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Environmental Assessment of Ground Water Compliance at the Tuba City Uranium Mill Tailings Site

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This EA has incorrectly numbered pages and appears to be missing pages 4, 12, 14, 16, and 17. However, upon reviewing the document it was determined that the document is complete.

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Acronyms and Abbreviations

CFR	U.S. Code of Federal Regulations
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ft	feet
mg/L	milligrams per liter
pCi/L	picocuries per liter
UMTRA	Uranium Mill Tailings Remedial Action (Project)
UMTRCA	Uranium Mill Tailings Radiation Control Act

1.0 Introduction

The U.S. Department of Energy (DOE) has selected a ground water compliance strategy for the Tuba City Uranium Mill Tailings Remedial Action (UMTRA) Project site (Tuba City site). This compliance strategy must meet U.S. Environmental Protection Agency (EPA) ground water standards defined in Title 40, Part 192 of the *U.S. Code of Federal Regulations* (40 CFR 192) entitled "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings." Contamination in the ground water consists of residual radioactive material, which is defined in the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA) (42 *U.S. Code*, Section 4321 *et seq.*) 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." DOE has prepared this Environmental Assessment to provide the public with information on the potential effects of its proposed ground water compliance strategy.

1.1 Site Description

The Tuba City site is in Coconino County, Arizona, just south of U.S. Highway 160 in Sections 17 and 20, Township 32 North, Range 12 East, Gila and Salt River Meridian. The site is within the boundaries of the Navajo Nation and is close to the Hopi Reservation; it is approximately 5 miles east of Tuba City, Arizona, and 85 miles northeast of Flagstaff (Figure 1). Approximately 5 miles southwest of the Tuba City site, along Moenkopi Wash, is Moenkopi Village.

The Tuba City site lies at an elevation of approximately 5,100 feet (ft) above sea level on a terrace that slopes gently to the south. Surface drainage is to the south toward Moenkopi Wash (Figure 2). The Tuba City site, which is surrounded by a chain-link security fence, comprises approximately 146 acres; the top of the disposal cell covers approximately 31 acres.

The area in the vicinity of the Tuba City site is semiarid and desertlike. Land immediately adjacent to the site is used for grazing. Lands farther from the site are used for dry farming, irrigated farming, and residences. The *Environmental Assessment of Remedial Action at the Tuba City Uranium Mill Tailings Site, Tuba City, Arizona* (DOE 1986) and the Site Observational Work Plan (DOE 1998b) provide detailed descriptions of the Tuba City site.

1.2 Background

UMTRCA authorized DOE to perform remedial action at 24 inactive uranium-ore processing sites. The Tuba City site was one of the 24 sites identified for cleanup. During its 10 years of operation, the mill at the Tuba City site processed approximately 800,000 tons of uranium ore. It ceased operations in 1966. DOE began surface cleanup at the site in 1988. Uranium mill tailings and associated materials were moved and stabilized in an engineered disposal cell on the site. Surface cleanup was completed in April 1990, and since then, DOE has monitored contaminants

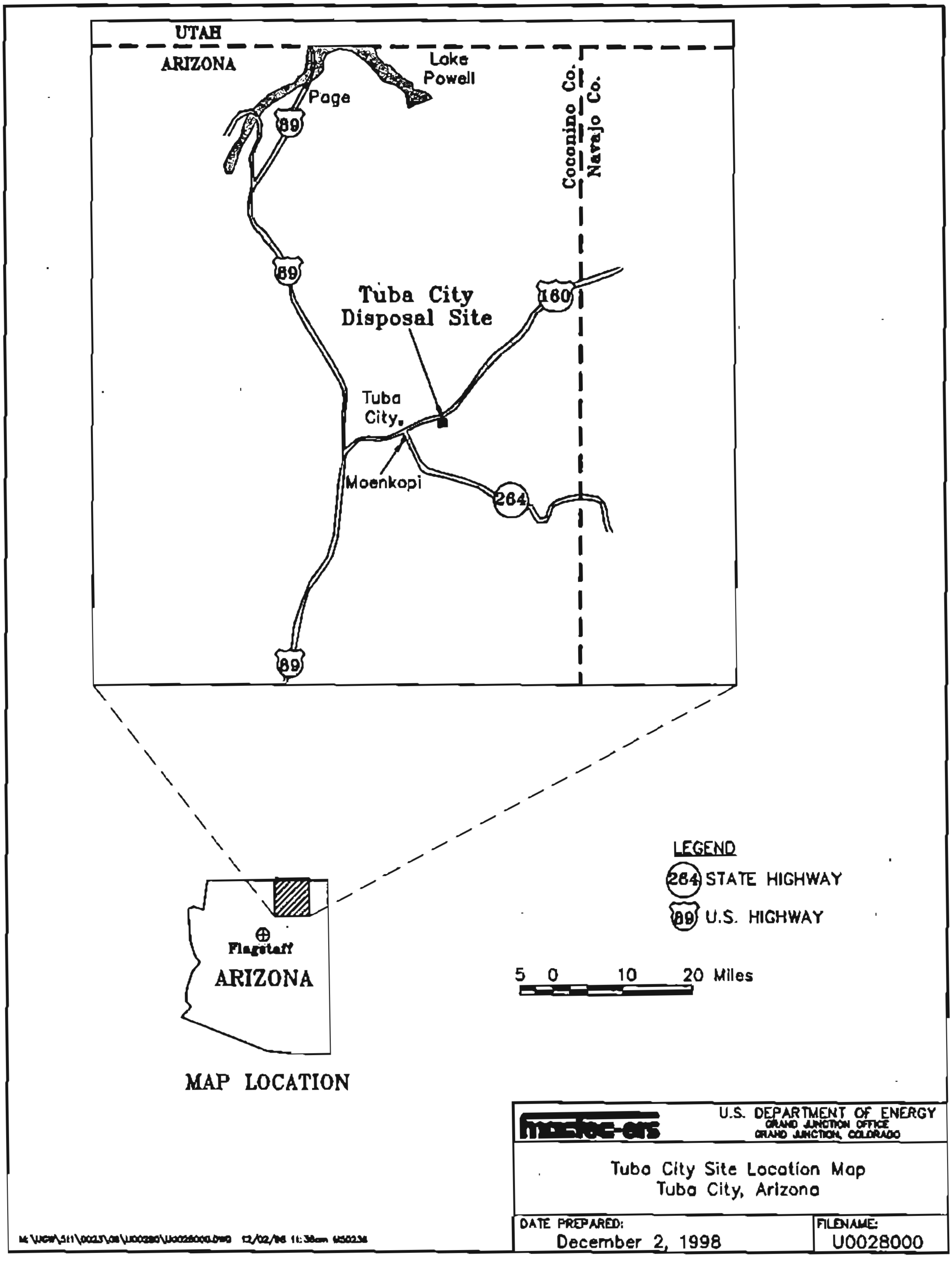

Figure 1. Location of the Tuba City Site

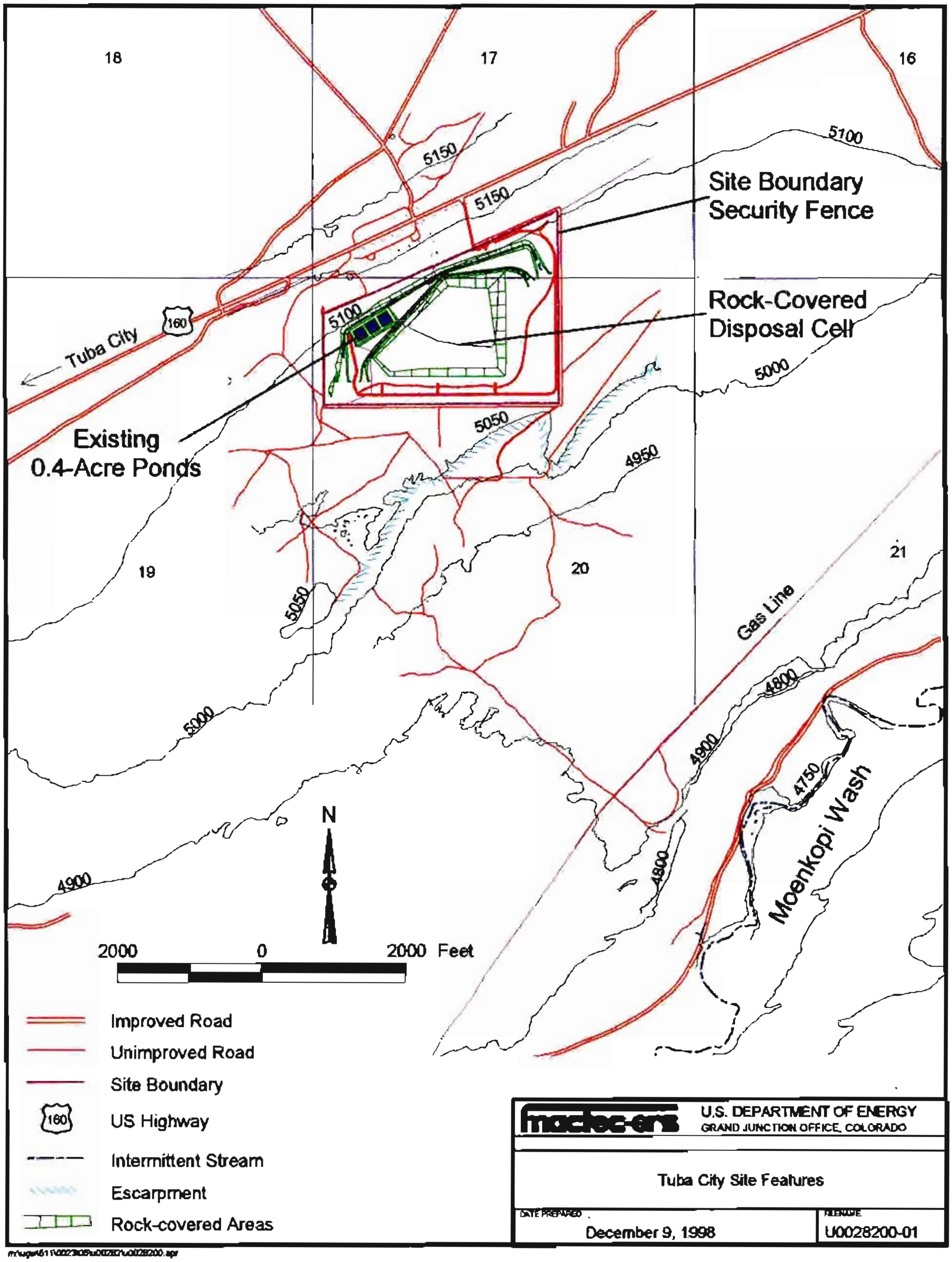

Figure 2. Tuba City Site Features

in the ground water beneath the site, as required by EPA's ground water regulations (40 CFR 192). Results of the monitoring indicate that up to 1.7 billion gallons of water are contaminated, primarily with nitrate and sulfate as well as lesser amounts of uranium, molybdenum, and selenium. Nitrate, uranium, molybdenum, and selenium are present in concentrations that exceed the maximum concentration limits in 40 CFR 192; sulfate does not have a maximum concentration limit. Ground water contamination has been detected as far as 1,500 ft downgradient from the former millsite and to a depth of 86 ft below the water table. This contamination currently poses no risk to human health or the environment because there are no domestic or drinking-water wells that withdraw the contaminated ground water. However, the contamination may pose a human-health or ecological risk if the ground water is withdrawn and used in the future. Additional information about the site history is presented in Section 3 of the Site Observational Work Plan (DOE 1998b) and in Section 2 of the Baseline Risk Assessment (DOE 1994).

