DOE/EA–1313
Rev. 0

Office of Legacy Management

Environmental Assessment of Ground Water Compliance at the Monument Valley, Arizona, Uranium Mill Tailings Site

Final

March 2005

U.S. Department of Energy

Office of Legacy Management

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

Finding of No Significant Impact

Ground Water Compliance at the Monument Valley, Arizona, Uranium Mill Tailings Site

U.S. DEPARTMENT OF ENERGY
FINDING OF NO SIGNIFICANT IMPACT

FINAL ENVIRONMENTAL ASSESSMENT: The *Environmental Assessment of Ground Water Compliance at the Monument Valley, Arizona, Uranium Mill Tailings Site* (DOE/EA 1313) (attached) assesses two alternatives: the proposed actions for pilot studies and ground water compliance at the site, and the no action alternative. This site is one of four Uranium Mill Tailings Radiation Control Act (UMTRCA) sites located on Navajo Nation tribal lands. The proposed actions will minimize risk to human health and the environment and will require both administrative and field actions, including implementation of institutional controls and grazing management.

The purpose of DOE's actions is to protect human health and the environment, as required by U.S. Environmental Protection Agency ground water standards defined in Title 40 *Code of Federal Regulations* (CFR) Part 192. Ground water in two aquifers (alluvial and De Chelly) at the Monument Valley site is contaminated with residual radioactive materials from historical processing of uranium ore.

The Environmental Assessment was tiered from the *Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project* (PEIS) (DOE/EIS 0198), which presents a step-by-step approach for determining the site-specific compliance strategy for this site. Tiering from the PEIS is consistent with the concept of tiering described in the Council on Environmental Quality National Environmental Policy Act (NEPA) regulations (40 CFR 1508.28).

The Environmental Assessment analyzes the relevant environmental issues at the Monument Valley site, which include ground water, surface water, human health, air quality, wildlife/endangered species, vegetation, soils, cultural resources, visual resources, socioeconomics, transportation, and environmental justice considerations.

FINDING: On the basis of the Environmental Assessment, which analyzes the relevant environmental issues and the concerns of stakeholders, DOE finds that no significant impact would result from implementing the proposed pilot studies and compliance strategies. This Finding of No Significant Impact (FONSI) is pursuant to NEPA, 42 *U.S. Code* 4321 et seq.; the Council on Environmental Quality Regulations for Implementing NEPA, 40 CFR 1500; and the DOE NEPA Implementing Procedures, 10 CFR 1021. The proposed action does not constitute a major federal action that would significantly affect the quality of the environment within the mandate of NEPA. Therefore, implementation of the proposed action does not require the preparation of an environmental impact statement.

Signed in Grand Junction, Colorado, this 22 day of March, 2005.

R.M. Plieness
Office of Legacy Management

PUBLIC AVAILABILITY OF EA AND FONSI: Copies of the EA and FONSI are available for review at the Navajo UMTRA Office (Window Rock, AZ), the affected Navajo Chapters, local libraries, and Dine College. To obtain copies of the EA and FONSI, please contact:

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March 2005

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

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Acronyms and Abbreviations

CFR	Code of Federal Regulations
cm	centimeter
DOE	U.S. Department of Energy
EA	environmental assessment
EPR	enhanced passive remediation
EPA	U.S. Environmental Protection Agency
ft	foot
MCL	maximum concentration limit (established in 40 CFR 192)
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MNA	monitored natural attenuation
PEIS	Programmatic Environmental Impact Statement
SOWP	site observational work plan
UMTRA	Uranium Mill Tailings Remedial Action (Project)
UMTRCA	Uranium Mill Tailings Radiation Control Act

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Executive Summary

Pursuant to the National Environmental Policy Act (NEPA), the U.S. Department of Energy (DOE) has prepared this environmental assessment (EA) for pilot studies and ground water compliance strategies (remediation alternatives) at the Monument Valley uranium mill tailings site. The site, which is one of 24 former uranium-ore processing sites identified in the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) for potential remedial action, is located in northern Arizona within the Navajo Nation. UMTRCA was passed to minimize potential human health and ecological risks from exposure to low-level radioactive contamination, including risks associated with ground water.

The U.S. Environmental Protection Agency (EPA) established regulations at Title 40 *Code of Federal Regulations* Part 192, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings," to implement UMTRCA. The regulations include numerical standards for remediation of contaminated surface materials (soils and buildings) and ground water at UMTRCA sites. Contaminated surface materials at the site were removed in 1994 and disposed of at the Mexican Hat, Utah, disposal cell. However, ground water in two of the three aquifers at the site is believed to be contaminated as a result of historical uranium-ore processing.

The aquifers beneath the Monument Valley site are the alluvial (uppermost) aquifer, the underlying Shinarump aquifer, and the deeper De Chelly aquifer. The alluvial aquifer is the focus of this EA. Approximately 1,660 acre-feet (540 million gallons) of ground water may be contaminated in the alluvial aquifer at levels that could pose an unacceptable risk to human health if the water were used as a long-term source of drinking water. The contaminants of concern in this aquifer are nitrate, sulfate, and uranium. Nitrate is the primary contaminant of concern. Uranium contamination is not believed to be widespread; however, elevated concentrations have been detected recently in deeper portions of the aquifer. No EPA ground water standards have been established under 40 CFR 192 for sulfate.

DOE believes that soils beneath the surface of the historical tailings pile locations (subpile soils) may be a continuing source of ammonium and nitrate contamination to the alluvial aquifer. On the basis of pilot studies conducted before 2002, DOE concluded that phytoremediation (uptake of contaminants by plants) would be a viable option for remediating nitrate and sulfate in the shallow areas of the alluvial aquifer and the subpile soils area (DOE 2002). This option is also consistent with revegetation and land management goals at the site. However, DOE also determined that additional pilot studies should be conducted prior to final selection of the compliance strategy for nitrate and sulfate in the alluvial aquifer. The goal of the proposed pilot studies is to gather additional information to support the compliance strategies proposed in this EA for the alluvial aquifer.

In accordance with DOE's NEPA regulations, the proposed additional pilot studies would likely meet the criteria for categorical exclusion and would normally be completed before an EA is initiated. However, the Navajo Nation has required that an EA be completed to address the entire scope of DOE's proposal, including the pilot studies and proposed compliance strategies. Navajo officials have determined that this approach is necessary to demonstrate full disclosure to local residents who may be affected by DOE's actions. Consequently, the proposed compliance

strategies for the alluvial aquifer in this EA are contingent upon the results of the proposed pilot studies, which are anticipated to be completed in 2 to 3 years. Assuming the pilot studies are successful, DOE is proposing the following compliance strategies for the three areas of concern in the alluvial aquifer:

- Subpile soils—passive remediation (for ammonium and nitrate)
- Shallow alluvial aquifer—passive remediation (for nitrate and sulfate)
- Deeper alluvial aquifer—passive or active remediation (land farming) for all contaminants.

If the pilot studies indicate that the proposed compliance strategies for the alluvial aquifer would not comply with EPA standards and remediation goals, additional NEPA assessment and documentation would likely be necessary.

Ground water in the Shinarump aquifer, which directly underlies the alluvial aquifer, has slightly elevated concentrations of naturally occurring constituents. These constituents do not appear to be site-related, and concentrations are close to background levels; none exceed EPA ground water standards or a Navajo Nation goal. Therefore, no pilot studies or compliance strategy are proposed for this aquifer, and only limited discussion of the Shinarump is provided in this EA.

Evidence indicates that the De Chelly aquifer, the deepest of the three aquifers, has levels of uranium slightly above the EPA standard in one isolated location, which is discussed further in Section 1.4 of this EA. Although uranium concentration at this location is decreasing with time, DOE is proposing passive remediation as a compliance strategy because the uranium appears to be site-related. However, no pilot studies are proposed for this aquifer. Therefore, the pilot studies would not change the proposed compliance strategy for the De Chelly aquifer, and the need for additional NEPA documentation is not anticipated.

1.0 Introduction

The U.S. Department of Energy (DOE) is proposing ground water compliance strategies for the alluvial and De Chelly aquifers at the Monument Valley, Arizona, Uranium Mill Tailings Radiation Control Act (UMTRCA) site. Although a compliance strategy is proposed for the De Chelly aquifer because of an isolated area of contamination, the focus of this environmental assessment (EA) is the alluvial (uppermost) aquifer.[1] Pilot studies will be conducted for only the alluvial aquifer prior to implementation of the proposed compliance strategies.

1.1 Background

UMTRCA (42 *United States Code* 4321 et seq.) was enacted to control and mitigate risks to human health and the environment from residual radioactive materials that resulted from processing uranium ore. UMTRCA authorized DOE to perform remedial action at 24 inactive uranium-ore processing sites. The Monument Valley site is one of four former processing sites located within the Navajo Nation.

U.S. Environmental Protection Agency (EPA) regulations in Title 40 *Code of Federal Regulations* (CFR) Part 192, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings," were established to implement the requirements of UMTRCA. The regulations establish procedures and numerical standards for remediation of residual radioactive materials in land, buildings, and ground water. UMTRCA defines residual radioactive materials as "waste in the form of tailings or other material that is present as a result of processing uranium ores at any designated processing site, and other waste at a processing site which relates to such processing…." The regulations also require that selection and performance of remedial action be completed with full participation of states, in consultation with affected tribes, and with the concurrence of the U.S. Nuclear Regulatory Commission.

DOE completed the *Environmental Assessment of Remedial Action at the Monument Valley Uranium Mill Tailings Site, Monument Valley, Arizona* (DOE 1989) before conducting surface remediation of the land and mill tailings in 1992. That EA described the affected environment, including surface water and ground water, and the effects associated with removal of tailings and debris at the Monument Valley site. Surface materials contaminated with residual radioactive materials were disposed of at the Mexican Hat, Utah, disposal cell. Surface remediation was completed in 1994.

After the source of ground water contamination (i.e., the tailings pile) is removed, EPA regulations require that the site be evaluated to determine if contaminant concentrations in ground water of the uppermost aquifer comply with EPA ground water standards in 40 CFR 192. The *Final Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project* (PEIS) (DOE 1996b) provides a general discussion of ground water contamination at the 24 former processing sites. The PEIS also provides a

[1] The uppermost aquifer consists mainly of fine-grained to medium-grained windblown sand and is referred to as the alluvial aquifer in this EA.

framework for selecting site-specific ground water compliance strategies that comply with EPA regulations.

The regulations outline several criteria for determining compliance with ground water standards:

- A characterization/monitoring program to determine background ground water quality.
- Identification of residual radioactive materials present and whether concentrations of these constituents exceed background or maximum concentration limits established in 40 CFR 192 (Table 1 to Subpart A).
- The extent of contamination as a result of residual radioactive materials.
- Potential risks to human health and the environment.

To comply with these criteria, DOE completed the *Final Site Observational Work Plan for the UMTRA Project Site at Monument Valley, Arizona* (SOWP) (DOE 1999a), a site evaluation and findings, and an update of the original Baseline Risk Assessment (DOE 1996a). The Baseline Risk Assessment evaluated potential human health and ecological risks that could result from exposure to residual radioactive materials. Results of the fieldwork were completed in 1997 and 1998, and the recommended compliance strategies, which are the basis for the proposed action in this EA, are documented in the final SOWP. Project documents that provided guidance for the SOWP include the *UMTRA Ground Water Management Action Process (MAP) Document* (DOE 1999b) and the *Technical Approach to Groundwater Restoration* (DOE 1993).

To comply with EPA regulations concerning consultation with tribes, DOE entered into a cooperative agreement with the Navajo Nation and has held numerous meetings over the past several years with representatives of the Navajo Nation, including Navajo Uranium Mill Tailings Remedial Action (UMTRA) Project, Navajo EPA, and Navajo Water Code Administration, to address concerns at the Monument Valley site. In addition, data, documents, and work plans, including the SOWP, were provided to the Navajo Nation for their review and comment. In June 1998, DOE received comments from the Navajo Nation and completed the SOWP. The Navajo Nation provided DOE additional comments on the final SOWP on October 7, 1999.

To minimize risks to potential water users in the short term, DOE met with Navajo Nation representatives on September 21, 1999, and agreed to install a water supply system to serve the Monument Valley area. The Navajo Tribal Utility Authority, in cooperation with the Bureau of Indian Affairs, prepared the appropriate National Environmental Policy Act (NEPA) documentation for the alternate water supply. The water line and infrastructure were completed in September 2003.

On October 7, 1999, comments were received from the Navajo Nation on the draft Ground Water Compliance Action Plan, which would implement the proposed action identified in the draft version of this EA that was originally completed in September 1999. On October 25, 1999, DOE announced the availability of the draft *Environmental Assessment of Ground Water Compliance at the Monument Valley Uranium Mill Tailings Site*. Comments were received from the Navajo Nation on December 8, 1999. By letter dated December 20, 1999, from DOE to the Navajo Nation, DOE suspended completion of the EA pending resolution of comments. On February 24, 2000, DOE met with representatives of the Navajo Nation at Mexican Hat, Utah, to discuss the feasibility of implementing phytoremediation and land farming (see Section 3.1) to remediate ground water. In addition, DOE conducted an alternatives evaluation (DOE 2000a) to ensure that all feasible alternatives to remediate ground water had been considered.

In June 2000, DOE and the Navajo Nation agreed to conduct additional pilot studies focusing on remediation options for nitrate in the alluvial aquifer prior to completing this EA. In July 2000, DOE completed an Environmental Checklist (DOE 2000b) to conduct these studies, which included grazing management, fencing, and land farming. On August 7, 2000, the DOE-NEPA Compliance Officer determined that the pilot studies met the criteria for categorical exclusion. Pilot studies for the De Chelly aquifer were not deemed necessary. DOE and Navajo UMTRA representatives held field meetings on September 17, 2000, and May 8, 2003, at Monument Valley with local residents, stakeholders, Navajo Nation agency officials, and Indian Health Services to discuss the pilot studies and potential related actions. These actions could include a grazing management plan, access notifications, and implementation of institutional controls.

At a meeting between DOE and the Navajo Nation on November 12, 2003, in Durango, Colorado, the Navajo Nation agreed to move forward with the pilot studies as described in Section 3.2 of this EA. Results of the proposed pilot studies would be the basis for remediation of the alluvial aquifer and subpile soils.

In November 2004, DOE issued the draft EA for public comment. Upon request of the Navajo Nation and stakeholders, DOE extended the public comment period through December 30, 2004. On January 5, 2005, three comments were received from Navajo UMTRA, and 11 comments were received from Navajo EPA. The comments and responses are attached as Appendix A to this EA. No other comments were received from federal or state agencies or public stakeholders.

In accordance with DOE's NEPA policy and regulations, the proposed additional pilot studies described in Section 3.2 would normally be completed before an EA is begun and would likely meet the criteria for categorical exclusion. However, the Navajo Nation has required that an EA be completed to address the entire scope of DOE's proposal, including the pilot studies and proposed compliance strategies. This would allow the Navajo Nation to consider access requirements, institutional controls, and other actions comprehensively and simultaneously. If the pilot studies indicate that the proposed compliance strategies for the alluvial aquifer would not comply with EPA standards and remediation goal, additional NEPA assessment and documentation may be necessary.

DOE would perform remedial action at the Monument Valley site in compliance with EPA and Navajo Nation regulations, according to the Cooperative Agreement, and with the concurrence of the U.S. Nuclear Regulatory Commission.

1.2 Site Description

The Monument Valley site is within in the Navajo Nation in northeastern Arizona, about 15 miles south of Mexican Hat, Utah (Figures 1 and 2). The site is on the west side of Cane Valley

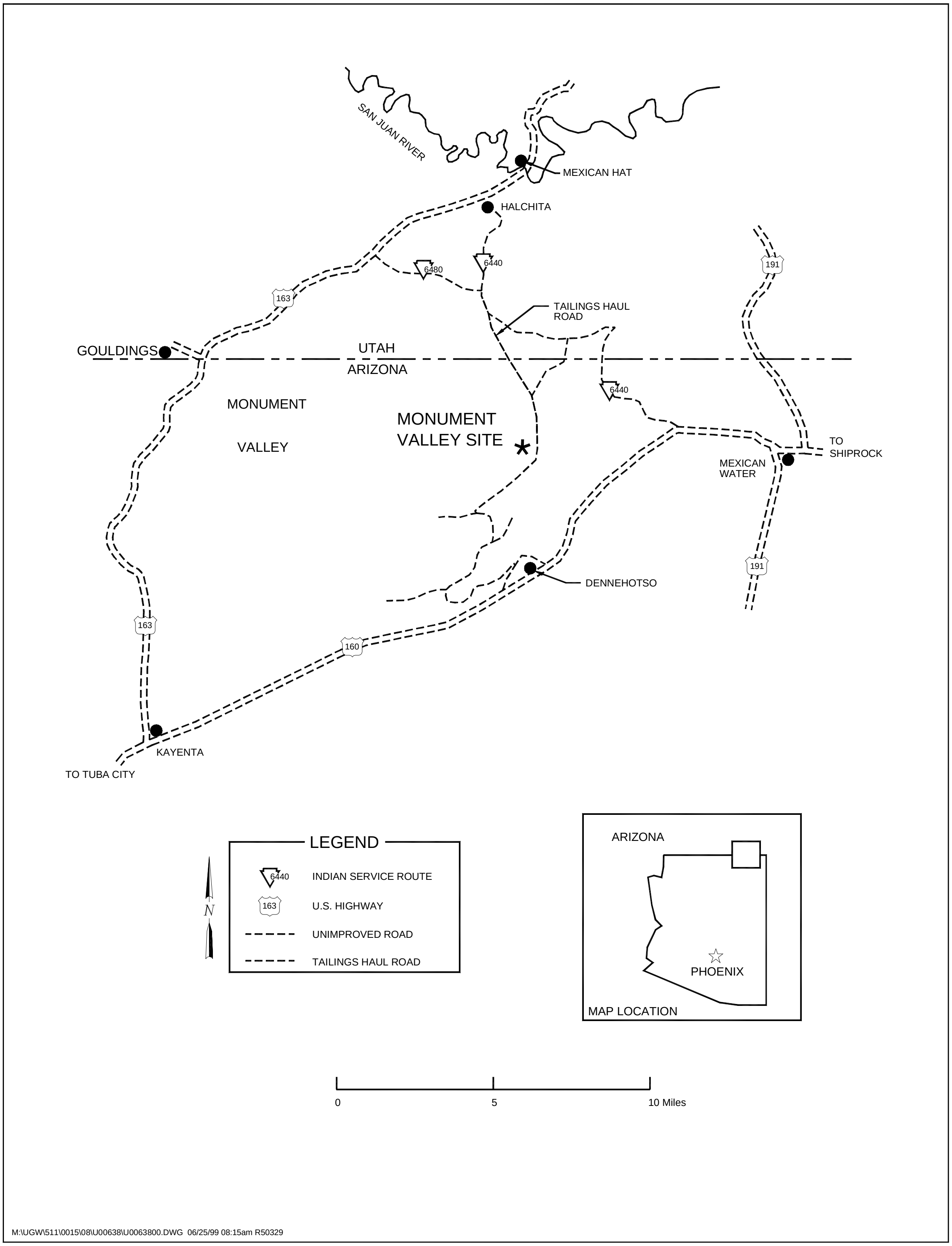

Figure 1. Location of the Monument Valley Site

Modified from the USGS 15' Dennehotso, Arizona, topographic map, 1952 ed.

