04002259

Department of Energy
Office of Legacy Management

JAN 29 2009

Myron Fliegel
U.S. Nuclear Regulatory Commission
Mail Stop T8 F5
Washington, DC 20555-0001

Subject: Draft Long-Term Surveillance Plan for the Gas Hills North, Wyoming, UMTRCA Title II Site

Dear Mr. Fliegel:

Enclosed for U.S. Nuclear Regulatory Commission (NRC) review and comment are four copies of the draft *Long-Term Surveillance Plan for the Gas Hills North (UMTRCA Title II) Disposal Site, Fremont County, Wyoming* (LTSP).

The draft LTSP is complete, except for "placeholders" that were left in Appendix A for the following site real property instruments (that are in process): the warrantee deed, the Public Land Order Notice of Permanent Withdrawal as posted in the Federal Register, the BLM right-of-way permit for site access, and the legal description.

The U.S. Department of Energy (DOE) understands that NRC cannot give final concurrence to this LTSP until these items are inserted into the document. However, in order to facilitate NRC's review of the draft LTSP—in an effort to accommodate site transfer from Pathfinder Mines Corporation to DOE—the document is being submitted, with these "placeholders," so that a technical review may be performed. Once these real property actions have been completed and the associated documentation has been obtained and inserted into the draft LTSP, the revised final draft LTSP will be submitted to NRC for concurrence.

This LTSP captures information provided in licensee site documents and establishes the program of post closure care for the site. This LTSP is intended to satisfy the requirements set forth in 10 CFR 40.28 whereby the long-term custodian must provide an LTSP to the NRC as a step in the licensing/license termination process.

Your prompt reply with any comments to this draft LTSP is appreciated. A 90-day review period is anticipated. Please call me at (720) 377-9682 if you have questions.

Sincerely,

2009.01.22
14:37:42 -07'00'

Scott Surovchak
Site Manager

Enclosures

2597 B 3/4 Road, Grand Junction, CO 81503 ☐ 3600 Collins Ferry Road, Morgantown, WV 26505
1000 Independence Ave., S.W., Washington, DC 20585 ☐ 11025 Dover St., Suite 1000, Westminster, CO 80021
10995 Hamilton-Cleves Highway, Harrison, OH 45030 ☐ 955 Mound Road, Miamisburg, OH 45342
232 Energy Way, N. Las Vegas, NV 89030 ☐
REPLY TO: Grand Junction Office

cc w/enclosures:
T. Carter, NRC (4 copies)
File: GHN 505.15 (Roberts)

cc w/o enclosures:
W. von Till, NRC
R. Bush, DOE-LM
C. Carpenter, Stoller (e)
M. Widdop, Stoller (e)
S. Hall, Stoller (e)

Survchak\1-22-09 LTSP Gas Hills North.doc

LMS/GHN/S01333-0.0

U.S. Department of Energy

Long-Term Surveillance Plan for the Gas Hills North UMTRCA Title II Disposal Site Fremont County, Wyoming

January 2009

U.S. DEPARTMENT OF ENERGY | Office of Legacy Management

This page intentionally left blank

LMS/GHN/S01333-0.0

U.S. Department of Energy Office of Legacy Management

Long-Term Surveillance Plan
for the
Gas Hills North UMTRCA Title II Disposal Site
Fremont County, Wyoming

January 2009

This page intentionally left blank

Contents

Figures

Tables

Appendixes

Acronyms and Abbreviations

ACL	alternate concentration limit
BLM	Bureau of Land Management
CFR	*Code of Federal Regulations*
D_{50}	median diameter
DOE	U.S. Department of Energy
EMS	environmental management system
EPA	U.S. Environmental Protection Agency
ft	feet, foot
LM	Office of Legacy Management
LTSP	Long-Term Surveillance Plan
m^2	square meters
mg/L	milligram(s) per liter
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
pCi	picocurie
pCi/g	picocurie(s) per gram
pCi/L	picocurie(s) per liter
PMC	Pathfinder Mines Corporation
PMF	probable maximum flood
POC	point of compliance
POE	point of exposure
Ra	radium
ROW	right of way
s	seconds
TDS	total dissolved solids
Th	thorium
UMTRCA	Uranium Mill Tailings Radiation Control Act
USC	*United States Code*
WDEQ	Wyoming Department of Environmental Quality

This page intentionally left blank

1.0 Introduction

1.1 Purpose

This Long-Term Surveillance Plan (LTSP) explains how the U.S. Department of Energy (DOE) will fulfill general license requirements of Title 10 *Code of Federal Regulations* Part 40.28 (10 CFR 40.28) as the long-term custodian of the Gas Hills North disposal site (formerly known as the Pathfinder Mines Corporation [PMC] Lucky Mc uranium mill tailings disposal site) in Fremont County, Wyoming. The DOE Office of Legacy Management (LM) is responsible for the preparation, revision, and implementation of this LTSP, which specifies procedures for inspecting the site, monitoring, conducting maintenance, fulfilling annual and other reporting requirements, and maintaining records pertaining to the site.

1.2 Legal and Regulatory Requirements

The Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978 (Title 42, *United States Code*, Section 7901 [42 USC §7901]) as amended, provides for the remediation (or reclamation) and regulation of uranium mill tailings under either Title I or Title II of the act. Title I addresses former uranium millsites that were unlicensed as of January 1, 1978, and essentially abandoned. Title II addresses uranium millsites under specific license as of January 1, 1978. In both cases, the licensing agency for uranium production is the U.S. Nuclear Regulatory Commission (NRC) or, in the case of certain Title II disposal sites, an Agreement State. The Gas Hills North disposal site is regulated under Title II of UMTRCA. The State of Wyoming is not an Agreement State.

Federal regulations at 10 CFR 40.28 provide for the licensing, custody, and long-term care of uranium and thorium mill tailings sites closed (reclaimed) under Title II of UMTRCA.

A general license is issued by NRC for the custody and long-term care—including monitoring, maintenance, and emergency measures—necessary to ensure that uranium and thorium mill tailings disposal sites will be cared for in such a manner as to protect public health, safety, and the environment after closure (completion of reclamation activities).

The general license becomes effective when NRC or an Agreement State approves the site reclamation and terminates the operating license, and NRC accepts a site-specific LTSP (this document).

Requirements of the LTSP and general requirements for the long-term custody of the Gas Hills North disposal site specified in 10 CFR 40 are addressed in various sections of the LTSP as shown in Table 1–1.

The plans, procedures, and specifications in this LTSP are based on *Guidance for Implementing the Long-Term Surveillance Program for UMTRCA Title I and Title II Disposal Sites* (DOE 2001). Rationale and procedures in the guidance document are considered part of this LTSP.

Table 1–1. Requirements of the LTSP and for the Long-Term Custodian of the Gas Hills North, Wyoming, Disposal Site

	Requirements of the LTSP	
	Requirement	***LTSP Section***
1.	Description of the final site conditions	Section 2.0
2.	Legal description of the site	Appendix A
3.	Description of the long-term surveillance program	Section 3.0
4.	Criteria for follow-up inspections	Section 3.5.1
5.	Criteria for maintenance and emergency measures	Section 3.6.3
	Requirements for the Long-Term Custodian (DOE)	
	Requirement	***LTSP Section***
1.	Notification to NRC of changes to the LTSP	Section 3.1
2.	NRC permanent right-of-entry	Section 3.1
3.	Notification to NRC of significant construction, actions, or repairs at the site.	Sections 3.5 and 3.6

1.3 Role of the U.S. Department of Energy

In 1988, DOE designated the Grand Junction facility as the program office for managing long-term surveillance and maintenance of DOE disposal sites that contain regulated low-level radioactive materials and portions of sites that do not have a DOE mission after cleanup, as well as other sites (including Title II sites) as assigned, and to establish a common office for the security, surveillance, monitoring, and maintenance of those sites.

In December 2003, DOE formally established the LM office. The LM mission includes "implementing long-term surveillance and maintenance projects at sites transferred to LM to ensure sustainable protection of human health and the environment." LM is responsible for implementing this LTSP after it is accepted by NRC and the site becomes regulated under the general license.

According to the objectives of DOE Order 450.1A, *Environmental Protection Program*, DOE sites must implement sound stewardship practices protective of the air, water, land, and other natural and cultural resources potentially affected by their operations. DOE Order 450.1A requires DOE sites to have an environmental management system (EMS) to implement these practices. The LM EMS incorporates federal mandates specified in Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management* and DOE Order 430.2B, *Departmental Energy Renewable Energy and Transportation Management*.

The LM EMS is a systematic process for reducing the environmental impacts resulting from LM and contractor work activities, products, and services; and directs work to occur in a manner that protects workers, the public, and the environment. The process adheres to "Plan-Do-Check-Act" principles, mandates environmental compliance, and integrates green initiatives into all phases of work, including scoping, planning, construction, subcontracts, and operations. The EMS provides specific procedures that anticipate and mitigate negative impacts on the environment by promoting the use of recycled materials; recycling to the extent practicable; conserving fuel, energy, and natural resources; and minimizing the generation of greenhouse gases, the use of toxic chemicals, and the generation of hazardous wastes.

2.0 Final Site Conditions

The Gas Hills North mill facility was decommissioned from 1993 to 1994 in accordance with the NRC-approved Decommissioning Plan (PMC 1992a). From 1996 to 1997, windblown contaminated soils were cleaned up according to the NRC-approved Reclamation Plan (PMC 1992b). A final completion report verifying and documenting the cleanup was published in 1999 (ERG 1999). This section summarizes the site milling history and the final cleanup.

2.1 Site History

Uranium milling at the Gas Hills North site was conducted from 1958 through 1988. The ore for the mill came from open pit mines in the immediate vicinity of the mill. A total of 12 million tons of ore was processed at the site. There, milling was accomplished using a sulfuric acid leaching process, counter current decantation, ion exchange, solvent extraction, precipitation, and yellowcake drying and packaging (NRC 1993).

During the milling period, depleted tailings were slurried into a series of tailings impoundments, or ponds, which were constructed at the head of a natural draw (Reid Draw) located directly north–northwest of the original millsite. The tailings system consists of a series of earthen embankments across Reid Draw, which extends some 3,500 meters down the draw. The upper portion of the tailings system consists of Tailings Impoundments 1, 2, and 2A, which are located immediately north of the former mill and contain all of the solid tailings that were generated at the site. The lower portion of the tailings system, which is downgradient and north of the solid tailings impoundments, consists of a series of three solution ponds that held the so-called barren solution (recoverable uranium had been removed) that was generally not recycled through the mill. This solution had low pH (2.0–3.0) and contained high concentrations of dissolved solids (including various heavy metals) and radionuclides such as thorium-230 (Th-230) and radium-226 (Ra-226). Solution Ponds 3, 3A, and 4 were used to contain these tailings solution liquids and constitute the lower portion of the tailings system (NRC 1993).

During early operations, from 1958 until 1960, excess tailings solution was routinely discharged down Reid Draw from Tailings Impoundment 1; this practice was considered acceptable at the time, as the site was routinely inspected by the U.S. Atomic Energy Commission (PMC 1998). The practice was discontinued after the construction of Tailings Impoundment 2 was completed in June 1960. The farthest downgradient containment embankment, Solution Pond 4 dam, was constructed in 1961 (and reconstructed in 1980, as discussed in Section 2.4). During a period of unusually rainy weather in June 1963, the capacity of Solution Pond 4 was taxed. Out of concern for the integrity of the dam in the event of an uncontrolled overtopping that appeared imminent, a relief overflow was cut into the dam and an estimated 23 million gallons of water was released down Reid Draw (diluted significantly by the precipitation runoff). The environmental assessment concluded that no significant health risks resulted from this intentional release from Solution Pond 4. Groundwater down gradient (north) of the site is considered by the State of Wyoming to be Class III—suitable for livestock. Therefore, the proposed "no action" alternative for the affected portion of Reid Draw downgradient of Solution Pond 4 dam was accepted by NRC in consultation with the Wyoming Department of Environmental Quality (WDEQ). The "no action" alternative for Reid Draw was posted in the *Federal Register* on March 17, 1999, and subsequently reflected in License Condition No. 29 (PMC 1998, NRC 1999a, NRC 1999b, NRC 2008).

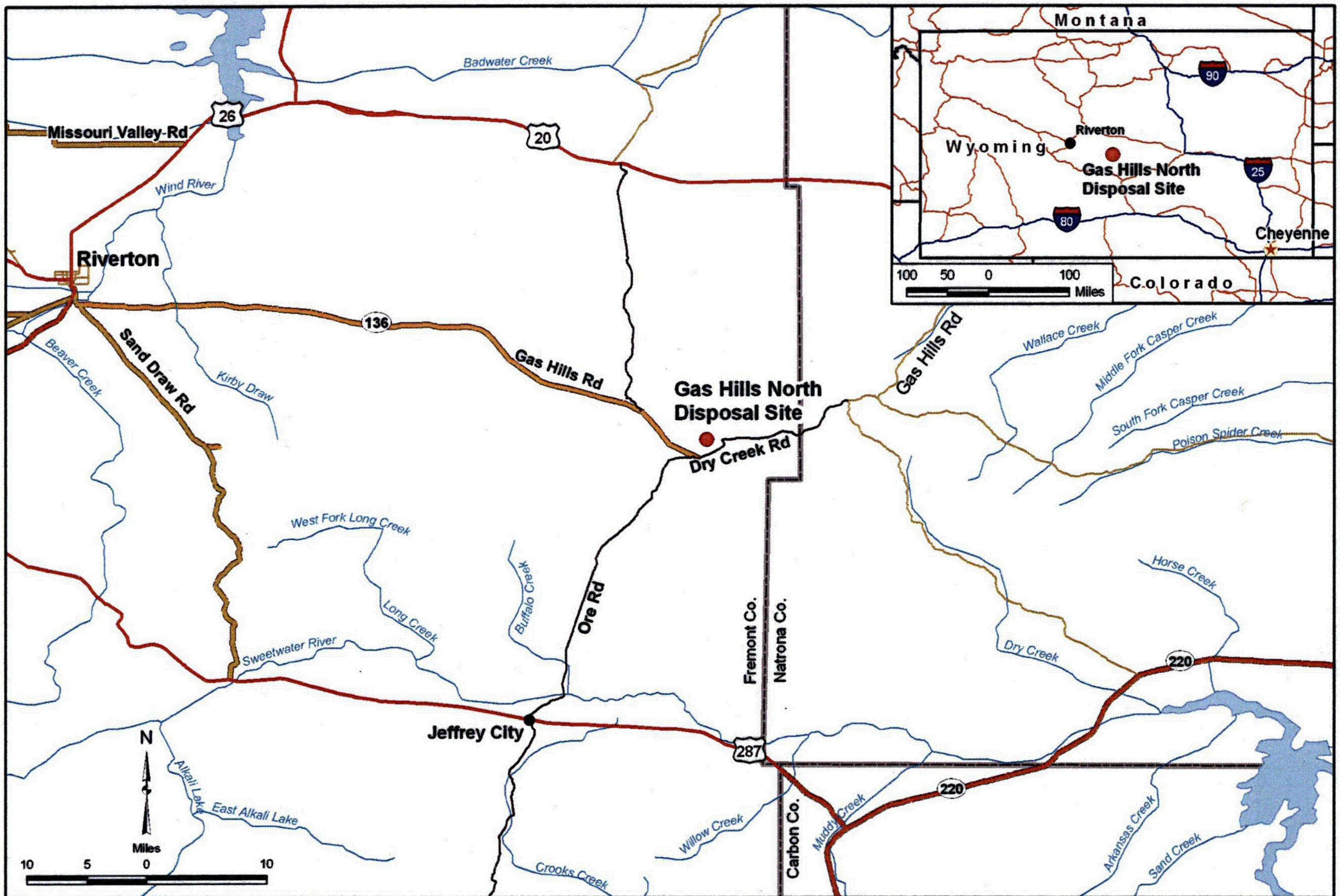
From approximately mid-1974 to late 1981, groundwater from mine dewatering operations was routinely discharged into Fraser Draw under a permit issued initially by the U.S. Environmental Protection Agency (EPA) and subsequently by WDEQ (EPA 1974, WDEQ 1978). This permit was issued in compliance with the National Pollutant Discharge Elimination System (NPDES). The average discharge rate was 940,000 gallons per day under these permits (un-permitted discharges had occurred down Fraser Draw since the late 1950s, prior to the creation of EPA and the NPDES program). The permits allowed the discharge of water with concentrations of uranium ranging up to a daily maximum of 4 milligrams per liter (mg/L), not to exceed a monthly average of 2 mg/L. Based on site records, the average uranium concentration in the permitted discharge waters was 0.77 mg/L, or 2.74 kilograms per day.

The uranium mill facilities were decommissioned from 1993 to 1994 according to the Mill Decommissioning Plan (PMC 1992a), as approved by NRC as License Condition No. 29 (NRC 2008). Some of the contaminated soils from Solution Ponds 3, 3A, and 4 were removed and placed in Tailings Impoundments 1, 2, and 2A according to the *Revised Solution Pond Area Reclamation Design* (Hydro-Engineering 2002a). The balance of the contaminated soils in Solution Ponds 3, 3A, and 4 were stabilized in place. Soils contaminated by windblown tailings were also disposed of in these ponds during site reclamation. The uranium mill facilities were razed, and the mill debris was placed in the tailings impoundments along with process residues.

Groundwater corrective action at the site began in 1980 when pumping was begun from a series of collection wells installed within the contaminate plume. Restoration continued through 1988, at which time the system was augmented with the addition of several more collection wells and two horizontal collection drains. In 1989, the groundwater corrective action was enhanced with upgradient fresh-water injection via a system that was placed in operation to drive the contaminated groundwater toward downgradient collection wells and therefore, more effectively collect the contaminated groundwater by flushing the affected area. The groundwater restoration program also included a tailings-dewatering component that was brought online in 1989 and was later expanded in 1992 (Hydro-Engineering 2002b). Recovered contaminated groundwater and tailings pore water were pumped into a lined evaporation pond (subsequently reclaimed in place). By the end of 2000, the groundwater corrective action had produced 187 million gallons from the aquifer system and 199 million gallons from the tailings-dewatering program. In addition, approximately 172 million gallons of fresh water was injected into the aquifer system as part of the groundwater corrective action (Hydro-Engineering 2002b). Because cleanup goals could not be achieved and simulated continued corrective action predicted no measurable change in groundwater contaminant concentrations, an application for alternate concentration limits (ACLs) was submitted to NRC (Hydro-Engineering 2002b). The groundwater corrective action program was terminated in 2002 upon approval of the ACL application by NRC.

2.2 General Description of the Disposal Site Vicinity

The Gas Hills North disposal site is located in the Gas Hills region of Fremont County, Wyoming, approximately 45 miles east of Riverton, Wyoming (Figure 2–1). The site encompasses approximately 1,276 acres (Figure 2–2). The elevation at the site ranges from about 6,200 to 6,500 feet (ft) above sea level (Figure 2–3). The topography in the immediate vicinity of the site is characterized by gently rolling hills.



