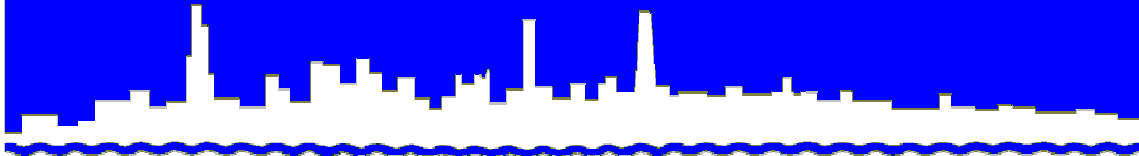


*Protecting Our Water Environment*



***Metropolitan Water Reclamation District of Greater Chicago***

***MONITORING AND RESEARCH  
DEPARTMENT***

***REPORT NO. 10-34***

***RADIOLOGICAL MONITORING OF THE RAW SEWAGE,  
FINAL EFFLUENT, SLUDGES, AND BIOSOLIDS OF THE  
METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO***

***2009 ANNUAL REPORT***

***JUNE 2010***

**Metropolitan Water Reclamation District of Greater Chicago**  
100 East Erie Street Chicago, IL 60611-2803 (312) 751-5600

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METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO  
2009 ANNUAL REPORT

By

Abdul Khalique  
Radiation Chemist

Monitoring and Research Department  
Louis Kollias, Director

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## DISCLAIMER

Mention of proprietary equipment and chemicals in this report does not constitute endorsement by the Metropolitan Water Reclamation District of Greater Chicago.

## SUMMARY AND CONCLUSIONS

The discharge of radioactive materials into the sanitary sewer system of the Metropolitan Water Reclamation District of Greater Chicago (District) is regulated by the Illinois Emergency Management Agency, Division of Nuclear Safety (IEMA-DNS). In Illinois, hospitals, industries, research organizations, and other radioactive material license holders are authorized to dispose of radionuclides into the District's sanitary sewer system in accordance with 32 Illinois Administrative Code (IAC), Section 340.1030. Naturally occurring radionuclides in groundwater and stormwater runoff also enter the sanitary sewer system.

The purpose of wastewater treatment is to reduce or remove pollutants from raw sewage to ensure adequate effluent quality before it is discharged to surface water. The low concentrations of radioactive material from natural and man-made sources discharged into the sanitary sewer system may become concentrated in the sewage sludge during wastewater treatment and sludge processing.

This study was conducted to determine the concentration of radioactive material in raw sewage, final effluent, waste-activated sludge, anaerobically digested biosolids, and air-dried biosolids at the facilities owned and operated by the District. Radiological monitoring was conducted to develop baseline data on radioactivity occurring in the District's sewage sludge and biosolids, and to compare the current radioactivity levels with the radioactivity levels in the past.

One raw sewage and one final effluent sample (composited over a period of 24 hours) were collected once a month from each of the District's seven Water Reclamation Plants (WRPs). Sewage sludge samples were also collected once a month from all the WRPs. Biosolids samples from the Hanover Park WRP East lagoon and Hanover Park WRP West lagoon were collected in April, July and November 2009. Final air-dried biosolids samples from the Calumet WRP East and West Solids Management Site (SMS), Harlem Avenue Solids Management Area (HASMA), Lawndale Avenue Solids Management Area (LASMA), Marathon Solids Drying Site (SDS) and Vulcan SDS samples were collected in July, August and September, 2009.

The raw sewage, final effluent, waste-activated sludge, anaerobically digested biosolids, lagooned biosolids, and air-dried biosolids samples from the WRPs were analyzed for gross alpha and gross beta radioactivity. Biosolids samples from the District's solids drying areas, lagooned biosolids samples from Hanover Park WRP, and quarterly sludge and biosolids samples from Hanover Park, Stickney, Calumet, John E. Egan (Egan), and Lemont WRPs were also analyzed for gamma-emitting radionuclides.

The analytical data demonstrate that radioactivity in the final effluent of all the WRPs is generally lower than the corresponding raw sewage of the WRP. This indicates that the WRPs remove radioactivity from the raw sewage. Analytical data also indicate that the radioactivity removed is concentrated in the sewage sludge generated at the various WRPs. The 2009 radiological monitoring data was compared with the historical data of the last thirteen years. The data show

that there was not a major change in the radioactivity concentrations of sludge and biosolids samples of the WRPs over the last fourteen years.

The amount of gross alpha and gross beta radioactivity in the final effluent is less than the allowable contaminant levels in the drinking water standards set by the United States Environmental Protection Agency (USEPA) National Primary Drinking Water Regulations, 40 CFR Part 141, published in 2000. The USEPA limit for gross alpha radioactivity (excluding radon and uranium) is 15 pCi/L and for gross beta radioactivity (excluding naturally occurring potassium-40) the limit is 50 pCi/L. The gross beta radioactivity in the final effluent is also less than the General Use water quality standard, 100 pCi/L, established by the Illinois Pollution Control Board (IPCB), 35C IAC, Section 302.207. There are no IPCB standards for gross alpha radioactivity in General Use waters. However, the District uses the IPCB General Use water limit for gross beta radioactivity as the standard for monitoring effluents. The monitoring data indicate that the discharge of the final effluent from the seven WRPs is not likely to have any adverse effect on the radiological quality of the Chicago Area Waterway System.

Measurable concentrations of gross alpha and gross beta radioactivity were found in Hanover Park WRP lagooned biosolids and in biosolids from the solids drying areas of the District. Samples of the anaerobically digested biosolids from four WRPs (Calumet, Egan, Hanover Park, and Stickney), waste-activated sludge from the Lemont WRP, lagooned biosolids from Hanover Park WRP, and biosolids samples from the solids drying areas were further analyzed for 27 specific radionuclides by gamma spectroscopy. Of these radionuclides, nine were detected in measurable quantities in these samples. Eight of these radionuclides are of natural origin, and one, cesium-137, is a manmade radionuclide.

The presence of unduly high levels of radioactivity in biosolids is of environmental concern. The District routinely monitors the radiological quality of its biosolids to see if any unusually high radioactivity concentrations are occurring. This helps the District ensure worker safety, minimize the buildup of radionuclides in landfills, and ensure that the biosolids are low in radioactivity and suitable for land application as fertilizer. Radioactivity concentrations found in the District's biosolids in 2009 do not pose any significant risk to human health or the environment.

## INTRODUCTION

The District is located within the boundaries of Cook County, Illinois, and serves an area of 883 square miles. The area served by the District includes the City of Chicago and 125 suburban communities with a combined population of 5.25 million people. In addition, a waste-load equivalent of 5.1 million people is contributed within the District's service area by industrial and commercial sources. On the average, the District treats 1.5 billion gallons per day of wastewater at its seven WRPs.

The discharge of radionuclides to the District's sewerage system is regulated by the IEMA-DNS. Radioactivity in the sewerage system may come from a variety of sources including industries, hospitals, and research organizations. Naturally occurring and atmospheric fallout radionuclides also enter the sewerage system from groundwater and through stormwater runoff. Radionuclides in the sanitary sewer system pass through the wastewater treatment process where some fraction of these radionuclides is removed from the wastewater and becomes concentrated in the biosolids, or remains in solution and passes with the effluent to the receiving water. Radioactivity contained in WRP effluents and the potential radioactivity concentration in municipal biosolids may be of environmental concern because of the discharge of effluents to receiving waters and the landfilling or land application of biosolids as fertilizer and soil conditioner.

The District monitors the quality of its raw sewage, effluents, sludges, and biosolids for possible radioactive contamination. As a part of its monitoring program, the District's Radiochemistry Laboratory routinely monitors raw sewage, final effluent, and sludge samples from all the WRPs, and biosolids samples from solids drying areas (SDAs) for gross alpha and gross beta radioactivity. Samples of the anaerobically digested biosolids from four WRPs (Calumet, Egan, Hanover Park, and Stickney), waste-activated sludge from the Lemont WRP, lagooned biosolids from the Hanover Park WRP, and biosolids samples from the District's SDAs are also examined for gamma-emitting radionuclides. In 1996, the Radiochemistry Section expanded its monitoring program of District sludges and biosolids in response to the increased emphasis on sludge characteristics brought about by adoption of USEPA sludge regulations (40 CFR Part 503). Although there are no standards for radioactivity in these regulations, the District expanded its database to include the radiological characteristics of its biosolids to be prepared to address any future regulatory limits on radioactivity in biosolids.

