DOE–LM/GJ629–2004

Office of Legacy Management

Record of Decision for the Monticello Mill Tailings (USDOE) Site Operable Unit III, Surface Water and Ground Water, Monticello, Utah

May 2004

U.S. Department of Energy

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Work Performed Under DOE Contract No. DE−AC01−02GJ79491
for the U.S. Department of Energy Office of Legacy Management.

Acronyms

AEC	U.S. Atomic Energy Commission
ARAR	applicable or relevant and appropriate requirement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	*Code of Federal Regulations*
COC	contaminant of concern
CT	central tendency
DOE	U.S. Department of Energy
EDE	effective dose equivalent
EPA	U.S. Environmental Protection Agency
ft	feet
FR	*Federal Register*
HI	hazard index
HQ	hazard quotient
MCL	maximum contaminant level
µg/L	micrograms per liter
mg/L	milligrams per liter
MMTS	Monticello Mill Tailings Site
mrem/yr	millirems per year
NRC	U.S. Nuclear Regulatory Commission
OU	operable unit
pCi/L	picocuries per liter
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RME	reasonable maximum exposure
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
U.A.C.	Utah Administrative Code
U.C.A.	Utah Code Annotated
UDEQ	Utah Department of Environmental Quality
UMTRCA	Uranium Mill Tailings Radiation Control Act
VCA	Vanadium Corporation of America
yd^3	cubic yards

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Glossary

Cancer Risk: The added probability of an individual or population developing cancer during a lifetime as a result of exposure to specific contaminants.

Contaminants of Concern (COCs): Site-related contaminants, which are identified during the site investigations and risk assessment, that cause potential risks because of their toxicities and potential routes of exposure to human health and the environment.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): A federal law passed in 1980 and modified in 1986 by the Superfund Amendments and Reauthorization Act. The acts created a special tax that goes into a trust fund, commonly known as Superfund, to investigate and clean up abandoned or uncontrolled hazardous waste sites.

Ground Water: Underground water that fills spaces between soil particles and openings in rocks.

Hazard Index: The sum of more than one hazard quotient for multiple substances or multiple pathways. As a rule, the greater the hazard index is above 1, the greater the level of concern.

Hazard Quotient: The ratio of the exposure level of a single substance to a noncarcinogenic toxicity value.

Institutional Controls: Institutional controls (ICs) are non-engineered instruments, such as administrative and/or legal controls, that help to minimize the potential for human exposure to contamination and/or protect the integrity of the remedy. ICs work by limiting land or resource use and/or by providing information that helps modify or guide human behavior at the site. Common examples of ICs include zoning restrictions, building or excavation permits, well drilling prohibitions, and easements and covenants. ICs often play an important role in remedies to help minimize the potential for exposure and protect engineered remedies (e.g., covers and fencing).

Interim Remedial Action: A term used under CERCLA to describe actions that partially clean up or stabilize a site and are typically followed by other actions designed to provide long-term protection of human health and the environment. They are often short-term or temporary steps to prevent further spread of contamination or to achieve significant risk reduction quickly.

National Oil and Hazardous Substances Pollution Contingency Plan: The federal regulation that guides the Superfund program.

National Priorities List: The U.S. Environmental Protection Agency's published list of the highest priority hazardous waste sites in the United States for investigation and cleanup under CERCLA.

Net Present Value: The amount of money necessary to secure the promise of a future payment or a series of payments (annual costs) at an assumed interest rate.

Noncarcinogens: Compounds that may cause negative health effects other than cancer.

Operable Unit: A discrete portion of a larger overall cleanup project.

Permeable Reactive Barrier: An engineered zone of reactive material placed underground that removes contamination in ground water flowing through it by chemical processes.

Plume: A volume of contaminated ground water flowing from a specific source.

Record of Decision: A required report that documents the chosen remedy for a site. The report certifies that the remedy selection process was conducted in accordance with CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan and provides the public with a document that consolidates information about the site and the chosen remedy.

DECLARATION FOR THE FINAL REMEDIAL ACTION

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DECLARATION

Site Name and Location

Operable Unit III, Surface Water and Ground Water
Monticello Mill Tailings (USDOE) Site
Monticello, Utah
CERCLIS ID No. UT3890090035

Statement of Basis and Purpose

This decision document presents the Selected Remedy for Operable Unit (OU) III, Surface Water and Ground Water, Monticello Mill Tailings (USDOE) Site (MMTS), in Monticello, Utah, which was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 42, *United States Code* § 9601 et seq., and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan, Title 40 *Code of Federal Regulations* (CFR) Part 300 (National Contingency Plan).

The decision to select this remedy culminates the assessment of potential and actual risk to human health and the environment. All relevant information leading to this decision is documented within the Administrative Record for the site and is available for viewing and copying at the site information repositories located at the U.S. Department of Energy (DOE) office in Grand Junction, Public Reading Room, 2597 B¾ Road, Grand Junction, Colorado 81503, (970) 248–6089, Monday through Friday 7:30 a.m. to 4 p.m.; U.S. DOE Repository Site Office, 7031 South Highway 191, Monticello, Utah 84535, (435) 587–2098, Monday through Friday, 8 a.m. to 5 p.m. or by appointment.

Assessment of the Site

The response action selected in this Record of Decision (ROD) is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

Description of the Selected Remedy

OU III, the subject of this ROD, is the final response action for the MMTS. The selected remedy for OU III consists of:

- Monitored natural attenuation, including comprehensive monitoring to evaluate its effectiveness. Specifically included as part of monitored natural attenuation is an evaluation of selenium concentration trends and the potential impacts of selenium concentrations on ecological receptors.
- Continued implementation and enforcement of the institutional controls that restrict use of the contaminated shallow alluvial aquifer and the restrictive easement that prohibits removal of contaminated sediments from the Montezuma Creek floodplain.
- Removal of the permeable reactive barrier, which was constructed as a full-scale treatability study during the Interim Remedial Action, when the permeable reactive barrier ceases to be effective in removing contaminants from the ground water.

These activities will be continued until the remediation goals are met. If the selected remedy does not remain protective of human health and the environment or results of the monitoring program do not indicate that the remediation goals can be achieved within 42 years, contingency remedies will be evaluated and will be implemented if determined necessary.

OU III is one of three operable units at the MMTS. A ROD was signed for OU I (the millsite) and OU II (peripheral properties adjacent to the millsite) in 1990 (DOE 1990b) stipulating that contaminated materials from OU I and OU II would be excavated and placed in an on-site repository. Excavation of contaminated soils and sediment for remediation of OU I and OU II was completed in August 1999, and restoration of the millsite was completed in August 2001. OU II properties without soil or ground water contamination were delisted in October 2003. Mill tailings piles and contaminated soils and sediments associated with OU I and OU II of the MMTS were the primary sources of OU III surface water and ground water contamination. The ROD for OU I and OU II also stipulated that a ROD for a permanent remedy for OU III would be prepared when sufficient data were gathered and presented in a focused Remedial Investigation and Feasibility Study.

A Remedial Investigation report for OU III was prepared and finalized in 1998 (DOE 1998c). In addition to surface water and ground water, the Remedial Investigation report addressed contaminated soils and sediments along Montezuma Creek. DOE, the U.S. Environmental Protection Agency (EPA), and the Utah Department of Environmental Quality (UDEQ) jointly agreed during preparation of the draft feasibility study for OU III in summer 1997 (DOE 1998b) that it was not possible at that time to definitively predict the effects of millsite remediation on the ground water and surface water systems. Therefore, potential risks associated with these media could not be accurately assessed. To address these uncertainties, a decision was made to conduct an Interim Remedial Action and complete the feasibility study at a later date. In September 1998, DOE signed, EPA approved, and UDEQ concurred on an Interim Remedial Action ROD for OU III (DOE 1998d). Soil and sediments originally included as part of OU III were remediated as a nontime-critical removal action and disposed of and documented as part of OU II remedial activities. Therefore, only surface water and ground water are included in this ROD for OU III.

Since the Interim Remedial Action ROD was signed, cleanup of mill tailings and contaminated soils and sediments included in OU III has been completed. Those contaminant sources were excavated and disposed of in the repository south of the former millsite. The major components of the Interim Remedial Action for OU III surface water and ground water also included (1) implementation of institutional controls to restrict use of contaminated ground water; (2) continued ground water extraction and treatment during excavation and dewatering of the millsite; (3) continued monitoring, including surface water and ground water sampling, to better understand effects of millsite remediation on water quality; and (4) installation of a pilot-scale treatability study permeable reactive barrier hydraulically downgradient (east) of the millsite to assess its effectiveness in reducing contaminant levels in OU III surface water and ground water.

A Remedial Investigation Addendum/Focused Feasibility Study was recently completed (DOE 2004c) to present current site conditions and to evaluate permanent remediation alternatives for ground water and surface water. As a result, a final remedy, consistent with the activities conducted in the Interim Remedial Action, was selected for OU III.

Statutory Determinations

The selected remedy is protective of human health and the environment, complies with federal and State of Utah requirements that are applicable or relevant and appropriate to the remedial action, is cost-effective, and utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable. The remedy for this operable unit does not rely on treatment to achieve remediation goals and, therefore, does not satisfy the statutory preference for treatment as a principal element of the remedy. Because the source of contamination constituting the principal threat has been removed in prior actions, that source is not addressed in this action. No alternative entirely meets the criterion for reduction of toxicity, mobility, or volume through treatment (see Section 10.3, Table 10).

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within 5 years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment. The next statutory review is to be conducted in 2007.

Data Certification Checklist

The following information is included in the Decision Summary section of this ROD. Additional information is available in the Administrative Record file for this site.

- How source materials constituting principal risks are addressed (Section 2.0, “Site History and Enforcement Activities”).
- Contaminants of concern and their respective concentrations (Section 5.3, “Nature and Extent of Contamination”).
- Current and reasonably anticipated future land use assumptions and current and potential beneficial uses of ground water used in the baseline risk assessment and ROD (Section 6.0, “Current and Potential Future Site and Resource Uses”).
- Potential land and ground water use that will be available at the site as a result of the selected remedy (Section 6.0, “Current and Potential Future Site and Resource Uses”).
- Baseline risk represented by the contaminants of concern (Section 7.0, “Summary of Site Risks”).
- Cleanup levels established for these contaminants of concern and the basis for these levels (Section 8.0, “Remedial Action Objectives”).
- Key factors that led to selecting the remedy (i.e., how the selected remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decision) (Section 11.1, “Summary of Rationale for the Selected Remedy”).
- Estimated capital, annual operation and maintenance, and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected (Section 11.3, “Summary of Estimated Remedy Costs”).

Signatures

U.S. Department of Energy, Grand Junction, Colorado

Donna Bergman-Tabbert   May 26, 2004

Donna Bergman-Tabbert   Date
Manager

State of Utah Department of Environmental Quality

Dianne R. Nielson   6/01/04

Dianne R. Nielson, Ph.D.   Date
Executive Director

U.S. Environmental Protection Agency, Region VIII

Terry Anderson   6·2·04

Terry L. Anderson   Date
Director, Federal Facilities Program

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MONTICELLO MILL TAILINGS (USDOE) SITE
DECISION SUMMARY FOR THE RECORD OF DECISION

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Decision Summary

1.0 Site Name, Location, and Description

The Monticello Mill Tailings (USDOE) Site (MMTS) is located in southeast Utah, in and near the City of Monticello in San Juan County (Figure 1); the city of Monticello has a population of approximately 1,900. The site is identified in the Comprehensive Environmental, Response, Compensation, and Liability Information System under number UT3890090035. Operable Unit (OU) III encompasses ground water and surface water at and hydraulically downgradient of the Monticello millsite. The former millsite is a 110-acre tract of land that has been transferred by the U.S. Department of Energy (DOE) to the City of Monticello. Surface water and ground water contamination are the subjects of this remedial action Record of Decision (ROD). DOE has the federal lead for remediation of the site. The U.S. Environmental Protection Agency (EPA) and the State of Utah (the State) share oversight; EPA has ultimate responsibility for program oversight. DOE funds remediation of the site.

A detailed description of OU III is presented in the Remedial Investigation report (DOE 1998c) and in the Remedial Investigation Addendum for OU III (DOE 2004c). The MMTS is located in the east-central part of the Colorado Plateau physiographic province. The Abajo Mountains, Great Sage Plain, and Blanding Basin are the three physiographic subdivisions that dominate the landscape in the Monticello area. Approximately 5 miles west of Monticello, the Abajo Mountains rise more than 4,000 ft above the broad, nearly flat, upland surface of the Great Sage Plain to elevations of 11,000 feet (ft). A canyon network, consisting of the upper part of Montezuma Creek and its tributaries, has incised the western part of the Great Sage Plain. Montezuma Creek canyon becomes more deeply incised as the creek flows southward into Blanding Basin.

The millsite and adjoining areas within the Montezuma Creek valley are underlain by two ground water-bearing units (aquifers). The upper unit is the alluvial aquifer consisting of unconsolidated silt, sand, and gravel. The water table is generally 5 to 10 ft below the ground surface. The alluvial aquifer discharges ground water to and receives surface water from Montezuma Creek, depending on location. The alluvial aquifer and Montezuma Creek have been contaminated by past millsite activities. Arsenic, uranium, and vanadium are the contaminants that present the greatest potential human health risks at the site; selenium is of greatest concern for ecological receptors. Discharge of contaminated water to wetland areas and Montezuma Creek on the millsite is the primary cause of surface water contamination and is ultimately responsible for potential risk to ecological receptors. A lower sandstone aquifer within the Burro Canyon Formation is separated from the alluvial aquifer by sandstones and shales of the Dakota Sandstone Formation in much of the site area. These formations restrict vertical ground water movement. The Burro Canyon Formation is used as a secondary source of potable water.

The upper surface of the Burro Canyon Formation is about 125 ft below the ground surface in the western portion of the millsite and 60 ft below ground surface immediately east of the millsite. About 4,000 ft east of the millsite, erosion has removed the entire thickness of the relatively impermeable Dakota Sandstone Formation, and the alluvial aquifer and Burro Canyon aquifer are in direct contact. Where this occurs, ground water flows upward from the Burro Canyon aquifer into the alluvial aquifer. Upward movement of Burro Canyon ground water has prevented contaminant movement from the alluvial aquifer to the Burro Canyon aquifer.

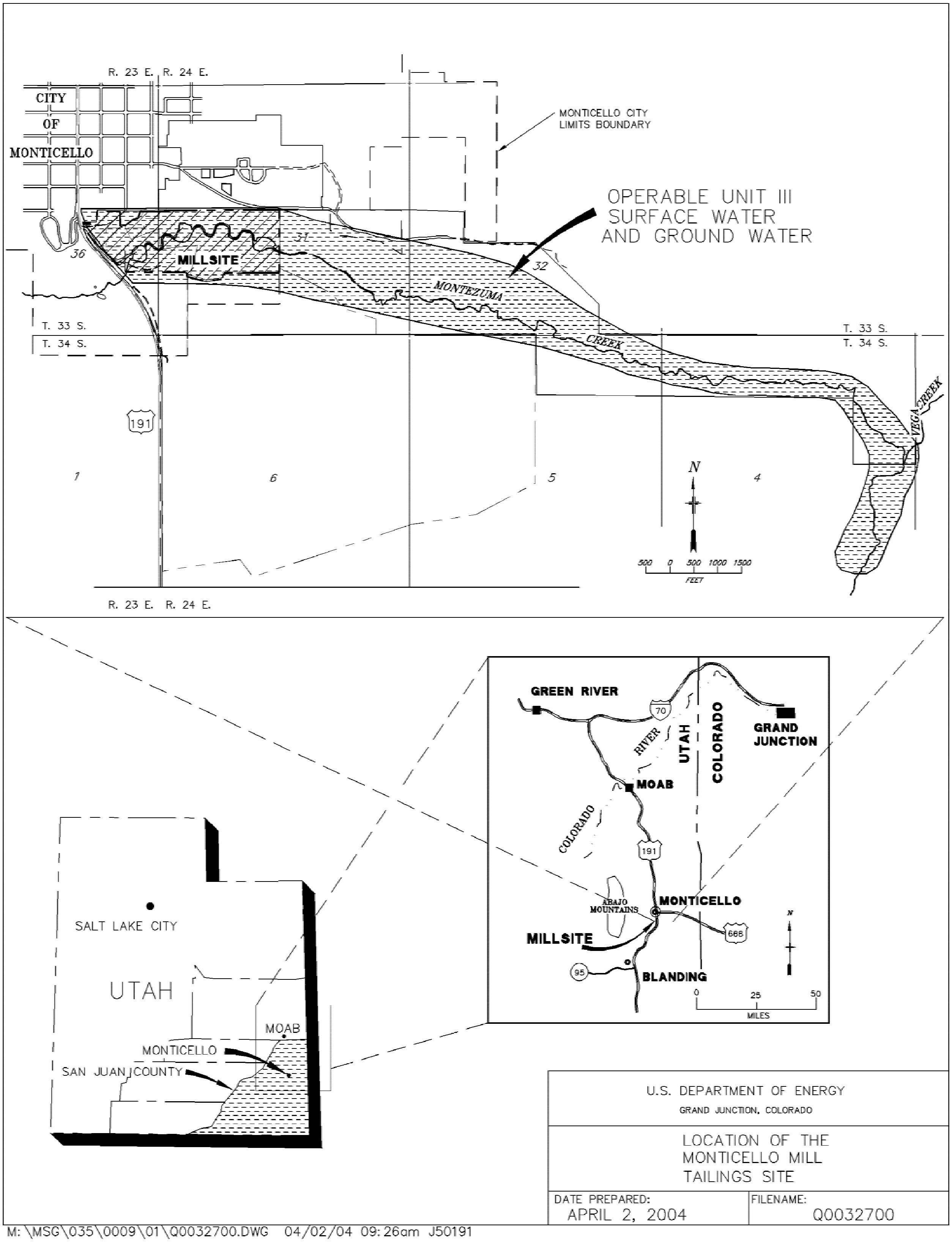


Figure 1. Monticello Mill Tailings Site, San Juan County, Utah

Surrounding private lands are used for residential, recreational, and agricultural (both farming and grazing) purposes. Ground water within the alluvial aquifer is not currently used for any domestic, agricultural, or industrial purpose. Anthropologic use of water from Montezuma Creek is for agricultural purposes only. However, wetland and riparian habitats that occur along the creek are used by a number of wildlife species. The area is used by the State sensitive spotted bat and northern goshawk, and the creek/canyon area is potential habitat for the federally endangered southwestern willow flycatcher.

2.0 Site History and Enforcement Activities

The Monticello Mill Tailings Site has been owned by DOE or its predecessor agencies since the early 1940s. The Vanadium Corporation of America (VCA) constructed the mill in 1942 with funds from the Defense Plant Corporation. Initially, the mill was built to produce vanadium, a metal used for hardening steel needed for World War II. However, with the scale-up of the nuclear weapons program in 1943, the mill began processing a uranium-vanadium sludge for the Manhattan Engineer District. The milling operations by VCA ceased in 1944. The mill operated intermittently under a lease agreement from 1944 to 1948, continuing the production of uranium-vanadium sludge for the Manhattan Engineer District. The mill was purchased by the U.S. Atomic Energy Commission (AEC) in 1948, and operations continued until 1960 when the mill was permanently closed.

The former mill area (approximately 10 acres) was transferred to the Bureau of Land Management in 1960 (this property was later deeded back to DOE in 1990). The tailings impoundment area (approximately 68 acres) remained under AEC ownership. During the operation of the site, approximately 900,000 tons of ore was processed at the Monticello mill. Processing of the ores resulted in the generation of soil-like waste products (mill tailings) that were slurried into tailings impoundments or piled on the site. Four distinct tailings piles were evident in the former tailings impoundment area and are generally believed to be attributable to the time of operations and the technologies that were used to mill and process the ore.

After cessation of operations in 1960, contaminated surface soils from ore-buying stations on adjacent peripheral properties were taken to the millsite and used as cover material over the existing tailings piles. During this time period, the piles were also seeded with native grasses to minimize wind and water erosion. However, the high initial content of moisture in the tailings, inflow of surface water from Montezuma Creek that had been relocated on a bedrock bench above the alluvial aquifer and the placement of a significant portion of the tailings within the saturated zone of the alluvial aquifer provided a continuing source of ground water contamination.

Environmental investigations of the MMTS have been conducted at and near OU III since the early 1950s, when it was determined that leachate from the tailings ponds was causing radium concentrations to increase in Montezuma Creek. DOE conducted annual environmental monitoring inspections of the MMTS and prepared annual reports from the early 1960s until the mid-1990s. Beginning in the early 1980s, the environmental investigations were more comprehensive than earlier studies and focused on development of an overall conceptual model for the site. Efforts focused on supplementing monitoring data with information needed to complete site characterization and ground water modeling as part of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

In December 1988, DOE, EPA, and the State of Utah entered into a Federal Facilities Agreement (DOE 1988), pursuant to Section 120 of CERCLA, for the MMTS. A hazard ranking system score of 35.86 was developed that led to the inclusion of MMTS on EPA's National Priorities List on November 21, 1989. As stated in the Federal Facilities Agreement, DOE serves as the federal lead agency and provides the principal staff and resources to plan, direct, and implement response actions at the MMTS. EPA and the State of Utah share the responsibility for oversight of the MMTS activities performed under the Federal Facilities Agreement. However, EPA has ultimate responsibility and authority for program oversight. Oversight at the State level is through the Utah Department of Environmental Quality (UDEQ).

Separate from the MMTS operable units, the Monticello Radioactively Contaminated Properties Site (remediated as the Monticello Vicinity Properties [MVP] Project) was listed on the National Priorities List in 1986. The MVP site eventually totaled 424 private and commercial properties within the City of Monticello. These properties were contaminated with windblown mill tailings from the millsite or from tailings used for fill or other purposes. Remediation of these properties was addressed in a ROD signed for the MVP site in 1989. Contaminated material from the vicinity properties was placed in an interim repository at the millsite. Subsequent to the excavation and removal of the contaminated material from the millsite to the final repository, the Monticello Radioactively Contaminated Properties Site was fully deleted from the National Priorities List on February 28, 2000 (64 *Federal Register* [FR] 73423, December 30, 1999) after removal of tailings-related contamination was completed to project standards.

DOE prepared its initial Remedial Investigation and Feasibility Study for the MMTS in 1988, and the Federal Facilities Agreement parties signed a ROD in 1990 (DOE 1990b) for surface remediation of the MMTS which stipulated that contaminated materials from OU I (the former millsite) and OU II (peripheral properties) would be excavated and placed in an on-site repository. Approximately 1,800,000 cubic yards (yd^3) of tailings and contaminated soil was identified at that time. The ROD for OU I and OU II also stipulated that a ROD for OU III would be deferred until remediation of the soils and contaminated material on the millsite was completed and sufficient data were gathered through a focused Remedial Investigation and Feasibility Study. The 1990 ROD also specified that "the Upper and Lower Montezuma Creek peripheral properties" (which are now referred to as Upper, Middle, and Lower Montezuma Creek) would be remediated as part of OU III.

Data collection for the OU III Remedial Investigation began in November 1992 and continued through 1996. The OU III Remedial Investigation (DOE 1998c, final) and a draft Feasibility Study (DOE 1998b, draft) were prepared concurrently in 1998, prior to completion of OU I and OU II remediation. During preparation of the draft Feasibility Study in summer 1997, DOE, EPA, and UDEQ jointly agreed that it was not possible at that time to predict the effects that millsite remediation would have on the ground water and surface water systems. Consequently, potential risks associated with these media could not be accurately assessed. Instead, an Interim Remedial Action ROD (DOE 1998d) was signed in 1998, and the action subsequently implemented. Significant actions taken since 1998 include

- Remediation of 2.5 million yd^3 of tailings, soils, and debris on the millsite, including residual source material below the water table (OU I remediation). Restoration of the millsite, including aquifer and wetlands reconstruction along Montezuma Creek (OU I remediation).

- Application of supplemental standards within the floodplain of Montezuma Creek on peripheral properties hydraulically downgradient from the millsite. Alternative cleanup levels were established based on present and anticipated land use. Approximately 71,000 yd^3 of contaminated soil with contaminant concentrations exceeding the alternate cleanup levels was removed from the floodplain. A restrictive easement, prohibiting construction of habitable structures and the removal of contaminated material from within the restrictive easement area, was also implemented through the U.S. Army Corps of Engineers. An Explanation of Significant Differences prepared in February 1999 and concurred upon by EPA and UDEQ documented this change.
- Implementation of an institutional control in the form of a Ground Water Management Policy through the State of Utah Engineers' office to prevent domestic use of the contaminated alluvial aquifer (OU III Interim Remedial Action).
- A permeable reactive barrier, an innovative treatment technology, was constructed in the alluvial aquifer (OU III Interim Remedial Action) approximately 800 ft hydraulically downgradient from the millsite boundary.

Fundamental changes to site conditions as a result of remediation and restoration actions include

- Primary and secondary sources of ground water and surface water contamination (i.e., principal threat wastes) were removed, causing the concentrations of most contaminants to decrease in surface water and ground water (this decrease is predicted to continue in the future).
- Ground water flow dynamics have stabilized to a new set of conditions.
- Contaminants in ground water, such as arsenic, molybdenum, selenium, uranium, and vanadium, have been immobilized in the permeable reactive barrier, reducing their transport.
- Institutional controls that mitigate against human exposure to the contaminated alluvial ground water have been implemented.

On August 13, 2003, EPA published a direct final notice of partial deletion of the MMTS (68 FR 48314). The partial delisting pertains to a portion of the site designated as the OU II Non-Surface and Ground-Water Impacted Peripheral Properties. These properties consist of 22 of the 34 total properties that constitute OU II. Radioactive materials in soils and sediment at the properties have been removed to cleanup levels promulgated in Title 40 *Code of Federal Regulations* (CFR) Part 192, and no contamination is present in ground water or surface water at these properties. The direct final partial deletion was effective October 14, 2003.

The remaining 12 peripheral properties and the former millsite, which exhibit ground water and surface water contamination, were retained in OU III. An additional site investigation was conducted subsequent to surface remediation of contaminated soil and sediments to characterize post-remediation conditions and to evaluate alternatives for a final ground water and surface water remedial action. Data were also collected to support evaluation of monitored natural attenuation as a viable alternative for the site. Data collected during the Interim Remedial Action were also used in this evaluation. The Remedial Investigation Addendum and a Focused Feasibility Study were completed in December 2003 (DOE 2004c).

3.0 Highlights of Community Participation

The most recent Community Relations Plan prepared for MMTS was for fiscal year 2001 and is the final such plan anticipated for the site. The plan provides for additional communication with the public through (1) distribution of fact sheets and other written materials, (2) news releases to the local newspaper, (3) public meetings, (4) display advertisements announcing the availability of key documents and meetings, (5) public comment periods, and (6) responsiveness summaries for RODs.

The public participation requirements of CERCLA Section 113(k)(2)(B)(i–v) and Section 117 were followed for this final remedial action. Display advertisements were published in local newspapers to inform the public of the availability and locations of site-specific documents, Proposed Plan, and public meetings.

Events to encourage community participation included

- Development of the *Proposed Plan for the Monticello Mill Tailings Site, Operable Unit III Surface and Ground Water* (DOE 2003b).
- Development of a fact sheet (DOE 2003a) that presented a discussion about the Remedial Investigation Addendum and the Focused Feasibility Study.
- Presentation of the Proposed Plan at a public meeting. The public meeting was held on December 9, 2003, at the San Juan County Courthouse in Monticello, Utah. Representatives from DOE, EPA, and the State of Utah answered questions at this meeting about the site and the preferred alternative, which has become the selected final remedial action. Public comments received at that meeting and during the public comment period are presented in the Responsiveness Summary of this document.
- Establishment of a public comment period concerning the Proposed Plan. The public comment period on the final remedial action was held from December 1, 2003, through January 15, 2004.

On November 26, 2003, DOE mailed letters to 65 key individuals, including potentially affected landowners, informing them of the public meeting (held on December 9, 2003) concerning the Proposed Plan. Included with the letters were copies of the Proposed Plan (DOE 2003b) and the fact sheet (DOE 2003a) that presented a discussion about the Remedial Investigation Addendum and the Focused Feasibility Study. Addresses and telephone numbers for DOE, EPA, and UDEQ were provided to enable stakeholders to ask questions or to obtain additional information.

A notice of availability of the Proposed Plan and a notice of the public meeting and comment period were published in the local Monticello newspaper (the “San Juan Record”) on November 26, 2003, and December 3, 2003, and in the Blanding, Utah newspaper (the “Blue Mountain Panorama”) on November 26, 2003.

Copies of all site-specific documents used in developing the remedial action decision were made available to the public through the Administrative Record for the site. The Administrative Record is housed at the site information repository and at the DOE office in Grand Junction. Copies of the OU III Draft Final Remedial Investigation Addendum/Focused Feasibility Study were released in September 2003 and were placed in the reading room and in the Administrative Record in October 2003 before the start of the public comment period. Copies of the Proposed

Plan (DOE 2003b) and a fact sheet that presented a summary of the OU III Remedial Investigation Addendum/Focused Feasibility Study were also placed in the site Administrative Record.

4.0 Scope and Role of Operable Unit III Surface Water and Ground Water Strategy Within the MMTS

OU III, the subject of this ROD, presents the final response action for the MMTS. OU III is one of three operable units at the MMTS. The ROD for OU I and OU II, signed in September 1990, stipulated that contaminated tailings and soil and debris from OU I and OU II, the former millsite and peripheral properties would be excavated and placed in an on-site repository. The ROD also identified the need to include a third operable unit: OU III, surface water and ground water contaminated properties. The selection of a final remedy for OU III was deferred until remedial action was completed at OU I and OU II and the effects of the source removal on surface water and ground water could be determined.

Leachate from the tailings piles and from contaminated soil and debris was the primary source of contaminants to surface and ground water. Ingestion of water extracted from the shallow alluvial aquifer within the Montezuma Creek flood plain poses a current and potential risk to human health because EPA’s acceptable risk range is exceeded and concentrations of contaminants are greater than the maximum contaminant levels for drinking water.

An Interim Remedial Action ROD was signed for OU III in 1998 to take early action prior to final remedy selection. The four major components of the Interim Remedial Action are (1) prevent the use of contaminated ground water by implementing institutional controls; (2) remove soluble contaminants from the ground water and, in turn, surface water, by treating extracted ground water through dewatering activities; (3) continue to monitor the changing conditions in the alluvial aquifer and in surface water; and (4) examine the feasibility of a permeable reactive barrier for in situ treatment of contaminated ground water by conducting a pilot-scale treatability study. The Interim Remedial Action complemented OU I and OU II soil and sediment cleanup activities, and data collected during that action was used to evaluate alternatives for long-term surface water and ground water cleanup described in this ROD. Changed site conditions resulting from remediation of OU I and OU II and the activities taken pursuant to the Interim Remedial Action were described and evaluated in the Remedial Investigation Addendum/Focused Feasibility Study for OU III. On the basis of information developed in the Remedial Investigation Addendum, alternative remedial actions were evaluated in the Focused Feasibility Study, and a preferred remedy was chosen and presented in the Proposed Plan.

5.0 Summary of Site Characteristics

The 1998 Remedial Investigation (DOE 1998c) presented a summary of the type and extent of site-related contamination and evaluated risk to human health and the environment associated with contaminated surface water, ground water, soil, and sediment. Alternatives for soil and sediment cleanup along Montezuma Creek were evaluated in the Alternatives Analysis of Soil and Sediment (DOE 1998a). That contamination was remediated as part of a nontime-critical removal action, and the decision was made to address the final remedy selection for soils and sediments under OU II. This decision was documented in an Explanation of Significant Differences for the OU I and OU II ROD; application of supplemental standards was also conducted under OU II. Because source removal was conducted through remediation of OU I and OU II, this ROD for OU III addresses only surface water and ground water. The revised conceptual model for OU III (DOE 2004c) differs from the conceptual model presented in the 1998 Remedial Investigation (DOE 1998c) because the primary source of ground water contamination has been removed, leaving only residual ground water contamination. For example, uranium concentrations in ground water samples from wells located on the millsite that averaged 1,640 to 5,390 micrograms per liter (µg/L) from 1992 to 1998 (prior to source removal) decreased to 144 to 199 µg/L in the 2001 to 2002 time period (after source removal). Surface water contamination is the result of ground water discharge in some areas of OU III. Contaminant concentrations in surface water and ground water are expected to decrease over time in the absence of a continuing contaminant source.

The main exposure routes to contamination would be through contact with contaminated surface water or ground water. However, the potential also exists for certain contaminants, particularly selenium, to accumulate in sediments deposited in surface water along Montezuma Creek. Organisms, such as benthic macroinvertebrates, that come in contact with this contaminated sediment and surface water may potentially accumulate selenium. Because benthic invertebrates are a significant dietary component of a number of species in the area, bioaccumulation of contamination can be propagated throughout the food chain.

The description of the site provided in this section and subsequent evaluations of risk and development of remedial action objectives and alternatives are based on this revised conceptual site model for OU III. Because the contaminant source has been removed, emphasis is placed on describing and evaluating only residual ground water and surface water contamination.

5.1 Hydrologic Setting

The following discussion is a summary of information in the OU III Remedial Investigation report (DOE 1998c) and the Remedial Investigation Addendum (DOE 2004c). Additional information is available in those documents.

5.1.1 Surface Water

The primary surface water body in OU III is Montezuma Creek, which flows west to east and transverses most of the OU III area. Approximately 2.5 miles east of the millsite, Montezuma Creek is joined by a lesser tributary, Vega Creek, at which point stream flow is south through Montezuma Canyon (Figure 2). Other surface water bodies include seeps and springs, municipal water-treatment lagoons, Loyd's Lake, and various ponds used to water livestock.

