

## 5.0 Shirley Basin South, Wyoming, Disposal Site

### 5.1 Compliance Summary

The Shirley Basin South, Wyoming, Uranium Mill Tailings Radiation Control Act (UMTRCA) Title II Disposal Site, inspected on June 11, 2008, was in excellent condition. Infestations of Canada thistle, a state-listed noxious weed found during the inspection, were sprayed with herbicide. No other maintenance needs were identified. Groundwater monitoring indicated that radium-228 continues to exceed its alternate concentration limit at two wells; the cause for the increase has not been determined. Six additional monitor wells were installed in fall 2008 to assist in evaluating the two uppermost aquifers at the site. No cause for a follow-up inspection was identified.

### 5.2 Compliance Requirements

Requirements for the long-term surveillance and maintenance of the Shirley Basin South, Wyoming, Disposal Site are specified in the *Long-Term Surveillance Plan [LTSP] for the U.S. Department of Energy Shirley Basin South (UMTRCA Title II) Disposal Site, Carbon County, Wyoming* (DOE–LM/GJ766–2004, December 2004) and in procedures established by the U.S. Department of Energy (DOE) to comply with requirements of Title 10 *Code of Federal Regulations* Part 40.28 (10 CFR 40.28). Table 5–1 lists license requirements for this site.

Table 5–1. License Requirements for the Shirley Basin South, Wyoming, Disposal Site

Requirement	Long-Term Surveillance Plan	This Report
Annual Inspection and Report	Section 3.3 and 3.4	Section 5.3.1
Follow-up Inspections	Section 3.5	Section 5.3.2
Routine Maintenance and Emergency Measures	Section 3.6	Section 5.3.3
Environmental Monitoring	Section 3.7	Section 5.3.4

**Institutional Controls**—The 1,512-acre disposal site is owned by the United States of America and was accepted under the U.S. Nuclear Regulatory Commission (NRC) general license (10 CFR 40.28) in 2005. DOE is the licensee and, in accordance with the requirements for UMTRCA Title II sites, is responsible for the custody and long-term care of the site. Institutional controls at the disposal site, as defined by DOE Policy 454.1, consist of federal ownership of the property, a site perimeter fence, warning/no trespassing signs placed along the property boundary, and a locked gate at the site entrance. Verification of these institutional controls is part of the annual inspection. No off-site institutional controls are needed because contaminated groundwater is contained within the federal land boundary.

### 5.3 Compliance Review

#### 5.3.1 Annual Inspection and Report

The disposal site, located approximately 35 miles south of Casper, Wyoming, was inspected on June 11, 2008. Results of the inspection are described below. Features and photograph locations (PLs) mentioned in this report are shown on Figure 5–1. Numbers in the left margin of this report refer to items summarized in the Executive Summary table.

### 5.3.1.1 Specific Site Surveillance Features

**Access, Gates, Fences, and Perimeter Signs**—Access to the Shirley Basin South Disposal Site is immediately off of Carbon County Road 2 and is unimpaired; no private property is crossed to gain access. A wire entrance gate is secured by a locked chain and was in excellent condition.

A four-strand barbed wire perimeter fence encompasses the site. The perimeter fence was inspected with the use of an all-terrain vehicle and, except for a damaged portion crossing the north end of Pit 4, was in excellent condition. The damaged portion will be difficult to maintain because of steep slopes and recurring snow damage. The grazing licensee (see Section 5.3.1.2), in cooperation with the adjacent property owner (Pathfinder Mines Corporation), erected an electric fence around the north rim of Pit 4 in 2007 to bypass the damaged section and to allow cattle access to each side of the pit. Sections along the north perimeter that were open at the time of the 2005 inspection remained closed with temporary wire fence at the time of the 2008 inspection. These sections are used by Pathfinder Mines Corporation (Pathfinder) to gain access to a topsoil stockpile area on the DOE site. Additional information regarding this activity is provided in Section 5.3.1.2.

5A Property ownership/warning signs (perimeter signs) are positioned around the disposal cell at 25 locations, and another 9 signs are located along the site perimeter at potential points of access. Perimeter sign P3, which had been used to replace missing sign P26 during the 2007 inspection, was replaced during the 2008 inspection. Other than bullet holes in P2, the signs are in excellent condition.

**Site Marker and Boundary Monuments**—The granite site marker, located at the site entrance, was in excellent condition. All 26 boundary monuments delineating DOE property were located and were in excellent condition (PL-1).

**Monitor Wells**—The original site groundwater monitoring network consisted of eight wells, and all of them are located on the site. Monitor well MW-K.G.S. #3 was open to accommodate discharge tubing for a solar pump; the well protector was later modified to allow the lid to be closed over the tubing and was secured with a DOE lock. The other wells were in excellent condition and locked. The wells are accessible by vehicle along reclaimed mine roads. As agreed to by DOE and NRC, six additional monitor wells were installed in fall 2008 and will be included in the monitoring network.

### 5.3.1.2 Transects

To ensure a thorough and efficient inspection, the site was divided into three areas referred to as transects: (1) the cover of the tailings impoundment; (2) the containment dam and diversion channels; and (3) the balance of the site and the site perimeter.

Within each transect, inspectors examined specific site surveillance features. Each transect was inspected for evidence of erosion, settling, slumping, or other disturbances that might affect site integrity or the long-term performance of the cell.

**Cover of the Tailings Impoundment**—The tailings impoundment, completed in 2000, occupies approximately 142 acres and has a grass cover (PL-2). The cell surface is constructed at two elevations separated by a riprap-armored slope (PL-3). The slope is in excellent condition.

