LMS/RFN/RFO/47149

2022 and 2023 Verification Monitoring Report for the Old and New Rifle, Colorado, Processing Sites

June 2024

New Rifle Site During Milling Operations, Circa 1974

U.S. DEPARTMENT OF ENERGY | Legacy Management

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Abbreviations

ACL	alternate concentration limit
bgs	below ground surface
CCR	*Code of Colorado Regulations*
CDPHE	Colorado Department of Public Health and Environment
CFR	*Code of Federal Regulations*
COC	contaminant of concern
DOE	U.S. Department of Energy
EC	Environmental Covenant
EPA	U.S. Environmental Protection Agency
ft	feet
GCAP	Groundwater Compliance Action Plan
GEMS	Geospatial Environmental Mapping System
IC	institutional control
IFRC	Integrated Field Research Challenge
LM	Office of Legacy Management
LOESS	locally estimated scatterplot smoothing
MCL	maximum concentration limit
mg/L	milligrams per liter
NRC	U.S. Nuclear Regulatory Commission
POC	point of compliance
POE	point of exposure
Ra-226	radium-226
RAI	request for additional information
RBC	risk-based concentration
RSL	Regional Screening Level
SDWA	Safe Drinking Water Act
SOP	standard operating procedure
SOWP	Site Observational Work Plan
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	Uranium Mill Tailings Radiation Control Act
USL	upper simultaneous limit
VMR	Verification Monitoring Report

Executive Summary

This Verification Monitoring Report (VMR) presents and interprets groundwater and surface water monitoring data collected at the Old and New Rifle, Colorado, Processing Sites through November 2023. These two former vanadium and uranium-ore processing sites are near the City of Rifle, Colorado, on a floodplain of the Colorado River. Both sites are managed by the U.S. Department of Energy (DOE) Office of Legacy Management (LM) under the Uranium Mill Tailings Radiation Control Act (UMTRCA) Title I program. Surface remediation at both sites was completed in 1996. As a result of former milling operations, alluvial aquifer groundwater was contaminated with uranium, vanadium, and selenium, the primary contaminants of concern (COCs) common to both sites.

Compliance strategies for the Old and New Rifle sites, formalized in corresponding Groundwater Compliance Action Plans (GCAPs) issued in 2001 and 2003, respectively, were developed based on site characterization activities conducted in the late 1990s and subsequent modeling efforts. For both sites, the initial selected strategy was a combination of natural flushing and application of alternate concentration limits (ACLs), in tandem with institutional controls (ICs) preventing domestic use of groundwater. Subsequent reevaluation of the conceptual site models indicated that some contaminants (e.g., uranium and vanadium) were projected to persist in groundwater at concentrations above corresponding regulatory limits for longer than 100 years, the time frame permitted under UMTRCA regulations for a natural flushing strategy. Based on those observations, LM developed revised compliance strategies for both sites, both of which withdrew the initially proposed natural flushing component, as documented in revised GCAPs issued in 2016 and 2017. LM is currently responding to U.S. Nuclear Regulatory Commission (NRC) requests for additional technical information on both draft GCAPs.

LM has conducted routine water quality monitoring at both sites since 1998. This report documents the most recent (2022 and 2023) monitoring results and summarizes key findings and contaminant trends since the previous (2021) VMR was issued. Verification monitoring in 2022 and 2023 at the Old and New Rifle sites entailed routine semiannual sampling of groundwater and surface water and monitoring of ICs.

Old Rifle Site Status and Findings

The Old Rifle processing site is 0.3 mile southeast of the City of Rifle, situated on a floodplain north of the Colorado River. The current NRC-approved compliance strategy for the site is a combination of natural flushing for uranium, no remediation with the application of ACLs for selenium and vanadium, and implementation of ICs. Compliance monitoring at the Old Rifle site currently includes semiannual sampling of eight monitoring wells (including two background wells), two onsite surface water features (a seep and a ditch), and three Colorado River locations. Along with this routine sampling, in 2022 and 2023, LM sampled eight additional wells to provide data to update the conceptual site model in support of a GCAP revision.

With respect to routine sampling, uranium continues to exceed the UMTRCA standard of 0.044 milligrams per liter (mg/L) in five of the six onsite monitoring wells; concentrations generally range from 0.1 to 0.2 mg/L. Two of these wells show no attenuation (no statistically significant trend) and in one well (0305), uranium concentrations are significantly increasing. Concentrations of selenium and vanadium are below NRC-approved compliance goals in most wells. During this reporting period, selenium concentrations exceeded the corresponding

0.05 mg/L ACL in only one well (0655). Although the exceedance is slight (most recent result of 0.059 mg/L), the trend is significantly increasing. Vanadium concentrations continue to be low relative to the 1.0 mg/L ACL in all routinely monitored wells with decreasing or no trends.

In November 2023, the highest concentrations of COCs at the Old Rifle site were measured in wells that are not routinely monitored. Uranium concentrations were highest in the northern region of the site (0.38 mg/L in well 0746). Selenium and vanadium concentrations in well 0743 along the southern boundary of the site (0.086 and 3.3 mg/L, respectively) exceeded corresponding ACLs. Based on these findings, continued monitoring may be warranted in these regions of the site.

Since 2014, concentrations of uranium and selenium have increased fivefold at the ditch sample location (0398). While uranium concentrations in the ditch now exceed the 0.044 mg/L UMTRCA maximum concentration limit (MCL), selenium concentrations remain low relative to water quality benchmarks. The reason for these increasing trends is not known. COC concentrations in samples collected from seep 0395 north of the site have been consistently below corresponding benchmarks.

New Rifle Site Status and Findings

The 142-acre New Rifle site is approximately 2.3 miles west of the City of Rifle, adjacent to and north of the Colorado River. The compliance strategy for the site has undergone several iterations over the years as more data have been collected and LM's understanding of the conceptual site model has evolved. To date, NRC has not approved a GCAP for the site. Based on the most recent (2016) GCAP update, the proposed compliance strategy for the alluvial aquifer at the site is no remediation with the application of ACLs, implementation of ICs, and continued groundwater monitoring of six COCs: arsenic, molybdenum, nitrate, selenium, uranium, and vanadium. Ammonia was withdrawn as a COC in the 2016 draft GCAP but retained in the monitoring program.

Compliance monitoring at the New Rifle site consists of sampling 16 onsite or downgradient monitoring wells screened in the alluvium, 1 background well, and 8 surface water locations. In addition to three Colorado River locations, LM routinely samples three locations in the adjacent mitigation wetland and two in the Roaring Fork gravel pit ponds, proposed as point of exposure (POE) locations in the most recent draft GCAP. To better define the extent of downgradient contamination, LM installed four new monitoring wells on the western end of the current IC boundary in November 2022. Three new surface water level monitoring stations (stilling wells) were installed along the Colorado River in October 2022. Along with the 17 routinely sampled wells and the 4 new downgradient locations, LM also sampled 7 additional existing wells not included in the routine network.

Of the six COCs currently monitored in alluvial aquifer groundwater, uranium, molybdenum, and vanadium are present at the most elevated concentrations relative to corresponding compliance goals. The 0.044 mg/L MCL for uranium is currently exceeded in most wells within the former tailings area footprint and in near downgradient wells in the pond region. Accounting for all monitoring results, the highest uranium concentrations (approximately 0.1–0.2 mg/L) are found in the Roaring Fork ponds and wetland locations. Molybdenum concentrations are highest onsite and in adjacent downgradient wells in the ponds area (recent maximum of 1.9 mg/L). Elevated vanadium (currently as high as 26 mg/L) is limited to onsite wells in the region of the

former tailings area. Selenium has a similar spatial distribution, with elevated concentrations (approximately 1 mg/L) limited to the site. Although less than the 0.05 mg/L drinking water standard, selenium concentrations are increasing significantly in some offsite wells, most notably in near-river well 0635 and farther downgradient well 0170. Nitrate concentrations in most wells throughout the study region are currently lower than the 10 mg/L MCL.

Arsenic concentrations have been below the 0.05 mg/L standard in all far downgradient wells, but trends are increasing in five of these wells, in particular well 0172 near the western IC boundary. Ammonia, not considered a COC but monitored because of its association with nitrate, is elevated relative to background (0.1 mg/L) in most onsite and near downgradient wells.

Monitoring results for the new downgradient wells installed in November 2022 were below corresponding compliance goals or background levels for all constituents except for uranium in well 0919 (0.048 mg/L in November 2023). This result just slightly exceeds the 0.044 mg/L MCL and is consistent with uranium measured in farther downgradient well 0620 (0.056 mg/L).

The Roaring Fork ponds have been a focus in recent NRC reviews of the draft GCAP; uranium concentrations in the ponds currently exceed those measured in groundwater samples. Analysis of historical monitoring data in light of previous risk evaluations indicates that potential exposures to contaminants in the ponds are unlikely to pose any potential risk that would warrant additional water use restrictions.

Colorado River Water Quality Monitoring

Surface water quality of the Colorado River, a POE at both the Old and New Rifle sites, remains unaffected by groundwater discharge from either site. Concentrations of COCs in Colorado River samples adjacent to and downstream of the site have been similar to those in background (upstream) samples and below corresponding water quality standards.

Institutional Controls

At both sites, multiple ICs prevent domestic use of groundwater and ensure protection of human health and the environment. Three ICs—a zone overlay, a quitclaim deed, and an Environmental Covenant (EC)—are in place at the Old Rifle site. These overlapping measures restrict a number of activities at the site and limit access to the subsurface and groundwater without written permission from the Colorado Department of Public Health and Environment (CDPHE) and DOE.

At the New Rifle site, DOE, CDPHE, the City of Rifle, and Garfield County, Colorado, have enacted a series of four ICs to prevent humans and livestock from being exposed to site-related contaminants on the former mill site and downgradient properties. These controls consist of a quitclaim deed on the site proper, a large zone overlay to restrict consumption of contaminated groundwater, an EC to limit access to groundwater and prevent livestock from accessing water in former gravel pit ponds, and an overlay zone district that further limits activities on the former mill site.

1.0 Introduction

This Verification Monitoring Report (VMR) presents and interprets groundwater and surface water monitoring data collected at the Old and New Rifle, Colorado, Processing Sites through November 2023. These two former vanadium and uranium-ore processing sites are near the City of Rifle in Garfield County, Colorado, on a floodplain of the Colorado River near the northeastern edge of the Colorado Plateau physiographic province (Figure 1). Both sites are managed by the U.S. Department of Energy (DOE) Office of Legacy Management (LM) under the Uranium Mill Tailings Radiation Control Act (UMTRCA) Title I program. Surface remediation at both sites was completed in 1996, and tailings were stabilized in an engineered repository about 6 miles north of Rifle (the Rifle, Colorado, Disposal Site).

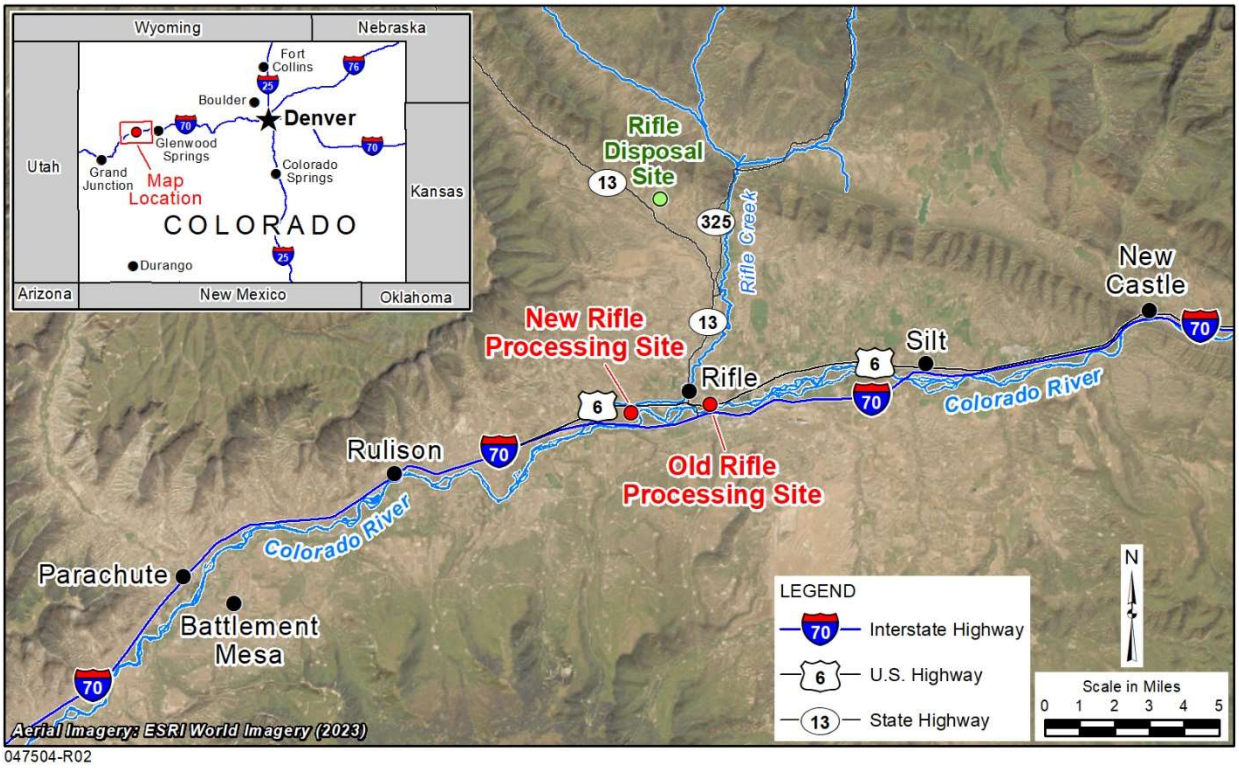


Figure 1. Locations of the Old and New Rifle, Colorado, Processing Sites

LM has conducted routine water quality monitoring at both sites since 1998—semiannually at the Old Rifle site (typically June and November) and annually or semiannually at the New Rifle site. This report documents the most recent (2022 and 2023) monitoring results and summarizes key findings and contaminant trends since the previous (2021) VMR (DOE 2022) was issued. Although there are elements common to both the Old and New Rifle sites (e.g., geographic region, milling and remediation history, overlap in contaminants of concern [COCs], and the important role of institutional controls [ICs] in the compliance strategy), the corresponding conceptual site models and contaminant distribution and transport characteristics are distinct. Therefore, in contrast to previous VMRs that were organized largely by topic, this report is organized by site, so the presentation of site-specific information and analytical results is uninterrupted. As an introduction, key elements common to both sites are discussed below.

1.1 Background

This section provides an overview of the regulatory framework and compliance strategy elements common to both Old and New Rifle sites. It concludes with a brief summary of the data management and visualization approaches applied throughout this report.

1.1.1 Overview of Old and New Rifle Site Compliance Strategies

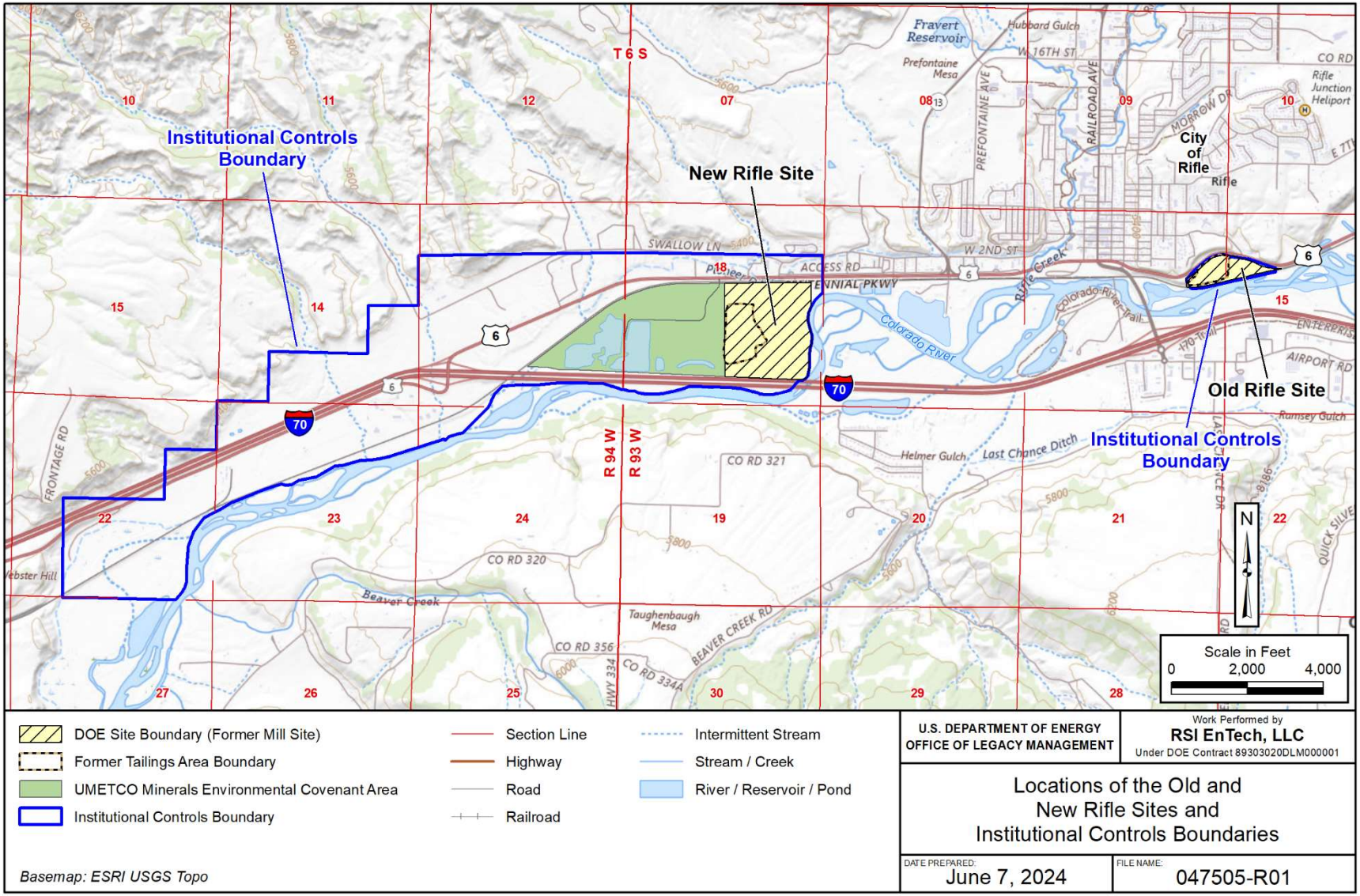
Compliance strategies for the Old and New Rifle sites are documented in each site's Groundwater Compliance Action Plan, or GCAP. Initial GCAPs for the Old and New Rifle sites (DOE 2001; DOE 2003) were issued shortly after corresponding Site Observational Work Plans (SOWPs) and conceptual site models were developed (DOE 1999a; DOE 1999b). At both sites, results of early site characterization and modeling efforts supported a combination of natural flushing and application of alternate concentration limits (ACLs) in tandem with implementation and enforcement of ICs. Subsequent reevaluation of the conceptual site models indicated that some contaminants were projected to persist in groundwater at concentrations above corresponding regulatory limits for longer than 100 years, the time frame permitted under UMTRCA regulations for a natural flushing strategy. Those observations prompted LM to develop revised compliance strategies for the Old and New Rifle sites, both of which withdrew the initially proposed natural flushing component (DOE 2017 and DOE 2016, respectively).

Details of the initial and revised compliance strategies for both sites are addressed in Section 2.0 and Section 3.0 for the Old and New Rifle sites, respectively. For both sites, the compliance strategy requires formal concurrence from the U.S. Nuclear Regulatory Commission (NRC) and consultation with the Colorado Department of Public Health and Environment (CDPHE). To date, only the initial Old Rifle site GCAP (DOE 2001) has received concurrence from NRC (NRC 2002). As discussed in Section 3.0, NRC has not approved a GCAP for the New Rifle Site. LM is currently identifying data gaps and updating the conceptual site models to support development of revised GCAPs for both sites.

1.1.2 Institutional Controls

ICs are measures to control access to a site and minimize disturbances to engineered measures established by the licensee to control the residual radioactivity. ICs include administrative mechanisms (e.g., land use restrictions) and may include, but are not limited to, physical controls (e.g., signs, markers, landscaping, and fences). Durable ICs are reliable and sustainable for the specified period, in accordance with NUREG-1757 (NRC 2020a). To be effective, ICs must mitigate or prevent intrusion into contaminated groundwater and restrict access to or use of contaminated groundwater for unacceptable purposes. ICs are required to (1) protect public health and the environment, (2) have a high degree of permanence, (3) satisfy beneficial uses of groundwater, (4) be enforceable by administrative or judicial branches of government entities, and (5) be implemented in a manner that can be effectively maintained and verified.

Alluvial aquifer groundwater beneath both the Old and New Rifle sites was contaminated as a result of former uranium and vanadium-ore processing operations. Therefore, multiple layers of ICs restricting groundwater use have been established within the boundaries shown in Figure 2.



Note: A more detailed presentation of ICs for the New Rifle site is provided in Section 3.0 of this report.

Figure 2. IC Boundaries Established for the Old and New Rifle Sites

Ultimately, the City of Rifle, CDPHE, and (for the New Rifle site) Garfield County are the regulatory agencies with the responsibility and authority to enforce the ICs. LM continues to work closely, in a supporting role, with the city, state, and county toward the successful implementation of ICs. As demonstrated later in this report (in Section 2.6 and Section 3.6, respectively), the ICs at both Old and New Rifle processing sites are robust and layered, thereby providing ample protection.

1.2 Data Analysis and Visualization Approach

In accordance with LM's quality assurance procedures, field duplicates are routinely collected during semiannual sampling events. In interpreting and mapping the data for this VMR, and for consistency with the data used for trend analyses, only the original sample is used for reporting purposes (results of duplicate analyses are excluded). At times, the field duplicate results are higher than the corresponding initial sample, but these results are generally within the range of laboratory variation associated with the analytical method. All analytical data presented herein have been validated in accordance with LM's rigorous quality assurance protocols.

For chemical data, all time-concentration plots presented in this report were developed using a faceting approach, whereby data are partitioned into a matrix of panels, with each panel plotting data for a single well. In each facet, a nonparametric smoothing method—locally estimated scatterplot smoothing (LOESS)—is used, whereby the surrounding shaded area represents the 95% pointwise confidence interval. Using this approach, overall trends in the data are more apparent and not obscured by "noise" or random variation. All temporal plots in this report were developed using R, version 4.3.3 (R Core Team 2024), and the ggplot2 package, version 3.5.1 (Wickham 2016).

Because of the wide range in contaminant concentrations measured across both Old and New Rifle site monitoring locations, in subsequent figures, most data are plotted on a semilogarithmic scale. This approach allows changes in lower-concentration wells (or surface locations) to be compared with those in higher-concentration wells. Results labelled in all time-concentration plots and in the corresponding spatial distribution figures are rounded to two significant figures.

To facilitate interpretation of the analytical results and to assess the effectiveness of the current or proposed compliance strategies, Mann-Kendall trend analysis was performed for all monitoring well-COC combinations. Only wells routinely monitored were included in these analyses. The Mann-Kendall nonparametric test is used to statistically assess if there is an upward or downward trend of the variable of interest over time. This test characterizes the direction of concentration trends using a 0.05 significance (or alpha) level, meaning there is a 5% chance of concluding that a trend exists that could simply be the result of random chance. For both Old and New Rifle sites, Mann-Kendall trends were calculated from 1998, when postremediation monitoring began, through 2023. To account for more recent shifts in contaminant concentration trends observed at some locations, a second set of trend tests was run for the period 2014 to 2023.

Historical water quality and water level data for both Old and New Rifle sites are available on the LM website through the Geospatial Environmental Mapping System (GEMS) at https://gems.lm.doe.gov. A link to GEMS can also be found within the "Site Links" tab on the LM website (https://www.energy.gov/lm/rifle-colorado-disposal-site-and-processing-sites).

2.0 Old Rifle Site

The Old Rifle site is a former vanadium- and uranium-ore processing mill approximately 0.3 mile east of Rifle, Colorado, a city on the north bank of the Colorado River (Figure 1; Figure 3). This section summarizes semiannual water quality monitoring data through November 2023 and assesses the progress and status of the current compliance strategy.

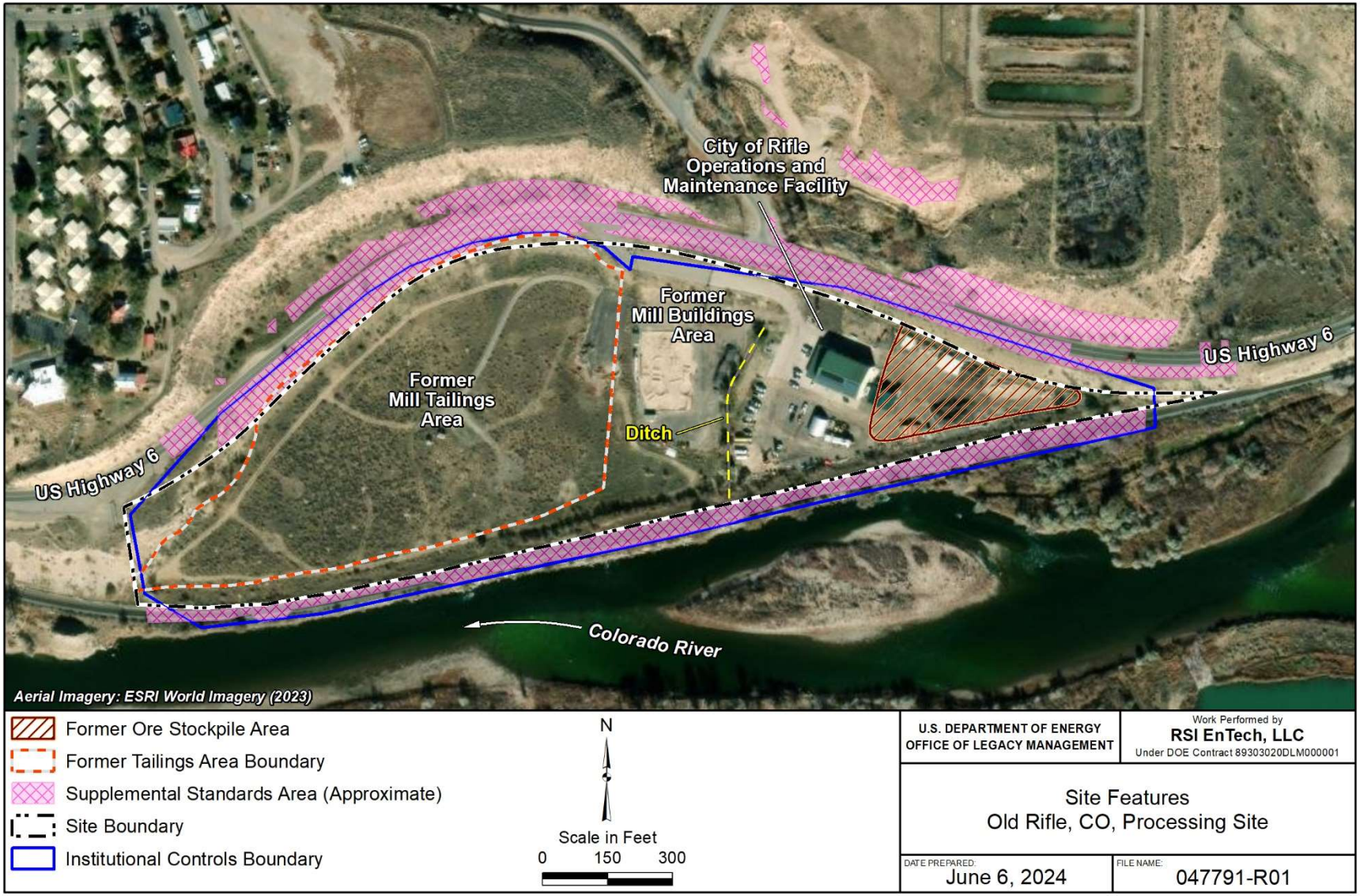
2.1 Site History

The mill operated on the 21-acre site during two separate periods between 1924 and 1958 (Table 1). U.S. Vanadium Company constructed the original mill in 1924 to produce vanadium (Merritt 1971). Union Carbide Corporation purchased the assets of the U.S. Vanadium Company in 1926 and established U.S. Vanadium Corporation as a subsidiary (Chenoweth 1982). The subsidiary operated the former Old Rifle plant intermittently until 1946, when it was modified to include the recovery of uranium, as well as vanadium. Production continued until 1958, when the old plant was replaced with a new mill approximately 2.3 miles west of Rifle, now referred to as the New Rifle site. In 1967, approximately 13 acres of tailings were stabilized at the Old Rifle site in accordance with State of Colorado regulations.

Surface remediation began in spring 1992 and was completed in October 1996. These activities entailed the removal and offsite disposal of mill tailings and contaminated soils from the entire site to meet the Title 40 *Code of Federal Regulations* Section 192 (40 CFR 192) activity standard of 5 picocuries per gram for radium-226 (Ra-226) averaged over the first 15 centimeters of soil below the surface. Because removal of soils and alluvial sediments generally stopped at the water table due to difficulties in excavating below this level, some soils exceeding the Ra-226 standard were left in place under the supplemental standards provision of UMTRCA (DOE 1997). Supplemental standards were also applied to an estimated 24,000 cubic yards of subsurface soils in other designated areas because of concerns about worker safety. These areas, shown in in Figure 3, included under and along U.S. Highway 6 along the northern perimeter of the site and under the railroad right-of-way abutting the southern perimeter of the site and the riverbank (DOE 1997). Site evaluation and characterization efforts conducted between 1996 and 1998 culminated in the SOWP, a report documenting the site conceptual model on which the compliance strategy was based (DOE 1999b).

The Old Rifle site was previously established as an Integrated Field Research Challenge (IFRC) site through DOE's Office of Science. Biogeochemical experiments were conducted between 2003 and 2015 to better understand the behavior of uranium and other contaminants in the alluvial aquifer. Observations and findings stemming from this work were considered in LM's review of the natural flushing remedy (DOE 2011) and in developing the draft revised GCAP (DOE 2017). Chemical injections, intended to form the mineral apatite and in turn remove uranium from groundwater, were performed in 2017 in an experimental well plot. Since then, researchers from Sandia National Laboratories and Lawrence Berkeley National Laboratory have conducted routine sampling in support of the apatite study. These studies are separate from the routine monitoring efforts addressed in this VMR and are not discussed further in this report.

Along with the historical activities described above, Table 1 summarizes the key events, evaluations, and correspondence germane to the Old Rifle site and this VMR evaluation.



Note: Supplemental standards areas are from Figure 5 of the 2017 draft GCAP (DOE 2017).

Figure 3. Old Rifle Site Features

Table 1. Summary of Key Old Rifle Site Activities, Events, and Evaluations

Activity or Evaluation	Date or Time Frame	Description or Major Findings
Mill operation	1924–1932 1942–1958	The U.S. Vanadium Company constructed the original Old Rifle processing plant in 1924 for the production of vanadium (Merritt 1971). Union Carbide Corporation purchased the mill in 1926. The plant closed in 1932 because of a shortage of vanadium ore. Union Carbide resumed vanadium production in 1942 and modified the plant in 1946 to allow for recovery of uranium as well as vanadium. Uranium and vanadium production continued until 1958 when the plant was replaced with a new mill (the New Rifle site).
Stabilization of tailings	1967	Approximately 13 acres of tailings were stabilized at the site in accordance with State of Colorado regulations.
Surface remediation	1992–1996	Surface remediation began in spring 1992 and was completed in October 1996. Tailings and related materials were relocated to the Rifle disposal site, approximately 6 miles to the north (Figure 1).
Site characterization	1997–1999	Postremediation site characterization efforts.
SOWP issued	August 1999	Site characterization efforts culminated in the SOWP, a report documenting the site conceptual model on which the compliance strategy was based (DOE 1999b).
Initial GCAP issued	December 2001	The initially proposed compliance strategy was natural flushing for uranium, application of ACLs for selenium and vanadium, and enforcement and implementation of ICs.
NRC approval of GCAP	July 2002	NRC approved the 2001 GCAP contingent upon the transfer of the site to the City of Rifle and the formalization of ICs (NRC 2002).
City of Rifle acquisition of the site	2003	The City of Rifle acquired ownership of the property.
City of Rifle building construction	2007	The City of Rifle constructed an operations and maintenance facility on the east end of the property in 2007.
Review of natural flushing remedy	2011	This evaluation determined that natural flushing processes at the site would not successfully remove uranium from the alluvial aquifer within a reasonable time frame and recommended consideration of an alternative compliance strategy (DOE 2011).
LM submitted revised draft GCAP	2017	The July 2017 draft GCAP (DOE 2017) was submitted by letter dated September 21, 2017. LM proposed a revised strategy of no remediation with application of ACLs for all three COCs and continued implementation of ICs.
NRC TIR regarding July 2017 draft GCAP	October 31, 2019	NRC determined that additional information was required to complete their review of the 2017 draft GCAP. The TIR included seven comments, several of which warranted more detailed evaluation by LM.
Ongoing work supporting GCAP revision	2020–present	Ongoing work to address the issues raised in NRC's 2019 TIR and to update the conceptual site model in support of a revised GCAP.

Note:
Most DOE reports cited above are available on the LM website at: https://www.energy.gov/lm/rifle-colorado-disposal-site-and-processing-sites.

Abbreviation:
TIR = technical information request

2.2 Compliance Strategy and Water Quality Monitoring

Based on the conceptual site model developed in the SOWP (DOE 1999b), DOE prepared a GCAP that was submitted to NRC in late 2001 (DOE 2001). This initial strategy was a combination of 100-year natural flushing for uranium, the primary contaminant in terms of magnitude and extent, and no remediation with the application of ACLs for selenium and vanadium, the other two site COCs. The conditions of the natural flushing compliance strategy were to establish ICs and to conduct routine semiannual monitoring until concentrations of COCs decreased to corresponding groundwater standards listed in Table 2.

The UMTRCA standard for uranium in groundwater is 0.044 milligrams per liter (mg/L), the maximum concentration limit (MCL) established in 40 CFR 192. The U.S. Environmental Protection Agency (EPA) primary drinking water standard of 0.05 mg/L was proposed as an ACL for selenium because background concentrations were higher than the corresponding UMTRCA standard of 0.01 mg/L (DOE 2001). Vanadium is not regulated under UMTRCA nor under EPA's Safe Drinking Water Act (SDWA) (Title 42 *United States Code* Section 300f), referred to as the SDWA standard. Therefore, an ACL of 1.0 mg/L was proposed, which was higher than the maximum observed concentration at the site at that time.[1] In July 2002, NRC concurred with the 2001 GCAP, contingent on the transfer of the site to the City of Rifle and the formalization of ICs (NRC 2002).

Because subsequent evaluations (e.g., DOE 2010) indicated that the natural flushing compliance strategy was not performing as expected, LM issued a revised GCAP in 2017. The proposed revised compliance strategy is no remediation with the application of ACLs for all three COCs (DOE 2017). ICs enacted by LM, CDPHE, and the City of Rifle would be carried forward as an integral component of the compliance strategy. Proposed ACLs for uranium, vanadium, and selenium are 0.36 mg/L, 1.0 mg/L (unchanged from 2001), and 0.122 mg/L, respectively (DOE 2017). The ACLs for uranium and selenium are nonparametric 95% upper simultaneous limits (USLs) calculated for wells 0310 and 0305, respectively (the wells with the highest concentrations at that time). These USLs are essentially equivalent to the maximum or nonoutlier maximum concentration in the data sets. Table 2 lists corresponding UMTRCA standards and the initial (approved) and proposed ACLs.

2.2.1 Current Status of the Draft GCAP

In 2019, NRC determined that additional information was required to complete the agency's review of the 2017 draft GCAP (NRC 2019). The technical information request included seven comments, several of which warranted more detailed evaluation by LM. NRC's primary concerns related to characterization of contaminant sources (e.g., supplemental standards areas) and attenuation mechanisms and the protectiveness of the proposed ACL for uranium given increasing concentration trends at well 0656. Those observations prompted LM to update the conceptual site model for the site in support of a revised GCAP. These activities are ongoing.

[1] Based on data for the 1997–2001 period following remediation and leading up to development of the GCAP, the maximum vanadium concentration measured was 0.88 mg/l, in well 0305 in November 2000. Higher vanadium concentrations, ranging from 1.1 to 5.2 mg/L, were later measured in several IFRC wells (including multichannel well 0743) between 2010 and 2013.

Table 2. Compliance Standards and ACLs for Old Rifle Site Groundwater COCs

COC[a]	40 CFR 192 (UMTRCA) MCL	ACL Proposed in 2001 GCAP[b]	ACL Proposed in 2017 Draft GCAP[c]	Background Range[d]
Uranium	0.044	–	0.36	Wells 0292, 0292A: 0.0135–0.06 Well 0658: 0.0071–0.067[e]
Selenium	0.01	0.05 (EPA SDWA standard)	0.122	0.000039–0.041
Vanadium	–	1.0 (applies to POC, = any site monitoring well) 0.33 (applies to POE, the Colorado River)[f]	1.0 (no change)	0.00021–0.0039

Notes:
All units are milligrams per liter (mg/L).

[a] Arsenic was initially identified as a COC based on concentrations exceeding background at a single location in the footprint of the tailings pile. Arsenic was ultimately eliminated from the monitoring program because concentrations in all wells were consistently below the 0.05 mg/L MCL established in 40 CFR 192.

[b] ACLs listed for selenium and vanadium are from the NRC-approved GCAP (DOE 2001).

[c] ACLs proposed in the 2017 draft GCAP (DOE 2017). Proposed ACLs for uranium and selenium are nonparametric 95% USLs calculated for wells 0310 and 0305, respectively. The proposed ACL for vanadium did not change relative to that proposed in the 2001 NRC-approved GCAP (DOE 2001; DOE 2017). The 0.33 mg/L ACL previously applied to the river, considered the POE, was withdrawn.

