IEMA

Illinois Emergency Management Agency

Bureau of Radiation Safety

Environmental Monitoring in the Environs of the Honeywell Metropolis Works Facility Report for Calendar Year 2013

February 2015

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Introduction

Located on 1,100 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.

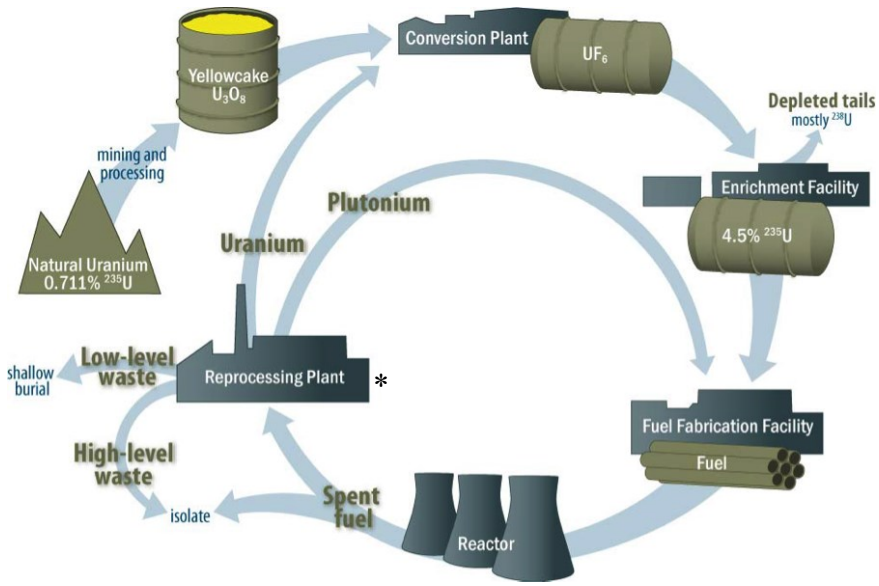

FIGURE 1 (* please note reprocessing does not occur commercially in the U.S.)

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 to observe long term trends in environmental radiation levels.

These objectives are achieved through a network of 5 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.

In 2013, all test results for samples collected as part of IEMA's environmental monitoring program for the HMW facility were consistent with historical data and below regulatory standards and guidelines.

Due to the unfortunate Fukushima Daiichi disaster in March of 2011, the US NRC reassessed all fuel cycle facilities in the United States. As a result, in June of 2012, the US NRC issued a Confirmatory Action Letter to the HMW facility in essence stating operations at the facility would not be allowed to take place until an upgrade in plant infrastructure and improved emergency preparedness procedures were in place. The ordered shut down lasted from June 2012 to July 2013. Because of HMW's geographical relation to the New Madrid Fault Line, specific infrastructure improvements included seismic resistant building upgrades as well as tornadic resistant improvements. IEMA continued environmental monitoring activities during the shutdown.

Environmental Monitoring Program

During 2013, 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 to observe 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 1 – 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 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. In **Table 12**, locations with an asterisk (*) preceding 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.

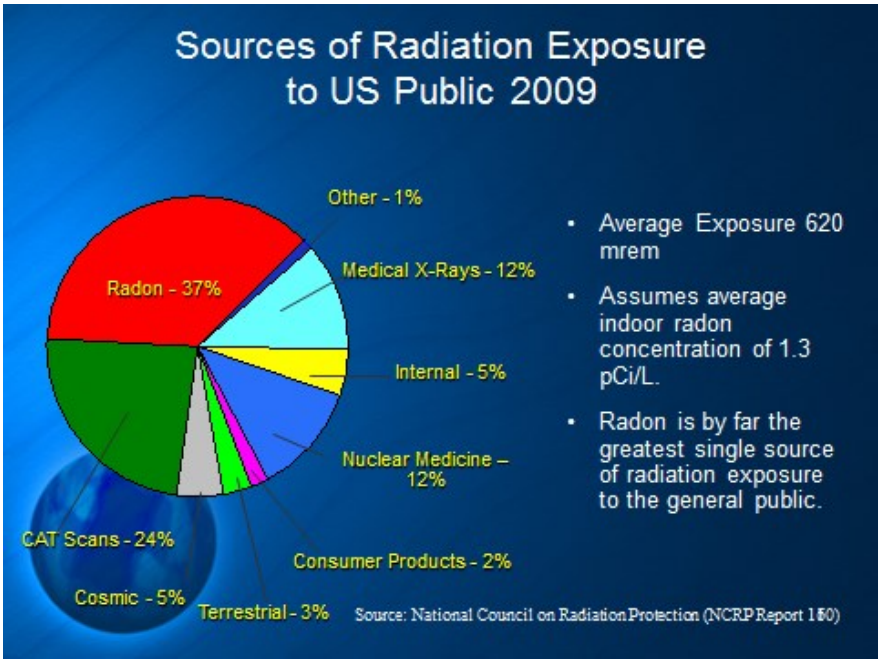

FIGURE 2

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 uranium-235 and uranium-238 and their decay progeny. Vegetation and soil samples were collected on August 26, 2013, and sediment samples were collected on November 11, 2013. Results for

vegetation samples are shown in **Table 6**, results for soil samples are shown in **Table 7**, and results for sediment samples are shown in **Table 8**. Results for water samples are shown in **Tables 9, 10 and 11**. **Table 9** shows Gross Alpha / Beta Screening Results, and **Table 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 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.

