TECHNICAL MEMORANDUM

EVALUATION OF NURE DATA WITH RESPECT TO THE BACKGROUND CHARACTERIZATION SAMPLING LOCATIONS SELECTED FOR THE MIDNITE MINE RI/FS PROJECT

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EPA Region 10

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1.0 INTRODUCTION

This technical memorandum presents a summary of the findings of the National Uranium Resource Evaluation (NURE) Spokane Mountain Exploration Project (Babcock et al 1981) and a discussion of the Midnite Mine Remedial Investigation/Feasibility Study (RI/FS) background characterization program. The Spokane Mountain studies were conducted during the period of 1976 to 1981 by Bendix Field Engineering Corporation (BFEC) to evaluate exploration techniques that could be used to identify "blind" uranium deposits. The Spokane Mountain uranium deposit had previously been delineated by an exploration drilling program conducted by Western Nuclear in the early 1970's, but has not been developed. Therefore, the area offered a known, unmined buried uranium deposit at depth that could be used to test the ability of various exploration techniques to identify favorable areas for uranium mineralization.

The Spokane Mountain uranium deposit was also chosen by URS, on behalf of the U.S. Environmental Protection Agency, to represent an unmined analog to the Midnite Mine for the purposes of evaluating the natural background concentrations of radionuclides, metals, and other inorganic parameters in the groundwater, surface water, sediments, and surface materials of the area, as described in the Midnite Mine Phase 1A Quality Assurance Project Plan (QAPP) (URS Greiner 1999) and Midnite Mine Phase 2A/1B QAPP (URS 2000). The purpose of this technical memorandum is to further evaluate and describe the RI/FS background characterization program in light of the data presented in the BFEC report, especially with respect to the appropriateness and coverage of the locations sampled during the RI/FS program. Sample locations chosen for the background characterization should be representative of the range of geologic conditions present before the area was mined (i.e., mineralized and non-mineralized locations should be included). In addition, the background analog should be of the same type of deposit as the Midnite Mine with respect to the host rock geology and origin and geochemistry of the ore materials.

2.0 GEOLOGIC SETTING

Geologic units exposed in the area, which includes Spokane Mountain and the Midnite Mine, consist of metasedimentary rocks of the Togo Formation, a series of quartz monzonite intrusions of Tertiary age, igneous dikes, and alluvial deposits derived from these rocks. The Precambrian Togo Formation consists of a sequence of metasedimentary rocks including phyllite, marble, and quartzite. The unit is in excess of 4,000 feet thick in the area and has been folded and overturned to the east as part of the regional northeast-trending Deer Trail Anticline. The Togo Formation has been intruded by a quartz monzonite stock of Tertiary age that is exposed at the Midnite Mine. This stock is one of at least eight plutons exposed in the area that are all considered to be part of the Loon Lake Batholith (Becraft and Weis 1963). Granite, dacite, pegmatite, and aplite dikes also occur in the area. The granite, pegmatite, and aplite dikes are associated with the intrusion of the quartz monzonite stock. The dacite dikes intrude zones of structural weakness at the Midnite Mine and were likely feeder dikes for the Sanpoil Volcanics that once covered the entire area (Nash 1975). Unconsolidated materials in the study area include residual soils, colluvium, fluvial sediments, and glacial debris.

Uranium and other metallic mineral deposits at Spokane Mountain and the Midnite Mine are localized along the contact between the Togo Formation and the quartz monzonite intrusion and are considered to be of primary hydrothermal origin (Barrington and Kerr 1961; Sheldon 1959). The contact zone parallels the Deer Trail Anticline and is localized along the Midnite Trend, a northeast-trending zone of variable width that is delineated by a subparallel alignment of rock types, structures, geophysical lineaments, and uranium deposits and prospects. The Midnite Trend begins to the south of the Midnite Mine, passes through the Midnite and Spokane Mountain deposits, and then extends to the northeast beyond Sand Creek.

3.0 NATIONAL URANIUM RESOURCE EVALUATION STUDY TECHNIQUES

The Spokane Mountain deposit and the surrounding area, which includes the area surrounding the Midnite Mine, was studied by BFEC for the NURE project during the Spokane Mountain Exploration Project using geological, geophysical, geochemical, and emanometric exploration procedures. Basic geologic information was gathered from the files of Western Nuclear and other reports on the geology of the area. Geologic studies conducted included the assessment of subsurface conditions from drill core logs of the area; interpretation of the environment of ore deposition, metamorphic effects, alteration, and mineralization from detailed petrographic studies; and overviews of regional stratigraphy, structure, and mineralization. Geophysical techniques utilized included airborne spectroradiometrics, regional gravity studies, and magnetic, induced-polarization, and VLF surveys. Geochemical studies included stream water and sediment surveys and soil surveys. Soil geochemical surveys were conducted on three scales to investigate the effect of the scale studied on the ability of identify anomalies. Emanometric studies of helium and radon distribution were also performed over the area to evaluate the usefulness of these techniques in identifying buried uranium deposits. Figure 1 shows the area covered by the various surveys conducted by BFEC with respect to the Midnite Mine and other geographic features. The following sections summarize the findings of each of the studies conducted for the NURE Spokane Mountain project and discuss the findings relevant to the Midnite Mine RI/FS background characterization program.