In 1996, DOE completed the *Final Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project* (DOE 1996a). In that document, DOE analyzed the potential effects of implementing four alternatives for achieving ground water compliance at the UMTRA Project processing sites. A Record of Decision was issued in April 1997 in which DOE selected the "Proposed Action Alternative" for conducting the UMTRA Ground Water Project. Under the Proposed Action Alternative, DOE has the option of implementing active remediation, natural flushing, no ground-water remediation,[1] or any combination of the three strategies. These options, identified as "strategies" in the Programmatic Environmental Impact Statement, provide the possible alternatives for this site-specific Environmental Assessment.

DOE used a step-by-step approach established in the Proposed Action Alternative of the Programmatic Environmental Impact Statement to identify the specific strategy for the Tuba City site that would comply with ground water regulations and ensure protection of human health and the environment. The flow diagram in Figure 3 illustrates the process that DOE used to assess each of the possible strategies. First, the criterion in box 2 of Figure 3 was evaluated. Because the concentrations of molybdenum, nitrate, selenium, and uranium in the ground water beneath and downgradient of the Tuba City site exceed their EPA maximum concentration limits and because sulfate exceeds its background concentration, this criterion was met. Therefore, the criterion in box 4 was evaluated next. Ground water at the Tuba City site does not qualify for supplemental standards on the basis of limited-use ground water.

Next, the criterion in box 6 was evaluated. The criterion asks whether the contaminated ground water qualifies for alternate concentration limits on the basis of human health risks, environmental risks, and other factors. The ground water does not qualify for alternate concentration limits because of the potential future uses of ground water in the area surrounding the site. The water quality of the Navajo aquifer is very good and has value as a future

[1] "No remediation" is not the same as the "no action" alternative discussed in this Environmental Assessment. The "no remediation" sites require activities such as site characterization to show that no remediation is warranted.

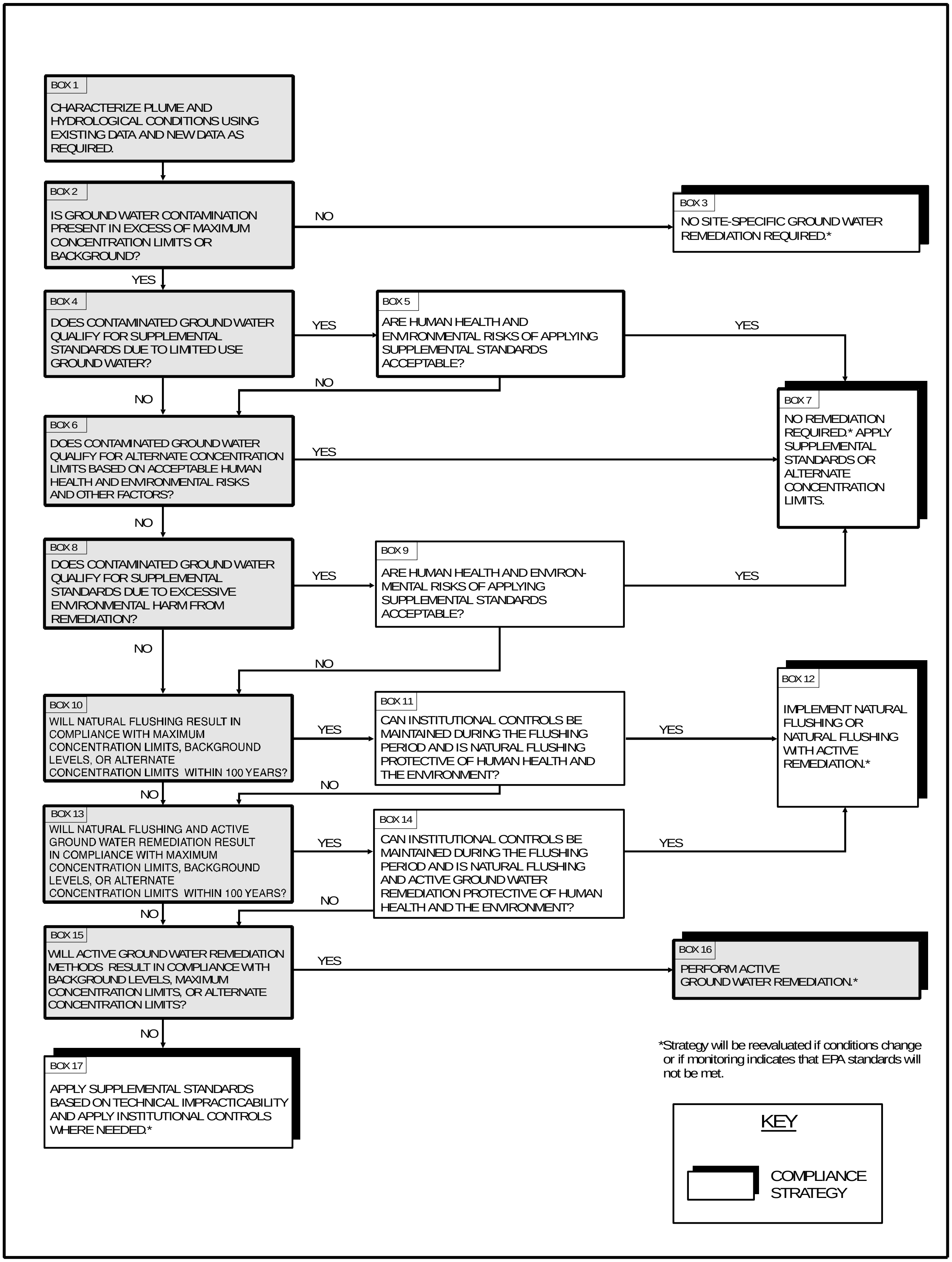

Figure 3. Compliance Selection Framework, Tuba City Site

source of drinking water. Therefore, because the extent of contamination and the concentration of constituents in the ground water pose a substantial potential hazard to human health and the environment, the application of alternate concentration limits is not appropriate under a no-remediation scenario.

The next step (box 8 in Figure 3) evaluated whether excessive environmental harm would result from remediation of the ground water. Although remediation of the ground water at the Tuba City site could lower the water table in areas immediately adjacent to the site (see Section 4.1.2), it is not expected to cause excessive environmental harm and, therefore, the criterion in box 8 of Figure 3 is not applicable.

The feasibility of natural attenuation, also known as natural flushing, was evaluated next (box 10 in Figure 3). Given the natural gradient, more than 200 years would be required to flush one pore volume[1] through the contaminated area. The regulatory time limit for natural flushing is 100 years, during which time institutional controls would be maintained. Therefore, natural flushing was not considered a feasible regulatory strategy.

Consistent with the criterion in box 13 of Figure 3, a combination of active remediation and natural flushing was considered. Because the time period for natural flushing is so long (i.e., more than 200 years for one pore volume), a combination of natural flushing and active remediation probably would not result in compliance for contaminants such as uranium and nitrate that have high concentrations relative to their maximum concentration limits.

Active ground water remediation (box 15 in Figure 3) was evaluated next to determine if it would result in compliance with the standards. Available information suggests that compliance with the standards may be achieved through active remediation, and therefore, the strategy to perform active remediation (box 16 in Figure 3) for molybdenum, nitrate, selenium, and uranium, was selected. In addition to these contaminants, the Navajo Nation requested cleanup goals for total dissolved solids, chloride, pH, corrosivity, sulfate, and sodium. These additional cleanup goals are discussed in Section 4.1.

The decision to select the active remediation strategy is further supported by the Baseline Risk Assessment (DOE 1994) and the Site Observational Work Plan (DOE 1998b). This Environmental Assessment discusses the active-remediation and no-action compliance strategies for the Tuba City site (see Section 3.0). On the basis of data gathered during the site characterization and the subsequent site conceptual model, the natural-flushing and no-remediation compliance strategies identified in the Programmatic Environmental Impact Statement were eliminated from further consideration and are not addressed in this Environmental Assessment. The issues discussed and the environmental impacts analyzed in this Environmental Assessment are supported by several environmental documents as allowed by National Environmental Policy Act regulations in 10 CFR 1021.210(e).

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[1]One pore volume is the amount (volume) of ground water within the contaminant plume. The term “pore” is used because water exists within the pores of the sandstone formation.

2.0 Need for DOE Compliance Strategy

In the portions of the aquifer that are unaffected by Tuba City millsite-related contaminants, ground water is of high quality and is suitable for all domestic uses. However, past milling activities have resulted in degradation of ground water quality beneath and downgradient of the former millsite. Eighteen site-related constituents were detected in ground water at concentrations above background; of those, five are present in concentrations that exceed maximum allowable limits or that could pose a future human-health or ecological risk. By implementing the Proposed Action Alternative, DOE would attempt to remediate the contaminated portion of the aquifer until contaminant concentrations are within EPA standards and, to the extent practicable, until concentrations are within the cleanup goals requested by the Navajo Nation (see Section 4.1).

