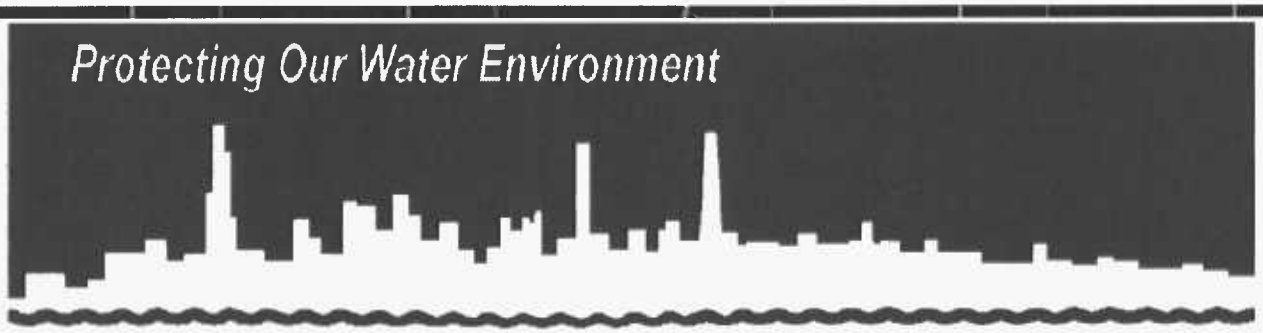

Metropolitan Water Reclamation District of Greater Chicago

MONITORING AND RESEARCH DEPARTMENT

REPORT NO. 16-35

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

2015 ANNUAL REPORT

October 2016

Metropolitan Water Reclamation District of Greater Chicago
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RADIOLOGICAL MONITORING OF THE RAW SEWAGE, FINAL EFFLUENT, SLUDGE, AND BIOSOLIDS OF THE METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO 2015 ANNUAL REPORT

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LIST OF ACRONYMS

District	Metropolitan Water Reclamation District of Greater Chicago
dw	dry weight
Egan	John E. Egan
g	gram
IEMA-DNS	Illinois Emergency Management Agency, Division of Nuclear Safety
IPCB	Illinois Pollution Control Board
Kirie	James C. Kirie
O'Brien	Terrence J. O'Brien
L	liter
pCi	picocurie
USEPA	United States Environmental Protection Agency
WRP	water reclamation plant

ACKNOWLEDGMENT

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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, 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, waste activated sludge, and final effluent at the facilities owned and operated by the District.

During the 2015 calendar year, one raw sewage, one final effluent sample (composited over a period of 24 hours), and one grab sample of sludge was collected once per month from each of the District's seven Water Reclamation Plants (WRPs) and analyzed for gross alpha and gross beta radioactivity. In 2012, the raw sewage and final effluent samples were also analyzed quarterly for radium-226, radium-228, and strontium-90 radioactivity.

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. The 2015 gross alpha and gross beta radioactivity monitoring data was compared with the historical data from the last nineteen years. The data show that there was not a major change in the radioactivity concentrations of raw sewage and final effluent samples of the WRPs over the last nineteen years.

The gross alpha and gross beta radioactivity in the final effluent is regularly 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 picocuries per liter (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 far less than the General Use Water Quality Standard, 100 pCi/L, established by the Illinois Pollution Control Board (IPCB), 35C IAC, Section 302.207. The 2012 radium-226 and radium-228 combined concentration and the strontium-90 concentration in the effluent were also less than the General Use Water Quality Standards of 3.75 pCi/L and 2.0 pCi/L, respectively. There are no IPCB standards for gross alpha radioactivity in General Use waters. The monitoring data indicate that the discharge of the final effluent from the seven WRPs is unlikely to have any adverse effect on the radiological quality of the receiving waters.

INTRODUCTION

The District is located within the boundaries of Cook County, Illinois, and serves an area of 883.5 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 approximately 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 in the combined sewer areas.

The District has monitored the quality of its raw sewage and effluents from all WRPs monthly for gross alpha and gross beta radioactivity since 1996. The District also monitored gross alpha and gross beta radioactivity of waste activated sludge or biosolids, which is the sludge after anaerobic digestion, 1996-2010 and in 2015. In 2012, the raw sewage and final effluent samples were also analyzed quarterly for radium-226, radium-228 and strontium-90 radioactivity.

This report presents the yearly gross alpha and gross beta radioactivity concentrations in raw sewage, final effluent, anaerobically digested biosolids, and sludge from the District's seven WRPs. The 2015 radiological monitoring data for gross alpha and gross beta radioactivity are compared with the historical data of the last nineteen years.

