Baseline Water Quality Review - Elbert County, Colorado

S.S. PAPADOPULOS & ASSOCIATES, INC.
Boulder, Colorado

May 4, 2012

3100 Arapahoe Avenue, Suite 203, Boulder, Colorado 80303-1050 • (303) 939-8880

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Prepared for:

Colorado Oil and Gas Conservation Commission

Prepared by:

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1.0 INTRODUCTION

The Colorado Oil and Gas Conservation Commission (COGCC) is conducting a baseline water quality study for Elbert County, Colorado (Figure 1.1), to characterize groundwater conditions in an area where oil and gas drilling activity has been relatively idle for the last several years, but where drilling activity may increase in the near future. The water quality conditions of the Denver Basin aquifers are the primary focus of the study since these hydrologic units provide the majority of water for domestic, livestock watering, and irrigation purposes throughout Elbert County, including in the northwestern portion of the county where COGCC sampling has been concentrated.

S. S. Papadopulos and Associates, Inc. (SSPA) has been retained by the COGCC to review water quality sample results and stable isotope data previously collected from water wells, springs and surface waters in Elbert County and to document the general composition of the native water quality. This report summarizes and briefly evaluates the analytical results and stable isotope composition for water well samples and gas samples in the study area.

1.1. Objectives

The objectives of the water quality study are to:

- Develop an electronic database of geographic and geochemical data obtained from water sampled in the area of interest.
- Evaluate background water quality in Elbert County based on major ion analysis and identify areas where quality is impaired (based on drinking water standards).
- Evaluate water quality in areas where COGCC has sampled, including background water quality and incidences where drinking water standards are exceeded.
- Discuss characteristics of water chemistry that could potentially be related to impacts from oil and gas production activities.

1.2. Data Sources

Water quality sample results from wells, surface water, and springs were obtained from a 2,100 square mile area that encompasses Elbert County, as well as the western half of the townships bordering Douglas County along Range 65 West and the southern half of the townships bordering Arapahoe County along Township 5 South (Figure 1.2). The primary area of interest within the study area is the northwestern corner of Elbert County near producing oil and gas wells in Township 6 South and Ranges 62 through 65 West. This area is semi-rural and increasingly being populated with low density residential developments, unlike most of the county, which is undeveloped or rural.[1] Currently, there are less than 150 producing oil and gas wells in Elbert County, one approved permit to drill in Elbert County and no pending permits to drill in Elbert County (COGCC, May 3, 2012). Within the area of interest in neighboring counties, there are no approved permits to drill in eastern Douglas County, eleven approved permits to drill in southern Arapahoe County, and no pending permits in either of the neighboring areas.

Groundwater samples for 25 domestic water wells (areas highlighted in yellow on Figure 1.2) were collected by the COGCC (or its contractor) and analyzed for a suite of inorganic and organic parameters. Samples were collected between October 2010 and October 2011 except one sample collected in Arapahoe County in November 2002. Reported analytes vary by sample location and typically include major water quality parameters (cations and anions), metals, the volatile organic compounds (VOCs), including the hydrocarbons benzene, toluene, ethylbenzene and xylenes (BTEX), and methane. Water from three wells was sampled for gas composition and for carbon and hydrogen stable isotopes of methane. In addition to water well samples, 59 produced water samples and one natural gas sample from oil and gas wells in Elbert County were provided by the COGCC.

Supplemental groundwater and surface water quality data was obtained from the U. S. Geological Survey National Water Inventory System (USGS-NWIS) for the entire area of interest. This water quality dataset includes results from 1964 to 2011 for 209 groundwater

[1] Elbert County has only three incorporated communities, Elizabeth, Kiowa, and Simla, and a total population of approximately 23,000 and less than 9,000 households according to the 2010 US Census.

or springs locations and five surface water locations (http://nwis.waterdata.usgs.gov/co/nwis/qwdata).

2.0 HYDROGEOLOGIC SETTING

2.1. Geology

The Denver Basin is an asymmetric structural trough (more steeply dipping beds on the west side of the basin than the east) containing Tertiary and Upper Cretaceous sedimentary rocks that form a major aquifer system east of the Colorado Front Range[2]. The Basin stretches from southern El Paso County northward to Greeley in Weld County. All of Elbert County, except for its eastern border is within the Denver Basin, and the large majority of the water wells in the county are completed in the bedrock aquifers of the basin. The water-bearing formations of the Denver Basin, from youngest to oldest, are the Dawson, Denver, Arapahoe, Laramie, and Fox Hills Sandstone formations. Together, these units are over 3,000 feet thick in much of the basin. The base of the water-productive Denver Basin is formed by the Pierre Shale, a widespread, fine-grained formation that is from 2,500 to more than 4,500 feet thick in Elbert County (Shurr, 1980).

The Denver Basin, as delineated above, covers an area of 6,700 square miles. The Denver-Julesburg (D-J) Basin, which encompasses the Denver Basin, but also includes the underlying Pierre Shale and earlier Cretaceous to Pennsylvanian sedimentary formations, covers an area of approximately 70,000 square miles and extends from southeastern Wyoming into western Nebraska and central Colorado (Higley and Cox, 2007) (Figure 1.1). These deeper rocks generally are not productive water-bearing units (e.g., Pierre Shale) or do not contain fresh water suitable for agricultural or water supply use. The D-J Basin is important, however, as a hydrocarbon-producing region, with oil and gas production having occurred in the basin since the late 1800's. Several hundred oil and gas wells have been drilled in Elbert County, and while many of the wells in the county have been plugged and abandoned, it is expected that a new influx of drilling will occur in the near future as producers begin to exploit tight low-permeability formations such as the Niobrara Formation within the D-J Basin.

[2] Much of the information provided in this section, especially that related to the Denver Basin is taken from Topper (2004), an overview paper contained in a Rocky Mountain Association of Geologists volume on the bedrock aquifers of the Denver Basin.

2.2. Hydrogeology Characteristics

The great majority of the water supply wells in Elbert County are completed in Denver Basin bedrock aquifers. The productive units in the Denver Basin are divided into the Dawson, Denver, Arapahoe, and Laramie-Fox Hills aquifers. The stratigraphic and hydrogeologic unit characteristics are shown in Figure 2.1 (from Robson and Banta, 1985). The Denver Basin aquifer units are made up primarily of sandstones and siltstones and are separated from each other by intervening finer-grained layers. In Elbert County, the Dawson formation and aquifer, which is the uppermost of the units, is present at the ground surface along the western edge of the northern portion of the county (Figure 2.2). The Dawson aquifer is characterized by conglomeritic, coarse-grained sandstones with minor amounts of interbedded clay and clay shale. The Dawson aquifer has a saturated thickness of up to 400 feet. The Denver formation and aquifer are present at the ground surface east of the Dawson to approximately the center of the county. The Denver formation includes interbedded lenses of shale, claystone, siltstone, sandstone, and scattered coal beds. The water-bearing units of the Denver aquifer are discontinuous in nature and have a total thickness between 100 and 350 feet. Most of the wells sampled by COGCC in Elbert County are completed in the Dawson or the Denver aquifers.

The Arapahoe aquifer lies beneath the Denver aquifer and rocks of the Arapahoe formation are present at the ground surface in a relatively narrow band trending north-south through central Elbert County. The Arapahoe formation consists of interbedded conglomerate, sandstone, siltstone, and shale, and the aquifer is the most productive of the Denver Basin aquifers. The lower portion of the Laramie formation and the Fox Hills sandstone are grouped together as the Laramie-Fox Hills aquifer. The upper portion of the Laramie formation is dominated by shale layers and is not a water producing unit.

The wells whose water sample results are used in the geochemical analysis for Elbert County are shown in Figure 2.2. The figure also shows the aquifers that the wells are completed in based on information obtained from the Colorado Division of Water Resources (DWR) and the USGS-NWIS. Where available, the depths of the wells are shown in Figure 2.3 and a stacked histogram summarizing the well information is shown in Figure 2.4. Of the 86 wells shown on Figure 2.3 whose productive horizons were known, only 9 were

completed in younger unconsolidated alluvial deposits above the Denver Basin bedrock formations and most of these are located just west of Elbert County in Douglas County. (Many wells in Arapahoe County immediately north of the study area are completed in alluvium; however, because such completions are rare in Elbert County, the area containing those wells and further north were excluded from the Elbert County analysis). While the few alluvial wells evaluated are all less than 80 feet deep, the wells completed in the bedrock aquifers are from 100 to 1,000 feet deep (except for one 2,150-foot-deep well completed in the Arapahoe aquifer in Section 18, Township 8 South, Range 64 West) with the majority of the wells ranging between 200 and 600 feet deep. Potentiometric surface mapping (Robson, 1987) indicates that the groundwater in the Denver Basin aquifers in Elbert County flows predominantly in a northward direction.

Recharge to the Denver Basin aquifers in Elbert County occurs where each of the aquifer formations are exposed at the ground surface. Recharge is primarily from precipitation, which is severely limited by the county's relatively dry climate, and there is the potential to over-produce groundwater causing long-term lowering of water levels and concurrent depletion (or mining) of the groundwater resource. Special rules that are designed to mitigate the effects of over-production from the bedrock aquifers have been implemented for the Denver Basin (http://water.state.co.us/DWRDocs/Rules/Pages/CGWCRules.aspx).

To date, all oil and gas production in Elbert County has occurred beneath the Pierre Shale, which thickens from 2,500 feet in the southeast corner of the county to greater than 4,500 feet on the western edge of the county (Shurr, 1980). Therefore, the Pierre Shale provides a barrier of several thousand feet below the deepest water supply wells in the county and the oil and gas producing horizons below. There is the potential for oil or gas exploration in the Pierre Shale to be conducted at some point in the future, but at present, the formation is not known to be productive locally or even to be a target for future exploration.

3.0 WATER QUALITY CONDITIONS

This section summarizes analytical results for both water quality parameters (major anions and cations, metals, BTEX, MTBE, and dissolved methane) and for gas composition and methane gas isotopes. The results are considered in relation to state and federal health and water quality standards and are further evaluated with respect to overall hydrologic setting and for potential effects from activities that are normally associated with oil and natural gas production.

For the Elbert County geochemical evaluation, SSPA developed an electronic database from analytical results obtained from the COGCC and the USGS-NWIS website. Analytical sample results were checked for ion balance (a comparison of total anion charges of the water to total cation charges) and were censored if the ion balance inequality was greater than 10%. Duplicate sample and laboratory QA/QC results were removed from the dataset used for geochemical analysis.

Geographic and sample site information for all locations where sample results were available are provided in Appendix A. A total of 524 water sample results from 239 locations were compiled in the database for the area of interest. Sample results from 145 locations (424 samples) were censored from the geochemical water type analysis, often because there were no bicarbonates reported in sample results from the USGS-NWIS. Of the remaining 100 sample results from 94 locations included in the geochemical characteristics evaluation (Figure 1.2), 21 water samples from domestic wells were collected and reported by the COGCC and 79 samples from 73 site locations (three sites have data for multiple sampling events) were obtained from USGS-NWIS. Samples from USGS-NWIS include 65 groundwater wells, seven springs, and one surface water location.

Produced water sample results from oil and gas wells were censored using the same requirements described above. Of the 59 samples available, 32 were within the ion balance requirements. Produced water samples are presented in the discussions below as a comparison for water samples collected from domestic wells, springs or surface water locations.

3.1. Groundwater Geochemical Characterization

Uncensored groundwater, spring, and surface water analytical results were evaluated for major ion chemistry and water quality composition. A summary of the inorganic parameter results for all uncensored samples and for all samples collected by COGCC or their contractors (whether censored or uncensored) is presented in Table 3.1.

Piper diagrams (also called trilinear plots) were developed to illustrate the overall geochemical characteristics and trends for the groundwater in Elbert County. The Piper diagrams use major cation and anion concentrations to demonstrate relationships among multiple samples or sample groups (Hem, 1985). In these diagrams the reactive quantities of the ions (measured in milliequivalents per liter; meq/L) are the basis for the plots rather than the mass quantities, milligrams/L (mg/L), presented in Table 3.1.

Piper diagrams are presented for each drinking water aquifer in the study area. The piper diagram for alluvial wells and surface water samples is shown in Figure 3.1a. The water in almost all of the alluvial wells is dominated by calcium (Ca) cations and bicarbonate (HCO_3) anions (i.e., has a Ca-HCO_3 geochemical signature) and by low total dissolved solids (TDS, a measure of the total ions present in the water) concentrations. This pattern is typical of shallow unconfined alluvial aquifers that are not recharged by precipitation or by pristine surface water and are not affected by high dissolved solids surface waters. In the study area only one 14-foot deep well with TDS of 2820 mg/L and a Ca-SO_4 geochemical signature, located in the far northeast corner of Elbert County, fell well outside of this norm. The distribution of geochemical signatures for the samples evaluated for this project is shown in Figure 3.2.

The Piper diagrams for the Denver and Dawson aquifers (Figure 3.1b) and the Arapahoe and Laramie Fox Hills aquifers (Figure 3.1c) illustrate the progression from Ca-HCO_3 dominated water for the overlying Dawson formation water as it evolves towards sodium sulfate (Na-SO_4) water in the Denver formation. In general TDS trends upward with the progression from the Dawson to the Denver aquifer samples. For the wells sampled by COGCC or their contractors, this change is well illustrated by the inset on Figure 3.2; all of the southwest cluster of wells are completed in the Dawson aquifer and have TDS

concentrations less than 250 mg/L while all of the northeast cluster of wells are completed in the Denver aquifer and, with one exception, have TDS concentrations between 250 and 500 mg/L (Figure 3.3a). The pattern is similar for sulfate (Figure 3.3b), where all the wells in the southwest cluster have concentrations less than 125 mg/L, while the northeast cluster includes several wells with concentrations between 125 mg/L and 250 mg/L and one well with a concentration of 270 mg/L.

Water from the Arapahoe and Laramie-Fox Hills aquifers extends the same anion-cation trends, although the signal is less clear for the Laramie-Fox Hills wells. Notably, as shown in the anion base triangle of the Piper diagram (Figure 3.1c), the water from these lower two aquifers have consistently low proportions of chloride among the total anions, even compared to samples from the alluvial and other bedrock aquifers. These trends are also evident in the plots of anions to TDS and cations to TDS shown in Figures 3.4a and 3.4b and in the plot of chloride and sulfate to sodium shown in Figure 3.4c.

As would be expected, the piper diagram for produced water from natural gas wells in Elbert County (Figure 3.1d) shows that the produced waters are dominated by sodium cations and chloride anions, which are indicative of brackish water and saltwater brines. Only two samples of the 34 evaluated show mixed signatures, one with bicarbonate and one with both bicarbonate and sulfate.

Overall, the geochemical characteristics of the water samples from Elbert County are typical for water in the Denver Basin aquifers and for other Tertiary and Upper Cretaceous aquifers in the state of Colorado. None of the results indicate impacts from the deeper, higher salinity water present in the oil and gas producing strata in the Basin.

3.2. Health and Drinking Water Standards

All water sample results, including those censored from major ion chemistry analysis, were included in drinking water health standards evaluations. Water quality results for major ions, metals, halides, and methane sample results are shown in Tables 3.1 and 3.2. Any compounds that exceed either primary or secondary Colorado Basic Groundwater Standards (CBGWS) are highlighted in the tables.

CBGWS are regulatory human health and drinking water quality standards for groundwater used for human consumption. The primary or human health standards (same as federal maximum contaminant levels; MCLs) are established based on potential health effects resulting from exposure to drinking water containing a given compound while secondary water quality standards are related to the aesthetic qualities of water, such as odor and taste.

3.2.1. Inorganic Water Quality Standards

In the dataset collected for this study, the presence and distribution of wells where primary and secondary CBGWS are evaluated are biased by sample results from several very shallow wells (one 60 feet deep and the remainder less than 40 feet deep) located in the far northeast corner of Elbert County. Many of these wells, which appear to be part of an ongoing water quality study (possibly being conducted by the USGS), have been sampled multiple times (up to a maximum of over 40 times) and all are located in an area with almost no oil and gas development. The wells appear to be monitoring, irrigation, or livestock wells and they do not include any drinking water wells. The discussion below does not include the wells from this study.

For the remainder of the results reviewed for this study, primary CBGWS for inorganic water quality (major ions, metals, and halides) were exceeded as described below:

- Arsenic (As) concentrations were detected at the primary CBGWS of 0.01 mg/L in two out of 31 locations sampled. No results exceeded 0.011 mg/L.
- Selenium (Se) was detected at 39 locations and selenium concentrations exceeded the primary CBGWS of 0.05 mg/L in one well located in Section 34, Township 6 South, Range 63 West. This well had a selenium concentration of 0.06 mg/L; all other results were at or below 0.02 mg/L.
- Nitrate (NO_3) concentrations exceeded the primary CBWS of 10 mg/L as N at two locations sampled. Nitrate is a common indicator of anthropogenic impacts and is often prevalent in shallow wells in permeable alluvial aquifers. One of the nitrate exceedances is from a spring located just inside Douglas County at the southwest corner of western Elbert County (Section 36, Township 10 South, Range 65 West) and one is from a 100-foot deep well completed in the Denver formation in Section 32, Township 10 South, Range 61 West. Both locations had nitrate concentrations of 13 mg/L, only slightly above the CBGWS.

- None of the locations sampled by the COGCC or their contractors had any inorganic compounds that exceeded primary water quality standards.

Secondary CBGWS for drinking water quality are established as guidelines for water aesthetics. Concentrations of TDS, sulfate, manganese (Mn), and iron (Fe) exceeded secondary CBGWS drinking water limits in several of the wells sampled:

- TDS was detected above its nominal secondary standard of 500 mg/L in 22 locations sampled (including only censored results). As discussed above, the wells with TDS exceedances are primarily those wells completed in the lower of the Denver Basin aquifers, the Arapahoe and the Laramie-Fox Hills (Figure 3.3a). Only one of the wells sampled by COGCC or its contractors contained TDS above the CBGWS secondary standard.

- Sulfate (SO_4) was detected above its secondary standard of 250 mg/L in 18 locations sampled. As shown in Figure 3.3b, and as would be expected based on the positive correlation between TDS and sulfate in the geochemical evolution of groundwater in the Denver Basin, most of the wells where sulfate exceeds CBGWS are completed in the Arapahoe and the Laramie-Fox Hills aquifers. Only one of the wells sampled by COGCC or its contractors contained sulfate above the CBGWS secondary standard.

- Manganese (Mn) was detected above its secondary standard of 0.05 mg/L in 27 of 78 locations sampled, and iron (Fe) was detected above its secondary standard of 0.3 mg/L in 13 of 81 locations sampled The wells with detects of both iron and manganese above CBGWS are spread throughout Elbert County (Figures 3.3c and 3.3d). With two exceptions, in all of the wells where iron was present above its standard, manganese was also present above standard. Of the wells sampled by GOGCC or its contractors, manganese was present at concentrations slightly above standard at three locations; none of the samples exceeded standard for iron.

In general, water quality of the drinking water wells in Elbert County is good and only a minority of the locations sampled had any exceedances of either primary or secondary CBGWS.

3.2.2. Volatile Organic Compounds

Volatile organic compounds (VOCs) include those compounds commonly associated with industrial chemicals and solvents, with some household cleansers and related compounds, and with petroleum hydrocarbons such as gasoline, diesel fuel, and unrefined crude oil and natural gas liquid condensates. Frequently, sampling of suburban or rural

domestic wells does not include the broad spectrum of VOCs normally associated with industrial processes; instead selected constituents of petroleum hydrocarbons are monitored. These include benzene, toluene, ethylbenzene, and xylenes (BTEX), and the former gasoline additive MTBE. For the Elbert County study area, 43 locations were sampled for BTEX (including all the wells sampled by COGCC or their contractors) and except a single well with a detection of 0.47 micrograms/Liter (µg/L) of toluene, there were no measureable concentrations of BTEX detected in any of the samples. This concentration is well below the primary CBGWS of 560 µg/L. Only one sample was analyzed for MTBE (in Arapahoe County in 2002) and that sampled was a non-detect.

All of the samples from Elbert County collected by COGCC or their contractors were analyzed for an extensive list of VOCs. Except for the single toluene detect discussed above, there were no VOCs detected in any of the samples.

3.2.3. Methane in Groundwater

Methane is an odorless and tasteless gas and does not present a known health hazard to humans; however, it can create flammable or explosive conditions when it occurs in groundwater at elevated concentrations, especially if it is allowed to accumulate within confined areas. As such, concentrations below 1 mg/L are considered harmless, with concern for hazards increasing at concentrations in well water at or above 7 mg/L.

The COGCC analyzed groundwater samples for dissolved methane at 24 well locations in the area of interest in the northwestern portion of Elbert County and in one sample from 2002 from southern Arapahoe County. Dissolved methane was detected in 15 of the locations sampled; although at four locations the detects were less than 0.001 mg/L, above the detection limit, but below the reporting limit (quantitation limit) of 0.005 mg/L for the laboratory analyses (Table 3.2). All but three of the samples concentrations were below 1 mg/L. The distribution of dissolved methane in groundwater is shown in Figure 3.5. All three of the wells with groundwater dissolved methane concentrations above 1 mg/L are completed in the Denver aquifer and are completed at depths ranging from 460 to 905 feet deep.

COGCC will normally resample wells where dissolved methane concentrations in groundwater exceed 1 mg/L, and will analyze the samples for compositional gases and for hydrogen and carbon isotopes of methane (see the next section) to help evaluate the source of the methane. When concentrations in groundwater exceed 2 mg/L, a regular sampling program is recommended and mitigation of methane buildup may be necessary. For the Elbert County samples collected under COGCC direction, three of the methane detections were above 2 mg/L concentration and two were above 7 mg/L, which is considered to be a level above which mitigation efforts should be undertaken.