3.0 Proposed Action and No Action Alternatives

3.1 Alternatives Considered But Eliminated

To achieve the proposed compliance strategy of active ground water remediation, DOE evaluated a number of alternatives for cleaning up ground water at the Tuba City site. Alternatives were developed by dividing the remediation process into two components: (1) extraction and disposal of the ground water and (2) treatment of the extracted ground water. Two pumping alternatives were developed to address extraction and disposal of the ground water. One alternative required vertical wells for extraction and solar evaporation for disposal of the ground water. The other pumping alternative required vertical wells for extraction and a combination of vertical injection wells and an infiltration trench for disposal of treated ground water. Pumping and treatment alternatives were evaluated on effectiveness, implementability, and cost. Table 1 lists the treatment alternatives that were evaluated and eliminated from further consideration. Detailed descriptions of those alternatives are presented in Section 8.0 of the Site Observational Work Plan.

Early in the evaluation and after consultation with stakeholders, DOE concluded that extraction of contaminated ground water and some type of above-ground treatment would be the best method for remediating the site. An Innovative Treatment Remediation Demonstration team, which had been formed to identify and assess new or innovative technologies for remediating ground water, focused its studies on ways to enhance an extraction and above-ground treatment technology. The team was composed of representatives from EPA, industry, the Hopi Tribe, Navajo Nation, and DOE. The teams's final report (Hightower 1998) presented a qualitative evaluation of several technologies but did not recommend any particular technology as the best solution for the Tuba City site.

Table 1. Alternatives Eliminated From Further Consideration

Category	Reason for Eliminating
Evaporation systems	Water pumped from the aquifer could not be reinjected; the resulting lowering of the water table could be detrimental to the overall cleanup effort.
Through-medium processes such as ion exchange	Impractical for liquids with total dissolved solids higher than about 1,500 mg/L; dissolved solids concentration in the contaminant plume is 2 to 7 times that amount.
Land application (land/plant treatment process)	• Primarily effective for removing nitrate; technologies for removing sulfate and metals are not fully tested. • Only operational during the growing season (mid-March until October). • Water pumped during the off-season months could require a pond having a large surface area (more than 8 acres).
Chemical treatment and biological denitrification	• A complex treatment system that would require specially trained persons to operate the system. • There is considerable uncertainty that the sequencing batch reactors would denitrify the water within a reasonable time. • Annual operation and maintenance costs made this method the most expensive of all the alternatives considered. • This method would not minimize wastes.
Nanofiltration with biological denitrification	• Moderate to high potential for schedule delays because of technical problems caused by the complexity of the system. • Specialists would be needed to build the system or oversee its construction. • Method is dependent upon temperature and other variables that are difficult to manage. • Requires the largest solar evaporation pond to handle the reject water (brine). • Produces a large quantity of reject water (about 20 percent of the total feed).

The method DOE selected for actively remediating contaminated ground water at the Tuba City site is discussed in Section 3.2 as the Proposed Action Alternative. The proposed action combines the pumping alternative that uses extraction wells, injection wells, and an infiltration trench with a treatment alternative that uses distillation.

DOE is required to consider the No Action Alternative by regulations in 10 CFR 1021, paragraph 321(c). That alternative is described in Section 3.3.

3.2 Proposed Action Alternative

The Proposed Action Alternative combines the most effective aspects of the extraction and treatment technologies considered for the Tuba City site. Of the alternatives considered in the Site Observational Work Plan, the Proposed Action Alternative would result in the least loss of water from the aquifer during treatment, produce the least amount of waste, and produce the highest quality of treated water. Implementation of the alternative would involve (1) installing wells to extract contaminated ground water, (2) constructing a facility to treat the recovered water by a distillation process, and (3) installing additional wells and an infiltration trench to inject the treated ground water back into the aquifer. The objectives of the extraction and injection system would be to contain the spread of contaminants while removing contaminants from the ground water plume to achieve compliance with ground water standards.

Two phases for implementing the extraction and injection system are planned. Phase I would involve installing 5 to 15 extraction wells and 5 to 10 injection wells in and around the site and installing an infiltration trench north of the disposal cell (see Figure 4). The distillation treatment system would require installation of a large (20–70 ft high and up to 50 ft long) treatment unit on the site (see Figure 5). The Phase I treatment unit would process up to 140,000 gallons of contaminated ground water per day and is expected to operate for 2 to 4 years. During this initial operating period, sampling of the extracted and treated water would be conducted periodically to evaluate the effectiveness of the system. Monitoring and modeling results would be used (i.e., the “observational approach” would be used) to design Phase II of the system, which would involve the installation of 40 to 55 additional extraction wells, 20 to 30 additional injection wells, and an additional treatment unit (see Figure 6). The precise number of additional wells would depend upon site conditions. During Phase II, up to 280,000 gallons of contaminated ground water would be treated per day. Current estimates are that the system would require approximately 16 years of operation before EPA ground water standards would be met in the aquifer. Ground water samples would be collected throughout the operational life of the system.

Wells would probably be installed with truck-mounted rotary drill rigs; rotary drilling has been used in previous well installations at the site and appears to be the most effective drilling method to use there. Wells would be installed to depths of less than 150 ft.

Extraction wells would be connected to a 30,000-gallon (approximate) above-ground storage tank (Figure 5) by underground pipe. The existing 0.4-acre ponds (Figure 5) would ***not*** be used to store influent water because of the evaporation potential. Pipe installation would require trenching of the site between the well and pond locations. Trenching would be done with standard construction equipment and would require disturbance of the site soils and vegetation. Before surface-disturbing activities would begin, DOE would conduct a plant survey to ensure that no threatened or endangered plant species are present at the site. If any are found, the areas containing the species would be avoided. Disturbances to other vegetation would be minimized by requiring construction equipment to stay on established routes. After installation of the pipes, trenches would be backfilled and the disturbed areas would be revegetated.

In addition, DOE would conduct a Class III cultural resources survey before ground would be disturbed. Any significant sites would be avoided.

Water from the extraction wells would be piped to and collected in the above-ground storage tank. Storage of water would dampen variations in the extraction rate and allow a constant feed rate to the treatment unit. Because of the high alkalinity of the ground water, influent would be pretreated with a chemical (e.g., sulfuric acid or soda ash) to enable the treatment unit to perform to its optimum capacity. Water would then be pumped to the treatment unit. The unit would be installed using standard construction practices and safety procedures and would operate with electricity. Electrical service currently exists at the site.

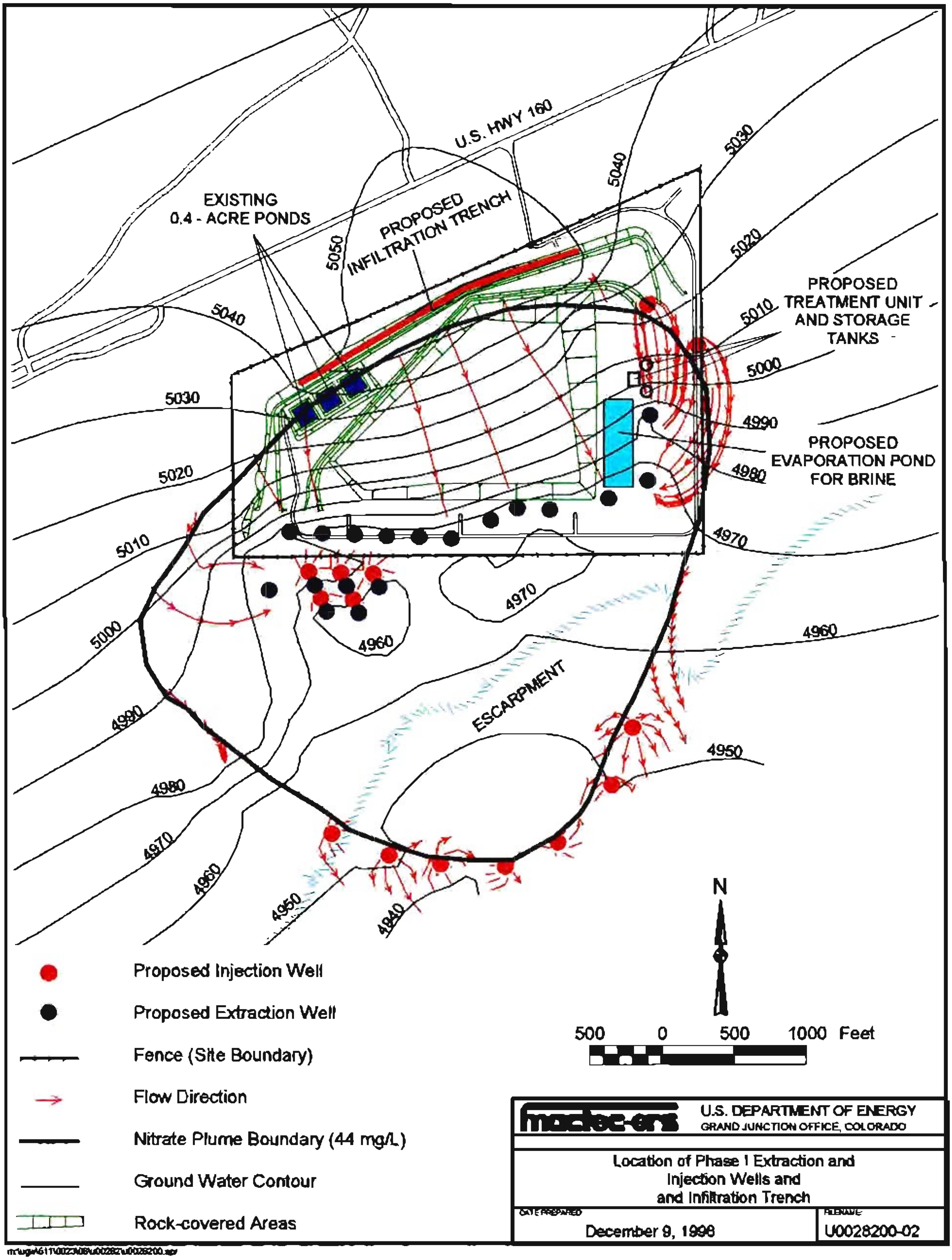

Figure 4. Proposed Locations of Phase I Extraction and Injection Wells and Infiltration Trench

