State of Illinois
Illinois Emergency Management Agency

2018 Radiological Environmental Monitoring Report of the Honeywell Metropolis Works Facility

IEMA

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Introduction

The Illinois Emergency Management Agency (IEMA) is charged with protecting the citizens of Illinois from the potentially harmful effects of radioactive materials. In support of that mission, IEMA's Division of Nuclear Safety monitors the environment in Illinois for the presence of radionuclides through its radiological environmental monitoring program. This program has three primary functions: 1) collection of diverse samples from carefully chosen locations on a routine basis; 2) analyzing samples for radionuclides; and 3) evaluation of test results on both an annual and historical basis.

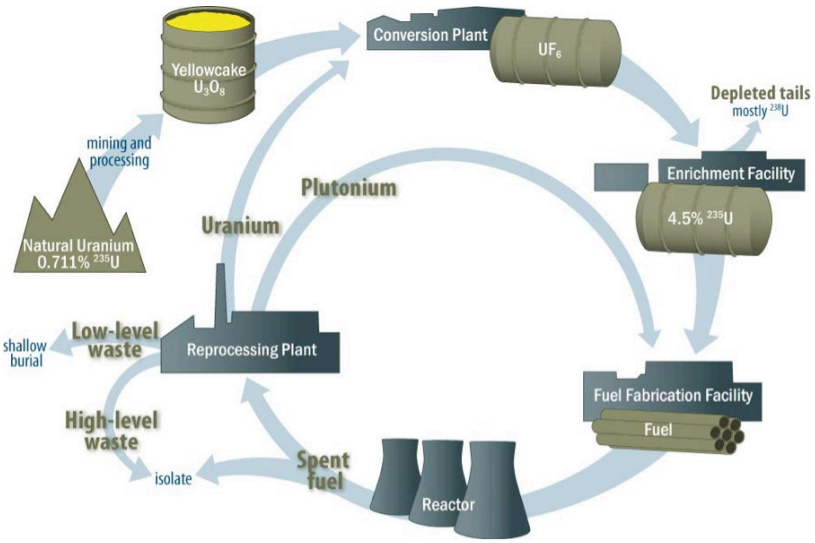
One of the locations monitored by IEMA is the environs of the Honeywell Metropolis Works (HMW) Facility near Metropolis, Illinois. The purpose of this report is to provide updated results of monitoring conducted during calendar year 2018.

Site Description

Located on approximately 1,100 acres of land within Massac County and on the peripheries of Metropolis, Illinois, the Honeywell Metropolis Works (HMW) facility perimeter is formed by U.S. Highway 45 to the north, the Ohio River to the south, a coal terminal to the west, and the city of Metropolis to the east. The facility footprint and the land immediately surrounding the facility form a 60-acre restricted area as required by HMW's United States Nuclear Regulatory Commission's (US NRC) Radioactive Materials License, number SUB-526. This restricted area is intended for the protection of the public from exposure to radiation and radioactive materials.

Opened in 1958, the HMW, a subsidiary company of Honeywell International Inc., plays a crucial role in the nuclear fuel cycle by converting uranium ore (U_3O_8) into uranium hexafluoride (UF_6). HMW is unique in that it is the only facility in the United States that produces UF_6. As depicted in Figure 1, conversion is the second step in the nuclear fuel cycle immediately following mining and processing and preceding enrichment

Figure 1. Nuclear Fuel Cycle



HMW uses a dry conversion process to convert U_3O_8 to UF_6. The process first strips the U_3O_8 of impurities such as sodium and potassium. The material is then treated with nitrogen to form UO_2 and then hydrofluorinated with hydrofluoric acid to form uranium tetra-fluoride (UF_4). The UF_4 is treated with fluorine gas to form UF_6. After HMW converts U_3O_8 into UF_6, the UF_6 is then processed, packaged and transported to enrichment plants, both domestic and foreign, where the UF_6 is enriched either by gaseous diffusion or gas centrifugation. The enriched UF_6 is then sent to fuel fabrication facilities and processed into fuel pellets for nuclear power plants.

In 2017, Honeywell announced plans to idle the HMW plant. Preparation for the idle state began late in the year, with plans to have the plant completely idle by early 2018. Full uranium hexafluoride cylinders continued to be shipped through March 2018. The plant reached a ready-idle state by the end of March 2018. During the ready-idle state, the plant will conduct minimal operations and the amount of hazardous materials on-site has been greatly reduced. Uranium ore will continue to be received, sampled, assayed, and stored throughout the idle period. Security will be maintained, and emergency response capabilities will be commensurate with the hazards on-site. Honeywell's current plans are for the plant to remain idle until 2020, or until the market conditions improve. Additionally, Honeywell is in the process of, and will continue to pursue a license renewal with the NRC.

Although the HMW facility is licensed by the US NRC, the Illinois Emergency Management Agency (IEMA) maintains a presence in the surrounding communities through our radiological environmental monitoring program. The overall purpose of IEMA's radiological environmental monitoring program, in relation to the HMW facility, is to determine if a radiological environmental impact is detected in the environs of the facility due to its operation, as well as determine long-term trends in environmental radiation levels.

IEMA Radiological Environmental Monitoring Program

The IEMA radiological environmental monitoring program consists of sample collection and laboratory analysis, as well as review and analysis of the resulting data. As part of the 2018 HMW radiological environmental monitoring program, samples were collected from various locations around the HMW facility and the greater Metropolis area. Appendix A contains maps of the area around the HMW plant that indicate IEMA's sampling locations.

Sampling included water, vegetation, air, direct radiation, soil, and sediment. Analyses vary from media to media but focus primarily on natural uranium. A general description of sample collection, analysis, and results follows. Sample result tables are located in Appendix B and C.

Sampling and Monitoring Activities

Air Sampling

Air particulate samples are collected from a network of five strategically positioned environmental monitoring stations (EMS) within the environs of HMW. Each EMS is comprised of a continuous low-volume vacuum pump and air filter assembly. Particulate filter samples are exchanged and analyzed weekly.

Soil Sampling

Soil samples are collected from four sampling locations during the second and third quarters of the year and analyzed for radionuclides that may have been transported from the environment and incorporated into the soil. Soil is sampled at a depth of six inches to monitor the migration of radionuclides away from the soil surface and at one inch to monitor for deposition of radionuclides on the soil surface.

In October of 2018, IEMA collected deposition and migration soil samples from ten southern Illinois locations in order to establish background soil concentrations that better represent the area. Results from these samples will be used to determine future analytical thresholds and may be used for data comparison purposes.

Sediment Sampling

Sediment samples are collected from two sampling locations during the second and third quarters of the year to determine whether contaminants previously in solution or suspension have settled out of a body of water and, therefore, cannot be identified through water sampling.

Vegetation Sampling

Vegetation samples are collected from four sampling locations during the second and third quarters of the year and analyzed for radionuclides that may have been transported from the environment and incorporated into or on plant tissue.

Water Sampling

Water samples are collected and analyzed to ensure that radionuclides attributable to the HMW facility have not migrated into off-site water sources.

Direct Radiation Monitoring

Unlike the environmental samples described above, dosimeters do not provide information on what radionuclides are found in the environment. Instead, dosimeters provide a direct measurement of the total dose produced by all sources of gamma radiation, including naturally occurring radionuclides and cosmic rays. A network of nineteen optically-stimulated luminescent dosimeters (OSLs) is arrayed around the HMW facility; dosimeters are exchanged and analyzed quarterly.

Background Reference Areas

IEMA has established the environs of Sangchris Lake State Park, a cooling lake for a coal-fired power station near Kincaid, IL, as the background sampling location for water, sediment, and vegetation samples. Air monitoring stations in Springfield and Marion, IL are used for background reference locations for air samples. To establish "background" radiation levels, samples are collected and analyzed utilizing the same procedures and methodologies used for the Sheffield LLRW site samples.

As mentioned in the soil sampling section of this report, in October of 2018 IEMA collected deposition and migration soil samples from ten southern Illinois locations in order to establish a background soil concentration that better represents the area.

Results for background samples can be found in Appendix C.

General Sampling and Monitoring Information

Every effort is made to collect all scheduled environmental samples; however, occasionally samples are unobtainable due to weather conditions, water levels, or obstructed access.

Laboratory Analysis

Soil, sediment, vegetation, water, and air samples were analyzed by the IEMA Radiochemistry Laboratory located in Springfield, IL. The laboratory participates in semi-annual proficiency testing programs through Environmental Resource Associates, an accredited proficiency testing provider, and the Department of Energy (DOE) Radiological and Environmental Science Laboratory's Mixed Analyte Performance Evaluation Program (MAPEP). A general description of each analysis performed is provided below.