This report presents the gross alpha and gross beta radioactivity concentrations in raw sewage, final effluent, sewage sludge, and biosolids from the District's seven WRPs and biosolids from the District's SDAs. The concentrations of gross alpha and gross beta radioactivity and gamma-emitting radionuclides in quarterly samples of anaerobically digested biosolids, lagooned biosolids, and air-dried biosolids samples are also reported. The 2009 radiological monitoring data are compared with the historical data of the last thirteen years.

## MATERIALS AND METHODS

### Sample Collection

**Raw Sewage.** One raw sewage sample (composited over a period of 24 hours) was collected once a month from the Stickney, Egan, North Side, James C. Kirie (Kirie), Hanover Park, Calumet, and Lemont WRPs. The samples were preserved with hydrochloric acid.

**Final Effluent.** One final effluent sample (composited over a period of 24 hours) was collected once a month from the effluent sampler at all the WRPs. The samples were preserved with hydrochloric acid.

**Sludge and Biosolids.** Anaerobically digested biosolids samples were collected monthly from the Stickney, Calumet, Egan, and Hanover Park WRPs. Waste-activated sludge samples were collected monthly from the Lemont, North Side, and Kirie WRPs; these WRPs do not have digesters.

Lagooned biosolids samples were collected quarterly from Hanover Park WRP East, and Hanover Park WRP West lagoons.

Final air-dried biosolids samples were collected from solids drying areas of the District. The samples analyzed for radioactivity included biosolids from the Marathon drying cells, LASMA drying cells, Vulcan drying cells, HASMA drying cells, Calumet WRP East drying cells, and Calumet WRP West drying cells.

### Sample Analysis

The samples of raw sewage, final effluent, sludge and biosolids were analyzed by the District's radiochemistry laboratory from the inception of the program through 2007. The samples collected in 2008 were analyzed by the Environmental Inc., Midwest Laboratory (EIML) and samples collected in 2009 were analyzed by Eberline Analytical Corporation.

The sludge and biosolids samples were also analyzed for gamma-emitting radionuclides by the District's radiochemistry laboratory from the inception of the program through 2007. The samples collected in 2008 were analyzed by the EIML and samples collected in 2009 were analyzed by Eberline Analytical Corporation.

## RESULTS AND DISCUSSION

### Stickney Water Reclamation Plant

In 2009, the gross alpha radioactivity in the raw sewage of the Stickney WRP ranged from less than 2.4 to 13.4 pCi/L (Table 1). The gross alpha radioactivity in the effluent was below the detection limit (1.7 to 5.9 pCi/L) (Table 1). The gross alpha radioactivity in anaerobically digested biosolids ranged from 4.1 to 15.4 pCi/g dw (Table 1).

The yearly average gross alpha radioactivity in the Stickney WRP raw sewage, final effluent, and anaerobically digested biosolids from 1996 to 2009 are summarized in Table 2. The gross alpha radioactivity in raw sewage was below the detection limit (3.6 to 6.3 pCi/L) with detected values ranging from 4.6 to 8.6 pCi/L. The gross alpha radioactivity in the effluent was below the detection limit (2.6 to 5.2 pCi/L). The gross alpha radioactivity in anaerobically digested biosolids ranged from 5.2 to 12.4 pCi/g dw.

The gross beta radioactivity in the raw sewage of the Stickney WRP ranged from 7.7 to 30.1 pCi/L, and in the effluent it ranged from 5.3 to 10.3 pCi/L (Table 3). The gross beta radioactivity in anaerobically digested biosolids ranged from 16.4 to 30.5 pCi/g dw (Table 3).

The yearly average gross beta radioactivity in the Stickney WRP raw sewage, final effluent, and anaerobically digested biosolids from 1996 to 2009 are summarized in Table 4. The gross beta radioactivity in the raw sewage ranged from 11.7 to 29.3 pCi/L, and in the effluent it ranged from 5.9 to 11.4 pCi/L. The gross beta radioactivity in anaerobically digested biosolids ranged from 22.8 to 27.3 pCi/g dw.

### Calumet Water Reclamation Plant

In 2009, the gross alpha radioactivity in the raw sewage of the Calumet WRP was below the detection limit (1.9 to 5.0 pCi/L) with the detected values ranging from 3.3 to 3.9 pCi/L (Table 5). The gross alpha radioactivity in the effluent was below the detection limit (1.2 to 5.2 pCi/L) except for the May sample which was 4.5 pCi/L (Table 5). The gross alpha radioactivity in anaerobically digested biosolids ranged from 3.0 to 18.5 pCi/g dw (Table 5).

The yearly average gross alpha radioactivity in the Calumet WRP raw sewage, final effluent, and anaerobically digested biosolids from 1996 to 2009 are summarized in Table 6. The gross alpha radioactivity in the raw sewage was below the detection limit (3.5 to 5.5 pCi/L). The gross alpha radioactivity in the effluent was also below the detection limit (2.3 to 5.1 pCi/L). The gross alpha radioactivity in anaerobically digested biosolids ranged from 5.1 to 17.6 pCi/g dw.

TABLE 1: GROSS ALPHA RADIOACTIVITY IN STICKNEY WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS - 2009

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
January	13.4	<3.7	4.9
February	3.6	<2.7	4.1
March	<4.5	<5.9	4.9
April	<6.7	<5.6	15.4
May	3.9	<4.8	8.1
June	<2.4	<2.5	14.3
July	<4.0	<4.6	9.1
August	3.5	<1.8	8.9
September	4.6	<1.7	10.8
October	<3.0	<2.2	11.3
November	4.0	<4.4	10.4
December	<3.8	<3.9	12.4

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).



TABLE 2: YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN STICKNEY WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2009

Year*	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
1996	<3.8	<3.1	5.3
1997	<3.6	<3.1	5.3
1998	4.6	<2.6	5.2
1999	5.0	<3.6	6.1
2000	<5.0	<4.6	7.5
2001	6.1	<4.4	12.3
2002	<5.2	<4.7	11.3
2003	5.0	<3.6	11.7
2004	<6.0	<4.1	12.1
2005	<6.3	<4.3	11.3
2006	6.2	<4.8	10.4
2007	<6.1	<5.2	9.9
2008	8.6	<4.0	12.4
2009	<4.8	<3.6	9.6

\* Am-241 self-absorption standards were used up to June 30, 2001, and Th-230 self-absorption standards were used from July 1, 2001 for generating attenuation curve for gross alpha radioactivity.

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

TABLE 3: GROSS BETA RADIOACTIVITY IN STICKNEY WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS – 2009

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
January	30.1	10.3	16.4
February	12.2	7.9	20.2
March	7.7	9.7	22.0
April	9.7	8.9	23.4
May	10.0	6.0	26.6
June	11.9	5.4	30.0
July	9.9	10.0	30.5
August	19.0	9.5	26.5
September	13.2	6.3	28.1
October	7.8	9.1	22.2
November	8.8	5.3	24.8
December	11.0	8.7	24.2

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

TABLE 4: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN STICKNEY WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2009

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
1996	11.7	5.9	22.8
1997	20.4	9.0	23.4
1998	26.4	11.4	23.6
1999	28.9	11.1	25.9
2000	29.3	9.8	27.2
2001	19.7	9.2	27.3
2002	17.3	9.0	24.7
2003	16.6	7.7	24.8
2004	17.7	9.8	24.8
2005	17.4	8.8	23.2
2006	15.9	8.4	25.4
2007	17.0	8.4	26.1
2008	17.9	7.8	26.8
2009	12.6	8.1	24.6

TABLE 5: GROSS ALPHA RADIOACTIVITY IN CALUMET WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS – 2009

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
January	<5.0	<1.2	3.0
February	<3.5	<4.4	4.8
March	<3.4	<5.2	9.2
April	3.5	<3.4	11.2
May	3.9	4.5	9.2
June	<3.2	<2.6	13.9
July	<4.6	<3.9	10.6
August	<2.9	<2.2	11.1
September	<1.9	<1.8	16.0
October	<2.6	<4.1	15.5
November	3.3	<1.7	14.0
December	<3.8	<3.7	18.5

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

TABLE 6: YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN CALUMET WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2009

Year*	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
1996	<3.7	<3.5	5.9
1997	<4.0	<3.5	5.1
1998	<3.8	<3.0	6.1
1999	<4.6	<3.8	6.5
2000	<4.7	<4.5	8.4
2001	<5.1	<4.5	12.6
2002	<4.8	<4.1	12.1
2003	<4.3	<3.8	12.4
2004	<4.8	<4.4	14.1
2005	<5.3	<4.5	13.6
2006	<5.3	<5.0	12.8
2007	<5.5	<5.1	11.5
2008	<4.6	<2.3	17.6
2009	<3.5	<3.2	11.4

\* Am-241 self-absorption standards were used up to June 30, 2001, and Th-230 self-absorption standards were used from July 1, 2001 for generating attenuation curve for gross alpha radioactivity.

