19.0 Tuba City, Arizona, Disposal Site

19.1 Compliance Summary

The Tuba City, Arizona, Uranium Mill Tailings Radiation Control Act (UMTRCA) Title I Disposal Site was inspected on May 7, 2024. No significant changes were observed on the disposal cell or in the associated drainage features. Inspectors identified maintenance needs but found no cause for a follow-up inspection.

The U.S. Department of Energy (DOE) Office of Legacy Management (LM) conducts semiannual groundwater monitoring at the site to compare current conditions to baseline postconstruction groundwater quality. Evaluative groundwater monitoring is performed instead of normal point of compliance (POC) monitoring, as preexisting milling-related groundwater contamination may mask contamination leaching from the disposal cell. The most recent semiannual sampling events occurred in February and August 2024. Analytical results from the 2024 evaluative monitoring effort indicate that groundwater quality in site wells continues to be degraded relative to baseline conditions. Since 2015, concentrations of nitrate, selenium, and uranium (the primary site contaminants) are significantly increasing in several wells, most notably in offsite downgradient well 0903.

19.2 Compliance Requirements

Requirements for the long-term surveillance and maintenance of the site are specified in the site-specific Long-Term Surveillance Plan (DOE 1996) (LTSP) in accordance with procedures established to comply with the requirements of the U.S. Nuclear Regulatory Commission (NRC) general license at Title 10 *Code of Federal Regulations* Section 40.27 (10 CFR 40.27). Table 19-1 lists these requirements.

Table 19-1. License Requirements for the Tuba City, Arizona, Disposal Site

Requirement	LTSP	This Report	10 CFR 40.27
Annual Inspection and Report	Section 6.0	Section 19.4	(b)(3)
Follow-Up Inspections	Section 7.0	Section 19.5	(b)(4)
Maintenance and Repairs	Section 8.0	Section 19.6	(b)(5)
Environmental Monitoring	Section 5.2	Section 19.7	(b)(2)
Corrective Action	Section 9.0	Section 19.8	—

19.3 Institutional Controls

The 145-acre site, defined by the property boundary shown in Figure 19-1, is held in trust by the U.S. Bureau of Indian Affairs. The Navajo Nation retains title to the land. UMTRCA authorized DOE to enter into a Cooperative Agreement (DE-FC04-85AL26731) with the Navajo Nation to perform remedial actions at the former uranium processing sites (DOE 1984). DOE and the Navajo Nation executed a Custodial Access Agreement that conveys to the federal government title to the residual radioactive materials stabilized at the site and ensures that DOE has perpetual access to the site.

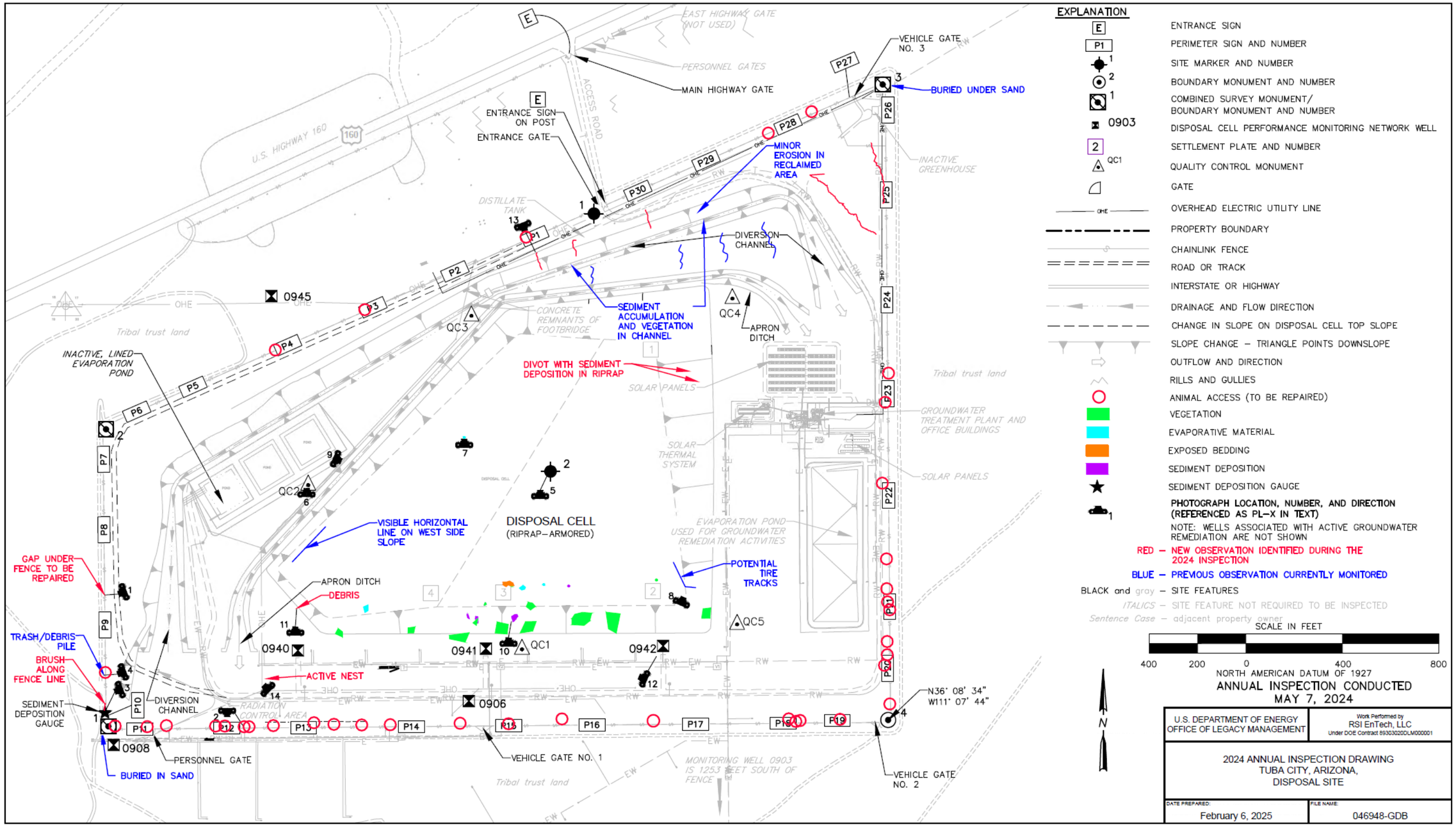


Figure 19-1. 2024 Annual Inspection Drawing for the Tuba City, Arizona, Disposal Site

The site was accepted under the NRC general license in 1996. DOE is the licensee and, in accordance with the requirements for UMTRCA Title I sites, LM is responsible for the custody and long-term care of the site. Institutional controls (ICs) at the site include federal custody of the disposal cell and its engineered features, administrative controls, and the following physical ICs that are inspected annually: the disposal cell and associated drainage features, entrance gates and signs, perimeter fence and signs, site markers, survey and boundary monuments, and wellhead protectors.

19.4 Inspection Results

The site, 6 miles northeast of Tuba City, Arizona, was inspected on May 7, 2024. The inspection was conducted by H. Katz, N. Lind, K. Lund, Z. Schuler, S. Salt, C. Stewart, and P. Wetherstein of the Legacy Management Support contractor. J. Tallbull (LM), R. Lamson (Hopi Tribe Department of Natural Resources, Office of Mining and Mineral Resources), and E. Grayeyes (Navajo Abandoned Mine Lands) also attended the inspection. The purposes of the inspection were to confirm the integrity of visible features at the site, identify changes in conditions that might affect conformance with the LTSP, and evaluate whether maintenance or follow-up inspection and monitoring are needed.