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.

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 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.

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.

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

Date	Result		Uncertainty		MDC	
	Alpha	Beta	Alpha	Beta	Alpha	Beta
1/2/2013	2.5	41.2	0.8	2.4	1.1	2.3
1/8/2013	1.9	61.7	0.9	3.3	1.5	3.0
1/15/2013	2.7	27.8	0.9	2.2	1.3	2.6
1/22/2013	3.3	27.2	0.9	2.1	1.3	2.5
1/29/2013	3.3	40.8	1.0	2.6	1.3	2.6
2/4/2013	5.4	31.0	1.2	2.5	1.4	2.9
2/13/2013	2.2	24.1	0.7	1.7	1.0	1.9
2/19/2013	9.5	25.8	1.5	2.4	1.3	3.0
2/25/2013	0.5	18.5	0.7	2.4	1.3	3.8
3/5/2013	2.2	20.9	0.7	2.0	1.0	2.8
3/11/2013	1.0	15.2	0.7	2.3	1.4	3.8
3/19/2013	1.6	25.3	0.7	2.0	1.0	2.3
3/26/2013	2.3	21.4	0.8	1.9	1.1	2.4
4/1/2013	1.0	13.8	0.7	1.9	1.3	3.0
4/8/2013	1.7	11.2	0.8	2.0	1.2	3.5
4/15/2013	7.5	23.6	1.3	2.5	1.3	3.8
4/22/2013	5.8	16.4	1.2	2.4	1.3	3.7
4/29/2013	4.3	18.0	1.0	2.2	1.2	3.2
5/6/2013	1.0	10.0	0.8	1.9	1.5	3.2
5/13/2013	1.4	16.2	0.8	2.2	1.3	3.6
5/20/2013	4.6	30.6	1.1	2.4	1.2	2.6
5/28/2013	2.3	13.7	0.8	1.6	1.2	2.3
6/3/2013	5.8	16.7	1.3	2.6	1.6	4.3
6/10/2013	2.6	18.9	0.9	2.2	1.3	3.6
6/17/2013	4.0	22.0	1.0	2.0	1.3	2.6
6/24/2013	5.2	29.9	0.9	2.2	0.9	2.8
7/2/2013	5.7	21.3	1.0	2.0	1.0	2.9
7/15/2013	1.9	13.5	0.9	2.0	1.4	3.1
7/23/2013	4.1	19.4	0.9	1.9	1.0	2.3
7/30/2013	2.4	20.7	0.8	2.1	1.1	3.1
8/5/2013	3.8	34.3	1.0	2.8	1.3	3.8
8/13/2013	4.5	27.2	0.9	2.1	1.1	2.9
8/26/2013	4.7	36.9	1.1	2.5	1.3	3.2
9/3/2013	6.3	41.3	1.2	2.4	1.1	2.8
9/9/2013	2.6	40.8	1.1	2.9	1.5	3.8
9/16/2013	2.9	50.3	1.0	2.8	1.4	3.2
9/24/2013	4.0	48.3	0.9	2.7	1.0	3.0
9/30/2013	2.4	35.0	0.9	2.8	1.5	3.8
10/8/2013	6.6	43.9	1.2	2.5	1.1	2.8

Date	Result		Uncertainty		MDC	
	Alpha	Beta	Alpha	Beta	Alpha	Beta
10/15/2013	3.7	31.1	0.9	2.4	1.2	3.2
10/21/2013	8.9	35.2	1.5	2.8	1.5	3.9
11/4/2013	8.6	43.1	1.5	3.1	1.5	3.8
11/12/2013	4.2	30.7	0.9	2.2	1.1	2.8
11/18/2013	9.0	26.3	1.4	2.6	1.4	3.8
11/25/2013	1.7	29.3	0.7	2.3	1.2	3.1
12/2/2013	4.9	38.8	1.0	2.3	1.1	2.3
12/9/2013	5.1	38.4	1.0	2.3	1.2	2.2
12/17/2013	4.2	47.9	0.9	2.3	1.0	2.0
12/23/2013	3.8	24.5	1.3	2.8	2.0	4.4
12/30/2013	6.3	39.0	1.1	2.6	1.2	3.3

