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2008 Verification Monitoring Report for the Old and New Rifle, Colorado, Processing Sites

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Contents

Figures

Tables

Appendixes

Acronyms

CDPHE	Colorado Department of Public Health and Environment
COC	contaminant of concern
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ft	foot (feet)
GCAP	Ground Water Compliance Action Plan
ICs	institutional controls
MCL	maximum concentration limit
mg/L	milligram per liter
NRC	U.S. Nuclear Regulatory Commission
RRM	residual radioactive material
SOWP	Site Observational Work Plan
UMTRA	Uranium Mill Tailings Remedial Action (Project)

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1.0 Introduction

1.1 Purpose of Report

The purpose of this Verification Monitoring Report is to evaluate and interpret ground water monitoring data collected at the Old and New Rifle, Colorado, Uranium Mill Tailings Remedial Action (UMTRA) Project processing sites (Figure 1 and Figure 2) and to assess the progress of meeting the compliance strategy for ground water cleanup. Detailed information for the Old and New Rifle sites and water quality data through 1998 and 1999 are found in the Final Site Observational Work Plans (SOWPs) (DOE 1999a and 1999b) for the sites.

1.2 Compliance Strategy

The proposed compliance strategy for both the New and Old Rifle sites is natural flushing in conjunction with continued ground water and surface water monitoring, and institutional controls (ICs) that would restrict access to contaminated ground water (DOE 2005 and 2001). Also, the U.S. Department of Energy (DOE) and the State of Colorado constructed an alternate domestic water supply system in 2003 to service users near and downgradient of the New Rifle site (Figure 2). This compliance strategy will be protective of human health and the environment.

1.3 Site Status

The Old Rifle SOWP (DOE 1999a) and Ground Water Compliance Action Plan (GCAP) (DOE 2001) are complete and have received concurrence from the U.S. Nuclear Regulatory Commission (NRC) and the Colorado Department of Public Health and Environment (CDPHE). The conditions are to maintain ICs over the site and conduct a monitoring program until levels of contaminants of concern (COCs) decrease to acceptable levels. An Environmental Checklist was completed and accepted for the Old Rifle site. The Old Rifle site is currently owned by the City of Rifle.

The New Rifle SOWP (DOE 1999b) and the draft GCAP (DOE 2006) were submitted to NRC and CDPHE. The GCAP is currently undergoing revision based on comments received from NRC and the State. Final concurrence of the GCAP will occur when any outstanding issues have been adequately resolved. The conditions are to maintain ICs over the site and downgradient areas (Figure 3) and continue a monitoring program until concentrations of COCs decrease to acceptable levels. An Environmental Assessment resulting in a Finding of No Significant Impact was completed and distributed to stakeholders (DOE 2003). The annual verification monitoring proposed in the GCAPs for these sites is currently being implemented, and results of the April 2008 monitoring are presented in this report.

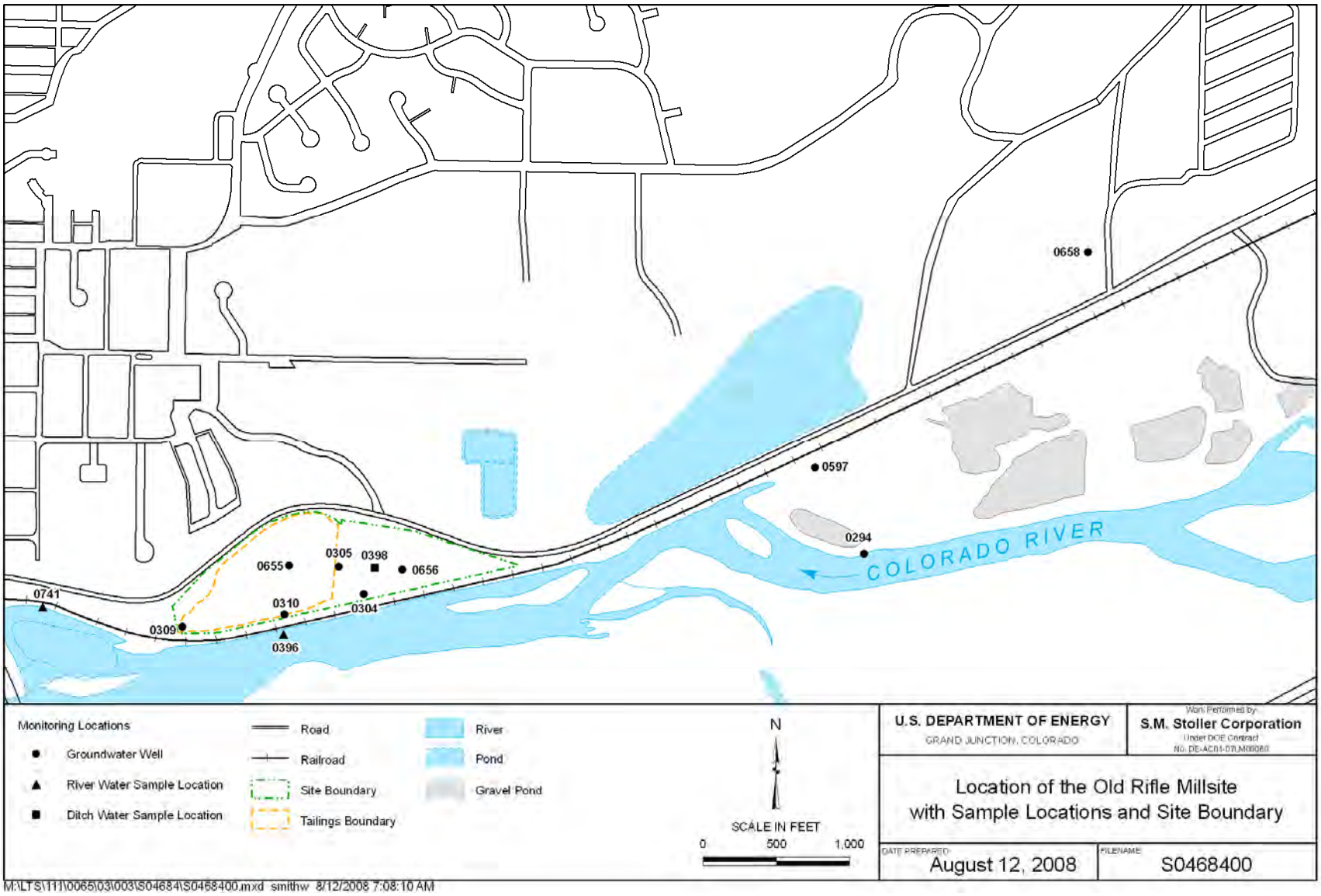

Figure 1. Location of the Old Rifle Mill Site with Sample Locations and Site Boundary

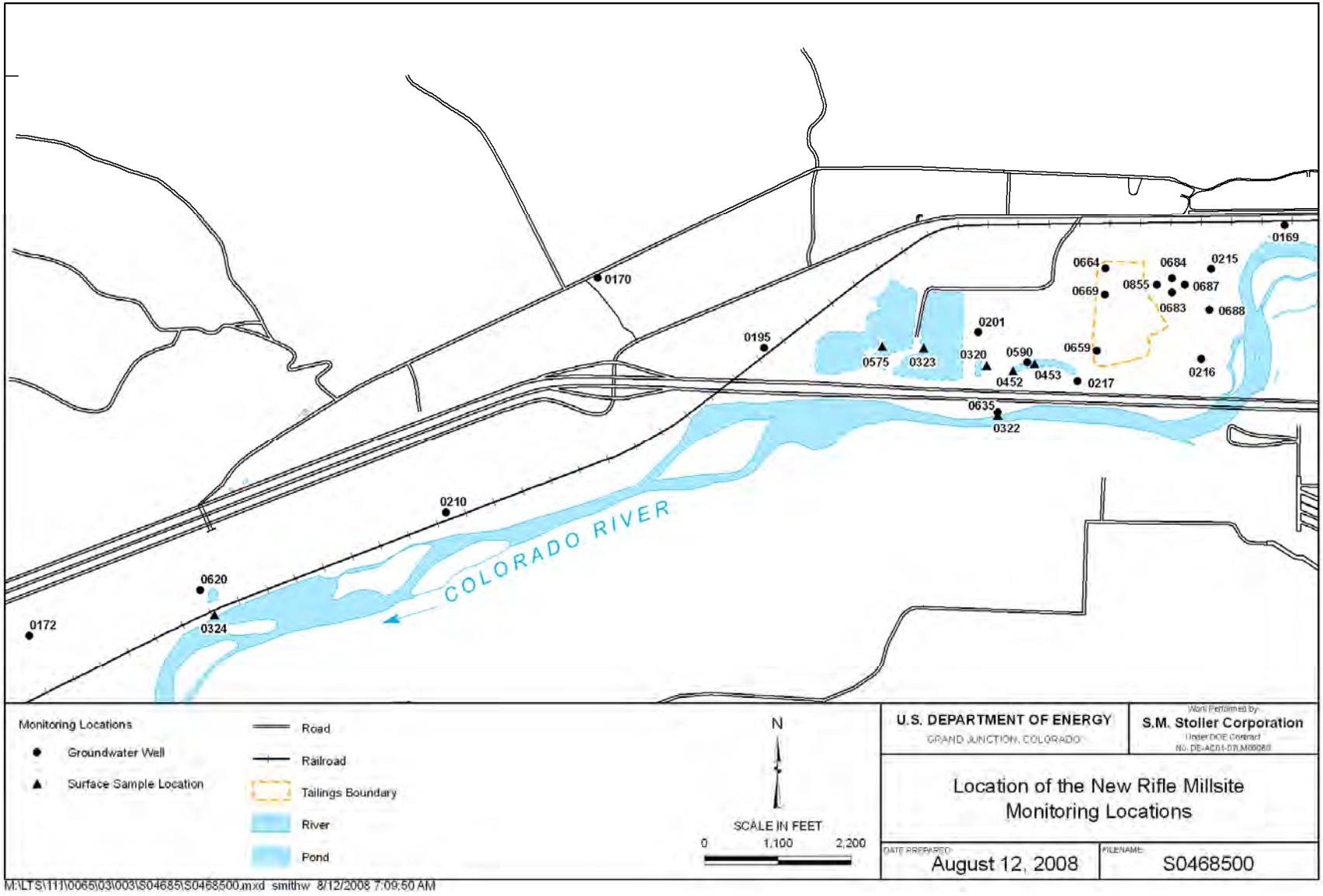

Figure 2. Location of the New Rifle Mill Site Monitoring Locations

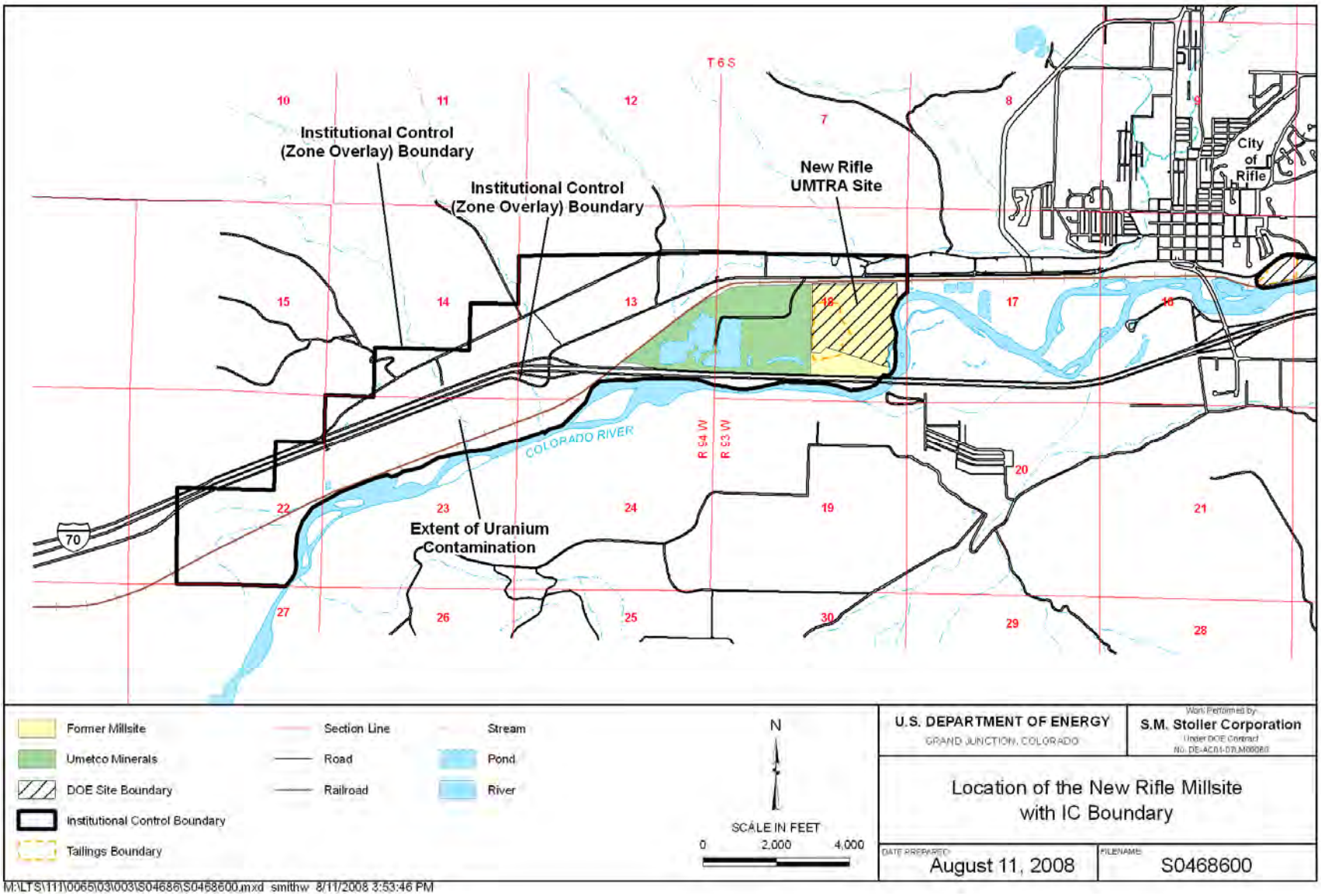

Figure 3. Location of the New Rifle Mill Site With IC Boundary

2.0 Site Conditions

2.1 Hydrogeology

The former Old Rifle processing site is 0.3 mile southeast of the city of Rifle, in a floodplain on the north side of the Colorado River (Figure 1). Ground water occurs under unconfined conditions in the uppermost aquifer, which consists of river alluvium and the upper weathered surface of the Tertiary Wasatch Formation. The uppermost aquifer is 5 to 25 feet (ft) thick; saturation occurs from 5 to 10 ft below ground surface. The uppermost aquifer is composed of poorly sorted sediments ranging from clay-sized material through gravel, with cobbles and occasional boulders. Ground water in the alluvial aquifer generally flows to the west-southwest; hydraulic conductivity ranges from 1.2 ft/day in the alluvium to 0.02 ft/day in the weathered Wasatch. Recharge is from ground water ephemeral seeps above the mill site, precipitation, and an unlined irrigation return ditch that flows across the middle of the site. The Colorado River can briefly recharge the mill site ground water during periods of maximum flow associated with spring runoff. Ground water discharge is mainly to the Colorado River; another source of discharge is evapotranspiration. At Old Rifle, alluvium pinches out against bedrock outcrops at the downgradient end of the site. The Old Rifle site has no hydrological connection to the New Rifle site. Additional data regarding the hydrogeology of the Old Rifle site is provided in the SOWP (DOE 1999a).

The former New Rifle processing site is located about 1.5 miles west of the city of Rifle and is also situated on the north floodplain of the Colorado River (Figure 2). As with the Old Rifle site, the uppermost aquifer consists of river alluvium and the weathered surface of the Wasatch Formation. Other hydrologic properties are similar to those at the Old Rifle site (DOE 1999b). Alluvium is thickest along the western and southern portions of the site and is continuous for at least 4 miles downgradient of the site. The alluvium provides a source for domestic water in the area. Recharge is from ephemeral streams from the north and precipitation; ground water discharge is to the Colorado River and evapotranspiration.

At one time, Roaring Fork Resources operated a gravel mine on the property adjacent to and downgradient of the New Rifle site. Water was pumped from an active on-site mining pit where excavation was occurring to another on-site pit for storage and infiltration. (These pits have been referred to previously as the "Roaring Fork ponds.") During its period of operation, the pumping affected ground water flow downgradient of the New Rifle site, creating both a cone of depression in and a ground water mound on the alluvial aquifer water table (DOE 1999b). Operation of the gravel mine ceased in early 2003, and natural alluvial ground water flow conditions have been reestablished, though effects of the ponds on contaminant distribution persist today.

2.2 Ground Water Quality

Alluvial ground water in background locations near the Rifle sites has concentrations of selenium and uranium that are above applicable standards (DOE 1995b). Sulfate levels in background locations have also been relatively high, far exceeding the secondary drinking water standard of 250 milligrams per liter (mg/L) (non-enforceable; based on aesthetic considerations). However, it has been demonstrated that ground water in the uppermost aquifer beneath the Old

Rifle site and beneath and downgradient of the New Rifle site was contaminated by site-related activities.

Table 1 presents historical data for COCs in ground water at both sites prior to completion of surface remediation. A comparison of historical data with benchmarks indicates that criteria were exceeded for a number of constituents; contamination at the New Rifle site was much greater than at the Old Rifle site. Additionally, while ground water was not being used in the vicinity of the Old Rifle site, several private wells were present in the alluvial aquifer downgradient of the New Rifle site (DOE 1995b).

Table 1. Historical Ground Water Chemistry for Old and New Rifle Site COCs

COC (all units mg/L)		Old Rifle Site		New Rifle Site	
	Benchmark	Historical Range[a] Aug. 1990–Aug. 1994	Median	Historical Range[a] Aug. 1990–Aug. 1994	Median
Ammonia as NH_4[b]	na	na	na	506–1,750	1,030
Arsenic	0.05[c]	na	na	0.97–1.3	1.1
Molybdenum	0.01[c]	na	na	2.3–3.7	2.9
Nitrate + Nitrite as N	10[c]	na	na	124–251	177
Selenium	0.036[d]	0.007–0.085	0.072	<0.002–0.3	<0.05
Uranium	0.067[d]	1.6–2.1	1.8	0.24–0.37	0.29
Vanadium	na	0.5–-0.75	0.55	0.59–2.8	1.3

[a]Ranges and median values are from the Baseline Risk Assessment (DOE 1995a), Table 3.1. (Pre-remedial action)
[b]No longer considered as a COC; included to understand nitrate behavior.
[c] EPA UMTRA Ground Water Project standard (40 CFR 192).
[d]Maximum background value, cleanup goal.
na=not applicable

During surface remediation, mill tailings and other residual radioactive materials (RRM) were removed; surface remediation was completed by 1996, and tailings were stabilized in an engineered repository located about 15 miles north of Rifle. RRM was removed down to and, in some cases, just below the ground water surface. Clean gravel and soil were used to fill the excavations, and the surface was given 6 inches of topsoil and sown with seed mixtures.