The District monitored the radioactivity in anaerobically digested sludge from the Calumet, John E. Egan (Egan), Hanover Park and Stickney WRPs, waste-activated sludge from the Lemont WRP, lagooned biosolids from the Hanover Park WRP, and biosolids samples from the District's solids drying areas from 1996 to 2010. The radiological monitoring data show that the District's biosolids are low in radioactivity, and their use on land does not appear to increase the risk of radiation exposure to the public or have a negative impact on human health and the environment.

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, Terrence J. O'Brien (O'Brien {formerly North Side}), James C. Kirie (Kirie), Hanover Park, Calumet, and Lemont WRPs. The samples were preserved with hydrochloric acid.

Sludge. One waste activated sludge grab sample was collected once a month from the Stickney, Egan, O'Brien, Kirie, Hanover Park, and Calumet WRPs. One undigested sludge grab sample was collected once a month from the O'Brien, Kirie, and Lemont WRPs. The samples were preserved by storing them in a 4-8°C refrigerator.

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.

Sample Analysis

The raw sewage, anaerobically digested biosolids, and final effluent samples were analyzed by the District's radiochemistry laboratory from the inception of the program through 2007. The samples collected in 2008, 2011-2013, and 2015 were analyzed by the Environmental Inc., Midwest Laboratory and samples collected in 2009 and 2010 were analyzed by Eberline Analytical Corporation.

RESULTS AND DISCUSSION

Stickney Water Reclamation Plant

In 2015, the average gross alpha radioactivity of the Stickney WRP ranged from 2.2 to 14.2 pCi/L, with values below the detection limit for the following months: January, <2.6 pCi/L; March, <3.9 pCi/L; May, <2.1 pCi/L; and September, <1.9 pCi/L (Table 1). Two thirds of the total gross alpha radioactivity values were below detection; these detection limits ranged from 1.5 to 3.9 pCi/L. The gross alpha activity in the Stickney effluent was below the detection limit for all samples (1.4 to 4.5 pCi/L) except for March, where it measured 33.8 pCi/L (Table 1).

The yearly average gross alpha radioactivity in the Stickney WRP raw sewage and final effluent from 1996 through 2015 are summarized in Table 2. Also summarized in Table 2 are the gross alpha radioactivity in the Stickney WRP anaerobically digested biosolids (1996-2010) and waste activated sludge (2015). The gross alpha radioactivity in raw sewage had values ranging from <3.6 to 8.6 pCi/L. The gross alpha radioactivity in the effluent was below the detection limit (1.8 to 5.2 pCi/L) for all years sampled except 2015, which had an average of 4.8 pCi/L. The gross alpha radioactivity in anaerobically digested biosolids ranged from 5.2 to 12.4 picocuries per gram (pCi/g) dry weight (dw). The 2015 average gross alpha radioactivity of the waste activated sludge was 11.5 pCI/g dw.

The gross beta radioactivity in the raw sewage of the Stickney WRP ranged from 5.3 to 19.4 pCi/L, and in the effluent it ranged from 2.6 to 8.4 pCi/L (Table 3).

The yearly average gross beta radioactivity in the Stickney WRP raw sewage and final effluent from 1996 through 2015 are summarized in Table 4. Also summarized in Table 4 are the gross beta radioactivity in the Stickney WRP anaerobically digested biosolids (1996-2010) and waste activated sludge (2015). The gross beta radioactivity in the raw sewage ranged from 8.5 to 29.3 pCi/L, and in the effluent gross beta radioactivity ranged from 4.1 to 11.4 pCi/L. The gross beta radioactivity in anaerobically digested biosolids ranged from 20.5 to 27.3 pCi/g dw. The 2015 average gross beta radioactivity of the waste activated sludge was 24.5 pCi/g dw.

Calumet Water Reclamation Plant

In 2015, gross alpha radioactivity in the raw sewage of the Calumet WRP was below the detection limit (1.5 to 2.9 pCi/L) in nine of the monthly samples, and the detected values ranged from 2.1 to 4.4 pCi/L in the remaining periods (Table 5). The gross alpha radioactivity in the effluent was below the detection limit (1.4 to 2.6 pCi/L) for all the values (Table 5).

