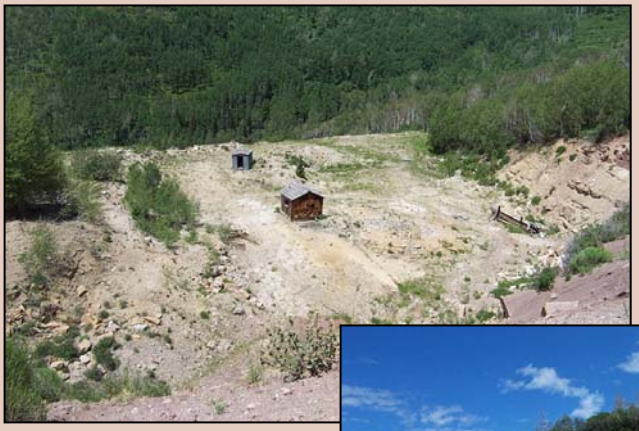
SITE ASSESSMENT REPORT
BUTTERFLY AND BURRELL MINES
RIO BLANCO COUNTY, COLORADO



Butterfly Mine

Burrell Mine

Prepared for

White River National Forest

December 20, 2005

Au' Authum Ki, Inc.
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(970) 241-8890

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1.0 INTRODUCTION

The United States Forest Service (USFS) White River National Forest (WRNF) retained Au' Authum Ki, Inc. (AAK) under Order Number 43-82D7-4-0038, "Butterfly and Burrell Mine Site Assessment." to assess potential human-health and ecological threats posed by waste rock and adit drainage at the Butterfly and Burrell Mines. The scope of work involved (1) preparing a Sampling and Analysis Plan (SAP) for water and a SAP for soil/waste rock describing the procedures to be used to assess each medium, (2) preparing a Site Safety and Health Plan (SSHP) describing the health and safety procedures and protocols to be implemented during the characterization effort, (3) measuring gamma-exposure rates at the mines, (4) collecting waste-rock and surface-water samples at the mines for laboratory analysis, (5) measuring radon levels within each mine portal and in a background area adjacent to the mines, and (6) conducting a screening-level risk evaluation to assess the relative hazards to human health and the environment posed by the mines.

The goal of the project was to obtain the information needed to accomplish the following objectives:

- Assess the general nature and extent of metals, inorganic, and radiological constituents, in the waste rock and surface water at the mines.
- Assess gamma exposure rates at each mine.
- Assess radon levels within each mine portal.
- Assess the relative hazards to human health and the environment posed by the mines on the basis of a screening-level risk evaluation.

2.0 MINE DESCRIPTIONS

The Butterfly and Burrell Mines are two abandoned uranium mines located on lands under the jurisdiction and control of the WRNF. The mines are located approximately 20 miles northeast of Meeker, Colorado, in the northwest ¼ of Section 25 and northeast ¼ of Section 26, Township 2 North, Range 92 West of the 6th Principal Meridian (Figures 2.1 and 2.2). Both mines are situated on the south facing slope of the Coal Creek drainage at an elevation of 8,920 feet above mean sea level (amsl). Coal Creek is a perennial stream that ultimately discharges to the White River. The mines were constructed for extraction of uranium-bearing ore from roll-front deposits in the Salt Wash Member of the Morrison Formation.

The Butterfly Mine consists of a primary adit (partially collapsed), a secondary adit adjacent to the primary adit (open), a collapsed ancillary adit located approximately 300 feet northwest of the primary

adit, a wood-sided cabin and small metal-sided shop, loadout/grizzly area, miscellaneous rusted mine debris (pipes, rails, timbers), and a waste rock dump (Figure 2.3 and Appendix A – Photographs). The mine bench covers approximately 63,000 square feet (1.4 acres), and the waste-rock dump covers approximately 55,000 square feet (1.3 acres). The toe of the waste-rock dump is approximately 800 feet from a perennial stream (referred to herein as the Butterfly Tributary) that discharges to Coal Creek. During site visits conducted by AAK and WRNF personnel in July 2004 and July 2005, ponded water was present within the primary mine adit but no perceptible flow from the adit was evident; no water was present within the secondary adit or outside of the collapsed ancillary adit.

The Burrell Mine consists of an adit, ore load-out area, miscellaneous mine debris (pipes, rails, timbers), and a waste-rock dump (Figure 2.3 and Appendix A – Photographs). The mine bench covers approximately 57,000 square feet (1.3 acres), and the waste-rock dump covers approximately 35,000 square feet (0.8 acre). The mine is situated approximately 1,700 feet from Coal Creek. No water is present at mine adit.

3.0 SITE INVESTIGATION

AAK conducted site investigation activities designed to obtain the information necessary to assess (1) the general nature and extent of metals, radiological constituents, and inorganic constituents in the waste-rock and surface water, (2) gamma-exposure rates on the mine benches, (3) radon levels in the mine adits, and (4) the relative hazards to human health and the environment posed by the mines on the basis of a screening-level risk evaluation. This information will allow the USFS to make informed decisions regarding the management of these abandoned mine lands.

3.1 Site Investigation Activities

Site investigation activities were conducted on July 6, 2005. Field work was performed by AAK employees, Mr. Bill Merrill and Mr. Bruce Smith. All work was performed in accordance with the *Site Safety and Health Plan – Uranium Peak AML Sits; Butterfly and Burrell Mines* (AAK, 2004a), *Uranium Peak ALM Sites – Sampling and Analysis Plan for Soils* (AAK, 2004b), and *Uranium Peak ALM Sites – Sampling and Analysis Plan for Water* (AAK, 2004c). Samples collected in support of the investigation were submitted to ACZ Laboratories, Inc., with offices located in Steamboat Springs, Colorado. The tasks performed to complete the investigation included:

- Collection of waste-rock and soil samples for laboratory analysis
- Collection of surface-water samples for laboratory analysis
- Radon monitoring within the open adit at each mine, abandoned cabin at the Butterfly Mine, and in a background area located between the two mine sites.
- General scan of gamma-exposure rates across the mine bench area at each mine.

Waste-rock and soil sampling locations are shown in Figure 3.1 and described as follows:

- Butterfly Mine
    - One near-surface (0- to 6-inch depth) composite background soil sample (UP-BKG) in an undisturbed area measuring 25 feet by 25 feet and located approximately 100 feet northwest of the Butterfly Mine waste-rock dump. The sample was analyzed for the parameters listed in Table 3.1.
    - One near-surface (0- to 6-inch depth) composite waste-rock sample (BFLY-01), consisting of six sub-samples from the loadout/grizzly area. A duplicate sample (WR-DUP) was prepared from the composite sample for quality assurance/quality control (QA/QC) purposes. The sample was analyzed for the parameters listed in Table 3.1.
    - One near-surface (0- to 6-inch depth) composite sample (BFLY-02), consisting of six sub-samples of the surficial material covering the primary mine bench area. The sample was analyzed for the parameters listed in Table 3.1.
    - One near-surface (0- to 6-inch depth) composite waste-rock sample (BFLY-03), consisting of six sub-samples from the waste-rock dump. The sample was analyzed for the parameters listed in Table 3.2 (includes synthetic precipitation leaching procedure [SPLP] analysis).
- Burrell Mine
    - One near-surface (0- to 6-inch depth) composite waste-rock sample (BUR-01), consisting of eight sub-samples from the mine bench. The sample was analyzed for the parameters listed in Table 3.1.
    - One near-surface (0- to 6-inch depth) composite sample (BUR-02), consisting of five sub-samples of the waste-rock dump. The sample was analyzed for the parameters listed in Table 3.2 (includes SPLP analysis).
    - One near-surface (0- to 6-inch depth) composite sample (BFLY-03), consisting of five sub-samples of the material comprising the loadout rib. The sample was analyzed for the parameters listed in Table 3.1.

The surface-water features of interest in this study include ponded water within the Butterfly adit, flow along the Butterfly Tributary downgradient of the Butterfly Mine, flow within Coal Creek both upstream

and downstream of the mines, and flow within an un-named tributary to Coal Creek that drains the south side of the Coal Creek drainage. The conceptual hydrologic model developed for the mine area is summarized as follows:

- Mine water present within the Butterfly Mine drains by either surface or surbsurface flow to the Butterfly Tributary which ultimately discharges to Coal Creek.

- Precipitation and runoff contacting the Butterfly Mine area drains by either surface or surbsurface flow to the Butterfly Tributary which ultimately discharges to Coal Creek.

- Precipitation and runoff contacting the Burrell Mine area drains by either surface or surbsurface flow to Coal Creek.

The analytical program for the surface-water sampling program is presented in Table 3.3. Surface-water sampling locations are shown in Figure 3.2 and described as follows:

- A background sample (BKG-1) was collected from a perennial tributary of Coal Creek, originating on the south side of the Coal Creek drainage area and located in the NE ¼ SW ¼ of Section 26, Township 2 North, Range 92 West of the 6th Principal Meridian. The sample was collected to assess constituent levels in water draining areas not impacted by mine operations.

- Samples “COAL CK UP” and “COAL CK DN” were collected from Coal Creek to assess potential water-quality impacts to Coal Creek as a result of mine operations. Sample “COAL CK UP” was collected from Coal Creek upstream of potential influences from the Butterfly or Burrell Mines. Sample “COAL CK DN” was collected from Coal Creek downstream of the Butterfly Tributary.

- One sample (BUTTERFLY GULLY) was collected from the Butterfly Tributary, approximately 350 feet upstream of its confluence with Coal Creek. The sample was collected to assess potential water-quality impacts resulting from potential discharges from the Butterfly Mine and runoff contacting the waste-rock dump.

- One sample (BUTTERFLY ADIT) was collected from the pool of water present within the primary adit at the Butterfly Mine to assess the quality of water present at the mine portal. A duplicate sample (SW-DUP) was also collected at the adit for QA/QC purposes.

The equipment used to collect the soil and waste-rock samples was thoroughly decontaminated prior to initial use and between sampling locations. Surface-water samples were collected using new sampling equipment at each sample location; therefore, equipment decontamination was not required for collection of surface-water samples. For QA/QC purposes, a sample of the final rinse water used to decontaminate the soil/waste-rock sampling equipment was collected and submitted to the laboratory for analysis of the parameters listed in Table 3.4.

Radon levels within the portal of each mine were measured by placing an alpha-tract detector within the primary portal at each mine. In addition, detectors were placed in the Butterfly Mine cabin and in a background area located between the two mine sites. All detectors remained in place for a 91-day monitoring period. The detectors were collected at the end of the monitoring period and submitted to Landauer, Inc. for testing. Monitoring results for the detectors placed in the mines and cabin were compared to the results reported for the background area. Evaluation results were used to assess the amount of exposure at the mine portals and cabin relative to background areas.

Gamma-exposure rates at the two mines were measured by using a Ludlum Model 19 micro-R survey meter to perform a general walking survey and collecting static measurements at specific locations on the mine bench at each mine. A background gamma-exposure rate was established by measuring levels within the background area used for collection of the background soil sample.

3.2 Site Investigation Results

Field documents compiled in support of the site investigation are provided in Appendix B. The documents include completed soil/mine-waste sampling forms, completed surface-water monitoring forms, and chain-of custody records. The analytical data package provided by the laboratory is provided in Appendix C.

3.2.1 Waste Rock

Composite soil and waste-rock samples were collected at the Butterfly and Burrell Mines as described in Section 3.1 and as shown in Figure 3.1 and the site sketches provided on the completed sampling forms (Appendix B). Sample BFLY-01 was divided into one investigative sample and one duplicate sample (WR-DUP). Metals and radiological results for the soil and waste-rock samples collected at the mines are summarized in Table 3.5.

For the background soil sample, the metals reported at the highest levels (greater than 100 milligrams per kilogram [mg/Kg] were iron (11,200 mg/Kg) and manganese (509 mg/Kg). The metals reported at concentrations ranging from 10 to 100 mg/Kg were chromium (11 mg/Kg), Lead (10 B mg/Kg), vanadium (15.8 mg/Kg), and zinc (31 mg/Kg). Radiological constituent activities which included gross alpha, gross beta, radium-226, radium-228, and thorium-228, -230 and -232, reported for the background sample were all less than 10 picoCuries per gram (pCi/g), with the highest activities reported for gross alpha (6.2 pCi/g) and gross beta (6.7 pCi/g).

At the Butterfly Mine, metals concentrations were generally higher in the sample collected at the loadout/grizzly area (BFLY-01) than at the mine bench (BFLY-02) or the waste-rock dump (BFLY-03). In general, the waste-rock dump contained the lowest metals concentrations at the mine. The metals reported at the highest concentrations (greater than 100 mg/Kg) at the loadout/grizzly area were iron (4,960 mg/Kg), manganese (116 mg/Kg), uranium (479 mg/Kg), and vanadium (1,750 mg/Kg). Exceptions to this general trend were noted for iron and manganese which were reported at the highest levels of 7180 mg/kg and 164 mg/kg, respectively, at the mine bench and arsenic which was reported at the highest level of 47.7 mg/kg at the waste-rock dump. The highest radiological activities at the Butterfly Mine were reported for the sample collected at the loadout/grizzly area, where the highest activities were reported for gross alpha (940 pCi/g), gross beta (430 pCi/g), radium-226 (320 pCi/g), and thorium-230 (230 pCi/g).

At the Burrell Mine, metals concentrations were highest in the samples collected at the mine bench (BUR-01) and the loadout rib (BUR-02). The metals reported at the highest concentrations (greater than 100 mg/Kg) at the mine bench and loadout rib were iron (10,000 mg/Kg), manganese (234 mg/Kg), uranium (411 mg/Kg), and vanadium (1,200 mg/Kg). The highest radiological activities at the mine were reported for the sample collected at the mine bench (BUR-01), where the highest activities were reported for gross alpha (520 pCi/g), gross beta (230 pCi/g), radium-226 (130 pCi/g), and thorium-230 (160 pCi/g). The lowest metals concentrations and radiological activities at the mine were reported for the sample collected at the waste-rock dump.

In addition to metals and radiological analyses, the samples collected at the Butterfly Mine waste-rock dump (BFLY-03) and the Burrell Mine waste-rock dump (BUR-02) were also analyzed for SPLP metals analyses. The SPLP analytical results for the samples are presented in Table 3.6. As shown, the only metals reported at concentrations above the method detection limits were arsenic, iron, uranium, and vanadium; selenium was reported at the method detection limit in sample BFLY-03 and manganese was reported at the method detection limit in sample BUR-02.

3.2.2 Surface Water

Surface-water samples were collected for assessment of the Butterfly and Burrell Mines as described in Section 3.1 and as shown in Figure 3.2 and the site descriptions provided on the completed sampling forms (Appendix B). Sample BUTTERFLY ADIT was divided into one investigative sample and one duplicate sample (SW-DUP). Analytical metal results for surface water are summarized in Table 3.7.