3.3. Gases in water

Isotech Laboratories in Champaign, Illinois, analyzed water or headspace gas samples from three wells with methane groundwater concentrations above 1 mg/L for atmospheric and hydrocarbon gas composition and stable isotopes of methane. The results are summarized in Table 3.3. Gas composition results are reported as the molar percentage of each gas (where total gases equal 100 percent). The detection limits for common gases nitrogen (N_2), oxygen (O_2), carbon dioxide (CO_2), and argon (Ar) are 30-50 ppm in undiluted samples of headspace gas.

For the carbon stable isotopes analyses, the results are given as the parts per thousand (permil or ‰; 1 permil = 1/1000) ratio of the stable carbon isotopes ($^{13}C/^{12}C$)[3] .from the sample compared to the ratio in an industry-accepted marine carbonate standard. (This value is indicated in literature using the abbreviation $\delta^{13}C$). Specifically, $\delta^{13}C$ is defined as:

$$\delta^{13}C = \frac{R_S - R_{PDB}}{R_{PDB}} \times 1000$$

where R denotes the ratio of the heavy to light isotope ($^{13}C/^{12}C$), and R_S and R_{PDB} are the ratios in the sample and standard, respectively. The reference standard for carbon (*PDB*) is a calcite ($CaCO_3$), which by definition has a $\delta^{13}C$ value of 0. A positive δ value means that the isotopic ratio of the sample is higher (i.e. has more of the heavy isotope) than the standard; a negative δ value means that the isotopic ratio of the sample is lower (i.e. has less of the heavy

[3] That is, the ratio of carbon with a seventh neutron in the nucleus to carbon with the normal six neutrons.

isotope) than the standard. For example, a $\delta^{13}C$ value of -20 per mil means that the $^{13}C/^{12}C$ ratio of the sample is 20 parts per thousand or 2.0 % lower than that of the *PDB* standard.

Isotopes of hydrogen in methane are determined similarly. The two isotopes measured are hydrogen with a molecular weight of 1 (H1) and the deuterium (D or H2) isotope which has a molecular weight of 2 grams/mole. The permil ratio is for D/H1 and is referred to as δD, where the reference standard has been established as VSMOW (or Vienna Standard Mean Ocean Water).

The compositional gases and isotope results for the three samples collected for COGCC are shown in Table 3.3. Methane groundwater concentrations for these wells were elevated, ranging from 5.9 to 11 mg/L. Even though the Skoglund well had the highest groundwater methane concentration of the three wells, it had atmospheric gas concentrations that more closely resembled atmospheric air concentrations and a significantly lower methane (C1) gas concentration than the samples from the Allen and Purvis wells (4.03% versus 29.73% and 29.12%, respectively). Notably, for all three wells, the concentrations of the heavier hydrocarbon gases ethane (C2) and propane (C3) were very low or below detection limit, resulting in C1/(C2+C3) ratios of 1600 to 2000, which is a strong indicator (in conjunction with other measures) of gases that are biogenic in origin. Thermogenic methane from conventional oil and natural gas deposits normally has a C1/(C2+C3) ratio of less than 100 (Whiticar, 1990).

The stable isotopes of methane, $\delta^{13}C$ and δD were determined for all three gas samples (Table 3.3). As demonstrated in Figure 3.6, results show that both that $\delta^{13}C$ and δD values are characteristic of biogenic methane and not thermogenic methane that is associated with conventional oil and natural gas deposits or with coalbed gases. The $\delta^{13}C$ values for the three Elbert County water wells were all less than (i.e., isotopically lighter and more negative than) -86 ‰ and δD values were less than -319 ‰. Thermogenic methane from conventional oil or gas deposits, in contrast, is considerably heavier, with $\delta^{13}C$ generally being greater than (i.e., less negative than) -50 ‰, and δD values greater than approximately -250 ‰ (Whiticar, 1990).

For the three samples, the combination of the hydrocarbon gas concentrations and C1/(C2+C3) ratios and the very low methane isotopic values indicates the methane in the wells is biogenic in origin and in absence of nearby anthropogenic sources such as landfills, is likely a naturally occurring phenomenon.

4.0 CONCLUSIONS

SSPA evaluated 25 groundwater samples collected by the COGCC or their contractors, and augmented the evaluation by incorporating 209 groundwater and springs locations, and 5 surface water samples obtained through the USGS on-line NWIS database in order to allow a broader assessment of groundwater conditions in Elbert County to be conducted. Parameters evaluated included major ions, metals, halides, methane, and BTEX in water, and compositional gases and isotopes of methane for three gas samples. Conclusions of this evaluation are provided below.

- The large majority of the samples evaluated were groundwater from water wells (spring samples were included and considered to be representative of groundwater from the formations they emanated from).
- Most of the water supply wells are completed in one of the Denver Basin bedrock aquifers. Excluding an area in the far northeast corner of Elbert County where a shallow groundwater quality study is apparently being conducted, only 9 of the wells were completed in alluvium; all of those wells are in Douglas County and are less than 80 feet deep. In contrast, the majority of the bedrock wells were between 200 and 600 feet deep.
- Geochemical analysis of major ion groundwater results indicate that the groundwater present in the alluvial aquifers has low TDS and mixed cation and anion concentration with the majority of the samples having a Ca-HCO_3 geochemical signature. The results are consistent with shallow groundwater that is not affected by elevated TDS surface water influences.
- Geochemical signature of the bedrock aquifer samples indicate an overall evolution from Ca-HCO_3 water towards a Na-SO_4 end member; probably as flowpaths within the bedrock aquifers increase and naturally soluble sodium and sulfate are leached into the water from the bedrock itself.
- Chloride concentrations were relatively low in all the groundwater samples, and there was no suggestion of any trend of increasing chloride with increasing TDS or sodium in the samples.
- There are very few wells with any inorganic compound primary groundwater standards exceedances (two wells for arsenic and nitrate, and one for selenium). Similarly, BTEX, was nearly absent from the samples, with only one sample having a very low concentration of toluene.
- Secondary groundwater standards were exceeded in a minority of the groundwater samples analyzed for inorganic parameters. Exceedances of TDS, sulfate, manganese, and/or iron were reported in 89 of the 239 locations evaluated for this study.

- Dissolved methane in groundwater was present at detectable concentrations in 15 of the 24 wells sampled. Concentrations were below 1 mg/L in all wells but three. Gas composition and methane stable isotopes were sampled for the three wells with elevated groundwater methane concentrations. In all three wells, both the ratios of the C1 through C6 range hydrocarbon gases and the carbon and hydrogen stable isotopes of methane indicated a biogenic origin for the methane in the wells.
- Generally, groundwater quality in the wells sampled for this study is good. There is no evidence that water quality has been impacted by activities related to oil and natural gas exploration or production activities.

5.0 REFERENCES

Hem, J. D., 1985. Study and Interpretation of the Chemical Characteristics of Natural Water, Third Edition. U. S. Geological Survey Water-Supply Paper 2254. 263 pp.

Higley, D. K., and D. O. Cox, 2007. Oil and Gas Exploration and Development along the Front Range in the Denver Basin of Colorado, Nebraska, and Wyoming. In Higley, D. K., *ed.*, Petroleum Systems and Assessment of Undiscovered Oil and Gas in the Denver Basin Province, Colorado, Kansas, Nebraska, South Dakota, and Wyoming—USGS Province 39. U. S. Geological Survey Digital Data Series DDS-69-P, Version 1.0. Chapter 2.

Robson, S. G., 1987. Bedrock Aquifers in the Denver Basin, Colorado—A Quantitative Water-Resources Appraisal. U. S. Geological Survey Professional Paper 1257. 73 pp.

Robson, S.G. and E.R. Banta, 1995. Groundwater Atlas of the United States- Arizona, Colorado, New Mexico, Utah. U. S. Geological Survey Hydrologic Investigations Atlas 730-C. Figure 83.

Shurr, G. W., 1980. Geologic Setting of the Pierre Shale, Northern Great Plains. U. S. Geological Survey, Open-File Report 80-675. 8 pp.

Topper, R., 2004. Aquifers of the Denver Basin, Colorado. *In* Raynolds, R. G., and M. Reynolds, *eds.*, A Special Issue on Bedrock Aquifers of the Denver Basin. The Mountain Geologist, October 2004, V. 41, No. 4. pp. 145-152.

US Census Bureau State and County QuickFacts, March 15, 2003. (http://quickfacts.census.gov/qfd/states/08/08039.html,)

Whiticar, M. J., 1990. A geochemical perspective of natural gas and atmospheric methane. Advances in Organic Geochemistry, vol. 16, nos. 1-3, pp. 531-547.

Figures

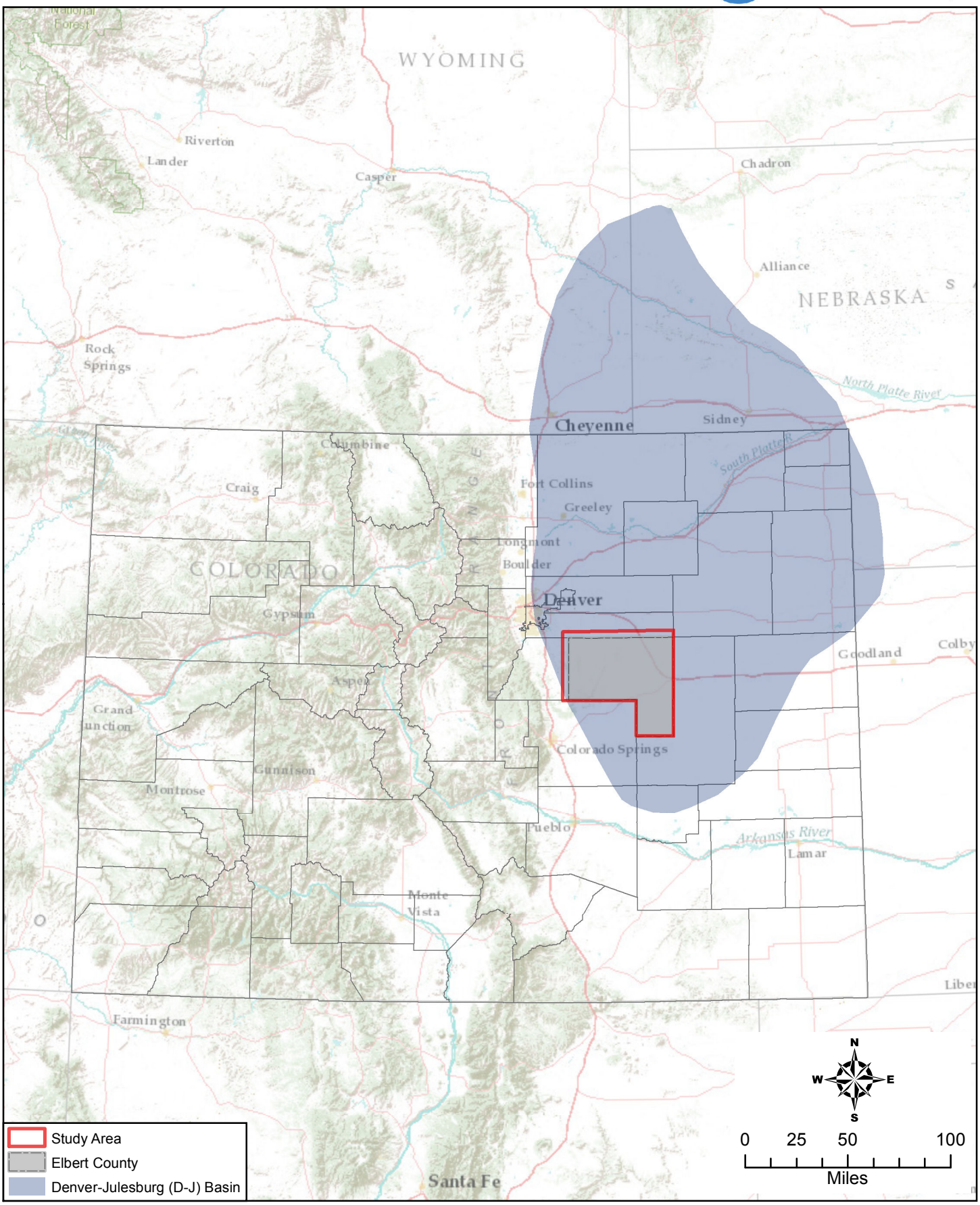

Figure 1.1 Site Location Map, Elbert County and the Denver-Julesburg Basin, Colorado

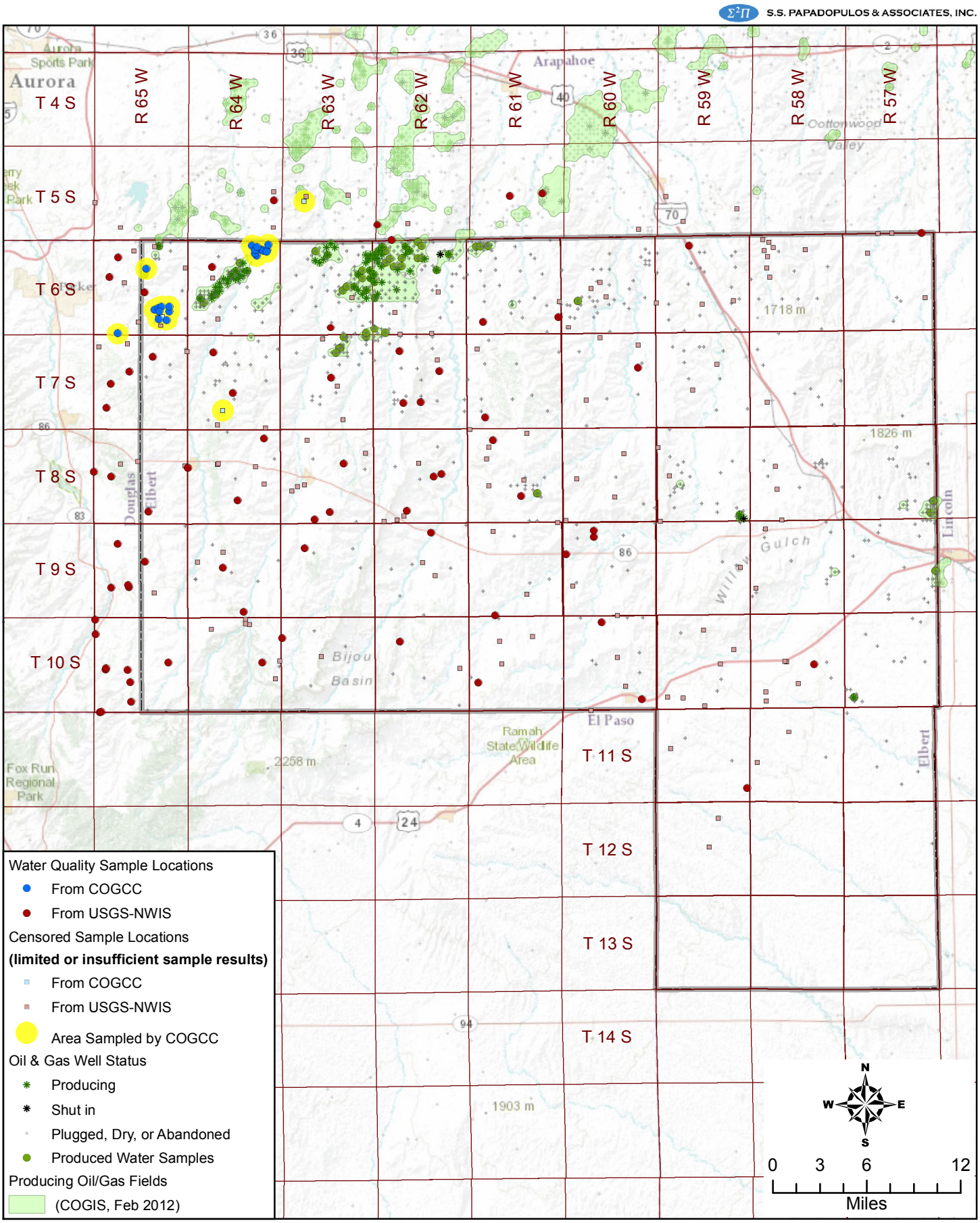

Figure 1.2 Location of Oil and Gas Production Fields, Sample Locations with Water Quality Information, and Other Wells in Elbert County and Surrounding Area

Era	System	Series	Stratigraphic unit	Unit thickness (feet)	Physical characteristics	Hydrogeologic unit	Saturated thickness (feet)	Hydrologic characteristics
Cenozoic	Quaternary	Holocene / Pleistocene	Alluvium	0 – 125	Unconsolidated gravel, sand, silt, and clay	Alluvial aquifer	0 – 100	Shallow water-table aquifer. Very permeable. May yield as much as 3,000 gallons per minute
	Tertiary	Oligocene	Castle Rock Conglomerate	0 – 50	Fine to coarse arkosic sandstone and conglomerate. Exposed in cliffs	none	0	Generally forms caprock on buttes. Well drained. Does not yield water
		Eocene	Dawson Arkose	800 – 1,400	Sandstone and conglomeratic sandstone with interbedded siltstone and shale. Sandstone generally coarse, quartzose, arkosic, poorly to well consolidated	Dawson aquifer	0 – 400	Uppermost Denver basin aquifer. Contains a water table in shallow units but generally confined at depth. Moderately permeable. May yield as much as 200 gallons per minute
		Paleocene	Denver Formation	600 – 1,100	Shale, silty claystone, and interbedded sandstone. Beds of lignite and carbonaceous siltstone and shale common. Sandstone generally andesitic, lenticular, moderately consolidated	Denver aquifer	0 – 350	Confined in central part. Contains a water table only near outcrops. Moderately permeable. May yield as much as 200 gallons per minute
Mesozoic	Cretaceous	Upper Cretaceous	Arapahoe Formation	400 – 700	Sandstone, conglomeratic sandstone, and interbedded shale and siltstone. Sandstone generally quartzose, fine to coarse, poorly to well consolidated	Arapahoe aquifer	0 – 400	Confined in central part. Contains a water table only near outcrops. Most permeable of Denver basin aquifers. May yield as much as 700 gallons per minute
			Laramie Formation	100 – 600	Upper part shale, silty shale, siltstone, and interbedded fine sandstone. Bituminous coal seams	Laramie confining unit	0 – 400	Shale is impermeable
					Lower part sandstone and shale. Sandstone fine to medium, friable, carbonaceous	Laramie-Fox Hills aquifer	0 – 300	Lowermost Denver basin aquifer. Confined in central part. Contains a water table only near outcrops. Moderately permeable. May yield as much as 300 gallons per minute
			Fox Hills Sandstone	100 – 200	Sandstone and siltstone interbedded with shale. Sandstone generally very fine to fine, poorly consolidated			
			Pierre Shale	5,000 – 7,000	Shale, silty, dense, calcareous, fossiliferous	Lower confining unit	0	Impermeable. Forms base of Denver basin aquifer system

Denver Basin aquifer system

Figure 2.1 Hydrogeologic Units in the Denver Basin (from Robson and Banta, 1995)

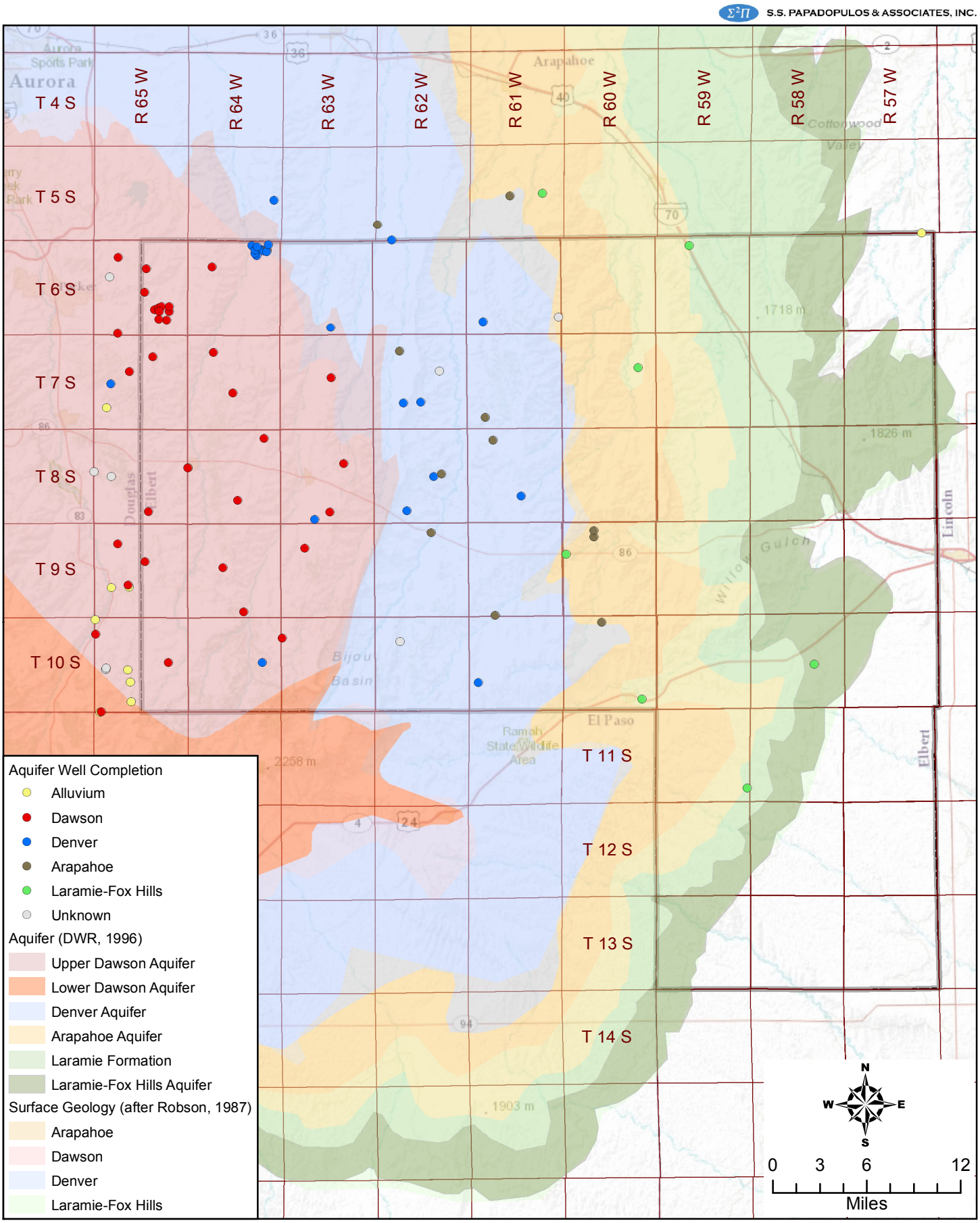

Figure 2.2 Surface Geology (from DWR, 1996; after Robson, 1987) and Aquifer Well Completion