[d] Data are from background wells 0292 (former background well abandoned in July 2008), 0292A (replacement background well), and 0658 (Figure 4); cited ranges reflect detections only.

[e] The draft GCAP (DOE 2017) cites a background value for uranium of 0.067 mg/L, the maximum concentration measured at well 0658 in March 2005. As demonstrated later in this report, uranium trends at this well exhibit a statistically significant decreasing trend since 1998. Because of this decreasing trend, well 0658 does not qualify as a representative background well. Therefore, for purposes of this VMR, LM now applies the more conservative 0.044 mg/L UMTRCA standard.

[f] The 0.33 mg/L vanadium concentration originally proposed as the ACL to be applied at the POE was based on an EPA residential screening value developed in 2000. EPA's risk-based screening levels have evolved over time. The most recent EPA Regional Screening Level (RSL) table (from May 2024) cites a risk-based value for tap water of 0.086 mg/L (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables).

Abbreviations:
– = not applicable (contaminant does not have an MCL in 40 CFR 192 or a proposed ACL for the time frame)
POC = point of compliance
POE = point of evaluation
RSL = regional screening level

2.2.2 Groundwater and Surface Water Monitoring Network

Table 3 lists the wells and surface water locations that constitute the routine monitoring network at the Old Rifle processing site. The network consists of eight monitoring wells (including two background wells) and five surface water locations shown in Figure 4. In both GCAPs (DOE 2001; DOE 2017), all onsite wells were considered point of compliance (POC) wells (i.e., the wells to which ACLs would be applied). The Colorado River, where groundwater discharges from the site, was considered the point of exposure (POE). Although the approved GCAP proposed reducing the sampling frequency after 5 years (Table 3), LM continues to sample semiannually.

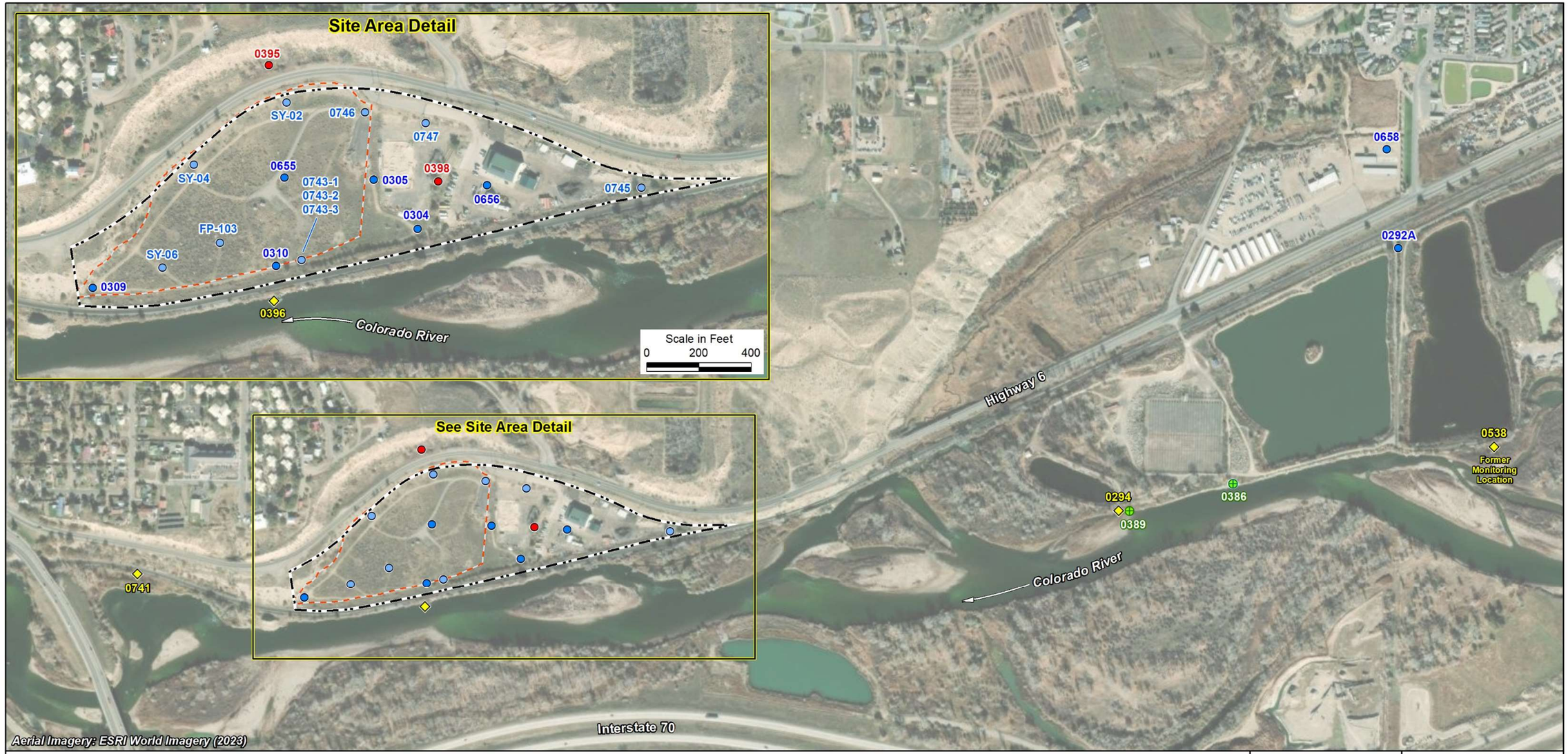
Table 3. Summary of GCAP Monitoring Requirements for the Old Rifle Site

Locations[a]	Monitoring Purpose	Analytes	Frequency
0305, 0655	Within uranium plume, west side of ditch	Uranium Selenium Vanadium	2001 GCAP: Semiannual sampling for 5 years; at least once every 5 years thereafter until 2030 2017 Draft GCAP (Proposed): Annually for first 5 years following NRC concurrence, after which LM would reevaluate monitoring requirements
0656	Within uranium plume, east side of ditch		
0304, 0309, 0310	Downgradient edge of plume		
0292A, 0658[b]	Background groundwater quality; upgradient monitoring wells		
0395, 0398	Monitor surface water recharging aquifer; seep and onsite ditch		
0294 (replaced 0538), 0396, 0741	Upgradient, adjacent to site, and downgradient locations along the Colorado River, respectively		

Notes:

[a] Locations shown in Figure 4. More detailed information is provided in Appendix A, Table A-1; this table also lists all nonroutine locations sampled in 2022 and 2023.

[b] Both background locations are from the 2017 draft GCAP (DOE 2017). Background well 0292A was added to the network in April 2009 to replace former background well 0292 (from DOE 2001) that was abandoned in July 2008. Well 0658 was applied as a background well in the SOWP (DOE 1999) but was not sampled again until 2005; it was reapplied as a background well in the subsequent draft GCAP (DOE 2017).



Note: Only those locations routinely monitored or other locations (IFRC wells) sampled in 2022 and 2023 are shown in this figure. Former background well 0292—previously located 0.23 mile northeast of current background well 0292A and abandoned in July 2008—is not shown. The IC boundary overlaps or encompasses the site boundary as shown in Figure 3.

Figure 4. Monitoring Locations at the Old Rifle Site

2.2.3 Old Rifle Site ICs

As discussed in Section 4.1.2 of the 2017 draft GCAP (DOE 2017), residual contamination will remain in the groundwater for an extended period; therefore, it is critical that restrictions on groundwater use be maintained to ensure protectiveness of the remedy. ICs are enforceable mechanisms for implementing these restrictions. Groundwater contamination at the Old Rifle site has not migrated into any offsite aquifers. Rather, it discharges directly into the Colorado River, the only POE to site-related contamination, where it rapidly mixes with river water. Constituent concentrations in samples of river water collected adjacent to and downstream of the former mill site are indistinguishable from those in background samples collected upstream of the site (DOE 2022). Given these conditions, ICs only need to be applied within the site boundary. Multiple layers of ICs restricting groundwater use have been established for the Old Rifle site, including the following:

- Quitclaim deed restrictions
- An Environmental Covenant (EC)
- The Uranium Mill Tailings Remedial Action (UMTRA) Project (UMTRA Project) overlay zone district

These ICs are discussed in greater detail in Section 4.2 of the draft GCAP (DOE 2017), along with the general performance requirements; Appendix A of that report documents the ICs in their entirety.

2.3 Groundwater Flow Conditions

The Old Rifle processing site is 0.3 mile southeast of the City of Rifle, situated on a floodplain north of the Colorado River (Figure 1; Figure 4). Groundwater is unconfined in the alluvial aquifer, which consists of river alluvium and the upper weathered portion of the Wasatch Formation. The alluvial aquifer is 5 to 25 feet (ft) thick; saturation occurs from 5 to 10 ft below ground surface (bgs). The alluvial aquifer is composed of poorly sorted sediments that range from clay-sized material to cobbles and occasional boulders. The weathered portion of the Wasatch Formation thickness is variable across the site but is generally considered to be only a few feet thick before the unweathered Wasatch Formation is encountered. Groundwater in the alluvial aquifer flows to the west-southwest, discharging to the Colorado River (Figure 5). Hydraulic conductivity estimates for the alluvial aquifer range from 100 to 125 ft per day; estimates for the weathered Wasatch Formation are about 0.02 ft per day (DOE 1999b).

Recharge to the alluvial aquifer is from an unlined irrigation return ditch that flows east across the northern boundary of the site, and then across the middle of the site (Figure 3), subsurface inflow from north of U.S. Highway 6, and precipitation. Figure 5 shows measured water level elevations within the alluvial aquifer and equipotential contours for June and November 2023, respectively. As expected, water levels are generally more elevated in June during higher Colorado River stages due to mountain snowmelt. The general groundwater flow direction was to the west-southwest for both time periods.

Note: The June 2023 elevation for multichannel well location 0743 is from 0743-3, screened at an interval of 16.2–16.7 ft bgs (Appendix A).
*No water level measurement was taken at 0743-3 in November 2023, and the uppermost intervals—0743-1 and 0743-2—were dry.

Abbreviation: NAVD 88 = North American Vertical Datum of 1988

Figure 5. June and November 2023 Groundwater Elevations at the Old Rifle Site

Water levels onsite rise and fall seasonally in tandem with flows in the Colorado River. While rises in stage can increase water levels by roughly 5 ft (Figure 6), flow directions do not significantly change. The rise and fall of water levels saturating different parts of the alluvial aquifer likely impacts measured groundwater chemistry. At the Old Rifle site, alluvium pinches out against bedrock outcrops at the western downgradient end of the site (DOE 2011). The alluvial aquifer at the Old Rifle site has no hydraulic connection to the alluvial aquifer at the New Rifle site (DOE 2014).

The SOWP (DOE 1999b) provides additional data regarding the hydrogeology of the Old Rifle site and the conceptual site model. Results of subsequent IFRC studies indicated that the conceptual site model was more complex than that developed based on initial modeling conducted for the SOWP. LM revised the conceptual site model in 2011 to reflect IFRC's findings and to account for groundwater inputs from north of the site and to account for the naturally reducing zones along the southern margin of the site (DOE 2011).

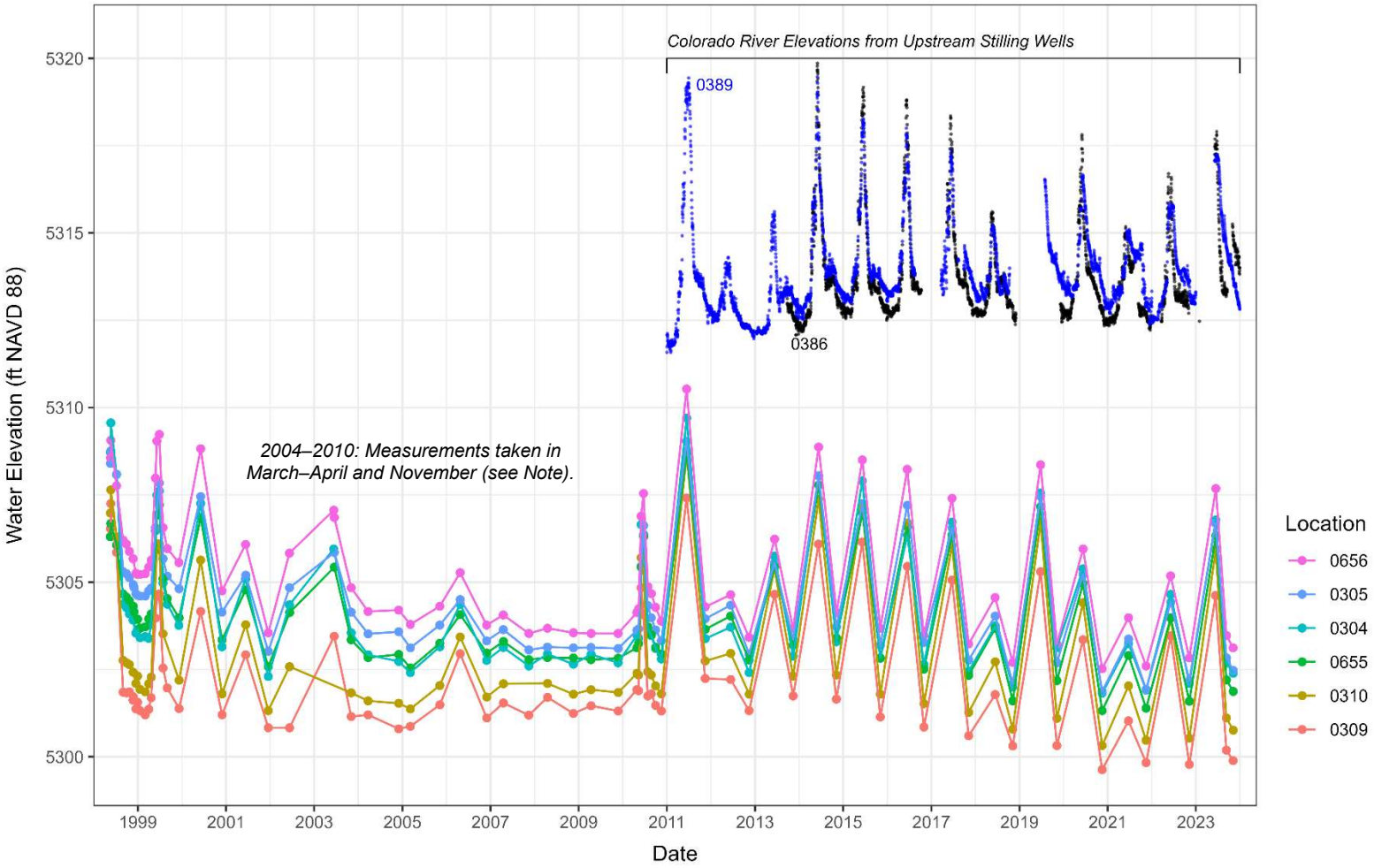
2.4 Groundwater Monitoring Results and COC Concentration Trends

This section presents and interprets the results of groundwater and surface water sampling conducted at the Old Rifle site through November 2023. During this (2022–2023) reporting period, eight monitoring wells and five surface water locations, including three Colorado River locations, were sampled in June and November of each year.

Along with this routine sampling, eight additional wells, installed to support the IFRC program, were sampled to provide data for LM's ongoing update and evaluation of the conceptual site model. Figure 4 shows all Old Rifle site routine and nonroutine monitoring locations sampled in 2022 and 2023. Supporting details are provided in Appendix A, Table A-1.

In this section, following the approach outlined in Section 1.2, historical contaminant trends are evaluated for 1998–2023, the period since postremediation site characterization activities were initiated. Mann-Kendall trend analysis was performed for each well-COC combination; results of these analyses are listed in Table 4. For well-analyte combinations identified as having statistically significant trends, the direction of the trend is indicated on the corresponding time-concentration plot. As shown in Table 4, a second set of trend tests was run starting in 2014, coinciding with a shifting trend observed in some wells (e.g., uranium in well 0656).

Detailed trend analysis results, including corresponding linear regression trends for each COC, are provided in Appendix A (Tables A-2 and A-3). Trend analyses were not conducted for the eight IFRC wells sampled in 2022–2023 because of insufficient sample numbers and inconsistent sampling frequency. These nonroutine wells are: 0743, 0745, 0746, 0747, FP-103, SY-02, SY-04, and SY-06 (Figure 4; Appendix A, Table A-1).



Notes:

Groundwater elevations for onsite monitoring wells are from measurements taken during semiannual sampling events between 1998 and November 2023. In the legend, monitoring wells are listed in order of descending average groundwater elevation. Between 2004 and 2010, seasonal variation is not fully captured because the first semiannual sampling event was in March or April (preceding peak river flows), not June. Elevation data from stilling wells 0386 and 0389, approximately 0.5–0.6 ft upstream from the site, are also shown.

Data for background wells 0292A and 0658 (Figure 4) are not shown. Surface elevations at these wells are approximately 10 ft higher than those at onsite wells, with corresponding average groundwater elevations of 5315 and 5320 ft, respectively.

Abbreviation: NAVD 88 = North American Vertical Datum of 1988

Figure 6. Temporal Trends of Water Elevations in Old Rifle Site Monitoring Wells

Table 4. Mann-Kendall Trend Test Results for Old Rifle Site Wells

Location	Initial Trend Analysis Date	Final Trend Analysis Date	Most Recent Result (mg/L)	1998–2023 Time Frame				2014–2023 Time Frame		
				Number of Samples	Number of Nondetects	Kendall's tau	Trend	Number of Nondetects	Kendall's tau	Trend
Uranium										
0304	5/19/1998	11/7/2023	0.052	58	0	0.07	None	0	−0.01	None
0305	5/19/1998	11/7/2023	0.13	57	0	0.43	Increasing	0	0.75	Increasing
0309	5/19/1998	11/6/2023	0.016	58	0	−0.21	Decreasing	0	−0.56	Decreasing
0310	5/19/1998	11/7/2023	0.13	58	0	−0.59	Decreasing	0	−0.37	Decreasing
0655	5/18/1998	11/7/2023	0.13	58	0	−0.13	None	0	0.28	None
0656	5/20/1998	11/6/2023	0.19	58	0	0.51	Increasing	0	−0.43	Decreasing
*0292A**	4/14/2009	11/6/2023	0.044	37	0	0.21	None	0	0.27	None
*0658**	5/21/1998	11/7/2023	0.0093	47	0	−0.57	Decreasing	0	−0.15	None
Selenium										
0304	5/19/1998	11/7/2023	<0.0015	58	10	−0.55	Decreasing	9	−0.11	None
0305	5/19/1998	11/7/2023	0.011	57	0	−0.74	Decreasing	0	0.03	None
0309	5/19/1998	11/6/2023	<0.0015	58	38	0.10	None	18	−0.03	None
0310	5/19/1998	11/7/2023	<0.0015	58	27	0.23	Increasing	13	0.10	None
0655	5/18/1998	11/7/2023	0.059	58	0	0.28	Increasing	0	0.33	Increasing
0656	5/20/1998	11/6/2023	<0.0015	58	5	−0.30	Decreasing	4	−0.29	None
*0292A**	4/14/2009	11/6/2023	0.0023	37	13	−0.05	None	11	0.04	None
*0658**	5/21/1998	11/7/2023	0.0033	47	3	0.10	None	2	0.28	None
Vanadium										
0304	5/19/1998	11/7/2023	0.016	58	1	−0.53	Decreasing	12	0.17	None
0305	5/19/1998	11/7/2023	0.41	57	0	−0.47	Decreasing	1	−0.52	Decreasing
0309	5/19/1998	11/6/2023	<0.0033	58	35	0.17	None	0	0.29	None
0310	5/19/1998	11/7/2023	0.0083	58	1	−0.58	Decreasing	14	0.03	None
0655	5/18/1998	11/7/2023	0.29	58	0	−0.51	Decreasing	1	−0.40	Decreasing
0656	5/20/1998	11/6/2023	0.084	58	0	0.07	None	0	0.05	None
*0292A**	4/14/2009	11/6/2023	<0.0033	37	16	0.15	None	0	0.75	Increasing
*0658**	5/21/1998	11/7/2023	<0.0033	47	17	−0.08	None	13	−0.03	None

Shaded values denote most recent result ≤ the corresponding NRC-approved MCL or ACL: 0.044 mg/L uranium, 0.05 mg/L selenium, and 1.0 mg/L vanadium.
Significant increasing trend based on Mann-Kendall trend test. Significant decreasing trend based on Mann-Kendall trend test.
* Wells 0292A and 0658 are background locations.

Notes:
Trend tests were run for two time frames: 1998–2023 (the entire monitoring period) and 2014–2023 (start date of June 11–12; 21 samples collected).
Trend tests for uranium, with no nondetect results, were conducted using the Kendall package in R, version 2.2.1 (McLeod 2022). Trend tests for selenium and vanadium were performed using the NADA (Nondetects and Data Analysis for Environmental Data) package in R, version 1.6-1.1 (Lee 2020). The NADA trend test is similar to the traditional Mann-Kendall trend test except that it accounts for the presence of nondetects at multiple detection limits. Trend analyses were not conducted for wells that are not routinely sampled because of insufficient sample numbers. All trend analyses were conducted at the 0.05 significance (or alpha) level using a two-sided test. The test statistic, Kendall's tau, is a measure of the strength of the association between two variables, with values always falling between −1 and +1.

2.4.1 Uranium

Figure 7 plots the most recent (November 2023) uranium concentrations measured in Old Rifle site monitoring wells along with surface water sampling results. Corresponding time-series data for monitoring wells are shown in Figure 8.

Uranium concentrations in five of the six onsite wells routinely monitored continue to exceed the UMTRCA standard (0.044 mg/L), generally ranging from 0.1 to 0.2 mg/L. The highest concentration, 0.19 mg/L, was measured at well 0656 (just south of the City of Rifle operations and maintenance facility), where uranium concentrations were previously increasing (Figure 8). NRC noted this increasing trend in the 2019 technical information request (NRC 2019). Since 2014, however, trends in that well show a statistically significant decreasing trend. A statistically significant increasing trend was found for well 0305 for both time frames (Table 4; Figure 8). Statistically significant decreasing trends were found for wells 0309 and 0310. Well 0309, in the southwest corner of the site, is the only routinely monitored onsite well with uranium concentrations below the UMTRCA standard (historical range of 0.015 to 0.037 mg/L). Apart from the 2004 result for well 0310 (ACL basis), uranium concentrations in all routinely monitored wells have been below the proposed ACL of 0.36 mg/L (Figure 8).

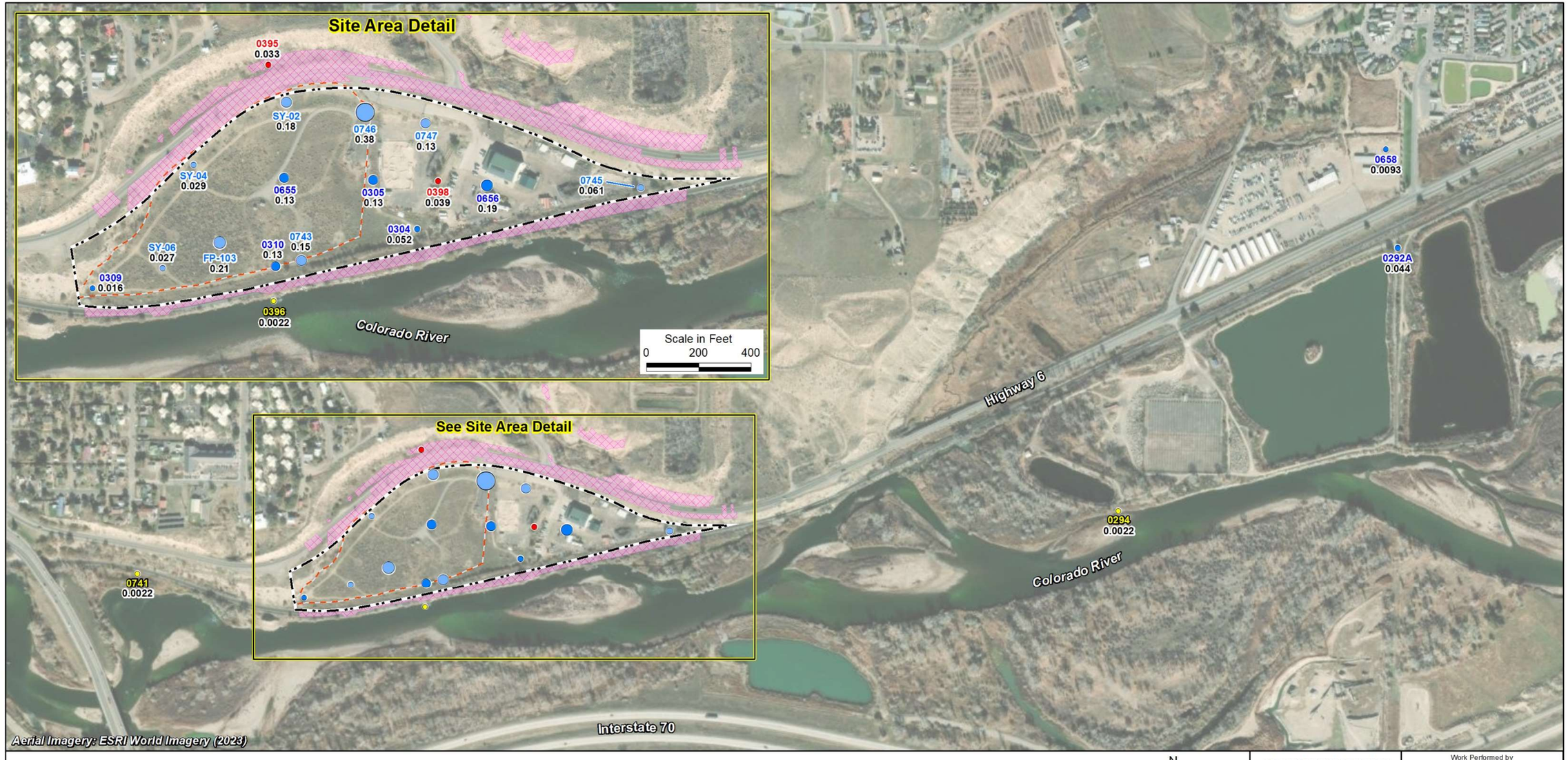
Uranium concentrations in five wells not routinely monitored—0743, 0746, 0747, FP-103, and SY-02—exceeded the 0.044 mg/L UMTRCA standard (Figure 7). These nonroutine results are not shown in the time-concentrations plots because of insufficient sample numbers for trending. However, they can be found on GEMS (https://gems.lm.doe.gov).

In November 2023, the highest uranium concentration, 0.38 mg/L, was measured in well 0746 near the northeast corner of the former tailings area south of the supplemental standards region. This value slightly exceeds the 0.36 mg/L ACL proposed in the 2017 draft GCAP. As this ACL has not been approved by NRC, no corrective action is warranted. However, these findings indicate the need for continued monitoring in the northern region of the site and a reevaluation of the ACLs proposed in 2017.

2.4.2 Selenium

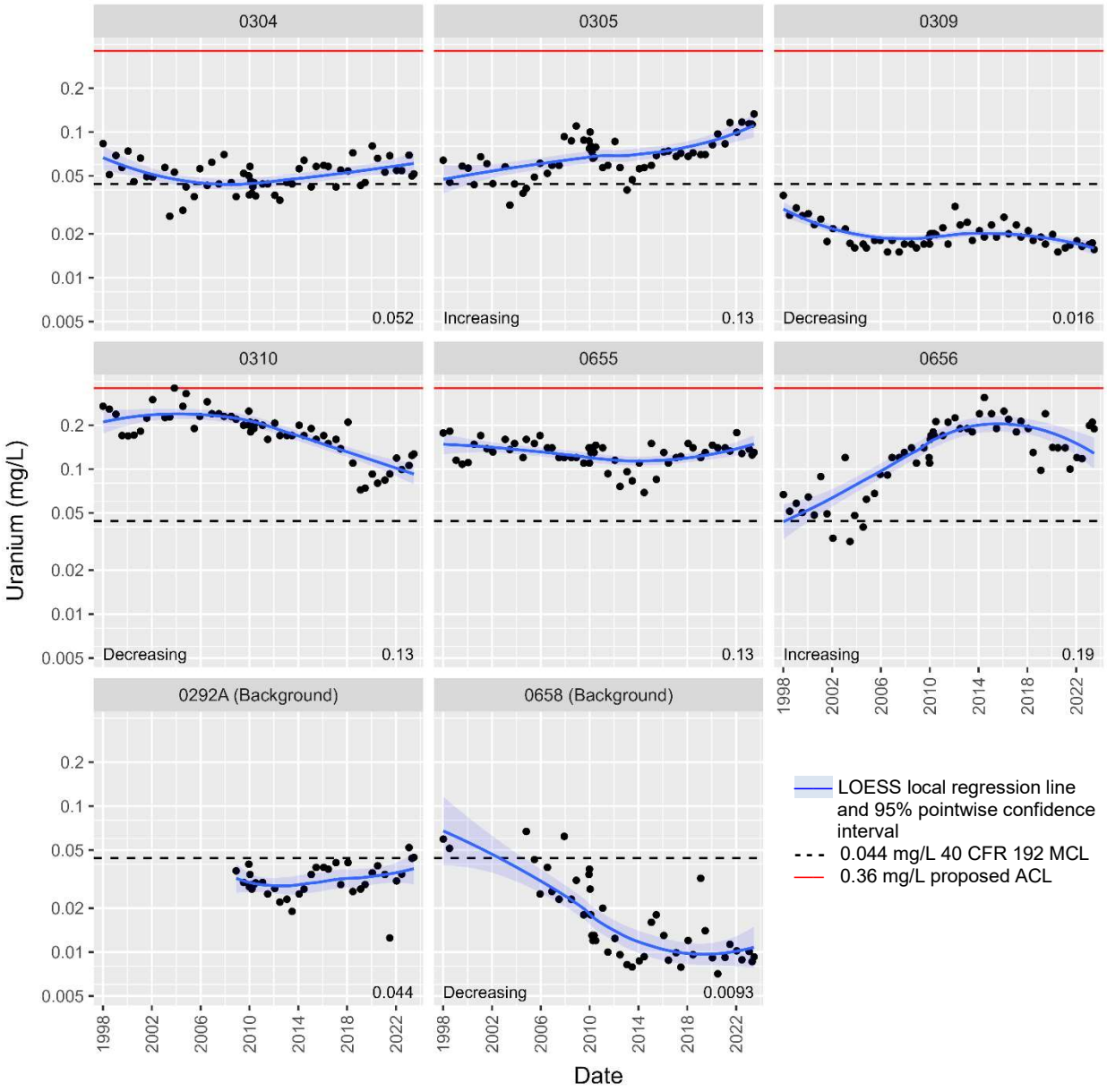
Figure 9 plots the most recent (November 2023) selenium concentrations measured in Old Rifle site monitoring wells along with surface water sampling results. Corresponding time-series data for monitoring wells are plotted in Figure 10. In routinely monitored wells, selenium concentrations have exceeded the 0.05 mg/L ACL (SDWA standard) in two wells: 0655 and 0305, characterized by statistically significant increasing and decreasing trends, respectively (Table 4). In June of 2022 and 2023, selenium concentrations in well 0655 (in the center of the former tailings area) exceeded the proposed ACL of 0.122 mg/L, ranging from 0.16 to 0.18 mg/L. The most recent (November 2023) result was 0.059 mg/L, slightly exceeding the 0.05 mg/L ACL.

Well 0305 is west of the north-south trending ditch that conveys surface runoff from north of the site to the Colorado River. Since 1998, concentrations in this well have decreased by approximately an order of magnitude, from 0.1 to 0.01 mg/L, but have more recently stabilized (Table 4; Figure 10).



Note: The uranium result posted for multichannel well 0743 is from 0743-3, screened at an interval of 16.2–16.7 ft bgs (Appendix A). In November 2023, the uppermost intervals (0743-1 and 0743-2) were dry.

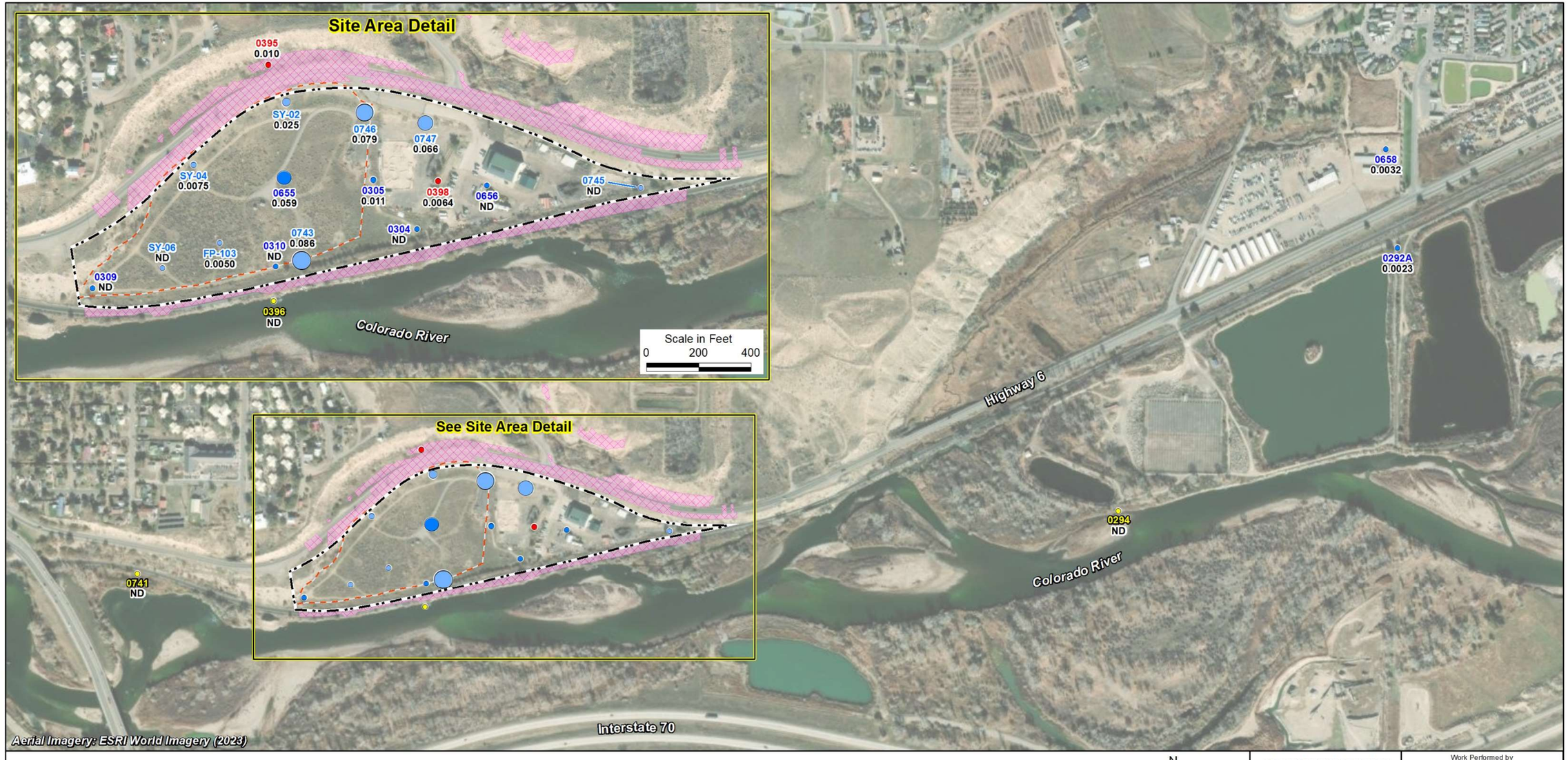
Figure 7. Uranium Concentrations in Old Rifle Site Samples, November 2023 Results



Notes:
The most recent (November 2023) results are labeled in the lower right corner of each plot.

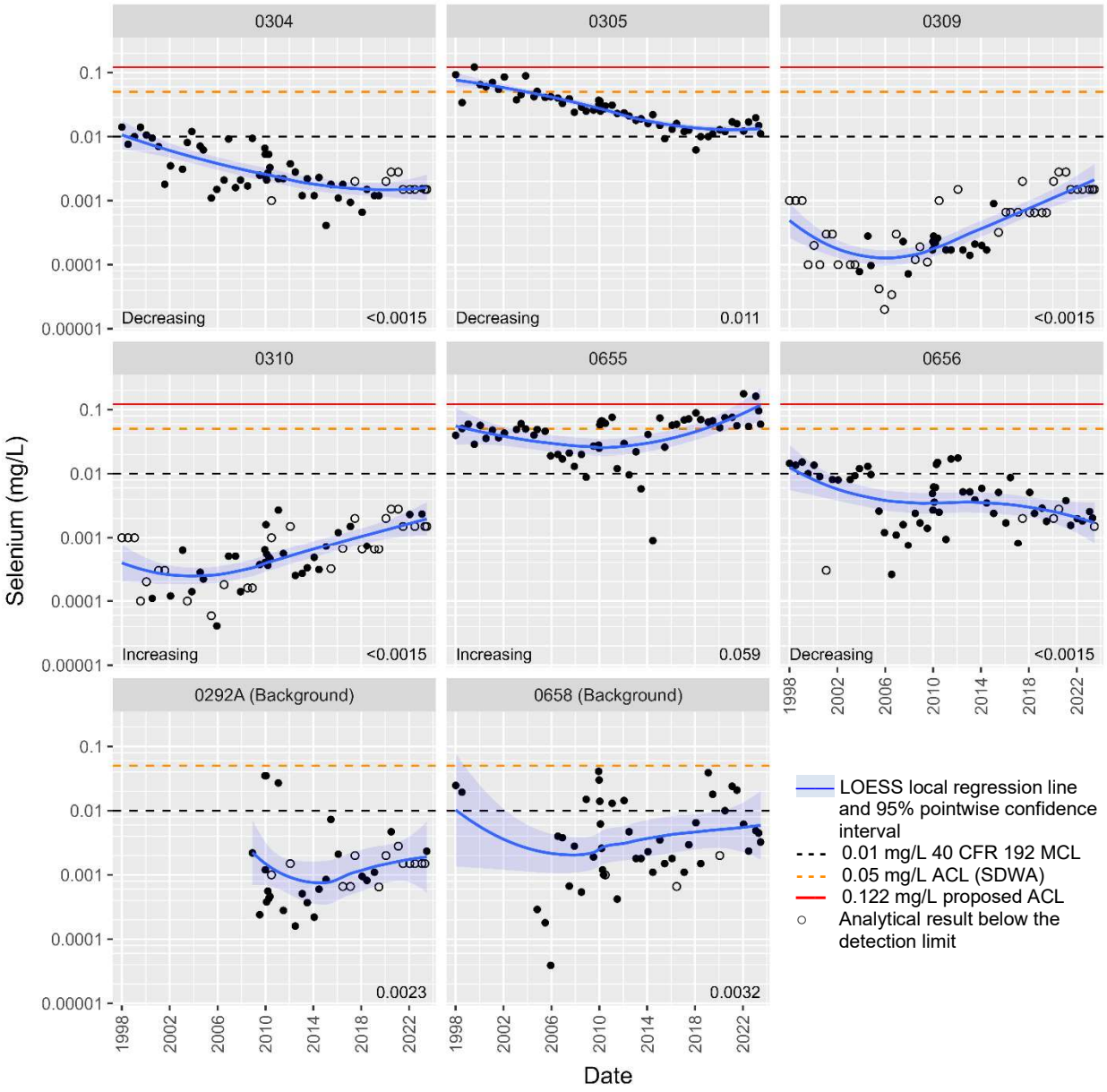
For wells with statistically significant trends for the 1998–2023 time frame, the direction of the trend is indicated on the plot. Because of the apparent shift in uranium concentration trends in some wells (e.g., in well 0656), trend tests were also run for the more recent 2014–2023 period. Trend analysis results are summarized in Table 4; supporting details are provided in Appendix A (Tables A-2 and A-3).