19.4.1 Site Surveillance Features

Figure 19-1 shows the locations of site features, including site surveillance features and inspection areas, in black and gray font. Some site features that are present but not required to be inspected are shown in italic font. Observations from previous inspections that are currently monitored are shown in blue, and new observations identified during the 2024 annual inspection are shown in red. Inspection results and recommended maintenance activities associated with site surveillance features are described in the following subsections. Photographs to support specific observations are noted in the text and in Figure 19-1 by photograph location (PL) numbers. The photographs and photograph log are presented in Section 19.10.

19.4.1.1 Access Road, Entrance Gates, and Entrance Signs

Access to the site is from U.S. Highway 160. Perpetual access to the site is granted by the Custodial Access Agreement. A gate in a chainlink fence on the main highway right-of-way allows access to the site via a gravel road. The entrance gate is in the inner chainlink perimeter fence between perimeter signs P1 and P30. Both gates were operational at the time of the inspection. Vehicle gates are also present in the northeast corner of the site and along the southern fence line to facilitate access for offsite activities. All gates were secured and functional.

Entrance signs are posted on the main highway gate and near the entrance gate. Vehicle gates 1–3 purposefully do not have a sign. An informational sign exists on the main entrance gate. No maintenance needs were identified.

19.4.1.2 Perimeter Fence and Signs

A chainlink perimeter fence encloses the site. Windblown sand and tumbleweeds regularly accumulate along the perimeter fence line. Wind scouring also occurs, which results in gaps

under the fence (PL-1). There are also many gaps under the fence from animal access (PL-2). These areas will be repaired before the next inspection. The sediment deposition gauge installed in 2023 between perimeter signs P9 and P10 will be read every year to quantify sand deposition as part of the annual inspection. At the time of the inspection, sand accumulated to a height of approximately 1.6 feet (PL-3). Similar to previous years, trash and debris have accumulated outside the fence near perimeter sign P9 (PL-4).

Thirty pairs of perimeter signs, designated P1 through P30, are attached to steel posts set in concrete directly inside and along the perimeter fence. One of the sign pairs is textual, and the other is pictorial. No maintenance needs were identified.

19.4.1.3 Site Markers

The site has two granite site markers. Site marker SMK-1 is just inside the entrance gate, and site marker SMK-2 is on the top slope of the disposal cell (PL-5). No maintenance needs were identified.

19.4.1.4 Survey and Boundary Monuments

One boundary monument and three combined survey and boundary monuments delineate the corners of the site. Combined survey and boundary monuments SM/BM-1 and SM/BM-3 tend to get covered with windblown sand and are marked with steel T-posts. All other survey and boundary monuments were located and in good condition. No maintenance needs were identified.

19.4.1.5 Aerial Survey Quality Control Monuments

Five aerial survey quality control monuments were located and in good condition (PL-6).

19.4.1.6 Monitoring Wells

Seven monitoring wells (wells 0903, 0906, 0908, 0940, 0941, 0942, and 0945) constitute the disposal cell performance monitoring network. Monitoring wells 0906, 0908, 0940, 0941, and 0942 are inside or immediately outside the perimeter fence. Inspectors checked the wellhead protectors of these five wells in May 2024; all were found to be undamaged and locked (offsite wells 0903 and 0945 were not checked). No maintenance needs were identified.

19.4.2 Inspection Areas

In accordance with the LTSP, the site is divided into three inspection areas (referred to as "transects" in the LTSP) to ensure a thorough and efficient inspection. The inspection areas are (1) the disposal cell, (2) the area between the disposal cell and the site boundary, and (3) the outlying area. Inspectors examined specific site surveillance features within each area and looked for evidence of erosion, settling, slumping, or other modifying processes that might affect the site's conformance with LTSP requirements.

19.4.2.1 Disposal Cell

The disposal cell, completed in 1989, occupies 50 acres. The disposal cell is armored with riprap to control erosion and deter animal and human intrusion. Inspectors confirmed parallel tracks on the top slope of the disposal cell that were reported in previous annual reports. An evaporative mineral, caused by water pooling and subsequent evaporation, on top of windblown deposited sediment within riprap matrixes was noted on the top of the disposal cell (PL-7). Some exposed bedding layer was also noted on the top of the disposal cell. Potential tire tracks were observed on the southeast corner of the disposal cell (PL-8). These areas will continue to be monitored. There was no evidence of erosion, settling, slumping, or other modifying processes on the disposal cell.

The riprap-covered side slopes were in good condition. There were visible horizontal channels along the southwest slopes (PL-9). The channels are most likely formed from surface flow from melting snow cover or precipitation, or both. Sediment deposition (PL-10) and debris (PL-11) were noted on the south slope of the disposal cell. Two 3-inch divots with sediment deposition were noted in the riprap of the east slope of the disposal cell. These features do not currently pose a threat to the integrity of the disposal cell; however, continued monitoring is recommended to ensure that erosion features do not create any problems that could undermine the soil and rock interface or the rock side slope below.

In accordance with the LTSP, deep-rooted vegetation is controlled to prevent potential penetration of the radon barrier. Windblown sediments continue to accumulate on the rock-covered surfaces, providing a favorable environment for plant growth. Periodic spot application of herbicide has been effective in controlling deep-rooted vegetation growth on the disposal cell cover. No deep-rooted shrubs were observed on top of the disposal cell, but some shrubs have become established on the side slopes (PL-12), as noted in previous inspections. This will be treated with herbicide before the next inspection.

19.4.2.2 Area Between the Disposal Cell and the Site Boundary

The disposal cell is protected from stormwater runoff by a disposal cell apron ditch and a diversion channel, both of which are armored with riprap along the north and northwest sides of the disposal cell. Windblown sand and vegetation accumulate in the apron ditch and the diversion channel along the north and northwest sides of the disposal cell. The sand deposition and associated vegetation establishment have not adversely affected the performance of these structures.

The north slope above the diversion channel consists of noncohesive sandy soil and is subject to erosion from stormwater runoff. Erosion repair conducted in this area in 2013 reduced the rate of erosion and subsequent soil deposition in the channel. Some erosion and deposition continue north and northeast of the diversion channel—an erosional gully and soil accumulation were observed (PL-13). Erosion will be monitored, and erosion control repairs will be performed as needed.

In 2022, inspectors noted that much of the woody vegetation grew in reclaimed areas around the disposal cell. These areas were of concern to tribal officials (Mr. Honie) as they could present a potential fire hazard. In July 2023, an extensive brush removal effort was completed where dead

vegetation was chipped in place to reduce potential fire hazards at the site. Continued brush removal will occur annually.

Two of the three evaporation ponds near the northwest side of the disposal cell were removed in 2007. The area was reclaimed and seeded with a native seed mix in 2007 and again in 2013.

The remaining historical evaporation pond, containing windblown sand and evaporites, is retained as a backup for the main evaporation pond on the east side of the site. The steel cable and caution signs surrounding the pond and the high-density polyethylene liner were intact. What was previously thought to be a plastic geofabric that stabilizes the south-facing slope of the pond is actually the geocell erosion-prevention grid. The visual exposure is the grid material. Vegetation was establishing in the geocells, and the slope is stable. Inspectors will continue to monitor this area. No other maintenance needs were identified.

Erosional gullies were noted along the northern perimeter fence. These gullies are originating near the main highway and are most prominent between the highway and the inner chainlink perimeter fence. This erosional area will be monitored but does not currently affect the integrity of the disposal cell. No maintenance needs were identified.

