October 19, 2005

Mr. T.W. Hardgrove
Manager, Reclamation Operations
Pathfinder Mines Corporation
935 Pendell Boulevard
Mills, WY 82644

SUBJECT: AMENDMENT OF SOURCE MATERIAL LICENSE SUA-442 FOR ALTERNATE CONCENTRATION LIMITS, PATHFINDER MINES CORPORATION, SHIRLEY BASIN SITE, CARBON COUNTY, WYOMING, AMENDMENT 57 (TAC LU0095)

Dear Mr. Hardgrove:

By letter dated April 3, 2000, Pathfinder Mines Corporation (PMC) submitted a license amendment application requesting alternate concentration limits (ACLs) for four hazardous ground-water constituents (selenium, uranium, radium-226 & -228, thorium-230) at its Shirley Basin, Carbon County, Wyoming, uranium mill tailings site. A revised application was submitted on August 29, 2001, that addressed issues raised in a July 20, 2001, request for additional information (RAI). Following further staff RAIs and PMC submittals, the U.S. Nuclear Regulatory Commission (NRC) staff prepared a draft Environmental Assessment (EA) dated December 24, 2002. Comments were subsequently received from various State and Federal agencies which led to additional investigations and analyses by PMC. Additionally, during the comment period, PMC proposed ACLs for three nonhazardous constituents (chloride, sulfite, and total dissolved solids). A final (EA) was issued on August 3, 2005, which addressed agency comments regarding the draft EA.

NRC staff has documented its review of the licensee's requested amendment in a technical evaluation report (Enclosure 1), in which the staff determined that the proposed hazardous and nonhazardous ACLs would be protective of human health, safety, and the environment. Approval of the requested modifications required wording changes to License Conditions 47 and 50. The revised license, reissued as Amendment No. 57 to Source Materials License SUA-442, is enclosed (Enclosure 2). If you have any questions regarding this letter or the enclosures, please contact Mr. Stephen J. Cohen, at (301) 415-7182 or via e-mail to sjc7@nrc.gov.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/NRC/reading-rm/adams.html.

Sincerely,

/RA/

Gary S. Janosko, Chief
Fuel Cycle Facilities Branch
Division of Fuel Cycle Safety
and Safeguards
Office of Nuclear Material Safety
and Safeguards

Docket No.: 40-6622
License No.: SUA-442

Enclosures: Technical Evaluation Report
Amendment No. 57 to License SUA-442

cc: M. Thiesse, WDEQ
M. Moxley, WDEQ
J. Wagner, WDEQ
R. Plieness, DOE-GJO
D. Wichers, COGEMA

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TECHNICAL EVALUATION REPORT
ALTERNATIVE CONCENTRATION LIMITS APPLICATION
PATHFINDER MINES CORPORATION
SHIRLEY BASIN SITE, CARBON COUNTY, WYOMING

Docket No.: 40-6622 **License No.:** SUA-442

DATE: October 6, 2005

FACILITY: Pathfinder - Shirley Basin, Wyoming

TECHNICAL REVIEWERS: William von Till, Dick Codell, Stephen J. Cohen

PROJECT MANAGER: Stephen J. Cohen

SUMMARY AND CONCLUSIONS

By letter dated April 3, 2000, Pathfinder Mines Corporation (PMC) submitted a license amendment application requesting alternate concentration limits (ACLs) for four hazardous ground-water constituents (selenium, uranium, radium-226 & -228, thorium-230) at its Shirley Basin, Carbon County, Wyoming, uranium mill tailings site (the Site) (PMC 2000a). U.S. Nuclear Regulatory Commission (NRC) staff conducted an acceptance review with several comments issued by letter dated May 4, 2000. PMC provided responses by letter dated June 1, 2000 (PMC 2000b). A request for additional information (RAI) was sent to PMC by letter dated July 20, 2001 (NRC 2001). PMC responded by letters dated August 29 (PMC 2001a) and October 15, 2001 (PMC 2001b), and satisfactorily addressed most of the staff's concerns. Attached to the August 29, 2001, letter was a revised ACL license amendment application.

At that time, remaining open issues included the source term concentration used in the fate and transport model and the proposed compliance monitoring. NRC staff visited the Site on July 30, 2002, and met with PMC personnel. Subsequently, PMC submitted information to the NRC by letter dated August 21, 2002 (PMC 2002a). By memorandum dated October 4, 2002, NRC staff concurred with PMC's modeling approach (NRC 2002a). An acceptable compliance monitoring program was submitted by PMC on November 21, 2002 (PMC 2002b), and on December 24, 2002, NRC staff issued a draft environmental assessment (EA) supporting a Finding of No Significant Impact (FONSI) for the proposed amendment (NRC 2002b).

NRC staff received comments from the following agencies: Wyoming Game and Fish Department (WGFD) (WFGD 2003), U.S. Fish and Wildlife Service (FWS) (FWS 2003), U.S. Environmental Protection Agency (EPA) (EPA 2003), and the Wyoming Department of Environmental Quality (WDEQ) (WDEQ 2003(a)). Except for the WFGD, which had no comments, agency comments exhibited a few main themes: an environmental impact statement (EIS) would have been more appropriate than an EA; the Draft EA did not sufficiently discuss alternatives to ACLs; and turning off the system would result in unacceptable levels of pollution in Spring Creek.

NRC staff reviewed the need for an EIS and determined that an EA would be appropriate and could support a FONSI. However, NRC staff, in an RAI dated September 15, 2003, requested that PMC explore additional alternatives (NRC 2003a). PMC provided an alternatives analysis by letter dated November 14, 2003 (PMC 2003). NRC staff also reviewed the technical aspects of deactivating the entire corrective action system at once and determined that such a deactivation would not significantly impact water quality in Spring Creek. This determination was supported by fate and transport modeling performed by PMC and accepted by NRC staff.

In some of its comments, WDEQ also expressed concerns regarding the lack of water quality and biological data from Spring Creek. NRC staff incorporated this request into the aforementioned RAI dated September 15, 2003. As a result, PMC performed additional investigations to obtain aquatic biological, surface water quality, and hydrologic data, from Spring Creek, Fox Creek, Mine Creek, Murdock Creek, and the Little Medicine Bow River. PMC submitted a report presenting the results of these investigations in January 2005 (Intermountain Resources 2004)(Hydro-Engineering 2005). WDEQ also requested that NRC staff require ACLs for chloride, sulfate, and total dissolved solids (TDS). PMC submitted nonhazardous constituent ACLs by letter dated November 14, 2003 (PMC 2003).

A final EA was issued on August 3, 2005, that addressed agency comments by incorporating additional requested information and modifying proposed license amendments presented in the December 24, 2002, draft EA (NRC 2005). Those modifications included an expansion of the monitoring network, increased monitoring frequency, and an agreement by PMC to leave the corrective action system in place for at least the first year, in the event additional active remediation is required.

Based on the staff's review of the PMC submittals, agency comments, and associated responses, the staff recommends the approval of the proposed ACLs. NRC staff finds that the ACLs are protective of human health and the environment; are as low as reasonably achievable (ALARA); and PMC adequately considered other corrective action alternatives. The required monitoring program and the ability to reactivate the corrective action system provide adequate protection in the event that modeling predictions are incorrect.

TECHNICAL EVALUATION

Background

The Site is a former uranium milling facility that operated from 1971 through 1992. A total of 8,564,130 tons of ore were processed using a conventional acid leaching procedure. The facility is located in the sparsely populated Shirley Basin mining area of Wyoming with the nearest residence located 4.8 kilometers (3 miles) to the east and the nearest downgradient residence located 9.6 kilometers (6 miles) from the Site. The Site contains two tailings impoundments; the No. 4 impoundment occupies 158 acres, and the No. 5 impoundment occupies 135 acres (see Figure 1). Seepage from these impoundments has impacted ground water in the Surficial aquifer, which discharges in its entirety to Spring Creek located east of the impoundments. Spring Creek flows into Little Medicine Bow River approximately 4.8 kilometers (3 miles) southeast of the Site. According to WDEQ Surface Water Classification List, Spring Creek is a Class 2C surface water (non-drinking water, known to or has potential to support non-game fish populations) (WDEQ 2001a). By letter dated January 3, 2003, WDEQ stated that ground water at the Site long term surveillance plan (LTSP) boundary must meet Class I ground-water standards (WDEQ 2003). Baseflow in Spring Creek through reach adjacent to the Site is 0.017 cubic meters per second (cms) (0.6 cubic feet per second (cfs)), and the area receives an average of 48 cm (11 inches) of precipitation annually.