Montezuma Creek forms at the confluence of North and South Creeks about 0.5 mile upstream (west) of the millsite. Its watershed includes portions of the east flanks of the 11,000-ft Abajo Mountains, 4 miles farther west. An earth dam 1.5 miles upstream of the millsite impounds South Creek in Loyd's Lake reservoir. Base flow in Montezuma Creek is maintained by leakage through the dam and from flows in North Creek, which joins Montezuma Creek about 0.5 mile below the dam. Natural flow in North Creek is interrupted by the operation of the municipal water treatment plant and irrigation diversions. Flow in Montezuma Creek, as measured since November 1992, is typically less than about 0.5 cubic foot per second (1 cubic foot per second is equal to approximately 450 gallons per minute). As part of site restoration, Montezuma Creek

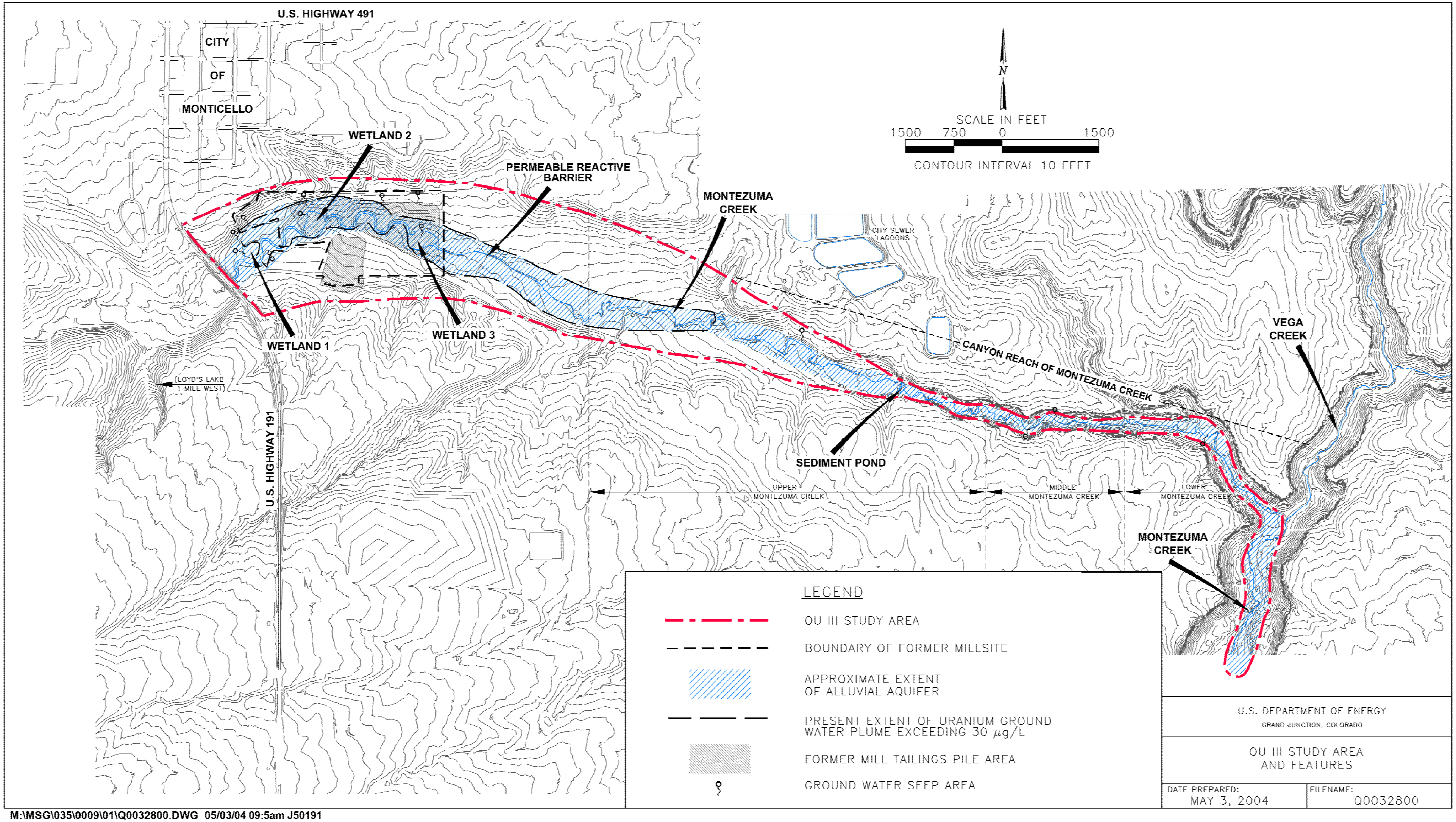


Figure 2. Site Features and Approximate Extent of Ground Water Contaminant Plume

was realigned and reconstructed to its present configuration on the millsite and in the area of the permeable reactive barrier. At that time, three engineered basins were constructed along the creek to allow establishment of wetland habitat on the millsite (Wetlands 1, 2, and 3; Figure 2). These wetlands capture ground water, which is then diverted to Montezuma Creek.

The State of Utah groups surface waters of the state into classes to protect against controllable pollution for the beneficial uses designated within each of those classes (R317-2-6, *Utah Administrative Code* [UAC]). Four broad classes of use are recognized: domestic, recreational, aquatic, and agricultural. In addition, subclasses are identified within some of these classes (e.g., 2A, 2B). Higher standards of water quality apply to lower number classes and to subclass alphanumeric designations that have letters earlier in the alphabet.

Montezuma Creek water is not used as a source of potable water but is used as a water source for livestock. Montezuma Creek is classified in the Utah Administrative Code as follows:

- 1C: Protected for domestic purposes with prior treatment processes as required by the Utah Division of Drinking Water.

- 2B: Protected for secondary contact recreation such as boating, wading, or similar uses.

- 3A: Protected for cold-water species of game, fish, and other cold-water aquatic life, including the necessary aquatic organisms in their food chain.

- 4: Protected for agricultural uses, including irrigation of crops and stock water.

5.1.2 Ground Water

The hydrologic units associated with OU III are an upper alluvial aquifer consisting mostly of Quaternary alluvium and colluvium deposited within the valley of Montezuma Creek, an aquitard of Dakota Sandstone, and the underlying Burro Canyon Formation aquifer. Below the Burro Canyon aquifer is the Brushy Basin Member of the Morrison Formation, which is relatively impermeable to ground water flow. Ground water flow in the alluvial aquifer is generally to the east, parallel to the axis of Montezuma Creek. Flow rates of alluvial ground water moving past the eastern edge of the millsite are approximately 10 to 15 gallons per minute.

The saturated thickness of the alluvial aquifer ranges from approximately 2 to 9 ft within the valley of Montezuma Creek and thins to zero toward the margins where the coarse channel deposits pinch out against bedrock or fine-grained colluvium (DOE 2004c). The alluvial aquifer is recharged by infiltration of precipitation, surface water loss from Montezuma Creek, and lateral ground water flow hydraulically upgradient of the millsite. Another major source of recharge occurs from suspected cultural origins (e.g., irrigation) north of the millsite. Depths to ground water generally range from 5 to 10 ft below ground surface beneath the valley floor and 20 to 30 ft below ground surface on the flanking slopes.

The alluvial aquifer is not currently used for drinking water, irrigation, or livestock watering. The State of Utah has not formally classified this ground water.

The Dakota Sandstone acts as an aquitard between the alluvial aquifer and the underlying Burro Canyon aquifer in the former millsite area. Approximately 1 mile east of the former millsite, the

Dakota Sandstone has been entirely removed by erosion by Montezuma Creek, and the alluvial aquifer is in direct contact with the Burro Canyon Formation. Ground water discharges from the Burro Canyon aquifer to the alluvial aquifer and Montezuma Creek within the valley where Dakota Sandstone is absent. Discharge from the Burro Canyon aquifer also occurs from springs at the base of the outcrops along the canyon walls. The primary recharge zone for the Burro Canyon aquifer is in outcrop areas on the flanks of the Abajo Mountains. The Burro Canyon Formation in this area is about 110 ft thick. The ground water potentiometric surface varies from about 100 ft below ground at the west end of the millsite to several feet above ground at the east end of Upper Montezuma Creek. In this latter area, the upward flow of ground water from the Burro Canyon aquifer mixes with the alluvial aquifer. A portion of this mixture is displaced to Montezuma Creek.

The City of Monticello has historically distributed Burro Canyon Formation ground water only for nondomestic purposes (municipal and residential irrigation). Because of recent drought, Burro Canyon ground water is now available to augment the culinary water supply.

5.2 Operable Unit III Source Areas

Previous investigations, including the Remedial Investigation for OU I and OU II (DOE 1990a), have shown that the primary source of ground water contamination associated with OU III was the former mill tailings piles on the millsite (OU I). Contaminated soils and sediments in the floodplain of Montezuma Creek downstream from the millsite may have been a secondary source of ground water contamination, but surface water sampling results indicate that those were not a significant source. The mill tailings piles and contaminated soils and sediments have been excavated from the floodplain and disposed of in the on-site repository. These actions removed the primary source and some of the secondary source material that contributed to surface and ground water contamination.

5.3 Nature and Extent of Contamination

Analysis of monitoring data indicates that ground water contamination is restricted to the alluvial aquifer and has not penetrated through the Mancos Shale and/or Dakota Sandstone into the underlying Burro Canyon Formation. The contaminant plume follows Montezuma Creek and extends approximately 1 mile east of the millsite (Figure 2). Monitoring data also indicates that surface water in Montezuma Creek is contaminated throughout the OU III area. The removal of the major source of ground water contamination (the tailings piles), and the dewatering and treatment of excavation waters during remediation of OU I has resulted in a significant decrease in all mill-related contamination (with the exception of selenium) in OU III surface water and ground water. Flow-and-transport modeling results presented in the Remedial Investigation Addendum and the Focused Feasibility Study (a summary of the results is provided in Section 8.3 of this document) indicate that these decreases should continue. Based on modeling projections, it is estimated that remedial action objectives will be met within 42 years (starting in October 2002).

Contaminants of concern (COCs) for human health and ecological risk were identified during preparation of the 1998 Remedial Investigation. Since that time, site conditions have changed, and the list of COCs has been revised, as described in the Remedial Investigation Addendum (DOE 2004c). Table 1 presents the COCs that were identified in the 1998 Remedial Investigation and those that were finalized in the Remedial Investigation Addendum. Only those remaining COCs are discussed in this document and in the context of site risks.

Table 1. Operable Unit III Contaminants of Concern

COC	Human Health COCs		Ecological COCs	
	1998 Surface Water and/ or Ground Water COC	Current (2003) Surface Water or Ground Water COC	1998 COC	Current (2003) COC
Metals				
Arsenic	X	X	X	X
Cobalt			X	
Copper			X	
Lead			X	
Manganese	X	X		
Molybdenum		X	X	X
Nitrate (as N)		X	X	X
Selenium	X	X	X	X
Sodium	X[a]	X[a]		
Sulfate	X[a]	X[a]		
Uranium	X	X	X	X
Vanadium	X	X	X	X
Zinc			X	
Radionuclides				
Pb-210	X		X	
Ra-226	X		X	
Rn-222	X			
Th-230	X		X	
U-234	X	X	X	
U-235+daughters	X	X	X	
U-238+daughters	X	X	X	
Gross alpha	X	X[b]		
Gross beta	X	X[b]		

[a]Included as a COC but not quantifiable because toxicity information is not available.
[b]Indicator constituents; not quantifiable for risk assessment purposes.

5.3.1 Surface Water Contamination

Locations where surface water contaminant concentrations exceed standards or aquatic criteria are fairly limited. Table 2 lists the surface water COCs for which surface water standards are available. Maximum concentrations detected during surface water sampling in October 2002 are provided for comparison. In most cases, the highest concentrations of COCs were detected in samples from seep locations on the former millsite. The completion of surface remediation and the interim remedial action appear to have resulted in decreased concentrations of most constituents in surface water, with the exception of selenium.

Table 2. Contaminants of Concern and Surface Water Standards

COC	Maximum Concentration[a]	Utah Surface Water Standard
Arsenic	10 µg/L	10 µg/L
Gross alpha[b]	5 pCi/L	15 pCi/L
Nitrate (as N)	52 mg/L	4 mg/L
Selenium	112 µg/L	5 µg/L

[a]Maximum concentrations detected in the October 2002 sampling round.
[b]Excluding uranium.
µg/L = micrograms per liter; pCi/L = picocuries per liter; mg/L = milligrams per liter.

Selenium concentrations in both surface water and ground water samples increased following completion of OU I remedial action. Two of the bedrock units in the area, Mancos Shale and Dakota Sandstone, are known to contain naturally high concentrations of selenium. The selenium concentration increases in surface water and ground water samples were likely due to release of selenium through weathering of bedrock, which was freshly exposed during remediation of the millsite prior to emplacement of backfill. Surface water and ground water with elevated selenium levels also enter the alluvial aquifer at the northeast corner of the millsite, possibly the result of irrigation waters that leach selenium from Mancos Shale and shale-derived soils; similar circumstances have been shown to produce elevated selenium concentrations in ground water samples in other Mancos Shale areas (Wright and Butler 1993). Drought conditions during the last few years may have contributed to the mobilization of selenium by creating oxidizing conditions under which selenium leaching is enhanced. Concentrations of selenium appear to have peaked in 2001 at most of the affected locations, but a stable trend since that time is yet to establish.

5.3.2 Ground Water Contamination

Concentrations of a number of constituents in alluvial ground water exceed a drinking water or ground water standard or other benchmark. Table 3 lists the ground water COCs, maximum concentrations detected in the alluvial aquifer, and applicable benchmarks. Though sodium and sulfate were identified as COCs, no benchmarks were established due to lack of toxicological data, and these constituents are not included in Table 3. Figure 2 indicates the approximate extent of the contaminant plume based on uranium, which is the most pervasive site-related constituent. Plumes for other constituents are much less extensive; with few exceptions, only wells hydraulically upgradient of the permeable reactive barrier have COC concentrations that exceed applicable standards or benchmarks.

Burro Canyon ground water is not contaminated. The Dakota Sandstone appears to be an adequate aquitard in areas where the water level in the alluvial aquifer is greater than that in the Burro Canyon aquifer (downward flow potential). East of the millsite, where the alluvial aquifer directly overlies the Burro Canyon aquifer, there is upward flow from the Burro Canyon aquifer to the alluvial aquifer, which prevents contaminant movement into the Burro Canyon aquifer. In these eastern areas, the alluvial aquifer ground water quality is strongly affected by influx from the Burro Canyon aquifer.

Table 3. Contaminants With Concentrations That Exceed Utah Ground Water Benchmarks

COC	Maximum[a]	SDWA MCL or RBC	
Arsenic	18.8 μg/L	10 μg/L	SDWA
Manganese	14,200 μg/L	880 μg/L	RBC
Molybdenum	230 μg/L	100 μg/L	UMTRCA
Nitrate (as N)	14.5 mg/L	10 mg/L	SDWA
Selenium	237 μg/L	50 μg/L	SDWA
Uranium	929 μg/L	30 μg/L	SDWA
Vanadium	731 μg/L	330 μg/L	SDWA
Uranium-234/-238	637[b] pCi/L	30 pCi/L	SDWA
Gross alpha	68[c] pCi/L	15 pCi/L[c]	SDWA

SDWA MCL = Safe Drinking Water Act maximum contaminant level; RBC = EPA Region 3 risk-based concentration (EPA 2003) based on default exposure assumptions; UMTRCA = Uranium Mill Tailings Radiation Control Act.
[a]Maximum concentration detected in the October 2002 sampling round.
[b]Calculated, assumes equilibrium.
[c]Excluding uranium.

6.0 Current and Potential Future Site and Resource Uses

The area encompassing OU III is sparsely populated and is used primarily for ranching, a confined-animal facility, and dry land farming. Areas of OU III which lie within the canyon reach of Montezuma Creek are also used seasonally for hunting. Historically the middle and lower canyon area were used as homesteads: however, the residences within these areas have been abandoned for more than 50 years. Irrigation water was provided to the middle canyon via shallow open ditches that carried water from Montezuma Creek or its tributaries upgradient of the millsite. The alluvial aquifer currently is not used for drinking water, irrigation, or livestock watering. Surface water and ponds do provide water for livestock and wildlife. Irrigation water is provided to several private landowners from the City of Monticello’s sewage treatment lagoons and to a limited extent from water rights on Montezuma Creek.

The Monticello Site Specific Advisory Board was established in 1993 as an independent, community-based forum to establish timely, direct contact between the public, State and Federal agencies; to communicate issues related to the DOE Monticello projects; and to develop and provide recommendations and advice on the cleanup of the sites. DOE, with the concurrence of EPA and the State of Utah, initially selected the members through public meetings, community interviews, and discussions with local officials, press releases, and a recruiting advertisement. DOE supported the Monticello Site Specific Advisory Board in its deliberations on Monticello project issues. The Site Specific Advisory Board provided valuable input and recommendations on OU III related issues including water usage, land use, and transfer of the millsite and other government-owned property to the City of Monticello. With the conclusion of remediation on the millsite, the peripheral properties, and vicinity properties, the Site Specific Advisory Board disbanded following the October 20, 1999, meeting.

In determining future use of the OU III area DOE worked with the Site Specific Advisory Board, the City of Monticello, and San Juan County to determine the potential for future land uses. The projected use of the middle and lower canyon is expected to remain in open grazing for cattle and in seasonal recreational uses and hunting. The upper canyon is anticipated to remain in rural agricultural usage with homesites set out of the floodplain of Montezuma Creek on relatively large parcels. The potential to develop the alluvial aquifer as a domestic source, even in the absence of site-related contamination, is low because the saturated zone is thin and generally unproductive in the area where housing construction is feasible above the Montezuma Creek floodplain. Furthermore, potential future home sites could feasibly be provided with municipal water and if water was unavailable from the city the potential exists to tap into the underlying Burro Canyon Formation for potable water.

In the 1960's, the former millsite was transferred to the Bureau of Land Management. As late as 1989, the Bureau of Land Management used the former millsite as an office and equipment maintenance area. In 1990 this area was deeded back to DOE prior to the remediation of the millsite. In August 1999, DOE and the City of Monticello entered into a Cooperative Agreement wherein the city would be responsible for completing restoration of the former millsite with support from DOE. In accordance with CERCLA, DOE prepared a Covenant Deferral Request (DOE 2000a) for transfer of ownership of the millsite and several adjacent properties to the City of Monticello prior to completion of remedial action. The Governor of Utah and the EPA Regional Administrator approved the request. In June 2000, ownership was transferred to the City of Monticello under the federal Lands-to-Parks Program administered by the National Park Service. The Lands-to-Parks Program requires that the property be used solely for public park and recreational purposes in perpetuity; this stipulation is included in the quitclaim deed for the millsite. The quitclaim deed for the millsite also prohibits residential development, and the use of any ground water within the property boundary for human consumption. Restoration of the millsite was completed on August 31, 2001. Part of the restoration process included backfilling areas to provide proper drainage. Restoration also created a new channel for Montezuma Creek, an alluvial aquifer centered on the creek, and three new "backwater" wetland areas which when fully developed are expected to attract waterfowl and other wildlife.

Various institutional controls have been implemented which will influence future land use within the OU III area on land which is privately owned. Because radioactively contaminated soil and sediment exceeding radium-226 standards in Title 40 *Code of Federal Regulations* (CFR) Part 192 remained in the Montezuma Creek floodplain following hot-spot remediation, restrictive easements were placed on private properties to which supplemental standards were applied. The restrictive easements prohibit the building of a habitable structure and the removal of soils from within the easement area, generally defined as an area 50 ft on either side of Montezuma Creek. Property owners were compensated for restrictive easements on their properties. These restrictive easements have been recorded on the affected property deeds and bind future owners to comply with the current restrictions.

Institutional controls have been applied at OU III to prevent use of contaminated alluvial ground water. The Utah State Engineers' office issued the *Ground Water Management Policy for the Monticello Mill Tailings Site and Adjacent Areas,* which 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. The policy states that applications to drill wells into the deeper Burro Canyon Formation 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 3.

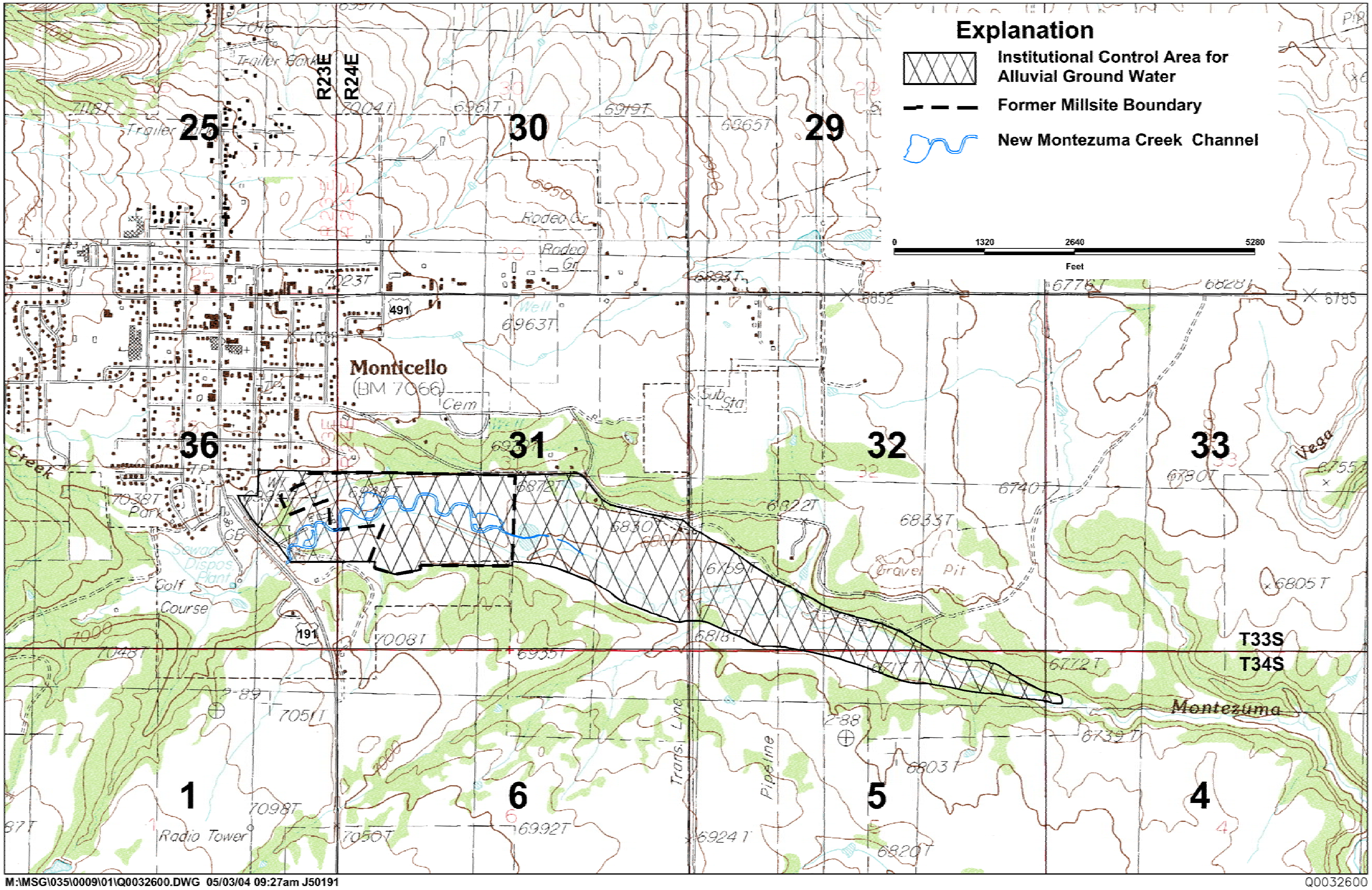


Figure 3. Monticello Ground Water Restricted Area

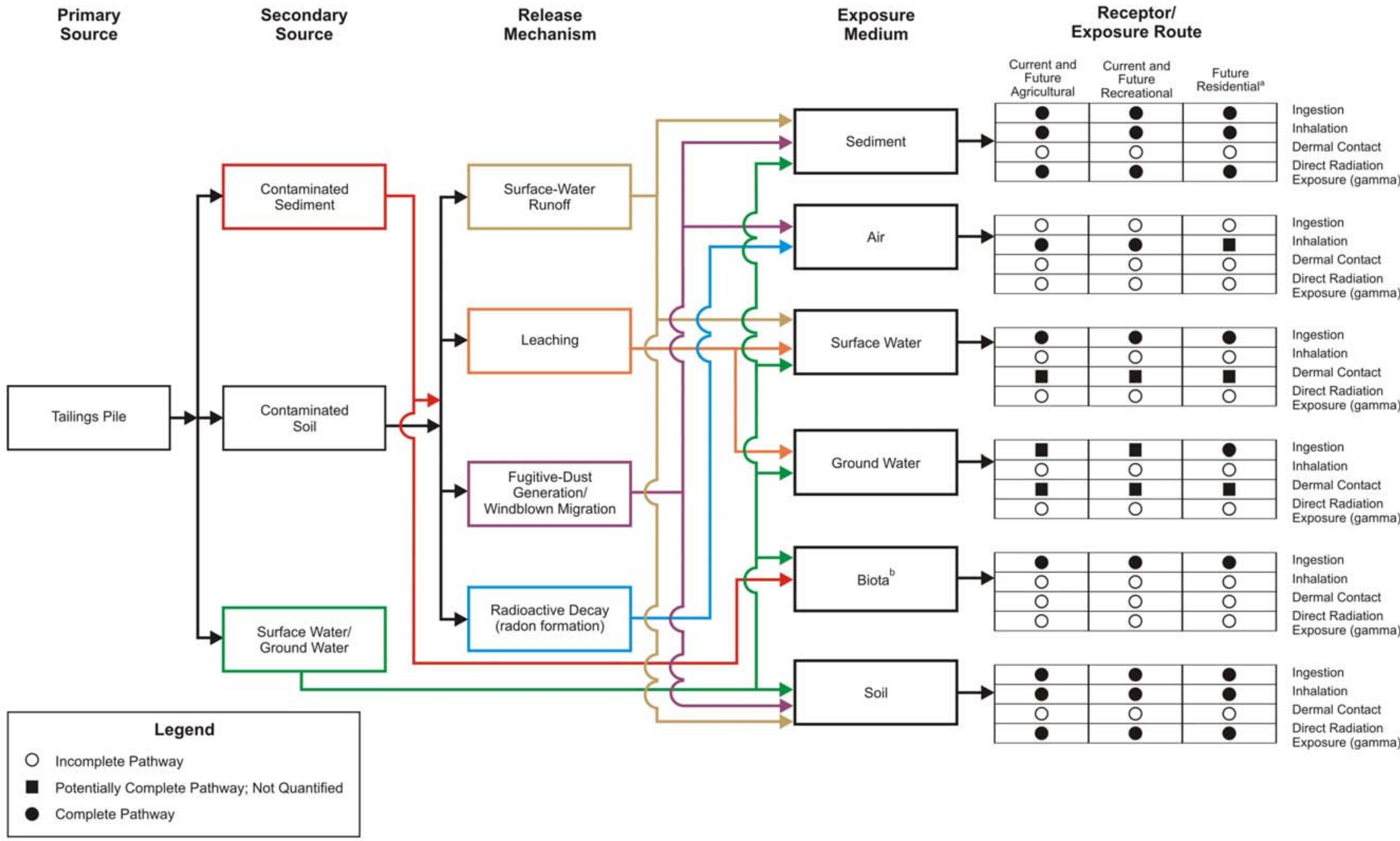
Existing developmental trends in Monticello and the availability of infrastructure necessary for development generally lie outside of the OU III area. The OU III area remains in large tracts of either public or privately held properties. Institutional controls that have been implemented will help to keep the lands in present usage for the immediate future. The Summary of Site Risks has been developed with full consideration of the current and future land uses.

7.0 Summary of Site Risks

The human health risk assessment completed in 1998 evaluated risks for all sources of OU III contamination (DOE 1998c). The primary populations exposed to contaminants within OU III were nearby residents who used the land along Montezuma Creek for agricultural (e.g., cattle grazing, elk ranching, growing alfalfa) or recreational (e.g., hunting) uses. In 1998, the assumed future use of the Montezuma Creek valley from the eastern millsite boundary to the area where the canyon narrows was considered an “extended backyard” for nearby residents (i.e., slightly more intensive use). Further east of this area in the Canyon Reach of Montezuma Creek and downstream to the terminus of the OU III boundary (see Figure 2), the 1998 uses (i.e., agricultural, occasional hunting, and recreational uses) were expected to continue in the future because the rugged nature of the terrain and the narrow valley floor would continue to preclude use as an extended backyard.

Figure 4 depicts the 1998 human health conceptual site model for OU III. The conceptual site model identified three major categories of potential receptors: (1) current and future agricultural workers, (2) current and future recreational users, and (3) future residents. Exposure pathways included incidental ingestion of soil and water, inhalation of dust, and direct exposure to gamma radiation. The exposure pathway analysis developed for the 1998 Remedial Investigation is summarized in Section 4, “Baseline Risk Assessment Update” (DOE 2004c). Site-specific exposure factors were developed by DOE, EPA, and UDEQ in 1998 and were based on existing and anticipated future land use scenarios. Exposures were determined using both the reasonable maximum exposures (RMEs) and central tendency (CT) exposure parameters. RME is defined as exposure well above average but still within the range of possible values; it is analogous to “high-end” exposure estimates. CT uses exposure assumptions that result in average or best-estimate exposures, with a tendency to still be somewhat conservative.

Carcinogenic risks were compared to the National Contingency Plan acceptable cancer risk range of 10^{-6} to 10^{-4} (40 CFR 300). For noncarcinogens, hazard quotients (HQs) were summed to produce a hazard index (HI). An HI that exceeds 1.0 is a numerical indication of unacceptable exposure levels. An aggregate dose assessment was also conducted in which effective dose equivalent (EDE) was estimated by summing external gamma plus inhalation and ingestion of radionuclides that emit radiation to internal organs. The EDE was compared to existing radiation protection benchmarks established by the U.S. Nuclear Regulatory Commission (NRC) of 25 millirems per year (mrem/yr) (NRC 1997) or Utah’s dose limit for individual members of the public of 100 mrem/yr (R313-15-301, *Utah Administrative Code* [U.A.C.]).



[a]Residential land use is assumed to occur only in upper Montezuma Creek.
[b]Includes terrestrial animals (e.g., cattle, deer), farm-grown crops, and garden vegetables.

Figure 4. Human Health Conceptual Site Model

Table 4 presents a summary of the results of the 1998 Remedial Investigation for a future-use residential exposure scenario (ground water ingestion, beef ingestion, and exposure from recreation and agricultural use of the contaminated area along Montezuma Creek). This scenario would result in the highest human health risks.

Table 4. Risk Characterization Summary: Future-Use Residential Scenario

Assessment	OU III Setting		Background		Increment Above Background		OU III Setting/ Background	
	RME	CT	RME	CT	RME	CT	RME	CT
Added Cancer Risk, Nonradionuclides[a]	4.3×10^{-4}	7.0×10^{-5}	3.2×10^{-5}	5×10^{-6}	4×10^{-4}	6.5×10^{-5}	13	14
Added Cancer Risk, Radionuclides[b]	4.5×10^{-4}	9.0×10^{-5}	6.4×10^{-5}	9.0×10^{-6}	3.9×10^{-4}	8.1×10^{-5}	7.0	10
Hazard Index[c]	10.4	5.5	0.3	0.13	10.1	5.4	35	42
EDE (mrem/yr)	15.8	8.3	4.4	2.0	11.3	6.3	3.6	4.2

[a]All the risks in this category are attributable to arsenic.
[b]The risk drivers in this category are lead-210, uranium-234, and uranium-238.
[c]For noncarcinogenic compounds, the risk drivers are uranium and vanadium.

- For the RME case for OU III, the added cancer risk estimates for nonradionuclides and radionuclides are within EPA's 10^{-6} to 10^{-4} risk range. The HI for noncarcinogens exceeds 1.0 for both the RME and CT cases. The excess is directly related to the unlikely assumption of future ground water ingestion.
- For the background setting, assuming RME and CT exposure factors, cancer risk estimates are within EPA's 10^{-6} to 10^{-4} risk range; the HI is less than 1.0.
- Incremental risks (i.e., the increase above background) are of the same order of magnitude as the risks associated with OU III.
- EDEs for OU III, background, and increment above background are below 25 mrem/yr, the 1997 NRC benchmark.

Overall conclusions of the 1998 human health risk assessment were (1) future ground water ingestion results in the largest theoretical, but unlikely exposure; (2) inhalation is a minor contributor to total risk; and (3) intakes of contaminants from muscle tissue (beef and game animals) are much smaller than potential intakes from future ingestion of ground water.

7.1 Human Health Risk Assessment Update

The risk assessment was updated in the Remedial Investigation Addendum (DOE 2004c) using more recent site-specific ground water data for the COCs listed in Table 3. Remedial activities completed since 1998 that have affected surface and ground water contaminant concentrations include excavation and relocation of the tailings piles, soil and sediment removal along Montezuma Creek, treatment of excavation water during remediation of the millsite, and installation of a permeable reactive barrier that treats ground water within the Montezuma Creek alluvial aquifer. On the basis of recent monitoring data, the decision was made to no longer consider lead-210, radium-226, radon-222, and thorium-230 to be COCs in surface water and ground water. At the same time, it was determined that molybdenum and nitrate would be considered as COCs in ground water.

Table 5 presents a summary of the results of the human health risk assessment update. Risks were calculated for residential and recreational/agricultural scenarios. The risk scenarios were evaluated using a near-term or current (October 2002) contaminant concentration level and 20-year projected concentration levels for the principal COC (uranium). All risk scenarios have been reduced from the 1998 assessment because of lower contaminant concentrations identified in analytical results of surface water and ground water samples. Carcinogenic risks for nonradionuclides were lower because of the lower arsenic concentrations in ground water. Elimination of the radionuclide COCs (mostly lead-210) and the lower contaminant concentrations reduced cancer risk from 1998 levels. Noncarcinogenic risks were also reduced because of decreasing contaminant concentrations; only a small increase in risks occurred with the addition of molybdenum and nitrates as COCs.

