ATTACHMENT 2

Radiation Protection Program Manual

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Radiation Protection Program Manual

Homestake Grants Reclamation Project

Cibola County, New Mexico

Revision 3

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APPROVALS

This Radiation Protection Program (RPP) for decommissioning and remediation operations at the Homestake Grants Reclamation Project has been reviewed and approved by the following:

Name	Title	Date
_____	Site Closure Manager	_____
_____	Radiation Safety Officer	_____

Changes to this RPP must be reviewed and approved by the above management personnel. A controlled hard copy of this RPP Manual will be maintained onsite by the Radiation Safety Officer (RSO) and Radiation Safety Technician (RST).

Revision History

Revision #	Date
0	03-01-18
1	03-21-18
2	10-26-18
3	06-03-19

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1. INTRODUCTION

Uranium milling occurred between 1958 and 1990 at the Homestake Mining Company of California's (HMC) Grants millsite (Site). The facility, located approximately 5 miles north of Milan, New Mexico, currently functions as a site decommissioning and environmental reclamation project under Radioactive Materials License SUA-1471 with the U.S. Nuclear Regulatory Commission (NRC). Former milling facility buildings (e.g. crusher, ore bins, grind/leach, separation and yellowcake drying and packaging) have been demolished and disposed onsite in accordance with the approved Decommissioning and Reclamation Plan (AKG and Jenkins, 1993a and 1993b).

Remaining structures include two engineered uranium mill tailings impoundments including the Large Tailings Pile (LTP) and Small Tailings Pile (STP), three lined evaporation ponds (EP1, EP2, and EP3), two lined wastewater collection ponds (East Collection Pond and West Collection Pond), a Reverse Osmosis (RO) water treatment plant, two lined zeolite water treatment facilities (on top of the LTP), shop/maintenance and administration buildings (Figure 1), and hundreds of groundwater extraction, injection, and water quality monitoring wells and associated piping infrastructure across the Site.

Containing an estimated 21 million tons of mill tailings, the LTP covers an area of about 200 acres. The STP contains approximately 1.2 million tons of mill tailings in a 40-acre impoundment with a lined evaporation pond (EP1) constructed on top. As was standard practice for the uranium industry in the late 1950's, the tailings impoundments were unlined and seepage from the two piles has since resulted in contamination of shallow underlying groundwater aquifers.

The LTP side slopes have been fully reclaimed with a radon barrier, freeze/thaw protective soil layer, and rock erosion protection. The top surface has an interim soil cover and the lined zeolite treatment systems on its top surface. The STP has been partially reclaimed with interim soil cover on the side slopes and top as well as the lined EP1 on its surface. Portions of the STP are still used for burial of Byproduct material wastes from reclamation activities. Spray misters are used on the evaporation ponds seasonally to increase evaporation of stored waters.

The objective of this Radiation Protection Plan (RPP) Manual is to provide a cohesive and detailed description of the methods and procedures used to manage, control, monitor and limit occupational and public exposures to ionizing radiation from licensed radioactive materials associated with the tailings piles and ongoing remediation of impacted groundwater. Although most terrestrial sources of licensed material have been disposed in tailings impoundments that are capped with interim and/or final cover, there are still residual sources to which workers and the public could potentially become exposed.

2. NECESSITY AND OBJECTIVES

2.1 Radiological Exposures

The primary radioactive elements at the Site include natural uranium (U-nat), radium-226 (Ra-226), thorium-230 (Th-230), and radon-222 (Rn-222) gas with its short-lived decay products. These radionuclides, as well as several stable and potentially toxic heavy metals, are found in uranium mill tailings and residual solids (sludge/evaporites) in evaporation and collection ponds. Because the tailings

and former mill processing buildings and infrastructure are isolated from the active surface environment (buried), and since most soil contamination has been cleaned up and disposed with tailings, potential radiation exposure pathways are limited to the following:

- Accidental ingestion of dissolved radionuclides in process water contained in evaporation or collection ponds or the Zeolite water treatment facilities.
- Accidental ingestion of radionuclides in tailings or contaminated drill cuttings brought to the surface. Includes potential offsite transport of associated contamination on personnel or equipment.

Figure 1: General Site layout and features of routine operational areas at the HMC Grants Site.

- Inhalation of long-lived radionuclides in airborne particulates released from dried evaporative salts or exposed sludge from the ponds, or from liquid aerosols released by turbo misters used to accelerate

evaporation of Site process water. This pathway includes potential offsite transport of associated contamination on personnel or equipment.

- Inhalation of short-lived radon decay products (radon progeny) in air associated with the escape of radon gas from the covered tailings piles, or from release of radon gas incidental to the water treatment process in the RO Plant.
- Exposure to external (direct) gamma radiation from buried tailings with relatively thin amounts of interim cover soil, or from radioactive sludge contained in the collection or evaporation ponds. Figure 2 shows the spatial distribution of gamma exposure rates in routine work areas as measured in December of 2017.

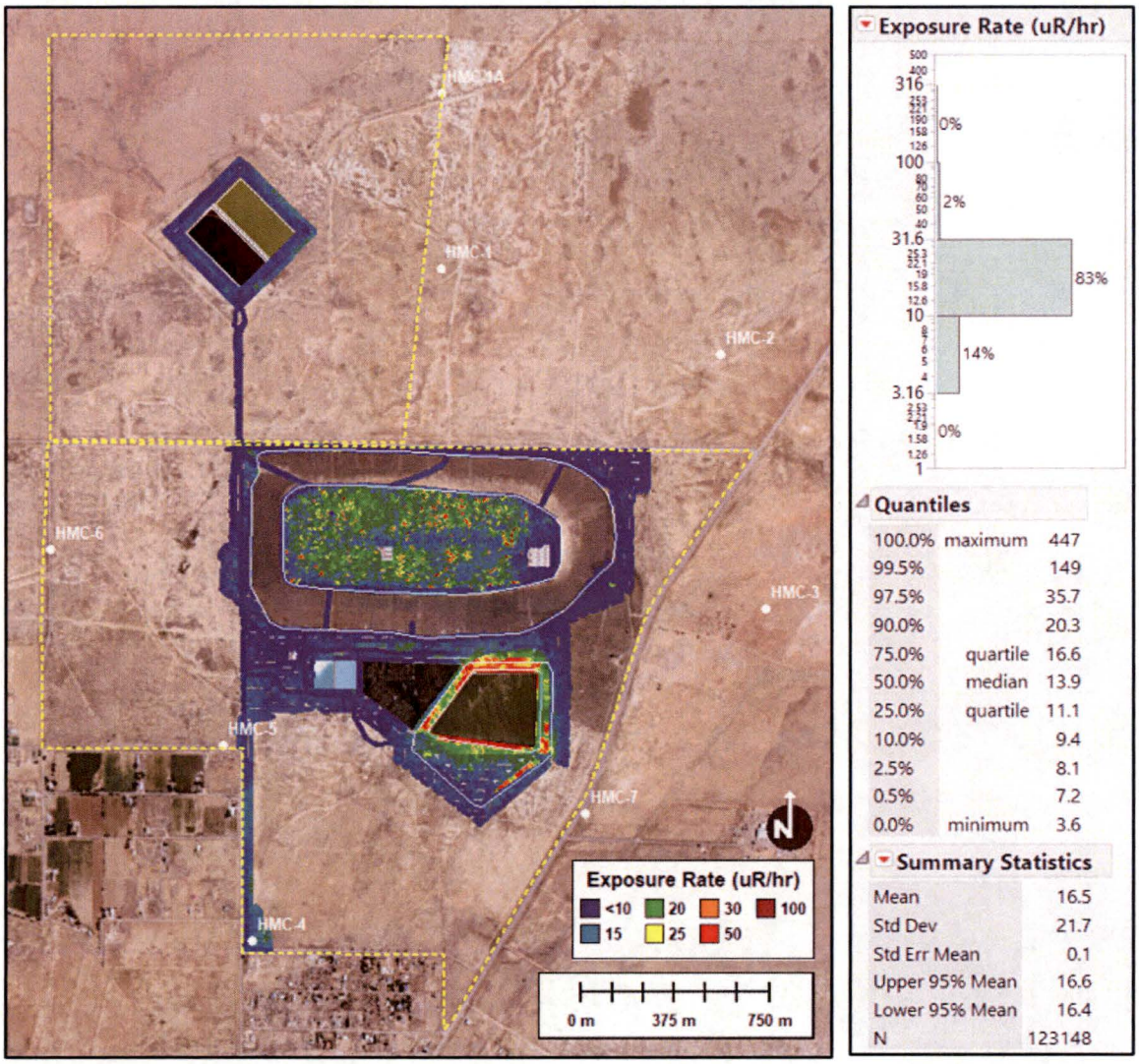

Figure 2: Measured gamma exposure rates across routine operational areas at the Site, December 2017.

2.2 Radiation Dose

Based on occupational and environmental monitoring data, the potential for radiation doses to workers

or the public from Site operations is low. The maximum annual external dose measured for any worker over the past 5 years was 23 mrem[1]. Annual external dose is generally below the reported detection limit of 1 mrem, and this trend is expected to continue under routine operational conditions. This contribution is within the variability in background levels.

