**Department of Energy**
Washington, DC 20585

December 27, 2018

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Deputy Director
Mail Stop T8-F5
Washington, DC 20555-0001

Subject: Position Paper: Suspension of Groundwater Extraction and Evaporation Pond Operations, Shiprock, New Mexico, Disposal Site (NRC Docket No. WM-0058)

To Whom It May Concern:

Enclosed for U.S. Nuclear Regulatory Commission (NRC) review is a Position Paper prepared by the U.S. Department of Energy (DOE), Office of Legacy Management (LM) entitled *Position Paper: Suspension of Groundwater Extraction and Evaporation Pond Operations, Shiprock, New Mexico, Disposal Site* (Document No. S16070).

In April 2017 groundwater extracted by the remediation system and transmitted to the evaporation pond at the Shiprock site reached the maximum operational design capacity, at a depth of 8 feet (equating to approximately 25 million gallons of water in the pond). Consequently, LM temporarily suspended the active remediation groundwater extraction.

This paper presents LM's position that the temporary suspension of pumping to the evaporation pond should be continued to facilitate decommissioning of either the evaporation pond or the evaporation pond liner. Although the evaporation pond and pond liner are currently functioning as designed, the polypropylene pond liner is exhibiting signs of deterioration. It is LM's position that the decommissioning described in the enclosed report should be conducted prior to the 20-year design life of the pond liner.

DOE is reviewing options for future groundwater compliance actions through collaboration with the Navajo Nation, consistent with the National Environmental Policy Act, and plans to issue a draft Environmental Assessment of those options near the end of fiscal year 2019.

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Sincerely,

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NMSS01

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# Position Paper:
# Suspension of Groundwater Extraction and Evaporation Pond Operations, Shiprock, New Mexico, Disposal Site

## 1.0 Introduction

The U.S. Department of Energy (DOE) Office of Legacy Management (LM) is responsible for groundwater remediation at the Shiprock, New Mexico, Uranium Mill Tailings Radiation Control Act (UMTRCA) site. The Groundwater Compliance Action Plan (GCAP) describes the scope of the remediation activities conducted by LM (DOE 2002). Groundwater remediation began in March 2003, entailing groundwater extraction from the terrace area of the site and groundwater extraction from the floodplain to aid the natural flushing process. The extracted groundwater is pumped to a single-lined, 11-acre solar evaporation pond on the terrace. The components of the remediation system and the evaporation pond are shown in Figure 1.

The evaporation pond is a key component of the groundwater remediation system and has been in use for 15 years, approaching a 20-year design life. Between March 2003 and late April 2017, nearly 200 million gallons of contaminated water were pumped to the pond for evaporation. In April 2017 water in the pond reached the maximum operational capacity at a depth of 8 feet (equating to approximately 25 million gallons) and groundwater extraction operations were temporarily suspended. Although the evaporation pond and pond liner are currently functioning as designed, the polypropylene pond liner is exhibiting signs of deterioration. It is LM's position that the temporary suspension of pumping to the evaporation pond should be continued to allow for decommissioning of the pond liner, and for removal and disposal of the contaminated material currently in the pond, in a manner approved by the U.S. Nuclear Regulatory Commission (NRC). It is LM's position that these actions should be conducted prior to realization of the 20-year design life of the pond liner.

Although these proposed actions deviate from the current compliance strategies approved by NRC and described in the GCAP, LM believes that these actions are necessary to ensure protection of human health and the environment. An overview of the current evaporation pond status and groundwater extraction effectiveness, proposed changes to remedial actions, implementation challenges, and recommendations are discussed following the background information below.

## 2.0 Background

The Shiprock site is divided into two distinct areas: the floodplain and the terrace. The floodplain remediation system consists of two groundwater extraction wells, a seep collection drain, and two collection trenches (trenches 1 and 2). The terrace remediation system consists of nine groundwater extraction wells, two collection drains (Bob Lee Wash and Many Devils Wash), and a terrace drainage channel diversion structure. The rationales for pumping on the floodplain and terrace areas of the site are described at length in the GCAP (DOE 2002) and summarized below.