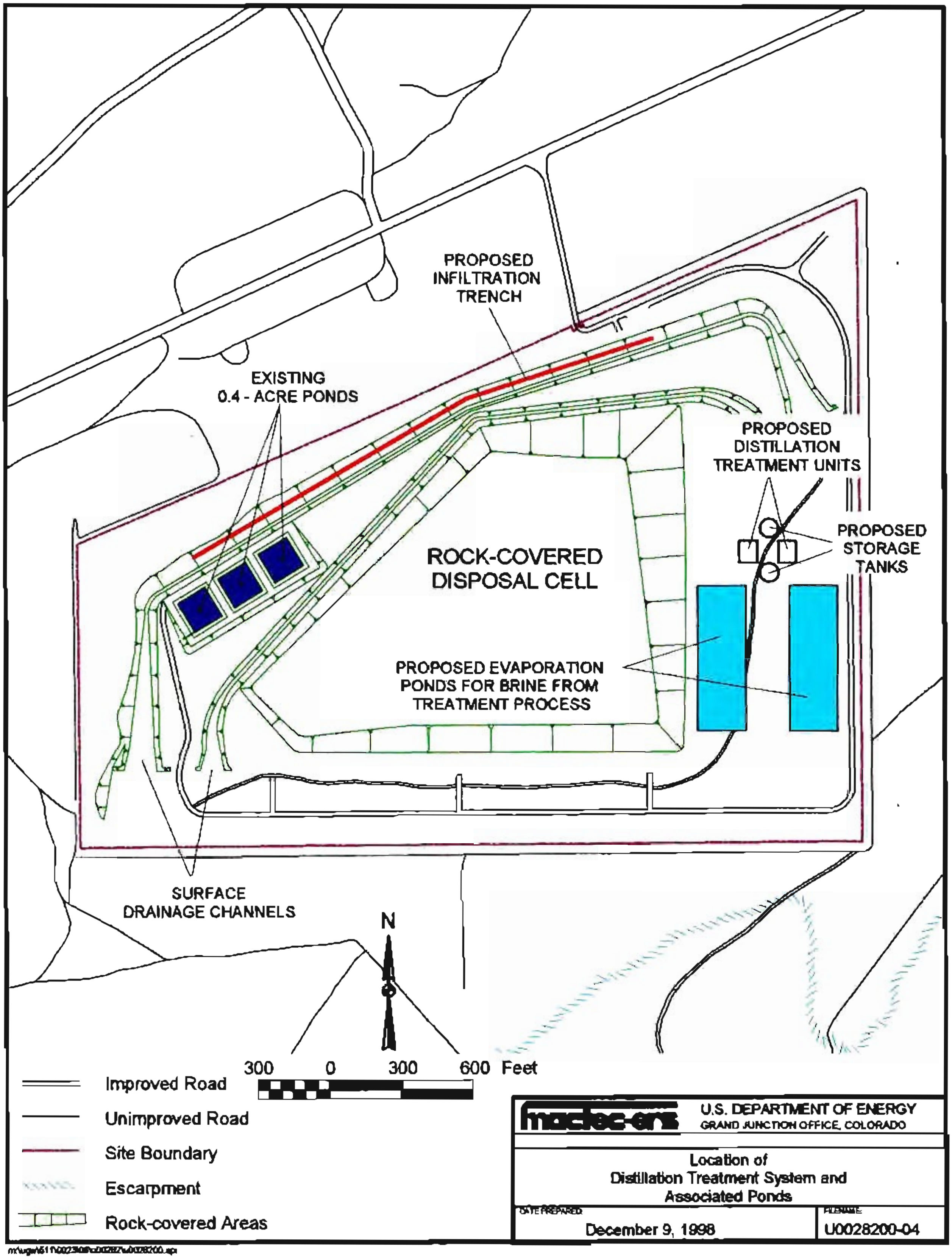

Figure 5. Location of the Distillation Treatment System, Storage Tanks, and Ponds

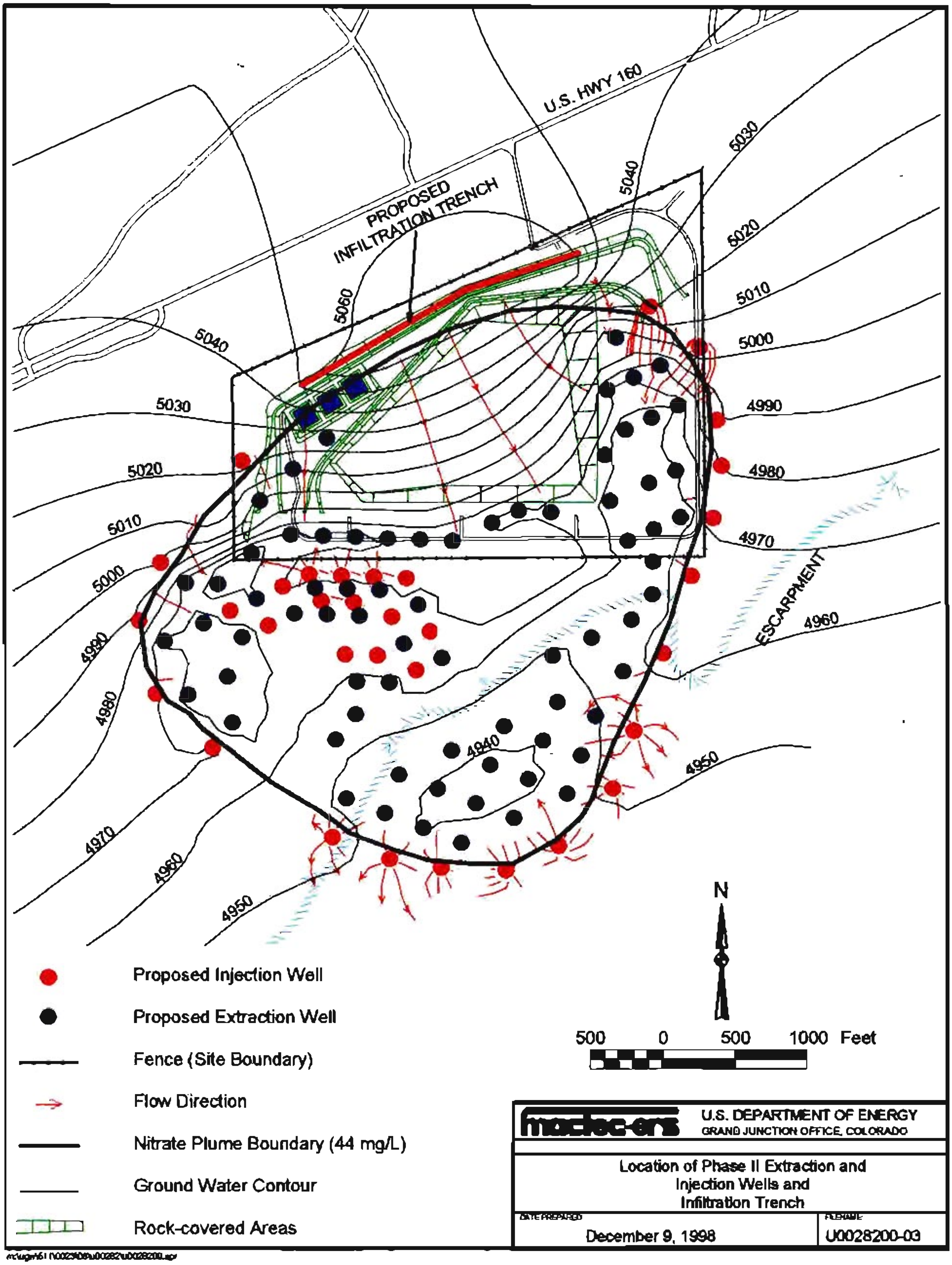

Figure 6. Proposed Locations of Phase II Extraction and Injection Wells and Infiltration Trench

During the distillation process, extracted ground water would be vaporized by heating it to its boiling point in a chamber. The water vapor would then be condensed in a separate vessel. Nonvolatile contaminants such as nitrate, uranium, molybdenum, selenium, sulfate, and other dissolved solids would concentrate in the chamber. The "clean," treated water would be temporarily stored in a 10,000-gallon (approximate) above-ground storage tank and then pumped back into the aquifer through the injection wells and infiltration trench; the concentrated water (called brine or reject water) would be collected separately.

Operation of the treatment unit would require a minimum of managerial and technical supervision and maintenance. The pretreatment system could operate with minimal oversight, although periodic replenishing of the chemicals would be required, as well as occasional maintenance.

The brine water, which would consist of approximately 5 percent of the original extracted ground water, would be disposed of on site in double-lined solar evaporation ponds (Figure 5) equipped with leak detection systems. Up to 4 acres of land may be required for the ponds. One or more of the existing 0.4-acre ponds (Figure 5) may be used as a "back-up" solar evaporation pond in wetter years if additional storage and evaporation were needed. One of these ponds is currently double-lined. If the other ponds were to be used, they would be re-built as double-lined ponds. "Brine sludge" generated through the evaporation process would be removed periodically from the ponds and disposed of off site (see Section 3.2.2). Moisture levels in the brine sludge would be monitored and maintained to prevent dust releases.

The fence at the site would prevent access to the ponds by livestock and other large mammals as well as unauthorized humans. Other preventative measures such as nets, silhouettes, and reflectors would be developed to discourage use of the ponds by wildlife.

Treated water would be pumped through underground piping to the injection wells and infiltration trench, where it would re-enter the aquifer. The pipe would be buried to protect it from degradation by the sun. Injection wells would be installed as described previously. The infiltration trench would be installed on the upgradient side of the disposal cell (Figure 5) to facilitate flushing of the aquifer beneath the disposal cell. The excavated trench would be filled with a perforated drain pipe bedded in a natural granular filter, such as pea gravel.

At the completion of ground water cleanup activities, DOE would remove the distillation treatment units, water storage tank, evaporation ponds, existing 0.4-acre ponds, and infiltration trench. The pipelines also would likely be removed. A limited number of the injection and extraction wells would be left in place for use as ground water monitoring wells. Most of the wells would be decommissioned in accordance with State and tribal regulations. All disturbed areas would be regraded, if necessary, and revegetated.

3.2.1 Limitations of the Proposed Action Alternative

Of all the alternatives considered, distillation would produce the highest quality of treated water. However, the effectiveness of remediation could be limited by the efficiency of the extraction system. Hydraulic inefficiencies (e.g., movement of contaminants into low-permeability areas), heterogeneity of the aquifer (e.g., changes in hydraulic conductivity and porosity), and adsorption of contaminants to the aquifer material could limit the effectiveness of the extraction system. Adsorption of contaminants is not expected to be significant for nitrate, uranium, and major anions such as sulfate but may be significant for selenium and molybdenum. Hydraulic inefficiencies and aquifer heterogeneities are the main factors that would determine the effectiveness of the extraction system (DOE 1998a).

