LMS/NAP/43947

2022 Verification Monitoring Report for the Naturita, Colorado, Processing Site

July 2023

U.S. DEPARTMENT OF ENERGY | Legacy Management

This document has been designed for online viewing.

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Abbreviations

ACL	alternate concentration limit
BLRA	baseline risk assessment
CDPHE	Colorado Department of Public Health and Environment
CFR	*Code of Federal Regulations*
COPC	contaminant of potential concern
DOE	U.S. Department of Energy
DVP	Data Validation Package
EA	Environmental Assessment
EPA	U.S. Environmental Protection Agency
ft	feet
GCAP	Groundwater Compliance Action Plan
IC	institutional control
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
RAI	request for additional information
SDWA	Safe Drinking Water Act
SOWP	Site Observational Work Plan
TDS	total dissolved solids
UMTRCA	Uranium Mill Tailings Radiation Control Act
USGS	U.S. Geological Survey
VCA	Vanadium Corporation of America
VMR	Verification Monitoring Report
yd^3	cubic yards

Executive Summary

This Verification Monitoring Report (VMR) for the Naturita, Colorado, Processing Site (the site) presents and interprets groundwater and surface water monitoring data collected through calendar year 2022 and evaluates these data in accordance with the 2002 draft *Ground Water Compliance Action Plan for the Naturita, Colorado, UMTRA Project Site*, also called the GCAP. The site is a former vanadium and uranium ore mill located in western Colorado, Montrose County, approximately 2 miles northwest of the town of Naturita. The former mill operated intermittently between 1939 and 1958; surface remediation at the site was completed in 1998. The site encompasses 79 acres and is situated on an elongate section of floodplain between Colorado State Highway 141 on the west and the San Miguel River on the east. The site is managed by the U.S. Department of Energy Office of Legacy Management (LM) under the Uranium Mill Tailings Radiation Control Act (UMTRCA) Title I program and is regulated by the U.S. Nuclear Regulatory Commission (NRC). The site is mostly within an institutional control (IC) boundary encompassing an area of approximately 155 acres, which includes the former mill site and an area extending approximately 0.7 miles north (downgradient) to Calamity Bridge.

Groundwater and surface water quality characterization performed in the 1990s culminated in identifying uranium, vanadium, and arsenic as contaminants of potential concern (COPCs) for groundwater and surface water at the site. Given the nature of past milling operations and the extent of contamination, uranium and vanadium are considered the primary COPCs. Maximum concentration limits (MCLs) for uranium and arsenic in groundwater are 0.044 milligrams per liter (mg/L) and 0.05 mg/L, respectively, the groundwater standards established in Title 40 *Code of Federal Regulations* Section 192 (40 CFR 192). Groundwater standards have not been established for vanadium.

The compliance strategy for the site proposed in the 2002 draft GCAP was developed based on site characterization conducted in the late 1990s and subsequent modeling efforts. The proposed compliance strategy for the site, which NRC has not formally concurred with, is no remediation with the application of alternate concentration limits (ACLs) for uranium (3 mg/L) and vanadium (6 mg/L). For arsenic, the initial proposed strategy was natural flushing in tandem with ICs. Sampling for arsenic was discontinued in 2004 because arsenic concentrations had declined to levels below the 0.05 mg/L standard set forth in 40 CFR 192. LM resumed monitoring for arsenic in 2009 as requested by NRC.

Compliance monitoring at the site consists of sampling eight onsite or downgradient monitoring wells screened in the alluvium and four surface water (San Miguel River) locations. Uranium and vanadium concentrations in groundwater remain below the proposed ACLs in every monitoring well. With few exceptions, arsenic concentrations have been below the 0.05 mg/L MCL across the monitoring network. COPC concentrations measured in the San Miguel River adjacent to and downgradient of the former mill site have been consistently the same as levels in the upgradient location and below acute and chronic Colorado surface water standards.

ICs are an important component of the remedy as described in the GCAP. ICs for downgradient areas are in place and LM monitors IC status annually; ICs were previously pending at the time the last monitoring evaluation report was submitted (in April 2011).

In summary, based on available data, the proposed compliance strategy selected for groundwater at the Naturita processing site continues to be protective of human health and the environment. No complete exposure pathways exist for contaminated groundwater. Vanadium and uranium concentrations in groundwater remain below the proposed ACLs. Arsenic in groundwater remains below the MCL in 40 CFR 192.

1.0 Introduction

The Naturita, Colorado, Processing Site (the site) is a former vanadium and uranium ore mill located in western Colorado, Montrose County, approximately 2 miles northwest of the town of Naturita (Figure 1). The site encompasses 79 acres and is situated on an elongate northeast-southwest section of floodplain between Colorado State Highway 141 on the west and the San Miguel River on the east. The site is 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 and is regulated by the U.S. Nuclear Regulatory Commission (NRC). The site is mostly within an institutional control (IC) boundary encompassing an area of approximately 155 acres, which includes the former mill site and a downgradient area extending 0.7 miles north to Calamity Bridge (Figure 2).

As described in the draft *Ground Water Compliance Action Plan for the Naturita, Colorado, UMTRA Project Site*, also called the GCAP (DOE 2002a), the proposed compliance strategy for the Naturita processing site is no remediation with the application of alternate concentration limits (ACLs) for uranium and vanadium, the two primary contaminants of potential concern (COPCs) in groundwater at the site. ICs (Figure 2) and compliance monitoring at the locations shown in Figure 3 are also key components of the compliance strategy. The purpose of this Verification Monitoring Report (VMR) is to report groundwater and surface water monitoring data that have been collected at the Naturita processing site since 1999 and to assess the performance of the proposed groundwater compliance strategy presented in the draft GCAP.

1.1 Site History

While built in 1930 by the Rare Metals Company, the Naturita mill did not go into operation until 1939, when it was purchased by Vanadium Corporation of America (VCA). The mill operated intermittently between 1939 and 1958, during which time it processed approximately 704,000 tons of uranium and vanadium ore (Ford, Bacon & Davis Utah 1977; DOE 2002b). Initially, a salt-roast, water-leaching process was used during the early period of vanadium recovery but VCA modified that process in 1942 to allow coproduction of uranium and vanadium (Merritt 1971). Figure 4 is a photograph of the mill taken in 1957, just prior to its closure in 1958. VCA operated a uranium upgrader at the site from late 1961 until the mill was dismantled in 1963. In 1967, VCA merged with Foote Mineral Company (the new site owner); the tailings were stabilized in 1969–1970 (ORNL 1980). In the late 1970s to early 1980s, Foote Mineral leased a portion of the site to General Electric to accommodate a uranium ore-buying station (DOE 1998). In 1976, Ranchers Exploration and Development Corporation purchased the 24-acre tailings portion of the site and, between 1977 and 1979, removed and transported an estimated 360,000 tons of tailings to the nearby Durita disposal facility for reprocessing.

Surface remediation at the site occurred between January 1993 and September 1998. During this period, approximately 793,000 cubic yards (yd^3) of contaminated material was removed from the site (MK-F 1998) and stabilized in an engineered disposal cell at the Naturita, Colorado, Disposal Site (formally the Upper Burbank disposal cell), about 15 miles northwest of the processing site, near the former town of Uravan, Colorado (Figure 1). Supplemental standards were applied to the areas shown in Figure 2, totaling approximately 11 acres on the Naturita processing site and another 11 acres on the adjoining vicinity property downgradient of the site.