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

The gross beta radioactivity in the raw sewage of the Calumet WRP ranged from 8.0 to 13.8 pCi/L, and in the effluent it ranged from 5.9 to 16.8 pCi/L (Table 7). The gross beta radioactivity in the Calumet WRP anaerobically digested biosolids ranged from 19.3 to 33.9 pCi/g dw (Table 7).

The yearly average gross beta radioactivity in the Calumet WRP raw sewage, final effluent, and anaerobically digested biosolids from 1996 to 2009 are summarized in Table 8. The gross beta radioactivity in the raw sewage ranged from 8.5 to 24.9 pCi/L and in the effluent it ranged from 6.9 to 14.1 pCi/L. The gross beta radioactivity in anaerobically digested biosolids ranged from 21.0 to 30.6 pCi/g dw.

### **North Side Water Reclamation Plant**

In 2009, the gross alpha radioactivity in the raw sewage of the North Side WRP was below the detection limit (1.7 to 5.4 pCi/L) (Table 9). The gross alpha radioactivity in the effluent was also below the detection limits (1.5 to 5.0 pCi/L) except for the May sample which was 4.9 pCi/L (Table 9). The gross alpha radioactivity in waste-activated sludge ranged from 2.0 to 10.2 pCi/g dw (Table 9).

The yearly average gross alpha radioactivity in the North Side WRP raw sewage, final effluent, and waste-activated sludge from 1996 to 2009 are summarized in Table 10. The gross alpha radioactivity in the raw sewage was below the detection limit (2.8 to 5.0 pCi/L). The gross alpha radioactivity in the effluent was also below the detection limit (2.3 to 4.9 pCi/L). The gross alpha radioactivity in waste-activated sludge ranged from 2.6 to 7.8 pCi/g dw.

The gross beta radioactivity in the raw sewage of the North Side WRP ranged from 5.5 to 9.7 pCi/L, and in the effluent it ranged from 5.2 to 10.5 pCi/L (Table 11). The gross beta radioactivity in the North Side WRP waste-activated sludge ranged from 8.9 to 28.2 pCi/g dw (Table 11).

The yearly average gross beta radioactivity in the North Side WRP raw sewage, final effluent, and waste-activated sludge from 1996 to 2009 are summarized in Table 12. The gross beta radioactivity in the raw sewage ranged from 7.0 to 20.4 pCi/L and in the effluent it ranged from 5.7 to 10.9 pCi/L. The gross beta radioactivity in waste-activated sludge ranged from 12.8 to 16.2 pCi/g dw.

### **John E. Egan Water Reclamation Plant**

In 2009, the gross alpha radioactivity in the raw sewage of the Egan WRP was below the detection limits (3.0 to 5.8 pCi/L) except for the January, April and August samples which were 6.9, 4.7 and 5.4 pCi/L respectively (Table 13). The gross alpha radioactivity in the effluent was below the detection limits (2.3 to 4.6 pCi/L) (Table 13). The gross alpha radioactivity in anaerobically digested biosolids samples ranged from 2.8 to 15.0 pCi/g dw (Table 13).

TABLE 7: GROSS BETA RADIOACTIVITY IN CALUMET WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS – 2009

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
January	12.5	7.3	22.0
February	8.6	9.6	21.2
March	9.0	6.9	22.9
April	8.0	6.8	23.5
May	11.3	6.9	24.3
June	11.5	9.8	33.9
July	13.8	9.6	28.9
August	8.3	10.9	28.3
September	9.9	8.0	27.4
October	11.3	5.9	19.3
November	8.5	9.2	26.1
December	11.5	16.8	28.4

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

TABLE 8: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN CALUMET WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2009

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
1996	9.3	6.9	21.5
1997	18.6	11.2	21.4
1998	19.5	13.2	23.7
1999	24.9	14.1	22.6
2000	22.0	10.2	25.2
2001	13.6	9.4	24.1
2002	15.9	9.4	21.0
2003	15.1	9.6	23.7
2004	12.3	9.2	24.8
2005	12.1	8.3	23.2
2006	11.4	8.1	26.2
2007	9.8	6.9	25.5
2008	8.5	7.0	30.6
2009	10.3	9.0	25.5



TABLE 9: GROSS ALPHA RADIOACTIVITY IN NORTH SIDE WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE ON A MONTHLY BASIS – 2009

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Sludge Gross Alpha (pCi/g dw)
January	<2.7	<3.2	3.0
February	<3.8	<3.4	2.0
March	<2.8	<5.0	4.0
April	<5.4	<4.7	4.8
May	<2.5	4.9	9.2
June	<3.0	<4.5	8.9
July	<3.5	<2.8	9.5
August	<2.7	<1.7	2.2
September	<3.7	<1.5	8.7
October	<1.7	<2.5	10.2
November	<3.1	<3.4	9.7
December	<2.4	<3.4	9.0

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

TABLE 10: YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN NORTH SIDE WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE FROM 1996 THROUGH 2009

Year*	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Sludge Gross Alpha (pCi/g dw)
1996	<3.3	<3.0	3.5
1997	<3.6	<3.3	2.6
1998	<3.3	<2.8	3.0
1999	<4.0	<3.5	3.7
2000	<4.9	<4.1	4.9
2001	<4.9	<4.5	7.8
2002	<4.0	<4.0	6.6
2003	<3.6	<3.5	6.2
2004	<4.1	<3.6	7.8
2005	<4.4	<3.8	7.1
2006	<4.8	<4.8	7.2
2007	<5.0	<4.9	7.0
2008	<2.8	<2.3	7.8
2009	<3.1	<3.4	6.8

\* Am-241 self-absorption standards were used up to June 30, 2001, and Th-230 self-absorption standards were used from July 1, 2001 for generating attenuation curve for gross alpha radioactivity.

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

TABLE 11: GROSS BETA RADIOACTIVITY IN NORTH SIDE WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE ON A MONTHLY BASIS – 2009

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Sludge Gross Beta (pCi/g dw)
January	8.0	8.9	12.5
February	6.7	6.4	10.3
March	6.5	6.0	13.9
April	5.5	8.4	16.2
May	6.2	9.9	19.7
June	8.7	5.4	12.3
July	5.7	10.5	28.2
August	6.3	9.9	8.9
September	5.5	5.2	14.3
October	7.3	5.5	16.3
November	9.7	5.3	17.4
December	8.0	6.6	10.5

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

TABLE 12: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN NORTH SIDE WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE FROM 1996 THROUGH 2009

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Sludge Gross Beta (pCi/g dw)
1996	8.5	5.7	14.8
1997	16.1	<7.8	14.0
1998	18.4	9.8	14.4
1999	19.1	10.9	13.6
2000	20.4	8.9	15.0
2001	12.8	8.5	15.8
2002	11.3	8.4	12.8
2003	10.0	7.9	13.3
2004	10.9	9.3	12.8
2005	10.3	7.4	13.5
2006	10.1	8.0	14.4
2007	9.0	6.5	14.4
2008	7.5	6.3	16.2
2009	7.0	7.3	15.0

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

TABLE 13: GROSS ALPHA RADIOACTIVITY IN JOHN E. EGAN WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS – 2009

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
January	6.9	<2.4	3.7
February	<3.4	<2.8	2.8
March	<5.8	<2.4	3.5
April	4.7	<4.3	12.5
May	<4.7	<4.3	6.4
June	<3.9	<2.3	11.8
July	<4.4	<2.5	9.6
August	5.4	<3.7	11.8
September	<3.7	<4.6	13.8
October	<3.0	<3.9	15.0
November	<3.4	<3.4	9.4
December	<3.4	<3.0	13.4

<= The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

The yearly average gross alpha radioactivity in the Egan WRP raw sewage, final effluent, and anaerobically digested biosolids from 1996 to 2009 are summarized in [Table 14](#). The gross alpha radioactivity in the raw sewage was below the detection limit (2.8 to 5.4 pCi/L). The gross alpha radioactivity in the effluent was also below the detection limit (2.0 to 5.2 pCi/L). The gross alpha radioactivity in anaerobically digested biosolids ranged from 4.4 to 13.8 pCi/g dw.

The gross beta radioactivity levels in the raw sewage of the Egan WRP ranged from 6.7 to 15.6 pCi/L, and in the effluent it ranged from 5.4 to 10.8 pCi/L ([Table 15](#)). The gross beta radioactivity in the Egan WRP anaerobically digested biosolids ranged from 13.9 to 21.8 pCi/g dw.

