COLORADO GEOLOGICAL SURVEY

Open-File Report OF-24-13
Technical Memorandum
Baseline Radiological Study Year 3: San Luis Valley

Citation

Sebol, L.A., and Buch-Leviatan, O., 2024, Baseline Radiological Study Year 3: San Luis Valley: Colorado Geological Survey Open-File Report 24-13, https://doi.org/10.58783/cgs.of2413.jovi9151. Also available at: https://coloradogeologicalsurvey.org/publications/baseline-radiological-san-luis-valley-colorado/.

ABOUT THIS REPORT

The Colorado Geological Survey (CGS), a department of the Colorado School of Mines, has been funded through a grant from the Colorado Department of Public Health & Environment (CDPHE) to conduct a 5-year study of baseline naturally occurring radionuclides and metals in groundwater obtained from privately owned residential water wells throughout Colorado. This report presents the methodology and results of Year 3 conducted in 2024 in the central portion of the San Luis Valley (SLV) located in south-central Colorado. The study area included parts of Alamosa, Conejos, Costilla, Rio Grande, and Saguache counties (Figure 1). Principal towns within the study area from north to south include Moffat, Center, Hooper, Alamosa, Blanca, Fort Garland, A Jara, and Sanford.

To view .pdf files

For further information or assistance, contact the Colorado Geological Survey at:
Colorado Geological Survey / Colorado School of Mines
1801 Moly Road, Golden, CO 80401
(303) 384-2655 / CGS_Pubs@mines.edu
https://coloradogeologicalsurvey.org/

COLORADO GEOLOGICAL SURVEY
COLORADO SCHOOL OF MINES

Colorado School of Mines
1801 Moly Road
Golden, CO 80401

Matthew L. Morgan
State Geologist and Director

Robert Hillegas
Physical Sciences Researcher / Scientist
Environmental Data Unit
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, Colorado 80246-1530

RE: Baseline Groundwater Study Year 3 Report, San Luis Valley, Contract 2024*4140

The Colorado Geological Survey (CGS), a department of the Colorado School of Mines, has been funded through a grant from the Colorado Department of Public Health & Environment (CDPHE) to conduct a 5-year study of baseline naturally occurring radionuclides and metals in groundwater obtained from privately owned residential water wells throughout Colorado. This report presents the methodology and results of Year 3 conducted in 2024 in the central portion of the San Luis Valley (SLV) located in south-central Colorado. The study area included parts of Alamosa, Conejos, Costilla, Rio Grande, and Saguache counties (**Figure 1**). Principal towns within the study area from north to south include Moffat, Center, Hooper, Alamosa, Blanca, Fort Garland, A Jara, and Sanford.

Purpose: Per CDPHE, the primary purpose is as follows: "Ambient monitoring of groundwater will give scientists and the people of Colorado an idea of background conditions of radionuclides and metals in groundwater in Colorado. This information will help decision makers make informed decisions regarding the care and use of groundwater in these regions of the state. This project will help the state build a baseline water quality dataset for groundwater." CDPHE also stated that the study was to be education focused for homeowners on wells.

Background: The SLV is greater than 100 miles long and 65 miles wide, extending from the Colorado Continental Divide on the northwest rim into New Mexico. Within Colorado, the valley is bordered by the Sangre de Cristo Mountain Range on both the southeast and east sides and to the north, west, and southwest by the San Juan Mountain Range. Streams carrying sediment shed from the surrounding mountains form alluvial fans around much of the valley floor, the most extensive being the Rio Grande fan. Additionally, wind deposited (eolian) silt and sands migrate across the basin from the west to east. Although outside the study area, the eastern edge of the SLV contains the Great Sand Dunes National Park and Preserve, an important tourist destination.

The San Luis basin consists of a northern and southern basin divided at the structural and physiographic high terrain of the San Luis Hills, close to the Colorado-New Mexico state line. The San Luis Hills consist of a series of upthrown geologic blocks arranged northeasterly across the central part of the basin[1]. Thus, our study area is contained within the northern basin, known as the Alamosa Basin.

[1] Burroughs, R.L., 1981, A Summary of the Geology of the San Luis Basin, Colorado - New Mexico with Emphasis on the Geothermal Potential for the Monte Viste Graben, Colorado Geological Survey Special Publication 17, Department of Natural Resources, Denver Colorado.

The Alamosa Basin can be further divided into two subbasins at approximately the latitude of the Great Sand Dunes and San Luis Lake. The northern subbasin of the SLV is an endorheic basin where surface water does not exit this area but instead flows into seasonal (playa) or permanent lakes or infiltrates directly into the subsurface. This area is known as the Closed Basin and its low point is San Luis Lake west of the Great Sand Dunes. Within the Closed Basin streams draining the west face of the Sangre de Cristos flow only a short distance onto the valley floor, recharging the near surface groundwater.

The southern subbasin is drained primarily by the Rio Grande River which is sourced from the San Juan Mountains and flows east/southeast through the towns of Del Norte, Monte Vista, and Alamosa and then southerly into New Mexico. While the SLV currently contains small playa lakes, the majority was once covered by a large lake "Lake Alamosa" from about 3 million to about 440,000 years ago (Pliocene to middle Pleistocene time).[2] Lake Alamosa extended as far south as the San Luis Hills and covered the central portion of the SLV (**Figure 2**). As a result of sediments deposited in that large lake, much of the SLV floor today is relatively flat. Based on modeled data, not yet published but provided to the CGS by Dr. Ryan Smith of Colorado State University (CSU), the central portion of the valley is generally finer grained (more clay rich).

Geology and Hydrogeology: The SLV is part of the upper portion of the Rio Grande Rift which began developing during the Oligocene and continues today. The Rio Grande Rift consists of alternating half grabens which in the SLV is hinged on the west and drops to the east bounded by an extensive fault system along the Sangre de Cristos.[3] The SLV basin is divided into a western ("Monte Vista") graben and eastern ("Baca") graben by a basement high termed the "Alamosa horst".[1] The older Baca graben has a greater degree of easterly tilt and is deeper, reaching about 21,000 feet deep.[3] These buried grabens are covered by a series of volcanic deposits and then by younger Quaternary deposits. The older and deeper volcanic deposits (Oligocene andesitic lava flows and volcaniclastic rocks of the Conejos Formation) are eastward tilted, but the overlying Oligocene ash-flow tuffs are not tilted due to the timing of tectonic events that created the grabens.[3] Today, near surface geologic deposits in the SLV consist of Quaternary unconsolidated clay, silt, sand, and gravel sourced from alluvial fans and lacustrine (lake), and eolian processes.

Two aquifers used for drinking water exist in the SLV, an upper unconsolidated aquifer overlying a confined artesian aquifer. A "blue clay" layer separates the two aquifers through much of the central valley, but not along the outer edges. This clay layer coincides with the inferred extent of former Lake Alamosa (Figure 2).[2] The lake extended southerly to the northern edge of the San Luis Hills. The underlying confined aquifer is composed of layers of unconsolidated sediments (sand, gravel, clay) interbedded with various layers of volcanic rock and tuff sourced from the San Juan Mountains, particularly in Conejos and Costilla Counties. From well and test drilling data, along with seismic and other geophysical data, the deepest part of the confined aquifer may be as much as 4,000 feet or even deeper in the northeast part of the SLV.[3]

---

[2] Machette, M.N., Marchetti, D.W., and Thompson R.A., Ancient Lake Alamosa and the Pliocene to Middle Pleistocene Evolution of the Rio Grande *in* 2007 Rocky Mountain Section Friends of the Pleistocene Field Trip—Quaternary Geology of the San Luis Basin of Colorado and New Mexico, Chapter G by Michael N. Machette, Mary-Margaret Coates, and Margo L. Johnson, September 7–9.

[3] Brister, B.S., and Gries, R.R., 1994, Tertiary stratigraphy and tectonic development of the Alamosa basin (northern San Luis Basin), Rio Grande rift, south-central Colorado, *in* Keller, G.R., and Cather, S.M., eds., Basins of the Rio Grande Rift: Structure, Stratigraphy, and Tectonic Setting: Boulder Colorado, Geological Society of America Special Paper 291, pp. 39-58.

Historic Water & Soil Chemistry Data: Prior and ongoing research in the SLV has identified uranium and other heavy metals in the SLV. This research consists of a 5-year study led by Dr. Katherine James at Colorado University (CU) Anschutz together with Ryan Smith at Colorado State University (CSU) and in partnership with the SLV Ecosystem Council.[4, 5] They are testing residential wells across the SLV for heavy metals and a few other parameters to collect water quality data for developing the best models to describe how drought is impacting water supplies and to aid the community in adaptation and mitigation strategies to build water resources capacity in the SLV. Their focus is arsenic along with uranium, which appears to have the potential to be elevated in portions of the confined and unconfined aquifers, respectively.

Additionally, Karl Mauch of the Colorado Department of Agriculture (CDA) conducted split sampling with Dr. James group in 2021 of 43 residential wells in both the unconfined and confined aquifers, and then in 2023 installed 45 monitoring wells across the SLV. While CDA's primary focus is agricultural related pesticides and nutrients, their split sampling also included analysis of 16 metals. Per Karl, their monitoring reports are pending but these data show the presence of uranium in the unconfined aquifer and arsenic in the confined aquifer that can be above guideline values. Karl provided a copy of his monitoring-well data and approved its use for this study.

Pre-1960 soil data in the SLV measured by field scintillometer showed elevated radioactivity at the base of the San Juan Mountains in the Cat Creek drainage and was generally higher along the western valley boundary and lowest in the north and southeastern portions.[6]

Historic groundwater uranium data in wells and springs are shown in **Figure 3**. Data were sourced from the National Water Quality Monitoring Council Water Quality Portal (WQP) which includes the National Uranium Resource Evaluation (NURE) dataset, along with the monitoring well data provided directly by CDA. Other databases investigated which had no radionuclide groundwater quality data in the SLV included the Colorado Energy & Carbon Management Commission (ECMC), formerly known as the Colorado Oil and Gas Conservation Commission (COGCC), and the CDA online database.

Exceedances of the uranium 0.030 milligram per liter (mg/L) drinking water guideline for the groundwater data are shown in red in Figure 3. Four of the CDA monitoring wells and two of the WQP wells exhibited exceedances. All were in the central portion of the valley.

2024 Methodology

The Year 3 contract included a total of 45 possible samples in the SLV. To obtain representative coverage targeting uranium, a sampling grid was created using existing 1:24,000 scale geologic map boundaries (Figure1). Grid creation was refined using the Colorado Division of Water Resources (DWR) completed residential wells in the five counties of the SLV downloaded on August 14, 2024. If there were only a few residential wells present in a grid area which would result in a low likelihood of obtaining volunteers, then either (1) a numbered grid space was not created or (2) multiple geologic map quadrangle areas were combined to create a larger numbered grid space. A total of 21 grid spaces were created (Figure 1).

---

[4] San Luis Valley Ecosystem Council, 2024 May 9, SLV Water Quality Testing Updates, https://www.slvec.org/household-well-water-testing

[5] Osei, S., 2023 November 30, SLVEC warns of elevated heavy metals in Valley water, The Crestone Eagle https://crestoneeagle.org/slvec-warns-of-elevated-heavy-metals-in-valley-water/

[6] Daniel Jr., J.C., and Blain, R.L., 1959, Background radiation and endemic faunal range in the San Luis Valley of southern Colorado: Great Basin Naturalist Vol. 19, No. 1, Article 4.

To assist in distributing the samples in the grid spaces, the uranium data provided by CDA in combination with a fine-grained sediment map provided by CSU that reportedly may correlate with uranium occurrences were used to create a sample grid. The number of water samples per grid varies between 1 and 4 samples.

The overall sampling approach was for the CGS to solicit volunteers whose water supply was from privately owned residential use wells, send them sampling kits to fill and ship (pre-paid) back to the CGS. Received groundwater samples were assigned anonymized samples numbers and kept until there were enough to ship to the analytical laboratory in batches of typically 6 or 12 samples (one or two coolers). Sample numbers were generated as follows: the year was listed first (2024) followed by the Federal Information Processing System (FIPS) code for the county, then the FIPS Colorado code (08) and finally a sequential sample number within the county. For the five counties in the SLV study area, the county FIPS were as follows: Alamosa – 003, Conejos – 021, Costilla – 023, Rio Grande –105, and Saguache – 109.

