LMS/DUP/S11345

# Verification Monitoring Report and Analytical Update for the Durango, Colorado, Processing Site

August 2014

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# Contents



# Figures

# Tables

# Appendixes

# Abbreviations

| | |
|---|---|
| ACL | alternate concentration limit |
| AR | activity ratio |
| BLRA | Baseline Risk Assessment |
| CCR | *Code of Colorado Regulations* |
| CDPHE | Colorado Department of Public Health and Environment |
| CFR | *Code of Federal Regulations* |
| DOE | U.S. Department of Energy |
| EPA | U.S. Environmental Protection Agency |
| ft | feet |
| $ft^3$/day | cubic feet per day |
| GCAP | Groundwater Compliance Action Plan |
| MCL | maximum concentration limit |
| µg/L | micrograms per liter |
| mg/L | milligrams per liter |
| NRC | U.S. Nuclear Regulatory Commission |
| POC | point of compliance |
| RAP | Remedial Action Plan |
| SOWP | Site Observational Work Plan |
| TDS | total dissolved solids |
| U | uranium |
| UMTRCA | Uranium Mill Tailings Radiation Control Act |
| UPL | upper prediction limit |
| VMR | Verification Monitoring Report |

# Executive Summary

This Verification Monitoring Report (VMR) for the Durango, Colorado, Processing Site summarizes monitoring data for calendar year 2013 and assesses remedy performance. The report also contains a data evaluation that takes a more in-depth look at historical information and site monitoring data than were presented in past VMRs. The primary objectives of the data evaluation were to identify opportunities for improving the groundwater compliance approach and the long-term monitoring plan at the site.

Different wells have been used as a measure of background groundwater quality in different reports for the mill tailings area. Generally, background water quality in the vicinity of the site is poor—consistent with that for the greater Durango area. Background concentrations are elevated for several constituents—most notably sulfate, but also iron, manganese, and chloride. A comparison of background and onsite groundwater indicates that the most reliable indicator of milling-related contamination is uranium. An evaluation of uranium isotope data indicates that most uranium in site groundwater is milling-related rather than derived from Mancos Shale. On the other hand, sulfate in site groundwater appears to be predominantly from nonmilling sources. While sulfate concentrations have declined significantly at well locations most affected by milling, concentrations remain high and constant where other sulfate sources are present. Onsite sulfate concentrations are within prediction limits computed for site background wells. Several wells that are screened partially across Mancos Shale exhibit significantly elevated concentrations of sulfate that do not decrease over time, suggesting a continuing source.

One well at the site (0612) contains elevated concentrations of several metals, including cadmium, manganese, molybdenum, and zinc, some of which exceed concentrations observed in tailings fluids. Concentrations do not appear to be declining so a continuing source is likely present. The well is constructed through a slag layer that is a remnant of a historical zinc and silver smelting operation at the site. The metals observed in groundwater at this location are consistent with those that are commonly found in byproduct materials from smelting operations. The collective influence of nonmilling-related contaminants at the site indicates that groundwater at the site may qualify for supplemental standards based on limited use.

Studies of potential impacts of contaminated groundwater on receptors in the Animas River (human and ecological) has indicated that post-surface remediation site conditions are protective of human health and the environment. A statistical comparison of post-remediation groundwater with more recent groundwater conditions indicates that groundwater quality at the site is generally improving over time and can be considered stable. Recent concentrations of all site constituents have remained within prediction limits based on post-remediation data. These results suggest that, based on site protectiveness, alternate concentration limits may be applied to mill tailings groundwater (particularly uranium) in lieu of more stringent standards (e.g., maximum concentration limits).

Uranium in mill tailings area groundwater is declining, on average, across the site. An analysis of attenuation rates for individual wells and site average indicate that at the average observed rates, natural flushing of uranium may still achieve maximum concentration limits (the current remediation goal) within the allotted 100-year time period. However, the uncertainty associated with such predictions is high. In addition, the compliance goal for sulfate is unrealistically low given the contributions by background and Mancos Shale. Improvements to the current compliance strategy, as discussed above, may be appropriate to consider.

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# 1.0 Introduction and Purpose

This Verification Monitoring Report (VMR) presents monitoring data for the Durango, Colorado, Processing Site. The Verification Monitoring Report (VMR) typically assesses the progress of the groundwater remedy in achieving cleanup goals at a site. VMRs have been prepared for the Durango processing site since 2003. Previous VMRs for the site have focused on the mill tailings area and generally comparing current concentrations to modeled concentrations to determine if natural flushing was progressing within the modeled 100-year time frame. While that historical aspect of a VMR is still included as Groundwater and Surface Water Quality Data, Appendix A, this 2013 VMR includes a comprehensive analytical update.

Following this introduction, Section 2.0 presents site background information and includes pertinent information on site history, hydrology, and monitoring wells. Section 3.0 provides an additional data evaluation including:

- Background conditions at the mill site (Section 3.1.1).
- The potential impacts of milling and nonmilling sources on site water quality (Sections 3.1.2 through 3.1.5).
- Improvements to the current compliance strategy and potential alternatives (interspersed throughout Sections 3.1.1 to 3.1.7 and summarized in Section 3.1.8).
- Potential ways to optimize the monitoring approach (interspersed throughout Sections 3.1.1 to 3.1.7 and summarized in Section 3.1.8).
- Additional evaluation of the raffinate ponds area (Section 3.2).

Observations/Conclusions are provided in Section 4.0 that include recommended changes in the monitoring approach and information that impacts the site compliance strategy. Section 5.0 presents the references.

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# 2.0 Site Background Information

The Durango processing site is located in La Plata County approximately 0.25 mile southwest of the central business district of Durango (Figure 1). The site consists of two areas: (1) the mill tailings area, which is the setting of former uranium-ore milling and storage of mill tailings, as well as a lead smelter plant that operated before the uranium mill; and (2) a raffinate ponds area where liquid process wastes were impounded during milling operations. The former mill tailings area encompasses about 40 acres on a bedrock-supported river terrace between Smelter Mountain to the west, the Animas River to the east, and Lightner Creek to the north (Figure 1). The raffinate ponds area occupies about 20 acres on a separate river terrace located 1,500 feet (ft) south (downstream) of the mill tailings area (Figure 1).

## 2.1 Site Operations/Surface Remediation

### 2.1.1 Mill Tailings Area

Before being used for processing mill tailings, the site was the location of a large lead and silver smelting operation, giving Durango the nickname of “Smelter City” (https://www.durangoutdoors.com/trails/smelter-mountain-trail.htm). Smelting at the site began in about 1880, and the operation was Durango’s largest employer until 1930, when the operation was shut down due to the Great Depression. It reopened in the 1940s for the purpose of processing uranium ore. During smelting operations, the facility produced gold, silver, lead, and copper. By the end of 1893, the plant was treating 300 tons of ore per day and employed 300 fulltime employees (HAER 1988). Wastes from the smelting operations in the form of slag were disposed of on part of the property. The slag, along with manmade fill, served as the base for disposal of one of the uranium mill tailings piles onsite. The Remedial Action Plan (RAP) (DOE 1991) for the site notes that the slag heaps were leveled to provide the site foundation and that up to 25 feet of slag overlies natural alluvial materials. This is an indication that, at least in some areas, the slag is not a solid layer, but can transmit water. Tailings were reportedly slurried into place against the base of Smelter Mountain (DOE 1991) and upon the slag foundation; tailings consisted of interlayered sands and slimes.

The U.S. Department of Energy (DOE) began surface cleanup of the mill tailings and raffinate ponds areas in November 1986 to meet the U.S. Environmental Protection Agency (EPA) standards for radium in soil. A total of 2.5 million cubic yards of contaminated material was relocated to the Durango disposal cell in Bodo Canyon several miles southwest of the processing site. Supplemental cleanup standards were applied to tailings that remained on the steep slopes of Smelter Mountain (Figure 1) and along the banks of the Animas River (DOE 1991). In addition, a thin lens of “uranium precipitate” was left in place at the mill tailings area below layers of slag along portions of the river.

A description in the supplemental standards application (DOE 1991, Attachment 6) describes the uranium lens as a “seam” of crystallized uranium salts located at the base of the slag material. This “deposit” was hypothesized to have formed as a result of an old spill on the slag that slowly leached through the slag layer, which is described as being vitreous and fractured. The same document refers to problems with excavating and drilling through the slag. It is unclear whether supplemental standards were formally applied to the uranium deposit beneath the slag, which had uranium concentrations averaging 94 picocuries per gram. It was further hypothesized that the precipitate layer would eventually be washed away during spring runoff. It is not clear if the supposed precipitate layer washed away as expected or persisted for some time.

Figure 1 shows the approximate extent of the slag layer where supplemental standards were proposed based on information provided in the RAP. The boundary of the supplemental standards area appears to not coincide exactly with the extent of the slag. The well log for well 0617 (Figure 2) indicates that slag is present at that location; however, 0617 is located outside the designated supplemental standards area (Figure 3). The quitclaim deed places similar restrictions on the slag area, the river bank, and the windblown areas of Smelter Mountain (see Section 2.3).

To restore the site, approximately 230,000 cubic yards of uncontaminated soil was backfilled, contoured, and seeded. Riprap was placed in some sensitive areas along the Animas River to prevent erosion. Remedial action was completed in May 1991.

### 2.1.2 Raffinate Ponds Area

Raffinates from the second stage of processing were pumped to a tank above the mill, which discharged into a 3,000 ft long ditch that carried the waste to the raffinate ponds area. An additional 3,000 ft of ditch carried the raffinate through a series of ponds on the terraced slope of the raffinate ponds area. The raffinate evaporated and percolated into the underlying alluvium, colluvium, and sandstone bedrock. The ponds and tailings were removed during surface remedial action completed in 1991. Unlike the mill tailings area, there is no indication that the raffinate ponds area was used for anything but mill-related processes.

## 2.2 Hydrogeology

### 2.2.1 Mill Tailings Area

The uppermost aquifer at the mill tailings area is shallow and consists mostly of poorly sorted colluvium derived from Smelter Mountain, which rises steeply to the southwest. A portion of the shallow aquifer also comprises alluvial deposits associated with the Animas River and Lightner Creek. The colluvium and alluvium are underlain by the low-permeability Mancos Shale bedrock, which essentially acts as a hydraulic barrier that prevents downward migration of contaminants from the shallow groundwater system. Approximately 70 ft of colluvium overlies bedrock along the base of Smelter Mountain. These deposits thin eastward to about 15 ft in thickness close to the Animas River. Depth to groundwater increases from about 5 ft on the river terrace to about 60 ft near the mountain front. The saturated zone is thin (less than 10 ft thick), unconfined, of limited extent, and of low yield. Groundwater flow is generally to the southeast, parallel to the Animas River, at an average gradient of approximately 0.02 ft/ft. Hydraulic conductivity of the colluvium and alluvium ranges from 10 to 70 ft/day.

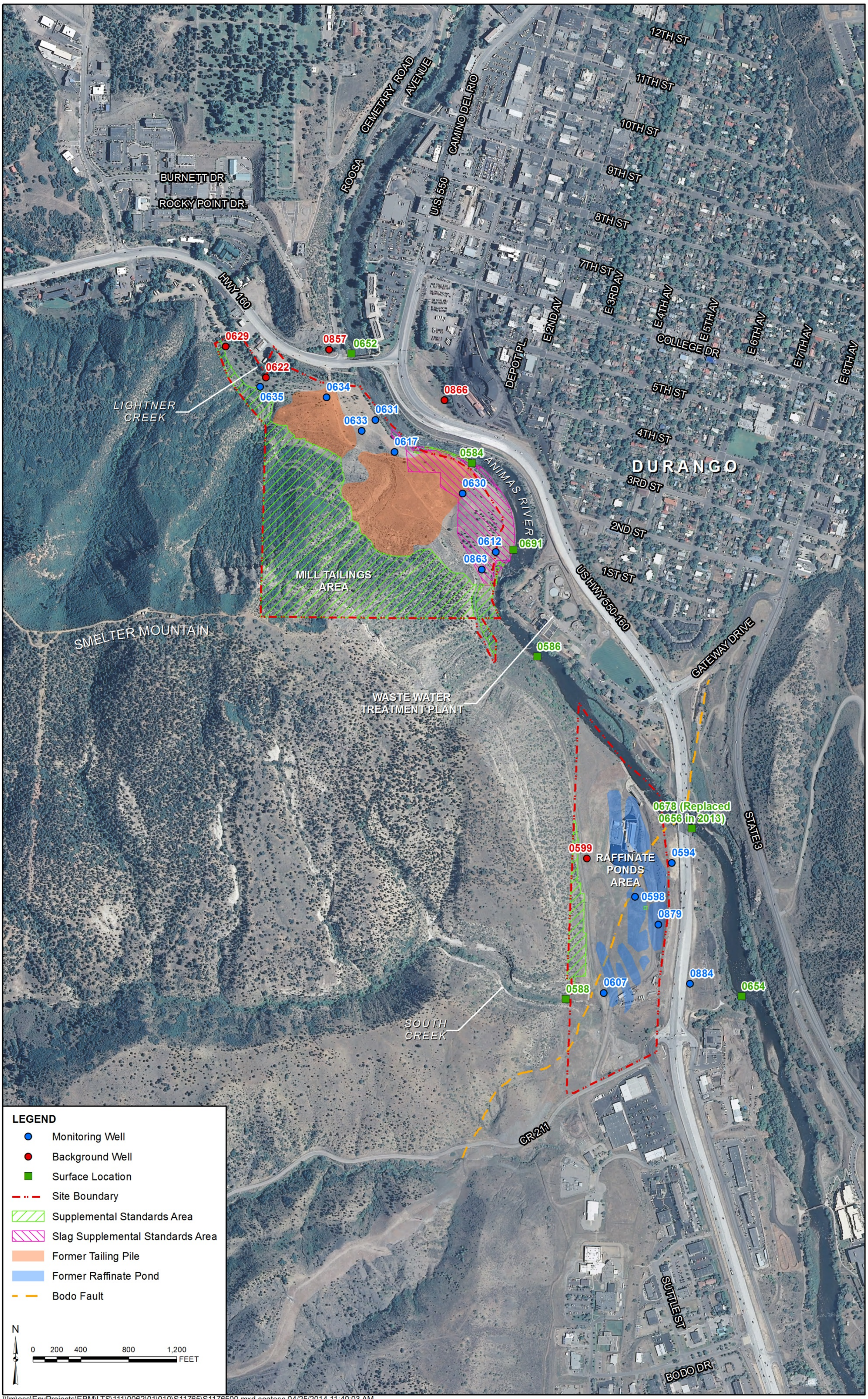


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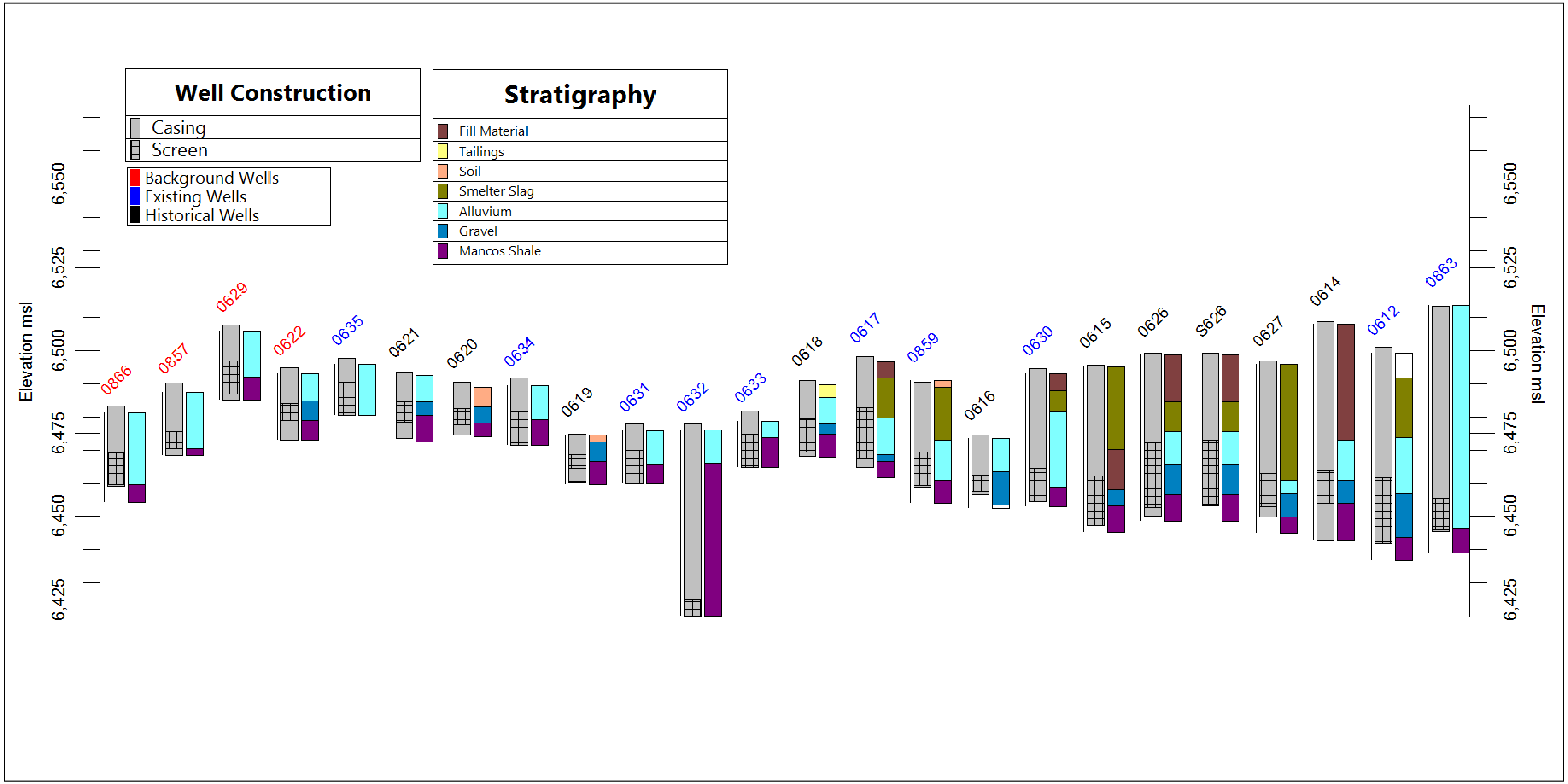
*Figure 1. Durango Processing Site Features and Sampling Locations*




Note: No log data available for historical well 0604 and background well 0658

*Figure 2. Well Construction and Stratigraphic Logs for Existing and Historical Wells*

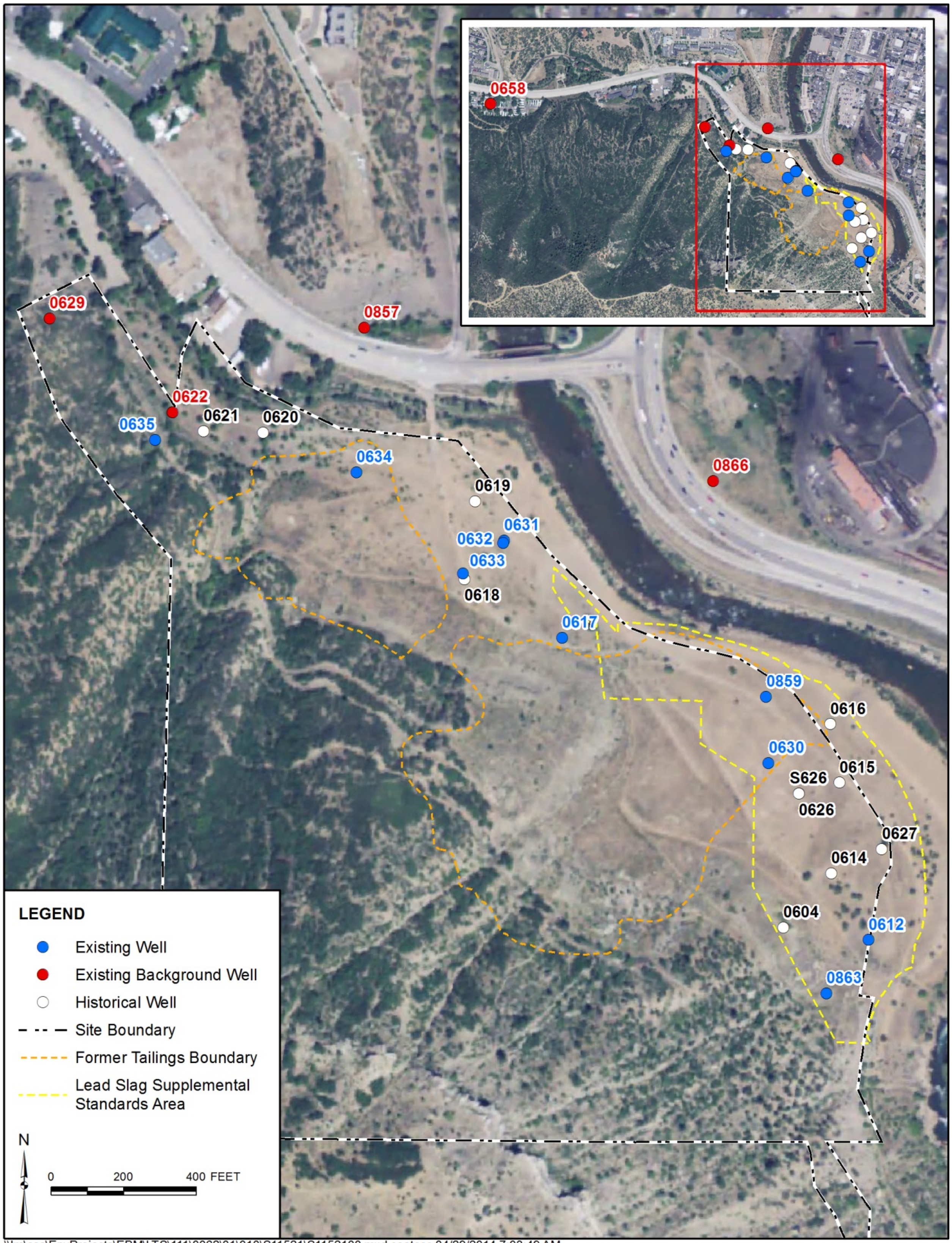



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*Figure 3. Mill Tailings Area Existing and Historical Wells*

The colluvium is recharged primarily by runoff from Smelter Mountain and infiltrating precipitation, and the river alluvium receives inflow from Lightner Creek and from river loss along the upstream reach of a prominent river meander that defines the middle third of the mill tailings area's east boundary. Groundwater discharges to the Animas River along the upper and lower thirds of the river reach adjacent to the mill tailings area. Under average conditions, the estimated volume of groundwater discharge from the mill tailings area is 1,480 cubic feet per day ($ft^3$/day); approximately 840 $ft^3$/day of this total enters the Animas River near the mouth of Lightner Creek, and the remaining 640 $ft^3$/day enters the Animas River east and southeast of the footprint of a former tailings pile (DOE 2002a). The alluvium and colluvium pinch out against bedrock cliffs near the southeast corner of the site, at which point groundwater discharge to the river is complete (DOE 2002a).

### 2.2.2 Raffinate Ponds Area

Groundwater in the raffinate ponds area occurs in two bedrock units, both formations of the Mesa Verde Group, that are separated by the northeast-trending Bodo Fault (Figure 1). The Point Lookout Sandstone, the basal formation of the Mesa Verde Group, lies south of the fault and is divided into two members: a lower transitional member consisting of interbedded lenticular sandstones and shales, and an upper massive sandstone member. The Menefee Formation, north of the fault, consists of massive sandstone and shale along with beds of carbonaceous shale and coal. The Bodo Fault, a normal fault, dips to the southeast at approximately 55 degrees. The Point Lookout Sandstone is downthrown approximately 200 ft along the fault.

Groundwater in the raffinate ponds area is assumed to be unconfined. It is recharged by infiltration of precipitation and runoff from the Smelter Mountain area and the ephemeral South Creek. Eastward-flowing subsurface water also enters the groundwater system near the intersection of Bodo Fault and South Creek (Figure 1). Hydraulic conductivity data indicate that the Point Lookout Sandstone is the least conductive of the various bedrock units underlying the raffinate ponds area. The lower member (predominantly shale and siltstone) of the Point Lookout Sandstone is considered an aquitard. The Menefee Formation consists of mostly low-conductivity sandstone but is relatively permeable where fractures or lenticular coal beds are present. The largest hydraulic conductivities appear to occur near Bodo Fault and in the coal beds within the Menefee.

## 2.3 Land/Water Use and Institutional Controls

The primary water source for the city of Durango is the Florida River upstream of its confluence with the Animas River. Additional water is withdrawn from the Animas River during high-demand periods (usually during the summer) from a location approximately 2 miles upstream of the mill tailings area. The portion of the Animas River bordering the mill tailings area of the Durango site is popular for seasonal boating and fishing. Development plans for both the mill tailings area and the raffinate ponds area do not include residential use (DOE 2002a). The quitclaim deed requires that land is used for public purposes and that ownership is restricted to a government entity within the state.

As part of the compliance strategy, public health will be protected at the mill tailings area through an environmental covenant between the State of Colorado and the City of Durango (landowner) that restricts access to contaminated alluvial groundwater. Additionally, deed restrictions (which serve as a notice to the public) for the mill tailings area prohibit access to groundwater without written permission from DOE and the Colorado Department of Public Health and Environment (CDPHE). Groundwater use in the raffinate ponds area is restricted in perpetuity through a deed restriction that also requires DOE's permission before use of groundwater for any purpose. In addition, DOE must approve any construction plans, designs, or specifications before such activities may take place. Any habitable structures are required to employ a radon ventilation system or other mitigation measures. The State of Colorado is currently in the process of trying to obtain a signed environmental covenant agreement for the raffinate ponds area.

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# 3.0 Data Evaluation

Surface remediation and source removal was completed in 1991, and more than 2 decades of monitoring data have been collected since that time. The purpose of this data evaluation is to take a more in-depth look at the monitoring data than was presented in previous VMRs. Data used includes all historical data for the site as well as the data collected for calendar year 2013 since the last VMR was completed. A discussion of the 2013 monitoring data in included in Appendix A.

This analytical update includes an evaluation of background data, an evaluation of potential contaminant sources, and a look at spatial and temporal patterns observed for onsite wells. This analysis also includes a discussion of potential causes for observed trends and distributions of constituents in groundwater. The majority of this discussion pertains to the mill tailings area, though it also briefly reviews data for the raffinate ponds area. This VMR also provides suggestions for optimizing the monitoring approach for both portions of the site based on results of the data evaluation.

The key questions this analysis focuses on are summarized as follows:

1. Is groundwater contamination present in excess of maximum concentration limits or background levels?
2. Does contaminated groundwater meet the criteria for supplemental standards based on limited use groundwater?
3. Does contaminated groundwater qualify for alternate concentration limits (ACLs) based on acceptable human health and environmental risks and other factors?
4. Will natural flushing result in compliance with maximum concentration limits, background levels, or alternate concentration limits within 100 years?

This analysis addresses each of these questions in an effort to optimize the current compliance approach. Section 3.1.1 discusses background water quality for the site. Sections 3.1.2 through 3.1.5 describe potential sources of contamination at the site (milling and nonmilling) and the behavior of constituents identified in site groundwater over time. These sections combined can be used to answer questions 1 and 2. Section 3.1.6 evaluates the protectiveness of groundwater at the site since completion of surface remediation and addresses question 3. Section 3.1.7 provides a statistical evaluation of the progress of natural flushing to address question 4. Section 3.1.8 summarizes the potentially applicable compliance improvements.

## 3.1 Mill Tailings Area

The uppermost aquifer is comprised of primarily an alluvial/colluvial system on top of Mancos Shale (aquitard). Various deposits have been recognized (including gravels, fill), but essentially the site consists of shallow unconsolidated materials on top of bedrock. According to the Baseline Risk Assessment (BLRA) for the site (DOE 1995), the colluvium covers the half of the site that borders Smelter Mountain; alluvium is present on the half of the site adjacent to the Animas River. Reportedly the colluvium yields little water, which may explain the lack of wells on that half of the site. Most of the mill site wells are screened predominantly in alluvial material. However, several have screens that extend at least partially into the Mancos Shale

(Figure 2). Well 0632, which was sampled only once due to a lack of water, is screened completely in the Mancos.

At the southeastern end of the site along the Animas River, there is a layer of slag from the former lead/silver smelting operation, as discussed in Section 2.1.1. Where present, the slag sits on top of alluvium or soil and in most locations is either present at the land surface or is covered with fill. The slag is up to 30 ft thick and predates the milling operation. Based on the descriptions of the slag, it does not appear to be a solid impermeable layer but is capable of transmitting water. The above-described uranium "deposit" (Section 2.1.1) reportedly formed due to fluids migrating through the slag layer and precipitating at its base. Some portions of the slag layer may be more solid than others. One reason that the slag was not removed during surface remediation (other than the fact that it was determined to not be residual radioactive material) was reportedly due to difficulties in excavation and drilling of the material (DOE 1991, Attachment 6). As shown in Figure 2, the wells in the slag area are completed below this layer and are screened below or partially in the slag layer. No wells are screened exclusively in the slag.

### 3.1.1 Background Water Quality

Different wells have been designated as background for the mill tailings area in different reports. Background wells for the mill tailings area that were used in the Site Observational Work Plan (SOWP, DOE 2002a) included 0629, 0857, and 0866. It appears that well 0622 was determined to be a background well during development of monitoring requirements for the Groundwater Compliance Action Plan (GCAP; DOE 2003), and sampling of that well was subsequently discontinued. Well 0658 is located upgradient of the site along Lightner Creek (Figure 3), and groundwater in 0658 is unaffected by site-related activities.

The primary source of recharge (according to the SOWP; DOE 2002a) for the mill tailings area is Lightner Creek. Wells 0629, 0622, and 0635, located upgradient of the tailings piles and adjacent to the creek, are likely most representative of recharge from this source. Well 0658 also is likely to receive recharge from this source. Background wells 0857 and 0866, while unaffected by site-related activities, may not be representative of the bulk of background groundwater entering the mill site, as they are hydrogeologically separated from the mill site area (Figure 3). Water from these wells may be more similar to the Animas River recharge component. A combination of all of these background areas may be more representative of water entering the site than any one well.

This evaluation examines the likelihood that samples from wells 0635 and 0622 are representative of background water quality and whether data from those wells can be pooled with the data from other accepted background wells to form a larger, more representative data set. Uranium and sulfate, which have been considered to be the best indicators of site-related contamination, are the focus of this evaluation. Figure 4 and Figure 5 show uranium and sulfate time-concentrations plots for wells 0622 and 0635 along with the other recognized background wells.

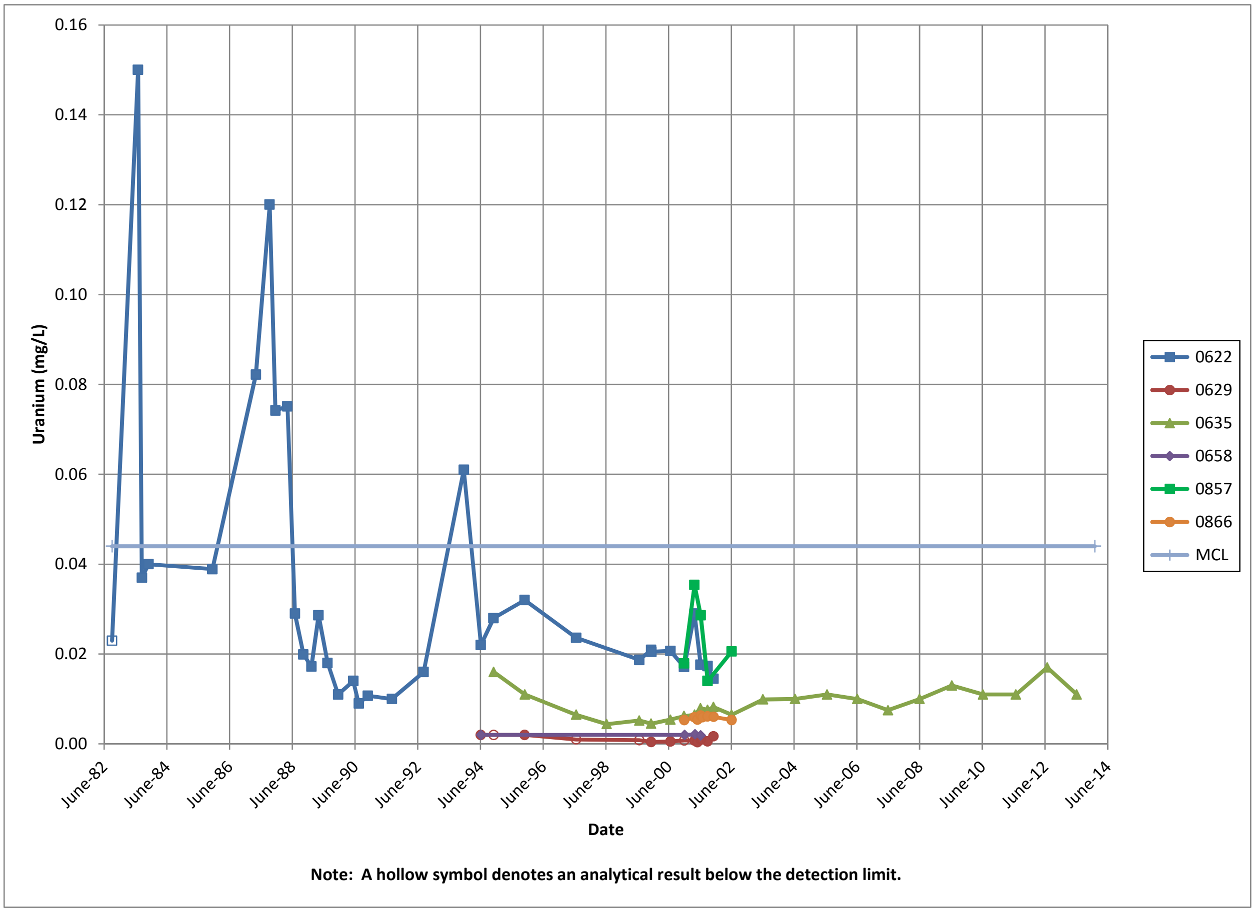


*Figure 4. Uranium Concentrations in Background Wells*

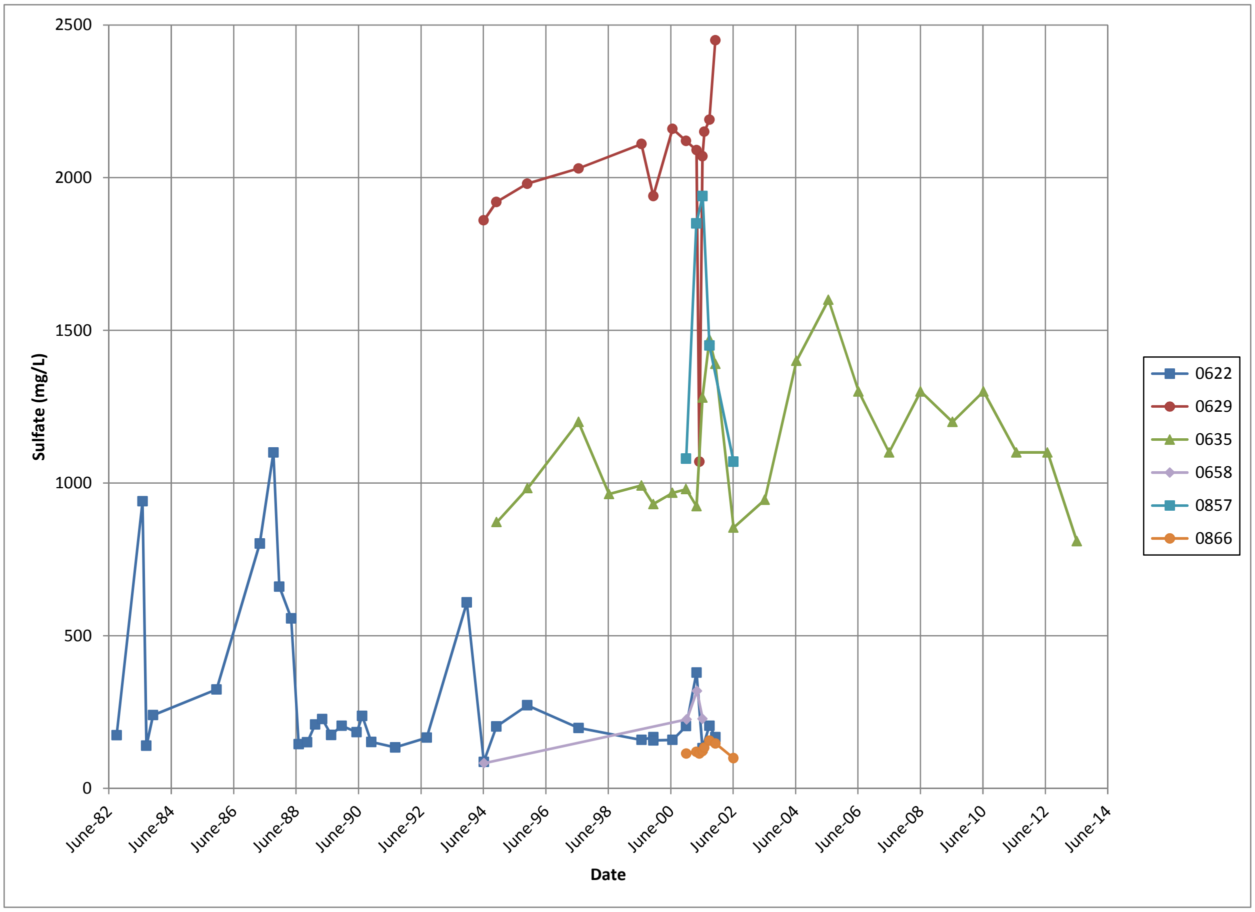


*Figure 5. Sulfate Concentrations in Background Wells*

Well 0622 does have elevated uranium concentrations compared to most of the other wells, with a couple of spikes occurring during surface remediation. However, only a single sample collected from well 0622 since the completion of surface remediation exceeded the maximum concentration observed in background well 0857. Although the RAP does not mention groundwater mounding associated with tailings, the BLRA (DOE 1995) attributed pre-surface remediation uranium at well 0622 to tailings seepage. That report also concluded that all site-related contamination had been "completely flushed" by the time that document was completed in 1995.

The most recent uranium data available for well 0622 overlaps with that from well 0857 (Figure 4), which is not affected by site-related contamination (being physically and hydrologically separate from the mill tailings area). These two wells display the highest background concentrations. Lowest uranium concentrations are observed in wells 0629 and 0658, which are also unaffected by site-related contamination. Wells 0635 and 0866 have concentrations between the two extremes. Data from well 0635 show an apparent downward trend followed by an upward one. It is not clear if these trends are meaningful or if they reflect the natural variability of the groundwater system. The short monitoring history for some wells that may be unequivocally considered to be background may not accurately capture the natural variability of the alluvial system. The uranium fluctuations observed in well 0857 illustrate this point.

Figure 5 shows sulfate concentrations for the same wells discussed above. As with uranium, well 0857 has among the highest sulfate concentrations observed. In contrast, well 0629, with very low uranium, displays the highest observed sulfate concentrations. As shown in Figure 2, well 0629 is screened partially across Mancos Shale, while the other background wells are completed mostly in alluvial material. Well 0622 has sulfate concentrations comparable to those in wells 0866 and 0658, which are unaffected by site-related contamination. Sulfate concentrations from well 0635, as with uranium, tend to be intermediate between the observed highs and lows for background.

Data for wells 0622 and 0635 for other known site-related constituents (e.g., vanadium, molybdenum, cadmium) are low and indistinguishable from other established background locations. Therefore, for the remainder of this report, it is assumed that since the completion of surface remediation, wells 0622 and 0635 are representative of background (i.e., nonmilling groundwater quality) for the mill tailings area. Background statistics are computed using the entire record of data for well 0635 and data collected since 1994 for well 0622 along with all data for wells 0629, 0658, 0857, and 0866.

Regionally, shallow groundwater for the Durango area is considered to be poor (DOE 1995). Hardness is high and concentrations of iron and manganese are elevated. Site-specific background analyses support this assessment. Wells have high levels of total dissolved solids (TDS), sulfate, manganese, and iron that exceed secondary drinking water standards. Different wells are high in different constituents, though all are elevated in TDS compared to the secondary drinking water standard of 500 milligrams per liter (mg/L). Table 1 provides a summary of background data reported in the SOWP; standards provided in the table are only for comparison to indicate that ambient groundwater is generally poor. State standards are provided where available, as these are most relevant for the purposes of aquifer classification. However, the UMTRCA maximum concentration limits (MCLs) from Title 40 *Code of Federal Regulations* Part 192 (40 CFR 192) are most relevant from a compliance standpoint.

Table 2 provides updated background statistics for the wells discussed above. EPA's ProUCL software, Version 4.1.00, was used to compute these statistics (EPA 2010). In addition to standard summary statistics, a 95 percent upper prediction limit (UPL 95) was calculated for each constituent. A prediction interval (specified by upper and lower prediction limits) is an estimate of an interval in which future individual observations will fall, given what has already been observed. For data sets with greater variability, prediction intervals are generally wider. Upper prediction limits, usually a UPL 95, are often used to define an upper threshold value for a background data set in a detection monitoring program (EPA 2009). As long as observed concentrations remain below the UPL 95, it is concluded that groundwater quality is consistent with background. Results from the ProUCL statistical analysis are included in Appendix B. Note that background wells used in the SOWP were last sampled in 2002.