Subsequent characterization completed at the New Rifle site as part of a pilot study for removal of vanadium from the ground water (DOE 2000) indicated that some residual soil contamination remains at that site below the water table. Analyses showed elevated concentrations of vanadium; several samples also showed residual concentrations of molybdenum, uranium, and arsenic. Most of these soils are associated with the location of a former disposal pond and, to a lesser extent, with former tailings pile locations. Soil characterization was not conducted at the Old Rifle site except to confirm that radiological cleanup criteria were met.

2.3 Land and Water Use

The City of Rifle acquired the former Old Rifle processing site from the State of Colorado in 2000. Because all ground water contamination is contained on the mill site and discharges into the Colorado River, adjacent property is not sampled. The City built a maintenance facility on the east end of the site and has made no decision on future use of the western end of the property.

The former New Rifle processing site was transferred from the State of Colorado to the City of Rifle in 2004. The adjacent downgradient property was owned by Umetco Minerals Corporation, which was acquired by DOW Chemical (Figure 3); other private parties own parcels farther downgradient of the site. The City is constructing a wastewater treatment facility on the northeastern portion of the site and has other long-range plans for the remainder of the site. Historically, domestic wells present downgradient of the New Rifle site were used for drinking water. However, these wells are no longer in use, and water at these locations is supplied by the City. The Roaring Fork gravel pit (now owned by DOW Chemical) ceased operation in 2003, and the ponds have since filled and equilibrated with the local water table. The banks of the ponds have been contoured and seeded. According to an agreement between DOW Chemical and the State of Colorado, use of the ponds by livestock will be restricted, probably by fencing. No immediate plans are in place for this property.

3.0 Monitoring Program

3.1 Monitoring Network

Sampling locations comprising the monitoring network at the Old Rifle processing site are listed in Table 2. The monitoring network consists of eight monitor wells, six on site and two background; and four surface water locations, one upgradient of the site, two at the site, and one downgradient of the site (Figure 1). Selenium, uranium, and vanadium are monitored at most of these locations.

Table 2. Summary of Monitoring Requirements for the Old Rifle Site

Location	Monitoring Purpose	Analytes	Frequency
RFO–0305, –0655	Center of plume west side of ditch	Se, U, V	Once every 5 years until 2030[a]
RFO–0656	Center of plume east side of ditch	Se, U, V	Once every 5 years until 2030[a]
RFO–0304, –0309, −0310	Farthest downgradient location; leading edge of plume	Se, U, V	Once every 5 years until 2030[a]
RFO–0292, −0658, −0597	Background ground water quality; upgradient monitor well	Se, U, V	Once every 5 years until 2030[a]
RFO–0398	Monitor surface water background U recharging aquifer; on-site ditch	U	Once every 5 years until 2030[a]
RFO–0538, –0396, −0741	Upgradient, adjacent to site, and downgradient locations on Colorado River; monitor effect of site on river	Se, U, V	Once every 5 years until 2030[a]

[a]Annual monitoring will be reinitiated when a contaminant concentration decreases to or below a respective compliance standard. Monitoring will be discontinued when/if the contaminant concentrations have remained below the compliance levels for 3 consecutive years.

Monitoring requirements for the New Rifle site are listed in Table 3. The monitoring network consists of 17 monitor wells at various locations and seven surface sampling sites. The two Old Rifle background wells also serve as background for the New Rifle site. The analytes monitored vary with sample location.

Table 3. Summary of Monitoring Requirements for the New Rifle Site

Location	Monitoring Purpose	Analytes	Frequency
0170, 0172, 0210, 620	Monitor middle and leading edge of molybdenum, uranium, and nitrate plumes.	Molybdenum, uranium, nitrate	All wells and locations, annually until 2010. Monitoring requirements will be reevaluated at that time.
0195, 0201, 0215, 0216, 0217, 0590, 0635, 0658, 0659, 0664, 0669, 0670, 0855	Monitor flushing in main body of plumes.	Molybdenum, nitrate, uranium	
0320, 0322, 0323, 0324, 0452, 0453, 0575	Monitor surface water to determine impact of ground water discharge to surface water and ecological receptors.	Molybdenum, nitrate, uranium, vanadium	
0215, 0216, 0217, 0590, 0658, 0659, 0664, 0669, 0670, 0855	Monitor flushing in main body of plumes.	Vanadium	

[a]Monitoring for a COC will be discontinued if concentrations are below its standard for 3 consecutive years.

3.2 Results of the Monitoring Program

3.2.1 Old Rifle Site

3.2.1.1 Surface Water

Results of surface water monitoring in the Colorado River (locations 0538, 0396, and 0741) indicate that water quality of the river adjacent to and downgradient from the Old Rifle site is indistinguishable from background water quality. This confirms the calculations included in the SOWP (DOE 1999a) demonstrating that ground water discharged to the river would immediately undergo rapid mixing with river water. Sampling of the site ditch (RFO0398), which serves as a source of recharge to the alluvial aquifer, indicates that measurable amounts of uranium (0.038 mg/L) are present in that surface water body.

3.2.1.2 Ground Water

Spot plots showing the distribution of COCs in ground water at the Old Rifle site are presented in Figure 4 through Figure 6. Time-concentration graphs for wells sampled at both the Old and New Rifle sites are presented in Appendix A. Table 4 presents statistics for monitoring results for the Old Rifle site for two time periods—1998/1999, shortly after completion of surface remediation, and the most recent monitoring results from April 2008. Comparison of these two groups of data should provide some indication of the progress of natural flushing since surface cleanup ended.

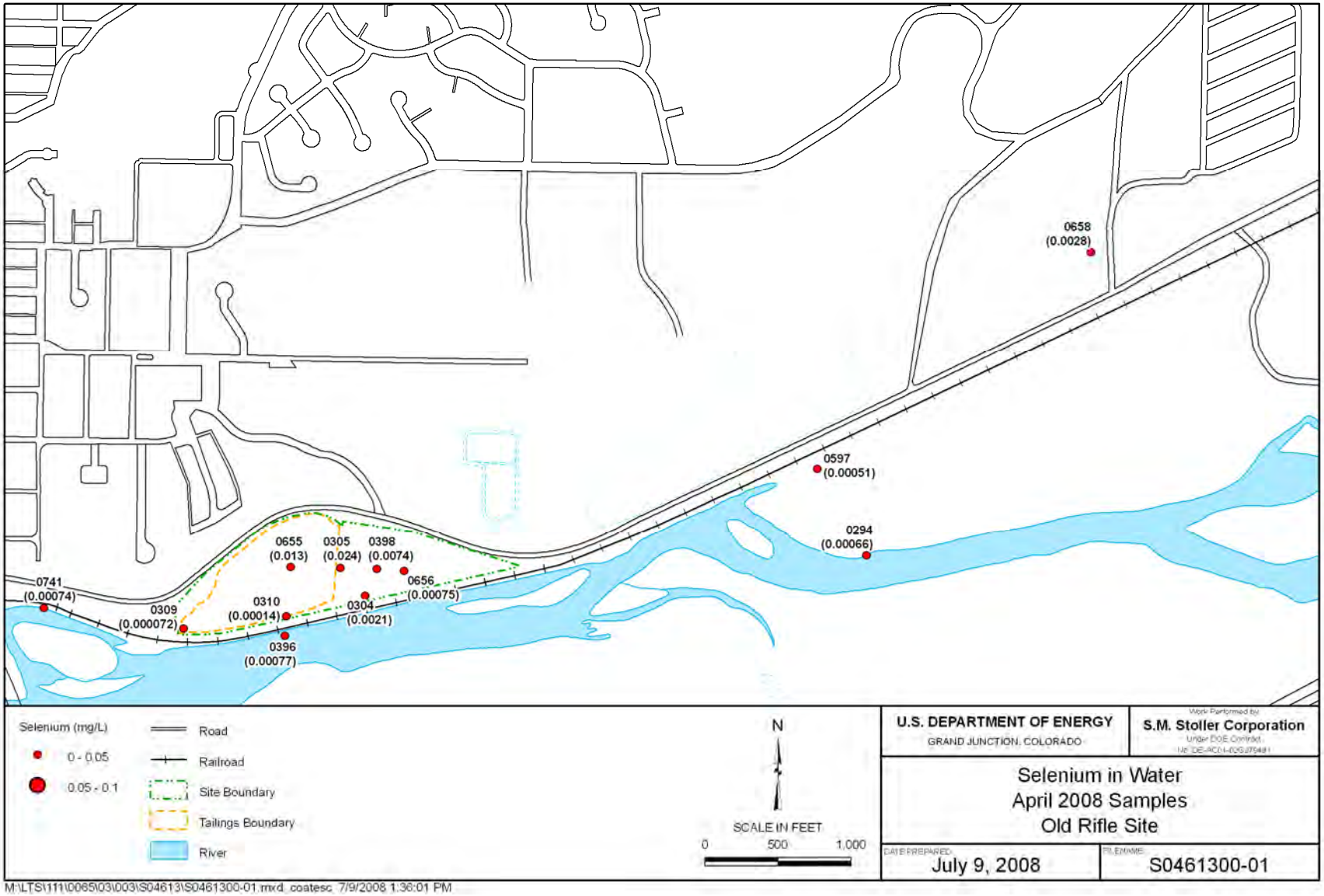

Figure 4. Selenium in Water at the Old Rifle Site

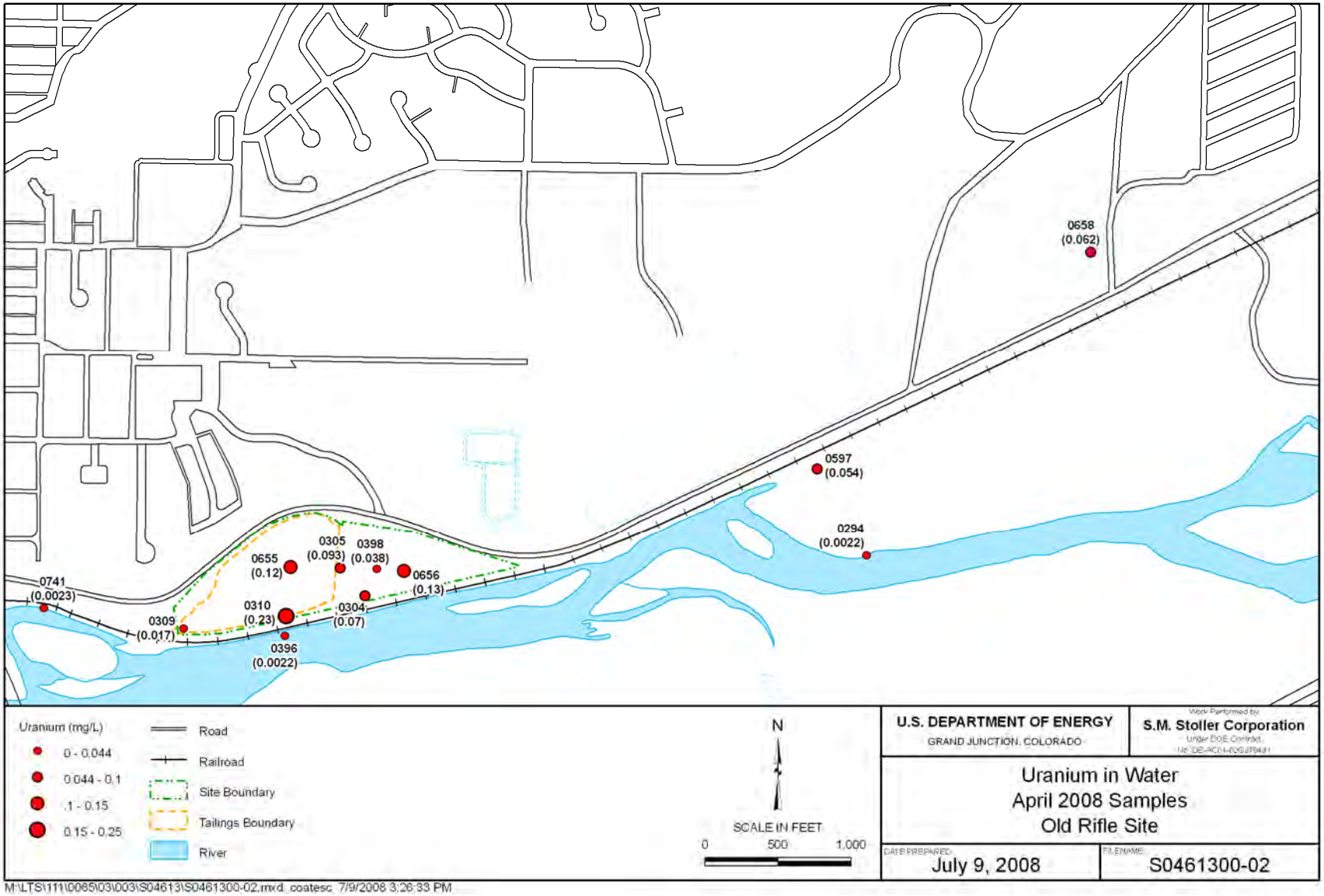

Figure 5. Uranium in Water at the Old Rifle Site

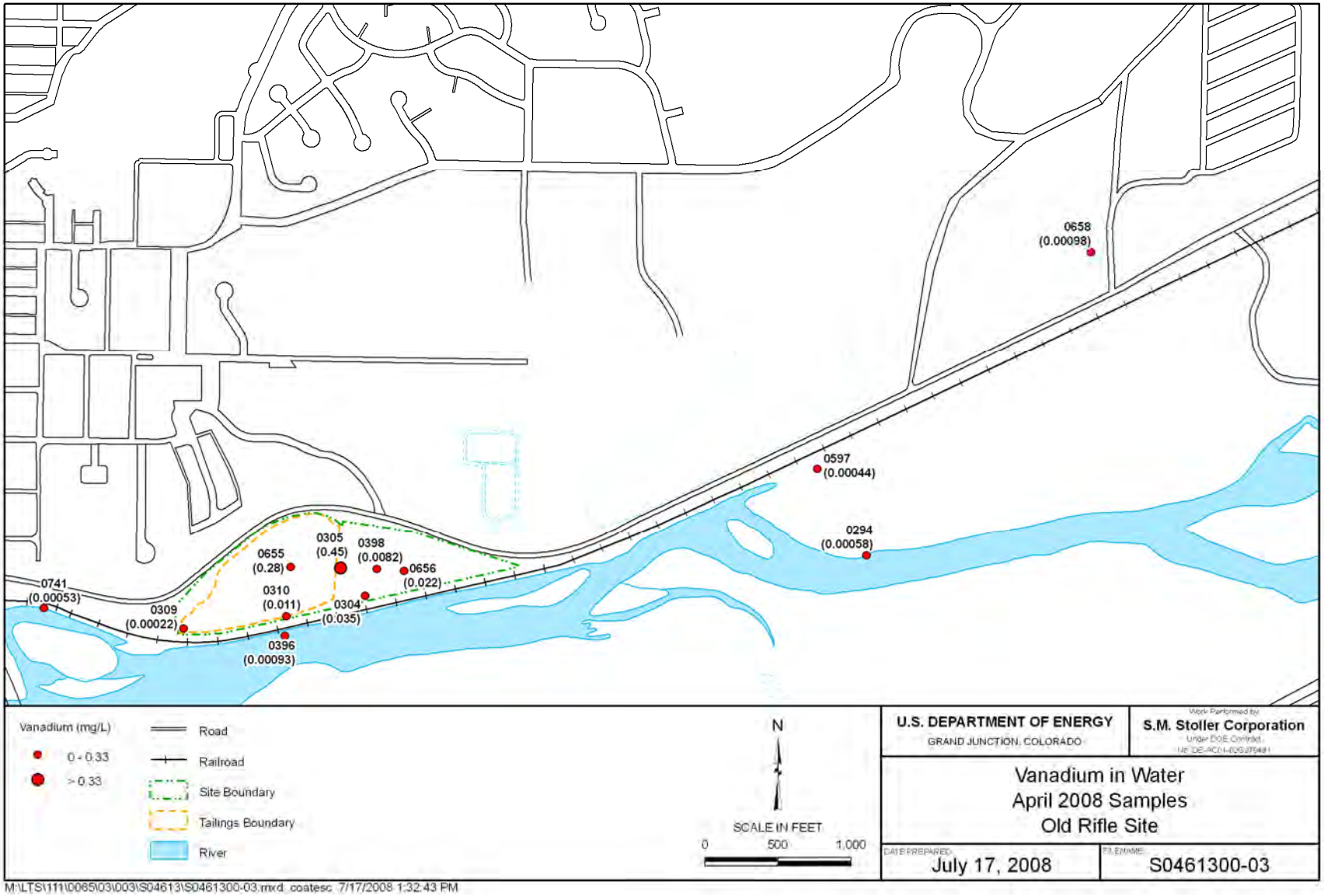

Figure 6. Vanadium in Water at the Old Rifle Site

Table 4. Post-Remediation Ground Water Monitoring Results for the Old Rifle Site

COC (all units mg/L)	Benchmark	Range 1998–1999	Mean 1998–1999	Range April 2008	Mean April 2008
Selenium	0.05[a]	<0.0001–0.122	0.023	0.00007–0.024	0.0067
Uranium	0.044[b]	0.0268–0.270	0.0997	0.017–0.23	0.11
Vanadium	0.33[c]	<0.0006–0.799	0.2337	0.00022–0.45	0.133

Data for wells 0304, 0305, 0309, 0310, 0655, 0656
[a]EPA Safe Drinking Water Act standard and approved alternate concentration limit.
[b]EPA UMTRA Ground Water Project standard (40 CFR 192)
[c]Risk-based concentration

Data in Table 4 indicate that currently the average concentration of vanadium in Old Rifle alluvial ground water is below the benchmark value of 0.33 mg/L; only a single location (0305) exceeded this value. Selenium concentrations at all locations were below the benchmark of 0.05 mg/L for 2008. In contrast, uranium concentrations at all locations except one (0309) exceeded the uranium standard. A comparison of 1998/1999 monitoring results (post–surface remediation) with recent data indicates that average concentrations of vanadium have decreased by about one half, while selenium has decreased to less than a third over that time frame. The current average concentration of uranium is slightly higher than it was 10 years ago. Maximum observed concentrations for all COCs have decreased.