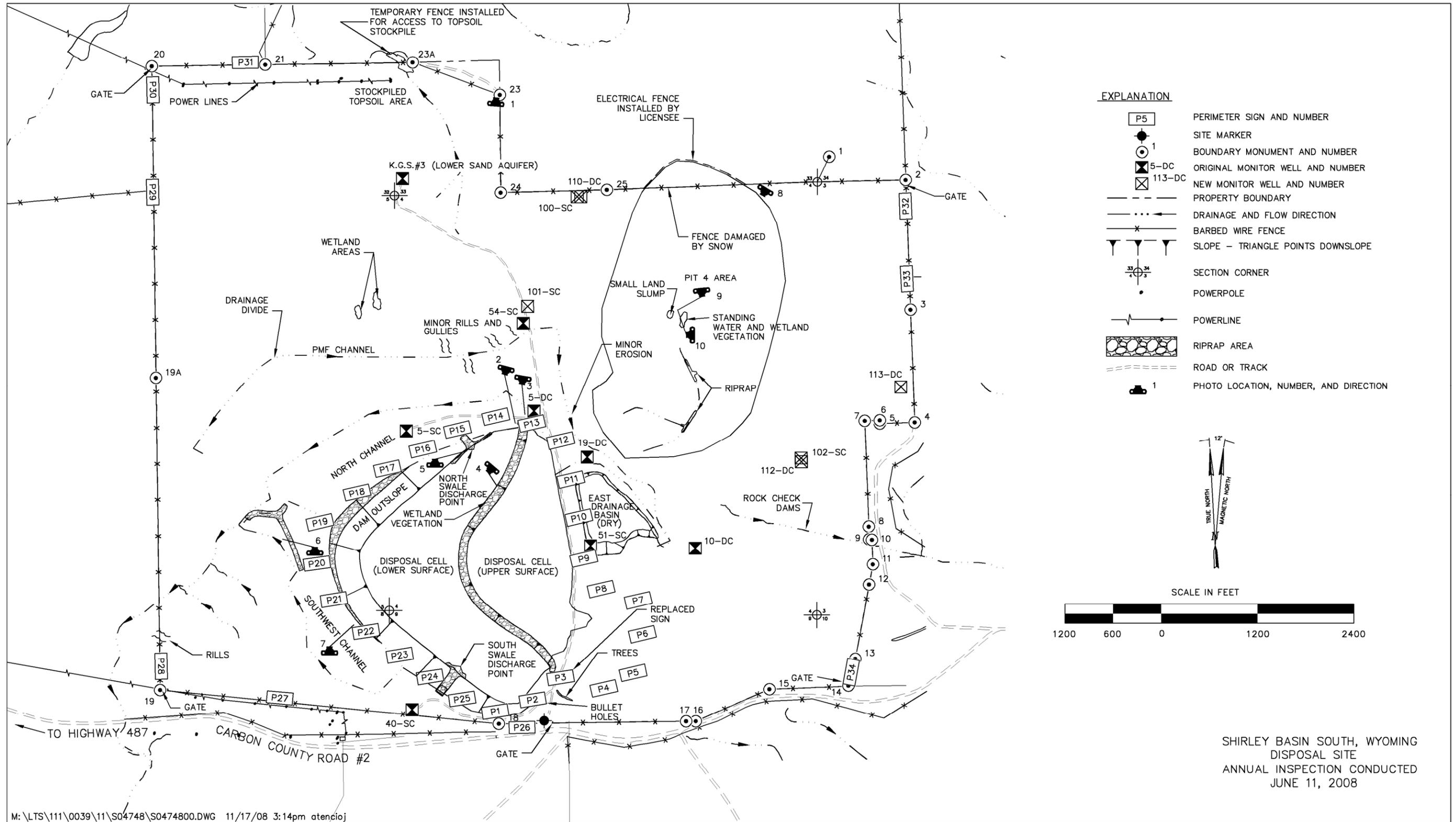


Figure 5-1. 2008 Annual Compliance Drawing for the Shirley Basin South, Wyoming, Disposal Site

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Windblown sediment is accumulating and vegetation continues to encroach on the slope, and wetland vegetation is beginning to establish in areas at the toe of the slope that are wet due to precipitation and snowmelt runoff (PL-4).

The eastern (upper) surface is contoured to drain into a basin east of the cell and west over the riprap-protected slope to the western (lower) surface. The lower surface drains to the north and south at riprap-armored discharge points. Standing water was present at the base of both discharge points (PL-5).

The grass is well established and in excellent condition. The grazing licensee is allowed to graze his cattle on the grass cover and to cut it for hay. Cattle feeding stations have been installed by the grazing licensee at several locations, and cattle were present on the site at the time of the inspection (PL-6). There were no indications of erosion, settlement, or other modifying processes that might affect the integrity of the cell. Animal burrows have been observed in previous inspections, and the approximately 5-foot-thick cover will continue to be monitored for burrowing activity to ensure that tailings are not brought to the surface.

**Containment Dam and Diversion Channels**—The tailings pile was reclaimed in place and was contained behind a horseshoe-shaped earthen dam. The containment dam is predominantly grass covered, with the north and south swale discharge points and the steeper sections (5:1 slope) of the dam protected by riprap (PL-7). There were no indications of erosion, settlement, or other modifying processes that might affect the integrity of the dam. Vegetation is encroaching on the riprap surfaces, which enhances the stability of the slopes.

The surface water diversion system consists of a combination of contoured surfaces and drainage and collection channels. Riprap armor was placed on the steeper slopes and flow concentration points where design flow velocities would have the potential to erode surfaces and possibly impact the tailings dam and impoundment (PL-6). A probable maximum flood (PMF) channel was constructed north of the tailings impoundment. Part of the PMF channel drains to the southwest and discharges to a small closed basin. A larger drainage area is captured by the portion of the PMF channel that flows eastward and discharges into the East Drainage Basin. These closed drainage basins are large enough to accommodate the PMF water volumes. The diversion channels were in excellent condition and indicated no signs of active erosion in the channels. Minor erosion is occurring at locations on the uphill and downhill slopes along the PMF channel but is not affecting the function of the channel.

**Balance of the Site and the Site Perimeter**—The other major feature on the site is reclaimed Pit 4 located in the northeast portion of the site (PL-8). Reclamation activities included rounding the side slopes, partially backfilling the pit to an elevation above the local water table, revegetating the surfaces, and protecting potential erosion areas with riprap. Vegetation is well established, and a wetland area is forming at the bottom of the pit where standing water from runoff often is present (PL-9). One small land slump (PL-10) and other minor displacement features are present on the west side slope of the pit; otherwise, the pit is in excellent condition.

Other areas on the site were in excellent condition. Due to significant snow accumulations during the past winter and subsequent snowmelt runoff and rainfall, ponded water was present at locations in the northwest portion of the site.

The site is surrounded by private property and public land administered by the U.S. Bureau of Land Management (BLM). Land on three sides is used primarily for livestock grazing. Pathfinder is the property owner north of the site and is in the process of reclaiming the UMTRCA Title II Shirley Basin North disposal site. Pathfinder's access to and use of stockpiled topsoil on the DOE site is in accordance with an agreement between Petrotoomics Company, the former licensee of the Shirley Basin South site, and Pathfinder. In accordance with the agreement, DOE is the successor to Petrotoomics and the terms of the agreement remain in effect. The Wyoming Department of Environmental Quality (WDEQ) extended Pathfinder's mine area permit to include the soil stockpile area and requires that Pathfinder reclaim the disturbed area, including fence replacement, when finished removing topsoil from the stockpile. This activity is not adversely affecting the security of the site, and no evidence of recent topsoil removal was observed.

DOE established a grazing license with a local rancher in 2007. The license allows the rancher to graze the site with his livestock, mow the grass on the disposal cell, and use water from well MW-K.G.S. #3 for stock-watering purposes (at the request of DOE, the State of Wyoming changed the permitted use of the well from monitoring only to monitoring and stock water use). Well MW-K.G.S. #3 is completed in the Lower Sand Aquifer of the Wind River Formation and is hydraulically isolated from the upper contaminated aquifers. The licensee installed a solar pump in well MW-K.G.S. #3 in December 2007 and plans to install a storage tank and stock-watering tank near the well. In exchange for these uses of the site, the rancher will be responsible for maintaining the perimeter fence and notifying DOE of observed trespassing, vandalism, erosion, or other problems at the site.

### **5.3.1.3 Noxious Weeds**

5B Infestations of Canada thistle, a state-listed noxious weed, were found at several locations on the site during the 2007 inspection and subsequently were sprayed with herbicide. New thistle plants were growing in some of the treated areas, and other untreated patches were found; these weeds were sprayed in June and September 2008. Canada thistle infestations will continue to be sprayed with herbicide in an effort to prevent the spread of the weeds and eventually eradicate them.

### **5.3.2 Follow-up Inspections**

DOE will conduct follow-up inspections if (1) a condition is identified during the annual inspection or other site visit that requires a return to the site to evaluate the condition, or (2) DOE is notified by a citizen or outside agency that conditions at the site are substantially changed. No follow-up inspections were required in 2008.