Regulatory Framework

Ground-water protection programs for Title II uranium mill and tailings sites per 10 CFR Part 40, Appendix A, Criterion 5, must include the following four elements:

C A list of site-specific hazardous constituents per criterion 5B(2);

C Ground-water concentration limits (or standards) for these constituents;

C A compliance location where the concentration limits must be met; and

C A time period during which compliance is required.

Criterion 5B(5) requires that the concentration limits for individual constituents must not exceed:

1) The Commission-approved background concentration of a constituent in the ground water;

2) The respective value given in Table 5C of Appendix A if the constituent is listed in that table and if the background level of the constituent is below the value listed (which correspond to EPA's maximum concentration limits (MCLs) for drinking water);

3) An ACL limit established by the Commission.

   Criterion 5B(6) of Appendix A states that ACLs can be established on a site-specific basis, provided the following is demonstrated:

   a) The constituents will not pose a substantial present or potential hazard to human health or the environment, as long as the ACLs are not exceeded.

   b) The ACLs are ALARA, after considering practicable corrective actions.

Licensee's Amendment Request

The current standards in PMC's license are the following:

arsenic = 0.05 mg/l, barium = 1.0 mg/L, beryllium = 0.02 mg/L, cadmium = 0.01 mg/L, chromium = 0.05 mg/L, gross alpha = 15 pCi/L, lead = 0.05 mg/L, molybdenum = 0.10 mg/L, nickel = 0.05 mg/L, radium-226 and 228 = 5.0 pCi/L, selenium = 0.01 mg/L, thorium-230 = 0.3 pCi/L, and uranium = 0.07 mg/L.

PMC is proposing ACLs for four hazardous constituents and three nonhazardous constituents listed in Table 1. Because the NRC has exclusive regulatory authority at this Site, NRC staff is requiring ACLs for nonhazardous, as well as hazardous ground-water constituents to address WDEQ concerns regarding water quality degradation.

Table 1
Proposed Point of Exposure (POE) and ACL Concentrations

Constituents	Current Standards	Model-Predicted POE Concentration	Proposed ACLs (POC[1] NP-01)	Proposed ACLs (POC RPI-19B)
Uranium (mg/l)	0.07	0.15	4.400	4.45
Selenium (mg/l)	0.01	0.0056	0.158	0.163
Ra-226 + Ra-228 (pCi/l)	5.0	1.50	12.70	13.76
Thorium-230 (pCi/l)	0.3	0.28	5.53	5.76
Chloride (mg/l)	None	118	3,275	3,712
Sulfate	None	183	4,612	5,056
Total Dissolved Solids (TDS)	None	649	11,529	12,641

1. Point of Compliance

Current concentrations of the constituents in Table 1 are below the ACLs (PMC 2005) at the POC. For example, uranium concentrations in wells NP-01 and RPI-19B are 0.08 and 0.07 mg/l, respectively. Future concentrations of constituents in Table 1 are also expected to be below the proposed ACLs. Therefore, PMC also requests permission to discontinue active ground-water remediation, so long as the standards are not exceeded. Predicted POE concentrations are expected to be consistent with class of use. For example, a comparison of the proposed chloride concentration to the WDEQ numeric water quality standard (WDEQ 2001b) indicates that the predicted POE concentrations would be below the current standard for chloride (230 mg/l, chronic aquatic standard). Also, a review of the WDEQ ground-water standards indicates that all nonhazardous constituents would be below the Class 1 standards (250 mg/l chloride, 250 mg/l sulfate, 500 mg/l TDS), except TDS at the peak concentration. All nonhazardous constituents would also be below the livestock use standards (2,000 mg/l chloride, 3,000 mg/l sulfate, 5,000 mg/l TDS), which is the current and expected future use of Surficial aquifer ground water.

Environmental Setting

Geology

The uppermost geologic unit is the Surficial deposit, which was formed *in-situ* from underlying geologic materials. This unit is a maximum of 21 meters (70 feet) thick and overlies 3 to 18 meters (10 to 60 feet) of claystone and siltstone. Underlying the claystone and siltstone is the White River Formation divided into lower and upper members. The lower member of the White River Formation is a tuffaceous siltstone interbedded with claystone, sandstone, tuff, conglomerate, and limestone in some areas. The upper member is a tuffaceous siltstone interbedded with very coarse sandstone and boulder conglomerate.

Underlying the White River Formation is the Wind River Formation, which is the mined unit at the Site. The Wind River Formation is generally an interbedded siltstone and sandstone with considerable amounts of interbedded lignite. The Wind River Formation is approximately 152 meters (500 feet) thick. Two members comprise the Wind River Formation, the Lower and Main Wind River units.

Surface Water

Surface waters in the vicinity of the Shirley Basin tailings include Spring Creek and its tributaries Fox Creek and Mine Creek, the Area 2/8 reclamation reservoir, the Area 3 reclamation reservoir, and the industrial pond. Flow in Mine Creek originates largely from fresh water injection associated with the corrective action system and will likely cease after system deactivation. The industrial pond will be modified during tailings reclamation to serve as a surge/detention pond. As a result, this pond would be dry much of the year, as it will contain only surface water runoff. Reclamation reservoirs are fed by both surface runoff and ground water and, therefore, will always contain water.

As previously stated, Spring Creek is designated as Class 2C surface water (warm water fisheries, non-drinking water, known to or has potential to support non-game fish populations). Spring Creek is a perennial stream, and it eventually flows into the Little Medicine Bow River approximately 4.8 km (3 miles) southeast of the tailings area. Spring Creek receives approximately 13 percent of its baseflow from Surficial aquifer discharge, as it flows past the Site.

In July 2004, PMC measured stream flows and sampled surface water and stream sediments in Spring Creek, Mine Creek, Fox Creek, Little Medicine Bow River, and Murdock Creek, as part of a surface water quality assessment. Results of the study indicated that flows in Spring Creek were approximately 0.017 cms (0.6 cfs), and no measurable surface water quality impacts from the tailings were identified. Sediment samples from Mine Creek exhibited the highest uranium concentrations of the samples collected during the study. According to PMC, this result was likely due to high evaporation rates near this particular sampling point located within a boggy area. Evaporation at the boggy area sampling location concentrates and sequesters metals and salts. This evaporation and concentration process would likely continue until the injection wells are deactivated.

Ground Water

The Surficial aquifer is the saturated unit of primary concern at the Site; it occurs in a confined state under the tailings and an unconfined state between the tailings and Spring Creek. Claystone and siltstone underlie the Surficial aquifer and act as a bottom confining layer. Underlying the claystone and siltstone is the White River aquifer, which is also confined below by claystone and siltstone. Below the White River aquifer confining layers is the Wind River aquifer. The Wind River Aquifer is subdivided into the Main Wind River and the Lower Wind River aquifers. These aquifers are separated by a claystone and siltstone aquitard. Uranium was mined from the Main and Lower Wind River members in open pits adjacent to the tailings facility.

Seepage from the tailings has impacted portions of the Surficial aquifer at the Site; consequently, this is the aquifer for which site standards and corrective actions were developed. Ground water in the Surficial aquifer flows east of the tailings and discharges to Spring Creek. Most of the ground water discharging to Spring Creek is conveyed through more permeable materials in the Mine Creek area. The Surficial aquifer is of limited extent, bounded by the reclaimed Area 2/8 pit on the west side of the tailings and by Spring Creek on the east side (see Figure 1).

