RAI 12.F. Description of Deficiency The information provided in TR Section 2.6 does not meet the applicable requirements of 10 CFR Part 40, using the review procedures in Section 2.6.2 and using acceptance criteria in Section 2.6.3 of NUREG-1569. Request for Additional Information Please address the following issues regarding the proposed preoperational environmental monitoring program for the MEA: F. In TR Section 2.9.6, the applicant stated that transects will be made across the MEA to collect surface and subsurface soil samples in areas of the proposed well field. While general guidance in RG 4.10 was followed in preparing the proposed baseline soil sampling program, staff cannot determine that the full extent of operations within the proposed MEA will have the necessary baseline soil sampling performed to meet 10 CFR Part 40, Appendix A, Criterion 7, requirements. Please provide a more detailed description of where surface and subsurface oil sampling will be performed.	Cameco December 23, 2013 Response: A sampling plan with details on where and how surface and subsurface soil sampling will occur will be submitted for NRC review in January 2013. Following resolution of any issues, the application will be revised to highlight the elements of that plan. Sampling will be conducted in late spring or early summer of 2014, prior to construction. Section 2.9.6 has been revised accordingly.

Cameco January 24, 2014 Supplemental Response for RAI 12.F.

NUREG-1569, Acceptance Criterion 2.9.3(1), states: "(m)onitoring programs to establish background radiological characteristics, including sampling frequency, sampling methods, and sampling location and density are established in accordance with pre-operational monitoring guidance provided in Regulatory Guide 4.14 (RG 4.14), Revision 1, Section 1.1 (NRC, 1980). The recommendations for soil sampling in RG 4.14 are intended for use at conventional uranium mill sites rather than at ISR sites with satellite facilities and mine units.

Rather than using the fixed position soil sampling locations specified in RG 4.14, Cameco requests the use of an alternate preoperational surface soil sampling method at the Marsland Expansion Area (MEA). This alternate method will use three work phases:

1. Conducting preoperational comprehensive gamma scanning surveys throughout the satellite area and the mine units,
2. Using the gamma scanning survey results to direct the soil sampling at selected locations to establish the correlation between the Ra-226 soil concentration and the gamma scanning radiation levels, and
3. Applying the soil sampling Ra-226 correlation results to the comprehensive gamma scanning data to predict the Ra-226 soil concentration throughout each of these areas.

For the first phase of work Cameco will conduct comprehensive gamma scanning surveys to characterize the gamma radiation levels within the license areas of interest. Gamma exposure rates will be measured with sodium iodide (NaI) scintillation detectors conveyed over the areas of interest using vehicular-based gamma scanning survey systems. The vehicle-based systems will typically deploy multiple detectors to optimize survey coverage. Backpack-based single detector systems will be used when vehicle use is not feasible or not safe. These survey systems pair the NaI detectors with global positioning system (GPS) receivers. They include an onboard personal computer or a handheld data logger to display, record, and map thousands of gamma measurements each hour for each gamma detector that is deployed.

The typical gamma detector data collection rate is 1 gamma count rate measurement reading per second, the survey system scanning rate is approximately 0.75 meters per second (m/s), and the distance between adjacent lanes is approximately 2.5 m. This gamma scanning protocol produces approximately 50 gamma measurement readings for each 100 m2 area. The resulting data density of these gamma scanning survey results greatly exceeds that required by RG 4.14. In comparison to the limited set of measurement points designated in RG 4.14, the proposed comprehensive gamma scanning survey coverage facilitates the production a comprehensive map of all of the areas surveyed.

NaI detectors are energy dependent and respond differently to radionuclides with higher or lower gamma energies compared to its calibration radionuclide. True gamma exposure rates are best measured with an energy independent system such as a high-pressure ionization chamber (HPIC). NaI detectors are more durable so they are a better choice under the field conditions at the MEA. To address this issue, the NaI detectors will be cross-calibrated with an HPIC. Cross-calibration allows a direct means for comparison of the preoperational data with data obtained later without relying on identical detectors. This will also facilitate conversion of the gamma detector count rates to gamma exposure rates for subsequent comparison to MILDOS AREA dose predictions.

