Meeting Challenges to Optimize Ground Water Remediation as Part of the Moab Uranium Mill Tailings Remedial Action Project - 10481

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ABSTRACT

Federal law mandates acceleration of the DOE Moab Uranium Mill Tailings Remedial Action Project in Utah to remove 14.5 million tonnes (16 million tons) of material that is a source of a ground water plume. More than 40 years of seepage from a 53-hectare (130-acre) uranium mill tailings pile at the Moab site resulted in ammonia and uranium contamination of naturally occurring saline ground water in alluvium adjacent to the Colorado River.

An interim ground water remedial action system was installed in stages beginning in 2003. Forty-one extraction wells are present. Conditioning of tailings on top of the tailings pile as a part of the removal process has necessitated the elimination of zones of the sprinkler system used to eliminate contaminated ground water. The reduced evaporative capacity has compelled the project to implement more efficient extraction of contaminated ground water. To accomplish this, seven additional wells will be installed upgradient of the existing well field, along the axis of the contaminant plume closer to the tailings pile.

INTRODUCTION

Ground water from a uranium mill tailings pile that is adjacent to Arches National Park in southeastern Utah discharges ammonia to the Colorado River, at times affecting backwater channel habitat. Uranium and to a lesser extent several other heavy metals also discharge to the river. The Moab site tailings pile rests 230 meters (750 feet) from the Colorado River within the 100-year floodplain.

The DOE Moab Uranium Mill Tailings Remedial Action (UMTRA) Project site is a former uranium ore-processing facility that sits along the Colorado River 4.8 km (3 miles) northwest of Moab, Utah (see Fig. 1). The 178-hectares (439-acre) site includes a 130-acre (16-million-ton) uranium mill tailings pile. Relocation of the mill tailings to a permanent disposal cell being constructed in phases 48 km (30 miles) north near Crescent Junction, Utah, began in April 2009. The tailings are excavated and conditioned at the Moab site and transported by rail in intermodal containers.

Active cleanup of contaminated ground water at the Moab site is part of the scope of the Moab UMTRA Project. Previous investigations have projected active ground water cleanup at the Moab site could take as long as 75 years to complete [1]. In 2007, congressional legislation mandated that DOE complete removal of the tailings pile by the end of 2019 [2]. The project goal is to complete active remediation of contaminated ground water at the same time as the surface remediation is completed. To accomplish this, the current interim ground water remediation system must be expanded. This paper summarizes site conditions and describes the plan to expand the system.

