	13	29S	67W	37.528496	-104.848771	6167	Planned LatLong	Wildcat	383595	Huerfano	A
05-055-06169	PETROGLYPH ENERGY INC	ANDREATTA 13-12	211931	PA	8667	70830	2186	S	551	W	NWSW	13	29S	67W	37.522477	-104.847258	6874	Actual LatLong	Purgatoire River	324529	Huerfano	A
05-055-06170	PETROGLYPH ENERGY INC	ANDREATTA 14-10	211932	PA	8667	99999	2176	S	2389	E	NWSE	14	29S	67W	37.522366	-104.857872	6828	Planned LatLong	Wildcat	383596	Huerfano	A
05-055-06171	PETROGLYPH ENERGY INC	HURTADO 13-02	211933	PA	8667	70830	302	N	1662	E	NWNE	13	29S	67W	37.529501	-104.838696	6753	Actual LatLong	Purgatoire River	324530	Huerfano	A
05-055-06172	PETROGLYPH ENERGY INC	MARTINEZ 7-11	211934	PA	8667	70830	1842	S	2100	W	NESW	7	29S	66W	37.534545	-104.825757	6789	Actual LatLong	Purgatoire River	324531	Huerfano	A
05-055-06173	PETROGLYPH ENERGY INC	LIVELY 35-04	211935	AL	8667	99999	882	N	882	W	NWNW	35	28S	67W	37.572365	-104.864492	6533	Planned LatLong	Wildcat	383597	Huerfano	A
05-055-06174	PETROGLYPH ENERGY INC	LIVELY 04-02	211936	AL	8667	99999	218	N	2010	E	NWNE	4	29S	67W	37.560185	-104.892563	6670	Planned LatLong	Wildcat	383598	Huerfano	A
05-055-06175	PETROGLYPH ENERGY INC	LIVELY 01-12	211937	AL	8667	99999	1780	S	345	W	NWSW	1	29S	67W	37.550145	-104.848251	6686	Planned LatLong	Wildcat	383599	Huerfano	A
05-055-06176	PETROGLYPH ENERGY INC	LIVELY 35-11 B	211938	PA	8667	70830	2106	S	2399	W	NESW	35	28S	67W	37.565823	-104.859054	6541	Actual LatLong	Purgatoire River	324532	Huerfano	A
05-055-06177	PETROGLYPH ENERGY INC	MCCONNELL 01-07	211939	AL	8667	99999	1697	N	1707	E	SWNE	1	29S	67W	37.554835	-104.839201	6687	Planned LatLong	Wildcat	383600	Huerfano	A
05-055-06178	PETROGLYPH ENERGY INC	LIVELY 02-10	211940	AL	8667	99999	2027	S	1980	E	NWSE	2	29S	67W	37.550895	-104.856272	6678	Planned LatLong	Wildcat	383601	Huerfano	A
05-055-06179	PETROGLYPH ENERGY INC	STATE 36-02	211941	PA	8667	70830	536	N	1604	E	NWNE	36	28S	67W	37.572682	-104.838740	6572	Actual LatLong	Purgatoire River	324533	Huerfano	A
05-055-06213	PETROGLYPH ENERGY INC	STATE 1W	256976	AL	8667	99999	205	N	206	W	NWNW	36	28S	67W	37.574035	-104.848412	6473	Planned LatLong	Wildcat	383632	Huerfano	A
05-055-06214	PETROGLYPH ENERGY INC	STATE 2W	256977	PA	8667	70830	242	N	761	W	NWNW	36	28S	67W	37.573907	-104.846476	6492	Actual LatLong	Purgatoire River	324536	Huerfano	A
05-055-06215	PETROGLYPH ENERGY INC	STATE 3W	256978	PA	8667	70830	435	N	1190	W	NENW	36	28S	67W	37.573293	-104.845011	6518	Actual LatLong	Purgatoire River	324537	Huerfano	A
05-055-06216	PETROGLYPH ENERGY INC	STATE 4W	256979	PA	8667	70830	750	N	1525	W	NENW	36	28S	67W	37.572366	-104.843875	6527	Actual LatLong	Purgatoire River	324538	Huerfano	A
05-055-06217	PETROGLYPH ENERGY INC	STATE 5W	256980	AL	8667	99999	1040	N	1860	W	NENW	36	28S	67W	37.571385	-104.842751	6542	Planned LatLong	Wildcat	383633	Huerfano	A
05-055-06218	PETROGLYPH ENERGY INC	STATE 6W	256981	AL	8667	99999	1355	N	2170	W	SENW	36	28S	67W	37.570455	-104.841701	6576	Planned LatLong	Wildcat	383634	Huerfano	A
05-055-06219	PETROGLYPH ENERGY INC	STATE 7W	256982	PA	8667	70830	1534	N	2000	E	SWNE	36	28S	67W	37.570011	-104.840162	6612	Actual LatLong	Purgatoire River	324539	Huerfano	A
05-055-06220	PETROGLYPH ENERGY INC	STATE 8W	256983	AL	8667	99999	1960	N	2377	E	SWNE	36	28S	67W	37.568775	-104.841351	6639	Planned LatLong	Wildcat	383635	Huerfano	A
05-055-06221	PETROGLYPH ENERGY INC	STATE 9W	256984	PA	8667	70830	2145	N	1900	E	SWNE	36	28S	67W	37.568173	-104.837566	6655	Actual LatLong	Purgatoire River	324540	Huerfano	A

Table C-16 Well Inventory Summary, Raton Basin, Colorado, Retrospective Case Study

API Number	Operator	Well Name	Facility ID	Status	Operator Number	Field Code	Distance N/S of Section Line	Direction from Section Line	Distance E/W of Section Line	Direction Section Line	Quarter	Section	Township	Range	Latitude	Longitude	Ground Elevation	Location Quality	Field Name	Location ID	County	Search Area
05-055-06222	PETROGLYPH ENERGY INC	STATE 10W	256985	DA	8667	99999	2442	N	1662	E	SENE	36	28S	67W	37.567295	-104.838911	6626	Planned LatLong	Wildcat	324551	Huerfano	A
05-055-06223	PETROGLYPH ENERGY INC	STATE 11W	256986	AL	8667	99999	2520	S	1400	E	NESE	36	28S	67W	37.566365	-104.838031	6635	Planned LatLong	Wildcat	383636	Huerfano	A
05-055-06242	PETROGLYPH ENERGY INC	ANSELMO 07-05	258074	PA	8667	70830	1831	N	660	W	SWNW	7	29S	66W	37.539651	-104.830862	6705	Actual LatLong	Purgatoire River	324542	Huerfano	A
05-055-06243	PETROGLYPH ENERGY INC	MARTINEZ 07-06	258075	PA	8667	70830	2271	N	1960	W	SENW	7	29S	66W	37.538345	-104.826353	6760	Actual LatLong	Purgatoire River	324543	Huerfano	A
05-055-06244	PETROGLYPH ENERGY INC	MARTINEZ 07-01	258076	PA	8667	70830	1351	N	982	E	NENE	7	29S	66W	37.540673	-104.817962	6770	Actual LatLong	Purgatoire River	324544	Huerfano	A
05-055-06255	PETROGLYPH ENERGY INC	MARTINEZ 07-14	260564	PA	8667	70830	578	S	1939	W	SESW	7	29S	66W	37.531183	-104.826300	6811	Actual LatLong	Purgatoire River	324547	Huerfano	A
05-055-06256	PETROGLYPH ENERGY INC	MARTINEZ 07-03	260565	PA	8667	70830	517	N	1553	W	NENW	7	29S	66W	37.543193	-104.827846	6669	Actual LatLong	Purgatoire River	324548	Huerfano	A
05-055-06257	PETROGLYPH ENERGY INC	MARTINEZ 06-16	260566	PA	8667	70830	572	S	634	E	SESE	6	29S	66W	37.545930	-104.816947	6760	Actual LatLong	Purgatoire River	324549	Huerfano	A
05-055-06258	PETROGLYPH ENERGY INC	MARTINEZ 07-07	260567	PA	8667	70830	2460	N	1803	E	SWNE	7	29S	66W	37.537687	-104.820612	6782	Actual LatLong	Purgatoire River	324550	Huerfano	A
05-055-06261	PETROGLYPH ENERGY INC	STATE 10WB	261770	PA	8667	70830	2440	N	1707	E	SENE	36	28S	67W	37.567248	-104.836857	6626	Actual LatLong	Purgatoire River	324551	Huerfano	A
05-055-06265	PETROGLYPH ENERGY INC	ANSELMO 07-12	263156	PA	8667	70830	1983	S	717	W	NWSW	7	29S	66W	37.535267	-104.830584	6755	Actual LatLong	Purgatoire River	324553	Huerfano	A
05-055-06268	PETROGLYPH ENERGY INC	ANSELMO 07-13	263157	PA	8667	70830	611	S	481	W	SWSW	7	29S	66W	37.531532	-104.831335	6769	Actual LatLong	Purgatoire River	324556	Huerfano	A
05-055-06269	PETROGLYPH ENERGY INC	ANSELMO 18-03	263159	AL	8667	70830	559	N	1939	W	NENW	18	29S	66W	37.528076	-104.826321	6863	Planned LatLong	Purgatoire River	383660	Huerfano	A
05-055-06266	PETROGLYPH ENERGY INC	ANSELMO 12-16	263161	PA	8667	70830	403	S	640	E	SESE	12	29S	67W	37.531196	-104.835189	6745	Actual LatLong	Purgatoire River	324554	Huerfano	A
05-055-06271	PETROGLYPH ENERGY INC	ANSELMO 18-04	263164	AL	8667	70830	605	N	647	W	NWNW	18	29S	66W	37.528046	-104.830771	6821	Planned LatLong	Purgatoire River	383661	Huerfano	A
05-055-06272	PETROGLYPH ENERGY INC	MARTINEZ 06-15	263165	PA	8667	70830	410	S	1873	E	SWSE	6	29S	66W	37.545584	-104.821234	6759	Actual LatLong	Purgatoire River	324558	Huerfano	A
05-055-06273	PETROGLYPH ENERGY INC	MARTINEZ 06-09	263166	PA	8667	70830	1985	S	688	E	NESE	6	29S	66W	37.549811	-104.817071	6735	Actual LatLong	Purgatoire River	324559	Huerfano	A
05-055-06274	PETROGLYPH ENERGY INC	MARTINEZ 07-10	263167	PA	8667	70830	1817	S	1884	E	NWSE	7	29S	66W	37.534298	-104.820685	6802	Actual LatLong	Purgatoire River	324560	Huerfano	A
05-055-06292	PETROGLYPH ENERGY INC	ROHR 8-1	272799	PA	8667	70830	715	N	553	E	NENE	8	29S	67W	37.544630	-104.906195	6820	Actual LatLong	Purgatoire River	324570	Huerfano	A
05-055-06291	PETROGLYPH ENERGY INC	ROHR 4-14	272800	PA	8667	70830	757	S	2157	W	SESW	4	29S	67W	37.548359	-104.896800	6741	Actual LatLong	Purgatoire River	324569	Huerfano	A
05-055-06290	PETROGLYPH ENERGY INC	ROHR 09-04	272801	PA	8667	70830	736	N	803	W	NWNW	9	29S	67W	37.544443	-104.901514	6818	Actual LatLong	Purgatoire River	324568	Huerfano	A
05-055-06289	PETROGLYPH ENERGY INC	ROHR 9-05	272802	PA	8667	70830	1995	N	805	W	SWNW	9	29S	67W	37.540978	-104.901631	6851	Actual LatLong	Purgatoire River	324567	Huerfano	A
05-055-06288	PETROGLYPH ENERGY INC	ROHR 5-16	272803	PA	8667	70830	615	S	558	E	SESE	5	29S	67W	37.548421	-104.906190	6784	Actual LatLong	Purgatoire River	324566	Huerfano	A
05-071-06296	PIONEER NATURAL RESOURCES USA INC	WHARTON 33-32	217519	PR	10084	70830	1523	S	1733	E	NWSE	32	32S	66W	37.211780	-104.799510	7400	Actual LatLong	Purgatoire River	307345	Las Animas	A
05-071-06876	PIONEER NATURAL RESOURCES USA INC	BONNEVILLE 31-6	256234	PR	10084	70830	1111	N	2078	E	NWNE	6	33S	66W	37.204610	-104.818780	7295	Actual LatLong	Purgatoire River	333872	Las Animas	A
05-071-06963	PIONEER NATURAL RESOURCES USA INC	MONTEREY 33-6	256911	PR	10084	70830	1808	S	1637	E	NWSE	6	33S	66W	37.197920	-104.818310	7250	Actual LatLong	Purgatoire River	333691	Las Animas	A
05-071-07089	PIONEER NATURAL RESOURCES USA INC	MONTE CARLO 31-7	258247	PR	10084	70830	290	N	2390	E	NWNE	7	33S	66W	37.192230	-104.820060	7240	Actual LatLong	Purgatoire River	333416	Las Animas	A
05-071-07134	PIONEER NATURAL RESOURCES USA INC	BAKERSFIELD 11-5	258700	PR	10084	70830	379	N	1248	W	NWNW	5	33S	66W	37.206680	-104.807430	7411	Actual LatLong	Purgatoire River	307875	Las Animas	A
05-071-07472	PIONEER NATURAL RESOURCES USA INC	PONY EXPRESS 44-31	260770	PR	10084	70830	475	S	853	E	SESE	31	32S	66W	37.208990	-104.814630	7355	Actual LatLong	Purgatoire River	333903	Las Animas	A
05-071-07534	PIONEER NATURAL RESOURCES USA INC	COTTER 44-32	261970	PR	10084	70830	522	S	156	E	SESE	32	32S	66W	37.208990	-104.794020	7475	Actual LatLong	Purgatoire River	308110	Las Animas	A
05-071-07550	PIONEER NATURAL RESOURCES USA INC	MONTEREY 33-6TR	262314	PR	10084	70830	1777	S	1783	E	NWSE	6	33S	66W	37.197860	-104.818840	7170	Actual LatLong	Purgatoire River	333691	Las Animas	A
05-071-07704	PIONEER NATURAL RESOURCES USA INC	BONNEVILLE 31-6 TR	264519	PR	10084	70830	1111	N	1978	E	NWNE	6	33S	66W	37.204560	-104.818440	7295	Actual LatLong	Purgatoire River	333872	Las Animas	A
05-071-07881	PIONEER NATURAL RESOURCES USA INC	MOLSON 23-8	268485	PR	10084	70830	2246	S	1841	W	NESW	8	33S	66W	37.184820	-104.805690	7196	Actual LatLong	Purgatoire River	308355	Las Animas	A
05-071-07896	PIONEER NATURAL RESOURCES USA INC	SALTY 42-6	268861	PR	10084	70830	2380	N	695	E	SENE	6	33S	66W	37.201100	-104.813820	7338	Actual LatLong	Purgatoire River	333905	Las Animas	A
05-071-08238	PIONEER NATURAL RESOURCES USA INC	SALTY 42-6 TR	274520	PR	10084	70830	2409	N	599	E	SENE	6	33S	66W	37.201040	-104.813500	7338	Actual LatLong	Purgatoire River	333905	Las Animas	A
05-071-08545	PIONEER NATURAL RESOURCES USA INC	PONY EXPRESS 44-31 TR	280226	PR	10084	70830	384	S	847	E	SESE	31	32S	66W	37.208710	-104.814650	7367	Actual LatLong	Purgatoire River	333903	Las Animas	A
05-071-08623	PIONEER NATURAL RESOURCES USA INC	JOPLIN 44-5	281479	PR	10084	70830	262	S	418	E	SESE	5	33S	66W	37.193200	-104.795070	7300	Actual LatLong	Purgatoire River	308785	Las Animas	A
05-071-08642	PIONEER NATURAL RESOURCES USA INC	ALABASTER 11-8	281856	PR	10084	70830	1249	N	215	W	NWNW	8	33S	66W	37.189520	-104.811460	7249	Actual LatLong	Purgatoire River	308796	Las Animas	A
05-071-08707	PIONEER NATURAL RESOURCES USA INC	WILDCARD 31-5	283138	PR	10084	70830	624	N	1852	E	NWNE	5	33S	66W	37.205900	-104.799990	7390	Actual LatLong	Purgatoire River	308839	Las Animas	A
05-071-08743	PIONEER NATURAL RESOURCES USA INC	PANHEAD 32-8	284122	PR	10084	70830	1503	N	2269	E	SWNE	8	33S	66W	37.188586	-104.801357	7220	Actual LatLong	Purgatoire River	308865	Las Animas	A

Table C-16 Well Inventory Summary, Raton Basin, Colorado, Retrospective Case Study

API Number	Operator	Well Name	Facility ID	Status	Operator Number	Field Code	Distance N/S of Section Line	Direction from Section Line	Distance E/W of Section Line	Direction Section Line	Quarter	Section	Township	Range	Latitude	Longitude	Ground Elevation	Location Quality	Field Name	Location ID	County	Search Area
05-071-08777	PIONEER NATURAL RESOURCES USA INC	CROCKET 11-4	284520	PR	10084	70830	895	N	1107	W	NWNW	4	33S	66W	37.205149	-104.789763	7596	Actual LatLong	Purgatoire River	333389	Las Animas	A
05-071-08949	PIONEER NATURAL RESOURCES USA INC	STORM PEAK 44-6	286419	PR	10084	70830	208	S	490	E	SESE	6	33S	66W	37.193530	-104.813680	7179	Actual LatLong	Purgatoire River	309006	Las Animas	A
05-071-08975	PIONEER NATURAL RESOURCES USA INC	MONTE CARLO 31-7 TR	286684	PR	10084	70830	180	N	2286	E	NWNE	7	33S	66W	37.192470	-104.819920	7224	Actual LatLong	Purgatoire River	333416	Las Animas	A
05-071-09018	PIONEER NATURAL RESOURCES USA INC	LOBO 13-4	287509	PR	10084	70830	2167	S	1254	W	NWSW	4	33S	66W	37.198550	-104.789300	7444	Actual LatLong	Purgatoire River	309046	Las Animas	A
05-071-09144	PIONEER NATURAL RESOURCES USA INC	CROCKET 11-4 TR	288632	PR	10084	70830	920	N	1176	W	NWNW	4	33S	66W	37.205050	-104.789430	7591	Actual LatLong	Purgatoire River	333389	Las Animas	A
05-071-09192	PIONEER NATURAL RESOURCES USA INC	HOMESTEAD 14-5	289198	PR	10084	70830	1309	S	1029	W	SWSW	5	33S	66W	37.196430	-104.808440	7262	Actual LatLong	Purgatoire River	309167	Las Animas	A
05-071-09250	PIONEER NATURAL RESOURCES USA INC	HELLZAPOPPIN 24-32	290232	PR	10084	70830	907	S	2129	W	SESW	32	32S	66W	37.210110	-104.804450	7492	Actual LatLong	Purgatoire River	309213	Las Animas	A
05-071-09439	PIONEER NATURAL RESOURCES USA INC	NORTHER 23-6	293725	PR	10084	70830	2650	N	2470	W	NESW	6	33S	66W	37.200370	-104.821420	7297	Actual LatLong	Purgatoire River	309358	Las Animas	A
05-071-09588	PIONEER NATURAL RESOURCES USA INC	HOLE IN THE WALL 42-5	295810	AL	10084	70830	2425	N	417	E	SENE	5	33S	66W	37.200900	-104.794990	7426	Planned LatLong	Purgatoire River	309481	Las Animas	A
05-071-09671	PIONEER NATURAL RESOURCES USA INC	PANTHER 33-5	299153	PR	10084	70830	2299	N	2622	E	NWSE	5	33S	66W	37.199060	-104.802580	7267	Actual LatLong	Purgatoire River	309541	Las Animas	A
05-071-09752	PIONEER NATURAL RESOURCES USA INC	PANTHER 35-5 TR	301615	AL	10084	70830	2334	S	2638	E	NWSE	5	33S	66W	37.199160	-104.802630	7269	Planned LatLong	Purgatoire River	309541	Las Animas	A
05-071-09775	PIONEER NATURAL RESOURCES USA INC	HOLST 41-6	414636	AL	10084	70830	1145	N	152	E	NE/NE	6	33S	66W	37.204510	-104.812290	7484	Planned LatLong	Purgatoire River	414606	Las Animas	A
05-071-09793	PIONEER NATURAL RESOURCES USA INC	HELLZAPOPPIN 24-32 TR	415349	PR	10084	70830	964	S	2109	W	SESW	32	32S	66W	37.210260	-104.804460	7488	Actual LatLong	Purgatoire River	309213	Las Animas	A
05-071-09795	PIONEER NATURAL RESOURCES USA INC	SALUKI 41-8	415674	AL	10084	70830	1116	N	799	E	NENE	8	33s	66W	37.189530	-104.796430	7260	Planned LatLong	Purgatoire River	415706	Las Animas	A
05-071-09486	PIONEER NATURAL RESOURCES USA INC	MARILYN DEEP 24-3	246	PR	10084	70830	1271	S	2217	W	SESW	3	33S	67W	37.197060	-104.876380	7534	Actual LatLong	Purgatoire River	311883	Las Animas	B
05-071-06985	PIONEER NATURAL RESOURCES USA INC	SURFERS 44-34	256947	PR	10084	70830	600	S	913	E	SESE	34	32S	67W	37.209410	-104.868710	7715	Actual LatLong	Purgatoire River	307810	Las Animas	B
05-071-07628	PIONEER NATURAL RESOURCES USA INC	SCAMPER 44-3	263375	PR	10084	70830	573	S	884	E	SESE	3	33S	67W	37.195000	-104.869220	7644	Actual LatLong	Purgatoire River	333656	Las Animas	B
05-071-07633	PIONEER NATURAL RESOURCES USA INC	CELTIC 43-3	263380	PR	10084	70830	2184	S	1162	E	NESE	3	33S	67W	37.200100	-104.869460	7555	Actual LatLong	Purgatoire River	333896	Las Animas	B
05-071-07653	PIONEER NATURAL RESOURCES USA INC	COMET 31-3	263988	PR	10084	70830	1070	N	2081	E	NWNE	3	33S	67W	37.204810	-104.872670	7552	Actual LatLong	Purgatoire River	308195	Las Animas	B
05-071-07780	PIONEER NATURAL RESOURCES USA INC	SHINARUMP 11-11 TR	265603	PR	10084	70830	947	N	414	W	NWNW	11	33S	67W	37.190790	-104.864830	7518	Actual LatLong	Purgatoire River	308294	Las Animas	B
05-071-07783	PIONEER NATURAL RESOURCES USA INC	BUTCH 33-10	265607	PR	10084	70830	2196	S	1450	E	NWSE	10	33S	67W	37.185080	-104.870290	7560	Actual LatLong	Purgatoire River	308297	Las Animas	B
05-071-07826	PIONEER NATURAL RESOURCES USA INC	MADISON 14-2	266520	PR	10084	70830	727	S	1028	W	SWSW	2	33S	67W	37.195410	-104.862690	7585	Actual LatLong	Purgatoire River	333689	Las Animas	B
05-071-07833	PIONEER NATURAL RESOURCES USA INC	DUKE 12-10	266711	PR	10084	70830	2240	N	455	W	SWNW	10	33S	67W	37.187400	-104.882390	7320	Actual LatLong	Purgatoire River	308327	Las Animas	B
05-071-07834	PIONEER NATURAL RESOURCES USA INC	AVANT 14-3	266743	PR	10084	70830	223	S	1266	W	SWSW	3	33S	67W	37.194270	-104.879750	7540	Actual LatLong	Purgatoire River	333667	Las Animas	B
05-071-07837	PIONEER NATURAL RESOURCES USA INC	GAMMA 13-3	266793	PR	10084	70830	2058	S	700	W	NWSW	3	33S	67W	37.199370	-104.881710	7470	Actual LatLong	Purgatoire River	333885	Las Animas	B
05-071-07840	PIONEER NATURAL RESOURCES USA INC	SCHNEIDER 12-3	266838	PR	10084	70830	1488	N	493	W	SWNW	3	33S	67W	37.203750	-104.882170	7518	Actual LatLong	Purgatoire River	308332	Las Animas	B
05-071-07849	PIONEER NATURAL RESOURCES USA INC	FUTURA 32-10	267096	PR	10084	70830	1404	N	2134	E	SWNE	10	33S	67W	37.189560	-104.873590	7570	Actual LatLong	Purgatoire River	333663	Las Animas	B
05-071-07877	PIONEER NATURAL RESOURCES USA INC	GRAFF 31-9V	268338	PR	10084	70830	690	N	1819	E	NWNE	9	33S	67W	37.191580	-104.889990	7560	Actual LatLong	Purgatoire River	333742	Las Animas	B
05-071-07909	PIONEER NATURAL RESOURCES USA INC	MADISON 14-2 KV	269310	PR	10084	70830	628	S	1039	W	SWSW	2	33S	67W	37.195200	-104.862640	7585	Actual LatLong	Purgatoire River	333689	Las Animas	B

Table C-16 Well Inventory Summary, Raton Basin, Colorado, Retrospective Case Study

API Number	Operator	Well Name	Facility ID	Status	Operator Number	Field Code	Distance N/S of Section Line	Direction from Section Line	Distance E/W of Section Line	Direction Section Line	Quarter	Section	Township	Range	Latitude	Longitude	Ground Elevation	Location Quality	Field Name	Location ID	County	Search Area
05-071-07911	PIONEER NATURAL RESOURCES USA INC	CELTIC 43-3 TR	269318	PR	10084	70830	2200	S	1063	E	NESE	3	33S	67W	37.200080	-104.869770	7555	Actual LatLong	Purgatoire River	333896	Las Animas	B
05-071-07910	PIONEER NATURAL RESOURCES USA INC	SCAMPER 44-3 TR	269319	PR	10084	70830	467	S	912	E	SESE	3	33S	67W	37.194620	-104.869310	7622	Actual LatLong	Purgatoire River	333656	Las Animas	B
05-071-07926	PIONEER NATURAL RESOURCES USA INC	PEGASIS 31-4	269704	PR	10084	70830	536	N	2242	E	NWNE	4	33S	67W	37.206340	-104.891550	7525	Actual LatLong	Purgatoire River	333747	Las Animas	B
05-071-07931	PIONEER NATURAL RESOURCES USA INC	FUTURA 32-10 TR	269892	PR	10084	70830	1471	N	2028	E	SWNE	10	33S	67W	37.189370	-104.873260	7563	Actual LatLong	Purgatoire River	333663	Las Animas	B
05-071-07976	PIONEER NATURAL RESOURCES USA INC	CAVE CANYON 23-4	271175	PR	10084	70830	1827	S	2225	W	NESW	4	33S	67W	37.198490	-104.894320	7675	Actual LatLong	Purgatoire River	333654	Las Animas	B
05-071-08037	PIONEER NATURAL RESOURCES USA INC	GRAFF 31-9R	271872	PR	10084	70830	707	N	1713	E	NWNE	9	33S	67W	37.191550	-104.889660	7554	Actual LatLong	Purgatoire River	333742	Las Animas	B
05-071-08071	PIONEER NATURAL RESOURCES USA INC	MCLEOD 42-9V	272388	PR	10084	70830	1658	N	415	E	SENE	9	33S	67W	37.188870	-104.885200	7425	Actual LatLong	Purgatoire River	333748	Las Animas	B
05-071-08092	PIONEER NATURAL RESOURCES USA INC	MCLEOD 42-9R	272576	PR	10084	70830	1748	N	372	E	SENE	9	33S	67W	37.188680	-104.885100	7415	Actual LatLong	Purgatoire River	333748	Las Animas	B
05-071-08123	PIONEER NATURAL RESOURCES USA INC	LYNN 32-4	273038	PR	10084	70830	2088	N	1598	E	SWNE	4	33S	67W	37.202050	-104.889230	7549	Actual LatLong	Purgatoire River	333968	Las Animas	B
05-071-08292	PIONEER NATURAL RESOURCES USA INC	PEGASIS 31-4 TR	275634	PR	10084	70830	607	N	2385	E	NWNE	4	33S	67W	37.206130	-104.892080	7525	Actual LatLong	Purgatoire River	333747	Las Animas	B
05-071-08463	PIONEER NATURAL RESOURCES USA INC	AVANT 14-3 TR	279052	PR	10084	70830	170	S	1174	W	SWSW	3	33S	67W	37.194080	-104.879990	7535	Actual LatLong	Purgatoire River	333667	Las Animas	B
05-071-08524	PIONEER NATURAL RESOURCES USA INC	GAMMA 13-3 TR	279743	PR	10084	70830	2127	S	738	W	NWSW	3	33S	67W	37.199170	-104.881460	7423	Actual LatLong	Purgatoire River	333885	Las Animas	B
05-071-08649	PIONEER NATURAL RESOURCES USA INC	BUTCH 33-10 TR	282121	PR	10084	70830	2309	S	1337	E	NWSE	10	33S	67W	37.185290	-104.870450	7571	Actual LatLong	Purgatoire River	308297	Las Animas	B
05-071-08675	PIONEER NATURAL RESOURCES USA INC	HORSEFEATHERS 24-34	282630	PR	10084	70830	183	S	1570	W	SESW	34	32S	67W	37.208230	-104.878430	7651	Actual LatLong	Purgatoire River	308814	Las Animas	B
05-071-09214	PIONEER NATURAL RESOURCES USA INC	BACKYARD 34-34	289704	PR	10084	70830	1165	S	2303	E	SWSE	34	32S	67W	37.210950	-104.873510	7716	Actual LatLong	Purgatoire River	309180	Las Animas	B
05-071-09261	PIONEER NATURAL RESOURCES USA INC	MAUER 41-3	290365	PR	10084	70830	954	N	702	E	NENE	3	33S	67W	37.205110	-104.868050	7695	Actual LatLong	Purgatoire River	309222	Las Animas	B
05-071-09260	PIONEER NATURAL RESOURCES USA INC	BOOF 12-2	290366	PR	10084	70830	2107	N	353	W	SWNW	2	33S	67W	37.201900	-104.864590	7712	Actual LatLong	Purgatoire River	309221	Las Animas	B
05-071-09551	PIONEER NATURAL RESOURCES USA INC	MARILYN 23-3	295446	AL	10084	70830	1307	S	2191	W	NESW	3	33S	67W	37.197160	-104.876480	7531	Planned LatLong	Purgatoire River	311883	Las Animas	B
05-071-09552	PIONEER NATURAL RESOURCES USA INC	MARILYN 24-3 TR	295448	AL	10084	70830	1225	S	2247	W	SESW	3	33S	67W	37.196940	-104.876290	7529	Planned LatLong	Purgatoire River	311883	Las Animas	B
05-071-09665	PIONEER NATURAL RESOURCES USA INC	CAVE CANYON 23-4 TR	298443	PR	10084	70830	1792	S	2216	W	NESW	4	33S	67W	37.198690	-104.894360	7710	Actual LatLong	Purgatoire River	333654	Las Animas	B
05-071-09709	PIONEER NATURAL RESOURCES USA INC	RAINBOW TROUT 23-3	300205	AL	10084	70830	2356	S	1978	W	NESW	3	33S	67W	37.200060	-104.877170	7548	Planned LatLong	Purgatoire River	309571	Las Animas	B
05-071-09712	PIONEER NATURAL RESOURCES USA INC	LYNN 32-4 TR	300358	PR	10084	70830	2117	N	1598	E	SWNE	4	33S	67W	37.202010	-104.889420	7530	Actual LatLong	Purgatoire River	333968	Las Animas	B
05-071-09754	PIONEER NATURAL RESOURCES USA INC	BOOF 12-2 TR	301617	PR	10084	70830	2119	N	398	W	SWNW	2	33S	67W	37.201910	-104.864440	7710	Actual LatLong	Purgatoire River	386827	Las Animas	B
05-071-09765	PIONEER NATURAL RESOURCES USA INC	SHINARUMP 11-11 KP HB	302101	AL	10084	70830	772	N	194	W	NWNW	11	33S	67W	37.191290	-104.865480	7538	Planned LatLong	Purgatoire River	386835	Las Animas	B
05-071-09784	PIONEER NATURAL RESOURCES USA INC	SHINARUMP 11-11 KV	415060	AL	10084	70830	892	N	308	W	NWNW	11	33S	67W	37.190950	-104.865070	7536	Planned LatLong	Purgatoire River	308294	Las Animas	B
05-071-09881	PIONEER NATURAL RESOURCES USA INC	REDMOND 44-33	424565	XX	10084	70830	202	S	249	E	SESE	33	32S	67W	37.208390	-104.884710	7442	Planned LatLong	Purgatoire River	424571	Las Animas	B
05-071-08913	PIONEER NATURAL RESOURCES USA INC	MONTOYA 11-6V	47	PR	10084	70830	286	N	638	W	NWNW	6	33S	67W	37.207010	-104.935850	8272	Actual LatLong	Purgatoire River	333365	Las Animas	C
05-071-09492	PIONEER NATURAL RESOURCES USA INC	MICHELLE DEEP 31-25	319	SI	10084	70830	51	N	2459	E	NWNE	25	32S	68W	37.236990	-104.946100	8336	Actual LatLong	Purgatoire River	309407	Las Animas	C
05-071-06154	PRECISIONEERING INC	O'NEAL 1-10B	217378	AL	71800	99999	6	S	258	W	SWSW	10	33S	68W	37.181851	-104.992253	8398	Planned LatLong	Wildcat	386486	Las Animas	C

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API Number	Operator	Well Name	Facility ID	Status	Operator Number	Field Code	Distance N/S of Section Line	Direction from Section Line	Distance E/W of Section Line	Direction Section Line	Quarter	Section	Township	Range	Latitude	Longitude	Ground Elevation	Location Quality	Field Name	Location ID	County	Search Area
05-071-06155	PRECISIONEERING INC	O'NEAL 1-14A	217379	SI	71800	99999	715	N	743	W	NWNW	14	33S	68W	37.177709	-104.971379	8065	Actual LatLong	Wildcat	307289	Las Animas	C
05-071-06156	PRECISIONEERING INC	O'NEAL 1-16C	217380	SI	71800	99999	2550	N	976	E	SENE	16	33S	68W	37.174509	-104.995203	8189	Actual LatLong	Wildcat	307290	Las Animas	C
05-071-07850	PIONEER NATURAL RESOURCES USA INC	VALEJO 12-8V	267366	PR	10084	70830	1510	N	1460	W	SENW	8	33S	67W	37.189830	-104.914980	7804	Actual LatLong	Purgatoire River	308085	Las Animas	C
05-071-07885	PIONEER NATURAL RESOURCES USA INC	KING KONG 41-26	268644	PA	10084	70830	468	N	5	E	NENE	26	32S	68W	37.236190	-104.956470	8430	Actual LatLong	Purgatoire River	386782	Las Animas	C
05-071-07886	PIONEER NATURAL RESOURCES USA INC	MONTOYA 11-18R	268679	PR	10084	70830	964	N	1062	W	NWNW	18	33S	67W	37.176010	-104.934050	7830	Actual LatLong	Purgatoire River	308357	Las Animas	C
05-071-07887	PIONEER NATURAL RESOURCES USA INC	MONTOYA 12-7V	268680	SI	10084	70830	1764	N	728	W	SWNW	7	33S	67W	37.188140	-104.934930	7831	Actual LatLong	Purgatoire River	333922	Las Animas	C
05-071-07890	PIONEER NATURAL RESOURCES USA INC	LATILUPPE 13-8V	268708	SI	10084	70830	1433	S	885	W	NWSW	8	33S	67W	37.182940	-104.917160	7906	Actual LatLong	Purgatoire River	333957	Las Animas	C
05-071-07918	PIONEER NATURAL RESOURCES USA INC	MONTOYA 13-18V	269551	PR	10084	70830	1360	S	1075	W	NWSW	18	33S	67W	37.168055	-104.934090	7884	Actual LatLong	Purgatoire River	333944	Las Animas	C
05-071-07917	PIONEER NATURAL RESOURCES USA INC	YWAM 32-7V	269552	PR	10084	70830	2423	N	2412	E	SWNE	7	33S	67W	37.186510	-104.928490	7710	Actual LatLong	Purgatoire River	333926	Las Animas	C
05-071-07939	PIONEER NATURAL RESOURCES USA INC	LAVEDURE 44-7V	270282	PR	10084	70830	969	S	601	E	SESE	7	33S	67W	37.181550	-104.922210	7745	Actual LatLong	Purgatoire River	333897	Las Animas	C
05-071-07940	PIONEER NATURAL RESOURCES USA INC	ANDERSON 42-18V	270298	PR	10084	70830	1668	N	1110	E	SENE	18	33S	67W	37.174240	-104.923960	7429	Actual LatLong	Purgatoire River	308375	Las Animas	C
05-071-07949	PIONEER NATURAL RESOURCES USA INC	SMITH 22-18V	270633	PR	10084	70830	1966	N	1922	W	SENW	18	33S	67W	37.173340	-104.931140	7787	Actual LatLong	Purgatoire River	308379	Las Animas	C
05-071-07953	PIONEER NATURAL RESOURCES USA INC	MCCULLOUGH 34-32	270661	PR	10084	70830	261	S	2098	E	SWSE	32	32S	67W	37.208510	-104.909120	7560	Actual LatLong	Purgatoire River	333657	Las Animas	C
05-071-08021	PIONEER NATURAL RESOURCES USA INC	MONTOYA 41-13V	271532	PR	10084	70830	449	N	891	E	NENE	13	33S	68W	37.177430	-104.940770	7870	Actual LatLong	Purgatoire River	333391	Las Animas	C
05-071-08020	PIONEER NATURAL RESOURCES USA INC	MONTOYA 14-6V	271533	PR	10084	70830	765	S	790	W	SWSW	6	33S	67W	37.195160	-104.934870	7814	Actual LatLong	Purgatoire River	333695	Las Animas	C
05-071-08019	PIONEER NATURAL RESOURCES USA INC	MONTOYA 14-7V	271534	PR	10084	70830	535	S	501	W	SWSW	7	33S	67W	37.180340	-104.935930	7797	Actual LatLong	Purgatoire River	333715	Las Animas	C
05-071-08018	PIONEER NATURAL RESOURCES USA INC	MONTOYA 21-7V	271535	PR	10084	70830	735	N	2070	W	NENW	7	33S	67W	37.191080	-104.930350	7657	Actual LatLong	Purgatoire River	308432	Las Animas	C
05-071-08022	PIONEER NATURAL RESOURCES USA INC	MELANIE 44-23	271606	PR	10084	70830	790	S	1050	E	SESE	23	32S	68W	37.239590	-104.960100	8378	Actual LatLong	Purgatoire River	333739	Las Animas	C
05-071-08023	PIONEER NATURAL RESOURCES USA INC	IRON MAN 14-24	271607	PR	10084	70830	906	S	701	W	SWSW	24	32S	68W	37.239680	-104.953810	8275	Actual LatLong	Purgatoire River	333681	Las Animas	C
05-071-08035	PIONEER NATURAL RESOURCES USA INC	LATILUPPE 13-8R	271868	PR	10084	70830	1495	S	946	W	NWSW	8	33S	67W	37.183100	-104.917020	7895	Actual LatLong	Purgatoire River	333957	Las Animas	C
05-071-08038	PIONEER NATURAL RESOURCES USA INC	VALEJO 12-8R	271871	PR	10084	70830	1351	N	1562	W	SENW	8	33S	67W	37.189650	-104.914850	7801	Actual LatLong	Purgatoire River	308085	Las Animas	C
05-071-08094	PIONEER NATURAL RESOURCES USA INC	MONTOYA 44-12V	272574	PR	10084	70830	698	S	699	E	SESE	12	33S	68W	37.180590	-104.940090	7877	Actual LatLong	Purgatoire River	333755	Las Animas	C
05-071-08093	PIONEER NATURAL RESOURCES USA INC	J & P 21-13R	272575	PR	10084	70830	749	N	2082	W	NENW	13	33S	68W	37.176920	-104.948490	8013	Actual LatLong	Purgatoire River	333740	Las Animas	C
05-071-08091	PIONEER NATURAL RESOURCES USA INC	J & P 33-12V	272577	PR	10084	70830	2005	S	1928	E	NWSE	12	33S	68W	37.184310	-104.944190	7957	Actual LatLong	Purgatoire River	333394	Las Animas	C
05-071-08090	PIONEER NATURAL RESOURCES USA INC	LAVEDURE 44-7R	272579	PR	10084	70830	976	S	521	E	SESE	7	33S	67W	37.181550	-104.921960	7742	Actual LatLong	Purgatoire River	333897	Las Animas	C
05-071-08089	PIONEER NATURAL RESOURCES USA INC	J & P 21-13V	272580	WO	10084	70830	718	N	1988	W	NENW	13	33S	68W	37.177010	-104.948780	8009	Actual LatLong	Purgatoire River	333740	Las Animas	C
05-071-08121	PIONEER NATURAL RESOURCES USA INC	MASTERS 33-32	272945	PR	10084	70830	1431	S	2144	E	NWSE	32	32S	67W	37.211740	-104.909260	7598	Actual LatLong	Purgatoire River	308495	Las Animas	C
05-071-08138	PIONEER NATURAL RESOURCES USA INC	J & P 24-12V	273079	PR	10084	70830	803	S	2007	W	SESW	12	33S	68W	37.181210	-104.948730	7966	Actual LatLong	Purgatoire River	308506	Las Animas	C
05-071-08137	PIONEER NATURAL RESOURCES USA INC	J & P 24-12R	273080	PR	10084	70830	649	S	2391	W	SESW	12	33S	68W	37.180710	-104.947440	7981	Actual LatLong	Purgatoire River	308505	Las Animas	C

Table C-16 Well Inventory Summary, Raton Basin, Colorado, Retrospective Case Study