Eurofins St. Louis of Earth City, MO was contracted by the CDPHE for this project in 2024, using the same list of analytes as 2023 (presented in a later section). Upon receipt of the data, individual results were sent by email to the homeowners. Also provided with each sample result was a copy of the 2023 CDPHE Fact Sheet.

The CGS created sampling kits, which included 9x9x9 inch cardboard boxes lined with a plastic bag, a laboratory supplied sample container pre-preserved with a small amount of nitric acid, and a large Ziploc bag containing a pair of nitrile sampling gloves, sampling instructions, a sample form to be completed by the homeowner, tape for repackaging the box, and a prepaid FedEx Ground return shipping label. Homeowners had only to collect the sample, fill out the sample form and seal the form inside the Ziplock bag, repackage the box, and drop it off at the local FedEx shipping office (or drop box) or arrange with FedEx to have it picked up.

The sample form included their contact information, sample date and time, and they were asked on a voluntary basis to provide well information (if known) such as well depth, DWR permit number, and whether the well was completed in overburden or bedrock.

If the homeowner had a filtration system, they were asked in the sample instructions to bypass it to obtain “raw” water. All were asked to run their water long enough to obtain fresh water from the well rather than water that may have been sitting in the piping or a water tank.

Volunteer Solicitation:

Five residential well locations had elevated uranium concentrations in the 2021 residential well data provided by Karl Mauch. These well owners were directly invited to participate in this study and all agreed. Karl Mauch, who was sampling monitoring wells in the SLV at the time, collected the samples from a few of these owners who were too busy due to it being harvest season.

The CGS created a newspaper ad soliciting volunteers which was placed in the Valley Courier for four weeks. The ad explained the grant funded study and included a grid map showing the allotted number of well samples per numbered grid. Volunteers were requested to email Lesley Sebol at the CGS with their physical address, phone number (needed for FedEx shipping) and what grid number they thought they might be located within. As volunteers were obtained, the grid map was updated to reflect the remaining grid samples available for next week’s ad. Completed grids were progressively removed from the updated map. If too many volunteers were obtained from a grid space, they were notified that they had been placed on reserve. However, that only occurred in two grids, and they were incorporated shortly thereafter due to an overall low response in the SLV.

The CGS also contacted the local county governments (through the county commissioners) to ask that they place information about the sampling program on their websites or social media pages. Saguache County did so.

The CGS made additional efforts to increase Year 3 homeowner participation within the study area. About 160 residential water-well records in the downloaded DWR database were reviewed against the county Assessor's information to identify owners who lived at or near their property. Those with contact addresses out of state were excluded for sampling logistic reasons. Initially, owners with viable email addresses were contacted, which was later expanded to include direct phoning for a total of 40 direct contacts.

Discussions with local DenverDWR staff resulted in the CGS being connected to their local Water Division 3 staff person, who emailed a project flyer crafted by the CGS to people who might be interested in volunteering. The local staff person then followed up with an additional attempt to directly solicit volunteers in select grid areas using extra sampling kits that had been shipped for this purpose. Unfortunately, that extra effort was not successful.

Nine well owners (excluding the original five provided by CDA) volunteered through direct contact by email and/or phone (about one volunteer per five contacted) and six through the emailed flyer. The remaining well owners volunteered through indirect efforts. The CGS received a total of 34 samples. Sampled well locations are shown in **Figure 5**.

A spreadsheet was used to track incoming volunteer requests and solicited volunteers, extra volunteers placed on reserve (if any), the status of sample kit shipments, address location coordinates, and the well-specific information. Volunteers were also tracked in ArcGIS Pro using the street address, as it provided necessary information confirming which grid an address was located within, and relative proximity to other volunteers.

On the well sampling form, most volunteers were able to fill out their well information at least partially, with well depth being the most common well item completed. For wells without DWR permit numbers on the sample form, the DWR database was queried. If found, then the provided well depth on the sample form was verified, and where different was adjusted to match the well record in the project data table. Also, the geologic formation from the driller's well log was obtained or verified, where available.

Sample Shipping to Eurofins St. Louis: The CDPHE contracted Eurofins St. Louis of Earth City, MO for this project in 2024. The CGS stockpiled received water samples until there were enough to fill a cooler (typically six per cooler). When one or more coolers were filled, the CGS dropped them off at the local Eurofins Denver laboratory using standard chain of custody procedures. Eurofins Denver then shipped it overnight to their St. Louis laboratory. The St. Louis lab logged in received water samples and assigned a unique lab ID number to each sample.

The 2024 list of metal and radionuclide analytes included:

- Metals (aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, selenium, silver, thallium, thorium, tin, uranium, vanadium, and zinc),
- Gross alpha and gross beta,
- Isotopic radium-226 and radium-228, and
- Isotopic thorium-228, thorium-230, and thorium-232.

Homeowners were emailed their individual lab reports along with the CDPHE-provided 2023 Fact Sheet entitled "Private well water and your health, potential health impacts from select metals and radionuclides". This Fact Sheet contained guidance criteria and potential health impacts for the above analyte list, along with water treatment related information.

2024 Lab Results

Table 1 summarizes all sampled wells in the SLV, including their assigned sample numbers, location coordinates, well depth information (where available), and water quality data. It also includes the laboratory-assigned ID number for each sample. Results in Table 1 with concentrations greater than the applicable drinking water guidelines are bolded.

The spatial distribution of the groundwater quality data for specific metals and radionuclides that exhibited exceedances of their applicable drinking water guidelines is shown in **Figures 5 through 13**. Also included are radionuclides that either have no drinking water guideline (thorium) or exhibited no guideline exceedances but are contributors to the gross radionuclide measurements. Figures generated include uranium (Figure 5), thorium (Figure 6), gross alpha (Figure 7), gross beta (Figure 8), radium-226 plus radium-228 (Figure 9), thorium-230 plus thorium-232 (Figure 10), arsenic (Figure 11), lead (Figure 12), and vanadium (Figure 13). Sample locations with no detections of the analyte of interest in these figures are depicted by small, gray filled circles. Concentrations at or below the drinking water guideline (including detected estimated values below the reporting limit) were shown in blue, with guideline exceedances being shown in red. Figures were not generated for non-radioactive metals having no exceedances of their respective water quality guidelines.

Data Evaluation:

Analytes exhibiting exceedances of the applicable drinking water guidelines are listed with the number of exceedances from most to least: arsenic (6), gross alpha (4), uranium (3), lead (2), and vanadium (1). These are all highlighted in Table 1. The following bulleted list presents observations for the various analytes:

- Uranium was detected above the reporting limit at 20 of 34 sampled locations, but only three exceedances were reported (Figure 5). The exceedances were in grids #8 and #9. All three exceedances occurred in the unconsolidated aquifer.
- Thorium was detected at estimated concentrations in the mg/L range at only two locations (Figure 6) but was not detected above the reporting limit. These two locations were in grids #11 and #15, north and east of Alamosa.
- Gross alpha (Figure 7) and gross beta (Figure 8) were detected above their calculated reporting limits at 16 and 29 locations, respectively. However, gross alpha only exhibited 4 exceedances, all in the unconsolidated aquifer. These were within grids #8 and #9, like the uranium exceedances. Gross beta had no exceedances.
- Radium-226 and radium-228 (Figure 9) were detected at seven and one location(s), respectively. Radium-226 and radium-228 were detected together at only one location in grid #9. None exhibited exceedance of the combined Radium-226+228 guideline of 5 pCi/L.
- Thorium-228 was not detected. Thorium-230 was detected in low concentrations at five locations. Thorium-232 was detected at only one location. The detections occurred in both the unconfined and confined aquifers. There were no exceedances of the thorium-230+232 guideline of 60 pCi/L (Figure 10).
- Arsenic was detected above the reporting limit at seven locations, of which all but one exceeded the 0.01 guidance criteria (Figure 11). The exceedances reportedly occurred in the confined aquifer for all but one location. Arsenic was also present at estimated concentrations below the reporting limit at 14 locations which occurred in both the unconfined and confined aquifers.
- Lead was detected at estimated concentrations below the reporting limit at five locations and above the reporting limit at two other locations (Figure 12). All detections above the reporting limit are considered exceedances of the "present" guidance criteria. These two exceedances occurred in the confined aquifer.

- Vanadium was detected above the reporting limit at seven locations (Figure 13). Most were in the confined aquifer, with one being unknown and one being in deep sand and gravel. Only one of these detections exceeded the 0.07 mg/L guidance criteria and was in the confined aquifer in grid #14.

Best Regards,

Lesley Sebol, PhD
Senior Hydrogeologist

&

Orna Buch Leviatan
Geologist

Attachments:

Table 1. Water quality data

Figure 1. Sampling grid and residential water wells in the San Luis Valley, Colorado
Figure 2. Outline of the paleo Lake Alamosa in the central San Luis Valley, Colorado
Figure 3. Historic groundwater uranium data in the central San Luis Valley, Colorado
Figure 4. Sampled residential water wells in the San Luis Valley, Colorado
Figure 5. Uranium concentrations in milligrams per liter (mg/L) from water wells in the San Luis Valley, Colorado
Figure 6. Thorium concentrations in milligrams per liter (mg/L) from water wells in the San Luis Valley, Colorado
Figure 7. Gross Alpha concentrations in picocuries per liter (pCi/L) from water wells in the San Luis Valley, CO
Figure 8. Gross Beta concentrations in picocuries per liter (pCi/L) from water wells in the San Luis Valley, CO
Figure 9. Radium 226+228 conc.s in picocuries per liter (pCi/L) from water wells in the San Luis Valley, Colorado
Figure 10. Thorium 230+232 conc.s in picocuries per liter (pCi/L) from water wells in the San Luis Valley, Colorado
Figure 11. Arsenic concentrations in milligrams per liter (mg/L) from water wells in the San Luis Valley, Colorado
Figure 12. Lead concentrations in milligrams per liter (mg/L) from water wells in the San Luis Valley, Colorado
Figure 13. Vanadium concentrations in milligrams per liter (mg/L) from water wells in the San Luis Valley, CO