Surficial aquifer recharge originates from infiltrating precipitation, seepage from the tailings, and the fresh water injection associated with the current corrective action system. Fresh water injection rates exceed collection well extraction rates from the Surficial aquifer forming a ground-water mound or hydraulic barrier. Deactivating the corrective action system will result in the elimination of the ground-water mound and a reduction in saturated thickness of the Surficial aquifer near areas of injection. Pre-mining and post-reclamation potential yield from the Surficial aquifer is dramatically limited by the relatively small recharge area to this local ground-water system. Most of the affected aquifer area is contained within the long-term care boundary (surface use to be restricted by the Federal government).

By letter dated January 3, 2003, WDEQ stated that ground water leaving the Shirley Basin site long-term care boundary must meet Class I, Domestic Use standards. WDEQ based this requirement on the fact that concentrations of nonhazardous substances (e.g., sulfate, chloride, TDS) fall below the respective Class I standards (WDEQ 2003b). A review of the WDEQ's Quality Standards for Wyoming Ground Waters indicates that expected peak chloride and sulfate concentrations meet the Class I standards (WDEQ undated); however, TDS might exceed the Class I standards. This is not expected to be an issue because, as discussed later, toxicity and cancer risks due to TDS are insignificant, especially since the Surficial aquifer is not a likely future source of potable water.

PMC performed an investigation to determine whether ground-water flow, and consequently contamination could flow below Spring Creek and contaminate ground water east of the creek. Investigation results were originally presented in August 2001 and were reiterated in a letter dated January 11, 2005 (PMC 2005). PMC's investigation consisted of installing wells east of Spring Creek, measuring water levels, and modeling ground-water flow. Results of this investigation indicated that hydraulic gradients east of Spring Creek were actually directed west toward Spring Creek; therefore, contamination from the Site would not likely flow below Spring Creek. By letter dated August 11, 2005, WDEQ noted that two wells east of the creek contained elevated concentrations of TDS and uranium. WDEQ also states that the source is not likely the Site considering that gradients are toward Spring Creek; therefore, they are considering other sources (WDEQ 2005).

Background Water Quality

Background ground-water quality at this Site has been monitored since 1979 using well MC-14 which is north of the tailings. Water quality in well MC-14 reflects the derivation of some Surficial aquifer materials from natural uranium mineralization. Naturally higher levels of radiological constituents are expected in this ground water due to contact with this mineralization. Concentrations of uranium and thorium-230 measured at the background well, routinely exceed the Site standards, and measured uranium concentrations in Spring Creek upstream of the Site (SW1A) approach the Federal drinking water standard of 0.03 mg/l.

Table 2 presents the average background water quality for Surficial aquifer well MC-14, using data from 1979 to 2000. Background ground-water quality, as measured at well MC-14, has remained relatively consistent.

Table 2
Summary of Background Ground-Water Quality Concentrations

Constituents	No. of Samples	Concentrations in Well MC-14			
		Minimum	Maximum	Median	Mean
Uranium, mg/l	61	0.01	0.13	0.08	0.08
Thorium-230, pCi/l	49	<0.20	3	0.2	0.4
Ra-226+228[1], pCi/l	24	0.2	19.5	1.47	2.99
Selenium[1], mg/l	38	<0.001	0.015	<0.001	0.002
Gross Alpha, pCi/l	24	<1.0	25.6	2.2	5.33
Barium[1], mg/l	25	<0.02	0.05	<0.20	0.2
Chloride, mg/l	79	<1.00	17.9	5.3	6
Sulfate, mg/l	79	12.4	129	24	26
TDS, mg/l	71	186	594	347	350

[1] More than 50 percent non-detects

Background surface water quality values were developed by sampling Spring Creek at upgradient sampling location SW1A. Table 3 contains the background surface water quality values.

Table 3
Summary of Background Surface Water Quality Concentrations

Constituents	Concentrations in Sample Location SW1A				
	Mean	**St. Dev.**	**Median**	**Minimum**	**Maximum**
Uranium, mg/l	0.0387	0.0451	0.0216	0.0146	0.203
Thorium-230, pCi/l[1]	0.1563	0.1548	<0.2	<0.2	0.6
Ra-226+228[1], pCi/l[2]				<1.2	<1.4
Selenium, mg/l	0.0018	0.0009	0.002	<0.001	0.003
Chloride, mg/l	10.8	13.8	2.77	<1.0	40.1
Sulfate, mg/l	31.7	27.2	18.5	13.2	92
TDS, mg/l	284.5	101.3	249	196	525

1. 93.8 percent non-detects
2. 100 percent non-detects

<u>Current and Future Water Uses</u>

Currently no downstream or downgradient residential surface water or ground-water users exist within 9.6 km (6 miles) of the tailings area. The nearest ranch (residence) is approximately 4.8 km (3 miles) east of the tailings area and is located in the Little Medicine Bow River drainage east of Spring Creek. This residence is upstream of the Spring Creek/Little Medicine Bow River confluence and is outside the Surficial aquifer zone. Consequently, no hydraulic communication exists in surface water or Surficial aquifer ground water between the tailings and the ranch site. Surface water in Spring Creek is currently used by livestock and wildlife.

Future foreseeable uses of water from the Surficial aquifer in this area are not expected to change. Residential or commercial development in the region is highly unlikely due to the relatively isolated and inhospitable environment. The limited extent of the local Surficial aquifer and the accessibility of deeper and more productive aquifers should limit its potential use.

<u>Ecology</u>

In response to concerns from the WDEQ, NRC staff requested that PMC perform a benthic macroinvertebrate study and physical stream survey to document water and habitat quality within Spring Creek and some tributaries. These investigations were performed within upstream and downstream reaches, as well as those adjacent to and within the Site.

Macroinvertebrate samples were collected at eleven locations in Spring Creek, Fox Creek, Mine Creek, Little Medicine Bow River, and Murdock Creek. Samples were analyzed by documenting the particular species and abundance of organisms in each sample. This data was used to perform the Wyoming Stream Integrity Index (WSII), Macroinvertebrate Scoring. This system uses macroinvertebrate abundance, diversity, and the presence of certain sensitive species to calculate a rating. Based on the ratings, an assessment might be drawn regarding overall stream health.

According to the results, upstream sampling locations (SP1A, SP1, and FC1) were rated as poor. Sampling locations adjacent and immediately downstream of the Site (SP2A, SP3, SP4) were all rated as fair. Sampling location SP5, which is upstream of the Spring Creek/Little Medicine Bow River confluence was rated as poor. These results indicate that the Spring Creek reach adjacent to the Site of a higher quality than reaches upstream and downstream. Therefore, contaminated ground water does not appear to be impacting Spring Creek. PMC attributes the poor ratings upstream and downstream of the Site to cattle grazing near the stream that in-turn affected macroinvertebrate habitat.

One impact of the ACL option is that deactivating the corrective action system could affect macroinvertebrate communities by virtue of lowering hydraulic gradients. Lower hydraulic gradients would likely result in lower discharges to Spring Creek, resulting in lower baseflows. Lower baseflows could affect macroinvertebrate abundance and diversity. However, NRC staff does not view this as a significant impact because the ACL option would return the Spring Creek aquifer to a state that more closely resembles pre-mining conditions.

Current Remedial Actions

Ground-water corrective actions started in 1984 with extraction near the base of impoundment No. 5. Over time, injection wells were added on the No. 5 dam and downgradient of the collection (extraction) wells, and more collection wells were added to enhance the restoration system. PMC implemented a tailings dewatering program consisting of a series of extraction wells that have removed a substantial portion of the drainable water from the tailings. The current corrective action system includes ground-water extraction using 19 wells and fresh water injection downgradient of the extraction wells. Fresh water injection along the No. 5 dam ceased in late 2003 to allow PMC to start tailings reclamation.