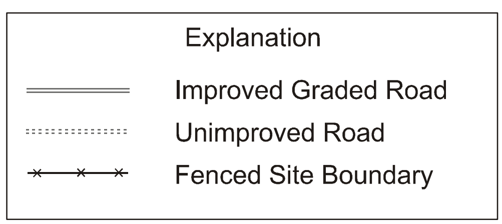

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Figure 2. Regional Setting of the Monument Valley Site

Wash at an elevation of approximately 4,800 feet (ft) above sea level and is bordered on the west by Yazzie Mesa and on the east by Comb Ridge. The climate is semiarid, and the site receives approximately 6.4 inches of precipitation annually. May and June are typically the driest months; July, August, and December through February are the wettest months.

1.3 Site History

Uranium was first discovered in the Monument Valley area approximately one-half mile west of the former millsite in 1942. A total of 767,166 tons of uranium and vanadium ore was mined from the original deposit between 1943 and 1968, when the mill closed and the lease with the Navajo Nation expired. Most structures were removed shortly thereafter.

From 1955 until 1964, ore at the site was processed by mechanical milling using an upgrader, which crushed the ore and separated it by grain size. During that period the only chemical used was minor amounts of flocculent (a substance used to consolidate particles within a liquid). The finer-grained material, which was higher in uranium content, was shipped to other mills for chemical processing. Coarser-grained materials were stored on site in the “old tailings pile.” Some ground water contamination may have resulted from water draining through the tailings piles during that period.

From 1964 until 1968, batch leaching and heap leaching were used to process an estimated 1.1 million tons of tailings and low-grade ore at the site. In the batch-leaching process, sandy tailings were placed in lined steel tanks, and uranium and vanadium were leached by an upward flow of sulfuric acid solution. Heap leaching consisted of placing crushed, low-grade ore on polyethylene sheeting and percolating a sulfuric acid solution through the ore. Both heap-leaching and batch-leaching operations used ammonia and quicklime (calcium oxide) to produce a bulk precipitate of concentrated uranium and vanadium. Chemical solutions used in ore processing are believed to have been discharged to the “new tailings pile.” The new tailings pile contained both sandy tailings and processing solutions. An evaporation pond was on the east side of the new tailings pile. The purpose of the evaporation pond is unknown, but it may have been used to retain seepage from the new tailings pile.

The former sources of ground water contamination at the site (Figure 3) include (1) the old tailings pile and heap-leach area, (2) the new tailings pile, and (3) the evaporation pond. Surface remediation at the site took place from 1992 through 1994 and resulted in the removal of these source materials and other site-related contamination. However, analysis of subpile soil samples (samples collected from beneath the “footprint” of the former tailings piles) indicates these soils may be a continuing source of ground water contamination. Ammonium in the subpile soil appears to be contributing to nitrate contamination in ground water.

1.4 Overview of Contamination

Three aquifers in the Monument Valley area were studied and discussed in the SOWP (DOE 1999a): the alluvial (uppermost), Shinarump, and the De Chelly (the deepest of the three aquifers). Of these, only the alluvial and De Chelly showed evidence of site-related

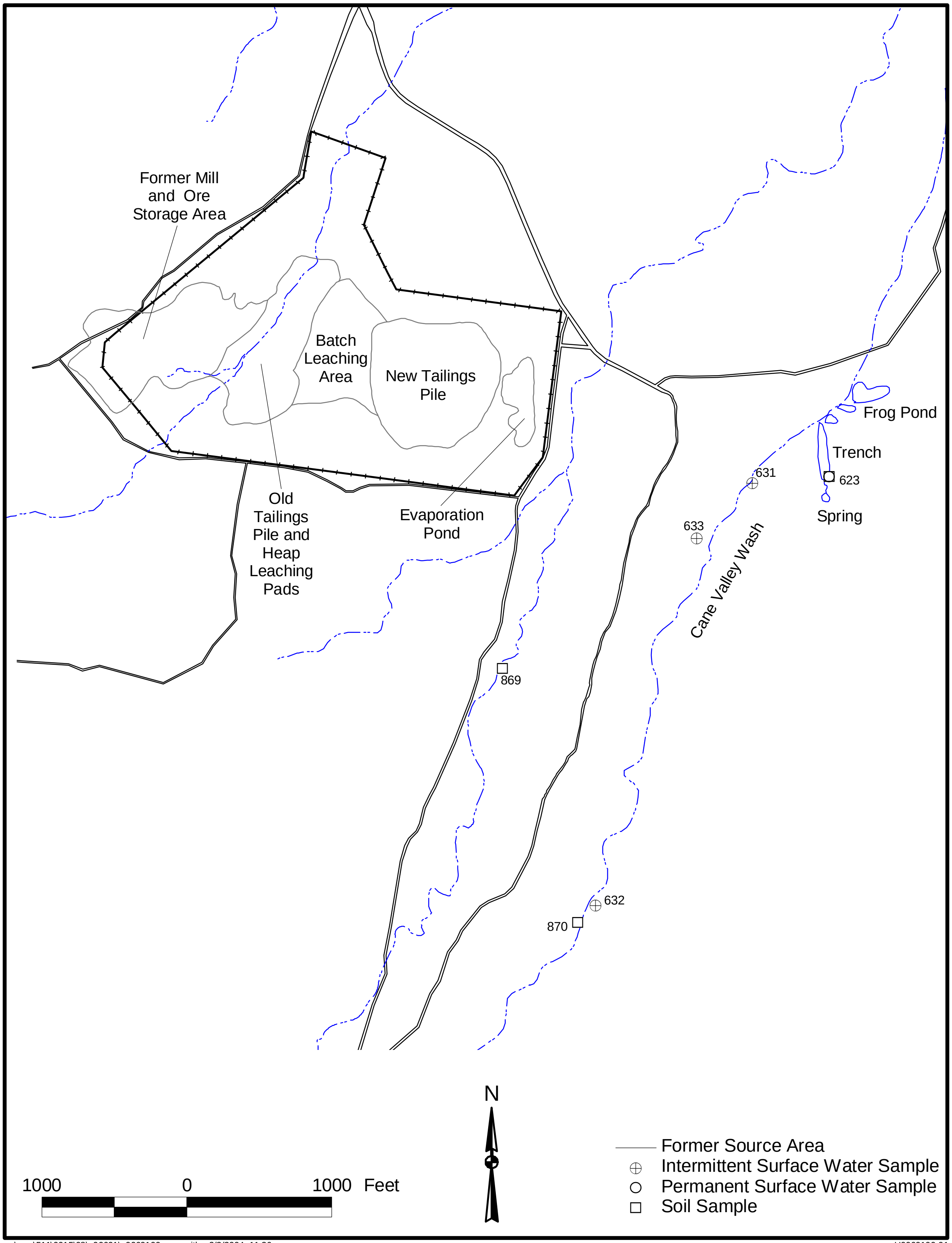


Figure 3. Sources of Ground Water Contamination; Surface Water and Soil Sample Locations

contamination. The Shinarump aquifer, which directly underlies the alluvial aquifer and is above the De Chelly, has slightly elevated concentrations of naturally occurring constituents. Concentrations of constituents in the Shinarump are close to background levels, and none exceed EPA ground water standards or the Navajo Nation remediation goal. Studies conducted for this aquifer show no evidence of site-related contamination. The Shinarump has a slightly upward hydraulic gradient and may provide some recharge to the alluvial aquifer. Therefore, it is unlikely that contaminants in the alluvial aquifer would enter the Shinarump. The Moenkopi Formation underlies the Shinarump and forms an aquitard between the De Chelly and Shinarump aquifers. Because site-related contamination has not affected the Shinarump aquifer, and the proposed action will not affect the Shinarump, only the alluvial and De Chelly aquifers are addressed in this EA.

2.0 Purpose and Need for Action

Through UMTRCA, Congress directed EPA to establish standards that protect human health and the environment from milling-related contaminants in soil and ground water at designated uranium-ore processing sites. EPA's ground water standards are codified at 40 CFR 192, Table 1 to Subpart A. Past uranium-ore processing activities at the Monument Valley site have resulted in ground water contamination in the alluvial and De Chelly aquifers that exceeds EPA standards in 40 CFR 192. An estimated 1,660 acre-feet (540 million gallons) of alluvial ground water are contaminated with sulfate, nitrate, and uranium; contaminants are present in both the shallow and deeper portions of the aquifer. Of these, nitrate is the primary contaminant of concern (DOE 1999a). A small, isolated area of the De Chelly aquifer is contaminated with uranium, although the concentration is only slightly above the EPA standard. DOE is proposing compliance strategies that are protective of potential future uses of ground water in both aquifers.

3.0 Proposed Action and Alternatives

DOE is proposing to implement ground water compliance strategies, which include institutional controls and monitoring, for the alluvial and De Chelly aquifers at the Monument Valley site. The proposed compliance strategies are consistent with the PEIS (DOE 1996b), which provides options (compliance strategies) for complying with EPA's ground water standards and assesses in general terms the effects associated with each compliance strategy.

Before implementing compliance strategies, DOE would conduct pilot studies for the alluvial aquifer to determine the feasibility of using passive remediation or a combination of passive remediation and land farming to comply with EPA standards for nitrate and uranium and the Navajo Nation remediation goal for sulfate. The studies would address three aspects of the aquifer: subpile soils, shallow alluvial ground water, and deeper alluvial ground water. For discussion in this EA, shallow alluvial ground water is defined as ground water where the depth to the water table is less than 50 ft below land surface, and deeper alluvial ground water is where the water table is generally more than 50 ft below land surface. Results of the pilot studies would be used to implement the proposed compliance strategies described in this EA. The use of pilot studies is consistent with the intent of an observational approach as described in the PEIS. No pilot studies would be conducted for the De Chelly aquifer. Table 1 shows the projected schedule for completing the pilot studies and implementing the proposed actions.

Table 1. Conceptual Implementation of Pilot Studies and Proposed Compliance Strategies

Pilot Study Components	GCAP[a] Components	Full Site Remediation Components	LTS&M[b] Components	Confirmation Report
Pilot Studies (2005 to 2008) →	GCAP (2008 to 2009) →	Remediation (2009 to 2029) →	LTS&M (2030 to 2040) →	Confirmation Report (2040)
• Phytoremediation of subpile soils • Investigate attenuation processes • Evaluate enhancement methods • Evaluate land farming options	• Draft GCAP • Final GCAP • U.S. Nuclear Regulatory Commission and Navajo Nation concurrence	• Remediation of alluvial aquifer • Construction of active (land farming) system for deeper aquifer if needed • Natural flushing of De Chelly aquifer	• Continue remediation until standards are met • Operations and maintenance	• Document method of meeting standards

Notes: Time periods and components are estimates and may change because of funding constraints, technical considerations, or completion of the NEPA process.
[a]GCAP = Ground Water Compliance Action Plan
[b]LTS&M = long-term surveillance & maintenance activities; LTS&M components refer only to ground water remediation activities. LTS&M at the site will continue for 200 to 1,000 years.

Section 3.1 addresses the background and recommendations of the previous pilot studies. Section 3.2 addresses the proposed pilot study objectives and actions. Section 3.3 discusses the proposed pilot studies schedule and location. Section 3.4 addresses the proposed compliance strategies for the alluvial and De Chelly aquifers in detail, based on the anticipated outcome of the proposed pilot studies. Section 3.5 discusses alternatives that were considered but eliminated. Section 3.6 addresses the no action alternative.

3.1 Pilot Studies: Background and Recommendations

3.1.1 Background

Previous pilot studies conducted at the site have focused on passive remediation methods, including both natural and enhanced phytoremediation (see textbox) for the subpile soils and shallow alluvial ground water. No pilot studies were conducted for deeper portions of the alluvial aquifer or for the De Chelly aquifer. A pilot study is a trial study (or experiment) to evaluate a feasible remedy before final remedial actions are selected and implemented. In this case, the pilot studies were used to evaluate methods of reducing concentrations of nitrate in the alluvial aquifer. DOE completed the *Monument Valley Ground Water Remediation Work Plan: Native Plant Farming and Phytoremediation Pilot Study* (DOE 1998), which concluded that phytoremediation is a viable option for reducing ammonium and nitrate concentrations in the subpile soils and the shallow portions of the alluvial aquifer; this option is consistent with revegetation and land management goals for the site.

> **Natural Phytoremediation** relies on the deep roots of existing plants in their natural environment to uptake water and nutrients that are essential for plant growth and health. Nitrate and ammonium are among those nutrients that enhance plant growth.
> **Enhanced Phytoremediation** involves human intervention to speed up or augment the phytoremediation process. This may include planting additional plants, watering and fertilizing plants, and managing land uses (e.g., grazing) until the phreatophyte plants can survive under natural conditions.
> **Land Farming** is a form of active remediation whereby ground water is pumped from deeper portions of the alluvial aquifer and used to irrigate plantings in the phytoremediation area.

Phytoremediation uses phreatophytes (deep-rooted plants that extract water and nutrients from a permanent ground water supply) to remove nitrate from the alluvial aquifer and ammonium (which converts to nitrogen) from subpile soils.

Two native phreatophyte populations grow over the plume area: black greasewood (*Sarcobatus vermiculatus*) and fourwing saltbush (*Atriplex canescens*). Greasewood is a phreatophyte that requires a permanent ground water supply and has roots that can reach water as deep as 59 ft below ground surface (Nichols 1993). Saltbush is a shrub that takes advantage of ground water when present but can tolerate periods of low water availability. The rooting depth of saltbush may exceed 26 ft (Foxx et al. 1984). Both populations are currently in poor condition from heavy grazing and possibly from herbicide applications.

3.1.2 Recommendations

This effort, and follow-up studies conducted independently by the University of Arizona's Environmental Research Laboratory, DOE's collaborator on the pilot studies, led to the following additional conclusions and recommendations.

Subpile Soils

> **Natural Attenuation** is a term used to describe a variety of natural physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or ground water (EPA 1999).
>
> **Natural Flushing** is the regulatory term used to describe all the natural attenuation processes.

- The initial pilot studies show that passive remediation, including phytoremediation and natural attenuation processes, are helping to achieve remediation objectives at the Monument Valley site and that enhancement of these processes can accelerate reduction of ammonium and nitrate concentrations.
- Investigations at the plume source, the subpile soil, show that an irrigated planting of fourwing saltbush is extracting ammonium and nitrate from the subpile soil faster than anticipated and is preventing recharge and leaching of nitrogen into the alluvial aquifer.
- Much of the nitrate removal can be attributed to microbial (natural attenuation) processes.

- An evaluation should be completed for microbial processes and enhancements and for expansion of the irrigated planting as the remedy for the remainder of the subpile soil ammonium.

Sampling methods for the subpile soils will be similar to those described in the 2002 phytoremediation study (DOE 2002); methods are also described in detail in the work plan for the planned phytoremediation study (DOE 2004).

Shallow Ground Water

- Small-plot studies show that two native phreatophytic shrubs—black greasewood and fourwing saltbush—where rooted in shallow ground water could remove much of the nitrate plume if grazing is restricted to allow for plant growth.

- The small-plot studies also show that plantings of fourwing saltbush in shallow ground water areas, where the surface was cleared of vegetation during surface remediation, could enhance natural phytoremediation if grazing is restricted.

3.2 Proposed Actions for Pilot Studies

This section presents a framework (Figure 4) for using results of the proposed additional pilot studies to select methods to remediate nitrate and sulfate in subpile soils and shallow alluvial ground water at the Monument Valley site. The framework assumes that (1) natural attenuation processes occur at the site and (2) guidelines stating that the contribution of natural attenuation to attaining remediation goals are acceptable. Both monitored natural attenuation (MNA) and enhanced passive remediation (EPR) methods are key components of the framework. A large-scale pilot study is necessary to evaluate the feasibility of using a combination of phytoremediation and other natural and enhanced passive remediation options for the shallow ground water plume.