Gross Alpha/Beta Analysis

Air particulate filters are exchanged and analyzed weekly for airborne radioactivity through gross alpha and beta analysis using a gas proportional counter. Since radionuclides associated with natural uranium emit either alpha or beta particles, analysis of air particulate samples for gross alpha/beta activity provides a good method of screening for the presence of radioactive materials.

Two "trigger" levels are used to determine if additional analysis is required for air particulate samples. These levels represent approximately 25% and 100% of the total uranium effluent concentration limit of 90 fCi/m³ established in 10CFR20, Appendix B.

Trigger levels are set at:

- Gross alpha results at or above 25.0 fCi/m3 are evaluated to determine if Kinetic Phosphorescence Analyzer (KPA) analysis will need to be performed.
- Samples with gross alpha results at or above 90 fCi/m3 require KPA analysis.

Gamma Analysis

Soil, vegetation, and sediment samples are analyzed to determine the concentration of individual radionuclides using a high-purity germanium detector in a process called gamma spectroscopy. Gamma spectroscopy results for soil, sediment, and vegetation are reported using Uranium-238 daughter products, Radium-226 and Thorium-230. Gamma spectroscopy results are displayed in Appendix B-Tables B.6 and B.7 for soil and Table B.14 for sediment samples.

For soil and sediment samples, an additional analysis for gamma ingrowth is completed. After the initial gamma spectroscopy analysis is complete, samples are sealed and stored for at least 28 days to allow for the ingrowth of daughter products. The samples are once again analyzed using gamma spectroscopy for radium-226 and thorium-230. Gamma spectroscopy results for gamma ingrowth are displayed in Appendix B-Tables B.8 and B.9 for soil and Table B.15 for sediment samples.

Isotopic Uranium Analysis

Isotopic uranium analysis via alpha spectroscopy is used to determine specific uranium-234 (U-234), uranium-235 (U-235), and uranium-238 (U-238) concentrations. Although more labor intensive, isotopic uranium analysis provides a more accurate representation of the concentration of uranium present within a sample compared to the past practice of using Pa-234m as a surrogate for U-238, and is capable of detecting much smaller concentrations. All soil, vegetation, and sediment samples are analyzed using this method. Isotopic Uranium results can be found in in Appendix B-Tables B.10 and B.11 for soil, and Table B.16 for sediment samples.

Kinetic Phosphorescence Analyzer (KPA) Analysis

Water samples are analyzed for the presence of uranium using Kinetic Phosphorescence Analyzer (KPA) analysis. Air particulate samples with results above the established Gross alpha/beta Triggering Levels may also be analyzed using KPA.

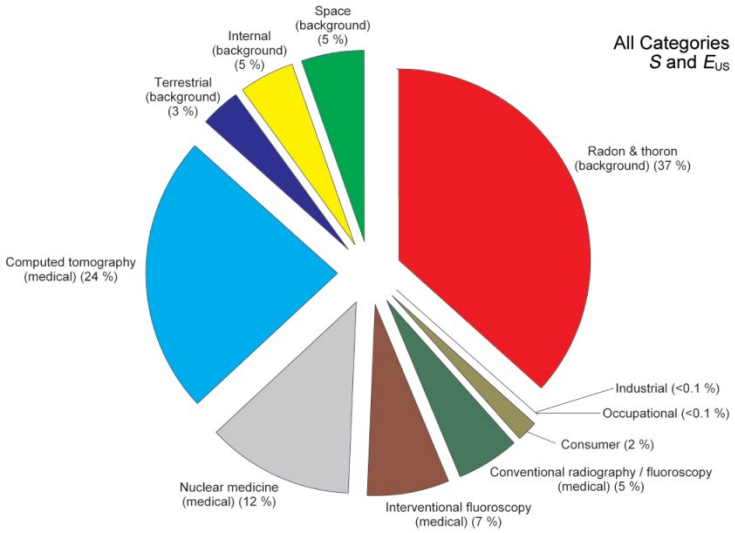
Optically Stimulated Luminescence Analysis

Optically Stimulated Luminescence (OSL) dosimeters provide a direct measurement of the total dose received from all sources of gamma radiation, including naturally occurring radionuclides and cosmic rays. The dosimeters are used to monitor for small changes in ambient background levels of gamma radiation that could result from releases of radioactive material or exposure to large quantities of stored material on-site.

OSLs are analyzed by IEMA staff using a Landauer In Light System Auto Reader. Results are expressed as the average milliroentgen (mR) per quarter, and are also calculated to the approximate mR per year that would have been accrued by an individual at that location for an entire year.

The ambient gamma results can be compared to the average annual radiation exposure to an individual of 620 mR/year from various sources (according to the 2009 National Council on Radiation Protection's (NCRP) Report 160). Approximately 8% (49.6 mR/year) of that exposure is from Terrestrial and Cosmic radiation (background radiation), Figure 2.

Figure 2. Sources of Radiation Exposure to Man



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Minimum Detectable Concentration (MDC)

All analytical methods have limitations: amounts that are too small to be detected. The Minimum Detectable Concentration (MDC) is an "a priori" measure of that limitation – an estimate of the lower limit of detection. It is defined as the smallest quantity that an analytical method has 95% likelihood of detecting. For example, the MDC for IEMA's method for tritium in water is 200 picocuries per liter (pCi/L). Given a sample with a tritium concentration of 200 pCi/L, our laboratory would detect that tritium approximately 95 times out of 100. Samples with less than 200 pCi/L could be detected, but with less certainty. Conversely, samples with more than 200 pCi/L would be more likely to be detected, approaching 100% as concentrations increase. Analytical methods are chosen, in part, on their MDC. As a general rule, methods are chosen such that their MDC is less than 10% of any applicable regulatory limit.

Radiological Environmental Sampling and Monitoring Results

Air Sampling Results

Air particulate sample results are compared to historical data collected from the environs of the HMW facility, and to sample data collected from the background reference locations. Results from each of the five air monitoring stations are displayed in Appendix B -Tables B.1 – B.5.

Results are comparable to results obtained from background EMSs located in Marion and Springfield, IL, and are consistent with data previously collected by IEMA as part of its HMW radiological environmental monitoring program. All air particulate sample results for 2018 remain below the Trigger Levels established by IEMA.

Soil Sampling Results

Soil sample results are compared to historical data collected from the environs of the HMW facility, sample data collected from the background reference location, and to sample data collected from soil sampling performed in October 2018 to establish an area wide background concentration level. Analytical results are shown in Table B.6-B.11.

Gamma and gamma ingrowth spectroscopy results for soil samples are comparable to results obtained from the background sampling locations and are consistent with data previously collected by IEMA as part of its HMW radiological environmental monitoring program.

Isotopic uranium results for samples collected from the Metropolis Airport and from the intersection of Gurley and Devers are comparable to results obtained from the background sampling locations and consistent with historical data. Results from samples taken from the Massac Creek at Country Club Road location are significantly lower than background sample results, likely due to the sand content of the soil at that location. Results from samples collected at the Nearest Residence, although consistent with historical data, are higher than results found at the background reference location in Kincaid, IL, as well as results obtained from samples collected in and around the Massac County area in October of 2018.

Sediment Sampling Results

Sediment sample results are compared to historical data collected from the environs of the HMW facility, and to sample data collected from the background reference location. Analytical results are shown in Table B.14-B.16.

Results for gamma spectroscopy analysis indicated a slightly elevated concentration of Ra-226 in the Ohio River at Joppa sample collected in May of 2018. Results from gamma ingrowth analysis on a sample collected from that location in August of 2018 show that the Ra-226 concentration had returned to a level consistent with historical and background data.
Results from gamma ingrowth analysis, although above the established MDC for Ra-226, are comparable to historical data collected from the environs of the HMW facility, and to sample data collected from the background reference location.

Results for isotopic uranium analysis of sediment samples collected from the Ohio River at Joppa on May 1, 2018 and the public boat launch near Harrah's Casino on August 8, 2018 indicated a slight elevation in U-234 and U-238 concentrations when compared to sediment samples collected from the background reference locations. Since 2018 was the first year that isotopic uranium analysis was performed on sediment samples, there is no historical data to compare the results to. However, the U-234 and U-238 concentrations found in the sediment samples are comparable to the concentrations found in soil samples collected by IEMA in October of 2018 to establish a representative background concentration for the area.

Vegetation Sampling Results

Vegetation sample results are compared to historical data collected from the environs of the HMW facility, and to sample data collected from the background reference location. Analytical results are shown in Table B.12 for gamma analysis and B.13 for isotopic uranium analysis.

