TETRA TECH

October 22, 2015

Mr. James Johnson
On-Scene Coordinator
U.S. Environmental Protection Agency, Region 7
11201 Renner Boulevard
Lenexa, Kansas 66219

Subject: **Final Data Summary of Radiological Parameters Analyzed During Baseline Off-Site Air Monitoring**
West Lake Landfill Site, Bridgeton, Missouri
CERCLIS ID: MOD079900932
EPA Region 7, START 4, Contract No. EP-S7-13-06, Task Order No. 0058
Task Monitor: James Johnson, On-Scene Coordinator

Dear Mr. Johnson:

Tetra Tech, Inc. is submitting the attached Final Data Summary Report regarding radiological parameters assessed during the April 2014 to July 2015 air monitoring at locations off site of the West Lake Landfill site (WLLS) in Bridgeton, Missouri. This monitoring occurred during a baseline period prior to start of construction of an isolation barrier at WLLS. If you have any questions or comments, please contact me at (816) 412-1775.

Sincerely,

Robert Monnig, PE
START Project Manager

for Ted Faile, PG, CHMM
START Program Manager

Enclosures

cc: Debra Dorsey, START Project Officer (cover letter only)

X9025.14.0058.000

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FINAL DATA SUMMARY OF BASELINE OFF-SITE AIR MONITORING RADIOLOGICAL PARAMETERS

WEST LAKE LANDFILL SITE
BRIDGETON, MISSOURI
CERCLIS ID: MOD079900932

Superfund Technical Assessment and Response Team (START) 4
Contract No. EP-S7-13-06, Task Order No. 0058

Prepared For:

U.S. Environmental Protection Agency
Region 7
Superfund Division
11201 Renner Blvd.
Lenexa, Kansas 66219

October 22, 2015

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EXECUTIVE SUMMARY

The Tetra Tech, Inc. (Tetra Tech) Superfund Technical Assessment and Response Team (START) assisted the U.S. Environmental Protection Agency (EPA) with baseline monitoring at off-site locations around the West Lake Landfill site (WLLS) in Bridgeton, Missouri, during a pre-construction, baseline period prior to initiation of construction of a planned isolation barrier at WLLS. This air monitoring will provide data for use to (1) evaluate pre-construction concentrations of chemical and radiological parameters of potential concern in outdoor air, and (2) optimize the sampling and monitoring plan for off-site air monitoring to occur during construction of the isolation barrier. During barrier construction, air monitoring will occur to address concerns that construction operations at WLLS could impact human health and the environment via release to ambient air of solid waste landfill gases of concern or of particulates with radiologically-impacted materials (RIM). This report summarizes data sets of radiological parameters acquired from the start of monitoring in April 2014 to its conclusion in July 2015 and supersedes the previous interim reports for radiological parameters dated January 19, 2015 and March 16, 2015.

West Lake Landfill is an approximately 200-acre property that includes several closed solid waste landfill units that accepted wastes for landfilling from the 1940s or 1950s through 2004, plus a solid waste transfer station, a concrete plant, and an asphalt batch plant. The WLLS is at 13570 St. Charles Rock Road in Bridgeton, St. Louis County, Missouri, approximately 1 mile north of the intersection of Interstate 70 and Interstate 270. The WLLS was used for limestone quarrying and crushing operations from 1939 through 1988. Beginning in the late 1940s or early 1950s, portions of the quarried areas and adjacent areas were used for landfilling municipal refuse, industrial solid wastes, and construction/demolition debris. In 1973, approximately 8,700 tons of leached barium sulfate residues (a remnant from the Manhattan Engineer District/Atomic Energy Commission project) were reportedly mixed with approximately 39,000 tons of soil from the 9200 Latty Avenue site in Hazelwood, Missouri, transported to the WLLS, and used as daily or intermediate cover material. In December 2004, the Bridgeton Sanitary Landfill—the last landfill unit at WLLS to receive solid waste—stopped receiving waste pursuant to an agreement with the City of St. Louis to reduce potential for birds to interfere with Lambert Field International Airport operations. In December 2010, Bridgeton Landfill detected changes—elevated temperatures and elevated carbon monoxide levels—in its landfill gas extraction system in use at the South Quarry of the Bridgeton Sanitary Landfill portion of the WLLS (a landfill portion not associated with known RIM). Further investigation indicated that the South Quarry Pit landfill was undergoing an exothermic subsurface smoldering event (SSE). In 2013, potentially responsible parties committed to constructing an isolation barrier that would separate the landfill portion undergoing the SSE from the RIM-containing area (EPA 2014).

EPA and START began setup of five off-site monitoring stations in April 2014 with monitoring and sampling devices (including particulate air samplers, RAE Systems AreaRAEs, Saphymo GammaTRACERs, electret ion chamber radon detectors, and optically stimulated luminescent dosimeters) and a wireless remote monitoring network. The baseline period off-site air monitoring and sampling occurred at the following monitoring stations according to the approved quality assurance project plan (QAPP) (Tetra Tech 2014a):

Station 1 – Robertson Fire Protection District Station 2, 3820 Taussig Rd., Bridgeton, Missouri

Station 2 – Pattonville Fire Department District, 13900 St Charles Rock Rd., Bridgeton, Missouri

Station 3 – Pattonville Fire Department District Station 2, 3365 McKelvey Rd., Bridgeton, Missouri

Station 4 – Spanish Village Park, 12827 Spanish Village Dr., Bridgeton, Missouri

Station 5 – St. Charles Fire Department Station #2, 1550 S. Main St., St. Charles, Missouri.

The Station 1 through 4 locations were selected primarily for their proximate positions around WLLS (these stations are approximately 0.3 to 1 mile from WLLS, in various directions from WLLS). Station 5, designated as a reference (or background) station, is farther away from WLLS than the other stations, but still within the general vicinity so as to be representative of the North St. Louis County and eastern St. Charles County area.

The radiation air monitoring measured three forms of ionizing radiation (alpha, beta and gamma) by specific exposure pathways (dust/particulate, radon, and ambient gamma exposure). The monitoring included weekly laboratory analysis of particulate filters, weekly radon monitoring with electrets, approximately monthly deployments of environmental dosimeters for gamma exposure, and continuous gamma exposure rate monitoring. In March 2015, baseline monitoring ended at Stations 1, 2, 3, and 5. Baseline monitoring at Station 4 ended in July 2015. This report summarizes the radiation air monitoring and sampling results for the entire baseline period—starting in April 2014 and ending in July 2015. Overall, the radiation air monitoring and sampling results appear typical of an outdoor environment. The following are specific observations regarding the radiological parameters being measured at the five air monitoring stations off site of WLLS:

Radionuclides on Airborne Particulates

Airborne particulates were collected onto glass fiber filter media by use of high-volume air samplers. The air filters were submitted for laboratory analyses for gross alpha, gross beta, gamma-emitting radionuclides, isotopic uranium, isotopic thorium, and total alpha-emitting radium. The air filter results evaluated in this report are gross alpha/beta, uranium-238 (^{238}U), ^{230}Th, and total alpha-emitting radium (including ^{226}Ra). The medians and distributions of these parameters appear to be similar among the five monitoring stations. Two statistics tests—the Kruskal-Wallis and Friedman tests—were used to test for differences in concentrations of gross alpha/beta, ^{238}U, ^{230}Th, and total alpha-emitting radium (including ^{226}Ra) among the five monitoring stations. The Kruskal-Wallis test did not identify significant differences in the mean/median characteristics among the five monitoring stations for the data examined, and the Friedman test found no indication that one station had yielded larger or smaller measurements than any other station.

Radon

Radon (^{222}Rn) has been identified as a radiological parameter of interest because it is a decay product of ^{226}Ra, a radionuclide of concern at the WLLS. Radon is also generated by decay of ^{226}Ra naturally occurring in soil and rock, and a significant portion of this radon is naturally released from the ground into the atmosphere because, as a noble gas, radon becomes unbound to soil and rock. Average weekly ^{222}Rn concentrations were measured at the five off-monitoring stations by use of electret ion chamber radon detectors (Rad Elec E-PERM®). Examination of the ^{222}Rn box plots appears to show similar median ^{222}Rn concentrations among the five monitoring stations (although results from statistical tests used to evaluate the data suggest that ^{222}Rn measurements at Stations 2 and 4 tend to be smaller than those at the other stations).

Exposure Rate Measurements

Hourly exposure rate measurements were obtained by use of Saphymo GammaTRACERs exposure rate monitors installed at each of the five off-site monitoring stations. Although a release of RIM via airborne particulates from the WLLS is not anticipated to yield an off-site external gamma exposure rate distinguishable from background variability, acquisition of these data occurred for possible use as a reference for future monitoring campaigns that will include exposure rate measurements. Review of the GammaTRACER data revealed that exposure rates at the five monitoring stations fluctuated around 10 microroentgens per hour (μR/hr)—a typical exposure rate within outdoor environments (National Council on Radiation Protection and Measurements [NCRP] 1987)—with exposure rates at some stations tending slightly higher or lower than 10 μR/hr (an expected outcome due to variations in local geology and surface conditions). Notably, numerous temporary spikes in the exposure rate readings corresponded to precipitation events, indicating likely precipitation scavenging (or washout) of airborne radionuclides (a process whereby radionuclides—primarily radon daughter products—suspended as aerosols in the atmosphere coalesce with precipitation and are transported with the falling precipitation to the ground surface). Overall, the gamma rate measurements appear typical for an outdoor environment.

Environmental Dosimetry

Approximately month-long environmental dosimetry measurements were obtained at the off-site monitoring stations by use of Landauer, Inc. InLight optically stimulated luminescent (OSL) dosimeters to supplement the exposure rate measurements obtained by use of the Saphymo GammaTRACERs. The OSL dosimetry data appear normal for outdoor ambient measurements.

1.0 INTRODUCTION

The Tetra Tech, Inc. (Tetra Tech) Superfund Technical Assessment and Response Team (START) was tasked by the U.S. Environmental Protection Agency (EPA) to assist with baseline monitoring at off-site locations around the West Lake Landfill site (WLLS) in Bridgeton, Missouri. The monitoring effort began in April 2014 and concluded in July 2015. This report summarizes data sets of radiological parameters acquired from the start to end of baseline monitoring.

START's tasks included: (1) assembling and maintaining a network of off-site air monitoring stations with instrumentation and sampling devices to measure radiological and chemical parameters of concern, (2) collecting samples and coordinating laboratory analysis, (3) assisting EPA with data acquisition and management, (4) documenting the off-site air monitoring efforts, and (5) validating/verifying initial screening of the data.

The objective of this report is to present a summary of the radiological data acquired, including findings related to data validation, verification, and usability. Tabulated data summaries and plots of the data appear within the relevant report sections. A site figure is in Appendix A. Tabulated sampling results are in Appendix B. Calculations supporting the radon measurements are in Appendix C. Results of statistical analyses are in Appendix D. Exposure rate measurement plots are in Appendix E. Manufacturer datasheets regarding the monitoring and sampling equipment are included in Appendix F.

2.0 PROBLEM DEFINITION, BACKGROUND, AND SITE DESCRIPTION

EPA conducted air monitoring at locations off site of WLLS during a pre-construction, baseline period prior to initiation of construction of a planned isolation barrier at WLLS. Air monitoring during the baseline period will provide data for use to (1) evaluate pre-construction concentrations of chemical and radiological parameters of potential concern in outdoor air, and (2) optimize the sampling and monitoring plan for the off-site air monitoring to occur during construction of the isolation barrier. During barrier construction, air monitoring will occur to address concerns that operations at WLLS could impact human health and the environment via release to ambient air of solid waste landfill gases of concern or of particulates with radiologically-impacted materials (RIM).

West Lake Landfill is an approximately 200-acre property including several closed solid waste landfill units that accepted wastes for landfilling from the 1940s or 1950s through 2004, plus a solid waste transfer station, a concrete plant, and an asphalt batch plant. The WLLS is at 13570 St. Charles Rock Road in Bridgeton, St. Louis County, Missouri, approximately 1 mile north of the intersection of Interstate 70 and Interstate 270 (see Appendix A, Figure 1). WLLS was used for limestone quarrying and crushing operations from 1939 through 1988. Beginning in the late 1940s or early 1950s, portions of the quarried areas and adjacent areas were used for landfilling municipal refuse, industrial solid wastes, and construction/demolition debris. In 1973, approximately 8,700 tons of leached barium sulfate residues (a remnant from the Manhattan Engineer District/Atomic Energy Commission project) were reportedly mixed with approximately 39,000 tons of soil from the 9200 Latty Avenue site in Hazelwood, Missouri, transported to the WLLS, and used as daily or intermediate cover material. In December 2004, the Bridgeton Sanitary Landfill—the last landfill unit at WLLS to receive solid waste—stopped receiving waste pursuant to an agreement with the City of St. Louis to reduce potential for birds to interfere with Lambert Field International Airport operations. In December 2010, Bridgeton Landfill detected changes—elevated temperatures and elevated carbon monoxide levels—in its landfill gas extraction system operating at the South Quarry of the Bridgeton Sanitary Landfill portion of the WLLS (a landfill portion not associated with known RIM). Further investigation indicated that the South Quarry Pit landfill was undergoing an exothermic subsurface smoldering event (SSE). In 2013, potentially responsible parties committed to constructing an isolation barrier that would separate the landfill portion undergoing the SSE from the RIM-containing area (EPA 2014).

3.0 SAMPLING STRATEGY AND METHODOLOGY

EPA and START began setup of the five off-site monitoring stations in April 2014; these activities included installations of electrical service, instrument weather housings, monitoring and sampling devices (including particulate air samplers, RAE Systems AreaRAEs, Saphymo GammaTRACERs, electret ion chamber radon detectors, and optically stimulated luminescent [OSL] dosimeters), and a wireless remote monitoring network. The baseline period off-site air monitoring and sampling occurred at the following monitoring stations according the approved quality assurance project plan (QAPP) (Tetra Tech 2014a) (see Appendix A, Figure 1):

Station 1 – Robertson Fire Protection District Station 2, 3820 Taussig Rd., Bridgeton, Missouri

Station 2 – Pattonville Fire Department District, 13900 St Charles Rock Rd., Bridgeton, Missouri

Station 3 – Pattonville Fire Department District Station 2, 3365 McKelvey Rd., Bridgeton, Missouri

Station 4 – Spanish Village Park, 12827 Spanish Village Dr., Bridgeton, Missouri

Station 5 – St. Charles Fire Department Station #2, 1550 S. Main St., St. Charles, Missouri.

The Station 1 through 4 locations were selected primarily for their proximate positions around WLLS (these stations are approximately 0.3 to 1 mile from WLLS, in various directions from WLLS). Station 5 was designated as a reference (or background) station, and its location was selected according to the criterion that it be frequently upwind of WLLS and farther away from WLLS than the other stations, but still within the general vicinity so as to be representative of the North St. Louis County and eastern St. Charles County area. Station 5 is farther away from WLLS than the other stations (approximately 2.3 miles west of WLLS), frequently upwind of WLLS, roughly twice the distance from WLLS than the next closest station (Station 3), and within the general vicinity of the North St. Louis County and eastern St. Charles County area so as to be representative of that area (see wind rose presented in Appendix A, Figure 1).

The radiological parameters of potential concern were identified in the QAPP (Tetra Tech 2014a) based on historical information regarding the site and program experience with similar types of sites. During the baseline sampling period, assessment of presence of naturally occurring alpha-, beta-, and gamma-emitting radionuclides on airborne particulates is occurring. The radionuclides of potential concern based on characteristics of the West Lake RIM are thorium-230 (^{230}Th), radium-226 (^{226}Ra), and radon (^{222}Rn). Assessments of gross alpha, beta, and gamma activities (including environmental dosimetry measurements) also occurred at each monitoring station.

Sampling was consistent with EPA methods and standard operating procedures (SOP) specified in the approved QAPP (Tetra Tech 2014a). Presented in Section 4.0 with the data summaries are descriptions of the project-specific sampling methods associated with the various radiological parameters assessed.

In March 2015, baseline monitoring ended at Stations 1, 2, 3, and 5. Baseline monitoring at Station 4 ended in July 2015. This report summarizes the radiation air monitoring and sampling results for the entire baseline period—starting in April 2014 and ending in July 2015.

4.0 SUMMARY AND EVALUATION OF RADIOLOGICAL DATA

The following sections present data summaries of the radionuclide parameters assessed during the ongoing baseline monitoring period, including time series and box plots of the data, and results of statistical analyses. Tabulated data are in Appendix B.

4.1 RADIONUCLIDES ON AIRBORNE PARTICULATES

Presence of naturally occurring alpha-, beta-, and gamma-emitting radionuclides on airborne particulates is being assessed. Based on characteristics of the West Lake Landfill RIM, the radionuclides of potential concern measurable via sampling and analyzing airborne particulates are uranium-238 (^{238}U), ^{230}Th, and ^{226}Ra. START began collecting weekly air filter samples at the five off-site monitoring stations on May 8, 2014. Weekly collection of air filters continued through March 4, 2015 for Stations 1, 2, 3, and 5 and through July 30, 2015 for Station 4. The Station 2 air sampler failed at unknown time during the weekly sampling period ending July 2, 2105 and the total sampling volume could not be determined; therefore, the July 2, 2015 Station 2 air filter sample was not submitted for laboratory analysis.

4.1.1 Sampling Procedure

To determine airborne concentrations of radionuclides transported via airborne particulates, airborne particulates were collected onto 2-inch-diameter borosilicate glass fiber filter media by use of high-volume air samplers (RADeCO Model HD28 or equivalent air sampler). One air sampler is operated at each off-site monitoring station to collect airborne particulates continuously onto the filter media for a duration of 7 days. The air samplers were operated at a flow rate of at least 2.0 cubic feet per minute to yield a minimum air sample volume of 20,160 cubic feet (571 cubic meters [m^3]). At the end of the sampling period, the sampled filter was submitted for laboratory analysis, a new filter installed, and a new 7-day sampling period began.

The filters were analyzed by TestAmerica of Earth City, Missouri, for gross alpha, gross beta, gamma-emitting radionuclides, isotopic uranium, isotopic thorium, and total alpha-emitting radium. The laboratory results were reported as total activity (in picoCuries [pCi]) per filter. Total air volume drawn through the filter is recorded by the field sampler at the time of filter collection. Air concentrations were calculated by dividing the per filter total activity (in pCi) by the volume of air drawn through the filter (in m^3) to yield an air concentration in units of pCi/m^3.

4.1.2 Data Validation, Verification, and Usability

As laboratory analytical reports were received for the airborne particulate radionuclide analysis, START reviewed and qualified the data according to EPA Contract Laboratory Program guidelines (EPA 2008), the *Multi-Agency Radiological Laboratory Analytical Protocols Manual* (EPA 2004), and other criteria specified in the applicable methods. Findings of these reviews were documented in a data validation report appended to each analytical laboratory report and included in the data deliverable packages (see Tetra Tech 2014b, c, d, e, f and Tetra Tech 2015a, b, c, d, e, f, g). Suggested qualifications to the data from START's review are indicated by qualifier flags that accompany the data presented herein. Overall, review of the laboratory analytical data packages indicated that quality of the airborne particulate data was acceptable and usable as qualified for the intended purposes of those data.

4.1.3 Gross Alpha Results and Evaluation

The following describes gross alpha results from weekly air filter samples collected during the baseline monitoring period.

<u>Summary Statistics</u>

Table 1 lists frequency of detection and minimum, median, and maximum gross alpha concentrations.

TABLE 1

SUMMARY STATISTICS OF GROSS ALPHA RESULTS

Summary Statistic	Station 1	Station 2	Station 3	Station 4	Station 5 (background)
Detections[1]	36/44	34/44	30/44	40/64	32/44
Minimum Concentration[2]	1.99E-04 U	1.93E-04 U	1.02E-04 U	1.17E-04 U	1.10E-04 U
Median Concentration[3]	6.42E-04	6.25E-04	6.32E-04	6.06E-04	6.97E-04
Maximum Concentration[4]	1.63E-03 J	1.68E-03 J	1.58E-03 J	1.38E-03 J	1.65E-03 J

Notes:

All concentrations in picoCuries per cubic meter (pCi/m^3)

J Indicates an estimated result
U Indicates a non-detected result

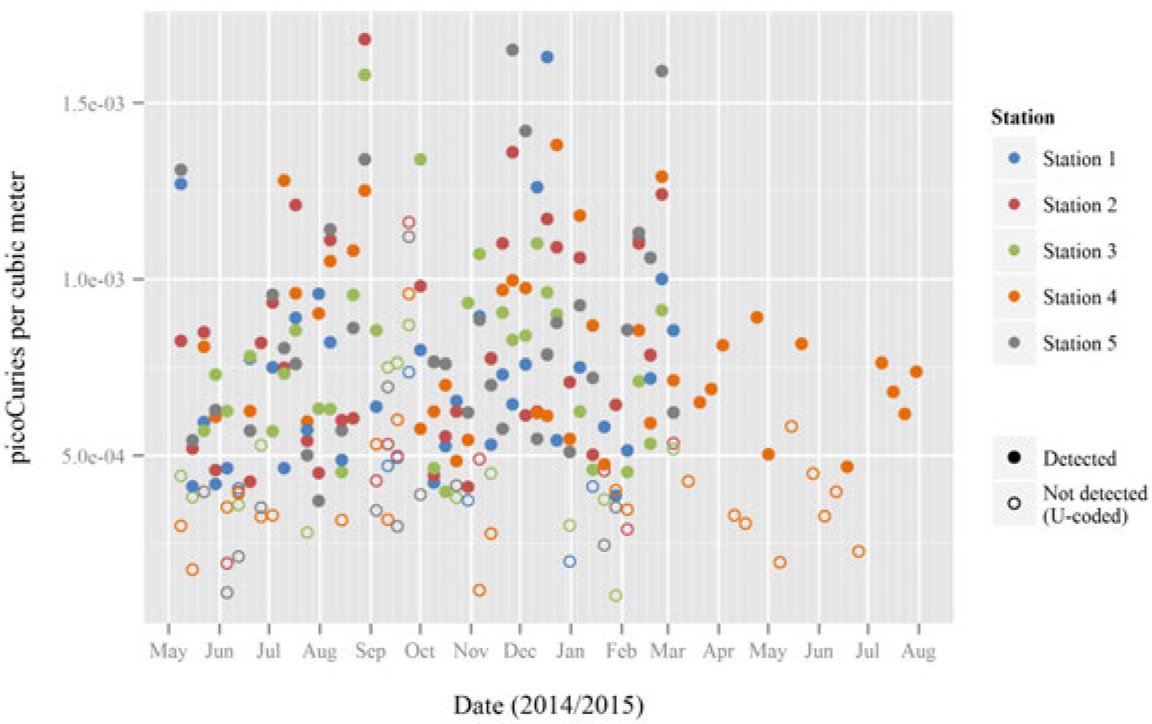
1 Number of detections / number of samples. U-coded results were counted as not detected.
2 Includes lowest reported value among both U-coded and non-U-coded results.
3 Median concentration among U-coded and non-U-coded results.
4 Maximum detected (non-U-coded) concentration.

Time Series Plot

Exhibit 1 is a time series graph of the gross alpha results. This graph shows no discernable trends or patterns in the data.

EXHIBIT 1

TIME SERIES PLOT OF GROSS ALPHA ACTIVITY

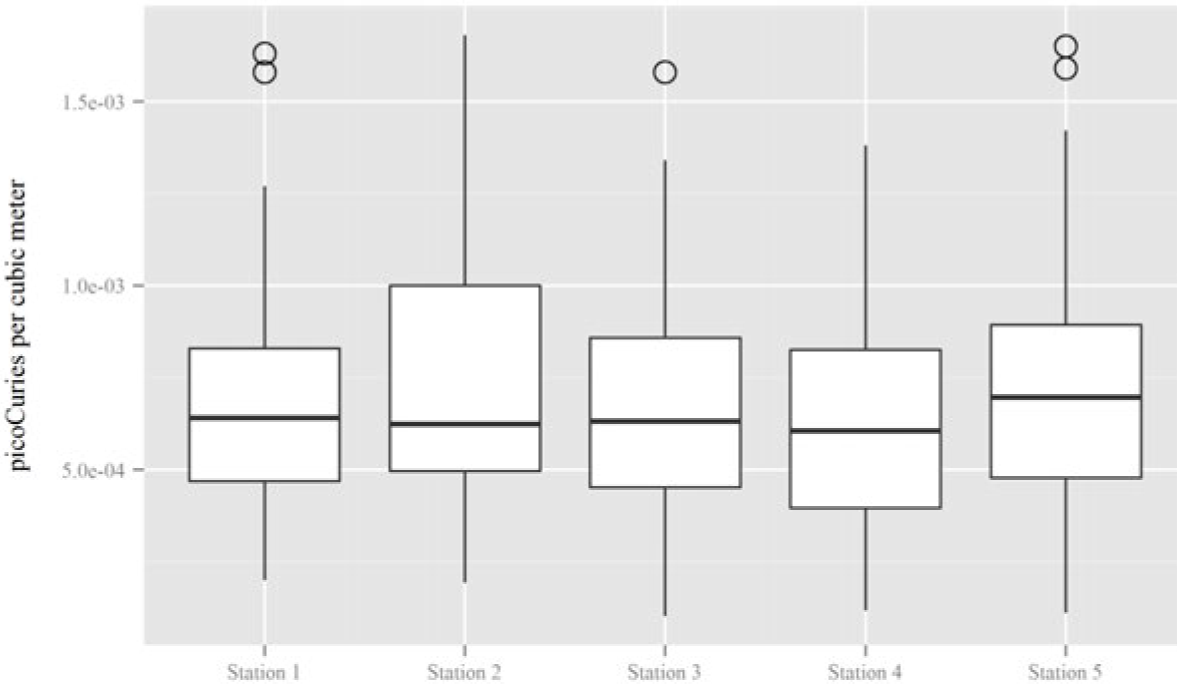


Box Plots

Exhibit 2 shows box plots of the gross alpha results. These plots suggest similar median concentrations and distributions among the five monitoring stations. The box plots suggest several upper end outlier concentrations (indicated by open circles) for Stations 1, 3, and 5. Data users should be aware of these suggested outliers because their representation of the parameter being measured is uncertain. The cause of the suggested outliers in the gross alpha data is unknown, but outliers are often attributed to measurement error or can occur by chance in any distribution. Regarding the suggested outliers in the gross alpha data, one should consider that (1) maximum detected gross alpha concentrations among the five stations were within an order of magnitude (the station maximums ranged from 1.38E-03 to 1.68E-03 pCi/m^3), (2) suggested outliers occurred at multiple stations, and (3) statistical analyses suggest that the median/mean characteristics of the distributions were similar among the five stations, and that no station tended to yield higher or lower results than any other station (see Section 4.1.8).

EXHIBIT 2

BOX PLOTS OF GROSS ALPHA ACTIVITY



4.1.4 Gross Beta Results and Evaluation

The following describes the gross beta results from weekly air filter samples collected during the baseline monitoring period.

Summary Statistics

Table 2 lists frequency of detection and minimum, median, and maximum gross beta concentrations.

TABLE 2

SUMMARY STATISTICS OF GROSS BETA RESULTS

Summary Statistic	Station 1	Station 2	Station 3	Station 4	Station 5 (reference)
Detections[1]	44/44	44/44	44/44	64/64	44/44
Minimum Concentration	1.15E-02	4.13E-03 J	1.32E-02 J	1.16E-02 J	1.21E-02 J
Median Concentration	1.98E-02	2.05E-02	2.04E-02	1.87E-02	1.93E-02
Maximum Concentration	3.95E-02	4.36E-02	3.96E-02	4.15E-02	4.31E-02

Notes:

All concentrations in picoCuries per cubic meter (pCi/m^3)

J Indicates an estimated result

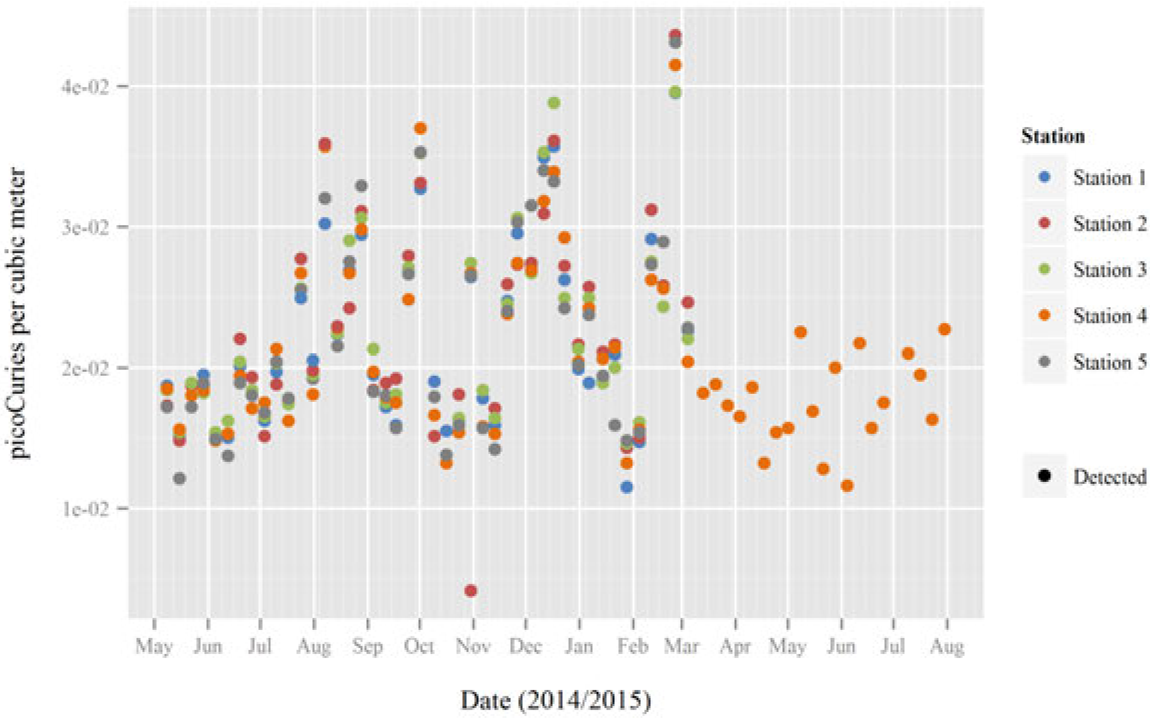
[1] Number of detections / number of samples (no gross beta results are U-coded).

Time Series Plot

The gross beta time series plot in Exhibit 3 shows no discernable trends or patterns in the data, except that gross beta results from filters collected during the same week appear to be related by a common component that varies irregularly from week to week. The cause of this is unknown, but possibly this is attributable to naturally occurring, short-lived radon daughters collected onto the filters that variably contribute to the gross beta concentrations (depending on the amount of time between filter collection and analysis allowing for decay).

EXHIBIT 3

TIME SERIES PLOT OF GROSS BETA ACTIVITY

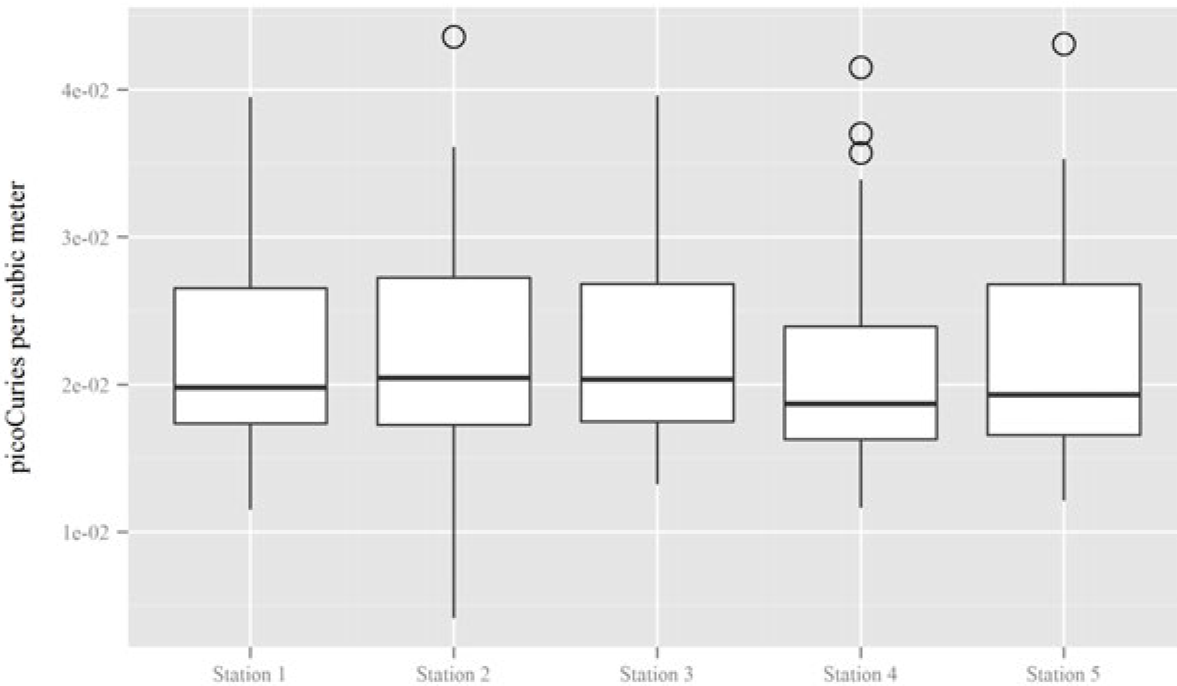


<u>Box Plots</u>

Exhibit 4 shows box plots of the gross beta results. These plots suggest similar median concentrations and distributions among the five monitoring stations. The box plots suggest several upper end outlier concentrations (indicated by open circles) for Stations 2, 4, and 5. Data users should be aware of these suggested outliers because their representation of the parameter being measured is uncertain. The cause of the suggested outliers in the gross beta data is unknown, but outliers are often attributed to measurement error or can occur by chance in any distribution. Regarding the suggested outliers in the gross beta data, one should consider that (1) maximum detected gross beta concentrations among the five stations were within an order of magnitude (the station maximums ranged from 3.95E-02 to 4.36E-02 pCi/m^3), (2) suggested outliers occurred at multiple stations, and (3) statistical analyses, overall, did not appear to indicate differences in gross beta results among the five stations (see Section 4.1.8).

EXHIBIT 4

BOX PLOTS OF GROSS BETA ACTIVITY



4.1.5 Uranium-238 Results and Evaluation

The following describes ^{238}U results from weekly air filter samples collected during the baseline monitoring period.

Summary Statistics

Table 3 lists frequency of detection and minimum, median, and maximum ^{238}U concentrations.

TABLE 3

SUMMARY STATISTICS OF URANIUM-238 RESULTS

Summary Statistic	Station 1	Station 2	Station 3	Station 4	Station 5 (reference)
Detections[1]	19/44	24/44	22/44	21/64	14/44
Minimum Concentration[2]	-1.61E-04 U	-8.55E-05 U	-4.42E-05 U	-1.34E-05 U	-2.39E-05 U
Median Concentration[3]	9.38E-05	1.24E-04	1.12E-04	1.03E-04	1.02E-04
Maximum Concentration[4]	6.22E-04 J	1.08E-03 J	3.86E-04 J	3.07E-04 J	2.25E-04 J

Notes:

All concentrations in picoCuries per cubic meter (pCi/m^3)

J Indicates an estimated result
U Indicates a non-detected result

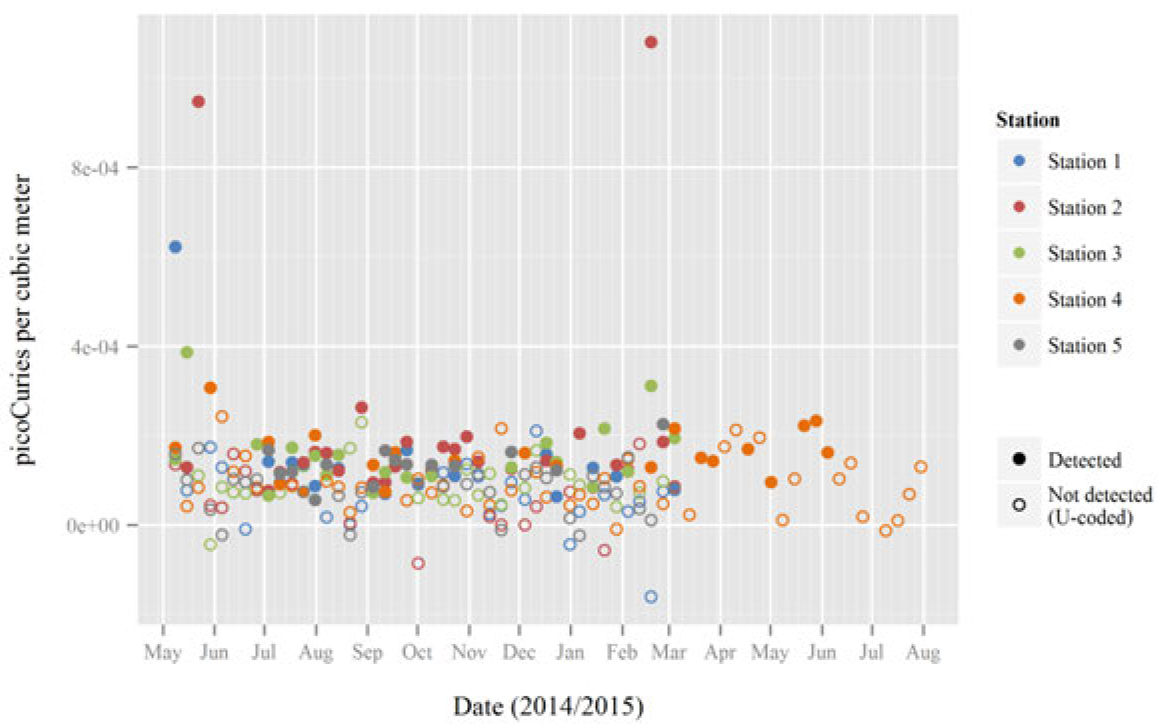
1 Number of detections / number of samples. U-coded results were counted as not detected.
2 Includes lowest reported value among both U-coded and non-U-coded results.
3 Median concentration among U-coded and non-U-coded results.
4 Maximum detected (non-U-coded) concentration.

<u>Time Series Plot</u>

The time series plot of ^{238}U results in Exhibit 5 shows no discernable trends or patterns in the data.

EXHIBIT 5

TIME SERIES PLOT OF URANIUM-238

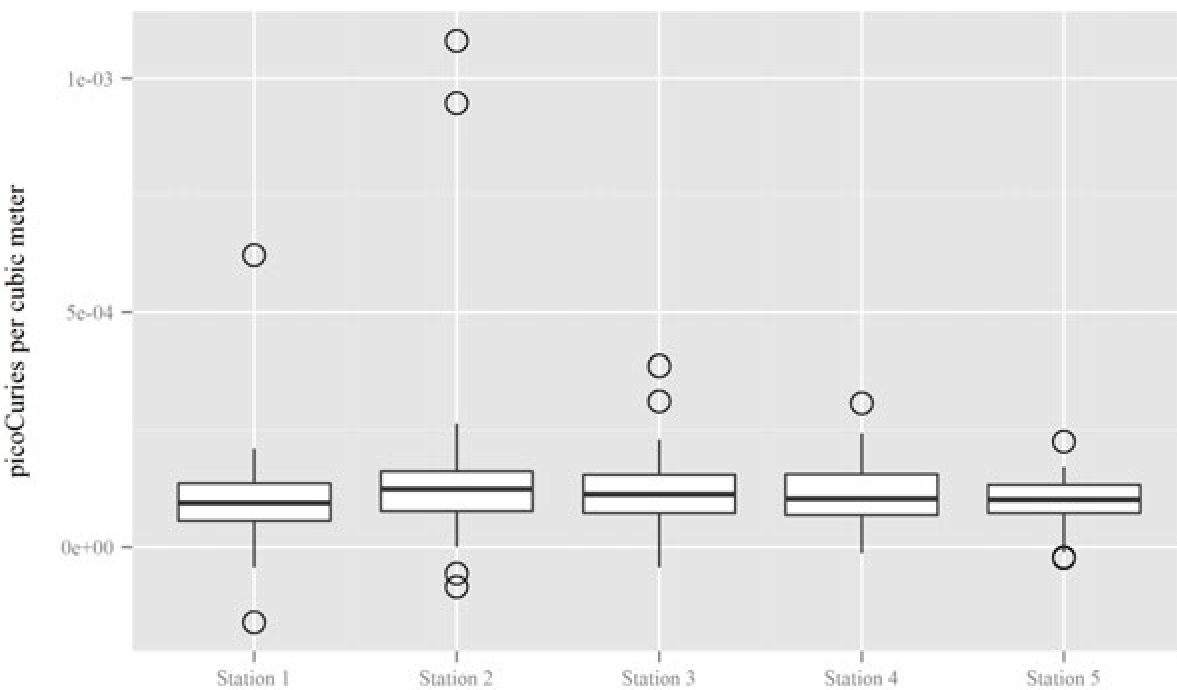


Box Plots

Exhibit 6 shows box plots of the ^{238}U results. As with the gross alpha and beta results, these plots suggest similar median concentrations and distributions among the five monitoring stations. The box plots suggest upper end outlier concentrations (indicated by open circles) at each of the five stations. Data users should be aware of these suggested outliers because their representation of the parameter being measured is uncertain. The cause of the suggested outliers in the ^{238}U data is unknown, but outliers are often attributed to measurement error or can occur by chance in any distribution. Regarding the suggested outliers in the ^{238}U data, one should consider that (1) maximum detected ^{238}U concentrations among the five stations were within an order of magnitude (the station maximums ranged from 2.25E-04 to 1.08E-03 pCi/m^3), (2) suggested outliers occurred at each of the stations, and (3) statistical analyses suggested that median/mean characteristics of the distributions were similar among the five stations, and that no station tended to yield higher or lower results than any other station (see Section 4.1.8).