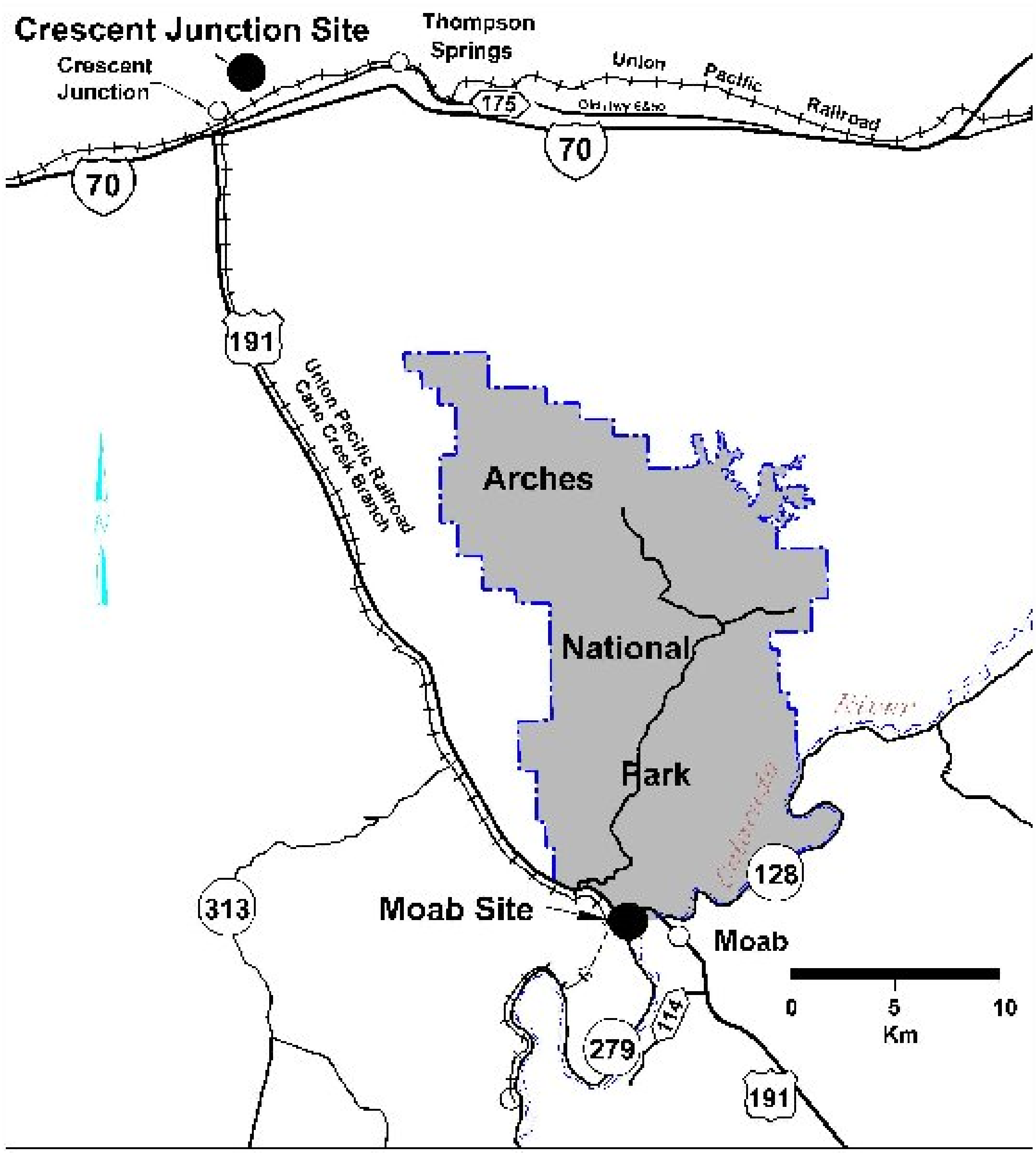

Fig. 1. This map shows the location of the Moab UMTRA Project site.

PROCESSING HISTORY

The Moab mill began uranium ore processing operations in October 1956. Initially, the mill used an acid-leach process, which was later switched to an alkaline process due to changes in ore composition. The tailings disposal pond, which accumulated over time creating a pile more than 24 meters (80 feet thick), is the primary source of ground water contamination. Early in the mill's processing history, the pond received the greatest volume and diversity of effluents; later many of the processing fluids were recycled. In addition, early on the bottom of the tailings pond probably had a higher permeability than in later years. As milling progressed and more tailings were disposed, fine clayey "slimes" settled out in the center of the pile with coarser sand-sized grains remaining around the perimeter of the pond. The fine-grained material may have sealed off portions of the pond bottom along with precipitates from the pond fluids.

Wells to monitor water quality have been installed on the Moab site. Results of investigations indicated that site-related contaminants have leached from the tailings pile into the shallow ground water [1]. The average seepage rate from the tailings pond was about 284 liters per minute (lpm) (75 gallons per minute [gpm]) during the early years as represented by data from 1971 [3]. The seepage rate was reduced to 170 lpm (45 gpm) after implementing process changes in 1974. The seepage likely fell to 76 lpm (20 gpm) after processing operations ceased in 1984. Investigation results also indicated that some of the more mobile constituents, especially ammonia and uranium, have migrated downgradient and are discharging to the Colorado River adjacent to the site.

PHYSICAL AND ENVIRONMENTAL SETTING

The primary hydrogeologic unit present at the Moab site is unconsolidated alluvial soils (see Fig. 2). Underlying the alluvium is bedrock of the Paradox Formation, which consists largely of salt beds (halite). The alluvial soils at the Moab site are mostly from either Moab Wash alluvium or basin-fill alluvium. Moab Wash is an ephemeral stream that transects the site and discharges into the Colorado River. Moab Wash alluvium is composed of fine-grained sand, gravelly sand, and detrital material that has traveled down the wash and interfingered with the basin-fill alluvium deposited by the Colorado River near the northwest boundary of the site.