*Table 1. Summary of Background Water Quality for the Mill Tailings Area (from SOWP; DOE 2002a)[e]*

| Constituent | FOD | Minimum (mg/L) | Maximum (mg/L) | Mean (mg/L) | Standard |
|---|---|---|---|---|---|
| Arsenic | 0/20 | <0.0013 | na | na | 0.01[a]/0.05[f] |
| Cadmium | 0/20 | <0.007 | na | na | 0.005[a]/0.01[f] |
| Chloride | 20/20 | 9.90 | 265 | 64.2 | 250[a] |
| Sulfate | 20/20 | 114 | 2190 | 1255 | 250[a] |
| Iron | 15/18 | 0.12 | 14.7 | 3.38 | 0.3[a]/5[b] |
| Manganese | 20/20 | 0.073 | 1.05 | 0.601 | 0.05[a]/0.2[b] |
| Molybdenum | 0/20 | <0.0057 | na | na | 0.21[a]/0.1[f] |
| Selenium | 8/20 | <0.011 | 0.0148 | 0.014 | 0.05[a]/0.01[f] |
| TDS | 20/20 | 623 | 3860 | 2528 | 500[d] |
| Uranium | 11/20 | 0.005 | 0.035 | 0.012 | 0.0168 to 0.03[c]/0.044[f] |
| Vanadium | 0/20 | <0.0020 | na | na | 0.1[b] |

[a] Domestic water supply—drinking water standard (Volume 5 *Code of Colorado Regulations* 1002-41 [5 CCR 1002-41])
[b] Agricultural Standard (5 CCR 1002-41)
[c] Domestic water supply—human health standards (5 CCR 1002-41)
[d] Federal Secondary Drinking Water Regulations
[e] Data from wells 0629, 0857, 0866; June 1999 through August 2001
[f] 40 CFR 192 groundwater standards; standard for uranium assumes secular equilibrium between U-234 and U-238
na = not applicable
FOD = frequency of detection

*Table 2. Updated Background Statistics for Selected Constituents (1994+)*

| Constituent | Number of Samples | Minimum (mg/L) | Maximum (mg/L) | Mean (mg/L) | UPL 95[a] |
|---|---|---|---|---|---|
| Chloride | 54 | 1.45 | 265 | 33.66 | 264 |
| Iron | 39 | 0.0047 | 14.7 | 1.576 | 17.18 |
| Manganese | 70 | 0.0023 | 3.22 | 0.347 | 2.486 |
| Sulfate | 63 | 42 | 2,450 | 1,044 | 4,234 |
| Uranium | 60 | 0.0003 | 0.034 | 0.00996 | 0.0464 |

[a] Nonparametric Chebyshev UPL was used; wells 0622, 0629, 0635, 0857, 0866

For the Durango processing site, the background UPL 95 for a number of constituents exceeds water quality standards. Most of the exceeded standards are only secondary standards that are not compliance related. However, these exceedances are consistent with the observation that regional groundwater quality in the Durango area is generally poor. As with the raffinate ponds area, this suggests that ambient contamination, unrelated to uranium milling, is present in the uppermost aquifer in the mill tailings area.

### 3.1.2 Milling-Related Contamination

To determine the potential effects of uranium milling on groundwater quality at the site, it is important to determine which constituents were attributed to the milling process. This section provides a summary of information on milling-related contamination. Most milling-related data were collected during preparation of the RAP to help characterize mill-related contaminants; data from this time frame are limited. Samples of tailings-related fluids were collected from the tailings piles before the start of surface remediation using suction lysimeters. According to the RAP, sample volume "was sufficient" for analysis of major anions and cations, radium-226 and radium-228, and uranium. The description of the lysimeter sampling appeared to indicate that excessive amounts of fluids were not present. Radium-226 in tailings fluids was reported to range from 1.3 to 33 picocuries per liter and uranium from 0.047 to 2.89 mg/L. No other constituent results were reported in the RAP.

After relocation of tailings to Bodo Canyon, monitoring wells were installed within the tailings, and a more complete suite of analyses were performed from collected samples. Table 3 presents a summary of these results. It is assumed that these results are representative of tailings leachate compositions that could have affected site groundwater. Based on these data, it appears that tailings fluids were elevated in nearly all constituents except chloride relative to the standards. Iron in tailings fluids was higher than the domestic standard but less than the agricultural standard. In a comparison of Table 2 and Table 3, tailings concentrations of chloride, iron, and sulfate are not different from concentrations expected in background groundwater. However, uranium concentrations are markedly higher than background levels.

*Table 3. Tailings Pore Water Samples (from DOE 1991)*

| Contaminant | Number of Samples | Minimum (mg/L) | Maximum (mg/L) | Median (mg/L) | Standard |
|---|---|---|---|---|---|
| Arsenic | 15 | 0.09 | 0.57 | 0.19 | 0.01[a]/0.05[e] |
| Cadmium | 15 | 0.014 | 0.063 | 0.037 | 0.005[a]/0.01[e] |
| Chloride | 15 | 59 | 210 | 75 | 250[a] |
| Iron | 15 | 0.09 | 0.63 | 0.14 | 250[a] |
| Manganese | 15 | 3.03 | 8.63 | 6.01 | 0.3[a]/5[b] |
| Molybdenum | 15 | 0.81 | 3.9 | 1.73 | 0.05[a]/0.2[b] |
| Selenium | 15 | 0.045 | 0.408 | 0.132 | 0.21[a]/0.1[e] |
| Sulfate | 15 | 1540 | 2800 | 1710 | 0.05[a]/0.01[e] |
| TDS | 15 | 2790 | 5080 | 3250 | 500[d] |
| Uranium | 15 | 1.47 | 21.6 | 4.54 | 0.0168 to 0.03[c]/0.044[e] |
| Vanadium | 5 | 5.7 | 14.4 | 11.1 | 0.1[b] |

[a] Domestic water supply—drinking water standard (Volume 5 *Code of Colorado Regulations* 1002-41 [5 CCR 1002-41])
[b] Agricultural Standard (5 CCR 1002-41)
[c] Domestic water supply—human health standards (5 CCR 1002-41)
[d] Federal Secondary Drinking Water Regulations
[e] 40 CFR 192 groundwater standards; standard for uranium assumes secular equilibrium between U-234 and U-238

Groundwater samples were collected from the mill tailings area shortly after the completion of surface remediation in the vicinity of the tailings piles; those results are summarized in Table 4 These samples likely represent the most highly contaminated groundwater that was historically present at the site; natural attenuation processes have reduced milling-related concentrations since that time. Maximum values for uranium, manganese, cadmium, selenium, arsenic, TDS, and chloride were all elevated above background. However, minimum and median values for these constituents suggest that only uranium has had a significant impact on site groundwater, with more than half the samples exceeding applicable standards.

*Table 4. Groundwater Data for Former Tailings Area Alluvial Wells—1987 to 1991 (from DOE 1991)*

| Contaminant | Number of Samples | Minimum (mg/L) | Maximum (mg/L) | Median (mg/L) | Standard |
|---|---|---|---|---|---|
| Arsenic | 37 | <0.006 | 0.05 | <0.006 | 0.01[a]/0.05[e] |
| Cadmium | 37 | <0.001 | 0.061 | 0.002 | 0.005[a]/0.01[e] |
| Chloride | 37 | 2.1 | 795 | 52.2 | 250[a] |
| Iron | 37 | <0.03 | 0.15 | 0.07 | 250[a] |
| Manganese | 37 | <0.01 | 6.44 | 0.03 | 0.3[a]/5[b] |
| Molybdenum | 37 | <0.01 | 0.42 | 0.03 | 0.05[a]/0.2[b] |
| Selenium | 37 | <0.005 | 0.226 | 0.036 | 0.21[a]/0.1[e] |
| Sulfate | 37 | 134 | 3,360 | 1,990 | 0.05[a]/0.01[e] |
| TDS | 37 | 468 | 6,560 | 3,440 | 500[d] |
| Uranium | 37 | <0.001 | 4.67 | 0.201 | 0.0168 to 0.03[c]/0.044[e] |
| Vanadium | 20 | <0.01 | 0.61 | 0.01 | 0.1[b] |

[a] Domestic water supply—drinking water standard (Volume 5 *Code of Colorado Regulations* 1002-41 [5 CCR 1002-41])
[b] Agricultural Standard (5 CCR 1002-41)
[c] Domestic water supply—human health standards (5 CCR 1002-41)
[d] Federal Secondary Drinking Water Regulations
[e] 40 CFR 192 groundwater standards; standard for uranium assumes secular equilibrium between U-234 and U-238

### 3.1.3 Spatial and Temporal Variation in Onsite Water Quality

This section examines the spatial and temporal variation in water quality at the mill tailings site to determine if any patterns emerge that enhance the understanding of the site. This discussion builds on the data presented in the background and milling-related contamination sections (Sections 3.1.1 and 3.1.2). Background wells located on the mill site (wells 0629, 0622, and 0635; Figure 3) are included on a number of figures for comparison. The first part of this section focuses on uranium and sulfate and provides a discussion of time-concentration plots and statistical trend analysis. The end of this section looks at data for other constituents observed at the site to examine the possibility that sources other than mill tailings may be adversely affecting groundwater quality in some portions of the site. Two such sources of contamination are considered—the Mancos Shale (Section 3.1.4) and the slag layer (Section 3.1.5).

Based on the discussion in Section 3.1.2, uranium is the most likely milling-related constituent at the site. Figure 6 through Figure 8 show time-concentration plots for uranium in onsite wells. Concentrations in wells 612 and 0633 are an order of magnitude higher than concentrations in all other wells. These locations are the closest downgradient wells from each of the former tailings piles and likely received the most highly concentrated mill-related fluids. Data for historical site wells indicate that locations upgradient of well 0612 had concentrations of uranium as high as 6 mg/L. Concentrations in well 0633 have declined by approximately 1 mg/L since monitoring began at this location. Concentrations at location 0612 have declined approximately 3 mg/L since their peak.

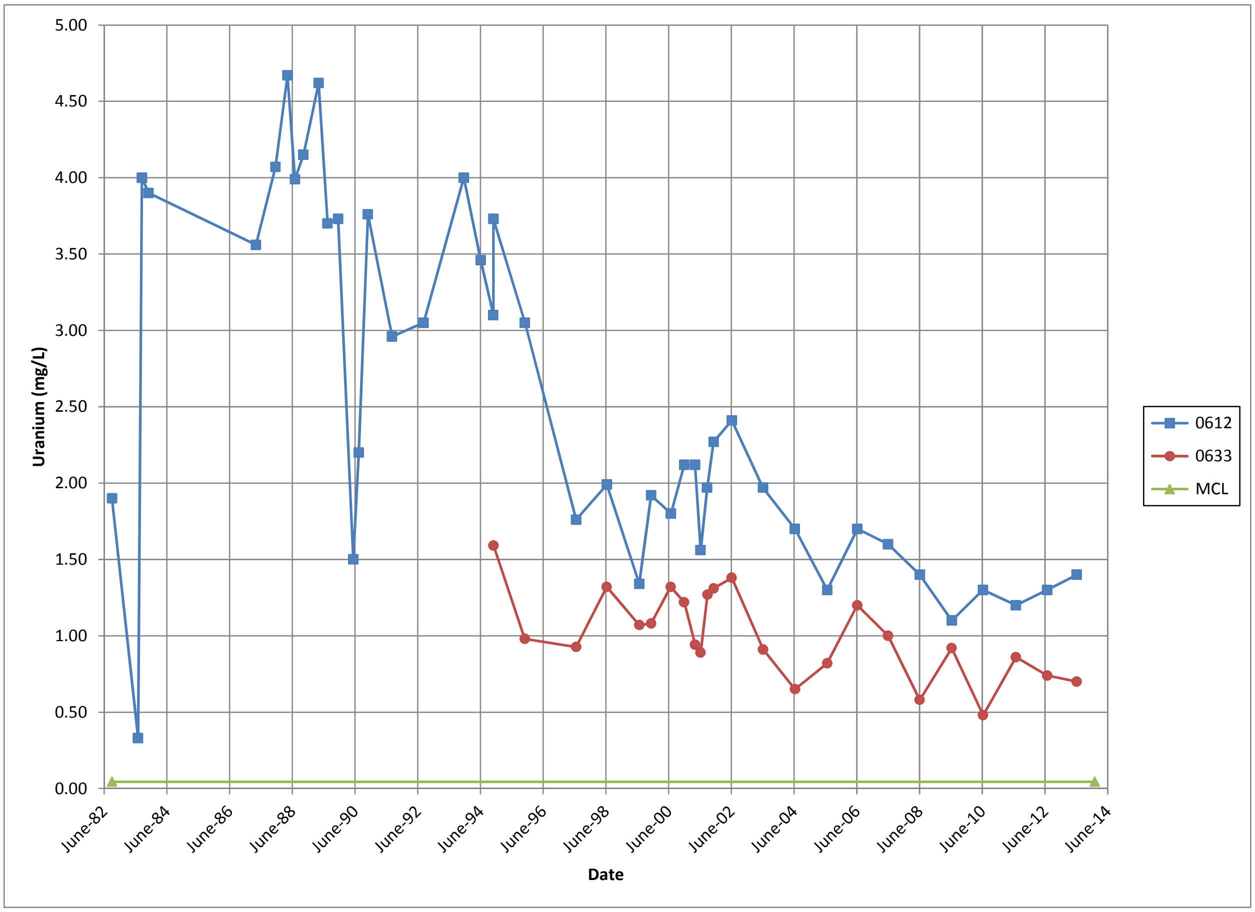


*Figure 6. Uranium Concentrations Wells 0612 and 0633*

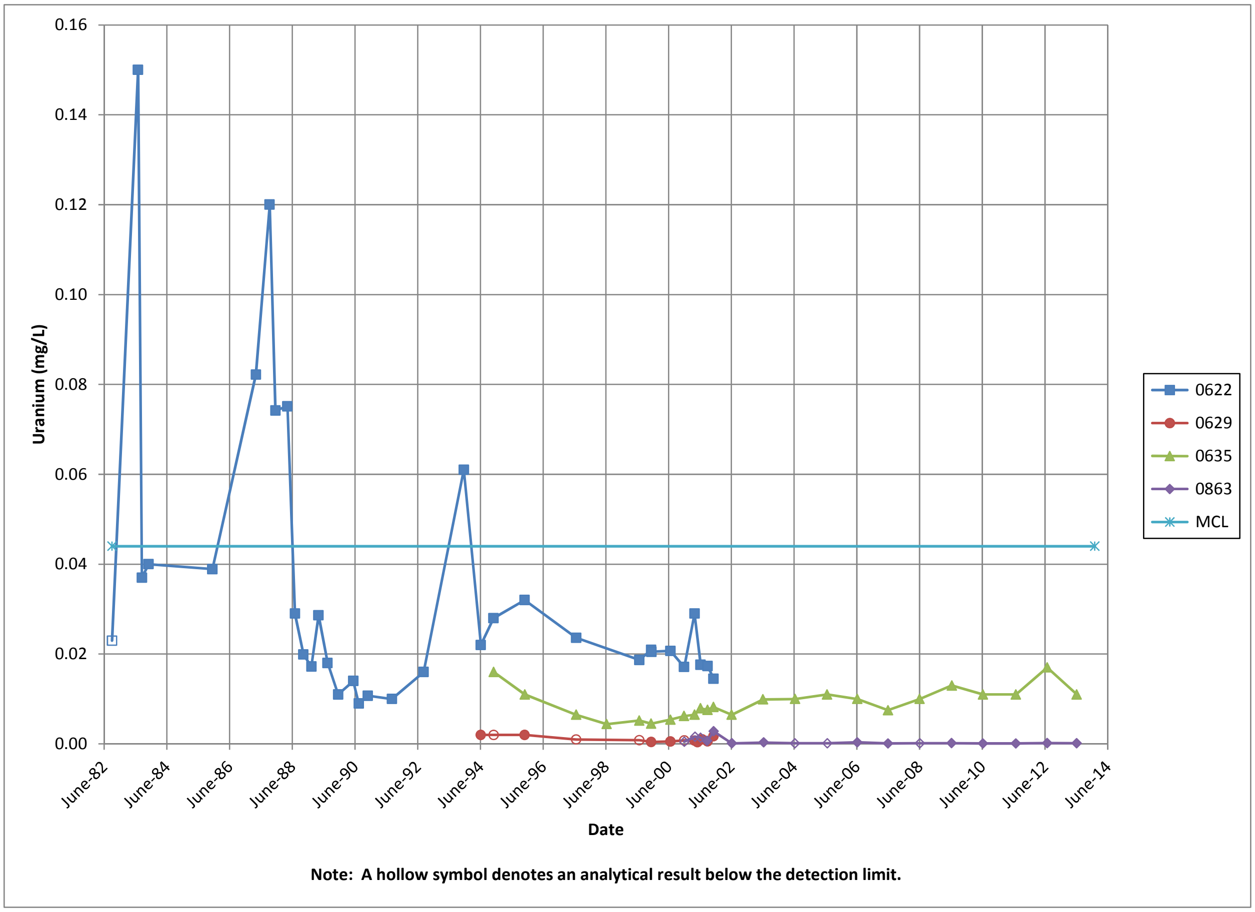


*Figure 7. Uranium Concentrations Wells 0622, 0629, 0635, and 0863*

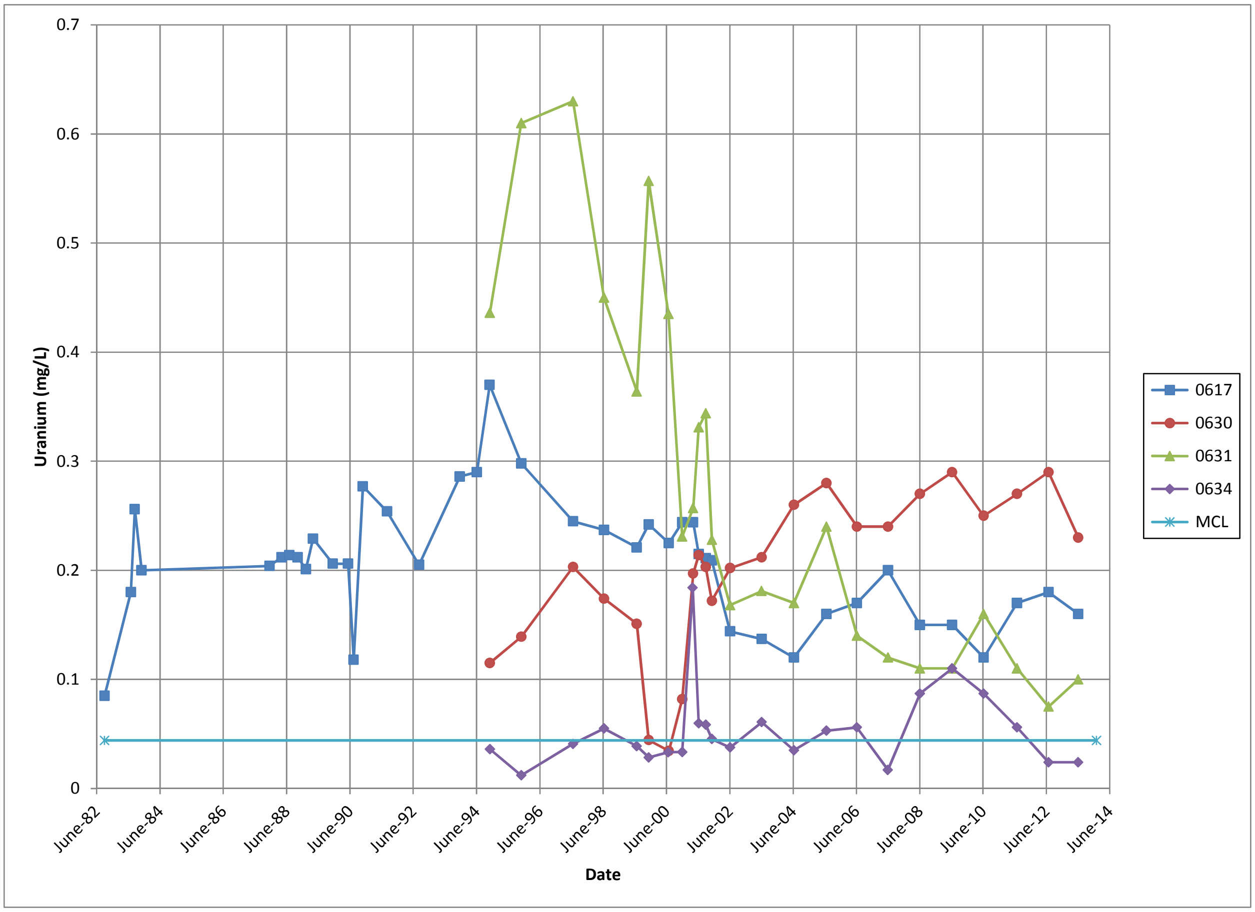


*Figure 8. Uranium Concentrations Wells 0617, 0630, 0631, and 0634*

The lowest uranium concentrations on the site are from wells 0629, 0635, and 0863. All of these wells have been below the uranium standard of 0.044 mg/L throughout their monitoring histories. Concentrations in well 0622 have also been relatively low and below the standard since about 1994.

Wells 0617, 0630, and 0634 have had concentrations regularly elevated above the UMTRCA groundwater standard. Uranium concentration in well 0617 appeared to be increasing prior to 1994 and declining after that time. Well 0630 appears to display an increasing trend, and uranium in well 0634 fluctuates around a concentration of about 0.05 mg/L. Note how wells 0617 and 0631 show opposite and crossing trends compared to well 0630 since the late 1990s. This is possibly due to a slug of uranium moving downgradient from the vicinity of wells 0631 and 0617 toward location 0630. While some water likely discharges to the river in the northern part of the site, movement parallel to the river from location 0617 to 0630 is consistent with the flowlines in the groundwater model (DOE 2002a). If uranium behavior at location 0630 parallels that of 0617 and 0631, uranium in 0630 should start declining in the near future.

Along with uranium, sulfate has historically been thought of as an indicator of site-related contamination in the mill tailings area. Figure 9 through Figure 11 show sulfate concentrations for highest to lowest concentration wells. Highest sulfate wells are 0612 and 0633, which have been in the 3,000 to 3,500 mg/L range. Medium concentration wells include onsite wells 0617, 0630, and 0634 and background well 0629, with concentrations in the 2,000 mg/L range. Lowest wells include background wells 0622 and 0635 along with onsite wells 0631 and 0863; these wells have concentrations that are generally below 1,500 mg/L.

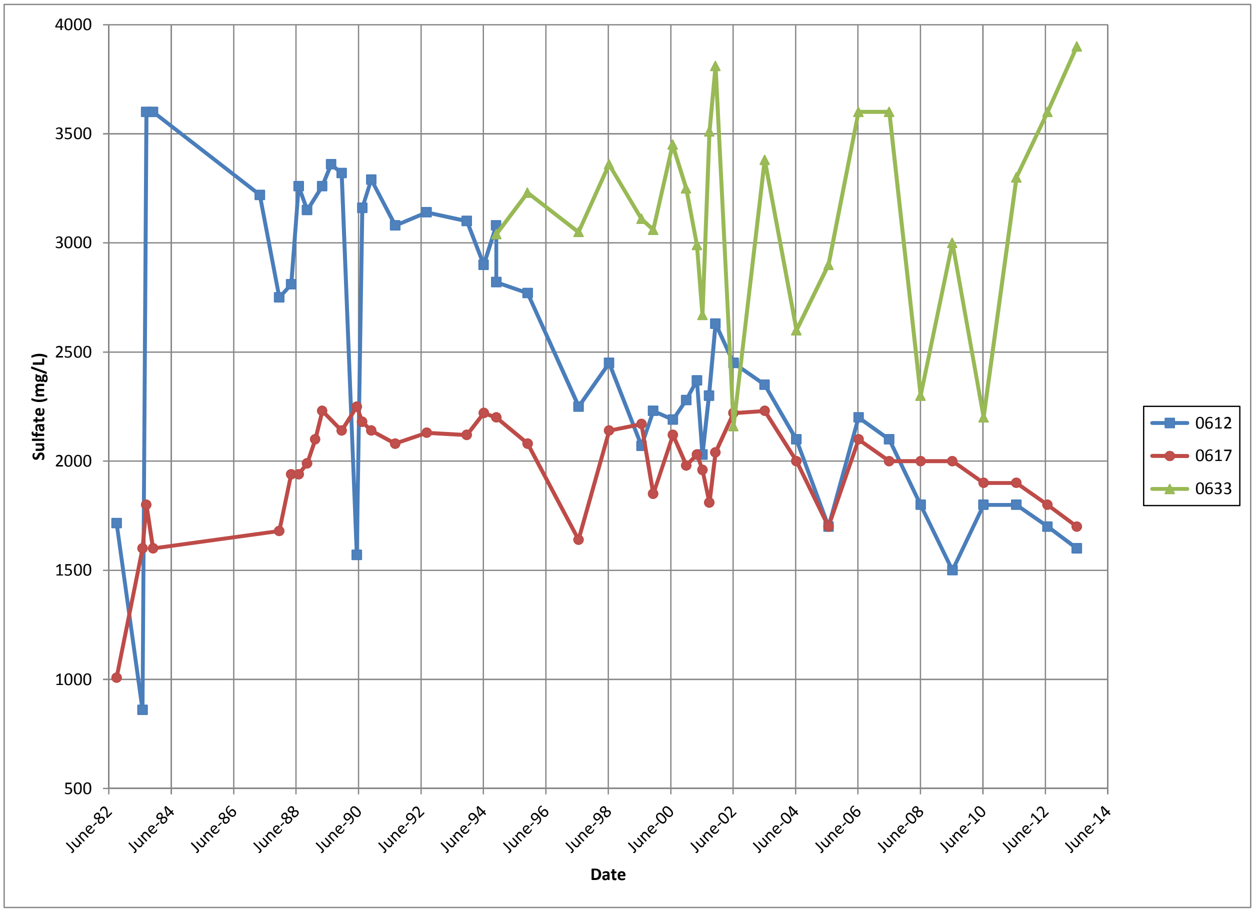


*Figure 9. Sulfate Concentrations Wells 0612, 0617, and 0633*

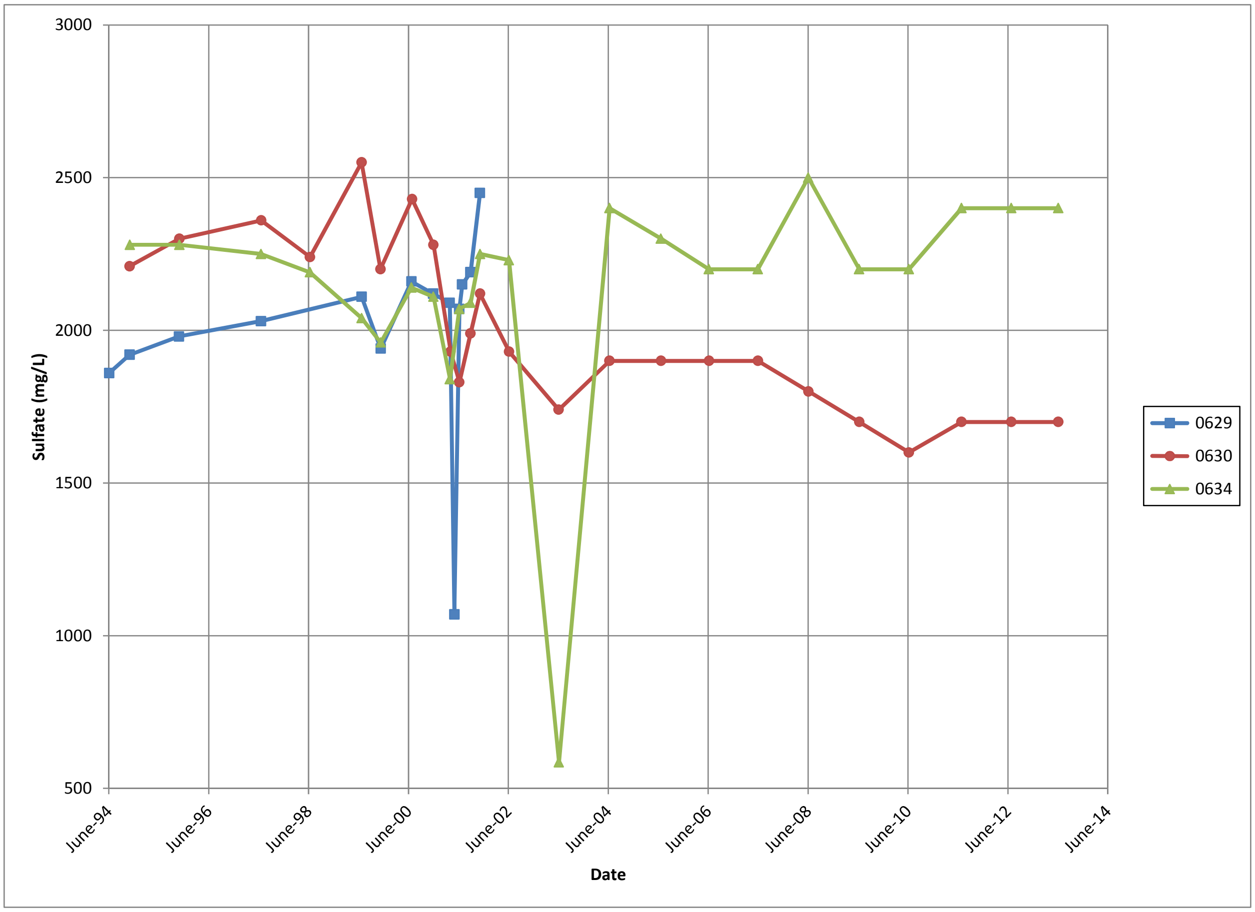


*Figure 10. Sulfate Concentrations Wells 0629, 0630, and 0634*

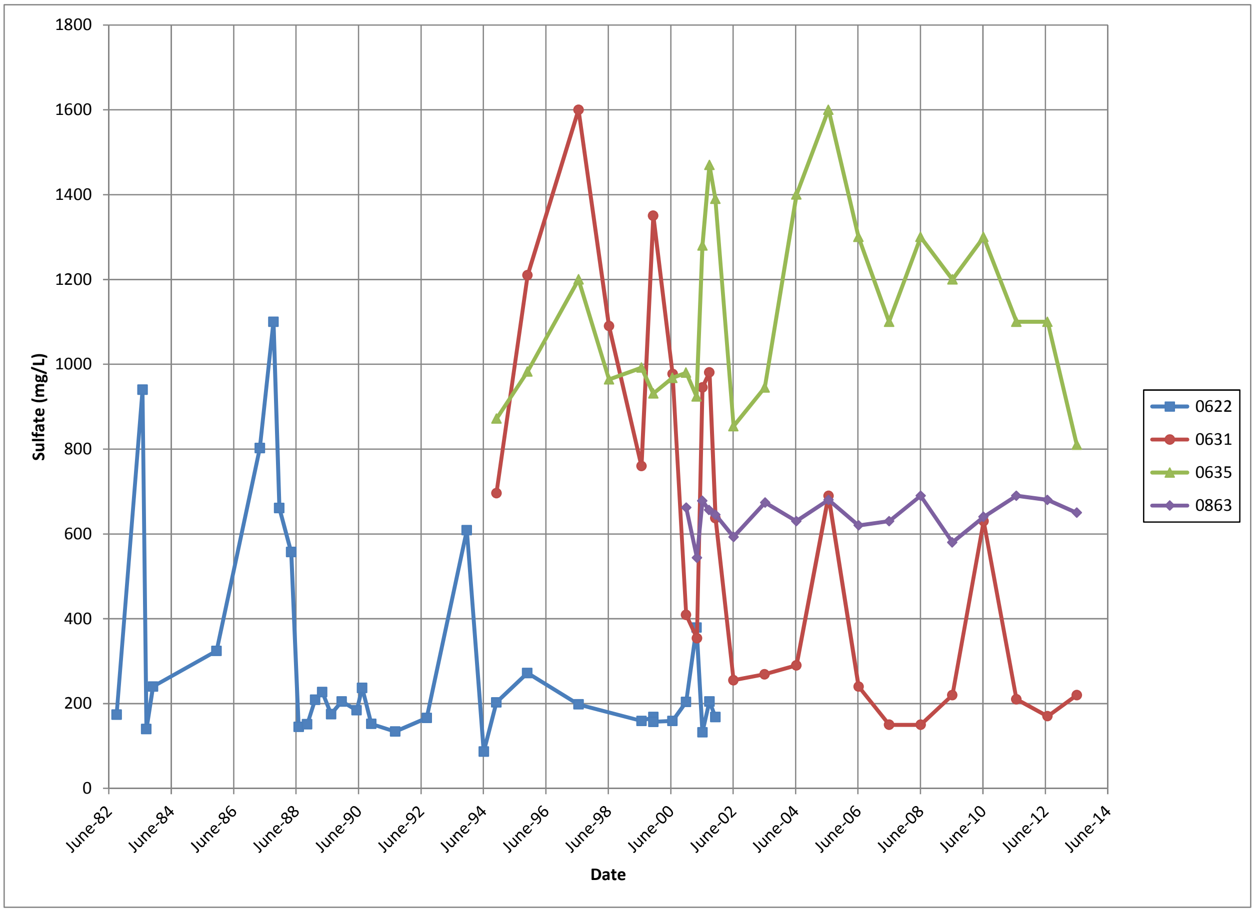


*Figure 11. Sulfate Concentrations Wells 0622, 0631, 0635, 0863*

Wells 0612, 0630, and 0631 have discernible downward trends on the time-concentration plots. For other wells, concentrations appear to fluctuate (quite markedly in some instances) about a somewhat constant level. For example, well 0617 appears to fluctuate above and below a concentration of around 2,000 mg/L; well 0633 has a wider fluctuation range about a concentration of around 3,000 mg/L. As with uranium, 0612 and 0633 have highest concentrations, but while 0612 displays a declining trend in sulfate, 0633 does not.

The discussion regarding background levels of sulfate indicated that fairly high levels of sulfate are attributed to background sources. All onsite samples have sulfate concentrations below the UPL 95 for background. Only wells 0612 and 0633 display concentrations that exceed the maximum observed in background wells of approximately 2,500 mg/L. As concentrations in well 0612 have declined to within the background range, it is likely that the excess sulfate observed at that location was derived from tailings fluids. In contrast, sulfate at location 0633 seems anomalous and distinct from that in the remainder of onsite wells. Historical wells 0626 and 0618 had concentrations comparable to those in 0633 (>3,000 mg/L). All of these wells are screened across the Mancos Shale. Wells 0629, 0630, and 0634 (Figure 10) are also partially screened across the Mancos. Well 0631 is also screened across the Mancos Shale, but recent results for sulfate are among the lowest observed at the site. This well is located immediately adjacent to the Animas River, and it is likely that surface water interaction with groundwater affects water quality at this location.

Although well 0863 is located closest to well 0612, it has sulfate concentrations that are more comparable to the lowest background wells. While sulfate at well 0612 has declined significantly over time, the low and steady concentrations observed in well 0863 suggest that site-related groundwater may be bypassing this well and flowing eastward to the river from location 0612. Well 0863 may be considered more of a background location than a downgradient one with respect to site-related contamination.

Statistical trend testing was performed in an attempt to quantify the apparent trends for uranium and sulfate observed and discussed above. The Mann-Kendall test for trend was used to determine if individual wells showed increasing or decreasing trends and at what level of significance. According to Gilbert (1987), this test "can be viewed as a nonparametric test for zero slope of the linear regression of time-ordered data versus time." As the confidence level approaches 50 percent, the slope approaches zero. EPA's ProUCL software, Version 4.1.00 (EPA 2010), was used to perform the Mann-Kendall statistical method. Initially, the entire data set of uranium for each well was used for the evaluation, including some data collected prior to the completion of surface remediation. Because time-concentration plots suggested that trends could be biased based on very high concentrations observed before source (i.e., tailings) removal, another evaluation was completed for both uranium (U) and sulfate ($SO_4$) data collected a number of years after the completion of surface remediation (2001 onward). Results are reported in Table 5. Appendix B Section B.3 provides the ProUCL output from the evaluation.

*Table 5. Mann-Kendall Results for Mill Tailings Area Wells*

| Well Designation | Uranium Trend based on entire record (Confidence Level) | U Trend based on 2001+ Data (Confidence Level) | Sulfate Trend based on 2001+ Data (Confidence Level) |
|---|---|---|---|
| 0622 | decreasing (95%) | na | decreasing (95%) |
| 0635 | increasing (95%) | increasing (95%) | increasing (85%) |
| 0634 | increasing (80%) | decreasing (80%) | increasing (95%) |
| 0633 | decreasing (95%) | decreasing (95%) | increasing (70%) |
| 0631 | decreasing (95%) | decreasing (95%) | decreasing (95%) |
| 0617 | decreasing (95%) | decreasing (90%) | decreasing (95%) |
| 0630 | increasing (95%) | increasing (95%) | decreasing (95%) |
| 0612 | decreasing (95%) | decreasing (95%) | decreasing (95%) |
| 0863 | na | decreasing (95%) | increasing (75%) |
| Average onsite wells | na | decreasing (95%) | decreasing (90%) |

**Notes:** na = not applicable; only 1 year of data are available for well 0622 from 2001+; only 1 year of data available for well 0863 prior to 2001; average excludes well 0622 (assumed to be background).

Mann-Kendall trend results are generally the same for both pre- and post-remediation uranium data sets, with the exception of well 0634. The wells with highest uranium concentrations (e.g., 0612 and 0633) show strongly decreasing trends. Well 0622 also shows a strongly decreasing trend, supporting the hypothesis that milling-related uranium affected that location but has subsequently been flushing from the system. Well 0630 shows increasing uranium for both data sets; as noted above, this could be the result of an upgradient pulse of uranium moving through the groundwater system, consistent with natural flushing. While test results indicate a strongly increasing trend in uranium for well 0635, concentrations in this well are low and within the range of background; it is unclear if this trend is meaningful. A strongly decreasing trend for the average of onsite wells for uranium indicates that from a sitewide standpoint, natural flushing appears to be occurring.

As with time-concentration plots, Mann-Kendall results for sulfate are less clear than they are for uranium. Trend results confirm that wells 0612, 0630, and 0631 display downward trends in sulfate at a high level of confidence. On average for the site, sulfate appears to be decreasing, but with a slightly lower level of confidence than uranium. Well 0635, as with uranium, shows an increasing trend. Wells 0633 and 0863 also display increasing trends.

Figure 12 and Figure 13 show pre-remediation and post-remediation plume maps for both uranium and sulfate. To provide the most coverage, the maps were constructed using data collected over multiple years. The pre-remediation maps plot maximum concentrations obtained between 1983 and 1994 for any wells at the site. This should provide a “worst-case” picture of the groundwater before source removal was complete. The post-remediation plume maps plot the most recent result obtained for any site wells from the period 2001 to 2013. These maps show the result of natural flushing on groundwater quality. Different sets of wells were used for plume interpretation for the historical and recent maps. Fewer wells were available to construct the post-remediation map because a number of historical wells were abandoned. The southwestern half of the plume cannot be viewed with any confidence because it is based only on extrapolation from existing data using the kriging routine in the software package (no wells are located in this area). However, as noted above, this portion of the site is dominated by colluvium, which yields little water. Therefore, the figures are most useful for observing concentration changes in the alluvium.

Figure 12 seems to indicate that uranium is declining on a sitewide basis. Concentrations in the vicinity of the northern tailings pile that were on the order of 1 to 2 mg/L have declined by an order of magnitude or more in some cases. Likewise, concentrations in the downgradient portion of the site (based on well 0612) have declined by several milligrams per liter. The apparent flushing in the vicinity of well 0863 is probably not real because data for this well was not available for the pre-remediation map. It is more likely that the pre-remediation plume in this area was similar to the post-remediation plume and that milling-affected groundwater bypassed this area.

