IEMA

Illinois Emergency Management Agency

Bureau of Radiation Safety

Environmental Monitoring in the Environs of the Honeywell Metropolis Works Facility
Report for Calendar Year 2015

October 2016

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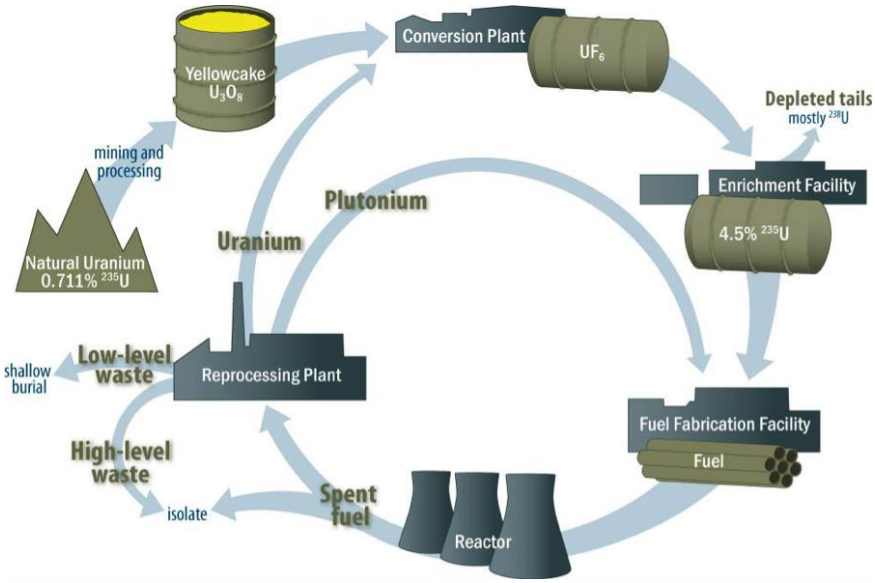
Introduction

Located on 1,000 acres of land within Massac County and on the peripheries of Metropolis, Illinois, the Honeywell Metropolis Works Facility (HMW) site perimeter is formed by U.S. Highway 45 to the north, the Ohio River to the south, an industrial coal blending plant to the west, and the city of Metropolis to the east. The facility footprint and the land immediately surrounding the facility form a 59-acre restricted area as required by HMW's United States Nuclear Regulatory Commission's (US NRC) Radioactive Materials License, number SUB-526. The 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. Simplified, this 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.

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 environmental monitoring program. The overall purpose of IEMA's environmental monitoring program is to determine if a public

health or environmental radiological impact is detected in the environs of the HMW facility due to its operation, as well as determine long-term trends in environmental radiation levels.

In 2015, all test results for samples collected as part of IEMA's environmental monitoring program for the Honeywell Metropolis Works facility were consistent with historical data and below regulatory standards and guidelines.

These objectives are achieved through a network of four strategically positioned environmental monitoring stations (EMS) within the environs of the HMW. Each EMS is comprised of a continuous low-volume vacuum pump and air filter assembly. An additional network of optically stimulated luminescence (OSL) dosimeters, which passively detects ionizing gamma radiation, is also positioned within the HMW environs and around the facility fence line. Additionally, IEMA collects water, sediment, soil and vegetation samples from the environs surrounding the HMW. All samples are analyzed at IEMA's Radiochemistry Laboratory in Springfield, Illinois.

Environmental Monitoring Program

During Calendar Year 2015, the IEMA Environmental Monitoring program consisted of sample collection, sample analysis by the IEMA Radiochemistry Laboratory in Springfield, and data review and analysis of the results. The overall purpose of IEMA's environmental monitoring program is to determine if a public health or environmental radiological impact is detected in the environs of the HMW facility due to exposure from its operation, as well as determine long-term trends in environmental radiation levels.

Radiological exposure to the population can occur through direct pathways such as immersion/inhalation, or indirectly through the food chain. The inhalation and immersion exposure pathways are monitored through collection of air samples and the use of OSL dosimetry.

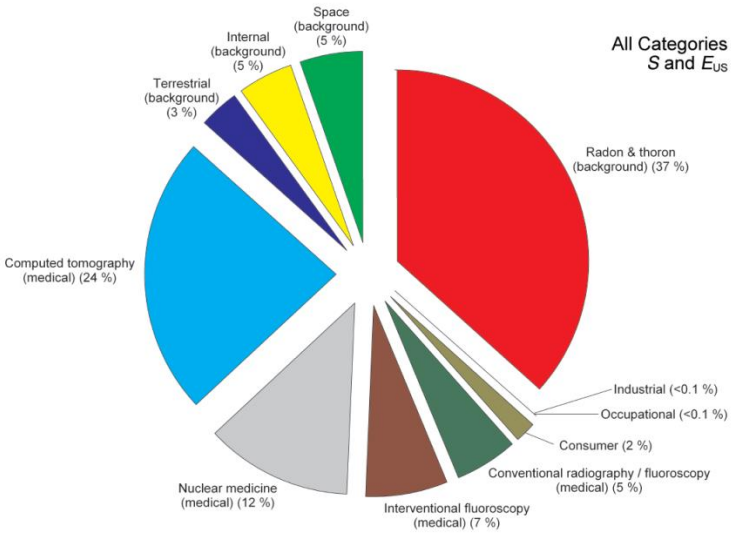
Air particulate samples are collected continuously by low-volume samplers at five different locations throughout Metropolis, and are exchanged and analyzed weekly for airborne radioactivity through gross alpha and beta analysis. Results from each of the five air monitoring stations are displayed in **Tables B.1 – B.5** with results in femtocuries per meter cubed (fCi/m^3).

OSL dosimeters provide a direct measurement of the total dose produced by all sources of gamma radiation, including naturally occurring radionuclides and cosmic rays. The dosimeters are arrayed in and around the HMW site and are exchanged and analyzed quarterly. IEMA performs the analyses of the dosimeters.

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. The locations identified by a star (*) after the location name are actually on the fence immediately surrounding the plant. The other side of the fence is an area controlled by HMW with restricted access. The results are expected to be higher in these locations because of the proximity to stored radioactive material. The other locations are in and around the city of Metropolis, and are more indicative of exposure to members of the public.

Table 12 shows results for OSL dosimeters analyzed during 2013. In addition to the quarterly results, which are expressed as the average millirem per day, we have used those results to calculate the approximate millirem per year that would have been accrued by an individual at that location for an entire year. Those numbers can be compared to the average radiation exposure to an individual of 620 millirem per year from various sources of radiation (according to the 2009 National Council on Radiation Protection's Report, **Figure 2**). Approximately 8% of that exposure is from terrestrial and cosmic radiation (background radiation), and equals approximately 49.6 millirem per year.

Figure 2. Sources of Radiation Exposure to Man



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Determined by IEMA as site-specific indirect exposure pathways, water, vegetation, soil and sediment samples are collected annually and analyzed for radionuclide accumulation in the environment. Sample analyses vary from media to media but focus primarily on natural Uranium (by looking at Uranium-235 and Uranium-238 and their decay progeny). The tables in **Appendix B** provide the results of analysis of different samples collected and analyzed by IEMA over calendar year 2015. Vegetation, soil and sediment samples were collected on May 19 and August 10, 2015. Results for soil samples are shown in **Table B.6**, results for vegetation samples are shown in **Table B.7**, and results for sediment samples are shown in **Table B.8**. Results for water samples are shown in **Tables B.9, B.10 and B.11**. **Table B.9** shows Gross Alpha / Beta Screening Results, and **Table B.10** shows results when the water was analyzed by gamma spectroscopy, with a focus on Uranium-235 and Uranium-238 and their decay progeny. **Table B.11** shows the results of water samples analyzed for trace quantities of total uranium using Kinetic Phosphorescence Analysis (KPA). **Figure 3** shows all of IEMA's sample locations.

Laboratory Analysis

Samples were analyzed by the IEMA Radiochemistry Laboratory located in Springfield. The laboratory participates in semi-annual proficiency testing programs through Environmental Resource Associates, an accredited proficiency testing provider.

The laboratory uses standard published radioanalytical procedures. Since the radionuclides of interest around the HMW site are Uranium and its progeny, which emit either alpha or beta particles, all environmental samples are analyzed for total alpha and beta radioactivity. This provides a good method of screening samples for the presence of radioactive material.

Limits of Detection

All analytical methods have limitations: amounts that are just 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. The MDCs for each analytical method are not included in this report.

Analysis of Data

Negative numbers in the tables of this report are the values reported by the IEMA Radiochemistry Laboratory. Each batch of samples is counted with a sample blank to determine a background for each machine and each type of medium being analyzed. That 'background' reading is then subtracted from the analytical results. When the sample has very little radioactivity, subtracting the background values may actually result in a negative number.