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

Date	Result		Uncertainty		MDC	
	Alpha	Beta	Alpha	Beta	Alpha	Beta
1/2/2013	1.2	28.2	0.7	2.1	1.2	2.3
1/8/2013	1.0	28.1	0.8	2.5	1.6	3.2
1/15/2013	1.4	25.7	0.7	2.1	1.2	2.4
1/22/2013	1.0	22.6	0.7	2.1	1.3	2.6
1/29/2013	2.8	33.7	0.9	2.4	1.3	2.6
2/4/2013	2.6	29.6	1.0	2.4	1.4	2.9
2/13/2013	0.6	15.0	0.5	1.5	1.0	2.0
2/19/2013	2.0	20.8	0.9	2.2	1.3	3.0
2/25/2013	1.2	24.5	0.8	2.6	1.3	3.8
3/5/2013	2.1	20.7	0.7	2.0	1.0	2.9
3/11/2013	1.0	16.9	0.8	2.4	1.4	4.0
3/19/2013	2.5	20.9	0.8	1.8	1.0	2.3
3/26/2013	1.2	20.4	0.7	2.0	1.2	2.6
4/1/2013	1.5	14.3	0.8	2.0	1.4	3.1
4/8/2013	3.4	28.2	1.0	2.5	1.2	3.5
4/15/2013	1.6	21.2	0.8	2.3	1.2	3.5
4/22/2013	1.9	17.5	0.8	2.3	1.3	3.5
4/29/2013	2.2	18.3	0.8	2.2	1.2	3.2
5/6/2013	1.1	15.0	0.8	2.1	1.5	3.1
5/13/2013	0.8	16.5	0.7	2.2	1.3	3.6
5/20/2013	1.7	34.7	0.8	2.4	1.2	2.6
5/28/2013	2.1	14.4	0.8	1.6	1.2	2.2
6/3/2013	2.0	8.6	0.9	2.2	1.5	4.1
6/10/2013	2.6	27.1	0.9	2.5	1.3	3.5
6/17/2013	2.9	25.5	0.9	2.2	1.3	2.6
6/24/2013	4.1	33.1	1.0	2.6	1.1	3.4
7/2/2013	3.8	25.5	0.9	2.1	1.0	2.9
7/9/2013	1.2	14.1	0.7	2.1	1.1	3.5
7/15/2013	1.1	18.5	0.8	2.2	1.5	3.1
7/23/2013	2.8	15.4	0.8	1.7	1.0	2.3
7/30/2013	0.1	4.4	0.5	1.8	1.2	3.6
8/5/2013	1.1	33.0	0.8	2.8	1.3	4.0
8/13/2013	3.2	26.5	0.8	2.1	1.1	2.9

Date	Result		Uncertainty		MDC	
	Alpha	Beta	Alpha	Beta	Alpha	Beta
8/19/2013	2.9	22.4	0.9	2.4	1.4	3.7
8/26/2013	3.7	39.7	1.1	2.6	1.3	3.2
9/3/2013	3.3	38.4	0.9	2.4	1.2	2.9
9/9/2013	2.2	44.4	1.1	3.0	1.6	3.8
9/16/2013	1.6	35.6	0.9	2.5	1.4	3.2
9/30/2013	2.2	36.2	0.9	2.8	1.5	3.8
10/8/2013	2.9	28.4	0.9	2.2	1.1	2.8
10/15/2013	3.7	33.5	0.9	2.5	1.2	3.2
10/21/2013	3.0	24.6	1.0	2.5	1.4	3.8
11/4/2013	3.0	35.9	1.0	2.9	1.5	3.8
11/12/2013	2.7	33.8	0.8	2.2	1.1	2.8
11/18/2013	3.3	20.0	1.0	2.4	1.5	3.8
11/25/2013	2.5	31.1	0.8	2.4	1.3	3.3
12/2/2013	4.0	40.6	1.0	2.4	1.2	2.4
12/9/2013	2.4	30.1	0.8	2.1	1.2	2.3
12/17/2013	4.8	36.9	0.9	2.1	1.1	2.1
12/23/2013	2.3	23.2	1.1	2.5	1.7	3.9
12/30/2013	4.6	39.2	1.0	2.6	1.1	3.2

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

Date	Result		Uncertainty		MDC	
	Alpha	Beta	Alpha	Beta	Alpha	Beta
1/2/2013	3.2	46.3	0.9	2.5	1.1	2.3
1/8/2013	3.3	78.5	1.1	3.6	1.5	3.0
1/15/2013	2.3	33.3	0.9	2.4	1.3	2.6
1/22/2013	0.7	17.2	0.6	1.8	1.3	2.5
1/29/2013	3.1	28.1	0.9	2.2	1.3	2.5
2/4/2013	1.3	25.0	0.8	2.4	1.5	3.0
2/13/2013	0.6	10.2	0.5	1.4	1.0	2.1
2/19/2013	3.7	29.2	1.1	2.6	1.4	3.3
2/25/2013	1.9	24.6	0.9	2.8	1.4	4.2
3/5/2013	2.0	21.4	0.7	2.0	1.1	3.0
3/11/2013	1.2	19.4	0.8	2.4	1.4	3.9
3/19/2013	1.6	23.5	0.6	1.9	1.0	2.2
4/1/2013	1.6	21.8	0.8	2.2	1.3	3.0
4/8/2013	2.3	25.2	0.8	2.4	1.2	3.5
4/15/2013	0.8	17.1	0.7	2.2	1.2	3.6
4/22/2013	3.2	15.8	1.0	2.4	1.3	3.7
4/29/2013	2.3	17.3	0.9	2.2	1.2	3.3
5/6/2013	2.0	14.3	0.9	2.1	1.5	3.2
5/13/2013	0.2	14.9	0.7	2.3	1.4	3.7
5/20/2013	2.1	36.7	0.8	2.5	1.2	2.6
5/28/2013	1.4	14.8	0.7	1.7	1.2	2.3
6/3/2013	2.2	11.5	1.0	2.3	1.6	4.2
6/10/2013	3.4	25.7	1.0	2.5	1.4	3.6
6/17/2013	2.5	25.4	0.9	2.2	1.4	2.6