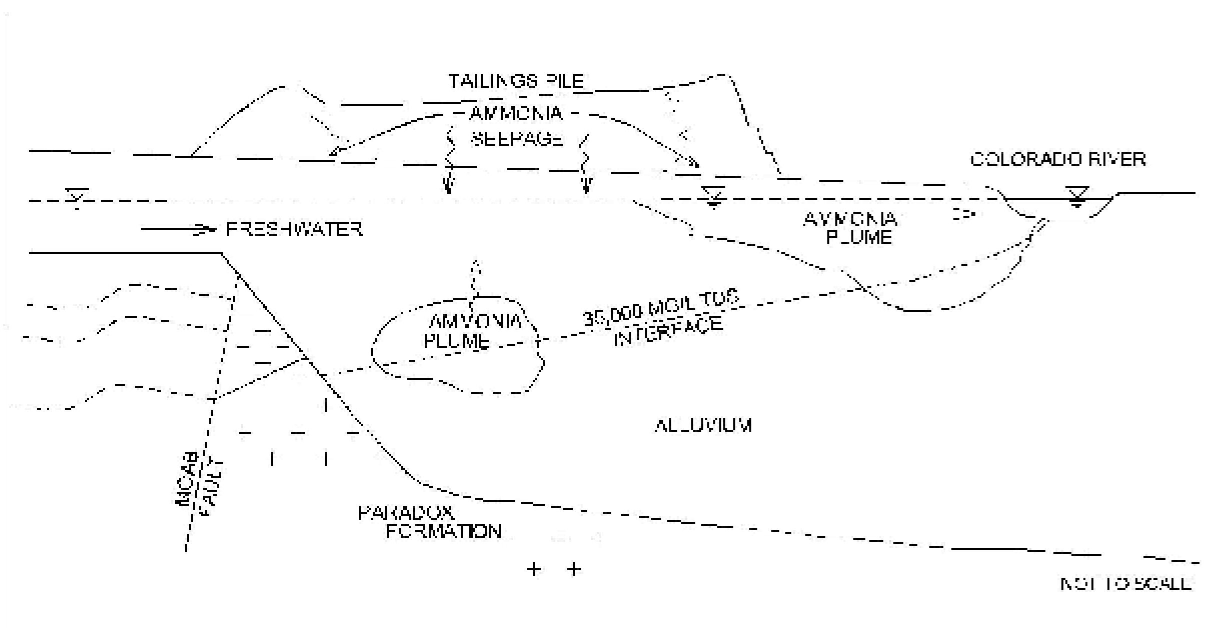

Fig. 2. Cross-sectional conceptual model of the Moab site.

Ground water surface elevation contours (see Fig. 3) and pore water velocities indicate that nearly all of the ground water moving southeast discharges to the river along a relatively small portion of the total riverbed width [4]. The greatest discharge occurs near the west bank and gradually decreases toward the center of the river. Estimates of ground water discharge at the Moab site to the Colorado River range from 1135 to 1741 lpm (300 to 460 gpm). Sampling results have shown that a mixing zone for ammonia extended approximately 7.6 meters (25 feet) transversely into the river channel; the uranium mixing zone extended 15 meters (50 feet) into the river.

The saline water interface, delineated at 35,000 milligrams per liter (mg/L), occurs naturally beneath the Moab site. The interface moves laterally and vertically over the course of each year in response to such stresses as seasonal transpiration and changes in stage of the Colorado River [5].