4.0 NATIONAL URANIUM RESOURCE EVALUATION GEOLOGICAL STUDIES

Detailed studies of the mineralogy, petrology, and alteration of rocks from the Spokane Mountain deposit and the surrounding area were conducted by BFEC for the NURE project. The studies were performed on materials supplied by Western Nuclear from over 100 boreholes drilled on Spokane Mountain and from outcrop hand samples collected at survey points for the geochemical surveys and other studies. These studies concentrated on the uranium mineralogy and its relationship to mineralization, alteration, and structure.

Intrusive rocks in the area are classified as porphyritic granite, granodiorite, and quartz monzonite. These rocks typically consist of 30-45% quartz, 25-40% potassium feldspar, 20-35% plagioclase, and 3-5% biotite or hornblende. Accessory minerals include muscovite, apatite, magnetite, pyrite, zircon, rutile, and epidote. Minor alteration, which was caused largely by hydrothermal processes, is evidenced by corroded or strained quartz grains, cloudy potassium feldspar, sericitized plagioclase, and chloritized biotite and hornblende. All granitic rocks in the area are altered to some degree. The degree of alteration is highest near the contact zone where microfractures are filled with calcite, quartz, and muscovite.

The Togo Formation is the primary host rock for uranium mineralization at both Spokane Mountain and the Midnite Mine. The phyllitic units of the Togo Formation contain abundant graphite and pyrrhotite. Mineralized zones are characterized by an increase in grain size, foliation, and iron sulfide (pyrite and pyrrhotite) abundances. Isotopic studies of uranium and lead conducted by Nash and Ludwig (1979) indicate that the Togo Formation is not the source rock for the uranium found in the deposits.

The Spokane Mountain uranium deposit was discovered in 1975 following a 5-year period of intensive exploration by Western Nuclear. The deposit is approximately 150 feet in width by 1,000 feet in length, and is present at depths ranging from 46 to 152 meters (Robbins 1978). The Spokane Mountain deposit is located approximately 2 miles northeast of Midnite Mine. The highest concentrations of uranium mineralization in the NURE study area were found in the phyllitic facies of the Precambrian Togo Formation a short distance from the contact with the quartz monzonite (Babcock et al. 1981). At the Spokane Mountain deposit, primary and secondary uranium mineralization occurs as veinlets and coatings of uraninite (pitchblende) and coffinite along fractures and chloritic shear zones within the phyllite and as oxidized uranium minerals (chiefly autunite and meta-autunite) within the fractured ground of the contact zone. The uranium minerals occur in association with the sulfide minerals arsenopyrite, chalcopyrite, sphalerite, molybdenite, pentlandite, pyrrhotite, and pyrite. Common gangue minerals include graphite, chlorite, biotite, calcite, quartz, tremolite, muscovite, siderite, magnetite, epidiote, and clinozoisite.

The occurrence and mineralogy of the Midnite Mine ore bodies is very similar to that of the Spokane Mountain deposit. Prior to mining, the ore bodies at the Midnite Mine were localized within the phyllite and calc-silicate hornfels of the Togo Formation adjacent to the contact with the quartz monzonite intrusion (Barrington and Kerr 1961; Becraft and Weis 1963; Nash 1975;

Sheldon 1959). Eight ore bodies were present at the mine along the intrusive contact for a distance of about one mile (Barrington and Kerr 1961). The depth to ore was reported to be less to 5 meters to about 100 meters (Nash 1975), with two ore bodies having no surface expression (Barrington and Kerr 1961). Individual ore bodies ranged from a few feet to 700 feet in length and from a few feet to 200 feet in width with the greatest concentrations of ore occurring above depressions in subhorizontal intrusive contacts (Barrington and Kerr 1961; Nash 1975). All of the ore bodies at the Midnite Mine occurred either along the crests of ridges or on steeply sloping sidehills (Sheldon 1959).

The upper portions of the ore deposits at the Midnite Mine were composed of oxidized uranium minerals (chiefly autunite and meta- autunite) with uraninite and coffinite predominating at depth (Barrington and Kerr 1961; Sheldon 1959; Nash 1975). Uranium mineralization at the Midnite Mine was associated with deposition of pyrite and marcasite (Nash 1975; Sheldon 1959; Becraft and Weis 1963) with lesser amounts of arsenopyrite, chalcopyrite, sphalerite, molybdenite, and magnetitie (Barrington and Kerr 1961).

