UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

EA-16-114

April 29, 2021

Mr. Brad Bingham
Closure Manager
Grants Reclamation Project
Homestake Mining Co. of CA
P.O. Box 98/Highway 605
Grants, NM 87020

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION REVIEW OF REPORTS FOR COMPLIANCE WITH CONFIRMATORY ORDER EA-16-114, CONDITIONS 14 AND 15, FOR RELEASE OF FORMER GROUNDWATER LAND APPLICATION AREAS, HOMESTAKE MINING COMPANY OF CALIFORNIA, GRANTS RECLAMATION PROJECT, LICENSE SUA-1471, EA-16-114, DOCKET NUMBER 040-08903

Dear Mr. Bingham:

The U.S. Nuclear Regulatory Commission (NRC) has completed its review of reports for compliance with Confirmatory Order EA-16-114 (CO), Conditions 14 and 15, for release of former groundwater land application irrigation areas at the Homestake Mining Company of California (HMC), Grants Reclamation Project (Grants) site in Grants, NM. Enclosed, please find the Safety Evaluation Report (SER) documenting the NRC staff's review.

On March 28, 2017, the NRC issued a CO against HMC for five apparent violations, including failure to obtain NRC approval prior to discharging liquid effluents containing byproduct material to the land application irrigation (LAI) areas.[1] The CO is the result of an agreement reached during Alternative Dispute Resolution mediation sessions conducted on December 12, 2016, and February 15, 2017. Conditions 14 and 15 of the CO required the licensee to submit a land application assessment of the LAI areas and final status survey plans to demonstrate that the radiological doses and non-radiological risks are below NRC-approved remedial action levels.

HMC submitted a Land Application Impact Assessment Report to document their assessment of the impacts from irrigating the LAI areas with potentially impacted groundwater sources.[2] A final status survey (FSS) plan, "Final Status Survey Plan for Release of Former Land Application Areas"[3], and FSS Report, "Final Status Survey Report for Release of Former Land

[1] Agencywide Documents and Management System (ADAMS) Accession No. ML17061A455
[2] ADAMS Accession No. ML17270A066
[3] ADAMS Accession No. ML17321A085

Application Areas"[4], were also submitted by HMC to demonstrate that the concentrations of constituents of concern in soil across the LAI areas do not exceed the proposed criteria for unrestricted release as specified in the Land Application Impact Assessment Report.

The enclosed SER evaluates HMC's responses to Conditions 14 and 15 of the CO. The NRC staff has determined that dose calculations considered reasonably foreseeable land use scenarios, appropriate exposure pathways, and site-specific parameter values that provide reasonable assurance that doses are below the NRC's regulatory limits and satisfy as low as reasonably achievable requirements. The NRC staff finds that HMC has fulfilled its requirements under Condition 14 of the CO. Since NRC staff finds that the results of HMC's analysis discussed in Condition 14 of this section indicates that radiological doses and non-radiological risks are not in excess of the NRC-approved remedial action levels (i.e., the concentrations of constituents of concern in the LAI areas meet the requirements for unrestricted release in accordance with 10 CFR Part 40, Appendix A, Criterion 6(6) and Criterion 6(7)), HMC is not required to take further corrective actions as discussed in Condition 15.

The NRC requested comments from the Environmental Protection Agency, New Mexico Environment Department, and the Department of Energy. The agencies responded with minor comments that were incorporated in the final SER.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice and Procedure," a copy of this letter will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records component of NRC's document system ADAMS. ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

[4] ADAMS Accession No. ML18186A568

If you have any questions regarding this letter or the enclosures, please contact Mr. Ron C. Linton at (301) 415-7777 or by e-mail to Ron.linton@nrc.gov.

Sincerely,

Bill Von Till, Chief
Uranium Recovery and Materials
Decommissioning Branch
Division of Decommissioning, Uranium Recovery
and Waste Programs
Office of Nuclear Materials Safety
and Safeguards

Docket No. 040-08903
License No. SUA-1471

Enclosure: Safety Evaluation Report

SUBJECT: U.S. NUCLEAR REGULATORY COMMISSION REVIEW OF REPORTS FOR COMPLIANCE WITH CONFIRMATORY ORDER EA-16-114, CONDITIONS 14 AND 15, FOR RELEASE OF FORMER GROUNDWATER LAND APPLICATION AREAS, HOMESTAKE MINING COMPANY OF CALIFORNIA, GRANTS RECLAMATION PROJECT, LICENSE SUA-1471, EA-16-114, DOCKET NUMBER 040-08903 Dated: April 29, 2021

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Date	04/09/2020	04/29/2020	

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SAFETY EVALUATION REPORT (SER)

DATE:	April 29, 2021
DOCKET:	040-08903
LICENSEE:	Homestake Mining Company of California
SITE:	Grants Reclamation Project, Grants, New Mexico
PROJECT MANAGER:	Ron Linton
TECHNICAL REVIEWERS:	Ronald A. Burrows, Adam Schwartzman, Ron Linton
SUBJECT:	Review of Reports for Compliance with Confirmatory Order EA-16-114, Conditions 14 and 15, for Release of Former Groundwater Land Application Areas

BACKGROUND

The Homestake Mining Company of California (HMC or the licensee) maintained a land application irrigation program at the Grants Reclamation Project (GRP) site in Cibola County, New Mexico, from 2000 through 2012. The system discharged effluents containing byproduct material to land application areas to remediate groundwater contaminant plumes that had migrated beyond the mill site and the primary collection system. The system consisted of collection wells that extracted contaminated water to reduce levels of natural uranium (U-nat) and selenium (Se) (referred to by HMC as constituents of concern (COCs) (HMC, 2017a)) in the aquifer. The water was used to irrigate four fields, referred to collectively as land application irrigation (LAI) areas, used to grow alfalfa and grass (HMC, 2014a). A description of the North and South Irrigation water system and water quality supplied to the LAI areas are provided in Appendix A of the Land Application Impact Assessment Report (LAIA Report) (HMC, 2017a).