EXHIBIT 6

BOX PLOTS OF URANIUM-238 ACTIVITY



4.1.6 Thorium-230 Results and Evaluation

The following describes ^{230}Th results from weekly air filter samples collected during the baseline monitoring period.

Summary Statistics

Table 4 lists frequency of detection and minimum, median, and maximum ^{230}Th concentrations.

TABLE 4

SUMMARY STATISTICS OF THORIUM-230 RESULTS

Summary Statistic	Station 1	Station 2	Station 3	Station 4	Station 5 (reference)
Detections[1]	42/44	39/44	42/44	55/64	42/44
Minimum Concentration[2]	1.77E-04 U	2.63E-04 J	1.37E-04 J	1.81E-04 J	2.71E-04 U
Median Concentration[3]	4.71E-04	5.66E-04	5.10E-04	5.38E-04	5.17E-04
Maximum Concentration[4]	4.37E-03	1.36E-03 J	8.86E-04 J	1.80E-03 J	1.99E-03 J

Notes:

All concentrations in picoCuries per cubic meter (pCi/m^3)

J Indicates an estimated result
U Indicates a non-detected result

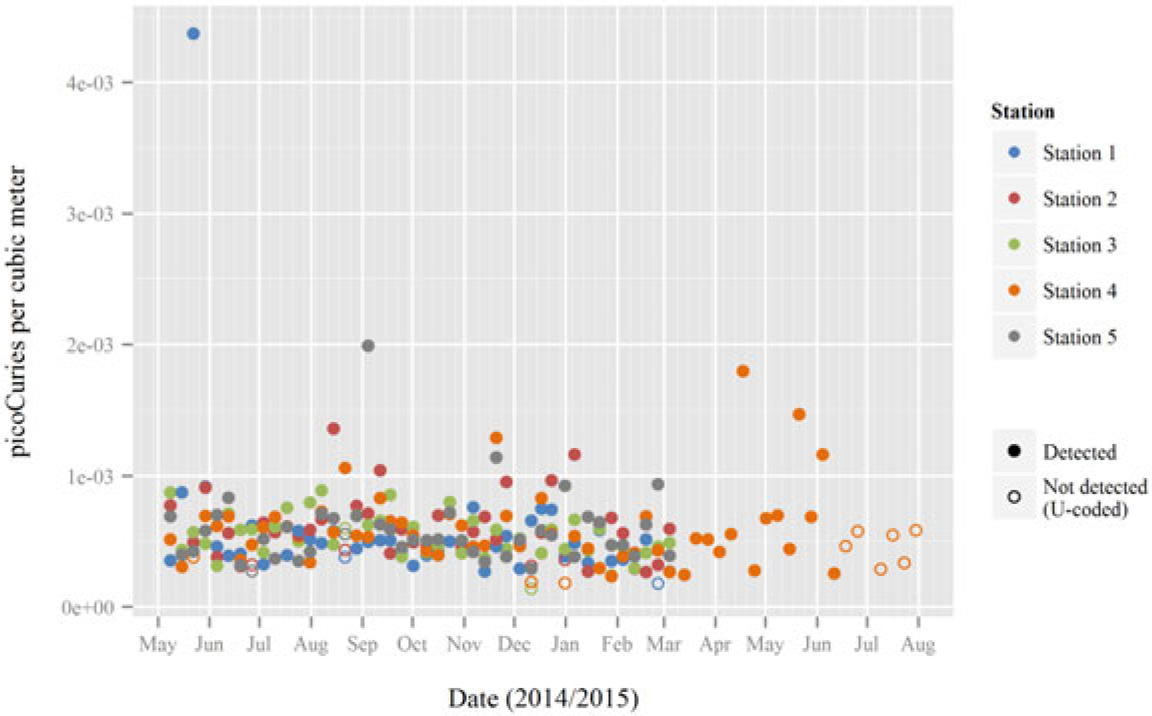
1 Number of detections / number of samples. U-coded results were counted as not detected.
2 Includes lowest reported value among both U-coded and non-U-coded results.
3 Median concentration among U-coded and non-U-coded results.
4 Maximum detected (non-U-coded) concentration.

Time Series Plot

The time series plot of ^{230}Th results in Exhibit 7 shows no discernable trends or patterns in the data.

EXHIBIT 7

TIME SERIES PLOT OF THORIUM-230

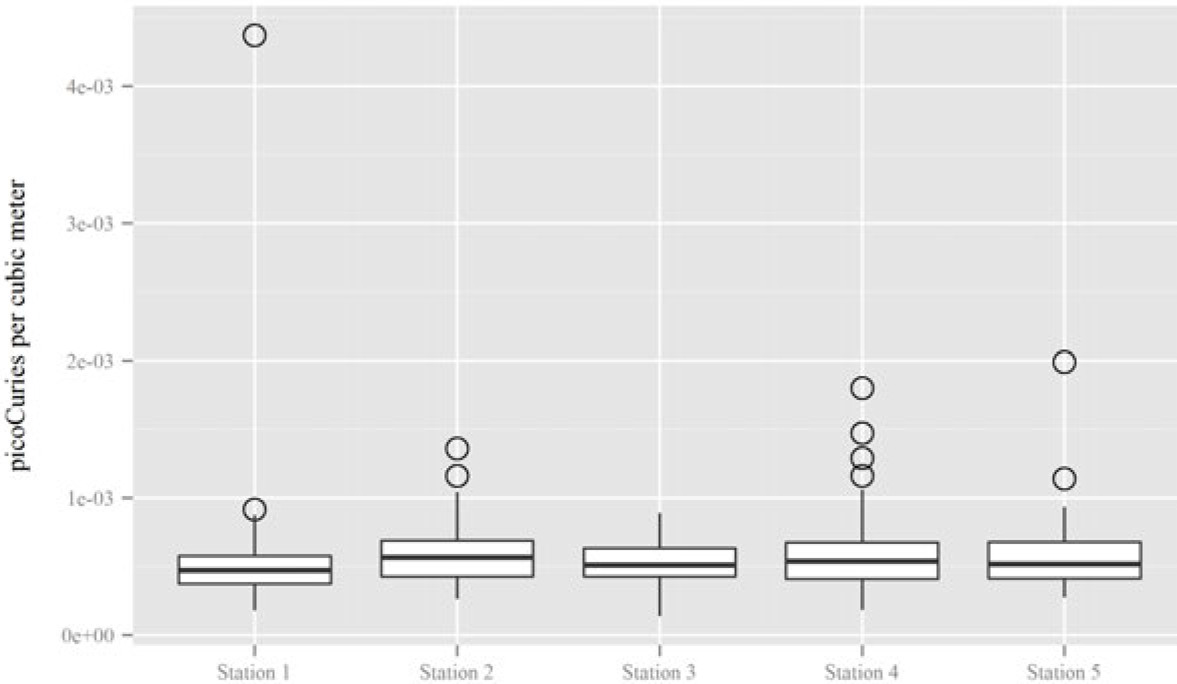


<u>Box Plots</u>

Exhibit 8 shows box plots of the ^{230}Th results. As with the aforementioned gross alpha/beta and ^{238}U results, these plots suggest similar median concentrations and distributions among the five monitoring stations. The box plots suggest several upper end outlier concentrations (indicated by open circles) at Stations 1, 2, 4, and 5. Data users should be aware of these suggested outliers because their representation of the parameter being measured is uncertain. The cause of the suggested outliers in the ^{230}Th data is unknown, but outliers are often attributed to measurement error or can occur by chance in any distribution. Regarding the suggested outliers in the ^{230}Th data, one should consider that (1) maximum detected ^{230}Th concentrations among the five stations were within an order of magnitude (the station maximums ranged from 8.86E-04 to 4.37E-03 pCi/m^3), (2) suggested outliers occurred at multiple stations (including Station 5, the reference station), and (3) statistical analyses suggested that the median/mean characteristics of the distributions were similar among the five stations, and that no station tended to have higher or lower results than any other station (see Section 4.1.8).

EXHIBIT 8

BOX PLOTS OF THORIUM-230 ACTIVITY



4.1.7 Total Alpha-Emitting Radium Results and Evaluation

The following describes the total alpha-emitting radium results from weekly air filter samples collected during the baseline monitoring period. Although the radium isotope of interest for WLLS is ^{226}Ra, as a cost-savings measure and to reduce analysis time, the samples were first analyzed via a method that reports total alpha-emitting radium, which includes the radium isotopes ^{223}Ra, ^{224}Ra, and ^{226}Ra. If a sample yielded a total alpha-emitting radium result exceeding 5 pCi per filter (corresponding to an air concentration of 8.8E-3 pCi/m^3 for the targeted air volume of 571 m^3), that sample was to be re-analyzed via a ^{226}Ra-specific method. However, none of the total alpha-emitting radium results exceeded 5 pCi per filter, although the laboratory mistakenly prepared the samples collected on May 15, 2014, for a ^{226}Ra-specific analysis, and the reported results were ^{226}Ra concentrations (these data are flagged "$_{(226)}$").

Summary Statistics

Table 5 lists frequency of detection and minimum, median, and maximum total alpha-emitting radium concentrations.

TABLE 5

SUMMARY STATISTICS OF TOTAL ALPHA-EMITTING RADIUM RESULTS

Summary Statistic	Station 1	Station 2	Station 3	Station 4	Station 5 (reference)
Detections[1]	3/43	4/43	3/43	3/63	2/43
Minimum Concentration[2]	-2.50E-04 U	-6.83E-04 U	-1.56E-04 U	-4.86E-04 U	-4.34E-04 U
Median Concentration[3]	4.49E-04	4.55E-04	3.50E-04	4.58E-04	4.68E-04
Maximum Concentration[4]	1.10E-03 J	1.80E-03 J	2.01E-03	1.38E-03 J	4.40E-03

Notes:

All concentrations in picoCuries per cubic meter (pCi/m^3)
J Indicates an estimated result
U Indicates a non-detected result

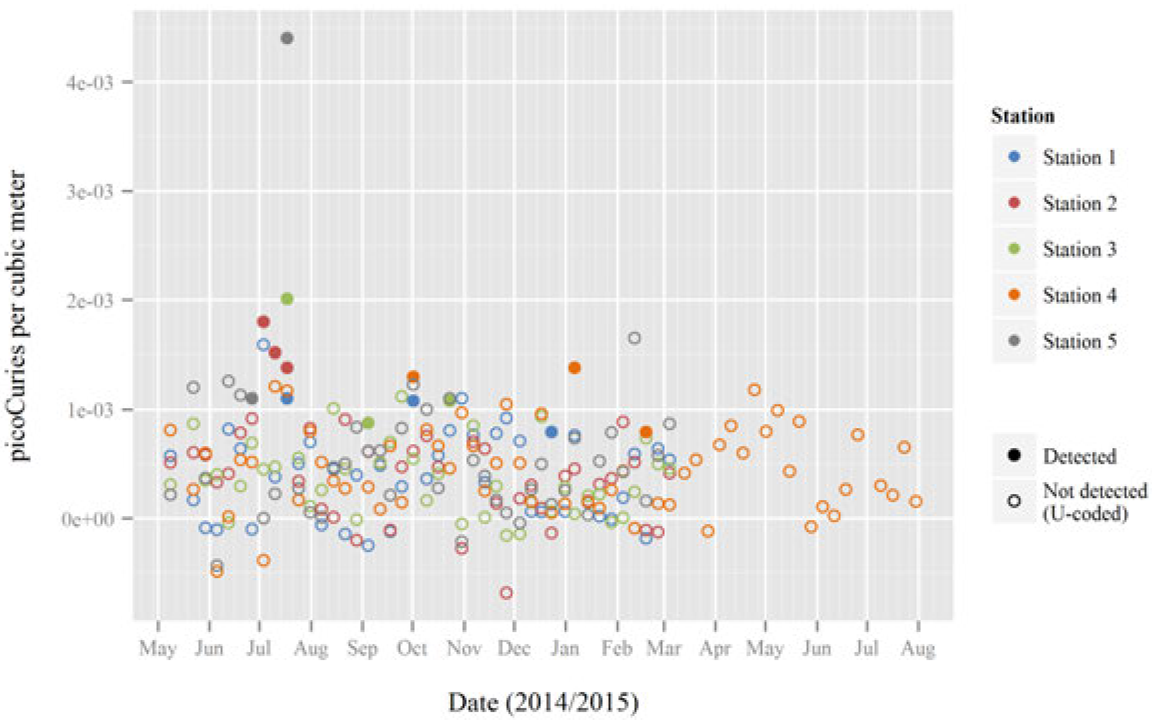
[1] Number of detections / number of samples. U-coded results were counted as not detected.
[2] Includes lowest reported value among both U-coded and non-U-coded results.
[3] Median concentration among U-coded and non-U-coded results.
[4] Maximum detected (non-U-coded) concentration.

Time Series Plot

The total alpha-emitting radium time series plot in Exhibit 9 shows no discernable trends or patterns in the data. Notably, almost 90 percent of the data are U-coded, indicating a non-detect result.

EXHIBIT 9

TIME SERIES PLOT OF TOTAL ALPHA-EMITTING RADIUM

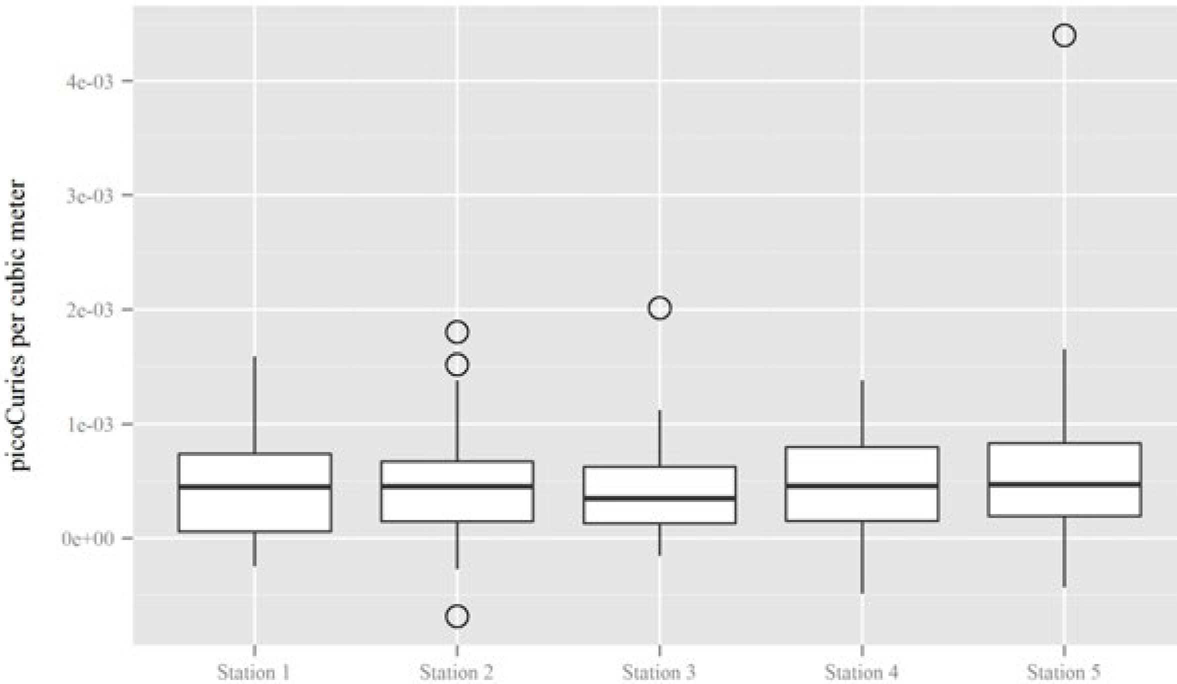


<u>Box Plots</u>

Exhibit 10 shows box plots of the total-alpha emitting radium results; however, utility of these plots is limited because nearly 90 percent of the total-alpha emitting radium results were non-detect (the box plots show both U-coded and non-U-coded results).

EXHIBIT 10

BOX PLOTS OF TOTAL ALPHA-EMITTING RADIUM RESULTS



4.1.8 Statistical Analyses

Two statistics tests—the Kruskal-Wallis and Friedman tests—were used to test for differences in gross alpha/beta results, and concentrations of ^{238}U, ^{230}Th, and total alpha-emitting radium (including ^{226}Ra) among the five monitoring stations. The Kruskal-Wallis and Friedman tests are non-parametric statistical tests that compare multiple treatments (such as the multiple monitoring locations). The Kruskal-Wallis test assumes data sets are independent, whereas the Friedman Rank Sum test accounts for related (or cluster-correlated) data. Because the time-series plots suggested that some data were unrelated (such as the gross-alpha results that showed no obvious clustering from week to week) and some were related (such as the gross-beta results showing obvious clustering from week to week), both tests were used. The data underwent the Kruskal-Wallis and Friedman tests by use of the statistical software package R (see Appendix D for the input data sets, R scripts, and R output). Table 6 summarizes the Kruskal-Wallis and Friedman test results.

The Kruskal-Wallis test did not identify significant differences in mean/median characteristics of the data examined (gross alpha, gross beta, ^{238}U, ^{230}Th, and total alpha-emitting radium) among the five monitoring stations. The Friedman test found no tendency for one station to yield larger or smaller measurements than any other station, except for gross beta results (based on a *p-value* of 0.01773);

however, a post-hoc analysis of the Friedman test detected no differences among stations. Overall, these statistical tests do not appear to indicate differences in gross alpha/beta results, and concentrations of ^{238}U, ^{230}Th, and total alpha-emitting radium (including ^{226}Ra) among the five monitoring stations.

TABLE 6

SUMMARY OF STATISTICAL TEST EXAMINING AIRBORNE PARTICULATE RADIONUCLIDE RESULTS

Statistical Test	Result of Statistical Test				
	Gross Alpha	**Gross Beta**	**^{238}U**	**^{230}Th**	**Total Alpha-Emitting Radium**
Kruskal-Wallis[1]	No significant differences ($p = 0.5697$)	No significant differences ($p = 0.5693$)	No significant differences ($p = 0.2733$)	No significant differences ($p = 0.2331$)	No significant differences ($p = 0.7941$)
Friedman[2]	No station tended to have larger or smaller measurements than any other ($p = 0.4204$)	Test resulted in a *p-value* of 0.01773, but a post-hoc analysis did not detect differences among the stations	No station tended to have larger or smaller measurements than any other ($p = 0.4293$)	No station tended to have larger or smaller measurements than any other ($p = 0.1211$)	No station tended to have larger or smaller measurements than any other ($p = 0.3313$)

Notes:

1 Results from the statistical software package R version 3.2.0 using the non-parametric Kruskal-Wallis test to compare the various radionuclide mean/median characteristics among the five monitoring stations. A p-value equal to or less than 0.05 suggests significant differences in mean/median characteristics among the stations. A p-value of greater than 0.05 suggests that the mean/median characteristics among the stations are comparable. See Appendix D to examine the Kruskal-Wallis test output from R.

2 Results from the statistical software package R version 3.2.0 using the non-parametric Friedman test to identify tendencies for measurements from one station to be larger or smaller than at any other station. A p-value equal to or greater than 0.05 suggests no tendency for one station to yield larger or smaller measurements than any other station. A p-value less than 0.05 suggests that one or more stations tended to yield measurements larger or smaller than other stations. See Appendix D to examine the test output from R.

4.1.9 Comparison of Gross Alpha to Radionuclide-Specific Results

The radionuclide-specific results examined in this section—^{238}U, ^{230}Th, and total alpha-emitting radium results—were compared to gross alpha results. Because each of these radionuclides (^{238}U, ^{230}Th, as well as ^{223}Ra, ^{224}Ra, and ^{226}Ra included in the total alpha-emitting radium result) is an alpha-emitting radionuclide, its concentration in a sample will be a component of (and not exceed) the gross (or total) alpha activity of the sample. To determine if the data conform to this relationship, the detected (non-U-coded) radionuclide-specific results were plotted against detected (non-U-coded) gross alpha results (see Exhibits 11-13). Each plot has a line representing a 1:1 ratio for the subject alpha-emitting radionuclide vs gross alpha (i.e., points on the line would indicate equal reported alpha-emitting radionuclide and gross alpha concentrations). Points above this line represent samples exhibiting a radionuclide-specific result that was less than its gross alpha result, indicating conforming data because the alpha-emitting radionuclide result was a component of, and did not exceed, the gross alpha result. Points below the 1:1 line represent a sample with an alpha-radionuclide result greater than its gross alpha result. This would not conform to the expectation that alpha-emitting radionuclide results would be less than gross alpha results (some nonconforming data may be expected when results are near the method detection limit).

EXHIBIT 11

URANIUM-238 AND GROSS ALPHA RESULTS

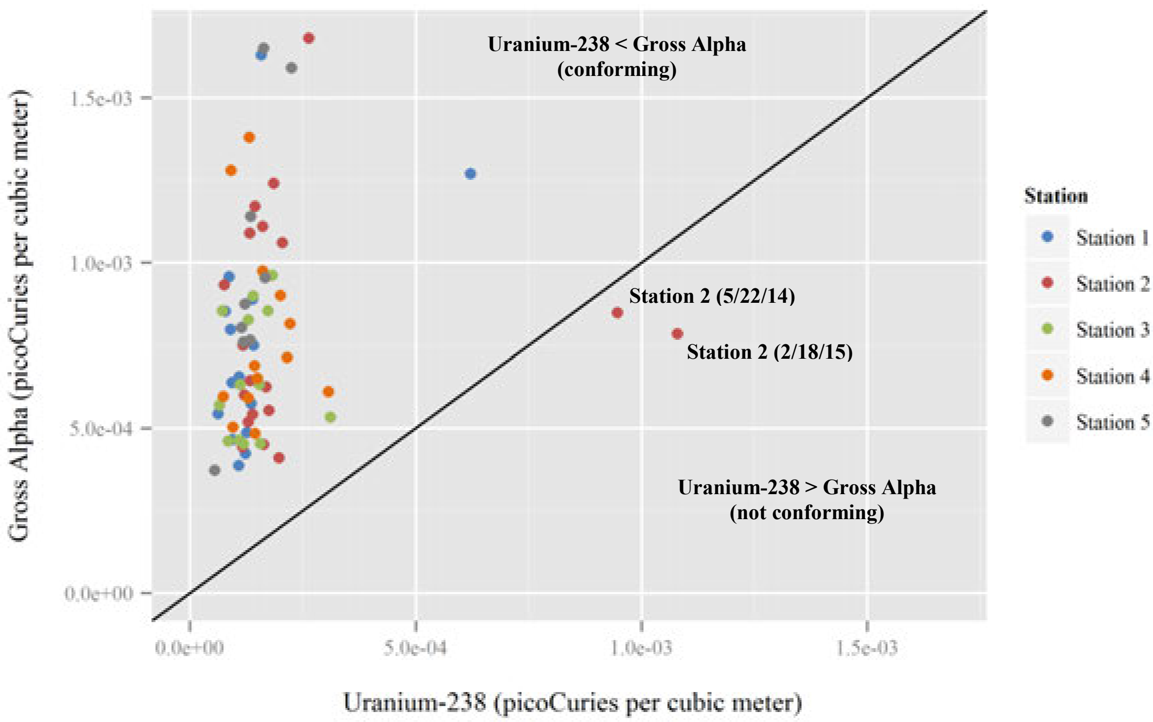


Exhibit 11 shows that all but two of the ^{238}U results conform to their corresponding gross alpha results. The two exceptions were the samples collected at Station 2 on May 22, 2014 and February 18, 2015, which yielded ^{238}U results of 9.47E-04 and 1.08E-03 pCi/m^3,respectively. These ^{238}U samples results are notably the highest among the data evaluated.

EXHIBIT 12

THORIUM-230 AND GROSS ALPHA RESULTS

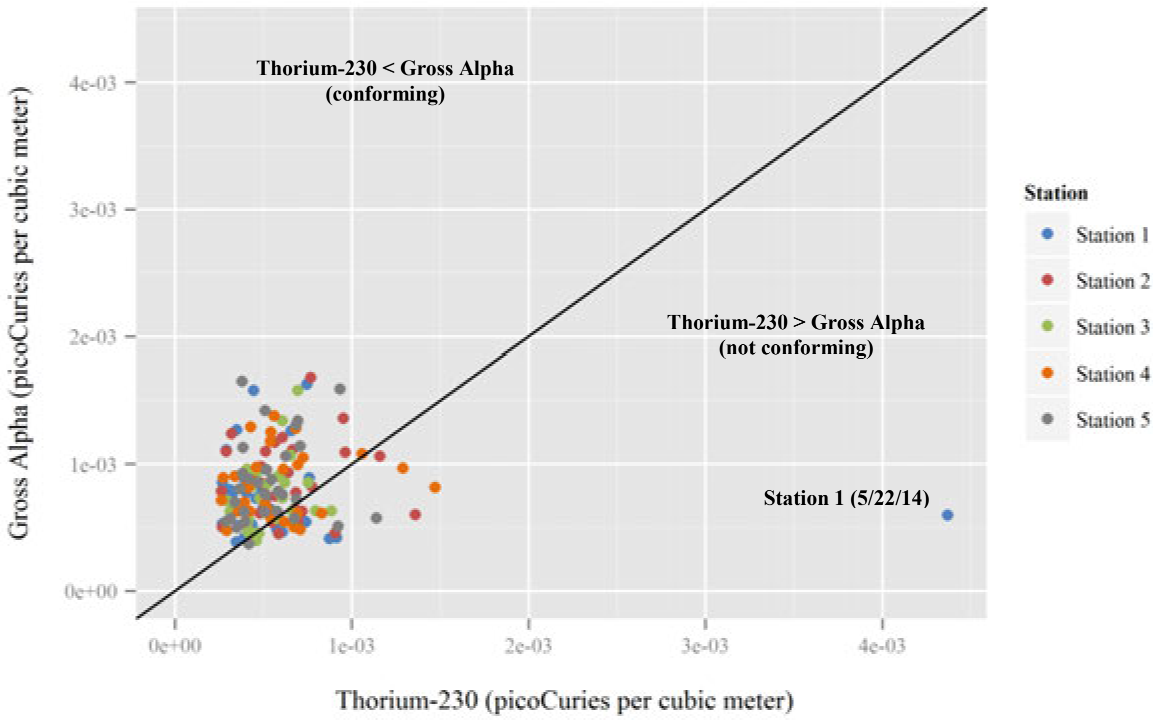


Exhibit 12 indicates numerous ^{230}Th results that do not conform to the corresponding gross alpha results. Many of these occurrences possibly relate to nearness of results to the laboratory detection capability (note that all results but one are in a cluster spanning the low end of the 1:1 line). The highest ^{230}Th result of 4.37E-03 pCi/m^3 (from the sample collected at Station 1 on May 22, 2014) notably does not conform to its corresponding gross alpha result of 5.95E-04 pCi/m^3. This observation prompts some speculation regarding its representativeness of actual ^{230}Th concentrations.

EXHIBIT 13

TOTAL ALPHA-EMITTING RADIUM AND GROSS ALPHA RESULTS

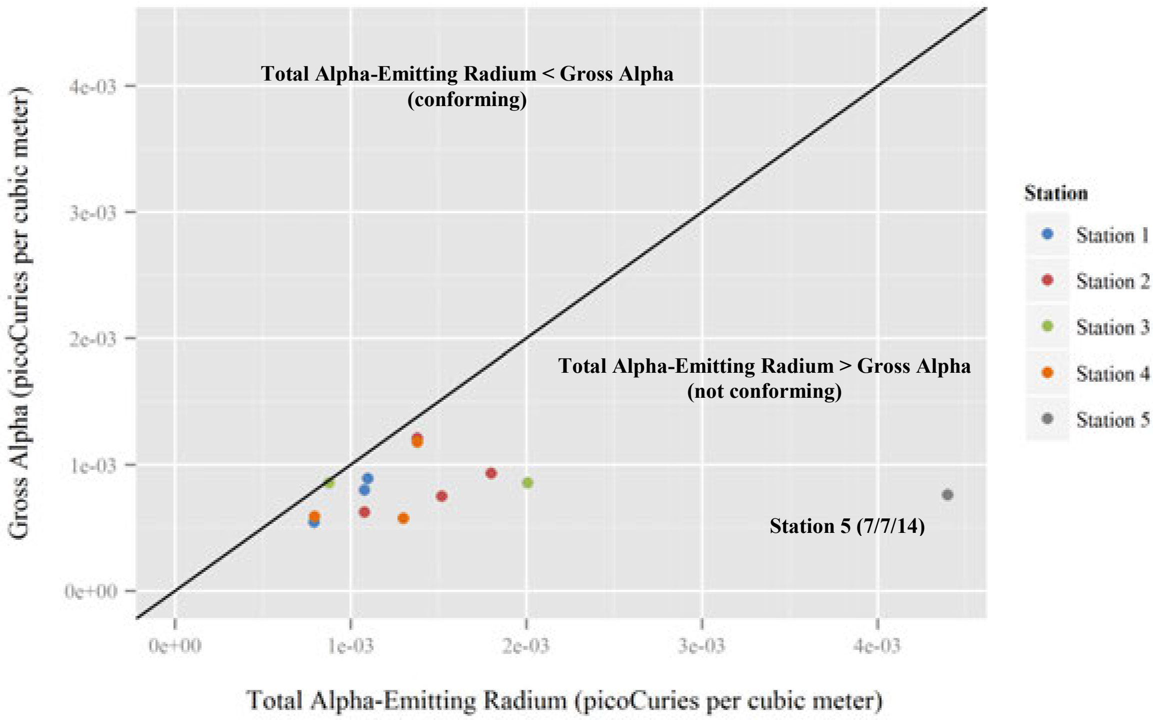


Exhibit 13 shows that most of the detected total-alpha emitting radium results do not conform to their corresponding gross alpha result. Many of these occurrences possibly relate to nearness of results to the laboratory detection capability, but as observed with the ^{238}U and ^{230}Th data, the highest total alpha-emitting radium result of 4.40E-03 pCi/m^3 (from the sample collected at Station 5 on July 7, 2014) notably does not conform to its corresponding gross alpha result of 7.59E-04 pCi/m^3. Likewise, this observation prompts some speculation that this maximum total alpha-emitting radium result is possibly unrepresentative.

Overall, a comparison of specific alpha-emitting radionuclide results (^{238}U, ^{230}Th, and total alpha-emitting radium results) to their corresponding gross alpha results indicated occasions of nonconformance of the radionuclide-specific result to its gross alpha result (because the radionuclide-specific result exceeded its corresponding gross alpha result). Data users should be aware of this characteristic in the data.

4.2 RADON MONITORING

Radon (^{222}Rn) has been identified as a radiological parameter of interest because it is a decay product of ^{226}Ra, a radionuclide of concern at WLLS. ^{222}Rn is also generated by decay of ^{226}Ra naturally occurring in soil and rock, and a significant portion of this ^{222}Rn is naturally released from the ground into the atmosphere because, as a noble gas, radon becomes unbound to soil and rock. The rate of release from the ground and concentration of ^{222}Rn in outdoor air depend on a number of factors including local geology, soil porosity, soil moisture, and atmospheric pressure. Outdoor ^{222}Rn levels fluctuate but are normally around 0.4 pCi/L of air (EPA 2012).

4.2.1 Sampling Procedure

Electret ion chamber radon detectors (Rad Elec E-PERM®) equipped with high-volume chamber ("H-chamber") short-term ("ST") electrets were used to assess ^{222}Rn levels at each off-site monitoring station. Electret measurements proceed by use of an Electret Voltage Reader to measure a beginning and final electrical charge on the electret exposed for a specified time period. In addition, one pocket ion chamber per station (co-located with the electret ion chamber radon detectors) provides a gross gamma activity measurement used in the final ^{222}Rn measurement calculation (see Appendix C to examine this calculation). Electrets and pocket ion chambers were read weekly to yield a ^{222}Rn measurement that was continuously integrated (averaged) over the week-long exposure duration. Three electret ion chambers were deployed per off-site monitoring station to provide redundant measurements in case of a device failure, and to provide an indication of total method precision.

4.2.2 Data Validation, Verification, and Usability

^{222}Rn measurements were reviewed by the START project manager and were qualified as necessary based on sampling deviations noted in the field or any irregularities in the data. Qualifiers assigned to the radon measurements included the following:

<u>Off-Scale Pocket Ion Chamber Readings (G1)</u>

Several pocket ion chamber exposure readings exceeded the 2.0 milliroentgen (mR) scale of the pocket ion chamber; for these measurements, a final exposure reading of 2.0 mR (the maximum scale reading) was assumed, possibly resulting in a low bias to the gamma exposure value input to the calculation of ^{222}Rn concentration. Because higher gamma exposure values induce larger subtractions to the final ^{222}Rn concentration, ^{222}Rn concentrations associated with off-scale pocket ion chamber readings (those flagged "G1") may be biased high.

Electret Measurements Below Usable Voltage (LV1, LV2, and LV3)

Per the manufacturer, an electret showing a reading of less than 200 volts should not be used for measurements because the weaker electrostatic field is not as consistent in collecting the ions efficiently. Some replicate measurements were associated with a final reading below 200 volts; these readings were not used in calculation of the weekly station ^{222}Rn measurement. Weekly station measurements associated with electret readings below 200 volts were flagged either "LV1" (one replicate was below 200 volts), "LV2" (two of the three replicate electrets fell below 200 volts), or "LV3" (each of the three replicates fell below 200 volts). Only one weekly ^{222}Rn measurement was flagged "LV3" (the measurement at Station 4 from June 20-27); because each of the three replicate measurements was unusable, no ^{222}Rn concentration was reported. Starting on October 21, 2014, the corrective action of removing from service any electret with a reading of less than 300 volts was taken to decrease occurrences of final electret readings below 200 volts.

Missing Measurements (V1, V2, and E)

Vandalism affected ^{222}Rn measurements at Station 4 during weeks ending July 3 and 11, 2014 (see Appendix B, Table B-6 for explanations of qualifiers "V1" and "V2"). Several measurements were associated with one or more replicate electret readings yielding a negative ^{222}Rn concentration; these values were not included in the weekly calculated ^{222}Rn concentration for the station, and are flagged as "E1," "E2,", or "E3" indicating the number of negative replicate measurements (no mean ^{222}Rn concentration is reported for measurements flagged "E3").

Replicate Measurements Identified as Outliers by Statistical Evaluation (OH and OL)

Following determination of data usability with respect to the aforementioned qualifiers, an assessment for low and high outliers was conducted where three usable replicate measurements remained (a minimum of three measurements is required to statistically assess for outliers). Dixon's statistical procedure for outlier identification was used to assess for outliers; this procedure was implemented as described in *U.S. Nuclear Regulatory Commission NUREG 1475*, Chapter 26.4, assuming a probability of erroneously labeling an observation as an outlier (α) of 0.05. Use of Dixon's procedure was also recommended by Rad Elec, Inc., the manufacturer of the radon detectors used at WLLS, to identify any suspect measurements. Where an outlier was detected, it was not reflected in the reported weekly station ^{222}Rn concentration (the replicate ^{222}Rn concentrations are listed in Appendix C, Table C-1). The qualifiers "OH" and "OL" indicate that one of the three replicate ^{222}Rn measurements was identified either as high (OH) or low (OL), and was not used to calculate the reported mean weekly station ^{222}Rn concentration.

Some weekly measurements could not be assessed for identification of outliers using Dixon's procedure because fewer than three replicate measurements were available. Data users should be aware that because these weekly station measurements were not amenable to this procedure, they may be less robust than measurements amenable to Dixon's procedure that led to removal of detected outliers from the reported average result. Measurements flagged "LV1," "LV2," "E1," and "E2" are affected because these derived from fewer than three usable replicate measurements; these measurements are regarded as not meeting data quality objectives (DQO), and are depicted as open circles in the radon time series plot on Exhibit 14 and are not included in the boxplot on Exhibit 15.

4.2.3 Radon Results and Evaluation

The following describes ^{222}Rn results from weekly monitoring from April 25 through February 17, 2015.

Summary Statistics

For each monitoring station, Table 7 lists minimum, median, and maximum ^{222}Rn concentrations.

TABLE 7

SUMMARY STATISTICS OF RADON-222 RESULTS

Summary Statistic	Station 1	Station 2	Station 3	Station 4	Station 5 (reference)
Number of Measurements	43	43	43	41	42
Minimum Concentration	0.19	0.15	0.12	0.09	0.11
Median Concentration	0.28	0.24	0.27	0.21	0.30
Maximum Concentration	1.01	1.81 LV2	1.88 LV1	0.95 E1	1.45 LV1

Notes:

All concentrations in picoCuries per liter (pCi/L)

E Indicates one of three replicate measurements yielded a negative radon concentration. The negative radon value was not included in the reported mean radon concentration.

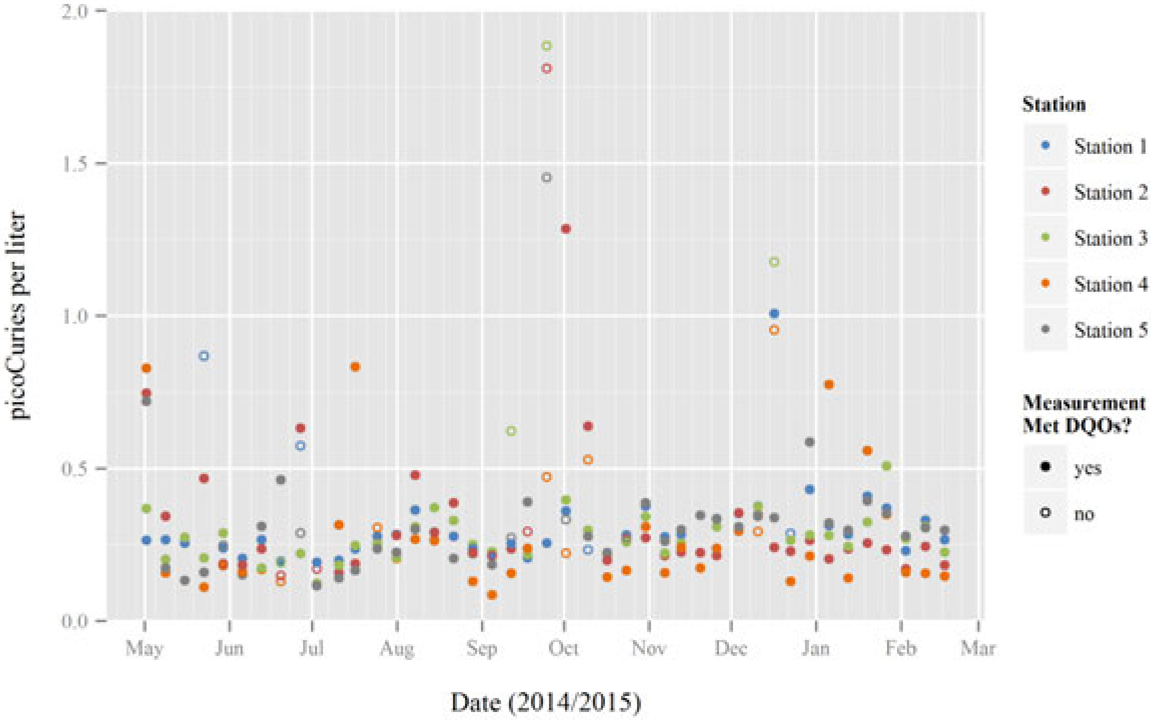
LV Indicates one (LV1) or two (LV2) of the three replicate measurements were not used in the calculation of the reported mean ^{222}Rn concentration because the measurement derived from an electret showing a reading below 200 volts.