Table 1. Water quality data in the San Luis Valley, Colorado

Sample ID	Lab ID	Latitude	Longitude	Sample Date	Time	Well Depth	Geology[1]	Gross Alpha (pCi/L)	(±)[2]	Gross Beta (pCi/L)	(±)	Radium-226 (pCi/L)	(±)	Radium-228 (pCi/L)	(±)	Ra-226+228 (pCi/L)	Thorium-228 (pCi/L)	(±)	Thorium-230 (pCi/L)	(±)	Thorium-232 (pCi/L)	(±)	Th-230+232 (pCi/L)
							DWG[3]:	*15*		*50*		--->		--->		*5*	--->		--->		--->		*60*
202410508-01	*160-55784-1*	37.75	-106.05	9/8/2024	18:10	99	*Unconfined aquifer*	1.77 U	1.3	3.19	0.9	0.0246 U	0.05	0.0259 U	0.37	ND	-0.0289 U	0.14	0.288	0.25	0.0640 U	0.08	0.288
202400308-02	*160-55784-2*	37.48	-105.85	9/16/2024	11:15	500	*Confined aquifer*	-0.504 U	0.9	1.55	0.6	0.0104 U	0.05	0.183 U	0.43	ND	-0.0286 U	0.13	0.109 U	0.23	0.0174 U	0.06	ND
202400308-03	*160-55784-3*	37.38	-105.97	9/16/2024	19:08	402	*Confined aquifer*	0.911 U	1.3	5.41	1.1	0.155	0.08	0.0345 U	0.48	0.155	0.0444 U	0.16	0.191 U	0.22	0.00409 U	0.05	ND
202410908-04	*160-55784-4*	38.07	-105.90	9/14/2024	9:00	400	*Confined aquifer*	4.85	2.3	2.99	0.9	0.0576 U	0.06	-0.423 U	0.45	ND	-0.011 U	0.17	0.00621 U	0.18	0.0047 U	0.05	ND
202410508-05	*160-55784-5*	37.69	-106.14	9/25/2024	12:03	69	*Unconfined aquifer*	9.00	3.0	5.45	1.3	0.0743 U	0.07	0.0574 U	0.37	ND	0.0146 U	0.15	0.0292 U	0.19	0.0171 U	0.05	ND
202410908-06	*160-55784-6*	37.64	-105.89	9/23/2024	16:30	100	*Unconfined aquifer*	**39.5**	9.8	22	3.9	0.225	0.10	0.724 U	0.54	0.225	-0.0452 U	0.15	0.127 U	0.21	-0.0182 U	0.03	ND
202400308-07	*160-55784-7*	37.75	-105.88	9/23/2024	11:00	86	*Unconfined aquifer*	**19.2**	5.0	12	2.2	0.17	0.09	-0.213 U	0.31	0.17	0.0643 U	0.16	0.192 U	0.23	0.0120 U	0.05	ND
202400308-08	*160-55784-8*	37.65	-105.93	9/23/2024	15:30	80	*Unconfined aquifer*	7.5 U	8.0	12.3	3.8	0.0507 U	0.06	0.212 U	0.37	ND	0.0374 U	0.16	0.373	0.27	0.0182 U	0.05	0.373
202400308-09	*160-55784-9*	37.57	-105.86	9/25/2024	8:30	840	*Confined aquifer*	1.17 U	2.9	1.21 U	1.1	0.0964 U	0.08	0.427 U	0.40	ND	-0.0286 U	0.15	0.154 U	0.21	0.00835 U	0.05	ND
202402108-10	*160-55784-10*	37.41	-105.95	10/2/2024	13:00	500	*Confined aquifer*	0.417 U	1.3	8.82	1.4	0.0516 U	0.07	0.431 U	0.33	ND	-0.076 U	0.13	0.0283 U	0.19	0.0331 U	0.07	ND
202410508-11	*160-55907-1*	37.41	-106.04	10/14/2024	11:27	180	*Confined aquifer*	1.53 U	1.2	5.30	0.9	0.0210 U	0.07	0.383 U	0.50	ND	0.0816 U	0.17	0.110 U	0.22	-0.00554 U	0.03	ND
202400308-12	*160-55907-2*	37.44	-105.88	10/11/2024	14:00	800	*Confined aquifer*	-0.399 U	1.1	3.82	0.9	0.141 U	0.1	0.430 U	0.51	ND	-0.0459 U	0.15	0.231 U	0.25	0.0204 U	0.08	ND
202402108-13	*160-55907-3*	37.36	-106.08	10/14/2024	13:45	200	*Confined aquifer*	2.19	1.4	3.39	0.9	0.0885 U	0.1	0.377 U	0.5	ND	0.123 U	0.17	0.229 U	0.24	-0.0191 U	0.03	ND
202410508-14	*160-55979-1*	37.63	-106.17	10/16/2024	13:00	55	*Unconfined aquifer*	0.104 U	1.0	1.43	0.6	-0.00377 U	0.1	0.182 U	0.3	ND	-0.199 U	0.13	0.51	0.30	-0.0240 U	0.03	0.51
202400308-15	*160-55979-2*	37.45	-105.63	10/17/2024	17:15	80	*Unconfined aquifer*	4.21	2.2	4.19	1.1	0.166	0.1	0.123 U	0.4	0.166	0.155 U	0.20	0.707	0.34	0.124	0.12	0.831
202402308-16	*160-55979-3*	37.42	-105.62	10/17/2024	14:30	97	*Unconfined aquifer*	1.88	1.3	2.74	0.8	0.0387 U	0.1	0.408 U	0.4	ND	-0.0387 U	0.14	0.0819 U	0.20	-0.0137 U	0.02	ND
202400308-17	*160-55979-4*	37.74	-105.86	10/18/2024	15:20	80	*Unconfined aquifer*	**30.5**	7.9	19.7	3.3	0.395	0.2	0.645	0.4	1.04	-0.0589 U	0.16	0.214 U	0.26	0.0435 U	0.09	ND
202410908-17	*160-56068-1*	38.04	-105.93	10/18/2024	15:20	560	*Confined aquifer*	0.819 U	1.1	1.05	0.6	0.0820 U	0.1	0.287 U	0.3	ND	0.0854 U	0.21	0.0832 U	0.24	0.00806 U	0.07	ND
202402308-18	*160-56068-2*	37.39	-105.47	10/21/2024	10:45	200	*Existing well, unk*	4.54	2.0	1.71	0.8	0.167 U	0.1	-0.0912 U	0.4	ND	-0.0441 U	0.23	-0.0130 U	0.22	-0.0121 U	0.03	ND
202410908-19	*160-56068-3*	38.04	-105.91	10/24/2024	12:12	128	*Unconfined aquifer*	2.62	1.8	1.67	0.7	0.127 U	0.1	0.0986 U	0.3	ND	0.0178 U	0.22	0.259 U	0.29	0.0152 U	0.07	ND
202402308-20	*160-56303-1*	37.45	-105.19	10/24/2024	10:15	170	*Confined aquifer*	1.86	1.2	1.16	0.7	0.125	0.1	0.352 U	0.5	0.125	-0.0416 U	0.14	0.0209 U	0.19	0.00793 U	0.05	ND
202410508-21	*160-56303-2*	37.75	-106.11	10/31/2024	7:10	unk	*Unconsolidated*	1.04 U	0.9	1.30	0.6	0.0291 U	0.1	-0.0678 U	0.3	ND	0.0429 U	0.15	0.111 U	0.22	-0.0314 U	0.03	ND
202400308-22	*160-56303-3*	37.66	-105.80	11/10/2024	17:34	40	*Unconfined aquifer*	**43.2 G**	12.3	21.4	4.7	0.122 U	0.1	0.118 U	0.5	ND	-0.101 U	0.14	0.0326 U	0.19	-0.0345 U	0.03	ND
202410908-23	*160-56435-1*	37.76	-106.05	11/13/2024	19:30	85	*Unconfined aquifer*	0.698 U	1.0	5.60	1.1	0.0320 U	0.1	-0.179 U	0.4	ND	0.0620 U	0.18	0.127 U	0.21	0.0125 U	0.05	ND
202402108-24	*160-56435-2*	37.26	-105.77	11/12/2024	8:40	70	*Volcanic*	2.69	1.4	2.98	1.0	-0.0485 U	0.1	0.113 U	0.3	ND	0.121 U	0.24	0.00220 U	0.19	0.0228 U	0.07	ND
202400308-25	*160-56435-3*	37.54	-106.06	11/17/2024	19:00	300	*Confined aquifer*	0.141 U	1.1	4.27	0.9	0.0294 U	0.1	-0.147 U	0.2	ND	0.0191 U	0.14	0.0436 U	0.18	0.0327 U	0.06	ND
202402108-26	*160-56435-4*	37.29	-106.07	11/18/2024	12:25	37	*unknown*	-0.509 U	1.0	0.455 U	0.5	0.0105 U	0.1	-0.143 U	0.3	ND	0.0134 U	0.14	-0.0605 U	0.17	-0.0292 U	0.03	ND
202402308-27	*160-56435-5*	37.39	-105.34	11/18/2024	15:00	245	*Confined aquifer*	0.438 U	0.9	0.235 U	0.6	-0.0370 U	0.1	0.200 U	0.4	ND	0.0963 U	0.18	0.134 U	0.21	-0.00989 U	0.02	ND
202402308-28	*160-56435-6*	37.39	-105.34	11/18/2024	15:00	250	*Alluvial fan*	2.56	1.4	1.03 U	0.9	0.116 U	0.1	0.548 U	0.5	ND	-0.122 U	0.13	0.162 U	0.21	-0.0342 U	0.03	ND
202400308-29	*160-56444-1*	37.61	-105.94	11/23/2024	11:00	57	*Unconfined*	1.21 U	1.2	1.78	0.7	-0.0234 U	0.04	-0.0219 U	0.5	ND	-0.149 U	0.11	0.0165 U	0.18	-0.0181 U	0.03	ND
202400308-30	*160-56444-2*	37.47	-105.71	11/22/2024	9:30	135	*Unk*	0.574 U	0.7	-0.471 U	0.4	0.0568 U	0.1	0.202 U	0.6	ND	-0.0953 U	0.15	0.00596 U	0.18	0.0165 U	0.05	ND
202402108-31	*160-56444-3*	37.43	-105.66	11/22/2024	11:30	120	*sand and gravel*	0.275 U	1.5	4.64	1.1	0.171	0.1	0.831 U	0.6	0.171	0.0368 U	0.15	0.552	0.29	0.00792 U	0.05	0.552
202410508-32	*160-56444-4*	37.65	-106.16	11/20/2024	11:00	77	*Unconfined*	3.22	1.8	2.70	0.8	0.0991 U	0.1	0.294 U	0.5	ND	-0.0716 U	0.16	0.0604 U	0.21	0.0332 U	0.07	ND
202402308-33	*160-56447-1*	37.40	-105.33	12/3/2024	6:10	218	*S&G*	3.78	1.7	2.58	0.9	0.0101 U	0.1	0.186 U	0.3	ND	-0.0139 U	0.16	0.201 U	0.23	0.00436 U	0.05	ND

NOTES:

[1] Geology is based on well driller's log where available or homeowner self-reported information.

[2] Radionuclide total uncertainty value (2 sigma) shown as (±).

[3] DWG are drinking water guidelines. Results greater than these guidelines are bolded.

"U" = Result is less than the sample detection limit (i.e., not detected (ND)).

"J" = Value estimated between method detection limit (MDL) and practical quantitation limit (PQL).

"B" = Compound was found in the lab blank and sample.

"^+" = Continuing Calibration Verification (CCV) is outside acceptance limits, high biased.

Radionuclide data values preceded by minus sign "-" are equivalent to ND.