3.2.2.1 Background Water Quality

A background sample (BKG-1) was collected near the mouth of a perennial tributary to Coal Creek that originates on the south side of the Coal Creek drainage. Field parameter data for sample BKG-1 indicate near normal pH, low specific conductance, high dissolved oxygen, and a low capacity for reduction. Analytical results for the sample indicate low total dissolved solids (TDS) and generally low metals concentrations, with the highest metals concentrations reported for dissolved calcium (31,900 milligrams per liter [mg/L]), dissolved copper (120 mg/L), dissolved magnesium (8,000 mg/L), dissolved potassium (500 mg/L), and dissolved sodium (1,200 mg/L). Low radiological activities were reported for the background sample.

3.2.2.2 Butterfly Adit and Tributary

Field parameters for the sample collected at the BUTTERFLY ADIT indicate slightly basic pH and slightly higher specific conductance and slightly higher oxidation-reduction potential compared to the background and Coal Creek samples. The parameters reported in the BUTTERFLY ADIT sample at levels that are 2.0 or more times greater than the levels reported in the background sample are as follows:

- Dissolved nitrate as N:
  - Adit: 0.36 mg/L
  - Background: 0.06 B mg/L (increase factor of 6.0)
- Dissolved nitrate/nitrite as N:
  - Adit: 0.36 mg/L
  - Background: 0.06 B mg/L (increase factor of 6.0)
- Dissolved arsenic:
  - Adit: 2.5 B µg/L
  - Background: 1.1 B µg/L (increase factor of 2.3)
- Total recoverable arsenic:
  - Adit: 2.3 B µg/L
  - Background: 1.1 B µg/L (increase factor of 2.1)
- Dissolved selenium:
  - Adit: 2 B µg/L
  - Background: < 1 µg/L (increase factor of 2.0)
- Dissolved uranium:
  - Adit: 35.4 µg/L
  - Background: 0.2 B µg/L (increase factor of 177)

- Total uranium:
  - Adit: 41 µg/L
  - Background: 0.2 B µg/L (increase factor of 205)

- Dissolved vanadium:
  - Adit: 11 B µg/L
  - Background: < 5 µg/L (increase factor of 2.2)

- Gross alpha:
  - Adit: 40 pCi/g
  - Background: 1.5 pCi/g (increase factor of 27)

- Gross beta:
  - Adit: 21 pCi/g
  - Background: 2.1 pCi/g (increase factor of 10)

- Radium-226:
  - Adit: 6.1 pCi/g
  - Background: 2.7 pCi/g (increase factor of 2.3)

Field parameters for the sample collected at the BUTTERFLY TRIBUTARY indicate near normal pH and slightly higher specific conductance and slightly lower dissolved oxygen compared to the background and Coal Creek samples. The parameters reported in the BUTTERFLY TRIBUTARY sample at levels that are 2.0 or more times greater than the levels reported in the background sample are as follows:

- Sulfate:
  - Tributary: 20 B mg/L
  - Background: < 10 µg/L (increase factor of 2.0)

- Total recoverable arsenic:
  - Tributary: 1.4 B µg/L
  - Background: < 0.5 µg/L (increase factor of 2.8)

- Dissolved iron:
  - Tributary: 60 µg/L
  - Background: 30 µg/L (increase factor of 2.0)

- Total recoverable iron:
  - Tributary: 290 µg/L
  - Background: 70 µg/L (increase factor of 4.1)

- Dissolved manganese:
  - Tributary: 81 µg/L
  - Background: < 5 µg/L (increase factor of 16.2)

- Dissolved potassium:
  - Tributary: 1,400 µg/L
  - Background: 500 B µg/L (increase factor of 2.8)

- Dissolved uranium:
  - Tributary: 6.4 µg/L
  - Background: 0.2 B µg/L (increase factor of 32.0)

- Total uranium:
  - Tributary: 6.5 µg/L
  - Background: 0.2 B µg/L (increase factor of 32.5)

- Gross alpha:
  - Tributary: 6.4 pCi/g
  - Background: 1.5 pCi/g (increase factor of 4.3)

These findings suggest that the elevated levels, relative to background, reported for parameters listed above in the Butterfly Tributary may be attributed, in part, to surface water sources (mine drainage and runoff) at the Butterfly Mine. Alternatively, elevated analyte concentrations in the surface water of Butterfly Tributary could be attributed to natural mineralization within the drainage.

3.2.2.3 Coal Creek

Surface-water samples COAL CK UP and COAL CK DN were collected from Coal Creek upstream and downstream of the area in which surface water at the mines could impact water quality in the creek. Field parameter data for the Coal Creek samples indicate similar conditions to the background sample, including near normal pH, low specific conductance, high dissolved oxygen, and a low capacity for reduction. The analytical data for samples COAL CK UP and COAL CK DN show that the inorganic, metals, and radiological levels are very similar. In most cases, any differences noted between the two samples are within the expected range of analytical precision. The parameters reported in the downstream sample at levels that are 2.0 or more times greater than the levels reported in the upstream sample are as follows:

- Hardness
  - Upstream: 34 mg/L
  - Downstream: 86 mg/L (increase factor of 2.5)

- TDS
  - Upstream: 50 mg/L
  - Downstream: 100 mg/L (increase factor of 2.0)

- Dissolved calcium
  - Upstream: 10,700 micrograms per liter (µg/L)
  - Downstream: 27,000 µg/L (increase factor of 2.5)

- Dissolved magnesium
  - Upstream: 1,700 µg/L
  - Downstream: 4,600 µg/L (increase factor of 2.7)

- Dissolved mercury
  - Upstream: < 0.2 µg/L
  - Downstream: 1.3 µg/L (increase factor of 6.5)

- Dissolved uranium
  - Upstream: 0.01 B µg/L
  - Downstream: 0.08 µg/L (increase factor of 8.0)

- Total uranium
  - Upstream: 0.02 B µg/L
  - Downstream: 0.09 µg/L (increase factor of 4.5)

Except possibly uranium, these findings suggest that surface water sources (adit drainage and runoff) at the Butterfly and Burrell Mines have not significantly impacted water quality in Coal Creek. The slightly elevated concentration of uranium in the downstream sample, relative to the upstream sample, may be attributed, in part, to surface water sources at the mines. The dissolved mercury concentration of 1.3 µg/L in the downstream sample is likely an anomaly; mercury concentrations were below detection in all other surface water samples.

3.2.3 Radon Monitoring

Radon monitoring was conducted by placing alpha-tract detectors within the primary portal at each mine, in the Butterfly Mine cabin, and in a background area located between the two mine areas. Test results reported by Landauer, Inc. for the four detectors following the 91-day monitoring period are presented in Table 3.8. The highest radon exposure rate (13.85 pCi/L/hr) was reported for the detector placed within the Burrell Mine portal. The exposure rate for the detector placed in the Butterfly Mine portal was 6.05 pCi/L/hr, and the exposure rate for the detector placed in the cabin at the Butterfly Mine was 0.03 pCi/L/hr. The radon exposure rate reported for the background area was less than 0.01 pCi/L/hr.

3.2.4 Gamma-Exposure Rates

A gamma-exposure rate of 12 microroentgen per hour (µR/hr) was measured within the background area established near the Butterfly Mine. At the Butterfly Mine, gamma-exposure rates were generally 100 µR/hr across the mine bench, 200 µR/hr in front of the loadout/grizzly, and 300 to 400 µR/hr on the face of the loadout/grizzly structure. The highest gamma-exposure rate measured at the Butterfly Mine was

600 µR/hr, recorded in an isolated area immediately west of the grizzly structure. At the Burrell Mine, gamma-exposure rates generally ranged from 100 to 200 µR/hr across the mine bench and along the loadout rib (with isolated spots showing up to 300 µR/hr), 300 to 400 µR/hr in the vicinity of the loadout, and less than 100 µR/hr on the vegetated bench at the top of the waste-rock dump. The highest gamma-exposure rate measured at the Burrell Mine was 400 µR/hr at the loadout.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

Samples collected for QA/QC purposes included one duplicate waste-rock sample, one duplicate surface-water sample, and one equipment rinse sample. The analytical data for waste rock show that the duplicate waste-rock sample (WR DUP 1) concentrations were generally agreeable with those reported for the original sample (BFLY-01), with the exception of radium-226. The activity of radium-226 in the duplicate sample was 4.1 times less than the original sample (78 pCi/g versus 320 pCi/g). The quality control information provided by the analytical laboratory does not indicate a quality control issue with laboratory procedures or equipment. The apparent cause for the difference in radium-226 activities in the two samples is sample heterogeneity, i.e. the potential for radium-226 to concentrate within an individual rock particle.

The analytical data for surface water show that the duplicate sample (SW-DUP) concentrations were consistent with those reported in the original sample (BUTTERFLY ADIT).

One rinse blank sample was collected from decontaminated sampling equipment and tools (stainless steel hand tools) used to collect the soil and waste-rock samples. The sampling tools were cleaned between each sample location by washing in a solution of Alconox® and deionized water followed by a deionized water rinse. Analytical results for the equipment rinse water samples collected during the site characterization effort are presented in Table 4.1. The results indicate that there were no significant contamination problems and decontamination procedures were thorough.

5.0 SCREENING-LEVEL RISK EVALUATION

The streamlined risk evaluation process was used to assess potential threats to human-health and the environment as a result of former operations at the Butterfly and Burrell Mines. The process was implemented in accordance with the streamlined risk evaluation guidance presented in *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (EPA, 1993). The evaluation was

performed by comparing analytical results for soil and waste-rock samples at the mines and area surface-water samples to background levels and risk-based state and federal standards. A separate evaluation was performed for human and ecological receptors.

5.1 Human Health Risk

Site visitors are the primary human receptors potentially exposed to contaminants at the mines. The site visitors most likely expected at the mines include individuals using the mine areas for camping, hiking, ATV driving, or other forms of recreation, and individuals who may work on the mine areas. Of these site visitors, the risks associated with the mines pose the greatest threat to individuals using the mine areas for camping. Therefore, human-health risks at the mines are evaluated on the basis of the camper scenario. The principal exposure routes to the camper include ingestion, inhalation, dermal contact, and direct radiation.

5.1.1 Soil and Waste Rock

The potential threats to human-health posed by metals in soil and waste rock at the mines were evaluated by comparing analytical results for the soil and waste-rock samples collected during the site investigation to analyte concentrations in the background soil sample, Risk Management Criteria (RMC) established by the BLM for the camper exposure scenario (Ford, 2004), EPA Region 3 Risk Based Concentrations (RBCs), and EPA Region 9 Preliminary Remediation Goals (PRGs). Table 5.1 presents the BLM RMC, EPA Region 3 RBCs, and EPA Region 9 PRGs used in this evaluation. The EPA Region 3 RBCs and Region 9 PRGs are intended to assist risk assessors in initial screening-level evaluations of environmental measurements. The RBCs and PRGs used in this evaluation assume the industrial (i.e., outdoor worker) scenario. EPA Region 3 RBCs are available at www.epa.gov/reg3hwmk/risk. Region 9 PRGs are available at www.epa.gov/Region9/waste/sfund/prg/index.html. It is recognized that the RBCs and PRGs established for the industrial scenario are likely to be more restrictive than for the camper scenario; however, the levels allow identification of the analytes that may pose a threat to individuals using the mine areas for camping. Analyte concentrations found to exceed RBCs or PRGs were then compared to background levels to assess the relative magnitude of the levels reported for the samples collected at the mines with respect to the levels reported for background soil. Metals concentrations reported for the soil and waste-rock samples are compared to the screening criteria, with exceedances of 1 to 10 times the screening level denoted with “+” (low to moderate risk), greater than 10 to 100 times the screening level denoted with “++” (high risk), and greater than 100 times the screening level denoted with “+++” (very

high risk). In general, exceedances of less than 2 times are considered to pose low risk, while exceedances of 2 to 10 times are considered to pose moderate risk.

Radiological constituents for which specific risk benchmarks have not been established for the camper scenario were evaluated by comparing analytical results reported for samples collected at the mines to the levels reported for the background soil sample. While these comparisons are not indicative or predictive of risk, the comparisons provide a descriptive means of evaluating radiological levels at the mines. In addition, radium-226 activities reported for near-surface samples are compared to the Uranium Mill Tailings Radiation Control Act (UMTRCA) standard of 5 pCi/g over background in the upper 6 inches of soil. This standard was established as a health-based standard for protection against exposure to gamma radiation and to limit the risk from inhalation of radon decay products in houses built on land contaminated with tailings. The standard was intended to signify when a Title I site had been cleaned up to a level suitable for unrestricted use. It is recognized that the UMTRCA standard is not applicable at the mine sites as the mines are not Title I sites and will not be released for unrestricted use, e.g., construction of habitable structures. Nevertheless, the standard is relevant and appropriate and is used as a guide in this evaluation to identify the areas where exposure to gamma radiation may pose a human-health threat to campers at the mines. Radiological activities reported for the soil and waste rock samples are compared to the maximum levels reported for background samples, with exceedances of 1 to 10 times maximum background denoted with “+”, greater than 10 to 100 times maximum background denoted with “++”, and greater than 100 times maximum background denoted with “+++.”

A comparison of total metal and radiological results for soil and waste rock at the mines to human-health screening criteria is presented in Table 5.2. Except for iron, manganese, mercury, and silver, metal concentrations exceeded background levels in one or more of the waste-rock samples collected at both mines; copper and molybdenum were also reported at concentrations less than background at the Butterfly Mine. Except thorium-228 and thorium-232, each of the radiological constituents was reported at activities exceeding background levels in all of the samples collected at the mines. Thorium-228 activities were less than the background level in samples BFLY-03 (waste-rock dump) and BUR-02 (waste-rock dump), and thorium-232 activities were less than the background level in samples BFLY-03 (waste-rock dump), BUR-02 (waste-rock dump), and BUR-03 (loadout rib).

The metals reported at concentrations exceeding the most restrictive screening levels were arsenic, uranium, and vanadium. Arsenic concentrations in soil and waste rock at the mines exceeded the screening level in each of the samples; however, it should be noted that the arsenic concentration reported

for the background sample also exceeded the screening level. Arsenic concentrations were greatest in the samples collected from the waste-rock dump at the Butterfly Mine and the loadout rib at the Burrell Mine; arsenic levels were higher at the Burrell Mine than at the Butterfly Mine. Uranium and vanadium concentrations exceeded the screening level in the sample collected at the Butterfly Mine loadout/grizzly (BFLY-01) and the sample collected at the Burrell Mine bench (BUR-01).