Time Series Plot

The only discernable trend or pattern shown on the Exhibit 14 time series plot of ^{222}Rn results is that radon concentrations measured over the same week often appear related by a common component that varies in a sinusoidal pattern.

EXHIBIT 14

TIME SERIES PLOT OF RADON-222

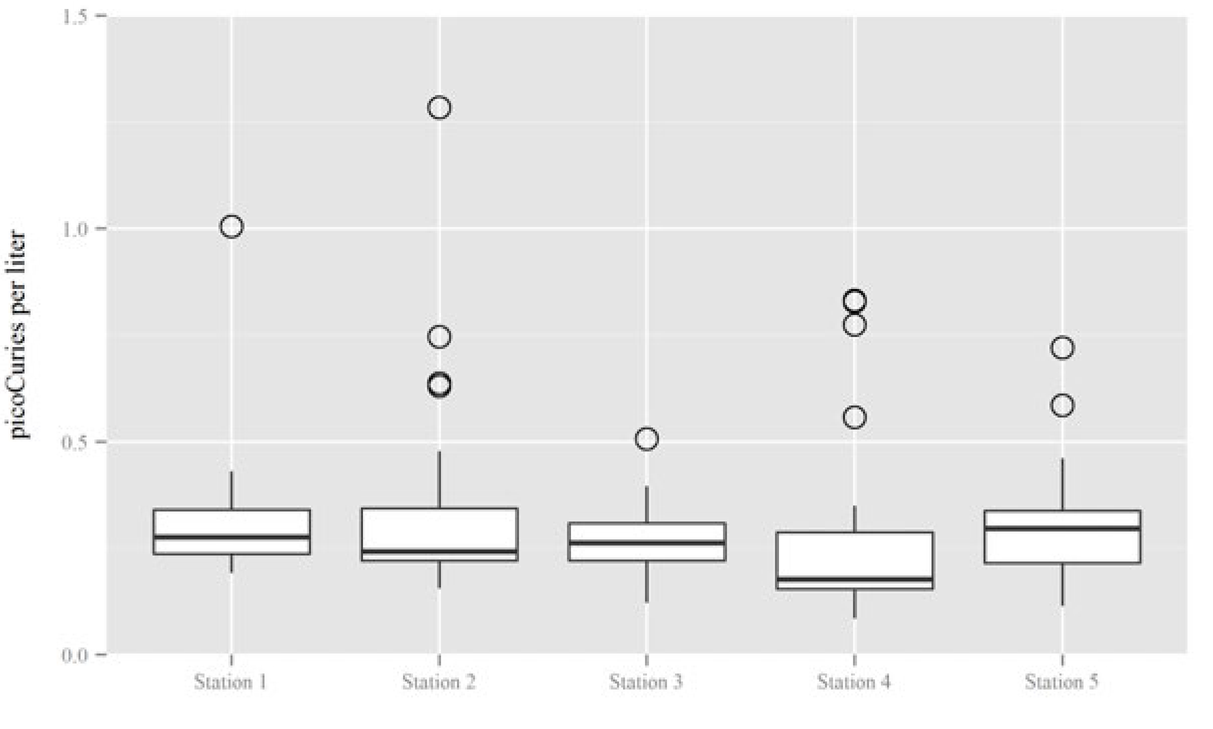


Box Plots

Examination of the ^{222}Rn box plots in Exhibit 15 suggests that the median of ^{222}Rn concentrations is similar among the five monitoring stations. The box plots suggest upper end outlier concentrations (indicated by open circles) at each of the five stations (including the reference Station 5), about which data users should be aware; however and notably, maximum ^{222}Rn concentrations detected at each of the five stations are within an order of magnitude.

EXHIBIT 15

BOX PLOTS OF RADON ACTIVITY



4.2.4 Statistical Analyses

The Kruskal-Wallis and Friedman tests were used to evaluate the ^{222}Rn data, as these were applied to evaluate the airborne particulate radionuclide data (see Section 4.1.8). Statistical software package R was used to apply the Kruskal-Wallis and Friedman tests (see Appendix D for the input data sets, R scripts, and R output). Radon measurements not meeting DQOs (those flagged "LV1," "LV2," "E1," and "E2"—see Section 4.2.2) were not included in the statistical analyses.

The Kruskal-Wallis and Friedman test found a tendency for some station ^{222}Rn measurements to be larger or smaller than measurements at other stations; however, none of the perimeter stations (Stations 1– 4) showed a tendency to yield larger or smaller measurements than the reference station (Station 5). Table 8 summarizes the Kruskal-Wallis and Friedman test results.

TABLE 8

SUMMARY OF STATISTICAL TEST EXAMINING RADON-222 RESULTS

Statistical Test	Result of Statistical Test for Radon-222
Kruskal-Wallis[1]	Station 4 tended to yield smaller measurements than Station 1; however, none of the perimeter stations (Stations 1 – 4) showed a tendency to yield larger or smaller measurements than the reference station (Station 5) (p = 0.00851)
Friedman[2]	Station 2 tended to have smaller measurements than Station 1 and Station 4 tended to yield smaller measurements than Stations 1 and 3; however, none of the perimeter stations (Stations 1-4) showed a tendency to yield larger or smaller measurements than the reference station (Station 5). (p = 0.0002538)

Notes:

1 Results from the statistical software package R version 3.1.2 using the non-parametric Kruskal-Wallis test to compare the various radionuclide mean/median characteristics among the five monitoring stations. A p-value equal to or less than 0.05 suggests significant differences in mean/median characteristics among the stations. A p-value of greater than 0.05 suggests that the mean/median characteristics among the stations are comparable. See Appendix D to examine the Kruskal-Wallis test output from R.

2 Results from the statistical software package R version 3.1.2 using the non-parametric Friedman test to identify tendencies for measurements at one station to be larger or smaller than at any other station. A p-value equal to or greater than 0.05 suggests no tendency for one station to yield larger or smaller measurements than any other station. A p-value less than 0.05 suggests that one or more stations tended to yield measurements larger or smaller than other stations. See Appendix D to examine the test output from R.

4.3 EXPOSURE RATE MEASUREMENTS

The following sections discuss continuous external gamma exposure rate measurements taken at the five monitoring stations by use of Saphymo GammaTRACERs. Measurements were recorded from May 1, 2014 through May 26, 2015 at Stations 1, 2, 3, and 5, and May 1, 2014 through May 1, 2015 at Station 4. Although a release of RIM via airborne particulates from WLLS is not anticipated to result in an off-site external gamma exposure rate distinguishable from background variability, acquisition of these data continues because the data possibly will be used as a reference for future monitoring campaigns that include exposure rate measurements. Moreover, sources of gamma activity not related to West Lake Landfill RIM may occasionally induce a detector response above background. Such sources may include nuclear medical materials passing by the detector (including patients receiving nuclear medicine), cosmic events (such as naturally occurring gamma-ray bursts), or precipitation to which naturally occurring airborne radionuclides adhere (as indicated in measurements presented herein and discussed in Section 4.3.2).

4.3.1 Monitoring Procedure

At each of the five monitoring stations, EPA installed a Saphymo GammaTRACER exposure rate monitor that incorporates two Geiger-Mueller (GM) detector tubes (a high-range detector and a low-range detector). The GM tubes respond to ionization produced within the detector by gamma radiation. On an hourly basis, the GammaTRACER was programmed to report an average exposure rate reading from the previous hour-long interval. The exposure rate measurement was reported in units of microRoentgens per hour (μR/hr). The hourly measurements were transmitted wirelessly to a field command post computer and then logged by EPA Environmental Response Team's Viper data management software. Typical exposure rate readings in outdoor environments fluctuate around 10 μR/hr—this background radiation is primarily the result of cosmic and terrestrial sources of radiation (NCRP 1987).

4.3.2 Data Validation, Verification, and Usability

The exposure rate data underwent review by a member of the EPA Environmental Response Team knowledgeable of the Saphymo GammaTRACER system, and by START field staff aware of day-to-day field activities. These reviews have revealed the following information regarding the data about which users should be aware:

- At Station 1, exposure rate readings dropped by approximately 2 to 3 μR/hr on August 22, 2014. This shift in the exposure rate readings was investigated and found to have been caused by an approximately 1-foot layer of crushed limestone gravel that had been placed on the ground surface beneath the Station 1 GammaTRACER. The gravel had been placed in preparation for construction of a training structure for the Robertson Fire Protection District adjacent to firehouse #2. The gravel had evidently caused measurable shielding of naturally occurring terrestrial radiation. The lower exposure rate readings continued until September 30, 2014, when the Station 1 GammaTRACER had to be moved to make way for the construction (the GammaTRACER was moved approximately 370 feet to the north-northeast closer to the firehouse #2 building). As evident in the plot of exposure rate readings for Station 1 (see Appendix E, Exhibit E-1), exposure rate readings increased 2 to 3 μR/hr after movement of the GammaTRACER to the new location.

- Plots of the GammaTRACER data revealed numerous temporary spikes in the exposure rate readings at each of the stations that occurred simultaneously at the five stations. Plotting the GammaTRACER data against precipitation events revealed a strong correlation (see Exhibit 16), indicating that the temporary spikes in exposure rate readings likely had resulted from "precipitation scavenging" (or washout) of airborne radionuclides. In this process, radionuclides (primarily radon daughter products) suspended as aerosols in the atmosphere coalesce with precipitation and are transported with the falling precipitation to the ground surface. These precipitation-scavenged radionuclides can then cause an increase in exposure rates measured in air near the ground surface (Paatero and Hatakka 1999).

Overall, the Saphymo GammaTRACER measurements are usable for the intended purpose of providing pre-construction baseline exposure rate data.

4.3.3 GammaTRACER Monitoring Data and Evaluation

Exhibits 16 and 17 shows a time series plots of GammaTRACER data acquired from May 1, 2014 to December 31, 2014 and from January 1, 2015 to June 24, 2015. Also on the plots, precipitation events are indicated by vertical bands. These events were identified by use of data obtained from the National Oceanic and Atmospheric Administration (NOAA) Quality Controlled Local Climatological Data (QCLCD) dataset (NOAA 2015)—specifically precipitation data acquired at the Lambert-St. Louis International Airport Station 13994, approximately 2 miles east of WLLS. A vertical band indicates a recorded hourly precipitation of 0.01 inch or more (events of only trace precipitation are not represented on Exhibit 16). Thicker bands indicate a precipitation event persisting over multiple hours. Time series plots of individual station data are in Appendix E.

EXHIBIT 16

TIME SERIES PLOT OF EXPOSURE RATE BY SAPHYMO GAMMATRACERS – MAY 1 THRU DECEMBER 31, 2014

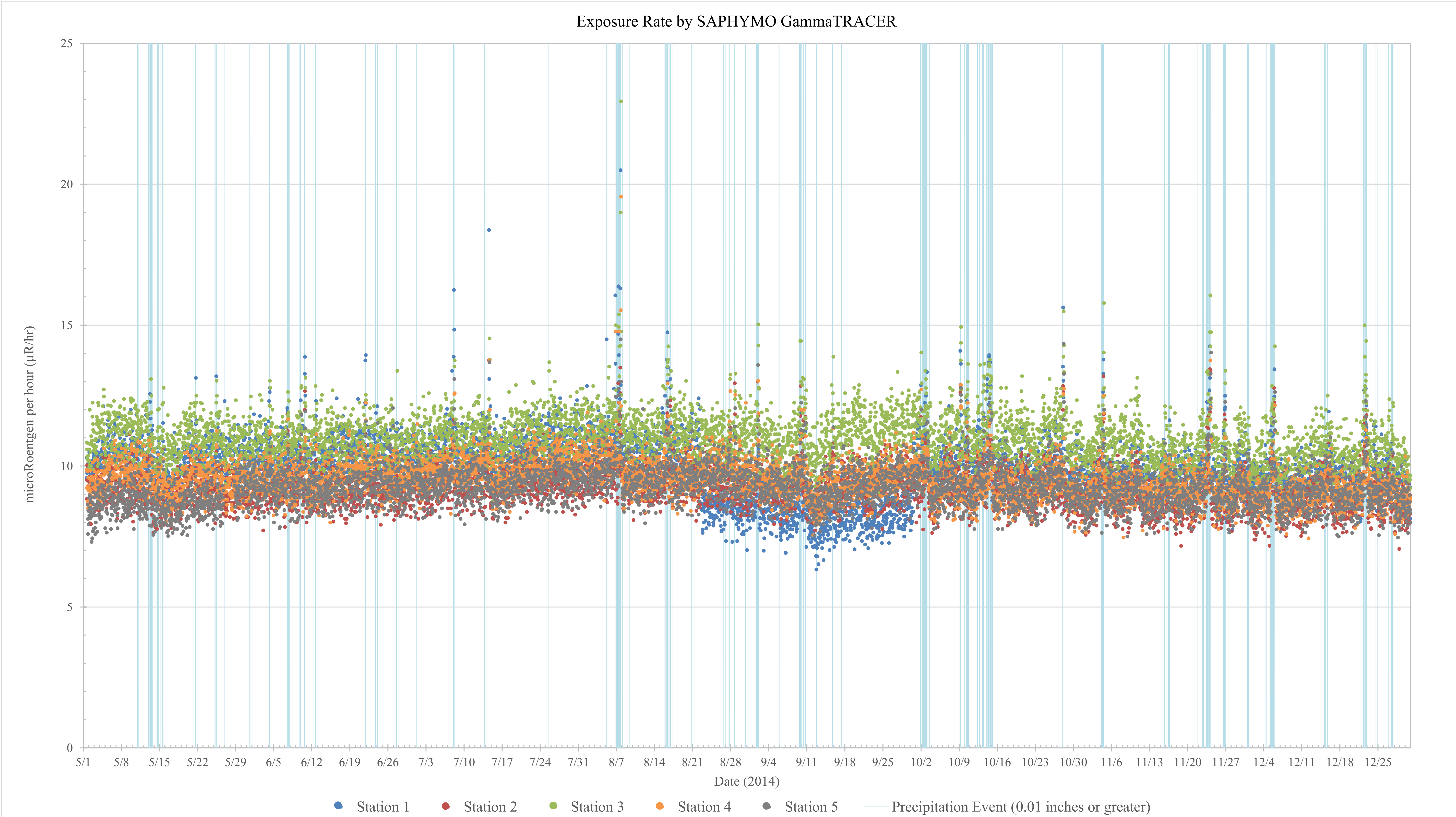


EXHIBIT 17

TIME SERIES PLOT OF EXPOSURE RATE BY SAPHYMO GAMMATRACERS – JANUARY 1 THRU JUNE 24, 2015

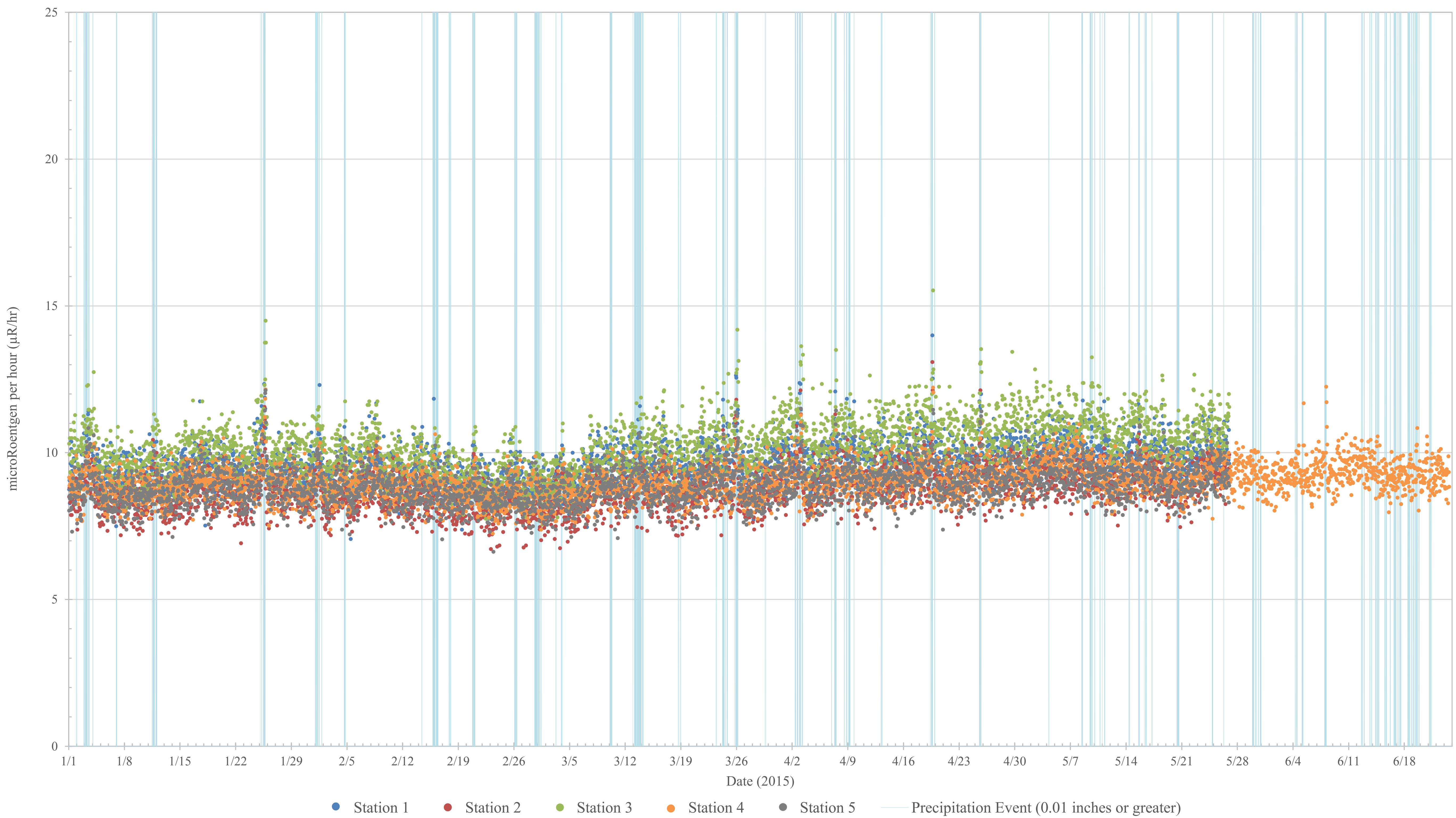


Exhibit 16 illustrates the following characteristics of the GammaTRACER data:

- Exposure rates are around 10 µR/hr—a typical exposure rate within outdoor environments (NCRP 1987)—with rates at some stations tending to be slightly higher or lower than 10 µR/hr (an expected outcome due to variations in local geology and surface conditions).

- At Station 1, exposure rate readings were noticeably lower between August 22 and September 30, 2014. As discussed in Section 4.3.2, this was the time period when crushed limestone gravel was beneath the detector (related to a nearby construction project). Exposure rate readings increased when the detector was moved to a new location to make way for construction.

- Numerous temporary spikes in the exposure rate readings strongly correspond to precipitation events. As discussed in Section 4.3.2, these occurrences likely resulted from precipitation scavenging of naturally occurring airborne radionuclides (likely radon daughter products) that caused a temporary increase in near ground-level exposure rates. Notably, all measurements exceeding 15 µR/hr appear to be associated with a precipitation event.

Overall, the gamma rate measurements appear typical for an outdoor environment.

4.3.4 Statistical Analysis

Statistical analysis to compare the mean/median characteristics among stations was not conducted because differences in the mean/median characteristics among the five stations are already evident on plots of the data (e.g., Stations 1, 2, 4, and 5 tend to have lower exposure rate measurements than Station 3). These differences are anticipated because localized differences in geology and ground surface conditions measurably affect exposure rates (e.g., placement of crushed limestone gravel beneath the Station 1 GammaTRACER detector noticeably lowered the exposure rate).

4.4 ENVIRONMENTAL DOSIMETRY

Landauer, Inc. InLight optically stimulated luminescent dosimeters (OSLs) were deployed at the stations to passively measure external exposure, supplementing the exposure rate measurements obtained from the Saphymo GammaTRACERs (see Section 4.3). The InLight OSLs, generally deployed for 3 to 6 weeks, provided long-term dose measurements. The InLight OSLs have a nominal minimum detectable dose of 0.1 millirem (mrem) (detecting x-ray and gamma photons with energies exceeding 15 kiloelectron-volts [keV]), and measurements are reported as an ambient dose equivalent. (Although the OSLs were deployed primarily to measure external gamma activity, the OSLs are also sensitive to beta radiation with energies exceeding 500 keV at a minimum detectable dose of 20 mrem.)

Consistent with discussion regarding the Saphymo GammaTRACER exposure rate measurements (Section 4.3), a release of RIM via airborne particulates from WLLS is not anticipated to induce an off-site external exposure that would be measureable by use of OSLs; however, the data were acquired for possible use as a reference for future monitoring campaigns that include dosimeter measurements.

4.4.1 Monitoring Procedure

Landauer, Inc. InLight OSLs were deployed at each station for continuous periods of approximately 3 to 6 weeks. Three OSLs were deployed per station to provide replicate measurements. When the deployment period ends, the OSLs were retrieved and shipped to the dosimeter provider for analysis.

4.4.2 Data Validation, Verification, and Usability

Review of the OSL data and field observations have revealed the following information regarding the data about which users should be aware:

- After reception of the first two rounds of OSL readings, it was suspected that elevated gamma activity from nearby masonry walls may have been contributing to OSL dose readings at some stations. This was confirmed in June 2014, when EPA and START, using a Ludlum microR, detected higher dose readings near the masonry walls at Stations 2, 3, and 4 near where the OSLs had been deployed (it is not uncommon for buildings constructed of stone or bricks to have higher natural radiation levels than buildings made of other materials such as wood [Nuclear Regulatory Commission [NRC] 2011]). Based on this information, the OSLs were re-positioned away from masonry walls (the OSLs at each station were re-positioned next to that station's GammaTRACER detector). The OSLs at Stations 1, 2, 3, and 5 were re-positioned on July 1, 2014. The OSLs at Station 4 were re-positioned on October 31, 2014.

- The dosimeter provider reports a gross dose in units of mrem for each OSL badge. The gross dose includes the dose received during the 3 to 6 week deployment, but also includes ambient dose received during the pre- and post-deployment periods because the element in the OSL is continuously exposed to ambient gamma radiation (pre-deployment time being the duration beginning when the badge is prepared by the provider and ending when the badge is deployed by the user; post-deployment being the duration beginning when the badge is retrieved by the user and ending when the badge is read by the provider). Thus, for a badge deployed for 3 to 6 weeks, a significant portion of the gross dose reported is likely to be from doses received during pre- and post-deployment periods. Because of this, net dose values—calculated by determining differences in gross dose measurements among OSL badges—may be more useful depending on intended use of the data.

Overall, the OSL environmental dosimetry measurements are usable for measuring relative differences in long-term dose rates among the stations; however, data users should be aware that, as stated above, the OSL badges receive doses during pre- and post-deployment periods (e.g., dose received during shipment), resulting in dose readings that vary among the measurements during a particular deployment. Moreover, data users should be aware that a release of RIM via airborne particulates from WLLS is not anticipated to induce an off-site external exposure that would be measureable by use of OSLs.

4.4.3 Environmental Dosimeter Results and Evaluation

Table 9 lists the monthly OSL environmental dosimeter results.

TABLE 9

ENVIRONMENTAL DOSIMETER RESULTS – GROSS DOSE

Deployment Period …beginning	…ending	Days Deployed	Station 1	Station 2	Station 3	Station 4	Station 5 (background)
04/29/14	05/30/14	31	9.8	12.9	9.9	10.9	9.2
05/30/14	07/01/14	32	15.0	17.4	15.3	15.9	13.9
07/01/14	08/01/14	31	11.8	10.9	11.5	12.4	10.9
08/01/14	09/02/14	32	10.8	10.8	10.9	11.9	10.6
09/02/14	10/03/14	31	8.8	10.0	10.2	11.4	10.1
10/03/14	10/31/14	28	11.9	10.9	11.4	12.5	11.5
10/31/14	12/02/14	32	11.1	10.6	11.0	11.0	11.0
12/02/14	01/07/15	36	11.2	11.5	12.0	11.8	11.4
01/07/15	02/06/15	30	10.1	9.5	9.9	10.4	9.2
02/06/15	03/06/15	28	9.6	9.1	9.3	9.6	9.1
03/06/15	04/10/15	35	11.7	11.3	11.7	11.8	11.7
04/10/15	05/05/15	25	10.7	10.8	11.0	11.6	10.8
05/05/15	06/18/15	44	13.9	13.6	14.1	14.1	13.7
06/18/15	07/31/15	43	- [a)]	- [a)]	- [a)]	14.3	- [a)]

Notes:

All units in millirem (mrem)

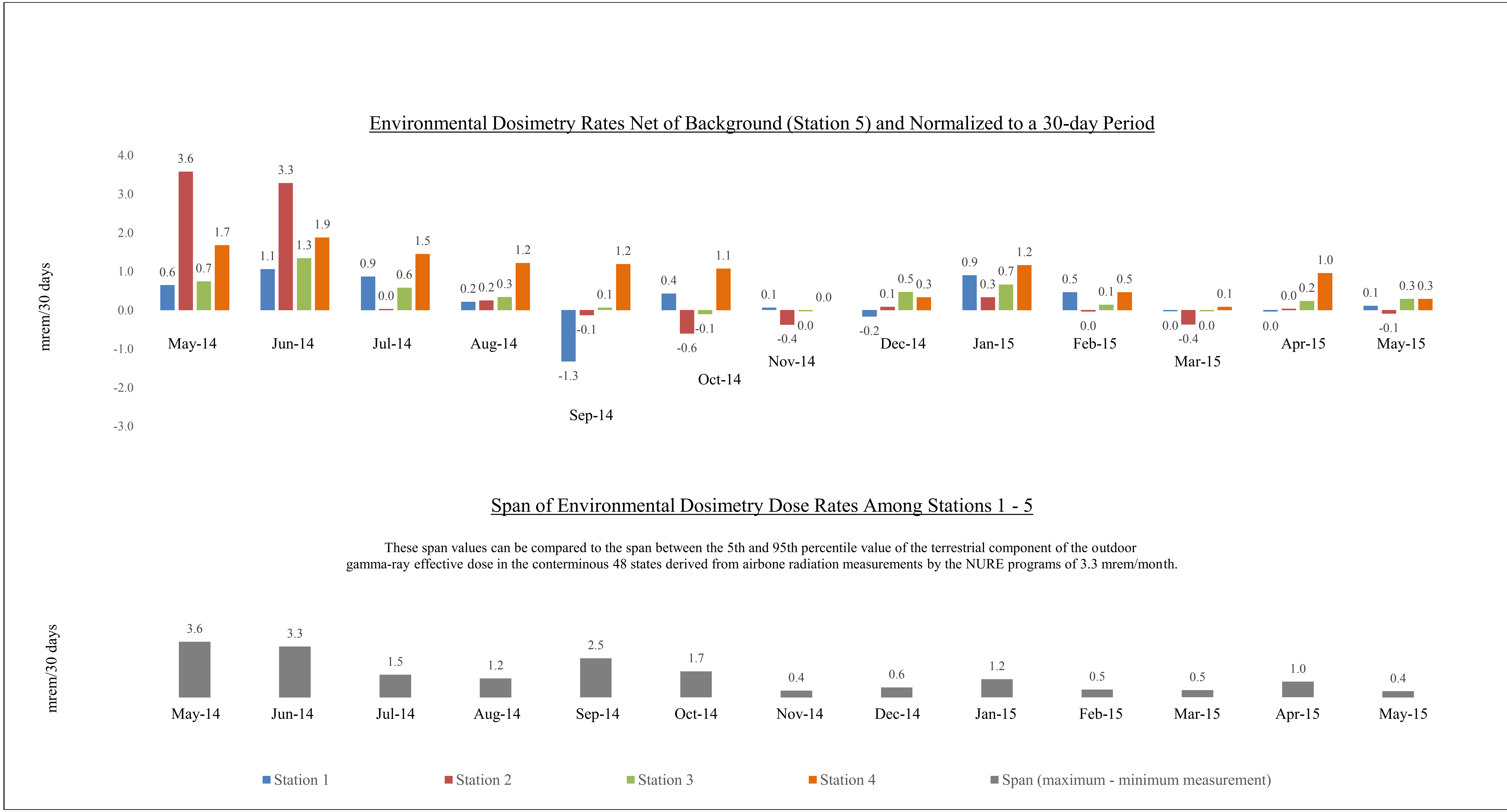
[a)] Environmental dosimeters were deployed at Station 4 only during the last deployment period.

Typical outdoor environmental dosimetry readings range from 5 to 15 mrem per month (see NCRP 1987, Table 5.4); however, as previously described, OSL dosimeter results include contributions to dose received during pre- and post-deployment periods.

Exhibit 18 shows the Station 1 through 4 OSL environmental dosimetry results net of the Station 5 (the reference station) OSL result and normalized to a 30-day period. Relative differences between OSL results were notably greater before the OSLs were moved away from masonry building walls (on July 1 for Stations 1, 2, 3, and 5, and October 31 for Station 4). Also shown on Exhibit 17 is the difference between the minimum and maximum result (or span) for each deployment period. These values can be compared to the span between the reported 5th and 95th percentile values of the terrestrial component of the outdoor gamma-ray effective dose in the conterminous 48 states derived from airborne radiation measurements by the National Uranium Resource Evaluation (NURE) programs of 3.3 mrem/month (NCRP 2009).

EXHIBIT 18

ENVIRONMENTAL DOSIMETRY RATES BY OSL DOSIMETERS



Overall, the OSL dosimetry data appear normal for outdoor ambient measurements, considering the likely contributions to the dose readings from masonry building walls that occurred before the OSLs were re-positioned away from building walls.

4.4.4 Statistical Analysis

Statistical analysis to compare the mean/median characteristics among stations was not conducted because differences in the mean/median characteristics among the five stations is anticipated (as with the GammaTRACER exposure rate data)—localized differences in geology and ground surface conditions measurably affect exposure rates.

5.0 SUMMARY OF OBSERVATIONS

The following summarizes observations regarding radiological data acquired during the baseline monitoring period (from May 2014 to July 2015) at off-site monitoring stations:

Radionuclides on Airborne Particulates

To determine airborne concentrations of radionuclides transported via airborne particulates, airborne particulates were collected onto glass fiber filter media by use of high-volume air samplers. Air sampling occurred continuously, and air filter samples were collected approximately every 7 days and submitted for laboratory analysis for gross alpha, gross beta, gamma-emitting radionuclides, isotopic uranium, isotopic thorium, and total alpha-emitting radium. The air filter results evaluated were gross alpha/beta, ^{238}U, ^{230}Th, and total alpha-emitting radium (including ^{226}Ra). Examination of box plots indicated similarity of medians and distributions of these parameters among the five monitoring stations. The box plots did reveal some suggested outliers about which data users should be aware, but the outliers were within an order of magnitude of the maximum concentrations detected among the other stations.

Two statistics tests—the Kruskal-Wallis and Friedman tests—were used to test for differences in gross alpha/beta, ^{238}U, ^{230}Th, and total alpha-emitting radium (including ^{226}Ra) concentrations among the five monitoring stations. The Kruskal-Wallis test did not identify significant differences in the mean/median characteristics among the five monitoring stations based on the data examined (gross alpha/beta, ^{238}U, ^{230}Th, and total alpha-emitting radium), and the pair-wise Friedman test found no tendency for one station to yield larger or smaller measurements than any other station.

A comparison of specific alpha-emitting radionuclide results (^{238}U, ^{230}Th, and total alpha-emitting radium results) to their corresponding gross alpha results occurred to determine if the data conformed to expectation that alpha-emitting radionuclide results would be a component of (and thus less than) gross alpha results. This evaluation revealed numerous instances of nonconformity of the data to this expectation. Notably, the maximum detected ^{238}U, ^{230}Th, and total alpha-emitting radium concentrations did not conform to corresponding gross alpha concentrations. Data users should be aware of this characteristic of the data.

Radon

^{222}Rn has been identified as a radiological parameter of interest because it is a decay product of ^{226}Ra, a radionuclide of concern at WLLS. ^{222}Rn is also generated by decay of ^{226}Ra naturally occurring in soil and rock, and a significant portion of this ^{222}Rn is naturally released from the ground into the atmosphere because, as a noble gas, radon becomes unbound to soil and rock. Average weekly ^{222}Rn concentrations were measured at the five off-monitoring stations by use of electret ion chamber radon detectors (RadElec E-PERM®).

Examination of the radon box plots appears to show similar median radon concentrations among the five monitoring stations (although statistical testing suggested that Stations 2 and 4 tended to yield smaller radon measurements than other stations). The box plots suggest upper end outlier concentrations (indicated by open circles) at each of the five stations (including the reference Station 5) about which data users should be aware; however and notably, maximum detected radon concentrations among the five stations are within an order of magnitude (the station maximums range from 1.01 to 1.88 pCi/L).

Data users should be aware that about one in every three of the weekly radon measurements was qualified; these qualifications were primarily because either (1) one or more replicate measurements was deemed not usable because the final voltage reading was not within the manufacturer's recommended range for a reliable measurement, or (2) Dixon's statistical procedure detected an outlier among three usable replicate measurements.

Exposure Rate Measurements

Hourly exposure rate measurements were obtained by use of Saphymo GammaTRACER exposure rate monitors installed at each of the five off-site monitoring stations. Although a release of RIM via airborne particulates from the WLLS is not anticipated to induce an off-site external gamma exposure rate that would be distinguishable from background variability, the data were acquired for possible use as a reference for future monitoring campaigns that include exposure rate measurements. Review of the GammaTRACER data revealed that exposure rates at the five monitoring stations fluctuated around 10 μR/hr—a typical exposure rate for outdoor environments (NCRP 1987)—with readings at some stations tending to be slightly higher or lower than 10 μR/hr (expected due to variations in local geology and surface conditions). Numerous temporary spikes in the exposure rate readings corresponded to precipitation events, indicating likely precipitation scavenging (or washout) of airborne radionuclides (a process whereby radionuclides—primarily radon daughter products—suspended as aerosols in the atmosphere coalesce with precipitation and are transported with the falling precipitation to the ground surface). Overall, the gamma rate measurements appear typical for an outdoor environment.

Environmental Dosimetry

Approximately month-long environmental dosimetry measurements were obtained at the off-site monitoring stations by use of Landauer, Inc. InLight OSLs to supplement exposure rate measurements obtained by use of Saphymo GammaTRACERs. The OSL dosimetry data appear normal for outdoor ambient measurements.