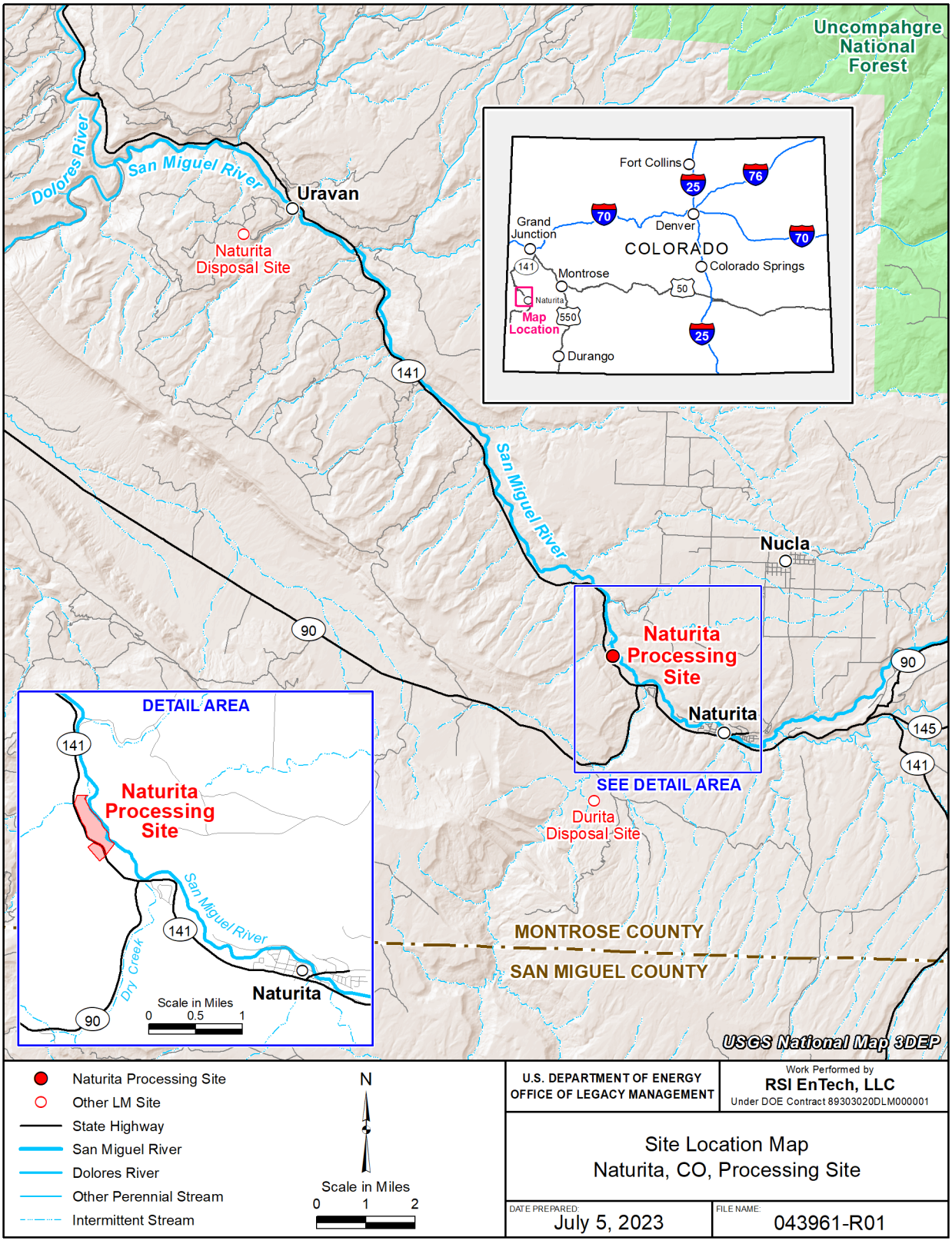


Figure 1. Naturita, Colorado, Processing Site Location

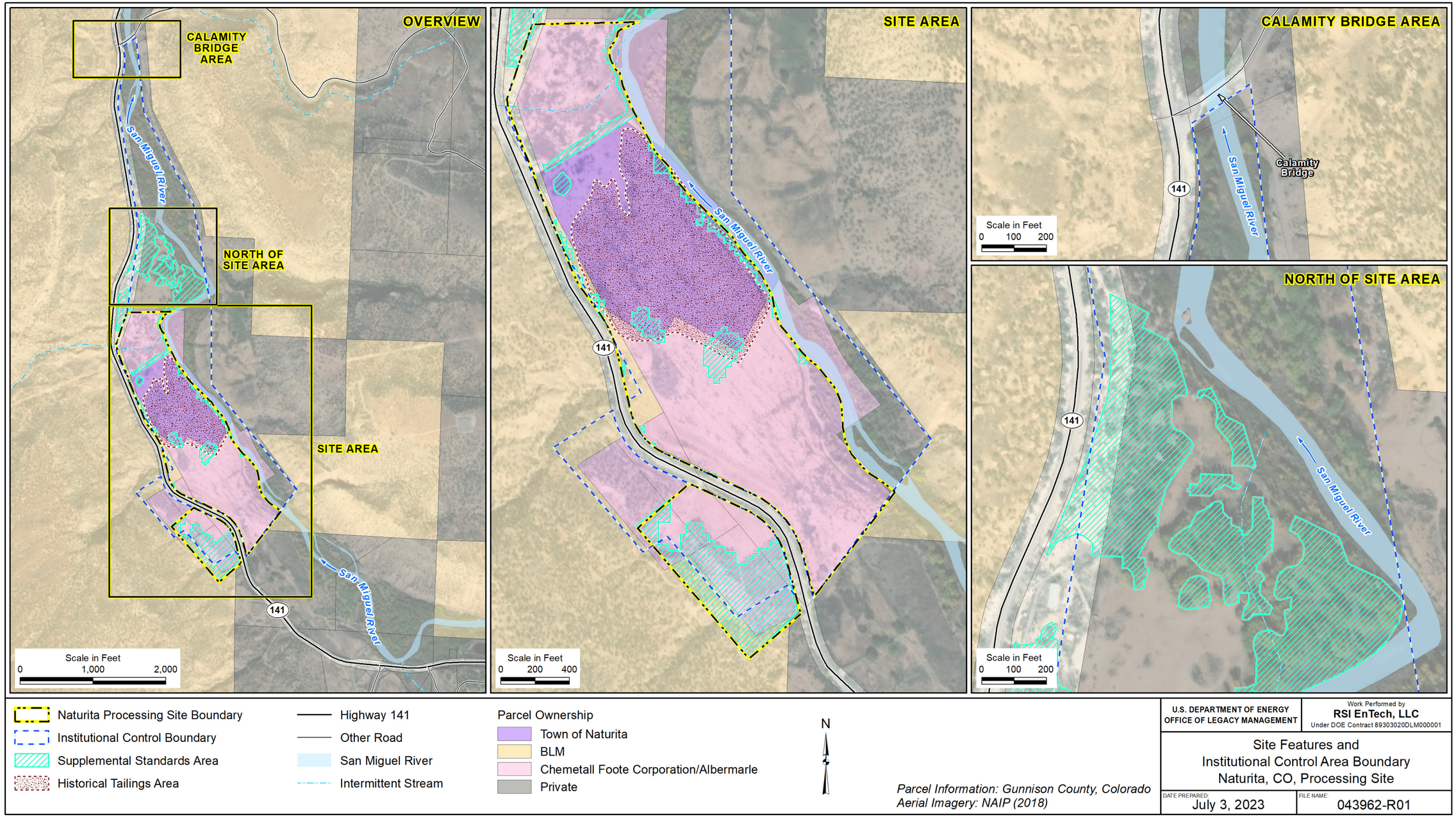
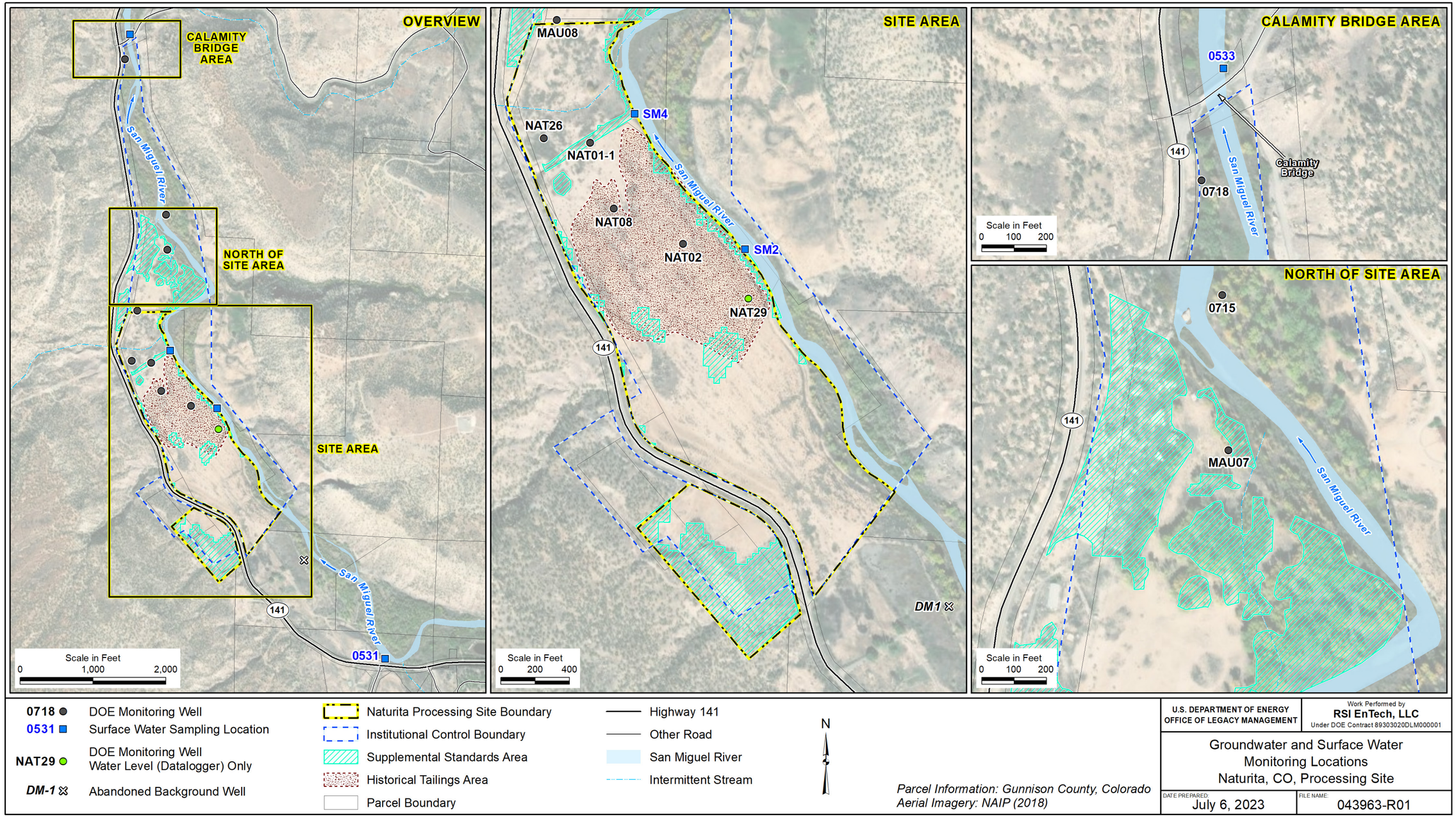


Figure 2. Site Features, Parcel Ownership, and Institutional Control Area Boundary



Note: Only a subset of existing well locations have been routinely sampled since the GCAP (DOE 2002a) was submitted. Appendix A, Figure A-1, shows existing wells.

Figure 3. Groundwater and Surface Water Monitoring Locations

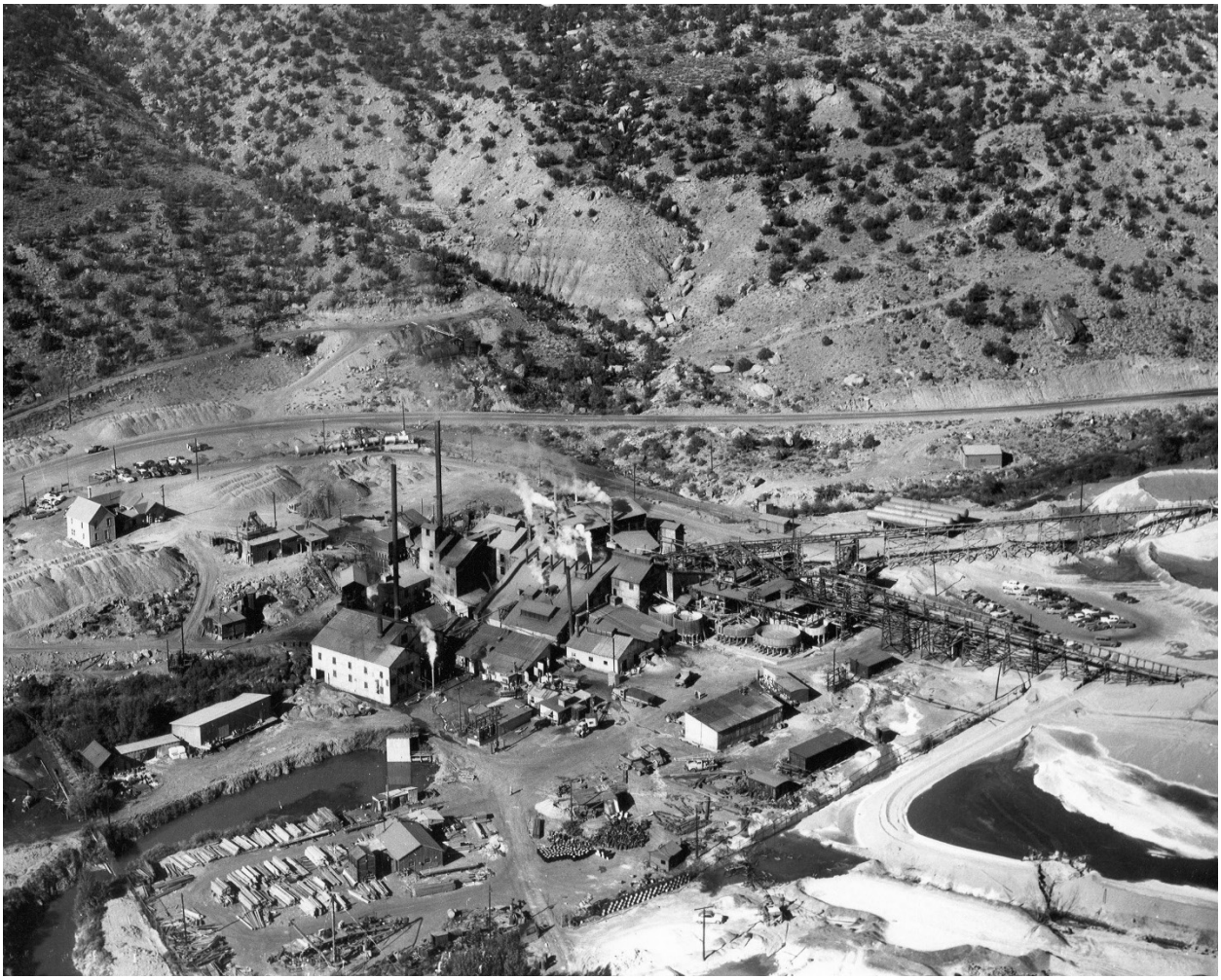


Figure 4. Naturita Mill in 1957, View to Northwest

More detailed historical information is provided in the *Environmental Assessment of Ground Water Compliance at the Naturita, Colorado, UMTRA Project Site*, also called the EA (DOE 2003), and on the LM website.[1] Site characterization activities began in 1998 in collaboration with the U.S. Geological Survey (USGS). These activities, in combination with flow and transport modeling, culminated in the development of the Site Observational Work Plan (SOWP) (DOE 2002b), the proposed compliance strategy outlined in the GCAP (DOE 2002a), and the EA (DOE 2003). The compliance strategy is discussed in detail in Section 1.3.

In addition to performing monitoring well installation and environmental sampling, USGS conducted a series of investigations, including a field demonstration of a uranium (VI) surface complexation model (NRC 2003). Although not germane to this VMR, LM may utilize results of subsequent USGS investigations (e.g., Davis et al. 2006) while developing a revised GCAP for the site (see Section 1.3.1.3 of this report).

Table 1 summarizes the key historical events and site evaluations discussed above as well as other activities relevant to development of the site compliance strategy and this VMR.

[1] https://lmpublicsearch.lm.doe.gov/SitePages/default.aspx?sitename=Naturita_Processing

Table 1. Summary of Key Site Activities and Historical Evaluations

Activity or Evaluation	Date or Time Frame	Description
Mill operation	1939–1958	During this period, the mill processed 704,000 tons of ore. The mill shut down at the end of World War II but reopened in 1947 (DOE 1998).
Uranium upgrader operations and mill dismantling	1961–1963	VCA operated a uranium upgrader for sand-slime separation (Merritt 1971). The mill was dismantled in 1963.
Foote Mineral Corporation purchases VCA	1967	VCA merged with Foote Mineral Company, and the site ownership passed to Foote (DOE 1998).
Foote Mineral leases part of site to General Electric	1975	General Electric used a portion of the site as a buying station for uranium ore. These operations continued into the 1980s (DOE 2003).
Tailings removed from site	1976–1979	Ranchers Exploration and Development Corporation purchased the tailings pile portion of the site in 1976. An estimated 360,000 tons of tailings were removed and transported offsite for reprocessing between 1977 and 1979.
Surface remediation and BLRA development	1993–1998	During this time, approximately 793,000 yd^3 of residual radioactive materials were removed from the site. This volume included 771,400 yd^3 from the mill site and an additional 21,820 yd^3 from adjoining vicinity properties (MK-F 1998). The BLRA was developed based on data from 1989–1994 (DOE 1995) and recommended continued monitoring of uranium, vanadium, and arsenic.
Site characterization	1998–2001	Site characterization efforts culminated in the SOWP, a report documenting the site conceptual model on which the compliance strategy was based (DOE 2002b).
Well 0715 installed across the San Miguel River SOWP and draft GCAP submitted to NRC	2002	A new well (0715) was installed across the river in April. SOWP and GCAP issued in May and September, respectively (DOE 2002b; DOE 2002a). Initial IC boundary established.
EA issued	April 2003	DOE submits EA of groundwater compliance (DOE 2003).
Monitoring frequency reduced from semiannual to annual	2004	At this time, because arsenic concentrations were below the 0.05 mg/L UMTRCA maximum concentration limit, monitoring for arsenic was suspended until 2009 (see below).
NRC comments on the DOE 2002 GCAP	May 2005	NRC issued an RAI for the SOWP (DOE 2002b) and the GCAP (DOE 2002a).
Installation of downgradient alluvial well 0718	October 2008	To better understand the extent of uranium contamination downgradient of the site boundary, alluvial well 0718 was installed just upstream from Calamity Bridge (Figure 3). At this time, LM also conducted field work to verify the presence of bedrock outcrops north of the modeled no-flow-boundary area (Kautsky 2009).
LM response to NRC RAI	2009	LM responded to NRC's RAI in July 2009 (Kautsky 2009) and resumed monitoring for arsenic at groundwater and surface water locations. LM also resumed sampling of downgradient well 0715, across the San Miguel River (Figure 4). Prior to 2009, this well had last been sampled in 2002, shortly after installation.
Previous seep (location 0538) covered with cobbles to prevent exposure	April 2010	A persistent groundwater seep (surface location 0538) with elevated uranium concentrations was covered with cobbles and sand under a permit issued by the U.S. Army Corps of Engineers. This action was taken to eliminate potential exposure routes and risks to livestock and wildlife.
Background well (DM1) abandonment	July 2016	Background well DM1 was abandoned on July 19, 2016, at the request of the private owner.

