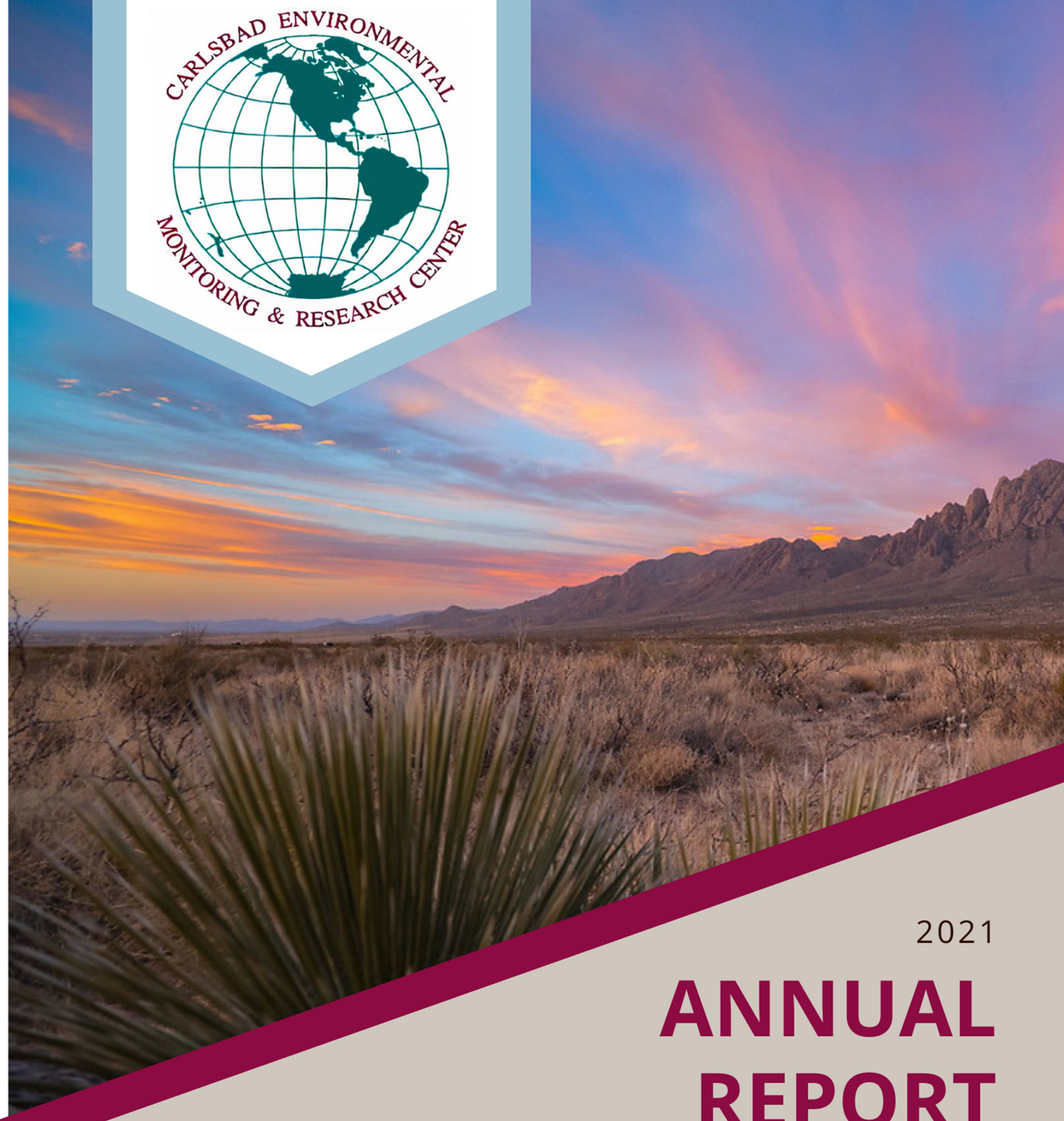

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ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

Am	americium
Al	aluminum
ANSI	American National Standards Institute
ASER	annual site environmental report
B	boron
Ba	barium
Bq	becquerel(s)
Bq/g	becquerels per gram
Bq/kg	becquerels per kilogram
Bq/L	becquerels per liter
Bq/m^3	becquerels per cubic meter
Bq/sample	becquerels per composite air filter sample
BOMAB	bottle mannikin absorber
CBFO	(U.S. Department of Energy) Carlsbad Field Office
CEMRC	Carlsbad Environmental Monitoring & Research Center
CFR	Code of Federal Regulations
cm	centimeter
Ca	calcium
Ce	cerium
Co	cobalt
Cd	cadmium
Cs	cesium
Cr	chromium
Cu	copper
CY	calendar year
DOE	U.S. Department of Energy
Dy	dysprosium
EEG	environmental evaluation group
EPA	U.S. Environmental Protection Agency
Er	erbium
Eu	europium
FAS	fixed air sample(r/s)
Fe	iron
Ga	gallium
GC-MS	gas chromatography-mass spectrometry
Gd	gadolinium
HEPA	high-efficiency particulate air (filter)
Hg	mercury

HPGe	high purity germanium
ICP-MS	inductively coupled plasma mass spectrometry
ID	internal dosimetry
Ir	iridium
K	potassium
km	kilometer
L	liter
La	lanthanum
L_c	decision level
LDBC	lie down and be counted
LWBC	lung and whole-body counting (facility)
Li	lithium
LWA	(Waste Isolation Pilot Plant) land withdrawal act (as amended)
m	meter
m^3	cubic meter
m^3/min	cubic meters per minute
mBq	millibecquerel
MAPEP	mixed analyte performance evaluation program
MDC	minimum detectable concentration
MDL	method detection limit
mg/L	milligrams per liter
mi	mile
min	minute
mL	milliliter
Mn	manganese
Mo	molybdenum
MOC	management and operating contractor
Mg	magnesium
N/A	Not applicable
Na	sodium
NATTS	national air toxics trends station
Nd	neodymium
NIST	National Institute of Standards and Technology
NMED	New Mexico Environment Department
NMSU	New Mexico State University
NRIP	national institute of standards and technology radiochemistry intercomparison program
NWP	Nuclear Waste Partnership LLC
P	phosphorus
Pb	lead
pCi/L	picocurie per liter
pH	negative logarithm of the hydrogen ion activity in a solution (a measure of the acidity or alkalinity of a solution)

Pr	praseodymium
PT	proficiency testing
Pu	plutonium
QA	quality assurance
QA/QC	quality assurance / quality control
Sb	antimony
Sc	scandium
Se	selenium
Si	silicon
Sr	strontium
Th	thorium
Tl	thallium
Ti	titanium
TRU	transuranic
U	uranium
Unc.	uncertainty
U.S.	United States
V	vanadium
VOC	volatile organic compound(s)
WIPP	Waste Isolation Pilot Plant
WIPP-EM	Waste Isolation Pilot Plant-Environmental Monitoring
Zn	zinc

SYMBOLS

˚C	degrees Celsius
>	greater than
<	less than
≤	less than or equal to
$\mu g/m^3$	micrograms per cubic meter
ng/m^3	nanograms per cubic meter
µg/L	micrograms per liter
%	percent

EXECUTIVE SUMMARY

The role of the Carlsbad Environmental Monitoring and Research Center's (CEMRC's) Environmental Monitoring Program is to establish and maintain a health and environmental monitoring program in the vicinity of the U.S. Department of Energy's (DOE's) Waste Isolation Pilot Plant (WIPP). The DOE funds CEMRC through a Financial Assistance Grant in which an important distinguishing feature from other funding mechanisms is the absence of substantial federal involvement in or contribution to the technical aspects of the project. The project was implemented during the WIPP pre-operational phase and continues during the operational (disposal) phase. Under the CEMRC monitoring program, air (ambient as well as WIPP exhaust air), water (drinking and surface waters), soil, sediment, vegetation, and people (whole-body counting for the public as well as workers) are analyzed. The results of the monitoring program are easily available to all interested parties. Public access to the monitoring data and the public's ability to directly participate in CEMRC's whole-body counting program provides a key element of trust and transparency.

The mission of the WIPP is to provide permanent, underground disposal of defense-related transuranic (TRU) and TRU-mixed wastes (wastes that also have hazardous chemical components). TRU waste is defined as having alpha activity greater than 37000 Bq/g for radioactive isotopes with atomic numbers higher than uranium and half-life greater than 20 years.

CEMRC's Environmental Monitoring Program is designed to monitor pathways that radionuclides and other contaminants could take to reach the environment surrounding the WIPP facility. Pathways monitored include people (whole-body counting for the public as well as workers), water (drinking and surface waters), soil, sediment, vegetation, air (ambient as well as WIPP effluent air), and volatile organic compounds (VOCs). The monitoring program's goal is to determine if the local ecosystem has been, or is being, adversely impacted by WIPP facility operations and if so, to evaluate the severity, extent, and environmental significance of those impacts.

Important Aspects of the CEMRC Monitoring Program

Timely Analyses

- Monthly summary of gross alpha and beta measurements from airborne effluent monitoring are provided to the DOE within fourteen (14) days of the end of each month.
- Any anomalies in airborne effluent gross alpha and beta measurements because of rock falls or due to investigative and clean-up efforts by underground personnel are immediately reported to DOE verbally, and in writing, within eight (8) hours of discovery.
- While representative air samples have been collected from Station A by other entities, CEMRC is the only organization that has been continuously performing actinide analysis on Station A filters.

Unique Capabilities

- The CEMRC program has capabilities to detect radionuclides rapidly in case of accidental releases from the repository or from the nuclear facilities anywhere in the world.
- A state-of-the-art whole-body counting system that can measure the body burden of radioactive elements, including transuranics, at extremely low levels.
- Ability to monitor to below background levels by increasing the counting time on alpha spectroscopy to 5 days and on gamma to 2 days, unlike most environmental programs that only monitor down to compliance or action levels.
- Public's access to the monitoring data and their direct participation in CEMRC's whole-body counting program aids in minimizing concern in the region over radioactive releases.

Key Highlights of the Monitoring Results

- Gross alpha and beta activities remain mostly close to the normal background levels in 2021.
- Occasional detections of trace levels of ^{241}Am, ^{238}Pu, and $^{239+240}$Pu were recorded in a few weekly composite filters from Station A.
- There were few detections of transuranics in ambient air particulates. The levels detected were within the normal background for the area.
- No detection of transuranic radionuclides in any of the drinking and surface water samples.
- Trace levels of $^{239+240}$Pu were detected in sediments of three regional reservoirs and trace levels of ^{241}Am were detected in sediments of two of the same regional reservoirs. The levels detected were within the normal background for these reservoirs.
- Non-radiological monitoring of effluent air, drinking water, surface water, and the surface VOCs showed no increase in contaminants that could be attributed to the WIPP operations in any way.

In summary, the results of these programs, including observations, analytical data, interpretations, and trend analysis demonstrated that the operations at the WIPP facility have not had a negative impact on human health or the environment.

CHAPTER 1 - INTRODUCTION

The Carlsbad Environmental Monitoring and Research Center (CEMRC) is an independent organization that conducts health and environmental monitoring in the vicinity of the Waste Isolation Pilot Plant (WIPP) site. The CEMRC is funded by the U.S. Department of Energy (DOE) and is part of New Mexico State University's (NMSU) College of Engineering.

The primary purpose of the CEMRC is to evaluate the radiological fingerprint of the WIPP facility throughout its operational lifetime. This is done by comparing the current radiation levels to an established baseline that was determined before operations began. The CEMRC has been conducting independent monitoring since 1998 and has made the results easily accessible to all interested parties. This public access helps to build trust and transparency between the CEMRC and the community.

The WIPP is a deep geologic repository operated by the DOE. The purpose of the repository is to dispose of defense-related transuranic (TRU) waste. TRU waste is a type of radioactive waste that contains elements heavier than uranium, such as plutonium and americium. The TRU waste inventory at the WIPP consists mostly of contaminated industrial trash, as well as sludges from solidified liquids, glass, metal, construction debris, and other materials.

The upper waste acceptance criteria for the WIPP are less than 0.85 TBq/L (less than 23 Ci/L) of total activity and less than 10 Sv/h dose rate on contact with unshielded waste containers. Two types of TRU waste are currently stored in the WIPP repository: (1) TRU waste, containing only radioactive elements, and (2) mixed transuranic waste (MTRU), containing hazardous waste components, in addition to the radioactive elements.

The WIPP facility became operational on March 26, 1999, and the first waste shipment was received on April 28, 1999. The WIPP facility was operated without incident until February 2014, when a fire on February 5 and an unrelated accidental radiological release on February 14 resulted in the temporary suspension of shipments to the facility. The facility resumed accepting waste shipments on April 10, 2017.

1.1 Environmental Setting of the WIPP

The WIPP facility is currently the world's only licensed deep geologic repository permitted to permanently dispose of transuranic waste generated from defense operations. The WIPP facility is located in Eddy County, in southeastern New Mexico, approximately 42 km (26 mi) east of Carlsbad (Figure 1.1). The facility is located on a sandy plain at an elevation of 1,040 m (3,410 ft) above sea level. Prominent natural features near the facility include Livingston Ridge and Nash Draw, about 8 km (5 mi) west of the facility. Nash Draw is a shallow, dog bone-shaped drainage course between 14 km (8.5 mi) and 18 km (11 mi) wide and characterized by surface impoundments of brine. Livingston Ridge is a bluff that marks the eastern edges of Nash Draw. Other prominent features of the region include the Pecos River, located about 22 km (14 mi) west of the facility, and Carlsbad Caverns National Park, located about 68 km (42 mi) west-southwest of the WIPP facility.

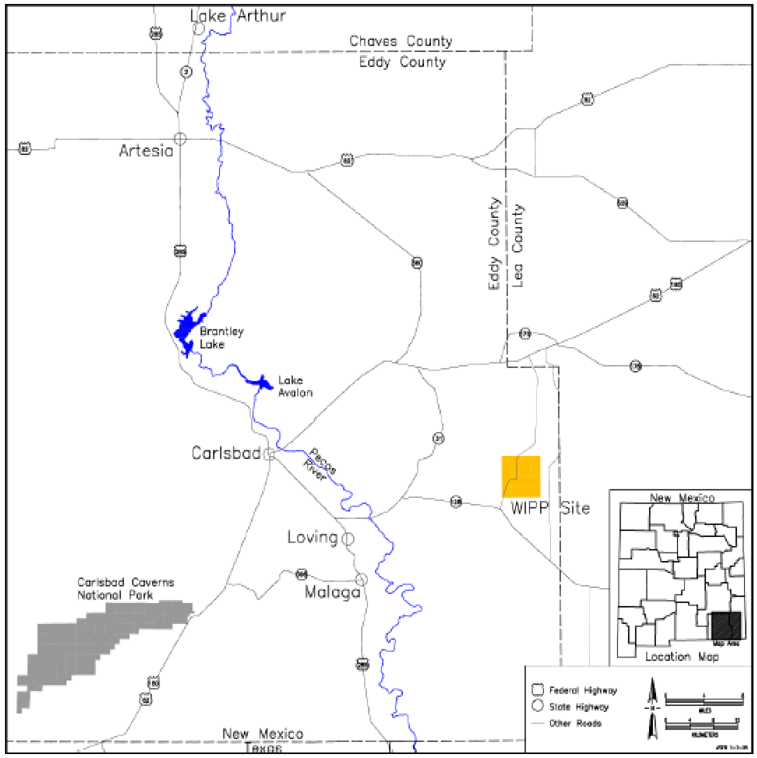


Figure 1.1. Location of the WIPP Site Identified by the Orange Box

The climate of the facility's region is semi-arid, with a typical annual precipitation ranging between 280 and 300 mm (11 to 13 inches), with much of this precipitation falling during intense thunderstorms in the spring and summer seasons. Winds are generally from the southeast with an average speed of 14 km/h (8.8 mi/h).