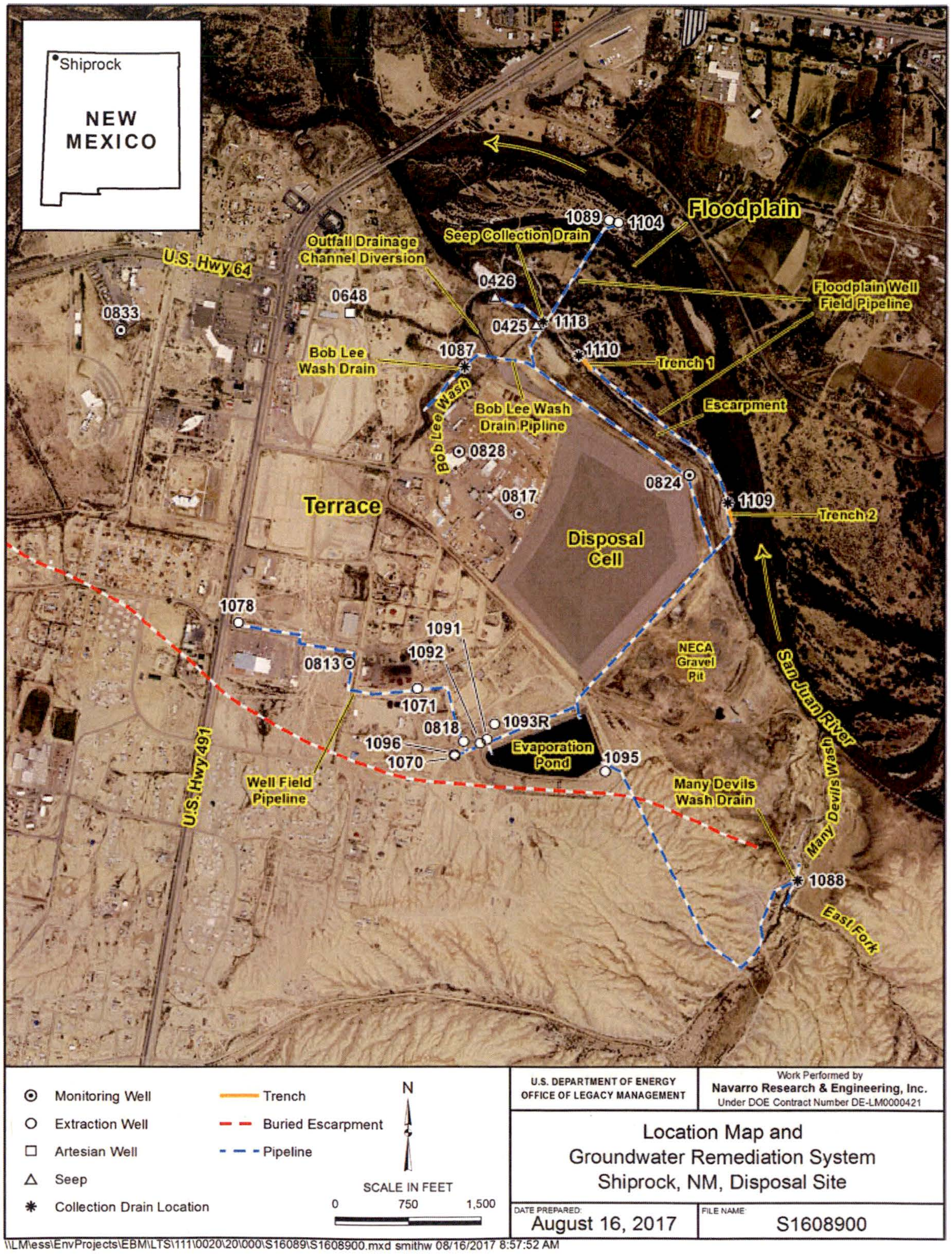


*Figure 1. Location Map and Remediation System Features*

The compliance strategy for the floodplain alluvial aquifer is natural flushing supplemented by active remediation as a best management practice, involving the extraction of groundwater to enhance the natural flushing process. Pumping from the floodplain was intended to reduce contaminant concentrations in floodplain wells and prevent or minimize risk to aquatic life in the nearby San Juan River (DOE 2002; DOE 2011). The GCAP states that the extraction of groundwater from the floodplain may continue for as long as 20 years in response to supplying adequate water for the evaporation pond and to remove contaminants, and that after pumping is discontinued, natural flushing would continue to remove remaining contaminants from the floodplain.

The compliance strategy for the east terrace (terrace areas east of Highway 491) is active remediation until potential risks to humans and the environment have been eliminated. Specifically, groundwater is pumped from extraction wells in an area north of a buried escarpment and from interceptor drains along Many Devils and Bob Lee Washes. The objective of the terrace groundwater extraction is to eliminate the exposure pathways at the washes and seeps (i.e., dry up the seeps and washes), thus eliminating the risk associated with ingestion of contaminated water. The compliance strategy for the west terrace (area west of Highway 491) is the application of supplemental standards, based on the limited use of groundwater in this area and the presence of widespread ambient (non-anthropogenic) contamination derived from the Mancos Shale (not related to uranium-milling processes).

The 11-acre evaporation pond is the collection point for contaminated groundwater pumped from the floodplain and the terrace. Pond construction was completed in October 2002 and warrantied by the liner manufacturer and installer for 20 years. The pond is lined with a 45-mil-thick, scrim-reinforced polypropylene geosynthetic liner underlain by a compacted soil base. Quality assurance/quality control testing of the liner was conducted during and after installation to ensure that no leaks were present before filling of the pond began. A leak detection system was not included in the pond design. Although the GCAP discussed the uncertainties and contingencies associated with the compliance strategies for the Shiprock site (including the evaporation pond), the useful functional life of the single pond liner and removal and disposal of the contaminated pond contents were not addressed (DOE 2002).

# 3.0 Current Status of Shiprock Remediation

This section summarizes the effectiveness of active groundwater extraction in meeting compliance objectives for the floodplain and terrace areas of the site and concludes with a discussion of the current status of the evaporation pond. As shown in Figure 2, the remediation system has removed over 197 million gallons of contaminated groundwater (through April 2017) since pond construction was completed in 2002.

## 3.1 Floodplain Remediation Status

Groundwater in the floodplain system is extracted from two wells (wells 1089 and 1104) adjacent to the San Juan River north of the disposal cell, two collection trenches, and a seep collection sump (Figure 1). Approximately 150 million gallons of groundwater have been extracted from the floodplain aquifer system to date (May 2017). The volume of water transmitted to the pond increased significantly following the installation of the floodplain trenches in 2006 (Figure 2).