A summary of the metals concentrations exceeding screening levels at each mine is presented in Table 5.3. As shown, arsenic concentrations exceeded the most restrictive criterion, the EPA Region 9 industrial soil PRG of 1.6 mg/Kg, by a factor of up to 29.8 at the Butterfly Mine and by a factor of up to 65 at the Burrell Mine. These results suggest that, under the industrial scenario, arsenic concentrations at the Butterfly Mine pose a high risk to human health at the waste-rock dump and moderate threat to human health on the mine bench and within the loadout/grizzly area. At the Burrell Mine, arsenic concentrations pose a high risk to human health under the industrial scenario on the mine bench, waste-rock dump, and loadout rib. Comparison of arsenic concentrations to the camper RMC of 20 mg/Kg indicates that the greatest threat to campers at the mines occur on the Butterfly Mine waste-rock dump (47.7 mg/Kg) and Burrell Mine loadout rib (104 mg/Kg); areas considered less suitable for camping than elsewhere at the mines. The arsenic concentration for the sample collected in the area considered most suitable for camping at the Butterfly Mine (mine bench) exceeded the RMC by a factor of 1.3, suggesting low risk to campers. The arsenic concentration for the sample collected in the area considered most suitable for camping at the Burrell Mine (mine bench) exceeded the RMC by a factor of 3.4, suggesting moderate risk to campers. Uranium and vanadium concentrations exceeded the most restrictive criteria (200 mg/Kg and 1,000 mg/Kg, respectively) at the Butterfly Mine loadout/grizzly area and the Burrell Mine bench. The uranium and vanadium concentrations in these areas exceeded the criteria by factors of less than 2.5, suggesting the levels likely pose low to moderate risk to human health under the industrial scenario. RMC for uranium and vanadium have not been established by the BLM.

Radiological activities reported for the soil and waste-rock samples were compared to background levels as shown in Table 5.2. As previously discussed, the reported activities exceeded background levels in all but three of the samples. The highest radiological activities relative to background levels were reported for gross alpha (7.6 to 152 times background), gross beta (2.7 to 64 times), radium-226 (8.1 to 200 times background), and thorium-230 (13 to 299 times background). At the Butterfly Mine, the highest levels for these analytes were reported for the sample collected at the loadout/grizzly area. At the Burrell Mine, the highest levels for these analytes were reported for the sample collected at the mine bench. The lowest radiological activities relative to background levels were reported for radium-228 (1.4 to 2.4 times

background), thorium-228 (less than 1 to 1.7 times background), and thorium-232 (less than 1 to 2.1 time background).

Radium-226 activities reported for the soil and waste-rock samples collected at the mines were compared to the UMTRCA standard of 5 pCi/g over background. As discussed, the UMTRCA standard applies to unrestricted use (e.g., construction of habitable structures), and therefore, is not directly applicable to the mine area and is only used to identify the areas where radium-226 levels could potentially pose a potential threat to campers at the mine. A factor of 26 (365 days/14 days; assuming an average camping duration of 14 days per year) was applied to better assess the threats posed under the camper scenario, where radium-226 levels less than 26 times the UMTRCA standard are considered to not pose a threat to campers. The background level reported for radium-226 in the background soil sample was 1.6 pCi/g, resulting in a criterion of 6.6 pCi/g and a modified criterion of 171.6 pCi/g. The radium-226 activities reported for all of the samples collected at the mines exceeded 6.6 pCi/g; however, only the sample collected at the Butterfly Mine loadout/grizzly area contained radium-226 at an activity (320 pCi/g) greater than the modified criterion. The radium-226 activity for the corresponding duplicate sample was 78 pCi/g, well below the modified criterion.

Results of this streamlined risk evaluation suggest that arsenic concentrations in soil and waste rock at the mines likely pose a moderate to high threat and uranium and vanadium pose a low threat to human health under the industrial scenario. Under the camper scenario, arsenic concentrations in the areas considered most suitable for camping likely pose a low to moderate threat to human health. The results also indicate that radiological levels in soil and waste rock at the mines are elevated with respect to background levels, with the highest activities relative to background reported for gross alpha, gross beta, radium-226, and thorium-230. Based on application of the UMTRCA standard, exposure to gamma radiation may pose a threat to individuals camping in the ore loadout/grizzly area at the Butterfly Mine.

5.1.2 Surface Water

The risks associated with metals in surface water at the Butterfly Adit and in the Butterfly Tributary were evaluated by comparing the reported analyte concentrations for the mine and tributary water to camper RMC (swimming) and modified Maximum Contaminant Levels (MCLs) where a modifying exposure factor of 365/14 days (times 26) was applied to EPA drinking water MCLs to better estimate the risk posed to campers who may ingest water from the mine or tributary water. MCLs established by the EPA for protection of public drinking water sources assume an exposure duration of 365 days per year.

Therefore, it is recognized that MCLs are not applicable under the camper scenario but are relevant and appropriate. The camper (swimming) scenario is used in the evaluation because the shallow pool within the mine portal and flow within the Butterfly Tributary are of sufficient size and depth to potentially be used by recreational visitors for wading and bathing. Table 5.4 presents the surface-water criteria (camper RMC and modified MCLs) used for the human-health risk evaluation. The analytes for which RMC or MCLs have not been established were evaluated by comparing the reported results to the levels reported for the background surface-water sample. While these comparisons are not indicative or predictive of risk, the comparisons provide a descriptive means of evaluating the levels reported for these analytes.

A comparison of analytical results for the surface-water samples to background levels and human-health criteria is presented in Table 5.5. As shown, analyte levels did not exceed the camper RMC or modified MCLs in any of the surface-water samples. Of the analytes for which RMC or MCLs have not been established, uranium was the only analyte reported for the Butterfly Adit and Butterfly Tributary at concentrations more than 10 times above background. The dissolved uranium concentration of 35.4 µg/L was 177 times background at the Butterfly Adit. The dissolved uranium concentration of 6.4 µg/L was 32 times background at the Butterfly Tributary. However, these elevated uranium levels with respect to background are not considered to be of concern because the total uranium concentrations for these samples were below the modified MCL of 480 µg/L. These findings indicate that analyte levels in surface water at the Butterfly Adit and within the Butterfly Tributary pose low risk to campers.

5.1.3 Radon

Radon poses a potential hazard at the mines. The relative risks posed by radon at the mines were evaluated by comparing radon levels inside the mine portals and Butterfly Mine cabin to levels reported for a background area located between the two mine sites. Radon-monitoring results are presented in Table 3.8. The monitoring results indicate that high exposures to radon occur within the mine portals and exposures within the cabin are slightly elevated in comparison to the background area. Although high exposures were indicated within the mine portals, the radon levels likely decrease rapidly outside of the enclosed portal feature.

5.1.4 Radiation Exposure

Radiation exposure at the mines was evaluated by comparing gamma-exposure rates measured at the mines to gamma-exposure rates measured in background areas. In addition, gamma-exposure rates at the mine were used to calculate the radiation exposure in milliroentgen equivalent man (mRem) that would be expected for an individual camping at the mine for a period of 14 days. The calculations were performed using the relationship of 1 milliroentgen per hour (mR/hr) is approximately equal to 1 milliroentgen equivalent man per hour (mRem/hr) which is considered appropriate given the accuracy of the field meters. The resulting gamma-exposure rates were compared to a ceiling level of 100 mRem per year (mRem/yr) exclusive of background radiation, based on the dose limit for individual members of the public for active licensees (10 CFR 20.1301-1302).

The evaluation was performed by assuming that an individual camps at the mine for 14 days per year. The scenario is considered highly conservative because it assumes the individual spends the entire 14-day period at the mine. A background gamma-exposure rate of 4 mRem/yr was calculated for the 14-day camper scenario based on the measured background reading of 12 µR/hr. Therefore, the ceiling of 100 mRem/yr exclusive of background radiation would only be exceeded if the individual spends the entire 14-day period in an area where gamma-exposure rates exceeded 310 µR/hr. Results of the general gamma-exposure survey conducted at the mines suggest that campers would only be exposed to levels above the ceiling on the face of the ore loadout/grizzly at the Butterfly Mine and in the loadout area at the Burrell Mine.

5.2 Ecological Risk

The primary ecological receptors potentially affected by contaminants at the mine include terrestrial biota (wildlife and livestock) and aquatic biota. The principal exposure routes to ecological receptors include ingestion, inhalation, direct contact, and direct radiation.

5.2.1 Soil and Waste Rock

The ecological risks associated with metals in soil and waste rock at the mines were evaluated by comparing the analytical results for waste rock to elk RMC for metals in soil, including 2005 criteria for uranium and vanadium derived by the BLM and USEPA, respectively. The RMC for elk was used as the basis for evaluation of risk to terrestrial wildlife, because the elk RMC generally correspond with the median RMC for all receptors and are more protective than the RMC for cattle, which may frequent the

mine areas. The elk RMC may be modified by the size of their home range. This modification, referred to as an "area use factor", is the quotient of the mine area divided by the home range (640 acres). The RMC is then modified by dividing the RMC by the area use factor. The resulting modified RMC provides a better estimate of the risk posed to elk at the mine. Where ecological RMC have not been established for a particular analyte, soil and waste-rock results were compared to the levels reported for the soil samples collected within the background area. While these comparisons to background levels are not indicative or predictive of risk, the comparisons provide a descriptive means of evaluating the analytical results.

Because of the proximity of the waste-rock dumps to the Butterfly Tributary and Coal Creek, RMC were derived in this evaluation based on the leaching characteristics of the waste rock. The leaching RMC are intended to protect aquatic life from leaching of metals. The leaching RMC were derived by using the aquatic-life standards specified for Coal Creek and the total metals and SPLP metals results reported for the waste-rock samples. The mean proportion leaching under the SPLP test was computed by dividing the total metal concentration by the SPLP concentration. A dilution-attenuation factor (DAF) of 20 was then applied using EPA's Soil Screening Level guidance (USEPA, 1996). Leaching RMC were calculated according to the following formula:

$$\text{Leaching RMC} = \text{Aquatic-Life Standard} \times \text{Total Metals/SPLP} \times \text{DAF}$$

The derived leaching RMC are compared to the total concentrations of the respective metals in the waste rock to assess whether the total metal concentrations pose a threat to aquatic life based on the leaching characteristics of the waste rock.

A comparison of total metal results for soil and waste rock at the Butterfly Mine to background soil levels and the BLM RMC for elk is presented in Table 5.6. A comparison of total metal results for soil and waste rock at the Burrell Mine to background soil levels and the BLM RMC for elk is presented in Table 5.7. The elk RMC listed in each table were modified with area use factors of 0.004 for the Butterfly Mine (total area of 2.7 acres) and 0.003 for the Burrell Mine (total area of 2.1 acres). Metals concentrations in the soil and waste-rock samples collected at the mines did not exceed the modified RMC for elk, suggesting the analytes for which RMC have been established pose low risk to elk. Of the analytes for which RMC have not been established, concentrations at the Butterfly Mine exceeded background levels in the loadout/grizzly area sample (chromium by a factor of 1.1, nickel by a factor of 1.2, and selenium by a factor of 37), mine bench sample (nickel by a factor of 1.1 and selenium by a factor of 34), and waste-

rock dump sample (selenium by a factor of 32). Of the analytes for which RMC have not been established, concentrations at the Burrell Mine exceeded background levels in the mine bench sample (antimony by a factor of 1.5, molybdenum by a factor of 2.5, nickel by a factor of 1.3, and selenium by a factor of 61), waste-rock dump sample (selenium by a factor of 5), and loadout rib sample (antimony by a factor of 2, chromium by a factor of 1.1, molybdenum by a factor of 5, nickel by a factor of 1.6, and selenium by a factor of 24).

Except for thorium-228 and -232, radiological constituent activities exceeded background levels in each of the samples collected at the Butterfly and Burrell Mines The highest radiological activities relative to background levels were reported for gross alpha (7.6 to 152 times background), gross beta (2.7 to 64 times), radium-226 (8.1 to 200 times background), and thorium-230 (13 to 299 times background). At the Butterfly Mine, the highest levels for these analytes were reported for the sample collected at the loadout/grizzly area. At the Burrell Mine, the highest levels for these analytes were reported for the sample collected at the mine bench. The lowest radiological activities relative to background levels were reported for radium-228 (1.4 to 2.4 times background), thorium-228 (less than 1 to 1.7 times background), and thorium-232 (less than 1 to 2.1 time background).

A comparison of total metals results for waste rock at the mines to leaching RMC is presented in Table 5.8. As shown, total metals concentrations did not exceed leaching RMC in either sample collected for SPLP analysis. These results indicate that leachate generated from the waste-rock dumps does not likely pose a threat to aquatic life.

5.2.2 Surface Water

The ecological risks associated with surface water at the mines were evaluated by comparing the analytical results for the adit drainages to Colorado aquatic-life standards for Coal Creek, specified in Regulation 37 – Classification and Numeric Standards for Lower Colorado River Basin (Segment 10b of the White River Basin). The risks associated with surface water to terrestrial biota were not directly assessed in this evaluation. It is recognized that any actions taken to protect aquatic life and humans (camper) would also provide protection for terrestrial biota.

A comparison of analytical results for the surface-water samples to aquatic-life criteria is presented in Table 5.9. As shown, copper and gross alpha were the only analytes reported at levels exceeding the criteria. Copper was reported at a concentration of 120 µg/L, 13 times the criterion, in the background

sample. Gross alpha was reported at an activity of 40 pCi/L, 2.7 times the criterion, in the sample collected at the Butterfly adit. It should be noted that an aquatic-life standard has not been established for gross alpha in Colorado; the standard established in Utah was used in this evaluation. The elevated gross gamma levels in the adit water are not expected to pose a threat to aquatic life in the vicinity of the mine because the water occurs within an isolated pool within the mine and surface drainage from the mine, if any, likely occurs on an infrequent basis. Analyte levels reported for the samples collected from the Butterfly Tributary and Coal Creek (both upstream and downstream of the mines) did not exceed aquatic-life standards.

Of the analytes for which standards have not been established, radium-226 was the only analyte reported at levels exceeding background by more than 10 times. The radium-226 activity in the sample collected at the Butterfly Mine adit was 6.1 pCi/L, 23 times greater than the level reported for the background sample.

5.2.3 Radiation Exposure

Hazards to ecological receptors due to radiation exposure were evaluated by comparing gamma-exposure rates measured at the mine to the International Atomic Energy Administration (IAEA) standard for wildlife of 0.1 radiation absorbed dose (Rad) per day, or 4,167 µR/hr (where 1 R of gamma radiation exposure results in about 1 Rad of absorbed dose). The maximum gamma-exposure rate measured at the mines was 600 µR/hr, recorded in an isolated area near the loadout/grizzly at the Butterfly Mine. Therefore, radiation exposure is expected to pose low risk to wildlife at the mines.