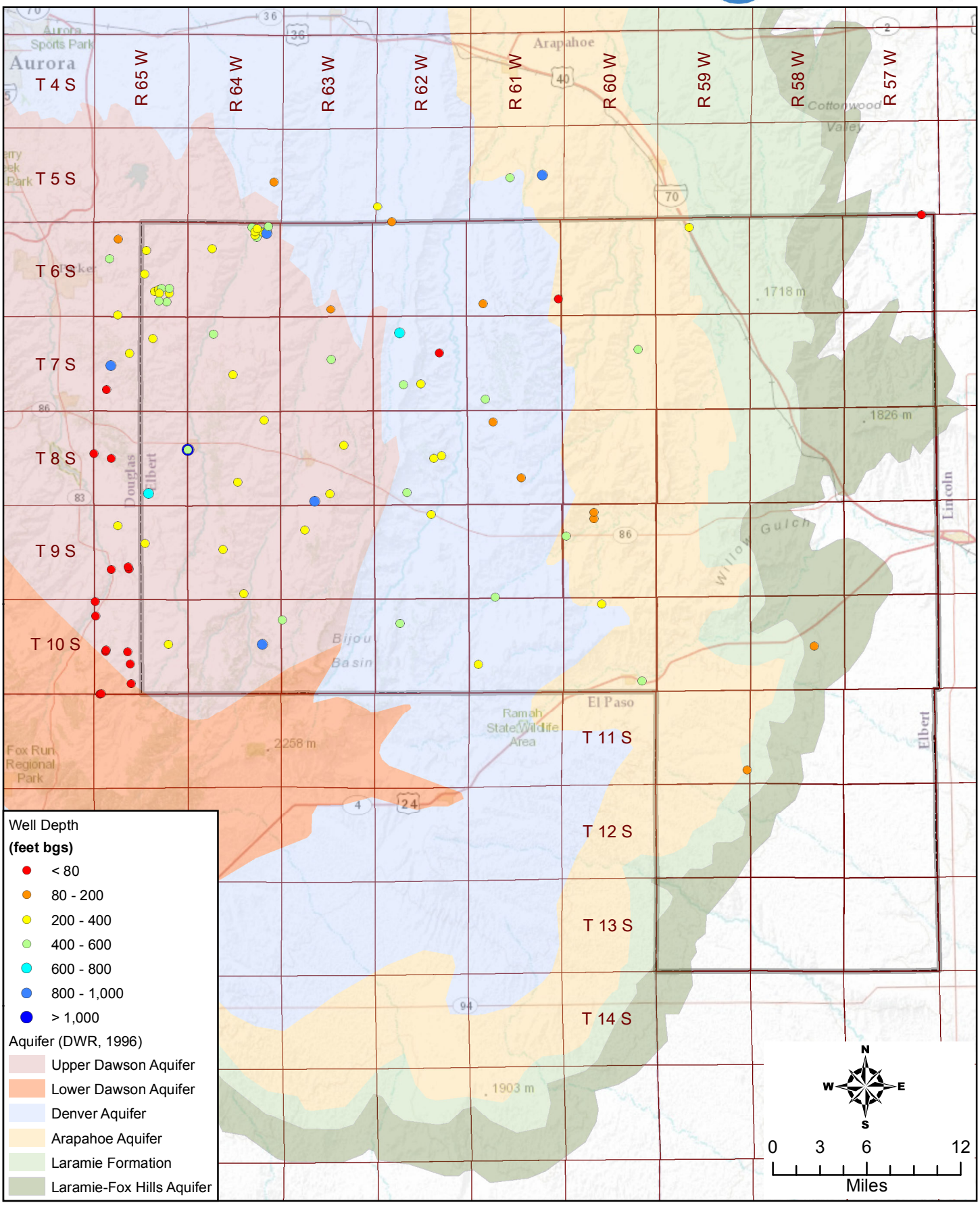

Figure 2.3 Well Depth

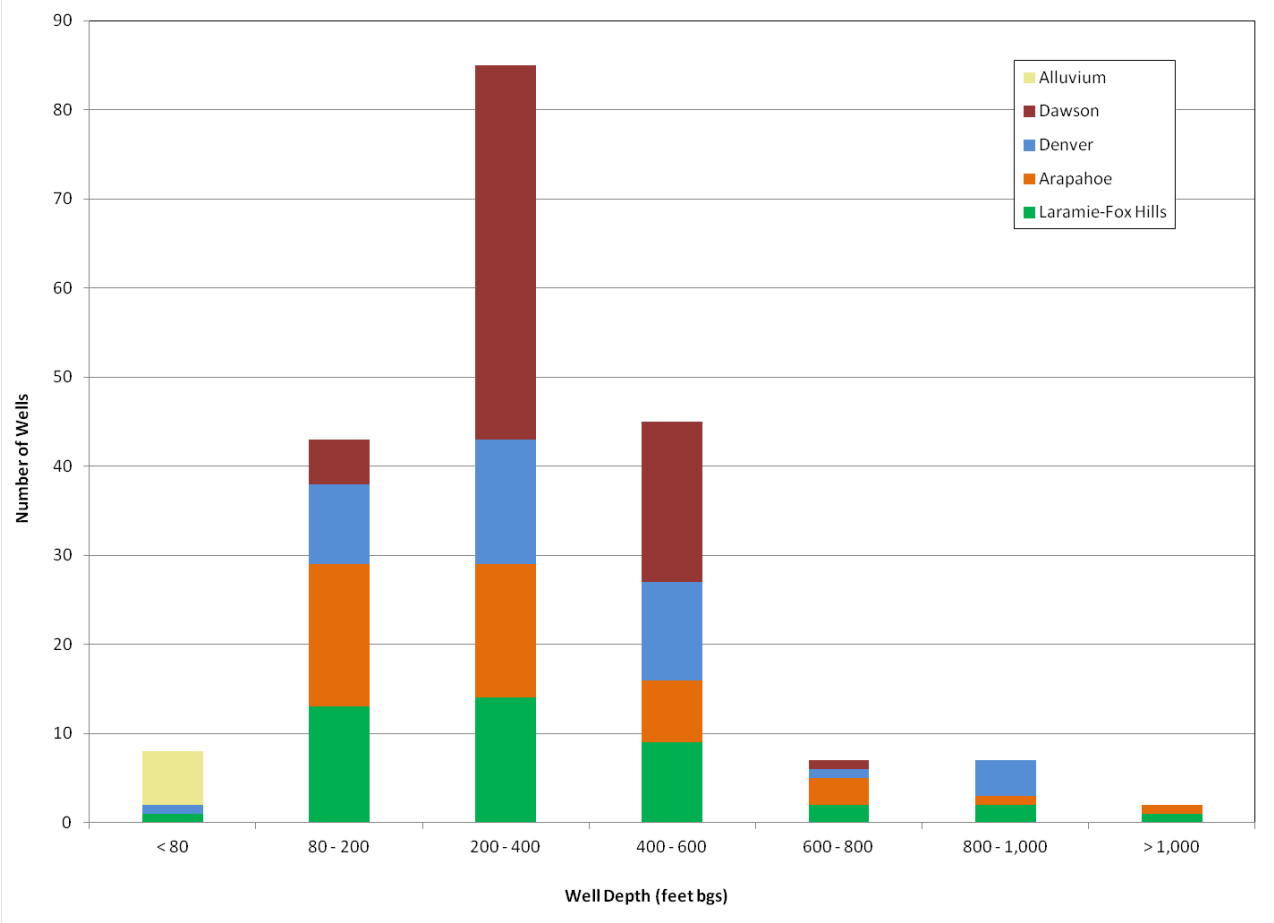

Figure 2.4 Histogram of Well Depths by Producing Aquifer

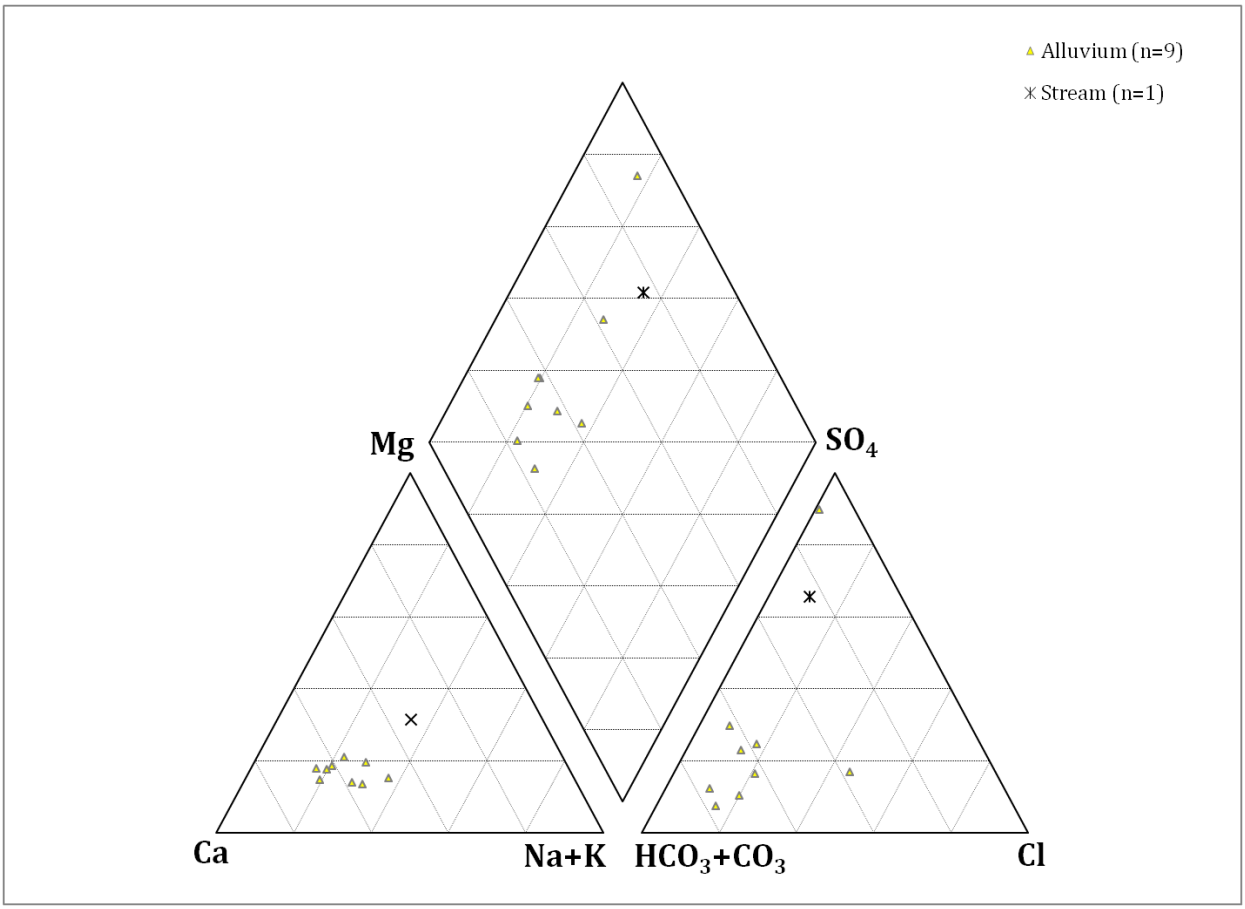

Figure 3.1a Piper Diagram of Alluvial Wells and Surface Water Samples [1]

[1] Location of wells shown in Figure 2.2

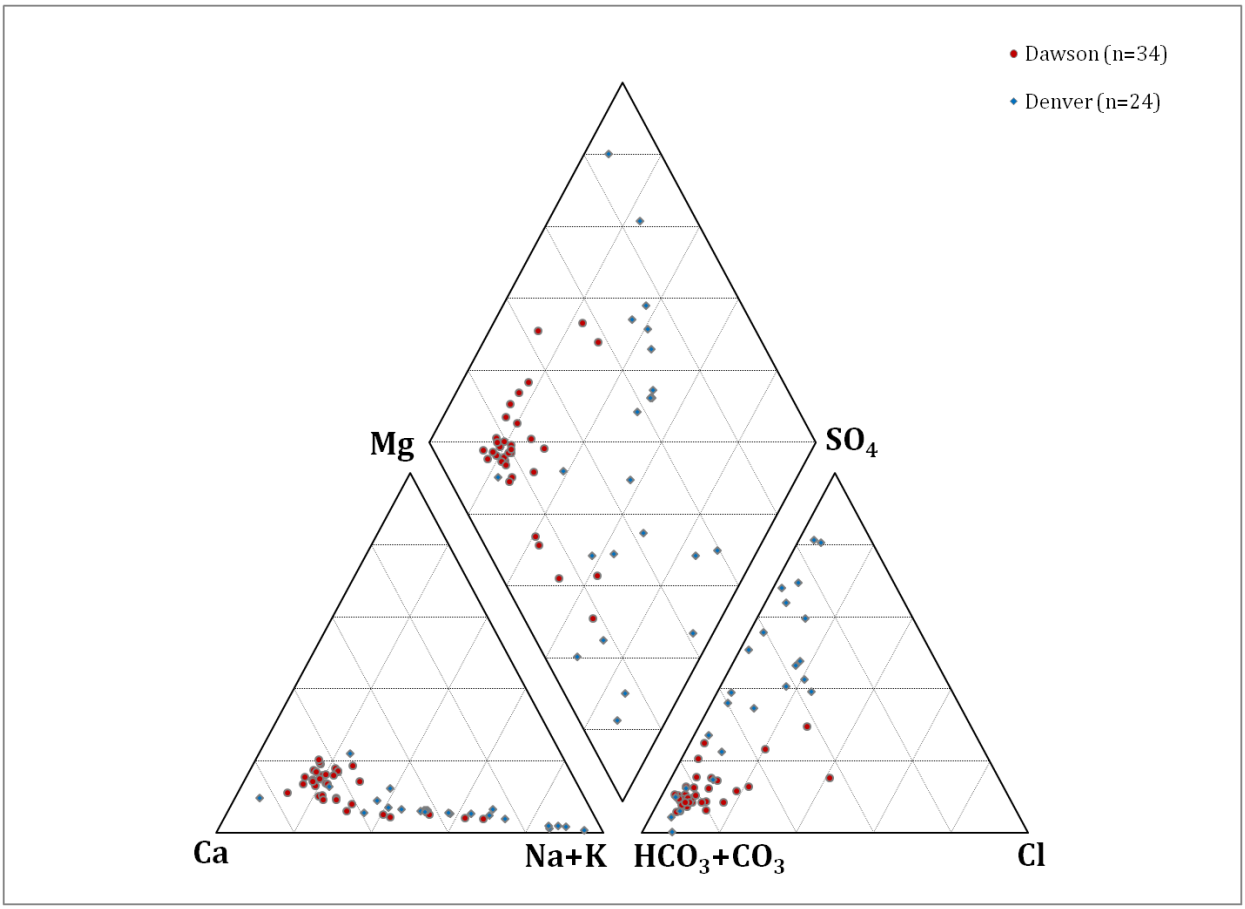

Figure 3.1b Piper Diagram for Wells in the Denver and Dawson Aquifers

[1] Location of wells shown in Figure 2.2

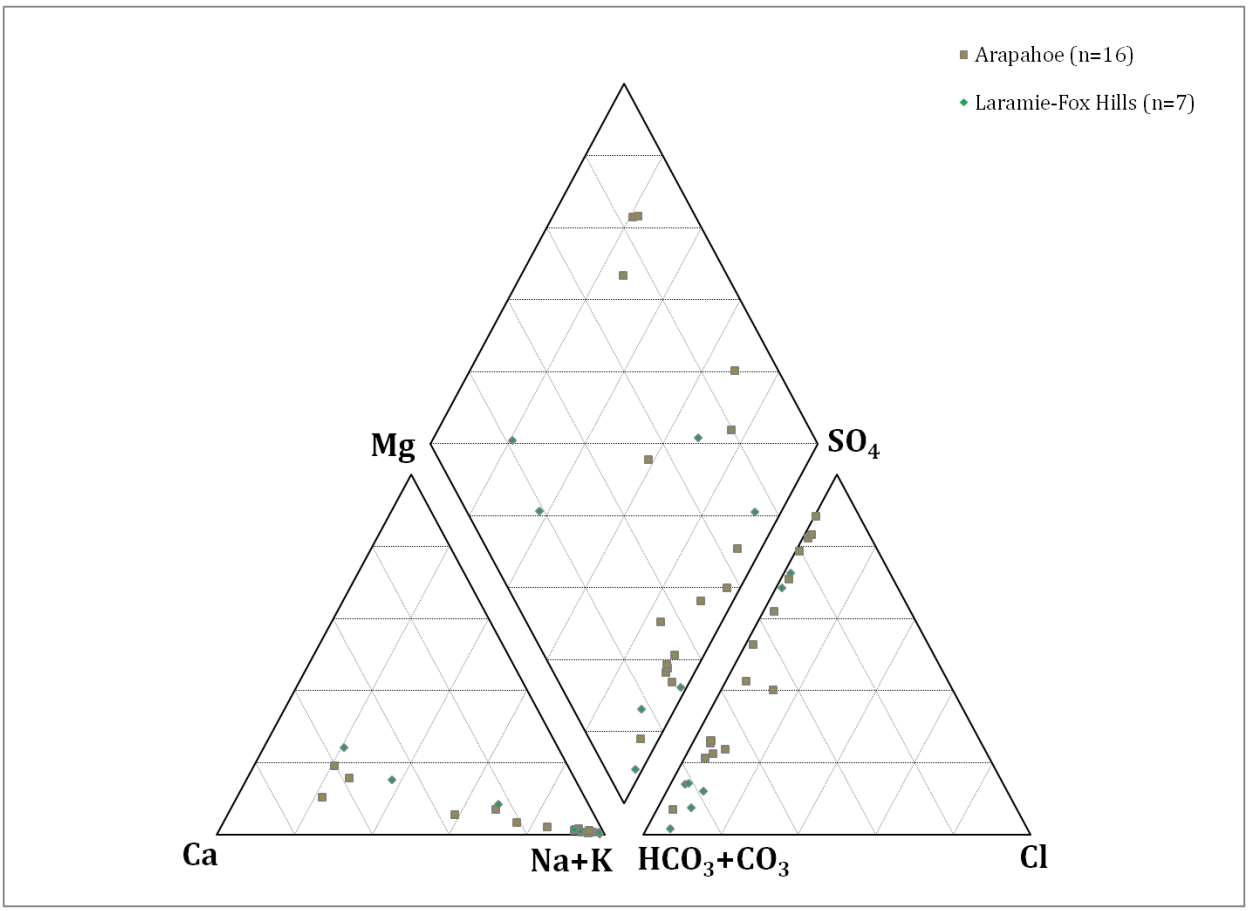

Figure 3.1c Piper Diagram for Wells in the Arapahoe and Laramie-Fox Hills Aquifer