6.0 REFERENCES

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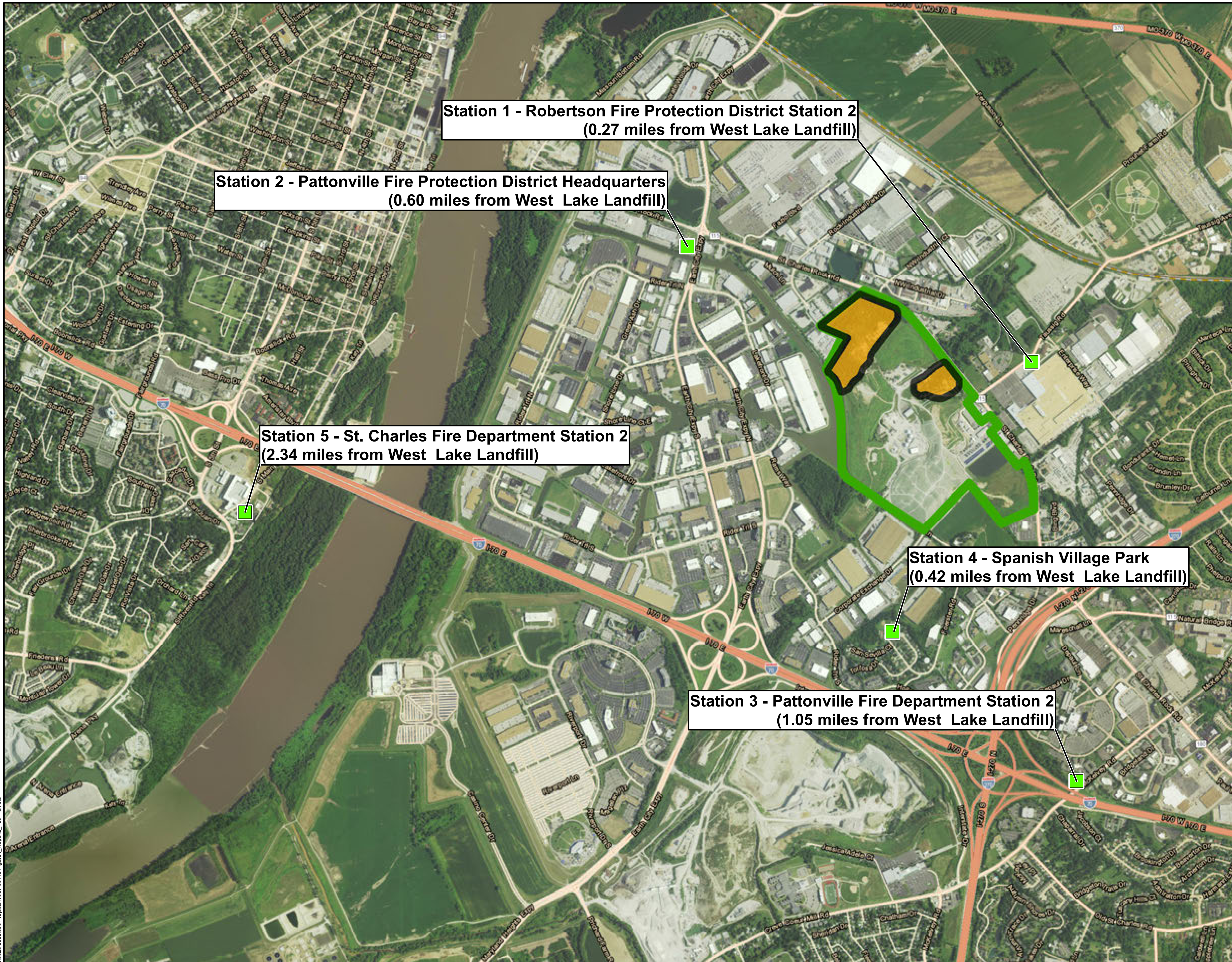
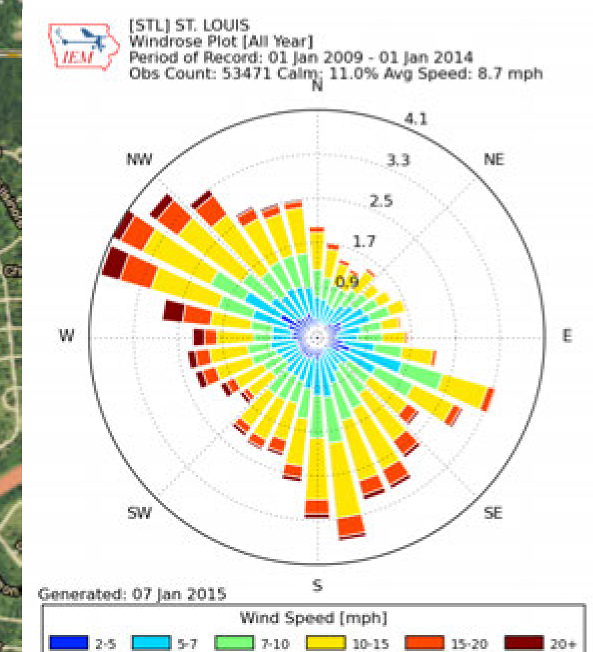
APPENDIX A

FIGURES



Legend

- Off-site air monitoring station
- West Lake Landfill Site Operable Unit 1 (radiological area)
- Bridgeton Landfill



N

0 1,000 2,000

Feet

Source: ArcGIS Online Aerial Imagery, 2013; Iowa State University of Science and Technology, 2015

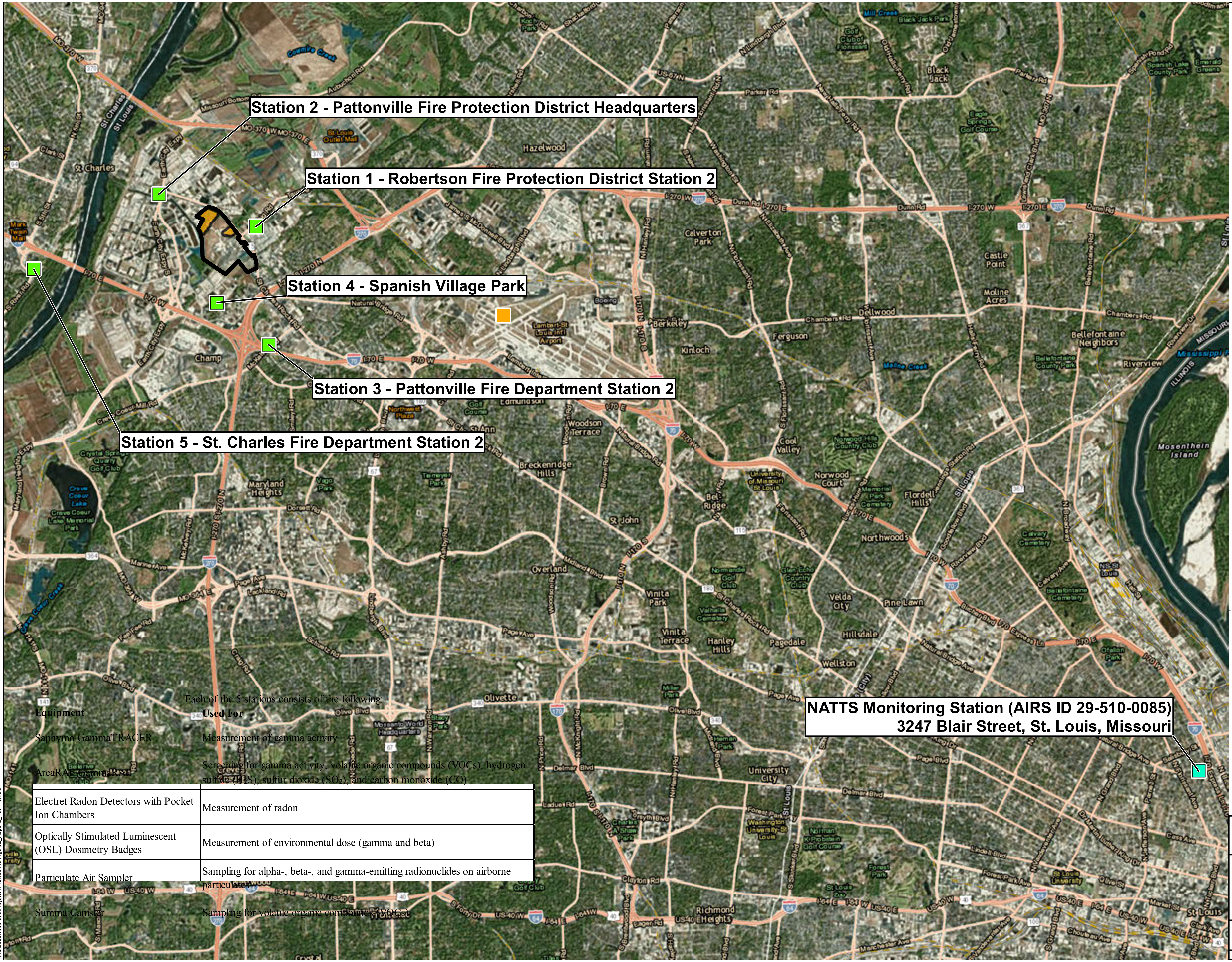
West Lake Landfill
Bridgeton, Missouri

Figure 1

Off-Site Air Monitoring Stations

TETRA TECH

Date: 10/1/2015 | Drawn By: Bill Spiking | Project No: X9025.14.0058.000



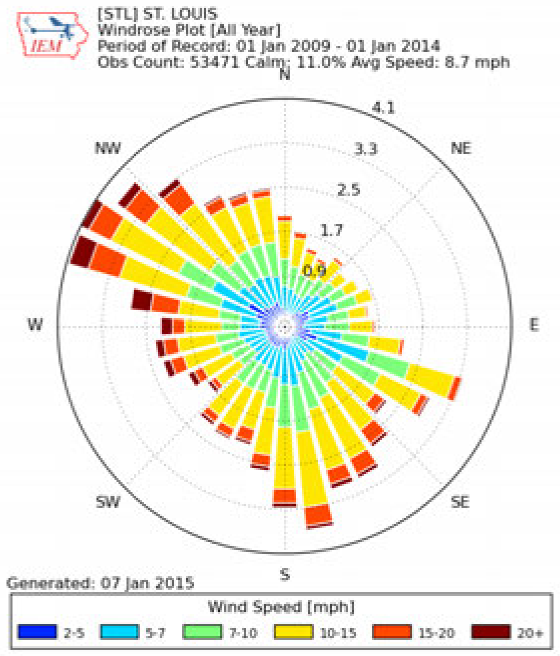
Each of the 5 stations consists of the following:

Equipment	Used For
Saphymo GammaTRACER	Measurement of gamma activity
AreaRAE Gamma Rae	Screening for gamma activity, volatile organic compounds (VOCs), hydrogen sulfide (H_2S), sulfur dioxide (SO_2), and carbon monoxide (CO)
Electret Radon Detectors with Pocket Ion Chambers	Measurement of radon
Optically Stimulated Luminescent (OSL) Dosimetry Badges	Measurement of environmental dose (gamma and beta)
Particulate Air Sampler	Sampling for alpha-, beta-, and gamma-emitting radionuclides on airborne particulates
Summa Canister	Sampling for volatile organic compounds (VOCs)

Legend

- Lambert St. Louis International Airport Metar Station
- NATTS monitoring station
- Off-site air monitoring station
- Bridgeton Landfill
- West Lake Landfill Site Operable Unit 1 (radiological area)

NATTS National Air Toxics Trends Station



N

0 3,500 7,000

Feet

Source: ArcGIS Online Aerial Imagery, 2013; Iowa State University of Science and Technology, 2015

West Lake Landfill
Bridgeton, Missouri

Figure 2

Location of St. Louis NATTS Air Monitoring Station

TETRA TECH

Date: 10/1/2015 Drawn By: Gustavo Orozco Project No: X9025.14.0058.000

APPENDIX B

TABULATED AIR MONITORING RESULTS

TABLE B-1

GROSS ALPHA ON AIRBORNE PARTICULATES
WEST LAKE LANDFILL OFF-SITE BASELINE AIR MONITORING

Date	Gross Alpha				
	Station 1 Robertson St. 2	Station 2 Pattonville Adm.	Station 3 Pattonville St. 2	Station 4 Spanish Village	Station 5 [a] St. Charles St. 2
05/08/14	1.27E-03 J	8.23E-04 J	4.42E-04 U	3.00E-04 U	1.31E-03 J
05/15/14	4.12E-04 J	5.19E-04 J	3.82E-04 U	1.76E-04 U	5.42E-04 J
05/22/14	5.95E-04 J	8.48E-04 J	5.70E-04 J	8.07E-04 J	3.97E-04 U
05/29/14	4.18E-04 J	4.58E-04 J	7.30E-04 J	6.10E-04 J	6.28E-04 J
06/05/14	4.64E-04 J	1.93E-04 U	6.26E-04 J	3.53E-04 U	1.10E-04 U
06/12/14	4.06E-04 U	3.97E-04 U	3.60E-04 U	3.92E-04 U	2.13E-04 U
06/19/14	7.74E-04 J	4.25E-04 J	7.80E-04 J	6.26E-04 J	5.70E-04 J
06/26/14	3.25E-04 U	8.18E-04 J	5.29E-04 U	3.26E-04 U	3.51E-04 U
07/03/14	7.50E-04 J	9.33E-04 J	5.69E-04 J	3.30E-04 U	9.54E-04 J
07/10/14	4.64E-04 J	7.49E-04 J	7.32E-04 J	1.28E-03 J	8.03E-04 J
07/17/14	8.89E-04 J	1.21E-03 J	8.54E-04 J	9.59E-04 J	7.59E-04 J
07/24/14	5.73E-04 J	5.41E-04 J	2.81E-04 U	5.96E-04 J	5.00E-04 J
07/31/14	9.57E-04	4.50E-04	6.32E-04	9.01E-04	3.71E-04
08/07/14	8.20E-04 J	1.11E-03 J	6.31E-04 J	1.05E-03 J	1.14E-03 J
08/14/14	4.87E-04 J	6.00E-04 J	4.53E-04 J	3.16E-04 U	5.71E-04 J
08/21/14	1.08E-03 J	6.06E-04 J	9.55E-04 J	1.08E-03 J	8.60E-04 J
08/28/14	1.58E-03 J	1.68E-03 J	1.58E-03 J	1.25E-03 J	1.34E-03 J
09/04/14	6.38E-04 J	4.28E-04 U	8.54E-04 J	5.32E-04 U	3.44E-04 U
09/11/14	4.70E-04 U	5.32E-04 U	7.50E-04 U	3.17E-04 U	6.94E-04 U
09/17/14	4.93E-04 U	4.98E-04 U	7.62E-04 U	6.01E-04 U	2.99E-04 U
09/24/14	7.36E-04 U	1.16E-03 U	8.68E-04 U	9.57E-04 U	1.12E-03 U
10/01/14	7.98E-04 J	9.79E-04 J	1.34E-03 J	5.75E-04 J	3.88E-04 U
10/09/14	4.22E-04 J	4.43E-04 J	4.63E-04 J	6.25E-04 J	7.65E-04 J
10/16/14	5.26E-04 J	5.54E-04 J	3.97E-04 J	6.99E-04 J	7.59E-04 J
10/23/14	6.55E-04 J	6.25E-04 J	3.80E-04 U	4.84E-04 J	4.14E-04 U
10/30/14	3.72E-04 U	4.10E-04 J	9.31E-04 J	5.44E-04 J	6.22E-04 J
11/06/14	8.93E-04 J	4.90E-04 U	1.07E-03 J	1.17E-04 U	8.83E-04 J
11/13/14	5.30E-04 J	7.75E-04 J	4.48E-04 U	2.78E-04 U	7.00E-04 J
11/20/14	7.30E-04 J	1.10E-03 J	9.04E-04 J	9.68E-04 J	5.75E-04 J
11/26/14	6.45E-04 J	1.36E-03 J	8.26E-04 J	9.95E-04 J	1.65E-03 J
12/04/14	7.58E-04 J	6.13E-04 J	8.38E-04 J	9.74E-04 J	1.42E-03 J
12/11/14	1.26E-03 J	6.24E-04 J	1.10E-03 J	6.20E-04 J	5.46E-04 J
12/17/14	1.63E-03 J	1.17E-03 J	9.61E-04 J	6.12E-04 J	7.85E-04 J
12/23/14	5.43E-04 J	1.09E-03 J	8.99E-04 J	1.38E-03 J	8.75E-04 J
12/31/14	1.99E-04 U	7.07E-04 J	3.01E-04 U	5.46E-04 J	5.10E-04 J
01/06/15	7.50E-04 J	1.06E-03 J	6.25E-04 J	1.18E-03 J	9.24E-04 J
01/14/15	4.11E-04 U	5.01E-04 J	4.60E-04 J	8.67E-04 J	7.20E-04 J
01/21/15	5.81E-04 J	4.56E-04 U	3.75E-04 U	4.74E-04 J	2.45E-04 U
01/28/15	3.86E-04 J	6.44E-04 J	1.02E-04 U	4.00E-04 U	3.53E-04 U
02/04/15	5.14E-04 J	2.90E-04 U	4.52E-04 J	3.46E-04 U	8.55E-04 J
02/11/15	1.11E-03 J	1.10E-03 J	7.10E-04 J	8.54E-04 J	1.13E-03 J
02/18/15	7.19E-04 J	7.84E-04 J	5.33E-04 J	5.91E-04 J	1.06E-03 J
02/25/15	1.00E-03 J	1.24E-03 J	9.11E-04 J	1.29E-03 J	1.59E-03 J
03/04/15	8.53E-04 J	5.35E-04 U	5.18E-04 U	7.13E-04 J	6.22E-04 J
03/13/15	NS	NS	NS	4.26E-04 U	NS
03/20/15	NS	NS	NS	6.50E-04 J	NS
03/27/15	NS	NS	NS	6.88E-04 J	NS
04/03/15	NS	NS	NS	8.11E-04 J	NS
04/10/15	NS	NS	NS	3.30E-04 U	NS
04/17/15	NS	NS	NS	3.07E-04 U	NS
04/24/15	NS	NS	NS	8.91E-04 J	NS
05/01/15	NS	NS	NS	5.03E-04 J	NS
05/08/15	NS	NS	NS	1.96E-04 U	NS
05/15/15	NS	NS	NS	5.82E-04 U	NS
05/21/15	NS	NS	NS	8.15E-04 J	NS
05/28/15	NS	NS	NS	4.49E-04 U	NS
06/04/15	NS	NS	NS	3.27E-04 U	NS
06/11/15	NS	NS	NS	3.97E-04 U	NS

TABLE B-1 (Continued)

GROSS ALPHA ON AIRBORNE PARTICULATES
WEST LAKE LANDFILL OFF-SITE BASELINE AIR MONITORING

Date	Gross Alpha				
	Station 1 Robertson St. 2	**Station 2** Pattonville Adm.	**Station 3** Pattonville St. 2	**Station 4** Spanish Village	**Station 5 [a]** St. Charles St. 2
06/18/15	NS	NS	NS	4.68E-04 J	NS
06/25/15	NS	NS	NS	2.28E-04 U	NS
07/09/15	NS	NS	NS	7.62E-04 J	NS
07/16/15	NS	NS	NS	6.80E-04 J	NS
07/23/15	NS	NS	NS	6.17E-04 J	NS
07/30/15	NS	NS	NS	7.37E-04 J	NS
No. of Detects	36	34	30	40	32
No. of Samples	44	44	44	64	44
Minimum	1.99E-04 U	1.93E-04 U	1.02E-04 U	1.17E-04 U	1.10E-04 U
Median	6.42E-04	6.25E-04	6.32E-04	6.06E-04	6.97E-04
Maximum	1.63E-03 J	1.68E-03 J	1.58E-03 J	1.38E-03 J	1.65E-03 J

Notes:

All concentrations in picoCuries per cubic meter (pCi/m^3)

[a] Reference station

J Indicates an estimated result (result is less than the reporting limit)

NS Not sampled

U Indicates a non-detected result (result is less than the sample detection limit)

TABLE B-2

GROSS BETA ON AIRBORNE PARTICULATES
WEST LAKE LANDFILL OFF-SITE BASELINE AIR MONITORING

Date	Gross Beta				
	Station 1 Robertson St. 2	Station 2 Pattonville Adm.	Station 3 Pattonville St. 2	Station 4 Spanish Village	Station 5 [a] St. Charles St. 2
05/08/14	1.87E-02	1.73E-02	1.84E-02	1.85E-02	1.72E-02
05/15/14	1.52E-02	1.48E-02	1.54E-02	1.56E-02	1.21E-02 J
05/22/14	1.88E-02	1.87E-02	1.89E-02	1.80E-02	1.72E-02
05/29/14	1.95E-02	1.88E-02	1.82E-02	1.84E-02	1.89E-02
06/05/14	1.53E-02	1.49E-02	1.54E-02	1.48E-02	1.49E-02
06/12/14	1.50E-02	1.62E-02	1.62E-02	1.53E-02	1.37E-02 J
06/19/14	2.01E-02	2.20E-02	2.04E-02	1.94E-02	1.89E-02
06/26/14	1.80E-02	1.93E-02	1.84E-02	1.71E-02	1.80E-02 J
07/03/14	1.62E-02	1.51E-02	1.65E-02	1.75E-02	1.68E-02
07/10/14	1.97E-02	1.88E-02	2.03E-02	2.13E-02	2.04E-02
07/17/14	1.74E-02	1.76E-02	1.74E-02	1.62E-02	1.78E-02
07/24/14	2.49E-02	2.77E-02	2.56E-02	2.67E-02	2.55E-02
07/31/14	2.05E-02	1.98E-02	1.95E-02	1.81E-02	1.92E-02
08/07/14	3.02E-02	3.59E-02	3.20E-02	3.57E-02	3.20E-02
08/14/14	2.23E-02	2.29E-02	2.24E-02	2.28E-02	2.15E-02
08/21/14	2.69E-02	2.42E-02	2.90E-02	2.67E-02	2.75E-02
08/28/14	2.94E-02	3.11E-02	3.06E-02	2.98E-02	3.29E-02
09/04/14	1.95E-02	1.84E-02	2.13E-02	1.97E-02	1.83E-02
09/11/14	1.72E-02	1.89E-02	1.75E-02	1.79E-02	1.80E-02
09/17/14	1.59E-02	1.92E-02	1.81E-02	1.75E-02 J	1.57E-02 J
09/24/14	2.70E-02	2.79E-02	2.71E-02	2.48E-02	2.66E-02
10/01/14	3.27E-02	3.31E-02	3.52E-02	3.70E-02	3.53E-02
10/09/14	1.90E-02	1.51E-02	1.66E-02	1.66E-02	1.79E-02
10/16/14	1.55E-02	1.32E-02 J	1.32E-02 J	1.32E-02 J	1.38E-02 J
10/23/14	1.63E-02	1.81E-02	1.64E-02	1.54E-02	1.59E-02
10/30/14	2.64E-02	4.13E-03 J	2.74E-02	2.67E-02	2.65E-02
11/06/14	1.78E-02	1.58E-02	1.84E-02	1.58E-02 J	1.57E-02
11/13/14	1.59E-02	1.71E-02	1.64E-02	1.53E-02	1.42E-02 J
11/20/14	2.47E-02	2.59E-02	2.45E-02	2.38E-02	2.40E-02
11/26/14	2.95E-02	2.73E-02	3.06E-02	2.74E-02	3.03E-02
12/04/14	2.73E-02	2.74E-02	2.67E-02	2.69E-02	3.15E-02
12/11/14	3.49E-02	3.09E-02	3.53E-02	3.18E-02	3.40E-02
12/17/14	3.57E-02	3.61E-02	3.88E-02	3.39E-02	3.32E-02
12/23/14	2.62E-02	2.72E-02	2.49E-02	2.92E-02	2.42E-02
12/31/14	1.99E-02	2.16E-02	2.13E-02	2.04E-02	2.02E-02
01/06/15	1.89E-02	2.57E-02	2.49E-02	2.42E-02	2.37E-02
01/14/15	1.92E-02	2.11E-02	1.89E-02	2.06E-02	1.94E-02
01/21/15	2.09E-02	2.16E-02	2.00E-02	2.14E-02	1.59E-02
01/28/15	1.15E-02	1.43E-02	1.46E-02	1.32E-02	1.48E-02
02/04/15	1.47E-02	1.50E-02	1.61E-02	1.56E-02	1.54E-02
02/11/15	2.91E-02	3.12E-02	2.75E-02	2.62E-02	2.73E-02
02/18/15	2.58E-02	2.58E-02	2.43E-02	2.56E-02	2.89E-02
02/25/15	3.95E-02	4.36E-02	3.96E-02	4.15E-02	4.31E-02
03/04/15	2.26E-02	2.46E-02	2.20E-02	2.04E-02	2.28E-02
03/13/15	NS	NS	NS	1.82E-02	NS
03/20/15	NS	NS	NS	1.88E-02	NS
03/27/15	NS	NS	NS	1.73E-02	NS
04/03/15	NS	NS	NS	1.65E-02	NS
04/10/15	NS	NS	NS	1.86E-02	NS
04/17/15	NS	NS	NS	1.32E-02 J	NS
04/24/15	NS	NS	NS	1.54E-02	NS
05/01/15	NS	NS	NS	1.57E-02	NS
05/08/15	NS	NS	NS	2.25E-02	NS
05/15/15	NS	NS	NS	1.69E-02	NS

TABLE B-2 (Continued)

GROSS BETA ON AIRBORNE PARTICULATES
WEST LAKE LANDFILL OFF-SITE BASELINE AIR MONITORING

Date	Gross Beta				
	Station 1 Robertson St. 2	**Station 2** Pattonville Adm.	**Station 3** Pattonville St. 2	**Station 4** Spanish Village	**Station 5** [a] St. Charles St. 2
05/21/15	NS	NS	NS	1.28E-02 J	NS
05/28/15	NS	NS	NS	2.00E-02	NS
06/04/15	NS	NS	NS	1.16E-02 J	NS
06/11/15	NS	NS	NS	2.17E-02	NS
06/18/15	NS	NS	NS	1.57E-02	NS
06/25/15	NS	NS	NS	1.75E-02	NS
07/09/15	NS	NS	NS	2.10E-02	NS
07/16/15	NS	NS	NS	1.95E-02	NS
07/23/15	NS	NS	NS	1.63E-02	NS
07/30/15	NS	NS	NS	2.27E-02	NS
No. of Detects	44	44	44	64	44
No. of Samples	44	44	44	64	44
Minimum	1.15E-02	4.13E-03 J	1.32E-02 J	1.16E-02 J	1.21E-02 J
Median	1.98E-02	2.05E-02	2.04E-02	1.87E-02	1.93E-02
Maximum	3.95E-02	4.36E-02	3.96E-02	4.15E-02	4.31E-02

Notes:

All concentrations in picoCuries per cubic meter (pCi/m^3)

[a] Reference station

J Indicates an estimated result (result is less than the reporting limit)

NS Not sampled

TABLE B-3

URANIUM-238 ON AIRBORNE PARTICULATES
WEST LAKE LANDFILL OFF-SITE BASELINE AIR MONITORING

Date	Uranium-238				
	Station 1 Robertson St. 2	Station 2 Pattonville Adm.	Station 3 Pattonville St. 2	Station 4 Spanish Village	Station 5 [a] St. Charles St. 2
05/08/14	6.22E-04 J	1.35E-04 U	1.47E-04 J	1.73E-04 J	1.59E-04 U
05/15/14	7.68E-05 U	1.29E-04 J	3.86E-04 J	4.18E-05 U	1.01E-04 U
05/22/14	1.71E-04 U	9.47E-04	1.10E-04 U	8.35E-05 U	1.71E-04 U
05/29/14	1.74E-04 U	4.35E-05 U	-4.42E-05 U	3.07E-04 J	3.45E-05 U
06/05/14	1.29E-04 U	3.86E-05 U	8.49E-05 U	2.42E-04 U	-2.25E-05 U
06/12/14	1.59E-04 U	1.59E-04 U	7.23E-05 U	1.19E-04 U	1.02E-04 U
06/19/14	-1.03E-05 U	1.20E-04 U	7.10E-05 U	1.54E-04 U	9.53E-05 U
06/26/14	8.22E-05 U	7.66E-05 U	1.80E-04 J	8.34E-05 U	1.02E-04 U
07/03/14	1.41E-04 J	7.64E-05 J	6.58E-05 J	1.85E-04 J	1.67E-04 J
07/10/14	9.43E-05 J	1.18E-04 J	7.12E-05 U	9.15E-05 J	1.15E-04 J
07/17/14	1.39E-04 J	9.21E-05 U	1.73E-04 J	8.72E-05 U	1.19E-04 J
07/24/14	1.36E-04 J	1.39E-04 J	1.32E-04 J	7.37E-05 J	7.43E-05 U
07/31/14	8.69E-05 J	1.63E-04 J	1.54E-04 J	2.01E-04 J	5.52E-05 J
08/07/14	1.66E-05 U	1.61E-04 J	1.11E-04 J	9.77E-05 U	1.35E-04 J
08/14/14	1.26E-04 J	1.21E-04 J	1.56E-04 J	8.41E-05 U	6.58E-05 U
08/21/14	0.00E+00 U	4.43E-06 U	1.71E-04 U	2.75E-05 U	-2.24E-05 U
08/28/14	4.14E-05 U	2.63E-04 J	2.29E-04 U	8.35E-05 U	7.23E-05 U
09/04/14	9.32E-05 J	9.38E-05 J	7.19E-05	1.34E-04 J	8.51E-05 J
09/11/14	7.01E-05 J	9.50E-05 J	1.18E-04 J	7.37E-05 J	1.66E-04 J
09/17/14	1.55E-04 J	1.31E-04 J	1.49E-04 J	1.62E-04 J	1.45E-04 J
09/24/14	1.67E-04 J	1.86E-04 J	1.06E-04 J	5.50E-05 U	1.35E-04 J
10/01/14	9.00E-05 J	-8.55E-05 U	5.95E-05 U	1.03E-04 U	9.31E-05 U
10/09/14	1.23E-04 J	1.17E-04 J	1.09E-04 J	7.16E-05 U	1.34E-04 J
10/16/14	1.17E-04 U	1.75E-04 J	5.67E-05 U	8.90E-05 U	8.54E-05 U
10/23/14	1.09E-04 J	1.69E-04 J	5.41E-05 U	1.44E-04 J	1.32E-04 J
10/30/14	1.36E-04 U	1.97E-04 J	1.24E-04 U	3.08E-05 U	9.11E-05 U
11/06/14	1.08E-04 U	1.42E-04 J	6.60E-05 U	1.51E-04 U	1.14E-04 U
11/13/14	2.47E-05 U	1.83E-05 U	1.15E-04 U	4.39E-05 U	7.28E-05 U
11/20/14	4.31E-05 U	0.00E+00 U	4.51E-05 U	2.15E-04 U	-1.20E-05 U
11/26/14	9.52E-05 U	1.25E-04 U	1.29E-04 J	7.66E-05 U	1.63E-04 J
12/04/14	5.67E-05 U	0.00E+00 U	8.27E-05 U	1.61E-04 J	1.13E-04 U
12/11/14	2.10E-04 U	4.08E-05 U	1.66E-04 U	1.18E-04 U	1.29E-04 U
12/17/14	1.58E-04 J	1.44E-04 J	1.83E-04 J	6.17E-05 U	1.05E-04 U
12/23/14	6.29E-05 J	1.33E-04 J	1.40E-04 J	1.32E-04 J	1.22E-04 J
12/31/14	-4.45E-05 U	7.34E-05 U	1.13E-04 U	4.41E-05 U	1.45E-05 U
01/06/15	3.04E-05 U	2.05E-04 J	8.94E-05 U	6.79E-05 U	-2.39E-05 U
01/14/15	1.28E-04 J	8.32E-05 U	8.45E-05 J	4.70E-05 U	1.09E-04 U
01/21/15	6.76E-05 U	-5.66E-05 U	2.16E-04 J	1.04E-04 U	8.43E-05 U
01/28/15	1.08E-04 J	1.34E-04 J	4.08E-05 U	-9.39E-06 U	7.10E-05 U
02/04/15	2.94E-05 U	1.23E-04 U	1.19E-04 J	1.47E-04 U	1.51E-04 U
02/11/15	5.19E-05 U	1.81E-04 U	7.18E-05 U	8.61E-05 U	3.67E-05 U
02/18/15	-1.61E-04 U	1.08E-03 J	3.11E-04 J	1.29E-04 J	1.08E-05 U
02/25/15	7.51E-05 U	1.86E-04 J	9.80E-05 U	4.70E-05 U	2.25E-04 J
03/04/15	7.85E-05 J	8.54E-05 U	1.94E-04 J	2.15E-04 J	8.09E-05 U
03/13/15	NS	NS	NS	2.26E-05 U	NS
03/20/15	NS	NS	NS	1.50E-04 J	NS
03/27/15	NS	NS	NS	1.43E-04 J	NS
04/03/15	NS	NS	NS	1.75E-04 U	NS
04/10/15	NS	NS	NS	2.12E-04 U	NS
04/17/15	NS	NS	NS	1.69E-04 J	NS
04/24/15	NS	NS	NS	1.95E-04 U	NS
05/01/15	NS	NS	NS	9.52E-05 J	NS
05/08/15	NS	NS	NS	1.02E-05 U	NS
05/15/15	NS	NS	NS	1.03E-04 U	NS

TABLE B-3 (Continued)

URANIUM-238 ON AIRBORNE PARTICULATES
WEST LAKE LANDFILL OFF-SITE BASELINE AIR MONITORING

Date	Uranium-238				
	Station 1 Robertson St. 2	Station 2 Pattonville Adm.	Station 3 Pattonville St. 2	Station 4 Spanish Village	Station 5 [a] St. Charles St. 2
05/21/15	NS	NS	NS	2.22E-04 J	NS
05/28/15	NS	NS	NS	2.33E-04 J	NS
06/04/15	NS	NS	NS	1.62E-04 J	NS
06/11/15	NS	NS	NS	1.03E-04 U	NS
06/18/15	NS	NS	NS	1.38E-04 U	NS
06/25/15	NS	NS	NS	1.78E-05 U	NS
07/09/15	NS	NS	NS	-1.34E-05 U	NS
07/16/15	NS	NS	NS	9.87E-06 U	NS
07/23/15	NS	NS	NS	6.86E-05 U	NS
07/30/15	NS	NS	NS	1.30E-04 U	NS
No. of Detects	19	24	22	21	14
No. of Samples	44	44	44	64	44
Minimum	-1.61E-04 U	-8.55E-05 U	-4.42E-05 U	-1.34E-05 U	-2.39E-05 U
Median	9.38E-05	1.24E-04	1.12E-04	1.03E-04	1.02E-04
Maximum	6.22E-04 J	1.08E-03 J	3.86E-04 J	3.07E-04 J	2.25E-04 J

Notes:

All concentrations in picoCuries per cubic meter (pCi/m^3)

[a] Reference station

J Indicates an estimated result (result is less than the reporting limit)

NS Not sampled

U Indicates a non-detected result (result is less than the sample detection limit)

TABLE B-4

THORIUM-230 ON AIRBORNE PARTICULATES
WEST LAKE LANDFILL OFF-SITE BASELINE AIR MONITORING

Date	Thorium-230				
	Station 1 Robertson St. 2	Station 2 Pattonville Adm.	Station 3 Pattonville St. 2	Station 4 Spanish Village	Station 5 [a] St. Charles St. 2
05/08/14	3.51E-04 J	7.74E-04 J	8.74E-04 J	5.14E-04 J	6.88E-04 J
05/15/14	8.73E-04 J	4.10E-04 J	4.33E-04 J	3.05E-04 J	3.98E-04 J
05/22/14	4.37E-03	4.90E-04	5.70E-04	3.77E-04 U	4.21E-04
05/29/14	9.15E-04 J	9.08E-04 J	4.82E-04 J	6.93E-04 J	5.78E-04 J
06/05/14	4.58E-04 J	3.78E-04 J	3.13E-04 J	6.17E-04 J	7.00E-04 J
06/12/14	3.89E-04 J	5.61E-04 J	7.12E-04 J	6.90E-04 J	8.32E-04 J
06/19/14	4.05E-04 J	3.07E-04 U	5.85E-04 J	3.58E-04 J	3.16E-04 J
06/26/14	6.21E-04 J	3.19E-04 U	5.92E-04 J	4.74E-04 J	2.71E-04 U
07/03/14	3.23E-04 J	6.41E-04 J	4.16E-04 J	6.06E-04 J	5.19E-04 J
07/10/14	6.09E-04 J	5.67E-04 J	6.08E-04 J	6.84E-04 J	3.68E-04 J
07/17/14	3.92E-04 J	6.09E-04 J	7.54E-04 J	6.13E-04 J	6.09E-04 J
07/24/14	5.81E-04 J	5.51E-04 J	4.99E-04 J	5.35E-04 J	3.50E-04 J
07/31/14	5.14E-04 J	5.86E-04 J	7.95E-04 J	3.39E-04 J	4.18E-04 J
08/07/14	4.84E-04 J	6.66E-04 J	8.86E-04 J	7.26E-04 J	7.10E-04 J
08/14/14	5.75E-04 J	1.36E-03 J	4.75E-04 J	5.67E-04 J	6.75E-04 J
08/21/14	3.77E-04 U	4.33E-04 U	5.99E-04 U	1.06E-03 J	5.53E-04 U
08/28/14	4.45E-04 J	7.69E-04 J	6.96E-04 J	5.44E-04 J	6.94E-04 J
09/04/14	4.94E-04 J	7.13E-04 J	6.23E-04 J	5.32E-04 J	1.99E-03 J
09/11/14	5.08E-04 J	1.04E-03 J	6.57E-04 J	8.30E-04 J	6.28E-04 J
09/17/14	5.06E-04 J	4.08E-04 J	8.54E-04 J	6.51E-04 J	5.90E-04 J
09/24/14	4.25E-04 J	5.89E-04 J	3.81E-04 J	6.40E-04 J	4.55E-04 J
10/01/14	3.12E-04 J	4.90E-04 J	6.08E-04 J	5.43E-04 J	5.09E-04 J
10/09/14	3.93E-04 J	4.63E-04 J	4.13E-04 J	4.24E-04 J	5.08E-04 J
10/16/14	4.36E-04 J	6.95E-04 J	4.63E-04 J	3.94E-04 J	5.14E-04 J
10/23/14	4.99E-04 J	7.20E-04 J	8.00E-04 J	7.08E-04 J	7.19E-04 J
10/30/14	5.05E-04 J	4.58E-04 J	4.06E-04 J	6.20E-04 J	5.07E-04 J
11/06/14	7.60E-04 J	5.74E-04 J	6.55E-04 J	4.58E-04 J	4.17E-04 J
11/13/14	2.68E-04 J	6.84E-04 J	3.71E-04 J	4.66E-04 J	3.41E-04 J
11/20/14	4.59E-04 J	5.13E-04 J	5.85E-04 J	1.29E-03 J	1.14E-03 J
11/26/14	5.38E-04 J	9.52E-04 J	4.40E-04 J	6.94E-04 J	3.81E-04 J
12/04/14	2.92E-04 J	4.80E-04 J	5.21E-04 J	4.62E-04 J	5.11E-04 J
12/11/14	6.58E-04 J	3.12E-04 U	1.37E-04 U	1.89E-04 U	2.91E-04 J
12/17/14	7.47E-04 J	5.64E-04 J	4.08E-04 J	8.30E-04 J	5.84E-04 J
12/23/14	7.41E-04 J	9.65E-04 J	5.90E-04 J	5.63E-04 J	5.45E-04 J
12/31/14	3.83E-04 J	3.58E-04 U	4.42E-04 J	1.81E-04 U	9.23E-04 J
01/06/15	4.83E-04 J	1.16E-03 J	6.62E-04 J	5.41E-04 J	3.83E-04 J
01/14/15	3.36E-04 J	2.70E-04 J	4.29E-04 J	4.43E-04 J	6.86E-04 J
01/21/15	5.84E-04 J	6.21E-04 J	5.95E-04 J	2.94E-04 J	6.47E-04 J
01/28/15	3.49E-04 J	6.80E-04 J	2.38E-04 J	2.31E-04 J	4.70E-04 J
02/04/15	3.59E-04 J	5.62E-04 J	4.56E-04 J	3.86E-04 J	4.71E-04 J
02/11/15	2.91E-04 J	2.90E-04 J	2.95E-04 J	4.12E-04 J	3.85E-04 J
02/18/15	5.13E-04 J	2.63E-04 J	4.11E-04 J	6.88E-04 J	6.27E-04 J
02/25/15	1.77E-04 U	3.21E-04 J	4.59E-04 J	4.28E-04 J	9.33E-04 J
03/04/15	2.69E-04 J	5.95E-04 J	4.89E-04 J	2.64E-04 J	3.91E-04 J
03/13/15	NS	NS	NS	2.42E-04 J	NS
03/20/15	NS	NS	NS	5.22E-04 J	NS
03/27/15	NS	NS	NS	5.12E-04 J	NS
04/03/15	NS	NS	NS	4.17E-04 J	NS
04/10/15	NS	NS	NS	5.53E-04 J	NS
04/17/15	NS	NS	NS	1.80E-03 J	NS
04/24/15	NS	NS	NS	2.74E-04 J	NS
05/01/15	NS	NS	NS	6.73E-04 J	NS
05/08/15	NS	NS	NS	6.95E-04 J	NS
05/15/15	NS	NS	NS	4.40E-04 J	NS

TABLE B-4 (Continued)

THORIUM-230 ON AIRBORNE PARTICULATES
WEST LAKE LANDFILL OFF-SITE BASELINE AIR MONITORING

Date	Thorium-230				
	Station 1 Robertson St. 2	Station 2 Pattonville Adm.	Station 3 Pattonville St. 2	Station 4 Spanish Village	Station 5 [a] St. Charles St. 2
05/21/15	NS	NS	NS	1.47E-03 J	NS
05/28/15	NS	NS	NS	6.84E-04 J	NS
06/04/15	NS	NS	NS	1.16E-03 J	NS
06/11/15	NS	NS	NS	2.53E-04 J	NS
06/18/15	NS	NS	NS	4.64E-04 U	NS
06/25/15	NS	NS	NS	5.76E-04 U	NS
07/09/15	NS	NS	NS	2.87E-04 U	NS
07/16/15	NS	NS	NS	5.47E-04 U	NS
07/23/15	NS	NS	NS	3.34E-04 U	NS
07/30/15	NS	NS	NS	5.82E-04 U	NS
No. of Detects	42	39	42	55	42
No. of Samples	44	44	44	64	44
Minimum	1.77E-04 U	2.63E-04 J	1.37E-04 J	1.81E-04 J	2.71E-04 U
Median	4.71E-04	5.66E-04	5.10E-04	5.38E-04	5.17E-04
Maximum	4.37E-03	1.36E-03 J	8.86E-04 J	1.80E-03 J	1.99E-03 J

Notes:

All concentrations in picoCuries per cubic meter (pCi/m^3)

[a] Reference station

J Indicates an estimated result (result is less than the reporting limit)

NS Not sampled

U Indicates a non-detected result (result is less than the sample detection limit)