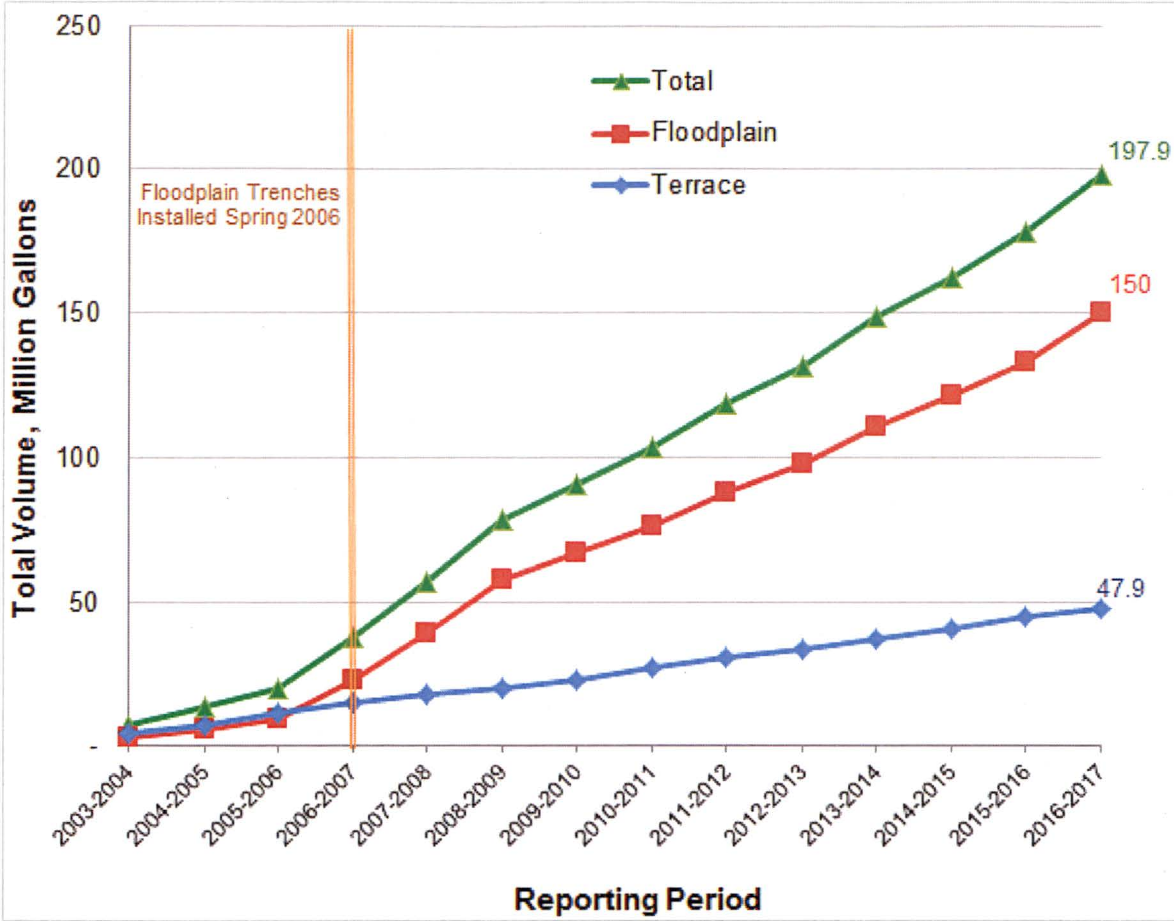


*Figure 2. Total Groundwater Volume Pumped to the Shiprock Site Evaporation Pond*

The floodplain remediation has been effective at fulfilling the remediation objective of accelerating the natural flushing process in the floodplain alluvial aquifer. An example of this effectiveness is provided in Figure 3, which illustrates the wide-scale reduction in groundwater concentrations of uranium, the primary contaminant of concern (COC) at the site, especially within the main plume area. Similar reductions are apparent for nitrate and sulfate, the other COCs monitored for remediation progress on the floodplain (DOE 2016). Estimated masses of uranium, nitrate, and sulfate removed from the floodplain since 2003 are (rounded) 680 pounds; 77,450 pounds; and 6,095,500 pounds, respectively (DOE 2016). Despite these mass reductions, standards are still exceeded over most of the floodplain for these contaminants.