API Number	Operator	Well Name	Facility ID	Status	Operator Number	Field Code	Distance N/S of Section Line	Direction from Section Line	Distance E/W of Section Line	Direction Section Line	Quarter	Section	Township	Range	Latitude	Longitude	Ground Elevation	Location Quality	Field Name	Location ID	County	Search Area
05-071-08139	PIONEER NATURAL RESOURCES USA INC	MONTOYA 41-12V	273081	SI	10084	70830	1081	N	530	E	NENE	12	33S	68W	37.190130	-104.939290	7960	Actual LatLong	Purgatoire River	333893	Las Animas	C
05-071-08141	PIONEER NATURAL RESOURCES USA INC	MONTOYA 11-1V	273135	PR	10084	70830	1134	N	618	W	NWNW	1	33S	68W	37.204840	-104.953570	8244	Actual LatLong	Purgatoire River	308508	Las Animas	C
05-071-08142	PIONEER NATURAL RESOURCES USA INC	MONTOYA 44-1V	273136	PR	10084	70830	753	S	990	E	SESE	1	33S	68W	37.195150	-104.940980	7925	Actual LatLong	Purgatoire River	333684	Las Animas	C
05-071-08143	PIONEER NATURAL RESOURCES USA INC	SILVA 22-6V	273137	PR	10084	70830	1936	N	1798	W	SENW	6	33S	67W	37.202500	-104.931840	7890	Actual LatLong	Purgatoire River	308509	Las Animas	C
05-071-08144	PIONEER NATURAL RESOURCES USA INC	MONTOYA 41-1V	273138	SI	10084	70830	610	N	1205	E	NENE	1	33S	68W	37.206360	-104.941960	8211	Actual LatLong	Purgatoire River	308510	Las Animas	C
05-071-08157	PIONEER NATURAL RESOURCES USA INC	MCCULLOUGH 34-32 TR	273307	PR	10084	70830	394	S	2077	E	SWSE	32	32S	67W	37.208870	-104.909040	7560	Actual LatLong	Purgatoire River	333657	Las Animas	C
05-071-08170	PIONEER NATURAL RESOURCES USA INC	LYNCH 43-30	273424	PR	10084	70830	1438	S	429	E	NESE	30	32S	67W	37.226380	-104.921720	7724	Actual LatLong	Purgatoire River	333664	Las Animas	C
05-071-08171	PIONEER NATURAL RESOURCES USA INC	MONTOYA 22-1V	273432	PR	10084	70830	2385	N	2511	W	SENW	1	33S	68W	37.201630	-104.947210	7826	Actual LatLong	Purgatoire River	312003	Las Animas	C
05-071-08192	PIONEER NATURAL RESOURCES USA INC	CODY 44-11V	273552	PR	10084	70830	652	S	715	E	SESE	11	33S	68W	37.180720	-104.958050	7795	Actual LatLong	Purgatoire River	311908	Las Animas	C
05-071-08194	PIONEER NATURAL RESOURCES USA INC	MONTOYA 24-1V	273584	PR	10084	70830	605	S	2557	W	SESW	1	33S	68W	37.194940	-104.946980	7725	Actual LatLong	Purgatoire River	311940	Las Animas	C
05-071-08227	PIONEER NATURAL RESOURCES USA INC	YWAM 23-7V	273974	PR	10084	70830	1596	S	1795	W	NESW	7	33S	67W	37.183090	-104.931450	7776	Actual LatLong	Purgatoire River	333377	Las Animas	C
05-071-08239	PIONEER NATURAL RESOURCES USA INC	MONTOYA 44-1R	274551	PR	10084	70830	668	S	1052	E	SESE	1	33S	68W	37.194960	-104.941160	7925	Actual LatLong	Purgatoire River	333684	Las Animas	C
05-071-08240	PIONEER NATURAL RESOURCES USA INC	MONTOYA 12-7R	274554	PR	10084	70830	1769	N	658	W	SWNW	7	33S	67W	37.188200	-104.935230	7831	Actual LatLong	Purgatoire River	333922	Las Animas	C
05-071-08241	PIONEER NATURAL RESOURCES USA INC	MONTOYA 41-12R	274555	PR	10084	70830	1086	N	610	E	NENE	12	33S	68W	37.190090	-104.939530	7956	Actual LatLong	Purgatoire River	333893	Las Animas	C
05-071-08242	PIONEER NATURAL RESOURCES USA INC	MONTOYA 14-6R	274556	PR	10084	70830	867	S	751	W	SWSW	6	33S	67W	37.195430	-104.934990	7924	Actual LatLong	Purgatoire River	333695	Las Animas	C
05-071-08257	PIONEER NATURAL RESOURCES USA INC	DUDE CANYON 22-32	274911	PR	10084	70830	1662	N	2446	W	SENW	32	32S	67W	37.217800	-104.911890	7670	Actual LatLong	Purgatoire River	333746	Las Animas	C
05-071-08261	PIONEER NATURAL RESOURCES USA INC	NORTH FORK RANCH 11-12V	274980	PR	10084	70830	937	N	522	W	NWNW	12	33S	68W	37.190880	-104.953912	7809	Actual LatLong	Purgatoire River	333378	Las Animas	C
05-071-08266	PIONEER NATURAL RESOURCES USA INC	FURU 6-23	275006	PR	10084	70830	2211	S	1780	W	NESW	6	33S	67W	37.199190	-104.931830	7889	Actual LatLong	Purgatoire River	333369	Las Animas	C
05-071-08265	PIONEER NATURAL RESOURCES USA INC	NORTH FORK RANCH 11-12R	275009	TA	10084	70830	953	N	448	W	NWNW	12	33S	68W	37.190860	-104.954160	7802	Actual LatLong	Purgatoire River	333378	Las Animas	C
05-071-08270	PIONEER NATURAL RESOURCES USA INC	FURU 23-6V	275074	PA	10084	70830	2111	S	1774	W	NESW	6	33S	67W	37.198940	-104.931670	7913	Actual LatLong	Purgatoire River	333369	Las Animas	C
05-071-08281	PIONEER NATURAL RESOURCES USA INC	UNDERWORLD 31-36	275326	PR	10084	70830	483	N	2620	E	NWNE	36	32S	68W	37.221080	-104.946820	8160	Actual LatLong	Purgatoire River	333359	Las Animas	C
05-071-08294	PIONEER NATURAL RESOURCES USA INC	NIAGARA 23-35	275644	DA	10084	70830	2001	N	995	W	NESW	35	32S	68W	37.213920	-104.969220	8011	Actual LatLong	Purgatoire River	386800	Las Animas	C
05-071-08359	PIONEER NATURAL RESOURCES USA INC	CACTUS FLOWER 13-24	276908	PR	10084	70830	2092	S	625	W	NWSW	24	32S	68W	37.243170	-104.954270	8337	Actual LatLong	Purgatoire River	308622	Las Animas	C
05-071-08371	PIONEER NATURAL RESOURCES USA INC	SILVA 43-1V	277461	PR	10084	70830	2010	S	614	E	NESE	1	33S	68W	37.198640	-104.940040	8002	Actual LatLong	Purgatoire River	333423	Las Animas	C
05-071-08372	PIONEER NATURAL RESOURCES USA INC	SILVA 43-1R	277462	PR	10084	70830	1971	S	526	E	NESE	1	33S	68W	37.198491	-104.939630	7991	Actual LatLong	Purgatoire River	333423	Las Animas	C
05-071-08374	PIONEER NATURAL RESOURCES USA INC	GRANITE 21-25	277529	PR	10084	70830	217	N	2482	W	NENW	25	32S	68W	37.236580	-104.947860	8365	Actual LatLong	Purgatoire River	334164	Las Animas	C
05-071-08381	PIONEER NATURAL RESOURCES USA INC	HAVANA 12-25	277815	PR	10084	70830	1981	N	535	W	SWNW	25	32S	68W	37.231950	-104.954530	8438	Actual LatLong	Purgatoire River	308638	Las Animas	C
05-071-08421	PIONEER NATURAL RESOURCES USA INC	DUDE CANYON 22-32TR	278291	PR	10084	70830	1741	N	2331	W	SENW	32	32S	67W	37.217700	-104.912210	7657	Actual LatLong	Purgatoire River	333746	Las Animas	C
05-071-08435	PIONEER NATURAL RESOURCES USA INC	MONTOYA 21-7R	278542	PR	10084	70830	445	N	1942	W	NENW	7	33S	67W	37.191893	-104.930747	7680	Actual LatLong	Purgatoire River	308677	Las Animas	C

Table C-16 Well Inventory Summary, Raton Basin, Colorado, Retrospective Case Study

API Number	Operator	Well Name	Facility ID	Status	Operator Number	Field Code	Distance N/S of Section Line	Direction from Section Line	Distance E/W of Section Line	Direction Section Line	Quarter	Section	Township	Range	Latitude	Longitude	Ground Elevation	Location Quality	Field Name	Location ID	County	Search Area
05-071-08431	PIONEER NATURAL RESOURCES USA INC	MELANIE 44-23 TR	278546	PR	10084	70830	871	S	922	E	SESE	23	32S	68W	37.239690	-104.959660	8378	Actual LatLong	Purgatoire River	333739	Las Animas	C
05-071-08443	PIONEER NATURAL RESOURCES USA INC	SHADOWLAND 33-24	278639	PR	10084	70830	1469	S	1575	E	NWSE	24	32S	68W	37.241190	-104.943030	8279	Actual LatLong	Purgatoire River	308682	Las Animas	C
05-071-08447	PIONEER NATURAL RESOURCES USA INC	LYNCH 43-30 TR	278884	PR	10084	70830	1431	S	301	E	NESE	30	32S	67W	37.226320	-104.921370	7724	Actual LatLong	Purgatoire River	333664	Las Animas	C
05-071-08450	PIONEER NATURAL RESOURCES USA INC	BLACK CAT 13-32	278887	PR	10084	70830	1665	S	1120	W	NWSW	32	32S	67W	37.212470	-104.916330	7800	Actual LatLong	Purgatoire River	333425	Las Animas	C
05-071-08461	PIONEER NATURAL RESOURCES USA INC	IRON MAN 14-24 TR	279050	PR	10084	70830	899	S	908	W	SWSW	24	32S	68W	37.239800	-104.953390	8275	Actual LatLong	Purgatoire River	333681	Las Animas	C
05-071-08475	PIONEER NATURAL RESOURCES USA INC	MICHELLE 31-25	279205	PR	10084	70830	422	N	1522	E	NWNE	25	32S	68W	37.235930	-104.942880	8206	Actual LatLong	Purgatoire River	308698	Las Animas	C
05-071-08510	PIONEER NATURAL RESOURCES USA INC	SCHWEITZER 22-30	279627	PR	10084	70830	2407	N	1966	W	SENW	30	32S	67W	37.230370	-104.931260	8005	Actual LatLong	Purgatoire River	308721	Las Animas	C
05-071-08518	PIONEER NATURAL RESOURCES USA INC	YWAM 32-7R	279672	PR	10084	70830	2355	N	2376	E	SWNE	7	33S	67W	37.186200	-104.928300	7710	Actual LatLong	Purgatoire River	333926	Las Animas	C
05-071-08536	PIONEER NATURAL RESOURCES USA INC	MONTOYA 21-1V	280040	PR	10084	70830	601	N	2284	W	NENW	1	33S	68W	37.206500	-104.947760	7867	Actual LatLong	Purgatoire River	311919	Las Animas	C
05-071-08537	PIONEER NATURAL RESOURCES USA INC	MONTOYA 22-1R	280041	PR	10084	70830	2517	N	2492	W	SENW	1	33S	68W	37.201270	-104.947260	7818	Actual LatLong	Purgatoire River	312003	Las Animas	C
05-071-08538	PIONEER NATURAL RESOURCES USA INC	MONTOYA 44-12R	280042	PR	10084	70830	713	S	798	E	SESE	12	33S	68W	37.180640	-104.940390	7875	Actual LatLong	Purgatoire River	333755	Las Animas	C
05-071-08539	PIONEER NATURAL RESOURCES USA INC	MONTOYA 11-18V-B	280043	PR	10084	70830	848	N	619	W	NWNW	18	33S	67W	37.176288	-104.935593	7850	Actual LatLong	Purgatoire River	308734	Las Animas	C
05-071-08546	PIONEER NATURAL RESOURCES USA INC	GREY GOOSE 33-30	280228	PR	10084	70830	1607	S	1793	E	NWSE	30	32S	67W	37.226750	-104.926500	7943	Actual LatLong	Purgatoire River	308739	Las Animas	C
05-071-08554	PIONEER NATURAL RESOURCES USA INC	MONTOYA 14-7R	280385	PR	10084	70830	628	S	454	W	SWSW	7	33S	67W	37.180540	-104.936160	7795	Actual LatLong	Purgatoire River	333715	Las Animas	C
05-071-08564	PIONEER NATURAL RESOURCES USA INC	TOUCHSTONE 11-32	280544	PR	10084	70830	853	N	407	W	NWNW	32	32S	67W	37.220070	-104.918810	7834	Actual LatLong	Purgatoire River	334167	Las Animas	C
05-071-08566	PIONEER NATURAL RESOURCES USA INC	MONTOYA 13-18R	280568	PR	10084	70830	1458	S	1045	W	NWSW	18	33S	67W	37.168315	-104.934140	7886	Actual LatLong	Purgatoire River	333944	Las Animas	C
05-071-08567	PIONEER NATURAL RESOURCES USA INC	SMITH 22-18R	280571	WO	10084	70830	2066	N	1923	W	SENW	18	33S	67W	37.173032	-104.931134	7826	Actual LatLong	Purgatoire River	308748	Las Animas	C
05-071-08602	PIONEER NATURAL RESOURCES USA INC	FLASHBACK 32-27	280929	WO	10084	70830	1538	N	2319	E	SWNE	27	32S	68W	37.232300	-104.982600	8360	Actual LatLong	Purgatoire River	308772	Las Animas	C
05-071-08616	PIONEER NATURAL RESOURCES USA INC	SPYGLASS 13-30	281266	PR	10084	70830	2450	S	12	W	NWSW	30	32S	67W	37.229060	-104.937530	8200	Actual LatLong	Purgatoire River	334166	Las Animas	C
05-071-08626	PIONEER NATURAL RESOURCES USA INC	TOUCHSTONE 11-32 TR	281723	PR	10084	70830	782	N	480	W	NWNW	32	32S	67W	37.220270	-104.918610	7829	Actual LatLong	Purgatoire River	334167	Las Animas	C
05-071-08645	PIONEER NATURAL RESOURCES USA INC	UNDERWORLD 31-36 TR	282116	PR	10084	70830	421	N	2502	E	NWNE	36	32S	68W	37.221220	-104.946530	8122	Actual LatLong	Purgatoire River	333359	Las Animas	C
05-071-08668	PIONEER NATURAL RESOURCES USA INC	SLATE 23-30	282389	PR	10084	70830	1320	S	1511	W	NESW	30	32S	67W	37.225980	-104.932270	8110	Actual LatLong	Purgatoire River	308809	Las Animas	C
05-071-08673	PIONEER NATURAL RESOURCES USA INC	TALON 34-25	282535	PR	10084	70830	784	S	1535	E	SWSE	25	32S	68W	37.224510	-104.943220	8143	Actual LatLong	Purgatoire River	308812	Las Animas	C
05-071-08704	PIONEER NATURAL RESOURCES USA INC	SPIKE 33-23	282946	PR	10084	70830	2185	S	1480	E	NWSE	23	32S	68W	37.243210	-104.961500	8362	Actual LatLong	Purgatoire River	308836	Las Animas	C
05-071-08721	PIONEER NATURAL RESOURCES USA INC	BLACK CAT 13-32 TR	283463	SI	10084	70830	1679	S	1150	W	NWSW	32	32S	67W	37.212650	-104.916030	7767	Actual LatLong	Purgatoire River	333425	Las Animas	C
05-071-08730	PIONEER NATURAL RESOURCES USA INC	KENNEDY 14-22	283660	PA	10084	70830	872	S	811	W	SWSW	22	32S	68W	37.238910	-104.990130	8618	Actual LatLong	Purgatoire River	308856	Las Animas	C
05-071-08738	PIONEER NATURAL RESOURCES USA INC	ELTON 34-22	284015	SI	10084	70830	695	S	2186	E	SWSE	22	32S	68W	37.238440	-104.982040	8459	Actual LatLong	Purgatoire River	308863	Las Animas	C
05-071-08826	PIONEER NATURAL RESOURCES USA INC	MONTOYA 31-6R	285222	PR	10084	70830	714	N	1871	E	NWNE	6	33S	67W	37.205860	-104.926690	7957	Actual LatLong	Purgatoire River	333390	Las Animas	C
05-071-08827	PIONEER NATURAL RESOURCES USA INC	MONTOYA 31-6V	285223	PR	10084	70830	616	N	1851	E	NWNE	6	33S	67W	37.206140	-104.926600	7958	Actual LatLong	Purgatoire River	333390	Las Animas	C

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API Number	Operator	Well Name	Facility ID	Status	Operator Number	Field Code	Distance N/S of Section Line	Direction from Section Line	Distance E/W of Section Line	Direction Section Line	Quarter	Section	Township	Range	Latitude	Longitude	Ground Elevation	Location Quality	Field Name	Location ID	County	Search Area
05-071-08834	PIONEER NATURAL RESOURCES USA INC	KAUAI 23-36 TR	285478	PR	10084	70830	1601	S	2574	W	NESW	36	32S	68W	37.212620	-104.946860	8074	Actual LatLong	Purgatoire River	333381	Las Animas	C
05-071-08835	PIONEER NATURAL RESOURCES USA INC	KAUAI 23-36	285482	PR	10084	70830	1684	S	2509	W	NESW	36	32S	68W	37.212804	-104.947120	8075	Actual LatLong	Purgatoire River	333381	Las Animas	C
05-071-08836	PIONEER NATURAL RESOURCES USA INC	JEEP TRAIL 43-36 TR	285483	PR	10084	70830	2436	S	1210	E	NESE	36	32S	68W	37.214740	-104.942070	8125	Actual LatLong	Purgatoire River	334091	Las Animas	C
05-071-08837	PIONEER NATURAL RESOURCES USA INC	MOLOKAI 13-36 TR	285484	DA	10084	70830	1536	S	631	W	NWSW	36	32S	68W	37.212190	-104.953560	8187	Actual LatLong	Purgatoire River	386812	Las Animas	C
05-071-08838	PIONEER NATURAL RESOURCES USA INC	MOLOKAI 13-36	285485	PR	10084	70830	1438	S	616	W	NWSW	36	32S	68W	37.211930	-104.953590	8204	Actual LatLong	Purgatoire River	308941	Las Animas	C
05-071-08839	PIONEER NATURAL RESOURCES USA INC	HAWAII 44-36	285486	PR	10084	70830	1023	S	520	E	SESE	36	32S	68W	37.210680	-104.939830	8164	Actual LatLong	Purgatoire River	311945	Las Animas	C
05-071-08840	PIONEER NATURAL RESOURCES USA INC	HAWAII 44-36 TR	285487	PR	10084	70830	923	S	538	E	SESE	36	32S	68W	37.210440	-104.939840	8162	Actual LatLong	Purgatoire River	311945	Las Animas	C
05-071-08845	PIONEER NATURAL RESOURCES USA INC	JEEP TRAIL 43-36	285494	PR	10084	70830	2506	S	1273	E	NESE	36	32S	68W	37.214880	-104.942330	8129	Actual LatLong	Purgatoire River	334091	Las Animas	C
05-071-08846	PIONEER NATURAL RESOURCES USA INC	SANCHINATOR 11-36 TR	285562	PR	10084	70830	1068	N	259	W	NWNW	36	32S	68W	37.219750	-104.955080	8399	Actual LatLong	Purgatoire River	334110	Las Animas	C
05-071-08847	PIONEER NATURAL RESOURCES USA INC	SANCHINATOR 11-36	285563	PR	10084	70830	971	N	233	W	NWNW	36	32S	68W	37.220000	-104.955190	8392	Actual LatLong	Purgatoire River	334110	Las Animas	C
05-071-08853	PIONEER NATURAL RESOURCES USA INC	CROSSWORD 41-36	285607	PR	10084	70830	1114	N	393	E	NENE	36	32S	68W	37.219230	-104.939320	8073	Actual LatLong	Purgatoire River	334100	Las Animas	C
05-071-08852	PIONEER NATURAL RESOURCES USA INC	CROSSWORD 41-36 TR	285608	PR	10084	70830	1163	N	484	E	NENE	36	32S	68W	37.219100	-104.939570	8078	Actual LatLong	Purgatoire River	334100	Las Animas	C
05-071-08850	PIONEER NATURAL RESOURCES USA INC	GRAND VALLEY 22-36	285610	PR	10084	70830	2039	N	1637	W	SENW	36	32S	68W	37.216890	-104.950220	8065	Actual LatLong	Purgatoire River	334101	Las Animas	C
05-071-08849	PIONEER NATURAL RESOURCES USA INC	GRAND VALLEY 22-36 TR	285611	PR	10084	70830	2033	N	1740	W	SENW	36	32S	68W	37.216900	-104.949920	8076	Actual LatLong	Purgatoire River	334101	Las Animas	C
05-071-08871	PIONEER NATURAL RESOURCES USA INC	NORTH FORK RANCH 14-1V	285679	PR	10084	70830	1031	S	638	W	SWSW	1	33S	68W	37.196250	-104.953600	7930	Actual LatLong	Purgatoire River	311942	Las Animas	C
05-071-08870	PIONEER NATURAL RESOURCES USA INC	NORTH FORK RANCH 14-1R	285680	PR	10084	70830	967	S	698	W	SWSW	1	33S	68W	37.196090	-104.953390	7931	Actual LatLong	Purgatoire River	311942	Las Animas	C
05-071-08872	PIONEER NATURAL RESOURCES USA INC	CODY 44-11R	285807	PR	10084	70830	554	S	684	E	SESE	11	33S	68W	37.180560	-104.957970	7784	Actual LatLong	Purgatoire River	311908	Las Animas	C
05-071-08875	PIONEER NATURAL RESOURCES USA INC	MONTOYA 24-1R	285864	PR	10084	70830	610	S	2477	W	SESW	1	33S	68W	37.195010	-104.947250	7726	Actual LatLong	Purgatoire River	311940	Las Animas	C
05-071-08874	PIONEER NATURAL RESOURCES USA INC	MONTOYA 41-13R	285865	PR	10084	70830	524	N	891	E	NENE	13	33S	68W	37.177240	-104.940740	7868	Actual LatLong	Purgatoire River	333391	Las Animas	C
05-071-08873	PIONEER NATURAL RESOURCES USA INC	KEYTON 41-7V	285866	PR	10084	70830	641	N	603	E	NENE	7	33S	67W	37.191480	-104.922280	7890	Actual LatLong	Purgatoire River	311941	Las Animas	C
05-071-08878	PIONEER NATURAL RESOURCES USA INC	KING KONG 11-25	285916	DA	10084	70830	473	N	47	W	NWNW	25	32S	68W	37.236150	-104.956290	8429	Actual LatLong	Purgatoire River	309088	Las Animas	C
05-071-08877	PIONEER NATURAL RESOURCES USA INC	MONTOYA 11-1R	285917	WO	10084	70830	1171	N	713	W	NWNW	1	33S	68W	37.204750	-104.953260	8245	Actual LatLong	Purgatoire River	308963	Las Animas	C
05-071-08876	PIONEER NATURAL RESOURCES USA INC	MONTOYA 41-1R	285918	PR	10084	70830	471	N	1161	E	NENE	1	33S	68W	37.206680	-104.942020	8225	Actual LatLong	Purgatoire River	308962	Las Animas	C
05-071-08879	PIONEER NATURAL RESOURCES USA INC	YWAM 23-7R	285935	PR	10084	70830	1657	S	1738	W	NESW	7	33S	67W	37.183260	-104.931580	7770	Actual LatLong	Purgatoire River	333377	Las Animas	C
05-071-08880	PIONEER NATURAL RESOURCES USA INC	CRUM 33-5R	285936	PR	10084	70830	1454	S	2398	E	NWSE	5	33S	67W	37.197400	-104.910040	7687	Actual LatLong	Purgatoire River	311962	Las Animas	C
05-071-08881	PIONEER NATURAL RESOURCES USA INC	CRUM 33-5V	285937	PR	10084	70830	1369	S	2330	E	NWSE	5	33S	67W	37.197190	-104.909820	7693	Actual LatLong	Purgatoire River	311921	Las Animas	C
05-071-08882	PIONEER NATURAL RESOURCES USA INC	MONTOYA 42-1V	285938	PR	10084	70830	1923	N	701	E	SENE	1	33S	68W	37.202610	-104.940440	8069	Actual LatLong	Purgatoire River	333361	Las Animas	C
05-071-08883	PIONEER NATURAL RESOURCES USA INC	MONTOYA 42-1R	285939	PR	10084	70830	1972	N	617	E	SENE	1	33S	68W	37.202470	-104.940120	8066	Actual LatLong	Purgatoire River	333361	Las Animas	C
05-071-08884	PIONEER NATURAL RESOURCES USA INC	MONTOYA 11-6R	285940	PR	10084	70830	319	N	528	W	NWNW	6	33S	67W	37.206930	-104.936220	8277	Actual LatLong	Purgatoire River	333365	Las Animas	C

Table C-16 Well Inventory Summary, Raton Basin, Colorado, Retrospective Case Study

API Number	Operator	Well Name	Facility ID	Status	Operator Number	Field Code	Distance N/S of Section Line	Direction from Section Line	Distance E/W of Section Line	Direction Section Line	Quarter	Section	Township	Range	Latitude	Longitude	Ground Elevation	Location Quality	Field Name	Location ID	County	Search Area
05-071-08902	PIONEER NATURAL RESOURCES USA INC	DUNN 14-5V	286044	PR	10084	70830	1126	S	1140	W	SWSW	5	33S	67W	37.196420	-104.916320	7742	Actual LatLong	Purgatoire River	311922	Las Animas	C
05-071-08897	PIONEER NATURAL RESOURCES USA INC	HOFFMAN 43-31	286049	PR	10084	70830	1378	S	1267	E	NESE	31	32S	67W	37.211600	-104.924570	7804	Actual LatLong	Purgatoire River	308973	Las Animas	C
05-071-08896	PIONEER NATURAL RESOURCES USA INC	HOFFMAN 43-31 TR	286050	AL	10084	70830	1877	S	886	E	NESE	31	32S	67W	37.213030	-104.923320	7804	Planned LatLong	Purgatoire River	308972	Las Animas	C
05-071-08894	PIONEER NATURAL RESOURCES USA INC	BRUSCHER 13-5V	286052	SI	10084	70830	2548	S	1190	W	NWSW	5	33S	67W	37.200350	-104.916150	7671	Actual LatLong	Purgatoire River	333366	Las Animas	C
05-071-08893	PIONEER NATURAL RESOURCES USA INC	BRUSCHER 13-5R	286053	PR	10084	70830	2557	S	1289	W	NWSW	5	33S	67W	37.200390	-104.915800	7670	Actual LatLong	Purgatoire River	333366	Las Animas	C
05-071-08892	PIONEER NATURAL RESOURCES USA INC	DUNN 14-5R	286054	PR	10084	70830	1130	S	1060	W	SWSW	5	33S	67W	37.196440	-104.916580	7755	Actual LatLong	Purgatoire River	311922	Las Animas	C
05-071-08911	PIONEER NATURAL RESOURCES USA INC	LEFT HAND FORK 32-31	286103	PR	10084	70830	1869	N	1705	E	SWNE	31	32S	67W	37.217210	-104.926110	7802	Actual LatLong	Purgatoire River	334108	Las Animas	C
05-071-08907	PIONEER NATURAL RESOURCES USA INC	KING SALMON 24-31	286107	PR	10084	70830	848	S	1425	W	SESW	31	32S	67W	37.210130	-104.933450	7920	Actual LatLong	Purgatoire River	311982	Las Animas	C
05-071-08906	PIONEER NATURAL RESOURCES USA INC	KING SALMON 24-31 TR	286108	PR	10084	70830	851	S	1326	W	SESW	31	32S	67W	37.210140	-104.933140	7914	Actual LatLong	Purgatoire River	311982	Las Animas	C
05-071-08938	PIONEER NATURAL RESOURCES USA INC	KEYSTONE 11-35	286289	SI	10084	70830	162	N	410	W	NWNW	35	32S	68W	37.220670	-104.973230	7991	Actual LatLong	Purgatoire River	308998	Las Animas	C
05-071-08933	PIONEER NATURAL RESOURCES USA INC	DIVIDE 14-26	286294	XX	10084	70830	989	S	1269	W	SWSW	26	32S	68W	37.224130	-104.970310	8217	Planned LatLong	Purgatoire River	308995	Las Animas	C
05-071-08945	PIONEER NATURAL RESOURCES USA INC	MACGREGOR 32-25 TR	286325	PR	10084	70830	1825	N	2176	E	SWNE	25	32S	68W	37.232100	-104.945440	8275	Actual LatLong	Purgatoire River	333380	Las Animas	C
05-071-08944	PIONEER NATURAL RESOURCES USA INC	MACGREGOR 32-25	286327	PR	10084	70830	1812	N	2078	E	SWNE	25	32S	68W	37.232140	-104.945080	8270	Actual LatLong	Purgatoire River	333380	Las Animas	C
05-071-08957	PIONEER NATURAL RESOURCES USA INC	MONTOYA 21-1R	286431	PR	10084	70830	699	N	2280	W	NENW	1	33S	68W	37.206230	-104.947800	7869	Actual LatLong	Purgatoire River	311919	Las Animas	C
05-071-08956	PIONEER NATURAL RESOURCES USA INC	J & P 33-12R	286432	WO	10084	70830	1926	S	1869	E	NWSE	12	33S	68W	37.184310	-104.944170	7955	Actual LatLong	Purgatoire River	333394	Las Animas	C
05-071-08968	PIONEER NATURAL RESOURCES USA INC	RULLESTAD 13-12R	286467	PR	10084	70830	2424	S	307	W	NWSW	12	33S	68W	37.185880	-104.954610	7850	Actual LatLong	Purgatoire River	311943	Las Animas	C
05-071-08967	PIONEER NATURAL RESOURCES USA INC	RULLESTAD 13-12V	286468	PR	10084	70830	2339	S	354	W	NWSW	12	33S	68W	37.185630	-104.954450	7850	Actual LatLong	Purgatoire River	311943	Las Animas	C
05-071-08972	PIONEER NATURAL RESOURCES USA INC	TREBOR 32-5V	286574	PR	10084	70830	2384	N	1525	E	SWNE	5	33S	67W	37.201290	-104.907110	7651	Actual LatLong	Purgatoire River	311944	Las Animas	C
05-071-08982	PIONEER NATURAL RESOURCES USA INC	GLORIA 42-25	286677	PR	10084	70830	1349	N	293	E	SENE	25	32S	68W	37.233340	-104.938840	8075	Actual LatLong	Purgatoire River	334118	Las Animas	C
05-071-08981	PIONEER NATURAL RESOURCES USA INC	GLORIA 42-25 TR	286678	PR	10084	70830	1344	N	197	E	SENE	25	32S	68W	37.233380	-104.938520	8061	Actual LatLong	Purgatoire River	334118	Las Animas	C
05-071-08978	PIONEER NATURAL RESOURCES USA INC	MAUI 13-31	286681	PR	10084	70830	2242	S	926	W	NWSW	31	32S	67W	37.213970	-104.934810	7972	Actual LatLong	Purgatoire River	334146	Las Animas	C
05-071-08977	PIONEER NATURAL RESOURCES USA INC	MAUI 13-31 TR	286682	PR	10084	70830	2221	S	829	W	NWSW	31	32S	67W	37.213920	-104.935150	7975	Actual LatLong	Purgatoire River	334424	Las Animas	C
05-071-08974	PIONEER NATURAL RESOURCES USA INC	TREBOR 32-5R	286685	PR	10084	70830	2329	N	1608	E	SWNE	5	33S	67W	37.201430	-104.907360	7650	Actual LatLong	Purgatoire River	311944	Las Animas	C
05-071-08991	PIONEER NATURAL RESOURCES USA INC	ANDERSON 42-18R	286820	PR	10084	70830	1751	N	1052	E	SENE	18	33S	67W	37.174010	-104.923800	7427	Actual LatLong	Purgatoire River	308375	Las Animas	C
05-071-08992	PIONEER NATURAL RESOURCES USA INC	TYCER 32-6R	286822	PR	10084	70830	2117	N	1521	E	SWNE	6	33S	67W	37.202000	-104.925490	7869	Actual LatLong	Purgatoire River	333424	Las Animas	C
05-071-08993	PIONEER NATURAL RESOURCES USA INC	TYCER 32-6V	286823	SI	10084	70830	2115	N	1421	E	SWNE	6	33S	67W	37.202050	-104.925145	7869	Actual LatLong	Purgatoire River	333424	Las Animas	C
05-071-08997	PIONEER NATURAL RESOURCES USA INC	SHADOW 33-31 TR	286840	AL	10084	70830	1618	S	2571	E	NWSE	31	32S	67W	37.212260	-104.929110	7918	Planned LatLong	Purgatoire River	386813	Las Animas	C
05-071-08996	PIONEER NATURAL RESOURCES USA INC	SHADOW 33-31	286841	PR	10084	70830	1664	S	2491	E	NWSE	31	32S	67W	37.212380	-104.928810	7907	Actual LatLong	Purgatoire River	309030	Las Animas	C
05-071-09008	PIONEER NATURAL RESOURCES USA INC	WOOD 43-2V	287189	PR	10084	70830	1675	S	777	E	NESE	2	33S	68W	37.197840	-104.958480	7910	Actual LatLong	Purgatoire River	333358	Las Animas	C

Table C-16 Well Inventory Summary, Raton Basin, Colorado, Retrospective Case Study

API Number	Operator	Well Name	Facility ID	Status	Operator Number	Field Code	Distance N/S of Section Line	Direction from Section Line	Distance E/W of Section Line	Direction Section Line	Quarter	Section	Township	Range	Latitude	Longitude	Ground Elevation	Location Quality	Field Name	Location ID	County	Search Area
05-071-09009	PIONEER NATURAL RESOURCES USA INC	WOOD 43-2 R	287191	AL	10084	70830	1637	S	715	E	NESE	2	33S	68W	37.197810	-104.958270	7913	Planned LatLong	Purgatoire River	333358	Las Animas	C
05-071-09021	PIONEER NATURAL RESOURCES USA INC	KENNEDY 34-34	287523	PR	10084	70830	548	S	2567	E	SWSE	34	32S	68W	37.207920	-104.983340	7830	Actual LatLong	Purgatoire River	309049	Las Animas	C
05-071-09019	PIONEER NATURAL RESOURCES USA INC	KENNEDY 11-34	287525	PR	10084	70830	597	N	1293	W	NWNW	34	32S	68W	37.219800	-104.988290	7936	Actual LatLong	Purgatoire River	309047	Las Animas	C
05-071-09052	PIONEER NATURAL RESOURCES USA INC	KENNEDY 23-28	287729	PR	10084	70830	1678	S	1450	W	NESW	28	32S	68W	37.226100	-105.006020	8544	Actual LatLong	Purgatoire River	309077	Las Animas	C
05-071-09063	PIONEER NATURAL RESOURCES USA INC	KING KONG 11-25R	287898	PR	10084	70830	417	N	58	W	NWNW	25	32S	68W	37.236290	-104.956250	8444	Actual LatLong	Purgatoire River	309088	Las Animas	C
05-071-09071	PIONEER NATURAL RESOURCES USA INC	KENNEDY 43-28	287979	PR	10084	70830	1405	S	985	E	NESE	28	32S	68W	37.225410	-104.996160	8284	Actual LatLong	Purgatoire River	309093	Las Animas	C
05-071-09070	PIONEER NATURAL RESOURCES USA INC	LEFT HAND FORK 32-31 TR	287980	AL	10084	70830	1957	N	1752	E	SWNE	31	32S	67W	37.216980	-104.926270	7810	Planned LatLong	Purgatoire River	334108	Las Animas	C
05-071-09090	PIONEER NATURAL RESOURCES USA INC	WOOD 31-2 R	288154	AL	10084	70830	906	N	1399	E	NW/NE	2	33S	68W	37.205060	-104.960490	8197	Planned LatLong	Purgatoire River	333974	Las Animas	C
05-071-09091	PIONEER NATURAL RESOURCES USA INC	WOOD 31-2	288155	PR	10084	70830	941	N	1452	E	NWNE	2	33S	68W	37.204950	-104.960670	8194	Actual LatLong	Purgatoire River	333974	Las Animas	C
05-071-09100	PIONEER NATURAL RESOURCES USA INC	LADYHAWKE 41-31	288260	PR	10084	70830	169	N	1275	E	NENE	31	32S	67W	37.221910	-104.924610	7924	Actual LatLong	Purgatoire River	334219	Las Animas	C
05-071-09095	PIONEER NATURAL RESOURCES USA INC	BASELINE 21-31	288265	PR	10084	70830	233	N	1769	W	NENW	31	32S	67W	37.221670	-104.931810	7902	Actual LatLong	Purgatoire River	334241	Las Animas	C
05-071-09105	PIONEER NATURAL RESOURCES USA INC	KEYTON 41-7R	288305	AL	10084	70830	688	N	514	E	NENE	7	33S	67W	37.191350	-104.921980	7884	Planned LatLong	Purgatoire River	311941	Las Animas	C
05-071-09119	PIONEER NATURAL RESOURCES USA INC	BASELINE 21-31 TR	288535	AL	10084	70830	262	N	1868	W	NENW	31	32S	67W	37.221610	-104.931510	7879	Planned LatLong	Purgatoire River	334241	Las Animas	C
05-071-09118	PIONEER NATURAL RESOURCES USA INC	LADYHAWKE 41-31 TR	288536	PR	10084	70830	208	N	1187	E	NENE	31	32S	67W	37.221800	-104.924320	7926	Actual LatLong	Purgatoire River	334219	Las Animas	C
05-071-09169	PIONEER NATURAL RESOURCES USA INC	KENNEDY 12-34	289013	AL	10084	70830	2539	N	185	W	SWNW	34	32S	68W	37.214560	-104.992080	8129	Planned LatLong	Purgatoire River	334346	Las Animas	C
05-071-09182	PIONEER NATURAL RESOURCES USA INC	MAGNUM 43-26	289046	PR	10084	70830	1784	S	213	E	NESE	26	32S	68W	37.227790	-104.956890	8382	Actual LatLong	Purgatoire River	309160	Las Animas	C
05-071-09181	PIONEER NATURAL RESOURCES USA INC	TAILGATE 14-25 TR	289047	PR	10084	70830	634	S	840	W	SWSW	25	32S	68W	37.224360	-104.953220	8247	Actual LatLong	Purgatoire River	334206	Las Animas	C
05-071-09180	PIONEER NATURAL RESOURCES USA INC	TAILGATE 14-25	289048	PR	10084	70830	555	S	800	W	SWSW	25	32S	68W	37.224130	-104.953380	8254	Actual LatLong	Purgatoire River	334206	Las Animas	C
05-071-09194	PIONEER NATURAL RESOURCES USA INC	OUTPOST 22-24	289277	PR	10084	70830	1997	N	2392	W	SENW	24	32S	68W	37.245930	-104.948110	8035	Actual LatLong	Purgatoire River	334199	Las Animas	C
05-071-09193	PIONEER NATURAL RESOURCES USA INC	OUTPOST 22-24 TR	289278	PR	10084	70830	1980	N	2491	W	SENW	24	32S	68W	37.245950	-104.947770	8025	Actual LatLong	Purgatoire River	334199	Las Animas	C
05-071-09211	PIONEER NATURAL RESOURCES USA INC	VALDEZ 44-6R	289668	AL	10084	70830	914	S	1076	E	SESE	6	33S	67W	37.195720	-104.923930	7833	Planned LatLong	Purgatoire River	333977	Las Animas	C
05-071-09210	PIONEER NATURAL RESOURCES USA INC	VALDEZ 44-6V	289669	TA	10084	70830	830	S	1130	E	SESE	6	33S	67W	37.195490	-104.924140	7832	Actual LatLong	Purgatoire River	333977	Las Animas	C
05-071-09229	PIONEER NATURAL RESOURCES USA INC	LEFT HAND FORK DEEP 32-31	289951	SI	10084	70830	2257	N	2127	E	SWNE	31	32S	67W	37.216140	-104.927550	7922	Actual LatLong	Purgatoire River	309194	Las Animas	C
05-071-09308	PIONEER NATURAL RESOURCES USA INC	FLASHBACK DEEP 22-27	290804	PR	10084	70830	1813	N	2376	W	SENW	27	32S	68W	37.231530	-104.984710	8439	Actual LatLong	Purgatoire River	309260	Las Animas	C
05-071-09313	PIONEER NATURAL RESOURCES USA INC	KENNEDY DEEP 12-34	290885	AL	10084	70830	2549	N	86	W	SWNW	34	32S	68W	37.214540	-104.992420	8127	Planned LatLong	Purgatoire River	334346	Las Animas	C
05-071-09367	PIONEER NATURAL RESOURCES USA INC	KEY LARGO 41-30	291751	PR	10084	70830	657	N	1148	E	NENE	30	32S	67W	37.235130	-104.924230	7810	Actual LatLong	Purgatoire River	309304	Las Animas	C
05-071-09374	PIONEER NATURAL RESOURCES USA INC	MONTOYA 12-1V	291813	AL	10084	70830	2470	N	1041	W	SWNW	1	33S	68W	37.201210	-104.952276	7927	Planned LatLong	Purgatoire River	333972	Las Animas	C
05-071-09373	PIONEER NATURAL RESOURCES USA INC	MONTOYA 12-1R	291814	AL	10084	70830	2460	N	1140	W	SWNW	1	33S	68W	37.201248	-104.951935	7924	Planned LatLong	Purgatoire River	333972	Las Animas	C
05-071-09371	PIONEER NATURAL RESOURCES USA INC	SAVANNAH 12-23	291816	PR	10084	70830	2389	N	1014	W	SWNW	23	32S	68W	37.244910	-104.971290	8432	Actual LatLong	Purgatoire River	309308	Las Animas	C

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API Number	Operator	Well Name	Facility ID	Status	Operator Number	Field Code	Distance N/S of Section Line	Direction from Section Line	Distance E/W of Section Line	Direction Section Line	Quarter	Section	Township	Range	Latitude	Longitude	Ground Elevation	Location Quality	Field Name	Location ID	County	Search Area
05-071-09375	PIONEER NATURAL RESOURCES USA INC	CACTUS FLOWER DEEP 13-24	291860	PA	10084	70830	1545	S	799	W	NWSW	24	32S	68W	37.241630	-104.953690	8380	Actual LatLong	Purgatoire River	386819	Las Animas	C
05-071-09384	PIONEER NATURAL RESOURCES USA INC	IRELAND 14-32 TR	292157	PR	10084	70830	290	S	1265	W	SWSW	32	32S	67W	37.208670	-104.915930	7895	Actual LatLong	Purgatoire River	309316	Las Animas	C
05-071-09390	PIONEER NATURAL RESOURCES USA INC	NIAGARA 23-35 R	292312	PR	10084	70830	2578	S	1468	W	NESW	35	32S	68W	37.213990	-104.969440	8062	Actual LatLong	Purgatoire River	309320	Las Animas	C
05-071-09398	PIONEER NATURAL RESOURCES USA INC	SHINING 33-22	292378	PR	10084	70830	2238	S	1813	E	NWSE	22	32S	68W	37.242590	-104.981000	8588	Actual LatLong	Purgatoire River	309326	Las Animas	C
05-071-09397	PIONEER NATURAL RESOURCES USA INC	GRANITE 21-25TR	292389	AL	10084	70830	200	N	2577	W	NENW	25	32S	68W	37.236610	-104.947610	8367	Planned LatLong	Purgatoire River	334164	Las Animas	C
05-071-09415	PIONEER NATURAL RESOURCES USA INC	SAINT ANTHONY 32-11V	292997	AL	10084	70830	1677	N	1685	E	SWNE	11	33S	68W	37.188330	-104.961460	7872	Planned LatLong	Purgatoire River	333979	Las Animas	C
05-071-09416	PIONEER NATURAL RESOURCES USA INC	SAINT FRANCIS 32-11R	292998	AL	10084	70830	1593	N	1642	E	SWNE	11	33S	68W	37.188570	-104.961320	7879	Planned LatLong	Purgatoire River	333979	Las Animas	C
05-071-09444	PIONEER NATURAL RESOURCES USA INC	ZAMORA 22-14V	293792	WO	10084	70830	1605	N	2124	W	SENW	14	33S	68W	37.173860	-104.966290	8029	Actual LatLong	Purgatoire River	309363	Las Animas	C
05-071-09445	PIONEER NATURAL RESOURCES USA INC	ZAMORA 43-14V	293793	AL	10084	70830	2025	S	671	W	NESE	14	33S	68W	37.169481	-104.957966	7549	Planned LatLong	Purgatoire River	309364	Las Animas	C
05-071-09446	PIONEER NATURAL RESOURCES USA INC	SVOBODA 21-15V	293794	AL	10084	70830	537	N	2054	W	NENW	15	33S	68W	37.176137	-104.985931	8317	Planned LatLong	Purgatoire River	309365	Las Animas	C
05-071-09462	PIONEER NATURAL RESOURCES USA INC	FILIPEK 22-10V	294062	WO	10084	70830	1683	N	2875	W	SENW	10	33S	68W	37.187290	-104.983350	7929	Actual LatLong	Purgatoire River	309381	Las Animas	C
05-071-09463	PIONEER NATURAL RESOURCES USA INC	FILIPEK 11-10V	294064	AL	10084	70830	956	N	873	W	NWNW	10	33S	68W	37.189317	-104.990273	8142	Planned LatLong	Purgatoire River	309382	Las Animas	C
05-071-09497	PIONEER NATURAL RESOURCES USA INC	MAZATLAN 23-25TR	294681	PR	10084	70830	1623	S	2201	W	NESW	25	32S	68W	37.226880	-104.948630	8149	Actual LatLong	Purgatoire River	334205	Las Animas	C
05-071-09498	PIONEER NATURAL RESOURCES USA INC	MAZATLAN 23-25	294682	PR	10084	70830	1677	S	2123	W	NESW	25	32S	68W	37.227070	-104.948880	8147	Actual LatLong	Purgatoire River	334205	Las Animas	C
05-071-09502	PIONEER NATURAL RESOURCES USA INC	FANTASY ISLAND 42-31	294687	PR	10084	70830	2173	N	313	E	SENE	31	32S	67W	37.216430	-104.921300	7825	Actual LatLong	Purgatoire River	334122	Las Animas	C
05-071-09503	PIONEER NATURAL RESOURCES USA INC	KEY LARGO 42-30TR	294693	AL	10084	70830	362	N	1097	E	NENE	30	32S	67W	37.235940	-104.924050	7794	Planned LatLong	Purgatoire River	334406	Las Animas	C
05-071-09527	PIONEER NATURAL RESOURCES USA INC	REEF DEEP 41-35	294944	PR	10084	70830	265	N	325	E	NENE	35	32S	68W	37.221900	-104.957150	8252	Actual LatLong	Purgatoire River	309432	Las Animas	C
05-071-09518	PIONEER NATURAL RESOURCES USA INC	HAWAII 43-36 H	294964	DA	10084	70830	1905	S	547	E	NESE	36	32S	68W	37.213120	-104.939850	8154	Actual LatLong	Purgatoire River	309531	Las Animas	C
05-071-09540	PIONEER NATURAL RESOURCES USA INC	KENNEDY 14-27	295255	PR	10084	70830	1026	S	625	W	SWSW	27	32S	68W	37.224320	-104.990640	7989	Actual LatLong	Purgatoire River	309445	Las Animas	C
05-071-09541	PIONEER NATURAL RESOURCES USA INC	KENNEDY 14-34	295256	PR	10084	70830	983	S	306	W	SWSW	34	32S	68W	37.209280	-104.991660	8086	Actual LatLong	Purgatoire River	309446	Las Animas	C
05-071-09543	PIONEER NATURAL RESOURCES USA INC	KEY LARGO DEEP 41-30	295390	AL	10084	70830	268	N	1127	E	NENE	30	32S	67W	37.236200	-104.924150	7884	Planned LatLong	Purgatoire River	334406	Las Animas	C
05-071-09598	PIONEER NATURAL RESOURCES USA INC	FANTASY ISLAND 42-13 KP HA	296087	AL	10084	70830	2150	N	265	E	SENE	31	32S	67W	37.216800	-104.921480	7811	Planned LatLong	Purgatoire River	334122	Las Animas	C
05-071-09593	PIONEER NATURAL RESOURCES USA INC	SPYGLASS 13-30 TR	296090	PR	10084	70830	2552	S	155	W	NWSW	30	32S	67W	37.229310	-104.937600	8142	Actual LatLong	Purgatoire River	334166	Las Animas	C
05-071-09653	PIONEER NATURAL RESOURCES USA INC	HAWAII 43-36 H-R	297956	PA	10084	70830	1905	S	542	E	NESE	36	32S	68W	37.213140	-104.939850	8154	Actual LatLong	Purgatoire River	309531	Las Animas	C
05-071-09658	PIONEER NATURAL RESOURCES USA INC	REEF 32-35	298166	AL	10084	70830	1331	N	1520	E	SWNE	35	32S	68W	37.218560	-104.961150	8020	Planned LatLong	Purgatoire River	309533	Las Animas	C
05-071-09677	PIONEER NATURAL RESOURCES USA INC	MIDNIGHT 12-11	299636	SI	10084	70830	1380	N	809	W	SWNW	11	33S	68W	37.188290	-104.970750	7676	Actual LatLong	Purgatoire River	309545	Las Animas	C
05-071-09685	PIONEER NATURAL RESOURCES USA INC	MAXIMUS 12-2	299670	WO	10084	70830	1834	N	522	W	SWNW	2	33S	68W	37.201530	-104.972350	7920	Actual LatLong	Purgatoire River	309553	Las Animas	C
05-071-09708	PIONEER NATURAL RESOURCES USA INC	KENT 44-25	300206	AL	10084	70830	222	S	274	E	SES	25	32S	68W	37.222910	-104.938880	8016	Planned LatLong	Purgatoire River	334392	Las Animas	C
05-071-09710	PIONEER NATURAL RESOURCES USA INC	HAUGHT 42-30	300354	PR	10084	70830	2457	N	1040	E	SENE	30	32S	67W	37.230210	-104.924000	7826	Actual LatLong	Purgatoire River	309572	Las Animas	C