	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Iron (mg/L)	Lead (mg/L)	Manganese (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Thallium (mg/L)	Thorium (mg/L)	Tin (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
Sample ID	***7***	***0.006***	***0.01***	***2***	***0.004***	***1.4***	***0.005***	***0.01***	***0.006***	***1.3***	***14***	***present***	***0.3***	***0.035***	***0.1***	***0.05***	***0.035***	***0.002***	***n/a***	***2.1***	***0.03***	***0.07***	***2***
202410508-01	ND	ND	0.0021 J	0.031	ND	0.028 J	ND	ND	ND	ND	0.032 J	ND	ND	0.0011 J	ND	ND	ND	ND	ND	ND	0.0016	ND	0.022
202400308-02	ND	ND	**0.022**	0.0063	ND	0.092 J	ND	ND	ND	ND	0.044 J	ND	0.0026 J	0.0023 J	ND	ND	ND	ND	ND	0.00086 J	0.00016 J	**0.13**	0.09
202400308-03	1.8	ND	0.0082 J	0.057	ND	0.022 J	ND	0.0021 J	0.00073 J	0.0058	1.4	0.0012 J	0.041	0.0012 J	0.0014 J	0.00067 J	ND	ND	ND	ND	0.00072 J	0.013	0.025
202410908-04	ND	ND	ND	0.048	ND	0.012 J	ND	0.0014 J	ND	ND	0.02 J	ND	ND	0.0012 J	ND	ND	ND	ND	ND	ND	0.0033	0.0044 J	0.011 J
202410508-05	ND	ND	ND	0.07	ND	0.033 J	ND	ND	ND	0.0018 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.011	ND	0.026
202410908-06	0.069 J	ND	0.0025 J	0.14	ND	0.21	ND	ND	ND	0.01	ND	ND	0.0036 J	0.00089 J	0.00097 J	0.002 J	ND	ND	ND	0.1	**0.048**	0.0075 J	0.051
202400308-07	ND	ND	0.003 J	0.092	ND	0.075 J	ND	ND	ND	0.0097	0.089	0.0014 J	0.0074	0.0015 J	ND	0.0017 J	ND	ND	ND	ND	0.022	0.0089 J	0.095
202400308-08	ND	ND	0.0019 J	0.035	ND	0.18	ND	ND	ND	0.0063	0.028 J	ND	ND	ND	ND	0.0022 J	ND	ND	ND	ND	0.014	ND	0.012 J
202400308-09	0.1	ND	ND	0.027	ND	1.1	0.00023 J	ND	ND	0.0032 B	0.088	ND	0.013	0.007	ND	ND	ND	ND	0.0014 J	0.00087 J	0.0002 J	ND	ND
202402108-10	ND	ND	**0.024**	0.05	ND	0.074 J	ND	ND	ND	ND	ND	ND	0.017	0.0029 J	ND	ND	ND	ND	ND	ND	0.0012	0.013	ND
202410508-11	ND	ND	0.010	0.029	ND	0.024 J	ND	0.0013 J	ND	ND	0.055	0.0015 J	ND	0.0018 J	ND	0.00077 J	ND	ND	ND	ND	0.0015	0.0095 J	ND
202400308-12	0.084 J	ND	**0.020**	0.038	ND	0.26	ND	ND	ND	0.039	0.040 J	**0.0040**	0.042	0.0029 J	ND	ND	ND	ND	ND	0.0014 JB	0.00029 J	ND	0.011 J
202402108-13	ND	ND	0.0018 J	0.041	ND	ND	ND	0.0026 J	0.00028 J	0.0013 J	0.12	0.0019 J	0.0031 J	ND	0.0029 J	ND	ND	ND	ND	ND	0.0024	ND	ND
202410508-14	ND	ND	ND	0.031	ND	0.017 J	ND	ND	ND	0.0013 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.00062 J	ND	ND
202400308-15	1.4	ND	0.0016 J	0.11	ND	0.018 J	ND	0.0036 J	0.00073 J	0.015	1.8 B	0.0027 J	0.059	0.0020 J	0.0024 J	ND	ND	ND	0.00061 J	ND	0.0079	0.0090 J	0.0096 J
202402308-16	ND	ND	ND	0.035	ND	0.040 J	ND	0.0022 J	ND	0.0048	0.024 JB	ND	ND	0.0013 J	ND	ND	ND	ND	ND	ND	0.0036	0.0053 J	0.013 J
202400308-17	ND	ND	0.0040 J	0.16	ND	0.16	ND	ND	ND	0.0073	ND	ND	ND	0.0014 J	ND	0.0038 J	ND	ND	ND	ND	**0.053**	0.0084 J	0.05
202410908-17	0.078 J	ND	0.0034 J	0.066	ND	0.025 J	ND	ND	ND	ND	0.10	ND	ND	0.0022 J	ND	ND	ND	ND	ND	ND	0.00076 J	0.0046 J	ND
202402308-18	ND	ND	ND	0.042	ND	0.016 J	ND	ND	ND	0.0061	ND	ND	ND	0.0018 J	ND	ND	ND	ND	ND	ND	0.0047	ND	0.0084 J
202410908-19	ND	ND	ND	0.047	ND	0.015 J	ND	ND	ND	0.011	0.12	ND	ND	0.0013 J	ND	ND	ND	ND	ND	ND	0.0024	ND	0.043
202402308-20	ND	ND	ND	0.014	ND	ND	ND	ND	ND	0.033	0.20	**0.0066**	0.0027 J	ND	ND	ND	ND	ND	ND	ND	0.0029	ND	0.41
202410508-21	ND	ND	0.0031 J	0.015	ND	0.012 J	ND	ND	ND	0.0049	ND	ND	ND	0.00060 J	ND	ND	ND	ND	ND	0.00087 J	0.00061 J	0.0077 J	0.015 J
202400308-22	ND	ND	ND	0.044	ND	0.19	ND	ND	ND	0.0036	3.3	ND	0.22	0.0044 J	ND	ND	ND	ND	ND	ND	**0.066**	ND	ND
202410908-23	ND	ND	0.0037 J	0.034	ND	0.016 J^+	ND	ND	ND	ND	0.066 B	ND	0.072	0.0012 J	ND	ND	ND	ND	ND	ND	ND	ND	0.019 J
202402108-24	ND	ND	0.0088 J	0.0067	ND	0.053 J^+	ND	ND	ND	0.0013 J	ND	ND	ND	0.0015 J	ND	ND	ND	ND	ND	ND	0.0038	0.025	ND
202400308-25	ND	ND	**0.073**	0.043	ND	0.29	ND	ND	ND	0.0017 J	0.13 B	ND	0.044	0.0082	0.0025 J	ND	ND	ND	ND	ND	0.00079 J	ND	ND
202402108-26	ND	ND	ND	0.03	ND	0.011 J^+	ND	ND	ND	0.013	0.22 B	ND	0.0044 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.016 J
202402308-27	ND	ND	**0.019**	ND	ND	0.13	ND	ND	ND	0.0025 J	ND	ND	ND	0.0023 J	ND	ND	ND	ND	ND	ND	0.00025 J	ND	0.0078 J
202402308-28	ND	ND	ND	0.0041	ND	0.042 J^+	ND	0.0022 J	ND	0.015	1.9 B	ND	ND	0.0061	0.0012 J	ND	ND	ND	ND	0.00098 J	0.0026	0.0062 J	0.033
202400308-29	ND	ND	**0.015**	ND	ND	0.17	ND	ND	ND	0.02	ND	ND	ND	0.0020 J	ND	ND	ND	ND	ND	0.00076 J	0.00017 J	0.039	ND
202400308-30	ND	ND	0.0033 J	0.014	ND	0.010 J	ND	0.0061 J	ND	0.0017 J	0.058	ND	ND	ND	0.0028 J	ND	ND	ND	ND	ND	0.00053 J	0.021	ND
202402108-31	0.065 J	ND	0.0063 J	0.037	ND	0.31	ND	ND	ND	0.015	0.21	ND	0.013	0.016	0.0014 J	ND	ND	ND	ND	ND	0.00054 J	0.016	0.026
202410508-32	ND	ND	ND	0.069	ND	0.030 J	ND	ND	ND	0.02	ND	ND	ND	ND	0.0013 J	ND	ND	ND	ND	ND	0.0011	ND	0.014 J
202402308-33	ND	ND	ND	0.037	ND	0.024 J	ND	0.0029 J	ND	0.0024 J	0.028 J	ND	ND	0.0020 J	ND	0.0022 J	ND	ND	ND	ND	0.0052	0.0049 J	0.019 J

NOTES:

[1] Geology is based on well driller's log where available or homeowner self-reported information.

[2] Radionuclide total uncertainty value (2 sigma) shown as (±).

[3] DWG are drinking water guidelines. Results greater than these guidelines are bolded.

"U" = Result is less than the sample detection limit (i.e., not detected (ND)).

"J" = Value estimated between method detection limit (MDL) and practical quantitation limit (PQL).

"B" = Compound was found in the lab blank and sample.

"^+" = Continuing Calibration Verification (CCV) is outside acceptance limits, high biased.

Radionuclide data values preceded by minus sign "-" are equivalent to ND.

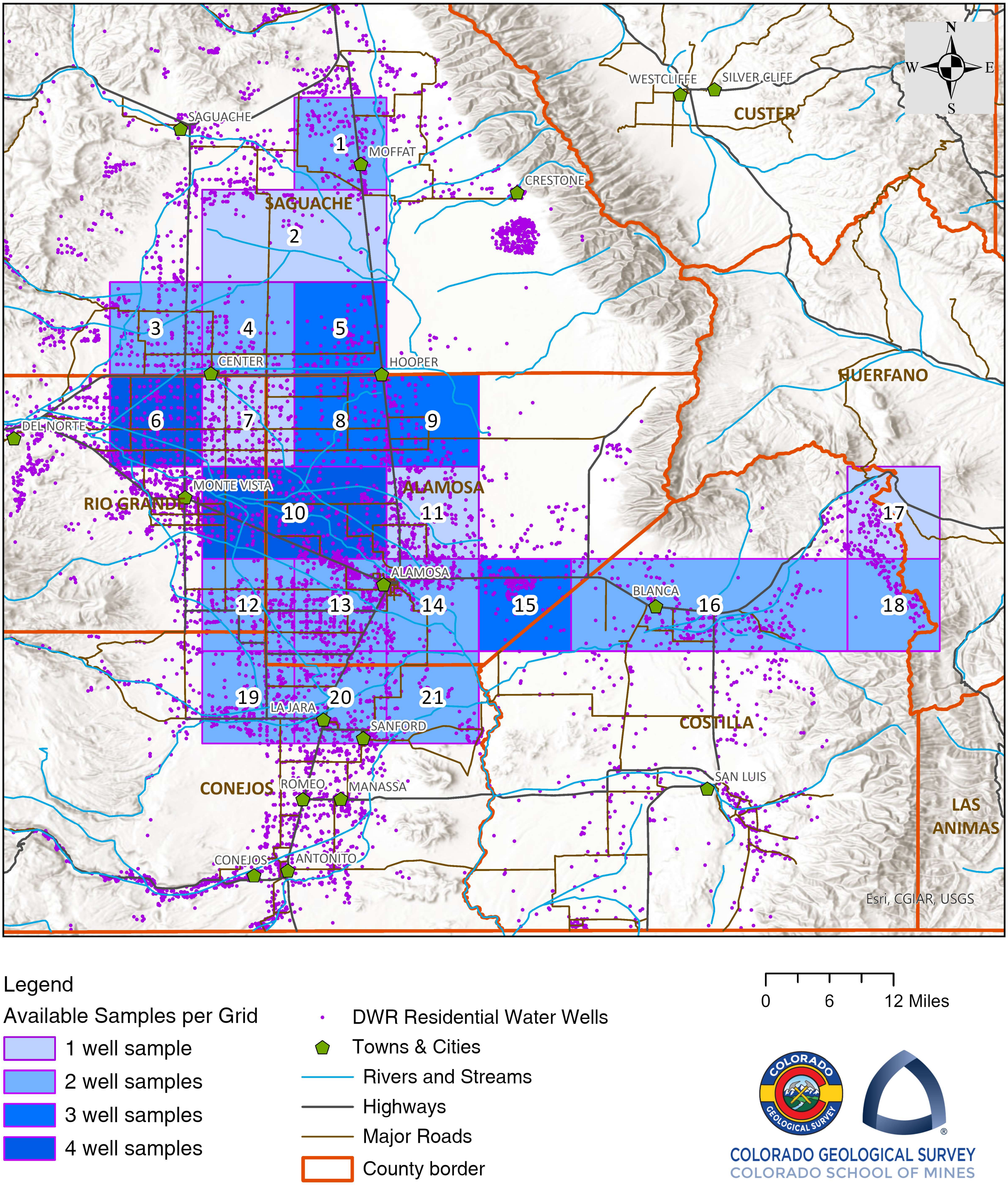


Figure 1. Sampling grid and residential water wells in the San Luis Valley, Colorado. The grid was designed using historic uranium data and fine-grained sediment patterns provided to the CGS. The original assigned number of samples per grid space are shown.