The yearly average gross beta radioactivity at the Egan WRP raw sewage, final effluent, and anaerobically digested biosolids from 1996 to 2009 are summarized in [Table 16](#). The gross beta radioactivity in the raw sewage ranged from 9.0 to 22.5 pCi/L and in the effluent it ranged from 6.8 to 12.7 pCi/L. The gross beta radioactivity in anaerobically digested biosolids ranged from 17.6 to 21.7 pCi/g dw.

### **Hanover Park Water Reclamation Plant**

In 2009, the gross alpha radioactivity levels in the raw sewage of the Hanover Park WRP were below the detection limit (1.8 to 4.3 pCi/L) ([Table 17](#)). The gross alpha radioactivity in the effluent was also below the detection limits (1.5 to 4.9 pCi/L) ([Table 17](#)). The gross alpha radioactivity in anaerobically digested biosolids ranged from 2.2 to 12.0 pCi/g dw ([Table 17](#)).

The yearly average gross alpha radioactivity in the Hanover Park WRP raw sewage, final effluent, and anaerobically digested biosolids from 1996 to 2009 are summarized in [Table 18](#). The gross alpha radioactivity in the raw sewage was below the detection limit (2.6 to 5.0 pCi/L). The gross alpha radioactivity in the effluent was also below the detection limit (1.9 to 5.0 pCi/L). The gross alpha radioactivity in anaerobically digested biosolids ranged from 3.2 to 10.2 pCi/g dw.

The gross beta radioactivity levels in the raw sewage of the Hanover Park WRP ranged from 5.8 to 20.4 pCi/L and in the effluent it ranged from 6.2 to 10.2 pCi/L ([Table 19](#)). The gross beta radioactivity in the Hanover Park WRP anaerobically digested biosolids ranged from 7.4 to 14.4 pCi/g dw ([Table 19](#)).

The yearly average gross beta radioactivity in the Hanover Park WRP raw sewage, final effluent, and anaerobically digested biosolids from 1996 to 2009 are summarized in [Table 20](#). The gross beta radioactivity in the raw sewage ranged from 8.9 to 20.3 pCi/L and in the effluent it ranged from 6.6 to 11.7 pCi/L. The gross beta radioactivity in anaerobically digested biosolids ranged from 11.8 to 15.5 pCi/g dw.

TABLE 14: YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN JOHN E. EGAN WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2009

Year*	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
1996	<3.6	<3.2	5.6
1997	<3.7	<3.3	4.4
1998	<3.8	<3.0	4.8
1999	<4.0	<3.5	5.2
2000	<4.5	<4.1	6.9
2001	<5.0	<4.6	10.5
2002	<4.8	<4.8	10.2
2003	<4.2	<3.6	9.7
2004	<4.4	<3.8	9.9
2005	<4.8	<4.2	10.1
2006	<4.8	<4.8	9.8
2007	<5.4	<5.2	9.3
2008	<2.8	<2.0	13.8
2009	<4.4	<3.3	9.5

\* Am-241 self-absorption standards were used up to June 30, 2001, and Th-230 self-absorption standards were used from July 1, 2001 for generating attenuation curve for gross alpha radioactivity.

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

TABLE 15: GROSS BETA RADIOACTIVITY IN JOHN E. EGAN WATER  
RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY  
DIGESTED BIOSOLIDS ON A MONTHLY BASIS – 2009

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
January	9.7	5.6	13.9
February	8.7	7.5	13.9
March	9.6	6.6	17.5
April	14.4	6.2	18.9
May	9.1	9.7	17.5
June	6.7	7.9	21.8
July	15.6	10.3	21.1
August	10.8	7.1	20.9
September	8.0	10.7	21.2
October	10.5	10.8	16.7
November	11.3	5.4	17.2
December	10.8	9.9	16.5



TABLE 16: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN JOHN E. EGAN WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2009

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
1996	10.8	6.9	20.3
1997	17.5	11.9	19.0
1998	19.1	12.7	20.5
1999	22.5	12.3	19.7
2000	20.8	10.6	21.3
2001	16.0	9.5	20.7
2002	15.4	12.0	18.3
2003	14.0	10.5	18.6
2004	13.9	11.3	19.3
2005	13.7	10.9	17.6
2006	13.0	11.0	18.5
2007	11.4	8.7	18.2
2008	9.0	6.8	21.7
2009	10.4	8.1	18.1

TABLE 17: GROSS ALPHA RADIOACTIVITY IN HANOVER PARK WATER  
RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY  
DIGESTED BIOSOLIDS ON A MONTHLY BASIS – 2009

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
January	<1.8	<4.5	2.2
February	<1.9	<2.9	2.8
March	<1.9	<2.8	3.4
April	<3.8	<3.0	7.6
May	<4.3	<3.5	6.9
June	<2.5	<4.9	8.6
July	<3.1	<4.3	8.0
August	<2.7	<3.6	8.8
September	<1.8	<3.4	8.8
October	<2.2	<4.1	12.0
November	<3.2	<3.2	6.9
December	<2.2	<1.5	10.3

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

TABLE 18: YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN HANOVER PARK WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2009

Year*	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
1996	<3.4	<3.1	4.7
1997	<3.6	<3.3	3.2
1998	<3.5	<3.0	4.0
1999	<4.2	<3.5	4.3
2000	<4.6	<4.2	5.7
2001	<4.7	<4.4	9.4
2002	<4.5	<4.0	8.0
2003	<4.1	<3.5	7.1
2004	<4.4	<3.7	8.2
2005	<4.6	<4.1	8.0
2006	<5.0	<4.6	7.5
2007	<5.0	<5.0	7.0
2008	<2.7	<1.9	10.2
2009	<2.6	<3.5	7.2

\* Am-241 self-absorption standards were used up to June 30, 2001, and Th-230 self-absorption standards were used from July 1, 2001 for generating attenuation curve for gross alpha radioactivity.

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

TABLE 19: GROSS BETA RADIOACTIVITY IN HANOVER PARK WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS – 2009

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
January	8.9	9.5	7.4
February	12.6	9.8	9.2
March	6.8	8.0	14.4
April	11.3	9.5	11.6
May	12.4	7.5	13.7
June	9.6	6.2	13.6
July	20.4	10.2	12.9
August	14.8	9.4	12.6
September	8.9	7.1	13.3
October	8.3	9.7	13.1
November	9.3	8.0	12.1
December	5.8	8.1	10.5

TABLE 20: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN HANOVER PARK WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2009

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
1996	9.7	6.6	13.2
1997	14.3	9.3	11.8
1998	20.3	10.3	13.5
1999	18.4	10.8	13.0
2000	16.1	9.5	13.8
2001	14.2	9.6	14.2
2002	14.5	11.7	12.0
2003	13.5	10.6	12.0
2004	13.6	11.0	12.1
2005	13.3	10.8	12.3
2006	12.9	11.2	13.6
2007	9.8	9.2	13.0
2008	8.9	8.1	15.5
2009	10.8	8.6	12.0

## **James C. Kirie Water Reclamation Plant**

In 2009, the gross alpha radioactivity levels in the raw sewage of the Kirie WRP was below the detection limit (2.0 to 6.4 pCi/L) except for January, February and September samples which were 4.2, 3.5 and 2.3 pCi/L, respectively (Table 21). The gross alpha radioactivity in the effluent was below the detection limit (1.7 to 5.4 pCi/L) (Table 21) and in the waste-activated sludge ranged from 2.8 to 17.4 pCi/g dw (Table 21).

The yearly average gross alpha radioactivity in the Kirie WRP raw sewage, final effluent, and waste-activated sludge from 1996 to 2009 are summarized in Table 22. The gross alpha radioactivity in the raw sewage was below the detection limit (3.1 to 5.6 pCi/L). The gross alpha radioactivity in the effluent was also below the detection limit (2.3 to 5.6 pCi/L). The gross alpha radioactivity in waste-activated sludge ranged from 3.1 to 9.3 pCi/g dw.

The gross beta radioactivity level in the raw sewage of the Kirie WRP ranged from 5.2 to 16.8 pCi/L, and in the effluent it ranged from 5.0 to 10.5 pCi/L (Table 23). The gross beta radioactivity in the Kirie WRP waste-activated sludge ranged from 11.7 to 24.6 pCi/g dw (Table 23).

The yearly average gross beta radioactivity in the Kirie WRP raw sewage, final effluent, and waste-activated sludge from 1996 to 2009 are summarized in Table 24. The gross beta radioactivity in the raw sewage ranged from 9.6 to 22.7 pCi/L and in the effluent it ranged from 8.0 to 16.8 pCi/L. The gross beta radioactivity in waste-activated sludge ranged from 13.3 to 17.7 pCi/g dw.