Table 5. Summary of Results of the Human Health Risk Assessment

Risk Type	Current Use Recreational/ Agricultural (all pathways)		Future Use Recreational/ Agricultural (all pathways)		Future Use Residential (near term) Ground Water Ingestion Only		Future Use Residential (20 years) Ground Water Ingestion Only	
	CT	RME	CT	RME	CT	RME	CT	RME
Chemical (added cancer risk, unitless probability)	8.8×10^{-9}	3.6×10^{-7}	8.8×10^{-9}	3.6×10^{-7}	5.7×10^{-5}	3.4×10^{-4}	5.5×10^{-6}	3.4×10^{-5}
Radionuclides (added cancer risk, unitless probability)	1.3×10^{-5}	1.3×10^{-4}	1.3×10^{-5}	1.3×10^{-4}	6.6×10^{-5}	3.4×10^{-4}	5.2×10^{-5}	3.4×10^{-4}
Noncarcinogenic risk (hazard index, unitless)	0.00	0.01	0.00	0.01	4.8	8.7	1.8	3.2
Dose assessment (effective dose equivalent, millirems per year)	1.8	5.5	1.8	5.5	26.1	40.2	20.5	31.6

CT = central tendency; representative of average exposure.
RME = reasonable maximum exposure; representative of a reasonable worst-case exposure.

Overall, the unlikely exposure scenario of the use of alluvial ground water as the primary drinking water source dominates the estimated risks for the residential scenario for both the near term and 20-year estimates. Risks associated with this pathway exceed the established risk management range of 10^{-4} to 10^{-6} and a hazard index of 1 for noncarcinogenic risk. For the more likely recreational agricultural scenario, risks are generally below any established benchmarks. The highest risks are for added cancer risks from radionuclides that range from 1.3×10^{-5} to 1.3×10^{-4} for CT and RME exposure factors, respectively. The EDE (in millirems per year) is well below the NRC benchmark of 25 mrem/yr for the more likely recreational/agricultural scenario.

7.2 Environmental Risk

The 1998 ecological conceptual site model (Figure 5) identified soil, sediment, and surface water as contaminated media. A determination was made that ground water and air were of negligible concern. Potential exposure routes included ingestion, direct contact, and inhalation, but inhalation was considered to be unimportant. Potential ecological receptors selected were the

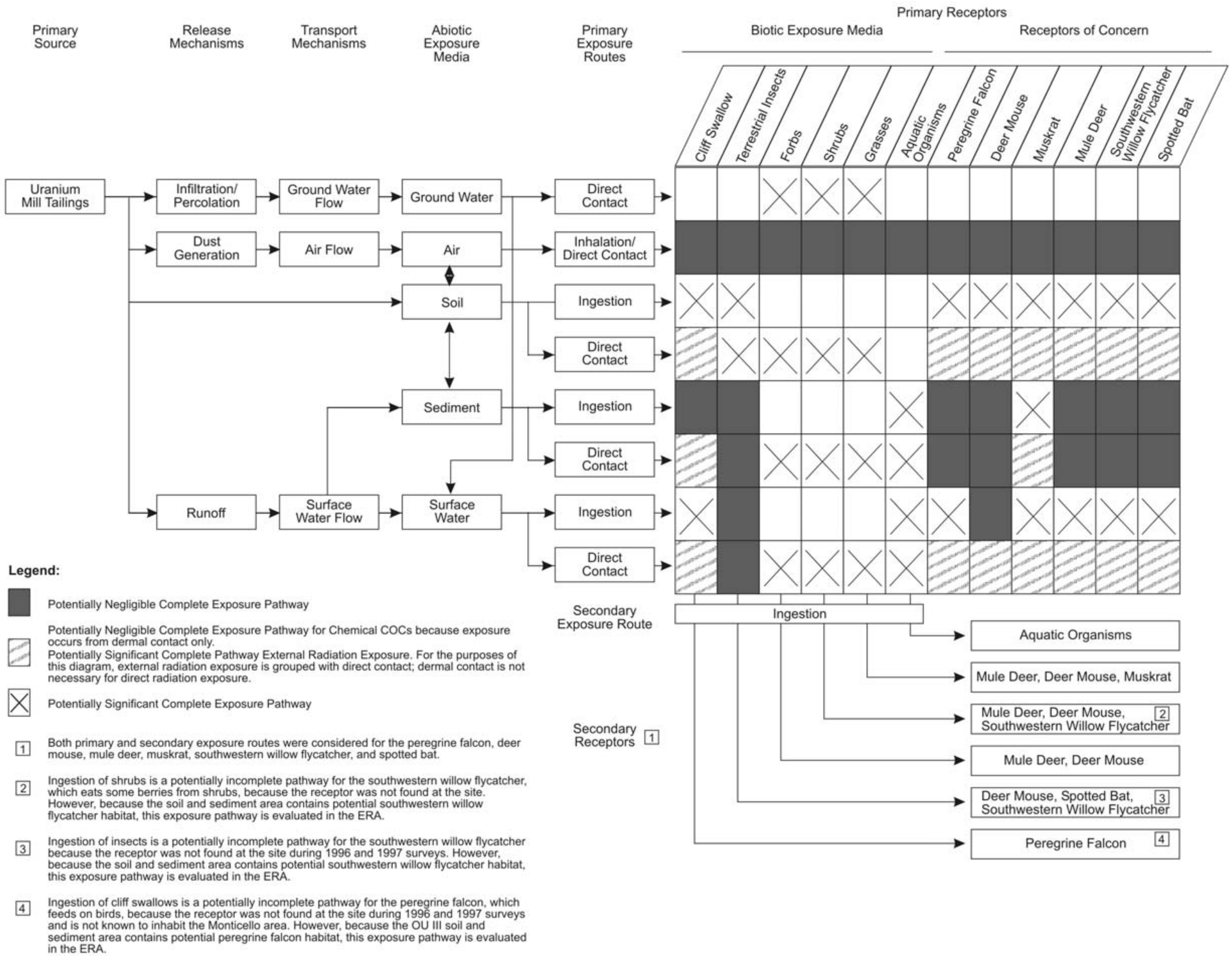


Figure 5. Ecological Conceptual Site Model

deer mouse, mule deer, muskrat, and aquatic organisms. Also included were the southwestern willow flycatcher, spotted bat, and peregrine falcon (federally listed threatened and endangered species). The risk assessment incorporated results of water, soil, and sediment sampling and analysis; macroinvertebrate sampling and analysis; bird tissue sampling and analysis; and benthic macroinvertebrate population surveys (DOE 1998c). Results of that ecological risk assessment led to the conclusion that even though some pathways and COCs (see Table 3) resulted in hazard quotients exceeding the threshold value of 1, risks were probably overestimated by using conservative assumptions; actual risks were interpreted to be low. Since the time of the assessment, concentrations of all COCs except selenium have been decreasing, and conclusions reached for those COCs are still valid. However, since completing the remediation and restoration of the former millsite, the selenium concentrations have been increasing in surface and ground water samples. In addition, the changed conditions at the site, particularly the creation of wetlands on the restored millsite and improved habitat along other reaches of Montezuma Creek, have resulted in the identification of potential ecological receptors that were not considered present in the ecological risk assessment that was completed in 1998.

Because of the changing environmental conditions at the site, data gaps still exist for the evaluation of ecological risk. Some of the data necessary to complete the ecological evaluation cannot be collected until a definitive trend in selenium concentrations has been established and the development of the wetlands on the former millsite has progressed to the state that the wetlands can maintain a high-quality habitat. If the wetlands on the former millsite develop as designed, there is a potential risk to ecological receptors (in particular waterfowl) if high selenium concentrations are present in surface water and sediments within the wetlands. Therefore, as part of the remedy, biomonitoring of the wetlands will be conducted using a stepwise dose-response approach (Section 11.2.1.3). DOE, EPA, UDEQ, and the U.S. Fish and Wildlife Service (agencies that constitute the Biological Technical Assistance Group) together established trigger levels (based on selenium concentrations in sediment and surface water samples) that, if met, will require additional biomonitoring. Data from sample collection and analysis will be evaluated during annual and 5-year reviews to determine if some type of remedial action is warranted. Included as part of the biomonitoring efforts will be an updated survey of potential receptors that might utilize upper Montezuma Creek and the associated wetlands for habitat and forage areas. Descriptions of the biomonitoring approach and the requirements are included in Appendix C.

On the basis of potential human health and ecological risks summarized in this document, the selected remedy in this ROD is necessary to protect public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

8.0 Remedial Action Objectives

Remedial action objectives provide descriptions of the goals that a remedial action is expected to accomplish. Remedial action objectives identify risk or compliance levels for specific COCs. Remedial action objectives specified for protecting human health are expressed both in terms of contaminant concentrations and exposure pathways because protection can be achieved through a reduction in contaminant concentrations and a reduction or elimination of the exposure pathways. Remedial action objectives were developed for ground water and surface water.

8.1 Ground Water Remedial Action Objectives

The following remedial action objectives were developed for OU III alluvial ground water:

- Prevent ingestion of alluvial ground water that contains COCs that may cause cancer and poses an incremental risk greater than the risk management range of 10^{-4} to 10^{-6} (1 in 10,000 to 1 in 1,000,000) or that has concentrations exceeding federal or state ground water standards.

- Prevent ingestion of alluvial ground water that contains COCs that may cause negative health effects other than cancer (noncarcinogens) with a hazard index or hazard quotient greater than 1.0 or that has concentrations exceeding federal or state ground water standards.

For OU III, acceptable risk-based levels of contamination are based on the potential future use of ground water and conservative exposure assumptions, such as the volume of contaminated water ingested per person each year. These remedial action objectives will be achieved when COC concentrations in ground water meet remediation goals (see Table 6).

Table 6. Operable Unit III Ground Water Remediation Goals

Contaminant of Concern	Remediation Goal	Remediation Goal Reference or Basis
Arsenic	10 µg/L	Safe Drinking Water Act
Manganese	880 µg/L	Risk based
Molybdenum	100 µg/L	Uranium Mill Tailings Radiation Control Act
Nitrate (as nitrogen)	10 mg/L	Safe Drinking Water Act
Selenium	50 µg/L	Safe Drinking Water Act
Uranium	30 µg/L	Safe Drinking Water Act
Vanadium	330 µg/L	Risk based
Uranium-234/Uranium-238	30 pCi/L	Uranium Mill Tailings Radiation Control Act
Gross alpha	15 pCi/L	Safe Drinking Water Act

µg/L = micrograms per liter; mg/L = milligrams per liter; and pCi/L = picocuries per liter.

8.2 Surface Water Remedial Action Objectives

Contamination associated with OU III surface water does not cause unacceptable risks to human health. Therefore, remedial action objectives were not based on risks to humans. Current risks to ecological receptors are generally acceptable, with the possible exception of exposure to selenium. Risks from selenium to ecological receptors will be evaluated further. Remediation goals were not based on potential ecological risks, but may be revised in the future if deemed necessary for protection of ecological receptors. Because concentrations of some COCs exceed State standards, the remedial action objective for OU III surface water is to achieve compliance with State surface water standards for COCs in Montezuma Creek. Table 7 presents specific remediation goals.

Table 7. Operable Unit III Surface Water Remediation Goals Adopted From Utah Surface Water Standards

Contaminant of Concern	Remediation Goal[a]
Arsenic	10 µg/L
Nitrate (as nitrogen)	4 mg/L
Selenium	5 µg/L
Gross alpha	15 pCi/L

[a]µg/L = micrograms per liter; mg/L = milligrams per liter; pCi/L = picocuries per liter.

8.3 Ground Water Modeling

A steady-state ground water flow model developed for the alluvial aquifer was used to simulate the occurrence and movement of ground water within OU III (DOE 2004c). The baseline conditions represented in the model characterize the ground water system and uranium ground water plume subsequent to source removal and site reconstruction. A coupled solute transport model predicted future concentrations of uranium in the alluvial aquifer for a simulated period of 50 years beginning October 2002. Uranium is the greatest single contributor to potential risk to human health and is the most widely distributed COC at concentrations above cleanup levels.

The ground water flow model, MODFLOW, represented the alluvial aquifer as an isotropic and homogeneous single layer. Model boundary and property specifications relied primarily on site-specific information and a comprehensive conceptual model (DOE 2004c). Calibration targets included water levels measured in 66 monitoring wells in October 2001 and water balance estimates obtained in part through measurement of large-scale aquifer dewatering rates, hydraulic and geochemical analysis of the permeable reactive barrier, and surface flow gauging.

Uranium transport, simulated using the computer program MT3D96, assumed linear, equilibrium-controlled (rapid and reversible) sorption. Laboratory methods evaluated the characteristics of uranium sorption in the alluvial aquifer and determined a representative value of the distribution coefficient used in the transport model. Specified initial concentrations in the transport model corresponded to October 2002 ground water sample results. Vadose zone leaching represented a remnant source of uranium contamination to ground water. Mass loading from this source was assigned on the basis of site-specific results from column leaching tests (concentration input) and field lysimetry (infiltration rate). The long-term effect of this source was found to be insignificant.

Uranium was predicted to decrease to less than 30 micrograms per liter (µg/L) throughout the study area in 42 years (starting in October 2002 and assuming no effect by the permeable reactive barrier). A natural hydrologic boundary, caused by discharge of the alluvial and bedrock aquifers, restricts plume movement downgradient. At that location, upward flow of ground water from the bedrock formation causes dilution within the alluvial aquifer and, combined with bedrock control, ultimate displacement to Montezuma Creek. Ground water quality on the former millsite is restored by inflows from the west and north, which dilute and flush much of the contaminated ground water to Montezuma Creek on the former millsite reach. By this process, predicted plume movement beyond the permeable reactive barrier requires about 13 years (to about year 2015). As these inflows continue, the contaminant plume is attenuated, west to east, and at the downgradient hydrologic boundary.

Sensitivity analysis of the flow and transport model evaluated the effects of key variables and assumptions on the predicted restoration period. The baseline flow model was calibrated to observations obtained near the onset of recent, regional drought and so represents intermediate flows as compared to periods of relatively high or low flow that could be expected at the site. Simulated drought conditions lengthened the overall period of aquifer restoration by several years only, whereas the overall time period was not affected in the simulation of surplus water year. Restoration within certain areas of the dry and wet year models differed significantly from the baseline model however. Remediation times of 22 to 140 years resulted by individually varying the uranium distribution coefficient and the hydraulic conductivity of the aquifer within reasonable ranges for the site. The potential benefit of the permeable reactive barrier was predicted to reduce the remediation time by 2 years compared to the baseline model. Enhancing the permeable reactive barrier to reduce the quantity of ground water that currently bypasses the system further reduced the time requirement by an additional 2 years.

9.0 Description of Alternatives

A primary objective of the Feasibility Study is to screen a wide range of possible cleanup alternatives and then to more completely evaluate the most promising alternatives. General response actions that were evaluated for OU III include no further action, institutional controls, monitored natural attenuation, containment, and active restoration. This initial evaluation included screening numerous specific technologies for ground water extraction, containment, and treatment.

The Remedial Investigation Addendum/Focused Feasibility Study (DOE 2004c) identified numerous remedies in addition to those which were presented in the *Proposed Plan for the Monticello Mill Tailing Site, Operable Unit III, Surface Water and Ground Water, Monticello, Utah* (DOE 2003b). The Proposed Plan identified alternative remedies based on the existing set of conditions.

- Treatment of the ground water plume by enhancing the effectiveness of the existing permeable reactive barrier. Pump-and-treat enhancement or in situ enhancement has been identified as potential options for this contingency. Section 5.6.4 of the Remedial Investigation Addendum/Focused Feasibility Study (DOE 2004c) discusses these options.

- Relocation and construction of a permeable reactive barrier at a location hydraulically downgradient of the existing permeable reactive barrier to intercept and treat contaminated ground water in the plume.

- Treatment of hot-spot ground-water extraction (small-scale pump and treat) with evaporative treatment using an existing pond located at the DOE repository site; and if necessary, pump and treat (utilizing either wells or trenches) of the contaminated ground-water plume downgradient of the permeable reactive barrier is considered together with evaporative treatment.

- Pump and treat (utilizing either wells or trenches) of the contaminated ground-water plume downgradient of the permeable reactive barrier will be considered together with evaporative treatment.

The above remedial alternatives were described in the Remedial Investigation Addendum/Focused Feasibility Study (DOE 2004c). Alternatives were eliminated from further consideration based on a number of criteria, including limited beneficial use of the aquifer, poor well yields, unlikely probability of human exposure, and predicted ability of the aquifer to reach remediation goals naturally in a reasonable time frame (less than 50 years). Therefore, aggressive forms of remediation were eliminated, and the Focused Feasibility Study for OU III evaluated the following alternatives in detail:

- Alternative 1, No further action with institutional controls
- Alternative 2, Monitored natural attenuation with institutional controls
- Alternative 3, Permeable reactive barrier with institutional controls and monitored natural attenuation
- Alternative 4 (Option 1), Enhanced permeable reactive barrier with institutional controls and monitored natural attenuation (pump-and-treat enhancement)
- Alternative 4 (Option 2), Enhanced permeable reactive barrier with institutional controls and monitored natural attenuation (in situ enhancement)

The remediation time frame for uranium was estimated for each alternative using the ground water model described in Section 8.3.

9.1 Description of Remedy Components

All the alternatives include institutional controls, CERCLA 5-year reviews, and decommissioning of the permeable reactive barrier as common elements. All the alternatives except Alternative 1 include monitored natural attenuation and contingency plans. A description of the specific remedy components of each alternative follows.

9.1.1 Alternative 1, No Further Action With Institutional Controls

- **Institutional controls:** This component includes the continued enforcement of existing institutional controls that prohibit the use of the shallow alluvial ground water system and restrict land use. The conditions at OU III will be monitored on a regular basis as part of DOE’s Office of Legacy Management activities to verify that ground water is not used for domestic purposes. The institutional control restricting the development of wells into the shallow alluvial aquifer will remain in place until remediation goals have been attained; restrictive easements on land use should remain in place in perpetuity. These controls are described in Section 6.0.

- **CERCLA 5-year reviews:** CERCLA mandates that all sites, where contamination is left on site, be reviewed at least every 5 years to ensure that the remedy is still effective and protective of human health and the environment. Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within 5 years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment. The next statutory review is to be conducted in 2007. Modifications of the remedy may be necessary to ensure protectiveness.

- **Decommission the permeable reactive barrier:** The permeable reactive barrier, which was installed in 1999, is currently treating contaminated ground water. Under Alternative 1, the permeable reactive barrier would be decommissioned as soon as practicable to alleviate DOE of all future obligations associated with operation of the permeable reactive barrier. Removal of the permeable reactive barrier would reduce the scope of monitoring requirements because a number of wells are necessary for monitoring the performance of the permeable reactive barrier.

- **Monitoring:** Monitoring would be required under this alternative, but results would not be evaluated against trends or predictions. Monitoring would determine when remediation goals are met, but no time allowance is specified for COCs to exceed remediation goals (though monitoring is anticipated for 42 years starting in October 2002).

9.1.2 Alternative 2, Monitored Natural Attenuation With Institutional Controls

- **Institutional controls:** This component includes the continued enforcement of existing institutional controls that prohibit the use of the shallow alluvial ground water system and restrict land use. The conditions at OU III will be monitored on a regular basis as part of DOE's Office of Legacy Management activities to verify that ground water is not used for domestic purposes. The institutional control restricting the development of wells into the shallow alluvial aquifer will remain in place until remediation goals have been attained; restrictive easements on land use should remain in place in perpetuity.

- **CERCLA 5-year reviews:** CERCLA mandates that all sites, where contamination is left on site, be reviewed at least every 5 years to ensure that the remedy is still effective and protective of human health and the environment. Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within 5 years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment. The next statutory review is to be conducted in 2007. Modifications of the remedy may be necessary to ensure protectiveness.

- **Decommission the permeable reactive barrier:** The permeable reactive barrier, which was installed in 1999, is currently treating contaminated ground water. However, the permeable reactive barrier will become less effective over time because of a reduction in reactivity and a restriction of flow through the permeable reactive barrier. Performance monitoring of the barrier would take place as part of this alternative. Decommissioning of the barrier would take place when continued ground water treatment provides only marginal benefit or when excessive ground water mounding overtops the reactive media and adversely affects land use. When either of these indicators of failure occurs, the permeable reactive barrier will be removed and disposed of in an off-site repository.

- **Monitored natural attenuation:** In the absence of a continuing source of contamination, contaminant concentrations in the ground water will naturally decrease over time through natural geochemical and hydrologic processes. Monitored natural attenuation refers to the tracking of the natural reduction of contaminant concentrations through regular analyses of ground water samples. Monitoring would take place to ensure that contaminants in ground water are attenuating as predicted and that the ground water is on track to meet remediation goals in the 42-year predicted time frame (since October 2002). Additional wells in accordance with an approved monitoring plan will be installed. Rationale supporting the use of monitored natural attenuation for OU III are listed in Section 11.2 and described in detail in Appendix A of this ROD.

- **Contingency Plan:** EPA guidance recommends that contingency plans should be flexible enough to allow for incorporation of new information about site risks and technologies. DOE, EPA, and UDEQ will jointly determine the need for and the appropriate contingency action based on an analysis of monitoring results (see Section 11.5 and Appendix B).

9.1.3 Alternative 3, Permeable Reactive Barrier With Institutional Controls and Monitored Natural Attenuation

- **Institutional controls:** This component includes the continued enforcement of existing institutional controls that prohibit the use of the shallow alluvial ground water system and restrict land use. The conditions at OU III will be monitored on a regular basis as part of DOE's Office of Legacy Management activities to verify that ground water is not used for domestic purposes. The institutional control restricting the development of wells into the shallow alluvial aquifer will remain in place until remediation goals have been attained; restrictive easements on land use should remain in place in perpetuity.

- **CERCLA 5-year reviews:** CERCLA mandates that all sites, where contamination is left on site, be reviewed at least every 5 years to ensure that the remedy is still effective and protective of human health and the environment. Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within 5 years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment. The next statutory review is to be conducted in 2007. Modifications of the remedy may be necessary to ensure protectiveness.

- **Operate/decommission the permeable reactive barrier:** The permeable reactive barrier, which was installed in 1999, is currently treating contaminated ground water. For this alternative, it is assumed that the barrier will continue to operate effectively for the next 15 years (starting July 1999). The permeable reactive barrier would be decommissioned when the existing COC plume has passed the permeable reactive barrier and when potential sources of ground water contamination above remediation goals on the millsite are no longer significant. At that time, the permeable reactive barrier would be removed and disposed of in an off-site repository.

- **Monitored natural attenuation:** In the absence of a continuing source of contamination, contaminant concentrations in the ground water will naturally decrease over time through natural geochemical and hydrologic processes. Monitoring would take place to ensure that contaminants in ground water are attenuating as predicted and that ground water is on track to meet remediation goals in the 40-year predicted time frame (since October 2002). Additional wells in accordance with an approved monitoring plan will be installed.

- **Contingency Plan:** EPA guidance recommends that contingency plans should be flexible enough to allow for incorporation of new information about site risks and technologies. The contingency plan for Alternative 3 includes the possibility of replacing, rejuvenating, or relocating the permeable reactive barrier. The need for and appropriate contingency action will be determined jointly by DOE, EPA, and UDEQ based on an analysis of monitoring results (see Section 11.5 and Appendix B).

Alternative 4 (Option 1), Enhanced Permeable Reactive Barrier With Institutional Controls and Monitored Natural Attenuation (pump-and-treat enhancement)

- **Institutional controls:** This is the continued enforcement of existing institutional controls that prohibit the use of the shallow alluvial ground water system and restrict land use. The conditions at OU III will be monitored on a regular basis as part of DOE's Office of Legacy Management activities to verify that ground water is not used for domestic purposes. The institutional control restricting the development of wells into the shallow alluvial aquifer will remain in place until remediation goals have been attained; restrictive easements on land use should remain in place in perpetuity.

- **CERCLA 5-year reviews:** CERCLA mandates that all sites, where contamination is left on site, be reviewed at least every 5 years to ensure that the remedy is still effective and protective of human health and the environment. Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within 5 years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment. The next statutory review is to be conducted in 2007. Modifications of the remedy may be necessary to ensure protectiveness.

- **Enhance, operate, and decommission the permeable reactive barrier:** The permeable reactive barrier, which was installed in 1999, is currently treating contaminated ground water. However, a certain amount of contaminated ground water flows around the south perimeter of the permeable reactive barrier (bypass flow) and is not treated. Under Alternative 4, Option 1, the effectiveness of the permeable reactive barrier would be enhanced by extracting flow around the south perimeter and distributing it along the top of the permeable reactive barrier gravel/zero-valent iron zone for subsequent treatment. Thus, most ground water upgradient of the permeable reactive barrier would undergo treatment. When remediation goals are met in upgradient ground water or when the permeable reactive barrier provides only marginal benefit, the permeable reactive barrier will be removed and disposed of in an off-site repository.

- **Monitored Natural Attenuation:** In the absence of a continuing source of contamination, contaminant concentrations in the ground water will naturally decrease over time through natural geochemical and hydrologic processes. Monitoring would take place to ensure that contaminants in ground water are attenuating as predicted and that ground water is on track to meet remediation goals in the 39-year predicted time frame (since October 2002). Additional wells in accordance with an approved monitoring plan will be installed. The current permeable reactive barrier monitoring network also would be augmented to monitor performance of the system enhancement.

- **Contingency Plan:** EPA guidance recommends that contingency plans should be flexible enough to allow for incorporation of new information about site risks and technologies. The contingency plan includes the possibility of replacing, rejuvenating, or relocating the permeable reactive barrier. DOE, EPA, and UDEQ will jointly determine the need for and the appropriate contingency action based on an analysis of monitoring (see Section 11.5 and Appendix B).

9.1.4 Alternative 4 (Option 2), Enhanced Permeable Reactive Barrier With Institutional Controls and Monitored Natural Attenuation (in situ enhancement)

- **Institutional controls:** This component is the continued enforcement of existing institutional controls that prohibit the use of the shallow alluvial ground water system and restrict land use. The conditions at OU III will be monitored on a regular basis as part of DOE's Office of Legacy Management activities to verify that ground water is not used for domestic purposes. The institutional control restricting the development of wells into the shallow alluvial aquifer will remain in place until remediation goals have been attained; restrictive easements on land use should remain in place in perpetuity.

- **CERCLA 5-year reviews:** CERCLA mandates that all sites, where contamination is left on site, be reviewed at least every 5 years to ensure that the remedy is still effective and protective of human health and the environment. Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within 5 years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment. The next statutory review is to be conducted in 2007. Modifications of the remedy may be necessary to ensure protectiveness.

- **Enhance, operate, and decommission the permeable reactive barrier:** The permeable reactive barrier, which was installed in 1999, is currently treating contaminated ground water. However, a certain amount of contaminated ground water flows around the south perimeter of the permeable reactive barrier (bypass flow) and is not treated. Under Alternative 4, Option 2, the effectiveness of the permeable reactive barrier would be enhanced by installing additional treatment in the bypass zone (beyond the south slurry wall). Thus, most ground water upgradient of the permeable reactive barrier would undergo treatment. When remediation goals are met in upgradient ground water or when the permeable reactive barrier provides only marginal benefit, the permeable reactive barrier would be removed and disposed of in an off-site repository.

- **Monitored Natural Attenuation:** In the absence of a continuing source of contamination, contaminant concentrations in the ground water will naturally decrease over time through natural geochemical and hydrologic processes. Monitoring would take place to ensure that contaminants in ground water are attenuating as predicted and that ground water is on track to meet remediation goals in the 38-year predicted time frame (since October 2002). Additional wells in accordance with an approved monitoring plan will be installed. The current permeable reactive barrier monitoring network would be augmented to monitor performance of the system enhancement.

- **Contingency Plan:** EPA guidance recommends that contingency plans should be flexible enough to allow for incorporation of new information about site risks and technologies. The contingency plan includes the possibility of replacing, rejuvenating, or relocating the permeable reactive barrier. DOE, EPA, and UDEQ will jointly determine the need for and the appropriate contingency action based on an analysis of monitoring (see Section 11.5 and Appendix B).

9.2 Common Elements and Distinguishing Features of Each Alternative

9.2.1 Alternative 1, No Further Action With Institutional Controls

- Estimated Capital Costs (decommission the permeable reactive barrier): $32,112
- Estimated Annual Costs (years 1–40): $37,080 (Year 1 starts October 2004)
- Estimated Net Present Value: $526,000
- Estimated Construction Time Frame: Less than 1 year to decommission the permeable reactive barrier
- Estimated Time To Achieve Remedial Action Objectives: 42 years starting in October 2002

This no further action alternative includes the decommissioning of the permeable reactive barrier that was installed in 1999. It would also have considerably less water-quality monitoring, mostly because the need to monitor the permeable reactive barrier would be eliminated. The institutional control restricting the development of wells into the shallow alluvial aquifer will be in place until remediation goals are obtained.

The expected outcomes for Alternative 1 include: existing restrictions on land use (removal of contaminated sediment and soil from the restrictive easement area) remain in perpetuity; unrestricted ground water use after cleanup levels are met (approximately the year 2044); and removal of the permeable reactive barrier and placement of reactive media in an environmentally acceptable repository.

9.2.2 Alternative 2, Monitored Natural Attenuation With Institutional Controls

- Estimated Capital Costs $45,112
  (decommission the permeable reactive barrier): $32,112;
  (construction of additional monitoring wells): $15,000
- Estimated Annual Costs (years 1–10): $123,580 (Year 1 starts October 2004)
- Estimated Annual Costs (years 11–40): $113,980
- Estimated Net Present Value: $1,489,000
- Estimated Construction Time Frame: Less than 1 year to decommission the permeable reactive barrier
- Estimated Time To Achieve Remedial Action Objectives: 42 years starting in October 2002

This alternative allows the permeable reactive barrier to remain operational as long as it continues to treat contaminated ground water effectively, but it does not rely on the permeable reactive barrier performance to meet remediation goals. It also includes comprehensive monitoring to evaluate the effectiveness of monitored natural attenuation and the permeable reactive barrier. The institutional control restricting the development of wells into the shallow alluvial aquifer will remain in place until the remediation goals are reached.

The expected outcomes for Alternative 2 include: existing restrictions on land use (removal of contaminated sediment and soil from the restrictive easement area) remain in perpetuity; unrestricted ground water use after cleanup levels are met (approximately the year 2044); and removal of the permeable reactive barrier and placement of reactive media in an environmentally acceptable repository.

9.2.3 Alternative 3, Permeable Reactive Barrier With Institutional Controls and Monitored Natural Attenuation

- Estimated Capital Costs $45,112
  (decommission the permeable reactive barrier): $32,112;
  (construction of additional monitoring wells): $15,000
- Estimated Annual Costs (years 1–10): $123,580
  (Year 1 starts October 2004)
- Estimated Annual Costs (years 11–38): $113,980
- Estimated Net Present Value: $1,475,000
- Estimated Construction Time Frame: Less than 1 year to decommission the permeable reactive barrier
- Estimated Time To Achieve Remedial Action Objectives: 40 years starting in October 2002

This alternative is similar to Alternative 2 except this alternative explicitly depends on the permeable reactive barrier to treat COCs effectively in the ground water entering the permeable reactive barrier and for the treated water exiting the permeable reactive barrier to enhance the effectiveness of monitored natural attenuation. Because this alternative takes credit for the permeable reactive barrier, the estimated time required to achieve remedial action objectives is 2 years shorter than Alternative 2, and the net present value costs are slightly lower because the monitoring costs associated with the shorter time frame are reduced. The institutional control restricting the development of wells into the shallow alluvial aquifer will remain in place until the remediation goals are reached.

The expected outcomes for Alternative 3 include: existing restrictions on land use (removal of contaminated sediment and soil from the restrictive easement area) remain in perpetuity; unrestricted ground water use after cleanup levels are met (approximately the year 2042); and removal of the permeable reactive barrier and placement of reactive media in an environmentally acceptable repository.

9.2.4 Alternative 4 (Option 1), Enhanced Permeable Reactive Barrier With Institutional Controls and Monitored Natural Attenuation (pump-and-treat enhancement)

- Estimated Capital Costs: $85,112
  (decommission the permeable reactive barrier): $32,112;
  (construction of additional monitoring wells): $25,000
  (construction of enhancements): $28,000
- Estimated Annual Costs (years 1–10): $128,380 (Year 1 starts October 2004)
- Estimated Annual Costs (years 11–37): $118,780
- Estimated Net Present Value: $1,538,000
- Estimated Construction Time Frame: Less than 1 year to plan and install the enhancement
- Estimated Time To Achieve Remedial Action Objectives: 39 years starting in October 2002

Some contaminated ground water is currently bypassing the permeable reactive barrier along the south slurry wall. This alternative takes credit for the permeable reactive barrier as described in Alternative 3 with the addition of active enhancements to reduce the flow of contaminated ground water around the permeable reactive barrier. Option 1 involves extracting the bypass flow and treating it in the permeable reactive barrier. Water would be extracted from the bypass zone using about three extraction wells and would be piped to the treatment portion of the permeable reactive barrier. This alternative also includes the installation of a limited number of small-diameter observation wells to monitor the performance of the permeable reactive barrier enhancement. There is greater uncertainty on the effectiveness of the enhancement than the behavior of the permeable reactive barrier as presently constructed. The institutional control restricting the development of wells into the shallow alluvial aquifer will remain in place until the remediation goals are reached.

The expected outcomes for Alternative 4 (Option 1) include: existing restrictions on land use (removal of contaminated sediment and soil from the restrictive easement area) remain in perpetuity; unrestricted ground water use after cleanup levels are met (approximately the year 2041); and removal of the permeable reactive barrier and placement of reactive media in an environmentally acceptable repository.

9.2.5 Alternative 4 (Option 2), Enhanced Permeable Reactive Barrier With Institutional Controls and Monitored Natural Attenuation (in situ enhancement)

- Estimated Capital Costs: $124,112

  (construction of enhancements): $62,000
  (construction of monitoring wells): $30,000
  (decommission the permeable reactive barrier): $32,112
- Estimated Annual Costs (years 1–10): $123,580
  (Year 1 starts October 2004)
- Estimated Annual Costs (years 11–36): $113,980
- Estimated Net Present Value: $1,535,000
- Estimated Construction Time Frame: Less than 1 year to plan and install the enhancement
- Estimated Time To Achieve Remedial Action Objectives: 38 years starting in October 2002

Alternative 4 (Option 2) is identical to Alternative 4 (Option 1) except in the approach used to treat the contaminated ground water that is bypassing the permeable reactive barrier. Option 2 consists of constructing an array of 10 to 20 large-diameter boreholes that extend to bedrock in the bypass zone. Each borehole would be backfilled with approximately a 10-foot column of the treatment material used in the permeable reactive barrier (zero-valent iron or a zero-valent iron and gravel mix). There is greater uncertainty on the effectiveness of the enhancement than the behavior of the permeable reactive barrier as presently constructed.