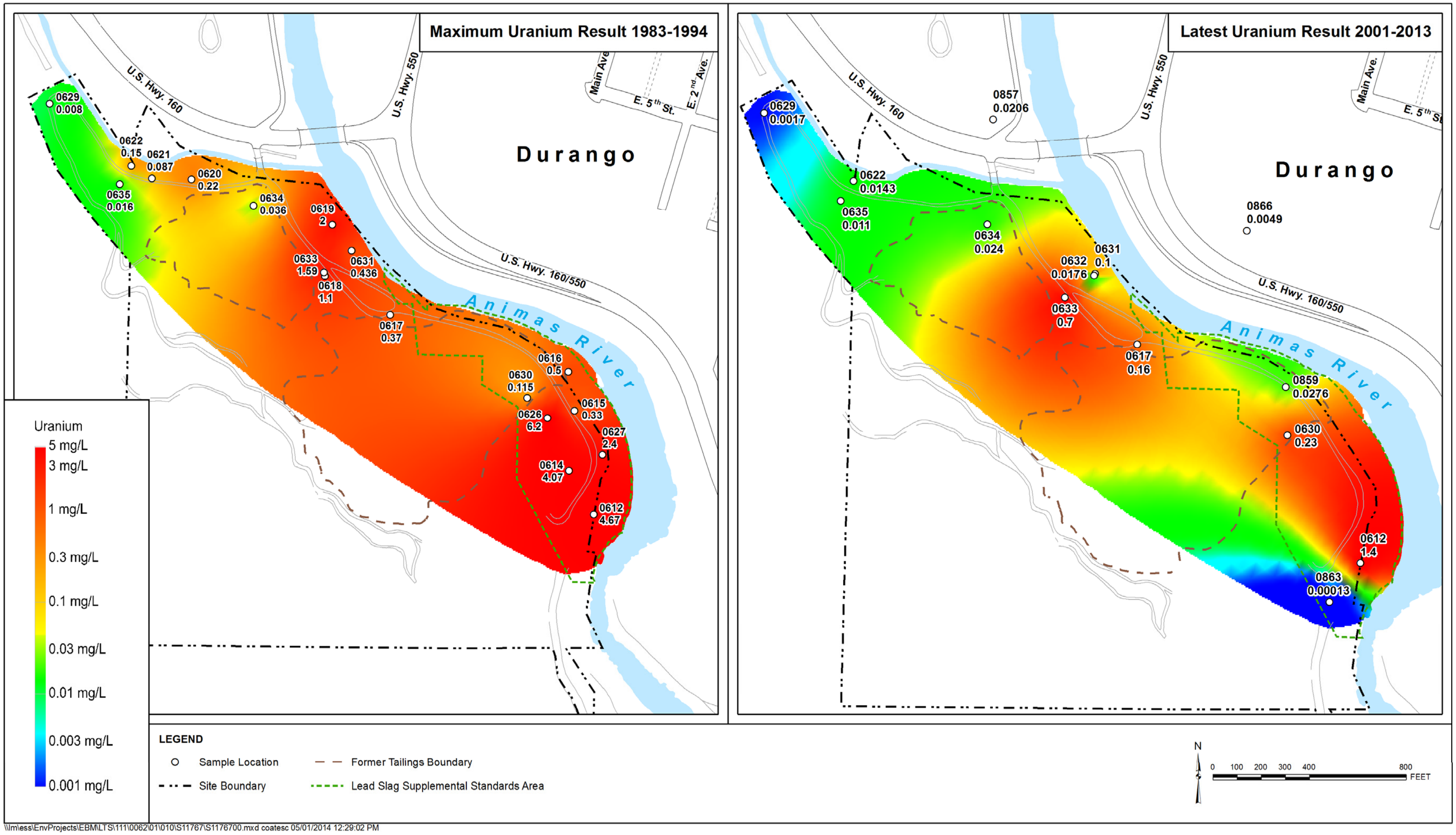


*Figure 12. Uranium Plume Maps Pre-Remediation (1983–1994) and Post-Remediation (2001–2013)*

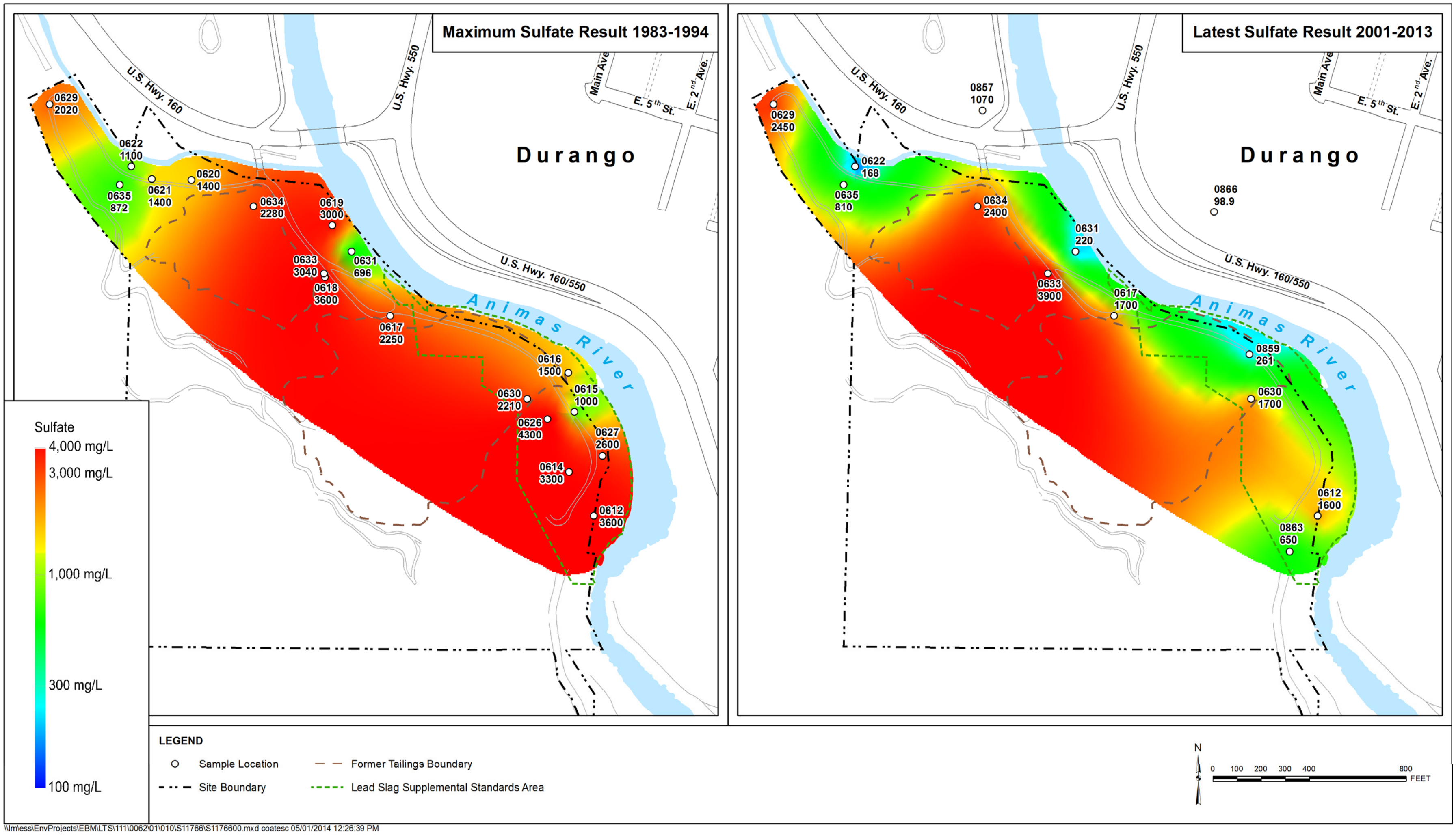


*Figure 13. Generalized Sulfate Plume Maps Pre-Remediation (1983–1994) and Post-Remediation (2001–2013)*

In contrast to uranium, sulfate concentrations in the vicinity of the northern tailings pile are not significantly different for pre- and post-remediation time frames. This reflects the relative constancy of most sulfate time-concentration plots for wells in this area. Based again on well 0612, sulfate concentrations have decreased in the downgradient portion of the site and in wells adjacent to the river. Again, the apparent flushing in the vicinity of well 0863 is likely not real. A comparison of the sulfate plume maps with the well logs in Figure 2 indicates that the highest concentration locations generally correspond to wells that are screened into the Mancos Shale. In particular, wells 0629, 0633, and 0634 have shown little change. The overall behavior of sulfate at the site suggests that while some sulfate may be milling-related and declining over time, a separate more constant source is needed to maintain the concentrations observed in the upgradient portion of the site.

Figure 14 through Figure 21 are time-concentration plots for a number of other constituents. These figures show all onsite wells and are intended for use in observing overall patterns, not in comparing trends on a well-by-well basis. For a number of constituents, the familiar pattern seen in well 0612 for uranium and sulfate is also apparent—initially high concentrations followed by a discernible decline over time. This pattern is observed for chloride, magnesium, selenium, nitrate, and molybdenum and is consistent with natural flushing of mill-related contamination. However, other observations are inconsistent with this interpretation. Cadmium and manganese concentrations in well 0612 have been higher than concentrations in other wells. Although, unlike most other constituents, these two do not display any well-defined trends, but rather seem to fluctuate within a fairly steady range. This suggests some other ongoing and constant source may be present. Well 0633, as with sulfate, shows anomalously high concentrations of magnesium. Selenium concentrations in well 0633 have also been among the highest observed in any wells and have fluctuated significantly over time. Nitrate levels in wells 0633 and 0617 have been elevated at times over those of other wells at the site. Well 0617 has displayed the highest concentration of selenium at the site, has had detectable levels of cadmium, and has had among the highest levels of molybdenum and manganese.

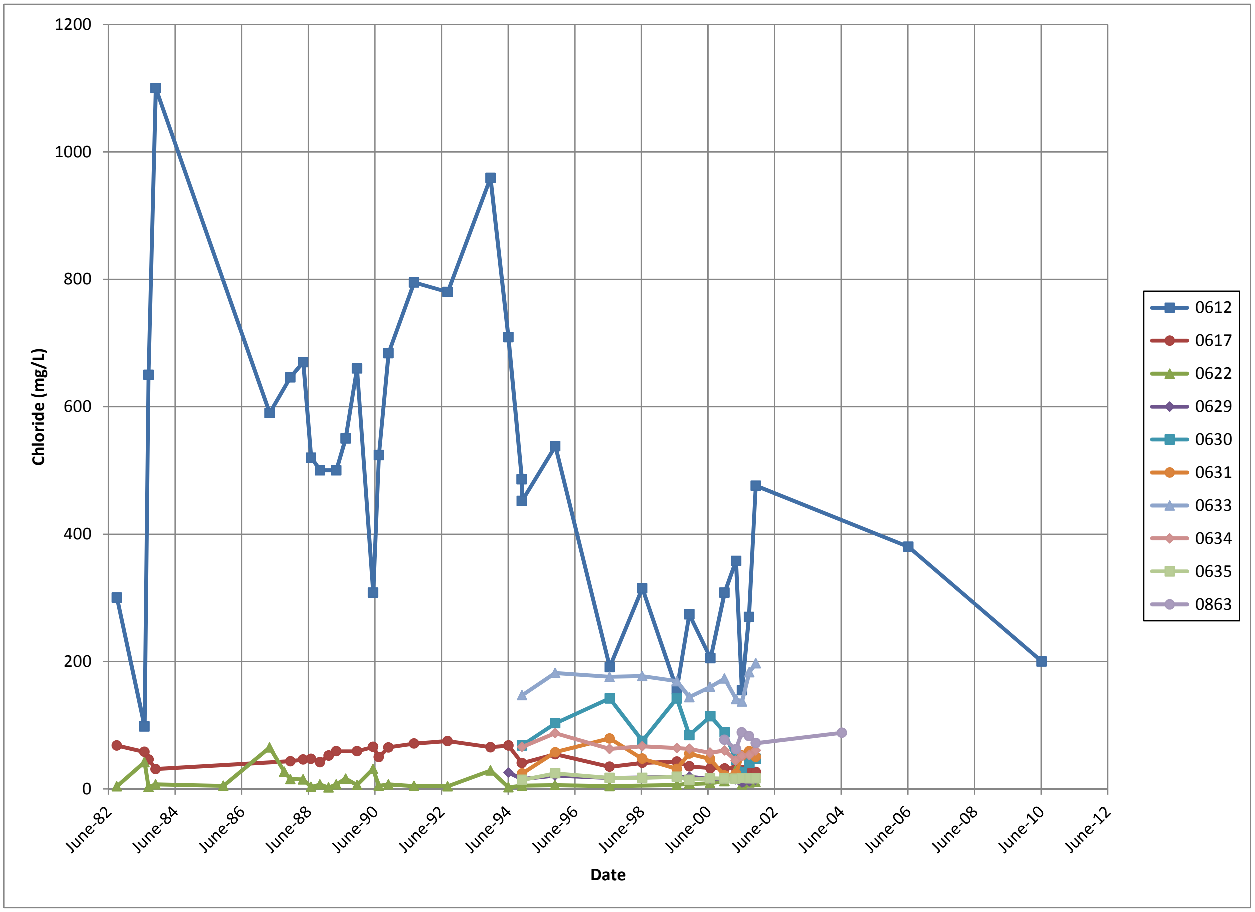


*Figure 14. Chloride Concentrations*

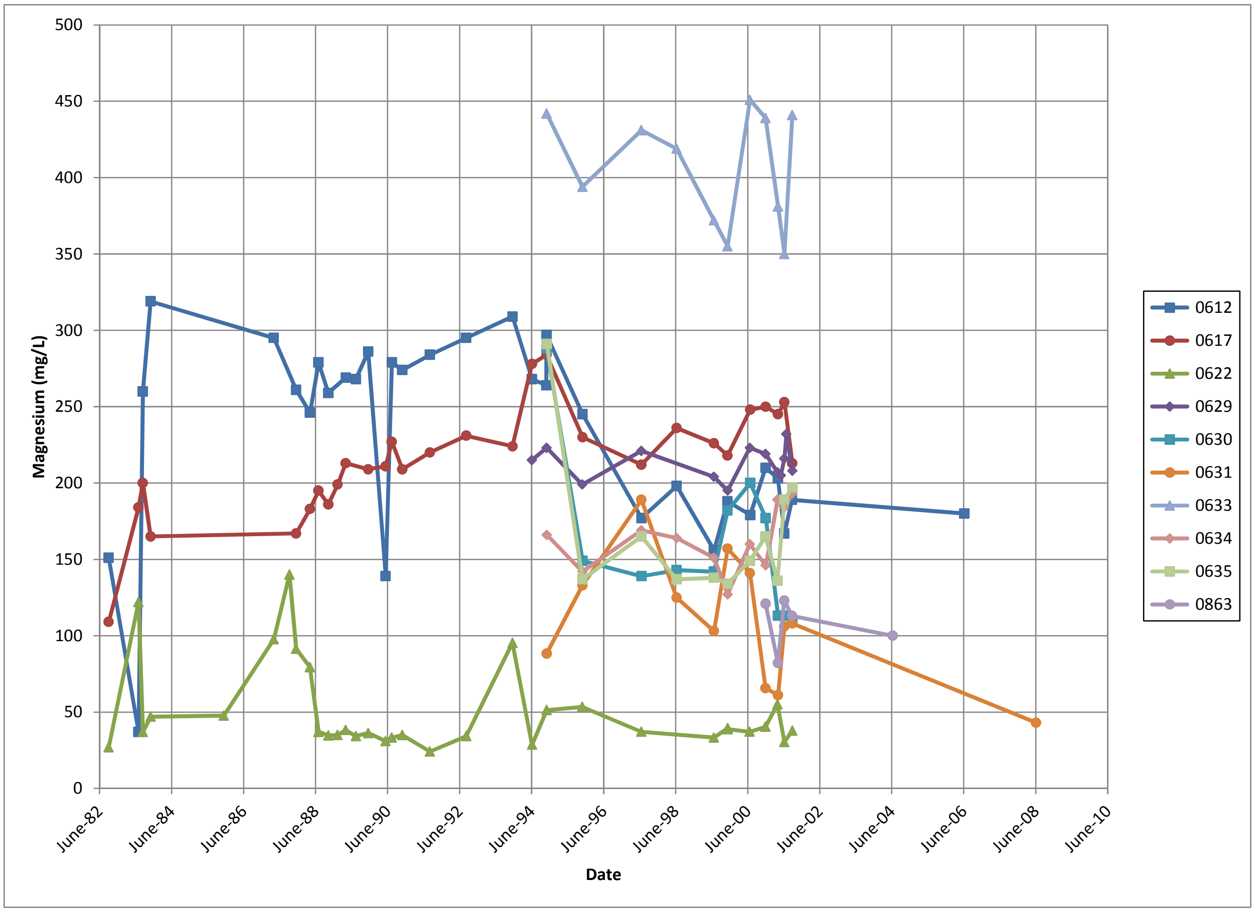


*Figure 15. Magnesium Concentrations*

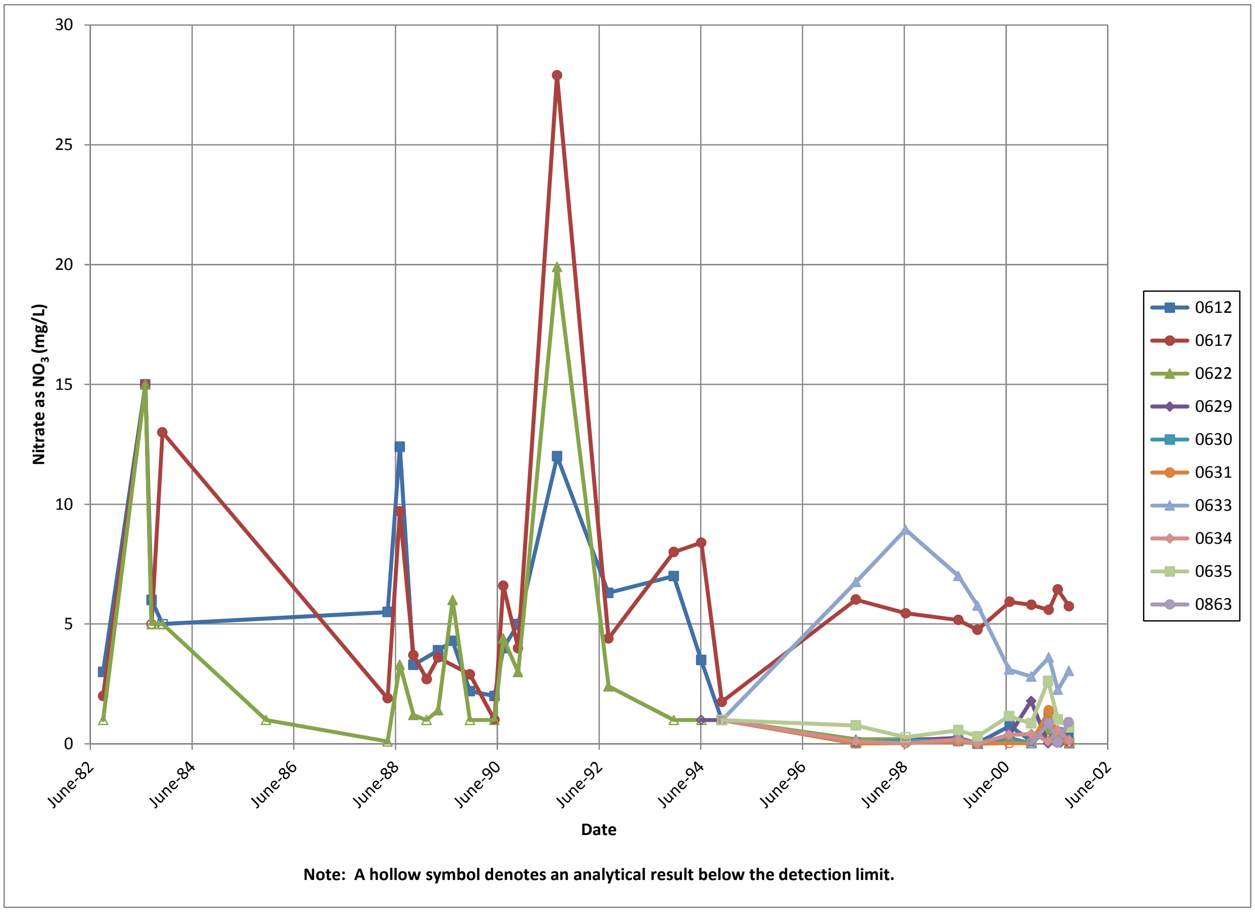


*Figure 16. Nitrate as $NO_3$ Concentrations*

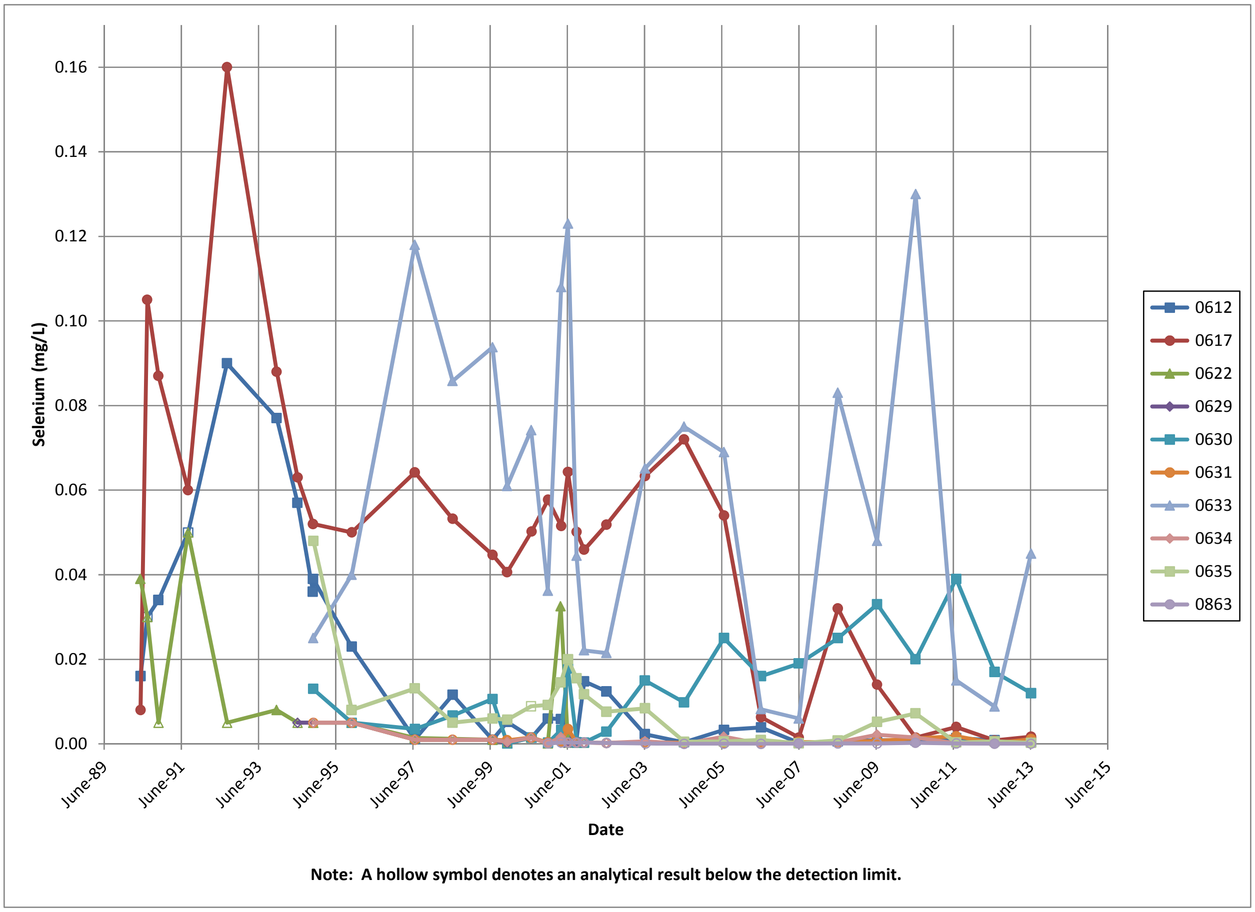


*Figure 17. Selenium Concentrations*

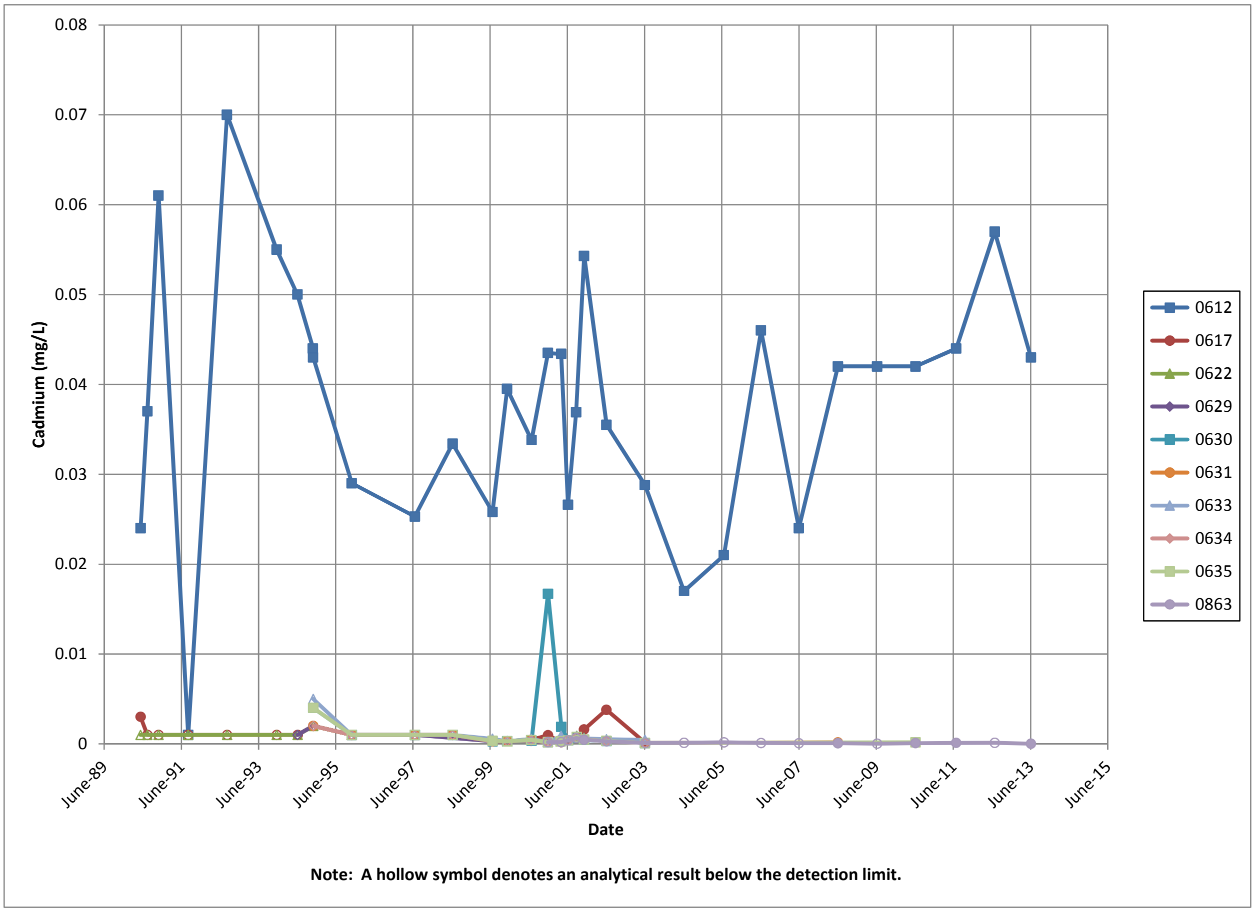


*Figure 18. Cadmium Concentrations*

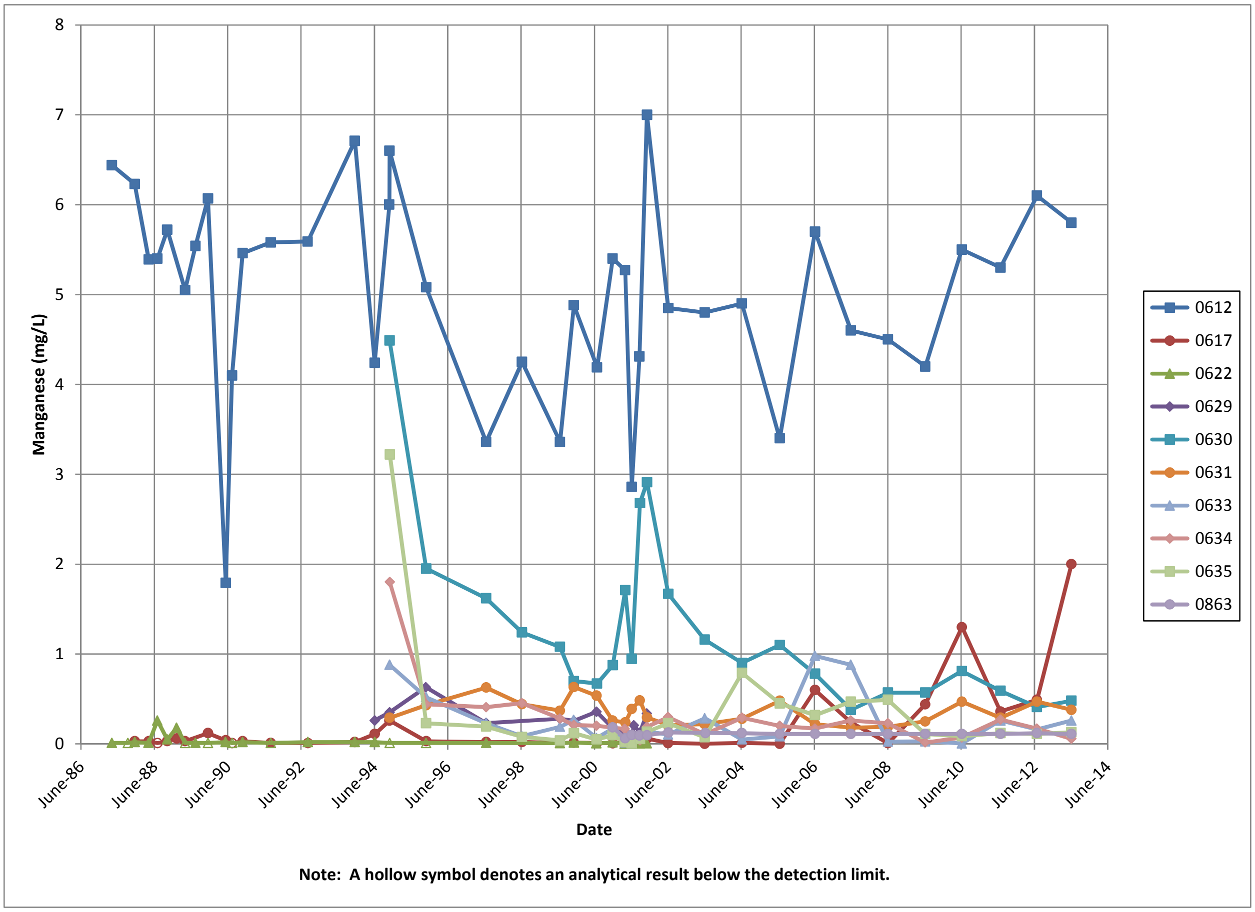


*Figure 19. Manganese Concentrations*

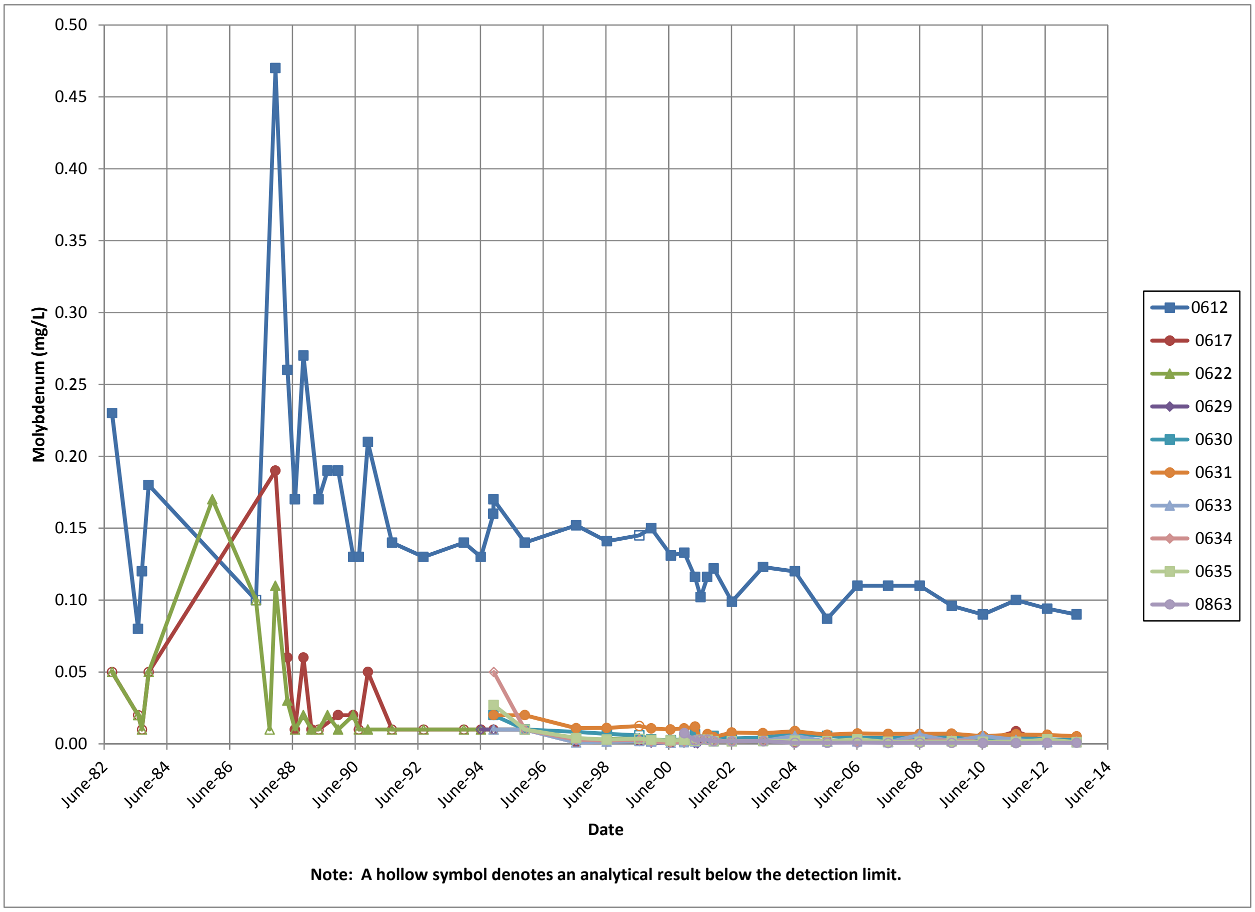


*Figure 20. Molybdenum Concentrations*

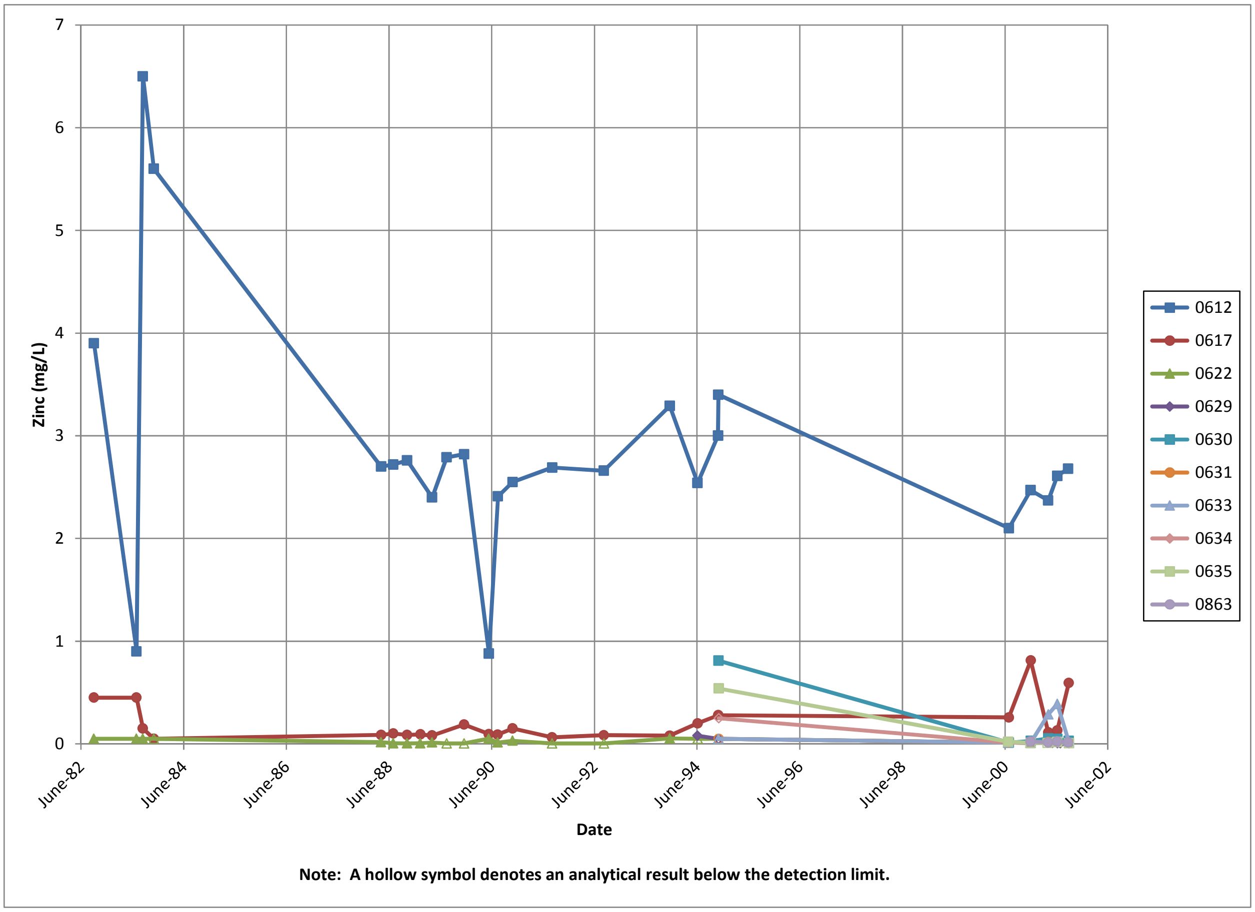


*Figure 21. Zinc Concentrations*

To explain the somewhat anomalous behaviors observed for some constituents in some wells, somewhat localized nonmilling sources are needed. As discussed previously, the alluvium/colluvium at the mill tailings site is underlain by Mancos Shale, and a number of site wells are screened across the Mancos. Mostly notably, well 0633 is screened almost entirely in Mancos Shale (Figure 2). Well 0629, which is the highest sulfate background well, is also partially screened in the Mancos. Mancos Shale also crops out along the western border of the site; water recharging the site could be interacting with Mancos before entering the site. Groundwater samples derived from the Mancos Shale have been associated with elevated levels of uranium, nitrate, selenium, sulfate, and magnesium, among other constituents (DOE 2011). Well 0633 shows elevated levels of all of these constituents. It is possible that the Mancos Shale may affect groundwater quality at the site to varying degrees. The potential for Mancos as an influence on site contamination is further explored in Section 3.1.4.

As discussed in Section 2.1.1, a slag layer that remains from a historical smelting operation underlies much of the southeastern portion of the mill site. It has been hypothesized in the past that the slag layer is a potential source for cadmium and possibly other constituents that have been observed in well 0612, which is screened below the slag layer. The possible influence of the slag layer on groundwater quality at the mill site (particularly at well 0612) is discussed further in Section 3.1.5.

### 3.1.4 Potential Mancos Shale Influence

The Mancos Shale underlies the alluvial and colluvial deposits in the mill tailings area and crops out on portions of the site. It has been hypothesized that naturally occurring constituents in the Mancos Shale could have affected groundwater quality at the Mill Tailings area. This hypothesis is in concert with analytical results of samples from numerous groundwater seeps in Mancos Shale throughout the Colorado Plateau. Many of the sample results showed uranium concentrations of about 150 micrograms per liter (µg/L) and sulfate concentrations of more than 10,000 mg/L (DOE 2011). This section provides a brief evaluation of the possibility that the Mancos Shale could be affecting shallow groundwater in the mill tailings area.

A suite of groundwater samples was collected in 2001 from the mill tailings area and analyzed for uranium-234 and uranium-238 as well as total uranium. The U-234/U-238 activity ratio (AR) has been used in the past to distinguish groundwaters that contain milling-related uranium from those that contain naturally occurring uranium. Mill tailings fluids typically have uranium AR values near the secular equilibrium value of 1, while natural waters tend to have AR values exceeding unity (1), with typical values up to 3 (Zielinski et al. 1997).

All of the mill tailings area wells that were sampled for uranium isotopes except 0632 have well screens that contact the alluvium; however, in most wells, the well screen also contacts a portion of the underlying Mancos Shale (Figure 2). Because the alluvium typically transmits water much more readily than Mancos Shale, it is likely that most of the water sampled in site wells is from alluvium. Table 6 provides results for uranium isotopes, AR values, and total uranium.

Duplicate samples were collected from three locations during the initial 2001 sampling event; additional samples were collected from wells 0866 and 0629 2 months after the initial sampling event. AR values obtained for location 0866 were 1.20 and 1.32 for the first sample and duplicate and 1.14 for the sample collected later. Duplicate samples for location 0631 produced ARs of 0.97 and 1.03; ARs for location 0633 were 0.96 and 0.99. AR values for well 0629 for first and second sampling events were 1.88 and 3.26, respectively. This is an indication that analytical or sampling variability can have a fairly significant impact on ARs for samples that are low in total uranium.

Figure 22 shows the 2001 uranium concentrations and $^{234}U/^{238}U$ ARs. For this diagram, wells were interpreted to be in one of three groups: background, offsite, and onsite. Wells designated backgrounds include the three onsite wells included as background in this VMR—0622, 0629, and 0635. Offsite wells include the background wells that are unaffected by site-related contamination—0857, 0866, and 0658. The remaining wells on the mill site are designated as onsite wells.

*Table 6. ARs and Total Uranium for Mill Tailings Area Wells*

| Location | U-234 (pCi/L) | U-238 (pCi/L) | U234/U238 | Total U (µg/L) |
|---|---|---|---|---|
| 0612 | 732 | 766 | 0.96 | 2,120 |
| 0617 | 90 | 163 | 0.55 | 244 |
| 0622 | 10 | 12.4 | 0.81 | 29 |
| 0629 | 0.62 | 0.33 | 1.88 | 1 |
| 0629 | 0.62 | 0.19 | 3.26 | 0 |
| 0630 | 75.4 | 74.7 | 1.01 | 197 |
| 0631 | 88.2 | 90.6 | 0.97 | 252 |
| 0631 | 92.5 | 89.9 | 1.03 | 257 |
| 0632 | 15.6 | 7.8 | 2.00 | 18 |
| 0633 | 316 | 328 | 0.96 | 851 |
| 0633 | 356 | 360 | 0.99 | 942 |
| 0634 | 58.5 | 63 | 0.93 | 184 |
| 0635 | 3.9 | 2.5 | 1.56 | 7 |
| 0658 | 0.92 | 0.86 | 1.07 | 2 |
| 0857 | 14.1 | 14.2 | 0.99 | 35 |
| 0859 | 18.8 | 22.9 | 0.82 | 55 |
| 0863 | 1.4 | 0.54 | 2.59 | 2 |
| 0866 | 3 | 2.5 | 1.20 | 6 |
| 0866 | 3.3 | 2.5 | 1.32 | 6 |
| 0866 | 2.4 | 2.1 | 1.14 | 5 |

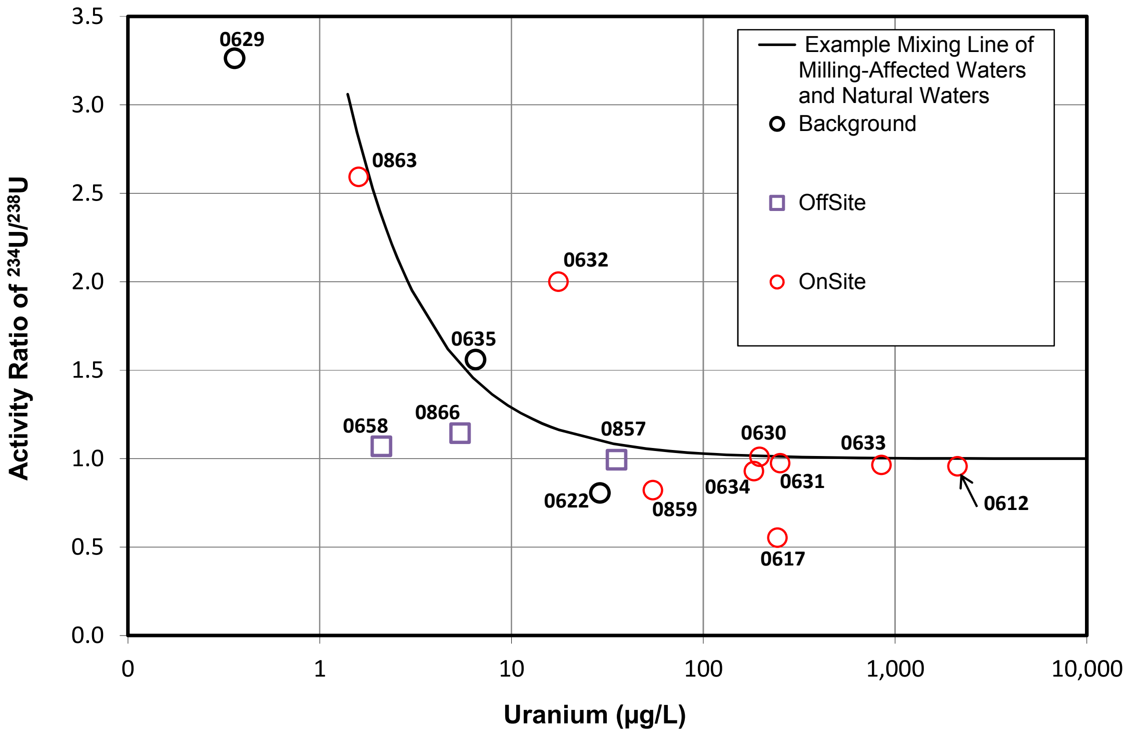


*Figure 22. Uranium Concentrations and $^{234}U/^{238}U$ Activity Ratios in Groundwater Samples Collected at the Durango Mill Site in 2001*

An obvious relationship shown by Figure 22 is that wells with higher concentrations of uranium (i.e., those exceeding the standard), which are the majority of onsite wells, have AR values close to one. This is an indication that most of the uranium in onsite wells is likely tailings derived. The onsite wells that have ARs significantly higher than 1 include 0632 and 0863. Well 0632 has a short well screen that is entirely within the Mancos Shale. This well has only been sampled once (the 2001 sampling) because it is normally dry. Well 0632 had a uranium concentration of 0.0176 mg/L and a relatively high AR value—signatures that are consistent with Mancos Shale. Well 0863 is predominantly screened in alluvium, but as discussed in Section 3.1.3, the water quality in this well is more similar to that in background wells than to water in wells with site-related contamination. The isotopic results support the hypothesis that site-related contamination bypasses this location and discharges to the river. Because of this, well 0863 is not useful for monitoring site-related contamination.