## **Lemont Water Reclamation Plant**

In 2009, the gross alpha radioactivity levels in the raw sewage of the Lemont WRP ranged from 3.1 to 40.4 pCi/L except for the April sample which was below the detection limit (6.3 pCi/L) (Table 25). The gross alpha radioactivity in the effluent ranged from 8.1 to 21.4 pCi/L except for April, June, July, August, November and December samples which were below the detection limit (3.2 to 7.7 pCi/L) (Table 25). The gross alpha radioactivity in the waste-activated sludge ranged from 12.5 to 130.0 pCi/g dw (Table 25).

The yearly average gross alpha radioactivity in the Lemont WRP raw sewage, final effluent, and waste-activated sludge from 1996 to 2009 are summarized in Table 26. The gross alpha radioactivity in the raw sewage ranged from 13.4 to 44.4 pCi/L. The gross alpha radioactivity in the effluent was below the detection limit (5.0 to 10.8 pCi/L) except for 2008 and 2009 samples which were 6.7 and 8.9 pCi/L respectively. The gross alpha radioactivity in the waste-activated sludge ranged from 38.9 to 141.1 pCi/g dw.

The gross beta radioactivity levels in the raw sewage of the Lemont WRP ranged from 12.2 to 34.8 pCi/L, and in the effluent it ranged from 6.9 to 37.9 pCi/L (Table 27). The gross beta radioactivity in the Lemont waste-activated sludge ranged from 9.5 to 72.6 pCi/g dw (Table 27).

TABLE 21: GROSS ALPHA RADIOACTIVITY IN JAMES C. KIRIE WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE ON A MONTHLY BASIS – 2009

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Sludge Gross Alpha (pCi/g dw)
January	4.2	<3.6	2.8
February	3.5	<2.4	3.0
March	<3.0	<4.0	2.8
April	<6.4	<5.4	4.0
May	<4.9	<3.0	17.4
June	<3.8	<4.5	7.5
July	<3.0	<4.8	14.9
August	<5.0	<3.4	8.7
September	2.3	<3.8	13.3
October	<2.6	<3.4	11.7
November	<2.0	<1.7	5.8
December	<3.5	<3.6	11.2

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

TABLE 22: YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN JAMES C. KIRIE WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE FROM 1996 THROUGH 2009

Year*	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Sludge Gross Alpha (pCi/g dw)
1996	<3.7	<3.3	5.0
1997	<3.8	<3.4	3.1
1998	<3.6	<2.8	3.2
1999	<4.2	<3.7	4.1
2000	<4.6	<4.5	4.8
2001	<5.3	<4.9	9.2
2002	<4.6	<4.1	7.4
2003	<4.2	<3.8	7.2
2004	<4.9	<4.2	7.1
2005	<5.1	<4.7	7.9
2006	<5.3	<4.8	6.8
2007	<5.6	<5.6	6.8
2008	<3.1	<2.3	9.3
2009	<3.7	<3.6	8.6

\* Am-241 self-absorption standards were used up to June 30, 2001, and Th-230 self-absorption standards were used from July 1, 2001 for generating attenuation curve for gross alpha radioactivity.

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).



TABLE 23: GROSS BETA RADIOACTIVITY IN JAMES C. KIRIE WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE ON A MONTHLY BASIS – 2009

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Sludge Gross Beta (pCi/g dw)
January	8.4	10.2	18.0
February	16.8	10.5	11.7
March	5.8	6.0	14.3
April	9.6	6.3	12.4
May	10.3	7.8	16.3
June	8.6	8.1	12.6
July	5.2	8.1	24.6
August	12.8	10.3	16.9
September	10.4	10.0	17.0
October	9.4	5.0	18.1
November	8.0	5.3	14.5
December	9.9	9.0	12.6

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

TABLE 24: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN JAMES C. KIRIE WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE FROM 1996 THROUGH 2009

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Sludge Gross Beta (pCi/g dw)
1996	11.6	8.1	16.8
1997	19.2	12.6	14.6
1998	22.3	15.6	14.2
1999	21.4	15.5	13.5
2000	22.7	16.8	14.8
2001	17.6	13.3	15.8
2002	17.4	14.8	14.0
2003	16.1	12.2	13.5
2004	15.7	12.9	13.3
2005	16.1	15.2	14.8
2006	13.4	12.6	13.7
2007	13.0	11.1	14.6
2008	11.8	8.7	17.7
2009	9.6	8.0	15.8

TABLE 25: GROSS ALPHA RADIOACTIVITY IN LEMONT WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE ON A MONTHLY BASIS – 2009

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Sludge Gross Alpha (pCi/g dw)
January	34.5	8.1	12.5
February	32.9	21.4	39.7
March	13.2	12.0	41.1
April	<6.3	<7.7	102.0
May	11.5	9.3	48.9
June	3.1	<3.2	80.1
July	11.2	<3.9	101.0
August	5.2	<4.8	130.0
September	5.1	10.5	79.2
October	40.4	14.4	18.1
November	11.7	<4.9	93.8
December	22.4	<6.4	93.1

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

TABLE 26: YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN LEMONT WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE FROM 1996 THROUGH 2009

Year*	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Sludge Gross Alpha (pCi/g dw)
1996	13.4	<5.4	45.3
1997	21.1	<5.9	38.9
1998	22.8	<5.0	48.8
1999	35.4	<6.8	76.6
2000	44.4	<7.9	106.1
2001	33.3	<9.1	141.1
2002	23.8	<9.7	121.2
2003	16.4	<9.3	86.5
2004	18.6	<8.6	100.2
2005	24.2	<10.5	110.4
2006	16.1	<10.1	90.0
2007	15.2	<10.8	76.8
2008	23.6	6.7	124.8
2009	16.5	8.9	70.0

\* Am-241 self-absorption standards were used up to June 30, 2001, and Th-230 self-absorption standards were used from July 1, 2001 for generating attenuation curve for gross alpha radioactivity.

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

TABLE 27: GROSS BETA RADIOACTIVITY IN LEMONT WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE ON A MONTHLY BASIS – 2009

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Sludge Gross Beta (pCi/g dw)
January	34.7	24.3	34.8
February	34.8	37.9	42.3
March	20.3	21.6	33.6
April	12.2	12.6	67.8
May	17.3	18.5	35.2
June	16.2	9.9	46.9
July	32.9	6.9	72.6
August	21.9	24.1	71.8
September	17.4	21.5	50.3
October	34.4	24.4	9.5
November	24.0	19.3	57.2
December	31.5	17.8	57.0

The yearly average gross beta radioactivity at the Lemont WRP raw sewage, final effluent, and waste-activated sludge from 1996 to 2009 are summarized in [Table 28](#). The gross beta radioactivity in the raw sewage ranged from 24.8 to 66.0 pCi/L and in the effluent it ranged from 13.4 to 24.9 pCi/L. The gross beta radioactivity in waste-activated sludge ranged from 48.3 to 121.9 pCi/g dw.

### **Hanover Park Water Reclamation Plant Lagoons**

[Table 29](#) presents the gross alpha and gross beta radioactivity concentrations in the Hanover Park WRP lagooned biosolids for 2009.

Average gross alpha radioactivity in the Hanover Park WRP East lagooned biosolids was 7.0 pCi/g dw and ranged from 2.3 to 9.4 pCi/g dw. Average gross alpha radioactivity in the Hanover Park WRP West lagooned biosolids was 8.8 pCi/g dw and ranged from 3.9 to 12.8 pCi/g dw.

Average gross beta radioactivity in the Hanover Park WRP East lagooned biosolids was 12.2 pCi/g dw and ranged from 9.6 to 15.4 pCi/g dw. Average gross beta radioactivity in the Hanover Park WRP West lagooned biosolids was 12.7 pCi/g dw and ranged from 10.7 to 15.3 pCi/g dw.

The yearly average gross alpha radioactivity in Hanover Park WRP lagooned biosolids, since the inception of this program, from 1998 to 2009 is summarized in [Table 30](#). The gross alpha radioactivity in the lagooned biosolids ranged from 4.6 pCi/g dw at Hanover Park WRP West lagoon in 1999 to 13.8 pCi/g dw at Hanover Park WRP West lagoon in 2004.

The yearly average gross beta radioactivity in the Hanover Park WRP lagooned biosolids from 1998 to 2009 is summarized in [Table 31](#). The gross beta radioactivity in lagooned biosolids ranged from 11.6 pCi/g dw at the Hanover Park WRP West Lagoon in 2003 to 18.1 pCi/g dw at the Hanover Park WRP West Lagoon in 1999.

### **Gross Alpha and Gross Beta Radioactivity in Metropolitan Water Reclamation District of Greater Chicago's Air-Dried Biosolids**

[Table 32](#) presents the gross alpha and gross beta radioactivity concentrations in District's air-dried biosolids for 2009.

