Colonie FUSRAP Site - Radioactive Dust Sampling of Residential and Commercial Properties – 16384

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ABSTRACT

The Colonie Formerly Utilized Sites Remedial Action Program (FUSRAP) Site is located in the Town of Colonie, Albany County, New York. The U.S. Army Corps of Engineers (USACE) is currently addressing environmental contamination associated with the Site. The area surrounding the Site consists of residential and commercial properties, known as vicinity properties (VPs). Cleanup activities have been completed on many of these VPs under the FUSRAP to address depleted uranium contamination.

Soil remediation activities have been substantially completed at the Colonie FUSRAP Site and its VPs under the FUSRAP. Recent studies performed by an independent party and under FUSRAP identified uranium within indoor dust in residencies and businesses in the immediate vicinity of the Site. The studies were limited to non-living areas such as basement window sills, garages, and attics.

This paper discusses the indoor dust sampling and analysis, in support of the Remedial Investigation (RI) for the VPs, and presents sampling results. The indoor dust sample media presented many technical challenges regarding sampling design, data reduction, and data interpretation. In addition, because the RI is focused on numerous resident-owned, rental, and commercial properties, challenges where presented regarding right-of-entry to sample. Isotopic uranium ratios observed in the majority of the samples are indicative of the depleted uranium contaminant, even at trace levels. While the sampling and analysis methods were effective at identifying depleted uranium in the majority of the samples, preliminary property-specific risk assessment results do not indicate the presence of depleted uranium in sufficient concentrations to pose unacceptable risk to VP inhabitants.

INTRODUCTION

USACE is executing assessment and cleanup of the Colonie FUSRAP Site under the FUSRAP Program. This is accomplished utilizing the administrative, procedural, and regulatory provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). USACE recently completed sampling and analysis of indoor dust on properties associated with the Colonie FUSRAP Site and Remedial Investigation (RI) reporting. These properties are referred to as Vicinity Properties (VPs) and collectively represent an Operable Unit (OU) of the Colonie FUSRAP Site (separate from the Main Site Soils and Groundwater OUs). The VPs are located in Albany and Colonie, New York, near or along the border of the two towns. Previous studies performed by USACE and others have identified the presence of uranium in

dust within non-living areas of residences (e.g., attics, garages, basements, etc.) (USACE, 2012).

Industrial operations at the Site began in 1923, when a facility was built for manufacturing wood products and toys. In 1937, National Lead (NL) purchased the facility for conducting electroplating operations. In 1958, the nuclear division of NL began producing items manufactured from uranium and thorium under a license issued by the Atomic Energy Commission (AEC) and New York State. The vast majority of NL's work with radioactive materials involved depleted uranium.

The New York State Supreme Court shut down the NL plant in 1984 due to environmental concerns, and ownership of the Site was transferred to the US Department of Energy (DOE). DOE surveyed the VPs surrounding the NL plant for radioactivity in 1980 and determined that depleted uranium released into the air had deposited on residential and commercial properties and structures. DOE's findings also showed that the majority of the deposited uranium was in the direction of the area's prevailing winds.

METHODS

The intent of the RI is to collect sampling data of sufficient quality and quantity to characterize the nature and extent of uranium in dust within VP structures and to determine if uranium in dust poses unacceptable risk to building occupants, requiring action under CERCLA[1]. This was accomplished by:

- Sampling living areas and non-living areas (e.g., attics, garages, crawl spaces) within a representative subset of residential VPs. Sampling is performed in accordance with guidance developed by the U.S. Environmental Protection Agency (USEPA) for sampling of a metal contaminant within household dust, *Guidance for the Sampling and Analysis of Lead in Indoor Residential Dust for Use in the Integrated Exposure Uptake Biokinetic (IEUBK) Model*. (USEPA, 2008).
- Sampling high-use areas (e.g., office areas, retail areas, work areas) and limited-use space (e.g., long term storage areas, attic spaces, lofts) in a smaller subset of commercial properties to verify assumptions regarding exposure potential and to ensure nature and extent of contamination is appropriately characterized.
- Analyzing collected samples for uranium concentration and comparing results to conservative risk-based screening levels to give a preliminary indication of potential for unacceptable risk and to determine if sampling at additional properties is warranted.