[1] Location of wells shown in Figure 2.2

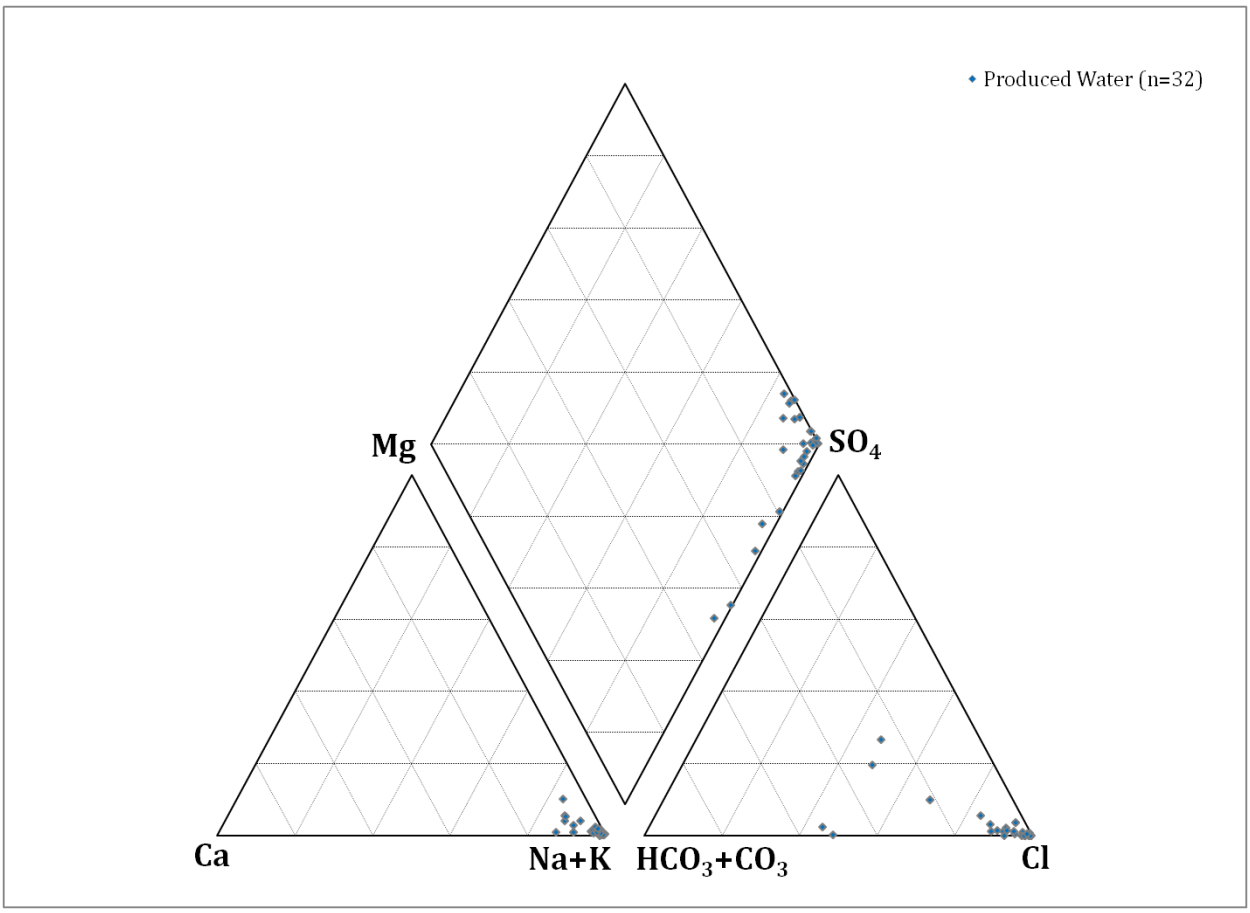

Figure 3.1d Piper Diagram for Produced Water from Gas Wells

[1] Location of wells shown in Figure 2.2

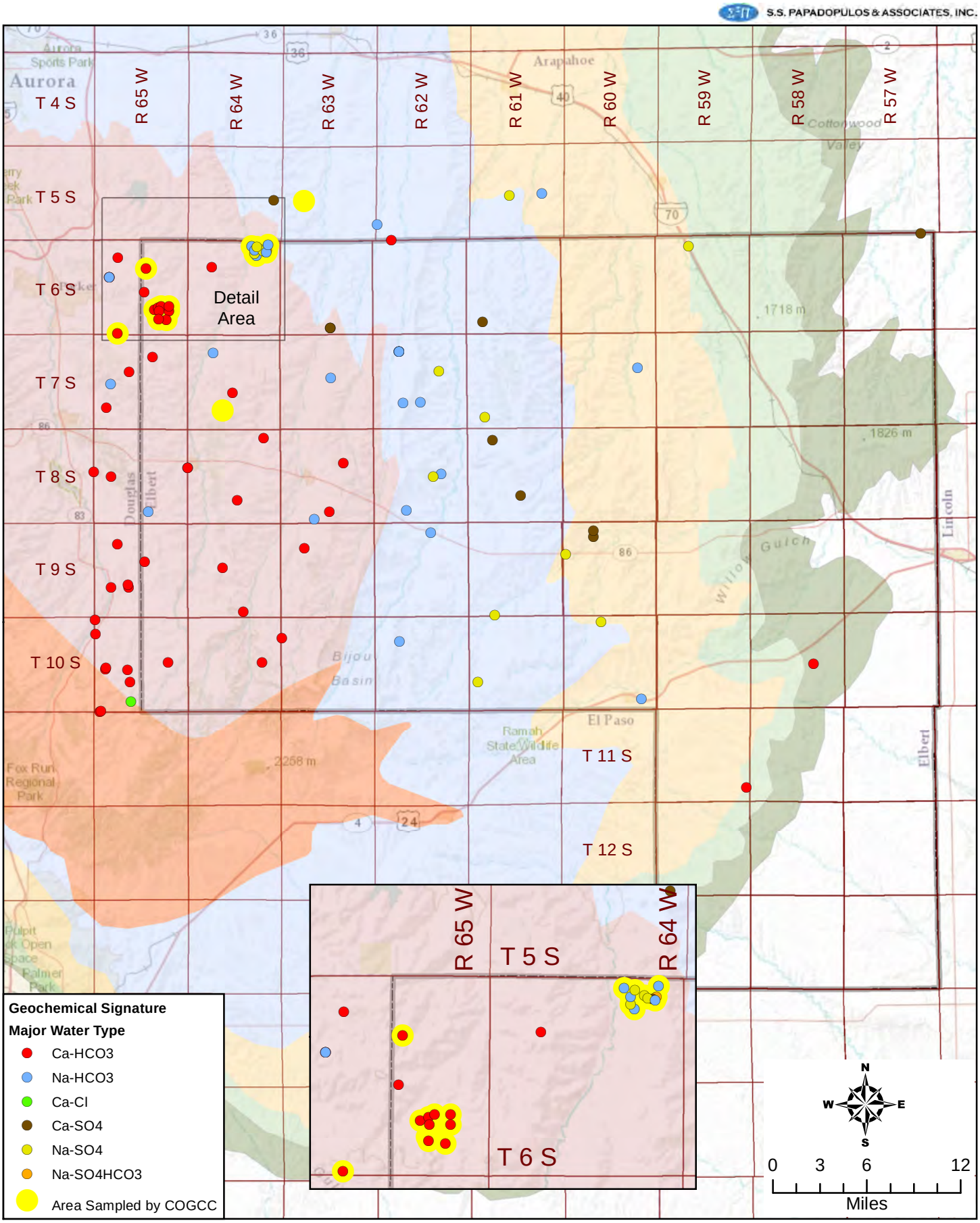

Figure 3.2 Distribution of Geochemical Signatures

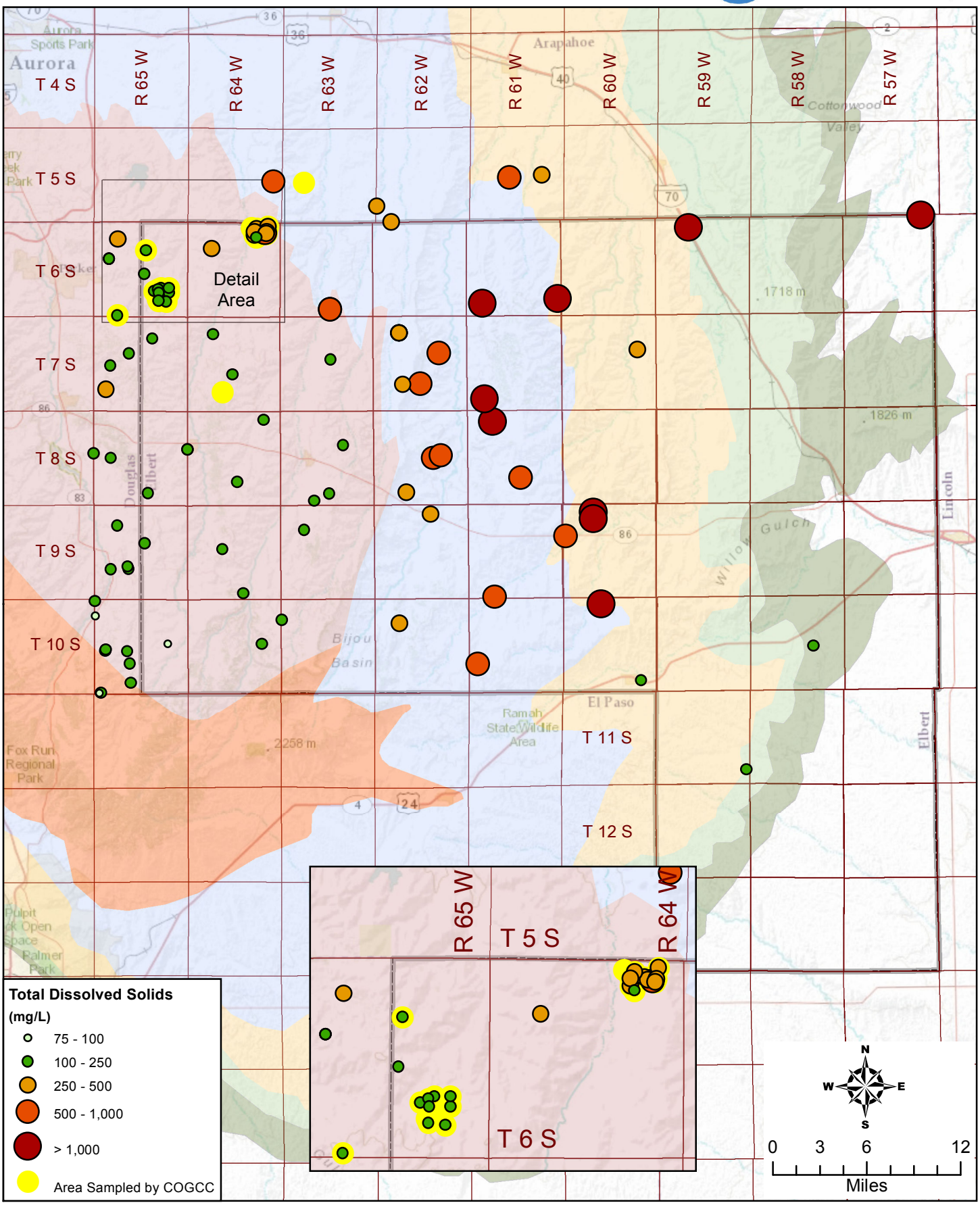

Figure 3.3a Distribution of Total Dissolved Solids (TDS)