With respect to internal doses, occupational air monitoring for internal exposures to long-lived airborne radionuclides via the inhalation pathway was discontinued in 2010 based on several years of high-volume air sampling data collected on top of the LTP that showed concentrations of long-lived radionuclides in airborne particulates consistent with background levels. In 2017, the NRC requested that HMC conduct an occupational radiation exposure monitoring study to characterize the potential for occupational doses to workers under current operational circumstances and conditions. The resulting data (ERG, 2018; see Appendix B) confirmed that there is not a reasonable likelihood of any worker exceeding the 500 mrem/yr threshold that requires occupational monitoring for radiological exposures as specified in 10 CFR 20.1502. However, this study also concluded that occupational monitoring is still appropriate for certain non-routine operational activities at the discretion of the RSO (e.g. under a RWP) as a higher potential for radiological exposures is still possible for activities involving potential contact with tailings, pond sludge, or waste streams from RO water treatment.

With respect to intakes of soluble uranium and associated toxicity concerns, bioassay results are typically below the 5 µg/L analytical detection limit for uranium. Results rarely show uranium levels above the detection limit, and it is exceedingly rare that a sample result has approached or exceeded any action level (e.g. 15 µg/L). In such cases, an actual intake has never been confirmed by follow-up investigations, which included additional bioassay sampling (i.e. lab error or sample contamination have generally been determined to be the most likely explanation).

2.3 Regulatory Requirements

A RPP is required for all NRC licensees by 10 CFR 20.1101 and 10 CFR 20.2102. Environmental monitoring for effluents and respective estimation and reporting of public exposure is required by 10 CFR 40.65 using limits and methods specified in 10 CFR 20.1301 and 20.1302 respectively. Annual measurements of average radon flux from the LTP and STP are required by LC 36(E). Occupational radiation exposure monitoring is currently conducted at the discretion of the RSO (see Table 4, Section 4.4.2) to ensure exposures of workers are being maintained ALARA in accordance with the guidance provided in NRC Regulatory Guide 8.31. Routine monitoring is no longer necessary as both recent and historic monitoring data over a number of years indicates that exposures are well below the regulatory threshold that requires individual monitoring per 10 CFR 20.1502 specifications (generally 10% of any limit, e.g. < 500 mrem/yr). A supporting report for an occupational exposure monitoring study directed by the RSO in 2018 (ERG, 2018) is provided in Appendix B.

[1] As measured with optically stimulated luminescent (OSL) dosimeters from Landauer.

2.4 ALARA Policy

As stated in 10 CFR 20.1101(b),"*The licensee shall use, to the extent practicable, procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA).*" An overarching objective of this RPP is to keep radiological doses and effluent releases ALARA. HMC company policy requires an independent ALARA Audit of the RPP annually in accordance with Section 2.3.3 of Regulatory Guide 8.31. Accordingly, the following company policy statement applies:

"HMC will maintain radiation exposures, and releases of radioactive materials in effluents to unrestricted areas, as low as is reasonably achievable considering the state of technology, and the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to the utilization of atomic energy in the public interest."

In addition, NRC Regulatory Guide 8.31, Section 2.3.2, specifies monthly ALARA evaluations and summary reports. Monthly ALARA evaluations of the status of the RPP are documented and reported to the Closure Manager, and as indicated above, an independent 3rd party ALARA Audit of the RPP is conducted annually with results reported to NRC.

3. MANAGEMENT AND ADMINISTRATION

3.1 Organizational Structure and Responsibilities

- **License Holder**

  Homestake Mining Company of California. Ensures that the necessary resources are available to support the RPP in compliance with license conditions and applicable regulations, supports general safety culture, ALARA policy, and recommendations of the Site Closure Manager with respect to radiation protection requirements.

- **Site Closure Manager**

  Reports directly to Barrick Management. Ensures that the necessary human resources and equipment are in place to support an effective RPP in compliance with license conditions and applicable regulations, supports general safety culture, ALARA policy, and serves as a member of any Safety and Environmental Review Panel (SERP) evaluations.

- **Radiation Safety Officer (RSO)**

  Reports directly to the Closure Manager. Responsible for RPP design and oversight including development of RPP elements and procedures, performs instrument selections, reviews RPP data, audits program records, performs dose calculations, develops and provides radiation safety training, reviews/approves corrective action plans, and modifies the RPP and associated SOPs as needed to keep radiological exposures ALARA. Reviews Field Level Risk Assessments (FLRAs) as needed to determine any special radiation protection procedures, or if a Radiation Work Permit (RWP) is

required, reviews/approves the RWP. Develops and submits required reports to applicable regulatory agencies and serves as a member of any SERP evaluations.

- **Alternate RSO (ARSO)**

  Reports directly to the RSO. Responsible for performing monthly ALARA audits and providing supplemental technical support to the RSO for management and onsite implementation of the RPP, and for acting on behalf of the RSO when the RSO is temporarily unavailable for time-sensitive decision making on radiation protection matters. This authority may include determination of the need for a RWP for a given Site activity, and review and approval of RWPs or other documentation that requires sign-off by the RSO.

- **Radiation Safety Technician (RST)**

  Reports to the RSO on all RPP matters, along with the Site Closure Manager where appropriate. Onsite management and implementation of the RPP including administration of personnel dosimetry and bioassay sampling programs, performs workplace surveys and occupational/environmental air monitoring, collects samples from groundwater wells and air monitoring equipment, inspects and maintains effluent control and waste management systems, enforces worker compliance with RPP procedures, ensures proper records keeping and instrument calibrations and maintenance. In addition, the RST evaluates potential exposure circumstances associated with non-routine work activities, and describes the scope of the work in FLRAs (where applicable) and to the RSO to obtain direction regarding the need for any special radiological controls, ranging from personnel and equipment contamination surveys, to issuance of a RWP with additional monitoring for potential worker exposures to radioactive materials.

- **Site Workers**

  Reports radiation safety issues or concerns to the RST, RSO or Closure Manager. Workers that could receive doses > 100 mrem/yr from occupational sources of radiation are considered "radiation workers" by the NRC. While worker doses are generally not expected to exceed 100 mrem/yr, all workers performing work in controlled or restricted areas are responsible for adhering to requirements of the RPP and associated SOPs.

3.2 Qualifications and Training

3.2.1 RPP Staff Qualifications

In general, qualifications for radiation protection staff are based on regulatory guidance found in NRC Regulatory Guide 8.31. However, since the HMC Grants Site is not an operational uranium mill, qualifications for the RST position (as described below) have been modified to be commensurate with the radiological hazards that are present at the Site. The minimum qualifications and training required for radiation protection staff and Site workers (including contractors) will be as follows:

- **Radiation Safety Officer (RSO)**

  A minimum of a 4-year degree in physical sciences, health physics, engineering or industrial hygiene with an accredited university, or an equivalent combination of training and relevant radiation

protection experience at uranium recovery (UR) facilities. Two years of relevant experience can be considered equivalent to 1 year of academic study. At least 1 year of work experience with applied health physics at a UR facility or similar industrial setting (this experience must include working with radiation measurement equipment, not strictly administrative or "desk" work).

In addition, the RSO must have at least 40 hours of specialized academic training in health physics as applicable to UR facilities, and attend RSO refresher training every 2 years. The RSO must have a thorough working knowledge of applicable health physics principles and equipment used in the facility, the procedures used for radiological sampling and monitoring, methods used to calculate doses from radiological exposures, and a thorough understanding of sources of ionizing radiation at the Site as well as applicable regulations.

- **Alternate RSO (ARSO)**

  Minimum of a 4-year degree in physical sciences, health physics, engineering or industrial hygiene with an accredited university, or an equivalent combination of training and relevant radiation protection experience at uranium recovery (UR) facilities. Two years of relevant experience can be considered equivalent to 1 year of academic study. At least 1 year of work experience with applied health physics at a UR facility or similar industrial setting (this experience must include working with radiation measurement equipment, not strictly administrative or "desk" work). The ARSO must have a thorough working knowledge of this RPP Manual and associated SOPs, along with an understanding of onsite sources of radiation, basic radiation protection regulations and applicable license conditions.

- **Radiation Safety Technician (RST)**

  The preferred credential for the RST position is a 2-year (associates) degree in physical sciences, engineering or a health-related field with an accredited university or community college, though a high school diploma is acceptable provided that the individual has received at least 40 hours of relevant training in basic radiation science, radiation protection principles and applicable regulations and at least two weeks of on-the-job training with respect to RST duties. The RST must demonstrate sufficient working knowledge of health physics principles and proficiency in the operation of radiological instruments used at the facility, surveying and sampling techniques, and associated records keeping requirements.

  Previous applied experience with the principles and implementation of RPPs at facilities with a radioactive materials license may be substituted for the above qualifications at the discretion of the RSO. Experience with uranium recovery facilities is preferred. The RST must acquire a thorough working knowledge of all elements of this RPP Manual and associated SOPs. The RST must also attend annual radiation protection refresher training given to all employees by the RSO.[2]

[2] Note that staff that work exclusively in the main office and do not access Controlled Areas of the site are not required to receive annual radiation safety training.

