

Rio Algom Mining LLC

**RADIATION PROTECTION
AND ENVIRONMENTAL
MONITORING
PROGRAM MANUAL**

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Acronyms and Definitions

Term	Definition ^a
ACL	alternate concentration limit
ALARA	as low as is reasonably achievable
ALI	annual limit on intake
ANSI	American National Standards Institute
byproduct material	The tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Underground ore bodies depleted by such solution extraction operations do not constitute "byproduct material" within this definition.
CDE	committed dose equivalent
CEDE	committed effective dose equivalent
CFR	Code of Federal Regulations
Ci	curie
contractor	an individual or business who has signed a contract, field services agreement, or purchase order and is completing work for RAML at the facility
COPC	constituent of potential concern
DAC	derived air concentration
DDE	deep dose equivalent
dpm 100cm ⁻²	disintegrations per minute per 100 square centimeters
employee	an employee of RAML who is completing work for RAML at the facility
facility	RAML's Ambrosia Lake West Mill facility
g	gram
GPS	groundwater protection standard
HP	health physicist
HPT	health physics technician
L	liter
LDE	lens dose equivalent (eye dose equivalent to the lens of the eye)
License	NRC License SUA-1473 for RAML's Ambrosia Lake West Mill facility
Licensed material	radioactive and non-radioactive constituents of potential concern which are regulated by NRC pursuant to the facility license
μCi mL ⁻¹	microcuries per milliliter
μR hr ⁻¹	micro-Roentgen per hour
ML#	Agencywide Documents Access and Management System accession number
NRC	United States Nuclear Regulatory Commission
Pb-210	lead-210
pCi g ⁻¹	picocuries per gram
R	Roentgen
Ra-226	radium-226
RAML	Rio Algom Mining LLC
rem y ⁻¹	Roentgen equivalent man (rem) per year

Term	Definition ^a
Rn-222	radon-222
RPEM	radiation protection and environmental monitoring
RSO	radiation safety officer
RWP	radiation work permit
SDE	shallow dose equivalent
SERP	Safety and Environmental Review Panel
SI	international system of units
SOP	standard operating procedure
SUA-1473	NRC license SUA-1473 for RAML's Ambrosia Lake West Mill facility
TEDE	total effective dose equivalent
Th-230	thorium-230
TODE	total organ dose equivalent
Uranium (U)	natural uranium
Visitor	any individual who is on-site at the facility who is not classified as a worker
Worker	an employee or contractor who is completing work for RAML

^a Definitions are based on the definitions in [10 CFR 20.1003](#) with the following exceptions: 1) facility-specific definitions are provided for contractor, employee, facility, license, licensed material, RAML, RPEM, SUA-1473, visitor, and worker; 2) byproduct material is defined in [10 CFR 40.4](#).

1.0 Introduction and Purpose

1.1 Introduction

This manual describes the radiation protection and environmental monitoring (RPEM) program at Rio Algom Mining LLC's (RAML) Ambrosia Lake West Mill facility (the "facility"), as required by the facility's radioactive materials license (license number SUA-1473 ["the license"]) issued by the United States Nuclear Regulatory Commission (NRC). RAML is committed to protecting human health and the environment at the facility and maintaining effective and compliant radiation protection practices during facility decommissioning.

The facility was placed in standby status in 1985 and transitioned to possession-only status in 2003 with amendment 52 to the license. Licensed material at the facility has largely been reclaimed in accordance with plans approved by the NRC. Current and future site activities have three objectives: 1) compliance with regulatory requirements, including the completion of facility decommissioning, 2) license termination, and 3) transition of the facility to the appropriate custodial agency for long-term care, as required by Title II of the *Uranium Mill Tailings Radiation Control Act* of 1978.

1.2 Purpose, Scope, and ALARA Policy

The RPEM program has been developed to ensure that (1) activities involving licensed material are performed according to applicable regulatory requirements, (2) licensed material is handled safely, and (3) exposures to licensed material are at levels that are as low as is reasonably achievable (ALARA).¹

The RPEM program incorporates all applicable requirements from Titles 10 and 40 of the Code of Federal Regulations (CFR) and considers relevant NRC guidance documents. Documents incorporated or considered, as appropriate, during the development of this RPEM program are listed in [Table 1](#) (regulations) and [Table 2](#) (guidance documents). Because many NRC guidance documents were developed for use at operational uranium mills, and this manual describes the RPEM program at a decommissioning facility, only specific elements of relevant guidance documents have been incorporated into RAML's RPEM program.

The RPEM program is also intended to limit radiation exposures from licensed radioactive material to ALARA levels. RAML's policy is that ALARA conditions are achieved and maintained by promoting open and honest communication among all workers at the facility and providing appropriate equipment, training, and guidance to ensure that all workers are aware of – and implement – appropriate radiation protection principles in the performance of their duties. To be effective, all individuals exposed to licensed material must take an active role in keeping radiation doses ALARA.

The RPEM program has been designed to satisfy all applicable regulatory requirements during any site activities performed as part of facility decommissioning, including activities that occur during active reclamation.

This manual is divided into five sections:

1. Introduction and Purpose
2. Organization and Management
3. Radiation Protection Program²
4. Environmental Monitoring Program³
5. Records⁴

¹ ALARA is defined in 10 CFR 20.1003. An ALARA approach is required by [10 CFR 20.1101](#).

² The radiation protection program is required by [10 CFR 20.1101](#) and the license.

³ This entails routine monitoring to demonstrate compliance with the public dose limits and groundwater protection standards contained in [10 CFR 20.1101](#), [10 CFR 20.1301](#), [40 CFR 190.10](#) and the license.

⁴ Records of the radiation protection program are required by [10 CFR 20.2102](#).

Table 1. Regulatory references adopted these references into this RPEM program manual, where required and/or appropriate.

Reference	Title
License SUA-1473	NRC license for RAML's Ambrosia Lake West Mill facility
10 CFR 19.13	Notifications and reports to individuals
10 CFR 20	Standards for Protection Against Radiation
10 CFR 40	Domestic Licensing of Source Material
40 CFR 190	Environmental Radiation Protection Standards for Nuclear Power Operations

Table 2. Guidance references considered during development of the RPEM program. RAML has adopted specific elements of these documents into its RPEM program, where appropriate.