Table C-16 Well Inventory Summary, Raton Basin, Colorado, Retrospective Case Study

API Number	Operator	Well Name	Facility ID	Status	Operator Number	Field Code	Distance N/S of Section Line	Direction from Section Line	Distance E/W of Section Line	Direction Section Line	Quarter	Section	Township	Range	Latitude	Longitude	Ground Elevation	Location Quality	Field Name	Location ID	County	Search Area
05-071-09713	PIONEER NATURAL RESOURCES USA INC	KENT 44-25TR	300360	AL	10084	70830	253	S	271	E	SESE	25	32S	68W	37.222990	-104.938870	8016	Planned LatLong	Purgatoire River	334392	Las Animas	C
05-071-09735	PIONEER NATURAL RESOURCES USA INC	HERA 12-29	300754	AL	10084	70830	2474	N	651	W	SWNW	29	32S	67W	37.230110	-104.918190	8049	Planned LatLong	Purgatoire River	334420	Las Animas	C
05-071-09736	PIONEER NATURAL RESOURCES USA INC	HERA 12-29TR	300755	AL	10084	70830	2456	N	693	W	SWNW	29	32S	67W	37.230160	-104.918040	8053	Planned LatLong	Purgatoire River	334420	Las Animas	C
05-071-09737	PIONEER NATURAL RESOURCES USA INC	N.F.R.A. 24-35	300806	AL	10084	70830	908	S	2325	W	SESW	35	32S	68W	37.209610	-104.966530	7862	Planned LatLong	Purgatoire River	309582	Las Animas	C
05-071-09738	PIONEER NATURAL RESOURCES USA INC	SCOTTSDALE 34-26	300807	AL	10084	70830	10	S	2205	E	SWSE	26	32S	68W	37.222040	-104.963640	7977	Planned LatLong	Purgatoire River	309583	Las Animas	C
05-071-09759	PIONEER NATURAL RESOURCES USA INC	SINCLAIR 11-30TR	301685	AL	10084	70830	254	N	144	E	NWNW	30	32S	67W	37.236340	-104.937180	8134	Planned LatLong	Purgatoire River	386833	Las Animas	C
05-071-09762	PIONEER NATURAL RESOURCES USA INC	SINCLAIR 11-30	301871	AL	10084	70830	237	N	189	W	NWNW	30	32S	67W	37.236380	-104.937010	8121	Planned LatLong	Purgatoire River	386833	Las Animas	C
05-071-09770	PIONEER NATURAL RESOURCES USA INC	PARRAS 21-12 KP HA	412915	AL	10084	70830	155	N	2129	E	NENW	12	33S	68W	37.192870	-104.948420	7869	Planned LatLong	Purgatoire River	413838	Las Animas	C
05-071-09799	PIONEER NATURAL RESOURCES USA INC	ALIBI 23-2	415990	PR	10084	70830	1451	S	2173	W	NESW	2	33S	68W	37.196120	-104.966280	7932	Actual LatLong	Purgatoire River	415926	Las Animas	C
05-071-09803	PIONEER NATURAL RESOURCES USA INC	ALIBI 23-2 TR	416091	AL	10084	70830	1468	S	2134	W	NESW	2	33S	68W	37.196150	-104.966420	7932	Planned LatLong	Purgatoire River	415926	Las Animas	C
05-071-09814	PIONEER NATURAL RESOURCES USA INC	DJEMBE 21-12	418227	PR	10084	70830	788	N	2203	W	NENW	12	33S	68W	37.191190	-104.948130	7717	Actual LatLong	Purgatoire River	418223	Las Animas	C
05-071-09815	PIONEER NATURAL RESOURCES USA INC	DJEMBE 21-12 TR	418229	AL	10084	70830	820	N	2138	W	NE/NW	12	33S	68W	37.191100	-104.948340	7709	Planned LatLong	Purgatoire River	418223	Las Animas	C
05-071-09817	PIONEER NATURAL RESOURCES USA INC	TIMBALE 32-12	418396	PR	10084	70830	1569	N	1854	E	SWNE	12	33S	68W	37.188930	-104.943610	7894	Actual LatLong	Purgatoire River	418411	Las Animas	C
05-071-09818	PIONEER NATURAL RESOURCES USA INC	TIMBALE 32-12 TR	418405	AL	10084	70830	1592	N	1786	E	SWNE	12	33S	68W	37.188880	-104.943390	7895	Planned LatLong	Purgatoire River	418411	Las Animas	C
05-071-09819	PIONEER NATURAL RESOURCES USA INC	POMPEII 43-7	418409	AL	10084	70830	2541	S	779	E	NESE	7	33S	67W	37.185770	-104.922810	7757	Planned LatLong	Purgatoire River	418402	Las Animas	C
05-071-09824	PIONEER NATURAL RESOURCES USA INC	ZATHURA 41-14	418785	AL	10084	70830	737	N	1292	E	NE/NE	14	33S	68W	37.176820	-104.961330	7494	Planned LatLong	Purgatoire River	418786	Las Animas	C
05-071-09825	PIONEER NATURAL RESOURCES USA INC	POPEYE 32-14	418787	AL	10084	70830	2141	N	1410	E	SW/NE	14	33S	68W	37.172960	-104.961730	7881	Planned LatLong	Purgatoire River	418788	Las Animas	C
05-071-09826	PIONEER NATURAL RESOURCES USA INC	MONTOYA 44-13 TR	419342	AL	10084	70830	450	S	989	E	SE/SE	13	33S	68W	37.165280	-104.941170	7719	Planned LatLong	Purgatoire River	419356	Las Animas	C
05-071-09827	PIONEER NATURAL RESOURCES USA INC	MONTOYA 44-13	419347	AL	10084	70830	403	S	955	E	SE/SE	13	33S	68W	37.165150	-104.941060	7703	Planned LatLong	Purgatoire River	419356	Las Animas	C
05-071-09829	PIONEER NATURAL RESOURCES USA INC	MONTOYA 33-13 TR	419485	AL	10084	70830	2632	S	1485	E	NWSE	13	33S	68W	37.171280	-104.942780	7891	Planned LatLong	Purgatoire River	419481	Las Animas	C
05-071-09830	PIONEER NATURAL RESOURCES USA INC	MONTOYA 33-13	419496	AL	10084	70830	2606	S	1540	E	NWSE	13	33S	68W	37.171210	-104.942970	7882	Planned LatLong	Purgatoire River	419481	Las Animas	C
05-071-09841	PIONEER NATURAL RESOURCES USA INC	FLAGSTONE 44-24	420941	AL	10084	70830	1040	S	186	E	SESE	24	32S	68W	37.239900	-104.938290	8181	Planned LatLong	Purgatoire River	420942	Las Animas	C
05-071-09842	PIONEER NATURAL RESOURCES USA INC	CLAVE 43-11 TR	420975	AL	10084	70830	2428	S	1304	E	NESE	11	33S	68W	37.185480	-104.960050	7980	Planned LatLong	Purgatoire River	420989	Las Animas	C
05-071-09843	PIONEER NATURAL RESOURCES USA INC	CLAVE 43-11	420976	PR	10084	70830	2378	S	1262	E	NESE	11	33S	68W	37.185380	-104.959940	7976	Actual LatLong	Purgatoire River	420989	Las Animas	C
05-071-09845	PIONEER NATURAL RESOURCES USA INC	POMPEII 43-7 TR	421059	AL	10084	70830	2482	S	799	E	NESE	7	33S	67W	37.185610	-104.922880	7757	Planned LatLong	Purgatoire River	418402	Las Animas	C
05-071-09847	PIONEER NATURAL RESOURCES USA INC	TALON 34-25 TR	421175	PR	10084	70830	753	S	1556	E	SWSE	25	32S	68W	37.224420	-104.943310	8133	Actual LatLong	Purgatoire River	308812	Las Animas	C
05-071-09855	PIONEER NATURAL RESOURCES USA INC	HAVANA 12-25 TR	422531	XX	10084	70830	1958	N	475	W	SW/NW	25	32S	68W	37.232060	-104.954710	8429	Planned LatLong	Purgatoire River	308638	Las Animas	C
05-071-09856	PIONEER NATURAL RESOURCES USA INC	LARISSA 32-35	422582	PR	10084	70830	2611	N	1685	E	SWNE	35	32S	68W	37.214990	-104.961600	7994	Actual LatLong	Purgatoire River	422584	Las Animas	C
05-071-09857	PIONEER NATURAL RESOURCES USA INC	LARISSA 32-35 TR	422583	XX	10084	70830	2616	N	1628	E	SWNE	35	32S	68W	37.214990	-104.961400	7996	Planned LatLong	Purgatoire River	422584	Las Animas	C

Table C-16 Well Inventory Summary, Raton Basin, Colorado, Retrospective Case Study

API Number	Operator	Well Name	Facility ID	Status	Operator Number	Field Code	Distance N/S of Section Line	Direction from Section Line	Distance E/W of Section Line	Direction Section Line	Quarter	Section	Township	Range	Latitude	Longitude	Ground Elevation	Location Quality	Field Name	Location ID	County	Search Area
05-071-09860	PIONEER NATURAL RESOURCES USA INC	KOSAR 21-11 TR	423089	XX	10084	70830	598	N	2534	W	NE/NW	11	33S	68W	37.191030	-104.964750	7943	Planned LatLong	Purgatoire River	423090	Las Animas	C
05-071-09861	PIONEER NATURAL RESOURCES USA INC	KOSAR 21-11	423093	PR	10084	70830	534	N	2537	W	NENW	11	33S	68W	37.191210	-104.964730	7939	Actual LatLong	Purgatoire River	423090	Las Animas	C

Source: Colorado Oil and Gas Conservation Commission, http://cogcc.state.co.us/cogis/

Key:

AL = Abandoned Location.
API = American Petroleum Institute.
DA = Dry and Abandoned.
E = East.
ID = Identification number.
N = North.
NI = No information available.
PA = Plugged and Abandoned.
PR = Producing.
S = South.
SI = Shut In.
TA = Temporarily Abandoned.
W = West.
WO = Waiting on Completion.
XX = Permitted Location.

Table C-17 Number of Permitted Oil and Gas Wells in Raton Basin Retrospective Case Study Site Areas, Colorado

Search Area	Search Area Radius (miles)	EPA HF Study Sampling Locations	Total Number of Oil and Gas wells	Oil and Gas Wells within 1 Mile of EPA HF Study Sampling Locations
Las Animas County				
A	1	RBDW11 RBDW12	31	31
B	1	RBSW02	41	41
C	3	RBDW01 RBDW02 RBDW03 RBDW04 RBDW05 RBDW13 RBMW01 RBMW02 RBMW03 RBPW01 RBPW02 RBPW03 RBSW01 RBSW03	237	119
Huerfano County				
A	3	RBDW06 RBDW07 RBDW08 RBDW09 RBDW10 RBDW14 RBMW04 RBMW05	75	39

Source: http://cogcc.state.co.us/home/gismain.cfm, accessed February 4, 2014. Specific metadata for "Oil and Gas Well Locations In Colorado" accessed from http://cogcc.state.co.us/COGIS_Help/GIS_Help/Documents/well_meta.htm

Table C-18 Environmental Database Review Summary, Raton Basin Retrospective Case Study, Las Animas County, Colorado

				Potential Candidate Cause			
Database	Name of Facility	Site Location and Address	Distance from Nearest Sample Point	Yes /No	Details/Justification	Groundwater Wells	Search Area
MINES	Basin Resources, Inc.	Latitude: 37.18583 Longitude: -104.80278	0.9 mi. S of RBDW12	Yes	Coal exploration; no violations cited. Coal mines are a potential source of contamination.	6 Federal USGS Wells 0 Federal FRDS Public Water Supply System 89 State Wells	A
Orphan FINDS, AIRS (AFS)	Summit Gas - Apache Canyon	9100 County Road 31.9 Weston, CO 81091 Latitude: 37.122082 Longitude: -104.859123	5.6 mi. S of RBSW02 (B) 6 mi. SW of RBDW11 (B) 6.5 mi. SE of RBWW01 (B)	No	Crude petroleum and natural gas extraction. In Air Facility System, Emission Inventory System, National Emissions Inventory (for several pollutants); no violations cited. Not a likely source of contamination due to distance from nearest sampling locations.		A
Orphan FINDS, AIRS (AFS)	KLT Gas - Golden Eagle Mine (#2871)	3 mi. W of Weston, CO 81091	>4 mi. SE of RBSW01	No	Crude petroleum and natural gas extraction. In Air Facility System and National Emissions Inventory. Not a likely source of contamination due to distance from nearest sampling locations.		A
Orphan FINDS, AIRS (AFS)	KLT Gas - Golden Eagle Mine (#2329)	3 mi. W of Weston, CO 81091	>4 mi. SE of RBSW01	No	Crude petroleum and natural gas extraction. In Air Facility System and National Emissions Inventory. Not a likely source of contamination due to distance from nearest sampling locations.		A
Orphan FINDS, AIRS (AFS)	Summit Gas - Golden Eagle # 7	NW NW SEC 21 T33S R67W 15.3 mi. W of Cokedale, CO 81091	2.8 mi. SSW of RBSW02	No	Natural gas transmission and distribution; no violations cited. Not a likely source of contamination due to distance from nearest sampling locations.		A
Orphan FINDS, AIRS (AFS)	Michael Browning - Wet Canyon Mine	NW SE SEC 28 T32S R67W 15.7 mi. W of Cokedale, CO 81082	2 mi. NNW of RBSW02	No	Construction sand and gravel mining quarry. No violations cited. Not a likely source of contamination due to distance from nearest sampling locations.		A

Table C-18 Environmental Database Review Summary, Raton Basin Retrospective Case Study, Las Animas County, Colorado

				Potential Candidate Cause			
Database	Name of Facility	Site Location and Address	Distance from Nearest Sample Point	Yes /No	Details/Justification	Groundwater Wells	Search Area
Orphan FINDS, AIRS (AFS)	Pioneer Natural Resources - Wet Canyon	NW SE SEC 23 T33S R67W 12.8 mi. W of Cokedale, CO 81091 Latitude: 37.15601 Longitude: -104.855881	3.7 mi. SE of RBSW02 3.9 mi. SE of RBSW01	No	Crude petroleum and natural gas extraction. In Air Facility System and National Emissions Inventory. Not a likely source of contamination due to distance from nearest sampling locations.		A
Orphan FINDS, AIRS (AFS)	Summit Gas - Hill Ranch 3 CS	SEC 8 T35S R67W 18.0 mi. SW of Cokedale, CO 81091	12.2 mi. SSE of RBSW01	No	Crude petroleum and natural gas extraction; no violations cited. Not a likely source of contamination due to distance from nearest sampling locations.		A
Orphan FINDS, AIRS (AFS)	XTO Energy, Inc - Apache Canyon	SEC 16 T34S R67W 15.3 mi. W of Cokedale, CO 81082	Exact location unknown Apache Canyon is approx: 7 mi. SW of RBDW11, 3.9 mi. SW of RBSW02, and 2.77 mi. SE of RBSW01	No	Crude petroleum and natural gas extraction. In Air Facility System and National Emissions Inventory. Not a likely source of contamination due to distance from nearest sampling locations.		A
Orphan LUST TRUST, LUST, UST	Picketwire Lodge	7600 Highway 12 Weston, CO 81091	3.7 mi. SW of RBDW13	No	1 closed UST (gasoline), 1 open UST (diesel), 2 open USTs (gasoline), 1 state lead LUST with a confirmed release on 06/19/2008. Not a likely source of contamination due to distance from nearest sampling locations.		A, B, C
Orphan LUST TRUST, LUST, NPDES, AST, UST, FTTP, FINDS, HIST FTTS	Primero High School	20200 Highway 12 Weston, CO 81091	5 mi. S of RBDW11 and RBDW12	No	2 closed USTs (gasoline), 2 closed AST (1 - gasoline, 1 - diesel), 1 closed LUST with a confirmed release on 11/16/1998. Not a likely source of contamination due to distance from nearest sampling locations.		A, B, C
Orphan FINDS, LUST, UST	Wyoming Fuel Co - New Elk Mine	10250 Highway 12 (6 mi. W of town) Weston, CO 81091 Latitude: 37.159299 Longitude: -104.9657	1.3 mi. SSW of RBDW01	Yes	Listed under RCRA as a CESQG, but no details were found. Confirmed release in 1990, tank now closed. 7 closed USTs (2 gasoline, 2 diesel, 2 unknown, 1 hazardous substance).		A

Table C-18 Environmental Database Review Summary, Raton Basin Retrospective Case Study, Las Animas County, Colorado

				Potential Candidate Cause			
Database	Name of Facility	Site Location and Address	Distance from Nearest Sample Point	Yes /No	Details/Justification	Groundwater Wells	Search Area
Orphan FINDS, LUST, CO ERNS	Basin Resources - Golden Eagle	14300 Highway 12 Weston, CO 81091	4.1 mi. SE of RBSW01	Yes	Coal mine, listed under RCRA as a CESQG, but no details were found. Release of 2,800 lbs. of HCl on 11/18/1994; spill cleaned; tank closed 6/6/90. Not a likely source of contamination due to distance from nearest sampling locations.		A, B, C
Orphan AST	Monument Lake Resort	4787 Highway 12 Weston, CO 81091	4.3 mi. W of RBDW04, RBDW03 and RBPW02	No	1 closed AST (liquid propane gas); no violations cited. Not a likely source of contamination due to distance from nearest sampling locations.		A, B, C
Orphan AST	Roundhouse Shop New Alta Mine	9100 Highway 12 Weston, CO 81091	2.6 mi. SW of RBDW01	No	1 closed AST (diesel); no violations cited. Not a likely source of contamination due to distance from nearest sampling locations.		A, B, C
Orphan RCRA-NLR	Lorencito Coal Co LLC	20500 Highway 12 Weston, CO 81091 Latitude:37.114444 Longitude: -104.8	5.7 mi. SE of RBDW11	No	Bituminous coal underground mining. NPDES program. Minor; General-Permit-covered facility. Violations listed, no details. Not a likely source of contamination due to distance from nearest sampling locations.		A, B, C
MINES	Golden Eagle Exploration 1989	Latitude: 37.18632 Longitude: -104.89275	1.08 mi. SW of RBSW02	Yes	Coal exploration; no violations cited. Coal mines are a potential source of contamination.	21 Federal USGS Wells 0 Federal FRDS Public Water Supply System 153 State Wells	B
MINES	93 Exploration	Latitude: 37.19176 Longitude: -104.904	1.4 mi. WSW of RBSW02	Yes	Coal exploration; no violations cited. Coal mines are a potential source of contamination.		B
MINES	New Elk Mine 2010 Exploration	10250 Highway 12 Weston, CO 89109 Latitude: 37.20056 Longitude: -104.91028	1.72 mi. WNW of RBSW02 and 2 mi. ENE of RBSW03	Yes	Coal mining/exploration. Coal mines are a potential source of contamination.		B, C
MINES	Golden Eagle Exploration	Latitude: 37.2004 Longitude: -104.83833	1.75 mi. W of RBDW11	Yes	Coal exploration; no violations cited. Coal mines are a potential source of contamination.		B

Table C-18 Environmental Database Review Summary, Raton Basin Retrospective Case Study, Las Animas County, Colorado

Database	Name of Facility	Site Location and Address	Distance from Nearest Sample Point	Potential Candidate Cause		Groundwater Wells	Search Area
				Yes /No	Details/Justification		
MINES	Wet Canyon Mine	Latitude: 37.22999999 Longitude: -104.89	2.2 mi. NNW of RBSW02	Yes	Surface mining, unknown commodity. Not a likely source of contamination due to distance from nearest sampling locations.		B
MINES	'93 Exploration	Latitude: 37.172159999 Longitude: -104.9107999	2.47 mi. SW of RBSW02	Yes	Coal exploration; no violations cited. Coal mines are a potential source of contamination.		B
MINES	Basin Resources, Inc.	Latitude: 37.15758 Longitude: -104.89225	2.87 mi. SSW of RBSW02	Yes	Mine site; coal exploration. Coal mines are a potential source of contamination.		B
MINES	Golden Eagle Exploration	Latitude: 37.21491 Longitude: -104.92834	1.53 mi. ESE of RBPW01	Yes	Coal exploration; no violations cited. Coal mines are a potential source of contamination.		B, C
MINES	Golden Eagle Exploration '90	Latitude: 37.17168 Longitude: -104.87466	1.82 mi. S of RBSW02	Yes	Coal exploration; no violations cited. Coal mines are a potential source of contamination.		B
Orphan LUST, UST, FINDS	Wyoming Fuel Co - New Elk Mine	10250 Highway 12 Weston, CO 81091	1.6 mi. SW of RBDW01	Yes	7 USTs listed (2-gasoline, 2-diesel, 1-hazardous substance, 2-unknown), all permanently closed. LUST record shows a confirmed release on 6/6/1990; closed. FINDS listing appears to be for RCRA Conditionally Exempt Small Quantity Generator.		B, C
Orphan ASBESTOS	Primero School District	20200 Highway 12 Weston, CO	4.9 mi. S of RBDW12	No	Primero School District asbestos abatement removal project. Multiple listings for the school property. Not a likely source of contamination due to distance from nearest sampling locations.		B, C
Orphan NPDES	Monument Lake WTP	State Highway 12	NI	No	Listed in NPDES database, not a likely source of contamination.		B, C
Orphan NPDES	New Elk Mine	12250 Highway 12 Weston, CO 81091	1.9 mi. SE of RBSW01	Yes	Listed in NPDES database. Potential mining operations, therefore potential source of contamination.		B, C
Orphan NPDES	Raton Basin Project	16920 Highway 12 Weston, CO 81091	4.92 mi. SSE of RBSW02	No	Listed in NPDES database. Not a likely source of contamination due to distance from nearest sampling locations.		B, C

Table C-18 Environmental Database Review Summary, Raton Basin Retrospective Case Study, Las Animas County, Colorado

				Potential Candidate Cause			
Database	Name of Facility	Site Location and Address	Distance from Nearest Sample Point	Yes /No	Details/Justification	Groundwater Wells	Search Area
CORRACTS, RCRA-CESQG	Wyoming Fuel Co - New Elk Mine	10250 Highway 12, Weston, CO 89109	1.1 mi. SW of RBSW01	Yes	Lists drum storage, acid spill areas, migration of contaminated ground water.	18 Federal USGS Wells 0 Federal FRDS Public Water Supply System 119 State Wells	C
MINES	New Jersey Zinc Exploration Co.	Latitude: 37.199939 Longitude: -104.96472	0.28 mi. E of RBDW03	Yes	Appears to have been coal mining operations; status is terminated. There is no report of post-mining use. Coal mines are a potential source of contamination.		C
MINES	Costa Pit	Latitude: 37.1825400 Longitude: -104.98304	1.13 mi. W of RBDW13	No	This is a surface mine (sand and gravel) whose status is terminated. It is now listed as pastureland. Surface stone quarry activities are not likely sources of contamination.		C
MINES	Barron Pit	Latitude: 37.1824599 Longitude: -104.98295	1.13 mi. W of RBDW13	No	This is a surface mine (sand and gravel) whose status is terminated. It is now listed as pastureland. Surface stone quarry activities are not likely sources of contamination.		C
MINES	Allen Mine	Latitude: 37.18247999 Longitude: -104.983009	1.13 mi. W of RBDW13	Yes	Appears to have been coal mining operations. Post-mining use is not reported. Coal mines are a potential source of contamination.		C
MINES	Pete Hill Quarry	Latitude: 37.1823899 Longitude: -104.98295	1.13 mi. W of RBDW13	No	This is a surface mine (sandstone) whose status is terminated. It is now listed as Wildlife Habitat. Surface stone quarry activities are not likely sources of contamination.		C
MINES	Toupal Gravel Pit	Latitude: 37.171990000 Longitude: -104.9287499	1.37 mi. ESE of RBSW01	No	This is a surface mine (gravel) whose status is terminated. It is now listed as Pastureland. Surface stone quarry activities are not likely sources of contamination.		C

Table C-18 Environmental Database Review Summary, Raton Basin Retrospective Case Study, Las Animas County, Colorado

Database	Name of Facility	Site Location and Address	Distance from Nearest Sample Point	Potential Candidate Cause		Groundwater Wells	Search Area
				Yes /No	Details/Justification		

Source: Environmental records search report by Environmental Data Resources, Inc (EDR)

Additional Sources

Colorado Division of Reclamation, Mining and Safety: http://mining.state.co.us/Reports/MiningData/Pages/SearchByMine.aspx

Colorado Storage Tank Information System (COSTIS) Web Site: http://costis.cdle.state.co.us/OIS2000/

Envirofacts: http://www.epa.gov/enviro/

Notes

Buffer A

EDR Inquiry Number: 3599777.14s

EDR Search Radius: 3 miles

Search Center: Lat. 37.1986000 (37° 11’ 54.96’’) Long. 104.8050000 (104° 48’ 18.00’’)

Buffer B

EDR Inquiry Number: 3599777.8s

EDR Search Radius: 3 miles

Search Center: Lat. 37.1979000 (37° 11’ 52.44’’) Long. 104.8792000 (104° 52’ 45.12’’)

Buffer C

EDR Inquiry Number: 3599777.2s

EDR Search Radius: 3 miles

Search Center: Lat. 37.2043000 (37° 12’ 15.48’’) Long. 104.9610000 (104° 57’ 39.60’’)

Key:

AFS - Aerometric Information Retrieval System (AIRS) Facility Subsystem
AIRS - Aerometric Information Retrieval System
AST - Above ground Storage Tank
E - East
ERNS - Emergency Response Notification System
FINDS - Facility Index System
FRDS - Federal Reporting Data System
HCl - Hydrochloric acid
LUST - Leaking Underground Storage Tanks
MANIFEST - Hazardous waste manifest information
mi - Mile
MINES - This data set portrays the approximate location of Abandoned Mine Land Problem Areas
N - North
NA - Not Applicable
NI - No information
NPDES - National Pollutant Discharge Elimination System
ORPHAN SITE - a site of potential environmental interest that appear in the records search but due to incomplete location information (i.e., address and coordinates) is unmappable and not included in the records search report provided by EDR Inc.
RCRA - Resource Conservation and Recovery Act
RMP - Risk Management Plans
S - South
TSCA - Toxic Substances Control Act
USGS - United States Geological Survey
UST - Underground Storage Tank
VCP - voluntary cleanup sites
W - West

Table C-18 Environmental Database Review Summary, Raton Basin Retrospective Case Study, Las Animas County, Colorado

				Potential Candidate Cause			
Database	Name of Facility	Site Location and Address	Distance from Nearest Sample Point	Yes /No	Details/Justification	Groundwater Wells	Search Area

Database:

US AIRS: Aerometric Information Retrieval System Facility Subsystem
ASBESTOS: Asbestos Abatement & Demolition Projects
AST: Listing of Colorado Regulated Aboveground Storage Tanks
CO ERNS: Colorado Emergency Response Notification System
CORRACTS: Listing of identified hazardous waste handlers with RCRA corrective action activity.
FINDS: Facility Index System/Facility Registry System
FTTS: FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fungicide, & Rodenticide Act)/TSCA (Toxic Substances Control Act). FTTS tracks administrative cases and pesticide enforcement actions and compliance activities related to FIFRA, TSCA and EPCRA (Emergency Planning and Community Right-to-Know Act).
HIST FTTS: FIFRA/TSCA Tracking System Administrative Case Listing
LUST: Leaking Underground Storage Tank Sites
LUST TRUST: Listings of eligible applicants to Colorado's Petroleum Storage Tank Fund. The Fund provides reimbursement for allowable costs in cleaning up petroleum contamination from under ground and above ground storage tanks.
US MINES: Mines Master Index File. The source of this database is the Dept. of Labor, Mine Safety and Health Administration
NPDES: National Pollutant Discharge Elimination System Permit Listing
RCRA-CESQG: Federal RCRA (Resource Conservation and Recovery Act) Conditionally Exempt Small Quantity Generator List
RCRA-NLR: No Longer Regulated
UST: Listing of Colorado Regulated Underground Storage Tanks

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-06296	Wharton #33-32	Pioneer Natural Resources USA Inc	10	3	11/19/1995	Spill/Release: Equipment failure caused a spill of 100 bbls of water. No ground water affected; unknown if surface waters affected.	Closed	
					11/20/1996	No secondary containment (berms) installed.	NI	
					4/12/1997	Spill/Release: Equipment failure caused a spill of 50 bbls of water. No ground water affected; unknown if surface waters affected.	Closed	
05-071-06876	Bonneville #31-6	Pioneer Natural Resources USA Inc	4	1	3/30/2004	Need to put up lease sign.	NI	
05-071-06963	Monterey #33-6	Pioneer Natural Resources USA Inc	7	1	3/30/2004	Need to put up lease sign.	NI	
05-071-07089	Monte Carlo #31-7	Pioneer Natural Resources USA Inc	5	2	7/9/2008	Install sign identifying well. Pit not lined and greater than 2 feet of freeboard.	NI	
					8/21/2008	Need to put up lease sign.	NI	
05-071-07134	Bakersfield #11-5	Pioneer Natural Resources USA Inc	5	0	NA	None	NA	
			NA	NA	2/8/2004	None - Summary of Complaint Records	NA	2/8/2004: Landowner claims water well has been impacted by nearby gas well. COGCC Resolution: Hydrant in front of house sampled, no water quality similarities to the nearby gas well.
05-071-07881	Molson #23-8	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
05-071-07896	Salty #42-6	Pioneer Natural Resources USA Inc	5	0	NA	None	NA	
05-071-07472	Pony Express #44-31	Pioneer Natural Resources USA Inc	3	0	NA	None	NA	
05-071-07534	Cotter #44-32	Pioneer Natural Resources USA Inc	3	0	NA	None	NA	
05-071-07550	Monterey #33-6 TR	Pioneer Natural Resources USA Inc	5	0	NA	None	NA	
05-071-07704	Bonneville #31-6 TR	Pioneer Natural Resources USA Inc	3	0	NA	None	NA	
05-071-08238	Salty #42-6 TR	Pioneer Natural Resources USA Inc	4	0	NA	None	NA	
05-071-06985	Surfers #44-34	Pioneer Natural Resources USA Inc	6	1	5/7/2007	Maintain at least 2 feet of freeboard.	NI	
05-071-07653	Comet #31-3	Pioneer Natural Resources USA Inc	4	0	NA	None	NA	
05-071-07877	Graff #31-9V	Pioneer Natural Resources USA Inc	4	0	NA	None	NA	
05-071-07628	Scamper #44-3	Pioneer Natural Resources USA Inc	4	0	NA	None	NA	

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-07633	Celtic #43-3	Pioneer Natural Resources USA Inc	3	0	NA	None	NA	
			NA	NA	5/1/2003 8/1/2004 8/24/2004	None - Summary of Complaint Records	NA	5/1/2003: Landowner concerned with the noise produced by the four gas wells on and near their property. Electric lines also visible from well head. COGCC Resolution: Noise monitoring conducted and noise levels are in compliance. 8/1/2004: Landowner concerned that operator is improperly using access roads through their property. Noise is still a concern and landowner not receiving compensation from operator. Status: In process. 8/24/2004: Landowner concerned about land erosion as operator has not restored the site and that wildlife has decreased. Status: In process.
05-071-07780	Shinarump #11-11 TR	Pioneer Natural Resources USA Inc	5	0	NA	None	NA	
05-071-07783	Butch #33-10	Pioneer Natural Resources USA Inc	6	1	11/29/2011	Spill/Release: A pipeline rupture caused a spill of 80 bbls of water. No ground or surface waters affected.	Closed	
05-071-07826	Madison #14-2	Pioneer Natural Resources USA Inc	4	0	NA	None	NA	
			NA	NA	1/19/2011	None - Summary of Complaint Records	NA	1/19/2011: Landowner requests baseline water sampling due to odor from well nearby. COGCC Resolution: Sampling conducted, no impacts from nearby CBM operations, although TDS and manganese above groundwater standards and elevated nuisance bacteria levels.
05-071-07833	Duke #12-10	Pioneer Natural Resources USA Inc	5	0	NA	None	NA	
05-071-07834	Avant #14-3	Pioneer Natural Resources USA Inc	8	1	11/8/2005	Need to put up lease sign.	NI	
			NA	NA	9/1/2005	None - Summary of Complaint Records	NA	9/1/2005: Landowner concerned noise levels are too high. COGCC Resolution: Noise monitoring conducted and noise levels are in compliance.
05-071-07837	Gamma #13-3	Pioneer Natural Resources USA Inc	8	1	9/16/2005	NOAV: The COGCC received a complaint concerning sediment in Wet Canyon Creek. A field investigation on 9/16/2005 by the COGCC Environmental Protection specialist observed excessive erosion and lack of maintenance at the access road for the Pioneer Gamma 13-3 and Gamma 13-3 TR.	Yes	
			NA	NA	4/29/2004	None - Summary of Complaint Records	NA	4/29/2004: Landowner concerned noise levels are too high. COGCC Resolution: Noise monitoring conducted and noise levels are in compliance.
05-071-07840	Schneider #12-3	Pioneer Natural Resources USA Inc	4	0	NA	None	NA	
05-071-07849	Futura #32-10	Pioneer Natural Resources USA Inc	6	0	NA	None	NA	
			NA	NA	10/28/2010	None - Summary of Complaint Records	NA	10/28/2010: Landowner concerned noise levels are too high. COGCC Resolution: Noise monitoring conducted and noise levels are in compliance.
05-071-07909	Madison #14-2 KV	Pioneer Natural Resources USA Inc	3	0	NA	None	NA	

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-07911	Celtic#43-3 TR	Pioneer Natural Resources USA Inc	2	1	2/25/2004	Need to put up lease sign. General housekeeping needed around well site.	NI	
05-071-07910	Scamper #44-3 TR	Pioneer Natural Resources USA Inc	4	0	NA	None	NA	
05-071-07926	Pegasis #31-4	Pioneer Natural Resources USA Inc	3	0	NA	None	NA	
05-071-07931	Futura #32-10 TR	Pioneer Natural Resources USA Inc	6	1	9/15/2004	Need to put up lease sign.	NI	
05-071-07976	Cave Canyon #23-4	Pioneer Natural Resources USA Inc	3	0	NA	None	NA	
05-071-08037	Graff #31-9 R	Pioneer Natural Resources USA Inc	3	0	NA	None	NA	
05-071-08071	McLeod #42-9 V	Pioneer Natural Resources USA Inc	3	0	NA	None	NA	
05-071-08092	McLeod #42-9 R	Pioneer Natural Resources USA Inc	3	0	NA	None	NA	
05-071-08123	Lynn #32-4	Pioneer Natural Resources USA Inc	6	0	NA	None	NA	
			NA	NA	3/10/2008	None - Summary of Complaint Records	NA	3/10/2008: Landowner observed silty water in Wet Canyon on a day with little snow melt. Landowner thought silt might be a result of produced water spill or other activities of operator in area upstream of their home. COGCC Resolution: No evidence of recent spills of produced water observed in the area where turbid water was observed in Wet Canyon. Operator installed additional sediment control BMPs in effort to prevent any meltwater-caused turbidity just above the confluence of San Pablo Canyon and Wet Canyon.
05-071-08292	Pegasis #31-4 TR	Pioneer Natural Resources USA Inc	3	0	NA	None	NA	
05-071-08463	Avant #14-3 TR	Pioneer Natural Resources USA Inc	6	1	11/8/2005	Need to put up lease sign.	NI	
05-071-06155	O'Neal #1-14 A	Precisioneering Inc	6	2	9/5/2002	Need to produce, MIT, or plug well.	NI	
					9/5/2002	NOAV: Not an active producing well. Well incapable of production. No surface production equipment; MIT performed and passed on 6/10/1997 and 4/30/2003. There is also no well sign.	Yes	
05-071-07887	Montoya #12-7V	Pioneer Natural Resources USA Inc	6	3	1/17/2013	Large off-site pit appears to have been reclaimed, but Form 27 has not been submitted as required by rule for pit closure process.	Yes	
					2/20/2004	NOAV: Operator failed to cement 5 1/2" casing to surface as required by drilling permit.	Yes	
					8/25/2006	Remediation: Remediation of soils and vegetation. Pit was reconstructed, source of leak found and corrected.	Yes	
05-071-08021	Montoya #41-13 V	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08020	Montoya #14-6 V	Pioneer Natural Resources USA Inc	5	2	8/16/2004	NOAV: Production casing was not cemented to surface as required by drilling permit.	Closed	NOAV 8/16/2004: Status is listed as closed, unknown if corrective action was properly completed.
					3/4/2010	Must produce, plug and abandon, or pass MIT before May 2011. Equipment not in use needs to be taken off site.	NI	
05-071-08018	Montoya #21-7 V	Pioneer Natural Resources USA Inc	5	1	8/31/2005	Spill/Release: Failure to shut off a valve, resulting in 8 bbls of water released. No ground or surface waters affected.	Closed	
05-071-08094	Montoya #44-12 V	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-08093	J & P #21-13 R	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-08091	J & P #33-12 V	Pioneer Natural Resources USA Inc	3	1	8/27/2004	NOAV: Production casing was not cemented to surface as required by drilling permit.	Yes	
05-071-08089	J & P #21-13 V	Pioneer Natural Resources USA Inc	6	2	6/20/2005	Fence needs to be put in place.	NI	
					3/6/2006	Fence needs to be put in place.	NI	
05-071-08138	J & P #24-12 V	Pioneer Natural Resources USA Inc	3	1	8/31/2004	NOAV: Production casing was not cemented to surface as required by drilling permit	Yes	
05-071-08137	J & P #24-12 R	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-08139	Montoya #41-12 V	Pioneer Natural Resources USA Inc	3	1	8/10/2004	NOAV: Production casing was not cemented to surface as required by drilling permit.	Yes	
05-071-08141	Montoya #11-1 V	Pioneer Natural Resources USA Inc	12	1	3/12/2007	Need to mitigate noise from well and fix disconnected muffler.	NI	
			NA	NA	3/7/2007 5/20/2009 5/21/2009	None - Summary of Complaint Records	NA	3/7/2007: Landowner concerned about noise levels, states they exceed 60 dBA at times. COGCC Resolution: Noise monitoring conducted, operator installed noise baffling walls. 5/20/2009: Landowner concerned about noise levels. COGCC Resolution: Noise monitoring conducted and noise levels in compliance. Operator required to fix disconnected muffler hose. 5/21/2009: Landowner concerned about noise levels. COGCC Resolution: Noise monitoring conducted and noise levels in compliance.
05-071-08142	Montoya #44-1 V	Pioneer Natural Resources USA Inc	5	0	NA	None	NA	
05-071-08143	Silva #22-6 V	Pioneer Natural Resources USA Inc	6	2	12/17/2009	Spill/Release: Equipment failure caused a release of 250 bbls of water from pit. No ground or surface waters impacted.	Closed	
					12/8/2011	Spill/Release: Equipment failure caused a release of 100 bbls of water. No ground waters impacted. Surface waters were impacted.	Closed	
05-071-08144	Montoya #41-1 V	Pioneer Natural Resources USA Inc	3	0	NA	None	NA	
05-071-08171	Montoya #22-1 V	Pioneer Natural Resources USA Inc	9	2	3/12/2007	Need to mitigate noise from well.	NI	
					4/5/2007	Need to put up noise baffling walls.	NI	
05-071-08192	Cody #44-11 V	Pioneer Natural Resources USA Inc	3	1	2/4/2011	Spill/Release: Due to equipment failure, 8 bbls of produced water was released. No ground or surface waters impacted.	Closed	
			NA	NA	11/24/2006	None - Summary of Complaint Records	NA	11/24/2006: Landowner concerned about strong odor coming from reserve pit after drilling operations complete and the potential for groundwater contamination. COGCC Resolution: Sampled drill cuttings from pit. Odor appeared to be related to lost circulation material used that according to MSDS produced a strong odor when material biodegraded.
05-071-08194	Montoya #24-1 V	Pioneer Natural Resources USA Inc	6	0	NA	None	NA	
05-071-08239	Montoya #44-1 R	Pioneer Natural Resources USA Inc	5	0	NA	None	NA	
05-071-08240	Montoya #12-7 R	Pioneer Natural Resources USA Inc	4	1	1/17/2013	Large off-site pit appears to have been reclaimed, but Form 27 has not been submitted as required by rule for pit closure process.	Yes	