If active remediation cannot achieve the cleanup standards after a reasonable time period and reasonable effort, DOE would consult with the Hopi Tribe and Navajo Nation to pursue other methods of protecting human health and the environment. At that time, the need for additional analysis under the National Environmental Policy Act would be evaluated. A provision in 40 CFR 192 allows the use of alternate concentration limits that would be set at higher concentrations than the current cleanup goals but would still be protective of human health and the environment. The use of alternate concentration limits may require implementation of institutional controls that would limit the use of ground water near the site. Using alternate concentration limits and implementing institutional controls would only be considered if active remediation could not effectively reduce contaminant concentrations in the aquifer to the cleanup standards.

3.2.2 Waste Management

During implementation of the Proposed Action Alternative, two main types of waste would be generated: (1) secondary wastes, which would be generated from the drilling, developing, and monitoring of extraction and injection wells, and (2) process wastes, which would be generated from the treatment of contaminated ground water. Secondary wastes would consist of both liquid and solid media. Liquid secondary wastes would include well development water, water from the 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 solid wastes associated with disposable field test kits. Process wastes would include the concentrated brine sludge.

DOE’s general approach to managing wastes at UMTRA sites and a summary of the key regulations potentially applicable to the management and disposal of wastes are described in the *Management Plan for Field-Generated Investigation Derived Wastes* (DOE 1997). Although this plan specifically addresses investigation-derived wastes, the policy and criteria discussed in the plan are applicable to the management of secondary wastes. The following discussion summarizes DOE’s plans for managing wastes at the Tuba City site.

Secondary waste that could not be disposed of on site would be hauled to a licensed landfill or to a facility authorized to accept residual radioactive material (e.g., a privately owned uranium mill tailings disposal site [Title II site] or the Cheney disposal cell in Grand Junction, Colorado), depending on the types and concentrations of contaminants in the waste. In accordance with the Memorandum of Understanding between DOE and the Mesa County Board of Commissioners (DOE 1996b), approvals by the State of Colorado and Mesa County Commissioners would be obtained before initiating off-site shipments to the Cheney disposal cell. Likewise, appropriate approvals would be obtained before shipping wastes to one of the privately owned disposal sites (e.g., UMETCO's disposal site in Uravan, Colorado).

The Navajo Nation Water Quality Codes state that no entity shall be entitled to take any action affecting the use of water within the Navajo Nation, unless such action is authorized by a permit. DOE would apply for well and water use permits through the Navajo Nation Department of Water Resources. DOE also would consult with the Navajo Nation EPA office for approval of a discharge permit for discharge of treated water to injection wells. Once approved, the requirements of these permits would guide DOE's management of liquid secondary wastes and treated ground water.

As approved by the Navajo Nation through the water use and discharge permits, and to the extent allowable under the screening procedures identified in DOE's programmatic plan for managing wastes (DOE 1997), the following wastes would be disposed of on site around the well itself, or beneath the surface of the ground: well development water, well purge water, equipment decontamination water, and drill cuttings. Empty containers and personal protective equipment would be rinsed with clean water or brushed clean and scanned for radioactive contamination. Decontaminated material would be disposed of as solid waste at a State-authorized municipal landfill. In the unlikely event that containers or personal protective equipment could not be decontaminated, they would be managed as residual radioactive material and disposed of at a facility authorized to accept such material.

The treatment system may treat as much as 1.7 billion gallons of ground water over the life of the project. Brine effluent resulting from the treatment process is expected to be between 5 and 10 percent of that volume, or 85 to 170 million gallons. This effluent would be discharged to holding ponds and evaporated. It is projected that 1 pound of solids would be generated for every 36 gallons of water processed; therefore, up to 24,000 tons of solids would be generated over the life of the project. This process waste (brine sludge) would be disposed of at a facility authorized to accept residual radioactive material.

Wastes expected to be generated during ground water remediation at the Tuba City site, the estimated volumes, and the approach for their management and disposal are summarized in Table 2.

3.3 No Action Alternative

Under the No Action Alternative, no further activities would take place to address contaminated ground water at the Tuba City site. Contaminated ground water would be left "as is" and no institutional controls would be implemented outside the fenced area. DOE would continue to maintain the fence and signs around the disposal cell and conduct annual inspections of the cell exterior; however, ground water monitoring would not be conducted, and no information would be collected to evaluate changing ground water quality.

Table 2. Summary of Wastes, Volumes, and Disposal Methods

Type of Waste	Estimated Maximum Volume of Waste	Disposal Option
Drill cuttings	840 drums (Seven 55-gallon drums per well x 120 wells)	Drill cuttings will be disposed of in accordance with applicable regulations and the *Management Plan for Field-Generated Investigation Derived Waste* (DOE 1997). When drilling into the former footprint of tailings, drill cuttings would be scanned to ensure they do not exceed surface remediation criteria for radioactive contaminants. If the cuttings do not exceed surface criteria, they would be dispersed on the ground. If the cuttings exceed surface criteria, they would be used to fill the annulus of the well or would be buried a minimum of 1 ft below the surface of the ground. For wells outside the former footprint, cuttings would be dispersed on the ground.
Well development water	24,000 gallons (200 gallons per well x 120 wells)	Before treatment system is in place, disposal would be by on-site surface dispersion in accordance with *Management Plan for Field-Generated Investigation Derived Waste* (DOE 1997). After treatment system is in place, all liquid secondary wastes would be treated and discharged into injection wells.
Equipment/personnel rinse water	7,200 gallons (10 gallons per well for equipment and 50 gallons for drill rig after drilling x 120 wells)	Before treatment system is in place, on-site surface dispersion would be allowable (DOE 1997). After treatment system is in place, all liquid secondary wastes would be treated and discharged into injection wells.
Monitoring well purge water	12,000 gallons (100 gallons per well x 120 wells)	Before treatment system is in place, on-site surface dispersion would be allowable (DOE 1997). After treatment system is in place, all liquid secondary wastes would be treated and discharged into injection wells.
Brine sludge (dry solids)	24,000 tons (1 pound of solids for every 36 gallons of water processed); [(1.7 billion gallons/ 36 gallons)/2000 pounds per ton]	Dispose of at a site authorized to accept residual radioactive material.
Field test-kit wastes	25 gallons of absorbed liquids (5 gallons per 25 wells)	On the basis of 40 CFR 261.5, liquid waste would be absorbed, and wastes would be disposed of at a municipal landfill or as residual radioactive material at an authorized facility.
	2.5 drums of solids (0.5 drums per 25 wells)	
Personal protective equipment	Well drilling and development: 12 drums noncontaminated personal protective equipment (1 drum per 10 wells)	Decontaminate as necessary and dispose of as general refuse in a municipal landfill.
	Initial well sampling: 12 drums noncontaminated personal protective equipment (1 drum per 10 wells)	Decontaminate as necessary and dispose of as general refuse in a municipal landfill.
	Contaminated personal protective equipment and miscellaneous wastes: 5 drums (1 drum per 25 wells)	Dispose of as residual radioactive material at an authorized facility.

4.0 Affected Environment and Environmental Consequences

This section describes the environmental issues or resources that are associated with the Tuba City site and the effects that the Proposed Action and No Action Alternatives may have on them. DOE has determined that some environmental resources are not present at the site and that some would not be affected by the alternatives. These resources include wetlands, floodplains, and recreational resources. Because they would not be affected by the alternatives or are not present at the site, these resources are not discussed in this Environmental Assessment. Sections 4.1 through 4.13 discuss the resources or issues that may be affected by the alternatives.

4.1 Ground Water

4.1.1 Affected Environment

During the 10 years that the Tuba City mill was in operation (1956 to 1966), milling process waters and tailings were discharged as a slurry (a mixture of solids and water) to evaporation ponds at the millsite. Because these ponds were unlined, not all of the water evaporated. Over this 10-year period, a large volume of contaminated water seeped downward into the aquifer beneath the Tuba City site. The water that percolated from the tailings ponds into the ground water contained high concentrations of dissolved constituents derived from the milling process. As described in Section 1.2, the main contaminants in the ground water are nitrate, uranium, molybdenum, selenium, and sulfate. Figure 4 depicts the approximate boundary of the contaminant plume identified at the Tuba City site.

Hydrogeology

The major aquifer in the area is the N-aquifer, which is made up of the Navajo Sandstone and the Kayenta Formation. The Navajo Sandstone is composed of medium- to fine-grained quartz sand weakly cemented with calcite and silica. The thickness of the Navajo Sandstone at the site is approximately 430 ft, and depth to water in the monitoring wells ranges from 30 to 60 ft below the land surface. Ground water in this unit is unconfined. Below the Navajo Sandstone lies the Kayenta Formation, which is about 400 ft thick near the site and consists of siltstones, mudstones, and sandstones cemented mainly with calcite.

Ground water beneath the Tuba City site is part of the N-aquifer system. The volume of water contained in the N-aquifer has been estimated to be at least 180 million acre-feet.[1] Regionally, the aquifer obtains its recharge from rainfall and snowmelt throughout the 1,400 square-mile area where the Navajo Sandstone is exposed. A small amount of recharge occurs as leakage from overlying confining beds. The estimated annual recharge to the aquifer is 13,000 acre-feet. The valley of Moenkopi Wash is an important regional discharge location for the N-aquifer. The discharge occurs as evapotranspiration,[2] direct discharge to springs and seeps along the axis of

[1]One acre-foot is the quantity of water that would cover 1 acre to a depth of 1 foot.

[2]Evapotranspiration is the total water loss that occurs by direct evaporation from the soil and by transpiration from the surfaces of plants.

Moenkopi Wash, and discharge to Moenkopi Wash alluvium. Annual discharge to Moenkopi Wash from the N-aquifer is estimated to be approximately 3,800 acre-feet.

The saturated thickness of the N-aquifer near the disposal cell is about 500 ft; however, within 2,000 ft south of the disposal cell, the N-aquifer thins rapidly. Depth to ground water also decreases rapidly over this reach. Approximately 4,000 ft south of the site, seeps are common along the cliff bands that border Moenkopi Wash. Evapotranspiration appears to be the mechanism whereby most water exits the N-aquifer.

Ground Water Quality

Background water quality of the N-aquifer is defined as the quality of ground water that was not affected by uranium processing activities.