Figure 8. Time-Concentration Plots of Uranium in Old Rifle Site Monitoring Wells



Note: The selenium result posted for multichannel well 0743 is from 0743-3, screened at an interval of 16.2–16.7 ft bgs (Appendix A). In November 2023, the uppermost intervals (0743-1 and 0743-2) were dry.
Abbreviation: ND = not detected

Figure 9. Selenium Concentrations in Old Rifle Site Samples, November 2023 Results



Notes:
The most recent (November 2023) results are labeled in the lower right corner of each plot.

For wells with statistically significant trends for the 1998–2023 time frame, the direction of the trend is indicated on the plot. Because of the apparent shift in selenium concentration trends in some wells (e.g., in well 0655), trend tests were also run for the more recent 2014–2023 period. Trend analysis results are summarized in Table 4; supporting details are provided in Appendix A (Tables A-2 and A-3).

Figure 10. Time-Concentration Plots of Selenium in Old Rifle Site Monitoring Wells

Statistically significant decreasing trends were also found for wells 0304 and 0656, where selenium concentrations have been consistently below the 0.05 mg/L ACL. Like well 0305, no trend was found for these wells in the recent decade. A statistically significant increasing trend was found for well 0310 for the 1998–2023 time frame but not for the more recent (2014–2023) period. Selenium concentrations are still well below all corresponding standards or benchmarks in this well (Table 4). This well has a high proportion of nondetects that were accounted for in the trend analysis.

As shown in Figure 9, in November 2023, the highest selenium concentrations were measured in wells that are not routinely monitored: 0743 (0.086 mg/L), 0746 (0.079 mg/L), and 0747 (0.066 mg/L). These results exceed the 0.05 mg/L ACL. During this reporting period, along with well 0655 discussed above, the 0.122 mg/L proposed ACL was exceeded in three nonroutine following samples: SY-02 (0.19 mg/L in September 2023) and 0743-1 and 0743-2 (1.43 mg/L and 0.48 mg/L, respectively, in June 2023). As noted for uranium, these results suggest that continued monitoring for selenium may be warranted in the aforementioned regions.

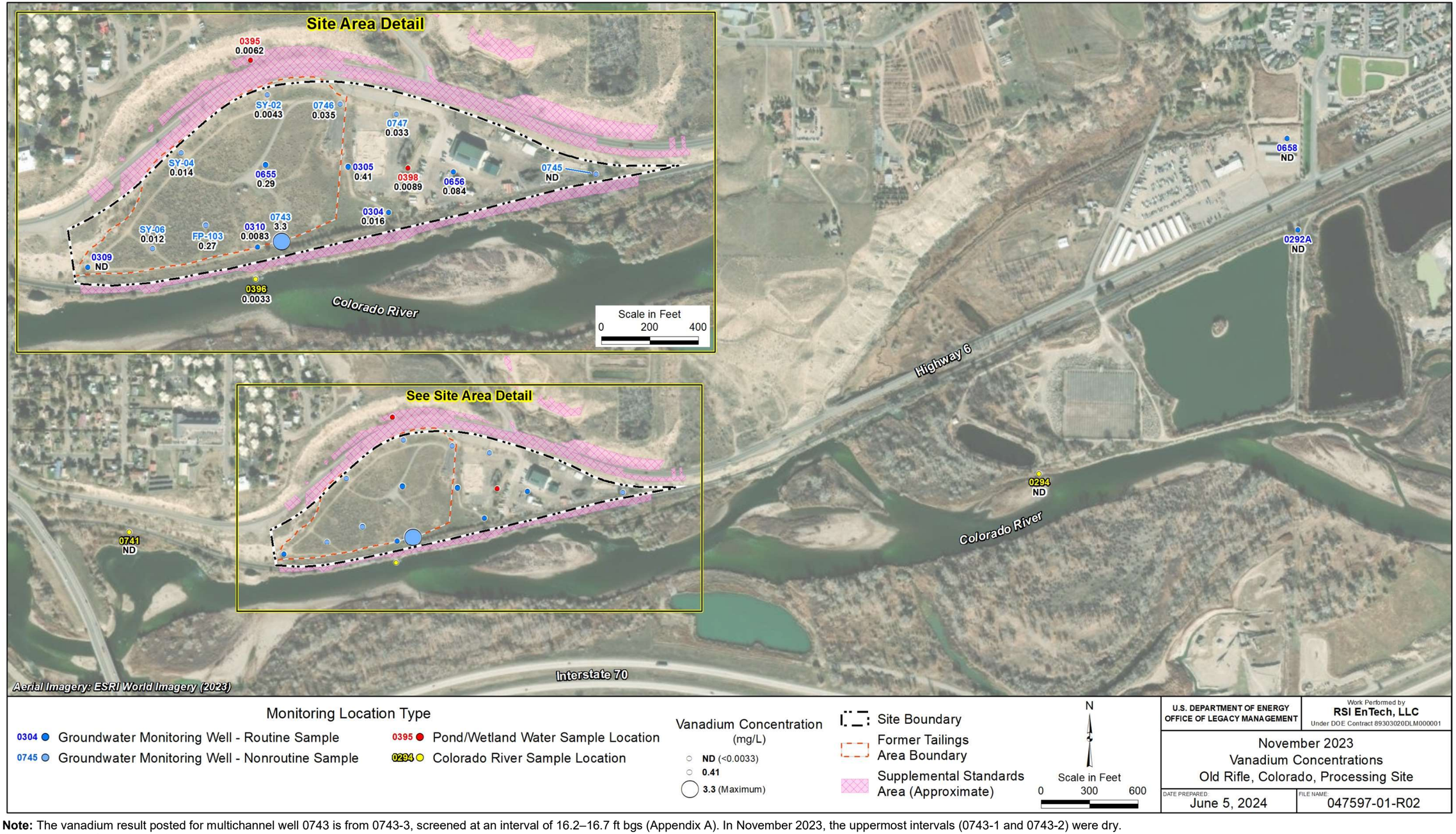
2.4.3 Vanadium

Figure 11 plots the most recent vanadium concentrations measured in Old Rifle site monitoring wells along with surface water sampling results. Corresponding time-series data for monitoring wells are plotted in Figure 12. In all routinely monitored wells, vanadium concentrations have been below the proposed ACL of 1.0 mg/L. In two wells (0309 and 0310), vanadium concentrations have been consistently below EPA's risk-based Regional Screening Level (RSL) of 0.086 mg/L for drinking water exposure. This is not a regulatory criterion and is shown in Figure 12 for comparative purposes only.

For the 1998–2023 time frame, statistically significant decreasing trends were found for four wells: 0304, 0305, 0310, and 0655. Two of these wells—0304 and 0310—show no trend for the more recent (2014–2023) period. A statistically significant increasing trend was found only for background well 0292A (2014–2023 only; Table 4).

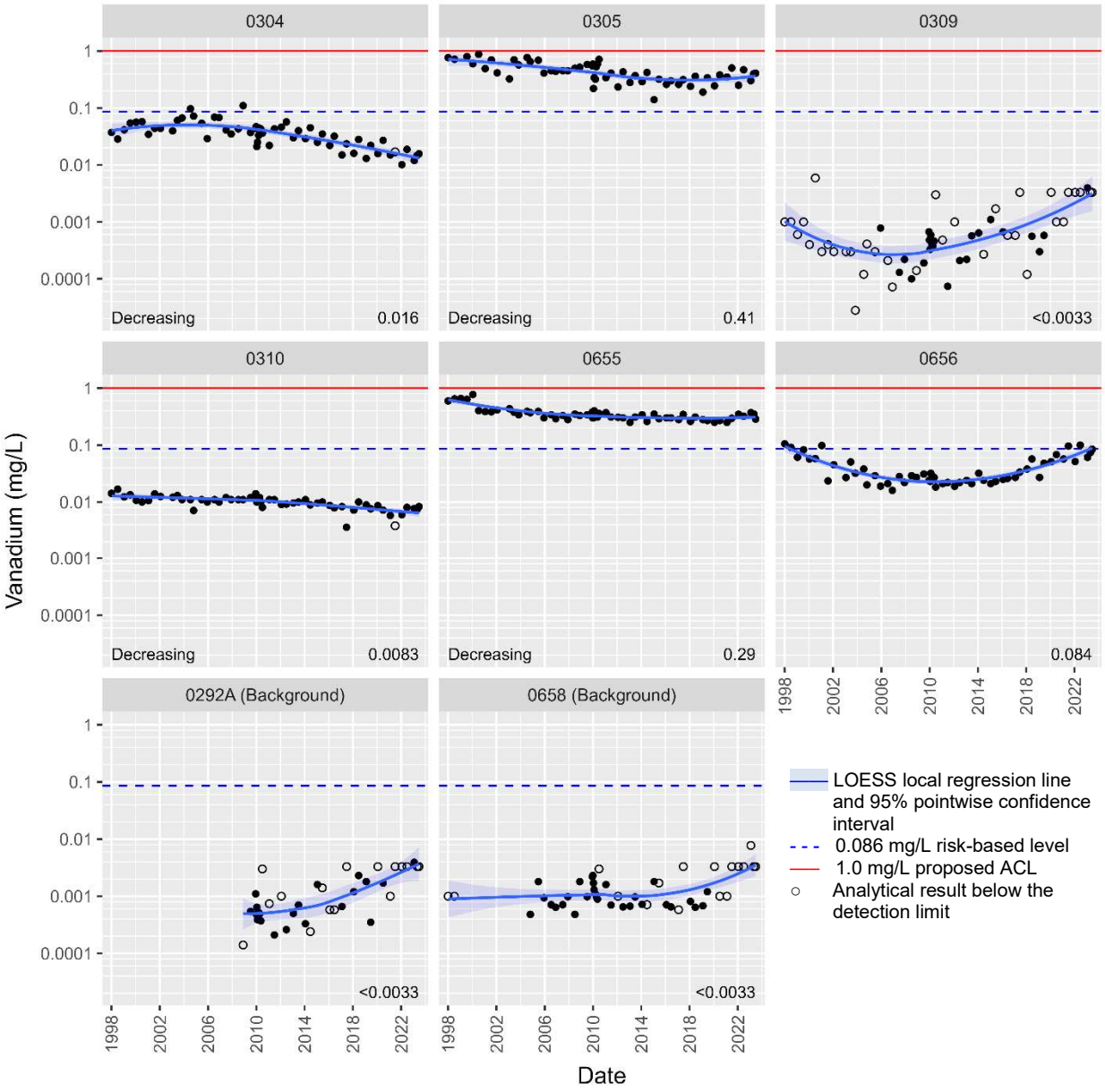
During this reporting period, vanadium concentrations in most nonroutine samples were well below the 1 mg/L ACL. An exception is multichannel well 0743, where vanadium concentrations ranged from 2.4 to 3.9 mg/L in 2022–2023 (the most recent result was 3.3 mg/L). As noted in Section 2.2, based on data for the 1997–2001 period following remediation and leading up to development of the GCAP, the maximum vanadium concentration measured at the site was 0.88 mg/l (in well 0305 in November 2000). This result served as the basis for the 1 mg/L ACL under the assumption that it was not likely to be exceeded (DOE 2001; DOE 2017).

However, similar concentrations (2.1–3.7 mg/L), in line with recent results, were measured at well 0743 in 2011 through 2013. As demonstrated in the following section, vanadium concentrations in Colorado River samples from nearby location 0396 have been comparable to background (upstream) results.



Note: The vanadium result posted for multichannel well 0743 is from 0743-3, screened at an interval of 16.2–16.7 ft bgs (Appendix A). In November 2023, the uppermost intervals (0743-1 and 0743-2) were dry.
Abbreviation: ND = not detected

Figure 11. Vanadium Concentrations in Old Rifle Site Samples, November 2023 Results



Notes:
The most recent (November 2023) results are labeled in the lower right corner of each plot.

For wells with statistically significant trends for the 1998–2023 time frame, the direction of the trend is indicated on the plot. Trend analysis results are summarized in Table 4; supporting details are provided in Appendix A (Tables A-2 and A-3).

Figure 12. Time-Concentration Plots of Vanadium in Old Rifle Site Monitoring Wells

2.5 Surface Water Monitoring Results

This section presents the results of historical surface water monitoring at the Old Rifle site. Corresponding ditch, seep, and Colorado River monitoring locations are shown in Figure 4. The most recent (November 2023) surface water sampling results are plotted in the preceding figures along with groundwater monitoring results (Figure 7, Figure 9, and Figure 11).

2.5.1 Seep and Ditch Locations

Figure 13 plots historical results for all three COCs in samples collected from the ditch (location 0398) and the seep north of the site (location 0395). Both locations were characterized in the most recent draft GCAP as representative of background surface or seep water recharging the onsite alluvial aquifer (DOE 2017, Table 5). Although not directly applicable to these data, groundwater standards or alternative risk-based standards from Table 2 are shown to provide a context for evaluating results. Current levels of all COCs are below these groundwater benchmarks. Since 2014, concentrations of COCs (most notably uranium and selenium) have increased at the ditch sample location. Uranium concentrations increased from about 0.01 mg/L to a maximum of 0.05 mg/L in June 2023, exceeding the 0.044 mg/L UMTRCA MCL. The reason for these increasing uranium trends is currently unknown. Although low relative to benchmarks, selenium concentrations have also increased by a factor of 5, from 0.002 mg/L to 0.01 mg/L. Vanadium concentrations have increased slightly since 2014 but are well below the conservative RSL of 0.086 mg/l (most recent result of 0.0089 mg/L).

COC concentrations in samples collected from seep 0395 north of the site have been consistently below corresponding benchmarks. Seasonal fluctuations are more apparent at this location, in contrast to ditch location 0398 (Figure 13), with the highest concentrations typically measured in November. Historically, flow rate measurements are not reported at these surface water locations.

2.5.2 Colorado River Water Quality Monitoring

In the most recent draft GCAP (DOE 2017), the Colorado River, where groundwater discharges from the site, was considered the POE for milling-related contamination. Recent and historical results of surface water monitoring indicate that the water quality of the river adjacent to and downgradient of the Old Rifle site (locations 0396 and 0741) is indistinguishable from background water quality (location 0294 and former location 0538). The Colorado River in the site vicinity is classified for agricultural, recreational, and water supply uses.[2] Water quality standards for the river are established in Regulation No. 37 of CDPHE's Water Quality Control Commission. As shown in Figure 14, based on historical semiannual sampling results, uranium and selenium concentrations in adjacent and downgradient river samples have not exceeded corresponding aquatic standards (there is no standard for vanadium). For all COCs, concentrations are also comparable to background surface water quality based on measurements from upgradient location 0294 and former location 0538. Higher detection limits for selenium and vanadium account for the upticks in selenium and vanadium concentrations in these samples.

[2] Applicable segment is COLCLC01: Mainstem of the Colorado River from the confluence with the Roaring Fork River to immediately below the confluence with Rifle Creek, designated as Aquatic Life Cold 1 and classified for agricultural, recreational, and water supply uses (Volume 5 *Code of Colorado Regulations* Section 1002-37 [5 CCR 1002-37]).

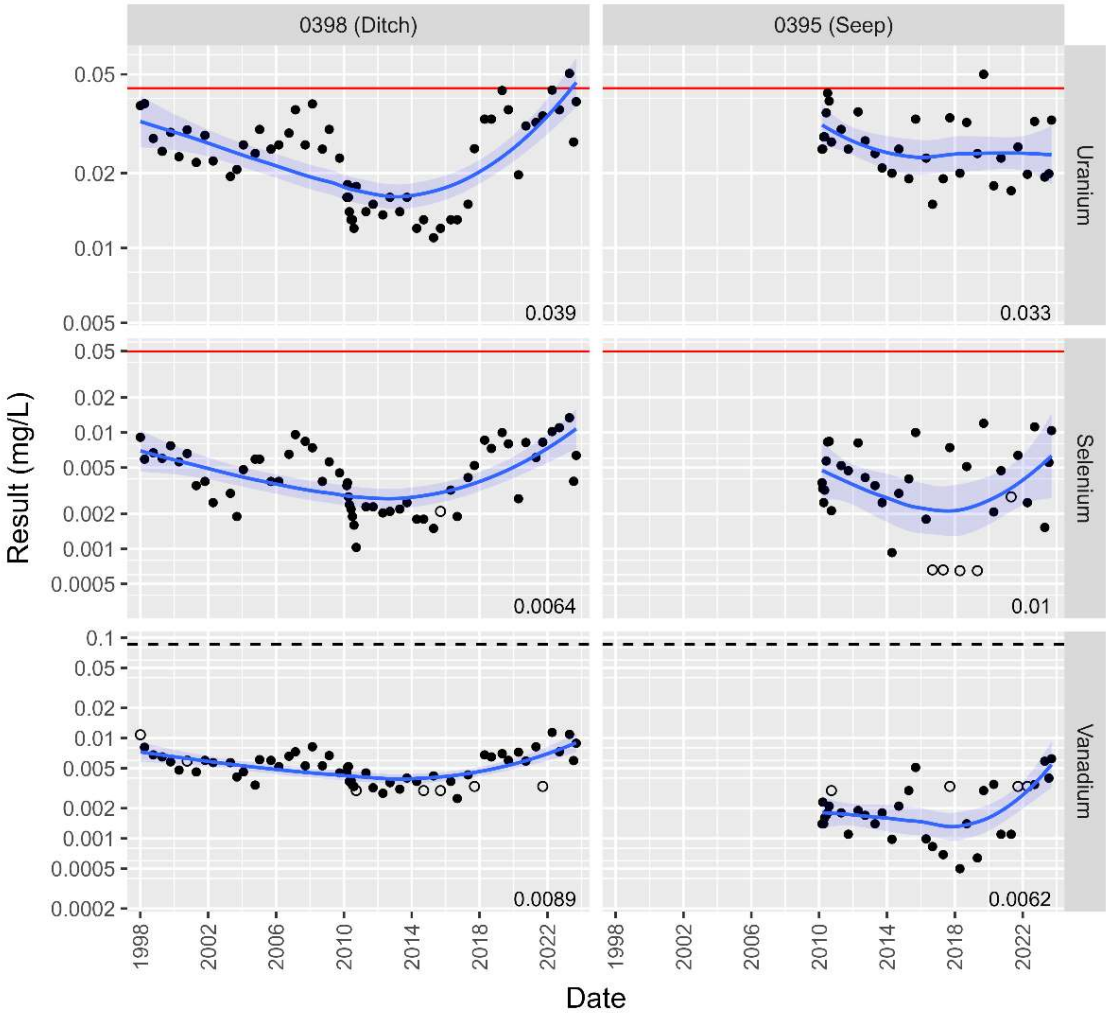
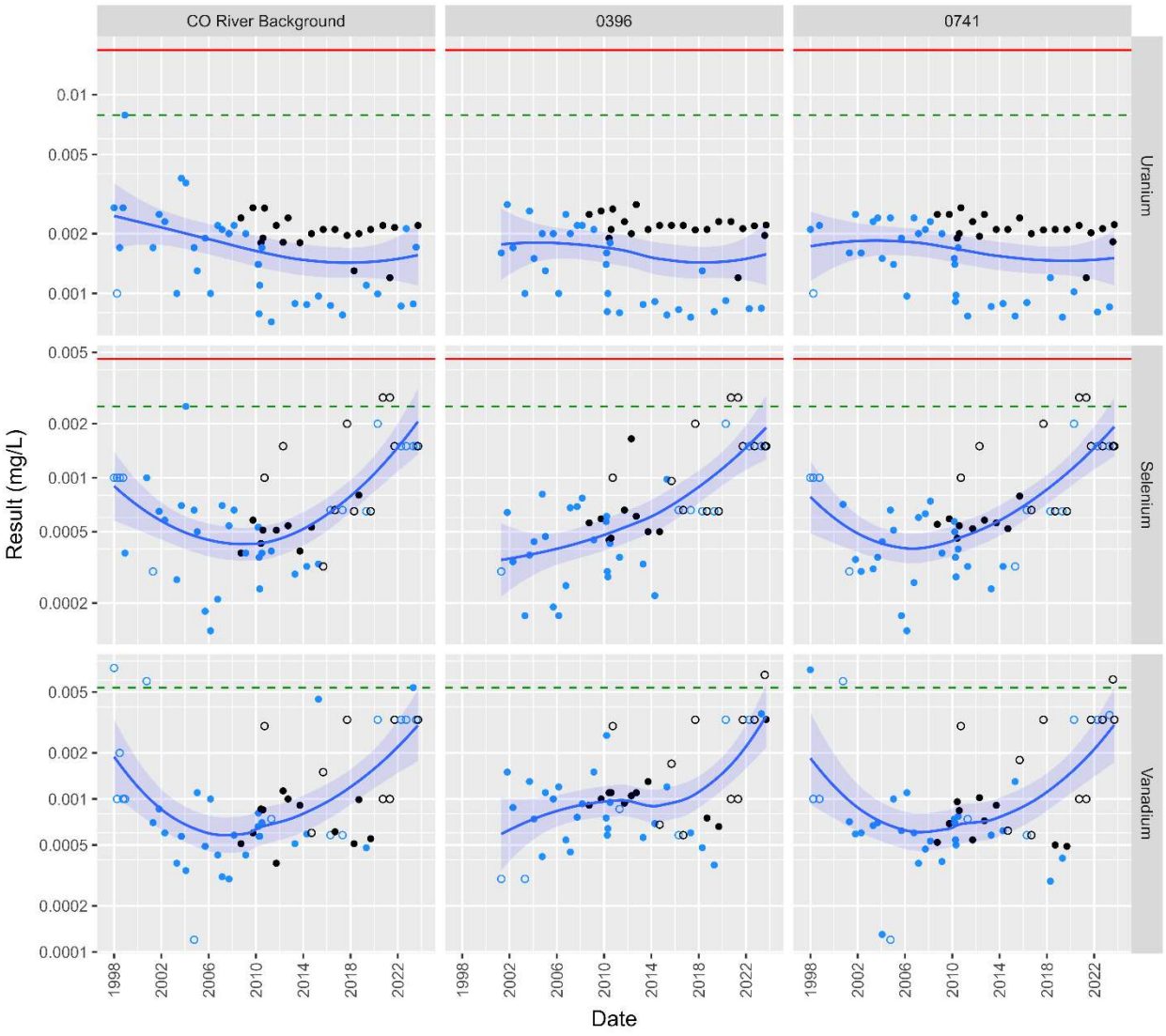


Figure 13. Time-Concentration Plots of COCs in Old Rifle Site Seep and Ditch Samples



Notes:

LOESS local regression line and 95% pointwise confidence interval.
Total (unfiltered).
Dissolved (filtered).
Analytical result below the detection limit.
Maximum detected concentration at upgradient (background) river locations 0538 or 0294: 0.0079 mg/L, 0.0025 mg/L, and 0.0054 mg/L for uranium, selenium, and vanadium, respectively.
"Surface Water Standard" (5 CCR 1002-37):
–For uranium, the lower bound of the cited range (0.0168–0.03 mg/L) is used.
–For selenium, the chronic standard of 0.0046 mg/L is shown.
–There is no surface water standard for vanadium.

Monitoring of current background Colorado River location 0294 began in November 2007. Data from the previous background river location—0538, roughly 0.5 mile upstream (east) of location 0294—are also plotted for the period 1998–2007.

Figure 14. Historical COC Concentrations in Colorado River Water Samples, Old Rifle Site

2.6 ICs Monitoring

Most of the formal obligations for verifying and enforcing the ICs rest with the City of Rifle and CDPHE. According to Section 10 of the EC, the owner of the EC (City of Rifle) is required to submit to CDPHE an annual report of site activities. The annual report details the owner's compliance, and any lack of compliance, with the terms of the EC. Verification of the restrictions in the zone overlay is required under No. 8 of Subsection (d), the standard operating procedures (SOPs). The city manager shall annually inform all department heads of the SOPs, deed restrictions, and ECs affecting the UMTRA Project sites.

DOE verification that the city has upheld the quitclaim deed conditions is an ongoing process, accomplished throughout each year by (1) discussions with city officials about construction projects and possible incursions of groundwater that could result from these activities; (2) physical inspection of the site by the State of Colorado or DOE (or both), usually during the annual Rifle disposal site inspection; and (3) observations during groundwater sampling activities at other times of the year. Observations made during inspection or groundwater sampling events are documented in the trip reports for those events.

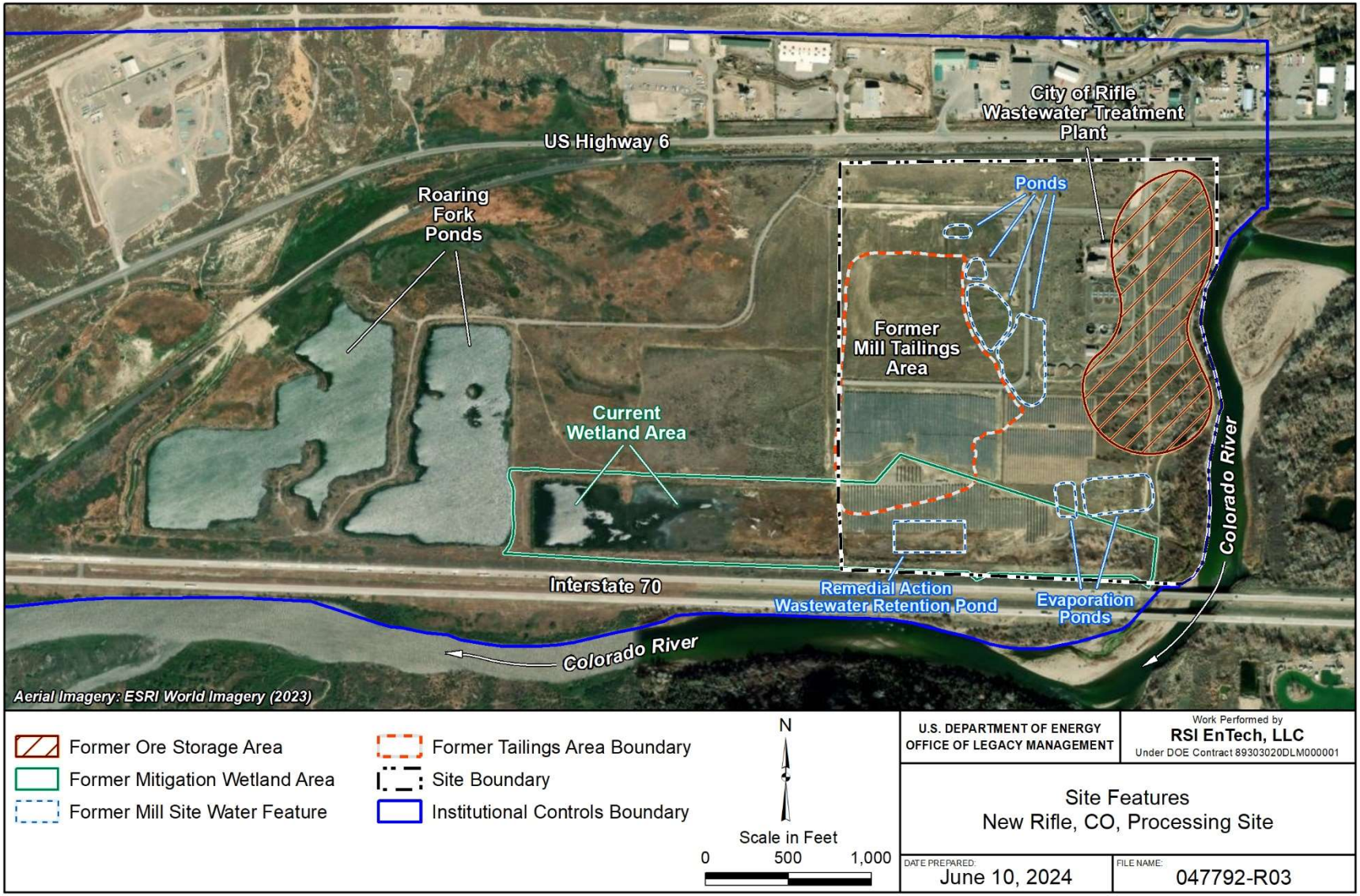
3.0 New Rifle Site

The New Rifle site is approximately 2.3 miles west of the City of Rifle (Figure 1; Figure 15), adjacent to and north of the Colorado River. The 142-acre site, which is accessible by U.S. Highway 6, is the location of a former vanadium and uranium mill that operated from 1958 through 1984. This section summarizes semiannual water quality monitoring data through November 2023 and assesses the progress and status of the current compliance strategy.

3.1 Site History

Uranium and vanadium production at the New Rifle mill lasted from 1958 to 1984 (DOE 1999a). From 1964 to 1967, the New Rifle mill also processed lignite ash. From 1973 to 1984, part of the mill was used to produce vanadium. This operation, which did not produce tailings, involved processing vanadium-bearing solutions from Union Carbide's plant at Uravan, Colorado, for various vanadium products used by the steel industry.

The west-central portion of the New Rifle mill site contained 33 acres of tailings in two distinct piles. Holding ponds for processing wastes (including vanadium and gypsum) were located east of the piles. All tailings, contaminated materials, and associated process buildings and structures were removed from the site during the surface remedial action completed in 1996. Prompted by the identification of contamination in the surficial alluvial aquifer, site characterization investigations in support of the SOWP began in 1997. Results of those investigations indicated the presence of site-related contamination in groundwater downgradient (west) of the site on private land. Figure 15 shows the locations of the former milling operations areas along with other key features on and adjacent to the site.



Note: The full extent of the ICs boundary is shown in Figure 2 and Figure 17.

Figure 15. Key Historical and Current Features On and Adjacent to the New Rifle Site

Several historical nonmilling activities at or adjacent to the New Rifle site affected local groundwater conditions. For an unknown period of time (start of operations not documented), Roaring Fork Resources operated a gravel mine on the property adjacent to and downgradient of the site. Water was pumped from an active onsite mining pit, where excavation was occurring, to another onsite pit for storage and infiltration. These pits are now referred to as the Roaring Fork ponds (locations shown in Figure 15). The Roaring Fork gravel pit ceased operations in 2003, and the ponds have since filled with groundwater and equilibrated with the local water table.

The State of Colorado subsequently transferred the site property to the City of Rifle in 2004. In 2008, the city began dewatering the aquifer in the eastern portion of the site (on city property) to provide dry footing for constructing foundations for a wastewater treatment plant. Dewatering created a cone of depression that extended west into areas of vanadium-contaminated sediments; the water table was lowered by 5 to 8 ft in places. The most recent draft GCAP (DOE 2016) provides a more detailed discussion of historical site activities. Along with the historical activities described above, Table 5 summarizes the key events, evaluations, and correspondence germane to the New Rifle site and this VMR evaluation.

3.2 Compliance Strategy and Water Quality Monitoring

The compliance strategy for the New Rifle site has undergone several iterations over the years as more data have been collected and LM's understanding of the conceptual site model has evolved. COCs initially identified for the underlying alluvial aquifer were ammonia, arsenic, fluoride, manganese, molybdenum, nitrate, selenium, uranium, and vanadium (DOE 2003). Based on discussions with CDPHE, fluoride and manganese were deemed to be of little concern at the site and were eliminated from the monitoring program (DOE 2014). LM issued a draft GCAP in 2003 recommending a strategy of natural flushing to either 40 CFR 192 MCLs or ACLs (DOE 2003). The conditions of this strategy were to establish ICs for groundwater use and to conduct routine semiannual monitoring until concentrations of COCs decreased to corresponding groundwater standards listed in Table 6. NRC responded to this submittal in August 2003 with a request for additional information (RAI) consisting of 12 comments (NRC 2003). NRC's primary concerns related to contaminant concentrations in the Roaring Fork ponds.

In response to NRC concerns, and because subsequent evaluations demonstrated that the initially proposed natural flushing was not performing as expected, LM issued a revised GCAP in 2016. The revised proposed compliance strategy for the alluvial aquifer at the site is no remediation with the application of ACLs, implementation of ICs for groundwater use, and continued groundwater monitoring of six COCs: arsenic, molybdenum, nitrate, selenium, uranium, and vanadium. Four wells—three onsite wells and one offsite downgradient well—were selected as POC wells, and the Roaring Fork gravel pit ponds were identified as the proposed POE. ACLs were based on a statistical analysis of data from source area well 0658. Constituents currently monitored at the New Rifle site are summarized in Table 6 along with the proposed ACLs. Ammonia was withdrawn as a COC but retained in the monitoring program (DOE 2016).

Since the draft GCAP was issued in 2016, LM has engaged in a series of communications with NRC to address requests for additional information to obtain concurrence on the draft GCAP. Table 5 provides a chronology of this correspondence.

Table 5. Summary of Key New Rifle Site Activities, Events, and Evaluations

Activity or Evaluation	Date or Time Frame	Description or Major Findings
Mill operation	1958–1984	The New Rifle mill was constructed in 1958 to replace the Old Rifle mill and operated until 1984. Milling operations included vanadium- and uranium-ore processing (1958–1972), lignite ash processing (1964–1967), and vanadium processing (1973–1984).
Surface remediation	1989–1996	Surface remediation began in 1989 and was completed in 1996. Tailings and related materials were relocated to the Rifle disposal site.
Site characterization	1997–1999	Postremediation site characterization efforts.
SOWP issued	November 1999	Site characterization efforts culminated in the SOWP, a report documenting the site conceptual model on which the New Rifle site compliance strategy was based (DOE 1999a).
Initial draft GCAP submitted Roaring Fork gravel pit ceased operations	2003	On April 30, 2003, DOE submitted a draft GCAP for review and comment (DOE 2003). The initially proposed compliance strategy was a combination of natural flushing and application of ACLs for seven COCs, combined with ICs and semiannual monitoring. The Roaring Fork gravel pit ceased operations in 2003 (start date is unknown).
City of Rifle acquired the site	2004	The State of Colorado transferred the site property to the City of Rifle.
NRC RAI regarding 2003 draft GCAP	August 14, 2003	NRC issued an RAI consisting of 12 comments, the primary concern being contaminant levels in the Roaring Fork ponds.
Wastewater treatment plant constructed and associated geochemical evaluations conducted	2008–2010	In 2008, the City of Rifle began dewatering the aquifer in the eastern portion of the site (the city's property) to provide dry footing for constructing foundations for a new wastewater treatment plant. These dewatering activities prompted LM to study geochemical mechanisms impacting the fate and transport of vanadium in groundwater. The study was ongoing for 2 years, from February 2008 through February 2010 (DOE 2010).
2016 revised draft GCAP submitted	January 19, 2017	LM submitted a draft GCAP (DOE 2016) proposing a revised compliance strategy of no remediation and application of ACLs.
NRC RAI regarding 2016 draft GCAP	July 21, 2017	NRC issued an RAI consisting of 15 comments regarding the 2016 draft GCAP (NRC 2017).
LM response to NRC 2017 RAI	September 26, 2019	LM responded to NRC's RAI in September 2019 (DOE 2019).
NRC response to LM's 2019 submittal	February 6, 2020	NRC responded to LM's 2019 submittal on February 6, 2020, concluding that LM's responses to 12 of NRC's 15 comments in the RAI were adequate. NRC requested that LM provide additional technical justification for three remaining comments regarding groundwater quality west of the Roaring Fork ponds, groundwater elevations, and spatial and temporal variations in groundwater flow in the alluvial aquifer (NRC 2020b).
LM response to remaining NRC RAIs	December 31, 2020	LM responded to NRC's three remaining comments (DOE 2020) and proposed a technical scope for future evaluations required to update the conceptual site model.
New monitoring well and stilling well installed	Fall 2022	To collect the additional data needed to address NRC's outstanding RAIs, in October and November 2022, LM installed three surface water level monitoring stations (stilling wells) along the Colorado River and installed four monitoring wells on the western end of the current ICs boundary.