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-08241	Montoya #41-12 R	Pioneer Natural Resources USA Inc	3	1	4/2/2008	Spill from pit is probable. Pit closed and Form 27 was not submitted. Signs incorrectly identify operator and emergency response phone number.	NI	Inspection record indicates a NOAV was going to be issued, however, no NOAV record was found in the COGCC database.
05-071-08242	Montoya #14-6 R	Pioneer Natural Resources USA Inc	4	0	NA	None	NA	
05-071-08261	North Fork Ranch #11-	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-08266	Furu #6-23	Pioneer Natural Resources USA Inc	3	0	NA	None	NA	
05-071-08265	North Fork Ranch #11-	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-08270	Furu #23-6 V	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08281	Underworld #31-36	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08294	Niagara #23-35	Pioneer Natural Resources USA Inc	3	2	1/27/2008	NOAV: Exploration and production wastes transported and dumped in location not permitted to receive such wastes. A pit permit had been issued for produced water storage and disposal from the Niagara 23-35. The Niagara was drilled and abandoned, and the pit was not closed and reclaimed in a timely manner. Wastes were hauled to and dumped in the lined pit from another of the operator's wells. Wastes from the Niagara 23-35 pit were later dumped on the ground and left there while closing the pit. The spills/releases of exploration waste were not properly reported by the operator as required. No characterization of the waste has been provided by the operator, nor has the operator provided information as to the source of the waste. Information on source of waste was requested but not provided by operator.	NI	
					3/7/2007	NOAV: BMPs to minimize erosion and off-site sedimentation by controlling stormwater runoff were not implemented. As a result, there were significant impacts on soil and waters of the state of Colorado.	Yes	
			NA	NA	2/20/2007 2/26/2009	None - Summary of Complaint Records	NA	2/20/2007: Landowner concerned with stormwater controls and BMPs; cement barriers covered with soil pushed over the top, culverts buried, steep banks in erosional areas, no erosion control, no silt fencing installed next to waterway. Status: In process. 2/26/2009: Landowner concerned with groundwater quality. COGCC Resolution: Sampling conducted, water quality good with safety hazard associated with high concentration of dissolved methane.
05-071-08371	Silva #43-1 V	Pioneer Natural Resources USA Inc	3	0	NA	None	NA	
05-071-08372	Silva #43-1 R	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08381	Havana #12-25	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-08435	Montoya #21-7 R	Pioneer Natural Resources USA Inc	7	2	4/2/2008	BMPs installed are inadequate to filter sediment as water runs off well pad. Ensure that transport of sediment off well pad into creek is stopped.	Yes	
					4/2/2008	NOAV: Erosion controls were ineffective or nonexistent at the lease road crossing over Santistevan Canyon to the well pad. The pad is contoured to drain runoff to the creek bed. Inadequate filtering structures were in place to filter sediments running off the well pad. The operator did not take adequate measures to control sediment transport, which resulted in active transport of sediment into the channel of the creek. The sediments transported off the well pad were actively being transported downstream on the day of inspection (200129732). The transport of sediment into the creek and transport downstream resulted in significant adverse impacts on the environment.	Yes	
05-071-08524	Gamma 13-3 TR	Pioneer Natural Resources USA Inc	4	0	NA	None	NA	
05-071-08536	Montoya 21-1V	Pioneer Natural Resources USA Inc	3	0	NA	None	NA	
05-071-08537	Montoya 22-1R	Pioneer Natural Resources USA Inc	4	0	NA	None	NA	
05-071-08538	Montoya 44-12R	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08545	Pony Express 44-31 TR	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-08602	Flashback 32-27	Pioneer Natural Resources USA Inc	7	5	8/21/2006	Lack of BMPs to minimize erosion on slope of pad and erosion along lease road.	Yes	Corresponding NOAV issued with inspection on 8/21/2006.
					8/21/2006	NOAV: BMPs to minimize erosion and off-site sedimentation by controlling stormwater runoff was not implemented. As a result, there were significant adverse environmental impacts on water and soil.	Yes	
					7/28/2007	NOAV: BMPs to minimize erosion and off-site sedimentation were not implemented, were not maintained properly, or were inadequate to control flow of sediments off the access road and into the stream channel of the Left Hand Fork of Logging Canyon. Eight individual flow paths of sediment to the Left Hand Fork of Logging Canyon were observed along 1.1 miles of lease access road from north of the Keystone access to north of the Flashback access. The operator did not take adequate precautions to prevent significant adverse impacts on water, soil, and biological resources.	Yes	
					2/28/2008	NOAV: Failure to implement BMPs to minimize erosion and control offsite sedimentation. A lack of maintenance of BMP's was observed along the lease access road between the Niagara access to north of the Keystone access road. Four individual flow paths of sediment transport into the stream channel of the Left Hand Fork of Logging Canyon were observed along approximately 1.5 miles of road. The operator did not take adequate precautions to prevent significant adverse impacts to water, soil, and biological resources.	Yes	
					3/11/2008	NOAV: Failure to implement and maintain adequate erosion controls along the lease access road between the Niagara and Flashback access roads. Overwhelmed and broken BMPs were observed along more than 1 mile of road. The lack of maintenance BMPs and the absence of BMPs resulted in two sediment flow paths leaving the access road and moving into arroyos or stream beds. The operator did not take adequate precautions to prevent significant adverse impacts on water, soil, and biological resources.	Yes	
			NA	NA	2/28/2008	None - Summary of Complaint Records	NA	2/28/2008: Complaint by landowner for noncompliance for stormwater permit. Lack of erosion controls or mitigation on disturbed soil on the Left Hand Fork Road of North Fork Ranch. Culvert covered over with mud and mud flowing down hill from road. Left hand Fork Creek is below these areas. Status: In process.
05-071-08623	Joplin 44-5	Pioneer Natural Resources USA Inc	4	0	NA	None	NA	
			NA	NA	1/2/2008	None - Summary of Complaint Records	NA	1/2/2008: Landowner concerned about quality of water well. COGCC Resolution: Sampling conducted.
05-071-08642	Alabaster 11-8	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08645	Underworld 31-36 TR	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08649	Butch 33-10 TR	Pioneer Natural Resources USA Inc	4	1	2/5/2009	Well leaking onto well pad. Stuffing box leaking and water migrating across well pad.	NI	
05-071-08673	Talon 34-25	Pioneer Natural Resources USA Inc	2	1	10/17/2008	NOAV: Operator did not use adequate precautions to prevent sediment from entering the bed of an arroyo beside lease road. No BMPs such as filtering structures were installed to prevent sediment transport into the arroyo. The lack of erosion controls along the lease road resulted in significant adverse environmental impact.	Yes	

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-08675	Horsefeathers 24-34	Pioneer Natural Resources USA Inc	4	0	NA	None	NA	
			NA	NA	3/16/2006	None - Summary of Complaint Records	NA	3/16/2006: Landowner claims that the Horsefeathers 24-34 well is 139 feet from his property line, not the 150 feet required by COGCC. Operator has positioned a culvert on the pad that the homeowner is concerned will cause water to flow onto his property during rain events. Status: In process.
05-071-08707	Wildcard 31-5	Pioneer Natural Resources USA Inc	11	5	9/10/2009	Operator needs to file Form 15 with water quality data. Also needs to implement collection of exploration and production wastes from drip and dispose of in manner consistent with Rule 907. Operator currently discharging water from drip at base of lease road and intersection with county road.	NI	
					10/13/2009	No pit permit on record.	NI	
					10/27/2009	No pit permit on record.	NI	
					3/14/2006	NOAV: Drill pit built in rocky fill, causing a leak and release of 300 bbls of produced water and drilling fluids. Well site located near a spring that discharges to a shallow alluvial aquifer. Also located near creek headwaters, and four shallow water wells are located within 1 mile downgradient.	Yes	
					3/17/2006	Spill/Release : Due to pit leak, 300 bbls of produced water released. No groundwater affected. Surface waters affected.	Closed	
			NA	NA	6/12/2006 8/12/2008 9/9/2009	None - Summary of Complaint Records	NA	6/12/2006: Landowner request for follow-up water well sampling for three different landowners. COGCC Resolution: Sampling conducted, water quality good and sampling result similar to previous sampling rounds. 8/12/2008: Landowner concerned about water well quality. COGCC Resolution: COGCC sent most recent sampling results which are consistent with previous results and have no impacts from nearby CBM operations. 9/9/2009: Landowner complaint of spill onto property from nearby CBM operations. COGCC Resolution: Multiple field inspections show no signs of continued discharge. No impacts to vegetation were seen when compared to predrilling aerial photos.
05-071-08743	Panhead 32-8	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-08777	Crocket 11-4	Pioneer Natural Resources USA Inc	3	2	2/24/2011	No pit permit on record.	NI	
					3/23/2011	Fluid levels in pit should be less than 2 feet of freeboard and should remain less than 2 feet at all times.	NI	
05-071-08834	Kauai 23-36 TR	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08835	Kauai 23-36	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08836	Jeep Trail 43-36 TR	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08837	Molokai 13-36 TR	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-08838	Molokai 13-36	Pioneer Natural Resources USA Inc	11	7	4/30/2008	Need to maintain 2 feet of freeboard. Tear in liner, water level in pit above tear.	NI	NOAV 7/18/2006: Status is listed as closed, unknown if corrective action was properly completed.
					7/18/2006	NOAV: Drilling operations for the Molokai 13-36 caused significant adverse environmental impacts on water resources and created a potential for harm to public health and safety and welfare. Impacts include adverse changes in water quality, including an increase in the concentration of dissolved methane, discoloration of the well water, and an increase in odor. Water quality standards established by the Water Quality Control Commission for waters of the state have been violated. Explosive levels of methane have been observed in the water well casing, creating a public health and safety issue.	Closed	
					7/18/2006	NOAV: Drilling operations for the Molokai 13-36 caused significant adverse environmental impacts to water resources and a created potential for harm to public health, safety, and welfare. Impacts include adverse changes in water quality, including an increase in the concentration of dissolved methane, discoloration of the well water, and water has noticeable odor. Water quality standards established by the Water Quality Control Commission for waters of the state have been violated. Explosive levels of methane have been measured in the water well casing creating a public health and safety issue.	Closed	
					1/13/2009	NOAV: The operator has failed to take adequate precautions to protect water-bearing formations while developing oil and gas resources and has failed to prevent significant adverse environmental impacts on water to the extent necessary to protect public health, safety, and welfare. The operator has failed to prevent contamination of fresh water by objectionable water, oil, or gas. The concentration of methane dissolved in ground water at a monitoring well installed by the operator as a point of compliance as a result of problems noted in 2006 has increased by greater than 7 mg/L since samples were first collected. The concentration of dissolved methane present in ground water pumped from the monitoring well has increased such that the concentration detected in samples collected in 2009 are greater than the concentration that could result in build up to explosive levels in an enclosed space. The operator has not reported any spill/release or incident that could be responsible for these adverse environmental impacts.	NI	

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
					2/25/2009	NOAV: The operator has failed to take adequate precautions to protect water-bearing formations while developing oil and gas resources and has failed to prevent significant adverse environmental impacts on water to the extent necessary to protect public health, safety, and welfare. The operator has failed to prevent contamination of fresh water by objectionable water, oil, or gas. The concentration of methane dissolved in ground water at a domestic well impacted in 2006 has increased by greater than 5 mg/L since samples were first collected. The concentration of dissolved methane present in ground water pumped from the monitoring well has increased such that the concentration detected in samples collected in 2009 are greater than the concentration that could result in a build up to explosive levels in an enclosed space. The operator has not reported any spill/release or incident that could be responsible for these adverse environmental impacts.	NI	
					1/26/2010	Spill/Release: Equipment failure caused a spill of 15 bbls of produced water. No ground or surface waters affected.	Closed	
					8/4/2006	Remediation: COGCC required operator to plug and abandon initial Molokai 13-36 surface casing borehole due to groundwater being affected. Analytical results determined water wells exceeded Regulation 41.	Closed	

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
			NA	NA	7/18/2006 7/19/2006 7/20/2006 7/31/2006 8/2/2006 3/23/3009	None - Summary of Complaint Records	NA	7/18/2006: Landowner concerned with excessive noise and contamination of North Fork Ranch Aquifer from human error and equipment failure. COGCC Resolution: Provided letter to homeowner indicating if felt private water well was impacted they would test it and provided noise abatement rules. 7/18/2006: Landowner does not agree with method that water well samples are being collected with by the operator. COGCC Resolution: Letter sent to landowner stating method being used is a standard and acceptable procedure, but a secondary method will also be used. 7/19/2006: Landowner has concern about water well quality following loud booms heard the day before. Status: In process. 7/20/2006: Landowner concerned that testing data has not been released by operator. Status: In process. 7/31/2006: Landowner concerned about various civil rights issues relating to drilling operations; drill broken in borehole, blowout, no written notification, violation of ceremonial Native American ground, and violation of religious constitutional rights. Status: In process. 8/2/2006: Landowner concerned that following a blow out and second well was permitted even after a citizen request for a cease and desist of operations. No site inspection and operator records incomplete. No information on resolution. Additional concern raised through another complaint record on same day, that the aquifer and well damage was a violation of SURA, damage to property value, and that methane and arsenic were present in well. COGCC Resolution: Sent letter to landowner stating that the issues were addressed through a NOAV or were out of the jurisdiction of COGCC. 3/23/2009: Landowner concerned about methane levels (5.4 mg/L) in their domestic well. Concerns about public health and environmental damage from nearby CBM operations. COGCC Resolution: Sampling conducted, methane levels have increased to hazardous levels. NOAV issued to operator. 7/19/2006: Landowner had two recorded complaints that were concerned with impacts to domestic well from CBM operations. COGCC Resolution: NOAV issued.
05-071-08839	Hawaii 44-36	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08845	Jeep Trail 43-36	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08846	Sanchinator 11-36 TR	Pioneer Natural Resources USA Inc	4	1	4/30/2008	No signs identifying operator or emergency contacts at the well site.	NI	
			NA	NA	4/19/2013	None - Summary of Complaint Records	NA	4/19/2013: Landowner has concern about increasing concentration of tert-butyl alcohol in their domestic well and what the source of the compound may be with nearby oil and gas activities. Status: In process.

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-08847	Sanchinator 11-36	Pioneer Natural Resources USA Inc	6	3	4/30/2008	No signs identifying operator or emergency contacts at the well site.	NI	
					5/29/2008	NOAV: The operator has failed to take adequate precautions to protect water-bearing formations while developing oil and gas resources and has failed to prevent significant adverse environmental impacts on water to the extent necessary to protect public health, safety, and welfare. The operator has failed to prevent contamination of fresh water by objectionable water, oil, or gas. Benzene was detected above the concentration established as a groundwater standard by the Water Quality Control Commission in ground water produced from a monitoring well installed by the operator as a point of compliance near the Sanchinator well pad. Benzene was not detected at 10-fold lower concentrations in several previous samples collected from the monitoring well. The concentration of dissolved methane present in ground water pumped from the monitoring well has increased to above a concentration greater than the concentration that could result in build up to explosive levels in an enclosed space. The operator has not reported any spill/release or incident that could be responsible for these adverse environmental impacts.	NI	
					6/28/2007	Spill/Release: Due to human error, the pit overflowed and 30 bbls of produced water was released. No ground or surface waters were affected.	Closed	
			NA	NA	3/4/2009	None - Summary of Complaint Records	NA	3/4/2009: Landowners concerned with environmental damage to groundwater resources due to oil and gas activities. Public health has been endangered by the impacts to groundwater. COGCC Resolution: COGCC sent letter stating that impacts to groundwater as a result of CBM operations were not properly reported and four NOAVs were issued to the associated operator.

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-08849	Grand Valley 22-36 TR	Pioneer Natural Resources USA Inc	6	3	4/30/2008	Install proper signs identifying well, operator, and emergency contacts. The pit for produced water should be lined or the use of pit stopped.	NI	
					7/16/2008	Install and maintain adequate stormwater controls to minimize erosion and transport of sediment away from the lease road right-of-way. Inadequate stormwater controls at first two culverts to the east of well pad. No filtering at downhill side of culvert; sediment being transported downhill from lease road. Part of the pit for produced water filled (eastern half), instead of being closed or lined to minimize chances of seepage or spills to the east.	NI	
					7/16/2008	NOAV: BMPs to control erosion and subsequent transport of sediment off the lease road were not implemented and maintained properly at two culverts just east of the well pad on lease road. Sediment had been transported onto forest floor. The operator did not take adequate precautions to protect environmental quality.	Yes	
05-071-08850	Grand Valley 22-36	Pioneer Natural Resources USA Inc	6	2	4/30/2008	Properly store chemicals or fuel on site. Repair or replace liner in pit or close pit. There should be more than 2 feet of freeboard in pit. Install signs per COGCC rules identifying well, operator, and emergency contacts.	NI	
					4/29/2008	NOAV: No permanent sign identifying the well was posted at the well site for more than nine months after well had been completed. The operator did not take adequate precautions to prevent significant adverse environmental impacts from chemical substances by leaving trash, wastes, and chemicals on the pad. The pit was not operated in manner that would protect the environment from significant adverse environmental impacts. No water quality data was submitted within 60 days of first gas sales, as required in permit for produced water pit. Records indicate first gas sales in July 2007, and no data has been submitted one year later.	Yes	
			NA	NA	4/29/2008	None - Summary of Complaint Records	NA	4/29/2009: Landowner concerned with various chemicals stored around site and general housekeeping. COGCC Resolution: Field investigation indicated these items had been addressed. A NOAV was issued for erosion issues seen during initial investigation.
05-071-08852	Crossword 41-36 TR	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08853	Crossword 41-36	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08870	North Fork Ranch 14-1	Pioneer Natural Resources USA Inc	4	1	3/9/2010	Remove unused equipment from pad. Ensure that adequate erosion controls are maintained on the downhill side of lease road. Recent construction disturbed parts of stormwater controls. Interim reclamation of drilling pit still needed after closure of drilling pit.	NI	
			NA	NA	1/10/2010 3/9/2010 3/29/2010	None - Summary of Complaint Records	NA	1/10/2010: Landowner concerned about impacts to their domestic well from nearby CBM operations. COGCC Resolution: Sampling completed, no impacts from CBM operations. Sampling results similar to those from previous sampling rounds. 3/9/2010: Landowner indicated that wastes were being disposed of in the nearby drilling pit. COGCC Resolution: Letter sent stating field investigations did not indicate any finding of violation. 3/29/2010: Landowner concerned about noise from nearby well site. COGCC Resolution: Noise monitoring conducted and noise levels within compliance.

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-08871	North Fork Ranch 14-1	Pioneer Natural Resources USA Inc	3	1	3/9/2010	Unlined, fenced pit that is not in use. Remove unused equipment and inaccurate identification sign.	NI	
			NA	NA	12/21/2009	None - Summary of Complaint Records	NA	12/21/2009: Landowner concerned about impacts to groundwater from possible damage to casing. Status: In process.
05-071-08872	Cody 44-11R	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
			NA	NA	5/10/2011	None - Summary of Complaint Records	NA	5/10/2011: Landowner requests baseline water sampling. COGCC Resolution: Sampling conducted, water quality good and all parameters less than groundwater standards.
05-071-08874	Montoya 41-13R	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-08875	Montoya 24-1R	Pioneer Natural Resources USA Inc	5	0	NA	None	NA	
05-071-08876	Montoya 41-1R	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08877	Montoya 11-1R	Pioneer Natural Resources USA Inc	6	1	7/7/2009	Need to produce, plug, and abandon well, or pass mechanical integrity test. Need to put up lease sign. No production records found and no mechanical integrity testing records found.	NI	
05-071-08882	Montoya 42-1V	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08883	Montoya 42-1R	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08884	Montoya 11-6R	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08913	Montoya 11-6V	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08933	Divide 14-26	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-08938	Keystone 11-35	Pioneer Natural Resources USA Inc	9	7	1/6/2009	Install appropriate sign identifying well, operator, and emergency contacts.	NI	
					6/4/2010	Install appropriate sign on tank at the Keystone well as required by 210 D.E. Submit Form 27 and associated data, including water quality data and soils data documenting proper closure of unpermitted produced water pit.	NI	
					3/7/2007	NOAV: BMPs to minimize erosion and offsite sediment transport by controlling stormwater runoff were not implemented and maintained. Significant impacts on soils and waters of the state of Colorado were made as a result of improper implementation of BMPs and failure to maintain the BMPs.	Yes	
					12/11/2008	NOAV: The operator has failed to take adequate precautions to protect water-bearing formations while developing oil and gas resources and has failed to prevent significant adverse environmental impacts on water to the extent necessary to protect public health, safety, and welfare. The operator has failed to prevent contamination of fresh water by objectionable water, oil, or gas. The concentration of methane dissolved in groundwater at a monitoring well installed by the operator as a point of compliance near the Keystone well pad has increased 3 mg/L since samples were first collected. The concentration of dissolved methane present in groundwater pumped from the monitoring well has increased to a concentration greater than the concentration that could result in build up to explosive levels in an enclosed space. The operator has not reported any spill/release or incident that could be responsible for these adverse environmental impacts.	NI	
					12/30/2008	Spill/Release: Due to equipment failure, 35 bbls of produced water released. No ground or surface waters affected.	Closed	
					6/2/2010	Spill/Release: Due to equipment failure, 5 bbls of produced water released. No ground or surface water affected.	Closed	
					9/22/2010	Remediation: Remediation of soils around/within the pit. Sampling and analysis indicated affected materials.	Closed	
			NA	NA	3/2/2009	None - Summary of Complaint Records	NA	3/2/2009: Landowner concerned about impacts to groundwater from nearby CBM operations. COGCC Resolution: Sampling conducted, no impacts found.
05-071-08945	MacGregor 32-25 TR	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08949	Storm Peak 44-6	Pioneer Natural Resources USA Inc	3	0	NA	None	NA	
			NA	NA	9/6/2013	None - Summary of Complaint Records	NA	9/6/2013: Landowner requests baseline water sampling. COGCC Resolution: Sampling conducted, water quality is consistent with other shallow water wells in area. No impacts from nearby CBM operations.
05-071-08956	J & P 33-12R	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-08957	Montoya 21-1R	Pioneer Natural Resources USA Inc	3	0	NA	None	NA	
05-071-08967	Rullestad 13-12V	Pioneer Natural Resources USA Inc	3	0	NA	None	NA	
05-071-08968	Rullestad 13-12R	Pioneer Natural Resources USA Inc	4	2	10/24/2008	Spill/Release: Due to equipment failure, 94 bbls of produced water released. No groundwater impacted. Surface waters impacted.	Closed	
					10/27/2008	Spill/Release: Due to equipment failure, 10 bbls of produced water released. No ground or surface waters impacted.	Closed	

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-08975	Monte Carlo 31-7 TR	Pioneer Natural Resources USA Inc	3	1	7/9/2008	Freeboard within pit should be more than 2 feet. Pit liner is torn and water is at the level of the tear.	NI	
05-071-09008	Wood 43-2V	Pioneer Natural Resources USA Inc	8	5	8/19/2008	Remove unused equipment from site. Pit has less than 2 feet of freeboard.	NI	
					8/30/2008	Remove unused equipment from site.	NI	
					9/13/2008	Maintain a minimum of 2 feet of freeboard in pit. Remove unused equipment from site. Install and maintain adequate BMPs to minimize erosion; lack of inadequate erosion controls along pad and lease road to the south. Form 19 was not filed for spill.	NI	
					8/19/2008	NOAV: Exploration and production wastes from other facilities were transported and released at location/facility not authorized to receive wastes from any source other than the well associated with the facility.	NI	
					9/13/2008	NOAV: A spill of greater than 20 bbls of produced water occurred at the Wood 2-43V on the morning of September 13, 2008. The spill has not been reported verbally within 24 hours of discovery or by means of a Form 19 within 10 days. Water quality data for the well has not been reported to the COGCC within 60 days of first gas sales as required by a condition of approval in the pit permit. The operator has failed to operate and maintain the pit in a manner that will protect the waters of the state from serious adverse environmental impacts. Pumping was started at the well with no mechanism in place to remove water from the pit as needed. The operator did not maintain adequate erosion controls along the lease road to minimize transport of sediment into an arroyo with subsequent transport of the pollutant down the arroyo. Two sets of signs identifying the well and its operator and emergency contacts were present on the site but two different operators were identified and two sets of emergency contacts. Trash and unused equipment has not been removed from the well site in a timely manner.	NI	
			NA	NA	6/9/2008 7/1/2008 9/13/2008 2/24/2009 2/26/2009 4/4/2009	None - Summary of Complaint Records	NA	6/9/2008: Landowner concerned about impacts to groundwater from hydraulic fracturing that is planned in a nearby well. COGCC Resolution: Letter sent summarizing most recent sampling. Water quality has remained relatively constant over last few years. 7/1/2008: Landowner concerned about impacts to water quality of domestic well. COGCC Resolution: Sampling conducted, sampling results sent to landowner. 9/13/2008: Landowner indicates that pit is overflowing and a spill occurring. COGCC Resolution: Field investigation indicated spill had occurred and a NOAV was issued. 2/24/2009: Landowner concerned about groundwater. COGCC Resolution: Letter sent summarizing recent sampling, no impacts from CBM operations were observed. 2/26/2009: Landowner concerned about groundwater. COGCC Resolution: Letter sent summarizing recent sampling, all results within groundwater standards and similar to previous sampling, no impacts from CBM operations were observed. 4/4/2009: Landowner indicated pit had less than 2 feet of freeboard, that water had green color, and was not from the correct well. COGCC Resolution: Sampling conducted on pit water, no further information available.

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-09009	Wood 43-2 R	Pioneer Natural Resources USA Inc	5	4	8/19/2008	Reserve pit constructed prior to drilling and pit has been receiving produced water. Do not utilize excavations for produced water disposal when no well exists and no pit permit exists to authorize produced water disposal. Remove incorrect signage.	NI	
					8/30/2008	Remove unused equipment and ensure than any signs on pad have current emergency contact numbers.	NI	
					9/13/2008	Remove unused equipment and ensure than any signs on pad have current emergency contact numbers.	NI	
					8/19/2008	NOAV: A release/spill of more than 20 bbls of exploration and production wastes was dumped into an unlined earthen excavation on the pad built for the Wood 2-43R (permitted, but not drilled at the time of the incident). The spill/release was not verbally reported by the operator within 24 hours of discovery, nor has it been reported via a Form 19 in more than 2 months since the incident occurred. The excavation is not an authorized means of disposal of exploration and production wastes. Release of exploration and production wastes at unauthorized locations significantly and adversely impacts environmental quality. Operator is not taking adequate precautions to prevent unauthorized discharge or disposal of exploration and production wastes.	NI	
			NA	NA	2/5/2008 8/19/2008	None - Summary of Complaint Records	NA	2/5/2008: Landowner concerned about groundwater quality from nearby drilling and hydraulic fracturing. COGCC Resolution: Sampling conducted, no measurable impacts to groundwater quality. 8/19/2008: Landowner indicated they observed two water trucks dumping water on the well pad. COGCC Resolution: Letter sent indicating field investigation, NOAVs issued.

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-09018	Lobo 13-4	Pioneer Natural Resources USA Inc	8	4	1/28/2011	Install new liner or make adequate repairs to current liner, including removing rocks from bed the liner is placed on.	NI	
					1/27/2011	NOAV: A spill of exploration and production wastes from the lined and permitted produced water pit at the Lobo 13-4 location occurred on or before January 27, 2011. The spill included water and other exploration and production wastes. Significant adverse impacts on ground water near the Lobo 13-4 pit have resulted from the lack of control of exploration and production wastes at the well. The operator failed to take adequate precautions to protect environmental resources and failed to manage exploration and production wastes in a manner that would protect those resources in that the pit was not constructed nor was it operated in a manner that would protect environmental resources.	Yes	
					4/12/2007	Spill/Release: Leaking pit liner released 25 bbls of produced water. No ground or surface waters impacted.	Closed	
					1/31/2011	Spill/Release: A torn pit liner allowed the release of 2,100 bbls of produced water. No ground or surface waters impacted.	Closed	
			NA	NA	1/31/2011 1/7/2014	None - Summary of Complaint Records	NA	1/31/2011: Landowner indicated a spill occurred from the lined pit and may have come near their domestic well. COGCC Resolution: Most recent sampling results sent to landowner and a NOAV issued to operator. 1/7/2014: Landowner concerned about groundwater impacts from nearby CBM operations. No information available about resolution.
05-071-09019	Kennedy 11-34	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09021	Kennedy 34-34	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09090	Wood 31-2 R	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-09091	Wood 31-2	Pioneer Natural Resources USA Inc	4	1	1/26/2012	Spill/Release: Due to human error, pressure in a water line caused it to rupture, and 5 bbls of produced water was released. No ground or surface waters impacted.	Closed	
05-071-09144	Crocket 11-4 TR	Pioneer Natural Resources USA Inc	2	1	2/24/2011	Unlined pit and no permit in the database.	NI	
05-071-09180	Tailgate 14-25	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09181	Tailgate 14-25 TR	Pioneer Natural Resources USA Inc	2	1	9/19/2008	Tear in pit liner and pit is constructed in fill. Noise levels high.	NI	
05-071-09182	Magnum 43-26	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09192	Homestead 14-5	Pioneer Natural Resources USA Inc	4	0	NA	None	NA	
			NA	NA	7/11/2008 10/23/2009 8/5/2010	None - Summary of Complaint Records	NA	7/11/2008: Landowner concerned about elevated methane levels in recent sampling results, feels could be the result of nearby CBM operations. COGCC Resolution: Sampling conducted and determined that methane is the result of thermogenic origin. 10/23/2009: Landowner requests follow-up of VOC sampling. COGCC Resolution: Sampling conducted, no impacts from CBM operations. 8/5/2010: Landowner request (per doctor) for chemicals used in downhole operations. Also concern if water from this well is used in road spreading for dust control. COGCC Resolution: Provided landowner with packet of chemical product information and well records.

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-09214	Backyard 34-34	Pioneer Natural Resources USA Inc	7	4	2/25/2009	Need to put up lease sign. No production records.	NI	
					4/11/2007	NOAV: Drilling fluids spilled through pit liner (spill #200109995). The liquids that were spilled threaten significant adverse impact on waters and soils. Spill was not reported as having potential impact on groundwater, even though operator has been sampling water well down-slope for possible impacts from spill. This spill from a lined pit during or shortly after drilling shows that proper practices for installation and care of liners are not used.	Yes	
					4/12/2007	Spill/Release: Due to leaking pit liner, 25 bbls of produced water was released. No ground or surface waters impacted.	Closed	
					12/5/2013	Remediation: Produced water was being stored in pit on site, may have affected soils. Pit has been closed	Closed	
05-071-09250	Hellzapoppin 24-32	Pioneer Natural Resources USA Inc	3	1	3/5/2012	Pit liner needs to be repaired.	NI	
05-071-09260	Boof 12-2	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09261	Mauer 41-3	Pioneer Natural Resources USA Inc	3	1	9/18/2008	Spill/Release: Due to a torn liner, 30 bbls of produced water was released. No ground or surface waters impacted.	Closed	
05-071-09308	Flashback Deep 22-27	Pioneer Natural Resources USA Inc	3	0	NA	None	NA	
05-071-09373	Montoya 12-1R	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
05-071-09374	Montoya 12-1V	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-09390	Niagara 23-35 R	Pioneer Natural Resources USA Inc	6	3	1/27/2008	NOAV: Exploration and production wastes transported and dumped in location not permitted to receive such wastes. A reserve pit had been constructed for use in future drilling operations or to contain exploration and production wastes from drilling at the Niagara 23-35R. This well has not been drilled. Wastes were hauled to and dumped in the unlined reserve pit from another of the operator's wells. Wastes from the Niagara 23-35R pit were later dumped on the ground and left there while closing the pit. The spills/releases of exploration waste were not properly reported by the operator as required. No characterization of the waste has been provided by the operator, nor has the operator provided information as to the source of the waste. Information on source of waste was requested but not provided by operator.	NI	
					1/14/2009	NOAV: Operator failed to take adequate precautions to protect water-bearing formations while developing oil/gas resources and failed to prevent significant adverse impacts on water to the extent necessary to protect public health, safety, and welfare. Operator failed to prevent the contamination of fresh water by objectionable water, oil, or gas. Benzene was detected above the established groundwater standards by the Water Quality Control Commission in groundwater from a monitoring well installed by operator as a point of compliance near the Niagara well pad. Benzene was detected at 3-4-fold lower concentrations in previous samples collected from the well. The concentration of dissolved methane present in groundwater pumped from the monitoring well has increased to above the concentration that could result in buildup to explosive levels in an enclosed space. Operator has not reported any spill/release/incident that could be responsible for these adverse environmental impacts. Operator did not alert the COGCC or nearby potentially impacted well owners as soon as practicable upon learning of adverse impacts on groundwater in the area.	NI	
					9/11/2013	Remediation: Produced water was being stored in pit on site, may have affected soils. Pit has been closed	Closed	
			NA	NA	2/5/2008 6/4/2008 2/23/2009 7/8/2010 5/10/2011	None - Summary of Complaint Records	NA	2/5/2008, 6/4/2008, 2/23/2009, 7/8/2010, 5/10/2011: Landowner concerned with impacts to groundwater from nearby CBM operations. COGCC Resolution: Multiple sampling rounds conducted over numerous years. All results within groundwater standards and water quality has remained constant over sampling rounds. 5/10/2011: Landowner concerned about impacts to groundwater. COGCC Resolution: Sampling conducted, no impacts from CBM operations and water quality has remained similar since 2009 sampling.
05-071-09415	Saint Anthony 32-11V	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
05-071-09416	Saint Francis 32-11R	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
05-071-09439	Norther 23-6	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-09444	Zamora 22-14V	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
05-071-09445	Zamora 43-14V	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
05-071-09486	Marilyn Deep 24-3	Pioneer Natural Resources USA Inc	5	0	NA	None	NA	

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-09497	Mazatlan 23-25TR	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-09498	Mazatlan 23-25	Pioneer Natural Resources USA Inc	5	4	7/24/2008	Inadequate erosion control practices in place along lease road. Sediment washing into arroyo. No filtering at downslope end of culvert, and 2-foot-deep gully has eroded out of road side. Signage not visible.	NI	
					9/19/2008	Install and maintain adequate erosion controls to minimize transport of sediment into unnamed tributary of Right Hand Fork of Dude Canyon. Erosion controls inadequate and not properly maintained at lease road to south east of well pad. Sediment entering arroyo from lease road, even after installation of BMPs in response to previous failure.	NI	
					4/24/2008	NOAV: Well is less than 150 feet from surface property line. No exception request with surface owner waiver has been filed. Inadequate erosion controls measures are in place to contain sediment from reaching an arroyo as the lease road crosses the arroyo. NOAV #200193025 was issued previously regarding erosion controls along the lease road to the Mazatlan well pad. The BMPs utilized by the operator in response to the previous NOAV are inadequate and are not being maintained properly to minimize sediment transport into and down the arroyo.	Yes	
					7/24/2008	NOAV: Operator did not use adequate precautions to prevent sediment from entering the bed of an arroyo at lease road crossing of arroyo. No BMPs such as filtering structures were installed at the uphill or downhill end of a culvert under the road. The lack of erosion controls along the lease road resulted in significant adverse environmental impacts.	Yes	
			NA	NA	7/22/2008	None - Summary of Complaint Records	NA	7/22/2008: Landowner indicates that well was drilled without surface owner notification and that it was incorrectly drilled on the wrong tract of land. Landowner also concerned that BMPs are not in place to prevent sediment into the arroyo and that a spring on their property is now dry possible due to oil and gas activities. COGCC Resolution: Field investigation indicated well was drilled within 150 feet of the surface property line, but on the correct tract; NOAV issued. Second NOAV issued for lack of maintenance and adequate erosion controls. USGS topographic maps show drainage (spring) as intermittent not perennial, field investigations confirmed this.
05-071-09518	Hawaii 43-36 H	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09527	Reef Deep 41-35	Pioneer Natural Resources USA Inc	4	0	NA	None	NA	
05-071-09540	Kennedy 14-27	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09551	Marilyn 23-3	Pioneer Natural Resources USA Inc	4	0	NA	None	NA	
05-071-09552	Marilyn 24-3 TR	Pioneer Natural Resources USA Inc	4	0	NA	None	NA	
05-071-09588	Hole in the wall 42-5	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09653	Hawaii 43-36 H-R	Pioneer Natural Resources USA Inc	2	1	12/2/2010	Production reports indicate produced water disposed of in pit, but no pit present and no permit on record. Signage is inadequate, both incorrect and not present.	NI	
05-071-09658	Reef 32-35	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-09665	Cave Canyon 23-4 Tr	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
			NA	NA	11/7/2008	None - Summary of Complaint Records	NI	11/7/2008: One approved well and two permits pending, landowner request baseline water sampling before drilling begins. COGCC Resolution: Sampling conducted, TDS exceeds groundwater standard.
05-071-09671	Panther 33-5	Pioneer Natural Resources USA Inc	5	0	NA	None	NA	
05-071-09677	Midnight 12-11	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
05-071-09685	Maximus 12-2	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
			NA	NA	5/6/2009 7/8/2010	None - Summary of Complaint Records	NA	5/6/2009: Landowner request for baseline water sampling due to concern that CBM operations are affecting groundwater in area. COGCC Resolution: Sampling conducted, results within groundwater standards and of generally good quality. 7/8/2010: Landowner concerned about groundwater quality due to CBM operations. COGCC Resolution: Sampling conducted, only manganese exceed groundwater standards, other results similar to those found during baseline sampling.
05-071-09708	Kent 44-25	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
05-071-09709	Rainbow Trout 23-3	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09712	Lynn 32-4 Tr	Pioneer Natural Resources USA Inc	3	1	10/25/2011	Spill/Release: Failure to close the valve on the produced water tank resulted in 50 bbls of produced water being released. No ground or surface waters impacted.	Closed	
05-071-09713	Kent 44-25TR	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
05-071-09737	N.F.R.A. 24-35	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
			NA	NA	6/7/2011	None - Summary of Complaint Records	NA	6/7/2011: Landowner requests an onsite inspection. Concern about minimizing road construction and tree removal, as just received packet from operator. Landowner has not started surface use agreement negotiations, but would like on-site request on record in event operator refiles. Status: In process.
05-071-09738	Scottsdale 34-26	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
05-071-09752	Panther 33-5 TR	Pioneer Natural Resources USA Inc	5	0	NA	None	NA	
05-071-09754	Boof 12-2 Tr	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09765	Shinarump 11-11 KP H	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09770	Parras 21-12 KP HA	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09775	Holst 41-6	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09784	Shinarump 11-11 KV	Pioneer Natural Resources USA Inc	2	0	NA	None	NA	
05-071-09793	Hellzapoppin 24-32 Tr	Pioneer Natural Resources USA Inc	2	1	3/5/2012	Liner torn on well side; fluid level is above liner tear. Barbed wire fence is not intact.	Yes	
05-071-09795	Saluki 41-8	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-09799	Alibi 23-2	Pioneer Natural Resources USA Inc	4	1	1/18/2011	No method to identify freeboard. Less than 2 feet of freeboard. Pit not permitted. Signage labeling incorrect.	NI	
			NA	NA	5/24/2010 6/30/2010 7/2/2010 10/28/2010 2/1/2011	None - Summary of Complaint Records	NA	5/24/2010: Landowner indicated that there may be issues with the surface casing cement job and was interested in when completion documents would be available. COGCC Resolution: Completion documents were reviewed and operator contacted; determination made that there did not appear to be a problem. 6/30/2010: Landowner concerned about particulates present in domestic well water following hydraulic fracturing of nearby well. COGCC Resolution: Sampling conducted, no apparent impacts. 7/2/2010: Landowner concerned about impacts to groundwater in domestic well following completion activities at a nearby well. COGCC Resolution: Sampling conducted, sampling results show no major changes in composition from 2008 and 2009 sampling events; no apparent impacts. 10/28/2010: Landowner concern with noise from nearby well. COGCC Resolution: Noise monitoring conducted and noise levels in compliance. 5/24/2010: Landowner concerned with green coloration of water bailed as part of rehabilitation process, believes related to nearby hydraulic fracturing operations. COGCC Resolution: It was determined that data presented did not show any violations of COGCC rules.
05-071-09803	Alibi 23-2 Tr	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09814	Djembe 21-12	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
05-071-09815	Djembe 21-12 TR	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
05-071-09817	Timbale 32-12	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09818	Timbale 32-12 TR	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09824	Zathura 41-14	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
05-071-09825	Popeye 32-14	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
05-071-09829	Montoya 33-13 TR	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
05-071-09830	Montoya 33-13	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
05-071-09842	Clave 43-11 TR	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09843	Clave 43-11	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09847	Talon 34-25 TR	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
05-071-09855	Havana 12-25 TR	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	
05-071-09856	Larissa 32-35	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09857	Larissa 32-35 TR	Pioneer Natural Resources USA Inc	1	0	NA	None	NA	
05-071-09860	Kosar 21-11 TR	Pioneer Natural Resources USA Inc	1	1	3/15/2012	Drilling pit has been used for produced water storage and not permitted. Pit now closed without submission of site investigation and remediation plan.	Yes	

Table C-19 Notice of Violations, Raton Basin Retrospective Case Study, Las Animas County, Colorado

API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violations	Violation Details	Corrected	Comments
05-071-09861	Kosar 21-11	Pioneer Natural Resources USA Inc	1	1	3/15/2012	Drilling pit has been used for produced water storage and not permitted. Pit now closed without submission of site investigation and remediation plan.	Yes	
			NA	NA	10/2/2011	None - Summary of Complaint Records	NA	10/2/2011: Landowner concerned about increased sediment in domestic well, stating they increased when operations began at nearby well. Status: In process.
05-071-09881	Redmond 44-33	Pioneer Natural Resources USA Inc	0	NA	NA	NA	NA	

Source: Colorado Oil and Gas Conservation Commission, http://cogcc.state.co.us/cogis/

Key:
API = American Petroleum Institute
bbls = barrels
BMP = Best management practice
CBM = Coal bed methane
COGCC = Colorado Oil and Gas Conservation Commission
dBA = Decibels adjusted
mg/L = milligram per liter
MIT = Mechanical Integrity Testing
MSDS = Material Safety Data Sheet
NA = Not applicable
NI = No information available
NOAV = Notice of Alleged Violation
SURA = Superior Urban Renewal Authority
TDS = Total dissolved solids
VOC = Volatile organic compound

Table C-20 Notable Notice of Violations - Identified Potential Candidate Causes and Distances from Raton Basin Retrospective Case Study, Las Animas County, Colorado

			EPA Sampling Point		EPA Sampling Point		EPA Sampling Point		EPA Sampling Point	
Well	Latitude	Longitude	ID	Distance (miles)	ID	Distance (miles)	ID	Distance (miles)	ID	Distance (miles)
Montoya #12-7V	37.1882850	-104.9350440	RBSW03	0.8 SE	RBSW01	1.3 NE	RBDW01	1.5 NE	RBDW13	1.6 NE
Montoya #14-6V	37.1952400	-104.9347320	RBSW03	0.7 E	RBDW05	1.5 E				
J & P #33-12V	37.1843310	-104.9441800	RBSW01	0.8 NE	RBSW03	0.8 S	RBDW01	0.9 NE	RBDW13	1.0 E
J & P #24-12V	37.1811190	-104.9484640	RBSW01	0.4 NE	RBDW01	0.5 E	RBDW13	0.8 E	RBSW03	1.0 SE
Montoya #41-12V	37.1901230	-104.9393500	RBSW03	0.6 SE	RBSW01	1.2 NE	RBDW01	1.3 NE	RBDW05	1.3 SE
Gamma #13-3	37.1990700	-104.8811240	RBSW02	0.2 NW						
Montoya #41-12R	37.1901180	-104.9396240	RBSW03	0.6 SE	RBSW01	1.2 NE	RBDW05	1.3 SE	RBDW13	1.4 NE
Niagara #23-35	37.2139200	-104.9692200	RBDW02	0.3 SW	RBDW04	0.5 N	RBMW01	0.6 SW	RBMW02	0.8 W
Montoya #21 - 7R	37.1918930	-104.9307470	RBSW03	1.0 SE	RBDW01	1.7 NE	RBSW01	1.7 NE		
Flashback 32 - 27	37.2323000	-104.9826000	RBMW01	1.2 NW	RBDW02	1.5 NW	RBDW04	1.8 NW	RBMW02	1.9 NW
Wildcard 31 -5	37.2059000	-104.7999900	RBDW12	0.5 NE	RBDW11	0.6 NE				
Molokai 13 - 36	37.2119300	-104.9535900	RBMW02	0.2 E	RBDW02	0.7 SE	RBMW03	0.5 S	RBMW01	0.9 SE
Sanchinator 11- 36	37.2200000	-104.9551900	RBMW03	0.0	RBMW01	0.5 SE	RBMW02	0.5 NE	RBDW02	0.7 NE
North Fork Ranch 14 - 1V	37.1962500	-104.9536000	RBSW03	0.4 W	RBDW05	0.5 E	RBDW03	0.9 SE		
Keystone 11 - 35	37.2206700	-104.9732300	RBPW02	0.0	RBMW01	0.5 W	RBDW02	0.5 NW	RBDW04	0.9 N
Rullestad 13 - 12R	37.1858800	-104.9546100	RBDW13	0.5 NE	RBDW01	0.6 NE	RBSW03	0.8 SW	RBDW05	0.9 SE
Wood 43 - 2V	37.1978400	-104.9584800	RBDW05	0.2 NE	RBDW03	0.6 E	RBSW03	0.6 NW		
Wood 43 - 2R	37.1978100	-104.9582700	RBDW05	0.2 NE	RBDW03	0.6 E	RBSW03	0.6 NW		
Lobo 13 - 4	37.1985500	-104.7893000	RBDW12	0.8 E	RBDW11	1.0 E				
Backyard 34 - 34	37.2109500	-104.8735100	RBSW02	1.0 NE						
Niagara 23 - 35R	37.2139900	-104.9694400	RBDW02	0.2 SW	RBDW04	0.4 N	RBMW01	0.6 SW	RBMW02	0.7 W
Hellzapoppin 24 - 32TR	37.2102600	-104.8044600	RBDW11	0.8 N	RBDW12	0.8 N				
Kosar 21 - 11	37.1912100	-104.9647300	RBDW05	0.4 SW	RBDW13	0.6 N	RBDW03	0.7 SE	RBSW03	1.0 SW
Wharton 33-32	37.211780	-104.799510	RBDW12	0.9 NE	RBDW11	1.0 NE				
Monte Carlo 31-7	37.192230	-104.820060	RBDW11	.09 SW						
Butch 33-10	37.185080	-104.870290	RBSW02	1.0 SE						
Montoya 21-7V	37.191080	-104.930350	RBSW03	1.0 SE						
Silva 22-6V	37.202500	-104.931840	RBSW03	1.0 NE						
Cody 44-11V	37.180720	-104.958050	RBDW01	0.2 NE	RBDW13	0.3 SE	RBSW01	0.3 NW		
Butch 33-10 TR	37.185290	-104.870450	RBSW02	1.0 SE						
Talon 34-25	37.224510	-104.943220	RBPW01	0.7 NE	RBPW03	0.7 NE	RBMW03	0.8 NE		
Grand Valley 22-36 TR	37.216900	-104.949920	RBMW03	0.4 SE	RBPW03	0.4 SE	RBPW01	0.4 SE		
Grand Valley 22-36	37.216890	-104.950220	RBMW03	0.3 SE	RBPW03	0.3 SE	RBPW01	0.4 SE		
Monte Carlo 31-7 TR	37.192470	-104.819920	RBDW11	0.9 SW	RBDW12	1.0 SW				