All gamma spectroscopy results for vegetation samples are below established MDCs. Isotopic uranium results for vegetation samples are comparable to results found in vegetation samples collected from the background reference locations at Kincaid, IL.

Water Sampling Results

Water sample results are compared to historical data collected from the environs of the HMW facility. Analytical results for water samples are displayed in Table B.18.

Results are consistent with data previously collected by IEMA as part of its HMW radiological environmental monitoring program. Water samples collected at the background reference locations in Kincaid, IL have not historically been analyzed using KPA. Beginning in 2019, all water samples collected from the Kincaid background locations will be analyzed using KPA, and compared to samples collected as part of the HMW radiological environmental monitoring program.

Direct Radiation Monitoring Results

OSL results are compared to historical data collected from the environs of the HMW facility, and to sample data collected from the background reference location. Results are displayed in Table B.18.

Results indicated that the highest annual exposures were found at locations METR-16, 31, 32, and 33. These four OSLs represent IEMA's nearest direct radiation monitoring points to the HMW plant. Due to their proximity to the facility, slightly elevated results can be expected.

The annual exposure recorded at the METR-32 location was over twice that seen at most Metropolis and background reference area monitoring locations. METR-32 is located near an entrance to the plant where

shipments of uranium ore are delivered. Therefore, much of the elevated exposure rate can be attributed to its close proximity to uranium ore transportation activities in that area, and not attributable to plant operations.

Summary

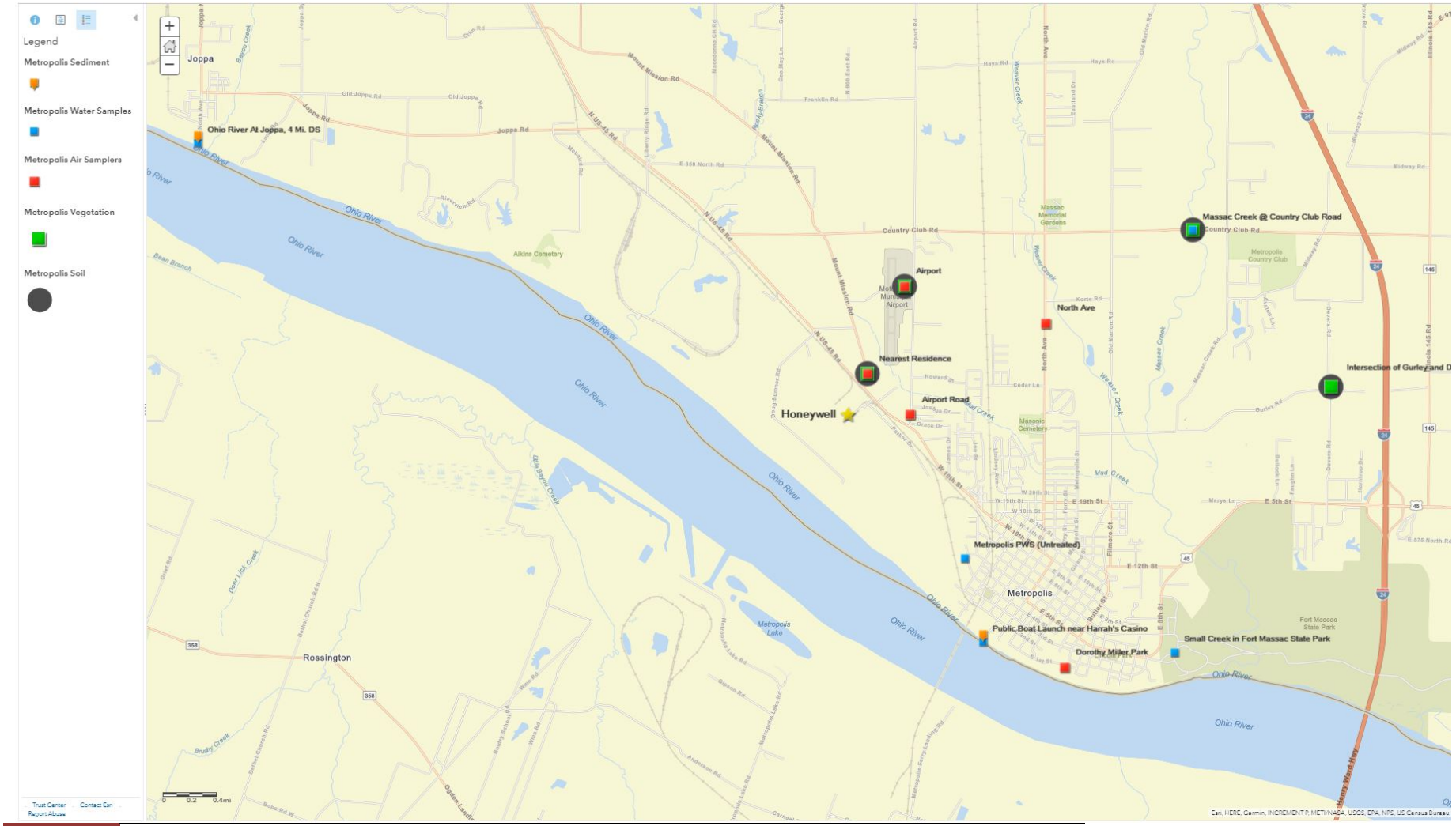
In 2018, sampling and monitoring results collected as part of IEMA's HMW radiological environmental monitoring program indicate that radioactivity levels remain consistent with data collected in previous years. As seen in previous years, results from sampling and monitoring locations found near the facility indicate slightly elevated levels of radioactivity in the soil and air when compared to samples collected away from the facility or from background reference areas. Similarly, direct radiation monitoring near the facility shows a slight increase in exposure in those areas when compared to other monitoring locations found away from the plant and background reference areas.

IEMA began using isotopic uranium analysis via alpha spectroscopy to determine specific uranium-234 (U-234), uranium-235 (U-235), and uranium-238 (U-238) concentrations for some soil samples collected in 2017, that practice was expanded in 2018 to include all soil, vegetation, and sediment samples collected. Although more labor intensive, isotopic uranium analysis provides a more accurate representation of the concentration of uranium present within a sample compared to the past practice of using Pa-234m as a surrogate, and is capable of detecting much smaller concentrations.

In March of 2018 the HMW plant was put in a ready-idle state. While in the ready-idle state the plant has discontinued production, greatly reduced the amount of hazardous materials on-site, and will conduct only minimal operations. Uranium ore will continue to be received, sampled, assayed, and stored throughout the idle period. Security will be maintained, and emergency response capabilities will be commensurate with the hazards on-site. Honeywell's current plans are for the plant to remain idle until 2020, or until the market conditions improve.

APPENDIX A
Maps of Monitoring and Sampling Locations around Metropolis

Map A.1. Sampling Locations



Map A.2. Optically Stimulated Luminescence (OSL) Monitoring Locations

APPENDIX B
Sample Analysis Results for Samples Collected from the Environs of the HMW Facility

Table B.1 Sample Results for Alpha / Beta Screening of Air Particulate Filters
Nearest Residence
Results are in femtocuries per cubic meter (fCi/m^3)

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Nearest Residence				
1/4/2018	8.9	3.9	49.3	5.2
1/9/2018	6.1	3.9	39.3	5.2
1/23/2018	<MDC	3.9	25.1	5.2
1/30/2018	4.0	3.9	29.9	5.2
2/6/2018	<MDC	3.9	24.5	5.2
2/14/2018	4.9	3.9	30.8	5.2
2/20/2018	<MDC	3.9	30.4	5.2
3/6/2018	<MDC	3.9	22.8	5.2
3/20/2018	<MDC	3.9	25.3	5.2
3/27/2018	4.5	3.9	23.3	5.2
4/3/2018	<MDC	3.9	19.1	5.2
4/11/2018	<MDC	3.9	24.7	5.2
4/18/2018	<MDC	3.9	19.1	5.2
4/23/2018	5.1	3.9	18.1	5.2
5/1/2018	<MDC	3.9	16.9	5.2
5/8/2018	<MDC	3.9	27.5	5.2
5/15/2018	<MDC	3.9	29.8	5.2
5/22/2018	<MDC	3.9	24.8	5.2
5/29/2018	<MDC	3.9	9.0	5.2
6/5/2018	<MDC	3.9	18.9	5.2
6/12/2018	<MDC	3.9	40.2	5.2
6/19/2018	<MDC	3.9	40.1	5.2
6/26/2018	<MDC	3.9	7.6	5.2