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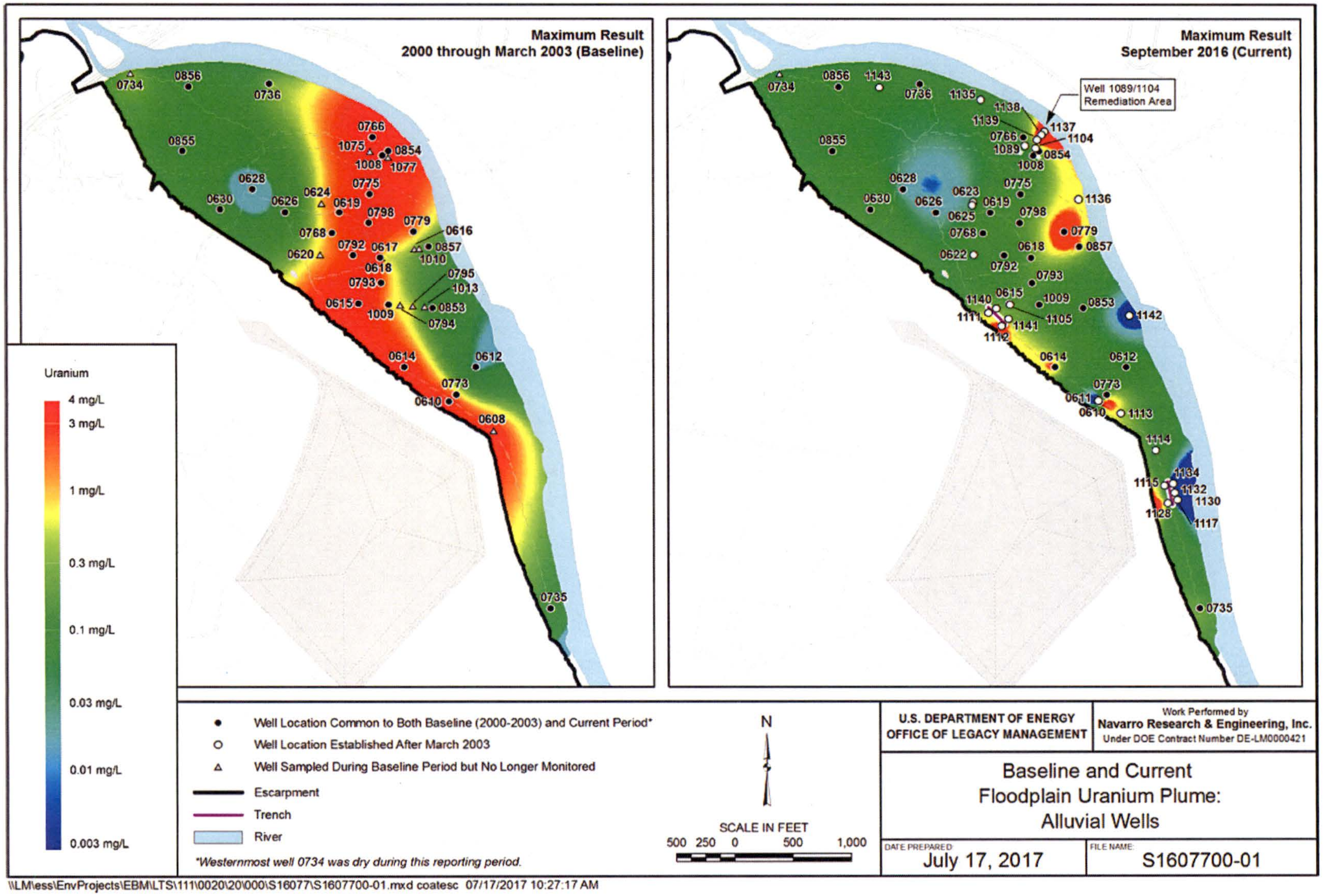


*Figure 3. Shiprock Site Baseline and Current Floodplain Uranium Plume*

## 3.2 Terrace Remediation Status

The terrace ground water system occupies the alluvial material deposited over the Mancos Shale by the ancestral San Juan River. Along the south part of the terrace system, the ancestral river channel eroded a swale in the underlying Mancos Shale bedrock. A buried escarpment (similar to the present escarpment north of the disposal cell) at the south edge of the swale marks the south boundary of the terrace system. Water flow in the terrace system moves to the northwest (DOE 2002).

The boundary between west and east terrace areas is just east of and roughly parallels U.S. Highway 491. Saturated thicknesses of the alluvial material in the terrace east system north of the swale are thin to nonexistent; whereas, saturated thicknesses in the terrace west system increase from essentially zero at the boundary between the two areas to more than 16 ft in the area near the escarpment. A hydrologic connection between terrace east and terrace west ground water extending northwest from the swale area follows the ancestral river channel along the south edge of the terrace system (DOE 2002).

### East Terrace

Groundwater in the east terrace is currently extracted from an interceptor drain in Bob Lee Wash and nine extraction wells. Approximately 48 million gallons of groundwater have been extracted from this region since 2003 (Figure 2).

The compliance strategy for the east terrace is active remediation until potential risks to humans and the environment have been eliminated. With the exception of Bob Lee Wash (discussion follows), the objectives of the terrace remedial action—to eliminate the exposure pathways at the washes and seeps—has been successful. Additionally, groundwater elevation levels in the majority of alluvial wells have declined relative to pre-remediation conditions (DOE 2016).

### West Terrace

Several west terrace alluvial wells have been dry for at least 7 years, and seeps on the west terrace that had been points of exposure have been dry since 2008 (DOE 2016).A reduction in agricultural irrigation on the west terrace has likely contributed to the decrease in overall water levels across the west terrace, however, the hydraulic connection between the east terrace and the west terrace may still exist.

