2.0 Significant Activities Since Preparation of the 1998 RI Document

Since data collection for the purposes of preparing the 1998 RI report ended in 1996, several significant activities have occurred on the Millsite and surrounding peripheral properties. The following subsections provide a brief description of these activities. At the conclusion of each subsection, a summary indicates whether the described activity invalidates or results in significant changes to the assumptions used in the ground water model and the human health and ecological risk assessments presented in the 1998 RI. If significant changes have resulted, general statements describe how the new conditions are accounted for in the RI Addendum/FFS. This information is also assembled in an overall summary (Section 2.9) that lists

- The changes in site conditions since the 1998 documents.
- How these changes affect conclusions reached in the 1998 RI document.
- How the ground water modeling has changed (Section 3.0) and how the risk assessments have been updated (Section 4.0) in this RI Addendum/FFS.

2.1 Source Removal on the Millsite

Following the cessation of milling operations, four tailings piles resulting from processing vanadium and uranium ore were left at the Millsite. The informal names for the separate tailings piles were the Carbonate Tailings Pile, the Vanadium Tailings Pile, the Acid Tailings Pile, and the East Tailings Pile (Figure 1–2). The total combined in-place volume of the four tailings piles and surrounding contaminated soils and related by-product material was approximately 2.2 million yd^3. The remedy for OUs I and II required removal of contaminated soils and tailings, placement of contamination in an on-site repository, and restoration of the Millsite.

UMTRCA was identified as an ARAR for the MMTS. UMTRCA cleanup standards (40 CFR 192 Subpart C) specify that soil in the top 15 centimeters of the land surface should be remediated until Ra-226 concentrations are less than or equal to 5 picocuries per gram (pCi/g) above background; at depths greater than 15 centimeters, soil should be remediated until Ra-226 concentrations are less than or equal to 15 pCi/g above background. The objectives of this standard are to limit the risk from inhalation of radon decay products in houses built on land contaminated with tailings, and to limit gamma radiation exposure to people using that land. Subpart C of 40 CFR 192 provides for alternate site-specific standards (supplemental standards) that may be established if certain criteria are met and as long as the remedial action is clearly consistent with the principle that cleanup levels are as low as reasonably achievable. One circumstance that warrants supplemental standards is that in which cleanup to the 40 CFR 192 standards would result in excessive environmental damage and cost compared to the health benefits.

Cleanup of the Millsite and properties contaminated by release of tailings or residual ore resulted in the placement of approximately 2.5 million yd^3 of contaminated material in the permanent on-site repository. Cleanup of the Millsite was to the 5/15 pCi/g cleanup standards; however, on some peripheral properties, supplemental standards were applied, and cleanup was to alternate site-specific standards. During remediation, much of the soil underneath the four tailings piles

was removed to competent bedrock. This removal included significant volumes of native alluvial deposits from below the water table. Tailings removal was completed August 31, 1999.

During and subsequent to cleanup to the Ra-226 standards on the Millsite, an additional 75,000 yd^3 of subpile soils that did not exceed the Ra-226 standards were removed. This additional source-control measure was performed to minimize residual uranium and metals contamination that could contribute to continued ground water contamination. The residual material was placed in the repository and on the outslopes of the repository cover. This additional soil removal was guided by soil sampling and analysis and column experiment results (Section 2.8.2) that were conducted as part of the OU III IRA. These tests were performed because the 1998 RI ground water modeling results indicated that residual sources on the millsite could significantly extend the ground water remediation time frame. The tests also identified that native deposits in the saturated zone had a significant mass of sorbed uranium that also represented a residual source of ground water contamination that could prolong aquifer restoration.

2.1.1 Summary

As a result of millsite excavation, the primary source of contamination (mill tailings) indicated in both the human health and ecological CSMs (Figure 1–6 and Figure 1–7, respectively) has been permanently removed at the site. By removing additional soil beyond that required to achieve cleanup to Ra-226 standards and by removing contaminated native deposits from below the water table, residual contamination in the vadose and saturated zones has also been removed as a potential significant source of continued ground water contamination.

- These excavation activities do not result in an overall change to the human health and ecological CSMs. The primary source has been removed, but secondary sources, pathways, and receptors remain the same.

The removal of primary and residual source material from the saturated and vadose zones and the resulting effect of that source removal on concentrations in the uranium plume were not accurately predicted in the 1998 RI modeling effort. Also, other activities performed during the IRA indicated that given the likely infiltration rate at the restored site, the minor amounts of contamination remaining in vadose zone soils would not be significant enough to require coupling of an unsaturated modeling code with ground water flow and transport as in 1998 (see Section 2.8).

- The excavation activities have resulted in significant changes to ground water contamination on and downgradient of the Millsite; current ground water contaminant concentrations are incorporated into a new ground water transport model (Section 3.0).

2.2 Millsite Restoration

Following Millsite excavation, restoration activities were required to restore the Millsite to an acceptable land use. As stated in Section 1.3, after approval of a Covenant Deferral Request, ownership of Millsite and several adjacent properties was transferred to the city of Monticello under the Federal Lands-To-Parks Program of the National Park Service. In August 2000, the city of Monticello selected a subcontractor to perform the activities necessary to restore the

Millsite as a city park. Restoration activities were completed in August 2001; however, revegetation success and soil cover stability are still being evaluated.

Part of the restoration process included backfilling areas to provide for proper drainage. Restoration also created a new channel for Montezuma Creek, an alluvial aquifer centered on the creek, and three "backwater" wetland areas. These changes have significantly affected the alluvial aquifer and surface water systems and are discussed more thoroughly in Section 3.2.1.

2.2.1 Summary

- Restoration activities have not resulted in any changes to the human health and ecological CSMs. However, the three "backwater" wetland areas created on the Millsite form new ponded areas where exposure to ecological receptors should be considered. Previously, significant ponded water only occurred downstream of the Millsite.
- Excavation and restoration activities have resulted in an increase in the concentration of selenium in surface water and ground water (Section 2.7); the potential effects of the increase in selenium concentrations on ecological receptors is discussed in Section 4.2.
- Restoration activities have resulted in significant changes to the ground water and surface water systems on and immediately downgradient of the Millsite; these new conditions are incorporated into the new ground water flow and transport model (Section 3.0).

2.3 Remediation of Soil and Sediment Along Montezuma Creek

A remedy was selected under OU III for peripheral properties along Montezuma Creek with contaminated soil and sediment. Potential remedies for the contaminated soil and sediment were evaluated in the *Monticello Mill Tailings Site, Operable Unit III, Alternatives Analysis for Soil and Sediment* (DOE 1998e). The alternatives included removal actions (i.e., excavation of contaminated soil and sediment and backfill with clean material) as well as remedies that applied supplemental standards. DOE recommended a removal action requiring excavation of contaminated soil and sediment at alternative action levels above the 5 pCi/g surface cleanup criterion and application of supplemental standards for Upper and Lower Montezuma Creek. For Middle Montezuma Creek, DOE recommended no excavation and application of supplemental standards. Institutional controls, consisting of long-term surveillance and maintenance (LTS&M) and restrictive easements, were also included for each section of the canyon. Following a public comment period, the decision to implement the non-time-critical removal action was documented in an Action Memorandum (DOE 1998c).

In Upper Montezuma Creek, the areal extent of remediation was determined by excavating soil and sediment with surface gamma exposure rates exceeding 35 microroentgens per hour (μR/h). Plate 1 shows the extent of radiologically contaminated material exceeding 35 μR/h that has been remediated and surficial radiologically contaminated material that remained when excavation was completed in 1999. Excavation continued at depth within the areas where surface gamma exposure rates exceeded 35 μR/h until Ra-226 concentrations did not exceed the 40 CFR 192 cleanup standard or until the excavation intersected the water table. A total of 20,800 yd^3 were removed from Upper Montezuma Creek. The Alternatives Analysis estimated that following cleanup, the RME human health risk was reduced to 3.9×10^{-5} added cancer risk (from the

baseline risk of 6.8×10^{-5}), and the CT human health risk was reduced to 4.0×10^{-6} added cancer risk (from the baseline risk of 6.9×10^{-6}).

No soil or sediment was removed from Middle Montezuma Creek because the RME risk was with the risk range of 10^{-4} to 10^{-6} and reduction in the risk could only be attained by causing environmental damage that would be excessive compared to the health benefits.

In Lower Montezuma Creek, a surface gamma exposure rate of 80 μR/h was used to select four areas for cleanup. Excavation of 135 yd^3 of contaminated soil and sediment was completed in 1998. Plate 2 shows the extent of contaminated material exceeding 80 μR/h that was remediated and the contaminated material that remained as of 1998.

Supplemental standards applications were prepared for those areas adjacent to Montezuma Creek where contamination above the standards in 40 CFR 192 Subpart C was left in place; EPA and UDEQ approval of the supplemental standards applications documented their acceptance of the removal actions as part of the final remedy. Restrictive easements prohibit construction of a habitable structure and removal of soils for use outside of the supplemental standards area (see Section 2.4 for additional discussion; the restrictive easement areas are shown on Plates 1 and 2). Property owners were compensated for restrictive easements on their properties. An Explanation of Significant Difference to the MMTS ROD was prepared to include the OU III peripheral properties (the soil and sediment area along Montezuma Creek) into the selected remedy for OU II.

2.3.1 Summary

Soil and sediment in Upper, Middle, and Lower Montezuma Creek have not been extensively sampled subsequent to remediation. It is likely that excavation of contaminated material has had the overall effect of decreasing the average contaminant concentrations while reducing the overall volume of contaminated material in soil and sediment along Montezuma Creek. The purpose of this RI Addendum/FFS is to reach a remedial decision for surface water and ground water: For soil and sediment, the appropriate level of cleanup for the properties along Montezuma Creek has been decided, cleanup is completed, and documentation is finalized; the protectiveness of the soil and sediment remedy will be evaluated during the CERCLA 5-year review.

- Excavation of contaminated material along Montezuma Creek does not result in an overall change to the human health and ecological CSMs. Some soil and sediment source material along Montezuma Creek has been removed. Release mechanisms for source material that was not remediated, exposure routes, and receptors remain the same.
- In the HHRA update (Section 4.1), soil and sediment exposure point concentrations are the same as those used in the 1998 RI. Therefore, estimates of total risk to human health may be somewhat conservative (i.e., higher than actual). However, this is not viewed as significant or as a limitation because the focus of the RI Addendum is on surface water and ground water.
- For the baseline ERA, the overall conclusion in the 1998 RI was that there is not significant risk to the environment. Hot-spot remediation of contaminated soil and sediment in Upper and Lower Montezuma Creek has not invalidated this conclusion. However, there have been short-term effects on the Montezuma Creek stream channel as a result of remediation. Until areas are successfully revegetated and the stream channel is stabilized, it cannot be expected

that the ecological community (primarily benthic macroinvertebrates) will be similar to that of background areas. Because of current land-use practices (cattle and elk ranching), the area along Montezuma Creek downstream of the Millsite may not ever return to natural conditions (i.e., those not affected by human activities) that were present prior to mill operation.

- Remediation in Upper and Lower Montezuma Creek has had no measurable impacts on surface water and ground water contaminant concentrations (as indicated by time-concentration plots [Appendix D2.0 and D3.0]) or flow dynamics (as indicated by gaining and losing reaches on Montezuma Creek); therefore, these changes do not require modifications to the baseline ground water flow and transport model.

2.4 Institutional Controls

Institutional controls have been applied at OU III to prevent use of contaminated alluvial ground water and to restrict land use on peripheral properties along Montezuma Creek where supplemental standards were applied. This section describes these institutional controls.

2.4.1 Alluvial Aquifer Institutional Controls

On October 21, 1998, the Utah State Engineer's office assumed responsibility for preparation of a ground water management policy for the contaminated alluvial ground water system. On March 18, 1999, the State Engineer issued notice of a public meeting regarding the proposal to prohibit drilling of shallow alluvial wells in the contaminated areas along Montezuma Creek. Property owners that could be affected by the institutional control received personal invitations to the meeting. The meeting was held on April 7, 1999, at the San Juan County Courthouse, and a draft ground water management policy was made available. Only one person (an affected property owner) attended the meeting. The property owner questioned whether his potential use of a well completed in the deeper Burro Canyon aquifer would be affected by the institutional control. The property owner was told that because the Burro Canyon aquifer has not been contaminated by the overlying shallow aquifer, his use of the well would not be affected by the institutional control; ultimately, use of the Burro Canyon well will be decided by Utah Division of Water Rights after an application to appropriate water from the well is filed.

The State Engineer's office did not receive comments during the 30-day public comment period. At the close of the public comment period the *Ground Water Management Policy for the Monticello Mill Tailings Site and Adjacent Areas* (a copy is provided in Appendix B) was issued and became effective May 21, 1999. The policy states that new applications to appropriate water for domestic use from the shallow alluvial aquifer within the boundaries of the Monticello Ground Water Restricted Area will not be approved; existing water rights are not affected. Also, change applications proposing to divert and use water from the shallow aquifer for domestic purposes will not be approved. The policy states that applications to drill wells into the deeper Burro Canyon Fm. would be approved if it could be demonstrated that the well construction would not allow the shallow alluvial water to flow to the deeper formation. The Monticello Ground Water Restricted Area (institutional control area) is shown on Figure 2–1.

The State Engineer's office conducted a search of their database for existing water rights appropriating water for domestic use. Only one, Water Right 09–0130, existed within the Monticello Ground Water Restricted Area. The water right was for 0.01 cfs of flow from a

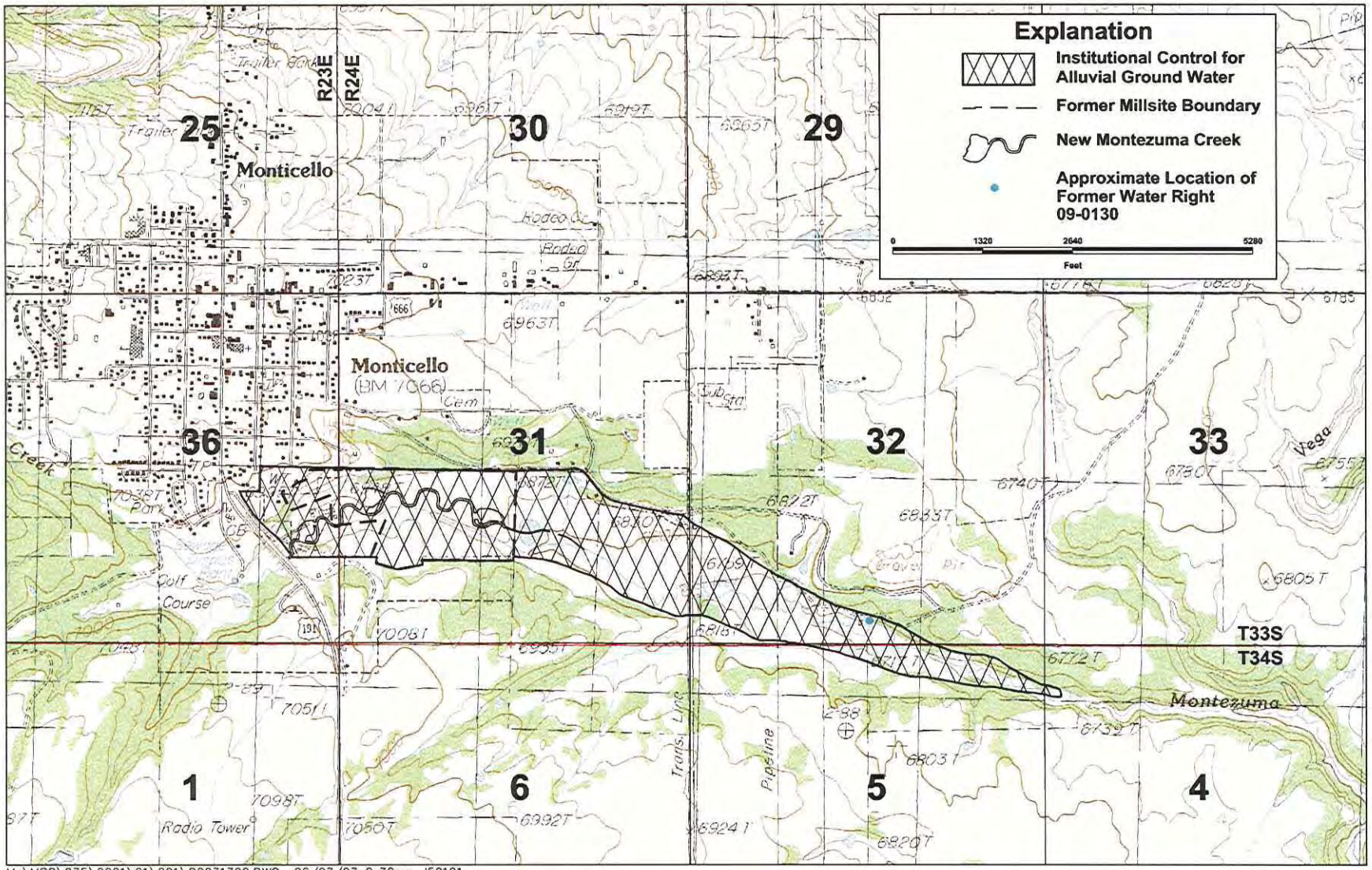

Figure 2–1. Monticello Ground Water Restricted Area

surface diversion of an unnamed spring. A field visit to the location of the water right was made on April 7, 1999. Water appears to have been taken from a shallow well or pumped from a sump to supply what is now an abandoned, dilapidated house nearby. After contacting the property owner, DOE made the decision to compensate the property owner for the taking of Water Right 09–0130.