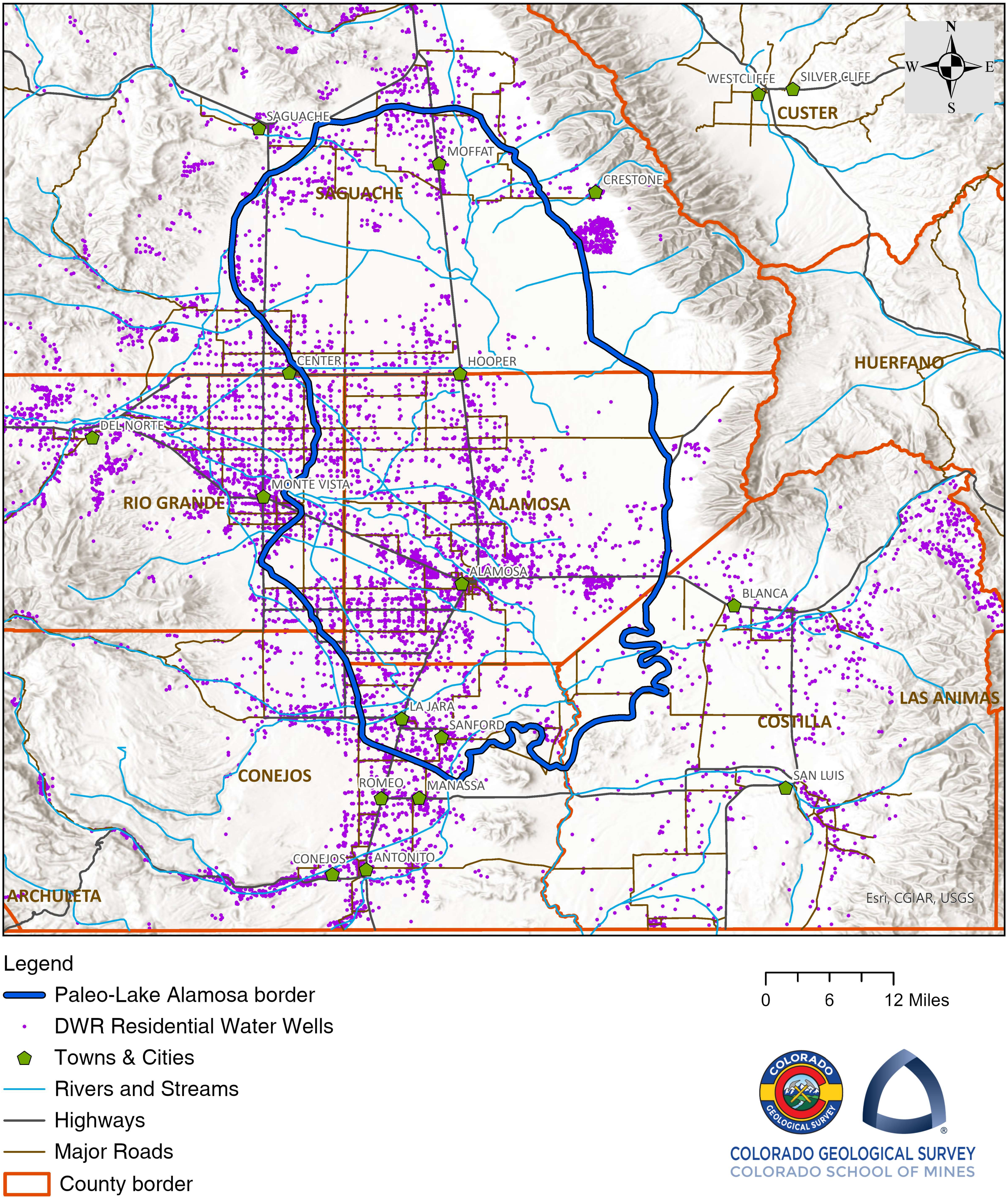


Figure 2. Outline of the paleo Lake Alamosa in the central San Luis Valley, Colorado. This lake existed from about 3 million to about 440,000 years ago (Machette and others, 2007). Clay deposited in the paleo-lake bottom caps a confined aquifer, in which water wells are artesian.

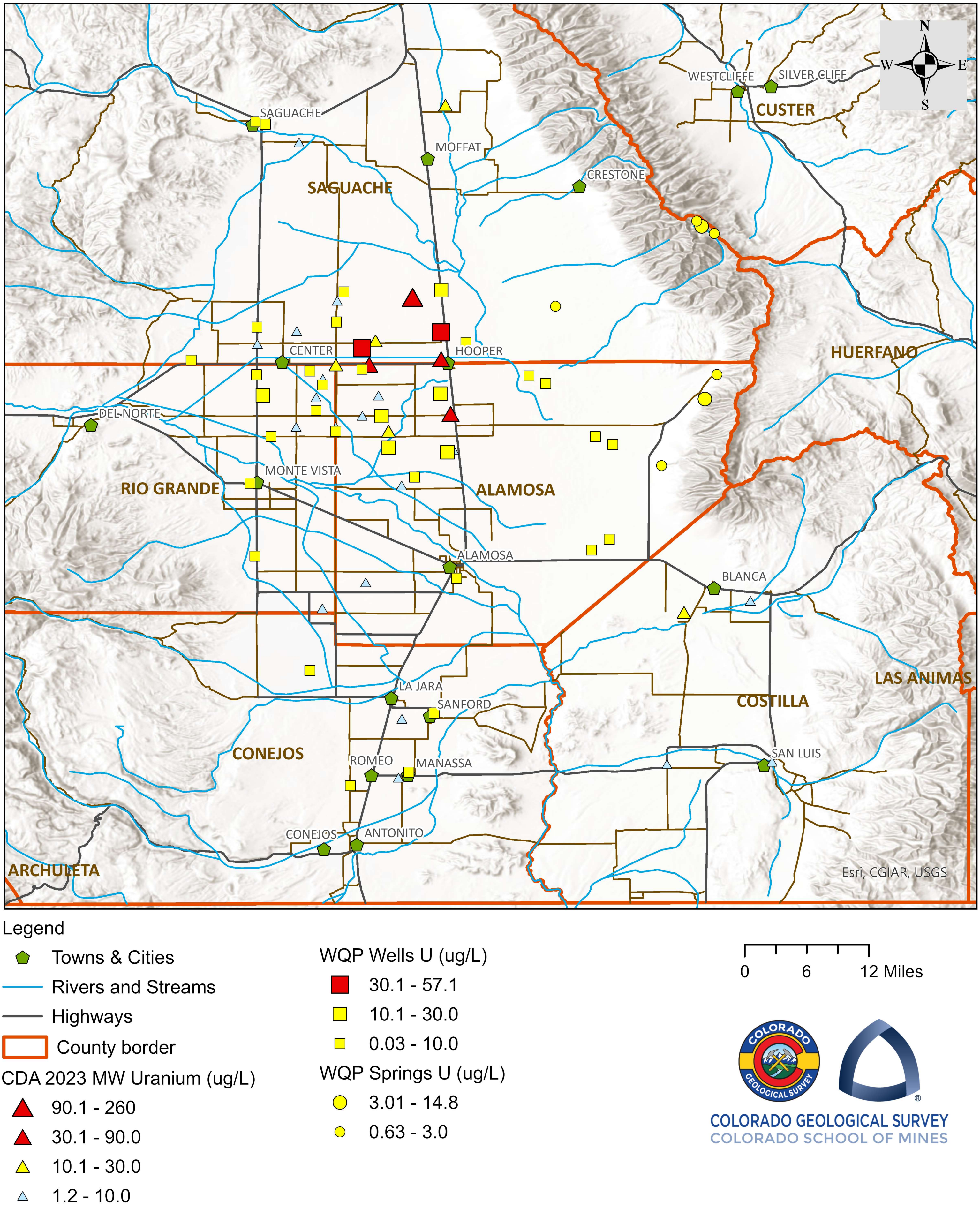
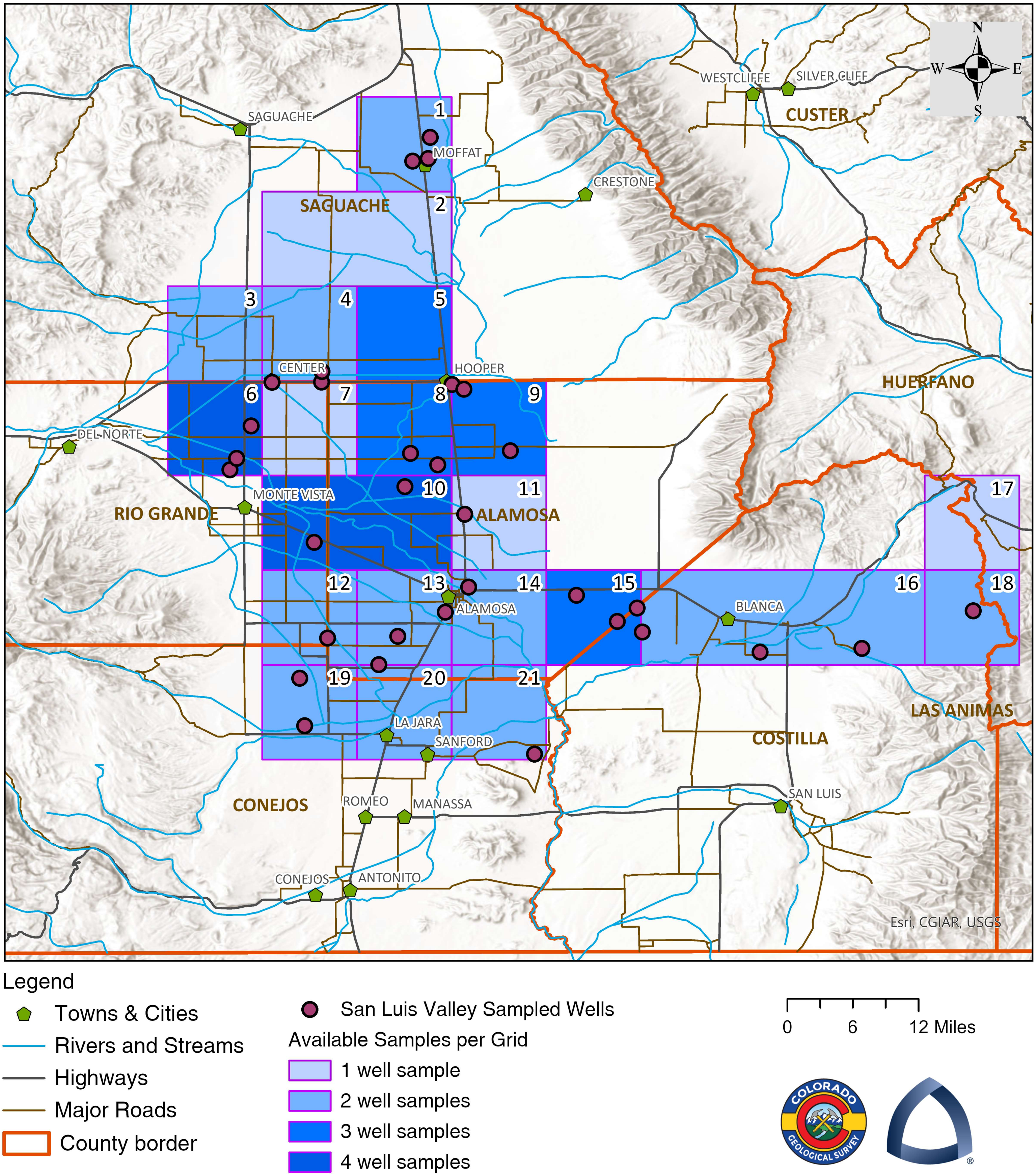
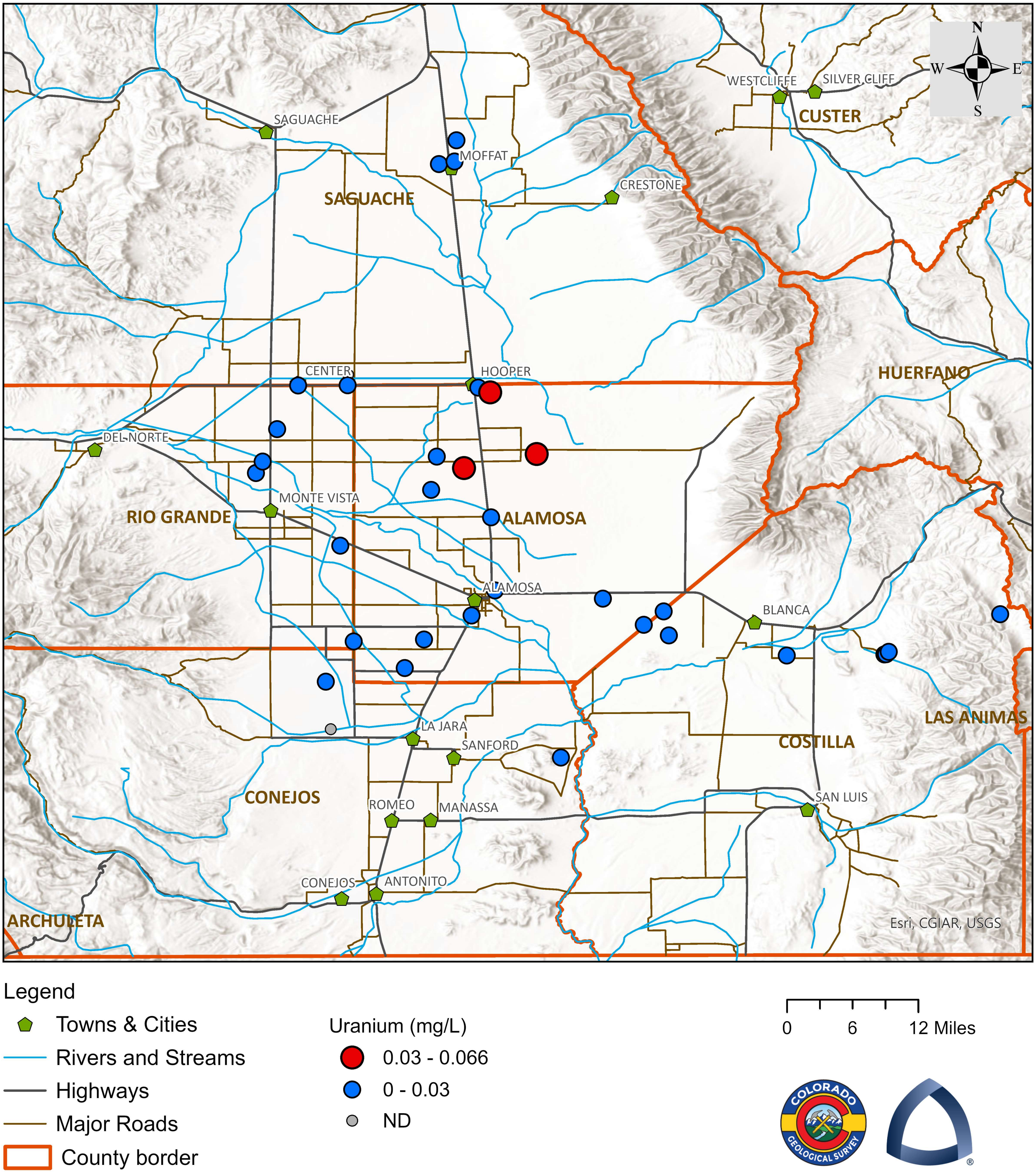