Reference	Title
ANSI/HPS N13.12-2013	Surface and Volume Radioactivity Standards for Clearance
DUQP-ISG-01 (2019)	Evaluations of Uranium Recovery Facility Surveys of Radon and Radon Progeny in Air and Demonstrations of Compliance with 10 CFR 20.1301
NUREG 1400	Air Sampling in the Workplace [ML13051A671]
NUREG 1620	Section 5.3 Radiation Safety Controls and Monitoring [ML032250190]
NUREG 1736	Consolidated Guidance: 10 CFR Part 20 – Standards for Protection Against Radiation – Section 3 subsections correspond to each line item in 10 CFR 20 . [ML013330106]
Regulatory Guide 4.14	Radiological Effluent and Environmental Monitoring at Uranium Mills [ML003739941]
Regulatory Guide 4.20	Constraint on Releases of Airborne Radioactive Materials to the Environment for Licensees Other Than Power Reactors [ML110120299]
Regulatory Guide 8.9	Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program
Regulatory Guide 8.13	Instruction Concerning Prenatal Radiation Exposure
Regulatory Guide 8.15	Acceptable Programs for Respiratory Protection
Regulatory Guide 8.22	Bioassay at Uranium Mills
Regulatory Guide 8.25	Air Sampling in the Workplace
Regulatory Guide 8.30	Health Physics Surveys in Uranium Recovery Facilities
Regulatory Guide 8.31	Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mills Will be As Low As Is Reasonably Achievable
Regulatory Guide 8.34	Monitoring Criteria and Methods to Calculate Occupational Radiation Doses
Regulatory Guide 8.36	Radiation Dose to the Embryo/Fetus

1.3 Constituents of Potential Concern

The constituents of potential concern (COPCs) for the RPEM program is byproduct material as defined in [10 CFR 40.4](#), including radioactive and non-radioactive constituents, which RAML is licensed to receive, acquire, possess, transfer, and dispose of. All references to specific compounds, elements, or isotopes herein mean those constituents only when derived from licensed sources.

During decommissioning, any licensed material remaining at the facility that does not have a beneficial future use is byproduct material as defined in [10 CFR 40.4](#) because all such material is “tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes.” Licensed material having a beneficial future use (e.g., check sources) is not a waste, and may not meet the definition of byproduct material.

Licensed radionuclides present at the facility are principally uranium decay products. Uranium is present at the facility in only limited amounts, as this radionuclide was separated during the milling process and shipped off-site as a mill product. The facility COPCs that represent the greatest exposure hazard for workers and/or the public are:

- thorium-230 (Th-230)
- radium-226 (Ra-226)
- radon-222 (Rn-222)
- short-lived decay products of Rn-222

While other radionuclides (e.g., uranium and other nuclides in the uranium decay series) may be present at the facility, these constituents are typically present in only small amounts and are relatively insignificant health risks due to their low radio- and/or chemotoxicity.

2.0 Organization and Management

The organization of workers and management for the facility are described in the following sections. [Figure 1](#) provides the functional RAML organizational chart.

2.1 Facility Employees and Contractors

Site Manager

The site manager is responsible for the health and safety of employees, contractors, and visitors at the facility. Specifically, the site manager ensures sufficient resources are available to effectively implement the RPEM program. The site manager will demonstrate visible leadership and proactive commitment to ensuring that activities are conducted according to the ALARA principle and other facility and regulatory requirements.

Manager responsibilities include:

- Lead by example in providing a strong commitment to – and continuing support for – the implementation of the RPEM program and the ALARA principle.
- Ensure that pertinent information and relevant training is provided to employees, contractors, and visitors.
- Continually evaluate the resources assigned to implement the programs, including staffing and support.

Site Principal

The site principal for the facility provides oversight of health and safety for all activities at the facility. The site principal supervises workers and coordinates work activities with the radiation safety officer (RSO) so that doses remain ALARA and work is performed according to facility requirements.

Workers

All workers (i.e., RAML employees and contractors) at the facility are responsible for performing all jobs in a safe manner, including any work involving licensed material. Workers will (1) participate in the RPEM program, including conforming to applicable radiation protection requirements, and (2) perform work involving licensed material according to the ALARA principle.

Worker responsibilities include:

- Be familiar with and adhere to all rules, notices, and procedures for radiation safety applicable to their work.
- Promptly report to the RSO, site principal, or site manager any situation which could result in increased radiological hazard to any individual or the environment.
- Take an active role in keeping exposures ALARA by suggesting improvements to the RPEM program.
- Notify the RSO of any occupational radiation exposures that occurred at another facility within the most recent calendar year
- Workers have the authority and responsibility to stop work if they observe unsafe conditions

2.2 RPEM Program Staff

Radiation Safety Officer

The RSO is responsible for management and implementation of the RPEM program. The RSO coordinates activities with the site principal and may oversee health physics staff, dependent upon site conditions. The RSO is also responsible for compliance with the license. A current copy of the license is available from the

RSO. The RSO provides guidance to RAML management regarding the effectiveness and proper implementation of the RPEM program and advises RAML representatives on regulatory requirements which may impact operations. The RSO may designate authority for responsibilities to another individual (RSO designee) if the individual meets the qualifications described below.

The minimum qualifications of the RSO include:

- A Bachelor of Science degree in health physics, the physical sciences, industrial hygiene, or engineering from an accredited college or university. Individuals possessing other degrees may act as RSO provided they have relevant experience commensurate with activities at the facility. Two years of relevant experience are generally considered equivalent to one year of academic study.
- A minimum of one year of directly related work experience relevant to the operation and/or decommissioning of uranium recovery facilities.
- At least four weeks of specialized classroom training in health physics specifically applicable to uranium recovery.
- Familiarity with the RPEM program, applicable regulations, and their implementation.
- And at least one of the following:
 - Maintenance of proficiency in radiation protection principles by attending classroom training pertinent to general or specific radiation safety program management topics. Training frequency will be at least every two years,
 - [or]
 - Maintenance of a Certified Health Physicist credential through the American Board of Health Physics which specifies a total of 80 continuing education units over a period of four years.

RSO responsibilities include:

- Have authority to enforce regulations and RAML policies that affect the RPEM program.
- Review and approve plans, changes to existing programs, procedures, and equipment that may affect the implementation of the RPEM program.
- Maintain adequate and appropriate equipment required to implement the RPEM program.
- Perform an annual review of the RPEM program content and an audit of RPEM program implementation.
- Review work plans to evaluate the radiation hazard for each proposed job task and to evaluate whether a radiation work permit (RWP) is necessary

Health Physicist

The health physicist (HP) assists the RSO with management and implementation of the RPEM program. The HP reports directly to the RSO and may assist the RSO in managing health physics technicians, as appropriate. Depending upon the nature of work being performed at the facility, this position may be unstaffed.

The HP will, at a minimum, hold a bachelor's degree in health physics, physical sciences, industrial hygiene, or engineering from an accredited college or university, and be familiar with the facility RPEM program, in addition to applicable regulations and their implementation.

Health Physics Technician

The health physics technician (HPT) is responsible for (1) collecting radiation protection samples, (2) performing radiation protection surveys, (3) maintaining equipment, (4) generating records, and (5) preparing and submitting reports for the RSO's review. Depending upon the nature of work being performed at the facility, this position may be unstaffed. The HPT will have a minimum of a high school diploma or the

equivalent and should be familiar with the RPEM program. Standard Operating Procedures and Radiation Work Permits

RAML maintains standard operating procedures (SOPs) for routine activities that involve handling, processing, or storing licensed material. SOPs will describe the appropriate radiation protection practices to be followed during the described activity. The RPEM program and all SOPs will be managed according to the requirements of the license.

When workers may be exposed to radiation in excess of the ALARA action levels described in [Table 3](#) and the work to be performed involves the non-routine handling, processing, or storage of licensed material, RAML will develop a radiation work permit (RWP) that describes radiation protection measures required during the work. RWPs will be managed as described in section [3.5](#).