The LAI areas are located in Sections 28, 33, and 34 in Township 12 North, Range 10 West, near Grants, New Mexico (See Figure 1-1 of HMC, 2014a). Irrigation supply water was divided into North and South irrigation systems. The North irrigation system supplied individual wells servicing the Section 28 center pivot area. The South irrigation system supplied individual wells servicing the center pivot and flood irrigation areas in Sections 33 and 34 (HMC, 2017a). The LAI areas are on HMC property but outside of the licensed boundary.

On March 28, 2017, the U.S. Nuclear Regulatory Commission (NRC) issued a Confirmatory Order (CO) (NRC, 2017) against HMC for five apparent violations, including failure to obtain NRC approval prior to discharging liquid effluents containing byproduct material to the LAI areas. The CO is the result of an agreement reached during Alternative Dispute Resolution mediation sessions conducted on December 12, 2016, and February 15, 2017. This SER evaluates HMC's responses to Conditions 14 and 15 of the CO.

Enclosure

Condition 14 of the CO states the following:

> HMC will identify sources of supply water, soil and groundwater data, and reports, and will use those data to develop a land application assessment of any impacts due to the use of the irrigation water containing byproduct material to past, current, or foreseeable future uses of the land application areas in Township 12 North, Range 10 West, Sections 28 (approximately 100 acres), 33 (approximately 150 acres and approximately 24 acres), and 34 (approximately 120 acres). The land application assessment will establish background concentrations, remedial action levels (radiological dose and non-radiological risk), and current concentrations of COCs in its license at all areas used for land application. The land application assessment will also identify and assess impacts from soil pore water data at the land application areas. HMC's land application assessment will be consistent with the requirements of 10 CFR 20.2002 and in accordance with Appendix F1.4 of NUREG-1620 (Agencywide Documents and Management System [ADAMS] Accession No. ML032250190) to demonstrate that the discharge of byproduct material containing both radiological and non-radiological constituents did not impact and will not impact members of the public or the environment. In addition, HMC will take immediate action to ensure that the land application areas are not being used to produce crops for human consumption. The land application assessment will be submitted for NRC review and approval within 180 days of issuance of this Confirmatory Order.

Condition 15 of the CO states the following:

> If the results of HMC's analysis discussed in Condition 14 of this Section indicates that radiological doses and non-radiological risks are in excess of the NRC-approved remedial action levels, HMC will propose appropriate measures to control both use and access to the impacted areas, a corrective action plan, if necessary, to achieve the NRC-approved remedial action levels, and final status survey plans to demonstrate that the radiological doses and non-radiological risks are below NRC-approved remedial action levels. If corrective actions are needed, HMC will submit corrective actions (that include completion timeframes), for NRC approval, within 60 days of NRC's approval of HMC's land application assessment.

HMC developed a land application assessment of impacts to:

I. identify sources of supply water, soil and groundwater data, as well as related reports, and use the information to assess any impacts due to the use of the irrigation water containing byproduct material to past, current, or foreseeable future uses of the land application areas;
II. establish background concentrations, remedial action levels (radiological dose and non-radiological risk), and current concentrations of COCs for all of the land application areas;
III. identify and assess impacts from soil pore water on the land application areas;

IV. demonstrate that the discharge of byproduct material containing both radiological and non-radiological constituents did not impact and will not impact members of the public or the environment consistent with the requirements of 10 CFR 20.2002 and in accordance with Appendix F1.4 of NUREG-1620 (NRC, 2003);

V. take immediate action to ensure that the land application areas are not being used to produce crops for human consumption.

HMC submitted its LAIA Report (HMC, 2017a) assessing the impacts from irrigating the LAI areas with potentially impacted groundwater sources. A final status survey (FSS) plan, "Final Status Survey Plan for Release of Former Land Application Areas" (HMC, 2017b), and FSS Report, "Final Status Survey Report for Release of Former Land Application Areas" (HMC, 2018a), were also submitted by HMC to support HMC's conclusion that the concentrations of COCs in soil across the LAI areas do not exceed the proposed criteria for unrestricted release as specified in the LAIA Report. HMC did not wait for the NRC to approve its FSS plan before performing FSS surveys, which was the NRC's expectation. Some aspects of the FSS Report were found unacceptable by NRC staff. This includes HMC's evaluations related to piping surveys and the use of radium background soil concentrations, which are discussed in Item IV. Ultimately, these issues did not impact the NRC staff's final conclusions regarding whether HMC has satisfied the requirements in Condition 14 of the CO, as discussed in detail below.

EVALUATION OF RESPONSES TO CONFIRMATORY ORDER CONDITION 14

The requirements stated in CO Condition 14 were individually evaluated by NRC staff in items I through V below.

I. Identify sources of supply water, soil and groundwater data, as well as related reports, and use the information to assess any impacts due to the use of the irrigation water containing byproduct material to past, current, or foreseeable future uses of the land application areas

By letter dated September 25, 2017 (HMC, 2017a), HMC submitted the LAIA Report. The LAIA Report presented data related to groundwater and soils in Sections 28, 33, and 34 in Township 12 North, Range 10 West, near Grants, New Mexico. These land areas encompass the former LAI areas.

In the LAIA Report, HMC compiled historical data from previously submitted evaluations monitoring the irrigation program (for example, see HMC, 2014a). These evaluations include groundwater quality, irrigation water contaminant concentrations and usage, and soil moisture and contaminant concentrations. The LAIA Report also presented an assessment of groundwater impacts (Section 4) and an assessment of potential radiological impacts to the public associated with irrigation activities (Section 5). The radiological impacts were modeled with the RESRAD-OFFSITE computer code (for reference, see ANL, 2020) using the resident farmer scenario. The radiological impacts to the public are discussed in detail in the NRC staff's evaluation in Item IV below.

The NRC staff finds that HMC has fulfilled this requirement of Condition 14 of the CO.

II. Establish background concentrations, remedial action levels (radiological dose and non-radiological risk), and current concentrations of COCs for all of the land application areas;

Based on HMC's analysis of the historical groundwater data related to the LAI areas in Sections 28, 33, and 34, it determined that the relevant COCs for assessing potential health and environmental impacts were U-nat and Se. HMC performed a risk-based (i.e., non-radiological, or chemical effects) and a radiation dose-based analysis.