M:\LTS\111\0059\01\S01335\S0133500.mxd coatesc 10/29/2008 2:13:42 PM

Figure 2–1. General Location Map of the Gas Hills North, Wyoming, Disposal Site

This page intentionally left blank

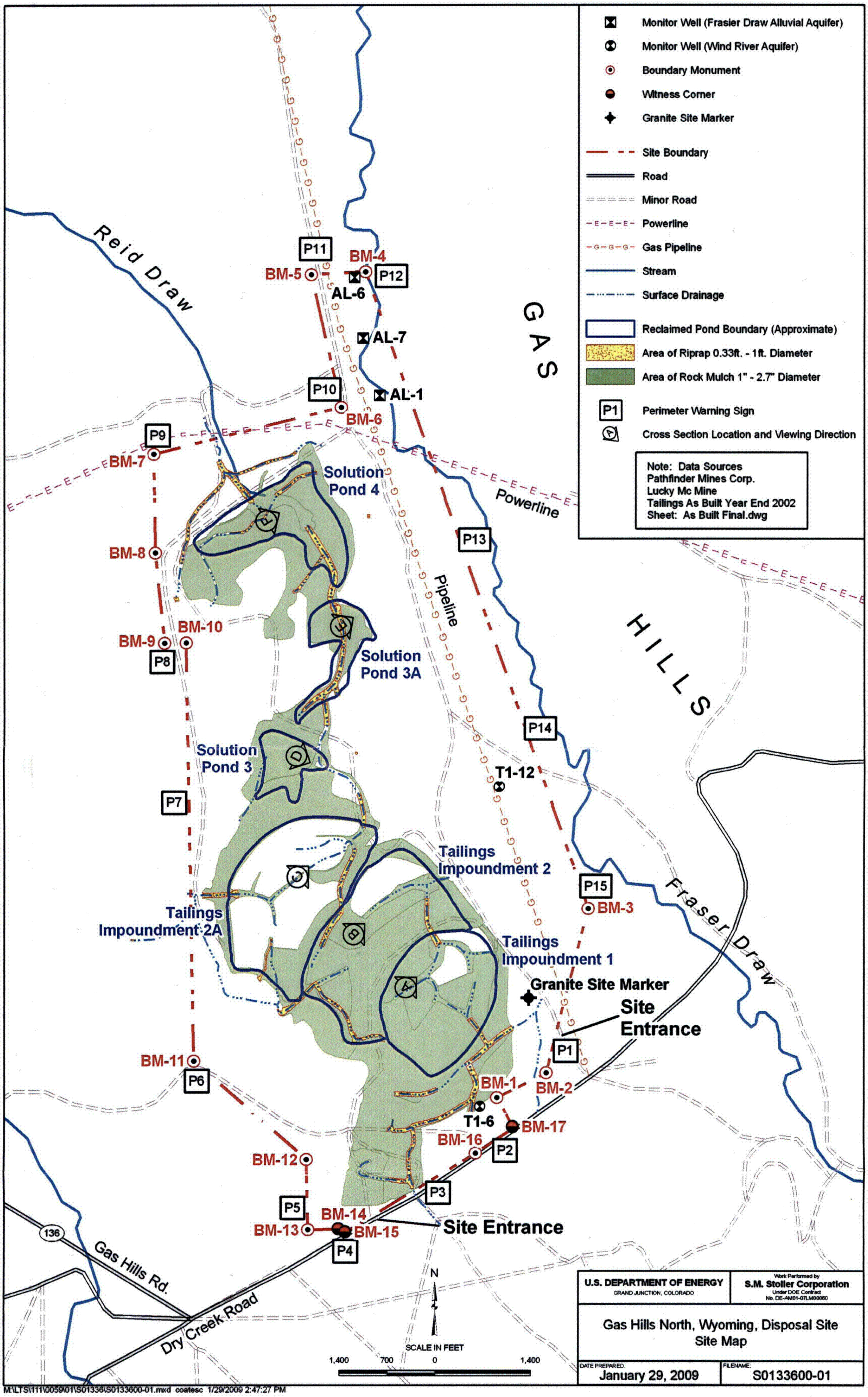


Figure 2–2. Gas Hills North, Wyoming, Disposal Site Map

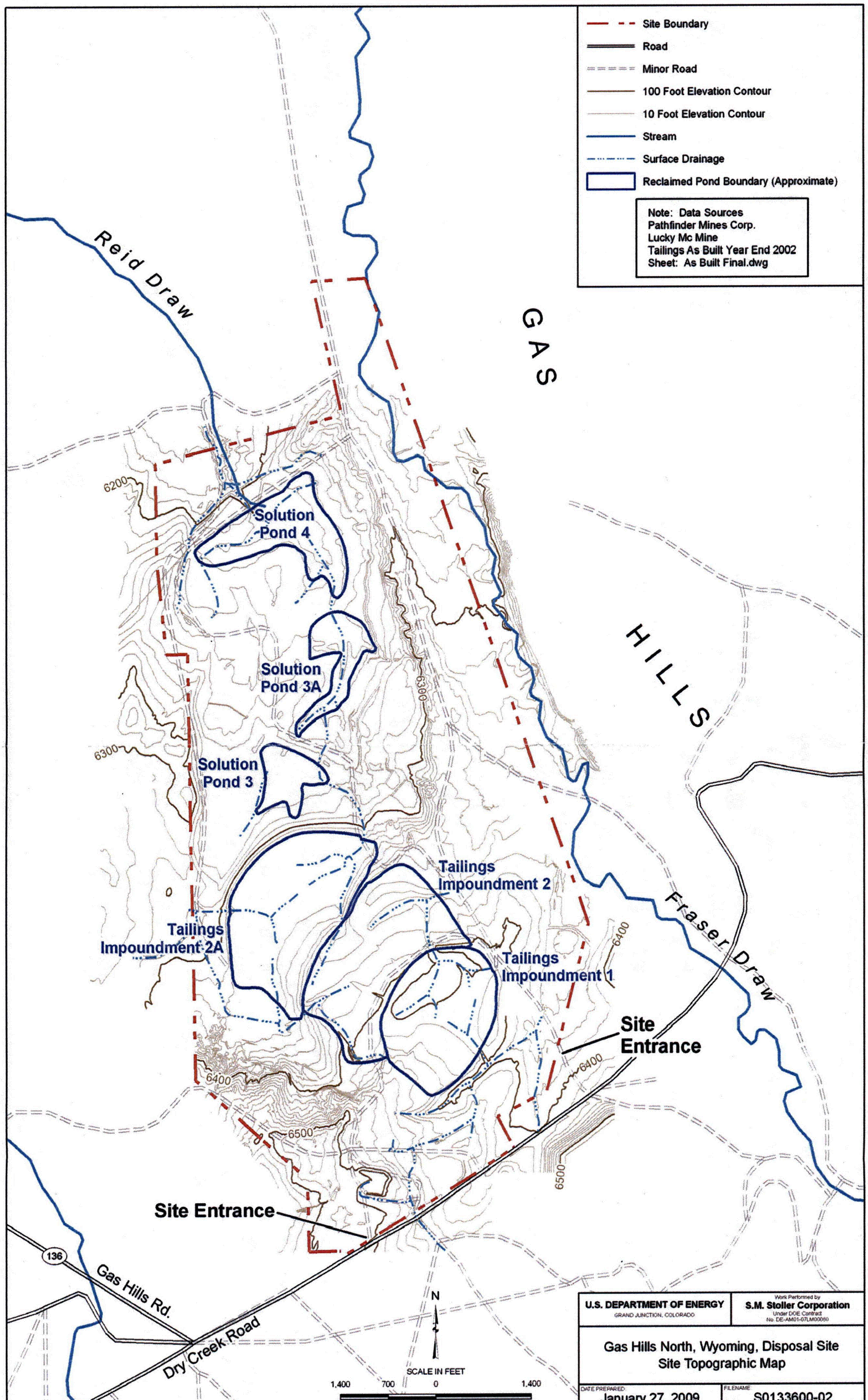


Figure 2–3. Gas Hills North, Wyoming, Disposal Site Topographic Map

The climate of the Gas Hills North area is semiarid, with annual precipitation of approximately 9 inches. More than half of the annual precipitation occurs during the spring months in the form of wet snow and rain (NRC 1993). The prevailing wind direction is from the south–southwest, and the mean annual wind speed is 12.8 miles per hour (http://www.crh.noaa.gov). The primary land uses in the immediate surrounding vicinity include cattle grazing (during the warmer months), minerals and oil and gas extraction, wildlife habitat, and hunting.

2.3 Disposal Site Description

2.3.1 Site Ownership

Upon completion of reclamation work, the U.S. Government assumed ownership of the 1,276-acre Gas Hills North disposal site property. Supporting real estate information for the site is presented in Appendix A (which includes the legal description, warranty deed, permanent withdrawal, and Bureau of Land Management [BLM] right-of-way [ROW] permit for the access route).

2.3.2 Directions to the Disposal Site

From Riverton, Wyoming, travel east on State Highway 136 approximately 45 miles to the terminus of State Highway 136, which is also the junction with Dry Creek Road. Turn left on Dry Creek Road, and proceed approximately 0.8 mile east to the site entrance, which is located on the north side of Dry Creek Road (Figures 2–1 and 2–2).

2.3.3 Description of Surface Conditions

The former mill area (approximately 56 acres), combined with the stabilized tailings impoundments and solution ponds (approximately 291 acres), encompasses approximately 347 acres of the 1,276-acre disposal site property. Post-reclamation Tailings Impoundments 1, 2, and 2A encompass approximately 61, 77, and 82 acres, respectively, and post-reclamation Solution Ponds 3, 3A, and 4 encompass approximately 14, 18, and 39 acres, respectively, and are illustrated on Figure 2–2.

The land surface at the Gas Hills North site was reclaimed to achieve gentle topography and a drainage pattern that distributes storm water away from the site. Tailings Impoundments 1, 2, and 2A were graded to achieve gentle top slopes and a 5H:1V slope for the dam-outslope area for Tailings Impoundment 2A (Hydro-Engineering 1999). Rock mulches were used on the top and side slopes of the tailings impoundments and on the outslope area of Tailings Impoundment 2A to provide long-term erosion protection to the reclaimed land surface. The reclaimed surface of Solution Ponds 3, 3A, and 4 is an extension of the cover that was placed over the tailings impoundments, also protected by riprap and rock mulch.

In accordance with the Soil Cleanup and Verification Plan (ERG 1999), surface soils that had Ra-226 concentrations exceeding the standard of 5 picocuries per gram (pCi/g) above background were removed and placed in the tailings impoundments. Subsurface soils (below 15 centimeters) with Ra-226 concentrations exceeding the standard of 15 pCi/g above background were also removed and placed in the tailings impoundments.

Drainage at the site was designed to decrease the peak runoff during storm events. To achieve this objective, the tailings disposal impoundments and solution pond areas were graded into 35 sub-basins. In addition, channel-control structures were used at the outlets to the sub-basins to further decrease peak discharges (Hydro-Engineering 1999). Various gradations of riprap were used in the drainages to protect against erosion.

The final surface at the Gas Hills North site combines grading and rock armoring to achieve the necessary surface water run-on and runoff control and erosion protection to satisfy the longevity design requirements.

All areas that were disturbed during construction, including cut and fill areas, were planted according to the specified seed mixture and covered with a dry mulch (Hydro-Engineering 1999). Additional revegetation was performed for those areas that did not succeed on the initial planting. Poor soils at the site (consisting primarily of clay) are attributed to the difficulty encountered in successfully establishing revegetation at the site.

There are five monitor wells at the Gas Hills North disposal site (Figure 2–2). The entire site property is encircled by a standard four-strand barbed-wire stock fence.

2.3.4 Permanent Site Surveillance Features

Boundary monuments, a site marker, and posted perimeter warning signs are the permanent surveillance features at the Gas Hills North disposal site. These features will be inspected and maintained as necessary as part of the passive controls for the site.

Seventeen survey monuments mark the site boundary. These boundary monuments are a combination of the standard UMTRCA disposal site aluminum-cap monuments (DOE 2001) placed by a licensed surveyor on behalf of the former site operator, PMC; brass-cap monuments placed by the U.S. General Land Office, BLM; previous PMC property boundary surveys; and three witness corners (which offset from the property boundary as a result of a physical obstruction).

One unpolished granite marker with an incised message identifying the site of the Gas Hills North disposal area is placed on site property just inside the main entrance gate. The message on the granite site marker is shown on Figure 2–4.

Fifteen warning signs displaying the DOE 24-hour telephone number (Figure 2–5) are placed along the site boundary, including one near the main entrance to the site as well as the secondary entrance.

The locations of the permanent site surveillance features are shown on Figure 2–2.

2.3.5 Site Geology

The Gas Hills North disposal site is located in the southeastern portion of the Wind River Basin along the western flank of the Dutton Basin Anticline—a northwest-plunging anticline exposing rocks of Precambrian through Tertiary ages. Northeast of the site are the Gas Hills; a series of hogbacks of steeply dipping shale and sandstone located along the north and west flanks of the anticline (NRC 1993).

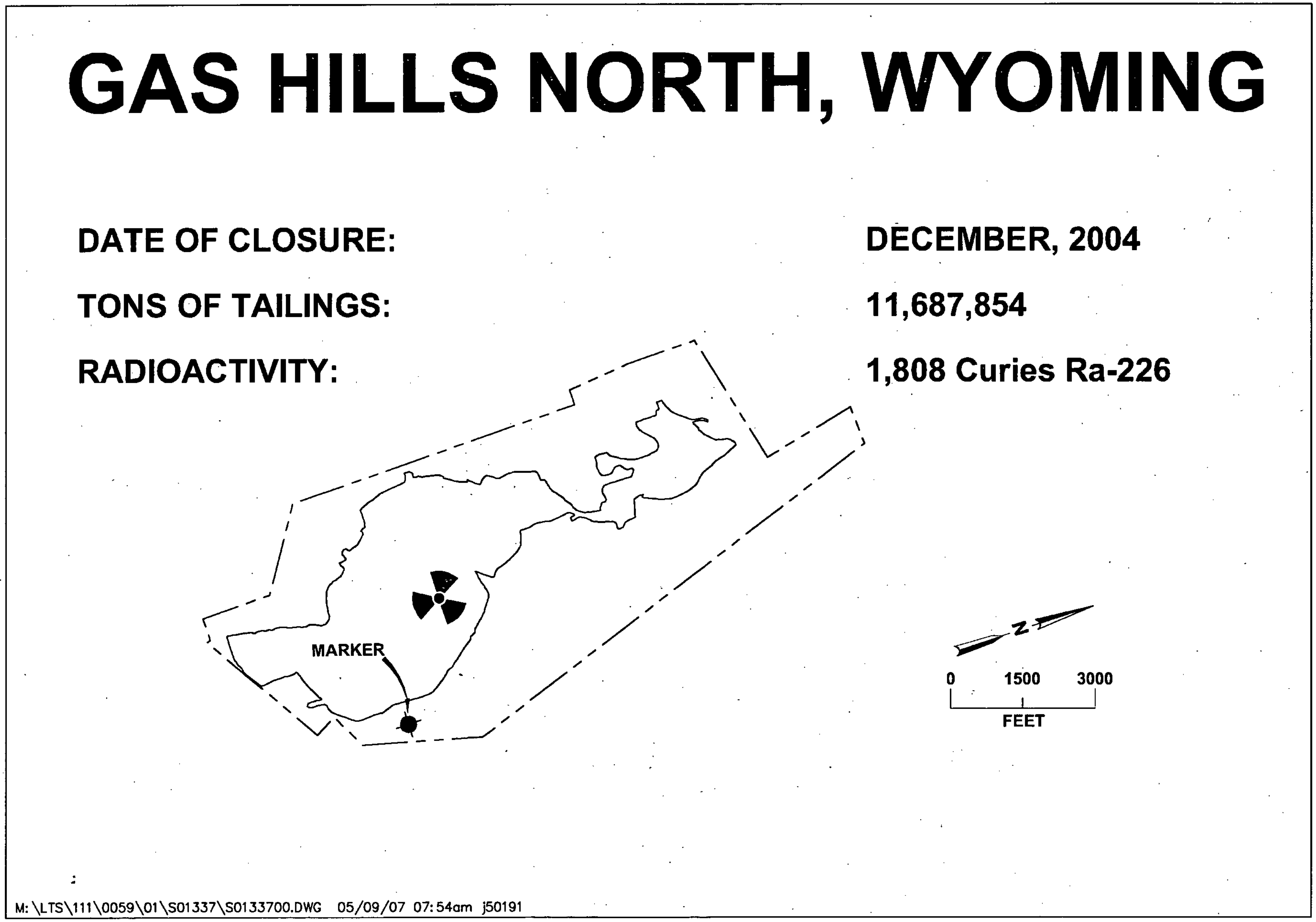


Figure 2–4. Site Marker at the Gas Hills North, Wyoming, Disposal Site

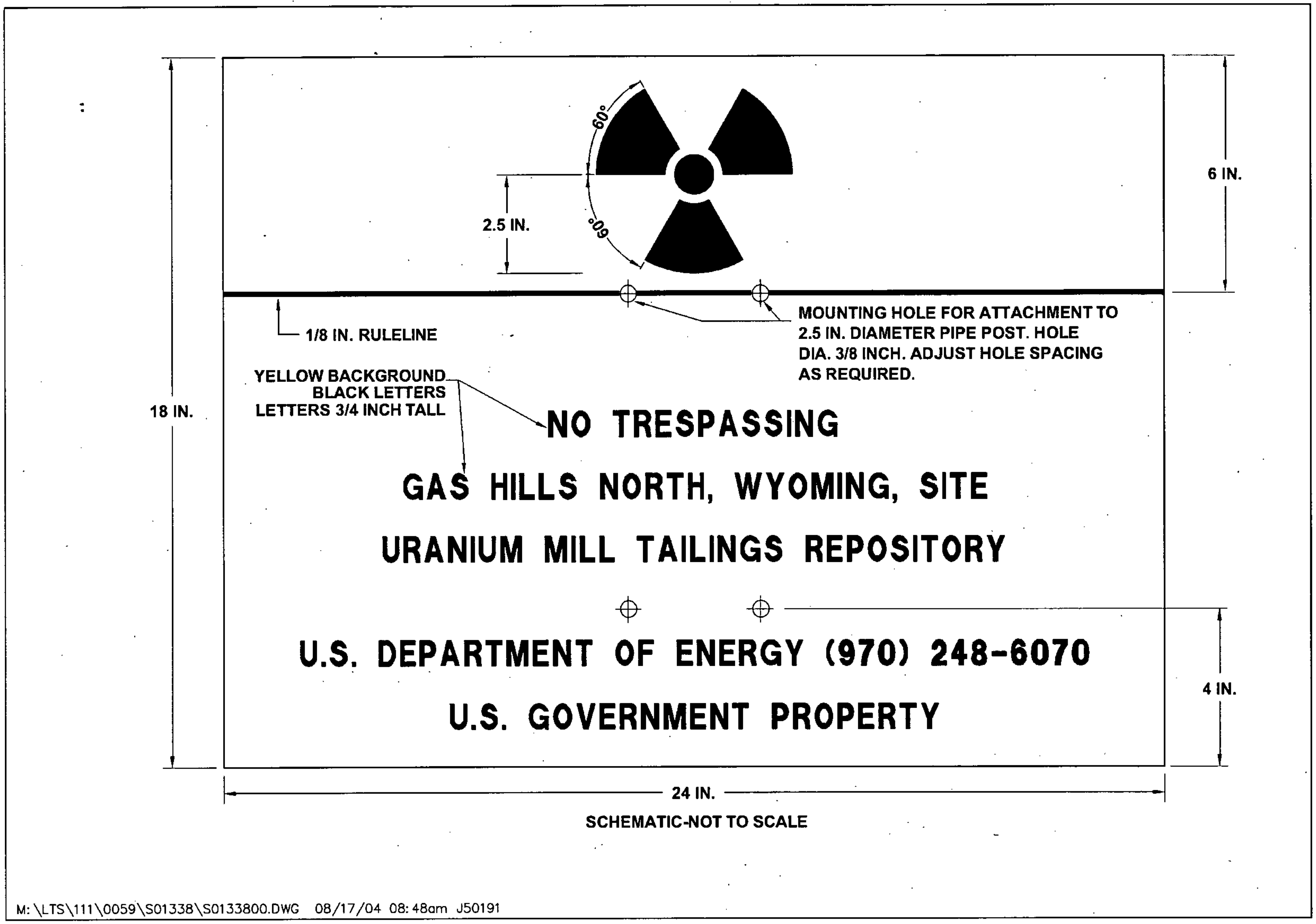


Figure 2–5. Warning Sign at Gas Hills North, Wyoming, Disposal Site

Major bedrock units in the vicinity of the Gas Hills North site are the Wind River Formation (Eocene) and the Cody Shale (Upper Cretaceous). Figure 2–6 is a partial stratigraphic column showing the geologic units in the area. The Wind River Formation, which dips to the south and consists of mainly sand and clay lens sequences, exists primarily south of the site. The Cody Shale is the main surface geologic unit in the area from the tailings impoundments to the north. The Fraser Draw alluvium lies directly east of the site.