Date	Result		Uncertainty		MDC	
	Alpha	Beta	Alpha	Beta	Alpha	Beta
6/24/2013	3.3	29.1	0.9	2.5	1.1	3.4
7/2/2013	4.4	21.6	0.9	2.0	1.0	3.0
7/15/2013	1.1	15.8	0.8	2.1	1.5	3.2
7/23/2013	1.2	20.0	0.6	1.9	1.1	2.4
7/30/2013	1.8	22.0	0.7	2.2	1.1	3.2
8/13/2013	3.3	24.9	0.8	2.1	1.1	2.9
8/19/2013	1.6	22.2	0.8	2.4	1.4	3.7
8/26/2013	3.4	40.9	1.0	2.6	1.3	3.1
9/3/2013	2.3	36.0	0.8	2.3	1.1	2.8
9/9/2013	0.7	33.3	0.8	2.6	1.5	3.6
9/16/2013	1.8	42.5	0.9	2.7	1.4	3.2
9/24/2013	3.0	36.2	0.8	2.4	0.9	2.9
9/30/2013	1.3	32.3	0.8	2.8	1.5	3.9
10/8/2013	1.3	15.1	0.7	1.9	1.2	2.9
10/15/2013	2.0	29.0	0.8	2.3	1.2	3.2
10/21/2013	2.4	26.7	0.9	2.6	1.5	3.8
10/29/2013	1.7	27.7	0.8	2.2	1.2	2.9
11/4/2013	3.2	39.4	1.0	2.9	1.5	3.8
11/12/2013	2.8	27.2	0.8	2.1	1.1	2.8
11/18/2013	2.2	21.8	0.9	2.5	1.5	3.9
11/25/2013	2.8	32.1	0.9	2.4	1.3	3.2
12/2/2013	3.2	38.6	0.9	2.3	1.2	2.3
12/9/2013	2.6	31.6	0.8	2.2	1.2	2.3
12/17/2013	4.1	47.0	0.9	2.3	1.0	2.1
12/23/2013	1.2	22.7	0.9	2.5	1.7	3.8
12/30/2013	4.4	29.4	1.0	2.4	1.1	3.2

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

Date	Result		Uncertainty		MDC	
	Alpha	Beta	Alpha	Beta	Alpha	Beta
1/2/2013	3.5	46.0	0.9	2.5	1.1	2.3
1/8/2013	1.1	37.1	0.8	2.7	1.5	3.1
1/15/2013	1.6	31.8	0.8	2.3	1.3	2.6
1/22/2013	1.0	22.0	0.7	2.0	1.3	2.5
1/29/2013	2.9	30.7	0.9	2.3	1.3	2.6
2/4/2013	2.6	26.6	1.0	2.4	1.5	3.0
2/13/2013	0.6	19.0	0.5	1.7	1.0	2.0
2/19/2013	3.9	17.5	1.1	2.1	1.3	3.0
2/25/2013	0.9	21.8	0.7	2.5	1.3	3.8
3/5/2013	1.4	21.3	0.6	2.0	1.0	2.8
3/11/2013	0.6	16.8	0.7	2.3	1.4	3.8
3/19/2013	1.9	24.6	0.7	1.9	1.0	2.2
3/26/2013	1.5	18.8	0.7	1.9	1.1	2.5
4/1/2013	1.0	20.5	0.7	2.2	1.4	3.0
4/8/2013	2.5	26.2	0.8	2.4	1.2	3.5