Understanding a Test Result with a Confidence Interval

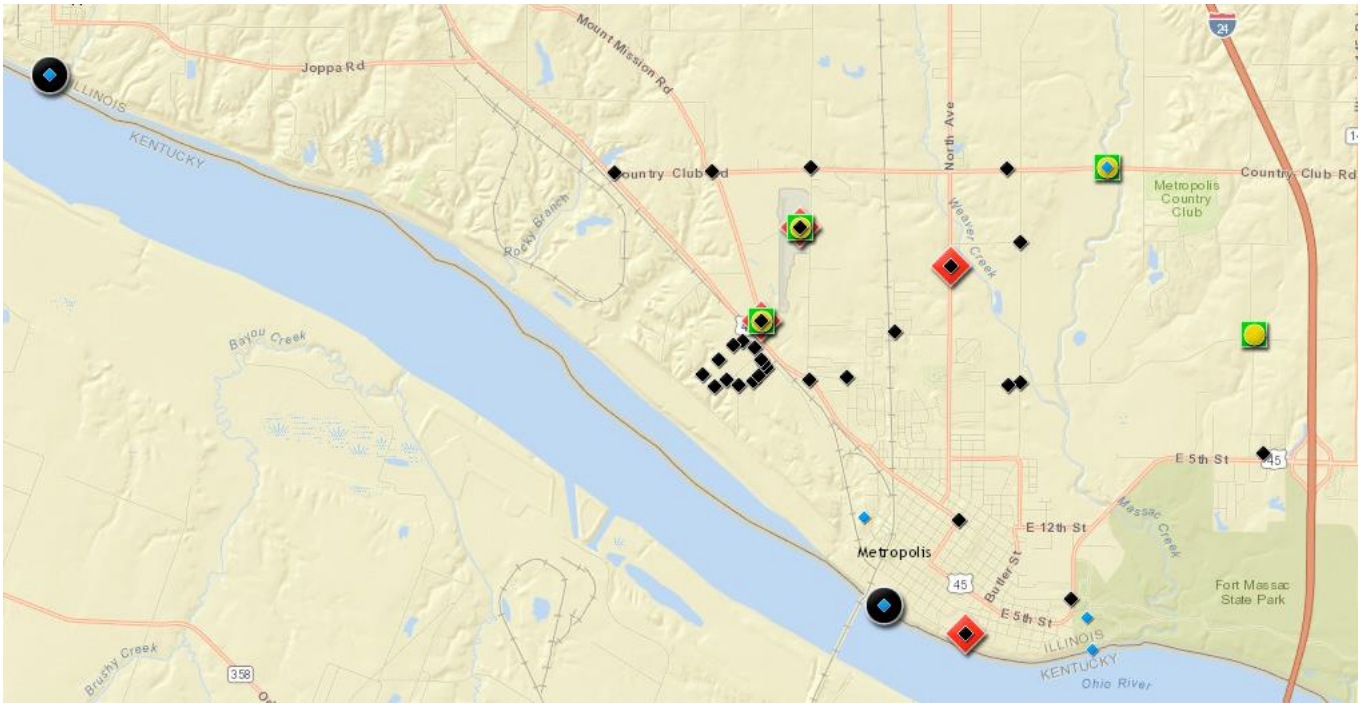
What does a tritium result of (519 ± 99.5) pCi/L, with 95% confidence, mean? First, the unit, pCi/L, is used to measure the amount of tritium, in picocuries (pCi), present in one liter (L) of the sample. Thus, the result tells us that the analysis found 519 picocuries of tritium per liter. However, all measurements have some uncertainty associated with them – some range of values which the analysis, if repeated, could reasonably be expected to be the result. In this case, the uncertainty is ± 99.5 pCi/L. If repeated, the analysis could reasonably be expected to return values as low as 519 – 99.5 = 419.5 pCi/L and as high as 519 + 99.5 = 618.5 pCi/L. The statement "with 95% confidence" tells us just how certain we can be about that range of values – in this case, we judge that there is a 95% probability that the sample contains between 419.5 and 618.5 picocuries of tritium per liter of water.

Background Reference Areas

For comparison, the tables in **Appendix C** provide the results of analysis of samples collected from Background Reference Areas of Springfield, Marion and Kincaid, Illinois.

APPENDIX A

Map A.1. Map of Monitoring Locations around Metropolis



Map Key:

- OSL*
- Air Sampler
- Vegetation
- Soil
- Sediment
- Water

*** OSL = Optically-Stimulated Luminescence Dosimeter**

Sample icons are stacked to indicate multiple types of samples collected at the same location.

APPENDIX B – Sample Analysis Results for Samples Collected Near Metropolis

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

Location	Alpha			Beta		
Date	Result		*U	Result		*U
Residence NNE Boundary						
1/5/2015	3.0	±	0.9	31.2	±	2.5
1/13/2015	5.8	±	1.0	30.1	±	2.3
1/20/2015	17.0	±	1.8	48.1	±	3.0
1/26/2015	7.7	±	1.5	32.2	±	3.2
2/9/2015	24.5	±	2.2	55.8	±	3.5
2/17/2015	2.7	±	0.8	29.1	±	2.4
2/23/2015	1.8	±	0.9	50.9	±	3.2
3/2/2015	2.7	±	0.8	36.6	±	2.7
3/9/2015	119.0	±	4.5	144.0	±	5.0
3/16/2015	2.4	±	0.9	24.7	±	2.5
3/23/2015	1.4	±	0.7	28.5	±	2.5
3/30/2015	4.1	±	1.0	25.1	±	2.4
4/6/2015	7.8	±	1.2	23.7	±	2.4
4/13/2015	13.7	±	1.6	39.3	±	2.9
4/20/2015	3.6	±	0.8	18.7	±	2.0
4/27/2015	5.7	±	1.0	24.7	±	2.3
5/4/2015	8.3	±	1.3	30.9	±	2.5
5/11/2015	27.3	±	2.2	61.8	±	3.3
5/18/2015	8.2	±	1.2	40.2	±	2.7
5/26/2015	5.4	±	1.0	25.9	±	2.2
6/1/2015	8.0	±	1.4	27.7	±	2.8
6/8/2015	29.8	±	2.3	59.5	±	3.4
6/15/2015	13.5	±	1.5	46.3	±	2.9
6/22/2015	20.2	±	1.9	44.9	±	3.0
6/29/2015	7.9	±	1.3	33.6	±	2.8

Location	Alpha			Beta		
Date	Result		*U	Result		*U
Residence NNE Boundary						
7/6/2015	5.3	±	1.2	35.6	±	2.9
7/13/2015	29.0	±	3.3	217.4	±	8.1
7/20/2015	8.2	±	1.3	102.0	±	3.9
7/27/2015	3.2	±	1.0	47.5	±	3.1
8/3/2015	2.2	±	0.9	52.0	±	3.2
8/10/2015	2.0	±	0.8	41.5	±	2.7
8/17/2015	1.7	±	0.8	35.9	±	2.6
8/24/2015	3.9	±	0.9	29.4	±	2.4
8/31/2015	2.2	±	0.8	39.5	±	2.7
9/8/2015	6.6	±	1.1	72.2	±	3.2
9/14/2015	3.8	±	1.0	35.9	±	2.8
9/21/2015	9.3	±	1.3	50.7	±	3.0
9/28/2015	1.0	±	0.7	35.7	±	2.7
10/5/2015	0.4	±	0.6	22.4	±	2.2
10/13/2015	4.9	±	0.9	41.9	±	2.5
10/19/2015	3.1	±	1.0	32.7	±	2.9
10/26/2015	7.2	±	1.2	41.3	±	2.8
11/2/2015	2.9	±	0.8	37.0	±	2.8
11/9/2015	5.7	±	1.1	38.1	±	2.6
11/16/2015	5.8	±	1.1	43.4	±	2.8
11/23/2015	7.6	±	1.2	30.1	±	2.5
11/30/2015	6.5	±	1.2	33.4	±	2.7
12/7/2015	4.8	±	1.0	49.5	±	3.0
12/14/2015	12.3	±	1.5	65.4	±	3.5
12/21/2015	6.6	±	1.2	37.2	±	2.7
12/28/2015	3.7	±	0.9	30.1	±	2.5

*U is Uncertainty at a 95% confidence level.

Table B.2. Sample Results for Alpha / Beta Screening of Air Particulate Filters
Metropolis Airport
Results are in femtocuries per cubic meter (fCi/m^3)

Location	Alpha			Beta		
Date	Result		*U	Result		*U
Metropolis Airport 1 Mi. NNE						
1/5/2015	2.3	±	0.8	32.1	±	2.5
1/13/2015	2.2	±	0.7	32.4	±	2.3
1/20/2015	4.1	±	1.0	35.2	±	2.7
1/26/2015	1.9	±	0.8	23.0	±	2.5
2/3/2015	1.0	±	0.6	21.7	±	2.1
2/9/2015	4.5	±	1.1	38.8	±	3.0
2/17/2015	1.9	±	0.7	31.8	±	2.4
2/23/2015	2.0	±	0.9	50.2	±	3.2
3/2/2015	2.2	±	0.8	38.5	±	2.8
3/9/2015	19.3	±	1.9	41.2	±	2.9
3/16/2015	1.2	±	0.7	24.4	±	2.5
3/23/2015	1.2	±	0.7	29.5	±	2.5
3/30/2015	1.3	±	0.7	24.2	±	2.4
4/6/2015	3.7	±	0.9	21.5	±	2.3
4/13/2015	3.3	±	0.9	26.7	±	2.5
4/20/2015	2.3	±	0.8	18.6	±	2.2
4/27/2015	2.4	±	0.8	18.4	±	2.2
5/4/2015	2.9	±	0.9	25.2	±	2.4
5/11/2015	6.5	±	1.2	30.3	±	2.7
5/18/2015	3.2	±	0.9	25.0	±	2.4
5/26/2015	1.4	±	0.6	19.1	±	2.0
6/1/2015	3.4	±	1.0	16.5	±	2.5
6/8/2015	8.8	±	1.3	30.1	±	2.7
6/15/2015	5.2	±	1.1	34.2	±	2.6
6/22/2015	5.3	±	1.1	25.8	±	2.6
6/29/2015	3.4	±	1.0	24.7	±	2.5