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Nearest Residence				
7/3/2018	<MDC	3.9	26.3	5.2
7/11/2018	<MDC	3.9	24.6	5.2
7/18/2018	<MDC	3.9	33.5	5.2
7/25/2018	<MDC	3.9	38.5	5.2
7/31/2018	<MDC	3.9	35.2	5.2
8/8/2018	<MDC	3.9	38.1	5.2
8/15/2018	<MDC	3.9	34.3	5.2
8/22/2018	<MDC	3.9	29.8	5.2
8/27/2018	<MDC	3.9	41.7	5.2
9/11/2018	<MDC	3.9	17.6	5.2
9/19/2018	<MDC	3.9	26.0	5.2
9/26/2018	<MDC	3.9	23.9	5.2
10/2/2018	4.4	3.9	36.1	5.2
10/9/2018	<MDC	3.9	29.8	5.2
10/17/2018	<MDC	3.9	19.1	5.2
10/22/2018	<MDC	3.9	21.5	5.2
10/29/2018	<MDC	3.9	29.7	5.2
11/8/2018	<MDC	3.9	28.7	5.2
11/14/2018	<MDC	3.9	32.3	5.2
11/21/2018	4.6	3.9	35.8	5.2
11/29/2018	4.5	3.9	40.3	5.2
12/5/2018	4.1	3.9	20.8	5.2
12/10/2018	<MDC	3.9	33.9	5.2
12/19/2018	<MDC	3.9	25.2	5.2

Table B.2 Sample Results for Alpha / Beta Screening of Air Particulate Filters
Metropolis Airport
Results are in femtocuries per cubic meter (fCi/m³)

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Airport 1 Mi. NNE				
1/4/2018	6.5	3.9	34.8	5.2
1/9/2018	6.2	3.9	41.3	5.2
1/23/2018[a]				
1/30/2018[a]				
2/6/2018[b]	<MDC	53.3	<MDC	134.6
2/14/2018	4.3	3.9	23.7	5.2
2/20/2018	<MDC	3.9	25.4	5.2
3/6/2018	<MDC	3.9	22.0	5.2
3/20/2018	<MDC	3.9	27.4	5.2
3/27/2018	<MDC	3.9	21.6	5.2
4/3/2018	<MDC	3.9	17.3	5.2
4/11/2018	<MDC	3.9	26.3	5.2
4/18/2018	<MDC	3.9	19.0	5.2
4/23/2018	<MDC	3.9	20.2	5.2
5/1/2018	<MDC	3.9	20.8	5.2
5/8/2018	<MDC	3.9	27.2	5.2
5/15/2018	<MDC	3.9	37.5	5.2
5/22/2018	<MDC	3.9	25.6	5.2
5/29/2018	<MDC	3.9	28.4	5.2
6/5/2018	<MDC	3.9	20.4	5.2
6/12/2018	<MDC	3.9	36.7	5.2
6/19/2018	<MDC	3.9	35.7	5.2
6/26/2018	<MDC	3.9	6.8	5.2

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Airport 1 Mi. NNE				
7/3/2018	<MDC	3.9	23.5	5.2
7/11/2018	<MDC	3.9	28.4	5.2
7/18/2018	<MDC	3.9	34.0	5.2
7/25/2018	<MDC	3.9	40.4	5.2
7/31/2018	<MDC	3.9	38.6	5.2
8/8/2018	<MDC	3.9	39.1	5.2
8/15/2018	<MDC	3.9	33.4	5.2
8/22/2018	<MDC	3.9	29.0	5.2
8/27/2018	<MDC	3.9	44.1	5.2
9/11/2018	<MDC	3.9	16.6	5.2
9/19/2018	<MDC	3.9	27.2	5.2
9/26/2018	<MDC	3.9	15.7	5.2
10/2/2018	<MDC	3.9	36.1	5.2
10/9/2018	<MDC	3.9	31.2	5.2
10/17/2018	<MDC	3.9	19.5	5.2
10/22/2018	<MDC	3.9	20.9	5.2
10/29/2018	<MDC	3.9	26.1	5.2
11/8/2018	<MDC	3.9	26.8	5.2
11/14/2018	<MDC	3.9	31.0	5.2
11/21/2018	<MDC	3.9	39.2	5.2
11/29/2018	4.1	3.9	42.8	5.2
12/5/2018	4.0	3.9	21.8	5.2
12/10/2018	<MDC	3.9	43.1	5.2
12/19/2018	<MDC	3.9	29.1	5.2

a) Pump issues led to no sample being collected during the week.
b) Sample had a significantly lower volume than normal, resulting in a much larger MDC.

Table B.3 Sample Results for Alpha / Beta Screening of Air Particulate Filters
North Avenue
Results are in femtocuries per cubic meter (fCi/m³)

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Fire Station North Ave				
1/4/2018	5.5	3.9	36.1	5.2
1/9/2018	6.9	3.9	48.5	5.2
1/23/2018	<MDC	3.9	27.4	5.2
1/30/2018	<MDC	3.9	28.2	5.2
2/6/2018	<MDC	3.9	23.3	5.2
2/14/2018	4.8	3.9	33.2	5.2
2/20/2018	<MDC	3.9	32.0	5.2
3/6/2018	<MDC	3.9	21.0	5.2
3/20/2018	4.1	3.9	27.5	5.2
3/27/2018	4.2	3.9	24.3	5.2
4/3/2018	<MDC	3.9	19.8	5.2
4/11/2018	<MDC	3.9	29.6	5.2
4/18/2018	3.9	3.9	23.4	5.2
4/23/2018	<MDC	3.9	19.6	5.2
5/1/2018	<MDC	3.9	20.1	5.2
5/8/2018	<MDC	3.9	26.7	5.2
5/15/2018	<MDC	3.9	35.5	5.2
5/22/2018	<MDC	3.9	26.5	5.2
5/29/2018	<MDC	3.9	27.8	5.2
6/5/2018	<MDC	3.9	15.3	5.2
6/12/2018	<MDC	3.9	40.9	5.2
6/19/2018	<MDC	3.9	32.9	5.2
6/26/2018	<MDC	3.9	18.7	5.2

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Fire Station North Ave				
7/3/2018	<MDC	3.9	25.4	5.2
7/11/2018	<MDC	3.9	26.3	5.2
7/18/2018	<MDC	3.9	31.8	5.2
7/25/2018	<MDC	3.9	35.8	5.2
7/31/2018	<MDC	3.9	38.8	5.2
8/8/2018	<MDC	3.9	35.9	5.2
8/15/2018	<MDC	3.9	34.4	5.2
8/22/2018	<MDC	3.9	25.7	5.2
8/27/2018	<MDC	3.9	41.6	5.2
9/11/2018	<MDC	3.9	18.7	5.2
9/19/2018	<MDC	3.9	29.1	5.2
9/26/2018	<MDC	3.9	27.5	5.2
10/2/2018	4.2	3.9	37.9	5.2
10/9/2018	<MDC	3.9	32.4	5.2
10/17/2018	<MDC	3.9	18.3	5.2
10/22/2018	4.1	3.9	23.8	5.2
10/29/2018	<MDC	3.9	26.5	5.2
11/8/2018	<MDC	3.9	28.2	5.2
11/14/2018	<MDC	3.9	33.3	5.2
11/21/2018	4.9	3.9	40.1	5.2
11/29/2018	4.8	3.9	43.5	5.2
12/5/2018	<MDC	3.9	22.9	5.2
12/10/2018	<MDC	3.9	41.1	5.2
12/19/2018	<MDC	3.9	25.0	5.2

Table B.4 Sample Results for Alpha / Beta Screening of Air Particulate Filters
Dorothy Miller Park
Results are in femtocuries per cubic meter (fCi/m³)

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Dorothy Miller Park				
1/4/2018	6.6	3.9	37.5	5.2
1/9/2018	5.5	3.9	41.3	5.2
1/23/2018	<MDC	3.9	28.6	5.2
1/30/2018	4.0	3.9	29.7	5.2
2/6/2018	<MDC	3.9	24.4	5.2
2/14/2018	5.3	3.9	33.9	5.2
2/20/2018	<MDC	3.9	30.8	5.2
3/6/2018[a]				
3/20/2018	<MDC	3.9	21.6	5.2
3/27/2018	4.7	3.9	27.3	5.2
4/3/2018	<MDC	3.9	19.3	5.2
4/11/2018	<MDC	3.9	27.5	5.2
4/18/2018	<MDC	3.9	21.7	5.2
4/23/2018	<MDC	3.9	20.2	5.2
5/1/2018	<MDC	3.9	20.8	5.2
5/8/2018[b]				
5/15/2018	<MDC	3.9	37.4	5.2
5/22/2018	<MDC	3.9	25.8	5.2
5/29/2018	<MDC	3.9	31.1	5.2
6/5/2018	<MDC	3.9	19.2	5.2
6/12/2018	<MDC	3.9	41.6	5.2
6/19/2018	<MDC	3.9	35.8	5.2
6/26/2018	<MDC	3.9	18.3	5.2