With regard to the institutional controls on ground water, DOE assumes responsibility through its LTS&M activities for ensuring that the Ground Water Management Policy is working. DOE conducts annual inspections of the properties for any evidence of well installations or ground water use. Inspections were conducted during October 1999, October/November 2000, October 2001, and October 2002; no new private wells have been installed, and there is no evidence of domestic use of alluvial ground water in the OU III area.

Summary

- Because there was no domestic use of the contaminated alluvial ground water when the 1998 HHRA was completed, ground water ingestion was not evaluated under a "current scenario" in that risk assessment. Because there is no current (2003) use, and because the Utah Ground Water Management Policy prohibits domestic use of alluvial ground water, ground water ingestion is also not a valid current exposure scenario for the HHRA update. To determine what the hypothetical current risk is from ingestion of alluvial ground water, the HHRA update assumes that the Ground Water Management Policy fails and that there is near-term exposure to the contaminated ground water as a primary drinking water source (Section 4.1).
- The Ground Water Management Policy does not have any effect on the validity of the ecological CSM or the conclusions reached in the 1998 ERA.
- The Ground Water Management Policy has no impact on the ground water modeling effort.

2.4.2 Restrictive Easements

Because radiologically contaminated soil and sediment exceeding standards in 40 CFR 192 remained in Upper, Middle, and Lower Montezuma Creek following hot-spot remediation (Section 2.3), institutional controls are necessary to prevent unacceptable use of the land. DOE made the decision to use restrictive easements as the institutional control on properties along Montezuma Creek on which supplemental standards were applied. The restrictive easement prohibits the building of a habitable structure and the removal of soils from within the easement area. USACE obtained appraisals to determine fair market value of the easements. Offers were mailed to the property owners by USACE via letter dated June 21, 2000.

A meeting was held on August 1, 2000, with the affected property owners, USACE, DOE, and DOE's contractor to discuss the offers. The three property owners at the meeting were unwilling to accept the offers presented. The owner's concerns were:

- Offers presented for the easement do not represent fair market value.
- There appeared to be a discrepancy in the average valuation price (dollars per acre) of the easement from one property to the next.

- The highest and best use identified in the appraisal was not correct, and the easement would affect the owners' future development plans for the property. Potential development plans mentioned by the property owners included a gravel extraction operation, subdivision for housing development, and fishing cabins.
- As proposed, the restrictive easement would also prohibit plowing, discing, or other disturbances. The owners were concerned that activities such as placing a culvert in the stream would not be permitted. The owners were informed that the language prohibiting plowing, discing and other disturbances would be removed from the easement. Language clarifying that disturbed soils must remain in the easement area would be added. This change in wording to the restrictive easement was initiated without the prior concurrence of EPA and UDEQ.

USACE met with the property owners to explain the government's position on the appraisals and the fair market value determination. By June 2001, USACE had negotiated settlement with all property owners regarding compensation for the restrictive easements along Montezuma Creek. The restrictive easement boundary on the Upper, Middle, and Lower Montezuma Creek peripheral properties is shown on Plates 1 and 2.

During July 2002, the owner of one of the properties created an impoundment in Montezuma Creek within a restrictive easement area on his property. A high-intensity storm occurred on July 27, 2002, and the resultant stream flow in Montezuma Creek overtopped the impoundment and, according to initial reports, washed radiologically contaminated materials downstream. On August 8, 2002, a representative of the Utah Division of Water Rights toured the property and indicated that he would contact USACE to determine if an enforcement action was warranted. Subsequent to the site tour, the Division of Water Rights has required the property owner to breech the impoundment and to go through the formal permit application process if the owner desires to rebuild the impoundment. As of August 2003, USACE has not initiated an enforcement action, citing that the property is a CERCLA site and, therefore, EPA has the regulatory authority.

On November 25 and 26, 2002, DOE performed a gamma survey extending from the impoundment area to approximately 700 ft downstream. Areas where gamma exposure rates exceeded 35 μR/h (the alternate cleanup level for Upper Montezuma Creek) were mapped, and soil samples and delta-gamma measurements were taken to estimate Ra-226 activity. Additional fieldwork was performed December 16–19 and 23–24 to obtain more surface gamma readings, waist-level gamma readings, Ra-226 estimates at depth, and additional soil samples. The field crews noted that some areas with elevated readings were in erosional features that have uncovered previously buried deposits along unremediated streambanks and are not recently deposited contaminated soil. There is some evidence that previous areas of contamination were not removed during the non-time-critical removal action. These data and the possible need for additional remediation are being evaluated under DOE's Monticello LTS&M Program and are the subject of current discussions with EPA and UDEQ.

Summary

- The restrictive easements do not result in any changes to the human health CSM. They ensure that a person does not build and inhabit a structure in the areas where supplemental standards were applied (Plates 1 and 2), thus preserving the assumed future-use exposure scenario.

- The restrictive easements do not result in any changes to the ecological CSM or the conclusions drawn in the 1998 ERA.
- The restrictive easements do not affect the ground water flow and transport model.

2.5 Millsite Dewatering and Treatment

The primary objective of Millsite dewatering and treatment was to facilitate excavation and removal of mill tailings and contaminated soil that extended below the water table. It was also realized that in treating contaminated ground water, contaminants would be permanently removed from the ground water system, thereby positively affecting ground water and surface water quality.

Water recovered from dewatering efforts was used for dust control or was treated at the wastewater treatment plant (WWTP) to UPDES standards before discharge to Montezuma Creek or use for dust control. Approximately 54 million gallons of water were treated or removed from the surface water and ground water systems during WWTP operation. An additional 4.08 million gallons were used for dust suppression after the WWTP was decommissioned in May 1999. Assuming uranium concentrations averaged between 0.5 and 1 milligram per liter (mg/L), it is estimated that during Millsite remediation, between 57.5 and 115 kilograms (kg) of uranium were removed from (and as source to) the alluvial aquifer. A mass of 1,800 kg uranium (dissolved and sorbed) was estimated to be present in the alluvial aquifer prior to Millsite remediation (see page 4-10, Table 4.5–1 of the draft FS [DOE 1998b]). The uranium removed during remediation is therefore approximately three to six percent of the total preremediation inventory.

Additional details concerning dewatering and treatment and the calculations described above are presented on page 3-1 of the 2001 IRA Progress Report (DOE 2001a).

2.5.1 Summary

- Millsite dewatering and treatment does not result in any changes to the human health and ecological CSMs; an additional source has been removed by this effort, contributing to changes in contaminant concentrations in surface water and ground water. New (2002) contaminant concentrations in surface water and ground water are discussed more fully in Section 2.8 and are incorporated into the risk assessment updates in Section 4.0.
- Millsite dewatering and treatment has affected contaminant concentrations in surface water and ground water. New (2002) concentrations are incorporated into the ground water model.

2.6 PRB Treatability Study

The draft FS (DOE 1998b) included as a remedial alternative a PRB for in situ ground water treatment and concluded that PRBs have the potential to treat contaminated water at a substantial cost savings compared to traditional methods but that design parameters and performance are uncertain. EPA and UDEQ agreed with these conclusions to the extent of recommending that the IRA include site-specific testing of a PRB at OU III to evaluate this technology. Construction of the PRB at the location shown in Figure 1–2, page 1–3, was completed on June 30, 1999. The PRB in Monticello consists of slurry walls that direct (funnel) ground water flow to the permeable ZVI reactive media (the PRB gate) in the mid section.

Various reports have been prepared to summarize design, installation, and performance monitoring activities. These include:

- *Permeable Reactive Treatment (PeRT) Wall, Results of Laboratory Treatability Testing for Monticello, Utah, PeRT Wall* (DOE 1998f).
- *Permeable Reactive Treatment (PeRT) Wall, Results of Field Treatability Studies for the Monticello, Utah, PeRT Wall* (DOE 1998g).
- *Permeable Reactive Treatment (PeRT) Wall, Characterization Report* (DOE 1998h).
- "Field Characterization Summary, March 1999 – Monticello PeRT Wall Project," dated March 4, 1999 (DOE 1999a).
- *Design Specifications for the MMTS PeRT Wall Ground Water Treatment System* (DOE 1999b).
- *Permeable Reactive Treatment (PeRT) Wall for Radionuclides and Metals, Performance Summary Report for the PeRT Wall at Monticello, Utah* (DOE 1999c).

The Monticello PRB has been studied more intensively than most existing PRBs, due in part to separate funding from DOE's Office of Science and Technology and EPA. Activities undertaken to evaluate the treatment and hydraulic performance of the PRB included:

- Regularly scheduled water quality and water level monitoring at wells within and near the PRB.
- A pumping test.
- Analysis of colloid movement.
- Multispecies tracer test.
- Monitor well slug testing.
- A coring project to provide chemical analysis data of the ZVI.

Data from the coring study were also used to predict the longevity of the PRB and the average rate of ground water flow through the PRB since its installation.

2.6.1 Monitoring Data

Overall, the PRB has been effective in reducing the concentrations of all COCs except manganese. In addition, the results have been generally consistent among the 10 comprehensive sampling events (during which at least 55 wells shown in Figure 2–2 were sampled) and the five reduced sampling events (during which 14 wells were sampled) conducted to date. Table 2–1 presents a comparison of the contaminant concentrations with the PRGs that have been developed for OU III (Section 5.3 discusses PRG development). This table contains average concentration data from the October 2002 sampling. All COC concentrations, including manganese, are less than their respective PRGs in ground water exiting the PRB. Ground water monitoring data are discussed in more detail in the 2000 and 2001 IRA Progress Reports (DOE 2000b and 2001a, respectively) and the *Monticello Mill Tailings Site, Operable Unit III, Evaluation of the Permeable Reactive Treatment Wall Treatability Study* (DOE 2002a).

Water level monitoring data have been evaluated to determine the effectiveness of ground water capture by the slurry walls and subsequent funneling to the PRB gate. Figure 2–3 illustrates the

water table and saturated thickness in the PRB area in October 2002. The saturated thickness of the aquifer in the PRB area is greatest (6 to 8 ft thick) directly upgradient of the PRB. Along the upgradient side of the slurry walls, the saturated thickness progressively decreases to 1 to 2 ft at either end. Similarly low values are observed in the wells across the eastern boundary of the Millsite. The water level data indicate that some ground water flows around the outer ends of the slurry walls. The flow around the outer ends of the slurry walls is referred to as "bypass flow."