Generalized Section of the Geologic Formations					
Era	**System**	**Series**	**Formation (thickness in ft)**	**Lithology**	**Occurrence of Groundwater**
Cenozoic	Quaternary	Pleistocene	Fraser Draw Alluvial Deposits (0–65)	Fine to coarse sand intermixed with silt and clay.	Yields enough water for stock and domestic supplies; yields may vary depending on seasonal recharge. The quality of the water ranges from suitable for domestic supplies to unsuitable for stock.
	Tertiary	Eocene	Wind River Formation (0–8,000)	Interbedded siltstone, sandstone, and conglomerate containing some carbonaceous shale and thin coal seams.	Large supplies have been developed in the Riverton and Gas Hills areas and could be developed elsewhere, especially along the margin of the basin. Yields small supplies to many widely distributed stock and domestic wells. The quality of water ranges from good for domestic uses to unfit for stock.
Mesozoic	Cretaceous	Upper Cretaceous	Cody Shale (3,000–5,000)	Shale containing some sandstone beds in upper half.	Yields only meager supplies of poor-quality water.

Modified after Whitcomb and Lowry (1968)

Figure 2–6. Partial Stratigraphic Column of the Gas Hills North, Wyoming, Disposal Site

Near the site, the Wind River Formation consists of a lower member composed of fine-grained siltstones and mudstones with a maximum thickness of 130 ft (40 meters), and an upper member composed of coarser-grained sandstones and conglomerates with a maximum thickness of more than 600 ft (180 meters). The lower, fine-grained member is the geologic unit that underlies portions of the site, including the upper portions of the tailings retention system. The Cody Shale is a massively thick formation of shale with some sandstone layers that acts as an aquitard, which restricts groundwater movement (Hydro-Engineering 2002b). The Cody Shale forms bedrock for most of the tailings retention system (NRC 1993).

All of the economically important uranium deposits in the area occur in the Wind River Formation. The ore was produced from open pit mining operations in the immediate vicinity of the site, primarily directly to the south (Hydro-Engineering 2002b).

2.4 Tailings Impoundments Design

There are six impoundments at the Gas Hills North site. Three of the impoundments, Tailings Ponds 1, 2, and 2A, were used to contain all of the solid tailings generated at the site. Tailings were deposited hydraulically to these ponds. The finer-grained materials were typically carried to the pool area in the center of the ponds where they were deposited as slimes. The transition from coarse to fine-grained materials is gradual. The three remaining impoundments, Solution Ponds 3, 3A, and 4, were used to contain tailings solutions only. All of the impoundments were constructed as embankments across Reid Draw.

During 1980 and 1981, Solution Pond No. 4 dam underwent a major reconstruction that entailed excavation down to Cody Shale in order to key the dam into impermeable material; the size of the dam was also expanded. The design of this reconstruction was intended to stop seepage from the impoundments from migrating farther down Reid Draw, acting as a failsafe containment structure for the entire tailings retention system (PMC 1998). Subsequent monitoring of the groundwater indicated no evidence of seepage through the reconstructed dam, based on data from piezometers and water quality from Point-of-Compliance (POC) Well R-2 located in Reid Draw (NRC 1999b). Monitoring of groundwater in Reid Draw was therefore terminated, and POC Well R-2 was decommissioned.

Tailings Ponds 1, 2, and 2A were reclaimed in place. A radon barrier, which was derived from Cody Shale and/or Lower Wind River claystone, was placed on Tailings Ponds 1 and 2 and a portion of Tailings Pond 2A. An engineered drainage channel system was designed and constructed to protect the stabilized tailings ponds from surface water runoff and run-on during catastrophic precipitation events (Hydro-Engineering 2002a).

2.4.1 Encapsulation Design

The tailings impoundments were designed and constructed with the objective of isolating the uranium mill tailings and associated tailings solutions from the surrounding environment (PMC 1992b). This was accomplished for each impoundment through the construction of a dam across Reid Draw designed to contain the downgradient flow of waste materials, and a cover designed to reduce radon gas emission rates to below the regulatory standard of 20 picocuries per square meter per second ($pCi/m^2/s$). The cover was also designed to minimizing the infiltration of precipitation that could potentially leach contaminants into the subsurface, and to physically contain the contaminated materials and prevent dispersion.

The RAECOM model (Rogers et al. 1984) was used to design the thickness of the radon-barrier covers required to protect human health and the environment. Based on these results, it was determined that the thickness of the radon barrier would be variable, depending upon the source term of the underlying contaminated materials. Generally, the solid tailings within the impoundments exhibit diminishing radium-226 content from south to north. This is due to the fact that the southerly impoundments, Tailings Impoundments 1 and 2, received tailings from the processing of higher grade ores than did the northernmost impoundment, Tailings Impoundment 2A (Figure 2–2). The solution ponds and former mill site required less radon barrier material than the tailings impoundments. The final cover also varied in thickness depending upon design gradients for overland flow that occurred in different areas of the disposal system. Therefore, a 3-ft-thick cover was placed on Tailings Impoundments 1 and 2, a 2-ft-thick cover was placed on Tailings Impoundment 2A, and re-graded dam outslopes received a 1.5-ft-thick cover. The radon barrier for Solution Ponds 3, 3A, and 4 varies from 13 inches thick on top to 26 inches thick on the Pond 3 outslope. A 1-ft-thick cover was placed over the ore stockpile area, and a 2-ft-thick cover was placed over the mill area (Hydro-Engineering 1999).

Construction of the cover for both the tailings impoundments and the solution ponds consisted of: (1) a compacted soil layer, comprised of Cody Shale and Lower Wind River claystone obtained from borrow areas located directly east and west of the solution ponds, that was designed to control radon emanation and the minimize the infiltration of precipitation; (2) a filterbed layer, comprised of sand, that was designed as a drainage layer to shed precipitation-related water; and (3) a rock mulch layer, comprised of crushed limestone with a median diameter (D_{50}) ranging in size from 1 inch to 4 inches, that was designed to control erosion on the covered surfaces. Portions of the impoundment tops were also covered with topsoil and seeded with native species.

A cross section of Tailings Impoundments 1, 2, and 2A is provided as Figure 2–7, and a cross section of Solution Ponds 3, 3A, and 4 is provided as Figure 2–8.

2.4.2 Storm Water Drainage System

The storm water drainage for the site was designed to reduce the surface area of tributary drainage basins in order to lower the potential of erosion by surface runoff. Major drainage areas were divided into smaller basins, and the discharge was routed off the tailings retention system in several directions to peripheral areas. This was accomplished through the construction of numerous riprap-armored channels located around and on top of the tailings impoundments (Figure 2–2). The Cody Shale borrow areas on either side of the solution ponds were incorporated into the drainage design by utilizing the depressions created as holding basins to dampen runoff events and to aid in diverting runoff away from the encapsulated tailings.

Slope grade, riprap-armoring, and the construction of diversion channels were the primary mechanisms for controlling erosion caused by surface water runoff (revegetation was also intended to provide additional erosion control). All riprap sizing was consistent with NRC staff guidance, and the rock utilized for the channels met NRC durability criteria. Riprap armoring was also placed on the steeper slopes and at flow-concentration points where design-flow velocities would have the potential to erode the tailings-encapsulation surfaces. The D_{50} of the riprap utilized on site ranged from 6 inch to 12 inch.

The design basis for the storm water drainage system was the probable maximum flood (PMF). A 1-hour, 1-square-mile storm with a precipitation of 9.70 inches was selected as the design PMF storm event (Hydro-Engineering 1999). Flow velocities and channel inundation profiles from this event were used as the basis for the riprap armoring of the drainage channels. Overland flow paths associated with this PMF storm event were used to design the rock mulch (Hydro-Engineering 1999).

2.5 Groundwater Conditions

The uppermost groundwater at the Gas Hills North disposal site is an unconfined, interconnected flow system composed of both the Wind River aquifer and the Fraser Draw alluvial groundwater system. The Wind River Formation south of the site is the groundwater aquifer that feeds this collective groundwater system.

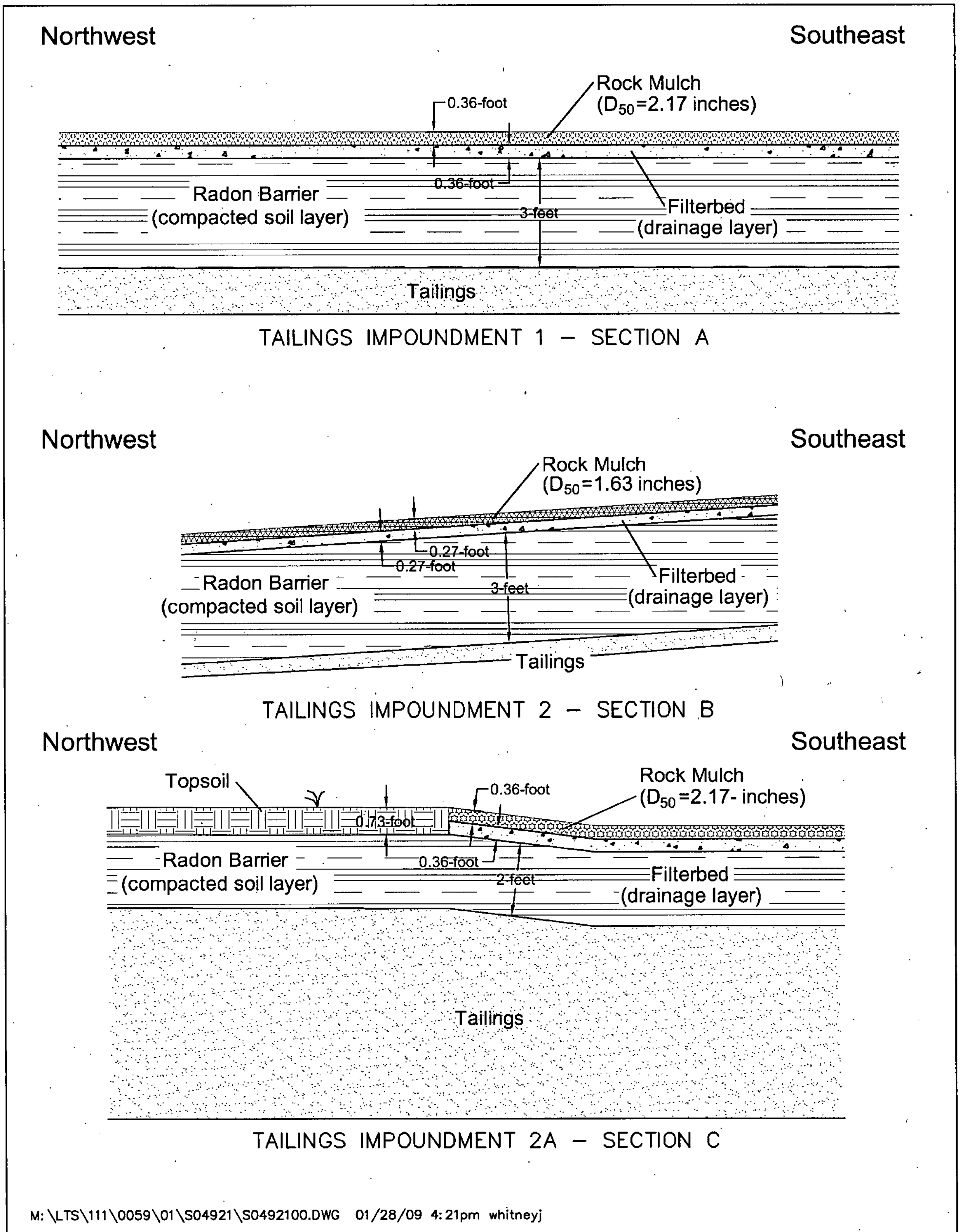


Figure 2–7. Cross Section of the Engineered Covers on Tailings Impoundments 1, 2, and 2A at the Gas Hills North, Wyoming, Disposal Site

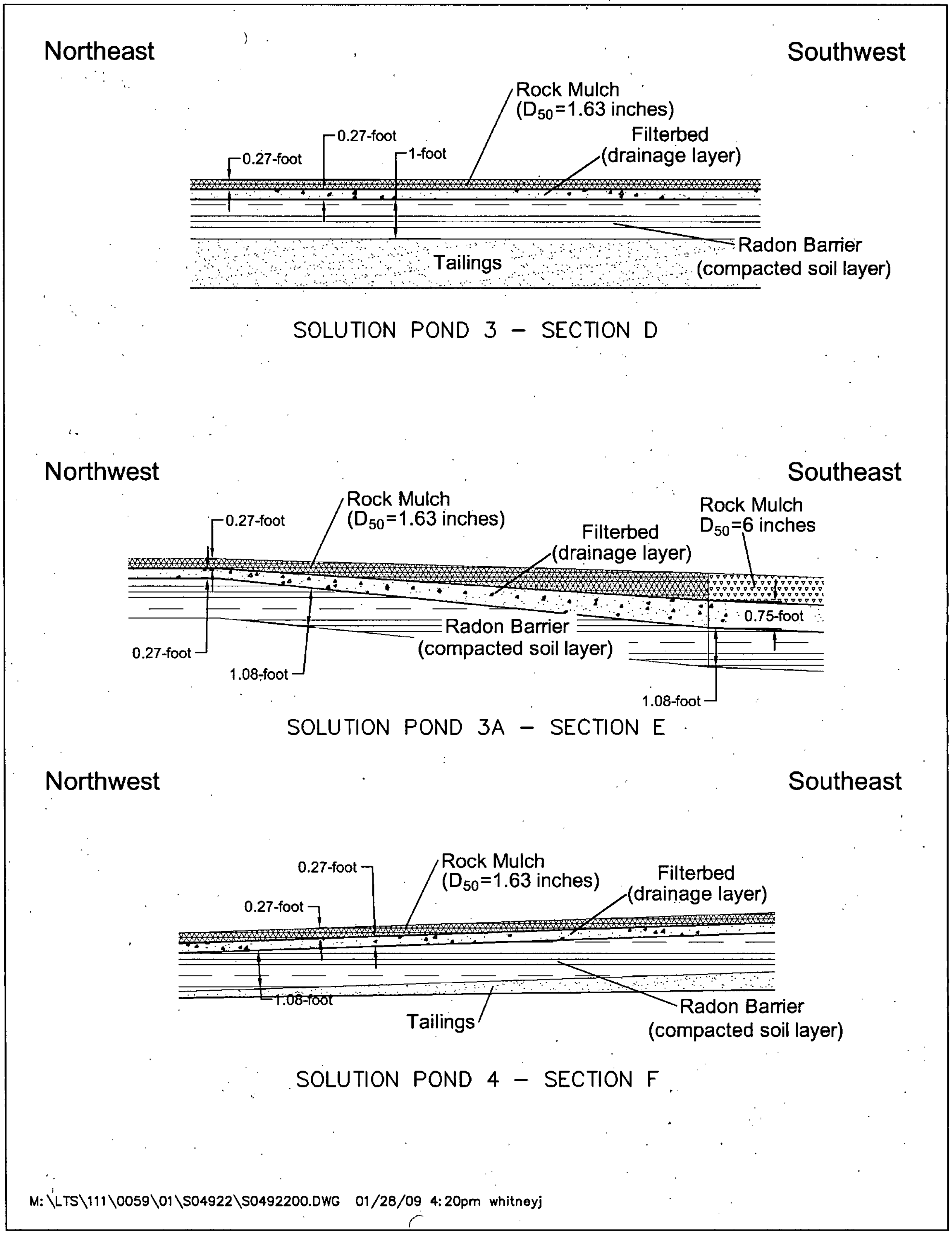


Figure 2–8. Cross Section of the Engineered Covers on Solution Ponds 3, 3A, and 4 at the Gas Hills North, Wyoming, Disposal Site

Both the Wind River Formation and the Cody Shale underlie the tailings retention system; the Wind River Formation underlies the upper portion of the system, and Cody Shale underlies the remaining majority of the system. The Wind River Formation consists mainly of sand and clay-lens sequences. A lower member of the Wind River Formation is composed mainly of clay, the upper surface of which is considered the base of the Wind River aquifer (Hydro-Engineering 2002b). The Cody Shale is a massively thick formation of shale, with some sandstone layers, that acts as an aquitard—restricting vertical groundwater movement (Hydro-Engineering 2002b).

Because of topographic and stratigraphic variability in the vicinity of the site, wells in the monitoring network sample both the Wind River aquifer and Fraser Draw alluvial groundwater system. However, these two units collectively make up the uppermost aquifer at the site and function as a single hydrologic unit referred to as the "Lucky Mc Aquifer" in the ACL application (Hydro-Engineering 2002b). Based on cross sections included in the ACL application for the site, the aquifer material can be as much as 45 ft thick in the vicinity of the site, though only a portion of this is saturated.

In the vicinity of the site, the Wind River aquifer and the Fraser Draw alluvium are bounded laterally by bedrock highs composed of Cody Shale. Channels eroded through the buried highs in the bedrock permit groundwater from the main aquifer south of the site to flow into the adjacent formation, creating relatively isolated occurrences of groundwater. One such occurrence of groundwater, present in the Wind River Formation, underlies the upper portion of the tailings retention system. Groundwater beneath the upper portion of the tailings retention system then flows east through another eroded-bedrock channel and into the Fraser Draw alluvial system, which flows north (Figure 2–8). However, it is anticipated that over time, as the pore water within the upper portion of the tailings retention system dissipates and the associated groundwater mound is reduced, the groundwater level will drop below the elevation of this eroded subsurface channel in the Cody Shale and cause the flow of seepage from this portion of the tailings retention system into the Fraser Draw alluvial system to discontinue.

Historically, some of the pore water stored in the tailings and solution ponds seeped into the underlying formations, as these ponds were not lined. As mentioned above, seepage that occurred at the upper portion of the tailings retention system entered the Wind River aquifer and flowed east through the eroded channels in the Cody Shale and into the Fraser Draw alluvial system (Figure 2–8). Any seepage that occurred in the remaining portion of the tailings retention system, downgradient to the eroded channels in the bedrock, would likely have slowly migrated to the base of Solution Pond 4 dam, which was keyed into the Cody Shale to stop any farther migration down Reid Draw. Historical monitoring results obtained from the POC well located directly downgradient of Solution Pond 4 dam demonstrated the effectiveness of the tailings retention system (Hydro-Engineering 2002b).

Seepage from the tailings retention system, which was more voluminous during milling, contains elevated concentrations of process-related chemicals, including uranium, selenium, nickel, combined Ra-226 and Ra-228, arsenic, beryllium, cadmium, chromium, Th-230, chloride, sulfate, nitrate, and total dissolved solids (TDS). Seepage from this system is a source of mill-related groundwater contamination in the area.