Average gross alpha radioactivity in biosolids ranged from 7.5 pCi/g dw at the Calumet East SMS to 18.0 pCi/g dw at the Calumet West SMS. Average gross beta radioactivity in biosolids ranged from 14.1 pCi/g dw at the Calumet East SMS to 22.5 pCi/g dw at the HASMA SDS.

TABLE 28: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN LEMONT WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE FROM 1996 THROUGH 2009

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Sludge Gross Beta (pCi/g dw)
1996	26.6	13.4	73.4
1997	44.3	20.8	77.0
1998	42.4	19.4	84.1
1999	59.1	21.8	101.4
2000	66.0	22.0	121.9
2001	50.0	22.3	90.7
2002	37.1	24.1	79.5
2003	26.4	18.4	61.1
2004	28.3	19.3	63.4
2005	34.9	24.9	68.6
2006	26.4	21.7	64.2
2007	26.3	20.0	64.8
2008	27.0	18.8	107.4
2009	24.8	19.9	48.3

TABLE 29: GROSS ALPHA AND GROSS BETA RADIOACTIVITY IN HANOVER PARK  
WATER RECLAMATION PLANT LAGOONED BIOSOLIDS – 2009

Lagoon Location	No. of Samples	Gross Alpha (pCi/g dw)			Gross Beta (pCi/g dw)		
		Average	Minimum	Maximum	Average	Minimum	Maximum
East	3	7.0	2.3	9.4	12.2	9.6	15.4
West	3	8.8	3.9	12.8	12.7	10.7	15.3



TABLE 30: YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN HANOVER PARK WATER RECLAMATION PLANT LAGOONED BIOSOLIDS FROM 1998 THROUGH 2009

Year*	Hanover Park East Gross Alpha (pCi/g dw)	Hanover Park West Gross Alpha (pCi/g dw)
1998	6.2	6.5
1999	5.0	4.6
2000	N/A	N/A
2001	13.6	13.2
2002	9.1	13.7
2003	9.0	8.6
2004	13.3	13.8
2005	9.4	9.7
2006	10.8	10.9
2007	9.4	7.9
2008	12.2	12.5
2009	7.0	8.8

\* Am-241 self-absorption standards were used up to June 30, 2001, and Th-230 self-absorption standards were used from July 1, 2001 for generating attenuation curve for gross alpha radioactivity.

N/A = Not Analyzed

TABLE 31: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN HANOVER PARK WATER RECLAMATION PLANT LAGOONED BIOSOLIDS FROM 1998 THROUGH 2009

Year	Hanover Park East Gross Beta (pCi/g dw)	Hanover Park West Gross Beta (pCi/g dw)
1998	15.2	17.2
1999	15.2	18.1
2000	N/A	N/A
2001	13.6	14.8
2002	14.1	15.3
2003	13.8	11.6
2004	14.8	14.8
2005	14.8	13.4
2006	14.6	12.8
2007	12.9	12.9
2008	16.0	16.4
2009	15.4	15.3

N/A = Not Analyzed

TABLE 32: GROSS ALPHA AND GROSS BETA RADIOACTIVITY IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS - 2009

Sample Location	No. of Samples	Gross Alpha (pCi/g dw)			Gross Beta (pCi/g dw)		
		Average	Minimum	Maximum	Average	Minimum	Maximum
LASMA	3	9.3	2.9	14.4	16.5	5.4	25.3
Calumet East	3	7.5	4.3	11.8	14.1	6.5	23.0
Calumet West	3	18.0	5.3	25.7	20.6	9.2	29.3
HASMA	3	10.5	7.2	14.5	22.5	14.4	26.8
Marathon	3	8.9	4.6	12.5	16.5	8.9	22.0
Vulcan	3	9.1	7.1	11.9	17.0	13.5	20.2

The yearly average gross alpha radioactivity in the District’s air-dried biosolids from 1996 to 2009 is summarized in Table 33. The gross alpha radioactivity in the biosolids ranged from 5.1 pCi/g dw at the Vulcan SDA in 1996 to 22.6 pCi/g dw at the RASMA drying site in 2004.

The yearly average gross beta radioactivity in the District’s air-dried biosolids from 1996 to 2009 is summarized in Table 34. The gross beta radioactivity in the biosolids ranged from 14.1 pCi/g dw at the Calumet East SMS in 2009 to 30.4 pCi/g dw at the Calumet West SMS in 2007.

**Gamma Radioactivity in Metropolitan Water Reclamation District of Greater Chicago’s Water Reclamation Plant Sludges and Biosolids**

In 2009, 20 sludge samples from five WRPs, 18 biosolids samples from six solids drying sites, and six biosolids samples from the Hanover Park WRP lagoons were analyzed for gamma-emitting radionuclides. The following is a list of radionuclides monitored:

Beryllium-7	Silver-108m	Barium-133
Sodium-22	Silver-110	Bismuth-207
Potassium-40	Antimony-125	Bismuth-212
Manganese-54	Cesium-134	Lead-212
Cobalt-57	Cesium-137	Bismuth-214
Cobalt-60	Cerium-144	Lead-214
Zinc-65	Europium-152	Radium-226
Niobium-94	Gadolinium-153	Actinium-228
Ruthenium-106	Europium-154	Protactinium-231

Of the 27 radionuclides analyzed, nine were detected at measurable levels. Of these, eight radionuclides are of natural origin, and one, cesium-137, is a manmade radionuclide.

Table 35 presents the concentrations of gamma-emitting radionuclides in the sludge and biosolids from the District WRPs for 2009.

The village of Lemont uses groundwater for its community water supply. This groundwater contains naturally occurring radium-226. The village uses an ion exchange system to remove radium-226 from groundwater. The backwash water from the Lemont community water

TABLE 33: YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2009

Year*	Gross Alpha Radioactivity (pCi/g dw)							
	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
1996	N/A	N/A	7.1	5.7	6.6	6.1	5.1	5.6
1997	N/A	N/A	7.2	8.2	6.9	6.6	6.6	8.1
1998	7.7	7.4	7.5	7.9	8.1	7.6	7.7	8.1
1999	6.9	7.4	6.8	7.4	6.8	7.9	6.0	6.7
2000	10.3	12.1	9.8	12.1	11.7	10.5	9.2	11.4
2001	13.1	17.6	17.5	16.4	17.5	15.2	15.8	17.7
2002	12.4	16.6	14.4	14.9	15.0	13.5	15.0	15.2
2003	16.2	17.0	15.7	16.8	15.4	14.6	15.8	16.6
2004	15.4	20.5	14.9	15.8	15.0	17.2	16.2	22.6

TABLE 33 (Continued): YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2009

Year*	Gross Alpha Radioactivity (pCi/g dw)							
	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
2005	11.8	13.7	16.0	17.8	17.2	13.6	15.5	15.3
2006	10.9	14.9	10.2	12.8	12.6	12.7	8.9	N/S
2007	13.5	14.0	13.9	12.8	14.4	10.8	12.8	N/S
2008	17.4	19.5	17.6	15.9	18.1	21.1	17.8	N/S
2009	7.5	18.0	9.3	10.5	8.9	N/S	9.1	N/S

\* Am-241 self-absorption standards were used up to June 30, 2001, and Th-230 self-absorption standards were used from July 1, 2001 for generating attenuation curve for gross alpha radioactivity.

N/A = Not Analyzed

N/S = No Sample

TABLE 34: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2009

Year	Gross Beta Radioactivity (pCi/g dw)							
	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
1996	N/A	N/A	23.0	23.8	27.5	22.5	22.4	24.2
1997	N/A	N/A	25.2	26.3	23.2	26.1	26.4	26.0
1998	23.8	21.8	23.8	24.4	24.9	24.5	24.9	24.9
1999	23.7	24.4	21.5	28.6	25.4	25.0	22.8	24.6
2000	27.5	27.1	28.0	27.6	29.7	28.6	26.3	30.2
2001	23.4	21.0	25.8	25.0	24.2	25.0	23.2	26.7
2002	24.7	22.1	24.9	25.7	27.4	23.8	26.7	27.0
2003	25.3	26.5	26.8	25.0	25.6	23.3	24.9	26.5
2004	21.8	22.5	24.3	23.8	24.1	25.0	24.2	25.2

TABLE 34 (Continued): YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2009

Year	Gross Beta Radioactivity (pCi/g dw)							
	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
2005	24.7	24.1	22.2	26.8	27.7	26.2	27.4	26.6
2006	25.2	24.4	27.0	27.5	27.9	27.1	25.5	N/S
2007	23.2	30.4	24.2	24.0	25.2	25.1	23.1	N/S
2008	27.0	32.2	29.7	27.1	28.8	31.9	28.2	N/S
2009	14.1	20.6	16.5	22.5	16.5	N/S	17.0	N/S