There are multiple structures and features associated with the former groundwater treatment system. Beginning in 2002, contaminated groundwater was extracted and treated through ion-exchange and distillation processes and then returned to the aquifer through an infiltration trench upgradient of the disposal cell. Operation of the groundwater treatment plant (GWTP) was suspended in September 2014 due to maintenance challenges. The structures associated with the GWTP remain onsite and include a Control Building; Lab and Shop Building; Evaporator Building; Softener Building; external tanks; solar water-heating system; two photovoltaic panel arrays for utility power generation; evaporation ponds; network of extraction, injection, and monitoring wells; and treated water infiltration trench. An inactive greenhouse and two sheds were removed in 2023. No other maintenance needs were identified.

An active bird nest was identified on a power pole southwest of the disposal cell (PL-14). Environmental Compliance personnel have been notified and measures to identify the type of bird nest are underway. The nest will be addressed to mitigate fire hazards, as well as to prevent electrical issues. This task will be completed before the 2025 inspection.

19.4.2.3 Outlying Area

The 0.25-mile area beyond the site boundary was visually observed for erosion, changes in land use, or other phenomena that might affect the long-term integrity of the site. No evidence of changed land use or maintenance needs were identified.

19.5 Follow-Up Inspections

LM will conduct follow-up inspections if (1) a condition is identified during the annual inspection or other site visit that requires a return to the site to evaluate the condition or (2) LM is notified by a citizen or outside agency that conditions at the site are substantially changed. No need for a follow-up inspection was identified.

19.6 Maintenance and Repairs

Inspectors noted the following maintenance items in 2024 that will be completed before the next inspection:

- Remove the trash and debris along the perimeter fence line
- Repair the animal access areas and gaps along the perimeter fence
- Control deep-rooted vegetation on the disposal cell
- Perform annual brush removal
- Address active bird nest on power pole southwest of disposal cell

19.7 Environmental Monitoring

In accordance with the LTSP, semiannual groundwater monitoring is conducted at the locations shown in Figure 19-2 to compare current conditions at the site to baseline postconstruction groundwater quality. Groundwater quality beneath and downgradient of the disposal cell has been degraded by contamination from former uranium-processing activities. This preexisting milling-related contamination might mask contamination leaching from the disposal cell, which limits the effectiveness of normal POC groundwater monitoring as a reliable indicator of disposal cell performance (40 CFR 192 Subpart A).

19.7.1 Groundwater Monitoring Program

Instead of POC monitoring, groundwater monitoring is performed in accordance with Section 5.2.2 of the LTSP and is defined as evaluative monitoring. Evaluative monitoring is performed to "(1) evaluate trends in ground water quality, (2) monitor the downgradient extent of contamination in ground water, (3) analyze the impacts of transient drainage and surface runoff, and (4) assess the effects of ground water restoration measures associated with containing the contamination related to uranium processing activities" (DOE 1996). Evaluative groundwater monitoring was conducted in August and February 2024 at the locations shown in Figure 19-2. Before addressing the most recent results of the evaluative groundwater monitoring program, a summary of historical and current groundwater remediation approaches is warranted.

Groundwater remediation is being conducted by an active treatment system that includes the operation of extraction wells and discharge of extracted (contaminated) groundwater to the onsite evaporation pond for volume reduction. The progress of groundwater remediation is evaluated and reported routinely (typically annually), separate from this site inspection reporting. As documented in recent performance evaluations, the remediation approach has changed over the years, from the continuous high-volume pumping approach applied at the start of active remediation in 2002 to the short-duration, high-volume pumping strategy currently applied since 2018 (DOE 2022; DOE 2024b).

Note: Well 0942 was converted from a monitoring well to an extraction well in 2015.

Figure 19-2. Evaluative Groundwater Monitoring Network at the Tuba City, Arizona, Disposal Site

Yearly short-duration, high-volume pumping occurs during periods of highest potential for evaporative flux that typically begin in July and end in October. As many as 11 extraction wells operate during this period. The annual extraction volume is currently constrained to about 4.6 million gallons due to the evaporation pond capacity and the evaporation rate of the pond (DOE 2024b). This volume equates to an average annual removal rate of 7 gallons per minute (gpm) using the present extraction system, compared to 80 gpm when the GWTP was operating as designed from 2002–2009.

Seven wells (Figure 19-2 and Table 19-2) identified in the LTSP are monitored for four hazardous constituents: molybdenum, nitrate, selenium, and uranium (DOE 1996). As a baseline for cell performance evaluation, provisional upper baseline limits (UBLs) for the four constituents were calculated in accordance with the U.S. Environmental Protection Agency's *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance* (EPA 1989) and documented in the LTSP (DOE 1996). The UBLs are listed in Table 19-3.

Table 19-2. LTSP Groundwater Monitoring Network at the Tuba City, Arizona, Disposal Site

Monitoring Well	Hydrologic Relationship	Monitoring Frequency
0903	Downgradient (offsite)	Annually
0906	Downgradient	Semiannually
0908	Downgradient	Semiannually
0940[a]	Downgradient	Semiannually
0941	Downgradient	Semiannually
0942[b]	Downgradient	No Longer Monitored[b]
0945	Upgradient (background)	Annually

Notes:
[a] Between August 2004 and February 2010, samples from well 0940 could not be obtained because of an insufficient volume of water. This explains the data gaps in Figure 19-3 through Figure 19-6.
[b] Well 0942 was converted from a monitoring well to an extraction well in 2015 and has not been sampled since then.

Table 19-3. Provisional UBLs for Groundwater at the Tuba City, Arizona, Disposal Site

Constituent	Provisional UBL (mg/L)[a]	MCL (mg/L)[b]
Molybdenum	0.14	0.10
Nitrate (as nitrogen)	311[c]	10
Selenium	0.05	0.01
Uranium	1.17	0.044

Notes:
[a] As documented in the LTSP (DOE 1996).
[b] MCLs as listed in 40 CFR 192 Subpart A.
[c] UBL for nitrate as nitrogen converted from the original UBL cited in the LTSP.

Abbreviations:
MCL = maximum concentration limit
mg/L = milligrams per liter

UBLs were described in the LTSP as provisional because "baseline conditions were established for locations other than the disposal cell monitor wells" (DOE 1996). Baseline conditions were established at wells 0906 and 0908 to determine "transient excursions from baseline conditions, potential chemical gradients between baseline and disposal cell locations, and stabilization of postclosure disposal cell hydrology" (DOE 1996). UBLs are concentrations that, with 95% confidence, would be exceeded less than 5% of the time during long-term monitoring if groundwater conditions near the monitoring well did not change.

Because the four constituents are present in tailings material, relatively mobile in groundwater, and found in low concentrations in background groundwater quality, exceedance of UBLs in more than 5% of sampling events over the long term could indicate that the disposal cell is not performing to design standards. However, the LTSP also notes that elevated concentrations could result from transient drainage of tailings fluid into the subsurface (directly beneath the cell) or from rainfall infiltrating through contamination in the unsaturated zone in the mill ponds area not covered by the disposal cell. Elevated concentrations attributed to transient drainage or infiltration would not be indicative of substandard performance for the cell.

Active groundwater remediation was anticipated when the LTSP was prepared in 1996, and it was expected that deviations from anticipated disposal cell performance could be detected even with ongoing groundwater remediation. However, the LTSP also noted that (1) POC sampling and analysis protocol to monitor cell performance could not be established until groundwater restoration was complete and (2) the LTSP would be revised at that time.