The proposed additional pilot studies have the following objectives:

- Estimate the total capacity of natural chemical and biological processes that are reducing concentrations of ground water contaminants and their source at the site.
- Investigate methods to enhance and sustain attenuation processes that could be implemented if the total capacity of natural processes is inadequate.
- Demonstrate methods for (1) characterizing attenuation rates, (2) verifying short-term results, and (3) monitoring performance of natural attenuation processes and enhancements.

- Evaluate land farming as an active remediation option if natural and enhanced attenuation processes are both inadequate.

EPA defines monitored natural attenuation as “the reliance on natural processes to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods” (EPA 1999). For MNA to be a viable approach at the Monument Valley site, the rate of contaminant removal from ground water by natural processes must exceed the rate of contaminant loading from the subpile soil source and natural sources.

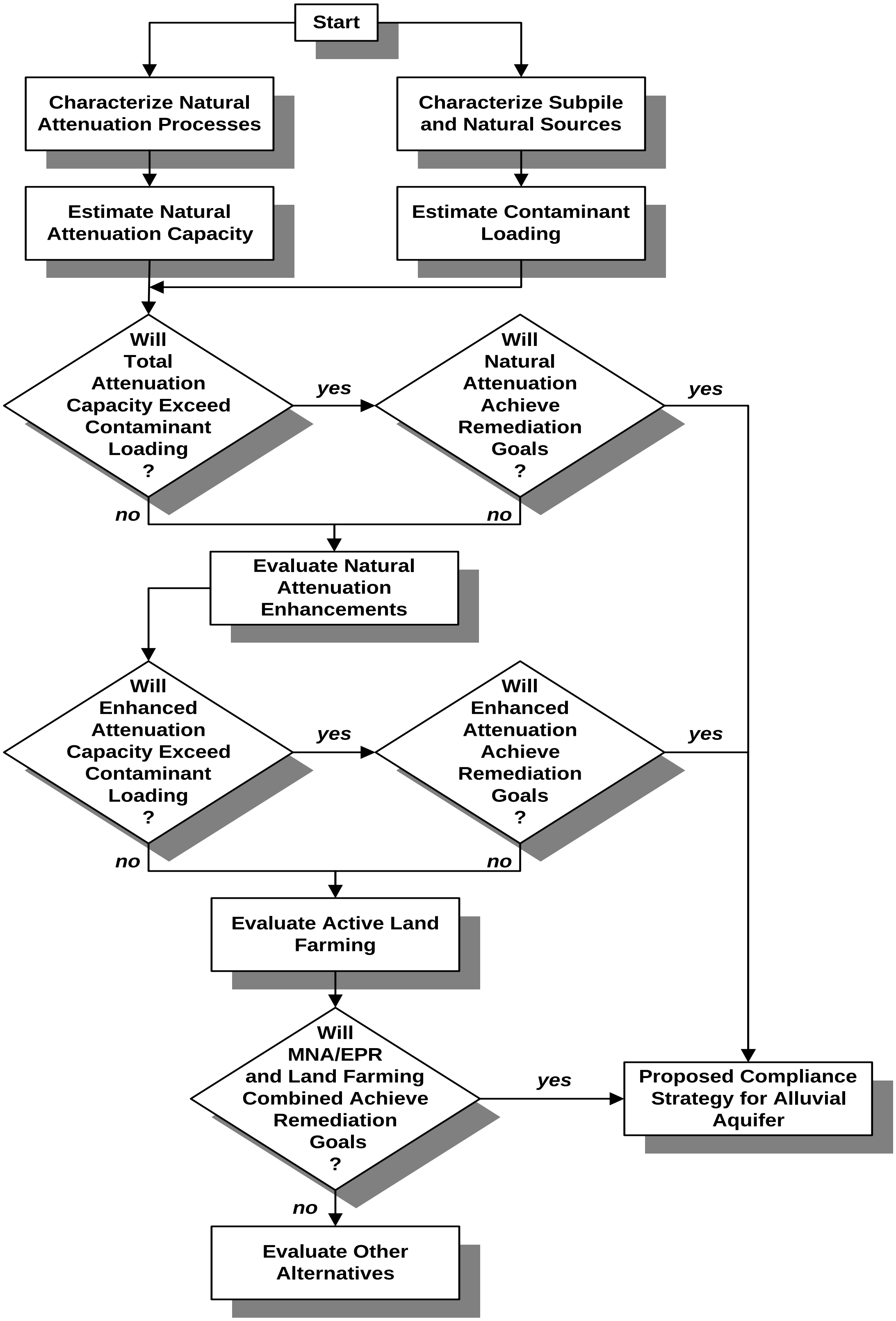


Figure 4. Pilot Study Framework

Therefore, MNA is considered only in combination with source control. EPA includes the word "monitored" to emphasize the reliance of MNA on a comprehensive monitoring program to provide reasonable assurance that "the remedy is performing as expected and is capable of attaining remediation objectives" (EPA 1999).

Enhanced passive remediation can be defined as "managing all or part of contaminated soil or ground water by initiating and/or augmenting natural and sustainable attenuation processes" (EPA 1999). EPR alternatives are considered if the natural attenuation capacity is estimated to be incapable of attaining remediation objectives. If enhancement technologies are implemented, an additional monitoring objective is to seek ways to improve implementation of the enhancement. EPR is different from MNA in that human intervention is allowed, but only to enhance natural and sustainable processes. A brief introduction of steps in the process follows.

Characterize Natural Attenuation Processes

The characterization step is necessary to identify and estimate the contribution of significant natural processes acting to degrade and attenuate nitrate and sulfate in the shallow aquifer and subpile soils. Degradation of sulfate includes sulfate uptake by plants and precipitation of sulfate as gypsum in a land farm soil, and dispersion (natural flushing). DOE has already shown that phytoremediation is a significant process. The pilot studies would also characterize other processes, including biodegradation and denitrification, and physical processes such as dispersion, advection, and dilution (natural flushing). First, a screening characterization will use a revision of the conceptual model for the site to identify likely natural attenuation processes. Additional characterization, as needed, would confirm the presence and significance of processes at the site and estimate rates of attenuation.

Estimate Natural Attenuation Capacity

The next step is to estimate the capacity of key attenuation processes at the site. Attenuation capacity can be thought of as the capacity of all natural processes that act to lower contaminant mass as the shallow ground water moves away from the subpile soil source. The capacity can be estimated as the sum of all the principal biological, physical, and chemical processes that biodegrade, disperse, transform, or immobilize nitrate and sulfate in the aquifer. Monitor well sampling data provide an indirect indication of the total attenuation capacity. Characterization data give estimates of the contributions of principal processes.

Characterize Sources and Estimate Contaminant Loading

Contaminant loading is the rate of nitrate and sulfate movement from the subpile soils into shallow ground water. DOE characterized the distribution of ammonium and nitrate in part of the subpile source as the basis for the previous subpile phytoremediation study (DOE 2002). The results of that study suggest that contaminant loading has been curtailed within the fourwing saltbush planting. Planned follow-up pilot studies will characterize the full extent of the subpile source and also characterize natural nitrate and sulfate sources (Nettleton 1991; Boettinger and Norton 1994; Woodward et al. 2003) as the basis for estimating the total mass of nitrate and sulfate entering the shallow aquifer.

Assess MNA Adequacy

The adequacy of MNA is evaluated as the mass balance of the delivery or loading of nitrate and sulfate from the subpile source and natural sources to the shallow aquifer, and the capacity or sum of natural processes to remove or disperse nitrate and sulfate. If the evaluation projects high confidence that contaminant loading is less than the sum of removal/dispersal processes, such that remediation objectives for the aquifer can be achieved in a reasonable time frame, then MNA will be selected as the final remedy. If confidence is low, or if the evaluation indicates that loading rates are equal to or greater than removal/dispersal rates, then natural attenuation enhancements would be considered.

Evaluate Attenuation Enhancements

The natural attenuation capacity may not be sufficient to reduce nitrate and sulfate concentrations in shallow ground water to acceptable levels. If this is the case, the next step would be to determine whether enhancing natural attenuation processes can raise the attenuation capacity beyond what is occurring naturally. The pilot studies will investigate a range of enhancements. A key goal of EPR pilot studies is to demonstrate enhancements that, once implemented, will be sustainable with little or no further intervention. For example, the pilot studies will evaluate additional plantings of native desert phreatophytes combined with grazing management as a means of (1) increasing plant uptake of nitrogen and sulfur from the shallow aquifer and (2) increasing transpiration so as to slow the movement of or hydrologically isolate the plume. Pilot studies would investigate other enhancements, as appropriate, such as stimulating or augmenting biodegradation in the shallow aquifer. This step will also evaluate an expanded subpile planting and microbial enhancements to further reduce contaminant loading.

Assess EPR Adequacy

The assessment of EPR adequacy seeks to answer two questions: Is the incremental increase in attenuation capacity provided by enhancements enough? Are enhancements sustainable without costly and prolonged intervention? If the answers to these questions are a confident *yes*, then a combination of MNA and EPR will be recommended as the final remedy. If the answers are *maybe* or *no*, then a more active remedy would likely be required.

Evaluate Active Land Farming

The land farm pilot study would address several issues: land suitability for irrigation, cropping system selection, nitrate uptake and toxicity, fate and toxicity of sulfate, irrigation management, farm operation requirements, and ecological and land-use impacts. Land farming is a form of active phytoremediation whereby ground water from deeper portions of the alluvial aquifer would be pumped and used to fertilize crops such as fodder for livestock or native plant seed that could be marketed (e.g., for mine land reclamation). Crops irrigated with water high in nitrate can accumulate nitrate and/or hydrocyanic acid. Phreatophytes rooted in the alluvial plume and crops grown in the pilot study land farm will be tested to determine if toxic levels of nitrate and hydrocyanic acid are accumulating in leaves and stems.

Evaluate the Health of Plants in the Phytoremediation Area

Although vanadium was dismissed as a contaminant of concern in the SOWP (DOE 1999a), it is possible that elevated vanadium concentrations in subpile soil may contribute to stunted plant growth observed in previous phytoremediation plantings. The potential for vanadium to affect plants rooted in subpile soil would be evaluated as part of the pilot studies.

The pilot studies would provide the information DOE and the Navajo Nation need to evaluate the potential for success.

3.3 Pilot Studies Schedule and Locations

Figure 5 shows the proposed locations for the pilot studies. The area required for additional fencing for the pilot studies would be approximately 7.5 acres. Approximately one acre of the pilot study area is within the existing 101-acre fenced area. The remaining 6.5 acres would require additional fencing adjacent to and northeast of the existing fenced area, and an area to the north. DOE, in cooperation with Navajo UMTRA, would consult with the appropriate Navajo agencies to secure necessary permits and authorizations for fencing this additional acreage. This additional fencing would eliminate grazing during the 2- to 3-year period that the pilot studies are being conducted.

Monitor well 618, screened in the De Chelly aquifer, will be used to supply irrigation water for the duration of the pilot studies.

3.4 Proposed Compliance Strategies

This section describes the proposed compliance strategies for the alluvial and De Chelly aquifers. Institutional controls and ground water monitoring would be implemented for both aquifers. Section 3.4.1 addresses the proposed action for the alluvial aquifer, which is based on the anticipated results of the pilot studies. Should the results not support the compliance strategy proposed for the alluvial aquifer, an amendment to the EA would be required. Section 3.4.2 addresses the compliance strategy for the De Chelly aquifer. Table 2 provides an overview of the proposed compliance strategies. Pilot tests will determine remediation time frames.

3.4.1 Alluvial Aquifer Compliance Strategy

For the purpose of discussing the proposed compliance strategies, the alluvial aquifer is addressed as three distinct areas of concern—subpile soils, shallow alluvial ground water, and deep alluvial ground water—based on the locations and depths of the contaminants. Passive remediation is proposed for all three areas of concern in the alluvial aquifer using a combination of phytoremediation and natural flushing.

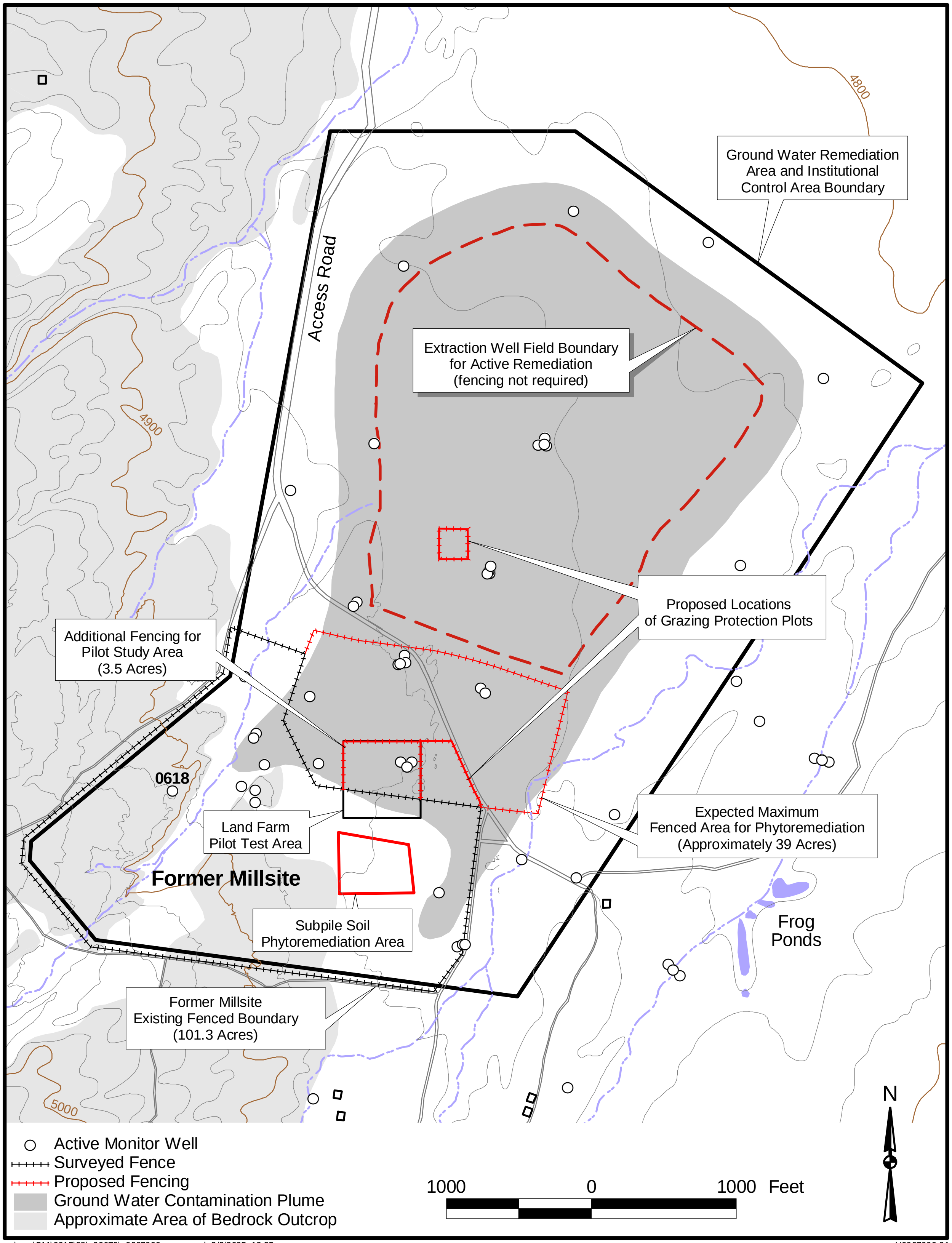


Figure 5. Locations of the Pilot Studies and Remediation Areas

Table 2. Summary of DOE's Proposed Action

Aquifer	Area	Contaminants To Be Monitored	Compliance Strategy	Rationale
Alluvial	Subpile soils	Ammonium, Nitrate	Passive remediation (natural flushing and phytoremediation)	Reduce concentrations of ammonium that could be a continuing source of nitrate contamination in the alluvial aquifer
	Shallow portions of aquifer	Nitrate, sulfate	Passive remediation (natural flushing and phytoremediation)	Reduce concentrations of nitrate and sulfate
	Deeper portions of aquifer	Nitrate, sulfate	Passive remediation (combination of natural flushing and land farming)	Reduce concentrations of nitrate and sulfate
		Uranium	Passive remediation (natural flushing)	Uranium contamination does not appear to be widespread, although anomalous elevated concentrations have recently been detected.
De Chelly	Isolated area	Uranium	Passive remediation (natural flushing)	Uranium concentration only slightly exceeds the MCL in an isolated area and is decreasing with time. There is no current human health or ecological risk.

MCL = maximum concentration limit established in 40 CFR 192.

In the subpile soils and shallow portions of the aquifer, passive remediation would include a combination of natural flushing and phytoremediation options. Phytoremediation may include both natural and enhanced methods as described in Section 3.2. The subpile soils area is within the existing fenced boundary and therefore will not likely require any additional surface disturbance or activities. Subpile soil cleanup would progress through the use of phreatophytic shrubs. Specifically, the shrubs would control recharge and leaching, and a combination of plant uptake and microbial denitrification would remove ammonium and nitrate from subpile soils. The methods of monitoring removal rates are described in detail in the 2002 phytoremediation study (DOE 2002). However, an additional 39 acres of fencing (Figure 5) would likely be required for phytoremediation of the shallow alluvial aquifer. The fencing would prevent grazing, which would maximize the potential for plant growth and expedite uptake of contaminants. Preliminary estimates indicate that phytoremediation could clean up the alluvial nitrate plume within 20 years (DOE 2002, McKeon et al. 2004).