The majority of the local population within 80 km (50 mi) of the WIPP site is concentrated in and around the New Mexico communities of Carlsbad, Hobbs, Eunice, Loving, Jal, Lovington, and Artesia.

According to the latest census data, the estimated population within this radius was 88,952. The nearest community is the village of Loving (with an approximate population of 1,400), 29 km (18 mi) west-southwest of the WIPP site. The closest majorly populated area is Carlsbad, 42 km (26 mi) west of the WIPP site. The 2020 census reported the population of Carlsbad as 32,238.

The transient population within 10 miles of WIPP is associated with ranching, oil and gas exploration and production, and potash mining. Three ranchers, Mills, Smith, and Mobley, have properties in the vicinity of the WIPP facility. The Mills ranch headquarters is located 5.6 km (3.5 mi) south-southwest of the facility center, the Smith headquarters is 8.8 km (5.5 mi) west-northwest of the facility, and the Mobley ranch is 9.6 km (6 mi) southwest of the facility. Although there are no dairies near the WIPP facility, the area produces a large amount of alfalfa. The alfalfa crop is used in cattle feeding operations, mainly in New Mexico and Texas.

In addition to alfalfa, cotton and pecans are the other major crops grown in the Pecos Valley region.

1.2 Repository Configuration and Effluent Monitoring

Figure 1.2 shows the current configuration of the WIPP site. The site consists of surface facilities and the underground repository. The repository currently comprises eight waste-disposal panels, each consisting of seven waste disposal rooms approximately 91 m (300 ft) long, 10 m (33 ft) wide, and 4.5 m (15 ft) high.

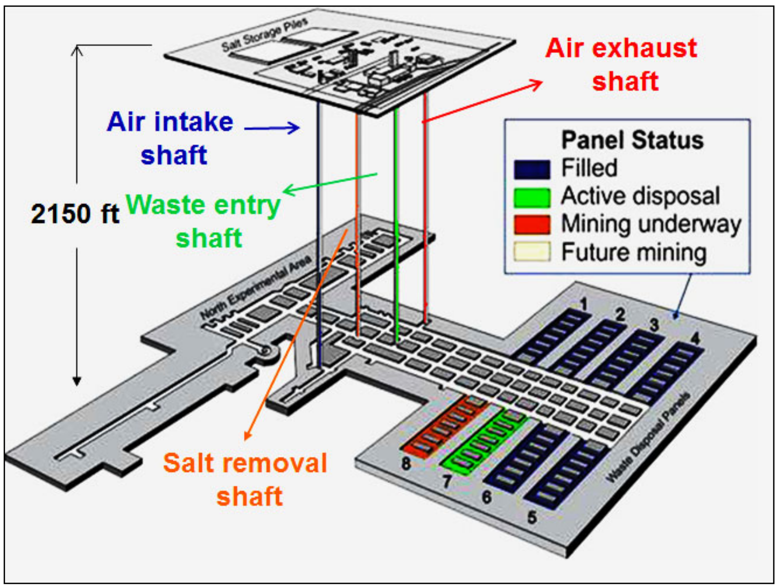


Figure 1.2. WIPP Layout

Seven of the panels have been excavated in the repository, while mining is currently underway in the eighth; the first six have been closed and sealed from ventilation air. The repository consists of common drifts for access and ventilation to the disposal panels as well as four shafts connecting surface operations to underground emplacement activities and above ground waste receipt and handling facilities. Ventilation of the repository occurs by drawing air from the surface into the underground. Because the air in the repository exits to the surface through an exhaust shaft, this shaft is the sole potential pathway for any contaminants to be released from the repository during normal operations. The release of contaminants to the atmosphere is mitigated by High-Efficiency Particulate Air (HEPA) filters that are located at the surface. Additionally, continuous air monitors (CAM) in the underground areas control whether ventilated air returning to the surface passes through the HEPA filter systems or is released directly to the atmosphere.

Both filtered and unfiltered exhaust air streams exiting the repository are monitored at the effluent air monitoring stations. Each station is equipped with at least one fixed air sampler (FAS) that collects representative particulate samples from the effluent air stream. Under normal operating conditions, unfiltered air is drawn through the repository and exhausted from the repository directly to the environment after passing by the Station A sampling port. Therefore, during normal operating conditions, the activities measured at Station A would represent the radiological activities present in the air within the repository and would be reflective of the level of contamination released directly to the environment. However, once contamination is detected in the underground via continuous air monitoring, the system shifts into “filtration mode” and the exhaust air is routed through the HEPA filters before being released into the environment. Monitoring of the exhaust air occurs at the Station B sampling port. Exhaust at Station B is representative of the level of contamination ultimately released into the environment while operating in filtration mode. Three organizations, CEMRC, the New Mexico Environment Department DOE Oversight Bureau (NMED-DOE-OB), and the WIPP Management and Operation contractor (M&OC) Nuclear Waste Partnership (NWP), independently analyze particulate samples collected at Stations A and B.

1.3 Environmental Monitoring

The scope of CEMRC’s WIPP environmental monitoring activities is broad and falls into three categories:

1) Collecting and analyzing environmental samples for a variety of radiological, non-radiological, and hazardous contaminants

2) Radiological screening of workers and local citizens

3) Evaluating whether WIPP-related activities have any environmental impacts

The environmental samples analyzed include ambient air, surface- and drinking water, soil, sediment, and vegetation. Ambient air monitoring establishes a baseline against which operational monitoring data are compared to identify any releases. For ambient air analyses, CEMRC operates four ambient air samplers in and around the WIPP site and two ambient air samplers in the two communities nearest to WIPP, Loving and Carlsbad. Public drinking water sources are sampled and analyzed to establish a baseline because water consumption is a primary pathway for contaminant ingestion. Soil, sediment, and surface water samples are also collected and analyzed to determine contaminant concentrations and establish the variability of background radioactivity as well as to allow the detection of potential releases. Finally, vegetation is also analyzed because consumption of potentially contaminated vegetation by livestock is another pathway for human exposure.

CEMRC also performs routine monitoring of workers and residents living within a 100-mile radius of the WIPP facility for the presence of gamma-emitting radioisotopes through its *Lie Down and Be Counted* (LDBC) program. As in other aspects of the WIPP-EM program, *in vivo* bioassay testing was used to establish a baseline profile of internally deposited radionuclides in a sample of local residents before disposal phase operations began. This testing has continued throughout the disposal phase into the present.

This report describes sample collection and analysis from January 2021 through December 2021, with historical data for the past twenty years. It evaluates environmental monitoring data and identifies trends that are important for demonstrating any impact WIPP operations might have on the local environment. Results from this year's monitoring shows that WIPP operations did not have an adverse effect on human health or the environment.

CHAPTER 2 - AIRBORNE EFFLUENT MONITORING

The WIPP repository is ventilated by drawing ambient air down three shafts (the air intake shaft, salt shaft, and waste handling shaft) to the underground then exhausting it out the exhaust shaft. Unfiltered exhaust air is sampled at Station A to quantify radionuclides released from the repository. Effluent monitoring at Station A provides the means for monitoring repository exhaust for radionuclides and other potentially harmful substances. A second sampling station, Station B, is used to sample the underground exhaust air after HEPA filtration. Samples from Station B are analyzed by CEMRC, the New Mexico Environment Department (NMED), and WIPP's contractor Nuclear Waste Partnership (NWP).

Effluent monitoring at Stations A and B is a major component of both the WIPP Environmental Monitoring (WIPP-EM) program and CEMRC's monitoring program. CEMRC has been sampling and analyzing WIPP exhaust air since December 12, 1998. Before the 2014 accidental release, Station A was used to monitor exhaust air compliance. Since 2014, Station B has been the sample point of record for emissions from the underground. The current scope-of-work requires particulate matter in the repository exhaust air to be collected daily at all Fixed Air Sampler (FAS) locations and composited for analysis. Individual samples are analyzed to determine total suspended particulates collected and to quantify gross alpha and gross beta activities. Radiological analyses are used to quantify radionuclides concern. Details of the sample collection and analyses are described in the following sections.

A schematic of the WIPP ventilation system and normal underground airflow is shown in Figure 2.1. WIPP effluent sampling systems are designed to collect at least 50% of the 10 μm diameter aerosols under the expected range of exhaust air velocities. Prior to the 2014 radiologic event, in normal operation, the ventilation system discharged unfiltered air. One or two of the unfiltered 700 fans were typically operated to generate approximately 225 m^3/s (475,000 ft^3/min) of unfiltered air underground. Since the radiologic event, the ventilation system has been maintained in filtration mode. In this mode, one of three filtration 860 fans operates to deliver 28.3 m^3/s (60,000 ft^3/min) to the underground.

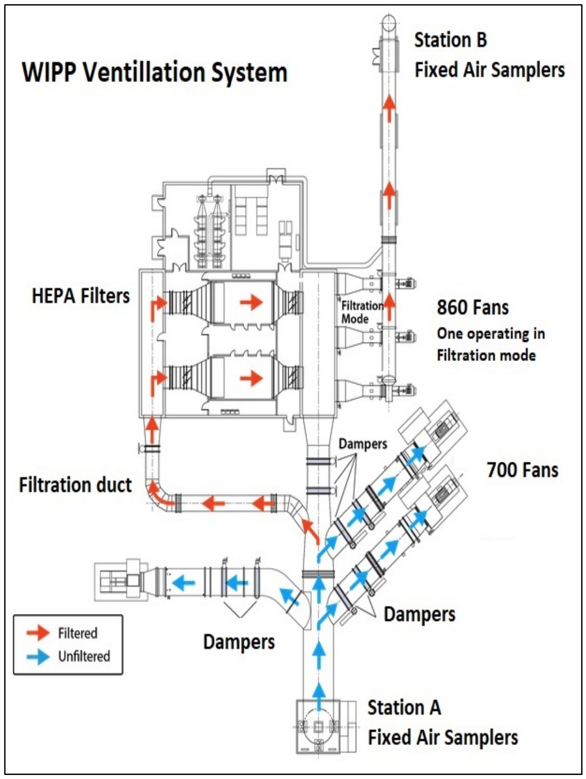


Figure 2.1. Schematic of WIPP Ventilation System

Quarterly composites were initially used to determine the actinide activities, but monthly compositing was implemented by CEMRC in July 2004 for better comparison with other groups who use monthly composites. These monthly composites are used to determine the gamma-emitting radionuclides as well. After the gamma measurements, the sample aliquot is archived.

For some time following the radiation release event, filters at Station A were changed every 8 hours; measurements were performed on each filter by CEMRC (and later daily combined filters) depending on the levels of contamination found. As airborne concentrations receded, the frequency of Station A filter collection was reduced to daily, but actinide measurements continue to be performed on weekly composite samples.

Both Station A and Station B are above-ground sampling platforms that collect particulates in exhaust air from the repository before and after HEPA filtration (Figure 2.2). Each station is equipped with three shrouded-probe aerosol samplers along with three separate sampling skids, denoted as A1, A2, and A3 (Figure 2.3). The airstream sampled by each skid is split among three legs allowing three concurrent samples to be collected from each skid. A total of three concurrent samples can be collected from each FAS, one each for CEMRC, the site contractor (WIPP Labs), and NMED.

Figure 2.2. Sampling Station A (top) and Station B (bottom)

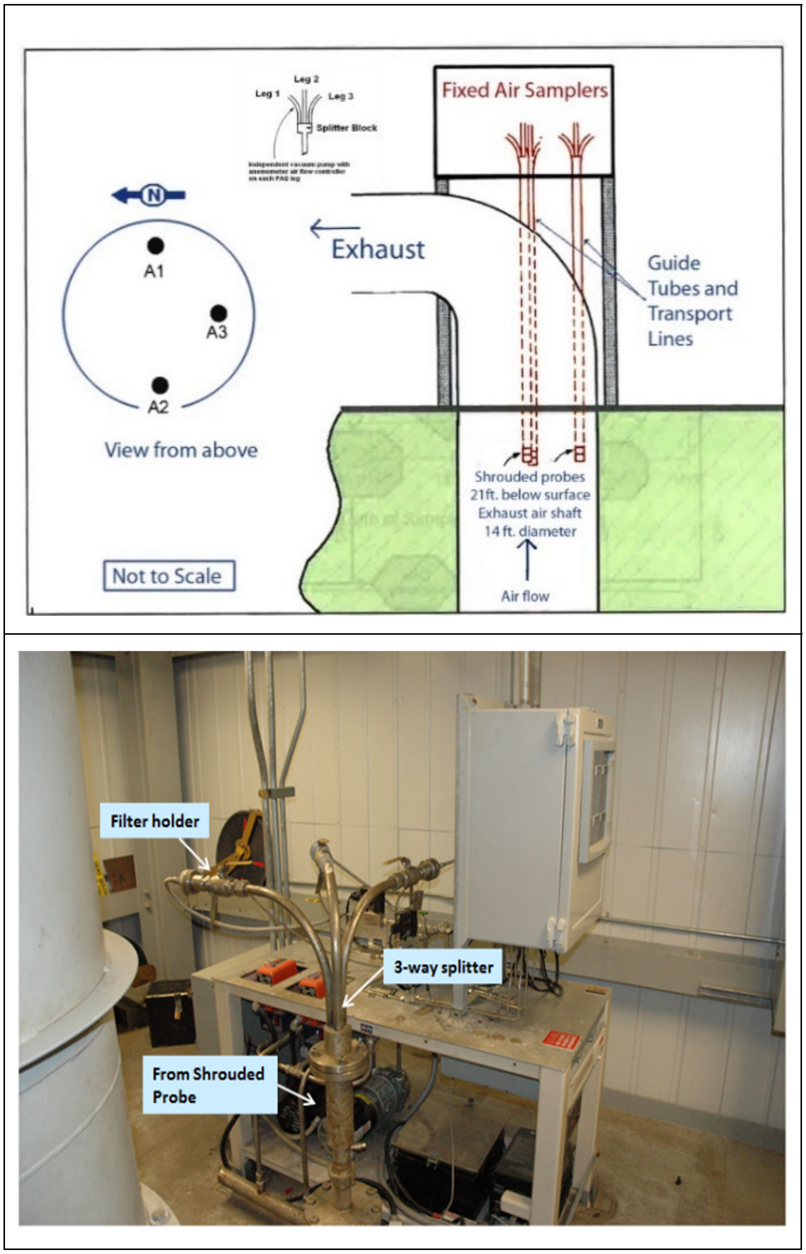


Figure 2.3. Schematic of Station A (top) and Fixed Air Samplers at Station A (bottom)

2.1 Sample Collection

Particulates in the exhaust air are collected on 47 mm diameter, pore size 3 µm membrane filters (Versapor^{TM} membrane filter, PALL Corporation, Port Washington, NY, USA) with the use of a cylindrical shrouded probe, commonly referred to as a fixed air sampler or FAS. The airflow through the FAS is approximately 170 L/min (6.0 ft^3/min). The samples at Station A are typically collected daily except for weekends (the weekend samples run from Friday to Monday, so the coverage is continuous). Occasionally, however, more than one sample per day is still collected when the flow rate on any of the sampler legs drops below 50 L/min (1.8 ft^3/min). If this occurs, a low-flow alarm on the sampler is activated and the filters are changed as needed by WIPP radiological control technicians. Under normal operating conditions, approximately 81 m^3 (2,875 ft^3) of air is filtered through each of the Versapor™ membrane filters at Station A and Station B each day.