[1] Where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10^{-4} and the non-carcinogenic hazard quotient is less than 1, action generally is not warranted unless there are adverse environmental impacts (USEPA, 1991).

- Performing a human health risk assessment for each property with sample results exceeding the screening levels to quantify carcinogenic and non-carcinogenic risk.

The properties that comprise the VP OU were designated by the DOE because they were contaminated with depleted uranium as a result of airborne deposition from stack emissions from the NL plant that formerly operated on the Main Site. The intent of the RI is to determine if uranium in dust poses potential unacceptable risk to occupants of the VPs. It is expected that the highest potential for exposure is to residential building occupants. Thus, the RI sampling effort primarily focused on VPs that are residences. Limited sampling was also performed on commercial properties to verify assumptions regarding exposure potential and to support appropriate characterization of contamination nature and extent. Sampling was conducted within a subset of the VPs.

Site Conceptual Model for Dust Distribution

The basis of the conceptual site model (CSM) for distribution of uranium in VP indoor dust starts with the initiation of nuclear operations at the NL Plant. Specifically, the potential for uranium dust distribution in and around the NL Plant location starts in 1958, when the nuclear division of NL began producing items manufactured from uranium and thorium under a license issued by the AEC. From 1958 through 1984, NL carried out a number of processes using radioactive materials consisting primarily of depleted uranium. Operations were conducted at the plant to reduce depleted uranium-tetrafluoride to depleted uranium metal, which was then fabricated into shielding components, ballast weights for airplanes, and armor piercing projectiles.

Fabrication processes at the NL Plant produced chemically unstable uranium scrap metal, which when finely divided can spontaneously combust due to uranium metal's pyrophoric characteristics. In order to manage this unstable waste stream, NL converted the uranium to an oxide form in a furnace with a filtered exhaust stack. In 1979 New York State investigated claims that the stack filters were bypassed, and subsequently forced the temporary closure of the plant for excessive emissions of uranium to the atmosphere (Romano, 1982). In 1980, Teledyne Isotopes was contracted by NL to perform a radiological survey of the facility and its vicinity; results indicated measurable deposition of radioactive contaminants on properties primarily to the northwest and southeast of the plant, in the directions of prevailing winds. The NL Plant later resumed limited operations after the temporary closure. In 1984 all operations at the NL Plant were ceased when the State of New York forced permanent closure of the facility.

The preceding paragraphs establish the timeframe of NL work with radioactive materials as 1958 through 1984 and a mechanism for contamination of the plant environs via stack emissions. These stack emissions resulted in the contamination of surface soils, roofs, and other outdoor surface features in the NL Plant environs. DOE and USACE have completed structure and soil remediation on affected properties and all properties now meet the soil unrestricted use release criteria. Recent dust

sampling performed by USACE and others indicate the presence of uranium in excess of background within dusts in non-living, limited-use, portions of some VP residences (USACE, 2012).

The primary method for contamination of dust within VP structures is from the airborne emissions that occurred from 1958 through 1984. Initial deposition of this uranium was impacted by environmental dispersion and wind direction at the time of emission. Current uranium concentrations in dust within VP structures may be reduced from the initial concentration at the time of settling due to: 1) routine and periodic cleaning activities; 2) dilution of contaminated dust by addition of uncontaminated dust that settled after 1984; 3) interior and exterior building construction/renovation activities; and 4) other activities that disturb settled dust.

Based on these facts, the CSM is summarized as follows:

- The period of dust contamination is 26 years, from 1958 through 1984, with no sources of uranium to impact VP structure dust in more than 30 years.
- Initial deposition of uranium in dust was caused by stack emissions and followed predominant wind directions. Initial soil contamination was also caused from stack emissions and is proportional to maximum initial dust concentrations.
- Airborne uranium entered VP structures, especially in areas designed to communicate indoor and outdoor air (e.g., roof vents and eaves) and settled in dust.
- Human activities that occurred since 1984 have the potential to reduce or eliminate deposited uranium from dust within VP structures. Routine cleaning activities in VP living areas and high-use areas have likely reduced and possibly eliminated uranium from VP indoor dust.
- The highest uranium concentrations in dust would be expected in undisturbed portions of VP structures. Uranium dust concentrations in these undisturbed locations would be proportional to initial deposition from the stack (and thus proportional to initial soil contamination).