Table 6. Compliance Standards and ACLs for New Rifle Site Groundwater COCs

Constituent[a]	40 CFR 192 (UMTRCA) MCL	ACL Proposed in 2003 Draft GCAP[b]	ACL Proposed in 2016 Draft GCAP[c]	Background Range[d]
Ammonia[a]	–	200 mg/L ammonia as NH_4 (or 155 mg/L ammonia as N)	–	<0.002–0.11
Arsenic	0.05	–	0.313	0.00011–0.0050
Molybdenum	0.10	–	7.3	<0.0018–0.024
Nitrate as N (Nitrate + Nitrite as N)	10	–	75	<0.01–9.0
Selenium	0.01	0.05 (SDWA)	1.43	<0.001–0.028
Uranium	0.044	–	0.364	0.016–0.042
Vanadium	–	0.33[e]	52	<0.000028–0.006

Notes:
All units are milligrams per liter (mg/L).
[a] Fluoride and manganese, initially identified as COCs in the initial draft GCAP (DOE 2003), are not listed because they were subsequently eliminated from the monitoring program (DOE 2014). Ammonia was withdrawn as a COC in the most recent draft GCAP but was retained in the monitoring program (DOE 2016).
[b] From Table 1 of DOE 2003.
[c] From Tables 7 and 8 of the draft GCAP (DOE 2016). Proposed ACLs are nonparametric 95% USLs calculated for source area well 0658 at that time. In the 2016 GCAP, ammonia was no longer considered a COC because it is not regulated under 40 CFR 192 and concentrations had declined to levels no longer of concern.
[d] Data from New Rifle site background well 0169 (1998–2023). Previous evaluations (DOE 2016) had also considered Old Rifle site background wells 0292A and 0658 as suitable New Rifle site background locations. As such, the maximum uranium concentration measured in Old Rifle site well 0658 (0.067 mg/L) was previously applied as a background context for evaluating New Rifle site alluvial aquifer groundwater data (DOE 2016). Because of hydrologic considerations and significant trends in uranium concentrations, this well is no longer used as a background well for the New Rifle site (DOE 2020).
[e] The 2003 draft GCAP cites a benchmark for vanadium of 0.33 mg/L, a previous EPA risk-based concentration dating back to the 2001 Old Rifle site GCAP (DOE 2001). EPA's risk-based screening levels have evolved over time. The most recent RSL table (from May 2024) cites a risk-based value for tap water of 0.086 mg/L. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

Abbreviations:
– = not applicable
N = nitrogen

3.2.1 Current Status of the Draft GCAP

Between 2017 and 2021, LM received several rounds of RAIs from NRC that ultimately led to LM's identification of data gaps warranting another revision of the conceptual site model and GCAP. In July 2017, NRC issued a letter stating that additional information was required to complete the agency's review of the 2016 draft GCAP (NRC 2017). LM addressed the 15 comments in September 2019 (DOE 2019), after which NRC concluded that LM's responses to 12 of the 15 comments were adequate (DOE 2020b). At that time, NRC requested that LM provide additional technical information regarding groundwater quality west of the Roaring Fork ponds, groundwater elevations, and spatial and temporal variations in groundwater flow in the alluvial aquifer (NRC 2020b). LM responded to NRC's comments on December 31, 2020 (DOE 2020). Along with this submittal, LM proposed a technical scope for future technical evaluations required to revise the conceptual site model.

3.2.2 Groundwater and Surface Water Monitoring Network

Table 7 lists the current monitoring requirements for the New Rifle site. As stipulated in the 2016 draft GCAP (DOE 2016), the monitoring network currently consists of 17 monitoring wells and 8 surface water sampling sites, including 3 Colorado River locations. These locations are shown in Figure 16 along with nonroutine locations sampled in 2022 and 2023.

3.2.3 Activities and Evaluations Conducted During this Reporting Period

After the last (2021) VMR was issued (DOE 2022), LM determined that the current well network downgradient of the mill site was too sparse to confidently define the extent of contamination. To address this data gap and NRC's remaining RAIs, LM installed four new monitoring wells on the western end of the current IC boundary in November 2022: 0907, 0909, 0919, and 0922 (Figure 16). All wells were constructed with 10-ft-long screened intervals except 0922, with a 5-ft-long screen.

LM also installed three new surface water level monitoring stations (stilling wells) along the Colorado River in October 2022. These locations, identified by an "SW" prefix, are shown in Figure 16. SW-1 was installed east of the City of Rifle wastewater treatment plant to measure the river levels upgradient of the site. SW-2 was installed near the south-central IC boundary to correlate river levels with nearby well 0635. SW-3 was installed near the west end of the IC boundary to measure the downgradient river stage.

3.2.4 New Rifle Site ICs

ICs are a critical component of the compliance strategy for the New Rifle site. A comprehensive ICs program has been implemented to prevent future use of contaminated groundwater associated with the New Rifle site. Figure 17 shows the areas impacted by the various overlapping ICs. The IC program consists of several enforceable mechanisms that can be combined into the following four types of administrative categories:

(1) Quitclaim deed restrictions covering the former mill site property

(2) City of Rifle and Garfield County zone overlays covering uses of groundwater in an expanded area of potentially contaminated groundwater

(3) State of Colorado EC with Umetco Minerals Corporation covering agricultural uses of groundwater at an adjacent and downgradient vicinity property

(4) City of Rifle UMTRA Project zone overlay to address potential future development at the former mill site

Table 7. Summary of GCAP Monitoring Requirements for the New Rifle Site

Locations[a]	Monitoring Purpose[a]	Analytes[a, b]	Frequency
0215, 0216, 0658, 0659*, 0664*, 0669*, 0670, 0855	Monitor COCs in onsite wells	Ammonia as N Arsenic Molybdenum Nitrate as N Selenium Uranium Vanadium	Semiannually[c]
0201, 0217*, 0590, 0635	Monitor COCs adjacent to and downgradient of the site and upgradient of the Roaring Fork ponds		
0170, 0172, 0195, 0620	Monitor COCs in wells farther downgradient of the site and downgradient of the Roaring Fork ponds		
0169[d]	Monitor background groundwater quality		
Roaring Fork ponds:[e] 0323, 0575 Colorado River: Old Rifle site background locations 0538 (former) and 0294 (current); 0322, 0324, 0326[f] Wetland locations: 0320, 0452, 0453	Monitor surface water to determine impact of groundwater discharge to surface water and ecological receptors		

* Asterisks denote locations designated as POC wells in the most recent draft GCAP (DOE 2016): 0217, 0659, 0664, and 0669.

Notes:

[a] Locations and monitoring purpose are from the most recent draft GCAP (DOE 2016); locations are shown in Figure 16. More detailed information is provided in Appendix B, Table B-1; this table also lists all nonroutine locations sampled at the New Rifle site in 2022 and 2023.

[b] New Rifle site COCs and proposed monitoring requirements have varied over the years (DOE 1999a; DOE 2003; DOE 2014; DOE 2016). The most recent draft GCAP (Table 10 of DOE 2016, Table 10) proposed a reduced analytical scope for downgradient offsite wells 0170, 0172, 0195, and 0620 (excluding arsenic, selenium, and vanadium). Until that GCAP is approved, all site locations listed above will continue to be monitored semiannually for the seven analytes listed above.

[c] The semiannual frequency listed here is consistent with the sampling regime proposed in the initial GCAP for onsite wells in the vanadium plume area (DOE 2003). Table 4 of the 2003 GCAP proposed a mix of semiannual and annual sampling frequencies that varied depending on the analyte and monitoring location. In the most recent draft GCAP (DOE 2016), a reduced frequency was proposed: annually for the first 5 years following acceptance of the GCAP, after which monitoring requirements would be reevaluated. Because LM continues work on updating the conceptual site model and a GCAP revision addressing NRC concerns, semiannual monitoring will continue at the New Rifle site until the data support a reduced frequency.

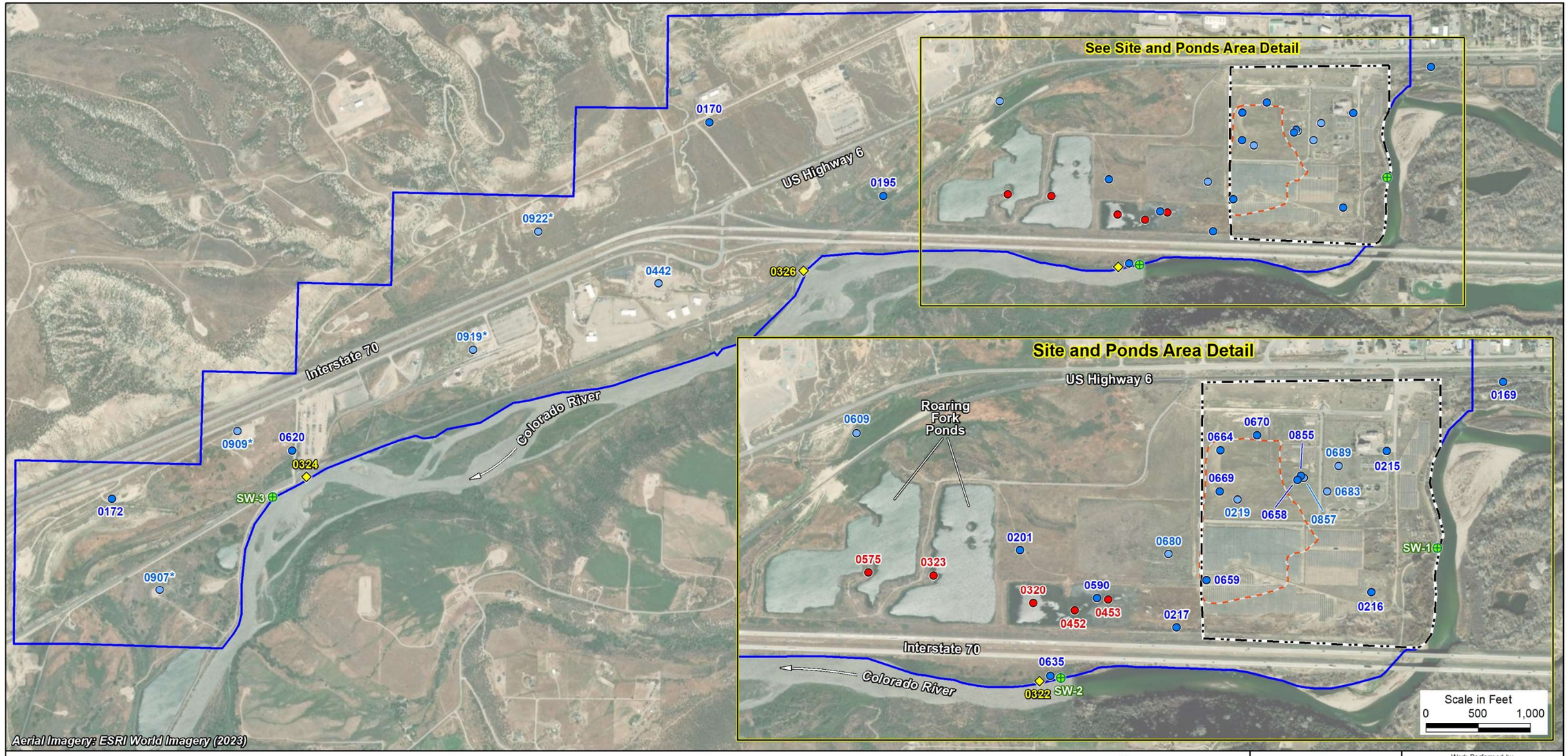
[d] Although the 2016 draft GCAP proposed that background groundwater quality monitoring be discontinued (the background dataset was deemed to be adequate), background well 0169 continues to be monitored for the full suite of COCs. Previous evaluations (DOE 2014; DOE 2016) also used background wells 0292A and 0658 from the Old Rifle site (refer to Table 3). These Old Rifle site wells are no longer considered valid background locations for the New Rifle site (DOE 2020; NRC 2020b).

[e] The Roaring Fork ponds were proposed as POE locations in the recent draft GCAP (DOE 2016).

[f] Colorado River location 0326 was established in June 2015.

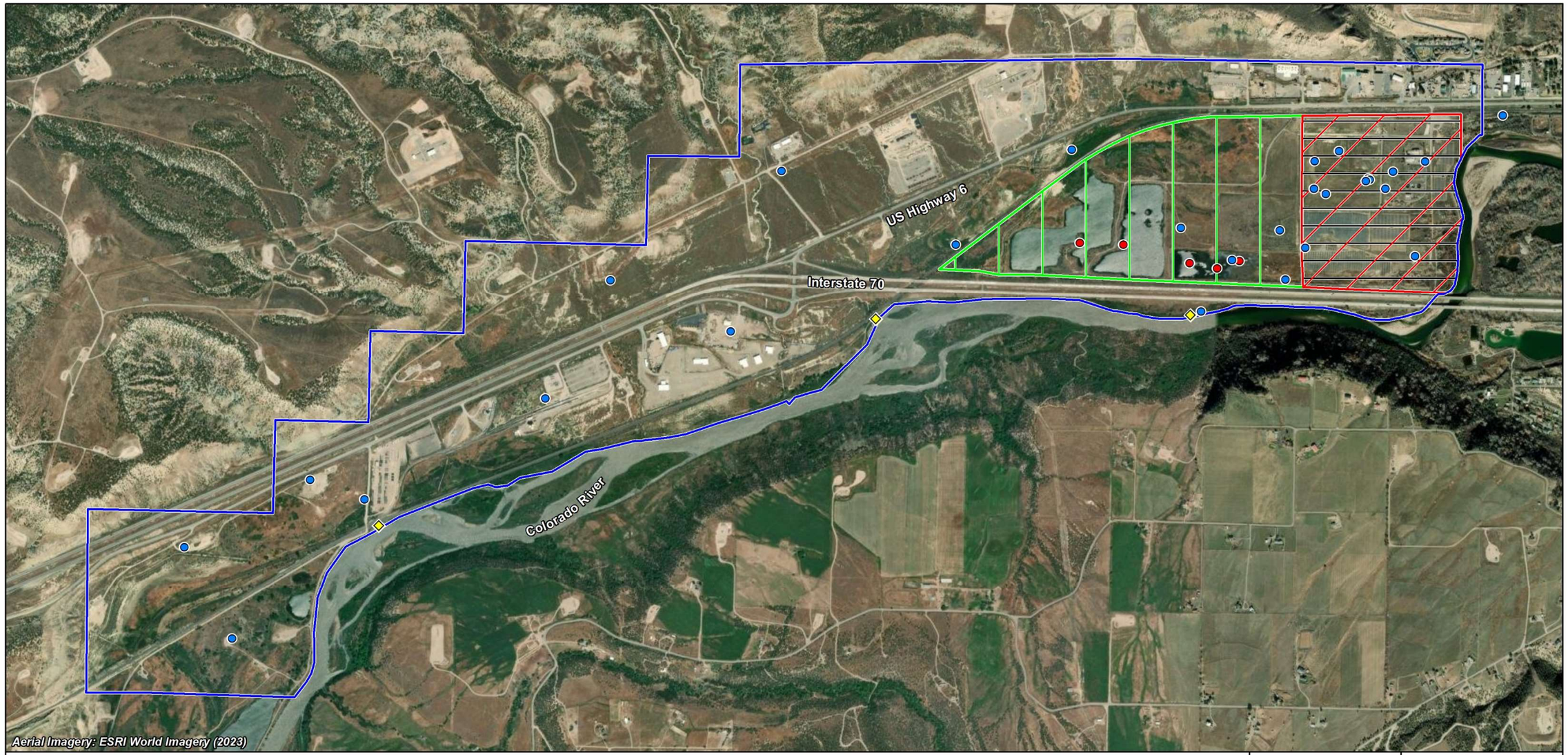
Abbreviations:

N = nitrogen



Only those locations sampled in 2022 and 2023 are shown in this figure. Of these, 17 wells are routinely monitored in accordance with the most recent draft GCAP (DOE 2016). Newly installed downgradient wells 0907, 0909, 0919, and 0922 will be slated for routine monitoring in the next GCAP revision. The remaining seven wells—onsite wells 0219, 0683, 0689, and 0857 and offsite wells 0442, 0609, and 0680—are not routinely monitored. All surface water (pond, wetland, and river) sample locations shown are routinely monitored. Stilling wells were installed in October 2022 as described in Section 3.2.3.

Figure 16. Monitoring Locations at the New Rifle Site



Note: The UMTRA Project overlay zone district overlaps almost directly with the quitclaim deed boundary.

Figure 17. Current IC Boundaries at the New Rifle Site

Where these restrictions are required, DOE must ensure that the beneficial uses of the groundwater, had they not been restricted, could be satisfied. DOE funded two water line extensions to the current municipal system to ensure the availability of potable water to properties affected by site-related contamination. Because the water line extension did not cover the full extent of the contaminated groundwater plume, DOE also provides funding for reverse osmosis systems for users who are within the ICs boundary but beyond the reach of the water line. In the past few years, the city limit boundary was expanded west along the water line extension, and residents were required to use municipal water. New Rifle site ICs are discussed in greater detail in Section 4.2 of the draft GCAP (DOE 2016); Appendix A of that report documents the ICs in their entirety.[3]

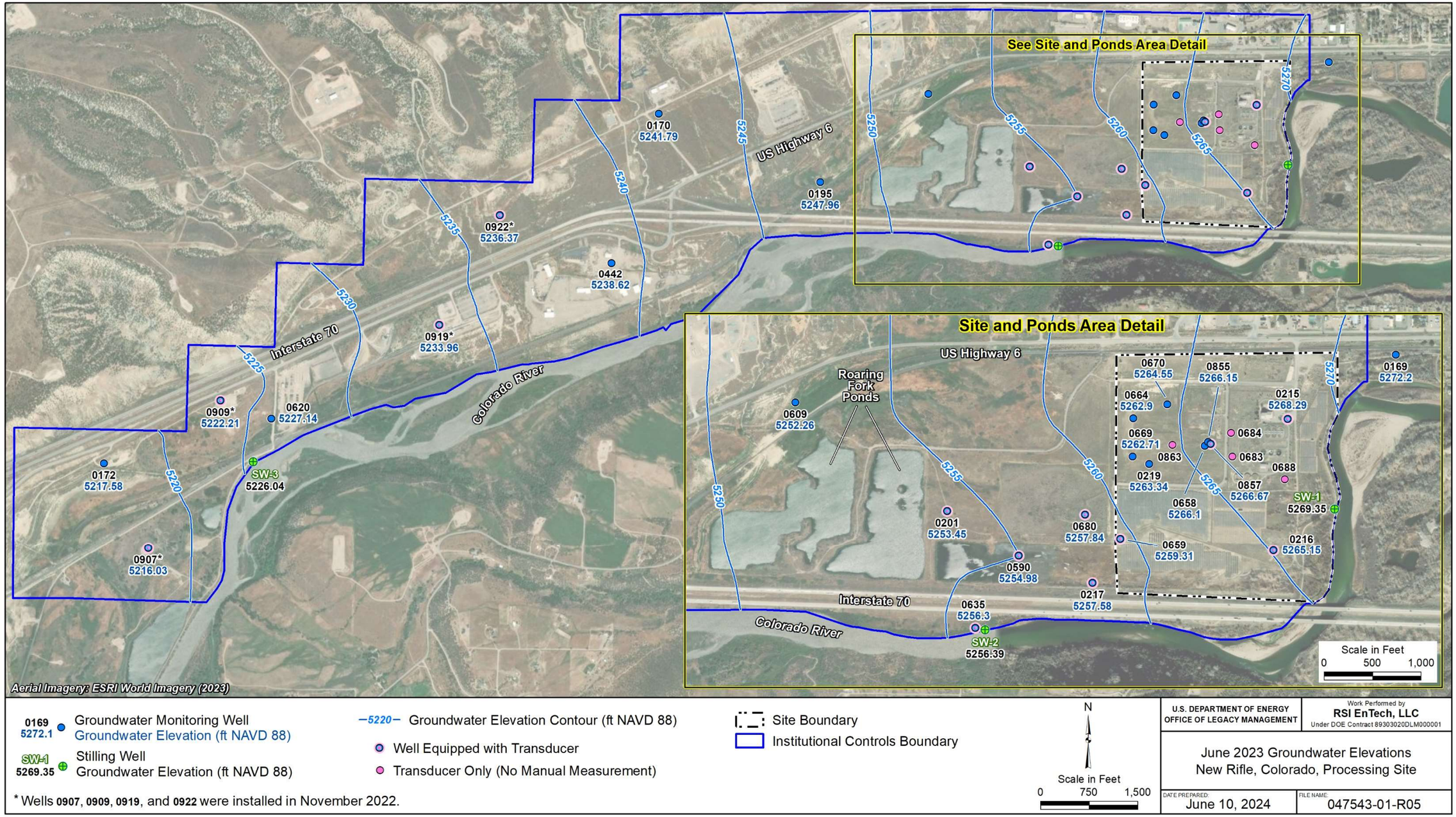
3.3 Groundwater Flow Conditions

The New Rifle former processing site is on the north floodplain of the Colorado River and, as with the Old Rifle site, the uppermost alluvial aquifer consists of poorly sorted river alluvium and the upper weathered portion of the Wasatch Formation. The alluvial aquifer ranges from 10 to 100 ft thick, with the thickest areas resulting from deposition of alluvial fans from ephemeral streams flowing from the northwest (DOE 2016). Estimated hydraulic conductivities for the alluvial aquifer range from 53 to 275 ft per day with an average of 114 ft per day (DOE 1999a). Known sources of recharge to the alluvial aquifer include surface water infiltration from the northwest-trending ephemeral streams, lateral inflow from the Colorado River near the eastern site boundary, and infiltration of precipitation (DOE 1999a). Discharge of Wasatch Formation groundwater into the alluvial aquifer's northern boundary was also identified as a potential source of recharge (DOE 2016). Groundwater discharges primarily to the Colorado River. Evapotranspiration also occurs in areas where groundwater is expressed as surface water, for example in the wetland area and in the Roaring Fork ponds (DOE 2016).

Figure 18 and Figure 19 show measured water level elevations within the alluvial aquifer and equipotential contours for June 2023 and November 2023, respectively.

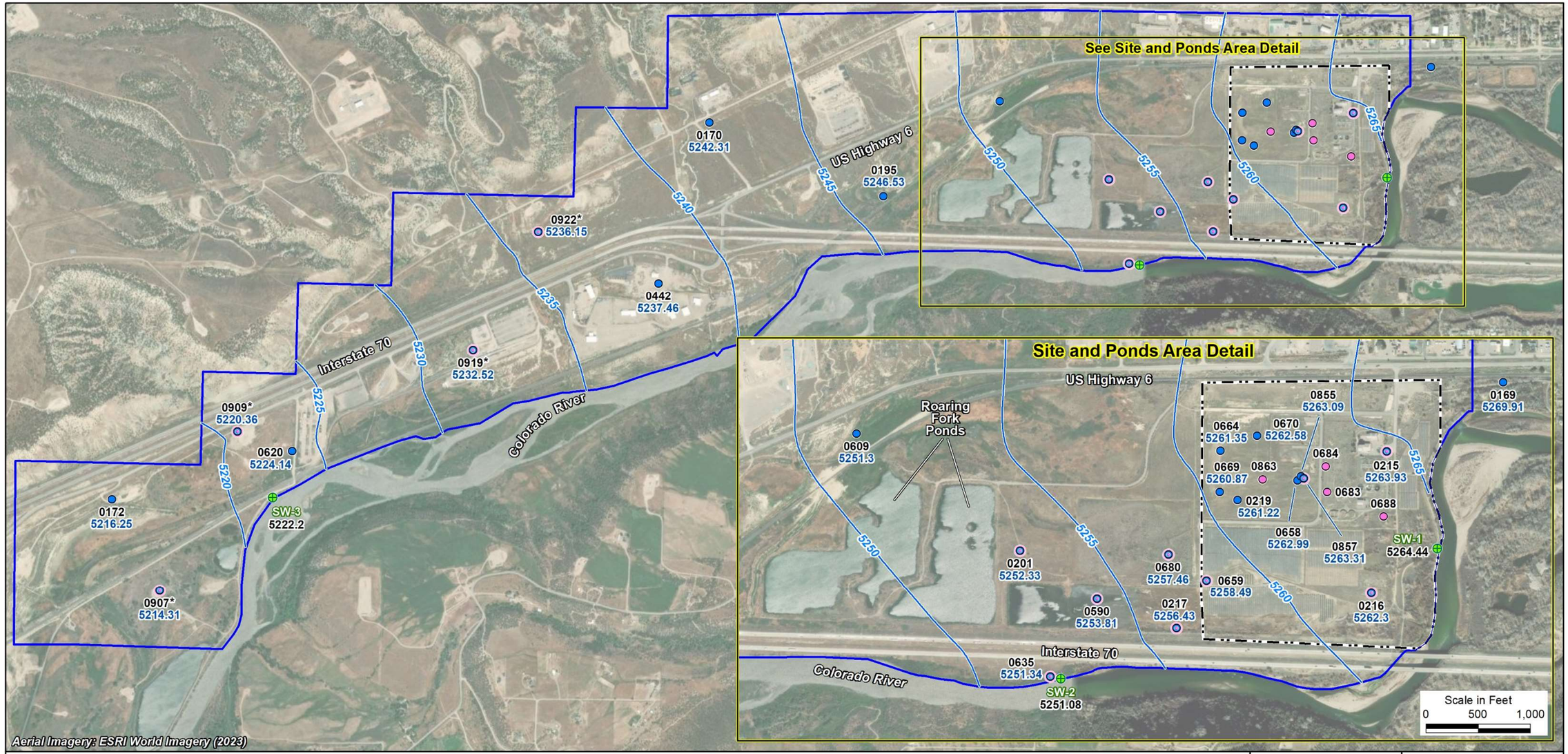
Water levels were generally more elevated in June, with the higher seasonal fluctuations measured closer to the Colorado River at the eastern site boundary and decreasing with distance west toward well 0907 at the southwestern IC boundary. General groundwater flow direction was to the west-southwest for both time periods. Seasonal and more localized assessments on groundwater flow directions using three-point estimations and well triangles will be included in future evaluations to better refine spatial and temporal variation of groundwater flow and potential discharge to the Colorado River.

[3] Summaries of ECs and use restrictions for both the Old and New Rifle sites are provided on the following CDPHE website (refer to Garfield County listings): https://cdphe.colorado.gov/sites-environmental-covenants-and-use-restriction.



Note: Groundwater elevations at monitoring wells are from manual measurements collected during the June 2023 semiannual sampling event (June 12–16, 2023). Colorado River elevations at stilling wells are daily average datalogger measurements on the date corresponding to that of manual measurements at the nearest monitoring well(s). Other wells (not identified as being equipped with a transducer) have been instrumented but the transducers were not employed or operational during this reporting period.
Abbreviation: NAVD 88 = North American Vertical Datum of 1988

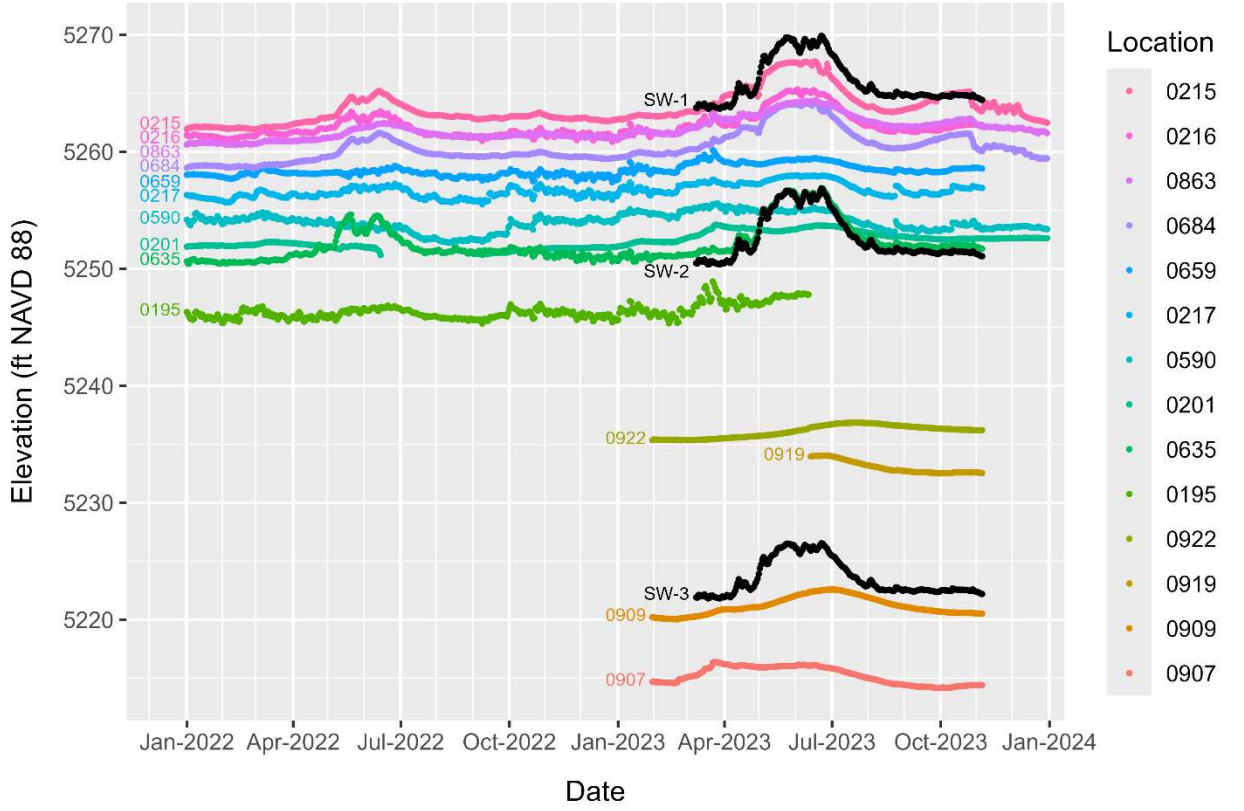
Figure 18. Groundwater Elevations in New Rifle Site Monitoring Wells: June 2023



Note: Groundwater elevations at monitoring wells are from manual measurements collected during the November 2023 semiannual sampling event (November 6–8). Colorado River elevations at stilling wells are daily average measurements recorded on November 6, when dataloggers were downloaded.
Abbreviation: NAVD 88 = North American Vertical Datum of 1988

Figure 19. Groundwater Elevations in New Rifle Site Monitoring Wells: November 2023

Pressure transducers were deployed in each of the stilling wells and at four downgradient well locations (0907, 0909, 0919, and 0922) to understand and compare temporal trends between alluvial aquifer groundwater levels and river stage. Figure 20 shows these water elevation data trends since January 2022 along with System Operation and Analysis at Remote Sites (SOARS) transducer data in selected onsite and near downgradient wells. Seasonal fluctuations in water elevations within the onsite wells were in phase with the timing of all three stilling wells in 2023. The peaks of the seasonal fluctuations in onsite wells were slightly less than those observed in the stilling wells. Comparison of these datasets suggests a strong seasonal influence of Colorado River stage on groundwater levels at the site. In contrast, seasonal water level trends in the four downgradient locations were minimally influenced by river levels in the stilling wells.



Notes:
In the legend, wells are listed in order of descending average groundwater elevation. Data from stilling wells SW-1, SW-2, and SW-3 are also shown (data plotted in black).
Abbreviation: NAVD 88 = North American Vertical Datum of 1988

Figure 20. Water Elevations from Transducers at New Rifle Site Wells and Stilling Wells

3.4 Groundwater Monitoring Results and COC Concentration Trends

This section presents and interprets the results of groundwater and surface water sampling conducted at the New Rifle site through November 2023. In accordance with the draft GCAP (DOE 2016), the routine monitoring network currently consists of 17 monitoring wells and 8 surface water sampling sites, including 3 Colorado River locations (Figure 16). These locations are typically sampled in June and November of each year (Table 7).

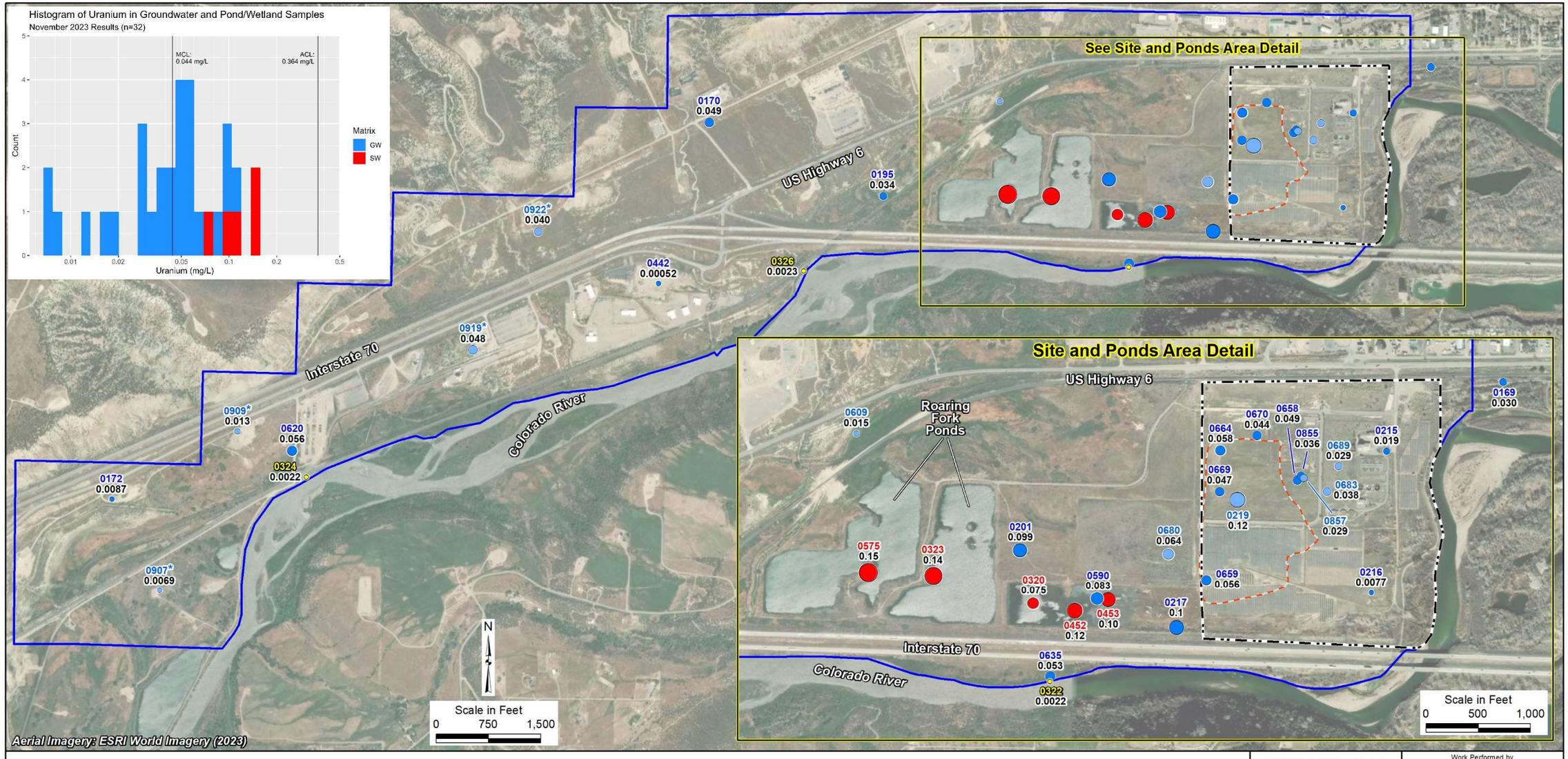
In addition to this routine monitoring well network, LM also sampled the four newly installed downgradient wells described in Section 3.2.3 (0907, 0909, 0919, and 0922). Seven additional existing wells not included in the routine network were also sampled during this period: 0219, 0442, 0609, 0680, 0683, 0689, and 0857. The new wells and nonroutine locations are identified by pale blue symbols in Figure 16. Supporting details and well location descriptions are provided in Appendix B, Table B-1.

In this section, following the approach outlined in Section 1.2, historical contaminant trends are evaluated for 1998–2023, the period since postremediation site characterization activities were initiated. Mann-Kendall trend analysis was performed for each well-COC combination for two time frames: 1998–2023 (the entire monitoring period) and, to account for stabilization or a shift in those trends, 2014–2023. Results of these analyses are addressed in the COC-specific discussions and reflected on the corresponding temporal plots. Mann-Kendall trend analysis results for all COCs are summarized at the end of this section (Section 3.4.8; Table 8 and Table 9). Detailed trend analysis results, including corresponding linear regression trends for each COC, are provided in Appendix B (Tables B-2 and B-3).

3.4.1 Uranium

Figure 21 plots the most recent (November 2023) uranium concentrations measured in New Rifle site monitoring wells along with surface water sampling results. Corresponding time-series data for monitoring wells are shown in Figure 22. As shown in these figures, elevated uranium concentrations persist throughout the New Rifle site monitoring well network. Based on November 2023 results, the 0.044 mg/L 40 CFR 192 MCL is currently exceeded in most wells within the former tailings area footprint and in near downgradient wells in the pond region. Apart from onsite well 0219 (with maximum uranium concentration of 0.12 mg/L), uranium concentrations are highest offsite in the region of the Roaring Fork ponds. Accounting for all results shown in Figure 21, the highest uranium concentrations are found in the Roaring Fork ponds (0.14–0.15 mg/L) and wetland locations (0.075–0.1 mg/L). These results are discussed further in Section 3.5.1.

Uranium concentrations are relatively low in the region east of the tailings area boundary; the lowest uranium concentrations (almost all <0.044 mg/L) have been measured in onsite wells 0215 and 0216. This is likely due to recharge from the north-south-aligned reach of the Colorado River that forms the east border of the site. COC concentrations in this region tend to be diluted by mixing with influent river water. Seasonal fluctuations likely account for the scatter found for well 0216 shown in Figure 22. Uranium concentrations in wells 0215 and 0216 are currently lower than that in the background well (0.019 and 0.0077 mg/L versus 0.03 mg/L in well 0169 [Figure 21]).



Monitoring Location Type

- 0169 Groundwater Monitoring Well - Routine Sample
- 0219 Groundwater Monitoring Well - Nonroutine Sample
- 0320 Pond/Wetland Water Sample Location
- 0322 Colorado River Sample Location

* Wells 0907, 0909, 0919, and 0922 were installed in November 2022.