The ventilation flow capacity of the Station B exhaust duct was increased in the fall of 2016 from 60,000 ft^3/min to 114,000 ft^3/min by the addition of two more HEPA filter trains, parallel to the existing two HEPA filter trains that have been in continuous use since the February 2014 radiological event. During 2021, the ventilation system associated with Station B operated normally at a nominal flow rate of 114,000 ft^3/min.

2.1.1 Sample Preparation and Analysis

2.1.1.1 Gross Alpha and Beta Analysis

Once the samples are collected from the site and returned to the laboratory, individual filters are desiccated for a minimum of 48 hours to guarantee that any moisture on the filters is evaporated and to ensure the complete decay of the immediate daughter products of ^{222}Rn and ^{220}Rn. Once dried, the filters are then weighed to determine mass loading concentrations. Following the desiccating and weighing process, the Station A and B filters are counted for gross alpha and beta activities on a Protean MPC 9604 low background gas proportional counter for 1200 min (20 h). Daily performance checks are executed using calibration sources, ^{239}Pu for alpha and $^{90}Sr/^{90}Y$ for beta, for efficiency control charting (2σ warning and 3σ limits) and to ensure that alpha/beta cross-talk is within limits (less than 0.1% alpha into beta and less than 0.1% beta into alpha). Sixty-minute background counts are also recorded daily by counting an empty planchet. The mean counting efficiencies for the systems are around 25% for alpha and 38% for beta activities.

2.1.1.2 Radiochemical Analysis

After gross alpha/beta measurements, daily filters collected over a period of one week are grouped into weekly composites for Station A and monthly composites for Station B. Filter samples for radiochemical analysis are prepared by wet digestion with nitric acid (HNO_3), hydrochloric acid (HCl), and perchloric acid ($HClO_4$) until the filter is totally dissolved. Generally, half of the sample is used for the determination of the actinide activities, while the other half is used for the gamma analysis. Gamma-emitting radionuclides in the air filters are measured by gamma spectroscopy, while alpha-emitting radionuclides are co-precipitated, separated on anion exchange and chromatography columns, and analyzed by alpha spectroscopy as described in previous CEMRC reports (http://www.cemrc.org/annual-reports). The samples are counted for 24 h for alpha and 48 h for gamma radionuclides as per CEMRC's standard counting protocol. Portions of digested solutions containing strontium are co-precipitated with barium as a carbonate, then dissolved in nitric acid and barium precipitated out as chromate. The supernatants obtained are mixed with ammonium hydroxide (NH_4OH) and saturated ammonium carbonate $(NH_4)_2CO_3$ to precipitate strontium as strontium carbonate ($SrCO_3$), and the beta-radiation-emitting radioactive isotope ^{90}Sr is then counted by liquid scintillation counting. Details are described in procedure WL-1011.

2.2 Results and Discussion

The activities of radionuclides in the WIPP underground air samples are reported in the following two ways: Activity Concentration in Bq/m^3 and Specific Activity in Bq/g. Activity Concentration is calculated as the activity of radionuclides reported in Becquerel (Bq) divided by the volume of air in cubic meters (m^3). Specific Activity is calculated as the activity of radionuclides reported in Becquerel (Bq) divided by the aerosol mass collected on the filter in grams (g).

2.2.1 Gross Alpha and Beta Concentrations at Station A

The pre- and post-release gross alpha and gross beta concentrations in Station A filters are shown in Figure 2.4 and Figure 2.5 for trend analysis purposes over a period of over twenty years. There are no data for the period between February and June 2014 because gross alpha and beta screening was not performed immediately following the February 14, 2014, underground radiation release event. Instead, an emergency actinide separation campaign was carried out for each individual or daily filter collected from Station A and Station B. However, as radiation levels receded, the gross alpha and beta analysis resumed beginning in March 2014 for the Station A filters and July 2014 for the Station B filters.

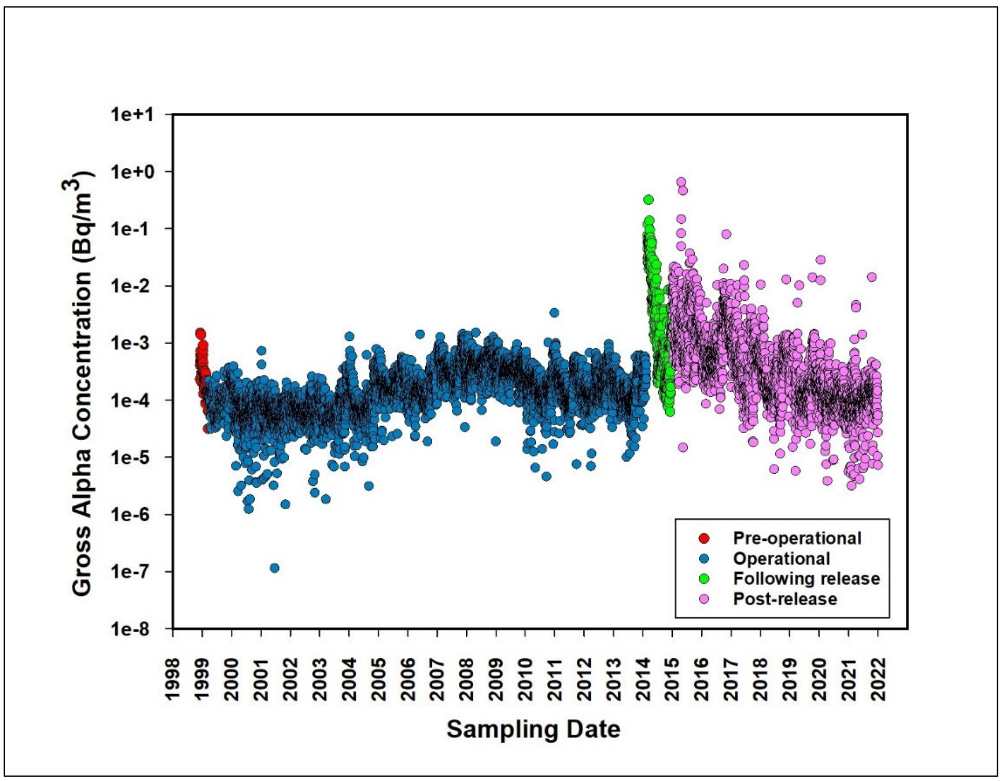


Figure 2.4. Historical Gross Alpha Concentrations at Station A

The two samples with elevated gross beta activity concentrations of approximately 0.058 Bq/m^3 observed in early 2001 are because of contamination released from an underground fire extinguisher (Figure 2.5). Follow-up measurements confirmed that the fire retardant containing ^{40}K was the cause of the elevated results and that WIPP waste had not been released.

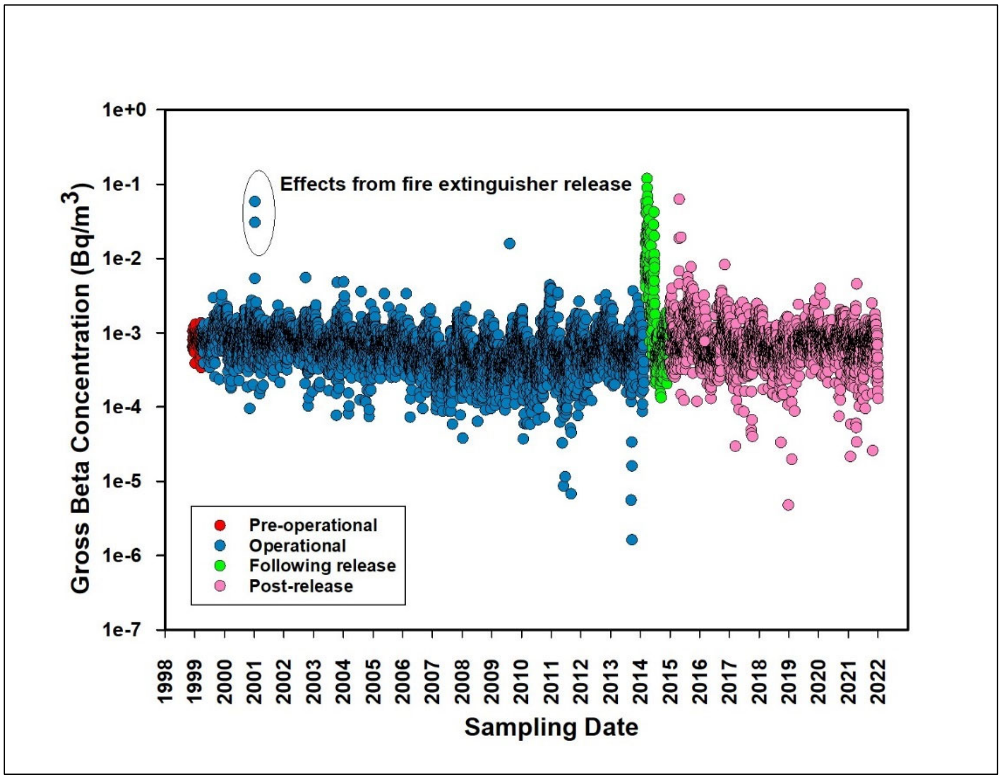


Figure 2.5. Historical Gross Beta Concentrations at Station A

The pre- and post-release gross alpha and gross beta specific activities (Bq/g) are shown in Figure 2.6 and Figure 2.7, respectively, for trend analysis purposes over a period of over twenty years. The gross alpha and beta activities appear to have returned to the pre-release levels in recent years.

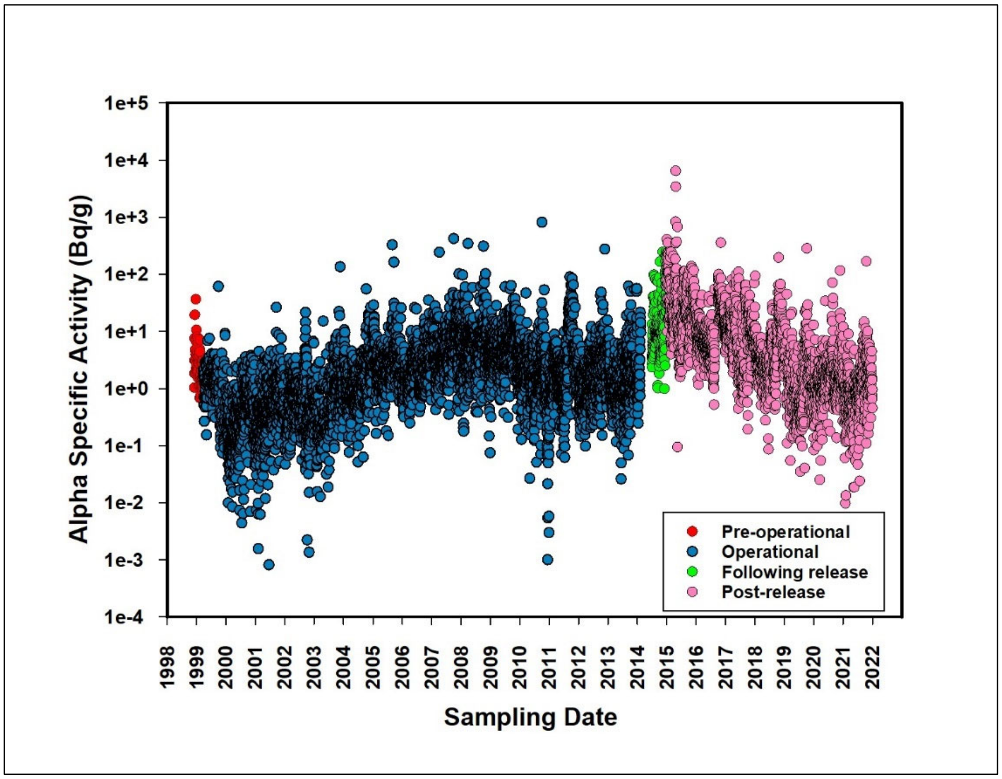


Figure 2.6. Historical Gross Alpha Specific Activities at Station A

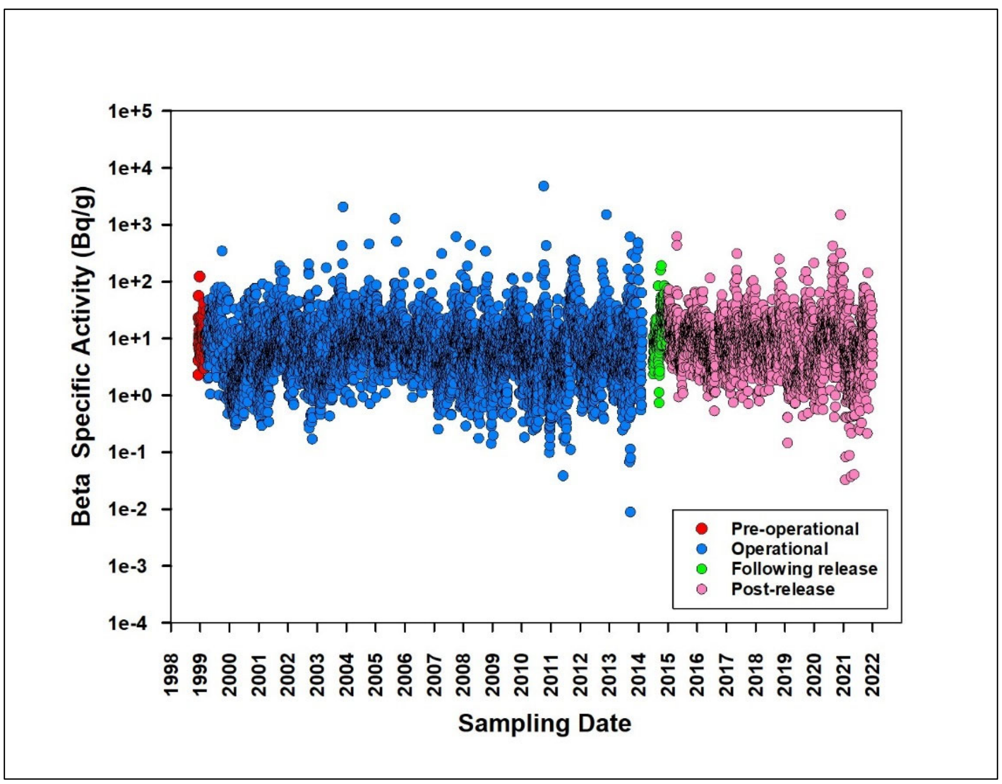


Figure 2.7. Historical Gross Beta Specific Activities at Station A

The daily gross alpha and gross beta concentrations in the unfiltered underground air are shown in Figure 2.8 and Figure 2.9, respectively. The gross alpha and beta activity in the air filters prior to the arrival of waste at the WIPP were used as a baseline concentration. The baseline concentrations of gross alpha and gross beta activities were 1.49 mBq/m^3 for alpha and 4.90 mBq/m^3 for beta. The current levels are within the range of normal background levels for Station A.