Date	Result		Uncertainty		MDC	
	Alpha	Beta	Alpha	Beta	Alpha	Beta
4/15/2013	0.8	16.0	0.6	2.2	1.2	3.6
4/22/2013	1.8	12.5	0.8	2.2	1.3	3.6
4/29/2013	2.5	20.5	0.8	2.2	1.2	3.1
5/6/2013	1.1	11.9	0.8	1.9	1.5	3.0
5/13/2013	1.4	18.2	0.8	2.2	1.2	3.4
5/20/2013	1.9	27.9	0.8	2.2	1.2	2.4
5/28/2013	2.9	13.9	0.8	1.6	1.2	2.3
6/3/2013	0.4	12.5	0.7	2.3	1.5	4.0
6/10/2013	3.7	27.0	1.0	2.4	1.3	3.5
6/17/2013	4.9	26.6	1.1	2.2	1.3	2.5
6/24/2013	3.1	29.3	0.9	2.4	1.1	3.3
7/2/2013	3.7	21.7	0.8	2.0	1.0	2.9
7/15/2013	0.8	17.6	0.8	2.1	1.5	3.1
7/23/2013	2.1	19.3	0.7	1.8	1.0	2.3
7/30/2013	0.9	25.0	0.6	2.2	1.1	3.2
8/5/2013	1.6	35.4	0.8	2.8	1.3	3.9
8/13/2013	3.1	28.1	0.8	2.1	1.1	2.8
8/26/2013	2.7	37.6	1.0	2.6	1.3	3.2
9/3/2013	2.6	36.2	0.9	2.3	1.2	2.8
9/9/2013	1.4	42.5	0.9	2.8	1.4	3.4
9/16/2013	1.5	35.9	0.9	2.5	1.4	3.2
9/24/2013	2.7	40.5	0.7	2.4	0.9	2.8
9/30/2013	1.2	33.9	0.8	2.8	1.5	3.8
10/8/2013	2.0	17.0	0.8	1.9	1.1	2.8
10/15/2013	2.2	33.3	0.8	2.4	1.2	3.2
10/21/2013	2.3	27.5	0.9	2.6	1.4	3.8
10/29/2013	0.8	28.3	0.7	2.1	1.2	2.8
11/4/2013	1.0	22.9	0.8	2.5	1.5	3.8
11/12/2013	2.6	30.4	0.8	2.2	1.1	2.8
11/18/2013	1.3	22.3	0.8	2.4	1.4	3.7
11/25/2013	1.6	29.4	0.8	2.4	1.3	3.2
12/2/2013	2.2	29.3	0.8	2.1	1.2	2.3
12/9/2013	2.1	33.0	0.8	2.2	1.2	2.2
12/17/2013	3.6	41.6	0.8	2.2	1.0	2.1
12/23/2013	2.0	23.1	1.0	2.5	1.7	3.9
12/30/2013	5.5	38.9	1.1	2.6	1.1	3.2

Table 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)

Date	Result		Uncertainty		MDC	
	Alpha	Beta	Alpha	Beta	Alpha	Beta
1/2/2013	3.0	44.8	0.6	1.7	0.6	1.2
1/8/2013	3.1	73.7	1.0	3.5	1.5	3.0
1/15/2013	1.6	36.7	0.8	2.4	1.3	2.5
1/22/2013	1.0	31.8	0.7	2.2	1.2	2.4

Date	Result		Uncertainty		MDC	
	Alpha	Beta	Alpha	Beta	Alpha	Beta
1/29/2013	2.7	44.2	0.9	2.6	1.3	2.6
2/13/2013	0.9	22.7	0.6	1.8	1.0	2.0
2/19/2013	1.6	24.0	0.8	2.4	1.3	3.1
2/25/2013	1.8	24.0	0.9	2.7	1.4	4.0
3/5/2013	1.7	21.9	0.7	2.0	1.0	2.8
3/11/2013	0.3	20.4	0.7	2.4	1.4	3.8
3/19/2013	1.6	24.6	0.7	1.9	1.0	2.2
3/26/2013	2.1	23.9	0.8	2.1	1.1	2.5
4/1/2013	1.0	20.8	0.7	2.2	1.3	3.0
4/8/2013	2.1	22.0	0.8	2.3	1.2	3.5
4/15/2013	1.0	19.3	0.7	2.3	1.2	3.6
4/22/2013	2.4	16.9	0.9	2.3	1.3	3.6
4/29/2013	2.2	17.0	0.8	2.1	1.2	3.2
5/6/2013	1.9	14.2	0.9	2.1	1.5	3.1
5/13/2013	0.9	16.9	0.7	2.3	1.3	3.6
5/20/2013	1.3	32.6	0.7	2.3	1.2	2.5
6/3/2013	0.9	11.3	0.8	2.3	1.6	4.2
6/10/2013	3.2	29.2	1.0	2.6	1.4	3.7
6/17/2013	2.8	24.0	0.9	2.1	1.3	2.5
6/24/2013	3.7	24.8	1.0	2.4	1.1	3.4
7/2/2013	3.7	19.0	0.9	2.0	1.0	3.0
7/15/2013	1.7	20.9	0.9	2.2	1.5	3.1
7/23/2013	1.1	16.4	0.6	1.7	1.0	2.3
7/30/2013	1.0	20.5	0.7	2.2	1.2	3.4
8/5/2013	1.3	37.4	0.8	2.9	1.3	3.9
8/13/2013	3.2	26.6	0.8	2.1	1.1	2.9
9/3/2013	2.8	42.3	1.0	2.7	1.4	3.4
9/9/2013	1.7	42.9	1.0	3.0	1.6	3.8
9/16/2013	1.9	31.9	0.9	2.5	1.4	3.3
9/24/2013	2.2	38.4	0.7	2.4	0.9	2.8
9/30/2013	1.6	33.7	0.8	2.7	1.5	3.8
10/8/2013	2.1	21.3	0.8	2.0	1.2	2.9
10/15/2013	2.9	35.1	0.9	2.5	1.2	3.2
10/21/2013	1.9	24.6	0.9	2.5	1.5	3.8
10/29/2013	2.3	28.3	0.9	2.2	1.2	2.9
11/4/2013	3.2	41.9	1.0	3.0	1.5	3.8
Air Sampler moved from Water Treatment Plant to Dorothy Miller Park						
Date	**Result**		**Uncertainty**		**MDC**	
	Alpha	**Beta**	**Alpha**	**Beta**	**Alpha**	**Beta**
11/12/2013	2.6	31.0	0.8	2.2	1.1	2.9
11/18/2013	1.2	21.0	0.8	2.3	1.4	3.6
11/25/2013	2.6	31.0	0.9	2.4	1.3	3.3
12/2/2013	2.5	36.7	0.8	2.2	1.1	2.2
12/9/2013	2.9	35.6	0.8	2.2	1.1	2.1
12/17/2013	2.7	29.0	0.7	1.9	1.0	2.0
12/23/2013	2.7	27.9	1.3	3.1	2.1	4.7
12/30/2013	5.1	37.8	1.0	2.6	1.1	3.3