Uranium Concentration (mg/L)

- 0.00052
- 0.044
- 0.15 (Maximum)

- Site Boundary
- Former Tailings Area Boundary
- Institutional Controls Boundary

U.S. DEPARTMENT OF ENERGY
OFFICE OF LEGACY MANAGEMENT

Work Performed by
RSI EnTech, LLC
Under DOE Contract 89303020DLM000001

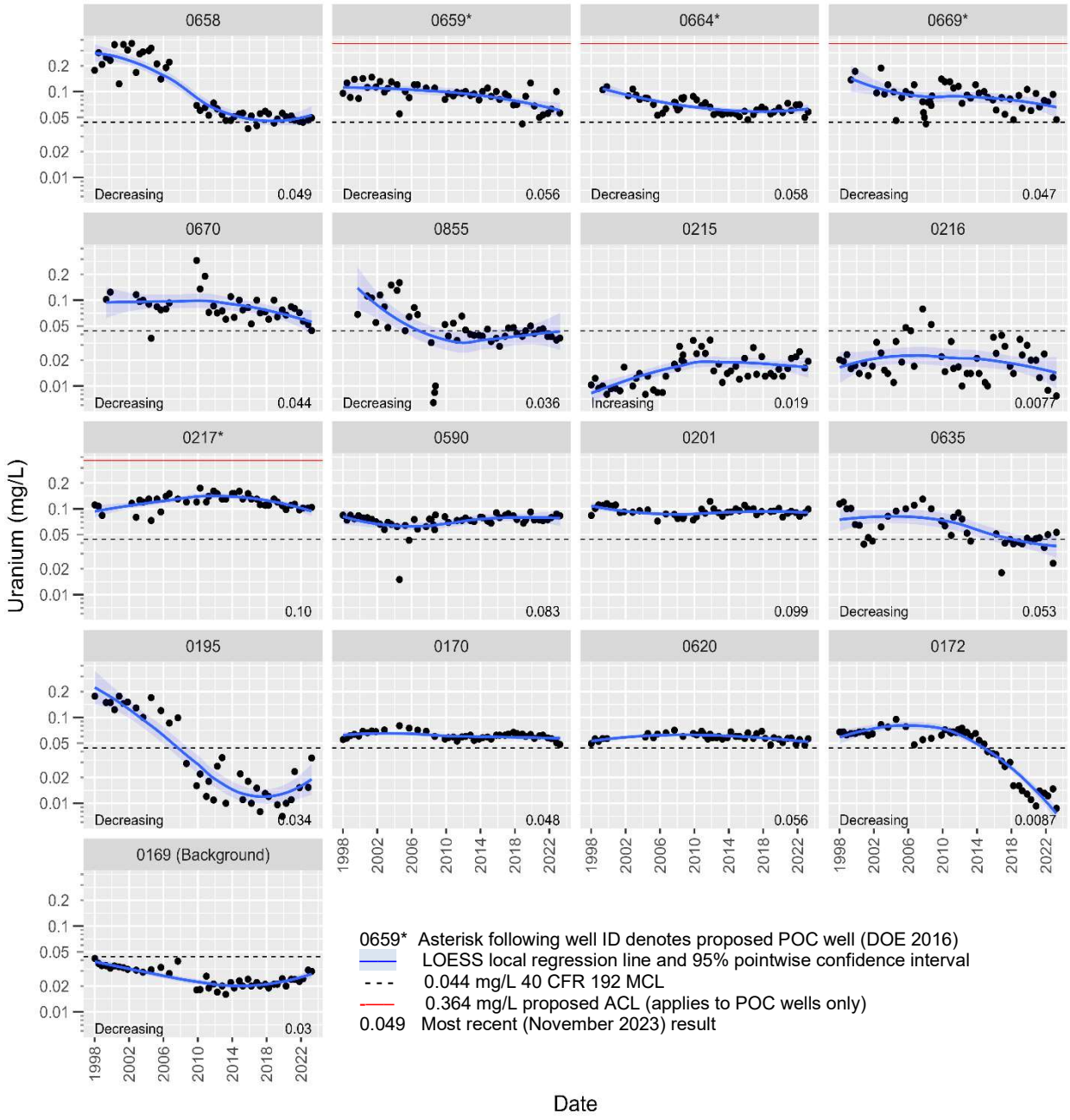
November 2023
Uranium Concentrations
New Rifle, Colorado, Processing Site

DATE PREPARED: June 6, 2024

FILE NAME: 047598-02-R01

Notes: For groundwater and nonriver surface water monitoring locations, the symbol size is proportional to the magnitude of the result relative to the range of the data (see legend).
The histogram in the upper left inset shows the distribution of uranium results relative to the 0.044 mg/L MCL and the proposed ACL of 0.364 mg/L (refer to Table 6).
Abbreviations: GW = groundwater; SW = surface water

Figure 21. Uranium Concentrations in New Rifle Site Samples, November 2023 Results



Notes:

Wells are ordered and grouped as follows:

Rows 1 and 2 = onsite wells.
Row 3 = adjacent downgradient wells.
Row 4 = farther downgradient offsite wells.
Row 5 = New Rifle site background well.

Onsite wells 0215 and 0216 are plotted last in the second row because of historically low COC concentrations relative to other onsite wells. Offsite wells (rows 3–4) are listed in general order of increasing distance from the site and former source areas.

For wells with statistically significant trends for the 1998–2023 time frame, the direction of the trend is indicated on the plot. Because of the apparent stabilization of uranium concentrations, trend tests were also run for the more recent 2014–2023 period. Trend analysis results are summarized in Table 8 and Table 9 at the end of this section; supporting details are provided in Appendix B. Low outlier concentrations shown for well 0855 correspond to the 2008 temporary dewatering (Table 5).

Figure 22. Time-Concentration Plots of Uranium in New Rifle Site Monitoring Wells

Farther downgradient wells include routinely sampled wells 0170, 0620, and 0172; well 0442 (nonroutine location); and newly installed wells (0907, 0909, 0919, and 0922). In this subset of wells, the MCL was exceeded at only three locations, listed in order of increasing distance from the site: 0170 (0.049 mg/L); 0919 (0.048 mg/L); and 0620 (0.056 mg/L).

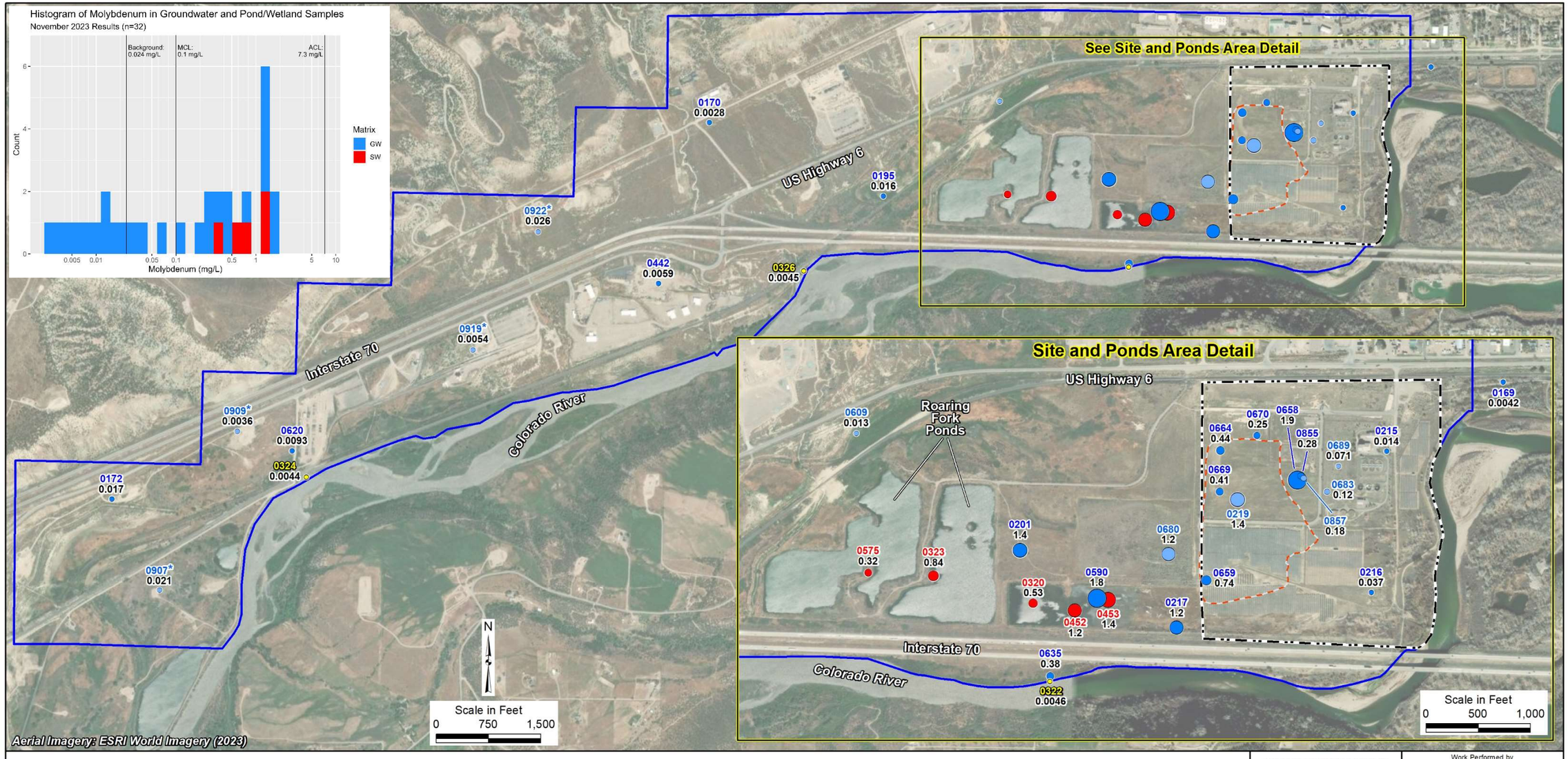
Statistically significant decreasing trends were found for 10 of the 17 wells routinely monitored, based on analysis of data from 1998–2023 (Figure 22). However, if only results since 2014 are considered, these decreasing trends were sustained for only four wells: onsite wells 0659 and 0670 and far downgradient wells 0620 and 0172. Uranium concentrations in remaining wells have stabilized.

Between 1998 and 2014, uranium concentrations in well 0172 were consistently slightly above the MCL, typically 0.06–0.07 mg/L (Figure 22), but have since markedly declined (most recent result of 0.0087 mg/L). The geochemical conditions accounting for this shift are not known at this time. As noted in the previous VMR (DOE 2022), uranium concentrations in well 0195, about 400 ft downgradient of the West Roaring Fork Pond, declined significantly between 1998 and 2018 but have since started increasing slightly. Uranium concentrations at background well 0169 have decreased overall but show an increasing trend since 2014.

3.4.2 Molybdenum

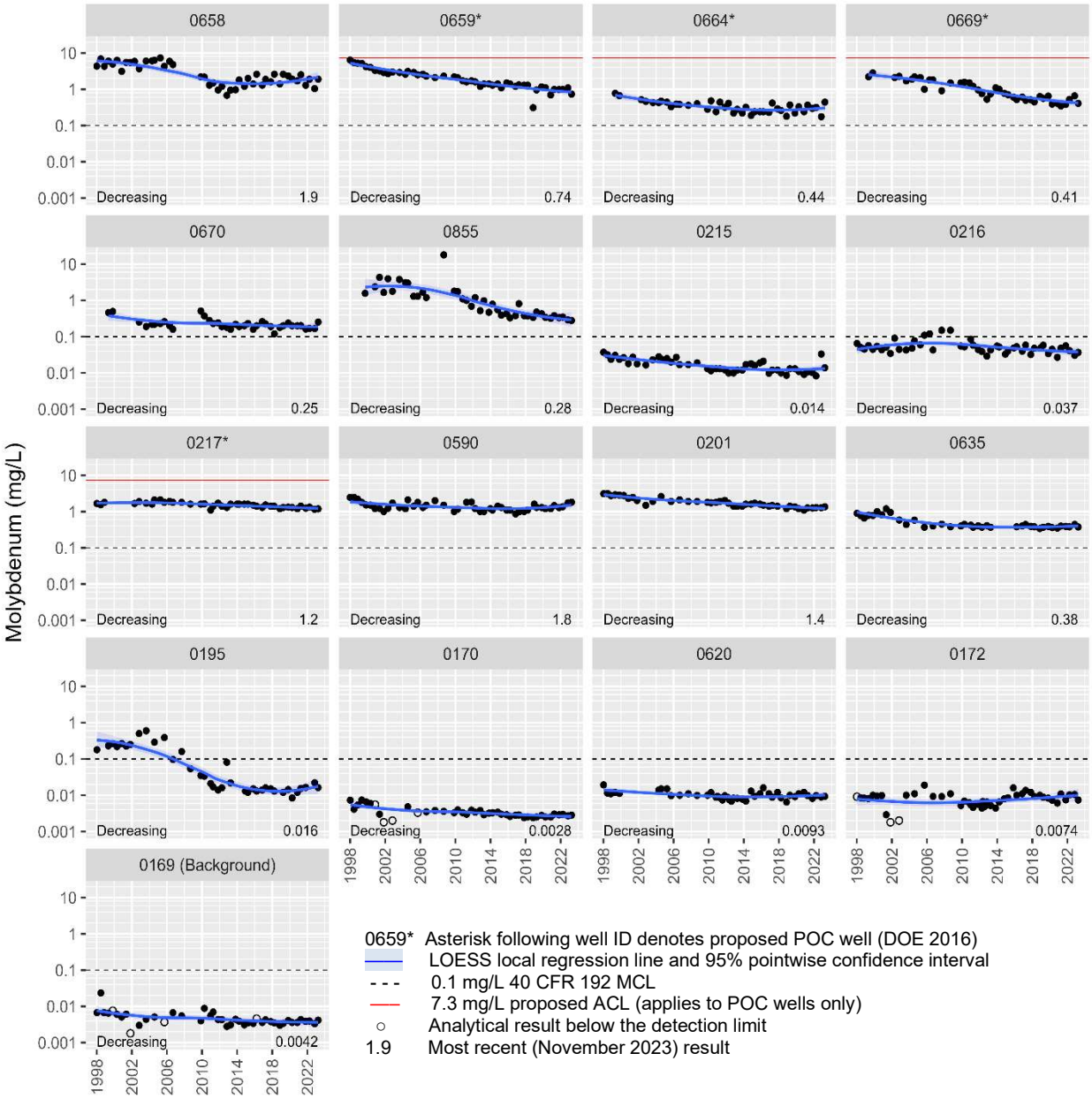
Figure 23 plots the most recent (November 2023) molybdenum concentrations measured in New Rifle site monitoring wells along with surface water sampling results. Corresponding time-series data for monitoring wells are shown in Figure 24. Onsite, molybdenum concentrations are highest in wells 0219 (1.4 mg/L) and 0658 (1.9 mg/L); concentrations exceed the 0.1 mg/L MCL by an order of magnitude. As discussed in Section 3.2, ACLs proposed for all COCs were based on 95% USLs (essentially maximum values) calculated for well 0658 (Table 6), considered to have the highest COC concentrations at that time (7.3 mg/L for molybdenum) . Similarly elevated concentrations (e.g., 1.8 mg/L in well 0590) are found in near downgradient wells east of the Roaring Fork ponds (Figure 23). Similar to observations for uranium, molybdenum concentrations in wells 0215 and 0216, where mixing with river water likely occurs, are lower, mostly less than the MCL as shown in Figure 24.

In November 2023, molybdenum concentrations in farther downgradient wells west of the Roaring Fork ponds, including the newly installed wells, were all less than 0.1 mg/L (range of 0.0028 to 0.026 mg/L). Apart from well 0195, with a maximum concentration of 0.6 mg/L and a previously marked concentration decrease (1998–2014) similar to that found for uranium, molybdenum concentrations in the far wells have been consistently below the MCL (Figure 24). All routinely monitored wells have statistically significant decreasing trends for 1998–2023, suggesting that there has been some (albeit unimpactful) downgradient migration of molybdenum. However, analysis of trends for the more recent (2014–2023) period indicates a stabilization of concentrations in most wells. Exceptions are onsite and near downgradient wells 0659, 0669, 0855, 0201, and 0217 (still decreasing) and well 0590 in the wetland area (location of maximum offsite molybdenum concentration of 1.8 mg/L) showing a recent increasing trend (Table 9).



Notes: For groundwater and nonriver surface water monitoring locations, the symbol size is proportional to the magnitude of the result relative to the range of the data (see legend).
The histogram in the upper left inset shows the distribution of molybdenum results relative to background (well 0169 maximum result), the 0.1 mg/L MCL, and the proposed ACL of 7.3 mg/L (refer to Table 6).
Abbreviations: GW = groundwater; SW = surface water

Figure 23. Molybdenum Concentrations in New Rifle Site Samples, November 2023 Results



Notes:

Wells are ordered and grouped as follows:

Rows 1 and 2 = onsite wells.
Row 3 = adjacent downgradient wells.
Row 4 = farther downgradient offsite wells.
Row 5 = New Rifle site background well.

Onsite wells 0215 and 0216 are plotted last in the second row because of historically low COC concentrations relative to other onsite wells. Offsite wells (rows 3–4) are listed in general order of increasing distance from the site and former source areas.

For wells with statistically significant trends for the 1998–2023 time frame, the direction of the trend is indicated on the plot. Trend tests were also run for the more recent 2014–2023 period. Trend analysis results are summarized in Table 8 and Table 9 at the end of this section. Supporting details are provided in Appendix B. The outliers shown for well 0855 correspond to the 2008 temporary dewatering (Table 5).

Figure 24. Time-Concentration Plots of Molybdenum in New Rifle Site Monitoring Wells

Despite the decreasing trends overall, linear regression of the log-transformed data for wells with elevated molybdenum indicates that the 0.1 mg/L MCL would not be achieved until the years 2032 to 2097 (most wells) and 2176 and 2225 (wells 0217 and 0590, respectively) (Appendix B, Table B-2). This flattening of the trend demonstrates the persistence of molybdenum at and immediately downgradient of the site. Of the COCs monitored at the site, molybdenum is key for demonstrating the infeasibility of the 100-year natural flushing strategy.

3.4.3 Vanadium

Figure 25 plots the most recent (November 2023) vanadium concentrations measured in New Rifle site monitoring wells along with surface water sampling results. Corresponding time-series data for monitoring wells are shown in Figure 26. Because there are no regulatory standards for vanadium, the only contexts for interpreting groundwater results are background (0.006 mg/L maximum concentration from well 0169[4]), EPA's current RSL for drinking water (0.086 mg/L), and the proposed ACL of 52 mg/L (see Table 6 and DOE 2016). This ACL was based on the distribution of results from well 0658, the location with the highest vanadium concentrations historically (and currently). The 26.2 mg/L result from November 2023 far exceeds that in other wells, even adjacent well 0855 (6.5 mg/L as shown in Figure 25). Although an increasing trend is found for well 0658 (1998–2014), concentrations have since stabilized for the period of 2014–2023 (Figure 26; Table 8 and Table 9).

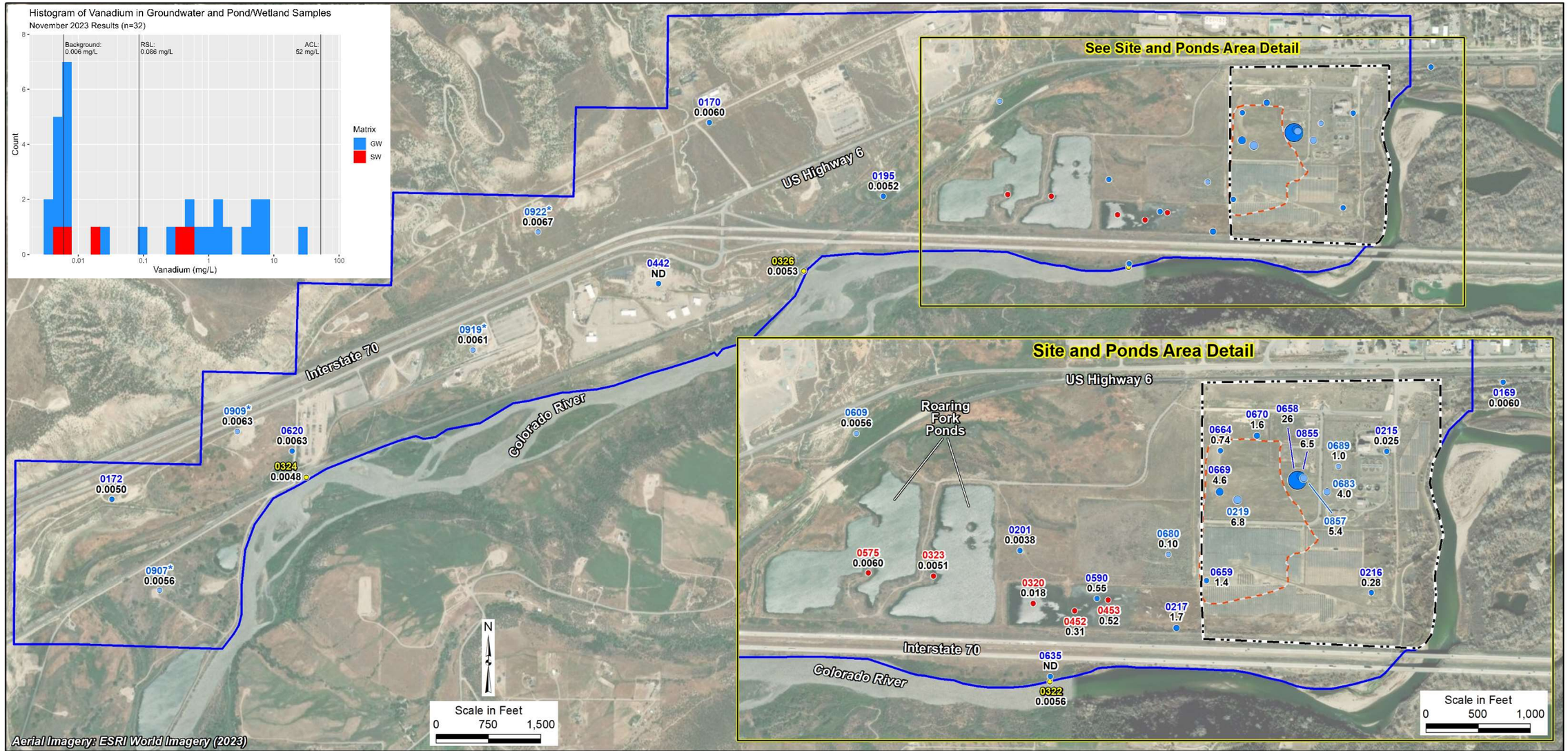
Vanadium concentrations are currently elevated relative to the 0.086 mg/L RSL in all onsite wells except well 0215 (Figure 26). Although the most recent result for this well, 0.025 mg/L, is below the RSL, concentrations are significantly increasing, both for the entire period and the 2014–2023 time frame. As demonstrated later in this section, vanadium concentrations at the background Colorado River location (0294) are also increasing (Figure 37). Given the influence of river water on well 0215 chemistry, it is possible that a portion of the observed increase in vanadium concentrations could be attributed to the change in signal at the upstream river location.

As discussed in previous VMRs (DOE 2022), the 2008–2009 spike in vanadium concentrations in well 0855 (up to 1600 mg/L) coincided with the City of Rifle's previous construction work and dewatering activities in the eastern portion of the site (DOE 2010; DOE 2016).

Adjacent to the site, vanadium concentrations are elevated in wells 0217 and 0590 (1.7 and 0.55 mg/L, respectively) and just slightly above the RSL in well 0680 (0.10 mg/L). Vanadium concentrations in remaining downgradient wells have been consistently low, roughly at or below the current background concentration at well 0169 (0.006 mg/L).

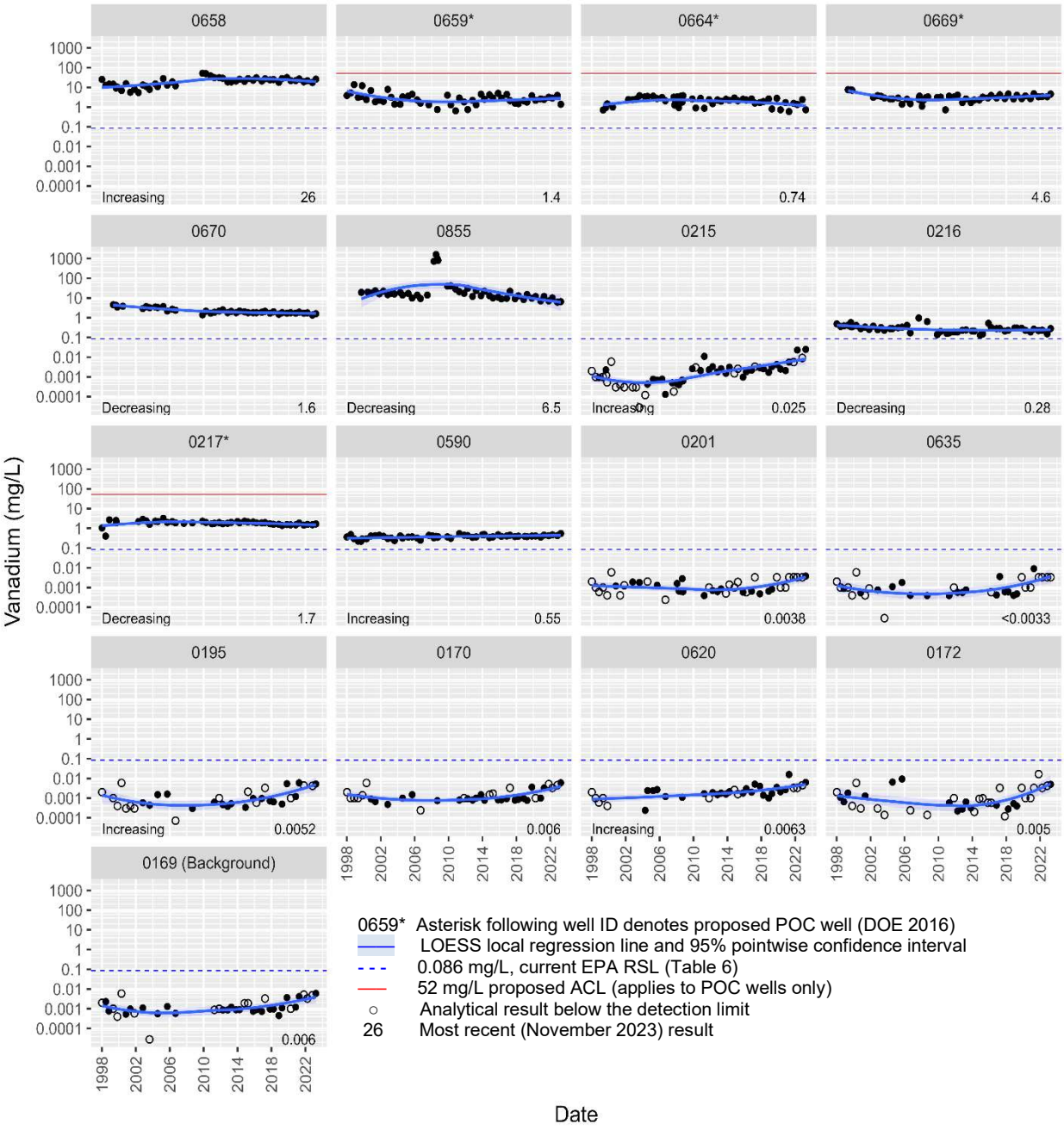
Mann-Kendall trend tests for the 1998–2023 time frame identified statistically significant increasing trends for five wells, including farther downgradient wells 0195 and 0620 (Figure 26). Analysis of more recent data for this subset (2014–2023) indicates significant increases only in well 0215 (discussed above). In two wells identified as having no trends for the entire monitoring period—onsite well 0669 and background well 0169—a significant increasing trend was found for the 2014–2023 time frame.

[4] As shown in Figure 26, the maximum background concentration was measured in November 2023.



Notes: For groundwater and nonriver surface water monitoring locations, the symbol size is proportional to the magnitude of the result relative to the range of the data (see legend).
The histogram in the upper left inset shows the distribution of vanadium results relative to background (well 0169 maximum result), the 0.086 mg/L RSL, and the proposed ACL of 52 mg/L (refer to Table 6).
Abbreviations: GW = groundwater; ND = not detected (<0.003 mg/L); SW = surface water

Figure 25. Vanadium Concentrations in New Rifle Site Samples, November 2023 Results



Notes:

Wells are ordered and grouped as follows:

Rows 1 and 2 = onsite wells.
Row 3 = adjacent downgradient wells.
Row 4 = farther downgradient offsite wells.
Row 5 = New Rifle site background well.

Onsite wells 0215 and 0216 are plotted last in the second row because of historically low COC concentrations relative to other onsite wells. Offsite wells (rows 3–4) are listed in order of increasing distance from the site and former source areas.

For wells with statistically significant trends for the 1998–2023 time frame, the direction of the trend is indicated on the plot. Trend tests were also run for the more recent 2014–2023 period. Trend analysis results are summarized in Table 8 and Table 9 at the end of this section; supporting details are provided in Appendix B. High outlier concentrations shown for well 0855 correspond to the 2008 temporary dewatering (Table 5).

Figure 26. Time-Concentration Plots of Vanadium in New Rifle Site Monitoring Wells

3.4.4 Selenium

Figure 27 plots the most recent (November 2023) selenium concentrations measured in New Rifle site monitoring wells along with surface water sampling results. Corresponding time-series data for monitoring wells are shown in Figure 28. Because selenium concentrations have, prior to 2010, exceeded the 40 CFR 192 (UMTRCA) standard of 0.01 mg/L in background well 0169, the SDWA standard of 0.05 mg/L was proposed as an ACL in the initial 2003 GCAP (DOE 2003). In the most recent GCAP revision (DOE 2016), an ACL of 1.43 mg/L was proposed based on the distribution of selenium in source area well 0658 (Table 6). This well continues to be the location of the maximum selenium concentration: 1.3 mg/L in November 2023, with no attenuation as shown in Figure 28.

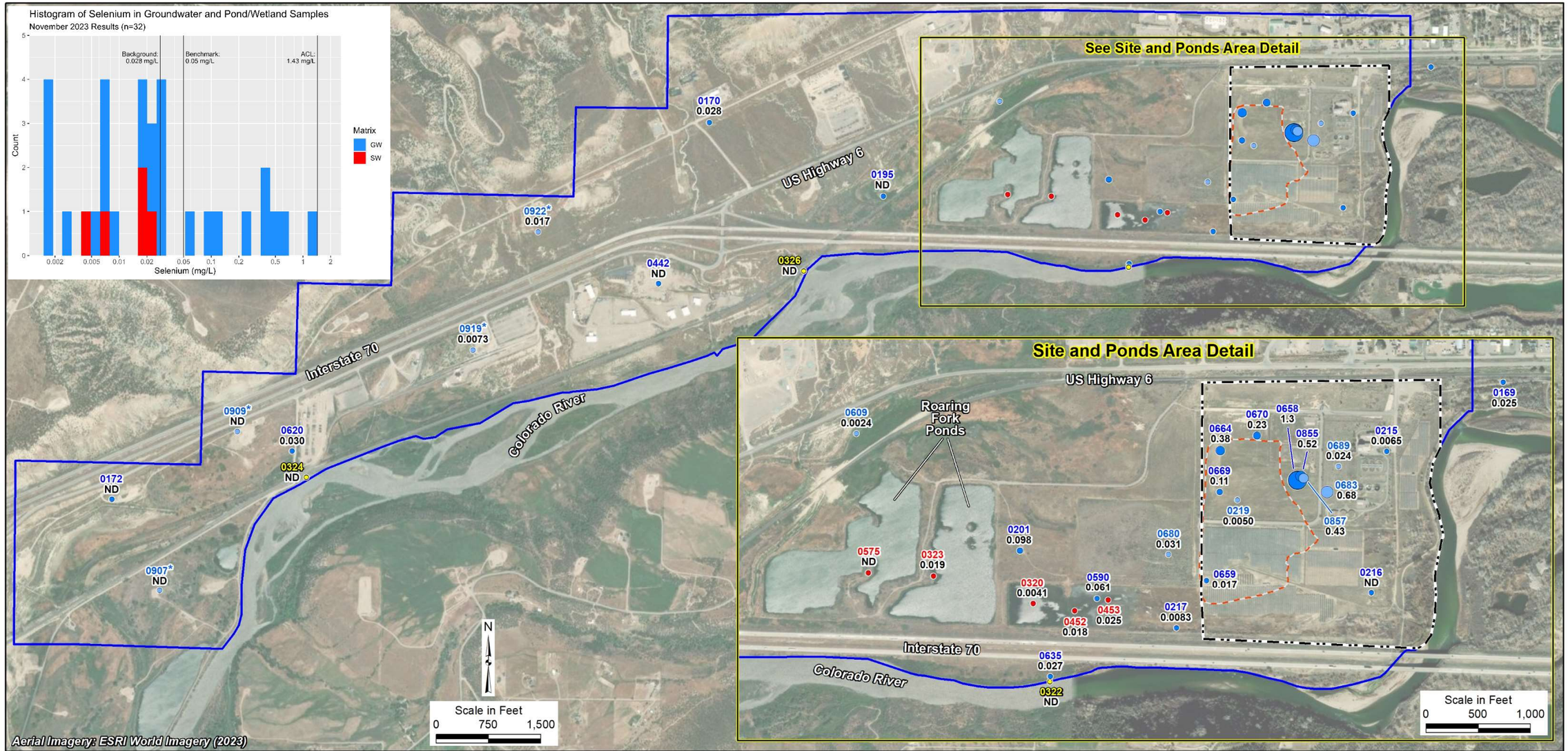
This ACL was intended to only be applied to onsite POC wells 0659, 0669, and 0855 and adjacent offsite POC well 0217. Although not exceeded in any POC wells since the draft GCAP was developed, the 1.43 mg/L ACL has been exceeded a few times in wells not designated as POCs:

- 1.6–1.8 mg/L in onsite well 0855 in 2009–2010.
- 2.0 mg/L in onsite well 0689 in 2020 (not routinely sampled).
- 1.6 mg/L in well 0857 in June 2023 (not routinely sampled).

Currently (based on November 2023 results), the 0.05 mg/L SDWA standard is exceeded only in onsite wells and adjacent downgradient wells 0201 (0.098 mg/L) and 0590 (0.061 mg/L). Onsite, the 0.05 mg/L standard is only exceeded in the northern region within and adjacent to the former tailings area (Figure 27). As noted previously, the low concentrations in wells 0215 and 0216 likely reflect influence by the Colorado River. The apparent slight uptick in selenium concentrations in well 0215 (Figure 28) may reflect a similar uptick in the method detection limit (this is also found for the Colorado River samples as shown later in Figure 37).

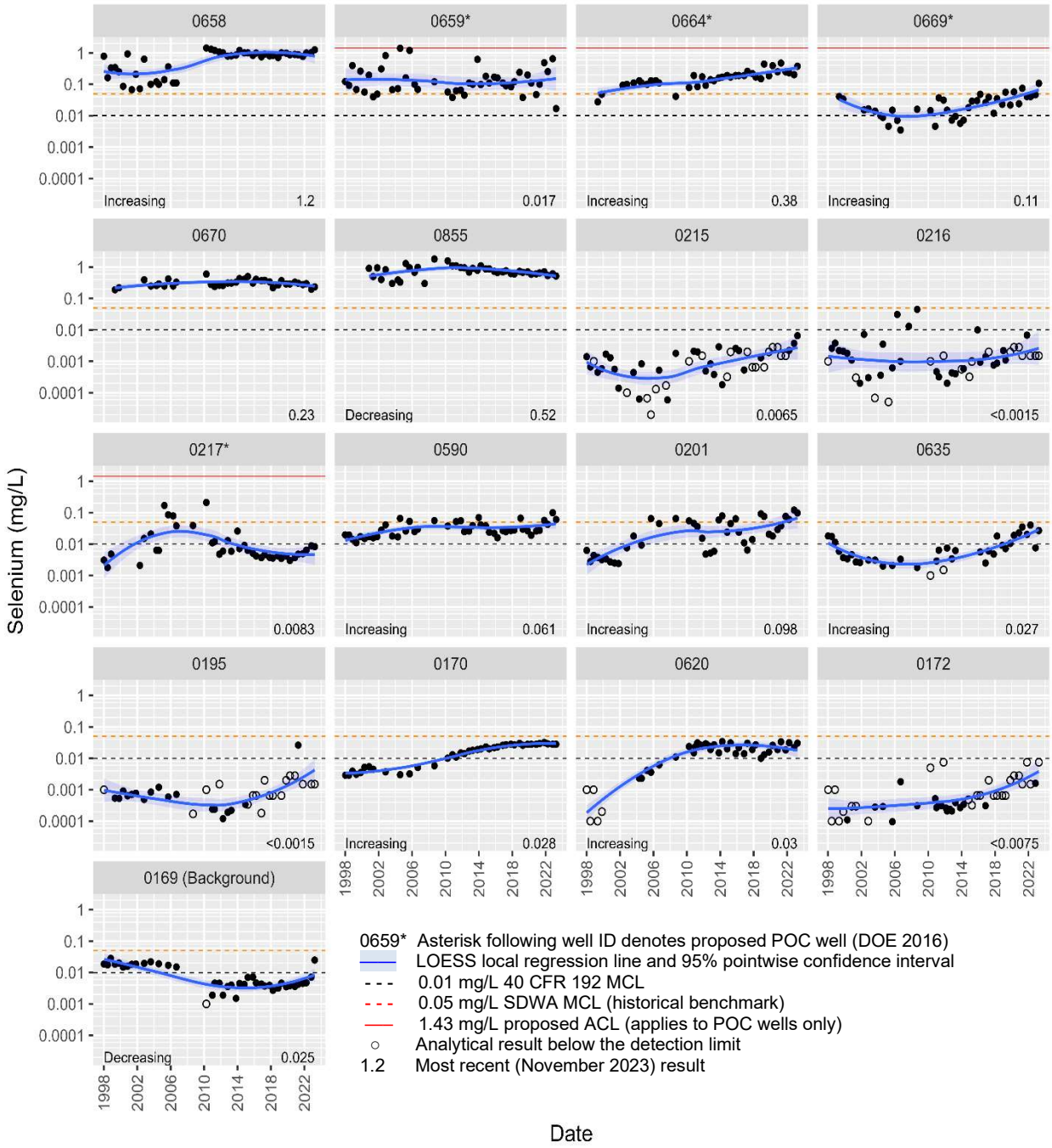
Farther downgradient, all results have consistently been below both the SDWA standard and background (0.028 mg/L maximum in well 0169). However, some statistically significant increasing trends are apparent, and several—most notably in near-river offsite well 0635 and downgradient well 0170—are sustained. Between 1998 and 2010, selenium concentrations in well 0620 increased but then plateaued at a level just below the 0.05 mg/L standard.