Natural flushing is proposed for the deeper portions of the alluvial aquifer. However, if the pilot studies conclude that natural flushing alone is insufficient to remediate nitrate, sulfate, and uranium, DOE would implement land farming to enhance natural flushing. Land farming would involve installation of extraction wells and pipelines (Figure 5) to pump ground water from deeper portions of the aquifer to the fenced-in areas. Fencing (as needed) and land-disturbing activities would likely require environmental clearances, permits, and authorizations from local residents, the local chapter of the Navajo Nation, and other tribal agencies. These activities would also require access to tribal lands in accordance with the Cooperative Agreement.

Figure 6 shows the compliance strategy selection framework applicable to this aquifer.

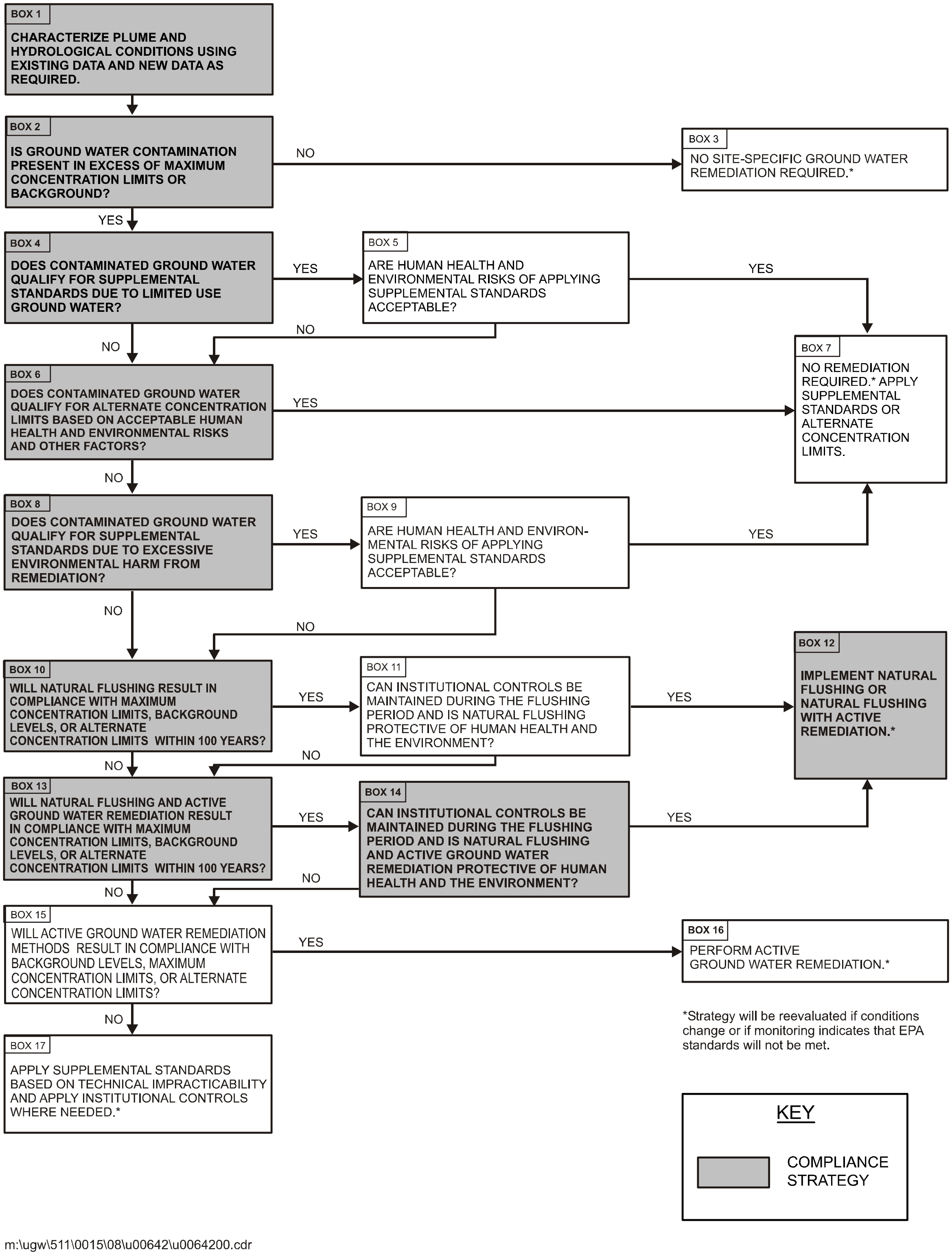


Figure 6. Compliance Selection Framework for the Alluvial Aquifer at the Monument Valley Site

The Navajo Nation Water Quality Code states that no entity shall be entitled to take any action affecting the use of water within the Navajo Nation, unless the action is authorized by a permit. DOE would apply for well and water-use permits through the Navajo Nation Department of Water Resources. Once these permits were approved, the requirements of the permits would guide DOE's management of wastes and treated ground water.

> **Institutional Controls** are used to limit or eliminate access to, or uses of, land, facilities, and other real and personal property to prevent inadvertent human and environmental exposure to residual contamination and other hazards. This maintains the safety and security of human health and the environment and of the site itself. Institutional controls may include legal controls such as zoning restrictions and deed annotations and physical barriers such as fences and markers. Also included are methods to preserve information and data and to inform current and future generations of the hazards and risks.
>
> ***DOE Policy 454.1 (DOE 2003)***

To protect the public and local residents, DOE would work with the Navajo Nation to implement institutional controls in addition to the fencing. These controls would likely include restrictions on access to, and use of, ground water during the remediation period. The institutional control boundary is shown on Figure 5. Fencing of the institutional control boundary is not proposed. Ground water monitoring would also be conducted during the remediation period. The monitoring program (summarized in Table 3) will specify the location, frequency, and types of samples and measurements to evaluate whether the remedy is performing as expected and is capable of attaining remediation objectives. No additional surface water monitoring is proposed because ground water monitoring will give sufficient notice if the contaminant plume will affect Cane Valley Wash. Figure 7 shows the proposed monitoring locations in relation to contamination.

Table 3. Summary of Alluvial Aquifer Monitoring Program

Monitor Well	Monitoring Purpose	Analyte	Frequency
604, 662, 669, 764, 767, 768	Lateral boundary of plume	Nitrate, sulfate, uranium, chloride	Semiannual
760, 761, and 762	Leading edge of plume	Nitrate, sulfate, chloride	Semiannual
650	Most downgradient location	Nitrate, sulfate, chloride	Semiannual
655, 656, 770, 771, 765, and 777	Vertical contaminant profile	Ammonium, nitrate, sulfate, chloride	Semiannual
606, 772, 774	On and near the site	Ammonium, nitrate, sulfate, and chloride plus uranium at location 774	Semiannual
Group I: 200, 400, and 402	Natural background	Nitrate, sulfate, chloride	Biennial[a]
Group II: 403, 602, and 640	Natural background	Nitrate, sulfate, chloride	Biennial[a]

[a]Groups I and II will be sampled annually and alternated with each annual sampling event.

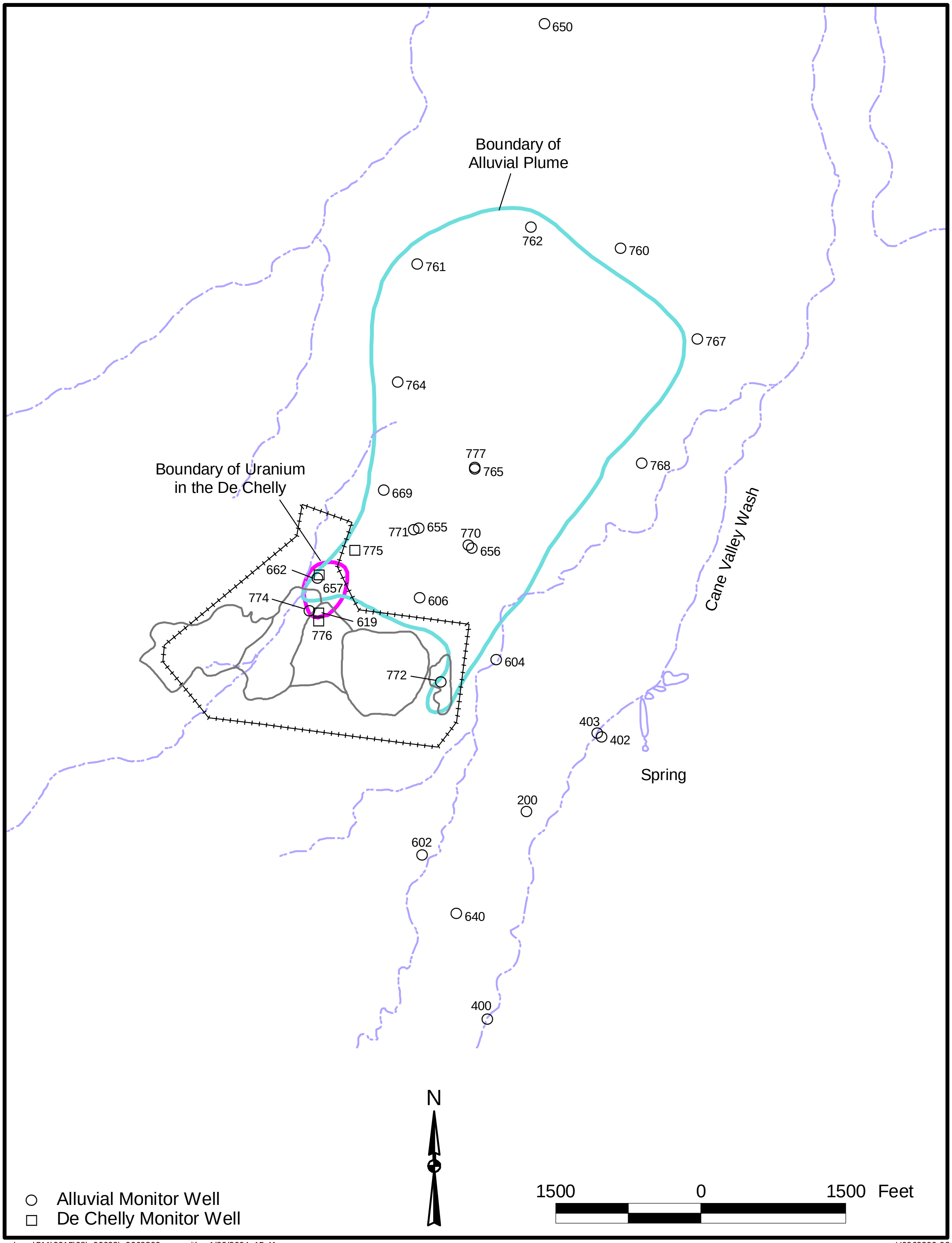


Figure 7. Monitoring Locations for the Alluvial and De Chelly Aquifers at the Monument Valley Site

Depending on the time frame and success of remediation, DOE would work with the Navajo Nation to determine what level of livestock grazing would be permissible within the fenced areas. Upon completion of remediation, all new fencing and other surface infrastructure (e.g., piping) would be removed. Wells would be decommissioned in accordance with federal and tribal regulations. Disturbed areas would be reclaimed to conditions similar to natural surroundings, which may include recontouring and reseeding with native mixes.

3.4.2 De Chelly Aquifer Compliance Strategy

The proposed compliance strategy for the De Chelly aquifer is natural flushing with monitoring and institutional controls. Future ground water monitoring in this aquifer would include the wells listed in Table 4. Monitoring would verify that uranium concentrations decrease below the 40 CFR 192 standard of 0.044 milligram per liter (mg/L). Uranium is only detected in well 619, and concentrations have decreased naturally from a high of 0.133 mg/L in 1993 to 0.055 mg/L (2004 data), which is near the standard of 0.044 mg/L. DOE would conduct contaminant flow and transport modeling during or after the pilot studies to predict the time frame for contaminant removal. Continued monitoring would verify that removal rate is progressing as expected. The time required for contaminant removal is expected to be well within the 100-year time frame established in 40 CFR 192.

Table 4. Summary of De Chelly Aquifer Monitoring Program

Monitor Well	Monitoring Purpose	Analyte	Frequency
619	Location of point source of uranium in the De Chelly aquifer	Uranium	Semiannual
776	Upgradient of point source	Uranium	Semiannual
657	Leading edge of point source	Uranium	Semiannual
775	Downgradient of point source	Uranium	Semiannual

3.5 Alternatives Considered But Eliminated

The SOWP for the Monument Valley site (DOE 1999a) and the *Draft Evaluation of Active Remediation Alternatives for the Monument Valley, Arizona, UMTRA Project Site* (DOE 2000a) evaluated individual technologies in detail for each of three categories: ground water extraction, effluent discharge, and ground water treatment. The evaluation was completed on the basis of comments received from the Navajo Nation. Several technologies were screened from further evaluation. The remainder were combined into separate pumping and treatment alternatives and retained for further evaluation. The two pumping alternatives were (1) plume-focused extraction wells without injection and (2) extraction and injection wells.

The four treatment alternatives were (1) land farming with contaminated ground water, (2) chemical treatment with biological denitrification, (3) distillation, and (4) reverse osmosis. All four treatment options included phytoremediation as a component of the treatment system. These treatment alternatives were evaluated against 10 evaluation criteria for effectiveness, implementability, and cost and were compared with one another using these criteria.

Each of the alternatives considered had advantages and drawbacks, although the chemical treatment with biological denitrification and the reverse osmosis alternatives were clearly inferior in some regards. Distillation was ranked first on the basis of 6 of the 10 criteria but was also the most expensive and had a lengthy remediation period. Land farming had several advantages, including lower cost and potential crop-use options.

3.6 No Action Alternative

By regulation (10 CFR 1021.321[c]), DOE is required to evaluate a no action alternative in environmental assessments to provide a baseline for comparing the effects of the proposed action. Under the no action alternative at the Monument Valley site, no further site activities would be performed, including well monitoring and implementation the proposed compliance strategies. DOE would take no action to bring contaminant concentrations in the alluvial aquifer into compliance with EPA ground water standards and the Navajo Nation remediation goal.

4.0 Affected Environment and Environmental Consequences

Natural flushing of the De Chelly aquifer would not result in any surface-disturbing activities. Therefore, this section describes only the environmental issues and resources that are associated with the alluvial aquifer at the Monument Valley site and the effects that the proposed action and no action alternatives may have on it. DOE has determined that some environmental resources are not present at the site or, if present, would not be affected by the proposed action and no action alternatives. These resources include wetlands, floodplains, and recreational resources. Therefore, these are not discussed further. Sections 4.3 through 4.17 discuss the resources or issues that may be affected by the alternatives.

4.1 Waste Management

No waste would be generated as a result of natural flushing and phytoremediation. If land farming were implemented, wastes would be generated from drilling, developing, and monitoring extraction wells. Table 5 presents a summary of the wastes expected if land farming were implemented.

Wastes would likely consist of both liquid and solid media. Liquid wastes would include well development water, water from decontamination of equipment and personal protective equipment, well purge water, and small amounts of liquid wastes associated with disposable field test kits. Solid secondary wastes would include drill cuttings, personal protective equipment, and wastes associated with disposable field test kits. Waste that could not be disposed of on site would be transported to a licensed landfill or to a facility authorized to accept residual radioactive materials, depending on the types and concentrations of contaminants in the waste.