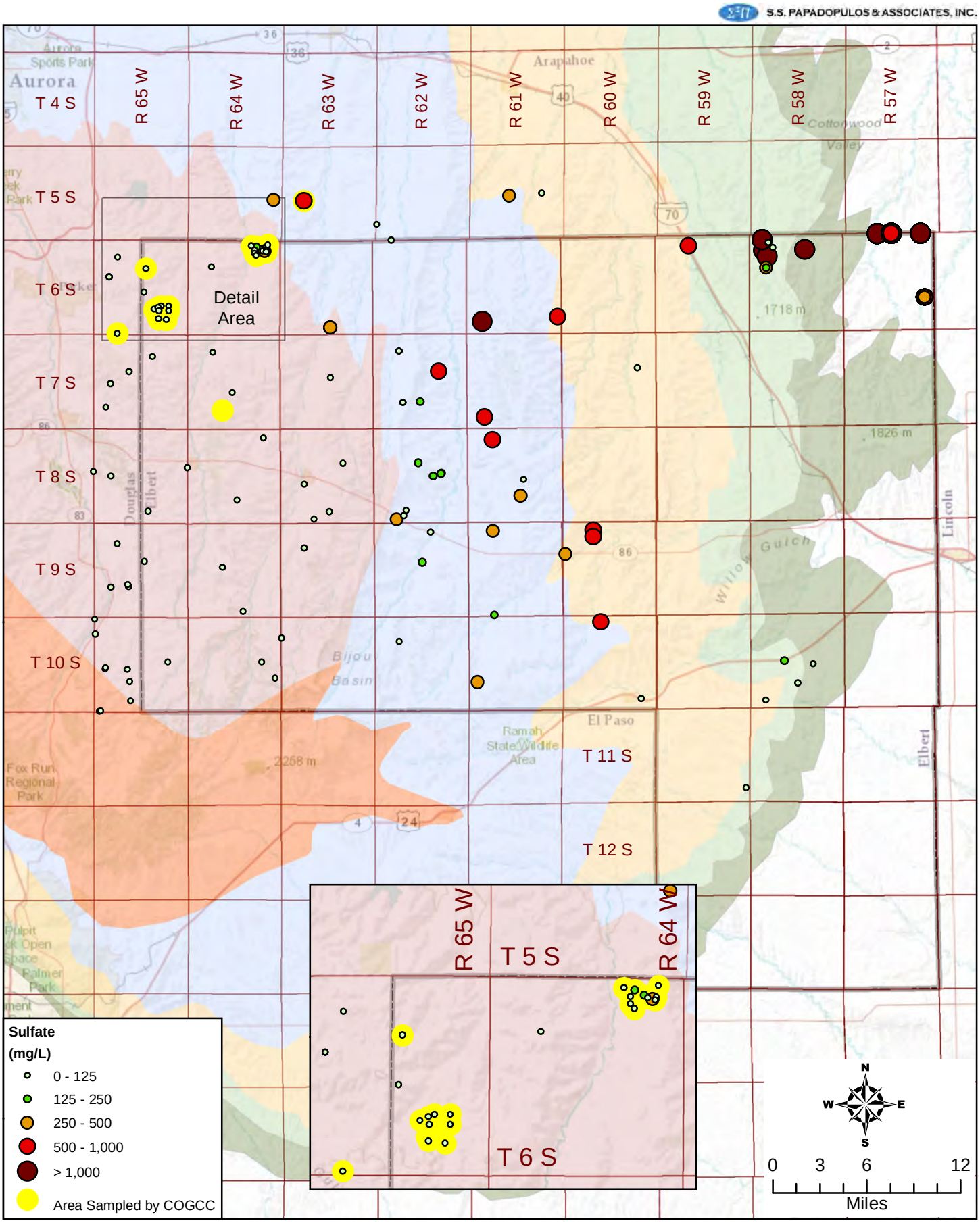

Figure 3.3b Distribution of Sulfate

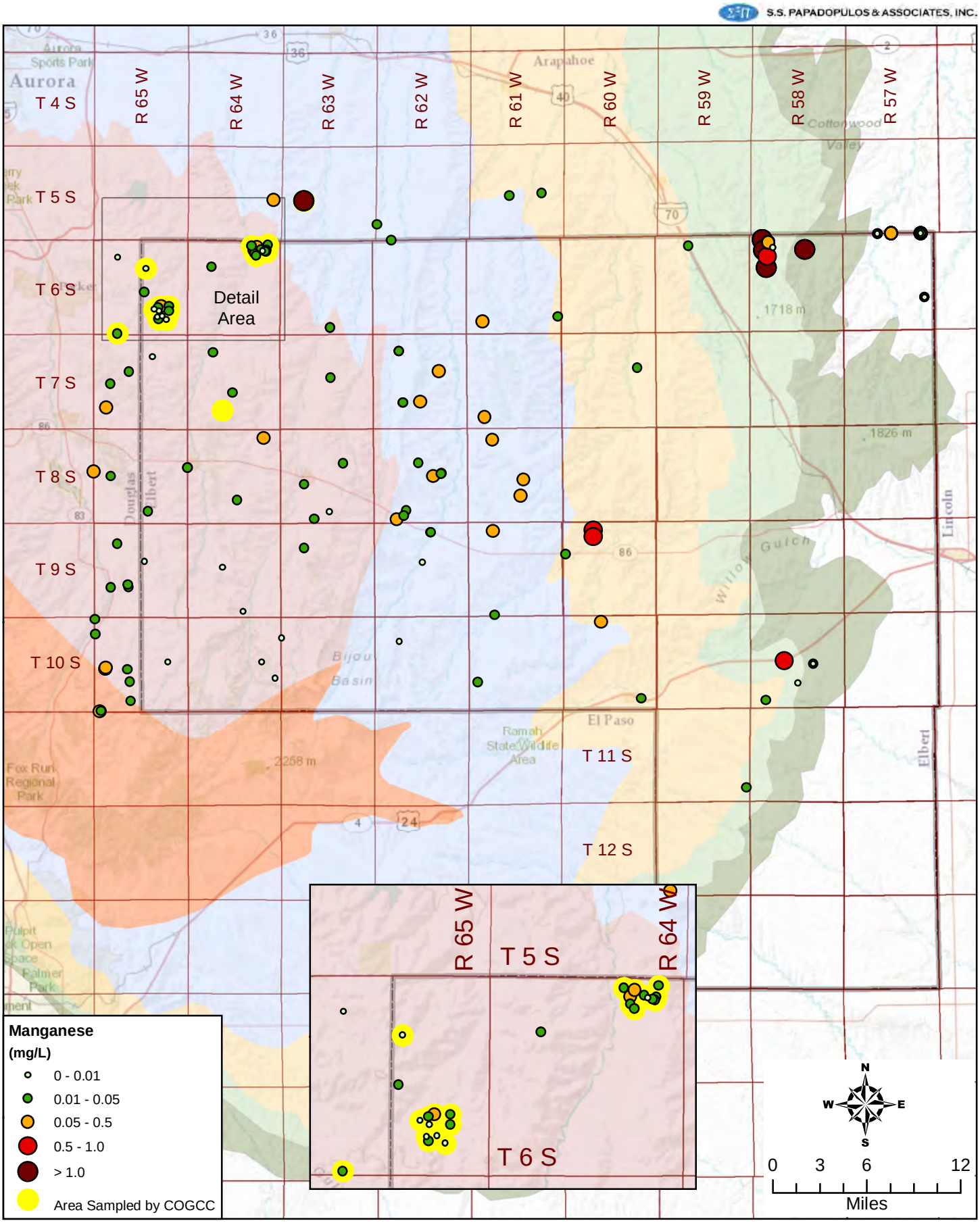

Figure 3.3c Distribution of Manganese

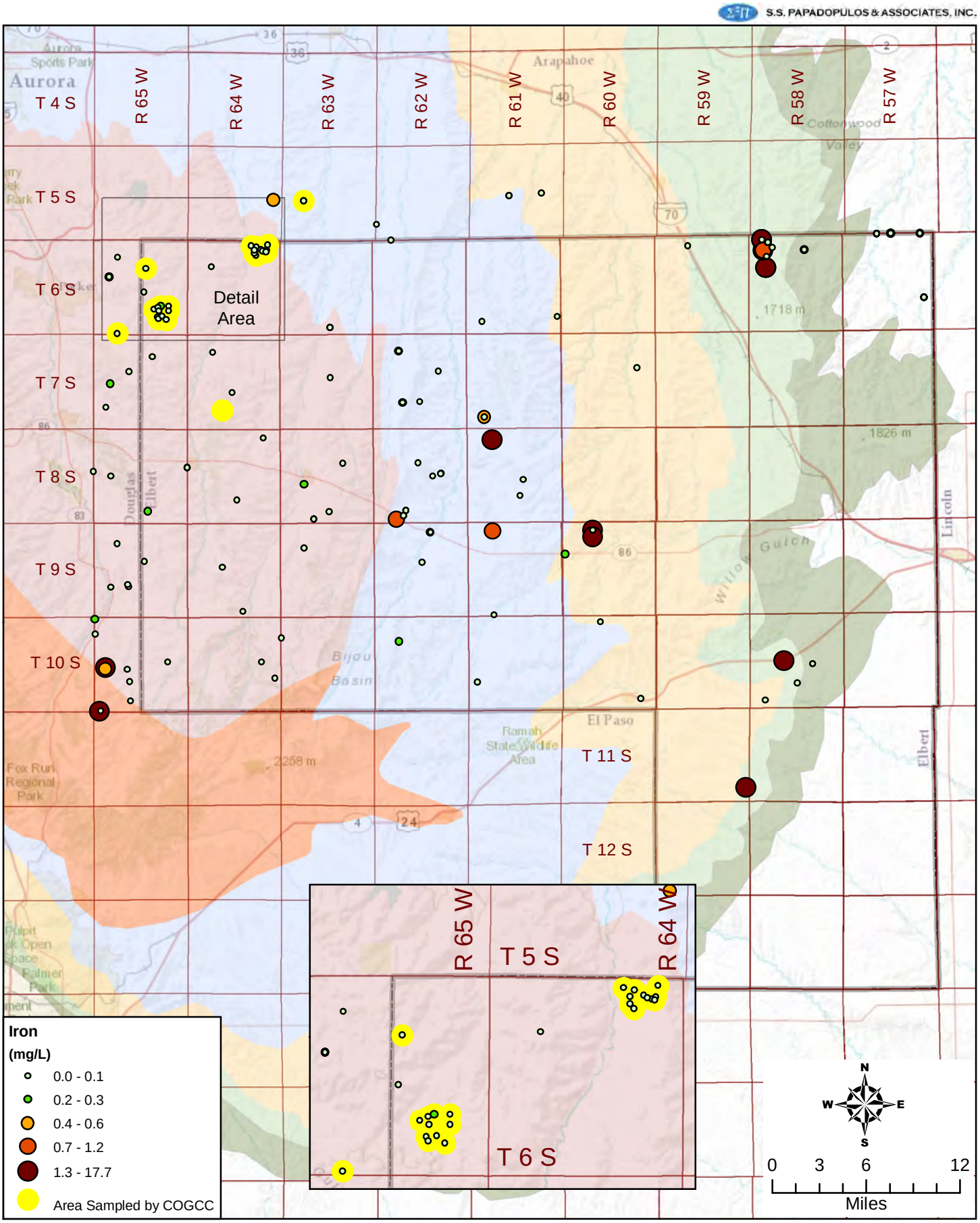

Figure 3.3d Distribution of Iron

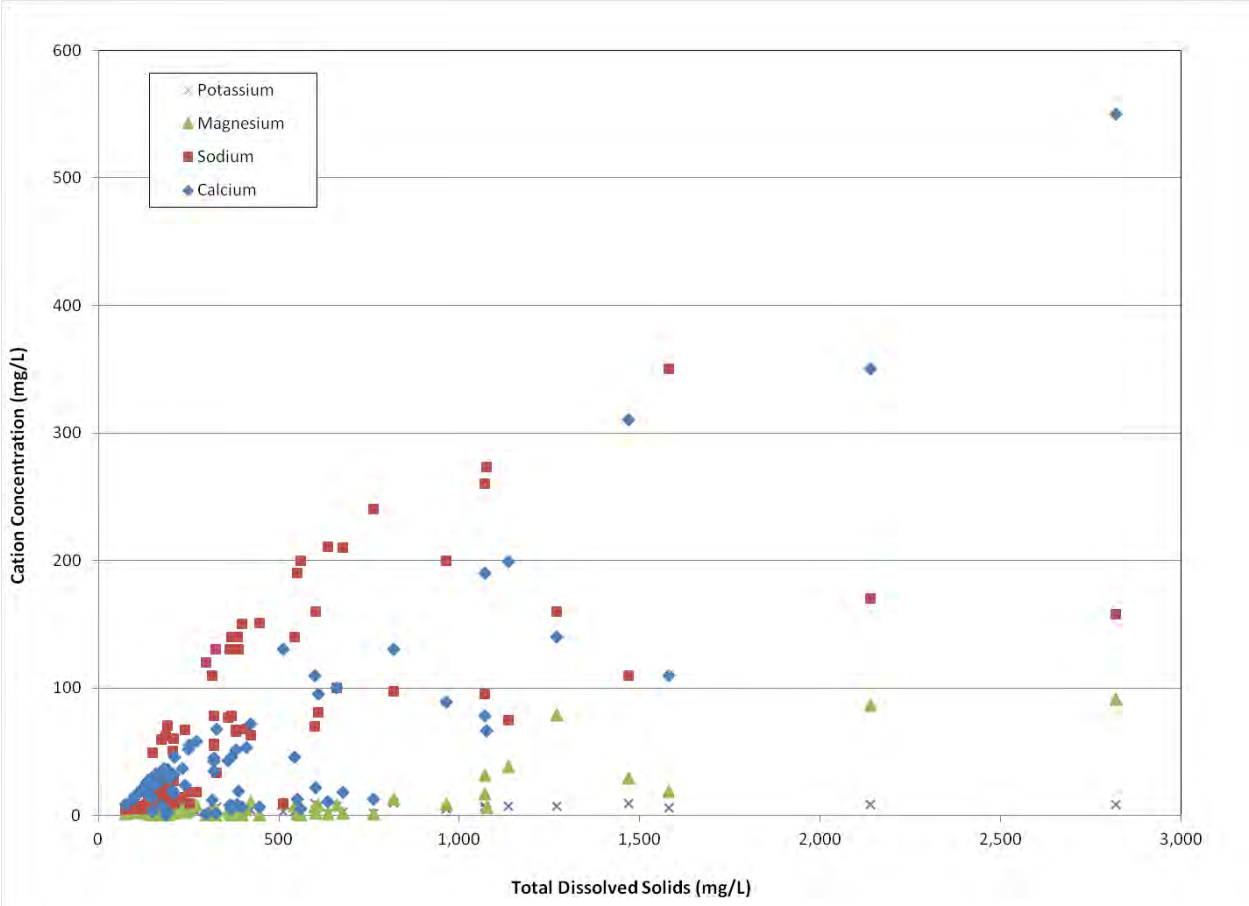

Figure 3.4a Plots of TDS versus Major Cations (Sodium, Calcium, Magnesium, and Potassium)

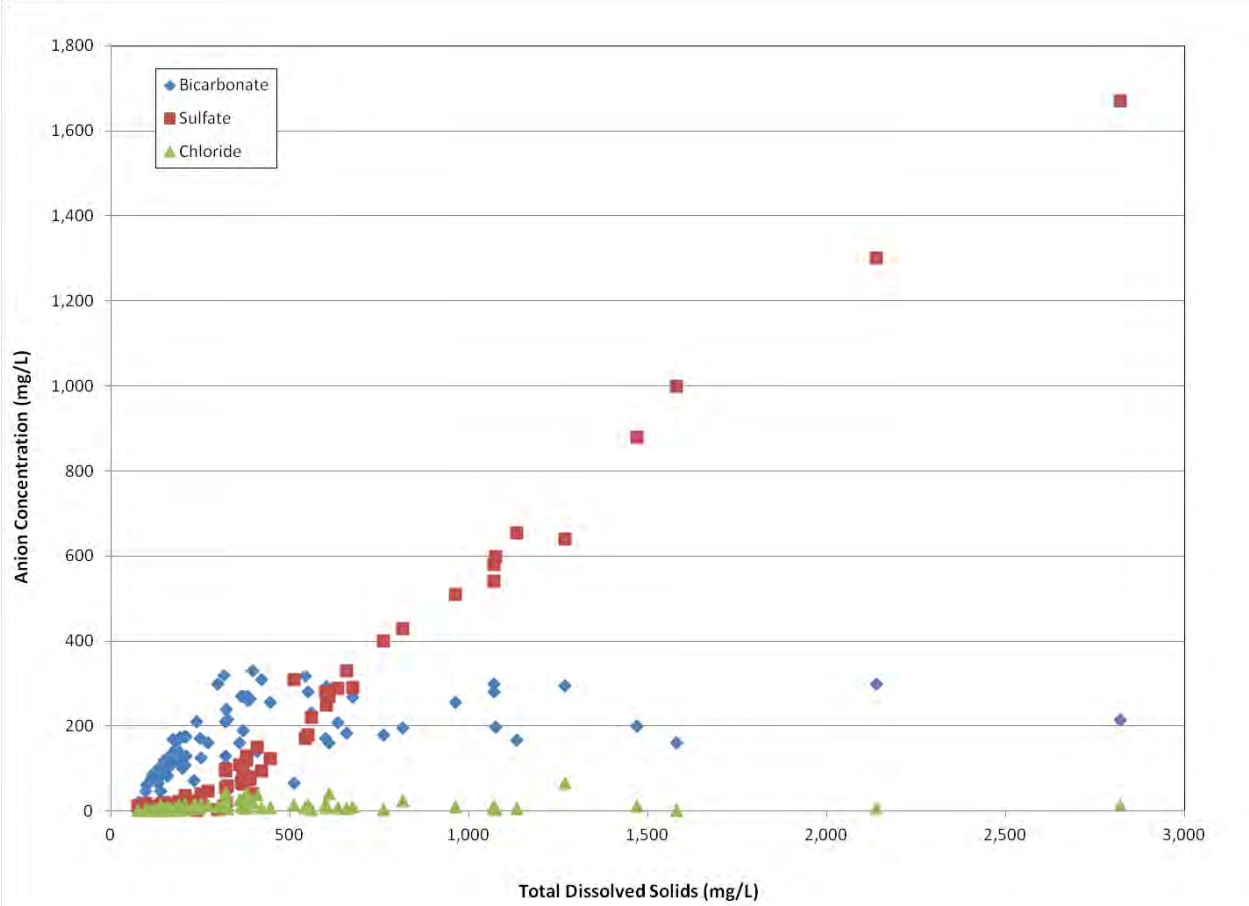

Figure 3.4b Plot of TDS versus Major Anions (Bicarbonate, Sulfate, and Chloride)

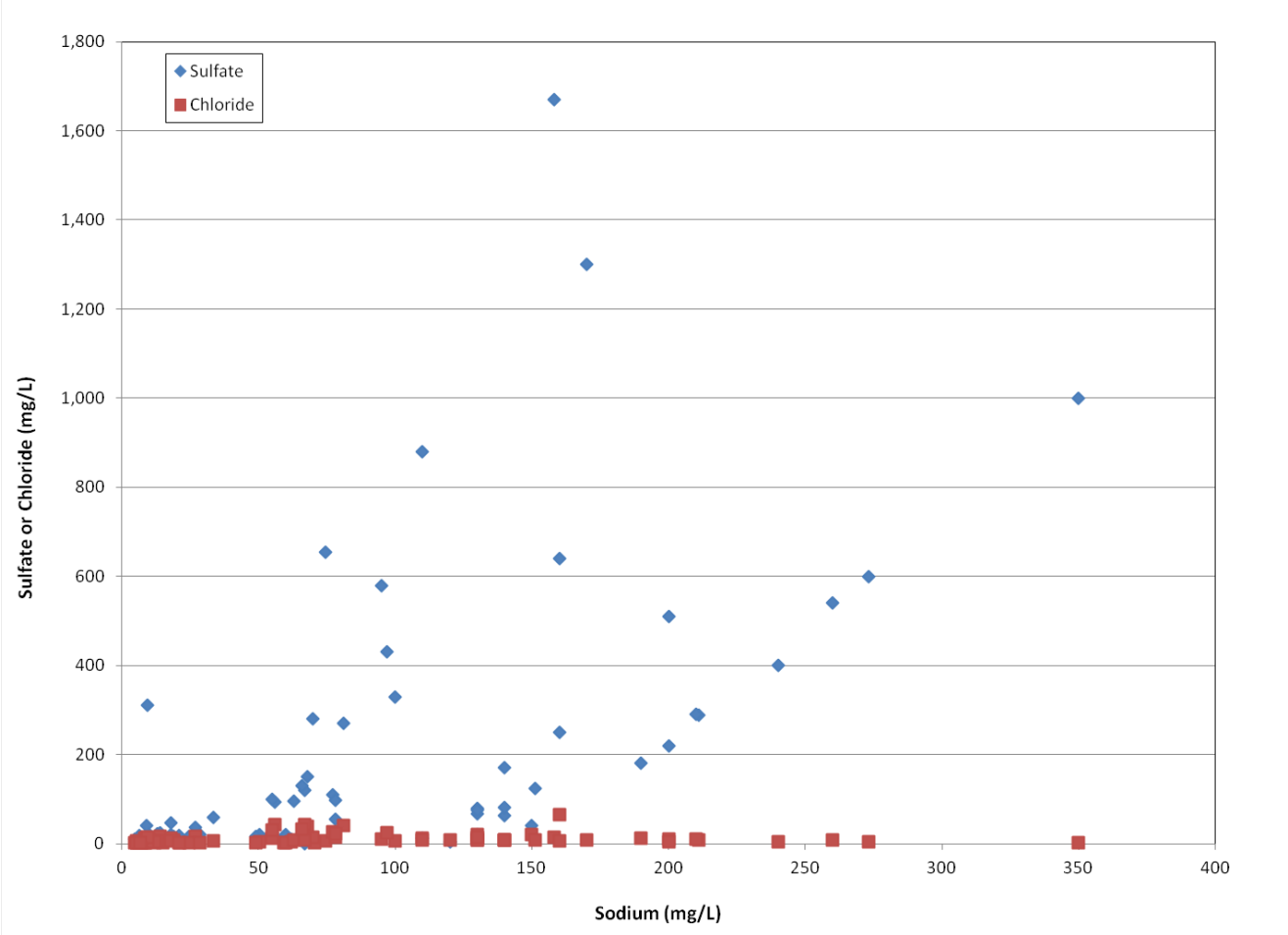

Figure 3.4c Plot of Sodium versus Chloride and Sulfate

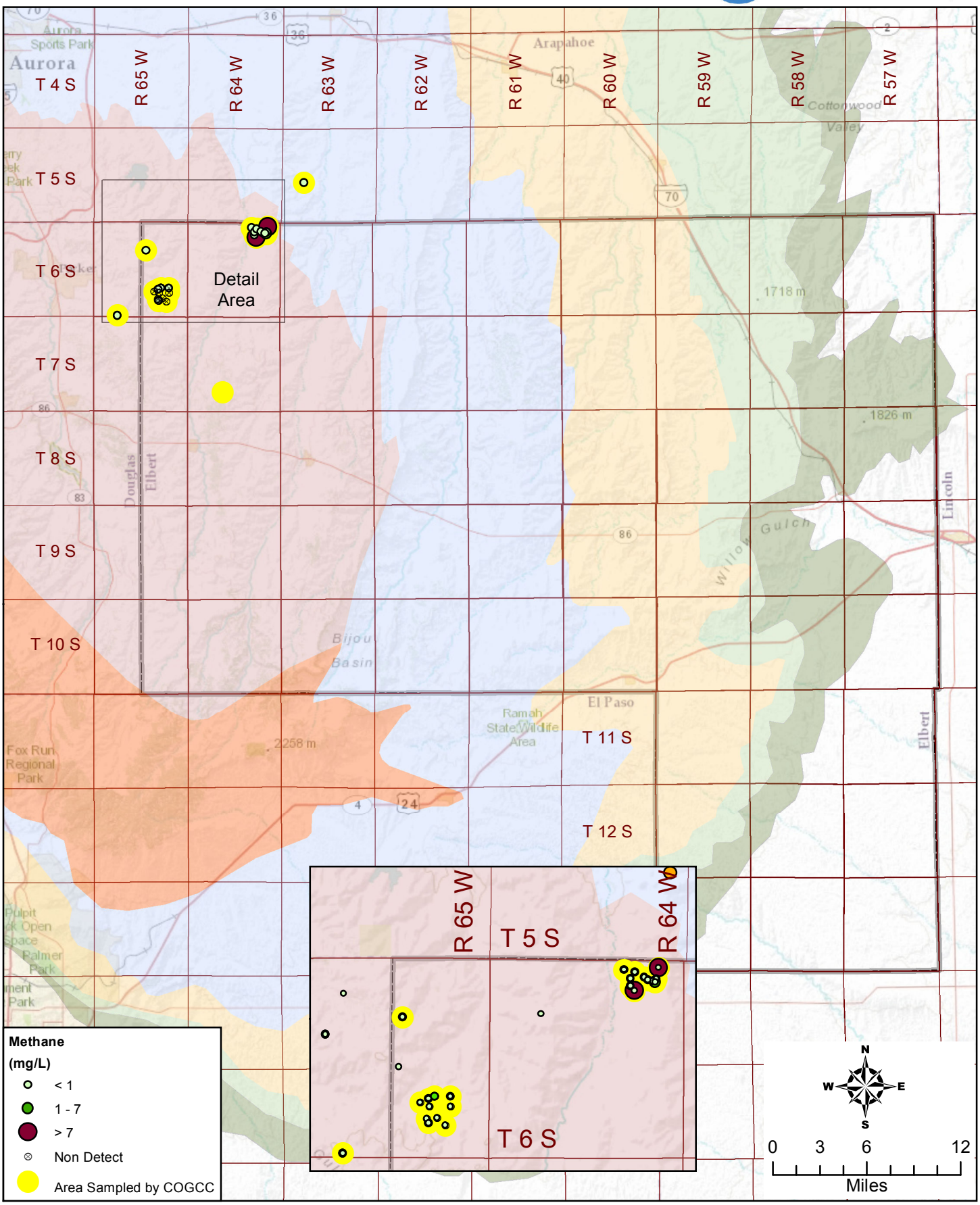

Figure 3.5 Distribution of Methane

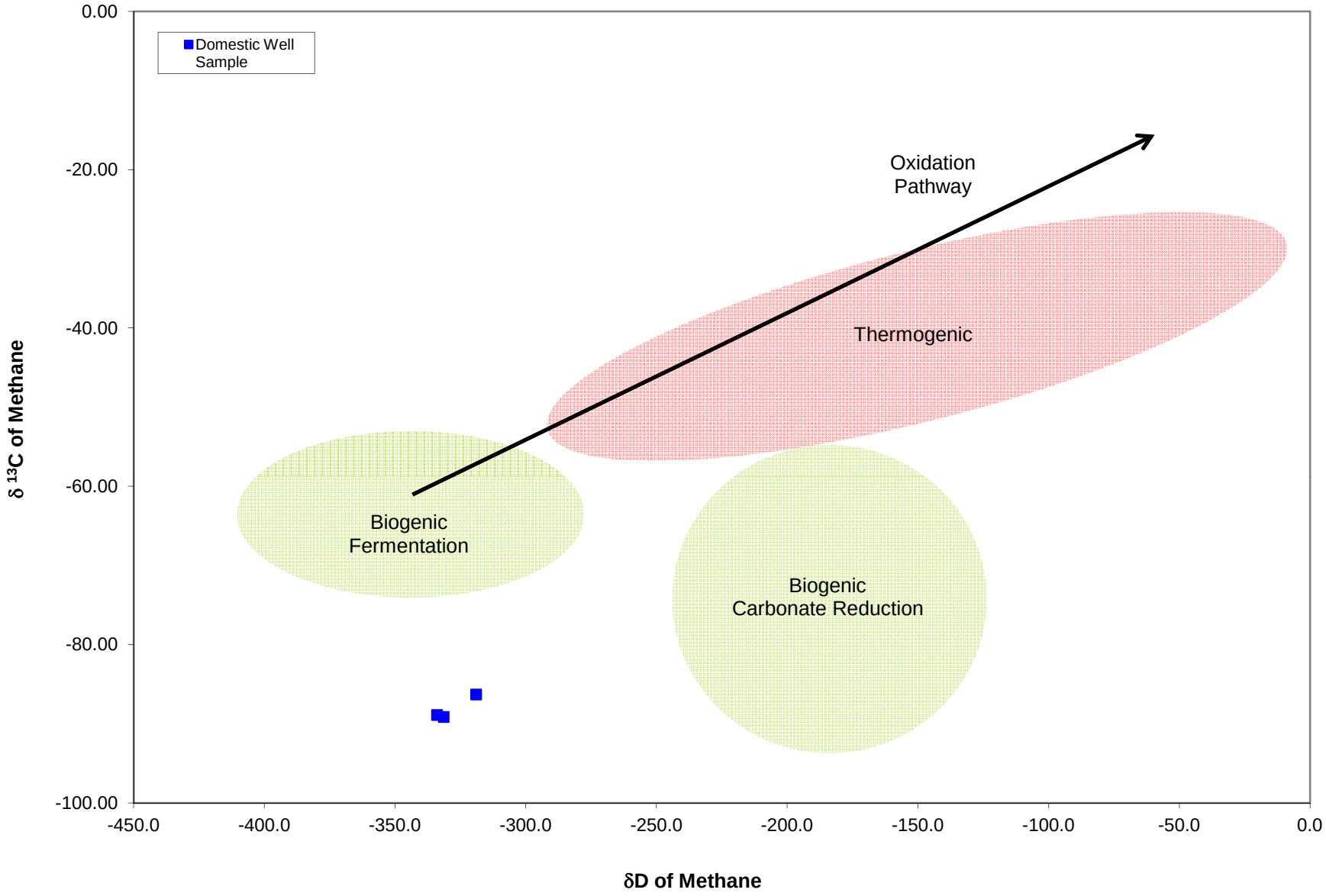

Figure 3.6 Carbon and Hydrogen Isotopes of Methane for Domestic Wells (adapted from Whiticar, 1990)

Tables

Table 3.1
Water Quality Results: Ions, pH and Total Dissolved Solids

Well ID	Sample Date and Time	Sodium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Nitrate Nitrite (mg/L as N)	Bicarbonate (mg/L as CaCO3)	Flouride (mg/L)	pH	Total Dissolved Solids (mg/L)	WATERTYPE
MCL/CO Human Health Standard								**10**		**4**			
Colorado Drinking Water Standard						**250**	**250**				**6.5-8.5**		
ALLEN 1	5/6/11 11:15	67	24	2.6	4.1	8.5	0.53	< 0.019	210	0.95	8.05	240	Na-HCO3
BAKER 1	5/5/11 10:40	68	53	4.6	5.5	39	150	0.065	140	0.45	7.97	410	Na-SO4
BOYD 1	1/18/11 12:10	10	46	5.3	2.9	8.7	21	2.5	130	0.34	7.09	210	Ca-HCO3
CASWELL 1	6/7/11 14:20	55	32	2.8	4.7	13	25	< 0.019	160	0.59	8.16		Na-HCO3
CORSI 1	5/5/11 12:35	81	95	7.8	7.6	41	270	0.12	160	0.38	7.60	610	Ca-SO4
DICCIARDELLO 1	1/12/11 15:00	8.8	29	2.6	2.8	3.1	8.7	0.29	100	0.4	7.01	160	Ca-HCO3
DORMAN 1	1/12/11 12:10	8.6	31	3.6	2.3	3.6	9.3	0.88	100	0.42	7.09	200	Ca-HCO3
EDWARDS 1	5/6/11 12:10	56	42	3.7	4.7	42	94	< 0.019	110	0.47	8.11	320	Na-SO4
EDWARDS II	5/6/11 12:50	55	45	3.7	5.2	30	99	< 0.019	130	0.49	8.10	320	Na-HCO3
FENNEL 1	5/6/11 9:50	18	52	4.8	2.8	6.9	21	0.82	170	0.77	7.08	250	Ca-HCO3
HAMPTON 1	1/12/11 10:05	7.2	27	4.2	1.7	3.1	5.1	0.79	100	0.3	7.11	150	Ca-HCO3
HARPERWW	12/22/10 12:50	9.6	31	2.8	3.5	3.8		0.71	98	< 0.06	7.25	170	-- Censored --
HATTON 1	1/12/11 13:15	12	30	2.6	3.5	3	9.6	< 0.019	110	0.4	7.22	170	Ca-HCO3
HINDS 1	5/5/11 11:30	67	51	4.6	5.4	42	120	0.46	130	0.49	7.91	380	Na-SO4
IRELAND 1	1/18/11 13:42	7.2	28	3.7	2	3.8	7.2	1.3	90	0.36	7.14	140	Ca-HCO3
JACOBS 1	1/12/11 14:10	8.6	33	4.2	2.3	3.5	7.8	1.1	110	0.43	7.06	160	Ca-HCO3
KNIGHT 1	1/12/11 11:10	12	24	1.9	3.5	3.3	13	< 0.019	83	0.4	7.26	140	Ca-HCO3
KREUTZER 1	1/12/11 15:45	9.2	28	2.3	3	3.4	7.4	0.73	92	0.37	7.08	140	Ca-HCO3
LUKE 1	5/5/11 13:20	77	43	4	5.4	26	110	< 0.019	160	0.69	7.95	360	Na-SO4HCO3
PETTINGER 1	5/5/11 14:50	66	51	4.1	5.6	33	130	< 0.019	130	0.47	8.03	380	Na-SO4
PURVIS 1	5/5/11 9:45	78	35	3.5	4.7	15	55	< 0.019	210	0.92	8.03	320	Na-HCO3
SKOGLUND 1	5/5/11 14:05	78	46	4.1	5.1	23	97	< 0.019	190	0.77	8.02	370	Na-HCO3
VAILWW	10/29/10 10:50	9	31	3.1				0.6			7.15	160	-- Censored --
Weimer	11/14/02 0:00	0.11	0.16	0.027		27.5	534	< 0.056		0.57		1150	-- Censored --
Zlatev Water Well	10/13/11 14:06	9.2	30	3.5	2.3 J	4.4	9.2	0.99 B		0.37 J	7.02	160 B	-- Censored --
06758700	9/29/75 13:05	160	140	79	7.5	65	**640**	3.3	294	1.1	8.30	1270	- Surface Water -
390316103563801	10/4/78 16:00	6.6	18	4.8	2	1.9	9.4	1.2	78	0.3	**6.20**	114	Ca-HCO3
390747104424101	5/6/77 10:00	6.4	13	3	3.3	3.1	18	0.06	48	0.1	**6.40**	98	Ca-HCO3
390748104423600	3/13/73 0:00	8.2	21	3.6	1.8	13	13	5.1	48	0.1	7.10	139	Ca-HCO3
390817104040301	9/21/78 12:20	49	3.4	0.4	0.9	1.6	16	0.26	120	0.5	7.40	150	Na-HCO3