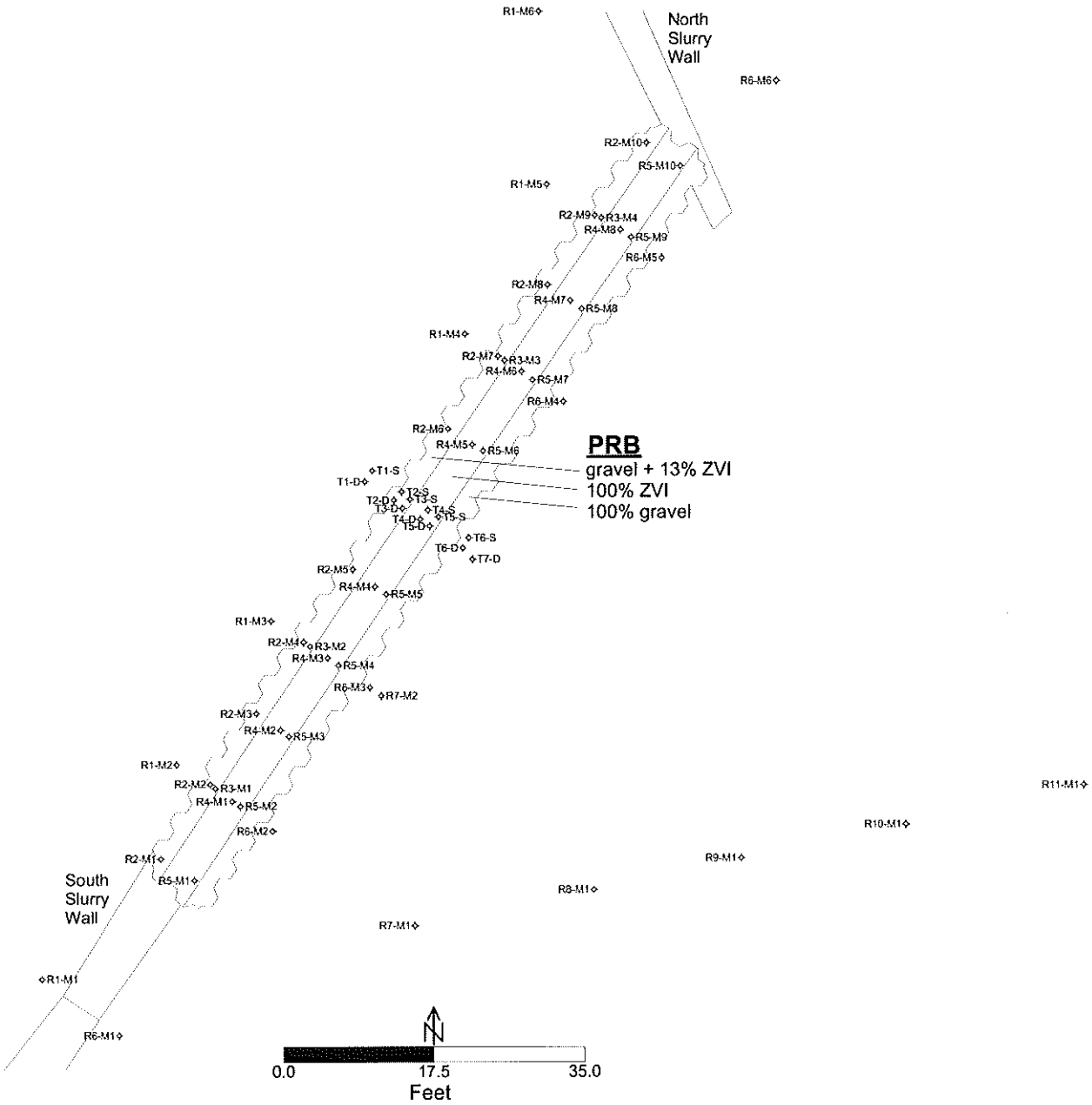

Figure 2–2. PRB Ground Water Monitor Well Locations and Identification

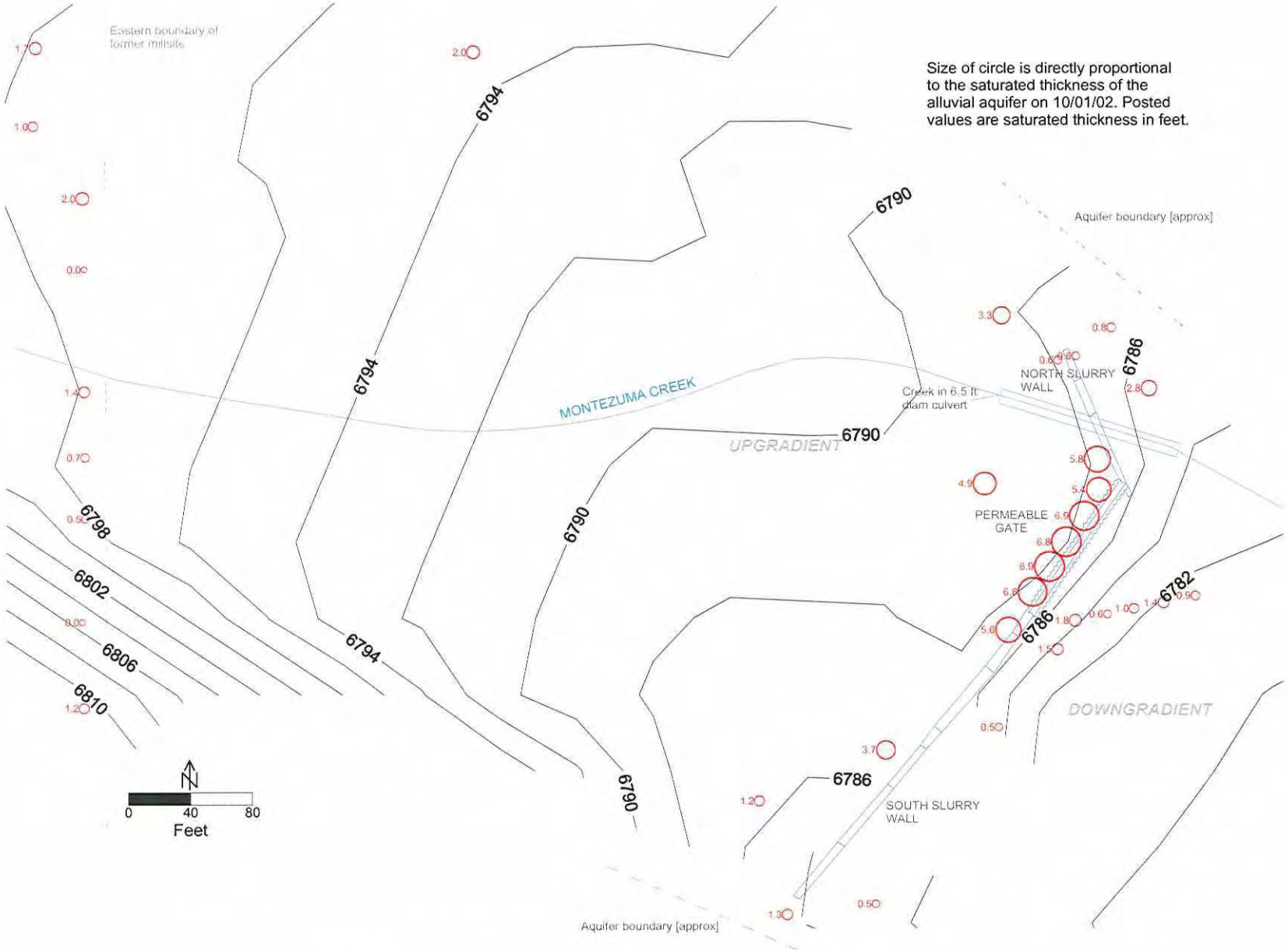

Figure 2–3. PRB Area Water Table and Saturated Thickness

Table 2–1. Contaminant Concentrations Compared to Preliminary Remediation Goals for OU III

Analyte	Upgradient Concentration[a] (µg/L)	Concentration Within the PRB (µg/L)	Downgradient Concentration (µg/L)	Preliminary Remediation Goal (µg/L)
Arsenic	10.7	<0.1	1.7	10
Manganese	171	338	767	880
Molybdenum	104	<1.7	<1.7	100
NO_3+NO_2 as N	2,080	27	32.5	10,000
Selenium	103	<0.13	<0.1	50
Uranium	535	<0.1	1.5	30
Vanadium	392	<0.3	0.5	330

[a]These contaminant concentrations are from the October 2002 sampling event. The upgradient concentrations are the mean values from the Row 1 wells (R1–M3 and R1–M4), the concentrations within the wall are the mean values from the Row 4 wells (R4–M3 and R4–M6), and the downgradient concentrations are the mean values from Row 6 wells (R6–M2 to R6–M5 and T6–D).

The influent and effluent interfaces of the PRB have been characterized by abrupt, steep hydraulic gradients. For example, until April 2001, there has been a 2-ft head loss across the influent interface. Similar drops occur along the downgradient interface between the PRB gravel zone and native alluvium, although the magnitude of the head loss is not as uniform. These steep gradients may be due to a zone of disturbed, lower conductivity alluvium separating undisturbed alluvium from the reactive media. The water table within the ZVI is essentially flat. Well hydrographs in Figure 2–4 illustrate the hydraulic behavior of the PRB through October 2002 (PRB monitor well locations are shown in Figure 2–2). The hydraulic gradients across the system are apparent in this figure as the vertical displacements between well groups. This figure also illustrates that the hydraulic gradient across the influent interface decreased from April 2001 to March 2002, in response to a water table rise within the PRB. During that time there was a 1-ft head loss across the influent interface. The cause of the increase in water levels in the PRB has not been evaluated in detail but may be due to precipitation of calcium carbonate or other minerals, causing a decrease in hydraulic conductivity. The PRB performance evaluation report (DOE 2002a) contains additional analysis of the hydraulic gradients in the vicinity of the PRB.

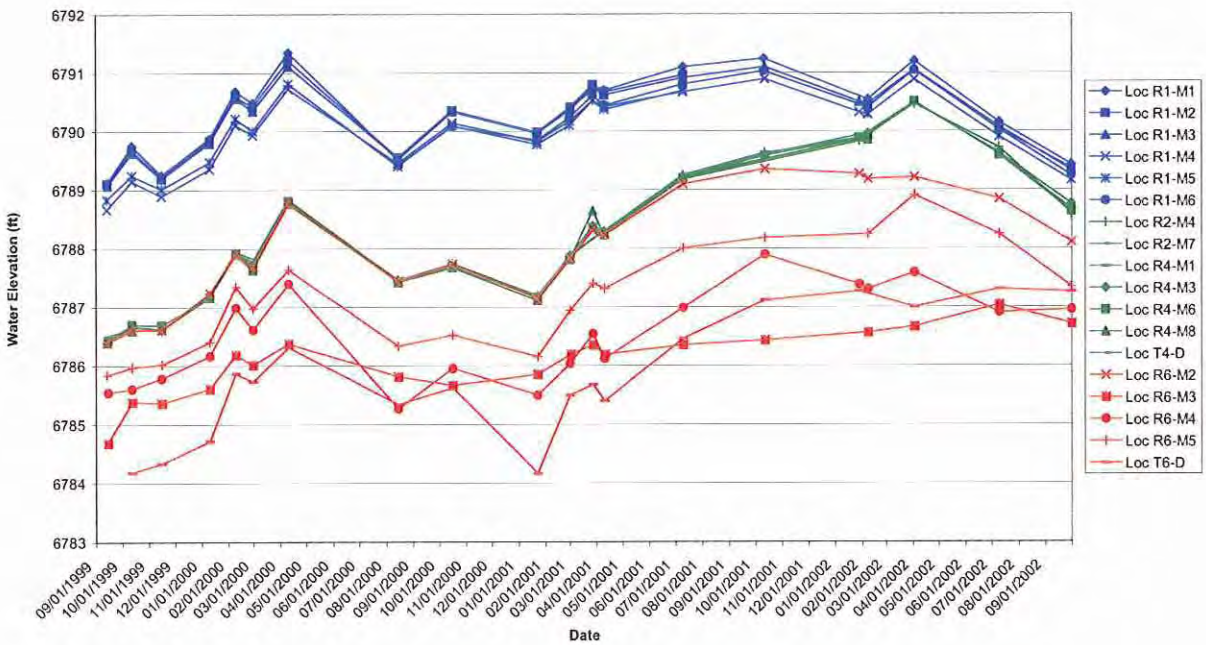

Figure 2–4. Well Hydrographs

Calculated estimates of ground water flow using Darcy's Law and tracer velocity data (see below) indicate flow through the PRB of 1.7 to 9.5 gpm and bypass flow around each slurry wall of 0.5 gpm.

2.6.2 Pumping Test

A step-drawdown pumping test and a recovery test conducted at the PRB in December 2001 indicated that the equilibrium flow rate through the PRB is about 9 gpm. Differences in drawdown between PRB wells and wells in the upgradient alluvium are consistent with the interpretation that a zone of less conductive material exists at the upgradient interface of the PRB. Pumping test conditions, drawdown and recovery curves, and test analysis are presented in the PRB performance evaluation report (DOE 2002a).

2.6.3 Slug Tests

In June 2000, Oak Ridge National Laboratory (ORNL) performed rising-head hydraulic tests at nine alluvial wells and three ZVI wells. Tests were performed in triplicate, and estimates of the hydraulic conductivity were made using the Bouwer and Rice solution (Bouwer and Rice 1976). Slug test results are summarized in Table 2–2. Additional information on the slug tests is presented on page 4-47 of the PRB performance evaluation report (DOE 2002a).

Table 2–2. Slug Test Results

Formation	Hydraulic Conductivity (cm/s)			
	Minimum	Maximum	Arithmetic Mean	Geometric Mean
Alluvium	2.50E–03	2.70E–02	1.3E-02	1.0E-02
ZVI	6.00E–02	7.40E–02	6.9E-02	6.9E-02

2.6.4 Analysis of Colloid Movement

In July 2000, ORNL used a colloidal borescope to estimate ground water velocity in the PRB. Six alluvial wells and four monitor wells in the 100 percent ZVI were tested to provide a broad view of the flow field and to identify possible flow anomalies. A detailed description of the borescope use and operation is included in *Monticello, Utah, Permeable Reactive Treatment (PeRT) Wall Ground Water Investigation, Work Plan, May 2000* (DOE 2000c). The results imply that in the upgradient alluvium, within a few feet of the gravel/ZVI zone, flow may be approximately perpendicular to the PRB and of relatively uniform magnitude over much of its length (i.e., there is not preferential flow into the PRB). Greater directional variability is implied in the ZVI zone that may result from heterogeneity within the ZVI zone, or heterogeneity along the effluent PRB/alluvium interface, which would create areas or windows of preferential outflow from the PRB.

2.6.5 Tracer Test

Also in July 2000, a multiple-species tracer test was performed at the PRB to investigate its hydraulic performance at that time and to provide a baseline that could be used to assess changes in performance over time. The tracer study was developed by ORNL; details of the test design

and results are documented in Liang et al. 2001 (Appendix F of DOE 2002a). Average velocities and residence times were estimated for three transects across the PRB (Figure 2–5).

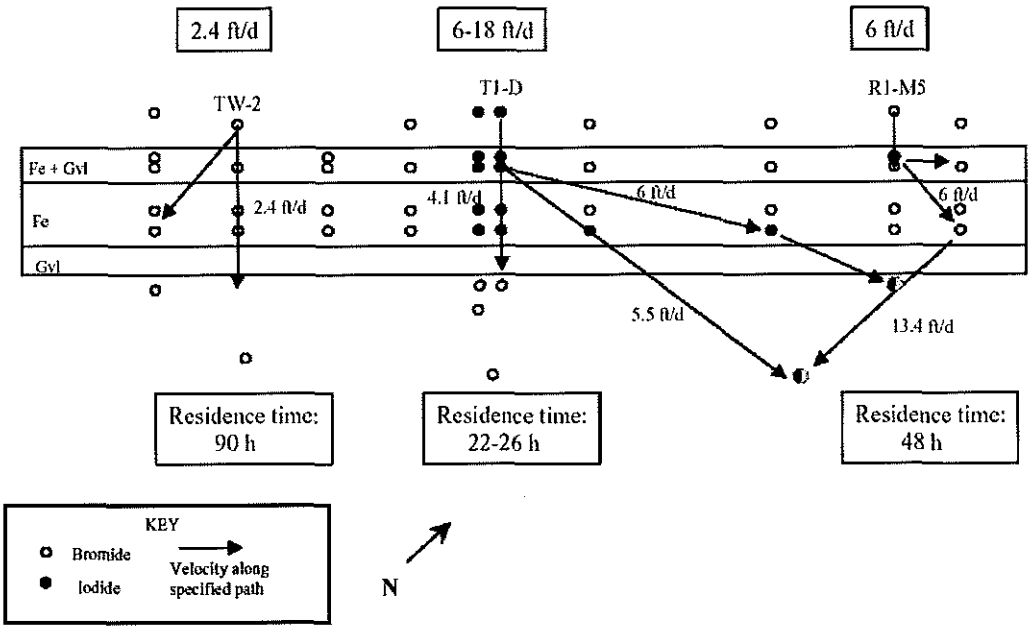

Figure 2–5. Schematic Drawing of Tracer Transport

ORNL investigators concluded that there is no evidence of a low permeability zone at the formation/ZVI interface because little or no tracer was detected in the wells located between the injection points and because tracers moved rapidly from the injection points to the PRB (Liang et al. 2001). This conclusion conflicts with the analysis of hydraulic head presented above. Furthermore, lateral flow is not be expected to occur exactly at the conductivity contrast; instead, a ground water mound will develop, and divergent flow will result some distance upgradient of the interface. Finally, a low-conductivity interface was implied in a previous analysis (DOE 2002a), which indicated that tracer velocity was less than the ground water velocity computed by Darcy's Law, using ORNL conductivity estimates and the hydraulic gradient in the alluvial aquifer.

2.6.6 Coring Project

A coring study was designed to provide an additional estimation of the mean flux of ground water through the PRB and to determine if the ground water flow was evenly distributed or preferred certain areas of the PRB. Cores were collected at six random locations along each of ten transect lines that trended perpendicular to the front interface of the PRB. Two random locations per transect were in the gravel/ZVI zones and four random locations were in the ZVI zone. Of these 60 locations, five were not completed due to drilling problems. Fifteen additional cores were collected at discretionary locations in the PRB, for a total of 70 sampling locations. Four samples from each core were selected randomly from 6-inch-long subsamples of the core for chemical analysis of calcium, uranium, and vanadium, resulting in 279 analyses. Core locations are shown in Figure 2–6.

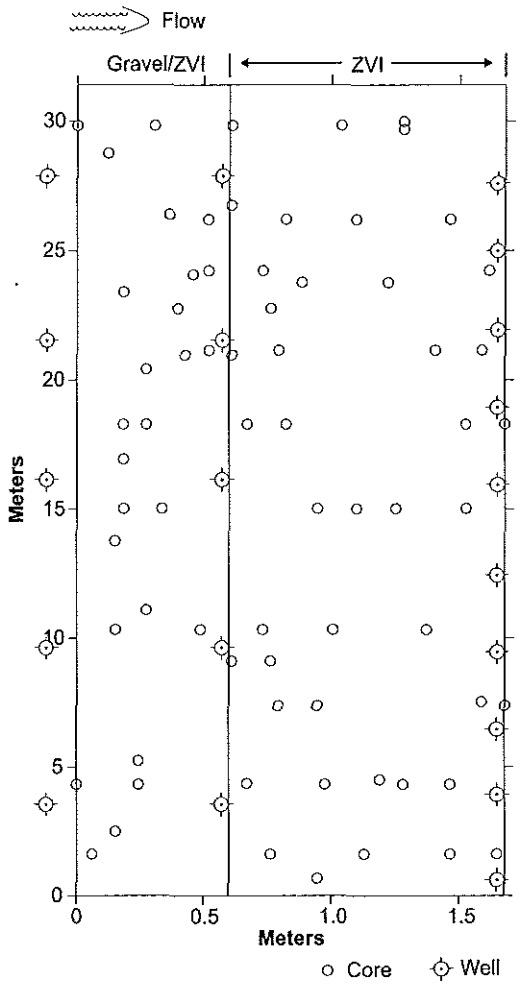

Figure 2–6. Core and Well Locations (width scale is expanded by a factor of 10)

Mean concentrations of calcium, uranium, and vanadium in each core hole from the gravel/ZVI zone range from 15.1 to 46.8 grams per kilogram (g/kg), 70 to 597 milligrams per kilogram (mg/kg), and 30 to 1,168 mg/kg, respectively, and are relatively evenly distributed along its length. The data indicated that flow has not bypassed any substantial portion of the PRB. Mean concentrations of calcium in cores from the ZVI zone range from 0.81 to 33.5 g/kg. Uranium and vanadium concentrations are similar to those of the parent material throughout the ZVI zone.