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Dorothy Miller Park				
7/3/2018	<MDC	3.9	21.6	5.2
7/11/2018	<MDC	3.9	29.2	5.2
7/18/2018	<MDC	3.9	37.0	5.2
7/25/2018	<MDC	3.9	35.3	5.2
7/31/2018	<MDC	3.9	40.5	5.2
8/8/2018	<MDC	3.9	44.1	5.2
8/15/2018	<MDC	3.9	37.4	5.2
8/22/2018	<MDC	3.9	28.9	5.2
8/27/2018	<MDC	3.9	41.2	5.2
9/11/2018	<MDC	3.9	20.6	5.2
9/19/2018	<MDC	3.9	27.6	5.2
9/26/2018	<MDC	3.9	25.8	5.2
10/2/2018	<MDC	3.9	40.8	5.2
10/9/2018	<MDC	3.9	34.5	5.2
10/17/2018	<MDC	3.9	19.4	5.2
10/22/2018	3.9	3.9	23.2	5.2
10/29/2018	<MDC	3.9	30.0	5.2
11/8/2018	<MDC	3.9	26.0	5.2
11/14/2018	4.3	3.9	31.7	5.2
11/21/2018	5.1	3.9	37.7	5.2
11/29/2018	<MDC	3.9	37.6	5.2
12/5/2018	<MDC	3.9	22.4	5.2
12/10/2018	<MDC	3.9	40.8	5.2
12/19/2018	<MDC	3.9	23.9	5.2

a) Flooding made the sample location inaccessible, no sample was collected.
b) There was no sample collection on the filter, no sample was submitted.

Table B.5 Sample Results for Alpha / Beta Screening of Air Particulate Filters
Airport Road
Results are in femtocuries per cubic meter (fCi/m³)

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Airport Road				
1/4/2018	5.9	3.9	37.0	5.2
1/9/2018	5.6	3.9	43.0	5.2
1/23/2018	<MDC	3.9	26.8	5.2
1/30/2018	<MDC	3.9	28.8	5.2
2/6/2018	<MDC	3.9	28.0	5.2
2/14/2018	5.1	3.9	33.4	5.2
2/20/2018	<MDC	3.9	29.0	5.2
3/6/2018	<MDC	3.9	20.4	5.2
3/20/2018	4.3	3.9	28.9	5.2
3/27/2018	4.7	3.9	23.2	5.2
4/3/2018	<MDC	3.9	19.5	5.2
4/11/2018	<MDC	3.9	29.2	5.2
4/18/2018	<MDC	3.9	21.3	5.2
4/23/2018	<MDC	3.9	18.7	5.2
5/1/2018	<MDC	3.9	20.3	5.2
5/8/2018	<MDC	3.9	24.0	5.2
5/15/2018	<MDC	3.9	30.7	5.2
5/22/2018	<MDC	3.9	24.8	5.2
5/29/2018	<MDC	3.9	28.4	5.2
6/5/2018	<MDC	3.9	20.5	5.2
6/12/2018	<MDC	3.9	37.4	5.2
6/19/2018	<MDC	3.9	31.3	5.2
6/26/2018	<MDC	3.9	19.8	5.2

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Airport Road				
7/3/2018	<MDC	3.9	25.1	5.2
7/11/2018	<MDC	3.9	26.2	5.2
7/18/2018	4.2	3.9	34.0	5.2
7/25/2018	<MDC	3.9	33.7	5.2
7/31/2018	<MDC	3.9	36.9	5.2
8/8/2018	<MDC	3.9	30.6	5.2
8/15/2018	<MDC	3.9	33.3	5.2
8/22/2018	<MDC	3.9	29.7	5.2
8/27/2018	<MDC	3.9	46.5	5.2
9/11/2018	<MDC	3.9	17.5	5.2
9/19/2018	<MDC	3.9	26.8	5.2
9/26/2018	<MDC	3.9	25.7	5.2
10/2/2018	5.2	3.9	35.9	5.2
10/9/2018	<MDC	3.9	32.5	5.2
10/17/2018	<MDC	3.9	18.1	5.2
10/22/2018	<MDC	3.9	20.9	5.2
10/29/2018	<MDC	3.9	27.9	5.2
11/8/2018	<MDC	3.9	24.1	5.2
11/14/2018	<MDC	3.9	28.2	5.2
11/21/2018	4.1	3.9	39.7	5.2
11/29/2018	5.3	3.9	42.2	5.2
12/5/2018	<MDC	3.9	19.6	5.2
12/10/2018	<MDC	3.9	44.0	5.2
12/19/2018	4.1	3.9	29.1	5.2

Table B.6 Gamma Spectroscopy Sample Results for Soil Migration Samples
Results in picocuries per gram (pCi/g)

Location	Ra-226		Th-230	
Date	Result	MDC	Result	MDC
Airport 1 Mi. NNE				
5/1/2018	1.1	0.1	<MDC	9.7
Intersection of Gurley and Devers				
5/1/2018	1.0	0.1	<MDC	9.7
Massac Creek at Country Club Rd				
5/1/2018	0.7	0.1	<MDC	9.7
Nearest Residence				
5/1/2018	1.2	0.1	<MDC	9.7

Table B.7 Gamma Spectroscopy Sample Results for Soil Deposition Samples
Results in picocuries per gram (pCi/g)

Location	Ra-226		Th-230	
Date	Result	MDC	Result	MDC
Airport 1 Mi. NNE				
5/1/2018	0.6	0.1	<MDC	9.7
Intersection of Gurley and Devers				
5/1/2018	0.7	0.1	<MDC	9.7
Massac Creek at Country Club Rd				
5/1/2018	0.3	0.1	<MDC	9.7
Nearest Residence				
5/1/2018	0.8	0.1	<MDC	9.7

Table B.8 Gamma Ingrowth Spectroscopy Sample Results for Soil Migration Samples
Results in picocuries per gram (pCi/g)

Location	Ra-226		Th-230	
Date	Result	MDC	Result	MDC
Airport 1 Mi. NNE				
8/8/2018	1.17	0.03	<MDC	7.5
Intersection of Gurley and Devers				
8/8/2018	1.11	0.03	<MDC	7.5
Massac Creek at Country Club Rd				
8/8/2018	0.35	0.03	<MDC	7.5
Nearest Residence				
8/8/2018	1.35	0.03	<MDC	7.5

Table B.9 Gamma Ingrowth Spectroscopy Sample Results for Soil Deposition Samples
Results in picocuries per gram (pCi/g)

Location	Ra-226		Th-230	
Date	Result	MDC	Result	MDC
Airport 1 Mi. NNE				
8/8/2018	1.11	0.03	<MDC	7.5
Intersection of Gurley and Devers				
8/8/2018	1.10	0.03	<MDC	7.5
Massac Creek at Country Club Rd				
8/8/2018	0.47	0.03	<MDC	7.5
Nearest Residence				
8/8/2018	1.23	0.03	<MDC	7.5

Table B.10 Isotopic Uranium Sample Results for Soil Migration Samples
Results in picocuries per gram (pCi/g)

Location	U-234		U-235		U-238	
Date	Result	MDC	Result	MDC	Result	MDC
Airport 1 Mi. NNE						
5/1/2018	1.33	0.02	0.08	0.03	1.36	0.03
8/8/2018	1.26	0.02	0.07	0.03	1.30	0.03
Intersection of Gurley and Devers						
5/1/2018	1.08	0.02	0.04	0.03	1.09	0.03
8/8/2018	1.07	0.02	0.04	0.03	1.15	0.03
Massac Creek at Country Club Rd						
5/1/2018	0.46	0.02	0.04	0.03	0.45	0.03
8/8/2018	0.35	0.02	<MDC	0.03	0.38	0.03
Nearest Residence						
5/1/2018	2.84	0.02	0.12	0.03	2.84	0.03
8/8/2018	2.30	0.02	0.09	0.03	2.26	0.03

Table B.11 Isotopic Uranium Sample Results for Soil Deposition Samples
Results in picocuries per gram (pCi/g)