PMC also discontinued tailings water extraction to allow for tailings reclamation and because water yields from the tailings diminished significantly. Reclaiming and covering the tailings impoundment would effectively minimize the quantity of contaminated seepage entering the Surficial aquifer system; conversely, continuing tailings dewatering would not have effectively improved containment. A limited number of tailings monitoring wells have been preserved to allow for future water level monitoring in the tailings impoundment

While the current system has not achieved ground-water protection standards for four hazardous constituents, it has sequestered contaminated ground water, promoted aquifer restoration, and reduced ground-water flow toward Spring Creek. Currently, PMC has extracted more than 330 million gallons of water from the Surficial aquifer and has injected more than 788 million gallons of fresh water through 2004. Also, PMC extracted approximately 516 million gallons of water from the tailings.

Assessments and Modeling

Spring Creek is the proposed POE. PMC conducted ground-water flow, fate and transport modeling to estimate the concentrations at a particular point in Spring Creek downstream of the Site; this location is referred to as the POE for modeling purposes. Predicted peak concentrations are presented in Table 1. Exposure and hazard assessments were subsequently performed using ground-water and fate and transport modeling results.

Ground-Water Flow Modeling

Ground-water flow modeling was performed to estimate the effects of three remediation scenarios on ground-water flow (PMC 2001a, Appendix D). PMC used MODFLOW, which is a 3-dimensional finite difference model for this effort. A two-layered model was used to represent the site; the upper layer represented the tailings impoundments, and the lower layer represented the Surficial aquifer. Scenario 1 assumed that the entire corrective action system was deactivated at the time of the model (year 2000). Scenario 2 assumed that the corrective action system was operated until mid-2001, and Scenario 3 represented continued corrective actions for an extended period until the end of 2004.

The actual model was constructed using a grid 77 rows by 177 columns with varying grid sizes. Finer grids were used over the area between Spring Creek and the tailings impoundments. The tailings impoundments were modeled as an unconfined aquifer. Hydraulic conductivity values varied from 0.024 ft/day for the slimes (finer grained materials) to 18 ft/day for the more granular material. Specific yield was set to a uniform value of 0.12.

The Surficial aquifer was modeled as a confined aquifer below the tailings impoundments and an unconfined aquifer between the tailings and Spring Creek. Hydraulic conductivities were varied between 0.01 and 70.0 ft/day to account for higher conductivities in the Mine Creek area. Storage coefficient (confined portion) and specific yield (unconfined portion) were 0.0001 and 0.10, respectively. Drains, rivers, collection/injection wells, and ground-water recharge were also accounted for in the model.

Results from Scenario 1 indicated that seepage from the tailings impoundments decreased from 5 to 3.4 gpm at the end of a 12-year simulation. Ground-water discharge to Mine Creek decreased from 3.9 to 1.7 gpm and discharges to Spring Creek decreased from 56 to 24 gpm. The ground-water mound formed by the fresh water injection system dissipated in 2 to 3 years.

Results from Scenario 2 indicated that seepage from the tailings impoundment was approximately 2.6 gpm approximately 1.5 years after dewatering is discontinued in 2001 and drops to approximately 1 gpm by year 2050. Discharge to Mine Creek decreases from a peak of 12 gpm to approximately 1.5 gpm, and discharge to Spring Creek decreases from 81 gpm to 23 gpm over the 50-year simulation period. Again the ground water mound due to injection dissipated over 2 to 3 years. PMC modified Scenario 2 by deactivating all injection and extraction by the end of year 2000. Although the ground-water mound decayed sooner, effects on tailings seepage rates were minor. It should be noted that fresh water injection caused peak discharges to Mine and Spring Creeks in Scenario 2 to be larger than those in Scenario 1.

Scenario 3 assumed that tailings dewatering continued until the end of 2004; fresh water injection ceased in mid-2001; and ground-water extraction continued until the end of 2002. Seepage control benefits were minor despite the additional corrective actions. Discharge to Mine Creek decreased from a 12-gpm peak to 1.5 gpm in the 19-year simulation period. Discharge to Spring Creek decreased from 81 gpm to 22 gpm over the simulation period. It should be noted that fresh water injection caused peak discharges to Mine and Spring creeks in Scenario 3 to be larger than those in Scenario 1. This modeling effort indicates that extended use of the corrective action system does not provide a substantial seepage reduction benefit.

Transport Modeling

MT3D was used to model constituent transport in the Surficial aquifer at the Site (PMC 2001a, Appendix E). This model incorporates the cell-specific output of MODFLOW and uses the same model features (i.e. grid setup). PMC used MT3D to model Scenario 2 with a start time of January 2000 and 1.5 years of continued remedial action using the No. 5 dam injection wells and the downgradient extraction/injection system.

PMC used conservative assumptions for dispersion and attenuation data input. Longitudinal dispersivity was set at 10, and the ratio of transverse or vertical dispersivity to longitudinal dispersivity was 0.2. Initial constituent concentrations in the tailings were assumed to be uniform so the dispersion process had little impact on the model. Adsorption and decay were not considered in the model, and a retardation factor of 1 was used. Therefore, ground-water contamination was assumed to migrate at the same rate as convective velocity. This model also assumes that PMC deactivated the corrective action system in 2001.

Contaminant transport was simulated for 50 years for uranium, thorium-230, selenium, radium-226 and -228, chloride, and TDS. Peak concentrations at the POE were estimated by compositing constituent concentrations in Mine Creek and Spring Creek. Results for uranium indicated that a peak POE concentration of 0.15 mg/l would occur in 2011. Thorium-230 would exhibit a peak concentration of 0.28 pCi/l in 2011. Table 1 contains peak POE concentrations of the remaining constituents. The Sulfate POE concentration was scaled from the TDS concentration. By memorandum dated October 4, 2002, NRC staff concurred with PMC's modeling results (NRC 2002).

Exposure Assessment

Human exposures to the metals of concern were evaluated based on two scenarios (PMC 2001a, Appendix A). The Spring Creek scenario assumed that water in Spring Creek was used for livestock watering and irrigating fields and home gardens. Potable water came from a well drilled below the Surficial aquifer because the surficial aquifer was not expected to contain enough water to sustain a household. The Little Medicine Bow River scenario assumed that drinking water came from a well drilled into alluvium with the same water quality as the river itself.

Table 4 presents the results of the exposure assessment.

Table 4
Exposure Assessment Results

	Spring Creek Scenario					Little Medicine Bow Scenario				
Dose	U_{Tox}	Se	U_{Rad}	Th	Ra	U_{Tox}	Se	U_{Rad}	Th	Ra
	mg/d-kg	mg/d-kg	pCi/d-kg	pCi/d-kg	pCi/d-kg	mg/d-kg	mg/d-kg	pCi/d-kg	pCi/d-kg	pCi/d-kg
Food	3.98 E-05	2.54 E-05	1.29 E-02	4.79 E-07	3.30 E-05	1.74 E-05	2.02 E-05	3.03 E-03	0.00 E+00	4.71 E-06
Total	3.98 E-05	2.54 E-05	1.29 E-02	4.79 E-07	3.30 E-05	3.22 E-04	3.84 E-05	9.58 E-02	0.00 E+00	3.09 E-04

U_{Tox} = Uranium Toxicity; U_{Rad} = Uranium Radiological Effects

A review of these results indicates that the food and total doses are the same for the Spring Creek scenario, which reflects the fact that drinking water would be obtained from a deeper aquifer. Doses for the Little Medicine Bow River scenario would be lower from food because of the lower concentrations of constituents present in this river. However, total dose is higher reflecting the fact that these constituents are being ingested by consumption of drinking water from an alluvial aquifer that is of similar water quality to the Little Medicine Bow River. Generally, even the most conservative scenario (Little Medicine Bow River) produces low intake values. Intakes from the Little Medicine Bow River scenario were used in the human health hazard assessment.

Human Health Hazard Assessment

A human health hazard (toxicity) assessment was performed to document the effects of the exposures discussed above on human health. Constituents of concern fell into four categories: chemical toxins or carcinogens (selenium), both chemical toxins and radiological hazards (uranium), carcinogens due to radiological properties (radium and thorium), and constituents with low or little known toxicity (chloride, sulfate, TDS). For calculating chemical toxicity effects, total constituent concentrations including background were used. Constituent concentrations above background were used to calculate carcinogenic effects.