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

Location	Date	Nuclide	Result	Uncertainty	MDC
Metropolis Airport 1 Mi. NNE	8/26/2013	Pa-234m	1.2	0.4	1.1
Metropolis Airport 1 Mi. NNE	8/26/2013	Ra-226	1.1	0.2	0.2
Metropolis Airport 1 Mi. NNE	8/26/2013	Th-230	1.4	0.5	1.5
Metropolis Airport 1 Mi. NNE	8/26/2013	Th-234	1.3	0.1	0.2
Metropolis Airport 1 Mi. NNE	8/26/2013	U-235	0.1	0.0	0.0
Residence NNE Boundary	8/26/2013	Pa-234m	4.2	0.5	1.6
Residence NNE Boundary	8/26/2013	Ra-226	1.2	0.4	0.2
Residence NNE Boundary	8/26/2013	Th-230	-1.6	1.3	4.0
Residence NNE Boundary	8/26/2013	Th-234	3.4	0.4	0.6
Residence NNE Boundary	8/26/2013	U-235	0.2	0.0	0.0

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

Location	Nuclide	Result	Uncertainty	MDC
Metropolis Airport 1 Mi. NNE	Pa-234m	1.6	2.3	6.4
Metropolis Airport 1 Mi. NNE	Ra-226	0.7	0.4	1.2
Metropolis Airport 1 Mi. NNE	Th-230	-10.8	4.8	14.4
Metropolis Airport 1 Mi. NNE	Th-234	0.3	0.7	2.2
Metropolis Airport 1 Mi. NNE	U-235	0.0	0.0	0.1
Residence NNE Boundary	Pa-234m	3.0	1.4	4.7
Residence NNE Boundary	Pa-234m	1.3	1.3	4.2
Residence NNE Boundary	Ra-226	0.2	0.2	0.5
Residence NNE Boundary	Ra-226	0.7	0.2	0.5
Residence NNE Boundary	Th-230	0.4	0.6	2.3
Residence NNE Boundary	Th-230	-0.5	0.7	2.6
Residence NNE Boundary	Th-234	0.2	0.1	0.3
Residence NNE Boundary	Th-234	0.2	0.1	0.3
Residence NNE Boundary	U-235	0.1	0.0	0.0
Residence NNE Boundary	U-235	0.0	0.0	0.0

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

Location	Nuclide	Result	Uncertainty	MDC
Ohio River At Joppa, 4 Mi. DS	Pa-234m	0.9	0.3	0.9
Ohio River At Joppa, 4 Mi. DS	Pa-234m	1.4	0.3	1.0
Ohio River At Joppa, 4 Mi. DS	Ra-226	0.7	0.2	0.1
Ohio River At Joppa, 4 Mi. DS	Ra-226	1.3	0.1	0.2
Ohio River At Joppa, 4 Mi. DS	Th-230	-4.9	1.6	4.8
Ohio River At Joppa, 4 Mi. DS	Th-230	0.7	0.3	1.1
Ohio River At Joppa, 4 Mi. DS	Th-234	0.7	0.1	0.1
Ohio River At Joppa, 4 Mi. DS	Th-234	0.8	0.3	1.0
Ohio River At Joppa, 4 Mi. DS	U-235	0.0	0.0	0.0
Ohio River At Joppa, 4 Mi. DS	U-235	0.1	0.0	0.0
Public Boat Launch near Harrah's Casino	Pa-234m	0.6	0.3	0.9
Public Boat Launch near Harrah's Casino	Ra-226	0.5	0.3	0.2
Public Boat Launch near Harrah's Casino	Th-230	2.3	1.0	3.2
Public Boat Launch near Harrah's Casino	Th-234	0.5	0.2	0.5
Public Boat Launch near Harrah's Casino	U-235	0.1	0.0	0.0