TABLE B-5

TOTAL ALPHA-EMITTING RADIUM ON AIRBORNE PARTICULATES
WEST LAKE LANDFILL OFF-SITE BASELINE AIR MONITORING

Date	Total Alpha-Emitting Radium [a]				
	Station 1 Robertson St. 2	Station 2 Pattonville Adm.	Station 3 Pattonville St. 2	Station 4 Spanish Village	Station 5 [a] St. Charles St. 2
05/08/14	5.74E-04 U	5.14E-04 U	3.11E-04 U	8.12E-04 U	2.19E-04 U
05/15/14	4.37E-04 J (226)	3.31E-04 J (226)	3.90E-04 J (226)	3.66E-04 J (226)	2.83E-04 U (226)
05/22/14	1.69E-04 U	6.05E-04 U	8.68E-04 U	2.65E-04 U	1.20E-03 U
05/29/14	-8.56E-05 U	5.84E-04 U	3.50E-04 U	5.99E-04 U	3.73E-04 U
06/05/14	-1.05E-04 U	3.32E-04 U	4.01E-04 U	-4.86E-04 U	-4.34E-04 U
06/12/14	8.19E-04 U	4.09E-04 U	-4.04E-05 U	1.40E-05 U	1.26E-03 U
06/19/14	6.40E-04 U	7.83E-04 U	2.97E-04 U	5.38E-04 U	1.13E-03 U
06/26/14	-9.72E-05 U	9.15E-04 U	6.90E-04 U	5.16E-04 U	1.10E-03 J
07/03/14	1.59E-03 U	1.80E-03 J	4.50E-04 U	-3.84E-04 U	0.00E+00 U
07/10/14	3.82E-04 U	1.52E-03 J	4.71E-04 U	1.21E-03 U	2.26E-04 U
07/17/14	1.10E-03 J	1.38E-03	2.01E-03	1.17E-03 U	4.40E-03
07/24/14	5.01E-04 U	3.40E-04 U	5.58E-04 U	1.71E-04 U	2.75E-04 U
07/31/14	7.02E-04 U	8.28E-04 U	1.13E-04 U	7.97E-04 U	5.44E-05 U
08/07/14	-5.75E-05 U	8.45E-05 U	2.63E-04 U	5.15E-04 U	8.81E-06 U
08/14/14	4.49E-04 U	1.01E-05 U	1.01E-03 U	3.44E-04 U	4.68E-04 U
08/21/14	-1.41E-04 U	9.08E-04 U	4.55E-04 U	2.75E-04 U	5.05E-04 U
08/28/14	3.97E-04 U	-2.01E-04 U	-1.28E-05 U	8.35E-04 U	8.36E-04 U
09/04/14	-2.50E-04 U	6.13E-04 U	8.78E-04 J	2.86E-04 U	6.19E-04 U
09/11/14	4.84E-04 U	5.14E-04 U	5.07E-04 U	8.47E-05 U	6.21E-04 U
09/17/14	-1.22E-04 U	-1.09E-04 U	7.01E-04 U	6.67E-04 U	2.14E-04 U
09/24/14	2.94E-04 U	4.72E-04 U	1.12E-03 U	1.48E-04 U	8.30E-04 U
10/01/14	1.08E-03 J	6.18E-04 U	5.49E-04 U	1.30E-03 J	1.23E-03 U
10/09/14	3.61E-04 U	7.57E-04 U	1.63E-04 U	8.15E-04 U	9.99E-04 U
10/16/14	5.79E-04 U	4.72E-04 U	4.13E-04 U	6.67E-04 U	2.80E-04 U
10/23/14	8.06E-04 U	1.08E-03 J	1.08E-03 J	4.58E-04 U	1.10E-03 U
10/30/14	1.10E-03 U	-2.74E-04 U	-5.23E-05 U	9.69E-04 U	-2.14E-04 U
11/06/14	7.67E-04 U	7.04E-04 U	8.52E-04 U	6.67E-04 U	5.32E-04 U
11/13/14	3.31E-04 U	6.40E-04 U	9.47E-06 U	2.51E-04 U	3.90E-04 U
11/20/14	7.78E-04 U	1.37E-04 U	2.95E-04 U	5.08E-04 U	1.69E-04 U
11/26/14	9.21E-04 U	-6.83E-04 U	-1.56E-04 U	1.05E-03 U	5.16E-05 U
12/04/14	7.10E-04 U	1.81E-04 U	-1.42E-04 U	5.09E-04 U	-4.05E-05 U
12/11/14	6.28E-05 U	3.04E-04 U	1.46E-04 U	1.55E-04 U	2.64E-04 U
12/17/14	5.73E-05 U	9.53E-05 U	9.36E-04 U	9.62E-04 U	4.97E-04 U
12/23/14	7.92E-04 J	-1.32E-04 U	6.54E-05 U	5.14E-05 U	1.31E-04 U
12/31/14	6.20E-05 U	3.89E-04 U	2.89E-04 U	1.36E-04 U	2.59E-04 U
01/06/15	7.64E-04 U	4.55E-04 U	4.00E-05 U	1.38E-03 J	7.36E-04 U
01/14/15	1.48E-04 U	1.60E-04 U	2.08E-04 U	1.50E-04 U	3.49E-05 U
01/21/15	1.94E-05 U	3.13E-04 U	2.23E-04 U	9.53E-05 U	5.24E-04 U
01/28/15	-7.19E-06 U	3.69E-04 U	-3.74E-05 U	2.63E-04 U	7.88E-04 U
02/04/15	1.92E-04 U	8.85E-04 U	7.62E-06 U	4.38E-04 U	4.30E-04 U
02/11/15	5.93E-04 U	5.16E-04 U	2.42E-04 U	-8.86E-05 U	1.65E-03 U
02/18/15	-1.81E-04 U	-1.06E-04 U	7.35E-04 U	7.95E-04 J	1.59E-04 U
02/25/15	6.40E-04 U	-1.26E-04 U	4.99E-04 U	1.37E-04 U	5.80E-04 U
03/04/15	5.37E-04 U	4.15E-04 U	4.56E-04 U	1.27E-04 U	8.67E-04 U
03/13/15	NS	NS	NS	4.15E-04 U	NS
03/20/15	NS	NS	NS	5.39E-04 U	NS
03/27/15	NS	NS	NS	-1.18E-04 U	NS
04/03/15	NS	NS	NS	6.74E-04 U	NS
04/10/15	NS	NS	NS	8.49E-04 U	NS
04/17/15	NS	NS	NS	5.98E-04 U	NS
04/24/15	NS	NS	NS	1.18E-03 U	NS
05/01/15	NS	NS	NS	7.98E-04 U	NS
05/08/15	NS	NS	NS	9.92E-04 U	NS

TABLE B-5 (Continued)

TOTAL ALPHA-EMITTING RADIUM ON AIRBORNE PARTICULATES
WEST LAKE LANDFILL OFF-SITE BASELINE AIR MONITORING

Date	Total Alpha-Emitting Radium [a]				
	Station 1 Robertson St. 2	Station 2 Pattonville Adm.	Station 3 Pattonville St. 2	Station 4 Spanish Village	Station 5 [a] St. Charles St. 2
05/15/15	NS	NS	NS	4.34E-04 U	NS
05/21/15	NS	NS	NS	8.90E-04 U	NS
05/28/15	NS	NS	NS	-7.57E-05 U	NS
06/04/15	NS	NS	NS	1.08E-04 U	NS
06/11/15	NS	NS	NS	2.23E-05 U	NS
06/18/15	NS	NS	NS	2.68E-04 U	NS
06/25/15	NS	NS	NS	7.68E-04 U	NS
07/09/15	NS	NS	NS	2.99E-04 U	NS
07/16/15	NS	NS	NS	2.15E-04 U	NS
07/23/15	NS	NS	NS	6.54E-04 U	NS
07/30/15	NS	NS	NS	1.56E-04 U	NS
No. of Detects	3	4	3	3	2
No. of Samples	43	43	43	63	43
Minimum	-2.50E-04 U	-6.83E-04 U	-1.56E-04 U	-4.86E-04 U	-4.34E-04 U
Median	4.49E-04	4.55E-04	3.50E-04	4.58E-04	4.68E-04
Maximum	1.10E-03 J	1.80E-03 J	2.01E-03	1.38E-03 J	4.40E-03

Notes:

All concentrations in picoCuries per cubic meter (pCi/m^3)

[a] Reference station

J	Indicates an estimated result (result is less than the reporting limit)
NS	Not sampled
U	Indicates a non-detected result (result is less than the sample detection limit)
(226)	Indicates the result is from a radium-226 specific laboratory method

TABLE B-6

RADON MONITORING RESULTS
WEST LAKE LANDFILL OFF-SITE BASELINE AIR MONITORING

Weekly Monitoring Period Ending	Average Weekly Radon Concentration				
	Station 1 Robertson St. 2	Station 2 Pattonville Adm.	Station 3 Pattonville St. 2	Station 4 Spanish Village	Station 5[a] St. Charles St. 2
05/02/14	0.26	0.75	0.37 OH	0.83	0.72
05/09/14	0.27	0.34 G1	0.20	0.16 G1 OH	0.17
05/16/14	0.25 OH	0.27 G1 OH	0.27	0.13	0.13 OH
05/23/14	0.87 LV1	0.47 OH	0.21	0.11	0.16 OH
05/30/14	0.24	0.19 G1 LV1	0.29	0.18	0.25 LV1
06/06/14	0.20	0.18 G1	0.18	0.16	0.15
06/13/14	0.26	0.23 G1 OH	0.17 OH	0.17	0.31
06/20/14	0.20	0.15 G1 LV1	0.19 LV1	0.13 LV1	0.46
06/27/14	0.57 LV1	0.63 G1	0.22 OH	-- LV3	0.29 E1
07/03/14	0.19	0.17 E	0.12	-- V1	0.11 OH
07/11/14	0.20	0.16	0.18	0.31 V2 OH	0.14
07/17/14	0.23	0.19	0.25	0.83	0.16
07/25/14	0.28	0.25	0.25	0.31 LV1	0.24 OH
08/01/14	0.28 OH	0.28	0.21	0.20	0.22
08/08/14	0.36	0.48	0.31	0.27	0.30
08/15/14	0.29	0.29	0.37	0.26	0.26
08/22/14	0.28	0.39	0.33	0.33 OH	0.20 OH
08/29/14	0.24	0.22	0.25	0.13	0.22
09/05/14	0.21	0.21 LV1	0.23	0.09	0.18
09/12/14	0.25 OH	0.24	0.62 LV1	0.16	0.27 LV1
09/18/14	0.21 OL	0.29 LV1	0.22	0.24 OH	0.39
09/25/14	0.25	1.81 LV2	1.88 LV1	0.47 LV1	1.45 LV1
10/02/14	0.36	1.28	0.40 OH	0.22 LV2	0.33 LV1
10/10/14	0.23 LV1	0.64	0.30	0.53 LV1	0.28
10/17/14	0.22 OL	0.20	0.21	0.14	0.22
10/24/14	0.28 OH	0.27 LV1	0.26	0.16	0.27 LV1
10/31/14	0.37	0.27	0.34	0.31	0.39 OH
11/07/14	0.27	0.21	0.22	0.16	0.26
11/13/14	0.28	0.22	0.25	0.24	0.30
11/20/14	0.35 OL	0.22	0.35	0.17	0.35
11/26/14	0.33	0.21	0.31	0.24	0.33
12/04/14	0.35	0.35	0.31 OH	0.29	0.31
12/11/14	0.38	0.35	0.37	0.29 E1	0.34
12/17/14	1.01	0.24	1.18 G1 E2	0.95 E1	0.34
12/23/14	0.28 E1	0.23	0.26	0.13	-- E3
12/30/14	0.43	0.26	0.28	0.21	0.59
01/06/15	0.31	0.20	0.28	0.77	0.32
01/13/15	0.28	0.24	0.24	0.14	0.30
01/20/15	0.41	0.25	0.32	0.56	0.39
01/27/15	0.37	0.23	0.51	0.35	0.35

TABLE B-6 (Continued)

RADON MONITORING RESULTS
WEST LAKE LANDFILL OFF-SITE BASELINE AIR MONITORING

Weekly Monitoring Period Ending	Average Weekly Radon Concentration				
	Station 1 Robertson St. 2	Station 2 Pattonville Adm.	Station 3 Pattonville St. 2	Station 4 Spanish Village	Station 5[a] St. Charles St. 2
02/03/15	0.23	0.17	0.27	0.16	0.28
02/10/15	0.33	0.24	0.31	0.16	0.30
02/17/15	0.27	0.18	0.22	0.15	0.30
No. of measurements	43	43	43	41	42
Minimum	0.19	0.15	0.12	0.09	0.11
Median	0.28	0.24	0.27	0.21	0.30
Maximum	1.01	1.81 LV2	1.88 LV1	0.95 E1	1.45 LV1

Notes:
All concentrations in picoCuries per liter (pCi/L)
[a] Reference station

G1	Final dose reading of pocket ion chamber exceeded the scale of 2.0 mR and a final reading of 2.0 was assumed. The reported radon result may be biased high.
OH / OL	Indicates one of the three replicate radon measurements was identified either a high (OH) or low (OL) outlier based on Dixon's procedure for outlier identification (see U.S. Nuclear Regulatory Commission (NRC) 1475, Chapter 26.4), assuming a probability of erroneously labeling an observation as an outlier (α) of 0.05. The detected outlier is not reflected in the reported mean radon concentration.
LV1/LV2	Indicates one (LV1) or two (LV2) of the three replicate measurements were not used in the calculation of the reported mean radon concentration because the replicate measurement(s) derived from electret(s) showing reading(s) below 200 volts. Per the manufacturer, unreliable data may result when electret voltage drops below 200 volts.
LV3	Indicates no mean radon concentration was calculated because each of the three replicate measurements derived from an electret showing a reading below 200 volts.
V1	No measurement was available due to equipment vandalism.
V2	Due to equipment vandalism, no gamma measurement was available; therefore, the average of gamma readings from the subsequent 3 weeks at the monitoring station was used.
E1/E2/E3	Indicates one (E1), two (E2) or three (E3) replicate measurements yielded a negative radon concentration. The negative radon values were not included in the reported mean radon concentration. No mean radon measurement was calculated if all measurements were negative (E3).

APPENDIX C

CALCULATIONS SUPPORTING RADON MEASUREMENTS

TABLE C-1

DETERMINATION OF RADON MEASUREMENTS AND OUTLIER DETECTION
WEST LAKE LANDFILL OFF-SITE BASELINE AIR MONITORING

Field Collected Measurements for Radon Monitoring															Replicate Radon Measurements[2]			Outlier Detection By Dixon's Procedure[3]							
Station	Start Date	Start Time	Stop Date	Stop Time	Sampling Time (days)	E-Perm 1 Start Volts	E-Perm 1 End Volts	E-Perm 2 Start Volts	E-Perm 2 End Volts	E-Perm 3 Start Volts	E-Perm 3 End Volts	Pocket Ion Chamber Start Dose (mR)	Pocket Ion Chamber End Dose (mR)	Gamma Rate[1] (µR/hr)	Radon Measurement 1 (pCi/L)	Radon Measurement 2 (pCi/L)	Radon Measurement 3 (pCi/L)	Usable measurements for Dixon's test	Sufficient Measurements for Dixon's Test?[4]	Dixon's Statistic for smallest observation[5]	Dixon's Statistic for largest observation[6]	Is the smallest measurement a suspected outlier?[7]	Is the largest measurement a suspected outlier?[7]	Are both the smallest and largest measurements suspected outliers?[8]	Mean Radon[9] (pCi/L)
1	04/25/14	10:30	05/02/14	09:30	6.96	777	728	764	708	770	715	0.10	1.30	6.59	0.202	0.302	0.287	3	yes	0.844	0.156	no	no	no	0.26
4	04/25/14	11:45	05/02/14	13:15	7.06	770	713	768	551	765	692	0.05	1.95	10.91	0.000	2.264	0.221	3	yes	0.098	0.902	no	no	no	0.83
2	04/25/14	11:00	05/02/14	13:00	7.08	759	627	770	687	758	681	0.10	1.60	8.24	1.231	0.541	0.464	3	yes	0.101	0.899	no	no	no	0.75
3	04/25/14	11:30	05/02/14	12:15	7.03	766	393	771	706	760	679	0.05	1.60	8.89	4.793	0.255	0.481	3	yes	0.050	0.950	no	yes	no	0.37 OH
5	04/25/14	12:15	05/02/14	12:40	7.02	749	693	774	727	766	590	0.10	1.55	8.02	0.200	0.069	1.890	3	yes	0.072	0.928	no	no	no	0.72
1	05/02/14	09:30	05/09/14	11:00	7.06	728	680	708	663	715	659	0.10	1.20	5.90	0.239	0.203	0.354	3	yes	0.240	0.760	no	no	no	0.27
4	05/02/14	13:15	05/09/14	12:30	6.97	713	591	551	485	692	621	0.00	2.00	11.96	0.891	0.151	0.164	3	yes	0.017	0.983	no	yes	no	0.16 G1 OH
2	05/02/14	13:00	05/09/14	11:45	6.95	627	546	687	585	681	617	0.00	2.00	11.99	0.342	0.618	0.067	3	yes	0.498	0.502	no	no	no	0.34 G1
3	05/02/14	12:15	05/09/14	12:05	6.99	393	329	706	648	679	611	0.05	1.85	10.43	0.297	0.077	0.230	3	yes	0.694	0.306	no	no	no	0.20
5	05/02/14	12:40	05/09/14	13:00	7.01	693	642	727	682	590	530	0.00	1.35	8.02	0.148	0.054	0.314	3	yes	0.361	0.639	no	no	no	0.17
1	05/09/14	11:00	05/16/14	13:50	7.12	680	495	663	609	659	600	0.00	1.30	7.61	2.108	0.217	0.290	3	yes	0.038	0.962	no	yes	no	0.25 OH
4	05/09/14	12:30	05/16/14	14:40	7.09	591	527	485	428	621	554	0.00	1.90	11.17	0.143	0.080	0.174	3	yes	0.665	0.335	no	no	no	0.13
2	05/09/14	11:45	05/16/14	15:00	7.14	546	328	585	507	617	543	0.00	2.00	11.68	2.506	0.310	0.235	3	yes	0.033	0.967	no	yes	no	0.27 G1 OH
3	05/09/14	12:05	05/16/14	15:25	7.14	329	271	648	580	611	540	0.00	1.70	9.92	0.244	0.258	0.317	3	yes	0.187	0.813	no	no	no	0.27
5	05/09/14	13:00	05/16/14	14:15	7.05	642	583	682	628	530	295	0.00	1.60	9.45	0.175	0.089	3.006	3	yes	0.029	0.971	no	yes	no	0.13 OH
1	05/16/14	13:50	05/23/14	13:10	6.97	495	376	609	76	600	548	0.00	1.05	6.27	1.416	LV (8.27)	0.318	2	no	--	--	--	--	--	0.87 LV1
4	05/16/14	14:40	05/23/14	15:20	7.03	527	470	428	374	554	491	0.00	1.85	10.97	0.085	0.077	0.165	3	yes	0.088	0.912	no	no	no	0.11
3	05/16/14	15:25	05/23/14	15:00	6.98	271	221	580	527	540	486	0.00	1.45	8.65	0.244	0.172	0.202	3	yes	0.410	0.590	no	no	no	0.21
2	05/16/14	15:00	05/23/14	13:50	6.95	328	263	507	223	543	475	0.00	1.40	8.39	0.497	4.015	0.437	3	yes	0.017	0.983	no	yes	no	0.47 OH
5	05/16/14	14:15	05/23/14	14:10	7.00	583	535	628	579	295	248	0.00	1.30	7.74	0.159	0.160	0.244	3	yes	0.011	0.989	no	yes	no	0.16 OH
1	05/23/14	13:10	05/30/14	16:30	7.14	376	330	779	730	548	488	0.00	1.25	7.30	0.213	0.135	0.365	3	yes	0.340	0.660	no	no	no	0.24
4	05/23/14	15:20	05/30/14	15:35	7.01	470	407	374	318	491	423	0.00	1.90	11.29	0.181	0.112	0.250	3	yes	0.504	0.496	no	no	no	0.18
3	05/23/14	15:00	05/30/14	16:00	7.04	775	707	527	465	486	420	0.00	1.60	9.47	0.253	0.264	0.344	3	yes	0.128	0.872	no	no	no	0.29
2	05/23/14	13:50	05/30/14	14:30	7.03	263	193	767	692	475	409	0.00	2.00	11.86	LV (0.366)	0.187	0.184	2	no	--	--	--	--	--	0.19 G1 LV1
5	05/23/14	14:10	05/30/14	15:05	7.04	535	477	579	522	248	193	0.00	1.45	8.58	0.262	0.231	LV (0.339)	2	no	--	--	--	--	--	0.25 LV1
5	05/30/14	15:05	06/06/14	15:05	7.00	477	426	522	474	776	724	0.00	1.40	8.33	0.198	0.137	0.117	3	yes	0.241	0.759	no	no	no	0.15
1	05/30/14	16:30	06/06/14	16:34	7.00	330	286	730	684	488	438	0.00	1.20	7.14	0.222	0.130	0.262	3	yes	0.694	0.306	no	no	no	0.20
3	05/30/14	16:00	06/06/14	15:51	6.99	707	643	465	407	420	364	0.00	1.70	10.13	0.182	0.188	0.175	3	yes	0.525	0.475	no	no	no	0.18
4	05/30/14	15:35	06/06/14	14:00	6.93	407	352	318	267	423	363	0.00	1.75	10.52	0.145	0.116	0.220	3	yes	0.280	0.720	no	no	no	0.16
2	05/30/14	14:30	06/06/14	14:39	7.01	770	696	692	618	409	346	0.00	2.00	11.89	0.173	0.206	0.168	3	yes	0.108	0.892	no	no	no	0.18 G1
5	06/06/14	15:08	06/13/14	11:10	6.83	426	369	474	419	724	658	0.00	1.40	8.53	0.322	0.269	0.337	3	yes	0.773	0.227	no	no	no	0.31
1	06/06/14	16:40	06/13/14	15:00	6.93	286	242	684	637	438	381	0.00	1.20	7.21	0.240	0.158	0.396	3	yes	0.346	0.654	no	no	no	0.26
4	06/06/14	14:05	06/13/14	14:13	7.01	352	295	267	215	363	305	0.00	1.80	10.71	0.180	0.134	0.191	3	yes	0.800	0.200	no	no	no	0.17
2	06/06/14	14:42	06/13/14	13:40	6.96	696	620	618	539	346	281	0.00	2.00	11.98	0.234	0.316	0.235	3	yes	0.008	0.992	no	yes	no	0.23 G1 OH
3	06/06/14	15:54	06/13/14	14:35	6.95	643	582	407	351	364	248	0.00	1.70	10.20	0.164	0.182	1.218	3	yes	0.017	0.983	no	yes	no	0.17 OH
5	06/13/14	11:10	06/20/14	12:20	7.05	369	319	419	320	658	605	0.00	1.40	8.28	0.222	0.995	0.165	3	yes	0.068	0.932	no	no	no	0.46
1	06/13/14	15:00	06/20/14	13:25	6.93	242	202	637	593	381	333	0.00	1.20	7.21	0.187	0.127	0.272	3	yes	0.410	0.590	no	no	no	0.20
4	06/13/14	14:13	06/20/14	12:45	6.94	295	243	215	167	305	252	0.00	1.80	10.81	0.122	LV (0.088)	0.135	2	no	--	--	--	--	--	0.13 LV1
2	06/13/14	13:40	06/20/14	11:55	6.93	620	553	539	473	281	153	0.00	2.00	12.03	0.137	0.157	LV (1.4)	2	no	--	--	--	--	--	0.15 G1 LV1
3	06/13/14	14:35	06/20/14	13:05	6.94	582	522	351	295	248	51	0.00	1.70	10.21	0.173	0.207	LV (2.85)	2	no	--	--	--	--	--	0.19 LV1
2	06/20/14	11:55	06/27/14	10:50	6.95	553	472	473	340	774	695	0.00	2.00	11.98	0.381	1.269	0.242	3	yes	0.135	0.865	no	no	no	0.63 G1
3	06/20/14	13:05	06/27/14	11:20	6.93	522	462	295	241	759	685	0.00	1.65	9.92	0.219	0.220	0.327	3	yes	0.014	0.986	no	yes	no	0.22 OH
5	06/20/14	12:20	06/27/14	12:50	7.02	319	265	320	317	605	541	0.00	1.50	8.90	0.269	E(-0.582)	0.304	2	no	--	--	--	--	--	0.29 E
1	06/20/14	13:25	06/27/14	10:15	6.87	202	159	593	543	333	249	0.00	1.20	7.28	LV (0.258)	0.231	0.914	2	no	--	--	--	--	--	0.57 LV1
4	06/20/14	12:45	06/27/14	12:25	6.99	243	-44	167	120	252	196	0.00	1.85	11.03	LV (4.539)	LV (0.07)	LV (0.19)	0	no	--	--	--	--	--	LV3
4	06/27/14	12:25	07/03/14	V1	V1	770	V1	777	V1	769	V1	V1	V1	V1	V1	V1	V1	0	no	--	--	--	--	--	V1
2	06/27/14	10:50	07/03/14	14:30	6.15	472	430	340	361	695	651	0.00	1.15	7.79	0.187	E (-0.941)	0.150	2	no	--	--	--	--	--	0.17 E
3	06/27/14	11:20	07/03/14	15:23	6.17	462	420	782	733	685	639	0.00	1.30	8.78	0.119	0.132	0.114	3	yes	0.265	0.735	no	no	no	0.12
5	06/27/14	12:50	07/03/14	15:00	6.09	265	216	771	728	541	502	0.00	1.15	7.87	0.407	0.115	0.114	3	yes	0.002	0.998	no	yes	no	0.11 OH
1	06/27/14	10:15	07/03/14	16:35	6.26	761	722	543	490	249	208	0.00	1.20	7.98	0.029	0.324	0.224	3	yes	0.662	0.338	no	no	no	0.19
1	07/03/14	16:35	07/11/14	14:33	7.92	722	661	490	429	763	697	0.00	1.60	8.42	0.155	0.235	0.203	3	yes	0.608	0.392	no	no	no	0.20
2	07/03/14	14:30	07/11/14	11:08	7.86	430	375	765	702	651	594	0.00	1.60	8.48	0.174	0.167	0.127	3	yes	0.850	0.150	no	no	no	0.16
3	07/03/14	15:23	07/11/14	14:00	7.94	420	362	733	670	639	576	0.00	1.65	8.66	0.200	0.157	0.188	3	yes	0.712	0.288	no	no	no	0.18
5	07/03/14	15:00	07/11/14	11:40	7.86	775	724	728	669	502	446	0.00	1.50	7.95	0.054	0.166	0.199	3	yes	0.769	0.231	no	no	no	0.14
4	07/03/14	16:00	07/11/14	12:18	7.85	715	632	725	650	529	286	0.00	1.79	9.51	0.367	0.261	2.750	3	yes	0.042	0.958	no	yes	no	0.31 V2 OH
1	07/11/14	14:33	07/17/14	15:38	6.05	661	613	429	383	697	646	0.00	1.20	8.27	0.206	0.256	0.243	3	yes	0.754	0.246	no	no	no	0.23
2	07/11/14	11:08	07/17/14	14:32	6.14	375	332	702	651	594	549	0.00	1.25	8.48	0.193	0.214	0.151	3	yes	0.670	0.330	no	no	no	0.19
3	07/11/14	14:00	07/17/14	13:14	5.97	362	317	670	619	576	525	0.00	1.25	8.73	0.243	0.232	0.267	3	yes	0.318	0.682	no	no	no	0.25
5	07/11/14	11:40	07/17/14	15:11	6.15	724	681	669	620	446	404	0.00	1.20	8.13	0.103	0.216	0.173	3	yes	0.615	0.385	no	no	no	0.16
4	07/11/14	12:18	07/17/14	13:55	6.07	632	500	650	594	286	227	0.00	1.25	8.58	1.629	0.319	0.549	3	yes	0.176	0.824	no	no	no	0.83
1	07/17/14	15:38	07/25/14	08:10	7.69	613	550	383	324	646	577	0.00	1.55	8.40	0.242	0.275	0.310	3	yes	0.488	0.512	no	no	no	0.28
2	07/17/14	14:32	07/25/14	08:30	7.75	332	281	651	583	549	488	0.00	1.50	8.07	0.192	0.311	0.255	3	yes	0.530	0.470	no	no	no	0.25
3	07/17/14	13:14	07/25/14	09:25	7.84	317	262	619	553	525	460	0.00	1.60	8.50	0.219	0.256	0.279	3	yes	0.622	0.378	no	no	no	0.25

TABLE C-1 (Continued)

DETERMINATION OF RADON MEASUREMENTS AND OUTLIER DETECTION
WEST LAKE LANDFILL OFF-SITE BASELINE AIR MONITORING

Field Collected Measurements for Radon Monitoring															Replicate Radon Measurements[2]			Outlier Detection By Dixon's Procedure[3]							
Station	Start Date	Start Time	Stop Date	Stop Time	Sampling Time (days)	E-Perm 1 Start Volts	E-Perm 1 End Volts	E-Perm 2 Start Volts	E-Perm 2 End Volts	E-Perm 3 Start Volts	E-Perm 3 End Volts	Pocket Ion Chamber Start Dose (mR)	Pocket Ion Chamber End Dose (mR)	Gamma Rate[1] (µR/hr)	Radon Measurement 1 (pCi/L)	Radon Measurement 2 (pCi/L)	Radon Measurement 3 (pCi/L)	Usable measurements for Dixon's test	Sufficient Measurements for Dixon's Test?[4]	Dixon's Statistic for smallest observation[5]	Dixon's Statistic for largest observation[6]	Is the smallest measurement a suspected outlier?[7]	Is the largest measurement a suspected outlier?[7]	Are both the smallest and largest measurements suspected outliers?[8]	Mean Radon[9] (pCi/L)
5	07/17/14	15:11	07/25/14	08:50	7.74	681	620	620	531	404	349	0.00	1.45	7.81	0.228	0.625	0.244	3	yes	0.039	0.961	no	yes	no	0.24 OH
4	07/17/14	13:55	07/25/14	09:47	7.83	500	427	594	510	227	143	0.00	2.00	10.65	0.252	0.358	LV (0.573)	2	no	--	--	--	--	--	0.31 LV1
4	07/25/14	09:47	08/01/14	12:30	7.11	427	362	510	442	767	698	0.00	1.90	11.13	0.230	0.237	0.144	3	yes	0.922	0.078	no	no	no	0.20
1	07/25/14	08:10	08/01/14	11:01	7.12	550	490	324	270	577	514	0.00	1.45	8.49	0.284	0.283	0.317	3	yes	0.009	0.991	no	yes	no	0.28 OH
2	07/25/14	08:30	08/01/14	11:32	7.13	281	227	583	526	488	432	0.00	1.40	8.19	0.323	0.247	0.267	3	yes	0.273	0.727	no	no	no	0.28
3	07/25/14	09:25	08/01/14	12:50	7.14	744	689	553	493	460	404	0.00	1.50	8.75	0.124	0.261	0.237	3	yes	0.826	0.174	no	no	no	0.21
5	07/25/14	08:50	08/01/14	12:12	7.14	620	570	531	476	349	298	0.00	1.35	7.88	0.153	0.256	0.263	3	yes	0.934	0.066	no	no	no	0.22
4	08/01/14	12:30	08/08/14	15:50	7.14	362	295	442	369	698	621	0.00	2.00	11.67	0.253	0.307	0.241	3	yes	0.181	0.819	no	no	no	0.27
1	08/01/14	11:01	08/08/14	14:15	7.13	490	427	270	210	514	448	0.00	1.50	8.76	0.333	0.389	0.368	3	yes	0.627	0.373	no	no	no	0.36
2	08/01/14	11:32	08/08/14	14:40	7.13	760	656	526	463	432	375	0.00	1.45	8.47	0.812	0.338	0.285	3	yes	0.100	0.900	no	no	no	0.48
3	08/01/14	12:50	08/08/14	15:20	7.10	689	622	493	428	404	341	0.00	1.60	9.38	0.269	0.323	0.333	3	yes	0.843	0.157	no	no	no	0.31
5	08/01/14	12:12	08/08/14	15:00	7.12	570	514	476	414	298	245	0.00	1.40	8.20	0.237	0.365	0.299	3	yes	0.479	0.521	no	no	no	0.30
5	08/08/14	15:00	08/15/14	09:40	6.78	514	466	414	360	769	718	0.00	1.20	7.38	0.230	0.366	0.195	3	yes	0.206	0.794	no	no	no	0.26
4	08/08/14	15:50	08/15/14	10:10	6.76	295	238	369	308	621	556	0.00	1.70	10.47	0.258	0.290	0.239	3	yes	0.368	0.632	no	no	no	0.26
1	08/08/14	14:15	08/15/14	09:00	6.78	427	373	763	708	448	392	0.00	1.30	7.99	0.317	0.210	0.341	3	yes	0.815	0.185	no	no	no	0.29
2	08/08/14	14:40	08/15/14	09:20	6.78	656	600	463	407	375	325	0.00	1.30	7.99	0.261	0.335	0.271	3	yes	0.144	0.856	no	no	no	0.29
3	08/08/14	15:20	08/15/14	09:55	6.77	622	555	428	372	341	289	0.00	1.30	8.00	0.440	0.350	0.320	3	yes	0.249	0.751	no	no	no	0.37
5	08/15/14	09:40	08/22/14	09:30	6.99	466	415	360	304	718	661	0.00	1.40	8.34	0.203	0.327	0.204	3	yes	0.013	0.987	no	yes	no	0.20 OH
4	08/15/14	10:10	08/22/14	10:50	7.03	760	687	308	246	556	489	0.00	1.60	9.49	0.328	0.368	0.328	3	yes	0.006	0.994	no	yes	no	0.33 OH
1	08/15/14	09:00	08/22/14	08:25	6.98	373	318	708	650	392	333	0.00	1.45	8.66	0.284	0.202	0.342	3	yes	0.590	0.410	no	no	no	0.28
2	08/15/14	09:20	08/22/14	08:55	6.98	600	539	407	350	325	258	0.00	1.40	8.35	0.305	0.323	0.530	3	yes	0.078	0.922	no	no	no	0.39
3	08/15/14	09:55	08/22/14	10:30	7.02	555	496	372	313	289	235	0.00	1.40	8.30	0.291	0.369	0.324	3	yes	0.418	0.582	no	no	no	0.33
3	08/22/14	10:30	08/29/14	10:40	7.01	496	434	313	261	768	708	0.00	1.50	8.92	0.321	0.238	0.188	3	yes	0.379	0.621	no	no	no	0.25
5	08/22/14	09:30	08/29/14	11:32	7.08	415	367	304	254	661	607	0.00	1.35	7.94	0.192	0.267	0.198	3	yes	0.089	0.911	no	no	no	0.22
4	08/22/14	10:50	08/29/14	11:10	7.01	687	620	770	708	489	425	0.00	1.90	11.29	0.149	0.048	0.188	3	yes	0.720	0.280	no	no	no	0.13
1	08/22/14	08:25	08/29/14	09:00	7.02	318	275	650	605	333	288	0.00	1.10	6.52	0.250	0.178	0.278	3	yes	0.720	0.280	no	no	no	0.24
2	08/22/14	08:55	08/29/14	09:30	7.02	539	483	350	297	258	212	0.00	1.45	8.60	0.231	0.259	0.178	3	yes	0.652	0.348	no	no	no	0.22
3	08/29/14	10:40	09/05/14	10:05	6.98	434	375	261	214	708	653	0.00	1.45	8.66	0.323	0.196	0.159	3	yes	0.226	0.774	no	no	no	0.23
5	08/29/14	11:32	09/05/14	09:45	6.93	367	324	254	209	607	558	0.00	1.30	7.82	0.152	0.228	0.168	3	yes	0.207	0.793	no	no	no	0.18
4	08/29/14	11:10	09/05/14	10:32	6.97	620	561	708	649	425	368	0.00	1.85	11.05	0.080	0.049	0.127	3	yes	0.401	0.599	no	no	no	0.09
1	08/29/14	09:00	09/05/14	08:55	7.00	275	236	605	563	288	247	0.00	1.05	6.25	0.219	0.168	0.248	3	yes	0.629	0.371	no	no	no	0.21
2	08/29/14	09:30	09/05/14	09:21	6.99	483	429	297	251	212	169	0.00	1.40	8.34	0.243	0.185	LV (0.166)	2	no	--	--	--	--	--	0.21 LV1
2	09/05/14	09:21	09/12/14	09:45	7.02	429	376	251	204	750	694	0.00	1.35	8.02	0.269	0.241	0.200	3	yes	0.590	0.410	no	no	no	0.24
3	09/05/14	10:05	09/12/14	10:30	7.02	375	276	214	164	653	597	0.00	1.40	8.31	1.033	LV (0.289)	0.211	2	no	--	--	--	--	--	0.62 LV1
5	09/05/14	09:45	09/12/14	11:15	7.06	324	281	209	164	558	504	0.20	1.55	6.78	0.226	LV (0.304)	0.317	2	no	--	--	--	--	--	0.27 LV1
4	09/05/14	10:32	09/12/14	10:10	6.98	561	503	649	587	368	308	0.20	2.00	10.74	0.108	0.134	0.223	3	yes	0.224	0.776	no	no	no	0.16
1	09/05/14	08:55	09/12/14	09:07	7.01	762	710	563	341	247	205	0.00	1.10	6.54	0.246	2.965	0.259	3	yes	0.005	0.995	no	yes	no	0.25 OH
1	09/12/14	09:07	09/18/14	09:15	6.01	710	670	341	307	765	732	0.00	0.90	6.24	0.206	0.207	0.079	3	yes	0.990	0.010	yes	no	no	0.21 OL
2	09/12/14	09:45	09/18/14	10:15	6.02	376	332	204	163	694	640	0.00	1.15	7.96	0.264	LV (0.277)	0.319	2	no	--	--	--	--	--	0.29 LV1
3	09/12/14	10:30	09/18/14	11:12	6.03	276	234	744	693	597	552	0.00	1.20	8.29	0.242	0.228	0.177	3	yes	0.786	0.214	no	no	no	0.22
5	09/12/14	11:15	09/18/14	10:33	5.97	281	245	755	713	504	462	0.20	1.05	4.54	0.390	0.349	0.426	3	yes	0.532	0.468	no	no	no	0.39
4	09/12/14	10:10	09/18/14	10:56	6.03	503	359	587	535	308	259	0.20	1.60	9.67	1.926	0.205	0.270	3	yes	0.038	0.962	no	yes	no	0.24 OH
1	09/18/14	09:15	09/25/14	09:30	7.01	670	617	307	268	732	682	0.00	1.05	6.24	0.308	0.208	0.247	3	yes	0.393	0.607	no	no	no	0.25
2	09/18/14	10:15	09/25/14	10:20	7.00	332	151	163	117	640	477	0.00	1.40	8.33	LV (2.511)	LV (0.24)	1.811	1	no	--	--	--	--	--	1.81 LV2
3	09/18/14	11:12	09/25/14	11:00	6.99	234	186	693	463	552	442	0.00	1.50	8.94	LV (0.204)	2.732	1.036	2	no	--	--	--	--	--	1.88 LV1
5	09/18/14	10:33	09/25/14	10:42	7.01	245	197	713	491	462	411	0.00	1.30	7.73	LV (0.282)	2.659	0.245	2	no	--	--	--	--	--	1.45 LV1
4	09/18/14	10:56	09/25/14	11:20	7.02	359	266	535	474	259	182	0.00	1.80	10.69	0.779	0.164	LV (0.575)	2	no	--	--	--	--	--	0.47 LV1
1	09/25/14	09:30	10/02/14	12:13	7.11	617	547	268	220	682	627	0.00	1.20	7.03	0.506	0.309	0.267	3	yes	0.177	0.823	no	no	no	0.36
3	09/25/14	11:00	10/02/14	11:35	7.02	733	523	463	396	442	383	0.00	1.40	8.30	2.404	0.455	0.338	3	yes	0.057	0.943	no	yes	no	0.40 OH
5	09/25/14	10:42	10/02/14	11:05	7.02	197	152	491	436	411	351	0.00	1.35	8.02	LV (0.228)	0.276	0.389	2	no	--	--	--	--	--	0.33 LV1
2	09/25/14	10:20	10/02/14	10:45	7.02	750	680	755	595	477	324	0.00	1.40	8.31	0.374	1.648	1.829	3	yes	0.876	0.124	no	no	no	1.28
4	09/25/14	11:20	10/02/14	11:55	7.02	266	181	474	407	182	121	0.00	1.95	11.57	LV (0.648)	0.221	LV (0.275)	1	no	--	--	--	--	--	0.22 LV2
1	10/02/14	12:13	10/10/14	11:30	7.97	547	481	220	163	627	566	0.00	1.60	8.36	0.279	LV (0.287)	0.184	2	no	--	--	--	--	--	0.23 LV1
4	10/02/14	11:55	10/10/14	11:45	7.99	181	122	407	343	505	385	0.00	2.00	10.43	LV (0.191)	0.162	0.894	2	no	--	--	--	--	--	0.53 LV1
3	10/02/14	11:35	10/10/14	11:40	8.00	523	457	396	329	383	324	0.00	1.60	8.33	0.287	0.355	0.246	3	yes	0.379	0.621	no	no	no	0.30
5	10/02/14	11:05	10/10/14	11:50	8.03	631	559	436	381	351	294	0.00	1.50	7.78	0.359	0.205	0.265	3	yes	0.393	0.607	no	no	no	0.28
2	10/02/14	10:45	10/10/14	11:35	8.03	680	614	595	449	324	262	0.00	1.55	8.04	0.246	1.336	0.332	3	yes	0.078	0.922	no	no	no	0.64
1	10/10/14	11:30	10/17/14	12:45	7.05	481	427	758	697	566	515	0.00	1.45	8.57	0.221	0.224	0.145	3	yes	0.965	0.035	yes	no	no	0.22 OL
4	10/10/14	11:45	10/17/14	12:26	7.03	757	688	343	288	385	325	0.00	1.90	11.26	0.149	0.109	0.172	3	yes	0.644	0.356	no	no	no	0.14
3	10/10/14	11:40	10/17/14	12:03	7.02	457	403	329	274	324	277	0.00	1.50	8.91	0.211	0.281	0.149	3	yes	0.470	0.530	no	no	no	0.21
5	10/10/14	11:50	10/17/14	11:23	6.98	559	504	381	336	294	249	0.00	1.30	7.76	0.273	0.179	0.211	3	yes	0.341	0.659	no	no	no	0.22
2	10/10/14	11:35	10/17/14	11:05	6.98	614	560	449	401	262	214	0.00	1.40	8.36	0.196	0.162	0.234	3	yes	0.481	0.519	no	no	no	0.20
1	10/17/14	12:45	10/24/14	11:13	6.94	427	375	697	638	515	435	0.00	1.30	7.81	0.277	0.284	0.682	3	yes	0.016	0.984	no	yes	no	0.28 OH

TABLE C-1 (Continued)