The expected outcomes for Alternative 4 (Option 2) include: existing restrictions on land use (removal of contaminated sediment and soil from the restrictive easement area) remain in perpetuity; unrestricted ground water use after cleanup levels are met (approximately the year 2040); and removal of the permeable reactive barrier and placement of reactive media in an environmentally acceptable repository.

10.0 Comparative Analysis of Alternatives

Alternatives under CERCLA are compared using the nine CERCLA evaluation criteria. This section first provides a description of those criteria and then compares the ability of each alternative to meet those criteria.

10.1 Description of Nine CERCLA Criteria

CERCLA requires that remediation alternatives be evaluated using the following nine criteria that are grouped into threshold, balancing, and modifying criteria.

10.1.1 Threshold Criteria

These criteria must be met for the alternative to be considered.

Overall protection of human health and the environment determines if an alternative eliminates, reduces, or controls threats to public health and the environment through institutional controls, engineering controls, or treatment.
Compliance with applicable or relevant and appropriate requirements (ARARs) evaluates if the alternative meets federal and state environmental statutes, regulations, and other requirements that pertain to the site.

10.1.2 Balancing Criteria

Long-term effectiveness and permanence considers the ability of an alternative to maintain protection of human health and the environment over time and the reliability of such protection.

Reduction of contaminant toxicity, mobility, or volume through treatment evaluates an alternative's use of treatment to reduce the harmful effects of the COCs, their ability to move in the environment, and the amount of contamination present.

Short-term effectiveness considers the length of time needed to implement an alternative and the risks the alternative poses to workers, nearby residents, and the environment during implementation.

Implementability considers the technical and administrative feasibility of implementing the alternative, such as the availability of equipment and skilled personnel or site access.

Cost includes estimated capital costs (such as the cost of treatment equipment); annual operating, maintenance, inspection, or monitoring costs; and net present value costs (total cost of an alternative over time in today's dollars).

10.1.3 Modifying Criteria

State acceptance considers whether the State of Utah agrees with DOE's recommendations presented in the Remedial Investigation Addendum and Focused Feasibility Study and the selected remedy.

Community acceptance of the preferred alternative will be evaluated after the public comment period and will be described in the ROD. The ROD will include a responsiveness summary that presents all the public comments and DOE's response to each comment. The preferred alternative can change in response to public comments or new information.

10.2 Comparison of Alternatives

10.2.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls.

All alternatives will prohibit ground water use through institutional controls and are protective of human health. All alternatives except Alternative 1 contain contingency plans to ensure protection of the environment and ecological receptors. Alternative 1 meets remediation objectives in 42 years, but has no specified time frame to accomplish this. Alternative 2 also meets remedial action objectives in 42 years.

Alternative 4 provides overall protection to human health in a shorter time frame (i.e., 38 years) than do Alternatives 1, 2, and 3, which require 42, 42, and 40 years, respectively. Alternatives 2, 3, and 4 have the added benefit of the permeable reactive barrier that intercepts ground water flow and mineralize contaminants. However, Alternative 4 would have the added benefit of the enhancement to the permeable reactive barrier which would improve incrementally the ability of the permeable reactive barrier to intercept ground water flow and immobilize contaminants.

Alternatives 2, 3, and 4 have a contingency plan (i.e., including alternative remedial actions) in the event that the remediation cleanup levels are not being attained. Alternative 1, the no action alternative, would not include the contingency plans nor does it ensure protection of ecological receptors.

Overall protection of Human Health and the Environment would be marginally better if Alternative 4 were selected. Protection of ecological receptors from potential increases in selenium is enhanced by the continued operation of the permeable reactive barrier which removes selenium from the ground water.

10.2.2 Compliance with ARARS

Section 121(d) of CERCLA and NCP §300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations which are collectively referred to as "ARARs," unless such ARARs are waived under CERCLA section 121(d)(4).

Potential Federal and State of Utah ARARs for OU III surface water and ground water are listed in Table 8 and Table 9. These ARARs were compiled and evaluated as a component of the OU III feasibility study (DOE 1998b and 2004c).

Table 8. Federal ARARs for OU III Surface Water and Ground Water

Standard, Requirement, Criterion, or Limitation	Citation	Description	Status	Comment
Safe Drinking Water Act National Primary and Secondary Drinking Water Standards	Title 42 *United States Code* Part 300(g) (42 U.S.C. 300[g]) 40 CFR Part 141 40 CFR Part 143	Establishes health-based standards for public water systems (maximum contaminant levels [MCLs]).	Relevant and appropriate through State of Utah standards as a chemical-specific requirement.	Because the quality of water in the alluvial aquifer could allow it to be used as a drinking water aquifer, the MCLs may apply as cleanup standards.
Clean Water Act Water Quality Criteria	33 U.S.C. 1251−1376 40 CFR Part 131 "Quality Criteria for Water"	Criteria for states to set water quality standards on the basis of toxicity to aquatic organisms and human health.	Applicable through State of Utah standards as a chemical-, location-, and action-specific requirement.	Addresses Montezuma Creek contamination.
National Pollutant Discharge Elimination System	40 CFR Parts 122 through 125	Establishes standards for discharges of pollutants into waterways and through the use of underground injection wells.	Applicable through State of Utah standards as an action-specific requirement.	Potential storm-water discharges into Montezuma Creek must be controlled.
Dredge or Fill Requirements (Section 404)	40 CFR Parts 230 and 231 33 CFR Part 323 40 CFR Part 404	Regulates the discharge of dredged or fill material into navigable waters and manages wetland areas.	Applicable as location- and action-specific requirement.	Dredged or fill material requirements applicable through State of Utah standards. EPA has jurisdiction over wetlands at CERCLA sites in the state.
Clean Air Act National Primary and Secondary Ambient Air Quality Standards	42 U.S.C. 7401−7462 40 CFR Part 50	Establishes standards for ambient air quality to protect public health and welfare.	Applicable through State of Utah standards as a location- and action-specific requirement.	Fugitive dust could be generated through clearing of land or use of construction equipment.
Resource Conservation and Recovery Act	42 U.S.C. 6901 et seq. 40 CFR Parts 260−279	Regulates the generation, treatment, storage, and disposal of hazardous waste.	Applicable through State of Utah standards as a chemical- and action-specific requirement.	Hazardous waste is not known to exist within OU III. However, these regulations will apply if hazardous waste is generated during the decommissioning of the permeable reactive barrier.

Table 8. Federal ARARs for OU III Surface Water and Ground Water (continued)

Standard, Requirement, Criterion, or Limitation	Citation	Description	Status	Comment
Uranium Mill Tailings Radiation Control Act (UMTRCA)	42 U.S.C. 2022, 42 U.S.C. 7901−7942	Establishes health-based ground water remediation standards for inactive uranium-ore processing sites.	Relevant and appropriate chemical- and action-specific requirement.	Although the cleanup standards apply only to certain specifically designated sites where uranium was processed, the ground water cleanup standards are relevant and appropriate to the OU III selected remedy because uranium and vanadium were processed at this site.
Fish and Wildlife Coordination Act	16 U.S.C. 661−666 40 CFR 6.302(g)	Requires consultation when a federal department or agency proposes or authorizes any modification of any stream or other water body; requires adequate provisions for protection of fish and wildlife resources.	Relevant and appropriate as a location- and action-specific requirement.	The Montezuma Creek channel may be modified during OU III remedial activities (i.e., decommissioning of the permeable reactive barrier), which may result in temporary habitat loss for wildlife species.
Endangered Species Act	16 U.S.C. 1531−1543 50 CFR Parts 17 and 402 40 CFR 6.302(h)	Requires federal agencies to ensure that any action authorized, funded, or carried out by such agencies is not likely to jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify critical habitat.	Applicable as a location- and action-specific requirement.	Although threatened and endangered species have not been identified in OU III, the MMTS is within the possible range of some of these species.
Floodplain/Wetlands Environmental Review	40 CFR Part 6, Appendix M	Establishes agency policy and guidance for carrying out the provisions of Executive Orders 11988, "Floodplain Management," and 11990, "Protection of Wetlands."	Applicable as a location- and action-specific requirement.	Remediation could affect site floodplains and wetlands.
National Environmental Policy Act (NEPA)	40 CFR 1500 10 CFR 1021	Requires that all federally undertaken actions be assessed for potential environmental impacts. All potential environmental impacts must be properly mitigated.	Relevant and appropriate as a location- and action-specific requirement.	NEPA values have been and will be incorporated in the CERCLA documentation.

Table 9. State ARARs for OU III Surface Water and Ground Water

Department/Division	Subject	Statute	Rule	Comments
Department of Environmental Quality, Division of Drinking Water	Safe Drinking Water Rules	Title 19, Chapter 4, Utah Code Annotated (U.C.A.)	R309, Utah Administrative Code (U.A.C.)	This is the state-implemented Safe Drinking Water Act program. The quality of the alluvial aquifer could allow it to be used as a drinking-water aquifer. Relevant and appropriate chemical-specific requirement.
Department of Environmental Quality, Division of Water Quality	Definitions and General Requirements	Title 19, Chapter 5, U.C.A.	R317-1, U.A.C.	Applicable chemical-, location-, and action-specific requirement.
	Standards for Quality for Waters of the State	Title 19, Chapter 5, U.C.A.	R317-2, U.A.C.	These rules are specific to Utah waters, though they are derived in part by using federal criteria. See particularly the nondegradation policy in R317-2-3. Applicable chemical-, location-, and action-specific requirement.
	Groundwater Quality Protection	Title 19, Chapter 5, U.C.A.	R317-6, U.A.C.	There is no corresponding federal program. Applicable chemical-, location-, and action-specific requirement.
	Utah Underground Injection Control	Title 19, Chapter 5, U.C.A.	R317-7, U.A.C.	Applicable chemical- and action-specific requirement if Class V injection wells are used in association with the selected ground water remedy.
	Utah Pollutant Discharge Elimination System	Title 19, Chapter 5, U.C.A.	R317-8, U.A.C.	Applicable location- and action-specific requirement for controlling storm-water runoff into Montezuma Creek associated with construction activities.
Department of Environmental Quality, Division of Air Quality	Utah Air Conservation Rules	Title 19, Chapter 2, U.C.A.	R307-101, R307-102, and R307-205, U.A.C.	This is the state-implemented National Ambient Air Quality Standards program. These rules are applicable through the State of Utah standards as a location- and action-specific requirement for controlling fugitive dust emissions from OU III.

Table 9. State ARARs for OU III Surface Water and Ground Water (continued)

Department/Division	Subject	Statute	Rule	Comments
Department of Environmental Quality, Division of Solid and Hazardous Waste	Hazardous Waste Management Rules (RCRA Subpart C)	Title 19, Chapter 6, Part 1, U.C.A.	R315, R315-1, R315-2, R315-5, R315-101, U.A.C.	The rules are applicable chemical- and action-specific requirements through the State of Utah standards; hazardous waste is not known to exist within OU III. However, these regulations will apply if hazardous waste is generated during the decommissioning of the permeable reactive barrier.
Department of Environmental Quality, Division of Radiation Control	Radioactive Material Management	Title 19, Chapter 3, U.C.A.	R313-12, R313-15-301, R313-19 through R313-22, and R313-25-18 through R313-25-22, U.A.C.	These provisions address the safe management, including disposal, of radioactive material. They also address standards for protection against radiation and licensing requirements. These state requirements are applicable chemical- and action-specific requirements.
Department of Environmental Quality, Division of Environmental Response and Remediation	Corrective Action Cleanup Standards Policy for CERCLA and Underground Storage Tank Sites	Title 19, Chapter 6, Part 1, U.C.A.	R311-211, U.A.C.	Remediation strategy must achieve compliance with this policy that sets forth criteria for establishing cleanup standards and requires source control or removal and prevention of further degradation. This policy is an applicable chemical-, location-, and action-specific state requirement.
Department of Natural Resources, Division of Water Rights	Well-drilling standards (standards for drilling and abandonment of wells)	73B3B25(2)(b), U.C.A.	R655B4, U.A.C.	Includes such requirements as performance standards for casing joints and requirements for abandoning a well. Also included are water rights issues associated with consumptive use. This law is applicable to all drilling anticipated for any of the alternatives and for any planned water use. Applicable action- and location-specific requirement.
	Dredge or fill requirements, including stream channel alteration.	73–3–29, U.C.A.		Applicable location- and action-specific requirement.

Alternative 1 does not meet ARARs because existing concentrations of COCs (e.g., uranium and selenium) presently exceed ground water standards. Alternative 1 would have administrative requirement difficulties in obtaining chemical specific ARAR waivers or a requirement to obtain Alternate Corrective Action Concentration Limits through the State of Utah.

Monitored natural attenuation would eventually result in meeting all ARARs; however, Alternative 1 would have no required time frame in which to meet standards. All the other alternatives do meet ARARs and must meet State ground water quality standards within the accepted remediation time frame (42 years). Protection of threatened and endangered species and State sensitive species is better provided by selection of Alternatives 2, 3, or 4.

10.2.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup levels have been met. This criterion includes the consideration of residual risk that will remain onsite following remediation and the adequacy and reliability of controls.

It is assumed that processes resulting in monitored natural attenuation will be permanent and that contaminants will not be re-released to the environment. Because all alternatives involve natural attenuation, then all will be effective in the long-term. Alternatives 2, 3, and 4 have the added benefit that additional contaminants will be mineralized in the permeable reactive barrier and will be removed from the site when the permeable reactive barrier is decommissioned.

All alternatives rely on institutional controls to prohibit the future use of contaminated ground water. The success of each alternative is dependent, in part, on the continuation of the existing institutional controls.

10.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

Monitored natural attenuation is the principal mechanism to reduce toxicity and mobility for all the alternatives including the no action alternative (Alternative 1). Alternatives 2 through 4 will continue to utilize the permeable reactive barrier until such time as the permeable reactive barrier is no longer effective in removing COCs from the ground water. Enhancement of the permeable reactive barrier which is provided for in Alternative 4 would make that alternative incrementally better than Alternatives 2 and 3. Alternative 4, if implemented will reduce toxicity in an incrementally shorter time frame than the other alternatives and will also result in the removal of an incrementally larger volume of the contaminants once the permeable reactive barrier is decommissioned.

10.2.5 Short-Term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community, and the environment during construction and operation of the remedy until cleanup levels are achieved.

All alternatives are equally protective in the short-term through the use of institutional controls which restrict the use of the alluvial ground water. All the alternatives will require approximately 40 years to achieve the remediation goals. The no action alternative (Alternative 1) will require 42 years to achieve the remediation goals. Alternative 4 is projected to meet remediation goals in approximately 38 years because of the enhancements to the permeable reactive barrier. It provides an incrementally shorter timeframe to meet remediation goals than do Alternatives 1, 2, and 3.

Although the uranium plume is predicted to diffuse and move downgradient of the permeable reactive barrier within a relatively short time (i.e., 12 to 15 years); selenium, which has shown an increasing trend in both surface and ground water since the completion of the millsite remediation, is also effectively removed by the permeable reactive barrier. Delaying the decommissioning of the permeable reactive barrier to provide continued treatment of selenium may be a consideration, even after the other contaminant plumes have moved downgradient of the existing permeable reactive barrier.

10.2.6 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

Alternative 1 would have administrative difficulties in obtaining a chemical specific ARARs waiver for uranium or other COCs through the State of Utah.

Alternatives 2 and 3 are both technically and administratively simple to implement. There are two major components which include: monitoring of the permeable reactive barrier performance; and continuation of institutional controls, and the enforcement, if necessary. Monitoring the performance of the permeable reactive barrier requires more extensive monitoring than Alternative 1. Monitoring of natural attenuation will require the installation of several wells on private lands to make certain that expected contaminant trends are met downgradient of the permeable reactive barrier. Alternative 4 (both options) is technically the most difficult to design and implement as there would be landowner concerns and possible difficulties with design and construction of the enhancements. Additional wells to monitor the performance of the enhancements will also need to be constructed.

10.2.7 Cost

Alternative 1 is the least costly. Costs for Alternatives 2, 3, and 4 are comparable. The cost for Alternative 4 is incrementally (about 4 percent) more costly than Alternatives 2 and 3. See Section 9.2 and Table 9 for cost comparisons.

10.2.8 State Acceptance

Alternative 1 is not acceptable to the State of Utah; Alternatives 2 through 4 are acceptable. The State's acceptance of Alternative 2 is premised on the understanding that EPA and DOE will continue to seek funds to research ways to optimize the permeable reactive barrier Treatability Study and evaluate alternatives to enhance the overall performance of the permeable reactive barrier.

10.2.9 Community Acceptance

Alternative 2 was presented to the community as the preferred alternative and is assumed to be acceptable based on the lack of any negative response. The City Manager for Monticello was present at the public hearing and appeared comfortable with the preferred alternative as presented. Since no comments were received on the other alternatives, either at the public hearing or in writing, it is not known whether any of the other alternatives would be acceptable.

10.3 Summary of Comparison

Table 10 presents a summary of a comparison of alternatives. On the basis of this comparison, Alternatives 2 and 3 best satisfy all the criteria. However, Alternative 2 does not rely on the permeable reactive barrier to achieve cleanup levels and, therefore, has less uncertainty associated with it. Alternative 2 is slightly more expensive than Alternative 3, but this difference is less than 1 percent of total net present value.

Table 10. Summary Evaluation of the Operable Unit III Alternatives

Evaluation Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 4 Options 1 and 2
Overall protection of human health and the environment	●	●	●	●
Compliance with applicable or relevant and appropriate requirements (ARARs)	◊	●	●	●
Long-term effectiveness and permanence	●	●	●	●
Reduction of toxicity, mobility, and volume through treatment[a]	◊	○	○	○
Short-term effectiveness[b]	●	●	●	●
Implementability	Implementable (see note)	Fully implementable	Fully implementable	Fully implementable (see note)
Cost: net present value	$526,000	$1,489,000	$1,475,000	$1,538,000 (Option 1) $1,535,000 (Option 2)
State acceptance	The Utah Department of Environmental Quality accepts Alternative 2.			
Community acceptance	The community accepts the preferred alternative. No dissenting public comments were received.			
Notes	ARAR waivers would be required for compliance.	Does not require specific performance of the permeable reactive barrier.	Requires specific performance of the permeable reactive barrier.	Requires landowner approval and effective performance of the permeable reactive barrier

[a]Alternative 4 is incrementally better than Alternative 3 which is incrementally better than Alternative 2 because there is a reduction in toxicity, mobility, and volume as more ground water is treated by the permeable reactive barrier.
[b]If the institutional control preventing use of the contaminated alluvial aquifer as a primary drinking water source fails, then Alternative 4 will have the greatest short-term effectiveness because it has the shortest time frame to meet remedial action objectives.

● = Fully meets criterion ○ = Partially meets criterion ◊ = Does not meet criterion

11.0 Selected Remedy

11.1 Summary of the Rationale for the Selected Remedy

On the basis of CERCLA requirements, the detailed analysis of alternatives, and public comments, DOE has determined that Alternative 2, Monitored Natural Attenuation and Institutional Controls, provides the best balance of trade-offs among the remedial alternatives. All alternatives evaluated are comparable in protectiveness and rely upon institutional controls that are already in place. Except for the no action alternative (Alternative 1), performance monitoring would be required for all alternatives. Alternative 2 differs from Alternatives 3 and 4 in that no credit is taken for performance of the permeable reactive barrier in estimating remediation time frames (as for Alternative 3) and no enhancements to performance of the permeable reactive barrier are planned (as for Alternative 4). Although estimated time frames for achievement of remediation goals are slightly longer for Alternative 2 than for Alternatives 3 and 4, the difference is not great (within 5 years) and is possibly overestimated by not factoring in performance of the permeable reactive barrier. Thus, Alternative 2 should provide a conservative estimate of the duration of remedial activities. Because it is unlikely that the alluvial aquifer would be used for significant beneficial use, even in the absence of site-related contamination, the benefits of a more active form of remediation are limited. Performance criteria provided in the monitoring strategy for the site (described in the following section) will verify that monitored natural attenuation is progressing as predicted; monitoring also will identify the potential for any adverse effects in areas where contaminated ground water discharges to the surface.

11.2 Description of the Selected Remedy

Alternative 2, the selected remedy, allows for natural geochemical and hydrologic processes to dissipate COC concentrations in ground water to cleanup levels within the established remediation time frame (42 years). The major elements associated with this alternative include: ground water and surface water monitoring (water quality analysis, water level monitoring, and stream flow monitoring); continued implementation and enforcement of the existing institutional controls; and decommissioning of the permeable reactive barrier when it no longer provides a benefit to remediation efforts. Monitoring results will be used to verify and compare progress of monitored natural attenuation to predicted restoration rates, evaluate the continued effectiveness of the permeable reactive barrier, and assess potential impacts to important ecological receptors.

Two of the three principal lines of evidence, contaminant source control and natural attenuation processes support the use of monitored natural attenuation at the site. In addition to the contaminant source control and natural attenuation processes, current and projected land use at the site and institutional controls which were put in place as part of the interim remedial action ROD also support the use of monitored natural attenuation at the site. The rationale are summarized here and more detail for each is presented in Appendix A.

Contaminant source removal:

- Removal of the primary sources of ground water contamination on the millsite (approximately 2.5 million yd^3 of mill tailings, and contaminated soil and sediment).

- Removal of 75,000 yd^3 of soil representing residual or secondary source material within the vadose zone beneath the former tailings piles from the millsite.

- Removal of soil and sediment hot-spot contamination along Montezuma Creek downstream (east) of the millsite. Intended primarily to mitigate risk associated with surface exposure, this action contributed to ground water contamination source control.

- Treatment of excavation water during millsite remediation removed an estimated 3 to 6 percent of the total preremediation inventory of uranium from the ground water system.

- Continued ground water treatment by a permeable reactive barrier, installed in 1999, and expected to operate effectively for an additional 5 to 10 years. The permeable reactive barrier immobilizes uranium and other COC's that flow through zero-valent iron, the reactive media. Approximately one-half to two-thirds of the flow of contaminated ground water in the alluvial aquifer is treated by the permeable reactive barrier.

Natural attenuation processes:

- A comprehensive conceptual model of ground water flow identifies natural hydrologic boundaries that control plume movement and attenuate COC concentrations. The downgradient extent of contamination has remained static since remedial investigation monitoring began in 1992.

- The primary contributor to potential human health risk (uranium) from ground water consumption can reasonably be expected to achieve its remediation goal in an acceptable time frame. Results of sorption batch tests justified the specific value of the uranium distribution coefficient used in the transport model.

In addition to the rationale discussed above, the potential for human exposure and risk has been mitigated by the implementation and enforcement of institutional controls and current and projected alluvial aquifer use.

- Effective institutional controls prevent ingestion of contaminated ground water and exposure to contamination that was left in place in the floodplain of Montezuma Creek so there is minimal risk to human health.

- The alluvial aquifer was not used for any purpose before the institutional controls were implemented, and future domestic use of the aquifer, if institutional controls were not in place, is not likely because of its low productivity.

- Alternate water supplies (municipal water or bedrock aquifer ground water) are readily available to the entire affected area.

11.2.1 Monitoring

Post-ROD monitoring of ground water and surface water as described in this section will provide the basis for evaluating the performance of natural attenuation in achieving OU III remediation goals. Post-ROD surface and ground water monitoring tasks consist of two general categories: water quality monitoring and hydrologic monitoring. The *MMTS Operable Unit III Post-Rod Monitoring Plan* (DOE 2004b) provides additional detail regarding monitoring locations, frequency, and rationale, as well as field and laboratory methods, and sample chain of custody protocols. Section 11.2.2, Monitored Natural Attenuation Progress Evaluation, and Appendix B describe in greater detail the evaluation of monitoring data that will be undertaken to ensure that the monitored natural attenuation is working effectively and that the remediation goals will be attained.

As part of the restoration of the former millsite, wetlands were designed and created to attract wildlife, including waterfowl. DOE wants to ensure that selenium, which has exhibited increasing trends since the remediation of the millsite was completed, does not accumulate in wetland sediments to concentrations that would harm waterfowl and other wildlife. To evaluate if selenium is accumulating in concentrations that may affect the health of waterfowl and other wildlife, DOE will conduct biomonitoring as described in Section 11.2.1.3 and Appendix C.

11.2.1.1 Water Quality Monitoring

Water quality monitoring will be conducted in the shallow alluvial aquifer, in surface water including a number of seeps on the former millsite, in the Burro Canyon Formation bedrock aquifer, and within the permeable reactive barrier. Water quality monitoring will be conducted in two separate events to occur each year during April and October, coincident with annual periods of high and low flow. Monitoring during these months will record the full range of analyte concentrations attributable to seasonal effects. Analyte concentrations are typically greatest during low-flow conditions (fall) and lowest during high-flow (spring).

Table 11 lists the anticipated maximum number of ground water and surface water samples that will be collected in October and April monitoring events during the post-ROD period. A conceptual view of the monitoring network is presented in Figure 6 and Figure 7. Each identified location was established for previous OU III Remedial Investigation or Interim Remedial Action monitoring tasks. Actual locations for post-ROD ground water and surface water monitoring are specified in DOE 2004b.

Table 11. Maximum Number of Surface Water and Ground Water Samples

Sample Type	Maximum Number of Locations per Event	
	October	April
Ground water in alluvial aquifer ground water	40[a]	30[a]
Ground water in Burro Canyon aquifer	3	1
Ground water within permeable reactive barrier[b]	4	4
Surface water in Montezuma Creek	8	8
Surface water at seeps	5	5
Surface water in Wetland 3	2	2

[a]Includes R-series alluvial wells located near the permeable reactive barrier and proposed new wells (Figure 6).
[b]R2-, R3-, and R4- series wells only (Figure 6).

Ground water and surface water samples will be analyzed for the current ground water and surface water COCs (arsenic, manganese, molybdenum, nitrate, selenium, uranium, and vanadium, plus alpha and beta radioactivity). Other noncontaminant species and properties indicative of geochemical conditions will also be measured. These and other field and laboratory protocols for sample collection and parameter analysis are specified in DOE 2004b.

Selected well locations will encompass the full extent of the contaminant plume, will provide information on background water quality, and will monitor quality within the reactive media of the permeable reactive barrier at immediately above and below the permeable reactive barrier.

Water quality in the bedrock aquifer will be monitored at one location upgradient of the millsite, one location within the contaminant plume in the alluvial aquifer, and two locations at the downgradient terminus of contamination in the alluvial aquifer.

Eight surface water sampling locations in Montezuma Creek have been identified, including one location upgradient of the millsite (background location), three locations on the former Millsite, and four location downgradient of the millsite. Surface water monitoring also includes five locations of ground water seepage on the north side of the former Millsite. Surface water monitoring at the described locations will enable assessment of the effect of ground water on surface water quality within OU III. Seeps 1 through 3, and open-marsh sites W3-03 and W3-04 at Wetland 3 (Figure 6) are particularly relevant in monitoring the contribution of selenium to ground water and surface water from the suspected natural sources (Mancos Shale and Dakota Sandstone) both on and off-site (see also Sections 5.3.1 and 4.2.3).

Installation of Additional Monitoring Wells

The monitoring network is to be expanded by the installation of three alluvial aquifer wells at the approximate locations identified in Figure 6. Existing well 82-07 (Figure 7), which is too shallow for reliable water quality monitoring in this central area of the plume, will be replaced by the proposed co-located new well. The remaining two new wells are proposed in a central area of the plume where no monitoring wells currently exist (see Figure 7). Water quality monitoring at the new wells will occur twice yearly beginning October 2004 subsequent to installation of the wells in summer of 2004.

11.2.1.2 Hydrologic Monitoring

The predicted remediation time for natural attenuation at OU III (approximately 42 years) assumes a stable hydrologic setting. For example, natural attenuation may be less rapid than the predicted rate during periods of drought because, compared to the model, less water is available to disperse the contamination. Hydrologic conditions will be evaluated through continued measurement of water levels in monitoring wells and measurement of flow rates in Montezuma Creek at the locations and frequency listed in Table 12 and shown in Figure 6 and Figure 7 (stream flow is measured at each surface water sampling location). Documentation of other field observations will include flow conditions at known seepage areas and relevant cultural or climatic conditions or anomalies. Hydrologic monitoring data are essential to the interpretation of observed contaminant concentration trends. The scope is the same for both April and October monitoring periods.

Table 12. Hydrologic Monitoring Frequency and Locations

Water level measurement (April and October)	
Location	**Approximate number of wells**
Alluvial aquifer	67
Bedrock aquifer	6
Permeable reactive barrier (reactive media zones only)	8
Flow measurement (April and October)	
Eight locations on Montezuma Creek coincident with surface water quality monitoring locations; plus visual observation of flow conditions at Seeps 1, 2, 3, 5, and 6 and other known seep locations.	

11.2.1.3 Biomonitoring

In addition to the regular surface water monitoring for evaluating the progress of monitored natural attenuation (Section 11.2.1.1), additional monitoring will be conducted to assess the potential for adverse ecological effects from selenium, as necessitated by recent concentration increases (Section 5.3.1). Biomonitoring of OU III will be conducted primarily to determine if selenium is accumulating to levels that are considered potentially harmful in areas that waterfowl and other wildlife are likely to inhabit. Waterfowl are the primary wildlife receptors of interest because they are the most likely to be attracted to wetland areas created on the former millsite and are likely to be most sensitive to selenium concentration increases. An updated wildlife survey will be completed to identify wildlife species using the area (including species identified as threatened and endangered and state sensitive) and determine appropriate sample locations and media. This will be done in consultation with the Biological Technical Assistance Group. The monitoring is designed to address concerns regarding exposure to surface water and sediment and the potential for bioaccumulation through the food chain.

The focus of the biomonitoring will be on Wetlands 1, 2, and 3 and the downstream sediment pond (Figure 2). It is anticipated that representative sediment samples and collocated surface water samples will be collected from three areas within each wetland and pond: one collection area where water is flowing into the wetland, one along the bank of the wetland, and one at the outflow point of the wetland. These locations are approximate and may be relocated based on site conditions or as agreed to by the Biological Technical Assistance Group. Benthic and water column macroinvertebrate collection devices will also be installed at those areas within the wetlands. A tiered approach for media sampling will be used. Representative sediment and surface water samples will be collected during the first year of biomonitoring from each biomonitoring location and analyzed for selenium to provide a baseline to analyze trends. Macroinvertebrate sampling will also be conducted during the second year of the biomonitoring task along with surface water and sediment. If results of the sampling indicate accumulation of selenium exceeding trigger levels agreed to by the Biological Technical Assistance Group and considered to be harmful, sampling of higher level receptors (e.g., eggs from water fowl) may be required. The Biological Technical Assistance Group will determine specific details regarding sampling design and data evaluation. The Biological Technical Assistance Group will also determine the need for implementing a contingency remedy. This could involve dredging a wetland or wetland relocation, among other options. If concentrations of selenium in sediment, surface water, and ground water remain below trigger levels for 3 successive years and the selenium concentrations in ground water and surface water have stabilized or are decreasing, continued biomonitoring may be deemed unnecessary.

Initially, biomonitoring sampling is expected to take place annually. The need for additional sampling, other types of sampling or analyses, or contingency action will be determined by the Biological Technical Assistance Group based on the first 2 years of sampling and results of the updated wildlife survey.

11.2.2 Monitored Natural Attenuation Progress Evaluation

The methods by which the progress of monitored natural attenuation is evaluated and reported for OU III is specified in the monitored natural attenuation evaluation plan attached to this ROD as Appendix B. The remainder of this section presents a summary of that plan.