Considering a uranium intake of 0.022 mg/day, the calculated uranium concentration in the kidney would be 0.005 µg/g. This is significantly below the 0.3 µg/g limit that is the no observed adverse effect level (PMC 2001a, Appendix B). Therefore, it is unlikely that the uranium toxicity limit would be exceeded.

For selenium the reference dose for this assessment was 0.005 mg/kg-day based on research, which demonstrated that selenium intakes of 0.853 mg/day for an adult resulted in no clinical toxicity (PMC 2000a, Appendix B). The predicted selenium intake in drinking water and food was 3.8E-05 mg/kg-day. This intake is significantly below the 0.005-mg/kg-day reference dose; therefore, no additional risk from selenium is expected.

Cancer risks for uranium, thorium-230, and radium-226 and -228 were calculated for radionuclide ingestion. Results of this analysis indicated that total increase risk of cancer from ingesting all the aforementioned radionuclides over 30 years is 3.9E-06, which is 4 percent of the NRC criterion of 1.0E-04 (NRC 2003b). Considering that this scenario is the most conservative, the total cancer risk is quite low. Cancer risks from inhaled and ingested dusts were considered insignificant.

Environmental Hazard Assessment

An environmental hazard assessment was performed to evaluate risks to aquatic and terrestrial species due to the constituents of concern (PMC 2001a, Appendix C). Types of species addressed in this assessment included terrestrial plants, terrestrial mammals and birds, soil invertebrates, and aquatic life (i.e., fish, macroinvertebrates). Results of this assessment indicated no probable toxic or radiological dose effects.

As previously stated, PMC performed a biological assessment, habitat assessment, and water quality study on Spring Creek and its tributaries in 2004. The purpose of these studies was to document existing conditions in these water bodies and determine if tailings seepage from the Shirley Basin site is currently impacting adjacent surface waters. Results of the biological and habitat investigations indicated that the reach of Spring Creek adjacent to the Site is of a higher quality than some upstream and downstream reaches. According to PMC, upstream and downstream cattle grazing has reduced riparian vegetation and viable macroinvertebrate habitat in those reaches. Results of water quality sampling indicated that tailings seepage was not impacting Spring Creek.

Site Visits

Several Site visits were conducted in support of this review by NRC staff. Staff visited the Site on June 20, 2001, and met with PMC representatives and their consultant. The Site visit focused on the location of the POE (Spring Creek), other land uses, characterization of the contaminant plume, and Site characteristics. NRC staff also inspected additional monitoring wells requested by the agency, as well as stream sampling locations. Livestock use was observed in the area adjacent to Spring Creek and the PMC property. The group briefly spoke with the rancher who works that area. His residence is in another ground-water system that would not be affected by the ground-water contamination since the surficial ground water seeps into Spring Creek.

Staff visited the Site on July 30, 2002, to resolve issues regarding the fate and transport model. PMC installed several additional monitoring wells to better delineate the boundaries of the contaminant plume and submitted additional information to support its source term concentration used in the model. The licensee’s model of a decrease in uranium concentration in the ground water caused by neutralization of the acidic tailings was supported by oxidation/reduction data. Furthermore, oxidation potentials are likely to diminish once the cover is in place because less oxygenated water will be able to seep into the ground. All issues raised by NRC staff were adequately addressed by PMC.

Corrective Action Assessment/ALARA

Based on the total average pumping rates provided in the 2004 Annual Hydrologic Report, it appears that the current corrective action system is approaching the point of diminishing returns. According to the aforementioned report, 14 of the 19 collection wells yield an annual average of less than 1 gallon per minute (gpm). Low well yields are primarily due to water table lowering due to significant seepage reduction from the tailings impoundments; discontinuation of recharge along the No. 5 dam; reduced injection downgradient of the collection wells from the loss of WR-20 (large capacity supply well); an ongoing drought; and well efficiency losses. Continued pumping at low well yields would not likely produce a substantive pollutant reduction benefit considering that the corrective action system has currently drawn back ground-water contamination to within the vicinity of the extraction wells. PMC has demonstrated that it has reduced ground-water contaminant levels ALARA by the implementation of active corrective action for over 20 years.

While it is clear that the corrective action system contained contamination, system deactivation would likely result in downgradient contaminant migration. PMC's hydrogeologic and contaminant transport models indicate that the net water quality impact would likely be negligible. These models incorporate conservative assumptions, such as no retardation in the aquifer, although some retardation is likely to occur. Also, the actual source term would likely be smaller because the corrective action system was operated 4 years beyond the point assumed in the model. Furthermore, deactivating the system along with capping the tailings would result in lower hydraulic gradients toward Spring Creek, due to decreased recharge. Lower hydraulic gradients translate to lower ground-water velocities, more retardation opportunities, and lower stream discharges.

Remedial Alternatives

Descriptions of remedial alternatives were provided by PMC in an RAI response letter dated November 14, 2003 (PMC 2003).

<u>No-Action Alternative (Continued Operation of Corrective Action System)</u>

The current ground-water corrective action system consists of Surficial aquifer collection wells located between the tailings area and Spring Creek and fresh water injection wells downgradient of the collection wells. A second set of injection wells was previously located atop the No. 5 dam; however, these were abandoned to allow for tailings reclamation. Collection wells serve to intercept seepage-impacted ground water and prevent downgradient migration. Fresh water injection between the collection wells and Spring Creek is used to increase gradients towards the collection system, accelerate the restoration process, and preclude ground-water contamination migration toward Spring Creek.

Operating the current corrective action system would cost approximately $70,000 per year; over 5 years the total cost would be $350,000. Annual operating cost would likely increase, as well, because low well efficiencies cause more frequent well pump malfunctions and well re-development. Consequently, the overall system cost-effectiveness would depreciate to the point beyond which continued operation would be fruitless. Therefore, NRC staff did not consider this option viable.

Extended Dewatering of Tailings

PMC presented an alternative that included extended tailings dewatering. However, tailings dewatering ceased at the end of 2003 because of low yields from the tailings wells. In 2001, PMC was dewatering tailings at a total rate (all dewatering wells) of 52 gpm. This rate dropped to 6.7 gpm by 2003. These low yields indicated that only a minimal amount of free water existed; therefore, continued dewatering would be of little benefit. Conversely, completing the tailings cover would isolate the tailings and further minimize seepage, which is a significant benefit. Therefore, extended tailings dewatering was eliminated from further consideration.

Interceptor Trench

An interceptor trench would perform essentially the same function as the existing Surficial aquifer ground-water collection system, which is to extract ground water along a specific alignment downgradient of the contaminant source. The alignment for such a trench would be roughly the same as the existing collection well system. Trench dimensions would be 9 to 12 meters (30 to 40 feet) deep and approximately 762 meters (2,500 feet) long. Total volume of excavation to install the interceptor trench in this configuration would be approximately 190,840 cubic meters (250,000 cubic yards).

An interceptor trench would have the operational advantage of consolidating ground-water collection to a single point. Operationally, trench yields would likely diminish rapidly considering that no artificial recharge would be available and the area is still under severe drought conditions. Operation of the trench would also dewater the Surficial aquifer to the point where yields would be too low to be viable. Consequently, baseflows in Spring Creek could be impacted to a greater extent than the ACL or No-Action alternatives.

PMC estimates the cost to install the interceptor trench system at $840,000, reflecting the anticipated difficulties in installing a trench system to a depth below the current water table. Considering the high estimated cost, the benefit realized at the POE would not be significant. The current system has already removed a significant amount of ground-water contamination and has substantially reduced the size of the contaminated area. Furthermore, the current corrective action system has contributed to water table reductions that would decrease the amount of time the interceptor trench would produce significant yields. This option was, therefore, eliminated from further consideration.