Offsite wells 0657-8, 0858, and 0866 are not affected by site-related contamination. Uranium ARs in wells 0858 and 0866 are above 1, but uranium has an AR of essentially 1 in well 0857. This is an indication that mill-related contamination cannot be identified solely on the basis of AR values. The high AR value observed for well 0629, however, does support its designation as a background well, with an AR signature quite distinct from those of onsite wells. Well 0635, with an AR of around 1.5, would also appear to be a candidate for background; however, it could also represent a mixture of background and site-related uranium. Figure 22 shows an example mixing line indicating that a range of ARs could be generated through mixing of high AR natural waters with low AR milling-affected waters. This curve could shift to the left or right depending on the total concentration of uranium in the natural waters. Both background wells 0635 and 0622 plot loosely along this mixing curve between the two extremes. This may be an indication that they represent mixtures of true background (perhaps represented by well 0629) and mill-related waters (represented by well 0612). Conversely, with the variety of ARs exhibited by locations that are known to be unaffected by milling, their ARs could also reflect natural background conditions.

Wells 0622, 0859, and 0617 all display ARs less than 1. ARs slightly below 1 are not unusual. Because wells 0622 and 0859 have fairly low uranium, analytical uncertainty could be responsible for these low values. However, uranium concentrations for well 0617 are high, so the low AR value is likely real. While AR values as low as that observed in well 0617 are not unheard of, they are unusual (Osmond and Cowart 1976). Well 0617 is the only current monitoring well that is screened partially across the slag layer. (Note that there is a discrepancy between the well log for well 0617 and the coordinate data describing the supplemental standards area. While the log indicates that the well is screened across the slag, coordinate data indicates that well 0617 is outside the supplemental standards boundary.) Well 0617 has occasionally shown elevated (relative to most other wells) concentrations of a number of metals including selenium, cadmium, zinc, manganese, and molybdenum and has also exhibited elevated nitrate (Figure 16 through Figure 21). It is possible that whatever is responsible for these characteristics is also responsible for the low AR for well 0617. Well 0617 is constructed through the slag layer and appears to be located close to the area where the uranium "seam" was observed beneath the slag (Attachment 6 of the RAP [DOE 1991]). Dissolution of this material or the slag itself could account for some of the unusual characteristics exhibited in monitoring results for this well. The potential contribution of the slag layer to water quality is discussed further in Section 3.1.5.

Generally, AR values in the onsite groundwater are close to secular equilibrium and are consistent with a mill tailings origin as opposed to a Mancos Shale origin. Although elevated uranium concentrations were found in Mancos Shale seeps at locations throughout the Colorado Plateau, the uranium concentrations in these seeps were seldom more than 150 µg/L—even in groundwater with TDS up to 30,000 mg/L (DOE 2011). Many of the historical uranium concentrations in groundwater collected from the Durango mill site were much higher than the Mancos seep values, suggesting a non-Mancos source.

Sampling and analysis for uranium isotopes at Durango was part of a larger effort that involved sampling at a number of other UMTRCA Title I sites. Figure 23 shows the Durango samples on a plot with data from the Rifle, Grand Junction, Tuba City, and Slick Rock UMTRCA sites. The Mancos Shale is not an influence at any of these sites. Samples from the Durango site generally overlap with those collected from other Title I sites. The three samples that plot outside the range at the low uranium end are for wells 0629 and 0863—further indication that these are background and are not affected by mill-tailings fluids.

Total uranium in the highest concentration samples from the Durango site (wells 0612 and 0633) was higher than observed for other Title I sites included in Figure 23. Thus, although well 0633 is screened mostly in the Mancos, the high uranium concentrations contributed by tailings fluids essentially obliterate any Mancos influence. For example, based on the data in Table 6, if equal portions of water with compositions of wells 0612 and 0893 (representing opposite ends of the spectrum) were combined, the AR value would essentially be the same as that for well 0612.

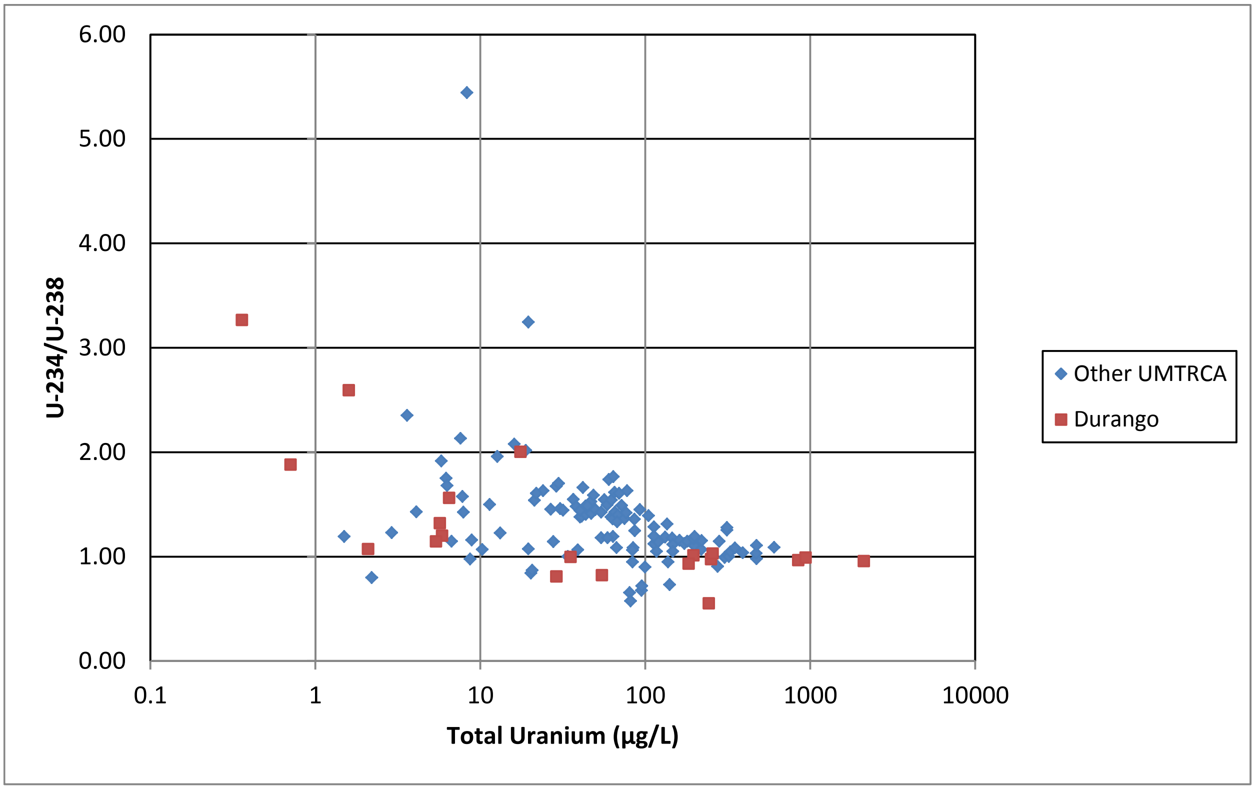


*Figure 23. Uranium Activity Ratios at Durango and Other UMTRCA Sites*

Figure 24 and Figure 25 compare the Durango samples to those collected at the terrace and floodplain areas, respectively, of the Shiprock Title I site. The terrace at the Shiprock site is situated directly on Mancos Shale, and groundwater in terrace wells is probably a combination of Mancos-derived and mill-derived chemistries. The floodplain area of the Shiprock site has received fluids from Mancos, milling, and other background sources. There is almost no overlap between the Durango samples and the Shiprock samples from the terrace. There is slightly more overlap between the Durango and floodplain samples, though all of the Shiprock samples tend to have higher AR values for comparable concentrations of total uranium.

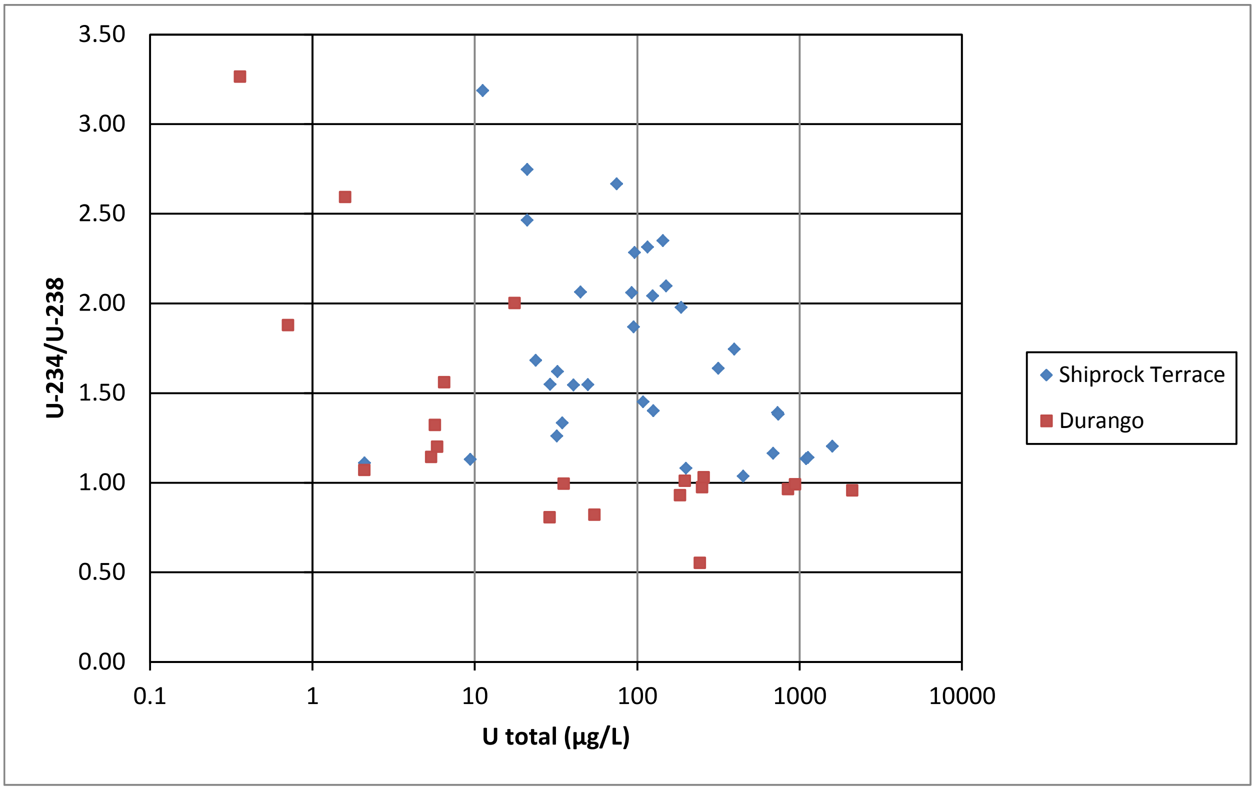


*Figure 24. Uranium Activity Ratios: Shiprock Terrace and Durango*

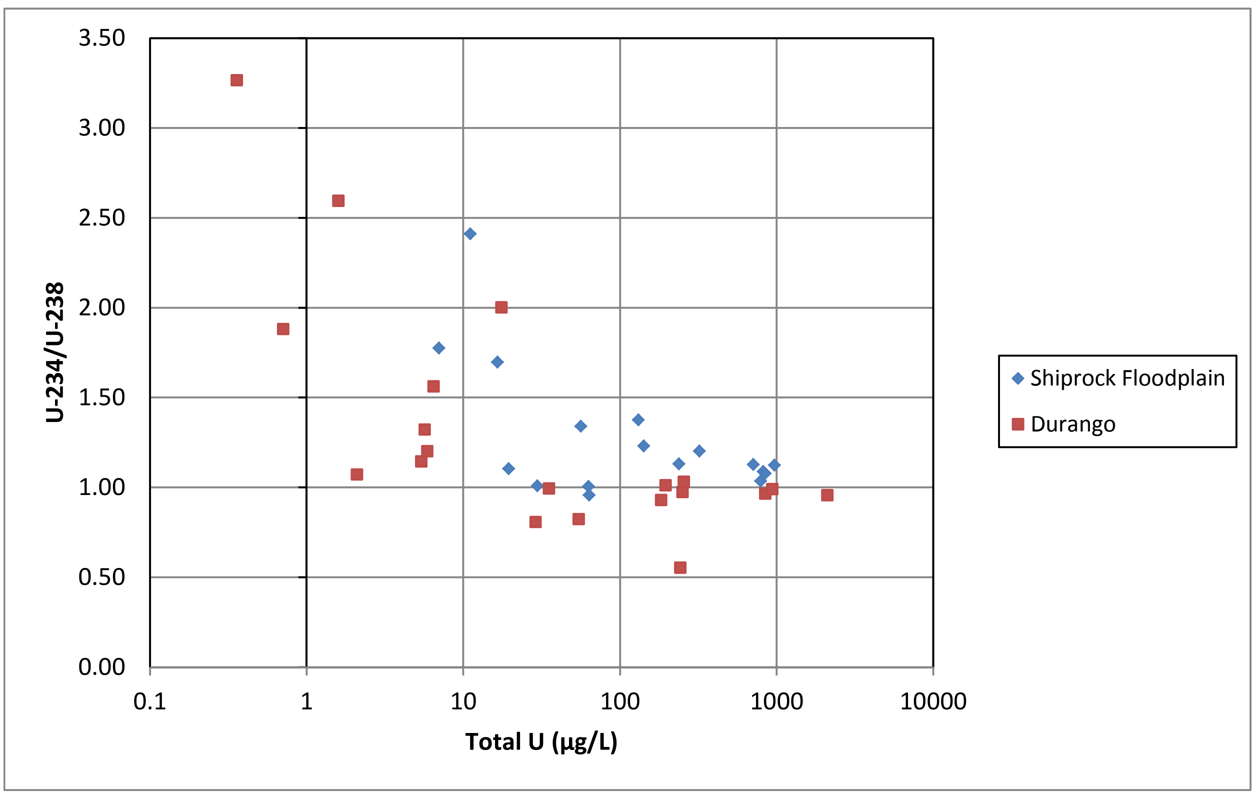


*Figure 25. Uranium Activity Ratios: Shiprock Floodplain and Durango*

It can be concluded that the Mancos shale is not a significant contributor to uranium at the site. However, it is possible that the presence of Mancos Shale in the region contributes to the elevated sulfate observed in background groundwaters as well as groundwater in onsite wells. Background well 0629 is screened partially across the Mancos and has elevated sulfate concentrations compared to background wells screened in the alluvium alone. Onsite well 0633 has the highest sulfate of any well at the site; concentrations appear to be level or increasing. This same well, which is screened predominantly in the Mancos, also has elevated concentrations of constituents such as magnesium and selenium, which are also derived from Mancos Shale. Sulfate in water from the Mancos Shale can have sulfate concentrations of 10,000 mg/L or more (DOE 2011). Therefore, although contributions of uranium from Mancos are obscured by uranium from tailings fluids, contributions of sulfate from the Mancos could have an influence at the site in addition to mill-related sulfate.

Figure 26 shows a plot of sulfate concentration versus the percent that a well is screened across the Mancos Shale. Wells that do not intersect the Mancos at all range from lowest to highest observed sulfate concentrations, indicating that wells do not need to intersect Mancos to have a high sulfate concentration. However, all the wells in which more than 40 percent of the screened length is in the Mancos had relatively high sulfate concentrations. Sulfate at all of these locations exceed the compliance goal identified in past VMRs of 1,276 mg/L, indicating that Mancos-related influences make that goal unrealistic.

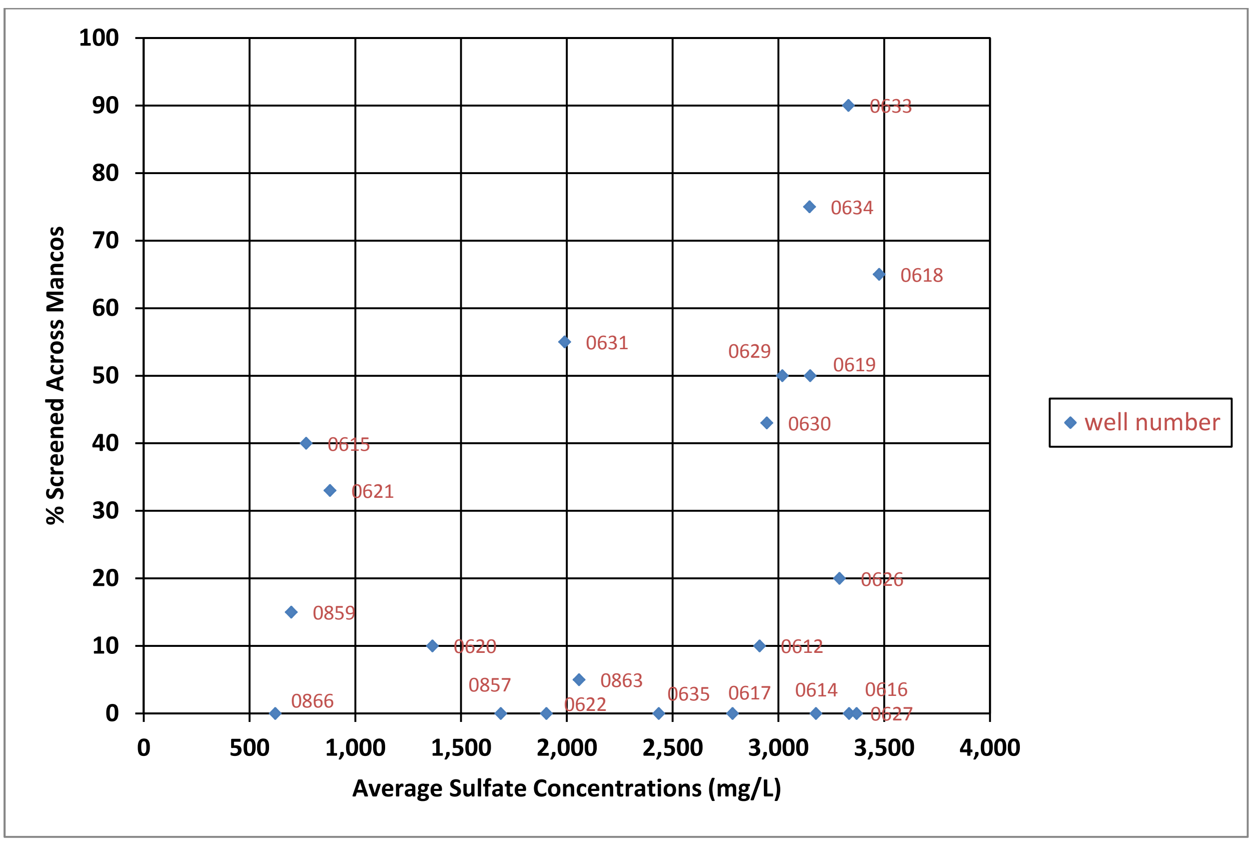


*Figure 26. Average Sulfate Concentrations Versus Percent Screened Across Mancos*

### 3.1.5 Potential Effects of the Slag Layer

Cadmium concentrations have been elevated in well 0612 since monitoring of that well began. Modeling of cadmium described in the SOWP indicated that it might not naturally flush in the allotted time frame. Previous monitoring reports have attributed the presence of cadmium at location 0612 to the slag layer. Figure 27 shows the distribution of cadmium and manganese, both historically (2000) and currently. Monitoring of cadmium in all wells except 0612 and 0863 was discontinued in about 2003 because concentrations were consistently below the detection limit. Concentrations of both cadmium and manganese have been elevated in well 0612 and have fluctuated over time. While the Mann-Kendall nonparametric method indicates a decreasing trend for both at a 70 percent confidence level, time-concentration plots for the two constituents show no apparent trend (Figure 28 and Figure 29). Very low $R^2$ values indicate a poor level of explained variability. Therefore any apparent trend is inconclusive.

Cadmium is primarily found in zinc, lead, and copper ores and is extracted as a byproduct during the production of these metals (ATSDR 2012). Slag from processing of lead and zinc ores contains many metals, including cadmium, manganese, and molybdenum, among others (DOE 2002b). It therefore seems plausible that the slag could serve as a source for elevated cadmium and manganese. In addition to cadmium and manganese, historical information shows that samples from well 0612 were also elevated in zinc (up to 3.3 mg/L; Figure 21), which could also be associated with the slag. Well 0612 is constructed through the slag, though it is screened completely below the slag. Well 0617 is screened partially across the slag layer. While cadmium has been present at detectable levels in a few samples from well 0617, concentrations have remained an order of magnitude lower than in samples from well 0612. Elevated zinc was found in samples from two other wells that penetrated the slag—0626 and 0627. No cadmium data were available for these wells.

Most constituents observed in samples from well 0612 are site-related. They were elevated in the early days of groundwater monitoring at the site during or immediately after surface remediation. Since that time they have declined. Conversely, concentrations of other constituents—most notably cadmium, manganese, and zinc—have remained fairly constant over the monitoring period. Significant post-source-removal attenuation has not occurred. The presence and behavior of these constituents suggests a continuing source. Because these constituents are commonly found in association with lead smelting operations, the slag is a plausible source of this contamination. As the slag is unrelated to milling and is a potential ongoing source of contamination at the site.

### 3.1.6 Protectiveness of Post-Surface-Remediation Groundwater Quality

The data presented in previous sections indicate that milling-related contamination exists at the mill tailings site today. Concentrations at a number of site locations have attenuated, but elevated concentrations persist. Other potential sources of contamination have been identified that are not milling-related. Natural background water quality is poor and exceeds several secondary drinking water standards. It has been suggested that supplemental standards could apply at the mill tailings site based on a classification of limited use groundwater, as defined in 40 CFR 192.11(e). ACLs could also be justified for the site if it can be demonstrated that current and future groundwater quality is protective of human health and the environment. The purpose of this section is to present information regarding the current and likely future protectiveness of the groundwater. A statistical analysis of post-surface-remediation groundwater data is conducted to provide a basis for establishing ACLs, should that option for groundwater compliance be considered.

The behavior of cadmium and manganese at well 0612 is in contrast to that of uranium. While uranium concentrations at well 0612 are also high, they show a steadily decreasing trend, consistent with a mill-related source that has been attenuating since source removal (Figure 30). Cadmium concentrations in well 0612 are consistently higher than those observed in tailings fluids and historical alluvial groundwater (Table 3 and Table 4), making the former upgradient tailings piles an unlikely source. As discussed in Section 3.1.5, zinc has also been elevated in well 0612. Molybdenum is also elevated compared to other wells; while it showed initial declines in concentration, consistent with natural flushing, molybdenum appears to have leveled off in response to a continuing source.

As noted previously, source removal at the mill tailings area began in 1986 and was completed in 1991. These activities eliminated most pathways to site-related contamination and resulted in significant improvements in groundwater quality for milling-related constituents (most notably uranium) during and immediately following remedial activities. After completion of surface remediation and implementation of institutional controls, the main complete pathway for exposure to groundwater contamination is where groundwater discharges to the Animas River.

A BLRA was completed for the site in 1995 (using data collected through January 1994). The evaluation focused primarily on risks associated with groundwater discharge to the Animas River. Human health risks associated with recreational use evaluated along with potential risks to ecological receptors in the river. EPA undertook another study not long after the completion of surface remediation (EPA 1998) that also focused on the Animas River; the emphasis of this study was on evaluating sediment quality and potential bioaccumulation of contaminants in fish. Both studies concluded that potential impacts to the river were very low. No contaminants of concern were detected in fish samples from EPA's study. Risks to human health were similar to background. Both of these studies demonstrated that conditions that prevailed at the site following surface remediation, including groundwater quality, are protective at the most likely points of exposure (i.e., along the Animas River). Annual surface water sampling at the mill tailings area was recently changed from the spring to the fall, when river flows are generally lower. Fall sampling results for site-related constituents have generally been comparable to, and often lower than, those for the spring.

The trend analysis in Section 3.1.3 demonstrated that average uranium concentration in mill tailings area groundwater has continued to decline since completion of surface remediation. Therefore, at least for uranium, it can be concluded that the site has remained protective since the time the BLRA and EPA study were conducted because concentrations discharging to the river have decreased over time. As long as concentrations continue to decline or to remain stable at post-remediation levels, continued protectiveness of the site will be assured.

To test the stability of uranium in groundwater following surface remediation, a new "baseline" condition was determined for each well using data collected between 1994 and 2004, as represented by the UPL 95 for uranium concentrations observed at each well. This provides a measure against which future monitoring data can be compared. This approach is consistent with that described in EPA (2009). Table 7 presents the 1994 to 2004 statistics for each onsite well for uranium. Statistics also include the site average, exclusive of background.

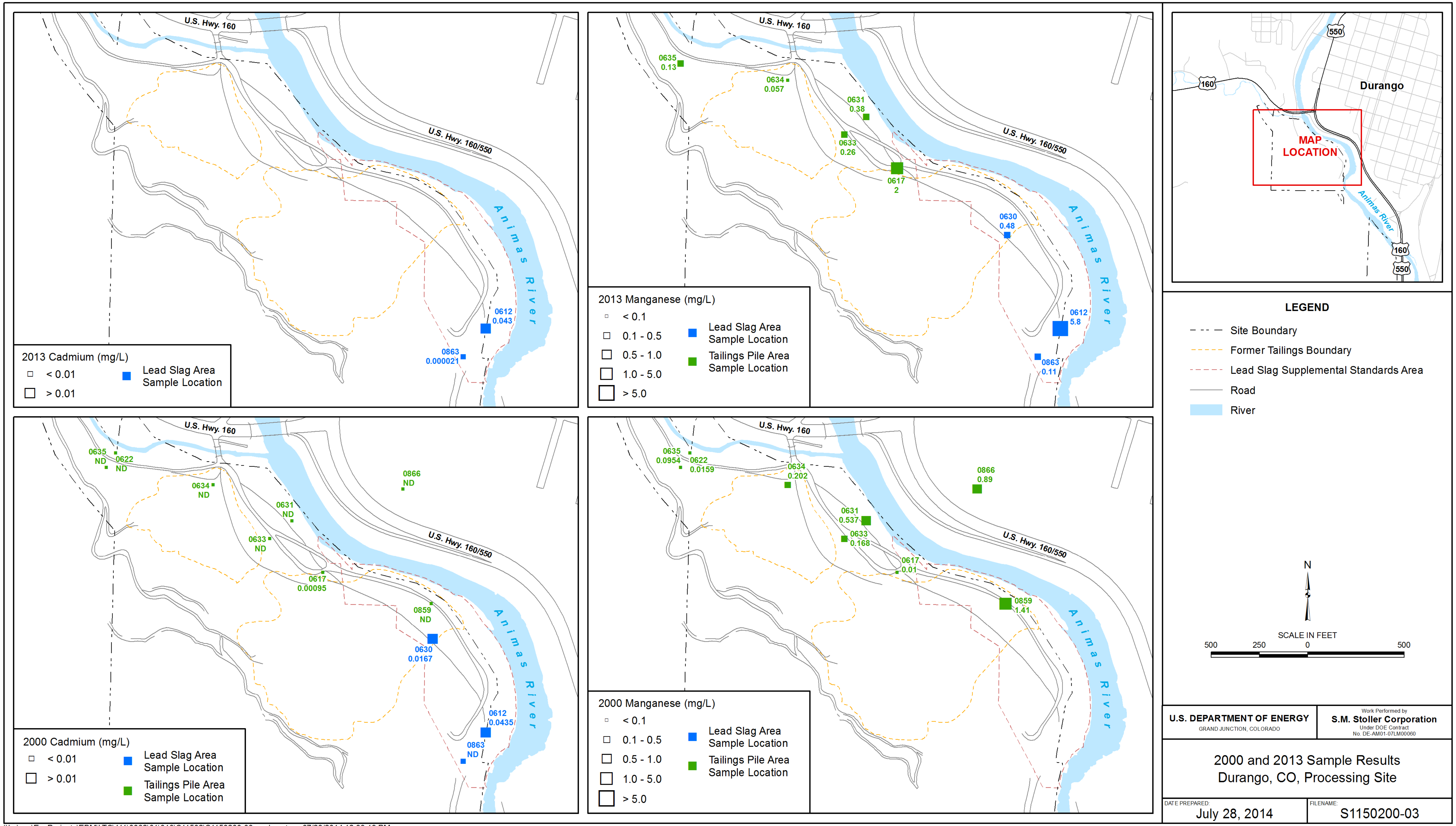


*Figure 27. Historical and Current Cadmium and Manganese Results*

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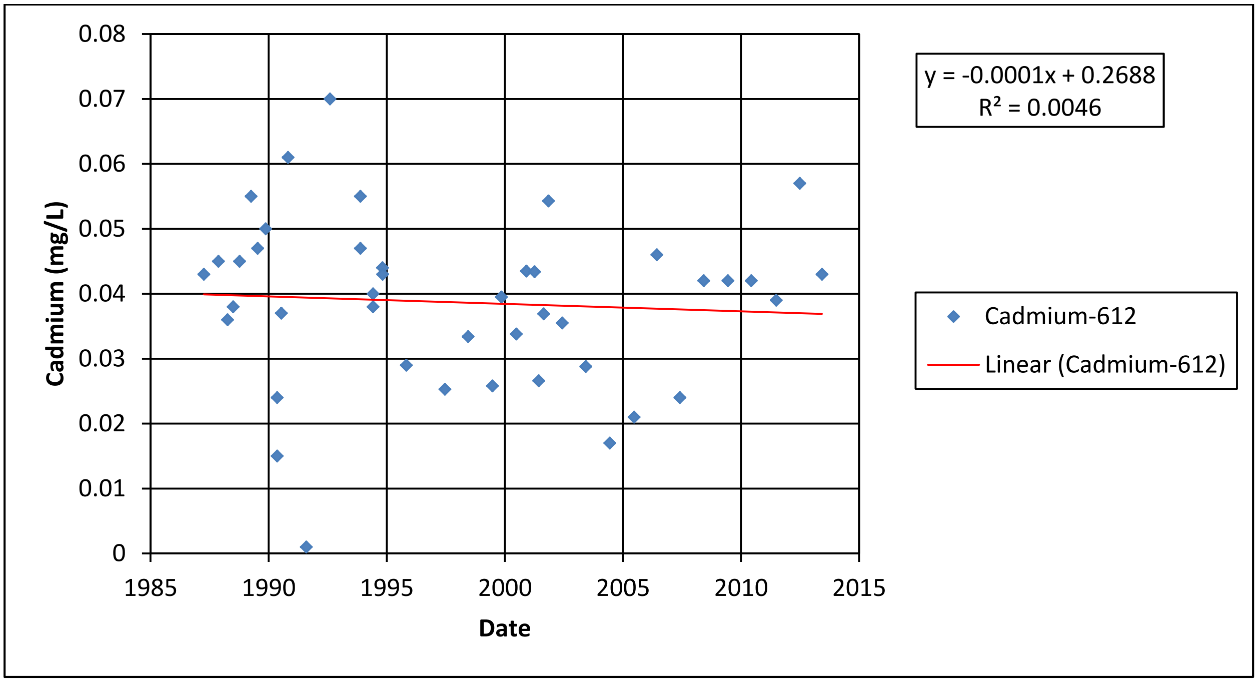


*Figure 28. Cadmium Time-Concentration Plot for Well 0612*

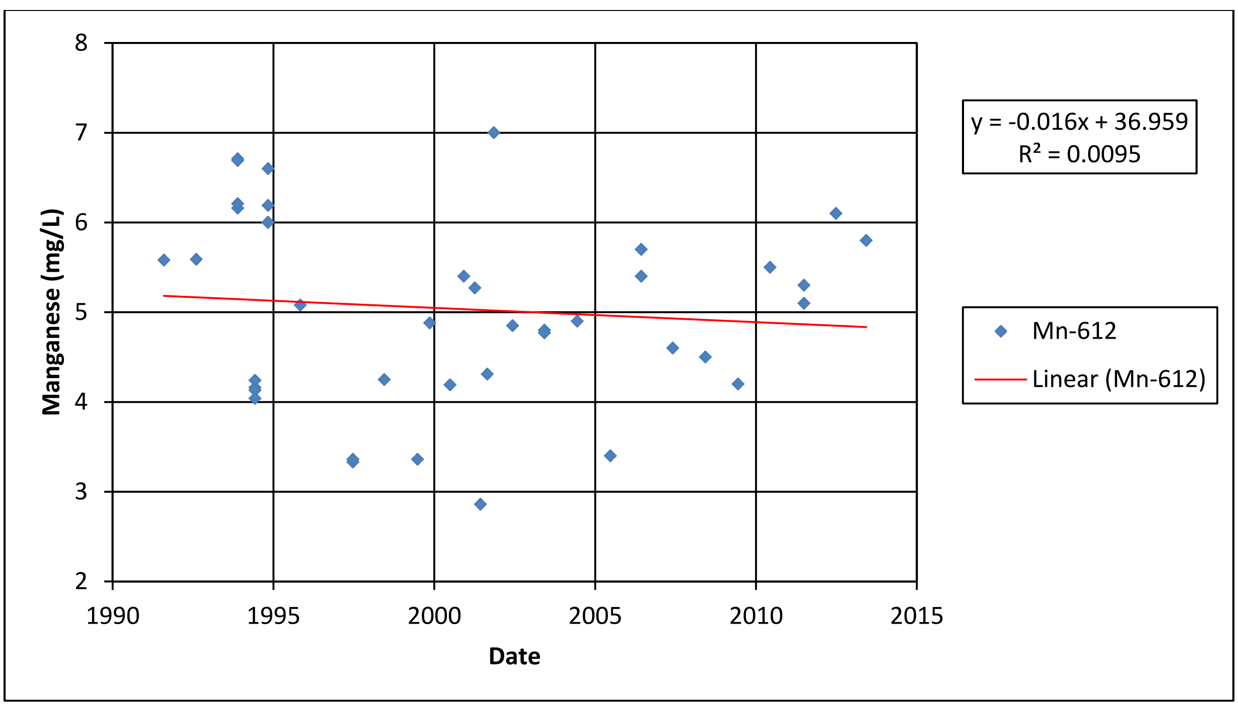


*Figure 29. Manganese Time-Concentration Plot for Well 0612*

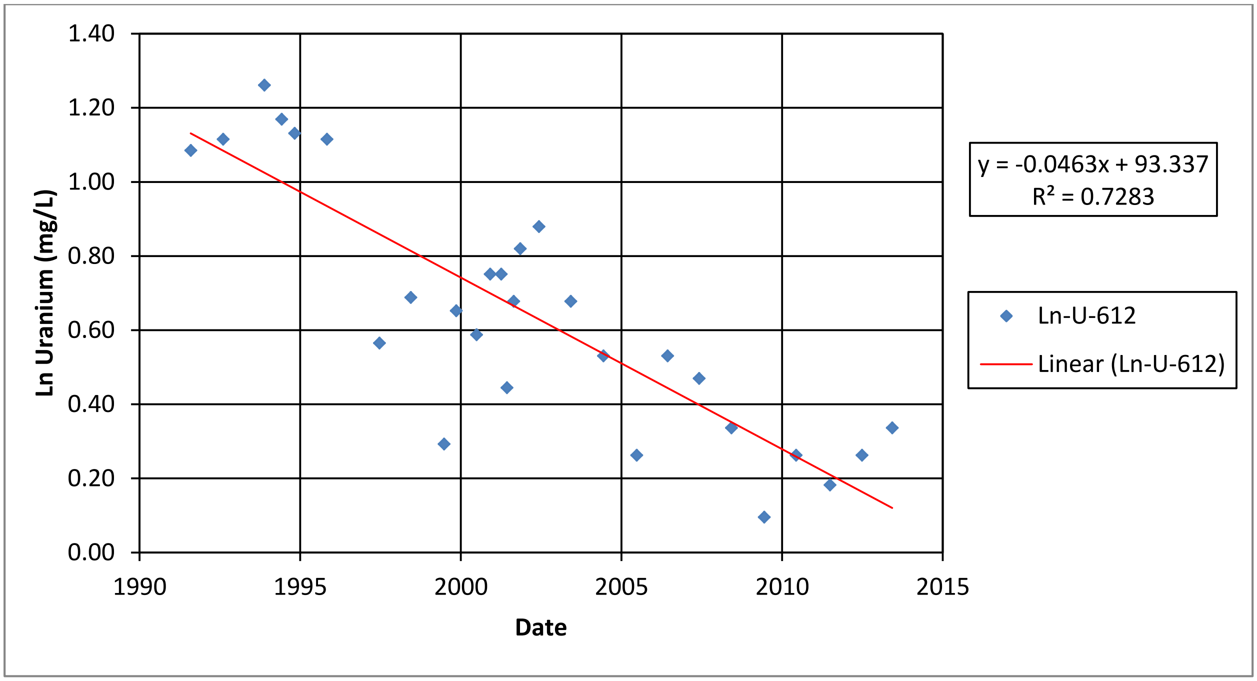


*Figure 30. Uranium Time-Concentration Plot for Well 0612*

*Table 7. Uranium (mg/L) Statistics for Mill Tailings Area (1994 Through 2004)*

| Well Number | Number of Samples | Minimum | Maximum | Mean | UPL 95[a] | Max since 2004 |
|---|---|---|---|---|---|---|
| 0612 | 16 | 1.34 | 3.22 | 2.14 | 4.62 | 1.7 |
| 0617 | 16 | 0.12 | 0.33 | 0.225 | 0.477 | 0.20 |
| 0630 | 15 | 0.0344 | 0.26 | 0.159 | 0.459 | 0.29 |
| 0631 | 15 | 0.168 | 0.63 | 0.357 | 1.06 | 0.24 |
| 0633 | 15 | 0.65 | 1.38 | 1.076 | 2.062 | 1.20 |
| 0634 | 15 | 0.012 | 0.184 | 0.0506 | 0.227 | 0.11 |
| Average | 15 | 0.421 | 0.729 | 0.563 | 0.965 | 0.584 |

[a] Nonparametric Chebyshev UPL was used

Data collected after baseline sampling are compared to UPL 95 values. Post-2004 uranium data for mill tailings wells were evaluated; maximum concentrations for each well are also provided in Table 6. Monitoring results for uranium have been within predicted limits for all onsite wells since 2004. This is an indication that groundwater quality is now stable and that site conditions remain protective of human health and the environment. On this basis, the application of ACLs for site groundwater, in lieu of more restrictive MCLs, could be justified.

This analysis could serve as the basis for establishing ACLs for the site. The approach for establishing ACLs varies from site to site—no single approach is considered "correct." For some sites, ACLs are established on a well-by-well basis. At others, a single sitewide value is established for each constituent—usually based on the wells with highest concentrations. Future monitoring results for individual wells are then compared with the ACL values. At yet other sites, ACLs and compliance monitoring are based on sitewide average concentrations. Because well 0612 has had the highest observed concentrations of site-related constituents, ACLs based on data from this well could serve as a basis for development of numerical values for ACLs.

### 3.1.7 Evaluation of Natural Flushing

For the mill tailings area, the current compliance strategy is natural flushing. Modeling presented in the SOWP indicated that mill-related uranium contamination should naturally attenuate at the site and meet the UMTRCA groundwater MCL of 0.044 mg/L within the 100-year period allotted for natural flushing. As discussed in Section 3.1.3 of this report, overall uranium concentrations in groundwater at the site are declining. This quantifies attenuation rates and discusses the likelihood that the compliance goals can be met within the established 100-year time frame.

EPA has developed guidance for evaluating the progress of natural attenuation (i.e., natural flushing) in groundwater (EPA 2011). For the first phase of analysis, trends are evaluated to estimate when cleanup goals are expected to be reached. The analysis assumes that the attenuation process follows a first-order rate law. This assumption is based on a review of contaminant trends at hundreds of hazardous waste sites, which showed that a first-order rate law is almost always a better fit than a zero rate law (EPA 2011). Natural-log-transformed concentration data that follow a first-order rate law should plot along a straight line.

Linear regression results for the log-transformed data can be used to predict when cleanup goals should be reached. The slope of the regression lines represents the attenuation rate constant. The uncertainty in the rate constant is described as a confidence interval on the rate constant (EPA 1999). EPA describes a procedure for estimating the slower, one-tailed 90 percent confidence interval on the rate constant (EPA 2011), providing an upper bound on attenuation estimates. The procedures from EPA (2011) were used, along with the data analysis package provided in Microsoft Excel, to estimate when uranium could be expected to reach the UMTRCA groundwater standard (0.044 mg/L). Calculations were also performed using the slower 90 percent confidence interval (Appendix C). Figure 31 shows an example time-concentration plot of log-transformed average uranium data for site monitoring wells. (The log-transformed standard of 0.044 mg/L is −3.12.) Results of the linear regression are also included on the figure. Plots and regression data for individual wells are included in Appendix C. Table 8 reports the results of the attenuation analysis compared to the numerical modeling predictions that were conducted for the SOWP and run again for the 2010 VMR (DOE 2010).