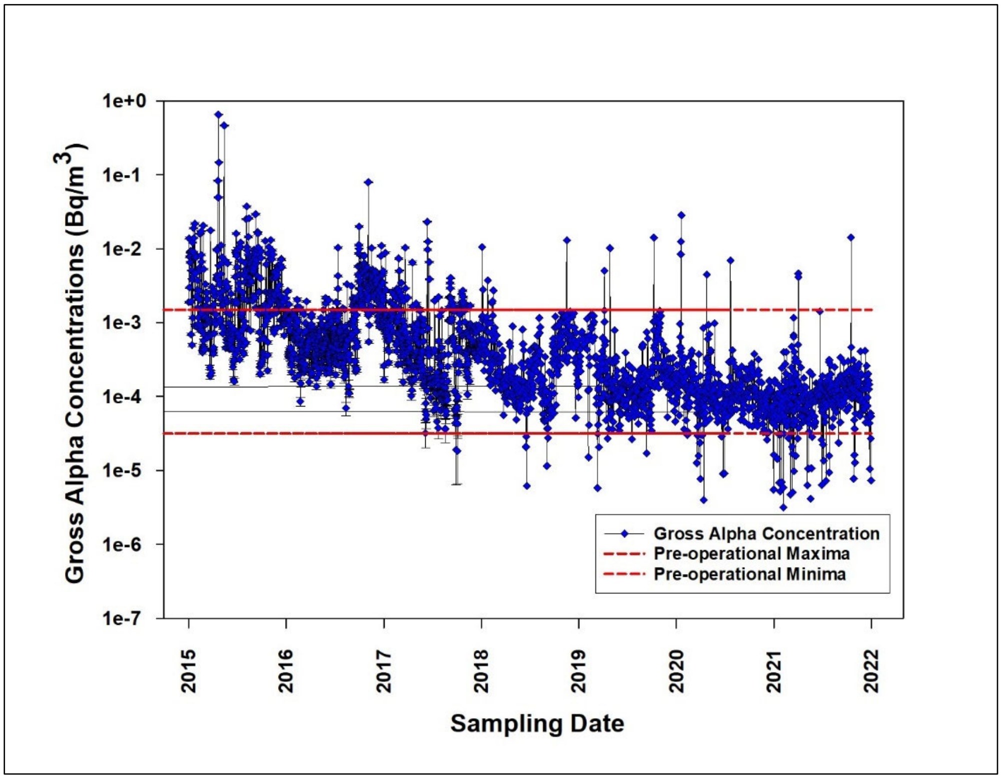


Figure 2.8. Gross Alpha Concentrations at Station A during 2015-2021

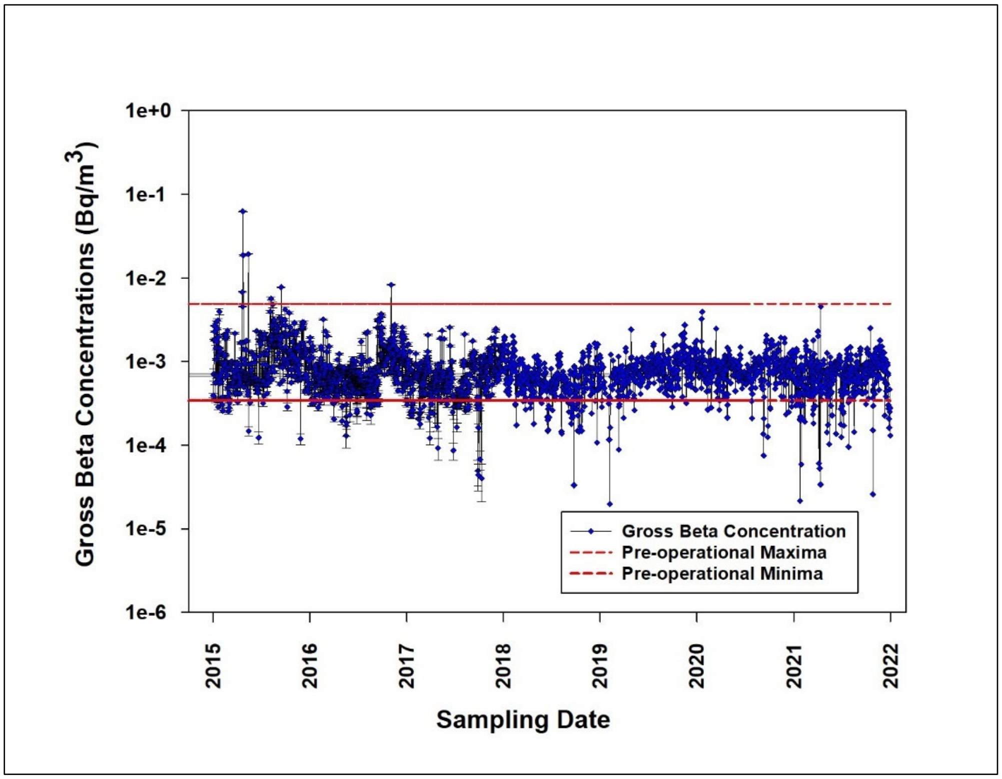


Figure 2.9. Gross Beta Concentrations at Station A during 2015-2021

These data are then compared against disposal phase data to assess the integrity of the WIPP project. The minimum detectable activity concentrations for the gross alpha emitters are ~ 3.18×10^{-6} Bq/m^3, while for gross beta emitters the corresponding value is ~ 2.15×10^{-5} Bq/m^3. During 2021, the alpha activity in the unfiltered exhaust air was in the range of <MDC-14.21mBq/m^3 with a mean value of 0.13±0.71 mBq/m^3, and beta activity was in the range of <MDC-4.55 mBq/m^3 with a mean value of 0.70±0.41 mBq/m^3. A spike in gross alpha activity during the third week of November 2018 is attributed to the rockfall in Room 6, Panel 7. Other small sporadic increases in gross alpha concentrations, shown in Figure 2.8, can be attributed to the disturbance of entrained materials, which allows them to be transported in the WIPP underground air due to ongoing investigative and clean-up efforts by underground personnel.

2.2.2 Actinide Concentrations at Station A

The weekly concentrations of ^{241}Am, $^{239+240}$Pu, and ^{238}Pu at Station A are shown in Figure 2.10; the individual values are listed in Tables A.1 through A.3 (Appendix A). Although the values that were measured were above the pre-release background levels, it is important to note that the levels detected were very low and well below any level of public health or environmental concern. The specific activities of ^{241}Am, $^{239+240}$Pu, and ^{238}Pu measured at Station A are shown in Figure 2.11 and the values are listed in Tables A.4 through A.6 (Appendix A).

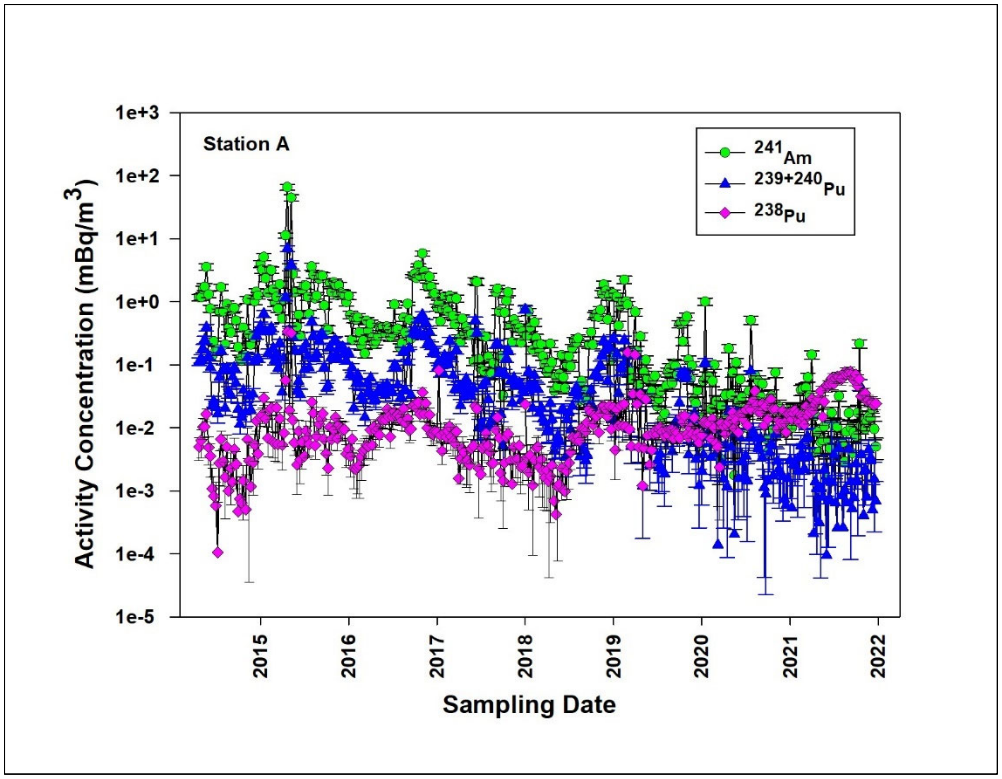


Figure 2.10. Weekly Concentrations of ^{241}Am, $^{239+240}Pu$, and ^{238}Pu at Station A

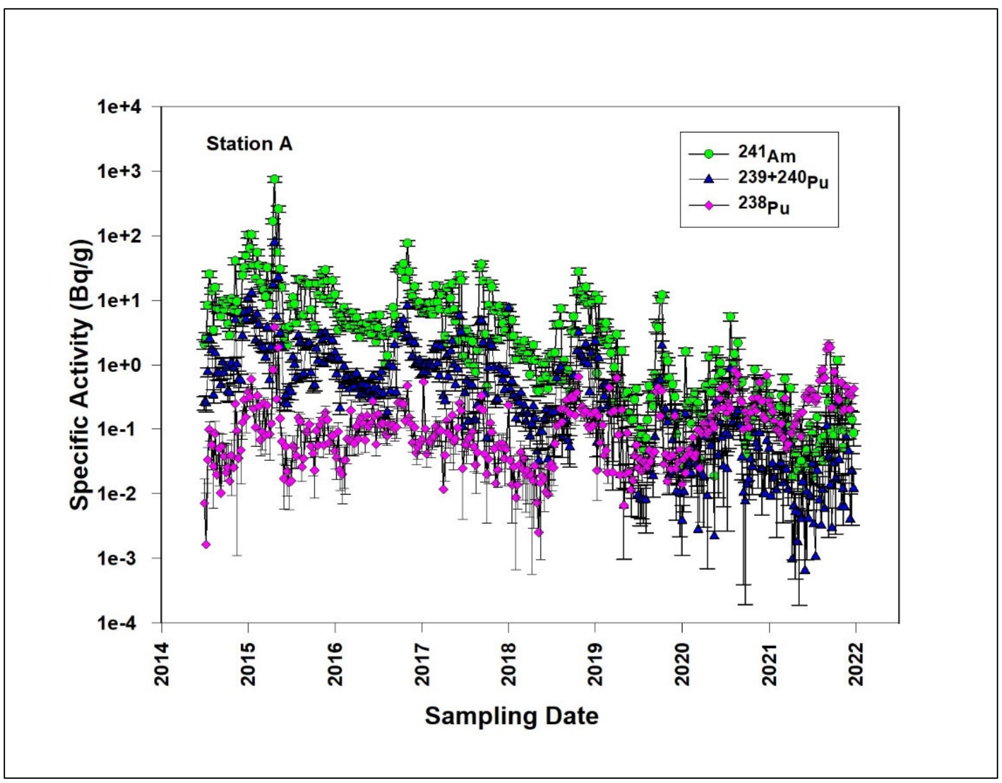
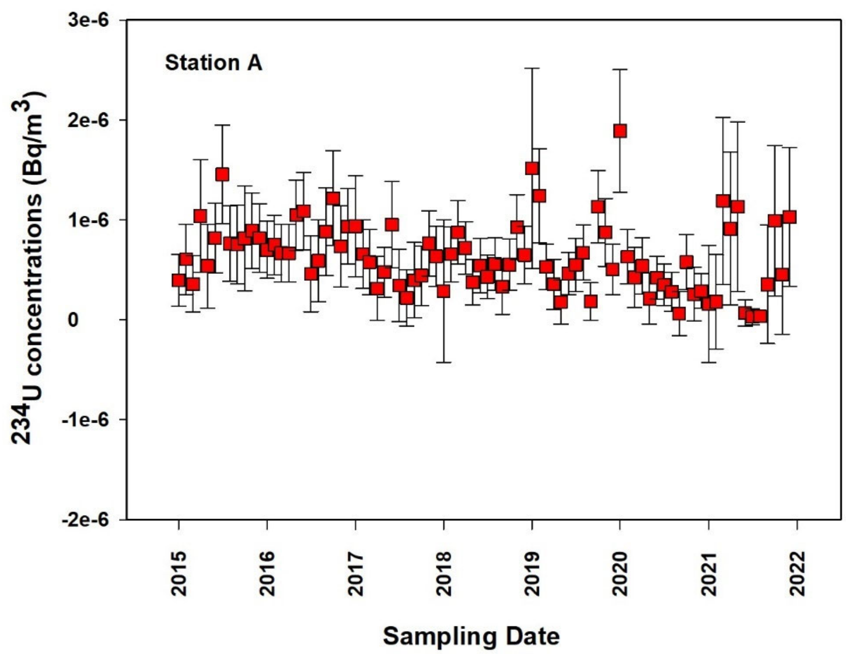


Figure 2.11. Weekly Specific Activities of ^{241}Am, $^{239+240}Pu$, and ^{238}Pu at Station A

2.2.3 Uranium Concentrations at Station A

Uranium isotopes, naturally occurring radionuclides found in the environment, were detected in some monthly composite samples collected from Station A during 2021. The individual uranium activity concentrations and specific activity measured in monthly composite samples are summarized in Tables A.7 and A.8 (Appendix A).