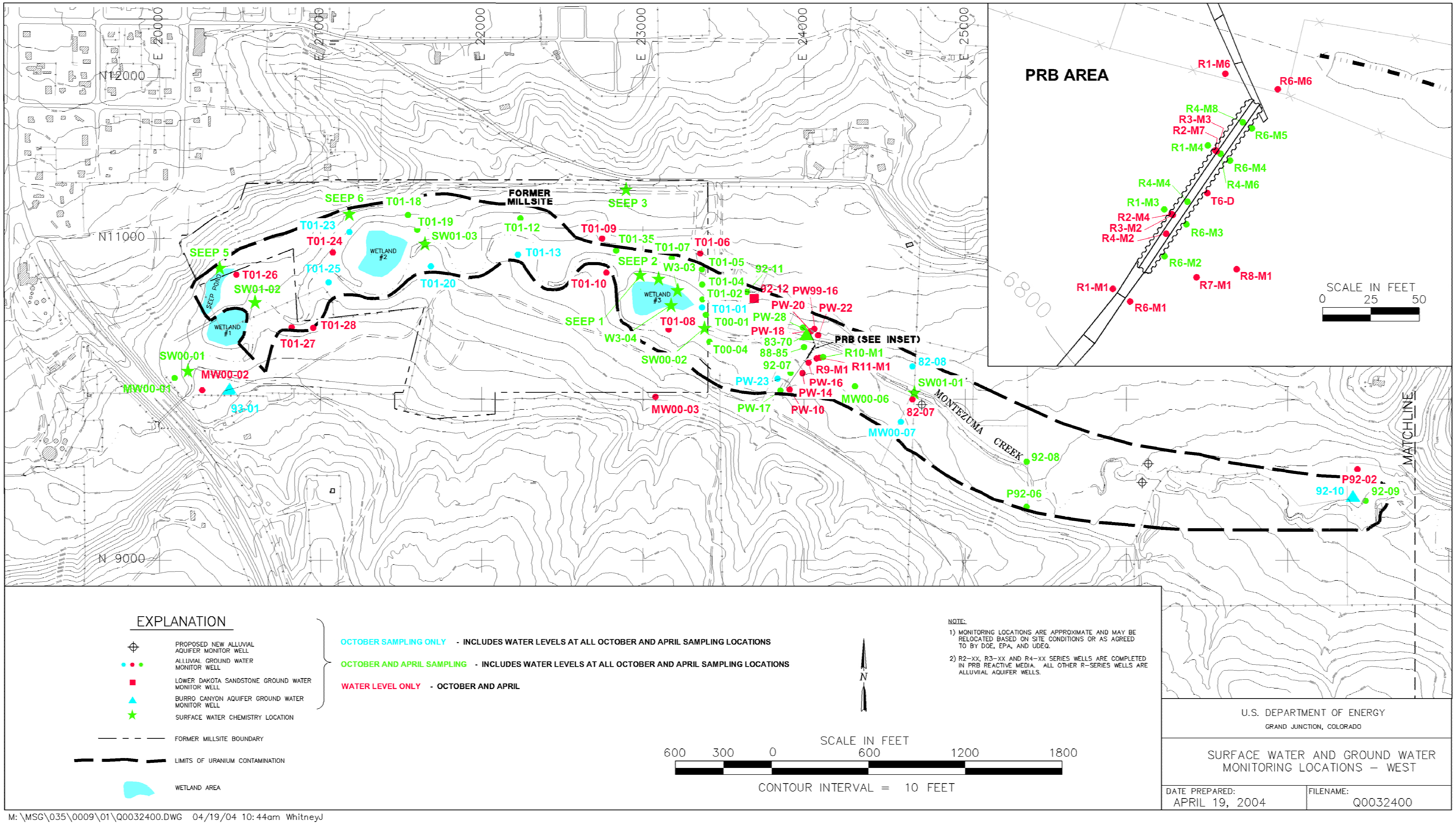


Figure 6. Conceptual Surface Water and Ground Water Monitoring Locations—West

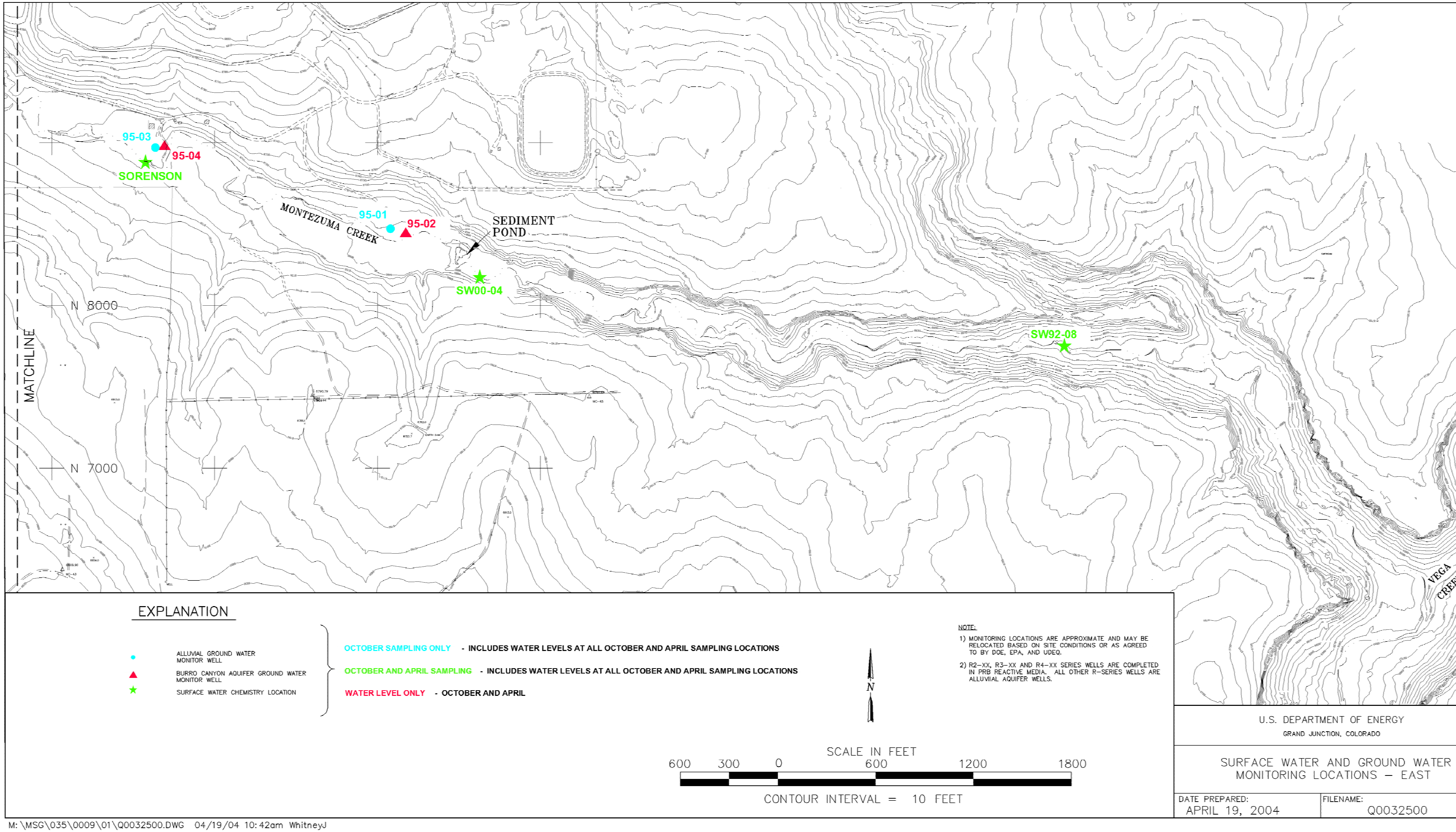


Figure 7. Conceptual Surface Water and Ground Water Monitoring Locations—East

Data collected under the monitoring program described in Section 11.2.1 will provide the basis to evaluate monitored natural attenuation progress by the following general criteria:

- Uranium concentrations decline at rates consistent with concentration trends predicted by ground water modeling documented in DOE 2004c and summarized in Appendix B.
- Plume expansion into uncontaminated regions does not occur.
- Concentrations of COCs other than uranium (e.g., arsenic, selenium, vanadium) decline at acceptable rates.

The progress of aquifer restoration will be evaluated primarily by comparing temporal trends of uranium concentration in ground water to concentrations predicted by a numerical ground water model. Uranium is the primary ground water contaminant at the site because it is the most widespread in extent and is the single greatest contributor to potential human health risk. Uranium trend analysis will be performed for five separate regions of the aquifer using concentration averaging from multiple wells for both the observed and model-predicted data sets. The five aquifer regions (see Figure 8 in Appendix B) represent distinct areas of contamination, hydrogeology, and geographic position relative to the permeable reactive barrier and the former millsite. A sentinel well (well 95-03, Figure 7) is located to evaluate plume advancement into uncontaminated regions of the aquifer.

Given an uncertainty of ±30 percent for the measured uranium concentrations that are due to natural variations (see Appendix B), the progress of monitored natural attenuation for a given region of the aquifer is considered to be consistent with the model trend as long as the lower limit of uncertainty does not exceed the model-predicted value for more than three consecutive semiannual sampling events. This criterion allows possible deviatory behavior to be analyzed during successive water years and provides a minimum number of data points to constitute a concentration "trend." Not meeting this criteria is considered a "significant deviation" and will initiate a discussion of potential response actions to correct the situation.

If the data are consistently above model predictions, a second assessment of the data will be performed during the 5-year review using additional statistical methods. In this evaluation, data for the region in question will be evaluated for the most recent 5-year period to determine if the observed trend for that period, assuming a 70-percent confidence interval, can meet the remediation goal in the established time frame. This second type of trend analysis accounts for linearly decreasing concentrations over time, as distinct from the highly nonlinear response predicted by the model. If the linear trend indicates an unacceptable remediation time, DOE, EPA, and UDEQ will determine the need to implement a contingency remedy. If the linear trend indicates that clean-up levels will be met in an acceptable time, then the selected remedy will be continued.

The rate at which COCs other than uranium (arsenic, manganese, molybdenum, nitrate, selenium, and vanadium) attenuate, as determined for individual wells or averaged for a region, will be compared to the remediation time frame. These constituents are expected to attenuate to safe levels within the remediation time frame because they generally do not greatly exceed the respective remediation goal and are present only in the small area between the former millsite and the permeable reactive barrier. Selenium mobilization from natural sources provides an exception (see Section 5.3.2 and Appendix C), as does the anomalous distribution of manganese that occurs in excess of its remediation goal only on the former millsite. Additional discussion of the mobility factors for COCs other than uranium is included in Appendix A.

Significant deviation from the expected progress of monitored natural attenuation, as defined in Sections 3.0 and 4.0 of the monitored natural attenuation evaluation plan (Appendix B) will initiate a response action consistent with the contingency plan for OU III described in Section 11.5 of this ROD. Failure of the permeable reactive barrier, as defined in Section 3.3 of the monitored natural attenuation evaluation plan (Appendix B), may initiate a separate response.

11.2.3 Institutional Controls

Institutional controls have been applied at OU III to prevent use of contaminated alluvial ground water and to restrict land use within the floodplain of Montezuma Creek where contaminated sediments were left in place and supplemental standards were applied. The former millsite which was transferred to the City of Monticello through the National Park Service also limits the use of the property in perpetuity as a public park.

The Utah State Engineers' office issued the *Ground Water Management Policy for the Monticello Mill Tailings Site and Adjacent Areas,* which 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. The policy states that applications to drill wells into the deeper Burro Canyon Formation 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 3.

Because radioactively contaminated soil and sediment exceeding radium-226 standards in Title 40 CFR Part 192.12 remained in the Montezuma Creek floodplain following hot-spot remediation, restrictive easements were placed on private properties to which supplemental standards were applied. The restrictive easements generally apply to the floodplain of Montezuma Creek and extend about 50 ft from the centerline of the creek. The restrictive easement prohibits the building of a habitable structure on and the removal of soils from within the easement area. Property owners were compensated for restrictive easements on their properties. The quitclaim deed transferring ownership of the millsite to the City of Monticello also prohibits construction of habitable structures, camping, and removal of soils from areas where supplemental standards were applied.

As part of the CERCLA process, DOE will continue to monitor the sites, with oversight provided by EPA and UDEQ, to ensure the following:

- Compliance with ARARs,
- Remedial actions taken remain protective of human health and the environment,
- Institutional Controls continue to be in force and enforcement actions are taken if necessary, and
- Adequate information is collected for preparation of the CERCLA Five-Year Review report.

DOE has implemented this monitoring program through the *Monticello Long-Term Surveillance and Maintenance Administrative Manual* (DOE 2002c), which describes long-term surveillance and maintenance activities that are conducted at the Monticello CERCLA sites. The document references operating procedures that define the work conducted by permanent employees located in Monticello, Utah. The work includes monitoring compliance with institutional controls (i.e., prohibitions on installation of wells into contaminated water, prohibitions on removal of contaminated soils, prohibitions on construction of habitable buildings in areas in which supplemental standards have been applied), monitoring the condition of the repository and associated facilities (i.e., evaporation pond, leachate collection and removal systems, leak detection systems, and temporary storage facility for contaminated materials), and monitoring contaminated soils left in place at areas in which supplemental standards have been applied. The operating procedures also identify how annual inspections and CERCLA 5-year reviews will be conducted.

11.3 Summary of Estimated Remedy Costs

The primary costs for the selected remedy are associated with annual monitoring. The only capital costs are for decommissioning of the permeable reactive barrier after it is no longer effective. Table 13 provides a cost breakdown.

Table 13. Alternative 2 Cost Estimate

Capital cost (decommission permeable reactive barrier)	$45,112
Annual monitoring and indirect costs: years 1 through 10	$123,580
Annual monitoring and indirect costs: years 11 through 40	$113,980
Annual long-term surveillance and maintenance costs	$10,400
Annual monitoring well maintenance	$500
Net Present Value	**$1,489,000**

11.4 Expected Outcomes of the Selected Remedy

Ground water flow-and-transport modeling of the site projects that the remedial action objective for uranium (Table 6 and Table 7) will be achieved within 42 years (starting October 2002). It is anticipated that objectives for other COCs will also be met in this time frame. These cleanup levels are presented in Table 14. Ground water use restrictions that are already in place will continue throughout that period. Contamination associated with OU III does not further limit potential land use other than restrict removal of soil and sediment from the floodplain. After remediation goals are achieved, use of ground water will be permitted pursuant to existing State regulations.

It is expected that wetland areas will continue to develop as designed and that these will attract desirable wildlife to the area. The biomonitoring approach will ensure that growth of the ecosystem will progress in a healthy manner.

Table 14. Cleanup Levels for Contaminants of Concern

Contaminant of Concern	Cleanup Level	Basis
Ground Water		
Arsenic	10 µg/L	Safe Drinking Water Act
Manganese	880 µg/L	Risk based
Molybdenum	100 µg/L	UMTRCA
Nitrate	10 mg/L	Safe Drinking Water Act
Selenium	50 µg/L	Safe Drinking Water Act
Uranium	30 µg/L	Safe Drinking Water Act
Vanadium	330 µg/L	Risk based
U-234/-238	30 pCi/L	UMTRCA
Gross alpha	15 pCi/L	Safe Drinking Water Act
Surface Water		
Arsenic	10 µg/L	Utah Surface Water Standards
Nitrate (as nitrogen)	4 mg/L	Utah Surface Water Standards
Selenium	5 µg/L	Utah Surface Water Standards
Gross alpha	15 pCi/L	Utah Surface Water Standards

µg/L = micrograms per liter; mg/L = milligrams per liter; pCi/L = picocuries per liter.

11.5 Contingency Plan

As described in Section 11.0, monitored natural attenuation is anticipated to achieve the remediation goals within an acceptable time period (less than 42 years). Institutional controls that prohibit the use of contaminated alluvial ground water have been implemented and will continue until remediation goals are met. Monitoring will be conducted in accordance with *the Monticello Mill Tailings Site Operable Unit III—Post-Record of Decision Monitoring Plan* (DOE 2004b) to verify that remediation goals will be met within the acceptable time frame. Analytical results will be evaluated in accordance with the performance evaluation plan presented in Appendix B. For the reasons cited in the lines of evidence (Appendix A), the contingent actions are not anticipated to be needed.

The Remedial Investigation Addendum/Focused Feasibility Study (DOE 2004c) identified numerous remedies in addition to those which were presented in the *Proposed Plan for the Monticello Mill Tailing Site, Operable Unit III, Surface Water and Ground Water, Monticello, Utah* (DOE 2003b). The Proposed Plan identified alternative remedies based on the existing set of conditions. Should the remedy not behave as predicted, or not be meeting goals, other remedies may be more appropriate for differing conditions. In the unlikely event that remediation goals will not be achieved within the acceptable time frame, DOE, EPA, and UDEQ will evaluate the need for further action and/or consider the following contingency actions which were described in the Remedial Investigation Addendum/Focused Feasibility Study (DOE 2004c).

- Treatment of the ground water plume by enhancing the effectiveness of the existing permeable reactive barrier. Pump-and-treat enhancement or in situ enhancement has been identified as potential options for this contingency. Section 5.6.4 of the Remedial Investigation Addendum/Focused Feasibility Study (DOE 2004c) discusses these options.

- Relocation and construction of a permeable reactive barrier at a location hydraulically downgradient of the existing permeable reactive barrier to intercept and treat contaminated ground water in the plume.

Other contingencies could be implemented if conditions change to the extent that a more aggressive treatment alternative is required. Potential remedial alternatives were described in the Remedial Investigation Addendum/Focused Feasibility Study (DOE 2004c). Depending on the nature of future potential problems, the following remedies may be implemented:

- Treatment of hot-spot ground-water extraction (small-scale pump and treat) with evaporative treatment using an existing pond located at the DOE repository site; and if necessary,
- Pumping (utilizing either wells or trenches) of the contaminated ground-water plume downgradient of the permeable reactive barrier will be considered together with evaporative treatment.

Technologies not available at the time this ROD was developed will also be evaluated in the event that the selected remedy fails to achieve the remediation goals within an acceptable time frame. In all the previously described instances, the existing institutional controls and the monitoring plans would be continued until the remediation goals were met.

12.0 Statutory Determinations

12.1 Protection of Human Health and the Environment

The selected remedy is protective of human health and the environment. It achieves protection by limiting the use of contaminated ground water until natural processes cause contaminants to decrease to levels suitable for unrestricted use. Monitoring will be conducted to ensure that attenuation is progressing as predicted and that the plume is not expanding. Biomonitoring will also ensure protection of the environment and provide contingencies for taking actions if the potential for adverse effects to ecological receptors is recognized.

12.2 Compliance with ARARs

This section identifies and describes the means to achieve compliance with the remedy-specific ARARs for OU III. The following regulations, which are a subset of all potential federal and state ARARs for OU III (Table 8 and Table 9), are ARARs for the selected remedy (DOE 2004c):

- Utah Safe Drinking Water Rules: relevant and appropriate chemical-specific requirement.
- Utah Groundwater Quality Protection: applicable chemical-, location-, and action-specific requirement.
- Utah Standards of Quality for Waters of the State: applicable chemical-, location-, and action-specific requirement.
- Utah Well Drilling Standards: applicable action- and location-specific requirement.

- Utah Pollutant Discharge Elimination System: applicable location- and action-specific requirement.

- Utah Air Conservation Rules: applicable chemical-, location-, and action-specific requirement.

- Utah Radioactive Material Management: chemical- and action-specific requirement.

- Uranium Mill Tailings Radiation Control Act: relevant and appropriate chemical- and action-specific requirement.

- Dredge and fill requirements: applicable location- and action-specific requirement.

- Fish and Wildlife Coordination Act: relevant and appropriate as a location- and action-specific requirement.

- Floodplain/Wetlands Environmental Review: applicable location- and action-specific requirement.

Contaminant concentrations currently exceed ground water standards in Utah Safe Drinking Water Rules, Utah Groundwater Quality Protection, and UMTRCA. However, the regulatory provision for monitored natural attenuation allows that compliance with these standards is determined at a future date defined by the remediation time frame for the site. A condition of the Focused Feasibility Study (DOE 2004c) was that no remedial alternative was evaluated in the detailed analysis for which the expected remediation time frame exceeded 50 years. Ground water modeling results and observed trends show that concentrations of the COCs will be below remediation cleanup levels in 42 years. During that time, institutional controls will prevent the use of the contaminated ground water. Selenium concentrations currently exceed state Standards of Quality for Water, but it is assumed that concentrations will decrease as the chemistry of surface water and ground water stabilizes following millsite remediation. If selenium concentrations do not decrease as expected, compliance with that standard will be reevaluated.

When the permeable reactive barrier is decommissioned, (1) temporary stream channel modifications may be needed to excavate the permeable reactive barrier, causing temporary habitat loss for wildlife species; (2) storm-water runoff may occur during construction activities (3) air emissions may occur during excavations; and (4) radioactive material may be generated, requiring transportation and disposal. Engineering controls will be used to capture and minimize the discharge of sediment to Montezuma Creek during construction activities to ensure meeting Utah Pollution Discharge Elimination System requirements. Engineering measures will also be used to mitigate air emissions during construction activities to ensure Utah Air Conservation Rules are met. Handling and disposal of radioactive contamination will conform to requirements of Utah Radioactive Material Management. If stream channel modifications are required, Stream Channel Alteration Permit requirements will be evaluated to ensure compliance with dredge-and-fill requirements. The U.S. Fish and Wildlife Service will be consulted to ensure that adequate provisions exist for the protection of wildlife resources. All wetland-area disturbances will follow the Monticello Wetlands Master Plan (DOE 1996) that was developed to adhere to Floodplain/Wetlands Environmental Review requirements.

Construction of additional monitoring wells and well decommissioning, if required, will meet the substantive requirements of Utah Well Drilling Standards.

12.3 Cost Effectiveness

The selected remedy is the most cost-effective alternative that can provide reasonable assurance of meeting remediation goals without reliance upon technology with uncertain long-term performance.

12.4 Use of Permanent Solutions and Treatment or Recovery to the Maximum Extent Practicable

The selected alternative utilizes treatment and permanent solutions to the potential threats posed by ground water contamination at the site to the maximum extent practicable. While not relying on the permeable reactive barrier to achieve remediation goals, the system effectively treats ground water passing through it and permanently removes contaminants from the alluvial system. Attenuation of contaminants in ground water through other natural processes should also result in permanent improvements in water quality.

12.5 Five-Year Review Requirements

Section 121(c) of CERCLA, the Superfund Amendments and Reauthorization Act (SARA), and the National Contingency Plan, Section 300.430(f)(5)(iii)(C) provides the statutory and legal bases for conducting 5-year reviews. Since hazardous substances, pollutants, or contaminants (i.e., arsenic, manganese, molybdenum, nitrate, selenium, uranium, and vanadium), remain at the site above levels that would allow for unlimited use and unrestricted exposure, DOE shall conduct a review of such remedial action no less often than each 5-year interval after the initiation of such remedial action to ensure that human health and the environment are being protected by the remedial action. Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within 5 years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment. The next statutory review is to be conducted in 2007.

Five-year reviews were completed for this site in 1997 and 2002. DOE will conduct 5-year reviews for OU III to coincide with those for OU I and OU II. The next 5-year review for OU I and OU II is scheduled for completion by August 2007; all data collected in the interim period for OU III will support a review of the OU III selected remedy at that time. Should the selected remedy not perform as predicted or if data evaluation shows that unacceptable risks are present, an appropriate contingency action will be selected and implemented.

13.0 References

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RESPONSIVENESS SUMMARY

Overview

A public meeting was held in Monticello, Utah, on December 9, 2003, to discuss the Proposed Plan. DOE presented the meeting; personnel from EPA, UDEQ, the City of Monticello, and S.M. Stoller Corporation (DOE's contractor) were in attendance to assist in answering questions and explaining the remedy selection process. Two members of the public attended the meeting. During the public comment period, one additional written comment was received.

Background on Community Involvement

Since initial meetings held in 1980 with the Monticello City Manager, San Juan County Commissioners, State of Utah representatives, and individual property owners, DOE has maintained its public involvement efforts to gather community opinion as part of the decision-making process for key issues related to the Monticello Projects.

In 1993, the Monticello Site Specific Advisory Board was established to give Monticello residents a forum to participate in DOE decisions about Monticello environmental restoration activities. The board represented the diversity of interests in San Juan County and was the focal point for input on decisions related to local hiring and purchasing practices, employee training, future land use, and environmental management topics. DOE has held public meetings and public availability sessions, conducted community interviews, issued press releases to local media, participated in Site Specific Advisory Board meetings, and held frequent briefings with the San Juan County Commissioners and Monticello City Council members.

With resolution of major project issues, the duties of the Site Specific Advisory Board came to an end. The board provided valuable citizen input to DOE for 6 years. The board was disbanded following the October 1999 meeting.

DOE published display ads in local newspapers to inform the public of the availability and location of site-specific documents, proposed remedial action, and public meetings.

Events to encourage community participation in remedy selection for OU III included

- Development of the *Proposed Plan for the Monticello Mill Tailings Site, Operable Unit III Surface and Ground Water* (DOE 2003b).
- Development of a fact sheet (DOE 2003a) discussing the Remedial Investigation Addendum/Focused Feasibility Study.
- Discussion about the Proposed Plan at a public meeting. The public meeting was held on December 9, 2003, at the San Juan County Courthouse in Monticello, Utah. Representatives of DOE, EPA, and the State of Utah answered questions about the site and the preferred alternative, which has become the selected final remedial action. Public comments received at that meeting and during the public comment period are presented in the Responsiveness Summary of this document.
- Held a public comment period concerning the Proposed Plan. The public comment period on the final remedial action extended from December 1, 2003, through January 15, 2004.

On November 26, 2003, DOE mailed letters to 65 key individuals, including potentially affected landowners, informing them of the public meeting (held on December 9, 2003) concerning the Proposed Plan. Included with the letters were copies of the Proposed Plan (DOE 2003b) and the fact sheet (DOE 2003a) discussing the Remedial Investigation Addendum/Focused Feasibility Study. Addresses and telephone numbers for DOE, EPA, and UDEQ were provided to enable stakeholders to ask questions or obtain additional information.

A notice of availability of the Proposed Plan and a notice of the public meeting and comment period were published in the local Monticello newspaper (the "San Juan Record") on November 26, 2003, and December 3, 2003, and in the Blanding, Utah newspaper (the "Blue Mountain Panorama") on November 26, 2003.

Public interest in the Monticello CERCLA sites has waned with the completion of remedial activities for OU I and OU II, as evidenced by the low turnout at the December 9, 2003, public meeting.

Summary of Comments Received During the Public Comment Period and Agency Response

Summary and Response to Local Community Concerns

One of the members of the public, representing a local newspaper, asked questions about the CERCLA process. No comments were received from this individual concerning the final remedial action.

Response: The individual was told that public comment was considered in selection of the final remedy for OU III and that comments were solicited at this public meeting. He was also informed of the 45-day public comment period in which comments would be accepted.

The other attendee, a local resident, was concerned about the physical condition of the former millsite. He commented that the walking trails were in disrepair and wanted to know who has the responsibility for maintaining the property. The comments did not refer to the final remedy for OU III and they have no impact on the final remedial action for ground water and surface water.

Response: The Monticello City Manager informed this local resident that maintenance of the property was the responsibility of the City of Monticello.

Comprehensive Response to Specific Legal and Technical Questions

DOE received one written comment during the public comment period. A technology vendor commented: "We feel that it is most pragmatic to treat the filtrate so that is made benign rather than store the radioactive material from the filtering process. New processes have been developed and demonstrated that renders said material unable to further undergo radioactive decay at costs that are actually less than long-term storage. This process can be implemented at the site. The end product can be safely disposed of in any landfill. Treating this filtrate so that it is made safe rather than storing it hot is the prudent course to follow. A practical and permanent solution that long-term storage cannot provide the environment and society. Heck, even Judy Fahys would agree with that. We look forward to your inquiry regarding this technology."

Response: DOE assumes that the vendor proposes to treat the permeable reactive barrier media at the time it is removed from service to render it nonradioactive. DOE will evaluate available treatment and disposal options before removal of the permeable reactive barrier. DOE will remain in compliance with DOE Order 435.1, *Radioactive Waste Management,* that governs disposal of radioactive material and treated radioactive material. If this order is superseded in the future, the radioactive waste management order current at the time of removal of the permeable reactive barrier will be followed.

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Appendix A

Monticello Mill Tailings (USDOE) Site
Rationale Supporting Monitored Natural Attenuation

1.0 Overview

Information in this appendix provides rationale supporting the use of monitored natural attenuation for ground water remediation at the Monticello Mill Tailings Site (MMTS) Operable Unit (OU) III. The information is organized into three main sections: contaminant source control, natural attenuation processes, and potential for exposure and risk. The references for project documents that provide additional details are in Section 13.0, "References," in the report.

2.0 Contaminant Source Control

Item 1. Removal of Primary Contaminant Sources

The primary sources of ground water contamination (radioactively and heavy metal contaminated tailings, soil, sediment, and debris) were removed pursuant to the remedy selected for OU I when approximately 2.5 million cubic yards (yd^3) of contaminated material was excavated from the former mill area, the tailings impoundment area, and an alluvial aquifer floodplain of a private property immediately east of the former millsite that had been heavily contaminated with windblown and waterborne tailings. These tailings and contaminated materials were placed in a permanent on-site repository (DOE 2004c, Section 2.1). Cleanup under this remedial action was to the 5/15 picocuries per gram (pCi/g) radium-226 standard. To achieve this standard, excavation and removal of contaminated tailings and alluvium extended beneath the water table to competent bedrock over large areas of the former millsite. In conjunction with on-site treatment of ground water (see Item 4, "Millsite Excavation, Dewatering, and Ground Water Treatment," in this section), source removal significantly reduced the extent of ground water contamination on and immediately downgradient of the former millsite and significantly eliminated further leaching of contaminants to the ground water. For example, ground water uranium concentrations in samples from wells located on the former millsite averaging 1,640 to 5,390 micrograms per liter (µg/L) uranium from 1992 to 1998 (prior to source removal) have been reduced to 144 to 199 µg/L uranium for the 2001 to 2002 time period (after source removal) (DOE 2004c, Table 2-10).

Item 2. Removal of Secondary Sources of Contamination

An additional 75,000 yd^3 of residual source material from the vadose zone beneath the former tailings piles was removed from the former millsite. Although not contaminated to the radium-226 standard, laboratory experiments indicated that the metals (arsenic, uranium, and vanadium) in this material had the potential to be a continuing source of ground water contamination DOE 2000b, Sections 4.2.1. and 4.2.2; DOE 2004c, Section 2.8.2).

Item 3. Soil and Sediment Remediation Along Montezuma Creek

Areas of hot-spot soil and sediment contamination adjacent to Montezuma Creek downstream (east) of the former millsite were remediated as an OU III nontime-critical removal action in 1998 and 1999. These materials consisted mainly of mill tailings that eroded from the tailings piles on the former millsite, were transported by Montezuma Creek, and were deposited in the floodplain hydraulically downgradient from the millsite. Approximately 21,000 yd^3 of contaminated sediment and soil was removed from the Montezuma Creek floodplain and replaced with clean soils. Additional details regarding soil and sediment remediation along

Montezuma Creek is provided in the *Monticello Mill Tailings Site, Operable Unit III—Remedial Investigation Addendum/Focused Feasibility Study* (DOE 2004c, Section 2.3).

Item 4. Millsite Excavation, Dewatering, and Ground Water Treatment

Excavation dewatering was required to remediate the former millsite to the cleanup standards because contamination extended below the water table. Most of the water collected in excavation dewatering was treated at an on-site water treatment plant before discharge to Montezuma Creek. This process removed an estimated 3 to 6 percent of the total preremediation inventory of uranium concentration in the ground water system. The water treatment plant was initially started in 1995 and ran intermittently during periods of process development until a reverse osmosis unit was added to the existing precipitation/filtration system in January 1998. This treatment configuration, which proved to be effective in meeting treatment standards, operated until it was dismantled in May 1999. Approximately 50 million gallons of contaminated water was treated during operation of the plant. Ground water was treated to meet Utah Pollutant Discharge Elimination System standards. Additional detail regarding water treatment during OU I remedial action is included in two reports (DOE 2000b, Section 3.0;DOE 2004c, Section 2.5).

Item 5. Permeable Reactive Barrier

A full-scale treatability study to evaluate the feasibility of permeable reactive barrier technology was implemented as part of an interim remedial action Record of Decision for OU III (DOE 1998d). The Monticello permeable reactive barrier, installed in summer 1999, is effective in treating contaminated ground water at the site and is expected to provide continued benefit for an additional 10 years (to year 2014). The permeable reactive barrier treats approximately two-thirds of the contaminated ground water flux at its location. Contaminants of concern that are being effectively removed from the ground water include arsenic, molybdenum, nitrate, selenium, uranium, and vanadium. Treatment by the permeable reactive barrier is not required to meet the remediation goals in the acceptable time frame (less than 42 years). However, it will continue to treat ground water and remain in place for further studies until it becomes ineffective or causes unacceptable changes in the hydrogeology (e.g., excessive ground water mounding). Recent studies to evaluate the longevity of the permeable reactive barrier from past performance are included in two reports (DOE 2002a, 2004a). Annual performance evaluations of the permeable reactive barrier are presented in three reports (DOE 2000b, 2001, and 2002b). DOE (2004c) presents summaries of performance and longevity estimates of the permeable reactive barrier.

3.0 Natural Attenuation Processes

Item 1. Hydrological Boundaries

DOE (2004c) provides a comprehensive conceptual model of ground water flow and contaminant transport at OU III. The numerical model based on that conceptual model (DOE 2004c) predicts that concentrations of the key contaminant at the site (uranium) will reduce to acceptable levels within the modeled remediation time frame (less than 42 years) without the benefit of the permeable reactive barrier. The hydrologic processes responsible for this outcome are (1) mixing and displacement of contaminated ground water to Montezuma

Creek by ground water inflows on the former millsite and (2) mixing and displacement of contaminated ground water to Montezuma Creek by inflows from the Burro Canyon sandstone aquifer near the hydraulically downgradient terminus of the uranium plume. The eastern extent of the plume has remained static since monitoring began in 1992. Hydrologic and geochemical indicators of these boundary effects have been documented in annual Interim Remedial Action status reports (DOE 2000b, 2001) and in the OU III Remedial Investigation Addendum/Focused Feasibility Study (DOE 2004c, Section 3.0). The conceptual and numerical models of ground water flow are based in part on measured ground water flow through various regions of the alluvial aquifer. These data include measured gain and loss in Montezuma Creek, ground water discharge to dewatering excavations on the former millsite, and ground water flux through the permeable reactive barrier estimated by geochemical and hydraulic tests.

Item 2. Contaminants of Concern Mobility and Transport

Transport characteristics of contaminants of concern (COCs) were investigated for OU III by laboratory methods (DOE 2001, Sections 4.2.9 and 4.2.10) using column leaching tests conducted on alluvial materials collected from contaminated regions of the aquifer. These tests demonstrated that among the primary ground water contaminants, only uranium and vanadium desorbed from aquifer sediments in significant concentrations relative to the remediation goals. For uranium, results of the leaching tests were qualitatively used to justify specifying reversible sorption of uranium in the uranium transport model (DOE 2004c, Section 3.7).

Results of sorption batch tests justified the specific value of the uranium distribution coefficient used in the transport model. The batch tests also demonstrated that the mobility of arsenic and vanadium are at least an order of magnitude less than that of uranium. Arsenic and vanadium mobility is not anticipated beyond existing limits, which is the area between the former millsite and the permeable reactive barrier. Because of their limited distributions and low concentrations (maximum concentrations are less than about 1.5 to 2 times the remediation goals), these constituents are expected to decrease to acceptable levels within the remediation time frame of less than 42 years.

Attenuation of nitrate and molybdenum is indicated to be relatively rapid in OU III ground water. This observation is substantiated by the dispersal of a significant nitrate plume, resulting from fertilizer application on the former millsite from approximately January 1999 to October 2001. During this period, nitrate concentrations (nitrate as nitrogen) increased from about 5 milligrams per liter (mg/L) to peak values of 25 to 35 mg/L and then decreased to about 5 mg/L. The transport model was calibrated to the movement of the nitrate (fertilizer) pulse previously described to determine aquifer dispersivity (DOE 2004c, Section 3.7.2). Recently, declining trends in molybdenum indicate that the molybdenum remediation goal (100 µg/L) is currently exceeded only at one other location. The permeable reactive barrier is effectively removing both constituents.

4.0 Potential for Exposure and Risk

Item 1. Institutional Controls

Two land use controls (a ground water management policy and a quitclaim deed) prevent consumption of contaminated ground water from the alluvial aquifer. The first control defines a

Ground Water Management Area that is administered by the Utah State Engineer; well drilling into the alluvial aquifer or diverting alluvial ground water for domestic use is prohibited in the Ground Water Management Area (see DOE 2004c, Section 2.4.1). DOE inspects for unauthorized ground water use during quarterly and annual site inspections. The second control, a quitclaim deed that transferred the former millsite and adjacent peripheral properties to the City of Monticello for use as a public park (in perpetuity), prohibits the use of any ground water within the boundary of the former millsite for the purpose of human consumption (see DOE 2004c, page ES-9).