The yearly average gross alpha radioactivity in the Calumet WRP raw sewage and final effluent from 1996 through 2015 are summarized in Table 6. Also summarized in Table 6 are the gross alpha radioactivity in the Calumet WRP anaerobically digested biosolids (1996-2010) and waste activated sludge (2015). The gross alpha radioactivity in the raw sewage was below the detection limit (3.5 to 5.5 pCi/L) for all years sampled, except for the last three consecutive years and 2015. The detected values for 2011-2013 and 2015 were 4.2, 2.6, 2.2, and 2.4 pCi/L,

TABLE 1: GROSS ALPHA RADIOACTIVITY IN STICKNEY WATER RECLAMATION PLANT RAW SEWAGE AND FINAL EFFLUENT ON A MONTHLY BASIS – 2015

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)
January	<2.6	<3.4
February	4.2	<4.5
March	<3.9	33.8
April	4.4	<2.1
May	<2.1	<1.7
June	7.5	<2.3
July	14.2	<1.7
August	2.7	<1.2
September	<1.9	<1.7
October	2.7	<1.7
November	2.2	<1.6
December	11.8	<1.4

< = 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 2015

Year[1]	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids[2] 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
2010	5.5	<3.2	7.0
2011	7.6	<2.3	-
2012	<4.2	<1.8	-
2013	6.5	<1.9	-
2015	5.0	4.8	11.5

[1]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.

[2]Gross alpha radioactivity analysis in biosolids was terminated in 2011. Waste activated sludge was analyzed during 2015.

< = 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 AND FINAL EFFLUENT ON A MONTHLY BASIS – 2015

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)
January	7.0	5.5
February	11.2	7.3
March	11.2	8.4
April	10.7	5.3
May	7.6	4.0
June	14.0	4.7
July	19.4	2.6
August	5.8	3.4
September	6.8	4.6
October	7.6	5.0
November	5.3	3.1
December	16.7	2.7

TABLE 4: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN STICKNEY WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2015

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids[1] 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
2010	13.5	8.0	20.5
2011	12.4	5.8	-
2012	8.5	4.1	-
2013	12.2	4.1	-
2015	10.2	4.7	24.5

[1]Gross beta radioactivity analysis in biosolids was terminated in 2011. Waste activated sludge was analyzed in 2015.

TABLE 5: GROSS ALPHA RADIOACTIVITY IN CALUMET WATER RECLAMATION PLANT RAW SEWAGE AND FINAL EFFLUENT ON A MONTHLY BASIS – 2015

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)
January	<2.6	<2.6
February	<2.9	<2.1
March	<2.0	<1.9
April	<1.9	<2.4
May	<2.5	<2.1
June	<2.0	<1.8
July	4.4	<2.1
August	2.1	<1.6
September	<1.6	<1.9
October	3.3	<1.7
November	<1.8	<1.4
December	<1.5	<1.4

< = 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 2015

Year[1]	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids[2] 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
2010	<4.2	<3.2	11.0
2011	4.2	<2.3	-
2012	2.6	<2.0	-
2013	2.2	1.9	-
2015	2.4	1.9	25.6

[1]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.

[2]Gross alpha radioactivity analysis in biosolids was terminated in 2011. Waste activated sludge was analyzed during 2015.

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

respectively. The gross alpha radioactivity in the effluent was also below the detection limit (2.0 to 5.1 pCi/L), except for years 2013 and 2015, both of which had a value of 1.9 pCi/L. The gross alpha radioactivity in anaerobically digested biosolids ranged from 5.1 to 17.6 pCI/g dw, and the 2015 waste activated sludge average was 25.6 pCi/g dw.

The gross beta radioactivity in the raw sewage of the Calumet WRP ranged from 2.7 to 7.4 pCi/L, and in the effluent gross beta radioactivity ranged from 2.4 to 4.6 pCi/L (Table 7).

The yearly average gross beta radioactivity in the Calumet WRP raw sewage and final effluent from 1996 through 2015 are summarized in Table 8. Also summarized in Table 8 are the gross beta radioactivity in the Calumet WRP anaerobically digested biosolids (1996-2010) and waste activated sludge (2015). The gross beta radioactivity in the raw sewage ranged from 4.8 to 24.9 pCi/L, and in the effluent it ranged from 3.5 to 14.1 pCi/L. The gross beta radioactivity in anaerobically digested biosolids ranged from 21.0 to 30.6 pCi/g dw, and the 2015 waste activated sludge average was 35.5 pCi/g dw.

Terrence J. O'Brien Water Reclamation Plant

In 2015, the gross alpha radioactivity in the raw sewage of the O'Brien WRP was mostly below the detection limit (1.5 to 4.7 pCi/L), with the exception of March and August, which had values of 15.0 and 1.6 pCi/L, respectively (Table 9). The gross alpha radioactivity in the effluent was below the detection limits (1.4 to 4.5 pCi/L) for all months but December, which was 1.8 pCi/L (Table 9).