NOTES: **<** = Less than, **B** = compound found in blank and sample, **J** = result is less than the RL but greater than or equal to the MDL-approximate value shown

Table 3.1, continued
Water Quality Results: Ions, pH and Total Dissolved Solids

Well ID	Sample Date and Time	Sodium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Nitrate Nitrite (mg/L as N)	Bicarbonate (mg/L as CaCO3)	Flouride (mg/L)	pH	Total Dissolved Solids (mg/L)	WATERTYPE
390821104402901	5/3/77 11:30	14	37	5.4	11	16	25	**13**	71	0.2	6.50	233	Ca-Cl
390917104154201	5/17/82 13:00	210	18	1.9	2.5	10	**290**	0.171	268	1.9	8.40	676	Na-SO4
390926104403200	2/17/77 15:30	8.4	23	5.2	3.6	6.7	7.1	1.5	92	0.1	6.50	134	Ca-HCO3
391006104404201	5/5/77 16:00	27	32	6.1	1.9	16	37	0.88	110	0.5	6.90	209	Ca-HCO3
391007103514501	9/21/78 11:35	21	25	4.9	3.1	1.7	18	0.57	130	0.6	7.50	164	Ca-HCO3
391008104421800	11/24/76 12:30	13	34	7.8	12	13	22	0.08	134	0.2	6.60	191	Ca-HCO3
391012104421600	11/24/76 13:00	8.9	25	5.1	3.2	4.7	19	0.01	100	0.2	**6.00**	145	Ca-HCO3
391028104310701	10/13/78 14:10	7	20	2.4	1.9	2.2	4.7	0.37	85	0.4	6.70	120	Ca-HCO3
391030104374901	10/4/78 10:45	5.3	15	2.7	1.5	2.2	5.3	1	61	0.4	**5.80**	100	Ca-HCO3
391135104211601	10/4/78 13:00	150	6.6	0.6	2	21	40	0.01	330	2.7	6.90	397	Na-HCO3
391148104294101	12/8/04 10:45	6.24	20.7	3.11	1.52	2.49	6.33	1.25	77	0.32	7.60	126	Ca-HCO3
391204104430000	2/10/77 11:30	4.7	8.4	1.3	0.8	1.4	11	2.4	20	0.1	**6.10**	75	Ca-HCO3
391234104065201	9/21/78 12:50	350	110	19	5.9	2.5	**1000**	0.01	160	0.3	7.40	1580	Na-SO4
391253104430000	2/9/77 14:30	19	31	4.6	1.4	8.9	16	0.52	127	0.4	6.90	185	Ca-HCO3
391300104142801	9/21/78 9:00	200	5	0.6	1.4	3.3	220	0.49	230	0.8	**8.70**	561	Na-SO4
391318104322501	10/4/78 11:35	5.7	15	2.6	1.4	2.5	3.9	1.3	65	0.3	**6.00**	105	Ca-HCO3
391440104415200	2/10/77 10:00	6.9	21	3.9	2	3.5	8.3	3.1	71	0.3	6.90	129	Ca-HCO3
391441104403600	2/11/77 11:15	8.8	27	4.6	1.5	9.1	17	2.5	82	0.3	6.60	158	Ca-HCO3
391449104404000	2/11/77 12:15	5.5	21	3.8	1.9	5.7	10	2.4	66	0.3	6.50	132	Ca-HCO3
391545104335401	11/22/04 9:50	6.89	23.8	3.31	1.89	2.44	6.31	0.762	93	0.43	7.60	132	Ca-HCO3
391606104392701	12/1/04 10:30	7.25	20.3	3.2	2.06	1.91	7.32	0.886	86	0.39	**6.40**	118.5	Ca-HCO3
391622104092201	9/21/78 9:35	240	13	1.2	1.9	3.4	**400**	0.79	180	0.6	8.10	762	Na-SO4
391648104280201	9/18/78 11:10	8.5	25	3.2	1.7	3.6	7.9	0.77	100	0.4	7.40	136	Ca-HCO3
391705104412301	10/13/78 10:20	9.3	30	4.6	2.7	5.9	9	2.5	100	0.5	**6.10**	158	Ca-HCO3
391719104072301	9/21/78 10:05	95	190	31	7.3	11	**580**	0.02	280	0.7	7.50	1070	Ca-SO4
391737104185901	9/18/78 9:45	140	5	0.4	1.3	8.2	64	0.07	270	1.7	**8.60**	369	Na-HCO3
391740104072401	7/14/05 11:30	74.5	199	38	6.97	5.67	**655**	0.028	166	1.12	7.10	1135	Ca-SO4
391825104272101	9/28/05 13:00	59.4	8.1	0.47	1.83	2.41	15.6	0.03	168	0.97	7.50	174.5	Na-HCO3
391848104261401	12/14/04 12:00	8.32	31.4	5.88	2.03	4.49	11.5	0.77	123	0.4	6.50	172.5	Ca-HCO3
391851104204501	12/29/05 11:50	151	6.24	0.638	1.56	7.37	124	0.03	255	1.63	8.50	445.5	Na-HCO3
391852104391301	11/17/04 9:50	21.4	16.2	1.16	2.76	1.63	9.17	0.068	96	0.53	7.10	137	Na-HCO3
391930104324901	9/18/78 12:00	6.2	24	3.8	1.1	2.1	11	1.7	87	0.5	7.60	137	Ca-HCO3

NOTES: **<** = Less than, **B** = compound found in blank and sample, **J** = result is less than the RL but greater than or equal to the MDL-approximate value shown

Table 3.1, continued
Water Quality Results: Ions, pH and Total Dissolved Solids

Well ID	Sample Date and Time	Sodium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Nitrate Nitrite (mg/L as N)	Bicarbonate (mg/L as CaCO3)	Flouride (mg/L)	pH	Total Dissolved Solids (mg/L)	WATERTYPE
391938104123301	5/18/82 9:25	100	100	8.1	7.4	6.1	**330**	0.165	183	0.5	7.10	659	Ca-SO4
392045104184601	5/18/82 10:55	160	22	2	3.2	6.8	**250**	0.022	293	0.9	8.30	602	Na-SO4
392050104415000	11/2/76 14:30	8.3	24	3.2	2.4	2.8	10	0.2	99	0.4	6.90	140	Ca-HCO3
392053104181301	9/18/78 9:15	190	13	1.3	2.6	13	180	0.59	280	1	8.20	552	Na-HCO3
392107104430400	11/4/76 9:30	10	25	3.3	3.2	3.9	9.3	0.2	110	0.4	6.90	150	Ca-HCO3
392118104362301	12/27/05 11:00	70.4	2.33	0.408	1.53	1.64	10.5	0.03	168	1.63	7.80	191.5	Na-HCO3
392119104362401	3/11/03 13:00	15	19.5	1.07	2.86	1.42	7.51	0.461	92	0.39	7.50	138.5	Ca-HCO3
392130104251201	9/18/78 10:10	9	27	3.4	2.7	3.7	10	0.65	100	0.5	7.70	143	Ca-HCO3
392244104143201	10/9/78 14:00	110	310	29	9.4	12	**880**	0.01	200	0.4	7.20	1470	Ca-SO4
392254104305601	12/14/04 12:05	24.5	29	1.46	4.02	2.94	16.8	0.03	173	0.43	6.80	193	Ca-HCO3
392400104150601	7/14/05 15:30	273	66.7	6.3	4.73	4.15	**599**	0.03	198	0.44	7.50	1075	Na-SO4
392440104420901	6/29/77 15:30	18	58	7.8	2.6	13	46	2.8	160	0.5	7.10	271	Ca-HCO3
392451104205401	10/9/78 14:40	110	12	1.3	3.1	7.7	12	0.02	320	1.9	8.00	316	Na-HCO3
392453104194101	5/18/82 14:00	140	46	7.2	3.2	8.7	170	0.179	317	1.5	7.60	544	Na-HCO3
392528104330601	9/18/78 13:05	13	26	5.3	1.5	5.4	17	1.7	110	0.6	7.50	159	Ca-HCO3
392559104415201	8/25/05 14:00	60	17.3	1.72	2.98	3.08	20.8	0.03	176	1.75	8.20	209.5	Na-HCO3
392616104260601	11/17/04 13:30	50.3	19.9	1.62	3.71	3.69	21.3	0.03	175	1.36	6.90	205.5	Na-HCO3
392635104181901	5/18/82 14:20	200	89	8.7	5.1	9.6	**510**	0.89	256	0.8	7.90	964	Na-SO4
392639104403001	9/18/78 13:45	5.4	26	3.5	2	2.2	5.5	0.71	100	0.3	7.60	134	Ca-HCO3
392640104040501	10/9/78 13:10	130	1.5	0.1	0.7	15	20	0.36	240	0.9	**8.80**	324	Na-HCO3
392727104385201	12/28/04 9:50	9.74	36.4	7.06	1.87	3.28	15.4	5.57	117	0.4	7.70	191.5	Ca-HCO3
392741104343101	11/16/04 10:00	28.5	14.3	1.07	3.01	1.66	19.7	0.032	92	0.74	7.60	147.5	Na-HCO3
392743104210901	4/14/77 11:30	140	7.8	1.3	2	7.6	81	0.05	260	1.2	8.50	385	Na-HCO3
392743104210901	5/5/77 13:45	130	7.8	0.8	2.3	12	67	0.02	270	1.5	8.40	364	Na-HCO3
392743104210901	6/30/77 11:15	130	7.9	0.9	2	7.6	77	0.07	270	1.3	8.40	370	Na-HCO3
392743104210901	10/18/77 11:15	130	8.7	1	2	7.4	80	0.4	270	0.5	8.10	383	Na-HCO3
392903104260501	9/19/78 11:45	70	110	6.3	9.5	15	**280**	0.32	170	0.8	7.40	600	Ca-SO4
392903104260501	5/12/82 9:47	9.4	130	9.1	2.9	14	**310**	0.048	66	1.5	7.90	513	Ca-SO4
392920104151001	10/9/78 17:15	170	350	86	8.6	8.2	**1300**	**13**	300	1.5	8.20	2140	Ca-SO4
393104104392501	9/18/78 14:50	12	30	2.7	3.5	3.7	12	0.11	120	0.5	6.80	164	Ca-HCO3
393156104415501	8/24/64 0:00	13	37	2.4	3.3	5	10	0.09	147	0.2	7.30	182	Ca-HCO3

NOTES: **<** = Less than, **B** = compound found in blank and sample, **J** = result is less than the RL but greater than or equal to the MDL-approximate value shown

Table 3.1, continued
Water Quality Results: Ions, pH and Total Dissolved Solids

Well ID	Sample Date and Time	Sodium (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Nitrate Nitrite (mg/L as N)	Bicarbonate (mg/L as CaCO3)	Flouride (mg/L)	pH	Total Dissolved Solids (mg/L)	WATERTYPE
393156104415501	9/14/65 0:00	13	36	4.1	3.2	4.9	17	0.361	142	0.6	7.70	181	Ca-HCO3
393156104415501	8/15/66 0:00	62	0.2	1.8	0.6	5	10	0.497	144	0.5	7.90	187	Na-HCO3
393227104343401	11/8/04 11:00	33.5	67.5	3.93	6.9	5.45	59.7	0.03	216	0.58	7.20	327	Ca-HCO3
393300104411901	12/20/04 17:30	9.09	55.5	4.96	2.74	15.4	40.7	3.98	125	0.35	**6.40**	253	Ca-HCO3
393326104002001	10/9/78 11:50	260	78	17	5	8.3	**540**	0.05	300	0.1	7.10	1070	Na-SO4
393353104213901	9/19/78 11:10	63	72	11	4.3	7.5	95	0.21	310	0.9	7.70	422	Ca-HCO3
393358103434200	10/11/01 15:30	158	550	90.9	8.8	13.7	**1670**	0.095	215	0.21	6.90	2820	Ca-SO4
393445104224201	11/29/05 13:40	130	18.8	1.69	2.99	19.6	74.7	0.03	263	1.24	7.90	389	Na-HCO3
393610104300601	5/12/82 10:46	97	130	13	10	24	**430**	0.129	195	1.1	7.60	817	Ca-SO4
393617104131101	6/29/05 11:30	211	10.6	0.889	1.65	8.08	**288**	0.03	208	0.8	8.50	635	Na-SO4
393626104104901	10/9/78 10:15	120	1.2	0.4	0.9	8.8	4	0.45	300	0.8	8.10	299	Na-HCO3

NOTES: **<** = Less than, **B** = compound found in blank and sample, **J** = result is less than the RL but greater than or equal to the MDL-approximate value shown

Table 3.2
Water Quality Results: Drinking Water Metals, Halides and Dissolved Methane

Well ID	Sample Date and Time	Arsenic (mg/L)	Barium (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Iron (mg/L)	Manganese (mg/L)	Lead (mg/L)	Selenium (mg/L)	Bromide (mg/L)	Methane (mg/L)
MCL/CO Human Health Standard		**0.01**	**2**	**0.005**	**0.1**			**0.05**	**0.05**		
Colorado Drinking Water Standard						**0.3**	**0.05**				
ALLEN 1	5/6/11 11:15	< 0.0044	0.15	< 0.00045	< 0.00066	< 0.022	0.012	0.0026 J	< 0.0049	0.19 J	**8.7**
BAKER 1	5/5/11 10:40	< 0.0044	0.012	< 0.00045	< 0.00066	0.027 J	0.044	< 0.0026	< 0.0049	0.48	0.0074
BOYD 1	1/18/11 12:10					< 0.022	0.0006 JB		< 0.0049	< 0.00011	< 0.00022
CASWELL 1	6/7/11 14:20	< 0.0044	0.13 B	< 0.00045	< 0.00066	0.042 JB	0.036	< 0.0026	< 0.0049	0.2	0.25
CORSI 1	5/5/11 12:35	< 0.0044	0.011	< 0.00045	< 0.00066	< 0.022	0.0063 J	0.0031 J	0.021	0.48	0.00052 J
DICCIARDELLO 1	1/12/11 15:00					< 0.022	0.0012 JB		0.0067 J	< 0.00011	< 0.00022
DORMAN 1	1/12/11 12:10					< 0.022	0.0015 JB		< 0.0049	< 0.00011	< 0.00022
EDWARDS 1	5/6/11 12:10	< 0.0044	0.082	< 0.00045	< 0.00066	< 0.022	0.041	< 0.0026	< 0.0049	0.39	0.077
EDWARDS II	5/6/11 12:50	< 0.0044	0.036	< 0.00045	< 0.00066	< 0.022	**0.056**	< 0.0026	0.0061 J	0.36	0.025
FENNEL 1	5/6/11 9:50	0.0084 J	0.068	< 0.00045	< 0.00066	< 0.022	< 0.00025	< 0.0026	0.0093 J	0.13 J	0.00022 J
HAMPTON 1	1/12/11 10:05					< 0.022	0.0068 JB		< 0.0049	< 0.00011	0.00035 JP
HARPERWW	12/22/10 12:50	< 0.0044	0.043	< 0.00045	< 0.00066	< 0.022	< 0.00025	< 0.0026	0.02		< 0.00022
HATTON 1	1/12/11 13:15					0.26	**0.057 B**		< 0.0049	< 0.00011	0.00067 J
HINDS 1	5/5/11 11:30	< 0.0044	0.034	< 0.00045	< 0.00066	< 0.022	< 0.00025	< 0.0026	0.0058 J	0.52	0.011
IRELAND 1	1/18/11 13:42					0.029 J	0.00041 JB		< 0.0049	< 0.00011	< 0.00022
JACOBS 1	1/12/11 14:10					< 0.022	0.00061 JB		0.0052 J	< 0.00011	< 0.00022
KNIGHT 1	1/12/11 11:10					0.031 J	0.031 B		< 0.0049	< 0.00011	<0.00022
KREUTZER 1	1/12/11 15:45					< 0.022	0.0017 JB		0.005 J	< 0.00011	<0.00022
LUKE 1	5/5/11 13:20	< 0.0044	0.041	< 0.00045	< 0.00066	0.024 J	0.037	< 0.0026	< 0.0049	0.38	0.034
PETTINGER 1	5/5/11 14:50	< 0.0044	0.019	< 0.00045	< 0.00066	0.04 J	**0.056**	< 0.0026	< 0.0049	0.42	0.018
PURVIS 1	5/5/11 9:45	< 0.0044	0.13	< 0.00045	< 0.00066	< 0.022	0.026	< 0.0026	< 0.0049	0.24	**5.9**
SKOGLUND 1	5/5/11 14:05	< 0.0044	0.11	< 0.00045	< 0.00066	0.037 J	0.047	< 0.0026	0.0049 J	0.3	**11**
VAILWW	10/29/10 10:50					< 0.022	< 0.00025				< 0.00022
Weimer	11/14/02 0:00					***28 B***	**2.1**				0.29

NOTES:

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- Does not include monitoring wells northeast of I-70 within the area of interest

Table 3.2, continued
Water Quality Results: Drinking Water Metals, Halides and Dissolved Methane

Well ID	Sample Date and Time	Arsenic (mg/L)	Barium (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Iron (mg/L)	Manganese (mg/L)	Lead (mg/L)	Selenium (mg/L)	Bromide (mg/L)	Methane (mg/L)
ZLATEV WATER WELL		0.0089 J	0.039	< 0.00045	< 0.00066	< 0.022	< 0.00025	< 0.0026	0.0057 J	< 0.00011	< 0.00022
06758700	9/29/75 13:05					0.03	0.01 <				
390316103563801	10/4/78 16:00					**1.6**	0.03				
390747104424101	5/6/77 10:00	0.001				**2.6**	**0.25**		0.001 <		
390748104423600	3/13/73 0:00					0.05	0.01 <				
390807103551101	9/6/79 11:55					0.07	0.03				
390817104040301	9/21/78 12:20					0.06	0.02				
390821104402901	5/3/77 11:30	0.001				0.03	0.01 <		0.003		
390904103525201	9/6/79 13:15					0.02	M				
390917104154201	5/17/82 13:00					0.02	0.03	M	0.001		
390926104403200	2/17/77 15:30	0.001				0.01 <	0.01 <		0.001 <		
390935104301001	12/7/04 15:15	0.0058	0.037	0.00004 <	0.0008 <	0.006 <	0.0002 <	0.0004	0.001	0.04	
391006104404201	5/5/77 16:00	0.002				0.08	0.04		0.001 <		
391007103514501	9/6/79 15:00					0.01 <	M				
391007103514501	9/21/78 11:35					0.01 <	0.01 <				
391008104421800	11/24/76 12:30	0.002				**0.4**	**0.33**		0.001 <		
391012104421600	11/24/76 13:00	0.001				**2**	**0.26**		0.001 <		
391017103534801	9/6/79 10:30					**2.3**	**0.62**				
391028104310701	10/13/78 14:10					0.01 <	M				
391030104374901	10/4/78 10:45					0.01 <	0.001 <				
391135104211601	10/4/78 13:00					0.16	M				
391148104294101	12/8/04 10:45	0.0047	0.029	0.00004 <	0.0008 <	0.006 <	0.0002 E	0.00057	0.0024	0.05	
391204104430000	2/10/77 11:30	0.001				0.02	0.01 <		0.002		
391234104065201	9/21/78 12:50					0.02	**0.36**				
391253104430000	2/9/77 14:30	0.012				0.26	0.03		0.001		
391300104142801	9/21/78 9:00					0.1	0.02				

NOTES:

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- Does not include monitoring wells northeast of I-70 within the area of interest

Table 3.2, continued
Water Quality Results: Drinking Water Metals, Halides and Dissolved Methane

Well ID	Sample Date and Time	Arsenic (mg/L)	Barium (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Iron (mg/L)	Manganese (mg/L)	Lead (mg/L)	Selenium (mg/L)	Bromide (mg/L)	Methane (mg/L)
391318104322501	10/4/78 11:35					0.02	M				
391440104415200	2/10/77 10:00	0.002				0.04	0.01 <		0.002		
391441104403600	2/11/77 11:15	0.001				0.04	0.01 <		0.002		
391449104404000	2/11/77 12:15	0.001				0.02	0.01 <		0.002		
391545104335401	11/22/04 9:50	0.0048	0.031	0.00003 E	0.0008 <	0.006 <	0.0002 <	0.00058	0.0013	0.06	
391558104193601	8/20/79 12:00					0.08	M				
391606104392701	12/1/04 10:30	0.004	0.035	0.00004 <	0.0008 <	0.006 <	0.0002 <	0.00032	0.0014	0.06	
391622104092201	9/21/78 9:35					0.16	0.04				
391648104280201	9/18/78 11:10					0.03	0.01 <				
391705104412301	10/13/78 10:20					0.03	0.01 <				
391719104072301	9/21/78 10:05					**2.8**	**0.75**				
391737104185901	9/18/78 9:45					0.13	0.02				
391738104185801	8/20/79 14:00					0.07	0.01 <				
391740104072401	7/14/05 11:30	0.0002 <	0.01	0.00004 <	0.0008 <	**4.1**	**0.868**	0.00039	0.0003 E	0.05	
391740104143201	8/20/79 3:30					**0.67**	**0.12**				
391822104212501	8/20/79 10:30					**1**	**0.37**				
391825104272101	9/28/05 13:00	0.00009 E	0.043	0.00004 <	0.00006	0.043	0.0185	0.00062	0.00008 <	0.05	
391834104205601	7/1/05 11:00	0.0001 E	0.032	0.00004 <	0.0008 <	0.032	0.0086	0.00008 <	0.0003 E	0.15	
391848104261401	12/14/04 12:00	0.0061	0.048	0.00004 <	0.0008 <	0.003 E	0.0002 <	0.00022	0.0037	0.09	
391851104204501	12/29/05 11:50	0.00012 <	0.079	0.00002 E	0.00004	0.027	0.0125	0.00008 <	0.00008 <	0.14	
391852104391301	11/17/04 9:50	0.0027	0.017	0.00004 <	0.0008 <	0.128	0.021	0.00008 E	0.0011	0.07	
391930104324901	9/18/78 12:00					0.04	0.01 <				
391938104123301	5/18/82 9:25					0.02	**0.11**	0.002 <	0.001 <		
392021104280000	1/25/01 11:50	0.002 <	0.0404	0.00004 <	0.001 <	0.119	0.0199	0.001 <	0.0004 <		
392031104121801	5/18/82 10:10					0.09	**0.16**	0.002 <	0.001 <		
392045104184601	5/18/82 10:55					0.03	**0.06**	0.002 <	0.001 <		

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- Does not include monitoring wells northeast of I-70 within the area of interest

Table 3.2, continued
Water Quality Results: Drinking Water Metals, Halides and Dissolved Methane

Well ID	Sample Date and Time	Arsenic (mg/L)	Barium (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Iron (mg/L)	Manganese (mg/L)	Lead (mg/L)	Selenium (mg/L)	Bromide (mg/L)	Methane (mg/L)
392050104415000	11/2/76 14:30	0.005				0.05	0.01 <		0.001		
392053104181301	9/18/78 9:15					0.05	0.01 <				
392055104181201	8/21/79 13:30					0.06	0.02				
392107104430400	11/4/76 9:30	0.003				0.06	**0.06**		0.001		
392118104362301	12/27/05 11:00	0.00012 <	0.037	0.00004 <	0.00003 E	0.03	0.0109	0.00071	0.00008 <	0.04	
392119104362401	3/11/03 13:00	0.0069	0.029	0.00004 <	0.0008 <	0.01 <	0.0012	0.00004 E	0.0029	0.02	
392130104195001	8/21/79 10:30					0.02	0.03				
392130104251201	9/18/78 10:10					0.02	0.01 <				
392244104143201	10/9/78 14:00					**1.3**	**0.34**				
392254104305601	12/14/04 12:05	0.0056	0.06	0.00004 <	0.0008 <	0.006 <	**0.0501**	0.00014	0.0002 E	0.06	
392400104150601	7/14/05 15:30	0.0002 <	0.021	0.00004 <	0.0008 <	**0.418**	**0.113**	0.00008 <	0.0004 E	0.06	
392440104420901	6/29/77 15:30	0.006				0.09	**0.07**		0.003		
392451104205401	10/9/78 14:40					0.14	0.02				
392451104205401	5/18/82 14:45					0.08	0.04	0.005 <	0.001 <		
392453104194101	5/18/82 14:00					0.05	**0.07**	0.002 <	0.001 <		
392528104330601	9/18/78 13:05					0.05	0.01 <				
392559104415201	8/25/05 14:00	0.0002 <	0.071	0.00004 <	0.0008 <	0.264	0.0165	0.00008 <	0.0004 <	0.24	
392616104260601	11/17/04 13:30	0.0007	0.039	0.00004 <	0.0008 <	0.006 <	0.0269	0.0002	0.0004 <	0.13	
392635104181901	5/18/82 14:20					0.04	**0.11**	0.001 <	0.001		
392639104403001	9/18/78 13:45					0.03	0.01 <				
392640104040501	10/9/78 13:10					0.02	0.01 <				
392727104385201	12/28/04 9:50	0.0071	0.058	0.00004 <	0.0008 <	0.006 <	0.0002 <	0.00052	0.0025	0.09	
392741104343101	11/16/04 10:00	0.0013	0.055	0.00004 <	0.0008 <	0.01	0.0265	0.00098	0.0004 <	0.04	
392743104210901	4/14/77 11:30	0.001 <				0.05	0.02		0.001 <		
392743104210901	5/5/77 13:45					0.11	0.02				
392743104210901	6/30/77 11:15	0.001 <				0.23	0.02		0.001		

NOTES:

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- Does not include monitoring wells northeast of I-70 within the area of interest

Table 3.2, continued
Water Quality Results: Drinking Water Metals, Halides and Dissolved Methane

Well ID	Sample Date and Time	Arsenic (mg/L)	Barium (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Iron (mg/L)	Manganese (mg/L)	Lead (mg/L)	Selenium (mg/L)	Bromide (mg/L)	Methane (mg/L)
392743104210901	10/18/77 11:15	0.001 <				0.16	0.02		0.001 <		
392903104260501	9/19/78 11:45					0.04	0.02				
392903104260501	5/12/82 9:47					0.02	**0.05**	0.001 <	**0.06**		
392920104151001	10/9/78 17:15					0.09	**0.21**				
393104104392501	9/18/78 14:50					0.08	0.02				
393156104415501						0.12					
393227104343401	11/8/04 11:00	0.0107	0.047	0.00004 <	0.0008 <	0.009	0.0367	0.00063	0.0002 E	0.09	
393300104411901	12/20/04 17:30	0.0053	0.081	0.00004 <	0.0011	0.006 <	0.0002 <	0.00017	0.003	0.16	
393326104002001	10/9/78 11:50					0.04	**0.05**				
393353104213901	9/19/78 11:10					0.06	0.04				
393445104224201	11/29/05 13:40	0.00012 <	0.05	0.00004 <	0.00003 E	0.03	0.0183	0.00005 E	0.00008 <	0.29	
393610104300601	5/12/82 10:46					**0.44**	**0.18**	0.001 <	0.001		
393617104131101	6/29/05 11:30	0.0002 <	0.048	0.00004 <	0.0008 <	0.05	0.0293	0.00008 <	0.0002 E	0.13	
393626104104901	10/9/78 10:15					0.06	0.01 <				

NOTES:

- **<** = Less than, **ND** = non detect, **E** = Estimated, **B** = compound found in blank and sample, **M** = Presence verified but not quantified, **J** = result is less than the RL but greater than or equal to the MDL-approximate value shown
- Does not include monitoring wells northeast of I-70 within the area of interest

Table 3.3

Summary of Gas Compostion and Stable Isotope Analyses

	Allen-1	Purvis-1	Skoglund-1
Sample Date	12/5/2011	12/5/2011	12/5/2011
Sample Time	11:20	12:09	12:45
Specific Gravity	0.860	0.863	0.980
BTU	301	295	41
Helium dilution factor *	0.58	0.65	0.77
MS Date	1/6/2012	1/6/2012	1/11/2012
H_2S	na	na	na
He	na	na	na
H_2	nd	nd	nd
Ar	1.05	1.14	1.66
O_2	5.83	5.17	13.72
CO_2	0.58	0.71	0.72
N_2	62.80	63.84	79.87
CO	nd	nd	nd
C_1	29.73	29.12	4.03
$d^{13}C_1$	-89.12	-88.88	***-86.3***
dDC_1	-331.4	-334.0	***-319***
C_2	0.0148	0.0179	0.0022
C_2H_4	nd	nd	nd
C_3	nd	0.0003	nd
C_3H_6	nd	nd	nd
iC_4	nd	nd	nd
nC_4	nd	nd	nd
iC_5	nd	nd	nd
nC_5	nd	nd	nd
C_6+	nd	nd	0.0013

Analysis is of gas extracted from water by headspace equilibration. Analysis has been corrected for helium added to create headspace.

Addition of helium negates the ability to detect native helium and may negate the ability to detect hydrogen.

nd = not detected, na = not analyzed

*** Isotopes obtained online via GC-C-IRMS/GC-P-IRMS*

Appendix

Appendix A
Sample Location Information

SITE ID	Site Name	Township Range Section	County	Data Source	Site Type	Well Depth	Aquifer	Censored Data?
ALLEN 1	ALLEN 1	6 S 64 W 2	Elbert	COGCC	GW	460	Denver	N
BAKER 1	BAKER 1	6 S 64 W 2	Elbert	COGCC	GW	418	Denver	N
BOYD 1	BOYD 1	6 S 65 W 27	Elbert	COGCC	GW	340	Dawson	N
CASWELL 1	CASWELL 1	6 S 64 W 2	Elbert	COGCC	GW	430	Denver	N
CORSI 1	CORSI 1	6 S 64 W 1	Elbert	COGCC	GW	542	Denver	N
DICCIARDELLO 1	DICCIARDELLO 1	6 S 65 W 26	Elbert	COGCC	GW	365	Dawson	N
DORMAN 1	DORMAN 1	6 S 65 W 26	Elbert	COGCC	GW	325	Dawson	N
EDWARDS 1	EDWARDS 1	6 S 64 W 2	Elbert	COGCC	GW	281	Denver	N
EDWARDS II	EDWARDS II	6 S 64 W 2	Elbert	COGCC	GW	361	Denver	N
FENNEL 1	FENNEL 1	6 S 65 W 10	Elbert	COGCC	GW	357	Dawson	N
HAMPTON 1	HAMPTON 1	6 S 65 W 32	Douglas	COGCC	GW	311	Dawson	N
HARPERWW	HARPERWW	6 S 65 W 26	Elbert	COGCC	GW	425	Dawson	Y
HATTON 1	HATTON 1	6 S 65 W 26	Elbert	COGCC	GW	600	Dawson	N
HINDS 1	HINDS 1	6 S 64 W 2	Elbert	COGCC	GW	261	Denver	N
IRELAND 1	IRELAND 1	6 S 65 W 35	Elbert	COGCC	GW	425	Dawson	N
JACOBS 1	JACOBS 1	6 S 65 W 26	Elbert	COGCC	GW	381	Dawson	N
KNIGHT 1	KNIGHT 1	6 S 65 W 26	Elbert	COGCC	GW	402	Dawson	N
KREUTZER 1	KREUTZER 1	6 S 65 W 26	Elbert	COGCC	GW	504	Dawson	N
LUKE 1	LUKE 1	6 S 64 W 1	Elbert	COGCC	GW	361	Arapahoe	N
PETTINGER 1	PETTINGER 1	6 S 64 W 2	Elbert	COGCC	GW	321	Denver	N
PURVIS 1	PURVIS 1	6 S 64 W 1	Elbert	COGCC	GW	905	Denver	N
SKOGLUND 1	SKOGLUND 1	6 S 64 W 1	Elbert	COGCC	GW	523	Denver	N
VAILWW	VAILWW	6 S 65 W 26	Elbert	COGCC	GW	400	Dawson	Y
Weimer	Weimer	5 S 63 W 20	Arapahoe	COGCC	GW	590	Dawson	Y
ZLATEV WATER WELL	ZLATEV WATER WELL	7 S 64 W 28	Elbert	COGCC	GW	410	Denver	Y
06758000	KIOWA CREEK AT ELBERT, CO.	10 S 64 W 3	Elbert	USGS-NWIS	Stream		--	Y
06758100	WEST KIOWA CREEK AT ELBERT, CO.	10 S 64 W 3	Elbert	USGS-NWIS	Stream		--	Y
06758200	KIOWA CREEK AT KIOWA, CO.	8 S 63 W 20	Elbert	USGS-NWIS	Stream		--	Y
6758700	MIDDLE BIJOU CREEK TRIBUTARY NR DEER TRAIL, CO.	6 S 61 W 25	Elbert	USGS-NWIS	Stream		--	N
390001103592201	SC01205915CDD1	12 S 59 W 15	Elbert	USGS-NWIS	GW	245	Laramie-Fox Hills	Y
390138103584201	SC01205910AAA1	12 S 59 W 10	Elbert	USGS-NWIS	GW	250	Laramie-Fox Hills	Y
390316103563801	SC01105936AAC1	11 S 59 W 36	Elbert	USGS-NWIS	GW	168	Laramie-Fox Hills	N
390442103555201	SC01105819DBB	11 S 58 W 19	Elbert	USGS-NWIS	GW	151	Laramie-Fox Hills	Y
390530104020201	SC01105918DAA1	11 S 59 W 18	Elbert	USGS-NWIS	GW	190	Arapahoe	Y
390623103533601	SC01105809DBB1	11 S 58 W 9	Elbert	USGS-NWIS	GW	200	Laramie-Fox Hills	Y
390742104074001	SC01006032DDD1	11 S 60 W 5	El Paso	USGS-NWIS	GW	180	Arapahoe	Y
390747104424101	SC01006531CDC1	10 S 65 W 31	Douglas	USGS-NWIS	Spring		Alluvium	N

Appendix A
Sample Location Information

SITE ID	Site Name	Township Range Section	County	Data Source	Site Type	Well Depth	Aquifer	Censored Data?
390748104423600	SC10-65-31CDD	10 S 65 W 31	Douglas	USGS-NWIS	GW		Dawson	N
390753103593301	SC01005934DCA1	10 S 59 W 34	Elbert	USGS-NWIS	GW	335	Laramie-Fox Hills	Y
390807103551101	DB-18 10S/58W-31AAA	10 S 58 W 32	Elbert	USGS-NWIS	GW		Unknown	Y
390817104040301	SC01006036BCC1	10 S 60 W 36	Elbert	USGS-NWIS	GW	438	Laramie-Fox Hills	N
390821104010601	SC01005932ACA1	10 S 59 W 32	Elbert	USGS-NWIS	GW	438	Laramie-Fox Hills	Y
390821104402901	SC01006533BDB1	10 S 65 W 33	Douglas	USGS-NWIS	Spring		Alluvium	N
390824104021201	SC01006035BAD1	10 S 59 W 31	Elbert	USGS-NWIS	GW	525	Laramie-Fox Hills	Y
390837103551201	SC01005830DDD1	10 S 58 W 30	Elbert	USGS-NWIS	GW	348	Laramie-Fox Hills	Y
390901104051101	SC01006026BCC1	10 S 60 W 26	Elbert	USGS-NWIS	GW		Laramie-Fox Hills	Y
390904103525201	DB 19 10S/58W-27BCC	10 S 58 W 27	Elbert	USGS-NWIS	GW		Unknown	Y
390917104154201	SC01006130ABC1	10 S 61 W 30	Elbert	USGS-NWIS	GW	227	Denver	N
390926104403200	SC01006528BAB TED SMITH	10 S 65 W 28	Douglas	USGS-NWIS	GW		Alluvium	N
390935104301001	SC01006424DCD DAWMAS26	10 S 64 W 24	Elbert	USGS-NWIS	GW	500	Dawson	Y
391006104170101	SC01006224BDA1	10 S 62 W 24	Elbert	USGS-NWIS	GW	527	Arapahoe	Y
391006104404201	SC01006521BCA1	10 S 65 W 21	Douglas	USGS-NWIS	GW	16.5	Alluvium	N
391007103514501	SC01005823BBC1	10 S 58 W 23	Elbert	USGS-NWIS	GW	200	Laramie-Fox Hills	N
391008104421800	SC01006519ACA DAN JONES SPRING #1 UPPER	10 S 65 W 19	Douglas	USGS-NWIS	Spring		Unknown	N
391011103582501	SC01005923BBB1	10 S 59 W 23	Elbert	USGS-NWIS	GW	212	Laramie-Fox Hills	Y
391012104421600	SC01006519ABD DAN JONES SPRING #1 LOWER	10 S 65 W 19	Douglas	USGS-NWIS	Spring		Unknown	N
391016103534101	SC01005821BAB1	10 S 58 W 21	Elbert	USGS-NWIS	GW	150	Laramie-Fox Hills	Y
391017103534801	DB-17 10S/58W-21BBA	10 S 58 W 21	Elbert	USGS-NWIS	GW		Unknown	Y
391018104140101	SC01006121BBB1	10 S 61 W 21	Elbert	USGS-NWIS	GW	510	Arapahoe	Y
391028104310701	SC01006414DDC1	10 S 64 W 14	Elbert	USGS-NWIS	GW	1000	Denver	N
391030104374901	SC01006514DCD1	10 S 65 W 14	Elbert	USGS-NWIS	GW	345	Dawson	N
391034104295001	SC01006413DDA1	10 S 64 W 13	Elbert	USGS-NWIS	GW	385	Dawson	Y
391037104054601	SC01006015DBC1	10 S 60 W 15	Elbert	USGS-NWIS	GW	705	Unknown	Y
391047104265201	SC01006316DBB1	10 S 63 W 16	Elbert	USGS-NWIS	GW	325	Denver	Y
391058103572601	SC01005913BCB1	10 S 59 W 14	Elbert	USGS-NWIS	GW	125	Laramie-Fox Hills	Y
391133104140801	SC01006108DAA1	10 S 61 W 8	Elbert	USGS-NWIS	GW	305	Arapahoe	Y
391135104211601	SC01006208DBB1	10 S 62 W 8	Elbert	USGS-NWIS	GW	447	Unknown	N
391148104114701	SC01006111BCB1	10 S 61 W 11	Elbert	USGS-NWIS	GW	484	Arapahoe	Y
391148104294101	SC01006307BCC DAWMAS27	10 S 63 W 7	Elbert	USGS-NWIS	GW	475	Dawson	N
391204103593601	SC01005903CCC1	10 S 59 W 3	Elbert	USGS-NWIS	GW	460	Laramie-Fox Hills	Y
391204104430000	SC01006507BBB EMIL ANDERSON SPRING	10 S 65 W 7	Douglas	USGS-NWIS	Spring		Dawson	N
391220104344201	SC01006405DBC1	10 S 64 W 5	Elbert	USGS-NWIS	GW	298	Dawson	Y
391234104065201	SC01006004BDD1	10 S 60 W 4	Elbert	USGS-NWIS	GW	240	Arapahoe	N