An additional institutional control has been implemented to prevent landowners from redistributing contaminated material from known locations to other areas. Restrictive easements that prohibit removal of contaminated soil and sediment from the floodplain were purchased from landowners downgradient of the former millsite.

Item 2. Land Use, Ground Water Use, and Water Availability

Before the institutional controls were implemented, the alluvial aquifer was not used for any purpose, and future domestic use, in the absence of the institutional controls, is not likely because the alluvial aquifer is generally very thin (less than 5 feet of saturated thickness), unproductive, and may be seasonally unreliable. Furthermore, alternate domestic water supplies (municipal water and bedrock aquifer ground water from the Burro Canyon Formation) are readily available to current and future residences in the Ground Water Management Area. Distribution pipelines for the City of Monticello municipal water supply presently extend to within about 0.5 mile of the eastern limit of the Ground Water Management Area (i.e., the great majority of the Ground Water Management Area is within the general service area of the municipal supply). Also, installation of bedrock aquifer wells for domestic use is permitted in the Ground Water Management Area provided intrusion of alluvial ground water into the well is prevented by proper well construction. Because of the natural abundance of total dissolved solids (TDS) in the alluvial ground water (1,000 to 2,000 mg/L TDS), ground water within the bedrock aquifer is of superior quality (less than 500 mg/L TDS). Predominantly agricultural land use in the Ground Water Management Area, both current and planned, provides additional support that the likelihood of exposure to contaminated ground water will be minimal.

Appendix B

Performance Evaluation Plan for Monitored Natural Attenuation at Monticello Mill Tailings Site Operable Unit III

Contents

Figures

Tables

End of current text

1.0 Plan Objective

This plan specifies the method, criteria, and reporting requirements for evaluating the progress of aquifer restoration within Operable Unit (OU) III of the Monticello Mill Tailings Site (MMTS) under the selected remedy of monitored natural attenuation.

2.0 Monitored Natural Attenuation Performance Evaluation Method

The progress of aquifer restoration will be evaluated primarily by comparing temporal trends of uranium concentration in ground water, as determined by semiannual monitoring data, to concentrations predicted by numerical modeling (DOE 2004c). Uranium is the primary ground water contaminant at the site because it is the most widespread in extent and is the single greatest contributor to potential human health risk. Uranium trend analysis will be performed for separate regions of the aquifer using concentration averaging for samples from multiple wells for both the observed and model-predicted data sets. Specific criteria in this plan define whether the observed restoration rate for uranium meets expectations. Attenuation rates of contaminants of concern (COCs) other than uranium will also be evaluated.

2.1 Aquifer Regions

Five aquifer regions, shown on Figure 1, represent distinct areas of contamination, hydrogeology, and geographic position relative to the permeable reactive barrier and former millsite. Aquifer restoration will be evaluated separately for each region.

Region 1 encompasses the north margin of the former millsite and former source areas. Ground water restoration occurs by underflow from the west and inflows from recharge sources to the north. Significant quantities of ground water in this area is displaced to Montezuma Creek. Uranium concentrations are moderately low (see Table 1) in this region, and except for manganese anomalies, the remaining COCs are below the respective remediation goals).

Table 1. Monitor Wells for Trend Analysis

Region	Monitor Wells for Trend Analysis	Representative Uranium Concentrations[a] (micrograms per liter [µg/L])
1	T01-07, T01-12, T01-19, T01-35	100 to 220
2	T01-01, T01-02, T01-04, T01-05	175 to 400
3	88-85, 92-11, 92-07, PW-17, PW-28	200 to 950
4	MW00-06, MW00-07, R10-M1, 82-08	<30 to 300
5	P92-06, 92-08, 92-09	100 to 400

[a]October 1999 through October 2003; single-point extreme values excluded.

Region 2 encompasses the general area from Wetland 3 to the eastern boundary of the former millsite. Most or all of the ground water that flows from the former millsite passes through or originates in this area. Leakage from Wetland 3 may significantly influence ground water flow in this region. Uranium concentrations are moderately high (Table 1) and the remediation goal for each COC except nitrate is exceeded in this region.

Region 3 is the area between the former millsite and the permeable reactive barrier; Region 3 encompasses the area of highest contamination downgradient of the former millsite. The remediation goal for each COC except manganese is exceeded in this region. Minor leakage from Montezuma Creek may locally affect ground water quality.

Region 4 extends from the permeable reactive barrier to monitor well 82-08, approximately 750 feet east of the permeable reactive barrier. Ground water quality is affected by localized irrigation returns, uncontaminated effluent from the permeable reactive barrier, possible leakage from Montezuma Creek, and flow of contaminated ground water around the south end of the permeable reactive barrier system. As a result, the uranium concentration varies widely in this region. The ground water model used to predict uranium concentration did not simulate treatment by the permeable reactive barrier. Remediation goals are exceeded only by uranium and selenium in this region.

Region 5 extends east of monitor well 82-08 to nearly the terminus of the uranium plume. One location of selenium contamination occurs within this region; otherwise, uranium is the only COC that exceeds its remediation goal. The uranium plume extends slightly east of the most downgradient monitor well in Region 5 (well 92-09). Significant advancement of the uranium plume beyond well 92-09 is prevented by ground water discharge from the bedrock aquifer that causes dilution and displacement of contaminated alluvial ground water to Montezuma Creek through this area.

2.2 Performance Evaluation Wells and Data Analysis

Table 1 lists the monitor wells that are used for analyzing COC trends in each region of the aquifer and representative uranium concentrations. Wells that exhibit erratic concentrations in recent years, are spatially correlated, or pose sampling problems were generally avoided in compiling this list. Each well listed in Table 1 has been used in characterizing aquifer conditions in the period following remediation of the former millsite and installation of the permeable reactive barrier. Many of the locations have been monitored since 1992. All wells listed in Table 1 will be sampled semiannually in April and October. Ground water monitoring at numerous existing OU III wells not listed in Table 1 or shown on Figure 1 will also occur during the post- Record of Decision (ROD) period (see DOE 2004b). Several new monitor wells will be installed in the alluvial aquifer during 2004 to complement or replace selected wells listed in Table 1 (see Section 2.2.3).

For each sampling event, the arithmetic mean of the uranium concentration, computed for each region using the wells listed in Table 1, is plotted as a point on a graph of concentration in relation to time for that region. On the same graph, a second trend line represents the average of the model-predicted uranium concentration for the same wells, starting from October 2002. Figure 2 illustrates example concentration trends for Regions 1, 2, and 3 based on recent monitoring results for wells listed in Table 1. Because some wells were not sampled during each event indicated in the figure, conclusions regarding restoration progress are not implied on Figure 2. The above method will be applied to the data beginning in October 2004.

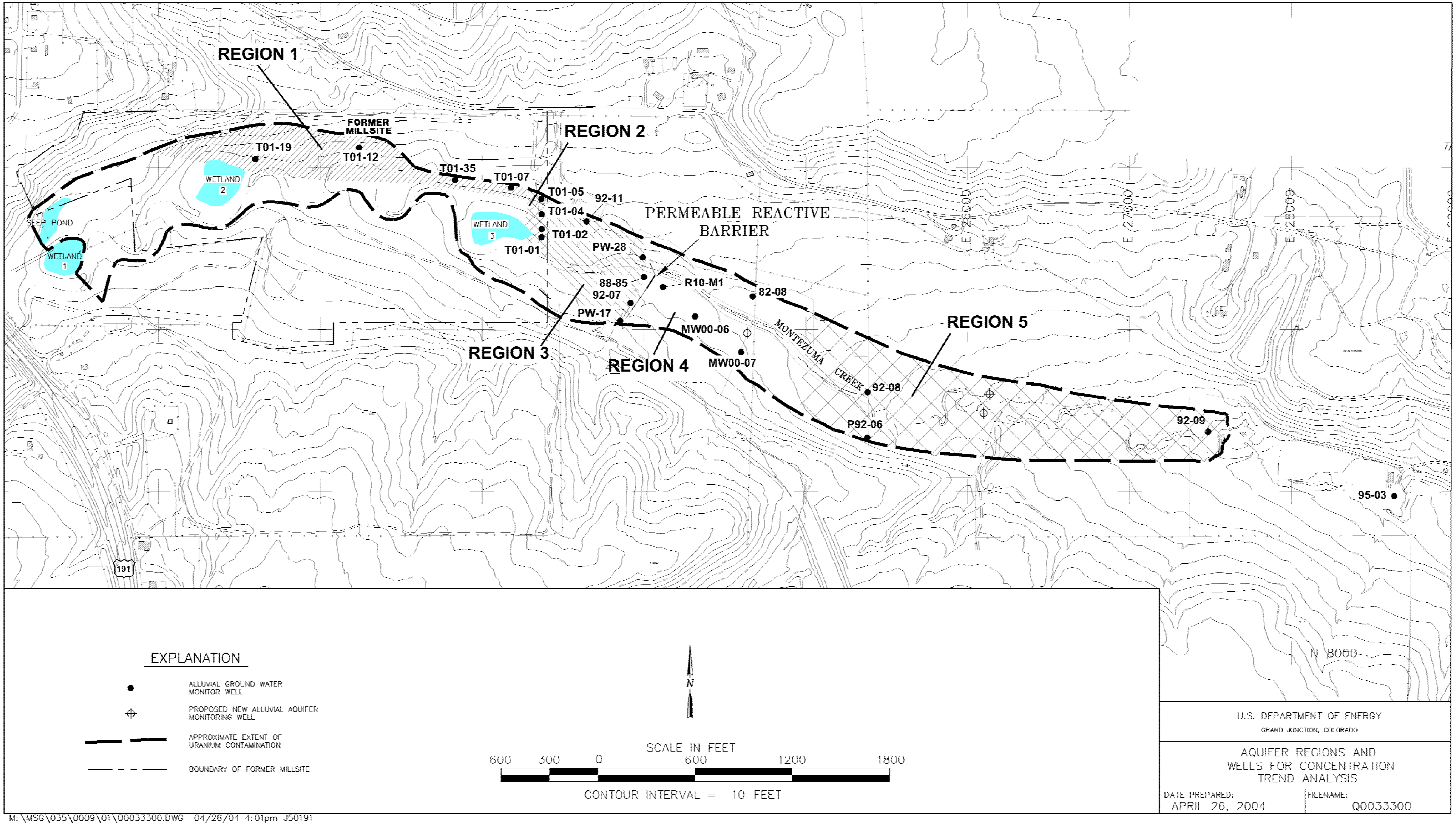

Figure 1. Aquifer Regions and Wells for Concentration Trend Analysis

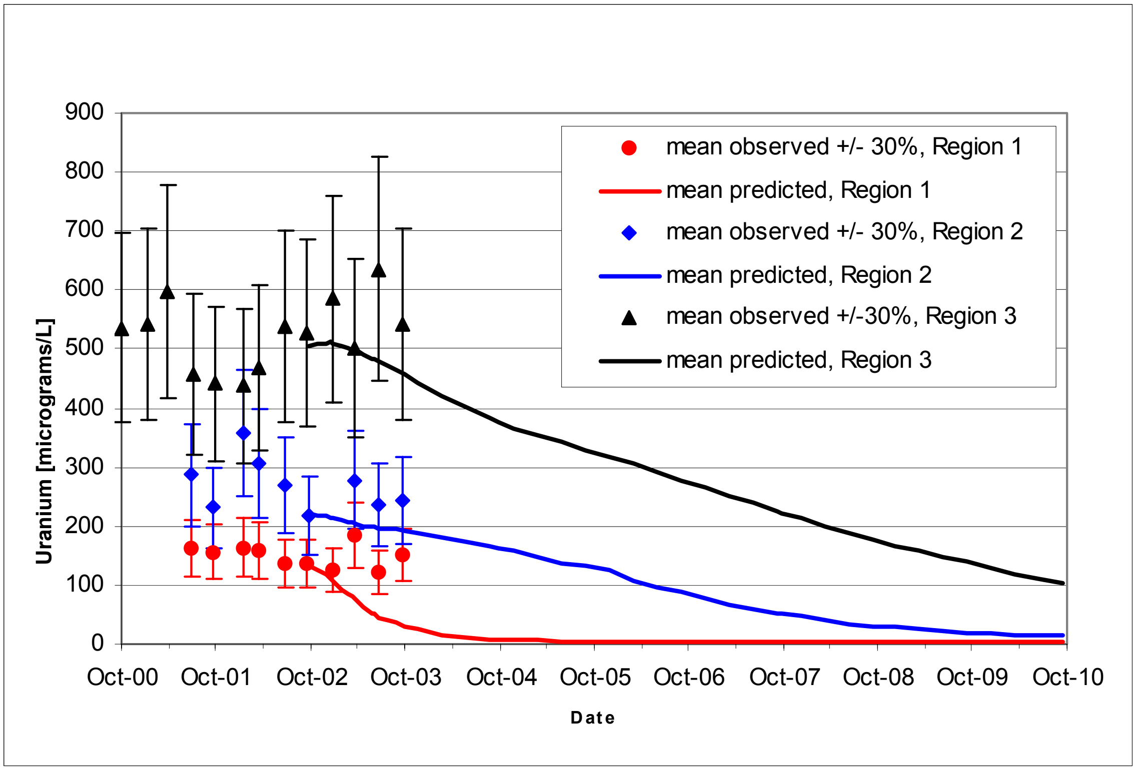

Figure 2. Example Trend Analysis Graph

2.2.1 Concentration Data Uncertainty Range

The uncertainty range displayed on Figure 2 (± 30 percent) accounts for the cumulative effects of natural variation in ground water flow and geochemistry, sample collection bias, and laboratory analytical uncertainty on measured uranium concentrations. This range was determined by analyzing the measured concentration of uranium over time at selected OU III monitor wells, including most of those listed in Table 1 and others in uncontaminated regions of the aquifer. Within the plume area, the variation in uranium was evaluated for the period of April 2000 through October 2003. At background locations, uranium concentrations dating to 1992 were evaluated.

For a given well, concentration residuals were calculated as the difference between the best-fit value, as determined by linear regression, and the observed concentration. Concentration residuals were calculated separately for background wells and wells within the uranium plume. For both of these data sets, the maximum and minimum percent differences of the concentration residuals computed for each well were averaged. The resulting overall range of the average concentration residuals was minus 20 to plus 30 percent. Observed concentrations for individual wells varied from the residual value by as much as 77 percent. Tables 2 through 8 (at the end of this appendix) provide computational summaries of this uncertainty analysis.

2.2.2 Model-Predicted Concentrations

Tables 9 through 13 (at the end of this appendix) provide the uranium concentrations predicted by the ground water model (DOE 2004c) in 1-year increments for 50 years of simulated time, starting October 2002, for the monitor wells listed in Table 1. Average uranium concentrations per well group (aquifer region) are also provided in the tables. Figures 3 through 7 illustrate model-predicted uranium concentration trends at individual wells and as the group average within the respective aquifer region. The time scales for Figures 3 through 7 do not extend through the full 50 years of simulation in order to show more clearly changes in the initial years.

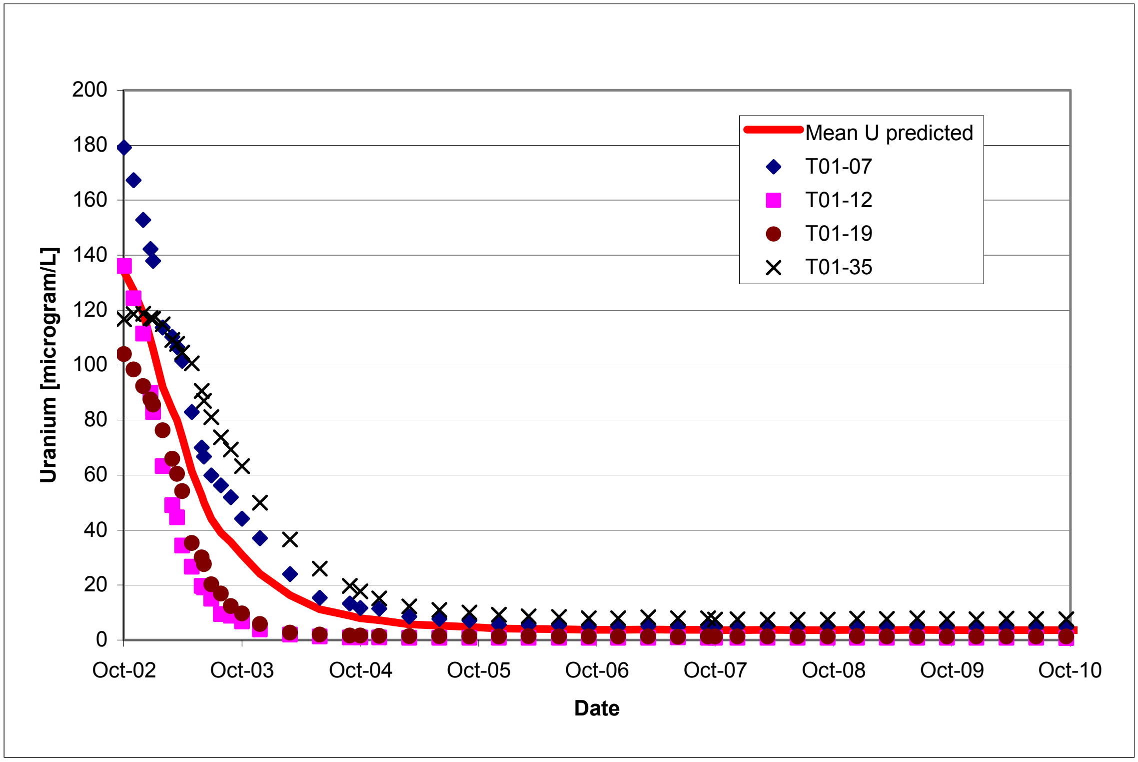

Figure 3. Model-Predicted Uranium Concentrations, Region 1

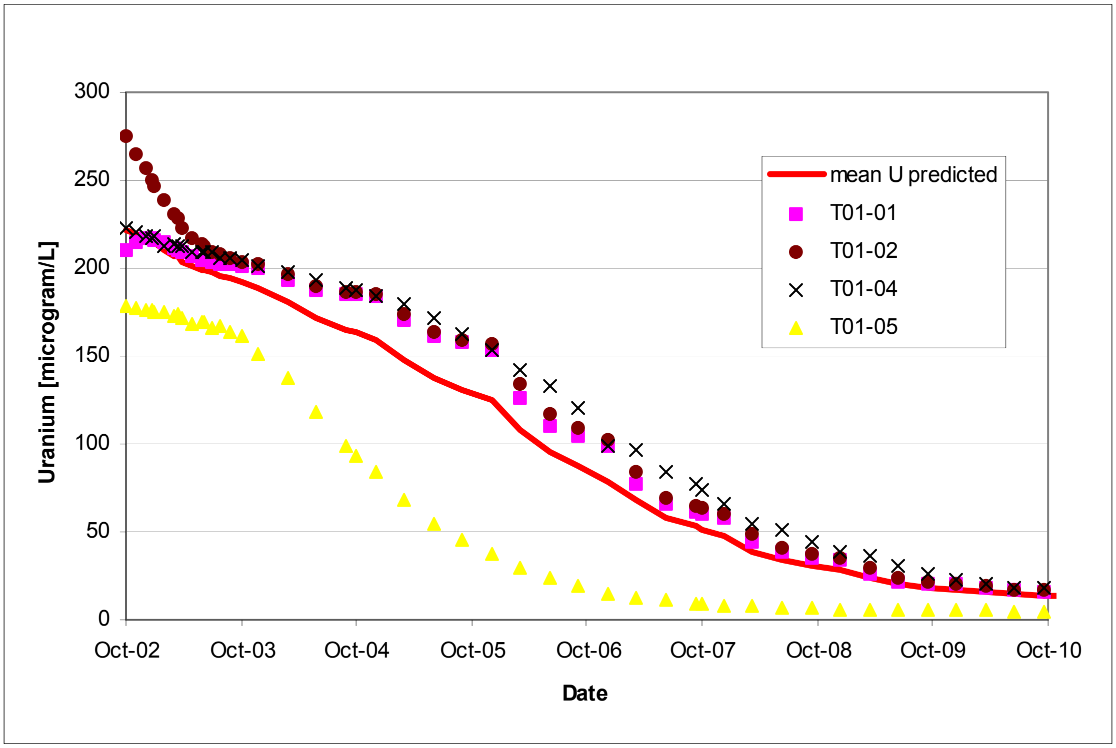

Figure 4. Model-Predicted Uranium Concentrations, Region 2

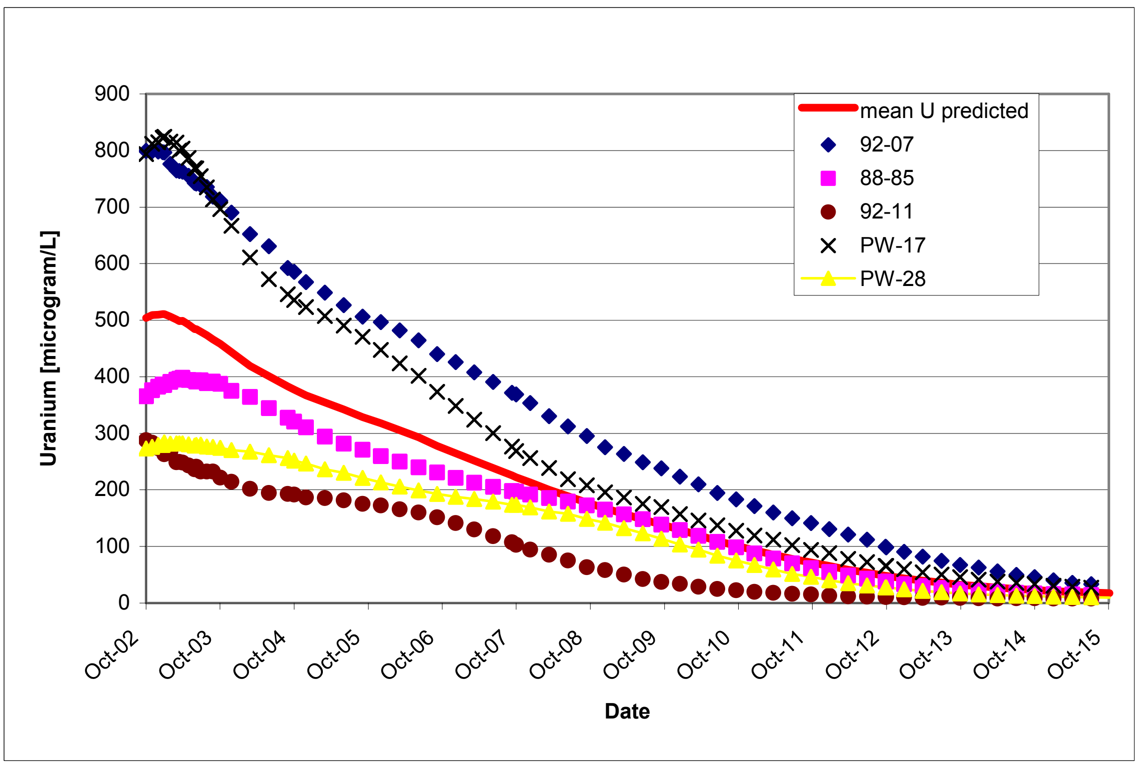

Figure 5. Model-Predicted Uranium Concentrations, Region 3

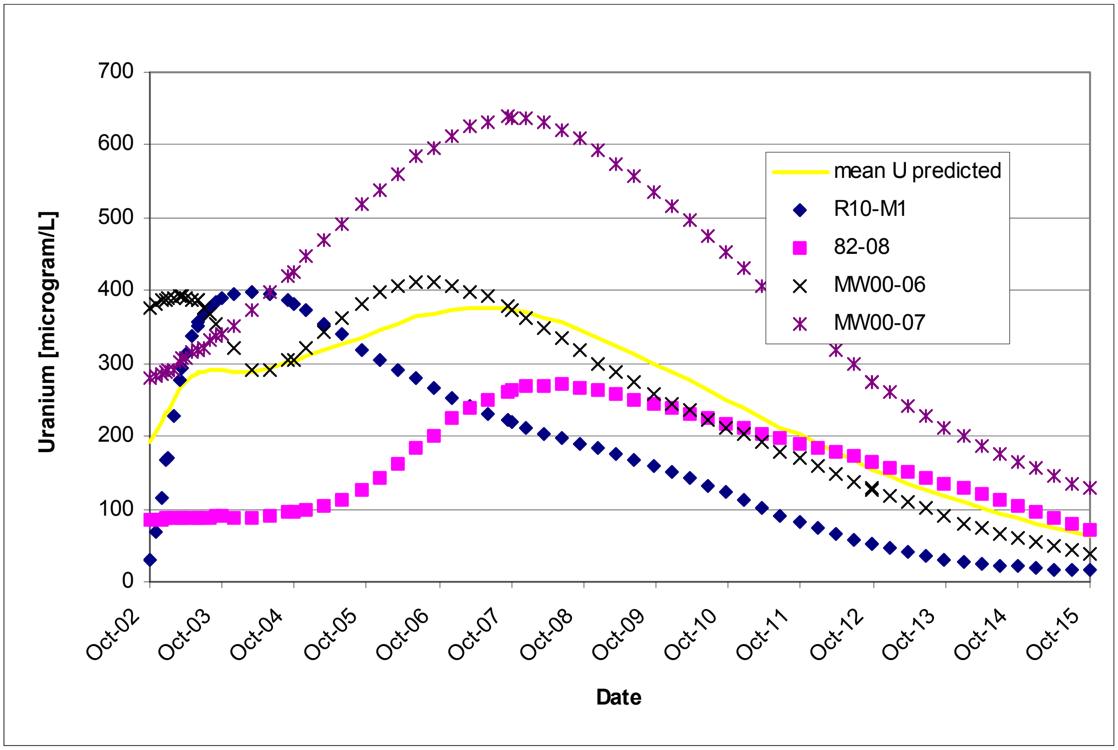

Figure 6. Model-Predicted Uranium Concentrations, Region 4

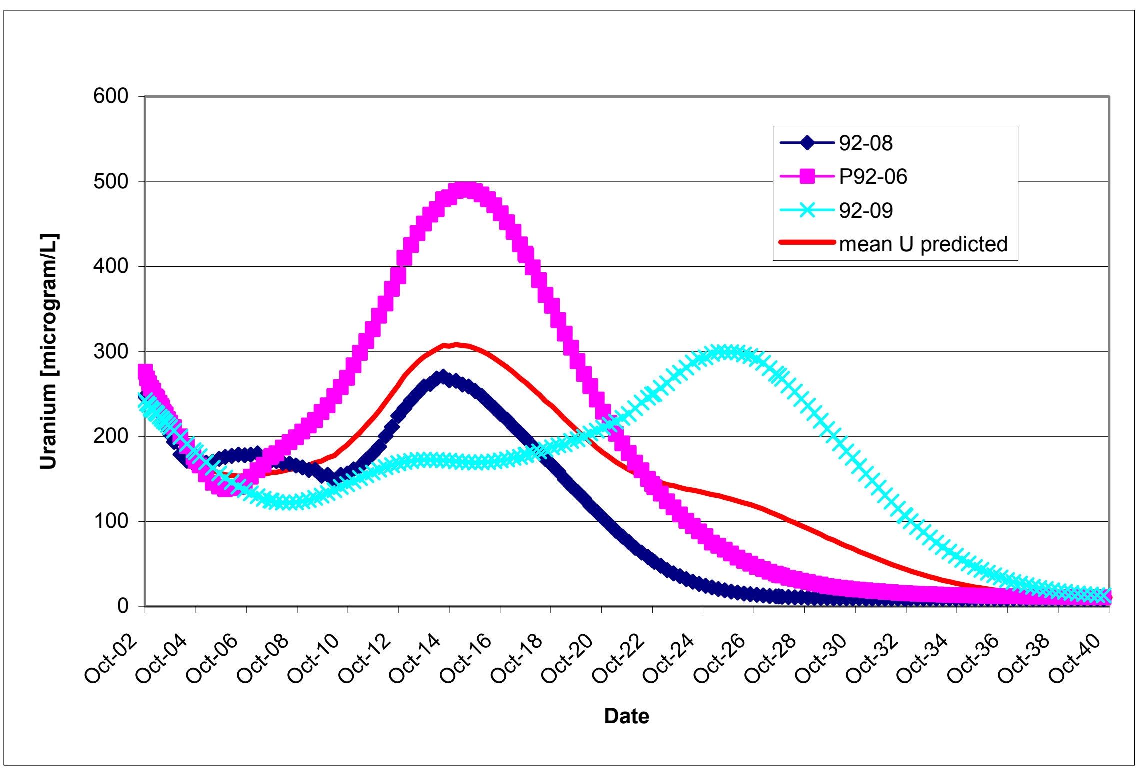

Figure 7. Model-Predicted Uranium Concentrations, Region 5

2.2.3 Addition of New Monitoring Wells

Three new wells will be installed into the alluvial aquifer in 2004 to complement the existing monitoring network. Proposed locations of the new wells are shown on Figure 1. The new well proposed in Region 4 (see Figure 1) will ultimately replace wells MW00-07 and 82-08 as a trend analysis well in that region. The limited saturated thickness (about 1 foot [ft]) and low yield of well MW00-07 pose sampling difficulties. Crop irrigation north of this well biases the monitoring results for samples from that location. The new well will be adjacent to and deeper than existing well 82-07 (well 82-07 is not shown on Figure 1) where recent low water levels are periodically below the screen. The two proposed wells in Region 5 will improve monitoring resolution in that region of the aquifer which is expected to be last in reaching remediation goals.

The new wells will be sampled semiannually to establish a seasonal water quality profile, and their concentration trends will be evaluated qualitatively to expected rates of ground water restoration. As predicted by numerical modeling, quantitative performance criteria (Section 3.1) cannot be immediately applied to the new wells because the ground water model was not based on concentration input from those locations. In 2007 (during the 5-year review), a decision will be made whether quantitative performance measures will subsequently be applied to the new wells.

3.0 Performance Criteria

3.1 Quantitative Evaluation of Uranium Attenuation

The progress of monitored natural attenuation for uranium is expected to closely approximate the model-predicted concentration trends. As long as the lower limit of the uncertainty range (minus 30 percent) associated with the observed concentration average for uranium does not exceed the model-predicted value for three consecutive sampling events, the progress of monitored natural attenuation is considered to be consistent with the model trend. This method allows possible deviatory behavior to be interpreted during successive water years and provides a minimum number of data points to constitute a concentration “trend.” Concentration trends at wells not listed in Table 1 will be analyzed to assist in the general interpretation of monitored natural attenuation progress. The method described in Section 2.2 will be applied to the data beginning in October 2004.

3.1.1 Aquifer Region 4

The previously defined quantitative performance criteria do not immediately apply to Region 4 because of the general complexity of this region (see Section 2.1). A decision will be made in 2007 (during the 5-year review) whether those criteria will be subsequently applied to Region 4. The decision will consider the general progress of ground water restoration in this portion of the aquifer and the status of the permeable reactive barrier based on concentration trends and other indicators of flow dynamics (e.g., creek flow and ground water levels).

3.2 Plume Expansion

Assessment of plume expansion uses a sentinel well located a short distance beyond the terminus of the uranium plume (well 95-03; Figure 1). The ground water model predicts slight increases in uranium concentrations east of the current extent of the uranium plume but predicts that the concentrations will never exceed the remediation goal at the location of well 95-03. Unexpected plume expansion will be indicated by concentrations in ground water sample results that exceed the uranium remediation goal at well 95-03.

Ground water discharge from the Burro Canyon sandstone aquifer represents a significant local process that limits plume migration beyond its current extent in the eastern portion of OU III. Hydraulic heads at the alluvial and Burro Canyon aquifer wells in the area of concern, measured semiannually to determine vertical flow potentials, will complement water quality data in evaluating plume expansion criteria.

3.3 Permeable Reactive Barrier Performance

The permeable reactive barrier will be monitored to ensure that no adverse impact to ground water quality or land use occurs. Permeable reactive barrier failure is indicated by loss of treatment effectiveness whereby COC concentrations in the permeable reactive barrier equal or exceed concentrations in the influent ground water, or when ground water mounding reaches the top of the permeable reactive media.

Concentration trend analysis will consider possible effects associated with the eventual decommissioning of the permeable reactive barrier. Such effects will depend on contaminant concentrations in ground water hydraulically upgradient of the permeable reactive barrier and whether the disturbance to the subsurface mobilizes contaminants to ground water or flow directions change following the removal of the permeable reactive barrier and replacement with clean fill.

3.4 Other Contaminants of Concern

The progress of aquifer restoration for the remaining COCs (arsenic, manganese, molybdenum, nitrate, selenium, and vanadium) will be evaluated using concentration trends determined from semiannual monitoring. The rate at which these trends (at an individual well or averaged for a region of the aquifer) approach the respective remediation goal will be compared to the remediation time frame as a qualitative measure of restoration progress. These COCs are expected to attenuate to safe levels within the remediation time frame because they generally do not greatly exceed the respective remediation goals and are present only in the small area between the former millsite and permeable reactive barrier. Selenium mobilization from natural sources provides an exception (see Sections 5.3.1 and 7.2 of the ROD), as does manganese, which occurs in excess of its remediation goal only in ground water samples from locations on the former millsite.

3.5 Surface Water Restoration

The selected remedy for OU III assumes that remediation goals for surface water will be achieved through aquifer restoration because of the strong interaction between surface water and ground water at the site and, with the exception of selenium, because the remediation goals for surface water and ground water are equal for the respective COCs. Therefore, ground water and surface water interaction cannot in itself cause remediation goals to be exceeded for COCs other than selenium. However, sufficient discharge of ground water that contains selenium at 50 µg/L (ground water remediation goal for selenium) may result in surface water concentrations that exceed the surface water remediation goal for selenium of 5 µg/L.