Location	U-234		U-235		U-238	
Date	Result	MDC	Result	MDC	Result	MDC
Airport 1 Mi. NNE						
5/1/2018	1.28	0.02	0.05	0.03	1.26	0.03
8/8/2018	1.26	0.02	0.07	0.03	1.22	0.03
Intersection of Gurley and Devers						
5/1/2018	0.90	0.02	0.05	0.03	0.97	0.03
8/8/2018	1.15	0.02	0.06	0.03	1.17	0.03
Massac Creek at Country Club Rd						
5/1/2018	0.37	0.02	0.04	0.03	0.34	0.03
8/8/2018	0.59	0.02	0.04	0.03	0.58	0.03
Nearest Residence						
5/1/2018	3.47	0.02	0.17	0.03	3.65	0.03
8/8/2018	3.70	0.02	0.19	0.03	3.79	0.03

Table B.12 Gamma Spectroscopy Sample Results for Vegetation Samples
Results in picocuries per gram (pCi/g)

Location	Ra-226		Th-230	
Date	Result	MDC	Result	MDC
Airport 1 Mi. NNE				
5/1/2018	<MDC	1.6	<MDC	43
8/8/2018	<MDC	1.6	<MDC	43
Intersection of Gurley and Devers				
5/1/2018	<MDC	1.6	<MDC	43
8/8/2018	<MDC	1.6	<MDC	43
Massac Creek at Country Club Rd				
5/1/2018	<MDC	1.6	<MDC	43
8/8/2018	<MDC	1.6	<MDC	43
Nearest Residence				
5/1/2018	<MDC	1.6	<MDC	43
8/8/2018	<MDC	1.6	<MDC	43

Table B.13 Isotopic Uranium Sample Results for Vegetation Samples
Results in picocuries per gram (pCi/g)

Location	U-234		U-235		U-238	
Date	Result	MDC	Result	MDC	Result	MDC
Airport 1 Mi. NNE						
5/1/2018	<MDC	0.01	<MDC	0.01	<MDC	0.02
8/8/2018	0.05	0.01	<MDC	0.01	0.07	0.02
Intersection of Gurley and Devers						
5/1/2018	<MDC	0.01	<MDC	0.01	<MDC	0.02
8/8/2018	<MDC	0.01	<MDC	0.01	<MDC	0.02
Massac Creek at Country Club Rd						
5/1/2018	0.03	0.01	<MDC	0.01	0.03	0.02
8/8/2018	0.01	0.01	<MDC	0.01	<MDC	0.02
Nearest Residence						
5/1/2018	<MDC	0.01	<MDC	0.01	<MDC	0.02
8/8/2018	0.03	0.01	<MDC	0.01	0.02	0.02

Table B.14 Gamma Spectroscopy Sample Results for Sediment Samples
Results in picocuries per gram (pCi/g)

Location	Ra-226		Th-230	
Date	Result	MDC	Result	MDC
Ohio River at Joppa, 4 Mi. DnS				
5/1/2018	2.3	0.3	<MDC	7.7

Table B.15 Gamma Ingrowth Spectroscopy Sample Results for Sediment Samples
Results in picocuries per gram (pCi/g)

Location	Ra-226		Th-230	
Date	Result	MDC	Result	MDC
Ohio River at Joppa, 4 Mi. DnS				
8/8/2018	0.62	0.03	<MDC	7.9
Public Boat Launch near Harrah's Casino				
8/8/2018	1.25	0.03	<MDC	7.9

Table B.16 Isotopic Uranium Sample Results for Sediment Samples
Results in picocuries per gram (pCi/g)

Location	U-234		U-235		U-238	
Date	Result	MDC	Result	MDC	Result	MDC
Ohio River at Joppa, 4 Mi. DnS						
5/1/2018	1.00	0.01	0.05	0.01	1.14	0.01
8/8/2018	0.58	0.01	0.02	0.01	0.61	0.01
Public Boat Launch near Harrah's Casino						
8/8/2018	0.97	0.01	0.05	0.01	1.00	0.01

Table B.17 KPA (Total Uranium) Sample Results for Water Samples
Results in picocuries per liter (pCi/L)

Location	Uranium	
Date	Result	MDC
Massac Creek at Country Club Rd		
1/30/2018	0.2	0.1
5/1/2018	<MDC	0.1
8/8/2018	<MDC	0.1
11/21/2018	<MDC	0.1
Ohio River at Joppa, 4 Mi. DnS		
1/9/2018	0.8	0.1
1/30/2018	0.5	0.1
5/1/2018	0.4	0.1
8/8/2018	0.5	0.1
11/21/2018	0.3	0.1
Public Boat Launch near Harrah's Casino		
1/30/2018	0.6	0.1
8/8/2018	0.3	0.1
11/21/2018	0.3	0.1
PWS (Untreated)		
1/30/2018	0.4	0.1
5/1/2018	0.4	0.1
8/8/2018	0.4	0.1
11/21/2018	0.4	0.1
Small Creek in Fort Massac State Park		
8/8/2018	<MDC	0.1

Table B.18 Summary of Ambient Gamma Results

Location	Quarter 1 mR/quarter	Quarter 2 mR/quarter	Quarter 3 mR/quarter	Quarter 4 mR/quarter	Annual Exposure mR/year
METR-01	7.4	8.1	8.8	7.8	32.1
METR-02	5.4	6.5	7.4	7.0	26.3
METR-03	7.9	9.0	7.5	9.3	33.8
METR-04	7.8	8.3	7.4	9.3	32.9
METR-05	7.8	7.9	8.9	8.8	33.4
METR-06	9.3	9.9	9.4	11.1	39.8
METR-16	9.0	11.0	11.2	10.4	41.7
METR-20	6.5	8.3	7.5	7.7	29.9
METR-21	10.0	7.7		12.1	39.8
METR-22	7.6	9.0	8.2	7.8	32.7
METR-25	4.0				16.1
METR-26	8.8	9.9	9.9	10.4	38.9
METR-27	6.8	7.4	6.5	7.7	28.4
METR-28	7.0	7.8	7.7	8.1	30.6
METR-29	8.2	8.1	7.6	8.5	32.4
METR-30	7.5	8.2	7.4	8.7	31.8
METR-31	13.0	13.7	12.1	14.4	53.2
METR-32	20.0	20.8	21.8	22.4	85.0
METR-33	11.3	11.3	10.8	12.3	45.7

Blanks in the table indicate that the dosimeter was missing at the end of the quarter.
The Annual Dose column is based on averages of all available data.
Quarters estimated to be 91.25 days in length.

APPENDIX C
Sample Analysis Results for Samples Collected from Established Background Locations

Table C.1 Sample Results for Alpha / Beta Screening of Air Samples
Springfield Background Location
Results are in femtocuries per cubic meter (fCi/m^3)

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Knotts Street Air Sampler				
1/3/2018	6.0	3.4	40.9	4.8
1/18/2018	4.5	3.4	37.8	4.8
1/22/2018	6.0	3.4	39.3	4.8
1/29/2018	<MDC	3.4	26.6	4.8
2/5/2018	<MDC	3.4	25.9	4.8
2/13/2018	3.5	3.4	38.7	4.8
2/20/2018	4.0	3.4	33.5	4.8
2/26/2018	<MDC	3.4	14.6	4.8
3/5/2018	4.4	3.4	26.2	4.8
3/12/2018	3.6	3.4	25.0	4.8
3/19/2018	4.6	3.4	30.3	4.8
3/27/2018	<MDC	3.4	20.8	4.8
4/2/2018	3.6	3.4	27.8	4.8
4/9/2018	<MDC	3.4	21.2	4.8
4/17/2018	4.3	3.4	22.1	4.8
4/25/2018	<MDC	3.4	22.4	4.8
5/1/2018	<MDC	3.4	20.2	4.8
5/8/2018	<MDC	3.4	28.0	4.8
5/14/2018	<MDC	3.4	37.4	4.8
5/21/2018	<MDC	3.4	32.3	4.8
5/29/2018	<MDC	3.4	32.4	4.8
6/5/2018	<MDC	3.4	22.6	4.8
6/11/2018	<MDC	3.4	34.0	4.8
6/18/2018	<MDC	3.4	31.6	4.8