2.3 Safety and Environmental Review Panel

As described in the license, a Safety and Environmental Review Panel (SERP) will be established to evaluate changes not previously assessed by the NRC or authorized by the license. The SERP will at a minimum consist of the RSO, the site principal, and the site manager. The RSO, site principal, or site manager may delegate their role on the SERP provided the designee has similar knowledge. The SERP may include others on a temporary or permanent basis when additional subject matter experts are needed. Subject matter experts will be RAML employees or contractors. At least one member of the SERP will be designated as chairperson.

The SERP may evaluate proposed changes consistent with the scope described in the license, including:

1. Changes to the RPEM program. Allowable changes include adding, modifying, or eliminating occupational or environmental monitoring locations, parameters, or other associated requirements.
2. Changes to facility operations or physical structures in support of decommissioning. Allowable changes include design, construction, installation, operation, and/or demolition of:
 - support facilities and equipment, including water tanks, fuel tanks, concrete pads, decontamination facilities and equipment, or similar
 - portable and temporary structures such as on-site laboratories, office space, storage structures and containers, or similar
 - temporary investigation derived waste storage containers, facilities, above- or below-grade stockpiles, other temporary infrastructure to manage investigation derived waste, or similar
 - roads, fences, gates, utility infrastructure, or similar.
3. Studies, tests, or experiments in support of site decommissioning. Allowable studies include well or aquifer pump tests, pilot reclamation tests, experiments at bench top or field scale, and studies regarding nature and extent of licensed material.

RAML will obtain a license amendment pursuant to [10 CFR 40.44](#) prior to implementing a proposed change if the SERP determines that the change:

1. Will result in an increased potential for release of licensed material that would result in a dose greater than the limits described in Sections [3.1](#) or [4.1](#), provided that the potential for such a release cannot be mitigated through appropriate engineering or administrative controls,
2. Will create a malfunction of an engineered structure, system, or control, or
3. Will result in a departure from the requirements of any condition of the license.

Written records of the evaluations made by the SERP will be produced. These records will provide the basis for determining if the implementation of the changes do not require a license amendment pursuant to [10 CFR 40.44](#). An annual report will be prepared which describes any actions taken by the SERP including changes to operating procedures, the facility, or tests and experiments that involve safety or the environment

enacted since the previous report was issued. The report will also document the reason for each change, whether the change required a license amendment, and the basis for determination.

2.4 Audits and Inspections

RPEM Program Audit

The RPEM program content and implementation will be reviewed and audited by the RSO annually.⁵ The results of the audit will be described in the annual ALARA report (section [5.5](#))⁶.

Facility Inspection

The RSO or the RSO's designee will perform periodic visual inspections of the facility to verify that proper radiation protection practices are being implemented. Inspection frequency will be quarterly unless a more frequent period is identified in an SOP. Specific areas subject to evaluation will include areas where work is being performed under an open RWP, including areas of active reclamation. During the visual inspection, the RSO will generate a written record describing any required corrective actions, and the condition of fences, gates, and signs.

2.5 NRC Reporting

Routine Reports

Routine reports (section [5.0](#)) are submitted to NRC via email to the project manager and via hardcopy mail to Document Control and the NRC region IV office.

Abnormal Event Reports

Non-routine events that require NRC reporting are described in [10 CFR 20, Subpart M](#) and [10 CFR 40.60](#). The following events are potentially relevant to RAML activities:

Telephone reporting to NRC Operations Center (301) 816-5100 will occur:

- *Immediately* after loss or theft of licensed material ≥ 1000 times the limits in [10 CFR 20, Appendix C](#) (section [3.6](#)) when it appears that an exposure to persons in unrestricted areas could occur.⁷
- *Immediately* after any event involving byproduct or source material that may have caused or threatens to cause: (1) an individual to receive a total effective dose equivalent (TEDE) of 25 rem, an eye dose equivalent to lens of the eye (LDE) of 75 rem, a shallow dose equivalent (SDE) of 250 rad, or (2) the release of licensed material to a normally occupied area at a concentration that, had an individual been present for 24 hours, the person could have received an intake in excess of five annual limits of intake (ALI) (air concentration in excess of ~ 416 derived air concentrations (DACs) for 24 hours).⁸
- *Immediately* after the discovery of an event (such as a fire, explosion, earthquake, etc.) that prevents immediate protective actions necessary to avoid exposures to radiation, licensed material that could exceed regulatory limits, or releases of licensed material that could exceed regulatory limits.⁹
- *Within 24 hours* after loss of control of byproduct or source material that may have caused or threatens to cause: (1) an individual to receive a TEDE of 5 rem, an LDE of 15 rem, an SDE of 50 rad, or (2) the release of licensed material to a normally occupied area at a concentration that, had an individual been present for 24 hours, the person could have received an intake in excess of one ALI (air concentrations in excess of ~ 83 DAC for 24 hours).¹⁰

⁵ Annual review is required by [10 CFR 20.1101](#).

⁶ [10 CFR 20.2102\(a\)](#) requires that the licensee maintain records of the radiation protection program, including: (1) The provisions of the program; and (2) Audits and other reviews of program content and implementation.

⁷ [10 CFR 20.2201\(a\)\(i\)](#)

⁸ [10 CFR 20.2202\(a\)](#)

⁹ [10 CFR 40.60\(a\)](#)

¹⁰ [10 CFR 20.2202\(b\)](#)

- *Within 24 hours* after an unplanned contamination event that requires access restrictions to the contaminated area for more than 24 hours by imposing additional radiological controls or prohibiting entry and involves a quantity of material greater than five times the lowest ALI.¹¹
- *Within 24 hours* after an event that requires unplanned medical treatment at a medical facility of an individual with spreadable licensed contamination on such individual's clothing or body.¹²
- *Within 24 hours* after an unplanned fire or explosion damaging any licensed material or any device, container, or equipment containing licensed material when the quantity of material involved is greater than five times the lowest ALI and the damage affects the integrity of the licensed material or its container.¹³
- *Within 30 days* after becoming aware of loss or theft of licensed material ≥ 10 times the limits in [10 CFR 20, Appendix C](#) (section [3.6](#)) which is still missing at the time of the report.¹⁴

Telephone reports should include: (i) The caller's name and call back telephone number; (ii) A description of the event, including date and time; (iii) The exact location of the event; (iv) The isotopes, quantities, and chemical and physical form of the licensed material involved; and (v) Any available worker radiation exposure data.¹⁵

Written reports to the address above will occur:

- *Within 30 days* of making a required telephone report.¹⁶
- *Within 30 days* of occurrence of doses above the occupational dose limits ([Table 3](#)) or public dose limits or ALARA constraints for air emissions ([Table 6](#)).¹⁷
- *Within 30 days* of an occurrence of licensed material in an unrestricted area in excess of 10 times any applicable limit in the license or [10 CFR 20](#) (regardless of dose).¹⁸

Written reports to the NRC must be formatted to have a detachable portion protecting the identifying information of individuals who have received exposure. When any of the preceding reports involves exposure of an identified individual, RAML will also provide the individual a report of his or her exposure data no later than the date of transmittal to the NRC.¹⁹

2.6 Quality Assurance and Quality Control for Radiological Monitoring

To ensure that the RPEM program is providing reliable and accurate data, the following quality assurance and quality control requirements will be followed.