Table 5. Summary of Wastes, Volumes, and Disposal Methods

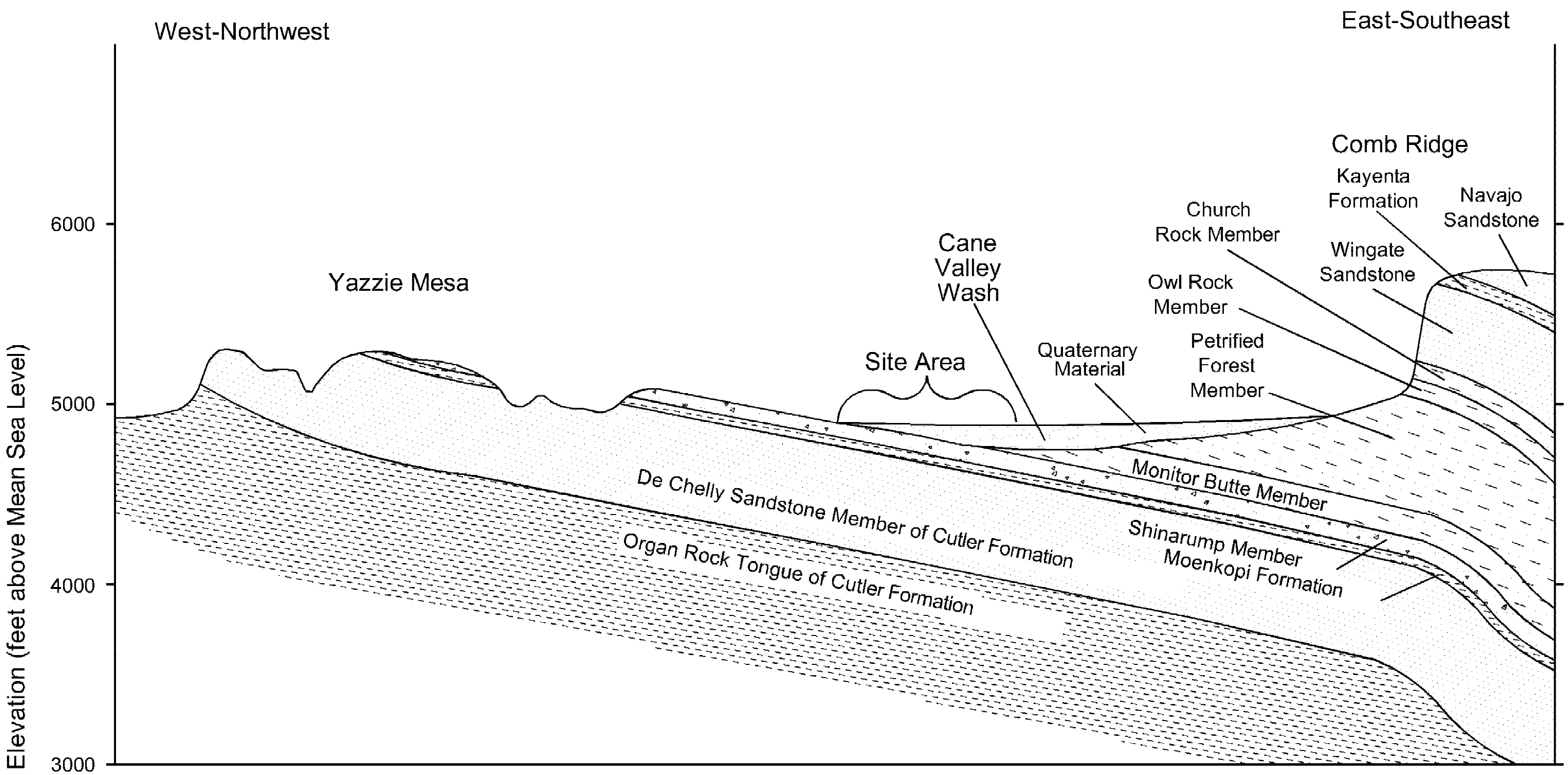
Type of Investigation-Derived Waste	Disposal Option
Drill cuttings	If drilling is required, drill cuttings will be scanned for gamma activity to ensure they do not exceed the surface remediation criterion for radioactivity. If below the criterion, the cuttings will be dispersed on the ground. If above the criterion, cuttings will be buried a minimum of 1 ft below the ground surface. Cuttings from non-subpile soils will be dispersed on the ground.
Well development water	All liquid waste will be treated and disposed of in accordance with federal and tribal regulations.
Equipment rinse water	All liquid waste will be treated and disposed of in accordance with federal and tribal regulations.
Monitor well purge water	All liquid waste will be treated and disposed of in accordance with federal and tribal regulations.
Field test kit wastes	Based on 40 CFR 261.5, liquid waste will be absorbed, and wastes will be disposed of at a municipal landfill or in a repository.
Personal protective equipment	Decontaminate as necessary and dispose of as general refuse in a municipal landfill.
	Dispose of at an approved disposal site (federal or private).

DOE's general approach to managing wastes at UMTRCA sites and a summary of the regulations potentially applicable to the management and disposal of wastes are described in the *Management Plan for Field-Generated Investigation-Derived Wastes* (DOE 2000c). Although this plan specifically addresses investigation-derived wastes, the policy and criteria discussed in the plan are applicable to management of the wastes described in this EA.

4.2 Geology

The Monument Valley site is in Cane Valley, which is in the eastern part of the larger feature known as Monument Valley that straddles the Monument Upwarp in northeastern Arizona and southeastern Utah. Cane Valley, drained by the north-flowing Cane Valley Wash, is floored by unconsolidated material of Quaternary age that consists of dune sand, alluvial material (sand and gravel), and fine-grained sediments that are probably lakebed deposits (clay or sandy clay). Thickness of the Quaternary material ranges from 0 to about 120 ft. Active and partly stabilized sand dunes up to 15 ft high cover much of the valley immediately north-northeast of the site. Several canyons have been incised through the sandstone, exposing older reddish siltstones and sandstones of Triassic and Permian age.

Cane Valley is at an elevation of about 4,800 ft above sea level in the area of the site. To the east, Comb Ridge rises abruptly to an elevation of about 5,600 ft. The slopes that gradually rise to the west to elevations of about 5,400 ft are, from north to south, Yazzie Mesa, Main Ridge, and South Ridge. Figure 8 shows the geologic formations relevant to the proposed action.



Note: The Chinle Formation is represented by five members.
The basal Hoskinnini Member is included within the Moenkopi Formation.
Cross section based mainly on geologic mapping by Witkind and Thaden (1963).

Vertical Exaggeration=2.64x

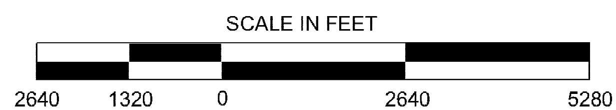


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Figure 8. Geologic Features in the Monument Valley Area

Geologic strata in the Monument Valley area likely contain significant quantities of the mineral gypsum ($CaSO_4 \cdot 2H_2O$). In particular, the Triassic Moenkopi Formation contains gypsum over most of its depositional area, including Monument Valley. At some localities, gypsum comprises at least 15 percent of the formation (Stewart et al. 1972). The gypsum occurs in the form of nodules, veinlets, sandstone cements, and beds. It results from evaporite deposition in shallow restricted seas common to the Moenkopi (Stewart et al. 1972). The nearest location to the Monument Valley site at which the presence of gypsum has been confirmed is about 22 miles away at a stratigraphic section measured by Stewart (Stewart et al. 1972). Stewart describes "rectangular white gypsum fragments" as large as 1 inch in maximum dimension, found in the upper part of the Moenkopi. It is likely that the Moenkopi contains gypsum in the immediate vicinity of the Monument Valley site as well.

The sedimentary gypsum can be eroded, transported by wind or water as solid matter or dissolved in precipitation, then redeposited where percolating water moves it down in a soil profile. Gypsum has a solubility of about 1.7 grams per liter, of which 950 mg/L is sulfate. Sulfate concentrations, due to gypsum dissolution, can be much higher if there is a sink (such as a calcium carbonate mineral) for calcium. In 301 analyses of alluvial ground water on the Hopi and Navajo Indian Reservations, Cooley et al. (1969) measured a sulfate range of 2.5 to 8,890 mg/L.

4.3 Soils

4.3.1 Affected Environment

Most soils at the site are derived from Quaternary sediments and consist of reddish-brown coppice dune sands that are more than 80 percent fine sand. A thin white crust covers the Quaternary material in large areas along the floor of Cane Valley adjacent to Cane Valley Wash. This crust is composed of gypsum (hydrous calcium sulfate) or gypsite (an earthy variety of gypsum containing sand and silt) that form as an efflorescent deposit by evaporation of the shallow (within a few feet of the surface) ground water in this area and deposition (crystallization) of its dissolved salts.

Calcification (formation of hardpan composed mainly of calcium carbonate) has occurred in places just below the surface. This hardpan is exposed along the east bank of the main tributary to Cain Valley Wash about 600 ft south of well 768 (Figure 7). There, the hardpan is white, well indurated, and about 3 ft thick.

In a recent study published in the journal *Science*, Walvoord et al. (2003) provide evidence for a natural pool of nitrogen, as nitrate, in the vadose zone beneath many desert soils of the southwestern United States. The source of nitrates is mainly from atmospheric deposition and litter decay during the Holocene. Nitrogen fixation by soil microorganisms is another possible natural source of soil nitrate. Walvoord et al. hypothesize that nitrates have leached from and accumulated below the soil zone in response to episodic wetting events followed by surface evaporation of water and extraction of water by plants.

The occurrence of natural nitrate in desert soils raises questions regarding the sources of nitrate in the alluvial aquifer at Monument Valley. Although the millsite appears to be the primary source of alluvial nitrate, it is possible that natural sources are contributing to the plume. A mass balance approach for evaluating MNA and EPR will require an estimate of natural source loading if it is occurring.

A set of reference soil samples collected upgradient from the former millsite contained 26–800 milligrams per kilogram (mg/kg) nitrate in the top 30–150 centimeters (cm) of soil (mean = 170 mg/kg). These values are consistent with the findings of Walvoord et al. (2003) for this location. In contrast, nitrate concentrations for samples taken from vadose zone soils within the top 100−200 cm directly over the plume were considerably lower (about 1 mg/kg). Because these data from the site are highly variable, the pilot studies will further investigate both the presence and mobility of subsurface nitrate.

Gypsiferous soils (soils high in gypsum content) form naturally in arid and semiarid landscapes of the Southwest and in other deserts of the world (Birkland 1984). Natural gypsiferous soils at Monument Valley, if they exist, may be a source of sulfate in the alluvial aquifer. Soils in arid and semiarid regions of the Southwest often have a carbonate-rich horizon below the surface called caliche or a calcrete soil layer. In areas receiving less than 12 inches per year precipitation, salts more soluble than carbonates, commonly gypsum, can accumulate at greater depths (Nettleton 1991).

Four potential origins for gypsum accumulation in soils have been established: (1) in situ weathering of existing parent material (Carter and Inskeep 1988), (2) sulfate-enriched precipitation, usually from an oceanic source (Podwojewski and Arnold 1994), (3) windblown or stream deposits of gypsum or sulfate-rich sediment (Taimeh 1992), and (4) in situ oxidation of sulfate minerals (Toulkeridis et al. 1998).

4.3.2 Environmental Consequences

Proposed Action Alternative

Soil stability would increase in the phytoremediation area once the plants are established. The proposed action would not affect soils outside the phytoremediation area. If the pilot study results indicate that land farming is necessary, some soil disturbance would occur during installation of the extraction wells and associated piping.

No Action Alternative

Because no surface-disturbing activities would take place, the no action alternative would have no effect on soils.

4.4 Subpile Soils

4.4.1 Affected Environment

The Monument Valley site had several periods of uranium-ore processing. During these periods, mill tailings, heap-leach residues, and various processing chemicals were stored in unlined ponds. Tailings and soils with radium-226 concentrations exceeding 15 picocuries per gram were removed during the surface remediation. However, the presence of site-related nonradioactive constituents in relatively high concentrations in samples of pore fluids (ground water in the pores between the mineral grains that compose the alluvial aquifer material) collected from the former source areas suggests that some of these constituents may have leached into the subpile soils beneath the storage pond and were undetected during the radiometric assessment for the tailings removal.

4.4.2 Environmental Consequences

Proposed Action Alternative

It is anticipated that the compliance strategy would reduce ammonium and nitrate concentrations in the subpile soils.

No Action Alternative

Ammonium concentrations in subpile soils would likely remain high and provide a continuing source of contamination to ground water.

4.5 Ground Water

4.5.1 Affected Environment

Three sources of ground water contamination were formerly present at the site and establish the basis for current ground water conditions: (1) the old tailings pile and heap-leach area, (2) the new tailings pile, and (3) the evaporation pond. The old tailings pile was composed of the sandy tailings that were a product of the mechanical upgrading of ore. The upgrading process used water containing minor amounts of flocculent but no other processing chemicals. Thus, tailings solutions in the old pile were water-equilibrated to minerals in the ore. Heap-leaching of these old tailings occurred in the area where they were stored. Old tailings were placed on the heap-leach pad, and sulfuric acid was added to the tailings. Heap-leach pads were lined to collect the leachate, which contained sulfuric acid. By contrast, the new tailings pile contained sand tailings and processing solutions. The processing solutions contained sulfate, nitrate, and ammonium from the processing chemicals. The evaporation pond was probably used to retain seepage from the new tailings pile.

Alluvial aquifer: There is a broad range in the depth to alluvial ground water across the site. The water table varies from 8 ft to 50 ft below ground surface; in the area of the nitrate plume, the water table is 30 to 40 ft below ground surface. Alluvial ground water generally flows north in the site vicinity (DOE 1999a); the aquifer material consists mainly of windblown fine- to medium-grained sand deposits. The hydraulic gradient ranges from about 0.016 (dimensionless) in the southern end of the site to about 0.009 (dimensionless) in the northern portion of the site.

Recharge to the alluvial aquifer results from infiltration of precipitation and from upward leakage from the underlying aquifers (DOE 1999a). The area receives approximately 6.4 inches of precipitation annually; most of the precipitation results from isolated thunderstorms during late summer and early fall. An estimated 1.6 inches of the annual 6.4 inches is available for recharge and runoff. However, due to loss from evaporation and plant uptake, only a fraction of the annual precipitation actually enters the aquifer.

De Chelly aquifer: This aquifer consists of fine-grained sandstone that is approximately 500 ft thick below the site. The maximum depth to ground water is approximately 165 ft in the vicinity of well 661. The Moenkopi Formation lies directly above the De Chelly (Figure 8). Ground water generally flows to the north. More detailed information is available in the SOWP (DOE 1999a).

Extent of Contamination

Alluvial aquifer: Approximately 540 million gallons of water are contaminated in the alluvial aquifer. Nitrate, sulfate, and uranium are the constituents of concern; concentrations exceed either EPA ground water standards or the Navajo Nation remediation goal. The EPA standards in 40 CFR 192 establish numerical maximum concentration limits (MCLs) for nitrate and uranium. The MCL for nitrate (as NO_3) is 44 mg/L, and the MCL for uranium is 0.044 mg/L. Because an EPA standard has not been established under 40 CFR 192 for sulfate, DOE will use best efforts to comply with the Navajo Nation remediation goal of 250 mg/L, background, or an agreed-upon risk-based benchmark. The primary source of current nitrate contamination in the alluvial aquifer appears to be related to process fluids draining from soils beneath the former location of the new tailings pile. Leakage from the evaporation pond to the east and the former old tailings pile and heap-leach areas to the west contribute lesser amounts of contamination.

Nitrate concentrations were used to represent the boundary of site-related contamination in the alluvial aquifer because nitrate occurs in relatively low concentrations in background ground water and is highly mobile. Figure 9 shows the nitrate concentrations based on December 2003 data. It is apparent that the leading edge of the plume has migrated more than 4,500 ft (0.85 mile) north of the former millsite. The northerly direction of plume migration is consistent with the direction of the ground water flow in the alluvial aquifer. The estimated linear ground water flow velocity is 150 ft/year, assuming that nitrate contamination first entered the aquifer at the start of the 1967 milling operation (4,500 ft/30 years). Between 1997 and December 2003, nitrate concentrations have decreased by about 150 mg/L at well 606 near the former source area and by about 120 mg/L in downgradient well 656. During the same time period, concentrations increased by about 10, 110, and 120 mg/L, respectively, in downgradient wells 669, 764, and 771.

Figure 9 shows the area of the nitrate plume starting at the former new tailings pile area and continuing approximately 4,500 ft north to well 762. The highest nitrate concentration of 878 mg/L occurs in alluvial ground water at monitor well 606 located near the former new tailings pile area. Nitrate concentrations decrease to the 44-mg/L MCL north (downgradient) between wells 762 and 650.

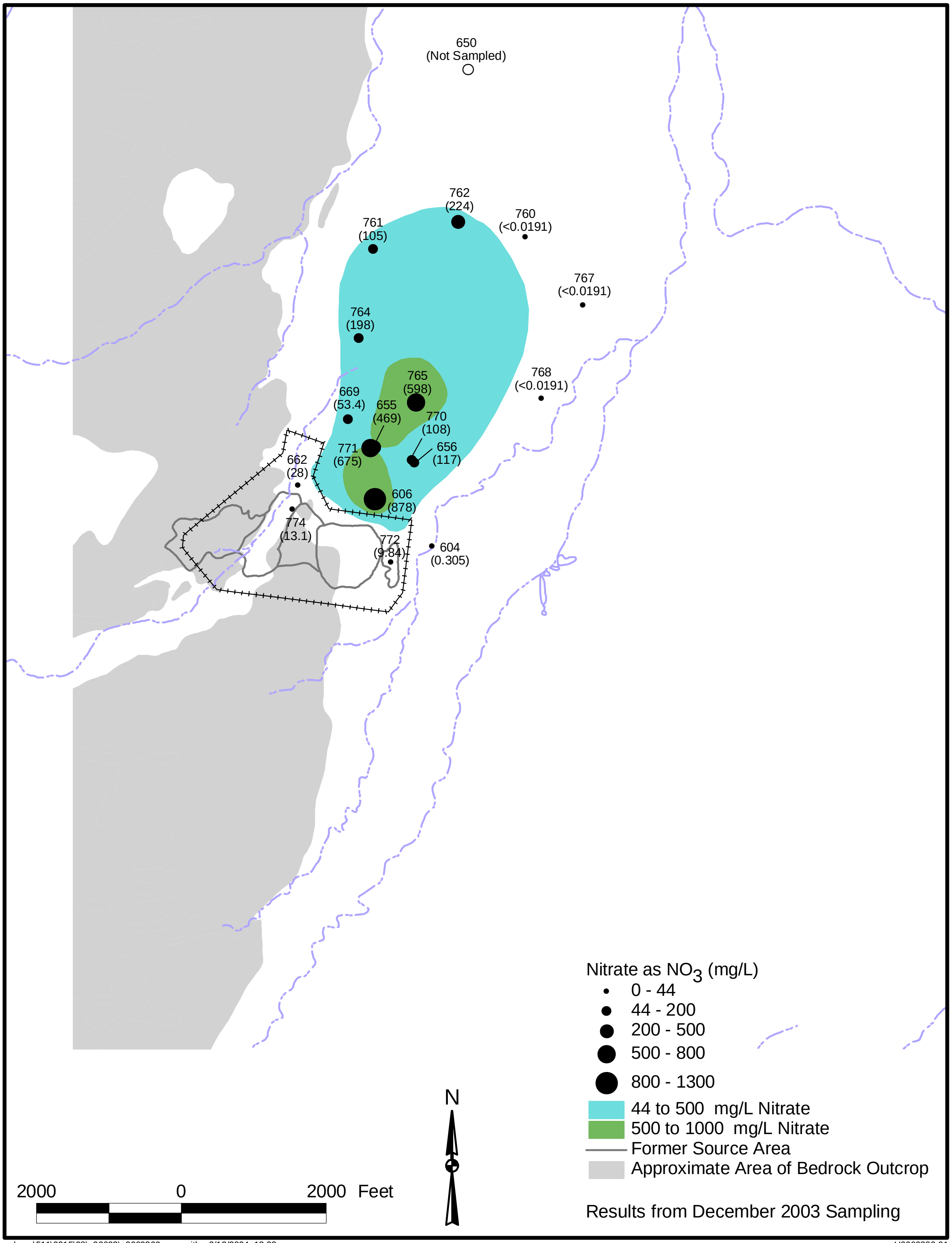

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Figure 9. Nitrate Concentrations in the Alluvial Aquifer at the Monument Valley Site

Downgradient lateral dispersion of the nitrate plume to the west of the site is limited by the Shinarump sandstone where the alluvial ground water intersects the Shinarump. Along this western edge of the plume, for example at well 669, the nitrate concentrations are close to the 44-mg/L MCL. Dilution of the plume water by surface water reentering the aquifer along the west margin of Cane Valley, where the eastward-dipping Shinarump crops out, probably contributes to these relatively low concentrations.