The yearly average gross alpha radioactivity in the O'Brien WRP raw sewage, final effluent, and undigested sludge from 1996 through 2015 are summarized in Table 10. The gross alpha radioactivity in the raw sewage was below the detection limit (1.9 to 5.0 pCi/L) for all years sampled except 2013 and 2015, which had 1.9 and 3.3 pCi/L, respectively. The gross alpha radioactivity in the effluent was also below the detection limit (1.7 to 4.9 pCi/L) every year except 2013 and 2015, which were 1.9 and 2.0 pCi/L, respectively. The gross alpha radioactivity in undigested sludge ranged from 2.6 to 7.8 pCi/g dw.

The gross beta radioactivity in the raw sewage of the O'Brien WRP ranged from 3.8 to 6.3 pCi/L, and in the effluent it ranged from 3.4 to 5.4 pCi/L (Table 11).

The yearly average gross beta radioactivity in the O'Brien WRP raw sewage, final effluent, and undigested sludge from 1996 through 2015 are summarized in Table 12. The gross beta radioactivity in the raw sewage ranged from 3.9 to 20.4 pCi/L, and in the effluent it ranged from 3.4 to 10.9 pCi/L. The gross beta radioactivity in undigested sludge ranged from 12.8 to 16.2 pCi/g dw.

John E. Egan Water Reclamation Plant

In 2015, the gross alpha radioactivity in the raw sewage of the Egan WRP was below the detection limits (1.5 to 1.9 pCi/L) for most samples. Detected values ranged from 1.5 to 3.1 pCi/L (Table 13). The gross alpha radioactivity in the effluent was always below the detection limits (1.4 to 2.3 pCi/L).

TABLE 7: GROSS BETA RADIOACTIVITY IN CALUMET WATER RECLAMATION PLANT RAW SEWAGE AND FINAL EFFLUENT ON A MONTHLY BASIS – 2015

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)
January	4.8	2.6
February	7.2	3.5
March	4.7	2.8
April	4.0	3.7
May	5.7	4.5
June	2.7	3.3
July	2.7	4.2
August	7.4	3.2
September	4.7	4.5
October	6.9	4.6
November	3.8	2.9
December	4.4	2.4

TABLE 8: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN CALUMET WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2015

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids[1] 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
2010	9.3	7.7	22.6
2011	7.2	4.0	-
2012	6.1	4.5	-
2013	4.8	4.0	-
2015	4.9	3.5	35.5

[1]Gross beta radioactivity analysis in biosolids was terminated in 2011. Waste activated sludge was analyzed during 2015.

TABLE 9: GROSS ALPHA RADIOACTIVITY IN TERRENCE J. O'BRIEN WATER RECLAMATION PLANT RAW SEWAGE AND FINAL EFFLUENT ON A MONTHLY BASIS – 2015

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)
January	<4.2	<4.5
February	<4.7	<2.9
March	15.0	<1.6
April	<2.0	<1.8
May	<2.1	<1.8
June	<2.1	<2.1
July	<1.8	<1.4
August	1.6	<1.6
September	<1.6	<1.4
October	<1.6	<1.7
November	<1.5	<1.6
December	<1.9	1.8

< = 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 TERRENCE J. O'BRIEN WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND UNDIGESTED SLUDGE FROM 1996 THROUGH 2015

Year[1]	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Sludge[2,3] 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
2010	<2.8	<2.9	6.6
2011	<2.9	<2.1	-
2012	<1.9	<1.7	-
2013	1.9	1.9	-
2015	3.3	2.0	7.4

[1]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.
[2]Gross Alpha radioactivity analysis in sludge was terminated in 2011 and reactivated during 2015.
[3]Undigested sludge, which is digested at Stickney Water Reclamation Plant.
< = 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 TERRENCE J. O'BRIEN WATER RECLAMATION PLANT RAW SEWAGE AND FINAL EFFLUENT ON A MONTHLY BASIS – 2015

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)
January	6.2	5.4
February	5.8	3.5
March	6.3	3.7
April	4.3	3.4
May	3.8	3.9
June	5.2	4.2
July	3.9	5.2
August	5.6	4.7
September	4.3	4.6
October	5.3	3.4
November	5.0	4.0
December	5.4	3.7

TABLE 12: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN TERRENCE J. O'BRIEN WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND UNDIGESTED SLUDGE FROM 1996 THROUGH 2015

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Sludge[1,2] 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
2010	7.9	8.8	13.7
2011	5.1	4.2	-
2012	4.0	3.5	-
2013	3.9	3.4	-
2015	5.1	4.1	13.8