Abbreviations:
BLRA = baseline risk assessment
mg/L = milligrams per liter
RAI = request for additional information

1.2 Hydrologic Setting

The unconfined alluvial aquifer beneath and downgradient of the former processing site is the uppermost aquifer at the site. It consists of a wedge of sediment that pinches out along the western bedrock and reaches a maximum thickness of about 23 feet (ft) by the San Miguel River along the northern portion of the site (DOE 2002b). Over most of the site, the alluvium is generally 5 to 10 ft thick. The underlying minimally permeable Brushy Basin Member of the Morrison Formation separates the alluvial aquifer from the deeper Salt Wash aquifer.

Recharge and discharge occur along the length of the San Miguel River, depending on the river level, but ultimately groundwater exits back into the river north of the site. Other sources of recharge include water entering the alluvial aquifer from arroyos draining from the west and precipitation. Detailed supporting information describing the site hydrologic system is provided in the SOWP (DOE 2002b) and the EA (DOE 2003).

1.3 Site Compliance Strategy and Water Quality Monitoring

1.3.1 Compliance Strategy Evolution

1.3.1.1 Initial Compliance Strategy (SOWP)

The compliance strategy proposed in the GCAP was adapted from the strategy initially proposed in the SOWP (DOE 2002b). The precursor to the SOWP, the baseline risk assessment (BLRA), concluded that three COPCs—uranium, vanadium, and (to a lesser degree) arsenic—posed a potential human health or ecological risk (DOE 1995). Based on evaluations of COPC migration and attenuation potentials, the SOWP proposed the following two compliance strategies for the site (DOE 2002b):

(1) Natural flushing with ICs and continued monitoring for arsenic

(2) No remedial action with the application of ACLs for uranium and vanadium, combined with ICs and continued monitoring as a best management practice

ACLs of 3 milligrams per liter (mg/L) and 6 mg/L were proposed as action levels at the points of compliance (POCs) for uranium and vanadium, respectively. These values correspond to the approximate maximum concentrations measured in groundwater in the years following surface remediation. The ACLs are considered protective of human health because of the lack of a complete exposure pathway for groundwater and expected dilution of any contaminants entering the San Miguel River (a factor of 3000–5000 [DOE 2002b]). POCs were defined in the SOWP as any location within the IC boundary, while points of exposure (POEs) were defined as any point along the San Miguel River (DOE 2002b). As such, any COPC concentration at or below the corresponding ACL in the POC wells would result in acceptable concentrations at the points of exposure along the San Miguel River.

1.3.1.2 Compliance Strategy Proposed in 2002 GCAP

The compliance strategy proposed in the GCAP is the same as that proposed in the SOWP with the exception of natural flushing and continued monitoring for arsenic (DOE 2002a). The rationale for this change was because, at the time the GCAP was developed, average arsenic

concentrations were at or below the UMTRCA standard (0.05 mg/L) and modeling indicated that concentrations would continue to decrease over time. Because arsenic was no longer considered a COPC, the compliance strategy ultimately proposed for the site was no remediation and application of ACLs for uranium and vanadium in tandem with ICs and routine monitoring (DOE 2002a). While the SOWP defined POCs as any location within the IC boundary, the GCAP defined these locations as all wells in the monitoring network (DOE 2002a).

1.3.1.3 Current Status

As of mid-2023, NRC has not approved the 2002 GCAP. In May 2005, NRC issued a request for additional information (RAI) pertaining to both the SOWP and the GCAP (Fliegel 2005). With respect to the GCAP, NRC's primary concerns pertained to the need for demonstration and verification of ICs (e.g., environmental covenants) and access controls, in particular for the supplemental standards areas. NRC also suggested that LM reconsider the exclusion of arsenic as a COPC given the pending lowering of the U.S. Environmental Protection Agency (EPA) maximum contaminant level from 0.05 mg/L (equivalent to the Title 40 *Code of Federal Regulations* Section 192 [40 CFR 192] maximum concentration limit [MCL]) to 0.01 mg/L (effective date of January 2006).[2, 3] LM responded to NRC comments in July 2009 (Kautsky 2009) and committed to resuming monitoring for arsenic in groundwater and surface water samples. In response to previous NRC comments and recent correspondence, LM intends to issue a revised GCAP for the site as soon as required evaluations are complete (e.g., confirming flow and transport assumptions used in the SOWP).

The last VMR and monitoring evaluation report issued for the site documented results of the 2009 and 2010 sampling efforts, respectively (DOE 2010b; DOE 2011). The monitoring evaluation report stated that VMRs were no longer required because the compliance strategy for the site does not include natural flushing or active remediation. Instead, LM committed to providing Data Validation Packages (DVPs) for the site as a mechanism for reporting monitoring results. However, LM stopped issuing DVPs in 2017 (DOE 2017). Given that: (1) 12 years have passed since the last monitoring evaluation report was issued (DOE 2011) and (2) the proposed compliance strategy has not been approved by NRC, LM has elected to continue annual sampling and resume reporting, through a biennial VMR, as demonstrated in this report.

1.3.2 Monitoring Program

Groundwater and surface water samples are typically collected annually (usually in July) from the eight monitoring wells and four surface water monitoring locations shown in Figure 3 and listed in Table 2. The monitoring wells currently monitored are screened in the alluvium between 5 and 18 ft below ground surface. In accordance with the GCAP, samples are routinely analyzed for uranium, vanadium, total dissolved solids (TDS), and field parameters (DOE 2002a). Although locations were initially monitored for arsenic (2000–2002), those analyses were suspended in 2004 to reflect the revised compliance strategy discussed in Section 1.3.1. Monitoring for arsenic was resumed in 2009 in response to NRC's RAI (Fliegel 2005; Kautsky 2009).

[2] https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=300065YM.txt

[3] NRC also requested that LM (1) provide quality assurance measures used during sample collection and (2) document approaches for evaluating and reporting data and for assessing whether site conditions are consistent with the modeling predictions. NRC's main comments focused on the demonstration of ICs and protectiveness.

Table 2. Naturita Site Sampling Locations

Location	Addressed in GCAP	Monitoring Purpose[a]
Groundwater Monitoring Locations[b, c]		
NAT02	No	Well installed in the center of the former tailings area; POC well for uranium and vanadium.
NAT08	Yes	POC well within former tailings area; location of maximum vanadium concentration.
NAT01-1	No	POC well added at NRC's request to monitor vanadium concentration migrating toward river.
NAT26*	Yes	POC well; location of maximum uranium concentration.
MAU08*	Yes	POC well to monitor uranium.
MAU07*	Yes	POC well adjacent to supplemental standards area (Figure 3).
0715	No	Installed in the alluvium on the east side of the San Miguel River, downgradient of site boundary. This well was first sampled in April 2002 shortly after installation but was not sampled again until 2009. It has been routinely monitored since then.
0718*	No	Alluvial well immediately upstream of Calamity Bridge. Well installed in October 2008 to assess extent of groundwater contamination.
Surface (San Miguel River) Location[d]		
0531	Yes	Upgradient San Miguel River.
0533	Yes	POE location, downgradient San Miguel River.
SM2	Yes	POE location
SM4	Yes	POE location
Historical Monitoring Locations		
DM1	Yes	Former background groundwater monitoring location (DOE 2002a). This well was abandoned in July 2016 at the request of the private owner.
Seep 0538	No	Seep on former private property north of the site (location shown in Appendix A, Figure A-1). This location no longer exists; a wetland project was completed to prevent surface water exposure to cattle or wildlife (DOE 2010a).

Notes:

[a] For most locations, the monitoring purpose was adapted from Table 3-2 of the GCAP (DOE 2002a).

[b] Monitoring wells are listed in order of increasing distance from the former tailings area and correspond to the general direction of groundwater flow.

[c] Locations followed by an asterisk were instrumented with transducers in June 2019 for continuous water level measurements.

[d] Surface water sampling locations are listed in order of upgradient to downgradient location.

Two locations previously routinely sampled are no longer monitored. Former background well DM1 was abandoned in July 2016 as requested by the private landowner. In the past, surface water was sampled at location 0538, a former seep in a historical channel of the San Miguel River where groundwater surfaced (location shown in Appendix A, Figure A-1). Uranium concentrations were fairly consistent at this location at about 0.2 mg/L, exceeding the 0.044 mg/L MCL. To eliminate any potential risk associated with wildlife and livestock exposure to the water, the area was converted to a wetland and filled with cobbles and sand in April 2010. The work was completed under a U.S. Army Corps of Engineers 404 Nationwide Permit, and it resulted in no net loss of wetlands (DOE 2010a). Surface water is no longer present in the historical channel except during periods of high river stage, when river water floods the area (DOE 2011).

The groundwater COPCs currently monitored at the site are summarized in Table 3 along with corresponding benchmarks and proposed ACLs. Comparative values for COPCs in surface water (San Miguel River) samples are provided in Section 2.3 of this VMR.

Table 3. Groundwater COPCs, Benchmarks, Proposed ACLs, and Background Ranges

COPC	40 CFR 192 MCL (mg/L)	Proposed ACL[a] (mg/L)	Alternate Benchmark (mg/L)	Background Range[b] (mg/L)	Comments
Uranium	0.044	3	NA	0.002–0.011	Primary COPC addressed in the GCAP. Although consistently below the proposed ACL, uranium concentrations have been elevated relative to the 0.044 mg/L MCL in site monitoring wells including, for a period, downgradient well 0718.
Vanadium	NA	6	0.33[c] 0.086[d]	0.0005–0.0009	As demonstrated in the following section, elevated vanadium concentrations are limited to wells installed in the former tailings area, NAT02 and NAT08.
Arsenic	0.05	NA	0.01[e]	0.0006–0.0025	Initially identified as a COPC in the BLRA and the SOWP (DOE 1995; DOE 2002b). Because concentrations in monitoring wells had declined to levels below the UMTRCA standard, arsenic was not addressed in the GCAP (DOE 2002a) and monitoring was discontinued in 2004. In response to a request by NRC, sampling for arsenic resumed in July 2009.

Notes:
[a] ACL proposed in the GCAP (DOE 2002a) based on the SOWP (DOE 2002b) and the BLRA (DOE 1995).
[b] Data are from former background well DM1, monitored 2002–2016; cited ranges reflect detections only. Well DM1 was abandoned in 2018 at the request of the private owner.
[c] Risk-based concentration for vanadium cited in the SOWP and the GCAP based on an EPA risk-based concentration applied in 2002.
[d] Current EPA Regional Screening Level table (May 2023) cites a lower risk-based value (for tap water) of 0.086 mg/L (https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables).
[e] EPA "Safe Drinking Water Act" (Title 42 *United States Code* Section 300f) maximum contaminant level.
Abbreviation: NA = not applicable

1.3.3 Institutional Controls

ICs are in place to restrict access to subsurface soils and groundwater within the boundary identified in Figure 2. The current IC boundary encompasses an area of approximately 155 acres, which includes the former mill site and a downgradient area extending approximately 0.7 miles north of the site boundary to Calamity Bridge. The historical mill site area consists of 79 acres and includes property now owned by the Town of Naturita and Albermarle (formerly Chemetall Foote Corporation). The ICs for the site are environmental covenants between the landowners and the State of Colorado, represented by the Colorado Department of Public Health and Environment (CDPHE). Currently, the environmental covenants address the processing site and areas within the IC boundary depicted in Figure 2. The covenants within the IC boundary prohibit excavation of soil and access to the alluvial groundwater. The covenant also prohibits the installation of wells in the alluvial aquifer for purposes other than environmental monitoring and remediation. LM routinely monitors the status of ICs as well as the IC boundary extent to ensure protection of human health and the environment.

2.0 Compliance Remedy Performance

The proposed groundwater compliance strategy at the Naturita site is application of ACLs for uranium and vanadium, with ICs encompassing the former mill site and a downgradient area extending 0.7 miles north to Calamity Bridge (Figure 2). Although not included in the compliance strategy in the GCAP (DOE 2002), this section also addresses arsenic in response to NRC's concern about historical concentrations present above the EPA Safe Drinking Water Act (SDWA) standard.

This section begins with a discussion of groundwater elevation trends; groundwater flow conditions are assumed to be the same as those described in the SOWP when the monitoring network was much more extensive. Historical concentrations of uranium, vanadium, and arsenic in groundwater and surface water are then evaluated to access localized groundwater trends at and downgradient of the site. The analysis is limited to an evaluation of concentration trends because the current monitoring network allows neither an evaluation of plume geometry over time nor an evaluation of bulk plume metrics.

