SENES Consultants Limited

121 Granton Drive
Unit 12
Richmond Hill, Ontario
Canada L4B3N4

Tel: (905) 764-9380
Fax: (905) 764-9386
E-mail: senes@senes.ca
Web Site: http://www.senes.ca

35019-1

12 February 2010
Mr. Dave Frydenlund
Vice President, Regulatory Affairs and Counsel
Denison Mines (USA) Corp.
1050 17th Street, Suite 950,
Denver, CO 80265

dfrydenlund@denisonmines.com

RE: Interrogatory, White Mesa Cell 4B UAC R313-24-3-01A/02

Dear Mr. Frydenlund:

Further to recent discussions, we are pleased to support Denison in responding to the Round 2 Interrogatory Statement, specifically concerning the following radiological issues:

(a) ***Follow-up to DUSA Response Section 2.1.3:*** *Please provide MILDOS input and output files from which the results presented in the "2008 MILDOS Evaluation" (Appendix C of Environmentally Report for Cell 4B, Revised September 11, 2009) were summarized.*

(b) *Compare the operational doses projected by MILDOS modelling to doses inferred from air monitoring results (operational). Demonstrate that the inferred operational doses corroborate MILDOS results and provide confidence that applicable regulations will be satisfied during operational and following closure, reclamation, and decommissioning.*

(c) ***Follow-up to DUSA Response Section 2.1.9:*** *Provide a sensitivity analysis to demonstrate whether reasonable variations in MILDOS input parameters (related to Cell 4B performance) due to uncertainty will change the conclusion of these analyses (i.e., that projected doses are less than regulatory limits).*

Our suggested responses follow.

(a) Provide MILDOS Input and Output files.

A pdf copy of MILDOS input and output files were provided separately last Friday (5 February) via e-mail (A. Ho to Dave Frydenlund).

We would be pleased to respond to any specific questions that may arise concerning the input file; however, we think the text of our 2008 MILDOS Evaluation is largely self-explanatory.

(b) Compare operational doses projected by MILDOS to doses inferred from air monitoring data.

Further to our telephone discussions, we have interpreted this request as specific to the doses arising from radioactive particulate from the mill's activities. Due to the inaccuracy of the radon measurement devices, the mill is not required to sample for enviromental radon under its license. The SENES (2008) report assessed possible future doses from the processing of Colorado Plateau and Arizona Strip ores. Recent processing at the White Mesa Mill has focussed on Colorado Plateau ores and hence this is the basis for our comparison. It should be noted however that the MILDOS runs reported in SENES 2008, were for generic assumptions of future processing and may not reflect the actual processing performed in 2008; hence, introducing additional uncertainty into the comparison.

The dose via air pathways is determined by the concentration of radionuclides in the air at any location. The indirect pathways then follow by deposition from air to soil and transfer through food pathways to people. Thus, our comparison is based on a comparison of MILDOS predicted concentrations with measured air concentrations (semi-annual environmental reports) at two locations: the nearest potential resident (BHV-1) and the nearest historical resident (BHV-2) during the processing of Colorado Plateau ore. These values are shown in Table 1.

Table 1
Airborne Radionuclides from Processing Colorado Plateau Ore

Location	Radionuclide	Predicted Airborne Concentrations pCi/m^3 (MILDOS-AREA) [a]	Measured Airborne Concentrations pCi/m^3 (includes background (2008)
Nearest Potential Resident (BHV-1)	U-238	3.41E-04	4.94E-04 [b]
	Th-230	5.54E-05	3.63E-04
	Ra-226	5.51E-05	2.62E-04
	Pb-210	5.69E-05	9.62E-03
Nearest Historical Resident (BHV-2)	U-238	4.63E-05	1.27E-04 [b]
	Th-230	9.55E-06	1.15E-04
	Ra-226	9.52E-06	1.06E-04
	Pb-210	9.75E-06	1.00E-02

a) Airborne concentration includes contributions from the mill (including ore pads), and tailings cells 3 and 4A (based on Phase 1 scenario in SENES 2008).
b) Measured U-238 calculated as measured U-nat activity * 0.489