Mann-Kendall trend analysis identified significant increasing trends in eight wells for the 1998–2023 time frame, both onsite and downgradient (Table 8). Trend tests run for the 2014–2023 time frame indicate that four wells—onsite wells 0664 and 0669 and offsite wells 0635 and 0170—had significant increasing trends (Table 9).



Notes: For groundwater and nonriver surface water monitoring locations, the symbol size is proportional to the magnitude of the result relative to the range of the data (see legend).
The histogram in the upper left inset shows the distribution of selenium results relative to background (well 0169 maximum result), the 0.05 mg/L SDWA standard, and the proposed ACL of 1.43 mg/L (refer to Table 6).
Abbreviations: GW = groundwater; ND = not detected (in most cases <0.0015 mg/L); SW = surface water

Figure 27. Selenium Concentrations in New Rifle Site Samples, November 2023 Results



Notes:

Wells are ordered and grouped as follows:

Rows 1 and 2 = onsite wells.
Row 3 = adjacent downgradient wells.
Row 4 = farther downgradient offsite wells.
Row 5 = New Rifle site background well.

Onsite wells 0215 and 0216 are plotted last in the second row because of historically low COC concentrations relative to other onsite wells. Offsite wells (rows 3–4) are listed in order of increasing distance from the site and former source areas.

For wells with statistically significant trends for the 1998–2023 time frame, the direction of the trend is indicated on the plot. Trend tests were also run for the more recent 2014–2023 period. Trend analysis results are summarized in Table 8 and Table 9 at the end of this section. Supporting details are provided in Appendix B.

Figure 28. Time-Concentration Plots of Selenium in New Rifle Site Monitoring Wells

3.4.5 Nitrate

In contrast to the other COCs discussed so far, with many results still exceeding corresponding UMTRCA or SDWA standards, nitrate concentrations in most wells throughout the study region are currently lower than the 10 mg/L MCL, and well below the proposed ACL of 75 mg/L (Figure 29). There are just two exceptions: 17 mg/L in near downgradient wells 0680 and 0201. The third highest concentration result (10.3 mg/L) was measured in far downgradient well 0172, essentially equivalent to the MCL and just slightly higher than the recent background result of 9 mg/L. As shown in Figure 30, nitrate concentrations ranged between about 100 and 300 mg/L in several onsite and offsite wells during the first decade of monitoring (1998–2008).

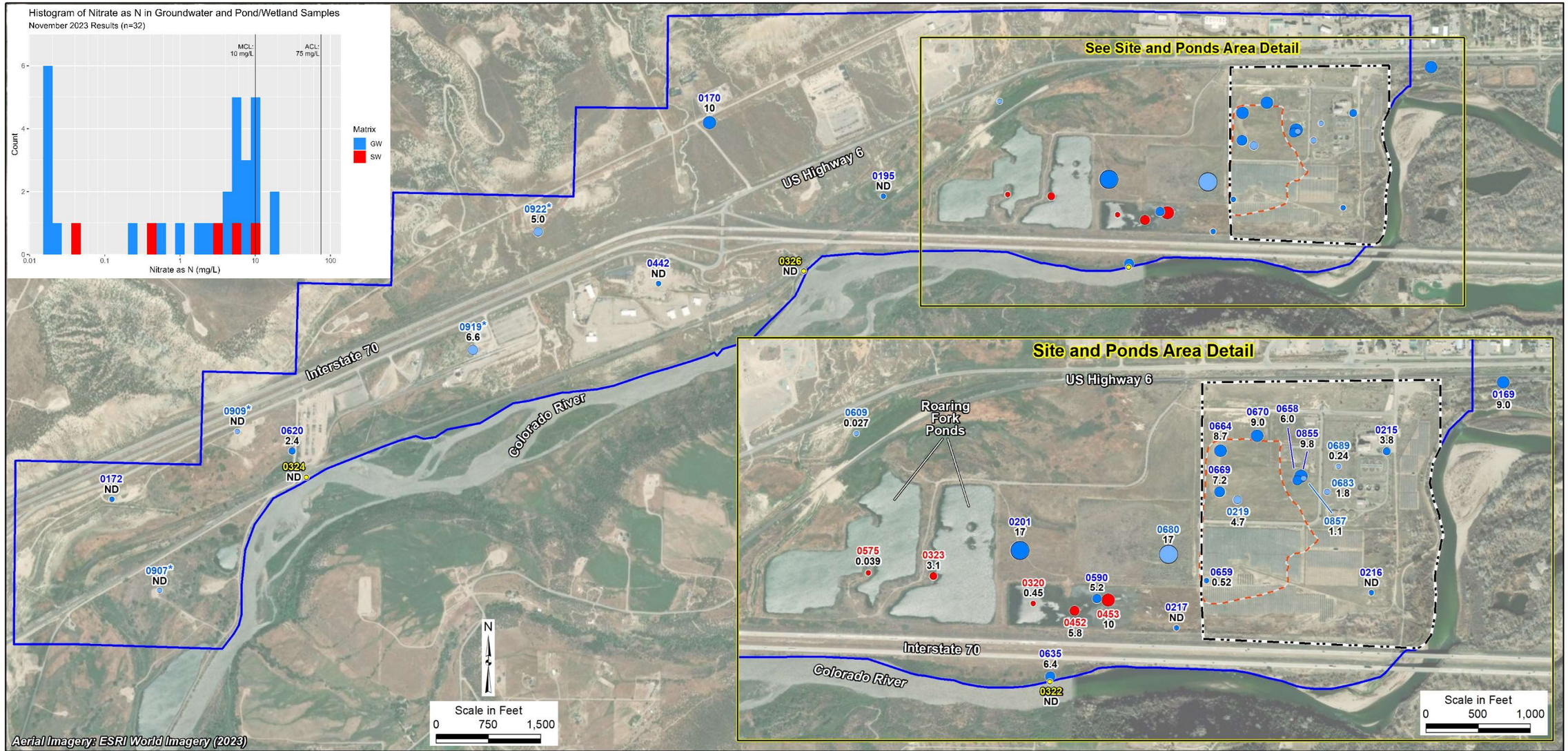
For the entire monitoring period, significant decreasing trends are found for 7 of the 17 wells routinely monitored, including background well 0169 (Figure 30). Similar to observations for selenium, statistically significant increasing trends since 2014 are found for three wells: onsite wells 0664 and 0669, and near-river downgradient well 0635.

3.4.6 Arsenic

Like nitrate, arsenic concentrations are low relative to the 0.05 mg/L MCL at most locations. Figure 31 plots the most recent (November 2023) arsenic concentrations measured in New Rifle site monitoring wells along with surface water sampling results. Corresponding time-series data for monitoring wells are shown in Figure 32. In November 2023, the MCL of 0.05 mg/L was exceeded in only three onsite wells: 0658 (0.15 mg/L), 0855 (0.077 mg/L), and (not routinely sampled) 0219 (0.063 mg/L). As observed for molybdenum and vanadium, the highest arsenic concentrations have been measured in well 0855, where levels spiked in 2009 (up to 2.2. mg/L) coinciding with adjacent dewatering activities. Arsenic concentrations are now highest in well 0658.

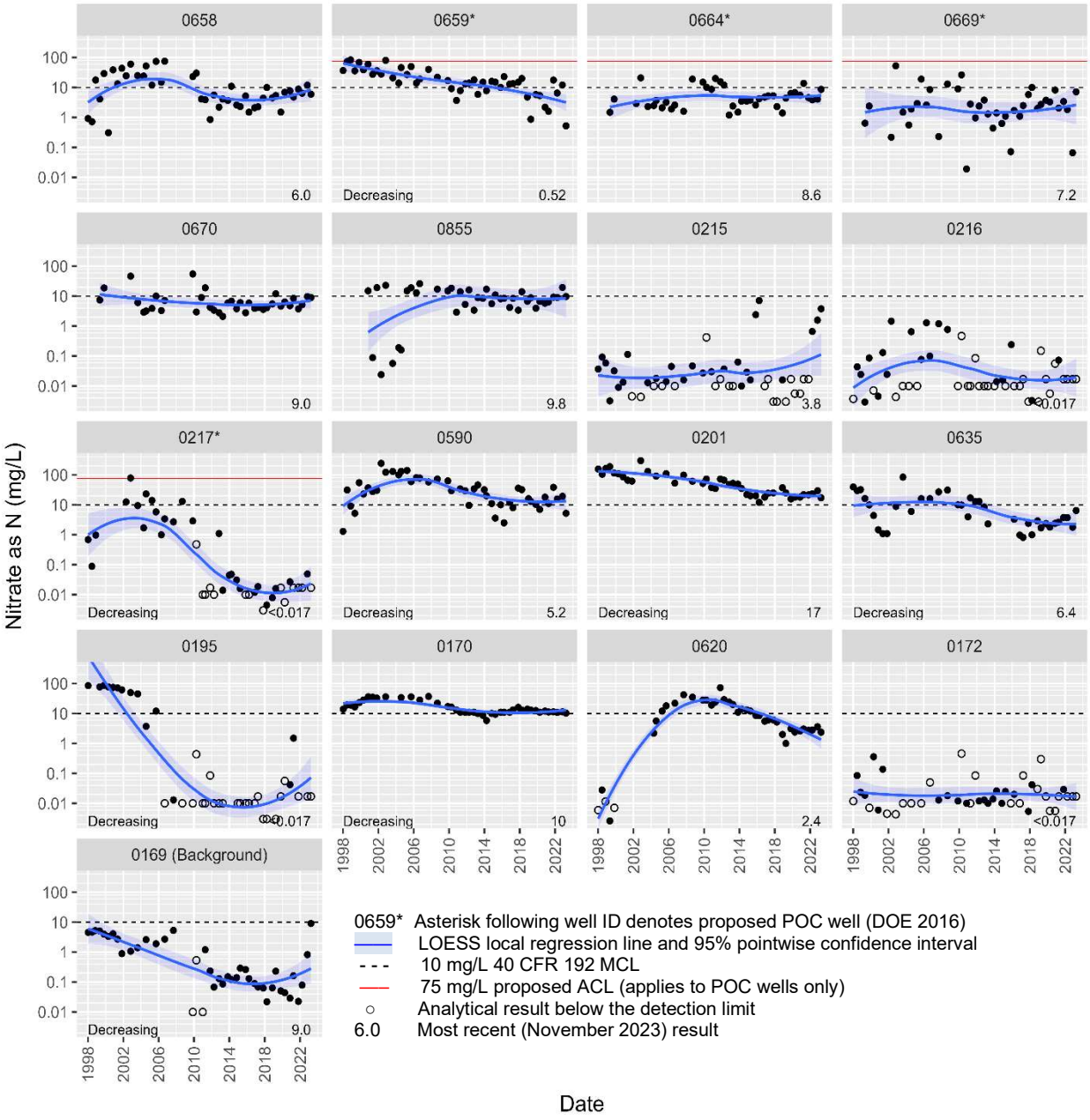
Mann-Kendall trend tests applied to the historical dataset (1998–2023) indicate statistically significant increasing trends in arsenic concentrations for 8 of the 17 monitoring wells routinely monitored. This subset of wells includes background well 0169, where the most recent result was 0.0034 mg/L. In contrast to other COCs (with recent stabilization of trends), the trend direction yielded based on analysis of the 2014–2023 dataset did not change relative to the initial trend results (Table 8 and Table 9). That is, the increasing trends identified based on the full data set still apply to the recent data. The only exception is well 0195, with no trend for the 2014–2023 period.

Although arsenic concentrations have been below the 0.05 mg/L standard, statistically significant increasing trends are still found for five downgradient wells (Table 9), most notably well 0172. Although arsenic is generally easily attenuated in oxidized unconfined aquifers, the prevalence of increasing trends in downgradient wells illustrated in Figure 32 requires further evaluation.



Notes: For groundwater and nonriver surface water monitoring locations, the symbol size is proportional to the magnitude of the result relative to the range of the data (see legend).
The histogram in the upper left inset shows the distribution of nitrate results relative to the 10 mg/L MCL and the proposed ACL of 75 mg/L (refer to Table 6).
Abbreviations: GW = groundwater, N = nitrogen, ND = not detected (<0.017 mg/L), SW = surface water

Figure 29. Nitrate (as N) Concentrations in New Rifle Site Samples, November 2023 Results



Notes:

Wells are ordered and grouped as follows:

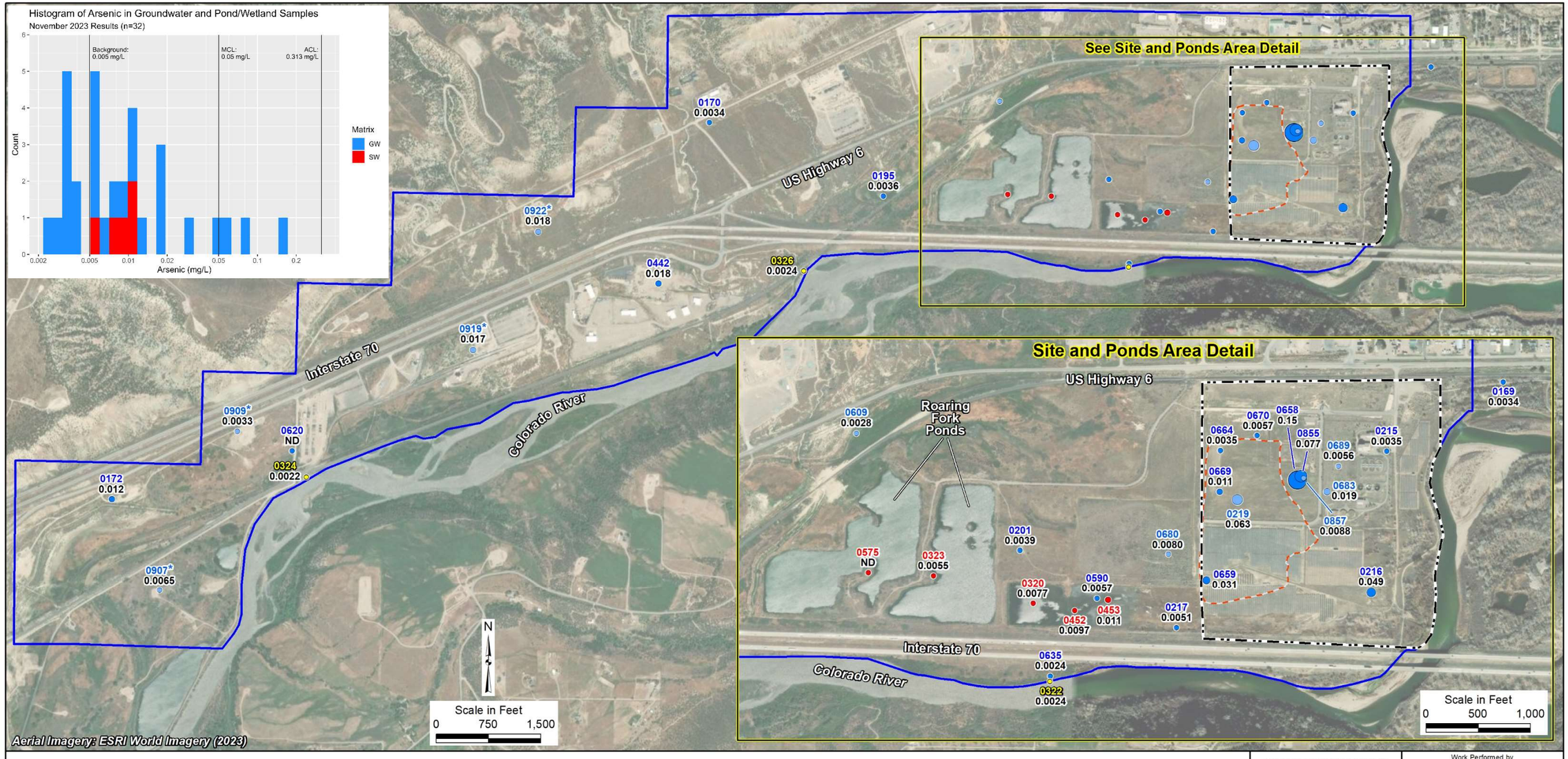
Rows 1 and 2 = onsite wells.
Row 3 = adjacent downgradient wells.
Row 4 = farther downgradient offsite wells.
Row 5 = New Rifle site background well.

Onsite wells 0215 and 0216 are plotted last in the second row because of historically low COC levels relative to other onsite wells. Offsite wells (rows 3–4) are listed in general order of increasing distance from the site and former source areas.

For wells with statistically significant trends for the 1998–2023 time frame, the direction of the trend is indicated on the plot. Trend tests were also run for the more recent 2014–2023 period. Trend analysis results are summarized in Table 8 and Table 9 at the end of this section. Supporting details are provided in Appendix B.

Abbreviation: N = nitrogen

Figure 30. Time-Concentration Plots of Nitrate as N in New Rifle Site Monitoring Wells



Monitoring Location Type

- 0169 Groundwater Monitoring Well - Routine Sample
- 0219 Groundwater Monitoring Well - Nonroutine Sample
- 0320 Pond/Wetland Water Sample Location
- 0322 Colorado River Sample Location

* Wells 0907, 0909, 0919, and 0922 were installed in November 2022.

Arsenic Concentration (mg/L)

- ND (<0.01)
- 0.05
- 0.15 (Maximum)

- Site Boundary
- Former Tailings Area Boundary
- Institutional Controls Boundary

U.S. DEPARTMENT OF ENERGY
OFFICE OF LEGACY MANAGEMENT

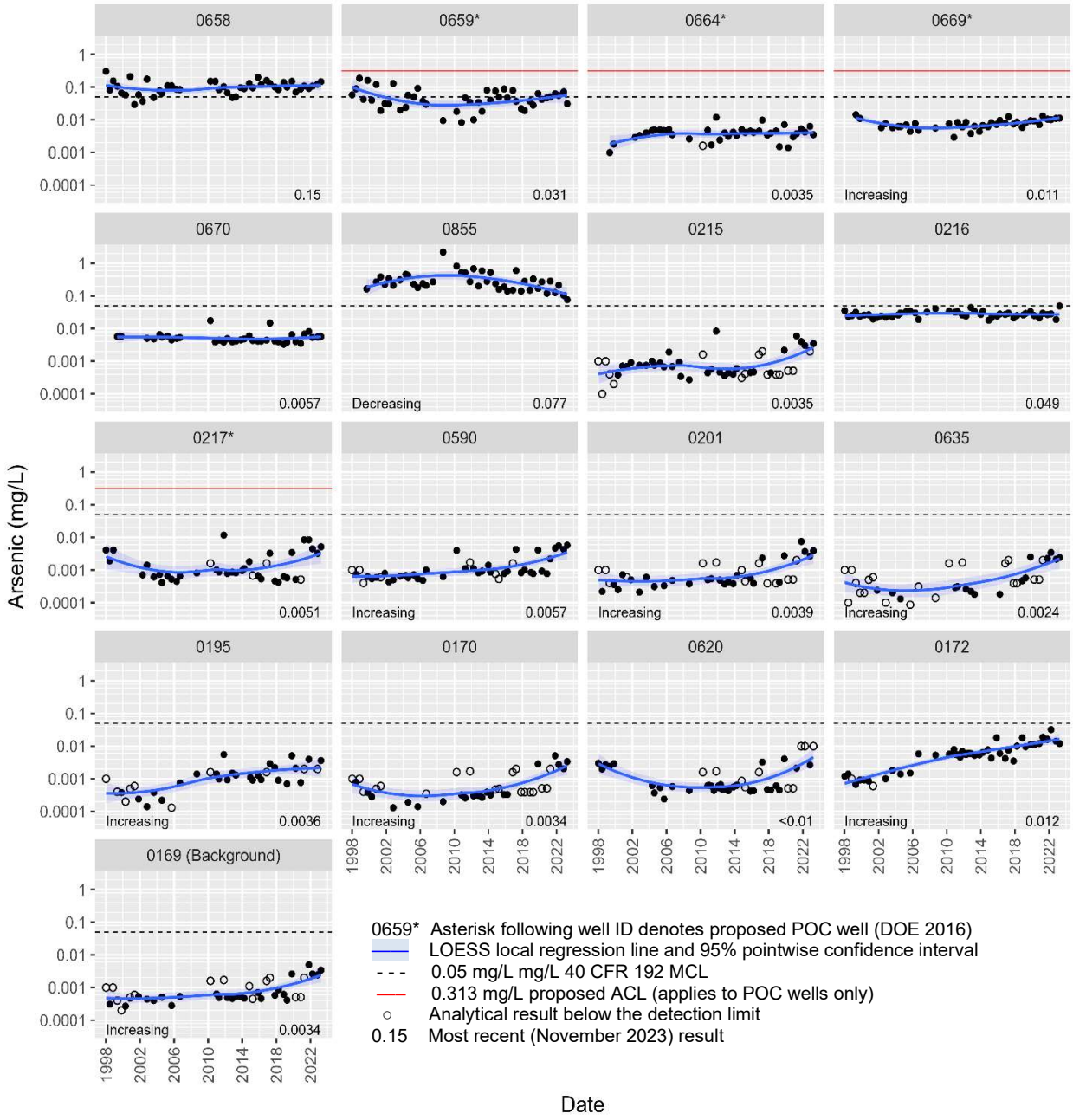
Work Performed by
RSI EnTech, LLC
Under DOE Contract 89303020DLM000001

November 2023
Arsenic Concentrations
New Rifle, Colorado, Processing Site

DATE PREPARED: June 6, 2024
FILE NAME: 047598-06-R01

Notes: For groundwater and nonriver surface water monitoring locations, the symbol size is proportional to the magnitude of the result relative to the range of the data (see legend).
The histogram in the upper left inset shows the distribution of arsenic results relative to background (0.005 mg/L), the 0.05 mg/L MCL and the proposed ACL of 0.313 mg/L (refer to Table 6).
Abbreviations: GW = groundwater, ND = not detected (<0.01 mg/L), SW = surface water

Figure 31. Arsenic Concentrations in New Rifle Site Samples, November 2023 Results



Notes:

Wells are ordered and grouped as follows:

Rows 1 and 2 = onsite wells.
Row 3 = adjacent downgradient wells.
Row 4 = farther downgradient offsite wells.
Row 5 = New Rifle site background well.

Onsite wells 0215 and 0216 are plotted last in the second row because of historically low COC levels relative to other onsite wells. Offsite wells (rows 3–4) are listed in order of increasing distance from the site and former source areas.

For wells with statistically significant trends for the 1998–2023 time frame, the direction of the trend is indicated on the plot. Trend tests were also run for the 2014–2023 period. Trend analysis results are summarized in Table 8 and Table 9 at the end of this section. Supporting details are provided in Appendix B.

Figure 32. Time-Concentration Plots of Arsenic in New Rifle Site Monitoring Wells

3.4.7 Ammonia

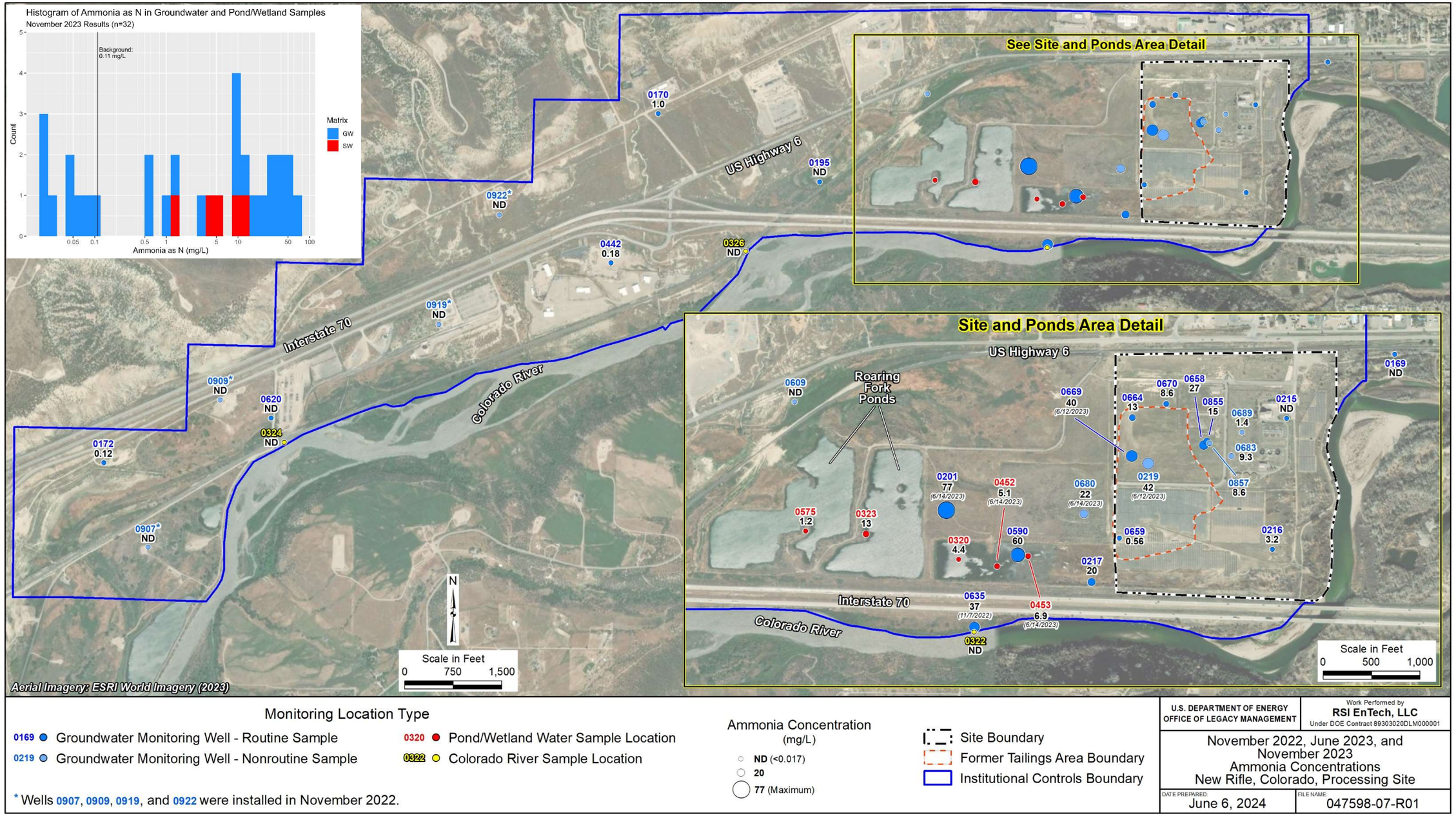
Ammonia was identified as a COC in the 2003 draft GCAP (DOE 2003) but was later withdrawn as a COC in the most recent draft GCAP (DOE 2016). For comprehensiveness, ammonia continues to be addressed in the VMRs because nitrate was likely derived from ammonia at the site (DOE 2016). Figure 33 shows the most recent distribution of ammonia based on results from 2022 and 2023. Because some of the results from November 2023 had high detection limits (up to 51 mg/L) due to method or calibration blank contamination, the previous (November 2022 or June 2023) results were used for mapping purposes (see "Notes" in Figure 33). As shown in Figure 34, the high nondetect results reported for November 2023 samples are consistent with the magnitude of previous detected results (e.g., wells 0669 and 0635).

Ammonia is elevated relative to background (0.1 mg/L) in most onsite and near downgradient wells. Concentrations are currently highest in wells adjacent to the site and east of the Roaring Fork ponds, in particular wells 0201 and 0590 (recent concentrations of 77 and 60 mg/L respectively). Although not known, these observations may be due to the presence of more reducing zones in that region. Mann-Kendall trend tests indicate significant decreasing ammonia trends throughout most of the New Rifle site monitoring well network. The only exception is well 0170, with significant increasing trends found for both 1998–2023 and 2014–2023 time frames (most recent result of 1.0 mg/L).

3.4.8 Global Trends and Mann-Kendall Trend Analysis Summary

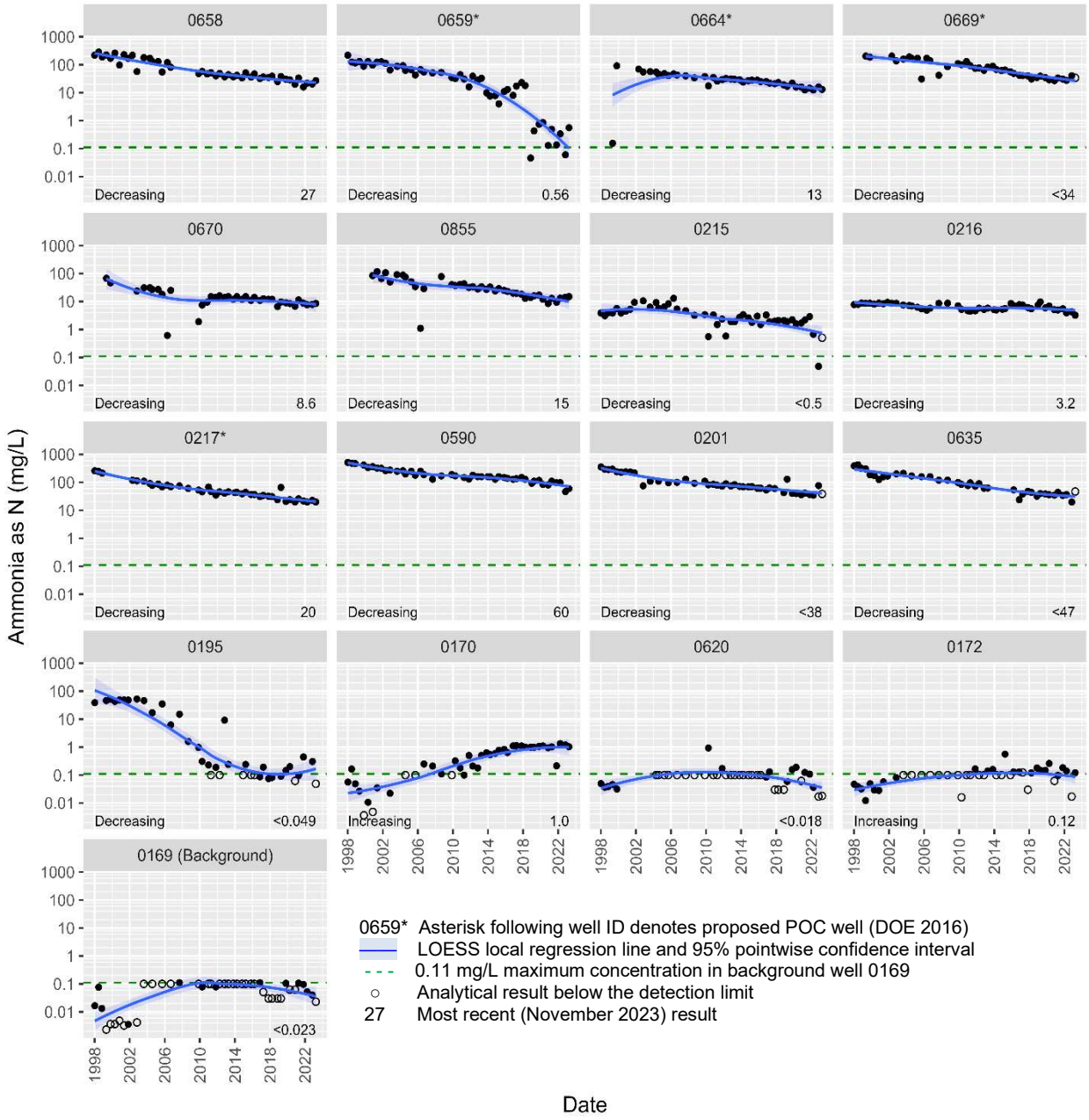
As discussed in Section 1.2, Mann-Kendall trend tests were initially run for the period 1998–2023, representing measurements collected since postremediation monitoring began. Statistically significant decreasing trends were identified for many well-analyte combinations, most notably uranium and molybdenum. In contrast, for selenium, significant increases were noted in about half of the wells. As evident in the preceding time-concentration plot figures, in some of these cases contaminant concentrations appear to have stabilized more recently. Therefore, a second set of Mann-Kendall trend tests was run for the 2014–2023 time frame. Table 8 and Table 9 provide high-level summaries of the Mann-Kendall trend tests run for all New Rifle site COCs for 1998–2024 and 2014–2024, respectively. Supporting details are provided in Appendix B, Tables B-2 and B-3. Results of corresponding linear regression analyses are also included in that appendix.

In Table 8 and Table 9, wells are grouped and ordered in a way consistent with the categories used in the draft GCAP (DOE 2016) and in the preceding time-series data plots. Onsite wells are listed first, followed by adjacent downgradient wells and farther downgradient wells. Offsite wells are listed in general order of increasing distance from the site and former source areas. For each analyte, cross-references to corresponding time-concentration plots are provided to facilitate review. In many cases, trend test results yielded for the larger (1998–2023) dataset differ from those obtained using the more recent (2014–2023) dataset. Usually these differences reflect the fact that no trend was found for the more recent time frame (e.g., uranium).



Notes: For groundwater and nonriver surface water monitoring locations, the symbol size is proportional to the magnitude of the result relative to the range of the data (see legend). Some of the results from November 2023 had high detection limits because of the 500-fold dilution required due to method or calibration blank contamination. Given the latter, for the results in question, the previous (June 2023) results were used for mapping purposes except for well 0635 adjacent to river. The November 2022 result is shown for well 0635 because it is more representative of the November time frame and does not reflect the dilution apparent in the (lower) June 2023 result. The histogram in the upper left corner shows the distribution of ammonia relative to the maximum background groundwater result.
Abbreviation: GW = groundwater, ND = not detected, SW = surface water

Figure 33. Ammonia Concentrations in New Rifle Site Samples, 2022–2023 Results



Notes:

Wells are ordered and grouped as follows:

Rows 1 and 2 = onsite wells.
Row 3 = adjacent downgradient wells.
Row 4 = farther downgradient offsite wells.
Row 5 = New Rifle site background well.

Onsite wells 0215 and 0216 are plotted last in the second row because of historically low COC levels relative to other onsite wells. Offsite wells (rows 3–4) are listed in order of increasing distance from the site and former source areas.

For wells with statistically significant trends for the 1998–2023 time frame, the direction of the trend is indicated on the plot. Trend tests were also run for the more recent 2014–2023 period. Trend analysis results are summarized in Table 8 and Table 9 at the end of this section. Supporting details are provided in Appendix B.

Abbreviation: N = nitrogen

Figure 34. Time-Concentration Plots of Ammonia (as N) in New Rifle Site Monitoring Wells

Table 8. Mann-Kendall Trend Test Results for New Rifle Site Monitoring Wells, 1998–2023

Well	Uranium	Molybdenum	Vanadium	Selenium	Nitrate	Arsenic	Ammonia
Figure Cross-Reference	Figure 22	Figure 24	Figure 26	Figure 28	Figure 30	Figure 32	Figure 34
Onsite Wells							
0658	Decreasing	Decreasing	Increasing	Increasing	No Trend	No Trend	Decreasing
0659 (POC)	Decreasing	Decreasing	No Trend	No Trend	Decreasing	No Trend	Decreasing
0664 (POC)	Decreasing	Decreasing	No Trend	Increasing	No Trend	No Trend	Decreasing
0669 (POC)	Decreasing	Decreasing	No Trend	Increasing	No Trend	Increasing	Decreasing
0670	Decreasing	Decreasing	Decreasing	No Trend	No Trend	No Trend	Decreasing
0855	Decreasing	Decreasing	Decreasing	Decreasing	No Trend	Decreasing	Decreasing
0215	Increasing	Decreasing	Increasing	No Trend	No Trend	No Trend	Decreasing
0216	No Trend	Decreasing	Decreasing	No Trend	No Trend	No Trend	Decreasing
Adjacent Downgradient Wells							
0217 (POC)	No Trend	Decreasing	Decreasing	No Trend	Decreasing	No Trend	Decreasing
0590	No Trend	Decreasing	Increasing	Increasing	Decreasing	Increasing	Decreasing
0201	No Trend	Decreasing	No Trend	Increasing	Decreasing	Increasing	Decreasing
0635	Decreasing	Decreasing	No Trend	Increasing	Decreasing	Increasing	Decreasing
Downgradient Wells							
0195	Decreasing	Decreasing	Increasing	No Trend	Decreasing	Increasing	Decreasing
0170	No Trend	Decreasing	No Trend	Increasing	Decreasing	Increasing	Increasing
0620	Decreasing	Decreasing	Increasing	Increasing	No Trend	No Trend	No Trend
0172	Decreasing	No Trend	No Trend	No Trend	No Trend	Increasing	Increasing
Background Well							
0169	Decreasing	Decreasing	No Trend	Decreasing	Decreasing	Increasing	No Trend

Statistically significant increasing trend

Statistically significant decreasing trend

Note:
Detailed test statistics are provided in Appendix B, Table B-2, along with linear regression results.