Background soil concentrations and irrigation soil concentrations for U-nat and Se are presented in Appendix B of the LAIA Report (HMC, 2017a). Based on these data, HMC determined that the Section 34 flood irrigation area had the highest U-nat and Se soil concentrations of the four LAI areas and analyses performed for Section 34 would represent the most conservative exposure assessment (HMC, 2017a). Figures B.1-3 and B.1-4 show the soil concentrations for U-nat and Se at depth for the years 2006, 2008, 2010, and 2012 for this area (HMC, 2017a). Generally, the U-nat and Se soil concentrations were highest near the surface and decreased to an approximate depth of 1 meter below the surface. There appears to be no discernable difference between the measured COCs in soil below 1 meter and the background value.

Based on the analysis performed by HMC for non-radiological exposure (refer to Section 3.4 of HMC, 2017a), HMC determined that U-nat and Se soil concentrations were below relevant State and Federal soil screening levels (SSLs). Therefore, HMC concluded that no soil remediation was required in any of the LAI areas.

For the dose-based analysis, HMC evaluated the Section 34 flood irrigation area as this area had the highest average U-nat soil concentrations (refer to Section 5.1 and Appendix G of HMC, 2017a). HMC calculated a maximum dose of less than 0.001 millisieverts per year (mSv/y) [0.1 millirem per year (mrem/y)] to a member of the public (HMC, 2017a).

During its review, NRC staff noted that HMC did not take background or irrigation soil samples for radium-226 (Ra-226) or thorium-230 (Th-230). HMC made this decision based on its analysis of the concentrations of Ra-226 and Th-230 in the applied irrigation water. The NRC staff performed additional analyses to further evaluate potential impacts related to Ra-226 and Th-230; these analyses are discussed in Section IV below.

Notwithstanding the issue noted above, as further evaluated in Item IV, the NRC staff finds that HMC has fulfilled this requirement of Condition 14 of the CO.

III. Identify and assess impacts from soil pore water on the land application areas;

HMC stated in the LAIA Report (HMC, 2017a) that lysimeters were installed within the soil profile in the irrigation areas and produced samples of soil pore water that defined constituent concentrations in the soil moisture; these are not a direct measurement of input to the groundwater. HMC concluded in its LAIA Report that water quality sample data for wells in and

adjacent to the land application areas is a more reliable measure of the groundwater impacts from the irrigation.

HMC evaluated U-nat and Se movement in the soil moisture and predicted that these constituents will not reach the groundwater at rates that would cause groundwater levels to exceed applicable groundwater protection standards (GWPS) (HMC, 2014b). HMC concluded from groundwater monitoring results that the alluvial groundwater in the Section 33 center pivot had small increases in sulfate, total dissolved solids (TDS) and chloride concentrations and that these small increases dissipated after irrigation ended. No increases in U-nat, Se or other constituents were observed. The groundwater in the Section 34 flood area also had small increases in sulfate, TDS, chloride and U-nat concentrations that may be attributed to the flood irrigation, but these small increases are dissipating and should continue to decrease. Because of the higher resident constituent concentrations in Section 28 groundwater, HMC indicated that no increases in concentrations have been detected in the Section 28 center pivot area, but groundwater mass loading similar to those observed in Section 33 center pivot groundwater likely occurred (HMC, 2017a).

The NRC staff reviewed the lysimeter data from 2010 to 2015 from the LAIA Report. The contaminant concentrations for U-nat and Se generally show decreasing trends from 2009 to 2015, with some exceptions. The U-nat concentrations in the Section 33 lysimeters are typically lower than the concentrations of the irrigation water and show a gradual decreasing trend, LY 4MU is the exception with U-nat concentrations above the irrigation water quality, however concentrations are declining. The U-nat concentrations in the Section 34 soil moisture are gradually declining after termination of the LAI program in this area. The U-nat concentration in the Section 28 lysimeter samples have generally decreased since termination of irrigation in this area in 2012. While some of the lysimeter samples show constituents above the GWPS for the alluvial aquifer, the groundwater data below the LAI areas show groundwater impacts to be minimal in the alluvial aquifer, as further discussed below. HMC stated in its 2019 Annual Report (HMC, 2020a) that no soil moisture samples or data were collected from the lysimeters in 2019 because the early October 2017 attempt to collect samples from the lysimeters was unsuccessful and that the successful collection of samples from the lysimeters becomes increasingly difficult as the soil dries out and the lysimeters become inoperable.

The NRC staff reviewed water quality data in the HMC 2019 Annual Report (HMC, 2020a) for Section 33. Wells 551, 647, 649, and 996 are all completed either below or very near the 150-acre center pivot area in Section 33 (see 2019 Annual Report Figure 4.3-2). Well 551 is completed below the 150-acre center pivot area, wells 647 and 649 are completed at the edge of the pivot area, and well 996 is completed just outside of the pivot area. Uranium concentrations shown in the 2019 Annual Report, Figure 4.3-69, are all below 0.1 milligrams per liter (mg/L) and below the 0.16 mg/L U-nat GWPS for wells 551, 647, 649, and 996. The plots show the U-nat concentrations in these wells have been stable since 2012, when the land application area program was terminated. Additionally, the NRC staff reviewed Se concentrations for wells 551, 647, 649, and 996 found in Figure 4.3-86 of the 2019 Annual Report. Selenium concentrations have remained stable and below 0.06 mg/L, well below the 0.32 mg/L Se GWPS, since 2012. Similar plots for sulfate, TDS, chloride, molybdenum and nitrate in the 2019 Annual Report show similar trends, and that the GWPS have not been exceeded at these wells since 2012. No alluvial wells were located under the Section 33 flood irrigation area.