Selection of Residential VPs to Sample

Of the 56 properties that comprise the VP OU, 30 are confirmed residential, potential residential, or mixed residential and commercial and the balance is commercial, industrial, vacant, and/or lacking permanent structures. These 30 VPs are considered “residential” for the purpose of determining properties to sample. Fourteen (14) VPs designated as residential were planned for sampling during the RI field effort. It was expected that sampling of these properties would provide sufficient information to characterize the nature and extent of uranium in residential household dust and support development of informed risk management decisions. This expectation is based on the fact that the primary mechanism for uranium to

become entrained in household dust is via past airborne deposition, which generally followed well characterized prevalent wind directions.

A stratified random sampling plan was developed, in accordance with USEPA guidance (USEPA, 2008), to increase the likelihood of obtaining a representative sample of the range of dust uranium concentrations across the VPs. Stratification was based on the potential for there to be uranium present in the dust above background and the potential magnitude of uranium concentrations in dust. Because uranium in excess of background was identified in non-living area dust samples from each of the four VPs sampled in the USACE 2011 confirmation sampling, the living areas of each of those properties were targeted for sampling. The remaining properties were divided into two groups based on estimated potential for uranium above background to be present as described below (with five properties targeted for sampling in each group).

Pre remediation surface soil sample results were used to stratify the VPs, assuming a positive relationship between the pre remediation surface soil and current dust concentrations (Watters, 2015). Figure 1 is an overlay of the pre remediation survey results on a map of the VPs. This map was used to divide the VPs into groups based on surface soil uranium concentrations prior to remediation.

Three residential stratification groups were ultimately developed:

Group R1: Consists of the four VPs sampled during the 2011 USACE effort (uranium above background was confirmed in non-living area dust in these residences). All properties in this group were targeted for living area sampling.

Group R2: Consists of the 13 residential VPs that had pre-remediation soil uranium concentrations in excess of 3,700 Bq/kg (100 pCi/gram). Five properties in this group were targeted for non-living and living area sampling.

Group R3: Consists of the 13 residential VPs that had pre-remediation soil uranium concentrations less than 2,700 Bq/kg (100 pCi/gram) but greater than 740 Bq/kg (20 pCi/gram). Five properties in this group were targeted for non-living and living area sampling.

Selection of Sample Locations

Four sample locations were established within the living areas of each residence. Sample collection was biased to assess the variability of dust uranium concentration within the residence while also characterizing the dust uranium concentration in areas of the home where children <7 years (<84 months) of age spend most of their time (if children reside in the residence). Dust sample collection was conducted on hard or carpeted surfaces, depending on the location where children spend their time. All sampling was performed on floors because these areas best represent average long-term dust exposure for children (USEPA, 2008). In the event that more than one residential structure existed on a VP, all living area samples were collected within the same structure.