Table C-20 Notable Notice of Violations - Identified Potential Candidate Causes and Distances from Raton Basin Retrospective Case Study, Las Animas County, Colorado

			EPA Sampling Point		EPA Sampling Point		EPA Sampling Point		EPA Sampling Point	
Well	Latitude	Longitude	ID	Distance (miles)	ID	Distance (miles)	ID	Distance (miles)	ID	Distance (miles)
Wood 31-2	37.204950	-104.960670	RBMW02	0.6 SW	RBDW04	0.6 SE	RBDW02	0.8 SE		
Tailgate 14-25 TR	37.224360	-104.953220	RBPW03	0.3 NE	RBPW01	0.3 NE	RBMW03	0.4 NE		
Hellzapoppin 24-32	37.210110	-104.804450	RBDW12	0.8 NW	RBDW11	0.8 NE				
Mauer 41-3	37.205110	-104.868050	RBSW02	0.8 NE						
Mazatlan 23-25	37.227070	-104.948880	RBPW03	0.6 NE	RBPW01	0.6 NE	RBMW03	0.6 NE		
Lynn 32-4 TR	37.202010	-104.889420	RBSW02	0.6 NW						
Kosar 21-11 TR	37.191030	-104.964750	RBDW05	0.4 SW	RBDW03	0.7 SE				
Crocket 11-4 TR	37.205050	-104.789430	RBDW12	0.9 NE						
Hawaii 43-36 H-R	37.213140	-104.939850	RBPW01	1.0 SE	RBPW03	1.0 SE	RBMW03	1.0 SE		

Key:

E = East

EPA = U.S. Environmental Protection Agency

ID = Identification number

N = North

S = South

W = West

Table C-21 Environmental Database Review Summary, Raton Basin Retrospective Case Study, Huerfano County, Colorado

Database	Name of Facility	Site Location and Address	Distance from Nearest Sampling Point	Potential Candidate Cause		Groundwater Wells
				Yes /No	Details/Justification	
MINES	Sand Arroyo, Walsenburg Sand & Gravel, Inc.	Latitude: 37.5878 Longitude: -104.88262	1.5 mi. NNE of RBDW14	No	Active surface mine (sand and gravel); no violations cited. Surface stone quarry activities are not likely sources of contamination.	5 Federal USGS Wells 0 Federal FRDS Public Water Supply System 181 State Wells
MINES	RBK Pit No. 70, RBK Construction, Inc.	Latitude: 37.59102 Longitude: -104.85992	1.35 mi. NW of RBDW07	No	Terminated surface mine (sand and gravel); no violations cited. EDR lists the site (pre- and post-operations) as pastureland. Surface stone quarry activities are not likely sources of contamination.	
ORPHAN FINDS, US AIRS	Huerfano County Government - Port EQ	Latitude: 37.62061 Longitude: -104.777391	>5 mi. N of RBDW07	No	In Air Facility System (AFS) that contains compliance and permit data for stationary sources of air pollution regulated by the EPA, state, and local air pollution agencies. Surface mine (quarry); no violations cited. Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN FINDS, US AIRS	Huerfano County - Andreatta Pit	NW NE SEC 4 T30S R67W 6.1 mi. SE of La Veta, CO 81089 Latitude: 37.470747 Longitude: -104.89406	>3.5 mi. SSW of RBDW06	No	Surface mine (quarry); no violations cited. Surface stone quarry activities are not likely sources of contamination.	
ORPHAN FINDS, US AIRS, AIRS	Leone Sand and Gravel - Leone Huerfano	SEC 31 32 T26S R67W 10.0 mi. NW of Walsenburg, CO 81089	12.3 mi. N of RBDW14	No	Surface mine (borrow material for construction quarry). Surface stone quarry activities are not likely sources of contamination.	
ORPHAN FINDS, US AIRS	Huerfano State Gravel Pit	W SW SEC 36 T26S R65W 10.1 mi. NE of Walsenburg, CO 81089	16.8 mi. NE of RBDW07	No	Surface mine (borrow material for construction quarry). Surface stone quarry activities are not likely sources of contamination.	
ORPHAN FINDS, US AIRS	Eastern Colorado Aggregates - Pott	SW NW SEC 4 T27S R66W 5.9 mi. N of Walsenburg, CO 81089	11 mi. NNE of RBDW07	No	Surface mine (borrow material for construction quarry). Surface stone quarry activities are not likely sources of contamination.	
ORPHAN FTTS, HIST FTTS, FINDS	CSU Huerfano County Ext.	Walsenburg, CO 81089	>5 mi. NE of RBDW07	No	Listed in FTTS and HIST FTTS, which indicates inspections under FIFRA, TSCA, and/or EPCRA. Shows investigations for general product and PCBs; no violations cited. Also listed in NCDB, which supports implementation of FIFRA and TSCA. Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN SWF/LF	La Veta SWDS	1 mi. west on County Road 450 La Veta, CO	>7 mi. SW of RBMW04	No	Solid waste facility. Air Pollutant Inventory. No violations cited. Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN SWF/LF	Huerfano County Waste Transfer Station	107 Industrial Blvd. Walsenburg, CO 81089	6.1 mi. NE of RBDW07	No	Solid waste facility. No violations cited. Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN SWF/LF	City Of Walsenburg, Walsenburg SWDS	1 mi. east off I-25 Walsenburg, CO 81089	>5 mi. E of RBDW07	No	Solid waste facility. No violations cited. Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN LUST, LUST TRUST, UST, AST	Our Chance Truck Stop	10928 Highway 160 W La Veta, CO 81055	12.5 mi. W of RBDW14	No	8 tanks, all closed: 2 USTs (diesel and waste oil) and 6 ASTs (diesel and gasoline). 1 closed LUST with a confirmed release on 04/09/1997 and closure in 2006. Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN LUST	Front Range Petroleum	310 Highway 10 Walsenburg, CO 81089	6.2 mi. NE of RBDW07	No	2 USTs, 1 closed LUST - confirmed release in 1998. Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN LUST, UST, AST, AIRS	Cliff Brice Stations (Acorn Food Store No. 3400)	5519 Highway 12 La Veta, CO 81055	>7.5 mi. SW of RBMW04	No	1 LUST - confirmed release in 2002 and closed in 2003. 1 diesel AST - closed. 3 open USTs (2 gasoline and 1 diesel). Permitted Facility & Emissions Listing (benzene and VOCs). Not a likely source of contamination due to distance from nearest sampling locations.	

Table C-21 Environmental Database Review Summary, Raton Basin Retrospective Case Study, Huerfano County, Colorado

				Potential Candidate Cause		
Database	Name of Facility	Site Location and Address	Distance from Nearest Sampling Point	Yes /No	Details/Justification	Groundwater Wells
ORPHAN LUST, LUST TRUST, UST, AST, AIRS	Acorn Food Store (Rambler 66)	455 US Highway 85 Walsenburg, CO 81089	6.1 mi. NE of RBDW07	No	8 ASTs, all permanently closed; 4 - gasoline, 4 - diesel. 5 USTs, 4 currently in use; 2 - gasoline, 1 - diesel, 1 - E85. 1 gasoline UST permanently closed. 3 Confirmed releases; 3/5/1995, 6/5/1996, and 11/13/09, all closed. Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN LUST, LUST TRUST, UST, AIRS	Cliff Brice Station (Western Convenience Stores, Inc.)	416 Highway 85 & 87 Walsenburg, CO 81089	6.4 mi. NE of RBDW07	No	2 open USTs (gasoline), 1 closed UST (diesel), 1 closed UST (waste oil), 1 LUST with a confirmed release on 04/27/2001, which is currently implementing CAP - Groundwater impacted above action levels is present off site. Permitted Facility & Emissions Listing (benzene and VOCs). Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN LAST, AST	Huerfano County Road and Bridge	316 S. Locust La Veta, CO 81055	>7 mi. WSW of RBMW04	No	1 active AST (diesel), 2 closed ASTs (diesel and gasoline), 1 closed LAST with confirmed release in 2005. Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN UST	Cuchara Resort	Box 3, Highway 12 La Veta, CO 81055	>7 mi. SW of RBSW06	No	Retail gas station. 1 closed UST (diesel); no releases documented. Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN UST	Spanish Peaks Campground	19816 Highway 12 La Veta, CO 81055	18.2 mi. SW of RBDW06	No	2 closed USTs (gasoline); no releases documented. Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN UST	J J Construction & Enterprise	25462 Highway 160 Walsenburg, CO 81089	3.2 mi. NE of RBDW07	No	2 closed USTs (gasoline); no releases documented. Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN AST	La Veta Propane	16417 Highway 85 La Veta, CO	> 10 mi. W of RBMW05	No	3 active ASTs (propane); no releases documented. Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN AST	Birco, Inc., Dakota Campground	Dakota Campground 1079 Highway 85 & 87 Walsenburg, CO 81089	5.9 mi. NE of RBDW07	No	2 liquid propane gas ASTs, 1 closed AST (2009); no documented releases. Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN RCRA NonGen / NLR, FINDS	Colorado Department of Highways - La Veta	420 South Poplar SH 12, MP 4.76 La Veta, CO 81055	7.1 mi. WNW of RBDW04	No	Classified as a non-generator/handler of hazardous waste; no releases documented. Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN RCRA NonGen / NLR, FINDS	Colorado Department of Transportation	US Highway 160 MP 281.35 La Veta, CO 81055 Latitude: 37.54125 Longitude: -105.06353	> 9 mi. W of RBMW05	No	Classified as a non-generator/handler of hazardous waste, highway and street construction (except elevated highways). Conditionally Exempt Small Quantity Generator (D001 waste). Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN RCRA NonGen / NLR, FINDS	Colorado - Ute Electric Assn., Inc.	14000 RD South 100 Walsenburg, CO 81089 Latitude: 37.724615 Longitude: -104.990983	>5 mi. NE of RBDW07	No	Classified as a non-generator/handler of hazardous waste (D002); no violations cited. Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN RCRA NonGen / NLR	Spanish Peaks Regional Health Center	23500 US Highway 160 Walsenburg, CO 81089	2.2 mi. NE of RBDW07	No	Facility is not located on Indian land. Air Facility System, Emission Inventory System, National Emissions Inventory, Resource Conservation And Recovery Act Information System. No violations cited. Not a likely source of contamination due to distance from nearest sampling locations.	

Table C-21 Environmental Database Review Summary, Raton Basin Retrospective Case Study, Huerfano County, Colorado

				Potential Candidate Cause		
Database	Name of Facility	Site Location and Address	Distance from Nearest Sampling Point	Yes /No	Details/Justification	Groundwater Wells
ORPHAN FINDS	Huerfano School District Re 2	126 East Garland Street La Veta, CO 81055	7.2 mi. SW of RBMW04	No	Site in NCDB that supports implementation of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Toxic Substances Control Act (TSCA). No violations cited. Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN FINDS	Colorado Coal Mining Co.	107 Industrial Blvd. Walsenburg, CO 81089	6.1 mi. NE of RBDW07	No	The database indicated that the property was inspected under AIRS; no violations cited. Not a likely source of contamination due to distance from nearest sampling locations.	
ORPHAN FINDS	Huerfano County - Hribar Pit	NE NE SEC 35 T26S R67W 7.9 mi. NW of Walsenburg, CO 81089	5.5 mi. NNW of RBDW14	No	Construction Sand And Gravel Mining. Listed in the Emission Inventory System (EIS), which maintains an inventory of large, stationary sources and voluntarily reported smaller sources of air point pollution emitters. Not a likely source of contamination due to distance from nearest sampling locations.	

Source: Environmental records search report by Environmental Data Resources, Inc. (EDR)

Additional Sources:

Colorado Division of Reclamation, Mining and Safety: http://mining.state.co.us/Reports/MiningData/Pages/SearchByMine.aspx

Colorado Storage Tank Information System (COSTIS) Web Site: http://costis.cdle.state.co.us/OIS2000/

Envirofacts: http://www.epa.gov/enviro/

Notes:

EDR Inquiry Number:: 3601313.2s

EDR Search Radius: 3 miles

Search Center: Lat. 37.5493000, (37° 32’ 57.48’’) Long. 104.8708000 (104° 52’ 14.88’’)

Key:

AST = Above ground storage tank
CAP = Corrective Action Plan
E = East
EPA = Environmental Protection Agency
FRDS = Federal Reporting Data System
mi = Mile
N = North
PCB = Polychlorinated biphenyls
S = South
USGS = United States Geological Survey
UST = Underground storage tank
VOC = organic
W = West

Databases:

AIRS: Permitted Facility and Emissions Listings
AST: Listing of Colorado Regulated Aboveground Storage Tanks
FINDS: Facility Index System/Facility Registry System
FTTS: FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fungicide, & Rodenticide Act)/TSCA (Toxic Substances Control Act). FTTS tracks administrative cases and pesticide enforcement actions and compliance activities related to FIFRA, TSCA and EPCRA (Emergency Planning and Community Right-to-Know Act)
HIST FTTS: FIFRA/TSCA Tracking System Administrative Case Listing
LAST: Leaking Aboveground Storage Tank Sites
LUST: Leaking Underground Storage Tank Sites
LUST TRUST: Listings of eligible applicants to Colorado's Petroleum Storage Tank Fund. The Fund provides reimbursement for allowable costs in cleaning up petroleum contamination from under ground and above ground storage tanks
MINES: Mines Master Index File. The source of this database is the Dept. of Labor, Mine Safety and Health Administration
NCDB: National Compliance Database
RCRA NonGen / NLR: Federal RCRA (Resource Conservation and Recovery Act) Non-Generator / No Longer Regulated
SWF/LF: Solid Waste Facilities and Landfill Sites.
US AIRS: Aerometric Information Retrieval System Facility Subsystem
UST: Listing of Colorado Regulated Underground Storage Tanks

Waste Codes:

Waste Code D001: Ignitable waste
Waste Code D002: Corrosive hazardous waste

Table C-22 Notice of Violations, Raton Basin Retrospective Case Study, Huerfano County, Colorado

LINK Field	API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violation(s)	Violation Details	Corrected	Comment
05506146	05-055-06146	Lively #3-10	Petroglyph Energy, Inc.	16	0	NA	None	NA	
				NA	NA	9/18/2007 12/3/2008 2/16/2010	None - Summary of Complaint Records	NA	9/18/2007: Landowner request for baseline water sampling. Sampling was conducted. 12/3/2008: Continued groundwater issue due to methane in the Poison Canyon Formation. Sampling conducted, similar analytical result to baseline sampling, except for decrease in methane which is most likely due to installation of treatment system. 2/6/2010: Landowner concerned about increased hydrogen sulfide odor in their domestic well. Sampling conducted, similar analytical results to previous sampling.
05506147	05-055-06147	Lively #3-12	Petroglyph Energy, Inc.	13	0	NA	None	NA	
				NA	NA	11/7/2012 4/30/2013	None - Summary of Complaint Records	NA	11/7/2012: Landowner concerned about groundwater quality of domestic well. Samples collected, similar analytical results to previous sampling. 4/30/13: Landowner concerned about possible changes in groundwater quality from the remediation and subsequent closure of the remediation of the Poison Canyon aquifer in the area. Unknown if complaint has been addressed.
05506148	05-055-06148	Lively #10-02	Petroglyph Energy, Inc.	15	1	6/4/1998	Oil spill from machinery on ground. CAR: Fence pits and clean up oil.	NI	
				NA	NA	3/2/2009	None - Summary of Complaint Records	NA	3/2/2009: Landowner concern about changes in groundwater chemistry in domestic well from the previous sampling round. Isotope ratio for carbon and hydrogen in dissolved methane from three recovery wells show variation. Results discussed with landowner.
05506149	05-055-06149	Lively #10-04	Petroglyph Energy, Inc.	16	0	NA	None	NA	
				NA	NA	9/22/2006 10/10/2007 11/10/2007 11/27/2007 3/12/2008 12/2/2008 12/3/2008 12/5/2008 12/18/2008 12/22/2008 8/25/2009 9/7/2010 5/10/2011 9/28/2012 11/7/2012 4/30/2013	None - Summary of Complaint Records	NA	9/22/06, 11/27/2007, 12/5/2008, 9/7/2010, 5/10/2011, 9/28/2012, 4/30/13: Landowner concerned about quality of groundwater. Sampling conducted, results have remained the same or lower. Also one complaint for noise, but monitoring indicated it was within compliance. Unknown if complaint on 4/30/2013 has been addressed. 10/10/2007, 3/12/2008, 12/18/2008, 8/25/2009, 11/7/2012, 4/30/13: Landowner concerned about quality of groundwater. Sampling conducted, results have remained relatively the same over sampling events. Unknown if complaint on 4/30/2013 has been addressed. 11/10/2007, 12/22/2008: Landowner has concern about quality of groundwater. Sampling conducted, results were lower for toluene and similar to previous for other analytes. 12/2/2008, 9/28/2012: Landowner concerned about quality of groundwater. Sampling conducted, groundwater quality is acceptable. 12/3/2008: Landowner concerned about groundwater quality. House currently in construction, sampling conducted, concern for methane upon completion of house.

Table C-22 Notice of Violations, Raton Basin Retrospective Case Study, Huerfano County, Colorado

LINK Field	API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violation(s)	Violation Details	Corrected	Comment
05506150	05-055-06150	Lively #10-12	Petroglyph Energy, Inc.	11	3	Inspection: 6/12/2000, 1/19/2006 NOAV: 6/12/2000	Inspection (6/12/2000): 1. MIT, produce or plug. 2. No hangar for 8 5/8" casing inside 13 3/8" casing. 3. Area to the west of the location unsatisfactorily revegetated. Inspection (1/19/2006): 1. Need to produce, plug or pass MIT. NOAV (6/12/2000): 1. Well shut in longer than 30 days without production equipment. 2. Areas not needed for a production site not satisfactorily revegetated.	Inspections: NI NOAV: Yes	NOAV corrective action: Integrity test witnessed by a representative of the Colorado Oil & Gas Conservation Commission; revegetate site and control weeds.
				NA	NA	1/12/2008	None - Summary of Complaint Records	NA	1/12/2008: Landowner concerned about toluene in groundwater. Sampling conducted, low levels of toluene found.
05506151	05-055-06151	Lively #2-12	Petroglyph Energy, Inc.	17	1	NOAV: 5/1/1998	Commencement of operations w/heavy equipment preparatory to drilling a well without securing an approved application for permit to drill (Form 2).	Yes	NOAV corrective action: Submit a written explanation as to why this location was built without a permit; reclaim and reseed the site if not already done.
05506153	05-055-06153	Lively #35-07	Petroglyph Energy, Inc.	16	1	8/25/2011	1. Pit fenced with barbed wire. 2. Well is scheduled to be plugged. 3. Vgs/Gmr various risers, 4 deadmen (concrete weights).	NI	
05506154	05-055-06154	Lively #35-09	Petroglyph Energy, Inc.	16	0	NA	None	NA	
05506155	05-055-06155	State #36-11	Petroglyph Energy, Inc.	13	0	NA	None	NA	
				NA	NA	10/4/2007 9/7/2010 5/10/2011	None - Summary of Complaint Records	NA	10/4/2007: Landowner requests baseline sampling after well started to vent methane. Sampling conducted. 9/7/2010 and 5/10/2011: Landowner concerned about groundwater quality. Sampling conducted, no further impacts noted and water quality similar to previous sampling round.
05506158	05-055-06158	Lively #03-04	Petroglyph Energy, Inc.	12	0	NA	None	NA	
05506159	05-055-06159	Lively #35-11	Petroglyph Energy, Inc.	2	0	NA	None	NA	
05506160	05-055-06160	Lively #03-01	Petroglyph Energy, Inc.	17	0	NA	None	NA	
				NA	NA	9/15/2006 9/18/2007	None - Summary of Complaint Records	NA	9/15/2006: Landowner had a noise complaint. Noise monitoring conducted, all levels within compliance. 9/18/2007: Landowner requests baseline water sampling. Sampling conducted.
05506161	05-055-06161	State #36-05	Petroglyph Energy, Inc.	13	0	NA	None	NA	
05506165	05-055-06165	Rohr #09-10	Petroglyph Energy, Inc.	12	0	NA	None	NA	
				NA	NA	4/30/2013	None - Summary of Complaint Records	NA	4/30/2013: Landowner concerned about impacts to groundwater. Unknown if complaint was addressed.
05506166	05-055-06166	Rohr #04-10	Petroglyph Energy, Inc.	15	0	NA	None	NA	
				NA	NA	9/16/2009	None - Summary of Complaint Records	NA	9/16/2009: Landowner and others who own River Ridge property are concerned about the groundwater quality. Sampling conducted, fluoride, total dissolved solids, and pH were above the groundwater standards. Methane was above a level which could potentially cause buildup in enclosed spaces. Other analytes were below the groundwater standards.
05506173	05-055-06173	Lively #35-04	Petroglyph Energy, Inc.	1	0	NA	None	NA	
05505012	05-055-05012	Ferdinand B Rohr #1	Pan American Petroleum Corp	1	0	NA	None	NA	
05505027	05-055-05027	Dick Realty & Inv Co. #1	Petroglyph Energy, Inc.	6	0	NA	None	NA	
05506004	05-055-06004	Goemmer Land Co. #1	Clark*E.B. Sr.	1	0	NA	None	NA	
05506023	05-055-06023	Golden Cycle #1	Minerals Management, Inc.	1	0	NA	None	NA	
05506038	05-055-06038	Golden Cycle Land Co. #1	Amoco Production Co.	1	0	NA	None	NA	
05506060	05-055-06060	Stan Searle #1	Alamosa Drilling, Inc.	1	0	NA	None	NA	
05506086	05-055-06086	Lively #03-03	Petroglyph Energy, Inc.	1	0	NA	None	NA	
05506174	05-055-06174	Lively #04-02	Petroglyph Energy, Inc.	1	0	NA	None	NA	
05506176	05-055-06176	Lively #35-11 B	Petroglyph Energy, Inc.	11	0	NA	None	NA	

Table C-22 Notice of Violations, Raton Basin Retrospective Case Study, Huerfano County, Colorado

LINK Field	API Number	Well Name	Operator	Number of Inspections	Number of Violations	Date of Violation(s)	Violation Details	Corrected	Comment
05506179	05-055-06179	State #36-02	Petroglyph Energy, Inc.	11	0	NA	None	NA	
				NA	NA	12/5/2006 8/28/2007 8/7/2009 1/28/2010	None - Summary of Complaint Records	NA	12/5/2006: Landowner concerned about decrease in quantity of water in well. Sampling conducted and potable water being delivered. 8/28/2007, 1/28/2010: Landowner requests baseline sampling due to concern about water quality. Baseline sampling conducted and sampling in 2010 indicated no impacts. 8/7/2009: Landowner requested baseline sampling, sampling conducted.
05506213	05-055-06213	State #1W	Petroglyph Energy, Inc.	2	0	NA	None	NA	
05506214	05-055-06214	State #2W	Petroglyph Energy, Inc.	13	0	NA	None	NA	
				NA	NA	10/28/2006 9/13/2007	None - Summary of Complaint Records	NA	10/28/2006: Landowner concerned with drop in water level of well and methane gas coming from well. Sampling conducted, unknown resolution to drop in water level. 9/13/2007: Landowner concerned about possible presence of methane in water well. Baseline sampling conducted.
05506215	05-055-06215	State #3W	Petroglyph Energy, Inc.	13	0	NA	None	NA	
05506216	05-055-06216	State #4W	Petroglyph Energy, Inc.	14	0	NA	None	NA	
05506217	05-055-06217	State #5W	Petroglyph Energy, Inc.	2	0	NA	None	NA	
05506218	05-055-06218	State #6W	Petroglyph Energy, Inc.	2	0	NA	None	NA	
05506219	05-055-06219	State #7W	Petroglyph Energy, Inc.	11	0	NA	None	NA	
05506220	05-055-06220	State #8W	Petroglyph Energy, Inc.	2	0	NA	None	NA	
05506221	05-055-06221	State #9W	Petroglyph Energy, Inc.	13	0	NA	None	NA	
05506222	05-055-06222	State #10W	Petroglyph Energy, Inc.	2	0	NA	None	NA	
05506223	05-055-06223	State #11W	Petroglyph Energy, Inc.	2	0	NA	None	NA	
05506261	05-055-06261	State #10WB	Petroglyph Energy, Inc.	10	0	NA	None	NA	
05506291	05-055-06291	Rohr #04-14	Petroglyph Energy, Inc.	11	0	NA	None	NA	
				NA	NA	8/29/2011	None - Summary of Remediation Records	NA	8/29/2011: Upon site/facility closure it was determined soils were impacted near a produced water pit at the well site. Background concentrations of arsenic exceeded screening criteria. It was not expected that the produced water stored in the pit communicated with or affected the groundwater. A remediation plan was put into place to reduce the levels of arsenic and the well was being plugged and abandoned.

Source: Colorado Oil and Gas Conservation Commission. Colorado Oil and Gas Information System (COGIS), http://cogcc.state.co.us Accessed February 2014.

Key:
CAR = Corrective Action Request
MIT = Mechanical Integrity Testing
NA = Not applicable
NI = No information available
NOAV = Notice of Alleged Violation

Table C-23 Notable Notice of Violations - Identified Potential Candidate Causes and Distances from Sampling Points
Raton Basin Retrospective Case Study, Huerfano County, Colorado

			EPA Sampling Point		EPA Sampling Point		EPA Sampling Point		EPA Sampling Point	
Well	Latitude	Longitude	ID	Distance (miles)	ID	Distance (miles)	ID	Distance (miles)	ID	Distance (miles)
Lively #10-02	37.543755	-104.874341	RBDW09	0.29 SW	RBDW08	0.49 SW	RBMW05	0.56 NW	RBMW04	0.70 SW

Appendix C Figures

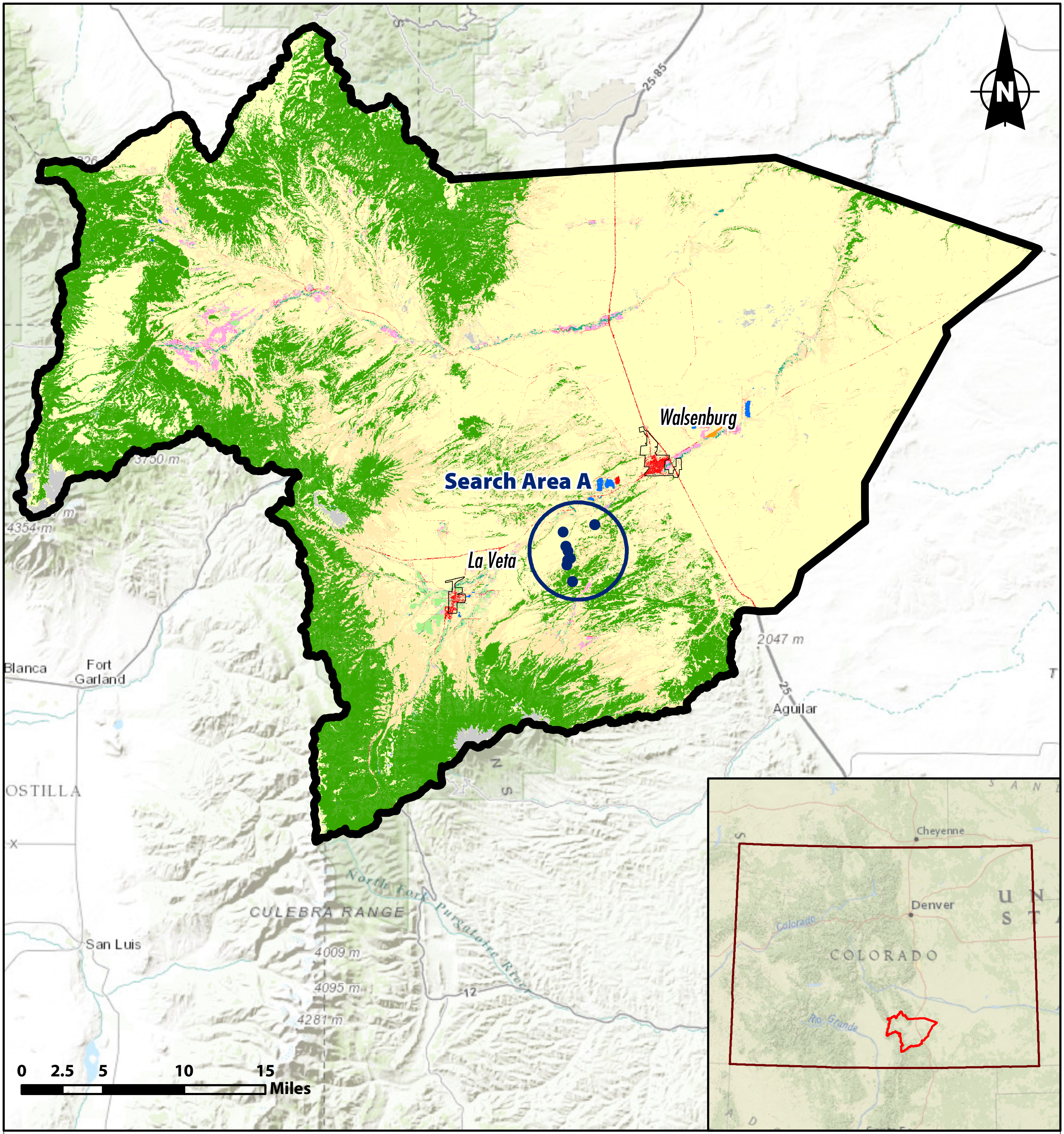


Figure C-1a
2012 Crop Lands
Huerfano County, Colorado

EPA Hydraulic Fracturing Study

Source: *Land Use, USDA; Municipalities, ESRI; Sample Locations, EPA ORD*

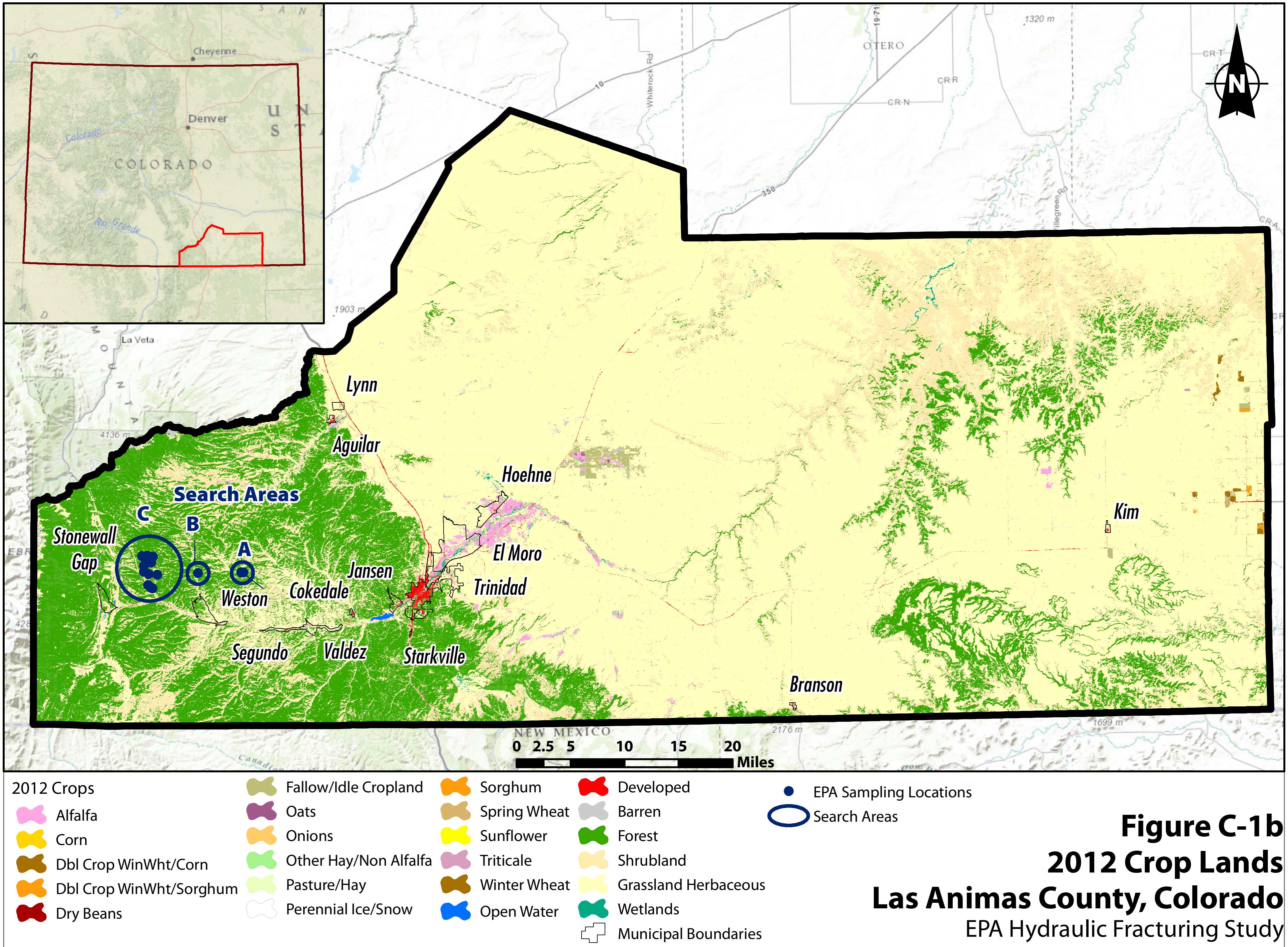


Figure C-1b
2012 Crop Lands
Las Animas County, Colorado
EPA Hydraulic Fracturing Study

Source: *Land Use, USDA; Municipalities, ESRI; Sample Locations, EPA ORD*

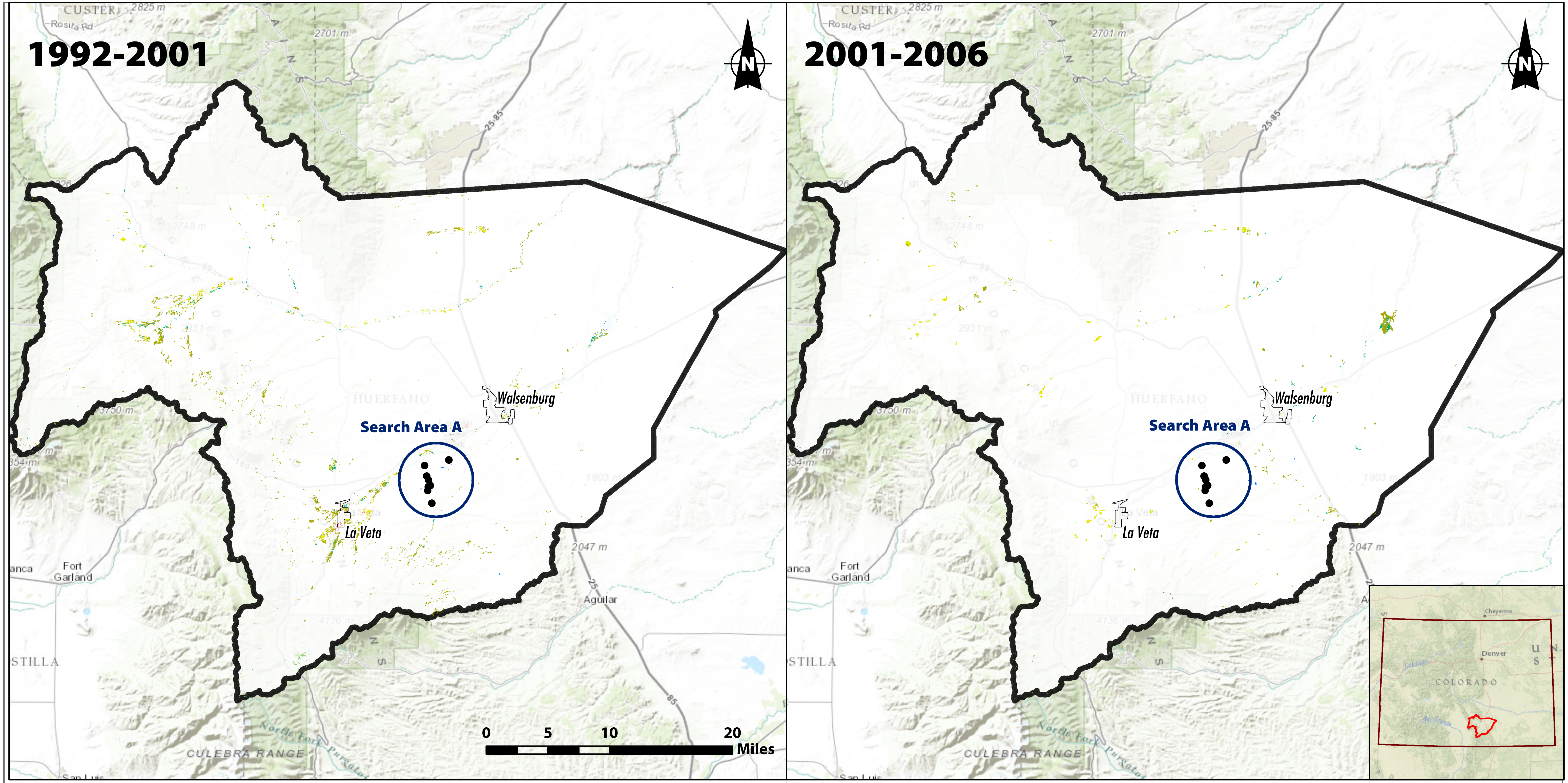


Figure C-2a
Land Use Changes
1992-2001 and 2001-2006
Huerfano County, Colorado

EPA Hydraulic Fracturing Study

Source: *Landuse, USGS National Land Cover Database (1992,2006); Municipalities, ESRI; Sampling Locations, US EPA ORD*

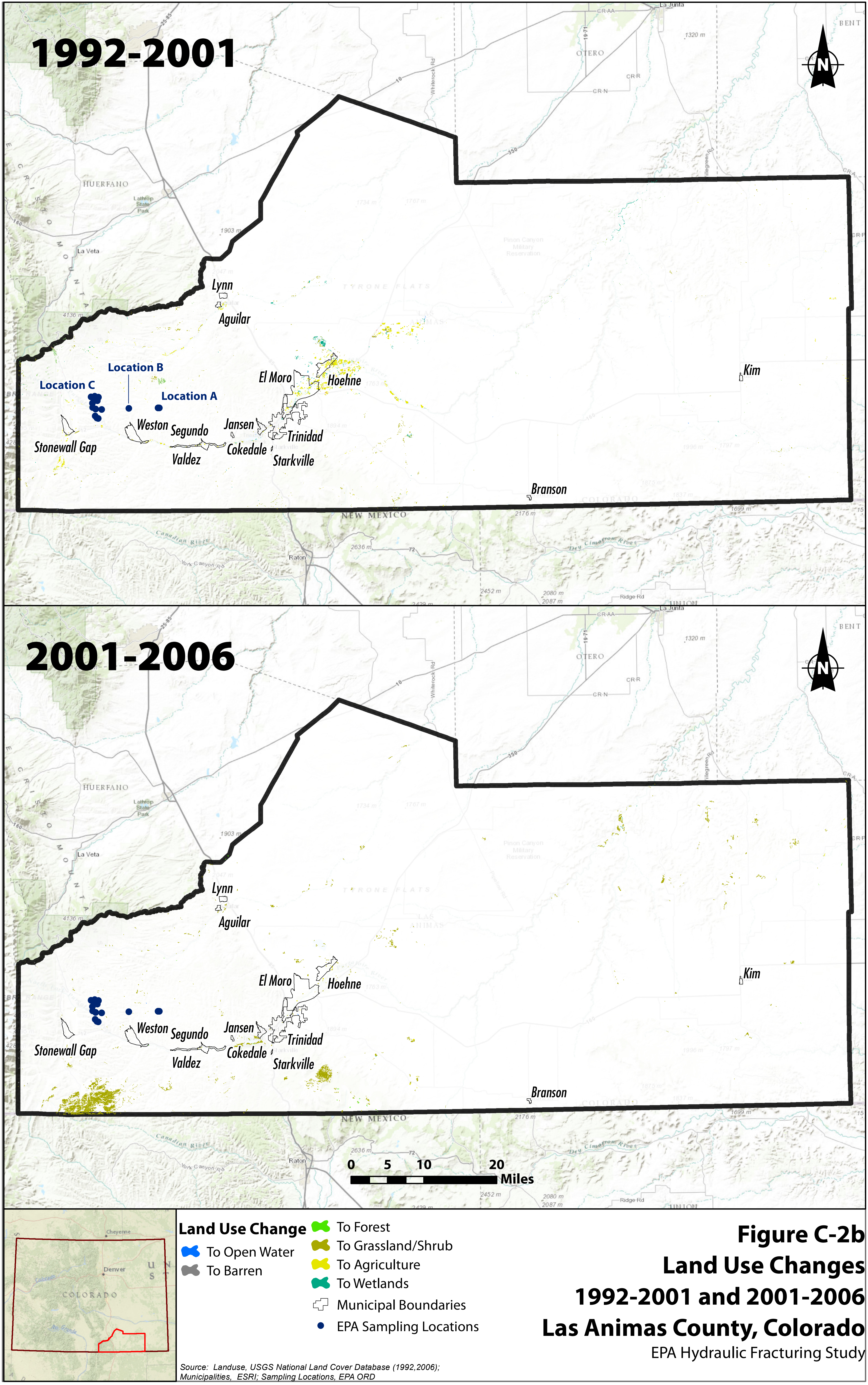


Figure C-2b
Land Use Changes
1992-2001 and 2001-2006
Las Animas County, Colorado

EPA Hydraulic Fracturing Study

Source: Landuse, USGS National Land Cover Database (1992,2006); Municipalities, ESRI; Sampling Locations, EPA ORD