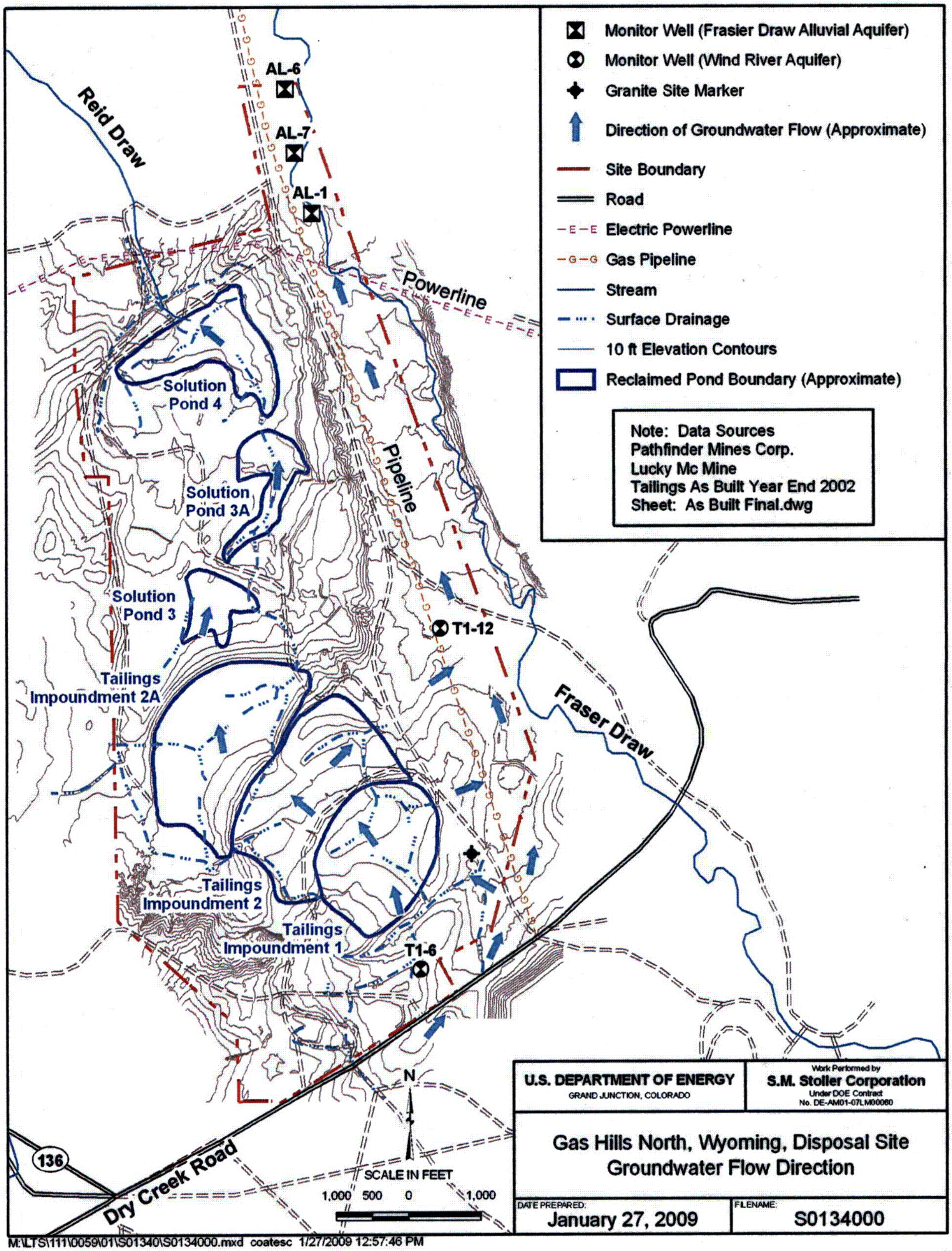


Figure 2–9. Approximate Groundwater Flow Direction at the Gas Hills North, Wyoming, Disposal Site

Another possible source of site-related contamination, particularly with respect to uranium, is the historical routine and permitted discharge of groundwater from mine dewatering operations that occurred into Fraser Draw (see Section 2.1). Beginning in 2001, groundwater monitoring was conducted beyond the site boundary within Fraser Draw, downgradient of the site. This monitoring continued until the approval to discontinue the off-site monitoring was received from NRC, with concurrence from WDEQ, in 2008 (NRC 2008, WDEQ 2008).

Groundwater contamination that migrated laterally from the upper portion of the tailings retention system and into the Wind River aquifer and the Fraser Draw alluvium was the target of corrective action performed from 1980 until 2002. Corrective action at the site had two objectives: (1) chemical-mass removal in the Wind River aquifer and Fraser Draw alluvium, and (2) dewatering of the tailings responsible for the seepage of process-related chemicals. The groundwater corrective action was effective in removing a substantial portion of the drainable water from the tailings, and at reducing the mass flux of contaminants. However, after considerable pumping, the operator concluded that further significant reductions in the concentrations of uranium, selenium, nickel, combined Ra-226 and Ra-228, beryllium, and cadmium were not readily achievable with continued pumping.

On December 21, 2000, the licensee submitted an ACL application to NRC for these constituents because their concentrations were deemed to be as low as reasonably achievable, considering practicable corrective actions. Based on 2001 data, all of the ACL constituents except uranium and selenium were confined to the groundwater immediately beneath the tailings ponds or immediately adjacent to the tailings in Fraser Draw. In addition to uranium and selenium, some other indicator constituents—chloride, sulfate, nitrate, and TDS—have migrated downgradient (north) within Fraser Draw.

NRC approved the ACL application on December 20, 2002 (NRC 2002), at which time groundwater corrective action was terminated. No restrictions were placed on groundwater use downgradient of the site, as the water quality met applicable standards and criteria for Class III (i.e., suitable for livestock). Class III is the designated State of Wyoming groundwater classification for this area, based on the naturally poor water quality.

3.0 Long-Term Surveillance Program

3.1 General License for Custody and Long-Term Care

States have right of first refusal for custody and long-term care of Title II disposal sites (UMTRCA, Section 202 [a]). On July 15, 1994, the State of Wyoming exercised its right of first refusal and declined the custody and long-term care of the Gas Hills North site (State of Wyoming 1994). Because the State declined this right, the site was transferred to DOE for custody and long-term care.

Upon NRC acceptance of this LTSP and termination of PMC's license (Number SUA–672), the site is included under NRC's general license for custody and long-term care (10 CFR 40.28 [b]). Concurrent with this action, a deed and title to the portion of the site owned by PMC were transferred to DOE (Appendix A). The balance of the site, which is federally owned, was withdrawn by BLM from public use and placed under DOE's jurisdiction for custody and long-term care (Appendix A).

Although sites are designed to last "for up to 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years" (10 CFR 40, Appendix A, Criterion 6), there is no termination of the general license for DOE's custody and long-term care of the site (10 CFR 40.28 [b]).

Should changes to this LTSP become necessary, NRC must be notified of the changes, and the changes may not conflict with the requirements of the general license. Additionally, NRC representatives must be guaranteed permanent right of entry for the purpose of periodic site inspections. Access to the site, as shown on Figures 2–1 and 2–2, is unimpeded from public roads across federal property as authorized by a BLM ROW permit (Appendix A).

3.2 Requirements of the General License

To meet the requirements of NRC's license at 10 CFR 40, Section 28, and Appendix A, Criterion 12, the long-term custodian must, at a minimum, perform the following tasks. The section in the LTSP where each requirement is addressed is given in parentheses.

1. Annual site inspection (Section 3.3).
2. Annual inspection report (Section 3.4).
3. Follow-up inspections and inspection reports, as necessary (Section 3.5).
4. Site maintenance, as necessary (Section 3.6).
5. Emergency measures in the event of catastrophe (Section 3.6).
6. Environmental monitoring (Section 3.7).

3.3 Annual Site Inspections

3.3.1 Frequency of Inspections

At a minimum, sites must be inspected annually to confirm the integrity of visible features at the site and to determine the need, if any, for maintenance, additional inspections, or monitoring (10 CFR 40, Appendix A, Criterion 12).

To meet this requirement, DOE will inspect the Gas Hills North disposal site once each calendar year. The date of the inspection may vary from year to year, but DOE will endeavor to inspect the site approximately once every 12 months unless circumstances warrant variance. Any variance to this inspection frequency will be explained in the inspection report. DOE will notify NRC and the State of Wyoming of the inspection at least 30 days in advance of the scheduled inspection date.

3.3.2 Inspection Procedure

For the purpose of inspection, the Gas Hills North disposal site will be divided into sections called *transects*. Each transect will be inspected individually. Proposed transects for the first inspection of the Gas Hills North site are listed in Table 3–1 and shown on Figure 3–1.

Table 3–1. Transects Used During First Inspection of the Gas Hills North Site

Transect	Inspection Description
Covers, Sideslopes, and Dams of Stabilized Tailings and Solution Ponds	Check integrity of impoundments—cover, sideslopes, dam, and rock mulch. Check for any visual evidence of seepage from the base of Solution Pond No. 4 dam.
Drainage Channels	Check for erosion, riprap placement, integrity, and functionality.
Site Perimeter and Balance of Site	Check integrity of the area between tailings impoundments and solution ponds, the site perimeter, site boundary, perimeter fence and gates, site entrance, boundary monuments, entrance sign, and site marker.
Outlying Area	Check 0.25 mile beyond site boundary for changes in land use.

The annual inspection will be a visual walk-through. The primary purpose of the inspection will be to look for evidence of disposal cell settlement, slumping, or cracking; riprap or rock mulch degradation; wind or water erosion; structural discontinuity of the containment dams; vegetation condition (including the presence of noxious weeds); animal or human intrusions that could result in adverse impacts to the site; or other modifying processes. Disposal site and disposal cell inspection techniques are described in detail in Attachment 4 of the guidance document (DOE 2001).

Any changes in site vegetation will be noted during routine site inspections. If encroachment of deep-rooted vegetation is observed growing on the tailings impoundments, an evaluation will be conducted to determine if any action is necessary. State, local, or federally listed noxious weeds present on site will be controlled.

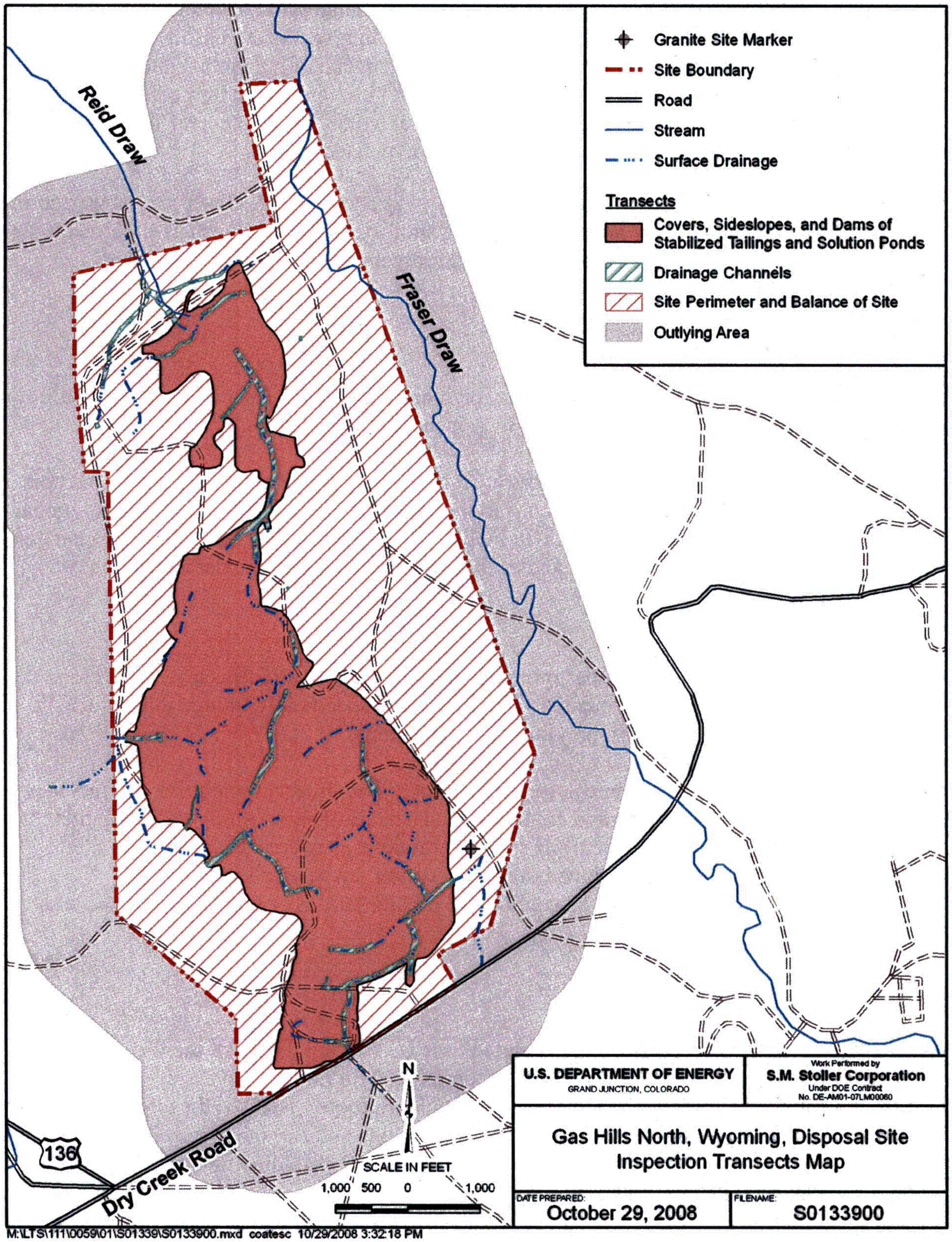


Figure 3–1. Inspection Transects for the Gas Hills North, Wyoming, Disposal Site

In addition to inspecting the site itself, inspectors will note changes and developments in the area surrounding the site, especially changes within the surrounding watershed basin. Significant changes within this area could include development or expansion of human habitation, erosion, road building, or other change in land use. Changes in land use in the area immediately surrounding the site could affect overland water flow characteristics and general site management considerations. Therefore, they should be evaluated.

It may be necessary to document certain observations with photographs. Observations warranting photographs include evidence of vandalism or a slow modifying process, such as rill erosion, that should be monitored more closely during general site inspections. Photographs will be documented in a field photograph log.

3.3.3 Inspection Checklist

The inspection checklist guides the inspection. The initial site-specific inspection checklist for the Gas Hills North disposal site is presented in Appendix B.

The checklist is subject to revision as necessary. At the conclusion of an annual site inspection, inspectors will make notes regarding revisions to the checklist in anticipation of the next annual site inspection. Revisions to the checklist will include such items as new discoveries or changes in site conditions that must be inspected and evaluated during the next annual inspection.

3.3.4 Personnel

Annual inspections normally will be performed by a minimum of two inspectors. Inspectors will be experienced engineers and scientists who have been specifically trained to conduct site inspections (through participation in previous site inspections).

Engineers typically will be geotechnical, geological, or civil engineers. Scientists will include geologists, hydrologists, biologists, and environmental scientists representing various fields (e.g., ecology, soils, range management). If serious or unique problems develop at the site, more than two inspectors may be assigned to the inspection. Inspectors specialized in specific fields may be assigned to the inspection to evaluate serious or unusual problems and make recommendations.

3.4 Annual Inspection Reports

Results of annual site inspections will be reported to NRC within 90 days of the last site inspection of that calendar year (10 CFR 40, Appendix A, Criterion 12). In the event that the annual report cannot be submitted within 90 days, DOE will notify NRC of the circumstances. Annual inspection reports also will be distributed to the State and any other stakeholders who request a copy. The annual inspection report for the Gas Hills North disposal site is included in a document containing the annual inspection reports for all sites licensed under 10 CFR 40.28.

3.5 Follow-Up Inspections

Follow-up inspections are unscheduled inspections that are targeted to evaluate specific findings or concerns.

3.5.1 Criteria for Follow-Up Inspections

Criteria necessitating follow-up inspections are described in 10 CFR 40.28 (b)(4). DOE will conduct follow-up inspections should any of the following occur:

- A condition is identified during the annual site inspection or other site visit that requires personnel, perhaps with specific expertise, to return to the site to evaluate the condition.
- DOE is notified by a citizen or outside agency that conditions at the site are substantially changed.
- An extreme natural condition, such as a 6.5-Richter-scale earthquake or a rainfall event of 9.70 inches or more in 1 hour (Hydro-Engineering 1999).

With respect to citizens and outside agencies, DOE will establish and maintain lines of communications with local law enforcement and emergency response agencies to facilitate notification in the event of significant trespass, vandalism, or a natural disaster. Due to the remote location of the Gas Hills North site, DOE recognizes that local agencies may not necessarily be aware of current conditions at the site. However, these agencies will be requested to notify DOE or provide information should they become aware of a significant event that might affect the security or integrity of the site.

DOE may request the assistance of local agencies to confirm the seriousness of a condition before conducting a follow-up inspection or emergency response.

The public may use the 24-hour DOE telephone number posted prominently on the entrance sign to request information or to report a problem at the site.

Once a condition or concern is identified at the site, DOE will evaluate the information and determine whether a follow-up inspection is warranted. Conditions that may require a routine follow-up inspection include changes in vegetation, erosion, storm damage, low-impact human intrusion, minor vandalism, or the need to evaluate, define, or perform maintenance tasks.

Conditions that threaten the safety or the integrity of the disposal site may require a more immediate follow-up inspection. Slope failure, a disastrous storm, a major seismic event, and deliberate human intrusion are among these conditions.

DOE will use a graded approach with respect to follow-up inspections. The urgency of the follow-up inspection will be in proportion to the seriousness of the condition. The timing of the inspection may be governed by seasonal considerations. For example, a follow-up inspection to investigate a vegetation problem may be scheduled for a particular time of year when growing conditions are optimum. A routine follow-up inspection to perform maintenance or to evaluate an erosion problem might be scheduled to avoid snow cover or frozen ground.

In the event of "unusual damage or disruption" (10 CFR 40, Appendix A, Criterion 12) that threatens or compromises site safety, security, or integrity, DOE will:

- Notify NRC pursuant to 10 CFR 40, Appendix A, Criterion 12, or 10 CFR 40.60, whichever is determined to apply.

- Begin the DOE Environment, Safety, and Health Reporting Process (DOE Order 231.1A, Chg. 1, or current guidance).
- Respond with an immediate follow-up inspection or emergency response team.
- Implement measures as necessary to contain or prevent the dispersion of radioactive materials (Section 3.6).

3.5.2 Personnel

Inspectors assigned to follow-up inspections will be selected on the same basis as for annual site inspections (see Section 3.3.4).

3.5.3 Reports of Follow-Up Inspections

Results of follow-up inspections will be included in the next annual inspection report (Section 3.4). Separate reports will not be prepared unless DOE determines that it is advisable to notify NRC or another outside agency of a problem at the site.

If follow-up inspections are required for more serious or emergency reasons, DOE will submit to NRC a preliminary report of the follow-up inspection within the required 60 days (10 CFR 40, Appendix A, Criterion 12).

3.6 Routine Site Maintenance and Emergency Measures

3.6.1 Routine Site Maintenance

UMTRCA disposal sites are designed and constructed so that "ongoing active maintenance is not necessary to preserve isolation" of radioactive material (10 CFR 40, Appendix A, Criterion 12). The tailings impoundments, stabilized solution ponds, and associated systems have been designed and constructed to minimize the need for routine maintenance.

The surface of the tailings impoundments and stabilized solution ponds were constructed with minimal slope to promote positive drainage while minimizing runoff water velocities that result in erosion. The surface was covered with rock mulch that is expected to endure for the long term. Because of the rock mulch and mild slopes, adverse wind or water erosion impacts that would require maintenance are not anticipated. The tailings impoundment area is fenced to prevent damage from any livestock grazing in the vicinity and to discourage intentional or unintentional trespassing. Areas where runoff water could achieve erosional velocities have been armored with riprap.

If an inspection of the disposal site cell does reveal that an as-built feature has failed or degraded in such a way that it compromises site protectiveness, repairs will be conducted to reestablish the as-built condition. DOE will perform routine site maintenance, where and when needed, to maintain protectiveness. Results of routine site maintenance will be summarized in the annual site inspection report.

In alignment with the LM EMS, proposed site maintenance activities will be assessed for opportunities to improve environmental performance and sustainable environmental practices. Some areas for consideration include reusing and recycling products or wastes, using environmentally preferable products (i.e., products with recycled content—such as office furniture, concrete, and asphalt—products with reduced toxicity, and energy-efficient products), using alternative fuels, using renewable energy, and improving environmental habitats.