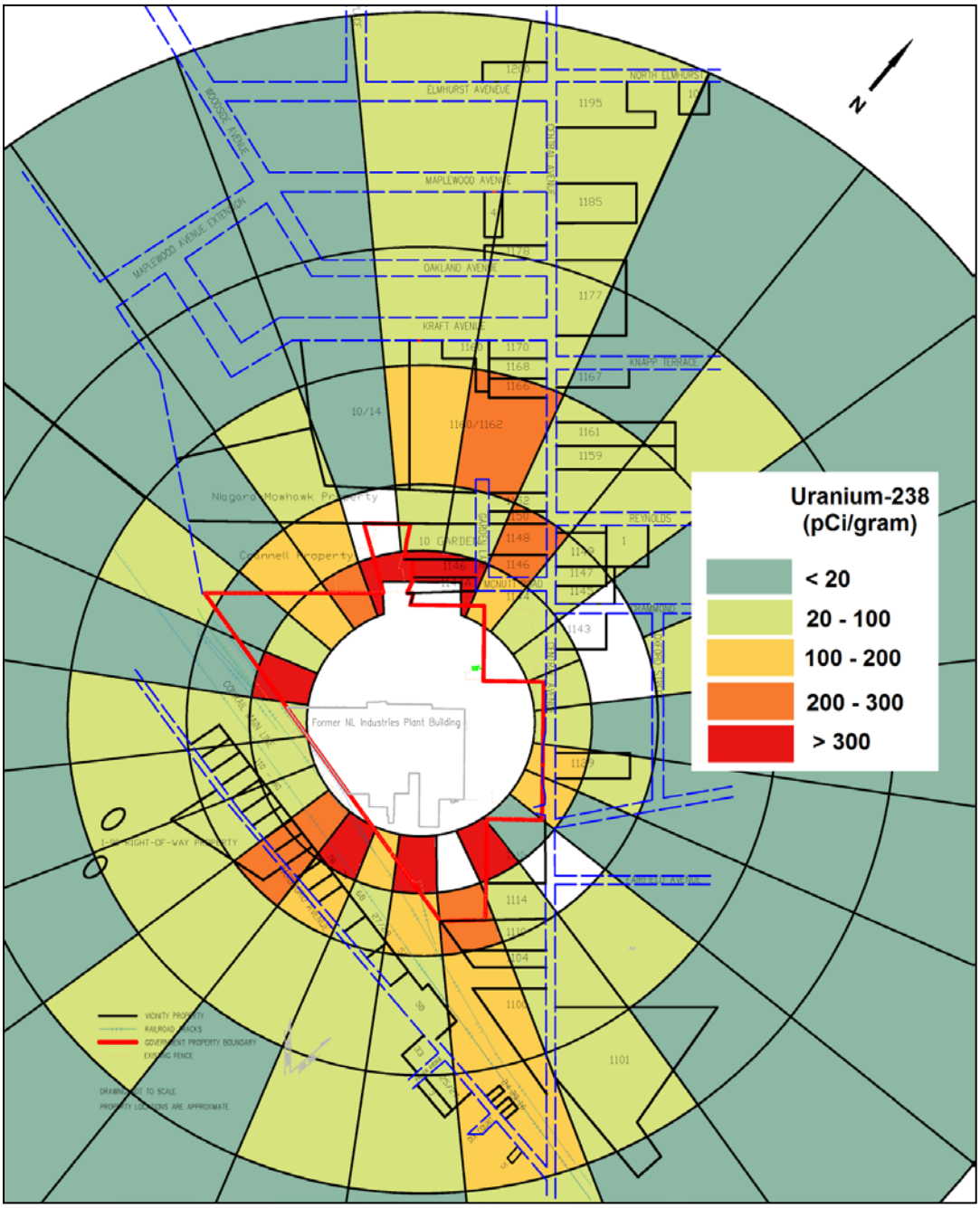

Fig. 1. Pre-Remediation Surface Soil Concentrations (circa 1980)

Four sample locations were established within the non-living areas of each residence, with the exception of Group R1 properties which were already sampled. Non-living areas that were targeted include unfinished attic areas, crawl spaces, unfinished basement areas, and any other unfinished areas where resident use is limited but possible. Such areas could be used for storage or other non-routine or sporadic building occupant use. Determination of sampling locations within each non-living area was performed on a VP-specific basis, as each residence has different conditions

and physical constraints. In some cases access was restricted to areas near the entry point of the non-living area (e.g., attics with a trap door entry). Obstacles such as hazardous floor conditions (e.g., lack of decking), insulation, limited crawl space, and the potential to damage the structure or household contents sometimes prevented access to all non-living areas.