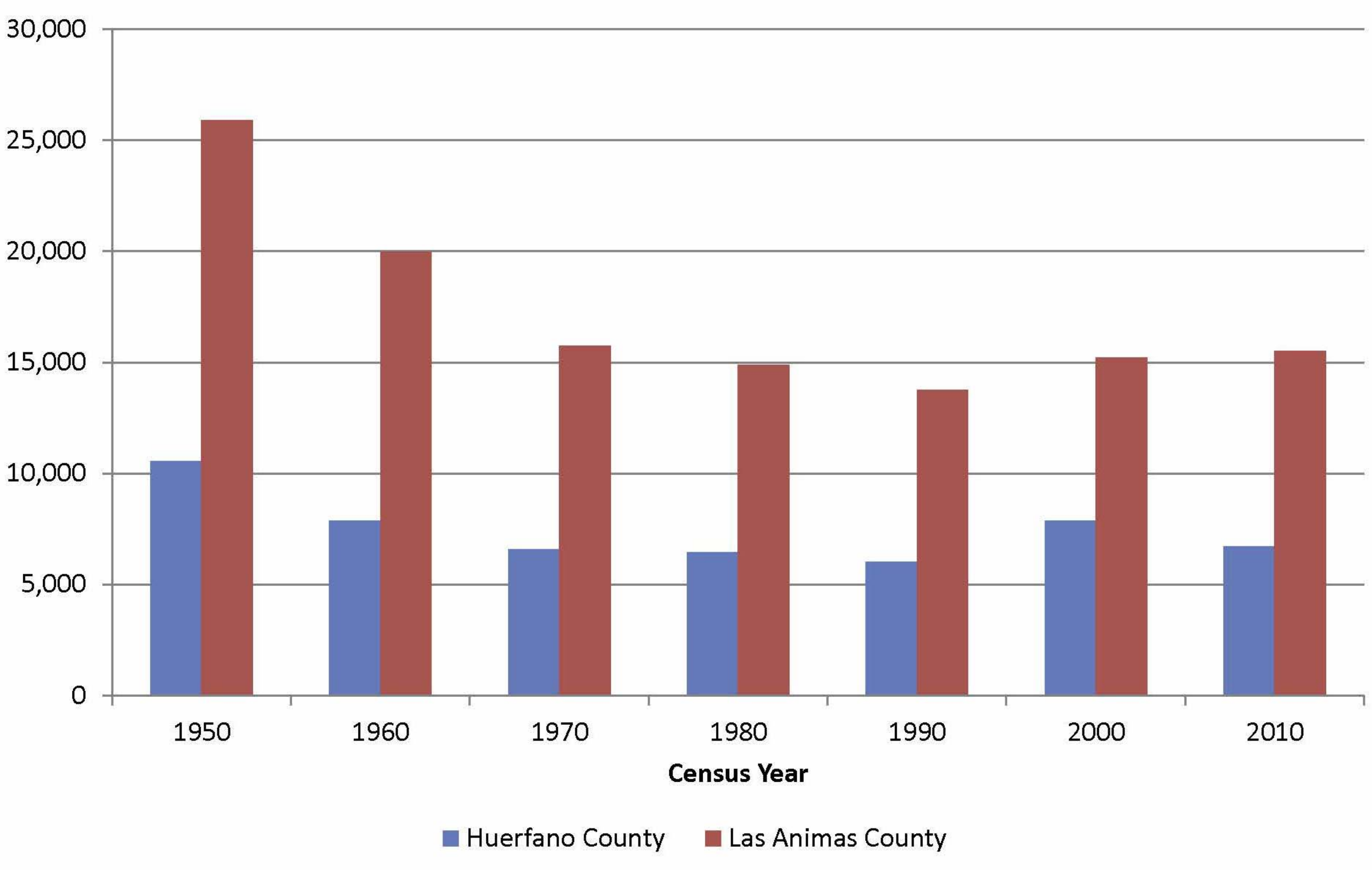
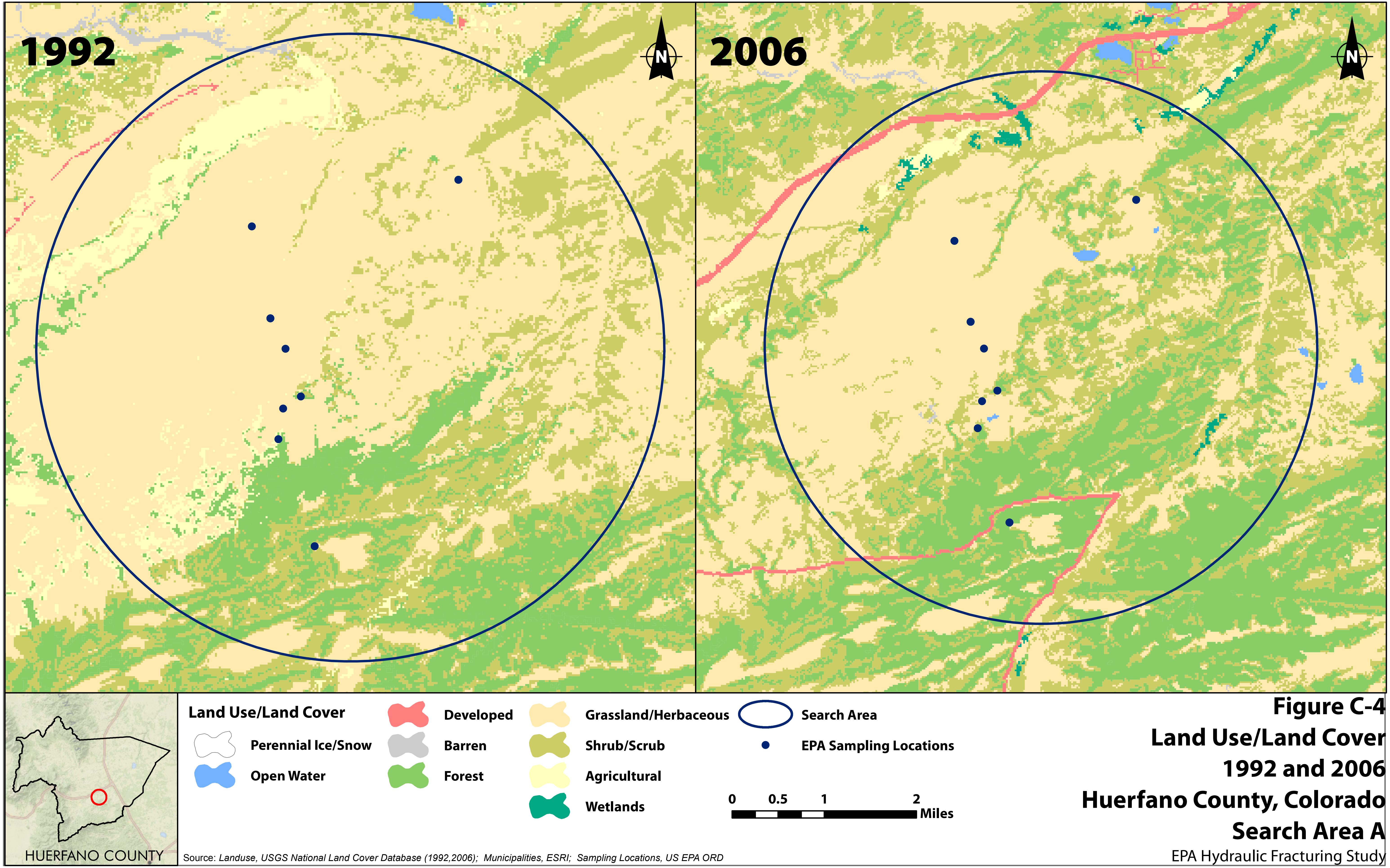
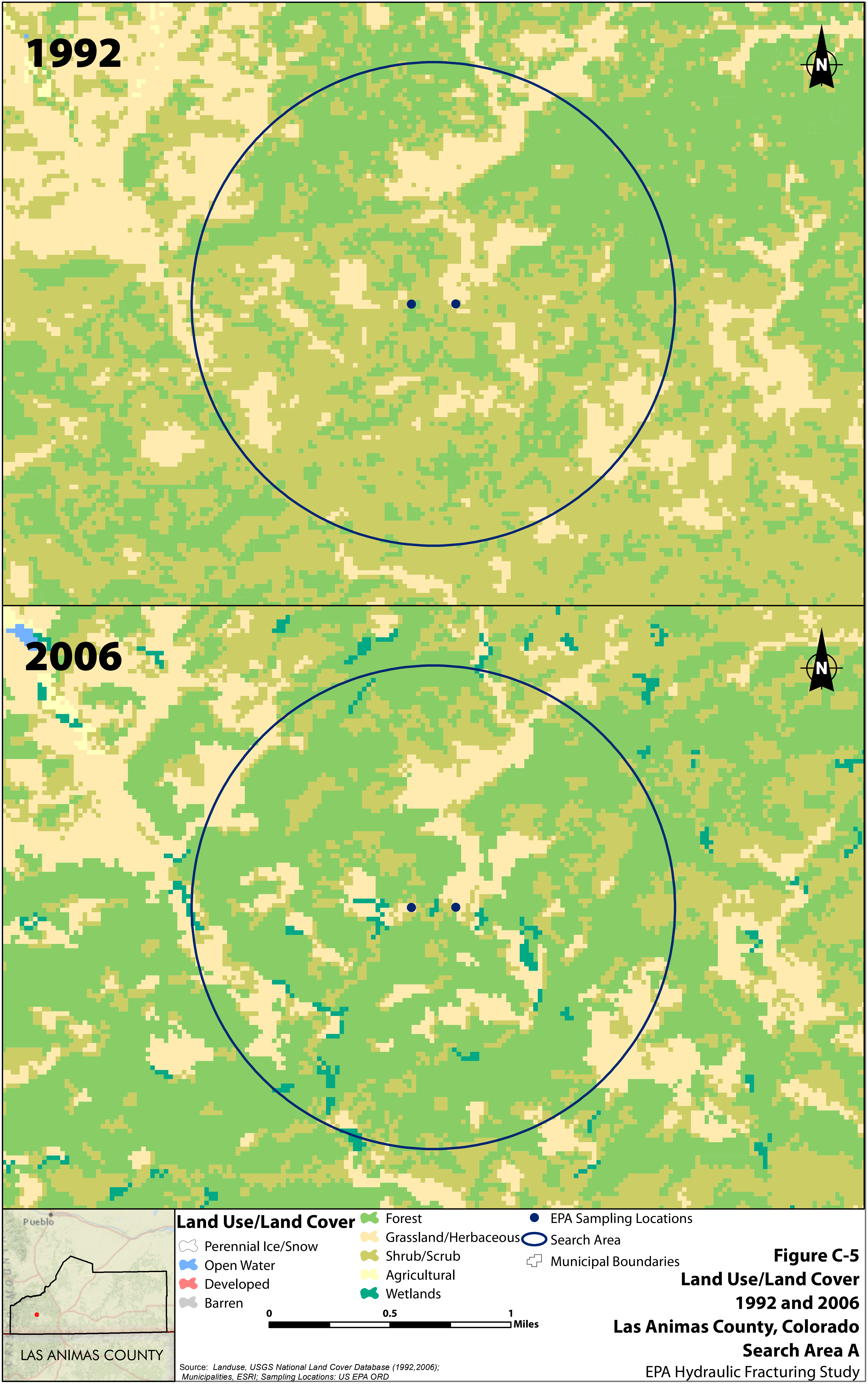


Figure C3 Population in Huerfano and Las Animas Counties, Colorado, 1950-2010



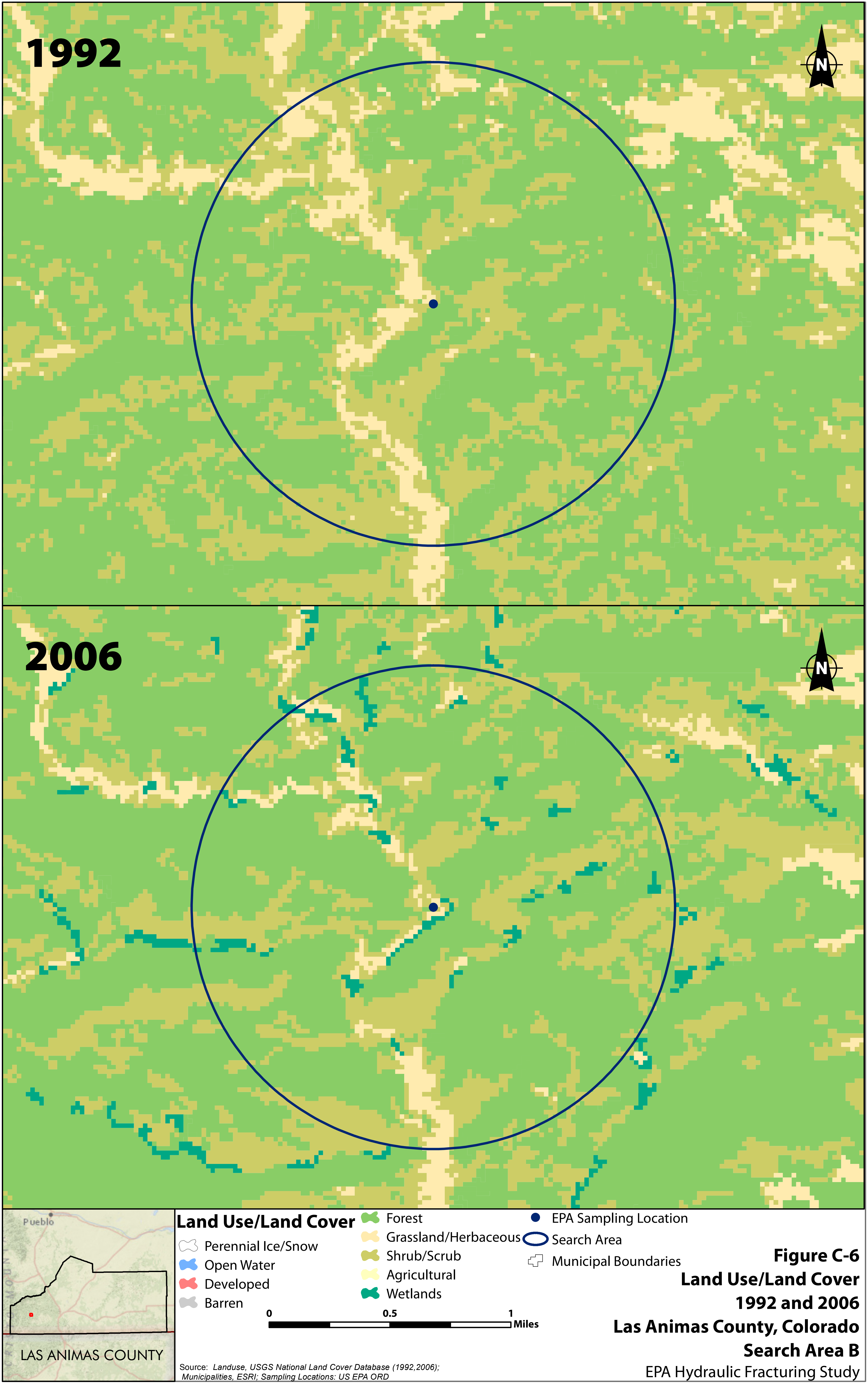
Source: *Landuse, USGS National Land Cover Database (1992,2006); Municipalities, ESRI; Sampling Locations, US EPA ORD*

Figure C-4
Land Use/Land Cover
1992 and 2006
Huerfano County, Colorado
Search Area A
EPA Hydraulic Fracturing Study



Source: *Landuse, USGS National Land Cover Database (1992,2006); Municipalities, ESRI; Sampling Locations: US EPA ORD*

Figure C-5
Land Use/Land Cover
1992 and 2006
Las Animas County, Colorado
Search Area A
EPA Hydraulic Fracturing Study



Source: *Landuse, USGS National Land Cover Database (1992,2006); Municipalities, ESRI; Sampling Locations: US EPA ORD*

Figure C-6
Land Use/Land Cover
1992 and 2006
Las Animas County, Colorado
Search Area B
EPA Hydraulic Fracturing Study

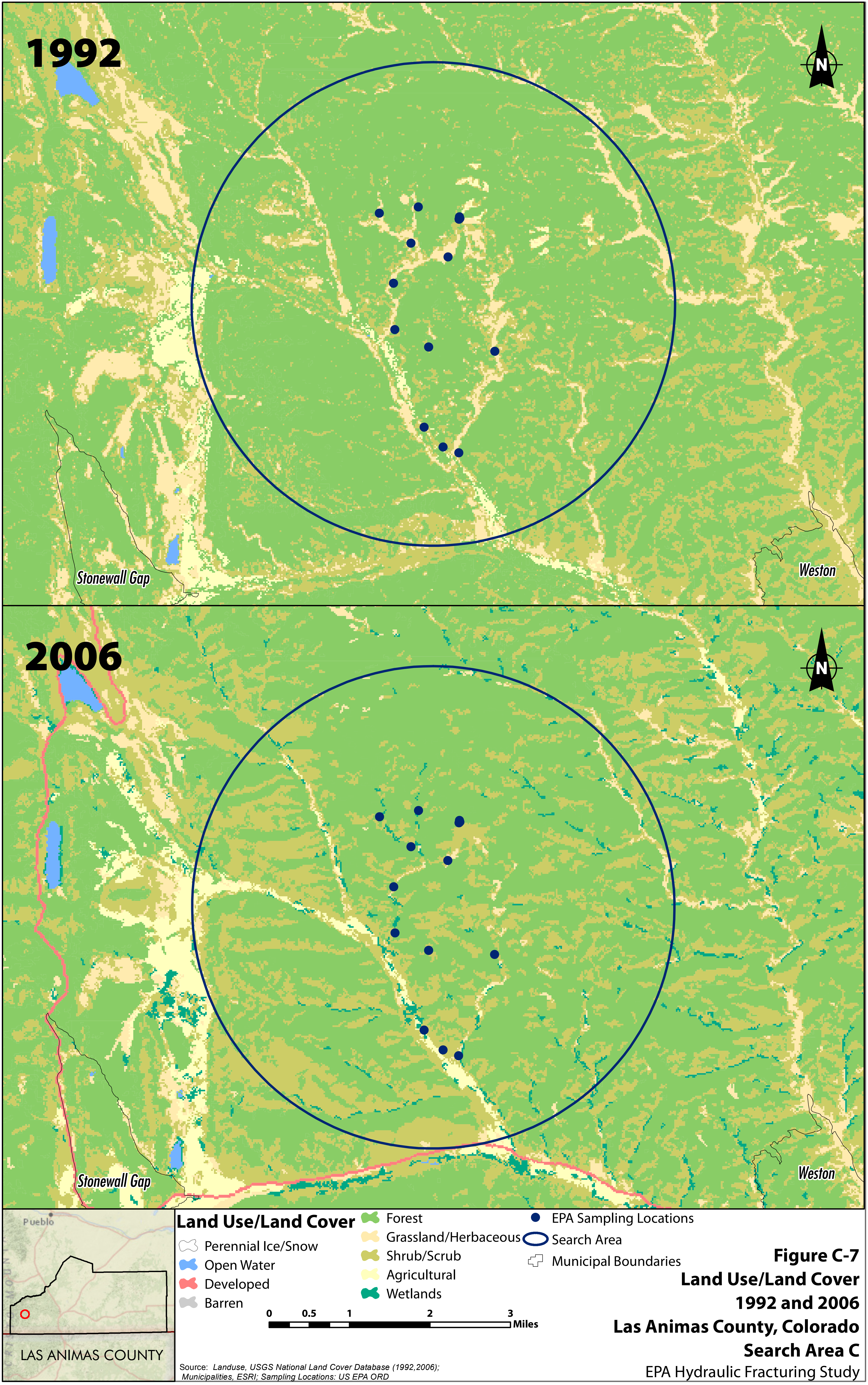
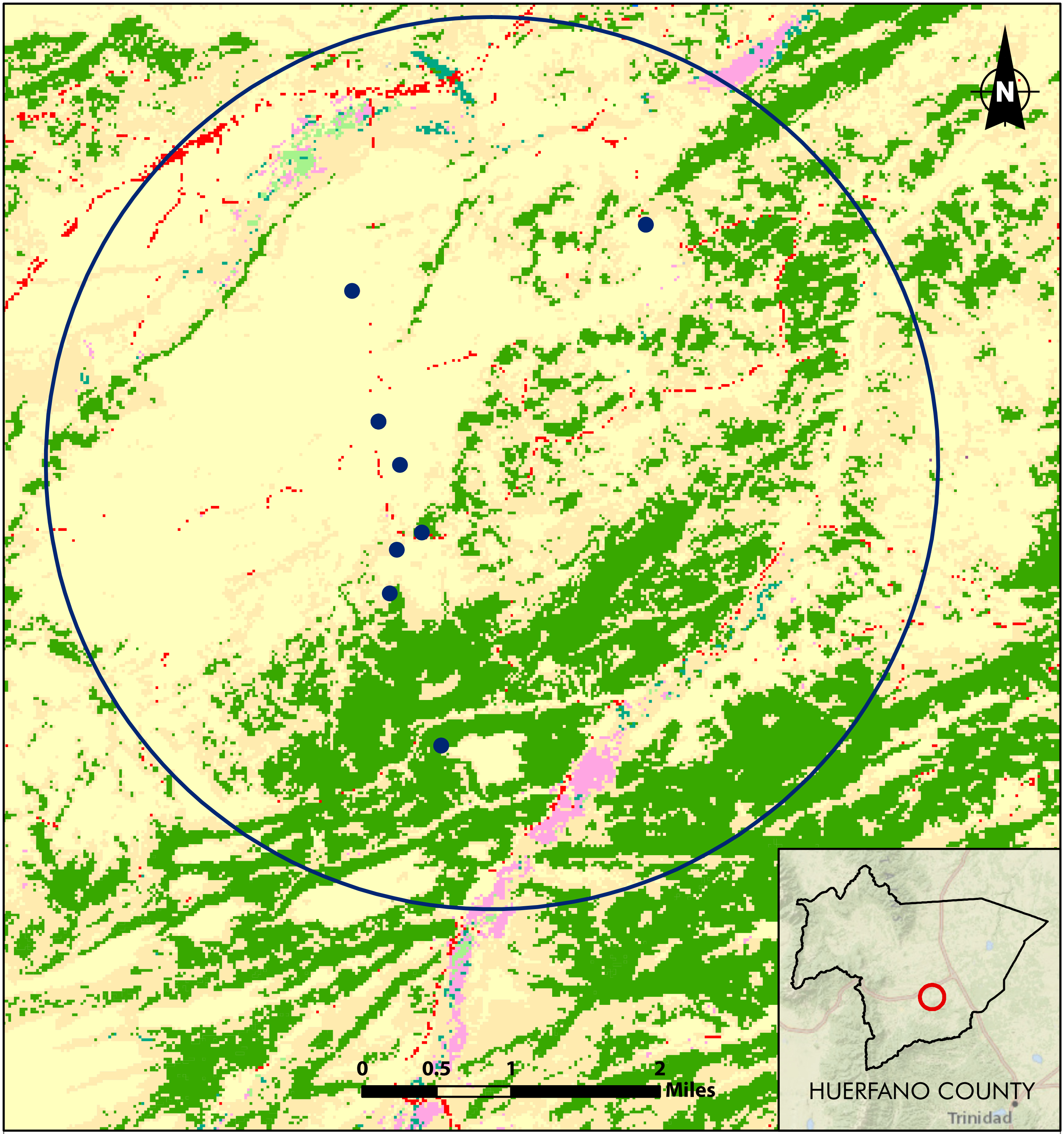


Figure C-7
Land Use/Land Cover
1992 and 2006
Las Animas County, Colorado
Search Area C
EPA Hydraulic Fracturing Study

Source: *Landuse, USGS National Land Cover Database (1992,2006); Municipalities, ESRI; Sampling Locations: US EPA ORD*



2012 Crops

- Alfalfa
- Fallow/Idle Cropland
- Oats
- Other Hay/Non Alfalfa
- Open Water
- Developed
- Barren
- Forest
- Shrubland
- Grassland Herbaceous
- Wetlands
- Search Area
- ● EPA Sampling Locations

Figure C-8
2012 Crop Lands
Huerfano County, Colorado
Search Area A

EPA Hydraulic Fracturing Study

Source: *Land Use, USDA; Municipalities, ESRI; Sample Locations, EPA ORD*

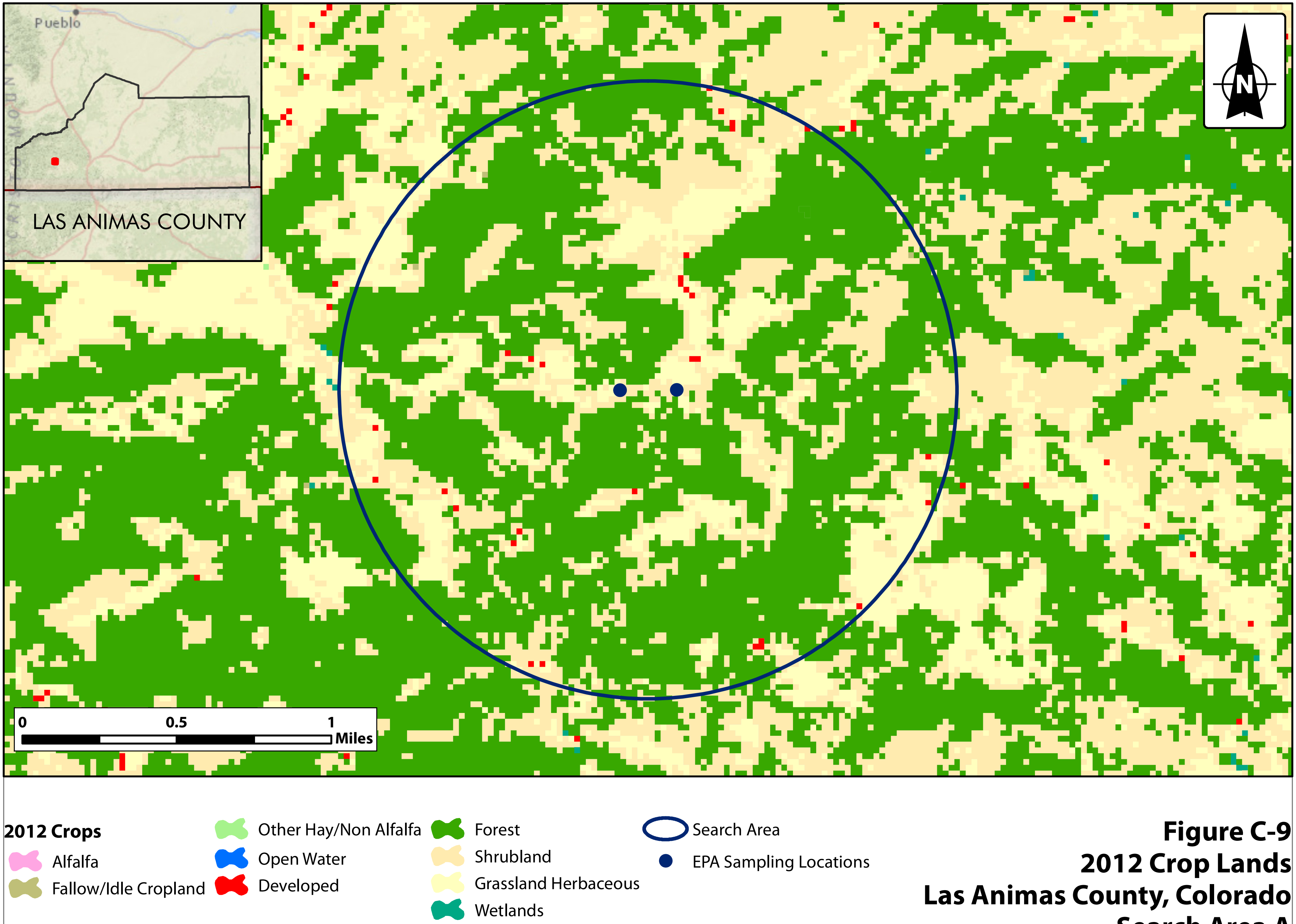
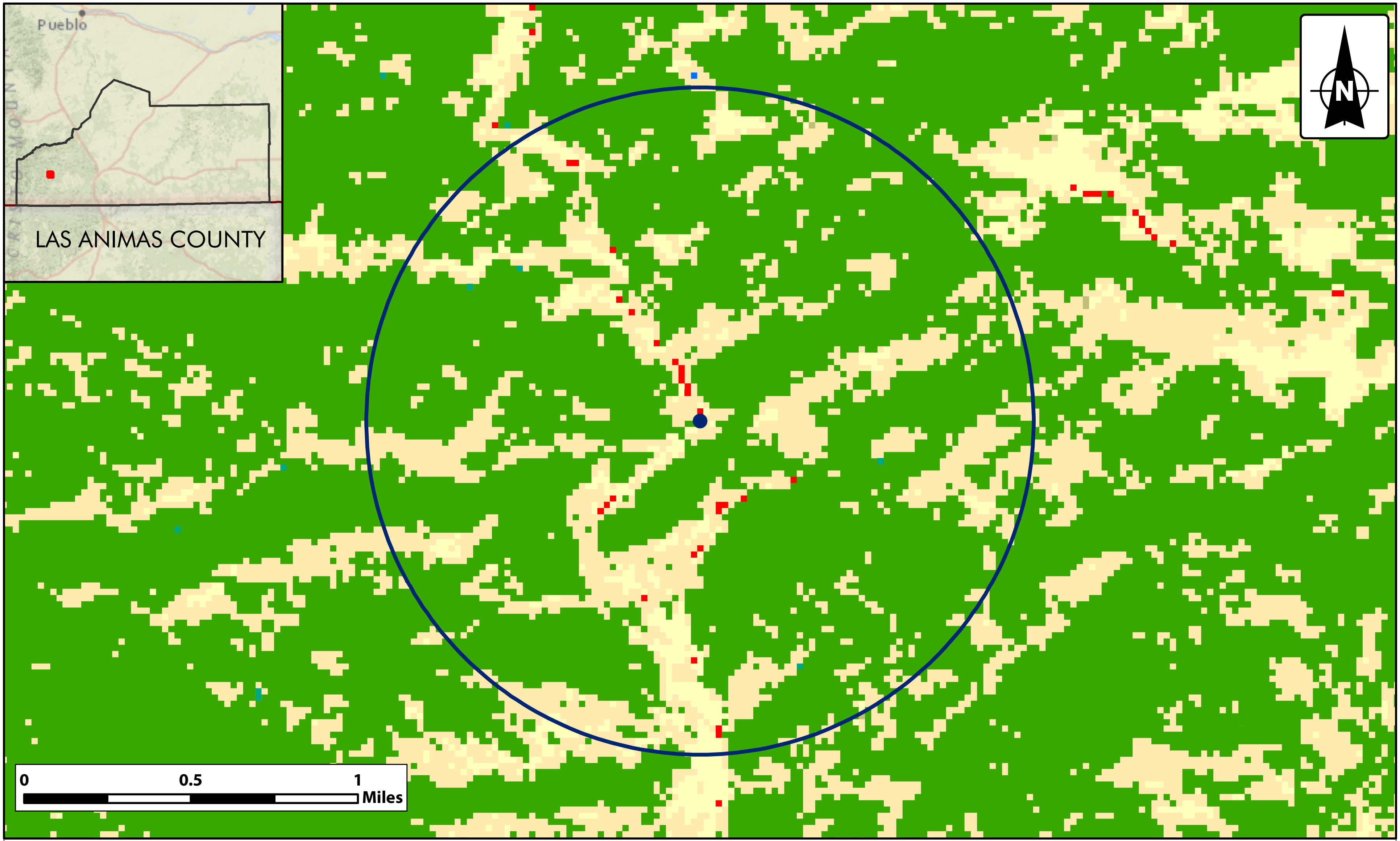


Figure C-9
2012 Crop Lands
Las Animas County, Colorado
Search Area A
EPA Hydraulic Fracturing Study

Source: *Land Use, USDA; Municipalities, ESRI; Sample Locations, EPA ORD*

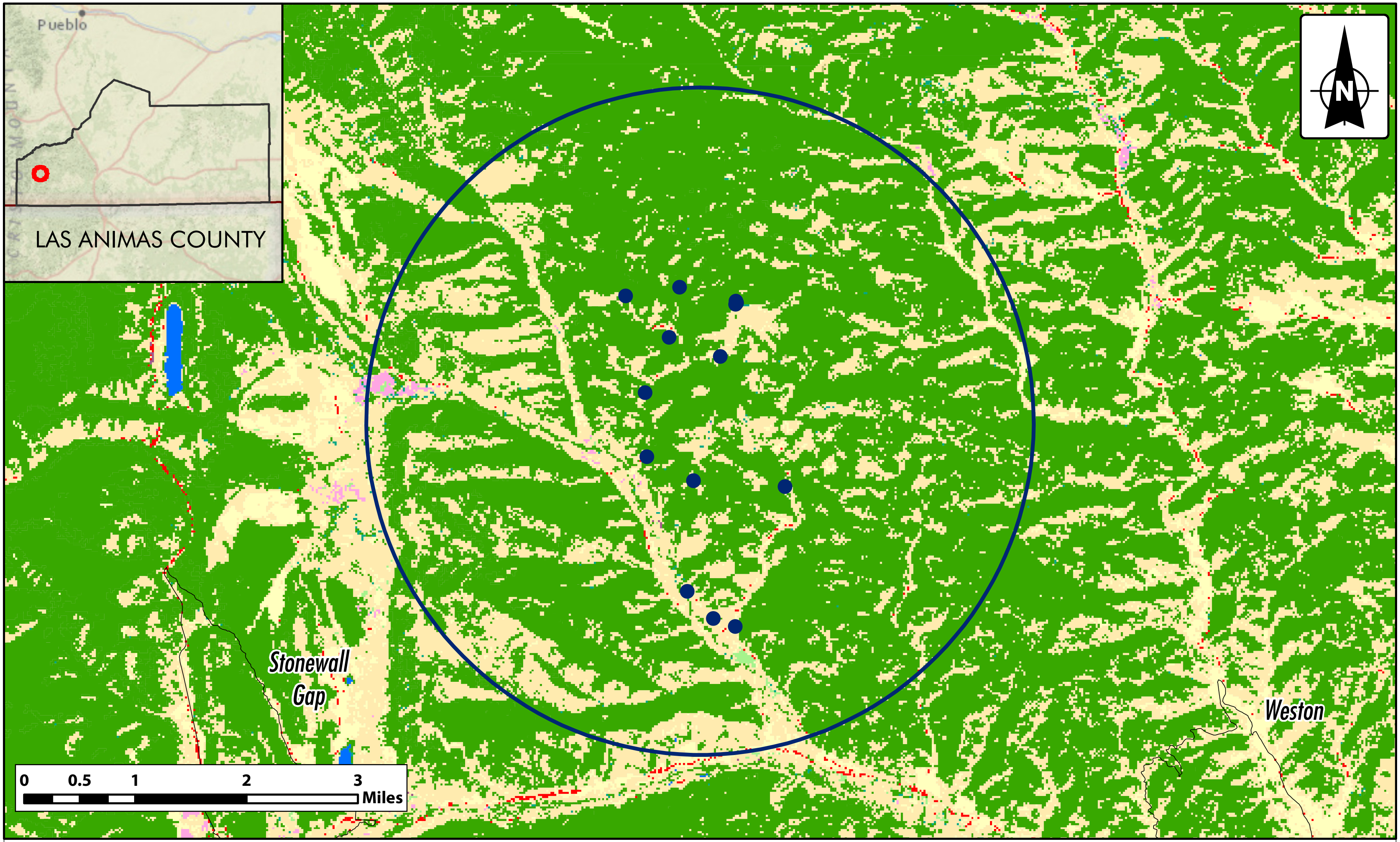


2012 Crops

- 🟫 Fallow/Idle Cropland
- 🟦 Open Water
- 🟥 Developed
- 🟩 Forest
- 🟨 Shrubland
- 🟨 Grassland Herbaceous
- 🟩 Wetlands
- ○ Search Area
- ● EPA Sampling Location

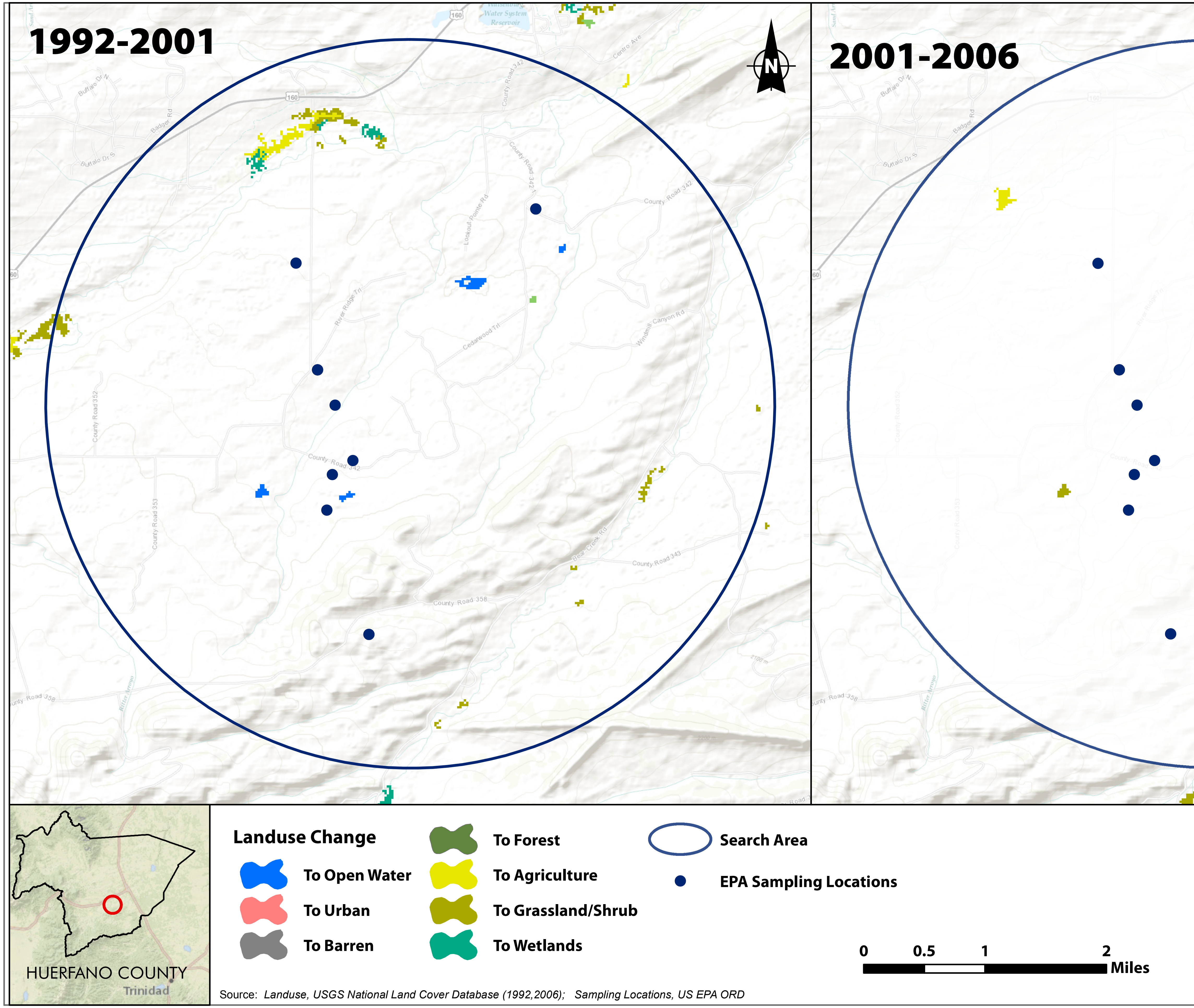
Figure C-10
2012 Crop Lands
Las Animas County, Colorado
Search Area B
EPA Hydraulic Fracturing Study

Source: *Land Use, USDA; Municipalities, ESRI; Sample Locations, EPA ORD*



Source: *Land Use, USDA; Municipalities, ESRI; Sample Locations, EPA ORD*

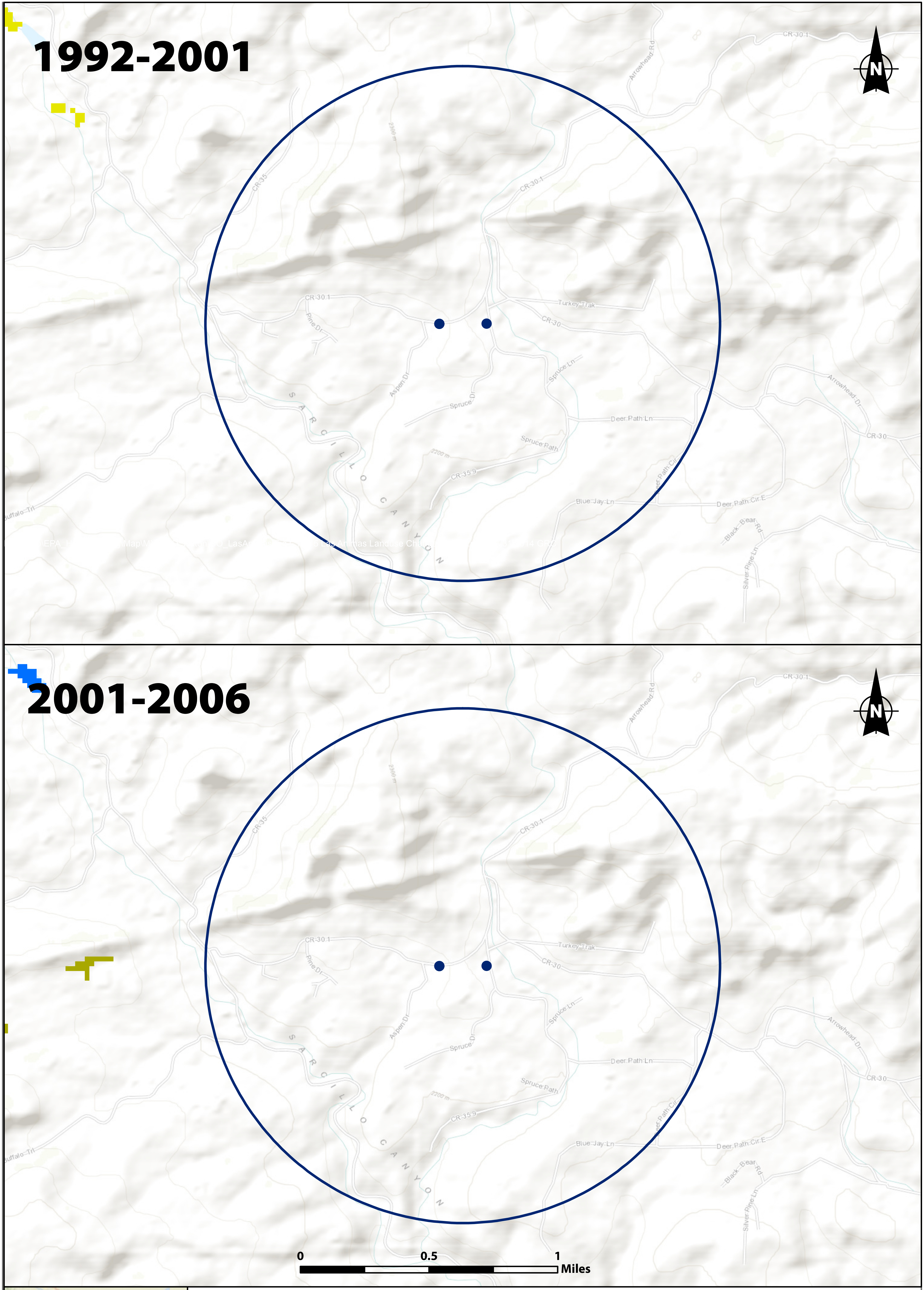
Figure C-11
2012 Crop Lands
Las Animas County, Colorado
Search Area C
EPA Hydraulic Fracturing Study

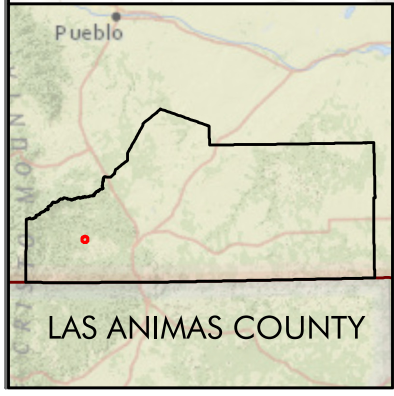


Source: *Landuse, USGS National Land Cover Database (1992,2006); Sampling Locations, US EPA ORD*

Figure C-12
Land Use Changes
1992-2001 and 2001-2006
Huerfano County, Colorado
Search Area A

EPA Hydraulic Fracturing Study





Land Use Change

- To Open Water
- To Barren
- To Forest
- To Grassland/Shrub
- To Agriculture
- To Wetlands
- ● EPA Sampling Locations
- ○ Search Area

Figure C-13
Land Use Changes
1992-2001 and 2001-2006
Las Animas County, Colorado
Search Area A

EPA Hydraulic Fracturing Study

Source: *Landuse, USGS National Land Cover Database (1992,2006); Sampling Locations, US EPA ORD*