The total masses of calcium, uranium, and vanadium deposited since installation of the PRB were estimated using the mean concentrations of those elements in the gravel/ZVI or ZVI zone and the total mass of material in each zone. From ground water chemistry data, the mean concentration gradients of calcium, uranium, and vanadium across the PRB were calculated plus or minus two standard error. The mean ground water flux through the PRB during the first 2.7 yr of its operation (when the coring study was done) was estimated by combining this information (Table 2–3); the mean ground water flux was calculated from the total deposited mass divided by the concentration gradients. The overall calculated range of ground water flux based on this chemistry data is 7.2 to 75 liters per minute or 2 to 20 gpm. The PRB performance evaluation report (DOE 2002a) presents a complete analysis of the coring study results, including equations used in the calculations.

Table 2–3. Mean Ground Water Flux Through the PRB Over the First 2.7 Years of Operation

Constituent	Zone	Ground Water Flux (L/min)		
		Low[a]	Mean	High[a]
Ca	Gravel/ZVI	12.9	24.0	75.0
Ca	ZVI	7.2	11.3	18.3
U	Gravel/ZVI	14.5	24.0	43.6
V	Gravel/ZVI	11.4	16.0	22.8

[a]Low and high values incorporate the combined uncertainty of two standard error for the mean of the concentration gradient across the PRB.
L/min = liters per minute; ZVI = zero-valent iron

Longevity

Longevity of PRBs is currently receiving much attention from researchers and practitioners. No methods are available to reliably predict longevity because the physical and chemical mechanisms acting within the reactive media are not well understood. Two mechanisms have been identified that could limit the longevity of PRBs: reduction of reactivity due to corrosion of ZVI and reduction of porosity from deposition of minerals; the interdependence of these mechanisms is not known. Published estimates of PRB longevity rely on a variety of assumptions and span a wide range of values.

Assessments of PRBs installed prior to Monticello offer some insight about longevity of ZVI. Applications of ZVI-based PRBs address a wide range of contaminants including both organic and inorganic compounds; however, it is likely that some of the fundamental chemical mechanisms that limit reactivity are universal. The first ZVI PRB was a demonstration-scale project emplaced at Canadian Forces Base Borden, which operated from 1991 to 1996. Coring of the ZVI/sand mix in 1995 indicated that only a trace amount of calcium carbonate had precipitated in the PRB (O'Hannesin and Gillham 1998). O'Hannesin and Gillham speculated that the Borden PRB should last at least 9 yr from the time of installation. The first commercial ZVI-based PRB was installed at an industrial site near Sunnyvale California in 1995 and is apparently still functioning after nearly 8 yr to remove volatile organic compounds (Warner et al. 1998a; Warner 2002). Since installation, some ground water has mounded upgradient of the PRB (Warner et al. 1998b). In 1996, a full-scale ZVI-based PRB was installed at a coast guard site near Elizabeth City, North Carolina, to treat chromium-contaminated ground water (Puls and Wilkin 2002). After 5 yr of operation, Puls and Wilkin indicate that chromium removal has been consistent but that the spatial distribution has changed due to heterogeneities imposed by ground water chemistry. These authors note that porosity loss ranges from 1 to 5 percent per year at Elizabeth City. A demonstration-scale ZVI-based PRB was emplaced in 1997 to treat uranium-contaminated ground water at the Fry Canyon site in southeastern Utah (Naftz et al. 2002). Naftz et al. indicate that the PRB is still functioning properly (after about 5 yr), although calcite and other minerals have precipitated in the ZVI medium.

After 4 yr of operation, the Monticello PRB has lost some of its reactivity. The loss of reactivity is thus far confined to the gravel/ZVI zone; the ZVI zone still reduces contaminant concentrations nearly to detection limits. Although nearly 9 metric tons of calcite has precipitated in the PRB, reactivity loss may be a more critical factor for long-term performance. Using data from the coring study and using a worst-case scenario of exponential decline in ZVI reactivity, a longevity estimate of 9 yr since installation was predicted for the Monticello PRB

from the model proposed by Morrison (2003). On the basis of field results from Monticello and comparisons with other ZVI-based PRBs, it is likely that the Monticello PRB will continue to meet the regulated standards (30 µg/L for uranium) for at least 15 yr from the time of installation. Even after effluent uranium concentrations exceed the ground water standard, the PRB will likely continue to improve ground water quality for several decades. Continued monitoring and reassessment will be necessary to confirm acceptable performance.

2.6.7 Summary

- The PRB treatability study has not resulted in any changes to the human health and ecological CSMs. Contaminant concentrations (primarily uranium) have decreased in ground water downgradient of the PRB. New contaminant concentrations in ground water are discussed more fully in Section 2.8 and are incorporated into the HHRA updated in Section 4.1. Receptors chosen for analysis in the ERA are not exposed to ground water.
- Because the PRB was not installed until 1999, its hydraulic features were not addressed in the 1998 ground water flow model. The hydraulic features of the PRB are incorporated into the current ground water flow model (Section 3.0). It is assumed that the ZVI does not decrease contaminant concentrations in ground water, allowing the current transport model to predict future contaminant concentrations in ground water as a "baseline condition" (i.e., without benefit of active treatment). The baseline ground water transport model is modified as part of the detailed Analysis of Alternatives in the FFS to evaluate the effectiveness of the PRB (Section 5.6).

2.7 Surface Water and Ground Water Monitoring

Since 1996, surface water and ground water samples have been collected from specified locations according to a variable schedule specified in monitoring plans and modified by program directives. Monitoring was conducted annually in October 1997, semiannually in 1998, and quarterly in 1999, 2000, 2001, and 2002. The plans specifying monitoring protocol and documents summarizing the results are listed in Table 2–4. All surface water and ground water monitoring data collected since 1996 are presented in Appendix C. Surface water locations monitored during the IRA are shown on Figure 2–7; ground water locations monitored during the IRA are shown on Figures 2–2 and 2–8. Plate 3 (in back pocket) shows the locations of historically monitored sites.

2.7.1 Changes to the COC List

When the COC lists were developed for the 1998 HHRA and ERA, some contaminants were retained for continued monitoring because the environmental data were not sufficient to justify their deletion or because ecological benchmarks to compare them to were not agreed upon among DOE, EPA, and UDEQ. Also, in some cases, the analytical detection limits were not sufficiently low to rule out the contaminants' presence. Table 2–5 compares surface water and ground water COCs for human health and ecological risk in the 1998 RI with current COCs and numerical criteria established in ARARs or to-be-considered criteria. The following paragraphs summarize the rationale for refining the COC list identified in 1998. Analytical data for analytes that have been eliminated as COCs for this RI Addendum are presented in Section C1.0 of Appendix C.

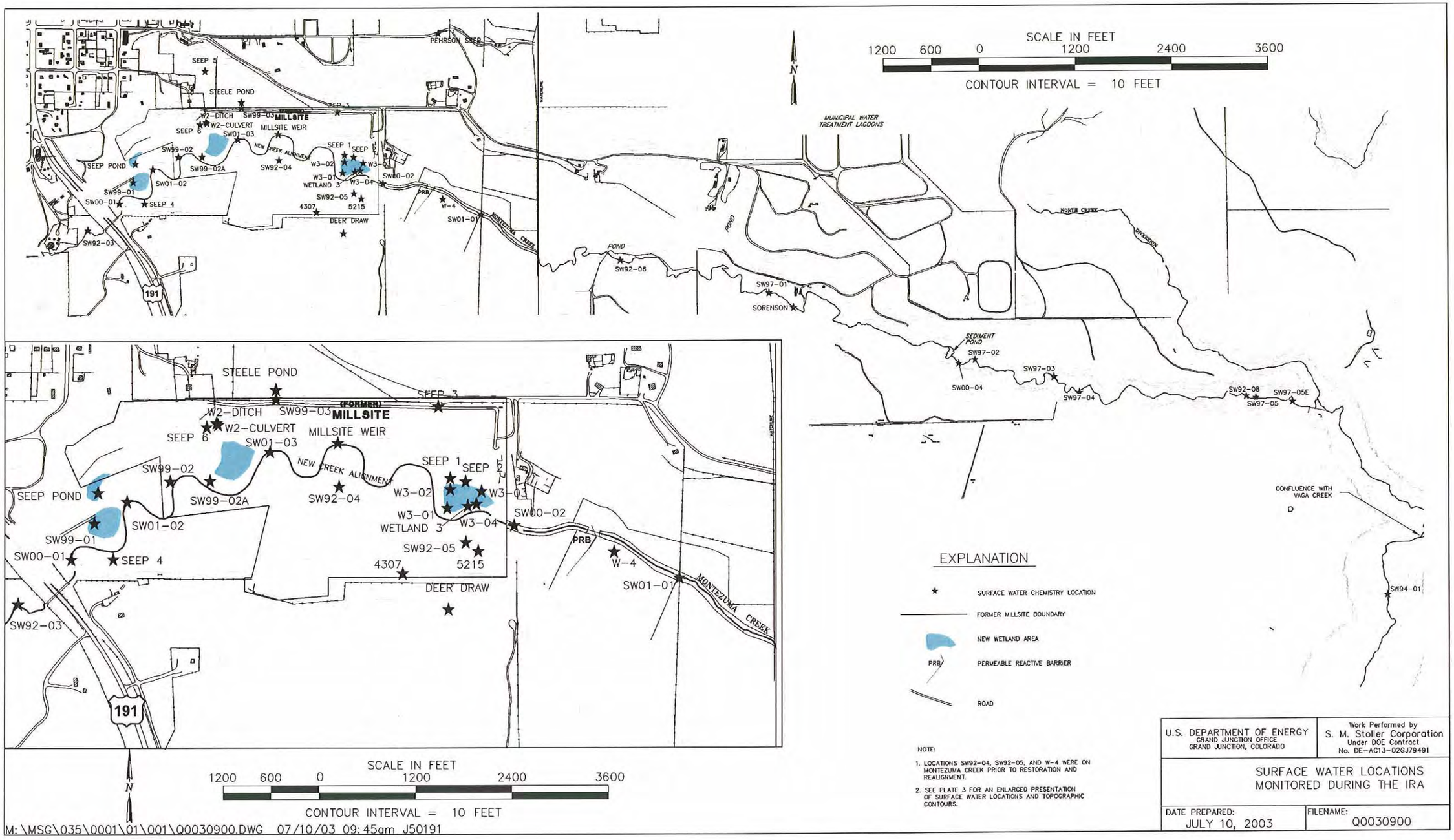

Figure 2–7. Surface Water Locations Monitored During the IRA

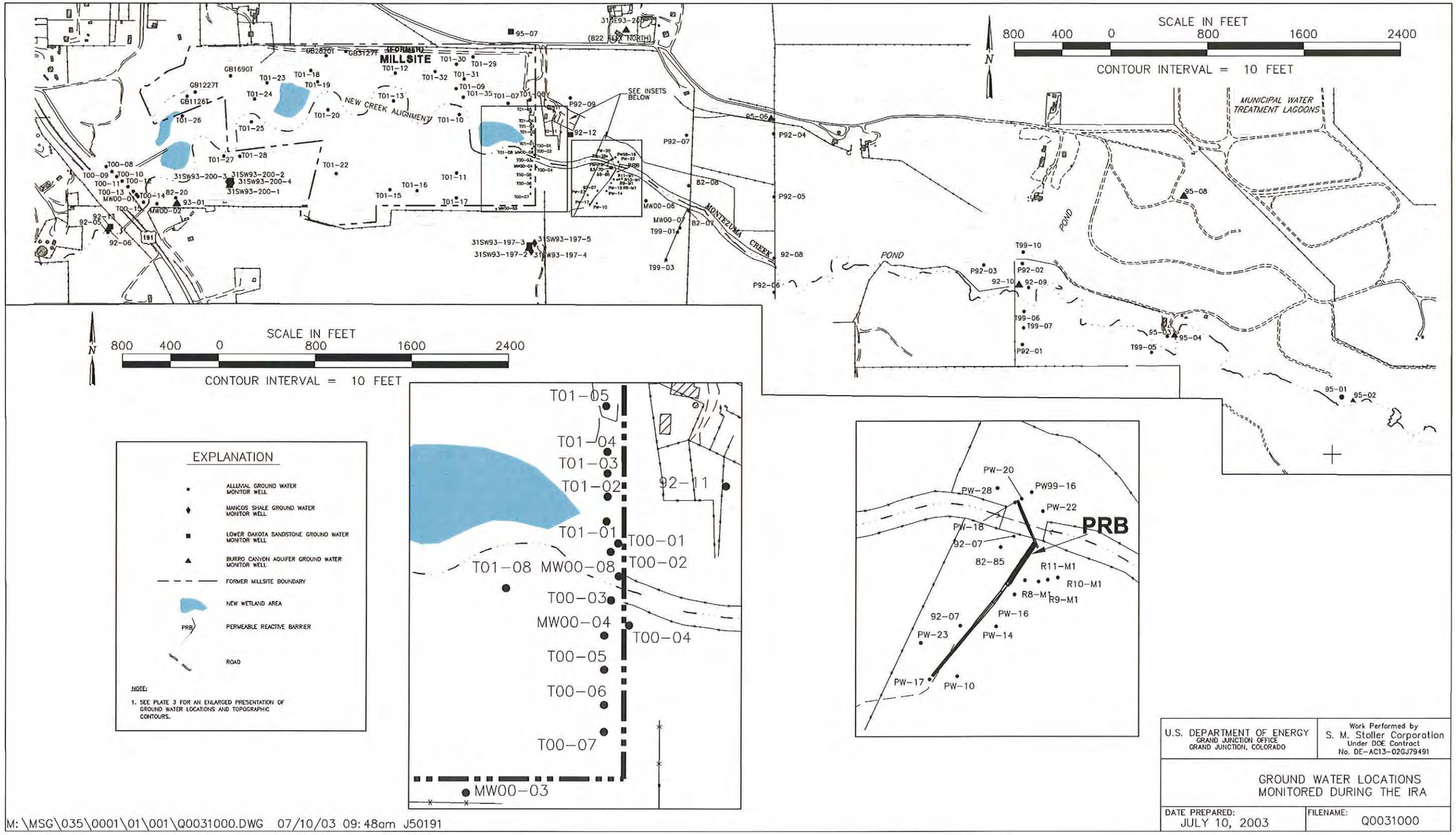

Figure 2–8. Ground Water Locations Monitored During the IRA

Table 2–4. Surface Water and Ground Water Monitoring Documents and Data Reports

Sampling Period		Monitoring Document	Program Directive	Data Documentation
Year	**Frequency**			
1997	**Annually** October	MMTS OU III Annual Monitoring Program (DOE 1997a)	MSGRAP 97–01	MMTS OU III, Data Summary Report, October 1996–April 1998 (DOE 1998i)
1998	**Semiannually** April	MMTS OU III Annual Monitoring Program (DOE 1997a)		MMTS OU III, Data Summary Report, October 1996–April 1998 (DOE 1998i)
	October			MMTS OU III, Surface Water and Ground Water Data Summary Report, October 1998–July 1999 (DOE 1999d)
1999	**Quarterly** January	MMTS OU III IRA Annual Monitoring Program (DOE 1998j)		MMTS OU III, Surface Water and Ground Water Data Summary Report, October 1998–July 1999 (DOE 1999d)
	April			
	July	MMTS OU III IRA Surface Water and Ground Water Monitoring Plan, Rev. 2 (DOE 1999e)	MSG 99–01	
	October		MSG 99–01 MSG 99–02	MMTS OU III, IRA Progress Report (DOE 2000b)
2000	**Quarterly** January	MMTS OU III IRA Surface Water and Ground Water Monitoring Plan, Rev. 3 (DOE 1999f)		MMTS OU III, IRA Progress Report (DOE 2000b)
	April		MSG 00–02 MSG 00–03	
	July		MSG 00–04	
	October		MSG 00–05	MMTS OU III, IRA Progress Report (DOE 2001a)
2001	**Quarterly** January	MMTS OU III IRA Surface Water and Ground Water Monitoring Plan, Rev. 3 (DOE 1999f)		MMTS OU III, IRA Progress Report (DOE 2001a)
	April	MMTS OU III, IRA Surface Water and Ground Water Monitoring Plan, Rev. 4 (DOE 2001b)	MSG 01–03	
	July		MSG 01–03 MSG 01–05	
	October		MSG 01–06	Remedial Investigation Addendum (DOE 2003)
2002	**Quarterly** January	MMTS OU III, IRA Surface Water and Ground Water Monitoring Plan, Rev. 4 (DOE 2001b)	MSG 02–01	Remedial Investigation Addendum (DOE 2003)
	April		MSG 02–01	
	July		MSG 02–01	
	October		MSG 02–03	

In November 1999, cobalt, copper, lead, and zinc were deleted as COCs because surface water data from the Millsite and downstream indicated that concentrations of these analytes had not exceeded identified benchmarks since RI data collection began in 1992. In the 1998 RI, cobalt, copper, lead, and zinc were not identified as COCs for human health nor did they exceed identified ground water benchmarks.