Background water quality was established with data from well 901, which is completed in the upper portion of the N-aquifer and is located approximately 2,000 ft upgradient of the disposal cell. Analyte concentrations in this well (shown in Table 3) have remained relatively constant over the last 10 years. Ground water in this area is considered to be of high quality and suitable for all domestic uses.

Table 3. Background and Downgradient Contaminant Concentrations and Corresponding EPA Standards

Contaminant	Background Concentration[a,b]	Median Downgradient Concentration[a,b]	Maximum Concentration Limit[a]
Molybdenum	<0.001	0.16	0.10
Nitrate	13	951	44
Selenium	0.0021	0.096	0.01
Uranium	0.002	0.404	0.044
Sulfate	18	2,257	None established

[a]All concentrations reported in mg/L.
[b]Data obtained from the Site Observational Work Plan (DOE 1998b).

At the Tuba City site, eighteen constituents attributable to milling activities were identified in the ground water at concentrations that exceeded background: ammonium, cadmium, calcium, chloride, chromium, iron, magnesium, manganese, molybdenum, nitrate, potassium, selenium, sodium, strontium, sulfate, tin, uranium, and zinc. The Baseline Risk Assessment (DOE 1994) and Section 6.0 of the Site Observational Work Plan (DOE 1998b) presented an evaluation of whether the concentrations of these constituents posed a human-health or ecological risk or exceeded the maximum concentration limits established in 40 CFR 192.

Thirteen of the 18 constituents—ammonium, cadmium, calcium, chloride, chromium, iron, magnesium, manganese, potassium, sodium, strontium, tin, and zinc—did not present excess potential risk or exceed maximum concentration limits. Five of the 18 constituents—nitrate, molybdenum, selenium, uranium, and sulfate—were detected in ground water at concentrations that exceed maximum concentration limits or that could pose a human-health or ecological risk. Table 3 shows a comparison of the most recent median downgradient data for the five main contaminants, their background concentrations, and their corresponding EPA ground water standards.

Site-related contamination in ground water has been detected at least 1,500 ft downgradient from the processing site and to a depth of 86 ft below the water table. Figure 4 shows the present location of the contaminant plume (as defined by nitrate concentration). This contamination in the ground water currently poses no risk to human health or the environment but may pose a risk if contaminated ground water is used in the future.

The Navajo Nation, in a letter dated September 18, 1997, proposed secondary cleanup standards for ground water at the Tuba City site that included constituents not listed in 40 CFR 192. DOE agreed to incorporate the suggested secondary cleanup standards as goals for ground water restoration (see Table 4) and will try to meet them to the extent practicable.

Table 4. Ground Water Cleanup Goals Requested by the Navajo Nation

Constituent	Cleanup Goal
Total Dissolved Solids	500 mg/L
Sulfate	250 mg/L
Chloride	250 mg/L
pH	6.5–8.5
Corrosivity	Noncorrosive
Sodium	20 mg/L[a]

[a]Sodium concentrations would be measured in the treated effluent, whereas concentrations of the other constituents would be measured in the aquifer.

Ground Water Use

Because of the limited and variable supply of surface water in this area, ground water is an important resource. The N-aquifer is the primary source of ground water due to the good quality and high yield from wells. There are currently no withdrawals of ground water between the disposal cell and Moenkopi Wash, including the area that is currently contaminated and the area that may become contaminated if the contaminant plume continues to move toward the wash.

Two points of ground water use are currently known within a 2-mile radius of the site. A low-yield domestic well approximately 1.5 miles east-northeast of the site is used by two or three families. Jimmy's Spring, located approximately 1.2 miles east-southeast of the site near Moenkopi Wash, is used to water livestock. Because of their locations, these sources of ground water will probably not be affected by contaminants that may migrate from the site.

The nearest residents to the site, less than a mile west, haul water from the Tuba City chapter house. Hauling water is a common practice on both reservations, since more than half the homes do not have plumbing or water supplies. The village of Lower Moenkopi does not have a community water or sewage system; however, Tuba City and parts of Upper Moenkopi rely upon the N-aquifer as a municipal water supply. Municipal water supply demands for the Tuba City area are expected to increase during the coming decades.

4.1.2 Environmental Consequences

Proposed Action Alternative

Under the Proposed Action Alternative, the concentrations of contaminants in ground water beneath the Tuba City site would be reduced. The treatment goals would be to restore the quality of the ground water to a condition such that the contaminant levels would be below EPA ground water standards in 40 CFR 192 and, to the extent practicable, would meet the water quality goals presented by the Navajo Nation. Current estimates are that the system would require approximately 16 years of operation before ground water standards are met.

The Proposed Action Alternative also would prevent the spread of contamination within the aquifer. The remediation method is designed to achieve containment of the contaminant plume through the creation of (1) a downgradient pressure ridge to prevent further expansion of the plume, and (2) an upgradient pressure ridge to divert uncontaminated ground water around the plume.

An estimated 95 percent or more of the water pumped from the aquifer for treatment would be returned to the aquifer through the infiltration trench and injection well system. The remaining 5 percent, or approximately 16 acre-feet per year, would be discharged to evaporation ponds as brine water as a result of the treatment process. This reduction in ground water volume could lower the water table immediately south of the site during the short term; however, no wells would be affected. Once ground water remediation is completed at the site, water tables would return to current levels. The water table 5 miles west of the site where the municipalities of Tuba City and Upper Moenkopi withdraw water would not be affected.

No Action Alternative

Under the No Action Alternative, ground water quality would change as the contaminant plume expanded within the aquifer. The mixing of water within the plume 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. It is estimated that more than 200 years could be required to flush one pore volume (about 5,000 acre-feet or 1.7 billion gallons) through the presently contaminated area, and it is unlikely that only one pore volume would completely flush the plume. Consequently, contaminant concentrations in ground water at the site would probably continue to exceed EPA standards for several hundred years.

Future use of ground water on and near the Tuba City site could be affected by the presence of contaminants. However, the contaminant plume is not expected to migrate to the west far enough to affect the municipal water supplies of Tuba City and Upper Moenkopi.

4.2 Surface Water

4.2.1 Affected Environment

The Tuba City site is located approximately 6,000 ft northwest of Moenkopi Wash, which is the dominant natural surface water feature in the area. This intermittent stream drains to the southwest into the Little Colorado River. No other watercourses, intermittent or ephemeral, exist in the vicinity of the site. The Tuba City site is approximately 300 to 400 ft in elevation above Moenkopi Wash.

Moenkopi Wash has a drainage area of approximately 1,500 square miles near the Tuba City site. Surface drainage from the site is to the southeast toward Moenkopi Wash. The drainage area above the site is bounded by U.S. Highway 160, which runs along a low ridge. All drainage on the north side of the highway flows toward Greasewood Lake, a large depression centered approximately 1.5 miles northeast of the site.

Streamflow records for Moenkopi Wash are available for a period of more than 21 years. Data obtained from the U.S. Geological Survey stream gauge station located 1.3 miles southeast of Moenkopi Village (100 ft upstream from the bridge on State Highway 264) indicate that the mean discharge at this location is about 9 cubic feet per second and the median discharge is about 2 cubic feet per second. The difference between the mean and median discharge suggests that large storm runoff events occur intermittently in the Tuba City area.

Surface Water Quality

During the mid 1980s, seeps that are tributaries to Moenkopi Wash were sampled under the UMTRA Project. Data indicate that no contamination from the Tuba City site has migrated to the wash. Collection of surface water samples continues at four seeps that flow into Moenkopi Wash.

Surface Water Use

Water from Moenkopi Wash is currently used for livestock watering and for agricultural diversions by the Navajos and Hopis near the site. Moenkopi Wash has been identified as a vital source of irrigation water for the Hopis. Traditional Hopi agriculture is important for sustenance as well as for cultural and religious reasons. Crops such as corn and beans are used in a variety of foods and play an extensive role in religious ceremonies.

4.2.2 Environmental Consequences

Proposed Action Alternative

Although there has been no indication to date that contaminants have migrated from the Tuba City site to Moenkopi Wash, the contaminant plume is migrating southeast toward Moenkopi Wash. Most of the contaminated ground water is expected to be “lost” through evapotranspiration before it reaches the wash. After several hundred years, however, contaminants could reach the seeps that are tributaries to the wash. The Proposed Action

Alternative would preclude this possibility by reducing the concentration of contaminants in the ground water and by using a downgradient pressure ridge to prevent the further migration of the contaminant plume.

Aquifer volumes would not be noticeably affected as a result of extracting and treating contaminated ground water at the Tuba City site because about 95 percent of the extracted water would be returned to the aquifer. Consequently, Moenkopi Wash and its tributary seeps that are recharged by the N-aquifer would not be noticeably affected, and therefore, existing surface water uses in the region would not be affected.

No Action Alternative

Under the No Action Alternative, the contaminant plume would continue to migrate toward Moenkopi Wash. No action would be taken to reduce contaminant concentrations in the aquifer or to contain the migration of the contaminant plume. Most of the contaminated ground water is expected to be "lost" through evapotranspiration before it reaches the wash. After several centuries, however, the plume could reach the alluvium in Moenkopi Wash and discharge to surface waters. Because inflows of clean ground water from the other slope of the wash and from areas around the plume would dilute the contaminants, it is unlikely that surface water quality in Moenkopi Wash would be affected. However, the Hopi Tribe depends on water in and near the wash for cultural and religious uses; the people who use this water perceive that any presence of contaminants, even in trace amounts, would render the water unfit for those purposes (Sakiestewa, Jr. 1998).

4.3 Human Health

4.3.1 Affected Environment

Contaminated ground water beneath the Tuba City site does not currently pose a health risk to humans because it is not used as a drinking water source. The main contaminants—nitrate, uranium, molybdenum, selenium, and sulfate—are present in concentrations up to 100 times greater than those recommended for human dietary intake.

4.3.2 Environmental Consequences

Proposed Action Alternative

Under the Proposed Action Alternative, human exposure to contaminated ground water would be restricted. The contaminant plume would be contained and limited to the area in the immediate vicinity of the Tuba City site. On-site activities required for operation and maintenance of the extraction and treatment system would ensure that no drinking-water wells were drilled in the area of the plume. The goal of ground water remediation is to meet EPA standards so that, in the future, unrestricted use of the ground water would be possible.