Definitions and Units

RAML adheres to the definitions in [10 CFR 20.1003](#). Units for radioactivity²⁰ will be in curies (Ci), exposure will be in Roentgens (R), dose will be in rad or rem, contamination will be in disintegrations per minute, and associated multiples and subdivisions, where:

- 1 curie = 3.7×10^{10} disintegrations per second = 3.7×10^{10} bequerel.
- 1 curie = 2.22×10^{12} disintegrations per minute.
- 1 rem = 0.01 sievert (1 millirem = 10 microsievert).

¹¹ [10 CFR 40.60\(b\)\(1\)](#)

¹² [10 CFR 40.60\(b\)\(3\)](#)

¹³ [10 CFR 40.60\(b\)\(4\)](#)

¹⁴ [10 CFR 20.2201\(a\)\(ii\)](#)

¹⁵ [10 CFR 40.60\(c\)](#)

¹⁶ See [10 CFR 20.2201\(b\)](#) and [10 CFR 40.60\(c\)](#) for details which must be included in written reports.

¹⁷ See [10 CFR 20.2203\(b\)](#) for required contents of reports.

¹⁸ [10 CFR 20.2203\(a\)](#)

¹⁹ [10 CFR 20.2205](#)

²⁰ [10 CFR 20.2101](#)

- Concentrations in environmental media will be reported in “per milliliter (mL⁻¹)” or “per liter (L⁻¹)” for air and in “per gram (g⁻¹)” for soil and sediment. Water will be reported in “per liter (L⁻¹)”.

Units will be clearly marked on required records. Values must be reported without substituting the term “not detected” or “< Lower Limit of Detection.” Quantities may be supplemented with international system (SI) units in parentheses.

Calibration of Radiation Detecting Equipment

Calibrations will occur annually²¹ or based on the equipment manufacturer’s recommendations, whichever is more frequent. Recalibration or replacement of equipment will also occur whenever equipment performance or integrity is suspect.

Function Checks

Radiation monitoring equipment will be function checked for response to site-specific background and check sources to verify that it is operating with adequate accuracy and stability over the range of its intended use. Additional detail regarding these checks is described in SOPs.

Data Quality for Radiological Monitoring

Representative samples are obtained by use of proper sampling equipment, proper locations of sampling points, and proper sampling procedures, consistent with guidance. Equipment and methods will be sensitive enough to detect constituents at the action levels for occupational and environmental monitoring ([Table 3](#) and [Table 6](#)). Uncertainty for radioactive constituents will be estimated and reported.

Results obtained from the monitoring and sampling programs will be reviewed and evaluated to determine their reasonableness and consistency with past results. Where appropriate, licenses, permits, workplans, and/or SOPs will establish control limits of samples requiring further assessment. If results of this review indicate discrepancies, further inquiry will be conducted and documented.

²¹ Periodic calibration is required by [10 CFR 20.1501](#).

3.0 Radiation Protection Program

The radiation protection program²² has been designed to limit radiation doses to ALARA levels during ongoing facility decommissioning activities. Specific procedures to perform radiation protection tasks are described in SOPs.

3.1 Occupational Dose Limits and Monitoring Thresholds

Occupational dose limits for individuals on-site for 6 or more days per year or who require unescorted access are presented in [Table 3](#); limits are consistent with applicable federal regulations.²³

Individuals who are on-site for fewer than 5 days per year or who are escorted at all times are considered members of the public. Public dose limits are provided separately in section [4.1](#).

The dose limits in [Table 3](#) are the basis for derived radiation protection standards, including derived DACs and annual limits of intake (ALIs) for radiation workers. DAC and ALI values presented in Table 1 of [10 CFR 20, Appendix B](#) are used to evaluate worker doses and to demonstrate compliance with the occupational dose limits.²⁴

[Table 3](#) provides applicable derived limits for the facility as well as administrative ALARA action levels that would cause RAML to increase monitoring, change radiation protection measures, or adjust reporting. Action levels are based on the monitoring thresholds in [10 CFR 20.1502](#) for anticipated exposure, the individual reporting requirements in [10 CFR 19.13](#), and guidance. When making monitoring decisions or calculating doses in the absence of isotopic data, RAML conservatively assumes any long-lived activity present in a sample is the most conservative radionuclide likely to be present and applies the most restrictive DAC or ALI for compliance calculations (most often, Th-230 solubility class W).

²² A radiation protection program is required by [10 CFR 20.1101](#).

²³ Occupational dose limits are specified in [10 CFR 20.1201](#), [10 CFR 20.1207](#), and [10 CFR 20.1208](#).

²⁴ [10 CFR 20.1201](#)

Table 3. Occupational radiation protection standards and ALARA action levels

Exposure Category	Definition	Occupational Standard ^{a,b,c}	ALARA Action Level	Action(s)
Total dose (sum of external and internal)	Total effective dose equivalent (TEDE) TEDE = DDE + CEDE	5 rem y ⁻¹	0.5 rem y ⁻¹	Evaluate worker's job duties, exposure controls (engineering and/or administrative), and occupational monitoring program
External dose	Deep dose equivalent (DDE)	5 rem y ⁻¹ in the absence of any internal exposure.	0.5 rem y ⁻¹	
Internal dose	Committed effective dose equivalent (CEDE)	5 rem y ⁻¹ stochastic in the absence of any external exposure	0.5 rem y ⁻¹	
Total organ dose (sum of external and internal)	Total organ dose equivalent (TODE) TODE = DDE + CDE	50 rem y ⁻¹	5 rem y ⁻¹	
Internal organ dose	Committed dose equivalent (CDE)	50 rem y ⁻¹ non-stochastic in the absence of any external exposure	5 rem y ⁻¹ non-stochastic in the absence of any external exposure	
Skin dose	Shallow dose equivalent (SDE) to skin of whole body	50 rem y ⁻¹	5 rem y ⁻¹	
Extremity dose	Shallow dose equivalent (SDE) to maximum extremity	50 rem y ⁻¹	5 rem y ⁻¹	
Eye dose	Eye dose equivalent to lens of the eye (LDE)	15 rem y ⁻¹	1.5 rem y ⁻¹	
Dose to embryo/fetus of declared pregnant worker ^d	Dose equivalent to the embryo/fetus during the entire pregnancy due to occupational exposure of a declared pregnant worker	0.5 rem during the entire pregnancy	0.1 rem per pregnancy	
Individual dose reporting	Requirements in 10 CFR 19.13(b)	0.1 rem y ⁻¹	N/A	
Soluble natural uranium	Concentration limited by 10 CFR 20.1201 and in Footnote 3 of 10 CFR 20, Appendix B.	10 mg week ⁻¹	2.5 mg week ⁻¹	Evaluate worker's job duties, exposure controls (engineering and/or administrative), and occupational monitoring program
Th-230 (Class W)	N/A	1 DAC (3E-12 μCi mL ⁻¹)	0.3 DAC	
Rn-222	Rn-222 with decay products above background (100% equilibrium)	1 DAC (3E-8 μCi mL ⁻¹)	1 DAC	
Personnel contamination surveys	N/A	Surface contamination criteria (Table 4)	10% of surface contamination criteria	Contact RSO for decontamination support

^a No employee under 18 years of age is allowed a dose or intake above 10% of the limits per [10 CFR 20.1207](#). RAML does not employ individuals under 18 years of age.