In the alluvial aquifer downgradient and east of the site, the eastern limit of the nitrate plume is defined by wells 604, 786, 767, and 760. Nitrate concentrations in each of these wells have remained steady and at background levels since 1997 (DOE 1999a). These monitoring results demonstrate that the eastern margin of the plume does not extend beneath Cane Valley Wash.

Sulfate concentrations in the alluvial aquifer have a geochemical dispersion pattern similar to that of nitrate. Figure 10 shows the sulfate plume as defined by the December 2003 sampling results. Changes in sulfate concentrations also show a trend similar to the trend of nitrate concentrations—sulfate levels increase downgradient and decrease near the former source area.

Given the environmental setting and the tendency of Southwest deserts to naturally accumulate nitrate and sulfate in soil horizons (Nettleton 1991; Boettinger and Norton 1994; Walvoord et al. 2003) and in the vadose zone, it is possible that natural sources may be contributing to elevated levels of nitrate and sulfate in the alluvial aquifer. The pilot studies would characterize natural nitrate and sulfate sources as part of an estimate of the total mass of nitrate and sulfate entering the shallow aquifer. For MNA or EPR to be viable compliance strategies, DOE must demonstrate that rates of contaminant removal from the aquifer exceed rates of contaminant loading from natural sources (i.e., soils) as described in Section 4.3.1.

Uranium concentrations have historically only slightly exceeded the EPA ground water MCL in alluvial well 774. At the time of the final SOWP (DOE 1999a), the uranium concentration at well 774 was 0.078 mg/L. In the December 2004 sample, uranium concentration at this well had dropped to 0.058 mg/L. However, the uranium concentration during the December 2004 sampling at well 662 was 0.28 mg/L, which represents an increase over earlier concentrations from that location. This increase creates an uncertainty that would be investigated further through additional soil sampling to determine the source. Uranium concentrations at all other monitoring locations are below the standard. The mean concentration of uranium on site and downgradient of the site is 0.0165 mg/L, which is within the range of background concentrations (<0.001–0.021 mg/L) in this region (DOE 1999a). Uranium tends to be mobile in the alluvial ground water under the conditions at the site, as indicated by the downgradient concentrations shown in Figure 11.

De Chelly aquifer: Uranium is the only constituent of concern in the De Chelly aquifer, and elevated concentrations are present in only a small, isolated area. Because of the location of the contamination and lack of evidence indicating widespread contamination, it is believed to have resulted from historical pumping of production well 619 during milling operations. This well is no longer being used, and an upward hydraulic gradient has been reestablished; evidence documented in the SOWP (DOE 1999a) has shown that there is no longer a source of contamination reaching the De Chelly aquifer. In addition, monitoring has shown that uranium

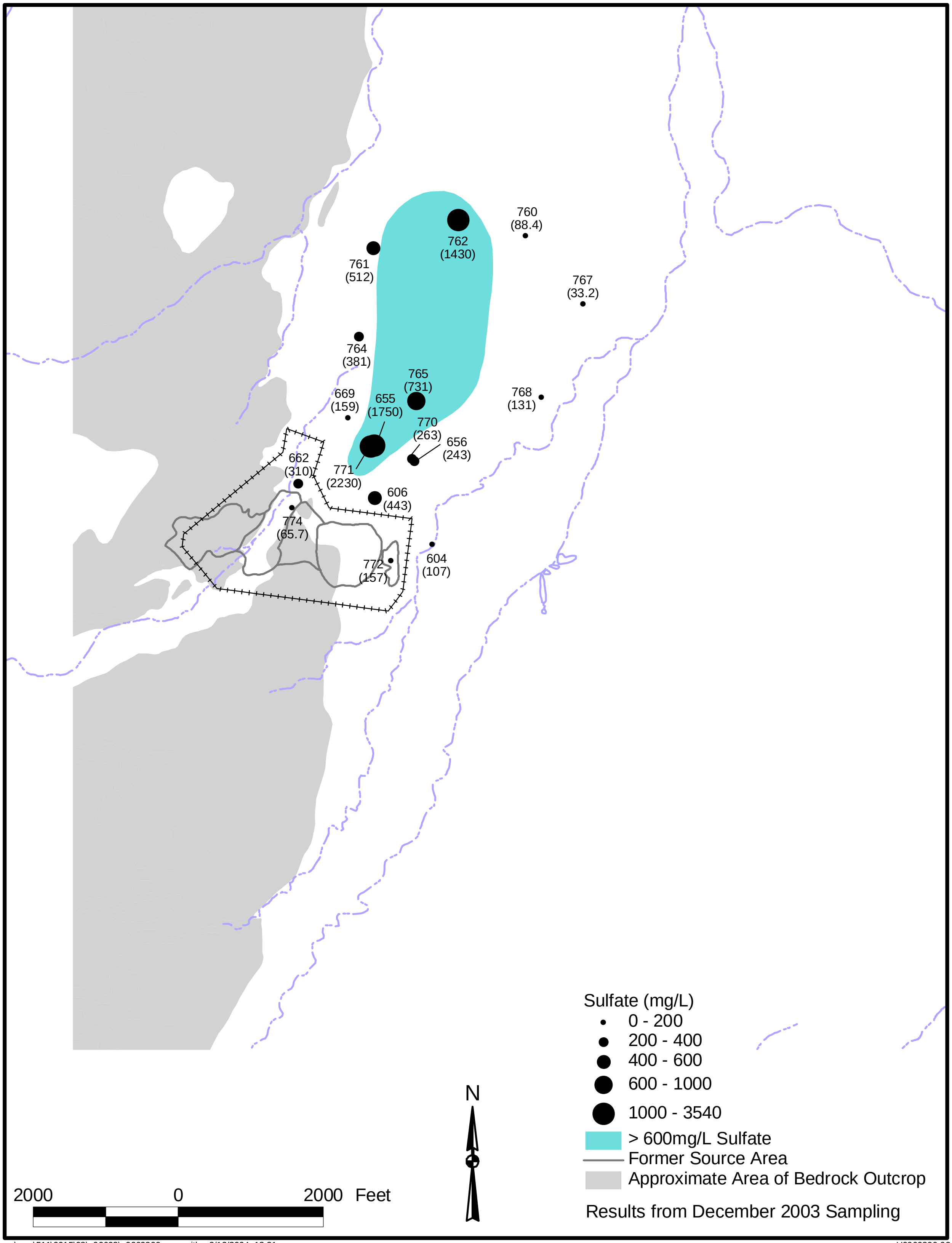

Figure 10. Sulfate Concentrations in the Alluvial Aquifer at the Monument Valley Site

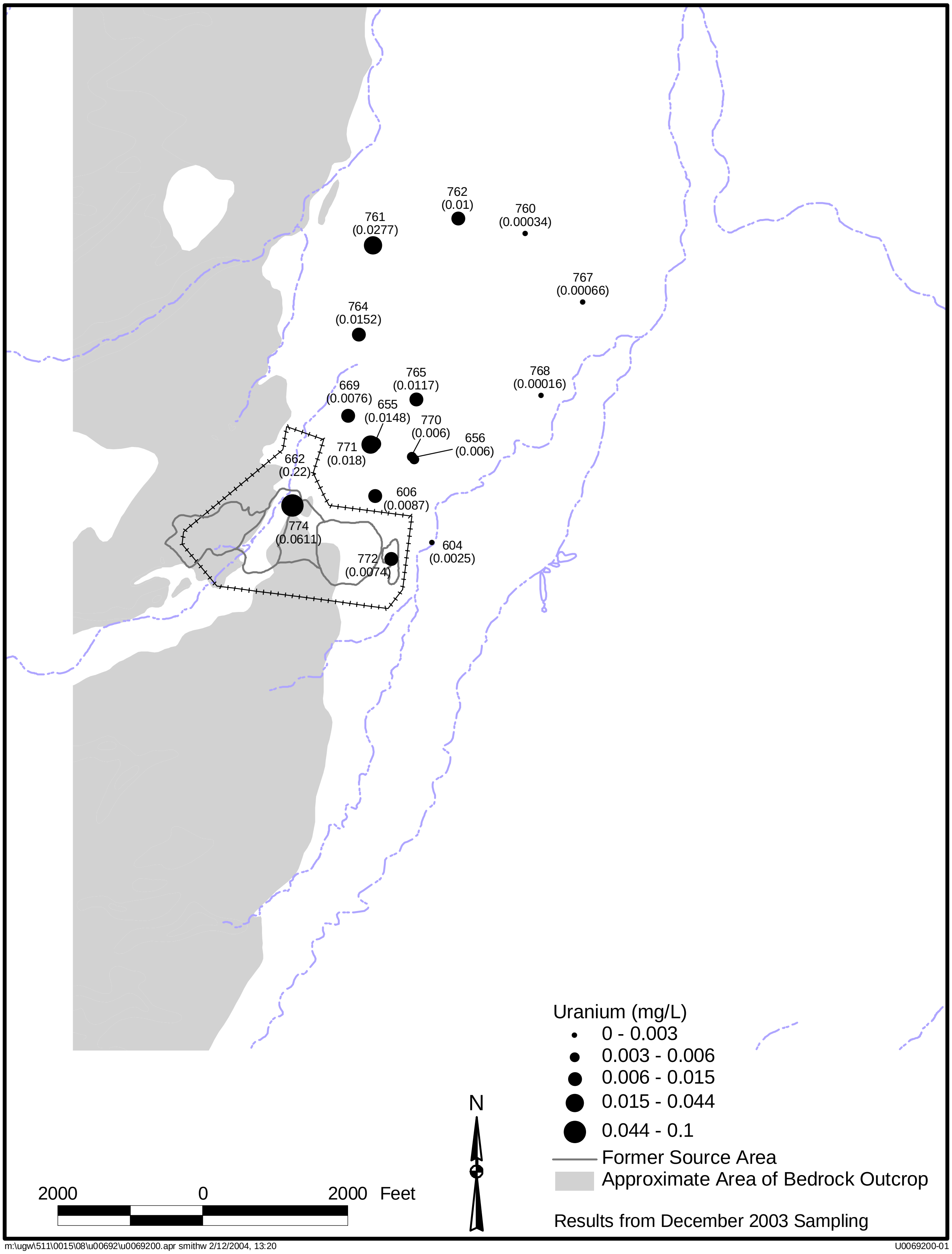

Figure 11. Uranium Concentrations in the Alluvial Aquifer at the Monument Valley Site

concentrations have decreased significantly since the well was pumped during an aquifer test in 1993. This trend is continuing. Results of the December 2004 sampling indicate that uranium concentration in well 619 is 0.055 mg/L, which is only slightly above the EPA standard of 0.044 mg/L.

Background Ground Water Quality

Background water quality in the alluvial aquifer near the former processing site is inferred from results of water samples collected from 1985 through 2003 at upgradient monitor wells 400, 402, 403, 404, 602, and 603 and at upgradient private wells 200, 616, 617, and 640 (Figure 12).

Background alluvial ground water has an average sulfate-to-chloride ratio of 4.9; total dissolved solids concentrations average 627 mg/L and range from 294 to 1,590 mg/L. The highest total dissolved solids concentrations are associated with the sodium sulfate–type waters, reflecting local evapotranspiration effects. Nitrate concentration averages 6.4 mg/L, which is well below the 44 mg/L standard. On average, the water pH is above neutral (pH 8.0), and the redox condition is oxidizing.

Ground Water Use

Ground water is the sole source of domestic water in the Monument Valley area. Domestic wells upgradient of the site and several domestic wells downgradient of the site have not been affected by the contaminant plume. In addition, an alternate water supply has been installed to discourage use of domestic wells.

4.5.2 Environmental Consequences

Proposed Action Alternative

Under the proposed action alternative, contaminant concentrations in the alluvial and De Chelly aquifers beneath the Monument Valley site would decrease. The remediation goals would be to restore the quality of the ground water to a condition such that contaminant levels would comply with EPA ground water standards for uranium and nitrate in 40 CFR 192. Current estimates are that the system would require approximately 20 years before ground water standards are met. It is anticipated that the Navajo Nation water quality goal for sulfate would also be met.

If active remediation in the form of ground water extraction for land farming were necessary in the alluvial aquifer, the water table could be lowered immediately south of the site during the short term; however, no domestic water supplies would be affected. Once ground water remediation is completed at the site, the water table would return to normal levels.

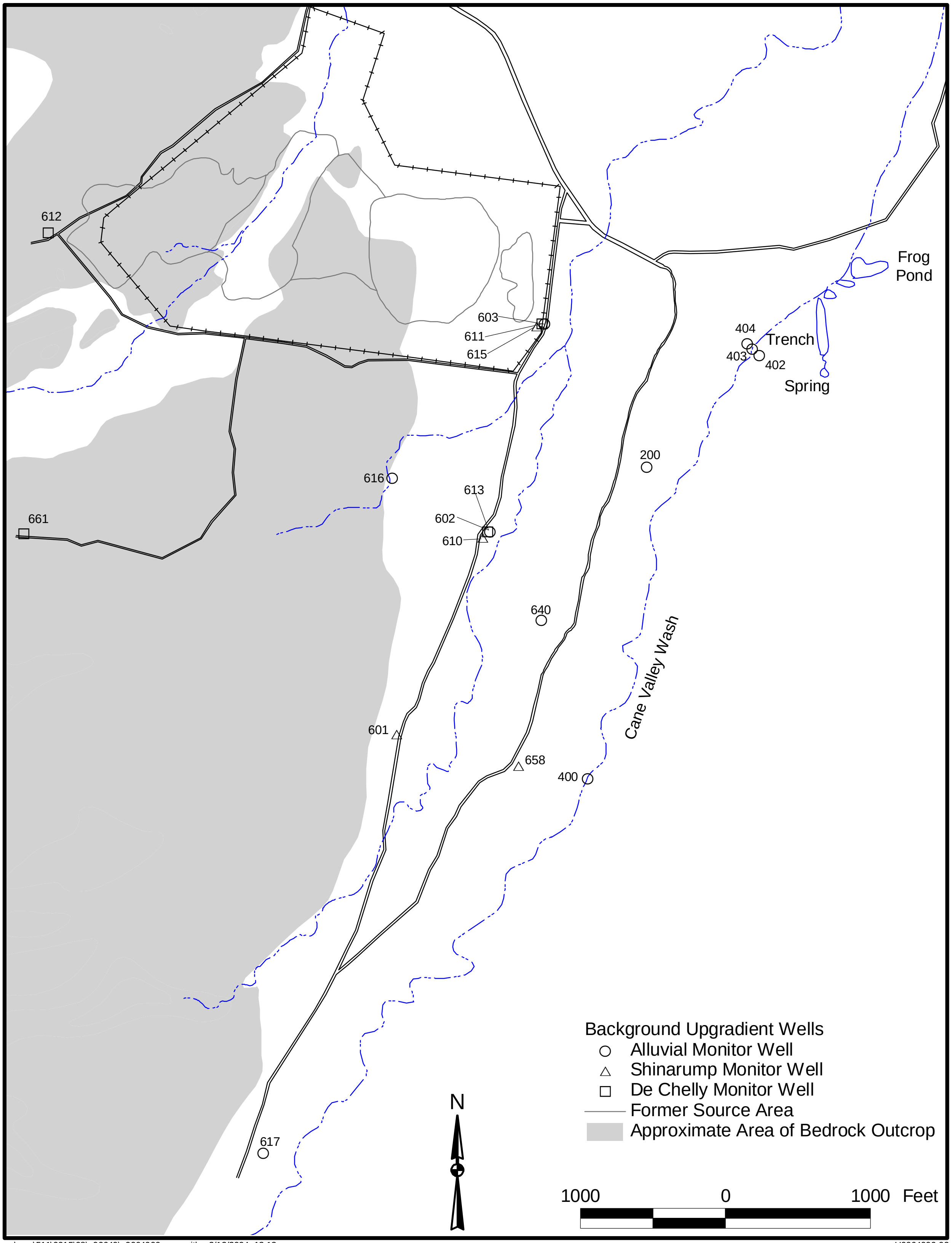

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Figure 12. Background Ground Water Sampling Locations at the Monument Valley Site

No Action Alternative

Under the no action alternative, ground water quality would change as the contaminant plume expands within the aquifer. The mixing of plume water with adjacent uncontaminated water would result in a decrease in contaminant concentrations within the plume but would also result in an increase in the areal extent of the plume. Future use of ground water on and near the Monument Valley site could be affected by the presence of contaminants.

It is possible that domestic wells could be drilled in areas downgradient of the plume, and as the plume expands, contaminant concentrations in certain wells could exceed MCLs for uranium and nitrate.