6.0 REFERENCES

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FIGURES

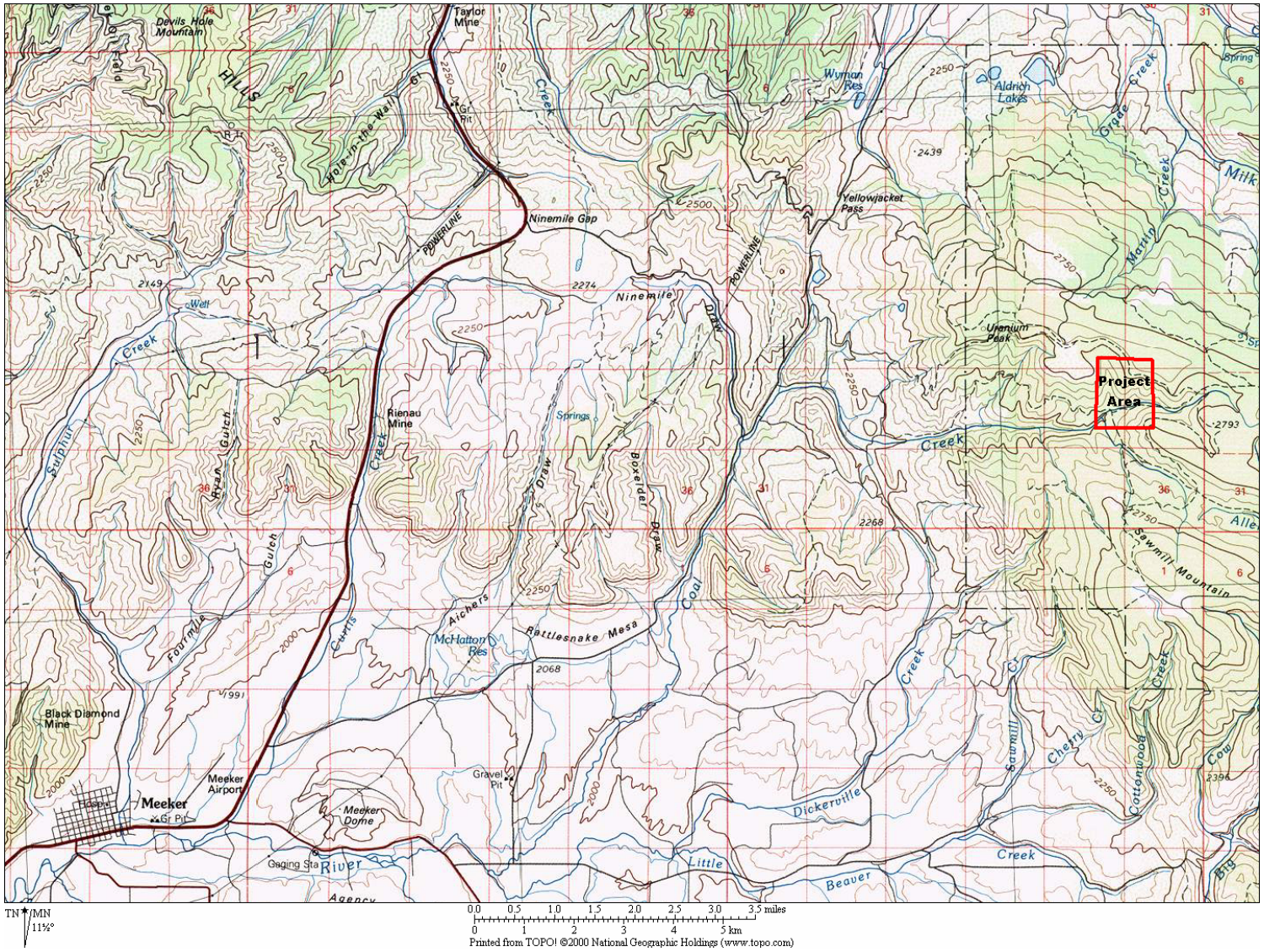


Figure 2.1: Project Area Location
Butterfly and Burrell Mines
Rio Blanco County, Colorado

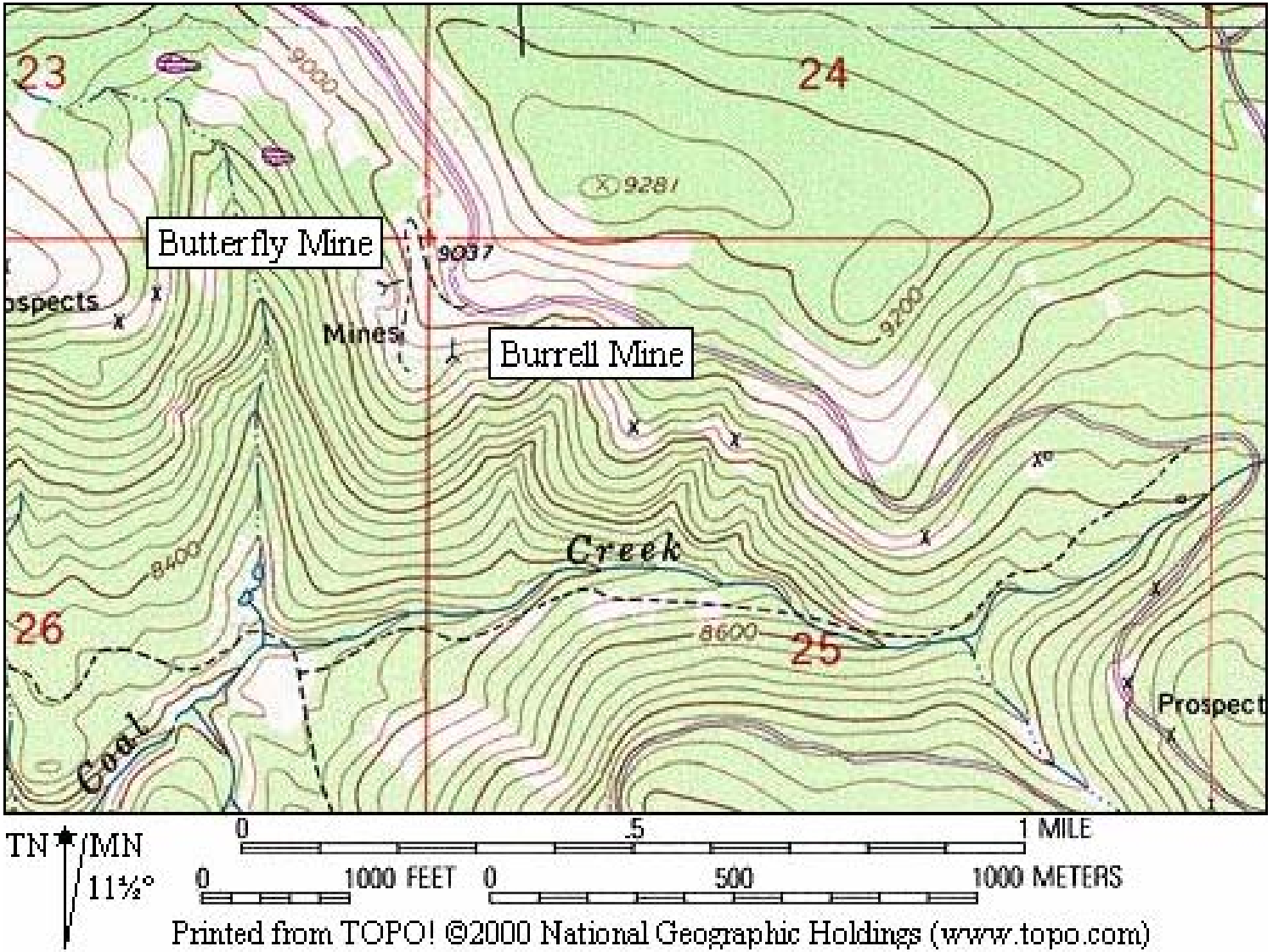
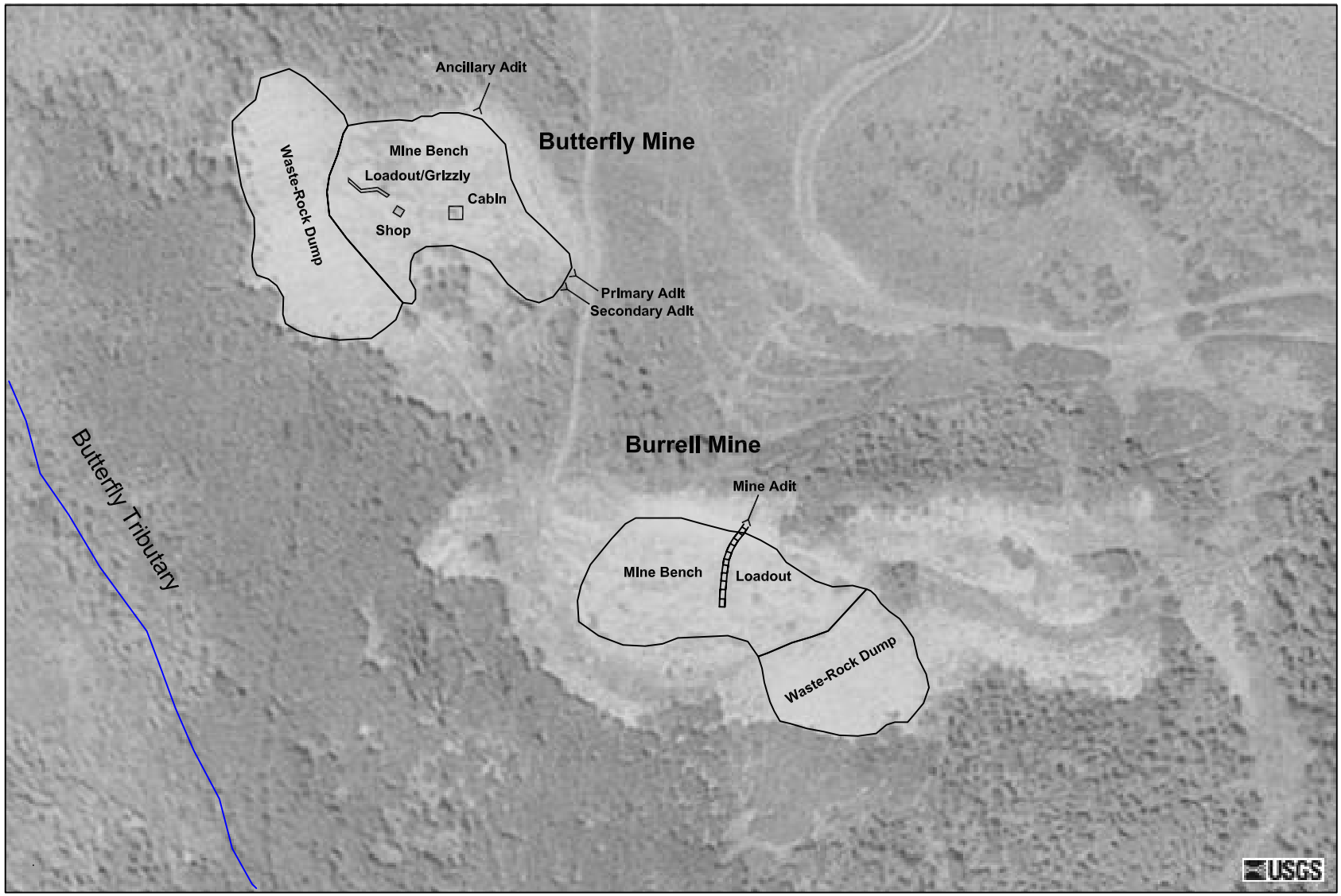


Figure 2.2: Mine Locations
Butterfly and Burrell Mines
Rio Blanco County, Colorado



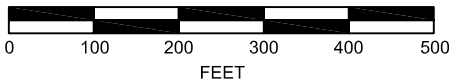
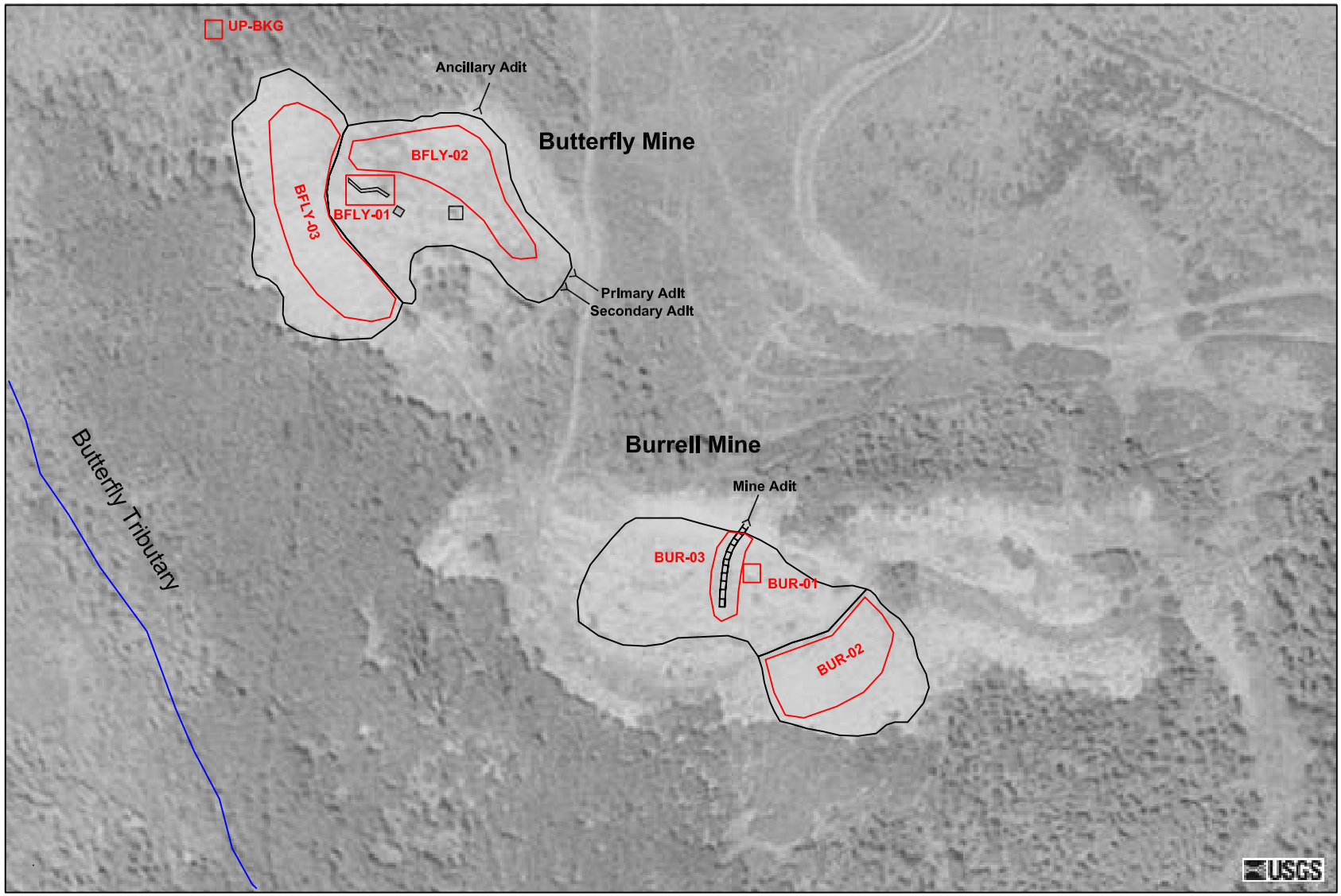