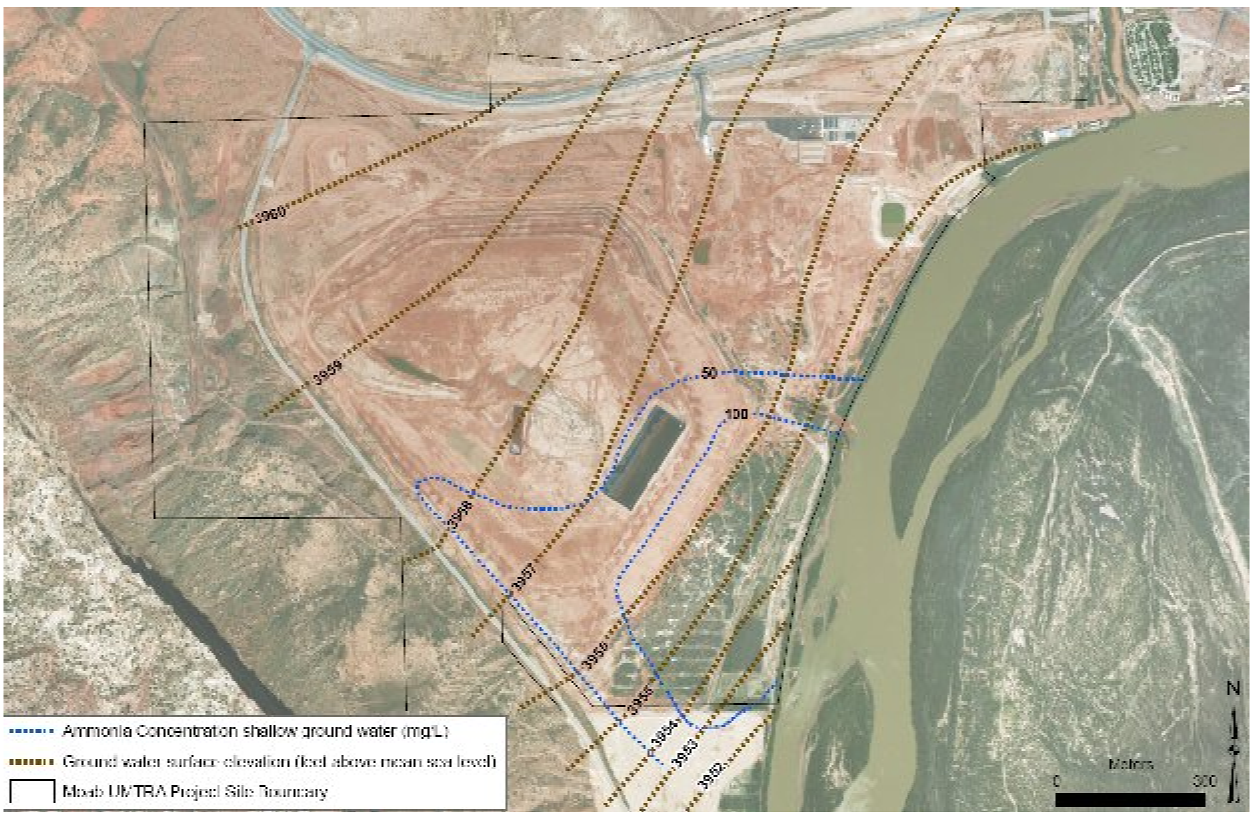

Fig. 3. Ground water surface elevation contours and ammonia concentration.

The tailings pile fluids contain total dissolved solid concentrations ranging from 50,000 to 150,000 mg/L, and have sufficient density to migrate vertically downward. This density-driven flow has created a body of dissolved ammonia that now resides below the saline water interface. This ammonia beneath the saline interface represents a long-term source of contamination to the alluvial ground water system. The volume of this ammonia plume is estimated at greater than 3.8 billion liters (1 billion gallons), which represents approximately 60 percent of the total ammonia plume that underlies the site [3].

However, the volume of relatively freshwater entering the site upgradient of the tailings pile may have diluted the ammonia levels in the shallow ground water (see Fig. 3). Oxidation of ammonia to nitrate or nitrogen may also contribute to lower ammonia concentrations observed in the upgradient shallow ground water beneath the tailings pile where aerobic conditions are more likely.

The potential effects of contaminants to critical fish habitat adjacent to the site are a concern. A biological assessment [3] concluded that the endangered fish species of razorback sucker and Colorado pikeminnow were in jeopardy. Flow in Moab Wash deposits sediment in the Colorado River that affects the presence of backwater channels adjacent to the Moab site that can become critical fish habitat for the endangered fish species. High river stage in the Colorado River tends to erode these backwater channels. A major summer storm in 2006 caused high flows in Moab Wash carrying coarse-grained sediment into the river that was deposited along the shore consequently changing the habitat from predominantly backwater channels to a sandbar with no sustained aquatic environment.

INITIAL AND INTERIM GROUND WATER REMEDIAL ACTIONS

Initial surface water and interim ground water remedial actions were implemented as temporary measures to reduce the ecological risk to sensitive aquatic species that may inhabit the slow-moving water (backwaters) at the edge of the river where elevated ammonia concentrations had been observed. These temporary actions will continue until a final long-term ground water remediation strategy is selected; this strategy will be described in a Ground Water Compliance Action Plan, as required by the NRC. The initial surface water action consists of flushing river water pumped from upstream into the backwater channels to dilute ammonia concentrations in the river. DOE monitors the river water flow each year and implements the initial action when habitat areas are present.