Attainment of surface water remediation goals will be tracked by continued water-quality monitoring during the post-ROD period at multiple locations on Montezuma Creek, in the constructed wetlands, and at ground water seeps. Figure 8 illustrates the locations of the post-ROD surface water monitoring sites as identified in DOE 2004b. Specific criterion by which selenium concentration trends in surface water will initiate response actions pertaining to ecological risk are described in Appendix C of this ROD.

4.0 Reporting Requirements and Response Action

Annual reports will document monitoring results and monitored natural attenuation performance for the period encompassing the previous two sampling events. Annual reports will be completed within 5 months after the second sampling event for the reporting period. Annual reports will include

- Water quality sample results and summary.
- Hydrogeologic data summary.
- Concentration trend analysis and comparison to performance criteria.
- Interpretation of any deviation from expected concentration trends.

Discussion of potential response actions under CERCLA will be initiated among U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), and the Utah Department of Environmental Quality (UDEQ) if, for any region of the aquifer, the lower limit of the uncertainty range (minus 30 percent) of the observed concentration average exceeds the model-predicted value for three consecutive sampling events. Example parameters that will be discussed include temporary climate changes (e.g., drought) from the assumed baseline conditions, changes in land use, identification of unremediated source material, and evaluation of discharge from the Burro Canyon aquifer. The sensitivity of the ground water model to the flow-and-transport variables (e.g., hydraulic conductivity, uranium partitioning coefficient) used to predict future concentrations will also be considered.

If the data are consistently above model predictions, a second assessment of the data will be performed during the 5-year review using additional statistical methods. In this evaluation, data for the region in question will be evaluated for the most recent 5-year period to determine if the observed trend for that period, assuming a 70-percent confidence interval, can meet the remediation goal in the established time frame. This second type of trend analysis accounts for linearly decreasing concentrations over time, as distinct from the highly nonlinear response predicted by the model. If the linear trend indicates an unacceptable remediation time, DOE, EPA, and UDEQ will determine the need to implement a contingency remedy. If the linear trend indicates that clean-up levels will be met in an acceptable time, then the selected remedy will be continued.

For the remaining COCs, if significant increases in the concentrations occur unexpectedly, or if average concentrations for the aquifer regions persist above the remediation goal, the need for response action will be evaluated. Failure of the permeable reactive barrier will initiate a separate response in which a strategy for its decommissioning will be developed by DOE, EPA, and UDEQ.

4.1 Plan Modification

This monitored natural attenuation performance evaluation plan may require modification during the post-ROD monitoring period. Plan modification may include reducing the scope of ground water monitoring as remediation goals are attained in regions of the aquifer, using wells other than those listed in Table 1 for quantitative trend analysis, or redefining quantitative performance criteria. DOE, EPA, or UDEQ may formally propose such changes. Any approval or proposal will be done in consultation between these parties pursuant to the then current agreement (currently 1989 Federal Facilities Agreement).

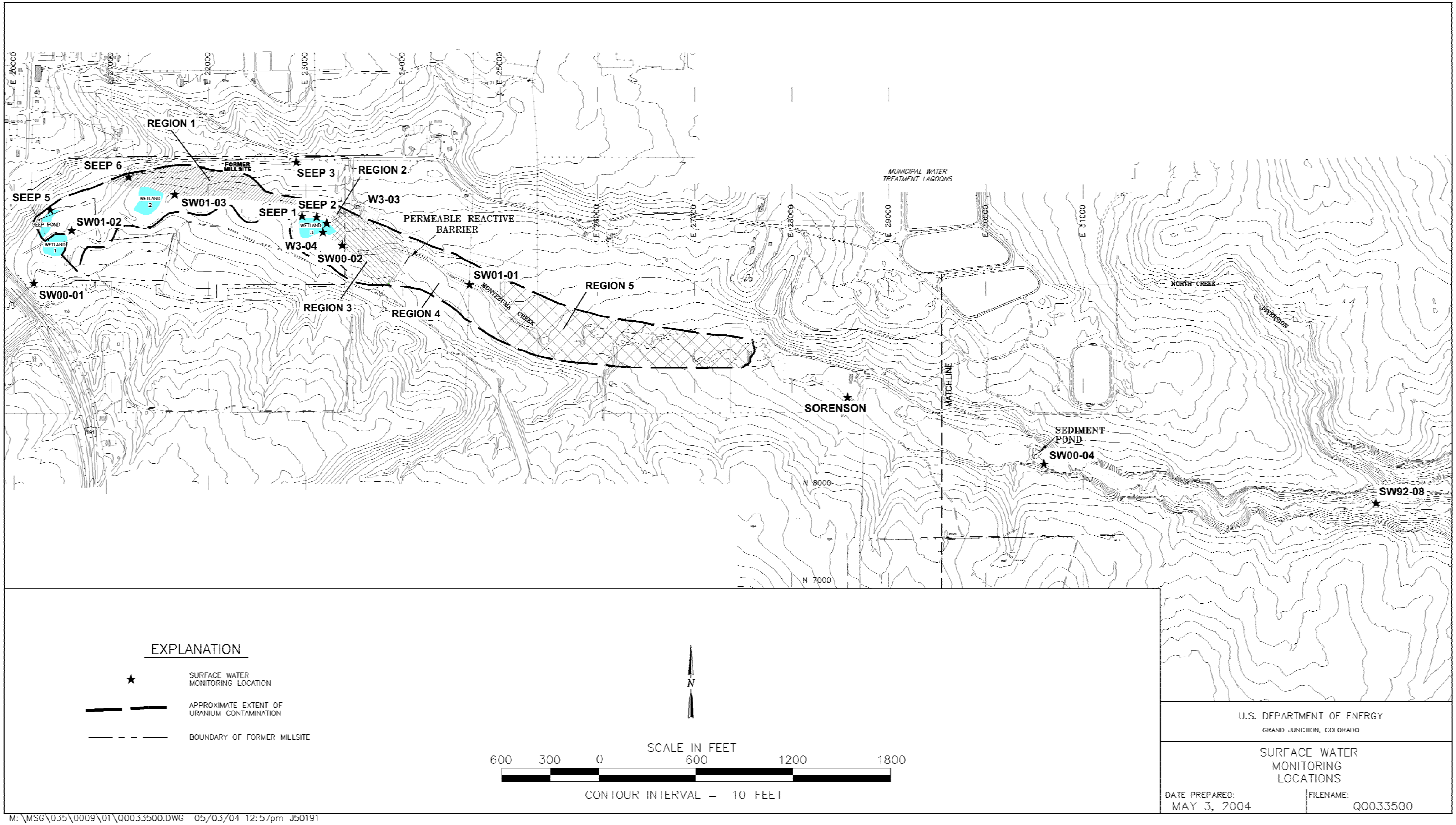

Figure 8. Locations of the Post-ROD Surface Water Monitoring Sites

Table 2. Residuals Analysis Summary

Well	Uranium Variation in Aquifer Regions 1, 2, 3, 5.				
	Maximum Percent Difference		Minimum Percent Difference		
T01-07		5.0435		-5.2708	
T01-12		54.3744		-28.3703	
T01-19		12.5641		-7.5272	
T01-35		18.6413		-15.5926	
T01-01		77.4739		-38.2691	
T01-02		17.3254		-15.2688	
T01-04		22.2202		-15.6268	
T01-05		14.0194		-16.4590	
88-85		19.6685		-17.1713	
92-07		59.6514		-22.0929	
92-11		30.9175		-22.1384	
PW-17		20.0616		-14.8996	
PW-28		24.2677		-24.7583	
92-08		57.9051		-29.4098	
92-09		10.6220		-8.8181	
P92-02		3.6398		-3.2010	
P92-06		72.8809		-23.4040	
	Mean	30.6633	Mean	-18.1340	
Well	**Uranium Variation at Background Locations**				
	Maximum Percent Difference		**Minimum Percent Difference**		
92-01		14.16706		-16.968	
92-03		13.68651		-22.9633	
92-05		21.20232		-36.1803	
mw00-01		48.30178		-25.3276	
mw00-02		44.33328		-23.0294	
	Mean	28.33819	Mean	-24.8937	

Table 3. Linear Regression Residuals Analysis: Uranium, Region 1 Wells

Observations								
Loc T01-07	Loc T01-07	Loc T01-12	Loc T01-12	Loc T01-19	Loc T01-19	Loc T01-35	Loc T01-35	
sample date	uran µg/l	sample date	uran µg/l	sample date	uran µg/l	sample date	uran µg/l	
07/11/2001	214	07/11/2001	164	07/11/2001	109	10/09/2001	159	
10/09/2001	201	10/09/2001	153	10/09/2001	111	01/31/2002	166	
01/31/2002	199	01/31/2002	161	01/31/2002	130	04/03/2002	155	
04/03/2002	203	04/03/2002	155	04/03/2002	128	07/09/2002	125	
07/09/2002	191	07/09/2002	119	07/09/2002	110	10/07/2002	115	
10/07/2002	183	10/07/2002	141	10/07/2002	105	01/13/2003	126	
04/08/2003	197	04/08/2003	282	04/08/2003	109	04/08/2003	148	
		07/07/2003	144	07/07/2003	109	07/07/2003	117	
Computational Summary								
Loc T01-07					**Loc T01-12**			
SUMMARY OUTPUT					SUMMARY OUTPUT			
Regression Statistics					*Regression Statistics*			
Multiple R	0.69				Multiple R	0.31163594		
R Square	0.48				R Square	0.097116959		
Adjusted R Square	0.37				Adjusted R Square	-0.053363547		
Standard Error	7.69				Standard Error	50.70147618		
Observations	7				Observations	8		
Loc T01-07					**Loc T01-12**			
RESIDUAL OUTPUT					RESIDUAL OUTPUT			
Observation	*Predicted Loc T01-07*	*Residuals*	*% difference*		*Observation*	*Predicted Loc T01-12*	*Residuals*	*% difference*
1	207.15	6.85	3.31		1	144.1387431	19.86125693	13.77926331
2	204.37	-3.37	-1.65		2	149.5916667	3.408333269	2.278424556
3	200.86	-1.86	-0.92		3	156.4987034	4.501296628	2.876251708
4	198.95	4.05	2.04		4	160.2551619	-5.255161896	-3.279246568
5	195.96	-4.96	-2.53		5	166.1322018	-47.13220184	-28.37029867
6	193.18	-10.18	-5.27		6	171.5851255	-30.58512551	-17.82504481
7	187.54	9.46	5.04		7	182.672737	99.32726304	54.37443195
		max % diff	**5.04**		8	188.1256606	-44.12566062	-23.4554183
		min % diff	**-5.27**				**max % diff**	**54.37**
							min % diff	**-28.37**
Loc T01-19					**Loc T01-35**			
SUMMARY OUTPUT					SUMMARY OUTPUT			
Regression Statistics					*Regression Statistics*			
Multiple R	0.312126766				Multiple R	0.681832728		
R Square	0.097423118				R Square	0.464895869		
Adjusted R Square	-0.053006362				Adjusted R Square	0.375711847		
Standard Error	9.757205407				Standard Error	16.05676988		
Observations	8				Observations	8		
Loc T01-19					**Loc T01-35**			
RESIDUAL OUTPUT					RESIDUAL OUTPUT			
Observation	*Predicted Loc T01-19*	*Residuals*	*% difference*		*Observation*	*Predicted Loc T01-35*	*Residuals*	*% difference*
1	117.8725355	-8.872535494	-7.527228847		1	159.0517341	-0.051734134	-0.032526608
2	116.8213209	-5.821320901	-4.983097996		2	151.8889542	14.11104575	9.290369944
3	115.4897824	14.51021758	12.56407041		3	147.9934073	7.006592709	4.734395158
4	114.7656124	13.23438764	11.53166647		4	141.8987612	-16.89876125	-11.90902662
5	113.6326366	-3.632636635	-3.196825087		5	136.243935	-21.24393502	-15.592573
6	112.581422	-7.581422042	-6.734167951		6	130.0864576	-4.086457573	-3.141339728
7	110.4439524	-1.44395237	-1.307407367		7	124.7457884	23.25421164	18.64127996
8	109.3927378	-0.392737777	-0.359016316		8	119.0909621	-2.090962132	-1.755768947
		max % diff	**12.56**				**max % diff**	**18.64**
		min % diff	**-7.53**				**min % diff**	**-15.59**

Table 4. Linear Regression Residuals Analysis: Uranium, Region 2 Wells

Observations

Loc T01-01	Loc T01-01	Loc T01-02	Loc T01-02	Loc T01-04	Loc T01-04	Loc T01-05	Loc T01-05
sample date	uran µg/l	sample date	uran µg/l	sample date	uran µg/l	sample date	uran µg/l
07/18/2001	326	07/18/2001	311	07/18/2001	221	10/09/2001	180
10/09/2001	321	01/31/2002	301	10/09/2001	192	01/31/2002	230
01/31/2002	651	04/03/2002	373	01/31/2002	251	04/03/2002	235
04/03/2002	331	07/10/2002	323	04/03/2002	282	07/10/2002	201
07/10/2002	326	10/08/2002	278	07/10/2002	226	10/08/2002	188
10/08/2002	193	04/09/2003	391	10/08/2002	213	04/09/2003	194
04/09/2003	291	07/07/2003	305	04/09/2003	233	07/07/2003	168

Computational Summary

Loc T01-01
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.329993297
R Square	0.108895576
Adjusted R Square	-0.069325309
Standard Error	146.8904189
Observations	7

Loc T01-01
RESIDUAL OUTPUT

Observation	*Predicted Loc T01-01*	*Residuals*	*% difference*
1	409.4980731	-83.49807308	-20.39034578
2	391.514606	-70.51460604	-18.01072168
3	366.8144224	284.1855776	77.47393784
4	353.3809892	-22.3809892	-6.33338801
5	332.147498	-6.147498003	-1.850833753
6	312.647353	-119.647353	-38.26910795
7	272.9970582	18.00294176	6.594555222
		max % diff	**77.47**
		min % diff	**-38.27**

Loc T01-02
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.172405518
R Square	0.029723663
Adjusted R Square	-0.164331605
Standard Error	44.13532343
Observations	7

Loc T01-02
RESIDUAL OUTPUT

Observation	*Predicted Loc T01-02*	*Residuals*	*% difference*
1	315.4811466	-4.481146618	-1.420416613
2	321.0409392	-20.04093919	-6.242487092
3	322.7907216	50.20927838	15.55474647
4	325.5565068	-2.556506757	-0.785272819
5	328.0965135	-50.09651351	-15.26883446
6	333.2611939	57.73880608	17.32539135
7	335.7729784	-30.77297838	-9.164816815
		max % diff	**17.33**
		min % diff	**-15.27**

Loc T01-04
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.135351376
R Square	0.018319995
Adjusted R Square	-0.178016006
Standard Error	31.25289678
Observations	7

Loc T01-04
RESIDUAL OUTPUT

Observation	*Predicted Loc T01-04*	*Residuals*	*% difference*
1	226.065262	-5.065262001	-2.240619349
2	227.560489	-35.56048895	-15.62682921
3	229.6141742	21.38582583	9.313809094
4	230.7310907	51.26890932	22.22019978
5	232.4965394	-6.496539375	-2.794252075
6	234.1178698	-21.11786981	-9.020187064
7	237.414575	-4.414575014	-1.859437237
		max % diff	**22.22**
		min % diff	**-15.63**

Loc T01-05
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.491576988
R Square	0.241647935
Adjusted R Square	0.089977522
Standard Error	23.77780404
Observations	7

Loc T01-05
RESIDUAL OUTPUT

Observation	*Predicted Loc T01-05*	*Residuals*	*% difference*
1	215.4631868	-35.46318679	-16.45904682
2	209.4017832	20.59821684	9.836696006
3	206.1052303	28.89476969	14.01942573
4	200.89455	0.10545	0.052490224
5	196.1092313	-8.109231347	-4.135058453
6	186.3790834	7.62091658	4.088933393
7	181.646935	-13.64693497	-7.512890309
		max % diff	**14.02**
		min % diff	**-16.46**

Table 5. Linear Regression Residuals Analysis: Uranium, Region 3 Wells

Observations						
	Loc 88-85	Loc 92-07	Loc 92-11	Loc PW-17	Loc PW-28	Loc PW-28
date_sampled	uran µg/l	uran µg/l	uran µg/l	uran µg/l	date_sampled	uran µg/l
10/18/2000	402	709	270	973	10/18/2000	324
01/29/2001	442	647	423	833	01/29/2001	370
04/12/2001	419	1170	370	727	04/12/2001	304
07/19/2001	393	576	307	761	07/19/2001	247
10/16/2001	366	620	254	759	10/16/2001	206
01/29/2002	350	645	292	686	01/29/2002	216
04/02/2002	374	664	321	753	04/02/2002	233
07/10/2002	417	771	362	881	07/10/2002	263
10/01/2002	417	806	317	836	10/01/2002	256
01/14/2003	397	838	303	803	04/08/2003	270
04/08/2003	329	759	360	792		
07/09/2003	475	845	355	866		

Computational Summary							
Loc 88-85				**Loc 92-07**			
SUMMARY OUTPUT				SUMMARY OUTPUT			
Regression Statistics				*Regression Statistics*			
Multiple R	0.024160903			Multiple R	0.135859654		
R Square	0.000583749			R Square	0.018457846		
Adjusted R Square	-0.099357876			Adjusted R Square	-0.07969637		
Standard Error	42.09817703			Standard Error	164.1459361		
Observations	12			Observations	12		
Loc 88-85				**Loc 92-07**			
RESIDUAL OUTPUT				RESIDUAL OUTPUT			
Observation	*Predicted Loc 88-85*	*Residuals*	*% difference*	*Observation*	*Predicted Loc 92-07*	*Residuals*	*% difference*
1	399.9075892	2.092410787	0.523223576	1	721.1815515	-12.18155148	-1.689110247
2	399.5990192	42.40098083	10.61088211	2	728.0083436	-81.00834357	-11.12739219
3	399.3803239	19.61967609	4.912529466	3	732.8467496	437.1532504	59.65138695
4	399.086733	-6.086732995	-1.525165457	4	739.342144	-163.342144	-22.09290318
5	398.8201045	-32.82010452	-8.229300415	5	745.2410226	-125.2410226	-16.80543862
6	398.5055428	-48.50554283	-12.17186152	6	752.2003738	-107.2003738	-14.25157146
7	398.3168058	-24.31680581	-6.104890745	7	756.3759845	-92.3759845	-12.21297164
8	398.0202191	18.97978092	4.768546926	8	762.9376584	8.062341553	1.056749718
9	397.7715656	19.22843445	4.834039462	9	768.4388598	37.56114016	4.887980309
10	397.4570039	-0.457003862	-0.114981962	10	775.398211	62.601789	8.073501861
11	397.2053545	-68.20535451	-17.17130792	11	780.9656919	-21.96569193	-2.812632124
12	396.9297386	78.07026145	19.66853422	12	787.0634091	57.93659086	7.361108418
		max % diff	**19.67**			**max % diff**	**59.65**
		min % diff	**-17.17**			**min % diff**	**-22.09**
Loc 92-11				**Loc PW-28**			
SUMMARY OUTPUT				SUMMARY OUTPUT			
Regression Statistics				*Regression Statistics*			
Multiple R	0.081275103			Multiple R	0.519495225		
R Square	0.006605642			R Square	0.269875288		
Adjusted R Square	-0.092733793			Adjusted R Square	0.178609699		
Standard Error	49.9039732			Standard Error	46.02957224		
Observations	12			Observations	10		
Loc 92-11							
RESIDUAL OUTPUT							
Observation	*Predicted Loc 92-11*	*Residuals*	*% difference*	**Loc PW-28**			
1	321.8700746	-51.87007463	-16.11522124	RESIDUAL OUTPUT			
2	323.1042655	99.89573452	30.91749172	*Observation*	*Predicted Loc PW-28*	*Residuals*	*% difference*
3	323.9789833	46.02101673	14.20493893	1	307.2362974	16.76370261	5.456289753
4	325.1532619	-18.15326194	-5.582986261	2	297.7443776	72.2556224	24.2676698
5	326.2196987	-72.21969869	-22.13836227	3	291.0170946	12.98290535	4.461217431
6	327.4778544	-35.47785442	-10.83366522	4	281.9859477	-34.98594767	-12.40698267
7	328.2327478	-7.232747848	-2.203542424	5	273.7841917	-67.78419173	-24.75825624
8	329.419009	32.58099104	9.89044049	6	264.1079628	-48.10796283	-18.21526406
9	330.4135511	-13.4135511	-4.059624992	7	258.3022255	-25.30222548	-9.795589424
10	331.6717068	-28.67170682	-8.644604357	8	249.1789239	13.82107606	5.546647301
11	332.6782314	27.32176861	8.212670992	9	241.5300954	14.46990463	5.990932353
12	333.7806155	21.21938455	6.357284864	10	224.1128833	45.88711666	20.47500169
		max % diff	**30.92**			**max % diff**	**24.27**
		min % diff	**-22.14**			**min % diff**	**-24.76**
Loc PW-17				**Loc PW-17**			
SUMMARY OUTPUT				RESIDUAL OUTPUT			
Regression Statistics				*Observation*	*Predicted Loc PW-17*	*Residuals*	*% difference*
Multiple R	0.038321931			1	810.4172801	162.5827199	20.06160578
R Square	0.00146857			2	809.4685597	23.53144027	2.907023379
Adjusted R Square	-0.098384573			3	808.7961657	-81.79616566	-10.11332263
Standard Error	81.56826183			4	807.8934996	-46.89349964	-5.804416011
Observations	12			5	807.0737315	-48.07373153	-5.956547667
				6	806.1065894	-120.1065894	-14.89959156
				7	805.5263041	-52.52630408	-6.520743495
				8	804.6144272	76.38557281	9.493438128
				9	803.8499243	32.15007566	3.999512184
				10	802.8827822	0.117217818	0.014599618
				11	802.1090685	-10.10906846	-1.260310954
				12	801.2616677	64.73833229	8.079549403
						max % diff	**20.06**
						min % diff	**-14.90**

Table 6. Linear Regression Residuals Analysis: Uranium, Region 5 Wells

Observations

Loc 92-08 date_sampled	Loc 92-08 uran µg/l	Loc 92-09 date_sampled	Loc 92-09 uran µg/l	Loc P92-02 date_sampled	Loc P92-02 uran µg/l	Loc P92-06 date_sampled	Loc P92-06 uran µg/l
10-Jan-00	467	12-Apr-00	271	12-Apr-00	66	10-Jan-00	1080
12-Apr-00	337	02-Nov-00	283	02-Nov-00	62	12-Apr-00	895
26-Jul-00	227	10-Apr-01	281	10-Apr-01	59	26-Jul-00	697
02-Nov-00	276	16-Oct-01	265	16-Oct-01	54	02-Nov-00	546
29-Jan-01	363	02-Apr-02	272	02-Apr-02	54	10-Apr-01	550
10-Apr-01	316	07-Oct-02	260	07-Oct-02	52	19-Jul-01	604
19-Jul-01	281	09-Apr-03	319	09-Apr-03	46	16-Oct-01	492
16-Oct-01	292	07-Oct-03	285			02-Apr-02	414
02-Apr-02	257					11-Jul-02	364
11-Jul-02	241					07-Oct-02	306
07-Oct-02	261					09-Apr-03	352
09-Apr-03	488					09-Jul-03	439
07-Oct-03	311					07-Oct-03	903

Computational Summary

Loc 92-08

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.06
R Square	0.00
Adjusted R Square	-0.10
Standard Error	88.44
Observations	12.00

Loc 92-08

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*	*% difference*
1	324.09	142.91	44.10
2	322.89	14.11	4.37
3	321.57	-94.57	-29.41
4	320.32	-44.32	-13.84
5	319.20	43.80	13.72
6	318.30	-2.30	-0.72
7	317.03	-36.03	-11.36
8	315.90	-23.90	-7.57
9	313.77	-56.77	-18.09
10	312.50	-71.50	-22.88
11	311.38	-50.38	-16.18
12	309.05	178.95	57.91
		max % diff	**57.91**
		min % diff	**-29.41**

Loc 92-09

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.35
R Square	0.13
Adjusted R Square	-0.05
Standard Error	20.01
Observations	7.00

Loc 92-09

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*	*% difference*
1	268.95	2.05	0.76
2	272.55	10.45	3.84
3	275.42	5.58	2.03
4	278.78	-13.78	-4.94
5	281.79	-9.79	-3.48
6	285.14	-25.14	-8.82
7	288.37	30.63	10.62
		max % diff	**10.62**
		min % diff	**-8.82**

Loc P92-02

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.98
R Square	0.96
Adjusted R Square	0.96
Standard Error	1.37
Observations	7.00

Loc P92-02

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*	*% difference*
1	65.27	0.63	0.97
2	61.92	0.18	0.29
3	59.25	-0.75	-1.26
4	56.10	-1.80	-3.20
5	53.31	0.89	1.67
6	50.17	1.83	3.64
7	47.19	-0.99	-2.09
		max % diff	**3.64**
		min % diff	**-3.20**

Loc P92-06

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.86
R Square	0.74
Adjusted R Square	0.71
Standard Error	123.71
Observations	12.00

Loc P92-06

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*	*% difference*
1	851.11	228.89	26.89
2	807.99	87.01	10.77
3	759.24	-62.24	-8.20
4	712.83	-166.83	-23.40
5	638.30	-88.30	-13.83
6	591.43	12.57	2.13
7	549.71	-57.71	-10.50
8	470.96	-56.96	-12.09
9	424.09	-60.09	-14.17
10	382.84	-76.84	-20.07
11	296.59	55.41	18.68
12	253.93	185.07	72.88
		max % diff	**72.88**
		min % diff	**-23.40**

Table 7. Uranium Concentration Variation: Background Locations

Well 92-01

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.105522584
R Square	0.011135016
Adjusted R Square	-0.153675815
Standard Error	0.69475875
Observations	8

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*	*% difference*
1	5.595656162	0.204343838	3.651829782
2	5.569847159	-0.669847159	-12.02631131
3	5.559835046	0.640164954	11.51409977
4	5.540033311	-0.940033311	-16.96800828
5	5.518229154	0.781770846	14.1670602
6	5.47640077	-0.17640077	-3.221107755
7	5.441914602	0.558085398	10.2553134
8	5.398083796	-0.398083796	-7.374539024

MW00-01

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.124976429
R Square	0.015619108
Adjusted R Square	-0.107428504
Standard Error	1.15283878
Observations	10

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*	*% difference*
1	5.236685903	-0.636685903	-12.15818391
2	5.26978024	-1.06978024	-20.30028182
3	5.326975889	2.573024111	48.30177882
4	5.360429947	0.139570053	2.603710043
5	5.392445121	0.007554879	0.140101168
6	5.456115749	0.243884251	4.469924436
7	5.490648971	-1.390648971	-25.32758838
8	5.523383587	-0.023383587	-0.423356202
9	5.58885282	-0.38885282	-6.957650028
10	5.654681774	0.545318226	9.643658975

Well 92-03

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.819116647
R Square	0.670952082
Adjusted R Square	0.506428123
Standard Error	0.717607129
Observations	4

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*	*% difference*
1	4.381528144	0.418471856	9.550819758
2	3.634633285	-0.834633285	-22.96334236
3	2.902719124	0.397280876	13.68650768
4	2.481119447	0.018880553	0.76096913

MW00-02

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.259558486
R Square	0.067370608
Adjusted R Square	-0.065862163
Standard Error	1.568932583
Observations	9

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*	*% difference*
1	7.037214156	-1.537214156	-21.84407241
2	6.928409028	3.071590972	44.33327997
3	6.738298969	-0.338298969	-5.020539617
4	6.625906859	-1.525906859	-23.029404
5	6.517101731	-0.017101731	-0.262413139
6	6.309056761	0.290943239	4.611517215
7	6.193077669	-1.193077669	-19.26469734
8	6.08307688	1.21692312	20.00505901
9	5.867857946	0.032142054	0.547764693

Well 92-05

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.153477295
R Square	0.02355528
Adjusted R Square	-0.074089192
Standard Error	0.915663985
Observations	12

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*	*% difference*
1	4.857432909	-1.757432909	-36.18028169
2	4.868343225	0.431656775	8.866605235
3	4.889709259	0.810290741	16.57134807
4	4.907438522	0.892561478	18.1879299
5	4.9296001	-1.0296001	-20.88607755
6	5.032907149	1.067092851	21.20231547
7	5.073479885	0.126520115	2.493754154
8	5.115871006	0.184128994	3.599171945
9	5.159398619	0.740601381	14.35441291
10	5.177923425	-0.277923425	-5.367468813
11	5.189288337	-0.789288337	-15.20995338
12	5.198607565	-0.398607565	-7.667583285

Table 8. Uranium Concentration Variation: Background Locations

Observations					
Date Sampled	Loc 92-01	Loc 92-03	Loc 92-05	Loc MW00-01	Loc MW00-02
	Uranium (mg/L)	Uranium (mg/L)	Uranium (mg/L)	Uranium (mg/L)	Uranium (mg/L)
11/12/1992	0.0058	0.0048			
03/08/1993	0.0049				
04/22/1993	0.0062				
07/20/1993	0.0046				
07/22/1993			0.0031		
10/26/1993	0.0063		0.0053		
10/27/1993		0.0028			
05/02/1994	0.0053		0.0057		
10/04/1994	0.006	0.0033			
10/05/1994			0.0058		
04/18/1995			0.0039		
04/19/1995	0.005	0.0025			
04/08/1996					
07/23/1996					
10/13/1997			0.0061		
10/14/1997					
04/21/1998					
10/05/1998			0.0052		
10/06/1998					
04/13/1999					
10/13/1999			0.0053		
10/25/1999					
04/10/2000					
08/01/2000				0.0046	
08/02/2000					0.0055
10/30/2000			0.0059		
11/01/2000				0.0042	0.01
04/09/2001				0.0079	0.0064
04/10/2001					
04/11/2001			0.0049		
07/11/2001				0.0055	
07/12/2001					0.0051
07/20/2001			0.0044		
10/08/2001				0.0054	
10/10/2001			0.0048		
10/11/2001					0.0065
10/17/2001					
04/03/2002				0.0057	0.0066
07/08/2002				0.0041	
07/09/2002					0.005
10/07/2002				0.0055	
10/08/2002					
10/09/2002					0.0073
04/07/2003				0.0052	0.0059
10/07/2003				0.0062	

Table 9. Model-Predicted Uranium Concentrations at Selected Region 1 Wells

Model Time Day	Model Time Yr	Normalized Time Calendar	T01-07 U (µg/L)	T01-12 U (µg/L)	T01-19 U (µg/L)	T01-35 U (µg/L)	Mean U Predicted U (µg/L)
0	0.0	15-Oct-02	179.1	136.1	104.0	116.7	134.0
365	1.0	15-Oct-03	44.2	6.8	9.7	63.3	31.0
730	2.0	14-Oct-04	11.7	0.9	1.6	17.7	8.0
1067	2.9	16-Sep-05	7.1	0.8	1.3	10.1	4.8
1436	3.9	19-Sep-06	4.9	0.8	1.3	8.0	3.7
1825	5.0	14-Oct-07	4.9	0.8	1.2	7.5	3.6
2173	6.0	26-Sep-08	5.1	0.8	1.3	7.4	3.7
2264	6.2	26-Dec-08	4.9	0.8	1.4	7.8	3.7
2542	7.0	29-Sep-09	4.8	0.8	1.3	7.7	3.7
2911	8.0	03-Oct-10	4.7	0.8	1.3	7.5	3.6
3279	9.0	07-Oct-11	4.8	0.8	1.3	7.8	3.7
3650	10.0	12-Oct-12	4.9	0.8	1.3	7.5	3.6
4015	11.0	12-Oct-13	4.6	0.8	1.3	7.8	3.6
4384	12.0	15-Oct-14	4.8	0.8	1.3	7.9	3.7
4752	13.0	19-Oct-15	4.7	0.8	1.3	7.4	3.6
5121	14.0	22-Oct-16	5.0	0.8	1.3	7.7	3.7
5475	15.0	11-Oct-17	4.9	0.8	1.3	7.7	3.7
5490	15.0	25-Oct-17	4.5	0.8	1.3	7.7	3.6
5859	16.1	29-Oct-18	5.0	0.8	1.3	7.7	3.7
6227	17.1	02-Nov-19	4.8	0.8	1.4	7.9	3.7
6596	18.1	04-Nov-20	4.9	0.8	1.3	7.6	3.6
6965	19.1	08-Nov-21	4.7	0.8	1.3	7.9	3.7
7300	20.0	10-Oct-22	4.7	0.8	1.3	7.6	3.6
7611	20.9	17-Aug-23	4.6	0.8	1.3	7.5	3.5
7980	21.9	19-Aug-24	4.9	0.8	1.3	7.5	3.6
8439	23.1	22-Nov-25	4.8	0.8	1.3	7.8	3.7
8808	24.1	26-Nov-26	4.8	0.8	1.3	7.6	3.6
9125	25.0	09-Oct-27	5.0	0.8	1.2	7.5	3.6
9544	26.1	30-Nov-28	4.9	0.8	1.3	7.6	3.6
9821	26.9	04-Sep-29	4.8	0.8	1.3	7.8	3.7
10191	27.9	09-Sep-30	4.7	0.8	1.3	7.9	3.7
10562	28.9	15-Sep-31	4.8	0.8	1.3	7.5	3.6
10654	29.2	16-Dec-31	4.8	0.8	1.2	7.6	3.6
10747	29.4	18-Mar-32	4.6	0.8	1.2	7.9	3.6
10950	30.0	07-Oct-32	4.7	0.8	1.3	7.8	3.7
11302	31.0	24-Sep-33	4.7	0.8	1.3	7.8	3.6
11672	32.0	29-Sep-34	5.0	0.8	1.2	7.6	3.7
12042	33.0	04-Oct-35	5.1	0.8	1.2	8.0	3.8
12413	34.0	09-Oct-36	4.8	0.8	1.3	8.0	3.7
12782	35.0	13-Oct-37	4.8	0.8	1.3	8.0	3.7
13153	36.0	19-Oct-38	5.1	0.8	1.3	7.8	3.8
13523	37.0	24-Oct-39	5.0	0.8	1.2	7.8	3.7
13893	38.1	28-Oct-40	4.8	0.8	1.3	7.9	3.7
14262	39.1	01-Nov-41	4.6	0.8	1.4	7.8	3.6
14600	40.0	05-Oct-42	4.8	0.8	1.3	8.0	3.7