3.6.2 Emergency Measures

Emergency measures are the actions that DOE will take in response to unusual damage or disruptions that threaten or compromise site safety, security, or integrity. DOE will contain or prevent the dispersal of radioactive materials in the unlikely event of a breach in impoundment cover materials.

3.6.3 Criteria for Routine Site Maintenance and Emergency Measures

Conceptually, there is a continuum in the progression from minor routine maintenance to the large-scale reconstruction of a tailings impoundment following a potential disaster. Although required by 10 CFR 40.28 (b)(5), criteria for triggering particular DOE responses for each increasingly serious level of intervention are not easily defined because the nature and scale of all potential problems cannot be foreseen. The information in Table 3–2 will, however, serve as a guide for appropriate DOE responses. The table shows that the difference between routine maintenance and emergency response is primarily one of urgency and degree of threat or risk. DOE's priority (urgency) in column 1 of Table 3–2 bears an inverse relationship with DOE's estimate of probability. The highest priority response is believed to be the least likely to occur.

Table 3–2. DOE Criteria for Maintenance and Emergency Measures

Priority	Description[a]	Example	Response
1	Breach of disposal impoundments with dispersal of radioactive material.	Seismic event that exceeds design basis and causes massive discontinuity in cover.	Notify NRC. Immediate follow-up inspection by DOE emergency response team. Emergency actions to prevent further dispersal, recover radioactive materials, and repair breach.
2	Breach of disposal impoundments without dispersal of radioactive material.	Partial or threatened exposure of radioactive materials.	Notify NRC. Immediate follow-up inspection by DOE emergency response team. Emergency actions to repair the breach.
3	Breach of site security.	Human intrusion, vandalism.	Restore security; urgency based on assessment of risk.
4	Maintenance of specific site surveillance features.	Deterioration of signs, markers.	Repair at first opportunity.
5	Minor erosion or undesirable changes in vegetation.	Erosion not immediately affecting disposal cell, invasion of undesirable plant species.	Evaluate, assess impact, respond as appropriate to address problem.

[a]Other changes or conditions will be evaluated and treated similarly on the basis of risk.

3.6.4 Reporting Maintenance and Emergency Measures

Routine maintenance completed during the previous 12 months will be summarized in the annual inspection report.

In accordance with 10 CFR 40.60, within 4 hours of discovery of any Priority 1 or 2 event listed in Table 3–2, DOE will notify the following group at NRC:

- Decommissioning and Uranium Recovery Licensing Directorate, Division of Waste Management and Environmental Protection, Office of Federal and State Materials and Environmental Management Programs, U.S. Nuclear Regulatory Commission.

The phone number for the required 4-hour contact to the NRC Operations Center is (301) 816-5100.

3.7 Environmental Monitoring

3.7.1 Groundwater Monitoring

As discussed in Section 2.5, NRC has granted an ACL for uranium, selenium, nickel, combined Ra-226 and Ra-228, beryllium, and cadmium (NRC 2002). The established ACL values and pertinent groundwater protection standards are shown in Table 3–3, along with modeled concentrations for Point-of-Exposure (POE) Well AL–6, and maximum and 95th percentile background concentrations for the area.

ACLs were established by modeling the maximum predicted concentration of each constituent at the designated site POC Well T1–12, downgradient of the tailings impoundments; these maximum concentrations are the ACL values. To determine protectiveness of the ACLs, fate and transport modeling was done to determine maximum predicted concentrations for each constituent at POE Well AL–6, the downgradient-most monitoring point on the site (Table 3–3). Because the ambient local groundwater is considered to be Class III (suitable for livestock), human health risks were calculated for ingestion of beef from cows using water with maximum predicted POE concentrations (Hydro-Engineering 2002b). All calculated risks were well below acceptable levels, which indicates that the ACLs are protective of human health through the most likely route of exposure (NRC 2002). Furthermore, these calculations indicate that the ACLs are not the maximum acceptable POC concentrations based on risk and that these values, if exceeded, do not signal an immediate or possibly even a future threat at the POE.

Since approval of the ACLs in December 2002, all quarterly monitoring results reported concentrations of beryllium and cadmium below the analytical method detection limit or at background concentrations—below their respective ACLs of 0.07 mg/L and 0.02 mg/L (Appendix C). Additionally, since 2002, concentrations of arsenic, chromium, and Th-230 were all reported below their respective groundwater protection standards of 0.05 mg/L, 0.05 mg/L, and 13.2 pCi/L, or have been within the range of background concentrations, as reported from Well T1–6, with one exception: arsenic was reported at a concentration of 0.032 mg/L in Well AL–1 in June 2003 (Appendix C). Historically, elevated concentrations of beryllium, cadmium, arsenic, chromium, and Th-230 occurred only in the tailings pore water and not in the surrounding groundwater system (exception; in 1988 Th-230 was reported at 16.1 ± 5.4 pCi/L, above the established ground water protection standard of 13.2 pCi/L). Therefore, DOE will analyze groundwater samples under the long-term monitoring program for uranium, selenium, nickel, combined Ra-226 and Ra-228. In addition, DOE will analyze groundwater samples for TDS, sulfate, chloride, and nitrate plus nitrite (as N) because these parameters are also useful indicators of contaminant migration.

Should monitoring results from these indicator parameters display trends that change abruptly, are contrary to groundwater modeling expectations, or raise concern, an evaluation of the monitoring program will be performed. The evaluation will include a determination as to whether beryllium, cadmium, arsenic, chromium, and Th-230 should be added to the analyte list for long-term groundwater monitoring.

Table 3–3. Analytes, ACLs, and Groundwater Protection Standards for the Gas Hills North, Wyoming, Disposal Site

Analyte	ACL	Groundwater Protection Standard	Modeled POE Concentration	Maximum Background Concentration (95th Percentile)[3]
Standard Applicable at the POC Well				
Arsenic[1]	NA	0.05 mg/L[2]	NA	0.012 mg/L (0.004 mg/L)
Beryllium[1]	0.07 mg/L	NA	0.05 mg/L	0.05 mg/L (0.03 mg/L)
Cadmium[1]	0.02 mg/L	NA	0.01 mg/L	0.016 mg/L (0.01 mg/L)
Chromium[1]	NA	0.05 mg/L[2]	NA	0.05 mg/L (0.04 mg/L)
Nickel	0.85 mg/L	NA	0.15 mg/L	0.39 mg/L (0.15 mg/L)
Ra-226 + Ra-228	7.50 pCi/L	NA	5.60 pCi/L	11.0 pCi/L (5.61 pCi/L)
Selenium	1.10 mg/L	NA	0.26 mg/L	0.25 mg/L (0.26 mg/L)
Th-230[1]	NA	13.2 pCi/L[3]	NA	12.1 pCi/L (2.60 pCi/L)
Uranium	1.70 mg/L	NA	1.17 mg/L	1.75 mg/L (0.91 mg/L)
Standard Applicable at the POE Well				
TDS	NA	5,000 mg/L[4]	NA	NA
Chloride	NA	2,000 mg/L[4]	187 mg/L	NA
Nitrate plus nitrite (as N)	NA	100 mg/L[4]	80 mg/L	NA
Sulfate	NA	3,000 mg/L[4]	2,080 mg/L	NA

[1]Analyte is not included in long-term monitoring unless the trending of other indicator parameters warrants.
[2] Maximum concentration limit (MCL) per 40 CFR 192.
[3]ACL application (Hydro-Engineering 2002b).
[4]Wyoming Class III groundwater protection standards (i.e., suitable for livestock).
pCi/L = picocuries per liter.
mg/L = milligram per liter (equivalent to parts per million [ppm]).

It must be noted that some POE concentrations, as well as background concentrations, are not protective for unrestricted groundwater use (i.e., residential use). Several predicted POE and background concentrations exceed drinking water standards. Based on water quality, the aquifer is defined by the State of Wyoming as Class III—suitable for livestock. Although designation as a Class III aquifer does not automatically restrict groundwater use for certain purposes, it is assumed that because of the naturally poor water quality, future use of groundwater for domestic purposes is unlikely. Most of the land downgradient of the site is currently under government (BLM) ownership, and it is assumed that this will continue into the foreseeable future. For ACLs to remain protective for the site, land use assumptions must remain valid. However, because site-related constituents downgradient of the property boundary are not present in concentrations distinguishable from background levels, it can be concluded that site-related contaminants do not pose any incremental hazards, regardless of land use.

Table 3–4 summarizes the long-term groundwater monitoring plan for the Gas Hills North disposal site. The locations of the monitor wells in the groundwater monitoring network are shown on Figures 2–2 and 2–8. The intent of the annual sampling is to verify that the ACLs are not exceeded at the POC wells, concentrations at the POE remain protective, and to verify continued compliance with the applicable groundwater protection standards at the site boundary. Concentrations at trend and POE wells will be compared to modeled concentrations to assess the validity of the groundwater model.

Table 3–4. Groundwater Monitoring Plan for the Gas Hills North, Wyoming, Disposal Site

Well Designation	Monitoring Frequency	Analytes	Comments
T1–12	Annually	Uranium, selenium, nickel, Ra-226 + Ra-228, TDS, sulfate, chloride, nitrate plus nitrite, pH, electrical conductivity, water level	Farthest upgradient POC well, Wind River aquifer
AL–1	Annually	Uranium, selenium, nickel, Ra-226 + Ra-228, TDS, sulfate, chloride, nitrate plus nitrite, pH, electrical conductivity, water level	Fraser Draw alluvial aquifer trend well between the POC and POE wells
AL–6	Annually	Uranium, selenium, nickel, Ra-226 + Ra-228, TDS, sulfate, chloride, nitrate plus nitrite, pH, electrical conductivity, water level	POE well, Fraser Draw alluvial aquifer at site boundary
AL–7	Annually	Uranium, selenium, nickel, Ra-226 + Ra-228, TDS, sulfate, chloride, nitrate plus nitrite, pH, electrical conductivity, water level	Fraser Draw alluvial aquifer trend well between the POC and POE wells
T1–6	Annually	Uranium, selenium, nickel, Ra-226 + Ra-228, TDS, sulfate, chloride, nitrate plus nitrite, pH, electrical conductivity, water level	Background well, Wind River aquifer

If an ACL is exceeded at a POC well, or trends indicate that a groundwater protection standard may be exceeded at the site boundary, DOE will inform NRC and WDEQ of the results and conduct confirmatory sampling. If the confirmatory sampling verifies the exceedance or threat of exceedance, DOE will develop an evaluative monitoring work plan and submit that plan to NRC for review prior to initiating the evaluative monitoring program. The program may simply involve a reassessment of potential site risks, or it could lead to a more detailed groundwater field investigation. Results of the evaluative monitoring program will be used in consultation with NRC to determine if corrective action is warranted.

It should be noted that historical groundwater monitoring results for radium (Ra-226 and Ra-228) have varied significantly at the wells in the monitoring network, including background well T1-6 (Appendix C). Though Ra-226 is contained in the tailings, it also occurs naturally in the Wind River Aquifer (the host formation for the uranium ore), which is a source of recharge to the Fraser Draw alluvium. Historical semi-annual groundwater monitoring reports (Hydro-Engineering 2007, 2008a, 2008b), submitted to NRC by the former licensee, attributed this variability as noted: "Measured radium activities generally exhibit more variability than other constituents, and little significance is given to occasional outliers." Thus, DOE will not develop an evaluative monitoring work plan based solely on fluctuations in radium concentrations, and occasional exceedances of the ACL for radium in a well will not necessarily signify noncompliance with regard to site-related groundwater contamination or a cell performance issue (e.g., in March 2007, prior to site transition to DOE, POE well AL–6 reported a radium concentration of 8.3 pCi/L; above the ACL of 7.5 pCi/L). If other site-related constituents that are generally low and stable in background groundwater (such as nitrate, chloride, and sulfate) also begin to exhibit changes in behavior, such as upward trends, an evaluation may then be warranted, in consultation with NRC. However, because these other site-related constituents are more mobile, constituents such as radium and uranium would likely be lagging, or possibly have attenuated, before a corresponding trend develops; particularly, the farther away from the source the concentrations are being observed.

Results of the groundwater monitoring program will be included in the annual inspection report (Section 3.4). Groundwater monitoring results will include time versus concentration graphs for selenium, uranium, combined radium-226 and radium-228, sulfate, chloride, and TDS, along with a hydrograph of water level measurements.

The groundwater monitoring program will be evaluated every 5 years to determine that the cell is performing as designed (i.e., no evidence of leakage). The monitoring frequency will be reduced as recommended by these evaluations. For example, monitoring frequency may be reduced to once every 3 years or once every 5 years. A change in monitoring frequency will occur following NRC concurrence but will not necessitate a revision to the LTSP. If the evaluation recommends discontinuation of groundwater monitoring, the LTSP will be revised and submitted to NRC for concurrence.

Once every 10 years, beginning in 2010, DOE will check the records at the Wyoming State Engineer's Office to determine if there have been significant changes in water demands in the vicinity of the site. Other nearby activities, such as uranium exploration or extraction, that could affect the site groundwater conditions will be noted during annual site inspections and subsequently evaluated.

3.7.2 Land Use Monitoring

During each annual site inspection, DOE will monitor land use in the area surrounding the site to ensure that changes in land or water use do not affect site protectiveness. For example, a resurgence of interest in uranium mining and processing could lead to increased activity in the vicinity of the site and an increased potential for site disturbance.

3.8 Institutional Controls

The Gas Hills North disposal site is owned by the U.S. Government, and DOE protects the site through institutional controls such as deed restrictions, inspections, and appropriate signage. DOE may also use fences and gates to control site access, and does so for this site. Once every 10 years, beginning in 2010, DOE will verify that the property deed remains on file in the Fremont County Courthouse.

3.9 Records

LM receives and maintains selected records to support post-closure site maintenance. Inactive records are preserved at a federal records center. Site records contain critical information required to protect human health and the environment, manage land and assets, protect the legal interests of DOE and the public, and mitigate community impacts resulting from the cleanup of legacy waste.

The records are managed in accordance with the following requirements:

- 44 USC 29, "Records Management by the Archivist of the United States and by the Administrator of General Services"; 44 USC 31, "Records Management by Federal Agencies"; and 44 USC 33, "Disposal of Records."
- 36 CFR 12, Subchapter B, "Records Management."
- DOE Guide 1324.5B, *Implementation Guide.*
- *LM Information and Records Management Transition Guidance.*

3.10 Quality Assurance

All activities related to the surveillance and maintenance of the Gas Hills North site will comply with DOE Order 414.1A, *Quality Assurance*. Quality assurance requirements are routinely fulfilled by the use of a work-planning process, standard operating procedures, trained personnel, documents and records maintenance, and assessment activities. Requirements will be transmitted through procurement documents to subcontractors if and when appropriate.

3.11 Health and Safety

Health and safety requirements and procedures for LM activities are consistent with DOE orders, federal regulations, and applicable codes and standards. The DOE Integrated Safety Management process serves as the basis for the contractor's health and safety program.

Specific guidance is contained in the *Office of Land and Site Management Project Safety Plan* (DOE 2007) or current guidance. This Project Safety Plan identifies specific hazards associated with the anticipated scope of work and provides direction for the control of these hazards. During the pre-inspection briefing, personnel are required to review the plan to ensure that they understand the potential hazards and the health and safety requirements associated with the work to be performed.

4.0 References

10 CFR 40. U.S. Nuclear Regulatory Commission, Title 10, Part 40, "Domestic Licensing of Source Material," *Code of Federal Regulations*, January 1, 2008.

36 CFR 12. National Archives and Records Administration, Title 36, Part 12, Subchapter B, "Records Management," *Code of Federal Regulations*, July 1, 2008.

40 CFR 192. U.S. Environmental Protection Agency, Title 40, Part 192, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings," *Code of Federal Regulations*, July 1, 2008.

DOE (U.S. Department of Energy), 2001. *Guidance for Implementing the Long-Term Surveillance Program for UMTRCA Title I and Title II Disposal Sites*, prepared by the U.S. Department of Energy, Grand Junction Office, Grand Junction, Colorado, GJO–2001–215–TAR, April.

DOE (U.S. Department of Energy), 2007. *Office of Land and Site Management Project Safety Plan*, DOE–LM/GJ1116-2006, Rev. 0, prepared for the U.S. Department of Energy, Office of Legacy Management, Grand Junction, Colorado, January.

DOE Orders: 231.1A, *Environment, Safety, and Health Reporting*, Chg. 1, August 19, 2005.
414.1C, *Quality Assurance*, June 17, 2005.
450.1, *Environmental Protection Program*, Chg. 2, December 7, 2005.

Executive Order 13423. *Strengthening Federal Environmental, Energy, and Transportation Management*, January 24, 2007.

ERG (Environmental Restoration Group, Inc.), 1999. *Lucky Mc Mill Site Completion Report*, prepared for Pathfinder Mines Corporation, Mills, Wyoming, February.

EPA (U.S. Environmental Protection Agency), 1974. *Authorization to Discharge Under the National Pollutant Discharge Elimination System*, Permit No. WY-0003131, June 26.

Hydro-Engineering, 1999. *Lucky Mc Mine Tailings Reclamation Plan Source Material License No SUA–672*, 2 volumes, prepared for Pathfinder Mines Corporation, Lucky Mc Mine, Gas Hills, Wyoming, July.

Hydro-Engineering, 2002a. *Lucky Mc Mine Tailings Reclamation Plan Source Material License No SUA-672*, Addendum 1, Revision 4 (Revised Solution Pond Area Reclamation Design), prepared for Pathfinder Mines Corporation, Lucky Mc Mine, Gas Hills, Wyoming, August.

Hydro-Engineering, 2002b. *Application for Alternate Concentration Limits Pathfinder Mines Corporation, Lucky Mc Mine*, License No. SUA–672, Docket No. 40–2259, prepared for Pathfinder Mines Corporation, Lucky Mc Mine, January.

Hydro-Engineering, 2007. *Semi-Annual Ground-Water Monitoring for Lucky Mc Mine*, prepared for Pathfinder Mines Corporation, Lucky Mc Mine, Gas Hills, Wyoming, July.

Hydro-Engineering, 2008a. *Semi-Annual Ground-Water Monitoring for Lucky Mc Mine*, prepared for Pathfinder Mines Corporation, Lucky Mc Mine, Gas Hills, Wyoming, January.

Hydro-Engineering, 2008b. *Semi-Annual Ground-Water Monitoring for Lucky Mc Mine*, prepared for Pathfinder Mines Corporation, Lucky Mc Mine, Gas Hills, Wyoming, September.

NRC (U.S. Nuclear Regulatory Commission), 1993. *Environmental Assessment for the Proposed Decommissioning and Reclamation of the Pathfinder Lucky Mc Mill and Tailings Ponds*, Docket Number 40–2259, July.

NRC (U.S. Nuclear Regulatory Commission), 1999a. Federal Register Notice; Finding of No Significant Impact–No Action Alternative in Reid Draw, Pathfinder Mines Corporation, Docket Number 40–2259, Volume 64, Page 13239, March 17.

NRC (U.S. Nuclear Regulatory Commission), 1999b. *Technical Evaluation of Environmental Report on Status of Radiological Contamination of Reid Draw at Gas Hills, Wyoming*, License No. SUA-672, Docket No. 40–2259, April 19.

NRC (U.S. Nuclear Regulatory Commission), 2002. Letter to T.W. Hardgrove, Pathfinder Mines Corporation, from D. M. Gillen, Chief, Fuel Cycle Facilities Branch, U.S. Nuclear Regulatory Commission, approving the proposed use of alternate concentration limits for groundwater at Pathfinder Mines Corporation's Lucky Mc Site, December 20.

NRC (U.S. Nuclear Regulatory Commission), 2008. *Materials License*, License Number SUA-672, Docket Number 40–2259, Pathfinder Mines Corporation, July (as amended).