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Knotts Street Air Sampler				
7/3/2018	<MDC	3.4	19.5	4.8
7/10/2018	3.6	3.4	29.3	4.8
7/17/2018	<MDC	3.4	29.1	4.8
7/23/2018	<MDC	3.4	28.5	4.8
7/31/2018	<MDC	3.4	27.8	4.8
8/6/2018	4.2	3.4	47.0	4.8
8/21/2018	<MDC	3.4	31.5	4.8
8/28/2018	<MDC	3.4	42.9	4.8
9/5/2018	<MDC	3.4	21.0	4.8
9/11/2018	<MDC	3.4	18.6	4.8
9/17/2018	<MDC	3.4	27.4	4.8
9/25/2018	<MDC	3.4	30.6	4.8
10/1/2018	4.4	3.4	29.9	4.8
10/9/2018	<MDC	3.4	24.4	4.8
10/15/2018	<MDC	3.4	17.1	4.8
10/23/2018	<MDC	3.4	24.9	4.8
10/31/2018	<MDC	3.4	23.3	4.8
11/5/2018	<MDC	3.4	24.6	4.8
11/13/2018	<MDC	3.4	21.9	4.8
11/19/2018	<MDC	3.4	31.6	4.8
11/27/2018	4.0	3.4	38.6	4.8
12/3/2018	<MDC	3.4	28.5	4.8
12/11/2018	<MDC	3.4	26.4	4.8
12/19/2018	<MDC	3.4	36.4	4.8

Table C.2 Sample Results for Alpha / Beta Screening of Air Samples
Marion Background Location
Results are in femtocuries per cubic meter (fCi/m³)

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Marion Office				
1/3/2018	5.9	3.8	37.2	5.1
1/9/2018	6.7	3.8	48.4	5.1
1/23/2018	<MDC	3.8	21.8	5.1
1/30/2018	<MDC	3.8	32.4	5.1
2/6/2018	<MDC	3.8	26.5	5.1
2/14/2018	4.5	3.8	30.3	5.1
2/20/2018	4.0	3.8	30.7	5.1
3/1/2018	<MDC	3.8	19.1	5.1
3/20/2018	4.1	3.8	25.6	5.1
3/27/2018	<MDC	3.8	23.4	5.1
4/3/2018	<MDC	3.8	20.0	5.1
4/11/2018	<MDC	3.8	29.8	5.1
4/18/2018	<MDC	3.8	20.1	5.1
4/23/2018	<MDC	3.8	17.8	5.1
5/1/2018	<MDC	3.8	19.7	5.1
5/8/2018	<MDC	3.8	26.3	5.1
5/15/2018	4.0	3.8	36.5	5.1
5/22/2018	<MDC	3.8	26.1	5.1
5/29/2018	<MDC	3.8	28.0	5.1
6/5/2018	<MDC	3.8	21.7	5.1
6/12/2018	<MDC	3.8	39.7	5.1
6/19/2018	<MDC	3.8	39.1	5.1
6/26/2018	<MDC	3.81	19.61	5.12

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Marion Office				
7/3/2018[a]				
7/11/2018	<MDC	3.8	13.1	5.1
7/18/2018	<MDC	3.8	34.6	5.1
7/25/2018	<MDC	3.8	36.4	5.1
7/31/2018	<MDC	3.8	30.9	5.1
8/8/2018	<MDC	3.8	40.8	5.1
8/15/2018	<MDC	3.8	39.0	5.1
8/22/2018	<MDC	3.8	31.5	5.1
8/27/2018	<MDC	3.8	48.6	5.1
9/11/2018	<MDC	3.8	17.2	5.1
9/19/2018[b]				
9/26/2018	<MDC	3.8	25.2	5.1
10/2/2018	<MDC	3.8	34.7	5.1
10/9/2018	3.9	3.8	32.7	5.1
10/17/2018	<MDC	3.8	17.2	5.1
10/22/2018	<MDC	3.8	20.5	5.1
10/29/2018	<MDC	3.8	25.7	5.1
11/8/2018	<MDC	3.8	27.6	5.1
11/14/2018	<MDC	3.8	30.2	5.1
11/21/2018	4.5	3.8	37.4	5.1
11/29/2018	5.0	3.8	39.9	5.1
12/5/2018	<MDC	3.8	18.9	5.1
12/10/2018	<MDC	3.8	39.4	5.1
12/19/2018	<MDC	3.8	25.9	5.1

a) Building was struck by lightning, causing a power outage at the air pump.
b) Pump issue led to no data being saved at the pump. No sample was submitted.

Table C.3 Gamma Spectroscopy Soil Migration Samples
Kincaid, IL Background Locations
Results are in picocuries per gram (pCi/g)

Location	Pa-234m		Ra-226	
Date	Result	MDC	Result	MDC
East Boat Ramp				
4/25/2018	<MDC	3.2	0.8	0.5
9/19/2018	<MDC	3.2	2.0	0.5
Strawkaws Boat Ramp				
4/25/2018	<MDC	3.2	1.4	0.5
9/19/2018	<MDC	3.2	1.0	0.5
West Boat Ramp				
4/25/2018	<MDC	3.2	0.6	0.5
9/19/2018	<MDC	3.2	1.0	0.5

Thorium-230 was not included in the gamma spectroscopy library for Kincaid when the first quarter samples were analyzed. Third quarter gamma ingrowth analysis included Thorium-230.

Table C.4 Gamma Spectroscopy Soil Deposition Samples
Kincaid, IL Background Locations
Results are in picocuries per gram (pCi/g)

Location	Pa-234m		Ra-226	
Date	Result	MDC	Result	MDC
East Boat Ramp				
4/25/2018	<MDC	3.2	1.4	0.5
Strawkaws Boat Ramp				
4/25/2018	<MDC	3.2	1.6	0.5
West Boat Ramp				
4/25/2018	<MDC	3.2	1.1	0.5

Thorium-230 was not included in the gamma spectroscopy library for Kincaid when the first quarter samples were analyzed. Third quarter gamma ingrowth analysis included Thorium-230.

Table C.5 Gamma Ingrowth Spectroscopy Soil Migration Samples
Kincaid, IL Background Locations
Results are in picocuries per gram (pCi/g)

Location	Ra-226		Th-230	
Date	Result	MDC	Result	MDC
East Boat Ramp				
9/19/2018	1.13	0.02	<MDC	7.8
Strawkaws Boat Ramp				
9/19/2018	1.27	0.02	<MDC	7.8
West Boat Ramp				
9/19/2018	1.21	0.02	<MDC	7.8

Table C.6 Gamma Ingrowth Spectroscopy Soil Deposition Samples
Kincaid, IL Background Locations
Results are in picocuries per gram (pCi/g)

Location	Ra-226		Th-230	
Date	Result	MDC	Result	MDC
East Boat Ramp				
9/19/2018	1.07	0.02	<MDC	7.8
Strawkaws Boat Ramp				
9/19/2018	1.23	0.02	<MDC	7.8
West Boat Ramp				
9/19/2018	1.23	0.02	<MDC	7.8

Table C.7 Isotopic Uranium Soil Migration Samples
Kincaid, IL Background Locations
Results are in picocuries per gram (pCi/g)

Location	U-234		U-235		U-238	
Date	Result	MDC	Result	MDC	Result	MDC
East Boat Ramp						
4/25/2018	0.97	0.03	0.07	0.03	1.06	0.03
9/19/2018	0.92	0.03	0.07	0.03	0.98	0.03
Strawkaws Boat Ramp						
4/25/2018	1.01	0.03	0.07	0.03	1.09	0.03
9/19/2018	1.13	0.03	0.04	0.03	0.95	0.03
West Boat Ramp						
4/25/2018	0.84	0.03	0.03	0.03	1.01	0.03
9/19/2018	0.98	0.03	0.07	0.03	1.09	0.03

Table C.8 Isotopic Uranium Soil Deposition Samples
Kincaid, IL Background Locations
Results are in picocuries per gram (pCi/g)

Location	U-234		U-235		U-238	
Date	Result	MDC	Result	MDC	Result	MDC
East Boat Ramp						
4/25/2018	1.00	0.03	0.06	0.03	0.97	0.03
9/19/2018	1.01	0.03	0.05	0.03	1.02	0.03
Strawkaws Boat Ramp						
4/25/2018	0.92	0.03	0.07	0.03	1.04	0.03
9/19/2018	0.99	0.03	0.05	0.03	1.01	0.03
West Boat Ramp						
4/25/2018	0.82	0.03	0.00	0.03	0.87	0.03
9/19/2018	1.02	0.03	0.04	0.03	1.13	0.03

Table C.9 Gamma Spectroscopy Vegetation Samples
Kincaid, IL Background Locations
Results are in picocuries per gram (pCi/g)