[1]Gross beta radioactivity analysis in sludge was terminated in 2011 and reactivated during 2015.
[2]Undigested sludge, which is digested at Stickney Water Reclamation Plant.
< = 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 AND FINAL EFFLUENT ON A MONTHLY BASIS – 2015

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)
January	<1.5	<1.9
February	<1.9	<2.3
March	<1.7	<1.7
April	3.1	<1.9
May	<1.8	<1.7
June	<1.8	<2.0
July	<1.9	<1.6
August	1.5	<1.4
September	<1.8	<1.9
October	1.7	<1.7
November	<1.8	<1.7
December	2.6	<1.5

< = 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 and final effluent from 1996 through 2015 are summarized in Table 14. Also summarized in Table 14 are the gross alpha radioactivity in the Egan WRP anaerobically digested biosolids (1996-2010) and waste activated sludge (2015). The gross alpha radioactivity in the raw sewage was below the detection limit (2.0 to 5.4 pCi/L) for all years sampled except 2013 and 2015, which were 2.4 and 1.9 pCi/L, respectively. The gross alpha radioactivity in the effluent was below the detection limit (1.8 to 5.2 pCi/L). The gross alpha radioactivity in anaerobically digested biosolids ranged from 4.4 to 13.8 pCi/g dw, and the 2015 average gross alpha radioactivity of the waste activated sludge was 10.8 pCi/g dw.

The 2015 gross beta radioactivity levels in the raw sewage of the Egan WRP ranged from 4.2 to 8.1 pCi/L, and the effluent ranged from 3.1 to 9.3 pCi/L (Table 15).

The yearly average gross beta radioactivity in the Egan WRP raw sewage and final effluent from 1996 through 2015 are summarized in Table 16. Also summarized in Table 16 are the gross beta radioactivity in the Egan WRP anaerobically digested biosolids (1996-2010) and waste activated sludge (2015). The gross beta radioactivity in the raw sewage ranged from 5.9 to 22.5 pCi/L, and in the effluent it ranged from 4.3 to 12.7 pCi/L. The gross beta radioactivity in anaerobically digested biosolids ranged from 15.1 to 21.7 pCi/g dw, and the 2015 average gross beta radioactivity of the waste activated sludge was 19.5 pCi/g dw.

Hanover Park Water Reclamation Plant

In 2015, the gross alpha radioactivity levels in the raw sewage of the Hanover Park WRP were below the detection limit (1.6 to 2.4 pCi/L); with the exception of April and September, which had 1.8 and 2.3 pCi/L (Table 17), respectively. All gross alpha radioactivity in the effluent was below the detection limits (1.3 to 2.1 pCi/L) (Table 17).

The yearly average gross alpha radioactivity in the Hanover Park WRP raw sewage and final effluent from 1996 through 2015 are summarized in Table 18. Also summarized in Table 18 are the gross alpha radioactivity in the Hanover Park WRP anaerobically digested biosolids (1996-2010) and waste activated sludge (2015). The gross alpha radioactivity in the raw sewage was below the detection limit (1.9 to 5.0 pCi/L) for all years sampled except 2013 and 2015, which had values of 1.8 and 1.9 pCi/L, respectively. The gross alpha radioactivity in the effluent was also below the detection limit (1.7 to 5.0 pCi/L) for all years analyzed except 2013, which also had a value of 1.8 pCi/L. The gross alpha radioactivity in anaerobically digested biosolids ranged from 3.2 to 10.2 pCi/g dw, and the 2015 average gross alpha radioactivity in waste activated sludge was 8.1 pCi/g dw.

The gross beta radioactivity levels in the raw sewage of the Hanover Park WRP ranged from 3.2 to 8.7 pCi/L and in the effluent it ranged from 3.4 to 9.8 pCi/L (Table 19).

The yearly average gross beta radioactivity in the Hanover Park WRP raw sewage and final effluent from 1996 through 2015 are summarized in Table 20. Also summarized in Table 20 are the gross beta radioactivity in the Hanover Park WRP anaerobically digested biosolids (1996-2010) and waste activated sludge (2015). The gross beta radioactivity in the raw sewage ranged

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 2015

Year[1]	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids[2] 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
2010	<4.1	<3.7	7.7
2011	<2.5	<2.3	-
2012	<2.0	<1.8	-
2013	2.4	<1.9	-
2015	1.9	<1.8	10.8

[1]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.

[2]Gross alpha radioactivity analysis in biosolids was terminated in 2011. Waste activated sludge was analyzed in 2015.