5.0 NATIONAL URANIUM RESOURCE EVALUATION GEOCHEMICAL STUDIES

5.1 Geochemical Stream Survey

A stream water and sediment survey was conducted by BFEC for the NURE project (Babcock et al. 1981) over an area of 105 square miles that includes the Spokane Mountain, Midnite, and Sherwood uranium deposits (Figure 1 – regional grid). The area covered by the survey encompasses all of the area sampled for the Midnite Mine RI/FS background characterization program. The stream geochemical data was separated into three subgroups by BFEC on the basis of the dominant lithology that is being drained by each area, as shown on Figure 2. The three subgroups are 1) plutonic rocks dominant (Loon Lake granitic rocks), 2) metasedimentary rocks dominant (Togo Formation), and 3) the contact zone between the metasediments and plutonic rocks. The subgroups were established due to the differences between the background elemental compositions between the plutonic rocks, metasediments, and contact rocks. The subgrouping is necessary to recognize geochemical anomalies. In addition, streams flowing through these areas should contain different background chemistry typical of the material being drained. The raw analytical data were analyzed statistically and then converted to z-scores (a z-score is equal to the mean plus the number of standard deviations above the mean for that element). An elemental concentration was considered to be anomalous if it was greater than the mean plus two standard deviations (z-score greater than two) for that element in that lithologic subgroup. Concentrations between the mean plus one and two standard deviations were treated as an inferred anomaly.

5.2 Stream-Water Survey Results

Uranium, arsenic, cobalt, copper, and nickel were detected in stream water samples collected from the area. Figure 3 shows the values of these elements in the stream waters in z-scores. Cobalt, nickel, copper, and arsenic were detected at only three locations, all to the south of the Midnite Mine. Uranium was detected at many locations at concentrations varying from 0.1 to 6,500 z-scores. The highest values were found along the drainages that flow south from the Midnite Mine and along Blue Creek. If the effects of the Midnite Mine are ignored, waters of the pluton-dominated Area 1 showed higher anomalous values of uranium (4.4 to 9.0 z-scores) than those sampled in contact rock-dominated Area 3 (1.1 to 6.2 z-scores). Samples from the metasediment-dominated Area 2 were all within the background population (0.1 to 0.7 z-scores). The higher uranium values in Area 1 are indicative of draining weathered uraniferous granitic rocks south and southeast of the Midnite Mine. Four anomalies were found in streams that drain Area 3 contact rocks. One anomaly (3.2 z-score) is located on a tributary along the eastern part of Sand Creek. A monitoring well was installed and a surface water/sediment sampling location was established at this location for the Midnite Mine RI/FS background characterization program based on this anomaly. A second anomaly (6.2 z-score) is located on Owl Creek downgradient of Spokane Mountain. Two more uranium anomalies were detected in the drainage east of the Midnite Mine (z-scores of 6 and 4.2). This area is also downgradient of Spokane Mountain and the saddle between Spokane Mountain and the ridge north of the Midnite Mine, but is not downgradient from the Midnite Mine itself. Several anomalies are also present along Oyachen Creek, which suggests that an unknown uranium deposit may exist south of Turtle Lake.

5.3 Stream-Sediment Survey Results

Uranium showed a higher mean concentration in sediments in the Area 3 contact rocks (17.7 ppm) than in sediments from the pluton-dominated Area 1 (16.4 ppm) and metasedimentary-dominated Area 2 (2.54 ppm). Five uranium-sediment anomalies (in z-scores) were found in the vicinity of the Midnite Mine, as shown on Figure 4. Two uranium-sediment anomalies and one inferred anomaly occur downslope (and downgradient) of the Spokane Mountain deposit. The anomaly to the west of Spokane Mountain coincides with the stream-water uranium anomaly on Owl Creek discussed above, while that to the east in coincident with a molybdenum sediment anomaly. Another uranium-sediment anomaly exists on a tributary to Sand Creek to the northeast of Grouse Ridge and coincides with the 3.2 z-score stream-water uranium anomaly. Aerial radiometric uranium highs were also found in proximity to these anomalies (see Section 6.0). A previous stream-sediment survey conducted by Otton (1976) also found high uranium in the sediments west and northeast of Grouse Ridge. These findings collectively suggest that a buried uranium deposit of the Midnite/Spokane Mountain type may exist beneath Grouse Ridge. Uranium anomalies also occur along the western part of Sand Creek and on Oyachen Creek, south of Turtle Lake.

Molybdenum anomalies occur to the south of the Midnite Mine, along Sand Creek to the north of Spokane Mountain, and in the Owl Creek and Rail Creek drainages (Figure 5). Anomalous molybdenum in the Rail Creek and Owl Creek sediments is present due to the molybdenum-tungsten mines in those areas (the Germania Consolidated and Orzada Mines). Molybdenum also occurs with uranium in the Midnite Mine and Spokane Mountain deposits.

The distribution of fluorine, nickel, cobalt, and arsenic in stream sediments of the area did not appear to correlate with the known uranium mineralization. Rare earth elements of the lanthanum-lutetium series were found to be elevated in sediments near the Midnite Mine and Spokane Mountain uranium deposits and the Germania Consolidated Mine. Similar rare earth anomalies also were found along Sand Creek downgradient of Grouse Ridge.

Statistical analysis of the stream survey data using the Pearson Correlation Analysis showed positive correlations of uranium concentrations with cobalt (0.2286), nickel (0.4475), and molybdenum (0.5466). According to Babcock et al. (1981) the correlation analysis conducted for the NURE project indicates that molybdenum is the best stream sediment indicator element for uranium mineralization (besides uranium) in the study area.