The NRC staff reviewed water quality data in the HMC 2019 Annual Report (HMC, 2020a) in Section 34. Wells 555, 556, 557, 844 and 845 are all completed either below or very near the flood irrigation area in Section 34 (see 2019 Annual Report Figure 4.3-2). Uranium concentrations shown in the 2019 Annual Report, Figure 4.3-65, have been below the 0.16 mg/L U-nat GWPS for wells 555, 556, 557, 844 and 845 since 2013. Well 844 showed U-nat concentrations above the GWPS in 2012 but have steadily declined and have been below the GWPS since 2013 and stable since 2015. Well 556 showed one sample above the U-nat GWPS in 2016, but this point sample appears to be an outlier, as the sample is approximately five times greater than 12 other samples taken since 2012 at well 556. Other than the outlier sample in well 556, the plots show the U-nat concentrations in these wells have been stable since 2013, one year after the land application area program was terminated. Additionally, the NRC staff reviewed Se concentrations for wells 555, 556, 557, 844 and 845 found in Figure 4.3-82 of the 2019 Annual Report. Selenium concentrations have remained stable and below 0.08 mg/L, which is well below the 0.32 mg/L Se GWPS, since 2012. While there are some exceedances for GWPS for TDS, sulfate, chloride, the plots for these constituents show the constituents have remained relativity stable or have been declining since 2012 and are expected to continue to decline as irrigation has ceased at the LAI areas. The GWPS exceedances at Section 34 have minimal impacts at the GRP. The exceedances are located in an area of historic groundwater contamination and groundwater at the GRP, including Section 34, and cannot be accessed due to a well prohibition in the Alluvial and Chinle Aquifers enacted by the New Mexico Office of the State Engineer (NMOSE 2014).

The NRC staff reviewed water quality data in the HMC 2019 Annual Report (HMC, 2020a) in Section 28. Wells 881, 882, 884, 886, and 893 are all completed below the 100-acre pivot area in Section 28 (see 2019 Annual Report Figure 4.3-2). Concentrations for sulfate, TDS, chloride, Se, molybdenum and nitrate in these wells have been below GWPS since 2013 as shown in the 2019 Annual Report (see Figures 4.3-16, 4.3-33, 4.3-50, 4.3-84, 4.3-101, and 4.3-118). Uranium concentrations shown in the 2019 Annual Report have exceeded the GWPS for wells 886 and 881 since 2012. While the standards are exceeded in wells 886 and 881, the U-nat concentrations have remained relativity stable or have been declining since 2012. Uranium concentrations for all other wells have been below GWPS since 2012, except for well 893, which has been below GWPS since 2016. As stated by HMC in the LAIA Report, U-nat concentrations have historically been above the GWPS in the Section 28 pivot area as shown in the 2019 Annual Report, Figure 1.1-16. The Section 28 pivot area is located downgradient of the contaminant plume that originates at the large tailing pile.

The NRC staff agrees with HMC's conclusion in the LAIA Report that the water quality sample data for wells in and adjacent to the LAI areas are a more reliable measure of the groundwater impacts from the LAI areas than the pore water data. This is because there are many more years of groundwater data at the LAI areas. HMC only reported 5 years of lysimeter data until the soil dried out and additional lysimeter data could not be obtained. The NRC staff reviewed the lysimeter data from the LAI areas and determined the impact to be minimal. As discussed above, concentrations in the lysimeters are typically lower than the concentrations of the irrigation water and show a decreasing trend. While some of the lysimeter samples show constituents above the GWPS for the alluvial aquifer, the groundwater data below the LAI areas show groundwater impacts to be minimal in the alluvial aquifer. The NRC staff reviewed the

groundwater data collected from the alluvial aquifer below the LAI areas in sections 33, 34, and 28, as described above, and determines that impacts from irrigation in the land application areas to groundwater are minimal.

The NRC staff finds that HMC has fulfilled this requirement of Condition 14 of the CO.

IV. Demonstrate that the discharge of byproduct material containing both radiological and non-radiological constituents did not impact and will not impact members of the public or the environment consistent with the requirements of 10 CFR 20.2002 and in accordance with Appendix F1.4 of NUREG-1620 (NRC, 2003);

REGULATORY CONSIDERATIONS

The LAIA Report was provided to the NRC to comply with Condition 14 of the CO. In accordance with Condition 14, the report is intended to document, in part, whether and to what extent the discharge of groundwater on the LAI areas impacted and will impact members of the public or the environment. The NRC staff applied the regulatory requirements of 10 CFR 20.2002 and 10 CFR 40, Appendix A, Criteria 6(6) and 6(7). The relevant requirement in 10 CFR 20.2002(d) specifies that doses are to be maintained as low as reasonably achievable (ALARA) and within the dose limits of Title 10 of the *Code of Federal Regulations* Part 20, "Standards for Protection Against Radiation".

SOIL

HMC evaluated the soil concentrations of a variety of constituents, both prior to and during LAI activities. Pre-irrigation soil concentrations were determined from samples collected prior to initiating the irrigation program (HMC, 2017a). Background soil concentrations were determined from samples collected outside the LAI areas after initiating the irrigation program. HMC defined mean background as the average of the pre-irrigation and background soil concentrations of all such samples collected (HMC, 2017a). HMC attributed increases in soil concentrations from the previously established pre-irrigation and background radionuclide concentrations to the addition of radionuclides as a result of LAI activities (HMC, 2017a).

Table 1, "Soil Release Criteria for the Land Application Areas," summarizes the proposed soil release criteria for the LAI areas. As specified in the LAIA Report and the FSS plan, the SSL values established for U-nat and Se are the U.S. Environmental Protection Agency (EPA) Regional SSL values considering a residential land use scenario. HMC assumed a background value for Ra-226 of 5.5 picoCuries per gram (pCi/g) that was previously approved by the NRC staff as part of the updated decommissioning and reclamation plan (HMC, 2013). However, this radium background value was approved for the licensed area and does not extend to the LAI areas (NRC, 1993). HMC did not provide any justification for applying this background value to the LAI areas.

Table 1. Soil Release Criteria for the Land Application Areas[1]

	Constituents of Potential Concern			
	Radium-226[2]	Natural Uranium[3,4]		Selenium
Soil Release Criteria	pCi/g	mg/kg	pCi/g	mg/kg
Surface soil (0 – 15 cm)	5	16	10.8	5.17
Subsurface soil (> 15 cm)	15	16	10.8	

[1] Adapted from Table 1 of the FSS Report (HMC, 2018a).
[2] Values represent total activity. NRC staff assumed no activity present in background because HMC did not provide sufficient justification for their assumed background concentration values.
[3] 0.677 pCi/g per mg/kg assumed for activity/mass concentration conversion.
[4] U-nat values include background U-nat concentrations in soil.