Spot plots in Figure 4 through Figure 6 indicate that elevated uranium concentrations persist across the site, while selenium and vanadium are more localized. Vanadium is much less mobile than uranium and is more likely to adsorb to subsurface materials. Selenium can be easily mobilized under certain geochemical conditions, but studies indicate that mobilizing conditions are not present at the Rifle sites (DOE 1999b). It is likely that the limited distribution and greater decreases in concentration of vanadium and selenium compared to uranium can be attributed to some type of adsorptive mechanisms. Attenuation through adsorption rather than true flushing of the aquifer is probably the cause for decreases in selenium to levels below benchmark values.

By contrast, uranium is a highly mobile constituent and tends to be carried in solution. The fact that large changes in uranium concentrations have not occurred at the site may indicate that ground water is not moving through the subsurface as rapidly as was previously thought. This could be partly due to the drought conditions that have dominated over the last several years, resulting in low rainfall and reduced river flows.

It can be concluded that concentrations of selenium and vanadium have reached compliance goals based on sitewide averages. Time-concentrations plots in Appendix A-1 indicate that these constituents have been relatively stable in Old Rifle wells for the last couple of years of monitoring. Uranium continues to persist at the site. Time-concentration plots are ambiguous with respect to attenuation of uranium. Portions of plots for some wells show increases, while others show decreases; plots for other wells appear to fluctuate around almost level concentrations. Uranium monitoring should continue until conclusions can be reached regarding the applicability of the natural flushing compliance strategy. At that time, a change in the monitoring approach may be called for.

3.2.2 New Rifle Site

3.2.2.1 Surface Water

Two surface water locations at the New Rifle site (locations 0322 and 0324) represent Colorado River water. The other five surface locations were samples collected from the wetland area and former Roaring Fork gravel pond; these samples may be more representative of ground water in the area, though they could have higher COC concentrations due to evaporation. The two river samples were chemically indistinguishable from one another as well as from background, indicating no site-related chemical signature. COC concentrations in river water samples were orders of magnitude less than concentrations in samples from the adjacent wetlands. No surface water standards were exceeded in the river. Sampling results confirm the calculations performed as part of the SOWP (DOE 1999b), which indicate that discharging ground water undergoes significant mixing with river water and that rapid attenuation of contaminants occurs.

Elevated levels of the site-related constituents molybdenum, nitrate, and uranium occur in the wetland area and in the Roaring Fork gravel pond. As natural flushing results in declining contaminant concentrations in the alluvial aquifer, corresponding declines should occur in these surface waters as well.

3.2.2.2 Ground Water

Ground water beneath the New Rifle site was contaminated by former vanadium- and uranium-ore-processing operations that were ongoing from 1958 through 1972, from lignite ash processing from 1964 to 1967, and from vanadium processing (which did not produce tailings but may have produced milling solutions) from 1973 to 1984. Site field investigations have shown that the alluvial aquifer is the only aquifer affected by the former milling operations. Previously identified COCs in the alluvial aquifer with concentrations that exceed ground water standards of 40 CFR 192 are arsenic, molybdenum, nitrate, selenium, and uranium. Fluoride levels have exceeded the Safe Drinking Water Act standard of 4 mg/L. Concentrations of ammonia, manganese, and vanadium have exceeded risk-based concentrations based on use of ground water for domestic purposes in a residential setting (DOE 1999). Based on discussions with CDPHE, it has been determined that ammonia, fluoride, and manganese are of little concern at the site because of their relatively low concentrations and limited distribution. In addition, the arsenic standard was exceeded in only one well at the site (0855), in the vicinity of the former raffinate ponds. As with selenium and vanadium in ground water at the Old Rifle site, it appears that arsenic at New Rifle has attenuated in ground water through adsorption onto subsurface soils in the vicinity of the source area, rather than being carried in solution and flushed from the alluvial system. Only the remaining constituents—molybdenum, nitrate, selenium, uranium, and vanadium—are discussed further in this document.

Spot plots showing the distribution of constituents monitored in New Rifle alluvial ground water and in surface water are presented in Figure 7 through Figure 11. These plots contain some sample locations that are not part of the regular monitoring network, but which were sampled as part of another project. They are shown here to provide a more complete picture of contaminant distribution. Those wells, however, are not included in site statistics so as to allow comparison