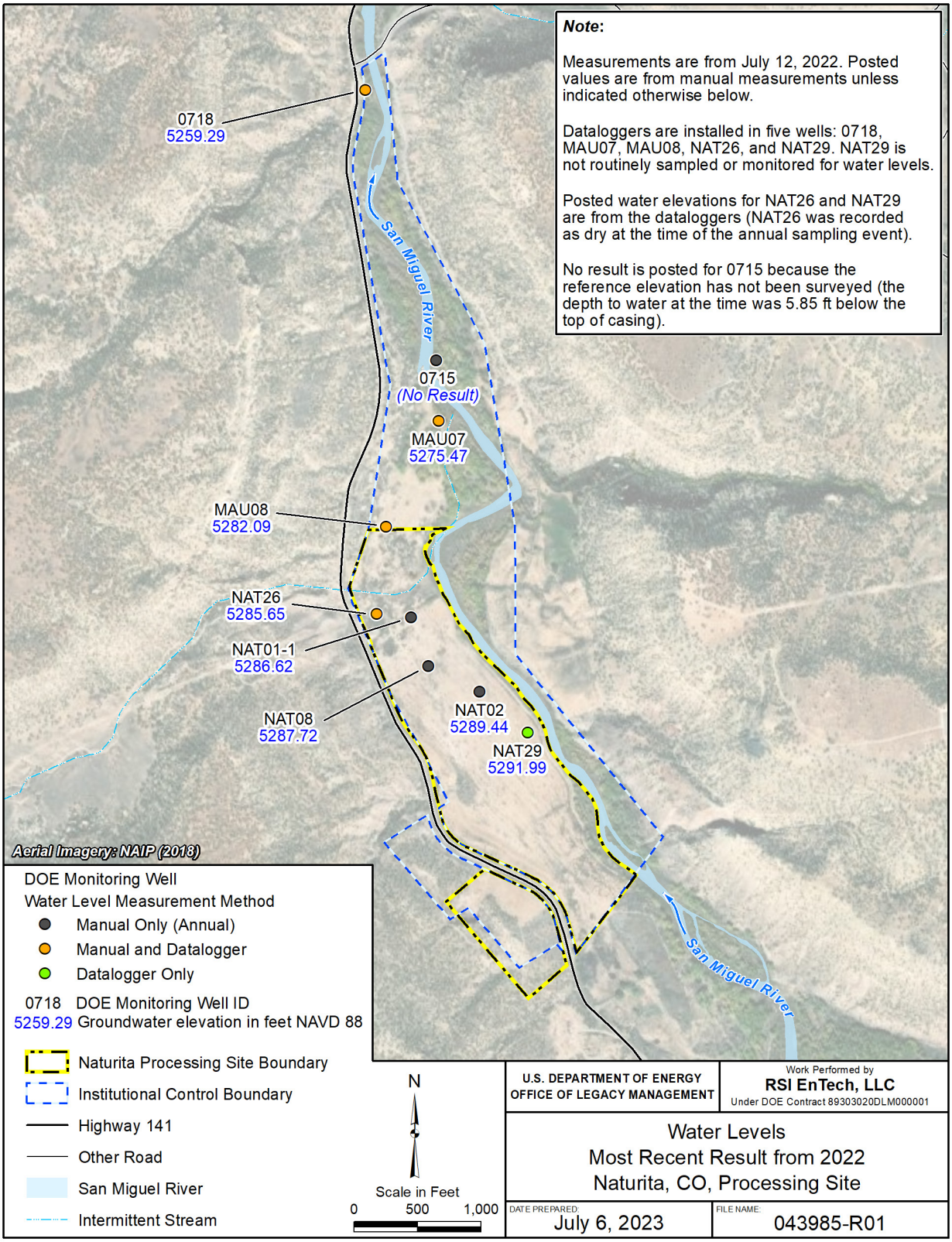
Water quality data, sampling locations, and other site information are available on the LM Geospatial Environmental Mapping System website.[4] The data plots provided in this VMR were developed using the software R, version 4.2.2 (R Core Team 2022) and ggplot2 (version 3.4.1) (Wickham 2016). Time-concentration plots were developed using a faceting approach, whereby data are partitioned into a matrix of panels, with each panel plotting data for a single well (Wickham 2016). In each facet, a nonparametric smoothing method—locally estimated scatterplot smoothing (LOESS)—is used. 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.

2.1 Groundwater Levels

Groundwater elevations measured in July 2022 for site monitoring wells are shown in Figure 5; corresponding temporal trends are shown in Figure 6. Groundwater elevation generally decreases with distance downstream and downgradient in the alluvial aquifer, as expected and consistent with groundwater flow directions characterized in the SOWP (DOE 2002b) and in the EA (DOE 2003). Historically, groundwater levels have fluctuated about 2–3 ft (Figure 6). Site-related groundwater contamination moves in a generally northeast direction toward the river (DOE 2002b). USGS river gage data from the vicinity of the site is not sufficient for correlating these data with San Miguel River stages.[5]

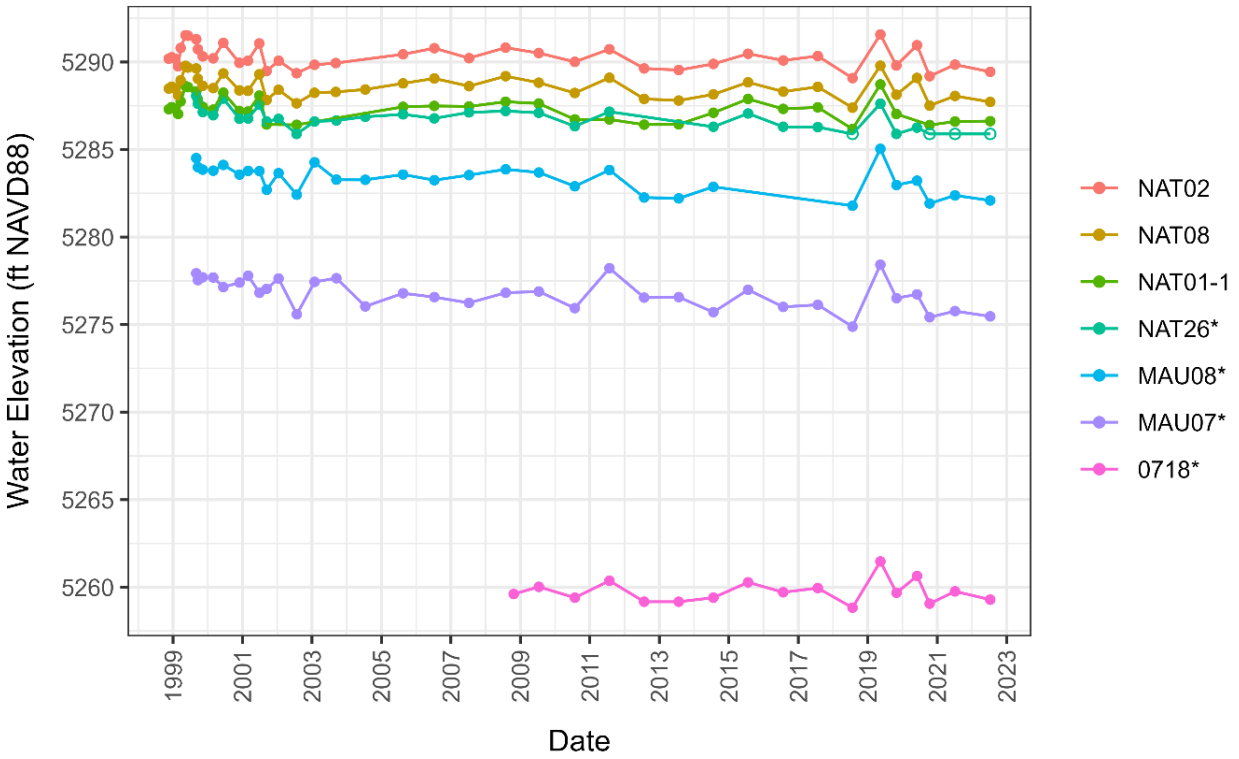
[4] https://gems.lm.doe.gov/#site=NAP

[5] The closest active USGS gage to the Naturita site is at Brooks Bridge near Nucla, Colorado (USGS 09174600): https://waterdata.usgs.gov/monitoring-location/09174600/#parameterCode=00065&period=P7D. While the San Miguel River gage at Naturita (USGS 09175500) is closer to the site, it is no longer monitored: https://waterdata.usgs.gov/nwis/inventory/?site_no=09175500&agency_cd=USGS.



Abbreviation: NAVD 88 = North American Vertical Datum of 1988
Note: Water table contours were not generated for this figure because there are insufficient data to do so. Groundwater elevation contours from January 2002 are shown in Figure 9 of the EA (https://lmpublicsearch.lm.doe.gov/lmsites/nap_ea.pdf).

Figure 5. July 2022 Groundwater Elevations in Site Alluvial Monitoring Wells

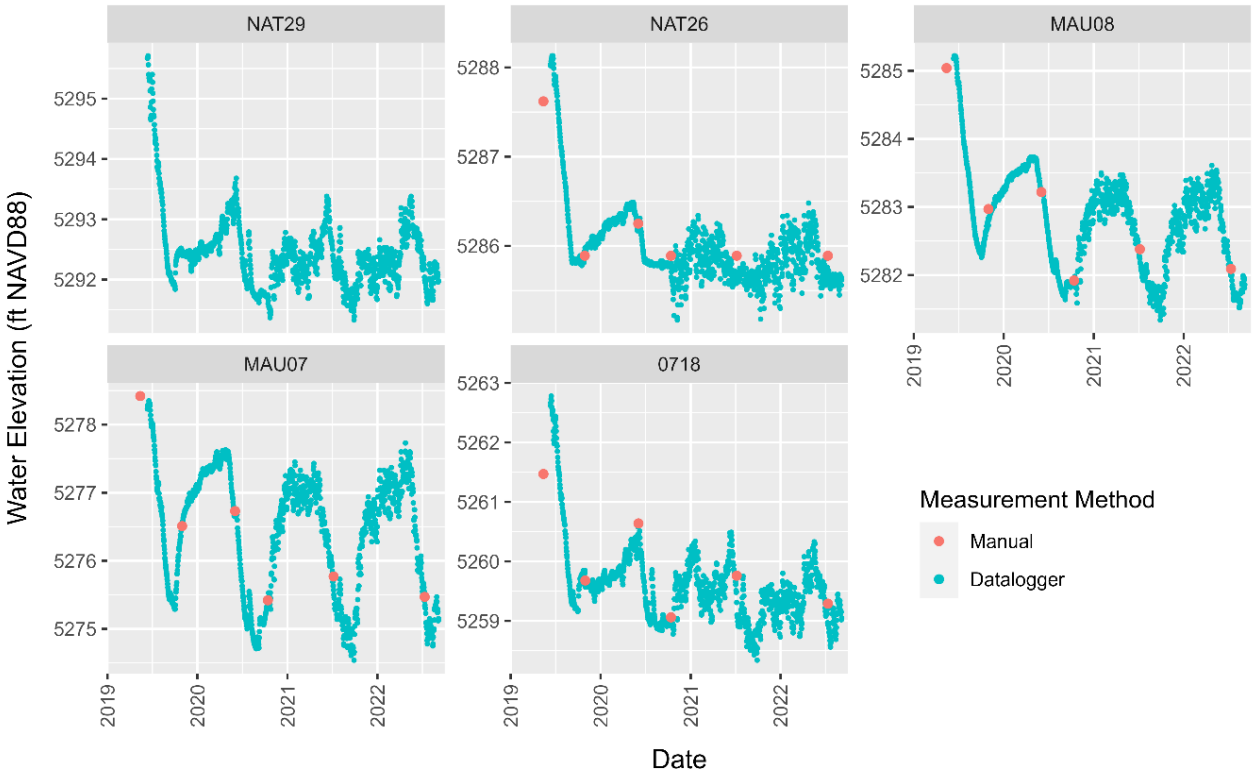


○ Hollow symbols denote that the well was dry or had insufficient water to sample.
For plotting purposes, these records are assigned values equal to the minimum recorded elevation.
Abbreviation: NAVD88 = North American Vertical Datum of 1988

Figure 6. Temporal Trends of Groundwater Elevations in Site Monitoring Wells, 1998–2022