5.4 Geochemical Soil Surveys

Geochemical soil surveys were conducted by BFEC for the NURE project on three scales in the study area, as shown on Figure 6. A subregional survey covered 16 square miles and included the area of the Midnite Mine and Spokane Mountain deposits and nearly all of the area covered by the

RI/FS background sampling program. Both known uranium deposits were indicated by the results of this survey. A detailed soil survey was conducted over an area of 0.5 square miles centered over the Spokane Mountain deposit and was used to identify geochemical halos directly over the uranium mineralization. An intermediate soil survey was also conducted that overlaps a portion of the detailed survey and extends to the southeast to evaluate the extent of the geochemical halo related to the Spokane Mountain deposit.

Analysis of selected samples of Midnite Mine ore was performed and revealed that iron, calcium, phosphorous, arsenic, copper, nickel, molybdenum, manganese, cobalt, silver, strontium, and titanium are associated with uranium mineralization at the Midnite Mine, and presumably, at Spokane Mountain as well. Therefore, these elements, among others, were considered by BFEC to be potential soil indicator elements for uranium mineralization in the area.

5.4.1 Detailed Soil Survey Results

Figure 7 shows the geochemical anomalies identified by the detailed soil survey. For that NURE survey, sample results were considered to be anomalous if they exceeded two standard deviations above the mean for that element (greater than 2 z-scores). The dashed outline on Figure 7 indicates the location of the Spokane Mountain uranium deposit as determined from the Western Nuclear exploration drilling program. Four uranium anomalies were detected in the detailed grid at locations which overlie or are peripheral to uranium mineralization on Spokane Mountain. Three of the four anomalies were supported by strong soil-radon anomalies. The fourth uranium anomaly is supported by the trace elements bismuth, arsenic, silver, and copper. The strong anomalies displayed by uranium and other pathfinder elements in the eastern portion of the area reflect the shallower depth to mineralization in this portion of the deposit. Drilling upslope of any of these strong multielement anomalies would have intersected uranium mineralization. Anomalous concentrations of elements in the soil were placed into three groupings that occur together. The groupings are described as: 1) coincident – those elements that are closely associated with soil-uranium anomalies (radon, bismuth, and barium); 2) internal – those elements that appear to be related to one another and occur upslope from the soil-uranium anomalies (lead, silver, arsenic, copper, nickel, cobalt, and vanadium); and 3) peripheral – those elements that occur peripheral to the underlying mineralization (selenium, molybdenum, and fluorine).

5.4.2 Subregional Soil Survey Results

The subregional soil survey (328 samples) was conducted for the NURE project over an area of 16 square miles. Samples collected for this survey were grouped according to the underlying rock type (plutonic or metasedimentary) for statistical analysis. Means and standard deviations were calculated for each element for both populations. Figure 8 shows the soil geochemical anomalies identified at a level of mean plus one standard deviation. Comparison of this figure with the summary map for the detailed soil survey (Figure 7) shows the effects of sample spacing on the data. For example, although the detailed soil survey showed several uranium anomalies on the north slope of Spokane Mountain, they are not indicated by the subregional survey. In addition, widely dispersed elements in the soils are more likely to be detected in a larger survey such as this. Hence, cobalt generates soil anomalies in several directions from the Spokane Mountain deposit and is a good soil pathfinder element for uranium mineralization for this survey.

A strong nickel anomaly extends to the southwest from the Spokane Mountain deposit and overlaps a combined uranium, cobalt, and copper anomaly. Very strong radon, helium, and airborne radiometrics anomalies are also associated with this area. This pattern may be the result of the indicator elements being dispersed in the soils to the southwest of the deposit, or may indicate that an extension of the Spokane Mountain deposit exists in this area along the contact between the Togo Formation and the quartz monzonite intrusion. A strong uranium anomaly, associated with copper, helium, and airborne radiometrics anomalies, is also seen dispersing to the southwest from the Midnite Mine.

Two other strong uranium anomalies were detected by the NURE survey. One is centered above Bear Mountain and is associated with radon, silver, arsenic, barium, cobalt, iron, and nickel anomalies. Based on these anomalies and other observations discussed in subsequent sections of this technical memorandum, Babcock et al. (1981) concluded that Bear Mountain has a high uranium exploration potential. The remaining strong uranium anomaly is located over Sand Creek directly to the north of Spokane Mountain. Radon, helium, silver, arsenic, and lead anomalies are associated with the uranium at this location. Magnetic and IP surveys of this area also suggest that three faults may intersect beneath this anomaly. This area is underlain by the Togo/quartz monzonite contact and was also considered to be an excellent target for additional uranium mineralization. In addition to these anomalies, a weak uranium anomaly that was centered on Grouse Ridge was rejected by the study authors because it was not associated with anomalous radon, helium, or other pathfinder elements. However, it is associated with a strong manganese anomaly and was indicated as a weak uranium anomaly by the airborne radiometrics survey, discussed in Section 6.0. In addition, uranium stream sediment and water anomalies were detected to the northeast of Grouse Ridge on a tributary to Sand Creek, as previously discussed.