An interim ground water remedial action system was installed in stages beginning in 2003 between the base of the tailings pile and the river to remove contaminant mass and to protect the habitat areas along the riverbank from exposure to ammonia. Forty extraction wells are present along the riverbank and one well is located closer to the base of the pile (see Fig. 4). Ground water extracted from the well field is pumped into an evaporation pond located on the pile. The plastic-lined, sloped bottom pond occupies about 0.4 hectares (1 acre). The bottom of the pond is 15 meters (50 feet) wide by 187 meters (615 feet) long and is 3.5 meters (11.5 feet) below the berm. With a 0.6-meter (2-foot) freeboard, the pond holds 19 million liters (5 million gallons).

Recovered water in the pond is eliminated through evaporation primarily using a sprinkler system installed on top and along the sides of the tailings pile that also aids in dust control. The sprinkler system consists of micro-spray nozzles on 7.6-meter (25-foot) centers and is operated to apply water at a rate and duration that will allow it to evaporate before it infiltrates more that 30 cm (12 inches) into the pile interim cover [6].

CHANGES IN GROUND WATER MANAGEMENT

When milling operations ceased, the surface of the tailings pile was stabilized with an interim cover that was completed in 1995; however, the tailings, particularly in the center of the pile, retained high water content. To dewater the pile, nearly 17,000 vertical band drains ("wicks") were installed in 2000. The vertical band drains penetrate the tailings and provide a pathway for water to more quickly travel out of the pile. The interim cover and off-pile contaminated soils were added to the top of the pile, which increases the pore pressure facilitating water movement into the vertical band drains. A lined evaporation pond known as the wick pond (see Fig. 4) located on top of the tailings pile collects the water. The pond covers about 0.13 hectares (0.333 acres) and is about 0.6 meters (2 feet) deep.