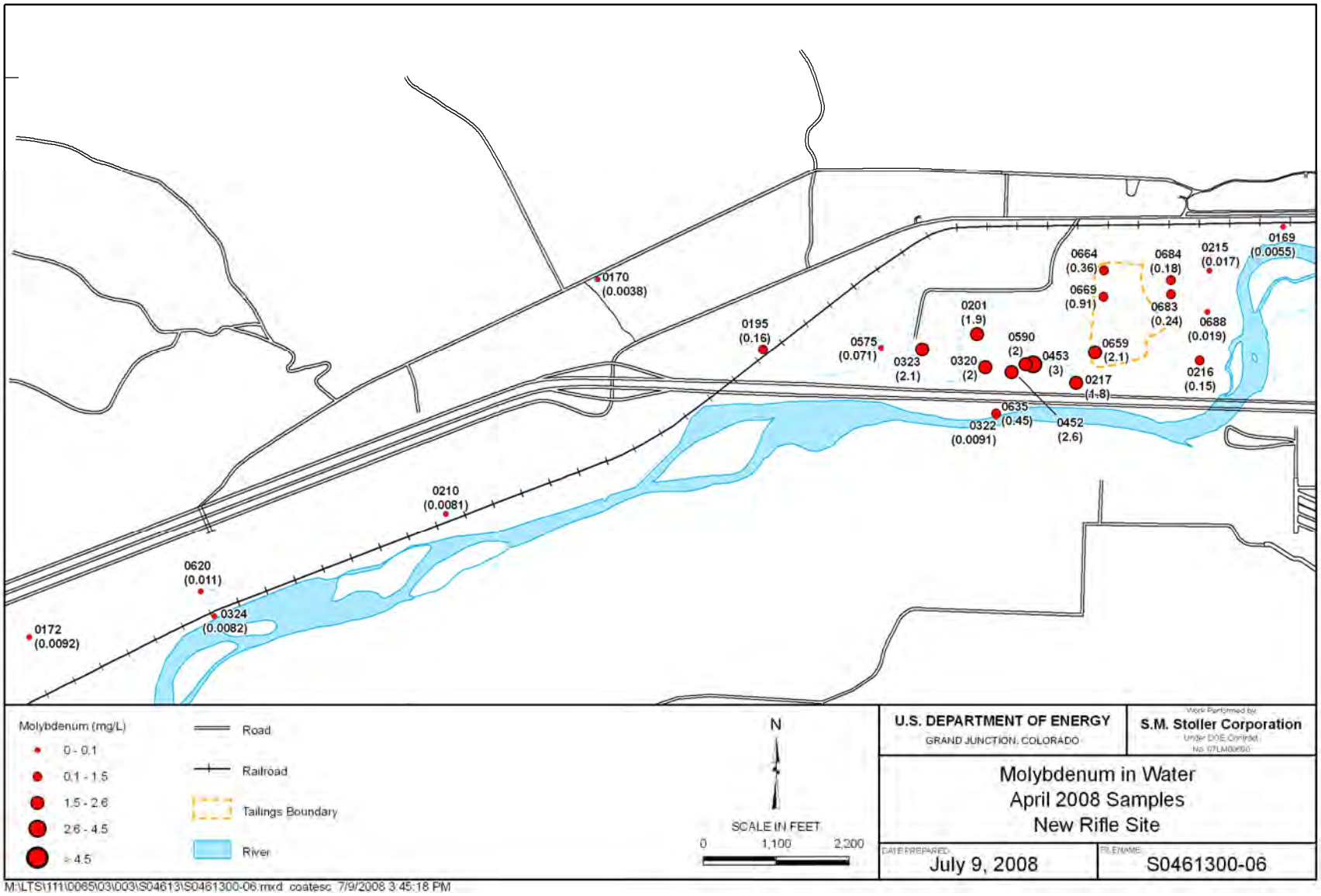

Figure 7. Molybdenum in Water at the New Rifle Site

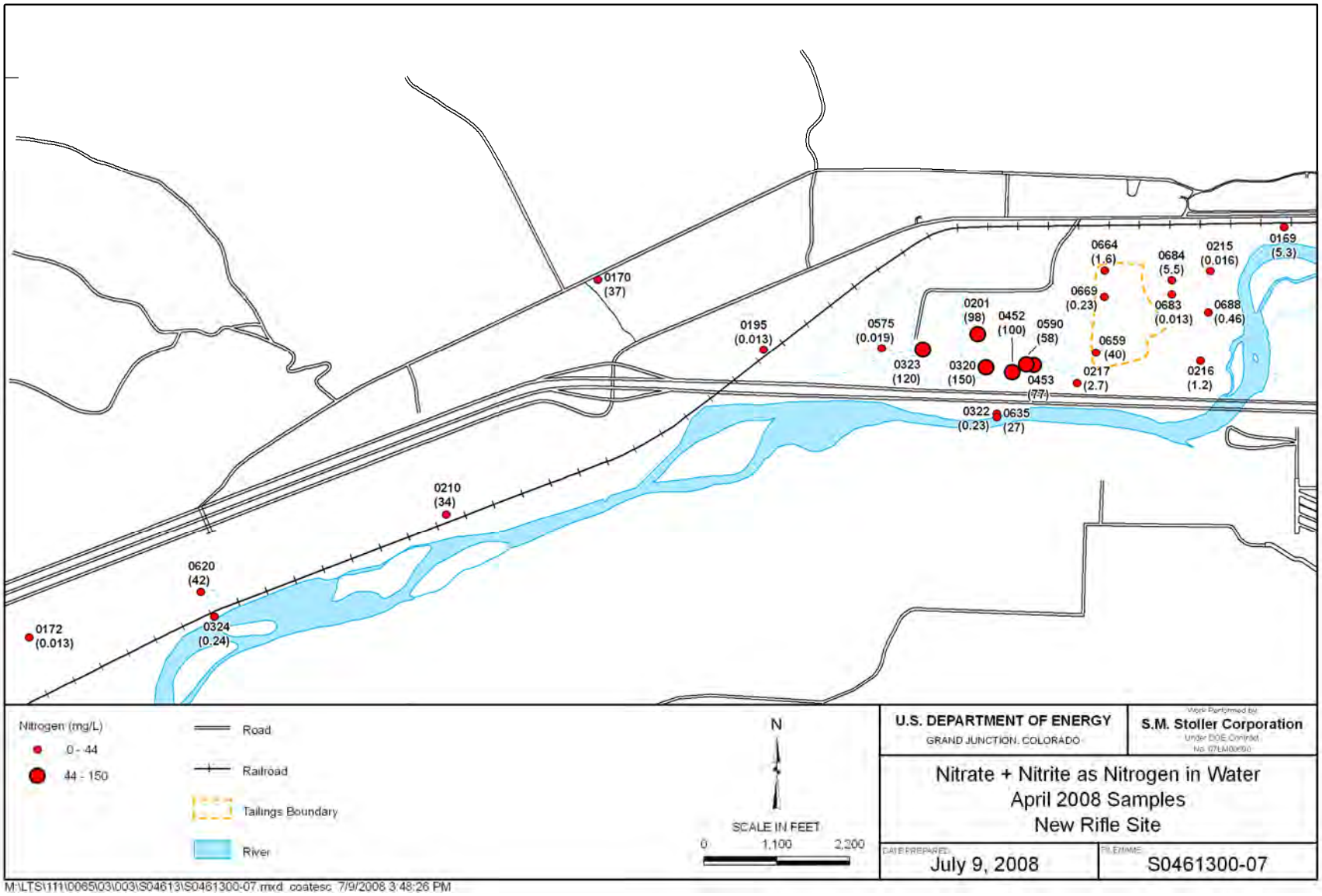

Figure 8. Nitrate + Nitrate as Nitrogen in Water at the New Rifle Site

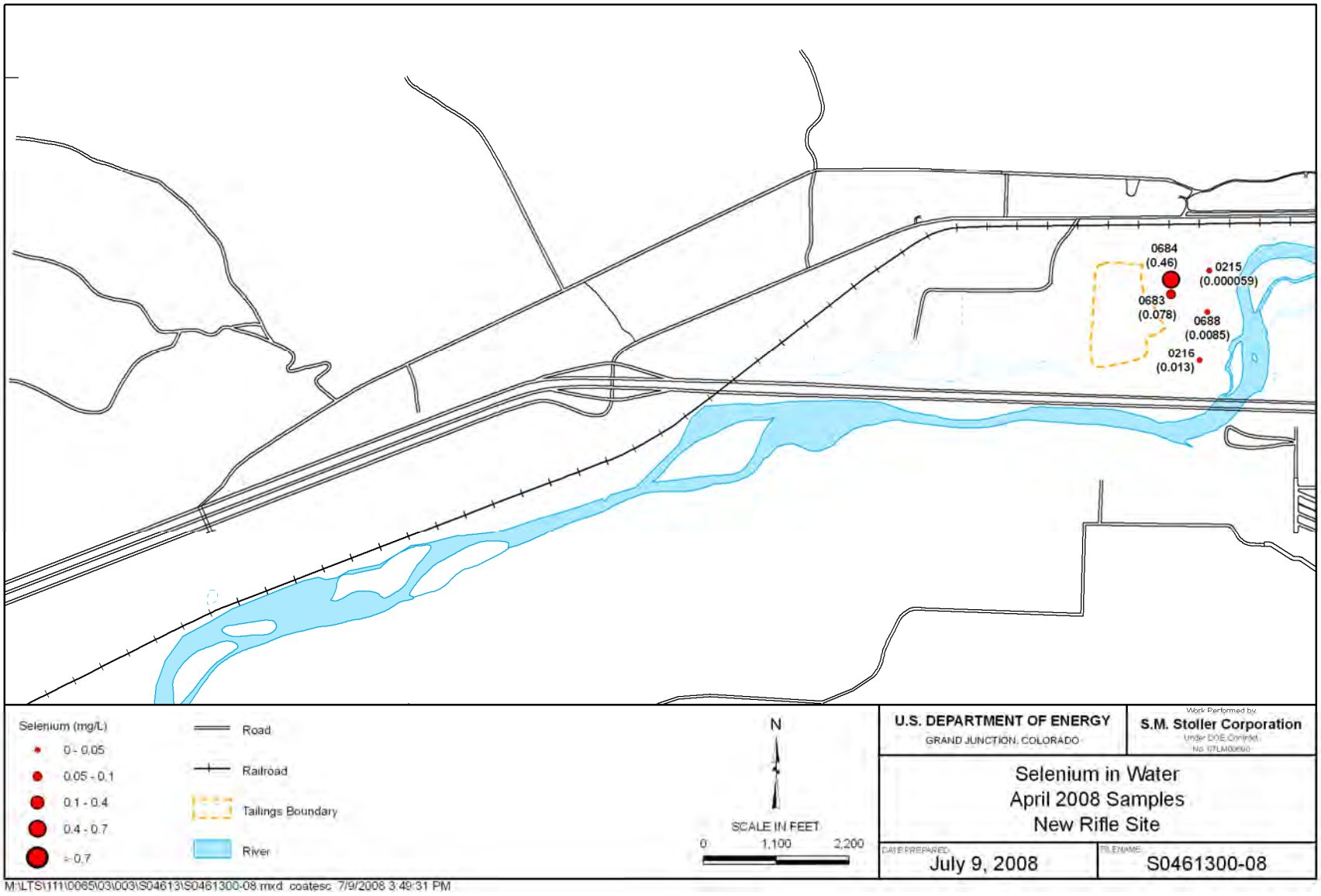

Figure 9. Selenium in Water at the New Rifle Site

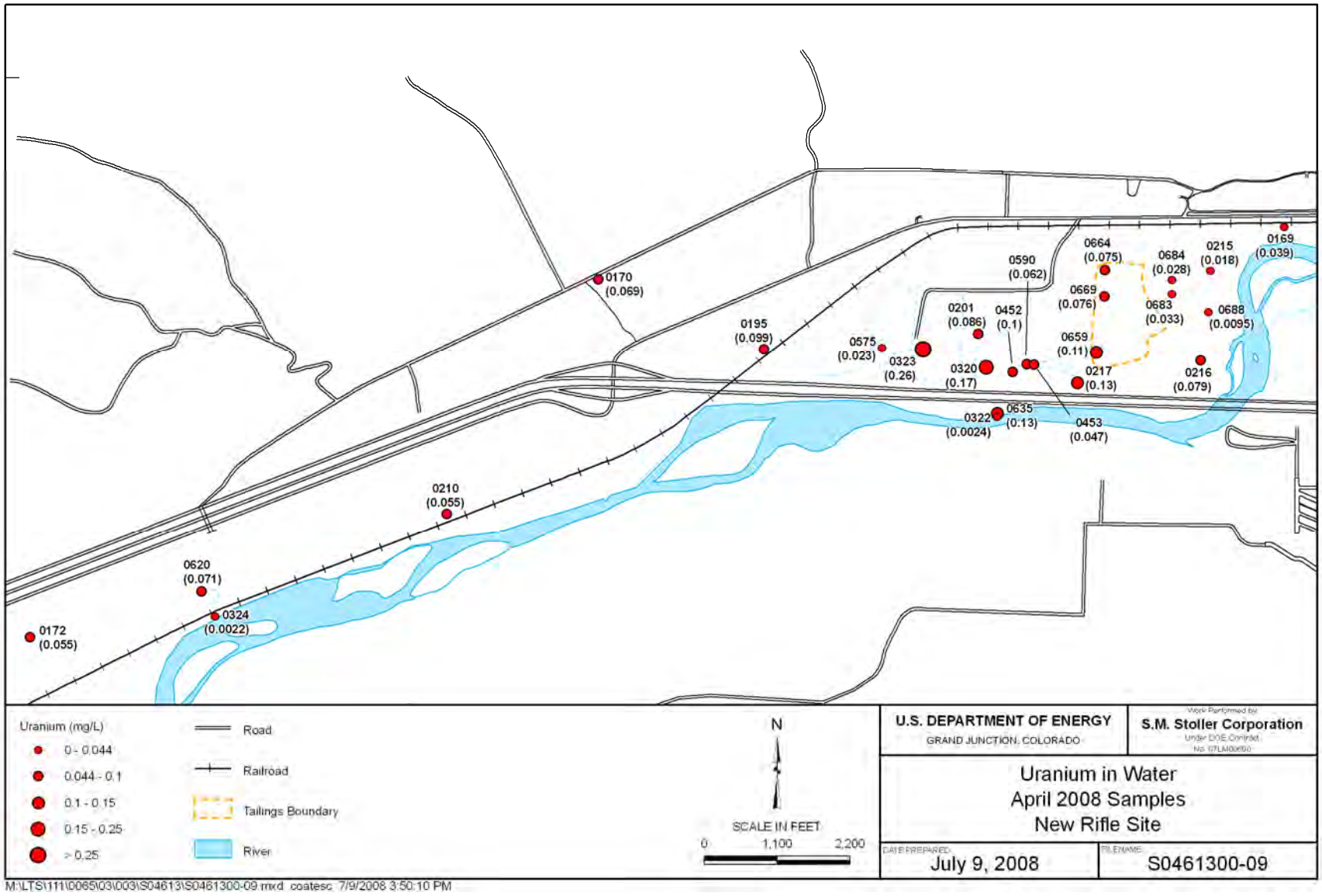

Figure 10. Uranium in Water at the New Rifle Site

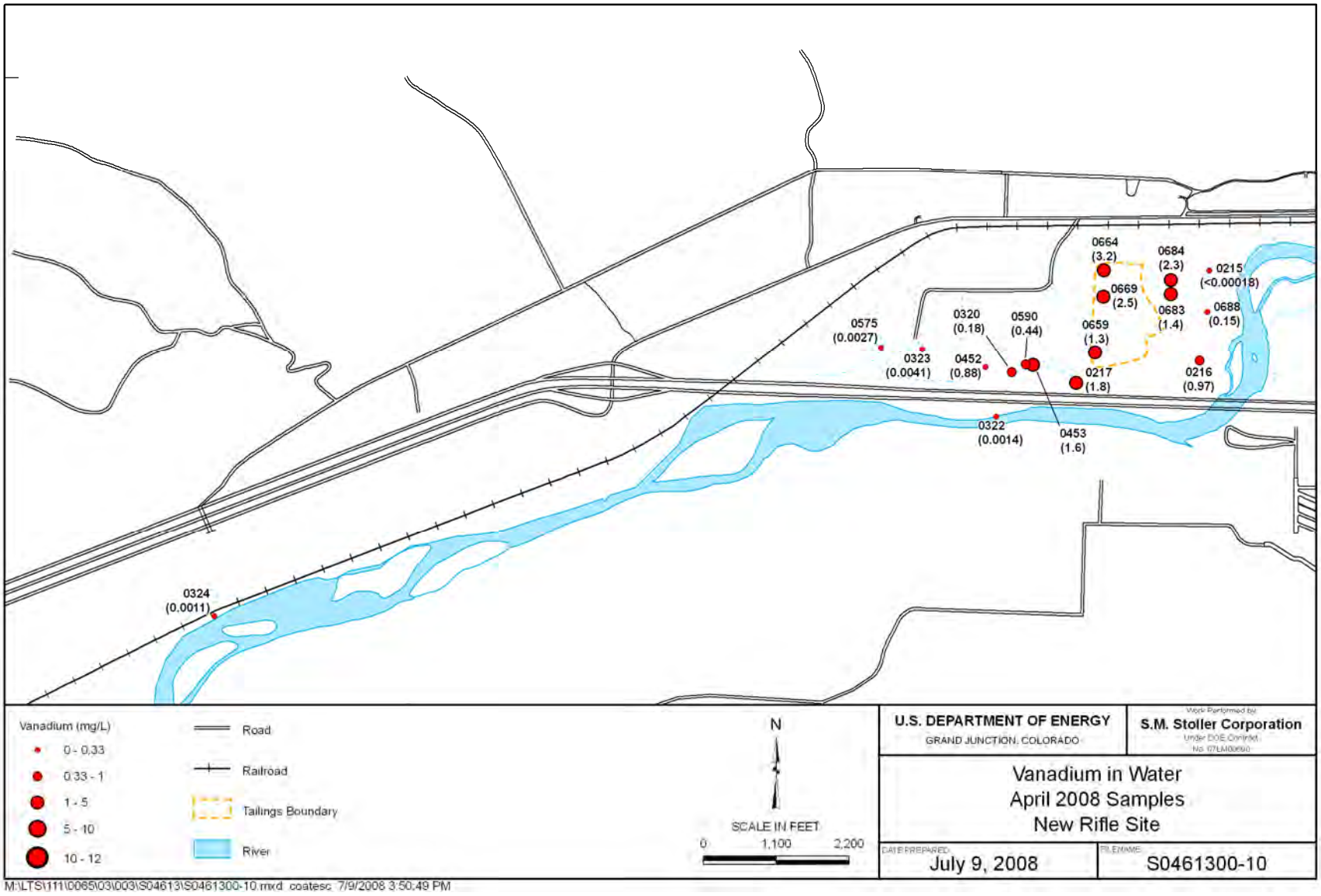

Figure 11. Vanadium in Water at the New Rifle Site

of the same well sets from year to year. In general, the contaminant plumes for the less mobile constituents, such as selenium and vanadium, are restricted in areal extent and are still concentrated around the former mill site. Plumes for more mobile constituents (nitrate, molybdenum, and uranium) are more extensive. To evaluate the progress of natural flushing at the New Rifle site, monitor wells were assigned to one of three groupings—on site, adjacent to site, and downgradient—for the purposes of computing statistics for analytical results.

On-site wells are those physically within the site boundary. As noted, residual soil contamination does exist at the New Rifle site below the water table. This contamination is most likely to affect ground water in contact with those soils and serve as a persistent source of contamination to ground water, and it would thus influence water quality of on-site wells. Although on-site wells are all grouped together for the purpose of computing ground water statistics and comparing the results to historical trends, three subgroups of on-site wells were recognized in previous verification monitoring reports based on patterns of time-concentration plots for the wells (time-concentration plots are included in Appendix A). These patterns were interpreted as being related to the location and proximity of wells with respect to former source areas.

Wells 0169, 0215, and 0216 are located adjacent to the Colorado River and are upgradient from the main source of site ground water contamination—the former raffinate ponds and tailings pile. Concentrations of most constituents in these wells are generally low and have had limited variability over the past 10 years. A notable exception is well 0216 in 2008, which showed sharply increased molybdenum, uranium, and vanadium concentrations. This may be due to ground water pumping in this immediate area by the City of Rifle during construction of infrastructure for the Wastewater Treatment Plant. Locations 0855, 0658, and 0659 are in the footprint of the former raffinate ponds and tailings pile. Soil sampling conducted during the pilot study for vanadium at the site indicated that residual contamination exists in these areas and may have local influence on ground water quality. These locations are characterized by time-concentration plots with the highest concentrations of most constituents and the greatest degree of variability over time. For the most part, no clear trends are observed in these wells. It is likely that adsorption/desorption reactions between ground water and soils occur in this area and that ground water concentrations are sensitive to fluctuations in the water table. The remaining on-site wells—0669, 0664, and 0670—are outside of the residual contamination area. Trends shown in time-concentration plots for these locations are more similar to those for off-site locations. They show some variability but are typically decreasing (with some exceptions) for constituents with concentrations above benchmarks.

Contamination in off-site wells is attributed solely to the migration of contaminated ground water downgradient and not from direct contact with a residual source. The wells downgradient of the New Rifle site were split into two groups according to their location from the Roaring Fork gravel ponds. As described previously, the ponds affected ground water flow direction during pumping operations, thus hydraulically separating those two groups of wells to some extent. Additionally, activities associated with wetland construction were more likely to influence water quality of the wells adjacent to the site compared with those farther downgradient. Table 5 and Table 6 provide statistics for the three main groups of wells. Statistics were not computed for arsenic and selenium because of the low number of detections. Water quality benchmarks are provided in Table 5 for comparison. Historical data provided in Table 1 are based on combined results of data from wells on and adjacent to the site. Time-concentration plots for the New Rifle wells are also included in Appendix A.

Table 5. Mean Concentrations in Ground Water—1998/1999 and April 2008 for the New Rifle Site

Contaminant	Benchmark (mg/L)	On Site[a]		Adjacent to Site[b]		Downgradient[c]	
		1998–99 mean (mg/L)	April 2008 mean (mg/L)	1998–99 mean (mg/L)	April 2008 mean (mg/L)	1998–99 mean (mg/L)	April 2008 mean (mg/L)
Molybdenum	0.1[d]	2.498	0.93	1.928	1.54	0.035	0.045
Nitrate + Nitrite as N	10[d]	61.13	8.6	230	46	75.8	18
Uranium	0.067[e]	0.1012	0.087	0.097	0.102	0.0752	0.07
Vanadium	na	5.68	3.66	0.367	1.12	<0.0001	na

[a]Includes wells 0215, 0216, 0658, 0659, 0664, 0669, 0670, 0855 (not all wells sampled for all analytes)
[b]Includes wells 0201, 0217, 0590, 0635 (only 0217 and 0590 for vanadium)
[c]Includes wells 0170, 0172, 0195, 0210
[d]EPA UMTRA Ground Water Project standard (40 CFR 192)
[e]Maximum background value, cleanup goal
na = not applicable

Table 6. Range of Concentrations in Ground Water—1998/1999 and April 2008 for the New Rifle Site

Contaminant	On Site[a]		Adjacent to Site[b]		Downgradient[c]	
	1998–99 range (mg/L)	April 2008 range (mg/L)	1998–99 range (mg/L)	April 2008 range (mg/L)	1998–99 range (mg/L)	April 2008 range (mg/L)
Molybdenum	0.0237–6.84	0.017–2.1	0.661–3.15	0.45–2.0	0.0041–0.231	0.0038–0.16
Nitrate + Nitrite as N	0.013–368	0.016–40	0.393–836	2.7–98	0.0522–377	0.013–37
Uranium	0.0103–0.284	0.018–0.16	0.0837–0.120	0.062–0.13	0.054–0.177	0.055–0.099
Vanadium	<0.001–25.3	<0.00018–14	<0.001–2.69	0.44–1.8	0.00065–0.0018	na

[a]Includes wells 0215, 0216, 0658, 0659, 0664, 0669, 0670, 0855 (not all wells sampled for all analytes)
[b]Includes wells 0201, 0217, 0590, 0635 (only 0217 and 0590 for vanadium)
[c]Includes wells 0170, 0172, 0195, 0210
na = not applicable

The spot plots continue to show patterns observed in the past. Concentrations of the least mobile constituents—vanadium and selenium—remain on the site in the vicinity of the source area. The main portions of the molybdenum and uranium plumes have moved off site and are located just upgradient of the Roaring Fork ponds. The nitrate plume is also located in this vicinity; its presence is due to degradation and downgradient movement of the former ammonia plume. Concentrations of uranium and nitrate in some wells in the farthest downgradient group exceed standards. The molybdenum plume extends at least as far downgradient as location 0195.

As noted, time-concentration plots for wells at the west edge of the mill site boundary generally show decreasing trends. Wells in the original source area have highest concentrations and greatest fluctuations. Plots of wells downgradient of the mill site show no consistent patterns. Portions of a number of plots have fluctuated around a somewhat constant concentration over the last 10 years (e.g., locations 0217 and 0201 for uranium). Others show increasing or decreasing portions at different times (e.g., uranium at location 0635). The lack of apparent trends is not unexpected given the number of factors that might influence plume behavior at a location—the proximity of the Colorado River, the presence of the Roaring Fork ponds, and the shallow water table, among others.

3.2.2.3 Mann-Kendall Test for Trend

Another method of data evaluation is the nonparametric Mann-Kendall test for trend (Gilbert 1987). The test does not require any particular data distribution and will accommodate missing values and data reported as less than the detection limit. Essentially, it analyzes a series of data by subtracting the values of data collected earlier from those of later data. The method results in a test statistic that is a positive or negative (meaning increasing or decreasing trend) and is used to estimate the probability that the trend is real. Appendix D-1 of the GCAP (DOE 2006) provides a description of the Mann-Kendall test for trend.

As a preliminary analysis, several wells from the New Rifle site were selected for application of the Mann-Kendall test based on their locations with respect to the uranium and molybdenum plumes. The test was applied to uranium and molybdenum concentrations because these constituents are the most widespread and the most mobile. Additionally, they are not affected by geochemical transformation processes as are ammonia and nitrate. Wells 0664 and 0669 are from two on-site locations near the original plume source areas (raffinate ponds and tailings piles). Well 0201 is located immediately downgradient of the site and upgradient of the Roaring Fork ponds; well 0195 is located immediately downgradient of the ponds. Results of applying the Mann-Kendall test statistic to uranium and molybdenum values for these wells are included in Appendix B. On-site wells 0664 and 0669 show strongly decreasing trends (at the 95 percent confidence level) for both uranium and molybdenum. Likewise, well 0201 shows a decrease in molybdenum (95 percent confidence level). However, downgradient well 0195 shows a lesser degree of decrease in uranium (90 percent confidence level) but a strongly increasing trend in molybdenum (95 percent confidence level).

These results support the conclusions that natural flushing for these two constituents is progressing and that the main portions of the uranium and molybdenum plumes are moving off site into the adjacent downgradient area. The results also illustrate that different portions of the plume would be expected to display differing characteristics over time and space depending on site-specific characteristics (e.g., source location, hydrologic features). This is an important factor in evaluating long-term trends and assessing the attainment of remediation goals.

3.2.2.4 Domestic Wells Downgradient from the New Rifle Site

Domestic wells 0442 and 0447 have been sampled in the past but are not being used for domestic water currently. The owners of these wells have already or will soon be hooked to municipal water.

4.0 Results and Conclusions

Concentrations of selenium and vanadium at the Old Rifle site continue to decrease. The mean uranium concentration is decreasing, but not as quickly as expected according to modeling results in the SOWP, which indicated uranium would meet its ground water standard sitewide within a 30-year period. The average concentrations of selenium (at established well locations) and vanadium meet site benchmarks (both alternate concentration limits). The vanadium benchmark is currently exceeded only marginally at one well; all wells currently meet the selenium benchmark.

As expected with natural flushing, contaminant plumes for a number of constituents associated with the New Rifle site have been decreasing in general and moving downgradient over time. The only significant constituents in terms of concentration and distribution are molybdenum, nitrate, uranium, and vanadium. The highest concentrations of the mobile constituents—molybdenum, nitrate, and uranium—were found downgradient of the site. Nitrate concentrations, which had been increasing in response to ammonia degradation, appear now to be on the decline. The uranium standard was exceeded over the entire plume length; concentrations appear to be nearly constant in some wells. Highest concentrations of vanadium were still found on site.

With the number of variables that can affect distribution of contaminants in the alluvial aquifer at New Rifle, it is probably too early to determine the effectiveness of natural flushing at the site. However, data collected for the site provide indications that some constituents are flushing, even if trends do not exactly match predictions. Generally speaking, ground water contamination is decreasing. While some individual wells may display increasing concentrations for certain constituents, this is to be expected as the plume centers migrate downgradient away from the site. On the basis of combined spatial and temporal data, it appears that plume centers for molybdenum, nitrate, and uranium have already moved off site and continue to dissipate downgradient. Arsenic and selenium have little mobility and will probably remain confined to site ground water. Vanadium, also relatively immobile, has migrated off site, but only to a very limited degree.

Surface water in the Colorado River is not being adversely affected by ground water discharge at either the Old or New Rifle sites. At the present time, the selected compliance strategies at both sites appear to be adequately protective. A more definitive evaluation may be possible after more monitoring data are collected.

5.0 References

40 CFR 192. "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings," *Code of Federal Regulations,* July 1, 2007.

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Appendix A−1

Time-Concentration Plots for Wells at the Old Rifle Site

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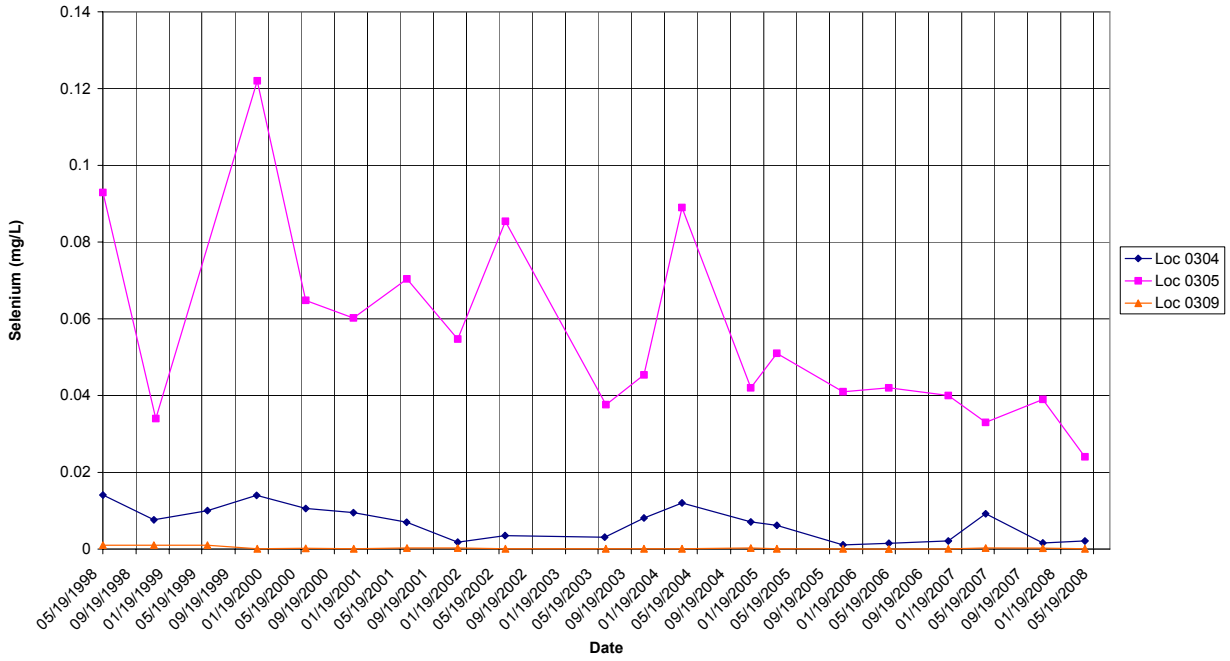
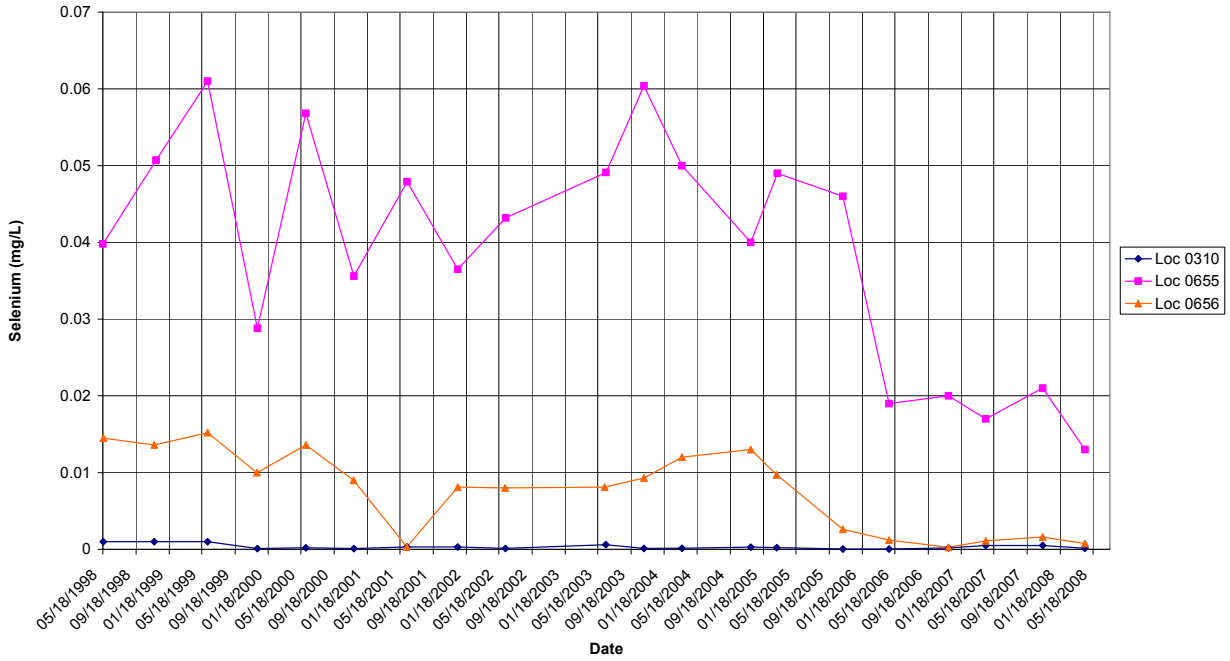
Rifle Old Processing Site (RFO01)