Figure 3. Historic groundwater uranium data in the central San Luis Valley, Colorado. Data is from drinking water and monitoring wells in the unconfined aquifer, except 7 of the drinking water wells are in the confined aquifer. Springs are also included. CDA data used with permission.



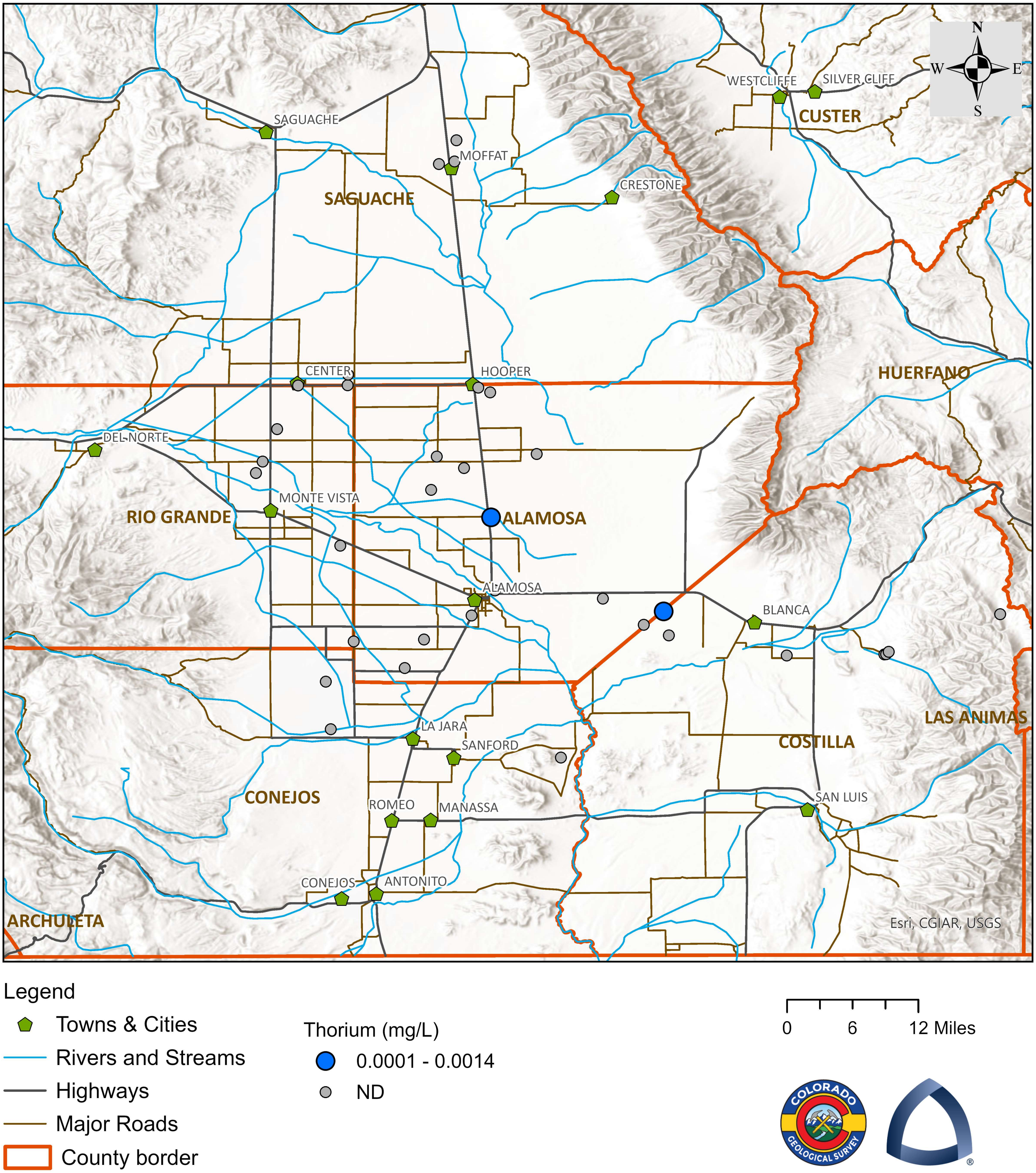
COLORADO GEOLOGICAL SURVEY
COLORADO SCHOOL OF MINES

Figure 4. Sampled residential water wells in the San Luis Valley, Colorado, in 2024. Not all grids were able to be filled.



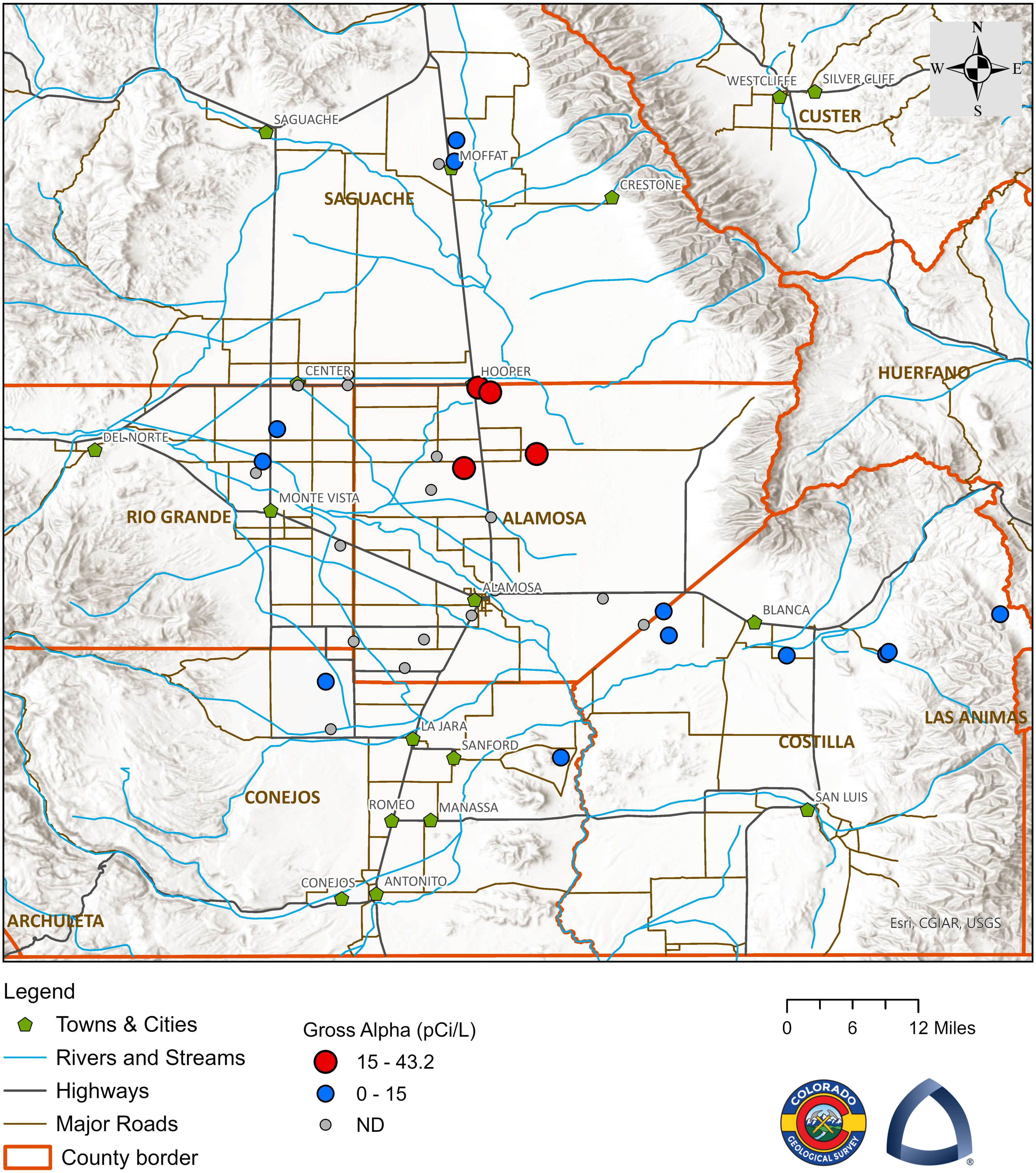
COLORADO GEOLOGICAL SURVEY
COLORADO SCHOOL OF MINES

Figure 5. Uranium concentrations in milligrams per liter (mg/L) from water wells in the San Luis Valley, Colorado. Locations where values were above the drinking water guideline of 0.03 mg/L are shown in red.



COLORADO GEOLOGICAL SURVEY
COLORADO SCHOOL OF MINES

Figure 6. Thorium concentrations in milligrams per liter (mg/L) from water wells in the San Luis Valley, Colorado. Thorium does not have a drinking water guideline, but it does contribute to other gross radionuclide measurements.



COLORADO GEOLOGICAL SURVEY
COLORADO SCHOOL OF MINES

Figure 7. Gross Alpha concentrations in picocuries per liter (pCi/L) from water wells in San Luis Valley, Colorado. Locations where values were above the drinking water guideline of 15 pCi/L are shown in red.