DETERMINATION OF RADON MEASUREMENTS AND OUTLIER DETECTION
WEST LAKE LANDFILL OFF-SITE BASELINE AIR MONITORING

Field Collected Measurements for Radon Monitoring															Replicate Radon Measurements[2]			Outlier Detection By Dixon's Procedure[3]							
Station	Start Date	Start Time	Stop Date	Stop Time	Sampling Time (days)	E-Perm 1 Start Volts	E-Perm 1 End Volts	E-Perm 2 Start Volts	E-Perm 2 End Volts	E-Perm 3 Start Volts	E-Perm 3 End Volts	Pocket Ion Chamber Start Dose (mR)	Pocket Ion Chamber End Dose (mR)	Gamma Rate[1] (µR/hr)	Radon Measurement 1 (pCi/L)	Radon Measurement 2 (pCi/L)	Radon Measurement 3 (pCi/L)	Usable measurements for Dixon's test	Sufficient Measurements for Dixon's Test?[4]	Dixon's Statistic for smallest observation[5]	Dixon's Statistic for largest observation[6]	Is the smallest measurement a suspected outlier?[7]	Is the largest measurement a suspected outlier?[7]	Are both the smallest and largest measurements suspected outliers?[8]	Mean Radon[9] (pCi/L)
2	10/17/14	11:05	10/24/14	09:37	6.94	560	500	401	353	214	166	0.00	1.35	8.11	0.329	0.201	LV (0.277)	2	no	--	--	--	--	--	0.27 LV1
3	10/17/14	12:03	10/24/14	10:35	6.94	403	349	274	224	277	229	0.00	1.40	8.41	0.278	0.265	0.229	3	yes	0.743	0.257	no	no	no	0.26
4	10/17/14	12:26	10/24/14	10:57	6.94	688	618	288	236	325	268	0.00	1.85	11.11	0.215	0.104	0.173	3	yes	0.624	0.376	no	no	no	0.16
5	10/17/14	11:23	10/24/14	09:55	6.94	504	449	336	18	249	203	0.00	1.30	7.81	0.295	LV (5.135)	0.248	2	no	--	--	--	--	--	0.27 LV1
1	10/24/14	11:13	10/31/14	09:30	6.93	375	320	638	566	435	375	0.00	1.40	8.42	0.306	0.456	0.362	3	yes	0.371	0.629	no	no	no	0.37
2	10/24/14	09:37	10/31/14	09:15	6.98	500	448	353	302	765	700	0.00	1.35	8.05	0.227	0.268	0.321	3	yes	0.432	0.568	no	no	no	0.27
3	10/24/14	10:35	10/31/14	09:46	6.97	349	295	764	695	746	677	0.00	1.40	8.37	0.299	0.357	0.364	3	yes	0.892	0.108	no	no	no	0.34
4	10/24/14	10:57	10/31/14	10:08	6.97	618	544	764	683	765	688	0.00	1.85	11.07	0.304	0.337	0.280	3	yes	0.413	0.587	no	no	no	0.31
5	10/24/14	09:55	10/31/14	10:54	7.04	449	388	761	687	763	693	0.00	1.35	7.99	0.386	0.445	0.388	3	yes	0.036	0.964	no	yes	no	0.39 OH
1	10/31/14	09:30	11/07/14	09:24	7.00	320	271	566	513	375	318	0.00	1.35	8.04	0.247	0.218	0.357	3	yes	0.207	0.793	no	no	no	0.27
2	10/31/14	09:15	11/07/14	08:00	6.95	448	397	302	255	700	642	0.00	1.40	8.40	0.211	0.201	0.226	3	yes	0.387	0.613	no	no	no	0.21
3	10/31/14	09:46	11/07/14	08:37	6.95	757	697	695	637	677	617	0.00	1.45	8.69	0.214	0.207	0.242	3	yes	0.203	0.797	no	no	no	0.22
4	10/31/14	10:08	11/07/14	08:58	6.95	544	479	683	616	688	622	0.00	1.90	11.39	0.181	0.152	0.136	3	yes	0.362	0.638	no	no	no	0.16
5	10/31/14	10:54	11/07/14	08:17	6.89	388	337	687	630	693	637	0.00	1.30	7.86	0.278	0.260	0.244	3	yes	0.479	0.521	no	no	no	0.26
1	11/07/14	09:24	11/13/14	09:56	6.02	730	673	513	465	318	278	0.00	1.15	7.96	0.355	0.284	0.210	3	yes	0.514	0.486	no	no	no	0.28
2	11/07/14	08:00	11/13/14	10:23	6.10	397	354	762	710	642	593	0.00	1.20	8.20	0.210	0.235	0.227	3	yes	0.678	0.322	no	no	no	0.22
3	11/07/14	08:37	11/13/14	10:10	6.06	697	648	637	587	617	564	0.00	1.20	8.24	0.210	0.247	0.305	3	yes	0.391	0.609	no	no	no	0.25
4	11/07/14	08:58	11/13/14	10:04	6.05	479	424	616	549	622	566	0.00	1.60	11.03	0.206	0.353	0.162	3	yes	0.231	0.769	no	no	no	0.24
5	11/07/14	08:17	11/13/14	10:16	6.08	337	293	630	580	637	591	0.00	1.05	7.19	0.325	0.321	0.251	3	yes	0.938	0.062	no	no	no	0.30
1	11/13/14	09:56	11/20/14	10:37	7.03	673	607	465	405	759	701	0.00	1.40	8.30	0.347	0.343	0.204	3	yes	0.972	0.028	yes	no	no	0.35 OL
2	11/13/14	10:23	11/20/14	09:10	6.95	354	299	710	648	593	535	0.00	1.55	9.29	0.252	0.217	0.202	3	yes	0.302	0.698	no	no	no	0.22
3	11/13/14	10:10	11/20/14	09:48	6.98	648	584	587	525	564	499	0.00	1.40	8.35	0.331	0.325	0.380	3	yes	0.095	0.905	no	no	no	0.35
4	11/13/14	10:04	11/20/14	10:12	7.01	424	357	549	486	566	497	0.00	2.00	11.90	0.226	0.105	0.189	3	yes	0.693	0.307	no	no	no	0.17
5	11/13/14	10:16	11/20/14	09:27	6.97	764	699	580	518	591	532	0.00	1.30	7.78	0.343	0.371	0.321	3	yes	0.445	0.555	no	no	no	0.35
1	11/20/14	10:37	11/26/14	08:32	5.91	607	553	405	358	701	651	0.00	1.10	7.75	0.384	0.340	0.280	3	yes	0.575	0.425	no	no	no	0.33
2	11/20/14	09:10	11/26/14	08:39	5.98	299	258	648	599	535	486	0.00	1.25	8.71	0.190	0.205	0.247	3	yes	0.270	0.730	no	no	no	0.21
3	11/20/14	09:48	11/26/14	08:52	5.96	584	535	525	473	499	447	0.00	1.20	8.39	0.254	0.330	0.341	3	yes	0.874	0.126	no	no	no	0.31
4	11/20/14	10:12	11/26/14	09:00	5.95	357	303	486	429	497	441	0.00	1.60	11.20	0.250	0.243	0.220	3	yes	0.779	0.221	no	no	no	0.24
5	11/20/14	09:27	11/26/14	09:09	5.99	699	649	518	469	532	483	0.00	1.05	7.31	0.302	0.351	0.345	3	yes	0.889	0.111	no	no	no	0.33
1	11/26/14	08:32	12/04/14	11:31	8.12	553	482	358	295	651	580	0.00	1.50	7.69	0.373	0.345	0.334	3	yes	0.292	0.708	no	no	no	0.35
2	11/26/14	08:39	12/04/14	11:54	8.14	755	651	599	534	486	422	0.00	1.70	8.71	0.624	0.205	0.234	3	yes	0.070	0.930	no	no	no	0.35
3	11/26/14	08:52	12/04/14	11:45	8.12	535	468	473	408	447	378	0.00	1.55	7.95	0.309	0.307	0.373	3	yes	0.032	0.968	no	yes	no	0.31 OH
4	11/26/14	09:00	12/04/14	11:39	8.11	303	233	429	353	441	368	0.00	2.00	10.27	0.295	0.318	0.270	3	yes	0.522	0.478	no	no	no	0.29
5	11/26/14	09:09	12/04/14	11:50	8.11	649	587	469	405	483	421	0.00	1.40	7.19	0.258	0.350	0.317	3	yes	0.643	0.357	no	no	no	0.31
1	12/04/14	11:31	12/11/14	08:34	6.88	482	421	757	689	580	521	0.00	1.30	7.88	0.402	0.393	0.330	3	yes	0.875	0.125	no	no	no	0.38
2	12/04/14	11:54	12/11/14	09:01	6.88	651	573	534	474	422	366	0.00	1.50	9.08	0.500	0.279	0.262	3	yes	0.070	0.930	no	no	no	0.35
3	12/04/14	11:45	12/11/14	08:50	6.88	468	408	408	349	378	317	0.00	1.40	8.48	0.350	0.360	0.408	3	yes	0.184	0.816	no	no	no	0.37
4	12/04/14	11:39	12/11/14	08:41	6.88	744	664	353	286	368	384	0.00	1.95	11.82	0.294	0.289	E(-1.096)	2	no	--	--	--	--	--	0.29 E
5	12/04/14	11:50	12/11/14	08:55	6.88	587	525	405	348	421	365	0.00	1.35	8.18	0.352	0.350	0.326	3	yes	0.934	0.066	no	no	no	0.34
1	12/11/14	08:34	12/17/14	14:02	6.23	421	360	689	636	521	369	0.00	1.10	7.36	0.569	0.318	2.129	3	yes	0.139	0.861	no	no	no	1.01
2	12/11/14	09:01	12/17/14	14:45	6.24	573	488	474	425	366	319	0.00	1.30	8.68	0.809	0.236	0.244	3	yes	0.013	0.987	no	yes	no	0.24
3	12/11/14	08:50	12/17/14	14:30	6.24	408	358	349	236	317	267	0.00	2.00	13.36	E(-0.046)	1.176	E(-0.005)	1	no	--	--	--	--	--	1.18 G1 E2
4	12/11/14	08:41	12/17/14	14:14	6.23	664	E (-13)	763	698	384	251	0.00	1.65	11.03	E	0.221	1.685	2	no	--	--	--	--	--	0.95 E
5	12/11/14	08:55	12/17/14	14:38	6.24	525	424	348	299	365	318	0.00	1.15	7.68	1.190	0.359	0.315	3	yes	0.051	0.949	no	yes	no	0.34
1	12/17/14	14:02	12/23/14	10:30	5.85	360	312	636	590	369	424	0.00	1.15	8.19	0.358	0.212	E(-1.625)	2	no	--	--	--	--	--	0.28 E
2	12/17/14	14:45	12/23/14	11:20	5.86	488	442	425	379	319	276	0.00	1.25	8.89	0.216	0.241	0.226	3	yes	0.420	0.580	no	no	no	0.23
3	12/17/14	14:30	12/23/14	11:12	5.86	358	314	770	717	745	696	0.00	1.15	8.17	0.279	0.284	0.226	3	yes	0.924	0.076	no	no	no	0.26
4	12/17/14	14:14	12/23/14	10:40	5.85	754	699	698	643	750	691	0.00	1.60	11.39	0.099	0.120	0.167	3	yes	0.311	0.689	no	no	no	0.13
5	12/17/14	14:38	12/23/14	11:00	5.85	424	380	299	256	318	277	0.00	2.00	14.25	E (-0.171)	E(-1.39)	E(-0.187)	0	no	--	--	--	--	--	E3
1	12/23/14	10:30	12/30/14	11:56	7.06	312	256	590	508	424	370	0.00	1.35	7.97	0.366	0.639	0.285	3	yes	0.230	0.770	no	no	no	0.43
2	12/23/14	11:20	12/30/14	11:48	7.02	442	388	379	326	714	653	0.00	1.40	8.31	0.258	0.268	0.261	3	yes	0.299	0.701	no	no	no	0.26
3	12/23/14	11:12	12/30/14	11:32	7.01	314	261	717	657	696	637	0.00	1.35	8.02	0.317	0.267	0.260	3	yes	0.122	0.878	no	no	no	0.28
4	12/23/14	10:40	12/30/14	11:25	7.03	699	630	643	572	691	622	0.00	1.85	10.96	0.193	0.245	0.196	3	yes	0.062	0.938	no	no	no	0.21
5	12/23/14	11:00	12/30/14	11:40	7.03	380	329	762	656	751	670	0.00	1.30	7.71	0.276	0.913	0.568	3	yes	0.459	0.541	no	no	no	0.59
1	12/30/14	11:56	01/06/15	10:55	6.96	749	682	508	451	370	318	0.00	1.35	8.08	0.357	0.303	0.278	3	yes	0.312	0.688	no	no	no	0.31
2	12/30/14	11:48	01/06/15	11:30	6.99	388	335	326	276	653	596	0.00	1.50	8.94	0.224	0.199	0.185	3	yes	0.374	0.626	no	no	no	0.20
3	12/30/14	11:32	01/06/15	11:12	6.99	711	648	657	597	637	543	0.00	1.40	8.35	0.292	0.269	0.778	3	yes	0.046	0.954	no	yes	no	0.28
4	12/30/14	11:25	01/06/15	11:05	6.99	630	566	572	449	622	491	0.00	1.90	11.33	0.129	1.056	1.136	3	yes	0.920	0.080	no	no	no	0.77
5	12/30/14	11:40	01/06/15	11:20	6.99	329	279	656	594	670	612	0.00	1.25	7.46	0.303	0.361	0.298	3	yes	0.075	0.925	no	no	no	0.32
1	01/06/15	10:55	01/13/15	13:00	7.09	682	627	451	397	318	269	0.00	1.25	7.35	0.247	0.314	0.286	3	yes	0.580	0.420	no	no	no	0.28
2	01/06/15	11:30	01/13/15	13:35	7.09	335	285	752	691	596	540	0.00	1.40	8.23	0.234	0.246	0.229	3	yes	0.309	0.691	no	no	no	0.24
3	01/06/15	11:12	01/13/15	13:20	7.09	648	592	597	539	543	490	0.00	1.35	7.93	0.231	0.278	0.223	3	yes	0.141	0.859	no	no	no	0.24
4	01/06/15	11:05	01/13/15	13:15	7.09	566	505	449	389	491	428	0.00	1.90	11.17	0.108	0.142	0.170	3	yes	0.541	0.459	no	no	no	0.14

TABLE C-1 (Continued)

DETERMINATION OF RADON MEASUREMENTS AND OUTLIER DETECTION
WEST LAKE LANDFILL OFF-SITE BASELINE AIR MONITORING

Field Collected Measurements for Radon Monitoring															Replicate Radon Measurements[2]			Outlier Detection By Dixon's Procedure[3]							
Station	Start Date	Start Time	Stop Date	Stop Time	Sampling Time (days)	E-Perm 1 Start Volts	E-Perm 1 End Volts	E-Perm 2 Start Volts	E-Perm 2 End Volts	E-Perm 3 Start Volts	E-Perm 3 End Volts	Pocket Ion Chamber Start Dose (mR)	Pocket Ion Chamber End Dose (mR)	Gamma Rate[1] (μR/hr)	Radon Measurement 1 (pCi/L)	Radon Measurement 2 (pCi/L)	Radon Measurement 3 (pCi/L)	Usable measurements for Dixon's test	Sufficient Measurements for Dixon's Test?[4]	Dixon's Statistic for smallest observation[5]	Dixon's Statistic for largest observation[6]	Is the smallest measurement a suspected outlier?[7]	Is the largest measurement a suspected outlier?[7]	Are both the smallest and largest measurements suspected outliers?[8]	Mean Radon[9] (pCi/L)
5	01/06/15	11:20	01/13/15	13:25	7.09	727	669	594	539	612	544	0.00	1.20	7.06	0.295	0.297	0.481	3	yes	0.012	0.988	no	yes	no	0.30
1	01/13/15	13:00	01/20/15	14:30	7.06	627	568	397	342	759	676	0.00	1.30	7.67	0.304	0.332	0.589	3	yes	0.101	0.899	no	no	no	0.41
2	01/13/15	13:35	01/20/15	13:15	6.99	598	534	691	631	540	484	0.00	1.40	8.35	0.351	0.256	0.253	3	yes	0.037	0.963	no	yes	no	0.25
3	01/13/15	13:20	01/20/15	13:50	7.02	592	533	539	479	490	435	0.00	1.30	7.72	0.319	0.354	0.297	3	yes	0.377	0.623	no	no	no	0.32
4	01/13/15	13:15	01/20/15	14:15	7.04	505	440	389	266	428	361	0.00	1.90	11.24	0.196	1.213	0.264	3	yes	0.067	0.933	no	no	no	0.56
5	01/13/15	13:25	01/20/15	13:35	7.01	669	605	539	475	544	485	0.00	1.25	7.43	0.384	0.437	0.359	3	yes	0.320	0.680	no	no	no	0.39
1	01/20/15	14:30	01/27/15	14:25	7.00	568	511	342	287	676	606	0.00	1.30	7.74	0.299	0.360	0.447	3	yes	0.410	0.590	no	no	no	0.37
2	01/20/15	13:15	01/27/15	12:24	6.96	534	476	631	574	484	430	0.00	1.45	8.67	0.266	0.212	0.221	3	yes	0.167	0.833	no	no	no	0.23
3	01/20/15	13:50	01/27/15	13:40	6.99	533	474	479	379	435	382	0.00	1.40	8.34	0.301	0.974	0.246	3	yes	0.075	0.925	no	no	no	0.51
4	01/20/15	14:15	01/27/15	14:00	6.99	440	377	754	653	361	297	0.00	1.90	11.33	0.196	0.601	0.251	3	yes	0.136	0.864	no	no	no	0.35
5	01/20/15	13:35	01/27/15	13:05	6.98	605	545	475	418	485	428	0.00	1.25	7.46	0.351	0.357	0.353	3	yes	0.279	0.721	no	no	no	0.35
1	01/27/15	14:25	02/03/15	15:18	7.04	511	459	755	700	606	552	0.00	1.30	7.70	0.242	0.205	0.239	3	yes	0.915	0.085	no	no	no	0.23
2	01/27/15	12:24	02/03/15	14:20	7.08	476	423	574	523	430	381	0.00	1.45	8.53	0.207	0.142	0.161	3	yes	0.293	0.707	no	no	no	0.17
3	01/27/15	13:40	02/03/15	14:50	7.05	474	421	379	326	382	334	0.00	1.30	7.68	0.271	0.308	0.226	3	yes	0.547	0.453	no	no	no	0.27
4	01/27/15	14:00	02/03/15	15:05	7.05	377	314	653	589	757	689	0.00	1.90	11.24	0.224	0.119	0.135	3	yes	0.156	0.844	no	no	no	0.16
5	01/27/15	13:05	02/03/15	14:35	7.06	545	489	418	369	428	377	0.00	1.25	7.37	0.310	0.249	0.277	3	yes	0.457	0.543	no	no	no	0.28
1	02/03/15	15:18	02/10/15	10:08	6.78	459	407	700	644	552	485	0.00	1.30	7.98	0.271	0.245	0.471	3	yes	0.114	0.886	no	no	no	0.33
2	02/03/15	14:20	02/10/15	10:24	6.84	423	369	523	470	381	330	0.00	1.40	8.53	0.273	0.218	0.241	3	yes	0.411	0.589	no	no	no	0.24
3	02/03/15	14:50	02/10/15	11:00	6.84	421	368	326	274	334	283	0.00	1.30	7.92	0.300	0.324	0.303	3	yes	0.115	0.885	no	no	no	0.31
4	02/03/15	15:05	02/10/15	11:25	6.85	314	258	589	529	689	625	0.00	1.80	10.95	0.185	0.130	0.151	3	yes	0.373	0.627	no	no	no	0.16
5	02/03/15	14:35	02/10/15	10:40	6.84	489	436	369	317	377	327	0.00	1.25	7.62	0.295	0.327	0.290	3	yes	0.141	0.859	no	no	no	0.30
1	02/10/15	10:08	02/17/15	11:54	7.07	407	358	644	589	485	432	0.00	1.25	7.36	0.252	0.260	0.286	3	yes	0.228	0.772	no	no	no	0.27
2	02/10/15	10:24	02/17/15	12:03	7.07	369	318	470	420	330	283	0.00	1.45	8.55	0.217	0.163	0.166	3	yes	0.061	0.939	no	no	no	0.18
3	02/10/15	11:00	02/17/15	12:12	7.05	368	317	747	689	768	708	0.00	1.40	8.27	0.238	0.207	0.228	3	yes	0.659	0.341	no	no	no	0.22
4	02/10/15	11:25	02/17/15	12:18	7.04	764	698	529	470	625	562	0.00	1.80	10.66	0.146	0.135	0.157	3	yes	0.528	0.472	no	no	no	0.15
5	02/10/15	10:40	02/17/15	12:22	7.07	436	385	317	269	327	278	0.00	1.20	7.07	0.294	0.291	0.304	3	yes	0.242	0.758	no	no	no	0.30

Notes

1 Gamma Rate (μR/hr) = [PIC End Dose - PIC Start Dose (mR)] * 1000 (μR/mR) / [Sampling Time (days) * 24 (hr/day)]

2 Radon (pCi/L) = (SV - EV - 0.066667*D)/(D * CF) - (Gamma x G), where SV = Start Volts, EV = End Volts, D = Sampling Time (days), CF = A + B*[(SV + EV)/2], Gamma = Gamma Rate (μR/hr), A = 7.2954, B = 0.004293, G = 0.07

3 Outlier detection based on Dixon's procedure (see U.S. Nuclear Regulatory Commission (NRC) 1475, Chapter 26.4), assuming a probability of erroneously labeling an observation as an outlier (α) of 0.05.

4 At least three usable measurements are needed for Dixon's procedure. "--" indicates no value because Dixon's procedure was not used.

5 Dixon's statistic for smallest observation = $(y_2 - y_1) / (y_n - y_1)$, where y_2 is second smallest measurement, y_1 is the smallest measurement, and y_n is largest measurement

6 Dixon's statistic for largest observation = $(y_n - y_{(n-1)}) / (y_n - y_1)$, where y_n is largest measurement, $y_{(n-1)}$ is the second largest measurement, and y_1 is the smallest measurement

7 The observation is a suspected outlier if its test statistic is larger than Dixon's criterion ($P_{1-\alpha}$). From NRC 1475, Table T-23, $P_{1-\alpha}$ is 0.941 for α = 0.05 and three measurements.

8 Dixon's test does not allow both the smallest and the largest measurements to be declared outliers.

9 Detected outliers are not reflected in the reported mean radon concentration.

mR milliRoentgen μR/hr microRoentgen per hour pCi/L picoCuries per liter

Data Qualifiers

E/E1/E2/E3	Indicates one (E1), two (E2), or three (E3) of the three replicate measurements yielded a negative radon concentration. The negative radon values were not included in the reported mean radon concentration.
G1	Final dose reading of pocket ion chamber exceeded the scale of 2.0 mR and a final reading of 2.0 was assumed. The reported radon result may be biased high.
LV ( )	Replicate measurement associated with eletret having an ending measurement below 200 volts. Per the manufacturer, unreliable data may result when electret voltage drops below 200 volts.
LV1/LV2	Indicates one (LV1) or two (LV2) of the three replicate measurements were not used in the calculation of the reported mean radon concentration because the measurement derived from an electret showing a reading below 200 volts.
LV3	Indicates no mean radon concentration was calculated because each of the three replicate measurements derived from an electret showing a reading below 200 volts.
OH / OL	Indicates one of the three replicate radon measurements was identified as either a high (OH) or low (OL) outlier based on Dixon's procedure for outlier identification.
V1	No measurement was available due to equipment vandalism.
V2	Due to equipment vandalism, no gamma measurement was available; therefore, the average of gamma readings from the subsequent 3 weeks at the monitoring station was used.

APPENDIX D

STATISTICAL ANALYSES

```
> #Kruskal-Wallis and Friedman's Tests for Rad Data
> library(pgirmess)
> library(reshape2)
> for(i in c(2,6,7,8,10)){ #1:length(analyte)){
+   #make subset
+   kwdata<-subset(rad, Analyte==analyte[i])
+   kwdata<-kwdata[c("Station", "Date_Collected","Result")]
+
+   #format a table for printing
+   kwdata.wide<-dcast(kwdata, Date_Collected ~ Station, value.var="Result",  na.rm = FAL
+   kwdata.wide<-kwdata.wide[order(as.Date(kwdata.wide$Date_Collected, "%m/%d/%Y")),]
+   print(paste(analyte[i],"data for Kruskal-Wallis Test"))
+   print(kwdata.wide, row.names = FALSE)
+
+   if(length(unique(kwdata$Station))>=2){
+
+     #run the Kruskal-Wallis test
+     kw<-kruskal.test(kwdata$Result,factor(kwdata$Station))
+     print(kw)
+
+     #if p value is equal to or less than 0.05, then run the post-hoc analysis
+     if(kw$p.value<=0.05){
+       kwmc<-kruskalmc(kwdata$Result, kwdata$Station)
+       print(kwmc)
+     }
+
+     #run Friedman's Test
+     ftdata.wide<-na.omit(kwdata.wide)              #remove incomplete datasets
+     print(paste(analyte[i],"data for Friedman's Test"))
+     print(ftdata.wide)
+     f<-friedman.test(as.matrix(ftdata.wide[2:6]))    #run Friedman's test
+     print(f)
+     #if p value is equal to or less than 0.05, then run the post-hoc analysis
+     if(f$p.value<=0.05){
+       fmc<-friedmanmc(as.matrix(ftdata.wide[2:6])) #run Post hoc test
+       print(fmc)
+     }
+   }
+ }
[1] "Thorium-230 data for Kruskal-Wallis Test"
 Date_Collected Station 1 Station 2 Station 3 Station 4 Station 5
       5/8/2014  0.000351  0.000774  0.000874  0.000514  0.000688
      5/15/2014  0.000873  0.000410  0.000433  0.000305  0.000398
      5/22/2014  0.004370  0.000490  0.000570  0.000377  0.000421
      5/29/2014  0.000915  0.000908  0.000482  0.000693  0.000578
       6/5/2014  0.000458  0.000378  0.000313  0.000617  0.000700
      6/12/2014  0.000389  0.000561  0.000712  0.000690  0.000832
      6/19/2014  0.000405  0.000307  0.000585  0.000358  0.000316
      6/26/2014  0.000621  0.000319  0.000592  0.000474  0.000271
       7/3/2014  0.000323  0.000641  0.000416  0.000606  0.000519
      7/10/2014  0.000609  0.000567  0.000608  0.000684  0.000368
      7/17/2014  0.000392  0.000609  0.000754  0.000613  0.000609
      7/24/2014  0.000581  0.000551  0.000499  0.000535  0.000350
      7/31/2014  0.000514  0.000586  0.000795  0.000339  0.000418
       8/7/2014  0.000484  0.000666  0.000886  0.000726  0.000710
      8/14/2014  0.000575  0.001360  0.000475  0.000567  0.000675
      8/21/2014  0.000377  0.000433  0.000599  0.001060  0.000553
      8/28/2014  0.000445  0.000769  0.000696  0.000544  0.000694
       9/4/2014  0.000494  0.000713  0.000623  0.000532  0.001990
      9/11/2014  0.000508  0.001040  0.000657  0.000830  0.000628
      9/17/2014  0.000506  0.000408  0.000854  0.000651  0.000590
      9/24/2014  0.000425  0.000589  0.000381  0.000640  0.000455
      10/1/2014  0.000312  0.000490  0.000608  0.000543  0.000509
      10/9/2014  0.000393  0.000463  0.000413  0.000424  0.000508
```

10/16/2014	0.000436	0.000695	0.000463	0.000394	0.000514
10/23/2014	0.000499	0.000720	0.000800	0.000708	0.000719
10/30/2014	0.000505	0.000458	0.000406	0.000620	0.000507
11/6/2014	0.000760	0.000574	0.000655	0.000458	0.000417
11/13/2014	0.000268	0.000684	0.000371	0.000466	0.000341
11/20/2014	0.000459	0.000513	0.000585	0.001290	0.001140
11/26/2014	0.000538	0.000952	0.000440	0.000694	0.000381
12/4/2014	0.000292	0.000480	0.000521	0.000462	0.000511
12/11/2014	0.000658	0.000312	0.000137	0.000189	0.000291
12/17/2014	0.000747	0.000564	0.000408	0.000830	0.000584
12/23/2014	0.000741	0.000965	0.000590	0.000563	0.000545
12/31/2014	0.000383	0.000358	0.000442	0.000181	0.000923
1/6/2015	0.000483	0.001160	0.000662	0.000541	0.000383
1/14/2015	0.000336	0.000270	0.000429	0.000443	0.000686
1/21/2015	0.000584	0.000621	0.000595	0.000294	0.000647
1/28/2015	0.000349	0.000680	0.000238	0.000231	0.000470
2/4/2015	0.000359	0.000562	0.000456	0.000386	0.000471
2/11/2015	0.000291	0.000290	0.000295	0.000412	0.000385
2/18/2015	0.000513	0.000263	0.000411	0.000688	0.000627
2/25/2015	0.000177	0.000321	0.000459	0.000428	0.000933
3/4/2015	0.000269	0.000595	0.000489	0.000264	0.000391
3/13/2015	NA	NA	NA	0.000242	NA
3/20/2015	NA	NA	NA	0.000522	NA
3/27/2015	NA	NA	NA	0.000512	NA
4/3/2015	NA	NA	NA	0.000417	NA
4/10/2015	NA	NA	NA	0.000553	NA
4/17/2015	NA	NA	NA	0.001800	NA
4/24/2015	NA	NA	NA	0.000274	NA
5/1/2015	NA	NA	NA	0.000673	NA
5/8/2015	NA	NA	NA	0.000695	NA
5/15/2015	NA	NA	NA	0.000440	NA
5/21/2015	NA	NA	NA	0.001470	NA
5/28/2015	NA	NA	NA	0.000684	NA
6/4/2015	NA	NA	NA	0.001160	NA
6/11/2015	NA	NA	NA	0.000253	NA
6/18/2015	NA	NA	NA	0.000464	NA
6/25/2015	NA	NA	NA	0.000576	NA
7/9/2015	NA	NA	NA	0.000287	NA
7/16/2015	NA	NA	NA	0.000547	NA
7/23/2015	NA	NA	NA	0.000334	NA
7/30/2015	NA	NA	NA	0.000582	NA

Kruskal-Wallis rank sum test

data: kwdata$Result and factor(kwdata$Station)
Kruskal-Wallis chi-squared = 5.5765, df = 4, p-value = 0.2331

[1] "Thorium-230 data for Friedman's Test"

	Date_Collected	Station 1	Station 2	Station 3	Station 4	Station 5
38	5/8/2014	0.000351	0.000774	0.000874	0.000514	0.000688
32	5/15/2014	0.000873	0.000410	0.000433	0.000305	0.000398
35	5/22/2014	0.004370	0.000490	0.000570	0.000377	0.000421
37	5/29/2014	0.000915	0.000908	0.000482	0.000693	0.000578
47	6/5/2014	0.000458	0.000378	0.000313	0.000617	0.000700
41	6/12/2014	0.000389	0.000561	0.000712	0.000690	0.000832
43	6/19/2014	0.000405	0.000307	0.000585	0.000358	0.000316
45	6/26/2014	0.000621	0.000319	0.000592	0.000474	0.000271
53	7/3/2014	0.000323	0.000641	0.000416	0.000606	0.000519
48	7/10/2014	0.000609	0.000567	0.000608	0.000684	0.000368
50	7/17/2014	0.000392	0.000609	0.000754	0.000613	0.000609
52	7/24/2014	0.000581	0.000551	0.000499	0.000535	0.000350
55	7/31/2014	0.000514	0.000586	0.000795	0.000339	0.000418
60	8/7/2014	0.000484	0.000666	0.000886	0.000726	0.000710
57	8/14/2014	0.000575	0.001360	0.000475	0.000567	0.000675

58	8/21/2014	0.000377	0.000433	0.000599	0.001060	0.000553
59	8/28/2014	0.000445	0.000769	0.000696	0.000544	0.000694
64	9/4/2014	0.000494	0.000713	0.000623	0.000532	0.001990
61	9/11/2014	0.000508	0.001040	0.000657	0.000830	0.000628
62	9/17/2014	0.000506	0.000408	0.000854	0.000651	0.000590
63	9/24/2014	0.000425	0.000589	0.000381	0.000640	0.000455
5	10/1/2014	0.000312	0.000490	0.000608	0.000543	0.000509
9	10/9/2014	0.000393	0.000463	0.000413	0.000424	0.000508
6	10/16/2014	0.000436	0.000695	0.000463	0.000394	0.000514
7	10/23/2014	0.000499	0.000720	0.000800	0.000708	0.000719
8	10/30/2014	0.000505	0.000458	0.000406	0.000620	0.000507
13	11/6/2014	0.000760	0.000574	0.000655	0.000458	0.000417
10	11/13/2014	0.000268	0.000684	0.000371	0.000466	0.000341
11	11/20/2014	0.000459	0.000513	0.000585	0.001290	0.001140
12	11/26/2014	0.000538	0.000952	0.000440	0.000694	0.000381
18	12/4/2014	0.000292	0.000480	0.000521	0.000462	0.000511
14	12/11/2014	0.000658	0.000312	0.000137	0.000189	0.000291
15	12/17/2014	0.000747	0.000564	0.000408	0.000830	0.000584
16	12/23/2014	0.000741	0.000965	0.000590	0.000563	0.000545
17	12/31/2014	0.000383	0.000358	0.000442	0.000181	0.000923
4	1/6/2015	0.000483	0.001160	0.000662	0.000541	0.000383
1	1/14/2015	0.000336	0.000270	0.000429	0.000443	0.000686
2	1/21/2015	0.000584	0.000621	0.000595	0.000294	0.000647
3	1/28/2015	0.000349	0.000680	0.000238	0.000231	0.000470
22	2/4/2015	0.000359	0.000562	0.000456	0.000386	0.000471
19	2/11/2015	0.000291	0.000290	0.000295	0.000412	0.000385
20	2/18/2015	0.000513	0.000263	0.000411	0.000688	0.000627
21	2/25/2015	0.000177	0.000321	0.000459	0.000428	0.000933
26	3/4/2015	0.000269	0.000595	0.000489	0.000264	0.000391

```
        Friedman rank sum test

data:  as.matrix(ftdata.wide[2:6])
Friedman chi-squared = 7.2947, df = 4, p-value = 0.1211

[1] "Uranium-238 data for Kruskal-Wallis Test"
```

Date_Collected	Station 1	Station 2	Station 3	Station 4	Station 5
5/8/2014	6.22e-04	1.35e-04	1.47e-04	1.73e-04	1.59e-04
5/15/2014	7.68e-05	1.29e-04	3.86e-04	4.18e-05	1.01e-04
5/22/2014	1.71e-04	9.47e-04	1.10e-04	8.35e-05	1.71e-04
5/29/2014	1.74e-04	4.35e-05	-4.42e-05	3.07e-04	3.45e-05
6/5/2014	1.29e-04	3.86e-05	8.49e-05	2.42e-04	-2.25e-05
6/12/2014	1.59e-04	1.59e-04	7.23e-05	1.19e-04	1.02e-04
6/19/2014	-1.03e-05	1.20e-04	7.10e-05	1.54e-04	9.53e-05
6/26/2014	8.22e-05	7.66e-05	1.80e-04	8.34e-05	1.02e-04
7/3/2014	1.41e-04	7.64e-05	6.58e-05	1.85e-04	1.67e-04
7/10/2014	9.43e-05	1.18e-04	7.12e-05	9.15e-05	1.15e-04
7/17/2014	1.39e-04	9.21e-05	1.73e-04	8.72e-05	1.19e-04
7/24/2014	1.36e-04	1.39e-04	1.32e-04	7.37e-05	7.43e-05
7/31/2014	8.69e-05	1.63e-04	1.54e-04	2.01e-04	5.52e-05
8/7/2014	1.66e-05	1.61e-04	1.11e-04	9.77e-05	1.35e-04
8/14/2014	1.26e-04	1.21e-04	1.56e-04	8.41e-05	6.58e-05
8/21/2014	0.00e+00	4.43e-06	1.71e-04	2.75e-05	-2.24e-05
8/28/2014	4.14e-05	2.63e-04	2.29e-04	8.35e-05	7.23e-05
9/4/2014	9.32e-05	9.38e-05	7.19e-05	1.34e-04	8.51e-05
9/11/2014	7.01e-05	9.50e-05	1.18e-04	7.37e-05	1.66e-04
9/17/2014	1.55e-04	1.31e-04	1.49e-04	1.62e-04	1.45e-04
9/24/2014	1.67e-04	1.86e-04	1.06e-04	5.50e-05	1.35e-04
10/1/2014	9.00e-05	-8.55e-05	5.95e-05	1.03e-04	9.31e-05
10/9/2014	1.23e-04	1.17e-04	1.09e-04	7.16e-05	1.34e-04
10/16/2014	1.17e-04	1.75e-04	5.67e-05	8.90e-05	8.54e-05
10/23/2014	1.09e-04	1.69e-04	5.41e-05	1.44e-04	1.32e-04
10/30/2014	1.36e-04	1.97e-04	1.24e-04	3.08e-05	9.11e-05
11/6/2014	1.08e-04	1.42e-04	6.60e-05	1.51e-04	1.14e-04

```
   11/13/2014  2.47e-05  1.83e-05  1.15e-04  4.39e-05  7.28e-05
   11/20/2014  4.31e-05  0.00e+00  4.51e-05  2.15e-04 -1.20e-05
   11/26/2014  9.52e-05  1.25e-04  1.29e-04  7.66e-05  1.63e-04
    12/4/2014  5.67e-05  0.00e+00  8.27e-05  1.61e-04  1.13e-04
   12/11/2014  2.10e-04  4.08e-05  1.66e-04  1.18e-04  1.29e-04
   12/17/2014  1.58e-04  1.44e-04  1.83e-04  6.17e-05  1.05e-04
   12/23/2014  6.29e-05  1.33e-04  1.40e-04  1.32e-04  1.22e-04
   12/31/2014 -4.45e-05  7.34e-05  1.13e-04  4.41e-05  1.45e-05
     1/6/2015  3.04e-05  2.05e-04  8.94e-05  6.79e-05 -2.39e-05
    1/14/2015  1.28e-04  8.32e-05  8.45e-05  4.70e-05  1.09e-04
    1/21/2015  6.76e-05 -5.66e-05  2.16e-04  1.04e-04  8.43e-05
    1/28/2015  1.08e-04  1.34e-04  4.08e-05 -9.39e-06  7.10e-05
     2/4/2015  2.94e-05  1.23e-04  1.19e-04  1.47e-04  1.51e-04
    2/11/2015  5.19e-05  1.81e-04  7.18e-05  8.61e-05  3.67e-05
    2/18/2015 -1.61e-04  1.08e-03  3.11e-04  1.29e-04  1.08e-05
    2/25/2015  7.51e-05  1.86e-04  9.80e-05  4.70e-05  2.25e-04
     3/4/2015  7.85e-05  8.54e-05  1.94e-04  2.15e-04  8.09e-05
    3/13/2015        NA        NA        NA  2.26e-05        NA
    3/20/2015        NA        NA        NA  1.50e-04        NA
    3/27/2015        NA        NA        NA  1.43e-04        NA
     4/3/2015        NA        NA        NA  1.75e-04        NA
    4/10/2015        NA        NA        NA  2.12e-04        NA
    4/17/2015        NA        NA        NA  1.69e-04        NA
    4/24/2015        NA        NA        NA  1.95e-04        NA
     5/1/2015        NA        NA        NA  9.52e-05        NA
     5/8/2015        NA        NA        NA  1.02e-05        NA
    5/15/2015        NA        NA        NA  1.03e-04        NA
    5/21/2015        NA        NA        NA  2.22e-04        NA
    5/28/2015        NA        NA        NA  2.33e-04        NA
     6/4/2015        NA        NA        NA  1.62e-04        NA
    6/11/2015        NA        NA        NA  1.03e-04        NA
    6/18/2015        NA        NA        NA  1.38e-04        NA
    6/25/2015        NA        NA        NA  1.78e-05        NA
     7/9/2015        NA        NA        NA -1.34e-05        NA
    7/16/2015        NA        NA        NA  9.87e-06        NA
    7/23/2015        NA        NA        NA  6.86e-05        NA
    7/30/2015        NA        NA        NA  1.30e-04        NA

	Kruskal-Wallis rank sum test

data:  kwdata$Result and factor(kwdata$Station)
Kruskal-Wallis chi-squared = 5.1393, df = 4, p-value = 0.2733

[1] "Uranium-238 data for Friedman's Test"
   Date_Collected Station 1 Station 2 Station 3 Station 4 Station 5
38       5/8/2014  6.22e-04  1.35e-04  1.47e-04  1.73e-04  1.59e-04
32      5/15/2014  7.68e-05  1.29e-04  3.86e-04  4.18e-05  1.01e-04
35      5/22/2014  1.71e-04  9.47e-04  1.10e-04  8.35e-05  1.71e-04
37      5/29/2014  1.74e-04  4.35e-05 -4.42e-05  3.07e-04  3.45e-05
47       6/5/2014  1.29e-04  3.86e-05  8.49e-05  2.42e-04 -2.25e-05
41      6/12/2014  1.59e-04  1.59e-04  7.23e-05  1.19e-04  1.02e-04
43      6/19/2014 -1.03e-05  1.20e-04  7.10e-05  1.54e-04  9.53e-05
45      6/26/2014  8.22e-05  7.66e-05  1.80e-04  8.34e-05  1.02e-04
53       7/3/2014  1.41e-04  7.64e-05  6.58e-05  1.85e-04  1.67e-04
48      7/10/2014  9.43e-05  1.18e-04  7.12e-05  9.15e-05  1.15e-04
50      7/17/2014  1.39e-04  9.21e-05  1.73e-04  8.72e-05  1.19e-04
52      7/24/2014  1.36e-04  1.39e-04  1.32e-04  7.37e-05  7.43e-05
55      7/31/2014  8.69e-05  1.63e-04  1.54e-04  2.01e-04  5.52e-05
60       8/7/2014  1.66e-05  1.61e-04  1.11e-04  9.77e-05  1.35e-04
57      8/14/2014  1.26e-04  1.21e-04  1.56e-04  8.41e-05  6.58e-05
58      8/21/2014  0.00e+00  4.43e-06  1.71e-04  2.75e-05 -2.24e-05
59      8/28/2014  4.14e-05  2.63e-04  2.29e-04  8.35e-05  7.23e-05
64       9/4/2014  9.32e-05  9.38e-05  7.19e-05  1.34e-04  8.51e-05
61      9/11/2014  7.01e-05  9.50e-05  1.18e-04  7.37e-05  1.66e-04
```