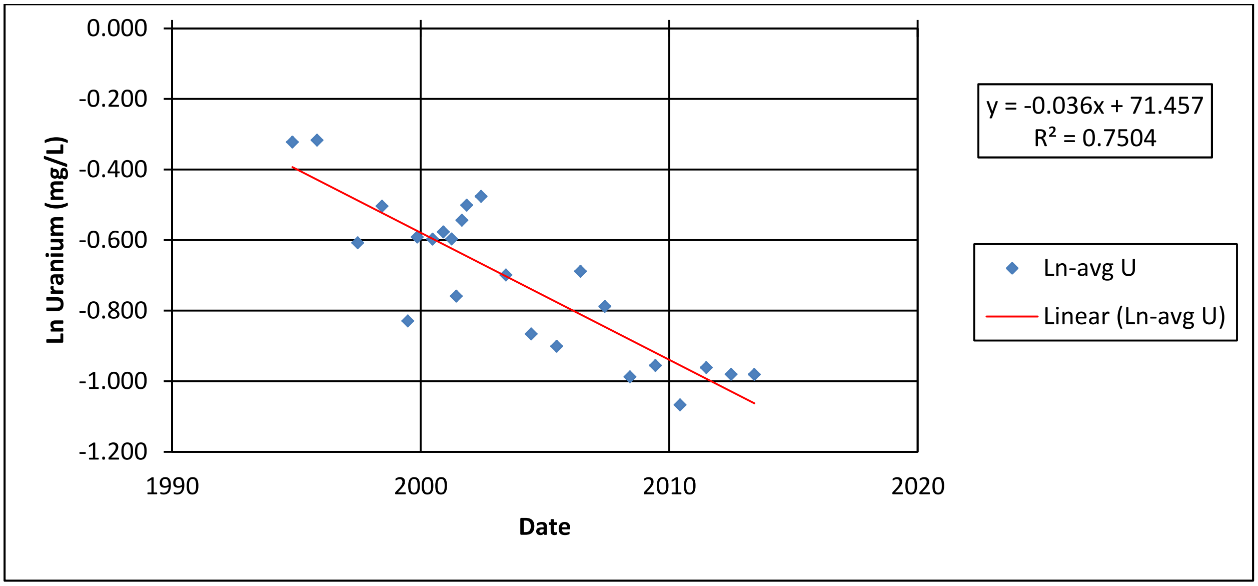


*Figure 31. Regression Results for Average U (Natural-Log-Transformed Data)*

*Table 8*. Uranium Attenuation Analysis Results

| Well Designation | Estimated Uranium Attenuation Year (1991+ data) | Estimated Uranium Attenuation Year (2001+ data) | Estimated Uranium Attenuation Year Based on Modeling[a] |
|---|---|---|---|
| 0612 | 2083 | 2088 | 2036 |
| 0617 | 2048 | 2083 | 2036 |
| 0631 | 2018 | 2020 | 2033 |
| 0633 | 2108 | 2080 | 2039 |
| 0634 | n/a—increasing | 2009 | 2009 |
| Average | 2072 | 2067 | – |

[a] Modeling uses 2002 as the baseline for predictions

Analyses were performed for two data sets—one from 1991 forward and the other from 2001 forward. This was done to evaluate whether attenuation rates have been declining and leveling off in more recent years. Steep declines are noted at many UMTRCA sites immediately following source removal; attenuation rates then commonly decline less rapidly and often level off completely. EPA notes that a natural attenuation evaluation should be restricted to time periods either before the start of active remediation or after the benefits of active remediation have been realized (EPA 2011). The coefficient of determination (i.e., $R^2$), which is included on the regression figures in Appendix C, represents the degree to which natural flushing (represented by time) explains the variation in the data. This statistic reflects the goodness of fit of the regression model. Rate constants obtained from regressions with lower values of $R^2$ are less reliable predictors of future concentrations that ones with $R^2$ closer to 1. Therefore estimated attenuation years should be viewed with more skepticism for regressions with lower $R^2$. Use of the slower one-tailed 90 percent confidence limit on the rate constant is a way of quantifying the uncertainty in attenuation times (EPA 1999).

Results of the linear regression analysis for wells showing a decreasing trend in uranium show that the uranium standard could be expected to be reached in a reasonable time frame (less than 100 years) based on the average estimated rate constants. However, using the slower one-tailed 90 percent confidence interval on the rate constants to estimate the longest durations required for flushing, estimated attenuation times were extended for tens to hundreds of years (Appendix C). This simply illustrates the great uncertainty associated with trying to make predictions over the time frame allotted for natural flushing (i.e., 100 years). Estimated time frames to meet the uranium standard are extended slightly for most locations using average rate constants for just the 2001+ data. One exception to this is for well 0633, for which estimates are reduced by more than 20 years. All wells in which uranium concentrations are declining are estimated to achieve the standard within 100 years based on the average attenuation rate.

Predictions based on the regression analysis indicate longer time frames for natural flushing for wells 0612, 0617, and 0633 compared with the modeled values. The regression prediction for well 0631 is shorter than the modeling prediction by more than a decade. Both the regression (2001+ data) and the model predicted that the standard should be met for well 0634 by the year 2009. In reality, concentrations in this well have been fluctuating above and below the standard throughout the monitoring period. Given the uncertainties associated with both methods of prediction (modeling and statistical), results are generally consistent with one another in that both indicate that flushing may achieve the uranium standard within the100-year time frame allotted by 40 CFR 192.

### 3.1.8 Summary of Mill Tailings Area

Based on the analysis provided above, several different groundwater compliance options appear to be justifiable for the mill tailings area, including the current compliance strategy of natural flushing. It was demonstrated in Section 3.1.1 that background water quality for the area is poor and is naturally elevated in a number of constituents. Information presented in Sections 3.1.3 through 3.1.5 suggests that additional sources other than milling can adversely impact groundwater quality at the site. These include impacts from Mancos Shale and the slag layer from past smelter operations. All of these factors together suggest that groundwater at the site may qualify for supplemental standards based on limited use, similar to the raffinate ponds area.

Data presented in Section 3.1.3 for the best milling-related indicator—uranium—indicate that natural flushing is occurring at the site and that overall uranium concentrations are trending downward. The current compliance strategy may still be appropriate provided that flushing can meet compliance objectives within a 100-year period. This evaluation has demonstrated that the current compliance objective for sulfate is unrealistically low considering site background and other sources of sulfate contamination. The current strategy assumes that the MCL is the appropriate compliance standard for uranium.

Studies summarized in Section 3.1.6 demonstrated that the site was protective after source removal was completed; no adverse impacts were found for the only complete pathway to groundwater contamination—the Animas River. Data presented in Section 3.1.6 indicate that groundwater quality at the site is stable or improving over time and will be protective into the future. Based on protectiveness of human health and the environment, the use of ACLs could also be justified in lieu of stricter groundwater standards. Several different approaches could be used to establish numerical values for ACLs.

Results presented in Section 3.1.7 indicate that natural flushing could meet the MCL for uranium in the allotted 100-year time frame. Based on average attenuation rate constants for individual wells and the average of on-site wells, compliance could be achieved in about 75 years. However, uncertainties in these predictions are high—actual time frames could extend for decades if not hundreds of years.

In terms of appropriateness of the site monitoring approach, this evaluation indicated that sulfate is not a good indicator of milling-related contamination. Similarly, elevated cadmium and manganese observed at well 0612 are likely derived from a nonmilling source—possibly the slag layer. Therefore, those constituents also are not useful for monitoring milling-related contamination. Wells 0622 and 0635 may have had some minor mill-related contamination at one time, but monitoring results for more than a decade demonstrate that they now represent background water quality. Monitoring data for the southernmost well in the monitoring network—well 0863—demonstrate that it is not in the flow path of site-related contamination. It is also representative of background. If the background data set for the site is found to be sufficient, monitoring of background wells could be discontinued. The evaluation has demonstrated that groundwater quality at the mill tailings area is protective at the point of exposure in the Animas River. It is also stable or improving and has remained within predicted limits over the last several years. Sampling of the river even at low flow times of the year results in surface water quality indistinguishable from background. A reduction in the frequency of monitoring could be justified on this basis.

## 3.2 Raffinate Ponds Area

The uppermost aquifer in the raffinate ponds consists of the Menefee Formation and Point Lookout Sandstone Formation bedrock units. These units are juxtaposed along the north-northeast trending Bodo Fault (Figure 1). It is assumed that these units function as a single aquifer and that water flows from near the base of Smelter Mountain toward the Animas River. Therefore, water originating in the Point Lookout Sandstone (on the west side of the fault) will flow across the fault and mix with water in the Menefee Formation.

### 3.2.1 Background

Well 0599 is completed in the Point Lookout Sandstone Formation and is located upgradient from the former raffinate ponds (Figure 1); it is considered to be background for the site (DOE 2002a). Generally, as with the mill tailings area, background water quality is poor. Based on data in the SOWP, background groundwater concentrations of nitrate, sulfate, iron, manganese, selenium, and TDS exceeded water quality standards. On the basis of high background levels of selenium, it was determined that supplemental standards applied to groundwater at the raffinate ponds area and that no further action was needed. Monitoring has been conducted as a best management practice only. A limited data evaluation was completed for the raffinate ponds area data; this focused on uranium, the best site-related indicator constituent.

### 3.2.2 Trends

The compliance strategy for the raffinate ponds area is not contingent upon natural flushing or other processes to reduce concentrations. However, to evaluate the stability of the groundwater system, a Mann-Kendall analysis was completed for site wells using uranium data. For wells with longer monitoring histories (e.g., 0598, 0607), the trend test was applied to different monitoring periods. Results are presented in Table 9. The wells located within the footprint of the former raffinate ponds (wells 0598, 0607, 0879; Figure 1) all show decreasing trends for complete data sets. Based on only the most recent data, concentrations in well 0598 appear to have stabilized; concentrations in well 0607 continue to decline. In contrast, the two wells downgradient of the raffinate ponds—wells 0594 and 0884—display increasing trends in uranium. This suggests that site-related contamination is migrating downgradient over time as would be expected based on natural processes.

*Table 9. Mann-Kendall Results for Uranium in the Raffinate Ponds Area*

| Well Designation | Years | Trend | Confidence Level |
|---|---|---|---|
| 0594 | 1991+ | increasing | 85% |
| 0598 | 1991+ | decreasing | 95% |
| 0598 | 2001+ | none | NA |
| 0607 | 1980+ | decreasing | 80% |
| 0607 | 1990+ | decreasing | 90% |
| 0607 | 2000+ | decreasing | 95% |
| 0879 | 2000+ | decreasing | 90% |
| 0884 | 2000+ | increasing | 95% |

### 3.2.3 Post-Surface-Remediation Water Quality

As with the data from the mill tailings area, uranium data were used to develop baseline statistics for the raffinate ponds area (Table 10). In order to have an adequate sample size to compute the statistics (8 to 10 analyses recommended), a longer time period was used than for the mill tailings area. Statistics were computed from available data between 1995 and 2009. These were compared to monitoring results obtained after 2009. As with the mill tailings area, uranium results for all wells since 2009 were below their respective UPL 95. This is an indication that the groundwater system is relatively stable. Results are consistent with predictions based on past observations. Even though the Mann-Kendall test indicated that a couple of wells displayed increasing trends, results have still remained within expected limits.

*Table 10. Uranium Statistics for the Raffinate Ponds Area (Data Collected 1995 Through 2009)*

| Well Number | Number of Samples | Minimum | Maximum | Mean | UPL 95[a] | Max since 2009 |
|---|---|---|---|---|---|---|
| 0594 | 10 | 0.0305 | 0.192 | 0.0656 | 0.284 | 0.10 |
| 0598 | 17 | 0.0497 | 0.278 | 0.121 | 0.43 | 0.11 |
| 0879 | 11 | 0.041 | 0.36 | 0.202 | 0.738 | 0.086 |
| 0607 | 18 | 0.0026 | 0.0063 | 0.00404 | 0.0085 | 0.0031 |
| 0884 | 13 | 0.04 | 0.18 | 0.0994 | 0.273 | 0.14 |

[a] Nonparametric Chebyshev UPL was used

### 3.2.4 Summary of Raffinate Pond Area

Monitoring at the raffinate ponds area is being conducted as a best management practice. For supplemental standards sites, groundwater monitoring is not required; all monitoring could be discontinued for this site. A trend evaluation for the raffinate ponds area indicates that site-related contamination is still moving past two downgradient site wells—0594 and 0884. All other wells have decreasing trends. If it is desirable to reduce, but not eliminate, monitoring at this site, the two downgradient wells would provide the most useful information. Monitoring of just these two wells for uranium would likely be adequate for monitoring behavior of milling-related contamination. A reduction in monitoring frequency could be considered.

# 4.0 Conclusions and Recommendations

Based on the evaluation included this report, the following observations can be made:

- A more detailed evaluation of background water quality for the mill tailings area indicates that natural groundwater quality is poor and elevated in a number of constituents that exceed secondary drinking water standards. Among these are sulfate, iron, manganese, and chloride. Other potential sources of nonmilling contamination have been identified that are likely to affect water quality at the site. These include Mancos Shale and a layer of smelter slag that predates the uranium milling operations. The presence of elevated background concentrations and nonmilling sources of contamination suggest that supplemental standards may be applicable based on limited use groundwater. Uranium appears to be the only good indicator of milling-related contamination at the mill tailings area. Natural flushing appears to be proceeding as expected for uranium at the mill tailings area. Overall, concentrations are trending downward. Average attenuation rates suggest flushing could occur within the allotted 100-year time frame. However, uncertainties associated with these predictions indicate standards may not be attainable within a reasonable period of time. Uranium isotope data indicate that the majority of uranium at the site is milling-related and not derived from natural sources. Background levels of uranium are not elevated above applicable standards.
- Historical data for the site indicate that sulfate was associated with the milling processes. However, current concentrations at the site are consistent with those observed in background groundwater and groundwater associated with Mancos Shale. These sources of sulfate likely obscure any remaining mill-related sulfate. Sulfate is therefore not a good indicator of milling-related contaminant behavior. The sulfate compliance goal identified in the GCAP is unrealistically stringent. All sulfate concentrations at the site are below the UPL 95 based on background. Sulfate could be eliminated as a contaminant of concern for the site.
- While some milling-related contamination may have affected well locations 0622 and 0635 in the past, concentrations of constituents in these wells have been consistent with background levels for the last decade. Southernmost well 0863 does not appear to be in the flow path of site-related contamination. Groundwater in this well is more similar to background groundwater. If the background data set is considered to be adequate, these wells could be eliminated from future monitoring.
- Past studies conducted at the site have demonstrated that post-remediation groundwater quality was protective of human health and the environment. Since that time frame, groundwater quality has remained stable at the site and continues to be protective. On the basis of protectiveness, ACLs could be established for the site. Molybdenum and selenium have met their respective standards in all mill tailings area wells for the last three sampling rounds. These analytes can be eliminated from future monitoring, as stated in the GCAP.
- Elevated levels of cadmium and manganese observed at well 0612 are likely derived from a source other than milling—possibly the slag layer. The concentrations and behaviors of these constituents are inconsistent with those that were derived from milling-related activities. Monitoring of these constituents is not useful for tracking the behavior of milling-related contamination.
- Monitoring in the raffinate ponds area is being conducted as a best management practice. Because data are not required for compliance purposes, it may be possible to eliminate or reduce the frequency of monitoring in this area (e.g., once every 5 years). The monitoring

network could be reduced to the two downgradient wells at the site—all others have shown stable or declining concentrations. Increasing trends in uranium at the two downgradient wells suggest that the maximum concentrations in the groundwater plume have not yet passed these locations.

- Surface water monitoring could be discontinued at both areas, as results are consistently below levels that are protective of surface water even during low flow.

# 5.0 References


5 CCR 1002-41. Colorado Department of Public Health and Environment, "The Basic Standards for Ground Water," *Code of Colorado Regulations*.

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

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# Appendix A

# Groundwater and Surface Water Quality Data

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# Results of 2013 Monitoring

The annual groundwater and surface water monitoring approach for the Durango processing site was established in the GCAP (DOE 2003). The GCAP specifies that monitoring will continue for the first 5 years following U.S. Nuclear Regulatory Commission (NRC) concurrence with the GCAP. Monitoring for cadmium at the mill tailings area will continue annually for the first 10 years following concurrence because of the greater uncertainty about whether this constituent will flush naturally within the allotted 100-year period established in 40 CFR 192. Monitoring data obtained through the initial 5-year period will measure the progress of natural flushing of the constituents listed in Table A-2. The GCAP specifies that after the 5-year annual monitoring period, the scope of subsequent monitoring will be addressed in a long-term management plan. Although NRC has not yet approved the GCAP, DOE has adopted the monitoring approach recommended in that document. However, the time frames mentioned above will not begin until after the GCAP is approved.

At the mill tailings area, monitoring wells 0612, 0617, 0630, 0631, 0633, 0634, 0635, and 0863 have been established as point-of-compliance (POC) wells that are used to monitor the progress of natural flushing in groundwater in the alluvial aquifer (Figure A-1). In accordance with provisions of the GCAP, natural flushing for a given analyte is complete when its concentration meets the compliance goal at all POC wells for three consecutive annual sampling events. Monitoring for that constituent may then be discontinued.

Surface water locations 0652, 0584, 0691, and 0586, located along the Animas River (Figure A-1), are sampled to verify continued protection of the aquatic environment. Table A-1 summarizes the rationale and requirements for compliance monitoring in the mill tailings area.

Groundwater and surface water of the raffinate ponds area are monitored only as a best management practice, and no POC wells have been established. Table A-2 summarizes the monitoring practices.

At the request of CDPHE, surface water sampling was conducted in September 2012 and again in September 2013 to determine if there is a seasonal low-flow effect on concentrations entering the Animas River.

## A.1 General Water Quality

Table A-3 compares the maximum concentrations of the site contaminants detected in June 2013 to the corresponding compliance goals established in the GCAP for the mill tailings area. The compliance goals for cadmium, molybdenum, and uranium are 40 CFR 192 MCLs. The compliance goal for selenium (0.05 mg/L) is adopted from the EPA Safe Drinking Water Act as an ACL (the 40 CFR 192 MCL is 0.01 mg/L). An ACL was established for selenium because selenium occurs naturally in groundwater beneath the site at levels above the 40 CFR 192 MCL. There are no MCLs for manganese and sulfate. The compliance goal for manganese is the EPA drinking water equivalent level. This is a lifetime exposure concentration that is protective of adverse, noncancer health effects; it assumes that all of the exposure to a contaminant is from drinking water (EPA 2004). The sulfate goal is equivalent to its average background concentration in local groundwater.

*Table A-1. Annual Groundwater and Surface Water Compliance Monitoring Requirements for the Mill Tailings Area*

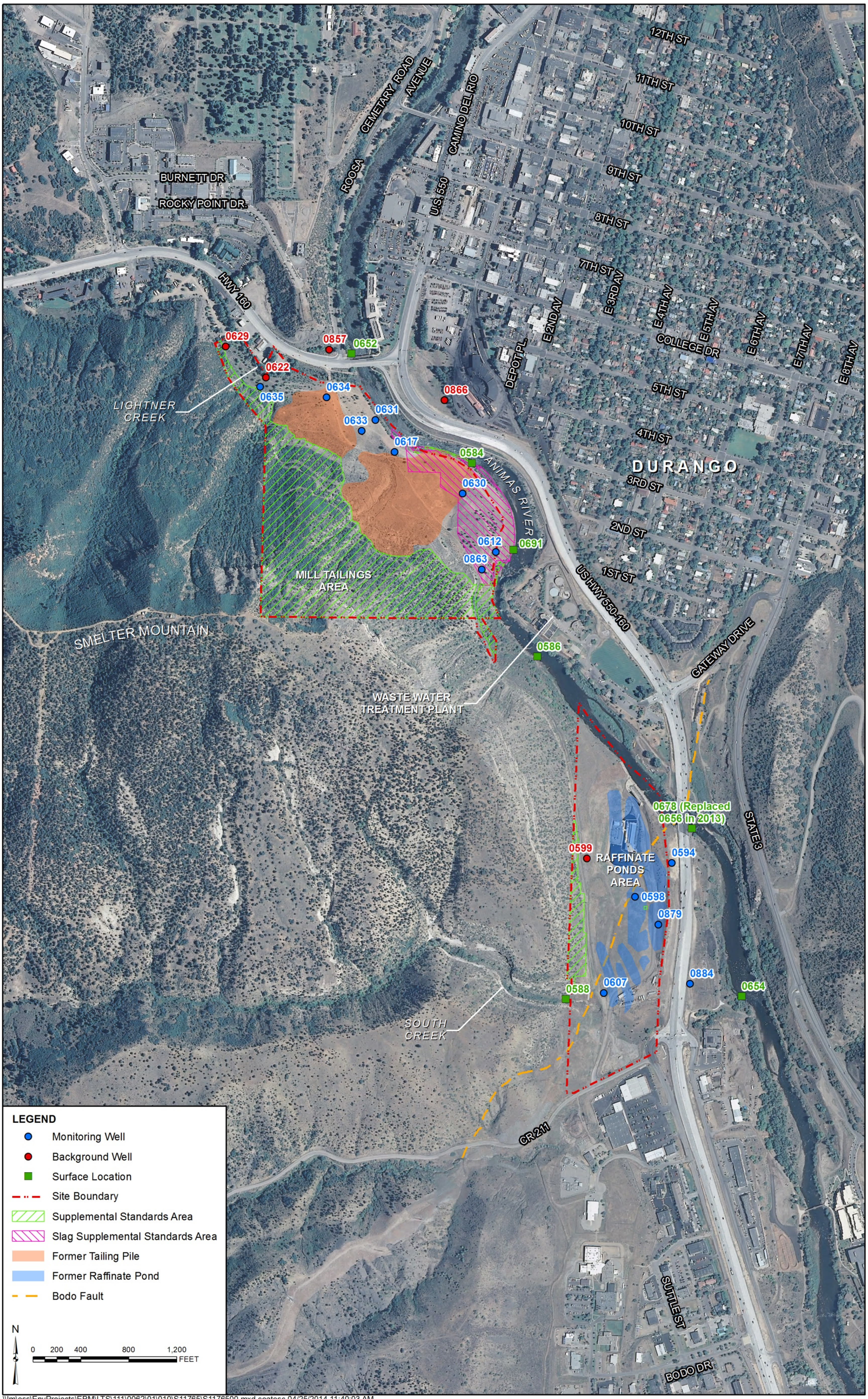
| Sampling Location | Monitoring Purpose | Analytes | Location |
|---|---|---|---|
| **Groundwater Monitoring** | | | |
| 0617, 0630, 0631, 0633, 0634, 0635 | POC/verify natural flushing | Manganese<br>Molybdenum<br>Selenium<br>Sulfate<br>Uranium | Onsite |
| 0612, 0863 | POC/verify natural flushing; verify cadmium flushing | Cadmium<br>Manganese<br>Molybdenum<br>Selenium<br>Sulfate<br>Uranium | Onsite downgradient |
| **Surface Water Monitoring** | | | |
| 0652 | Surface water background | Cadmium<br>Molybdenum<br>Selenium<br>Uranium | Offsite upstream |
| 0584, 0691 | Verify no site-related increase above background | | Offsite; site groundwater discharge area |
| 0586 | Verify no site-related increase above background | | Offsite; downstream of site groundwater discharge |

*Table A-2. Summary of Monitoring Practices at the Raffinate Ponds Area*

| Sampling Location | Monitoring Purpose | Analytes | Location |
|---|---|---|---|
| 0879, 0594 (replaced 0880) | Monitor concentrations in groundwater in the shallow bedrock. | Selenium<br>Uranium | Onsite |
| 0598 | Monitor concentrations in groundwater in the deep bedrock and Bodo Fault zone. | Selenium<br>Uranium | Onsite |
| 0607 | Monitor concentrations in groundwater entering the site. | Selenium<br>Uranium | Onsite |
| 0884 | Monitor offsite downgradient concentrations and migration. | Selenium<br>Uranium | Offsite downgradient |
| 0588 | Surface water quality entering the site. | Selenium<br>Uranium | Offsite upgradient |
| 0654, 0656 | Downgradient surface water concentrations. | Selenium<br>Uranium | Offsite downgradient |

*Table A-3. Current Groundwater Contaminants and Compliance Goals for the Mill Tailings Area*

| Contaminant of Concern | Compliance Goal (mg/L) | Compliance Goal Source | Maximum Concentration Observed in June 2013 (mg/L) |
|---|---|---|---|
| Cadmium | 0.01 | 40 CFR 192 MCL | 0.043 |
| Manganese | 1.6 | Drinking Water Equivalent Level (EPA 2004) | 5.8 |
| Molybdenum | 0.1 | 40 CFR 192 MCL | 0.090 |
| Selenium | 0.05 | ACL (DOE 2003) | 0.045 |
| Sulfate | 1,276.0 | Average Background (DOE 2002a) | 3,900.0 |
| Uranium | 0.044 | 40 CFR 192 MCL (activity based) | 1.4 |




\\lm\ess\EnvProjects\EBM\LTS\111\0062\01\010\S11765\S1176500.mxd coatesc 04/25/2014 11:40:03 AM

*Figure A-1. Durango Processing Site Features and Sampling Locations*

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Bedrock groundwater at the raffinate ponds area qualifies for supplemental standards on the basis of limited use groundwater as defined in 40 CFR 192. Because supplemental standards apply to groundwater in the raffinate ponds area, no numerical compliance goals have been established for that portion of the site.

Current monitoring of the Animas River verifies previous findings in the BLRA (DOE 1995) that past milling operations have negligible effect on surface water quality. Based on seasonal sampling results provided in the 2012 verification monitoring report, it was determined that September river flows were lower and surface water concentrations higher than in June. Surface water sampling in 2013 was therefore conducted in September to capture low-flow chemistry. Table A-4 provides surface water sampling results for selected constituents. Complete monitoring results for the mill tailings area are included in Attachment A-1.

*Table A-4. 2013 Sampling Results for Selected Constituents in the Animas River*

| Area | Location | Cadmium (mg/L) | Molybdenum (mg/L) | Selenium (mg/L) | Uranium (mg/L) |
|---|---|---|---|---|---|
| Background | 0652 | 0.0001 | 0.0012 | <0.0015 | 0.0010 |
| Mill Tailings | 0584 | 0.0001 | 0.0012 | <0.0015 | 0.0010 |
| Mill Tailings | 0586 | 0.0001 | 0.0012 | <0.0015 | 0.0010 |
| Mill Tailings | 0691 | 0.0001 | 0.0011 | <0.0015 | 0.0010 |
| Raffinate Ponds | 0654 | 0.0001 | 0.0012 | <0.0015 | 0.0010 |
| Raffinate Ponds | 0678 | 0.0001 | 0.0012 | <0.0015 | 0.0010 |

## A.2 Groundwater

### A.2.1 Mill Tailings Area

Groundwater was sampled from the eight POC locations (Figure A-1) and analyzed for the constituents shown in Table A-1. Sampling results for 2013 are provided in Attachment A-1 and are discussed below by constituent.

#### *A.2.1.1 Cadmium*

Figure A-2 contains a map view of the site showing the concentration of cadmium in groundwater at the compliance wells in June 2013. Consistent with past years, concentrations are elevated only in well 0612. As discussed above, based on historical information on tailings fluid composition and lack of trending, a source other than mill tailings is assumed for cadmium at this location. The slag layer represents a plausible source.

#### *A.2.1.2 Manganese*

Figure A-2 illustrates the distribution of manganese concentrations in groundwater in June 2013. As with cadmium, and consistent with past years, concentrations are elevated only in well 0612. A localized, persistent source is hypothesized as with cadmium. The slag layer is suggested as a plausible source.

#### *A.2.1.3 Molybdenum*

Molybdenum concentrations in June 2013 remained below the compliance goal of 0.1 mg/L at all locations. Because all locations have been below the standard for at least three consecutive sampling rounds, monitoring for this analyte can be discontinued as specified in the GCAP.

#### *A.2.1.4 Selenium*

Selenium concentrations in June 2013 remained below the compliance goal (0.05 mg/L) at all well locations. Because all locations have been below the standard for at least three consecutive sampling rounds, monitoring for this analyte can be discontinued as specified in the GCAP.

#### *A.2.1.5 Sulfate*

Figure A-2 shows sulfate concentrations for 2013. The highest concentrations observed in 2013 were at location 0633. As discussed above, concentrations in the well have been trending upward over time. Because this well is screened predominantly in the Mancos Shale, a Mancos-derived source is hypothesized. Other wells at the site that are screened across Mancos tend to have higher levels of sulfate, including background well 0629. Because background concentrations of sulfate are relatively high and because Mancos Shale represents another likely sulfate source, monitoring of sulfate is not very meaningful for evaluating natural flushing of site-related contamination. The current compliance goal of 1,276 mg/L is unrealistically low. The UPL 95 computed for sulfate in background wells was 4,234 mg/L (Table 2 main report). A UPL 95 for background data is commonly used as a “not-to-exceed” value for groundwater compliance monitoring (EPA 2009) and is probably a more reasonable compliance goal than that established in the GCAP. Sulfate in onsite wells has never exceeded the UPL 95 value.

#### *A.2.1.6 Uranium*

Uranium concentrations exceeded the compliance goal at all locations except wells 0634, 0635, and 0863 in June 2013 (Figure A-2). The evaluation in this report has demonstrated that uranium in mill tailings area groundwater is mostly milling-related. Concentrations continue to decline as mill-related contamination is naturally flushed from the system.

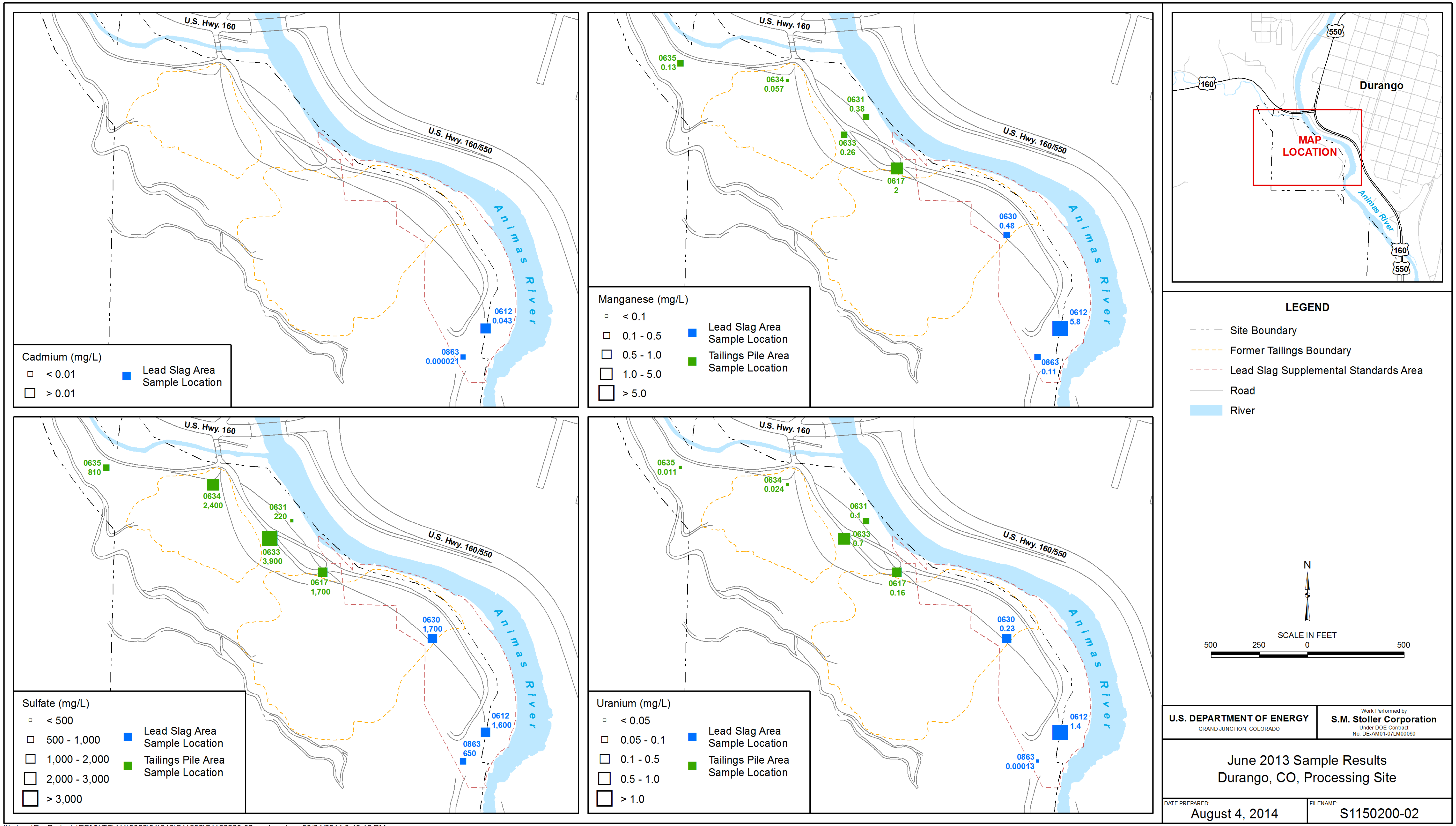


*Figure A-2. June 2013 Sample Results*

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### A.2.2 Raffinate Ponds Area

Groundwater in the raffinate ponds area is being monitored as a best management practice. Bedrock groundwater at the raffinate ponds area qualifies for supplemental standards on the basis of limited use groundwater due to widespread elevated concentrations of naturally occurring selenium. Because naturally occurring sources of both selenium and uranium are present in the area, groundwater concentrations of these constituents are not expected to flush to compliance goals. Therefore, no modeling was done for the raffinate ponds area.

Groundwater was sampled from five wells in the monitoring network in 2013 and analyzed for uranium and selenium. Complete monitoring results for the raffinate ponds area for 2013 are provided in Attachment A-2. Table A-5 summarizes the monitoring results for selenium and uranium.

*Table A-5. 2013 Uranium and Selenium Results for Raffinate Ponds Area*

| Well Location | Selenium (mg/L) | Uranium (mg/L) |
|---|---|---|
| 0594 | 0.0053 | 0.028 |
| 0598 | 0.230 | 0.096 |
| 0607 | 0.410 | 0.0031 |
| 0879 | 0.012 | 0.083 |
| 0884 | 0.550 | 0.100 |

## A.3 Surface Water

Surface water was sampled from six locations in the Animas River (Figure A-1) adjacent to both the mill tailings and raffinate ponds areas during September 2013 and analyzed for cadmium, molybdenum, selenium, and uranium. Sampling results indicate that locations adjacent to the sites are indistinguishable from background (Table A-4).

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# Attachment A-1

# Mill Tailings Processing Site (DUR01)

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GROUNDWATER QUALITY DATA BY PARAMETER WITH DEPTH (USEE200) FOR SITE DUR01, Durango Mill Tailings Process Site
REPORT DATE: 5/5/2014 8:45 am

| PARAMETER | UNITS | LOCATION CODE | LOCATION TYPE | SAMPLE: DATE | SAMPLE: ID | DEPTH RANGE (FT BLS) | RESULT | QUALIFIERS: LAB | QUALIFIERS: DATA | QUALIFIERS: QA | DETECTION LIMIT | UN-CERTAINTY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alkalinity, Total (As CaCO3) | mg/L | 0612 | WL | 06/04/2013 | N001 | 37.41 - 57.41 | 393 | | F | # | - | - |
| | mg/L | 0617 | WL | 06/04/2013 | N001 | 14.00 - 29.00 | 431 | | F | # | - | - |
| | mg/L | 0630 | WL | 06/04/2013 | N001 | 28.30 - 38.30 | 294 | | F | # | - | - |
| | mg/L | 0631 | WL | 06/04/2013 | N001 | 6.00 - 16.00 | 366 | | F | # | - | - |
| | mg/L | 0633 | WL | 06/04/2013 | N001 | 4.00 - 14.00 | 638 | | FQ | # | - | - |
| | mg/L | 0634 | WL | 06/04/2013 | N001 | 8.00 - 18.00 | 402 | | FQ | # | - | - |
| | mg/L | 0635 | WL | 06/04/2013 | N001 | 5.50 - 15.50 | 453 | | F | # | - | - |
| | mg/L | 0863 | WL | 06/04/2013 | N001 | 58.00 - 67.50 | 479 | | F | # | - | - |
| Cadmium | mg/L | 0612 | WL | 06/04/2013 | N001 | 37.41 - 57.41 | 0.043 | | F | # | 0.00058 | - |
| | mg/L | 0863 | WL | 06/04/2013 | N001 | 58.00 - 67.50 | 0.00002 | B | F | # | 1.2E-05 | - |
| | mg/L | 0863 | WL | 06/04/2013 | N002 | 58.00 - 67.50 | 0.00001 | B | F | # | 1.2E-05 | - |
| Manganese | mg/L | 0612 | WL | 06/04/2013 | N001 | 37.41 - 57.41 | 5.800 | | F | # | 0.00011 | - |
| | mg/L | 0617 | WL | 06/04/2013 | N001 | 14.00 - 29.00 | 2.000 | | F | # | 0.00011 | - |
| | mg/L | 0630 | WL | 06/04/2013 | N001 | 28.30 - 38.30 | 0.480 | | F | # | 0.00011 | - |
| | mg/L | 0631 | WL | 06/04/2013 | N001 | 6.00 - 16.00 | 0.380 | | F | # | 0.00011 | - |
| | mg/L | 0633 | WL | 06/04/2013 | N001 | 4.00 - 14.00 | 0.260 | | FQ | # | 0.00011 | - |
| | mg/L | 0634 | WL | 06/04/2013 | N001 | 8.00 - 18.00 | 0.057 | | FQ | # | 0.00011 | - |
| | mg/L | 0635 | WL | 06/04/2013 | N001 | 5.50 - 15.50 | 0.130 | | F | # | 0.00011 | - |
| | mg/L | 0863 | WL | 06/04/2013 | N001 | 58.00 - 67.50 | 0.110 | | F | # | 0.00011 | - |
| | mg/L | 0863 | WL | 06/04/2013 | N002 | 58.00 - 67.50 | 0.110 | | F | # | 0.00011 | - |
| Molybdenum | mg/L | 0612 | WL | 06/04/2013 | N001 | 37.41 - 57.41 | 0.090 | | F | # | 0.0016 | - |
| | mg/L | 0617 | WL | 06/04/2013 | N001 | 14.00 - 29.00 | 0.002 | | F | # | 0.00032 | - |
| | mg/L | 0630 | WL | 06/04/2013 | N001 | 28.30 - 38.30 | 0.0026 | | F | # | 0.00032 | - |
| | mg/L | 0631 | WL | 06/04/2013 | N001 | 6.00 - 16.00 | 0.0053 | | F | # | 0.00032 | - |
| | mg/L | 0633 | WL | 06/04/2013 | N001 | 4.00 - 14.00 | 0.001 | B | FQ | # | 0.00032 | - |

GROUNDWATER QUALITY DATA BY PARAMETER WITH DEPTH (USEE200) FOR SITE DUR01, Durango Mill Tailings Process Site
REPORT DATE: 5/5/2014 8:45 am

| PARAMETER | UNITS | LOCATION CODE | LOCATION TYPE | SAMPLE: DATE | ID | DEPTH RANGE (FT BLS) | RESULT | QUALIFIERS: LAB | DATA | QA | DETECTION LIMIT | UN-CERTAINTY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Molybdenum | mg/L | 0634 | WL | 06/04/2013 | N001 | 8.00 - 18.00 | 0.0016 | | FQ | # | 3.2E-05 | - |
| | mg/L | 0635 | WL | 06/04/2013 | N001 | 5.50 - 15.50 | 0.0012 | | F | # | 3.2E-05 | - |
| | mg/L | 0863 | WL | 06/04/2013 | N001 | 58.00 - 67.50 | 0.00061 | | F | # | 3.2E-05 | - |
| | mg/L | 0863 | WL | 06/04/2013 | N002 | 58.00 - 67.50 | 0.00064 | | F | # | 3.2E-05 | - |
| Oxidation Reduction Potential | mV | 0612 | WL | 06/04/2013 | N001 | 37.41 - 57.41 | 42.6 | | F | # | - | - |
| | mV | 0617 | WL | 06/04/2013 | N001 | 14.00 - 29.00 | -132.5 | | F | # | - | - |
| | mV | 0630 | WL | 06/04/2013 | N001 | 28.30 - 38.30 | 5.7 | | F | # | - | - |
| | mV | 0631 | WL | 06/04/2013 | N001 | 6.00 - 16.00 | -73.8 | | F | # | - | - |
| | mV | 0633 | WL | 06/04/2013 | N001 | 4.00 - 14.00 | -138.4 | | FQ | # | - | - |
| | mV | 0634 | WL | 06/04/2013 | N001 | 8.00 - 18.00 | 48.5 | | FQ | # | - | - |
| | mV | 0635 | WL | 06/04/2013 | N001 | 5.50 - 15.50 | -64.1 | | F | # | - | - |
| | mV | 0863 | WL | 06/04/2013 | N001 | 58.00 - 67.50 | 34.2 | | F | # | - | - |
| pH | s.u. | 0612 | WL | 06/04/2013 | N001 | 37.41 - 57.41 | 6.63 | | F | # | - | - |
| | s.u. | 0617 | WL | 06/04/2013 | N001 | 14.00 - 29.00 | 6.83 | | F | # | - | - |
| | s.u. | 0630 | WL | 06/04/2013 | N001 | 28.30 - 38.30 | 6.73 | | F | # | - | - |
| | s.u. | 0631 | WL | 06/04/2013 | N001 | 6.00 - 16.00 | 7.25 | | F | # | - | - |
| | s.u. | 0633 | WL | 06/04/2013 | N001 | 4.00 - 14.00 | 6.72 | | FQ | # | - | - |
| | s.u. | 0634 | WL | 06/04/2013 | N001 | 8.00 - 18.00 | 6.99 | | FQ | # | - | - |
| | s.u. | 0635 | WL | 06/04/2013 | N001 | 5.50 - 15.50 | 6.85 | | F | # | - | - |
| | s.u. | 0863 | WL | 06/04/2013 | N001 | 58.00 - 67.50 | 6.96 | | F | # | - | - |
| Selenium | mg/L | 0612 | WL | 06/04/2013 | N001 | 37.41 - 57.41 | 0.00044 | | FJ | # | 3.2E-05 | - |
| | mg/L | 0617 | WL | 06/04/2013 | N001 | 14.00 - 29.00 | 0.0017 | | F | # | 3.2E-05 | - |
| | mg/L | 0630 | WL | 06/04/2013 | N001 | 28.30 - 38.30 | 0.012 | | F | # | 0.00032 | - |
| | mg/L | 0631 | WL | 06/04/2013 | N001 | 6.00 - 16.00 | 0.0011 | | F | # | 3.2E-05 | - |
| | mg/L | 0633 | WL | 06/04/2013 | N001 | 4.00 - 14.00 | 0.045 | | FQ | # | 0.00032 | - |