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

Location	Quarter 1		Quarter 2		Quarter 3		Quarter 4	
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
Metropolis PWS								
Results	1.6	-0.5	1.0	3.0	1.9	0.9	2.1	1.2
Uncertainty	1.2	2.0	1.4	2.2	1.4	2.5	1.4	2.3
MDC	1.7	3.4	2.2	3.6	2.1	4.2	2.1	3.9
Ohio River, 2 Mi. US								
Results	-0.1	1.4	0.6	3.7	0.0	1.9	0.3	3.0
Uncertainty	1.1	2.0	1.4	2.2	1.3	2.5	1.3	2.4
MDC	1.7	3.4	2.2	3.6	2.1	4.2	2.1	3.9
Ohio River At Joppa, 4 Mi. DS								
Results	0.7	0.4	0.4	4.0	-0.5	3.4	2.4	0.9
Uncertainty	1.1	2.0	1.4	2.2	1.3	2.5	1.4	2.3
MDC	1.7	3.4	2.2	3.6	2.1	4.2	2.1	3.9
Public Boat Launch near Harrah's Casino								
Results	New Sampling Location Added in 4th Quarter						-0.1	0.8
Uncertainty							1.3	2.3
MDC							2.1	3.9

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

Location and Date	Nuclide	Result	Uncertainty	MDC
Metropolis PWS				
1/23/2013	Pa-234m	-95.7	145.9	412.6
	Ra-226	27.0	12.4	44.7
	Th-230	282.1	151.3	535.7
	Th-231	-42.7	97.1	338.3
	Th-234	15.8	15.1	53.7
	U-235	2.8	0.8	2.9
5/28/2013	Pa-234m	251.6	136.5	435.0
	Ra-226	-11.7	21.4	72.1
	Th-230	-88.2	99.1	337.7
	Th-231	-81.8	103.2	328.1
	Th-234	6.8	17.0	56.7
	U-235	-0.7	1.3	4.5
8/26/2013	Pa-234m	180.0	160.0	471.0
	Ra-226	-2.8	31.8	106.0
	Th-230	794.0	692.0	2270.0
	Th-231	-570.0	236.0	669.0
	Th-234	431.0	111.0	347.0
	U-235	-0.2	2.0	6.7
Ohio River 2 Mi. U.S.				
1/22/2013	Pa-234m	354.8	128.3	422.3
	Ra-226	-6.4	26.2	87.7
	Th-230	600.5	348.2	1132.3
	Th-231	11.5	140.8	455.0
	Th-234	-51.8	54.6	183.6
	Tl-208	11.9	2.7	9.6
	U-235	-0.4	1.6	5.5
5/28/2013	Pa-234m	295.5	128.5	417.5
	Ra-226	-18.6	24.6	83.0
	Th-230	260.2	341.6	1100.6
	Th-231	34.8	140.6	455.0
	Th-234	42.9	58.2	192.4
	U-235	-1.2	1.5	5.2
8/26/2013	Pa-234m	79.8	130.0	391.0
	Ra-226	-31.1	24.4	82.6
	Th-230	104.0	346.0	1110.0
	Th-231	-24.8	142.0	454.0
	Th-234	-38.7	54.0	181.0
	U-235	-2.0	1.5	5.2

Location and Date	Nuclide	Result	Uncertainty	MDC
Ohio River At Joppa, 4 Mi. D.S.				
1/22/2013	Pa-234m	248.4	223.2	360.0
	Ra-223	-0.7	7.1	11.7
	Ra-226	4.3	40.5	69.0
	Th-230	-190.4	202.4	346.8
	Th-231	88.6	195.4	325.0
	Th-234	-11.9	36.3	62.0
	U-235	0.3	2.5	4.3
5/28/2013	Pa-234m	28.4	163.8	451.8
	Ra-226	-61.6	31.6	107.3
	Th-230	827.2	688.4	2257.8
	Th-231	-397.0	228.5	657.6
	Th-234	221.9	106.9	346.5
	U-235	-3.9	2.0	6.7

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

Location	Date	Result	Uncertainty	MDC
Metropolis PWS	1/23/2013	0.2	0.0	0.0
Metropolis PWS	5/28/2013	0.1	0.0	0.0
Metropolis PWS	8/26/2013	0.4	0.0	0.1
Metropolis PWS	11/18/2013	0.4	0.0	0.1
Ohio River 2 Mi. US	1/22/2013	0.1	0.0	0.0
Ohio River 2 Mi. US	5/28/2013	0.0	0.0	0.0
Ohio River 2 Mi. US	8/26/2013	0.4	0.0	0.1
Ohio River 2 Mi. US	11/18/2013	0.4	0.0	0.1
Ohio River At Joppa, 4 Mi. DS	1/22/2013	0.1	0.0	0.0
Ohio River At Joppa, 4 Mi. DS	5/28/2013	0.1	0.0	0.0
Ohio River At Joppa, 4 Mi. DS	8/26/2013	0.7	0.0	0.1
Ohio River At Joppa, 4 Mi. DS	11/18/2013	1.6	0.1	0.1
Public Boat Launch near Harrah's Casino	11/18/2013	0.6	0.0	0.1