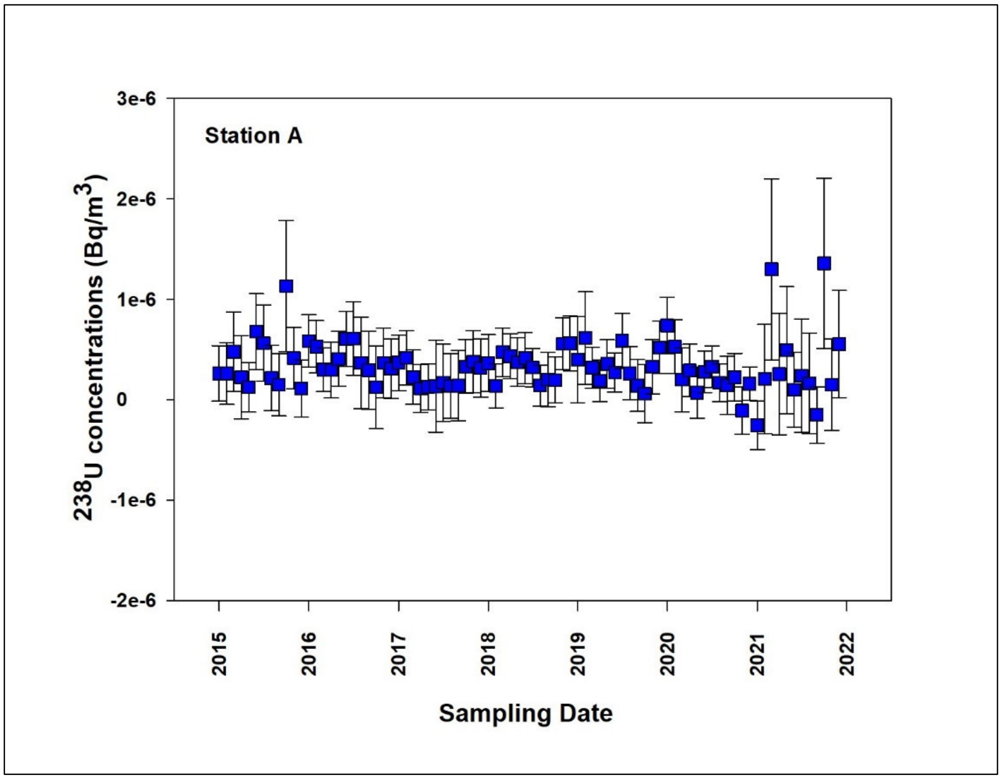
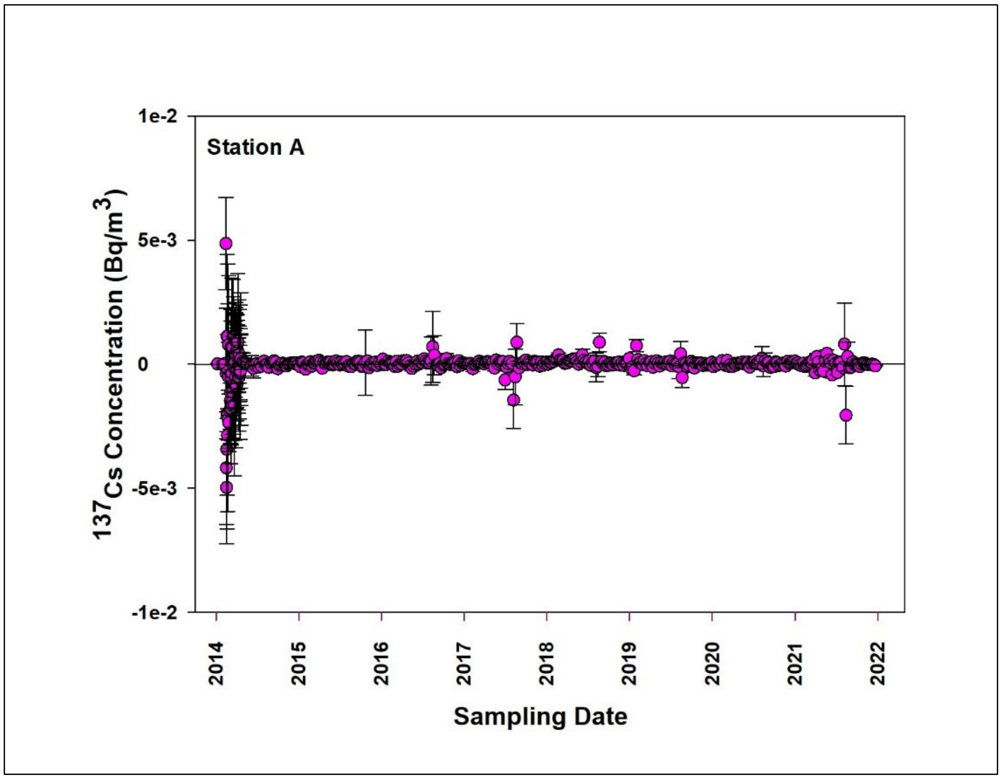
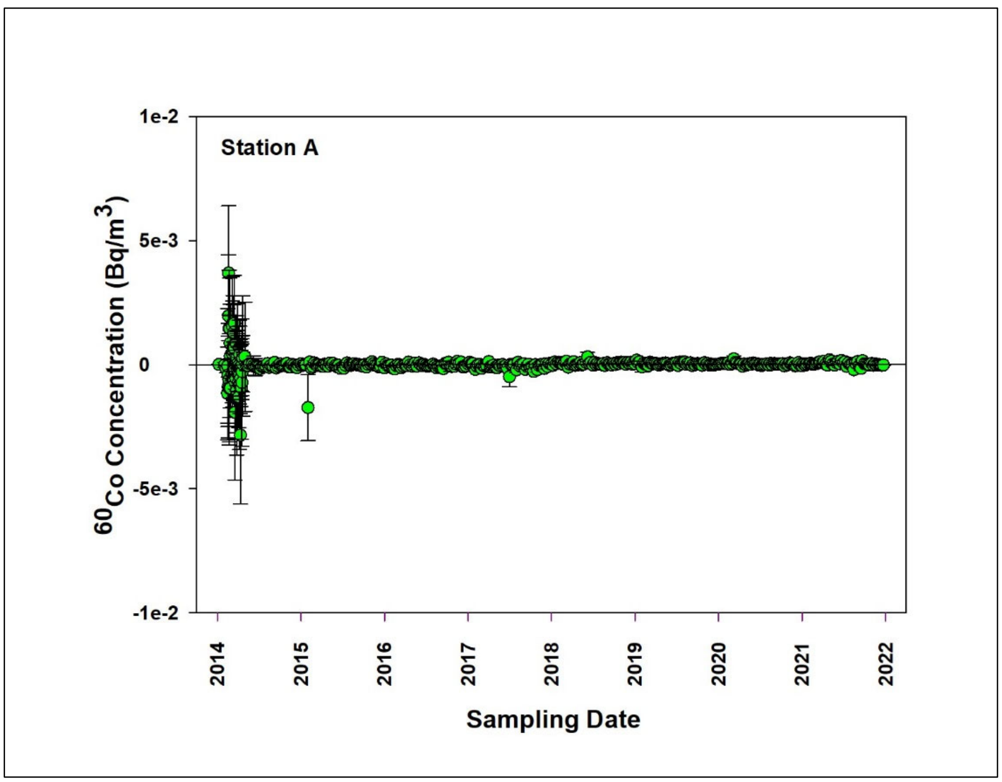


Figure 2.12. The ^{234}U (top) and ^{238}U (bottom) Activity Concentrations at Station A

2.2.4 Gamma Radionuclide Concentrations at Station A

The gamma-emitting radionuclides ^{137}Cs, ^{40}K, and ^{60}Co were not detected in any of the weekly composite samples during 2021. The concentrations of the gamma-emitting radionuclides ^{137}Cs, ^{60}Co, and ^{40}K measured in Station A filter samples are shown in Figure 2.13. The concentrations and specific activity of gamma emitting radionuclides are summarized in Appendix A, Tables A.9 through A.14. An analysis of historical operational data indicates that, except for the occasional detections of ^{40}K and the one-time detection of ^{137}Cs on February 14, 2014, immediately following the radiological release event at the WIPP, no detectable gamma-emitting radionuclides have been observed during the last sixteen years of monitoring.


Station A
^{137}Cs Concentration (Bq/m^3)
1e-2
5e-3
0
-5e-3
-1e-2
2014
2015
2016
2017
2018
2019
2020
2021
2022
Sampling Date


Station A
^{60}Co Concentration (Bq/m^3)
1e-2
5e-3
0
-5e-3
-1e-2
2014
2015
2016
2017
2018
2019
2020
2021
2022
Sampling Date

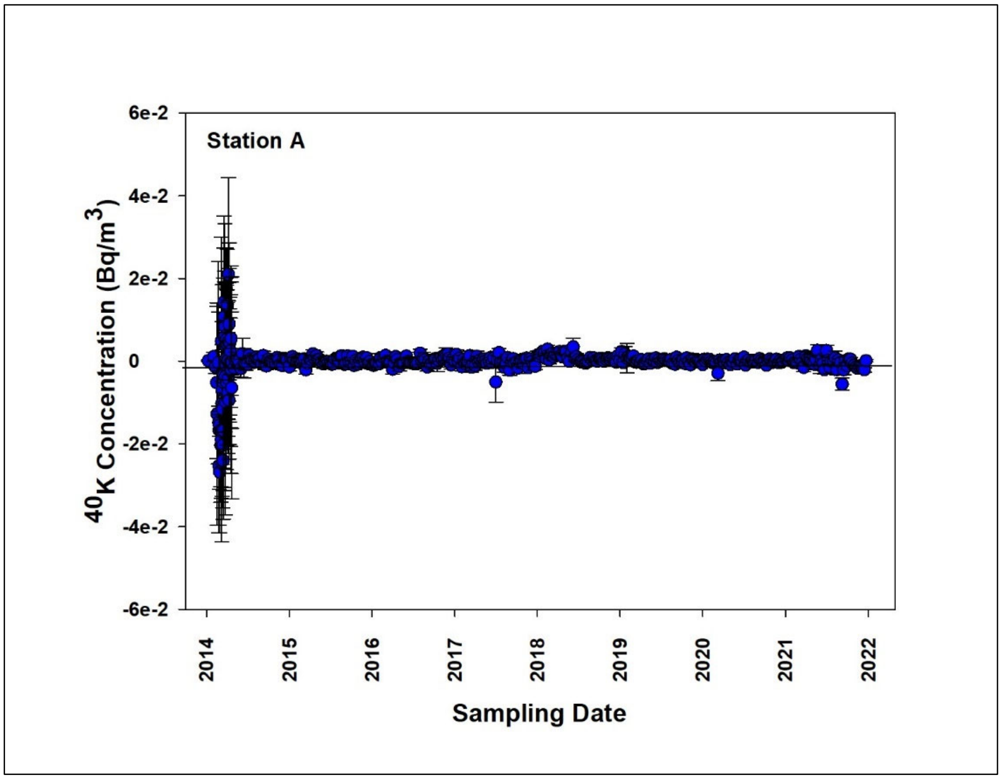


Figure 2.13. Concentrations of Gamma Emitting Radionuclides ^{137}Cs (top), ^{60}Co (middle), and ^{40}K (bottom) at Station A

2.2.5 Historical Concentrations of Actinides at Station A

An analysis of historical operational data from Station A indicates occasional detections of trace amounts of $^{239+240}$Pu, ^{238}Pu, and ^{241}Am in the exhaust air released from the WIPP over time (Figure 2.14). From 2000 through 2013, only nine Station A measurements could be declared as containing a certain detection of a radionuclide. Detectable concentrations of Pu isotopes ($^{239+240}$Pu or ^{238}Pu) and ^{241}Am only occurred in four monthly composite samples from 2003, 2008, 2009, and 2010 (CEMRC Report 2011). As ^{238}Pu concentrations were above detection limits in two of the monthly composite samples (February 2008 and April 2009), these two composite samples were used to calculate the activity ratios between ^{238}Pu and $^{239+240}$Pu. The February 2008 sample ratio was 0.039; the April 2009 sample ratio was 0.023. A mean ^{238}Pu /$^{239+240}$Pu activity ratio of 0.025±0.004 (0.019-0.039) is consistent with a global fallout origin, as reported in different studies (Kelly et al., 1999, Hardy et al., 1973). It is important to note that activities detected in those four composites were extremely low and did not trigger the underground Continuous Air Monitors (CAM) that detect any release of radioactivity. Based on extensive analyses of these data, CEMRC concludes that there has been no unambiguous evidence of releases from WIPP operations prior to the February 14, 2014, underground radiation release event.

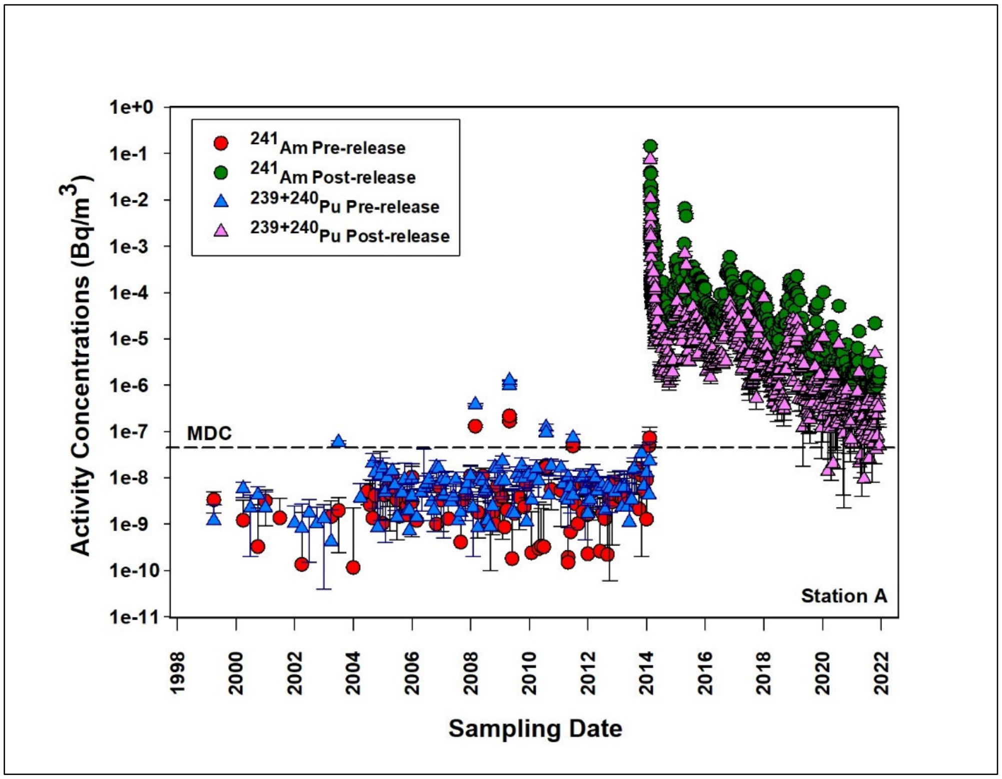


Figure 2.14. Historical Concentrations of ^{241}Am and $^{239+240}Pu$ at Station A

2.2.6 Strontium Concentration at Station A

The beta-emitting radionuclide ^{90}Sr was not detected in most of the weekly composite samples, except samples in the third and fourth weeks of February and the first week of March. The weekly composite concentrations of ^{90}Sr in these three samples were 1.17×10^{-2}, 1.43×10^{-2}, and 1.66×10^{-2} Bq/m^3, respectively. The corresponding ^{90}Sr specific activities (activity per unit mass) were 66.8, 115, and 109 Bq/g, respectively.