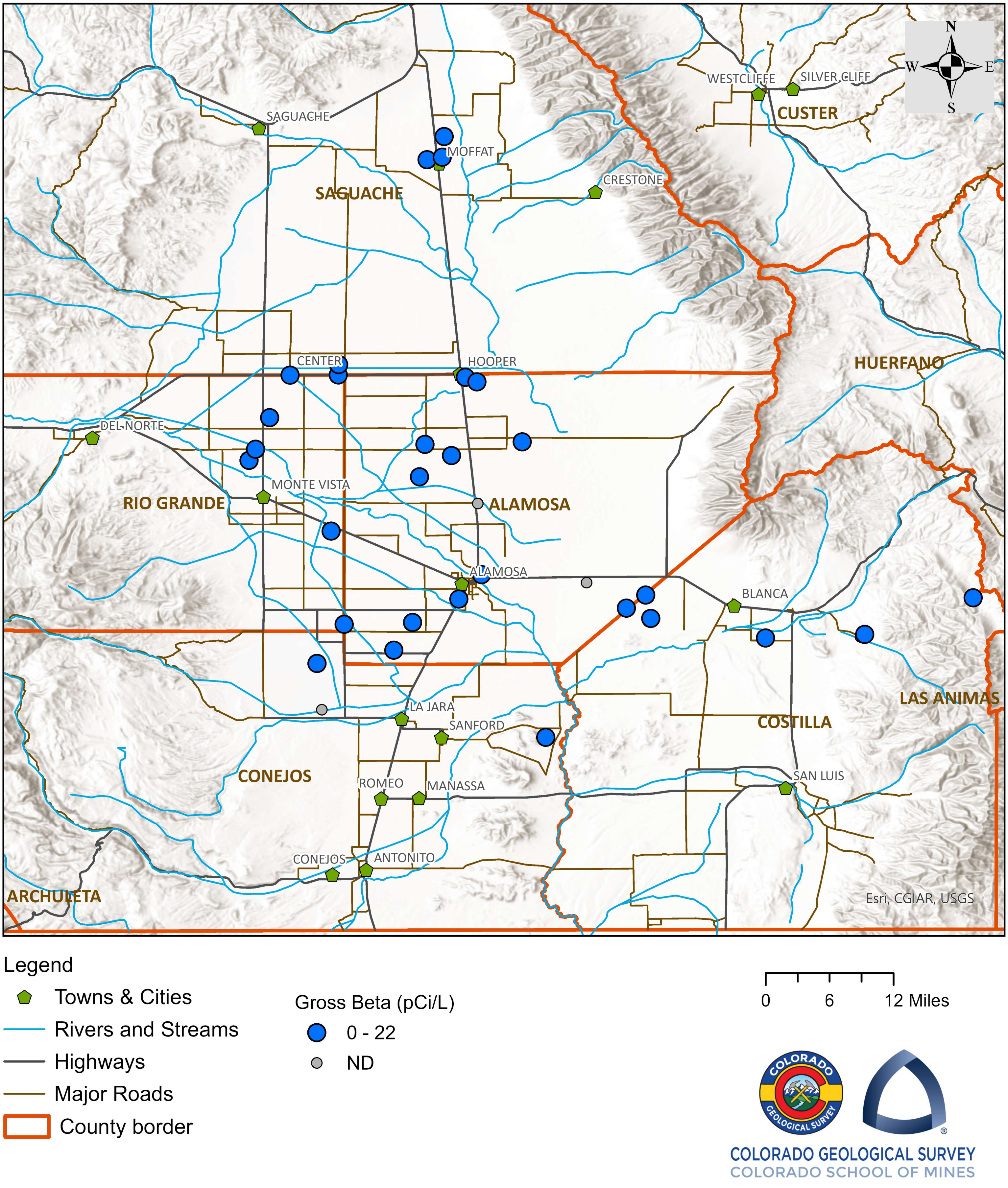


Figure 8. Gross Beta concentrations in picocuries per liter (pCi/L) from water wells in the San Luis Valley, Colorado. There are no locations where values were above the drinking water guideline of 50 pCi/L, but Gross Beta is a total radioactivity measurement from all beta-emitting elements.

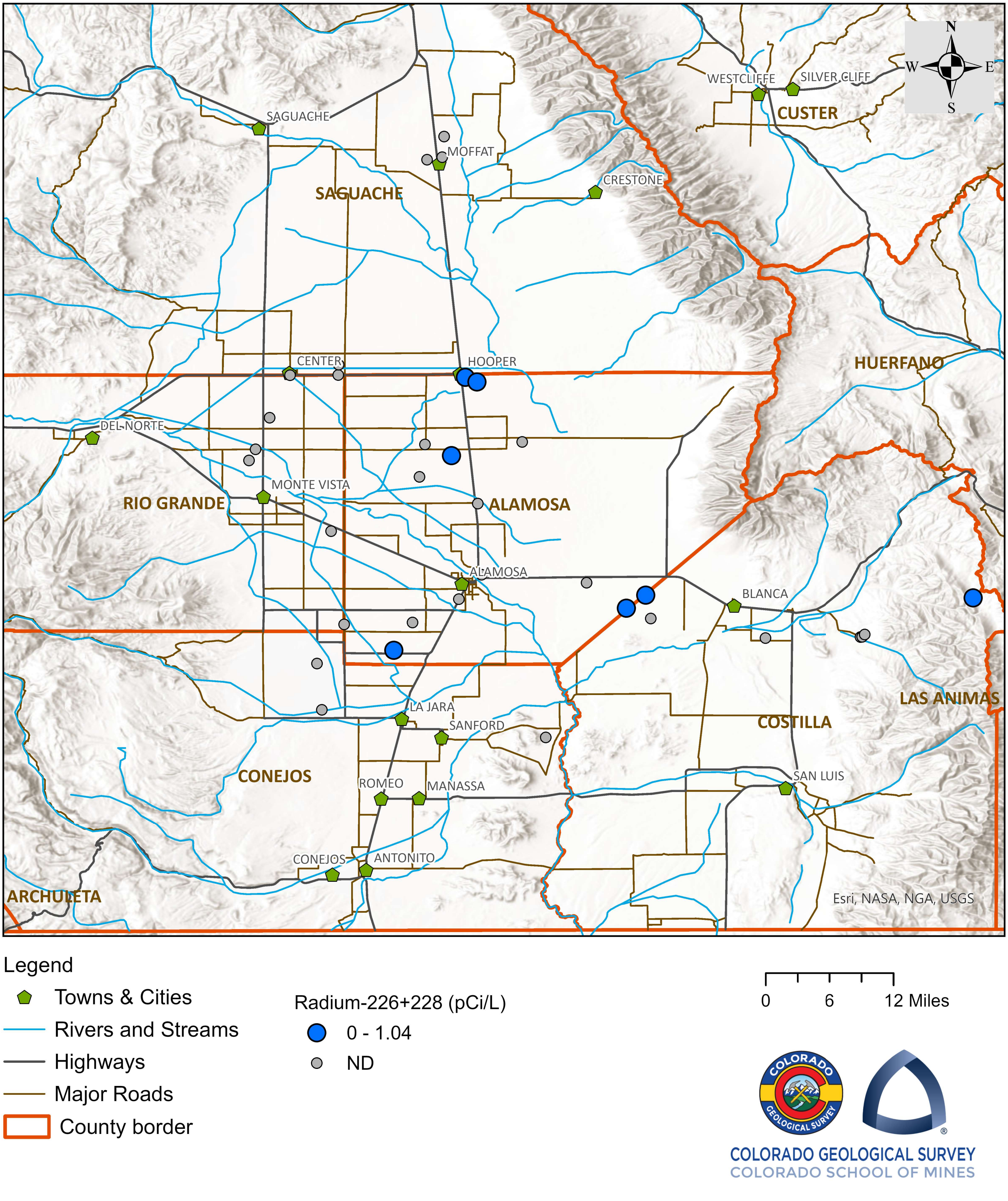
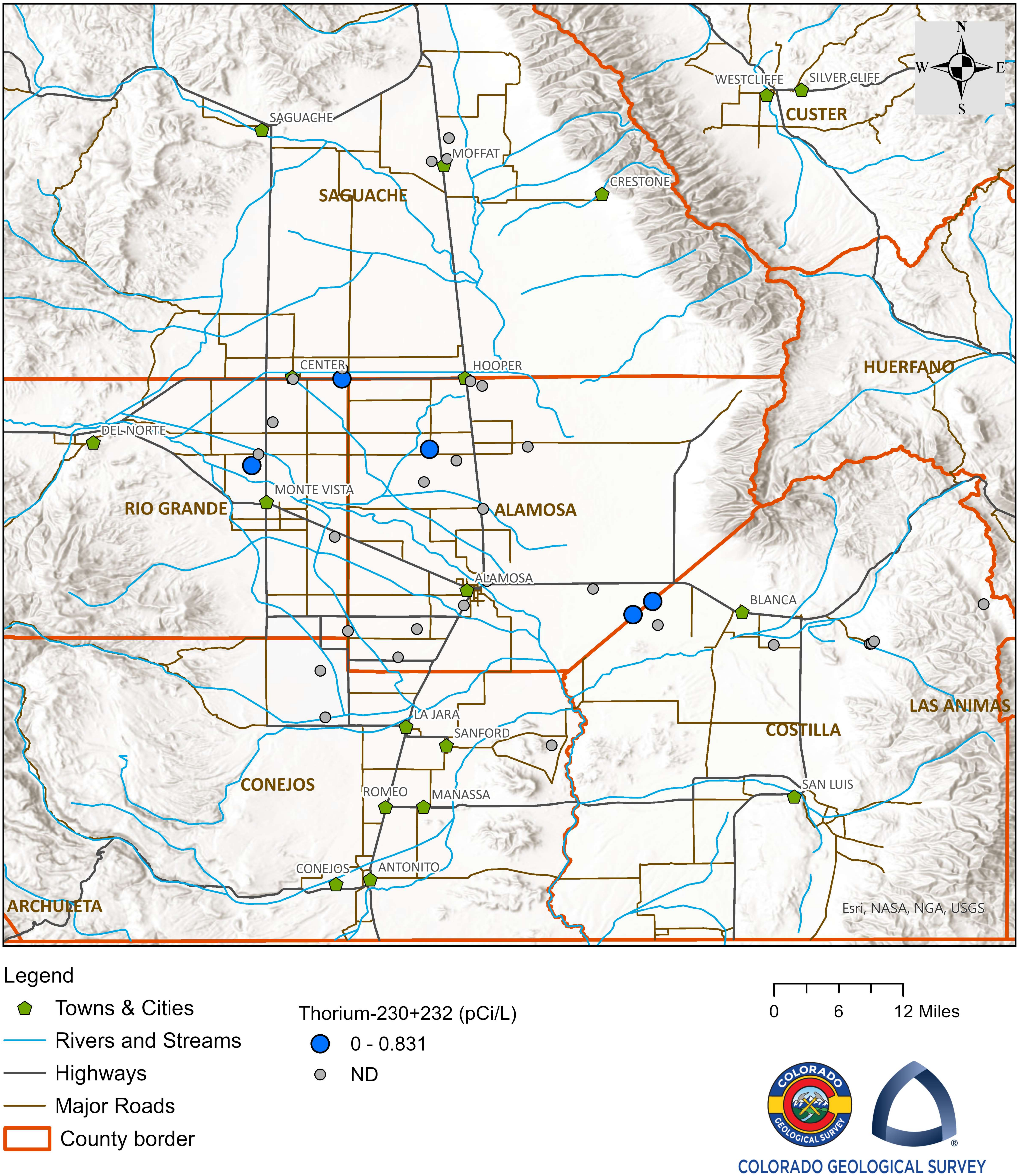
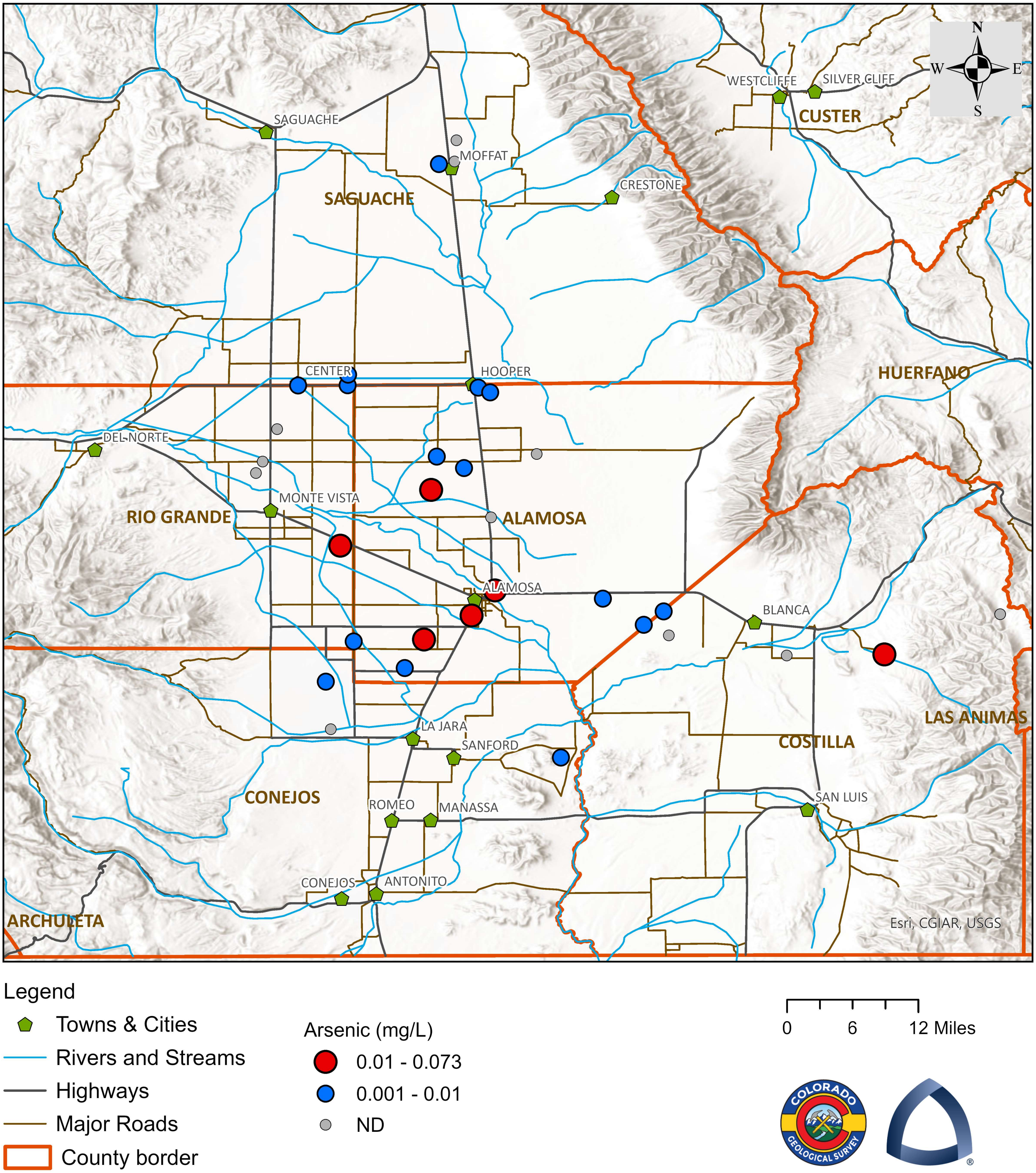