Table 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	0.09	0.08	0.09	0.11	34.04
METR-02	0.08	0.06	0.07	0.06	24.27
METR-03	0.11	0.09	0.12	0.12	39.69
METR-04	0.11	0.11	0.10	0.11	38.60
METR-05	0.11		0.12	0.10	39.54
METR-06	0.11	0.11	0.12	0.11	41.15
*METR-07	0.16	0.16	0.16	0.16	58.67
*METR-08	0.12	0.13	0.16	0.17	53.11
*METR-09	0.12	0.10	0.11	0.11	39.79
*METR-10	0.78	0.79	0.85	0.83	295.56
*METR-11	0.15	0.13	0.18	0.16	56.39
*METR-12	0.49	0.32	0.32	0.65	162.88
*METR-13	2.17	2.08	2.35	2.30	813.40
*METR-14	0.25	0.30	0.33	0.32	108.22

Asterisks signify that sampling locations are within the restricted access area immediately surrounding the facility, thus inaccessible to the public.
The blank in the table indicates that the dosimeter was missing at the end of the quarter.
The Annual Dose column is based on averages of all available data.
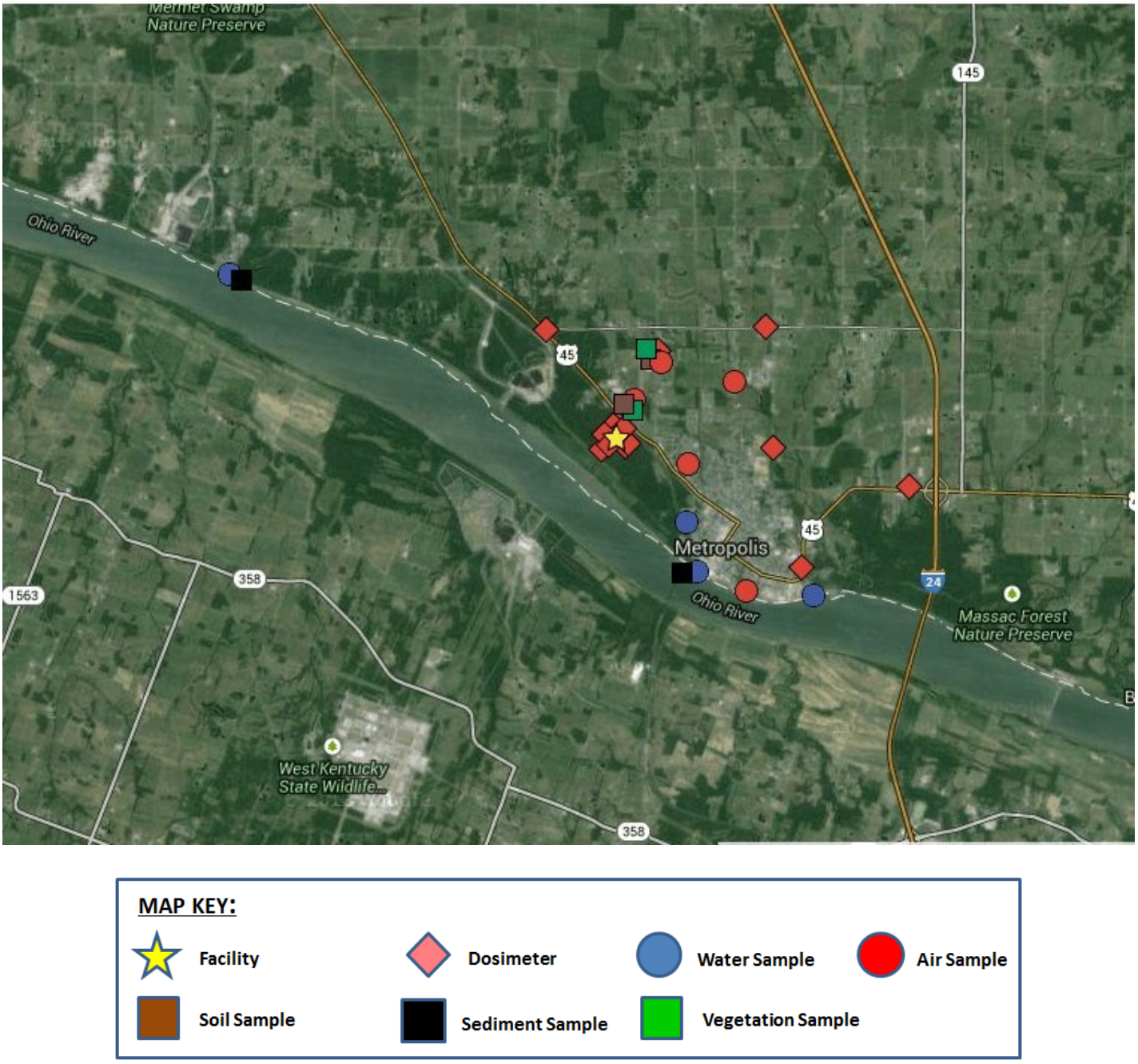
Figure 3. Map of Monitoring Locations around Metropolis