The NRC staff performed multiple comparisons with other relevant data to assess HMC's assumed use of the Ra-226 background soil concentration, a value approved for the licensed area, but not for the LAI areas. The NRC staff found that the mean Ra-226 concentrations found in the soil in the LAI areas by HMC, which range from 0.9 and 2.0 pCi/g with maximum values between 1.3 and 3.9 pCi/g, were less than the approved 5.5 pCi/g background concentrations (HMC, 2018a). The Ra-226 concentrations in soil collected during the confirmatory survey conducted by the Oak Ridge Institute for Science and Education (ORISE) were also less than the mean Ra-226 concentrations found in the soil in the LAI areas by HMC (refer to Tables 6.3 and 6.4, and Figure 6.3 of ORISE, 2019). The NRC staff also evaluated a Human Health Risk Assessment (HHRA) completed by the EPA in 2013 (EPA, 2014a). As part of the HHRA, soil samples were taken from the LAI areas and analyzed for metals and radionuclides (refer to Tables 2-15 and 2-16 of EPA, 2014a). The Ra-226 soil concentrations (minimum, maximum, mean) were consistent with the Ra-226 concentrations found by HMC and includes a maximum Ra-226 soil concentration of 3.11 pCi/g. The combination of these findings suggests that using an assumed Ra-226 background concentration of 5.5 pCi/g for the LAI areas would not be representative of the areas and would underestimate the potential impact from Ra-226 from LAI activities.

The measured Ra-226 soil concentrations from samples collected throughout the LAI areas following irrigation activities are also less than the release limit specified in 10 CFR Part 40, Appendix A, Criterion 6(6) (i.e., 5 pCi/g), before subtracting HMC's proposed background concentration for radium in soil (or a more accurate one). Therefore, more accurate background concentrations of radium are not necessary for the NRC staff to make its determination on the acceptability of the concentration of radium in soil.

HMC performed a radium benchmark dose analysis (RBD analysis) for the LAI areas in accordance with 10 CFR 40, Appendix A, Criterion 6(6) and as documented in Attachment 1 of the FSS plan. HMC used the RESRAD (renamed RESRAD-ONSITE), Version 6.6, computer code to perform this analysis. The RBD analysis resulted in maximum U-nat concentrations of 370 pCi/g in surface soil and 192 pCi/g in subsurface soil. However, because HMC did not use site-specific data for all RESRAD input parameters and did not justify the use of default values, the NRC staff did not consider the results of the RBD analysis for U-nat in its review.

The data presented in the FSS Report indicate that the maximum U-nat concentrations in soil in the LAI areas do not exceed 5 pCi/g [7.4 milligrams per kilogram (mg/kg)] (Tables 5, 7, 9, and

10 in HMC, 2018a). These findings are consistent with soil sampling and analysis performed by ORISE (Tables 6.3 and 6.4 of ORISE, 2019). In addition, the NRC staff reviewed an aerial survey of the area surrounding the GRP performed in 2009 that covered most, but not all, of the LAI areas. Results indicated that there were no statistically significant deviations from background conditions in the LAI areas surveyed and that the U-nat concentrations in the LAI areas are less than approximately 4 pCi/g (5.9 mg/kg) (refer to Images 38, 53, and 54 of EPA, 2013). Therefore, consistent with guidance provided in NUREG-1620, Appendix H, Section 2.0, RBD modeling is not required for U-nat since the NRC staff has reasonable assurance that the concentration of U-nat in soil in the LAI areas is less than 5 pCi/g.

Based on these evaluations, the NRC staff finds HMC's proposal to use the more restrictive SSL value (10.8 pCi/g versus 370 pCi/g) as the regulatory limit for determining whether U-nat concentrations in soil in each of the survey units are low enough to release the LAI areas for unrestricted use acceptable. The NRC staff notes that the SSL value for U-nat includes background radioactivity from naturally occurring U-nat, which must be considered when comparing samples.

According to HMC, Th-230 was not included in the RBD analysis because Th-230 concentrations measured in applied irrigation water were not significantly different from background concentrations in local groundwater. As a result, HMC did not address whether the concentration of Th-230 in the soils within the LAI areas is acceptable. The NRC staff reviewed previous HMC submittals (HMC, 2017a, 2014) to determine if this was an appropriate assumption. There was limited data on the Th-230 concentrations in the irrigation supply water (refer to Tables 2-3 and 2-5 of HMC, 2017a). However, the available data indicate that the concentration of Th-230 in the North and South irrigation supply water was less than the GWPS of 0.3 pCi/l as required in License Condition 35.B (NRC, 2020b). In addition, the majority of individual wells sampled for Th-230 (refer to Tables 2-4 and 2-6 of HMC, 2017a) had mean concentrations less than the GWPS of 0.3 pCi/l.

The NRC staff recognizes that the Th-230 concentration in irrigation water applied to the LAI areas is less than the GWPS but notes that Th-230 concentrations in water cannot be directly compared with Th-230 concentrations in soil. Because HMC did not perform analyses for Th-230 in the LAI area soils, the NRC staff evaluated other relevant historical data. Specifically, the NRC staff evaluated the Th-230 soil concentration data for the LAI areas provided in the EPA's HHRA (EPA, 2014a). The Th-230 soil concentrations (minimum, maximum, mean) analyzed by the EPA were consistent with the Th-230 soil concentrations sampled and analyzed as part of the NRC's confirmatory survey (ORISE, 2019). For example, the maximum Th-230 soil concentration found by the EPA was 1.88 pCi/g while ORISE measured a maximum Th-230 soil concentration of 3.4 pCi/g (refer to Table 6.3 of ORISE, 2019). Both Th-230 soil concentration analyses include contributions from background. NRC staff also note that, consistent with NUREG-1620, Appendix H, Section 2.0, RBD modeling is not required to calculate a corresponding Th-230 soil concentration because the NRC staff has reasonable assurance that the concentration of Th-230 in soil in the LAI areas is less than 5 pCi/g.