For cobalt, the surface water benchmark (3 µg/L) was obtained from the Great Lakes Water Quality Initiative Tier II methodology (see EPA 1996a, *ECO Update*, *Ecotox Thresholds*), which was used in absence of a Utah criterion in "Standards of Quality for Waters of the State" and of a Federal Ambient Water Quality Criterion. Since 1992, the maximum dissolved concentration of cobalt detected in surface water was 0.48 µg/L.

Copper in surface water was compared to an adjusted Utah standard for protection of aquatic wildlife. The adjusted criteria for copper are 39 µg/L for a 4-day average and 65 µg/L for a

Table 2–5. Comparison of 1998 and Current Human Health and Ecological Risk COCs

COC	Human Health COCs			Ecological COCs		
	SDWA MCL or Risk-Based Concentration	1998 Surface Water and/or Ground Water COC	Current (2003) Surface Water or Ground Water COC	State of Utah Aquatic Wildlife Criteria or Tier II	1998 COC	Current (2003) COC
Metals						
Arsenic	10 µg/L—SDWA	X	X	190 µg/L—AWC	X	X
Cobalt	2.2 mg/L—RBC			3 µg/L—Tier II	X	
Copper	1.3 mg/L—SDWA			39 µg/L—AWC (adjusted for hardness)	X	
Lead	15 µg/L—SDWA			19 µg/L—AWC (adjusted for hardness)	X	
Manganese	880 µg/L—RBC	X	X			
Molybdenum	100 µg/L—UMTRCA		X[a]	240 µg/L—Tier II	X	X
Nitrate (as N)	10 mg/L—SDWA		X[a]	4 mg/L—AWC	X	X
Selenium	50 µg/L—SDWA	X	X	5 µg/L—AWC	X	X
Sodium		X[b]	X[b]			
Sulfate		X[b]	X[b]			
Uranium	30 µg/L—SDWA	X	X	BVU	X	X
Vanadium	330 µg/L—RBC	X	X	19 µg/L—Tier II	X	X
Zinc	5 mg/L—SDWA			340 µg/L—AWC (adjusted for hardness)	X	
Radionuclides						
Pb-210	2 to 8 pCi/L—RBC[c]	X		100 millirad per day for chronic radiation exposure for terrestrial and aquatic receptors[d]	X	
Ra-226	5 pCi/L—SDWA	X			X	
Rn-222	BVU	X				
Th-230	BVU	X			X	
U-234	30 pCi/L total uranium—UMTRCA	X	X		X	
U-235+D		X	X		X	
U-238+D		X	X		X	
Gross Alpha	15 pCi/L—SDWA	X	X[b]			
Gross Beta	4 mrem—SDWA	X	X[b]			

Notes: Tier II—Great Lakes Water Quality Initiative Tier II Methodology (EPA 1996a)
BVU—Benchmark value unavailable; SDWA—Safe Drinking Water Act; RBC—EPA Region 3 risk-based concentration (EPA 2003) based on default exposure assumptions; UMTRCA—Uranium Mill Tailings Radiation Control Act.

[a]Molybdenum has been added as a COC to the current HHRA update because concentrations exceed an ARAR. Nitrate has been added as a COC to the current HHRA update because concentrations increased during remediation.

[b]Included as COC but not quantifiable because toxicity information is not available.

[c]PRG proposed in draft FS (1998)

[d]Unlike benchmark values developed for metal COCs that only consider intake, radionuclide benchmark values must consider dose from internal sources (ingestion) and external sources (the receptor's surroundings). The total radiation dose for all radionuclides combined is pertinent, not just the dose from each radionuclide ETAG selected (100 millirad/day). See Volume VII, Section 4.2.1, Ecological Benchmark Values, p 4-26 of the 1998 RI for additional information.

Document Number Q0029500

1-hour average filtered sample. Criteria are adjusted because the hardness of Montezuma Creek water (greater than 400 mg/L) is greater than 100 mg/L $CaCO_3$ that was used to calculate the criteria presented in the regulations. Appendix C, page C1–1 summarizes the hardness data for Montezuma Creek from November 1992 through October 2002 and the calculations used to adjust the aquatic benchmarks. Hardness data for each sampling location are presented along with the analytical data in Section C2.0 of Appendix C. Since 1992, the maximum dissolved concentration of copper detected in surface water was 6.0 µg/L.

For lead, the adjusted Utah standard for protection of aquatic wildlife is 19 µg/L for a 4-day average and 477 µg/L for a 1-hour average filtered sample (Appendix C, page C1–1). As with copper, the standards were adjusted because of the hardness of Montezuma Creek water. Since 1992, the maximum dissolved lead concentration in surface water was 2.0 µg/L.

Zinc in surface water was compared to the adjusted Utah standard for protection of aquatic wildlife of 340 µg/L for a 4-day average and 379 µg/L for a 1-hour average filtered sample (Appendix C, page C1–1). Since 1992, the maximum dissolved zinc concentration in surface water was 20.6 µg/L.

Pb-210, Ra-226/228, and Thorium-230 (Th-230) were deleted as COCs in April 2002 because they were not detected at concentrations above identified human health benchmarks in surface water and ground water samples that were collected since 1996. Radionuclide COCs are also responsible for internal and external radiation doses to ecological receptors. The 1998 ERA concluded that radiation exposure was not a concern because HIs were less than 0.1 in 1998 and for the scenario where 1,000 years of radioactive decay was accounted for (see the 1998 ERA pages 5–11 through 5–18). Therefore, risk from the individual radionuclides would also be of no concern. Surface water Pb-210 data are summarized in Appendix C, page C1–6.

Examination of the data indicates that the highest concentration of Pb-210 detected in surface water since the 1998 RI was 0.55 pCi/L, and most results are below the detection limit. Surface water Ra-226/228 data are summarized in Appendix C, pages C1–8 and C1–9, respectively. The highest concentration of Ra-226 detected in surface water since the 1998 RI was 2.7 pCi/L; Ra-228 results are all below the detection limit. Surface water Th-230 data are presented in Appendix C, page C1–11. Th-230 has been detected only once since the 1998 RI in surface water samples. That result was 0.76 pCi/L and was qualified as estimated.

Rn-222 was also deleted as a COC in April 2002 because the worst-case exposure scenario presented in the 1998 RI indicated that exposure would be less than EPA's indoor Rn-222 guideline. Analytical results for Pb-210, Ra-226/228, Th-230, and Rn-222 are presented in Section C1.0 of Appendix C.

On October 29, 2001, in an information transmittal prior to the FFA meeting scheduled for November 2001, DOE proposed deleting ammonia and phosphate from the quarterly monitoring list. Ammonia had been added as a potential COC because of the increase in nitrate concentrations that began in January 1999. Phosphate was added to the monitoring list not as a potential COC, but to analyze the possibility that the increase in nitrate was due to fertilizer use (phosphate is also a common constituent of fertilizers). In April 2002, regulatory agency concurrence was received on deleting phosphate from the monitoring list.

Prior to the January 2002 sampling round, UDEQ proposed benchmarks of 30 mg/L total ammonia as nitrogen for ground water and 0.5 mg/L total ammonia as nitrogen for surface water. Ground water concentrations are well below the proposed level, and it was agreed that ammonia could be deleted as a COC in that medium; however, there were no surface water data available for evaluation. A decision was made to collect surface water samples in January 2003 during low-flow conditions when concentrations are typically the highest. The ammonia as nitrogen results from the January round ranged from 0.0033 mg/L to 0.073 mg/L. At a May 14–15, 2002, meeting, a decision was made to collect samples in October 2002 to verify the January 2002 ammonia results. EPA and UDEQ reviewed the October 2002 results at a December 2–3, 2002, meeting. The results confirmed the low levels of ammonia detected in January 2002, and the regulatory agencies agreed that ammonia could be deleted as a COC. Analytical results for ammonia and phosphate are presented in Section C1.0 of Appendix C.

Summary

- The elimination of some of the 1998 analytes as COCs does not affect validity of the human health or ecological site conceptual models. Analytes that have been deleted as COCs are not included in calculations of human health risk presented in the update (Section 4.1).
- The elimination of some COCs does not affect the ground water flow and transport model.

2.7.2 Surface Water Results

The following discussion of surface water refers to current conditions at the site as represented by samples collected during 2002. Data are compared to numeric standards in regulations that have been identified as ARARs. In the absence of a numeric standard, the data are compared to risk-based concentrations (RBCs) that are identified as "to-be-considered" criteria. Numeric standards and RBCs have been chosen as PRGs. See Section 5.3 for a discussion on the selection of PRGs. Section C2.0 of Appendix C contains tables that summarize the RI surface water data and lists analytical results for samples collected during the IRA.

In surface water, concentrations of the COCs (arsenic, manganese, molybdenum, nitrate, selenium, uranium, and vanadium) at location SW00–01 near the western end of the Millsite were comparable to background concentrations measured at location SW92–03 (see Figure 2–7). Because of the similarity of results between the two locations, EPA and UDEQ agreed with DOE's proposal to limit background (upstream) sampling to location SW00–01, which is on city of Monticello property. Montezuma Creek was dry at SW00–01 and SW92–03 during 2002, and therefore no surface water samples were collected from those locations.

On the Millsite, the maximum concentrations of arsenic were detected at seep 2 (16.2 µg/L in January 2002) and at one of the four Wetland 3 sampling locations (10 µg/L in October 2002) (Plate 4). Downstream of the Millsite, arsenic is measured at concentrations less than 2 µg/L. The most stringent Utah surface water standard for arsenic is 50 µg/L, based on domestic use; however, this standard is anticipated to be revised to 10 µg/L to be consistent with the SDWA.

During 2001, manganese levels ranged from 3.6 to 23.2 µg/L at SW00–01; no upstream data are available in 2002 because of dry conditions. On the Millsite in 2002, the highest concentration was measured at one of the four Wetland 3 sampling locations (323 µg/L). Downstream of the Millsite, manganese concentrations varied from 10 µg/L at SW01–01 to 189 µg/L at the

Sorenson site (Plate 5). The increase in concentrations at the Sorenson site and to the east is consistent with historical data and is believed to be a result of Burro Canyon ground water discharge to the alluvial aquifer and to surface water. No surface water PRG has been identified for manganese; a PRG of 880 µg/L has been established for ground water based on human health risk.

On and downstream from the Millsite, molybdenum concentrations range from 2 to 23.9 µg/L (Plate 6). Overall, molybdenum concentrations have decreased in surface water east of the Millsite since the October 1994 sampling event. The decrease in molybdenum is attributed to the elimination of seep discharge from the tailings piles to the creek and to the positive effect of source removal at the Millsite and downstream along Montezuma Creek. No surface water PRG was identified for molybdenum; the PRG for molybdenum in ground water is 100 µg/L based on the UMTRCA standard.

Nitrate as nitrogen concentrations do not exceed the Utah surface water standard for nitrate (4.0 mg/L) at any Montezuma Creek locations on site or downstream. Concentrations of nitrate do exceed the standard at seep 3, located in the northeast corner of the Millsite and at W2-culvert and W2-ditch (Plate 7). Concentrations were highest at seep 3 and ranged from 45 to 52 mg/L during 2002.

Selenium concentrations increased in surface water beginning in January 2000, and during 2002 concentrations appeared to have stabilized. The highest concentration was measured on the Millsite at seep 3 (128 µg/L) in April 2002 (Plate 8). In Montezuma Creek, selenium concentrations ranged from 1.0 to 12.1 µg/L at locations on and downstream of the Millsite. The Utah criterion for protection of aquatic wildlife based on a 4-day average sample is 5 µg/L.

Uranium concentrations in Montezuma Creek progressively increase from background levels at SW00–01 based on 2001 data (SW00–01 was dry in 2002) on the western edge of the Millsite to a maximum concentration of 188 µg/L at the Sorenson site (see Plate 9). East of the Sorenson site, uranium concentrations either remain the same or decrease slightly at all other locations in the monitoring network. Uranium concentrations in 2002 samples are higher than those in 2001 samples (the maximum uranium concentration at the Sorenson site in 2001 was 114 µg/L). The increase in concentration is attributed to the drought conditions that existed in Monticello in 2002 that reduced the amount of clean water flowing in Montezuma Creek. Utah does not have a surface water standard for uranium. The SDWA standard for uranium as a metal is 30 µg/L.

Based on historical data from 1992 through 2001 (upgradient surface water locations were dry in 2002), vanadium is generally not detected in surface water samples collected west of the Millsite. Vanadium was detected at low concentrations (less than 2 µg/L) at most surface water sampling locations on the Millsite during 2002; however, a concentration as high as 53.2 µg/L was measured in Montezuma Creek at the eastern Millsite boundary and as high as 431 µg/L was measured at seep 2. These higher concentrations are consistent with ground water concentrations in the area. East of the Millsite, vanadium concentrations varied from nondetect to 28.2 µg/L during 2002 (Plate 10). Vanadium concentrations have stabilized since the decreases in concentrations were seen after seep discharge from the tailings piles was eliminated subsequent to the October 1994 sampling round. No surface water PRG was identified for vanadium; the risk-based concentration for protection of human health was used to establish the ground water PRG at 330 µg/L.

The Utah surface water standard for gross alpha does not exclude the contribution from radon or uranium. However, UDEQ Division of Environmental Response and Remediation and UDEQ Division of Water Quality have determined that, for the Monticello site, gross alpha concentrations in Montezuma Creek from the U.S. Highway 191 embankment eastward may exclude the contribution from radon and uranium. Surface water results for OU III adjusted in this manner do not exceed the 15 pCi/L standard.

In summary, recent (2002) data show that

- Arsenic, manganese, molybdenum, and vanadium concentrations in seeps or Montezuma Creek surface water do not exceed Utah surface water standards or, in their absence, ground water PRGs that are based on human health.
- Gross alpha results adjusted for uranium do not exceed the Utah surface water standard.
- Uranium concentrations exceed SDWA standards in Montezuma Creek on and downstream of the Millsite.
- Nitrate and selenium are the only COCs having concentrations that exceed Utah surface water standards. For nitrate, the Utah standard is exceeded only at seep 3. Selenium levels exceed the standard by a factor of 2 in Montezuma Creek and by as much as a factor of 25 at the seeps.

Surface water data for selenium, uranium, and vanadium are compared for three time periods in Tables 2–6, 2–7, and 2–8, respectively. Data from November 1992 through October 1998 represent site conditions prior to significant Millsite remediation. Data from January 1999 through October 2000 represent site conditions during significant Millsite disturbance from either excavation or backfilling. Data from January 2001 through October 2002 represent post-remediation site conditions.

Surface water time-concentration plots for arsenic, manganese, molybdenum, nitrate, selenium, uranium, and vanadium at downstream surface water locations are presented in Section D1.0 of Appendix D. Stream discharge measurements are presented in Section D2.0 of Appendix D.

Summary

- Changes in surface water COC concentrations do not affect the validity of the human health or ecological CSMs.
- Changes in surface water COC concentrations do require new exposure point concentrations to be evaluated in the human health risk assessment update (Section 4.1).
- Except for selenium, COC concentrations in Montezuma Creek have either decreased from or remained stable at 1998 levels and are below identified benchmarks. The increase in selenium concentrations in Montezuma Creek requires that risk to some receptors be reevaluated. The ETAG selected the southwestern willow flycatcher and spotted bat for reevaluation because these were the two receptors for which selenium was identified as a risk-driving COC in the 1998 RI. Benthic macroinvertebrates were also selected for reevaluation because they reside in the surface water and invertebrate ingestion was a risk-driving exposure pathway for the willow flycatcher and spotted bat. Section 4.2, "Ecological Risk Assessment Update," presents the results of the reevaluation of risk to these receptors.