Selenium Concentration



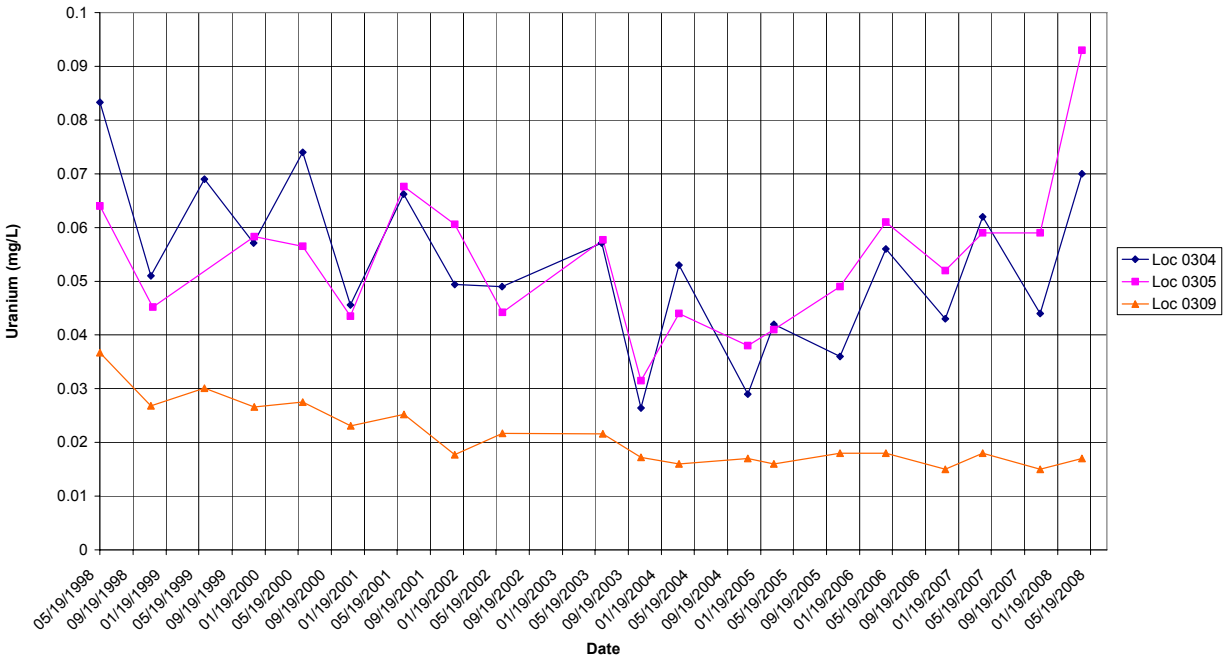
Rifle Old Processing Site (RFO01)

Selenium Concentration



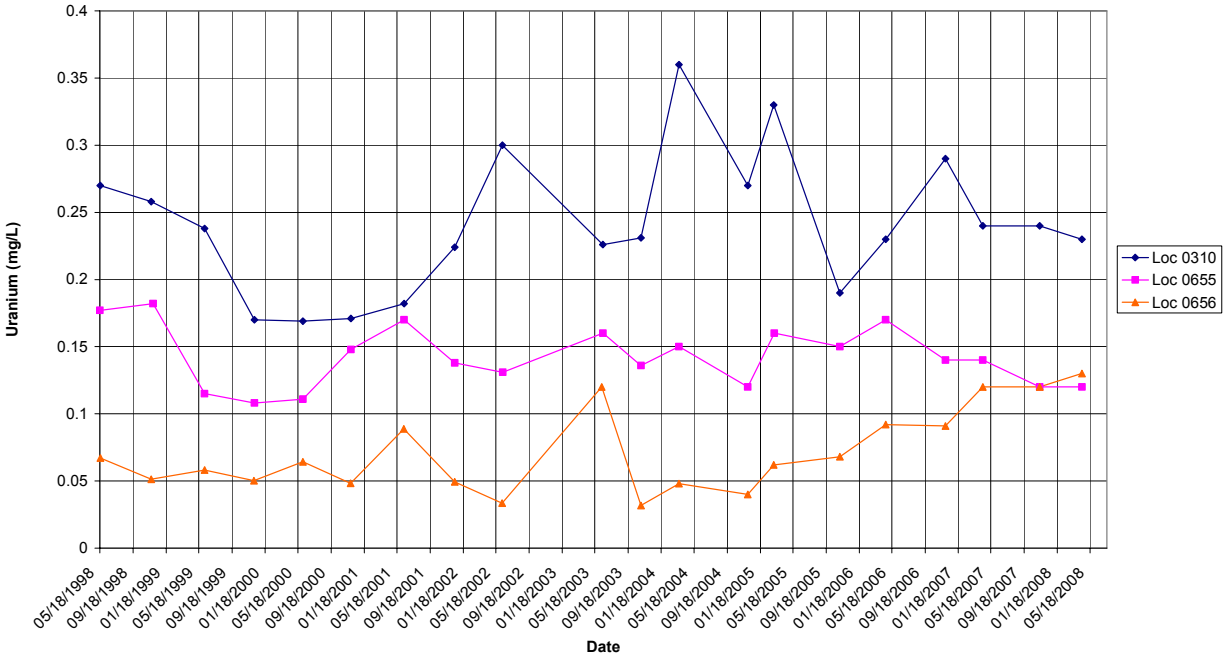
Rifle Old Processing Site (RFO01)

Uranium Concentration



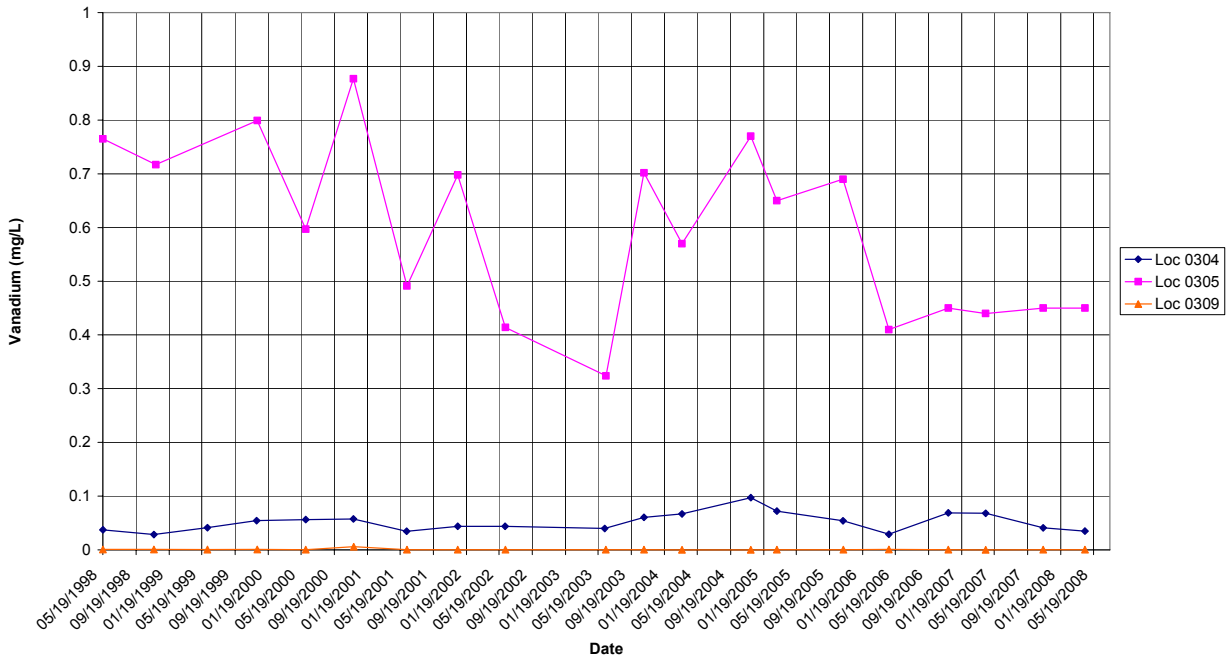
Rifle Old Processing Site (RFO01)

Uranium Concentration



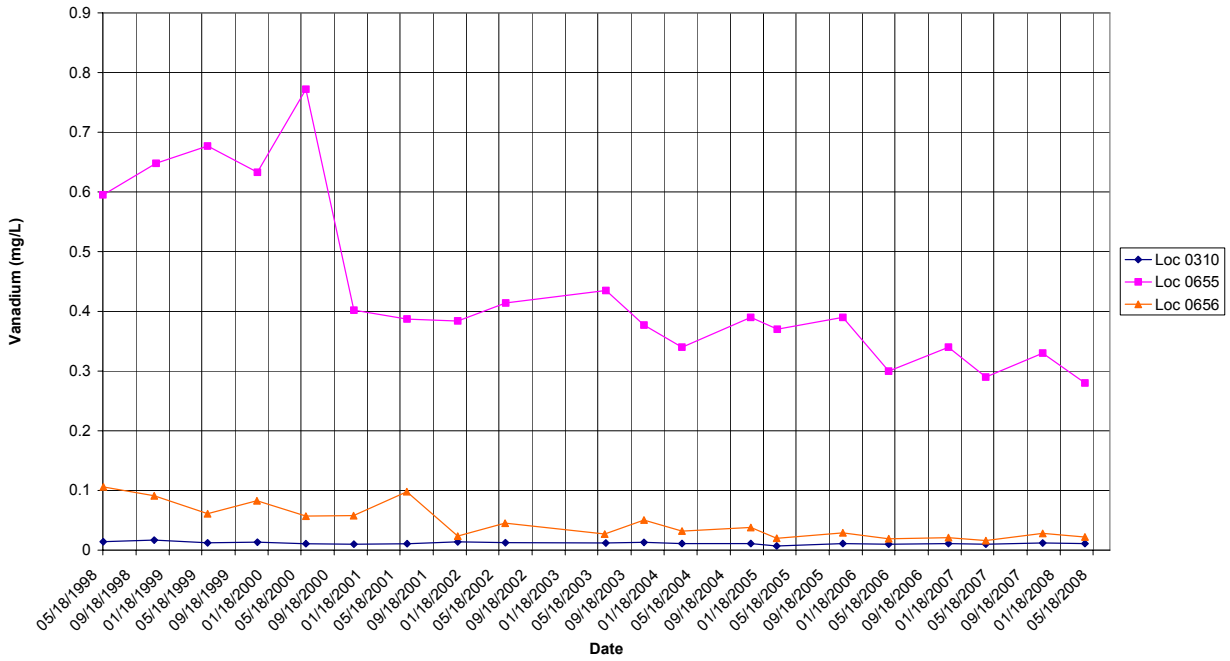
Rifle Old Processing Site (RFO01)

Vanadium Concentration



Rifle Old Processing Site (RFO01)

Vanadium Concentration



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Appendix A−2

Time-Concentration Plots for Wells at the New Rifle Site

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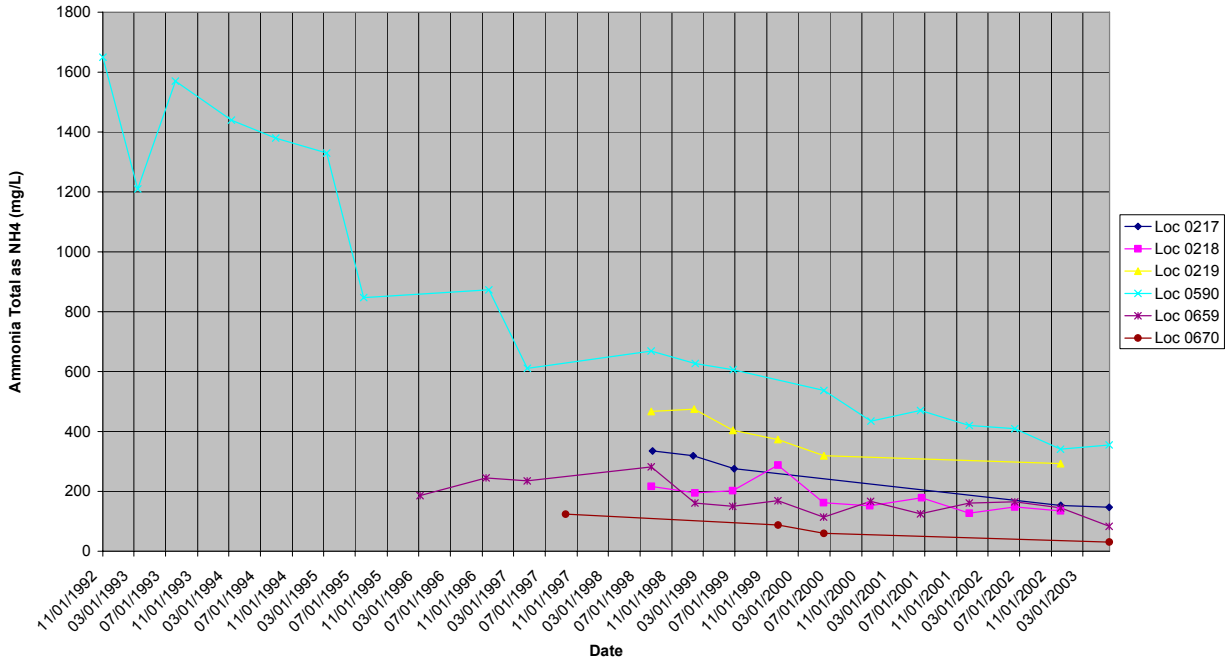
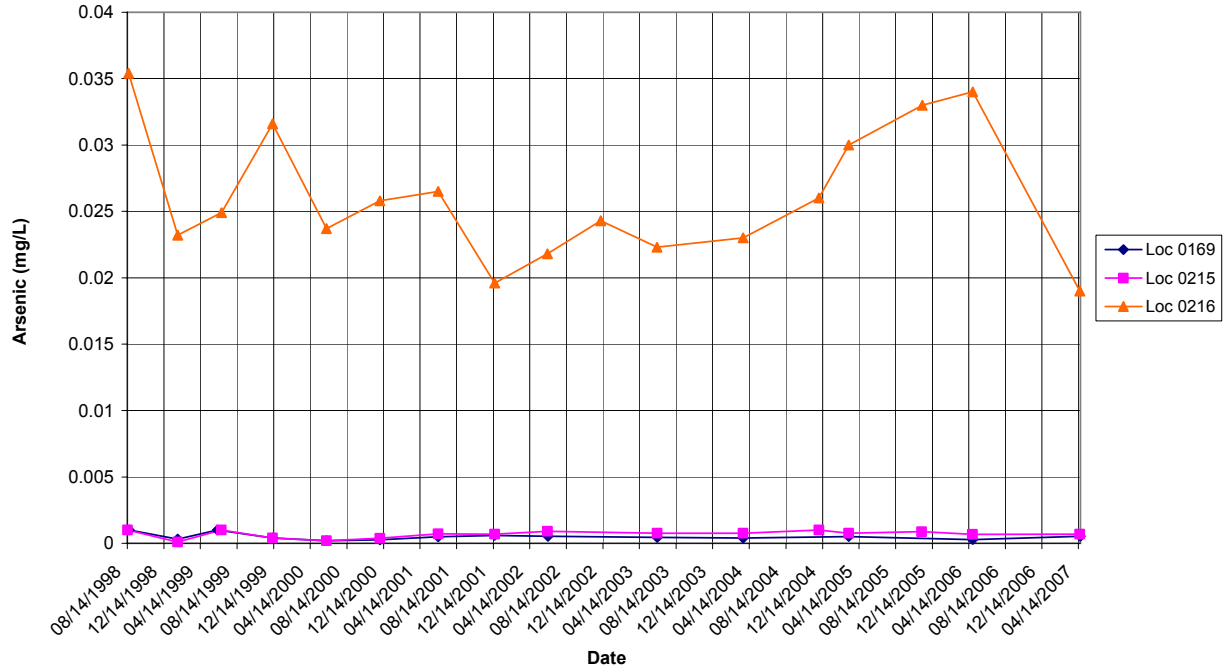
Rifle New Processing Site (RFN01)

Ammonia Total as NH4 Concentration



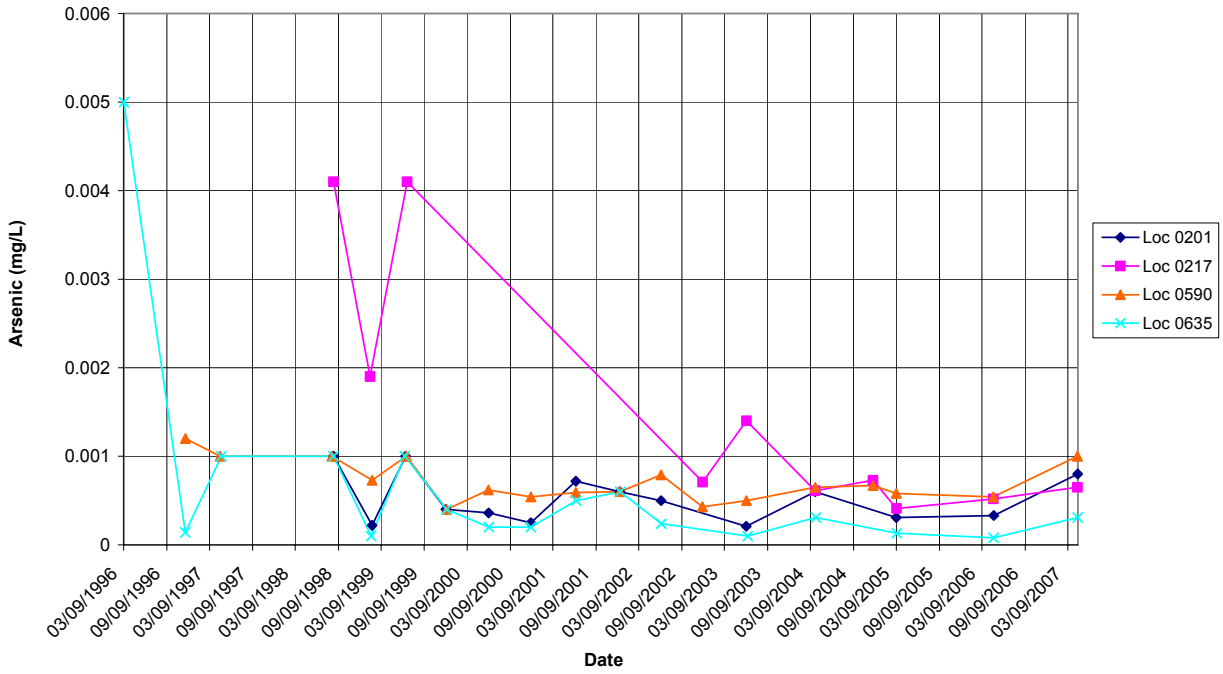
Rifle New Processing Site (RFN01)