The greatest health risks posed by the Proposed Action Alternative would probably be associated with construction and installation of the ground water treatment system and with activities during subsequent operation of the system. To mitigate these risks, standard safety precautions would be established, and standard construction practices would be followed. Operating procedures would be developed for the treatment unit, and a job safety analysis would be performed for the tasks associated with operation and maintenance. One of the safety attributes of the treatment system is that, if a leak should develop, the leak would discharge towards the interior rather than towards the exterior of the system because the system operates under vacuum. The treatment unit would be equipped with alarms and other protective measures that would serve as indicators of abnormal events.

No Action Alternative

Potential risks to human health would be increased 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. The Baseline Risk Assessment (DOE 1994) found that the most significant potential health hazard from ingestion of ground water at the Tuba city 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 observed in ground water at the Tuba City site, nitrate could have a lethal effect by interfering with an infant's ability to transport oxygen through the blood.

Uranium could also have toxic effects if ingested. Because uranium is radioactive, ingestion of this ground water contaminant could increase the risk of cancer above EPA's acceptable risk of 1 in 100,000 to an average lifetime cancer risk of 2 in 1,000. In addition to the potentially toxic effects of uranium, consumption of high levels of molybdenum could cause health problems associated with mineral imbalances. Ingestion of selenium at levels currently in the ground water would most likely not cause health problems. Sulfate concentrations in ground water could cause severe diarrhea, particularly in infants. Additional information concerning the effects of these contaminants on human health is presented in the Baseline Risk Assessment (DOE 1994).

4.4 Air Quality and Noise

4.4.1 Affected Environment

The Tuba City site lies within the Coconino County subdivision of the Arizona Bureau of Air Quality Control. Although no air quality monitoring station exists in the Tuba City area, the closest stations in Flagstaff, Page, and Grand Canyon (85 miles south, 80 miles north, and 80 miles west of the Tuba City site, respectively) indicate that pollutant concentrations in the area generally are well below Federal and State ambient air quality standards. On occasion, the total suspended particulates standard may be exceeded when fugitive dust from natural sources is picked up and carried by high winds.

Background noise levels at the Tuba City site are generated by wind, jet aircraft, and traffic on U.S. Highway 160. Typical daytime noise levels range from 57 to 66 decibels (on the A-weighted scale, which is the scale that most closely approximates the human ear) (DOE 1986). These levels are well below the Occupational Safety and Health Administration's action level of 85 decibels.

4.4.2 Environmental Consequences

Proposed Action Alternative

Well installation and construction during Phase I of the Proposed Action Alternative would disturb 5 to 6 acres within the site boundary fence and 4 to 5 acres outside the boundary fence; activities associated with Phase II would disturb an additional 3 to 4 acres within the boundary fence and 7 to 10 acres outside the boundary fence. At these disturbed sites, dust picked up and dispersed by traffic and wind could increase the concentration of total suspended particulates in the surrounding air. The potential increase in total suspended particulates would be minimized by application of water sprays or other dust suppressants in active work areas. With the application of these mitigation measures, Federal and State air quality standards are not expected to be exceeded. After vegetation is reestablished at these sites through reseeding, dust levels are expected to return to background conditions.

Emissions from the treatment unit would consist of minimal amounts of water vapor and would not affect air quality at the Tuba City site.

Under the Proposed Action Alternative, noise levels would temporarily increase during well drilling and trenching operations. Within 50 ft of operating equipment, noise levels would likely range between 75 and 95 decibels. Noise levels would decrease with distance and are expected to be the same as background levels at the nearest residence. On-site workers would be required to wear hearing protection when noise levels exceed the standard of 85 decibels. Noise levels during operation of the treatment unit are expected to be below 85 decibels.

No Action Alternative

Because no on-site activities would take place, the No Action Alternative would have no effect on air quality. Current background noise levels at the site would not be affected.

4.5 Wildlife

4.5.1 Affected Environment

Nocturnal rodents and black-tailed jackrabbits (*Lepus californicus*) are probably 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 macrousa*), northern mockingbird (*Mimus polyglottus*), horned lark (*Eremophila alpestris*), and the common poorwill (*Phalaenoptilus nutalli*) 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 hammondi*) likely reside in and near the area of Moenkopi Wash. The side-blotched lizard (*Uta stansburiana*) and western whiptail (*Cnemidophorus tigris*) are the principal reptile species that inhabit the site (DOE 1986).

On the basis of the local topography and habitat types, no federally listed threatened or endangered species are expected to be present on or near the Tuba City site. One tribally listed endangered species, the golden eagle (*Aquila chrysaetos*) potentially may inhabit areas in the vicinity of the Tuba City site. Two other tribally and federally listed species, the southwestern willow flycatcher (*Empidonax traillii extimus*) and the Kanab ambersnail (*Oxyloma haydeni kanabensis*), may inhabit areas of Moenkopi Wash more than 1.5 miles from the Tuba City site.

4.5.2 Environmental Consequences

Proposed Action Alternative

From 4 to 5 acres of habitat for small mammals and birds would be destroyed for approximately 16 years from construction and installation of the water treatment units and evaporation ponds. An additional 4 to 6 acres of habitat on the inside of the site boundary fence and 12 to 14 acres of habitat on the outside of the boundary fence would be temporarily disturbed from the installation of extraction and injection wells and underground pipelines. The noise and human activity associated with construction activities also would displace wildlife. In most cases, the species would likely return to the disturbed areas once construction was completed and the areas were revegetated. Over the long term, population abundance, distribution, and density of wildlife species, including the endangered golden eagle (if it were present),would not be noticeably affected.

Because so few surface water sources exist in the Tuba City area, the evaporation ponds at the site might attract waterfowl, other migratory birds, and birds that may be attracted by the presence of waterfowl, such as the bald eagle (*Haliaectus leucocephalus*) and peregrine falcon (*Falco peregrinus anatum*). Water quality within the ponds is expected to be poor. Although the ecological risk assessment conducted for the site did not evaluate the effects of contaminated ground water on birds, it is believed that the water could be harmful or lethal to birds if it was ingested over a period of time. The ecological risk assessment indicated that ground water from the contaminant plume could be lethal to livestock if it were their sole drinking water source. Contaminant concentrations in the brine water are expected to be much higher than they are in the ground water plume and thus would be more likely to be harmful or lethal. The affected area would be fenced off to prevent livestock from ingesting the brine.

Migratory birds, which include most waterfowl and birds that are thought to nest near the Tuba City site (mourning dove, northern mockingbird, horned lark, and the common poorwill), are protected by the Migratory Bird Treaty Act (16 *U.S. Code*, Sections 703–712). The act states that the “taking” or killing of migratory birds is unlawful unless permitted by the U.S. Fish and Wildlife Service. The bald eagle and peregrine falcon are protected by the Endangered Species Act (16 *U.S. Code*, Section 1531). DOE would consult with the Navajo Nation’s Natural Heritage Program, Fish and Wildlife Department, and other State and Federal wildlife agencies to decide on the best method for protecting these species. Options may include the use of nets, silhouettes, reflectors, or combinations of these and other methods. The protective measures that would actually be used at the site would be described in detail in the *Migratory Bird Management Plan for the Tuba City UMTRA Site* (DOE 1998c).

No Action Alternative

Wildlife species at the Tuba City 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. If a water well were drilled into the plume, wildlife could ingest contaminants by drinking water pumped from the plume. The ecological risk assessment 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.

Wildlife species that may inhabit Moenkopi Wash, including the endangered southwestern willow flycatcher and Kanab ambersnail, would not be affected by the No Action Alternative. As stated in the Surface Water and Vegetation sections of this EA, it is unlikely that surface water quality or vegetation would be affected within Moenkopi Wash; hence, the wildlife species that depend on this surface water and vegetation for habitat and feeding would not be affected.

4.6 Vegetation

4.6.1 Affected Environment

Vegetation at the Tuba City site consists of shrubs, grasses, and forbs that are adapted to the arid southwest. The primary shrubs consist of shadscale (*Atriplex confertifolia*), broom snakeweed (*Gutierrezia sarothrae*), Mormon tea (*Ephedra torreyana* and *E. viridis*), fourwing saltbush (*Atriplex canescens*), and black greasewood (*Sarcobatus vermiculatus*). Dominant grasses include black grama (*Bouteloua eripoda*), galleta (*Hilaria jamesii*), and Indian ricegrass (*Oryzopsis hymenoides*). Common forbs include the weedy, nonnative Russian thistle (*Salsola iberica*) and slimleaf bursage (*Ambrosia confertiflora*) and native species such as buckwheat (*Eriogonum* sp.) and globemallow (*Sphaeralcea rusbyi*).

Most of the area overlying contaminated ground water is either heavily grazed rangeland or regraded areas that were reseeded in 1990. The fence around the Tuba City disposal cell protects the vegetation within the fenced area from grazing. As a result, the protected areas have 1.5 to 2 times more vegetative cover than the unprotected areas on the outside of the fence; however, the abundance of weedy species such as Russian thistle and slimleaf bursage is greater on the outside of the fence (DOE 1998b).

Vegetation inventories of the Tuba City site and its vicinity, conducted in 1982 (Smith and Associates 1982) and the mid-1990s (DOE 1998b), indicate that federally listed threatened or endangered plant species likely do not occur near the site. The habitat for Welsh's milkweed

(*Asclepias welshii*), a federally listed threatened species, consists of sand dunes in sagebrush, juniper, and ponderosa pine communities at 5,570 to 6,230 foot elevations. This species is not believed to exist at the Tuba City site because of the site's desert shrub plant community and lower-elevation setting (5,100 feet). Parish alkali grass (*Puccinellia parishii*), a tribally listed endangered species, may occur in Moenkopi Wash more than 1.5 miles south of the site.

Currently, there is no evidence indicating that plant uptake of contaminants in ground water is occurring at the Tuba City site (DOE 1994). The shallowest depth to contaminated ground water is approximately 50 ft below land surface. The rooting depths for some types of plants growing at the site have been reported to reach maximum depths of approximately 30 ft near Los Alamos, New Mexico (Foxx and Tierney 1986).

4.6.2 Environmental Consequences

Proposed Action Alternative

Well installation and construction during Phase I of the Proposed Action Alternative would temporarily disturb 5 to 6 acres of vegetation within the site boundary fence and 4 to 5 acres of vegetation outside the boundary fence; activities associated with Phase II would temporarily disturb an additional 3 to 4 acres of vegetation within the boundary fence and 7 to 10 acres outside the boundary fence. Of the total disturbed area, vegetation would be removed from 5 to 6 acres for the construction of the treatment units and evaporation ponds. 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 would be expected to become reestablished after 2 to 4 years.