Review of the observed Pb-210 concentrations indicates that Pb-210 is much higher than the other radionuclides. This is in large part due to the presence of radon decay progeny from natural sources. The U.S. NCRP (U.S. NCRP 1987, Report 94, Table 6.5) reports measured values for Pb-210 in air in the continental U.S. ranging from 300 to 1500 uBq/m^3 (about 8E-03 to 4E-02 pCi/m^3). The measured levels at the two locations (BHV-1 and BHV-2) are within this range. The NCRP values for U-238, Th-230 and Ra-226 are much lower at 2E-05 pCi/m^3 for a national average. Site specific monitoring, in April 1977 prior to operations, measured U-nat, Th-230 and Ra-226 airborne concentrations at <1E-3 pCi/m^3 and therefore these are not sensitive enough for local background as the MDL exceeds recent concentrations (Dames & Moore, 1978). Pb-210 was measured at 1.3E-2 pCi/m^3 in 1977 and this coincides with the current measurements indicating little change in Pb-210 from pre-operational levels. We consider it inappropriate to compare predicted Pb-210 concentration to measured data due to the large differences between predicted values and local background. In the area of the White Mesa mill, there is potential for there to be higher levels of natural mineralization (and potentially dryer conditions) than for the average U.S. so that the U-238, Th-230 and Ra-226 background could be higher.

Since a suitable background is not available for the White Mesa area, the differences in the measured concentrations at the two locations (BHV-1 and BHV-2) were used to estimate the differences in the contribution from the facility at the two locations. The concept is simply that local natural background concentrations should be reasonably independent of location and that the differences in measured concentrations will be an estimate of the differences in contribution from the facility. These differences can then be compared with the differences in the MILDOS predicted concentrations at those locations. The differences estimated from measured concentrations and MILDOS predicted concentrations between BHV1 and BHV2 are shown in Table 2. The predicted difference from the MILDOS model concentrations range from almost equal for U-238 to about a factor of 5 lower for Th-230 and Ra-226 than the difference determined from observational data. Given that limitations of the data, the uncertainty introduced by the need to estimate background, and the uncertainty introduced through comparison of measured data for a specific year (2008) to generic MILDOS calculations for Colorado Plateau ore, the MILDOS predictions are considered to be reasonably similar for U-238, Th-230 and Ra-226 compared to the measurement data. This implies that doses attributable to the facility as calculated using the contribution from observed concentrations are similar to what would be predicted by MILDOS. Hence, a dose calculation is not considered necessary.

Table 2
Comparison of Differences in Radionuclide Concentrations at BHV-1 and BHV-2 using Measured and MILDOS Predictions

	Difference in Measured Concentrations (pCi/m^3)	Difference in Predicted MILDOS Concentrations (pCi/m^3)	Ratio of Predicted to Measured
U-238	3.67E-04	2.95E-04	0.80
Th-230	2.48E-04	4.59E-05	0.18
Ra-226	1.56E-04	4.56E-05	0.29

Note: Difference between BHV-1 and BHV-2

(c) Sensitivity Analysis

Further to our discussions, we have interpreted this request to focus on the effect of Cells 4A and 4B on the potential doses associated with milling and waste management at White Mesa. The key factors here are the areas of ponded water, beach and covered tailings, and the corresponding radon fluxes. For practical purposes, the radon flux from ponded areas is negligible.

(c.1) Sensitivity Analysis on Radon Release Rates

Radon emissions from Cell 4A and 4B will depend on the areas of ponded water, exposed beach and covered materials, and the corresponding radon emissions (pCi/m^2 per second) from these areas. During operations, the areas (surface size) will be variable due to operations and the radon release rates may also be variable. A sensitivity analysis was conducted to address the effect of these factors on the annual radon release (Ci/y).

Radon emission rate data from the nearby Cell 3 at White Mesa were considered representative of the radon emissions from the proposed Cell 4A and Cell 4B due to the similarity of materials and cell operation. Data on annual averages by area type (i.e. interim cover and exposed beach) have been extracted from the NESHAP's radon release reports for the recent years from 2007 through the draft 2009 report [Tellco 2007, 2008 and 2009]. These averages are presented in Table 3. There is variability evident from year to year and some differences between area types. The distributions of these annual averages were assumed to be log-normally distributed and the geometric mean and geometric standard deviation have been derived to represent the variability in radon release rates.