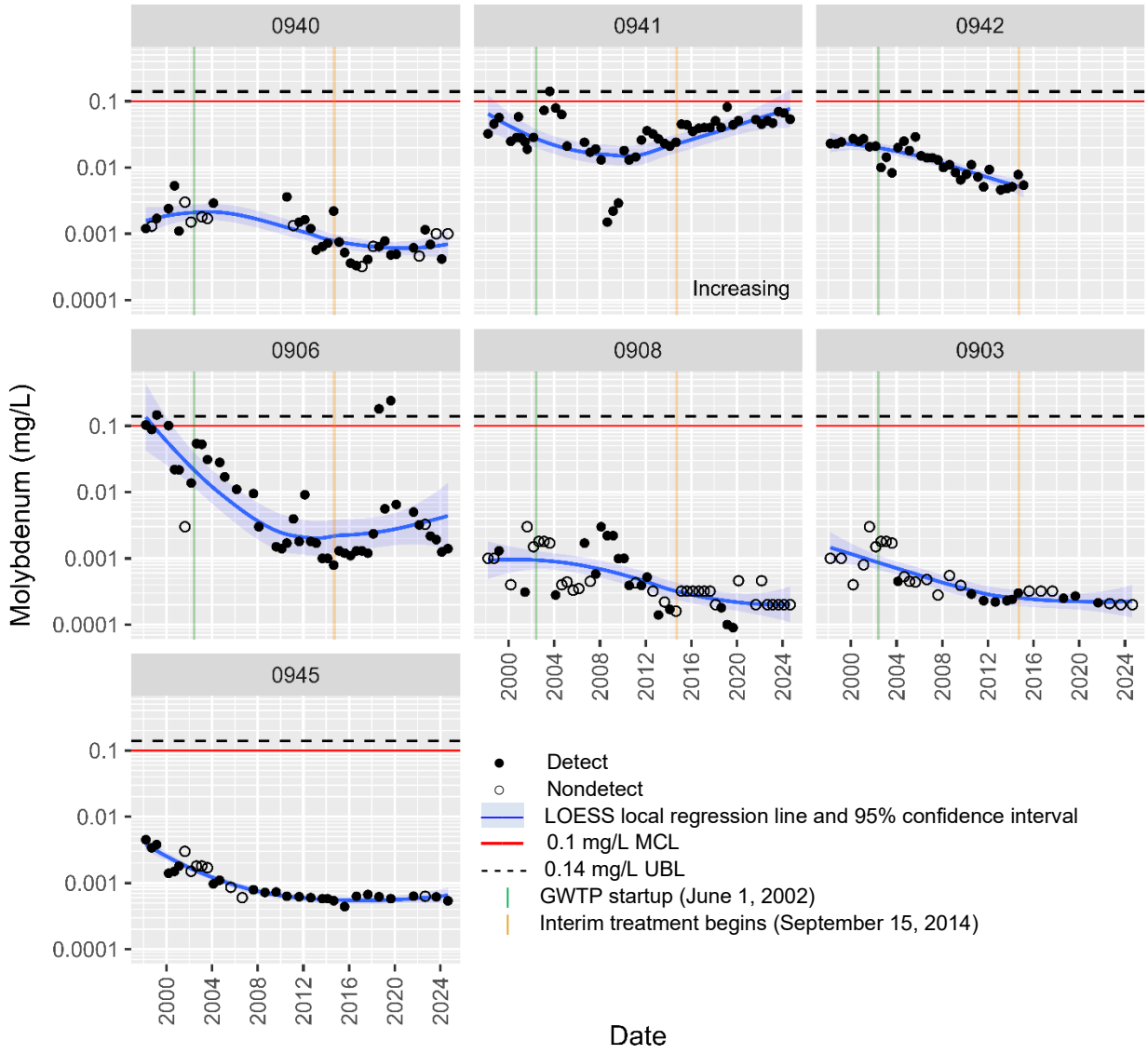
As noted in the LTSP, the UBL value should not be exceeded more than 5% of the time as long as conditions near the monitoring well do not change. Due to implementation of active remediation (2002–2014) and interim treatment (2015 to present), the conditions near the LTSP cell performance wells have constantly been affected, and exceedance of UBLs cannot be attributed to disposal cell performance. Recent operation of the interim treatment system, which potentially affects concentrations of target analytes in the LTSP-specified evaluative monitoring wells, is described in the following paragraphs.

19.7.2 Groundwater Monitoring Results

Figure 19-3 through Figure 19-6 show time-concentration plots for the four target analytes (molybdenum, nitrate, selenium, and uranium) along with corresponding UBLs and maximum concentration limits (MCLs). Interpretations of the analyte-specific data follow each figure. These figures were developed using a faceting approach, whereby data for each well are plotted separately. Downgradient wells (Table 19-2) are ordered in the general direction of groundwater flow or the distance from the disposal cell (Figure 19-2); data for the upgradient background well (0945) are plotted last. In each individual plot, the blue line is the best-fit locally estimated scatterplot smoothing (LOESS) regression line. The surrounding light blue area represents the 95% confidence interval range (above and below) the LOESS line. Although data are plotted for the entire evaluative monitoring network, because well 0942 was converted from a monitoring well to an extraction well in 2015 (precluding sampling), corresponding trends are no longer discussed.

All groundwater monitoring results for the site are reported and published on the LM Geospatial Environmental Mapping System (GEMS) website (https://gems.lm.doe.gov). In this section, the

MCLs shown are presented for informational purposes only. The LTSP requirement related to disposal cell performance is for evaluative monitoring over time, in comparison with the UBLs listed in Table 19-3. In accordance with LTSP requirements to evaluate analyte concentration trends in the monitoring wells (Section 5.2.2 of DOE 1996), Mann-Kendall trend analysis was conducted for all analyte-well combinations. These results are documented in Table 19-4 for the full monitoring period addressed in Figure 19-3 through Figure 19-6 (1998–2024). To facilitate interpretation of more recent trends, Table 19-5 presents the same information, but for the period since interim treatment began (2015 to present).



Note: Any statistically significant increasing trends for the 2015–2024 time frame (Table 19-5) are indicated on the appropriate plots.
Abbreviation: mg/L = milligrams per liter

Figure 19-3. Time-Concentration Plots of Molybdenum in Groundwater at the Tuba City, Arizona, Disposal Site, 1998–2024

Since 1998, molybdenum concentrations have been mostly at or below both the 0.14 milligram per liter (mg/L) UBL and the 0.1 mg/L MCL in all LTSP evaluative monitoring wells (Figure 19-3). The UBL has been exceeded three times in well 0906: 0.15 mg/L in February 1999 and 0.18–0.24 mg/L in 2018–2019. The latter spikes coincide with the short-duration, high-volume pumping occurring in the summer. Although statistically significant decreasing trends were found for three wells (0906, 0940, and 0945) using data since 1998 (Table 19-4), no trend was found for the 2015–2024 time frame (Table 19-5). Molybdenum concentrations in well 0941 have increased since 2015, accounting for the statistically significant trend overall (most recent result of 0.053 mg/L). Most results for wells 0908 and 0903 have been below detection limits.