5.4.3 Intermediate Soil Survey Results

The intermediate soil survey overlapped the northwest corner of the detailed soil survey and was sampled at a density about half that of the detailed survey. Figure 9 shows the anomalies identified from this survey. A large uranium anomaly extending to the east from the Spokane Mountain deposit was also revealed by the intermediate soil survey. Figure 9 shows associations between elemental anomalies that are similar to the detailed soil survey. In addition, the summit area of Spokane Mountain is revealed as a source of geochemically anomalous arsenic, cobalt, iron, nickel, copper, silver, and barium. The strong multi-element metals anomalies to the east of the summit of Spokane Mountain were also indicated by the subregional soil survey (Figure 8) but do not have associated uranium anomalies.

6.0 NATIONAL URANIUM RESOURCE EVALUATION GEOPHYSICAL STUDIES

Geophysical methods were utilized during the NURE Spokane Mountain studies to help identify structures that might be favorable to uranium mineralization. The methods used were regional gravity, airborne and ground magnetics, and Very Low Frequency (VLF)-resistivity surveys. In addition, induced polarization (IP) was used to identify areas rich in sulfide mineralization and airborne spectroradiometrics was employed to identify any radiometric signature from the area uranium deposits.

Regional gravity and magnetic studies revealed the structure of the study area. Figure 10 depicts the major structures in the area. The master structural feature is a 9-mile wide shear zone that is bounded by N 62º W gravity and magnetic lineaments, and is interpreted as the westerly extension of the regional Lewis and Clark Lineament that is associated with mineralization in the Coeur d'Alene district to the east. This lineament defines the northern limit of the Columbia River Basalt Province and has been active since the Precambrian. Analysis of the regional aeromagnetic data indicated an apparent 6.8-mile right lateral offset along this feature in the study area. The other principal structural features in the area are the Midnite Trend and Deer Trail Anticline that parallel each other and trend N 27º E, and Spokane River Fault that trends N 30º W. The Midnite Mine is located at the intersection of the Lewis and Clark Lineament and the Midnite Trend. The three other identified Midnite-type uranium deposits in the area (Spokane Mountain, Lowley Lease, and Deer Mountain) also lie on the Midnite Trend (Figure 10). In addition, the results of the geochemical studies presented in earlier sections of this technical memorandum indicate that three additional uranium exploration targets (Bear Mountain, Grouse Ridge, and the area along Sand Creek north of Spokane Mountain) also occur along the Midnite Trend.

A regional airborne spectroradiometrics survey was conducted in the area. Both the Midnite and Sherwood Mines generated strong uranium, thorium, and potassium anomalies. A strong uranium anomaly was detected 1,500 feet southwest of the Spokane Mountain deposit, suggesting that a southern extension of the Spokane Mountain deposit may exist in the area between the Midnite Mine and the summit of Spokane Mountain. This anomaly is located along a fault zone that passes through the deposit. Samples of the fault gouge were reported to contain up to 2,550 ppm uranium (Fleshman and Dodd, 1980). The Spokane Mountain deposit itself did not generate any anomalies because of the thick overburden present above the uranium mineralization. Uranium anomalies were also recorded near Deer Mountain, where uranium mineralization of the Midnite type has been observed (Becraft and Weis, 1963), and at Grouse Ridge. A strong uranium anomaly was also mapped along Sand Creek near the buried contact between the quartz monzonite and Togo Formation. This anomalous zone parallels the Midnite Trend and was considered by Babcock et al. (1981) to be an excellent exploration target.

The IP survey was performed by Western Nuclear prior to the discovery of the Spokane Mountain deposit. The survey detected a strong IP anomaly trending northeast along the Midnite Trend (Figure 11). This anomaly was interpreted to represent increased concentrations of iron sulfides (principally pyrrhotite) present in the Togo Formation along the folded area adjacent to the quartz monzonite intrusion (IP does not detect uranium). This anomaly crosses through Bear Mountain. The survey results also suggest that the location of Sand Creek in the vicinity of the survey may be structurally controlled.

The VLF resistivity survey revealed a series of elongated anomalies that trend N 20º W. This alignment corresponds directly to the Midnite Trend. In addition, the strike of the regional Deer Trail Anticline and the overturned Togo Formation in the study area also follow this trend. The structural interpretation of the VLF data is provided in Figure 12. The area labeled as “A” corresponds to the June Fault, which extends to the northwest from the Spokane Mountain deposit. The closely contoured area within the rectangle labeled “C” may reflect the intense alteration of the Togo Formation in this area, or may be a consequence of the numerous exploration roads and drill pads cut into the area. The dashed line labeled “D” was interpreted as a fault or the contact zone between the quartz monzonite and Togo Formation and is close to and parallels Sand Creek. The significance of the low-resistivity zones marked E1 through E4 is not known.

7.0 NATIONAL URANIUM RESOURCE EVALUATION EMANOMETRIC STUDIES

Radon and helium data were acquired by BFEC for the NURE project for two survey grids in the project area. The subregional radon and helium grid covered the same area as that covered by the subregional soil grid (see Figure 6) and consisted of 289 sample locations. A detailed sampling grid (187 sample locations) covering 0.5 square miles centered on the Spokane Mountain deposit was also conducted. Statistics were calculated for each of three rock types in the survey: Togo Formation, porphyritic quartz monzonite, and equigranular quartz monzonite. Anomalies were identified in areas where the radon or helium concentrations were greater than the mean plus three standard deviations. Values between the mean plus two standard deviations and mean plus three standard deviations were considered to be an inferred anomaly.