< = 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 AND FINAL EFFLUENT ON A MONTHLY BASIS – 2015

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)
January	4.2	3.1
February	6.2	4.7
March	6.1	5.5
April	8.1	5.3
May	4.6	3.9
June	4.6	4.1
July	5.0	3.8
August	6.0	3.3
September	6.4	9.3
October	7.4	5.0
November	8.0	3.9
December	4.6	3.8

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 2015

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids[1] 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
2010	11.4	11.0	15.1
2011	6.2	5.0	-
2012	6.2	4.9	-
2013	6.0	4.3	-
2015	5.9	4.6	19.5

[1]Gross beta radioactivity analysis in biosolids was terminated in 2011. Waste activated sludge was analyzed during 2015.

TABLE 17: GROSS ALPHA RADIOACTIVITY IN HANOVER PARK WATER RECLAMATION PLANT RAW SEWAGE AND FINAL EFFLUENT ON A MONTHLY BASIS – 2015

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)
January	<2.4	<1.8
February	<1.7	<2.1
March	<1.8	<1.8
April	1.8	<1.8
May	<2.0	<1.7
June	<2.0	<1.7
July	<1.6	<1.8
August	<1.6	<1.7
September	2.3	<1.6
October	<1.6	<1.3
November	<1.9	<1.4
December	<1.6	<1.4

< = 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 2015

Year[1]	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids[2] 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
2010	<3.2	<2.7	6.3
2011	<2.7	<2.1	-
2012	<1.9	<1.8	-
2013	1.8	1.8	-
2015	1.9	<1.7	8.1

[1]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.
[2]Gross alpha radioactivity analysis in biosolids was terminated in 2011. Waste activated sludge was analyzed during 2015.
< = 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 AND FINAL EFFLUENT ON A MONTHLY BASIS – 2015

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)
January	8.0	6.1
February	4.9	5.5
March	6.4	6.8
April	5.3	4.8
May	4.8	4.6
June	6.1	5.0
July	5.9	3.9
August	7.7	9.3
September	8.7	9.8
October	6.4	6.4
November	5.4	4.8
December	3.2	3.4

TABLE 20: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN HANOVER PARK WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2015

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids[1] Gross Beta (pCi/g dw)
1996	19.7	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
2010	9.7	9.1	11.2
2011	5.8	5.8	-
2012	6.1	5.3	-
2013	6.3	5.1	-
2015	6.1	5.9	14.1

[1]Gross beta radioactivity analysis in biosolids was terminated in 2011. Waste activated sludge was analyzed in 2015.

from 5.8 to 20.3 pCi/L, and in the effluent it ranged from 5.1 to 11.7 pCi/L. The gross beta radioactivity in anaerobically digested biosolids ranged from 11.2 to 15.5 pCi/g dw, and the 2015 average gross beta radioactivity in waste activated sludge was 14.1 pCi/g dw.

James C. Kirie Water Reclamation Plant

In 2015, most of the gross alpha radioactivity levels in the raw sewage of the Kirie WRP were below the detection limit (1.7 to 2.5 pCi/L). March, April, and August had values above the detection limit. These values were 17.9, 2.9 and 1.3 pCi/L, respectively (Table 21). The gross alpha radioactivity in the effluent was below the detection limit (1.6 to 2.4 pCi/L) for all samples analyzed in 2015 (Table 21).

The yearly average gross alpha radioactivity in the Kirie WRP raw sewage, final effluent, and undigested sludge from 1996 through 2015 are summarized in Table 22. The gross alpha radioactivity in the raw sewage was below the detection limit (1.9 to 5.6 pCi/L) for all years sampled except 2013 and 2015, which had average values of 2.6 and 3.5 pCi/L, respectively. The gross alpha radioactivity in the effluent was below the detection limit (2.0 to 5.6 pCi/L) for all years analyzed except 2013, which had a value of 1.9 pCi/L. The gross alpha radioactivity in undigested 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 4.4 pCi/L to 10.7 pCi/L, and in the effluent it ranged from 2.6 to 7.4 pCi/L (Table 23).

The yearly average gross beta radioactivity in the Kirie WRP raw sewage, final effluent, and undigested sludge from 1996 through 2015 are summarized in Table 24. The gross beta radioactivity in the raw sewage ranged from 5.7 to 22.7 pCi/L, and in the effluent it ranged from 4.5 to 16.8 pCi/L. The gross beta radioactivity in undigested sludge ranged from 13.3 to 17.7 pCi/g dw.

Lemont Water Reclamation Plant

In 2015, the gross alpha radioactivity levels in the raw sewage of the Lemont WRP ranged from 7.7 to 37.6 pCi/L (Table 25). The gross alpha radioactivity in the effluent ranged from 4.6 to 12.7 pCi/L (Table 25), with January being the only value which was lower than the detection limit, 2.3 pCi/L.