Table 19-4. Mann-Kendall Trend Analysis Results for Target Analytes in Tuba City, Arizona, Disposal Site Monitoring Wells, 1998–2024

Parameter[a]	Well	Initial Trend Analysis Date	Initial Trend Analysis Date	No. of Samples (No. of Nondetects)	Kendall's tau[b,c]	p-value[b,c]	Trend[b,c]
Molybdenum	0903	3/11/1998	8/27/2024	32 (22)	−0.08	0.48	No Trend
Molybdenum	0906	3/11/1998	8/27/2024	45 (2)	−0.39	<0.001	Decreasing
Molybdenum	0908	3/11/1998	8/28/2024	50 (32)	−0.18	0.056	No Trend
Molybdenum	0940	3/12/1998	8/27/2024	38 (11)	−0.31	0.006	Decreasing
Molybdenum	0941	3/12/1998	8/27/2024	50	0.25	0.012	Increasing
Molybdenum	0945	3/14/1998	8/28/2024	33 (8)	−0.47	<0.001	Decreasing
Nitrate as N	0903	3/11/1998	8/27/2024	32	0.49	<0.001	Increasing
Nitrate as N	0906	3/11/1998	8/27/2024	45	0.03	0.77	No Trend
Nitrate as N	0908	3/11/1998	8/28/2024	50	0.66	<0.001	Increasing
Nitrate as N	0940	3/12/1998	8/27/2024	38	0.13	0.26	No Trend
Nitrate as N	0941	3/12/1998	8/27/2024	50	0.68	<0.001	Increasing
Nitrate as N	0945	3/14/1998	8/28/2024	33	0.54	<0.001	Increasing
Selenium	0903	3/11/1998	8/27/2024	32	0.24	0.056	No Trend
Selenium	0906	3/11/1998	8/27/2024	45	0.37	<0.001	Increasing
Selenium	0908	3/11/1998	8/28/2024	50 (1)	−0.25	0.011	Decreasing
Selenium	0940	3/12/1998	8/27/2024	38	−0.15	0.19	No Trend
Selenium	0941	3/12/1998	8/27/2024	50	0.51	<0.001	Increasing
Selenium	0945	3/14/1998	8/28/2024	33 (2)	0.48	<0.001	Increasing
Uranium	0903	3/11/1998	8/27/2024	32	0.56	<0.001	Increasing
Uranium	0906	3/11/1998	8/27/2024	45	0.11	0.31	No Trend
Uranium	0908	3/11/1998	8/28/2024	50	−0.67	<0.001	Decreasing
Uranium	0940	3/12/1998	8/27/2024	38	0.20	0.078	No Trend
Uranium	0941	3/12/1998	8/27/2024	50	0.59	<0.001	Increasing
Uranium	0945	3/14/1998	8/28/2024	33	−0.19	0.12	No Trend

Notes:

[a] Trends for well 0942 are not shown because sampling was discontinued in 2015.

[b] Trend tests 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.

[c] Trend analyses were conducted at the 0.05 significance level using a two-sided test. A calculated p-value of less than 0.05 indicates that a significant trend in the time series exists. 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.

Abbreviation:

N = nitrogen

Table 19-5. Mann-Kendall Trend Analysis Results for Target Analytes in Tuba City, Arizona, Disposal Site Monitoring Wells, 2015–2024

Parameter	Well[a]	Initial Trend Analysis Date	Final Trend Analysis Date	No. of Samples (No. of Nondetects)	Kendall's tau[b,c]	p-value[b,c]	Trend[b,c]
Molybdenum	0903	8/12/2015	8/27/2024	9 (6)	−0.28	0.27	No Trend
Molybdenum	0906	2/16/2015	8/27/2024	18 (1)	0.12	0.49	No Trend
Molybdenum	0908	2/16/2015	8/28/2024	18 (15)	−0.02	0.93	No Trend
Molybdenum	0940	2/17/2015	8/27/2024	18 (5)	0.09	0.61	No Trend
Molybdenum	0941	2/17/2015	8/27/2024	18	0.50	0.004	Increasing
Molybdenum	0945	8/11/2015	8/28/2024	9 (1)	−0.19	0.52	No Trend
Nitrate as N	0903	8/12/2015	8/27/2024	9	0.58	0.036	Increasing
Nitrate as N	0906	2/16/2015	8/27/2024	18	−0.56	0.001	Decreasing
Nitrate as N	0908	2/16/2015	8/28/2024	18	0.54	0.002	Increasing
Nitrate as N	0940	2/17/2015	8/27/2024	18	0.21	0.24	No Trend
Nitrate as N	0941	2/17/2015	8/27/2024	18	−0.19	0.28	No Trend
Nitrate as N	0945	8/11/2015	8/28/2024	9	0.08	0.83	No Trend
Selenium	0903	8/12/2015	8/27/2024	9	0.81	0.003	Increasing
Selenium	0906	2/16/2015	8/27/2024	18	0.51	0.004	Increasing
Selenium	0908	2/16/2015	8/28/2024	18 (1)	−0.06	0.76	No Trend
Selenium	0940	2/17/2015	8/27/2024	18	0.69	<0.001	Increasing
Selenium	0941	2/17/2015	8/27/2024	18	0.007	1	No Trend
Selenium	0945	8/11/2015	8/28/2024	9	0.19	0.53	No Trend
Uranium	0903	8/12/2015	8/27/2024	9	0.83	0.002	Increasing
Uranium	0906	2/16/2015	8/27/2024	18	0.83	<0.001	Increasing
Uranium	0908	2/16/2015	8/28/2024	18	−0.52	0.003	Decreasing
Uranium	0940	2/17/2015	8/27/2024	18	−0.30	0.087	No Trend
Uranium	0941	2/17/2015	8/27/2024	18	0.09	0.62	No Trend
Uranium	0945	8/11/2015	8/28/2024	9	−0.14	0.66	No Trend

Notes:

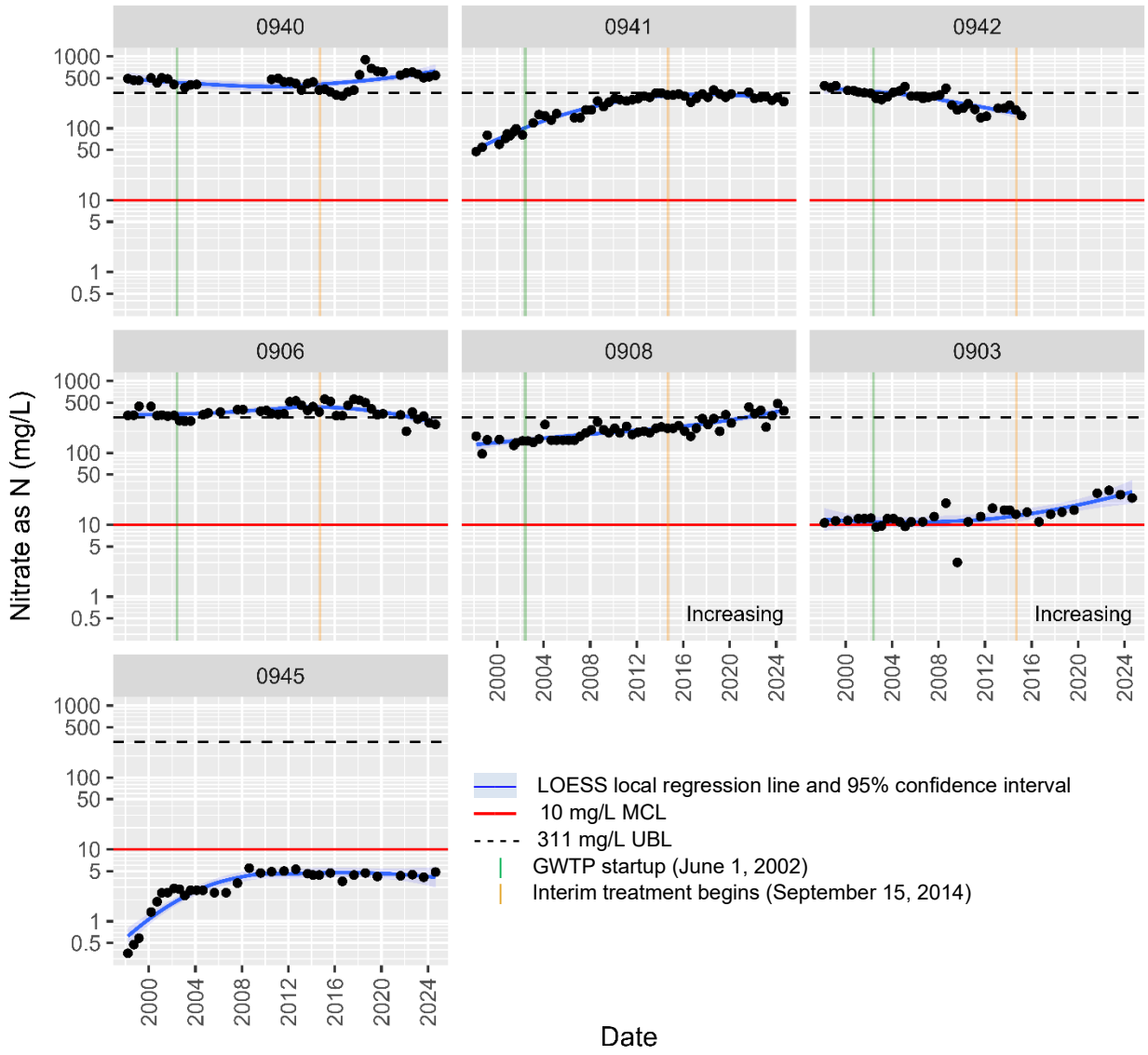
[a] Trends for well 0942 are not shown because sampling was discontinued in 2015.