Location	Alpha			Beta		
Date	Result		*U	Result		*U
Metropolis Airport 1 Mi. NNE						
7/6/2015	2.9	±	0.9	32.2	±	2.5
7/13/2015	5.5	±	1.1	47.9	±	3.0
7/20/2015	3.2	±	0.9	45.4	±	2.8
7/27/2015	3.0	±	0.9	39.6	±	2.8
8/3/2015	2.3	±	0.8	38.6	±	2.7
8/10/2015	1.8	±	0.7	39.8	±	2.7
8/17/2015	2.3	±	0.8	34.6	±	2.6
8/24/2015	1.5	±	0.7	27.2	±	2.4
8/31/2015	1.3	±	0.7	33.6	±	2.6
9/8/2015	5.0	±	1.0	71.5	±	3.1
9/14/2015	1.3	±	0.7	28.4	±	2.6
9/21/2015	2.5	±	0.8	37.0	±	2.6
9/28/2015	1.7	±	0.8	39.4	±	2.8
10/5/2015	1.0	±	0.6	21.6	±	2.2
10/13/2015	3.0	±	0.8	42.9	±	2.6
10/19/2015	2.5	±	0.9	32.0	±	2.9
10/26/2015	3.3	±	0.9	33.8	±	2.6
11/2/2015	2.1	±	0.7	34.4	±	2.7
11/9/2015	3.1	±	0.8	33.1	±	2.5
11/16/2015	1.7	±	0.7	40.8	±	2.7
11/23/2015	2.5	±	0.8	25.6	±	2.3
11/30/2015	2.4	±	0.8	26.5	±	2.5
12/7/2015	4.5	±	1.0	47.4	±	3.0
12/14/2015	5.4	±	1.1	50.7	±	3.1
12/21/2015	2.1	±	0.8	33.7	±	2.6
12/28/2015	0.7	±	0.6	24.2	±	2.4

*U is Uncertainty at a 95% confidence level.

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

Location Date	Alpha Result		*U	Beta Result		*U
Massac County Hospital Roof						
1/5/2015	1.9	±	0.8	27.7	±	2.4
1/13/2015	0.9	±	0.6	22.9	±	2.2

*U is Uncertainty at a 95% confidence level.

This data is included for completeness. Previous reports included air sampling data from the hospital roof. This air sampler was taken out of service in the middle of January 2015.

Table B.4. Sample Results for Alpha / Beta Screening of Air Particulate Filters – North Avenue
Results are in femtocuries per cubic meter (fCi/m^3)

Location	Alpha			Beta		
Date	Result		*U	Result		*U
North Ave.						
1/5/2015	1.9	±	0.8	30.0	±	2.5
1/13/2015	1.5	±	0.6	30.8	±	2.3
1/20/2015	3.0	±	0.9	38.3	±	2.8
1/26/2015	1.2	±	0.8	21.5	±	2.5
2/3/2015	1.0	±	0.6	21.0	±	2.1
2/9/2015	2.2	±	0.9	37.7	±	3.0
2/17/2015	2.8	±	0.8	43.8	±	2.6
2/23/2015	1.9	±	0.9	52.3	±	3.3
3/2/2015	1.9	±	0.8	37.1	±	2.7
3/9/2015	1.4	±	0.7	25.0	±	2.4
3/16/2015	1.3	±	0.8	21.7	±	2.4
3/23/2015	1.4	±	0.7	26.9	±	2.4
3/30/2015	1.2	±	0.7	22.3	±	2.3
4/6/2015	1.6	±	0.7	20.8	±	2.3
4/13/2015	2.1	±	0.8	25.7	±	2.5
4/20/2015	2.2	±	0.8	19.1	±	2.2
4/27/2015	2.5	±	0.8	20.3	±	2.2
5/4/2015	1.4	±	0.7	24.2	±	2.3
5/11/2015	2.6	±	0.9	27.6	±	2.5
5/18/2015	1.9	±	0.7	22.4	±	2.3
5/26/2015	1.2	±	0.6	17.5	±	2.0
6/1/2015	1.9	±	0.9	13.8	±	2.4
6/8/2015	3.8	±	1.0	27.9	±	2.6
6/15/2015	3.9	±	1.0	25.9	±	2.4
6/22/2015	3.4	±	0.9	22.3	±	2.4
6/29/2015	4.2	±	1.0	32.0	±	2.6

Location	Alpha			Beta		
Date	Result		*U	Result		*U
North Ave.						
7/6/2015	4.3	±	1.0	36.8	±	2.6
7/13/2015	4.6	±	1.0	33.3	±	2.7
7/20/2015	3.3	±	0.9	38.1	±	2.7
7/27/2015	1.6	±	0.8	29.3	±	2.5
8/3/2015	1.2	±	0.7	43.4	±	2.8
8/10/2015	2.6	±	0.8	37.0	±	2.6
8/17/2015	2.4	±	0.8	35.6	±	2.6
8/24/2015	1.2	±	0.7	26.2	±	2.3
8/31/2015	1.2	±	0.7	38.5	±	2.7
9/8/2015	5.3	±	1.1	73.3	±	3.3
9/14/2015	0.9	±	0.7	27.7	±	2.6
9/21/2015	1.6	±	0.7	33.4	±	2.6
9/28/2015	1.4	±	0.8	38.9	±	2.8
10/5/2015	1.0	±	0.6	18.1	±	2.1
10/13/2015	3.0	±	0.8	41.2	±	2.5
10/19/2015	3.8	±	1.0	31.8	±	2.9
10/26/2015	2.7	±	0.9	40.5	±	2.8
11/2/2015	5.9	±	1.2	31.2	±	2.7
11/9/2015	3.0	±	0.8	31.3	±	2.5
11/16/2015	1.9	±	0.8	39.6	±	2.7
11/23/2015	1.3	±	0.7	23.1	±	2.2
11/30/2015	1.4	±	0.7	26.7	±	2.5
12/7/2015	5.0	±	1.0	46.5	±	2.9
12/14/2015	4.6	±	1.0	51.5	±	3.1
12/21/2015	3.9	±	1.0	31.7	±	2.5
12/28/2015	0.9	±	0.6	22.5	±	2.3

*U is Uncertainty at a 95% confidence level.

Table B.5. Sample Results for Alpha / Beta Screening of Air Particulate Filters – Water Treatment Plant / Dorothy Miller Park
Results are in femtocuries per cubic meter (fCi/m^3)

Location	Alpha			Beta		
Date	Result		*U	Result		*U
Dorothy Miller Park						
1/5/2015	1.9	±	0.8	31.8	±	2.5
1/13/2015	1.8	±	0.7	32.1	±	2.3
1/20/2015	1.9	±	0.8	37.4	±	2.7
1/26/2015	0.8	±	0.7	24.5	±	2.6
2/3/2015	1.5	±	0.7	21.1	±	2.1
2/9/2015	1.5	±	0.8	38.0	±	3.0
2/17/2015	1.9	±	0.7	32.1	±	2.4
2/23/2015	2.8	±	1.0	50.6	±	3.2
3/2/2015	2.5	±	0.8	37.8	±	2.7
3/9/2015	0.9	±	0.7	25.6	±	2.4
3/16/2015	1.2	±	0.7	21.9	±	2.4
3/23/2015	1.6	±	0.7	25.1	±	2.4
3/30/2015	1.3	±	0.7	24.6	±	2.3
4/6/2015	0.6	±	0.6	17.7	±	2.2
4/13/2015	1.5	±	0.8	23.0	±	2.4
4/20/2015	1.5	±	0.7	17.4	±	2.2
4/27/2015	2.4	±	0.8	20.5	±	2.2
5/4/2015	1.7	±	0.8	22.8	±	2.4
5/11/2015	2.6	±	0.9	31.7	±	2.5
5/18/2015	1.2	±	0.6	20.7	±	2.1
5/26/2015	1.2	±	0.6	17.7	±	1.9
5/30/2015	0.6	±	1.0	15.5	±	3.4
6/15/2015	3.3	±	0.9	29.7	±	2.6
6/22/2015	2.7	±	0.9	22.1	±	2.4
6/29/2015	3.5	±	1.0	25.6	±	2.6

Location	Alpha			Beta		
Date	Result		*U	Result		*U
Dorothy Miller Park						
7/6/2015	2.6	±	0.8	31.6	±	2.6
7/13/2015	2.8	±	0.9	25.9	±	2.5
7/20/2015	2.9	±	0.8	23.0	±	2.3
7/27/2015	2.8	±	0.9	30.1	±	2.6
8/3/2015	2.4	±	0.9	65.5	±	3.3
8/10/2015	2.3	±	0.8	36.6	±	2.6
8/17/2015	1.6	±	0.8	35.5	±	2.7
8/24/2015	1.1	±	0.7	26.6	±	2.4
8/31/2015	2.0	±	0.8	39.6	±	2.7
9/8/2015	5.1	±	1.0	68.2	±	3.1
9/14/2015	1.9	±	1.1	28.3	±	3.5
9/21/2015	1.2	±	0.7	33.5	±	2.5
9/28/2015	1.2	±	0.7	37.3	±	2.7
10/5/2015	1.3	±	0.7	22.2	±	2.3
10/13/2015	1.0	±	0.6	11.9	±	1.8
10/19/2015	3.1	±	1.0	32.7	±	3.0
10/26/2015	1.7	±	0.8	33.1	±	2.6
11/2/2015	2.3	±	0.8	29.8	±	2.5
11/9/2015	4.2	±	1.0	31.3	±	2.5
11/16/2015	1.9	±	0.8	37.0	±	2.7
11/23/2015	1.1	±	0.7	24.2	±	2.3
11/30/2015	0.9	±	0.6	25.2	±	2.6
12/7/2015	3.7	±	0.9	47.4	±	3.0
12/14/2015	4.6	±	1.0	50.7	±	3.1
12/21/2015	2.2	±	0.8	30.0	±	2.5
12/28/2015	1.1	±	0.7	23.0	±	2.4

*U is Uncertainty at a 95% confidence level.