Table 3
Summary of Average Radon Release Rates (pCi/m^2 per s) from Cell 3 at White Mesa for the Period 2007 to 2009

	Reported Averages			Summary Statistics	
Area Type	**2007**	**2008**	**2009**	**Geometric Mean**	**Geometric Standard Deviation**
Cover	13.9	5.5	4.5	7.01	1.825
Beach	6.7	12.2	19.1	9.65	1.691

Radon emission estimates were previously conservatively estimated for Cell 4A and 4B using the NESHAPs limit of 20 pCi/m^2 per second applied to entire cell areas regardless of the cover (SENES 2008). Cell 4A and 4B individually have areas of 161,880 m^2 (40 acres each) and the radon release per cell would therefore be 102 Ci/y for each cell under the initial conservative assessment.

The sensitivity analysis incorporates the variability in radon release rates (pCi/m^2 per s) from the distributions in Table 3 with the proportion of the site by the varying area types. This was completed probabilistically (e.g. Monte Carlo analysis) to combine the variability in release rates with the differences in area coverage.

Table 4 shows the proportions of area types on the cells during production and non-production phases (Denison personal communication, February 2010).

Table 4
Operational Estimates of Cell Use Types

		Units	Cell Area Type			
			Interim Cover	Beach	Ponded Liquid	Total
Proportions						
Operational	Cell 4A	Proportion	0.33	0.33	0.33	1.00
Non-operational	Cell 4A	Proportion	0.33	0.50	0.17	1.00
Operational	Cell 4B	Proportion	0.00	0.33	0.67	1.00
Non-operational	Cell 4B	Proportion	0.00	0.50	0.50	1.00
Areas						
Operational	Cell 4A	m^2	53960	53960	53960	161880
Non-operational	Cell 4A	m^2	53960	80940	26980	161880
Operational	Cell 4B	m^2	0	53960	107920	161880
Non-operational	Cell 4B	m^2	0	80940	80940	161880

For each simulation, a radon release for the beach area and a radon release for the interim cover area were probabilistically selected from the distributions. From these, a weighted release rate (pCi/m^2 per s) and an annual emission (Ci/y) was determined for the entire cell and operational phase based on the proportion of the cover, beach and ponded areas for that cell under that operational phase as shown in Table 3.

Table 5 shows a summary of the sensitivity analyses. Typically, release rates tend to be higher for Cell 4A compared to Cell 4B and this is likely due to the lower amount of ponded liquid in Cell 4A. For individual cells, the lower ponded liquid during the non-operational phase causes higher radon release during the non-operational phase. Radon release rates for the cells are unlikely to exceed 15.4 pCi/m^2 per s with mean levels in the range of 3.5 to 8.6 pCi/m^2 per second. Annual average radon releases are unlikely to exceed the original estimate of 102 Ci/y.

Table 5
Conservative Estimates of Cell Use Types

		Radon Release (pCi/m^2 per s)		Annual Release (Ci/y)	
Cell	**Operation**	**Mean**	**95^{th}**	**Mean**	**95^{th}**
Cell 4A	Non-operate	8.5	15.4	43	79
Cell 4A	Operate	6.3	11.2	32	57
Cell 4B	Non-operate	5.6	11.7	29	60
Cell 4B	Operate	3.6	7.4	18	38

Note: Based on 1,000 trials using the distribution of radon release in Table 2 and the proportion of areas in Table 3.
It is unlikely that the 95^{th} percentile would be exceeded.

During the 1,000 trials, the radon releases for parts of the cell could exceed 20 pCi/m^2 per second. For example, the 95th percentile for beach releases was 23 pCi/m^2 per second. However, the entire cell would not necessarily exceed 20 pCi/m^2 per second because of the different areas (e.g. cover, beach) and differences in release rates between the beach and interim cover. The estimates are somewhat conservative as the area allocation maximizes the exposed beach which generally has higher radon release rates than the interim cover areas.