62	9/17/2014	1.55e-04	1.31e-04	1.49e-04	1.62e-04	1.45e-04
63	9/24/2014	1.67e-04	1.86e-04	1.06e-04	5.50e-05	1.35e-04
5	10/1/2014	9.00e-05	-8.55e-05	5.95e-05	1.03e-04	9.31e-05
9	10/9/2014	1.23e-04	1.17e-04	1.09e-04	7.16e-05	1.34e-04
6	10/16/2014	1.17e-04	1.75e-04	5.67e-05	8.90e-05	8.54e-05
7	10/23/2014	1.09e-04	1.69e-04	5.41e-05	1.44e-04	1.32e-04
8	10/30/2014	1.36e-04	1.97e-04	1.24e-04	3.08e-05	9.11e-05
13	11/6/2014	1.08e-04	1.42e-04	6.60e-05	1.51e-04	1.14e-04
10	11/13/2014	2.47e-05	1.83e-05	1.15e-04	4.39e-05	7.28e-05
11	11/20/2014	4.31e-05	0.00e+00	4.51e-05	2.15e-04	-1.20e-05
12	11/26/2014	9.52e-05	1.25e-04	1.29e-04	7.66e-05	1.63e-04
18	12/4/2014	5.67e-05	0.00e+00	8.27e-05	1.61e-04	1.13e-04
14	12/11/2014	2.10e-04	4.08e-05	1.66e-04	1.18e-04	1.29e-04
15	12/17/2014	1.58e-04	1.44e-04	1.83e-04	6.17e-05	1.05e-04
16	12/23/2014	6.29e-05	1.33e-04	1.40e-04	1.32e-04	1.22e-04
17	12/31/2014	-4.45e-05	7.34e-05	1.13e-04	4.41e-05	1.45e-05
4	1/6/2015	3.04e-05	2.05e-04	8.94e-05	6.79e-05	-2.39e-05
1	1/14/2015	1.28e-04	8.32e-05	8.45e-05	4.70e-05	1.09e-04
2	1/21/2015	6.76e-05	-5.66e-05	2.16e-04	1.04e-04	8.43e-05
3	1/28/2015	1.08e-04	1.34e-04	4.08e-05	-9.39e-06	7.10e-05
22	2/4/2015	2.94e-05	1.23e-04	1.19e-04	1.47e-04	1.51e-04
19	2/11/2015	5.19e-05	1.81e-04	7.18e-05	8.61e-05	3.67e-05
20	2/18/2015	-1.61e-04	1.08e-03	3.11e-04	1.29e-04	1.08e-05
21	2/25/2015	7.51e-05	1.86e-04	9.80e-05	4.70e-05	2.25e-04
26	3/4/2015	7.85e-05	8.54e-05	1.94e-04	2.15e-04	8.09e-05

```
        Friedman rank sum test

data:  as.matrix(ftdata.wide[2:6])
Friedman chi-squared = 3.8314, df = 4, p-value = 0.4293

[1] "Total Alpha-Emitting Radium data for Kruskal-Wallis Test"
```

Date_Collected	Station 1	Station 2	Station 3	Station 4	Station 5
5/8/2014	5.74e-04	5.14e-04	3.11e-04	8.12e-04	2.19e-04
5/22/2014	1.69e-04	6.05e-04	8.68e-04	2.65e-04	1.20e-03
5/29/2014	-8.56e-05	5.84e-04	3.50e-04	5.99e-04	3.73e-04
6/5/2014	-1.05e-04	3.32e-04	4.01e-04	-4.86e-04	-4.34e-04
6/12/2014	8.19e-04	4.09e-04	-4.04e-05	1.40e-05	1.26e-03
6/19/2014	6.40e-04	7.83e-04	2.97e-04	5.38e-04	1.13e-03
6/26/2014	-9.72e-05	9.15e-04	6.90e-04	5.16e-04	1.10e-03
7/3/2014	1.59e-03	1.80e-03	4.50e-04	-3.84e-04	0.00e+00
7/10/2014	3.82e-04	1.52e-03	4.71e-04	1.21e-03	2.26e-04
7/17/2014	1.10e-03	1.38e-03	2.01e-03	1.17e-03	4.40e-03
7/24/2014	5.01e-04	3.40e-04	5.58e-04	1.71e-04	2.75e-04
7/31/2014	7.02e-04	8.28e-04	1.13e-04	7.97e-04	5.44e-05
8/7/2014	-5.75e-05	8.45e-05	2.63e-04	5.15e-04	8.81e-06
8/14/2014	4.49e-04	1.01e-05	1.01e-03	3.44e-04	4.68e-04
8/21/2014	-1.41e-04	9.08e-04	4.55e-04	2.75e-04	5.05e-04
8/28/2014	3.97e-04	-2.01e-04	-1.28e-05	8.35e-04	8.36e-04
9/4/2014	-2.50e-04	6.13e-04	8.78e-04	2.86e-04	6.19e-04
9/11/2014	4.84e-04	5.14e-04	5.07e-04	8.47e-05	6.21e-04
9/17/2014	-1.22e-04	-1.09e-04	7.01e-04	6.67e-04	2.14e-04
9/24/2014	2.94e-04	4.72e-04	1.12e-03	1.48e-04	8.30e-04
10/1/2014	1.08e-03	6.18e-04	5.49e-04	1.30e-03	1.23e-03
10/9/2014	3.61e-04	7.57e-04	1.63e-04	8.15e-04	9.99e-04
10/16/2014	5.79e-04	4.72e-04	4.13e-04	6.67e-04	2.80e-04
10/23/2014	8.06e-04	1.08e-03	1.08e-03	4.58e-04	1.10e-03
10/30/2014	1.10e-03	-2.74e-04	-5.23e-05	9.69e-04	-2.14e-04
11/6/2014	7.67e-04	7.04e-04	8.52e-04	6.67e-04	5.32e-04
11/13/2014	3.31e-04	6.40e-04	9.47e-06	2.51e-04	3.90e-04
11/20/2014	7.78e-04	1.37e-04	2.95e-04	5.08e-04	1.69e-04
11/26/2014	9.21e-04	-6.83e-04	-1.56e-04	1.05e-03	5.16e-05
12/4/2014	7.10e-04	1.81e-04	-1.42e-04	5.09e-04	-4.05e-05
12/11/2014	6.28e-05	3.04e-04	1.46e-04	1.55e-04	2.64e-04

12/17/2014	5.73e-05	9.53e-05	9.36e-04	9.62e-04	4.97e-04
12/23/2014	7.92e-04	-1.32e-04	6.54e-05	5.14e-05	1.31e-04
12/31/2014	6.20e-05	3.89e-04	2.89e-04	1.36e-04	2.59e-04
1/6/2015	7.64e-04	4.55e-04	4.00e-05	1.38e-03	7.36e-04
1/14/2015	1.48e-04	1.60e-04	2.08e-04	1.50e-04	3.49e-05
1/21/2015	1.94e-05	3.13e-04	2.23e-04	9.53e-05	5.24e-04
1/28/2015	-7.19e-06	3.69e-04	-3.74e-05	2.63e-04	7.88e-04
2/4/2015	1.92e-04	8.85e-04	7.62e-06	4.38e-04	4.30e-04
2/11/2015	5.93e-04	5.16e-04	2.42e-04	-8.86e-05	1.65e-03
2/18/2015	-1.81e-04	-1.06e-04	7.35e-04	7.95e-04	1.59e-04
2/25/2015	6.40e-04	-1.26e-04	4.99e-04	1.37e-04	5.80e-04
3/4/2015	5.37e-04	4.15e-04	4.56e-04	1.27e-04	8.67e-04
3/13/2015	NA	NA	NA	4.15e-04	NA
3/20/2015	NA	NA	NA	5.39e-04	NA
3/27/2015	NA	NA	NA	-1.18e-04	NA
4/3/2015	NA	NA	NA	6.74e-04	NA
4/10/2015	NA	NA	NA	8.49e-04	NA
4/17/2015	NA	NA	NA	5.98e-04	NA
4/24/2015	NA	NA	NA	1.18e-03	NA
5/1/2015	NA	NA	NA	7.98e-04	NA
5/8/2015	NA	NA	NA	9.92e-04	NA
5/15/2015	NA	NA	NA	4.34e-04	NA
5/21/2015	NA	NA	NA	8.90e-04	NA
5/28/2015	NA	NA	NA	-7.57e-05	NA
6/4/2015	NA	NA	NA	1.08e-04	NA
6/11/2015	NA	NA	NA	2.23e-05	NA
6/18/2015	NA	NA	NA	2.68e-04	NA
6/25/2015	NA	NA	NA	7.68e-04	NA
7/9/2015	NA	NA	NA	2.99e-04	NA
7/16/2015	NA	NA	NA	2.15e-04	NA
7/23/2015	NA	NA	NA	6.54e-04	NA
7/30/2015	NA	NA	NA	1.56e-04	NA

Kruskal-Wallis rank sum test

data: kwdata$Result and factor(kwdata$Station)
Kruskal-Wallis chi-squared = 1.6812, df = 4, p-value = 0.7941

[1] "Total Alpha-Emitting Radium data for Friedman's Test"

	Date_Collected	Station 1	Station 2	Station 3	Station 4	Station 5
37	5/8/2014	5.74e-04	5.14e-04	3.11e-04	8.12e-04	2.19e-04
34	5/22/2014	1.69e-04	6.05e-04	8.68e-04	2.65e-04	1.20e-03
36	5/29/2014	-8.56e-05	5.84e-04	3.50e-04	5.99e-04	3.73e-04
46	6/5/2014	-1.05e-04	3.32e-04	4.01e-04	-4.86e-04	-4.34e-04
40	6/12/2014	8.19e-04	4.09e-04	-4.04e-05	1.40e-05	1.26e-03
42	6/19/2014	6.40e-04	7.83e-04	2.97e-04	5.38e-04	1.13e-03
44	6/26/2014	-9.72e-05	9.15e-04	6.90e-04	5.16e-04	1.10e-03
52	7/3/2014	1.59e-03	1.80e-03	4.50e-04	-3.84e-04	0.00e+00
47	7/10/2014	3.82e-04	1.52e-03	4.71e-04	1.21e-03	2.26e-04
49	7/17/2014	1.10e-03	1.38e-03	2.01e-03	1.17e-03	4.40e-03
51	7/24/2014	5.01e-04	3.40e-04	5.58e-04	1.71e-04	2.75e-04
54	7/31/2014	7.02e-04	8.28e-04	1.13e-04	7.97e-04	5.44e-05
59	8/7/2014	-5.75e-05	8.45e-05	2.63e-04	5.15e-04	8.81e-06
56	8/14/2014	4.49e-04	1.01e-05	1.01e-03	3.44e-04	4.68e-04
57	8/21/2014	-1.41e-04	9.08e-04	4.55e-04	2.75e-04	5.05e-04
58	8/28/2014	3.97e-04	-2.01e-04	-1.28e-05	8.35e-04	8.36e-04
63	9/4/2014	-2.50e-04	6.13e-04	8.78e-04	2.86e-04	6.19e-04
60	9/11/2014	4.84e-04	5.14e-04	5.07e-04	8.47e-05	6.21e-04
61	9/17/2014	-1.22e-04	-1.09e-04	7.01e-04	6.67e-04	2.14e-04
62	9/24/2014	2.94e-04	4.72e-04	1.12e-03	1.48e-04	8.30e-04
5	10/1/2014	1.08e-03	6.18e-04	5.49e-04	1.30e-03	1.23e-03
9	10/9/2014	3.61e-04	7.57e-04	1.63e-04	8.15e-04	9.99e-04
6	10/16/2014	5.79e-04	4.72e-04	4.13e-04	6.67e-04	2.80e-04
7	10/23/2014	8.06e-04	1.08e-03	1.08e-03	4.58e-04	1.10e-03

8	10/30/2014	1.10e-03	-2.74e-04	-5.23e-05	9.69e-04	-2.14e-04
13	11/6/2014	7.67e-04	7.04e-04	8.52e-04	6.67e-04	5.32e-04
10	11/13/2014	3.31e-04	6.40e-04	9.47e-06	2.51e-04	3.90e-04
11	11/20/2014	7.78e-04	1.37e-04	2.95e-04	5.08e-04	1.69e-04
12	11/26/2014	9.21e-04	-6.83e-04	-1.56e-04	1.05e-03	5.16e-05
18	12/4/2014	7.10e-04	1.81e-04	-1.42e-04	5.09e-04	-4.05e-05
14	12/11/2014	6.28e-05	3.04e-04	1.46e-04	1.55e-04	2.64e-04
15	12/17/2014	5.73e-05	9.53e-05	9.36e-04	9.62e-04	4.97e-04
16	12/23/2014	7.92e-04	-1.32e-04	6.54e-05	5.14e-05	1.31e-04
17	12/31/2014	6.20e-05	3.89e-04	2.89e-04	1.36e-04	2.59e-04
4	1/6/2015	7.64e-04	4.55e-04	4.00e-05	1.38e-03	7.36e-04
1	1/14/2015	1.48e-04	1.60e-04	2.08e-04	1.50e-04	3.49e-05
2	1/21/2015	1.94e-05	3.13e-04	2.23e-04	9.53e-05	5.24e-04
3	1/28/2015	-7.19e-06	3.69e-04	-3.74e-05	2.63e-04	7.88e-04
22	2/4/2015	1.92e-04	8.85e-04	7.62e-06	4.38e-04	4.30e-04
19	2/11/2015	5.93e-04	5.16e-04	2.42e-04	-8.86e-05	1.65e-03
20	2/18/2015	-1.81e-04	-1.06e-04	7.35e-04	7.95e-04	1.59e-04
21	2/25/2015	6.40e-04	-1.26e-04	4.99e-04	1.37e-04	5.80e-04
26	3/4/2015	5.37e-04	4.15e-04	4.56e-04	1.27e-04	8.67e-04

Friedman rank sum test

data: as.matrix(ftdata.wide[2:6])
Friedman chi-squared = 4.596, df = 4, p-value = 0.3313

[1] "Gross Alpha data for Kruskal-Wallis Test"

Date_Collected	Station 1	Station 2	Station 3	Station 4	Station 5
5/8/2014	0.001270	0.000823	0.000442	0.000300	0.001310
5/15/2014	0.000412	0.000519	0.000382	0.000176	0.000542
5/22/2014	0.000595	0.000848	0.000570	0.000807	0.000397
5/29/2014	0.000418	0.000458	0.000730	0.000610	0.000628
6/5/2014	0.000464	0.000193	0.000626	0.000353	0.000110
6/12/2014	0.000406	0.000397	0.000360	0.000392	0.000213
6/19/2014	0.000774	0.000425	0.000780	0.000626	0.000570
6/26/2014	0.000325	0.000818	0.000529	0.000326	0.000351
7/3/2014	0.000750	0.000933	0.000569	0.000330	0.000954
7/10/2014	0.000464	0.000749	0.000732	0.001280	0.000803
7/17/2014	0.000889	0.001210	0.000854	0.000959	0.000759
7/24/2014	0.000573	0.000541	0.000281	0.000596	0.000500
7/31/2014	0.000957	0.000450	0.000632	0.000901	0.000371
8/7/2014	0.000820	0.001110	0.000631	0.001050	0.001140
8/14/2014	0.000487	0.000600	0.000453	0.000316	0.000571
8/21/2014	0.001080	0.000606	0.000955	0.001080	0.000860
8/28/2014	0.001580	0.001680	0.001580	0.001250	0.001340
9/4/2014	0.000638	0.000428	0.000854	0.000532	0.000344
9/11/2014	0.000470	0.000532	0.000750	0.000317	0.000694
9/17/2014	0.000493	0.000498	0.000762	0.000601	0.000299
9/24/2014	0.000736	0.001160	0.000868	0.000957	0.001120
10/1/2014	0.000798	0.000979	0.001340	0.000575	0.000388
10/9/2014	0.000422	0.000443	0.000463	0.000625	0.000765
10/16/2014	0.000526	0.000554	0.000397	0.000699	0.000759
10/23/2014	0.000655	0.000625	0.000380	0.000484	0.000414
10/30/2014	0.000372	0.000410	0.000931	0.000544	0.000622
11/6/2014	0.000893	0.000490	0.001070	0.000117	0.000883
11/13/2014	0.000530	0.000775	0.000448	0.000278	0.000700
11/20/2014	0.000730	0.001100	0.000904	0.000968	0.000575
11/26/2014	0.000645	0.001360	0.000826	0.000995	0.001650
12/4/2014	0.000758	0.000613	0.000838	0.000974	0.001420
12/11/2014	0.001260	0.000624	0.001100	0.000620	0.000546
12/17/2014	0.001630	0.001170	0.000961	0.000612	0.000785
12/23/2014	0.000543	0.001090	0.000899	0.001380	0.000875
12/31/2014	0.000199	0.000707	0.000301	0.000546	0.000510
1/6/2015	0.000750	0.001060	0.000625	0.001180	0.000924
1/14/2015	0.000411	0.000501	0.000460	0.000867	0.000720

```
    1/21/2015 0.000581 0.000456 0.000375 0.000474 0.000245
    1/28/2015 0.000386 0.000644 0.000102 0.000400 0.000353
     2/4/2015 0.000514 0.000290 0.000452 0.000346 0.000855
    2/11/2015 0.001110 0.001100 0.000710 0.000854 0.001130
    2/18/2015 0.000719 0.000784 0.000533 0.000591 0.001060
    2/25/2015 0.001000 0.001240 0.000911 0.001290 0.001590
     3/4/2015 0.000853 0.000535 0.000518 0.000713 0.000622
    3/13/2015       NA       NA       NA 0.000426       NA
    3/20/2015       NA       NA       NA 0.000650       NA
    3/27/2015       NA       NA       NA 0.000688       NA
     4/3/2015       NA       NA       NA 0.000811       NA
    4/10/2015       NA       NA       NA 0.000330       NA
    4/17/2015       NA       NA       NA 0.000307       NA
    4/24/2015       NA       NA       NA 0.000891       NA
     5/1/2015       NA       NA       NA 0.000503       NA
     5/8/2015       NA       NA       NA 0.000196       NA
    5/15/2015       NA       NA       NA 0.000582       NA
    5/21/2015       NA       NA       NA 0.000815       NA
    5/28/2015       NA       NA       NA 0.000449       NA
     6/4/2015       NA       NA       NA 0.000327       NA
    6/11/2015       NA       NA       NA 0.000397       NA
    6/18/2015       NA       NA       NA 0.000468       NA
    6/25/2015       NA       NA       NA 0.000228       NA
     7/9/2015       NA       NA       NA 0.000762       NA
    7/16/2015       NA       NA       NA 0.000680       NA
    7/23/2015       NA       NA       NA 0.000617       NA
    7/30/2015       NA       NA       NA 0.000737       NA

	Kruskal-Wallis rank sum test

data:  kwdata$Result and factor(kwdata$Station)
Kruskal-Wallis chi-squared = 2.9296, df = 4, p-value = 0.5697

[1] "Gross Alpha data for Friedman's Test"
   Date_Collected Station 1 Station 2 Station 3 Station 4 Station 5
38       5/8/2014  0.001270  0.000823  0.000442  0.000300  0.001310
32      5/15/2014  0.000412  0.000519  0.000382  0.000176  0.000542
35      5/22/2014  0.000595  0.000848  0.000570  0.000807  0.000397
37      5/29/2014  0.000418  0.000458  0.000730  0.000610  0.000628
47       6/5/2014  0.000464  0.000193  0.000626  0.000353  0.000110
41      6/12/2014  0.000406  0.000397  0.000360  0.000392  0.000213
43      6/19/2014  0.000774  0.000425  0.000780  0.000626  0.000570
45      6/26/2014  0.000325  0.000818  0.000529  0.000326  0.000351
53       7/3/2014  0.000750  0.000933  0.000569  0.000330  0.000954
48      7/10/2014  0.000464  0.000749  0.000732  0.001280  0.000803
50      7/17/2014  0.000889  0.001210  0.000854  0.000959  0.000759
52      7/24/2014  0.000573  0.000541  0.000281  0.000596  0.000500
55      7/31/2014  0.000957  0.000450  0.000632  0.000901  0.000371
60       8/7/2014  0.000820  0.001110  0.000631  0.001050  0.001140
57      8/14/2014  0.000487  0.000600  0.000453  0.000316  0.000571
58      8/21/2014  0.001080  0.000606  0.000955  0.001080  0.000860
59      8/28/2014  0.001580  0.001680  0.001580  0.001250  0.001340
64       9/4/2014  0.000638  0.000428  0.000854  0.000532  0.000344
61      9/11/2014  0.000470  0.000532  0.000750  0.000317  0.000694
62      9/17/2014  0.000493  0.000498  0.000762  0.000601  0.000299
63      9/24/2014  0.000736  0.001160  0.000868  0.000957  0.001120
5       10/1/2014  0.000798  0.000979  0.001340  0.000575  0.000388
9       10/9/2014  0.000422  0.000443  0.000463  0.000625  0.000765
6      10/16/2014  0.000526  0.000554  0.000397  0.000699  0.000759
7      10/23/2014  0.000655  0.000625  0.000380  0.000484  0.000414
8      10/30/2014  0.000372  0.000410  0.000931  0.000544  0.000622
13      11/6/2014  0.000893  0.000490  0.001070  0.000117  0.000883
10     11/13/2014  0.000530  0.000775  0.000448  0.000278  0.000700
11     11/20/2014  0.000730  0.001100  0.000904  0.000968  0.000575
```

```
12      11/26/2014  0.000645  0.001360  0.000826  0.000995  0.001650
18       12/4/2014  0.000758  0.000613  0.000838  0.000974  0.001420
14      12/11/2014  0.001260  0.000624  0.001100  0.000620  0.000546
15      12/17/2014  0.001630  0.001170  0.000961  0.000612  0.000785
16      12/23/2014  0.000543  0.001090  0.000899  0.001380  0.000875
17      12/31/2014  0.000199  0.000707  0.000301  0.000546  0.000510
4         1/6/2015  0.000750  0.001060  0.000625  0.001180  0.000924
1        1/14/2015  0.000411  0.000501  0.000460  0.000867  0.000720
2        1/21/2015  0.000581  0.000456  0.000375  0.000474  0.000245
3        1/28/2015  0.000386  0.000644  0.000102  0.000400  0.000353
22        2/4/2015  0.000514  0.000290  0.000452  0.000346  0.000855
19       2/11/2015  0.001110  0.001100  0.000710  0.000854  0.001130
20       2/18/2015  0.000719  0.000784  0.000533  0.000591  0.001060
21       2/25/2015  0.001000  0.001240  0.000911  0.001290  0.001590
26        3/4/2015  0.000853  0.000535  0.000518  0.000713  0.000622

        Friedman rank sum test

data:  as.matrix(ftdata.wide[2:6])
Friedman chi-squared = 3.8952, df = 4, p-value = 0.4204

[1] "Gross Beta data for Kruskal-Wallis Test"
 Date_Collected Station 1 Station 2 Station 3 Station 4 Station 5
       5/8/2014    0.0187   0.01730    0.0184    0.0185    0.0172
      5/15/2014    0.0152   0.01480    0.0154    0.0156    0.0121
      5/22/2014    0.0188   0.01870    0.0189    0.0180    0.0172
      5/29/2014    0.0195   0.01880    0.0182    0.0184    0.0189
       6/5/2014    0.0153   0.01490    0.0154    0.0148    0.0149
      6/12/2014    0.0150   0.01620    0.0162    0.0153    0.0137
      6/19/2014    0.0201   0.02200    0.0204    0.0194    0.0189
      6/26/2014    0.0180   0.01930    0.0184    0.0171    0.0180
       7/3/2014    0.0162   0.01510    0.0165    0.0175    0.0168
      7/10/2014    0.0197   0.01880    0.0203    0.0213    0.0204
      7/17/2014    0.0174   0.01760    0.0174    0.0162    0.0178
      7/24/2014    0.0249   0.02770    0.0256    0.0267    0.0255
      7/31/2014    0.0205   0.01980    0.0195    0.0181    0.0192
       8/7/2014    0.0302   0.03590    0.0320    0.0357    0.0320
      8/14/2014    0.0223   0.02290    0.0224    0.0228    0.0215
      8/21/2014    0.0269   0.02420    0.0290    0.0267    0.0275
      8/28/2014    0.0294   0.03110    0.0306    0.0298    0.0329
       9/4/2014    0.0195   0.01840    0.0213    0.0197    0.0183
      9/11/2014    0.0172   0.01890    0.0175    0.0179    0.0180
      9/17/2014    0.0159   0.01920    0.0181    0.0175    0.0157
      9/24/2014    0.0270   0.02790    0.0271    0.0248    0.0266
      10/1/2014    0.0327   0.03310    0.0352    0.0370    0.0353
      10/9/2014    0.0190   0.01510    0.0166    0.0166    0.0179
     10/16/2014    0.0155   0.01320    0.0132    0.0132    0.0138
     10/23/2014    0.0163   0.01810    0.0164    0.0154    0.0159
     10/30/2014    0.0264   0.00413    0.0274    0.0267    0.0265
      11/6/2014    0.0178   0.01580    0.0184    0.0158    0.0157
     11/13/2014    0.0159   0.01710    0.0164    0.0153    0.0142
     11/20/2014    0.0247   0.02590    0.0245    0.0238    0.0240
     11/26/2014    0.0295   0.02730    0.0306    0.0274    0.0303
      12/4/2014    0.0273   0.02740    0.0267    0.0269    0.0315
     12/11/2014    0.0349   0.03090    0.0353    0.0318    0.0340
     12/17/2014    0.0357   0.03610    0.0388    0.0339    0.0332
     12/23/2014    0.0262   0.02720    0.0249    0.0292    0.0242
     12/31/2014    0.0199   0.02160    0.0213    0.0204    0.0202
       1/6/2015    0.0189   0.02570    0.0249    0.0242    0.0237
      1/14/2015    0.0192   0.02110    0.0189    0.0206    0.0194
      1/21/2015    0.0209   0.02160    0.0200    0.0214    0.0159
      1/28/2015    0.0115   0.01430    0.0146    0.0132    0.0148
       2/4/2015    0.0147   0.01500    0.0161    0.0156    0.0154
      2/11/2015    0.0291   0.03120    0.0275    0.0262    0.0273
```

2/18/2015	0.0258	0.02580	0.0243	0.0256	0.0289
2/25/2015	0.0395	0.04360	0.0396	0.0415	0.0431
3/4/2015	0.0226	0.02460	0.0220	0.0204	0.0228
3/13/2015	NA	NA	NA	0.0182	NA
3/20/2015	NA	NA	NA	0.0188	NA
3/27/2015	NA	NA	NA	0.0173	NA
4/3/2015	NA	NA	NA	0.0165	NA
4/10/2015	NA	NA	NA	0.0186	NA
4/17/2015	NA	NA	NA	0.0132	NA
4/24/2015	NA	NA	NA	0.0154	NA
5/1/2015	NA	NA	NA	0.0157	NA
5/8/2015	NA	NA	NA	0.0225	NA
5/15/2015	NA	NA	NA	0.0169	NA
5/21/2015	NA	NA	NA	0.0128	NA
5/28/2015	NA	NA	NA	0.0200	NA
6/4/2015	NA	NA	NA	0.0116	NA
6/11/2015	NA	NA	NA	0.0217	NA
6/18/2015	NA	NA	NA	0.0157	NA
6/25/2015	NA	NA	NA	0.0175	NA
7/9/2015	NA	NA	NA	0.0210	NA
7/16/2015	NA	NA	NA	0.0195	NA
7/23/2015	NA	NA	NA	0.0163	NA
7/30/2015	NA	NA	NA	0.0227	NA

Kruskal-Wallis rank sum test

data: kwdata$Result and factor(kwdata$Station)
Kruskal-Wallis chi-squared = 2.932, df = 4, p-value = 0.5693

[1] "Gross Beta data for Friedman's Test"

	Date_Collected	Station 1	Station 2	Station 3	Station 4	Station 5
38	5/8/2014	0.0187	0.01730	0.0184	0.0185	0.0172
32	5/15/2014	0.0152	0.01480	0.0154	0.0156	0.0121
35	5/22/2014	0.0188	0.01870	0.0189	0.0180	0.0172
37	5/29/2014	0.0195	0.01880	0.0182	0.0184	0.0189
47	6/5/2014	0.0153	0.01490	0.0154	0.0148	0.0149
41	6/12/2014	0.0150	0.01620	0.0162	0.0153	0.0137
43	6/19/2014	0.0201	0.02200	0.0204	0.0194	0.0189
45	6/26/2014	0.0180	0.01930	0.0184	0.0171	0.0180
53	7/3/2014	0.0162	0.01510	0.0165	0.0175	0.0168
48	7/10/2014	0.0197	0.01880	0.0203	0.0213	0.0204
50	7/17/2014	0.0174	0.01760	0.0174	0.0162	0.0178
52	7/24/2014	0.0249	0.02770	0.0256	0.0267	0.0255
55	7/31/2014	0.0205	0.01980	0.0195	0.0181	0.0192
60	8/7/2014	0.0302	0.03590	0.0320	0.0357	0.0320
57	8/14/2014	0.0223	0.02290	0.0224	0.0228	0.0215
58	8/21/2014	0.0269	0.02420	0.0290	0.0267	0.0275
59	8/28/2014	0.0294	0.03110	0.0306	0.0298	0.0329
64	9/4/2014	0.0195	0.01840	0.0213	0.0197	0.0183
61	9/11/2014	0.0172	0.01890	0.0175	0.0179	0.0180
62	9/17/2014	0.0159	0.01920	0.0181	0.0175	0.0157
63	9/24/2014	0.0270	0.02790	0.0271	0.0248	0.0266
5	10/1/2014	0.0327	0.03310	0.0352	0.0370	0.0353
9	10/9/2014	0.0190	0.01510	0.0166	0.0166	0.0179
6	10/16/2014	0.0155	0.01320	0.0132	0.0132	0.0138
7	10/23/2014	0.0163	0.01810	0.0164	0.0154	0.0159
8	10/30/2014	0.0264	0.00413	0.0274	0.0267	0.0265
13	11/6/2014	0.0178	0.01580	0.0184	0.0158	0.0157
10	11/13/2014	0.0159	0.01710	0.0164	0.0153	0.0142
11	11/20/2014	0.0247	0.02590	0.0245	0.0238	0.0240
12	11/26/2014	0.0295	0.02730	0.0306	0.0274	0.0303
18	12/4/2014	0.0273	0.02740	0.0267	0.0269	0.0315
14	12/11/2014	0.0349	0.03090	0.0353	0.0318	0.0340
15	12/17/2014	0.0357	0.03610	0.0388	0.0339	0.0332

16	12/23/2014	0.0262	0.02720	0.0249	0.0292	0.0242
17	12/31/2014	0.0199	0.02160	0.0213	0.0204	0.0202
4	1/6/2015	0.0189	0.02570	0.0249	0.0242	0.0237
1	1/14/2015	0.0192	0.02110	0.0189	0.0206	0.0194
2	1/21/2015	0.0209	0.02160	0.0200	0.0214	0.0159
3	1/28/2015	0.0115	0.01430	0.0146	0.0132	0.0148
22	2/4/2015	0.0147	0.01500	0.0161	0.0156	0.0154
19	2/11/2015	0.0291	0.03120	0.0275	0.0262	0.0273
20	2/18/2015	0.0258	0.02580	0.0243	0.0256	0.0289
21	2/25/2015	0.0395	0.04360	0.0396	0.0415	0.0431
26	3/4/2015	0.0226	0.02460	0.0220	0.0204	0.0228

```
        Friedman rank sum test

data:  as.matrix(ftdata.wide[2:6])
Friedman chi-squared = 11.949, df = 4, p-value = 0.01773

Multiple comparisons between groups after Friedman test
p.value: 0.05
Comparisons
    obs.dif critical.dif difference
1-2    34.5     41.63504      FALSE
1-3    27.5     41.63504      FALSE
1-4     1.5     41.63504      FALSE
1-5     3.0     41.63504      FALSE
2-3     7.0     41.63504      FALSE
2-4    36.0     41.63504      FALSE
2-5    37.5     41.63504      FALSE
3-4    29.0     41.63504      FALSE
3-5    30.5     41.63504      FALSE
4-5     1.5     41.63504      FALSE

>
```

```
> #Kruskal-Wallis and Friedman's Tests for Radon Data
> library(pgirmess)
> library(reshape2)
>
> #load radon measurements
> kwdata<-radon[c("Station.Name", "Stop_Date","result", "run.dixon")]
>
> #If measurements did not meet Data Quality Objectives (DQO) (less than usable replicate measure
ments)
> #then make the value "NA" so that it is not used in the Kruskal-Wallis test
> kwdata$result[kwdata$run.dixon=="no"] <- NA
>
> #format a table for printing
> kwdata.wide<-dcast(kwdata, Stop_Date ~ Station.Name, value.var="result",  na.rm = FALSE)
> kwdata.wide<-kwdata.wide[order(as.Date(kwdata.wide$Stop_Date, "%m/%d/%Y")),]
> print(kwdata.wide, row.names = FALSE)
```

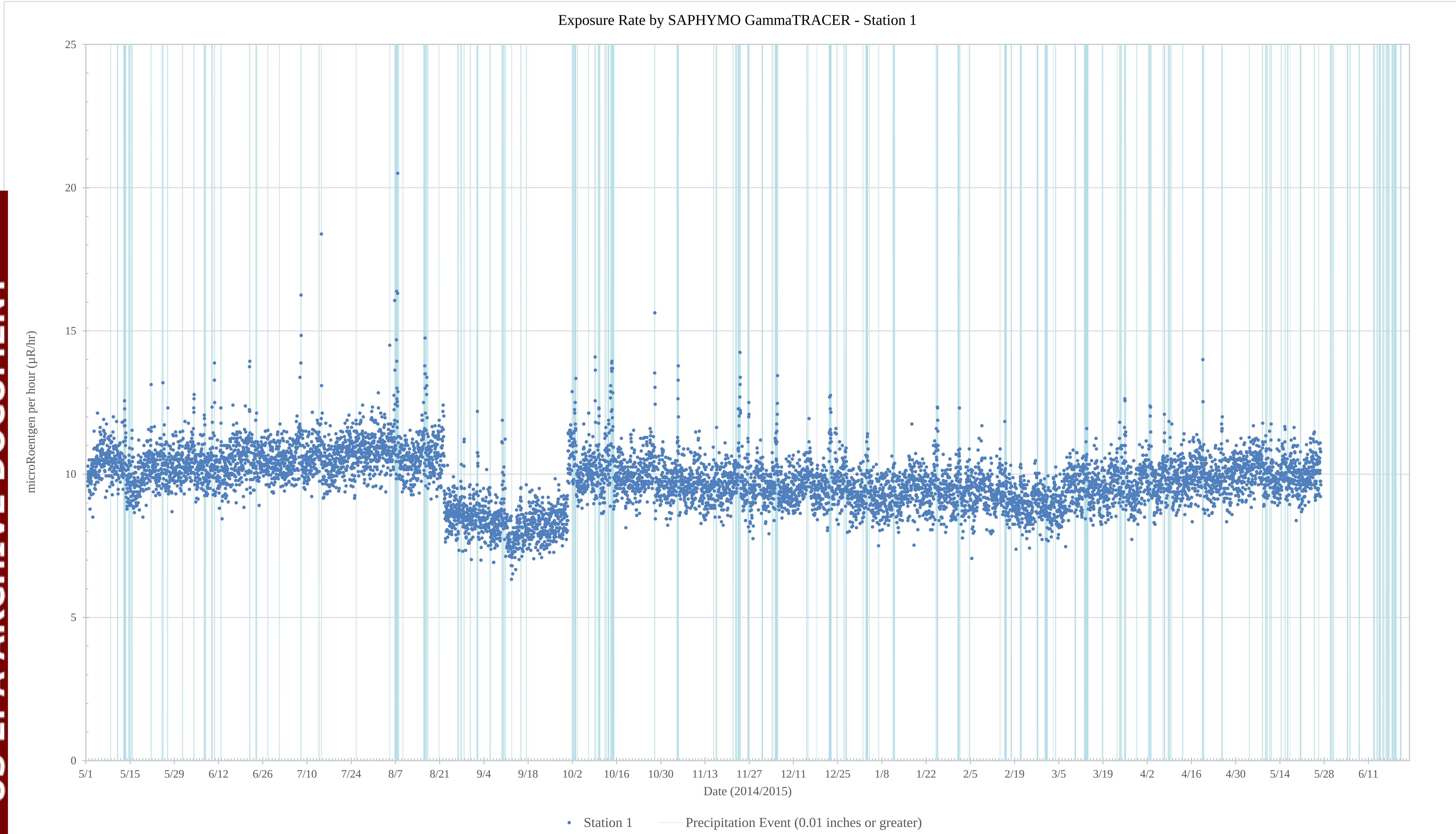
Stop_Date	Station 1	Station 2	Station 3	Station 4	Station 5
5/2/2014	0.263	0.746	0.368	0.828	0.720
5/9/2014	0.266	0.342	0.201	0.157	0.172
5/16/2014	0.254	0.273	0.273	0.132	0.132
5/23/2014	NA	0.467	0.206	0.109	0.159
5/30/2014	0.238	NA	0.287	0.181	NA
6/6/2014	0.204	0.182	0.182	0.160	0.151
6/13/2014	0.265	0.235	0.173	0.168	0.309
6/20/2014	0.195	NA	NA	NA	0.461
6/27/2014	NA	0.631	0.220	NA	NA
7/3/2014	0.192	NA	0.122	NA	0.114
7/11/2014	0.198	0.156	0.182	0.314	0.140
7/17/2014	0.235	0.186	0.247	0.832	0.164
7/25/2014	0.276	0.253	0.251	NA	0.236
8/1/2014	0.283	0.279	0.207	0.204	0.224
8/8/2014	0.363	0.478	0.308	0.267	0.300
8/15/2014	0.290	0.289	0.370	0.262	0.263
8/22/2014	0.276	0.386	0.328	0.328	0.204
8/29/2014	0.235	0.223	0.249	0.128	0.219
9/5/2014	0.212	NA	0.226	0.085	0.183
9/12/2014	0.252	0.236	NA	0.155	NA
9/18/2014	0.206	NA	0.216	0.237	0.389
9/25/2014	0.254	NA	NA	NA	NA
10/2/2014	0.360	1.284	0.396	NA	NA
10/10/2014	NA	0.638	0.296	NA	0.276
10/17/2014	0.223	0.197	0.214	0.143	0.221
10/24/2014	0.281	NA	0.257	0.164	NA
10/31/2014	0.375	0.272	0.340	0.307	0.387
11/7/2014	0.274	0.213	0.221	0.156	0.261
11/13/2014	0.283	0.224	0.254	0.240	0.299
11/20/2014	0.345	0.223	0.345	0.173	0.345
11/26/2014	0.335	0.214	0.308	0.237	0.333
12/4/2014	0.351	0.354	0.308	0.294	0.308
12/11/2014	0.375	0.347	0.373	NA	0.343
12/17/2014	1.005	0.240	NA	NA	0.337
12/23/2014	NA	0.227	0.263	0.128	NA
12/30/2014	0.430	0.263	0.281	0.212	0.586
1/6/2015	0.313	0.203	0.280	0.774	0.320
1/13/2015	0.282	0.236	0.244	0.140	0.296
1/20/2015	0.408	0.255	0.323	0.558	0.393
1/27/2015	0.369	0.233	0.507	0.349	0.354