Table 2–6. Comparison of Selenium Concentrations in Surface Water[a]

Surface Location	11/92 through 10/98[c,d]				01/99 through 10/00[e]				01/01 through 10/02[f]				10/02[g]
	Min	Max	Average	FOD	Min	Max	Average	FOD	Min	Max	Average	FOD	
Background													
SW92-01/-02/-03	1.0U	9.7	1.47	9/37	0.1	0.15	0.125	2/2	0.3U	0.65	0.457	2/3	--
SW00-01[b]	--	--	--	--	0.12	0.75	0.35	3/3	0.3U	0.56	0.287	1/3	--
Millsite													
SW92-05/SW00-02	1.0U	10.3	2.49	7/15	1.9	4.1	2.9	3/3	3.4	12.2	8.32	9/9	12.1
Downgradient													
W-4/SW01-01	1.0U	17.5	4	12/18	1.6	3.0	2.3	2/2	3.9	10	6.39	7/7	--
Sorenson	1.4	7.8	2.81	13/18	2.9	9.7	4.6	14/14	7.3	11.7	9.69	8/8	9.3
SW92-07/SW00-04/SW99-04	1.0U	19.6	3.65	9/14	1.9	7.6	4.04	10/10	2.5	9.8	6.98	4/4	2.5
SW92-08	1.0U	3.7	2.07	7/12	1.6	6.8	4.03	4/4	0.95	7.5	5.09	4/4	0.95
SW92-09	1.0U	4.1	2.25	6/10	1.8	2.0	1.9	2/2	--	--	--	--	--
SW94-01	1.0U	2.4	1.46	3/6	1.8	5.3	3.08	4/4	4.4	6.3	5.3	3/3	--

FOD = Frequency of detection
-- = No data; U = not detected; value is sample detection limit.
[a]Utah Criterion for protection of aquatic wildlife based on a 4-day average sample is 5 µg/L.
[b]Location was dry after October 2001 sampling event.
[c]Unfiltered samples were collected from 11/92 to 5/94, and in 6/96. All other results are from samples collected through 0.45 micrometer filter.
[d]Remediation data from November 1992 through October 1998 represent site conditions prior to significant Millsite disturbance.
[e]Data from January 1999 through October 2000 represent site conditions during significant Millsite disturbance from either excavation or backfilling.
[f]Data from January 2001 through October 2002 represent post-remediation site conditions.
[g]Data from October 2002 are used to assess near-term risk to human health.

Table 2–7. Comparison of Uranium Concentrations in Surface Water[a]

Surface Location	11/92 through 10/98[c,d]				01/99 through 10/00[e]				01/01 through 10/02[f]				10/02[g]
	Min	Max	Average	FOD	Min	Max	Average	FOD	Min	Max	Average	FOD	
Background													
SW92-01/-02/-03	1.0U	5.6	2.61	25/30	2.5	3	2.75	2/2	2.3	4.3	3.17	3/3	--
SW00-01[b]	--	--	--	--	2.4	3.9	3.33	3/3	2.5	4.5	3.33	3/3	--
Millsite													
SW92-05/SW00-02	4.4	202	61.5	12/12	14.3	23.7	18.8	3/3	30.3	79.5	47.5	9/9	79.5
Downgradient													
W-4/SW01-01	3.2	508	101	16/16	19.5	25.4	22.5	2/2	27.1	48.2	38.8	7/7	--
Sorenson	78.6	456	179	16/16	63.5	162	92.7	14/14	78	188	108	8/8	188
SW92-07/SW00-04/SW99-04	79.1	411	174	12/12	56	102	80.7	10/10	78.5	100	85.4	4/4	80.2
SW92-08	73.7	309	159	10/10	58.3	92.9	77.2	4/4	69.7	147	100	4/4	147
SW92-09	74.0	305	166	8/8	58.4	92.2	75.3	2/2	--	--	--	--	--
SW94-01	129	160	145	2/2	38.7	83.4	65.7	4/4	71.8	93.7	85.1	3/3	--

FOD = Frequency of detection
-- = No data; U = not detected; value is sample detection limit.
[a]Safe Drinking Water Act (SDWA) standard is 30 µg/L.
[b]Location was dry after October 2001 sampling event.
[c]Unfiltered samples were collected from 11/92 to 5/94, and in 6/96. All other results are from samples collected through 0.45 micrometer filter.
[d]Remediation data from November 1992 through October 1998 represent site conditions prior to significant Millsite disturbance.
[e]Data from January 1999 through October 2000 represent site conditions during significant Millsite disturbance from either excavation or backfilling.
[f]Data from January 2001 through October 2002 represent post-remediation site conditions.
[g]Data from October 2002 are used to assess near-term risk to human health.

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Table 2–8. Comparison of Vanadium Concentrations in Surface Water[a]

Surface Location	11/92 through 10/98[c,d]				01/99 through 10/00[e]				01/01 through 10/02[f]				10/02[g]
	Min	Max	Average	FOD	Min	Max	Average	FOD	Min	Max	Average	FOD	
Background													
SW92-01/-02/-03	1.0U	8.0U	2.69	2/37	1U	1.3U	0.575	0/2	0.96	4.8	2.35	3/3	--
SW00-01[b]	--	--	--	--	1.1	1.3U	0.8	1/3	0.87	5	2.49	3/3	--
Millsite													
SW92-05/SW00-02	1.8	446	104	11/15	1.8	4.1	2.73	3/3	12.2	89.4	47.2	9/9	53.2
Downgradient													
W-4/SW01-01	2.8	411	110	18/18	2.1	5.4	3.75	2/2	10.6	59.1	30	7/7	--
Sorenson	2.4	119	29.4	14/18	1.0U	4.8	2.83	10/14	1.9	16.9	9.71	8/8	1.9
SW92-07/SW00-04/SW99-04	2.3	77.0	24.8	10/14	1.0U	3.9	1.75	6/10	1	8.6	3.83	4/4	1
SW92-08	1U	44.0	17.3	9/12	1.0U	3.3	2.13	3/4	1.7	4.5	2.93	4/4	2.5
SW92-09	2.6	31.8	17.6	8/10	1.0U	1.8	1.15	1/2	--	--	--	--	--
SW94-01	1.9	8.4	4.4	3/6	1.0U	3.7	1.93	3/4	2.1	3	2.7	3/3	--

FOD = Frequency of detection
-- = No data; U = Not detected; value is sample detection limit.
[a]No surface water standard has been identified. The risk-based concentration for vanadium assuming domestic use is 330 µg/L.
[b]Location was dry after October 2001 sampling event.
[c]Unfiltered samples were collected from 11/92 to 5/94, and in 6/96. All other results are from samples collected through 0.45 micrometer filter.
[d]Remediation data from November 1992 through October 1998 represent site conditions prior to significant Millsite disturbance.
[e]Data from January 1999 through October 2000 represent site conditions during significant Millsite disturbance from either excavation or backfilling.
[f]Data from January 2001 through October 2002 represent post-remediation site conditions.
[g]Data from October 2002 are used to assess near-term risk to human health.

- Changes in surface water uranium concentrations require refinement of the 1998 hydrologic conceptual model and flow and transport model. Because COCs other than uranium were not modeled (see Section 3.0 for the justification), changes in surface water concentrations for other COCs do not affect the ground water model. The new ground water model is presented in Section 3.0.

2.7.3 Ground Water Results

Ground water analytical results from 2002 are discussed in the following paragraphs. Data are compared to numeric standards in regulations that have been identified as ARARs. In the absence of a numeric standard, the data are compared to RBCs that are identified as to-be-considered criteria. Numeric standards and RBCs have been chosen as PRGs. See Section 5.3 for a discussion on the selection of PRGs.

Alluvial Aquifer

In the alluvial aquifer, concentrations of COCs (arsenic, manganese, molybdenum, nitrate, selenium, uranium, and vanadium) at MW00–01 and MW00–02 just east of the U.S. Highway 191 embankment were comparable to background concentrations measured at location 92–05 west of the embankment (Section C3.0 of Appendix C). Near the highway embankment (location 82–20), concentrations of most COCs are also at or near background levels. Because of the similarity of results between the locations, EPA and UDEQ agreed with DOE's proposal to limit future background (upgradient) sampling to locations MW00–01 and MW00–02, which are on city of Monticello property.

Arsenic concentrations exceed the SDWA standard of 10 µg/L (the PRG) near the eastern margin of the Millsite and upgradient of the PRB (Plate 4). Concentrations are greatest at well T01–01 (33.1 µg/L) on the Millsite. Downgradient of the Millsite, concentrations are greatest at well 92–11, where they range from 12.8 to 17.9 µg/L.

Manganese concentrations are greatest at Millsite well T01–08, where the maximum concentration during 2002 was 14,200 µg/L (Plate 5). Well T01–08 is thought to be located in a relatively stagnant portion of the alluvial aquifer. Manganese concentrations are generally below the PRG of 880 µg/L east of the Millsite.

Molybdenum concentrations are greatest at Millsite wells T00–04 and T00–01, where concentrations during 2002 have at times exceeded the UMTRCA ground water standard of 100 µg/L (the PRG) by a factor of three (Plate 6). Downgradient of the Millsite, molybdenum concentrations generally do not exceed the PRG. The highest concentration during 2002 was 109 µg/L at well PW–23.

In October 2002, nitrate as nitrogen concentrations exceeded the SDWA standard of 10 mg/L (the PRG) only at well PW–23, located downgradient of the Millsite (Plate 7). The maximum concentration measured at this well in 2002 was 18.3 mg/L. Nitrate concentrations exceeded the standard at well PW–17 in January 2002 and at well P92–06 in January and April 2002; but, by July 2002, nitrate levels at these wells had dropped below the standard. Nitrate concentrations began to increase in January 1999 and generally peaked in April 2000 when concentrations in several wells exceeded 20 mg/L. Since April 2000, nitrate concentrations have been decreasing

at most wells. DOE believes that the increased nitrate concentrations in ground water are most likely the result of leaching of a chemical fertilizer that was applied to the Millsite and the peripheral property just east of the Millsite. Other possible explanations were identified and subsequently ruled out, including (1) use of irrigation water from the sewage treatment plant that may have been high in nitrate, (2) leaching of backfill borrow that had (or may have had) high levels of nitrate, and (3) leaching of a local nitrate source area. Appendix C of the 2001 IRA Progress Report (DOE 2001a) includes a discussion of these nitrate levels.

Selenium concentrations exceed the Utah ground water and SDWA standard of 50 µg/L (the PRG) at wells along the eastern Millsite boundary and at several wells within 1,500 ft of the eastern boundary. As shown on Plate 8, selenium concentrations began to increase in April 1999 and appeared to have peaked at some locations by April 2002. Possible explanations for the increase in selenium concentrations were explored and are presented in a white paper that was included as Appendix C of the 2001 IRA Progress Report (DOE 2001a). DOE believes that the increased levels are most likely due to weathering of Mancos Shale and Dakota Sandstone strata that were exposed after remediation and before backfill was emplaced, at which time selenium was released to the alluvial system. It is also hypothesized that selenium-rich ground water and surface water enters the Millsite from the north in the vicinity of seep 3 (Plate 8) as a result of irrigation practices in the city of Monticello that mobilize selenium from soils derived from Mancos Shale.

Uranium continues to be the most pervasive COC in the alluvial aquifer (Plate 9). Uranium concentrations exceed the SDWA standard of 30 µg/L and the UMTRCA standard of 30 pCi/L (44 µg/L) (both are PRGs) at all locations on the eastern margin and downgradient of the Millsite until Burro Canyon ground water discharges to the alluvial system and dilutes the ground water concentrations to levels below the standards at well 95–03 (Plate 9). The only exception to this generalization occurs at wells immediately downgradient of the PRB (e.g., PW–16, R10–M1), where water treated by the PRB has flushed or displaced contamination.

As shown by the time-concentration plot on Plate 7, after an initial significant decrease in concentration following Millsite remediation, uranium concentrations began to stabilize in January 2000, showed a slight downward trend through 2001, and increased slightly during 2002. The increase in 2002 is attributed to drought conditions that limited recharge of clean water to the alluvial system. Recharge to the alluvial system on the Millsite is primarily from underflow from the west and from hillsides on the north and south margins of the Millsite. Uranium time-concentration plots for additional wells not shown on Plate 9 are presented in Section D3.0 of Appendix D.

Vanadium concentrations in the ground water typically exceed an RBC for vanadium pentoxide of 330 µg/L (the PRG) at wells T00–01, T01–01, T01–02, 92–11, 88–85, and 92–07 (Plate 10). As shown in the time-concentration plot on Plate 10, vanadium concentrations have decreased from those presented in the 1998 RI; the decrease in vanadium concentrations is attributed to source removal on and downgradient of the Millsite.

In summary, recent (2002) data show that

- Manganese concentrations do not exceed the PRG in ground water off the Millsite.
- Molybdenum and nitrate as nitrogen concentrations exceed their PRGs at one location off the Millsite (PW–23).
- Arsenic and vanadium concentrations exceed their PRGs only at wells upgradient of the PRB.
- Selenium concentrations exceed the PRG by a factor of two within the first 0.5 mile downgradient from the Millsite boundary.
- Uranium concentrations exceed the PRG by at least a factor of 20 east of the Millsite and upgradient of the PRB; contamination greater than the PRG extends 1 mile to the east.

Ground water data for selenium, uranium, and vanadium are compared for three time periods in Tables 2–9, 2–10, and 2–11, respectively. Data from November 1992 through October 1998 represent site conditions prior to significant Millsite remediation. Data from January 1999 through October 2000 represent site conditions during significant disturbance from either excavation or backfilling. Data from January 2001 through October 2002 represent post-remediation site conditions.

Water level data for wells monitored during the IRA are presented in Section D4.0 of Appendix D. Hydrographs (Section D5.0 of Appendix D) show the low water level conditions in 2002. Additional discussion of ground water hydrology is presented in Section 3.2.

Bedrock Ground Water

Ground water samples collected from wells installed in bedrock formations indicate that contamination does not extend into those units. Bedrock data are presented in Section C4.0 of Appendix C.

Summary

- Changes in ground water concentrations do not affect the validity of the human health or ecological CSMs.
- Changes in ground water COC concentrations do require new exposure point concentrations to be evaluated in the HHRA update (Section 4.1).
- The ground water exposure pathway is not complete for the receptors chosen for the ERA; therefore, changes in ground water concentrations do not affect the ERA update.
- October 2002 ground water data represent the starting point for the current ground water transport model.

Table 2–9. Comparison of Selenium Concentrations in Ground Water[a]

Well and Location	11/92 through 10/98[d]				01/99 through 10/00[e]				01/01 through 10/02[f]				10/02[g]
	Min	Max	Average	FOD	Min	Max	Average	FOD	Min	Max	Average	FOD	
Background													
92-01/92-03/92-05[b]	1.0U	15.0UJ	1.87	6/25	0.94	1.3	1.12	2/2	0.49	2.4	1.49	4/4	--
MW00-01/MW00-02[b]	--	--	--	--	1.1	1.8	1.6	4/4	0.3U	2	1.2	12/13	1.1
Millsite													
82-40A/T01-12[c]	1.0U	3.0U	0.973	0/13	--	--	--	--	22.7	44.4	33	6/6	44.4
31SW91-14/T01-35[c]	7.0	15.6	11.3	11/11	--	--	--	--	34.4	50.3	40.2	5/5	50.3
31SW91-03/T01-07[c]	12.4	23.3	17.6	6/6	--	--	--	--	38.4	54.4	43.2	6/6	40
Millsite to PRB													
92-11[h]	**1.0U**	**50.8**	**10.9**	**13/16**	**19.3**	**142**	**89.9**	**9/9**	**85**	**197**	**124**	**8/8**	**85**
92-07	3.3U	37.9	11.9	10/11	4.2	54.2	15.7	9/9	16.6	93.7	65.4	12/12	80.5
88-85	2.0U	169	23.7	11/14	15.7	87	50.8	7/7	75.2	135	104	8/8	90.2
Downgradient of PRB													
82-08	--	--	--	--	4.5	17.5	9.75	8/8	26.4	57.9	44.2	7/7	47
P92-06	--	--	--	--	10.7	40	26.6	9/9	31.8	47.7	40.2	6/6	45.1
92-08	5.3	24.9	15.9	12/12	14.3	190	46.7	10/10	33.2	123	78.7	7/7	70.4
92-09[h]	**1.0U**	**6.0**	**1.1**	**1/20**	**0.1U**	**1.0U**	**0.292**	**1/6**	**0.1U**	**0.3U**	**0.11**	**0/5**	**0.1U**
95-03	1.0U	2.2U	0.85	0/8	0.1U	1.0U	0.208	0/6	0.1U	0.3U	0.125	0/4	0.1U
95-01	1.0U	2.2U	0.85	0/9	0.1U	1.0U	0.16	0/5	0.1U	1.2	0.467	1/3	0.1U

FOD = Frequency of detection
-- = No data; U = Not detected; value is sample detection limit.
[a]Utah ground water and Safe Drinking Water Act standard is 50 µg/L.
[b]Statistics combined for background well data sets.
[c]Wells T01-35, T01-07, and T01-12 were installed May to Oct. 2001 at the approximate location of wells 31SW91-14, 31SW91-03, and 82-40A, respectively. Wells 31SW91-14, 31SW91-03, and 82-40A were decommissioned in Oct. to Nov. 1996.
[d]Remediation data from November 1992 through October 1998 represent site conditions prior to significant Millsite disturbance.
[e]Data from January 1999 through October 2000 represent site conditions during significant Millsite disturbance from either excavation or backfilling.
[f]Data from January 2001 through October 2002 represent post-remediation site conditions.
[g]Data from October 2002 are used to establish initial concentrations in the ground water transport model and to assess near-term risk to human health.
[h]Near-term human health risk evaluated at well 92-11; 20-year future risk evaluated at well 92-09; see Section 4.1, "Human Health Risk Assessment," page 4–3 for explanation.