7.1 Subregional Survey Results

An area of overlapping radon and helium anomalies was detected by the NURE surveys to the west of the Spokane Mountain deposit along the contact zone between the quartz monzonite and Togo Formation (see Figure 8). This location is supported by an airborne radiometric anomaly. In addition, secondary uranium mineralization was reported in this area by Boudette and Weis (1956) and Western Nuclear penetrated low-grade uranium mineralization while drilling in the area (Nesbitt, 1980). A strong helium anomaly was also found to be associated with the Midnite Mine. Insufficient radon samples were collected in the Midnite Mine area to evaluate the presence of anomalies. Radon and helium anomalies were also found to the north of Spokane Mountain along Sand Creek, and near Grouse Ridge (Figure 8). The Spokane Mountain deposit was not detected by the subregional survey.

7.2 Detailed Survey Results

Two strong helium anomalies were detected by the NURE surveys along the trace of the June Fault, west of the Spokane Mountain deposit. Radon anomalies were detected on the east side of the Spokane Mountain deposit (see Figure 7). This area is underlain by uranium mineralization at depths of only about 30 feet. Radon anomalies were not detected directly over the central part of the deposit where there is strong mineralization. Babcock et al. (1981) attributed the lack of a radon signal over the deposit to the presence of several hundred feet of overburden and the apparent lack of permeable pathways to the surface caused by filling of fractures during mineralization.

8.0 DISCUSSION OF THE BACKGROUND CHARACTERIZATION PROGRAM

Background conditions in the vicinity of the Midnite Mine are currently being investigated by the U.S. EPA as part of the Midnite Mine RI/FS Study, as described in the Phase 1A QAPP (URS Greiner 1999) and the Phase 2A/1B QAPP (URS 2000). The QAPPs specify the approach for characterizing background concentrations of metals and radionuclides in stream sediments, stream water, groundwater, and surface materials. For all media, "background" is defined as the range of chemical/radiological concentrations that are naturally occurring in the site vicinity, in areas unaffected by previous mining operations. The approach being used to characterize background conditions is to measure natural constituent concentrations at locations that: (1) are near the Mined Area (the area of actual disturbance caused by mining activities) and Potentially Impacted Area (undisturbed but potentially impacted areas surrounding the Mined Area); (2) have similar hydrogeologic characteristics to the Midnite Mine; (3) have not been affected by mining; and (4) are accessible for drilling and sampling activities. The essence of this approach is that concentrations measured in surface water, groundwater, sediment, and surface materials at the selected background sampling locations are representative of the natural range of concentrations that were present at the Midnite Mine site prior to mining.

The NURE Spokane Mountain studies provide considerable data that demonstrate that the areas selected for the background sampling are geologically and geochemically similar to the Midnite Mine prior to mining, and therefore are appropriate as analogs to the unmined Midnite Mine site. For the RI/FS study, this NURE information was used to select RI/FS background sampling locations representative of both mineralized and unmineralized conditions.

The Spokane Mountain uranium deposit and surrounding area was investigated using various exploration techniques by BFEC as part of the NURE program (Babcock et al. 1981), as described in previous sections of this document. In summary, uranium deposits at Spokane Mountain and the Midnite Mine are localized along the contact between the Togo Formation and the quartz monzonite intrusion. The contact zone parallels the Deer Trail Anticline and is localized along the Midnite Trend, a northeast-trending zone of variable width that is delineated by a subparallel alignment of rock types, structures, magnetic and IP lineaments, and uranium deposits and prospects. Two other uranium prospects, the Lowley Lease and the Deer Mountain prospect, have been identified along this trend. Survey results from the NURE study also indicate that additional buried uranium mineralization may be present at Bear Mountain, at Grouse Ridge, and north of Spokane Mountain along Sand Creek.

The Midnite Mine RI/FS background characterization program overlaps much of the area covered by the NURE Spokane Mountain studies described above. Surface water, groundwater, sediments, and surface materials were sampled at various locations within this area. Table 1 lists the Midnite Mine RI/FS groundwater, surface water, and sediment background sampling locations and their relationship to the geochemical and geophysical anomalies identified by the NURE Spokane Mountain studies. In addition to the groundwater, surface water, and sediment background locations, two background surface material sampling grids containing twenty composite sample locations each were also established and sampled. At each selected sampling location within the two grids, composite surface material samples were collected at two depths as described in the Phase 2A/1B QAPP (URS 2000). Measurements of background external gamma radiation, radon flux, and airborne radon were also obtained within these grids.

Figure 13 shows the locations of the RI/FS background sampling locations with respect to the regional structural features and geochemical and geophysical anomalies identified by the NURE Spokane Mountain studies. Inspection of Figure 13 and Table 1 reveals that most of the monitoring wells and stream sampling sites for the RI/FS background program are located within the area of contact-dominated rocks defined by the NURE project which includes both mineralized and non-mineralized rocks. Midnite Mine is also located within the area of contact-dominated rocks as defined in Babcock et al. (1981). Four background monitoring wells and two stream sampling sites for the RI/FS are located within the pluton-dominated area. There are no background sampling locations located within the metasediment-dominated area (Figure 2). However, the geochemical data presented in Babcock et al. (1981) show that the contact-dominated rocks have the highest mean uranium concentrations in sediments and the pluton-dominated rocks the highest uranium concentrations in stream water. Samples from the metasedimentary-dominated rocks are unlikely to have higher concentrations than those from the other two rock types sampled. In addition, the metasedimentary-dominated rocks are located two or miles from the Midnite Mine site and are not representative of the pre-mining lithology at the mine site. Therefore, for the purpose of identifying the natural upper threshold value for uranium in stream sediments and water, the background locations sampled for the RI/FS should be adequate.