### **5.3.3 Routine Maintenance and Emergency Measures**

A missing perimeter sign was replaced and noxious weeds were sprayed with herbicide in 2008. No other maintenance or repairs were required.

Emergency measures are corrective actions that DOE will take in response to unusual damage or disruption that threaten or compromise site health and safety, security, integrity, or compliance with 40 CFR 192. No emergency measures were required in 2008.

### 5.3.4 Environmental Monitoring

5C Groundwater monitoring is required at the Shirley Basin South site. The monitoring network, as described in the LTSP, consists of eight DOE wells completed in aquifers of the Wind River Formation (Table 5–2). Water level, pH, and electrical conductivity are measured at the time of sampling, and the samples are analyzed for uranium, radium-226, radium-228, thorium-230, cadmium, chromium, lead, nickel, selenium, chloride, nitrate, sulfate, and total dissolved solids (TDS). Analytical results are compared to the alternate concentration limits (ACLs) and groundwater protection standards provided in Table 5–3. There are no applicable limits or standards for nitrate at this site. However, it is included as an analyte because it may be an indicator of contaminant migration. Water level elevations are measured at the wells to evaluate flow direction as the upper aquifers recover from mining and reclamation activities.

*Table 5–2. Groundwater Monitoring Network at the Shirley Basin South, Wyoming, Disposal Site*

Monitor Well	Network Application
5–SC	POC well; Upper Sand Aquifer
40–SC	Upgradient well; Upper Sand Aquifer
51–SC	POC well; Upper Sand Aquifer
54–SC	Upper Sand Aquifer
5–DC	POC well; Main Sand Aquifer
10–DC	Main Sand Aquifer
19–DC	POC well; Main Sand Aquifer
K.G.S. #3	Lower Sand Aquifer

Key: POC = point-of-compliance

*Table 5–3. Alternate Concentration Limits and Groundwater Protection Standards for the Shirley Basin South, Wyoming, Disposal Site*

Analyte	ACL	Groundwater Protection Standard <sup>a</sup>
Uranium (mg/L)	9.2	N/A
Radium-226 (pCi/L)	91.3	N/A
Radium-228 (pCi/L)	25.7	N/A
Thorium-230 (pCi/L)	2409	N/A
Cadmium (mg/L)	0.079	N/A
Chromium (mg/L)	1.83	N/A
Lead (mg/L)	0.05	N/A
Nickel (mg/L)	6.15	N/A
Selenium (mg/L)	0.12	N/A
Chloride (mg/L)	N/A	2,000
Sulfate (mg/L)	N/A	3,000
TDS (mg/L)	N/A	5,000

<sup>a</sup>Wyoming Class III Groundwater Protection Standards for livestock use are applicable to this site.

Key: ACL = alternate concentration limit; mg/L = milligrams per liter; pCi/L = picocuries per liter; TDS = total dissolved solids

The intent of the annual groundwater quality monitoring is to verify that the ACLs are not exceeded at point-of-compliance (POC) wells and to verify continued compliance with the pertinent groundwater protection standards. If an ACL is exceeded at a POC well, or trends indicate 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. Results of the evaluative monitoring program will be used, in consultation with NRC, to determine if corrective action is necessary.

The results for cadmium in POC well MW-5-SC and radium-228 in POC well MW-5-DC for the initial sampling by DOE in July 2005 exceeded their respective ACL. The 2005 radium-228 concentration in non-POC well MW-54-SC also was substantially above the ACL. Therefore, confirmatory sampling and analysis for cadmium and radium-228 at the three wells was conducted in November 2005, and the results confirmed the initial findings. When compared with historical results provided by the previous site owner, the results for cadmium in well MW-5-SC were within the range of historical measurements with no apparent upward or downward trend. The 2005 results for radium-228 in well MW-5-DC were substantially above historical measurements, and data indicate that radium-228 has equaled or exceeded the ACL on all but four semiannual sampling events beginning in 1995. This analytical information was provided to NRC and WDEQ with a recommendation to continue annual monitoring and perform an evaluation after 5 years of results to determine if corrective action is necessary.

5D Analytical results for the August 2008 sampling event are provided in Table 5-4. The concentration for cadmium in MW-5-SC remained below the ACL as it has for the last three sampling events (Figure 5-2). However, radium-228 continued above the ACL in an upward trend in both MW-5-DC and MW-54-SC (Figure 5-3). No other ACLs were exceeded.

Although the radium-228 concentrations are increasing in two of the wells, they are less than peak concentrations that occurred in these wells in the early 1990s during site groundwater remediation activities but prior to cell construction. Radium-228 is a decay product of thorium-232, which is highly immobile. Because the half-life of radium-228 is very short, the thorium-232 source must be near the wells of concern. Both of the aquifers at the site were dewatered during mining and remediation, and are still in the process of recovering; therefore, as the sand units are re-saturating, groundwater may be coming back into contact with thorium and other minerals in the ore body and the quality is returning to pre-remediation concentrations.

An evaluation of the well completion log and a 2008 video log of the well indicate that the screen in well MW-54-SC spans both the upper and main sand aquifers; the water level in the well suggests that it represents the main sand aquifer. The main sand unit of the Wind River Formation contained the uranium ore that was mined at the site; therefore, it is likely that the elevated radium-228 in this well is derived from natural thorium mineralization in the main sand unit instead of from milling or cell-related contamination in the upper sand aquifer.

5E As agreed to by DOE and NRC, DOE installed six additional monitor wells in fall 2008 to provide a better understanding of the groundwater chemistry and flow directions of the two aquifers of concern. Three wells were installed in the upper sand aquifer (one near MW-54-SC) and three wells were installed in the main sand aquifer. These wells will be sampled as part of

the monitoring network. The LTSP will be revised to address the new well monitoring network (including abandonment of well MW-54-SC) and recommendations regarding monitoring requirements. It will be submitted to NRC for concurrence in 2009.

Table 5-4. 2008 Groundwater Monitoring Results at the Shirley Basin South, Wyoming, Disposal Site

Analyte (Limit or Standard)	Upper Sand Aquifer Wells				Main Sand Aquifer Wells			Lower Sand Aquifer Well
	5-SC (POC)	40-SC	51-SC (POC)	54-SC	5-DC (POC)	10-DC	19-DC (POC)	K.G.S. #3
Cadmium (0.079 mg/L)	0.041	0.00018	0.0077	0.0019	0.00028	0.000094	0.000097	0.00011
Chloride (2,000 mg/L)	340	73	380	380	180	62	94	18
Chromium (1.83 mg/L)	0.31	ND	0.55	0.33	0.021	ND	ND	ND
Lead (0.05 mg/L)	0.0042	0.000074	0.00041	0.00065	0.0002	0.00062	0.00011	0.00085
Nickel (6.15 mg/L)	2.6	0.014	2.6	2.4	0.91	ND	0.11	ND
Nitrate/Nitrite as N (mg/L)	ND	0.61	ND	ND	ND	0.041	0.018	ND
Radium-226 (91.3 pCi/L)	5.93	0.496	1.81	19	9.74	14.7	6.26	0.205
Radium-228 (25.7 pCi/L)	2.28	1.15	ND	<b>125</b>	<b>55.9</b>	4.49	7.13	ND
Selenium (0.12 mg/L)	0.02	0.005	0.00043	0.00048	0.00036	0.00023	0.00027	0.000052
Sulfate (3,000 mg/L)	<i>14,000</i>	2,100	<i>11,000</i>	<i>9,100</i>	<i>6,400</i>	1,100	2,900	260
Thorium-230 (2,409 pCi/L)	518	ND	NA	5.69	1.53	ND	ND	ND
TDS (5,000 mg/L)	<i>20,000</i>	3,200	<i>14,000</i>	<i>14,000</i>	<i>9,000</i>	1,800	4,400	450
Uranium (9.2 mg/L)	3.6	0.00055	0.081	0.04	0.058	0.012	0.0002	0.0002
<b>Water Elev.</b> (feet)	6999.76	7049.11	6993.06	6950.70	6940.66	6941.53	6941.06	6946.45