As stated in the Proposed Action, DOE would remove the distillation treatment units, water storage tank, evaporation ponds, existing 0.4-acre ponds, and infiltration trench after completion of ground water cleanup activities. 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 establish within 2 to 4 years.

Plant uptake of ground water contaminants is not expected to occur under this alternative because the remediation method would contain the spread of the contaminant plume.

No Action Alternative

Under the No Action Alternative, the contaminant plume would continue to migrate southeast. 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 below the escarpment (Figure 2). 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.

4.7 Soils

4.7.1 Affected Environment

Soils at the Tuba City site are derived primarily from the Navajo Sandstone, a deeply weathered and easily eroded rock. As a result of the sandstone's erosion over time, active sand dunes and sandy soil deposits have formed on the land surface. Soils in the area generally are very deep (more than 60 inches), well-drained, and consist of fine- to medium-textured sands. They are classified as Torriorthents and Torripsamments. Although the soils are not highly erodible by water, they are erodible by wind. In many areas on and near the site, the wind has formed the sandy soils into small dunes.

4.7.2 Environmental Consequences

Proposed Action Alternative

Well installation and construction during Phase I of the Proposed Action Alternative would temporarily disturb 5 to 6 acres of soil within the site boundary fence and 4 to 5 acres of soil outside the boundary fence; activities associated with Phase II would temporarily disturb an additional 3 to 4 acres of soil within the boundary fence and 7 to 10 acres outside the boundary fence. Of the total acreage disturbed, surface soils would be removed from 5 to 6 acres for the construction of the treatment units and evaporation ponds. The soil's susceptibility to wind erosion would increase when vegetation is removed from the surface. This increase in erodibility could result in a net loss of soil from the site. During construction, mitigation measures outlined in a storm water pollution prevention plan would be implemented to minimize the amount of soil lost from the site. These measures may include installation of silt fencing, mulch, anchored straw bales, or sediment basins. Soils would be expected to restabilize 2 to 3 years after construction activities are ended and reclamation is completed.

No Action Alternative

Because no surface-disturbing activities would take place, the No Action Alternative would have no effect on soils.

4.8 Cultural Resources

4.8.1 Affected Environment

Humans have occupied the Tuba City area since as early as 9500 BC. To determine if historic or archaeologic sites are present on or near the Tuba City site, Class III (100-percent coverage pedestrian) cultural resource surveys were conducted in 1983, 1985, and 1994 (CASA [Complete Archaeological Service Associates] 1983, 1985, and 1994). The entire area that could potentially be disturbed under the Proposed Action Alternative was surveyed with the exception of an approximate 60-acre area southwest of the site. No historic or archaeologic sites were identified within the area of proposed activity, although one historic site, known as a traditional cultural property, and one archaeologic site were identified outside the area of proposed activity.

4.8.2 Environmental Consequences

Proposed Action Alternative

As stated in the Proposed Action, a Class III cultural resources survey would be conducted in the 60-acre unsurveyed area southwest of the site. Because all significant sites would be avoided, cultural resources would not be affected by this alternative.

No Action Alternative

Because no surface-disturbing activities would take place, the No Action Alternative would have no effect on cultural resources.

4.9 Visual Resources

4.9.1 Affected Environment

The visual resources of the Tuba City site are the views of sand-covered hills and distant mesas. The disposal cell cover is composed of dark-colored rock that contrasts sharply with the generally beige and light-green colors of the natural landscape. Although the rock cover is not visible from Tuba City or Moenkopi Village, it can be seen for several miles by travelers on U.S. Highway 160. Near the Tuba City site, foreground views are dominated by the disposal cell cover, scrub vegetation, and sand dunes. Alluvial terraces and canyons along Moenkopi Wash are visible to the south of the site. Distant mesas of the Painted Desert to the south and west of the site form a variety of color and textural changes on the horizon.

4.9.2 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 Tuba City site. Phase I activities would leave 9 to 11 acres of the surface devoid of vegetation for approximately 1 year, and Phase II activities would leave an additional 10 to 14 acres of surface devoid of vegetation for approximately 1 year. Although from one-half to two-thirds of this acreage would not be visible by travelers on U.S. Highway 160, the remaining portion could be noticeable. Revegetation of these disturbed areas would reduce the effects on the view, and after 2 to 4 years, the disturbances would not be noticeable.

More noticeable might be the treatment units and evaporation ponds. Each of the treatment units is expected to be from 20 to 70 ft high and up to 50 ft wide (or long); the ponds would be as large as 2 acres each. These structures would provide alterations in the color and texture of the foreground view for approximately 16 years.

No Action Alternative

Because no surface-disturbing activities would take place, the No Action Alternative would have no effect on visual resources.

4.10 Socioeconomics

4.10.1 Affected Environment

The 1996 populations of Tuba City and Moenkopi Village were 8,750 and 1,500, respectively (Choudhary 1998; Honahni 1998). Since 1980, when the population was 5,045, Tuba City has experienced an average annual population growth of 5 percent. This community is expected to continue to grow in the future. The Tuba City and Moenkopi Village combined labor force averaged 4,000 people in 1996. The unemployment rate for the Tuba City labor force averaged 20.2 percent in 1996, and for the Moenkopi Village labor force, averaged 45 percent in April 1998. Major employers in the area include the Bureau of Indian Affairs, Arizona Department of Transportation, Arizona Public Schools, the Navajo Nation, and Hopi Tribe.

4.10.2 Environmental Consequences

Proposed Action Alternative

Well installation and construction during Phases I and II of the Proposed Action Alternative would employ 5 to 10 local laborers for a period of 3 to 4 months during each phase. Once well installation and construction were completed, 4 to 5 local technicians would be employed over a period of approximately 16 years to maintain the wells and treatment unit at the site. These labor requirements are not expected to noticeably affect local unemployment rates.

No Action Alternative

Because no activities would take place, the No Action Alternative would not affect the socioeconomic characteristics of the area.

4.11 Transportation

4.11.1 Affected Environment

Major transportation routes in the Tuba City area consist of U.S. Highway 160, State Highway 264, and U.S. Highway 89 (see Figure 1). According to the Arizona Department of Transportation, the average daily traffic volume on the segment of highway between the Tuba

City site and Tuba City is approximately 5,100 vehicles per day. During the summer tourist season, traffic volumes are somewhat above average. Access to the Tuba City site is by a road from U.S. Highway 160, approximately 5 miles east of the intersection of U.S. Highway 160 and State Highway 264.

4.11.2 Environmental Consequences

Proposed Action Alternative

The Proposed Action Alternative would affect transportation primarily during the transport of brine sludge from the Tuba City site to the appropriate disposal facility. It is expected that the brine would be removed from the site approximately once every 5 or 10 years and would be transported in 30-ton tandem haul trucks equipped with trailers. If the brine were taken to the Cheney disposal cell in Grand Junction, Colorado, the 375-mile route would begin on U.S. Highway 160, extend east to U.S. Highway 191, and then extend north to Interstate 70. From Interstate 70, the haul route would extend east to Grand Junction and then southeast on U.S. Highway 50 to the Cheney disposal cell.

The volume of brine solids that would be generated under the Proposed Action Alternative would be approximately 24,000 tons, or an average of 1,500 tons per year over the life of the project. If the brine were hauled to a facility once every 5 years, it could be transported in approximately 250 truck loads. If 10 trucks per day were to haul from the Tuba City site, the brine sludge could be removed in approximately 25 working days. The use of 10 trucks per day would increase total vehicle traffic by about 0.2 percent on the segment of highway near the Tuba City site. The transportation activity would be managed to mitigate effects on local traffic; for example, hauling would be conducted during off-peak hours. Transportation of the brine would be conducted in concurrence with the Arizona, Utah, and Colorado Departments of Transportation and would comply with Federal, State, and Navajo Nation regulations.

Solid wastes such as personal protective equipment and miscellaneous debris would also require periodic hauling to a landfill or a facility that could accept residual radioactive material. This infrequent hauling is not expected to affect traffic in the Tuba City 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.

4.12 Environmental Justice Considerations

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 Tuba City uranium mill was located on tribal lands, contamination resulting from activities at the site has the potential to affect Navajo and Hopi tribal members almost exclusively. Under the Proposed Action Alternative, DOE would attempt to 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. Under the No Action Alternative, ground water quality would not be improved, and effects could be disproportionate to tribal members.

4.13 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 Tuba City site in the near or foreseeable future. There would be a beneficial cumulative effect to ground water quality associated with the Proposed Action Alternative in that the contamination in the ground water from past activities would be cleaned up to below EPA standards within approximately 16 years, and the movement of the plume would be contained. 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 an 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, when combined with the effects of other actions defined earlier, would not result in cumulatively significant impacts.

5.0 Persons or Agencies Consulted

Trib Choudhary — Economic Development Specialist
Navajo Nation, Division of Economic Development
Window Rock, Arizona

Troy Corman — Arizona Game and Fish Department
Non-Game Branch
Phoenix, Arizona

Jackie Hanson — Threatened and Endangered Species List
U.S. Fish and Wildlife Service
Phoenix, Arizona

Wilbert Honahni Sr. — Community Service Administrator
Hopi Tribe
Moenkopi Village, Arizona

Michelle James — U.S. Fish and Wildlife Service
Ecological Services Division
Flagstaff, Arizona

James Loper — Manager
Tuba City Solid Waste Transfer Station
Tuba City, Arizona

John Nystedt — Navajo Fish and Wildlife Department
Natural Heritage Foundation
Window Rock, Arizona

Robert Pike — Traffic Count Department
Arizona Department of Transportation
Phoenix, Arizona

In addition to these contacts, DOE has discussed the aspects of the proposed action with Navajo and Hopi representatives on a number of occasions, including the following:

Correspondence with the Navajo Nation concerning a "water-softening-type" of ground water treatment process, letters dated June 10, 1997 and August 4, 1997.

Correspondence with the Navajo Nation concerning secondary cleanup goals, letter dated September 18, 1997.

Meeting with representatives of the Navajo Nation and Hopi Tribe in Gallup, New Mexico, on December 3, 1997, concerning the proposed action.

Environmental Assessment scoping meetings with the Navajo Nation (June 9, 1998) in Tuba City, Arizona, and with the Hopi Tribe (June 10, 1998) in Moenkopi Village, Arizona.

6.0 References

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