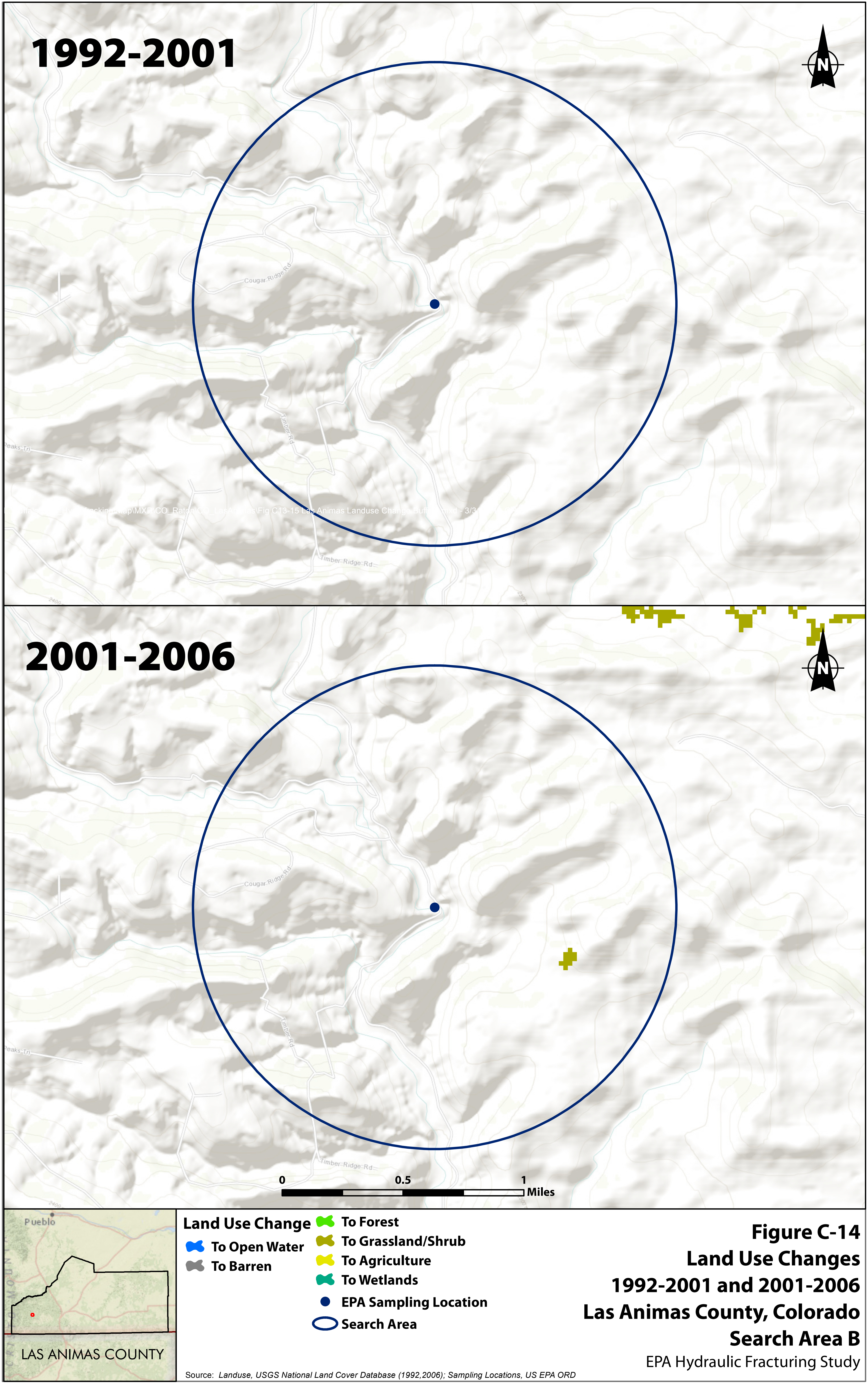


Figure C-14
Land Use Changes
1992-2001 and 2001-2006
Las Animas County, Colorado
Search Area B
EPA Hydraulic Fracturing Study

Source: *Landuse, USGS National Land Cover Database (1992,2006); Sampling Locations, US EPA ORD*

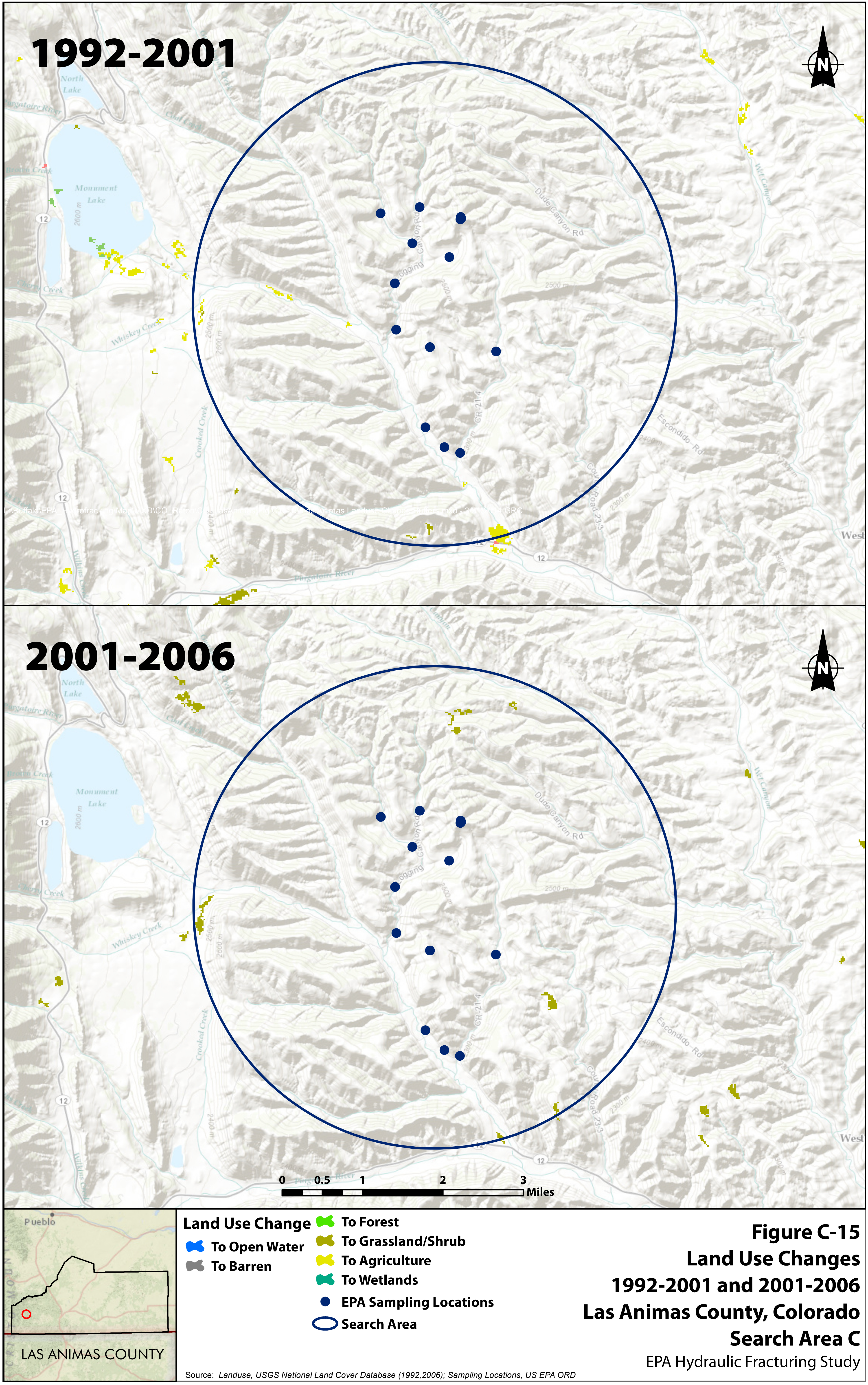
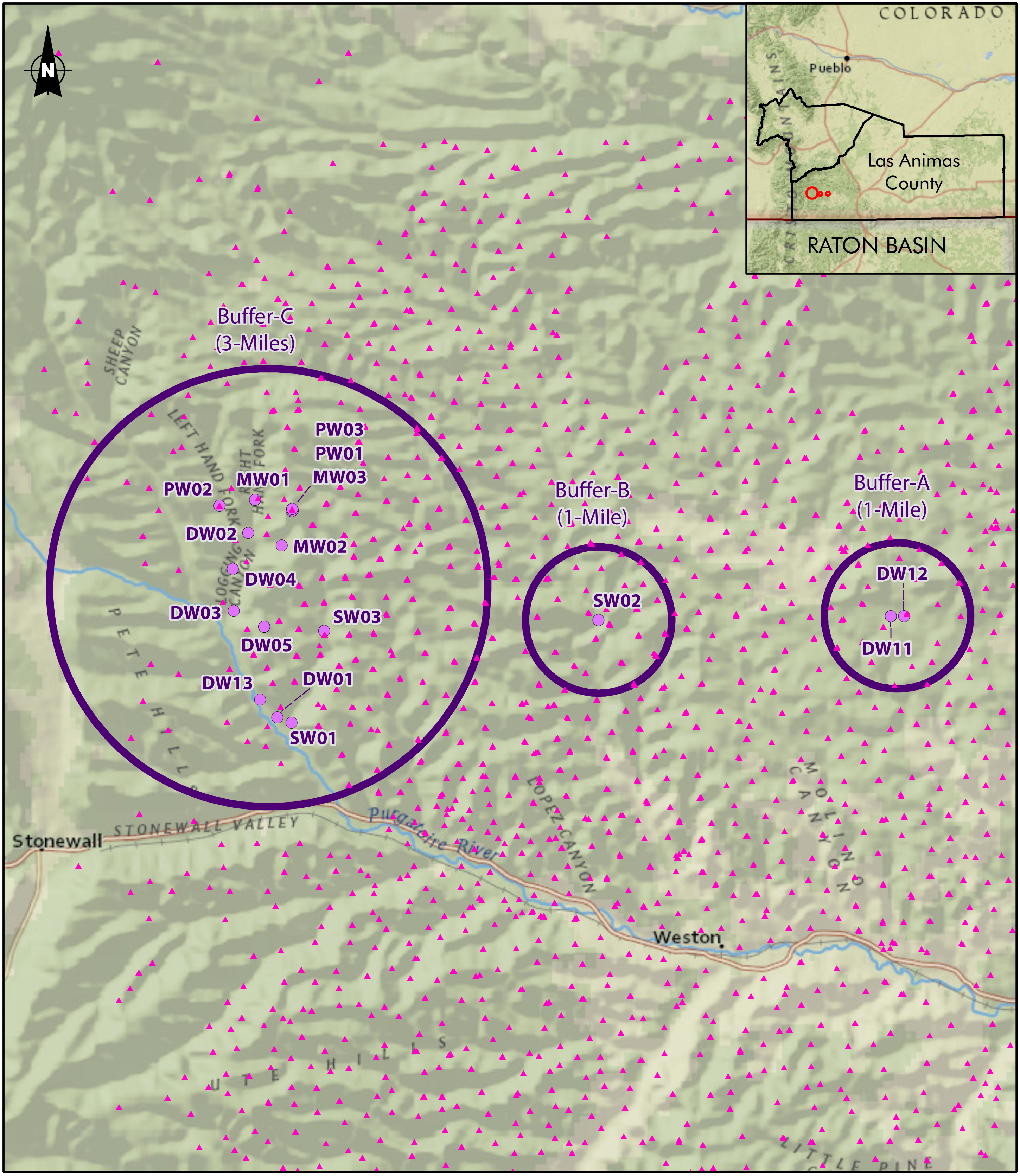


Figure C-15
Land Use Changes
1992-2001 and 2001-2006
Las Animas County, Colorado
Search Area C
EPA Hydraulic Fracturing Study

Source: *Landuse, USGS National Land Cover Database (1992,2006); Sampling Locations, US EPA ORD*



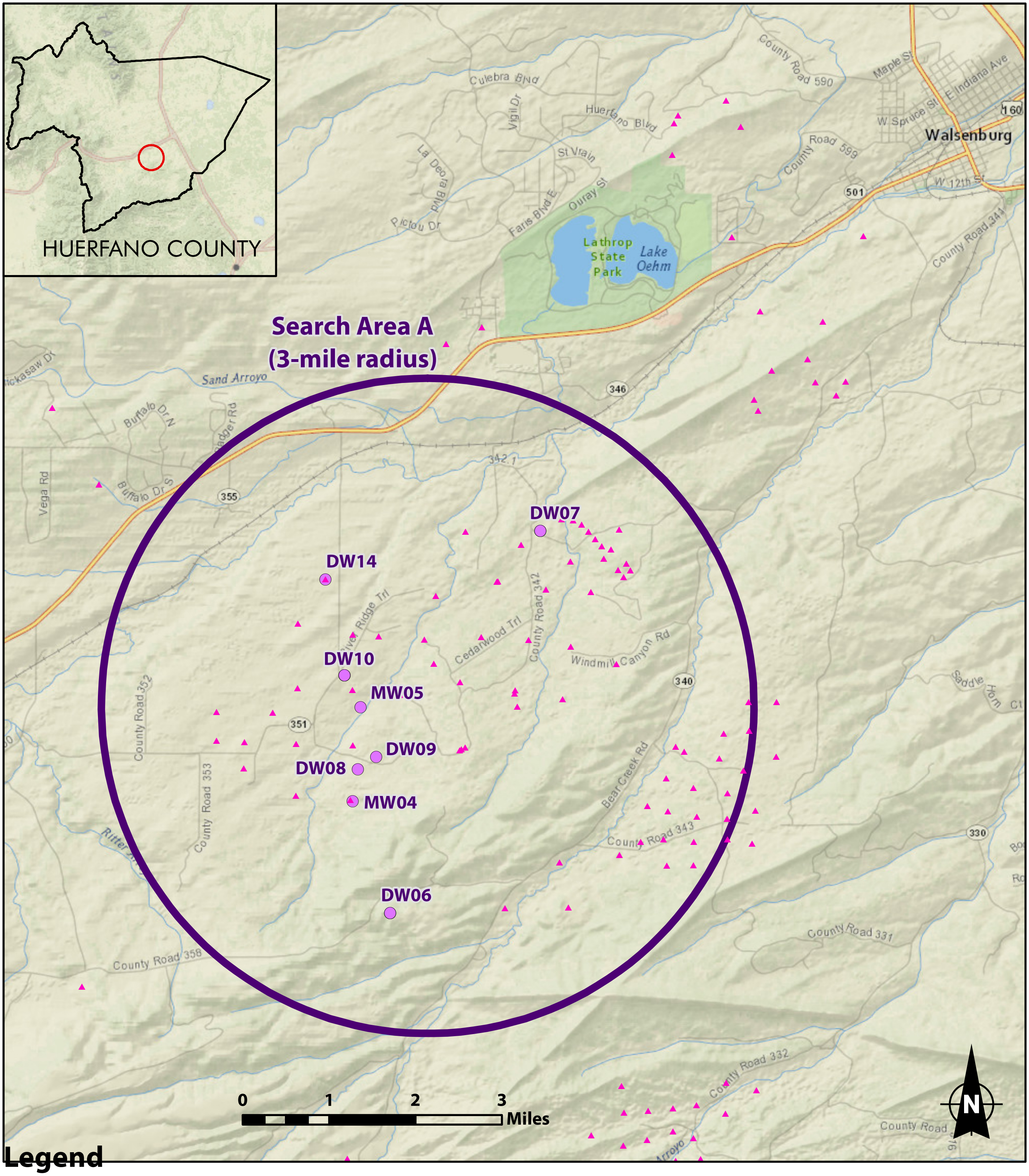
Sources- Imagery: ESRI, Wells and Samples: EPA ORD

Legend

▲ Oil & Gas Wells (COGCC)
○ Sampling Buffers
● Sampling Locations

0 1 2 3 Miles

Figure C16
Sample Location Map
Las Animas County, Colorado
EPA Hydraulic Fracturing Study



Legend

▲ CBM Wells (COGCC)

● EPA Sampling Locations

○ Search Area

Figure C-17
Sampling Location Map
Huerfano County, Colorado

EPA Hydraulic Fracturing Study

Sources: *Imagery, ESRI; Wells and Samples, EPA ORD, Colorado COGCC*

Attachment 1 EDR Records Search

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

To maintain currency of the following federal and state databases, EDR contacts the appropriate governmental agency on a monthly or quarterly basis, as required.

Number of Days to Update: Provides confirmation that EDR is reporting records that have been updated within 90 days from the date the government agency made the information available to the public.

STANDARD ENVIRONMENTAL RECORDS

Federal NPL site list

NPL: National Priority List

National Priorities List (Superfund). The NPL is a subset of CERCLIS and identifies over 1,200 sites for priority cleanup under the Superfund Program. NPL sites may encompass relatively large areas. As such, EDR provides polygon coverage for over 1,000 NPL site boundaries produced by EPA's Environmental Photographic Interpretation Center (EPIC) and regional EPA offices.

Date of Government Version: 02/01/2013	Source: EPA
Date Data Arrived at EDR: 03/01/2013	Telephone: N/A
Date Made Active in Reports: 03/13/2013	Last EDR Contact: 05/09/2013
Number of Days to Update: 12	Next Scheduled EDR Contact: 07/22/2013
	Data Release Frequency: Quarterly

NPL Site Boundaries

Sources:

EPA's Environmental Photographic Interpretation Center (EPIC)
Telephone: 202-564-7333

EPA Region 1 Telephone 617-918-1143	EPA Region 6 Telephone: 214-655-6659
EPA Region 3 Telephone 215-814-5418	EPA Region 7 Telephone: 913-551-7247
EPA Region 4 Telephone 404-562-8033	EPA Region 8 Telephone: 303-312-6774
EPA Region 5 Telephone 312-886-6686	EPA Region 9 Telephone: 415-947-4246
EPA Region 10 Telephone 206-553-8665	

Proposed NPL: Proposed National Priority List Sites

A site that has been proposed for listing on the National Priorities List through the issuance of a proposed rule in the Federal Register. EPA then accepts public comments on the site, responds to the comments, and places on the NPL those sites that continue to meet the requirements for listing.

Date of Government Version: 02/01/2013	Source: EPA
Date Data Arrived at EDR: 03/01/2013	Telephone: N/A
Date Made Active in Reports: 03/13/2013	Last EDR Contact: 05/09/2013
Number of Days to Update: 12	Next Scheduled EDR Contact: 07/22/2013
	Data Release Frequency: Quarterly

NPL LIENS: Federal Superfund Liens

Federal Superfund Liens. Under the authority granted the USEPA by CERCLA of 1980, the USEPA has the authority to file liens against real property in order to recover remedial action expenditures or when the property owner received notification of potential liability. USEPA compiles a listing of filed notices of Superfund Liens.

Date of Government Version: 10/15/1991	Source: EPA
Date Data Arrived at EDR: 02/02/1994	Telephone: 202-564-4267
Date Made Active in Reports: 03/30/1994	Last EDR Contact: 08/15/2011
Number of Days to Update: 56	Next Scheduled EDR Contact: 11/28/2011
	Data Release Frequency: No Update Planned

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

Federal Delisted NPL site list

DELISTED NPL: National Priority List Deletions

The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) establishes the criteria that the EPA uses to delete sites from the NPL. In accordance with 40 CFR 300.425.(e), sites may be deleted from the NPL where no further response is appropriate.

Date of Government Version: 02/01/2013	Source: EPA
Date Data Arrived at EDR: 03/01/2013	Telephone: N/A
Date Made Active in Reports: 03/13/2013	Last EDR Contact: 05/09/2013
Number of Days to Update: 12	Next Scheduled EDR Contact: 07/22/2013
	Data Release Frequency: Quarterly

Federal CERCLIS list

CERCLIS: Comprehensive Environmental Response, Compensation, and Liability Information System

CERCLIS contains data on potentially hazardous waste sites that have been reported to the USEPA by states, municipalities, private companies and private persons, pursuant to Section 103 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). CERCLIS contains sites which are either proposed to or on the National Priorities List (NPL) and sites which are in the screening and assessment phase for possible inclusion on the NPL.

Date of Government Version: 02/04/2013	Source: EPA
Date Data Arrived at EDR: 03/01/2013	Telephone: 703-412-9810
Date Made Active in Reports: 03/13/2013	Last EDR Contact: 04/05/2013
Number of Days to Update: 12	Next Scheduled EDR Contact: 06/10/2013
	Data Release Frequency: Quarterly

FEDERAL FACILITY: Federal Facility Site Information listing

A listing of National Priority List (NPL) and Base Realignment and Closure (BRAC) sites found in the Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) Database where EPA Federal Facilities Restoration and Reuse Office is involved in cleanup activities.

Date of Government Version: 07/31/2012	Source: Environmental Protection Agency
Date Data Arrived at EDR: 10/09/2012	Telephone: 703-603-8704
Date Made Active in Reports: 12/20/2012	Last EDR Contact: 04/10/2013
Number of Days to Update: 72	Next Scheduled EDR Contact: 07/22/2013
	Data Release Frequency: Varies

Federal CERCLIS NFRAP site List

CERCLIS-NFRAP: CERCLIS No Further Remedial Action Planned

Archived sites are sites that have been removed and archived from the inventory of CERCLIS sites. Archived status indicates that, to the best of EPA's knowledge, assessment at a site has been completed and that EPA has determined no further steps will be taken to list this site on the National Priorities List (NPL), unless information indicates this decision was not appropriate or other considerations require a recommendation for listing at a later time. This decision does not necessarily mean that there is no hazard associated with a given site; it only means that, based upon available information, the location is not judged to be a potential NPL site.

Date of Government Version: 02/05/2013	Source: EPA
Date Data Arrived at EDR: 03/01/2013	Telephone: 703-412-9810
Date Made Active in Reports: 03/13/2013	Last EDR Contact: 04/05/2013
Number of Days to Update: 12	Next Scheduled EDR Contact: 03/11/2013
	Data Release Frequency: Quarterly

Federal RCRA CORRACTS facilities list

CORRACTS: Corrective Action Report

CORRACTS identifies hazardous waste handlers with RCRA corrective action activity.

Date of Government Version: 02/12/2013	Source: EPA
Date Data Arrived at EDR: 02/21/2013	Telephone: 800-424-9346
Date Made Active in Reports: 02/27/2013	Last EDR Contact: 05/02/2013
Number of Days to Update: 6	Next Scheduled EDR Contact: 07/15/2013
	Data Release Frequency: Quarterly

Federal RCRA non-CORRACTS TSD facilities list

RCRA-TSDF: RCRA - Treatment, Storage and Disposal

RCRAInfo is EPA’s comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Transporters are individuals or entities that move hazardous waste from the generator offsite to a facility that can recycle, treat, store, or dispose of the waste. TSDFs treat, store, or dispose of the waste.

Date of Government Version: 02/12/2013	Source: Environmental Protection Agency
Date Data Arrived at EDR: 02/15/2013	Telephone: 800-438-2474
Date Made Active in Reports: 02/27/2013	Last EDR Contact: 05/02/2013
Number of Days to Update: 12	Next Scheduled EDR Contact: 07/15/2013
	Data Release Frequency: Quarterly

Federal RCRA generators list

RCRA-LQG: RCRA - Large Quantity Generators

RCRAInfo is EPA’s comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Large quantity generators (LQGs) generate over 1,000 kilograms (kg) of hazardous waste, or over 1 kg of acutely hazardous waste per month.

Date of Government Version: 02/12/2013	Source: Environmental Protection Agency
Date Data Arrived at EDR: 02/15/2013	Telephone: 800-438-2474
Date Made Active in Reports: 02/27/2013	Last EDR Contact: 05/02/2013
Number of Days to Update: 12	Next Scheduled EDR Contact: 07/15/2013
	Data Release Frequency: Quarterly

RCRA-SQG: RCRA - Small Quantity Generators

RCRAInfo is EPA’s comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Small quantity generators (SQGs) generate between 100 kg and 1,000 kg of hazardous waste per month.

Date of Government Version: 02/12/2013	Source: Environmental Protection Agency
Date Data Arrived at EDR: 02/15/2013	Telephone: 800-438-2474
Date Made Active in Reports: 02/27/2013	Last EDR Contact: 05/02/2013
Number of Days to Update: 12	Next Scheduled EDR Contact: 07/15/2013
	Data Release Frequency: Quarterly

RCRA-CESQG: RCRA - Conditionally Exempt Small Quantity Generators

RCRAInfo is EPA’s comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Conditionally exempt small quantity generators (CESQGs) generate less than 100 kg of hazardous waste, or less than 1 kg of acutely hazardous waste per month.

Date of Government Version: 02/12/2013	Source: Environmental Protection Agency
Date Data Arrived at EDR: 02/15/2013	Telephone: 800-438-2474
Date Made Active in Reports: 02/27/2013	Last EDR Contact: 05/02/2013
Number of Days to Update: 12	Next Scheduled EDR Contact: 07/15/2013
	Data Release Frequency: Varies

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

Federal institutional controls / engineering controls registries

US ENG CONTROLS: Engineering Controls Sites List

A listing of sites with engineering controls in place. Engineering controls include various forms of caps, building foundations, liners, and treatment methods to create pathway elimination for regulated substances to enter environmental media or effect human health.

Date of Government Version: 12/19/2012	Source: Environmental Protection Agency
Date Data Arrived at EDR: 12/26/2012	Telephone: 703-603-0695
Date Made Active in Reports: 02/27/2013	Last EDR Contact: 03/11/2013
Number of Days to Update: 63	Next Scheduled EDR Contact: 06/24/2013
	Data Release Frequency: Varies

US INST CONTROL: Sites with Institutional Controls

A listing of sites with institutional controls in place. Institutional controls include administrative measures, such as groundwater use restrictions, construction restrictions, property use restrictions, and post remediation care requirements intended to prevent exposure to contaminants remaining on site. Deed restrictions are generally required as part of the institutional controls.

Date of Government Version: 12/19/2012	Source: Environmental Protection Agency
Date Data Arrived at EDR: 12/26/2012	Telephone: 703-603-0695
Date Made Active in Reports: 02/27/2013	Last EDR Contact: 03/11/2013
Number of Days to Update: 63	Next Scheduled EDR Contact: 06/24/2013
	Data Release Frequency: Varies

LUCIS: Land Use Control Information System

LUCIS contains records of land use control information pertaining to the former Navy Base Realignment and Closure properties.

Date of Government Version: 12/09/2005	Source: Department of the Navy
Date Data Arrived at EDR: 12/11/2006	Telephone: 843-820-7326
Date Made Active in Reports: 01/11/2007	Last EDR Contact: 02/18/2013
Number of Days to Update: 31	Next Scheduled EDR Contact: 06/03/2013
	Data Release Frequency: Varies

Federal ERNS list

ERNS: Emergency Response Notification System

Emergency Response Notification System. ERNS records and stores information on reported releases of oil and hazardous substances.

Date of Government Version: 12/31/2012	Source: National Response Center, United States Coast Guard
Date Data Arrived at EDR: 01/17/2013	Telephone: 202-267-2180
Date Made Active in Reports: 02/15/2013	Last EDR Contact: 04/02/2013
Number of Days to Update: 29	Next Scheduled EDR Contact: 07/15/2013
	Data Release Frequency: Annually

State- and tribal - equivalent NPL

SHWS: Hazardous Sites Cleanup Act Site List

The Hazardous Sites Cleanup Act Site List includes sites listed on PA Priority List, sites delisted from PA Priority List, Interim Response Completed sites, and Sites Being Studied or Response Being Planned.

Date of Government Version: 01/08/2013	Source: Department Environmental Protection
Date Data Arrived at EDR: 01/24/2013	Telephone: 717-783-7816
Date Made Active in Reports: 02/19/2013	Last EDR Contact: 04/26/2013
Number of Days to Update: 26	Next Scheduled EDR Contact: 08/05/2013
	Data Release Frequency: Semi-Annually

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

HSCA: HSCA Remedial Sites Listing

A list of remedial sites on the PA Priority List. This is the PA state equivalent of the federal NPL superfund list.

Date of Government Version: 12/31/2012
Date Data Arrived at EDR: 01/25/2013
Date Made Active in Reports: 02/19/2013
Number of Days to Update: 25

Source: Department of Environmental Protection
Telephone: 717-783-7816
Last EDR Contact: 04/24/2013
Next Scheduled EDR Contact: 08/05/2013
Data Release Frequency: Varies

State and tribal landfill and/or solid waste disposal site lists

SWF/LF: Operating Facilities

The listing includes Municipal Waste Landfills, Construction/Demolition Waste Landfills and Waste-to-Energy Facilities.

Date of Government Version: 02/26/2013
Date Data Arrived at EDR: 02/28/2013
Date Made Active in Reports: 04/17/2013
Number of Days to Update: 48

Source: Department of Environmental Protection
Telephone: 717-787-7564
Last EDR Contact: 02/26/2013
Next Scheduled EDR Contact: 06/10/2013
Data Release Frequency: Semi-Annually

State and tribal leaking storage tank lists

LUST: Storage Tank Release Sites

Leaking Underground Storage Tank Incident Reports. LUST records contain an inventory of reported leaking underground storage tank incidents. Not all states maintain these records, and the information stored varies by state.

Date of Government Version: 03/04/2013
Date Data Arrived at EDR: 03/20/2013
Date Made Active in Reports: 04/18/2013
Number of Days to Update: 29

Source: Department of Environmental Protection
Telephone: 717-783-7509
Last EDR Contact: 05/02/2013
Next Scheduled EDR Contact: 07/01/2013
Data Release Frequency: Semi-Annually

UNREG LTANKS: Unregulated Tank Cases

Leaking storage tank cases from unregulated storage tanks.

Date of Government Version: 04/12/2002
Date Data Arrived at EDR: 08/14/2003
Date Made Active in Reports: 08/29/2003
Number of Days to Update: 15

Source: Department of Environmental Protection
Telephone: 717-783-7509
Last EDR Contact: 08/14/2003
Next Scheduled EDR Contact: N/A
Data Release Frequency: No Update Planned

LAST: Storage Tank Release Sites

Leaking Aboveground Storage Tank Incident Reports.

Date of Government Version: 03/04/2013
Date Data Arrived at EDR: 03/20/2013
Date Made Active in Reports: 04/18/2013
Number of Days to Update: 29

Source: Department of Environmental Protection
Telephone: 717-783-7509
Last EDR Contact: 05/02/2013
Next Scheduled EDR Contact: 07/01/2013
Data Release Frequency: Semi-Annually

INDIAN LUST R8: Leaking Underground Storage Tanks on Indian Land

LUSTs on Indian land in Colorado, Montana, North Dakota, South Dakota, Utah and Wyoming.

Date of Government Version: 08/27/2012
Date Data Arrived at EDR: 08/28/2012
Date Made Active in Reports: 10/16/2012
Number of Days to Update: 49

Source: EPA Region 8
Telephone: 303-312-6271
Last EDR Contact: 04/29/2013
Next Scheduled EDR Contact: 08/12/2013
Data Release Frequency: Quarterly

INDIAN LUST R10: Leaking Underground Storage Tanks on Indian Land
LUSTs on Indian land in Alaska, Idaho, Oregon and Washington.

Date of Government Version: 02/05/2013	Source: EPA Region 10
Date Data Arrived at EDR: 02/06/2013	Telephone: 206-553-2857
Date Made Active in Reports: 04/12/2013	Last EDR Contact: 04/29/2013
Number of Days to Update: 65	Next Scheduled EDR Contact: 08/12/2013
	Data Release Frequency: Quarterly

INDIAN LUST R1: Leaking Underground Storage Tanks on Indian Land
A listing of leaking underground storage tank locations on Indian Land.

Date of Government Version: 09/28/2012	Source: EPA Region 1
Date Data Arrived at EDR: 11/01/2012	Telephone: 617-918-1313
Date Made Active in Reports: 04/12/2013	Last EDR Contact: 05/01/2013
Number of Days to Update: 162	Next Scheduled EDR Contact: 08/12/2013
	Data Release Frequency: Varies

INDIAN LUST R7: Leaking Underground Storage Tanks on Indian Land
LUSTs on Indian land in Iowa, Kansas, and Nebraska

Date of Government Version: 12/31/2012	Source: EPA Region 7
Date Data Arrived at EDR: 02/28/2013	Telephone: 913-551-7003
Date Made Active in Reports: 04/12/2013	Last EDR Contact: 04/29/2013
Number of Days to Update: 43	Next Scheduled EDR Contact: 08/12/2013
	Data Release Frequency: Varies

INDIAN LUST R6: Leaking Underground Storage Tanks on Indian Land
LUSTs on Indian land in New Mexico and Oklahoma.

Date of Government Version: 09/12/2011	Source: EPA Region 6
Date Data Arrived at EDR: 09/13/2011	Telephone: 214-665-6597
Date Made Active in Reports: 11/11/2011	Last EDR Contact: 04/29/2013
Number of Days to Update: 59	Next Scheduled EDR Contact: 08/12/2013
	Data Release Frequency: Varies

INDIAN LUST R4: Leaking Underground Storage Tanks on Indian Land
LUSTs on Indian land in Florida, Mississippi and North Carolina.

Date of Government Version: 02/06/2013	Source: EPA Region 4
Date Data Arrived at EDR: 02/08/2013	Telephone: 404-562-8677
Date Made Active in Reports: 04/12/2013	Last EDR Contact: 04/29/2013
Number of Days to Update: 63	Next Scheduled EDR Contact: 08/12/2013
	Data Release Frequency: Semi-Annually

INDIAN LUST R9: Leaking Underground Storage Tanks on Indian Land
LUSTs on Indian land in Arizona, California, New Mexico and Nevada

Date of Government Version: 03/01/2013	Source: Environmental Protection Agency
Date Data Arrived at EDR: 03/01/2013	Telephone: 415-972-3372
Date Made Active in Reports: 04/12/2013	Last EDR Contact: 04/29/2013
Number of Days to Update: 42	Next Scheduled EDR Contact: 08/12/2013
	Data Release Frequency: Quarterly

State and tribal registered storage tank lists

UST: Listing of Pennsylvania Regulated Underground Storage Tanks
Registered Underground Storage Tanks. UST’s are regulated under Subtitle I of the Resource Conservation and Recovery Act (RCRA) and must be registered with the state department responsible for administering the UST program. Available information varies by state program.

Date of Government Version: 03/01/2013
Date Data Arrived at EDR: 03/21/2013
Date Made Active in Reports: 04/17/2013
Number of Days to Update: 27

Source: Department of Environmental Protection
Telephone: 717-772-5599
Last EDR Contact: 05/02/2013
Next Scheduled EDR Contact: 07/01/2013
Data Release Frequency: Varies

AST: Listing of Pennsylvania Regulated Aboveground Storage Tanks
Registered Aboveground Storage Tanks.

Date of Government Version: 03/01/2013
Date Data Arrived at EDR: 03/21/2013
Date Made Active in Reports: 04/17/2013
Number of Days to Update: 27

Source: Department of Environmental Protection
Telephone: 717-772-5599
Last EDR Contact: 05/02/2013
Next Scheduled EDR Contact: 07/01/2013
Data Release Frequency: Varies

INDIAN UST R4: Underground Storage Tanks on Indian Land
The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 4 (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee and Tribal Nations)

Date of Government Version: 02/06/2013
Date Data Arrived at EDR: 02/08/2013
Date Made Active in Reports: 04/12/2013
Number of Days to Update: 63

Source: EPA Region 4
Telephone: 404-562-9424
Last EDR Contact: 04/29/2013
Next Scheduled EDR Contact: 08/12/2013
Data Release Frequency: Semi-Annually

INDIAN UST R7: Underground Storage Tanks on Indian Land
The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 7 (Iowa, Kansas, Missouri, Nebraska, and 9 Tribal Nations).

Date of Government Version: 12/31/2012
Date Data Arrived at EDR: 02/28/2013
Date Made Active in Reports: 04/12/2013
Number of Days to Update: 43

Source: EPA Region 7
Telephone: 913-551-7003
Last EDR Contact: 04/29/2013
Next Scheduled EDR Contact: 08/12/2013
Data Release Frequency: Varies

INDIAN UST R5: Underground Storage Tanks on Indian Land
The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 5 (Michigan, Minnesota and Wisconsin and Tribal Nations).

Date of Government Version: 08/02/2012
Date Data Arrived at EDR: 08/03/2012
Date Made Active in Reports: 11/05/2012
Number of Days to Update: 94

Source: EPA Region 5
Telephone: 312-886-6136
Last EDR Contact: 04/29/2013
Next Scheduled EDR Contact: 08/12/2013
Data Release Frequency: Varies

INDIAN UST R6: Underground Storage Tanks on Indian Land
The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 6 (Louisiana, Arkansas, Oklahoma, New Mexico, Texas and 65 Tribes).

Date of Government Version: 05/10/2011
Date Data Arrived at EDR: 05/11/2011
Date Made Active in Reports: 06/14/2011
Number of Days to Update: 34

Source: EPA Region 6
Telephone: 214-665-7591
Last EDR Contact: 04/29/2013
Next Scheduled EDR Contact: 08/12/2013
Data Release Frequency: Semi-Annually

INDIAN UST R1: Underground Storage Tanks on Indian Land
The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 1 (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont and ten Tribal Nations).

Date of Government Version: 09/28/2012
Date Data Arrived at EDR: 11/07/2012
Date Made Active in Reports: 04/12/2013
Number of Days to Update: 156

Source: EPA, Region 1
Telephone: 617-918-1313
Last EDR Contact: 04/29/2013
Next Scheduled EDR Contact: 08/12/2013
Data Release Frequency: Varies

INDIAN UST R10: Underground Storage Tanks on Indian Land

The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 10 (Alaska, Idaho, Oregon, Washington, and Tribal Nations).

Date of Government Version: 02/05/2013
Date Data Arrived at EDR: 02/06/2013
Date Made Active in Reports: 04/12/2013
Number of Days to Update: 65

Source: EPA Region 10
Telephone: 206-553-2857
Last EDR Contact: 04/29/2013
Next Scheduled EDR Contact: 08/12/2013
Data Release Frequency: Quarterly

INDIAN UST R9: Underground Storage Tanks on Indian Land

The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 9 (Arizona, California, Hawaii, Nevada, the Pacific Islands, and Tribal Nations).

Date of Government Version: 02/21/2013
Date Data Arrived at EDR: 02/26/2013
Date Made Active in Reports: 04/12/2013
Number of Days to Update: 45

Source: EPA Region 9
Telephone: 415-972-3368
Last EDR Contact: 04/29/2013
Next Scheduled EDR Contact: 08/12/2013
Data Release Frequency: Quarterly

INDIAN UST R8: Underground Storage Tanks on Indian Land

The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 8 (Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming and 27 Tribal Nations).

Date of Government Version: 08/27/2012
Date Data Arrived at EDR: 08/28/2012
Date Made Active in Reports: 10/16/2012
Number of Days to Update: 49

Source: EPA Region 8
Telephone: 303-312-6137
Last EDR Contact: 04/29/2013
Next Scheduled EDR Contact: 08/12/2013
Data Release Frequency: Quarterly

FEMA UST: Underground Storage Tank Listing

A listing of all FEMA owned underground storage tanks.

Date of Government Version: 01/01/2010
Date Data Arrived at EDR: 02/16/2010
Date Made Active in Reports: 04/12/2010
Number of Days to Update: 55

Source: FEMA
Telephone: 202-646-5797
Last EDR Contact: 04/18/2013
Next Scheduled EDR Contact: 07/29/2013
Data Release Frequency: Varies

State and tribal institutional control / engineering control registries

ENG CONTROLS: Engineering Controls Site Listing

Under the Land Recycling Act (Act 2) persons who perform a site cleanup using the site-specific standard or the special industrial area standard may use engineering or institutional controls as part of the response action. Engineering controls include various forms of caps, building foundations, liners, and treatment methods to create pathway elimination for regulated substances to enter environmental media or effect human health.

Date of Government Version: 05/15/2008
Date Data Arrived at EDR: 05/16/2008
Date Made Active in Reports: 06/12/2008
Number of Days to Update: 27

Source: Department of Environmental Protection
Telephone: 717-783-9470
Last EDR Contact: 04/24/2013
Next Scheduled EDR Contact: 08/05/2013
Data Release Frequency: Varies

AUL: Environmental Covenants Listing

A listing of sites with environmental covenants.

Date of Government Version: 01/22/2013	Source: Department of Environmental Protection
Date Data Arrived at EDR: 01/24/2013	Telephone: 717-783-7509
Date Made Active in Reports: 02/19/2013	Last EDR Contact: 04/23/2013
Number of Days to Update: 26	Next Scheduled EDR Contact: 08/05/2013
	Data Release Frequency: Varies

INST CONTROL: Institutional Controls Site Listing

Under the Land Recycling Act (Act 2) persons who perform a site cleanup using the site-specific standard or the special industrial area standard may use engineering or institutional controls as part of the response action. Institutional controls include administrative measures, such as groundwater use restrictions, construction restrictions, property use restrictions, and post remediation care requirements intended to prevent exposure to contaminants remaining on site. Deed restrictions are generally required as part of the institutional controls.

Date of Government Version: 05/15/2008	Source: Department of Environmental Protection
Date Data Arrived at EDR: 05/16/2008	Telephone: 717-783-9470
Date Made Active in Reports: 06/12/2008	Last EDR Contact: 04/24/2013
Number of Days to Update: 27	Next Scheduled EDR Contact: 08/05/2013
	Data Release Frequency: Varies

State and tribal voluntary cleanup sites

INDIAN VCP R7: Voluntary Cleanup Priority Lisitng

A listing of voluntary cleanup priority sites located on Indian Land located in Region 7.

Date of Government Version: 03/20/2008	Source: EPA, Region 7
Date Data Arrived at EDR: 04/22/2008	Telephone: 913-551-7365
Date Made Active in Reports: 05/19/2008	Last EDR Contact: 04/20/2009
Number of Days to Update: 27	Next Scheduled EDR Contact: 07/20/2009
	Data Release Frequency: Varies

INDIAN VCP R1: Voluntary Cleanup Priority Listing

A listing of voluntary cleanup priority sites located on Indian Land located in Region 1.

Date of Government Version: 09/28/2012	Source: EPA, Region 1
Date Data Arrived at EDR: 10/02/2012	Telephone: 617-918-1102
Date Made Active in Reports: 10/16/2012	Last EDR Contact: 04/05/2013
Number of Days to Update: 14	Next Scheduled EDR Contact: 07/15/2013
	Data Release Frequency: Varies

VCP: Voluntary Cleanup Program Sites

The VCP listings included Completed Sites, Sites in Progress and Act 2 Non-Use Aquifer Determinations Sites. Formerly known as the Act 2, the Land Recycling Program encourages the voluntary cleanup and reuse of contaminated commercial and industrial sites.

Date of Government Version: 01/15/2013	Source: Department of Environmental Protection
Date Data Arrived at EDR: 01/16/2013	Telephone: 717-783-2388
Date Made Active in Reports: 02/19/2013	Last EDR Contact: 04/17/2013
Number of Days to Update: 34	Next Scheduled EDR Contact: 07/29/2013
	Data Release Frequency: Semi-Annually

State and tribal Brownfields sites

BROWNFIELDS: Brownfields Sites

Brownfields are generally defined as abandoned or underused industrial or commercial properties where redevelopment is complicated by actual or perceived environmental contamination. Brownfields vary in size, location, age and past use. They can range from a small, abandoned corner gas station to a large, multi-acre former manufacturing plant that has been closed for years.

Date of Government Version: 02/19/2013	Source: Department of Environmental Protection
Date Data Arrived at EDR: 02/21/2013	Telephone: 717-783-1566
Date Made Active in Reports: 04/17/2013	Last EDR Contact: 04/24/2013
Number of Days to Update: 55	Next Scheduled EDR Contact: 08/05/2013
	Data Release Frequency: Varies

ADDITIONAL ENVIRONMENTAL RECORDS

Local Brownfield lists

US BROWNFIELDS: A Listing of Brownfields Sites

Brownfields are real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. Cleaning up and reinvesting in these properties takes development pressures off of undeveloped, open land, and both improves and protects the environment. Assessment, Cleanup and Redevelopment Exchange System (ACRES) stores information reported by EPA Brownfields grant recipients on brownfields properties assessed or cleaned up with grant funding as well as information on Targeted Brownfields Assessments performed by EPA Regions. A listing of ACRES Brownfield sites is obtained from Cleanups in My Community. Cleanups in My Community provides information on Brownfields properties for which information is reported back to EPA, as well as areas served by Brownfields grant programs.

Date of Government Version: 12/10/2012	Source: Environmental Protection Agency
Date Data Arrived at EDR: 12/11/2012	Telephone: 202-566-2777
Date Made Active in Reports: 12/20/2012	Last EDR Contact: 03/26/2013
Number of Days to Update: 9	Next Scheduled EDR Contact: 07/08/2013
	Data Release Frequency: Semi-Annually

Local Lists of Landfill / Solid Waste Disposal Sites

ODI: Open Dump Inventory

An open dump is defined as a disposal facility that does not comply with one or more of the Part 257 or Part 258 Subtitle D Criteria.