Note: Results in bold font exceed an ACL; italicized results exceed a Wyoming Class III groundwater protection standard. Key: mg/L = milligrams per liter; NA = not analyzed (sample too small); ND = not detected (below detection limit); pCi/L = picocuries per liter; POC = point-of-compliance well; TDS = total dissolved solids

Although groundwater protection standards (applicable only to chloride, sulfate, and TDS) apply to water quality at the site boundary, the values were exceeded for sulfate and TDS in wells MW-5-SC, 51-SC, 54-SC, and 5-DC. When compared with previous DOE data and historical results provided by the previous site licensee, the 2008 results were within the range of historical measurements. Also, there are no upward trends in any of the wells that would indicate groundwater protection standards may be exceeded at the site boundary.

Analytical results from well MW-K.G.S. #3 confirm that the lower sand aquifer is hydraulically isolated from the overlying upper and main sand aquifers. This conclusion is based on significantly lower concentrations of chloride, sulfate, TDS, and uranium in the lower sand aquifer when compared with the upper and main sand aquifers.

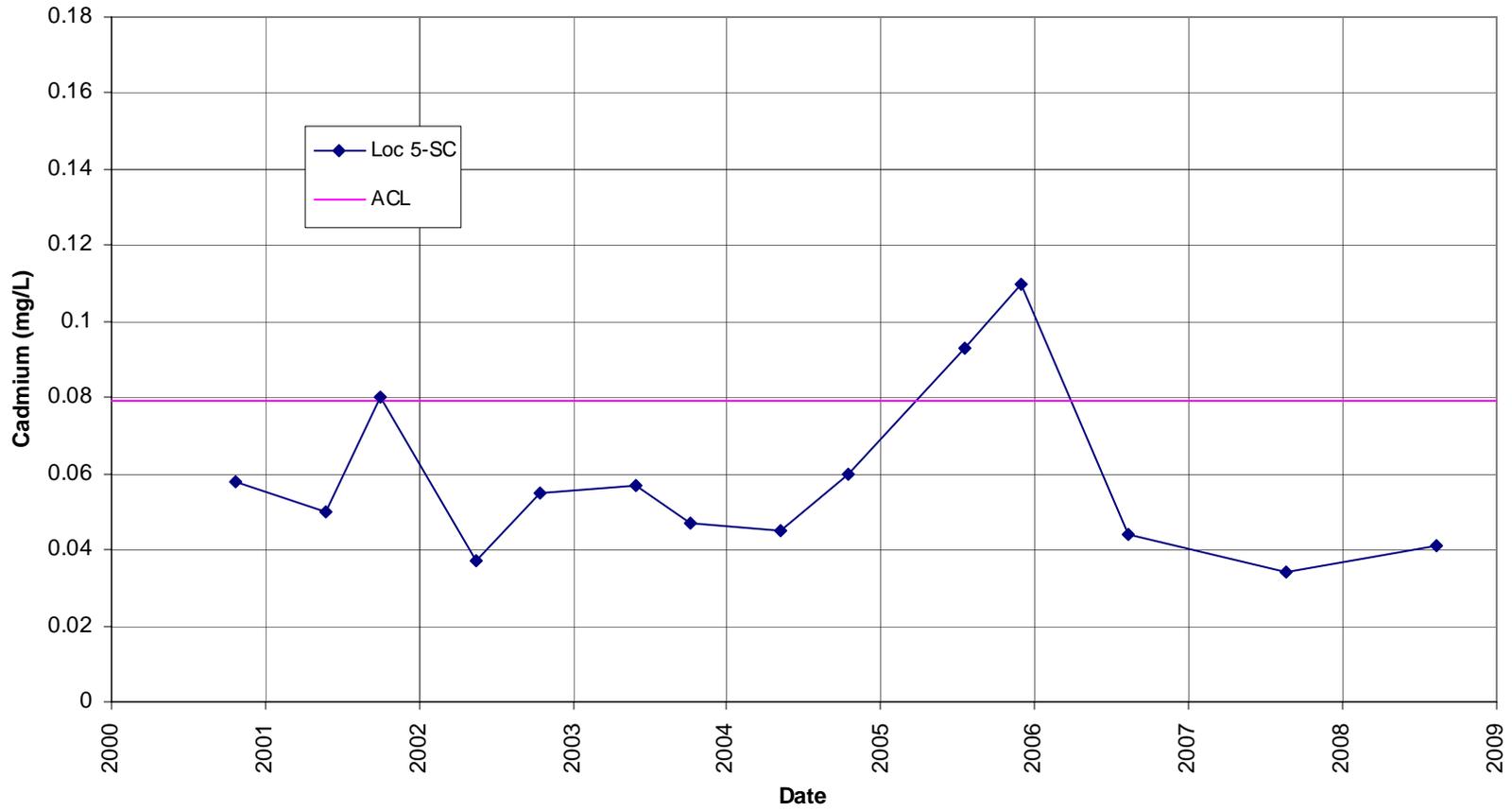


Figure 5-2. Cadmium Concentration in Well MW-5-SC Since Completion of the Disposal Cell