Table 9 (continued). Model-Predicted Uranium Concentrations at Selected Region 1 Wells

Model Time Day	Model Time Yr	Normalized Time Calendar	T01-07 U (µg/L)	T01-12 U (µg/L)	T01-19 U (µg/L)	T01-35 U (µg/L)	Mean U Predicted U (µg/L)
14997	41.1	06-Nov-43	5.0	0.8	1.2	8.0	3.8
15330	42.0	04-Oct-44	4.9	0.8	1.2	7.9	3.7
15695	43.0	04-Oct-45	5.0	0.8	1.3	7.8	3.7
16060	44.0	04-Oct-46	4.9	0.8	1.3	7.8	3.7
16425	45.0	04-Oct-47	4.9	0.8	1.4	7.7	3.7
16836	46.1	18-Nov-48	4.8	0.8	1.3	7.9	3.7
17206	47.1	23-Nov-49	5.1	0.8	1.3	7.9	3.8
17573	48.1	25-Nov-50	4.7	0.8	1.3	7.9	3.7
17851	48.9	30-Aug-51	4.7	0.8	1.3	7.7	3.6
18250	50.0	02-Oct-52	5.0	0.8	1.3	7.6	3.7

Table 10. Model-Predicted Uranium Concentrations at Selected Region 2 Wells

Model Time Day	Model Time Yr	Normalized Time Calendar	T01-01 U (µg/L)	T01-02 U (µg/L)	T01-04 U (µg/L)	T01-05 U (µg/L)	Mean U Predicted U (µg/L)
0	0.0	15-Oct-02	209.8	274.6	223.2	178.0	221.4
365	1.0	15-Oct-03	201.2	203.7	204.4	160.9	192.6
730	2.0	14-Oct-04	185.3	186.2	187.7	93.5	163.2
1067	2.9	16-Sep-05	157.6	159.1	162.6	45.0	131.1
1436	3.9	19-Sep-06	104.0	109.1	120.0	18.8	88.0
1825	5.0	14-Oct-07	60.4	63.5	73.4	9.1	51.6
2173	6.0	26-Sep-08	35.4	37.9	44.3	6.4	31.0
2264	6.2	26-Dec-08	33.5	35.7	38.7	5.9	28.5
2542	7.0	29-Sep-09	21.0	22.1	25.7	5.5	18.6
2911	8.0	03-Oct-10	16.3	16.7	17.8	5.1	14.0
3279	9.0	07-Oct-11	14.1	14.3	13.3	4.7	11.6
3650	10.0	12-Oct-12	13.0	13.1	11.8	4.8	10.7
4015	11.0	12-Oct-13	12.0	12.1	10.8	4.7	9.9
4384	12.0	15-Oct-14	11.8	11.8	10.4	4.7	9.7
4752	13.0	19-Oct-15	11.4	11.4	10.2	4.7	9.4
5121	14.0	22-Oct-16	11.4	11.3	10.3	4.5	9.4
5475	15.0	11-Oct-17	11.4	11.3	10.3	4.9	9.5
5490	15.0	25-Oct-17	11.4	11.3	10.2	4.8	9.4
5859	16.1	29-Oct-18	11.4	11.3	10.2	4.7	9.4
6227	17.1	02-Nov-19	11.4	11.3	10.2	4.7	9.4
6596	18.1	04-Nov-20	11.4	11.3	10.2	4.5	9.3
6965	19.1	08-Nov-21	11.4	11.3	10.2	4.7	9.4
7300	20.0	10-Oct-22	11.4	11.3	10.3	5.0	9.5
7611	20.9	17-Aug-23	11.4	11.3	10.2	4.8	9.4
7980	21.9	19-Aug-24	11.4	11.3	10.4	4.8	9.5
8439	23.1	22-Nov-25	11.4	11.3	10.2	4.6	9.4
8808	24.1	26-Nov-26	11.4	11.3	10.2	4.9	9.4
9125	25.0	09-Oct-27	11.4	11.3	10.2	4.8	9.4
9544	26.1	30-Nov-28	11.4	11.3	10.3	4.7	9.4
9821	26.9	04-Sep-29	11.4	11.3	10.3	4.8	9.4
10191	27.9	09-Sep-30	11.4	11.3	10.3	4.8	9.4
10562	28.9	15-Sep-31	11.4	11.3	10.2	4.8	9.4
10654	29.2	16-Dec-31	11.4	11.3	10.4	4.9	9.5
10747	29.4	18-Mar-32	11.4	11.3	10.3	4.9	9.5
10950	30.0	07-Oct-32	11.4	11.3	10.2	4.7	9.4
11302	31.0	24-Sep-33	11.4	11.3	10.2	4.9	9.4
11672	32.0	29-Sep-34	11.4	11.3	10.3	4.7	9.4
12042	33.0	04-Oct-35	11.4	11.3	10.1	4.4	9.3
12413	34.0	09-Oct-36	11.4	11.3	10.3	4.8	9.5
12782	35.0	13-Oct-37	11.4	11.3	10.2	5.0	9.5
13153	36.0	19-Oct-38	11.4	11.3	10.1	4.8	9.4
13523	37.0	24-Oct-39	11.4	11.3	10.4	4.7	9.4
13893	38.1	28-Oct-40	11.4	11.3	10.3	4.7	9.4
14262	39.1	01-Nov-41	11.4	11.3	10.5	4.9	9.5
14600	40.0	05-Oct-42	11.4	11.3	10.4	4.6	9.4

Table 10 (continued). Model-Predicted Uranium Concentrations at Selected Region 2 Wells

Model Time Day	Model Time Yr	Normalized Time Calendar	T01-01 U (µg/L)	T01-02 U (µg/L)	T01-04 U (µg/L)	T01-05 U (µg/L)	Mean U Predicted U (µg/L)
14997	41.1	06-Nov-43	11.4	11.3	10.6	4.9	9.5
15330	42.0	04-Oct-44	11.4	11.3	10.4	4.4	9.4
15695	43.0	04-Oct-45	11.4	11.3	10.3	4.9	9.5
16060	44.0	04-Oct-46	11.4	11.3	10.3	4.6	9.4
16425	45.0	04-Oct-47	11.4	11.3	10.3	5.0	9.5
16836	46.1	18-Nov-48	11.4	11.3	10.4	4.7	9.5
17206	47.1	23-Nov-49	11.4	11.3	10.4	4.6	9.4
17573	48.1	25-Nov-50	11.4	11.3	10.3	4.8	9.5
17851	48.9	30-Aug-51	11.4	11.3	10.2	4.8	9.4
18250	50.0	02-Oct-52	11.4	11.3	10.4	4.9	9.5

Table 11. Model-Predicted Uranium Concentrations at Selected Region 3 Wells

Model Time Day	Model Time Yr	Normalized Time Calendar	92-07 U (µg/L)	88-85 U (µg/L)	92-11 U (µg/L)	PW-17 U (µg/L)	PW-28 U (µg/L)	Mean U Predicted U (µg/L)
0	0.0	15-Oct-02	799.5	365.6	288.0	793.6	273.2	504
365	1.0	15-Oct-03	711.1	387.7	221.8	696.3	274.4	458
730	2.0	14-Oct-04	585.7	320.7	191.9	535.6	251.9	377
1067	2.9	16-Sep-05	506.2	270.8	175.4	470.7	221.0	329
1436	3.9	19-Sep-06	440.2	230.7	151.7	373.1	192.7	278
1825	5.0	14-Oct-07	368.8	196.9	103.0	268.5	173.9	222
2173	6.0	26-Sep-08	295.3	172.3	63.1	208.3	148.8	178
2264	6.2	26-Dec-08	275.2	165.4	58.0	195.6	142.0	167
2542	7.0	29-Sep-09	237.9	138.7	37.1	169.4	113.7	139
2911	8.0	03-Oct-10	183.4	98.2	22.6	127.9	75.3	101
3279	9.0	07-Oct-11	141.4	61.6	15.2	93.9	46.5	72
3650	10.0	12-Oct-12	98.7	37.9	10.5	65.5	27.6	48
4015	11.0	12-Oct-13	67.4	23.7	8.8	45.7	16.8	32
4384	12.0	15-Oct-14	45.7	16.9	8.6	33.1	12.2	23
4752	13.0	19-Oct-15	30.3	13.7	7.5	25.5	9.8	17
5121	14.0	22-Oct-16	21.6	12.2	7.6	21.2	8.8	14
5475	15.0	11-Oct-17	17.3	11.4	7.2	18.3	8.1	12
5490	15.0	25-Oct-17	17.2	11.3	7.3	18.5	8.1	12
5859	16.1	29-Oct-18	15.0	10.9	7.3	16.7	7.8	12
6227	17.1	02-Nov-19	13.1	10.6	7.3	15.4	7.7	11
6596	18.1	04-Nov-20	12.1	10.6	7.1	14.5	7.6	10
6965	19.1	08-Nov-21	11.5	10.6	7.2	13.7	7.7	10
7300	20.0	10-Oct-22	11.3	10.5	7.4	13.7	7.5	10
7611	20.9	17-Aug-23	11.1	10.5	7.2	13.2	7.6	10
7980	21.9	19-Aug-24	11.0	10.5	7.2	12.8	7.7	10
8439	23.1	22-Nov-25	10.9	10.5	7.3	12.6	7.7	10
8808	24.1	26-Nov-26	10.9	10.5	7.0	12.5	7.7	10
9125	25.0	09-Oct-27	10.9	10.5	7.1	12.1	7.6	10
9544	26.1	30-Nov-28	10.9	10.5	7.4	12.1	7.6	10
9821	26.9	04-Sep-29	10.9	10.5	7.4	12.0	7.6	10
10191	27.9	09-Sep-30	10.8	10.5	7.1	11.8	7.6	10
10562	28.9	15-Sep-31	10.8	10.5	7.3	11.9	7.6	10
10654	29.2	16-Dec-31	10.8	10.5	7.4	11.9	7.7	10
10747	29.4	18-Mar-32	10.8	10.5	7.6	11.9	7.7	10
10950	30.0	07-Oct-32	10.8	10.5	7.3	11.8	7.7	10
11302	31.0	24-Sep-33	10.8	10.5	7.3	11.6	7.7	10
11672	32.0	29-Sep-34	10.8	10.5	7.3	11.4	7.6	10
12042	33.0	04-Oct-35	10.8	10.5	7.4	11.3	7.6	10
12413	34.0	09-Oct-36	10.8	10.5	7.1	11.3	7.7	9
12782	35.0	13-Oct-37	10.8	10.5	7.4	11.3	7.5	9
13153	36.0	19-Oct-38	10.8	10.5	7.3	11.2	7.7	9
13523	37.0	24-Oct-39	10.8	10.5	7.2	11.1	7.7	9
13893	38.1	28-Oct-40	10.8	10.5	7.1	11.1	7.6	9
14262	39.1	01-Nov-41	10.8	10.5	7.3	11.0	7.6	9
14600	40.0	05-Oct-42	10.8	10.5	7.3	10.9	7.7	9

Table 11 (continued). Model-Predicted Uranium Concentrations at Selected Region 3 Wells

Model Time Day	Model Time Yr	Normalized Time Calendar	92-07 U (µg/L)	88-85 U (µg/L)	92-11 U (µg/L)	PW-17 U (µg/L)	PW-28 U (µg/L)	Mean U Predicted U (µg/L)
14997	41.1	06-Nov-43	10.8	10.5	7.4	10.8	7.7	9
15330	42.0	04-Oct-44	10.8	10.6	7.3	10.8	7.6	9
15695	43.0	04-Oct-45	10.8	10.5	7.5	10.9	7.7	9
16060	44.0	04-Oct-46	10.8	10.5	7.3	10.8	7.6	9
16425	45.0	04-Oct-47	10.8	10.6	7.5	10.7	7.5	9
16836	46.1	18-Nov-48	10.8	10.6	7.4	10.7	7.7	9
17206	47.1	23-Nov-49	10.8	10.5	7.2	10.6	7.7	9
17573	48.1	25-Nov-50	10.8	10.5	7.4	10.6	7.7	9
17851	48.9	30-Aug-51	10.8	10.5	7.3	10.5	7.8	9
18250	50.0	02-Oct-52	10.8	10.5	7.3	10.3	7.9	9

Table 12. Model-Predicted Uranium Concentrations at Selected Region 4 Wells

Model Time Day	Model Time Yr	Normalized Time Calendar	MW00-07 U (µg/L)	MW00-06 U (µg/L)	R10-M1 U (µg/L)	82-08 U (µg/L)	Mean U Predicted U (µg/L)
0	0.0	15-Oct-02	279.3	374.9	30.3	84.8	192.3
365	1.0	15-Oct-03	341.5	339.8	391.0	89.4	290.4
730	2.0	14-Oct-04	426.4	305.8	380.8	95.8	302.2
1067	2.9	16-Sep-05	519.0	381.6	317.8	125.5	336.0
1436	3.9	19-Sep-06	596.5	411.1	265.3	201.0	368.5
1825	5.0	14-Oct-07	638.2	373.5	218.4	263.3	373.3
2173	6.0	26-Sep-08	608.4	319.4	189.2	267.4	346.1
2264	6.2	26-Dec-08	592.5	300.4	183.0	264.5	335.1
2542	7.0	29-Sep-09	535.0	259.0	160.1	245.5	299.9
2911	8.0	03-Oct-10	452.4	212.3	122.2	216.0	250.7
3279	9.0	07-Oct-11	366.7	170.9	82.6	188.9	202.3
3650	10.0	12-Oct-12	275.5	127.4	51.0	164.0	154.5
4015	11.0	12-Oct-13	211.9	90.3	31.3	135.6	117.3
4384	12.0	15-Oct-14	163.5	61.3	20.8	103.5	87.3
4752	13.0	19-Oct-15	128.2	39.5	15.6	72.0	63.8
5121	14.0	22-Oct-16	97.4	27.8	13.2	46.4	46.2
5475	15.0	11-Oct-17	73.1	20.3	11.9	30.2	33.9
5490	15.0	25-Oct-17	72.2	20.6	11.9	29.3	33.5
5859	16.1	29-Oct-18	53.8	16.0	11.2	19.0	25.0
6227	17.1	02-Nov-19	40.8	14.1	10.9	13.8	19.9
6596	18.1	04-Nov-20	31.8	12.7	10.7	11.0	16.6
6965	19.1	08-Nov-21	26.1	11.9	10.6	9.7	14.6
7300	20.0	10-Oct-22	22.6	11.5	10.6	9.0	13.4
7611	20.9	17-Aug-23	20.0	11.3	10.6	8.6	12.6
7980	21.9	19-Aug-24	17.8	11.1	10.6	8.5	12.0
8439	23.1	22-Nov-25	16.1	11.0	10.6	8.3	11.5
8808	24.1	26-Nov-26	14.9	10.9	10.6	8.3	11.2
9125	25.0	09-Oct-27	14.2	10.9	10.6	8.3	11.0
9544	26.1	30-Nov-28	13.5	10.8	10.6	8.3	10.8
9821	26.9	04-Sep-29	13.2	10.8	10.6	8.3	10.7
10191	27.9	09-Sep-30	12.8	10.8	10.6	8.4	10.6
10562	28.9	15-Sep-31	12.4	10.7	10.6	8.3	10.5
10654	29.2	16-Dec-31	12.4	10.7	10.6	8.3	10.5
10747	29.4	18-Mar-32	12.3	10.7	10.6	8.2	10.5
10950	30.0	07-Oct-32	12.2	10.7	10.6	8.3	10.5
11302	31.0	24-Sep-33	11.9	10.7	10.6	8.3	10.4
11672	32.0	29-Sep-34	11.7	10.7	10.6	8.4	10.4
12042	33.0	04-Oct-35	11.5	10.7	10.6	8.3	10.3
12413	34.0	09-Oct-36	11.4	10.7	10.6	8.3	10.2
12782	35.0	13-Oct-37	11.3	10.7	10.6	8.3	10.2
13153	36.0	19-Oct-38	11.0	10.7	10.6	8.3	10.2
13523	37.0	24-Oct-39	10.8	10.7	10.6	8.2	10.1
13893	38.1	28-Oct-40	10.7	10.7	10.6	8.3	10.1
14262	39.1	01-Nov-41	10.5	10.7	10.6	8.4	10.0
14600	40.0	05-Oct-42	10.5	10.6	10.6	8.3	10.0

Table 12 (continued). Model-Predicted Uranium Concentrations at Selected Region 4 Wells

Model Time Day	Model Time Yr	Normalized Time Calendar	MW00-07 U (µg/L)	MW00-06 U (µg/L)	R10-M1 U (µg/L)	82-08 U (µg/L)	Mean U Predicted U (µg/L)
14997	41.1	06-Nov-43	10.4	10.6	10.6	8.3	10.0
15330	42.0	04-Oct-44	10.3	10.6	10.6	8.2	9.9
15695	43.0	04-Oct-45	10.2	10.6	10.6	8.2	9.9
16060	44.0	04-Oct-46	10.1	10.6	10.6	8.3	9.9
16425	45.0	04-Oct-47	9.9	10.6	10.6	8.2	9.8
16836	46.1	18-Nov-48	9.8	10.6	10.6	8.3	9.8
17206	47.1	23-Nov-49	9.8	10.6	10.6	8.3	9.8
17573	48.1	25-Nov-50	9.8	10.6	10.6	8.3	9.8
17851	48.9	30-Aug-51	9.7	10.6	10.6	8.3	9.8
18250	50.0	02-Oct-52	9.7	10.6	10.6	8.4	9.8

Table 13. Model-Predicted Uranium Concentrations at Selected Region 5 Wells

Model Time Day	Model Time Yr	Normalized Time Calendar	P92-06 U (µg/L)	P92-02 U (µg/L)	92-09 U (µg/L)	92-08 U (µg/L)	Mean U Predicted U (µg/L)
0	0.0	15-Oct-02	276.1	52.0	242.7	247.0	204.5
365	1.0	15-Oct-03	216.4	63.1	211.0	202.2	173.2
730	2.0	14-Oct-04	171.1	77.0	181.0	167.6	149.1
1067	2.9	16-Sep-05	140.7	75.9	156.4	173.7	136.7
1436	3.9	19-Sep-06	146.7	79.7	136.6	177.8	135.2
1825	5.0	14-Oct-07	177.1	87.7	124.2	172.0	140.3
2173	6.0	26-Sep-08	198.9	97.7	122.3	165.8	146.2
2264	6.2	26-Dec-08	205.5	99.9	123.4	163.4	148.1
2542	7.0	29-Sep-09	228.7	108.4	130.4	153.5	155.3
2911	8.0	03-Oct-10	268.9	121.2	144.0	156.3	172.6
3279	9.0	07-Oct-11	326.2	134.1	157.6	179.5	199.4
3650	10.0	12-Oct-12	389.7	144.4	168.2	224.4	231.7
4015	11.0	12-Oct-13	450.3	148.9	172.6	258.8	257.6
4384	12.0	15-Oct-14	481.3	145.5	171.2	266.1	266.0
4752	13.0	19-Oct-15	488.5	138.5	169.3	253.4	262.4
5121	14.0	22-Oct-16	462.4	130.9	171.9	226.2	247.8
5475	15.0	11-Oct-17	415.1	125.5	178.3	197.6	229.1
5490	15.0	25-Oct-17	413.1	124.9	178.7	196.5	228.3
5859	16.1	29-Oct-18	353.8	121.8	187.2	166.3	207.3
6227	17.1	02-Nov-19	288.5	118.8	196.6	134.6	184.6
6596	18.1	04-Nov-20	229.0	117.6	210.0	103.7	165.0
6965	19.1	08-Nov-21	180.6	123.8	226.3	75.7	151.6
7300	20.0	10-Oct-22	143.9	134.1	249.3	54.2	145.4
7611	20.9	17-Aug-23	116.3	150.8	270.8	38.8	144.2
7980	21.9	19-Aug-24	88.3	170.9	291.3	26.5	144.3
8439	23.1	22-Nov-25	62.2	188.3	299.0	17.4	141.7
8808	24.1	26-Nov-26	46.3	192.4	291.1	13.5	135.8
9125	25.0	09-Oct-27	37.0	189.2	271.7	11.6	127.4
9544	26.1	30-Nov-28	28.4	175.8	236.3	10.1	112.7
9821	26.9	04-Sep-29	23.9	161.3	208.7	9.7	100.9
10191	27.9	09-Sep-30	20.1	140.0	174.6	9.3	86.0
10562	28.9	15-Sep-31	17.5	116.0	139.7	9.1	70.6
10654	29.2	16-Dec-31	17.0	111.9	130.9	9.0	67.2
10747	29.4	18-Mar-32	16.4	103.7	123.2	9.0	63.1
10950	30.0	07-Oct-32	15.5	91.4	106.2	9.0	55.5
11302	31.0	24-Sep-33	14.2	73.0	80.8	8.9	44.2
11672	32.0	29-Sep-34	13.1	54.4	59.4	9.0	34.0
12042	33.0	04-Oct-35	12.4	39.3	42.8	8.9	25.8
12413	34.0	09-Oct-36	11.8	27.3	31.0	8.9	19.8
12782	35.0	13-Oct-37	11.4	19.9	23.0	8.9	15.8
13153	36.0	19-Oct-38	11.0	14.8	17.7	8.9	13.1
13523	37.0	24-Oct-39	10.8	11.2	14.5	8.9	11.3
13893	38.1	28-Oct-40	10.5	9.3	12.4	8.9	10.3
14262	39.1	01-Nov-41	10.3	8.2	11.1	8.9	9.6
14600	40.0	05-Oct-42	10.2	7.6	10.4	8.9	9.3
14997	41.1	06-Nov-43	10.0	7.2	9.8	8.9	9.0

Table 13 (continued). Model-Predicted Uranium Concentrations at Selected Region 5 Wells

Model Time Day	Model Time Yr	Normalized Time Calendar	P92-06 U (µg/L)	P92-02 U (µg/L)	92-09 U (µg/L)	92-08 U (µg/L)	Mean U Predicted U (µg/L)
15330	42.0	04-Oct-44	9.9	7.0	9.6	8.9	8.8
15695	43.0	04-Oct-45	9.7	6.9	9.3	8.9	8.7
16060	44.0	04-Oct-46	9.6	6.8	9.2	8.9	8.6
16425	45.0	04-Oct-47	9.4	6.8	9.1	8.9	8.5
16836	46.1	18-Nov-48	9.3	6.8	8.9	8.9	8.5
17206	47.1	23-Nov-49	9.2	6.8	8.9	8.8	8.4
17573	48.1	25-Nov-50	9.1	6.8	8.8	8.9	8.4
17851	48.9	30-Aug-51	9.1	6.7	8.8	8.8	8.4
18250	50.0	02-Oct-52	9.0	6.7	8.8	8.8	8.3

End of current text

Appendix C

Biomonitoring

1.0 Purpose and Scope

This appendix presents the biomonitoring approach for Operable Unit (OU) III to determine if likely ecological receptors have the potential to be affected adversely by contamination resulting from site remediation. The major constituent of concern for the biomonitoring effect is selenium, which displayed increasing concentrations in ground water and surface water samples during completion of surface cleanup activities. In addition to selenium, monitoring results of additional contaminants of concern (COCs) will be reviewed and compared to data in the remedial investigation to determine if their inclusion in future biomonitoring analysis is warranted. This decision will be made by the Biological Technical Assistance Group, which consists of the U.S. Fish and Wildlife Service (USFWS), the U.S. Environmental Protection Agency (EPA), the Utah Department of Environmental Quality (UDEQ), and the U.S. Department of Energy (DOE).

The main objective of the biomonitoring is to determine if selenium levels are present in environmental media at concentrations that could cause adverse effects on environmental receptors. As part of site remediation efforts, three “backwater” wetland areas were created on the former millsite adjacent to Montezuma Creek to attract wildlife to this area, which is planned for use as a park. Concerns are that increased selenium discharging to the surface along Montezuma Creek could accumulate in sediments to levels that may be harmful to wetland wildlife, including waterfowl that could nest in the area, as well as other species.

A multi-level sampling approach will be taken, with increasingly rigorous sampling requirements as simpler measures indicate. The simplest sampling requirements will apply unless results exceed established trigger levels that indicate more complex sampling is warranted. Updated wildlife surveys will be included as part of the baseline sampling effort. The most simplistic level of sampling will require sampling and analysis of surface water and sediment. Results of those analyses will determine the need for additional biota sampling. If the contaminant concentrations in surface water or sediment samples exceed established threshold values as described in Section 2.0, macroinvertebrate sampling will be required in addition to continued sediment and surface water sampling. If concentrations of selenium from analysis of macroinvertebrates exceed a threshold value (as discussed in Section 3.0), sampling of eggs from nesting birds will be required. Bird eggs would be examined for evidence of embryo deformity as well as undergo analysis for selenium content. This tiered approach prevents the unnecessary destruction of fauna of higher levels. If updated wildlife surveys for the area (see Section 4.0) result in the determination that other media (e.g., vegetation) represent likely exposure pathways, sampling of additional media can be added to the monitoring plan in the future. The need for sampling of additional media will be determined by the Biological Technical Assistance Group.

2.0 Collocated Surface Water and Sediment Sampling

In addition to the routine, semi-annual surface water sampling described in this section, annual collocated surface water and sediment sampling will take place in Wetlands 1, 2, and 3 and in the downstream sediment pond (Figure C−1). A stratified random sampling approach has been determined as the most appropriate and will provide the most representative data. It is anticipated that at least three strata will be identified at each wetland area based on the physical characteristics that exist at the time of sampling. One stratum will be located at the inflow for each area, where sediment is most likely to drop out because of changes in water velocity. Another possible stratum may be the low point (bottom) of each pond, and a third may be the bank areas where bird nesting is most likely. The Biological Technical Assistance Group will assist in designing the specific sampling approach, including strata identification and determination of the required numbers of samples.

Two surface water samples will be collected from each stratum prior to sediment sampling. Surface water sampling will take place only if water is flowing or ponded. Samples will be collected, filtered, and preserved in the field according to standard procedures and shipped to the laboratory for selenium analysis.

Appropriate sampling of other media will be performed for each stratum to evaluate the potential for bioaccumulation of selenium in receptors identified through the wildlife survey. Random subsamples of sediment should be collected and composited to provide a sample representative of that stratum. Composite sediment samples from each stratum will be submitted for laboratory analysis. Results will enable evaluation of variability within and between strata. Sediment should be collected from the upper 3 inches of the surface, which is the most likely area of selenium accumulation from surface water and the depth to which potential receptors will most likely be exposed.

Whole sediment samples will be digested for subsequent analysis. EPA Method 3051 (nitric acid microwave) is the digestion method to be used. This is not a complete digestion, but the method should extract any adsorbed or soluble forms of selenium. The analytical results should provide a conservative estimate of the amount of bioavailable selenium in the sediments (NAS 2003).

If the average total recoverable surface water concentration of selenium for a given stratum exceeds 5 micrograms per liter (µg/L) or average selenium sediment concentrations exceeds 4 milligrams per kilogram (mg/kg), macroinvertebrate sampling of that stratum will be required, as described in Section 3.0. Because recent analytical results of surface water samples have exceeded the 5 µg/L threshold, macroinvertebrate sampling will be conducted during the second year of biomonitoring (see schedule in Section 6.0).

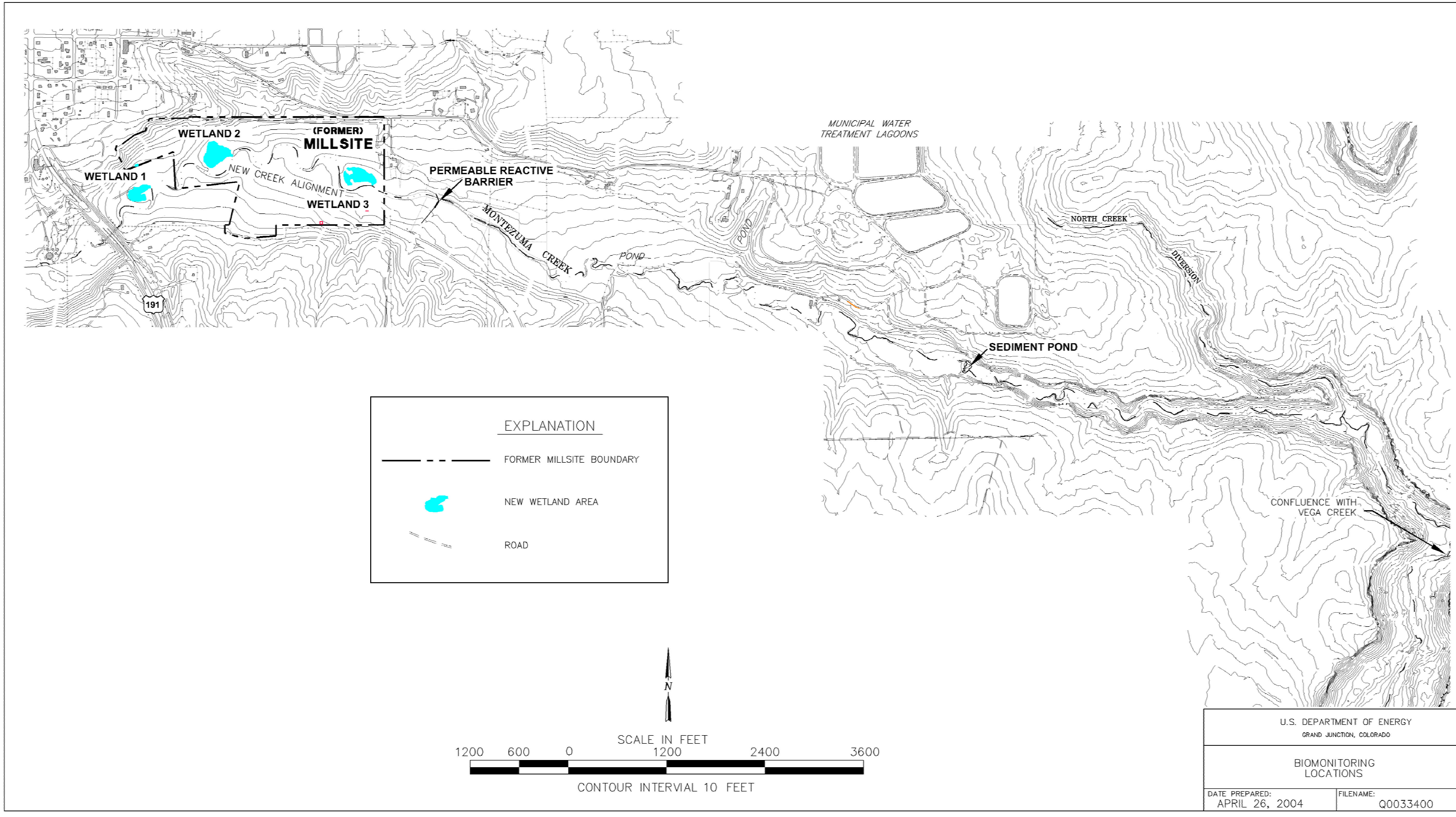

Figure C−1. Biomonitoring Locations

3.0 Macroinvertebrate Sampling

Macroinvertebrate sampling will be conducted in the second year of biomonitoring and during subsequent years, as warranted. During the initial biomonitoring sampling event when sampling strata are delineated, locations for macroinvertebrate sampling will also be determined. It is anticipated that one Hester-Dendy Multiple-Plate sampler will be placed in each strata at that time for subsequent macroinvertebrate sampling, if required. The American Society for Testing and Materials (ASTM) Standard E-1469-92 will be followed for sampler placement and sampling (see Appendix A for description of sampling procedure). Hester-Dendy samplers will yield water-column macroinvertebrates. In addition, a sediment grab sample will be collected with an Ekman Grab Sampler (ASTM Method D 4343; see Appendix A for description of sampling procedure) at the same location to obtain a sample of macroinvertebrates inhabiting soft sediments. Invertebrates from each location will be composited. ASTM invertebrate sampling procedures recommend a minimum of three replicate analyses from each sampling location. Composites will be split into three samples if enough sample material is recovered. Samples will be submitted to a laboratory for selenium analysis. If concentrations of selenium in macroinvertebrate tissue for any stratum exceed 7 mg/kg (http://sacramento.fws.gov/ec/GBP/Table1.htm), the Biological Technical Assistance Group will be consulted to determine the need for sampling of avian eggs. If egg sampling is required, the sampling and analysis approach will be determined at that time.

4.0 Wildlife Surveys

Surface conditions at the site have changed significantly since the last wildlife surveys were conducted in conjunction with the remedial investigation for the site. Species that were the subject of previous surveys included spotted bat (state sensitive species), northern goshawk (state sensitive), peregrine falcon (previously endangered), and the southwestern willow flycatcher (endangered). No sensitive or endangered species were identified at the site during previous surveys, though potential habitat does exist in the area. The last wildlife surveys were completed during the 1995 and 1996 field seasons. A new survey of the site vicinity is planned because of the changed nature of the site, and the disruption and restoration activities that have occurred. The same sensitive and endangered species identified in previous surveys will be targeted in particular, but other wildlife using the area will also be noted to enable selection of the most appropriate ecological receptors and media for estimation of potential site risks.

5.0 Biomonitoring Duration

It is anticipated that biomonitoring will only be required for the near term until it can be determined whether or not the wetland areas are accumulating selenium to a degree that may be harmful to ecological receptors. If no consistent increases in selenium are observed in water or sediment and if biota concentrations remain below trigger levels (if biota sampling is required) for 3 consecutive years, biomonitoring can be discontinued. If, however, biota sampling results indicate that selenium is present at concentrations that are having a negative impact on ecological receptors, some type of corrective action will be necessary (e.g., dredging wetlands, relocating wetlands, etc.). The appropriate type of corrective action will be determined in consultation with the Biological Technical Assistance Group.

6.0 Schedule

Table C−1 contains a schedule of biomonitoring activities.

Table C−1. Schedule of Biomonitoring Activities

Biomonitoring Task	Fiscal Year 2004	Fiscal Year 2005	Fiscal Year 2006	Out Years
Soil/sediment/surface water sampling	X	X	X	X
Wildlife survey		X		
Macroinvertebrate sampling		X	T	T
Other media (TBD)			T	T

TBD=to be determined by the Biological Technical Assistance Group.
T= only if trigger level exceeded.