Appendix H of NUREG-1620 indicates that chemical toxicity should also be considered when deriving a soil U-nat concentration limit if soluble forms of U-nat are present. As proposed in the LAIA Report and adopted in the FSS plan, HMC proposed a U-nat soil release criterion of

16 mg/kg (10.8 pCi/g) based on the 2017 EPA Regional SSL for residential land use (HMC, 2017a). The Se release criterion, 5.17 mg/kg, is equivalent to the New Mexico Environment Department's (NMED's) soil screening level value for protection of groundwater quality (HMC. 2017a). The NRC staff evaluated HMC's analysis of non-radiological hazards (i.e., U-nat and Se) and finds that it is consistent with Acceptance Criterion 5.2.3(9) in NUREG-1620 and therefore acceptable.

Based on the results of routine monitoring throughout the land application program, HMC assumed that if surface soils meet the Table 1 release criteria then it is reasonable to expect that subsurface soils would meet the criteria as well. The NRC staff evaluated the U-nat and Se soil concentration data in Appendix B of the LAIA Report (HMC. 2017a) and additional descriptions by HMC of the soil compositing methods in the 2014 Irrigation Evaluation Report (HMC, 2014a) and finds this approach to be acceptable.

SAMPLING AND EVALUATION OF CONTAMINATION IN THE LAND APPLICATION AREAS

SOIL

The FSS Report presented HMC's evaluation of the four survey units: 28 Pivot (28P), 33 Pivot (33P), 33 Flood (33F), and 34 Flood (34F). The surveys consisted of gamma radiation surveys and systematic and biased sampling of surface soils (0-15 cm) in each survey unit. The FSS Report provided the results from the FSS plan and is intended to demonstrate that COCs in surface soils across the LAI areas do not exceed proposed criteria for unrestricted release.

HMC performed gamma scans over each of the four survey units using Global Positioning System-based walkover and all-terrain vehicle scanning techniques. The gamma scan survey data were converted to exposure rate values and mapped to determine areas of elevated terrestrial gamma radiation. These results were used to select biased soil sampling locations within each irrigation area. Table 2 summarizes the exposure rates measured in each area and the resulting number of biased soil samples that were collected as a result of these analyses.

Table 2. Average and Range of Exposure Rate Measurements and the Resulting Number of Biased Soil Samples to be Collected

	Exposure Rate		
Survey Unit	Average (μR/hr)	Range (μR/hr)	# of Biased Soil Samples
28 Pivot (28P)	9.2	7.2 – 36.3	2
33 Pivot (33P)	9.9	7.7 – 12.8	4
33 Flood (33F)	11.9	9.5 – 14.9	2
34 Flood (34F)	13.1	9.7 – 16.1	7

The NRC staff reviewed the results of the gamma scans performed over the land application areas and recognizes the usefulness of these scans to generally indicate areas of relative increased exposure rates (i.e., hot spots) and to guide biased sampling. However, due to the lack of data demonstrating correlation of the gamma scans with release criteria, the NRC staff did not incorporate the results of the gamma scans into its evaluation of whether the COCs in

soil meet the cleanup criteria for land in accordance with the requirements in 10 CFR Part 40, Appendix A, Criterion 6(6). Instead, the NRC staff used the soil concentration measurements.

HMC proposed the use of a non-parametric statistical Sign test to demonstrate that the median concentrations of the COCs (Ra-226, U-nat, and Se) in each survey unit do not exceed the soil release criteria. HMC used the Visual Sampling Plan (VSP) computer code (PNNL, 2014) to develop a soil sampling plan and used the results to determine compliance for each of the individual COCs in each of the areas. The VSP inputs, described in Figure 2 of the FSS Plan (refer to Section 2.3 of HMC, 2017b), resulted in a minimum calculated sample size of 15 samples for each survey unit. Because of the large size of the survey units HMC increased the number of samples per survey unit to 20. Additional biased samples were also collected in cases where hot spots were identified from the gamma scan results. These additional samples are considered biased since they were specifically collected in areas found to have higher gamma readings and were intended to reduce the chance of missing hot spots located between established soil sampling locations. HMC limited soil sampling to surface soil samples (0-15 cm) as they anticipated excavating areas not in compliance to the depth necessary to attain compliance.

The NRC staff evaluated HMC's soil sampling plan, including the determination of the number of sampling points and procedures for handling samples that fail the release criteria, and finds that it is consistent with NUREG-1620, Acceptance Criteria 5.2.3(5) and (6) and therefore acceptable.

Results from the soil sampling are summarized in Table 3, which is a compilation of the results provided in Tables 4, 6, 8, and 10 of the FSS Report. None of the soil samples collected in Section 33 Pivot Irrigation Area, Section 33 Flood Irrigation Area, or the Section 34 flood irrigation area exceeded the release criteria for any of the COCs.

Concentrations of U-nat and Se measured in soil samples collected from Section 28 were all below the New Mexico SSLs, the defined regulatory limits. Section 28 soil samples did include one sample in which the Ra-226 concentration was 80.8 pCi/g, well above the 5 pCi/g cleanup criterion for Ra-226. HMC excavated the area until the follow-up gamma scan results approached the local background levels. At that point, a composite soil sample was collected from the area and evaluated. The resulting Ra-226 concentration following remediation was below the cleanup criterion.

Table 3. Average and range of COC concentrations in surface soils across the four irrigation areas.