Arsenic Concentration



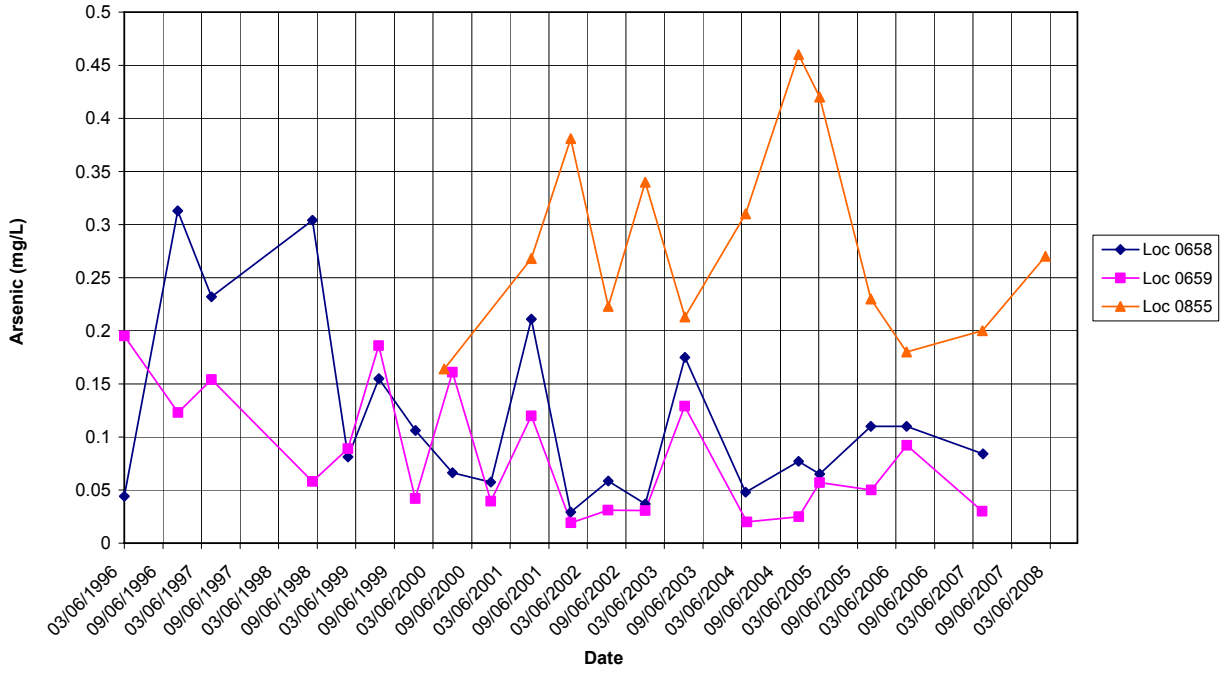
Rifle New Processing Site (RFN01)

Arsenic Concentration



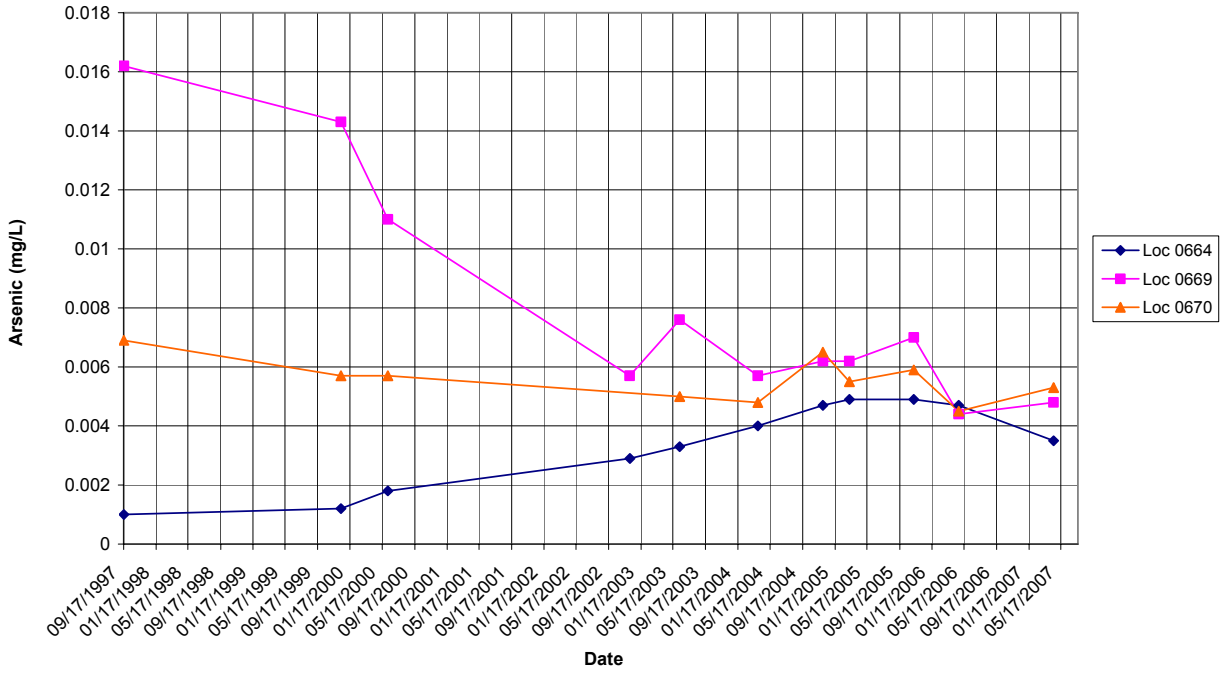
Rifle New Processing Site (RFN01)

Arsenic Concentration



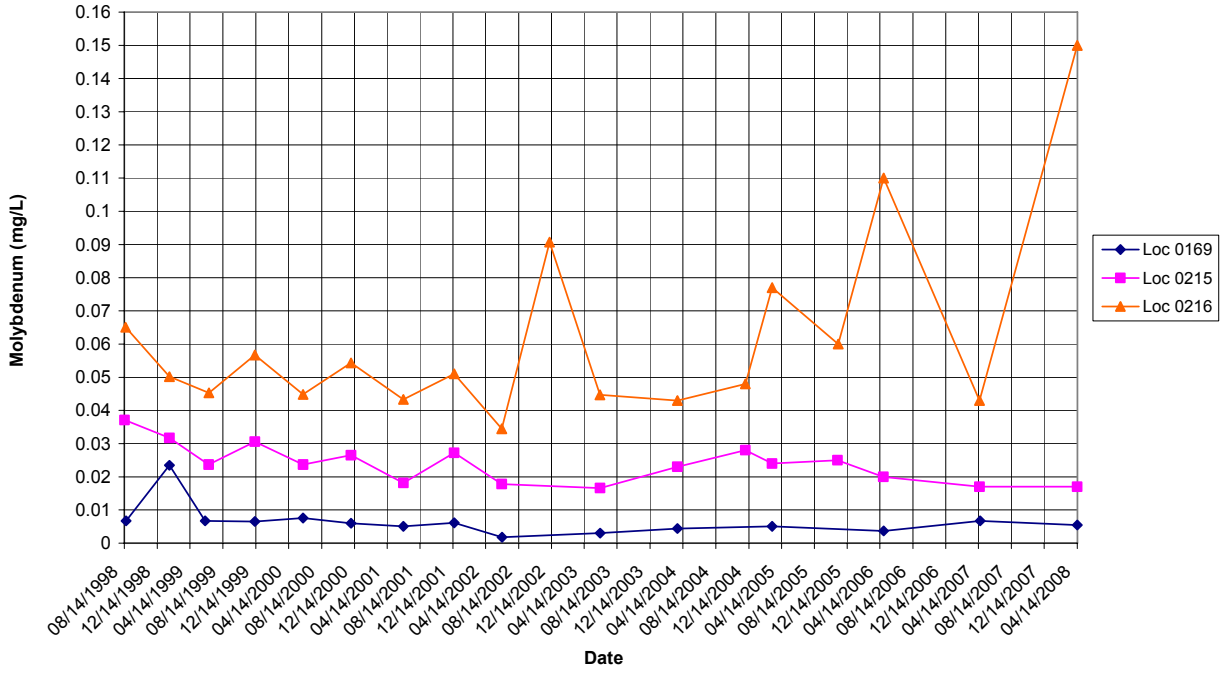
Rifle New Processing Site (RFN01)

Arsenic Concentration



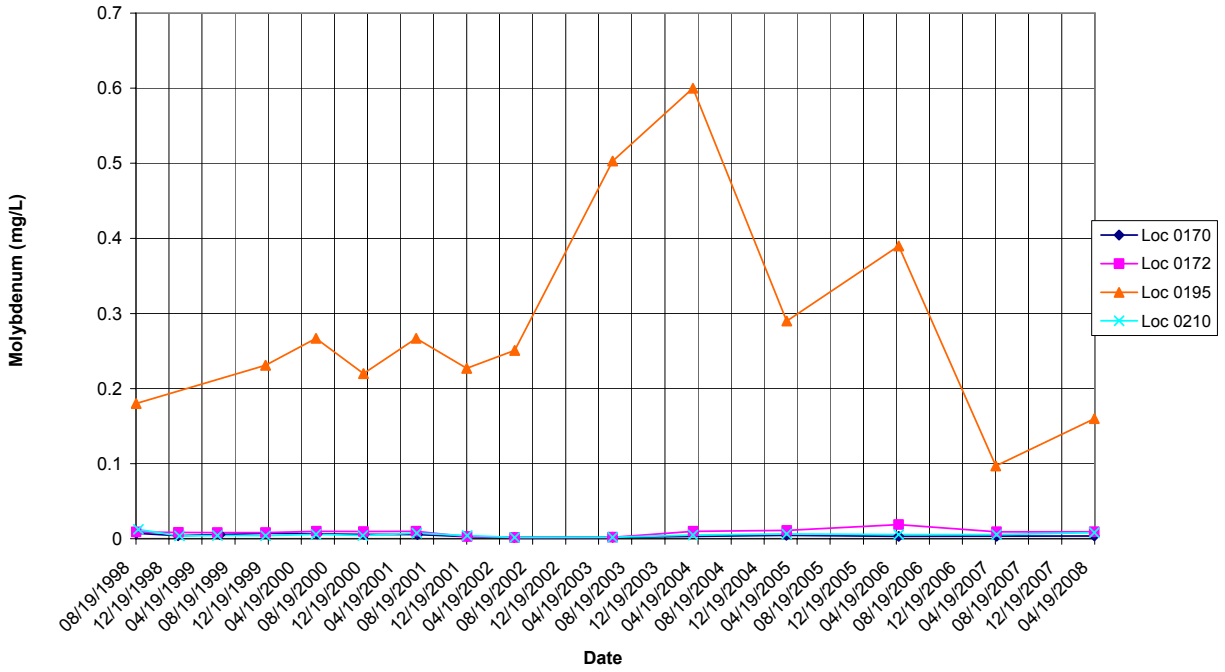
Rifle New Processing Site (RFN01)

Molybdenum Concentration



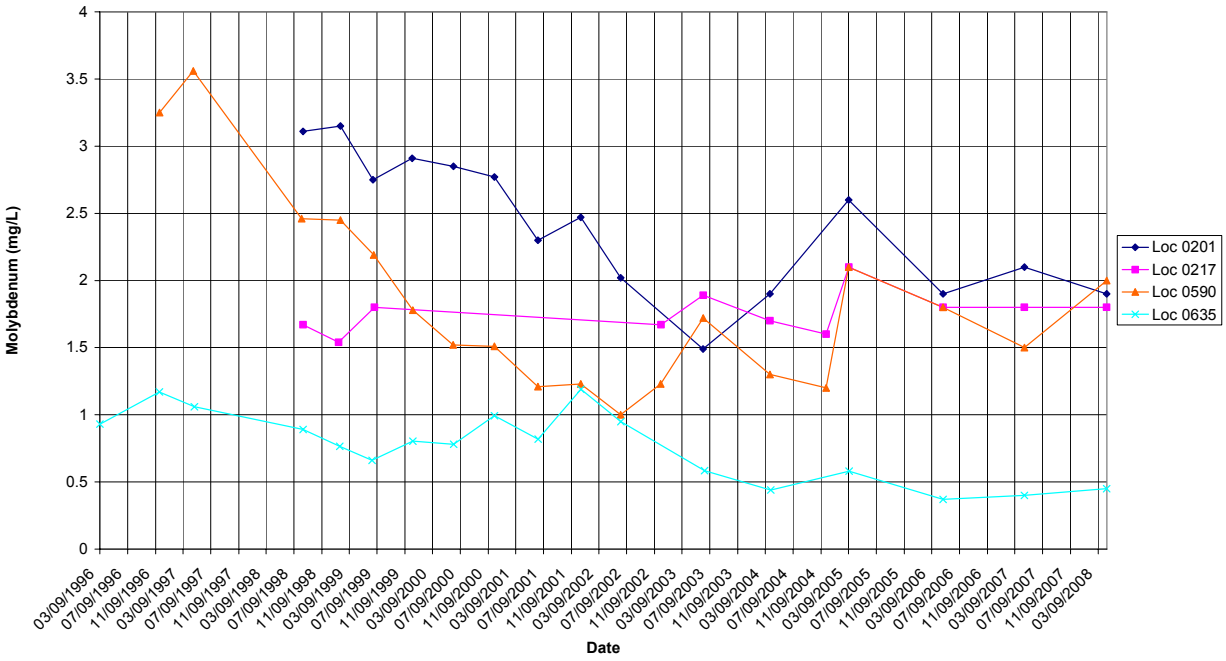
Rifle New Processing Site (RFN01)

Molybdenum Concentration



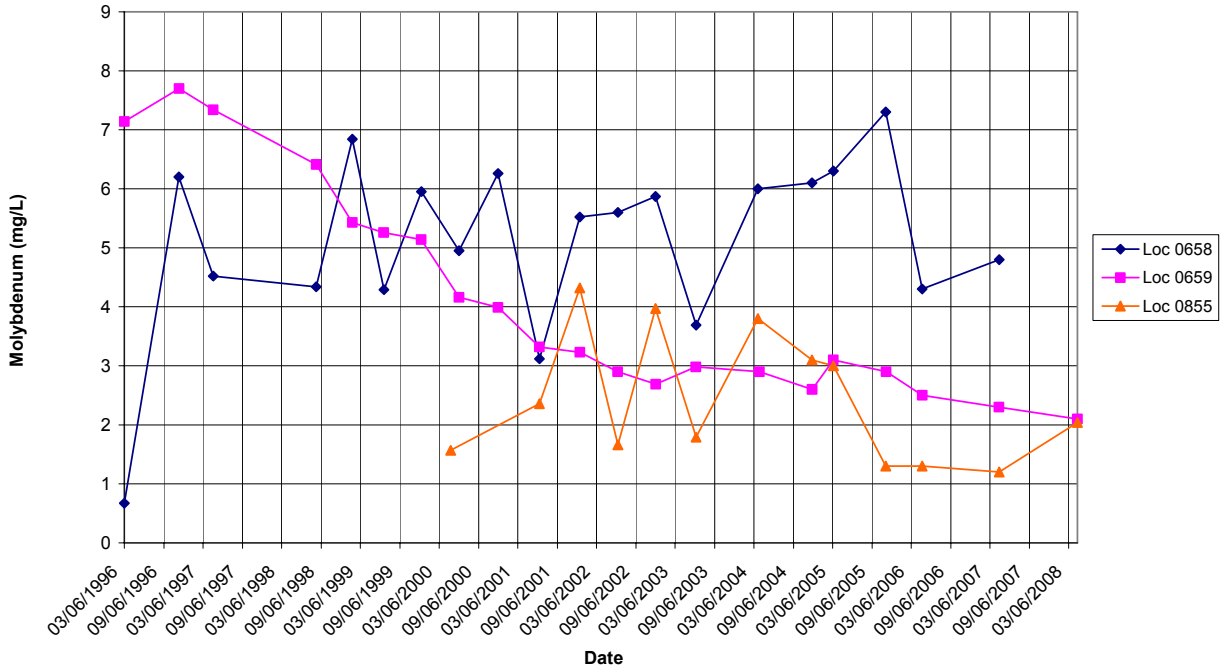
Rifle New Processing Site (RFN01)