Table 2–10. Comparison of Uranium Concentrations in Ground Water[a]

Well and Location	11/92 through 10/98[d]				01/99 through 10/00[e]				01/01 through 10/02[f]				10/02[g]
	Min	Max	Average	FOD	Min	Max	Average	FOD	Min	Max	Average	FOD	
Background													
92-01/92-03/92-05[b]	2.5	6.3	4.87	19/19	5.3	5.9	5.6	2/2	4.4	4.9	4.73	4/4	--
MW00-01/MW00-02[b]	--	--	--	--	4.2	10	6.08	4/4	4.1	7.9	5.78	13/13	5.5
Millsite													
82-40A/T01-12[c]	1390	12600	5390	11/11	--	--	--	--	119	164	149	6/6	141
31SW91-14/T01-35[c]	2530	4080	3080	8/8	--	--	--	--	115	166	144	5/5	115
31SW91-03/T01-07[c]	1410	2100	1640	4/4	--	--	--	--	183	214	199	6/6	183
Millsite to PRB													
92-11[h]	**819**	**2870**	**1760**	**14/14**	**270**	**1670**	**884**	**9/9**	**254**	**423**	**331**	**8/8**	**317**
92-07	678	1420	1110	9/9	593	1180	821	9/9	576	1170	725	12/12	806
88-85	460	717	587	11/11	323	837	580	7/7	350	442	397	8/8	417
Downgradient of PRB													
82-08	--	--	--	--	5.2	208	68.5	8/8	3.4	79.1	22.8	7/7	79.1
P92-06	--	--	--	--	546	1320	984	9/9	306	604	455	6/6	306
92-08	459	713	603	9/9	227	467	360	10/10	241	363	287	7/7	261
92-09[h]	**243**	**431**	**307**	**17/17**	**261**	**298**	**279**	**6/6**	**260**	**281**	**269**	**5/5**	**260**
95-03	5.9	7.1	6.54	5/5	7.0	8.1	7.57	6/6	6.6	7.5	7.08	4/4	7.4
95-01	0.42J	1.3	0.629	3/7	1.3	3.9	2.62	5/5	0.26	2.1	0.943	3/3	0.47

FOD = Frequency of detection
-- = No data; U = Not detected; value is sample detection limit.
[a]Safe Drinking Water Act (SDWA) standard is 30 µg/L.
[b]Statistics combined for background well data sets.
[c]Wells T01-35, T01-07, and T01-12 were installed May to Oct. 2001 at the approximate location of wells 31SW91-14, 31SW91-03, and 82-40A, respectively. Wells 31SW91-14, 31SW91-03, and 82-40A were decommissioned in Oct. to Nov. 1996.
[d]Remediation data from November 1992 through October 1998 represent site conditions prior to significant Millsite disturbance.
[e]Data from January 1999 through October 2000 represent site conditions during significant Millsite disturbance from either excavation or backfilling.
[f]Data from January 2001 through October 2002 represent post-remediation site conditions.
[g]Data from October 2002 are used to establish initial concentrations in the ground water transport model and to assess near-term risk to human health.
[h]Near-term human health risk evaluated at well 92-11; 20-year future risk evaluated at well 92-09; see Section 4.1, "Human Health Risk Assessment," page 4–3 for explanation.

Table 2–11. Comparison of Vanadium Concentrations in Ground Water[a]

Well and Location	11/92 through 10/98[d]				01/99 through 10/00[e]				01/01 through 10/02[f]				10/02[g]
	Min	Max	Average	FOD	Min	Max	Average	FOD	Min	Max	Average	FOD	
Background													
92-01/92-03/92-05[b]	1.1U	9.0	2.73	1/25	1U	1.3U	0.575	0/2	0.3U	0.4U	0.233	1/4	--
MW00-01/MW00-02[b]	--	--	--	--	1.3U	1.3U	0.65	0/4	0.3U	1.1	0.374	5/13	0.3U
Millsite													
82-40A/T01-12[c]	39.0	215	94.5	13/13	--	--	--	--	15.6	53	29.8	6/6	53
31SW91-14/T01-35[c]	749	992	866	11/11	--	--	--	--	222	262	245	5/5	249
31SW91-03/T01-07[c]	1200	1340	1270	6/6	--	--	--	--	86.2	102	92.6	6/6	102
Millsite to PRB													
92-11[h]	**756**	**1000**	**876**	**16/16**	**541**	**717**	**590**	**9/9**	**494**	**577**	**534**	**8/8**	**562**
92-07	351	467	419	11/11	294	416	342	9/9	291	397	344	12/12	395
88-85	374	458	426	14/14	304	441	360	7/7	291	417	341	8/8	417
Downgradient of PRB													
82-08	--	--	--	--	4.8	13.6	8.24	8/8	4	10	5.64	7/7	10
P92-06	--	--	--	--	0.4U	1.3U	0.444	0/9	0.3U	0.67	0.285	2/6	0.67
92-08	2.4	8.0U	3.05	3/12	1.0U	2.6J	1.57	8/10	1.6	2.8	2.23	7/7	2.8
92-09[h]	**1.0U**	**8.0U**	**2.02**	**0/20**	**0.4U**	**1.3U**	**0.442**	**0/6**	**0.3U**	**0.4U**	**0.16**	**0/5**	**0.3U**
95-03	1.0U	7.7U	1.93	0/8	0.40U	1.3U	0.442	0/6	0.3U	0.4U	0.163	0/4	0.3U
95-01	1.0U	7.7U	1.95	1/9	1.0U	3.6	1.75	2/5	0.3U	0.47	0.273	1/3	0.3U

FOD = Frequency of detection
-- = No data; U = Not detected; value is sample detection limit.
[a]Risk-based concentration assuming domestic use is 330 µg/L.
[b]Statistics combined for background well data sets.
[c]Wells MW00-01 and MW00-02 installed in June 2000. Wells T01-35, T01-07, and T01-12 were installed May to Oct. 2001 at the approximate location of wells 31SW91-14, 31SW91-03, and 82-40A, respectively. Wells 31SW91-14, 31SW91-03, and 82-40A were decommissioned in Oct. to Nov. 1996.
[d]Remediation data from November 1992 through October 1998 represent site conditions prior to significant Millsite disturbance.
[e]Data from January 1999 through October 2000 represent site conditions during significant Millsite disturbance from either excavation or backfilling.
[f]Data from January 2001 through October 2002 represent post-remediation site conditions.
[g]Data from October 2002 are used to establish initial concentrations in the ground water transport model and to assess near-term risk to human health.
[h]Near-term human health risk evaluated at well 92-11; 20-year future risk evaluated at well 92-09; see Section 4.1, "Human Health Risk Assessment," page 4–3 for explanation.

2.8 Data Collection Activities

In addition to routine sampling, numerous data collection and interpretation activities have been undertaken to revise the hydrological conceptual site model and, in turn, refine the ground water flow and transport model for the site. Tasks were implemented in a phased approach to characterize post-remediation conditions at the Millsite that affect the surface water and ground water systems. These tasks are reported in the 1999, 2000, and 2001 IRA Progress Reports and are summarized in the following sections.

2.8.1 Installation of Temporary and Permanent Monitor Wells

Throughout the Millsite and in some downgradient areas, wells were decommissioned or removed by remediation activities, interrupting monitoring capabilities. Temporary wells were installed in phases; some were installed after remediation was completed in an area, such as temporary wells GB1126T, GB1227T, GB1690T, GB2820T, and GB3127T in the northwestern and north central areas of the Millsite. Other temporary wells were installed after Millsite restoration.

Temporary wells were installed on six occasions: February, June, and October 1999, April/May 2000, February 2001, and May/June 2001. Temporary wells were also installed as part of the south source area investigation (Deer Draw Investigation); those wells are discussed in the 2001 IRA Progress Report (DOE 2001a). Borehole and well data were used to determine aquifer boundaries, to determine the extent of ground water contamination in areas not previously characterized, and to guide placement of wells for long-term monitoring. Depth to bedrock, water level, and lithologic information was obtained. Installation of the majority of temporary wells on the Millsite was postponed until May and June 2001 because of site restoration activities. Wells installed through April/May 2000 were reported in the 1999 and 2000 IRA Progress Reports (DOE 1999g and 2000b, respectively). Well installation in February and June 2001 was reported in the 2001 IRA Progress Report. Well installation and development followed procedures described in the IRA Work Plan (DOE 2000d).

Some temporary wells were decommissioned so that site restoration could be completed; other temporary wells on private property were decommissioned because of landowner concerns and because they were not essential to the monitoring network. Well decommissioning is discussed on Page 4-10 of the 2001 IRA Progress Report.

2.8.2 Evaluation of the Subpile Vadose Zone

To evaluate the significance of the vadose zone as a long-term source of ground water contamination, the distribution and mobility of COCs in the vadose zone were characterized.

Characterization of the Distribution of Metal COCs in Vadose Zone Soil

Surface soil samples were collected in accordance with the OU I verification plan (DOE 1997b), and subsurface sampling occurred in accordance with the IRA Work Plan. The purpose of these sampling events was to understand the distribution of metal COCs in vadose zone soil.

As remediation of the Millsite proceeded, analytical data from the surface and subsurface soil samples and column leach tests (discussed below) were used to guide soil removal beyond the excavation depth required to meet 40 CFR 192.12 (5/15 pCi/g) standards for radium. This resulted in removal of 75,000 yd^3 of residual uranium- and vanadium-contaminated soil from the Millsite beyond that required to meet the Ra-226 cleanup standard. After removal of the residual uranium- and vanadium-contaminated soil, arsenic, uranium, and vanadium concentrations in the upper 6 inches of soil and bedrock averaged 10.3 mg/kg, 8.5 pCi/g, and 37.6 mg/kg, respectively. Frequency plots and sample results are presented on page 4-28 of the 2000 IRA Progress Report. Using the analytical data presented in Appendix G–1 of 2000 IRA Progress Report, summary statistics and a frequency plot for selenium have been generated (Appendix C5.0, page C5–1). This analysis indicates that after removal of residual contaminated soil, the average selenium concentration in the upper 6 inches of soil on the Millsite was 0.41 mg/kg.

Additional soil sampling occurred at depths of up to 7 ft below the remediated surface. Analytical results from these samples indicate that arsenic concentrations do not vary widely with depth, uranium concentrations typically decrease with depth, and vanadium concentrations range widely in the upper 36 inches of soil but decrease and become less variable at greater depths. Depth profiles for arsenic, uranium, and vanadium are presented on page 4-32 of the 2000 IRA Progress Report.

During discussion of vadose zone modeling at the March 2001 FFA meeting, it was decided that additional vadose zone samples would be collected in the northeast corner of the former East Tailings Pile, in and around the construction staging area. During May and June 2001, soil samples were collected at six of the locations shown on Figure 2–8 (T01–07, –09, and T01–29 to –32). In general, arsenic and vanadium concentrations were consistent or less than the mean concentrations presented above. Uranium concentrations were less than the mean presented above at all locations except T01–07, where they were greater. Analytical results by location are presented in Section C5.0 of Appendix C.

Characterization of the Mobility of COCs in Vadose Zone Soils

Column leach testing was performed to evaluate the need for additional remediation beyond that required to meet the radiometric cleanup standard and to determine if post-remediation soil was a potential source of contamination to the alluvial aquifer. Soil samples used in the column tests were collected from subpile areas that had been remediated to the Ra-226 soil standard. Leaching of arsenic, uranium, and vanadium was evaluated because these analytes are the primary risk drivers identified in the 1998 RI (see RI Appendix L, "Human Health Risk Assessment"). The column testing was completed in May 2000 (DOE 2000e) and reported in the 2000 IRA Progress Report (DOE 2000b).

Results of the column testing indicate that uranium is readily mobilized by simulated surface water, ground water, and irrigation water (simulated surface water with a fertilizer component added). By extrapolation, the subpile vadose zone represents a source of contamination to the alluvial aquifer for a relatively long period if leached by precipitation, ground water, or irrigation water. However, the effect on ground water quality depends on infiltration rate, thickness and area of the subpile; volumetric flow of ground water beneath the source; source concentration; and contaminant mobility. On the basis of the column test results, additional soil was excavated

beyond the depth required to meet the Ra-226 standard as described above. In most areas of the Millsite, additional remediation occurred when soil uranium results exceeded 12 mg/kg.

Column testing results for arsenic and vanadium indicated that, for these COCs, the subpile soil is unlikely to be a significant source of contamination to the ground water. Nevertheless, additional excavation beyond the depth required to meet the Ra-226 standard occurred when vanadium concentrations in subpile soils exceeded 70 mg/kg over large areas (several verification grid blocks). Arsenic concentrations were only slightly elevated over background concentrations and therefore, a soil cleanup goal was not used for this constituent.

Summary

- Results of the subpile vadose zone evaluation have no effect on the HHRA or ERA conceptual site models.
- On the basis of results of the subpile vadose zone evaluation, DOE, EPA, and UDEQ agreed that a vadose zone flow and transport model was unnecessary and therefore was not developed or included in the ground water model update (Section 3.0), as was done for the 1998 ground water model. Results of the evaluation are used, however, to represent the contribution of uranium from subpile soil to ground water.

2.8.3 Evaluation of Contaminant Mobility in the Saturated Zone

Column leach and sorption batch tests were performed on samples of the aquifer substrate to evaluate contaminant mobility in the saturated zone as described below.

Column Leach Tests

Column leach tests were performed on samples of alluvium collected from the saturated zone (Figure 2–9) to determine if, after the primary source of contamination (mill tailings) is removed from the site, COCs will leach at significant concentrations from sediments within contaminated regions of the alluvial aquifer. The tests, performed at the Grand Junction , Colorado, Environmental Sciences Laboratory (ESL), evaluated the leaching behavior of arsenic, molybdenum, selenium, manganese, Pb-210, uranium, and vanadium. Separate reports were prepared by the ESL to document the procedures and results (DOE 2001c and DOE 2002b). Results were also presented in the 2001 IRA Progress Report (DOE 2001a). The results indicated that appreciable leaching of uranium from the sediments to ground water could be expected. Leaching of the remaining COCs did not represent a significant residual source of ground water contamination.

Sorption Batch Tests

Sorption batch tests were performed to estimate distribution ratios (K_d) for uranium, vanadium, and arsenic between aquifer sediment and an aqueous solution prepared in the laboratory to have the general chemistry of site ground water. The sediments tested consisted of native alluvial deposits from uncontaminated regions of the aquifer (sampling locations shown on Figure 2–10). Prior to the tests, the samples were air dried and sieved through a 2-millimeter (mm) screen. The weights of the size fractions (≤2 mm and >2 mm) were measured and recorded. A split from the

≤2-mm fraction was analyzed at the Grand Junction, Colorado, Analytical Chemistry Laboratory for arsenic, manganese, molybdenum, selenium, uranium, and vanadium to confirm that the samples were not contaminated. The ESL completed the laboratory batch tests in April 2001. Six-point variable mass batch testing was conducted according to ESL Procedure CB(Rd–1) (GJO 210), which follows an American Society for Testing and Materials procedure for batch-type testing (ASTM 1993). The ESL prepared a separate report to document the procedures and test results (DOE 2001d).