2.2.7 Gross Alpha and Beta Concentrations at Station B

The daily gross alpha and gross beta activity concentrations at Station B are shown in Figure 2.15. It is important to note that CEMRC has been performing gross alpha and gross beta analyses on Station B filters since July 2014. Filter samples collected prior to July 2014 were not counted for gross alpha and gross beta concentrations; instead, an emergency actinide separation campaign was carried out on the individual or daily filters collected from Station B to provide isotopic results to interested parties as quickly as possible. The pre-operational gross alpha and gross beta concentration values measured at Station A were used as a baseline concentration for the filter samples collected from Station B because CEMRC had not routinely conducted gross alpha/beta analyses on Station B filters prior to February 14, 2014. As would be expected, the Station B analyses showed much lower levels of activity as compared to those of Station A.

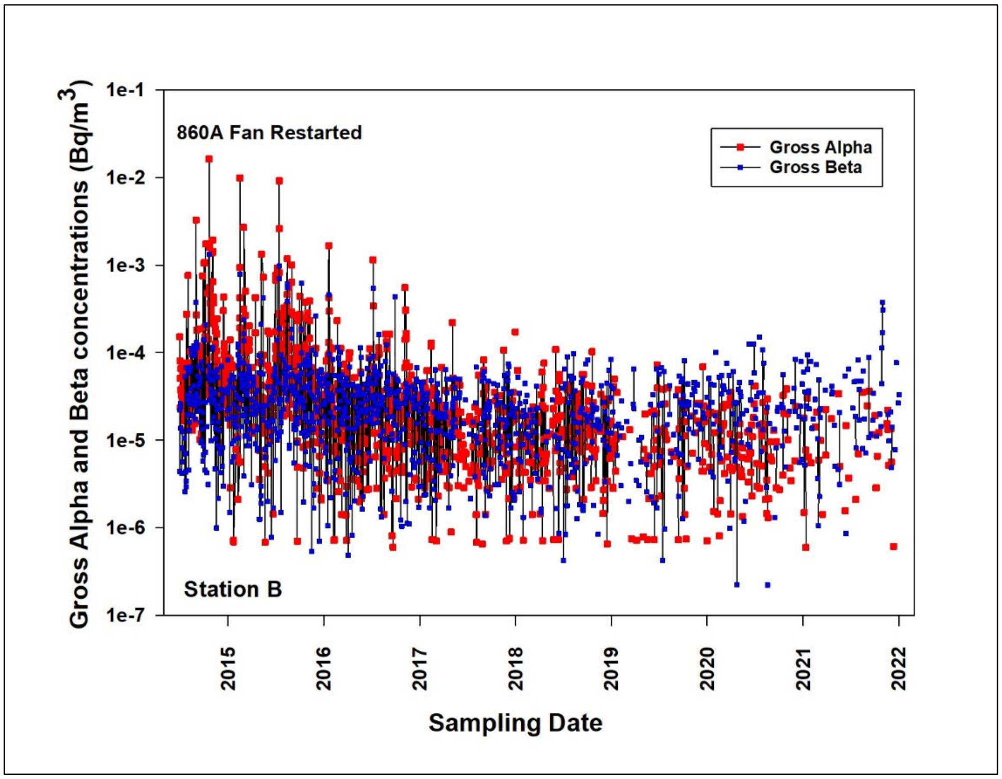
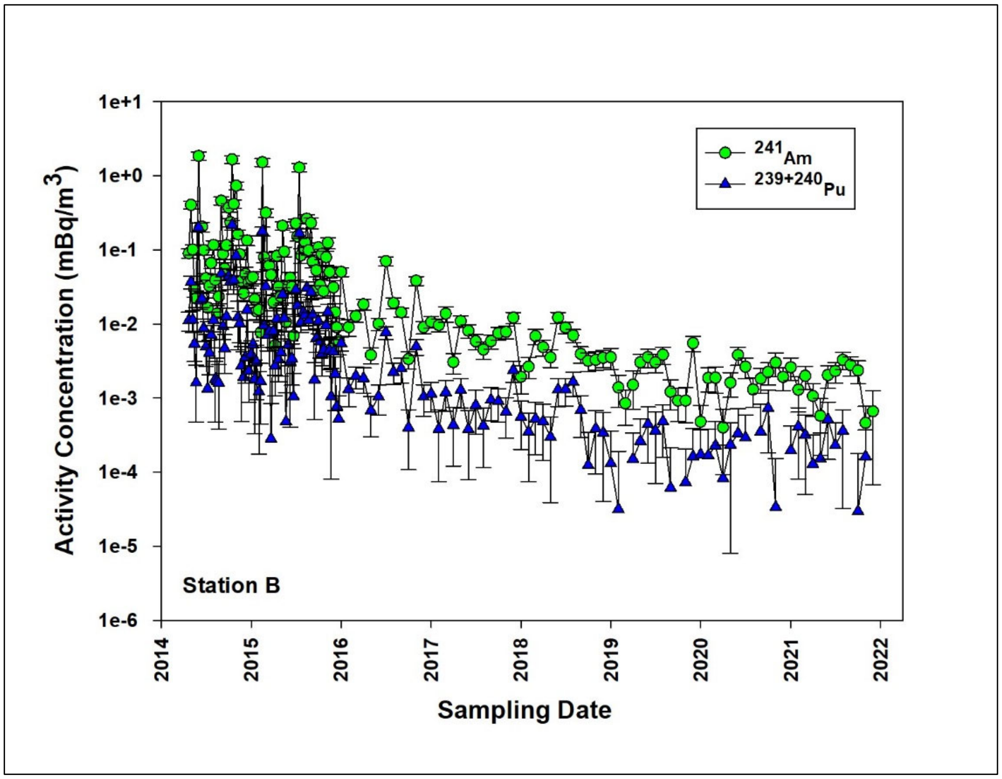


Figure 2.15. Daily Gross Alpha and Gross Beta Activity Concentrations at Station B

A spike in gross alpha activity during the third week of October 2014 is attributed to the restart of the 860A fan on October 21, 2014. The 860A fan ran for approximately two months following the February 2014 underground radiological incident before being taken off-line for maintenance-related activities. Since that time, the 860B or the 860C fans have been operated to continue the air filtration process. Because the 860A fan was operational immediately following the radiological release, it could be expected that a small amount of residual contamination might be present in the adjacent ductwork and the interior workings of the fan, which could result in a low level of contamination being released, as seen in the spikes between 2015 - 2017. The current gross alpha and beta activities at Station B are comparable to the pre-operational gross alpha and beta values measured for Station A filters prior to the arrival of TRU wastes in the WIPP and are typical "background gross alpha and beta" values.

2.2.8 Actinide Concentrations at Station B

The concentrations and specific activity of ^{241}Am, $^{239+240}$Pu, and ^{238}Pu in monthly composite samples from Station B are summarized in Appendix A, Tables A.15 through A.20. The concentrations of ^{241}Am were in the range of 4.61×10^{-4}-3.27×10^{-3} mBq/m^3, while that of $^{239+240}$Pu were in the range of -9.15×10^{-6}-5.14×10^{-4} mBq/m^3. The specific activity of ^{241}Am at Station B was in the range of 4.04×10^{-2}-8.80 Bq/g, while that of $^{239+240}$Pu was in the range of -5.07×10^{-2} - -3.00×10^{-1} Bq/g. The concentrations and specific activity of ^{241}Am and $^{239+240}$Pu measured at Station B are shown in Figure 2.16.



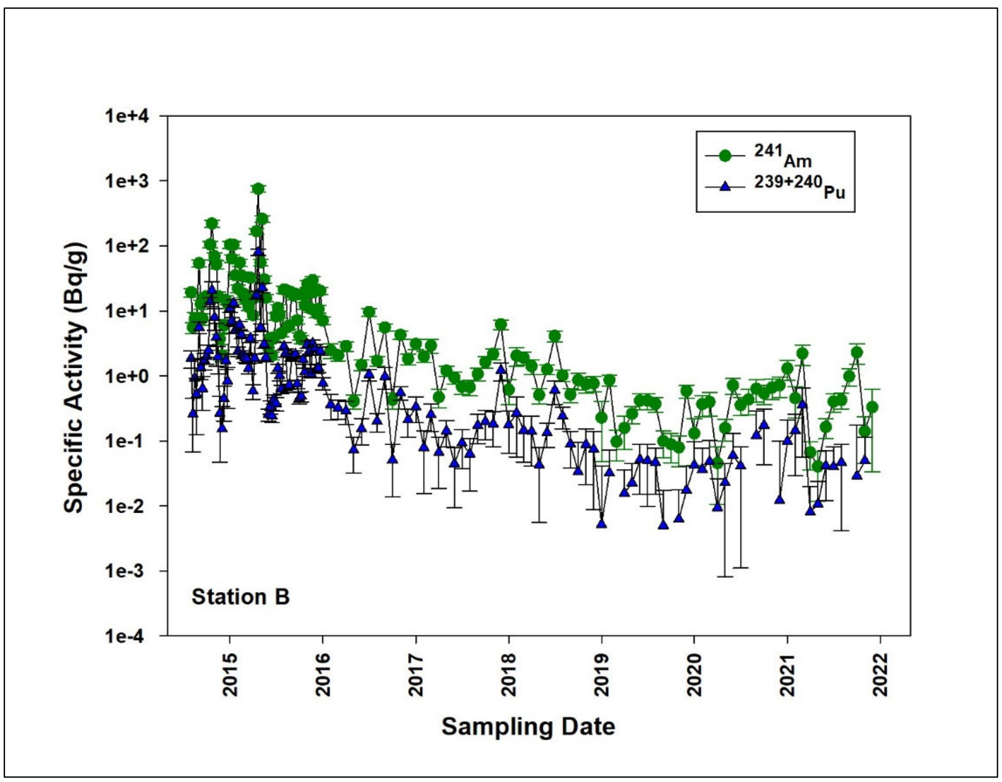
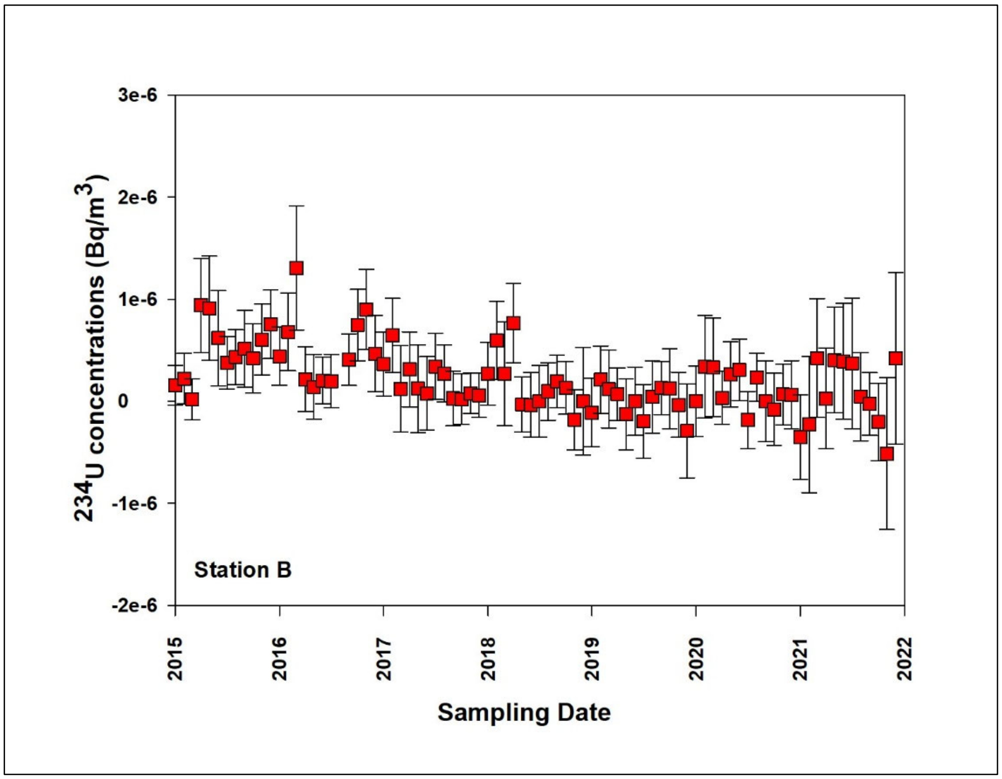


Figure 2.16 Activity Concentrations (top) and Specific Activities (bottom) of ^{241}Am and $^{239+240}Pu$ at Station B

2.2.9 Uranium Concentrations at Station B

From the naturally occurring isotopes of U, only ^{238}U was detected above the MDC in only one monthly composite sample from Station B in 2021. Isotopes of uranium have occasionally been detected at Station B. The activity concentrations of U isotopes measured in Station B filter samples are shown in Figure 2.17. The individual uranium activity concentrations and specific activity measured in monthly composite samples are summarized in Appendix A, Tables A.21 and A.22.