4.6 Surface Water

4.6.1 Affected Environment

The Monument Valley site is located approximately 1,800 ft west of Cane Valley Wash and the Frog Ponds (Figure 13), which are the dominant natural surface water features in the area. Cane Valley Wash is an intermittent stream that drains to the southwest into the Little Colorado River.

Most of the surface flow along Cane Valley Wash and other small drainage channels in the vicinity of the site is ephemeral (duration of flow is less than one month) as a direct result of local precipitation. Natural scours created by ephemeral flow along Cane Valley Wash are common, and many intersect the shallow ground water, forming small pools that may contain standing water for periods of several weeks or more (intermittent). In response to evaporation and transpiration, the pools get smaller and eventually go dry. These small intermittent pools have been observed just upstream of the Frog Ponds and downstream for several miles. In the areas where ground water reaches the surface, ponds that form are accessible by people and animals. However, these areas have not been affected by contaminated ground water and therefore do not form complete exposure pathways to contaminated ground water discharging to the surface water and sediment.

The only permanent surface water present in the area occurs east of the former millsite in what is referred to as the Cane Valley Frog Ponds. The Frog Ponds consist of two man-made ponds constructed during the 1950s and 1960s when the mill was in operation (Hammack 1993). Water was supplied by a concrete-lined cistern at the southern pond. The sides of the northern pond were lined with wooden planks braced by ore from the mines. The wooden planks, ore from in and around the northern pond, and evidence of the concrete cistern at the southern pond were removed during surface remediation in April 1994. The ponds are situated roughly in a north-south direction along the drainage axis of Cane Valley Wash. The southern pond is contained in a long, narrow, deep, bulldozer cut in a large sand dune. The bulldozer cut intersects the alluvial ground water, which provides some recharge to both ponds throughout the year.

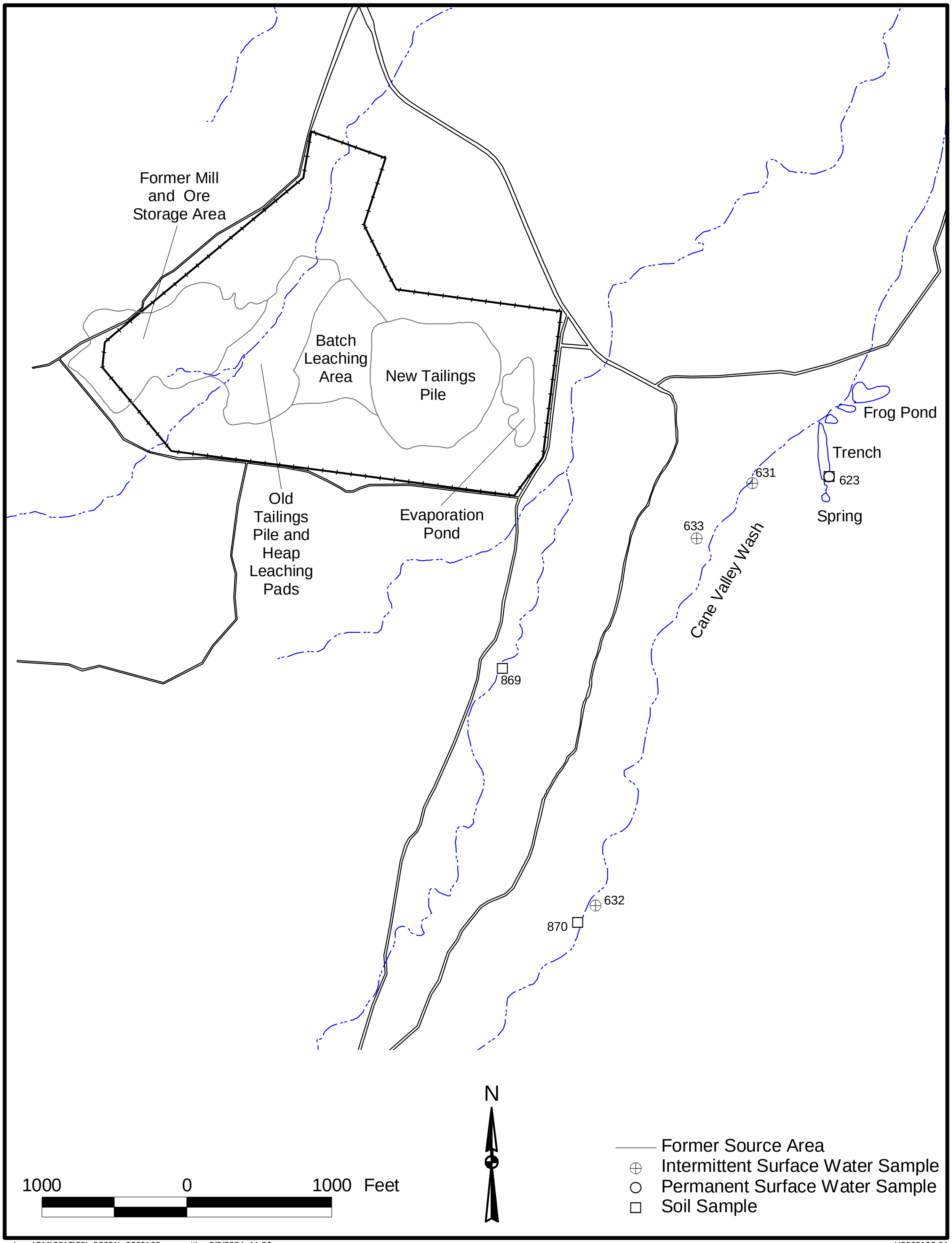

Figure 13. Background Surface Water and Soil Sample Locations

Surface Water Quality and Use

Geochemical similarities between the pond water and ground water from the De Chelly bedrock aquifer water suggest that the ponds may be receiving recharge through former uranium exploration boreholes that penetrated the artesian bedrock aquifer in the immediate area. The exploration boreholes were probably not properly plugged, thereby allowing artesian flow from the De Chelly aquifer into the alluvium. Water quality analyses for surface water samples collected from 1995 through 1997 are summarized in the SOWP (DOE 1999a).

Surface water located east of the site along Cane Valley Wash has not been affected by the former milling operations (DOE 1999a). Surface water samples collected from the Frog Ponds and intermittent pools along Cane Valley Wash indicate that the wash and the Frog Ponds are unaffected by site-related contaminants, as documented in the SOWP (DOE 1999a).

Surface water in Cane Valley Wash (when present) and the Frog Ponds is a potential source of water for livestock and wildlife, although the extent of use is unknown. There is no indication that surface water in the area is used for domestic consumption and irrigation.

4.6.2 Environmental Consequences

Proposed Action Alternative

Although there has been no indication that site-related contaminants are entering Cane Valley Wash or the Frog Ponds, the contaminant plume is migrating northeast to the west of Cane Valley Wash. However, even if contaminated ground water were detected in the wash, natural flushing would reduce concentrations in the long term. The limited deficit irrigation planned for establishing the plants in the phytoremediation area would have minimal impact on either aquifer; therefore, impacts to the Frog Ponds, if any, are expected to be negligible.

No Action Alternative

Under the no action alternative, no monitoring of either the alluvial or De Chelly aquifer would take place to verify that contaminated ground water was not affecting surface water quality in Cane Valley Wash and the Frog Ponds. No action would be taken to reduce contaminant concentrations in the alluvial aquifer. Although there is no evidence of alluvial ground water contamination in the Frog Ponds currently, there is the possibility for adverse effects to biota if no action were taken.

4.7 Land Use

4.7.1 Affected Environment

The Monument Valley site is located in a fairly remote area of the Navajo Reservation that is characterized as open rangelands. An area approximately 101 acres in size is currently fenced and believed to be a remnant of surface remediation. Vegetation in the area is considered marginal for grazing sheep and cattle. Historically, livestock grazing has been the primary land use. Density of both permanent and temporary housing is sparse. Traditional Navajo homes tend to be located in areas away from towns. Small dryland farms, usually less than 5 acres, are located a mile or more from the site. Currently, contaminated ground water is not being used for irrigation or domestic purposes. Investigations indicated that only one residence is within a mile of the site.

4.7.2 Environmental Consequences

Proposed Action Alternative

Under the proposed action alternative, the existing 101-acre fenced area would remain in place. Additional fencing would be placed around pilot study and phytoremediation areas (approximately 50 acres) for 20 years to prevent damage to plants from livestock grazing. This acreage would not be available for grazing under the current grazing allotments.

No Action Alternative

The no action alternative would have no effect on land use, and access notification to land users would not be required.

4.8 Human Health

4.8.1 Affected Environment

Contaminated ground water beneath the Monument Valley site does not currently pose a health risk to humans because it is not used as a drinking water source.

4.8.2 Environmental Consequences

Proposed Action Alternative

Under the proposed action alternative, human exposure to contaminated ground water would be controlled through implementation of institutional controls. The Navajo Water Code Administration would not issue well permits during the remediation period, the duration of which would be estimated upon completion of the pilot studies. Site inspections would verify that no drinking-water wells are drilled in the area of the plume. The goal of ground water remediation is to meet EPA standards so that eventual unrestricted use of the ground water would be possible.

The greatest health risks resulting from the proposed action alternative would likely be associated with construction and installation of an extraction system if land farming were implemented. The use of standard safety precautions and construction practices would reduce these risks. A job safety analysis would be performed for the tasks associated with on-site activities.

No Action Alternative

Potential risks to human health would increase under the no action alternative. Because no formal administrative controls would exist to prevent use of contaminated ground water for drinking water, domestic wells could be installed in the area. However, the potential for additional wells would be minimized because of the existing water supply line. The Baseline Risk Assessment (DOE 1996a) found that the most significant health hazard from ingestion of ground water at the Monument Valley site would be from nitrate. The primary concern would be for infants, because an infant's stomach absorbs nitrate differently than an adult's. At the concentrations detected in ground water at the Monument Valley site, nitrate could have a lethal effect by interfering with an infant's ability to transport oxygen through the blood.

4.9 Air Quality and Noise

4.9.1 Affected Environment

State of Arizona ambient air quality standards are the same as federal standards defined at 40 CFR 50. The closest air quality sampling station to the Monument Valley site is at Bullfrog Marina, Lake Powell, Utah, approximately 50 air miles to the north. Air quality in the area of the site is within state standards.

4.9.2 Environmental Consequences

Proposed Action Alternative

If extraction wells were needed, construction of the wells and piping would disturb 5 to 10 acres during the construction period (1 to 3 months). Dust created and dispersed by traffic and wind could increase the concentration of suspended particulates in the surrounding air. Application of water or other dust suppressants in active work areas would minimize the increase in suspended particulates. These mitigation measures should keep the suspended particulate concentrations within federal and state air quality standards. After vegetation is reestablished at the site through reseeding, dust levels would return to background conditions.

If extraction wells were necessary under the proposed action alternative, noise levels would temporarily increase during well drilling and pipeline operations. On-site workers would be required to wear hearing protection when noise levels exceed the standard of 85 decibels.

No Action Alternative

Because no on-site activities would take place, the no action alternative would not affect air quality. Current background noise levels at the site would not be affected.

4.10 Wildlife

4.10.1 Affected Environment

Nocturnal rodents and black-tailed jackrabbits (*Lepus californicus*) are the principal mammals inhabiting the site. The lack of habitat diversity and natural water sources limits the number of birds likely to visit the site. During spring and fall migrations, a variety of transient bird species may visit the site, and a few species, such as the mourning dove (*Zenaida macroura*), northern mockingbird (*Mimus polyglottos*), horned lark (*Eremophila alpestris*), and the common poorwill (*Phalaenoptilus nutallii*) may nest at the site. The presence of amphibian species is probably minimal, although a few individuals may occur in temporary pools formed during summer rains. Species such as the tiger salamander (*Ambystoma mavortium*) and western spadefoot toad (*Scaphiopus hammondii*) likely reside in the area. The side-blotched lizard (*Uta stansburiana*) and western whiptail lizard (*Cnemidophorus tigris*) are the principal reptile species that inhabit the site.

Species of concern[2] identified by the Navajo Nation Fish and Wildlife Service (Navajo Nation, July 1999, Letter to R. Bleil, MACTEC-ERS) as potentially present in the vicinity of the site include the following: the golden eagle (*Aquila chrysaetos*) is known to exist within one mile of the site; the ferruginous hawk (*Buteo regalis*), American dipper (*Cinclus mexicanus*), southwestern willow flycatcher (*Empidonax traillii extimus*), peregrine falcon (*Falco peregrinus*), black-footed ferret (*Mustella nigripes*), and northern leopard frog (*Rana pipiens*) may exist in the vicinity of the site.

Field observations conducted during 1999 indicate that these species were not present within the area of the proposed action.

4.10.2 Environmental Consequences

Proposed Action Alternative

In addition to the existing fenced area (101 acres), up to 6.5 acres of habitat for large mammals and livestock could be temporarily affected for approximately 3 years as a result of the pilot studies. The noise and human activity associated with the pilot studies would likely temporarily displace wildlife. In most cases, the species would likely return to the disturbed areas once the studies were completed. Over the long term, population abundance, distribution, and density of wildlife species would not be noticeably affected. An additional 40 to 50 acres of habitat for large mammals could also be temporarily affected for phytoremediation (20 years). However, successful phytoremediation would likely increase available wildlife habitat.

Field visits conducted during 1999 indicated that habitat for the black-footed ferret, southwestern willow flycatcher, and northern leopard frog does not exist within the area of the proposed action. Therefore, no adverse effects to threatened or endangered species would be expected.

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[2] Species of concern include protected, candidate, and other rare or sensitive species identified by the Navajo Nation, subject to the Endangered Species Act, the Migratory Bird Treaty Act, and Eagle Protection Act.

DOE will consult with the Navajo Fish and Wildlife Service to determine if they concur in this conclusion.

No Action Alternative

Wildlife species at the Monument Valley site would not be affected by the no action alternative during the short term. Over the long term, the contaminant plume would increase in size. In the absence of institutional controls, a water well could be drilled into the plume, and ground water could be withdrawn and allowed to pond. Wildlife could ingest contaminants in the water pumped from the plume. An update to the Baseline Risk Assessment completed for the SOWP indicated that the use of contaminated ground water as a sole source of drinking water for livestock could result in livestock deaths from the high concentrations of nitrate and sulfate. The same would be expected for most wildlife species that ingested the water. However, species-specific toxicological information has not been evaluated or does not exist for most wildlife species.

4.11 Vegetation

4.11.1 Affected Environment

The *Monument Valley Ground Water Remediation: Pilot Study Work Plan* (DOE 2004) describes plant types and ecology in detail. Black greasewood, fourwing saltbush, bush mint (*Poliomintha incana*), and Russian thistle (*Salsola iberica*) are the predominant vegetation communities overlying the contaminant plume at the site. Both black greasewood and fourwing saltbush are considered phreatophyte (i.e., deep-rooted) plants capable of extracting ground water from 39 to 59 ft below the surface. Although the site is relatively void of vegetation, Indian ricegrass (*Oryzopsis hymenoides*) and cheatgrass (*Bromus tectorum*) also grow in the area. The Navajo Nation provided a list of plants of interest that may grow at the site. A 1999 site field survey based on that list found no threatened or endangered plants. DOE will consult with the Navajo Fish and Wildlife Service to determine if they concur in the conclusion that no threatened or endangered plant species grow at the site.

4.11.2 Environmental Consequences

Proposed Action Alternative

Well installation and construction activities associated with ground water extraction would temporarily disturb vegetation. No areas containing threatened or endangered plant species, if they exist at the site, would be disturbed. All disturbed areas would be reseeded upon completion of construction, and vegetation should reestablish after 2 to 4 years.

The pipelines also would likely be removed. Most of the wells would be decommissioned in accordance with state and tribal regulations. These areas would be regraded, if necessary, and seeded. Vegetation should reestablish within 2 to 4 years.

Plant uptake of ground water contaminants is expected and planned as part of the phytoremediation process. Plants would use the contaminants as they do in the natural environment. No bioaccumulation is expected that would be harmful to other ecological receptors.

Fencing the phytoremediation area to prevent grazing would allow the vegetation to become established more rapidly. As plant density increases, ammonium and nitrate would be taken up at a faster rate. Eventually these constituents would be returned to the environment through decay and grazing. Grazing may be permitted in the future, although regulated to optimize plant growth and root uptake of the nitrogen compounds.

No Action Alternative

Under the no action alternative, the contaminant plume would continue to move downgradient to the north. Plant uptake of ground water contaminants could occur in areas where the water table is closer to the surface, such as in the greasewood plant community. Greenhouse studies (Baumgartner et al. 1996) have shown that the uptake of contaminated ground water would not elevate plant tissue concentrations of the contaminants above maximum tolerable levels and would have little or no effect on the health of the plant.

Because no surface-disturbing activities would take place under this alternative, the vegetation at the site would not be physically disturbed.

4.12 Cultural Resources

4.12.1 Affected Environment

Humans have occupied the Monument Valley area since as early as 9,500 B.C. To determine if historical or archaeological sites are present on or near the Monument Valley site, Class III (100-percent coverage pedestrian) cultural resource surveys were conducted by Complete Archaeological Service Associates (Hammack 1985, 1988, 1997) Results of these surveys indicate that no cultural sites eligible for inclusion in the National Register of Historic Places occur within the area of potential disturbance. In addition to the Class III surveys, an ethnological evaluation of the Monument Valley area was completed in 1985 (Schoepfle and Begishe 1985). Results of this report indicate that no traditional cultural properties or sacred sites occur within the area of potential disturbance.