The planned gamma scanning surveys will be performed using commercially available radiation detection equipment such as a Ludlum Model 44-10 sodium iodide (NaI) detector coupled to a Ludlum Model 2350 rate-meter with RS-232 data output, or equivalent. A GE Reuter-Stokes High Pressure Ion Chamber (HPIC), or equivalent, will be used to cross-calibrate the gamma scanning detectors before each day's surveys. This will establish the correlation between the scanning gamma detector measurements in counts per minute and the exposure rate measured by the HPIC in micro-Roentgens per hour (µR/hr).

The second phase of work will collect composite soil samples from ten (10) 10-x-10 m grids within each area of interest. The ten grids will be selected based on having average gamma scanning results that are representative of the range of the gamma scanning levels in the area of interest and which are located in a roughly radial pattern that extends outward from near the center of the area of interest.

These grids will be the basis for developing a statistical correlation between the measured soil Ra-226 concentrations and the gamma exposure rates measured at the center of the grid, and are therefore called "correlation" grids.

A composite sample of 10 subsamples to a depth of 15 cm will be collected using standardized equidistant subsampling locations within each correlation grid. The composites will be analyzed for Ra-226, natural uranium, Th-230, and Pb-210. The average gamma exposure rate will be measured at the center of each correlation grid and the gamma exposure rate reading and the corresponding GPS coordinates at the center of each sampling grid will be recorded.

The soil sampling results will be used to establish the correlation between the composite sample Ra-226 concentration in the surface soil and the average exposure rate at the center of the grid.

The third phase of work for the alternate surface soil sampling method is to produce a comprehensive map of the predicted Ra-226 soil concentration in each area of interest. The data obtained from the correlation grids will be applied to the gamma scanning survey data set to create comprehensive maps of the predicted Ra-226 soil concentration throughout the satellite area and the mine units of interest. The NaI/HPIC cross calibration data will be combined with the soil Ra-226 concentration data and the gamma exposure rate correlation data to correct the gamma scanning data for any differences in detector height to a standard height of 1 meter above grade. Given that sites that may have been surveyed at different heights due to terrain and brush issues, this standard height above grade will serve as the common point of reference to facilitate direct comparison of the final survey results.

The Radium-226 concentrations in soil throughout each area of interest will be estimated by kriging methods. Kriging is a geostatistical interpolation procedure that fits a mathematical function, such as the statistical correlation, to a specified number of nearest points within a defined radius to determine an output value for each location. The result will be continuous maps of the areas of interest that show the variation of the range of the Ra-226 concentrations throughout the areas of interest and the corresponding predicted gamma exposure rates at 1 meter above grade.

In addition to the above soil sampling, soil samples will also be collected at each of the 5 MEA air monitoring stations (AMS). Surface samples to a depth of 15 cm and subsurface samples from 15 cm to 30 cm will be collected. Each of these samples will be analyzed for Ra-226, natural uranium, Th-230, and Pb-210. The average gamma exposure rate will be measured at the sampling location with a HPIC at 1 meter above grade. The resultant gamma exposure rate measurement will be recorded with the GPS coordinates for each soil sampling location.

Three top-soil samples will also be collected at each of the AMS to a depth of 5 cm. These top-soil samples will be used to establish the baseline conditions for subsequent assessment of potential impacts on the surface soils due to AMS indications of an airborne release of potential concern. Findings of elevated top-soil sample concentrations above the baseline conditions could serve to validate any elevated AMS indications and could also aid in the assessment of potential ground deposition impacts.

RAI 12.G.1. <u>Description of Deficiency</u> The information provided in TR Section 2.6 does not meet the applicable requirements of 10 CFR Part 40, using the review procedures in Section 2.6.2 and using acceptance criteria in Section 2.6.3 of NUREG-1569. <u>Request for Additional Information</u> Please address the following issues regarding the proposed preoperational environmental monitoring program for the MEA: G. In TR Section 2.9.8, the applicant described its baseline direct radiation monitoring program. Please provide the following: (1) As noted in staff's review of the baseline soil sampling program, staff cannot determine that the full extent of operations within the proposed MEA will have the necessary baseline direct radiation monitoring performed to meet 10 CFR Part 40, Appendix A, Criterion 7, requirements. Please provide a more detailed description of where direct radiation monitoring will be performed.	Cameco December 23, 2013 Response: A sampling plan with details on where and how direct radiation monitoring will occur will be submitted for NRC review in January 2013. Following resolution of any issues, the application will be revised to highlight the elements of that plan. Sampling will be conducted in late spring or early summer of 2014, prior to construction. Section 2.9.8.1 was revised accordingly.