Dust Sampling Methodology

The approach for collecting dust at the four VPs was in accordance with the ASTM D5438-05 *Standard Practice for Collection of Floor Dust for Chemical Analysis* (ASTM, 2005). In this procedure, particulate matter was withdrawn from surfaces by means of a vacuum-induced suction device. Particles were drawn through a sampling nozzle at a specific velocity and flow rate, and then separated mechanically by a cyclone. The cyclone is designed to separate and collect particles with an aerodynamic diameter of approximately five micrometers and larger in a catch bottle. A fine-particle filter was added downstream of the cyclone to collect 99.9% of particles between five and 0.2 micrometers aerodynamic diameter. Non-expendable sampling equipment was decontaminated after each sampling event.

Sampling Equipment

Sampling within living/high-use areas was conducted using a modified HVS3 cyclone vacuum sampler, as specified in the ASTM standard, equipped with filters to collect the fine particles. The HVS3 sampling device was used to sample floor areas. Sampling within non-living/limited use areas was conducted using a modified HVFS cyclone vacuum sampler, as specified in the ASTM standard, equipped with filters to collect the fine particles. In advance of mobilizing to the site, the filters were pre-weighed and uniquely numbered by the analytical laboratory. Pre- and post-sampling weights were used to determine the mass of collected dust on the filters.

Sample Sieving Prior to Analysis

Prior to analysis, samples were sieved by the laboratory in accordance with USEPA guidance (USEPA, 2008). The guidance recommends analyzing only the portion of the dust sample that passes through a No. 60 sieve (250 µm). Researchers who have examined the particle size distribution of dust and soil on children's hands have found that dust particles <200–250 µm are most likely to stick to a child's hands. Sieving also removes non-dust material from the sample (e.g., lint, hair). Studies have also shown that there is generally an enrichment of contaminants in the fine fraction of material (USEPA, 2008).

Analytical Methods

The dust and filter samples from the VPs were analyzed for uranium isotopes via alpha spectrometry analysis (i.e., HASL 300 U-02-RC). Each filter sample was weighed, with the tare weight of the filter subtracted in order to determine the weight of the collected dust. Samples were then digested and analyzed, with both the sample weight (grams) and the isotopic activity (Bq) of the sample reported to support

determination of the activity concentration of all dust collected (both in the sample jar and on the filter).

Action Levels

Action levels were developed for living areas (high-use areas) and non-living areas (limited-use areas) to support evaluation of sampling data and are presented in Table I. Separate action levels were derived based on a dose limit of 0.1 mSv/year (10 mrem/year), a non-carcinogenic hazard quotient of one, and an incremental cancer morbidity risk of 10^{-6}. Sample results were compared to these action levels to give a preliminary indication of the potential for unacceptable risk at the property. As part of the RI, property-specific risk assessments were performed at properties where one or more sample results exceed an action level. The most restrictive action levels were used for this comparison.

TABLE I. Dust Action Levels

Basis	Depleted Uranium Action Level (Bq/kg)	
	Living/High-use Areas	Non-living/Limited-use Areas
Annual dose of 0.1 mSv/yr (10 mrem/yr)	5,700 (155 pCi/g)	41,000 (1,100 pCi/g)
Lifetime cancer risk (10^{-6})	89 (2.4 pCi/g)	2,000 (55 pCi/g)
Target Hazard Quotient of 1	5,100 (139 pCi/g)	5,100 (139 pCi/g)
Most Restrictive Action level	**89 (2.4 pCi/g)**	**2,000 (55 pCi/g)**

DISCUSSION

Early in the implementation process, it became apparent that obtaining rights of entry from property owners was going to be a challenge. The vast majority of the residential property owners contacted either denied entry or failed to respond to multiple requests for right to enter. Ultimately, all residential property owners were contacted and sampling was conducted at all VPs where access was granted.

The survey design included sampling of the living areas in the four Group R1 VPs (non-living areas were previously sampled in these VPs) and sampling of the living and non-living areas in five Group R2 VPs and five Group R3 VPs. These survey goals were not met due to VP owner reluctance to grant access for sampling. None of the Group R1 VP owners granted sampling access during the RI; thus, no living area samples were collected from R1 properties. Only three Group R2 and three Group R3 granted access for sampling; both living and non-living area samples were collected from three R2 and three R3 VPs.