(c.2) Implications of Sensitivity Analysis

The above sensitivity analysis relative to radon emissions (the largest contributor to dose) demonstrates that the assumption of 102 Ci/y from each cell as used in SENES (2008) was conservative as the 102 Ci/y exceeds the 95th percentile values estimated in the sensitivity analyses (38 to 79 Ci/y in Table 5). However, to further confirm that uncertainty would not change the original conclusion that projected doses would not exceed regulatory limits, the MILDOS run for Arizona strip ore was repeated, but increasing by a factor of two for both of the original conservative particulate and radon emissions used for tailings Cells 4A and 4B. The results of the revised MILDOS runs in comparison to the original Phase 2 (SENES 20White Mesa Interogatory08) results are shown in Table 6 (total annual effective dose) and Table 7 (total dose excluding radon dose)

Table 6
Effect of Doubling Cell 4A and 4B Emissions "Arizona Strip Ore"on Phase 2 Total Annual Effective Dose Commitments Including Radon

		Total Annual Dose Commitments (mrem/y)		Ratio
Location	**Age Group**	**Phase 2 [a] (SENES 2008)**	**Phase 2 [a] (Sensitivity Case) [b]**	**Phase 2 (Sensitivity Case)/ Phase 2 (SENES 2008)**
Nearest Potential Resident (BHV-1)	**Infant**	3.10	3.25	1.05
	Child	2.30	2.45	1.07
	Teenage	2.40	2.57	1.07
	Adult	2.12	2.26	1.07
Nearest Actual Resident	**Infant**	1.95	2.07	1.06
	Child	1.49	1.60	1.08
	Teenage	1.55	1.68	1.08
	Adult	1.39	1.50	1.08

a) Phase 2 includes emissions from mill (including ore pads), tailings cell 3 (interim cover), Cell 2(interim cover), and active tailings cell 4A and 4B.
b) Particulate and radon emissions from Tailings Cell 4A and 4B were increased by a factor of 2.

Table 7
Effect of Doubling Cell 4A and 4B Emissions " Arizona Strip Ore"on Phase 2 Total Annual Effective Dose Commitments Excluding Radon

		40CFR190 Total Annual Dose Commitments (mrem/y)		Ratio
Location	**Age Group**	**Phase 2 [a] (SENES 2008)**	**Phase 2 [a] 35019 (Sensitivity Case) [b]**	**Phase 2 (Sensitivity Case)/ Phase 2 (SENES 2008)**
Nearest Potential Resident (BHV-1)	**Infant**	1.38E+00	1.42E+00	1.03
	Child	5.81E-01	6.22E-01	1.07
	Teenage	6.89E-01	7.42E-01	1.08
	Adult	4.05E-01	4.38E-01	1.08
Nearest Actual Resident	**Infant**	8.04E-01	8.40E-01	1.04
	Child	3.39E-01	3.69E-01	1.09
	Teenage	4.02E-01	4.42E-01	1.10
	Adult	2.36E-01	2.61E-01	1.11

a) Phase 2 includes emissions from mill (including ore pads), tailings cell 3 (interim cover) and active tailings cells 4A and 4B.
b) Particulate and radon emissions from tailings cell 4A and 4B were increased by a factor of 2.

As can be seen from Tables 6 and 7, increasing the emissions of radon and dust from cells 4A and 4B by a factor of two above the 2008 emissions increased the resulting doses by a maximum of 11%. Cells 4A and 4B are generally small contributors to the dose compared to the mill, ore pads and cell 3 so that the total dose is relatively insensitive to emission from cell 4A and cell 4B. Relative to the total effective dose (Table 6), the maximum dose of 3.25 mrem/y under the increased emission rates is still a very small fraction of the 100 mrem/y dose limit. Similarly, relative to 40CFR190, the maximum dose (less radon) (Table 7) of 1.42 mrem/y under the assumed increased emission rates is also a small fraction of the 25 mrem/y limit.

The foregoing analysis supports the observation that the original conclusion in SENES (2008) that projected emissions would meet regulatory limits, is very robust relative to the uncertainties of the calculations for Cells 4A and 4B.

Closing

We trust that this response addresses the questions raised in the Round 2 Interrogatory Statement. We would be pleased to provide further information or answer any questions relative to this letter.

Yours very truly,

SENES Consultants Limited

DB Chambers

Douglas B. Chambers, PhD.
Vice-President, Director of Radioactivity and Risk Studies

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