Permeable Reactive Barrier

PMC reviewed the use of permeable reactive barriers (PRBs) using zero-valent iron (ZVI) as the treatment agent. The maximum PRB depth would approach 21 meters (70 ft) to completely penetrate the Surficial aquifer, and its length could approach 1,525 meters (5,000 ft). A funnel-and-gate arrangement would likely be the lower cost PRB configuration for this Site; funnel-and-gate PRBs consist of an impermeable barrier that directs water to a central opening filled with a treating agent (i.e., ZVI). According to PMC, sources in the literature indicate that PRBs successfully reduced uranium and metals concentrations (PMC 2003). However, years after installation, the effectiveness or porosity of the ZVI media may decline to the point where the media requires replacement/rejuvenation or removal and disposal. If the porosity of the media is reduced, the funnel-and-gate arrangement becomes a cutoff wall. It is also unclear whether or not

PRBs would treat nonhazardous constituents or if these substances would affect PRB effectiveness.

This alternative would provide little significant benefit to the ground-water resource because the funnel-and-gate arrangement would restrict the viable production zones of the Surficial aquifer to those immediately downgradient of the gate. Also, decreased flow downgradient of the PRB would reduce baseflows in Spring Creek, potentially impacting aquatic communities to a greater degree than the ACL and No-Action alternatives. Comparing the PRB and the ACL alternative, the actual difference in performance would likely be immeasurable at the POE. This is because both alternatives would reduce ground-water discharge to Spring Creek, consequently decreasing pollutant loads, and any pollutant loading to Spring Creek would be significantly diluted by a much larger baseflow.

Installing a PRB would cost approximately $20,000,000, based on a comparison of the proposed PRB with existing ones. The combination of high capital costs, extension of reclamation/restoration schedule for construction, unquantifiable benefits, and open questions regarding PRB longevity make this option unattractive. Therefore, this option was dismissed from further consideration.

Bioremediation

Bioremediation for the reduction of concentrations of uranium and other metals has been successful at some sites for both ground water and surface water. For the Shirley Basin site, the approach to bioremediation would likely entail a series of injection wells to supply nutrients and potentially inoculate with bacteria and collection wells to increase hydraulic gradients to further distribute nutrients within the ground water. For bioremediation to be effective, injection and collection should occur in the Surficial aquifer below the tailings impoundment to immobilize the maximum amount of uranium possible. This has some disadvantages. First, it would delay tailings reclamation, which would maintain or potentially increase the quantity of contaminated seepage emanating from the tailings. Second, due to the significantly diminished well yields in this area, the ability of the bioremediation system to distribute nutrients and microbes is reduced.

Although not currently necessary, bioremediation would be required in the Surficial aquifer between the tailings and Spring Creek to address potentially untreated contaminated seepage that could emanate from the tailings area. Such a program would be counter-productive because treatment would be required for areas currently restored.

A bioremediation system with 3 years of operation and maintenance is estimated to cost approximately $680,000. This includes a series of new wells to distribute nutrients and the necessary water supply, water disposal, and nutrient injection equipment. A minimum operational time for such a system would likely be 3 years or more with attendant operation of the equipment to introduce nutrients into the injection stream. Considering the disadvantages and cost, this option was dismissed from further review.

Reducing Agent Injection

A reductant would be injected into the tailings to reduce the mobility of uranium and selenium. Distribution of the reductant within the Surficial aquifer would likely require additional injection and extraction points within the immediate tailings area similar to the bioremediation option.

This option presents some technical difficulties. Thoroughly distributing the reductant in the tailings would not likely be possible because of current low extraction rates. Also reductant distribution would not be consistent because some portions of the tailings exhibit low permeabilities. Reduction beyond the tailings would not be cost-effective because recharging oxidized water would constantly overcome the reducing agent. Therefore, reductants would have little effect between the tailings and Spring Creek. PMC also did not consider whether or not nonhazardous constituents would be addressed by the reductant.

The projected costs of implementing a reductant injection program would be very similar to those of the bioremediation program. The same distribution system with additional collection/injection wells would likely be required and similar water supply and water disposal systems would be necessary. With the same minimum operational time of 3 years, a cost estimate of $680,000 for bioremediation is considered appropriate for the reductant injection program. Considering the cost, technical difficulties, and an uncertain outcome, this option was eliminated from further review.

Tailings Flushing

Flushing the tailings by injecting fresh water is a technique utilized by Homestake Mining Company at its Grants, New Mexico, site. This approach could reduce constituent concentrations in the resident tailings water and the seepage from the tailings. However, such a program could only be utilized with a downgradient ground-water extraction and treatment system to capture potential seepage that may emerge from flushing.

This alternative has some disadvantages. The Homestake site utilized an alkali leach process, while the Shirley Basin site used acid leach. These types of processes could result in differing ground-water oxidation-reduction conditions impacting the effectiveness of the flushing technique. Injecting fresh water into the tailings has the same distribution problems described above for reducing agent injection. Water that remains in the tailings is much more difficult to extract as reflected by current declining dewatering rates. Injected water would first enter the more permeable tailings that have already been dewatered and would only intrude into or drive the residual solution out of low permeability zones after long-term maintenance of the injection head. Resaturation of the tailings could potentially reintroduce contamination into the Surficial aquifer beyond the tailings, a condition the NRC staff would not receive favorably. Therefore, this alternative was dismissed from further consideration.

COMPLIANCE MONITORING

Considering model uncertainty, to assure protection of human health and the environment, a ground-water monitoring program will be continued. For the first 1.5 years after corrective action system deactivation, bi-monthly sampling will occur at the two POC wells (NP01 and RPI-19B); wells P-6, MC-7, RPI-8A, MC-10, RPI-10, MC-11, MC-14 (background), RPI-14, RPI-16A, RPI-

18A, RPI-20A, RPI-21B; and the following five locations in Spring Creek: SW1A (background), SC-2 (POE), WEIR-2, SC-10 (POE), and POE-DS (downstream). After 1.5 years, PMC will sample all of the above ground-water and surface water locations quarterly. These wells and stream locations are spaced to adequately monitor migration of the ground-water contamination over time. Furthermore, if NRC staff determines that an exceedance has occurred, the sampling frequency will be increased to monthly until three monthly samples indicate that the exceedance has abated either naturally or through additional corrective actions. Figures 2 and 3 present the ground-water and surface water monitoring networks.

RECOMMENDED LICENSE CHANGE:

The revision to License Conditions 47 and 50 would read as follows:

47. Alternate Concentration Limits for chloride, radium-226 and 228, selenium, sulfate, thorium-230, total dissolved solids (TDS), and uranium were approved based on licensee submittals of April 3, 2000, June 1, 2000, August 29, 2001, October 15, 2001, August 21, 2002, November 21, 2002, June 18, 2003, September 26, 2003, November 14, 2003, and January 11, 2005. The licensee shall implement a ground-water compliance monitoring program containing the following:

    A. Sample point of compliance (POC) monitoring wells NP01 and RPI-19B; wells P-6, MC-7, RPI-8A, MC-10, RPI-10, MC-11, MC-14 (background), RPI-14, RPI-16A, RPI-18A, RPI-20A, RPI-21B; and five locations in Spring Creek: SW-1A (background), SC-2 (POE), WEIR-2, SC-10 (POE), and POE-DS (downstream) at the following frequencies and parameters:

        I. For the first 1.5 years after deactivating the corrective action system, all wells and Spring Creek sample locations listed in Section A shall be sampled bi-monthly for the following parameters: arsenic, barium, beryllium, cadmium, chromium, chloride, gross alpha, lead, molybdenum, nickel, nitrate, radium-226 and 228, selenium, sulfate, thorium-230, TDS, and uranium, and field parameters (pH, conductivity, and water level (ground water only)).

        ii. After the first 1.5 years of ground-water and surface water sampling, all wells and Spring Creek sample locations listed in Section A shall be sampled quarterly for all the parameters listed in paragraph A.i. above.

    B. Comply with the following ground-water protection standards at point of compliance wells NP01 and RP-19B, with background being recognized in well MC14:

        At well RPI-19B: arsenic = 0.05 mg/l, barium = 1.0 mg/l, beryllium = 0.02 mg/l, cadmium = 0.01 mg/l, chromium = 0.05 mg/l, chloride = 3,712 mg/l, gross alpha = 15 pCi/l, lead = 0.05 mg/l, molybdenum = 0.10 mg/l, nickel = 0.05 mg/l, radium-226 and 228 = 13.76 pCi/l, selenium = 0.163 mg/l, sulfate = 5,056 mg/l, thorium-230 = 5.76 pCi/l, TDS = 12,641 mg/l, uranium = 4.45 mg/l.