GROUNDWATER QUALITY DATA BY PARAMETER WITH DEPTH (USEE200) FOR SITE DUR01, Durango Mill Tailings Process Site
REPORT DATE: 5/5/2014 8:45 am

| PARAMETER | UNITS | LOCATION CODE | LOCATION TYPE | SAMPLE: DATE | ID | DEPTH RANGE (FT BLS) | RESULT | QUALIFIERS: LAB | DATA | QA | DETECTION LIMIT | UN-CERTAINTY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Selenium | mg/L | 0634 | WL | 06/04/2013 | N001 | 8.00 - 18.00 | 0.00037 | | FQJ | # | 3.2E-05 | - |
| | mg/L | 0635 | WL | 06/04/2013 | N001 | 5.50 - 15.50 | 0.00025 | | FJ | # | 3.2E-05 | - |
| | mg/L | 0863 | WL | 06/04/2013 | N001 | 58.00 - 67.50 | 0.00003 | U | F | # | 3.2E-05 | - |
| | mg/L | 0863 | WL | 06/04/2013 | N002 | 58.00 - 67.50 | 0.00003 | U | F | # | 3.2E-05 | - |
| Specific Conductance | umhos/cm | 0612 | WL | 06/04/2013 | N001 | 37.41 - 57.41 | 3823 | | F | # | - | - |
| | umhos/cm | 0617 | WL | 06/04/2013 | N001 | 14.00 - 29.00 | 3152 | | F | # | - | - |
| | umhos/cm | 0630 | WL | 06/04/2013 | N001 | 28.30 - 38.30 | 3064 | | F | # | - | - |
| | umhos/cm | 0631 | WL | 06/04/2013 | N001 | 6.00 - 16.00 | 1433 | | F | # | - | - |
| | umhos/cm | 0633 | WL | 06/04/2013 | N001 | 4.00 - 14.00 | 7708 | | FQ | # | - | - |
| | umhos/cm | 0634 | WL | 06/04/2013 | N001 | 8.00 - 18.00 | 4636 | | FQ | # | - | - |
| | umhos/cm | 0635 | WL | 06/04/2013 | N001 | 5.50 - 15.50 | 2192 | | F | # | - | - |
| | umhos/cm | 0863 | WL | 06/04/2013 | N001 | 58.00 - 67.50 | 2146 | | F | # | - | - |
| Sulfate | mg/L | 0612 | WL | 06/04/2013 | N001 | 37.41 - 57.41 | 1600 | | F | # | 25 | - |
| | mg/L | 0617 | WL | 06/04/2013 | N001 | 14.00 - 29.00 | 1700 | | F | # | 25 | - |
| | mg/L | 0630 | WL | 06/04/2013 | N001 | 28.30 - 38.30 | 1700 | | F | # | 25 | - |
| | mg/L | 0631 | WL | 06/04/2013 | N001 | 6.00 - 16.00 | 220 | | F | # | 5 | - |
| | mg/L | 0633 | WL | 06/04/2013 | N001 | 4.00 - 14.00 | 3900 | | FQ | # | 50 | - |
| | mg/L | 0634 | WL | 06/04/2013 | N001 | 8.00 - 18.00 | 2400 | | FQ | # | 50 | - |
| | mg/L | 0635 | WL | 06/04/2013 | N001 | 5.50 - 15.50 | 810 | | F | # | 10 | - |
| | mg/L | 0863 | WL | 06/04/2013 | N001 | 58.00 - 67.50 | 650 | | F | # | 10 | - |
| | mg/L | 0863 | WL | 06/04/2013 | N002 | 58.00 - 67.50 | 650 | | F | # | 10 | - |
| Temperature | C | 0612 | WL | 06/04/2013 | N001 | 37.41 - 57.41 | 12.53 | | F | # | - | - |
| | C | 0617 | WL | 06/04/2013 | N001 | 14.00 - 29.00 | 12.59 | | F | # | - | - |
| | C | 0630 | WL | 06/04/2013 | N001 | 28.30 - 38.30 | 19.96 | | F | # | - | - |
| | C | 0631 | WL | 06/04/2013 | N001 | 6.00 - 16.00 | 14.23 | | F | # | - | - |

GROUNDWATER QUALITY DATA BY PARAMETER WITH DEPTH (USEE200) FOR SITE DUR01, Durango Mill Tailings Process Site
REPORT DATE: 5/5/2014 8:45 am

| PARAMETER | UNITS | LOCATION CODE | LOCATION TYPE | SAMPLE: DATE | ID | DEPTH RANGE (FT BLS) | RESULT | QUALIFIERS: LAB | DATA | QA | DETECTION LIMIT | UN-CERTAINTY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | C | 0633 | WL | 06/04/2013 | N001 | 4.00 - 14.00 | 14.71 | | FQ | # | - | - |
| | C | 0634 | WL | 06/04/2013 | N001 | 8.00 - 18.00 | 13.37 | | FQ | # | - | - |
| | C | 0635 | WL | 06/04/2013 | N001 | 5.50 - 15.50 | 13.56 | | F | # | - | - |
| | C | 0863 | WL | 06/04/2013 | N001 | 58.00 - 67.50 | 12.41 | | F | # | - | - |
| Turbidity | NTU | 0612 | WL | 06/04/2013 | N001 | 37.41 - 57.41 | 1.56 | | F | # | - | - |
| | NTU | 0617 | WL | 06/04/2013 | N001 | 14.00 - 29.00 | 9.7 | | F | # | - | - |
| | NTU | 0630 | WL | 06/04/2013 | N001 | 28.30 - 38.30 | 9.17 | | F | # | - | - |
| | NTU | 0631 | WL | 06/04/2013 | N001 | 6.00 - 16.00 | 1.69 | | F | # | - | - |
| | NTU | 0633 | WL | 06/04/2013 | N001 | 4.00 - 14.00 | 9.26 | | FQ | # | - | - |
| | NTU | 0634 | WL | 06/04/2013 | N001 | 8.00 - 18.00 | 3.94 | | FQ | # | - | - |
| | NTU | 0635 | WL | 06/04/2013 | N001 | 5.50 - 15.50 | 3.69 | | F | # | - | - |
| | NTU | 0863 | WL | 06/04/2013 | N001 | 58.00 - 67.50 | 2.62 | | F | # | - | - |
| Uranium | mg/L | 0612 | WL | 06/04/2013 | N001 | 37.41 - 57.41 | 1.400 | | F | # | 0.00015 | - |
| | mg/L | 0617 | WL | 06/04/2013 | N001 | 14.00 - 29.00 | 0.160 | | F | # | 2.9E-05 | - |
| | mg/L | 0630 | WL | 06/04/2013 | N001 | 28.30 - 38.30 | 0.230 | | F | # | 2.9E-05 | - |
| | mg/L | 0631 | WL | 06/04/2013 | N001 | 6.00 - 16.00 | 0.100 | | F | # | 2.9E-05 | - |
| | mg/L | 0633 | WL | 06/04/2013 | N001 | 4.00 - 14.00 | 0.700 | | FQ | # | 2.9E-05 | - |
| | mg/L | 0634 | WL | 06/04/2013 | N001 | 8.00 - 18.00 | 0.024 | | FQ | # | 2.9E-06 | - |
| | mg/L | 0635 | WL | 06/04/2013 | N001 | 5.50 - 15.50 | 0.011 | | F | # | 2.9E-06 | - |
| | mg/L | 0863 | WL | 06/04/2013 | N001 | 58.00 - 67.50 | 0.00013 | * | FJ | # | 2.9E-06 | - |
| | mg/L | 0863 | WL | 06/04/2013 | N002 | 58.00 - 67.50 | 0.0001 | | F | # | 2.9E-06 | - |

| PARAMETER | UNITS | LOCATION CODE | LOCATION TYPE | SAMPLE: DATE | ID | DEPTH RANGE (FT BLS) | RESULT | QUALIFIERS: LAB | DATA | QA | DETECTION LIMIT | UN-CERTAINTY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

RECORDS: SELECTED FROM USEE200 WHERE site_code='DUR01' AND (data_validation_qualifiers IS NULL OR data_validation_qualifiers NOT LIKE '%R%' AND data_validation_qualifiers NOT LIKE '%X%' ) AND DATE_SAMPLED between #1/1/2013# and #12/31/2013#

SAMPLE ID CODES: 000X = Filtered sample. N00X = Unfiltered sample. X = replicate number.

LOCATION TYPES: WL WELL

LAB QUALIFIERS:

- * Replicate analysis not within control limits.
- \+ Correlation coefficient for MSA < 0.995.
- > Result above upper detection limit.
- A TIC is a suspected aldol-condensation product.
- B Inorganic: Result is between the IDL and CRDL. Organic & Radiochemistry: Analyte also found in method blank.
- C Pesticide result confirmed by GC-MS.
- D Analyte determined in diluted sample.
- E Inorganic: Estimate value because of interference, see case narrative. Organic: Analyte exceeded calibration range of the GC-MS.
- H Holding time expired, value suspect.
- I Increased detection limit due to required dilution.
- J Estimated
- M GFAA duplicate injection precision not met.
- N Inorganic or radiochemical: Spike sample recovery not within control limits. Organic: Tentatively identified compund (TIC).
- P > 25% difference in detected pesticide or Aroclor concentrations between 2 columns.
- S Result determined by method of standard addition (MSA).
- U Analytical result below detection limit.
- W Post-digestion spike outside control limits while sample absorbance < 50% of analytical spike absorbance.
- X Laboratory defined (USEPA CLP organic) qualifier, see case narrative.
- Y Laboratory defined (USEPA CLP organic) qualifier, see case narrative.
- Z Laboratory defined (USEPA CLP organic) qualifier, see case narrative.

DATA QUALIFIERS:

- F Low flow sampling method used.
- G Possible grout contamination, pH > 9.
- J Estimated value.
- L Less than 3 bore volumes purged prior to sampling.
- N Presumptive evidence that analyte is present. The analyte is "tentatively identified".
- Q Qualitative result due to sampling technique
- R Unusable result.
- U Parameter analyzed for but was not detected.
- X Location is undefined.

QA QUALIFIER: # = validated according to Quality Assurance guidelines.

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SURFACE WATER QUALITY DATA BY PARAMETER (USEE800) FOR SITE DUR01, Durango Mill Tailings Process Site
REPORT DATE: 5/5/2014 8:47 am

| PARAMETER | UNITS | LOCATION CODE | SAMPLE: DATE | ID | RESULT | QUALIFIERS: LAB | DATA | QA | DETECTION LIMIT | UN-CERTAINTY |
|---|---|---|---|---|---|---|---|---|---|---|
| Alkalinity, Total (As CaCO3) | mg/L | 0584 | 09/04/2013 | N001 | 111 | | | # | - | - |
| | mg/L | 0586 | 09/04/2013 | N001 | 113 | | | # | - | - |
| | mg/L | 0652 | 09/04/2013 | N001 | 106 | | | # | - | - |
| | mg/L | 0691 | 09/04/2013 | N001 | 101 | | | # | - | - |
| Cadmium | mg/L | 0584 | 09/04/2013 | N001 | 0.0001 | B | | # | 0.00011 | - |
| | mg/L | 0586 | 09/04/2013 | N001 | 0.0001 | B | | # | 0.00011 | - |
| | mg/L | 0586 | 09/04/2013 | N002 | 0.0001 | B | | # | 0.00011 | - |
| | mg/L | 0652 | 09/04/2013 | N001 | 0.0001 | B | | # | 0.00011 | - |
| | mg/L | 0691 | 09/04/2013 | N001 | 0.0001 | B | | # | 0.00011 | - |
| Molybdenum | mg/L | 0584 | 09/04/2013 | N001 | 0.0012 | B | | # | 0.00017 | - |
| | mg/L | 0586 | 09/04/2013 | N001 | 0.0011 | B | | # | 0.00017 | - |
| | mg/L | 0586 | 09/04/2013 | N002 | 0.0012 | B | | # | 0.00017 | - |
| | mg/L | 0652 | 09/04/2013 | N001 | 0.0012 | B | | # | 0.00017 | - |
| | mg/L | 0691 | 09/04/2013 | N001 | 0.0011 | B | | # | 0.00017 | - |
| Oxidation Reduction Potential | mV | 0584 | 09/04/2013 | N001 | 126.0 | | | # | - | - |
| | mV | 0586 | 09/04/2013 | N001 | 100.4 | | | # | - | - |
| | mV | 0652 | 09/04/2013 | N001 | 131.7 | | | # | - | - |
| | mV | 0691 | 09/04/2013 | N001 | 129.0 | | | # | - | - |
| pH | s.u. | 0584 | 09/04/2013 | N001 | 8.06 | | | # | - | - |
| | s.u. | 0586 | 09/04/2013 | N001 | 7.96 | | | # | - | - |
| | s.u. | 0652 | 09/04/2013 | N001 | 8.17 | | | # | - | - |
| | s.u. | 0691 | 09/04/2013 | N001 | 8.14 | | | # | - | - |
| Selenium | mg/L | 0584 | 09/04/2013 | N001 | 0.0015 | U | | # | 0.0015 | - |
| | mg/L | 0586 | 09/04/2013 | N001 | 0.0015 | U | | # | 0.0015 | - |
| | mg/L | 0586 | 09/04/2013 | N002 | 0.0015 | U | | # | 0.0015 | - |
| | mg/L | 0652 | 09/04/2013 | N001 | 0.0015 | U | | # | 0.0015 | - |
| | mg/L | 0691 | 09/04/2013 | N001 | 0.0015 | U | | # | 0.0015 | - |
| Specific Conductance | umhos/cm | 0584 | 09/04/2013 | N001 | 522 | | | # | - | - |
| | umhos/cm | 0586 | 09/04/2013 | N001 | 523 | | | # | - | - |
| | umhos/cm | 0652 | 09/04/2013 | N001 | 487 | | | # | - | - |
| | umhos/cm | 0691 | 09/04/2013 | N001 | 521 | | | # | - | - |
| Temperature | C | 0584 | 09/04/2013 | N001 | 22.99 | | | # | - | - |
| | C | 0586 | 09/04/2013 | N001 | 18.09 | | | # | - | - |
| | C | 0652 | 09/04/2013 | N001 | 21.91 | | | # | - | - |
| | C | 0691 | 09/04/2013 | N001 | 23.37 | | | # | - | - |

SURFACE WATER QUALITY DATA BY PARAMETER (USEE800) FOR SITE DUR01, Durango Mill Tailings Process Site
REPORT DATE: 5/5/2014 8:47 am

| PARAMETER | UNITS | LOCATION CODE | SAMPLE: DATE | SAMPLE: ID | RESULT | QUALIFIERS: LAB | QUALIFIERS: DATA | QUALIFIERS: QA | DETECTION LIMIT | UN-CERTAINTY |
|---|---|---|---|---|---|---|---|---|---|---|
| Turbidity | NTU | 0584 | 09/04/2013 | N001 | 4.62 | | | # | - | - |
| | NTU | 0586 | 09/04/2013 | N001 | 6.15 | | | # | - | - |
| | NTU | 0652 | 09/04/2013 | N001 | 7.55 | | | # | - | - |
| | NTU | 0691 | 09/04/2013 | N001 | 4.56 | | | # | - | - |
| Uranium | mg/L | 0584 | 09/04/2013 | N001 | 0.0010 | | | # | 6.7E-05 | - |
| | mg/L | 0586 | 09/04/2013 | N001 | 0.0010 | | | # | 6.7E-05 | - |
| | mg/L | 0586 | 09/04/2013 | N002 | 0.0010 | | | # | 6.7E-05 | - |
| | mg/L | 0652 | 09/04/2013 | N001 | 0.0010 | | | # | 6.7E-05 | - |
| | mg/L | 0691 | 09/04/2013 | N001 | 0.0010 | | | # | 6.7E-05 | - |

RECORDS: SELECTED FROM USEE800 WHERE site_code='DUR01' AND (data_validation_qualifiers IS NULL OR data_validation_qualifiers NOT LIKE '%R%' AND data_validation_qualifiers NOT LIKE '%X%' ) AND DATE_SAMPLED between #1/1/2013# and #12/31/2013#

SAMPLE ID CODES: 000X = Filtered sample. N00X = Unfiltered sample. X = replicate number.

LAB QUALIFIERS:
- * Replicate analysis not within control limits.
- + Correlation coefficient for MSA < 0.995.
- > Result above upper detection limit.
- A TIC is a suspected aldol-condensation product.
- B Inorganic: Result is between the IDL and CRDL. Organic & Radiochemistry: Analyte also found in method blank.
- C Pesticide result confirmed by GC-MS.
- D Analyte determined in diluted sample.
- E Inorganic: Estimate value because of interference, see case narrative. Organic: Analyte exceeded calibration range of the GC-MS.
- H Holding time expired, value suspect.
- I Increased detection limit due to required dilution.
- J Estimated
- M GFAA duplicate injection precision not met.
- N Inorganic or radiochemical: Spike sample recovery not within control limits. Organic: Tentatively identified compund (TIC).
- P > 25% difference in detected pesticide or Aroclor concentrations between 2 columns.
- S Result determined by method of standard addition (MSA).
- U Analytical result below detection limit.
- W Post-digestion spike outside control limits while sample absorbance < 50% of analytical spike absorbance.
- X Laboratory defined (USEPA CLP organic) qualifier, see case narrative.
- Y Laboratory defined (USEPA CLP organic) qualifier, see case narrative.
- Z Laboratory defined (USEPA CLP organic) qualifier, see case narrative.

DATA QUALIFIERS:
- F Low flow sampling method used.
- J Estimated value.
- N Presumptive evidence that analyte is present. The analyte is "tentatively identified".
- R Unusable result.
- X Location is undefined.
- G Possible grout contamination, pH > 9.
- L Less than 3 bore volumes purged prior to sampling.
- Q Qualitative result due to sampling technique
- U Parameter analyzed for but was not detected.

QA QUALIFIER: # = validated according to Quality Assurance guidelines.

# Attachment A-2

# Raffinate Pond Processing Site (DUR02)

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GROUNDWATER QUALITY DATA BY PARAMETER WITH DEPTH (USEE200) FOR SITE DUR02, Durango Raffinate Pond Process Site
REPORT DATE: 5/5/2014 8:50 am

| PARAMETER | UNITS | LOCATION CODE | LOCATION TYPE | SAMPLE: DATE | ID | DEPTH RANGE (FT BLS) | RESULT | QUALIFIERS: LAB | DATA | QA | DETECTION LIMIT | UN-CERTAINTY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alkalinity, Total (As CaCO3) | mg/L | 0594 | WL | 06/04/2013 | N001 | 8.50 - 38.50 | 438 | | F | # | - | - |
| | mg/L | 0607 | WL | 06/03/2013 | 0001 | 35.00 - 55.00 | 329 | | FQ | # | - | - |
| | mg/L | 0879 | WL | 06/04/2013 | N001 | 27.00 - 36.90 | 423 | | | # | - | - |
| | mg/L | 0884 | WL | 06/04/2013 | N001 | 36.50 - 46.50 | 317 | | F | # | - | - |
| Oxidation Reduction Potential | mV | 0594 | WL | 06/04/2013 | N001 | 8.50 - 38.50 | 120.5 | | F | # | - | - |
| | mV | 0598 | WL | 06/04/2013 | N001 | 66.20 - 96.20 | -10.7 | | F | # | - | - |
| | mV | 0607 | WL | 06/03/2013 | N001 | 35.00 - 55.00 | 157.1 | | FQ | # | - | - |
| | mV | 0879 | WL | 06/04/2013 | N001 | 27.00 - 36.90 | 3.6 | | | # | - | - |
| | mV | 0884 | WL | 06/04/2013 | N001 | 36.50 - 46.50 | 50.0 | | F | # | - | - |
| pH | s.u. | 0594 | WL | 06/04/2013 | N001 | 8.50 - 38.50 | 7.00 | | F | # | - | - |
| | s.u. | 0598 | WL | 06/04/2013 | N001 | 66.20 - 96.20 | 6.86 | | F | # | - | - |
| | s.u. | 0607 | WL | 06/03/2013 | N001 | 35.00 - 55.00 | 7.48 | | FQ | # | - | - |
| | s.u. | 0879 | WL | 06/04/2013 | N001 | 27.00 - 36.90 | 6.79 | | | # | - | - |
| | s.u. | 0884 | WL | 06/04/2013 | N001 | 36.50 - 46.50 | 7.00 | | F | # | - | - |
| Selenium | mg/L | 0594 | WL | 06/04/2013 | N001 | 8.50 - 38.50 | 0.0053 | | F | # | 0.00032 | - |
| | mg/L | 0598 | WL | 06/04/2013 | N001 | 66.20 - 96.20 | 0.230 | | F | # | 0.00032 | - |
| | mg/L | 0607 | WL | 06/03/2013 | 0001 | 35.00 - 55.00 | 0.410 | | FQ | # | 0.00032 | - |
| | mg/L | 0879 | WL | 06/04/2013 | N001 | 27.00 - 36.90 | 0.012 | | | # | 0.00032 | - |
| | mg/L | 0884 | WL | 06/04/2013 | N001 | 36.50 - 46.50 | 0.550 | | F | # | 0.00032 | - |
| Specific Conductance | umhos/cm | 0598 | WL | 06/04/2013 | N001 | 66.20 - 96.20 | 7554 | | F | # | - | - |
| | umhos/cm | 0607 | WL | 06/03/2013 | N001 | 35.00 - 55.00 | 2184 | | FQ | # | - | - |
| | umhos/cm | 0879 | WL | 06/04/2013 | N001 | 27.00 - 36.90 | 7932 | | | # | - | - |
| | umhos/cm | 0884 | WL | 06/04/2013 | N001 | 36.50 - 46.50 | 3749 | | F | # | - | - |
| Temperature | C | 0594 | WL | 06/04/2013 | N001 | 8.50 - 38.50 | 20.98 | | F | # | - | - |

GROUNDWATER QUALITY DATA BY PARAMETER WITH DEPTH (USEE200) FOR SITE DUR02, Durango Raffinate Pond Process Site
REPORT DATE: 5/5/2014 8:50 am

| PARAMETER | UNITS | LOCATION CODE | LOCATION TYPE | SAMPLE: DATE | ID | DEPTH RANGE (FT BLS) | RESULT | QUALIFIERS: LAB | DATA | QA | DETECTION LIMIT | UN-CERTAINTY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | C | 0598 | WL | 06/04/2013 | N001 | 66.20 - 96.20 | 18.21 | | F | # | - | - |
| | C | 0607 | WL | 06/03/2013 | N001 | 35.00 - 55.00 | 17.26 | | FQ | # | - | - |
| | C | 0879 | WL | 06/04/2013 | N001 | 27.00 - 36.90 | 14.75 | | | # | - | - |
| | C | 0884 | WL | 06/04/2013 | N001 | 36.50 - 46.50 | 15.11 | | F | # | - | - |
| Turbidity | NTU | 0594 | WL | 06/04/2013 | N001 | 8.50 - 38.50 | 4.29 | | F | # | - | - |
| | NTU | 0598 | WL | 06/04/2013 | N001 | 66.20 - 96.20 | 7.83 | | F | # | - | - |
| | NTU | 0607 | WL | 06/03/2013 | N001 | 35.00 - 55.00 | 15.4 | | FQ | # | - | - |
| | NTU | 0879 | WL | 06/04/2013 | N001 | 27.00 - 36.90 | 1.62 | | | # | - | - |
| | NTU | 0884 | WL | 06/04/2013 | N001 | 36.50 - 46.50 | 2.05 | | F | # | - | - |
| Uranium | mg/L | 0594 | WL | 06/04/2013 | N001 | 8.50 - 38.50 | 0.028 | | F | # | 2.9E-05 | - |
| | mg/L | 0598 | WL | 06/04/2013 | N001 | 66.20 - 96.20 | 0.096 | | F | # | 2.9E-05 | - |
| | mg/L | 0607 | WL | 06/03/2013 | 0001 | 35.00 - 55.00 | 0.0031 | | FQ | # | 2.9E-05 | - |
| | mg/L | 0879 | WL | 06/04/2013 | N001 | 27.00 - 36.90 | 0.083 | | | # | 2.9E-05 | - |
| | mg/L | 0884 | WL | 06/04/2013 | N001 | 36.50 - 46.50 | 0.100 | | F | # | 2.9E-05 | - |

| PARAMETER | UNITS | LOCATION CODE | LOCATION TYPE | SAMPLE: DATE | ID | DEPTH RANGE (FT BLS) | RESULT | QUALIFIERS: LAB | DATA | QA | DETECTION LIMIT | UN-CERTAINTY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

RECORDS: SELECTED FROM USEE200 WHERE site_code='DUR02' AND (data_validation_qualifiers IS NULL OR data_validation_qualifiers NOT LIKE '%R%' AND data_validation_qualifiers NOT LIKE '%X%' ) AND DATE_SAMPLED between #1/1/2013# and #12/31/2013#

SAMPLE ID CODES: 000X = Filtered sample. N00X = Unfiltered sample. X = replicate number.

LOCATION TYPES: WL WELL

LAB QUALIFIERS:

- * Replicate analysis not within control limits.
- + Correlation coefficient for MSA < 0.995.
- > Result above upper detection limit.
- A TIC is a suspected aldol-condensation product.
- B Inorganic: Result is between the IDL and CRDL. Organic & Radiochemistry: Analyte also found in method blank.
- C Pesticide result confirmed by GC-MS.
- D Analyte determined in diluted sample.
- E Inorganic: Estimate value because of interference, see case narrative. Organic: Analyte exceeded calibration range of the GC-MS.
- H Holding time expired, value suspect.
- I Increased detection limit due to required dilution.
- J Estimated
- M GFAA duplicate injection precision not met.
- N Inorganic or radiochemical: Spike sample recovery not within control limits. Organic: Tentatively identified compund (TIC).
- P > 25% difference in detected pesticide or Aroclor concentrations between 2 columns.
- S Result determined by method of standard addition (MSA).
- U Analytical result below detection limit.
- W Post-digestion spike outside control limits while sample absorbance < 50% of analytical spike absorbance.
- X Laboratory defined (USEPA CLP organic) qualifier, see case narrative.
- Y Laboratory defined (USEPA CLP organic) qualifier, see case narrative.
- Z Laboratory defined (USEPA CLP organic) qualifier, see case narrative.

DATA QUALIFIERS:

| | | | | | |
|---|---|---|---|---|---|
| F | Low flow sampling method used. | G | Possible grout contamination, pH > 9. | J | Estimated value. |
| L | Less than 3 bore volumes purged prior to sampling. | N | Presumptive evidence that analyte is present. The analyte is "tentatively identified". | Q | Qualitative result due to sampling technique |
| R | Unusable result. | U | Parameter analyzed for but was not detected. | X | Location is undefined. |

QA QUALIFIER: # = validated according to Quality Assurance guidelines.

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SURFACE WATER QUALITY DATA BY PARAMETER (USEE800) FOR SITE DUR02, Durango Raffinate Pond Process Site
REPORT DATE: 5/5/2014 8:51 am

| PARAMETER | UNITS | LOCATION CODE | SAMPLE: DATE | ID | RESULT | QUALIFIERS: LAB | DATA | QA | DETECTION LIMIT | UN-CERTAINTY |
|---|---|---|---|---|---|---|---|---|---|---|
| Alkalinity, Total (As CaCO3) | mg/L | 0654 | 09/04/2013 | N001 | 96 | | | # | - | - |
| | mg/L | 0678 | 09/04/2013 | N001 | 109 | | | # | - | - |
| Cadmium | mg/L | 0654 | 09/04/2013 | N001 | 0.0001 | B | | # | 0.00011 | - |
| | mg/L | 0678 | 09/04/2013 | N001 | 0.0001 | B | | # | 0.00011 | - |
| Molybdenum | mg/L | 0654 | 09/04/2013 | N001 | 0.0012 | B | | # | 0.00017 | - |
| | mg/L | 0678 | 09/04/2013 | N001 | 0.0012 | B | | # | 0.00017 | - |
| Oxidation Reduction Potential | mV | 0654 | 09/04/2013 | N001 | 100.2 | | | # | - | - |
| | mV | 0678 | 09/04/2013 | N001 | 108.2 | | | # | - | - |
| pH | s.u. | 0654 | 09/04/2013 | N001 | 8.26 | | | # | - | - |
| | s.u. | 0678 | 09/04/2013 | N001 | 8.00 | | | # | - | - |
| Selenium | mg/L | 0654 | 09/04/2013 | N001 | 0.0015 | U | | # | 0.0015 | - |
| | mg/L | 0678 | 09/04/2013 | N001 | 0.0015 | U | | # | 0.0015 | - |
| Specific Conductance | umhos/cm | 0654 | 09/04/2013 | N001 | 518 | | | # | - | - |
| | umhos/cm | 0678 | 09/04/2013 | N001 | 527 | | | # | - | - |
| Temperature | C | 0654 | 09/04/2013 | N001 | 23.31 | | | # | - | - |
| | C | 0678 | 09/04/2013 | N001 | 26.84 | | | # | - | - |
| Turbidity | NTU | 0654 | 09/04/2013 | N001 | 5.25 | | | # | - | - |
| | NTU | 0678 | 09/04/2013 | N001 | 8.77 | | | # | - | - |
| Uranium | mg/L | 0654 | 09/04/2013 | N001 | 0.0010 | | | # | 6.7E-05 | - |
| | mg/L | 0678 | 09/04/2013 | N001 | 0.0010 | | | # | 6.7E-05 | - |

| PARAMETER | UNITS | LOCATION CODE | SAMPLE: DATE | ID | RESULT | QUALIFIERS: LAB | DATA | QA | DETECTION LIMIT | UN-CERTAINTY |
|---|---|---|---|---|---|---|---|---|---|---|

RECORDS: SELECTED FROM USEE800 WHERE site_code='DUR02' AND (data_validation_qualifiers IS NULL OR data_validation_qualifiers NOT LIKE '%R%' AND data_validation_qualifiers NOT LIKE '%X%' ) AND DATE_SAMPLED between #1/1/2013# and #12/31/2013#

SAMPLE ID CODES: 000X = Filtered sample. N00X = Unfiltered sample. X = replicate number.

LAB QUALIFIERS:

- * Replicate analysis not within control limits.
- + Correlation coefficient for MSA < 0.995.
- > Result above upper detection limit.
- A TIC is a suspected aldol-condensation product.
- B Inorganic: Result is between the IDL and CRDL. Organic & Radiochemistry: Analyte also found in method blank.
- C Pesticide result confirmed by GC-MS.
- D Analyte determined in diluted sample.
- E Inorganic: Estimate value because of interference, see case narrative. Organic: Analyte exceeded calibration range of the GC-MS.
- H Holding time expired, value suspect.
- I Increased detection limit due to required dilution.
- J Estimated
- M GFAA duplicate injection precision not met.
- N Inorganic or radiochemical: Spike sample recovery not within control limits. Organic: Tentatively identified compund (TIC).
- P > 25% difference in detected pesticide or Aroclor concentrations between 2 columns.
- S Result determined by method of standard addition (MSA).
- U Analytical result below detection limit.
- W Post-digestion spike outside control limits while sample absorbance < 50% of analytical spike absorbance.
- X Laboratory defined (USEPA CLP organic) qualifier, see case narrative.
- Y Laboratory defined (USEPA CLP organic) qualifier, see case narrative.
- Z Laboratory defined (USEPA CLP organic) qualifier, see case narrative.

DATA QUALIFIERS:

- F Low flow sampling method used.
- J Estimated value.
- N Presumptive evidence that analyte is present. The analyte is "tentatively identified".
- R Unusable result.
- X Location is undefined.
- G Possible grout contamination, pH > 9.
- L Less than 3 bore volumes purged prior to sampling.
- Q Qualitative result due to sampling technique
- U Parameter analyzed for but was not detected.

QA QUALIFIER: # = validated according to Quality Assurance guidelines.

# Appendix B

# ProUCL Output

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## B-1. Statistics for Background Wells—Mill Tailings Area

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**General Background Statistics for Full Data Sets**

| | |
|---|---|
| User Selected Options | |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Coverage | 90% |
| Different or Future K Values | 1 |
| Number of Bootstrap Operations | 2000 |

**uranium**

| | | | |
|---|---|---|---|
| General Statistics | | | |
| Total Number of Observations | 60 | Number of Distinct Observations | 48 |
| Tolerance Factor | 1.604 | | |
| | | | |
| Raw Statistics | | Log-Transformed Statistics | |
| Minimum | 3.60E-04 | Minimum | -7.929 |
| Maximum | 0.0354 | Maximum | -3.341 |
| Second Largest | 0.029 | Second Largest | -3.54 |
| First Quartile | 0.0048 | First Quartile | -5.34 |
| Median | 0.0069 | Median | -4.978 |
| Third Quartile | 0.015 | Third Quartile | -4.204 |
| Mean | 0.00996 | Mean | -5.1 |
| Geometric Mean | 0.00609 | SD | 1.186 |
| SD | 0.00828 | | |
| Coefficient of Variation | 0.832 | | |
| Skewness | 1.027 | | |
| | | | |
| Background Statistics | | | |
| Normal Distribution Test | | Lognormal Distribution Test | |
| Lilliefors Test Statistic | 0.162 | Lilliefors Test Statistic | 0.18 |
| Lilliefors Critical Value | 0.114 | Lilliefors Critical Value | 0.114 |
| Data not Normal at 5% Significance Level | | Data not Lognormal at 5% Significance Level | |
| | | | |
| Assuming Normal Distribution | | Assuming Lognormal Distribution | |
| 95% UTL with 90% Coverage | 0.0232 | 95% UTL with 90% Coverage | 0.0408 |
| 95% UPL (t) | 0.0239 | 95% UPL (t) | 0.045 |
| 90% Percentile (z) | 0.0206 | 90% Percentile (z) | 0.0279 |
| 95% Percentile (z) | 0.0236 | 95% Percentile (z) | 0.0429 |
| 99% Percentile (z) | 0.0292 | 99% Percentile (z) | 0.0962 |
| | | | |
| Gamma Distribution Test | | Data Distribution Test | |
| k star | 1.11 | Data Follow Appr. Gamma Distribution at 5% Significance Level | |
| Theta Star | 0.00897 | | |
| MLE of Mean | 0.00996 | | |
| MLE of Standard Deviation | 0.00945 | | |
| nu star | 133.2 | | |
| | | | |
| A-D Test Statistic | 0.829 | Nonparametric Statistics | |
| 5% A-D Critical Value | 0.776 | 90% Percentile | 0.021 |
| K-S Test Statistic | 0.114 | 95% Percentile | 0.0252 |
| 5% K-S Critical Value | 0.118 | 99% Percentile | 0.0316 |
| Data follow Appx. Gamma Distribution at 5% Significance Level | | | |
| | | | |
| Assuming Gamma Distribution | | 95% UTL with 90% Coverage | 0.025 |
| 90% Percentile | 0.0223 | 95% Percentile Bootstrap UTL with 90% Coverage | 0.0254 |
| 95% Percentile | 0.0288 | 95% BCA Bootstrap UTL with 90% Coverage | 0.0254 |
| 99% Percentile | 0.0435 | 95% UPL | 0.0284 |
| | | 95% Chebyshev UPL | 0.0464 |
| 95% WH Approx. Gamma UPL | 0.029 | Upper Threshold Limit Based upon IQR | 0.0302 |
| 95% HW Approx. Gamma UPL | 0.031 | | |
| 95% WH Approx. Gamma UTL with 90% Coverage | 0.0275 | | |
| 95% HW Approx. Gamma UTL with 90% Coverage | 0.0292 | | |

**sulfate**

| | | | |
|---|---|---|---|
| General Statistics | | | |
| Total Number of Observations | 63 | Number of Distinct Observations | 53 |
| Tolerance Factor | 1.595 | | |
| | | | |
| Raw Statistics | | Log-Transformed Statistics | |
| Minimum | 42 | Minimum | 3.738 |
| Maximum | 2450 | Maximum | 7.804 |
| Second Largest | 2190 | Second Largest | 7.692 |
| First Quartile | 203.5 | First Quartile | 5.316 |
| Median | 1070 | Median | 6.975 |
| Third Quartile | 1535 | Third Quartile | 7.335 |
| Mean | 1044 | Mean | 6.526 |
| Geometric Mean | 682.8 | SD | 1.099 |
| SD | 726.1 | | |
| Coefficient of Variation | 0.695 | | |
| Skewness | 0.141 | | |
| | | | |
| Background Statistics | | | |
| Normal Distribution Test | | Lognormal Distribution Test | |
| Lilliefors Test Statistic | 0.162 | Lilliefors Test Statistic | 0.247 |
| Lilliefors Critical Value | 0.112 | Lilliefors Critical Value | 0.112 |
| Data not Normal at 5% Significance Level | | Data not Lognormal at 5% Significance Level | |
| | | | |
| Assuming Normal Distribution | | Assuming Lognormal Distribution | |
| 95% UTL with 90% Coverage | 2203 | 95% UTL with 90% Coverage | 3944 |
| 95% UPL (t) | 2266 | 95% UPL (t) | 4343 |
| 90% Percentile (z) | 1975 | 90% Percentile (z) | 2793 |
| 95% Percentile (z) | 2239 | 95% Percentile (z) | 4165 |
| 99% Percentile (z) | 2733 | 99% Percentile (z) | 8809 |
| | | | |
| Gamma Distribution Test | | Data Distribution Test | |
| k star | 1.267 | Data do not follow a Discernable Distribution (0.05) | |
| Theta Star | 824.5 | | |
| MLE of Mean | 1044 | | |
| MLE of Standard Deviation | 927.9 | | |
| nu star | 159.6 | | |
| | | | |
| A-D Test Statistic | 3.144 | Nonparametric Statistics | |
| 5% A-D Critical Value | 0.773 | 90% Percentile | 2086 |
| K-S Test Statistic | 0.198 | 95% Percentile | 2147 |
| 5% K-S Critical Value | 0.115 | 99% Percentile | 2289 |
| Data not Gamma Distributed at 5% Significance Level | | | |
| | | | |
| Assuming Gamma Distribution | | 95% UTL with 90% Coverage | 2150 |
| 90% Percentile | 2268 | 95% Percentile Bootstrap UTL with 90% Coverage | 2150 |
| 95% Percentile | 2881 | 95% BCA Bootstrap UTL with 90% Coverage | 2150 |
| 99% Percentile | 4280 | 95% UPL | 2158 |
| | | 95% Chebyshev UPL | 4234 |
| 95% WH Approx. Gamma UPL | 2925 | Upper Threshold Limit Based upon IQR | 3532 |
| 95% HW Approx. Gamma UPL | 3131 | | |
| 95% WH Approx. Gamma UTL with 90% Coverage | 2770 | | |
| 95% HW Approx. Gamma UTL with 90% Coverage | 2944 | | |

**chloride**

| | | | |
|---|---|---|---|
| General Statistics | | | |
| Total Number of Observations | 54 | Number of Distinct Observations | 51 |
| Tolerance Factor | 1.624 | | |
| | | | |
| Raw Statistics | | Log-Transformed Statistics | |
| Minimum | 1.45 | Minimum | 0.372 |
| Maximum | 265 | Maximum | 5.58 |
| Second Largest | 260 | Second Largest | 5.561 |
| First Quartile | 10.6 | First Quartile | 2.361 |
| Median | 16.3 | Median | 2.791 |
| Third Quartile | 25.28 | Third Quartile | 3.23 |
| Mean | 33.66 | Mean | 2.916 |
| Geometric Mean | 18.47 | SD | 1.02 |
| SD | 52.35 | | |
| Coefficient of Variation | 1.555 | | |
| Skewness | 3.469 | | |
| | | | |
| Background Statistics | | | |
| Normal Distribution Test | | Lognormal Distribution Test | |
| Lilliefors Test Statistic | 0.32 | Lilliefors Test Statistic | 0.174 |
| Lilliefors Critical Value | 0.121 | Lilliefors Critical Value | 0.121 |
| Data not Normal at 5% Significance Level | | Data not Lognormal at 5% Significance Level | |
| | | | |
| Assuming Normal Distribution | | Assuming Lognormal Distribution | |
| 95% UTL with 90% Coverage | 118.7 | 95% UTL with 90% Coverage | 96.76 |
| 95% UPL (t) | 122.1 | 95% UPL (t) | 103.4 |
| 90% Percentile (z) | 100.8 | 90% Percentile (z) | 68.22 |
| 95% Percentile (z) | 119.8 | 95% Percentile (z) | 98.81 |
| 99% Percentile (z) | 155.5 | 99% Percentile (z) | 198 |
| | | | |
| Gamma Distribution Test | | Data Distribution Test | |
| k star | 0.924 | Data do not follow a Discernable Distribution (0.05) | |
| Theta Star | 36.41 | | |
| MLE of Mean | 33.66 | | |
| MLE of Standard Deviation | 35.01 | | |
| nu star | 99.84 | | |
| | | | |
| A-D Test Statistic | 3.353 | Nonparametric Statistics | |
| 5% A-D Critical Value | 0.781 | 90% Percentile | 66.43 |
| K-S Test Statistic | 0.248 | 95% Percentile | 106.9 |
| 5% K-S Critical Value | 0.125 | 99% Percentile | 262.4 |
| Data not Gamma Distributed at 5% Significance Level | | | |
| | | | |
| Assuming Gamma Distribution | | 95% UTL with 90% Coverage | 148 |
| 90% Percentile | 79.01 | 95% Percentile Bootstrap UTL with 90% Coverage | 129 |
| 95% Percentile | 103.7 | 95% BCA Bootstrap UTL with 90% Coverage | 129 |
| 99% Percentile | 161.3 | 95% UPL | 176 |
| | | 95% Chebyshev UPL | 264 |
| 95% WH Approx. Gamma UPL | 98.85 | Upper Threshold Limit Based upon IQR | 47.29 |
| 95% HW Approx. Gamma UPL | 98.04 | | |
| 95% WH Approx. Gamma UTL with 90% Coverage | 94.42 | | |
| 95% HW Approx. Gamma UTL with 90% Coverage | 93.3 | | |

**iron**

| | | | |
|---|---|---|---|
| General Statistics | | | |
| Total Number of Observations | 39 | Number of Distinct Observations | 35 |
| Tolerance Factor | 1.696 | | |
| | | | |
| Raw Statistics | | Log-Transformed Statistics | |
| Minimum | 0.0047 | Minimum | -5.36 |
| Maximum | 14.7 | Maximum | 2.688 |
| Second Largest | 11.8 | Second Largest | 2.468 |
| First Quartile | 0.03 | First Quartile | -3.507 |
| Median | 0.25 | Median | -1.386 |
| Third Quartile | 0.444 | Third Quartile | -0.823 |
| Mean | 1.576 | Mean | -1.646 |
| Geometric Mean | 0.193 | SD | 2.152 |
| SD | 3.536 | | |
| Coefficient of Variation | 2.243 | | |
| Skewness | 2.68 | | |
| | | | |
| Background Statistics | | | |
| Normal Distribution Test | | Lognormal Distribution Test | |
| Shapiro Wilk Test Statistic | 0.501 | Shapiro Wilk Test Statistic | 0.942 |
| Shapiro Wilk Critical Value | 0.939 | Shapiro Wilk Critical Value | 0.939 |
| Data not Normal at 5% Significance Level | | Data appear Lognormal at 5% Significance Level | |
| | | | |
| Assuming Normal Distribution | | Assuming Lognormal Distribution | |
| 95% UTL with 90% Coverage | 7.573 | 95% UTL with 90% Coverage | 7.418 |
| 95% UPL (t) | 7.613 | 95% UPL (t) | 7.603 |
| 90% Percentile (z) | 6.108 | 90% Percentile (z) | 3.041 |
| 95% Percentile (z) | 7.392 | 95% Percentile (z) | 6.645 |
| 99% Percentile (z) | 9.802 | 99% Percentile (z) | 28.8 |
| | | | |
| Gamma Distribution Test | | Data Distribution Test | |
| k star | 0.316 | Data appear Lognormal at 5% Significance Level | |
| Theta Star | 4.984 | | |
| MLE of Mean | 1.576 | | |
| MLE of Standard Deviation | 2.803 | | |
| nu star | 24.67 | | |
| | | | |
| A-D Test Statistic | 2.737 | Nonparametric Statistics | |
| 5% A-D Critical Value | 0.852 | 90% Percentile | 5.196 |
| K-S Test Statistic | 0.264 | 95% Percentile | 10.54 |
| 5% K-S Critical Value | 0.153 | 99% Percentile | 13.6 |
| Data not Gamma Distributed at 5% Significance Level | | | |
| | | | |
| Assuming Gamma Distribution | | 95% UTL with 90% Coverage | 11.8 |
| 90% Percentile | 4.618 | 95% Percentile Bootstrap UTL with 90% Coverage | 11.26 |
| 95% Percentile | 7.089 | 95% BCA Bootstrap UTL with 90% Coverage | 11.8 |
| 99% Percentile | 13.47 | 95% UPL | 11.8 |
| | | 95% Chebyshev UPL | 17.18 |
| 95% WH Approx. Gamma UPL | 5.749 | Upper Threshold Limit Based upon IQR | 1.065 |
| 95% HW Approx. Gamma UPL | 5.687 | | |
| 95% WH Approx. Gamma UTL with 90% Coverage | 5.682 | | |
| 95% HW Approx. Gamma UTL with 90% Coverage | 5.611 | | |

**manganese**

| | | | |
|---|---|---|---|
| General Statistics | | | |
| Total Number of Observations | 70 | Number of Distinct Observations | 61 |
| Tolerance Factor | 1.577 | | |
| | | | |
| Raw Statistics | | Log-Transformed Statistics | |
| Minimum | 0.0023 | Minimum | -6.075 |
| Maximum | 3.22 | Maximum | 1.169 |
| Second Largest | 1.05 | Second Largest | 0.0488 |
| First Quartile | 0.0257 | First Quartile | -3.695 |
| Median | 0.149 | Median | -1.91 |
| Third Quartile | 0.48 | Third Quartile | -0.735 |
| Mean | 0.347 | Mean | -2.149 |
| Geometric Mean | 0.117 | SD | 1.796 |
| SD | 0.487 | | |
| Coefficient of Variation | 1.403 | | |
| Skewness | 3.284 | | |
| | | | |
| Background Statistics | | | |
| Normal Distribution Test | | Lognormal Distribution Test | |
| Lilliefors Test Statistic | 0.239 | Lilliefors Test Statistic | 0.101 |
| Lilliefors Critical Value | 0.106 | Lilliefors Critical Value | 0.106 |
| Data not Normal at 5% Significance Level | | Data appear Lognormal at 5% Significance Level | |
| | | | |
| Assuming Normal Distribution | | Assuming Lognormal Distribution | |
| 95% UTL with 90% Coverage | 1.116 | 95% UTL with 90% Coverage | 1.981 |
| 95% UPL (t) | 1.166 | 95% UPL (t) | 2.378 |
| 90% Percentile (z) | 0.972 | 90% Percentile (z) | 1.165 |
| 95% Percentile (z) | 1.149 | 95% Percentile (z) | 2.236 |
| 99% Percentile (z) | 1.481 | 99% Percentile (z) | 7.604 |
| | | | |
| Gamma Distribution Test | | Data Distribution Test | |
| k star | 0.555 | Data appear Gamma Distributed at 5% Significance Level | |
| Theta Star | 0.625 | | |
| MLE of Mean | 0.347 | | |
| MLE of Standard Deviation | 0.466 | | |
| nu star | 77.76 | | |
| | | | |
| A-D Test Statistic | 0.749 | Nonparametric Statistics | |
| 5% A-D Critical Value | 0.81 | 90% Percentile | 0.927 |
| K-S Test Statistic | 0.0925 | 95% Percentile | 0.99 |
| 5% K-S Critical Value | 0.112 | 99% Percentile | 1.723 |
| Data appear Gamma Distributed at 5% Significance Level | | | |
| | | | |
| Assuming Gamma Distribution | | 95% UTL with 90% Coverage | 0.978 |
| 90% Percentile | 0.919 | 95% Percentile Bootstrap UTL with 90% Coverage | 0.98 |
| 95% Percentile | 1.285 | 95% BCA Bootstrap UTL with 90% Coverage | 1 |
| 99% Percentile | 2.177 | 95% UPL | 1.009 |
| | | 95% Chebyshev UPL | 2.486 |
| 95% WH Approx. Gamma UPL | 1.227 | Upper Threshold Limit Based upon IQR | 1.161 |
| 95% HW Approx. Gamma UPL | 1.326 | | |
| 95% WH Approx. Gamma UTL with 90% Coverage | 1.125 | | |
| 95% HW Approx. Gamma UTL with 90% Coverage | 1.2 | | |

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## B-2. Mann-Kendall Test results—Uranium for Mill Tailings Area Wells (1991+ data)

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| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 9:21 |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**U-612**

| | |
|---|---|
| General Statistics | |
| Number of Values | 28 |
| Minimum | 1.1 |
| Maximum | 3.53 |
| Mean | 2.005 |
| Geometric Mean | 1.898 |
| Median | 1.86 |
| Standard Deviation | 0.698 |
| SEM | 0.132 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | -224 |
| Critical Value (0.05) | -1.645 |
| Standard Deviation of S | 50.53 |
| Standardized Value of S | -4.413 |
| Approximate p-value | 5.09E-06 |

Statistically significant evidence of a decreasing
trend at the specified level of significance.