- **Site Workers**

  All workers (including contractors) that require access to Controlled Areas beyond the administration building (i.e. not including purely administrative staff or visitors confined to the administrative office) must at minimum watch the prepared video briefing on general radiation safety topics and Site-specific radiation protection practices, and must have the ability to understand and adhere to technical aspects of the RPP and associated SOPs, as well as sufficient knowledge, skills and abilities to perform assigned duties and responsibilities associated with the worker's role at the Site. All regular (full time) Site employees (except purely administrative staff) will receive at least 2 hours of radiation safety refresher training annually, including an exam (this training will be given by the RSO and documentation will be retained by HMC for at least 5 years).

3.2.2 Radiation Safety Training

All new employees and contractors (not including purely administrative staff) will review a radiation safety awareness video (with exam) and will receive specific instruction from the RST for operational activities that require worker awareness and/or participation in elements of the RPP. On an annual basis, all regular Site personnel that work in areas of the Site other than the Administrative building will receive at least 2 hours of refresher radiation protection training regarding the following general topics:

- Site-specific radiological hazards.
- Basic radiological science concepts (physics, units, etc.).
- Health effects of radiation exposure.
- Principles of radiation protection (justification, optimization and limitation).
- Regulatory jurisdictions and radiation protection requirements (e.g. NRC, EPA, NMED, dose limits, personnel/equipment release limits, effluent limits, spill reporting, etc.).
- RPP elements including worker exposure/dose monitoring, rad safety work rules, contamination control, instrument use, and accident and emergency response.
- Recent RPP performance including occupational exposures, accidents or unplanned releases of radioactive materials, identified Program or procedural deficiencies, corrective actions, and special radiation protection precautions based on current data and circumstances.
- Responsibilities and authorities of the pertinent regulatory agencies (NRC, EPA and NMED).
- Rights and responsibilities of workers as described in 10 CFR 19.

4. RADIATION PROTECTION CONTROLS AND MONITORING

4.1 Engineering Controls

4.1.1 Physical Controls on Access

Routine operations associated with the HMC Grants Reclamation Project generally occur in areas where radioactive byproduct materials are isolated from the environment with long-term or permanent engineering controls on containment. Two basic areas have been defined with respect to controls on access to the Site: 1) a Controlled Area of about 1,500 acres as depicted in Figure 1, and 2) small, temporary "Restricted Areas" as needed for any Site activity where the RSO determines that the potential

for radiologically significant contamination and/or worker exposures is sufficient to warrant special radiological controls (e.g. dosimetry, air monitoring, bioassay, and personnel/equipment release surveys). Controlled and Restricted Areas at the Site are defined as follows:

Controlled Area (CA): An area where signage and/or physical barriers (e.g. fencing) discourage or prevent unauthorized access to HMC property for any reason, including trespass, theft, vandalism, exposure to physical or radiological hazards, etc.

Restricted Area: An area where access is restricted to secure licensed radioactive material from unauthorized access, exposure, use or possession. Access to restricted areas requires specific training on radiological hazards and appropriate controls as determined by the RSO, including at minimum contamination surveys for all personnel, vehicles and equipment when exiting such areas.

4.1.2 Security of Licensed Radioactive Materials

To the extent possible, all radioactive waste materials associated with past milling (e.g. tailings) or current groundwater treatment (residual solids from water treatment and non-compliant extracted groundwater) will be maintained in engineered repositories within the Controlled Areas depicted in Figure 1. Most radioactive waste materials are contained within the LTP and STP, within enclosed piping or tanks, or in lined ponds. Releases of small amounts of waste material beyond these containment systems are possible (e.g. pipe breaks/leaks, radon flux from the tailings piles, and overspray from turbo misters on EP1). In the case of radioactive check sources for instrument quality control (QC) measurements, these sources are kept in a secured safe or locked drawer when not in use by authorized personnel (the RST or RSO). An inventory of all check sources is maintained, and inspections are performed at least annually. Annual leak or removable activity tests are also performed on all check sources used for instrument QC measurements.

4.2 Administrative Controls

In addition to the engineering controls described above, administrative controls will be used to help ensure that radiation protection is optimized in accordance with ALARA principles. In some cases, both types of controls are utilized as described below.

4.2.1 Administrative Controls on Access

- **Controlled Areas**

  In addition to physical barriers (fences), administrative controls will be used to restrict access to Controlled Areas (Figure 1). Controlled Area fences will be posted near main access points (gates) with "Caution Radioactive Materials" signs, and "No Trespassing" or similar signs may also be posted.[3]

[3] Per 10 CFR 20.1902 (Posting requirements), the licensee must post each area in which the quantity of licensed material that is stored or used exceeds 10 times the applicable quantities specified in appendix C to part 20 with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIOACTIVE MATERIAL(S)" or "DANGER, RADIOACTIVE MATERIAL(S)." Controlled Areas at the Site meet the criteria requiring such posting, and posting near primary access gates must be "conspicuous" and appropriate to meet this requirement.

Only authorized and trained Site personnel are permitted within Controlled Areas without escort by authorized personnel. Temporary contractors and Site visitors are required to log personal information (name, organization, date) along with Site arrival and departure times on a sign-in sheet maintained at the entrance to the Administrative Building. Egress from Controlled Areas does not require contamination release surveys for personnel and equipment as most radioactive materials are isolated from the active surface environment by engineering controls (i.e. the potential for contamination during routine operations is essentially absent).

- **Restricted Areas**

  Restricted Areas are areas that require administrative controls, and possibly additional radiological monitoring, to limit and quantify potential exposure to radioactive materials due to non-routine activities. Restricted Areas are delineated and enforced by the RST at the direction of the RSO. The boundaries of Restricted Areas may be marked with stanchions and rope/caution tape, pilons, or by other means. When physical demarcation of the Restricted Area is not practicable, these boundaries shall be verbally communicated to workers and enforced by the RST. Restricted Areas represent areas with temporary controls on access until the work in question has been completed (afterwards, access will no longer be restricted provided that radiological surveys revealed no contamination of equipment or personnel, and exposure levels in the area do not exceed any action level).[4]

4.2.2 Regulatory and Administrative Limits

Administrative limits are a means of ensuring compliance with the ALARA policy to keep radiological exposures/doses, contamination and effluent releases as low below regulatory limits as is reasonably achievable. Typically, administrative limits are set at 10% of the regulatory limit. A summary of regulatory and administrative limits is provided in Table 1.

[4] Temporary Restricted Areas are justified by the fact that the vast majority of radioactive materials at the Site are isolated from the active surface environment and are generally not subject to potential human exposures.

Table 1: Summary of Regulatory and Administrative radiological control limits.

Category	Parameter	Regulatory Limit	Administrative Limit
Limits on Occupational Exposure Levels	External Gamma Radiation	5 mrem/hour @ 30 cm [1]	1,000 µR/hr
	Airborne Particulate Radionuclides	DAC: [2, 3] U-nat: 2E-11 µCi/mL Th-230: 3E-12 µCi/mL Ra-226: 3E-10 µCi/mL	10% of DAC: U-nat: 2E-12 µCi/mL Th-230: 3E-13 µCi/mL Ra-226: 3E-11 µCi/mL
	Airborne Radon	30 pCi/L [4]	8.1 pCi/L [5]
Occupational Dose Limits	Total Effective Dose Equivalent (TEDE)	5,000 mrem/yr	500 mrem/yr (10% of regulatory limit)
Public Dose Limits	TEDE	100 mrem/yr	100 mrem/yr [6]
Environmental Effluent Limits	External Gamma Radiation	50 mrem/yr [7]	5 mrem/yr (10% of regulatory limit)
	Airborne Particulate Radionuclides	Effluent Conc.: [2, 7, 8] U-nat: 9E-14 µCi/mL Th-230: 2E-14 µCi/mL Ra-226: 9E-13 µCi/mL	10% of Effluent Conc.: U-nat: 9E-15 µCi/mL Th-230: 2E-15 µCi/mL Ra-226: 9E-14 µCi/mL
	Airborne Radon	1.3 pCi/L above background [9]	1 pCi/L above background [10]
Contamination Limits	Personnel	5,000 dpm/100 cm^2 [11] 1,000 dpm/100 cm^2 [12]	Background
	Equipment & Work Areas	5,000 dpm/100 cm^2 [11] 1,000 dpm/100 cm^2 [12]	200 dpm/100 cm^2, 25 µR/hr [13]

[1] Higher dose rates require "Radiation Area" posting (10 CFR 20.1003).

[2] Most restrictive DAC or Effluent Limit by solubility class is assumed applicable.

[3] Applicable only for continuous annual occupational exposure (2,000 hrs/yr).

[4] Assuming an equilibrium fraction of 1 (unity).

[5] IAEA recommended action level (equivalent to 300 Bq/ m^3) to limit public dose to 100 mrem/yr.

[6] Due to a recognized non-representative background radon location (low bias), 10% of the regulatory limit is not a reasonably achievable administrative limit.

[7] Considered a "limit" only if compliance with public dose limits is demonstrated based on the method specified in 10 CFR 20.1302 (2).

[8] Assumed to result in 50 mrem/yr public dose.

[9] Assuming an equilibrium fraction of 20%, and 75% occupancy.

[10] Assuming an equilibrium fraction of 20%, and 100% occupancy (an admin. limit of 10% of the regulatory limit is impractical and unlikely to be measurable above variability in background).