        At well NP01: arsenic = 0.05 mg/l, barium = 1.0 mg/l, beryllium = 0.02 mg/l, cadmium = 0.01 mg/l, chromium = 0.05 mg/l, chloride = 3,275 mg/l, gross alpha = 15 pCi/l, lead = 0.05 mg/l, molybdenum = 0.10 mg/l, nickel = 0.05 mg/l, radium-226 and 228 = 12.70 pCi/l, selenium = 0.158 mg/l, sulfate = 4,612 mg/l, thorium-230 = 5.53 pCi/l, TDS = 11,529 mg/l, uranium = 4.40 mg/l.

C. Submit, by March 1 and September 1 of each year, a ground-water monitoring report. The report shall contain results of ground-water and surface water sampling, a ground-water contour map for each sampling period, iso-concentration maps for chloride, radium-226 and 228, selenium, sulfate, thorium-230, TDS, and uranium; graphs illustrating concentration versus time for chloride, radium-226 and 228, selenium, sulfate, thorium-230, TDS, and uranium for wells MC-14, RPI-14, NP01, RPI-19B, RPI-18A, and surface water sampling locations SW-1A, SC-2, and POE-DS.

D. If a ground-water protection standard (as presented in License Condition 47.B) at the point of compliance is exceeded, the licensee shall notify the NRC within 30 days and shall increase the sampling frequency to monthly, until it is determined by the NRC staff, that a true exceedance has occurred. If NRC staff determines that a true exceedance has occurred, the licensee shall either restart the corrective action system, per License Condition 47.E, or otherwise comply with the requirements of 10 CFR 40, Appendix A, Criterion 5D, if the corrective action system has been removed. If NRC staff determines that a true exceedance has not occurred, the licensee shall revert back to the monitoring frequency specified in License Condition 47.A.

E. The licensee shall not remove any equipment that is part of the current corrective action system for at least 1 year after deactivating the system. After 1 year, the licensee may request a license amendment to remove the corrective action system equipment. Along with the license amendment request, the licensee shall provide ground-water monitoring data supporting the request to remove corrective action equipment. If NRC staff determines that an exceedance has occurred per License Condition 47.D, the corrective action system will be reactivated until three consecutive monthly samples indicate that the exceedances have been remediated.

[Applicable Amendments: 3, 7, 13, 15, 19, 22, 39, 57]

50. The licensee shall complete site reclamation in accordance with the approved reclamation plan in accordance with the following schedule.

A. To ensure timely compliance with target completion dates established in the Memorandum of Understanding with the Environmental Protection Agency (56 FR 55432, October 25, 1991), the licensee shall complete reclamation to control radon emissions as expeditiously as practicable, considering technological feasibility, in accordance with the following schedule:

(1) Windblown tailings retrieval and placement on the tailings pile - December 31, 1997.

(2) Placement of the interim cover to decrease the potential for tailings dispersal and e
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December 31, 2001.

(3) Placement of final radon barrier designed and constructed to limit radon emissions to an average flux of no more than 20 pCi/m^2/s above background - December 31, 2006.

B. Reclamation, to ensure required longevity of the covered tailings and ground-water protection, shall be completed as expeditiously as is reasonably achievable, in accordance with the following target dates for completion:

(1) Placement of erosion protection as part of reclamation to comply with Criterion 6 of Appendix A of 10 CFR Part 40 - December 31, 2006.

C. Any license amendment request to revise the completion dates specified in Section A must demonstrate that compliance was not technologically feasible (including inclement weather, litigation which compels delay to reclamation, or other factors beyond the control of the licensee).

D. Any license amendment request to change the target dates in Section B above, must address added risk to the public health and safety and the environment, with due consideration to the economic costs involved and other factors justifying the request such as delays caused by inclement weather, regulatory delays, litigation, and other factors beyond the control of the licensee.

[Applicable Amendments: 40, 43, 48, 52, 57]

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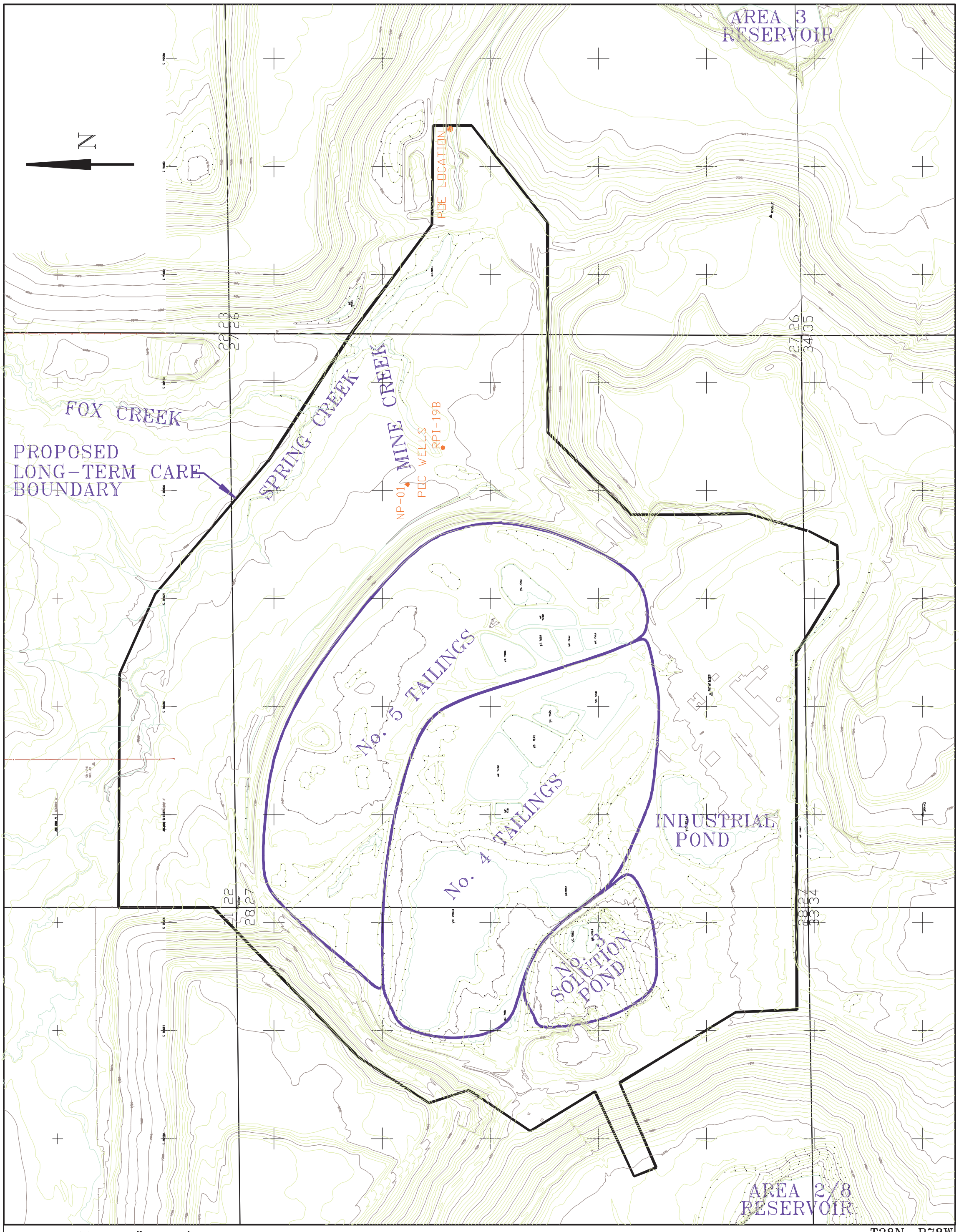