Mann-Kendall Trend Test Analysis

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 9:21 |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**U-617**

| | |
|---|---|
| General Statistics | |
| Number of Values | 28 |
| Minimum | 0.12 |
| Maximum | 0.33 |
| Mean | 0.207 |
| Geometric Mean | 0.2 |
| Median | 0.21 |
| Standard Deviation | 0.0547 |
| SEM | 0.0103 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | -226 |
| Critical Value (0.05) | -1.645 |
| Standard Deviation of S | 50.58 |
| Standardized Value of S | -4.449 |
| Approximate p-value | 4.32E-06 |

Statistically significant evidence of a decreasing
trend at the specified level of significance.

| | Mann-Kendall Trend Test Analysis |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 9:22 |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**U-630**

| | |
|---|---|
| General Statistics | |
| Number of Values | 24 |
| Minimum | 0.0344 |
| Maximum | 0.29 |
| Mean | 0.197 |
| Geometric Mean | 0.176 |
| Median | 0.208 |
| Standard Deviation | 0.0732 |
| SEM | 0.0149 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | 175 |
| Critical Value (0.05) | 1.645 |
| Standard Deviation of S | 40.25 |
| Standardized Value of S | 4.323 |
| Approximate p-value | 7.71E-06 |

Statistically significant evidence of an increasing
trend at the specified level of significance.

| | Mann-Kendall Trend Test Analysis |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 9:22 |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**U-631**

| | |
|---|---|
| General Statistics | |
| Number of Values | 24 |
| Minimum | 0.075 |
| Maximum | 0.63 |
| Mean | 0.272 |
| Geometric Mean | 0.226 |
| Median | 0.23 |
| Standard Deviation | 0.168 |
| SEM | 0.0343 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | -219 |
| Critical Value (0.05) | -1.645 |
| Standard Deviation of S | 40.27 |
| Standardized Value of S | -5.413 |
| Approximate p-value | 3.09E-08 |

Statistically significant evidence of a decreasing
trend at the specified level of significance.

| | Mann-Kendall Trend Test Analysis |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 9:23 |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**U-633**

| | |
|---|---|
| General Statistics | |
| Number of Values | 24 |
| Minimum | 0.48 |
| Maximum | 1.38 |
| Mean | 0.977 |
| Geometric Mean | 0.944 |
| Median | 0.931 |
| Standard Deviation | 0.251 |
| SEM | 0.0512 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | -105 |
| Critical Value (0.05) | -1.645 |
| Standard Deviation of S | 40.3 |
| Standardized Value of S | -2.58 |
| Approximate p-value | 0.00493 |

Statistically significant evidence of a decreasing
trend at the specified level of significance.

| | Mann-Kendall Trend Test Analysis |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 9:25 |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.8 |
| Level of Significance | 0.2 |

**U-634**

| | |
|---|---|
| General Statistics | |
| Number of Values | 24 |
| Minimum | 0.012 |
| Maximum | 0.184 |
| Mean | 0.053 |
| Geometric Mean | 0.0445 |
| Median | 0.0431 |
| Standard Deviation | 0.0362 |
| SEM | 0.00739 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | 41 |
| Critical Value (0.2) | 0.842 |
| Standard Deviation of S | 40.28 |
| Standardized Value of S | 0.993 |
| Approximate p-value | 0.16 |

Statistically significant evidence of an increasing
trend at the specified level of significance.

| | |
|---|---|
| | Mann-Kendall Trend Test Analysis |
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 9:26 |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**U-635**

| | |
|---|---|
| General Statistics | |
| Number of Values | 24 |
| Minimum | 0.0044 |
| Maximum | 0.017 |
| Mean | 0.00863 |
| Geometric Mean | 0.00814 |
| Median | 0.00805 |
| Standard Deviation | 0.00303 |
| SEM | 6.19E-04 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | 174 |
| Critical Value (0.05) | 1.645 |
| Standard Deviation of S | 40.02 |
| Standardized Value of S | 4.323 |
| Approximate p-value | 7.69E-06 |

Statistically significant evidence of an increasing
trend at the specified level of significance.

| | |
|---|---|
| | Mann-Kendall Trend Test Analysis |
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 9:27 |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**U-622**

| | |
|---|---|
| General Statistics | |
| Number of Values | 32 |
| Minimum | 0.009 |
| Maximum | 0.15 |
| Mean | 0.0344 |
| Geometric Mean | 0.0258 |
| Median | 0.0215 |
| Standard Deviation | 0.0324 |
| SEM | 0.00573 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | -176 |
| Critical Value (0.05) | -1.645 |
| Standard Deviation of S | 61.65 |
| Standardized Value of S | -2.839 |
| Approximate p-value | 0.00227 |

Statistically significant evidence of a decreasing trend at the specified level of significance.

## B-3. Mann-Kendall Test Results—Uranium for Mill Tailings Area Wells (2001+ data)

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| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 8:12 |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**U-0863**

| | |
|---|---|
| General Statistics | |
| Number of Values | 16 |
| Minimum | 8.50E-05 |
| Maximum | 0.0028 |
| Mean | 5.23E-04 |
| Geometric Mean | 2.58E-04 |
| Median | 1.55E-04 |
| Standard Deviation | 7.65E-04 |
| SEM | 1.91E-04 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | -55 |
| Tabulated p-value | 0.008 |
| Standard Deviation of S | 22.19 |
| Standardized Value of S | -2.434 |
| Approximate p-value | 0.00747 |

Statistically significant evidence of a decreasing
trend at the specified level of significance.

Mann-Kendall Trend Test Analysis

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 8:35 |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**U-612**

| | |
|---|---|
| General Statistics | |
| Number of Values | 16 |
| Minimum | 1.1 |
| Maximum | 2.41 |
| Mean | 1.644 |
| Geometric Mean | 1.6 |
| Median | 1.58 |
| Standard Deviation | 0.4 |
| SEM | 0.1 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | -66 |
| Tabulated p-value | 0.001 |
| Standard Deviation of S | 22.06 |
| Standardized Value of S | -2.946 |
| Approximate p-value | 0.00161 |

Statistically significant evidence of a decreasing trend at the specified level of significance.

| | |
|---|---|
| | Mann-Kendall Trend Test Analysis |
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 8:38 |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.9 |
| Level of Significance | 0.1 |

**U-617**

| General Statistics | |
|---|---|
| Number of Values | 16 |
| Minimum | 0.12 |
| Maximum | 0.244 |
| Mean | 0.171 |
| Geometric Mean | 0.168 |
| Median | 0.165 |
| Standard Deviation | 0.036 |
| SEM | 0.009 |

| Mann-Kendall Test | |
|---|---|
| Test Value (S) | -36 |
| Tabulated p-value | 0.058 |
| Standard Deviation of S | 22.12 |
| Standardized Value of S | -1.582 |
| Approximate p-value | 0.0568 |

Statistically significant evidence of a decreasing
trend at the specified level of significance.

| | Mann-Kendall Trend Test Analysis |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 8:39 |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**U-630**

| | |
|---|---|
| General Statistics | |
| Number of Values | 16 |
| Minimum | 0.172 |
| Maximum | 0.29 |
| Mean | 0.238 |
| Geometric Mean | 0.235 |
| Median | 0.24 |
| Standard Deviation | 0.0351 |
| SEM | 0.00877 |
| | |
| Mann-Kendall Test | |
| Test Value (S) | 66 |
| Tabulated p-value | 0.001 |
| Standard Deviation of S | 22.12 |
| Standardized Value of S | 2.938 |
| Approximate p-value | 0.00165 |

Statistically significant evidence of an increasing
trend at the specified level of significance.

| | |
|---|---|
| | Mann-Kendall Trend Test Analysis |
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 8:40 |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**U-631**

| | |
|---|---|
| General Statistics | |
| Number of Values | 16 |
| Minimum | 0.075 |
| Maximum | 0.344 |
| Mean | 0.177 |
| Geometric Mean | 0.162 |
| Median | 0.164 |
| Standard Deviation | 0.0811 |
| SEM | 0.0203 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | -89 |
| Tabulated p-value | 0 |
| Standard Deviation of S | 22.13 |
| Standardized Value of S | -3.977 |
| Approximate p-value | 3.49E-05 |

Statistically significant evidence of a decreasing
trend at the specified level of significance.

| | Mann-Kendall Trend Test Analysis |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 8:40 |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**U-633**

| | |
|---|---|
| General Statistics | |
| Number of Values | 16 |
| Minimum | 0.48 |
| Maximum | 1.38 |
| Mean | 0.91 |
| Geometric Mean | 0.874 |
| Median | 0.875 |
| Standard Deviation | 0.265 |
| SEM | 0.0662 |
| | |
| Mann-Kendall Test | |
| Test Value (S) | -40 |
| Tabulated p-value | 0.039 |
| Standard Deviation of S | 22.21 |
| Standardized Value of S | -1.756 |
| Approximate p-value | 0.0396 |

Statistically significant evidence of a decreasing
trend at the specified level of significance.

| | Mann-Kendall Trend Test Analysis |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 8:41 |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.8 |
| Level of Significance | 0.2 |

**U-634**

| | |
|---|---|
| General Statistics | |
| Number of Values | 16 |
| Minimum | 0.017 |
| Maximum | 0.184 |
| Mean | 0.0622 |
| Geometric Mean | 0.0523 |
| Median | 0.056 |
| Standard Deviation | 0.0409 |
| SEM | 0.0102 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | -25 |
| Tabulated p-value | 0.153 |
| Standard Deviation of S | 22.14 |
| Standardized Value of S | -1.084 |
| Approximate p-value | 0.139 |

Statistically significant evidence of a decreasing
trend at the specified level of significance.

| | Mann-Kendall Trend Test Analysis |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 9:28 |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**U-635**

| General Statistics | |
|---|---|
| Number of Values | 24 |
| Minimum | 0.0044 |
| Maximum | 0.017 |
| Mean | 0.00863 |
| Geometric Mean | 0.00814 |
| Median | 0.00805 |
| Standard Deviation | 0.00303 |
| SEM | 6.19E-04 |

| Mann-Kendall Test | |
|---|---|
| Test Value (S) | 174 |
| Critical Value (0.05) | 1.645 |
| Standard Deviation of S | 40.02 |
| Standardized Value of S | 4.323 |
| Approximate p-value | 7.69E-06 |

Statistically significant evidence of an increasing trend at the specified level of significance.

| | Mann-Kendall Trend Test Analysis |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 8:43 |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.8 |
| Level of Significance | 0.2 |

**average U**

| | |
|---|---|
| General Statistics | |
| Number of Values | 16 |
| Minimum | 0.344 |
| Maximum | 0.621 |
| Mean | 0.459 |
| Geometric Mean | 0.451 |
| Median | 0.438 |
| Standard Deviation | 0.0913 |
| SEM | 0.0228 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | -73 |
| Tabulated p-value | 0 |
| Standard Deviation of S | 22.19 |
| Standardized Value of S | -3.245 |
| Approximate p-value | 5.87E-04 |

Statistically significant evidence of a decreasing
trend at the specified level of significance.

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**B-4. Mann-Kendall Test Results—Sulfate for Mill Tailings Area Wells (2001+ data)**

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| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 9:31 |
| From File | WorkSheet_a.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**SO4-622**

| | |
|---|---|
| General Statistics | |
| Number of Values | 32 |
| Minimum | 42 |
| Maximum | 1100 |
| Mean | 287.6 |
| Geometric Mean | 225.8 |
| Median | 200.5 |
| Standard Deviation | 249.2 |
| SEM | 44.05 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | -117 |
| Critical Value (0.05) | -1.645 |
| Standard Deviation of S | 61.64 |
| Standardized Value of S | -1.882 |
| Approximate p-value | 0.0299 |

Statistically significant evidence of a decreasing
trend at the specified level of significance.

Mann-Kendall Trend Test Analysis

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 9:31 |
| From File | WorkSheet_a.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**SO4-612**

| | |
|---|---|
| General Statistics | |
| Number of Values | 24 |
| Minimum | 1500 |
| Maximum | 3080 |
| Mean | 2152 |
| Geometric Mean | 2119 |
| Median | 2195 |
| Standard Deviation | 385.1 |
| SEM | 78.61 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | -154 |
| Critical Value (0.05) | -1.645 |
| Standard Deviation of S | 40.23 |
| Standardized Value of S | -3.803 |
| Approximate p-value | 7.15E-05 |

Statistically significant evidence of a decreasing
trend at the specified level of significance.

| | Mann-Kendall Trend Test Analysis |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 9:32 |
| From File | WorkSheet_a.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**SO4-617**

| | |
|---|---|
| General Statistics | |
| Number of Values | 24 |
| Minimum | 1640 |
| Maximum | 2230 |
| Mean | 1982 |
| Geometric Mean | 1975 |
| Median | 2000 |
| Standard Deviation | 167.5 |
| SEM | 34.2 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | -82 |
| Critical Value (0.05) | -1.645 |
| Standard Deviation of S | 40.18 |
| Standardized Value of S | -2.016 |
| Approximate p-value | 0.0219 |

Statistically significant evidence of a decreasing
trend at the specified level of significance.

| | Mann-Kendall Trend Test Analysis |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 9:33 |
| From File | WorkSheet_a.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**SO4-630**

| | |
|---|---|
| General Statistics | |
| Number of Values | 24 |
| Minimum | 1600 |
| Maximum | 2550 |
| Mean | 1996 |
| Geometric Mean | 1979 |
| Median | 1915 |
| Standard Deviation | 267.6 |
| SEM | 54.63 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | -195 |
| Critical Value (0.05) | -1.645 |
| Standard Deviation of S | 40.09 |
| Standardized Value of S | -4.839 |
| Approximate p-value | 6.51E-07 |

Statistically significant evidence of a decreasing trend at the specified level of significance.

Mann-Kendall Trend Test Analysis

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 9:34 |
| From File | WorkSheet_a.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**SO4-631**

| | |
|---|---|
| General Statistics | |
| Number of Values | 24 |
| Minimum | 150 |
| Maximum | 1600 |
| Mean | 604.2 |
| Geometric Mean | 464.3 |
| Median | 519.5 |
| Standard Deviation | 427.8 |
| SEM | 87.32 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | -172 |
| Critical Value (0.05) | -1.645 |
| Standard Deviation of S | 40.29 |
| Standardized Value of S | -4.244 |
| Approximate p-value | 1.10E-05 |

Statistically significant evidence of a decreasing trend at the specified level of significance.

Mann-Kendall Trend Test Analysis

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 9:34 |
| From File | WorkSheet_a.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.7 |
| Level of Significance | 0.3 |

**SO4-633**

| | |
|---|---|
| General Statistics | |
| Number of Values | 24 |
| Minimum | 2160 |
| Maximum | 3900 |
| Mean | 3116 |
| Geometric Mean | 3078 |
| Median | 3170 |
| Standard Deviation | 483.7 |
| SEM | 98.74 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | 27 |
| Critical Value (0.3) | 0.524 |
| Standard Deviation of S | 40.27 |
| Standardized Value of S | 0.646 |
| Approximate p-value | 0.259 |

Statistically significant evidence of an increasing
trend at the specified level of significance.

| | |
|---|---|
| | Mann-Kendall Trend Test Analysis |
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 9:35 |
| From File | WorkSheet_a.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.95 |
| Level of Significance | 0.05 |

**SO4-634**

| | |
|---|---|
| General Statistics | |
| Number of Values | 24 |
| Minimum | 585 |
| Maximum | 2500 |
| Mean | 2146 |
| Geometric Mean | 2090 |
| Median | 2200 |
| Standard Deviation | 365.4 |
| SEM | 74.6 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | 70 |
| Critical Value (0.05) | 1.645 |
| Standard Deviation of S | 40.07 |
| Standardized Value of S | 1.722 |
| Approximate p-value | 0.0426 |

Statistically significant evidence of an increasing trend at the specified level of significance.

Mann-Kendall Trend Test Analysis

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 9:36 |
| From File | WorkSheet_a.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.85 |
| Level of Significance | 0.15 |

**SO4-635**

| | |
|---|---|
| General Statistics | |
| Number of Values | 24 |
| Minimum | 810 |
| Maximum | 1600 |
| Mean | 1123 |
| Geometric Mean | 1104 |
| Median | 1100 |
| Standard Deviation | 216.3 |
| SEM | 44.15 |
| | |
| Mann-Kendall Test | |
| Test Value (S) | 45 |
| Critical Value (0.15) | 1.036 |
| Standard Deviation of S | 40.21 |
| Standardized Value of S | 1.094 |
| Approximate p-value | 0.137 |

Statistically significant evidence of an increasing
trend at the specified level of significance.

| | |
|---|---|
| | Mann-Kendall Trend Test Analysis |
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 14:10 |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.9 |
| Level of Significance | 0.1 |

**avg sulfate**

| | |
|---|---|
| General Statistics | |
| Number of Values | 17 |
| Minimum | 1522 |
| Maximum | 1940 |
| Mean | 1664 |
| Geometric Mean | 1660 |
| Median | 1644 |
| Standard Deviation | 113.5 |
| SEM | 27.54 |
| | |
| Mann-Kendall Test | |
| Test Value (S) | -34 |
| Tabulated p-value | 0.088 |
| Standard Deviation of S | 24.28 |
| Standardized Value of S | -1.359 |
| Approximate p-value | 8.70E-02 |

Statistically significant evidence of a decreasing
trend at the specified level of significance.

| | Mann-Kendall Trend Test Analysis |
|---|---|
| User Selected Options | |
| Date/Time of Computation | 4/17/2014 9:38 |
| From File | WorkSheet_a.wst |
| Full Precision | OFF |
| Confidence Coefficient | 0.75 |
| Level of Significance | 0.25 |

**SO4-863**

| | |
|---|---|
| General Statistics | |
| Number of Values | 17 |
| Minimum | 544 |
| Maximum | 690 |
| Mean | 643.6 |
| Geometric Mean | 642.4 |
| Median | 650 |
| Standard Deviation | 41.13 |
| SEM | 9.975 |

| | |
|---|---|
| Mann-Kendall Test | |
| Test Value (S) | 19 |
| Tabulated p-value | 0.245 |
| Standard Deviation of S | 24.21 |
| Standardized Value of S | 0.743 |
| Approximate p-value | 0.229 |

Statistically significant evidence of an increasing trend at the specified level of significance.

## B-5. Post-Remediation Uranium Baseline Statistics—Mill Tailings Area Wells

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**Nonparametric Background Statistics for Full Data Sets--Data from 1994 to 2004--Uranium in onsite mill tailings area wells**

| | |
|---|---|
| User Selected Options | |
| From File | WorkSheet.wst |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Coverage | 90% |
| Number of Bootstrap Operations | 2000 |

**U-612**

| | |
|---|---|
| Some Non-Parametric Statistics | |
| Number of Valid Observations | 16 |
| Number of Distinct Observations | 14 |
| Minimum | 1.34 |
| Maximum | 3.22 |
| Second Largest | 3.1 |
| Mean | 2.144 |
| Geometric Mean | 2.082 |
| First Quartile | 1.79 |
| Median | 1.98 |
| Third Quartile | 2.305 |
| SD | 0.552 |
| Variance | 0.304 |
| Coefficient of Variation | 0.257 |
| Skewness | 0.889 |
| Mean of Log-Transformed data | 0.733 |
| SD of Log-Transformed data | 0.246 |

Data appear Normal at 5% Significance Level

| | |
|---|---|
| Non-Parametric Background Statistics | |
| 90% Percentile | 3.075 |
| 95% Percentile | 3.13 |
| 99% Percentile | 3.202 |
| | |
| 95% UTL with 90% Coverage | |
| Order Statistic | 16 |
| Achieved CC | 1 |
| UTL | 3.22 |
| | |
| 95% BCA Bootstrap UTL with 90% Coverage | 3.22 |
| 95% Percentile Bootstrap UTL with 90% Coverage | 3.22 |
| | |
| 95% UPL | 3.22 |
| 95% Chebyshev UPL | 4.622 |
| | |
| Upper Limit Based upon IQR | 3.078 |

**U-617**

| | |
|---|---|
| Some Non-Parametric Statistics | |
| Number of Valid Observations | 16 |
| Number of Distinct Observations | 16 |
| Minimum | 0.12 |
| Maximum | 0.33 |
| Second Largest | 0.298 |
| Mean | 0.225 |
| Geometric Mean | 0.218 |
| First Quartile | 0.211 |
| Median | 0.231 |
| Third Quartile | 0.244 |
| SD | 0.056 |
| Variance | 0.00314 |
| Coefficient of Variation | 0.249 |
| Skewness | -0.264 |
| Mean of Log-Transformed data | -1.524 |
| SD of Log-Transformed data | 0.276 |
| | |
| Data appear Normal at 5% Significance Level | |
| | |
| Non-Parametric Background Statistics | |
| 90% Percentile | 0.291 |
| 95% Percentile | 0.306 |
| 99% Percentile | 0.325 |
| | |
| 95% UTL with 90% Coverage | |
| Order Statistic | 16 |
| Achieved CC | 1 |
| UTL | 0.33 |
| | |
| 95% BCA Bootstrap UTL with 90% Coverage | 0.33 |
| 95% Percentile Bootstrap UTL with 90% Coverage | 0.33 |
| | |
| 95% UPL | 0.33 |
| 95% Chebyshev UPL | 0.477 |
| | |
| Upper Limit Based upon IQR | 0.295 |

**U-630**

| | |
|---|---|
| Some Non-Parametric Statistics | |
| Number of Valid Observations | 15 |
| Number of Distinct Observations | 14 |
| Minimum | 0.0344 |
| Maximum | 0.26 |
| Second Largest | 0.214 |
| Mean | 0.159 |
| Geometric Mean | 0.14 |
| First Quartile | 0.12 |
| Median | 0.174 |
| Third Quartile | 0.203 |
| SD | 0.0666 |
| Variance | 0.00444 |
| Coefficient of Variation | 0.419 |
| Skewness | -0.694 |
| Mean of Log-Transformed data | -1.968 |
| SD of Log-Transformed data | 0.601 |
| | |
| Data appear Normal at 5% Significance Level | |
| | |
| Non-Parametric Background Statistics | |
| 90% Percentile | 0.213 |
| 95% Percentile | 0.228 |
| 99% Percentile | 0.254 |
| | |
| 95% UTL with 90% Coverage | |
| Order Statistic | 15 |
| Achieved CC | 1 |
| UTL | 0.26 |
| | |
| 95% BCA Bootstrap UTL with 90% Coverage | 0.242 |
| 95% Percentile Bootstrap UTL with 90% Coverage | 0.26 |
| | |
| 95% UPL | 0.26 |
| 95% Chebyshev UPL | 0.459 |
| | |
| Upper Limit Based upon IQR | 0.328 |

**U-631**

| | |
|---|---|
| Some Non-Parametric Statistics | |
| Number of Valid Observations | 15 |
| Number of Distinct Observations | 15 |
| Minimum | 0.168 |
| Maximum | 0.63 |
| Second Largest | 0.61 |
| Mean | 0.357 |
| Geometric Mean | 0.325 |
| First Quartile | 0.23 |
| Median | 0.344 |
| Third Quartile | 0.443 |
| SD | 0.156 |
| Variance | 0.0244 |
| Coefficient of Variation | 0.438 |
| Skewness | 0.479 |
| Mean of Log-Transformed data | -1.124 |
| SD of Log-Transformed data | 0.454 |
| | |
| Data appear Normal at 5% Significance Level | |
| | |
| Non-Parametric Background Statistics | |
| 90% Percentile | 0.589 |
| 95% Percentile | 0.616 |
| 99% Percentile | 0.627 |
| | |
| 95% UTL with 90% Coverage | |
| Order Statistic | 15 |
| Achieved CC | 1 |
| UTL | 0.63 |
| | |
| 95% BCA Bootstrap UTL with 90% Coverage | 0.63 |
| 95% Percentile Bootstrap UTL with 90% Coverage | 0.63 |
| | |
| 95% UPL | 0.63 |
| 95% Chebyshev UPL | 1.06 |
| | |
| Upper Limit Based upon IQR | 0.762 |

**U-633**

| | |
|---|---|
| Some Non-Parametric Statistics | |
| Number of Valid Observations | 15 |
| Number of Distinct Observations | 14 |
| Minimum | 0.65 |
| Maximum | 1.38 |
| Second Largest | 1.32 |
| Mean | 1.076 |
| Geometric Mean | 1.054 |
| First Quartile | 0.919 |
| Median | 1.08 |
| Third Quartile | 1.29 |
| SD | 0.219 |
| Variance | 0.0479 |
| Coefficient of Variation | 0.203 |
| Skewness | -0.211 |
| Mean of Log-Transformed data | 0.0528 |
| SD of Log-Transformed data | 0.215 |
| | |
| Data appear Normal at 5% Significance Level | |
| | |
| Non-Parametric Background Statistics | |
| 90% Percentile | 1.32 |
| 95% Percentile | 1.338 |
| 99% Percentile | 1.372 |
| | |
| 95% UTL with 90% Coverage | |
| Order Statistic | 15 |
| Achieved CC | 1 |
| UTL | 1.38 |
| | |
| 95% BCA Bootstrap UTL with 90% Coverage | 1.356 |
| 95% Percentile Bootstrap UTL with 90% Coverage | 1.38 |
| | |
| 95% UPL | 1.38 |
| 95% Chebyshev UPL | 2.062 |
| | |
| Upper Limit Based upon IQR | 1.847 |

**U-634**

| | |
|---|---|
| Some Non-Parametric Statistics | |
| Number of Valid Observations | 15 |
| Number of Distinct Observations | 15 |
| Minimum | 0.012 |
| Maximum | 0.184 |
| Second Largest | 0.0608 |
| Mean | 0.0506 |
| Geometric Mean | 0.0426 |
| First Quartile | 0.0342 |
| Median | 0.0388 |
| Third Quartile | 0.0568 |
| SD | 0.0392 |
| Variance | 0.00154 |
| Coefficient of Variation | 0.776 |
| Skewness | 3.126 |
| Mean of Log-Transformed data | -3.156 |
| SD of Log-Transformed data | 0.569 |
| | |
| Data do not follow a Discernable Distribution (0.05) | |
| | |
| Non-Parametric Background Statistics | |
| 90% Percentile | 0.0604 |
| 95% Percentile | 0.0978 |
| 99% Percentile | 0.167 |
| | |
| 95% UTL with 90% Coverage | |
| Order Statistic | 15 |
| Achieved CC | 1 |
| UTL | 0.184 |
| | |
| 95% BCA Bootstrap UTL with 90% Coverage | 0.184 |
| 95% Percentile Bootstrap UTL with 90% Coverage | 0.184 |
| | |
| 95% UPL | 0.184 |
| 95% Chebyshev UPL | 0.227 |
| | |
| Upper Limit Based upon IQR | 0.0906 |

**U-635**

| | |
|---|---|
| Some Non-Parametric Statistics | |
| Number of Valid Observations | 15 |
| Number of Distinct Observations | 13 |
| Minimum | 0.0044 |
| Maximum | 0.011 |
| Second Largest | 0.01 |
| Mean | 0.00705 |
| Geometric Mean | 0.0068 |
| First Quartile | 0.0057 |
| Median | 0.0065 |
| Third Quartile | 0.00805 |
| SD | 0.00202 |
| Variance | 4.08E-06 |
| Coefficient of Variation | 0.287 |
| Skewness | 0.638 |
| Mean of Log-Transformed data | -4.991 |
| SD of Log-Transformed data | 0.281 |
| | |
| Data appear Normal at 5% Significance Level | |
| | |
| Non-Parametric Background Statistics | |
| 90% Percentile | 0.00996 |
| 95% Percentile | 0.0103 |
| 99% Percentile | 0.0109 |
| | |
| 95% UTL with 90% Coverage | |
| Order Statistic | 15 |
| Achieved CC | 1 |
| UTL | 0.011 |
| | |
| 95% BCA Bootstrap UTL with 90% Coverage | 0.011 |
| 95% Percentile Bootstrap UTL with 90% Coverage | 0.011 |
| | |
| 95% UPL | 0.011 |
| 95% Chebyshev UPL | 0.0162 |
| | |
| Upper Limit Based upon IQR | 0.0116 |

**U-avg**

| | |
|---|---|
| Some Non-Parametric Statistics | |
| Number of Valid Observations | 15 |
| Number of Distinct Observations | 15 |
| Minimum | 0.421 |
| Maximum | 0.729 |
| Second Largest | 0.725 |
| Mean | 0.563 |
| Geometric Mean | 0.557 |
| First Quartile | 0.521 |
| Median | 0.554 |
| Third Quartile | 0.605 |
| SD | 0.0892 |
| Variance | 0.00796 |
| Coefficient of Variation | 0.158 |
| Skewness | 0.348 |
| Mean of Log-Transformed data | -0.586 |
| SD of Log-Transformed data | 0.158 |

Data appear Normal at 5% Significance Level

| | |
|---|---|
| Non-Parametric Background Statistics | |
| 90% Percentile | 0.683 |
| 95% Percentile | 0.726 |
| 99% Percentile | 0.728 |
| 95% UTL with 90% Coverage | |
| Order Statistic | 15 |
| Achieved CC | 1 |
| UTL | 0.729 |
| 95% BCA Bootstrap UTL with 90% Coverage | 0.729 |
| 95% Percentile Bootstrap UTL with 90% Coverage | 0.729 |
| 95% UPL | 0.729 |
| 95% Chebyshev UPL | 0.965 |
| Upper Limit Based upon IQR | 0.731 |

**Statistics of avg. on-site wells without background**

Background Statistics

| | | | |
|---|---|---|---|
| Normal Distribution Test | | Lognormal Distribution Test | |
| Shapiro Wilk Test Statistic | 0.943 | Shapiro Wilk Test Statistic | 0.952 |
| Shapiro Wilk Critical Value | 0.881 | Shapiro Wilk Critical Value | 0.881 |
| Data appear Normal at 5% Significance Level | | Data appear Lognormal at 5% Significance Level | |
| Assuming Normal Distribution | | Assuming Lognormal Distribution | |
| 95% UTL with 90% Coverage | 0.871 | 95% UTL with 90% Coverage | 0.9 |
| 95% UPL (t) | 0.845 | 95% UPL (t) | 0.865 |
| 90% Percentile (z) | 0.789 | 90% Percentile (z) | 0.794 |
| 95% Percentile (z) | 0.827 | 95% Percentile (z) | 0.842 |
| 99% Percentile (z) | 0.898 | 99% Percentile (z) | 0.938 |
| Gamma Distribution Test | | Data Distribution Test | |
| k star | 34.32 | Data appear Normal at 5% Significance Level | |
| Theta Star | 0.0191 | | |
| MLE of Mean | 0.656 | | |
| MLE of Standard Deviation | 0.112 | | |
| nu star | 1029 | | |
| A-D Test Statistic | 0.347 | Nonparametric Statistics | |
| 5% A-D Critical Value | 0.735 | 90% Percentile | 0.796 |
| K-S Test Statistic | 0.166 | 95% Percentile | 0.845 |
| 5% K-S Critical Value | 0.221 | 99% Percentile | 0.847 |
| Data appear Gamma Distributed at 5% Significance Level | | | |
| Assuming Gamma Distribution | | 95% UTL with 90% Coverage | 0.848 |
| 90% Percentile | 0.803 | 95% Percentile Bootstrap UTL with 90% Coverage | 0.848 |
| 95% Percentile | 0.85 | 95% BCA Bootstrap UTL with 90% Coverage | 0.848 |
| 99% Percentile | 0.944 | 95% UPL | 0.848 |
| | | 95% Chebyshev UPL | 1.124 |
| 95% WH Approx. Gamma UPL | 0.857 | Upper Threshold Limit Based upon IQR | 0.854 |
| 95% HW Approx. Gamma UPL | 0.859 | | |
| 95% WH Approx. Gamma UTL with 90% Coverage | 0.888 | | |
| 95% HW Approx. Gamma UTL with 90% Coverage | 0.891 | | |

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## B-6. Post-Remediation Uranium Baseline Statistics—Raffinate Ponds Area Wells

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**General Background Statistics for Full Data Sets--Uranium data from post-1994 through 2009--Raffinate area onsite wells**

| | |
|---|---|
| User Selected Options | |
| From File | WorkSheet_a.wst |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Coverage | 90% |
| Different or Future K Values | 1 |
| Number of Bootstrap Operations | 2000 |

**U-594**

| | | | |
|---|---|---|---|
| General Statistics | | | |
| Total Number of Observations | 10 | Number of Distinct Observations | 10 |
| Tolerance Factor | 2.355 | | |
| | | | |
| Raw Statistics | | Log-Transformed Statistics | |
| Minimum | 0.0305 | Minimum | -3.49 |
| Maximum | 0.192 | Maximum | -1.65 |
| Second Largest | 0.084 | Second Largest | -2.477 |
| First Quartile | 0.0383 | First Quartile | -3.265 |
| Median | 0.053 | Median | -2.956 |
| Third Quartile | 0.067 | Third Quartile | -2.704 |
| Mean | 0.0656 | Mean | -2.887 |
| Geometric Mean | 0.0557 | SD | 0.555 |
| SD | 0.0478 | | |
| Coefficient of Variation | 0.729 | | |
| Skewness | 2.408 | | |
| | | | |
| Background Statistics | | | |
| Normal Distribution Test | | Lognormal Distribution Test | |
| Shapiro Wilk Test Statistic | 0.7 | Shapiro Wilk Test Statistic | 0.894 |
| Shapiro Wilk Critical Value | 0.842 | Shapiro Wilk Critical Value | 0.842 |
| Data not Normal at 5% Significance Level | | Data appear Lognormal at 5% Significance Level | |
| | | | |
| Assuming Normal Distribution | | Assuming Lognormal Distribution | |
| 95% UTL with 90% Coverage | 0.178 | 95% UTL with 90% Coverage | 0.206 |
| 95% UPL (t) | 0.158 | 95% UPL (t) | 0.162 |
| 90% Percentile (z) | 0.127 | 90% Percentile (z) | 0.113 |
| 95% Percentile (z) | 0.144 | 95% Percentile (z) | 0.139 |
| 99% Percentile (z) | 0.177 | 99% Percentile (z) | 0.202 |
| | | | |
| Gamma Distribution Test | | Data Distribution Test | |
| k star | 2.327 | Data appear Gamma Distributed at 5% Significance Level | |
| Theta Star | 0.0282 | | |
| MLE of Mean | 0.0656 | | |
| MLE of Standard Deviation | 0.043 | | |
| nu star | 46.54 | | |
| | | | |
| A-D Test Statistic | 0.63 | Nonparametric Statistics | |
| 5% A-D Critical Value | 0.732 | 90% Percentile | 0.0948 |
| K-S Test Statistic | 0.205 | 95% Percentile | 0.143 |
| 5% K-S Critical Value | 0.268 | 99% Percentile | 0.182 |
| Data appear Gamma Distributed at 5% Significance Level | | | |
| | | | |
| Assuming Gamma Distribution | | 95% UTL with 90% Coverage | 0.192 |
| 90% Percentile | 0.123 | 95% Percentile Bootstrap UTL with 90% Coverage | 0.192 |
| 95% Percentile | 0.148 | 95% BCA Bootstrap UTL with 90% Coverage | 0.192 |
| 99% Percentile | 0.204 | 95% UPL | 0.192 |
| | | 95% Chebyshev UPL | 0.284 |
| 95% WH Approx. Gamma UPL | 0.157 | Upper Threshold Limit Based upon IQR | 0.11 |
| 95% HW Approx. Gamma UPL | 0.158 | | |
| 95% WH Approx. Gamma UTL with 90% Coverage | 0.189 | | |
| 95% HW Approx. Gamma UTL with 90% Coverage | 0.192 | | |

**U-598**

| | | | |
|---|---|---|---|
| General Statistics | | | |
| Total Number of Observations | 17 | Number of Distinct Observations | 16 |
| Tolerance Factor | 2.002 | | |
| | | | |
| Raw Statistics | | Log-Transformed Statistics | |
| Minimum | 0.0497 | Minimum | -3.002 |
| Maximum | 0.278 | Maximum | -1.28 |
| Second Largest | 0.23 | Second Largest | -1.47 |
| First Quartile | 0.0718 | First Quartile | -2.634 |
| Median | 0.0983 | Median | -2.32 |
| Third Quartile | 0.13 | Third Quartile | -2.04 |
| Mean | 0.121 | Mean | -2.248 |
| Geometric Mean | 0.106 | SD | 0.529 |
| SD | 0.0688 | | |
| Coefficient of Variation | 0.568 | | |
| Skewness | 1.13 | | |
| | | | |
| Background Statistics | | | |
| Normal Distribution Test | | Lognormal Distribution Test | |
| Shapiro Wilk Test Statistic | 0.858 | Shapiro Wilk Test Statistic | 0.948 |
| Shapiro Wilk Critical Value | 0.892 | Shapiro Wilk Critical Value | 0.892 |
| Data not Normal at 5% Significance Level | | Data appear Lognormal at 5% Significance Level | |
| | | | |
| Assuming Normal Distribution | | Assuming Lognormal Distribution | |
| 95% UTL with 90% Coverage | 0.259 | 95% UTL with 90% Coverage | 0.305 |
| 95% UPL (t) | 0.245 | 95% UPL (t) | 0.273 |
| 90% Percentile (z) | 0.209 | 90% Percentile (z) | 0.208 |
| 95% Percentile (z) | 0.234 | 95% Percentile (z) | 0.252 |
| 99% Percentile (z) | 0.281 | 99% Percentile (z) | 0.362 |
| | | | |
| Gamma Distribution Test | | Data Distribution Test | |
| k star | 3.18 | Data appear Gamma Distributed at 5% Significance Level | |
| Theta Star | 0.0381 | | |
| MLE of Mean | 0.121 | | |
| MLE of Standard Deviation | 0.0679 | | |
| nu star | 108.1 | | |
| | | | |
| A-D Test Statistic | 0.506 | Nonparametric Statistics | |
| 5% A-D Critical Value | 0.743 | 90% Percentile | 0.224 |
| K-S Test Statistic | 0.152 | 95% Percentile | 0.24 |
| 5% K-S Critical Value | 0.21 | 99% Percentile | 0.27 |
| Data appear Gamma Distributed at 5% Significance Level | | | |
| | | | |
| Assuming Gamma Distribution | | 95% UTL with 90% Coverage | 0.278 |
| 90% Percentile | 0.212 | 95% Percentile Bootstrap UTL with 90% Coverage | 0.278 |
| 95% Percentile | 0.25 | 95% BCA Bootstrap UTL with 90% Coverage | 0.278 |
| 99% Percentile | 0.332 | 95% UPL | 0.278 |
| | | 95% Chebyshev UPL | 0.43 |
| 95% WH Approx. Gamma UPL | 0.258 | Upper Threshold Limit Based upon IQR | 0.217 |
| 95% HW Approx. Gamma UPL | 0.261 | | |
| 95% WH Approx. Gamma UTL with 90% Coverage | 0.28 | | |
| 95% HW Approx. Gamma UTL with 90% Coverage | 0.285 | | |