[b] Trend tests 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.

[c] Trend analyses were conducted at the 0.05 significance level using a two-sided test. A calculated p-value of less than 0.05 indicates that a significant trend in the time series exists. 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.

Abbreviation:

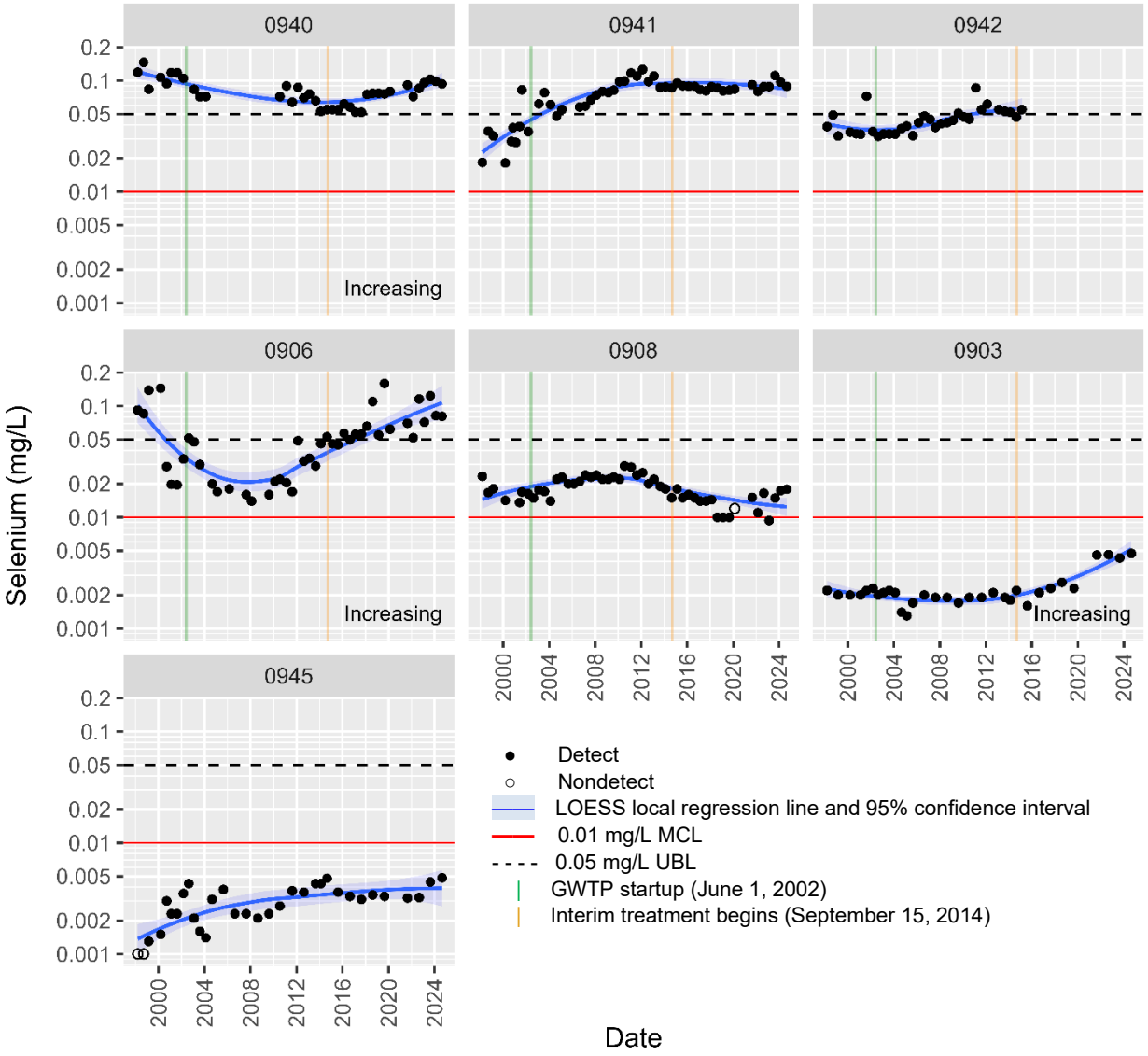
N = nitrogen



Notes: Downgradient wells are ordered in general direction of groundwater flow or distance from the disposal cell; data for upgradient well 0945 are plotted last. Any statistically significant increasing trends for the 2015–2024 time frame (Table 19-5) are indicated on the appropriate plots.
Abbreviation: N = nitrogen

Figure 19-4. Time-Concentration Plots of Nitrate (as N) in Groundwater at the Tuba City, Arizona, Disposal Site, 1998–2024

Nitrate (+ nitrite as nitrogen [N]) concentrations have historically exceeded the 10 mg/L MCL in all LTSP evaluative wells except background well 0945 (Figure 19-4). The 311 mg/L UBL has been exceeded in all downgradient evaluative monitoring wells except southernmost well 0903. In 2024, the UBL was exceeded in only two wells: 0908 (385–486 mg/L) and 0940 (520–545 mg/L). Using data since 1998, Mann-Kendall trend analysis indicates statistically significant increasing nitrate concentration trends in four of the six wells currently monitored: 0903, 0908, 0941, and background well 0945 (Table 19-4). For the 2015–2024 period, trends remain statistically significant only for wells 0908 and 0903 (Table 19-5). Nitrate concentrations in well 0903 have exceeded the 10 mg/L MCL since 2004, the maximum (30.1 mg/L) was detected in August 2022. The most recent (August 2024) nitrate result for well 0903 is 23.6 mg/L.