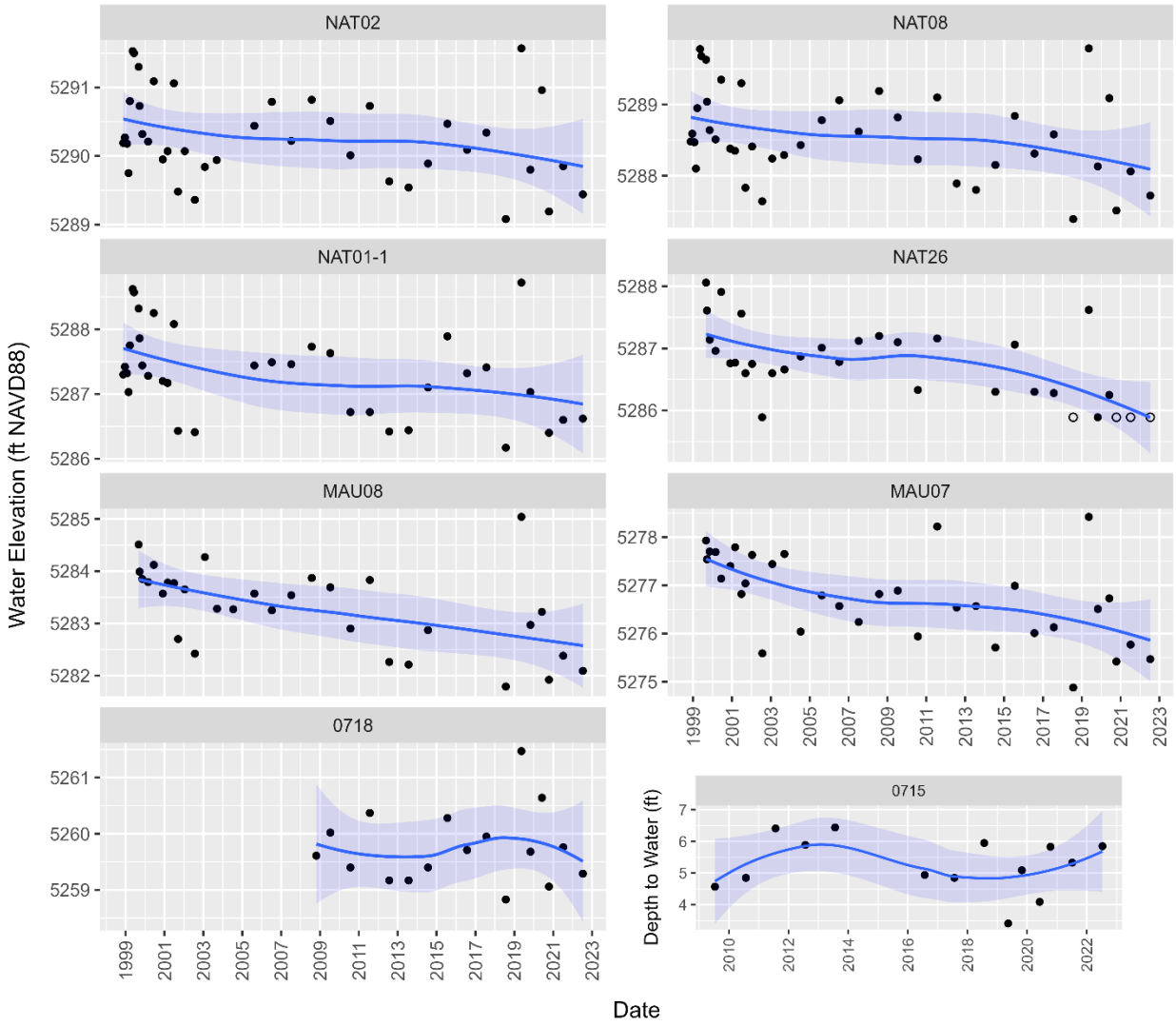
In June 2019, LM installed transducers in five monitoring wells for continuous monitoring of groundwater elevations. Figure 7 plots the datalogger measurements along with corresponding manual (annual sampling) results. Data plots for individual wells are in order of the general direction of groundwater flow (upgradient wells are listed first). Figure 7 shows that (1) there is close agreement between the datalogger measurements and the manual data and (2) the largest fluctuations in groundwater elevations for this 4-year period are found in well MAU07, closest to the river.

The y-axis scale in the line plot in Figure 6 spans approximately 30 ft due to the much lower elevation in downgradient-most well 0718. To provide greater resolution, Figure 8 plots the same data but using unique scales. This figure shows declines in groundwater elevations of about 1 to 2 ft relative to 1998 conditions (as shown in the SOWP). Well NAT26 has been dry or had insufficient water to sample since October 2020.



Abbreviation: NAVD88 = North American Vertical Datum of 1988

Figure 7. Datalogger Measurements in Selected Wells, June 2019–2022



Locally estimated scatterplot smoothing local regression line and 95% confidence interval

○ Hollow symbols denote that the well was dry or had insufficient water to sample. For plotting purposes, these records are assigned values equal to the minimum recorded elevation.

Notes:

To provide greater resolution, y-axis scales are unique for each well. Therefore, any between-well comparisons of groundwater elevations should be made with caution.

Well 0715, on the east side of the San Miguel River, has not been surveyed for a reference (top of casing) or surface elevation. The plot in the lower right portion of this figure plots depth to water instead.

Abbreviation: NAVD88 = North American Vertical Datum of 1988

Figure 8. Groundwater Elevations in Naturita Site Alluvial Wells, 1998–2022: Unique Scales

2.2 COPC Concentration Trends in Alluvial Aquifer Monitoring Wells

This section updates groundwater and surface water monitoring data collected at the site since surface remediation and assesses the status of the compliance strategy for groundwater cleanup. Concentrations of uranium, vanadium, and arsenic were plotted for wells within the monitoring well network for the period from 2000 to July 2022.[6] In evaluating concentration trends, arsenic is treated as a COPC even though it was not designated as such in the GCAP.

Because of the wide range in contaminant concentrations measured across site wells, time-concentrations plots presented in this section were generated using a semilogarithmic scale. In each figure, individual (well-specific) plots are arranged in general order of increasing distance from the former mill site and corresponding to flow direction, consistent with their listing in Table 2. The individual plots show the most recent result (most rounded to three significant figures) while the geospatial figures (the maps plotting only the most recent results) show the raw (unrounded) result from LM's Environmental Quality Information System (EQuIS) database.

Mann-Kendall trend analysis was performed to determine whether COPC concentrations in individual monitoring wells are declining, stable, or increasing. To facilitate review of the time-concentration plots, these results are reflected on each figure. For well-analyte combinations identified as having statistically significant trends ($p < 0.05$), the direction of the trend is indicated on the plot. Mann-Kendall trend tests were initially run for the period 2000–2022, representing measurements collected since postremediation monitoring began. To account for potential shifts in trends in the last decade, a second set of Mann-Kendall trend tests was run for the 2010–2022 time frame (Table 4). This second set of analyses also helps assess data trends since the last VMR was issued (DOE 2011).

2.2.1 Uranium

Figure 9 plots the most recent uranium results for site monitoring wells along with surface water sampling results. Results correspond to the 2022, sampling event except for well NAT26 (result from June 2020), which was dry at the time of the last two sampling events (Figure 6). Temporal trends of uranium concentrations in monitoring wells are shown in Figure 10.

Uranium concentrations in site wells have been consistently below the proposed ACL of 3 mg/L. However, concentrations continue to exceed the 0.044 mg/L MCL except for downgradient-most well 0718 (0.0359 mg/L in 2022). Uranium concentrations in remaining wells range from 0.0602–1.37 mg/L (Table 4). The highest uranium concentrations have been detected in well NAT26, farthest from the river. Uranium concentrations in well 0715, across the San Miguel River, have been stable at about 0.05–0.06 mg/L since monitoring resumed in 2009. Concentrations in well 0718 have periodically exceeded the 0.044 mg/L MCL (in Figure 10), for example in 2019 (0.047–0.087 mg/L). Mann-Kendall trend tests identified statistically significant decreasing trends for wells except wells 0715 and 0718 (Table 4). However, trends have stabilized in wells NAT26 and MAU07 for the more recent 2010–2022 sampling period.

[6] Although site remediation was completed in 1998, analytical results for groundwater samples collected in 1998 and 1999 were not validated and therefore are not included in this analysis.

Table 4. Mann-Kendall Trend Analysis Results: COPC Trends in Site Monitoring Wells

Well[a]	Initial Trend Analysis Date	Final Trend Analysis Date	Most Recent Result (mg/L)	2000–2022 Time Frame				2010–2022 Time Frame				
				No. of Samples (No. of Nondetects)	Kendall's Tau[b]	p-value[c]	Trend	Initial Trend Analysis Date	No. of Samples (No. of Nondetects)	Kendall's Tau[b]	p-value[c]	Trend
Uranium												
NAT02	11/29/2000	7/12/2022	0.0976	28	−0.69	0	Decreasing	7/27/2010	15	−0.438	0.025	Decreasing
NAT08	11/29/2000	7/12/2022	0.142	29	−0.729	0	Decreasing	7/27/2010	15	−0.438	0.025	Decreasing
NAT01-1	11/29/2000	7/12/2022	0.241	28	−0.767	0	Decreasing	7/27/2010	15	−0.438	0.026	Decreasing
NAT26	11/29/2000	6/2/2020	1.37	21	−0.776	0	Decreasing	7/27/2010	8	−0.107	0.799	No trend*
MAU08	11/30/2000	7/12/2022	0.316	29	−0.741	0	Decreasing	7/27/2010	15	−0.4	0.042	Decreasing
MAU07	12/1/2000	7/12/2022	0.282	29	−0.32	0.016	Decreasing	7/27/2010	15	0.067	0.767	No trend*
0715	7/14/2009	7/12/2022	0.0602	14	−0.077	0.743	No trend	Not applicable[d]				
0718	10/23/2008	7/12/2022	0.0359	17	−0.301	0.099	No trend					
Vanadium												
NAT02	11/29/2000	7/12/2022	0.145	28 (1)	−0.759	0	Decreasing	7/27/2010	15 (1)	−0.676	0	Decreasing
NAT08	11/29/2000	7/12/2022	1.2	29	−0.887	0	Decreasing	7/27/2010	15	−0.752	0	Decreasing
NAT01-1	11/29/2000	7/12/2022	<0.00376	28 (10)	−0.008	0.967	No trend	7/27/2010	15 (5)	−0.019	0.958	No trend
NAT26	11/29/2000	6/2/2020	0.00385	21 (10)	0.176	0.252	No trend	7/27/2010	8 (2)	0.107	0.793	No trend
MAU08	11/30/2000	7/12/2022	<0.00484	29 (14)	0.222	0.082	No trend	7/27/2010	15 (6)	0.295	0.12	No trend
MAU07	12/1/2000	7/12/2022	<0.00335	29 (22)	0.027	0.842	No trend	7/27/2010	15 (12)	0.086	0.655	No trend
0715	7/14/2009	7/12/2022	<0.00451	14 (1)	0.209	0.316	No trend	Not applicable[d]				
0718	10/23/2008	7/12/2022	<0.0033	17 (10)	0.081	0.659	No trend					
Arsenic												
NAT02	11/29/2000	7/12/2022	0.00632	24	−0.413	0.005	Decreasing	7/27/2010	15	−0.029	0.921	No trend*
NAT08	11/29/2000	7/12/2022	0.0204	25	−0.688	0	Decreasing	7/27/2010	15	−0.4	0.041	Decreasing
NAT01-1	11/29/2000	7/12/2022	0.0101	24	0.58	0	Increasing	7/27/2010	15	0.324	0.102	No trend*
NAT26	11/29/2000	6/2/2020	0.00307	16 (2)	−0.167	0.382	No trend	7/27/2010	8	0.143	0.702	No trend
MAU08	11/30/2000	7/12/2022	0.00611	24	0.239	0.106	No trend	7/27/2010	15	0.781	0	Increasing*
MAU07	12/1/2000	7/12/2022	0.00563	24	0.21	0.157	No trend	7/27/2010	15	0.133	0.519	No trend
0715	7/14/2009	7/12/2022	0.0059	14	0.264	0.205	No trend	Not applicable[e]				
0718	10/23/2008	7/12/2022	0.00747	17	0.397	0.029	Increasing					

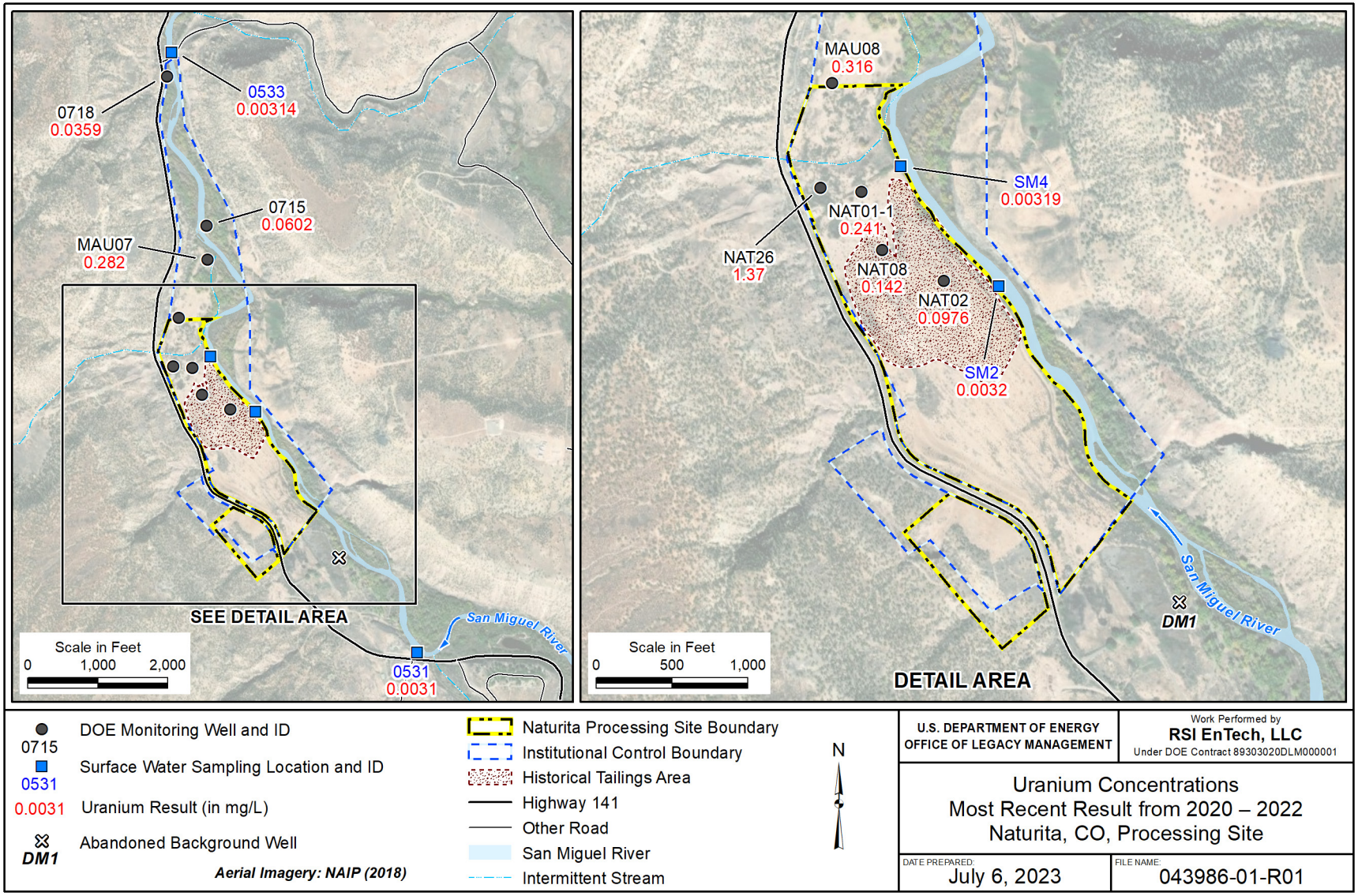
Notes:

[a] For each COPC, wells are listed in approximate order of increasing distance from the former tailings area and flow direction. Mann-Kendall trend test results for former background well DM1 are not listed above but are reflected in the time-concentration plots in this section for the 2000–2016 time frame.