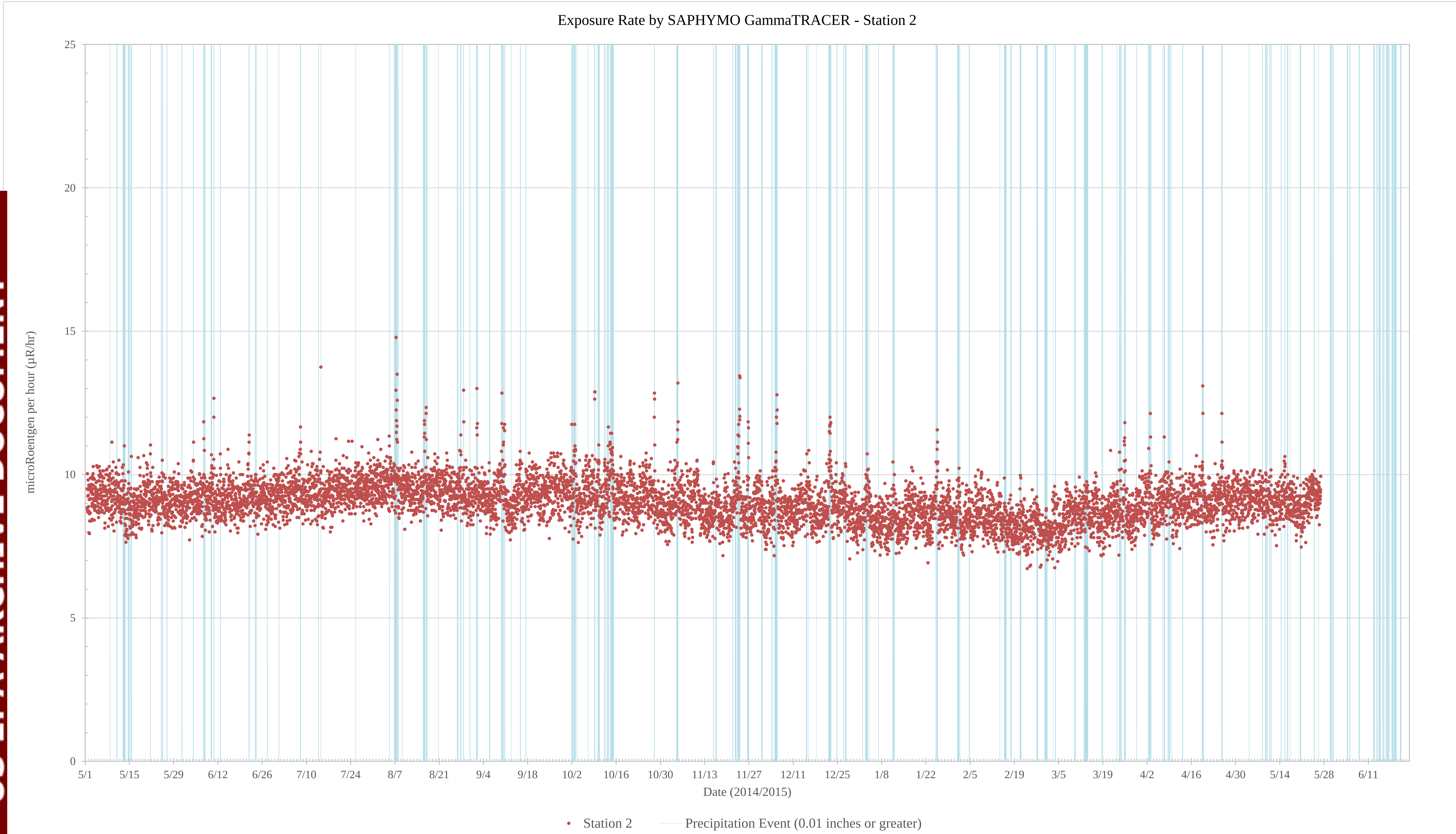
```
   2/3/2015     0.229     0.170     0.268     0.159     0.278
  2/10/2015     0.329     0.244     0.309     0.155     0.304
  2/17/2015     0.266     0.182     0.224     0.146     0.296
>
> #run the Kruskal-Wallis test
> kw<-kruskal.test(kwdata$result,factor(kwdata$Station.Name))
> kw

         Kruskal-Wallis rank sum test

data:  kwdata$result and factor(kwdata$Station.Name)
Kruskal-Wallis chi-squared = 13.6471, df = 4, p-value = 0.008511

>
> #if p value is equal to or less than 0.05, then run the post-hoc analysis
> if(kw$p.value<=0.05){
+   kwmc<-kruskalmc(kwdata$result,factor(kwdata$Station.Name))
+   print(kwmc)
+ }
Multiple comparison test after Kruskal-Wallis
p.value: 0.05
Comparisons
                      obs.dif critical.dif difference
Station 1-Station 2 12.879274     34.55404      FALSE
Station 1-Station 3 10.782051     33.85591      FALSE
Station 1-Station 4 43.100679     35.07854       TRUE
Station 1-Station 5  6.879274     34.55404      FALSE
Station 2-Station 3  2.097222     34.55404      FALSE
Station 2-Station 4 30.221405     35.75280      FALSE
Station 2-Station 5  6.000000     35.23835      FALSE
Station 3-Station 4 32.318627     35.07854      FALSE
Station 3-Station 5  3.902778     34.55404      FALSE
Station 4-Station 5 36.221405     35.75280       TRUE
Warning message:
In kruskalmc.default(kwdata$result, factor(kwdata$Station.Name)) :
  31 lines including NA have been omitted
>
> #Friedman's Test for Radon Data
> ftdata.wide<-na.omit(kwdata.wide)              #remove incomplete datasets
> ftdata.wide
    Stop_Date Station 1 Station 2 Station 3 Station 4 Station 5
23   5/2/2014     0.263     0.746     0.368     0.828     0.720
26   5/9/2014     0.266     0.342     0.201     0.157     0.172
22  5/16/2014     0.254     0.273     0.273     0.132     0.132
30   6/6/2014     0.204     0.182     0.182     0.160     0.151
27  6/13/2014     0.265     0.235     0.173     0.168     0.309
31  7/11/2014     0.198     0.156     0.182     0.314     0.140
32  7/17/2014     0.235     0.186     0.247     0.832     0.164
35   8/1/2014     0.283     0.279     0.207     0.204     0.224
39   8/8/2014     0.363     0.478     0.308     0.267     0.300
36  8/15/2014     0.290     0.289     0.370     0.262     0.263
37  8/22/2014     0.276     0.386     0.328     0.328     0.204
38  8/29/2014     0.235     0.223     0.249     0.128     0.219
6  10/17/2014     0.223     0.197     0.214     0.143     0.221
9  10/31/2014     0.375     0.272     0.340     0.307     0.387
13  11/7/2014     0.274     0.213     0.221     0.156     0.261
10 11/13/2014     0.283     0.224     0.254     0.240     0.299
```

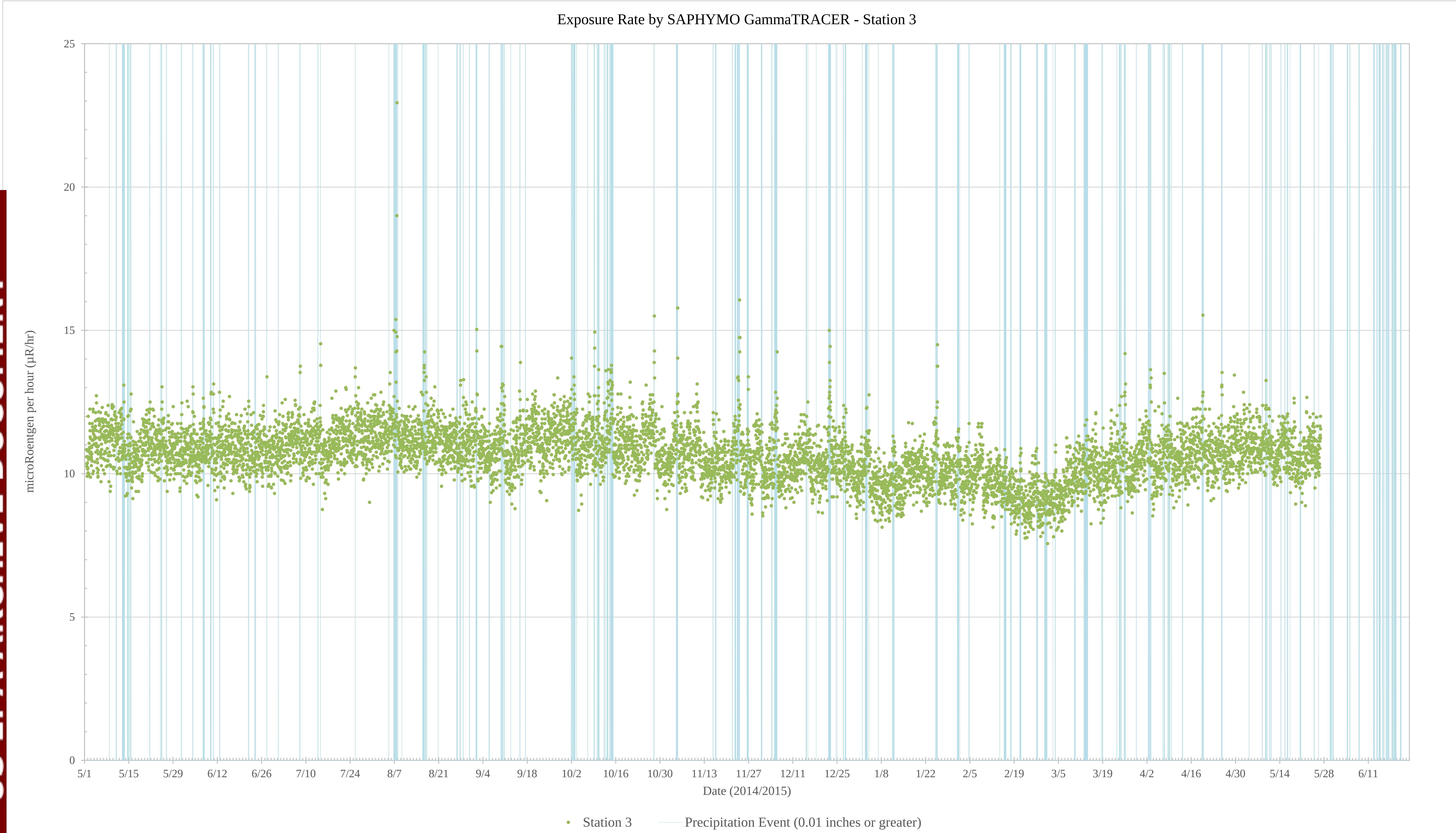
```
11 11/20/2014     0.345     0.223     0.345     0.173     0.345
12 11/26/2014     0.335     0.214     0.308     0.237     0.333
18  12/4/2014     0.351     0.354     0.308     0.294     0.308
17 12/30/2014     0.430     0.263     0.281     0.212     0.586
4    1/6/2015     0.313     0.203     0.280     0.774     0.320
1   1/13/2015     0.282     0.236     0.244     0.140     0.296
2   1/20/2015     0.408     0.255     0.323     0.558     0.393
3   1/27/2015     0.369     0.233     0.507     0.349     0.354
21   2/3/2015     0.229     0.170     0.268     0.159     0.278
19  2/10/2015     0.329     0.244     0.309     0.155     0.304
20  2/17/2015     0.266     0.182     0.224     0.146     0.296
> friedman.test(as.matrix(ftdata.wide[2:6]))     #run Friedman's test

         Friedman rank sum test

data:  as.matrix(ftdata.wide[2:6])
Friedman chi-squared = 21.484, df = 4, p-value = 0.0002538

> friedmanmc(as.matrix(ftdata.wide[2:6]))        #run Post hoc test
Multiple comparisons between groups after Friedman test
p.value: 0.05
Comparisons
    obs.dif critical.dif difference
1-2      34     32.61479       TRUE
1-3      17     32.61479      FALSE
1-4      50     32.61479       TRUE
1-5      19     32.61479      FALSE
2-3      17     32.61479      FALSE
2-4      16     32.61479      FALSE
2-5      15     32.61479      FALSE
3-4      33     32.61479       TRUE
3-5       2     32.61479      FALSE
4-5      31     32.61479      FALSE
>
> #compute ranks by date
> ftdata.wide.ranks<-cbind(ftdata.wide[1], t(apply(ftdata.wide[2:6],1,rank)))
> #show total ranks
> colSums(ftdata.wide.ranks[2:6])
Station 1 Station 2 Station 3 Station 4 Station 5
      105        71        88        55        86
```

APPENDIX E

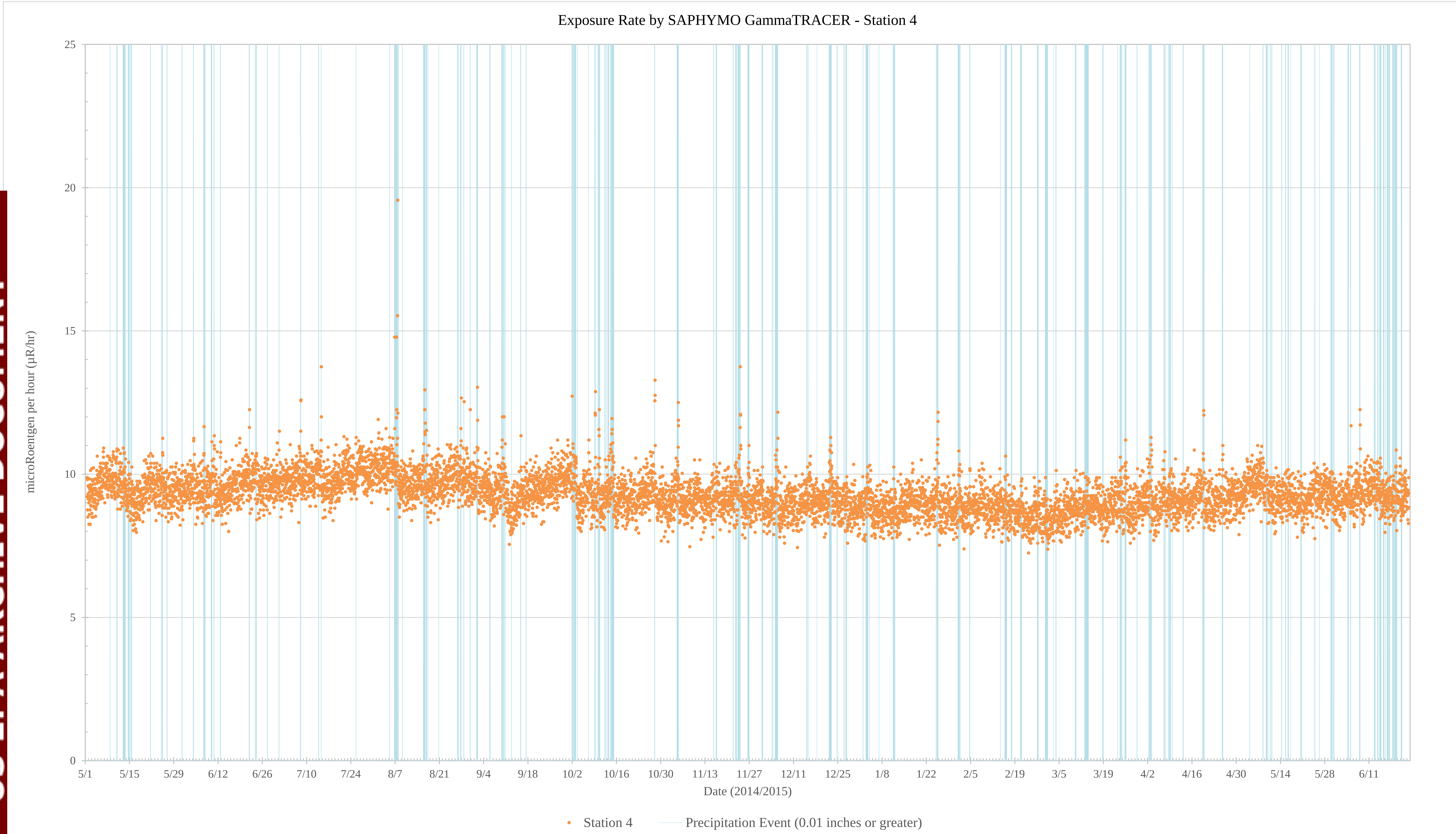
SAPHYMO GAMMATRACER PLOTS

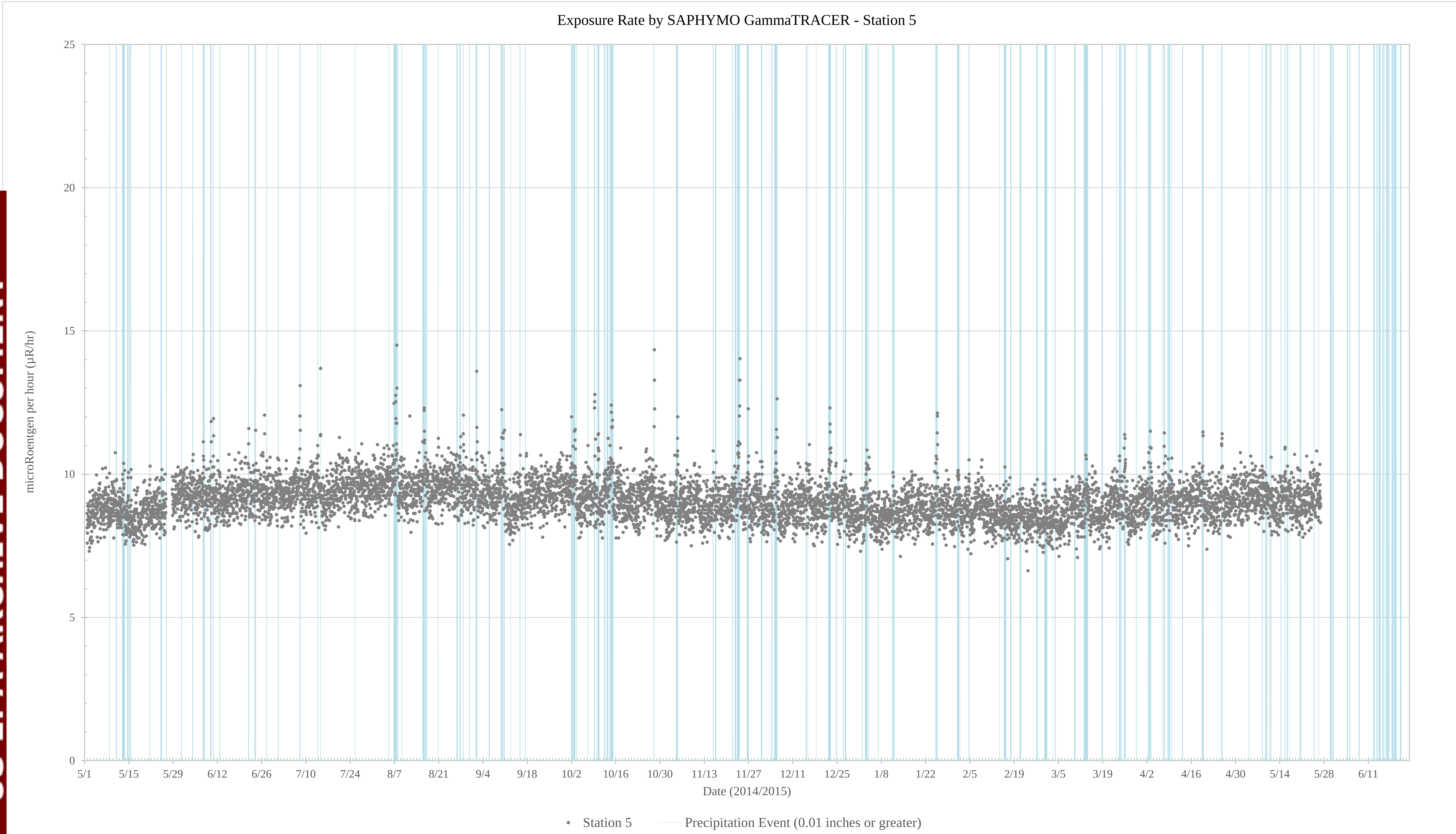

Exposure Rate by SAPHYMO GammaTRACER - Station 1
25
20
15
10
5
0
microRoentgen per hour (µR/hr)
5/1
5/15
5/29
6/12
6/26
7/10
7/24
8/7
8/21
9/4
9/18
10/2
10/16
10/30
11/13
11/27
12/11
12/25
1/8
1/22
2/5
2/19
3/5
3/19
4/2
4/16
4/30
5/14
5/28
6/11
Date (2014/2015)
Station 1
Precipitation Event (0.01 inches or greater)


Exposure Rate by SAPHYMO GammaTRACER - Station 2
25
20
15
10
5
0
microRoentgen per hour (μR/hr)
5/1
5/15
5/29
6/12
6/26
7/10
7/24
8/7
8/21
9/4
9/18
10/2
10/16
10/30
11/13
11/27
12/11
12/25
1/8
1/22
2/5
2/19
3/5
3/19
4/2
4/16
4/30
5/14
5/28
6/11
Date (2014/2015)
Station 2
Precipitation Event (0.01 inches or greater)



Exposure Rate by SAPHYMO GammaTRACER - Station 3
microRoentgen per hour (µR/hr)
25
20
15
10
5
0
5/1
5/15
5/29
6/12
6/26
7/10
7/24
8/7
8/21
9/4
9/18
10/2
10/16
10/30
11/13
11/27
12/11
12/25
1/8
1/22
2/5
2/19
3/5
3/19
4/2
4/16
4/30
5/14
5/28
6/11
Date (2014/2015)
Station 3
Precipitation Event (0.01 inches or greater)


Exposure Rate by SAPHYMO GammaTRACER - Station 4
microRoentgen per hour (µR/hr)
25
20
15
10
5
0
5/1
5/15
5/29
6/12
6/26
7/10
7/24
8/7
8/21
9/4
9/18
10/2
10/16
10/30
11/13
11/27
12/11
12/25
1/8
1/22
2/5
2/19
3/5
3/19
4/2
4/16
4/30
5/14
5/28
6/11
Date (2014/2015)
Station 4
Precipitation Event (0.01 inches or greater)


Exposure Rate by SAPHYMO GammaTRACER - Station 5
microRoentgen per hour (µR/hr)
25
20
15
10
5
0
5/1
5/15
5/29
6/12
6/26
7/10
7/24
8/7
8/21
9/4
9/18
10/2
10/16
10/30
11/13
11/27
12/11
12/25
1/8
1/22
2/5
2/19
3/5
3/19
4/2
4/16
4/30
5/14
5/28
6/11
Date (2014/2015)
Station 5
Precipitation Event (0.01 inches or greater)

APPENDIX F

MANUFACTURER DATASHEETS FOR SAMPLING AND MONITORING EQUIPMENT

Wednesday, Sep 30, 2015 TEXT_SIZE

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Particulate Filters
Accessories
Sample Cartridges
USAF Kit
Personal Air Samplers
RAD-H-2000
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Hand and Foot Monitor
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HD-28A

Features:

- Constant airflow maintained with Δp across the filter of up to 17" of mercury (flow rate dependent)
- Front panel mounted air flow indicator
- Elapsed time meter and constant air flow rate permit accurate calculation of sample volume
- Vacuum gauges for observing filter loading and pump performance
- Flow rate indication on rotometer, CFM or LPM
- Low noise level

The Model HD-28A portable "K-Flow" bench type constant flow air sampler is designed for use on perimeter and off-site monitoring stations in environmental monitoring systems and in production and laboratory areas where collection of precise air samples is required. Its combination vacuum pump and constant air flow regulator permits the collection of an airborne particulate and iodine sample at a constant flow rate until the ΔP across the filter media exceeds the capability of the pump. The higher flow rate the lower the ΔP for constant flow control. The controlled flow rate is adjustable from 0.5 to 3.5 CFM through various diameter filters (such as fiberglass and membrane types) and charcoal or silver zeolite cartridges used for Iodine-131 collection.

An internal air filtering system has been installed between the regulator valve and the pump to prevent particulates from reaching the self-adjusting carbon vanes and causing excess wear. A minimum of preventive maintenance assures a long performance life for the pump. A resettable elapsed time meter is mounted on the front instrument panel. By setting this timer to zero at the start of each sample period, an accurate sample volume may be readily calculated.

Specifications

Air Flow Rate: Adjustable from 0.5 to 3.5 CFM (15 -100 LPM).

Air Flow Regulation: + 5% of set air flow rate up to maximum capability of pump.

Dimensions/Weight: 18" Long x 11" Wide x 9" High (45.7 cm x 27.9 cm x 22.9 cm) 48 lbs (21.78 kg).

Power Requirement: 115V, 60Hz, 4.6 Amps, 230V, 50Hz, 2.3 Amps. Three wire cord; six feet; 10 Amp rating. British and European available.

Air Flow Indicator: Front panel mounted rotometer.

Air Mover/Motor: Self-adjusting carbon vane type. Pump is designed for continuous operation at 26" Hg vacuum. 1/4 horsepower; thermal overload protection.

Input Connection: 3/8" Female Quick Disconnect.

Unit Cooling: 120 CFM extra high flow at maximum back pressures. All metal continuous duty fan.

Re-settable Elapsed Time Meter: 99999 hours and 59 minutes, push button re-settable

Sample Holders Available	
Model No.	Description
2500-04	2" diameter filter, open face
2500-42	47 mm diameter filter, open face
2500-21	2" diameter filter/RADēCO cartridge, open face
2500-46	47 mm diameter filter/RADēCO cartridge, open face

2500-45	2” diameter filter/RADēCO cartridge
2500-44	47 mm diameter filter/RADēCO cartridge, in-line

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RADON

Radon Testing is one of the most profitable ancillary services a Home Inspector can provide. Over 1,500 Home Inspectors throughout the country are taking advantage of Rad Elec's E-PERM® System for Radon Testing for one very important reason — it is the most profitable radon testing method available! ®

Accuracy and Quality - For over fifteen years, Rad Elec's E-PERM® System has been recognized in the U.S. and around the world for its highly accurate, very durable, cost-effective radon detection equipment that is simple to use. Rad Elec's electret ion chamber® technology consistently out performed all other radon testing methods in the USEPA Radon Measurement Proficiency Program. ®

Flexibility: Conduct Short Term, Long Term, or Radon in Water Tests - The E-PERM® System gives you the ability to conduct short term or long term radon tests. If additional E-PERMs® are needed for commercial or multi-family testing programs, Rad Elec offers a low cost rental program. You can even conduct radon in water tests with the purchase of minimal additional equipment. ®

Low Cost Per Measurement Rad Elec's Starter Kit provides everything you need to set up a very profitable radon testing service. The Starter Kit includes 6 E PERM® detectors along with 3 Tamper Resistant Twin Boxes which allows for three simultaneous co located tests plus all of the other equipment you will need to read, analyze, and generate a Radon Test Report. The reusable E PERM® detectors lower your cost per test to less than $2.00 per measurement, and unlike charcoal canisters, you get the results immediately ® no more waiting for lab reports no more trips to the post office. The E PERM® System is simple, straight forward, and easy to use.

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NEWSFLASHES

2014/2015 Winter Newsletter

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State-of-the-art gamma monitoring

GammaTRACER

>>> NEW <<<

XL2 **probe version:**

- 1 sec measurement cycle/alert response
- Up to 3 high sensitivity GM tubes
- 9 decades measuring range
- Input for a further sensor
- GSM/GPS/GPRS/SMS integrated, with up to 10 years battery life

Standard Probes with battery extension pack up to 10 years life

ShortLINK/SkyLINK **option:**

- Wireless online transmission up to 100 km/60 miles
- Ideally suited for extreme climates and harsh environments
- Stationary and mobile use

>>> More than 2500 probes installed worldwide <<<

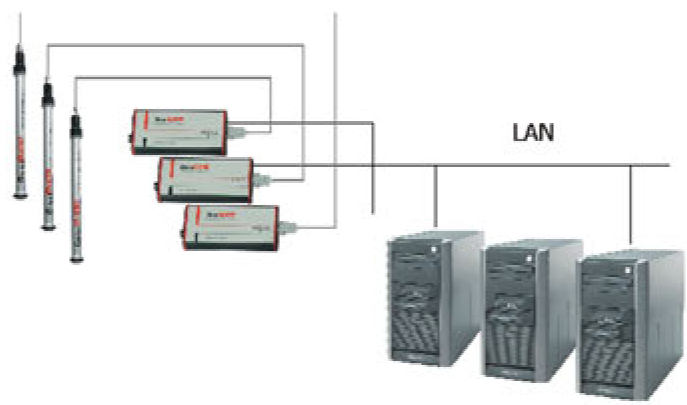
SAPHYMO GmbH

GAMMATRACER

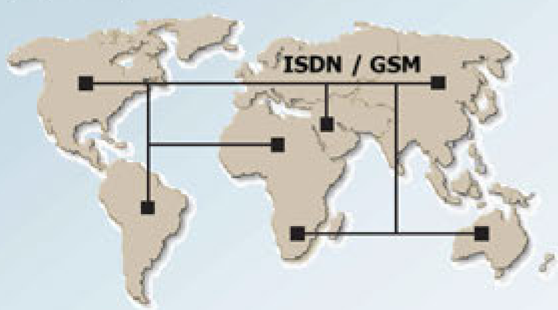
Stand-alone dose-rate monitoring

- Up to 10 years battery life with continuous operation
- Maintenance-free also in harsh climatic environments
- Hermetically sealed weatherproof casing
- Fast 1 sec measurement and alarm cycle (XL2 probe)
- Wide measurement range: 20 nSv/h – 10 Sv/h, i.e. over 9 decades
- Flexible communication capabilities

- Easy integration into monitoring networks
- Access possible from any computer
- Addressing of monitor via IP-address or alias name
- Only web browser required
- Reduced efforts for installation



- Remote control maintenance and software updates possible via hyperlink
- Reduction of travel expenses
- Operable with standard communication hardware (e.g. router)



- Wireless data transfer via *ShortLINK* or *SkyLINK* up to 100 km
- GSM/GPRS/SMS transmission, integrated battery up to 10 yrs. lifetime

Autonomous probes for the continuous, long-term surveillance of the environmental gamma radiation dose

GammaTRACER BASIC, WIDE, HIGH, XL

For the long-term surveillance of the gamma radiation dose in the past only two systems were available: Either sophisticated on-line measurement networks or passive-integrating dosimeters (e.g. TLD). First require high investment and maintenance, second loose by the integration of the dose rate valuable information of the variation of the gamma radiation dose.

With the autonomous measuring probe *GammaTRACER* the gamma radiation dose is continually registered in the chosen time sequence. Available types –BASIC, WIDE, HIGH and XL differ mainly for the counter tubes. They cover a broad range of applications, are lightweight and therefore ideally suited for both, mobile and stationary tasks. *GammaTRACER XL* incorporates a high-volume GM-tube, which qualifies it for applications requiring high sensitivity. The complete electronics and power supply of such an ADL-monitor (ADL: Autonomous Data Logging) are put in an hermetically sealed weatherproof casing, thus enabling the use in harsh climatic environments. Wide temperature options from -40°C to +60°C are also available.

Energy-saving chip technology allow **maintenance-free** non-stop operation of the *GammaTRACER* probe of typically five years, with extended battery pack up to ten years! Via an interactive infrared-port the registered values (built-in storage up to 12.800 values) are for disposition any time. *DataEXPERT*, a professional user-friendly database, communication- and analyzing software guarantees both, a simple and safe access to the stored data as well as their powerful visualization and fast, precise analysis.

Additional interface possibilities, ranging from serial interface modules (RS232, RS485) to sophisticated wireless transmitters (*ShortLINK*, *SkyLINK*), ensure high flexibility according to user needs. With the *DataGATE* interface device a direct connection to an Ethernet network or communication device (router or modem) can be set up.

Type-tested probes of PTB, Germany, CEA, France, Gos Standard, Russia, or the NRPB, Great Britain. More than 2.500 probes in operation worldwide (ask us for references and reports).

NEW GammaTRACER XL2 probe design

The new *XL2* probe design allows an even more flexible use and offers a variety of further options:

- Up to three high sensitivity GM counter tubes (*XL2-2* and *XL2-3* types) provide redundancy and
- Wide measurement range over nine decades
- Special fast response mode offers a 1 sec measurement and alarm cycle for emergency response teams
- Options for integrated battery powered GSM/GPRS/SMS/GPS modules, continuous operation up to 10 years.
- Proprietary ShortLINK/SkyLINK radio transmission up to 100 km equally available
- Integrated IR- / RS-232 interfaces allow to configure the probe at the spot and read data for several months
- Input of a further sensor or a weather station possible

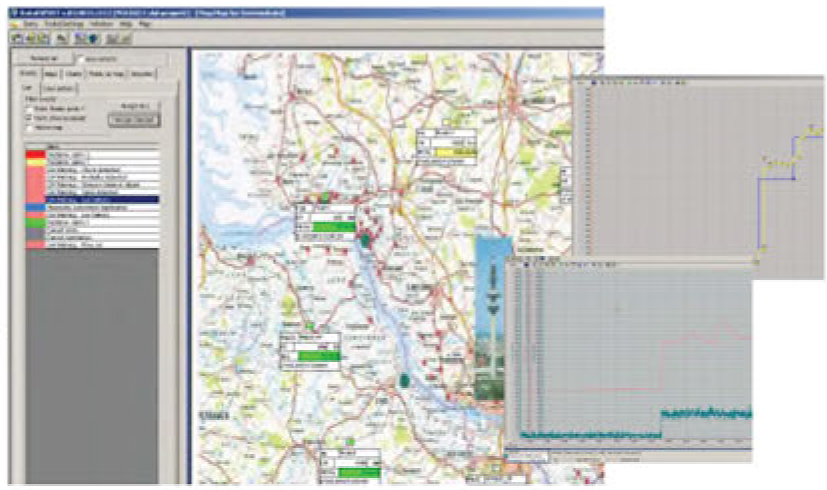
Range of applications

GammaTRACER can be used in a wide range of applications providing high reliability – a cost efficient solution:

- documentation of the natural radiation background, temporal variations for the presentation of evidence
- permanent online-surveillance for recording the emissions of nuclear facilities
- laboratories, accelerators, intermediate- and final waste storage or other facilities of the nuclear fuel cycle
- environmental monitoring of transport activities of burnt nuclear fuel, revision or decommissioning of NPP
- routine surveillance of means of transport for illegal transports of radioactive substances
- environmental monitoring in areas with weak infrastructure
- hospitals and other medical facilities f.ex. for the surveillance of storage materials

Software

The *DataEXPERT* software offers a wide variety of features for the management of measurement data. Due to the modular design the software can be scaled according to customers' needs.



Cost-efficient solutions for single-instrument applications are possible as well as powerful online-monitoring networks including alarm capability and MS SQL database interface. The *BASIC-module* of *DataEXPERT* provides built-in database storage, chart visualization with powerful zooming and visualization features, mathematical operations and comfortable data export functions.

There are various further powerful modules available with online and alarm capabilities for network operation: *MapVIEW, ONLINE, ALARM, REPORT and GeoMAP.* Export interface, redundant data management a.o.

Options:

Alarm unit

The alarm unit can be connected to the *GammaTRACER* by cable. It offers an acoustic alarm output and a relay output. Alarm thresholds are adjustable by PC.

Communication modules

- RS232/RS485
- ShortLINK (5 km) / SkyLINK (up to 100 km) proprietary radio transmission
- GSM/GPRS/SMS routine surveillance of means of transport for illegal transports of radioactive substances

Additional sensor

The XL2 probe provides the possibility for a direct input of an additional sensor, f. ex. rain, wind

GPS information

Information of a Global Positioning System which allows to exactly backtrace the position of the probe, useful for mobile applications (XL2 probe).

Fast 1 sec measurement and alarm cycle

For use in emergency response teams a fast, variable measurement cycle is available down to 1 sec (XL2 probe)

If you would like to know more on possibilities with the *GammaTRACER* probe, technical data etc. please ask for our extensive product brochure!

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Phone:+ 49 69 97 65 14 – 0, Fax: + 49 69 76 53 27
E-Mail: sales@saphymo.de Web:http://www. saphymo.de

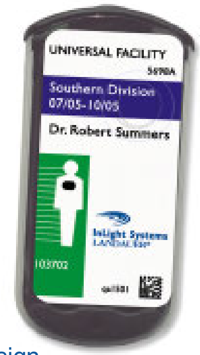
LANDAUER®

InLight® Systems Dosimeters

InLight dosimeters provide x, gamma, and beta radiation monitoring with optically stimulated luminescence (OSL) technology. OSL technology is the newest advancement in passive radiation protection dosimetry. Inlight dosimeters are engineered to be read out by an InLight reader.

InLight dosimeters are designed for the client with extensive data management capabilities who prefers to independently maintain data and issue dose reports. Dosimeters are provided for use with Landauer's dosimetry service that provides accredited processing and analysis, with dose results electronically transmitted to client; and as a direct sale in combination with InLight readers for a total turnkey solution enabling an in-house accredited dosimetry program.

For personnel, area/environmental, and emergency response monitoring, clinical dose measurements or any radiation assessment application.



Landauer Holder Design

Operational Advantages

Complete reanalysis capabilities
- Nondestructive read out allows for dose verification
- Dosimeter archiving made possible
- Track exposure over time—take incremental dose assessments

Dosimeter preparation eliminated
- No annealing
- No element correction factors required
- Engraved 2D bar code identifies dosimeter sensitivity

No fade
- Longer wear frequencies

Advanced Design

InLight dosimeters are built on an assembly of a case component with metal and plastic filters along with a four-positioned aluminum oxide detector slide component. Both the case and slide are uniquely bar coded with serial numbers for chain of custody and sensitivity identification. InLight dosimeters offer reanalysis capabilities, precision with a wide dynamic range of measurement, and long-term stability. The InLight Basic dosimeter consists of the principle assembly of the case and slide for use with a clear plastic holder.

The enhanced Landauer holder is designed to accommodate the optional CR-39 for neutron detection, the optional imaging component, client defined labels, and the principle assembly of the case and slide. The case component has an open window, with aluminum, copper, and plastic filters. The imaging component renders unique filter patterns to provide qualitative information about conditions during exposure. Dosimeter labels can be vertical or horizontal and offer numerous graphic and text fields definable by the client to meet the administrative needs of a radiation monitoring program.

The environmental dosimeter is designed to meet ANSI N545 Standard and HPS Draft Standard N13.29. The case has copper and plastic filters, and is sealed along with the slide component in a waterproof plastic pouch. Labels can be vertical or horizontal and offer numerous graphic and text fields definable by the client.

InLight Systems and OSL Technology

The InLight System measures radiation exposure with aluminum oxide detectors (Al_2O_3:C) read out by optically stimulated luminescence (OSL) technology. The read out process uses a light emitting diode (LED) array to stimulate the detectors, and the light emitted by the OSL material is detected and measured by a photomultiplier tube (PMT) using a high sensitivity photon counting system. The amount of light released during optical stimulation is directly proportional to the radiation dose and the intensity of stimulation light. A dose calculation algorithm is then applied to the measurement to determine exposure results.

Technical Specifications

- Linear from 10 µSv (1 mrem) to in excess of 10 Sv (1,000 rem)
- Energy range from 5 keV to 20 MeV
- Gamma, x-ray, beta minimal reporting: 50 µSv (5 mrem)
- Neutron detection with a CR-39, processed with Track Etch® technology minimal reporting:
  - Fast: 200 µSv (20 mrem)
  - Thermal/Intermediate: 100 µSv (10 mrem)