N/A = Not Analyzed

N/S = No Sample



TABLE 35: CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN WATER RECLAMATION PLANT SLUDGES AND BIOSOLIDS - 2009

Sample Location WRP	No. of Samples	Potassium-40 (pCi/g dw)			Radium-226 (pCi/g dw)			Cesium-137 (pCi/g dw)		
		Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
Calumet	4	22.2	12.3	25.1	3.2	2.5	4.0	ND	ND	ND
John E. Egan	4	10.7	6.8	13.5	2.8	1.7	3.9	ND	ND	ND
Hanover Park	4	10.0	6.5	13.3	1.7	1.3	2.7	ND	ND	ND
Stickney	4	20.2	14.7	28.3	1.9	1.1	2.3	ND	ND	ND
Lemont	4	13.5	9.5	16.8	38.3	23.3	68.0	ND	ND	ND

TABLE 35 (Continued): CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN WATER RECLAMATION PLANT SLUDGES AND BIOSOLIDS - 2009

Sample Location WRP	No. of Samples	Beryllium-7 (pCi/g dw)			Bismuth-212 (pCi/g dw)			Lead-212 (pCi/g dw)		
		Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
Calumet	4	18.6	12.3	25.1	ND	ND	2.6	1.1	0.7	1.4
John E. Egan	4	10.7	6.5	14.8	ND	ND	ND	0.8	ND	1.0
Hanover Park	4	5.4	ND	8.4	ND	ND	ND	0.8	0.4	1.4
Stickney	4	25.2	15.8	37.9	ND	ND	ND	0.9	0.5	1.2
Lemont	4	10.2	5.0	12.7	7.8	5.0	9.5	6.0	3.1	9.2

TABLE 35 (Continued): CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN WATER RECLAMATION PLANT SLUDGES AND BIOSOLIDS - 2009

Sample Location WRP	No. of Samples	Bismuth-214 (pCi/g dw)			Lead-214 (pCi/g dw)			Actinium-228 (pCi/g dw)		
		Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
Calumet	4	2.1	ND	3.8	2.3	0.8	4.4	3.3	2.7	3.8
John E. Egan	4	2.2	ND	3.9	2.4	0.9	4.6	2.1	ND	2.3
Hanover Park	4	1.9	ND	2.7	1.6	ND	1.9	2.0	ND	2.5
Stickney	4	1.5	ND	2.3	1.5	0.9	2.2	2.3	ND	3.2
Lemont	4	28.6	3.2	68.0	30.8	3.2	74.5	47.0	31.4	70.1

ND = Not Detected.

supply treatment system is discharged into the Lemont WRP. The District treats the raw sewage containing this radium-226 at the Lemont WRP to remove contaminants. The radium-226 removed during the wastewater treatment process is concentrated in sludge. The Lemont WRP does not have sludge treatment facilities, and it was transported by truck to the Stickney WRP for treatment.

The yearly average potassium-40, radium-226, and cesium-137 radioactivity in the District's WRPs sludges and biosolids from 1997 to 2009 are summarized in [Tables 36, 37, and 38](#), respectively. The potassium-40 radioactivity in the WRPs sludge ranged from 2.4 pCi/g dw at the Hanover Park WRP in 1997 to 22.2 pCi/g dw at the Calumet WRP in 2009. The radium-226 radioactivity in the WRPs sludges, excluding Lemont WRP, ranged from 1.7 pCi/g dw at the Hanover Park WRP in 2009 to 6.2 pCi/g dw at the Hanover Park WRP in 2008. The radium-226 radioactivity at the Lemont WRP ranged from 38.3 pCi/g dw in 2009 to 86.8 pCi/g dw in 2001. The cesium-137 radioactivity in the WRPs sludges ranged from non-detectable levels to 0.11 pCi/g dw in 1998 at the Stickney WRP.

[Table 39](#) presents the concentration of gamma-emitting radionuclides in the Hanover Park WRP lagooned biosolids for 2009. The data presents an average of three samples analyzed from both the Hanover Park WRP East and West lagoons

The yearly average potassium-40, radium-226, and cesium-137 radioactivity in the Hanover Park WRP lagooned biosolids from 1998 to 2009 is summarized in [Table 40](#). The yearly average potassium-40 radioactivity at the Hanover Park East lagoon ranged from 2.8 to 6.9 pCi/g dw. The yearly average radium-226 radioactivity ranged from 1.8 to 6.7 pCi/g dw, and cesium-137 radioactivity ranged from non-detectable levels to 0.2 pCi/g dw. The yearly average potassium-40 radioactivity in the Hanover Park West lagooned biosolids ranged from 3.5 to 6.7 pCi/g dw, radium-226 radioactivity ranged from 1.8 to 5.7 pCi/g dw, and cesium-137 radioactivity ranged from non-detectable levels to 0.3 pCi/g dw.

[Table 41](#) presents the concentration of gamma-emitting radionuclides in the District's air-dried biosolids collected from six solids drying sites in 2009.

The yearly average potassium-40, radium-226, and cesium-137 radioactivity in the District's air-dried biosolids from 1996 to 2009 are summarized in [Tables 42, 43, and 44](#), respectively. The potassium-40 radioactivity in the biosolids ranged from 6.2 to 17.5 pCi/g dw. The radium-226 radioactivity in the biosolids ranged from 0.9 to 5.2 pCi/g dw. The cesium-137 radioactivity in biosolids ranged from non-detectable levels to 0.6 pCi/g dw.

TABLE 36: YEARLY AVERAGE POTASIMUM-40 RADIOACTIVITY (pCi/g dw) IN WATER RECLAMATION PLANT  
SLUDGES AND BIOSOLIDS FROM 1997 THROUGH 2009

Year	Calumet	Egan	Hanover Park	Stickney	Lemont
1997	7.5	6.1	2.4	9.1	6.1
1998	9.0	10.1	5.1	11.7	8.5
1999	8.3	8.8	5.3	10.9	8.3
2000	7.6	8.1	4.1	10.4	8.5
2001	8.5	8.9	5.2	11.0	9.5
2002	8.5	8.3	4.9	11.1	7.9
2003	8.8	7.4	5.0	10.3	7.2
2004	8.6	8.2	4.6	9.8	6.3
2005	8.3	6.9	4.7	9.9	6.1
2006	9.4	8.9	5.3	10.3	6.7
2007	10.5	7.6	4.6	11.7	7.3
2008	11.2	8.8	6.7	12.2	11.1
2009	22.2	10.7	10.0	20.2	13.5

TABLE 37: YEARLY AVERAGE RADIUM-226 RADIOACTIVITY (pCi/g dw) IN WATER RECLAMATION PLANT  
SLUDGES AND BIOSOLIDS FROM 1997 THROUGH 2009

Year	Calumet	Egan	Hanover Park	Stickney	Lemont
1997	4.5	3.8	3.8	3.4	44.9
1998	4.5	4.5	4.7	3.4	55.8
1999	4.2	3.8	3.1	2.1	74.6
2000	4.6	4.3	4.4	4.0	80.2
2001	4.8	4.6	4.3	3.5	86.8
2002	4.0	4.2	3.8	3.4	85.0
2003	4.2	4.0	3.4	3.3	58.0
2004	5.5	3.8	3.6	4.0	65.6
2005	4.4	3.9	3.1	3.5	70.8
2006	4.5	3.9	3.8	3.4	56.7
2007	4.3	3.9	4.0	3.4	52.4
2008	6.0	5.6	6.2	4.4	45.2
2009	3.2	2.8	1.7	1.9	38.3

TABLE 38: YEARLY AVERAGE CESIUM-137 RADIOACTIVITY (pCi/g dw) IN WATER RECLAMATION PLANT SLUDGES AND BIOSOLIDS FROM 1997 THROUGH 2009

Year	Calumet	Egan	Hanover Park	Stickney	Lemont
1997	0.08	0.03	ND	0.10	0.06
1998	0.09	0.04	0.02	0.11	ND
1999	0.10	0.02	ND	0.10	ND
2000	0.06	ND	ND	0.08	ND
2001	0.06	ND	ND	0.07	ND
2002	0.06	ND	ND	0.08	ND
2003	0.07	ND	ND	0.06	ND
2004	0.06	ND	ND	0.05	ND
2005	0.05	ND	ND	0.06	ND
2006	0.06	ND	ND	0.05	ND
2007	0.05	ND	ND	0.06	ND
2008	0.07	0.05	ND	0.07	ND
2009	ND	ND	ND	ND	ND

ND = Not Detected

TABLE 39: CONCENTRATION (pCi/g dw) OF GAMMA-EMITTING RADIONUCLIDES  
 IN HANOVER PARK WATER RECLAMATION PLANT LAGOONED  
 BIOSOLIDS - 2009