Molybdenum Concentration



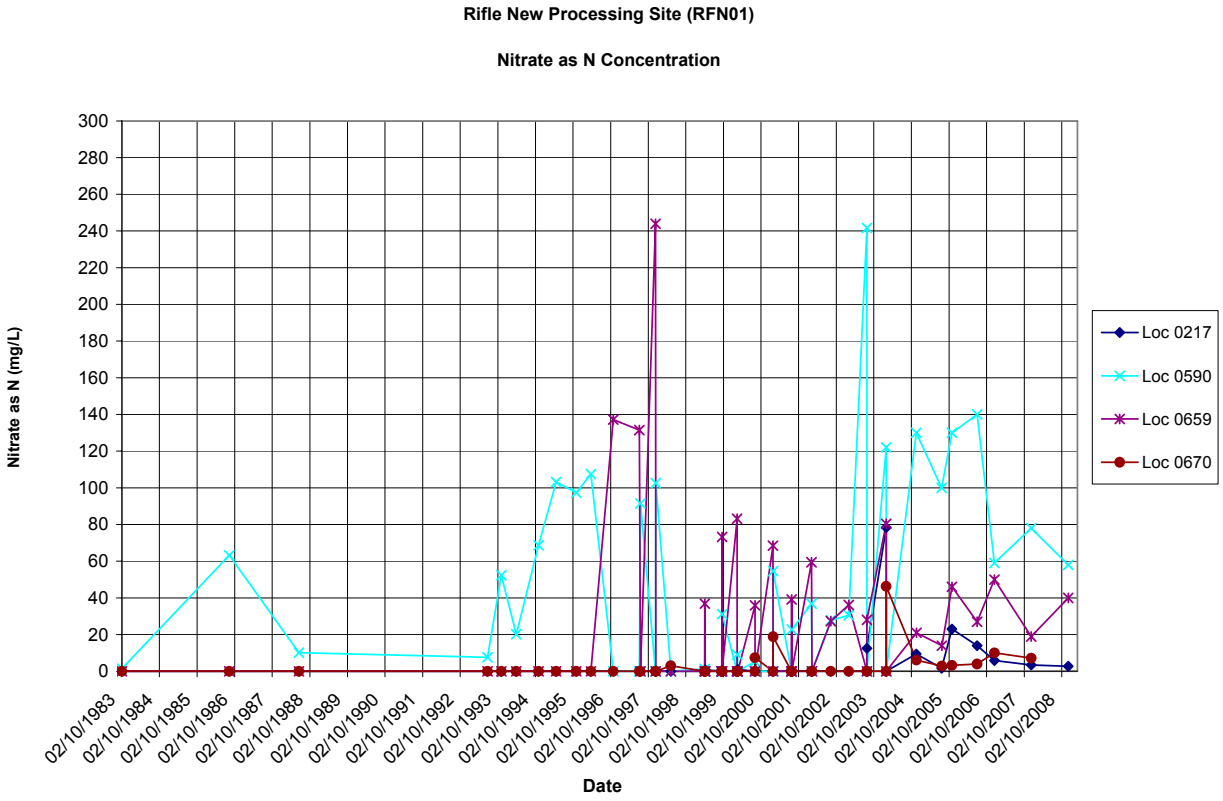
Rifle New Processing Site (RFN01)

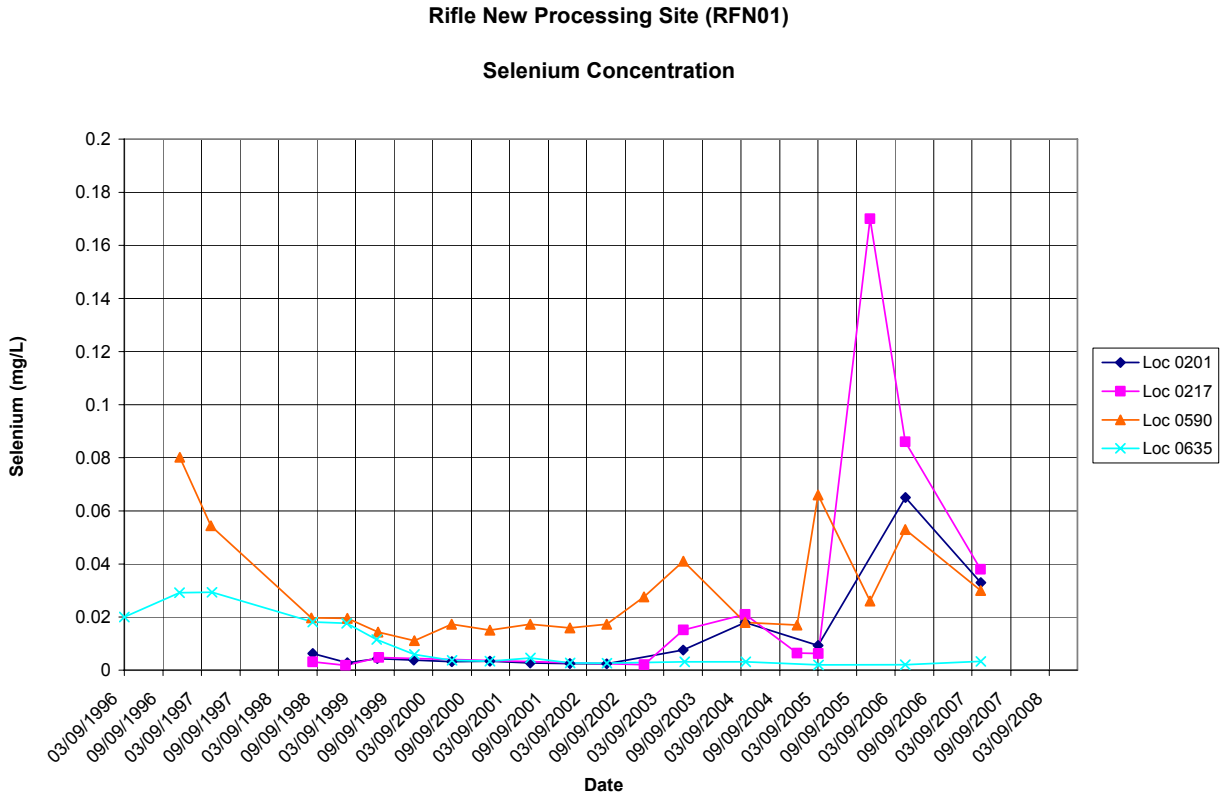
Molybdenum Concentration



Rifle New Processing Site (RFN01)

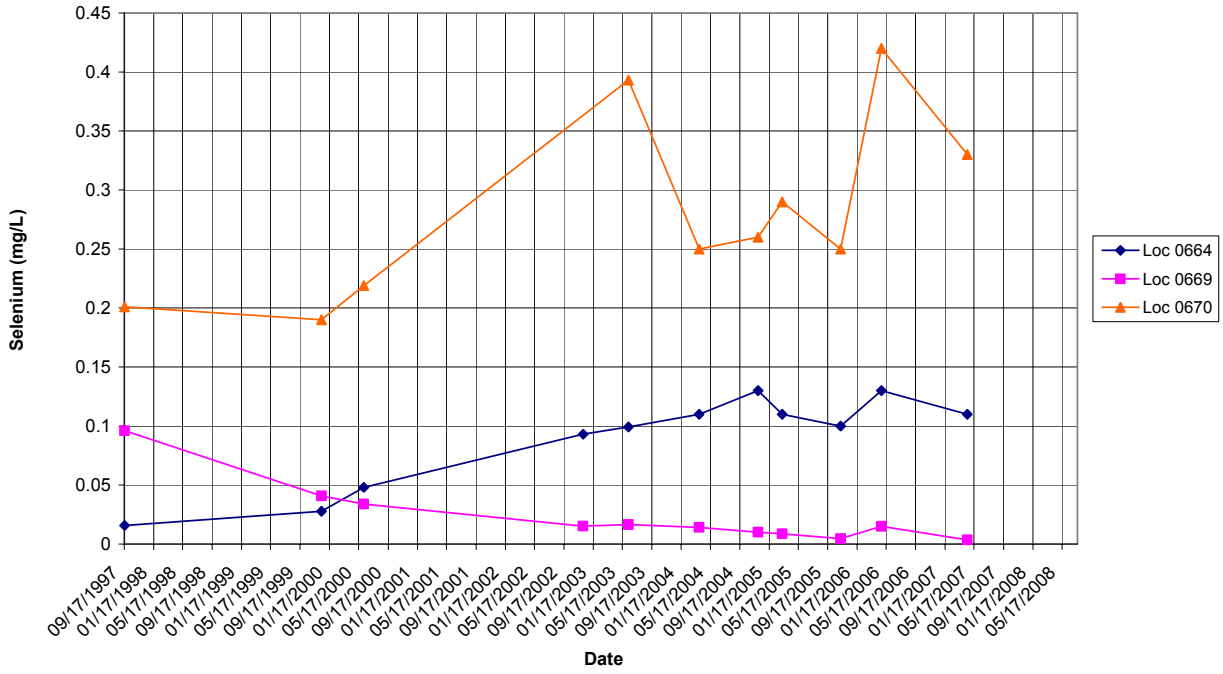
Molybdenum Concentration


Rifle New Processing Site (RFN01)
Nitrate as N Concentration
Nitrate as N (mg/L)
Date
Loc 0217
Loc 0590
Loc 0659
Loc 0670


Rifle New Processing Site (RFN01)
Selenium Concentration
Selenium (mg/L)
Date
Loc 0201
Loc 0217
Loc 0590
Loc 0635

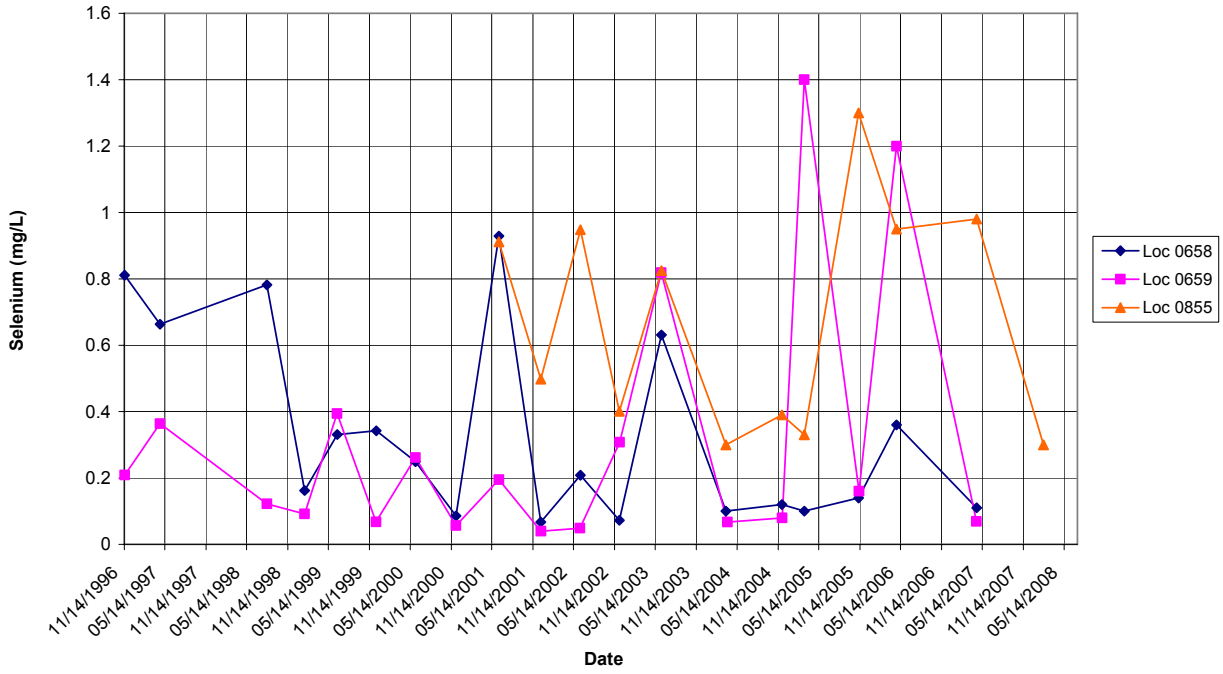
Rifle New Processing Site (RFN01)

Selenium Concentration



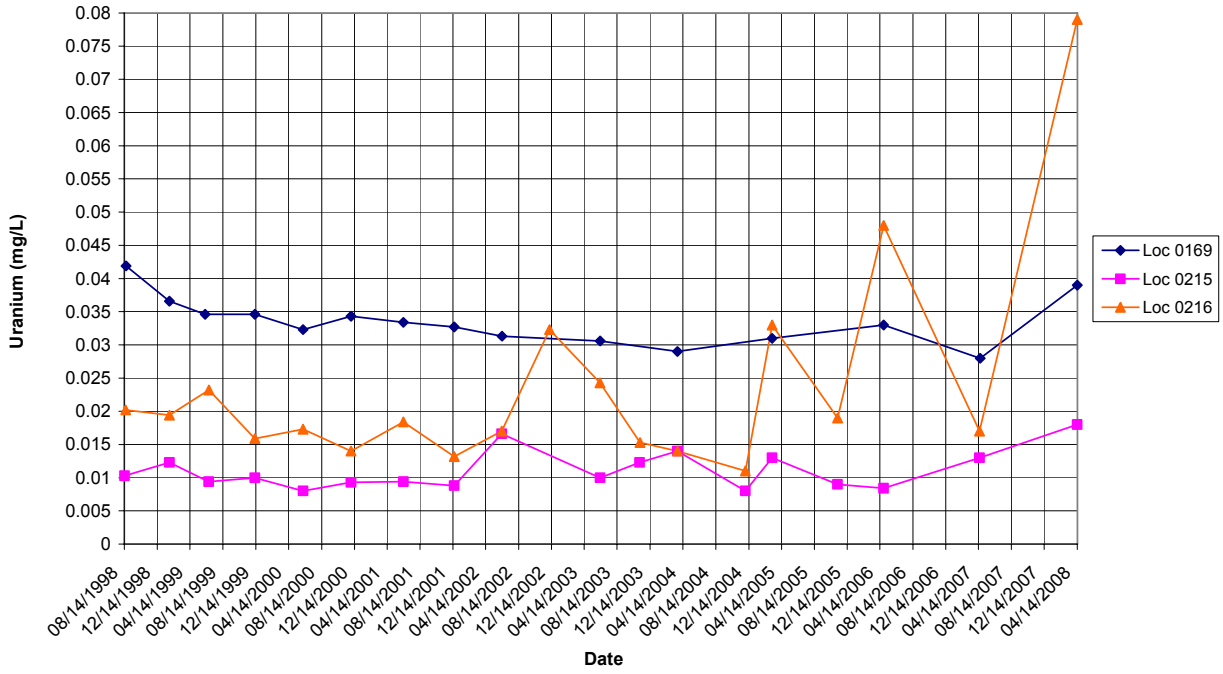
Rifle New Processing Site (RFN01)

Selenium Concentration



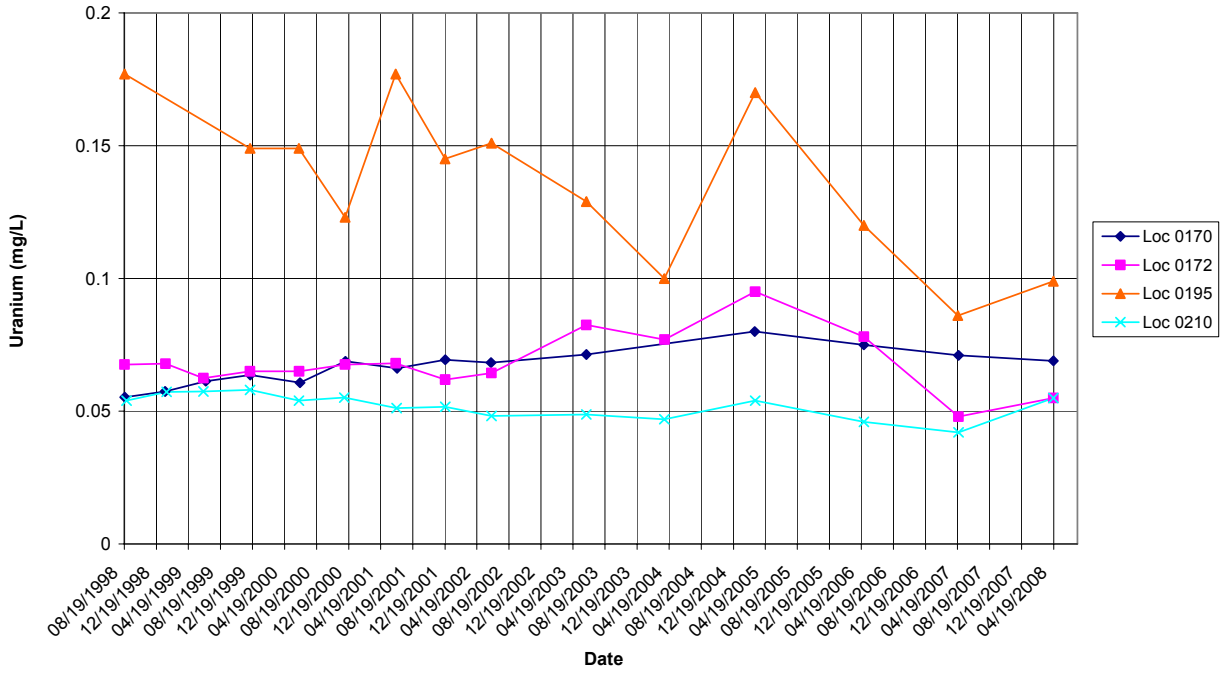
Rifle New Processing Site (RFN01)

Uranium Concentration



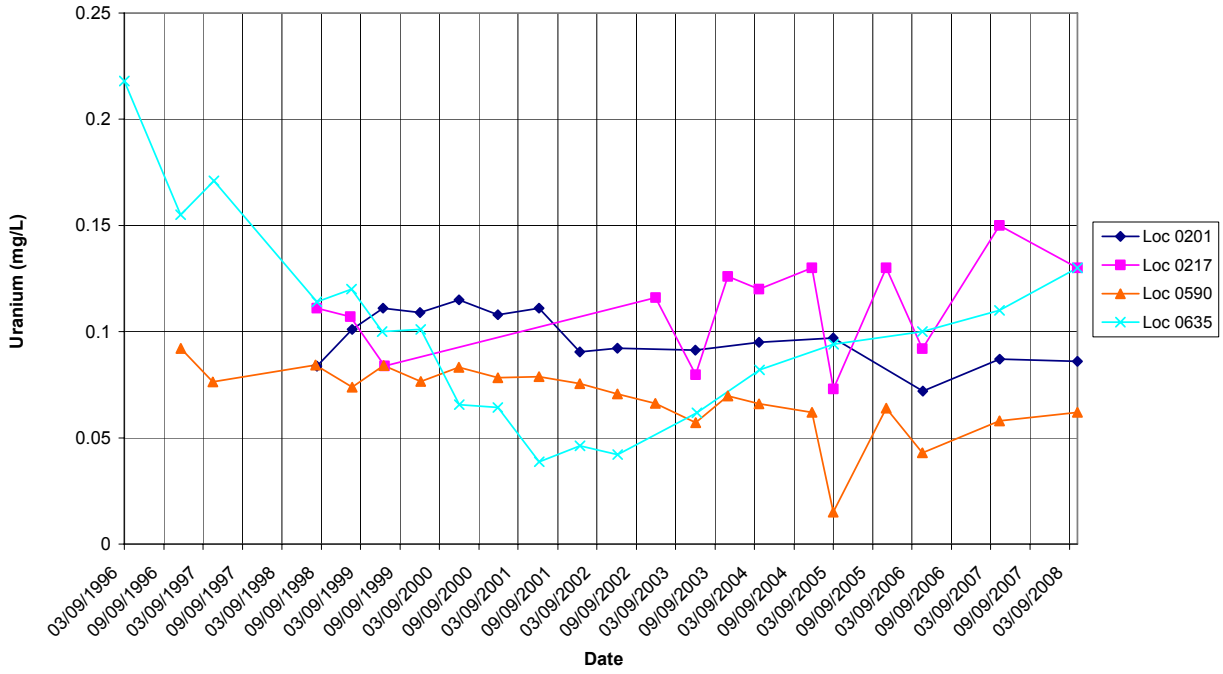
Rifle New Processing Site (RFN01)