[11] Fixed plus removable gross alpha (or beta) activity above background (NRC Reg Guide 8.30).

[12] Removable gross alpha (or beta) surface activity above background (NRC Reg Guide 8.30).

[13] Removable gross alpha (or beta) surface activity and gamma radiation above background (SOP 12).

4.2.3 Radiation Safety Work Rules

All workers and visitors will be instructed in the importance of adherence to the below radiation safety work rules. These work rules will be enforced by the RST, RSO and Site Closure Manager.

1. Personal Hygiene – all personnel must wash hands before eating or drinking in the designated lunch room or offsite after leaving Restricted Areas.
2. Workspace Organization and Cleanliness – all personnel are required to keep work areas clean and well organized, particularly in Controlled Areas where radioactive materials may be present.
3. Eating, Drinking and Tobacco Use – eating and tobacco use are prohibited within Controlled or Restricted Areas, except in designated locations (e.g. eating is permitted in the lunch room, but only after washing hands). Drinking of water or non-alcoholic beverages in Controlled Areas is allowed to prevent dehydration, but care must be taken to use only single-use containers (i.e. commercial bottled water in plastic bottles with a screw-type lid) to help avoid soiling of containers and accidental ingestion of trace amounts of contaminated material.
4. Personal Protective Equipment – standard personal protective equipment (PPE) is specified in Policy Guidance Document (PGD) 14 in the HMC Manual of Standard Practices and in individual SOPS, as appropriate. Disposable latex-type gloves will be worn when working with environmental samples, chemicals, transferring solutions or Zeolite media, or in any other circumstance involving the handling of materials with potential for radiological contamination.
5. Dosimeter Usage – As may be required by RWPs or at the discretion of the RSO for tasks that could involve external exposure rates > 1000 μR/hr (See Table 3). External doses to workers may be measured with optically stimulated luminescent (OSL) dosimeters or similar integrating dosimeters (e.g. "pocket" ionization chambers or digital solid-state dosimeters) or estimated based on measured exposure rates and occupancy times at the discretion of the RSO. The RSO is responsible for tracking external doses for workers, but it is the responsibility of workers to wear assigned dosimeters and report any badge loss to the RST and/or RSO.
6. Bioassay Sampling – Bioassay (urinalysis) sampling is required as part of the pre-employment process for all regular HMC employees that will work in Controlled Areas (entry bioassay), and again at termination of employment at the Site (exit bioassay).[5] Additionally, bioassay sampling may be required by RWPs or otherwise at the discretion of the RSO based on potential for intake (e.g. physically handling or working with tailings or solid residues from the evaporation ponds, a reasonable probability of average airborne uranium concentrations exceeding 10 % of the DAC, or if surface contamination is detected on the face of a worker). Additional detail on the bioassay program is provided in Section 4.4.2.3.

[5] It is recognized that gaining cooperation of terminated employees to give an exit bioassay sample may not be possible. Entry/exit bioassay may also be required by the RSO for contractors hired to perform short-term work in Restricted Areas under a RWP.

7. Breathing Zone Air Monitoring – at the discretion of the RSO, breathing zone (BZ) air monitoring with lapel-type samplers will be required for select workers, primarily those engaged in projects with significant potential for exposure to airborne particulate radionuclides under a RWP. Applicable procedures are given in SOP 11 as developed based on the recommendations provided in NRC Regulatory Guide 8.25, Sections 3 and 5.

8. Authorized Access to Controlled or Restricted Areas – only Site management and authorized and trained workers are allowed unescorted access to Controlled or Restricted Areas. Contractors who have received the training described in Section 3.2.2 are permitted unescorted access to Controlled and Restricted areas.

9. Personnel and Equipment Release Surveys – all personnel must perform exit contamination surveys before leaving Restricted Areas, and no equipment, vehicles or materials may be released from these areas unless radiological surveys (conducted by the RST) verify compliance with release limits for contamination associated with uranium decay series radionuclides (see Table 1).[6]

10. Decontamination – any detected contamination on personnel, equipment, vehicles or designated "clean area" workspaces shall be decontaminated in accordance with SOP 12 provisions.

11. Reporting of Potential Radiological Hazards – Site personnel must report activities suspected of having the potential for significant exposure to radioactive materials (e.g. tailings, solid or liquid water treatment residuals) to the RST. This information will be incorporated into the Field Level Risk Assessment (FLRA) for the activity (see SOP 2), and the RSO will review the FLRA for a determination of the need for any special radiological controls that may be needed (e.g. under a RWP). All personnel have the authority to stop any work activity if radiological hazards are identified that have not already been identified and evaluated by the RSO and/or RST.

12. Reporting of Accidents and Equipment Malfunctions – all accidents, equipment malfunctions or failure to follow procedures that has (or may have) resulted in unplanned radiological exposures or releases of radioactive materials to the environment must be reported to the RSO immediately.

4.2.4 Standard Operating Procedures for Radiation Protection

Radiation protection staff and workers (where applicable) will follow approved standard operating procedures (SOPs) for radiation protection under this RPP Manual. A current listing of respective SOP titles is given in Table 2, and these SOPs are included in Appendix A to this RPP Manual.

[6] Note that there are some potentially contaminated Site materials and used equipment that are currently stored in "boneyards" located within Controlled Areas (e.g. piping, pumps, etc.). The planned disposition or future use of these materials has not been established at this time. If these materials are to be released from the Site for unrestricted future use, they will need to be surveyed for radiological surface contamination to verify compliance with release limits (Table 1), even though they are not located in "Restricted Areas" as defined in this RPP.

Table 2: Standard Operating Procedure (SOP) numbers and titles for implementation of this RPP Manual.

SOP No.	SOP Title (and historic procedure No.)	Current Revision No.	Revision Date
SOP 2	Procedure for Conducting a Field Level Risk Assessment (FLRA)	2	11-14-2018
SOP 11	Radiological Air Monitoring for Occupational Exposures (HP-1)	2	11-14-2018
SOP 12	Radiological Contamination Surveys (HP-2)	16	06-03-2019
SOP 13	Calculation of Radiation Doses to Personnel (HP-3)	12	11-26-2018
SOP 14	Bioassay Sample Collection (HP-8)	15	01-14-2019
SOP 16	Instrument Test and Calibration Procedure (HP-10)	12	11-26-2018
SOP 18	Procedure for Implementing a Radiation Work Permit (HP-16)	9	11-26-2018
SOP 20	Environmental Monitoring Except Groundwater (EM-2)	17	11-26-2018
SOP 21	Spill Response and Reporting Procedure (EM-4)	3	11-26-2018
SOP 22	On-Site Disposal of Radiologically-Impacted Waste	1	11-26-2018
SOP 23	Evaporation Pond Operations	1	03-11-2019

4.2.5 Radiation Work Permits

At the discretion of the RSO, a Radiation Work Permit (RWP) will be issued for all work or nonroutine maintenance jobs where the potential for significant exposure to radioactive material exists and for which no standard written procedure already exists. RWPs will be approved by the RSO (or ARSO) and shall describe, at a minimum, the following:

- The scope of work to be performed.
- A summary description of the RSO's evaluation and determination that a RWP is needed.
- Any precautions necessary to reduce exposure to uranium and it progeny.
- Radiological monitoring and sampling that is necessary prior, during and following completion of the work.

Examples may include spill mitigation and equipment repair, non-routine maintenance, manual transfer of sludge or contaminated drill cuttings from tailings or contaminated areas to evaporation ponds, etc. The RSO will determine the need for a RWP and what radiological controls are appropriate as described in SOP-18, *Procedure for Implementing a Radiation Work Permit.*

4.2.6 Tracking of Radioactive Materials and Sources of Radiation

Up-to-date records will be maintained of all known check sources, both in storage and those routinely used for instrument calibrations or QC function checks. All check sources will be kept in a locked safe, or in locked drawers under the control of the RST. Leak tests will be conducted annually on all routinely used check sources, or for any stored source before being brought into use. Radioactive waste materials at the Site (e.g. tailings buried in the impoundments, pond sludge or evaporative salts, contaminated drill cuttings, etc.) will not be tracked or inventoried as their presence is generally known and approximate volumes and total activities can be estimated. However, all potentially contaminated waste materials disposed in the waste disposal trenches on the STP must be characterized in accordance with SOP 22 (e.g. dates, descriptions, photos and representative contamination surveys) and documented to help inform the final cover design.

4.2.7 Inspections and Audits

Periodic inspections and audits associated with the RPP will be conducted to ensure compliance with the specifications of this RPP Manual, applicable license conditions, and all applicable regulations. These administrative controls are used to identify deficiencies, develop corrective actions, and determine any necessary modifications to this RPP Manual and associated SOPs to ensure continued compliance with all regulatory requirements and to further improve overall radiation safety performance. Proper implementation of individual RPP elements requires continual inspection by the RST, and the RSO must be notified of any deviations or problems. ALARA Audits are conducted monthly by the RSO (or ARSO), and annually by a qualified independent contractor in accordance with Regulatory Guide 8.31 Sections 2.3.2 and 2.3.3 respectively. Summary findings of inspections/audits and any recommendations will be documented along with any corrective actions. The NRC also inspects elements of the RPP, typically on an annual or semiannual basis.