Figure 2.3: **Site Features**
Butterfly and Burrell Mines
Rio Blanco County, CO



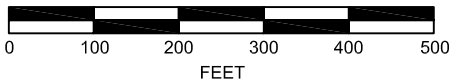


Figure 3.1: **Soil/Waste-Rock Samples Butterfly and Burrell Mines Rio Blanco County, CO**

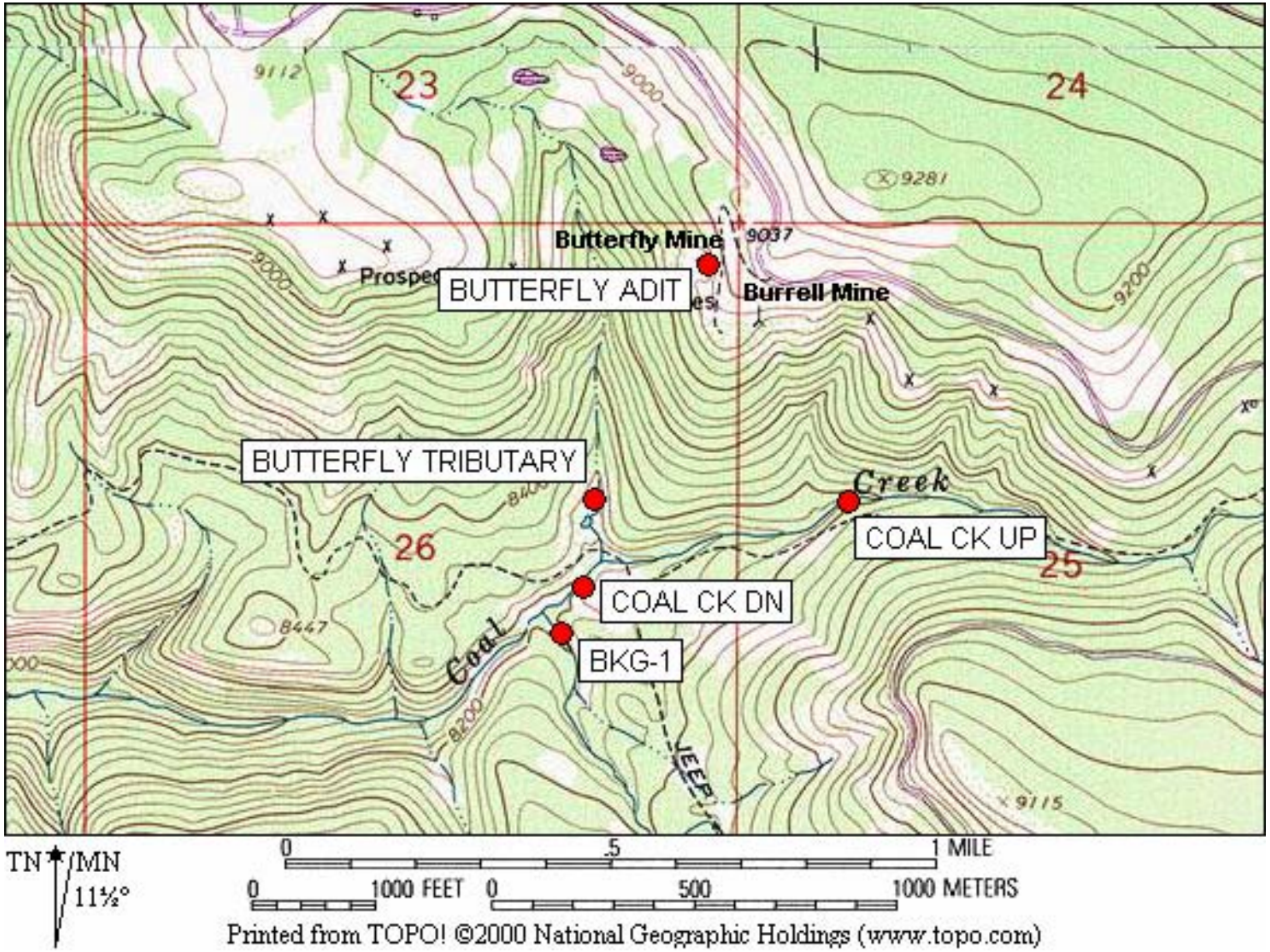


Figure 3.2: Surface-Water Samples Butterfly and Burrell Mines Rio Blanco County, Colorado

TABLES

Table 3.1: Analytical Parameters for Background Soil and Waste Rock - Group A Uranium Peak AML Sites

Parameter	Method	Detection Limit
METALS (mg/Kg))		
Antimony	EPA 6020 ICP-MS	0.2
Arsenic	EPA 6020 ICP-MS	0.01
Cadmium	EPA 6020 ICP-MS	0.01
Chromium	EPA 6010B ICP	1
Copper	EPA 6010B ICP	1
Iron	EPA 6010B ICP	1
Lead	EPA 6010B ICP	4
Manganese	EPA 6010B ICP	0.5
Mercury	EPA 7471 CVAA	0.02
Molybdenum	EPA 6010B ICP	1
Nickel	EPA 6010B ICP	1
Selenium	EPA 6020 ICP-MS	0.15
Silver	EPA 6010B ICP	0.5
Uranium	EPA 6020 ICP-MS	0.005
Vanadium	EPA 6010B ICP	0.5
Zinc	EPA 6010B ICP	1
RADIOLOGICAL (pCi/g)		
Gross Alpha	EPA 9310	1 to 3
Gross Beta	EPA 9310	1 to 3
Radium 226	EPA 9315	1
Radium 228	EPA 9320	1.5
Thorium 230	ESM 4506 TOPO Extract.	0.2
Thorium 232	ESM 4506 TOPO Extract.	0.2

Table 3.2: Analytical Parameters for Waste Rock - Group B
Uranium Peak AML Sites

Parameter	Method	Detection Limit
METALS (mg/Kg))		
Antimony	EPA 6020 ICP-MS	0.2
Arsenic	EPA 6020 ICP-MS	0.01
Cadmium	EPA 6020 ICP-MS	0.01
Chromium	EPA 6010B ICP	1
Copper	EPA 6010B ICP	1
Iron	EPA 6010B ICP	1
Lead	EPA 6010B ICP	4
Manganese	EPA 6010B ICP	0.5
Mercury	EPA 7471 CVAA	0.02
Molybdenum	EPA 6010B ICP	1
Nickel	EPA 6010B ICP	1
Selenium	EPA 6020 ICP-MS	0.15
Silver	EPA 6010B ICP	0.5
Uranium	EPA 6020 ICP-MS	0.005
Vanadium	EPA 6010B ICP	0.5
Zinc	EPA 6010B ICP	1
SPLP METALS (ug/L))		
Antimony	EPA 6020 ICP-MS	0.2
Arsenic	EPA 6020 ICP-MS	0.1
Cadmium	EPA 6020 ICP-MS	0.1
Chromium	EPA 6010B ICP	10
Copper	EPA 6010B ICP	10
Iron	EPA 6010B ICP	10
Lead	EPA 6010B ICP	40
Manganese	EPA 6010B ICP	5
Mercury	EPA 7470 CVAA	0.0002
Molybdenum	EPA 6010B ICP	10
Nickel	EPA 6010B ICP	10
Selenium	EPA 6020 ICP-MS	1.5
Silver	EPA 6020 ICP-MS	0.05
Uranium	EPA 6020 ICP-MS	0.05
Vanadium	EPA 6010B ICP	5
Zinc	EPA 6010B ICP	10
RADIOLOGICAL (pCi/g)		
Gross Alpha	EPA 9310	1 to 3
Gross Beta	EPA 9310	1 to 3
Radium 226	EPA 9315	1
Radium 228	EPA 9320	1.5
Thorium 230	ESM 4506 TOPO Extract.	0.2
Thorium 232	ESM 4506 TOPO Extract.	0.2

Table 3.3: Analytical Parameters for Surface Water
Uranium Peak AML Sites

Parameter	Method	Detection Limit
PHYSICAL		
Dissolved Oxygen (mg/L)	Field Parameter	0.1
pH	Field Parameter	0.1 units
Conductivity (uS/cm)	Field Parameter	1
Temperature (deg C)	Field Parameter	0.1
Oxidation-Reduction Potential (mv)	Field Parameter	1
Alkalinity as $CaCO_3$ (mg/L)	SM 2320B Titration	2
Total Suspended Solids (mg/L)	EPA 160.2 Gravimetric, 105 C	5
Hardness as $CaCO_3$ (total)	SM 2340B - Calculation	Calculation
INORGANIC (mg/L)		
Nitrite as N, dissolved	EPA 353.2	0.01
Nitrate as N, dissolved	Calculation	Calculation
Nitrate/Nitrite as N, dissolved	EPA 353.2	0.02
Chloride	EPA 325.2 - Colorimetric	1
Sulfate	EPA 375.3 Gravimetric	10
Sodium	EPA 200.7 ICP	0.3
Potassium	EPA 200.7 ICP	0.3
Calcium	EPA 200.7 ICP	0.2
Magnesium	EPA 200.7 ICP	0.2
Total Dissolved Solids	EPA 160.1 Gravimetric, 180 C	10
METALS (µg/L)		
Antimony, Dissolved	EPA 200.8 ICP-MS	0.2
Arsenic, Dissolved	EPA 200.8 ICP-MS	0.1
Arsenic, Total Recoverable	EPA 200.8 ICP-MS	0.1
Cadmium, Dissolved	EPA 200.8 ICP-MS	0.1
Chromium, Total Recoverable	EPA 200.7 ICP	10
Copper, Dissolved	EPA 200.7 ICP	10
Iron, Dissolved	EPA 200.7 ICP	10
Iron, Total Recoverable	EPA 200.7 ICP	10
Lead, Dissolved	EPA 200.8 ICP-MS	0.1
Manganese, Dissolved	EPA 200.7 ICP	5
Mercury, Dissolved	EPA 245.1 CVAA	0.2
Mercury, Total	EPA 245.1 CVAA	0.2
Molybdenum, Dissolved	EPA 200.7 ICP	10
Nickel, Dissolved	EPA 200.7 ICP	10
Selenium, Dissolved	EPA 200.8 ICP-MS	1.5
Silver, Dissolved	EPA 200.8 ICP-MS	0.05
Uranium, Dissolved	EPA 200.8 ICP-MS	0.05
Uranium, Total	EPA 200.8 ICP-MS	0.05
Vanadium, Dissolved	EPA 200.7 ICP	5
Vanadium, Total	EPA 200.7 ICP	5
Zinc, Dissolved	EPA 200.7 ICP	10
RADIOLOGICAL (pCi/L)		
Gross Alpha	EPA 900.0	2 to 4
Gross Beta	EPA 900.0	2 to 4
Radium 226	EPA 903.0	1
Radium 228	EPA 904.0	1
Thorium 230	ESM 4506	0.2
Thorium 232	ESM 4506	0.2
Uranium, Dissolved (WS)	EPA 200.8 ICP-MS/Calc	-----

Table 3.4: Analytical Parameters for Rinse-Blank Samples
Uranium Peak AML Sites

Parameter	Method	Detection Limit
METALS (µg/L)		
Antimony, Total	EPA 200.8 ICP-MS	0.2
Arsenic, Total	EPA 200.8 ICP-MS	0.1
Cadmium, Total	EPA 200.8 ICP-MS	0.1
Chromium, Total	EPA 200.7 ICP	10
Copper, Total	EPA 200.7 ICP	10
Iron, Total	EPA 200.7 ICP	10
Lead, Total	EPA 200.8 ICP-MS	0.1
Manganese, Total	EPA 200.7 ICP	5
Mercury, Total	EPA 245.1 CVAA	0.2
Molybdenum, Total	EPA 200.7 ICP	10
Nickel, Total	EPA 200.7 ICP	10
Selenium, Total	EPA 200.8 ICP-MS	1.5
Silver, Total	EPA 200.8 ICP-MS	0.05
Uranium, Total	EPA 200.8 ICP-MS	0.05
Vanadium, Total	EPA 200.7 ICP	5
Zinc, Total	EPA 200.7 ICP	10
RADIOLOGICAL (pCi/L)		
Gross Alpha	EPA 900.0	2 to 4
Gross Beta	EPA 900.0	2 to 4
Radium 226	EPA 903.0	1
Radium 228	EPA 904.0	1
Thorium 230	ESM 4506	0.2
Thorium 232	ESM 4506	0.2

Table 3.5: Total Metal and Radiological Results for Soil and Waste-Rock Samples
Butterfly and Burrell Mines

Parameter	Background	BUTTERFLY MINE				BURRELL MINE		
		BFLY-01		BFLY-02	BFLY-03	BUR-01	BUR-02	BUR-03
	UP-BKG	BFLY-01	WR-DUP					
METALS (mg/Kg)								
Antimony	< 0.2 U	< 0.2 U	0.3 B	0.2 B	0.3 B	0.3 B	< 0.2 U	0.4 B
Arsenic	4.7	22.2	25.9	23.7	47.7	67.9	51.4	104
Cadmium	0.69	1.47	1.91	1.47	1.15	4.21	0.95	5.44
Chromium	11	12	10	10	9	10	9	12
Copper	9	6	7	7	5 B	13	6	17
Iron	11200	4960	4080	7180	6160	9100	6900	10000
Lead	10 B	29	32	24	12 B	30	12 B	18 B
Manganese	509	116	115	164	112	181	200	234
Mercury	< 0.05 UH	< 0.04 UH	< 0.05 UH	< 0.05 UH	< 0.05 UH	< 0.05 UH	< 0.05 UH	< 0.05 UH
Molybdenum	2 B	< 1 U	< 1 U	1 B	2 B	5	2 B	10
Nickel	9	11	11	10	8	12	8	14
Selenium	< 0.6 U	22.1	12.4	20.5	19.2	36.4	3	14.6
Silver	< 1 U	< 1 U	< 1 U	< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
Uranium	1.33	479	436	131	108	411	27.4	129
Vanadium	15.8	1750	1720	506	531	1200	97.4	523
Zinc	31	54	56	40	29	57	20	41
RADIOLOGICAL (pCi/g)								
Gross Alpha	6.2	940	820	200	290	520	47	470
Gross Beta	6.7	430	340	82	130	230	18	150
Radium 226	1.6	320	78	54	66	130	13	100
Radium 228	1.7	2.9	3.3	2.3	2.7	3	4.1	3.7
Thorium 228	0.4	0.62	0.69	0.5	0.19	0.46	0.34	0.47
Thorium 230	0.77	230	160	56	84	160	9.7	88
Thorium 232	0.6	0.8	1.27	0.68	0.45	0.82	0.51	0.43
Percent Solids (%)	86.1	93.9	94.2	94.4	93.6	96.9	92.2	93.7

Qualifiers are defined as follows:
B Analyte detected at a value between Method Detection Limit and Practical Quantitation Limit
U Analyte was not detected at the Method Detection Limit
H Holding time was not met

Table 3.6: SPLP Analytical Results for Waste-Rock Samples
Butterfly and Burrell Mines