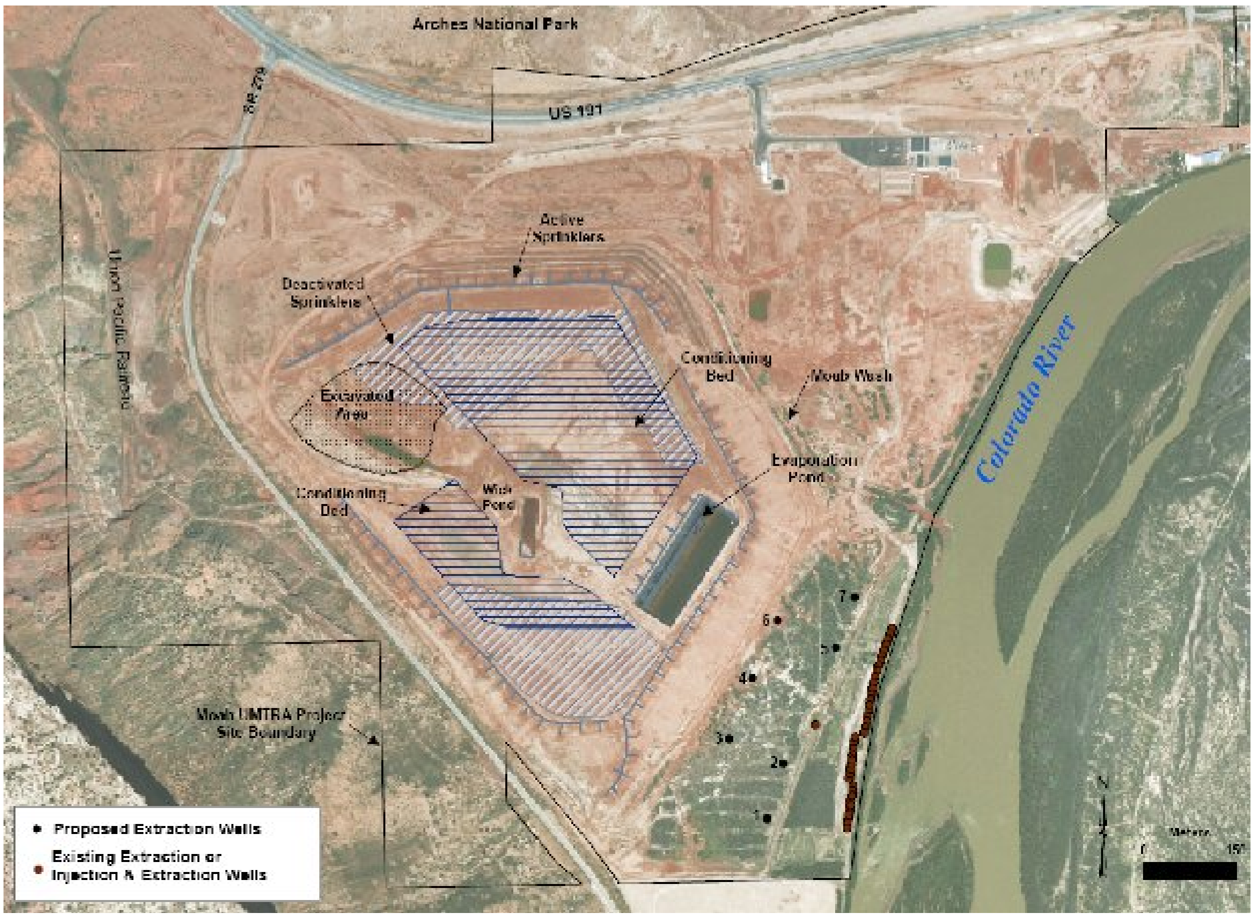

Fig. 4. Moab site tailings pile features and extraction well locations.

The rate of pore water discharge collected by the wick drain system has steadily dropped as pressure from the tailings and overburden materials dissipate. The spring of 2009 saw a dramatic increase in the amount of water in the drain sump. Water chemistry data suggest that this water is not derived from the deeper pore water within the slimes of the tailings pile, but are more likely surficial water that is intercepted by the collection system.

Excavation of the tailings pile began in February 2009 at the northwest corner where the original ground surface was at the highest elevation and therefore the tailings pile was only about 20 feet thick. The excavation is proceeding to the east where the tailings are as much as 80 feet thick. The excavated tailings are conditioned in preparation for shipment by being spread on the surface of the pile to air dry (see Fig. 4). With funding received through the American Recovery and Reinvestment Act (Recovery Act), the quantity of mill tailings being shipped has increased, thus prompting expansion of the size of the tailings excavation and conditioning areas. Although Recovery Act funds enabled the project to rapidly increase its excavation and conditioning activities, little time was available to consider the effects on ground water management.

The acceleration of excavation and conditioning activities has necessitated the elimination of zones of the sprinkler system. The project is investigating ways to maximize the remaining sprinklers as additional zones are eliminated. During the summer of 2009, the project began using water trucks for dust suppression on roads and areas that weren't covered by the sprinklers. In addition, two 45-gpm enhanced evaporation sprayers were placed on the pile in the fall to disperse more water from the evaporation pond. The reduction in water evaporation through the sprinklers has compelled the project to alter its plan for extraction of contaminated ground water to meet the accelerated tailings cleanup schedule, and completion of ground water cleanup. To accelerate the ground water cleanup, the extraction system is being altered.

Approximately 280 lpm (75 gpm) of contaminated ground water was being extracted through the existing well during most of the year to limit ammonia and uranium discharge to the Colorado River. Only about 37 lpm (10 gpm) was extracted during winter months because of the reduced evaporative capacity in cold temperatures. An evaluation of the interaction between the river and ground water was performed in 2008. Water quality in samples from monitoring wells of various depths and at different distances from the river bank was determined for rising and falling river stage. In addition the mass removal efficiency of each extraction well was determined to aid in establishing a priority for operations. The resulting optimization plan provided guidance for ground water withdrawal rates from the existing wells to maximize mass recovery while still remaining protective of habitat [5]. Further, seven additional wells will be installed in December 2009 upgradient of the existing well field. The wells will be placed along the axis of the plume closer to the tailings pile, the contaminant source (see Fig. 4). The wells near the pile will operate at a rate to more efficiently extract contaminant mass.

In 2010, the project will eliminate the wick pond and will design an alternate location for the evaporation pond or design a ground water treatment system.

REFERENCES

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2. U.S. Congress, Section 3402 of the National Defense Authorization Act for Fiscal Year 2008 Pub. L. No. 110-181 (2008).
3. DOE, Remediation of the Moab Uranium Mill Tailings, Grand and San Juan Counties, Utah Final Environmental Impact Statement, DOE/EIS-0355 (2005).
4. DOE, Moab UMTRA Project 2008 Performance Assessment of Ground Water Interim Action Well, DOE-EM/GJTAC1841 (2009).
5. DOE, Moab UMTRA Project Well Field Optimization Plan, DOE-EM/GJTAC1791 (2009).

6. DOE, Operations, Maintenance, and Performance Monitoring Plan for the Interim Action Ground Water Treatment System, Moab UMTRA Project, Rev 4, DOE-EM/GJ1220 (2008).