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

Location	Ac-228		Be-7		Bi-212		Bi-214		Cs-137		K-40		Pa-234m		Pb-210		Pb-212	
Date	Result	*U	Result	*U	Result	*U	Result	*U	Result	*U	Result	*U	Result	*U	Result	*U	Result	*U
Intersection of Gurley and Devers (@ Road Ends Sign)																		
5/19/2015	1.0	0.0	0.0	0.1	1.0	0.1	1.1	0.0	0.0	0.0	11.9	0.5	0.9	0.6	1.4	0.1	1.0	0.0
8/10/2015	1.0	0.0	-0.1	0.0	0.9	0.1	0.9	0.0	0.1	0.0	12.5	0.3	2.1	0.4	1.4	0.1	1.0	0.0
Massac Creek @ Country Club Road																		
5/19/2015	0.8	0.0	0.0	0.0	0.8	0.1	0.9	0.0	0.0	0.0	8.7	0.4	0.9	0.4	1.4	0.3	0.9	0.0
8/10/2015	0.5	0.0	0.0	0.0	0.4	0.0	0.4	0.0	0.0	0.0	1.9	0.1	1.0	0.3	0.2	2.3	0.5	0.0
Metropolis Airport 1 Mi. NNE																		
5/19/2015	1.0	0.0	-0.1	0.1	1.1	0.1	1.1	0.0	0.3	0.0	10.1	0.5	1.0	0.6	2.1	0.1	1.1	0.0
8/10/2015	1.1	0.0	-0.1	0.1	0.8	0.2	1.0	0.0	0.3	0.0	11.2	0.4	0.9	1.2	-14.0	12.0	1.1	0.0
Residence NNE Boundary																		
5/19/2015	1.0	0.0	0.0	0.1	1.1	0.1	1.2	0.0	0.2	0.0	12.6	0.6	3.5	0.9	1.8	0.1	1.1	0.0
8/10/2015	1.1	0.0	-0.1	0.0	1.0	0.1	1.0	0.0	0.3	0.0	14.2	0.3	2.8	0.5	4.0	4.0	1.2	0.0

Location	Pb-214		Ra-226		Th-230		Th-231		Th-234		Tl-208		U-234		U-235	
Date	Result	*U	Result	*U	Result	*U	Result	*U	Result	*U	Result	*U	Result	*U	Result	*U
Intersection of Gurley and Devers (@ Road Ends Sign)																
5/19/2015	1.2	0.0	1.5	0.5	2.1	1.1	-0.8	0.4	1.2	0.3	0.9	0.0	9.7	3.1	0.0	0.0
8/10/2015	1.0	0.0	1.2	0.3	1.0	0.8	-1.2	0.4	1.3	0.1	0.9	0.0	6.8	1.6	0.1	0.0
Massac Creek @ Country Club Road																
5/19/2015	1.0	0.0	1.6	0.1	0.0	1.7	-0.4	0.5	1.1	0.3	0.8	0.0	2.3	6.5	0.1	0.0
8/10/2015	0.4	0.0	0.9	0.1	-1.8	2.9	-1.7	0.7	0.3	0.2	0.4	0.0	6.0	21.0	0.1	0.0
Metropolis Airport 1 Mi. NNE																
5/19/2015	1.2	0.0	0.6	0.6	1.1	0.8	-0.9	0.4	1.6	0.4	0.9	0.0	8.0	3.3	0.1	0.0
8/10/2015	1.2	0.0	2.4	0.3	-3.4	15.3	-6.0	3.7	0.8	1.1	1.0	0.0	-30.0	110.0	0.1	0.0
Residence NNE Boundary																
5/19/2015	1.3	0.0	0.9	0.4	1.5	1.1	-0.6	0.5	3.2	0.6	0.9	0.0	8.3	3.5	0.2	0.0
8/10/2015	1.2	0.0	1.6	0.3	-5.0	5.1	-2.3	1.0	2.2	0.5	1.0	0.0	4.0	37.0	0.1	0.0

*U is Uncertainty at a 95% confidence level.

Table B.7. Gamma Spectroscopy Sample Results for Vegetation Samples
Results are in picocuries per kilogram (pCi/kg)

Location	Ac-228		Be-7		Bi-212		Bi-214		Cs-137		K-40		Pa-234m		Pb-210		Pb-212	
Date	Result	*U	Result	*U	Result	*U	Result	*U	Result	*U	Result	*U	Result	*U	Result	*U	Result	*U
Intersection of Gurley and Devers (@ Road Ends Sign)																		
5/19/2015	0.1	0.1	3.9	0.5	-0.1	0.5	0.1	0.1	0.0	0.0	11.3	1.1	2.3	3.9	0.5	0.2	0.0	0.0
8/10/2015	0.1	0.1	5.7	0.4	0.1	0.4	0.0	0.1	0.0	0.0	17.2	0.8	0.5	3.0	0.9	0.3	0.0	0.0
Massac Creek @ Country Club Road																		
5/19/2015	0.4	0.3	3.0	0.7	-0.4	0.7	0.2	0.1	0.0	0.1	19.1	1.8	4.8	7.3	0.2	0.6	0.0	0.1
8/10/2015	0.3	0.1	5.4	0.4	0.5	0.4	0.1	0.1	0.0	0.0	18.3	0.8	2.8	2.9	3.0	9.7	0.0	0.0
Metropolis Airport 1 Mi. NNE																		
5/19/2015	0.0	0.2	4.1	0.7	0.6	0.7	0.1	0.1	0.0	0.1	14.5	1.5	10.2	7.1	0.7	0.6	0.0	0.1
8/10/2015	0.2	0.1	2.9	0.3	0.1	0.2	0.1	0.1	0.0	0.0	17.4	0.7	1.3	2.5	0.0	0.4	0.0	0.0
Residence NNE Boundary																		
5/19/2015	0.0	0.1	2.0	0.4	-0.1	0.5	0.0	0.1	0.0	0.0	20.2	1.4	0.8	4.3	0.3	0.2	0.0	0.0
8/10/2015	0.0	0.0	1.5	0.1	-0.1	0.1	0.0	0.0	0.0	0.0	10.5	0.4	0.7	1.3	0.2	0.1	0.0	0.0

Location	Pb-214		Ra-226		Th-230		Th-231		Th-234		Tl-208		U-234		U-235	
Date	Result	*U	Result	*U	Result	*U	Result	*U	Result	*U	Result	*U	Result	*U	Result	*U
Intersection of Gurley and Devers (@ Road Ends Sign)																
5/19/2015	0.1	0.1	0.0	0.4	-3.1	2.2	0.1	2.4	0.1	0.2	0.1	0.1	9.7	6.9	0.0	0.0
8/10/2015	0.0	0.1	1.2	0.4	-2.4	2.6	3.5	2.1	1.3	0.3	0.1	0.1	13.7	8.4	0.1	0.0
Massac Creek @ Country Club Road																
5/19/2015	0.0	0.1	0.0	1.0	1.1	4.1	-2.8	4.3	0.1	0.7	0.2	0.2	14.9	13.3	0.0	0.1
8/10/2015	0.1	0.0	0.5	0.5	8.0	7.2	-3.9	2.9	0.6	1.1	0.3	0.1	111.0	100.0	0.0	0.0
Metropolis Airport 1 Mi. NNE																
5/19/2015	0.1	0.1	-0.4	0.8	-2.0	3.9	-3.7	4.1	0.0	0.6	0.1	0.2	0.8	12.5	0.0	0.1
8/10/2015	0.0	0.0	0.0	0.4	1.8	3.1	-0.5	1.6	0.4	0.4	0.1	0.1	45.0	11.0	0.0	0.0
Residence NNE Boundary																
5/19/2015	0.0	0.1	0.1	0.4	1.0	2.2	-1.3	2.4	0.6	0.3	0.0	0.1	3.8	7.3	0.0	0.0
8/10/2015	0.0	0.0	0.0	0.1	0.1	0.5	-0.1	0.4	0.1	0.1	0.0	0.0	1.7	1.2	0.0	0.0

*U is Uncertainty at a 95% confidence level.

Table B.8. Gamma Spectroscopy Sample Results for Sediment Samples
Results are in picocuries per gram (pCi/g)

Location	Ac-228			Be-7			Bi-212			Bi-214			Cs-137			K-40			Pa-234m			Pb-210			Pb-212		
Date	Result		*U	Result		*U	Result		*U	Result		*U	Result		*U	Result		*U	Result		*U	Result		*U	Result		*U
Ohio River At Joppa, 4 Mi. DS																											
5/18/2015	0.4	±	0.0	0.2	±	0.0	0.4	±	0.1	0.4	±	0.0	0.0	±	0.0	6.7	±	0.3	0.7	±	0.4	0.4	±	0.1	0.4	±	0.0
8/10/2015	0.7	±	0.0	0.6	±	0.0	0.7	±	0.0	0.6	±	0.0	0.0	±	0.0	9.7	±	0.2	0.8	±	0.3	1.7	±	2.9	0.7	±	0.0
Public Boat Launch near Harrah's Casino																											
5/19/2015	0.7	±	0.0	0.0	±	0.0	0.7	±	0.1	0.7	±	0.0	0.0	±	0.0	10.6	±	0.5	1.1	±	0.5	0.8	±	0.2	0.7	±	0.0
8/10/2015	0.7	±	0.0	0.0	±	0.0	0.7	±	0.0	0.6	±	0.0	0.0	±	0.0	9.6	±	0.2	1.0	±	0.2	0.6	±	0.1	0.7	±	0.0

Location	Pb-214			Ra-226			Th-230			Th-231			Th-234			Tl-208			U-234			U-235		
Date	Result		*U	Result		*U	Result		*U	Result		*U	Result		*U	Result		*U	Result		*U	Result		*U
Ohio River At Joppa, 4 Mi. DS																								
5/18/2015	0.4	±	0.0	0.8	±	0.1	1.0	±	1.0	-1.3	±	0.6	0.3	±	0.1	0.3	±	0.0	4.4	±	3.7	0.1	±	0.0
8/10/2015	0.8	±	0.0	0.7	±	0.3	1.0	±	1.1	-1.3	±	0.6	0.7	±	0.3	0.6	±	0.0	15.0	±	26.0	0.0	±	0.0
Public Boat Launch near Harrah's Casino																								
5/19/2015	0.8	±	0.0	0.3	±	0.5	-0.7	±	1.6	-0.2	±	0.4	0.7	±	0.3	0.6	±	0.0	4.4	±	5.9	0.1	±	0.0
8/10/2015	0.7	±	0.0	1.3	±	0.1	1.1	±	1.6	0.3	±	0.4	0.7	±	0.1	0.6	±	0.0	5.9	±	3.0	0.1	±	0.0

*U is Uncertainty at a 95% confidence level.