Parameter	Method Detection Limit	BFLY-03			BUR-02		
METALS (mg/L)							
Antimony	0.0004	<	0.0004	U	<	0.0004	U
Arsenic	0.0005		0.0086			0.0066	
Cadmium	0.0001	<	0.0001	U	<	0.0001	U
Chromium	0.01	<	0.01	U	<	0.01	U
Copper	0.01	<	0.01	U	<	0.01	U
Iron	0.02		0.07			0.16	
Lead	0.04	<	0.04	U	<	0.04	U
Manganese	0.005	<	0.005	U		0.005	B
Mercury	0.0002	<	0.0002	UH	<	0.0002	UH
Molybdenum	0.01	<	0.01	U	<	0.01	U
Nickel	0.01	<	0.01	U	<	0.01	U
Selenium	0.001		0.001	B	<	0.001	U
Silver	0.00005	<	0.00005	U	<	0.00005	U
Uranium	0.0001		0.0065			0.001	
Vanadium	0.005		0.093			0.007	B
Zinc	0.01	<	0.01	U	<	0.01	U

Qualifiers are defined as follows:

B Analyte detected at a value between Method Detection Limit and Practical Quantitation Limit
U Analyte was not detected at the Method Detection Limit
H Holding time was not met

Table 3.7: Analytical Results for Surface-Water Samples
Butterfly and Burrell Mines

Parameter/Analyte	Units	Background		Butterfly Mine Adit				BUTTERFLY		COAL CK		COAL CK	
		BKG-1		BUTTERFLY ADIT		SW-DUP		TRIBUTARY		UP		DN	
PHYSICAL (field parameters)													
Flow	cfs	---		0.00		---		~ 2.22E-02		~ 3.00		~ 3.00	
Temperature	°c	15.9		4.5		---		14.5		13.1		15.1	
pH	s.u.	7.52		8.63		---		7.16		6.9		6.85	
Specific Conductance	(uS/cm)	194		267		---		362		86.2		187	
Dissolved Oxygen	(mg/L)	8.34		8.27		---		5.23		9.02		8.62	
Oxidation Reduction Potential	(rmV)	96.2		188		---		112.4		175.8		118.4	
INORGANIC													
Bicarbonate as CaCO3	mg/L	102		137		133		185		36		65	
Carbonate as CaCO3	mg/L	3	B	2	B	2	B	< 2	U	< 2	U	< 2	U
Chloride	mg/L	< 1	U	< 1	U	< 1	U	< 1	U	1	B	< 1	U
Hardness as CaCO3	mg/L	113		136		136		194		34		86	
Hydroxide as CaCO3	mg/L	< 2	U	< 2	U	< 2	U	< 2	U	< 2	U	< 2	U
Nitrate as N, dissolved	mg/L	0.06	B	0.34		0.36		< 0.02	U	< 0.02	U	< 0.02	U
Nitrate/Nitrite as N, dissolve	mg/L	0.06	B	0.34		0.36		< 0.02	U	< 0.02	U	< 0.02	U
Nitrite as N, dissolved	mg/L	< 0.01	U	< 0.01	U	< 0.01	U	< 0.01	U	< 0.01	U	< 0.01	U
Residue, Filterable (TDS) @180	mg/L	110		160		160		200		50		110	
Residue, Non-Filterable (TSS)	mg/L	8	B	6	B	10	B	12	B	20		16	B
Sulfate	mg/L	< 10	U	< 10	U	< 10	U	20	B	< 10	U	10	B
Total Alkalinity	mg/L	105		140		136		185		36		65	
METALS													
Antimony, dissolved	µg/L	< 0.4	U	< 0.4	U	< 0.4	U	< 0.4	U	< 0.4	U	< 0.4	U
Arsenic, dissolved	µg/L	1.1	B	2.5	B	2.5	B	1.1	B	1.2	B	1	B
Arsenic, total recoverable	µg/L	< 0.5	U	2.3	B	2.3	B	1.4	B	1.1	B	1	B
Cadmium, dissolved	µg/L	< 0.1	U	< 0.1	U	< 0.1	U	< 0.1	U	< 0.1	U	< 0.1	U
Calcium, dissolved	µg/L	31900		51600		51800		59800		10700		27000	
Chromium, total recoverable	µg/L	< 10	U	< 20	U	< 10	U	< 10	U	< 10	U	< 10	U
Copper, dissolved	µg/L	120		< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
Iron, dissolved	µg/L	30	B	< 20	U	< 20	U	60		90		90	
Iron, total recoverable	µg/L	70		110		120		290		880		650	
Lead, dissolved	µg/L	0.2	B	< 0.1	U	< 0.1	U	< 0.1	U	< 0.1	U	0.1	B
Magnesium, dissolved	µg/L	8000		1600		1500		10800		1700		4600	
Manganese, dissolved	µg/L	< 5	U	< 5	U	< 5	U	81		6	B	< 5	U
Mercury, dissolved	µg/L	< 0.2	U	< 0.2	U	< 0.2	U	< 0.2	U	< 0.2	U	1.3	
Mercury, total	µg/L	< 0.2	U	< 0.2	U	< 0.2	U	< 0.2	U	< 0.2	U	< 0.2	U
Molybdenum, dissolved	µg/L	< 10	U	10	B	< 10	U	< 10	U	< 10	U	< 10	U
Nickel, dissolved	µg/L	< 10	U	< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
Potassium, dissolved	µg/L	500	B	900	B	700	B	1400		600	B	600	B
Selenium, dissolved	µg/L	< 1	U	2	B	2	B	< 1	U	< 1	U	< 1	U
Silver, dissolved	µg/L	0.07	B	0.08	B	0.08	B	< 0.05	U	< 0.05	U	0.06	B
Sodium, dissolved	µg/L	1200		800	B	700	B	1900		1500		1800	
Uranium, dissolved	µg/L	0.2	B	35.4		35		6.4		0.1	B	0.8	
Uranium, total	µg/L	0.2	B	40.1		41		6.5		0.2	B	0.9	
Vanadium, dissolved	µg/L	< 5	U	11	B	10	B	< 5	U	< 5	U	7	B
Vanadium, total	µg/L	< 10	U	10	B	16	B	< 5	U	< 5	U	< 5	U
Zinc, dissolved	µg/L	< 10	U	< 10	U	< 10	U	< 10	U	< 10	U	< 10	U
RADIONUCLIDES													
Gross Alpha	pCi/L	1.5		40		33		6.4		2.1		2.6	
Gross Beta	pCi/L	2.1		21		13		2.1		4.1		2.4	
Radium 226	pCi/L	0.27		6.1		6		0.38		0.01		0.28	
Radium 228	pCi/L	1.2		0		1.3		1.1		0.9		0.69	
Thorium 228	pCi/L	0		0		-0.03		0		0.1		0.1	
Thorium 230	pCi/L	-0.22		0.14		0.13		-0.23		-0.12		-0.34	
Thorium 232	pCi/L	-0.06		0.02		0.22		0.18		0.05		0.07	

Qualifiers are defined as follows:

B Analyte detected at a value between Method Detection Limit and Practical Quantitation Limit

U Analyte was not detected at the Method Detection Limit

Table 3.8: Radon Monitoring Results
Butterfly and Burrell Mines

Detector Number	Detector Identification	Starting Date	Ending Date	Total Exposure 91-day Period (pCi/L)	Average Exposure	
					Per Day (pCi/L)	Per Hour (pCi/L)
4547809	Background	6-Jul-05	5-Oct-05	< 30.0	< 0.3	< 0.01
4547808	Butterfly Mine Portal	6-Jul-05	5-Oct-05	13217.4	145.2	6.05
4547811	Butterfly Cabin	6-Jul-05	5-Oct-05	60.3	0.7	0.03
4547810	Burrell Mine Portal	6-Jul-05	5-Oct-05	30259.5	332.5	13.85

Table 4.1: Rinse Blank Results
Butterly and Burrell Mines

Parameter	Units	Rinse Blank		
Metals				
Antimony, total	mg/L	<	0.0004	U
Arsenic, total	mg/L	<	0.0005	U
Cadmium, total	mg/L		0.0002	B
Chromium, total	mg/L	<	0.01	U
Copper, total	mg/L	<	0.01	U
Iron, total	mg/L	<	0.02	U
Lead, total	mg/L	<	0.0001	U
Manganese, total	mg/L	<	0.005	U
Mercury, total	mg/L	<	0.0002	U
Molybdenum, total	mg/L	<	0.01	U
Nickel, total	mg/L	<	0.01	U
Selenium, total	mg/L	<	0.001	U
Silver, total	mg/L	<	0.00005	U
Uranium, total	mg/L	<	0.0001	U
Vanadium, total	mg/L	<	0.005	U
Zinc, total	mg/L	<	0.01	U
Radionuclides				
Gross Alpha	pCi/L		0.51	
Gross Beta	pCi/L		0	
Radium 226, total	pCi/L		0.18	
Radium 228	pCi/L		0.37	
Thorium 228	pCi/L		-0.03	
Thorium 230	pCi/L		-0.06	
Thorium 232	pCi/L		0.16	

Qualifiers are defined as follows:

B Analyte detected at a value between Method Detection Limit and Practical Quantitation Limit

U Analyte was not detected at the Method Detection Limit

Table 5.1: Human Health Screening Criteria for Soil and Waste Rock
Butterfly and Burrell Mines

Parameter	Screening Level[1]	EPA REGION III Industrial RBC[2]	EPA REGION IX Industrial PRG[3]	BLM Risk Management Criteria[4]		
				Camper Soil	ATV Driver Soil	Site Worker Soil
METALS (mg/Kg)						
Antimony	50	410	410	50	750	100
Arsenic	1.6	1.9	1.6	20	300	12
Cadmium	70	510	450	70	950	100
Chromium	450	----	450	-----	-----	-----
Copper	5,000	41,000	41,000	5,000	70,000	7,400
Iron	100,000	310,000	100,000	-----	-----	-----
Lead	800	----	800	1,000	1,000	2,000
Manganese	19,000	20,000	19,000	19,000	250,000	28,000
Mercury	40	----	310	40	550	60
Molybdenum	5,100	5,100	5,100			
Nickel	2,700	20,000	20,000	2,700	38,000	4,000
Selenium	700	5,100	5,100	700	9,600	1,000
Silver	700	5,100	5,100	700	9,600	1,000
Uranium	200	3,100	200	-----	-----	-----
Vanadium	1,000	1,000	1,000	-----	-----	-----
Zinc	40,000	310,000	100,000	40,000	550,000	60,000
RADIOLOGICAL (pCi/g)						
Gross Alpha	---- [5]	----	----	----	----	----
Gross Beta	---- [5]	----	----	----	----	----
Radium 226	---- [5]	----	----	----	----	----
Radium 228	---- [5]	----	----	----	----	----
Thorium 230	---- [5]	----	----	----	----	----
Thorium 232	---- [5]	----	----	----	----	----

[1] Screening Level corresponds to the most restrictive criterion
[2] From www.epa.gov/reg3hwmk/risk (October 2005 table)
[3] From www.epa.gov/Region9/waste/sfund/prg/index.html (2004 table)
[4] From Risk Management Criteria for Metals at BLM Mining Sites (Ford, 2004)
[5] Analytical results will be compared to levels reported for upgradient/background samples.

Table 5.2: Comparison of Analytical Results for Soil and Waste-Rock Samples to Human-Health Screening Levels
Butterfly and Burrell Mines

Parameter	Screening Level[1]	Background	BUTTERFLY MINE				BURRELL MINE		
			BFLY-01		BFLY-02	BFLY-03	BUR-01	BUR-02	BUR-03
		UP-BKG	BFLY-01	Duplicate					
METALS (mg/Kg)									
Antimony	50	< 0.2 U	< 0.2 U	0.3 B	0.2 B	0.3 B	0.3	< 0.2 U	0.4 B
Arsenic	1.6	**4.7 +**	**22.2 ++**	**25.9 ++**	**23.7 ++**	**47.7 ++**	**67.9 ++**	**51.4 ++**	**104 ++**
Cadmium	70	0.69	1.47	1.91	1.47	1.15	4.21	0.95	5.44
Chromium	450	11	12	10	10	9	10	9	12
Copper	5,000	9	6	7	7	5 B	13	6	17
Iron	100,000	11200	4960	4080	7180	6160	9100	6900	10000
Lead	800	10 B	29	32	24	12 B	30	12 B	18 B
Manganese	19,000	509	116	115	164	112	181	200	234
Mercury	40	< 0.05 UH	< 0.04 UH	< 0.05 UH	< 0.05 UH	< 0.05 UH	< 0.05 UH	< 0.05 UH	< 0.05 UH
Molybdenum	5,100	2 B	< 1 U	< 1 U	1 B	2 B	5	2 B	10
Nickel	2,700	9	11	11	10	8	12	8	14
Selenium	700	< 0.6 U	22.1	12.4	20.5	19.2	36.4	3	14.6
Silver	700	< 1 U	< 1 U	< 1 U	< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
Uranium	200	1.33	**479 +**	**436 +**	131	108	**411 +**	27.4	129
Vanadium	1,000	15.8	**1750 +**	**1720 +**	506	531	**1200 +**	97.4	523
Zinc	40,000	31	54	56	40	29	57	20	41
RADIOLOGICAL (pCi/g)									
Gross Alpha	----	6.2	**940 +++**	**820 +++**	**200 ++**	**290 ++**	**520 ++**	**47 +**	**470 ++**
Gross Beta	----	6.7	**430 ++**	**340 ++**	**82 ++**	**130 ++**	**230 ++**	**18 +**	**150 ++**
Radium 226	----	1.6	**320 +++**	**78 ++**	**54 ++**	**66 ++**	**130 ++**	**13 +**	**100 ++**
Radium 228	----	1.7	**2.9 +**	**3.3 +**	**2.3 +**	**2.7 +**	**3 +**	**4.1 +**	**3.7 +**
Thorium 228	----	0.4	**0.62 +**	**0.69 +**	**0.5 +**	0.19	**0.46 +**	0.34	**0.47 +**
Thorium 230	----	0.77	**230 +++**	**160 +++**	**56 ++**	**84 +++**	**160 +++**	**9.7 ++**	**88 +++**
Thorium 232	----	0.6	**0.8 +**	**1.27 +**	**0.68 +**	0.45	**0.82 +**	0.51	0.43
Percent Solids (%)	----	86.1	93.9	94.2	94.4	93.6	96.9	92.2	93.7

[1] Screening levels as shown in Table 5.1
Shaded value in bold indicates value exceeds screening level (metals) or background level (radiological)
+ Value exceeds screening level (metals) or background level (radiological) by 1 to 10 times
++ Value exceeds screening level (metals) or background level (radiological) by 10 to 100 times
+++ Value exceeds screening level (metals) or background level (radiological) by more than 100 times
Qualifiers are defined as follows:
B Analyte detected at a value between Method Detection Limit and Practical Quantitation Limit
U Analyte was not detected at the Method Detection Limit
H Holding time was not met