Uranium Concentration



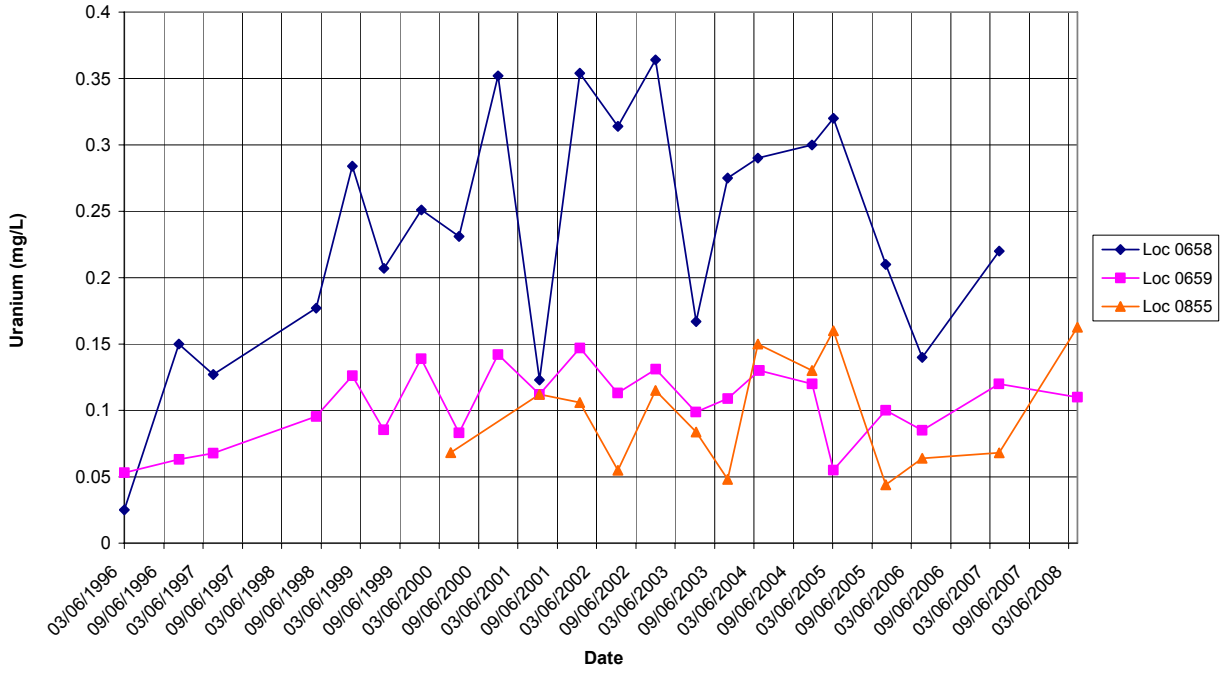
Rifle New Processing Site (RFN01)

Uranium Concentration



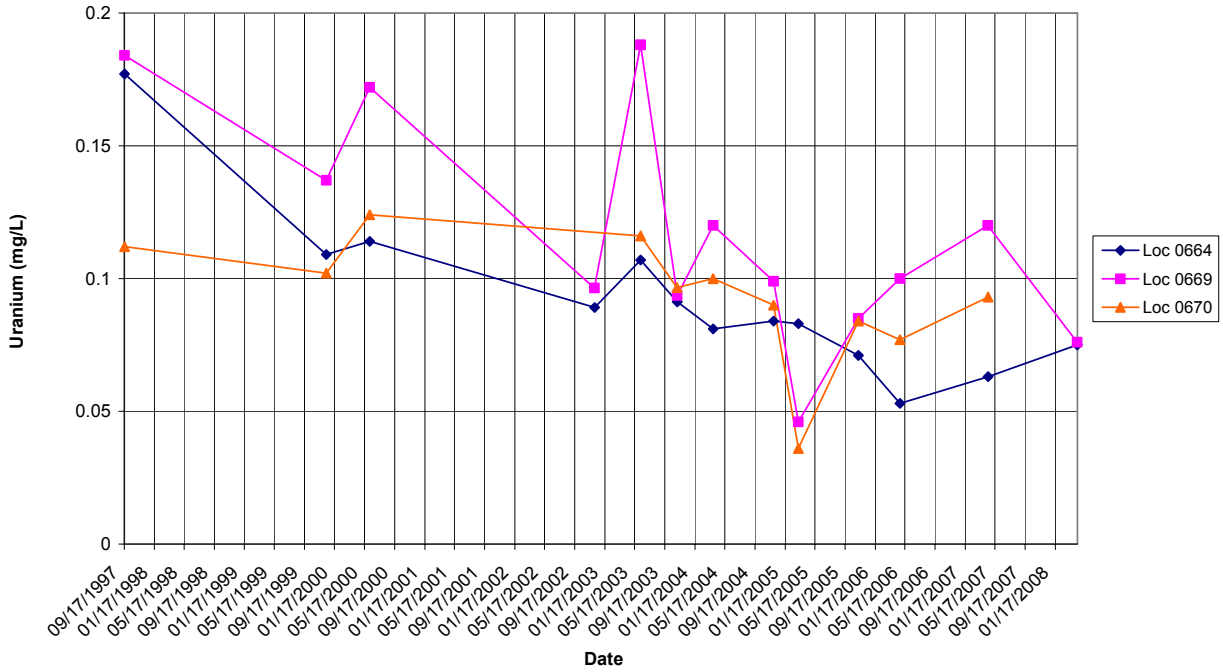
Rifle New Processing Site (RFN01)

Uranium Concentration



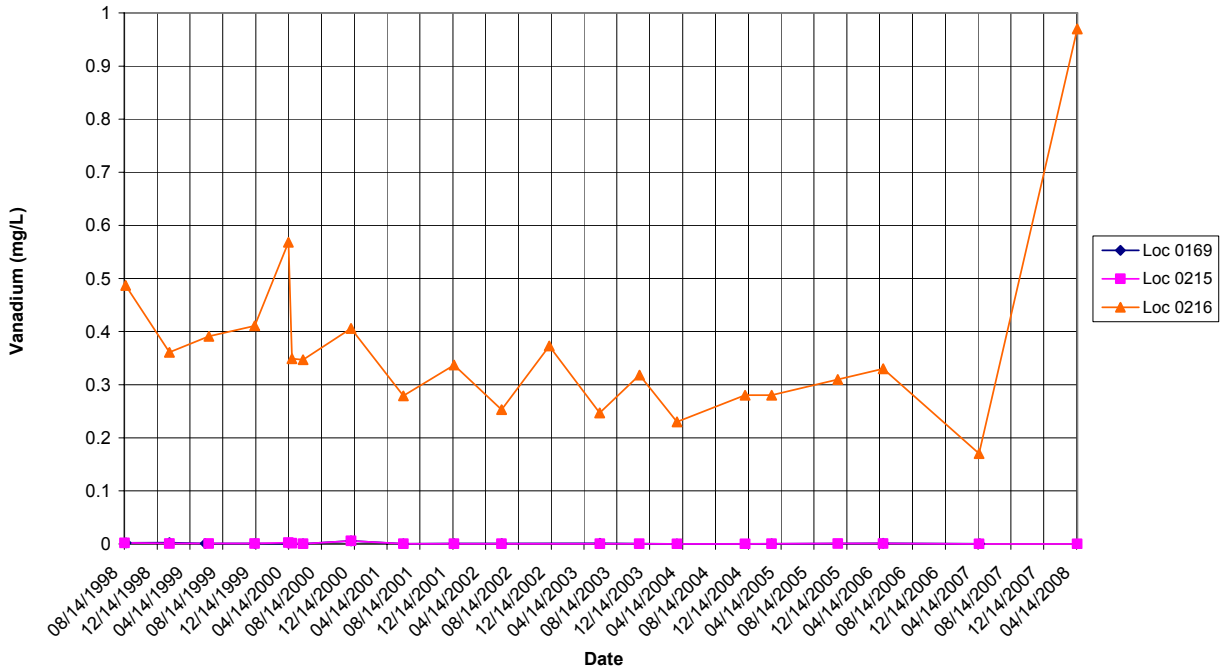
Rifle New Processing Site (RFN01)

Uranium Concentration



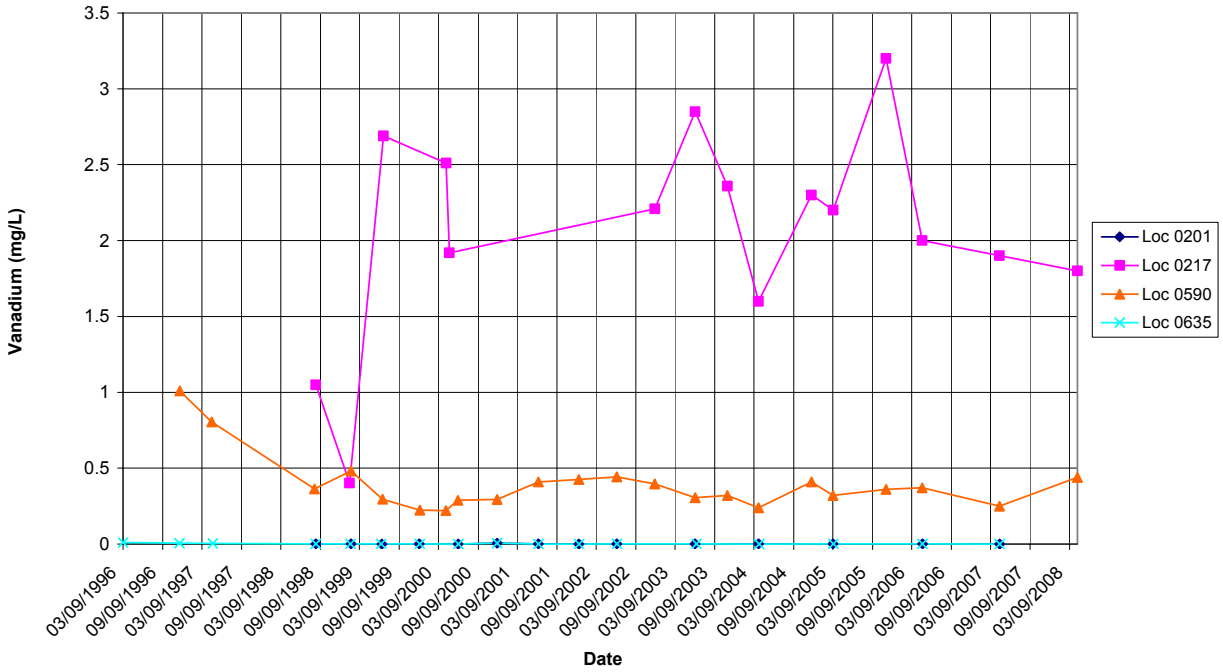
Rifle New Processing Site (RFN01)

Vanadium Concentration



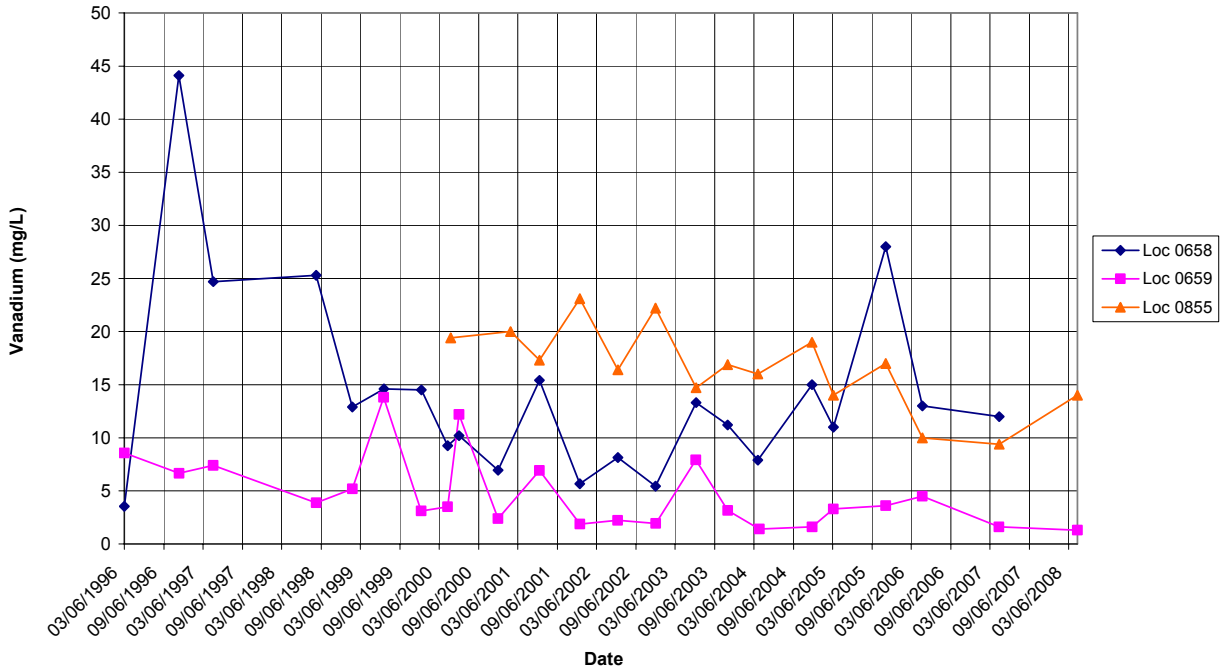
Rifle New Processing Site (RFN01)

Vanadium Concentration



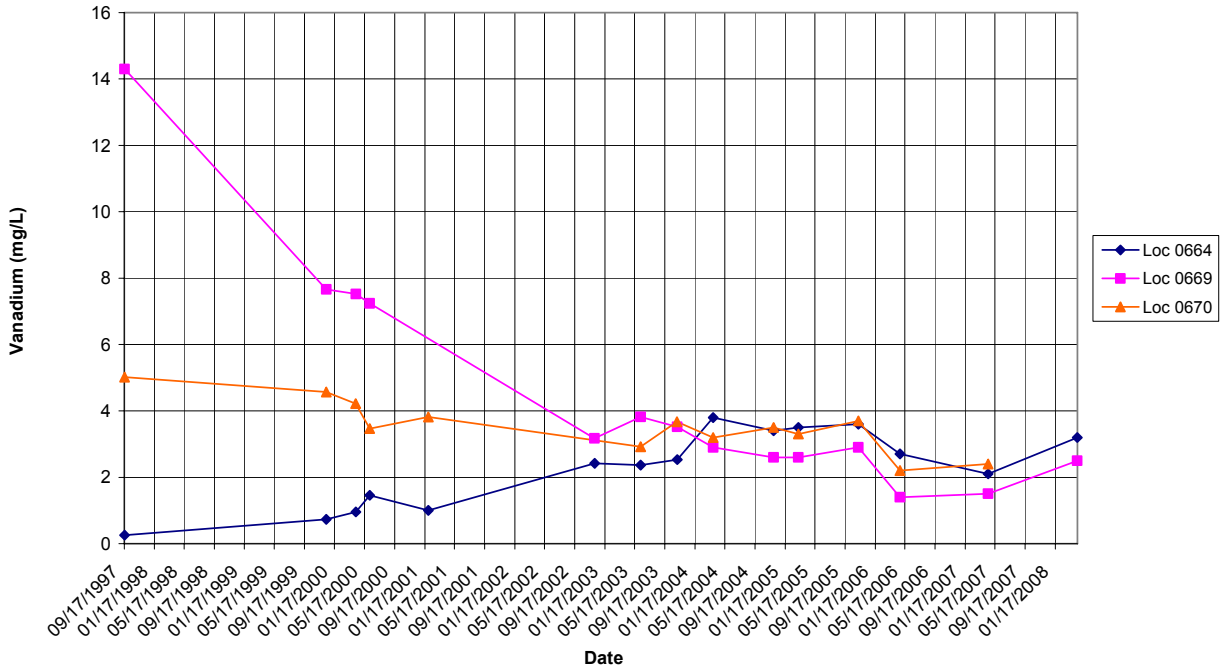
Rifle New Processing Site (RFN01)

Vanadium Concentration



Rifle New Processing Site (RFN01)

Vanadium Concentration



Appendix B

Preliminary Mann-Kendall Test Results for Selected Locations at the New Rifle Site

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The Visual Sample Plan (VSP) computer module used for the trend analysis is the nonparametric Mann-Kendall test for trend (Gilbert 1987). In this procedure missing values are allowed, and the data need not conform to any particular distribution. In this Mann-Kendall test only the relative magnitudes of the data are used rather than the measured values.

A one-tailed test is used because it is desired to test the null hypothesis, H_O, of no trend against the alternative hypothesis, H_A, of a downward trend. If no trend is detected, then it is desired to test the null hypothesis, H_O, of no trend against the alternative hypothesis, H_A, of an upward trend.

Alpha (α) is often called the level of significance. It is also referred to as a Type I error. For α = .05, this would be a 5 percent probability of rejecting the null hypothesis when the null hypothesis is true, that is, there is a 5 percent probability of concluding there is a trend when no trend is present. In table format the Type I and Type II errors can be expressed as shown in Table B−1.

Table B−1. Type I and Type II Errors

	Hypothesis is correct	**Hypothesis is incorrect**
Hypothesis is accepted	Correct decision	Type II error (β)
Hypothesis is rejected	Type I error (α)	Correct decision

Gilbert (1987) gives probability values only for *n* less than or equal 10. An extension of this table up to *n* = 40 is given in Table A.21 in Hollander and Wolfe (1973) and has been incorporated within the VSP.

The VSP module was used to analyze monitoring data collected from four wells at the New Rifle site. Results are based on data collected since surface remediation was completed (1998 time frame). Data for both uranium and molybdenum were used in the analysis. Results are summarized in Table B−2. Molybdenum did not show a trend, either downward or upward, at any of the alpha significance levels.

Table B−2. Summary of Mann-Kendall Test Results for Selected Wells at the New Rifle Site

Location	**Uranium trend**	**Alpha**	**Molybdenum trend**	**Alpha**
RFN-0195	down	5%	None	5%, 10%, or 15%
RFN-0201	down	5%	down	5%
RFN-0664	down	5%	down	5%
RFN-0669	down	5%	down	5%

References:

Gilbert, R.O., 1987. *Statistical Methods for Environmental Pollution Monitoring*, Van Nostrand Reinhold Company, New York.

Hollander, M., and D.A. Wolfe, 1973. *Nonparametric Statistical Methods*, Wiley, New York.

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