Table B.9. Sample Results for Gross Alpha / Beta Screening of Water Samples
Results are in picocuries per liter (pCi/L)

Location	Alpha			Beta		
Date	Result		*U	Result		*U
Massac Creek @ Country Club Road						
5/19/2015	-1.2	±	1.3	1.8	±	2.2
8/10/2015	-0.6	±	1.2	3.8	±	2.4
10/19/2015	-0.8	±	1.4	3.1	±	2.1
Metropolis PWS						
2/23/2015	1.3	±	1.4	1.5	±	2.5
8/10/2015	3.0	±	1.4	2.5	±	2.4
10/19/2015	2.4	±	1.5	2.0	±	2.1
Metropolis PWS - Well 8						
5/26/2015	4.3	±	1.6	1.6	±	2.2
Ohio River 2 Mi. US						
2/23/2015	0.6	±	1.4	1.3	±	2.5
5/18/2015	-0.7	±	1.3	1.3	±	2.2
8/10/2015	0.1	±	1.3	3.5	±	2.4
10/19/2015	-1.3	±	1.3	2.9	±	2.1
Ohio River At Joppa, 4 Mi. DS						
2/23/2015	0.8	±	1.4	2.9	±	2.5
5/18/2015	1.6	±	1.5	0.6	±	2.2
8/10/2015	-0.1	±	1.3	4.8	±	2.5
10/19/2015	0.1	±	1.4	3.8	±	2.2
Public Boat Launch near Harrah's Casino						
5/19/2015	-0.4	±	1.4	1.2	±	2.2
8/10/2015	0.3	±	1.3	1.5	±	2.4
10/19/2015	0.2	±	1.4	2.6	±	2.1
Small Creek in Fort Massac State Park						
5/26/2015	0.0	±	1.4	2.6	±	2.2
10/19/2015	0.2	±	1.4	4.6	±	2.2

*U is Uncertainty at a 95% confidence level.

Table B.10. Gamma Spectroscopy Sample Results for Water Samples
Results are in picocuries per liter (pCi/L)

Location / Date	Ac-228 Result	Ac-228 *U	Be-7 Result	Be-7 *U	Bi-212 Result	Bi-212 *U	Bi-214 Result	Bi-214 *U	Cs-137 Result	Cs-137 *U	K-40 Result	K-40 *U	Pa-234m Result	Pa-234m *U	Pb-210 Result	Pb-210 *U	Pb-212 Result	Pb-212 *U
Massac Creek @ Country Club Road																		
5/19/2015	7.8	8.4	6.6	19.0	6.0	29.4	6.0	4.5	-1.0	2.2	9.0	29.4	130.0	294.0	23.0	25.5	0.9	2.7
8/10/2015	6.1	4.6	-13.7	9.9	27.0	17.0	9.3	3.1	-1.4	1.1	19.0	18.0	30.0	150.0	11.0	13.0	2.4	1.4
10/19/2015	11.9	4.7	4.0	11.0	-11.0	17.0	4.9	2.5	0.4	1.2	5.0	15.0	80.0	140.0	-20.0	750.0	2.0	2.3
Metropolis PWS																		
2/23/2015	-1.3	7.1	3.3	11.8	22.0	23.5	2.7	3.9	0.6	1.8	-2.0	31.4	60.0	215.6	8.0	41.2	-0.3	3.3
8/10/2015	13.0	4.4	2.0	10.0	-1.0	14.0	9.8	2.2	-0.6	1.1	47.0	13.0	230.0	140.0	6.0	15.0	-1.8	2.0
10/19/2015	3.9	3.5	5.1	8.9	3.0	13.0	2.7	1.9	0.5	1.1	25.0	10.0	90.0	110.0	5.0	23.0	0.6	1.4
Metropolis PWS - Well 8																		
5/26/2015	12.1	6.7	19.4	17.8	1.0	23.5	-0.7	4.3	-1.0	1.5	42.0	31.4	100.0	235.2	-61.0	54.9	1.2	3.7
Ohio River 2 Mi. US																		
2/23/2015	6.9	6.9	-1.7	12.0	4.0	23.5	5.3	3.7	0.8	1.7	-10.0	35.3	169.0	188.2	26.0	41.2	1.7	3.3
5/18/2015	0.8	14.1	-1.1	14.6	5.0	41.2	2.8	8.2	0.4	3.1	23.0	47.0	260.0	392.0	-20.0	64.7	-1.7	6.7
8/10/2015	5.1	3.6	-8.4	7.2	17.0	13.0	8.8	1.9	-0.5	0.9	4.0	17.0	-40.0	140.0	27.0	22.0	1.5	1.7
10/19/2015	-4.6	3.5	-1.0	8.8	-20.0	13.0	4.0	1.8	1.7	0.8	33.0	11.0	62.0	97.0	22.0	28.0	0.1	1.3
Ohio River At Joppa, 4 Mi. DS																		
2/23/2015	0.2	7.1	2.2	14.3	-4.0	25.5	2.9	3.5	-1.2	2.0	8.0	23.5	50.0	196.0	4.0	43.1	1.6	2.5
5/18/2015	10.9	6.9	14.4	14.3	20.0	21.6	-0.7	4.7	-0.1	1.6	10.0	31.4	170.0	235.2	-35.0	51.0	3.0	3.7
8/10/2015	5.6	4.4	-3.0	11.0	55.0	15.0	9.2	2.5	0.3	1.3	11.0	15.0	340.0	130.0	490.0	760.0	0.1	2.5
10/19/2015	13.8	4.4	0.0	12.0	19.0	15.0	-1.9	2.2	0.5	1.2	66.0	14.0	360.0	140.0	-570.0	750.0	3.1	2.1
Public Boat Launch near Harrah's Casino																		
5/19/2015	2.9	6.3	11.0	13.9	18.0	23.5	11.0	3.9	-0.2	1.8	16.0	33.3	170.0	215.6	39.0	43.1	0.7	3.3
8/10/2015	3.0	4.7	4.0	11.0	25.0	17.0	8.9	2.3	0.5	1.1	23.0	17.0	180.0	150.0	20.0	13.0	1.3	1.4
10/19/2015	8.2	3.6	2.2	8.8	22.0	11.0	9.0	1.8	0.0	0.9	25.0	16.0	50.0	120.0	14.0	28.0	-0.9	1.7
Small Creek in Fort Massac State Park																		
5/26/2015	4.4	6.5	15.9	17.8	4.0	23.5	0.3	3.3	-0.6	1.6	31.0	19.6	-184.0	188.2	-58.0	54.9	-0.3	2.4
10/19/2015	1.0	3.5	4.4	7.9	-1.0	13.0	7.8	2.0	1.0	0.9	27.0	17.0	290.0	120.0	17.0	23.0	4.0	1.4

*U is Uncertainty at a 95% confidence level.

Table B.10.(Cont.) Gamma Spectroscopy Sample Results for Water Samples
Results are in picocuries per liter (pCi/L)