	Ra-226 (pCi/g)		U-nat (mg/kg)		Se (mg/kg)	
Survey Unit	Average	Range	Average	Range	Average	Range
28 Pivot (28P)	0.9	0.5 – 1.3	0.7	0.5 – 1.1	0.3	0.3 – 0.4
33 Pivot (33P)	1.2	0.7 – 2.1	1.3	0.6 – 2.5	0.6	0.3 – 1.2
33 Flood (33F)	1.7	1.2 – 3.9	1.6	1.3 – 2.0	0.6	0.4 – 0.7
34 Flood (34F)	2.0	1.5 – 2.8	4.1	1.8 – 7.2	1.3	0.7 – 2.6

The requirements in 10 CFR Part 40, Appendix A, Criterion 6(6), specify that if more than one residual radionuclide is present in the same 100-square-meter area, the sum of the ratios for each radionuclide concentration present to the concentration limit will not exceed “1”. Due to the difference in release limits in soil for U-nat (10.8 pCi/g, toxicity, versus 370 pCi/g, radiological, as calculated by RESRAD) the sum of fractions will be determined by the Ra-226 soil concentrations, which have been demonstrated to be below 5 pCi/g across the LAI areas. The maximum sum of fractions, assuming no background contribution, is 3.9/5, or 0.8.

Based on a review of the results discussed above, the NRC staff finds that the concentrations of COCs in the LAI areas meet the requirements for unrestricted release in accordance with 10 CFR Part 40, Appendix A, Criterion 6(6) and Criterion 6(7).

PIPING AND SPRINKLER SYSTEMS

Separate from the analyses discussed in the FSS Plan and FSS Report, HMC proposed surveying the piping used in the LAI program to determine final dispositioning of this material (HMC, 2018b; ERG, 2014). As stated in the Background Section, NRC staff did not agree with approaches in the FSS plan related to the piping surveys. However, in its latest response to a request for additional information from NRC staff regarding the status of the piping material, HMC stated (HMC, 2020b) that all piping used in the LAI program, including previously buried piping, has been removed from the LAI areas and will be disposed in the small tailings pile (STP). In addition, HMC stated (HMC, 2020b) that the above-ground center pivot sprinkler systems and all related piping have been removed from the LAI areas and will also be disposed in the STP. Therefore, the NRC staff did not evaluate HMC’s process for measuring surface contamination on the piping and other equipment used in the LAI program or the results of those measurements. NRC inspectors confirmed (NRC, 2020a) that all LAI program piping and above-ground center pivot sprinkler systems have been moved to the licensee’s controlled area (HMC, 2019).

DOSE ASSESSMENT

As described in the LAIA Report, HMC used two resident farmer exposure scenarios to calculate radiological doses to the public associated with irrigation activities performed in the LAI areas. The analyses, which were performed using the RESRAD-OFFSITE computer code, consider both an individual living near the irrigated area during the land application project (Scenario #1) as well as a future resident farmer living on the formerly irrigated area following cleanup activities (Scenario #2) (refer to Figure G-1 of HMC, 2017a). According to HMC (HMC, 2017a), although the resident farmer is considered the maximum plausible exposure scenario it is not a reasonably foreseeable land use scenario and is not included in HMC’s future plans for use of the LAI areas. The NRC staff agrees with HMC’s conclusion that the resident farmer exposure scenario is not a reasonably foreseeable land use scenario, given that the EPA has characterized future land use in the area surrounding the GRP as residential (EPA, 2016, 2014a).

The analyses provided by HMC in the LAIA Report used the Section 34 flood irrigation area for modeling the potential radiation dose because the average U-nat soil concentrations were the highest of the four areas and therefore provide the most conservative assessment of impacts

(i.e., the highest calculated radiation dose) from each of the four irrigation areas. HMC used the surface soil concentration for U-nat from the measurements taken in 2012 for the LAI areas as well as the background U-nat soil concentrations established for these areas (refer to Section II above, Establishment of Background Concentrations) in their analyses. Radionuclide soil concentrations for Ra-226, Ra-228, and Th-230 were calculated using the average concentrations of these radionuclides measured in the irrigation water.

Exposure pathways used in the RESRAD-OFFSITE dose calculations included external gamma radiation, inhalation of air particulates and radon, dietary ingestion of plants and meat, and incidental ingestion of soil exposure pathways. Although most residents obtain municipal treated drinking water, HMC also considered the consumption of well water. HMC used a combination of site-specific and default parameter values in the calculations. Specific inputs and additional details regarding the dose assessment calculations can be found in Appendix G of the LAIA Report.

The results of HMC's dose analyses indicate that the total dose for Scenario #1 is less than 0.001 mSv/y (0.1 mrem/y). The total dose to the resident farmer associated with Scenario #2 is 0.003 mSv/y (0.3 mrem/y). The NRC staff reviewed HMC's exposure assumptions, source terms, and site-specific input parameters and determined that they are consistent with NUREG-1620, Appendix H, and therefore acceptable. Although HMC incorporated default values into their dose calculations NRC staff found that their use did not impact the dose and that site-specific parameter values were used where appropriate and satisfy the criteria for ensuring ALARA.

However, as the NRC staff indicated in the Regulatory Considerations Section above, HMC did not provide sufficient justification for not evaluating Ra-226 in the LAI areas. To account for the potential dose from any Ra-226 deposited in the soil from irrigation activities, the NRC staff performed its own dose assessment using RESRAD-OFFSITE, Version 4.0.

For screening purposes, the NRC staff used the same onsite resident farmer scenario used by HMC in the LAIA Report to calculate a dose from Ra-226 in the Section 34 flood irrigation area. Section 34 was selected because it had the highest average Ra-226 concentration of the four sections. Therefore, the NRC staff considers this analysis to be a conservative assessment of impacts (i.e., the highest calculated radiation dose). Instead of evaluating an offsite resident farmer scenario similar to the one used by HMC to evaluate the dose associated with the average U-nat soil concentrations in Section 34, the NRC staff also evaluated an onsite resident gardener scenario. The onsite resident gardener, an individual living on the site and maintaining a small garden for personal use, is considered to be a more reasonably foreseeable land use scenario and is consistent with the EPA's evaluation of future uses for the GRP. This site-specific land use scenario is also consistent with current NRC decommissioning guidance (see, for example, Section 5 of NRC, 2006).

For modeling purposes, the NRC staff calculated the screening resident farmer dose from Ra-226 using the same site-specific exposure pathways and modeling parameters used by HMC to calculate doses from U-nat. The NRC staff then modified the site-specific parameter values to calculate doses to the resident gardener. The resident gardener scenario considered the same exposure scenarios as the resident farmer except for the dietary ingestion of meat. Table 4 lists

the parameter values used to evaluate the resident gardener scenario. All of the doses were calculated without the radon pathway turned on consistent with NUREG-1620.