^b RAML does not participate in planned special exposures as described in [10 CFR 20.1206](#).

^c RAML reduces individual workers' annual dose limit by the sum of any other occupational doses received by the worker from any other employer in that year. Individual workers must report other occupational radiation exposures to the RSO.

^d Dose limits for the embryo/fetus are specified in [10 CFR 20.1208](#). Monitoring is required in accordance with [10 CFR 20.1502](#) for declared pregnant workers likely to be exposed to licensed material resulting in a total effective dose equivalent to the embryo/fetus of 0.1 rem during the pregnancy.

3.2 Training

All individuals will receive radiation safety training that is commensurate with the potential radiological hazard(s) expected during their time at the facility. Training will be performed in person or remotely as described below.

Visitor Training

All individuals, other than delivery personnel on-site less than 20 hours per year, will receive a generic facility induction training before touring the facility. Induction training will include discussion of radiation safety, the ALARA principle, and the conditions of the facility. In addition to induction training, radiation safety awareness training is required for individuals who will be on-site for 5 or more days per year or who require unescorted site access.

Radiation Safety Awareness Training

Individuals who will be on-site for 5 or more days per year or who require unescorted access will receive radiation safety awareness training. Individuals will be trained prior to their first on-site work and at least annually thereafter. A written test will be given, and the questions and answers will be reviewed to ensure understanding. Topics addressed in the initial training will consist of the following at a minimum, consistent with guidance:

- Fundamentals of health protection.
- Personal hygiene at uranium recovery facilities.
- Facility-provided protection.
- Health protection measures.
- Radiation protection regulations.
- Radiation levels at the facility.
- Emergency procedures.
- In addition to the above topics, annual refresher training will include:
 - relevant information that has become available during the past year,
 - a review of safety issues that have arisen during the year,
 - changes in regulations and license conditions,
 - exposure trends, and
 - other current topics.

Training sign-in sheets and completed written tests, or an electronic version of these documents for remote trainings, will be maintained as a record of radiation safety awareness training.

Declared Pregnant Worker Training

Individuals receive information regarding working with radiation during a pregnancy as part of their initial and/or annual radiation safety awareness training. [Regulatory Guide 8.13](#) will be made available upon request, and the RSO or designee will offer to review the material with the worker and/or answer questions.

Department of Transportation Shipper Training

Any individual preparing or offering shipments of hazardous material will be trained according to the requirements of [49 CFR 172.704](#), as applicable.

Standard Operating Procedure Training

Workers will be trained to complete work under applicable SOPs. SOP training will consist of reading the applicable SOP individually, time for questions/discussion with a worker or supervisor who has previously been trained to the SOP and signing the SOP signature sheet. The record of SOP training will be the SOP signature sheet.

3.3 Radiological Surveys

The RSO will ensure that radiological surveys are performed according to SOPs to adequately evaluate the magnitude and extent of radiation levels, concentrations, or quantities of residual radioactivity, as well as the potential radiological hazards at the facility.²⁵ These surveys and any necessary corrective actions will be documented as described in section 5.

Adequate housekeeping will be maintained at the site trailer and other clean work areas to ensure control of radioactive contamination.

External Radiation Surveys

RAML conducted a comprehensive gamma survey of the facility in 2016 and produced a map of gamma exposure rates based on a manufacturer-recommended conversion of 1 µR hr⁻¹ from Ra-226 per 900 counts per minute for the detection system. Except for areas where tailings-derived wastes are stored prior to disposal, changes in gamma exposure rates will not occur unless reclamation occurs, in which case they will be lowered.

Therefore, RAML does not perform routine exposure rate surveys except for within- or near- tailings-derived waste storage area(s). When tailings-derived wastes are stored on-site prior to disposal, such waste storage areas will be routinely surveyed as described in SOPs.

Unrestricted Release Surveys

RPEM program staff will survey equipment and/or packages for release from the restricted areas as described in SOPs and consistent with license requirements.

[Table 4](#) provides RAML’s release limits for surface contamination, which follow the dose-based guidance in ANSI/HPS N13.12-2013 *Surface and Volume Radioactivity Standards for Clearance*. The primary criterion of this standard is to limit total effective dose to 0.001 rem y⁻¹ to any member of the public for unrestricted release of materials from regulatory control.

The RSO may elect to "hold for decay" materials and equipment that are suspected to be contaminated by the short-lived decay products of Rn-222. The effective half-life of Rn-222 decay products after removal of the source is approximately 30 minutes. Items suspected to be contaminated by the short-lived decay products of Rn-222 will be held for a minimum of eight times the effective half-life (4 hours total) prior to resurveying for unrestricted release.

Table 4. Surface contamination criteria

Radionuclides of Interest	Surface Contamination Criterion
Group 1: high energy gamma, radium, thorium and associated decay products (Pb-210, Ra-226, Ra-228, Th-228, Th-230, Th-232)	600 dpm 100cm ⁻²
Group 2 ^a : uranium and selected beta-gamma emitters	6,000 dpm 100cm ⁻²

^a The uranium criterion will be changed from group 2 to group 1 if decay-chain products are present (i.e., group 2 criterion only applies to separated uranium in the form of yellowcake). Natural uranium activity equals the activity from uranium isotopes (48.9% from U-238, 48.9% from U-234, 2.2% from U-235).

²⁵ [10 CFR 20.1501](#)

3.4 Occupational Monitoring

Occupational monitoring will continue at least until reclamation activities are complete. The monitoring schedule and frequency are listed in section 5. This program includes external monitoring (dosimeters and/or instrument measurements), personnel contamination surveys (frisking), and air monitoring, as appropriate.

To the extent practicable, RAML will use process or engineering controls to limit the concentration of licensed material in air.²⁶ When it is not practical to apply process or engineering controls, the RSO will use the ALARA principle to determine whether to proceed with the activity by controlling access and limiting exposure times.²⁷ RAML does not maintain a respiratory protection program and will not rely on respiratory protection to limit doses.

Occupational Dosimetry and Individual Dose Reporting

RAML calculates occupational doses and issues workers [NRC Form 5](#) consistent with the requirements of [10 CFR 19.13\(b\)](#)²⁸, [10 CFR Part 20, Subpart C](#), and [10 CFR 20.2106](#).