Location / Date	Pb-214 Result	Pb-214 *U	Ra-226 Result	Ra-226 *U	Th-230 Result	Th-230 *U	Th-231 Result	Th-231 *U	Th-234 Result	Th-234 *U	Tl-208 Result	Tl-208 *U	U-234 Result	U-234 *U	U-235 Result	U-235 *U
Massac Creek @ Country Club Road																
5/19/2015	4.4 ±	3.7	17.0 ±	37.2	170.0 ±	294.0	-64.0 ±	192.1	18.0 ±	29.4	2.2 ±	6.1	1130.0 ±	784.0	1.1 ±	2.4
8/10/2015	2.7 ±	2.5	44.0 ±	13.0	220.0 ±	150.0	193.0 ±	99.0	28.0 ±	15.0	5.1 ±	3.0	770.0 ±	410.0	3.2 ±	0.8
10/19/2015	6.0 ±	2.3	-19.0 ±	27.0	520.0 ±	690.0	-450.0 ±	180.0	130.0 ±	100.0	11.9 ±	3.3	-3000.0 ±	11000.0	-1.2 ±	1.7
Metropolis PWS																
2/23/2015	4.6 ±	3.1	19.0 ±	41.2	80.0 ±	313.6	70.0 ±	215.6	42.0 ±	33.3	5.3 ±	5.1	4130.0 ±	1293.6	1.2 ±	2.5
8/10/2015	0.8 ±	2.8	15.0 ±	21.0	-66.0 ±	99.0	92.0 ±	99.0	-6.0 ±	16.0	4.9 ±	4.0	930.0 ±	320.0	1.0 ±	1.3
10/19/2015	3.5 ±	2.1	15.0 ±	16.0	120.0 ±	180.0	-200.0 ±	140.0	-5.0 ±	18.0	2.4 ±	2.6	3280.0 ±	690.0	1.8 ±	1.0
Metropolis PWS - Well 8																
5/26/2015	2.0 ±	3.7	-19.0 ±	41.2	170.0 ±	392.0	60.0 ±	215.6	2.0 ±	49.0	-4.7 ±	6.7	1870.0 ±	1450.4	-1.2 ±	2.5
Ohio River 2 Mi. US																
2/23/2015	3.6 ±	3.3	-6.0 ±	37.2	-70.0 ±	294.0	280.0 ±	215.6	34.0 ±	33.3	-0.5 ±	5.3	3580.0 ±	1274.0	-0.4 ±	2.4
5/18/2015	4.1 ±	6.9	3.0 ±	80.4	-10.0 ±	392.0	80.0 ±	372.4	6.0 ±	68.6	4.8 ±	9.2	1120.0 ±	1274.0	0.2 ±	5.1
8/10/2015	8.7 ±	1.7	10.0 ±	21.0	-340.0 ±	160.0	90.0 ±	110.0	47.0 ±	18.0	6.8 ±	3.4	2860.0 ±	650.0	0.6 ±	1.3
10/19/2015	3.5 ±	1.9	43.0 ±	16.0	190.0 ±	220.0	60.0 ±	140.0	39.0 ±	33.0	0.0 ±	2.3	-500.0 ±	1100.0	3.1 ±	1.0
Ohio River At Joppa, 4 Mi. DS																
2/23/2015	1.3 ±	3.9	27.0 ±	29.4	-490.0 ±	333.2	-110.0 ±	254.8	-13.0 ±	35.3	-0.4 ±	4.7	1230.0 ±	1274.0	1.9 ±	1.9
5/18/2015	2.6 ±	3.7	-22.0 ±	37.2	-110.0 ±	392.0	-30.0 ±	215.6	26.0 ±	56.8	-3.0 ±	6.1	2120.0 ±	1470.0	-1.4 ±	2.4
8/10/2015	7.8 ±	2.6	-38.0 ±	24.0	880.0 ±	700.0	-40.0 ±	180.0	330.0 ±	110.0	10.2 ±	3.6	-7000.0 ±	10000.0	-2.4 ±	1.5
10/19/2015	7.5 ±	2.3	-36.0 ±	27.0	1200.0 ±	710.0	-200.0 ±	180.0	120.0 ±	100.0	7.0 ±	3.6	24500.0 ±	8800.0	-2.3 ±	1.7
Public Boat Launch near Harrah's Casino																
5/19/2015	3.1 ±	3.3	-6.0 ±	41.2	140.0 ±	313.6	110.0 ±	235.2	58.0 ±	35.3	9.4 ±	5.3	40.0 ±	1607.2	-0.4 ±	2.5
8/10/2015	3.1 ±	2.4	-8.0 ±	20.0	110.0 ±	150.0	-57.0 ±	96.0	-6.0 ±	15.0	9.2 ±	2.9	1700.0 ±	420.0	-0.5 ±	1.2
10/19/2015	-4.3 ±	2.1	-7.0 ±	21.0	-100.0 ±	210.0	130.0 ±	110.0	-6.0 ±	32.0	-0.3 ±	3.3	1580.0 ±	750.0	-0.4 ±	1.3
Small Creek in Fort Massac State Park																
5/26/2015	4.5 ±	3.7	34.0 ±	29.4	-190.0 ±	431.2	-100.0 ±	254.8	-46.0 ±	51.0	5.4 ±	4.3	4990.0 ±	1685.6	2.1 ±	1.9
10/19/2015	2.8 ±	1.8	-18.0 ±	22.0	100.0 ±	160.0	-50.0 ±	110.0	49.0 ±	18.0	9.5 ±	2.7	3240.0 ±	660.0	-1.2 ±	1.4

*U is Uncertainty at a 95% confidence level.

Table B.11. KPA (Total Uranium) Sample Results for Water Samples
Results are in picocuries per liter (pCi/L)

Location	Date	Result		*U
Massac Creek @ Country Club Road	5/19/2015	0.0	±	0.0
Massac Creek @ Country Club Road	8/10/2015	0.0	±	0.0
Massac Creek @ Country Club Road	10/19/2015	0.0	±	0.0
Metropolis PWS	2/23/2015	0.4	±	0.0
Metropolis PWS	8/10/2015	0.5	±	0.1
Metropolis PWS	10/19/2015	0.4	±	0.0
Metropolis PWS - Well 8	5/26/2015	0.3	±	0.0
Ohio River 2 Mi. US	2/23/2015	0.4	±	0.0
Ohio River 2 Mi. US	5/18/2015	0.4	±	0.0
Ohio River 2 Mi. US	8/10/2015	0.4	±	0.1
Ohio River 2 Mi. US	10/19/2015	0.4	±	0.0
Ohio River At Joppa, 4 Mi. DS	2/23/2015	0.7	±	0.1
Ohio River At Joppa, 4 Mi. DS	5/18/2015	1.1	±	0.1
Ohio River At Joppa, 4 Mi. DS	8/10/2015	0.7	±	0.1
Ohio River At Joppa, 4 Mi. DS	10/19/2015	0.6	±	0.0
Public Boat Launch near Harrah's Casino	5/19/2015	0.4	±	0.0
Public Boat Launch near Harrah's Casino	8/10/2015	0.5	±	0.0
Public Boat Launch near Harrah's Casino	10/19/2015	0.4	±	0.0
Small Creek in Fort Massac State Park	5/26/2015	0.0	±	0.0
Small Creek in Fort Massac State Park	10/19/2015	0.0	±	0.0

*U is Uncertainty at a 95% confidence level.

Table B.12. Summary of Ambient Gamma Results

Location	Quarter 1 mrem/day	Quarter 2 mrem/day	Quarter 3 mrem/day	Quarter 4 mrem/day	Annual Dose mrem/year
METR-01	0.22	0.087	0.09	0.103	45.63
METR-02	0.196	0.066	0.081	0.077	38.33
METR-03	0.246	0.094	0.102	0.107	50.10
METR-04		0.1	0.126	0.093	38.81
METR-05	0.212	0.081	0.112	0.109	46.90
METR-06	0.209	0.109	0.128	0.113	51.01
METR-07*	0.327	0.1	0.134	0.159	65.70
METR-08*	0.184	0.149	0.19	0.162	62.51
METR-09*	0.274	0.114	0.14	0.13	60.04
METR-10*	1.662	0.793	0.917	0.887	388.63
METR-11*	0.32	0.142	0.169	0.173	73.37
METR-12*	1.777	0.609	0.749	0.785	357.70
METR-13*	3.999	2.005	2.237	1.862	921.90
METR-14*	0.522	0.238	0.29	0.265	119.99
METR-16	0.256	0.102	0.128	0.124	55.66
METR-17*	1.333	0.624	0.711	0.644	302.22
METR-18*	4.686	2.257	2.286	2.22	1044.72
METR-19*	2.777	1.326	1.498	1.54	651.62
METR-20	0.181	0.078	0.088	0.096	40.42
METR-21	0.262	0.116	0.128	0.123	57.40
METR-22	0.223	0.106	0.124	0.111	51.47
METR-23			0.122	0.103	41.06
METR-24*				0.999	364.64

*Starred locations are within a restricted access area immediately surrounding the facility, thus inaccessible to the public.

The blank in the table for METR-04 indicates that the dosimeter was missing at the end of the quarter. The blanks in the table for METR-23 and METR-24 indicate that these were new dosimeters added at the end of the second and third quarters, respectively.

The Annual Dose column is based on averages of all available data.

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

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

Location	Alpha			Beta		
Date	Result		*U	Result		*U
Knotts Street, Springfield						
1/5/2015	0.5	±	0.7	29.3	±	2.6
1/12/2015	1.7	±	0.8	26.6	±	2.6
1/20/2015	0.0	±	0.5	32.7	±	2.4
1/26/2015	0.6	±	0.8	17.3	±	2.6
2/2/2015	0.8	±	0.6	16.6	±	2.2
2/9/2015	0.9	±	0.7	29.0	±	2.6
2/17/2015	-0.4	±	0.4	0.1	±	1.4
2/23/2015	2.4	±	1.0	55.8	±	3.5
3/2/2015	1.3	±	0.7	25.2	±	2.5
3/9/2015	0.8	±	0.7	24.2	±	2.5
3/16/2015	1.0	±	0.8	24.1	±	2.6
3/23/2015	1.5	±	0.7	18.0	±	2.2
3/30/2015	0.7	±	0.6	22.4	±	2.3
4/6/2015	1.1	±	0.7	16.7	±	2.2
4/13/2015	1.9	±	0.8	24.4	±	2.4
4/20/2015	1.4	±	0.7	22.6	±	2.3
4/27/2015	1.4	±	0.7	19.1	±	2.2
5/4/2015	2.2	±	0.8	23.3	±	2.4
5/11/2015	1.5	±	0.8	23.9	±	2.5
5/18/2015	0.9	±	0.6	16.3	±	2.1
5/26/2015	1.1	±	0.6	19.0	±	2.0
6/1/2015	1.1	±	0.7	14.5	±	2.3
6/8/2015	1.4	±	0.7	24.3	±	2.3
6/15/2015	2.5	±	0.9	25.2	±	2.5
6/22/2015	2.4	±	0.8	19.4	±	2.2
6/29/2015	1.9	±	0.8	16.9	±	2.2