Figure 13 also shows the locations of the uranium anomalies identified by BFEC in sediments (grey dots) and soils (cross-hatched areas). Anomalies of other trace metals, radon, helium, and airborne equivalent uranium are also shown where they coincide with these uranium anomalies. Uranium anomalies are located to the southwest of the Midnite Mine; to the west, north, and east of Spokane Mountain; east of Bear Mountain; and to the north of Spokane Mountain along Sand Creek. All of these anomalies essentially lie on the Midnite Trend. Sampling of sediment and surface water was conducted for the RI/FS background program downgradient from all of these features (Table 1).

For the RI/FS, groundwater and sediment samples (monitoring well MWBA-05 and sampling location SDBK-14) were also collected downgradient of the uranium stream-sediment anomaly located near the northeast corner of the map on a tributary to Sand Creek, and on Owl Creek downgradient from another uranium stream-sediment anomaly (monitoring well MWBA-08). Three RI/FS background groundwater monitoring wells are thought to be screened within unmined uranium ore. Monitoring wells MWBB-04 and MWBB-05 were screened within the upper ore zone of the Spokane Mountain uranium deposit. Monitoring well MWNW-06 appears to be screened within an unmined extension of the Midnite Mine Pit 4 orebody or a separate unmined ore body. Monitoring well MWBB-03 and stream water/sediment sampling location SDBK-08/SWBK-08 are located along an extension of the Spokane Mountain deposit on the trace of the June Fault. RI/FS sediment sample locations located along the northeast part of Sand Creek are also downgradient from the small uranium deposit identified at Deer Mountain (not shown on Figure 13).

The background mineralized surface material sampling grid was located above the known extent of the Spokane Mountain deposit to sample surface materials analogous to those that existed above the Midnite Mine orebodies prior to mining. These background sampling locations are representative of mineralized conditions that existed at the Midnite Mine site prior to mining.

In accordance with the strategy discussed in the QAPP to characterize the range of background concentrations of site-related constituents, the NURE data was also used to select background sampling locations for the RI/FS in areas that do not appear to be mineralized. These locations include groundwater monitoring wells MWBA-02, MWBA-03, MWBA-04, and MWBA-06, and surface water/sediment sampling locations SWBK-02/SDBK-02, SWBK-04/SDBK-04, SWBK-05/SDBK-05, and SWNW-03/SDNW-03. The background non-mineralized surface material sampling grid for the RI/FS was also located in an area where no geochemical anomalies were identified by the NURE Spokane Mountain studies.

TABLE 1
MIDNITE MINE RI/FS BACKGROUND GROUNDWATER, SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS

Site ID	Matrix	Dominant Rock Type[1]	Associated Upgradient Metal Anomalies	Associated Geophysical/ Structural Anomalies
MWBA-02	Alluvial groundwater	Pluton	None	None
MWBA-03	Alluvial groundwater	Pluton	None	None
MWBA-04	Alluvial groundwater	Pluton	None	None
MWBA-05	Alluvial groundwater	Contact	Sediment uranium	None
MWBA-06	Alluvial groundwater	Pluton	None	None
MWBA-07	Alluvial groundwater	Contact	Soil uranium and lead; emanometric radon; sediment uranium	Induced Polarization
MWBA-08	Alluvial groundwater	Contact	Soil uranium, nickel, copper, and cobalt; emanometric radon and helium; sediment uranium	Airborne uranium; Deer Trail Anticline
MWBA-09	Alluvial groundwater	Contact	Soil uranium, silver, and lead; emanometric radon	Deer Trail Anticline
MWBA-10	Alluvial groundwater	Contact	Soil uranium, arsenic, lead, and silver; emanometric radon and helium	Deer Trail Anticline
MWBB-01	Bedrock groundwater	Contact	None	Induced Polarization; VLF; June Fault
MWBB-02	Bedrock groundwater	Contact	Soil uranium, nickel, copper, and cobalt; emanometric radon and helium	Airborne uranium
MWBB-03	Bedrock groundwater	Contact	Soil uranium, silver, and lead; emanometric radon	VLF; June Fault
MWBB-04	Bedrock groundwater	Contact	Soil uranium	Induced Polarization; VLF; June Fault
MWBB-05	Bedrock groundwater	Contact	None	Induced Polarization; VLF; June Fault
MWNW-01	Bedrock groundwater	Contact	None	None
MWNW-02	Bedrock groundwater	Contact	None	None
MWNW-03	Bedrock groundwater	Contact	None	None
MWNW-04	Bedrock groundwater	Contact	None	None
MWNW-06	Bedrock groundwater	Contact	Soil uranium, nickel, copper, and cobalt; emanometric radon and helium	Airborne uranium
SWBK-01 / SDBK-01	Surface water/sediment	Contact	Soil uranium and copper	Airborne uranium; Deer Trail Anticline
SWBK-02 / SDBK-02	Surface water/sediment	Contact	None	None
SWBK-03 / SDBK-03	Sediment	Contact	None	None
SWBK-04 / SDBK-04	Surface water/sediment	Pluton	None	None
SWBK-05 / SDBK-05	Sediment	Pluton	None	None
SWBK-06 / SDBK-06	Sediment	Contact	Soil uranium, nickel, copper, and cobalt; emanometric radon and helium	Airborne uranium
SWBK-07 / SDBK-07	Sediment	Contact	Soil uranium and lead; emanometric radon; sediment uranium	Induced Polarization
SWBK-08 / SDBK-08	Sediment	Contact	Soil uranium, silver, and lead; emanometric radon	VLF; June Fault
SWBK-09 / SDBK-09	Surface water/sediment	Contact	Soil uranium, arsenic, lead, and silver; emanometric radon and helium	Deer Trail Anticline
SWBK-10 / SDBK-10	Sediment	Contact	Soil uranium, lead, and silver; emanometric radon	Deer Trail Anticline
SWBK-11 / SDBK-11	Surface water/sediment.	Contact	Soil uranium, arsenic, lead, and silver; emanometric radon and helium; sediment uranium	None
SWBK-12 / SDBK-12	Surface water/sediment	Contact	Soil uranium, arsenic, lead, and silver; emanometric radon and helium	None
SWBK-13 / SDBK-13	Surface water/sediment	Contact	Sediment uranium	Induced Polarization
SWBK-14 / SDBK-14	Sediment	Contact	Sediment uranium	None
SWBK-15 / SDBK-15	Sediment	Contact	None	None