Table 9. Mann-Kendall Trend Test Results for New Rifle Site Monitoring Wells, 2014–2023

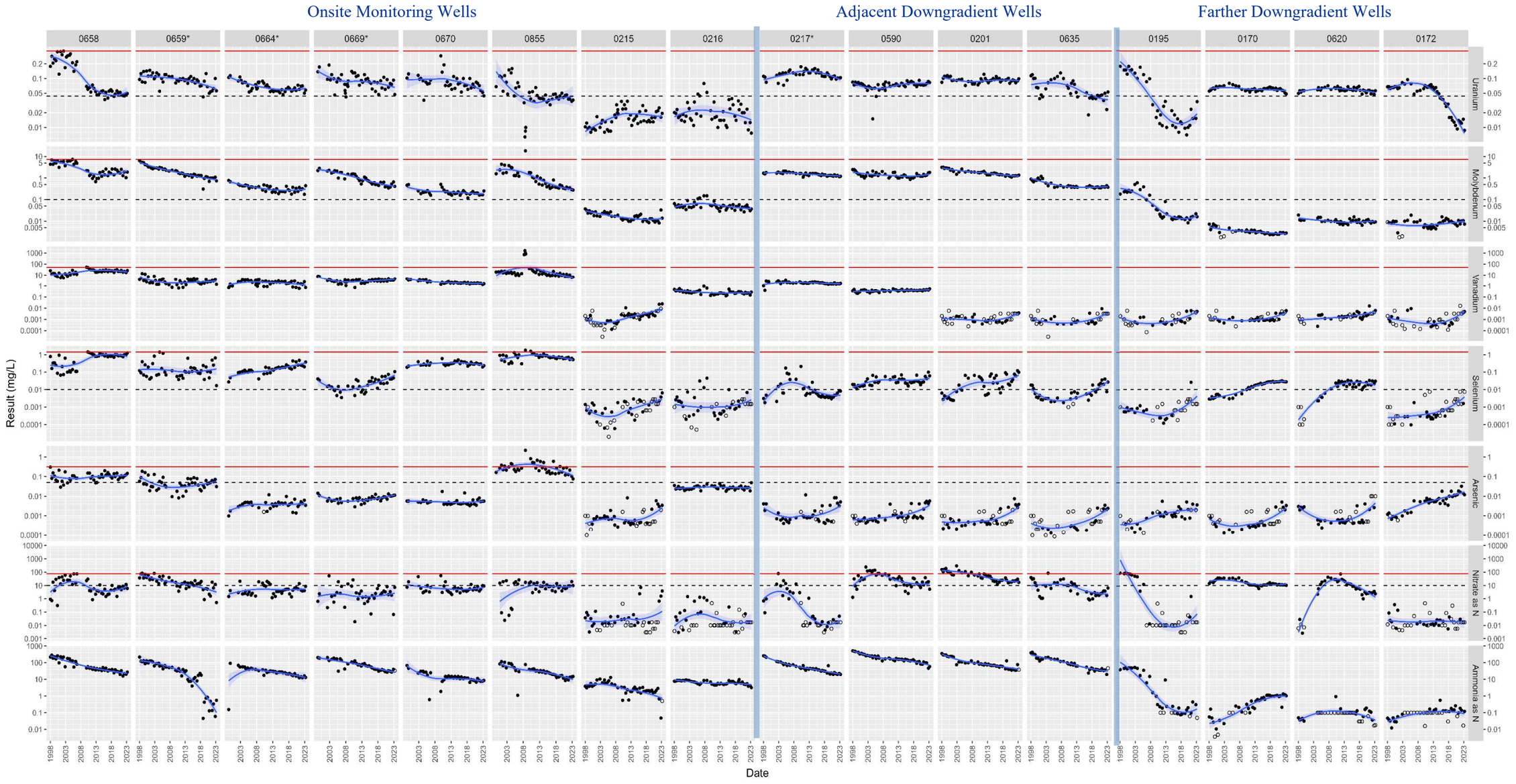
	Uranium	Molybdenum	Vanadium	Selenium	Nitrate	Arsenic	Ammonia
Figure Cross-Reference	Figure 22	Figure 24	Figure 26	Figure 28	Figure 30	Figure 32	Figure 34
Onsite Wells							
0658	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	Decreasing
0659 (POC)	Decreasing	Decreasing	No Trend	No Trend	Decreasing	No Trend	Decreasing
0664 (POC)	No Trend	No Trend	Decreasing	Increasing	Increasing	No Trend	Decreasing
0669 (POC)	No Trend	Decreasing	Increasing	Increasing	Increasing	Increasing	Decreasing
0670	Decreasing	No Trend	Decreasing	Decreasing	No Trend	No Trend	Decreasing
0855	No Trend	Decreasing	Decreasing	Decreasing	No Trend	Decreasing	Decreasing
0215	No Trend	No Trend	Increasing	No Trend	No Trend	No Trend	Decreasing
0216	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
Adjacent Downgradient Wells							
0217 (POC)	Decreasing	Decreasing	Decreasing	No Trend	No Trend	No Trend	Decreasing
0590	No Trend	Increasing	No Trend	No Trend	No Trend	Increasing	Decreasing
0201	No Trend	Decreasing	No Trend	No Trend	No Trend	Increasing	Decreasing
0635	No Trend	No Trend	No Trend	Increasing	Increasing	Increasing	No Trend
Downgradient Wells							
0195	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend	No Trend
0170	No Trend	No Trend	No Trend	Increasing	No Trend	Increasing	Increasing
0620	Decreasing	No Trend	No Trend	No Trend	Decreasing	No Trend	No Trend
0172	Decreasing	No Trend	No Trend	No Trend	No Trend	Increasing	No Trend
Background Well							
0169	Increasing	No Trend	Increasing	No Trend	No Trend	Increasing	No Trend

Statistically significant increasing trend

Statistically significant decreasing trend

Note:
Detailed test statistics are provided in Appendix B, Table B-3, along with linear regression results.

To conclude this section, Figure 35 provides a summary matrix of time-concentration plots for each New Rifle site monitoring well and analyte combination (background well 0169 is excluded). A total of 112 distinct monitoring well and analyte combinations is represented. In this figure, wells are ordered and grouped in a way that is consistent with the categories defined in the draft GCAP (DOE 2016) and listed in Table 7: onsite wells, adjacent downgradient wells (upgradient of the Roaring Fork ponds), and farther downgradient wells (downgradient of the Roaring Fork ponds). Offsite wells are listed in general order of increasing distance from the site and former source areas.



LOESS local regression line and 95% pointwise confidence interval.

- - - - 40 CFR 192 MCL (UMTRCA standard) from Table 6: 0.044 mg/L uranium, 0.1 mg/L molybdenum, 0.01 mg/L selenium, 0.05 mg/L arsenic, and 10 mg/L nitrate.

Proposed ACL in DOE 2016 (Table 6): 0.364 mg/L uranium, 7.3 mg/L molybdenum; 52 mg/L vanadium, 1.43 mg/L selenium, 0.313 mg/L arsenic, and 75 mg/L nitrate. There is no regulatory standard for ammonia.

Notes:
This figure is intended as an introduction to the discussion of individual constituents that follows; results plotted are for 1998 through 2023. Detailed plots providing greater resolution are provided in the COC-specific time-trend plots (Figure 22 through Figure 34). Wells are ordered consistent with the groupings in Table 7, whereby onsite wells are listed first and adjacent and farther downgradient wells follow. In the latter two categories, wells are listed in general order of increasing distance from the site. Well names followed by an asterisk (*) denote proposed POC wells (DOE 2016). Results for New Rifle site background well 0169 are not shown. A semilogarithmic scale is used because of the wide range in constituent concentrations across site wells; *y*-axis labels are duplicated on the secondary (right) *y*-axis to facilitate review of trends in the farthest downgradient wells.
Abbreviation: N = nitrogen

Figure 35. Summary Matrix of Temporal Trends of Contaminants in New Rifle Site Wells

3.5 Surface Water Monitoring Results

The primary surface water features at or near the New Rifle site include the Colorado River, the Roaring Fork gravel pit ponds, and the mitigation wetland. This section includes a brief summary of contaminant trends measured at these locations. A more detailed discussion, including an evaluation of potential ecological risks, is provided in the most recent GCAP (DOE 2016).

3.5.1 Roaring Fork Gravel Pit Ponds and Wetland Areas

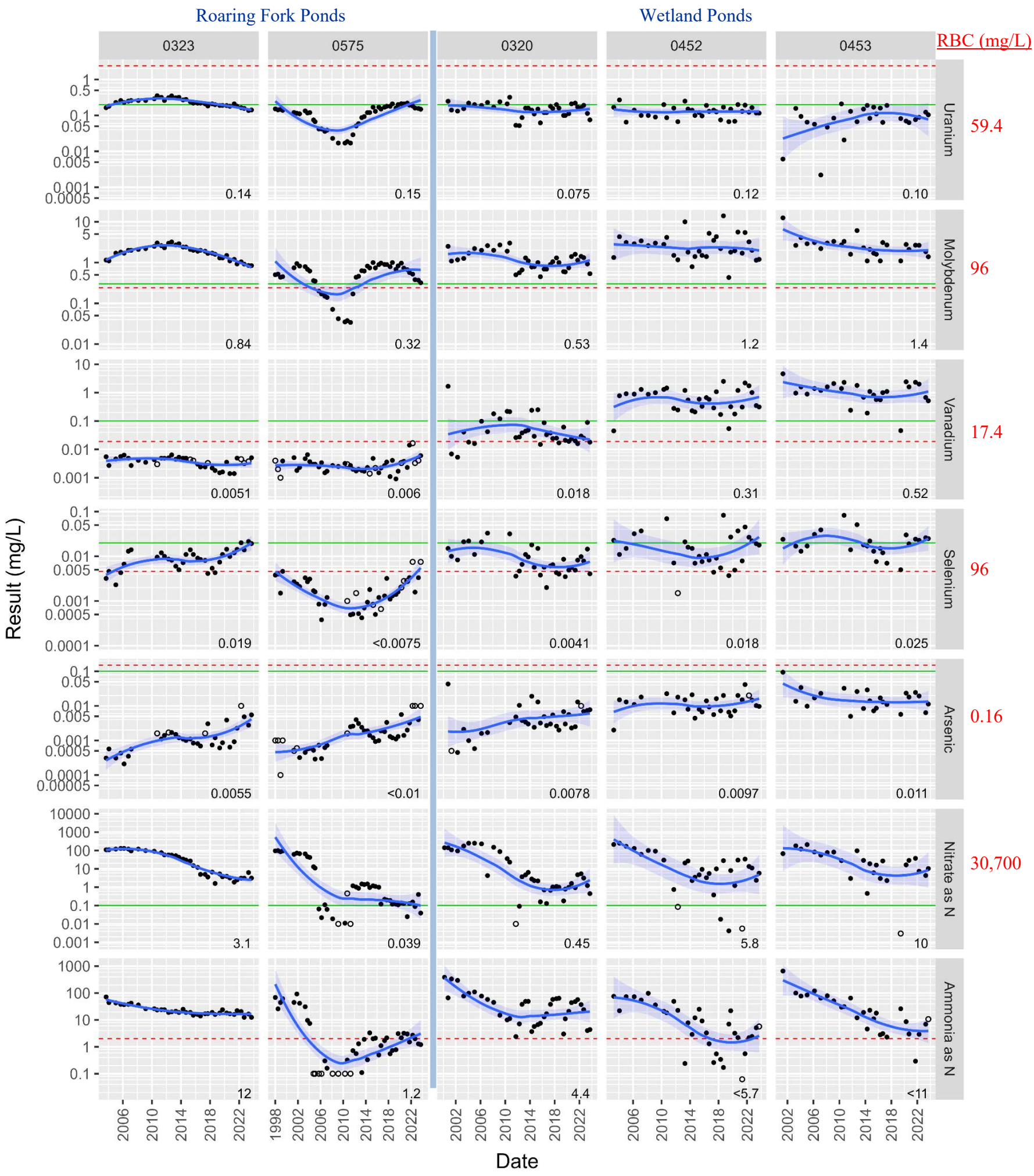
Figure 36 shows time-concentration plots of all COCs and ammonia for New Rifle site pond locations. Water is continuously present at locations 0323, the former East Roaring Fork Pond, and 0575, the former West Roaring Fork Pond. Both gravel pit pond locations were proposed as POE locations in the draft GCAP (DOE 2016). Monitoring locations 0320, 0452, and 0453 are in the reconstructed wetland. While water is usually present at wetland location 0320, it dries up occasionally during periods of low Colorado River flows. Wetland locations 0452 and 0453 dry up more frequently, again during low-water periods in the river. (Location 0453 was dry during the November 2022 sampling event.) There is no regular land use of either the gravel pit ponds or wetland areas other than the monitoring conducted by LM; much of the area is heavily vegetated.

To provide a context for interpreting results, data plotted in Figure 36 are shown relative to aquatic benchmarks and agricultural standards established in the draft GCAP (DOE 2016). With few exceptions, reported concentrations are from unfiltered samples (total fraction). Restrictions have been placed on use of surface water and groundwater for agricultural purposes, so that exposure pathway is incomplete. Risk-based concentrations (RBCs) corresponding to a recreational swimming scenario were also derived.[5] These values are shown to the right of the time-series plots in Figure 36 because monitoring results for all COCs have historically been below (in most cases, well below) the corresponding RBCs.

Uranium concentrations in gravel pit and wetland pond samples (currently about 0.1–0.2 mg/L) have always been well below the corresponding aquatic benchmark (2.4 mg/L) and the 59 mg/L RBC derived for a recreational (swimming) scenario (Figure 36). Molybdenum levels continue to exceed the 0.24 mg/L aquatic benchmark at all gravel pit and wetland sampling locations. Molybdenum concentrations in both gravel pit ponds are currently about 1 mg/L and slightly higher in the wetland ponds (maximum of 14 mg/L at location 0452 in 2018). However, all concentrations are below the 96 mg/L RBC.

Vanadium concentrations in the Roaring Fork ponds have been consistently low, less than the 0.019 mg/L aquatic benchmark, but exceed this value at wetland locations 0452 and 0453 (most recent results of 0.31 and 0.52 mg/L, respectively). Vanadium concentrations at all pond locations have been below the 17.4 mg/L RBC.

[5] As indicated in Section 2.5.1 (human health risk evaluation) of the draft GCAP (DOE 2016), it was assumed that children (the most sensitive receptors) could access the Roaring Fork ponds and would regularly swim in those ponds during summer months. The ponds are not known to be used for swimming; however, values for exposure parameters were chosen to provide conservative estimates of risk.



——— LOESS local regression line and 95% pointwise confidence interval.

○ Analytical result below the detection limit.

- - - Aquatic benchmark from Table 4 of the draft GCAP (DOE 2016). Where ranges are cited, the following lower bound values are used:

uranium = 2.4 mg/L
molybdenum = 0.24 mg/L
vanadium = 0.019 mg/L
selenium = 0.0046 mg/L
arsenic = 0.15 mg/L
ammonia (total) as nitrogen (N) = 2 mg/L

——— Agricultural standard from Table 4 (Ecological Risk Screening Table) of the draft GCAP (DOE 2016):

uranium = 0.2 mg/L
molybdenum = 0.3 mg/L
vanadium = 0.1 mg/L
selenium = 0.02 mg/L
arsenic = 0.1 mg/L
nitrate + nitrate as N = 100 mg/L

Notes:

RBCs derived for a conservative recreational (swimming) scenario (DOE 2016) are shown on the right margin because in most cases the RBCs far exceed the scale of the plots.

The agricultural standards are shown for context only. Restrictions have been placed on the use of surface water (and groundwater) for agricultural purposes, so the exposure pathway is incomplete.

Figure 36. Time-Concentration Plots of COCs and Ammonia in New Rifle Site Pond Samples

Selenium concentrations exceed the 0.0046 mg/L aquatic benchmark at all locations except west Roaring Fork pond 0575. During this reporting period, selenium concentrations ranged from 0.0016 to 0.027 mg/L (maximum at wetland pond 0452), below the 96 mg/L RBC.

Arsenic, while below the 0.15 mg/L aquatic benchmark and the 0.16 mg/L RBC, continues to increase at all locations except 0453. Though at times exceeding the 100 mg/L agricultural benchmark, nitrate concentrations have decreased significantly at all pond and wetland locations (Figure 36). Nitrate concentrations are currently highest in wetland pond locations 0452 and 0453, where they have stabilized at about 10 mg/L (equivalent to the groundwater MCL). Ammonia concentrations have consistently exceeded the 2 mg/L aquatic benchmark at location 0323 (former East Roaring Fork pond) and wetland pond location 0320. Ammonia has decreased significantly at all locations except 0575 (west gravel pit pond). The increase in ammonia concentrations since 2010 at the west pond parallels those seen for uranium, molybdenum, and selenium at that location (Figure 36).

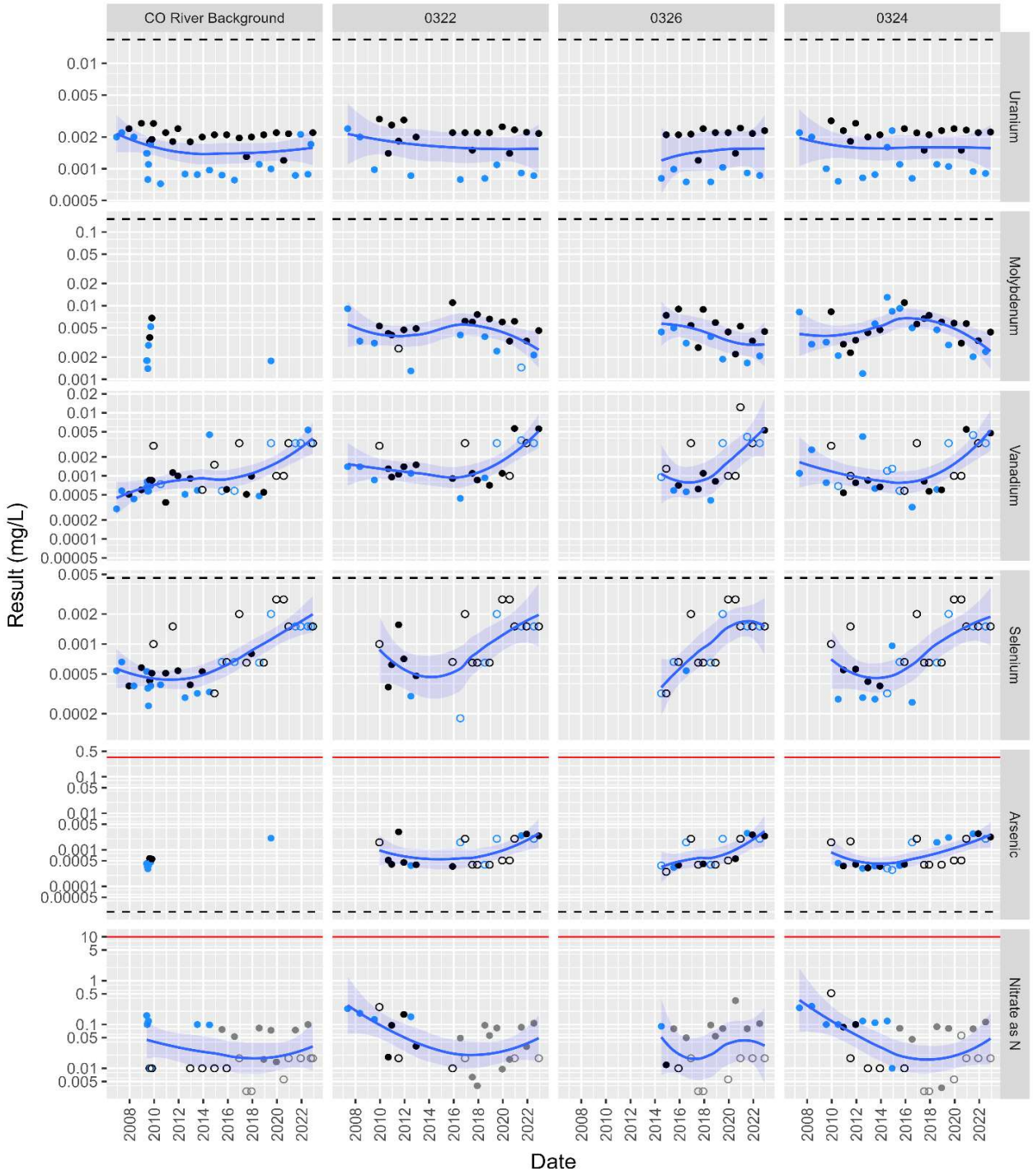
The Roaring Fork ponds have been a focus in recent NRC reviews of the draft GCAP (NRC 2020b). As shown in Figure 21, uranium concentrations in the ponds currently exceed those measured in groundwater samples. Analysis of historical monitoring data in light of the risk evaluations developed for the draft GCAP (DOE 2016) indicate that potential exposures to contaminants in the ponds—assuming those pathways are complete—are unlikely to pose any potential risk that would warrant additional controls or restrictions.

3.5.2 Colorado River Water Quality Monitoring

The Colorado River forms the eastern and southern boundary of the New Rifle site and is the dominant surface water feature. The Colorado River provides recharge to the alluvial aquifer on the eastern boundary. The river ultimately receives most of the surface drainage from the New Rifle site. Precipitation runoff at the site drains directly into the river and into the mitigation wetland ponds south of the site. However, some surface water runoff probably seeps into the groundwater system (i.e., recharges the aquifer) throughout each year (DOE 2016). The river also receives groundwater discharge from the alluvial aquifer along the southern portion of the site, especially at low river stages (Figure 19).

Concentrations at locations 0322 and 0324, in the Colorado River, were comparable to background. A relatively new location—0326, between 0322 and 0324—was established in 2010. The Colorado River in the site vicinity is classified for agricultural, recreational, and water supply uses.[6] As illustrated in Figure 37, the river water in the site vicinity does not exceed, nor has it exceeded, any of these standards, nor—with few exceptions—has it exceeded background surface water quality based on measurements from Old Rifle site upgradient locations 0538 and 0294 (former and current background locations, respectively). As observed for the Old Rifle site (Section 2.5.2; Figure 14), higher detection limits for selenium and vanadium may account for the upticks in selenium and vanadium concentrations seen in these samples (Figure 37).

[6] Applicable segment is COLCLC01: Mainstem of the Colorado River from the confluence with the Roaring Fork River to immediately below the confluence with Rifle Creek, designated as Aquatic Life Cold 1 and classified for agricultural, recreational, and water supply uses (5 CCR 1002-37). Downgradient of the site, in the approximate region of the southwest portion of the ICs area, the applicable Colorado River segment changes to COLCLC02A.



LOESS local regression line and 95% pointwise confidence interval

• Total (unfiltered) • Dissolved (filtered)

○ Analytical result below the detection limit

- - - "Chronic Surface Water Standard" (5 CCR 1002-37):
uranium = 0.0168 mg/L (lower bound of 0.0168–0.03 mg/L cited range)
molybdenum = 0.15 mg/L (chronic); selenium = 0.0046 mg/L (chronic);
arsenic = 0.00002 (chronic standard, exceeded at background locations); nitrate = 10 mg/L (acute)

"Acute Surface Water Standard" (5 CCR 1002-37): arsenic = 0.34 mg/L; nitrate = 10 mg/L

Note:
Monitoring of background Colorado River location 0294 began in November 2007. Data from the previous background river location—0538, roughly 0.5 mile upstream of location 0294—are also shown.

Figure 37. Historical COC Concentrations in Colorado River Water Samples, New Rifle Site

3.6 ICs Monitoring

A comprehensive ICs program has been implemented to prevent future use of contaminated groundwater associated with the New Rifle processing site. These ICs are robust and overlapping, providing ample protection; Appendix A of the draft GCAP (DOE 2016) documents the ICs for the New Rifle site in their entirety. To verify that the described ICs are being maintained as stated above, DOE conducts regular inspections and holds discussions with City of Rifle staff and other affected parties. As with the quitclaim deed verification, DOE accomplishes this by (1) discussions with city officials about construction projects and possible incursions of groundwater that could result from these activities; (2) physical inspection of the site by State of Colorado or DOE staff (or both), usually during the annual Rifle disposal site inspection; and (3) observations during groundwater sampling activities at other times of the year. LM will continue to work closely with CDPHE, as well as city and county officials, to maintain successful implementation of ICs and to ensure protection of human health and the environment.

4.0 Summary and Conclusions

Verification monitoring in 2022 and 2023 at the Old and New Rifle sites entailed routine semiannual sampling of groundwater and surface water and monitoring of ICs. To better understand the extent of contamination and to support LM's ongoing updates of the conceptual site models and GCAPs, additional (nonroutine) wells were sampled at both sites. Monitoring results continue to indicate that milling-related contamination persists at the sites.

Uranium is the most prevalent milling-related contaminant occurring in alluvial aquifer groundwater at the Old Rifle site. Concentrations continue to exceed the UMTRCA standard of 0.044 mg/L in five of the six onsite monitoring wells. Two of these wells show no attenuation (no statistically significant trend) and in one well (0305), uranium concentrations are significantly increasing. Selenium concentrations exceeded the corresponding NRC-approved ACL of 0.05 mg/L in only one well (0655). Although the exceedance is slight (0.059 mg/L), the corresponding trend is significantly increasing. No exceedances of the NRC-approved ACL of 1.0 mg/L were found for vanadium; all results were ≤ 0.41 mg/L during this reporting period.

In November 2023, the highest concentrations of Old Rifle site COCs were measured in wells that are not routinely monitored. Uranium concentrations were highest in the northern region of the site (0.38 mg/L in well 0746). Selenium and vanadium concentrations in well 0743 along the southern boundary of the site (0.086 and 3.3 mg/L, respectively) exceeded corresponding ACLs. Based on these findings, continued monitoring may be warranted in these regions of the site.

Since 2014, concentrations of uranium and selenium have increased fivefold at the ditch sample location (0398). While uranium concentrations in the ditch now exceed the 0.044 mg/L UMTRCA MCL, selenium concentrations remain low relative to water quality benchmarks. The reason for these increasing trends is not known. COC concentrations in samples collected from seep 0395 north of the site have been consistently below corresponding benchmarks.

Surface water quality of the Colorado River, a POE at both the Old and New Rifle sites, remains unaffected by groundwater discharge from either site. COC concentrations in river samples adjacent to and downstream of both sites have been similar to or lower than those in background (upstream) samples.

At the New Rifle site, uranium, molybdenum, and vanadium receive the most focus because of their magnitude and spatial extent. Although concentrations of these three constituents have generally decreased across the monitoring network (at times significantly), they are still elevated relative to corresponding compliance goals in most onsite and adjacent downgradient wells. Exceptions are onsite wells 0215 and 0216, where mixing with river water occurs. In November 2023, uranium concentrations exceeded the 0.044 mg/L UMTRCA MCL in 10 of 16 monitoring wells (excluding background) as far downgradient as well 0620. The highest uranium concentrations, approximately 0.1–0.2 mg/L and exceeding all groundwater results, are found in the Roaring Fork ponds and wetland locations.

Selenium concentrations exceed the 0.05 mg/L SDWA standard in most onsite wells. Although results for offsite wells have generally been below this standard, concentrations are increasing significantly at several downgradient locations, most notably in near-river well 0635 and farther downgradient well 0170.

Nitrate currently slightly exceeds the 10 mg/L benchmark in only two monitoring wells immediately downgradient of the site (both with most recent results of 17 mg/L). Arsenic concentrations have been below the 0.05 mg/L standard in all far downgradient wells, but trends are increasing in five of these wells, in particular well 0172 near the western IC boundary. Ammonia, not considered a COC but monitored because of its association with nitrate, is elevated relative to background (0.1 mg/L) in most onsite and near downgradient wells. Ammonia concentrations are currently highest in adjacent downgradient wells east of the Roaring Fork ponds and, in most wells, have declined significantly since 1998.

Monitoring results for the new downgradient wells installed in November 2022 were below corresponding compliance goals or background levels for all constituents except for uranium in well 0919 (0.048 mg/L in November 2023). This result just slightly exceeds the 0.044 mg/L MCL and is consistent with uranium measured in farther downgradient well 0620 (0.056 mg/L).

In addition to the Colorado River, other surface water features at or near the New Rifle site include the Roaring Fork gravel pit ponds and the mitigation wetland. Because water is continuously present in the Roaring Fork ponds (and not in the mitigation wetland), these sampling sites (0323 and 0575) were proposed as POE locations in the draft GCAP. In 2022–2023, uranium concentrations in the ponds exceeded those in all groundwater samples. Based on the risk evaluation documented in the 2016 draft GCAP, potential exposures to contaminants in the Roaring Fork ponds—assuming those pathways are complete—are unlikely to pose any potential risk that would warrant additional controls or restrictions.

At both the Old and New Rifle sites, multiple ICs are in place to prevent domestic use of groundwater and to ensure protection of human health and the environment. Three ICs—a zone overlay, a quitclaim deed, and an EC—are in place at the Old Rifle site. These overlapping measures restrict a number of activities at the site and limit access to the subsurface and groundwater without written permission from CDPHE and DOE.

At the New Rifle site, DOE, CDPHE, the City of Rifle, and Garfield County have enacted a series of four ICs to prevent humans and livestock from being exposed to site-related contaminants on the former mill site and on downgradient properties. These controls consist of a quitclaim deed on the site proper, a large zone overlay to restrict consumption of contaminated groundwater, an EC to limit access to groundwater and to prevent livestock from accessing water in former gravel pit ponds, and an overlay zone district that further limits activities on the former mill site.

5.0 References

Note: Many of the DOE reports cited here are available on the LM website at:
https://www.energy.gov/lm/rifle-colorado-disposal-site-and-processing-sites

5 CCR 1002-37. Colorado Department of Public Health and Environment Water Quality Control Commission, "Regulation No. 37, Classifications and Numeric Standards for Lower Colorado River Basin," *Code of Colorado Regulations*, https://www.epa.gov/sites/production/files/2014-12/documents/cowqs-no37-2006.pdf, accessed May 21, 2024.

40 CFR 192. U.S. Environmental Protection Agency, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings," *Code of Federal Regulations*.

42 USC 300f. U.S. Environmental Protection Agency, "Safe Drinking Water Act," *United States Code*.

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Appendix A

Supporting Information for the Old Rifle Site

Table A-1. Old Rifle Site Groundwater and Surface Water Locations Sampled During the 2022–2023 Reporting Period

Monitoring Location	Installation or Establishment Date	Screened Interval (bgs)	Location Description
Routine Groundwater Monitoring Locations			
0304	3/27/1998	13.2–18.2	Leading edge of plume
0305	3/30/1998	13.76–18.76	Within plume, west of ditch
0309	4/15/1998	16.93–21.93	Leading edge of plume
0310	4/15/1998	17.93–22.93	Leading edge of plume
0655	4/23/1998	13.6–23.6	Within plume, west of ditch
0656	4/8/1998	6.35–21.35	Within plume, east of ditch
0292A	10/10/2007	10.5–20.5	Background well; added April 2009 to replace former well 0292 that was abandoned in July 2008
0658	4/1/1998	2.3–17.3	Background well north of well 0292(A)
Routine Surface Water Monitoring Locations			
0395	4/29/2010	–	Seep north of site (added to network
0398	2/25/1998	–	Onsite ditch
0294	11/14/2007	–	Upgradient Colorado River location; replaced former location 0538
0396	6/13/2001	–	Colorado River location, adjacent to site (south of well 0310)
0741	2/24/1998	–	Downstream Colorado River location
IFRC Wells Sampled in 2022 and 2023 (Nonroutine Sampling)			
0743-1	7/20/2011	8.2–8.7	IFRC multichannel well
0743-2		12.2–12.7	
0743-3		16.2–16.7	
0745	3/30/2013	7.6–17.6	
0746	3/29/2013	9.1–24.1	
0747	3/30/2013	11.8–26.8	
FP-103	7/22/2011	11.4–21.4	
SY-02	3/26/2013	10.5–25.5	
SY-04	3/27/2013	12.6–27.6	

Note:
Descriptions for routine sample locations are based on characterizations in the GCAPs (DOE 2001; DOE 2017). Locations are shown in Figure 4 of the main report.

Abbreviation(s):
– = Not Applicable
bgs = below ground surface
IFRC = Integrated Field Research Challenge

Table A-2. Old Rifle Site Mann-Kendall Trend Analysis and Linear Regression Results, 1998–2023

Monitoring Well	Initial Trend Analysis Date	Final Trend Analysis Date	Number of Samples	Number of Nondetects	Most Recent Result (mg/L)	Mann-Kendall Trend Analysis Results		Linear Regression Results					
								Half-Life (years)			Year Compliance Goal Reached		
						Trend	Tau Value	Trend Line	Lower 95% Confidence Interval	Upper 95% Confidence Interval	Trend Line	Lower 95% Confidence Interval	Upper 95% Confidence Interval
Uranium (MCL = 0.044 mg/L)													
0304	5/19/1998	11/7/2023	57	0	0.052	None	0.07	Not applicable, no trend					
0305	5/19/1998	11/7/2023	56	0	0.13	Increasing	0.43	Not applicable, increasing trend					
0309	5/19/1998	11/6/2023	57	0	0.016	Decreasing	−0.21	Not applicable, concentration less than compliance goal					
0310	5/19/1998	11/7/2023	57	0	0.13	Decreasing	−0.59	17.69	14.42	22.87	2046	2040	2057
0655	5/18/1998	11/7/2023	57	0	0.13	None	−0.13	Not applicable, no trend					
0656	5/20/1998	11/6/2023	57	0	0.19	Increasing	0.51	Not applicable, increasing trend					
0292A*	4/14/2009	11/6/2023	36	0	0.045	None	0.21	Not applicable (background well)					
0658*	5/21/1998	11/7/2023	46	0	0.0093	Decreasing	−0.57						
Selenium (ACL = 0.05 mg/L)													
0304	5/19/1998	11/7/2023	57	10	<0.0015	Decreasing	−0.55	Not applicable, concentration less than compliance goal					
0305	5/19/1998	11/7/2023	56	0	0.011	Decreasing	−0.74						
0309	5/19/1998	11/6/2023	57	38	<0.0015	None	0.10						
0310	5/19/1998	11/7/2023	57	27	<0.0015	Increasing	0.23						
0655	5/18/1998	11/7/2023	57	0	0.059	Increasing	0.28	Not applicable, increasing trend					
0656	5/20/1998	11/6/2023	57	5	<0.0015	Decreasing	−0.30	Not applicable, concentration less than compliance goal					
0292A*	4/14/2009	11/6/2023	36	13	0.0023	None	−0.05						
0658*	5/21/1998	11/7/2023	46	3	0.0033	None	0.10						
Vanadium (ACL = 1.0 mg/L)													
0304	5/19/1998	11/7/2023	57	1	0.0157	Decreasing	−0.53	Not applicable, concentration less than compliance goal					
0305	5/19/1998	11/7/2023	56	0	0.41	Decreasing	−0.47						
0309	5/19/1998	11/6/2023	57	35	<0.0033	None	0.17						
0310	5/19/1998	11/7/2023	57	1	0.0083	Decreasing	−0.58						
0655	5/18/1998	11/7/2023	57	0	0.29	Decreasing	−0.51						
0656	5/20/1998	11/6/2023	57	0	0.084	None	0.07						
0292A*	4/14/2009	11/6/2023	36	16	<0.0033	None	0.15	Not applicable (background well)					
0658*	5/21/1998	11/7/2023	46	17	<0.0033	None	−0.08						

* Asterisk denotes background well.

Notes:

Trend tests for uranium, with no nondetect results, were conducted using the Kendall package in R, version 2.2.1 (McLeod 2022). Trend tests for selenium and vanadium were performed using the NADA (Nondetects and Data Analysis for Environmental Data) package in R, version 1.6-1.1 (Lee 2020). The NADA trend test is similar to the traditional Mann-Kendall trend test except that it accounts for the presence of nondetects at multiple detection limits. All trend analyses were conducted at the 0.05 significance (or alpha) level using a two-sided test. The test statistic, Kendall's tau, is a measure of the strength of the association between two variables, with values always falling between −1 and +1. Increasing trends for any well-analyte combinations are highlighted above.

For the wells identified as having decreasing trends (with concentrations exceeding compliance goals), linear regression of the log-transformed concentration data was performed to estimate when the well's COC concentration was expected to decline below the compliance goal.

Table A-3. Old Rifle Site Mann-Kendall Trend Analysis and Linear Regression Results, 2014–2023

Monitoring Well	Initial Trend Analysis Date	Final Trend Analysis Date	Number of Samples	Number of Nondetects	Most Recent Result (mg/L)	Mann-Kendall Trend Analysis Results		Linear Regression Results					
								Half-Life (years)			Year Compliance Goal Reached		
						Trend	Tau Value	Trend Line	Lower 95% Confidence Interval	Upper 95% Confidence Interval	Trend Line	Lower 95% Confidence Interval	Upper 95% Confidence Interval
Uranium (MCL = 0.044 mg/L)													
0304	6/12/2014	11/7/2023	21	0	0.052	None	−0.01	Not applicable, no trend					
0305	6/12/2014	11/7/2023	21	0	0.13	Increasing	0.75	Not applicable, increasing trend					
0309	6/11/2014	11/6/2023	21	0	0.016	Decreasing	−0.56	Not applicable, concentration less than compliance goal					
0310	6/12/2014	11/7/2023	21	0	0.13	Decreasing	−0.37	9.84	6.26	22.99	2033	2028	2053
0655	6/12/2014	11/7/2023	21	0	0.13	None	0.28	Not applicable, no trend					
0656	6/12/2014	11/6/2023	21	0	0.19	Decreasing	−0.43	11.95	6.88	45.25	2043	2033	2109
0292A*	6/12/2014	11/6/2023	21	0	0.045	None	0.27	Not applicable (background well)					
0658*	6/12/2014	11/7/2023	21	0	0.0093	None	−0.15						
Selenium (ACL = 0.05 mg/L)													
0304	6/12/2014	11/7/2023	21	9	<0.0015	None	−0.11	Not applicable, concentration less than compliance goal					
0305	6/12/2014	11/7/2023	21	0	0.011	None	0.03						
0309	6/11/2014	11/6/2023	21	18	<0.0015	None	−0.03						
0310	6/12/2014	11/7/2023	21	13	<0.0015	None	0.10						
0655	6/12/2014	11/7/2023	21	0	0.059	Increasing	0.33	Not applicable, increasing trend					
0656	6/12/2014	11/6/2023	21	4	<0.0015	None	−0.29	Not applicable, concentration less than compliance goal (no trend)					
0292A*	6/12/2014	11/6/2023	21	11	0.0023	None	0.04	Not applicable (background well)					
0658*	6/12/2014	11/7/2023	21	2	0.0033	None	0.28						
Vanadium (ACL = 1.0 mg/L)													
0304	6/12/2014	11/7/2023	21	1	0.0157	Decreasing	−0.52	Not applicable, concentration less than compliance goal					
0305	6/12/2014	11/7/2023	21	0	0.41	None	0.29						
0309	6/11/2014	11/6/2023	21	14	<0.0033	None	0.03						
0310	6/12/2014	11/7/2023	21	1	0.0083	Decreasing	−0.40						
0655	6/12/2014	11/7/2023	21	0	0.29	None	0.05						
0656	6/12/2014	11/6/2023	21	0	0.084	Increasing	0.75						
0292A*	6/12/2014	11/6/2023	21	12	<0.0033	None	0.17	Not applicable (background well)					
0658*	6/12/2014	11/7/2023	21	13	<0.0033	None	−0.03						

* Asterisk denotes background well.