4.12.2 Environmental Consequences

Proposed Action Alternative

Cultural resources investigations and surveys found no historical or cultural resources in the site area. Therefore, the proposed action alternative would have no effect. If cultural resources are discovered during implementation of the proposed action, DOE would stop work and notify authorities in the Navajo Nation.

No Action Alternative

Because no surface-disturbing activities would take place at the site, the no action alternative would have no effect on cultural resources.

4.13 Visual Resources

4.13.1 Affected Environment

The eastern boundary of the 30,000-acre Monument Valley Tribal Park is approximately 13 air miles west of the Monument Valley site. The Tribal Park is considered an important scenic resource that attracts tourists from around the world. Tourists and local residents may use the area because of its scenic value.

4.13.2 Environmental Consequences

Proposed Action Alternative

The primary effect on visual resources from the proposed action alternative would be the alteration in the foreground view of the Monument Valley site. The Tribal Park would not be affected by the proposed action alternative. Because of the remote location of the site and lack of a major highway, visual effects of the proposed action are unlikely to affect tourism. However, visual effects could be of concern to local residents.

No Action Alternative

Because no surface-disturbing activities would take place, the no action alternative would have no effect on visual resources.

4.14 Socioeconomics

4.14.1 Affected Environment

Dennehotso, Arizona, is about 6.5 air miles south of the site and has a population of approximately 616. The next closest town is Halchita, Utah, which is 17 miles to the north and has a population of about 400. The nearest schools are located in Gouldings, Utah; Kayenta, Arizona; and Halchita. Health care is available through the Navajo Health Service clinic in Kayenta. The Navajo Tribal Police have jurisdiction for law enforcement within the Navajo Nation. Currently, no telephone service, electrical power, or sewer facilities are available near the site. Tourism in the Monument Valley area is a significant contributor to the local economy but has no direct effect on local residents. Unemployment in the Monument Valley area is relatively high due to the remoteness of the area and historical and cultural preferences for obtaining sustenance from the land.

4.14.2 Environmental Consequences

Proposed Action Alternative

Construction and operations activities for the proposed action alternative could employ up to 10 local part-time laborers for a period of 6 months. Once construction activities were completed, four to five local technicians/laborers would be employed over a period of approximately 20 years to maintain the infrastructure at the site. These labor requirements are not expected to noticeably affect local unemployment rates. It does not appear that the local increase in laborers would have any effect on housing or the economy, as most laborers would be local or set up temporary residences in the area.

No Action Alternative

Because no activities would take place, the no action alternative would not affect the socioeconomic characteristics of the area.

4.15 Transportation

4.15.1 Affected Environment

Transportation routes near the Monument Valley site are Highway 160, Highway 163, Highway 191, and Indian Service Route 6440, which is an unimproved dirt road. Access to the site is by Indian Service Route 6440 from either Highway 163 or Highway 160.

4.15.2 Environmental Consequences

Proposed Action Alternative

Solid wastes such as personal protective equipment and miscellaneous debris would require periodic hauling to a landfill or a facility that could accept residual radioactive materials. This infrequent hauling is not expected to affect traffic in the Monument Valley area. Workers commuting to and from the site would not affect traffic.

No Action Alternative

Because no transportation would take place, the no action alternative would not affect transportation.

4.16 Environmental Justice Considerations

4.16.1 Affected Environment

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, states that federal programs and actions shall not disproportionately affect minority or low-income populations. Because the Monument Valley uranium mill was located on tribal lands, contamination resulting from activities at the site has the potential to affect members of the Navajo Nation almost exclusively.

4.16.2 Environmental Consequences

Proposed Action Alternative

Under the proposed action alternative, DOE would improve ground water quality to the standards specified in 40 CFR 192, which would beneficially affect ground water and the populations who depend on it. Therefore, disproportionate effects would not occur to tribal members.

No Action Alternative

Under the no action alternative, ground water quality would not be improved, and effects could be disproportionate to tribal members.

4.17 Cumulative Effects Assessment

The Council on Environmental Quality defines “cumulative impact” as the “impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions” (40 CFR 1508.7). No actions other than those proposed by DOE are anticipated at or near the Monument Valley site in the foreseeable future. There would be a beneficial cumulative effect to ground water quality associated with the proposed action alternative because contamination in the ground water from past activities would be cleaned up to concentrations below EPA standards within approximately 20 years. The cumulative effect of the no action alternative would be an eventual decrease in contaminant concentrations over the long term (greater than 100 years) and a potential increase in the areal extent of the contaminant plume.

No other resources discussed in Section 4.0 would be affected cumulatively from the proposed action or the no action alternatives. Therefore, the effects of the proposed action alternative would not result in cumulatively significant impacts.

5.0 Persons or Agencies Consulted

George Abe	Tuba City Agency
Nancy Olson	Arizona Game and Fish Department Non-Game Branch Phoenix, Arizona

Michelle James	U.S. Fish and Wildlife Service Ecological Services Division Flagstaff, Arizona
Madeline Roanhorse Levon Benally Terry Lameman	Navajo UMTRA Project Director Division of Natural Resources Window Rock, Arizona
Steve Austin	Navajo EPA Water Quality Division Shiprock, Arizona
Steve Rich	Navajo EPA Water Quality Division Tuba City, Arizona
Bennie Williams	Navajo Water Code Administration Fort Defiance, Arizona
Al Downer	Navajo Historic Preservation Department Window Rock, Arizona
Howard Draper	Navajo Project Review Window Rock, Arizona
Ray Russel	Navajo Abandoned Mine Lands Reclamation Window Rock, Arizona
John Nystedt Rita Whitehorse-Larsen	Navajo Fish and Wildlife Department Natural Heritage Foundation Window Rock, Arizona

In addition to these contacts, DOE has discussed the aspects of the proposed action with Navajo representatives and agencies, including the Dennehotso and Oljato Chapter representatives on a number of occasions. Public scoping meetings were conducted, including those identified in the introduction of this EA.

6.0 References

10 CFR 1021. U.S. Department of Energy, "National Environmental Policy Act Implementing Procedures," *Code of Federal Regulations*, January 1, 2004.

40 CFR 192. U.S. Environmental Protection Agency, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings," *Code of Federal Regulations*, July 1, 2003.

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Appendix A

Comment/Response Tracking Log

NEPA COMMENT/RESPONSE TRACKING LOG

DOCUMENT TITLE/NUMBER: *Environmental Assessment of Ground Water Compliance at the Monument Valley, Arizona, Uranium Mill Tailings Site* (DOE/EA-1313)

DOCUMENT DATE: March 2005

Comment Period Ending: 12/30/04

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Navajo UMTRA Comments (Received January 5, 2005)						
1	19 21	3.4.1 3.4.2	The EA reports that the ground water monitoring program for the alluvial and De Chelly aquifers will be on an annual basis. However, during the working meeting in Durango, Colorado on November 11, 2004, SM Stoller indicated that the sampling event would change to semiannual once the pilot study begins. We are still in concurrence with this decision. The text under the Frequency column in Tables 3 and Tables 4 on pages 19 and 21 should be changed to semiannual to reflect this decision.	S	Y	Tables 3 and 4 on pages 19 and 21 of the EA will be changed to reflect that sampling will be conducted on a semiannual basis.
2	19	3.4.1	Table 3. Summary of Alluvial Aquifer Monitoring Program—Well 662 should be included in the monitoring program for on and near the site purposes. Results for this well showed anomalously high uranium levels during the December 2003 sampling event. How does DOE plan to evaluate and address the isolated areas where uranium is elevated with passive remediation?	T T	Y Y	Well 662 is included in Table 3 on page 19 and will be continue to be included in the monitoring program. With elevated uranium concentrations appearing in well 662, uranium was added as an analyte in Table 3 for future characterization. Several actions are being considered to determine the cause of the anomalous increase in concentrations, including further characterization of uranium in the deeper portions of the alluvial aquifer. In December 2004, DOE implemented a more detailed sampling program to delineate the volume and source term of the subpile soils area, which could be causing the anomalously elevated uranium concentrations. In addition, DOE is considering modeling with NETPATH and PHREEQC, which could provide a better

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						understanding of the geochemical reactions that are occurring at the site; hence, forecasting how the ground water quality might change over time. A more frequent monitoring of hydraulic heads at well pairs 774/619 and 662/657 is also being considered. It is believed that this may provide a better understanding of ground water flow directions where the alluvial and bedrock units might be interconnected. Although the recently elevated uranium concentration does create some uncertainties in deeper portions of the alluvial aquifer, there is not sufficient evidence to change the compliance strategy at this time. As stated in the EA Executive Summary, and in Section 3.4, additional NEPA documentation would be necessary if the pilot studies do not support the proposed compliance strategies.
3	29	4.5.1	Paragraph 3. The assertion made in this paragraph that soils in the southwest deserts tend to naturally accumulate nitrate and sulfate and that they are attributed to the present high levels. What validation allows DOE to make this statement?	T	Y	DOE states, "it is possible that natural sources of both of these constituents may be contributing to elevated levels of nitrate and sulfate in the alluvial aquifer." The pilot studies are designed to see if soils at the Monument Valley site are similar to typical southwest desert soils. Sections 4.2, 4.3 and 4.5.1 of the EA will be revised to provide additional information and clarify this statement.
Navajo EPA Comments (Received January 5, 2005)						
1	8	3.0	Contaminants resulting from past operation of uranium mills are to be remediated to Maximum Contaminant Levels defined in the Navajo Nation Primary Drinking Water Regulations (NN PDWR).	R	N	The US EPA, which promulgated the UMTRA ground water regulations, considers tribes on an equivalent basis as states and not as subdivisions of states (this 1984 policy was reaffirmed on September 24, 2004). EPA's UMTRA ground water regulations (40 CFR 192), which establishes ground water remediation standards, specify that unlike other regulations, consistency with state regulations is not required by law. However, it does indicate that decisions regarding consistency of decisions "...with State laws and

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						regulations should be made by DOE in consultation with the States…" Therefore NN PDWR will be considered in establishing final remedial objectives for DOE sites located upon Navajo Nation lands.
2	19	3.4.1	2004 NN PDWR amendments are to be approved shortly by Navajo Nation lawmakers. The amendments include requirements for ground water monitoring at remediation sites. All metals analyses should be conducted from "total" (nonfiltered) ground water samples. If ground water turbidity values are high in monitor wells, it is suggested that attempts be made through purging to remove more sediment from the bottom of the well. If high turbidity is still present, consideration should be given to installing new monitor wells. Micropurging techniques currently being used by DOE during sampling should be reducing turbidity levels already; therefore, analyzing ground water samples for "total" (nonfiltered) metals should not be an issue.	T	N	DOE is conducting ground water monitoring in accordance with 40 CFR 192 requirements and the Cooperative Agreement between the Navajo Nation and DOE. Sampling at the Monument Valley site is being conducted to provide data for planned ground water modeling efforts, and to track changes in the concentrations of the contaminant plume. Therefore, it is necessary to continue to collect data in a consistent manner. However, during Spring 2005 sampling event, DOE will collect both filtered and nonfiltered uranium samples. The results will be used to determine the need to filter low turbidity uranium samples based on the data needs. It is believed that the focus of this comment is a concern that filtering metals samples will result in removing contaminants from the sample and provide results that are biased low. However, not filtering samples in poor producing, high turbidity wells can result in the entrainment of extraneous soil particles into the ground water sample (getting a soil sample mixed in with the water sample). The most important consideration in determining whether samples should be collected as filtered or nonfiltered is the intended use of the data. Despite extensive efforts, monitor wells producing limited water are often never possible to redevelop to the extent that the turbidity levels required by micropurging sampling techniques can be achieved. Also, natural turbidity levels in ground water may exceed the 10 nephelometric turbidity units (NTU) turbidity stabilization criteria (EPA 1996) for

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						well purging. The drilling and installation of new monitoring wells, in such cases, may not provide wells where samples can be collected with less turbidity.
3	6 26 29	1.4 4.5.1	Please provide justification for the upward hydraulic gradients discussed in page 6: lines 45 & 46, page 26: lines 37 & 38, and in page 29: line 31.	T	Y	The following references will be added to page 6: lines 45&46, and page 26: lines 37 & 38: "DOE 1999a; pg 5-25 thru 5-26". The following reference will be added to page 29, line 31: "DOE 1999a; pg 5-103".
4	29	4.5.1	Please provide justification for accumulation of sulfate and nitrate in desert soils on page 29: line 12.	T	Y	See response to Navajo UMTRA Comment #3, above.
5	29	4.5.1	Well 604 shows detectable nitrate very close to Cane Valley Wash. On page 29: lines 2 & 3, the EA states that the nitrate plume does not extend under the Cane Valley Wash. What evidence has been obtained to support this conclusion?	T	Y	The first paragraph on the page will be reworded to read as follows: "In the alluvial aquifer, downgradient and east of the site, the eastern limit of the nitrate plume is defined by wells 604, 786, 767, and 760. The nitrate concentrations in each of these wells have remained steady and at background levels since 1997 (DOE 1999a; pg. 5-71). These monitoring results demonstrate that the eastern margin of the plume does not extend under Cane Valley Wash.
6	19	3.4.1	Has the lateral and vertical extent of all contaminants associated with the former uranium mill been defined in ground water? And if not, when is DOE proposing to define them?	T	Y	The plume has been identified through characterization efforts over the past several years. In addition, see response to Navajo UMTRA Comment #2, above.
7			Has the use of De Chelly aquifer water for irrigation caused the plume to migrate faster to the north? Has the use of this water caused plume dilution? Has it change the hydraulic gradients at the site? How has the addition of De Chelly ground	T T T	N N N	DOE assumes that the plume being referred to is with regard to the alluvial aquifer. There is no evidence that the plume has been influenced by irrigation. The subpile phytoremediation pilot study was designed to control recharge, similar to a landfill cover—a phytoremediation cover—and instrumentation was installed to closely monitor the soil water profile and vadose-zone water flux. Therefore, dilution of the plume would not occur. Studies of soil water balance in arid and semiarid regions

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			water to alluvial ground water changed the ability to estimate contaminant mass removals rates?			do show that recharge occurs through thin and denuded soils. However, in many arid and semiarid ecosystems, relatively low precipitation, high potential ET, and thick unsaturated soils limit recharge to rates of a few mm/yr (Gee and Tyler, 1994). For this reason, desert environments have been advocated for waste disposal landfills (Winograd 1981; Reith and Thompson 1992). The subpile phytoremediation cover was designed to mimic this natural water conservation, to provide long-term hydrologic isolation of subpile soil nitrates while plants and microbes act to remove nitrogen. On landfills, these types of covers are often called evapotranspiration or ET covers, and generally consist of thick, fine-textured soil layers that store precipitation in the root zone where plants seasonally remove it (Anderson et al. 1993; Link et al. 1994; Ward and Gee 1997; EPA 2003; Waugh 2004). These studies, combined with monitoring, work well at Monument Valley because PET is high, and the deep-rooted desert shrubs planted in the subpile soil can rapidly extract the available water yet persist under conditions of water deficit. Monitoring data indicate that a deficit irrigation has been maintained, and little if any recharge is occurring below the root zone (DOE 2004).

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8	26	4.5.1	What are the values for the hydraulic gradients indicated on page 26: lines 34 & 35?	T	Y	The sentence beginning on line 32 will be revised to read: "Alluvial ground water generally flow north in the site vicinity (DOE 1999a; p. 5-17); ..." The sentence beginning on line 34 will be modified to read "The hydraulic gradient ranges from about 0.016 (dimensionless) in the southern end of the site to about 0.009 (dimensionless) in the northern portion".
			A ground water potentiometric surface map in the final EA would help to understand site ground water gradients.	T	N	Figures 5-4, 5-5, and 5-6 in the SOWP (DOE 1999a) provide this information
9	34	4.6.1	Have the areas referenced on page 34: line 17 been tested to know if they have been affected by contaminated ground water?	T	Y	Section 5.3 and 7.3 of the SOWP (DOE 1999a) provide results of characterization activities for the permanent and intermittent surface water features at the Monument Valley site, and provide a summary of the data stating " Surface water located east of the site along the Cane Valley Wash has not been affected by the former milling operations." This information will be added to the reference of the SOWP on the same page (34), at line 43.
10	41	4.6.1	Has sufficient data been gathered to determine if Cane Valley Wash has been affected by contaminated ground water?	T	N	Analytical data describing the ground water contamination are presented in the SOWP (DOE 1999a; p 5-41 thru 5-118). Results of the hydrogeochemical study show that for all the COPCs, except sulfate, there is little potential that Cane Valley Wash has been, or will be, affected by contaminated ground water. Elevated sulfate concentrations in ground water exist in proximity to Cane Valley Wash (DOE 1999a; p 5-75); however, these concentrations are believed to be indicative of locally elevated natural background values. Previous characterization has shown that site-background concentrations for sulfate are extremely variable. Because of the high variability, further studies of sulfate in ground water have been proposed. Results from this study will help

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						address whether the elevated sulfate concentrations along Cane Valley Wash are due to contamination or natural background.
11	36	4.6.2	Will irrigation plans (alluvial or De Chelly aquifers) dewater the Frog Ponds?	T	Y	Although the frog ponds receive recharge from both the alluvial and De Chelly aquifers, the limited deficit irrigation (see response to comment # 7) planned for establishing the plants will have minimal impact on either aquifer, and therefore impacts to the Frog Ponds, if any, are expected to be negligible.

[a]Comments may be paraphrased for summary when not submitted on comment-response forms. If this is the case the text of the comment is attached
[b]**T** = technical issue; **R** = regulatory issue; **S** = stakeholder concern that is not technical or regulatory in nature, **C** = Editing, corrections, typos, etc.