Table 5.3: Summary of Total Metal Concentrations in Soil and Waste Rock Exceeding Screening Levels
Butterfly and Burrell Mines

Analyte	Sample	Sample Result (mg/Kg)	Screening Level Criterion (mg/Kg)	Screening Level Exceedance Factor	Camper RMC Criterion (mg/Kg)	Camper RMC Exceedance Factor
Butterfly Mine						
Arsenic	BFLY-01 (Loadout/grizzly)	25.9	1.6	5.5	20	1.3
	BFLY-02 (Mine bench)	23.7	1.6	5.0	20	1.2
	BFLY-03 (Waste-rock dump)	47.7	1.6	29.8	20	2.4
Uranium	BFLY-01 (Loadout/grizzly)	479	200	2.4	---	NA
Vanadium	BFLY-01 (Loadout/grizzly)	1750	1000	1.8	---	NA
Burrell Mine						
Arsenic	BUR-01 (Loadout)	67.9	1.6	42.4	20	3.4
	BUR-02 (Waste-rock dump)	51.4	1.6	32.1	20	2.6
	BUR-03 (Loadout rib)	104	1.6	65.0	20	5.2
Uranium	BUR-01 (Loadout)	411	200	2.1	---	NA
Vanadium	BUR-01 (Loadout)	1200	1000	1.2	---	NA

Table 5.4: Human-Health Screening Criteria for Surface Water
Butterfly and Burrell Mines

Parameter/Analyte	Units	BLM Camper RMC[1]	EPA		EPA	
			MCL	Modified MCL[2]	Secondary Std	Mod. Sec. Std [2]
PHYSICAL (field parameters)						
Flow	cfs	-----	-----	-----	-----	-----
Temperature	^{o}C	-----	-----	-----	-----	-----
pH	s.u.	-----	-----	-----	6.5 - 8.5	6.5 - 8.5
Specific Conductance	(uS/cm)	-----	-----	-----	-----	-----
Dissolved Oxygen	(mg/L)	-----	-----	-----	-----	-----
Oxidation Reduction Potential	(rmV)	-----	-----	-----	-----	-----
INORGANIC						
Bicarbonate as CaCO3	mg/L	-----	-----	-----	-----	-----
Carbonate as CaCO3	mg/L	-----	-----	-----	-----	-----
Chloride	mg/L	-----	-----	-----	250	6500
Hardness as CaCO3	mg/L	-----	-----	-----	-----	-----
Hydroxide as CaCO3	mg/L	-----	-----	-----	-----	-----
Nitrate as N, dissolved	mg/L	-----	10	260	-----	-----
Nitrate/Nitrite as N, dissolve	mg/L	-----	-----	-----	-----	-----
Nitrite as N, dissolved	mg/L	-----	1	26	-----	-----
Residue, Filterable (TDS) @180	mg/L	-----	-----	-----	500	13000
Residue, Non-Filterable (TSS)	mg/L	-----	-----	-----	-----	-----
Sulfate	mg/L	-----	-----	-----	250	6500
Total Alkalinity	mg/L	-----	-----	-----	-----	-----
METALS						
Antimony, dissolved	µg/L	124	-----	-----	-----	-----
Arsenic, dissolved	µg/L	93	-----	-----	-----	-----
Arsenic, total recoverable	µg/L	-----	10	260	-----	-----
Cadmium, dissolved	µg/L	155	-----	-----	-----	-----
Calcium, dissolved	µg/L	-----	-----	-----	-----	-----
Chromium, total recoverable	µg/L	-----	100	2600	-----	-----
Copper, dissolved	µg/L	11,490	-----	-----	-----	-----
Iron, dissolved	µg/L	-----	-----	-----	-----	-----
Iron, total recoverable	µg/L	-----	-----	-----	300	7800
Lead, dissolved	µg/L	50	-----	-----	-----	-----
Magnesium, dissolved	µg/L	-----	-----	-----	-----	-----
Manganese, dissolved	µg/L	1,548	-----	-----	-----	-----
Mercury, dissolved	µg/L	93	-----	-----	-----	-----
Mercury, total	µg/L	-----	2	52	-----	-----
Molybdenum, dissolved	µg/L	-----	-----	-----	-----	-----
Nickel, dissolved	µg/L	6,194	-----	-----	-----	-----
Potassium, dissolved	µg/L	-----	-----	-----	-----	-----
Selenium, dissolved	µg/L	1,548	-----	-----	-----	-----
Silver, dissolved	µg/L	1,548	-----	-----	-----	-----
Sodium, dissolved	µg/L	-----	-----	-----	-----	-----
Uranium, dissolved	µg/L	-----	-----	-----	-----	-----
Uranium, total	µg/L	-----	30	780	-----	-----
Vanadium, dissolved	µg/L	-----	-----	-----	-----	-----
Vanadium, total	µg/L	-----	-----	-----	-----	-----
Zinc, dissolved	µg/L	92,909	-----	-----	-----	-----
RADIONUCLIDES						
Grpss Alpha	pCi/L	-----	-----	-----	-----	-----
Gross Alpha (excluding uranium)	pCi/L	-----	15	390	-----	-----
Gross Beta	pCi/L	-----	4 mrem/yr	104 mrem/yr	-----	-----
Radium 226/228 combined	pCi/L	-----	5	130	-----	-----
Thorium 228	pCi/L	-----	-----	-----	-----	-----
Thorium 230	pCi/L	-----	-----	-----	-----	-----
Thorium 232	pCi/L	-----	-----	-----	-----	-----

[1] From Ford, 2004; applies to swimming only.
[2] Modified by using exposure factor of 365/14 days (26x) for camper scenario.

Table 5.5: Comparison of Analytical Results for Surface Water to Background Levels and Human-Health Criteria
Butterfly and Burrell Mines

Parameter/Analyte	Units	BLM Camper RMC[1]	EPA Modified MCL[2]	EPA Mod. Sec. Std [2]	Background	Butterfly Mine Adit: Butterfly Adit	Butterfly Mine Adit: Duplicate	Butterfly Tributary	Coal Ck Up	Coal Ck Dn
PHYSICAL (field parameters)										
Flow	cfs	-----	-----	-----	---	0.00	---	~ 2.22E-02	~ 3.00	~ 3.00
Temperature	°C	-----	-----	-----	15.9	4.5	---	14.5	13.1	15.1
pH	s.u.	-----	-----	6.5 - 8.5	7.52	8.63	---	7.16	6.9	6.85
Specific Conductance	(uS/cm)	-----	-----	-----	194	267	---	362	86.2	187
Dissolved Oxygen	(mg/L)	-----	-----	-----	8.34	8.27	---	5.23	9.02	8.62
Oxidation Reduction Potential	(rmV)	-----	-----	-----	96.2	188	---	112.4	175.8	118.4
INORGANIC										
Bicarbonate as CaCO3	mg/L	-----	-----	-----	102	**137 +**	**133 +**	**185 +**	36	65
Carbonate as CaCO3	mg/L	-----	-----	-----	3 B	2 B	2 B	< 2 U	< 2 U	< 2 U
Chloride	mg/L	-----	-----	6500	< 1 U	< 1 U	< 1 U	< 1 U	1 B	< 1 U
Hardness as CaCO3	mg/L	-----	-----	-----	113	**136 +**	**136 +**	**194 +**	34	86
Hydroxide as CaCO3	mg/L	-----	-----	-----	< 2 U	< 2 U	< 2 U	< 2 U	< 2 U	< 2 U
Nitrate as N, dissolved	mg/L	-----	260	-----	0.06 B	**0.34 +**	**0.36 +**	< 0.02 U	< 0.02 U	< 0.02 U
Nitrate/Nitrite as N, dissolve	mg/L	-----	-----	-----	0.06 B	**0.34 +**	**0.36 +**	< 0.02 U	< 0.02 U	< 0.02 U
Nitrite as N, dissolved	mg/L	-----	26	-----	< 0.01 U	< 0.01 U	< 0.01 U	< 0.01 U	< 0.01 U	< 0.01 U
Residue, Filterable (TDS) @180	mg/L	-----	-----	13000	110	**160 +**	**160 +**	**200 +**	50	110
Residue, Non-Filterable (TSS)	mg/L	-----	-----	-----	8 B	6 B	**10 B+**	**12 B+**	**20 +**	**16 B+**
Sulfate	mg/L	-----	-----	6500	< 10 U	< 10 U	< 10 U	**20 B+**	< 10 U	10 B
Total Alkalinity	mg/L	-----	-----	-----	105	**140 +**	**136 +**	**185 +**	36	65
METALS										
Antimony, dissolved	µg/L	124	-----	-----	< 0.4 U	< 0.4 U	< 0.4 U	< 0.4 U	< 0.4 U	< 0.4 U
Arsenic, dissolved	µg/L	93	-----	-----	1.1 B	**2.5 B+**	**2.5 B+**	1.1 B	**1.2 B+**	1 B
Arsenic, total recoverable	µg/L	-----	260	-----	< 0.5 U	**2.3 B+**	**2.3 B+**	**1.4 B+**	**1.1 B+**	**1 B+**
Cadmium, dissolved	µg/L	155	-----	-----	< 0.1 U	< 0.1 U	< 0.1 U	< 0.1 U	< 0.1 U	< 0.1 U
Calcium, dissolved	µg/L	-----	-----	-----	31900	**51600 +**	**51800 +**	**59800 +**	10700	27000
Chromium, total recoverable	µg/L	-----	2600	-----	< 10 U	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U
Copper, dissolved	µg/L	11,490	-----	-----	120 ++	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Iron, dissolved	µg/L	-----	-----	-----	30 B	< 20 U	< 20 U	**60 +**	**90 +**	**90 +**
Iron, total recoverable	µg/L	-----	-----	7800	70	**110 +**	**120 +**	**290 +**	**880 ++**	**650 +**
Lead, dissolved	µg/L	50	-----	-----	0.2 B	< 0.1 U	< 0.1 U	< 0.1 U	< 0.1 U	0.1 B
Magnesium, dissolved	µg/L	-----	-----	-----	8000	1600	1500	**10800 +**	1700	4600
Manganese, dissolved	µg/L	1,548	-----	-----	< 5 U	< 5 U	< 5 U	**81 ++**	**6 B+**	< 5 U
Mercury, dissolved	µg/L	93	-----	-----	< 0.2 U	< 0.2 U	< 0.2 U	< 0.2 U	< 0.2 U	**1.3 +**
Mercury, total	µg/L	-----	52	-----	< 0.2 U	< 0.2 U	< 0.2 U	< 0.2 U	< 0.2 U	< 0.2 U
Molybdenum, dissolved	µg/L	-----	-----	-----	< 10 U	**10 B+**	< 10 U	< 10 U	< 10 U	< 10 U
Nickel, dissolved	µg/L	6,194	-----	-----	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Potassium, dissolved	µg/L	-----	-----	-----	500 B	**900 B+**	**700 B+**	**1400 +**	**600 B+**	**600 B+**
Selenium, dissolved	µg/L	1,548	-----	-----	< 1 U	**2 B+**	**2 B+**	< 1 U	< 1 U	< 1 U
Silver, dissolved	µg/L	1,548	-----	-----	0.07 B+	**0.08 B+**	**0.08 B+**	< 0.05 U	< 0.05 U	0.06 B
Sodium, dissolved	µg/L	-----	-----	-----	1200	800 B	700 B	**1900 +**	**1500 +**	**1800 +**
Uranium, dissolved	µg/L	-----	-----	-----	0.2 B	**35.4 +++**	**35 +++**	**6.4 ++**	0.1 B	**0.8 +**
Uranium, total	µg/L	-----	780	-----	0.2 B	**40.1 +++**	**41 +++**	**6.5 ++**	0.2 B	**0.9 +**
Vanadium, dissolved	µg/L	-----	-----	-----	< 5 U	**11 B+**	**10 B+**	< 5 U	< 5 U	**7 B+**
Vanadium, total	µg/L	-----	-----	-----	< 10 U	**10 B+**	**16 B+**	< 5 U	< 5 U	< 5 U
Zinc, dissolved	µg/L	92,909	-----	-----	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
RADIONUCLIDES										
Gross Alpha	pCi/L	-----	-----	-----	1.5	**40 ++**	**33 ++**	**6.4 +**	**2.1 +**	**2.6 +**
Gross Alpha (excluding uranium)	pCi/L	-----	390	-----	1.4	**13.1 +**	**5.5 +**	**2.0 +**	**2.0 +**	**2.0 +**
Gross Beta	pCi/L	-----	104 mrem/yr	-----	2.1	**21 +**	**13 +**	2.1	**4.1 +**	**2.4 +**
Radium 226/228 combined	pCi/L	-----	130	-----	1.47	**6.1 +**	**7.3 +**	**1.48 +**	0.91	0.97
Thorium 228	pCi/L	-----	-----	-----	0	0	-0.03	0	**0.1 +**	**0.1 +**
Thorium 230	pCi/L	-----	-----	-----	-0.22	**0.14 +**	**0.13 +**	-0.23	-0.12	-0.34
Thorium 232	pCi/L	-----	-----	-----	-0.06	**0.02 +**	**0.22 +**	**0.18 +**	**0.05 +**	**0.07 +**

[1] From Ford, 2004; applies to swimming only.
[2] Modified by using exposure factor of 365/14 days (26x) for camper scenario.
Value in bold indicates level exceeds criterion or background level
+ Value exceeds human-health criterion (shaded) or background (not shaded) by 1 to 10 times
++ Value exceeds human-health criterion (shaded) or background (not shaded) by 10 to 100 times
+++ Value exceeds human-health criterion (shaded) or background (not shaded) by more than 100 times

Qualifiers are defined as follows:
B Analyte detected at a value between Method Detection Limit and Practical Quantitation Limit
U Analyte was not detected at the Method Detection Limit

Table 5.6: Comparison of Analytical Results for Soil and Waste Rock at the Butterfly Mine to Ecological Risk Criteria