Location	Alpha			Beta		
Date	Result		*U	Result		*U
Knotts Street, Springfield						
7/6/2015	3.3	±	0.9	26.3	±	2.5
7/13/2015	2.0	±	0.8	15.8	±	2.2
7/20/2015	2.1	±	0.8	27.3	±	2.5
7/27/2015	2.2	±	0.9	21.7	±	2.4
8/3/2015	2.7	±	0.9	32.3	±	2.6
8/10/2015	1.5	±	0.7	34.2	±	2.7
8/17/2015	1.9	±	0.8	35.6	±	2.8
8/24/2015	1.1	±	0.7	28.5	±	2.5
8/31/2015	0.7	±	0.7	29.9	±	2.6
9/8/2015	3.8	±	1.0	62.4	±	3.1
9/14/2015	0.8	±	0.8	20.7	±	2.5
9/21/2015	1.1	±	0.7	28.2	±	2.4
9/28/2015	0.8	±	0.7	30.3	±	2.6
10/5/2015	0.5	±	0.6	20.0	±	2.3
10/13/2015	2.7	±	0.8	30.8	±	2.3
10/19/2015	1.0	±	0.7	19.7	±	2.5
10/26/2015	2.3	±	0.9	44.1	±	2.9
11/2/2015	1.0	±	0.6	26.7	±	2.5
11/9/2015	3.3	±	0.9	25.4	±	2.4
11/16/2015	1.9	±	0.8	35.6	±	2.7
11/23/2015	0.6	±	0.6	18.5	±	2.1
11/30/2015	1.4	±	0.7	25.9	±	2.5
12/7/2015	3.3	±	0.9	37.0	±	2.8
12/14/2015	3.3	±	0.9	46.7	±	3.1
12/21/2015	1.4	±	0.7	25.5	±	2.4
12/29/2015	1.9	±	0.7	28.6	±	2.2

*U is Uncertainty at a 95% confidence level.

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

Location	Alpha			Beta		
Date	Result		*U	Result		*U
Marion Office						
4/13/2015	1.8	±	0.8	21.1	±	2.3
4/20/2015	1.6	±	0.7	18.1	±	2.1
4/27/2015	1.5	±	0.7	16.2	±	2.0
5/4/2015	1.9	±	0.8	19.4	±	2.2
5/11/2015	2.3	±	0.8	24.8	±	2.3
5/18/2015	1.0	±	0.6	19.4	±	2.1
5/26/2015	0.9	±	0.6	16.7	±	1.9
6/1/2015	0.7	±	0.7	10.9	±	2.3
6/8/2015	2.9	±	0.9	22.5	±	2.6
6/15/2015	2.9	±	0.8	25.9	±	2.4
6/22/2015	2.5	±	0.9	18.2	±	2.3
6/29/2015	1.9	±	0.8	27.5	±	2.5
7/6/2015	3.6	±	0.9	27.0	±	2.4
7/13/2015	3.1	±	0.9	19.8	±	2.2
7/20/2015	2.5	±	0.8	24.4	±	2.3
7/27/2015	2.1	±	0.8	28.0	±	2.5
8/3/2015	1.9	±	0.8	32.3	±	2.5
8/10/2015	2.2	±	0.7	33.6	±	2.5
8/17/2015	2.0	±	0.8	35.7	±	2.7

Location	Alpha			Beta		
Date	Result		*U	Result		*U
Marion Office						
8/24/2015	0.9	±	0.6	26.8	±	2.3
8/31/2015	1.1	±	0.7	37.8	±	2.7
9/8/2015	3.9	±	1.0	63.0	±	3.1
9/14/2015	1.3	±	0.7	22.8	±	2.5
9/21/2015	1.0	±	0.6	33.6	±	2.5
9/28/2015	2.3	±	0.9	38.9	±	2.7
10/5/2015	0.8	±	0.6	22.4	±	2.2
10/13/2015		±			±	
10/19/2015	3.8	±	1.1	28.1	±	2.8
10/26/2015	1.8	±	0.8	32.5	±	2.6
11/2/2015	1.8	±	0.7	32.1	±	2.6
11/9/2015	2.5	±	0.8	31.0	±	2.5
11/16/2015	1.1	±	0.7	34.6	±	2.6
11/23/2015	0.6	±	0.6	21.9	±	2.2
11/30/2015	1.1	±	0.6	26.5	±	2.5
12/7/2015	3.5	±	0.9	44.0	±	3.0
12/14/2015	3.7	±	0.9	48.6	±	3.1
12/21/2015	1.7	±	0.8	27.3	±	2.5
12/28/2015	1.1	±	0.7	23.0	±	2.3

*U is Uncertainty at a 95% confidence level.

Routine air sampling started in Marion in April 2015.

Table C.2. Gamma Spectroscopy Sample Results for Soil Samples from the Background Reference Area
Results are in picocuries per gram (pCi/g)

Location / Date	Ac-228 Result	Ac-228 *U	Be-7 Result	Be-7 *U	Bi-212 Result	Bi-212 *U	Bi-214 Result	Bi-214 *U	Cs-137 Result	Cs-137 *U	K-40 Result	K-40 *U	Pa-234m Result	Pa-234m *U
Kincaid East Boat Dock														
4/7/2015	1.0	0.1	-0.1	0.2	1.4	0.3	1.2	0.1	0.1	0.0	15.3	1.0	1.6	2.4
7/22/2015	1.1	0.0	0.1	0.0	0.9	0.0	1.1	0.0	0.1	0.0	15.9	0.2	1.2	0.4
Kincaid Strawkaws Boat Ramp														
7/22/2015	1.1	0.0	0.2	0.0	1.1	0.0	1.1	0.0	0.1	0.0	16.3	0.3	0.6	0.3
Kincaid West Boat Ramp														
4/7/2015	1.1	0.0	0.0	0.0	0.9	0.1	1.0	0.0	0.1	0.0	15.1	0.5	0.9	0.8
7/22/2015	1.1	0.0	0.0	0.0	1.0	0.1	1.0	0.0	0.1	0.0	16.3	0.3	1.2	0.4

Location / Date	Pb-210 Result	Pb-210 *U	Pb-212 Result	Pb-212 *U	Pb-214 Result	Pb-214 *U	RA-226 Result	RA-226 *U	Th-234 Result	Th-234 *U	Tl-208 Result	Tl-208 *U	U-235 Result	U-235 *U
Kincaid East Boat Dock														
4/7/2015	1.7	0.4	1.0	0.1	1.2	0.1	1.6	1.6	0.9	0.2	0.9	0.1	0.0	0.1
7/22/2015	1.7	4.3	1.1	0.0	1.2	0.0	1.7	0.4	0.9	0.1	1.0	0.0	0.0	0.0
Kincaid Strawkaws Boat Ramp														
7/22/2015	4.1	0.2	1.1	0.0	1.1	0.0	2.1	0.1	1.1	0.2	1.0	0.0	0.1	0.0
Kincaid West Boat Ramp														
4/7/2015	1.5	0.1	1.0	0.0	1.0	0.0	1.9	0.5	0.8	0.1	1.0	0.0	0.0	0.0
7/22/2015	1.8	0.2	1.1	0.0	1.1	0.0	2.0	0.1	0.9	0.2	1.0	0.0	0.1	0.0

*U is Uncertainty at a 95% confidence level.

Table C.3. Gamma Spectroscopy Sample Results for Vegetation Samples from the Background Reference Area
Results are in picocuries per kilogram (pCi/kg)

Location / Date	Ac-228 Result	Ac-228 *U	Be-7 Result	Be-7 *U	Bi-212 Result	Bi-212 *U	Bi-214 Result	Bi-214 *U	Cs-137 Result	Cs-137 *U	K-40 Result	K-40 *U	Pa-234m Result	Pa-234m *U
Kincaid East Boat Dock														
4/7/2015	0.2	0.1	11.2	0.7	0.2	0.5	0.2	0.1	0.0	0.0	4.0	0.8	1.9	4.9
7/24/2015	0.1	0.0	4.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	7.1	0.2	-0.3	0.9
Kincaid Strawkaws Boat Ramp														
7/24/2015	0.2	0.1	5.7	0.5	0.5	0.4	0.1	0.1	0.0	0.0	26.5	0.9	3.4	3.4
Kincaid West Boat Ramp														
4/7/2015	0.2	0.2	9.8	0.7	0.3	0.5	0.1	0.1	0.0	0.0	1.1	0.9	3.1	5.7
7/24/2015	0.1	0.1	10.1	0.4	0.1	0.2	0.1	0.0	0.0	0.0	17.4	0.6	1.0	2.5

Location / Date	Pb-210 Result	Pb-210 *U	Pb-212 Result	Pb-212 *U	Pb-214 Result	Pb-214 *U	RA-226 Result	RA-226 *U	Th-234 Result	Th-234 *U	Tl-208 Result	Tl-208 *U	U-235 Result	U-235 *U
Kincaid East Boat Dock														
4/7/2015	6.0	0.5	0.1	0.0	0.1	0.1	-0.6	0.6	0.3	0.2	0.2	0.1	0.0	0.0
7/24/2015	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.1	-0.1	0.2	0.0	0.0	0.0	0.0
Kincaid Strawkaws Boat Ramp														
7/24/2015	0.8	0.3	0.0	0.0	0.0	0.1	-0.4	0.6	0.2	0.3	0.0	0.1	0.0	0.0
Kincaid West Boat Ramp														
4/7/2015	4.4	0.5	0.0	0.1	0.1	0.1	-0.2	0.7	0.1	0.2	0.2	0.1	0.0	0.0
7/24/2015	0.9	0.2	0.0	0.0	0.1	0.0	0.3	0.3	0.1	0.1	0.1	0.1	0.0	0.0

*U is Uncertainty at a 95% confidence level.