### Potential Non-Mill-Related Sources of Recharge

The effects of years of groundwater extraction on the terrace have resulted in decreased groundwater elevation levels at most terrace well locations. However, a few alluvial wells have shown anomalous increases in groundwater elevations as groundwater extraction on the terrace has progressed. In most cases, increased water elevations at these locations are believed to be associated with non-mill sources of recharge that have been identified by LM in recent years (e.g., leaking domestic waterlines and an irrigation system which waters the sod directly over well 828 [Figure 1]). Sources that contribute to the terrace groundwater system that are not mill-related have a contrary impact on the effectiveness of LM's groundwater extraction efforts. Consequently, LM is in the process of collecting information needed to identify and differentiate potential non-mill-related water inputs to the shallow terrace groundwater system. Although this work is ongoing, preliminary results indicate that much of the water LM is currently extracting from the terrace alluvial groundwater system may not be related to the former uranium processing site. In a study conducted by the U.S. Geological Survey, chlorofluorocarbon concentrations in some wells on the terrace (813, 817, 824, and 833 [Figure 1]) suggest that a substantial fraction of terrace groundwater is composed of younger (post-mill) water (Robertson et al. 2016).

**Many Devils Wash**

From 2003 to 2014, groundwater was also pumped from an interceptor drain in Many Devils Wash, because it had been assumed that constituents in the Many Devils Wash originated from the mill site (DOE 2016). However, investigations conducted by DOE and others since 2011 have resulted in an expanded understanding of the hydrologic and geochemical conditions in Many Devils Wash. Study findings, which were recently summarized in a position paper prepared by LM, showed that the origin of water and contaminants that were being extracted from Many Devils Wash is not related to the former uranium processing site (DOE 2017a). Consequently, the pumping of groundwater from Many Devils Wash has been discontinued.

**Bob Lee Wash**

After 15 years of groundwater extraction from the terrace, the only remaining surface expressions of terrace groundwater (excluding Many Devils Wash) are in upper Bob Lee Wash and at seeps 425 and 426 (Figure 1). Seeps 425 and 426 are locations where terrace groundwater surfaces along the base of the floodplain escarpment, just below Bob Lee Wash. Potential points of exposure were eliminated at seeps 425 and 426 when LM constructed drains below each seep to capture flow from the seeps and convey it to the evaporation pond; the drains continue to eliminate the surface expression of groundwater from these locations, even when active pumping is not occurring.

The current remediation system eliminates surface water in Bob Lee Wash. However, groundwater flows to the surface when the remediation pumps are not operated (for repairs and maintenance). Thus, the current terrace groundwater extraction system has been ineffective in achieving the remediation objective for Bob Lee Wash, reducing flow to eliminate exposure pathways. In general, the average annual extraction rate of groundwater pumped from the Bob Lee Wash interceptor drain has increased since remediation began (Figure 4).

Eliminating surface exposures in Bob Lee Wash when remediation pumps are not in operation will require implementing interim actions prior to suspending active pumping in support of decommissioning activities. Potential interim actions for consideration include piping water from the interceptor drain sump to the floodplain, armoring exposed water with rock, and the implementation of phytoremediation plantings.

LM will develop a revised GCAP for NRC concurrence prior to implementing any changes to the current groundwater compliance strategies. Additionally, LM will develop a technical approach plan to outline the planning elements and process for decommissioning the pond liner. An interim remediation plan, if necessary, for Bob Lee Wash and seeps 425 and 426 will be documented in both the GCAP and technical approach plan.