4.3 Contamination Control

Contamination control will be achieved by 1) following Radiation Safety Work Rules (Section 4.2.3), 2) regularly inspecting and performing maintenance on operating equipment to ensure proper function, 3) routine surveys of the surfaces of structures, equipment and personnel with radiation detection instruments, 4) use of proper decontamination procedures, and 5) records keeping and data analysis to identify trends and develop corrective actions as needed to keep contamination ALARA. Details of these elements of the Contamination Control Program are provided in the following Sub-Sections and in SOP 12, *Radiological Contamination Surveys and Decontamination*.

4.3.1 Inspection and Maintenance of Operational Equipment

Operational equipment and process systems (e.g. groundwater pumps, piping, RO equipment and pond operations) that could result in an unplanned release of liquids or solids containing radioactive byproduct material are visually inspected by the RST during routine operational activities, as specified in specific SOPs, and as otherwise directed by the Site Closure Manager. For example, inspection of evaporation pond operations is performed/documented on a daily schedule in accordance with SOP 23. Maintenance occurs at regularly scheduled intervals and as necessitated by any performance issues, including unplanned release/contamination events. These inspections are intended to ensure that systems are sufficiently maintained and operated to minimize the potential for unplanned release of licensed materials and to identify corrective actions as needed to ensure compliance with all regulatory requirements and to further improve the control and containment of liquids/solids that may contain radioactive constituents. These inspections and any recommendations are documented along with any follow-up modifications to the SOPs and/or implementation of any corrective actions.

4.3.2 Workplace Contamination Surveys

NRC regulations provide no specific limit on surface contamination levels in restricted work areas (NRC Regulatory Guide 8.30, Rev. 1, Section 2.5). NRC staff considers surface contamination levels of 10^{-3} $\mu Ci/cm^2$ acceptable to meet the ALARA concept in UR facilities, which equates to a gross alpha or beta

activity of 220,000 dpm/100 cm^2. Homestake procedures specify 200 dpm/100 cm^2 as the administrative limit for surface contamination in work areas (see SOP 12). Monthly routine workspace surveys will be conducted in office and administrative areas (lunchroom and sample preparation clean room), and routinely occupied work areas in the reverse osmosis (RO) plant. Results will be documented in accordance SOP 12 specifications.

4.3.3 Equipment Release Surveys

Like work area contamination surveys, surveys performed to release equipment and vehicles from Restricted Areas will be generally be conducted with a dual channel alpha/beta radiation detector (Section 4.3.6). Methods to be used will be consistent with SOP 12 specifications based on the recommendations provided in Regulatory Guide 8.30, Section 2.7. The regulatory and administrative limits given in Table 1 will be used to qualify any equipment or vehicles for release from Restricted Areas. Routine surveys of vehicles or equipment leaving the Controlled Areas of the Site need not be conducted unless the RSO has determined that a Restricted Area designation is appropriate for a given work task.

4.3.4 Personnel Exit Surveys

Exit surveys for personnel leaving the Restricted Area will be made with a zinc sulfide alpha scintillation instrument (Section 4.3.6) in accordance with SOP 12 specifications following the recommendations of Regulatory Guide 8.30, Section 2.6. Personnel working in a Restricted Area under a RWP are to scan their clothing, exposed skin, and shoes upon leaving the Area and document results on the Personnel Contamination Survey Form (EDF-15). Although NRC standards for releasing personnel with contamination on skin or clothing are the same as for equipment release surveys (Table 1), the administrative limit for personnel exit surveys will be set at values consistent with normal background levels (i.e. no measurable contamination). In this case, the administrative limit will be treated as a primary clearance criterion. In cases where this criterion cannot be met, the regulatory limit (Table 1) will be applied as a secondary standard since associated doses would be very low.

4.3.5 Decontamination

Contamination of structures, equipment or personnel in excess of applicable limits as specified in the preceding Sections will require decontamination in accordance with the decontamination procedures outlined in SOP 12 (Section 7). Decontamination procedures for personnel will generally consist of brushing off visible accumulations of dirt/mud, and if needed to meet the release criterion, washing the affected areas with water and/or mild soap as appropriate at the boundary of the Restricted Area. For equipment and vehicles, a special decontamination area, likely to be located near one of the water towers, will include a pressure washer and coarse gravel to "plate" the decontamination pad and contain wash-down water and residues prior to cleanup and transfer to the radiological waste disposal trench area on the STP. Secondary containment of the decontamination pad will be provided, and decontamination residues may periodically require maintenance cleaning prior to final decommissioning of the pad (when closure of the STP with the final radon barrier placement is eminent).

4.3.6 Contamination Survey Instruments and Applications

Surface contamination surveys will be conducted by the RST with a dual channel alpha/beta scintillation instrument pairing (Figure 3) to permit detection of alpha and/or beta radioactivity on the surfaces of work areas, equipment and personnel.[7] If significant contamination is present, the count rate indicated by the ratemeter will become elevated while scanning close to the surface across the affected area, and a static, 1-minute scaler count will be performed in accordance with SOP 12 to evaluate surface activity relative to applicable release limits (Table 1).

Figure 3: Ludlum 43-93 alpha/beta detector with Model 2360 ratemeter and scaler.

If detected, surface contamination will be cleaned (decontaminated) in accordance with SOP 12, Section 7 and follow-up measurements will be made for comparison against applicable release limits, and "swipe" samples may be taken to test for removable contamination with special absorbent pads that are subsequently measured in a special counting tray with an alpha/beta counter (Figure 4).[8] Designated eating/drinking or "clean areas" inside of the Admin Building will be surveyed monthly (see Section 4.3.2) for fixed and removable surface contamination and must meet applicable surface activity limits (Table 1).

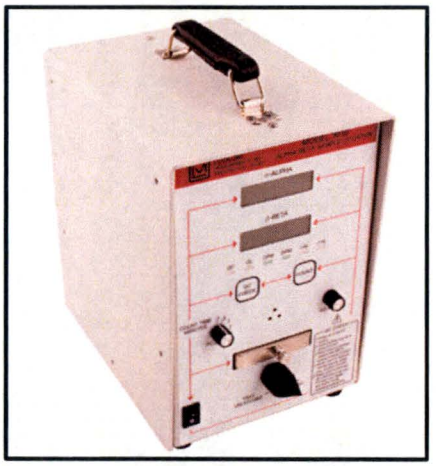

Figure 4: Ludlum Model 3030 sample counter with internal alpha/beta detectors and sample holder chamber.

Exit surveys for personnel leaving Restricted Areas will be performed with the same alpha/beta scintillation instrument used for other contamination surveys (Figure 3) in accordance with SOP 12, Section 6 and personnel will be trained accordingly. A target release criterion representing the maximum background reading for each specific instrument will be determined by the RST and specified on the exit survey form to be filled out by all personnel leaving Restricted Areas.

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[7] All instrument types and models described in this RPP are based on instrumentation commonly used at uranium recovery facilities in the U.S. Actual instrument manufacturers and models selected for use at the Grants Reclamation Project may vary but will be functionally equivalent to the instruments indicated in this RPP. The instruments and procedures specified in the previous revision of SOP 12 (Revision 12) are still acceptable, but Revision 13 of SOP 12, as provided in Appendix A of this Manual, has been revised to accommodate new alpha/beta scanning instruments that will be acquired by HMC to improve detection sensitivity and to simplify contamination survey procedures.

[8] Note that swipe testing is not necessary if scanning shows that fixed + removable activity is below the removable (only) limit. However, swipe samples must always be taken for major equipment to be released for unrestricted future use.

4.3.7 Response to Accidental Spills or Releases

When a significant spill and/or unauthorized discharge is discovered, the need for an emergency response "SWIMS" process as outlined below and as described in the ***Emergency Response Procedure*** (SOP-1) must be determined quickly and executed without delay when warranted. The degree of urgency in spill response and the nature of health and safety precautions required depend on the type of hazardous material, volume of material released, and circumstances that could present immediately hazardous exposure conditions. Spills of highly hazardous chemicals (e.g. acids, caustic, etc.) shall always be treated with SWIMS protocols:

Stop the leak
Warn others
Isolate the area
Minimize exposure
Standby for help to arrive

In general, leaks or spills of radiologically impacted groundwater are unlikely to warrant SWIMS measures as described above for emergency response situations. However, all unplanned groundwater releases shall at minimum be stopped, contained, documented and reported to the Closure Manager and/or RSO. In addition, immediate due diligence actions as described in HMC's ***Accident / Incident Reporting Policy*** (PDG-5) shall also be followed. Further details of the procedures for response and documentation/reporting of spills, leaks or other unplanned releases of radioactive or other hazardous materials are provided in SOP 21 (Spill Response and Reporting).

4.4 Limitation of Radiological Dose

Individual occupational radiation exposure monitoring is required under the conditions specified in 10 CFR 20.1502. Recent and historical occupational exposure data has consistently indicated the conditions requiring individual monitoring as defined in 10 CFR 20.1502 are not met at the HMC Site. A supporting report for an occupational exposure monitoring study directed by the RSO in 2018 (ERG, 2018) is provided in Appendix B. Accordingly, as described elsewhere in this manual, use of personnel dosimeters (OSLs), air sampling for uranium and/or progeny and requirements for bioassay (urinalysis) will be based at the discretion of the RSO on specific conditions or circumstances that warrant radiological controls (e.g. RWPs, tasks may involve external exposure rates ≥ 1000 μR/hr, air concentrations ≥ 10 % of the applicable DAC, or detection of contamination on the face).