Figure 9. Radium-226+228 concentrations in picocuries per liter (pCi/L) from water wells in the San Luis Valley, Colorado. There are no locations where values were above the drinking water guideline of 5 pCi/L, but Radium-226+228 does contribute to other gross radionuclide measurements.



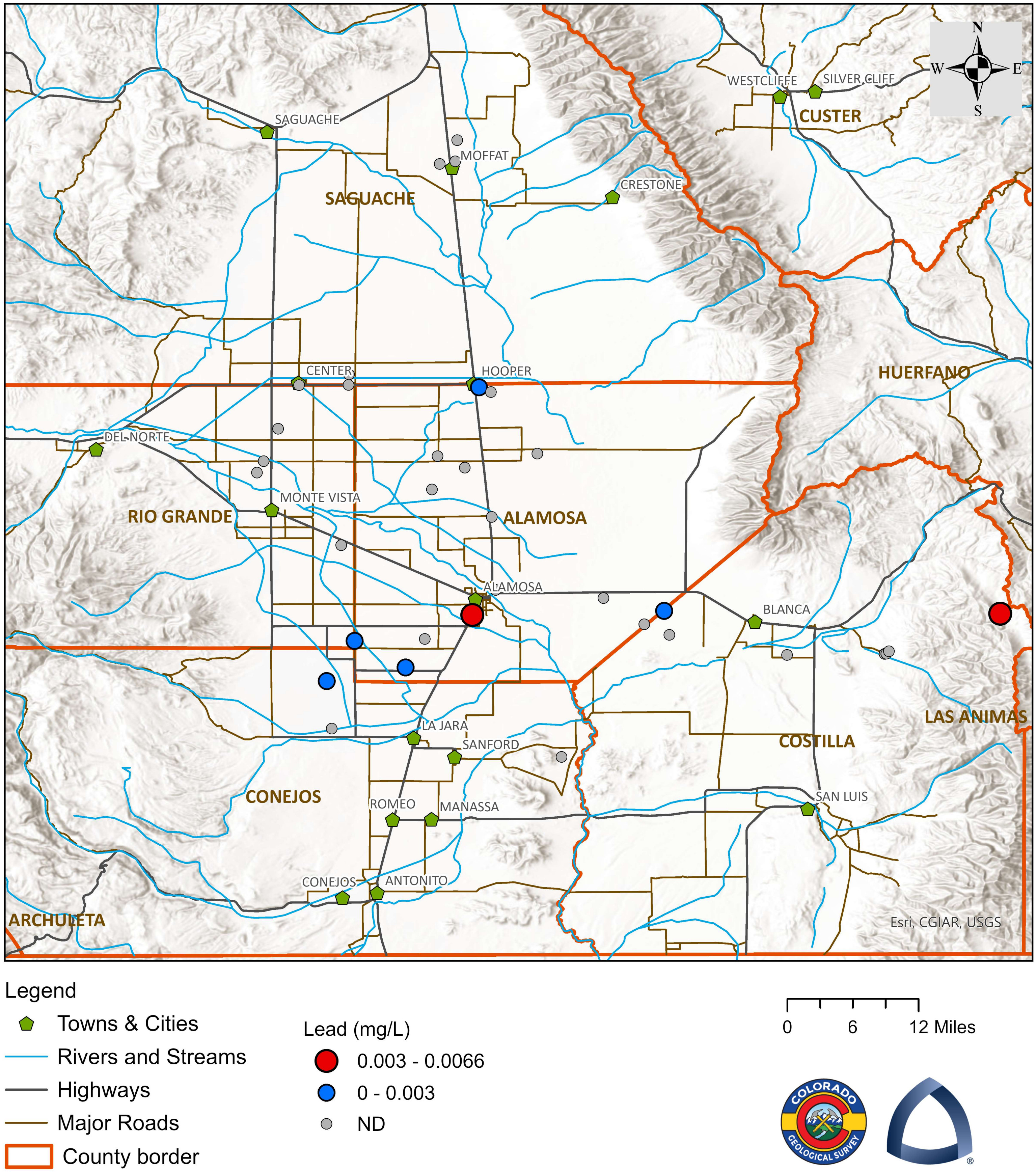
COLORADO GEOLOGICAL SURVEY
COLORADO SCHOOL OF MINES

Figure 10. Thorium-230+232 concentrations in picocuries per liter (pCi/L) from water wells in San Luis Valley, Colorado. There are no locations where values were above the drinking water guideline of 60 pCi/L, but Thorium-230+232 does contribute to other gross radionuclide measurements.



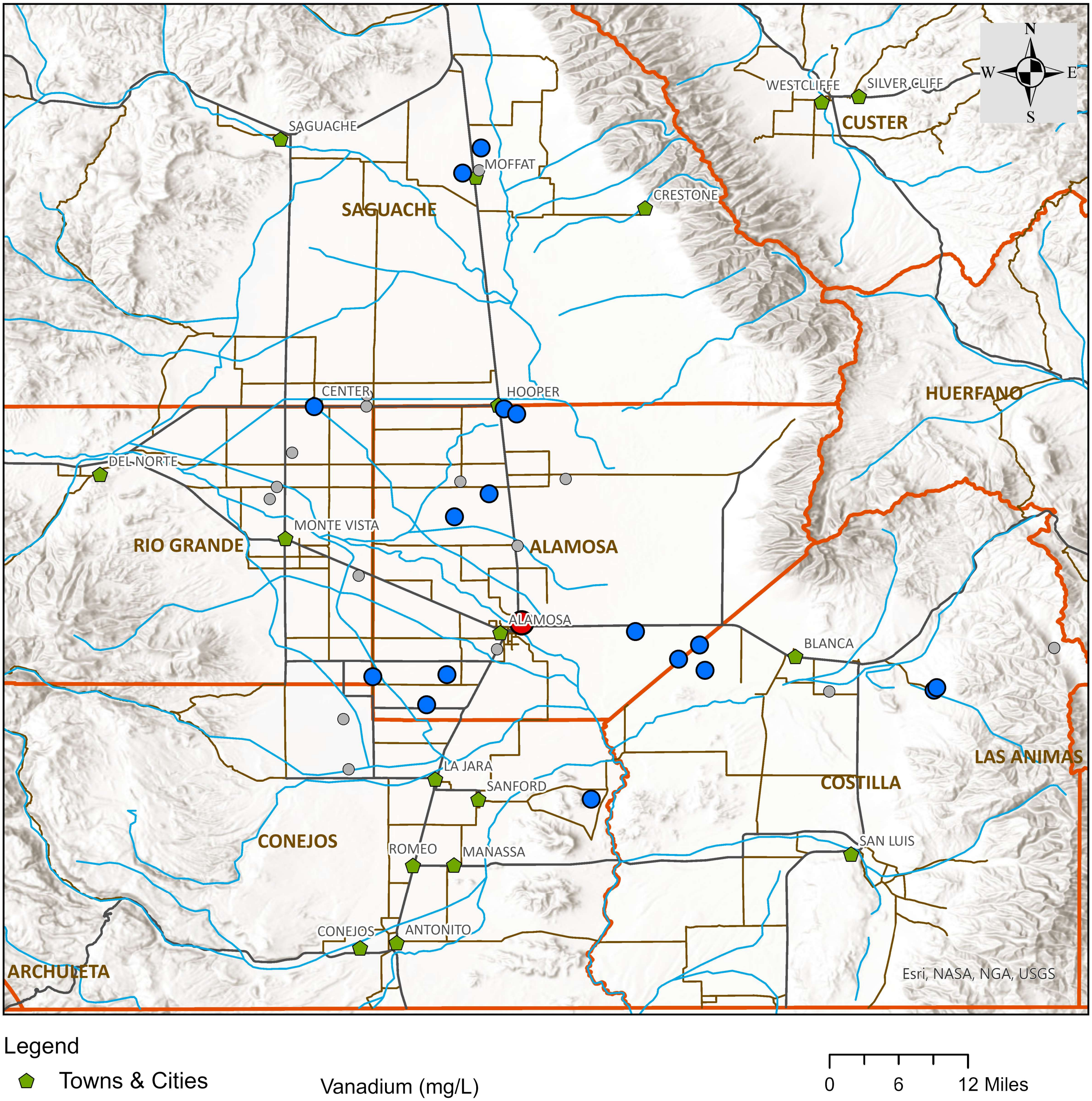
COLORADO GEOLOGICAL SURVEY
COLORADO SCHOOL OF MINES

Figure 11. Arsenic concentrations in milligrams per liter (mg/L) from water wells in the San Luis Valley, Colorado. Locations where values were above the drinking water guideline of 0.01 mg/L are shown in red.



COLORADO GEOLOGICAL SURVEY
COLORADO SCHOOL OF MINES

Figure 12. Lead concentrations in milligrams per liter (mg/L) from water wells in the San Luis Valley, Colorado. Locations where values were above the drinking water guideline of being "Present" above the analytical reporting limit are shown in red. Blue are estimated detections under the reporting limit.



COLORADO GEOLOGICAL SURVEY
COLORADO SCHOOL OF MINES

Figure 13. Vanadium concentrations in milligrams per liter (mg/L) from water wells in the San Luis Valley, Colorado. Locations where values were above the drinking water guideline of 0.07 mg/L are shown in red.