Cameco January 24, 2014 Supplement Response for RAI 12.G.1.

RG 4.14 recommends 80 direct radiation measurements at 150-meter (m) intervals up to a distance of 1500 m in eight directions from the center of the milling area. In addition, direct radiation measurements should also be made at the same locations used for the collection of particulate air samples once prior to site construction. RG 4.14 was designed for a conventional mill rather than an ISR facility. Conventional mill operations are centralized between the mill complex and tailings disposal impoundments, whereas ISR operations are dispersed in the licensed area with multiple wellfields and header houses at each wellfield.

Rather than using the fixed position direct radiation measurement locations recommended in RG 4.14, Cameco requests the use of an alternate method for conducting the preoperational direct radiation measurements at the MEA. This alternate method will use comprehensive preoperational gamma scanning surveys throughout the satellite area and mine units.

The three phases of work are detailed above in response to MEA RAI 12.F, which addresses the baseline soil monitoring program. The three phases of work described for the baseline soil monitoring program will produce detailed survey maps of the gamma exposure rate radiation levels throughout the satellite area and mine units.

The planned gamma scanning surveys will use commercially available radiation detection equipment such as a Ludlum Model 44-10 sodium iodide (NaI) scintillation detector coupled to a Ludlum Model 2350 rate-meter with RS-232 data output, or equivalent. A GE Reuter-Stokes High Pressure Ion Chamber (HPIC), or equivalent, will be used to cross-calibrate the gamma scanning detectors before each day's surveys. This will establish the correlation between the scanning gamma detector measurements in counts per minute to the exposure rate measured by the HPIC in micro-Roentgens per hour (µR/hr).

This alternate method yields maps of the gamma radiation measurement data in gamma counts per minute (CPM) and in gamma exposure rate or dose rate, with units of micro-Roentgens per hour (µR/hr) or micro-rem per hour (µrem/hr), respectively. This alternate method will follow the site characterization methodology recommended in NUREG-1575, Revision 1, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (NRC, 2000b).

RAI 12.G.2. Description of Deficiency The information provided in TR Section 2.6 does not meet the applicable requirements of 10 CFR Part 40, using the review procedures in Section 2.6.2 and using acceptance criteria in Section 2.6.3 of NUREG-1569. Request for Additional Information Please address the following issues regarding the proposed preoperational environmental monitoring program for the MEA: G. In TR Section 2.9.8, the applicant described its baseline direct radiation monitoring program. Please provide the following: (2) In TR Section 2.9.8, the applicant stated: "The type of survey instrument and procedures would be as described below..." However, there is no text provided that addresses these issues. Please provide the type of survey instrument used for performing baseline direct radiation monitoring and the procedures used, as indicated in TR Section 2.9.8.	Cameco December 23, 2013 Response: A sampling plan with details on where and how surface and subsurface soil sampling will occur will be submitted for NRC review in January 2013. Following resolution of any issues, the application will be revised to highlight the elements of that plan. The plan will provide details on the type of instrumentation and procedures used.

Cameco January 24, 2014 Supplemental Response for RAI 12.G.2.

With regard to the recommendations for performing baseline direct radiation monitoring in Regulatory Guide 4.14 Revision 1, Section 1.1 (NRC, 1980) and in NUREG-1569, Acceptance Criterion 2.9.3(1), CBR now requests the use of an alternate method as described above in response to RAI 12.G.1. Vehicular-based and backpack-based gamma survey systems will be used to conduct gamma scanning surveys throughout the satellite area and mine units to document the gamma background levels prior to the construction in those areas. Both of these survey systems utilize:

- a calibrated High Pressure Ion Chamber (HPIC) to accurately measure the ambient radiation level in micro-Roentgen per hour (µR/hr) and to cross-calibrate the gamma scintillator detectors used in the gamma scanning surveys for conversion of the gamma count rate to µR/hr;
- one or more gamma detection assemblies, each consisting of a calibrated radiation NaI scintillation detector and ratemeter to measure, time-stamp and transmit the radiation readings for data logging;
- a GPS positioning system to determine and map the real-time positioning and mapping of the survey coverage (typically to within 30 cm each second), time stamp and transmit the GPS coordinate readings for data logging; and
- a handheld data logger or a laptop computer loaded with the software needed to display, log and map the gamma radiation survey data in real-time.