External Dosimeters

RAML issues external dosimeters to all workers who are on-site 6 or more days per year or who require unescorted access. Dosimeters are exchanged on a quarterly basis. All occupational dosimeters are processed and evaluated by a dosimetry processor holding current personnel dosimetry accreditation from the National Voluntary Laboratory Accreditation Program of the National Institute of Standards and Technology, and who is approved in this accreditation process for the type of radiation monitored.²⁹

Personnel Contamination Surveys

Personnel contamination surveys are described in SOPs and are performed by site workers and visitors to ensure that exposures are ALARA and prevent the removal of contamination from restricted areas. Individuals that enter areas potentially containing licensed material are required to perform self-scans before leaving the job site and are encouraged to perform self-scans at any time they suspect potential contamination. A personnel contamination survey instrument and appropriate forms will be available at all times for self-scanning. Any questions regarding the proper use of the survey instrument should be directed to the RSO.

Occupational Air Monitoring

RAML does not perform routine occupational air monitoring because internal doses from airborne radionuclides are less than the action levels in [Table 3](#). When occupational air monitoring is deemed necessary by the RSO, sampling will follow SOPs and the monitoring program will be described in an RWP.

Bioassay Program

RAML does not have a bioassay program. Bioassay as part of an occupational internal dosimetry program is not required when internal doses due to exposure to licensed material are less than 10% of the applicable limits ([Table 3](#)). Additionally, exposure to soluble uranium is unlikely during decommissioning as uranium-containing products were removed from the facility during its operational period.

3.5 Radiation Work Permit Program

RAML will use a RWP to control non-routine work activities for which no SOP exists. RAML describes most non-routine work in work plans, which will be reviewed by the RSO or the RSO's designee to evaluate the radiation hazard for each proposed job task and to evaluate whether an RWP is necessary.

²⁶ [10 CFR 20.1701](#)

²⁷ [10 CFR 20.1702](#)

²⁸ [10 CFR 19.13\(b\)](#) requires that the licensee provide an annual report of dose to each monitored individual with an occupational dose exceeding 0.1 rem y⁻¹ or upon the monitored individual's request.

²⁹ [10 CFR 20.1501](#)

RWPs will establish specific radiation controls, provide a process to manage any radiological risks from licensed material, and limit radiation doses to ALARA levels. RWPs will describe the following at a minimum, consistent with the license:

- Scope of work to be performed.
- Any precautions necessary to reduce exposure to licensed material.
- Any supplemental monitoring that will be required prior to, during, or after the completion of the work.

RWPs will be issued by the RSO or the RSO's designee and will be forwarded to the work crew. The work supervisor will review the work plan and RWP requirements with workers prior to beginning work to ensure workers understand the potential hazards and the protective measures to be followed.

All workers will sign a RWP training form indicating that they have read and understood the requirements of the RWP. The supervisor will coordinate the job with the RSO to ensure that required monitoring is conducted and appropriate personal protective equipment is made available.

Should workers encounter unsafe conditions not anticipated in the RWP, work will be immediately suspended, and the job will be re-evaluated. All workers have the authority and responsibility to stop work if they observe unsafe conditions.

The RSO or the RSO's designee will inform the supervisor and workers working under the RWP of any monitoring results that require a change in work practices or controls. RWPs may be revised and approved by the RSO or the RSO's designee if changes are required. Workers will be informed of any changes and will be required to sign or initial their reading and understanding of such changes.

RAML maintains original copies of each RWP.

3.6 Radiological Posting and Labeling

Posting

Consistent with the license, RAML posts entrances to the controlled area ([Figure 2](#)) with conspicuous signs bearing the radiation symbol and the warning: "Any area within this mill may contain radioactive material". RAML will post radiological areas other than the controlled area consistent with the requirements of [10 CFR 20.1902](#).

Labeling

When required, RAML will ensure that containers of licensed material bear a durable, clearly visible label bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL" or "DANGER, RADIOACTIVE MATERIAL." The label will also provide the following information³⁰:

- Radionuclides present,
- Estimate of quantity of radioactivity,
- Date for which activity is estimated,
- Radiation levels, and
- Kinds of materials.

Before removal of empty uncontaminated containers to unrestricted areas, RAML will remove or deface any label or otherwise clearly indicate that the container no longer contains licensed material.³¹

Some containers do not require labelling,³² including:

³⁰ [10 CFR 20.1904](#)

³¹ [10 CFR 20.1904](#)

³² [10 CFR 20.1905](#)

- Containers that do not exceed specified quantities ([10 CFR 20, Appendix C](#)) or concentrations ([10 CFR 20, Appendix B, Table 3](#)). [Table 5](#) lists examples relevant to the facility,
- Containers attended by an individual who takes the precautions necessary to prevent the exposure of individuals in excess of the applicable limits, and/or
- Containers when they are in transport and packaged and labeled in accordance with the regulations of the United States Department of Transportation.

When determining whether a container requires labelling, RAML will use a sum of fractions calculation will be utilized for media with known concentration ratios; otherwise, the most restrictive value for Th-230 will be assumed.

Table 5. Radionuclide quantities and concentrations requiring labeling

Radionuclide	Quantity Requiring Labeling	Concentration Requiring Labeling	Examples
Natural uranium	100 μCi	$3\text{E-}6 \mu\text{Ci mL}^{-1}$	None
Th-230	0.001 μCi	$1\text{E-}6 \mu\text{Ci mL}^{-1}$	7,000 g soil at 15 pCi g^{-1} 700 g tailings at 150 pCi g^{-1}
Ra-226	0.1 μCi	$6\text{E-}7 \mu\text{Ci mL}^{-1}$	2,500 g soil at 40 pCi g^{-1} 250 g tailings at 400 pCi g^{-1}

3.7 Site Security

Site access will be controlled using fencing and locked gates. RAML no longer maintains a site security officer on-site pursuant to a letter from the NRC dated December 20, 2017 ([ML17293A342](#)) that concurred with RAML's notification eliminating this position ([ML16238A193](#)). Licensed material must be secure at all times behind a locked door/gate or under a person's supervision.³³

3.8 Waste Management - Byproduct Material

The management of byproduct material waste at the facility is described in SOPs. When disposal activities are ongoing, RAML maintains a procedure to describe its compliance with the waste disposal requirements of [10 CFR 20, Subpart K](#).

³³ [10 CFR 20, Subpart I](#)

4.0 Environmental Monitoring Program

The purposes of the environmental monitoring program are to (1) demonstrate compliance with public radiation dose limits³⁴ and license requirements, and (2) ensure doses from licensed material are ALARA. Environmental monitoring tasks are described within SOPs.

Because most licensed material has been consolidated and covered in accordance with NRC-approved plans, and because existing data demonstrate that radionuclide concentrations in environmental media are low, RAML has discontinued most of the components of its environmental monitoring program. Future licensed activities that have a potential for environmental release of licensed material will be controlled via an RWP, which will describe any environmental monitoring requirements associated with the licensed activity.

4.1 Public Dose Limits and Monitoring Thresholds

[Table 6](#) defines the environmental limits and action levels pertaining to members of the public which would cause RAML to increase monitoring or change radiation protection measures. RAML does not use effluent concentrations to demonstrate compliance with public dose limits.