Notes:

Trend tests for uranium, with no nondetect results, were conducted using the Kendall package in R, version 2.2.1 (McLeod 2022). Trend tests for selenium and vanadium were performed using the NADA (Nondetects and Data Analysis for Environmental Data) package in R, version 1.6-1.1 (Lee 2020). The NADA trend test is similar to the traditional Mann-Kendall trend test except that it accounts for the presence of nondetects at multiple detection limits. All trend analyses were conducted at the 0.05 significance (or alpha) level using a two-sided test. The test statistic, Kendall's tau, is a measure of the strength of the association between two variables, with values always falling between −1 and +1. Increasing trends for any well-analyte combinations are highlighted above.

For the wells identified as having decreasing trends (with concentrations exceeding compliance goals), linear regression of the log-transformed concentration data was performed to estimate when the well's COC concentration was expected to decline below the compliance goal.

Appendix B

Supporting Information for the New Rifle Site

Table B-1. New Rifle Site Groundwater and Surface Water Locations Sampled During the 2022–2023 Reporting Period

Monitoring Location	Installation or Establishment Date	Screened Interval (bgs)	Location Description
Routine Groundwater Monitoring Locations			
0169	5/7/1998	3.13–18.13	Upgradient (background) well
0170	6/3/1998	92.23–112.23	Downgradient, west of ponds
0172	6/24/1998	6.98–31.98	Downgradient, west of ponds
0195	6/15/1998	5.29–25.29	Downgradient, west of ponds
0201	7/27/1998	7.35–22.35	Downgradient, adjacent to site and east of ponds
0215	7/1/1998	6.84–21.84	Onsite well
0216	7/1/1998	5.5–20.5	Onsite well
0217	5/8/1998	7.4–22.4	Downgradient POC well, adjacent to site and east of ponds
0590	1/14/1983	5.21–19.21	Downgradient, adjacent to site and east of ponds
0620	3/17/1994	6.7–10.7	Downgradient, west of ponds
0635	9/30/1994	12–17	Downgradient, adjacent to site and east of ponds; adjacent to new stilling well SW-2
0658	2/14/1996	0.5–5.5	Onsite well
0659	2/14/1996	0.5–10.5	Onsite POC well
0664	9/19/1996	7.7–14.7	Onsite POC well
0669	9/21/1996	4–10.6	Onsite POC well
0670	9/22/1996	5.2–12.2	Onsite well
0855	4/7/2000	6–11	Onsite well
Newly Installed Wells Intended for Routine Sampling			
0907	11/16/2022	14–24	Downgradient-most new location
0909	11/17/2022	30.1–40.1	Located between wells 0620 and 0172 to north
0919	11/15/2022	21–31	About midway between well 0442 and 0620
0922	11/15/2022	65–70	North of highway
Additional Monitoring Wells Sampled in 2022–2023 (Nonroutine Samples)			
0219	7/7/1998	5–10.5	Onsite well
0442	4/1/1998	–	Offsite domestic well
0609	1/30/1985	6–21	Downgradient well
0680	1/8/2001	5–10	Downgradient well
0683	2/13/2008	13.2–18.2	Onsite well east of former tailings area
0689	5/25/2010	4.5–9.38	Onsite well east of former tailings area
0857	4/7/2000	19–23	Although a focus of the vanadium study (DOE 2010), this well is usually not routinely sampled
Routine Surface Water Monitoring Locations			
0323	11/6/2003	–	East Roaring Fork pond
0575	10/2/1991	–	West Roaring Fork pond
0320	5/2/2000	–	Wetland
0452	6/10/2003	–	Wetland
0453	6/18/2001	–	Wetland; this location is periodically dry, as was the case in November 2022
0322	12/5/2000	–	Colorado River, near well 0635
0324	11/7/2003	–	Colorado River (midpoint)
0326	6/10/2015	–	Downstream Colorado River location

Note: Descriptions for routine sample locations are based on characterizations in the 2016 draft GCAP (DOE 2016). Locations are shown in Figure 16.

Abbreviations:
– = not applicable
bgs = below ground surface
POC = point of compliance
POE = point of exposure

Table B-2. New Rifle Site Mann-Kendall Trend Analysis and Linear Regression Results, 1998–2023

Monitoring Well	Initial Trend Analysis Date	Final Trend Analysis Date	Number of Samples	Number of Nondetects	Most Recent Result (mg/L)	Mann-Kendall Trend Analysis Results		Linear Regression Results					
								Half-Life (years)			Year Compliance Goal Reached		
						Trend	Tau Value	Trend Line	Lower 95% CI	Upper 95% CI	Trend Line	Lower 95% CI	Upper 95% CI
Uranium (MCL = 0.044 mg/L)													
0169*	8/20/1998	11/7/2023	43	0	0.030	Decreasing	−0.33				Not applicable (background well)		
0170	8/20/1998	11/7/2023	43	0	0.049	None	−0.19	Not applicable, no trend					
0172	8/19/1998	11/7/2023	49	0	0.0087	Decreasing	−0.59	Not applicable, concentration less than compliance goal					
0195	8/19/1998	11/7/2023	38	0	0.034	Decreasing	−0.59						
0201	8/18/1998	11/8/2023	45	0	0.10	None	−0.08	Not applicable, no trend					
0215	8/14/1998	11/8/2023	49	0	0.019	Increasing	0.34	Not applicable, increasing trend					
0216	8/18/1998	11/7/2023	49	0	0.0077	None	−0.10	Not applicable, no trend					
0217	8/18/1998	11/8/2023	43	0	0.10	None	−0.08						
0590	8/12/1998	11/8/2023	50	0	0.083	None	0.16						
0620	8/17/1998	11/7/2023	45	0	0.056	Decreasing	−0.21	293.28					
0635	8/18/1998	11/8/2023	38	0	0.053	Decreasing	−0.45	20.00	14.09	34.42	2019	2017	2025
0658	8/13/1998	11/8/2023	47	0	0.049	Decreasing	−0.63	7.78	6.74	9.19			
0659	8/13/1998	11/8/2023	49	0	0.056	Decreasing	−0.45	30.36	22.07	48.63	2043	2034	2062
0664	12/14/1999	11/8/2023	46	0	0.058	Decreasing	−0.41	33.91	24.97	52.82	2033	2027	2044
0669	12/14/1999	11/8/2023	46	0	0.047	Decreasing	−0.28	35.58	20.38	139.87	2046	2032	2145
0670	12/14/1999	11/8/2023	39	0	0.044	Decreasing	−0.40	33.31	18.52	165.03	2043	2030	2160
0855	4/28/2000	11/8/2023	44	0	0.036	Decreasing	−0.43	Not applicable, concentration less than compliance goal					
Molybdenum (MCL = 0.1 mg/L)													
0169*	8/20/1998	11/7/2023	43	4	0.0042	Decreasing	−0.32				Not applicable (background well)		
0170	8/20/1998	11/7/2023	43	4	0.0028	Decreasing	−0.47	Not applicable, concentration less than compliance goal					
0172	8/19/1998	11/7/2023	49	3	0.0074	None	0.13						
0195	8/19/1998	11/7/2023	38	0	0.016	Decreasing	−0.58						
0201	8/18/1998	11/8/2023	43	0	1.4	Decreasing	−0.78	20.78	18.21	24.19	2097	2087	2111
0215	8/14/1998	11/8/2023	47	0	0.014	Decreasing	−0.53	Not applicable, concentration less than compliance goal					
0216	8/18/1998	11/7/2023	48	0	0.037	Decreasing	−0.24						
0217	8/18/1998	11/8/2023	42	0	1.2	Decreasing	−0.61	41.68	32.40	58.41	2176	2139	2241
0590	8/12/1998	11/8/2023	47	0	1.8	Decreasing	−0.22	56.65	32.68	212.72	2225	2135	2813
0620	8/17/1998	11/7/2023	45	0	0.0093	Decreasing	−0.26	Not applicable, concentration less than compliance goal					
0635	8/18/1998	11/8/2023	38	0	0.38	Decreasing	−0.54	20.70	16.42	27.97	2058	2048	2074
0658	8/13/1998	11/8/2023	46	0	1.9	Decreasing	−0.40	11.17	8.72	15.54	2063	2052	2083
0659	8/13/1998	11/8/2023	48	0	0.74	Decreasing	−0.88	9.58	8.55	10.89	2051	2047	2056
0664	12/14/1999	11/8/2023	41	0	0.44	Decreasing	−0.44	21.13	15.32	34.03	2049	2039	2071
0669	12/14/1999	11/8/2023	41	0	0.41	Decreasing	−0.76	8.38	7.37	9.70	2039	2036	2044

Table B-2. New Rifle Site Mann-Kendall Trend Analysis and Linear Regression Results, 1998–2023 (continued)

Monitoring Well	Initial Trend Analysis Date	Final Trend Analysis Date	Number of Samples	Number of Nondetects	Most Recent Result (mg/L)	Mann-Kendall Trend Analysis Results		Linear Regression Results					
								Half-Life (years)			Year Compliance Goal Reached		
						Trend	Tau Value	Trend Line	Lower 95% CI	Upper 95% CI	Trend Line	Lower 95% CI	Upper 95% CI
0670	12/14/1999	11/8/2023	38	0	0.25	Decreasing	−0.29	30.31	19.20	71.89	2048	2035	2094
0855	4/28/2000	11/8/2023	42	0	0.28	Decreasing	−0.76	6.16	5.07	7.82	2032	2029	2037
Vanadium (0.33 mg/L ACL proposed in 2003 draft GCAP)													
0169*	8/20/1998	11/7/2023	39	15	0.0060	None	0.21				Not applicable (background well)		
0170	8/20/1998	11/7/2023	38	15	0.0060	None	0.20	Not applicable, concentration less than compliance goal and no trend					
0172	8/19/1998	11/7/2023	39	23	0.0050	None	−0.06						
0195	8/19/1998	11/7/2023	34	15	0.0052	Increasing	0.28	Not applicable, increasing trend					
0201	8/18/1998	11/8/2023	41	24	0.0038	None	0.02	Not applicable, no trend					
0215	8/14/1998	11/8/2023	50	19	0.025	Increasing	0.43	Not applicable, increasing trend					
0216	8/18/1998	11/7/2023	50	0	0.28	Decreasing	−0.30	Not applicable, concentration less than compliance goal					
0217	8/18/1998	11/8/2023	43	0	1.7	Decreasing	−0.38	288.11					
0590	8/12/1998	11/8/2023	51	0	0.55	Increasing	0.35	Not applicable, increasing trend					
0620	8/17/1998	11/7/2023	36	11	0.0063	Increasing	0.35						
0635	8/18/1998	11/8/2023	35	17	<0.0033	None	0.07						
0658	8/13/1998	11/8/2023	48	0	26	Increasing	0.33	Not applicable, increasing trend					
0659	8/13/1998	11/8/2023	50	0	1.4	None	−0.15	Not applicable, no trend					
0664	12/14/1999	11/8/2023	48	0	0.74	None	−0.18						
0669	12/14/1999	11/8/2023	47	0	4.6	None	0.09						
0670	12/14/1999	11/8/2023	41	0	1.6	Decreasing	−0.66	18.12	15.29	22.25	2062	2054	2073
0855	4/28/2000	11/8/2023	46	0	6.5	Decreasing	−0.44	15.46	8.34	105.10	2100	2060	2608
Selenium (SDWA standard = 0.05 mg/L)													
0169*	8/20/1998	11/7/2023	41	1	0.025	Decreasing	−0.32	9.86	7.21	15.57	Not applicable (background well)		
0170	8/20/1998	11/7/2023	40	0	0.028	Increasing	0.86	Not applicable, increasing trend					
0172	8/19/1998	11/7/2023	46	26	<0.0075	None	0.11	Not applicable, concentration less than compliance goal and no trend					
0195	8/19/1998	11/7/2023	36	18	<0.0015	None	−0.14						
0201	8/18/1998	11/8/2023	41	0	0.098	Increasing	0.46	Not applicable, increasing trend					
0215	8/14/1998	11/8/2023	46	18	0.0065	None	0.11	Not applicable, concentration less than compliance goal and no trend					
0216	8/18/1998	11/7/2023	47	17	<0.0015	None	−0.07						
0217	8/18/1998	11/8/2023	39	0	0.0083	None	−0.21						
0590	8/12/1998	11/8/2023	45	0	0.061	Increasing	0.35	Not applicable, increasing trend					
0620	8/17/1998	11/7/2023	43	5	0.030	Increasing	0.41						
0635	8/18/1998	11/8/2023	36	2	0.027	Increasing	0.33						
0658	8/13/1998	11/8/2023	45	0	1.3	Increasing	0.36						
0659	8/13/1998	11/8/2023	46	0	0.017	None	0.02	Not applicable, concentration less than compliance goal and no trend					
0664	12/14/1999	11/8/2023	39	0	0.38	Increasing	0.67	Not applicable, increasing trend					

Table B-2. New Rifle Site Mann-Kendall Trend Analysis and Linear Regression Results, 1998–2023 (continued)

Monitoring Well	Initial Trend Analysis Date	Final Trend Analysis Date	Number of Samples	Number of Nondetects	Most Recent Result (mg/L)	Mann-Kendall Trend Analysis Results		Linear Regression Results					
								Half-Life (years)			Year Compliance Goal Reached		
						Trend	Tau Value	Trend Line	Lower 95% CI	Upper 95% CI	Trend Line	Lower 95% CI	Upper 95% CI
0669	12/14/1999	11/8/2023	39	0	0.11	Increasing	0.39						
0670	12/14/1999	11/8/2023	37	0	0.23	None	0.06	Not applicable, no trend					
0855	6/14/2001	11/8/2023	41	0	0.52	Decreasing	−0.23	3545.62					
Nitrate (MCL = 10 mg/L)													
0169*	8/20/1998	11/7/2023	43	3	9	Decreasing	−0.48	4.16	3.10	6.33	Not applicable (background well)		
0170	8/20/1998	11/7/2023	43	0	10.3	Decreasing	−0.41	16.53	12.44	24.62	2022	2020	2027
0172	8/19/1998	11/7/2023	44	23	<0.017	None	−0.08	Not applicable, no trend					
0195	8/19/1998	11/7/2023	38	24	<0.017	Decreasing	−0.46	Not applicable, concentration less than compliance goal					
0201	8/18/1998	11/8/2023	43	0	17	Decreasing	−0.69	7.82	6.68	9.45	2029	2026	2032
0215	8/14/1998	11/8/2023	47	20	3.8	None	−0.02	Not applicable, concentration less than compliance goal or no trend					
0216	8/18/1998	11/7/2023	48	29	<0.017	None	−0.17						
0217	8/18/1998	11/8/2023	42	14	<0.017	Decreasing	−0.46						
0590	8/12/1998	11/8/2023	47	0	5.2	Decreasing	−0.29						
0620	8/17/1998	11/7/2023	40	3	2.4	None	−0.19						
0635	8/18/1998	11/8/2023	39	0	6.4	Decreasing	−0.36						
0658	8/13/1998	11/8/2023	46	0	6.0	None	−0.15						
0659	8/13/1998	11/8/2023	48	0	0.52	Decreasing	−0.59						
0664	12/14/1999	11/8/2023	41	0	8.7	None	0.16						
0669	12/14/1999	11/8/2023	41	0	7.2	None	0.05						
0670	12/14/1999	11/8/2023	38	0	9	None	0.01						
0855	6/14/2001	11/8/2023	41	0	9.8	None	−0.04						
Arsenic (MCL = 0.05 mg/L)													
0169*	8/20/1998	11/7/2023	41	15	0.0034	Increasing	0.33				Not applicable (background well)		
0170	8/20/1998	11/7/2023	40	19	0.0034	Increasing	0.23	Not applicable, increasing trend (all concentrations <0.05 mg/L)					
0172	8/19/1998	11/7/2023	46	2	0.012	Increasing	0.66						
0195	8/19/1998	11/7/2023	36	10	0.0036	Increasing	0.39						
0201	8/18/1998	11/8/2023	41	14	0.0039	Increasing	0.27						
0215	8/14/1998	11/8/2023	46	16	0.0035	None	0.05	Not applicable, concentration less than compliance goal and no trend					
0216	8/18/1998	11/7/2023	47	0	0.049	None	0.04						
0217	8/18/1998	11/8/2023	40	4	0.0051	None	0.07						
0590	8/12/1998	11/8/2023	45	8	0.0057	Increasing	0.45	Not applicable, increasing trend (concentration <0.05 mg/L)					
0620	8/17/1998	11/7/2023	43	10	<0.01	None	−0.10	Not applicable, concentration less than compliance goal and no trend					
0635	8/18/1998	11/8/2023	36	21	0.0024	Increasing	0.33						
0658	8/13/1998	11/8/2023	45	0	0.15	None	0.15	Not applicable, concentration less than compliance goal or no trend					

Table B-2. New Rifle Site Mann-Kendall Trend Analysis and Linear Regression Results, 1998–2023 (continued)

Monitoring Well	Initial Trend Analysis Date	Final Trend Analysis Date	Number of Samples	Number of Nondetects	Most Recent Result (mg/L)	Mann-Kendall Trend Analysis Results		Linear Regression Results					
								Half-Life (years)			Year Compliance Goal Reached		
						Trend	Tau Value	Trend Line	Lower 95% CI	Upper 95% CI	Trend Line	Lower 95% CI	Upper 95% CI
0659	8/13/1998	11/8/2023	46	0	0.031	None	−0.05						
0664	12/14/1999	11/8/2023	39	1	0.0035	None	0.13						
0669	12/14/1999	11/8/2023	39	0	0.011	Increasing	0.34	Not applicable, increasing trend (concentration <0.05 mg/L)					
0670	12/14/1999	11/8/2023	37	0	0.0057	None	−0.14	Not applicable, concentration less than compliance goal and no trend					
0855	4/28/2000	11/8/2023	42	0	0.077	Decreasing	−0.26	23.21	12.23	227.55	2068	2042	2558
Ammonia (no compliance goal)													
0169*	8/20/1998	11/7/2023	43	30	0.023	None	0.08				Not applicable, no compliance goal		
0170	8/20/1998	11/7/2023	42	5	1.0	Increasing	0.69						
0172	8/19/1998	11/7/2023	43	19	0.12	Increasing	0.30						
0195	8/19/1998	11/7/2023	38	7	0.049	Decreasing	−0.60	2.09	1.77	2.56			
0201	8/18/1998	11/8/2023	43	1	39	Decreasing	−0.80	9.12	7.98	10.64			
0215	8/14/1998	11/8/2023	47	1	0.51	Decreasing	−0.50	8.63	6.43	13.12			
0216	8/18/1998	11/7/2023	47	0	3.2	Decreasing	−0.42	35.25	25.02	59.65			
0217	8/18/1998	11/8/2023	42	0	20	Decreasing	−0.86	7.81	7.05	8.74			
0590	8/12/1998	11/8/2023	46	0	60	Decreasing	−0.86	10.69	9.59	12.06			
0620	8/17/1998	11/7/2023	40	25	0.018	None	0.09						
0635	8/18/1998	11/8/2023	38	1	47	Decreasing	−0.82	7.18	6.55	7.94			
0658	8/13/1998	11/8/2023	46	0	27	Decreasing	−0.81	7.19	6.44	8.12			
0659	8/13/1998	11/8/2023	48	0	0.56	Decreasing	−0.82	2.70	2.31	3.26			
0664	12/14/1999	11/8/2023	41	0	13	Decreasing	−0.76	26.49					
0669	12/14/1999	11/8/2023	41	1	34	Decreasing	−0.76	7.97	6.79	9.63			
0670	12/14/1999	11/8/2023	38	0	8.6	Decreasing	−0.56	13.45	7.94	43.91			
0855	6/14/2001	11/8/2023	41	0	15	Decreasing	−0.74	8.41	6.12	13.47			

* Asterisk denotes background well.

Notes:
Trend tests for COCs with no nondetect results (e.g., uranium) were conducted using the Kendall package in R, version 2.2.1 (McLeod 2022). Trend tests for selenium and vanadium were performed using the NADA (Nondetects and Data Analysis for Environmental Data) package in R, version 1.6-1.1 (Lee 2020). The NADA trend test is similar to the traditional Mann-Kendall trend test except that it accounts for the presence of nondetects at multiple detection limits. All trend analyses were conducted at the 0.05 significance (or alpha) level using a two-sided test. The test statistic, Kendall's tau, is a measure of the strength of the association between two variables, with values always falling between −1 and +1. Increasing trends for any well-analyte combinations are highlighted above.

For the wells identified as having decreasing trends (with concentrations exceeding compliance goals), linear regression of the log-transformed concentration data was performed to estimate when the well's COC concentration was expected to decline below the compliance goal.

Abbreviation:
CI = confidence interval

Table B-3. New Rifle Site Mann-Kendall Trend Analysis and Linear Regression Results, 2014–2023

Monitoring Well	Initial Trend Analysis Date	Final Trend Analysis Date	Number of Samples	Number of Nondetects	Most Recent Result (mg/L)	Mann-Kendall Trend Analysis Results		Linear Regression Results					
								Half-Life (years)			Year Compliance Goal Reached		
						Trend	Tau Value	Trend Line	Lower 95% CI	Upper 95% CI	Trend Line	Lower 95% CI	Upper 95% CI
Uranium (MCL = 0.044 mg/L)													
0169*	6/9/2014	11/7/2023	20	0	0.030	Increasing	0.42				Not applicable (background well)		
0170	6/11/2014	11/7/2023	20	0	0.049	None	−0.15	Not applicable, no trend or concentration less than compliance goal					
0172	6/10/2014	11/7/2023	20	0	0.0087	Decreasing	−0.83						
0195	7/20/2015	11/7/2023	16	0	0.034	None	0.12						
0201	6/9/2014	11/8/2023	19	0	0.10	None	−0.20	Not applicable, no trend					
0215	6/9/2014	11/8/2023	20	0	0.019	None	0.25	Not applicable, no trend and concentration less than compliance goal					
0216	8/7/2014	11/7/2023	20	0	0.0077	None	−0.22						
0217	8/11/2014	11/8/2023	20	0	0.10	Decreasing	−0.69	15.17	11.82	21.17	2041	2036	2049
0590	8/7/2014	11/8/2023	20	0	0.083	None	0.02	Not applicable, no trend					
0620	6/11/2014	11/7/2023	20	0	0.056	Decreasing	−0.48	32.36	19.47	95.77	2031	2026	2055
0635	11/1/2016	11/8/2023	15	0	0.053	None	0.19	Not applicable, no trend					
0658	6/9/2014	11/8/2023	20	0	0.049	None	−0.11						
0659	6/11/2014	11/8/2023	20	0	0.056	Decreasing	−0.35	14.08	7.54	104.87	2030	2025	2101
0664	6/11/2014	11/8/2023	20	0	0.058	None	0.30	Not applicable, no trend					
0669	6/11/2014	11/8/2023	20	0	0.047	None	−0.26						
0670	6/11/2014	11/8/2023	20	0	0.044	Decreasing	−0.36	16.63	9.03	105.48	2031	2025	2094
0855	6/9/2014	11/8/2023	20	0	0.036	None	−0.02	Not applicable, no trend and concentration less than compliance goal					
Molybdenum (MCL = 0.1 mg/L)													
0169*	6/9/2014	11/7/2023	20	1	0.0042	None	0.08	Not applicable, no trend and concentration less than compliance goal					
0170	6/11/2014	11/7/2023	20	0	0.0028	None	−0.24						
0172	6/10/2014	11/7/2023	20	0	0.0074	None	−0.01						
0195	7/20/2015	11/7/2023	16	0	0.016	None	0.30						
0201	6/9/2014	11/8/2023	19	0	1.4	Decreasing	−0.55	24.53	16.79	45.48	2112	2082	2191
0215	6/9/2014	11/8/2023	20	0	0.014	None	−0.23	Not applicable, no trend and concentration less than compliance goal					
0216	8/7/2014	11/7/2023	20	0	0.037	None	−0.20						
0217	8/11/2014	11/8/2023	20	0	1.2	Decreasing	−0.66	22.31	17.04	32.33	2103	2083	2141
0590	8/7/2014	11/8/2023	20	0	1.8	Increasing	0.39	Not applicable, increasing trend					
0620	6/11/2014	11/7/2023	20	0	0.0093	None	−0.06	Not applicable, no trend and concentration less than compliance goal					
0635	11/1/2016	11/8/2023	15	0	0.38	None	−0.12	Not applicable, no trend					
0658	6/9/2014	11/8/2023	20	0	1.9	None	0.11						
0659	6/11/2014	11/8/2023	20	0	0.74	Decreasing	−0.55	12.57	6.42	292.77	2061	2041	3014
0664	6/11/2014	11/8/2023	20	0	0.44	None	0.21	Not applicable, no trend					
0669	6/11/2014	11/8/2023	20	0	0.41	Decreasing	−0.50	9.36	6.27	18.47	2042	2034	2064

Table B-3. New Rifle Site Mann-Kendall Trend Analysis and Linear Regression Results, 2014–2023 (continued)

Monitoring Well	Initial Trend Analysis Date	Final Trend Analysis Date	Number of Samples	Number of Nondetects	Most Recent Result (mg/L)	Mann-Kendall Trend Analysis Results		Linear Regression Results					
								Half-Life (years)			Year Compliance Goal Reached		
						Trend	Tau Value	Trend Line	Lower 95% CI	Upper 95% CI	Trend Line	Lower 95% CI	Upper 95% CI
0670	6/11/2014	11/8/2023	20	0	0.25	None	−0.08	Not applicable, no trend					
0855	6/9/2014	11/8/2023	20	0	0.28	Decreasing	−0.56	11.20	7.00	28.02	2041	2033	2075
Vanadium (0.33 mg/L ACL proposed in 2003 draft GCAP)													
0169*	6/9/2014	11/7/2023	20	7	0.0060	Increasing	0.32				Not applicable (background well)		
0170	6/11/2014	11/7/2023	20	7	0.0060	None	0.23	Not applicable, no trend and concentration less than compliance goal					
0172	6/10/2014	11/7/2023	20	14	0.0050	None	0.13						
0195	7/20/2015	11/7/2023	16	6	0.0052	None	0.27						
0201	6/9/2014	11/8/2023	19	13	0.0038	None	0.18						
0215	6/9/2014	11/8/2023	20	5	0.025	Increasing	0.42	Not applicable, increasing trend					
0216	8/7/2014	11/7/2023	20	0	0.28	None	0.02	Not applicable, no trend and concentration less than compliance goal					
0217	8/11/2014	11/8/2023	20	0	1.7	Decreasing	−0.60	17.55	12.59	28.97	2061	2049	2088
0590	8/7/2014	11/8/2023	20	0	0.55	None	0.16	Not applicable, no trend					
0620	6/11/2014	11/7/2023	20	5	0.0063	None	0.22	Not applicable, no trend and concentration less than compliance goal					
0635	11/1/2016	11/8/2023	15	8	<0.0033	None	−0.02						
0658	6/9/2014	11/8/2023	20	0	26	None	−0.10	Not applicable, no trend					
0659	6/11/2014	11/8/2023	20	0	1.4	None	−0.21						
0664	6/11/2014	11/8/2023	20	0	0.74	Decreasing	−0.40	7.38	4.27	27.02	2036	2029	2082
0669	6/11/2014	11/8/2023	20	0	4.6	Increasing	0.38	Not applicable, increasing trend					
0670	6/11/2014	11/8/2023	20	0	1.6	Decreasing	−0.45	31.20	18.59	96.86	2095	2064	2255
0855	6/9/2014	11/8/2023	20	0	6.5	Decreasing	−0.41	9.97	5.92	31.42	2069	2048	2176
Selenium (SDWA standard = 0.05 mg/L)													
0169*	6/9/2014	11/7/2023	20	0	0.025	None	0.18				Not applicable (background well)		
0170	6/11/2014	11/7/2023	20	0	0.028	Increasing	0.70	Not applicable, increasing trend (concentration less than MCL)					
0172	6/10/2014	11/7/2023	20	16	<0.0075	None	0.07	Not applicable, no trend and concentration less than compliance goal					
0195	7/20/2015	11/7/2023	16	14	<0.0015	None	0.06						
0201	6/9/2014	11/8/2023	19	0	0.098	None	0.21						
0215	6/9/2014	11/8/2023	20	11	0.0065	None	0.13						
0216	8/7/2014	11/7/2023	20	11	<0.0015	None	0.11						
0217	8/11/2014	11/8/2023	20	0	0.0083	None	−0.14						
0590	8/7/2014	11/8/2023	20	0	0.061	None	0.20	Not applicable, no trend					
0620	6/11/2014	11/7/2023	20	0	0.030	None	0.10	Not applicable, no trend and concentration less than compliance goal					
0635	11/1/2016	11/8/2023	15	0	0.027	Increasing	0.64	Not applicable, increasing trend (concentration less than MCL)					
0658	6/9/2014	11/8/2023	20	0	1.3	None	0.04	Not applicable, no trend					
0659	6/11/2014	11/8/2023	20	0	0.017	None	−0.05	Not applicable, no trend and concentration less than compliance goal					
0664	6/11/2014	11/8/2023	20	0	0.38	Increasing	0.43	Not applicable, increasing trend					

Table B-3. New Rifle Site Mann-Kendall Trend Analysis and Linear Regression Results, 2014–2023 (continued)

Monitoring Well	Initial Trend Analysis Date	Final Trend Analysis Date	Number of Samples	Number of Nondetects	Most Recent Result (mg/L)	Mann-Kendall Trend Analysis Results		Linear Regression Results					
								Half-Life (years)			Year Compliance Goal Reached		
						Trend	Tau Value	Trend Line	Lower 95% CI	Upper 95% CI	Trend Line	Lower 95% CI	Upper 95% CI
0669	6/11/2014	11/8/2023	20	0	0.11	Increasing	0.51						
0670	6/11/2014	11/8/2023	20	0	0.23	Decreasing	−0.54	12.39	8.30	24.45	2081	2060	2141
0855	6/9/2014	11/8/2023	20	0	0.52	Decreasing	−0.59	14.74	10.55	24.45	2109	2083	2168
Nitrate (MCL = 10 mg/L)													
0169*	6/9/2014	11/7/2023	20	0	9	None	−0.16	Not applicable, no trend and concentration ≤ 10 mg/L					
0170	6/11/2014	11/7/2023	20	0	10.3	None	0.18						
0172	6/10/2014	11/7/2023	20	12	<0.017	None	−0.16						
0195	7/20/2015	11/7/2023	16	14	<0.017	None	0.13						
0201	6/9/2014	11/8/2023	19	0	17	None	−0.14	Not applicable, no trend					
0215	6/9/2014	11/8/2023	20	10	3.8	None	−0.02	Not applicable, no trend and concentration less than MCL					
0216	8/7/2014	11/7/2023	20	15	<0.017	None	−0.07						
0217	8/11/2014	11/8/2023	20	9	<0.017	None	−0.17						
0590	8/7/2014	11/8/2023	20	0	5.2	None	0.04						
0620	6/11/2014	11/7/2023	20	0	2.4	Decreasing	−0.62						
0635	11/1/2016	11/8/2023	15	0	6.4	Increasing	0.40	Not applicable, increasing trend (concentration less than MCL)					
0658	6/9/2014	11/8/2023	20	0	6.0	None	0.32	Not applicable, concentration less than MCL					
0659	6/11/2014	11/8/2023	20	0	0.52	Decreasing	−0.34						
0664	6/11/2014	11/8/2023	20	0	8.7	Increasing	0.43	Not applicable, increasing trend (concentration <10 mg/L)					
0669	6/11/2014	11/8/2023	20	0	7.2	Increasing	0.36						
0670	6/11/2014	11/8/2023	20	0	9	None	0.22	Not applicable, no trend and concentration less than MCL					
0855	6/9/2014	11/8/2023	20	0	9.8	None	0.07						
Arsenic (MCL = 0.05 mg/L)													
0169*	6/9/2014	11/7/2023	20	7	0.0034	Increasing	0.32	Not applicable, increasing trend (concentration less than MCL)					
0170	6/11/2014	11/7/2023	20	11	0.0034	Increasing	0.33						
0172	6/10/2014	11/7/2023	20	0	0.012	Increasing	0.50						
0195	7/20/2015	11/7/2023	16	3	0.0036	None	0.12	Not applicable, no trend and concentration less than MCL					
0201	6/9/2014	11/8/2023	19	8	0.0039	Increasing	0.33	Not applicable, increasing trend (concentration less than MCL)					
0215	6/9/2014	11/8/2023	20	10	0.0035	None	0.27	Not applicable, no trend and concentration less than MCL					
0216	8/7/2014	11/7/2023	20	0	0.049	None	0.13						
0217	8/11/2014	11/8/2023	20	3	0.0051	None	0.23						
0590	8/7/2014	11/8/2023	20	3	0.0057	Increasing	0.43	Not applicable, increasing trend (concentration less than MCL)					
0620	6/11/2014	11/7/2023	20	8	<0.01	None	0.14	Not applicable, no trend and concentration less than MCL					
0635	11/1/2016	11/8/2023	15	7	0.0024	Increasing	0.45	Not applicable, increasing trend (concentration less than MCL)					
0658	6/9/2014	11/8/2023	20	0	0.15	None	0.01	Not applicable, no trend					

Table B-3. New Rifle Site Mann-Kendall Trend Analysis and Linear Regression Results, 2014–2023 (continued)

Monitoring Well	Initial Trend Analysis Date	Final Trend Analysis Date	Number of Samples	Number of Nondetects	Most Recent Result (mg/L)	Mann-Kendall Trend Analysis Results		Linear Regression Results					
								Half-Life (years)			Year Compliance Goal Reached		
						Trend	Tau Value	Trend Line	Lower 95% CI	Upper 95% CI	Trend Line	Lower 95% CI	Upper 95% CI
0659	6/11/2014	11/8/2023	20	0	0.031	None	−0.09	Not applicable, no trend and concentration less than MCL					
0664	6/11/2014	11/8/2023	20	0	0.0035	None	−0.03						
0669	6/11/2014	11/8/2023	20	0	0.011	Increasing	0.51	Not applicable, increasing trend (concentration less than MCL)					
0670	6/11/2014	11/8/2023	20	0	0.0057	None	0.04	Not applicable, no trend and concentration less than MCL					
0855	6/9/2014	11/8/2023	20	0	0.0767	Decreasing	−0.33	8.44	4.35	140.78	2035	2027	2297
Ammonia (no compliance goal)													
0169*	6/9/2014	11/7/2023	20	14	0.023	None	0.09				Not applicable, no compliance goal		
0170	6/11/2014	11/7/2023	20	0	1.0	Increasing	0.38						
0172	6/10/2014	11/7/2023	20	7	0.12	None	0.03	27.59					
0195	7/20/2015	11/7/2023	16	5	0.049	None	0.14						
0201	6/9/2014	11/8/2023	19	1	39	Decreasing	−0.55	10.30	6.13	32.17			
0215	6/9/2014	11/8/2023	20	1	0.51	Decreasing	−0.39	3.40	2.13	8.37			
0216	8/7/2014	11/7/2023	20	0	3.2	None	−0.28	18.21					
0217	8/11/2014	11/8/2023	20	0	20	Decreasing	−0.70	7.98	5.59	13.93			
0590	8/7/2014	11/8/2023	20	0	60	Decreasing	−0.73	7.16	5.49	10.28			
0620	6/11/2014	11/7/2023	20	12	0.018	None	0.11						
0635	11/1/2016	11/8/2023	15	1	47	None	−0.30	13.79					
0658	6/9/2014	11/8/2023	20	0	27	Decreasing	−0.55	9.12	6.35	16.18			
0659	6/11/2014	11/8/2023	20	0	0.56	Decreasing	−0.38	1.30	0.91	2.25			
0664	6/11/2014	11/8/2023	20	0	13	Decreasing	−0.77	7.86	6.50	9.93			
0669	6/11/2014	11/8/2023	20	1	34	Decreasing	−0.75	6.63	5.28	8.91			
0670	6/11/2014	11/8/2023	20	0	8.6	Decreasing	−0.57	10.88	7.62	19.00			
0855	6/9/2014	11/8/2023	20	0	15	Decreasing	−0.65	6.56	4.99	9.58			

* Asterisk denotes background well.

Notes:
Trend tests for COCs with no nondetect results (e.g., uranium) were conducted using the Kendall package in R, version 2.2.1 (McLeod 2022). Trend tests for selenium and vanadium were performed using the NADA (Nondetects and Data Analysis for Environmental Data) package in R, version 1.6-1.1 (Lee 2020). The NADA trend test is similar to the traditional Mann-Kendall trend test except that it accounts for the presence of nondetects at multiple detection limits. All trend analyses were conducted at the 0.05 significance (or alpha) level using a two-sided test. The test statistic, Kendall's tau, is a measure of the strength of the association between two variables, with values always falling between −1 and +1. Increasing trends for any well-analyte combinations are highlighted above.

For the wells identified as having decreasing trends (with concentrations exceeding compliance goals), linear regression of the log-transformed concentration data was performed to estimate when the well's COC concentration was expected to decline below the compliance goal.

Abbreviation:
CI = confidence interval