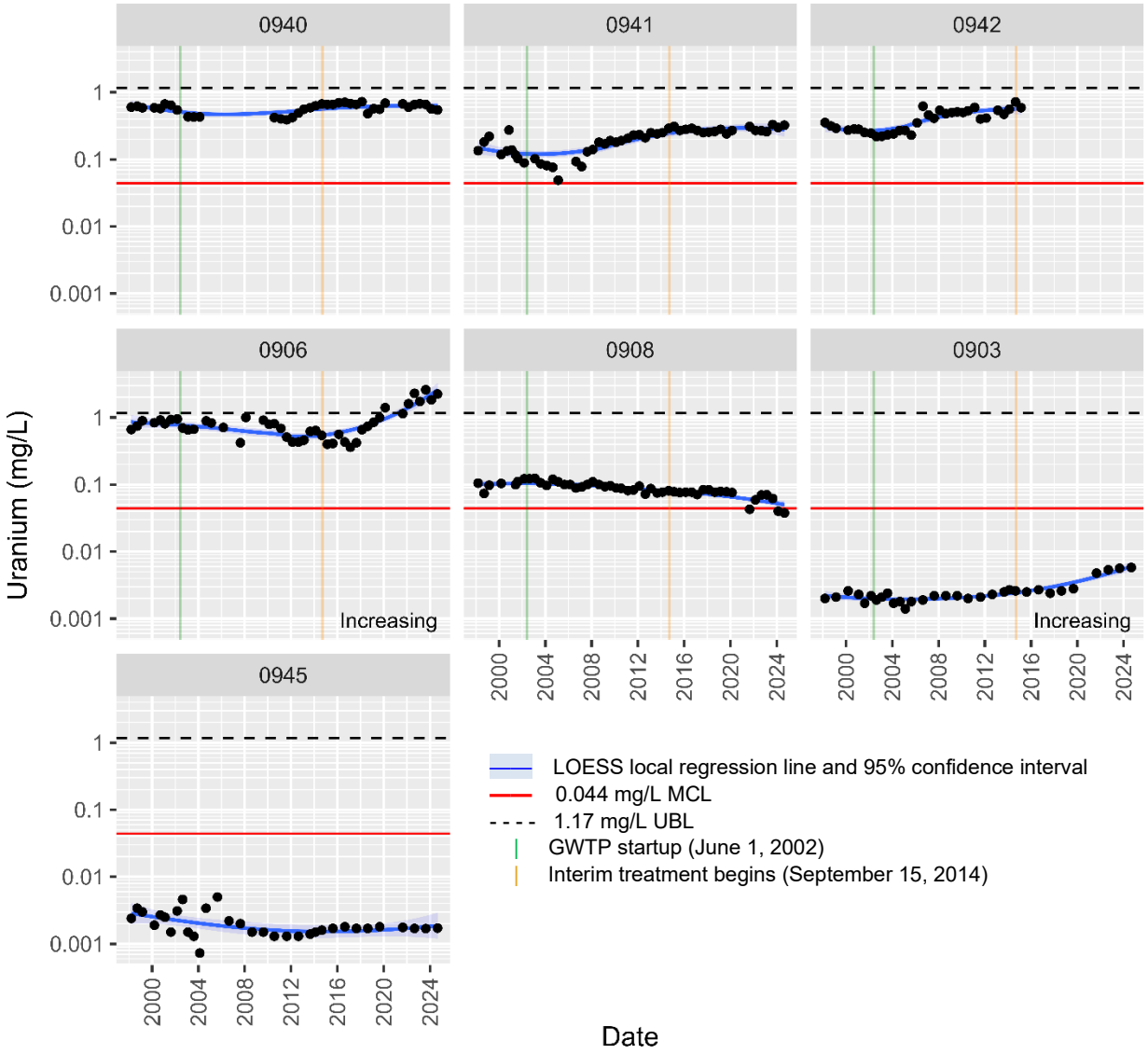


Note: Any statistically significant increasing trends for the 2015–2024 time frame (Table 19-5) are indicated on the appropriate plots.

Figure 19-5. Time-Concentration Plots of Selenium in Groundwater at the Tuba City, Arizona, Disposal Site, 1998–2024

Selenium concentrations have historically exceeded the 0.01 mg/L MCL in all non-background evaluative monitoring wells except southernmost well 0903 (Figure 19-5). Of the wells currently monitored, the 0.05 mg/L UBL has been exceeded in three wells: 0940, 0941, and 0906 (most recent [2024] results of 0.08–0.10 mg/L). Mann-Kendall trend analysis for 1998–2024 indicates statistically significant increasing trends in two of these wells (0941 and 0906), along with background well 0945 (Table 19-4). The increase in selenium concentrations in well 0906 since 2009 correlates with the period when average annual cumulative extraction rates dropped from 80 to 35 gpm due to intermittent shutdowns of the GWTP (DOE 2020). For the more recent period (2015–2024), three wells (0906, 0940, and 0903) have significant increasing trends (Table 19-5). Although below both the UBL and the MCL, selenium concentrations in well 0903 (most recent result of 0.005 mg/L) warrant continued monitoring.

Uranium concentrations have historically exceeded the 0.044 mg/L MCL in all downgradient compliance wells except for well 0903 and (recently) well 0908 (Figure 19-6). The 1.17 mg/L UBL has not been exceeded except for well 0906, where uranium concentrations began increasing significantly after interim treatment started in 2015. The UBL was exceeded for the first time in February 2020 and concentrations have since increased to 2–3 mg/L (most recent result of 2.24 mg/L). Mann-Kendall trend analysis for 1998–2024 indicates statistically significant increasing uranium concentration trends in wells 0941 and 0903. For 2015–2024, the statistically significant increasing trend for downgradient well 0903 continues, in addition to the previously noted trend for well 0906 (Table 19-5). Although still below both the MCL and the UBL, the most recent (August 2024) uranium concentration in well 0903 is the highest result on record for this well at 0.0058 mg/L.



Note: Any statistically significant increasing trends for the 2015–2024 time frame (Table 19-5) are indicated on the appropriate plots.

Figure 19-6. Time-Concentration Plots of Uranium in Groundwater at the Tuba City, Arizona, Disposal Site, 1998–2024