Ultimately, samples were collected from ten residential VPs, three commercial VPs, and one background property. The background property was approximately 8 km

from the Colonie Site, in a direction where wind was not predominant.

Results of Sampling

The dust and filter samples were analyzed for uranium isotopes via alpha spectrometry analysis. For each sample location, filter results and volumetric results were combined to determine total uranium activity. Table II provides a summary of the results.

Many of the sample results exceeded the established RI action levels and most of the VPs sampled had at least one sample result in excess of an action level. The RI design included performance of, property-specific risk assessments at properties where one or more sample results exceed an action level. However, due to the number of results in excess of action levels and for the sake of conservatism and completeness, property-specific risk assessments were performed at all properties (see "Human Health Risk Assessment" below).

TABLE II. Summary of Dust Sample Results

Property ID	Total Uranium (Bq/kg)				Total Uranium (pCi/g)			
	High Use		Limited Use		High Use		Limited Use	
	avg	max	avg	max	avg	max	avg	max
BACKGROUND	26	31	25	32	0.7	0.84	0.69	0.86
Residential 01	--	--	500	880	--	--	13	24
Residential 02	--	--	**2,500**	**5,400**	--	--	**69**	**150**
Residential 03	--	--	**10,000**	**23,000** [(a)]	--	--	**270**	**630** [(a)]
Residential 04	**110**	**155**	48	52	**2.9**	**4.2**	1.3	1.4
Residential 05	37	48	170	400	1.0	1.3	4.5	11
Residential 06	68	**110**	200	330	1.8	**3.0**	5.3	9.0
Residential 07	68	**100**	56	67	1.8	**2.8**	1.5	1.8
Residential 08	**92**	**130**	320	650	**2.5**	**3.5**	8.8	18
Residential 09	75	82	570	1400	2.0	2.2	15	38
Residential 10	--	--	900	**2,600**	--	--	24	**71**
Commercial 01	42	80	67	110	1.1	2.1	1.8	2.9
Commercial 02	39	49	85	200	1.0	1.3	2.3	5.4
Commercial 03	44	53	135	193	1.2	1.4	3.7	5.2

Bold indicates result in excess of survey action level
"--" indicates sample not collected
[(a)] Sample collected from detached garage attic

Depleted Uranium Persistence

Natural uranium is ubiquitous to the environment and was identified in samples collected from the background sampling location at an average total uranium concentration of 26 Bq/kg (0.7 pCi/gram). Natural uranium is expected to exhibit a ^{238}U to ^{234}U activity concentration ratio of approximately one, as was observed in the background samples which exhibited ratios of approximately one.

Over 95% of the VP sample total uranium results exceeded the average background result and are indicative of trace or greater quantities of depleted uranium. The depleted uranium contaminant at the Colonie FUSRAP Site exhibits a ^{238}U to ^{234}U activity concentration ratio of approximately 5.3. The vast majority of the VP samples exhibited ^{238}U to ^{234}U activity concentration ratios in excess of one. Figure 2 is a plot of observed net ^{238}U to ^{234}U ratios (with average background subtracted) for all samples with total uranium in excess of twice background. Isotopic ratios for these samples typically exceed one and approach the expected value of 5.3 as total uranium concentration increases (as the relative uncertainty in the ratio is smaller with higher concentrations). The average of all data in Figure 2 is 5.2, which is statistically equivalent to the contaminant ratio of 5.3.