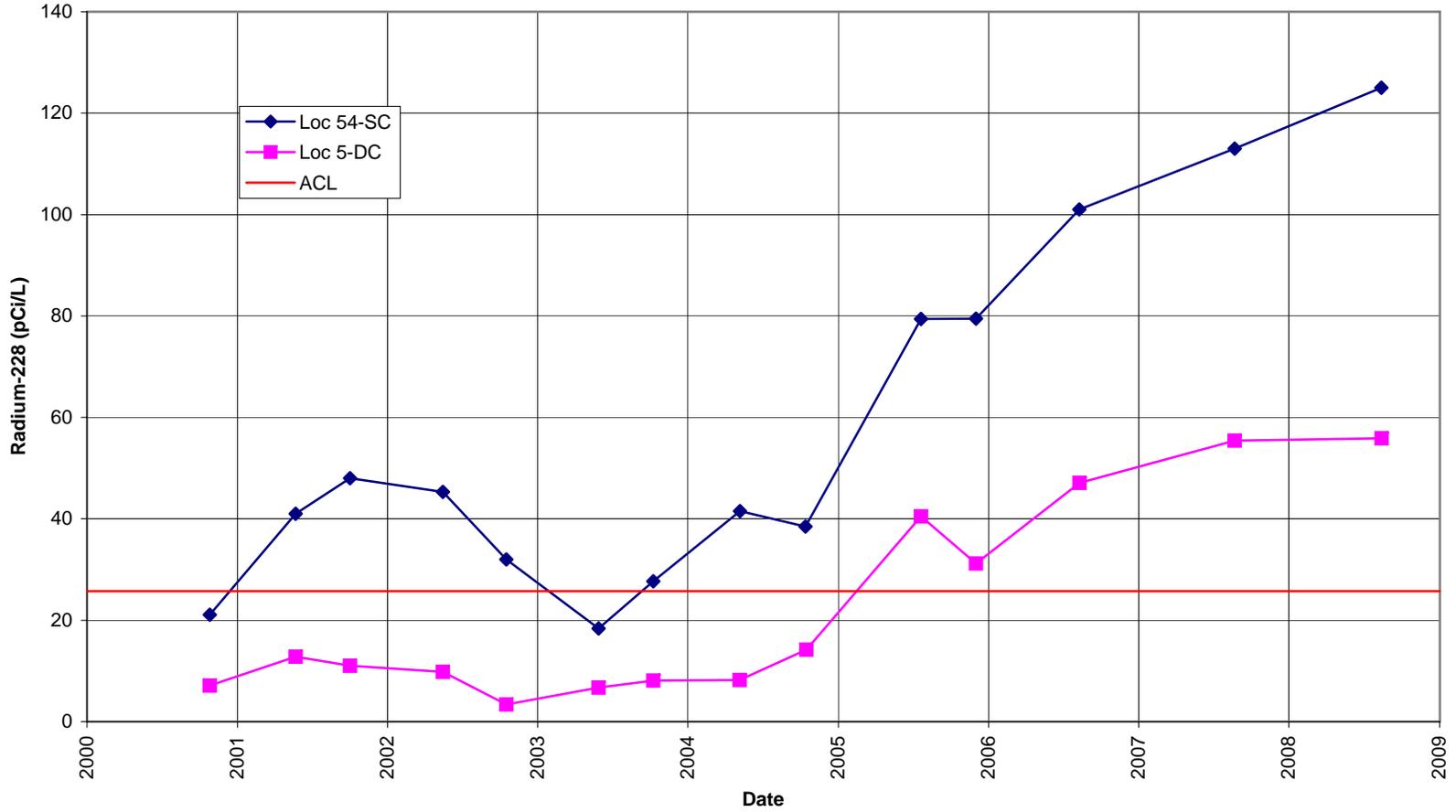


Figure 5-3. Radium-228 Concentrations in Wells MW-5-DC and MW-54-SC Since Completion of the Disposal Cell

The LTSP specifies that this report provide iso-concentration maps for uranium and sulfate. However, the four original wells in the upper sand aquifer and the three original wells in the main sand aquifer do not provide sufficient data points to develop contour maps of the contaminant plumes. Instead, 2008 concentrations for uranium in the two aquifers are shown on Figures 5-4 and 5-5, and concentrations for sulfate are shown on Figures 5-6 and 5-7. There were no significant changes in uranium concentrations from 2007 to 2008; concentrations in MW-5-SC indicate a slight downward trend. Sulfate concentrations were within the range of historical results with no apparent trends.

Groundwater contour maps are also specified in the LTSP; however, insufficient data points are provided through the existing well network to develop them. Regional (pre-mining) groundwater flows are generally to the north-northeast for the upper sand aquifer and to the east for the main sand aquifer. However, local flow directions were altered by mining and dewatering activities at Pit 4 on the site and Pathfinder Pit 33 north of the site. Water elevations in the upper sand aquifer wells, based on 2008 measurements, continue to indicate a northeast groundwater flow direction (Figure 5-8). This direction is comparable to the flow direction predicted for the year 2010 in the Petrotoomics Company ACL application prepared in 1996. Water elevations in the three main sand aquifer wells, all located on the same line, are essentially equal and do not provide a means to determine flow direction. The estimated northeast flow direction shown on Figure 5-9 is the predicted 2010 flow direction included in the ACL application and likely represents current site conditions.

### 5.3.5 Photographs

Photograph Location Number	Azimuth	Description
PL-1	5	Boundary monument BM-23 at the fence corner.
PL-2	195	The lower disposal cell cover and the rock-armored slope of the upper cell surface.
PL-3	190	Perimeter sign P13 and the rock-armored slope of the upper cell surface.
PL-4	220	Ponded water and wetland vegetation along the toe of the rock-armored slope of the upper cell surface.
PL-5	0	Ponded water at the base of the north swale discharge point.
PL-6	0	Rock-armored southwest channel and cattle near the PMF channel.
PL-7	0	Rock-armored slope of the disposal cell dam.
PL-8	210	View of Pit 4 area.
PL-9	175	Wetland area in the bottom of Pit 4.
PL-10	270	Land slump on a side slope of Pit 4.

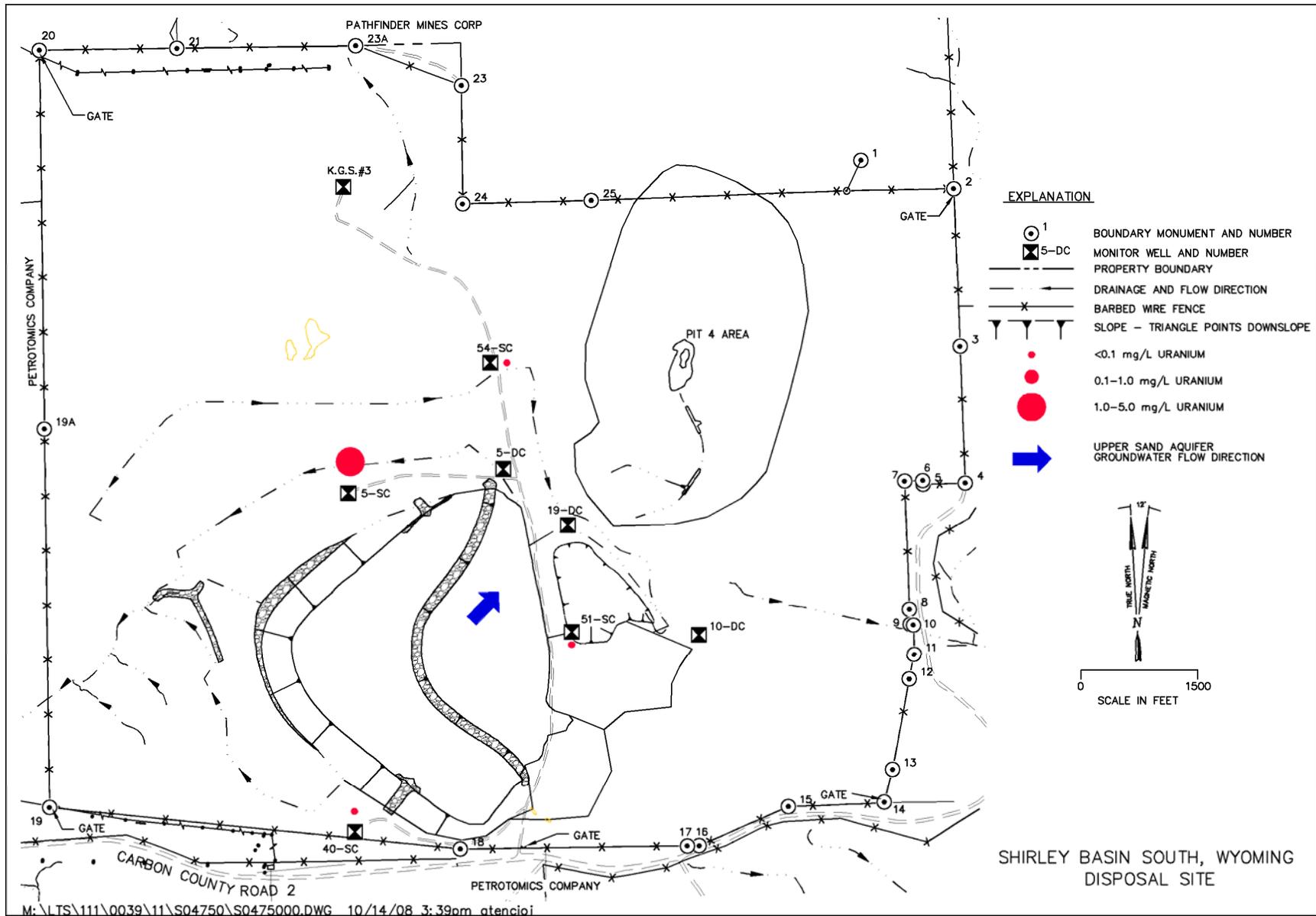


Figure 5-4. August 2008 Uranium Concentrations in the Upper Sand Aquifer at the Shirley Basin South, Wyoming, Disposal Site