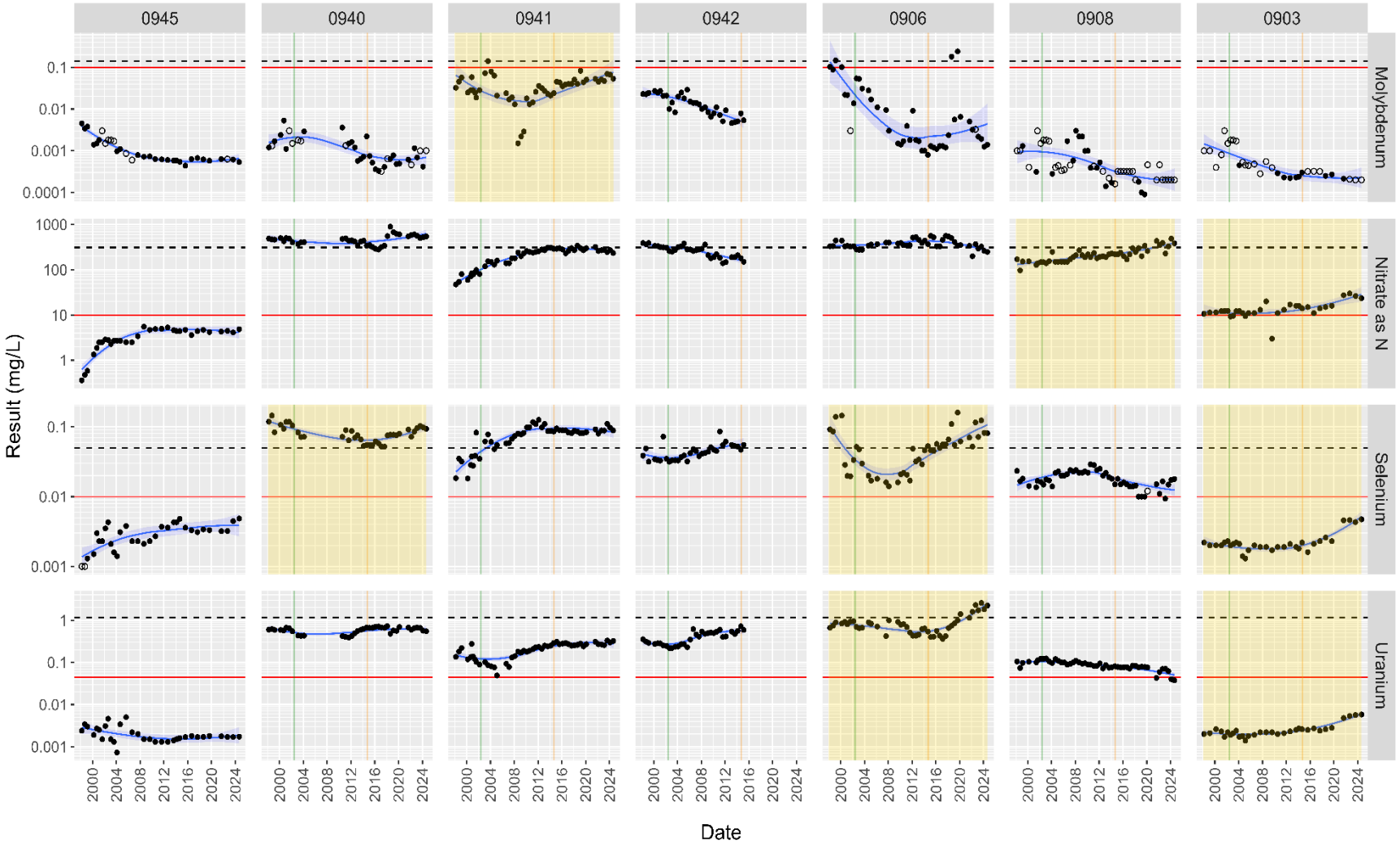
Similar to conclusions drawn in the previous annual report (DOE 2024a), analytical results from the 2024 evaluative monitoring effort indicate that groundwater quality in downgradient wells is still degraded relative to background concentrations in upgradient well 0945 (Figure 19-7). The only exceptions to the latter are molybdenum concentrations in wells 0908 and 0903, which are comparable to background. Since 2015 (when interim treatment began), contaminant concentrations are significantly increasing for the following well-analyte combinations (wells ordered in the general direction of groundwater flow or the distance from the disposal cell):

- Well 0940—selenium
- Well 0941—molybdenum
- Well 0906—selenium and uranium
- Well 0908—nitrate
- Well 0903—nitrate, selenium, and uranium

These increasing trends warrant continued monitoring, especially those in well 0903, the southernmost downgradient well. These increases correlate with the timing of the GWTP shutdown, after which the site began operating under interim treatment with an average annual cumulative extraction rate of 7 gpm. Analysis of water quality trending and progress of the groundwater remedy are reported in the site-specific remedy performance reports for the Tuba City site (DOE 2022; DOE 2024b).

19.8 Corrective Action

Corrective action is taken to correct out-of-compliance or hazardous conditions that create a potential health and safety problem or that may affect the integrity of the disposal cell or compliance with 40 CFR 192. No need for corrective action was identified.



● Detect ○ Nondetect LOESS local regression line and 95% confidence interval

Limits from Table 19-3: = MCL; - - - = UBL

| GWTP startup (June 1, 2002); | Interim treatment begins (September 15, 2014)

Shaded plots denote well-analyte combinations with statistically significant increasing concentration trends since 2015 (Table 19-5).

Note: Wells are ordered in general direction of groundwater flow or distance from the disposal cell (Figure 19-2); data for upgradient well 0945 are plotted first.

Figure 19-7. Summary of Historical Evaluative Monitoring Results at the Tuba City, Arizona, Disposal Site (1998–2024)

19.9 References

Note

Site-related documents are available on the LM public webpages at https://lmpublicsearch.lm.doe.gov/SitePages.

10 CFR 40.27. U.S. Nuclear Regulatory Commission, "General License for Custody and Long-Term Care of Residual Radioactive Material Disposal Sites," *Code of Federal Regulations*.

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

40 CFR 192 Subpart A. U.S. Environmental Protection Agency, "Standards for the Control of Residual Radioactive Materials from Inactive Uranium Processing Sites," *Code of Federal Regulations.*

DOE (U.S. Department of Energy), 1984. *Cooperative Agreement Between the United States Department of Energy, the Navajo Tribe of Indians, and the Hopi Tribe of Indians*, DE-FC04-85AL26731, December.

DOE (U.S. Department of Energy), 1996. *Long-Term Surveillance Plan for the Tuba City, Arizona, Disposal Site,* DOE/AL/62350-182, Rev. 0, October.

DOE (U.S. Department of Energy), 2020. *Interim Treatment System Evaluation Report, Tuba City, Arizona, Disposal Site*, LMS/TUB/S18785, Office of Legacy Management, March.

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DOE (U.S. Department of Energy), 2024a. *2023 Annual Site Inspection and Monitoring Report for Uranium Mill Tailings Radiation Control Act Title I Disposal Sites*, LMS/43755, Office of Legacy Management, March.

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EPA (U.S. Environmental Protection Agency), 1989. *Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance*, EPA/530-SW-89-026, Office of Solid Waste, Waste Management Division, Washington, D.C., February.

Lee, L., 2020. "NADA: Nondetects and Data Analysis for Environmental Data," R package, version 1.6-1.1, https://CRAN.R-project.org/package=NADA, accessed December 12, 2024.

19.10 Photographs

Photograph Location Number	Azimuth	Photograph Description
PL-1	248	Gap Under Fence near Perimeter Sign P9
PL-2	270	Gap Created by Animals Under Fence Between Perimeter Signs P12 and P13
PL-3	248	Sediment Deposition Gauge Between Perimeter Signs P9 and P10
PL-4	248	Debris near Perimeter Sign P9
PL-5	—	Site Marker SMK-2
PL-6	—	Quality Control Monument QC-2
PL-7	—	Evaporative Materials on Top Slope of Disposal Cell
PL-8	90	Potential Tire Tracks on the Southeast Corner of the Disposal Cell
PL-9	113	Horizontal Lines on West Slope of Disposal Cell
PL-10	—	Sediment Deposition on the South Slope of the Disposal Cell
PL-11	—	Debris on the South Slope of Disposal Cell
PL-12	293	Vegetation on South Slope of the Disposal Cell
PL-13	158	Erosional Gully and Soil Accumulation in Diversion Ditch North of Disposal Cell
PL-14	315	Active Bird Nest on Power Pole Southwest of Disposal Cell

Note:
— = Photograph taken vertically from above.

PL-1. Gap Under Fence near Perimeter Sign P9

PL-2. Gap Created by Animals Under Fence Between Perimeter Signs P12 and P13

PL-3. Sediment Deposition Gauge Between Perimeter Signs P9 and P10

PL-4. Debris near Perimeter Sign P9

PL-5. Site Marker SMK-2

PL-6. Quality Control Monument QC-2

PL-7. Evaporative Materials on Top Slope of Disposal Cell

PL-8. Potential Tire Tracks on the Southeast Corner of the Disposal Cell

PL-9. Horizontal Lines on West Slope of Disposal Cell

PL-10. Sediment Deposition on the South Slope of the Disposal Cell

PL-11. Debris on the South Slope of Disposal Cell

PL-12. Vegetation on South Slope of the Disposal Cell

PL-13. Erosional Gully and Soil Accumulation in Diversion Ditch North of Disposal Cell

PL-14. Active Bird Nest on Power Pole Southwest of Disposal Cell