Table 6. Public dose limits and ALARA action levels

Type of Exposure	Limit	ALARA Action Level	Action
Maximum public TEDE from air emissions, excluding Rn-222 and its decay products ^a	0.01 rem y ⁻¹	Any reclamation activities involving soil disturbance that extend for a period of longer than 30 days	Initiate air particulate monitoring program
Maximum public TEDE, all pathways, above background ^b	0.1 rem y ⁻¹	0.01 rem y ⁻¹	Review and potentially adjust environmental monitoring
Ambient dose rate in any unrestricted area from licensed material ^b	0.002 rem h ⁻¹	0.0002 rem h ⁻¹	Engineering controls

^a [10 CFR 20.1101](#)

^b [10 CFR 20.1301](#)

4.2 Airborne Particulates

Airborne particulate monitoring was discontinued effective December 31, 2017 pursuant to a letter from the NRC dated December 20, 2017 ([ML17293A342](#)) that concurred with RAML's request to eliminate this component of the monitoring program ([ML16242A149](#)). If RAML anticipates an activity will generate particulate concentrations that may exceed the action levels in [Table 6](#), the RWP for the activity will contain a requirement to perform airborne environmental monitoring and describe the location(s) at which monitoring will be performed.

4.3 Radon-222

Radon track etch detector data are collected at the seven environmental air sampling stations shown on [Figure 2](#). The detectors are passive monitors provided by an outside vendor that measure concentrations of Rn-222. The detectors are exchanged quarterly and returned to the contract vendor for analysis. The results are submitted to the NRC in RAML's semiannual effluent reports.

³⁴ [10 CFR 20.1302](#)

4.4 Groundwater

The license describes required groundwater monitoring and reporting, including required frequency and analytical suite for routine sample collection from certain groundwater monitoring wells to ensure compliance with groundwater protection standards (GPS) or alternate concentration limits (ACL) that are specific to the water-bearing unit from which the groundwater sample was collected.

5.0 Records

5.1 Schedule of Programs

[Table 7](#) provides a schedule of RPEM program components which generate records.³⁵ Further detail on several of these reports is also provided below.

Table 7 Schedule of programs and recordkeeping

RPEM Section	Program	Frequency	Record
2.3	SOP review	Annual	SOP binder with signed and dated procedures
2.5	RSO facility inspections	Defined in SOP	RSO inspection form; external exposure surveys of waste storage area(s)
2.7	Instrument calibration	Annual or as required by equipment manufacturer recommendations	Calibration records
2.7	Instrument function checks	Range for new/newly calibrated instrument; daily for in-service instruments	Function check range forms; function check log forms
3.2	Radiation safety awareness training	As needed for new workers based on work scope and duration on-site; annual refresher for all other trained workers on-site	Training sign-in sheet; graded exams
3.2	Department of Transportation training	As needed	Training certificate(s)
3.2	SOP training	As needed based on work scope	SOP signature page
3.3	External radiation surveys	As needed or required by RWP	Exposure rate survey form
3.3	Unrestricted release surveys	As needed or required by RWP	Radiation survey release forms
3.4	Occupational dosimetry	Internal dosimetry: <ul style="list-style-type: none"> as needed or required by RWP External dosimetry: <ul style="list-style-type: none"> Quarterly for workers on-site 5 or more days per year or who require unescorted access; As needed for visitors on-site for less than 5 days per year and who will be escorted while on-site 	Determinations of current year prior occupational dose ^a ; occupational dose record (NRC Form 5); external dosimeter lab reports
3.4	Personnel contamination surveys	Daily for on-site activities in controlled areas	Personnel contamination survey log

³⁵ Records of the radiation protection program are required by [10 CFR 20.2102](#).

RPEM Section	Program	Frequency	Record
3.4	Occupational air monitoring	As needed or required by RWP	Occupational air sampling form; working level measurements for Rn-222
3.5	Radiation work permits	As needed	RWP; RWP training form; monitoring results associated with the RWP
4.1	Public dosimetry	Annual	ALARA report
5.2	Effluent reporting	Semiannual	Semiannual effluent report
5.3	Groundwater reporting	Semiannual; quarterly	Semiannual groundwater report; quarterly groundwater report
5.5	ALARA reporting	Annual	ALARA report

^a Determinations of prior occupational dose are limited to the current calendar year and will be made, at the discretion of the RSO, for new workers who have potential radiation exposure from another workplace. Lifetime dose history will not be requested as RAML workers do not participate in planned special exposures.

5.2 Semiannual Effluent Report

The RSO will compile all environmental monitoring data required by the license, except for groundwater data, collected within the previous six months and generate a report to be submitted to the NRC, site principal, and site manager. Reporting will be consistent with the requirements of the license. RAML will maintain records sufficient to demonstrate compliance with the dose limit for individual members of the public (section [4.1](#)).³⁶

5.3 Semiannual Groundwater Report

Groundwater reports associated with licensed activities encompassing the previous six months will be compiled to generate a report to be submitted to the NRC, site principal, and site manager. Reporting will be consistent with the license.

5.4 Quarterly Groundwater Report

If monthly monitoring is being performed due to an exceedance of the associated groundwater protection standard or ACL, quarterly groundwater reports documenting the sampling results for those specific constituents will be submitted to the NRC. Quarterly groundwater reports will not be submitted after the second and fourth quarters of each year because the information will be submitted in the more comprehensive semiannual groundwater reports that are described in section [5.3](#).

5.5 Annual ALARA Reports

The RSO will prepare an annual report summarizing RPEM program activities for the previous calendar year. This annual ALARA report will summarize occupational monitoring results and discuss trends in data and any corrective actions. The report will also evaluate whether proper radiation protection practices are being implemented and may contain ALARA recommendations. A component of this report will be an internal audit of the RPEM program to verify that all aspects of the program comply with the license (section [2.5](#)). The ALARA report is provided to the site principal and site manager.

³⁶ [10 CFR 20.2107](#)

5.6 Record Retention

Records will be maintained in accordance with federal regulations³⁷ and the license.

³⁷ Record retention requirements are specified in [10 CFR 20.1501](#), [10 CFR 20, Subpart L](#), [10 CFR 40.36\(f\)](#), and [10 CFR 40 Appendix A Criterion 6\(4\)](#).