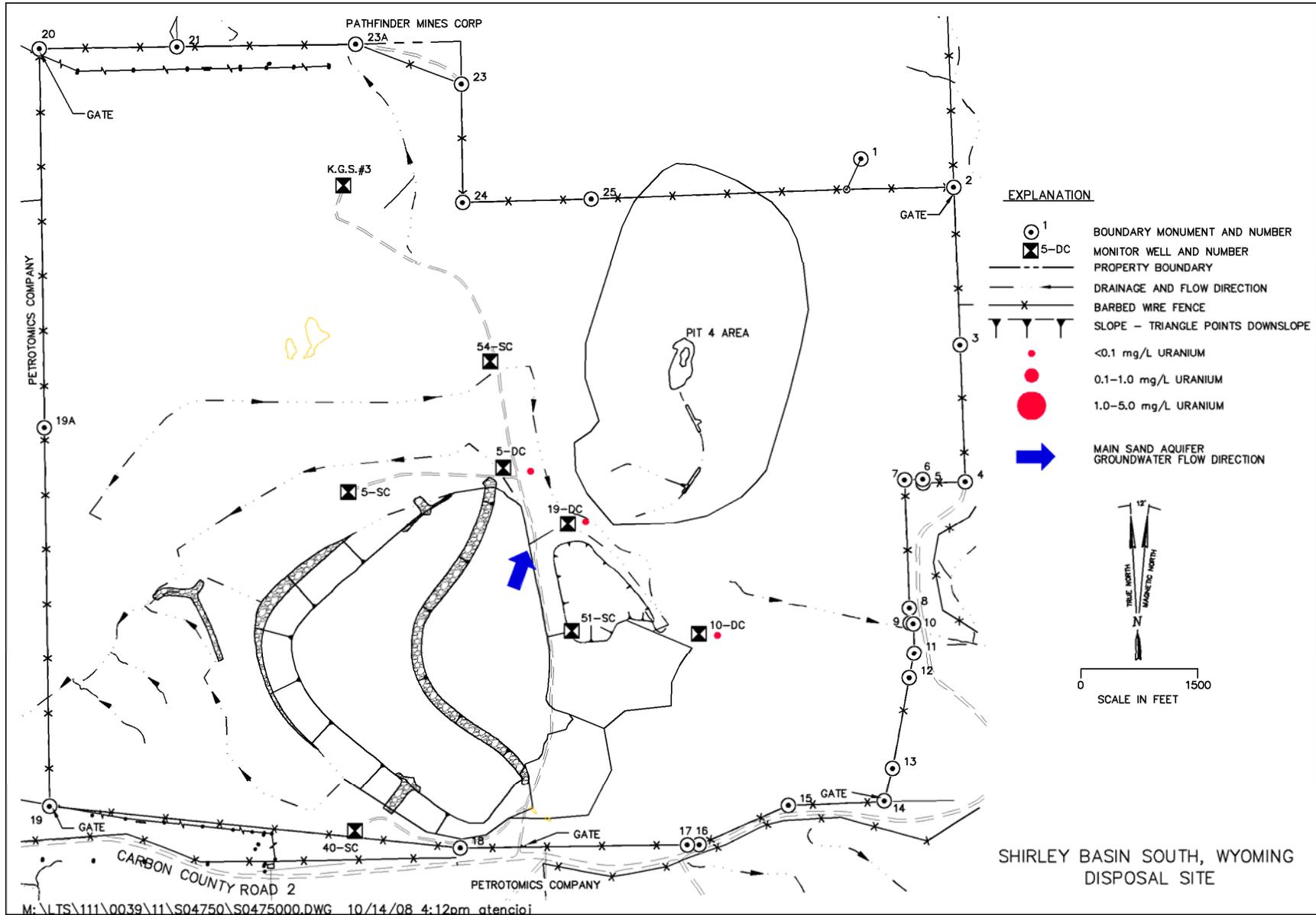


Figure 5-5. August 2008 Uranium Concentrations in the Main Sand Aquifer at the Shirley Basin South, Wyoming, Disposal Site