Person-carried backpack systems will be used where the access for vehicular-based systems is restricted due to site features, terrain, or brush issues. These systems use a single detector and ratemeter assembly to minimize weight.

The vehicular-based systems typically use multiple detector and ratemeter assemblies. The vehicles used range from 4-wheeled ATV's to fullsize trucks or vans. They generally are deployed with two or three detectors assemblies. Deploying more detectors can increase the area survey coverage rate or the scanning gamma survey data density for a given scan rate. The gamma radiation readings from each detector assembly are typically recorded at one second intervals and are time-stamped accordingly.

During the conduct of a gamma scanning survey with either the handheld data logger or the laptop, the display updates the map of the surveyor GPS coordinates each second and shows the survey coverage. Subsequent to field data surveying and mapping, additional data processing is performed to accurately correlate the gamma radiation readings with the GPS positioning coordinates based on their respective time stamps and to confirm the quality of the gamma radiation survey data.

The planned gamma scanning surveys will be performed using commercially available radiation detection equipment such as a Ludlum Model 44-10 sodium iodide (NaI) scintillation detector coupled to a Ludlum Model 2350 rate-meter with RS-232 data output, or equivalent. A GE Reuter-Stokes High Pressure Ion Chamber (HPIC), or equivalent, will be used to cross-calibrate the gamma scanning detectors for each day's surveys.

The gamma scanning detectors are typically positioned from from 0.5 m to 1.5 m above grade, depending on the required height to avoid gamma detector impacts with terrain or brush. A height of 1 m results in a scanning field of view for each deployed 2x2 NaI detector of approximately 2.5 meters in diameter. This is generally suitable for detection of a planar 10 m^2 source with slightly elevated concentrations of Ra-226 above the typical environmental levels of gamma radiation that are encountered.

The major procedural steps required to perform these gamma scanning surveys include the following:

1. At a designated location for periodic equipment calibration purposes, determine the relationship between the background gamma exposure rate reading in micro-Roentgens per hour (µR/hr) and the gamma detector count rate in counts per minute (CPM) at 0.3 meters (m), 0.5 m, 1 m, and 1.5 m above grade for each of the gamma survey detectors to be used. Use a calibrated HPIC, GE Reuter Stokes RSDetection Environmental Radiation Monitor, or equivalent) and calibrated gamma scintillation detectors (Ludlum Model 44-10 2x2 (5 cm x 5 cm) sodium iodide (NaI) detector with a Ludlum Model 2350 ratemeter, or equivalent). Plot and analyze the results to establish the correlation between HPIC exposure rate in micro-Roentgens per hour (uR/hr) to gamma detector count rate in counts per minute (CPM) over this range of detector heights.
2. Conduct routine performance checks for quality assurance prior to and during each use of the gamma scanning system.
3. Conduct comprehensive gamma scanning surveys using the gamma survey detector systems throughout the MEA satellite and well field areas to measure and record the gamma radiation levels using commercially available systems for gamma detection, GPS tracking, data logging, analysis, and mapping. Set the gamma survey detector height above grade to provide sufficient clearance for brush and terrain. Set the gamma detector data collection rate to 1 second. Perform the gamma scanning surveys throughout the area of interest at a scan rate of approximately 0.75 m/s with adjacent lanes of approximately 2.5 m.
4. Create color-coded maps that document the gamma count rate survey coverage and illustrate the intensity of the gamma count rates each second.
5. Apply Kriging methods to create comprehensive color coded maps of the gamma scanning survey data to show the spatial variation in the background gamma radiation levels throughout the areas of interest.
6. Analyze the resulting gamma scanning survey results for identification of ten 100 m^2 grids within each of the surveyed MEA areas that are characterized by gamma count rates that range from low to high readings. The soil sampling results from these grids will be used to establish

the correlation between the soil Ra-226 concentrations and their respective exposure rates.