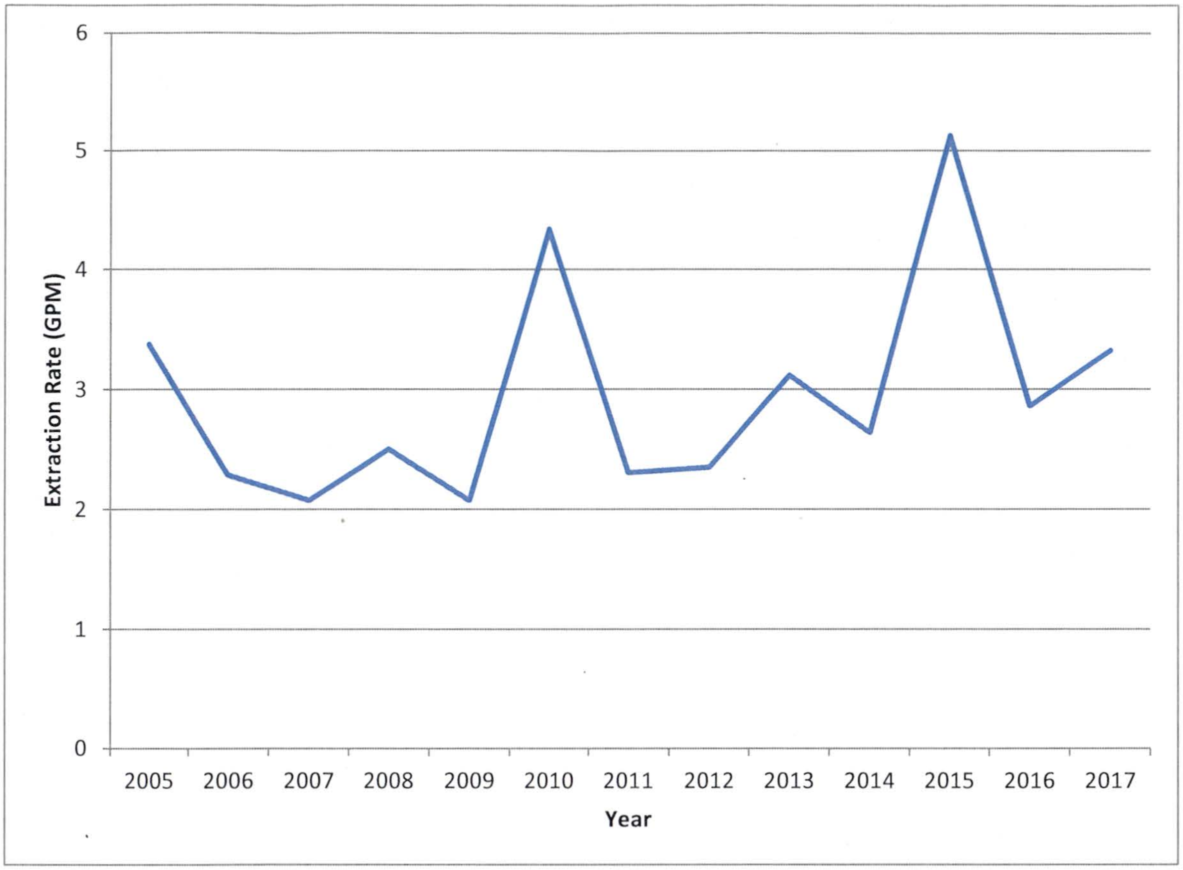


*Figure 4. Average Annual Extraction Rates from Bob Lee Wash: 2005–2017*

# 4.0 Current Status of the Evaporation Pond

## 4.1 Pond Capacity

The evaporation pond has a total depth of 10 feet, and was designed for a maximum fill capacity of 8 feet, which allows for a freeboard of 2 feet above the water level when filled to capacity. When full (8 feet of water), the pond provides a total capacity of 25.37 million gallons of liquid. In April 2017, the water level in the pond reached the maximum fill capacity of 8 feet. The volume of solids in the bottom of the pond is not known.

The amount of water that can be evaporated from the pond is determined by rates of precipitation and evaporation; the latter is significantly inhibited by the presence of dissolved salts (DOE 2002). With ongoing evaporation (rates vary seasonally at the site), the concentration of total dissolved solids (TDS) in the pond water in September 2016 was 130,000 milligrams per liter (mg/L) (DOE 2017b).

## 4.2 Pond Liner

The pond liner is nearing the end of its warranty based design life. Many physical factors and environmental conditions may contribute to degradation, which affects the life of a polypropylene liner. Degradation involves a change in the physical properties of the liner material that could increase the permeability of the material or reduce the material's strength or ductility.

Polypropylene is susceptible to thermal degradation. At high temperatures the components of the long chain backbone of the polymer can begin to separate (molecular scission) and react with one another to change the properties of the polymer. Other degradation mechanisms can occur from a variety of causes such as; light (photo degradation), oxygen (oxidative degradation), and weathering (generally UV degradation). Ultraviolet light can cause chain reactions and bond breaking of polymeric material due to the penetration of short wavelength energy. Oxidation occurs when free radicals and oxygen are present and results in chain scission (Reddy and Boris 1999).

The modes of failure are as follows: a) softening and loss of physical properties due to depolymerization and molecular scission, b) stiffening and embrittlement due to loss of plasticizers and additives, c) reduction of mechanical properties and increase of permeability, and d) failure of membrane seams. In the majority of cases there are combinations of these factors, which can damage the liner system (Reddy and Boris 1999).

The engineering design for the evaporation pond was intended to meet the requirements for the active remediation timeframes anticipated and described in the GCAP; for a period of 7 years on the terrace, and for a period of up to 20 years on the floodplain. Consequently, DOE required the manufacturer and installer to provide a 20 year warranty for the polypropylene liner. The frequency of the need for liner repairs has increased over time. Since 2012, repairs to the Shiprock evaporation pond liner have become increasingly difficult. Pond liner repair efforts in recent years have included the following.

**August 2012**
A liner inspection resulted in the need to repair small holes at eight locations. The liner repair crew noted the number of required repairs was very small for a liner that had been in service for 10 years. The overall evaluation of the liner at that time (2012) was that the liner was in very good condition.

**Spring 2014**
During maintenance work at the pond, several holes above the water line were identified. During repair of these areas feedback from the liner repair crew indicated that patching was becoming more difficult due to the age of the liner.

**July 2016**
A power wash was performed on the liner to remove scale on the surface of the side slopes. Because of the magnitude of the scaling (difficult to remove), the power wash was reapplied to localized (smaller) areas, causing additional tears in the liner and an additional round of repairs. While the liner repair company was on site to repair the known areas of damage from the power

wash, they were asked to inspect the remainder of the liner. Several additional locations needing repair were identified and repaired.

With each successive visit the liner repair crew commented on the increased difficulty in patching the liner. LM's main concern is that the liner is beginning to develop areas of degradation from exposure to the sun (polypropylene is a simple chain polymer and it has a high degradation rate when exposed to UV light like the Sun. UV light causes the bonds holding the polymer together to break which weakens the plastic.). Consequently, it becomes more problematic to find enough surface area that can be ground to a clean surface for welding patches. Additionally, the thickness of the remaining polypropylene above the scrim and reinforcing material is insufficient to establish a good seal. As a result, future repairs will require a different patching method. For example, if there is insufficient surface to grind, double-sided tape can be used to patch and seal areas requiring repair.