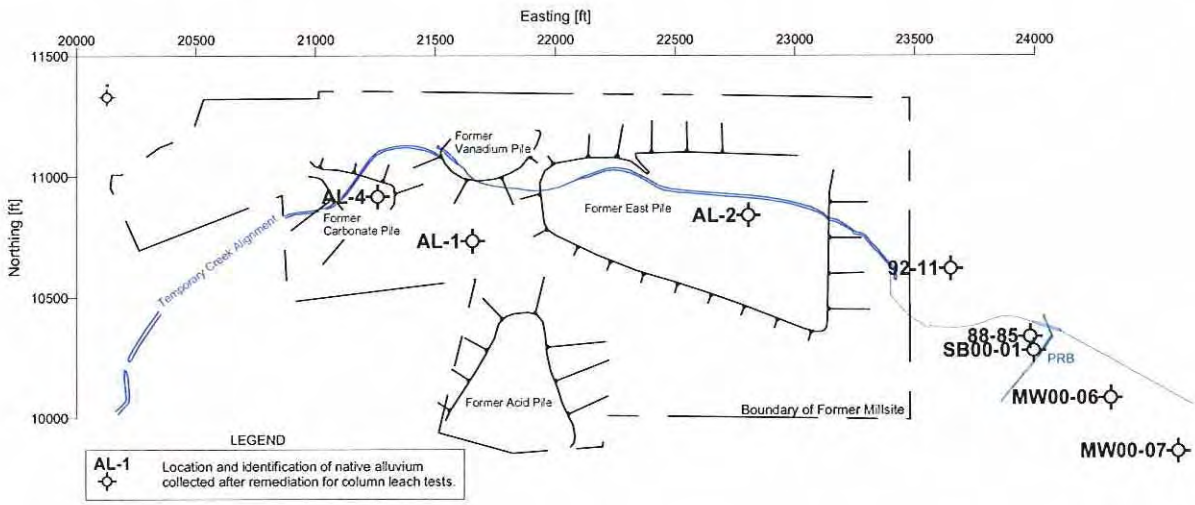

Figure 2–9. Location of Samples Collected for Column Leach Tests

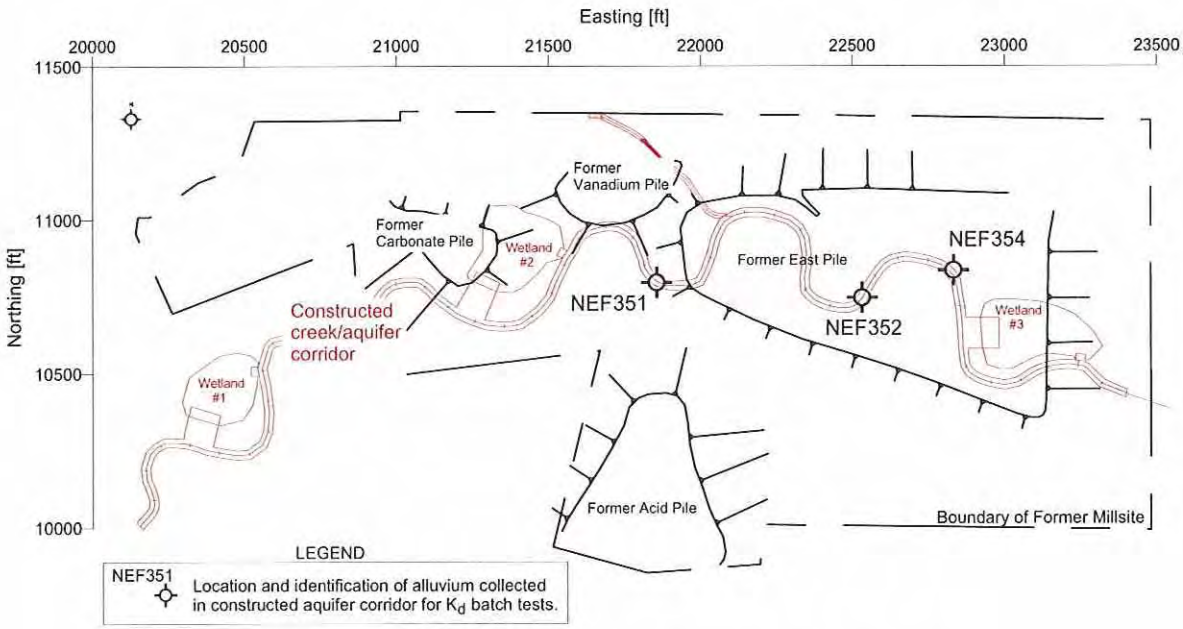

Figure 2–10. Location of Samples Collected for K_d Batch Tests

Recent literature recommends several methods to correct K_d values determined on ≤2-mm fractions to account for the relatively nonsorptive proportion of the larger grains (Kaplan 2000). The ESL-corrected values for the mean K_d for each sample are shown in Table 2–12. The corrections assume no sorptive capacity of the >2-mm fraction.

Table 2–12. Mean Distribution Ratios (K_d) for Uranium, Arsenic, and Vanadium From Monticello OU III, Adjusted for Grain Size

Sample Location	Uranium Mean K_d (mL/g)[a]	Arsenic Mean K_d (mL/g)	Vanadium Mean K_d (mL/g)
NEF351	2.1	110	90
NEF352	0.5	33	25
NEF354	0.79	46	23
Representative Value	0.65[b]	40[b]	24[b]

[a]mL/g = milliliters per gram
[b]The representative K_d is an average of the values for NEF 352 and NEF 354. See text for explanation.

The results indicate that the bulk alluvial sediment is mildly retentive of uranium, whereas its ability to sorb arsenic and vanadium is much greater. It is common practice to assign a single K_d value to an aquifer in a ground water flow and contaminant transport model. Because ground water flow will favor coarser materials, the data for sample NEF351 may yield a K_d value that is too conservative for the site, because it had a much greater proportion of fine grains. The ESL reports that the recommended K_d values from these test results are the average for samples NEF352 and NEF354, which had a much greater proportion of coarse grains.

Additional details on test conditions, results, and recommendations are presented in the ESL report (DOE 2001d), and the 2001 IRA Progress Report (DOE 2001a).

Summary

- The evaluation of contaminant mobility in the saturated zone has not changed the HHRA or ERA CSMs.
- Results of column leach tests indicate that only uranium is expected to be leached from the aquifer sediments in appreciable quantities. Because the other COCs have limited distribution in ground water, and leaching of those COCs from aquifer sediments is not expected to be significant, modeling transport of the other COCs is not necessary in the update. The 1998 ground water model will be updated using K_d values obtained from the sorption batch test analysis.

2.8.4 Aquifer Testing

A pumping test of the alluvial aquifer was conducted at well 95–03 in November 2001. Results of the test were to provide hydraulic conductivity information within the eastern portion of the existing network of monitor wells. Drawdown and water level recovery were monitored at four temporary piezometers, the pumping well, and adjacent bedrock well 95–04. Pumping rates were increased stepwise from the initial rate of 0.47 gpm to 1.3 and then 2.2 gpm. The durations of the pumping steps were 4.8, 13.5, and 6.3 hours, respectively. The maximum available drawdown in the pumping well was approached at the final pumping rate. Water level recovery was recorded for a period of time that exceeded the pumping period.

Analysis of the drawdown data produced widely varying estimates of hydraulic conductivity, depending on the method employed and the observation well. The overlapping effects of multiple recognized hydrologic boundaries probably invalidate analysis of the test data by conventional methods. Furthermore, the initial pumping period was probably much too short for the intended purpose of the test, and there is no method available to analyze recovery data from a step drawdown test. The test results and hydraulic conductivity were therefore inconclusive and were disregarded.

A second pumping test planned for the constructed creek/aquifer corridor on the Millsite was not performed because of expected difficulties in properly conducting and interpreting the test. A pumping test on the PRB horizontal air sparging pipe was conducted instead. The PRB pumping test is summarized in Section 2.6.2 of this document and fully described on Page 4-24 of the *MMTS OU III, Evaluation of the Permeable Reactive Treatment Wall Treatability Study* (DOE 2002a).

2.8.5 South Millsite Source Investigation

During a site visit on April 4 and 5, 2000, DOE, EPA, and UDEQ decided to add two surface water/seep sample locations to the quarterly sampling round that was scheduled for mid-April. The surface water of concern was located in the southeastern part of the Millsite, near the downstream/downgradient end of Deer Draw, a prominent drainage ravine. Analytical results showed elevated total uranium concentrations.

The analytical results were reviewed with the regulatory agencies, and the decision was made to conduct soil sampling in the vicinity of the seeps. Soil samples were collected in June, July, and August 2000. Seven temporary wells were installed along the Millsite's southeastern boundary and were sampled in August 2000. Results from these samples indicate that Deer Draw does not funnel a significant quantity of ground water into the Millsite alluvium. In November 2000, the temporary wells along the southern boundary of the Millsite were decommissioned so that the restoration contractor could place backfill in the area.

During a September 26, 2000, meeting, a decision was made to gather and review topographic maps, information from old photographs and reports, elevations of wells, and lithologic information prior to making any further decisions concerning additional fieldwork that might be needed to identify the source of the contaminated water. As part of that effort, the Site Analysis Report (DOE 1984) provided information on the leaching process and water management practices during the time the tailings impoundment that eventually became the Acid Pile was in use (mill tailings were hydraulically emplaced at this location). The report stated that about 3,500 gallons of process water were bled from the elution cycle daily and were disposed of in separate ponds and allowed to evaporate. An aerial photograph taken in 1962 showed three ponds east of the impoundment. One of the ponds lies directly over the location of one of the seeps. Seep sample results from the 1980s showed high uranium concentrations and nondetectable vanadium. The lack of vanadium would be expected from these tailings because vanadium recovery had ended before use of the Acid Pile had begun (i.e., vanadium was not mobilized during ore processing). Samples from seeps 4307 and 5215 (Figure 2–6) are also characterized by very low concentrations of vanadium.

The historical information was discussed with the regulatory agencies, and it was agreed that one of the three former ponds in the vicinity of the Acid Pile was the likely source of contamination. This source may have been remobilized by water associated with the off-site drainage control ditch and southern ditch that was constructed through the area by the remediation contractor. After additional soil sampling in November 2000, the decision was made to not pursue additional fieldwork. The accepted explanation for the source of uranium is that sediment beneath the old evaporation ponds is contaminated because of process water that was disposed of in the ponds and that contamination associated with the sediments is being mobilized by surface water diversion.

A complete summary of the South Millsite Source Investigation begins on Page 4-38 of the 2001 IRA Progress Report.

2.9 Summary of Significant Activities Since the 1998 RI

Tables 2–13 through 2–15 summarize the activities described in the previous sections and describe briefly the changes that are required in the ground water model or the HHRA or ERA updates to address those changes. Table 2–13 summarizes how the activities have affected the ground water flow and transport model. Table 2–14 summarizes how the new site conditions are incorporated into the HHRA update. Table 2–15 summarizes how the new site conditions necessitate a reevaluation of ecological risk to certain receptors; the reevaluation is presented in the ERA update.

Table 2–13. Effects on the Ground Water Model

Activity	Direct Effect on Ground Water Flow Model	Direct Effect on Contaminant Transport Model
Millsite excavation	Major physical changes to ground water and surface water setting affect water balance.	Physical removal of primary and residual sources of ground water contamination
Millsite restoration		None
Montezuma Creek soil and sediment remediation	None	None
Ground Water Management Policy	None	None
Restrictive Easement	None	None
Millsite dewatering and treatment	Indirect efforts only—improved conceptual water balance.	Indirect effects only—contaminant removal reflected in ground water monitoring data.
Permeable reactive barrier treatability study	Physically altered local ground water flow and hydraulic heads.	Uranium in ground water is immobilized in the permeable reactive barrier.
Contaminants of concern	None	None
Ground water data	Ground water level monitoring and stream flow monitoring provide head and flow targets for model calibration.	Provides new starting concentrations in ground water for the transport model.
Surface water data		None
Monitoring well installation	Indirect only.	Indirect only.
Subpile vadose zone evaluation	None	Input of residual contaminant source based directly on site-specific test results.
Evaluation of contaminant mobility in saturated zone	None	Input of uranium distribution coefficient based directly on site-specific test results.
Aquifer testing	Evaluated flow rate through the permeable reactive barrier.	None
South Millsite source investigation	None	None

Table 2–14. Impacts to Human Health Risk Assessment

Activities Since 1998 RI	1998 Human Health CSM Still Valid?	Update HHRA?
Millsite Remediation		
Millsite excavation	Yes	No. Indirect effect. Removal of primary source of contamination.
Millsite restoration	Yes	No
Millsite dewatering and treatment	Yes	No. Activity has affected surface water and/or ground water concentrations. The impact of this activity on the risk assessment is accounted for by assessing new surface water and/or ground water data and incorporating new data into the update.
Montezuma Creek soil and sediment remediation	Yes	No. 21,500 yd^3 of contaminated soil/sediment removed from Montezuma Creek floodplain. Current and future exposure from these media is expected to be less than it was prior to remediation (or at the worst no greater). The 1998 exposure point concentrations used give a conservative estimate of total risk to human health.
Institutional Controls		
Ground Water Management Policy	Yes	No. 1998 HHRA did not evaluate ground water ingestion under the current scenario because there was domestic use of ground water. Currently (2003), there is also no domestic use of ground water.
Restrictive Easement	Yes	No. 1998 HHRA assumed that habitable structures would not be built in the supplemental standards areas along Montezuma Creek. These restrictive easements ensure that future use is consistent with the assumed exposure scenario.
PRB treatability study	Yes	No. Activity has affected surface water and/or ground water concentrations. The impact of this activity on the risk assessment is accounted for by assessing new surface water and/or ground water data and incorporating new data into the update.
Surface Water and Ground Water Monitoring		
COC list changes	Yes	Yes. HHRA update will not consider exposure to COCs that have been eliminated and will include molybdenum and nitrate, which have been added.
Surface water data	Yes	Yes. HHRA update will evaluate 2002 data to arrive at exposure point concentrations.
Ground water data	Yes	Yes. HHRA update will evaluate 2002 data to arrive at exposure point concentrations.
Data Collection		
Monitor well installation	Yes	No. Indirect effect only. Data gained from this effort are input to the current ground water model.
Subpile vadose zone evaluation	Yes	No
Evaluation of contaminant mobility in saturated zone	Yes	No. Indirect effect only. Data gained from this effort are input to the current ground water model.
Aquifer testing	Yes	No. Indirect effect only. Data gained from this effort are input to the current ground water model.
South Millsite source investigation	Yes	No

Table 2–15. Effects on Ecological Risk Assessment

Activities Since 1998 RI	1998 Ecological CSM Still Valid?	Update ERA?
Millsite Remediation		
Millsite excavation	Yes	No. Indirect effect. Removal of primary source of contamination.
Millsite dewatering and treatment	Yes	No. Activity may have affected surface water concentrations. The impact of this activity on the risk assessment is accounted for by assessing new surface water data and incorporating new data into the update.
Millsite restoration	Yes	Yes. New wetlands (ponds) were created on the Millsite. In the 1998 ERA, ponds only existed downstream of the Millsite. ERA update will use new surface water data in the vicinity of Millsite ponds to evaluate risk to receptors selected by the ETAG.
Montezuma Creek soil and sediment remediation	Yes	No. 21,500 yd^3 of contaminated soil/sediment removed from Montezuma Creek floodplain. Current and future exposure from these media is expected to be less than it was prior to remediation (or at the worst no greater). The 1998 exposure point concentrations used give a conservative estimate of total risk to ecological receptors.
Institutional Controls		
Ground Water Management Policy	Yes	No
Restrictive Easement	Yes	No
PRB treatability study	Yes	No. Activity may have affected surface water concentrations. The impact of this activity on the risk assessment is accounted for by assessing new surface water data and incorporating new data into the update.
Surface Water and Ground Water Monitoring		
COC list changes	Yes	Yes. The ERA update will not consider exposure to cobalt, copper, lead, and zinc because these analytes were eliminated as COCs.
Surface water data	Yes	Yes. Except for selenium, the concentrations of all COCs in surface water have decreased or at least remained the same. The selenium increase will be evaluated in the ERA update.
Ground water data	Yes	No. Ground water is not a complete exposure pathway in either the 1998 ERA or the ERA update.
Data Collection		
Monitor well installation	Yes	No
Subpile vadose zone evaluation	Yes	No
Evaluation of contaminant mobility in saturated zone	Yes	No
Aquifer testing	Yes	No
South Millsite source investigation	Yes	No