**U-879**

| | | | |
|---|---|---|---|
| General Statistics | | | |
| Total Number of Observations | 11 | Number of Distinct Observations | 11 |
| Tolerance Factor | 2.275 | | |
| | | | |
| Raw Statistics | | Log-Transformed Statistics | |
| Minimum | 0.041 | Minimum | -3.194 |
| Maximum | 0.4 | Maximum | -0.916 |
| Second Largest | 0.36 | Second Largest | -1.022 |
| First Quartile | 0.101 | First Quartile | -2.291 |
| Median | 0.223 | Median | -1.501 |
| Third Quartile | 0.271 | Third Quartile | -1.308 |
| Mean | 0.202 | Mean | -1.796 |
| Geometric Mean | 0.166 | SD | 0.711 |
| SD | 0.118 | | |
| Coefficient of Variation | 0.583 | | |
| Skewness | 0.309 | | |
| | | | |
| Background Statistics | | | |
| Normal Distribution Test | | Lognormal Distribution Test | |
| Shapiro Wilk Test Statistic | 0.949 | Shapiro Wilk Test Statistic | 0.937 |
| Shapiro Wilk Critical Value | 0.85 | Shapiro Wilk Critical Value | 0.85 |
| Data appear Normal at 5% Significance Level | | Data appear Lognormal at 5% Significance Level | |
| | | | |
| Assuming Normal Distribution | | Assuming Lognormal Distribution | |
| 95% UTL with 90% Coverage | 0.47 | 95% UTL with 90% Coverage | 0.836 |
| 95% UPL (t) | 0.425 | 95% UPL (t) | 0.637 |
| 90% Percentile (z) | 0.353 | 90% Percentile (z) | 0.413 |
| 95% Percentile (z) | 0.396 | 95% Percentile (z) | 0.534 |
| 99% Percentile (z) | 0.476 | 99% Percentile (z) | 0.867 |
| | | | |
| Gamma Distribution Test | | Data Distribution Test | |
| k star | 2.024 | Data appear Normal at 5% Significance Level | |
| Theta Star | 0.0998 | | |
| MLE of Mean | 0.202 | | |
| MLE of Standard Deviation | 0.142 | | |
| nu star | 44.52 | | |
| | | | |
| A-D Test Statistic | 0.276 | Nonparametric Statistics | |
| 5% A-D Critical Value | 0.735 | 90% Percentile | 0.36 |
| K-S Test Statistic | 0.189 | 95% Percentile | 0.38 |
| 5% K-S Critical Value | 0.257 | 99% Percentile | 0.396 |
| Data appear Gamma Distributed at 5% Significance Level | | | |
| | | | |
| Assuming Gamma Distribution | | 95% UTL with 90% Coverage | 0.4 |
| 90% Percentile | 0.392 | 95% Percentile Bootstrap UTL with 90% Coverage | 0.4 |
| 95% Percentile | 0.477 | 95% BCA Bootstrap UTL with 90% Coverage | 0.4 |
| 99% Percentile | 0.667 | 95% UPL | 0.4 |
| | | 95% Chebyshev UPL | 0.738 |
| 95% WH Approx. Gamma UPL | 0.511 | Upper Threshold Limit Based upon IQR | 0.524 |
| 95% HW Approx. Gamma UPL | 0.533 | | |
| 95% WH Approx. Gamma UTL with 90% Coverage | 0.608 | | |
| 95% HW Approx. Gamma UTL with 90% Coverage | 0.645 | | |

**U-607**

| | | | |
|---|---|---|---|
| General Statistics | | | |
| Total Number of Observations | 18 | Number of Distinct Observations | 16 |
| Tolerance Factor | 1.974 | | |
| | | | |
| Raw Statistics | | Log-Transformed Statistics | |
| Minimum | 0.0026 | Minimum | -5.952 |
| Maximum | 0.0063 | Maximum | -5.067 |
| Second Largest | 0.0052 | Second Largest | -5.259 |
| First Quartile | 0.00318 | First Quartile | -5.753 |
| Median | 0.00385 | Median | -5.56 |
| Third Quartile | 0.00473 | Third Quartile | -5.355 |
| Mean | 0.00404 | Mean | -5.539 |
| Geometric Mean | 0.00393 | SD | 0.244 |
| SD | 9.95E-04 | | |
| Coefficient of Variation | 0.246 | | |
| Skewness | 0.516 | | |
| | | | |
| Background Statistics | | | |
| Normal Distribution Test | | Lognormal Distribution Test | |
| Shapiro Wilk Test Statistic | 0.955 | Shapiro Wilk Test Statistic | 0.969 |
| Shapiro Wilk Critical Value | 0.897 | Shapiro Wilk Critical Value | 0.897 |
| Data appear Normal at 5% Significance Level | | Data appear Lognormal at 5% Significance Level | |
| | | | |
| Assuming Normal Distribution | | Assuming Lognormal Distribution | |
| 95% UTL with 90% Coverage | 0.00601 | 95% UTL with 90% Coverage | 0.00637 |
| 95% UPL (t) | 0.00582 | 95% UPL (t) | 0.00609 |
| 90% Percentile (z) | 0.00532 | 90% Percentile (z) | 0.00538 |
| 95% Percentile (z) | 0.00568 | 95% Percentile (z) | 0.00588 |
| 99% Percentile (z) | 0.00636 | 99% Percentile (z) | 0.00694 |
| | | | |
| Gamma Distribution Test | | Data Distribution Test | |
| k star | 14.94 | Data appear Normal at 5% Significance Level | |
| Theta Star | 2.71E-04 | | |
| MLE of Mean | 0.00404 | | |
| MLE of Standard Deviation | 0.00105 | | |
| nu star | 537.7 | | |
| | | | |
| A-D Test Statistic | 0.278 | Nonparametric Statistics | |
| 5% A-D Critical Value | 0.739 | 90% Percentile | 0.00513 |
| K-S Test Statistic | 0.118 | 95% Percentile | 0.00537 |
| 5% K-S Critical Value | 0.203 | 99% Percentile | 0.00611 |
| Data appear Gamma Distributed at 5% Significance Level | | | |
| | | | |
| Assuming Gamma Distribution | | 95% UTL with 90% Coverage | 0.0063 |
| 90% Percentile | 0.00543 | 95% Percentile Bootstrap UTL with 90% Coverage | 0.0063 |
| 95% Percentile | 0.00591 | 95% BCA Bootstrap UTL with 90% Coverage | 0.0063 |
| 99% Percentile | 0.00687 | 95% UPL | 0.0063 |
| | | 95% Chebyshev UPL | 0.0085 |
| 95% WH Approx. Gamma UPL | 0.00597 | Upper Threshold Limit Based upon IQR | 0.00705 |
| 95% HW Approx. Gamma UPL | 0.006 | | |
| 95% WH Approx. Gamma UTL with 90% Coverage | 0.00621 | | |
| 95% HW Approx. Gamma UTL with 90% Coverage | 0.00625 | | |

**U-884**

| | | | |
|---|---|---|---|
| General Statistics | | | |
| Total Number of Observations | 13 | Number of Distinct Observations | 12 |
| Tolerance Factor | 2.155 | | |
| | | | |
| Raw Statistics | | Log-Transformed Statistics | |
| Minimum | 0.04 | Minimum | -3.219 |
| Maximum | 0.18 | Maximum | -1.715 |
| Second Largest | 0.15 | Second Largest | -1.897 |
| First Quartile | 0.078 | First Quartile | -2.551 |
| Median | 0.1 | Median | -2.303 |
| Third Quartile | 0.107 | Third Quartile | -2.235 |
| Mean | 0.0994 | Mean | -2.382 |
| Geometric Mean | 0.0924 | SD | 0.41 |
| SD | 0.0383 | | |
| Coefficient of Variation | 0.385 | | |
| Skewness | 0.567 | | |
| | | | |
| Background Statistics | | | |
| Normal Distribution Test | | Lognormal Distribution Test | |
| Shapiro Wilk Test Statistic | 0.962 | Shapiro Wilk Test Statistic | 0.965 |
| Shapiro Wilk Critical Value | 0.866 | Shapiro Wilk Critical Value | 0.866 |
| Data appear Normal at 5% Significance Level | | Data appear Lognormal at 5% Significance Level | |
| | | | |
| Assuming Normal Distribution | | Assuming Lognormal Distribution | |
| 95% UTL with 90% Coverage | 0.182 | 95% UTL with 90% Coverage | 0.224 |
| 95% UPL (t) | 0.17 | 95% UPL (t) | 0.197 |
| 90% Percentile (z) | 0.148 | 90% Percentile (z) | 0.156 |
| 95% Percentile (z) | 0.162 | 95% Percentile (z) | 0.181 |
| 99% Percentile (z) | 0.188 | 99% Percentile (z) | 0.24 |
| | | | |
| Gamma Distribution Test | | Data Distribution Test | |
| k star | 5.447 | Data appear Normal at 5% Significance Level | |
| Theta Star | 0.0182 | | |
| MLE of Mean | 0.0994 | | |
| MLE of Standard Deviation | 0.0426 | | |
| nu star | 141.6 | | |
| | | | |
| A-D Test Statistic | 0.23 | Nonparametric Statistics | |
| 5% A-D Critical Value | 0.735 | 90% Percentile | 0.146 |
| K-S Test Statistic | 0.142 | 95% Percentile | 0.162 |
| 5% K-S Critical Value | 0.237 | 99% Percentile | 0.176 |
| Data appear Gamma Distributed at 5% Significance Level | | | |
| | | | |
| Assuming Gamma Distribution | | 95% UTL with 90% Coverage | 0.18 |
| 90% Percentile | 0.156 | 95% Percentile Bootstrap UTL with 90% Coverage | 0.18 |
| 95% Percentile | 0.178 | 95% BCA Bootstrap UTL with 90% Coverage | 0.174 |
| 99% Percentile | 0.224 | 95% UPL | 0.18 |
| | | 95% Chebyshev UPL | 0.273 |
| 95% WH Approx. Gamma UPL | 0.183 | Upper Threshold Limit Based upon IQR | 0.151 |
| 95% HW Approx. Gamma UPL | 0.186 | | |
| 95% WH Approx. Gamma UTL with 90% Coverage | 0.202 | | |
| 95% HW Approx. Gamma UTL with 90% Coverage | 0.206 | | |

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# Appendix C

# Regression Output from Excel

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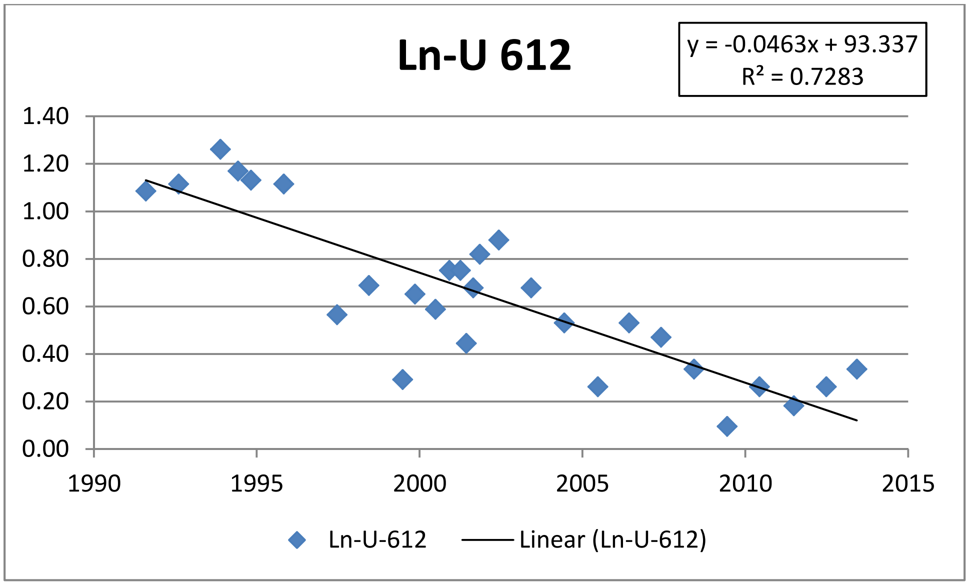
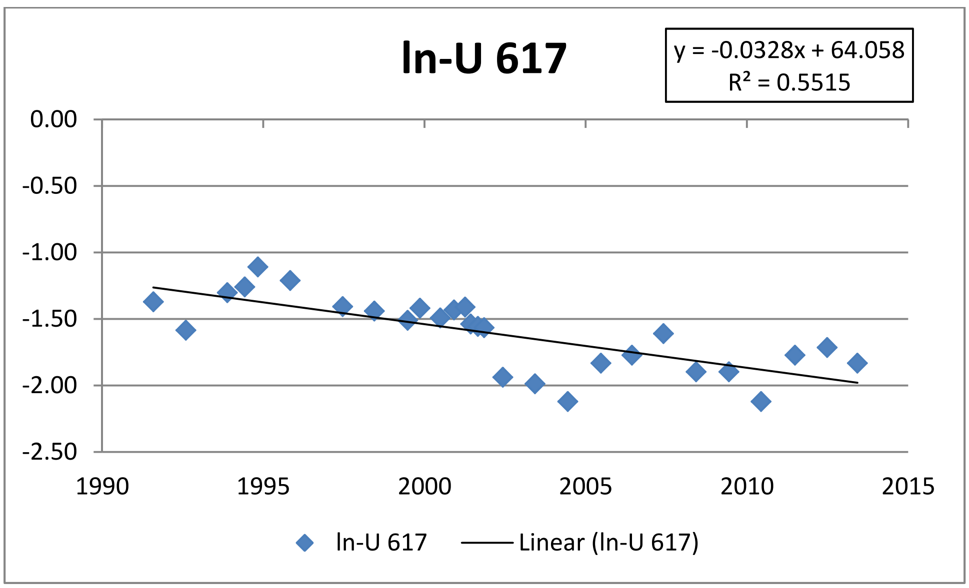
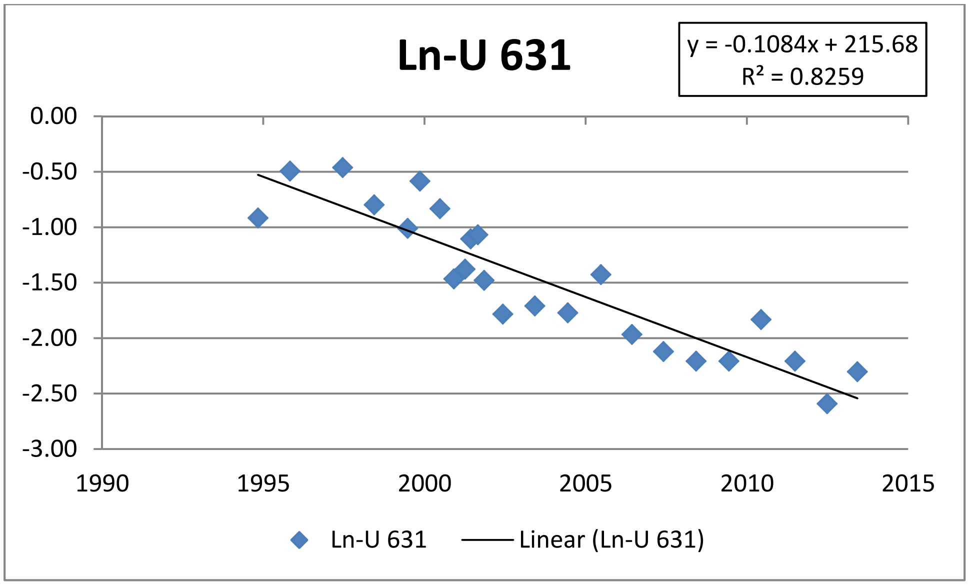
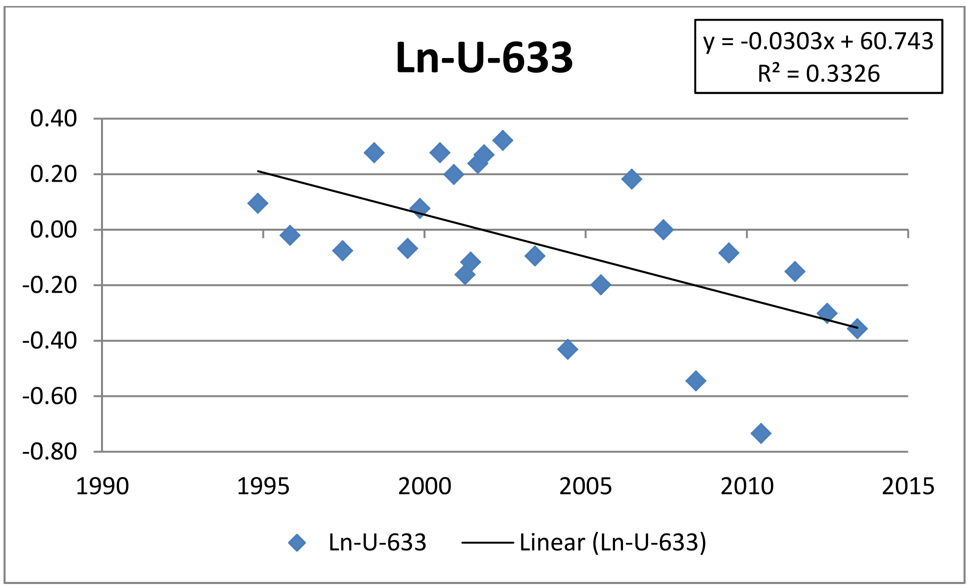
Regression backup for appendix

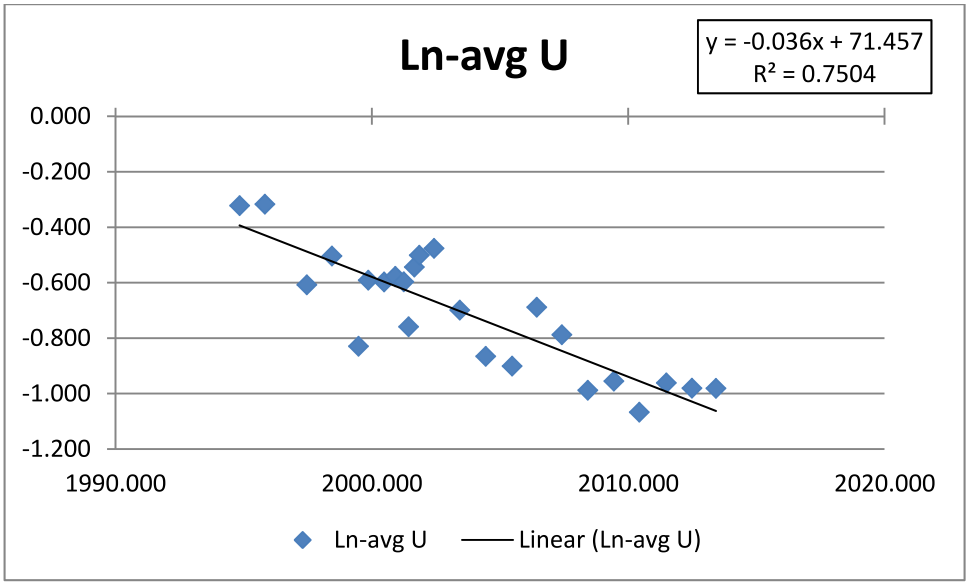
Plots for wells in Mill Tailings Area 1991+



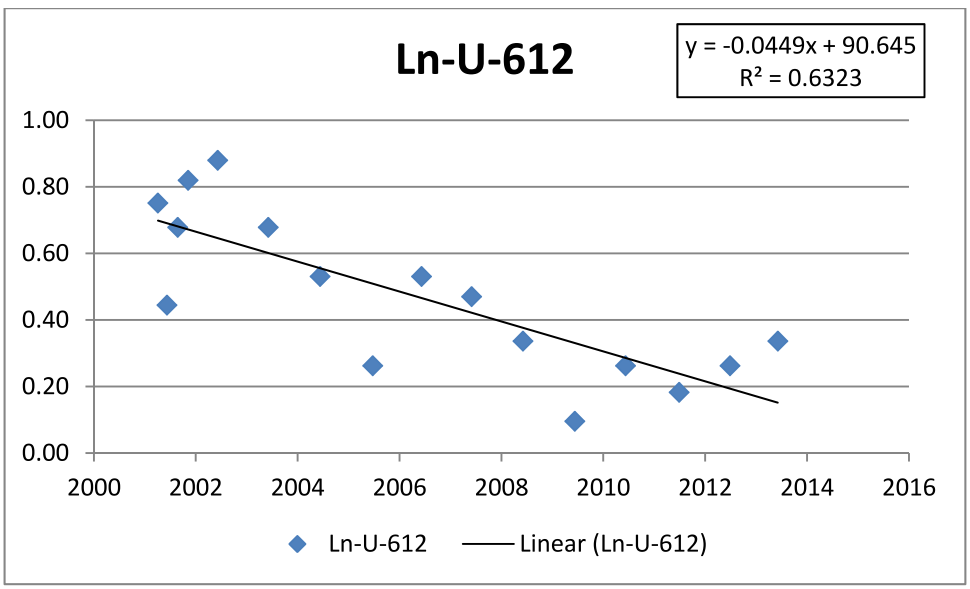



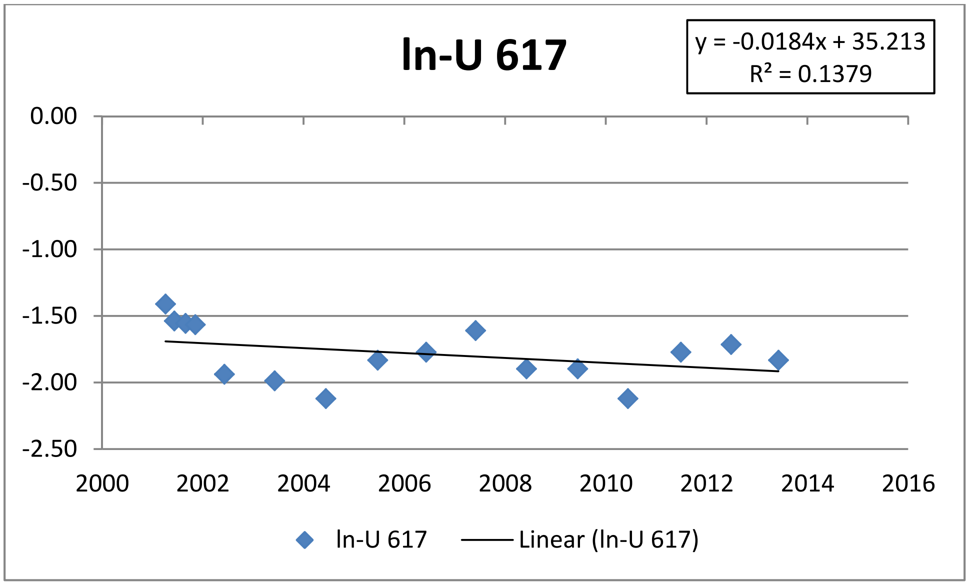

Ln-U 631
y = -0.1084x + 215.68
R² = 0.8259
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
1990
1995
2000
2005
2010
2015
Ln-U 631
Linear (Ln-U 631)


Ln-U-633
y = -0.0303x + 60.743
R² = 0.3326
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
1990
1995
2000
2005
2010
2015
Ln-U-633
Linear (Ln-U-633)

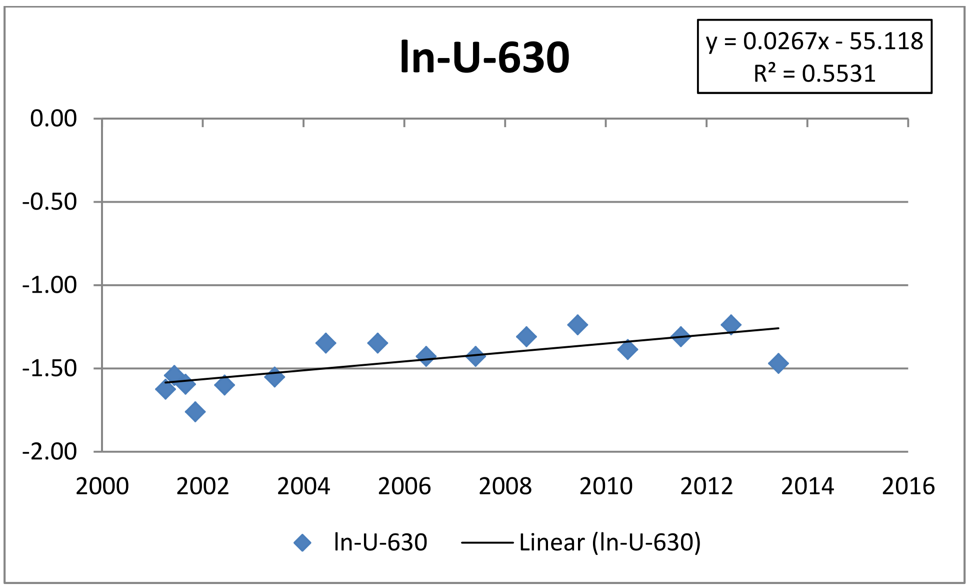



Plots for wells in Mill Tailings Area 2001+

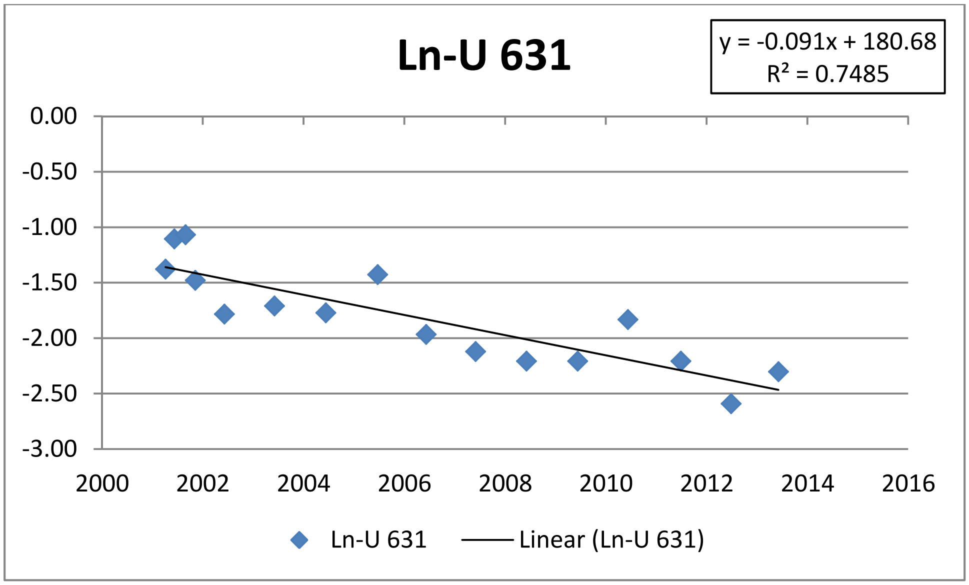




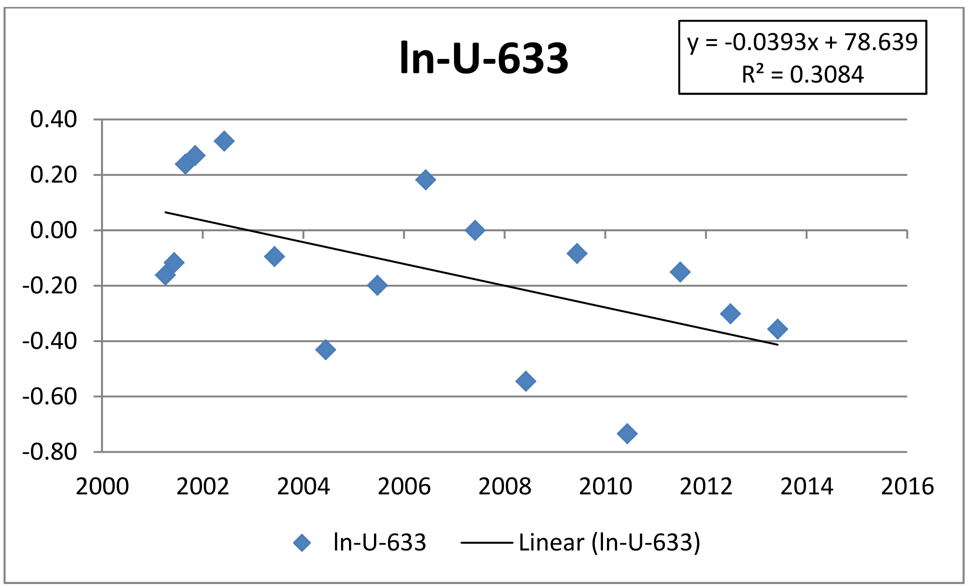
ln-U 617
y = -0.0184x + 35.213
R² = 0.1379
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
2000
2002
2004
2006
2008
2010
2012
2014
2016
ln-U 617
Linear (ln-U 617)

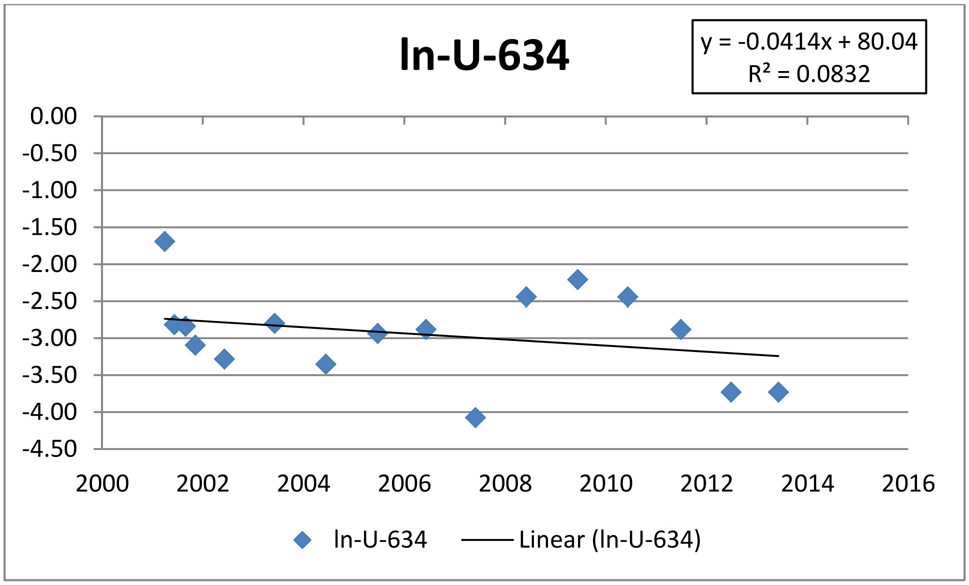
ln-U-630
y = 0.0267x - 55.118
R² = 0.5531
0.00
-0.50
-1.00
-1.50
-2.00
2000
2002
2004
2006
2008
2010
2012
2014
2016
ln-U-630
Linear (ln-U-630)

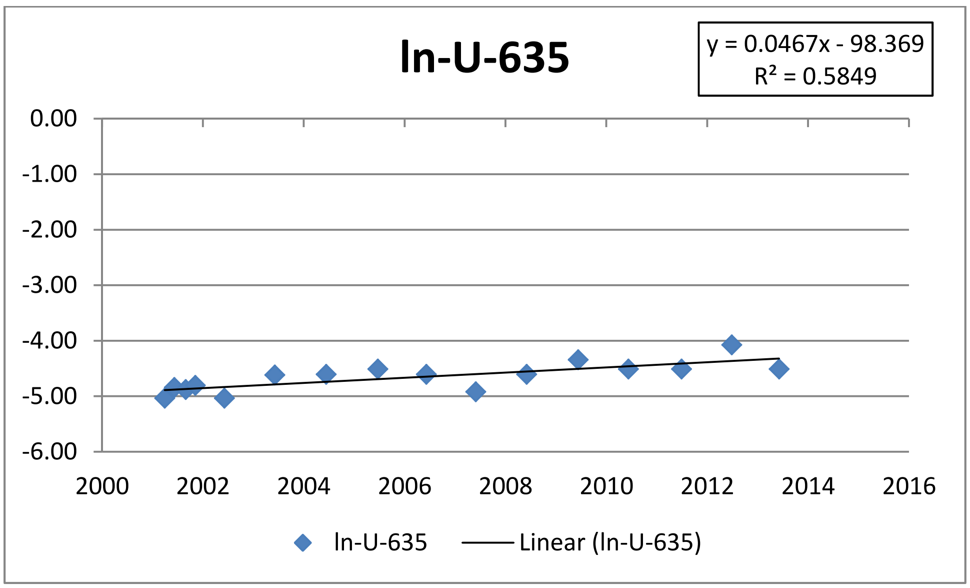


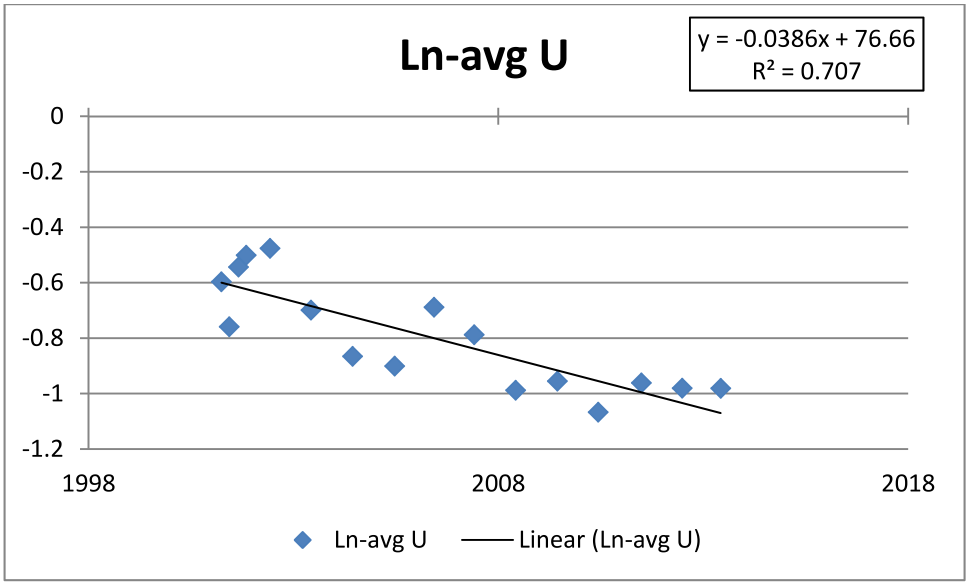
Ln-U 631
y = -0.091x + 180.68
R² = 0.7485
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
2000
2002
2004
2006
2008
2010
2012
2014
2016
Ln-U 631
Linear (Ln-U 631)

ln-U-633
y = -0.0393x + 78.639
R² = 0.3084
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
2000
2002
2004
2006
2008
2010
2012
2014
2016
ln-U-633
Linear (ln-U-633)


ln-U-634
y = -0.0414x + 80.04
R² = 0.0832
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
-3.50
-4.00
-4.50
2000
2002
2004
2006
2008
2010
2012
2014
2016
ln-U-634
Linear (ln-U-634)


ln-U-635
y = 0.0467x - 98.369
R² = 0.5849
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
2000
2002
2004
2006
2008
2010
2012
2014
2016
ln-U-635
Linear (ln-U-635)


Ln-avg U
y = -0.0386x + 76.66
R² = 0.707
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
1998
2008
2018
Ln-avg U
Linear (Ln-avg U)

SUMMARY OUTPUT for Well 0612--Uranium

| Regression Statistics | |
|---|---|
| Multiple R | 0.85337921 |
| R Square | 0.728256075 |
| Adjusted R Square | 0.717804386 |
| Standard Error | 0.177531083 |
| Observations | 28 |

ANOVA

| | df | SS | MS | F | Significance F |
|---|---|---|---|---|---|
| Regression | 1 | 2.196071249 | 2.196071 | 69.67831193 | 7.90E-09 |
| Residual | 26 | 0.819449423 | 0.031517 | | |
| Total | 27 | 3.015520672 | | | |

| | Coefficients | Standard Error | t Stat | P-value | Lower 95% | Upper 95% | Lower 80.0% | Upper 80.0% |
|---|---|---|---|---|---|---|---|---|
| Intercept | 93.33669996 | 11.10490423 | 8.404998 | 6.92E-09 | 70.51024241 | 116.1631575 | 78.73406335 | 107.9393366 |
| Decimal date | -0.046297361 | 0.005546352 | -8.34735 | 7.90E-09 | -0.05769805 | -0.03489667 | -0.053590657 | -0.039004064 |

SUMMARY OUTPUT for Well 0617 - Uranium

| Regression Statistics | |
|---|---|
| Multiple R | 0.742606833 |
| R Square | 0.551464908 |
| Adjusted R Square | 0.534213558 |
| Standard Error | 0.18567794 |
| Observations | 28 |

ANOVA

| | df | SS | MS | F | Significance F |
|---|---|---|---|---|---|
| Regression | 1 | 1.102085837 | 1.102086 | 31.96648 | 6.04E-06 |
| Residual | 26 | 0.896383732 | 0.034476 | | |
| Total | 27 | 1.998469569 | | | |

| | Coefficients | Standard Error | t Stat | P-value | Lower 95% | Upper 95% | Lower 80.0% | Upper 80.0% |
|---|---|---|---|---|---|---|---|---|
| Intercept | 64.05759203 | 11.61473632 | 5.5152 | 8.68E-06 | 40.18315961 | 87.93202445 | 48.78454056 | 79.3306435 |
| date | -0.032798138 | 0.005800986 | -5.65389 | 6.04E-06 | -0.044722235 | -0.02087404 | -0.040426271 | -0.025170005 |

SUMMARY OUTPUT - Well 0631--Uranium

| Regression Statistics | |
|---|---|
| Multiple R | 0.908814 |
| R Square | 0.825944 |
| Adjusted R Square | 0.818032 |
| Standard Error | 0.267576 |
| Observations | 24 |

ANOVA

| | df | SS | MS | F | Significance F |
|---|---|---|---|---|---|
| Regression | 1 | 7.474408 | 7.474408 | 104.3959 | 8.15E-10 |
| Residual | 22 | 1.575129 | 0.071597 | | |
| Total | 23 | 9.049536 | | | |

| | Coefficients | Standard Error | t Stat | P-value | Lower 95% | Upper 95% | Lower 80.0% | Upper 80.0% |
|---|---|---|---|---|---|---|---|---|
| Intercept | 215.6787 | 21.25463 | 10.14737 | 9.24E-10 | 171.599257 | 259.7580638 | 187.5962632 | 243.7610576 |
| Date | -0.10838 | 0.010608 | -10.2174 | 8.15E-10 | -0.130381845 | -0.08638401 | -0.122398142 | -0.09436771 |

SUMMARY OUTPUT - Well 0633--Uranium

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.576678 |
| R Square | 0.332558 |
| Adjusted R Square | 0.302219 |
| Standard Error | 0.231189 |
| Observations | 24 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 0.585881 | 0.585881 | 10.96165 | 0.003179252 |
| Residual | 22 | 1.175862 | 0.053448 | | |
| Total | 23 | 1.761744 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 60.74255 | 18.3642 | 3.30766 | 0.003203 | 22.65752427 | 98.82758426 | 22.65752427 | 98.82758426 |
| Dec. date | -0.03034 | 0.009165 | -3.31084 | 0.003179 | -0.049351477 | -0.01133692 | -0.049351477 | -0.01133692 |

SUMMARY OUTPUT Average Uranium

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.866281 |
| R Square | 0.750442 |
| Adjusted R Square | 0.739099 |
| Standard Error | 0.111697 |
| Observations | 24 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 0.825379938 | 0.82538 | 66.15589008 | 4.48E-08 |
| Residual | 22 | 0.274478336 | 0.012476 | | |
| Total | 23 | 1.099858275 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 80.0%* | *Upper 80.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 71.4566 | 8.872930016 | 8.053326 | 5.29E-08 | 53.05526804 | 89.8579292 | 59.7333575 | 83.17983978 |
| date | -0.03602 | 0.004428257 | -8.13363 | 4.48E-08 | -0.045201438 | -0.0268342 | -0.041868571 | -0.030167018 |

**Calculation of Estimated Date for Attenuation to Standard**

Regression Equation: Y = mX + b
Rearranged to solve for X: X = (Y-b)/a
Y = ln uranium standard (0.044) = -3.12

**For data from 1991+**

| Well | Y | b | a | X | |
|---|---|---|---|---|---|
| | 612 | -3.12 | 93.337 | -0.0463 | 2083 |
| | 617 | -3.12 | 64.058 | -0.0328 | 2048 |
| | 631 | -3.12 | 215.68 | -0.1084 | 2018 |
| | 633 | -3.12 | 60.743 | -0.0303 | 2108 |
| avg U | | -3.12 | 71.47 | -0.036 | 2072 |

**For data from 2001+**

| Well | Y | b | a | X | |
|---|---|---|---|---|---|
| | 612 | -3.12 | 90.645 | -0.0449 | 2088 |
| | 617 | -3.12 | 35.213 | -0.0184 | 2083 |
| | 631 | -3.12 | 180.68 | -0.091 | 2020 |
| | 633 | -3.12 | 78.639 | -0.0393 | 2080 |
| | 634 | -3.12 | 80.04 | -0.0414 | 2009 |
| avg U | | -3.12 | 76.66 | -0.0386 | 2067 |

**For 90% upper confidence estimate of slowest attenuation rate**