PMC (Pathfinder Mines Corporation), 1992a. *Mill Decommissioning Plan, Lucky Mc Mine, Source Material License No. SUA-672*, Docket Number 40–2259, March.

PMC (Pathfinder Mines Corporation), 1992b. *Lucky Mc Mine Tailings Reclamation Plan, Source Material License No. SUA-672,* Volumes I and II, July.

PMC (Pathfinder Mines Corporation), 1998. *Environmental Report: Remediation of Reid Draw Near the Lucky Mc Mill Site*, August (revised November 1998 and February 1999).

Rogers, V.C., K.K. Nielson, and D.R. Kalkwarf, 1984. *Radon Attenuation Handbook for Uranium Mill Tailings Cover Design*, NUREG/CR–3533; PNL–4878; RAE–18–5.

State of Wyoming, 1994. Letter to J. E. Virgona, Project Manager, U.S. Department of Energy, from D. Hemmer, Director, Wyoming Department of Environmental Quality, declining custody of all UMTRCA Title II sites within the State of Wyoming, July 15.

44 USC 29. "Records Management by the Archivist of the United States and by the Administrator of General Services," *United States Code*.

44 USC 31. "Records Management by Federal Agencies," *United States Code*.

44 USC 33. "Disposal of Records," *United States Code*.

WDEQ (Wyoming Department of Environmental Quality), 1978. *Authorization to Discharge Under the National Pollutant Discharge Elimination System*, Permit No. WY-0003131, July 31.

WDEQ (Wyoming Department of Environmental Quality), 2008. Letter to K. I. McConnell, Deputy Director, Decommissioning and Uranium Recovery Licensing Directorate, U.S. Nuclear Regulatory Commission, from M. Thiesse, West District Supervisor, GPC Program, Water Quality Division, Wyoming Department of Environmental Quality, providing concurrence to discontinue offsite groundwater monitoring in Fraser Draw, July 23.

Whitcomb, Harold A., and Marlin E. Lowry, 1968. *Ground-Water Resources and Geology of the Wind River Basin Area, Central Wyoming*, United States Geological Survey Hydrologic Investigations Atlas HA–270.

This page intentionally left blank

Appendix A

Real Estate Information

(To be inserted; warranty deed, permanent withdrawal, BLM ROW permit for access route)

This page intentionally left blank

Legal Description of Site Boundary

The legal description of the 1,276-acre Gas Hills North disposal site follows:

A parcel of land located in the SE¼ of Section 9, the NW¼, SW¼, and the SE¼ of Section 10, Section 15, the NE¼ and the SE¼ of Section 21, and Section 22, all in Township 33 North, Range 90 West, of the 6th Principal Meridian, Fremont County, Wyoming, said parcel being more particularly described as follows:

Beginning at a point on the east line of section 21, N. 0° 42' W., 2169.70 feet from the southeast corner of said section;
Thence N. 47° 52' W., 1328.11 feet to DOE monument PC 11;
Thence N. 0° 18' W., 2211.31 feet to a point on the south line of section 16, monumented with a rebar and aluminum cap;
Thence N. 89° 48' E., 983.05 feet on the south line of section 16 to the southeast corner of said section, point not monumented;
Thence N. 0° 10' W., 5276.75 feet on the east line of section 16 to the northeast corner of said section, point not monumented;
Thence WEST, 1422.34 feet on the south line of section 9 to DOE monument PC8;
Thence N. 0° 05' W., 1445.37 feet to DOE monument PC 7;
Thence N. 76° 35' E., 1438.94 feet to a point on the east line of section 9, N. 0° 48' W., 1779.53 feet from the southeast corner of said section; point not monumented;
Thence N. 76° 35' E., 1387.16 feet to DOE monument PC 6;
Thence N. 12° 00' W., 1992.53 feet to DOE monument PC 5;
Thence N. 87° 28' E., 796.55 feet to DOE monument PC 4;
Thence S. 18° 29' E., 4337.37 feet to a point on the north line of section 15, N. 87° 26' W., 2124.35 feet from the northeast corner of said section, monumented with a 2 ½ " iron pipe with 1973 BLM brass cap;
Thence S. 18° 29' E., 5580.17 feet to DOE monument PC 3 on the north line of section 22, N. 89° 29' W., 400.17 feet, from the northeast corner of section 22, monumented with a 2 ½ " iron pipe with 1973 BLM brass cap;
Thence S. 15° 02' W., 2499.09 feet to DOE monument PC 2, identical with Corner No. 1, Mill Site No. 50, Mineral Survey No. 649;
Thence S. 63° 52' W., 812.30 feet to DOE Monument PC 1;
Thence S. 27° 51' E., 274.09 feet to a point on the south line of Mineral Survey No. 645 monumented with a rebar and aluminum cap;
Thence departing said Mineral Survey 649, S.27° 51' E., 211.41 feet to WC for DOE monument PC 16;
Thence S.27° 51' E., 20.00 feet to true point for DOE monument PC 16; point not monumented;
Thence S. 56° 48' W., 667.38 feet to DOE monument PC 12, identical with Corner No.3, Mill Site 183, Mineral Survey No. 645;
Thence continuing along the south line of Mineral Survey No. 645, S. 59° 13'. W., 2244.61 feet to WC for DOE monument PC 15;
Thence S. 59° 13' W., 65.00 feet to true point for DOE monument PC 15, point not monumented;
Thence N. 18° 08' W., 85.92 feet to true point for DOE monument PC 14, point not monumented;

Thence S. 89° 27' W., 15.00 feet to WC for DOE monument PC 14;
Thence S. 89° 27' W., 447.16 feet to DOE monument PC 13 on the west line of Mineral Survey No. 645, N. 0° 34' W., 150.00 feet from Corner No. 1, Mill Site No. 190, Mineral Survey No. 645, point not monumented;
Thence N. 0° 34' W., on the west line of Mineral Survey 645, 1048.64 feet to Corner No. 1 Mill Site 189 and Corner No. 1, Mill Site No. 177 Mineral Survey No. 645;
Thence departing said Mineral Survey 645, N. 47° 52' W., 861.73 feet to the POINT OF BEGINNING of said described parcel;

Basis of bearings being True North.

Appendix B

Initial Site Inspection Checklist

This page intentionally left blank

Inspection Checklist: Gas Hills North

Date of This Revision: ____________

Last Annual Inspection: ____________

Inspectors: ____________ and ____________

Next Annual Inspection (Planned): ____________

No.	Item	Issue	Action
1	Access	Access is from the BLM road directly south of the site.	None.
2	Specific site surveillance features	See attached list.	Inspect. Identify maintenance requirements.
3	Impoundments and associated drainage structures	Tailings and solution ponds were stabilized in-place within constructed impoundments that are protected from surface runoff by a series of drainage structures.	Check integrity of impoundments; look for slumping, settling, and erosion damage. Check functionality of drainage structures.
4	Rock mulch	The surfaces of the tailings impoundments and solution ponds have been covered with rock mulch to control wind and water erosion.	Inspect impoundment cover and note condition of rock mulch and evidence of displacement.
5	Riprap	Certain areas have been armored with riprap for erosion protection.	Inspect riprap; note evidence of rock displacement, rock degradation, hydraulic scour, or bank cutting.
6	Site perimeter and balance of site	The area between the tailings impoundments and solution ponds have been contoured and revegetated. Specific site surveillance features were installed in this area.	Check integrity of the area between tailings impoundments and solution ponds, site boundary, perimeter fence and gates, site entrance, boundary monuments, entrance sign, and site marker.
7	Outlying Areas	Check land use 0.25 mile beyond site boundary for changes and developments. Check for domestic wells installed.	Status ownership and land use adjacent to the site.

Checklist of Site-Specific Surveillance Features: Gas Hills North

Feature	Comment
Access Road	Dirt road. Verify road is passable (provide maintenance on ROW, as needed).
Entrance Gate	Total: 2
Entrance and Perimeter Signs	Total: 15
Perimeter Fence	Barbed-wire stock fence
Boundary Monuments	Total: 17 (3 are witness corners)
Site Marker	Total: 1
Monitor Wells	Total: 5 Background Well (Wind River Aquifer) T1–6 POC Well (Wind River Aquifer) T1–12 POC Wells (Fraser Draw Alluvial Aquifer) AL–1, AL–7 POE Well (Fraser Draw Alluvial Aquifer) AL–6

Appendix C

Time-Concentration Plots of Historical Groundwater Monitoring Data from the Gas Hills North, Wyoming, Disposal Site

This page intentionally left blank

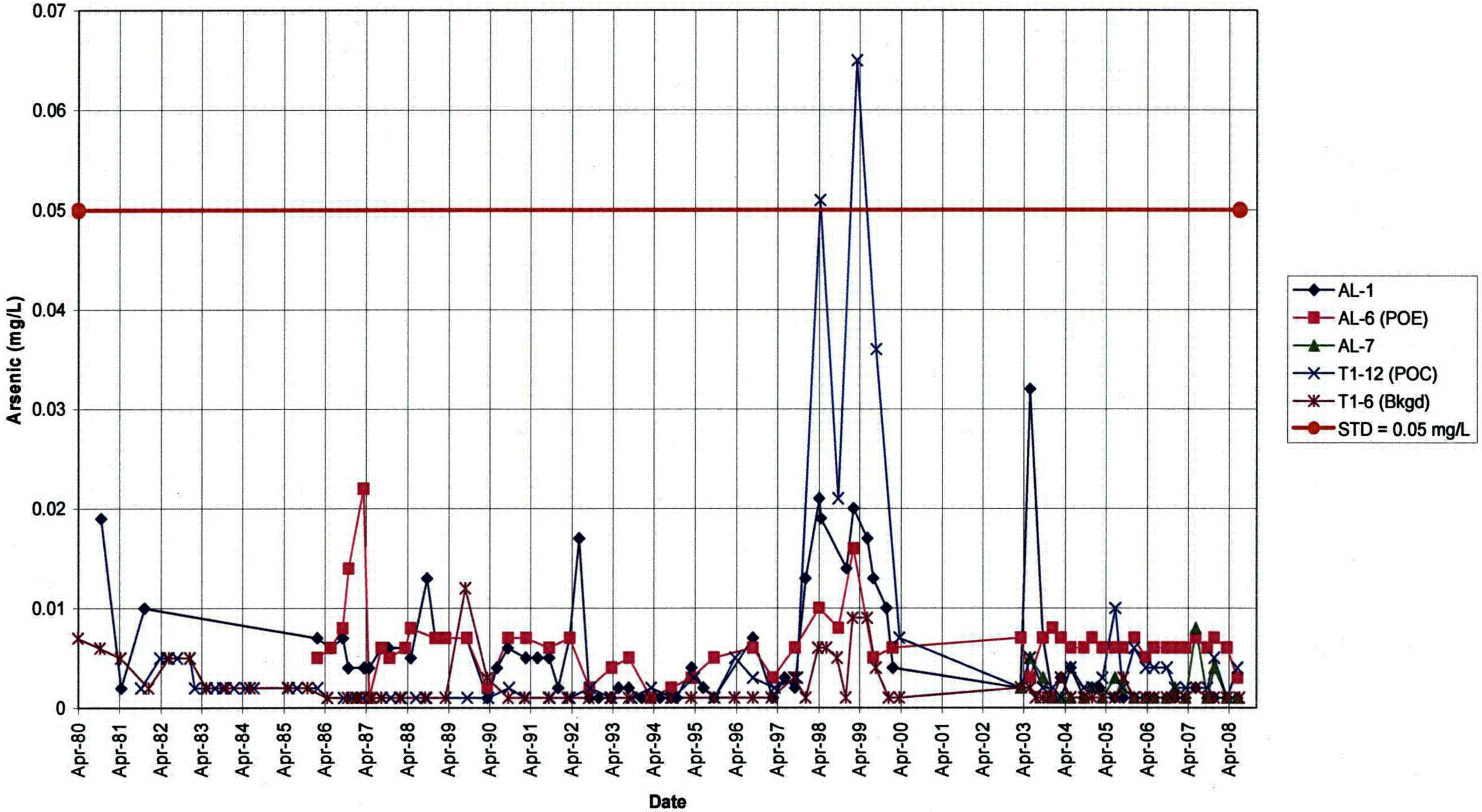


Figure C–1. Time-Concentration Plots of Arsenic in the Groundwater at the Gas Hills North, Wyoming, Disposal Site

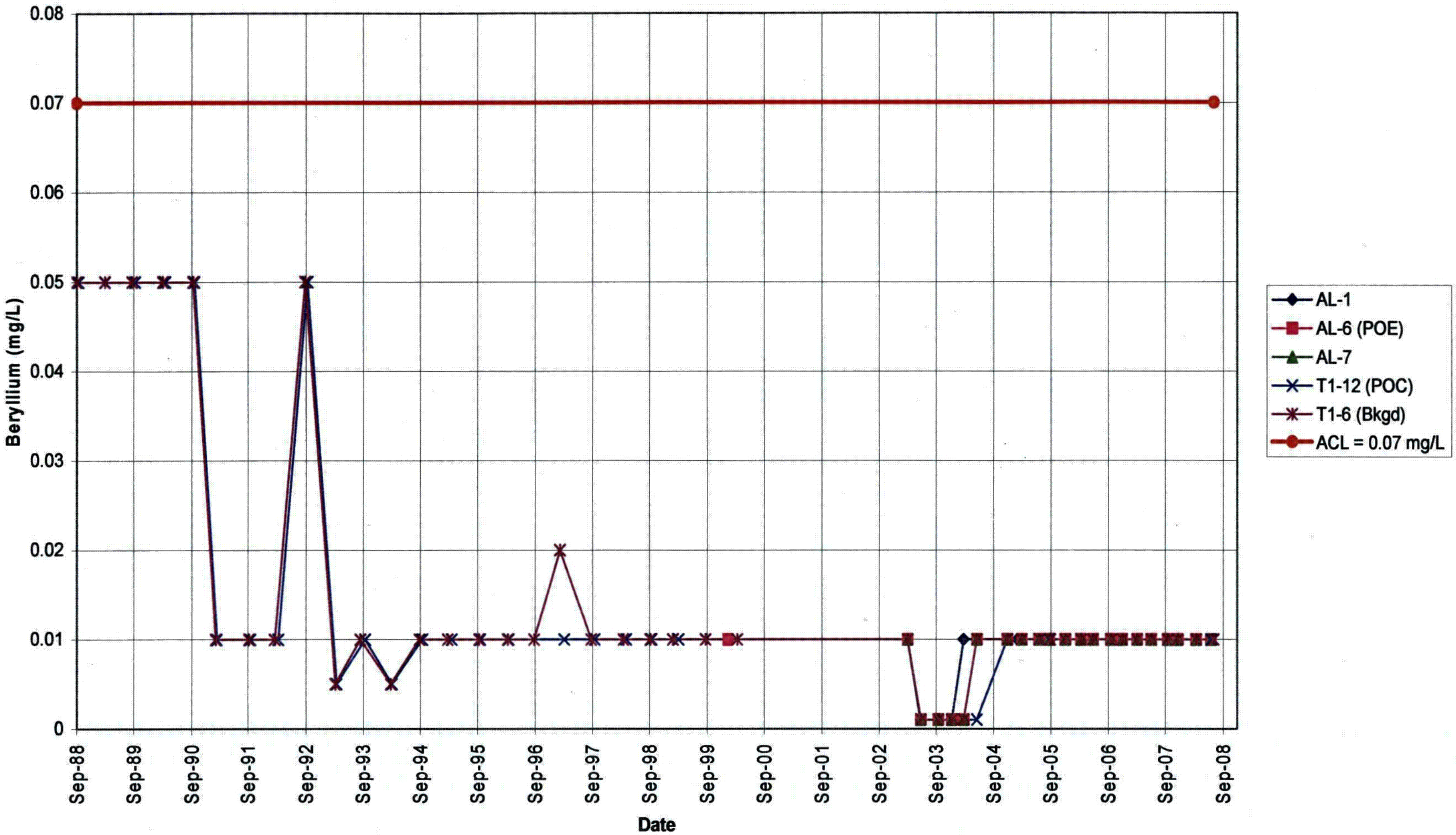


Figure C–2. Time-Concentration Plots of Beryllium in the Groundwater at the Gas Hills North, Wyoming, Disposal Site

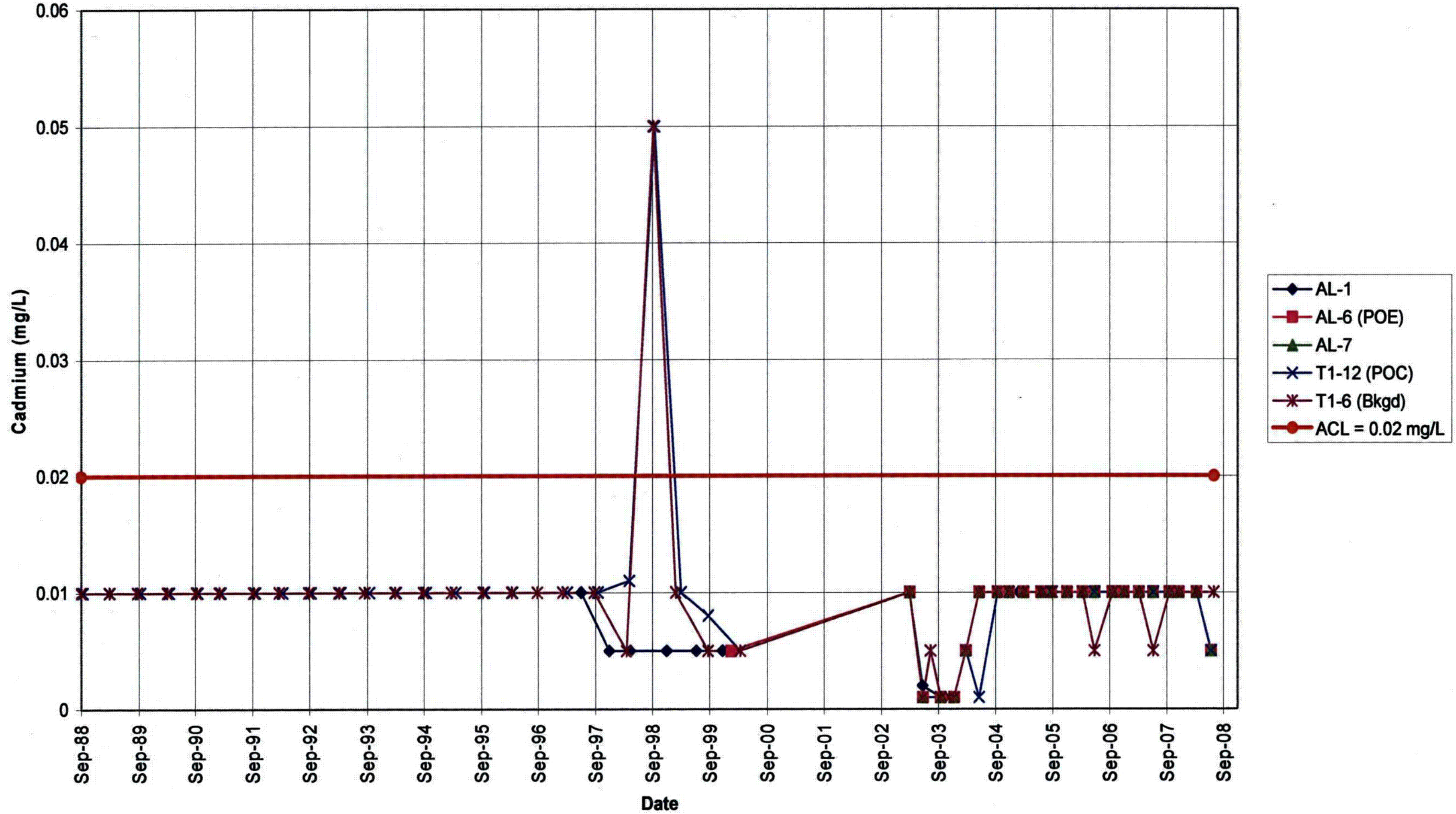


Figure C–3. Time-Concentration Plots of Cadmium in the Groundwater at the Gas Hills North, Wyoming, Disposal Site