7. Collect soil samples at 10 prescribed standard locations within each of the ten 100 m^2 correlation grids and collect a 60 second static gamma count rate measurements at 1 m above grade at each sampling location.
8. Collect a 15 cm deep surface soil sample and a subsurface 15 cm soil sample (15 cm to 30 cm below grade) at each soil sampling location within each of the ten 100 m^2 grids.
9. Submit the soil samples for analysis by an accredited laboratory for the measurement of radium-226 and uranium-238. Measure approximately 10% of the soil samples for thorium-232 and lead-210.
10. Use the results to establish correlation plots to demonstrate the correlation between Ra-226 concentration and the detector gamma count rate.
11. Review and report the soil sampling results with graphs that show the results in comparison to the regulatory limits and plots of the correlation between the soil sampling results and the gamma detector radiation readings.
12. Include a detail narrative discussion of the findings.

RAI 13 Description of Deficiency Staff cannot complete its evaluation of NUREG-1569, Acceptance Criterion 2.9.3(2). Basis for Request 10 CFR Part 40, Appendix A, Criterion 7, requires: "At least one full year prior to any major site construction, a preoperational monitoring program must be conducted to provide complete baseline data on a milling site and its environs. Throughout the construction and operating phases of the mill, an operational monitoring program must be conducted to measure or evaluate compliance with applicable standards and regulations; to evaluate performance of control systems and procedures; to evaluate environmental impacts of operation; and to detect potential long-term effects." RG 4.14 provides guidance on the preoperational and operational aspects of effluent and environmental monitoring at uranium mills. NUREG-1569, Acceptance Criterion 2.9.3(2), states: "Soil sampling is conducted at both a 5-cm [2-inch] depth as described in Regulatory Guide 4.14, Section 1.1.4 (NRC, 1980) and 15 cm [6 in] for background decommissioning data." During its review, NRC staff found no 15-cm soil samples proposed in the TR. Request for Additional Information Please provide justification for not performing soil samples at 15-cm depths, or indicate where this can be found in the TR.	Cameco December 23, 2013 response: A sampling plan with details on where and how surface and subsurface soil sampling will occur will be submitted for NRC review in January 2013. Following resolution of any issues, the application will be revised to highlight the elements of that plan. Sampling will be conducted in late spring or early summer of 2014, prior to construction. Section 2.9.6 has been revised accordingly.
Cameco January 24, 2014 Supplemental Response for RAI 13. Please refer to RAI response 12.F, above.	
RAI 41 Description of Deficiency In TR Section 6.4, the applicant refers to its RESRAD calculations in TR Appendix N for Marsland site-specific cleanup criteria. However, staff can't verify that the applicant utilized Marsland site-specific input data (e.g., soil type, wind speed, precipitation, etc.) for RESRAD appropriate for the site. Basis for Request NUREG-1569, Acceptance Criterion 6.4.3(1), states: "The cleanup criteria for radium in soils are met as provided in 10 CFR Part 40, Appendix A, Criterion 6(6)." This criterion states	Cameco December 23, 2013 Response: A sampling plan with details on where and how Marsland site-specific cleanup criteria are to be determined will be submitted for NRC review in January 2013. Following resolution of any