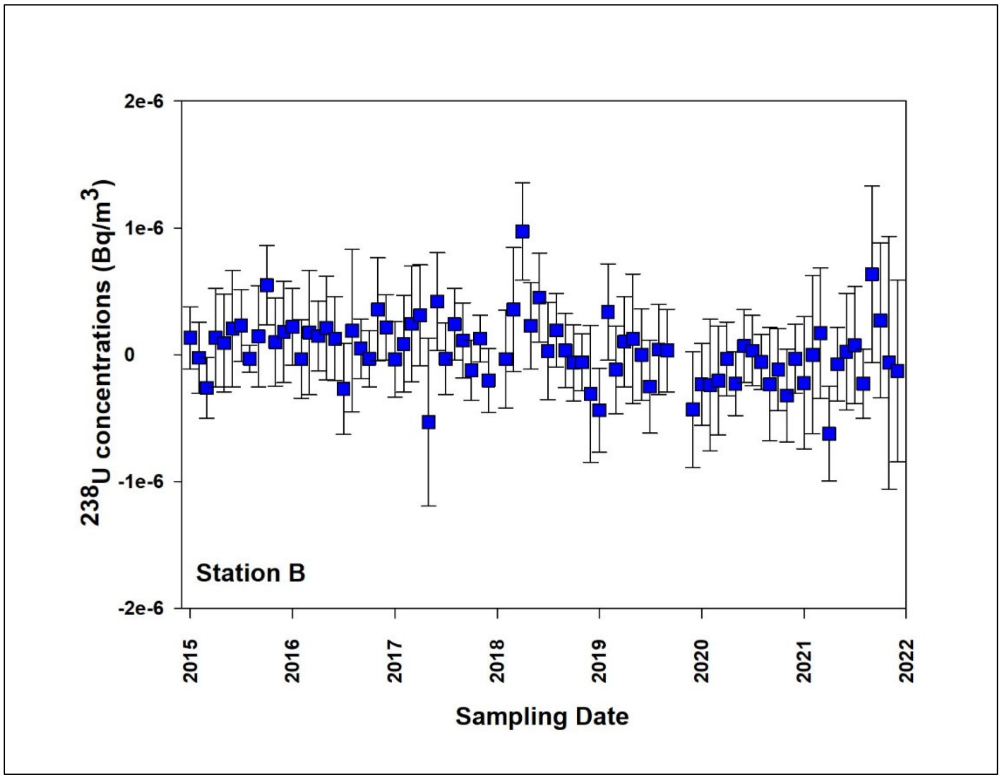
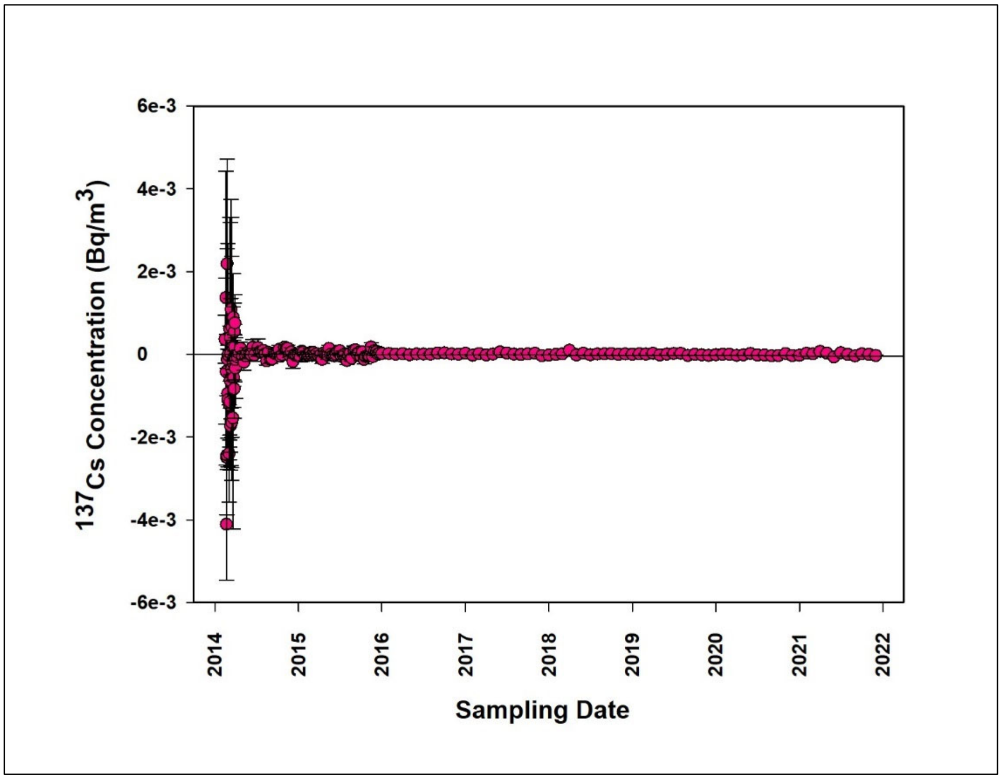


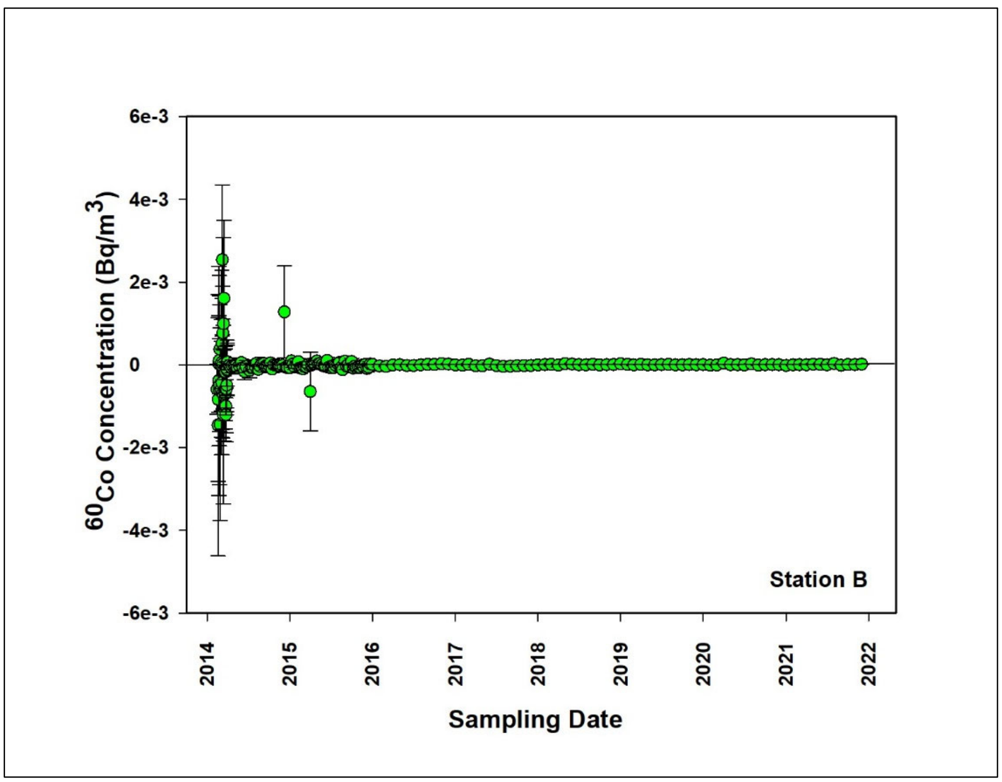
Figure 2.17. The ^{234}U (top) and ^{238}U (bottom) Activity Concentrations at Station B

2.2.10 Gamma Radionuclide Concentrations at Station B

The concentrations of the gamma-emitters ^{137}Cs, ^{40}K, and ^{60}Co in Station B filter samples are shown in Figure 2.18. No detectable gamma-emitting radionuclides were observed in any of the filter samples collected from Station B in 2021, which is consistent with the previous report. The concentrations and specific activity of these gamma-emitting radionuclides are summarized in Appendix A, Tables A.23 through A.28.



6e-3
4e-3
2e-3
0
-2e-3
-4e-3
-6e-3
137Cs Concentration (Bq/m3)
2014
2015
2016
2017
2018
2019
2020
2021
2022
Sampling Date



6e-3
4e-3
2e-3
0
-2e-3
-4e-3
-6e-3
60Co Concentration (Bq/m3)
Station B
2014
2015
2016
2017
2018
2019
2020
2021
2022
Sampling Date

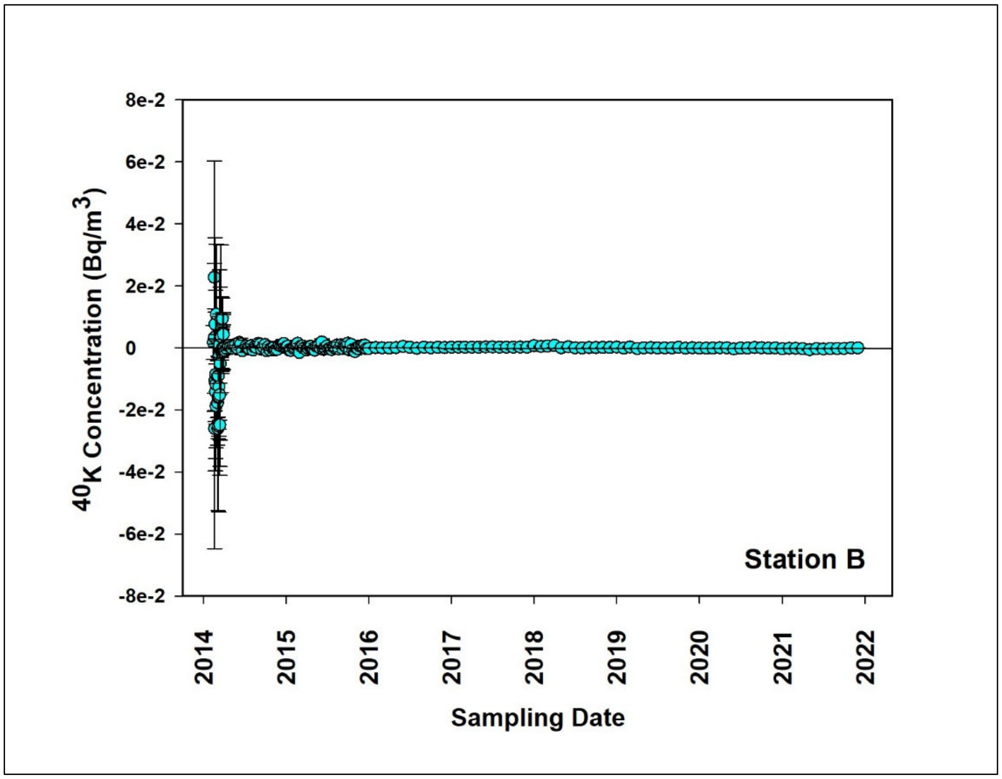


Figure 2.18. The Concentrations of Gamma Emitting Radionuclides ^{137}Cs (top), ^{60}Co (middle), and ^{40}K (bottom) at Station B

2.2.11 Historical Concentrations of Actinides at Station B

Before the 2014 accidental release, the concentrations of ^{241}Am and $^{239+240}$Pu were all below the MDC. Since CEMRC was not performing Station B analyses before the events, the WIPP contractor's NWP data were used to show the historical trend (ASER Report, wipp.energy.gov). It should be noted that quarterly composite samples were used from 1999 until 2013 by the NWP to determine the actinides. The current concentrations of ^{241}Am and $^{239+240}$Pu at Station B are close and, in some instances, below the corresponding MDC values (Figure 2.19).

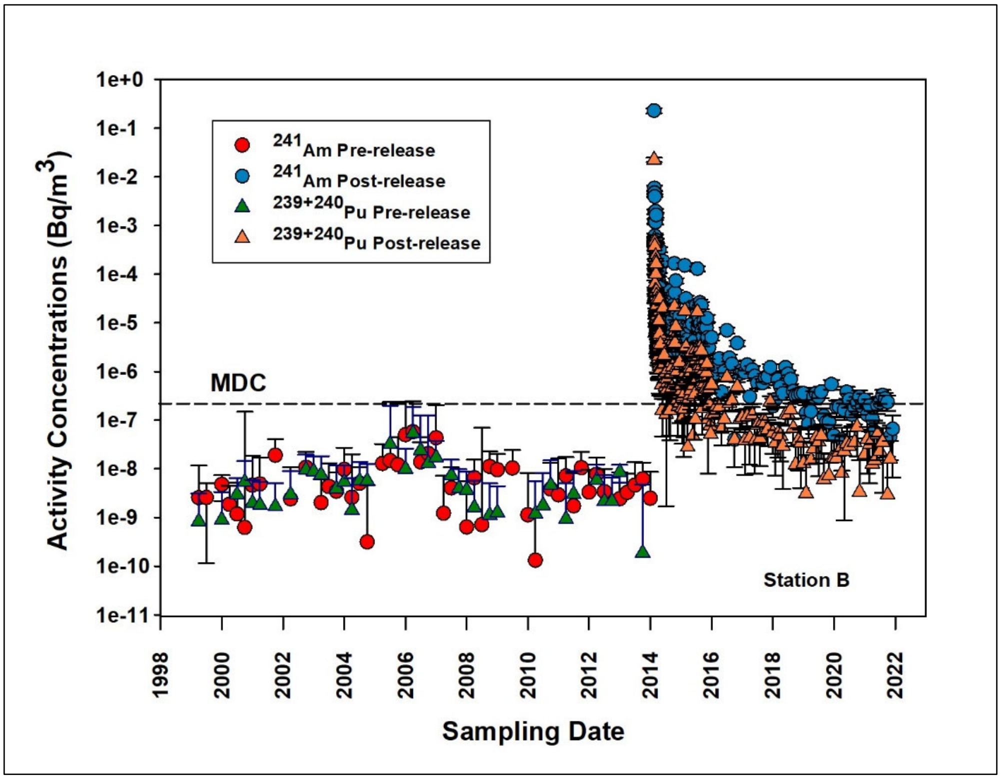


Figure 2.19. Historical Concentrations of ^{241}Am and $^{239+240}$Pu and at Station B

2.2.12 Strontium Concentration at Station B

The beta-emitting radionuclide ^{90}Sr was not detected in any of the monthly composite samples at Station B.

2.3 Conclusion

This chapter summarizes the results of the effluent air-monitoring program for the calendar year 2021. For this monitoring period, the alpha activity at Station A was in the range of <MDC-14.21mBq/m^3 with a mean value of 0.13±0.71 mBq/m^3, and beta activity was in the range of <MDC-4.55 mBq/m^3 with a mean value of 0.70±0.41 mBq/m^3. The gross alpha and beta activities appear to have gone back to the pre-release levels in recent years. The activity concentrations of actinides were in the range of 1.57×10^{-3}-2.17×10^{-1} mBq/m^3 for ^{241}Am; 9.48×10^{-5}-4.85×10^{-2} mBq/m^3 for $^{239+240}$Pu; and 1.11×10^{-2}-7.85×10^{-2} mBq/m^3 for ^{238}Pu at Station A, while at Station B they varied in the range of 4.61×10^{-4}-3.27×10^{-3} mBq/m^3 for ^{241}Am and -9.15×10^{-6}-5.14×10^{-4} mBq/m^3 for $^{239+240}$Pu. These levels continued to be lower than the levels measured in previous years. As expected, the naturally occurring isotopes of U were detected in some monthly composite samples collected from Station A, while no uranium isotopes were detected in any of the Station B composite samples. Gamma radionuclides were also not detected in any of the weekly/monthly composite samples from Station A and Station B. However, CEMRC's historical operational data show occasional detections of ^{40}K at Station A. ^{40}K is a naturally occurring gamma-emitting radionuclide that is ubiquitous in

soils, and therefore it would be expected to be detected from time to time in the WIPP exhaust air samples. The beta-radiation-emitting ^{90}Sr radionuclide was detected in only three weekly composite samples from Station A and it was not detected in any monthly composite samples at Station B.