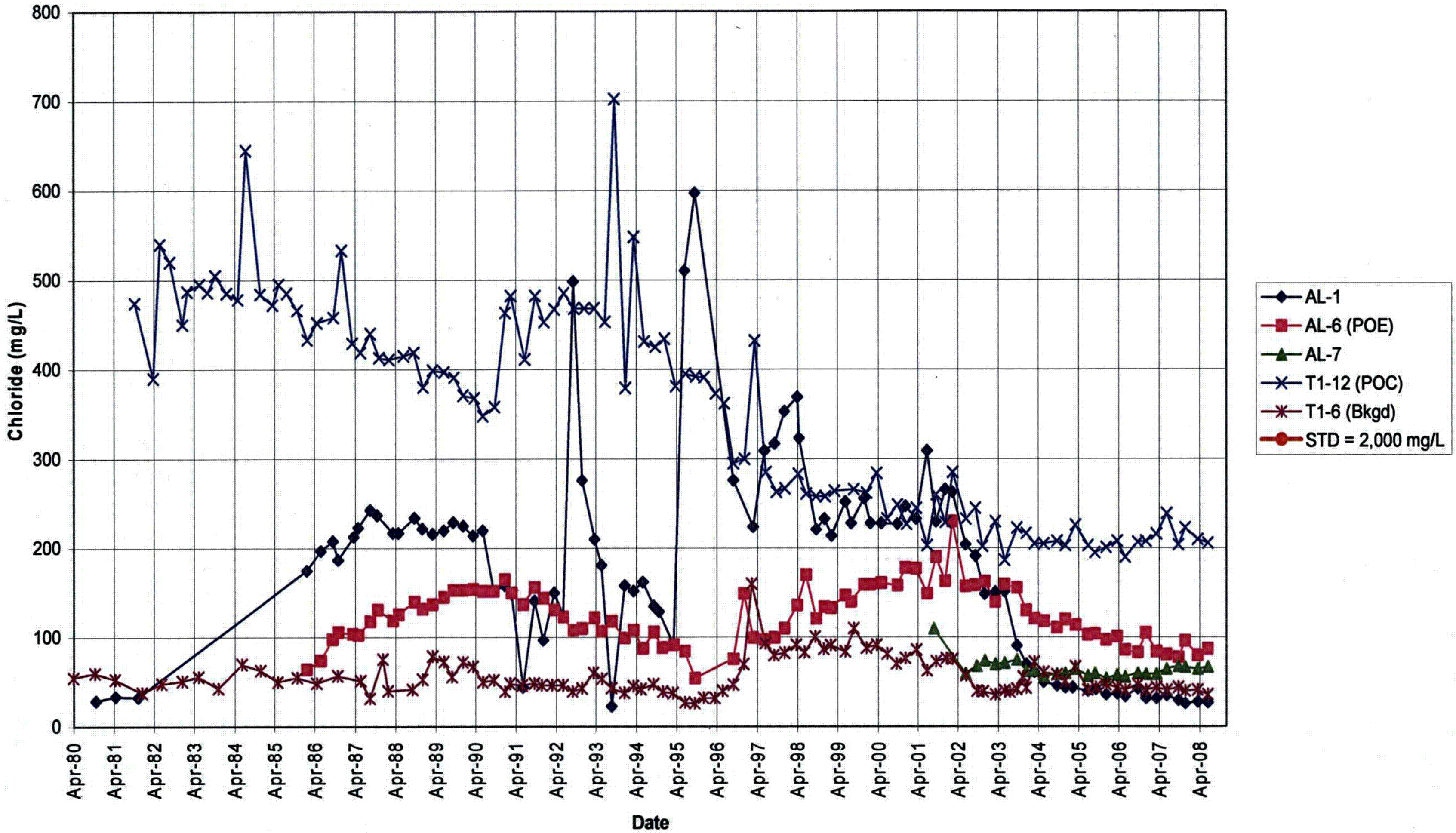


Figure C–4. Time-Concentration Plots of Chloride in the Groundwater at the Gas Hills North, Wyoming, Disposal Site

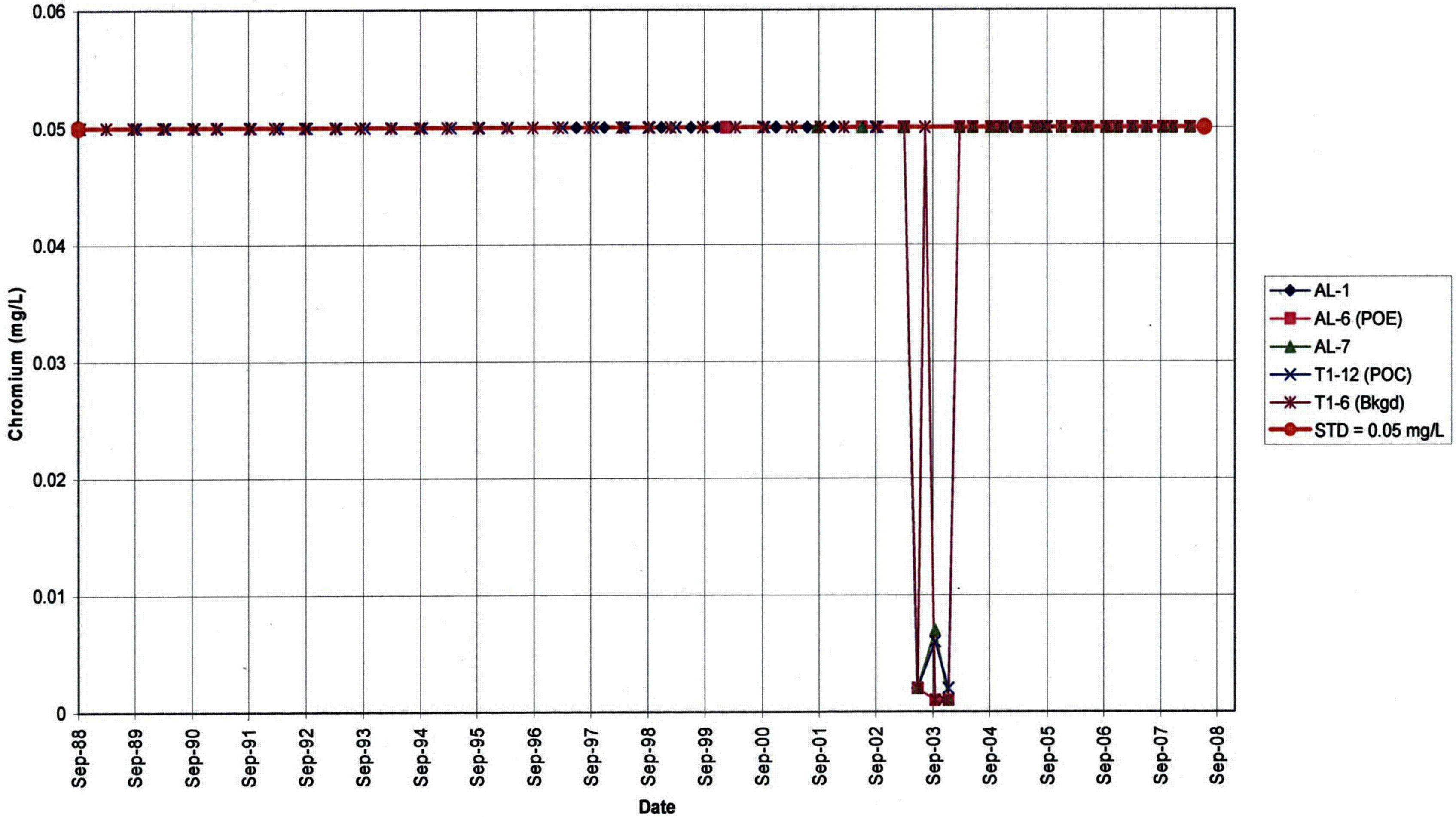


Figure C–5. Time-Concentration Plots of Chromium in the Groundwater at the Gas Hills North, Wyoming, Disposal Site

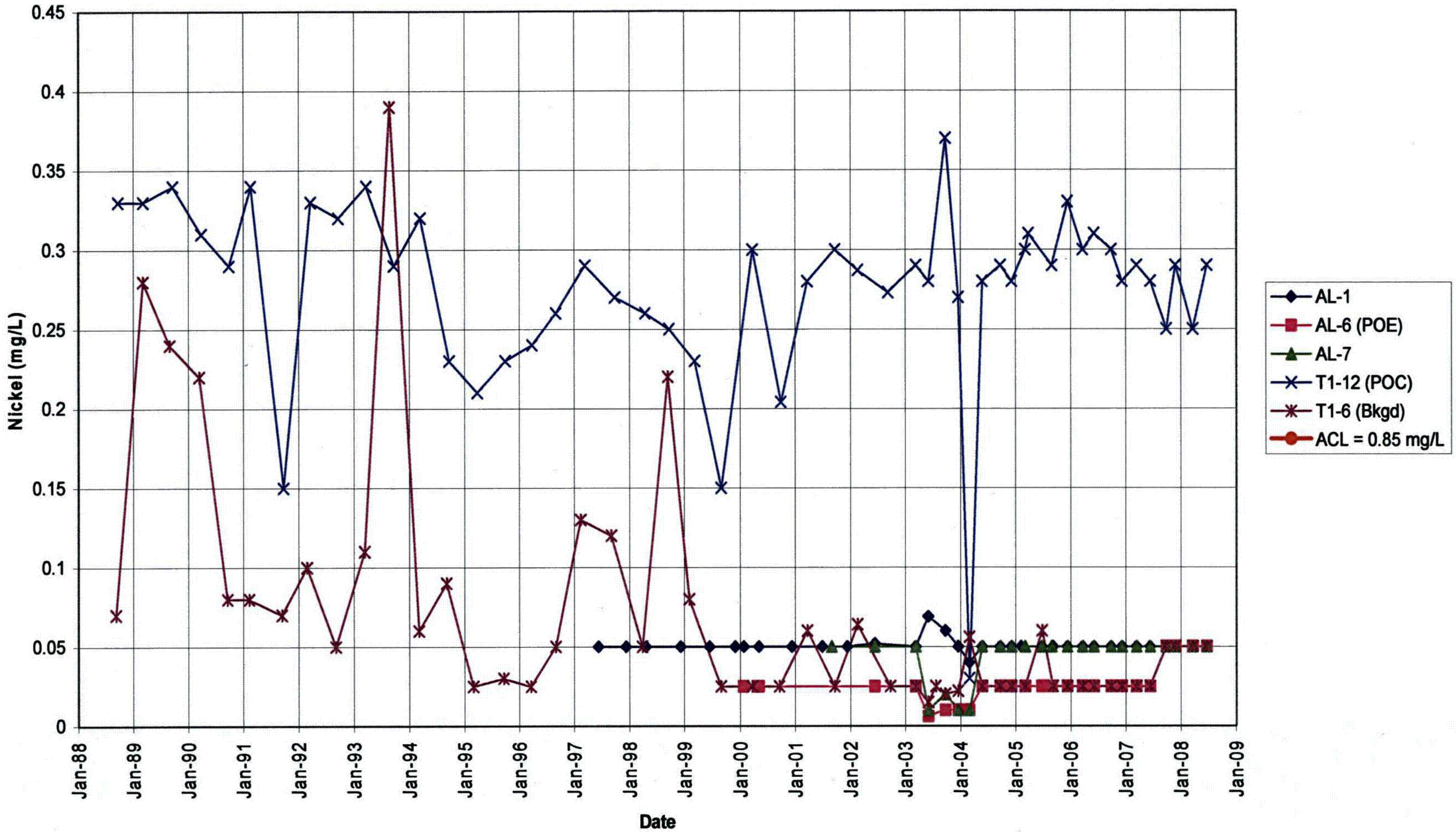


Figure C–6. Time-Concentration Plots of Nickel in the Groundwater at the Gas Hills North, Wyoming, Disposal Site

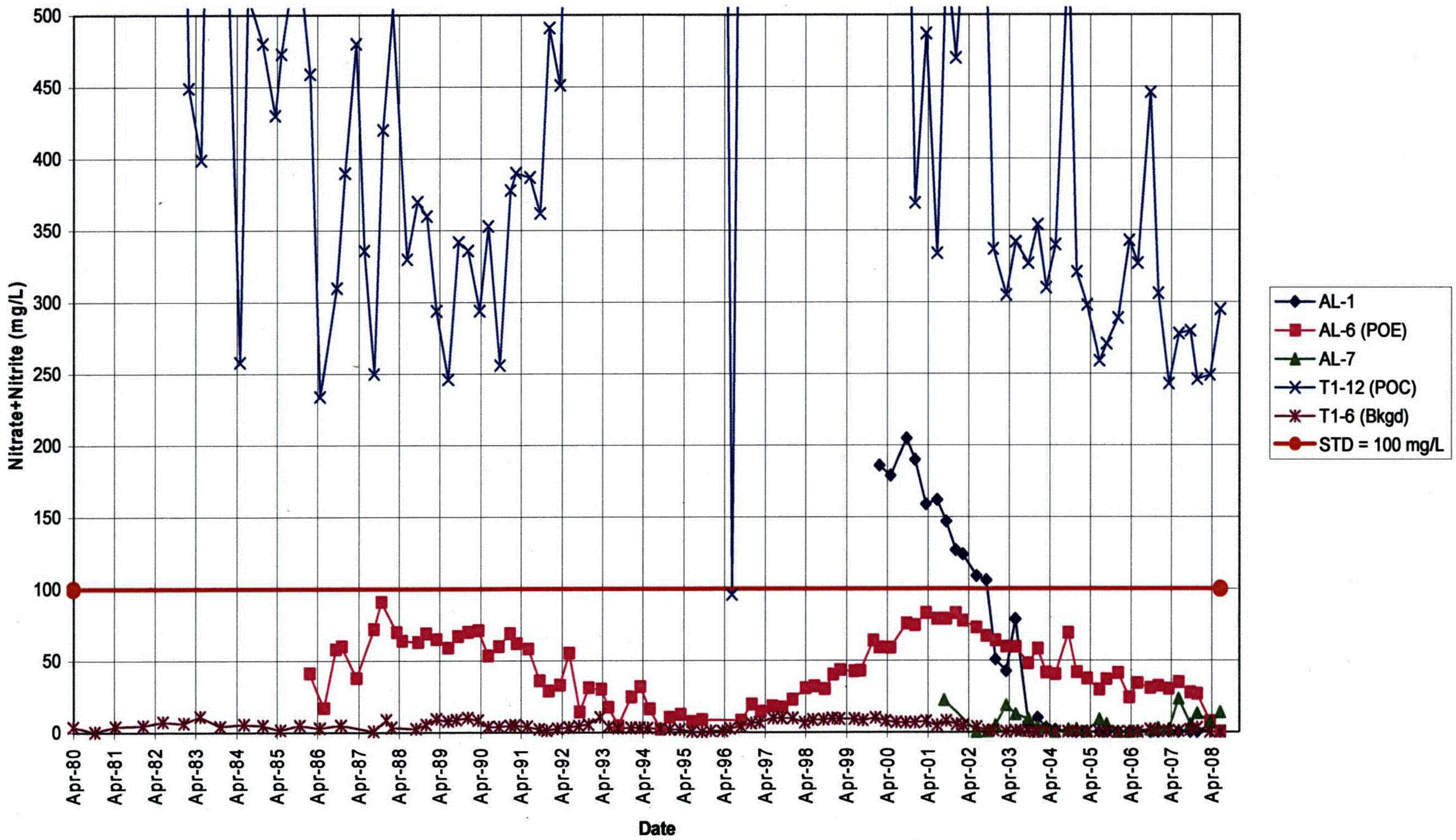


Figure C–7. Time-Concentration Plots of Nitrate+Nitrite in the Groundwater at the Gas Hills North, Wyoming, Disposal Site

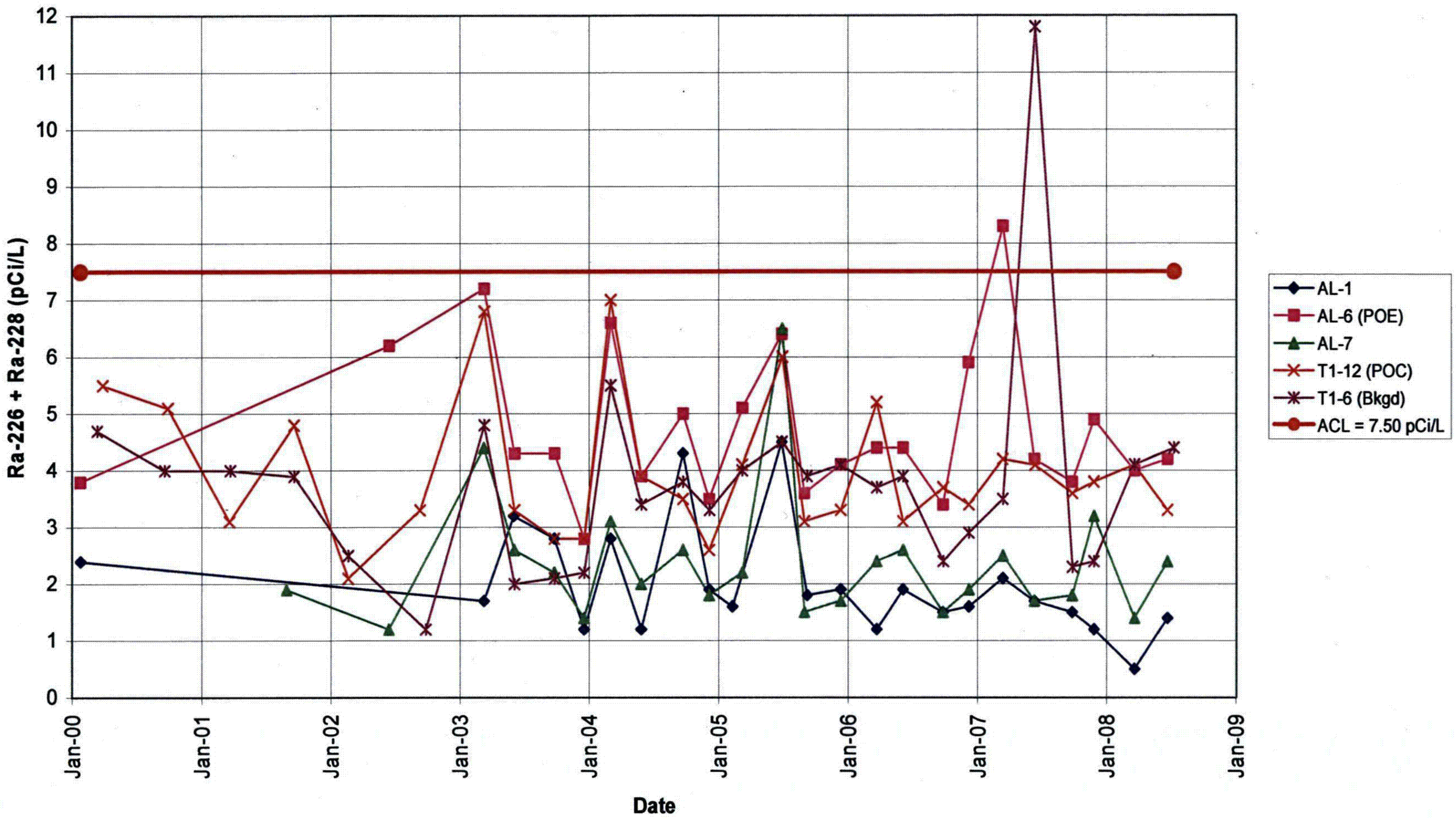


Figure C–8. Time-Concentration Plots of Ra-226+Ra-228 in the Groundwater at the Gas Hills North, Wyoming, Disposal Site