The yearly average gross alpha radioactivity in the Lemont WRP raw sewage, final effluent, and undigested sludge from 1996 through 2015 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) for all years sampled except 2008, 2009, 2010, 2012, 2013, and 2015, which had 6.7, 8.9, 6.7, 6.5, 7.9, and 7.2 pCi/L, respectively. The gross alpha radioactivity in the undigested 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 7.9 to 30.2 pCi/L, and in the effluent it ranged from 8.0 to 20.9 pCi/L (Table 27).

TABLE 21: GROSS ALPHA RADIOACTIVITY IN JAMES C. KIRIE WATER RECLAMATION PLANT RAW SEWAGE AND FINAL EFFLUENT ON A MONTHLY BASIS – 2015

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)
January	<2.3	<2.4
February	<2.5	<2.1
March	17.9	<2.2
April	2.9	<2.2
May	<2.1	<2.2
June	<2.4	<2.4
July	<2.1	<1.8
August	1.3	<1.7
September	<2.1	<1.9
October	<1.7	<2.0
November	<2.0	<1.6
December	<2.2	<1.7

< = 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 UNDIGESTED SLUDGE FROM 1996 THROUGH 2015

Year[1]	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Sludge[2,3] 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
2010	<3.4	<4.2	7.5
2011	<3.1	<2.4	-
2012	<1.9	<2.4	-
2013	2.6	1.9	-
2015	3.5	<2.0	7.5

[1]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.
[2]Gross alpha radioactivity analysis in sludge was terminated in 2011 and reactivated during 2015.
[3]Undigested sludge, which is digested at the John E. Egan Water Reclamation Plant.
< = 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 AND FINAL EFFLUENT ON A MONTHLY BASIS – 2015

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)
January	6.3	5.8
February	7.3	7.3
March	10.7	6.8
April	7.7	4.8
May	6.0	4.8
June	6.4	4.6
July	6.4	4.2
August	4.4	7.4
September	6.7	6.1
October	6.0	6.7
November	7.0	3.6
December	5.7	2.6

TABLE 24: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN JAMES C. KIRIE WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND UNDIGESTED SLUDGE FROM 1996 THROUGH 2015

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Sludge[1,2] 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
2010	10.5	9.3	14.1
2011	6.6	5.6	-
2012	5.7	5.7	-
2013	5.7	4.5	-
2015	6.7	5.4	13.9

[1]Gross beta radioactivity analysis in sludge was terminated in 2011 and reactivated during 2015.
[2]Undigested sludge, which is digested at John E. Egan Water Reclamation Plant.

TABLE 25: GROSS ALPHA RADIOACTIVITY IN LEMONT WATER RECLAMATION PLANT RAW SEWAGE AND FINAL EFFLUENT ON A MONTHLY BASIS – 2015

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)
January	20.8	<2.3
February	37.6	12.7
March	15.8	8.3
April	12.8	4.6
May	14.6	4.9
June	6.8	6.9
July	26.9	5.8
August	22.2	5.8
September	26.2	10.0
October	16.1	8.4
November	12.1	11.0
December	7.7	6.1

TABLE 26: YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN LEMONT WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND UNDIGESTED SLUDGE FROM 1996 THROUGH 2015

Year[1]	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Sludge[2,3] 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
2010	21.0	6.7	71.0
2011	13.9	<6.0	-
2012	14.7	6.5	-
2013	16.8	7.9	-
2015	18.3	7.2	115.3

[1]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.
[2]Gross alpha radioactivity analysis in sludge was terminated in 2011 and reactivated during 2015.
[3]Undigested sludge, which is digested at Stickney Water Reclamation Plant.
< = 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 AND FINAL EFFLUENT ON A MONTHLY BASIS – 2015

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)
January	17.8	8.8
February	29.2	20.9
March	24.9	17.9
April	13.4	11.6
May	16.8	10.6
June	7.9	8.2
July	7.9	12.0
August	26.7	13.3
September	30.2	19.9
October	17.3	19.2
November	18.3	10.3
December	9.7	8.0

The yearly average gross beta radioactivity in the Lemont WRP raw sewage, final effluent, and sludge from 1996 through 2015 are summarized in Table 28. The gross beta radioactivity in the raw sewage ranged from 16.9 to 66.0 pCi/L, and in the effluent it ranged from 13.4 to 24.9 pCi/L. The gross beta radioactivity in undigested sludge ranged from 44.5 to 121.9 pCi/g dw.