In the event that a pregnant female worker is asked to participate in any activity determined by the RSO to warrant radiological exposure monitoring, the worker has a right to declare her pregnancy and receive appropriate radiological monitoring for the remaining duration of the gestation period. This notification must be made in writing to the Closure Manager whom will in turn notify the RSO. The dose limit to the fetus is 500 mrem for the duration of the pregnancy, equivalent to 50 mrem/month. In this circumstance, the declared pregnant worker will be issued two dosimeter badges, one to be worn as normal and the other to be worn at waist level near the position of the fetus. Both badges will be analyzed on a monthly basis. At the discretion of the RSO or by request, the worker will also be issued a BZ air sampler for the

duration of the work activities in question. The RSO will estimate dose to the fetus based on the resulting radiological monitoring data.

4.4.1 Regulatory and Administrative Dose Limits

Regulatory and Administrative Dose Limits are summarized in Table 1. A detailed accounting of NRC regulatory dose limits for uranium recovery facilities is given in Table 3.[9] These limits are further discussed in SOP 13 (Calculation of Radiation Doses to Personnel).

4.4.2 Occupational Dose Monitoring

Individual occupational exposure monitoring and assessment will be performed for all HMC employees and contractors working on the HMC Grants site under (1) a RWP approved by the RSO that requires use of individual dosimetry, breathing zone sampling or bioassay, or (2) for any other reason at the discretion of the RSO. The components of the Occupational Monitoring Program are shown in Table 4. For contractors, consultants, and other vendors who are expected to perform routine work within Controlled Areas of the Site (Figure 1), completion of the site's radiation training video, ALARA training, and Hazards Briefing Form are required. Once completed, an OSL dosimeter badge will be issued where applicable as described above.

4.4.2.1 Dosimetry Monitoring

All HMC employees and contractors working on the HMC Grants site will be issued OSL dosimeters if required under the conditions specified in Section 4.4.2 above. Employees and vendors who provide services to the Site, but only do so (or are only expected to do so) within the administrative areas (e.g. the main office) do not require dosimetry. For each task or project requiring dosimetry, OSL badges are returned to the manufacturer on a quarterly basis for analysis and reporting. The net accumulated deep dose equivalent (DDE), calculated as the issued badge DDE minus the control badge DDE, is documented to represent external occupational dose.

Personnel OSL dosimeters, when required by the RSO, will be exchanged and evaluated in accordance with SOP 13, *Procedure for Calculating Radiation Doses to Personnel.* Currently, there are no occupationally exposed locations within Controlled Areas with gamma exposure rates in excess of 500 µR/h (Figure 2). In the event that gamma radiation readings in any future work area exceed 1,000 µR/h, this will automatically trigger dosimetry for all exposed personnel.[10] Pocket ion chamber dosimeters or digital electronic dosimeters may be used for such non-routine monitoring. Alternatively, external doses may be calculated by the RSO based on documented occupancy time and measured exposure rates in subject areas.

[9] Note that there is an additional dose limit of 500 mrem to the fetus during pregnancy that will be observed in accordance with RG 8.13, Instruction Concerning Prenatal Radiation Exposure.

[10] Exposure to a gamma field of 1,000 µR/hr for 8 hours per day over a two-month period would theoretically result in an ambient dose equivalent (as measured with OSL dosimeters) that approaches the 500 mrem/yr dose threshold which requires monitoring under 10 CFR 20.1502.

Table 3: Regulatory Dose limits, reproduced from NRC Regulatory Guide 8.30 (Revision 1, 2002).

Dose Limits and Associated Terminology

Type of Exposure	10 CFR Part 20 Designation	Dose Limit
Total Whole Body Dose (Sum of External and Internal)	Total Effective Dose Equivalent (TEDE) TEDE = DDE + CEDE	5 rem/year
External Dose	Deep Dose Equivalent (DDE)	(a)
Internal Whole Body Dose	Committed Effective Dose Equivalent (CEDE)	(a)
Total Organ Dose (Sum of External and Internal)	Total Organ Dose Equivalent (TODE) TODE = DDE + CDE	50 rem/year
Internal Organ Dose	Committed Dose Equivalent (CDE)	(a)
Skin Dose	Shallow Dose Equivalent (SDE), Skin of Whole Body	50 rem/year
Extremity Dose	Shallow Dose Equivalent (SDE), Maximum Extremity	50 rem/year
Eye Dose	Eye Dose Equivalent to Lens of the Eye (LDE)	15 rem/year

(a) Included in limits for whole body and individual organs. In the absence of any internal exposure, external dose is limited to 5 rem per year. In the absence of any external exposure, internal exposure is limited to 2000 DAC-hours per year or 1 annual limit on intake (ALI) (50 rem/yr non-stochastic, 5 rem/yr stochastic).

Table 4: Occupational exposure/dose monitoring requirements under LC 10 (adapted from Table 3 of the 1993 license amendment request).

Type of Sample	Number	Locations	Procedure	Frequency	Analytical Parameters
Lapel Personal Air Sample	As required by RWP or at RSO discretion	As required by RWP (2-3 L/min or equivalent)	SOP 11 (HP-1)	As required by RWP or at RSO discretion	Alpha, U-nat
Lapel Air Sampler Calibration	All units in current use	N/A	Manufacturer Specifications	As required by RWP	Flow rate
Release of Equipment	As required by RWP	Potentially Contaminated Equipment and Materials	SOP 12 (HP-4)	As required by RWP	Alpha, beta gamma
ALARA	N/A	As required by RSO	HP-6 [A]	N/A	As required by RSO
Respiratory Protection [B]	As required by RWP	As required by RWP	N/A (HP-7) [B]	N/A	N/A
Bioassay	Entry/exit samples and as required by RWP	As required by RWP	SOP 14 (HP-8)	Entry/exit samples and as required by RWP	U-nat in urine
Instrument Calibration	Variable	Radiation Detection Instruments in use	SOP 16 (HP-10)	Annually	N/A
Dosimetry	As required by RWP or at RSO discretion	Personnel	SOP 13 (HP-3)	As required by RWP or at RSO discretion	Gamma
Personnel Contamination	As required by RWP	As required by RWP	SOP 12 (HP-12)	As required by RWP	Alpha
Radiation Protection Training	As required	HMC site	Taught by RSO or RST designee. [C]	Initial & annual refresher for personnel that work in Controlled Areas.	Training class & written test

[A] In 2018 HP-6 was added to the current list of SOPs in the Radiation Protection Program (RPP) Manual as SOP 33.

[B] Respiratory protection not expected to be necessary for current site decommissioning and reclamation activities. Procedure HP-7 has been inactivated and is not included in current RPP Manual or in the HMC Manual of Standard Practices.

[C] Annual refresher training is given by the RSO for all regular HMC employees that work in Controlled Areas. Temporary contractors are generally trained by the Radiation Safety Technician (RST) as a designee of the RSO, often with the aid of a previously developed radiation safety video followed by testing.

4.4.2.2 Occupational Air Monitoring

Airborne Particulate Radionuclides

Occupational air monitoring for long-lived radionuclides was discontinued in 2010 based on several years of high-volume air monitoring on top of the LTP. In late 2017 the NRC requested that HMC conduct a new occupational exposure monitoring study to better characterize the potential for occupational doses to workers under current operational circumstances and conditions. The results of this new study (ERG, 2018; see Appendix B) demonstrate that routine occupational monitoring for radiological exposures is not required under 10 CFR 20.1502 criteria.[11] This determination is based on 1) an estimated maximum potential Total Effective Dose Equivalent (TEDE) to any worker on the order of 53 mrem/yr, 2) potential intakes well below 10% of the annual limit on intake (ALI), and 3) average air concentrations well below 10% of the derived air concentration (DAC) for applicable radionuclides as given in 10 CFR 20, Appendix B. Applicable ALI and DAC limits for relevant radionuclides are compiled in Table 5. Based on the results of this study, routine occupational radiation exposure monitoring will be discontinued, though non-routine monitoring will continue at the discretion of the RSO (e.g. under a RWP) in accordance with applicable SOPs.

Table 5: Relevant occupational intake limits from 10 CFR 20 Appendix B.

	U-nat (µCi)	Th-230 (µCi)	Ra-226 (µCi)
$NALI_{ingest}$*	10	4	2
$SALI_{ingest}$*	20	9	5
$NALI_{inhal}$*	1	0.006	-
$SALI_{inhal}$*	2	0.02	0.6
	U-nat (µCi/mL)	**Th-230 (µCi/mL)**	**Ra-226 (µCi/mL)**
DAC (day)	5E-10	-	-
DAC (week)	3E-10	3E-12	3E-10
DAC (year)	2E-11	6E-12	-

NALI = Non-stochastic ALI

SALI = Stochastic ALI

* Most restrictive solubility class assumed: day for U-nat, week for Th-230 and Ra-226

Airborne Radon

Radon-222 (Rn-222) gas is widely known as an important radionuclide with respect to radiation dose, but it is the short-lived decay products of radon (progeny) that impart most of the dose via the inhalation pathway. Occupational DAC limits given in 10 CFR 20 Appendix B range from 4,000 pCi/L for radon gas without progeny present, to 30 pCi/L when the concentration of progeny is in secular equilibrium with Rn-222 gas (the latter value is equivalent to a DAC of 0.33 "working level" when only the progeny concentration is measured).