[b] 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. Trend tests were run using a 0.05 significance (or alpha) level.

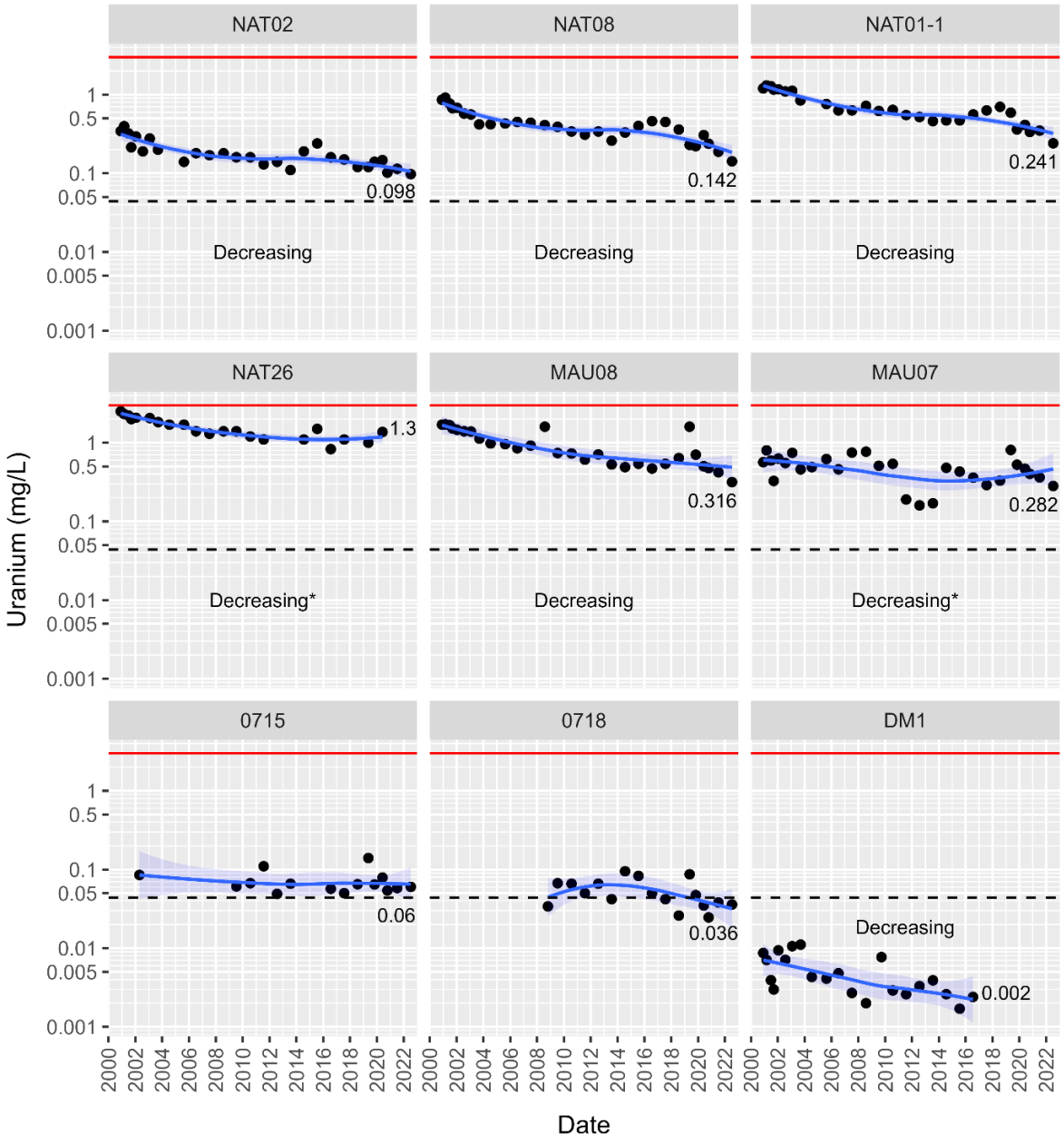
[c] A calculated p-value of less than 0.05 indicates the null-hypothesis is rejected and a significant trend in the time series exists.

[d] A second set of trend analyses was not run for wells 0715 or 0718 because the overall monitoring was shorter (beginning in 2008–2009).



Note: Posted results are from the 2022 annual sampling event except for well NAT26, which was dry or had insufficient water to sample in 2021 and 2022. The uranium result posted for well NAT26 corresponds to the sample collected in 2020.

Figure 9. Uranium Concentrations in Groundwater and Surface Water Samples, 2022



Notes:
Plots for onsite and downgradient wells are listed in order of increasing distance from the former tailings area corresponding to the general direction of groundwater flow. Results for former background well DM1, last sampled in 2016, are plotted last. Values shown in individual graphs are the most recent (July 2022 or, for well NAT26, June 2020) results. For wells with statistically significant trends ($p < 0.05$) (Table 4), the direction of the trend is indicated on the plot. Trend designations overlain on the plots are as follows:

Decreasing: Significant decreasing trend applies to 2000–2022 and (if run) 2010–2022 time frames.

Decreasing*: Significant decreasing trend for 2000–2022 time frame, but no trend for recent (2010–2022) time frame.

Figure 10. Uranium Concentration Trends in Naturita Site Monitoring Wells, 2000–2022

2.2.2 Vanadium

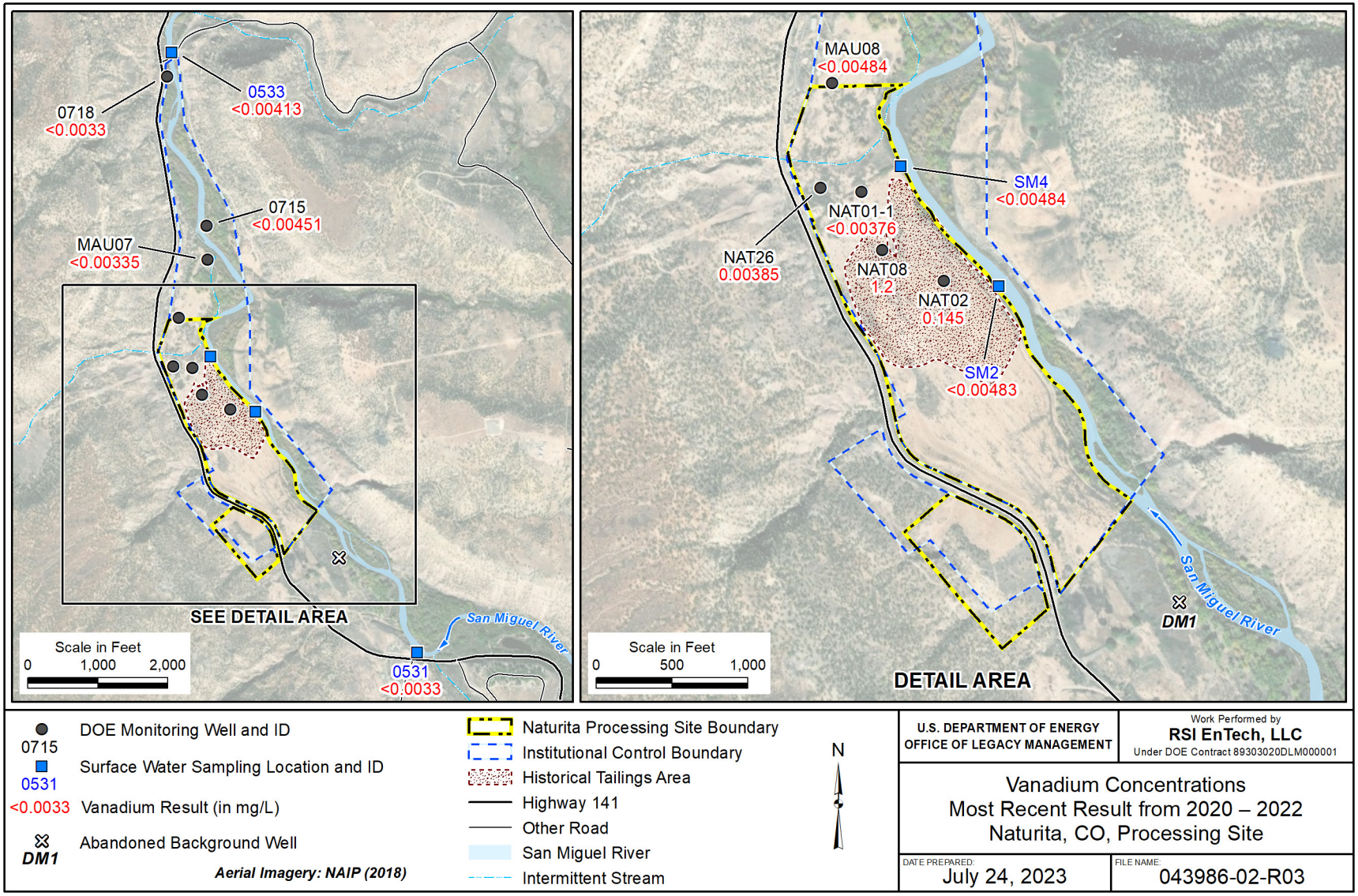
Figure 11 plots the most recent (2020–2022) vanadium results for Naturita site monitoring wells along with surface water sampling results. Again, results correspond to the 2022 sampling event except for well NAT26 (2020 results shown). Temporal trends of vanadium concentrations in monitoring wells are shown in Figure 12. Vanadium concentrations in site wells have been consistently below the proposed ACL of 6 mg/L. With the exception of wells NAT02 and NAT08 (both installed in the former tailings region), vanadium concentrations have also been below regional screening level values established by EPA for tap water (Table 2). This localized spatial extent has been attributed to vanadium's low mobility (DOE 1995; DOE 2002b). Mann-Kendall trend tests identified statistically significant decreasing trends for both NAT02 and NAT08 (Table 4).

2.2.3 Arsenic

Temporal trends of arsenic concentrations in monitoring wells are shown in Figure 13. Except for well NAT08 (early in the monitoring program), arsenic concentrations in site wells have been consistently below the UMTRCA standard. Arsenic concentrations have also been below the more conservative SDWA standard in most wells. Exceptions are wells NAT01-1, NAT08, and (only once) MAU07. Statistically significant increasing trends in well MAU08 and downgradient-most well 0718 (Table 4) warrant continued monitoring.