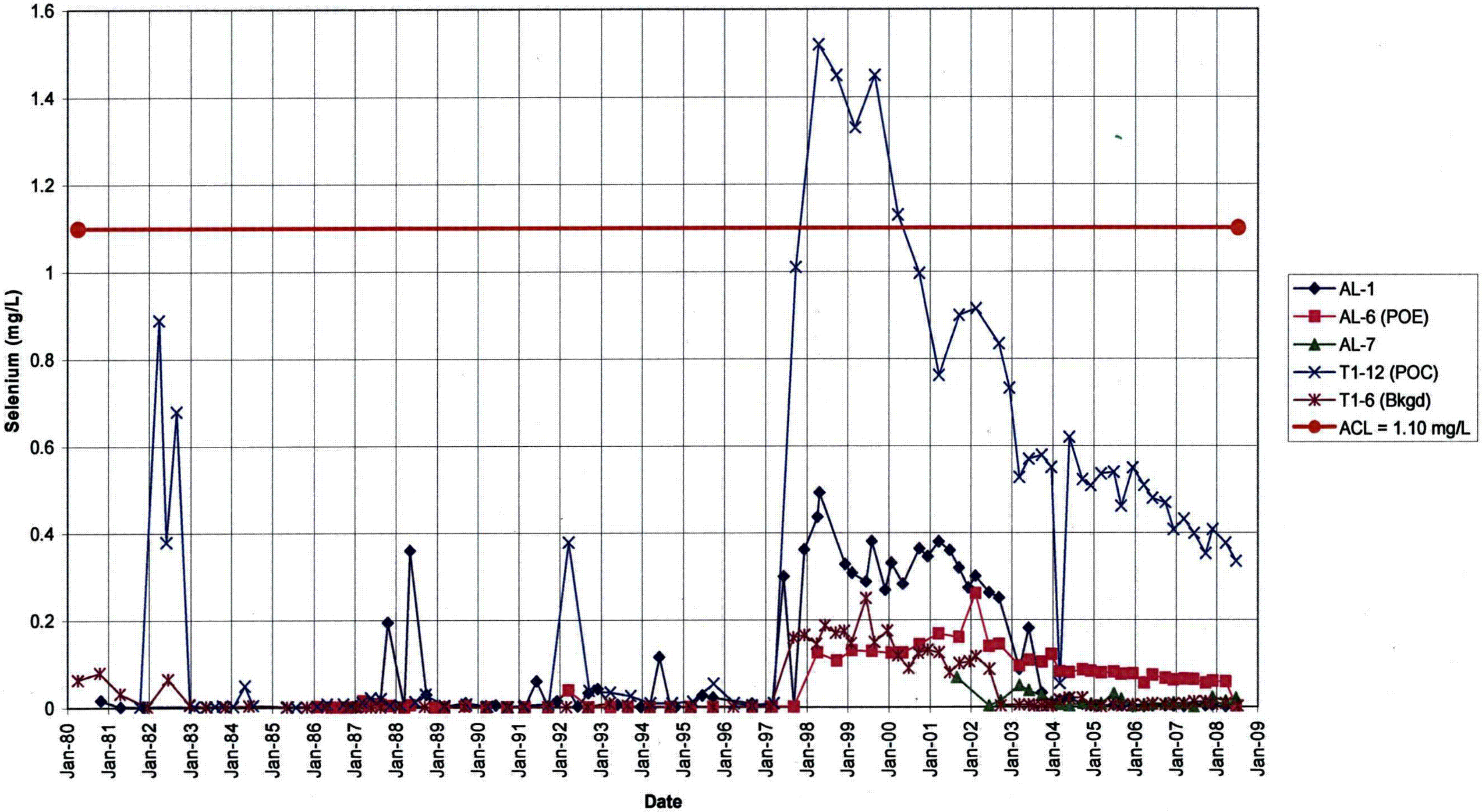


Figure C–9. Time-Concentration Plots of Selenium in the Groundwater at the Gas Hills North, Wyoming, Disposal Site

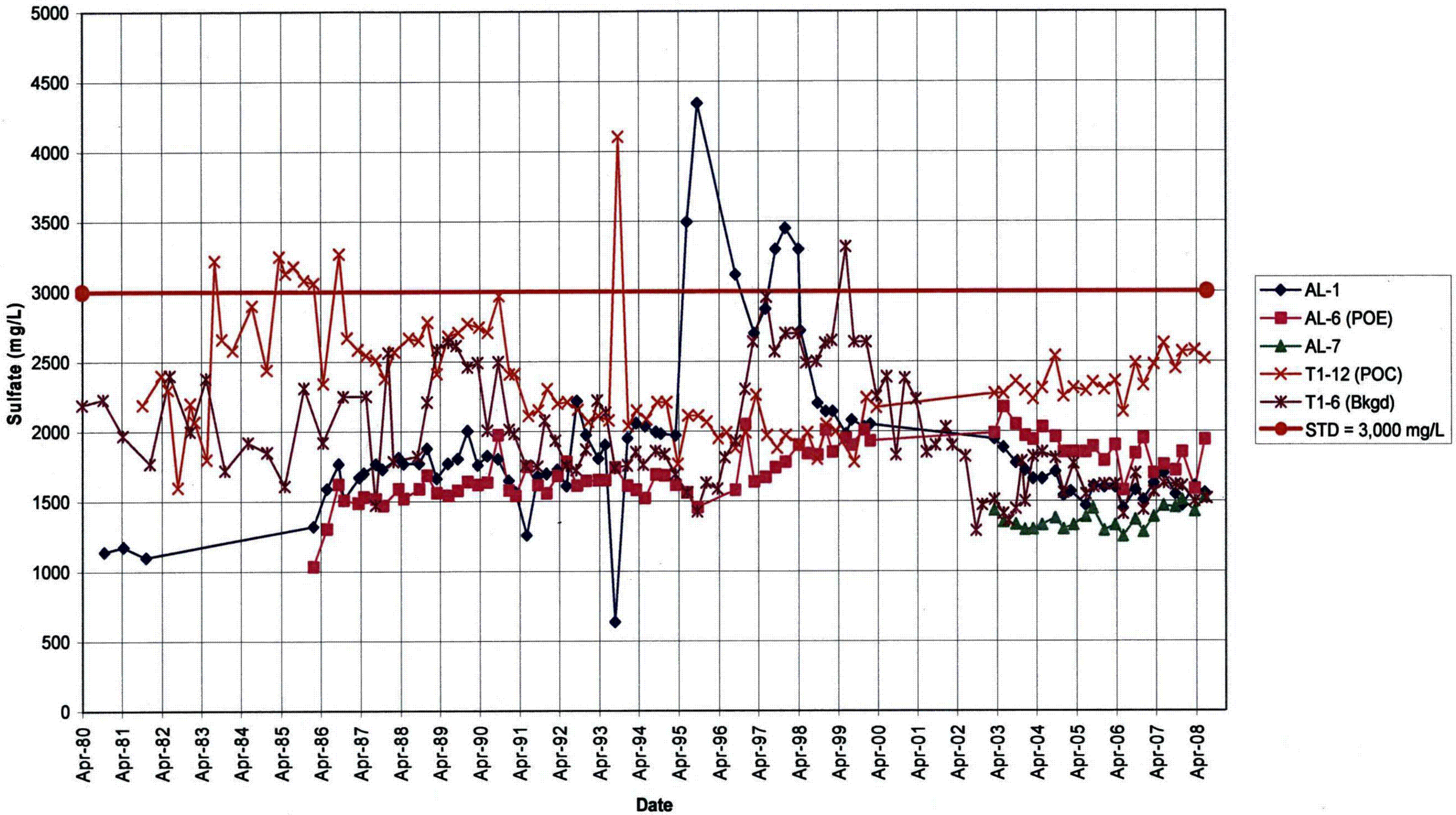


Figure C–10. Time-Concentration Plots of Sulfate in the Groundwater at the Gas Hills North, Wyoming, Disposal Site

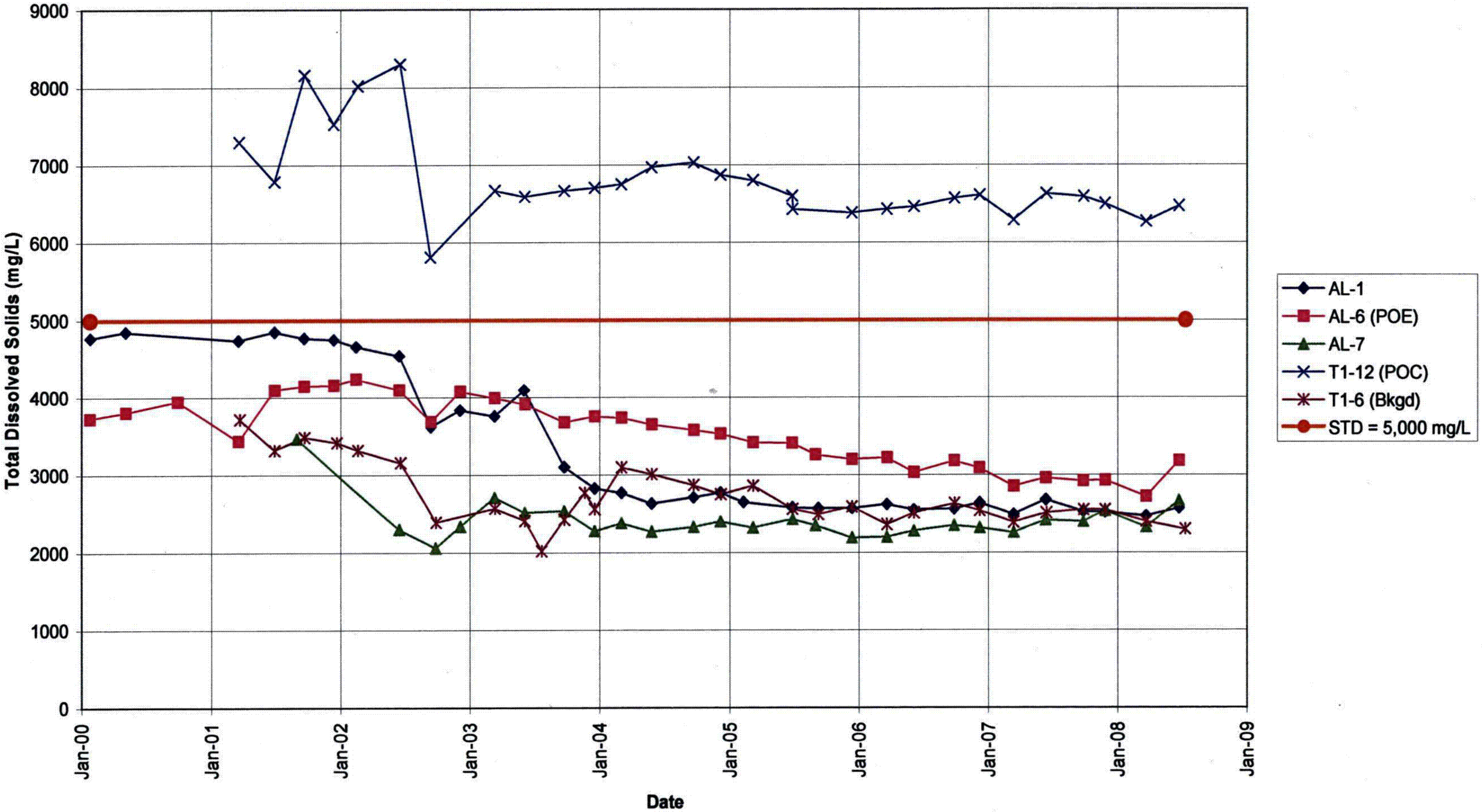


Figure C–11. Time-Concentration Plots of Total Dissolved Solids in the Groundwater at the Gas Hills North, Wyoming, Disposal Site

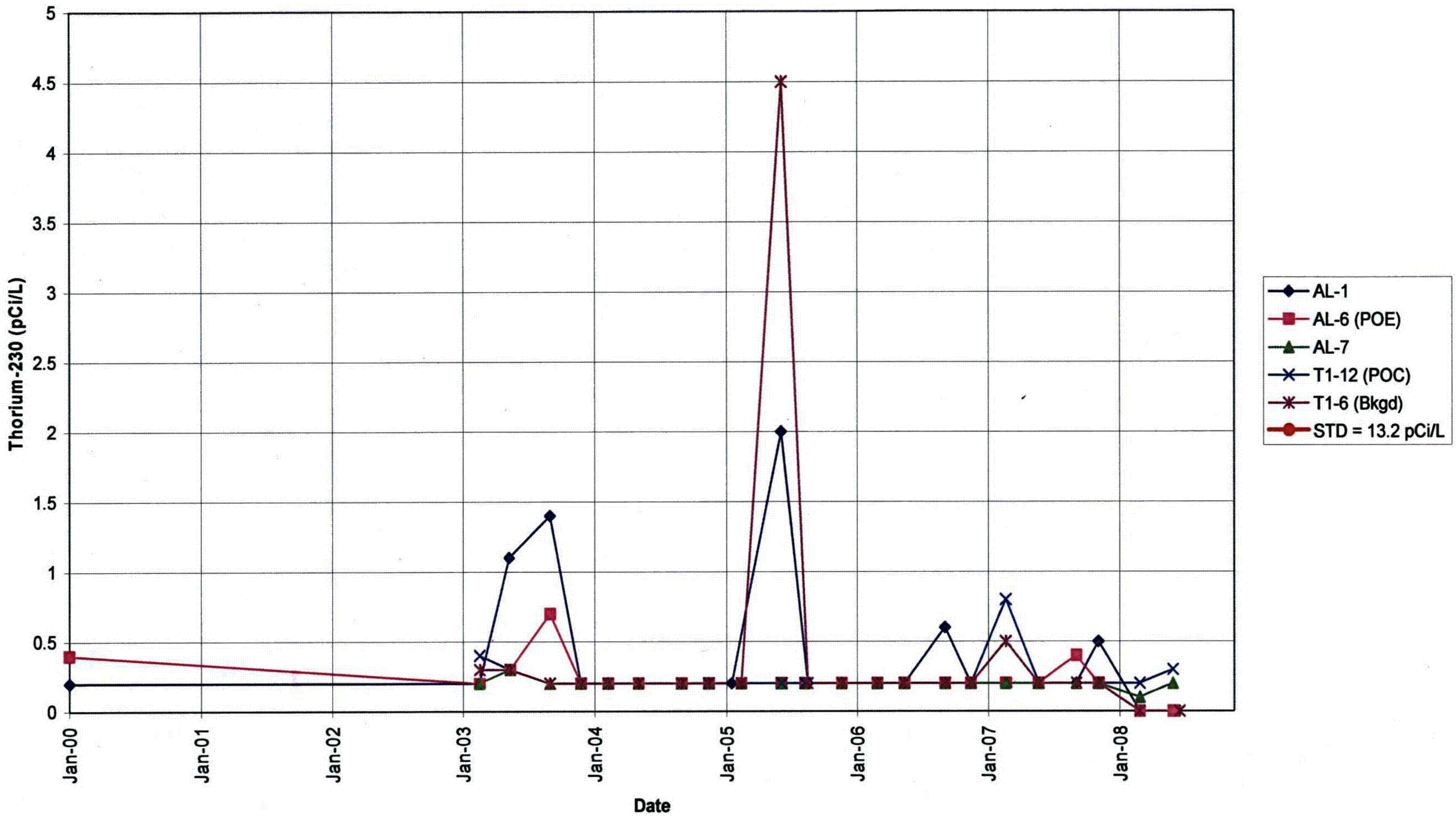


Figure C–12. Time-Concentration Plots of Thorium-230 in the Groundwater at the Gas Hills North, Wyoming, Disposal Site

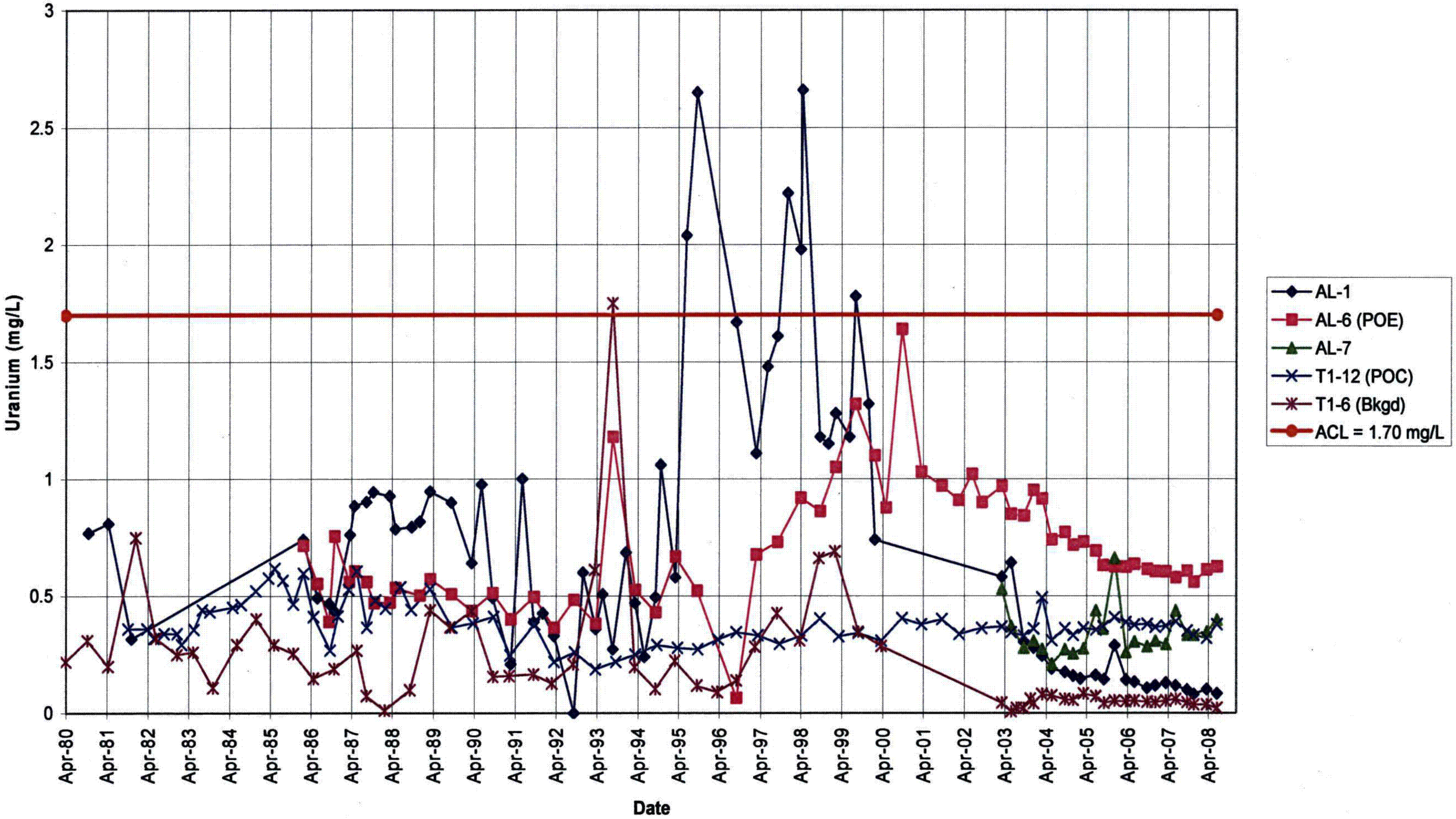


Figure C–13. Time-Concentration Plots of Uranium in the Groundwater at the Gas Hills North, Wyoming, Disposal Site

This page intentionally left blank