# 5.0 Proposed Changes to Remedial Actions

LM recommends suspension of pumping to the evaporation pond to facilitate planning and decommissioning of the evaporation pond. As of April 2017, the pond held approximately 25 million gallons of contaminated water and an unknown volume of contaminated sediment (Figure 5). The polypropylene pond liner is increasingly exhibiting signs of deterioration. To ensure that operation of the evaporation pond continues in a manner protective of human health and the environment, these actions should be conducted well in advance of the 20-year design life of the pond liner. Planning for decommissioning activities and evaporation of the current volume of water in the pond will require several years.

Three water-balance calculations have been conducted to estimate the time required for dewatering the evaporation pond once remediation is suspended. Water balance calculations sum inflows and outflows to the evaporation pond and divide that number by the surface area of the pond to determine the change in pond level for the period of evaluation. Inflows to the evaporation pond are average monthly Shiprock precipitation and remedial system monthly pumping volumes. Outflows are average monthly open water evaporation rates for the Shiprock area. The assumed start date for this analysis is the beginning of January 2018, and the assumed starting pond elevation is 4981.0 feet above mean sea level (amsl), or 0.5 feet below the maximum pond elevation at the base of the pond's freeboard requirements (the volume in the pond as of May 2017, shortly after remediation had been suspended). The bottom of the pond has an approximate elevation of 4973.5 feet amsl.

*Figure 5. Current Evaporation Pond Conditions*

The triangles in Figure 6 illustrate how pond water elevations would change in response to evaporation at the Shiprock site assuming that pumping of contaminated groundwater has completely ceased (non-pumping scenario). These results are based on the assumption that evaporation occurs at rates associated with freshwater, which are also shown in Figure 6. Calculated pond-water elevations suggest that it would require about 21 months (1.75 years) of evaporation to totally dewater the pond under the no-pumping scenario. In comparison, if limited delivery of pumped contaminated groundwater from key locations (wells 1089 and 1104, sump 1118, drain 1087) were to continue in future years (blue squares in Figure 6) assuming freshwater evaporation rates, the pond would dewater in about 3.5 years (July 2021). Note that the predicted durations for the pond to completely dewater for the non-pumping and pumping scenarios are estimates; the actual times will be a function of future climatic conditions, specifically rainfall and temperature, which are unknown but are not expected to be significantly different, long-term, than those assumed for the calculation duration.