The International Atomic Energy Agency (IAEA) currently recommends an action level of 27 pCi/L (1,000 Bq/m^3) for indoor radon gas in the workplace, and 8.1 pCi/L (300 Bq/m^3) for members of the public, assuming a progeny/gas equilibrium fraction of 0.4 (IAEA, 2014). Absent robust data on indoor or outdoor equilibrium fractions at the Site, the administrative action level for radon gas will be set at 8.1 pCi/L since this is the action level recommended by IAEA to limit public dose from indoor radon to 100 mrem/yr (the public dose limit under NRC regulations). An equilibrium fraction of 0.4 is conservative relative to relative to the 0.34 maximum average equilibrium ratio measured at the Site during the 2018 occupational radiation exposure monitoring study (ERG, 2018).

[11] Environmental monitoring for public dose at Site boundaries will continue until the RML is terminated.

Because these limits are based on long-term average concentrations, indoor radon levels (in the RO plant and main office building) will be monitored with time-integrating alpha track-etch detectors as detailed in SOP 11 (Air Monitoring). In the highly unlikely event that the administrative limit for indoor radon gas is exceeded (see the 2018 occupational radiation exposure study report in Appendix B), follow-up radon progeny air sampling may be directed by the RSO, and an evaluation of potential sources and adequacy of ventilation or other factors will be conducted to determine if there are potential corrective actions that could be taken to either lower radon concentrations or to limit worker occupancy times at subject locations. Should radon progeny measurements become necessary, the Kusnetz method as specified in SOP 11 will be used.

4.4.2.3 Bioassay

Urine bioassay samples will be collected in accordance with the procedures given in SOP 14, *Procedure for Bioassay Sample Collection*. This includes "entry" bioassay sampling prior to employment to establish initial baseline uranium values, "exit" bioassay sampling upon termination of employment for comparison, and special bioassay sampling if appropriate at the discretion of the RSO. Circumstances for special bioassay sampling may include working with tailings or pond sludge or evaporative salts under a RWP, or if there is evidence that continual exposure to average air concentrations exceeding 10% of the DAC may have occurred.

If a bioassay result exceeds the lab's 5 µg/mL detection limit for uranium, the lab has been instructed to immediately notify the RSO, and a follow-up investigation will be conducted including additional bioassay sampling at the discretion of the RSO. Note that laboratory analysis or sample contamination issues are not uncommon, and follow-up bioassay samples may not be possible for temporary contractors that are no longer onsite by the time results are known.

If any bioassay sampling result exceeds 15 µg/mL, the responses recommended in Table A-1 of NRC Regulatory Guide 8.22 (Revision 2, 2014) will be followed. Unless the approximate time of a potential intake of uranium is known (e.g. if on a given day an air monitoring sample shows unusually high airborne radioactivity levels or contamination on the face is discovered), calculation of the amount of uranium intake (based on published intake retention fractions) may be grossly inaccurate. However, because special bioassay sampling is limited to RWPs at the discretion of the RSO, and since most RWPs are relatively short in duration (e.g. < 1 month), special bioassay samples are considered sufficient to evaluate compliance with NRC Regulatory Guide 8.22 (Revision 2, 2014) action level criteria and the NRC's occupational intake limit of 10 mg of soluble uranium per week (per 10 CFR 20.1201).

As noted previously in this RPP Manual and as documented in previous annual ALARA Audit reports, bioassay results have consistently remained below the 5 µg/mL detection limit for uranium for many years, and semi-annual sampling provides data of little value unless the date of the suspected intake is known. Accordingly, semiannual bioassay sampling has been discontinued.

4.4.2.4 Records Keeping and Reporting

Per the requirements of 10 CFR 20.2103, all occupational radiation monitoring data used in the evaluation of doses to workers will be retained by HMC until the license is terminated by the NRC. Records of

contamination surveys will be retained by HMC for at least three years after the record is made. Occupational radiation monitoring data and associated dose estimates for workers, along with any NRC or internal inspection findings, will be summarized in the Annual ALARA Audit report to be submitted to the NRC by March 31 of the following year.

4.5 Effluent Controls

The NRC defines "effluent" as "Liquid or gaseous waste containing plant-related, licensed radioactive material, emitted at the boundary of the facility (e.g., buildings, end-of-pipe, stack, or container) as described in the final safety analysis report (FSAR)" NRC Regulatory Guide 1.21, 2009. "Effluent discharge" is defined as "The portion of an effluent release that reaches an unrestricted area".

The primary effluents from the HMC Grants Reclamation Project Site include migration of impacted groundwater beyond Controlled areas, and release of radon gas from the LTP and STP that may increase ambient radon concentrations above background levels beyond Controlled Areas. Mechanical acceleration of process water evaporation (e.g. with Turbo Misters on EP1) is a source of releases of particulate radionuclides to air (in the form of liquid aerosols), but these releases are not expected to measurably impact environmental media (air, water, soil or vegetation) beyond Controlled Areas of the Site.

The primary controls on effluents are engineering based, including capture and treatment of impacted groundwater under the Corrective Action Plan (CAP), and interim cover materials (e.g. clean soil) placed above mill tailings contained in the LTP and STP (to prevent release of windblown tailings and reduce radon gas emissions). Administrative controls on effluent releases include environmental monitoring and comparison of results against regulatory and administrative limits.

4.5.1 Radiological Waste Management

Because the Site is no longer an operational uranium mill, the total inventory of radioactivity in wastes at the Site is static. While no new radioactive wastes are being generated at the Site, the spatial distribution of existing radioactive wastes is changing over time as radionuclides in impacted groundwater are removed and consolidated in the form of residual solids (sludge and evaporative salts) within the collection and evaporation ponds. In addition, contaminated equipment and operational wastes are being buried in waste disposal trenches on the STP. Because management of radioactive wastes (including handling, transfer and containment) can impact effluent releases beyond Controlled Areas, this aspect of Site operations is subject to consistency with ALARA principles.

4.5.1.1 Inspection of Process and Waste Containment Systems

Per SOP 23 (Evaporation Pond Operations), pond conditions are visually inspected at least weekly, including documentation of water/freeboard levels, fluid volumes discharged into or transferred between ponds, and inspection of leak detection systems. Tailings impoundments are also visually inspected at least weekly, and the Professional Engineer of record formally inspects and documents the structural

integrity of the impoundments on an annual basis. Water treatment systems (RO and Zeolite plants) are also inspected periodically in accordance with applicable SOPs.

4.5.2 Limits on Radiological Releases to the Environment

Limits on gaseous effluent releases to the environment for site-specific radionuclides are summarized Table 1 of this RPP, based on "effluent concentrations" provided in 10 CFR 20 Appendix B.[12] Because these values are benchmarked against a hypothetical radiation dose of 50 mrem/yr, they provide a conservative means for direct evaluation of individual environmental monitoring parameters in terms of dose-based limits on effluent releases from the facility. The overall public dose limit for effluent releases from all sources of radiological emissions from the Site is 100 mrem/yr at Controlled Area boundaries. Public dose estimation at the HMC Grants facility is based on measured above-background concentrations of airborne radionuclides and ambient external dose rates, with semiannual reporting per 10 CFR 40.65 requirements (due to NRC by March 31 and September 30). In addition, 10 CFR 40 Appendix A, Criterion 6 gives a numeric limit on radon releases from the tailings impoundments (20 pCi/m^2-s), and in accordance with LC 36(e), the average radon flux from the STP and the top of the LTP are measured directly on an annual basis (these values are also provided in semiannual reports required by 10 CFR 40.65).

4.6 Environmental Monitoring and Public dose

4.6.1 Monitored Environmental Media and Program Design

Because contaminated soil cleanup at the Site is largely completed, the primary environmental media that are monitored for radiological effluents are air and groundwater. Groundwater sampling is conducted in accordance with SOP 17. All other environmental monitoring, which includes sampling for long-lived radionuclide concentrations in air particulates, ambient radon gas levels, and gamma radiation dose rates, is conducted in accordance with SOP 20 specifications (Table 6).

4.6.2 Radon Flux Measurements

In addition to the above effluent and environmental monitoring parameters, average radon flux rates from the top of the LTP and accessible portions of the STP are measured on an annual basis in accordance with LC 36(E) using methods consistent with EPA Method 115. Radon flux measurements provide direct quantification of gaseous radon releases from the source, though associated effluent concentrations are measured at or near the boundaries of the Controlled Areas as shown in Figure 1 and Table 6. Results of all environmental monitoring parameters are reported in semiannual Effluent and Environmental Monitoring Reports in accordance with 10 CFR 40.65 and LC 36(e) requirements.

[12] Note that "effluent concentrations" in Appendix B of 10 CFR 20 are considered "limits" only if compliance with public dose limits is demonstrated based on the method specified in 10 CFR 20.1302 (2).

Table 6: Environmental Monitoring Program excluding Groundwater Monitoring (reproduced from SOP 20).