Analyte	Elk RMC[1]	Modified Elk RMC[2]	Background UP-BKG	BUTTERFLY MINE			
				BFLY-01		BFLY-02	BFLY-03
				BFLY-01	WR-DUP		
METALS (mg/Kg)							
Antimony, total (3050)	----	----	< 0.2 U	< 0.2 U	0.3 B	0.2 B	0.3 B
Arsenic, total (3050)	328	77748	4.7	22.2	25.9	23.7	47.7
Cadmium, total (3050)	3	711	0.69	1.47	1.91	1.47	1.15
Chromium, total (3050)	----	----	11	**12 +**	10	10	9
Copper, total (3050)	131	31052	9	6	7	7	5 B
Iron, total (3050)	----	----	11200	4960	4080	7180	6160
Lead, total (3050)	127	30104	10 B	29	32	24	12 B
Manganese, total (3050)	----	----	509	116	115	164	112
Mercury, total	11	2607	0 UH	0 UH	0 UH	0 UH	0 UH
Molybdenum, total (3050)	----	----	2 B	< 1 U	< 1 U	1 B	2 B
Nickel, total (3050)	----	----	9	**11 +**	**11 +**	**10 +**	8
Selenium, total (3050)	----	----	< 0.6 U	**22.1 ++**	**12.4 ++**	**20.5 ++**	**19.2 ++**
Silver, total (3050)	----	----	< 1 U	< 1 U	< 1 U	< 1 U	< 1 U
Uranium, total (3050)	3323 [3]	787674	1.33	479	436	131	108
Vanadium, total (3050)	280 [4]	66370	15.8	1750	1720	506	531
Zinc, total (3050)	275	65185	31	54	56	40	29
RADIOLOGICAL (pCi/g)							
Gross Alpha	----	----	6.2	**940 +++**	**820 +++**	**200 ++**	**290 ++**
Gross Beta	----	----	6.7	**430 ++**	**340 ++**	**82 ++**	**130 ++**
Radium 226 (3050)	----	----	1.6	**320 +++**	**78 ++**	**54 ++**	**66 ++**
Radium 228 (3050)	----	----	1.7	**2.9 +**	**3.3 +**	**2.3 +**	**2.7 +**
Thorium 228	----	----	0.4	**0.62 +**	**0.69 +**	**0.5 +**	0.19
Thorium 230	----	----	0.77	**230 +++**	**160 +++**	**56 ++**	**84 +++**
Thorium 232	----	----	0.6	**0.8 +**	**1.27 +**	**0.68 +**	0.45
Percent Solids (%)	----	----	86.1	93.9	94.2	94.4	93.6

[1] From *Risk Management Criteria for Metals at BLM Mine Sites* (Ford, 2004)
[2] Modified by area use factor (RMC/(2.7 acres/640 acres); area measured from Figure 3.1.
[3] Value derived by the BLM in 2005 based on ORNL (1996) chemical toxicity values and uptake to plants.
[4] Value specific for mammalian receptors; from *Ecological Soil Screening Levels for Vanadium* (EPA, 2005)
Shaded value in bold indicates value exceeds RMC or background level (where no RMC established)
+ Value exceeds RMC or background level (where no RMC established) by 1 to 10 times
++ Value exceeds RMC or background level (where no RMC established) by 10 to 100 times
+++ Value exceeds RMC or background level (where no RMC established) by more than 100 times
Qualifiers are defined as follows:
B Analyte detected at a value between Method Detection Limit and Practical Quantitation Limit
U Analyte was not detected at the Method Detection Limit
H Holding time was not met

Table 5.7: Comparison of Analytical Results for Soil and Waste Rock at the Burrell Mine to Ecological Risk Criteria

Analyte	Elk RMC[1]	Modified Elk RMC[2]	Background UP-BKG	Burrell Mine BUR-01	Burrell Mine BUR-02	Burrell Mine BUR-03
METALS (mg/Kg)						
Antimony, total (3050)	----	----	< 0.2 U	**0.3 +**	< 0.2 U	**0.4 B+**
Arsenic, total (3050)	328	99962	4.7	67.9	51.4	104
Cadmium, total (3050)	3	914	0.69	4.21	0.95	5.44
Chromium, total (3050)	----	----	11	10	9	**12 +**
Copper, total (3050)	131	39924	9	13	6	17
Iron, total (3050)	----	----	11200	9100	6900	10000
Lead, total (3050)	127	38705	10 B	30	12 B	18 B
Manganese, total (3050)	----	----	509	181	200	234
Mercury, total	11	3352	0 UH	0 UH	0 UH	0 UH
Molybdenum, total (3050)	----	----	2 B	**5 +**	2 B	**10 +**
Nickel, total (3050)	----	----	9	**12 +**	8	**14 +**
Selenium, total (3050)	----	----	< 0.6 U	**36.4 ++**	**3 +**	**14.6 ++**
Silver, total (3050)	----	----	< 1 U	< 1 U	< 1 U	< 1 U
Uranium, total (3050)	3323 [3]	1012724	1.33	411	27.4	129
Vanadium, total (3050)	280 [4]	85333	15.8	1200	97.4	523
Zinc, total (3050)	275	83810	31	57	20	41
RADIOLOGICAL (pCi/g)						
Gross Alpha	----	----	6.2	**520 ++**	**47 +**	**470 ++**
Gross Beta	----	----	6.7	**230 ++**	**18 +**	**150 ++**
Radium 226 (3050)	----	----	1.6	**130 ++**	**13 +**	**100 ++**
Radium 228 (3050)	----	----	1.7	**3 +**	**4.1 +**	**3.7 +**
Thorium 228	----	----	0.4	**0.46 +**	0.34	**0.47 +**
Thorium 230	----	----	0.77	**160 +++**	**9.7 ++**	**88 +++**
Thorium 232	----	----	0.6	**0.82 +**	0.51	0.43
Percent Solids (%)	----	----	86.1	96.9	92.2	93.7

[1] From *Risk Management Criteria for Metals at BLM Mine Sites* (Ford, 2004)

[2] Modified by area use factor (RMC/(2.1 acres/640 acres); area measured from Figure 3.1.

[3] Value derived by the BLM in 2005 based on ORNL (1996) chemical toxicity values and uptake to plants.

[4] Value specific for mammalian receptors; from *Ecological Soil Screening Levels for Vanadium* (EPA, 2005)

Shaded value in bold indicates value exceeds RMC or background level (where no RMC established)

+ Value exceeds RMC or background level (where no RMC established) by 1 to 10 times

++ Value exceeds RMC or background level (where no RMC established) by 10 to 100 times

+++ Value exceeds RMC or background level (where no RMC established) by more than 100 times

Qualifiers are defined as follows:

B Analyte detected at a value between Method Detection Limit and Practical Quantitation Limit

U Analyte was not detected at the Method Detection Limit

H Holding time was not met

Table 5.8: Comparison of Total Metals Results for Soil and Waste Rock to Leaching RMC
Butterfly and Burrell Mines

Parameter	BFLY-03			BUR-02		
	SPLP (mg/L)	Leaching RMC (mg/Kg)	Total Metals (mg/Kg)	SPLP (mg/L)	Leaching RMC (mg/Kg)	Total Metals (mg/Kg)
METALS (mg/L)						
Antimony	< 0.0004 U	NS	0.3 B	< 0.0004 U	NS	< 0.2 U
Arsenic	0.0086	5547	47.7	0.0066	7788	51.4
Cadmium	< 0.0001 U	1012	1.15	< 0.0001 U	836	0.95
Chromium	< 0.01 U	1800	9	< 0.01 U	1800	9
Copper	< 0.01 U	180	5 B	< 0.01 U	216	6
Iron	0.07	1760000	6160	0.16	862500	6900
Lead	< 0.04 U	30	12 B	< 0.04 U	30	12 B
Manganese	< 0.005 U	1478400	112	0.005 B	1320000	200
Mercury	< 0.0002 UH	---	< 0.05 UH	< 0.0002 UH	---	< 0.05 UH
Molybdenum	< 0.01 U	NS	2 B	< 0.01 U	NS	2 B
Nickel	< 0.01 U	1664	8	< 0.01 U	1664	8
Selenium	0.001 B	1766	19.2	< 0.001 U	552	3
Silver	< 0.00005 U	---	< 1 U	< 0.00005 U	---	< 1 U
Uranium	0.0065	498462	108	0.001	822000	27.4
Vanadium	0.093	NS	531	0.007 B	NS	97.4
Zinc	< 0.01 U	13572	29	< 0.01 U	9360	20

Qualifiers are defined as follows:
B Analyte detected at a value between Method Detection Limit and Practical Quantitation Limit
U Analyte was not detected at the Method Detection Limit
H Holding time was not met
NS No aquatic life standard (chronic) has been established for this parameter
Shaded value in bold indicates level exceeds leaching RMC
+ Value exceeds RMC by 1 to 10 times
++ Value exceeds RMC by 10 to 100 times
+++ Value exceeds RMC by more than 100 times

Table 5.9: Comparison of Analytical Results for Surface Water to Aquatic-Life Criteria[1]
Butterfly and Burrell Mines

	Screening Level	Acute	Chronic	Background	Butterfly Mine Adit: Butterfly Adit	Butterfly Mine Adit: Duplicate	Butterfly Tributary	Coal Ck Up	Coal Ck Dn
PHYSICAL									
Dissolved Oxygen (mg/L)	6.0	6.0		8.34	8.27	---	5.23	9.02	8.62
pH	6.5 - 9.0	6.5 - 9.0		7.52	8.63	---	7.16	6.9	6.85
INORGANIC (mg/L)									
Nitrite	0.05	0.05		< 0.01 U	< 0.01 U	< 0.01 U	< 0.01 U	< 0.01 U	< 0.01 U
Nitrate	10	10		0.06 B	**0.34 +**	**0.36 +**	< 0.02 U	< 0.02 U	< 0.02 U
Chloride	250	250		< 1 U	< 1 U	< 1 U	< 1 U	1 B	< 1 U
Sulfate	250	250		< 10 U	< 10 U	< 10 U	**20 B+**	< 10 U	10 B
METALS (µg/L)									
Antimony, Dissolved	---[2]	-----	-----	< 0.4 U	< 0.4 U	< 0.4 U	< 0.4 U	< 0.4 U	< 0.4 U
Arsenic, Dissolved	---[2]	-----	-----	1.1 B	**2.5 B+**	**2.5 B+**	1.1 B	**1.2 B+**	1 B
Arsenic, Total Recoverable	50	50	-----	< 0.5 U	**2.3 B+**	**2.3 B+**	**1.4 B+**	**1.1 B+**	**1 B+**
Cadmium, Dissolved	2.2	3.7 [3]	2.2 [3]	< 0.1 U	< 0.1 U	< 0.1 U	< 0.1 U	< 0.1 U	< 0.1 U
Calcium, dissolved	---[2]	-----	-----	31900	**51600 +**	**51800 +**	**59800 +**	10700	27000
Chromium, Total Recoverable	50	50	-----	< 10 U	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U
Copper, Dissolved	9	13 [3]	9 [3]	**120 ++**	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Iron, Dissolved	---[2]	-----	-----	30 B	< 20 U	< 20 U	**60 +**	**90 +**	**90 +**
Iron, Total Recoverable	1000	-----	1000	70	**110 +**	**120 +**	**290 +**	**880 ++**	**650 +**
Lead, Dissolved	2.5	65 [3]	2.5 [3]	0.2 B	< 0.1 U	< 0.1 U	< 0.1 U	< 0.1 U	0.1 B
Magnesium, dissolved	---[2]	-----	-----	8000	1600	1500	**10800 +**	1700	4600
Manganese, Dissolved	1,650	2,986 [3]	1,650 [3]	< 5 U	< 5 U	< 5 U	**81 ++**	**6 B+**	< 5 U
Mercury, Dissolved	---[2]	-----	-----	< 0.2 U	< 0.2 U	< 0.2 U	< 0.2 U	< 0.2 U	**1.3 +**
Mercury, Total	0.01	-----	0.01	< 0.2 U	< 0.2 U	< 0.2 U	< 0.2 U	< 0.2 U	< 0.2 U
Molybdenum, Dissolved	---[2]	-----	-----	< 10 U	**10 B+**	< 10 U	< 10 U	< 10 U	< 10 U
Nickel, Dissolved	52	468 [3]	52 [3]	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Potassium, dissolved	---[2]	-----	-----	500 B	**900 B+**	**700 B+**	**1400 +**	**600 B+**	**600 B+**
Selenium, Dissolved	4.6	18.4	4.6	< 1 U	**2 B+**	**2 B+**	< 1 U	< 1 U	< 1 U
Silver, Dissolved	0.08	2.0 [3]	0.08 [3]	0.07 B+	**0.08 B+**	**0.08 B+**	< 0.05 U	< 0.05 U	0.06 B
Sodium, dissolved				1200	800 B	700 B	**1900 +**	**1500 +**	**1800 +**
Uranium, Dissolved	1,500	2,401 [3,4]	1,500 [3,4]	0.2 B	**35.4 +++**	**35 +++**	**6.4 ++**	0.1 B	**0.8 +**
Uranium, Total	---[2]	-----	-----	0.2 B	**40.1 +++**	**41 +++**	**6.5 ++**	0.2 B	**0.9 +**
Vanadium, Dissolved	---[2]	-----	-----	< 5 U	**11 B+**	**10 B+**	< 5 U	< 5 U	**7 B+**
Vanadium, Total	---[2]	-----	-----	< 10 U	**10 B+**	**16 B+**	< 5 U	< 5 U	< 5 U
Zinc, Dissolved	117	117 [3]	118 [3]	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
RADIOLOGICAL (pCi/L)									
Gross Alpha	15	15 [5]		1.5	**40 +**	**33 +**	**6.4 +**	**2.1 +**	**2.6 +**
Gross Beta	50	50 [5]		2.1	**21 +**	**13 +**	2.1	**4.1 +**	**2.4 +**
Radium 226	---[2]	-----	-----	0.27	**6.1 ++**	**6 ++**	**0.38 +**	0.01	**0.28 +**
Radium 228	---[2]	-----	-----	1.2	0	**1.3 +**	1.1	0.9	0.69
Thorium 228	---[2]	-----	-----	0	0	-0.03	0	**0.1 +**	**0.1 +**
Thorium 230	---[2]	-----	-----	-0.22	**0.14 +**	**0.13 +**	-0.23	-0.12	-0.34
Thorium 232	---[2]	-----	-----	-0.06	**0.02 +**	**0.22 +**	**0.18 +**	**0.05 +**	**0.07 +**

[1] Colorado standards from Regulation No. 37 – Classification and Numeric Standards for Lower Colorado River Basin. Colorado standards are based on designated use classifications which for Coal Creek include recreation 1b, agriculture, aquatic life cold 1, and water supply.

[2] No specified level; concentration will be compared to upgradient/background sample results.

[3] Hardness dependent criterion calculated using equations presented in Regulation No. 37 - Classification and Numeric Standards for Lower Colorado River Basin. Because no hardness data are available for Coal Creek, calculated value based on a conservative hardness value of 100 mg/L.

[4] No standard for uranium is specified for Coal Creek; therefore, table value standards computed using numerical criteria set forth in the Regulation 31, Basic Standards and Methodologies for Surface Water.

[5] No standards have been adopted by the Colorado Water Quality Control Commission for gross alpha and gross beta; therefore, aquatic life and agriculture standards adopted by the State of Utah are used to determine screening levels for these parameters.

Value in bold indicates level exceeds criterion or background level
+ Value exceeds human-health criterion (shaded) or background (not shaded) by 1 to 10 times
++ Value exceeds human-health criterion (shaded) or background (not shaded) by 10 to 100 times
+++ Value exceeds human-health criterion (shaded) or background (not shaded) by more than 100 times
Qualifiers are defined as follows:
B Analyte detected at a value between Method Detection Limit and Practical Quantitation Limit
U Analyte was not detected at the Method Detection Limit