6.0 Figures

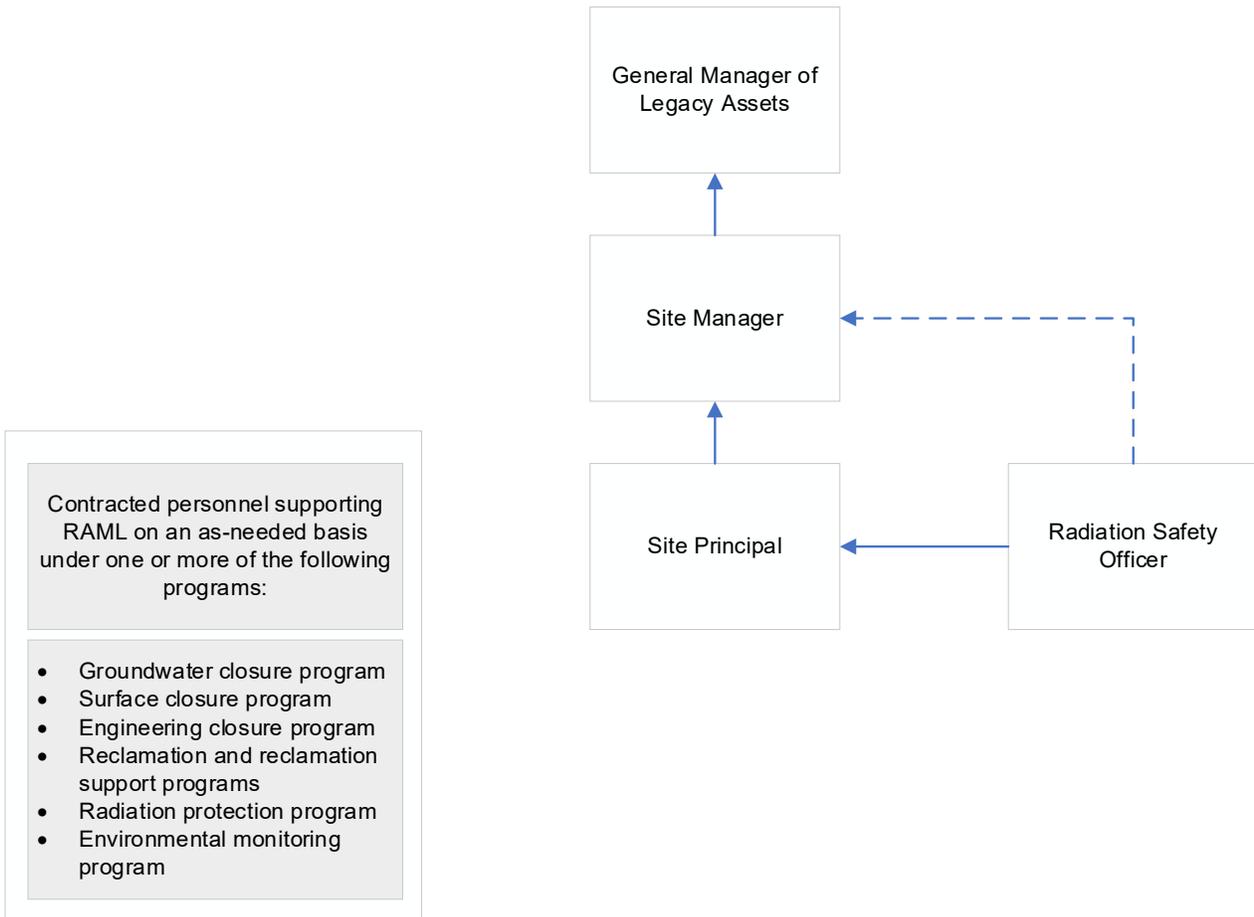
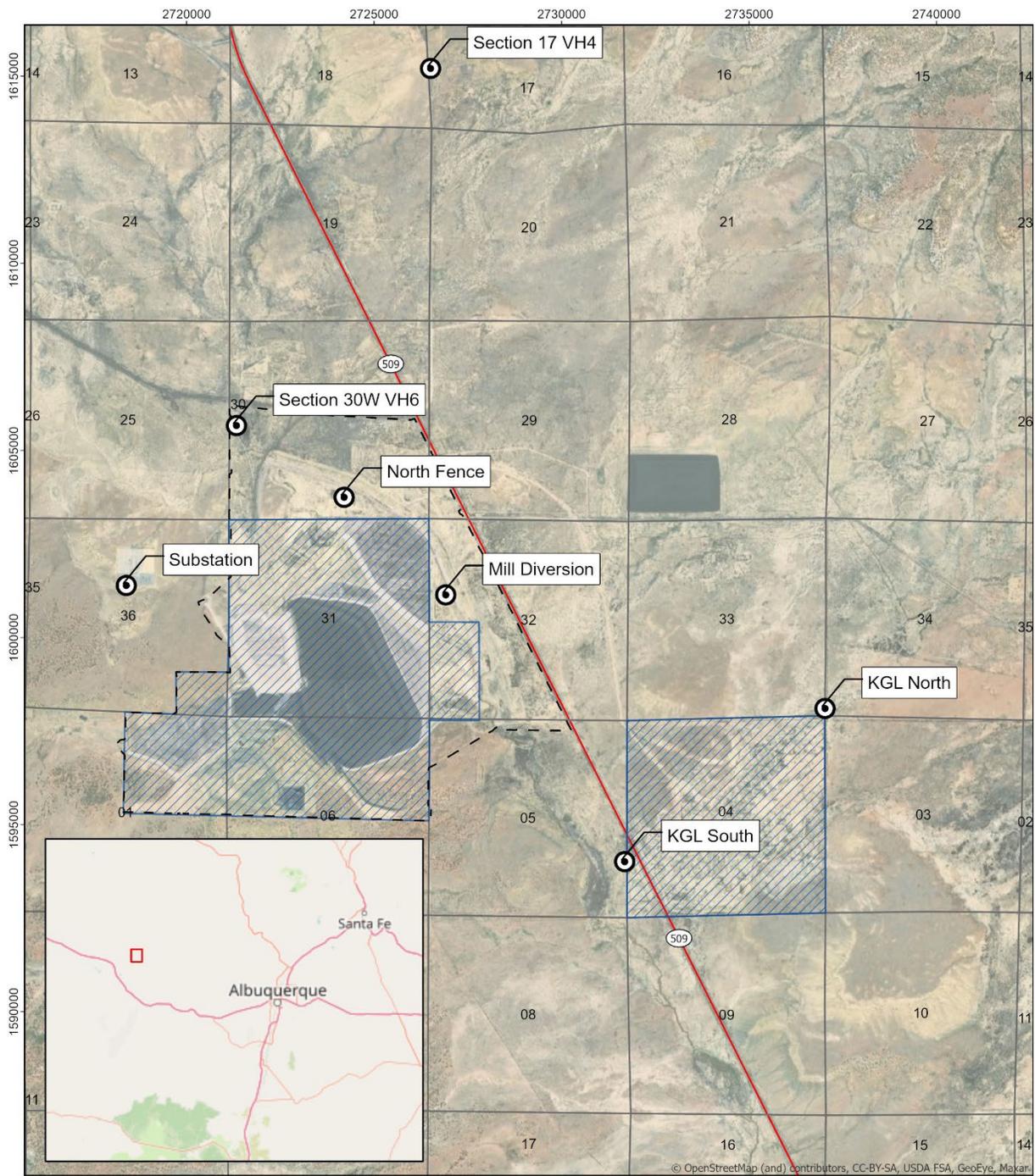


Figure 1. RAML organizational structure.



<p>Legend</p> <ul style="list-style-type: none"> Radon-222 monitoring location Controlled area (September 2020) Restricted area (1986 license) Section line State highway 		 Miles Author: jess.joyce - Date: 3/22/2021
<p>Map Coordinate System: NAD 1983 StatePlane New Mexico West FIPS 3003 Feet</p> <p>Document Path: P:\GIS\Rio Algom\Ambrosia Lake\Projects\Environmental Monitoring.aprx</p>		

Figure 2. Radon-222 monitoring locations at the facility. If needed, the controlled area may be updated in RAML’s annual land use report.