Table C.4. Gamma Spectroscopy Sample Results for Sediment Samples from the Background Reference Area
Results are in picocuries per gram (pCi/g)

Location / Date	Ac-228 Result	*U	Be-7 Result	*U	Bi-212 Result	*U	Bi-214 Result	*U	Cs-137 Result	*U	K-40 Result	*U	Pa-234m Result	*U
Kincaid East Boat Dock														
4/7/2015	0.8	0.1	0.0	0.2	1.0	0.2	0.7	0.0	0.0	0.0	15.1	0.9	0.9	1.6
7/24/2015	0.8	0.0	0.7	0.0	0.7	0.0	0.6	0.0	0.0	0.0	13.5	0.2	0.6	0.3
Kincaid West Boat Ramp														
4/7/2015	0.7	0.1	0.2	0.2	0.8	0.3	0.8	0.1	0.0	0.0	13.9	0.9	2.0	2.0
7/24/2015	0.8	0.0	0.1	0.0	0.6	0.0	0.6	0.0	0.0	0.0	13.8	0.2	0.3	0.3

Location / Date	Pb-210 Result	*U	Pb-212 Result	*U	Pb-214 Result	*U	Ra-226 Result	*U	Th-234 Result	*U	Tl-208 Result	*U	U-235 Result	*U
Kincaid East Boat Dock														
4/7/2015	0.9	0.8	0.8	0.0	0.7	0.0	1.0	0.4	0.5	0.2	0.7	0.1	0.1	0.0
7/24/2015	1.4	0.2	0.7	0.0	0.6	0.0	1.0	0.3	0.6	0.0	0.7	0.0	0.0	0.0
Kincaid West Boat Ramp														
4/7/2015	0.8	0.6	0.5	0.1	0.8	0.0	1.3	0.3	0.9	0.5	0.7	0.1	0.1	0.0
7/24/2015	6.6	3.2	0.8	0.0	0.7	0.0	1.3	0.1	0.4	0.0	0.7	0.0	0.1	0.0

*U is Uncertainty at a 95% confidence level.

Table C.5. Sample Results for Gross Alpha / Beta Screening of Water Samples from the Background Reference Area
Results are in picocuries per liter (pCi/L)

Location / Date	Alpha Result		*U	Beta Result		*U
Kincaid East Boat Dock						
1/21/2015	0.4	±	1.3	3.9	±	2.7
4/7/2015	1.0	±	1.4	1.0	±	2.1
7/22/2015	-0.2	±	1.3	2.9	±	2.3
10/21/2015	-0.6	±	1.4	4.4	±	2.2
Kincaid Strawkaws Boat Ramp						
1/21/2015	0.6	±	1.4	5.8	±	2.7
4/7/2015	0.6	±	1.4	0.9	±	2.1
7/22/2015	0.1	±	1.4	2.5	±	2.3
10/21/2015	0.4	±	1.4	3.9	±	2.2
Kincaid West Boat Ramp						
1/21/2015	0.9	±	1.4	1.8	±	2.6
4/7/2015	2.2	±	1.5	1.8	±	2.1
7/22/2015	0.6	±	1.4	1.1	±	2.2
10/21/2015	0.0	±	1.4	4.2	±	2.2

*U is Uncertainty at a 95% confidence level.

Table C.6. Gamma Spectroscopy Sample Results for Other Radionuclides in Water from the Background Reference Area
Results are in picocuries per liter (pCi/L)

Location	Ac-228			Be-7			Bl-212			Bl-214			Cs-137			K-40			Pa-234m		
Date	Result		*U	Result		*U	Result		*U	Result		*U	Result		*U	Result		*U	Result		*U
Kincaid East Boat Dock																					
1/21/2015	1.8	±	6.9	-3.3	±	12.9	5.0	±	23.5	9.0	±	3.7	-0.1	±	1.8	-26.0	±	33.3	290.0	±	196.0
4/7/2015	7.6	±	9.4	7.0	±	19.6	14.0	±	31.4	7.6	±	5.3	1.6	±	2.5	15.0	±	31.4	310.0	±	254.8
7/22/2015	13.6	±	4.8	7.3	±	9.9	15.0	±	13.0	5.5	±	2.2	0.0	±	1.0	60.0	±	13.0	30.0	±	150.0
10/21/2015	6.7	±	4.5	-28.0	±	11.0	31.0	±	16.0	3.8	±	2.3	-1.1	±	1.1	26.0	±	17.0	-40.0	±	160.0
Kincaid Strawkaws Boat Ramp																					
1/21/2015	-0.1	±	6.9	14.1	±	16.5	14.0	±	25.5	2.6	±	3.9	0.2	±	1.9	-11.0	±	23.5	170.0	±	215.6
4/7/2015	13.2	±	8.2	-2.8	±	17.6	8.0	±	29.4	4.1	±	4.1	0.1	±	1.7	43.0	±	27.4	450.0	±	254.8
7/22/2015	3.1	±	4.2	-9.0	±	11.0	-43.0	±	17.0	2.2	±	2.8	0.5	±	1.1	76.0	±	14.0	100.0	±	140.0
10/21/2015	1.6	±	3.2	-10.4	±	9.0	6.0	±	12.0	5.6	±	1.8	0.5	±	0.8	30.1	±	9.3	60.0	±	95.0
Kincaid West Boat Ramp																					
1/21/2015	1.0	±	6.3	-1.2	±	15.9	-9.0	±	23.5	2.3	±	3.5	0.0	±	1.6	-11.5	±	19.4	-39.0	±	194.0
4/7/2015	4.3	±	7.4	3.0	±	15.7	28.0	±	21.6	6.8	±	3.5	0.2	±	1.6	24.0	±	31.4	170.0	±	215.6
7/22/2015	5.9	±	3.5	-4.1	±	8.7	14.0	±	11.0	3.4	±	2.6	-1.0	±	0.9	-25.0	±	15.0	110.0	±	110.0
10/21/2015	14.4	±	4.4	-6.0	±	10.0	5.0	±	13.0	9.7	±	2.0	1.6	±	1.0	46.0	±	14.0	90.0	±	140.0
Location	**Pb-210**			**Pb-212**			**Pb-214**			**Ra-226**			**Th-234**			**Tl-208**			**U-235**		
Date	**Result**		***U**	**Result**		***U**	**Result**		***U**	**Result**		***U**	**Result**		***U**	**Result**		***U**	**Result**		***U**
Kincaid East Boat Dock																					
1/21/2015	22.0	±	45.1	6.2	±	2.7	4.6	±	2.9	10.0	±	41.2	42.0	±	31.4	6.9	±	5.1	0.7	±	2.5
4/7/2015	-190.0	±	1528.8	1.2	±	4.9	3.5	±	4.7	9.0	±	52.9	-270.0	±	254.8	2.4	±	7.1	0.5	±	3.3
7/22/2015	0.0	±	14.0	-1.2	±	2.0	7.1	±	1.8	-9.0	±	22.0	3.0	±	13.0	-0.4	±	3.9	-0.6	±	1.4
10/21/2015	33.0	±	14.0	1.6	±	1.4	3.5	±	1.8	2.0	±	20.0	14.0	±	13.0	3.3	±	3.0	0.1	±	1.3
Kincaid Strawkaws Boat Ramp																					
1/21/2015	8.0	±	45.1	1.9	±	2.5	0.7	±	3.5	9.0	±	31.4	-3.0	±	29.4	2.4	±	4.9	-0.4	±	2.0
4/7/2015	650.0	±	294.0	3.0	±	2.7	5.0	±	3.9	9.0	±	47.0	-80.0	±	100.0	5.8	±	5.7	0.6	±	2.9
7/22/2015	8.0	±	13.0	4.1	±	1.4	6.6	±	1.9	-11.0	±	19.0	18.0	±	13.0	6.3	±	3.2	-0.7	±	1.2
10/21/2015	4.0	±	30.0	1.7	±	1.2	0.3	±	1.8	51.0	±	16.0	86.0	±	27.0	1.9	±	2.3	2.2	±	1.0
Kincaid West Boat Ramp																					
1/21/2015	45.0	±	56.8	-0.1	±	2.4	0.0	±	3.5	23.0	±	45.1	9.0	±	27.4	3.6	±	4.3	1.4	±	2.7
4/7/2015	1.0	±	58.8	2.2	±	3.9	3.8	±	3.3	8.0	±	43.1	-15.0	±	49.0	2.4	±	6.1	0.5	±	2.7
7/22/2015	1.0	±	29.0	-1.0	±	1.8	9.1	±	1.9	13.0	±	21.0	-42.0	±	24.0	5.0	±	2.7	0.8	±	1.3
10/21/2015	-1.0	±	14.0	-0.6	±	1.9	6.8	±	1.7	-34.0	±	21.0	-2.0	±	14.0	1.1	±	3.9	-2.1	±	1.3

*U is Uncertainty at a 95% confidence level.

Table C.7. Summary of Ambient Gamma Results from the Background Reference Area

Location	Quarter 1 mrem/day	Quarter 2 mrem/day	Quarter 3 mrem/day	Quarter 4 mrem/day	Annual Dose mrem/year
KC-01	0.102	0.112	0.119	0.095	39.06
KC-02	0.102	0.118	0.137	0.117	43.25
KC-03	0.095		0.11	0.112	38.57
KC-04	0.12	0.11	0.123	0.104	41.70
KC-05	0.131	0.12	0.118	0.092	42.07
KC-06	0.085	0.088	0.106	0.076	32.39
KC-07	0.11	0.087	0.112	0.113	38.51
KC-08	0.105	0.101	0.129	0.094	39.15
KC-09	0.105	0.125	0.121	0.099	41.06
KC-10	0.095	0.119	0.108	0.117	40.06
KC-11	0.112	0.12	0.144	0.108	44.17
KC-12	0.114	0.1	0.127	0.118	41.88
KC-13	0.111		0.122	0.108	41.49
KC-14	0.115		0.135	0.11	43.80
KC-15	0.1	0.108	0.135		41.73

The 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.