FIGURE 1. LOCATION OF SHIRLEY BASIN TAILINGS

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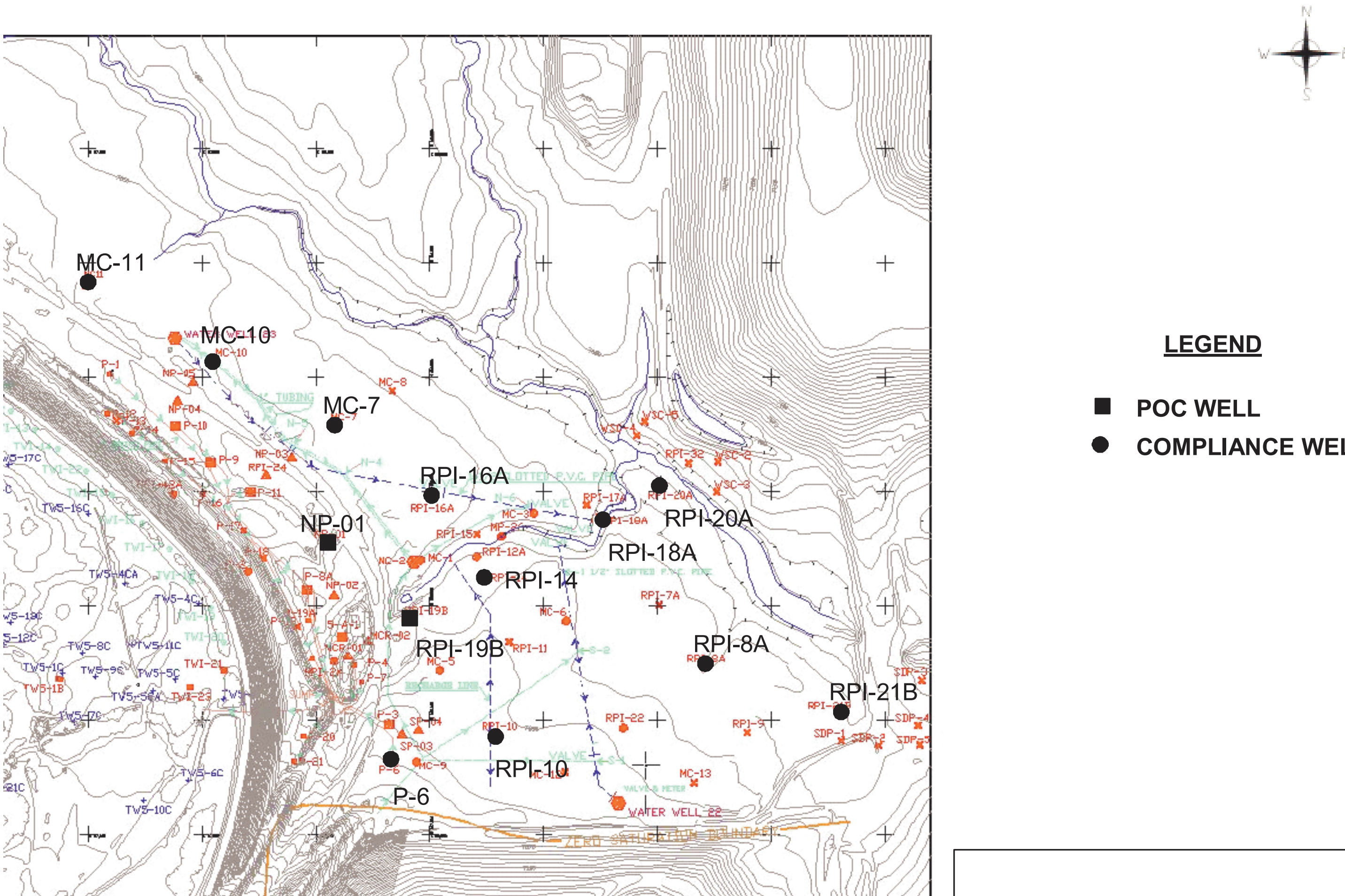

LEGEND

■ POC WELL

● COMPLIANCE WELL

FIGURE 2
GROUND-WATER COMPLIANCE MONITORING NETWORK

BASEMAP: PATHFINDER MINES CORPORATION, 2005

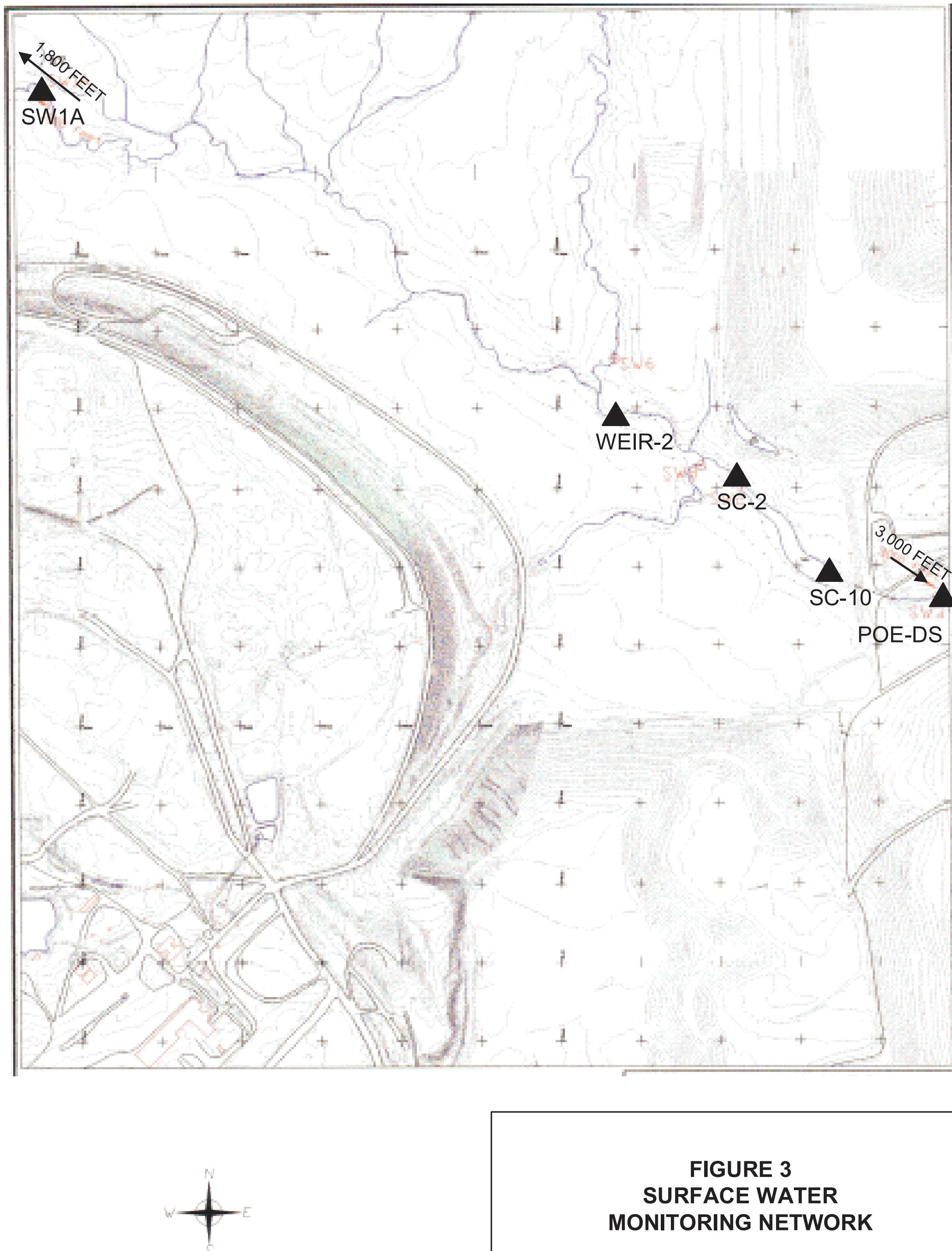

FIGURE 3
SURFACE WATER
MONITORING NETWORK

BASEMAP: PATHFINDER MINES CORPORATION, 2005