Date of Government Version: 06/30/1985	Source: Environmental Protection Agency
Date Data Arrived at EDR: 08/09/2004	Telephone: 800-424-9346
Date Made Active in Reports: 09/17/2004	Last EDR Contact: 06/09/2004
Number of Days to Update: 39	Next Scheduled EDR Contact: N/A
	Data Release Frequency: No Update Planned

DEBRIS REGION 9: Torres Martinez Reservation Illegal Dump Site Locations

A listing of illegal dump sites location on the Torres Martinez Indian Reservation located in eastern Riverside County and northern Imperial County, California.

Date of Government Version: 01/12/2009	Source: EPA, Region 9
Date Data Arrived at EDR: 05/07/2009	Telephone: 415-947-4219
Date Made Active in Reports: 09/21/2009	Last EDR Contact: 04/29/2013
Number of Days to Update: 137	Next Scheduled EDR Contact: 08/12/2013
	Data Release Frequency: No Update Planned

HIST LF INACTIVE: Inactive Facilities List

A listing of inactive non-hazardous facilities (10000 & 300000 series). This listing is no longer updated or maintained by the Department of Environmental Protection. At the time the listing was available, the DEP?s name was the Department of Environmental Resources.

Date of Government Version: 12/20/1994	Source: Department of Environmental Protection
Date Data Arrived at EDR: 07/12/2005	Telephone: 717-787-7381
Date Made Active in Reports: 08/11/2005	Last EDR Contact: 06/21/2005
Number of Days to Update: 30	Next Scheduled EDR Contact: 12/19/2005
	Data Release Frequency: No Update Planned

HIST LF INVENTORY: Facility Inventory

A listing of solid waste facilities. This listing is no longer updated or maintained by the Department of Environmental Protection. At the time the listing was available, the DEP?s name was the Department of Environmental Resources.

Date of Government Version: 06/02/1999	Source: Department of Environmental Protection
Date Data Arrived at EDR: 07/12/2005	Telephone: 717-787-7381
Date Made Active in Reports: 08/11/2005	Last EDR Contact: 09/19/2005
Number of Days to Update: 30	Next Scheduled EDR Contact: 12/19/2005
	Data Release Frequency: No Update Planned

HIST LF ALI: Abandoned Landfill Inventory

The report provides facility information recorded in the Pennsylvania Department of Environmental Protection ALI database. Some of this information has been abstracted from old records and may not accurately reflect the current conditions and status at these facilities

Date of Government Version: 01/04/2005	Source: Department of Environmental Protection
Date Data Arrived at EDR: 01/04/2005	Telephone: 717-787-7564
Date Made Active in Reports: 02/04/2005	Last EDR Contact: 11/26/2012
Number of Days to Update: 31	Next Scheduled EDR Contact: 03/11/2013
	Data Release Frequency: Varies

INDIAN ODI: Report on the Status of Open Dumps on Indian Lands

Location of open dumps on Indian land.

Date of Government Version: 12/31/1998	Source: Environmental Protection Agency
Date Data Arrived at EDR: 12/03/2007	Telephone: 703-308-8245
Date Made Active in Reports: 01/24/2008	Last EDR Contact: 05/03/2013
Number of Days to Update: 52	Next Scheduled EDR Contact: 08/19/2013
	Data Release Frequency: Varies

Local Lists of Hazardous waste / Contaminated Sites

US CDL: Clandestine Drug Labs

A listing of clandestine drug lab locations. The U.S. Department of Justice ("the Department") provides this web site as a public service. It contains addresses of some locations where law enforcement agencies reported they found chemicals or other items that indicated the presence of either clandestine drug laboratories or dumpsites. In most cases, the source of the entries is not the Department, and the Department has not verified the entry and does not guarantee its accuracy. Members of the public must verify the accuracy of all entries by, for example, contacting local law enforcement and local health departments.

Date of Government Version: 11/14/2012	Source: Drug Enforcement Administration
Date Data Arrived at EDR: 12/11/2012	Telephone: 202-307-1000
Date Made Active in Reports: 02/15/2013	Last EDR Contact: 03/04/2013
Number of Days to Update: 66	Next Scheduled EDR Contact: 06/17/2013
	Data Release Frequency: Quarterly

US HIST CDL: National Clandestine Laboratory Register

A listing of clandestine drug lab locations. The U.S. Department of Justice ("the Department") provides this web site as a public service. It contains addresses of some locations where law enforcement agencies reported they found chemicals or other items that indicated the presence of either clandestine drug laboratories or dumpsites. In most cases, the source of the entries is not the Department, and the Department has not verified the entry and does not guarantee its accuracy. Members of the public must verify the accuracy of all entries by, for example, contacting local law enforcement and local health departments.

Date of Government Version: 09/01/2007	Source: Drug Enforcement Administration
Date Data Arrived at EDR: 11/19/2008	Telephone: 202-307-1000
Date Made Active in Reports: 03/30/2009	Last EDR Contact: 03/23/2009
Number of Days to Update: 131	Next Scheduled EDR Contact: 06/22/2009
	Data Release Frequency: No Update Planned

Local Lists of Registered Storage Tanks

ARCHIVE UST: Archived Underground Storage Tank Sites

The list includes tanks storing highly hazardous substances that were removed from the DEP's Storage Tank Information database because of the Department's policy on sensitive information. The list also may include tanks that are removed or permanently closed.

Date of Government Version: 03/01/2013	Source: Department of Environmental Protection
Date Data Arrived at EDR: 03/21/2013	Telephone: 717-772-5599
Date Made Active in Reports: 04/18/2013	Last EDR Contact: 05/02/2013
Number of Days to Update: 28	Next Scheduled EDR Contact: 07/01/2013
	Data Release Frequency: Varies

ARCHIVE AST: Archived Aboveground Storage Tank Sites

The list includes aboveground tanks with a capacity greater than 21,000 gallons that were removed from the DEP's Storage Tank Information database because of the Department's policy on sensitive information. The list also may include tanks that are removed or permanently closed.

Date of Government Version: 03/01/2013	Source: Department of Environmental Protection
Date Data Arrived at EDR: 03/21/2013	Telephone: 717-772-5599
Date Made Active in Reports: 04/18/2013	Last EDR Contact: 05/02/2013
Number of Days to Update: 28	Next Scheduled EDR Contact: 07/01/2013
	Data Release Frequency: Varies

Local Land Records

LIENS 2: CERCLA Lien Information

A Federal CERCLA ('Superfund') lien can exist by operation of law at any site or property at which EPA has spent Superfund monies. These monies are spent to investigate and address releases and threatened releases of contamination. CERCLIS provides information as to the identity of these sites and properties.

Date of Government Version: 02/16/2012	Source: Environmental Protection Agency
Date Data Arrived at EDR: 03/26/2012	Telephone: 202-564-6023
Date Made Active in Reports: 06/14/2012	Last EDR Contact: 04/29/2013
Number of Days to Update: 80	Next Scheduled EDR Contact: 08/12/2013
	Data Release Frequency: Varies

ACT 2-DEED: Act 2-Deed Acknowledgment Sites

This listing pertains to sites where the Department has approved a cleanup requiring a deed acknowledgment under Act 2. This list includes sites remediated to a non-residential Statewide health standard (Section 303(g)); all sites demonstrating attainment of a Site-specific standard (Section 304(m)); and sites being remediated as a special industrial area (Section 305(g)). Persons who remediated a site to a standard that requires a deed acknowledgment shall comply with the requirements of the Solid Waste Management Act or the Hazardous Sites Cleanup Act, as referenced in Act 2. These statutes require a property description section in the deed concerning the hazardous substance disposal on the site. The location of disposed hazardous substances and a description of the type of hazardous substances disposed on the site shall be included in the deed acknowledgment. A deed acknowledgment is required at the time of conveyance of the property.

Date of Government Version: 04/23/2010	Source: Department of Environmental Protection
Date Data Arrived at EDR: 04/28/2010	Telephone: 717-783-9470
Date Made Active in Reports: 04/30/2010	Last EDR Contact: 07/22/2011
Number of Days to Update: 2	Next Scheduled EDR Contact: 11/07/2011
	Data Release Frequency: Varies

Records of Emergency Release Reports

HMIRS: Hazardous Materials Information Reporting System

Hazardous Materials Incident Report System. HMIRS contains hazardous material spill incidents reported to DOT.

Date of Government Version: 12/31/2012	Source: U.S. Department of Transportation
Date Data Arrived at EDR: 01/03/2013	Telephone: 202-366-4555
Date Made Active in Reports: 02/27/2013	Last EDR Contact: 04/02/2013
Number of Days to Update: 55	Next Scheduled EDR Contact: 07/15/2013
	Data Release Frequency: Annually

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

SPILLS: State spills

A listing of hazardous material incidents.

Date of Government Version: 01/16/2013	Source: DEP, Emergency Response
Date Data Arrived at EDR: 01/24/2013	Telephone: 717-787-5715
Date Made Active in Reports: 02/19/2013	Last EDR Contact: 04/29/2013
Number of Days to Update: 26	Next Scheduled EDR Contact: 07/29/2013
	Data Release Frequency: Varies

Other Ascertainable Records

RCRA NonGen / NLR: RCRA - Non Generators

RCRAInfo is EPA’s comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Non-Generators do not presently generate hazardous waste.

Date of Government Version: 02/12/2013	Source: Environmental Protection Agency
Date Data Arrived at EDR: 02/15/2013	Telephone: 800-438-2474
Date Made Active in Reports: 02/27/2013	Last EDR Contact: 05/02/2013
Number of Days to Update: 12	Next Scheduled EDR Contact: 07/15/2013
	Data Release Frequency: Varies

DOT OPS: Incident and Accident Data

Department of Transporation, Office of Pipeline Safety Incident and Accident data.

Date of Government Version: 07/31/2012	Source: Department of Transporation, Office of Pipeline Safety
Date Data Arrived at EDR: 08/07/2012	Telephone: 202-366-4595
Date Made Active in Reports: 09/18/2012	Last EDR Contact: 05/07/2013
Number of Days to Update: 42	Next Scheduled EDR Contact: 08/19/2013
	Data Release Frequency: Varies

DOD: Department of Defense Sites

This data set consists of federally owned or administered lands, administered by the Department of Defense, that have any area equal to or greater than 640 acres of the United States, Puerto Rico, and the U.S. Virgin Islands.

Date of Government Version: 12/31/2005	Source: USGS
Date Data Arrived at EDR: 11/10/2006	Telephone: 888-275-8747
Date Made Active in Reports: 01/11/2007	Last EDR Contact: 04/19/2013
Number of Days to Update: 62	Next Scheduled EDR Contact: 07/29/2013
	Data Release Frequency: Semi-Annually

FUDS: Formerly Used Defense Sites

The listing includes locations of Formerly Used Defense Sites properties where the US Army Corps of Engineers is actively working or will take necessary cleanup actions.

Date of Government Version: 12/31/2011	Source: U.S. Army Corps of Engineers
Date Data Arrived at EDR: 02/26/2013	Telephone: 202-528-4285
Date Made Active in Reports: 03/13/2013	Last EDR Contact: 03/11/2013
Number of Days to Update: 15	Next Scheduled EDR Contact: 06/24/2013
	Data Release Frequency: Varies

CONSENT: Superfund (CERCLA) Consent Decrees

Major legal settlements that establish responsibility and standards for cleanup at NPL (Superfund) sites. Released periodically by United States District Courts after settlement by parties to litigation matters.

Date of Government Version: 12/31/2011	Source: Department of Justice, Consent Decree Library
Date Data Arrived at EDR: 01/15/2013	Telephone: Varies
Date Made Active in Reports: 03/13/2013	Last EDR Contact: 04/01/2013
Number of Days to Update: 57	Next Scheduled EDR Contact: 07/15/2013
	Data Release Frequency: Varies

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

ROD: Records Of Decision

Record of Decision. ROD documents mandate a permanent remedy at an NPL (Superfund) site containing technical and health information to aid in the cleanup.

Date of Government Version: 12/18/2012	Source: EPA
Date Data Arrived at EDR: 03/13/2013	Telephone: 703-416-0223
Date Made Active in Reports: 04/12/2013	Last EDR Contact: 03/13/2013
Number of Days to Update: 30	Next Scheduled EDR Contact: 06/24/2013
	Data Release Frequency: Annually

UMTRA: Uranium Mill Tailings Sites

Uranium ore was mined by private companies for federal government use in national defense programs. When the mills shut down, large piles of the sand-like material (mill tailings) remain after uranium has been extracted from the ore. Levels of human exposure to radioactive materials from the piles are low; however, in some cases tailings were used as construction materials before the potential health hazards of the tailings were recognized.

Date of Government Version: 09/14/2010	Source: Department of Energy
Date Data Arrived at EDR: 10/07/2011	Telephone: 505-845-0011
Date Made Active in Reports: 03/01/2012	Last EDR Contact: 02/25/2013
Number of Days to Update: 146	Next Scheduled EDR Contact: 06/10/2013
	Data Release Frequency: Varies

US MINES: Mines Master Index File

Contains all mine identification numbers issued for mines active or opened since 1971. The data also includes violation information.

Date of Government Version: 08/18/2011	Source: Department of Labor, Mine Safety and Health Administration
Date Data Arrived at EDR: 09/08/2011	Telephone: 303-231-5959
Date Made Active in Reports: 09/29/2011	Last EDR Contact: 03/06/2013
Number of Days to Update: 21	Next Scheduled EDR Contact: 06/17/2013
	Data Release Frequency: Semi-Annually

TRIS: Toxic Chemical Release Inventory System

Toxic Release Inventory System. TRIS identifies facilities which release toxic chemicals to the air, water and land in reportable quantities under SARA Title III Section 313.

Date of Government Version: 12/31/2009	Source: EPA
Date Data Arrived at EDR: 09/01/2011	Telephone: 202-566-0250
Date Made Active in Reports: 01/10/2012	Last EDR Contact: 02/26/2013
Number of Days to Update: 131	Next Scheduled EDR Contact: 06/10/2013
	Data Release Frequency: Annually

TSCA: Toxic Substances Control Act

Toxic Substances Control Act. TSCA identifies manufacturers and importers of chemical substances included on the TSCA Chemical Substance Inventory list. It includes data on the production volume of these substances by plant site.

Date of Government Version: 12/31/2006	Source: EPA
Date Data Arrived at EDR: 09/29/2010	Telephone: 202-260-5521
Date Made Active in Reports: 12/02/2010	Last EDR Contact: 03/28/2013
Number of Days to Update: 64	Next Scheduled EDR Contact: 07/08/2013
	Data Release Frequency: Every 4 Years

FTTS: FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fungicide, & Rodenticide Act)/TSCA (Toxic Substances Control Act)

FTTS tracks administrative cases and pesticide enforcement actions and compliance activities related to FIFRA, TSCA and EPCRA (Emergency Planning and Community Right-to-Know Act). To maintain currency, EDR contacts the Agency on a quarterly basis.

Date of Government Version: 04/09/2009	Source: EPA/Office of Prevention, Pesticides and Toxic Substances
Date Data Arrived at EDR: 04/16/2009	Telephone: 202-566-1667
Date Made Active in Reports: 05/11/2009	Last EDR Contact: 02/25/2013
Number of Days to Update: 25	Next Scheduled EDR Contact: 06/10/2013
	Data Release Frequency: Quarterly

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

FTTS INSP: FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fungicide, & Rodenticide Act)/TSCA (Toxic Substances Control Act)
A listing of FIFRA/TSCA Tracking System (FTTS) inspections and enforcements.

Date of Government Version: 04/09/2009	Source: EPA
Date Data Arrived at EDR: 04/16/2009	Telephone: 202-566-1667
Date Made Active in Reports: 05/11/2009	Last EDR Contact: 02/25/2013
Number of Days to Update: 25	Next Scheduled EDR Contact: 06/10/2013
	Data Release Frequency: Quarterly

HIST FTTS: FIFRA/TSCA Tracking System Administrative Case Listing
A complete administrative case listing from the FIFRA/TSCA Tracking System (FTTS) for all ten EPA regions. The information was obtained from the National Compliance Database (NCDB). NCDB supports the implementation of FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act) and TSCA (Toxic Substances Control Act). Some EPA regions are now closing out records. Because of that, and the fact that some EPA regions are not providing EPA Headquarters with updated records, it was decided to create a HIST FTTS database. It included records that may not be included in the newer FTTS database updates. This database is no longer updated.

Date of Government Version: 10/19/2006	Source: Environmental Protection Agency
Date Data Arrived at EDR: 03/01/2007	Telephone: 202-564-2501
Date Made Active in Reports: 04/10/2007	Last EDR Contact: 12/17/2007
Number of Days to Update: 40	Next Scheduled EDR Contact: 03/17/2008
	Data Release Frequency: No Update Planned

HIST FTTS INSP: FIFRA/TSCA Tracking System Inspection & Enforcement Case Listing
A complete inspection and enforcement case listing from the FIFRA/TSCA Tracking System (FTTS) for all ten EPA regions. The information was obtained from the National Compliance Database (NCDB). NCDB supports the implementation of FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act) and TSCA (Toxic Substances Control Act). Some EPA regions are now closing out records. Because of that, and the fact that some EPA regions are not providing EPA Headquarters with updated records, it was decided to create a HIST FTTS database. It included records that may not be included in the newer FTTS database updates. This database is no longer updated.

Date of Government Version: 10/19/2006	Source: Environmental Protection Agency
Date Data Arrived at EDR: 03/01/2007	Telephone: 202-564-2501
Date Made Active in Reports: 04/10/2007	Last EDR Contact: 12/17/2008
Number of Days to Update: 40	Next Scheduled EDR Contact: 03/17/2008
	Data Release Frequency: No Update Planned

SSTS: Section 7 Tracking Systems
Section 7 of the Federal Insecticide, Fungicide and Rodenticide Act, as amended (92 Stat. 829) requires all registered pesticide-producing establishments to submit a report to the Environmental Protection Agency by March 1st each year. Each establishment must report the types and amounts of pesticides, active ingredients and devices being produced, and those having been produced and sold or distributed in the past year.

Date of Government Version: 12/31/2009	Source: EPA
Date Data Arrived at EDR: 12/10/2010	Telephone: 202-564-4203
Date Made Active in Reports: 02/25/2011	Last EDR Contact: 04/29/2013
Number of Days to Update: 77	Next Scheduled EDR Contact: 08/12/2013
	Data Release Frequency: Annually

ICIS: Integrated Compliance Information System
The Integrated Compliance Information System (ICIS) supports the information needs of the national enforcement and compliance program as well as the unique needs of the National Pollutant Discharge Elimination System (NPDES) program.

Date of Government Version: 07/20/2011	Source: Environmental Protection Agency
Date Data Arrived at EDR: 11/10/2011	Telephone: 202-564-5088
Date Made Active in Reports: 01/10/2012	Last EDR Contact: 04/15/2013
Number of Days to Update: 61	Next Scheduled EDR Contact: 07/29/2013
	Data Release Frequency: Quarterly

PADS: PCB Activity Database System

PCB Activity Database. PADS Identifies generators, transporters, commercial storers and/or brokers and disposers of PCB's who are required to notify the EPA of such activities.

Date of Government Version: 11/01/2010
Date Data Arrived at EDR: 11/10/2010
Date Made Active in Reports: 02/16/2011
Number of Days to Update: 98

Source: EPA
Telephone: 202-566-0500
Last EDR Contact: 04/19/2013
Next Scheduled EDR Contact: 07/29/2013
Data Release Frequency: Annually

MLTS: Material Licensing Tracking System

MLTS is maintained by the Nuclear Regulatory Commission and contains a list of approximately 8,100 sites which possess or use radioactive materials and which are subject to NRC licensing requirements. To maintain currency, EDR contacts the Agency on a quarterly basis.

Date of Government Version: 06/21/2011
Date Data Arrived at EDR: 07/15/2011
Date Made Active in Reports: 09/13/2011
Number of Days to Update: 60

Source: Nuclear Regulatory Commission
Telephone: 301-415-7169
Last EDR Contact: 03/11/2013
Next Scheduled EDR Contact: 06/24/2013
Data Release Frequency: Quarterly

RADINFO: Radiation Information Database

The Radiation Information Database (RADINFO) contains information about facilities that are regulated by U.S. Environmental Protection Agency (EPA) regulations for radiation and radioactivity.

Date of Government Version: 01/08/2013
Date Data Arrived at EDR: 01/09/2013
Date Made Active in Reports: 04/12/2013
Number of Days to Update: 93

Source: Environmental Protection Agency
Telephone: 202-343-9775
Last EDR Contact: 04/11/2013
Next Scheduled EDR Contact: 07/22/2013
Data Release Frequency: Quarterly

FINDS: Facility Index System/Facility Registry System

Facility Index System. FINDS contains both facility information and 'pointers' to other sources that contain more detail. EDR includes the following FINDS databases in this report: PCS (Permit Compliance System), AIRS (Aerometric Information Retrieval System), DOCKET (Enforcement Docket used to manage and track information on civil judicial enforcement cases for all environmental statutes), FURS (Federal Underground Injection Control), C-DOCKET (Criminal Docket System used to track criminal enforcement actions for all environmental statutes), FFIS (Federal Facilities Information System), STATE (State Environmental Laws and Statutes), and PADS (PCB Activity Data System).

Date of Government Version: 10/23/2011
Date Data Arrived at EDR: 12/13/2011
Date Made Active in Reports: 03/01/2012
Number of Days to Update: 79

Source: EPA
Telephone: (215) 814-5000
Last EDR Contact: 03/12/2013
Next Scheduled EDR Contact: 06/24/2013
Data Release Frequency: Quarterly

RAATS: RCRA Administrative Action Tracking System

RCRA Administration Action Tracking System. RAATS contains records based on enforcement actions issued under RCRA pertaining to major violators and includes administrative and civil actions brought by the EPA. For administration actions after September 30, 1995, data entry in the RAATS database was discontinued. EPA will retain a copy of the database for historical records. It was necessary to terminate RAATS because a decrease in agency resources made it impossible to continue to update the information contained in the database.

Date of Government Version: 04/17/1995
Date Data Arrived at EDR: 07/03/1995
Date Made Active in Reports: 08/07/1995
Number of Days to Update: 35

Source: EPA
Telephone: 202-564-4104
Last EDR Contact: 06/02/2008
Next Scheduled EDR Contact: 09/01/2008
Data Release Frequency: No Update Planned

RMP: Risk Management Plans

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

When Congress passed the Clean Air Act Amendments of 1990, it required EPA to publish regulations and guidance for chemical accident prevention at facilities using extremely hazardous substances. The Risk Management Program Rule (RMP Rule) was written to implement Section 112(r) of these amendments. The rule, which built upon existing industry codes and standards, requires companies of all sizes that use certain flammable and toxic substances to develop a Risk Management Program, which includes a(n): Hazard assessment that details the potential effects of an accidental release, an accident history of the last five years, and an evaluation of worst-case and alternative accidental releases; Prevention program that includes safety precautions and maintenance, monitoring, and employee training measures; and Emergency response program that spells out emergency health care, employee training measures and procedures for informing the public and response agencies (e.g the fire department) should an accident occur.

Date of Government Version: 05/08/2012	Source: Environmental Protection Agency
Date Data Arrived at EDR: 05/25/2012	Telephone: 202-564-8600
Date Made Active in Reports: 07/10/2012	Last EDR Contact: 04/29/2013
Number of Days to Update: 46	Next Scheduled EDR Contact: 08/12/2013
	Data Release Frequency: Varies

BRS: Biennial Reporting System

The Biennial Reporting System is a national system administered by the EPA that collects data on the generation and management of hazardous waste. BRS captures detailed data from two groups: Large Quantity Generators (LQG) and Treatment, Storage, and Disposal Facilities.

Date of Government Version: 12/31/2011	Source: EPA/NTIS
Date Data Arrived at EDR: 02/26/2013	Telephone: 800-424-9346
Date Made Active in Reports: 04/19/2013	Last EDR Contact: 02/26/2013
Number of Days to Update: 52	Next Scheduled EDR Contact: 06/10/2013
	Data Release Frequency: Biennially

UIC: Underground Injection Wells

A listing of underground injection well locations.

Date of Government Version: 03/26/2013	Source: Department of Environmental Protection
Date Data Arrived at EDR: 03/26/2013	Telephone: 717-783-7209
Date Made Active in Reports: 04/18/2013	Last EDR Contact: 03/26/2013
Number of Days to Update: 23	Next Scheduled EDR Contact: 07/08/2013
	Data Release Frequency: Varies

NPDES: NPDES Permit Listing

A listing of facilities with an NPDES permit.

Date of Government Version: 12/26/2012	Source: Department of Environmental Protection
Date Data Arrived at EDR: 03/13/2013	Telephone: 717-787-9642
Date Made Active in Reports: 04/18/2013	Last EDR Contact: 03/13/2013
Number of Days to Update: 36	Next Scheduled EDR Contact: 06/24/2013
	Data Release Frequency: Varies

PA MANIFEST: Manifest Information

Hazardous waste manifest information.

Date of Government Version: 12/31/2011	Source: Department of Environmental Protection
Date Data Arrived at EDR: 07/23/2012	Telephone: 717-783-8990
Date Made Active in Reports: 09/18/2012	Last EDR Contact: 04/23/2013
Number of Days to Update: 57	Next Scheduled EDR Contact: 08/05/2013
	Data Release Frequency: Annually

DRYCLEANERS: Drycleaner Facility Locations

A listing of drycleaner facility locations.

Date of Government Version: 03/25/2013	Source: Department of Environmental Protection
Date Data Arrived at EDR: 03/25/2013	Telephone: 717-787-9702
Date Made Active in Reports: 04/18/2013	Last EDR Contact: 03/25/2013
Number of Days to Update: 24	Next Scheduled EDR Contact: 07/08/2013
	Data Release Frequency: Varies

AIRS: Permit and Emissions Inventory Data
Permit and emissions inventory data.

Date of Government Version: 12/31/2011	Source: Department of Environmental Protection
Date Data Arrived at EDR: 01/04/2013	Telephone: 717-787-9702
Date Made Active in Reports: 02/15/2013	Last EDR Contact: 04/01/2013
Number of Days to Update: 42	Next Scheduled EDR Contact: 07/15/2013
	Data Release Frequency: Annually

INDIAN RESERV: Indian Reservations
This map layer portrays Indian administered lands of the United States that have any area equal to or greater than 640 acres.

Date of Government Version: 12/31/2005	Source: USGS
Date Data Arrived at EDR: 12/08/2006	Telephone: 202-208-3710
Date Made Active in Reports: 01/11/2007	Last EDR Contact: 04/19/2013
Number of Days to Update: 34	Next Scheduled EDR Contact: 07/29/2013
	Data Release Frequency: Semi-Annually

SCRD DRYCLEANERS: State Coalition for Remediation of Drycleaners Listing
The State Coalition for Remediation of Drycleaners was established in 1998, with support from the U.S. EPA Office of Superfund Remediation and Technology Innovation. It is comprised of representatives of states with established drycleaner remediation programs. Currently the member states are Alabama, Connecticut, Florida, Illinois, Kansas, Minnesota, Missouri, North Carolina, Oregon, South Carolina, Tennessee, Texas, and Wisconsin.

Date of Government Version: 03/07/2011	Source: Environmental Protection Agency
Date Data Arrived at EDR: 03/09/2011	Telephone: 615-532-8599
Date Made Active in Reports: 05/02/2011	Last EDR Contact: 05/06/2013
Number of Days to Update: 54	Next Scheduled EDR Contact: 08/05/2013
	Data Release Frequency: Varies

PCB TRANSFORMER: PCB Transformer Registration Database
The database of PCB transformer registrations that includes all PCB registration submittals.

Date of Government Version: 02/01/2011	Source: Environmental Protection Agency
Date Data Arrived at EDR: 10/19/2011	Telephone: 202-566-0517
Date Made Active in Reports: 01/10/2012	Last EDR Contact: 05/03/2013
Number of Days to Update: 83	Next Scheduled EDR Contact: 08/12/2013
	Data Release Frequency: Varies

US FIN ASSUR: Financial Assurance Information
All owners and operators of facilities that treat, store, or dispose of hazardous waste are required to provide proof that they will have sufficient funds to pay for the clean up, closure, and post-closure care of their facilities.

Date of Government Version: 11/20/2012	Source: Environmental Protection Agency
Date Data Arrived at EDR: 11/30/2012	Telephone: 202-566-1917
Date Made Active in Reports: 02/27/2013	Last EDR Contact: 02/19/2013
Number of Days to Update: 89	Next Scheduled EDR Contact: 06/03/2013
	Data Release Frequency: Quarterly

EPA WATCH LIST: EPA WATCH LIST
EPA maintains a "Watch List" to facilitate dialogue between EPA, state and local environmental agencies on enforcement matters relating to facilities with alleged violations identified as either significant or high priority. Being on the Watch List does not mean that the facility has actually violated the law only that an investigation by EPA or a state or local environmental agency has led those organizations to allege that an unproven violation has in fact occurred. Being on the Watch List does not represent a higher level of concern regarding the alleged violations that were detected, but instead indicates cases requiring additional dialogue between EPA, state and local agencies - primarily because of the length of time the alleged violation has gone unaddressed or unresolved.

Date of Government Version: 07/31/2012	Source: Environmental Protection Agency
Date Data Arrived at EDR: 08/13/2012	Telephone: 617-520-3000
Date Made Active in Reports: 09/18/2012	Last EDR Contact: 02/12/2013
Number of Days to Update: 36	Next Scheduled EDR Contact: 05/27/2013
	Data Release Frequency: Quarterly

US AIRS MINOR: Air Facility System Data

A listing of minor source facilities.

Date of Government Version: 11/15/2012	Source: EPA
Date Data Arrived at EDR: 11/16/2012	Telephone: 202-564-5962
Date Made Active in Reports: 02/15/2013	Last EDR Contact: 04/01/2013
Number of Days to Update: 91	Next Scheduled EDR Contact: 07/15/2013
	Data Release Frequency: Annually

US AIRS (AFS): Aerometric Information Retrieval System Facility Subsystem (AFS)

The database is a sub-system of Aerometric Information Retrieval System (AIRS). AFS contains compliance data on air pollution point sources regulated by the U.S. EPA and/or state and local air regulatory agencies. This information comes from source reports by various stationary sources of air pollution, such as electric power plants, steel mills, factories, and universities, and provides information about the air pollutants they produce. Action, air program, air program pollutant, and general level plant data. It is used to track emissions and compliance data from industrial plants.

Date of Government Version: 11/15/2012	Source: EPA
Date Data Arrived at EDR: 11/16/2012	Telephone: 202-564-5962
Date Made Active in Reports: 02/15/2013	Last EDR Contact: 04/01/2013
Number of Days to Update: 91	Next Scheduled EDR Contact: 07/15/2013
	Data Release Frequency: Annually

MINES: Abandoned Mine Land Inventory

This data set portrays the approximate location of Abandoned Mine Land Problem Areas containing public health, safety, and public welfare problems created by past coal mining.

Date of Government Version: 10/02/2012	Source: PASDA
Date Data Arrived at EDR: 01/30/2013	Telephone: 814-863-0104
Date Made Active in Reports: 02/21/2013	Last EDR Contact: 05/02/2013
Number of Days to Update: 22	Next Scheduled EDR Contact: 08/12/2013
	Data Release Frequency: Semi-Annually

FEDLAND: Federal and Indian Lands

Federally and Indian administrated lands of the United States. Lands included are administrated by: Army Corps of Engineers, Bureau of Reclamation, National Wild and Scenic River, National Wildlife Refuge, Public Domain Land, Wilderness, Wilderness Study Area, Wildlife Management Area, Bureau of Indian Affairs, Bureau of Land Management, Department of Justice, Forest Service, Fish and Wildlife Service, National Park Service.

Date of Government Version: 12/31/2005	Source: U.S. Geological Survey
Date Data Arrived at EDR: 02/06/2006	Telephone: 888-275-8747
Date Made Active in Reports: 01/11/2007	Last EDR Contact: 04/19/2013
Number of Days to Update: 339	Next Scheduled EDR Contact: 07/29/2013
	Data Release Frequency: N/A

PRP: Potentially Responsible Parties

A listing of verified Potentially Responsible Parties

Date of Government Version: 12/02/2012	Source: EPA
Date Data Arrived at EDR: 01/03/2013	Telephone: 202-564-6023
Date Made Active in Reports: 03/13/2013	Last EDR Contact: 04/04/2013
Number of Days to Update: 69	Next Scheduled EDR Contact: 07/15/2013
	Data Release Frequency: Quarterly

2020 COR ACTION: 2020 Corrective Action Program List

The EPA has set ambitious goals for the RCRA Corrective Action program by creating the 2020 Corrective Action Universe. This RCRA cleanup baseline includes facilities expected to need corrective action. The 2020 universe contains a wide variety of sites. Some properties are heavily contaminated while others were contaminated but have since been cleaned up. Still others have not been fully investigated yet, and may require little or no remediation. Inclusion in the 2020 Universe does not necessarily imply failure on the part of a facility to meet its RCRA obligations.

Date of Government Version: 11/11/2011	Source: Environmental Protection Agency
Date Data Arrived at EDR: 05/18/2012	Telephone: 703-308-4044
Date Made Active in Reports: 05/25/2012	Last EDR Contact: 02/15/2013
Number of Days to Update: 7	Next Scheduled EDR Contact: 05/27/2013
	Data Release Frequency: Varies

LEAD SMELTER 2: Lead Smelter Sites

A list of several hundred sites in the U.S. where secondary lead smelting was done from 1931and 1964. These sites may pose a threat to public health through ingestion or inhalation of contaminated soil or dust

Date of Government Version: 04/05/2001	Source: American Journal of Public Health
Date Data Arrived at EDR: 10/27/2010	Telephone: 703-305-6451
Date Made Active in Reports: 12/02/2010	Last EDR Contact: 12/02/2009
Number of Days to Update: 36	Next Scheduled EDR Contact: N/A
	Data Release Frequency: No Update Planned

LEAD SMELTER 1: Lead Smelter Sites

A listing of former lead smelter site locations.

Date of Government Version: 01/29/2013	Source: Environmental Protection Agency
Date Data Arrived at EDR: 02/14/2013	Telephone: 703-603-8787
Date Made Active in Reports: 02/27/2013	Last EDR Contact: 04/08/2013
Number of Days to Update: 13	Next Scheduled EDR Contact: 07/22/2013
	Data Release Frequency: Varies

COAL ASH EPA: Coal Combustion Residues Surface Impoundments List

A listing of coal combustion residues surface impoundments with high hazard potential ratings.

Date of Government Version: 08/17/2010	Source: Environmental Protection Agency
Date Data Arrived at EDR: 01/03/2011	Telephone: N/A
Date Made Active in Reports: 03/21/2011	Last EDR Contact: 03/15/2013
Number of Days to Update: 77	Next Scheduled EDR Contact: 06/24/2013
	Data Release Frequency: Varies

COAL ASH DOE: Sleam-Electric Plan Operation Data

A listing of power plants that store ash in surface ponds.

Date of Government Version: 12/31/2005	Source: Department of Energy
Date Data Arrived at EDR: 08/07/2009	Telephone: 202-586-8719
Date Made Active in Reports: 10/22/2009	Last EDR Contact: 04/18/2013
Number of Days to Update: 76	Next Scheduled EDR Contact: 07/29/2013
	Data Release Frequency: Varies

EDR HIGH RISK HISTORICAL RECORDS

EDR Exclusive Records

EDR MGP: EDR Proprietary Manufactured Gas Plants

The EDR Proprietary Manufactured Gas Plant Database includes records of coal gas plants (manufactured gas plants) compiled by EDR’s researchers. Manufactured gas sites were used in the United States from the 1800’s to 1950’s to produce a gas that could be distributed and used as fuel. These plants used whale oil, rosin, coal, or a mixture of coal, oil, and water that also produced a significant amount of waste. Many of the byproducts of the gas production, such as coal tar (oily waste containing volatile and non-volatile chemicals), sludges, oils and other compounds are potentially hazardous to human health and the environment. The byproduct from this process was frequently disposed of directly at the plant site and can remain or spread slowly, serving as a continuous source of soil and groundwater contamination.

Date of Government Version: N/A	Source: EDR, Inc.
Date Data Arrived at EDR: N/A	Telephone: N/A
Date Made Active in Reports: N/A	Last EDR Contact: N/A
Number of Days to Update: N/A	Next Scheduled EDR Contact: N/A
	Data Release Frequency: No Update Planned

EDR US Hist Auto Stat: EDR Exclusive Historic Gas Stations

EDR has searched selected national collections of business directories and has collected listings of potential gas station/filling station/service station sites that were available to EDR researchers. EDR's review was limited to those categories of sources that might, in EDR's opinion, include gas station/filling station/service station establishments. The categories reviewed included, but were not limited to gas, gas station, gasoline station, filling station, auto, automobile repair, auto service station, service station, etc. This database falls within a category of information EDR classifies as "High Risk Historical Records", or HRHR. EDR's HRHR effort presents unique and sometimes proprietary data about past sites and operations that typically create environmental concerns, but may not show up in current government records searches.

Date of Government Version: N/A	Source: EDR, Inc.
Date Data Arrived at EDR: N/A	Telephone: N/A
Date Made Active in Reports: N/A	Last EDR Contact: N/A
Number of Days to Update: N/A	Next Scheduled EDR Contact: N/A
	Data Release Frequency: Varies

EDR US Hist Cleaners: EDR Exclusive Historic Dry Cleaners

EDR has searched selected national collections of business directories and has collected listings of potential dry cleaner sites that were available to EDR researchers. EDR's review was limited to those categories of sources that might, in EDR's opinion, include dry cleaning establishments. The categories reviewed included, but were not limited to dry cleaners, cleaners, laundry, laundromat, cleaning/laundry, wash & dry etc. This database falls within a category of information EDR classifies as "High Risk Historical Records", or HRHR. EDR's HRHR effort presents unique and sometimes proprietary data about past sites and operations that typically create environmental concerns, but may not show up in current government records searches.

Date of Government Version: N/A	Source: EDR, Inc.
Date Data Arrived at EDR: N/A	Telephone: N/A
Date Made Active in Reports: N/A	Last EDR Contact: N/A
Number of Days to Update: N/A	Next Scheduled EDR Contact: N/A
	Data Release Frequency: Varies

EDR US Hist Cleaners: EDR Proprietary Historic Dry Cleaners - Cole

Date of Government Version: N/A	Source: N/A
Date Data Arrived at EDR: N/A	Telephone: N/A
Date Made Active in Reports: N/A	Last EDR Contact: N/A
Number of Days to Update: N/A	Next Scheduled EDR Contact: N/A
	Data Release Frequency: Varies

EDR US Hist Auto Stat: EDR Proprietary Historic Gas Stations - Cole

Date of Government Version: N/A	Source: N/A
Date Data Arrived at EDR: N/A	Telephone: N/A
Date Made Active in Reports: N/A	Last EDR Contact: N/A
Number of Days to Update: N/A	Next Scheduled EDR Contact: N/A
	Data Release Frequency: Varies

OTHER DATABASE(S)

Depending on the geographic area covered by this report, the data provided in these specialty databases may or may not be complete. For example, the existence of wetlands information data in a specific report does not mean that all wetlands in the area covered by the report are included. Moreover, the absence of any reported wetlands information does not necessarily mean that wetlands do not exist in the area covered by the report.

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

CT MANIFEST: Hazardous Waste Manifest Data

Facility and manifest data. Manifest is a document that lists and tracks hazardous waste from the generator through transporters to a tsd facility.

Date of Government Version: 02/18/2013
Date Data Arrived at EDR: 02/18/2013
Date Made Active in Reports: 03/21/2013
Number of Days to Update: 31

Source: Department of Energy & Environmental Protection
Telephone: 860-424-3375
Last EDR Contact: 02/18/2013
Next Scheduled EDR Contact: 06/03/2013
Data Release Frequency: Annually

NJ MANIFEST: Manifest Information

Hazardous waste manifest information.

Date of Government Version: 12/31/2011
Date Data Arrived at EDR: 07/19/2012
Date Made Active in Reports: 08/28/2012
Number of Days to Update: 40

Source: Department of Environmental Protection
Telephone: N/A
Last EDR Contact: 04/19/2013
Next Scheduled EDR Contact: 07/29/2013
Data Release Frequency: Annually

NY MANIFEST: Facility and Manifest Data

Manifest is a document that lists and tracks hazardous waste from the generator through transporters to a TSD facility.

Date of Government Version: 02/01/2013
Date Data Arrived at EDR: 02/07/2013
Date Made Active in Reports: 03/15/2013
Number of Days to Update: 36

Source: Department of Environmental Conservation
Telephone: 518-402-8651
Last EDR Contact: 05/09/2013
Next Scheduled EDR Contact: 08/19/2013
Data Release Frequency: Annually

RI MANIFEST: Manifest information

Hazardous waste manifest information

Date of Government Version: 12/31/2011
Date Data Arrived at EDR: 06/22/2012
Date Made Active in Reports: 07/31/2012
Number of Days to Update: 39

Source: Department of Environmental Management
Telephone: 401-222-2797
Last EDR Contact: 02/25/2013
Next Scheduled EDR Contact: 06/10/2013
Data Release Frequency: Annually

VT MANIFEST: Hazardous Waste Manifest Data

Hazardous waste manifest information.

Date of Government Version: 02/15/2013
Date Data Arrived at EDR: 02/21/2013
Date Made Active in Reports: 03/15/2013
Number of Days to Update: 22

Source: Department of Environmental Conservation
Telephone: 802-241-3443
Last EDR Contact: 01/21/2013
Next Scheduled EDR Contact: 05/06/2013
Data Release Frequency: Annually

WI MANIFEST: Manifest Information

Hazardous waste manifest information.

Date of Government Version: 12/31/2011
Date Data Arrived at EDR: 07/19/2012
Date Made Active in Reports: 09/27/2012
Number of Days to Update: 70

Source: Department of Natural Resources
Telephone: N/A
Last EDR Contact: 03/18/2013
Next Scheduled EDR Contact: 07/01/2013
Data Release Frequency: Annually

Oil/Gas Pipelines: This data was obtained by EDR from the USGS in 1994. It is referred to by USGS as GeoData Digital Line Graphs from 1:100,000-Scale Maps. It was extracted from the transportation category including some oil, but primarily gas pipelines.

Electric Power Transmission Line Data
Source: Rextag Strategies Corp.
Telephone: (281) 769-2247
U.S. Electric Transmission and Power Plants Systems Digital GIS Data

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

Sensitive Receptors: There are individuals deemed sensitive receptors due to their fragile immune systems and special sensitivity to environmental discharges. These sensitive receptors typically include the elderly, the sick, and children. While the location of all sensitive receptors cannot be determined, EDR indicates those buildings and facilities - schools, daycares, hospitals, medical centers, and nursing homes - where individuals who are sensitive receptors are likely to be located.

AHA Hospitals:
Source: American Hospital Association, Inc.
Telephone: 312-280-5991
The database includes a listing of hospitals based on the American Hospital Association’s annual survey of hospitals.
Medical Centers: Provider of Services Listing
Source: Centers for Medicare & Medicaid Services
Telephone: 410-786-3000
A listing of hospitals with Medicare provider number, produced by Centers of Medicare & Medicaid Services, a federal agency within the U.S. Department of Health and Human Services.
Nursing Homes
Source: National Institutes of Health
Telephone: 301-594-6248
Information on Medicare and Medicaid certified nursing homes in the United States.
Public Schools
Source: National Center for Education Statistics
Telephone: 202-502-7300
The National Center for Education Statistics’ primary database on elementary and secondary public education in the United States. It is a comprehensive, annual, national statistical database of all public elementary and secondary schools and school districts, which contains data that are comparable across all states.
Private Schools
Source: National Center for Education Statistics
Telephone: 202-502-7300
The National Center for Education Statistics’ primary database on private school locations in the United States.
Daycare Centers: Child Care Facility List
Source: Department of Public Welfare
Telephone: 717-783-3856

Flood Zone Data: This data, available in select counties across the country, was obtained by EDR in 2003 & 2011 from the Federal Emergency Management Agency (FEMA). Data depicts 100-year and 500-year flood zones as defined by FEMA.

NWI: National Wetlands Inventory. This data, available in select counties across the country, was obtained by EDR in 2002 and 2005 from the U.S. Fish and Wildlife Service.

Scanned Digital USGS 7.5’ Topographic Map (DRG)
Source: United States Geologic Survey
A digital raster graphic (DRG) is a scanned image of a U.S. Geological Survey topographic map. The map images are made by scanning published paper maps on high-resolution scanners. The raster image is georeferenced and fit to the Universal Transverse Mercator (UTM) projection.

STREET AND ADDRESS INFORMATION

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