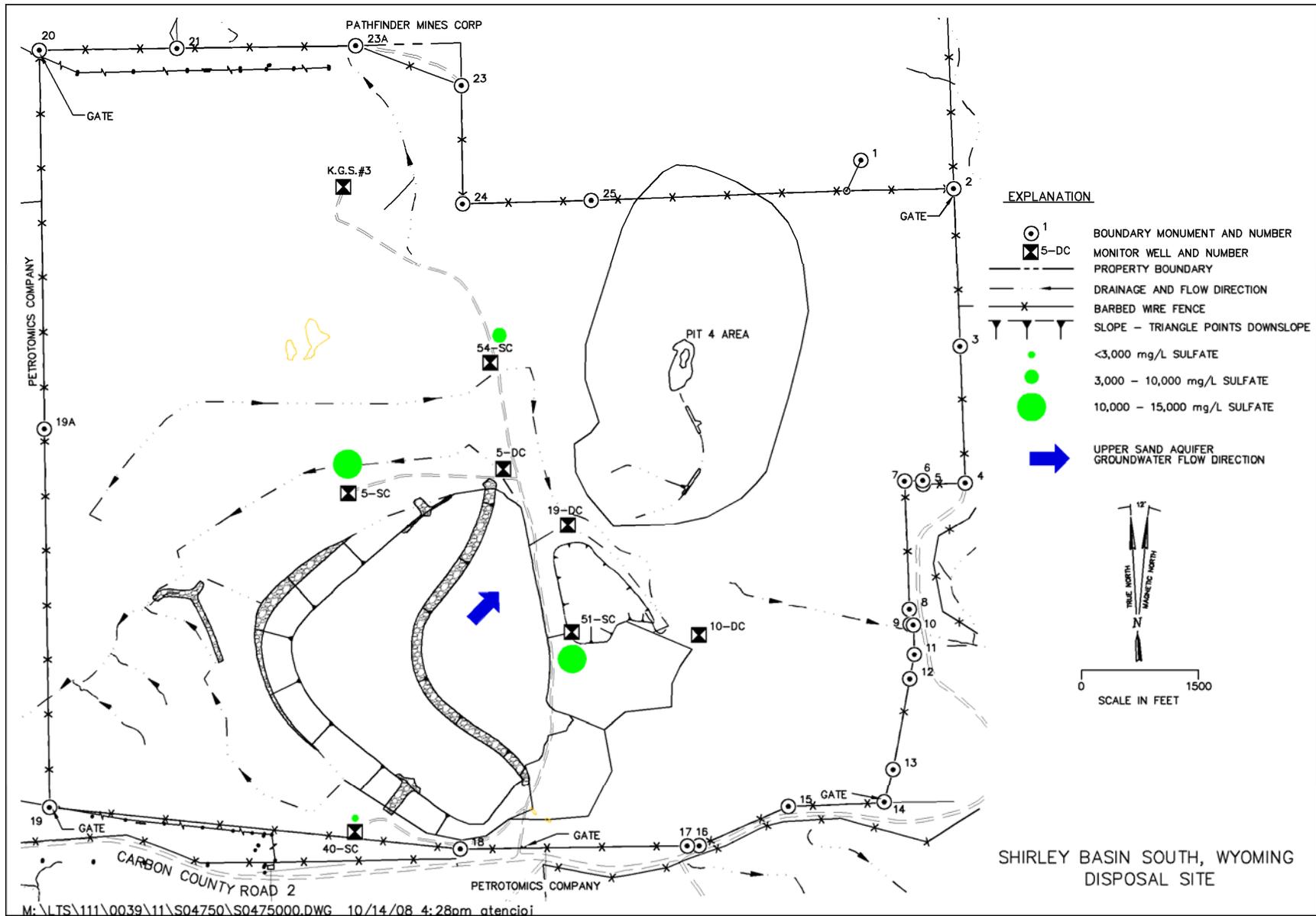


Figure 5-6. August 2008 Sulfate Concentrations in the Upper Sand Aquifer at the Shirley Basin South, Wyoming, Disposal Site

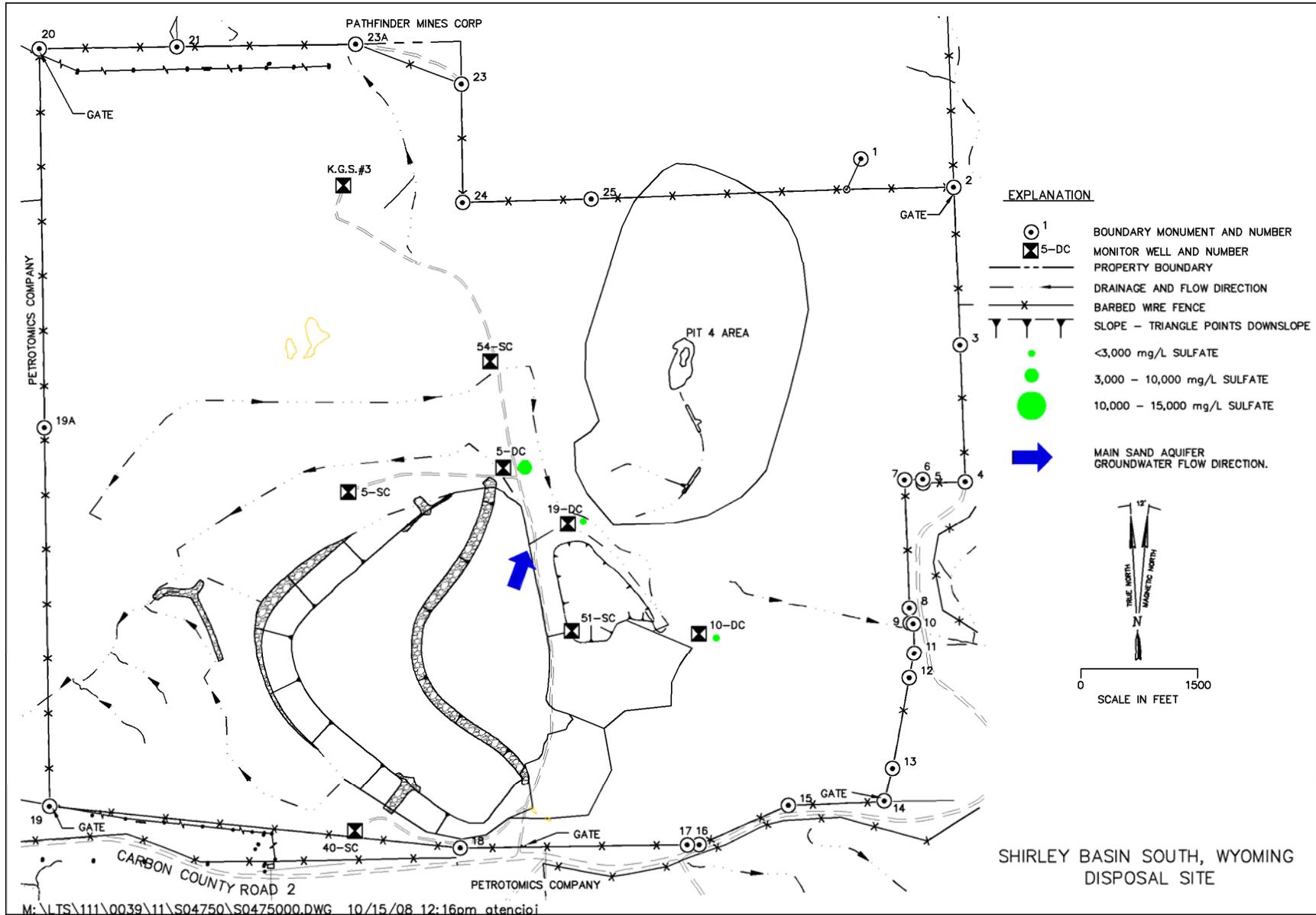


Figure 5-7. August 2008 Sulfate Concentrations in the Main Sand Aquifer at the Shirley Basin South, Wyoming, Disposal Site