TABLE 1
MIDNITE MINE RI/FS BACKGROUND GROUNDWATER, SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS

Site ID	Matrix	Dominant Rock Type[1]	Associated Upgradient Metal Anomalies	Associated Geophysical/ Structural Anomalies
SWBK-16 / SDBK-16	Surface water/sediment	Contact	None	None
SWBK-17 / SDBK-17	Surface water/sediment	Contact	Soil uranium, iron, cobalt, and nickel; emanometric radon	Induced Polarization
SWBK-18 / SDBK-18	Surface water/sediment	Contact	Soil uranium and lead; emanometric radon; sediment uranium	Induced Polarization
SWBK-19 / SDBK-19	Surface water/sediment	Contact	None	Induced Polarization
SWBK-20	Surface water	Contact	None	None
SWBK-21	Surface water	Contact	None	Deer Trail Anticline
SWBK-22	Surface water	Contact	None	None
SWBK-23/ SDBK-23	Surface water/sediment	Contact	None	Induced Polarization; VLF; June Fault
SWBK-24	Surface water	Contact	None	None
SWNW-01 / SDNW-01	Surface water/sediment	Contact	Soil uranium, nickel, copper, and cobalt; emanometric radon and helium	Airborne uranium
SWNW-02 / SDNW-02	Surface water/sediment	Contact	None	None
SWNW-03 / SDNW-03	Surface water/sediment	Contact	None	None

[1]Pluton-dominated or hydro thermal contact-dominated rocks as described by Babcock et al (1981)

9.0 CONCLUSIONS

The NURE Spokane Mountain studies have provided a wealth of information concerning the areal distribution of mineralization, the background concentrations of metals and radionuclides, regional structure and rock types, and recognition of geochemical soil, water, and stream-sediment anomalies in the area surrounding the Midnite Mine. The area of the regional stream-water and stream-sediment surveys conducted by BFEC encompasses the area sampled for the EPA's RI/FS background characterization program. Soil surveys were also conducted by BFEC and covered most of the background area. Results from the NURE geochemical surveys, combined with the NURE results from airborne radiometric and geophysical surveys, identified anomalous concentrations of uranium, trace metals, radon, and helium in the vicinity of the Midnite Mine and the Spokane Mountain uranium deposit. In addition, BFEC identified three other areas as significant exploration targets for additional uranium mineralization. These areas are located on Bear Mountain, Grouse Ridge, and north of Spokane Mountain along Sand Creek.

For the EPA's RI/FS project, URS collected samples of groundwater, stream water, and stream sediments during the fall of 1999 and spring and fall of 2000 from locations downgradient of all of the uranium anomalies identified by the NURE study in the background area. RI/FS background samples of groundwater, stream water, and stream sediments were also collected in and downgradient of non-mineralized areas identified by the NURE study. In addition, surface materials were sampled in two grids representing mineralized and non-mineralized background conditions. The areas sampled for the RI/FS to characterize background constituent levels are analogous to the Midnite Mine in terms of geologic setting and the geochemical processes that caused the mineralization and deposition of uranium and other metals. Consequently, the RI/FS background characterization program has sampled locations that are unaffected by mining activities and that represent the range of natural concentrations of metals and radionuclides in the sediments, surface water, groundwater, and surface materials near the Midnite Mine.

10.0 REFERENCES

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