Radium-226, Radium-228, and Strontium-90 Radioactivity in the Raw Sewage and Final Effluent of the Water Reclamation Plants in 2012

In 2012, four raw sewage and four effluent samples from each of the District's seven WRPs were analyzed for the concentration of radium-226, radium-228, and strontium-90 radioactivity. Tables 29 and 30 show the average concentration of these radionuclides in the four raw sewage and final effluent samples, respectively, from the WRPs for 2012. The average radium-226 radioactivity concentration in the raw sewage ranged from less than 0.4 pCi/L at the Kirie, Stickney (Westside), and O'Brien WRPs to 7.6 pCi/L at the Lemont WRP. The average radium-228 radioactivity concentration in the raw sewage of the WRPs was below the detection limit (1.7 to 2.0 pCi/L) except for the Egan WRP (2.0 pCi/L) and Lemont WRP (5.4 pCi/L). The average strontium-90 radioactivity concentration in the raw sewage at all the WRPs was below the detection limit (0.9 to 1.1 pCi/L). The average radium-226 radioactivity concentration in final effluent was below the detection limit (0.4 to 0.8 pCi/L) except for Lemont WRP (3.4 pCi/L). The average radium-228 concentration in final effluent was below the detection limit (1.6 to 2.0 pCi/L) except for Lemont WRP (4.4 pCi/L). The average strontium-90 radioactivity concentration in final effluent at all the WRPs was below the detection limit (1.0 to 1.4 pCi/L).

TABLE 28: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN LEMONT WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND UNDIGESTED SLUDGE FROM 1996 THROUGH 2015

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Sludge[1,2] 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
2010	24.4	18.9	44.5
2011	17.2	13.4	-
2012	16.9	14.2	-
2013	19.6	14.6	-
2015	18.3	13.4	90.3

[1]Gross beta radioactivity analysis in sludge was terminated in 2011 and reactivated during 2015.
[2]Undigested sludge, which is digested at Stickney Water Reclamation Plant.

TABLE 29: CONCENTRATION OF RADIUM-226, RADIUM-228, AND STRONTIUM-90
IN RAW SEWAGE OF THE WATER RECLAMATION PLANTS – 2012

Sample Location WRP	No. of Samples	Radium-226 (pCi/L)			Radium-228 (pCi/L)			Strontium-90 (pCi/L)		
		Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
Calumet	4	0.5	<0.3	0.9	<1.8	<1.6	<2.1	<1.0	<0.9	<1.1
Egan	4	<0.6	<0.2	<1.0	2.0	<1.7	2.6	<1.0	<0.9	<1.1
Hanover Park	4	0.4	<0.2	0.8	<1.7	<1.6	<1.7	<1.0	<0.9	<1.1
Kirie	4	<0.4	<0.2	<0.8	<2.0	<1.9	<2.2	<1.1	<0.9	<1.3
Lemont	4	7.6	5.3	9.5	5.4	3.7	7.3	<0.9	<0.8	<0.9
O'Brien	4	<0.4	<0.2	<0.7	<1.9	<1.6	<2.6	<1.0	<0.8	<1.2
Stickney (Southwest)	4	1.3	0.3	3.6	<2.0	1.7	2.2	<1.1	<1.0	<1.4
Stickney (Westside)	4	<0.4	<0.2	0.9	<1.8	<1.5	<2.1	<1.1	<0.9	<1.5

TABLE 30: CONCENTRATION OF RADIUM-226, RADIUM-228, AND STRONTIUM-90 IN FINAL EFFLUENT OF THE WATER RECLAMATION PLANTS – 2012

Sample Location WRP	No. of Samples	Radium-226 (pCi/L)			Radium-228 (pCi/L)			Strontium-90 (pCi/L)		
		Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
Calumet	4	<0.4	<0.2	<0.8	<1.6	<1.4	<1.9	<1.0	<0.8	<1.3
Egan	4	<0.4	<0.2	<0.6	<1.9	<1.5	<2.0	<1.0	<0.9	<1.1
Hanover Park	4	<0.4	<0.1	<0.9	<1.8	<1.5	<2.0	<1.0	<0.9	<1.1
Kirie	4	<0.4	<0.2	<0.6	<2.0	<1.6	<2.3	<1.4	<1.0	<2.2
Lemont	4	3.4	2.6	4.1	4.4	2.2	7.5	<1.1	<0.9	<1.3
O'Brien	4	<0.5	<0.2	<1.1	<1.9	<1.6	<2.1	<1.1	<0.8	<1.5
Stickney	4	<0.8	<0.2	<1.9	<1.9	<1.4	3.2	<1.0	<0.9	<1.2