Appendix A
Sample Location Information

SITE ID	Site Name	Township Range Section	County	Data Source	Site Type	Well Depth	Aquifer	Censored Data?
391253104321501	SC01006403AAB1	10 S 64 W 3	Elbert	USGS-NWIS	GW	130	Dawson	Y
391253104430000	SC01006506BBC EMIL ANDERSON	10 S 65 W 6	Douglas	USGS-NWIS	GW		Alluvium	N
391256104054301	SC00906034DCC1	9 S 60 W 34	Elbert	USGS-NWIS	GW	165	Arapahoe	Y
391300104142801	SC00906132DCD1	9 S 61 W 32	Elbert	USGS-NWIS	GW	567	Arapahoe	N
391318104322501	SC00906434DBA1	9 S 64 W 34	Elbert	USGS-NWIS	GW	287	Dawson	N
391410104121101	SC00906127DBA	9 S 61 W 27	Elbert	USGS-NWIS	GW	150	Arapahoe	Y
391422103554901	SC00905830BDB1	9 S 58 W 30	Elbert	USGS-NWIS	GW	376	Laramie-Fox Hills	Y
391423104384701	SC00906528ADD1	9 S 65 W 27	Elbert	USGS-NWIS	GW	228	Dawson	Y
391436104085401	SC00906030ABA1	9 S 60 W 30	Elbert	USGS-NWIS	GW	130	Arapahoe	Y
391440104415200	SC00906529BBB DARRELL BELL NO 1	9 S 65 W 29	Douglas	USGS-NWIS	GW		Alluvium	N
391441104403600	SC00906528BBA PATRICK REYNOLDS WELL	9 S 65 W 28	Douglas	USGS-NWIS	GW		Alluvium	N
391449104404000	SC00906521CCD GILLILAND SPRING	9 S 65 W 21	Douglas	USGS-NWIS	Spring		Dawson	N
391514104184201	SC00906223BCC1	9 S 62 W 22	Elbert	USGS-NWIS	GW	602	Arapahoe	Y
391532103565501	SC00905924BAA1	9 S 59 W 24	Elbert	USGS-NWIS	GW	170	Laramie-Fox Hills	Y
391545104335401	SC00906416CDB DAWMAS22	9 S 64 W 16	Elbert	USGS-NWIS	GW	360	Dawson	N
391558104193601	DB-7 9S/62W-15CBB	9 S 62 W 15	Elbert	USGS-NWIS	GW		Unknown	Y
391604104354101	SC00906418ACD1	9 S 64 W 18	Elbert	USGS-NWIS	GW	270	Dawson	Y
391606104392701	SC00906515BDC DAWMAS15	9 S 65 W 15	Elbert	USGS-NWIS	GW	315	Dawson	N
391622104092201	SC00906018BBA1	9 S 60 W 18	Elbert	USGS-NWIS	GW	560	Laramie-Fox Hills	N
391637104335001	SC00906409CDB1	9 S 64 W 9	Elbert	USGS-NWIS	GW	322	Dawson	Y
391648104280201	SC00906308DBB1	9 S 63 W 8	Elbert	USGS-NWIS	GW	210	Dawson	N
391705104412301	SC00906508ACB1	9 S 65 W 8	Douglas	USGS-NWIS	GW	315	Dawson	N
391706104412301	SC00906613ACA1	9 S 65 W 8	Douglas	USGS-NWIS	GW	380	Dawson	Y
391719104072301	SC00906005DDD1	9 S 60 W 4	Elbert	USGS-NWIS	GW	183	Arapahoe	N
391737104185901	SC00906203DBD1	9 S 62 W 3	Elbert	USGS-NWIS	GW	302	Arapahoe	N
391738104185801	DB-8 9S/62W/3DBB	9 S 62 W 3	Elbert	USGS-NWIS	GW		Unknown	Y
391740103550501	SC00905806DAA1	9 S 58 W 5	Elbert	USGS-NWIS	GW	157	Laramie-Fox Hills	Y
391740104072401	SC00906005DAA ARAPMAS27	9 S 60 W 4	Elbert	USGS-NWIS	GW	130	Arapahoe	N
391740104143201	DB-9 9S/61W-5BDD	9 S 61 W 5	Elbert	USGS-NWIS	GW		Unknown	Y
391740104143301	SC00906105DBB1	9 S 61 W 5	Elbert	USGS-NWIS	GW	378	Arapahoe	Y
391809103535401	SC00805833CCC1	8 S 58 W 33	Elbert	USGS-NWIS	GW	165	Laramie-Fox Hills	Y
391809104023601	SC00805931CDC1	8 S 59 W 31	Elbert	USGS-NWIS	GW	585	Laramie-Fox Hills	Y
391809104095501	SC00806136DCD1	9 S 61 W 1	Elbert	USGS-NWIS	GW	1047	Laramie-Fox Hills	Y
391815104092101	SC00806031CCA1	8 S 60 W 31	Elbert	USGS-NWIS	GW	175	Arapahoe	Y
391817104221901	SC00806231DCD1	8 S 62 W 31	Elbert	USGS-NWIS	GW	383	Denver	Y
391822104212501	DB00806232CDA	8 S 62 W 32	Elbert	USGS-NWIS	GW		Unknown	Y
391825104272101	SC00806333CBD DENMAS06	8 S 63 W 33	Elbert	USGS-NWIS	GW	963	Denver	N
391834104205601	SC00806232DAA ARAPMAS22	8 S 62 W 32	Elbert	USGS-NWIS	GW	832	Arapahoe	Y

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Sample Location Information

SITE ID	Site Name	Township Range Section	County	Data Source	Site Type	Well Depth	Aquifer	Censored Data?
391848104261401	SC00806334BCA DAWMAS28	8 S 63 W 34	Elbert	USGS-NWIS	GW	388	Dawson	N
391851104204501	SC00806233BBC DENMAS05	8 S 62 W 33	Elbert	USGS-NWIS	GW	545	Denver	N
391852104391301	SC00806534ACB DAWMAS16	8 S 65 W 34	Elbert	USGS-NWIS	GW	720	Dawson	N
391930104324901	SC00806427CAC2	8 S 64 W 27	Elbert	USGS-NWIS	GW	235	Dawson	N
391932104055001	SC00806027BDC1	8 S 60 W 27	Elbert	USGS-NWIS	GW	240	Arapahoe	Y
391938104123301	SC00806127BDB1	8 S 61 W 27	Elbert	USGS-NWIS	GW	200	Denver	N
391951103541301	SC00805924DCC1	8 S 58 W 20	Elbert	USGS-NWIS	GW	270	Laramie-Fox Hills	Y
392001104285401	SC00806319DDC1	8 S 63 W 19	Elbert	USGS-NWIS	GW	133	Dawson	Y
392013104144901	SC00806120CAB1	8 S 61 W 20	Elbert	USGS-NWIS	GW	135	Arapahoe	Y
392021104280000	SC00806308DBB	8 S 63 W 20	Elbert	USGS-NWIS	GW	610	Denver	Y
392024104305401	SC00806423ADD1	8 S 64 W 23	Elbert	USGS-NWIS	GW	288	Dawson	Y
392031104121801	SC00806122ACB1	8 S 61 W 22	Elbert	USGS-NWIS	GW	174	Denver	Y
392033104083201	SC00806019AAD1	8 S 60 W 19	Elbert	USGS-NWIS	GW	240	Arapahoe	Y
392041104015501	SC00805919AAB1	8 S 59 W 19	Elbert	USGS-NWIS	GW	150	Arapahoe	Y
392045104184601	SC00806222AAB1	8 S 62 W 22	Elbert	USGS-NWIS	GW	275	Denver	N
392050104415000	SC00806520BBA RUSSELVILLE SPRING	8 S 65 W 20	Douglas	USGS-NWIS	Spring		Unknown	N
392053104181301	SC00806214CDC1	8 S 62 W 14	Elbert	USGS-NWIS	GW	400	Arapahoe	N
392055104181201	DB-11 8S/62W/14CDC	8 S 62 W 14	Elbert	USGS-NWIS	GW		Unknown	Y
392107104430400	SC00806518CBC ROBT WELBORN WELL #1	8 S 65 W 18	Douglas	USGS-NWIS	GW		Unknown	N
392107104430401	SC00806518CBC	8 S 65 W 18	Douglas	USGS-NWIS	GW	45	Alluvium	Y
392108103542001	SC00805817ACC1	8 S 58 W 17	Elbert	USGS-NWIS	GW	106	Laramie-Fox Hills	Y
392118104362301	SC00806418BCC ARAPMAS15	8 S 64 W 18	Elbert	USGS-NWIS	GW	2149	Arapahoe	N
392119104362401	SC0086418BCB SWQA-1	8 S 64 W 18	Elbert	USGS-NWIS	GW	536	Dawson	N
392122104313001	SC00806414BDA1	8 S 64 W 14	Elbert	USGS-NWIS	GW	232	Dawson	Y
392126104363301	SC00806513ADB1	8 S 65 W 13	Elbert	USGS-NWIS	GW	203	Dawson	Y
392130104195001	DB-10 8S/62W 16AAC	8 S 62 W 16	Elbert	USGS-NWIS	GW		Unknown	Y
392130104251201	SC00806314BBC1	8 S 63 W 14	Elbert	USGS-NWIS	GW	265	Dawson	N
392130104341401	SC00806417AAD1	8 S 64 W 17	Elbert	USGS-NWIS	GW	270	Dawson	Y
392131104351701	SC00806417BBC DAWMAS21	8 S 64 W 17	Elbert	USGS-NWIS	GW	435	Dawson	Y
392132104411001	SC00706532DCD1	8 S 65 W 17	Douglas	USGS-NWIS	GW	300	Dawson	Y
392133104341001	SC00806416BBC1	8 S 64 W 16	Elbert	USGS-NWIS	GW	328	Dawson	Y
392141104395501	SC00806516AAA1	8 S 65 W 16	Douglas	USGS-NWIS	GW	452	Dawson	Y
392142104145701	SC00806108CCD1	8 S 61 W 8	Elbert	USGS-NWIS	GW	261	Arapahoe	Y
392156104050901	SC00806010DAD1	8 S 60 W 10	Elbert	USGS-NWIS	GW	100	Arapahoe	Y
392205104233801	SC00806312DBB1	8 S 63 W 12	Elbert	USGS-NWIS	GW	170	Dawson	Y
392214104024201	SC00805907BCA1	8 S 59 W 7	Elbert	USGS-NWIS	GW	90	Arapahoe	Y
392221104144801	SC00806108BAC1	8 S 61 W 8	Elbert	USGS-NWIS	GW	150	Denver	Y
392244104143201	SC00806105DBC1	8 S 61 W 5	Elbert	USGS-NWIS	GW	144	Arapahoe	N

Appendix A
Sample Location Information

SITE ID	Site Name	Township Range Section	County	Data Source	Site Type	Well Depth	Aquifer	Censored Data?
392249104274801	SC00806305DAC1	8 S 63 W 5	Elbert	USGS-NWIS	GW	128	Dawson	Y
392254104305601	SC00806402DAA DAWMAS29	8 S 64 W 2	Elbert	USGS-NWIS	GW	280	Dawson	N
392307104120501	SC00806103ADB1	8 S 61 W 3	Elbert	USGS-NWIS	GW	715	Arapahoe	Y
392321104161001	SC00806106BBA1	8 S 61 W 6	Elbert	USGS-NWIS	GW	289	Arapahoe	Y
392331104304701	SC00706436CCC1	7 S 64 W 36	Elbert	USGS-NWIS	GW	285	Dawson	Y
392342104341301	SC00706432DAD1	7 S 64 W 32	Elbert	USGS-NWIS	GW	236	Dawson	Y
392357104251301	SC00706335BCA1	7 S 63 W 35	Elbert	USGS-NWIS	GW	75	Denver	Y
392400104150601	SC00706132BBC ARAPMAS28	7 S 61 W 32	Elbert	USGS-NWIS	GW	434	Arapahoe	N
392440104420901	SC00706530DAC1 MIDDLE W DON ROTHSCHOPF	7 S 65 W 30	Douglas	USGS-NWIS	GW		Alluvium	N
392442103545201	SC00705829BCC1	7 S 58 W 29	Elbert	USGS-NWIS	GW	197	Laramie-Fox Hills	Y
392451104205401	SC00706229ADA1	7 S 62 W 29	Elbert	USGS-NWIS	GW	479	Denver	N
392453104194101	SC00706227BCB1	7 S 62 W 27	Elbert	USGS-NWIS	GW	307	Denver	N
392455104074801	SC00706029ABC1	7 S 60 W 29	Elbert	USGS-NWIS	GW	486	Arapahoe	Y
392525104001001	SC00705921CAA1	7 S 59 W 21	Elbert	USGS-NWIS	GW	376	Laramie-Fox Hills	Y
392528104330601	SC00706421DAD1	7 S 64 W 21	Elbert	USGS-NWIS	GW	395	Dawson	N
392548104253701	SC00706322ABD1	7 S 63 W 22	Elbert	USGS-NWIS	GW	180	Denver	Y
392559104415201	SC00706520BBA DENMAS01	7 S 65 W 20	Douglas	USGS-NWIS	GW	940	Denver	N
392616104260601	SC00706315CAC DAWMAS30	7 S 63 W 15	Elbert	USGS-NWIS	GW	435	Dawson	N
392635104181901	SC00706214BDB1	7 S 62 W 14	Elbert	USGS-NWIS	GW		Unknown	N
392639104403001	SC00706516BDB1	7 S 65 W 16	Douglas	USGS-NWIS	GW	313	Dawson	N
392640104040501	SC00706014AAD1	7 S 60 W 14	Elbert	USGS-NWIS	GW	550	Laramie-Fox Hills	N
392650103582601	SC00705910DDD1	7 S 59 W 15	Elbert	USGS-NWIS	GW	170	Laramie-Fox Hills	Y
392712104182601	SC00706211CBA1	7 S 62 W 11	Elbert	USGS-NWIS	GW	189	Denver	Y
392727104385201	SC00706510ADC DAWMAS17	7 S 65 W 10	Elbert	USGS-NWIS	GW	295	Dawson	N
392741104343101	SC00706408ABA DAWMAS20	7 S 64 W 8	Elbert	USGS-NWIS	GW	455	Dawson	N
392743104210901	SC00706208AAB	7 S 62 W 8	Elbert	USGS-NWIS	GW	685	Arapahoe	N
392745104362201	SC00706512AAA1 USGS 392745104362201	7 S 65 W 12	Elbert	USGS-NWIS	GW	295	Dawson	Y
392748104153501	SC00706106DCD1	7 S 61 W 6	Elbert	USGS-NWIS	GW	360	Arapahoe	Y
392756104040301	SC00706002DAD1	7 S 60 W 2	Elbert	USGS-NWIS	GW	395	Laramie-Fox Hills	Y
392802104424001	SC00706506BDC1	7 S 65 W 6	Douglas	USGS-NWIS	GW	405	Dawson	Y
392811104403801	SC00706504DBA1	7 S 65 W 4	Douglas	USGS-NWIS	GW	280	Dawson	Y
392821104064701	SC00706004ACB1	7 S 60 W 4	Elbert	USGS-NWIS	GW	155	Arapahoe	Y
392825104263901	SC00706304AAC1	7 S 63 W 4	Elbert	USGS-NWIS	GW	240	Denver	Y
392839104210601	SC00606232DDC1	6 S 62 W 32	Elbert	USGS-NWIS	GW	527	Denver	Y
392841104185001	SC00606234DDC1	6 S 62 W 34	Elbert	USGS-NWIS	GW	363	Arapahoe	Y
392858104090101	SC00606031DBB1	6 S 60 W 31	Elbert	USGS-NWIS	GW	216	Arapahoe	Y

Appendix A
Sample Location Information

SITE ID	Site Name	Township Range Section	County	Data Source	Site Type	Well Depth	Aquifer	Censored Data?
392903104260501	SC00606334CAB1	6 S 63 W 34	Elbert	USGS-NWIS	GW	155	Denver	N
392914104381501	SC00606535BDB1	6 S 65 W 35	Elbert	USGS-NWIS	GW	310	Dawson	Y
392920104151001	SC00606132BBC	6 S 61 W 32	Elbert	USGS-NWIS	GW	100	Denver	N
392927104395101	SC00606533AAB1	6 S 65 W 33	Douglas	USGS-NWIS	GW	318	Dawson	Y
392936104340801	SC00606428CCC1	6 S 64 W 28	Elbert	USGS-NWIS	GW	225	Dawson	Y
392953104212801	SC00606229CAA1	6 S 62 W 29	Elbert	USGS-NWIS	GW	205	Denver	Y
393012103592501	SC00605928ABC1	6 S 59 W 27	Elbert	USGS-NWIS	GW	265	Laramie-Fox Hills	Y
393018104024201	SC00605930BBB1	6 S 59 W 30	Elbert	USGS-NWIS	GW	460	Laramie-Fox Hills	Y
393022103571101	SC00605924CCC1	6 S 59 W 24	Elbert	USGS-NWIS	GW	170	Laramie-Fox Hills	Y
393024103432800	SC00605724CDD DTX3 BEAVER CREEK	6 S 57 W 24	Elbert	USGS-NWIS	GW	16.01	Alluvium	Y
393025104093901	SC00606124DDD1	6 S 61 W 24	Elbert	USGS-NWIS	GW	872	Laramie-Fox Hills	Y
393039104061901	SC00606021DAA1	6 S 60 W 21	Elbert	USGS-NWIS	GW	180	Arapahoe	Y
393043104243101	SC00606323DBA1	6 S 63 W 23	Elbert	USGS-NWIS	GW	298	Denver	Y
393100104182101	SC00606223BBD1	6 S 62 W 23	Elbert	USGS-NWIS	GW	83	Arapahoe	Y
393104104392501	SC00606515CAA1	6 S 65 W 22	Elbert	USGS-NWIS	GW	380	Dawson	N
393108104072301	SC00606021BBB1	6 S 60 W 20	Elbert	USGS-NWIS	GW	730	Laramie-Fox Hills	Y
393128104064301	SC00606016DBC1	6 S 60 W 16	Elbert	USGS-NWIS	GW	620	Laramie-Fox Hills	Y
393137104405001	SC00606517DAD1	6 S 65 W 17	Douglas	USGS-NWIS	GW	440	Dawson	Y
393138103543401	SC00605817CAB1	6 S 58 W 17	Elbert	USGS-NWIS	GW	60	Laramie-Fox Hills	Y
393151104343001	SC00606417ACA1	6 S 64 W 17	Elbert	USGS-NWIS	GW	300	Dawson	Y
393156104415501	SC00606518ADA USGS 393156104415501	6 S 65 W 18	Douglas	USGS-NWIS	GW	409	Unknown	N
393207103544800	SC00605808CCC D21	6 S 58 W 8	Elbert	USGS-NWIS	GW	18	Unknown	Y
393224104362701	SC00606512DAC1	6 S 65 W 12	Elbert	USGS-NWIS	GW	500	Denver	Y
393227104343401	SC00606408DBB DAWMAS19	6 S 64 W 8	Elbert	USGS-NWIS	GW	320	Dawson	N
393247103543800	SC00605808BAC D20	6 S 58 W 8	Elbert	USGS-NWIS	GW	20	Unknown	Y
393253103473201	SC0060570BABA1 SOUTH-1	6 S 57 W 8	Elbert	USGS-NWIS	Lake		--	Y
393300104411901	SC00606508ABB DAWMAS18	6 S 65 W 8	Douglas	USGS-NWIS	GW	190	Dawson	N
393307103515900	SC00605803DCA D22	6 S 58 W 3	Elbert	USGS-NWIS	GW	37	Unknown	Y
393307103545500	SC00605805CBB D16	6 S 58 W 6	Elbert	USGS-NWIS	GW	23	Unknown	Y
393311103541800	SC00605805DBC D19 MUDDY CREEK	6 S 58 W 5	Elbert	USGS-NWIS	GW	28	Unknown	Y
393321104400801	SC00606504DBC1	6 S 65 W 4	Douglas	USGS-NWIS	GW	425	Dawson	Y
393326104002001	SC00605904BCD1	6 S 59 W 4	Elbert	USGS-NWIS	GW	242	Laramie-Fox Hills	N
393327103541200	SC00605805BDB D17 MUDDY CREEK	6 S 58 W 5	Elbert	USGS-NWIS	GW	20	Unknown	Y
393330103545300	SC00605806AAD D23	6 S 58 W 6	Elbert	USGS-NWIS	GW	13.5	Unknown	Y
393336104383801	SC00606503ADB1	6 S 65 W 3	Elbert	USGS-NWIS	GW	510	Denver	Y
393353104213901	SC00506232CCC1	5 S 62 W 32	Arapahoe	USGS-NWIS	GW	186	Denver	N
393358103434200	SC00605701BAB DTX4 BEAVER CREEK	5 S 57 W 35	Elbert	USGS-NWIS	GW	14.02	Alluvium	N

Appendix A
Sample Location Information

SITE ID	Site Name	Township Range Section	County	Data Source	Site Type	Well Depth	Aquifer	Censored Data?
393358103454800	SC00605703BAB DTX5 BEAVER CREEK	6 S 57 W 3	Elbert	USGS-NWIS	GW	18.5	Alluvium	Y
393358103464800	SC00605704BAA DTX6 BEAVER CREEK	6 S 57 W 4	Elbert	USGS-NWIS	GW	36.5	Alluvium	Y
393422104035501	SC00506035DAB1	5 S 60 W 35	Arapahoe	USGS-NWIS	GW	495	Laramie-Fox Hills	Y
393439104300801	SC00506436BAA1	5 S 64 W 36	Arapahoe	USGS-NWIS	GW	340	Denver	Y
393441104410501	SC00506532ABD1	5 S 65 W 32	Arapahoe	USGS-NWIS	GW	435	Dawson	Y
393445104224201	SC00506230CCC ARAPMAS21	5 S 62 W 30	Arapahoe	USGS-NWIS	GW	282	Arapahoe	N
393449104004301	SC00505932ABA1	5 S 59 W 32	Arapahoe	USGS-NWIS	GW	337	Laramie-Fox Hills	Y
393451104202901	SC00506228DDA1	5 S 62 W 28	Arapahoe	USGS-NWIS	GW	340	Arapahoe	Y
393529103565101	SC00505925BCB1	5 S 59 W 25	Arapahoe	USGS-NWIS	GW	260	Laramie-Fox Hills	Y
393605104425601	SC00506519CBB1	5 S 65 W 19	Arapahoe	USGS-NWIS	GW	449	Dawson	Y
393610104300601	SC00506424BDA	5 S 64 W 24	Arapahoe	USGS-NWIS	GW	156	Denver	N
393612104015701	SC00505919ACC1	5 S 59 W 19	Arapahoe	USGS-NWIS	GW	320	Laramie-Fox Hills	Y
393617104131101	SC00506121ABC ARAPMAS29	5 S 61 W 21	Arapahoe	USGS-NWIS	GW	420	Arapahoe	N
393622104274501	SC00706512AAA1 USGS 393622104274501	5 S 63 W 20	Arapahoe	USGS-NWIS	GW	295	Unknown	Y
393625104244501	SC00506323BBA1	5 S 63 W 23	Arapahoe	USGS-NWIS	GW		Denver	Y
393626104104901	SC00506123ABB1	5 S 61 W 23	Arapahoe	USGS-NWIS	GW	890	Laramie-Fox Hills	N
393638104300501	SC00506413CDA1	5 S 64 W 13	Arapahoe	USGS-NWIS	GW	203	Denver	Y