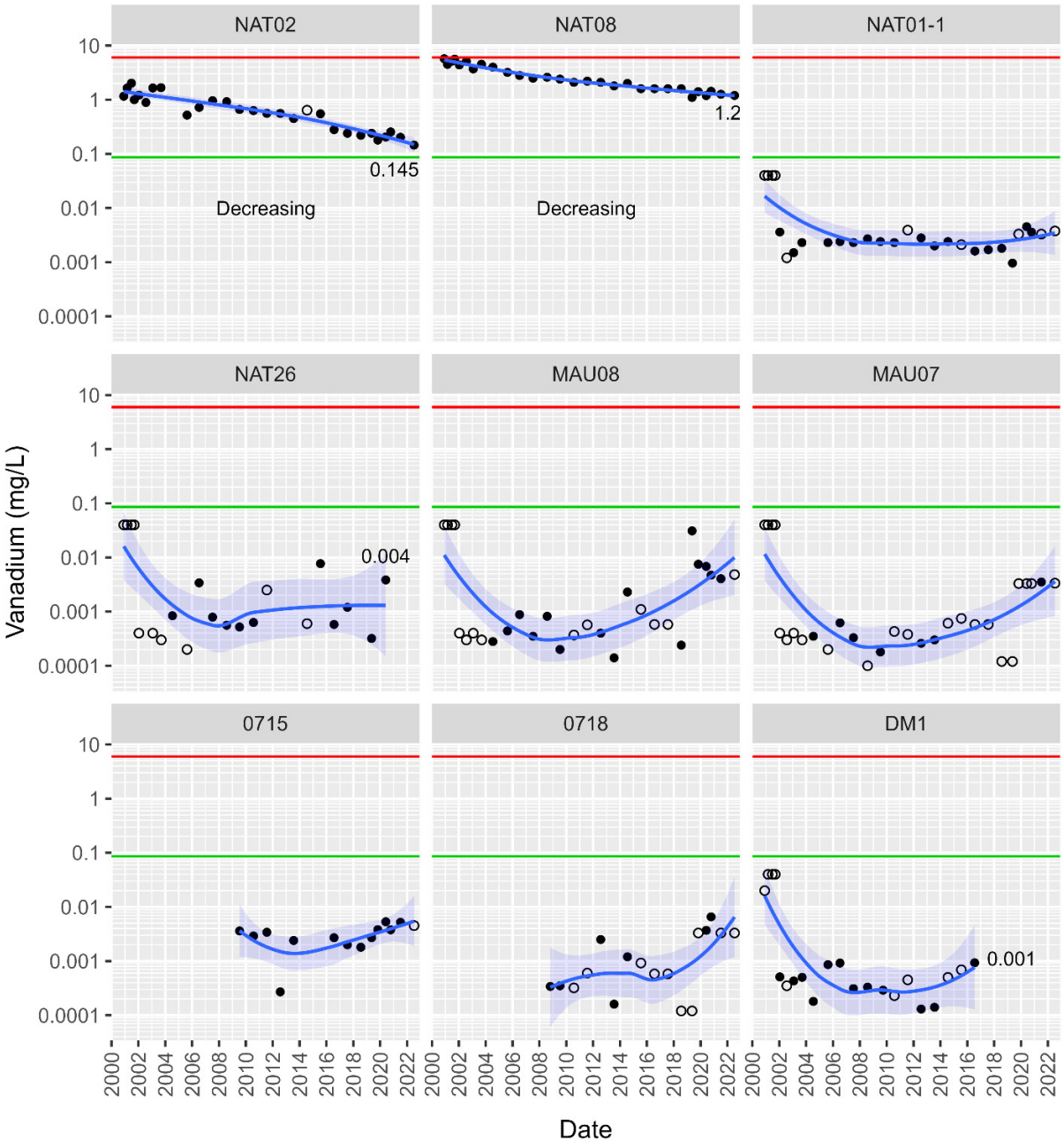
2.2.4 Summary

As a summary, Figure 14 is a matrix of results discussed here in addition to those for TDS, an analyte that is routinely monitored as required by the GCAP (DOE 2002a). Uranium is the most prevalent milling-related contaminant in alluvial aquifer groundwater at the Naturita site. While below the proposed ACL of 3 mg/L, uranium concentrations exceed the 0.044 mg/L MCL in wells except downgradient well 0718.



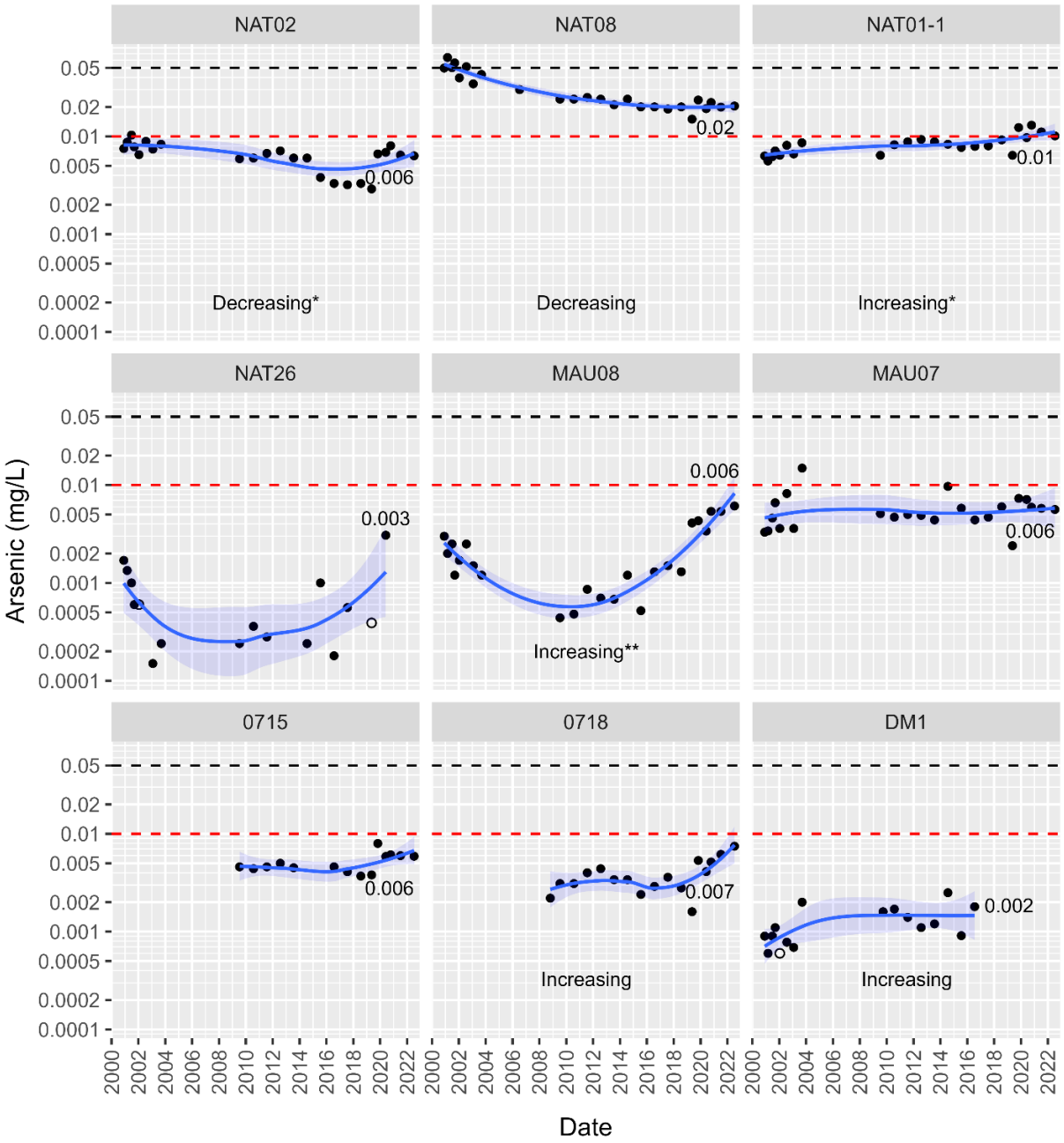
Note: Posted results are from the 2022 annual sampling event except for well NAT26, which was dry or had insufficient water to sample the last 2 years. The vanadium result posted for well NAT26 corresponds to the sample collected in 2020.

Figure 11. Vanadium Concentrations in Groundwater and Surface Water Samples, 2022



Notes:
Plots for onsite and downgradient wells are listed in order of increasing distance from the former tailings area corresponding to the general direction of groundwater flow. Results for former background well DM1 are plotted last.
Values shown in individual graphs are the most recent (2022 or, for well NAT26, 2020) results (applied only to results above the detection limit). For wells with statistically significant trends ($p < 0.05$) (Table 4), the direction of the trend is indicated on the plot.

Figure 12. Vanadium Concentration Trends in Naturita Site Monitoring Wells, 2000–2022



Notes:

Consistent with the order in Table 2, plots for onsite and downgradient wells are listed in order of increasing distance from the former tailings area corresponding to the general direction of groundwater flow. Results for former background well DM1 are plotted last. Values shown in individual graphs are the most recent (July 2022 or, for well NAT26, June 2020) results.

For wells with statistically significant trends ($p < 0.05$) (Table 4), the direction of the trend is indicated on the plot. Unless otherwise noted, trend designations overlain on the plots apply to both 2000–2022 and (if run) 2010–2022 analysis time frames. Exceptions are indicated as follows:

Decreasing*: Significant decreasing trend for 2000–2022 but no trend for 2010–2022.
Increasing*: Significant increasing trend for 2000–2022 but no trend for 2010–2022.
Increasing**: No trend for 2000–2022 but significant increasing trend for 2010–2022.

Figure 13. *Arsenic Concentration Trends in Naturita Site Monitoring Wells, 2000–2022*