Table 4. Site-specific parameter values used to calculate the dose to the resident gardener

Parameter	Site-specific value
Contaminated Area	2000 m^2
Contamination Depth	1 m
Occupancy Factors	
Outdoors	0.25
Indoors	0.5
Irrigation applied to:	
Fruit, grain, non-leafy vegetables	0.1 m/y
Leafy vegetables	0.1 m/y
Pasture silage	0 m/y
Livestock feed grain	0 m/y
Offsite dwelling location	0 m/y
Well pumping rate	1140 m^3/y

To account for the dose contributions from the land application activities, the NRC staff performed two dose calculations for both the resident farmer and resident gardener scenarios. The first dose calculation considered the average Ra-226 soil concentration for Section 34, 2.01 pCi/g. The second dose was calculated using a Ra-226 soil concentration of 1.25 pCi/g, the mean Ra-226 soil concentration from the EPA's evaluation of a soil background area near the GRP used for its analysis of a soil removal action for homes in the nearby subdivisions (EPA, 2013). The NRC staff subtracted the doses associated with the background concentrations from the doses calculated using the average Ra-226 concentration associated with Section 34 of the LAI areas to get a net dose of 0.07 mSv/y (7.0 mrem/y) to the resident farmer and 0.02 mSv/y (2.0 mrem/y) to the resident gardener. These calculated Ra-226 doses, when summed with the doses calculated for U-nat, are less than the public dose limit of 1 mSv/y (100 mrem/y) in 10 CFR 20.1301.

In accordance with Condition 14 of the CO, the land application impact assessment must also address non-radiological impacts in accordance with NUREG-1620, Appendix F, Section F.1.4. NRC staff agrees with the use of SSLs established by NMED and the EPA for performing this review. These SSLs have been determined to be protective of human health. As noted in Section 3.4 of the LAIA Report, no U-nat or Se soil concentrations exceeded the established SSL values and therefore pose no health risks, either past, present, or future.

ORISE CONFIRMATORY SURVEY

ORISE performed confirmatory surveys of the four LAI areas. The surveys consisted of gamma radiation surface soil scans and surface (0-15 cm) and subsurface (15-30 cm, 30-60 cm) soil sampling. The null hypothesis statements are identified in the ORISE Report (ORISE, 2019).

Gamma radiation surface soil scans were performed over a systematic, randomly selected population of 400 m^2 areas to identify areas of elevated direct radiation indicative of residual

radioactive contamination. In areas where contamination was identified, further investigation via targeted soil sampling was performed in addition to the random soil sampling. Results from the scans did not identify elevated direct radiation distinguishable from the local background in any of the LAI areas or while traversing between these areas. Therefore, no locations were selected for targeted sampling. Static surface and subsurface gamma measurements collected pre- and post-sampling at all random locations were also consistent with typical detector background count rates for soils. Although background soil samples were not collected, the radionuclide concentrations in the LAI confirmatory soil samples were consistent with expected naturally occurring radioactive material background levels, were less than the proposed release criteria, and were consistent with HMC's FSS results.

Based on the combination of analytical results and gamma radiation scans, ORISE did not identify any anomalies that exceeded the proposed release criteria for Ra-226, and total U-nat. In addition, the confirmatory surveys indicated that radionuclides had not selectively migrated into the subsurface soils (refer to Figures A-52 through A-54 of ORISE, 2019). ORISE also concluded that Th-230 concentrations are not elevated.

The NRC staff finds that HMC has fulfilled this requirement of Condition 14 of the CO.

V. Take immediate action to Ensure that the LAI Areas are not Being Used to Produce Crops for Human Consumption

By memorandum dated June 16, 2017, HMC submitted a statement verifying that it is not using former irrigation areas to produce crops for human consumption. HMC also submitted photographs of the LAI areas corroborating HMC's statement that it is not using former irrigation areas to produce crops for human consumption. In addition, as described in the Background Section of this evaluation, NRC inspectors confirmed (NRC, 2020a) that all LAI program piping and above-ground center pivot sprinkler systems have been moved to the licensee's controlled area (HMC, 2019).

The NRC staff finds that HMC has fulfilled this requirement of Condition 14 of the CO.

CONCLUSION

In accordance with the CO, HMC was instructed to develop a land application assessment to address a series of issues related to previous LAI activities. NRC staff reviewed the LAIA Report, the results of the FSS, and ORISE's independent confirmatory survey to determine whether results of the remediation activities that occurred in the LAI areas satisfy these requirements. In addition, the NRC staff evaluated previous related studies performed by the EPA. Based on the findings in these reports, the NRC staff concludes that conditions within the LAI areas meet the NRC-approved release criteria in Condition 14 of the CO.

HMC was able to identify relevant details related to the LAI project and assess the past, present, and future impacts to LAI areas. Background concentrations, relevant remedial action levels, and current concentrations of COCs in the surface and subsurface were evaluated. Dose calculations considered reasonably foreseeable land use scenarios, appropriate exposure pathways, and site-specific parameter values that provide reasonable assurance that doses are

below the NRC's regulatory limits and satisfy ALARA requirements. These findings are further supported by the findings in ORISE's independent confirmatory survey of the LAI areas.

The NRC staff notes that any change to HMC's proposed disposition of LAI program piping and above-ground center pivot sprinkler systems that does not include disposal in the STP will require the approval of the NRC.

As documented in this evaluation, the NRC staff finds that HMC has fulfilled its requirements under Condition 14 of the CO. Since NRC staff finds that the results of HMC's analysis discussed in Condition 14 of this section indicates that radiological doses and non-radiological risks are not in excess of the NRC-approved remedial action levels (i.e., the concentrations of contaminants of concern in the LAI areas meet the requirements for unrestricted release in accordance with 10 CFR Part 40, Appendix A, Criterion 6(6) and Criterion 6(7)), HMC is not required to take further corrective actions as discussed in Condition 15.

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