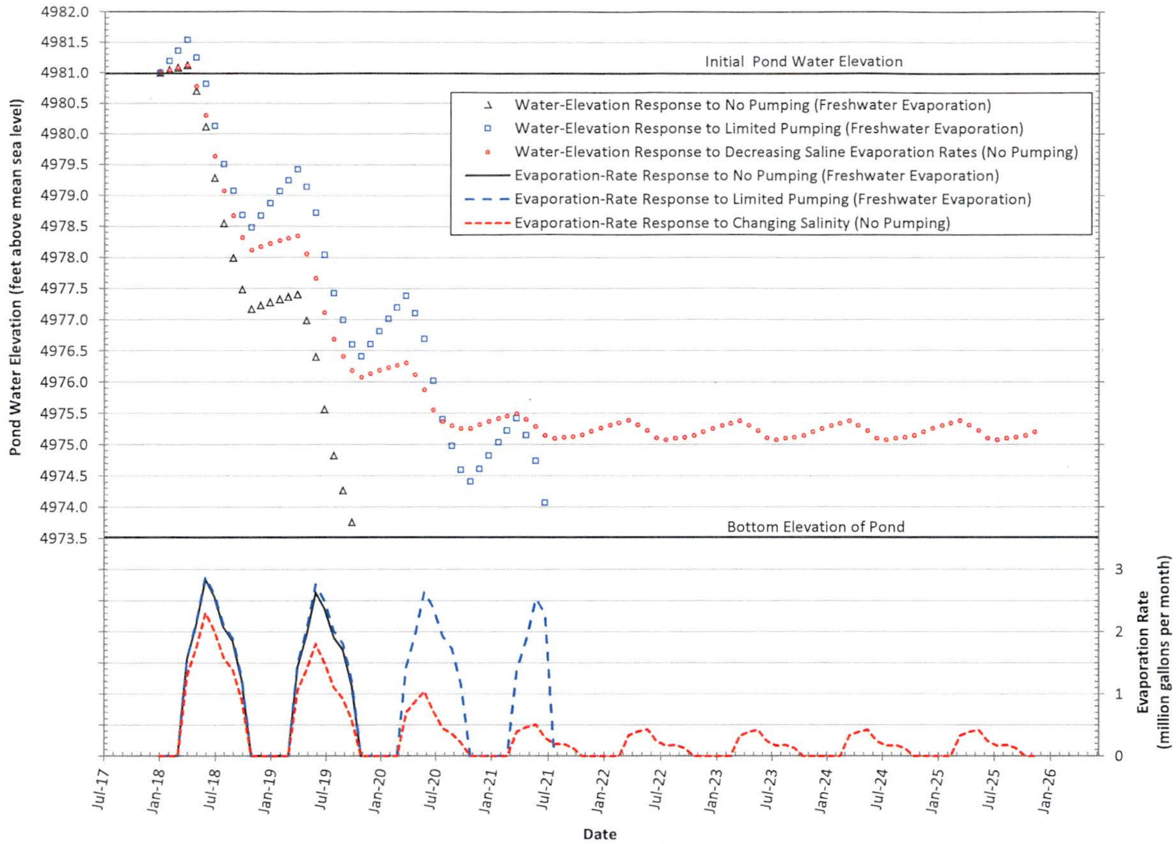


*Figure 6. Calculated Decreases in the Pond Water Elevation Due to Evaporation*

Studies of natural evaporation from reservoirs containing brine indicate that the evaporation rate is significantly reduced compared to freshwater rates. Given that the TDS concentration in the Shiprock site pond is currently about 130,000 mg/L, future evaporation rates at the site are expected to be less than those used in the previous freshwater, non-pumping and pumping scenarios. A quantitative relationship between evaporation rate and salinity level was developed using data from studies that examined how evaporation rates are affected by TDS concentration and that relationship was used to assess the decrease in pond water levels, assuming an initial TDS level of 130,000 mg/L. The resulting computed pond water elevations, shown by the red circles in Figure 6, suggest that the pond evaporation rate will be similar to the freshwater evaporation rate for the first 18 months of dewatering and then evaporation rates will decline and stabilize (at approximately 2.5 years) when the yearly precipitation volumetric contribution to the pond matches the yearly evaporation volume. However, this result is probably conservative because the calculation does not account for the likely precipitation of solids from the pond's briny water as TDS levels continue to increase. Nonetheless, the decreased evaporation rates expected with increased salinity could end up slowing the dewatering, resulting in pond water elevations that remain at 1 to 2 feet above the pond's base elevation of 4973.5 feet amsl. Note that the residual 1 to 2 feet of water remaining in the pond due to salinity effects is the same for both non-pumping and pumping (not shown) scenarios. The only difference between the two scenarios is it will take longer to reach stable pond water levels for the pumping scenario relative to the non-pumping scenario.

LM will conduct routine inspections of the evaporation pond to document the pond conditions as water levels decrease due to the suspension of active groundwater pumping. LM will develop a plan and implementation requirements for addressing pond sediments exposed as a consequence of decreasing pond water levels to ensure that wind-blown dispersion of sediments do not present a risk to human health and the environment.

# 6.0 Implementation Challenges

Decommissioning the Shiprock site evaporation pond, in a manner that is safe and complies with all regulatory requirements, will require several years. To date, only conceptual level planning has been conducted; however, LM will prepare a planning document to consider the following issues related to the proposed actions:

- Requirements to ensure the viability of remediation infrastructure (monitoring equipment, pumps, valves, piping, electronics) during an extended shutdown period.
- Options and recommendations for removal methods and transportation for the contaminated pond sediment, subsoils, and liner material.
- Regulatory requirements and approvals, including those required by the Navajo Nation, State of New Mexico, U.S. Environmental Protection Agency, U.S. Department of Transportation, and U.S. Nuclear Regulatory Commission.
- Options and recommendations for methods to dewater contaminated and saturated pond sediments.
- Options and regulatory requirements for enhancing the evaporation of pond water and construction of a secondary pond, if necessary.
- Protection measures for the local community and workers during decommissioning operations, including air and radiation monitoring.
- Development of processes and plans for preventing wind-blown dispersion of contamination as decreasing pond water levels expose sediments.

# 7.0 Summary Discussion and Recommendations

With the exception of Bob Lee Wash, the remediation objectives for the terrace have been achieved and groundwater extraction should be suspended. LM proposes that, during the time groundwater extraction from the terrace is suspended, the following be conducted:

- Continued monitoring of terrace groundwater chemistry and water levels, to evaluate the response to the suspension of active groundwater extraction.
- Complete the current evaluation of mill- and non-mill-water input to the terrace.
- Evaluate the source of water in Bob Lee Wash and at seeps 425 and 426.
- Modify the infrastructure at seeps 425 and 426 to allow for a more accurate assessment of the volume of water flowing from the seeps.
- Begin phytoremediation plantings to supplement the remediation objectives.

- Modify the Bob Lee Wash infrastructure to minimize exposure from water that will flow from the sump when pumping is stopped. Pumping from all locations will need to be suspended to decommission the current evaporation pond liner.

As with the terrace, LM proposes suspending remediation activities in the floodplain to evaluate the effectiveness of past remediation actions, and help guide decisions on the need for any future remedial action, i.e. natural flushing.

Additionally, LM proposes the following:

- Continued monitoring of floodplain groundwater chemistry and water levels, to evaluate the response to the suspension of active groundwater extraction.
- Continued monitoring of the San Juan River to ensure protectiveness.
- Evaluate alternative treatment options such as uranium sequestration and phytoremediation to supplement natural flushing.
- Evaluate natural flushing progress without groundwater extraction.

The data obtained by these actions would be used to reassess the terrace and floodplain compliance strategies and provide a basis for potential revisions to the GCAP. The requirements for continued operation of an evaporation pond to achieve the compliance objectives will also be incorporated into future revisions to the GCAP, with input from the Navajo Nation, and submitted to NRC for concurrence. LM will remain committed to its primary mission of protection of human health and the environment.

# 8.0 References


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