that the design requirements for longevity and control of radon releases apply to any portion of a licensed and/or disposal site unless such portion contains a concentration of radium in land, averaged over areas of 100 m2, which as a result of byproduct material, does not exceed the background level by more than: (i) 5 picocuries per gram (pCi/g) of radium-226, or, in the case of thorium byproduct material, radium-228, averaged over the first 15 cm [5.9 in.] below the surface, (ii) 15 pCi/g of radium-226, or, in the case of thorium byproduct material, radium-228, averaged over 15-cm [5.9-in.] thick layers more than 15 cm [5.9 in.] below the surface." NUREG-1569, Acceptance Criterion 6.4.3(3), states: "Acceptable cleanup criteria for uranium in soil, such as those in Appendix E of this standard review plan, are proposed by the applicant. This is the radium benchmark dose approach of 10 CFR Part 40, Appendix A, Criterion 6(6)." NUREG-1569, Acceptance Criterion 6.4.3(4), states: "For areas that already meet the radium cleanup criteria, but that still have elevated thorium levels, the applicant proposes an acceptable cleanup criterion for thorium-230. One acceptable criterion is a concentration that, combined with the residual concentration of radium-226, would result in the radium concentration (residual and from thorium decay) that would be present in 1,000 years meeting the radium cleanup standard." NUREG-1569, Acceptance Criterion E2.1.3(2), states, in part: "...The code/calculation input data are appropriate for the site and represent current or long-term conditions, whichever is more applicable to the time of maximum dose. When code default values are used, they are justified as appropriate (representative) for the site..." <u>Request for Additional Information</u> Please address the following issues related to the soil cleanup criteria for the MEA: A. In TR Section 6.4.1, the applicant stated that the ALARA goal for natural uranium in the top 15 cm soil layer is 150 pCi/g averaged over *more than* 100 m2. The averaging of radionuclides over more than 100 m2 is not consistent with the requirements of 10 CFR Part 40, Appendix A, Criterion 6(6) or NUREG-1569, Acceptance Criterion 6.4.3(1). Please provide a justification for averaging the natural uranium concentration over more than 100 m2. B. Consistent with NUREG-1569, Acceptance Criteria 6.4.3(3) and E2.1.3(2), please confirm that site-specific parameters relevant to the MEA (e.g., soil type, wind speed, precipitation, etc.) were used for the RESRAD analysis and thus deriving the radium benchmark dose. If the MEA site-specific parameters are different from what was analyzed, please provide a relevant RESRAD and radium benchmark dose analysis. C. In TR Section 6.4, the applicant refers to its analysis of Th-230 at its main facility for the Marsland analysis without assessing if this analysis is applicable to the MEA. Consistent with NUREG-1569,	issues, the application will be revised to highlight the elements of that plan. Any required sampling will be conducted in late spring or early summer of 2014, prior to construction.

Acceptance Criterion 6.4.3(4), please provide a MEA site-specific discussion on Th-230, or indicate where this information can be found.	
Cameco January 24, 2014 Supplemental Response for RAI 41 A. The averaging of radionuclides will be performed over areas of not more than 100 m2. The text will be revised accordingly. B. An MEA site-specific radium benchmark dose analysis will be provided to NRC for written verification when the soil sampling described in RAI Response 12.F. is completed. C. An MEA site-specific discussion on Th-230 will be provided to NRC for written verification when the soil sampling described in RAI Response 12.F. is completed.	
RAI 42 <u>Description of Deficiency</u> In TR Section 6.4.2, the applicant provided a gamma action level of 17,900 cpm as the level corresponding to the Marsland soil cleanup criterion. In TR Appendix N, the applicant described its derivation of the gamma action level of 17,900 cpm. However, the gamma action level was derived from data at the main facility (i.e., background levels, etc.) and there is no justification addressing why this data can be applied to Marsland, an unrelated land area. <u>Basis for Request</u> NUREG-1569, Acceptance Criterion 6.4.3(5), states: "The survey method for verification of soil cleanup is designed to provide 95-percent confidence that the survey units meet the cleanup guidelines. Appropriate statistical tests for analysis of survey data are described in NUREG–1575, 'Multi-Agency Radiation Survey and Site Investigation Manual' (NRC, 2000)." <u>Request for Additional Information</u> Consistent with NUREG-1569, Acceptance Criterion 6.4.3(5), please provide a technical justification for applying a gamma action level of 17,900 cpm to the Marsland facility when data used to derive this action level is based on site-specific data for the main facility, an unrelated land area.	Cameco December 23, 2013 Response: A sampling plan with details on where and how a Marsland site-specific gamma action level is to be determined will be submitted for NRC review in January 2013. Following resolution of any issues, the application will be revised to highlight the elements of that plan. Sampling will be conducted in late spring or early summer of 2014, prior to construction.
Cameco January 24, 2014 Supplemental Response for RAI 42 A site-specific Marsland gamma level for soil cleanup criteria will be provided to NRC for written verification when the soil sampling described in RAI Response 12.F is complete.	