Location	Pa-234m		Ra-226		Th-230	
Date	Result	MDC	Result	MDC	Result	MDC
East Boat Ramp						
4/25/2018	<MDC	13.5	<MDC	2.49		
9/19/2018	<MDC	13.5	<MDC	2.49	<MDC	5.1
Strawkaws Boat Ramp						
4/25/2018	<MDC	13.5	<MDC	2.49		
9/19/2018	<MDC	13.5	<MDC	2.49	<MDC	5.1
West Boat Ramp						
4/25/2018	<MDC	13.5	<MDC	2.49		
9/19/2018	<MDC	13.5	<MDC	2.49	<MDC	5.1

Table C.10 Isotopic Uranium Vegetation Samples
Kincaid, IL Background Locations
Results are in picocuries per gram (pCi/g)

Location	U-234		U-235		U-238	
Date	Result	MDC	Result	MDC	Result	MDC
East Boat Ramp						
4/25/2018	<MDC	0.01	<MDC	0.01	0.01	0.01
9/19/2018	0.04	0.01	<MDC	0.01	0.03	0.01
Strawkaws Boat Ramp						
4/25/2018	0.02	0.01	<MDC	0.01	0.02	0.01
9/19/2018	0.01	0.01	<MDC	0.01	0.01	0.01
West Boat Ramp						
4/25/2018	<MDC	0.01	<MDC	0.01	0.02	0.01
9/19/2018	<MDC	0.01	<MDC	0.01	<MDC	0.01

Table C.11 Gamma Spectroscopy Sample Results for Sediment Samples
Kincaid, IL Background Locations
Results are in picocuries per gram (pCi/g)

Location	Pa-234m		Ra-226	
Date	Result	MDC	Result	MDC
East Boat Ramp				
4/25/2018	1.1	1.0	0.9	0.2
West Boat Ramp				
9/26/2018	<MDC	1.0	0.7	0.2

Thorium-230 was not included in the gamma spectroscopy library for Kincaid when the first quarter samples were analyzed. Third quarter gamma ingrowth analysis included Thorium-230.

Table C.12 Gamma Ingrowth Spectroscopy Sample Results for Sediment Samples
Kincaid, IL Background Locations
Results are in picocuries per gram (pCi/g)

Location	Ra-226		Th-230	
Date	Result	MDC	Result	MDC
West Boat Ramp				
9/26/2018	0.72	0.02	<MDC	3.8

Table C.13 Isotopic Uranium Sample Results for Sediment Samples
Kincaid, IL Background Locations
Results are in picocuries per gram (pCi/g)

Location	U-234		U-235		U-238	
Date	Result	MDC	Result	MDC	Result	MDC
East Boat Ramp						
4/25/2018	0.67	0.01	0.03	0.02	0.70	0.01
West Boat Ramp						
9/26/2018	0.68	0.01	0.05	0.02	0.79	0.01

Table C.14 Summary of Ambient Gamma Results
Kincaid, IL Background Locations

Location	Quarter 1 mR/quarter	Quarter 2 mR/quarter	Quarter 3 mR/quarter	Quarter 4 mR/quarter	Annual Exposure mR/year
KC-01	11.1	11.1	10.6	10.6	43.4
KC-02	11.1	10.3	10.0	9.1	40.6
KC-03	9.8	8.3	10.5	7.5	36.0
KC-04	9.4	9.9	9.7	9.1	38.1
KC-05	10.5	8.5	11.5	9.5	40.0
KC-06	9.8	9.8	10.4	9.3	39.2
KC-07	8.9	8.9	11.6	7.2	36.6
KC-08	9.9	8.8	8.5	9.0	36.1
KC-09	9.6	8.9	10.2	9.5	38.2
KC-10	8.9	10.1	11.4	9.3	39.7
KC-11		11.1	10.6	11.0	43.6
KC-12	10.0	10.1	11.1	9.3	40.6
KC-13		11.0	10.2	8.2	39.3
KC-14	10.4	8.6	9.8	8.7	37.4
KC-15	11.3	11.5	9.9	9.7	42.3

Blanks in the table indicate that the dosimeter was missing at the end of the quarter.
The Annual Dose column is based on averages of all available data.
Quarters estimated to be 91.25 days in length.

Table C.15 Gamma Ingrowth Spectroscopy Soil Deposition Samples
Massac County Background Locations
Results are in picocuries per gram (pCi/g)

Location	Ra-226		Th-230	
Date	Result	MDC	Result	MDC
Cache River				
10/4/2018	1.20	0.02	<MDC	8
Dixon Springs Park				
10/4/2018	0.38	0.02	<MDC	8
Fern Clyffe State Park				
10/4/2018	0.95	0.02	<MDC	8
Joppa Park				
10/4/2018	1.12	0.02	<MDC	8
Lower Cache River Access				
10/4/2018	1.04	0.02	<MDC	8
Marion Scales				
10/4/2018	1.17	0.02	<MDC	8
Massac State Park				
10/4/2018	1.20	0.02	<MDC	8
Mermet State Park				
10/4/2018	1.02	0.02	<MDC	8
Metropolis Rest Area				
10/4/2018	1.11	0.02	<MDC	8
Shawnee National Forest Fishing Hole Lane				
10/4/2018	1.10	0.02	<MDC	8

Table C.16 Gamma Ingrowth Spectroscopy Soil Migration Samples
Massac County Background Locations
Results are in picocuries per gram (pCi/g)

Location	Ra-226		Th-230	
Date	Result	MDC	Result	MDC
Cache River				
10/4/2018	1.29	0.02	<MDC	8
Dixon Springs Park				
10/4/2018	0.40	0.02	<MDC	8
Fern Clyffe State Park				
10/4/2018	1.04	0.02	<MDC	8
Joppa Park				
10/4/2018	1.39	0.02	<MDC	8
Lower Cache River Access				
10/4/2018	1.27	0.02	<MDC	8
Marion Scales				
10/4/2018	1.12	0.02	<MDC	8
Massac State Park				
10/4/2018	1.22	0.02	<MDC	8
Mermet State Park				
10/4/2018	1.45	0.02	<MDC	8
Metropolis Rest Area				
10/4/2018	1.26	0.02	<MDC	8
Shawnee National Forest Fishing Hole Lane				
10/4/2018	1.10	0.02	<MDC	8

Table C.17 Isotopic Uranium Soil Deposition Samples
Massac County Background Locations
Results are in picocuries per gram (pCi/g)

Location	U-234		U-235		U-238	
Date	Result	MDC	Result	MDC	Result	MDC
Cache River						
10/4/2018	1.09	0.02	0.07	0.02	1.21	0.02
Dixon Springs Park						
10/4/2018	0.44	0.02	<MDC	0.02	0.37	0.02
Fern Clyffe State Park						
10/4/2018	0.87	0.02	0.04	0.02	0.75	0.02
Joppa Park						
10/4/2018	1.02	0.02	0.03	0.02	1.02	0.02
Lower Cache River Access						
10/4/2018	1.02	0.02	0.04	0.02	1.02	0.02
Marion Scales						
10/4/2018	1.18	0.02	0.06	0.02	1.07	0.02
Massac State Park						
10/4/2018	0.93	0.02	0.04	0.02	1.02	0.02
Mermet State Park						
10/4/2018	1.03	0.02	0.06	0.02	1.08	0.02
Metropolis Rest Area						
10/4/2018	1.17	0.02	0.07	0.02	1.17	0.02
Shawnee National Forest Fishing Hole Lane						
10/4/2018	1.03	0.02	0.07	0.02	1.02	0.02

Table C.18 Isotopic Uranium Soil Migration Samples
Massac County Background Locations
Results are in picocuries per gram (pCi/g)

Location	U-234		U-235		U-238	
Date	Result	MDC	Result	MDC	Result	MDC
Cache River						
10/4/2018	1.30	0.02	0.06	0.02	1.31	0.02
Dixon Springs Park						
10/4/2018	0.39	0.02	0.03	0.02	0.36	0.02
Fern Clyffe State Park						
10/4/2018	0.81	0.02	0.05	0.02	0.88	0.02
Joppa Park						
10/4/2018	1.14	0.02	0.05	0.02	1.14	0.02
Lower Cache River Access						
10/4/2018	1.06	0.02	0.06	0.02	1.17	0.02
Marion Scales						
10/4/2018	1.08	0.02	0.06	0.02	1.17	0.02
Massac State Park						
10/4/2018	0.98	0.02	0.05	0.02	1.10	0.02
Mermet State Park						
10/4/2018	1.33	0.02	0.04	0.02	1.31	0.02
Metropolis Rest Area						
10/4/2018	1.18	0.02	0.05	0.02	1.23	0.02
Shawnee National Forest Fishing Hole Lane						
10/4/2018	0.98	0.02	0.06	0.02	1.09	0.02

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