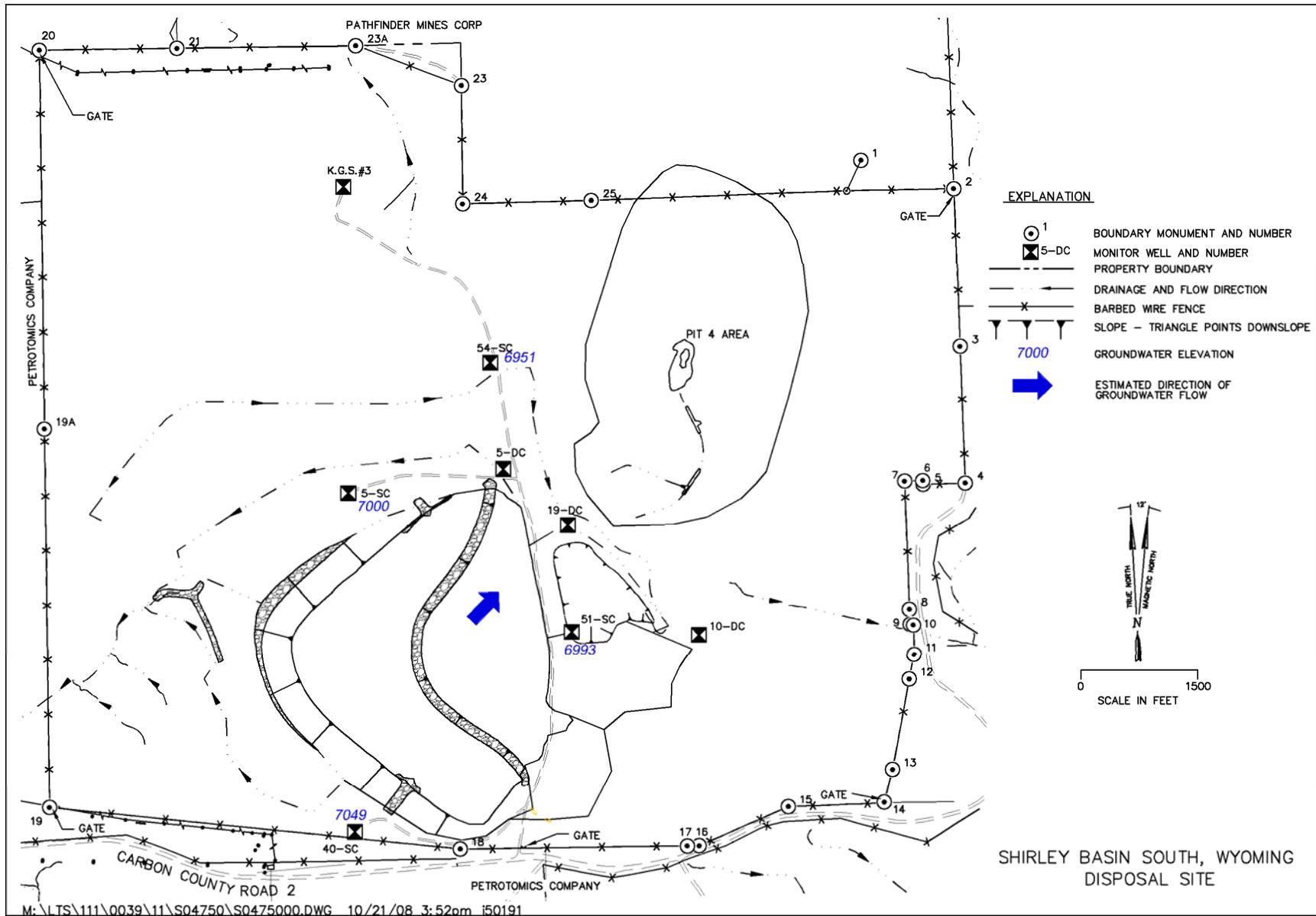


Figure 5-8. Groundwater Elevations and Estimated Flow Direction in the Upper Sand Aquifer at the Shirley Basin South, Wyoming, Disposal Site

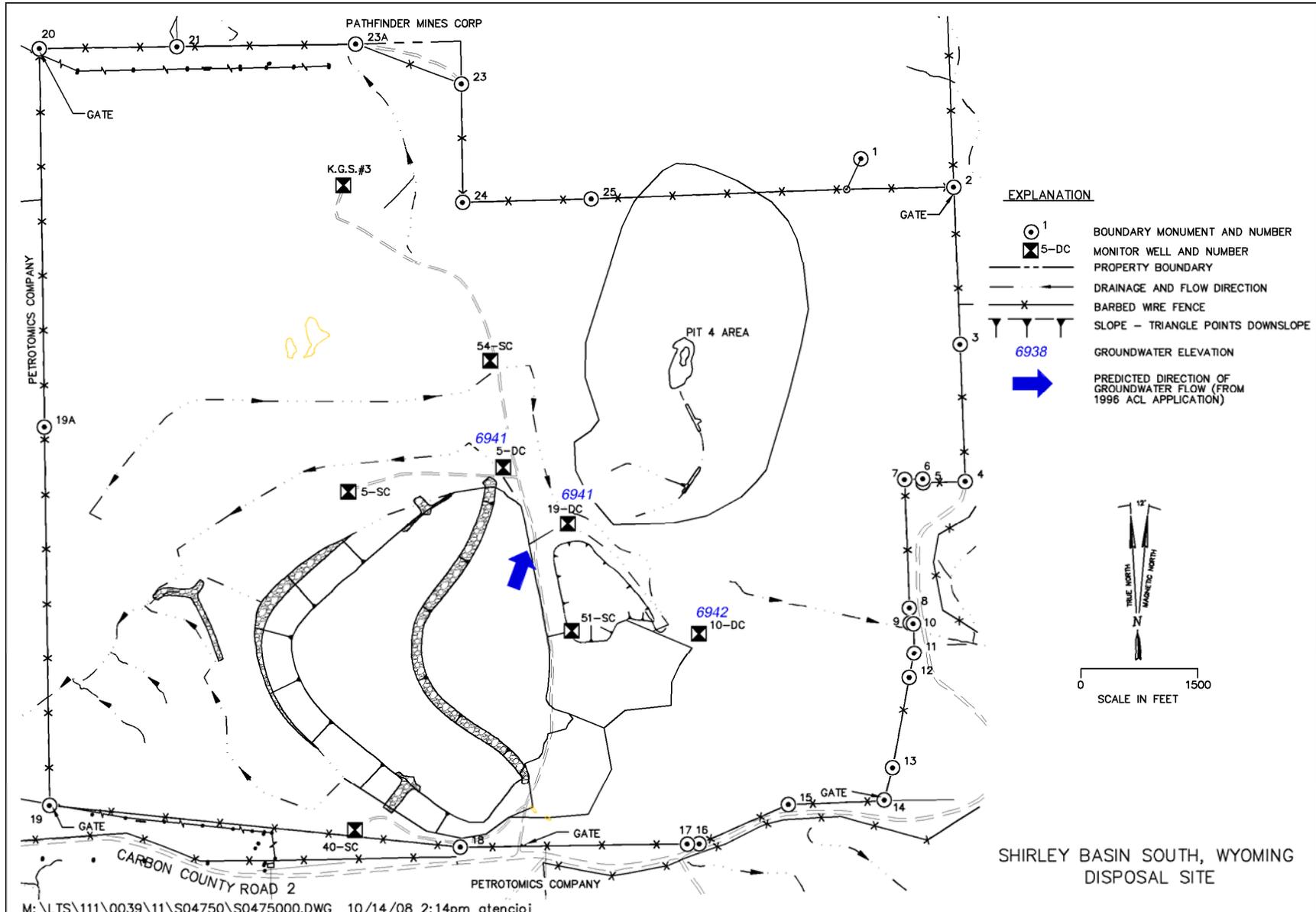


Figure 5-9. Groundwater Elevations and Estimated Flow Direction in the Main Sand Aquifer at the Shirley Basin South, Wyoming, Disposal Site



*SBS 6/2007. PL-1. Boundary monument BM-23 at the fence corner.*



*SBS 6/2007. PL-2. The lower disposal cell cover and the rock-armored slope of the upper cell surface.*



*SBS 6/2007. PL-3. Perimeter sign P13 and the rock-armored slope of the upper cell surface.*



*SBS 6/2007. PL-4. Ponded water and wetland vegetation along the toe of the rock-armored slope of the upper cell surface.*



*SBS 6/2007. PL-5. Ponded water at the base of the north swale discharge point.*



*SBS 6/2007. PL-6. Rock-armored southwest channel and cattle near the PMF channel.*



*SBS 6/2007. PL-7. Rock-armored slope of the disposal cell dam.*



*SBS 6/2007. PL-8. View of Pit 4 area.*



*SBS 6/2007. PL-9. Wetland area in the bottom of Pit 4.*



*SBS 6/2007. PL-10. Land slump on a side slope of Pit 4.*

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