Type of Sample	Number	Locations	Method	Frequency	Analytical Parameters
Air Particulates	4	HMC1, HMC1A, HMC2, and HMC3 at or near the site boundary in sectors that have the highest predicted concentrations of radioactive airborne particulates.	Continuous (High Vol.)	Weekly filter change, or as needed. Samples composited and analyzed quarterly.	Natural Uranium, Radium-226, Thorium-230
Air Particulates	2	HMC4 and HMC5 at nearest occupied residences	Continuous (High Vol.)	Weekly filter change, or as needed. Samples composited and analyzed quarterly.	Natural Uranium, Radium-226, Thorium-230
Air Particulates	1	HMC6 as a background location	Continuous (High Vol.)	Weekly filter change, or as needed. Samples composited and analyzed quarterly.	Natural Uranium, Radium-226, Thorium-230
Radon Gas	30	2 Each at the locations described in Air - Particulates, HMC7 on south boundary, HMC1OFF, and HMC16 as a background location	Continuous Track-etch	Quarterly	Rn-222
Direct Radiation	8 + 2TC	Locations described in Air - Particulates and HMC16 as a background location	Continuous OSL	Semi-Annual	Gamma Exposure Rate

NOTE: The total number of OSL detectors needed for direct radiation measurements is 10. This includes the 8 needed for deployment on site and 2 transit controls (TC).

4.6.3 Public Dose Determination

The primary criterion for limitation of effluent releases from the facility is the 100 mrem/yr public dose limit at Controlled Area boundaries. Public dose estimation is based on effluent and environmental monitoring data collected and reported per 10 CFR 40.65 requirements, including semi-annual reporting (due to NRC by March 31 and September 30). Dose to the nearest member of the public is estimated based on results at environmental monitoring locations HMC-4 and HMC-5 based on proximity to the nearest resident.

4.6.3.1 Special Considerations for Public Dose Estimation

Only terrestrial effluents (airborne radionuclides and sources of external gamma radiation) are considered in public dose estimates as local residents obtain water for domestic use only from treated municipal water supplies (i.e. an intake pathway for impacted groundwater ingestion does not exist). In addition, because the radionuclides of concern in Site effluents are naturally occurring in the environment, public dose estimates based on environmental monitoring data include a subtraction of background concentrations.

It is well known that radon is the primary driver for calculated public dose estimates at the Site. It is also recognized that the background radon monitoring station (HMC-16), located on a ridge above the ephemeral San Mateo Creek basin, is not representative of background radon levels along the floor of this basin, and the San Mateo Creek drainage runs through Controlled Areas at the Site and adjacent areas

where the nearest members of the public reside. The result of this circumstance is that public dose estimates are believed to be artificially inflated because background radon levels at HMC-16 are about half that of background levels in the San Mateo Creek drainage (ERG, 2013).

Radon modeling with the MILDOS-AREA computer code indicates that effluent concentrations of radon at air monitoring stations HMC-4 and HMC-5 due to measured radon flux rates from the LTP and STP are consistent with the above observations (ERG, 2017). The modeling suggests that the levels of radon at the nearest resident location are very low, within the variability in background radon levels. Modeling, measurements and qualitative observation support a contention that the current method for estimating public dose is inaccurate, biasing estimates high by as much as a factor of two.

Homestake previously studied this issue (ERG, 2017) and proposed to NRC a new background location at HMC-1OFF, but NRC has not approved (as of issue date of this RPP manual) a new background location. In the first half of 2018, HMC conducted a radon monitoring study to help further evaluate equilibrium ratios upgradient of the LTP (HMC-1OFF), on top of the LTP, and hydrologically downgradient of the LTP (HMC-5) (ERG, 2018; see Appendix B). The study was based on the premise that radon gas, being denser-than-air, will flow in a hydrologically downgradient direction under relatively calm wind conditions, and any influence of releases from the LTP might be measurable at the downgradient location. Results indicate that radon gas levels on top of the LTP are higher than at the downgradient location (HMC-5), but average radon levels at HMC-5 are statistically indistinguishable from those at the upgradient location (HMC 1-OFF) (ERG, 2018). Although non-parametric testing indicates that median radon gas concentrations at HMC-5 are statistically slightly higher than at HMC 1-OFF, no statistical differences in measured radon progeny levels were observed between any of these locations (ERG, 2018). These results provide further evidence that the current method of estimating public dose from radon emissions from the tailings piles is biased high as noted above.

On July 31, 2018, NRC issued to HMC a Request for Additional Information (RAI) regarding demonstration of compliance with public dose limits given in 10 CFR 20.1301 and 20.1302 (ADAMS Accession No. ML18159A366). HMC responded with a proposal to estimate public dose to the nearest resident based on annual MILDOS-AREA modeling with a source term defined by annual radon flux measurements on the LTP and STP, along with an assumed equilibrium ratio if 0.5 and 100% occupancy (HMC, 2018). This approach would eliminate potential overestimation of public radon dose from the facility due to an inappropriate background radon monitoring location. As of the date of this RPP, NRC has not approved this proposal. Until issues of public radon dose estimation are resolved, HMC will continue to use "background" radon data from HMC-16 for estimation of public dose in the same manner as was done in 2017 and in previous years.

4.6.4 Assessment and Response to Trends or Changing Conditions

All environmental monitoring data, including gaseous and liquid effluents, will be evaluated for potential temporal trends that may occur due to changing conditions over time. Increasing trends will be assessed in terms of potential corrective actions that may be employed to reverse such trends, and this information will be reported to the NRC in semiannual effluent and environmental monitoring reports.

4.6.5 Records Keeping and Reporting

All effluent and environmental monitoring data and estimates of public dose will be reported per the requirements of 10 CFR 40.65, and will be retained by HMC until the license is terminated by the NRC.

4.7 Quality Assurance

4.7.1 Programmatic Performance-based Indicators

Performance-based indicators of the quality and effectiveness of the RPP will be reflected in measured doses, contamination levels, effluent concentrations, and environmental monitoring results. Compliance with respective regulatory limits or levels will meet minimum performance criteria for the RPP, but compliance with administrative limits will ensure optimal program performance and consistency with the ALARA policy.

4.7.2 Quality Control for Radiological Field Measurements

Quality control (QC) for individual measurement data refers to ensuring acceptable degrees of accuracy (deviation from the true value) and precision (reproducibility). Collectively, these measurement parameters determine the degree of analytical uncertainty reflected in the data. Analytical uncertainty can be minimized and quantified with proper instrument calibrations and routine QC measurements. The purpose of this Section is to provide an overview of the practices that will be used to ensure that measurements made under the RPP are of a defined and acceptable quality.

4.7.2.1 Calibration

Calibration of radiological measurement instruments and devices is necessary to ensure that the degree of accuracy achieved is sufficient to meet measurement objectives. All electronic radiation measurement instruments will be calibrated independently by the manufacturer or by a vendor that is qualified to perform such services. Calibrations will be performed in accordance with manufacturer SOPs, or using methods or standards that have been established, or are otherwise widely accepted, by relevant international agencies.

All electronic radiation measurement instruments will be calibrated at minimum on an annual basis as specified in SOP 16. Calibration is also required in the event of instrument maintenance or repair. Instruments will be used only if the calibration is current. Passive measurement devices such as dosimeters or radon track etch detectors will include analyses that are calibrated by the qualified/accredited vendor against accurately known (certified) quantities. All instrument calibration status will be tracked by the RSO and RST.

4.7.2.2 Quality Control Measurements

The continuing stability and performance of each field instrument after calibration will be monitored with QC measurements taken each day prior to and after use, the results of which will be documented in an electronic form on HMC computers in accordance with SOP 16 [Instrument Test and Calibration Procedure (HP-10)]. Quality control measurements must meet uncertainty (precision) limits of ± 20% of the nominal

(average) reading for background and a check source over time in a consistent location/geometry to demonstrate acceptable instrument performance.

5. REFERENCES

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APPENDIX A – Standard Operating Procedures (SOPs) for the Radiation Protection Program

SOP No.	SOP Title (and historic procedure No.)	Current Revision No.	Revision Date
SOP 2	Procedure for Conducting a Field Level Risk Assessment (FLRA)	2	10-15-2018
SOP 11	Radiological Air Monitoring for Occupational Exposures (HP-1)	2	10-15-2018
SOP 12	Radiological Contamination Surveys (HP-2)	14	10-15-2018
SOP 13	Calculation of Radiation Doses to Personnel (HP-3)	12	10-15-2018
SOP 14	Bioassay Sample Collection (HP-8)	15	10-15-2018
SOP 16	Instrument Test and Calibration Procedure (HP-10)	12	10-15-2018
SOP 18	Procedure for Implementing a Radiation Work Permit (HP-16)	9	10-15-2018
SOP 20	Environmental Monitoring Except Groundwater (EM-2)	17	09-09-2018
SOP 21	Spill Response and Reporting Procedure (EM-4)	3	10-15-2018
SOP 22	On-Site Disposal of Radiologically-Impacted Waste	1	10-20-2018
SOP 23	Evaporation Pond Operations	1	10-15-2018

APPENDIX B – 2018 OCCUPATIONAL RADIATION EXPOSURE STUDY