Radionuclides	No. of Samples	Hanover Park East Lagoon	Hanover Park West Lagoon
Beryllium-7	3	6.6	4.2
Potassium-40	3	6.9	6.7
Cesium-137	3	ND	ND
Bismuth-212	3	ND	ND
Lead-212	3	0.6	0.7
Bismuth-214	3	1.4	1.1
Lead-214	3	1.1	1.2
Radium-226	3	2.0	1.8
Actinium-228	3	1.9	2.0

ND = Not Detected



TABLE 40: YEARLY AVERAGE POTASSIUM-40, RADIUM-226, AND CESIUM-137 RADIOACTIVITY (pCi/g dw)  
IN HANOVER PARK WATER RECLAMATION PLANT LAGOONED BIOSOLIDS FROM 1998 THROUGH 2009

Year	Hanover Park WRP East Lagoon			Hanover Park WRP West Lagoon		
	Potassium-40	Radium-226	Cesium-137	Potassium-40	Radium-226	Cesium-137
1998	4.4	5.2	0.2	4.8	5.1	0.3
1999	5.0	4.4	ND	4.6	4.2	ND
2000	N/A	N/A	N/A	N/A	N/A	N/A
2001	4.0	4.6	ND	4.2	5.7	ND
2002	5.0	4.2	ND	5.3	4.7	ND
2003	3.8	3.8	ND	3.5	3.7	ND
2004	2.8	3.7	ND	4.1	4.2	ND
2005	4.7	3.9	ND	4.5	3.8	ND
2006	4.2	3.9	0.04	3.8	3.6	0.04
2007	3.9	4.0	ND	4.2	3.8	ND
2008	6.5	6.7	ND	4.7	4.4	0.05
2009	6.9	1.8	ND	6.7	1.8	ND

ND = Not Detected  
N/A = Not Analyzed

TABLE 41: CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS – 2009

Sample Location	No. of Samples	Potassium-40 (pCi/g dw)			Radium-226 (pCi/g dw)			Cesium-137 (pCi/g dw)		
		Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
Calumet East	3	6.2	3.7	10.6	1.4	0.5	2.8	ND	ND	ND
Calumet West	3	8.9	5.4	12.6	1.9	0.7	3.4	ND	ND	ND
HASMA	3	10.2	7.8	12.5	1.3	0.9	1.8	ND	ND	ND
LASMA	3	7.1	2.4	10.3	0.9	0.2	2.3	ND	ND	ND
Marathon	3	7.1	3.3	11.0	1.0	0.2	2.2	ND	ND	0.08
Vulcan	3	9.1	6.0	12.3	1.2	0.4	1.9	ND	ND	0.1

TABLE 41 (Continued): CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS – 2009

Sample Location	No. of Samples	Beryllium-7 (pCi/g dw)			Bismuth-212 (pCi/g dw)			Lead-212 (pCi/g dw)		
		Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
Calumet East	3	10.8	5.5	19.0	ND	ND	ND	0.7	0.3	1.1
Calumet West	3	ND	ND	ND	ND	ND	ND	1.2	0.6	2.0
HASMA	3	ND	ND	ND	ND	ND	0.8	1.0	0.8	1.2
LASMA	3	ND	ND	ND	ND	ND	ND	0.7	0.1	1.0
Marathon	3	ND	ND	ND	ND	ND	ND	0.8	0.3	1.3
Vulcan	3	ND	ND	1.0	0.8	ND	1.2	1.0	0.7	1.3

TABLE 41 (Continued): CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS – 2009

Sample Location	No. of Samples	Bismuth-214 (pCi/g dw)			Lead-214 (pCi/g dw)			Actinium-228 (pCi/g dw)		
		Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
Calumet East	3	1.2	0.4	2.8	1.3	ND	3.0	1.3	ND	2.4
Calumet West	3	1.6	0.4	3.4	1.6	0.5	3.5	1.2	0.7	1.6
HASMA	3	1.2	0.6	1.8	1.2	0.6	1.9	1.0	0.6	1.1
LASMA	3	1.1	0.2	2.3	1.2	0.2	2.3	ND	ND	ND
Marathon	3	1.0	ND	2.2	1.1	0.2	1.1	0.9	ND	1.4
Vulcan	3	1.1	0.4	1.9	1.1	0.4	2.0	1.0	0.6	1.3

ND = Not Detected.

TABLE 42: YEARLY AVERAGE POTASIUM-40 RADIOACTIVITY (pCi/g dw) IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2009

Year	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
1996	7.4	7.0	9.0	9.6	9.7	8.6	9.9	10.4
1997	10.2	10.1	9.8	10.0	8.8	9.0	9.7	9.8
1998	9.8	8.6	11.7	9.7	10.8	8.9	9.8	9.3
1999	11.3	9.3	10.7	10.6	10.4	10.0	12.4	10.9
2000	10.4	9.9	9.4	9.6	10.2	10.3	10.0	10.4
2001	10.4	7.4	9.9	11.1	10.3	8.9	11.3	11.3
2002	10.9	7.1	10.8	14.4	11.6	9.4	11.3	11.5
2003	11.4	11.8	10.4	10.0	11.0	8.9	9.9	10.4
2004	7.0	7.5	9.7	8.8	10.5	8.8	9.2	9.4
2005	8.0	9.7	8.6	9.2	10.0	8.8	9.9	9.9
2006	8.6	7.6	12.5	9.2	12.1	8.9	9.6	NS
2007	8.8	17.5	10.7	8.6	11.1	8.7	9.4	NS

TABLE 42 (Continued): YEARLY AVERAGE POTASSIUM-40 RADIOACTIVITY (pCi/g dw) IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2009

Year	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
2008	7.6	11.2	9.0	8.3	8.9	9.1	8.9	NS
2009	6.2	8.9	7.1	10.2	7.1	NS	9.1	NS

NS = No Sample

TABLE 43: YEARLY AVERAGE RADIUM-226 RADIOACTIVITY (pCi/g dw) IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2009

Year	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
1996	4.6	4.5	4.3	4.1	3.9	3.6	3.6	4.0
1997	3.6	3.7	3.1	3.4	3.1	3.3	3.1	3.0
1998	3.6	4.3	4.0	3.6	4.0	3.8	3.0	3.5
1999	3.8	4.1	3.7	3.5	3.5	3.6	2.9	3.6
2000	3.4	4.4	3.5	4.0	3.7	3.6	4.0	3.5
2001	4.6	5.2	3.9	3.6	4.3	4.4	4.0	3.8
2002	4.6	4.5	4.0	3.5	3.8	4.0	3.6	4.0
2003	4.4	4.6	4.0	3.9	3.8	3.8	4.0	3.8
2004	4.8	4.8	4.1	3.8	3.8	4.0	3.9	3.7
2005	4.7	4.3	3.7	4.0	3.8	4.0	3.7	3.8
2006	4.5	4.9	3.0	3.9	3.2	4.2	3.7	NS
2007	4.4	3.6	3.4	3.7	3.4	3.9	3.6	NS

TABLE 43 (Continued): YEARLY AVERAGE RADIUM-226 RADIOACTIVITY (pCi/g dw) IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2009

Year	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
2008	4.2	3.8	4.1	3.7	3.6	4.4	3.8	NS
2009	1.4	1.9	0.9	1.3	1.0	NS	1.2	NS

NS = No Sample



TABLE 44: YEARLY AVERAGE CESIUM-137 RADIOACTIVITY (pCi/g dw) IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2009

Year	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
1996	0.2	0.3	0.4	0.4	0.4	0.6	0.4	0.3
1997	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1998	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1999	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2000	0.09	0.08	0.1	0.11	0.09	0.09	0.09	0.1
2001	0.06	0.08	0.09	0.07	0.09	0.09	0.07	0.08
2002	0.05	0.07	0.09	0.08	0.09	0.08	0.08	0.09
2003	0.07	0.07	0.09	0.09	0.08	0.07	0.08	0.08
2004	0.06	0.06	0.08	0.07	0.06	0.07	0.07	0.06
2005	0.06	0.06	0.06	0.08	0.08	0.07	0.07	0.07
2006	0.07	0.06	0.04	0.07	0.05	0.07	0.07	NS
2007	0.04	0.04	0.05	0.06	0.06	0.06	0.06	NS

TABLE 44 (Continued): YEARLY AVERAGE CESIUM-137 RADIOACTIVITY (pCi/g dw) IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2009

Year	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
2008	0.05	0.06	0.06	0.06	0.06	0.07	0.07	NS
2009	ND	ND	ND	ND	ND	NS	ND	NS

NS = No Sample  
 ND = Not Detected