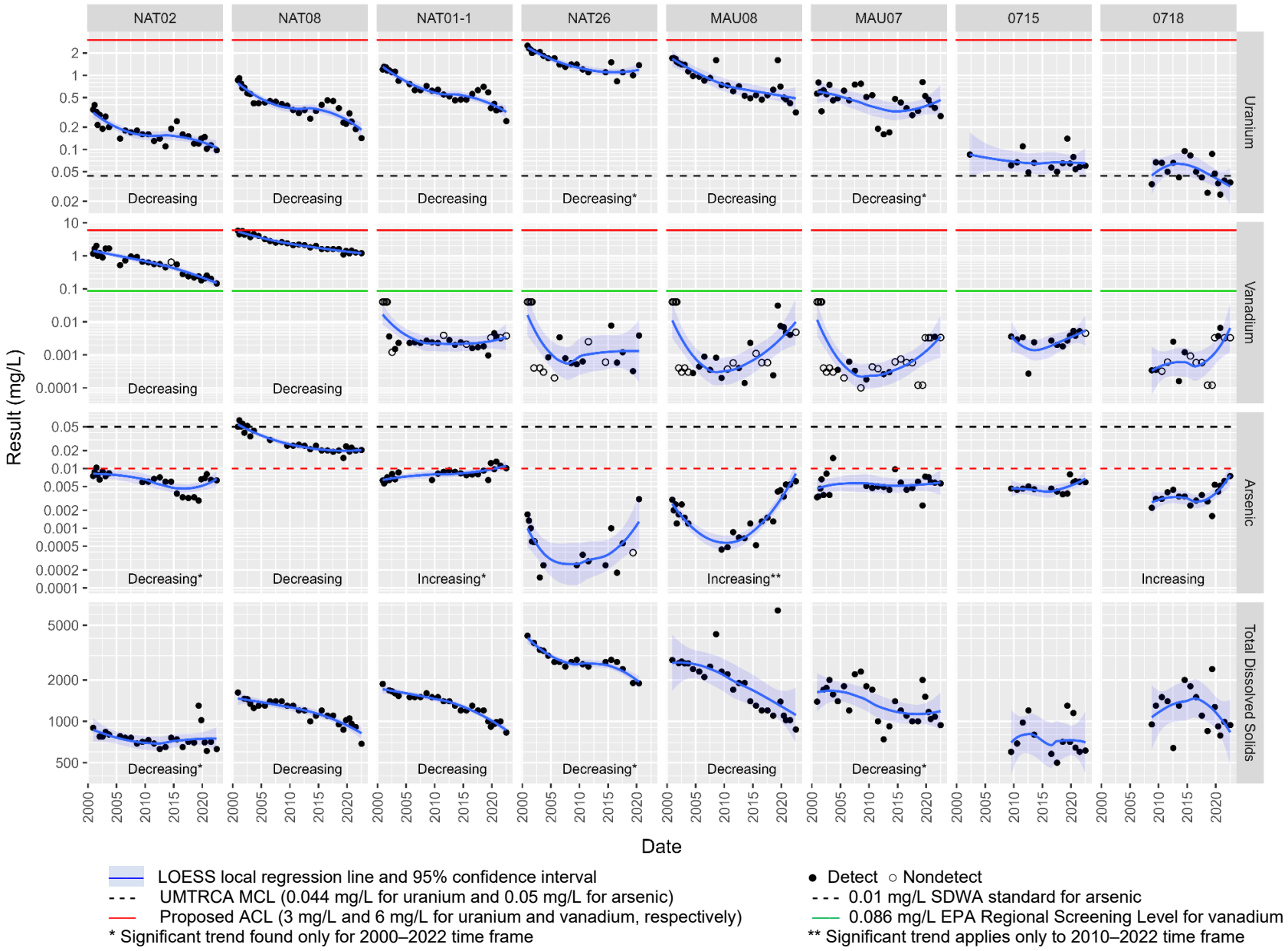


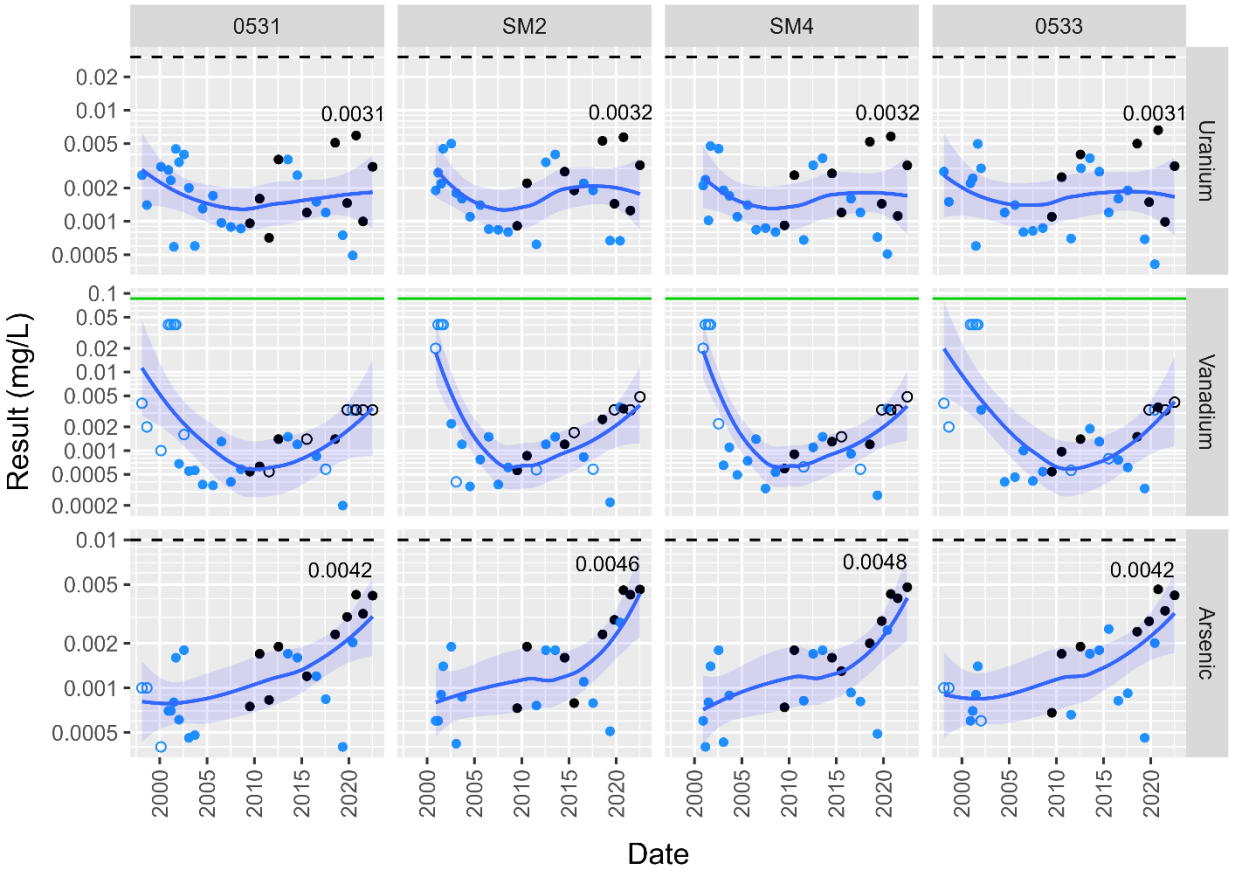
Figure 14. Temporal Trends of COPCs and TDS in Site Monitoring Wells, 2000–2022

2.3 COPC Concentration Trends in Surface Water

The Naturita site is adjacent to the San Miguel River and hydrologic gradients indicate that the alluvial aquifer below the Naturita site discharges to the river (DOE 1995). As specified in the GCAP (DOE 2002a), LM currently monitors four San Miguel River locations: one upstream location (0531), two locations adjacent to the Naturita site (SM2 and SM4), and one downstream location (0522), just north of Calamity Bridge and about 0.84 miles downriver from the northern site boundary. Figure 15 plots historical concentrations of uranium, vanadium, and arsenic; Table 5 lists the corresponding CDPHE water quality criteria.

The GCAP (2002a) identifies the entire reach of San Miguel River adjacent to and downgradient of the processing site as 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 Naturita processing site (locations SM2, SM4, and 0533) is indistinguishable from background water quality (location 0531). The San Miguel River in the site vicinity is classified for agricultural, recreational, and water supply uses.[7]

[7] Applicable classification for this segment is COGUSM05A: Mainstem of the San Miguel River from a point immediately below the confluence of Naturita Creek to a point immediately below the confluence of Coal Canyon. This segment is characterized as "Aquatic Life Warm 1" and is designated for agricultural, recreational ("Recreation E"), and water supply uses (Volume 5 *Code of Colorado Regulations* Section 1002-35, page 217).



Note:
The plots are ordered as follows: upgradient San Miguel River monitoring location 0531 is listed first followed by remaining surface locations in the direction of river flow. Values shown in individual graphs are the most recent (July 2022) results (applied only to results above the detection limit).

Figure 15. COPC Concentration Trends in Naturita Site Surface Water Samples

Table 5. State of Colorado Surface Water Quality Standards for COPCs: San Miguel River Watershed, Segment 5a

Parameter	Aquatic Life[a,b]		Agriculture (Chronic)[a,c]	Domestic Water Supply[a,c]	Water + Fish (Chronic)[a]	Fish Ingestion (Chronic)[a]
	Acute	Chronic				
Arsenic	0.34	0.15	0.1	0.00002–0.01[d]	0.00002[d]	0.0076
Uranium	8.5[e]	5.3[e]	NA	0.0168–0.03[f] (chronic)	NA	NA
Vanadium	NA	NA	NA	NA	NA	NA

Values are in mg/L.

Notes:

[a] Volume 5 *Code of Colorado Regulations* Section 1002-31 (5 CCR 1002-31); refer to Table III, "Metal Parameters."

[b] 5 CCR 1002-35 (page 217, standards for San Miguel River segment COGUSM05A)

[c] Standards for agricultural and domestic uses apply to the total recoverable fraction.

[d] The lower bound of the range of arsenic standards cited for domestic water supply use and water and fish ingestion, 0.00002 mg/L, is 20 times lower than the minimum arsenic concentration (0.0004 mg/L) measured in samples collected from the upgradient San Miguel River sampling location 0531. As such, this standard is not feasible.

[e] Acute and chronic table value standards for uranium apply only to the dissolved fraction and are dependent on (and directly related to) hardness (as $CaCO_3$), a parameter that has not been measured in site surface water (San Miguel River) samples. Hardness was estimated using concentration values for calcium and magnesium from upgradient (background) San Miguel River location 0531 for the period 2019–2022. The mean (average) calcium and magnesium concentrations were 90.5 and 21.7 mg/L, corresponding to a calculated hardness value of 315 mg/L (as $CaCO_3$). Acute and chronic standards were calculated using the following equations provided for uranium in Table III of 5 CCR 1002-31:

$$\text{Acute} = e^{(1.1021 \times \ln(\text{hardness}) + 2.7088)}$$

$$\text{Chronic} = e^{(1.1021 \times \ln(\text{hardness}) + 2.2382)}$$

[f] The uranium standard is a range. The first number in the range (0.0168 mg/L) is a strictly health-based value, based on the CDPHE Water Quality Control Commission's established methodology for human-health-based standards. The second number in the range (0.03 mg/L) is the MCL defined in 5 CCR 1002-31. These standards apply to the total recoverable fraction.

Abbreviations:

$CaCO_3$ = calcium carbonate
ln = natural logarithm
NA = not applicable or available

3.0 Compliance Remedy Performance Summary

Evaluation of historic water quality data indicates the following:

- Uranium and vanadium concentrations in groundwater currently and historically remain below the proposed ACLs of 3 mg/L and 6 mg/L, respectively.
- Although arsenic was not retained as a COPC in the GCAP, it has been routinely monitored at the site since 2009 in response to an NRC comment (Fliegel 2005). Except for onsite well NAT08, concentrations have generally been below both the UMTRCA MCL (0.05 mg/L) and the 0.01 mg/L SDWA standard across the monitoring network.
- Surface water quality of the San Miguel River, considered the POE at the site, remains unaffected by groundwater discharge from the site. COPC concentrations in river samples adjacent to and downstream of the site have been similar to or lower than those in background (upstream) samples.

In addition to being in compliance with regard to ACLs, multiple ICs are in place to prevent domestic use of groundwater and to ensure protection of human health and the environment.

The compliance strategy selected for groundwater at the Naturita processing site continues to be protective of human health and the environment. No complete exposure pathways exist for contaminated groundwater and ICs are routinely monitored. Annual verification monitoring of groundwater and surface water at the site will continue, and will be documented in biennial VMRs, pending regulatory concurrence on a revised GCAP.

4.0 References

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5 CCR 1002-35. "Regulation No. 35 – Classifications and Numeric Standards for Gunnison and Lower Dolores River Basins," *Code of Colorado Regulations*, 5 CCR 1002-35.

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. "Definitions," *United States Code*.

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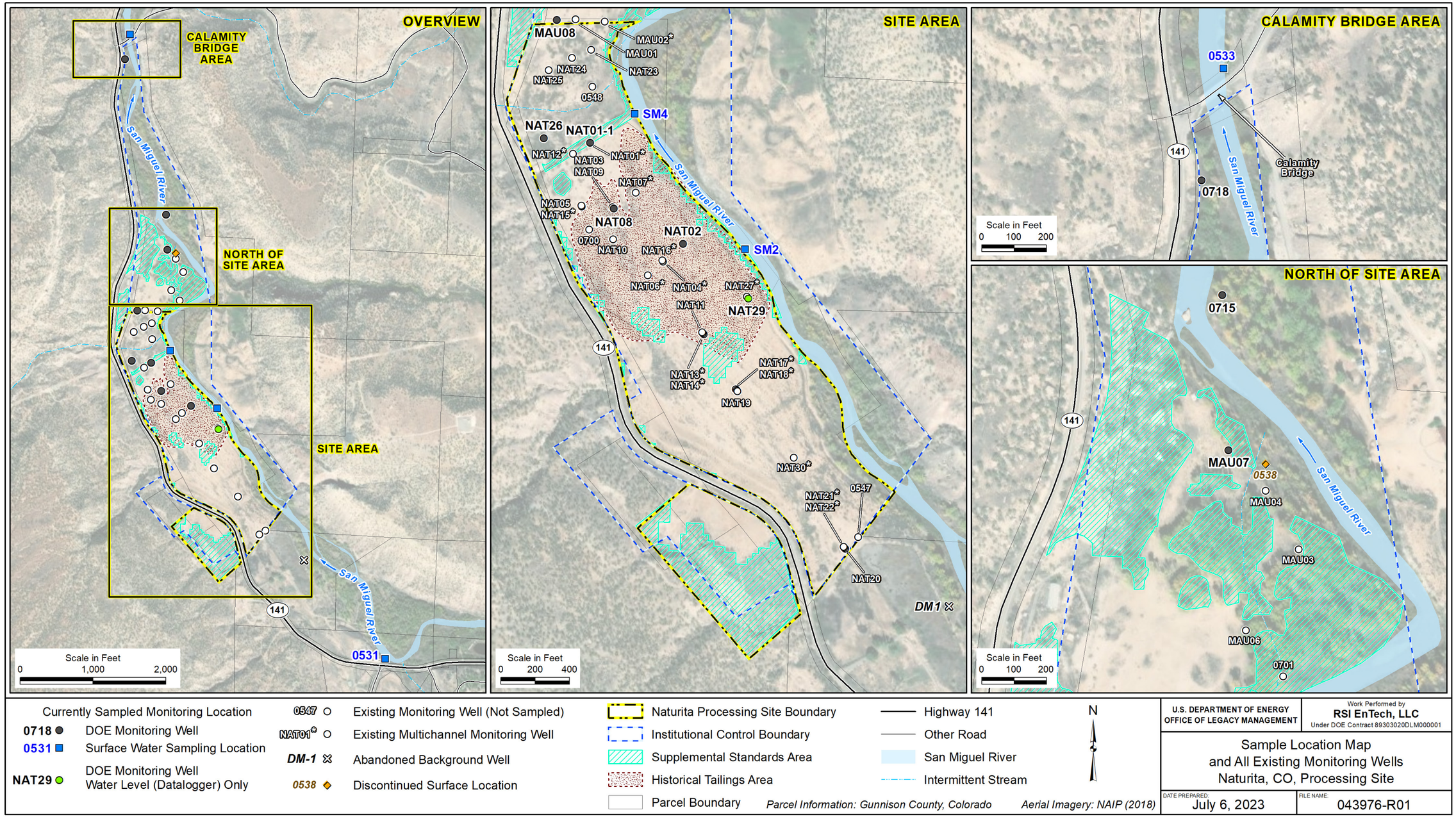
Appendix A

Naturita, Colorado, Processing Site Sample Location Map Showing Existing Monitoring Wells



Currently Sampled Monitoring Location
0718 DOE Monitoring Well
0531 Surface Water Sampling Location
NAT29 DOE Monitoring Well Water Level (Datalogger) Only

0547 Existing Monitoring Well (Not Sampled)
NAT01* Existing Multichannel Monitoring Well
DM-1 Abandoned Background Well
0538 Discontinued Surface Location

Naturita Processing Site Boundary
Institutional Control Boundary
Supplemental Standards Area
Historical Tailings Area
Parcel Boundary

Highway 141
Other Road
San Miguel River
Intermittent Stream

N

Parcel Information: Gunnison County, Colorado
Aerial Imagery: NAIP (2018)

U.S. DEPARTMENT OF ENERGY OFFICE OF LEGACY MANAGEMENT	Work Performed by RSI EnTech, LLC Under DOE Contract 89303020DLM000001
Sample Location Map and All Existing Monitoring Wells Naturita, CO, Processing Site	
DATE PREPARED: July 6, 2023	FILE NAME: 043976-R01

Figure A-1. Naturita Site Sample Location Map Showing Existing Monitoring Wells