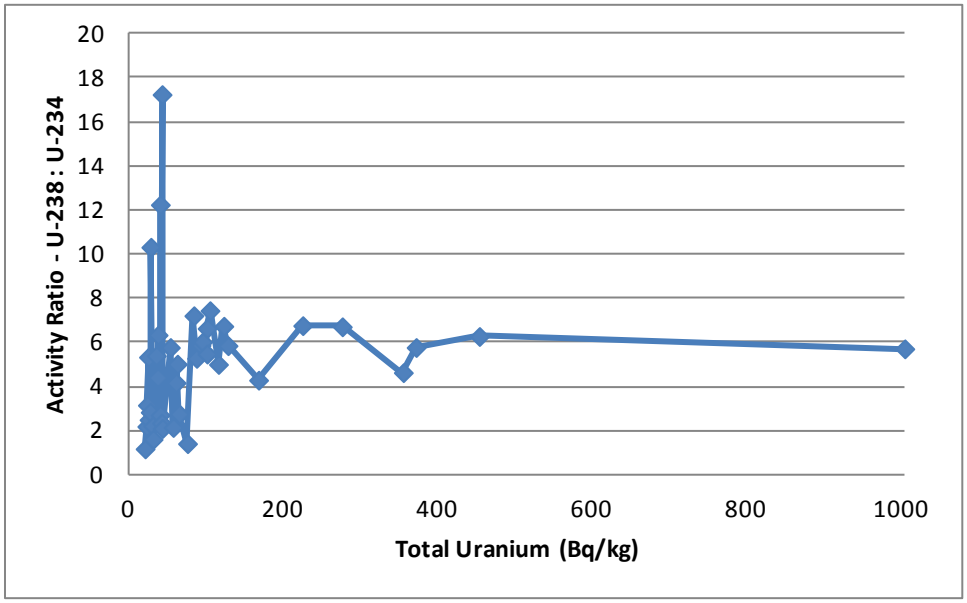

Fig. 2. Observed Isotopic Ratios (^{238}U : ^{234}U)

Human Health Risk Assessment – Preliminary Results

All RI sample results were less than the annual dose based action level and it was unnecessary to perform a dose assessment based on RI data. However, some results exceeded other action levels. Thus, a human health risk assessment (HHRA) was performed. The HHRA evaluated potential current or future human cancer and

non-cancer health hazards from exposure to depleted uranium in indoor dust in the ten residential, three commercial, and one background properties. The receptor types evaluated included both residential (child and adult), adolescent garage user and worker receptors. HHRA results are considered preliminary at this time because the RI report is not yet finalized.

For each property, the dust sample having the maximum depleted uranium concentration was conservatively used to estimate potential receptor exposure and calculate potential human health risks and hazards. The primary target organ for depleted uranium by both the ingestion and inhalation routes of exposure is the kidney for both child and adult receptors.

For resident child receptors, non-cancer hazard indices were less than unity for all 13 VPs. All carcinogenic risks for child receptors were within the carcinogenic risk range of from 1E-06 to 1E-04 and did not pose an unacceptable risk to children. When carcinogenicity was considered for a combined child/adult, results for all 13 VPs were below or within the CERCLA carcinogenic risk range.

At one VP, where a detached garage was sampled, an adolescent receptor was considered. The adolescent garage user exhibited a non-cancer hazard index of less than unity. The carcinogenic risk for the adolescent receptor was within the CERCLA carcinogenic risk range as well.

The non-cancer hazard quotient for the adult workers exposed to depleted uranium in indoor dust at the three commercial vicinity properties were all far less than 1 for all three properties. The carcinogenic risk for adult workers was below the CERCLA risk range as well.

CONCLUSIONS

The USACE successfully implemented an RI field effort to sample uranium in dust within residential and commercial VP properties at the Colonie FUSRAP Site. The USEPA sampling guidance for lead in homes, *Guidance for the Sampling and Analysis of Lead in Indoor Residential Dust for Use in the Integrated Exposure Uptake Biokinetic (IEUBK) Model*, has proven to be a useful and appropriate sampling framework for the effort. Dust sampling methods identified in *ASTM Method D5438 – 05, Standard Practice for Collection of Floor Dust for Chemical Analysis* (ATSM, 2005) are appropriate for sampling of uranium in dust and are implementable with procurement of off-the-shelf sampling devices.

Obtaining rights of entry on properties proved to be a challenge and limited the ultimate scope of RI sampling. Observed isotopic uranium ratios in the majority of the VP samples are indicative of depleted uranium, even when present at trace levels. While the sampling and analysis methods were effective at identifying depleted uranium in the majority of the samples, preliminary property-specific risk assessment

results do not indicate the presence of depleted uranium in sufficient concentrations to pose unacceptable risk to VP inhabitants.

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