CHAPTER 3 - AIRBORNE PARTICULATE MONITORING

Airborne particulate monitoring plays a crucial role in the comprehensive environmental monitoring program of the Carlsbad Environmental Monitoring and Research Center (CEMRC). This program is designed to monitor both routine and unforeseen releases of airborne particles, ensuring that the facility remains compliant with public radiological dose limits. The data collected from this monitoring effort are utilized to assess any potential impacts on the environment over time. Furthermore, the program serves as a precautionary measure in the event of an accidental release of radioactive materials.

The primary objective of CEMRC's ambient air monitoring program is to ascertain whether the handling and storage operations of nuclear waste at the Waste Isolation Pilot Plant (WIPP) have resulted in the release of radionuclides into the surrounding environment. To achieve this, CEMRC maintains a network of continuously operating samplers at six strategically chosen locations near the WIPP site and the adjacent communities. These monitoring sites are positioned based on prevalent wind directions from the facility, ensuring accurate detection of any potential releases. Additionally, monitoring sites in the nearby communities of Loving and Carlsbad provide supplementary information to local residents and maintain public confidence, as these communities are in closest proximity to the WIPP.

Earlier studies conducted by CEMRC yielded significant findings. One notable discovery was the correlation between plutonium activity and the concentration of aluminum in ambient air particles. This correlation was attributed to the resuspension of dust particles contaminated with radioactive fallout from historical nuclear weapons testing. Similar results were observed for americium and aluminum. Concurrent soil studies conducted within and around the WIPP site also revealed correlations between aluminum and naturally occurring as well as bomb-derived radionuclides, including $^{239+240Pu}$ (Kirchner et al., 2002).

In the current scope of work, particulate samples are collected at varying frequencies determined by mass loading and airflow from all designated monitoring locations. Each individual sample undergoes analysis to determine the total suspended particulates collected and to quantify the presence of gamma-emitting radionuclides and actinides of concern. Specific details regarding sample collection methodologies and analytical procedures are provided in the subsequent sections.

3.1 Sample Collection

Particulates in the ambient air are collected using high-volume samplers (“HiVols,” flow rate approximately 1.13 m^3/min) from six monitoring stations. These stations are at the following locations: (1) Onsite, which is 0.1 km northwest of the WIPP exhaust shaft; (2) the East Side of the WIPP facility (3) Near Field, about 1 km northwest of the facility, (4) Cactus Flats, about 19 km southeast of the WIPP site; (5) Carlsbad (behind the CEMRC facility), and (6) the south side of Loving. These samplers are primarily located in the prevailing downwind direction and were selected based on an analysis of probable wind-direction and speed scenarios in case of an accident involving a release of radioactivity during the operation of WIPP. Ambient air sampling locations and a typical high-volume air sampling station are shown in Figure 3.1.

Particulates in the ambient air were collected on 20×25 cm A/E™ glass fiber filters with a pore size 1 μm (Pall German Laboratory, Ann Arbor, MI, USA). A typical sampling period lasts about three to four weeks depending on the levels of particulate matter that accumulates on the filters. These samplers are operated to maximize particulate loading without impacting airflow; if the flow rate drops to 0.99 m^3/min, the filters are changed. Filter change-outs also occur in the event of a power outage or if a sampler stops due to some mechanical issue. Each filter is weighed before and after sampling to determine the mass of aerosol material collected. Actinide analyses are performed on individual filters by CEMRC. The sampling height of each aerosol station is approximately 5 m from the ground.

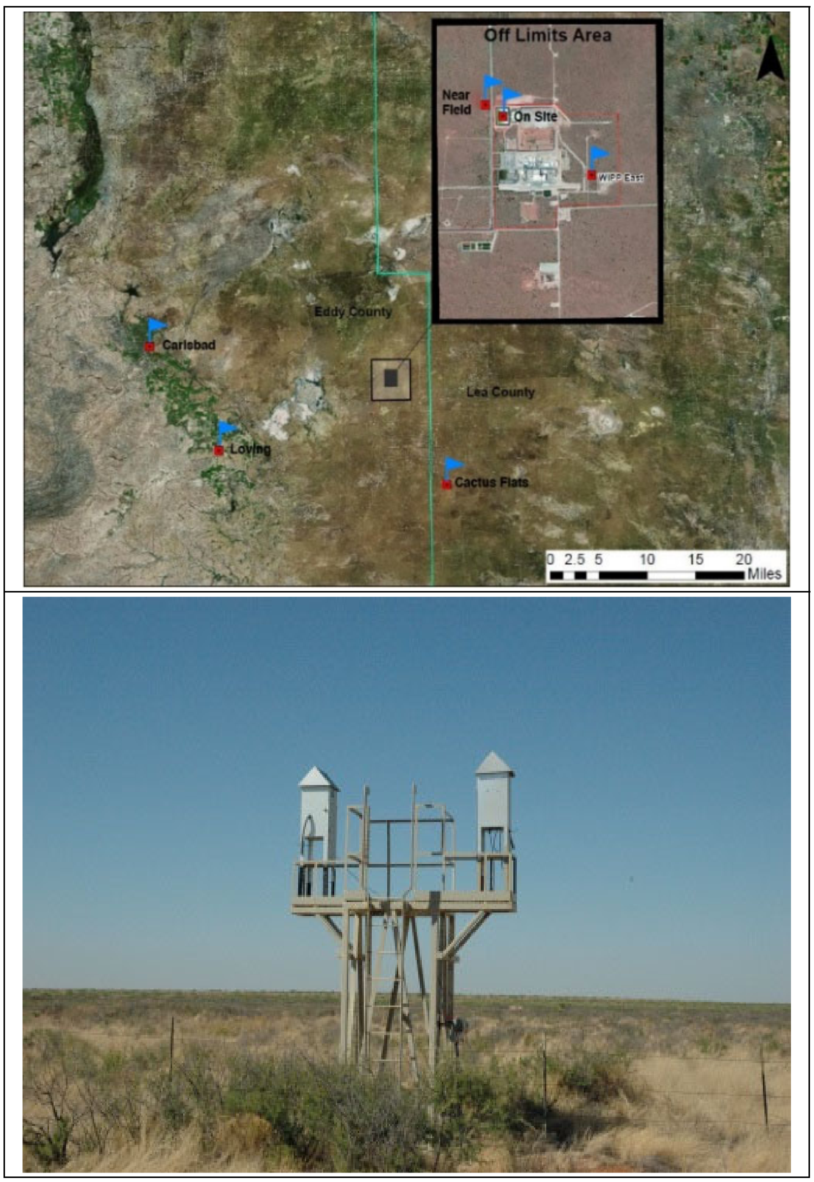


Figure 3.1. Ambient Air Sampling Locations (top) and Typical High-Volume Sampling Station (bottom)

3.2 Sample Preparation and Analysis

The individual filters are heated in a muffle furnace at 500 °C for six hours. Filter samples for radiochemical analysis are prepared by wet digestion with nitric acid (HNO_3), hydrochloric acid (HCl), and hydrofluoric acid (HF) until completely dry. The mixture is then heated with concentrated perchloric acid ($HClO_4$) to ensure that all residual HF is removed from the sample matrix. The residues are then dissolved in 1.0 M HCl for subsequent radionuclide separation and analysis. The activity measured is multiplied by two to account for the total activity in the filter.

3.3 Radiochemical Analysis

The acid digestate from the filter samples is then split into two fractions. One-half of each sample is used for gamma analysis of ^{137}Cs, ^{40}K, and , ^{60}Co. The other half is analyzed for the actinides after $Fe(OH)_3$ co-precipitation and separation occurs using an anion exchange and chromatography column as described in previous CEMRC reports (http://www.cemrc.org/annual-reports). Gamma-emitting radionuclides in the ambient air filters are measured by gamma spectroscopy for 48 hours., while alpha-emitting radionuclides are measured using alpha spectroscopy (Mirion Technologies Inc, San Ramon, CA, USA) for five days as per CEMRC's standard counting protocol. Portions of digested solutions containing strontium are co-precipitated with barium as a carbonate, then dissolved in nitric acid and barium precipitated out as chromate. The supernatants obtained are mixed with ammonium hydroxide (NH_4OH) and saturated ammonium carbonate $(NH_4)_2CO_3$ to precipitate strontium as strontium carbonate ($SrCO_3$), and the beta-radiation-emitting radioactive isotope ^{90}Sr is then counted by liquid scintillation counting. Details are described in procedure WL-1011.

3.4 Results and Discussion

The activities of the actinides and gamma-emitting radionuclides in air samples are reported in the following two ways. Activity Concentration in Bq/m^3 and Specific Activity in Bq/g. Activity Concentration is calculated as the activity of radionuclides reported in Becquerel (Bq) divided by the volume of air in cubic meters (m^3). Specific Activity is calculated as the activity of radionuclides reported in Becquerel (Bq) divided by the aerosol mass collected on the filter in grams (g).

3.4.1 Actinide Concentrations in Ambient Air

The concentrations of ^{241}Am and $^{239+240}$Pu slightly above the MDC were detected in a few ambient air samples at all monitoring stations, while ^{238}Pu was not detected above the MDC in any air filter sample at the Onsite station. Detecting these radionuclides generally depends on the amount of dust collected on the filters. More dust is collected during dry and windy seasons, typically from March to June. Therefore, during most years studied, the positive detections of $^{239+240}$Pu or ^{241}Am occur during the March to June timeframe, which is when strong and gusty winds in the area frequently give rise to blowing dust. The concentrations of $^{239+240}$Pu measured were in the range of 3.27×10^{-9} to 1.97×10^{-7} Bq/m^3 at the Onsite station, -4.09×10^{-9} to 2.50×10^{-8} Bq/m^3 at the Near Field station, 4.72×10^{-16} to 6.29×10^{-8} Bq/m^3 at the Cactus Flats station, -3.37×10^{-9} to 4.85×10^{-8} Bq/m^3 at the Loving station, 2.51×10^{-9} to 2.43×10^{-7} Bq/m^3 at the Carlsbad station, and 1.27×10^{-9} to 8.71×10^{-8} Bq/m^3 at the WIPP's East station. The corresponding concentrations of ^{241}Am were in the range from -6.91×10^{-9} to 4.68×10^{-6} Bq/m^3 at the Onsite station, -1.47×10^{-8} to 2.02×10^{-8} Bq/m^3 at the Near Field station, -8.97×10^{-9} to 4.02×10^{-8} Bq/m^3 at the Cactus Flats station, -4.19×10^{-9} to 1.69×10^{-8} Bq/m^3 at the Loving station, -4.00×10^{-9} to 1.64×10^{-8} Bq/m^3 at the Carlsbad station, and -2.48×10^{-9} to 2.55×10^{-8} Bq/m^3 at the WIPP's East station.

The WIPP's historical ambient air monitoring data indicate frequent detection of $^{239+240}$Pu and ^{241}Am in ambient aerosol samples collected on filters around the WIPP. The detection of ^{238}Pu is relatively infrequent because the origin of this radionuclide is not primarily weapons fallout but rather a release by the burn-up of nuclear-powered satellites, such as the SNAP-9A (Hardy et al., 1973, Harley 1980). Peaks in the $^{239+240}$Pu and ^{241}Am activity concentrations in aerosol samples from the three study sites generally occur from March to June, which is when strong and gusty winds in the area frequently give rise to blowing dust. The observed seasonality in Pu and Am activity concentrations in the WIPP environment is, therefore, attributable to the re-suspension of contaminated soil dust. Furthermore, ^{241}Am and $^{239+240}$Pu activities were highly correlated, and their concentrations were similar at all stations. Figure 3.2 and Figure 3.3 show the concentrations of $^{239+240}$Pu and ^{241}Am at the Cactus Flats, Near Field, and Onsite monitoring stations, while Figure 3.4 and Figure 3.5 show the concentrations of these two radionuclides at the Carlsbad, Loving, and WIPP east monitoring stations.

The concentrations of $^{239+240}$Pu, ^{241}Am, and ^{238}Pu in ambient air filters measured during 2021 are listed in Appendix B, Tables B.1 to B.3 for the Onsite Station, Tables B.4 to B.6 for the Near Field Station, Tables B.7 to B.9 for the Cactus Flats Station, Table B.10 for the Loving monitoring station, Table B.11 for the Carlsbad monitoring station, and Table B.12 for the WIPP East monitoring station.

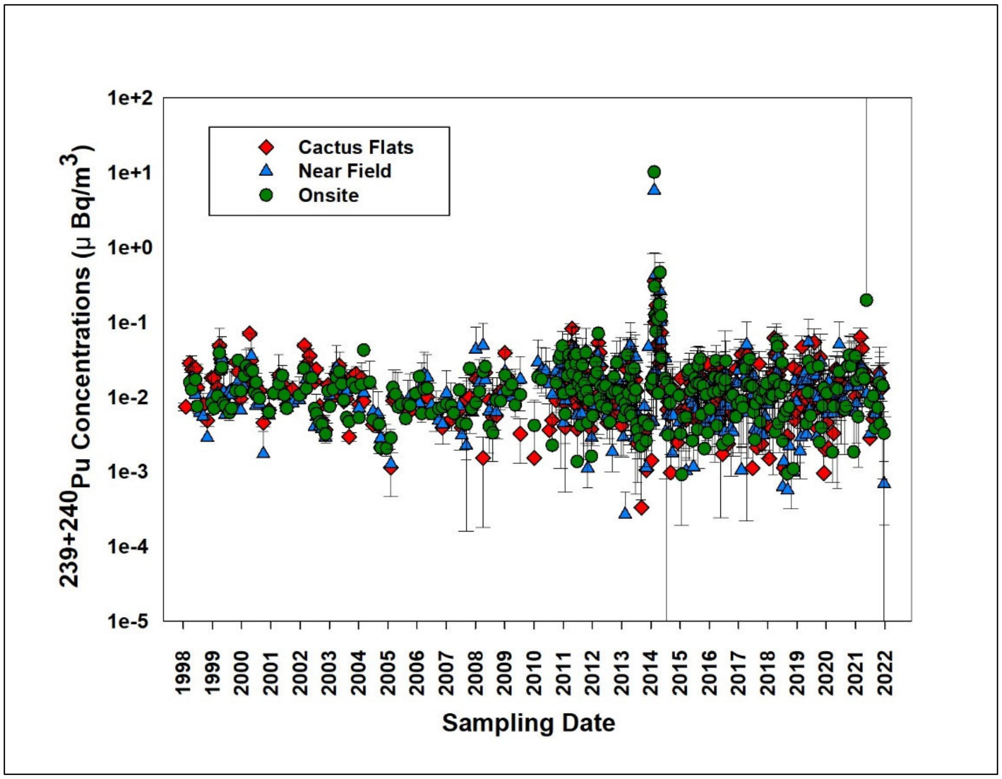


Figure 3.2. Historical $^{239+240}Pu$ Concentrations at the Cactus Flats, Near Field, and Onsite Stations

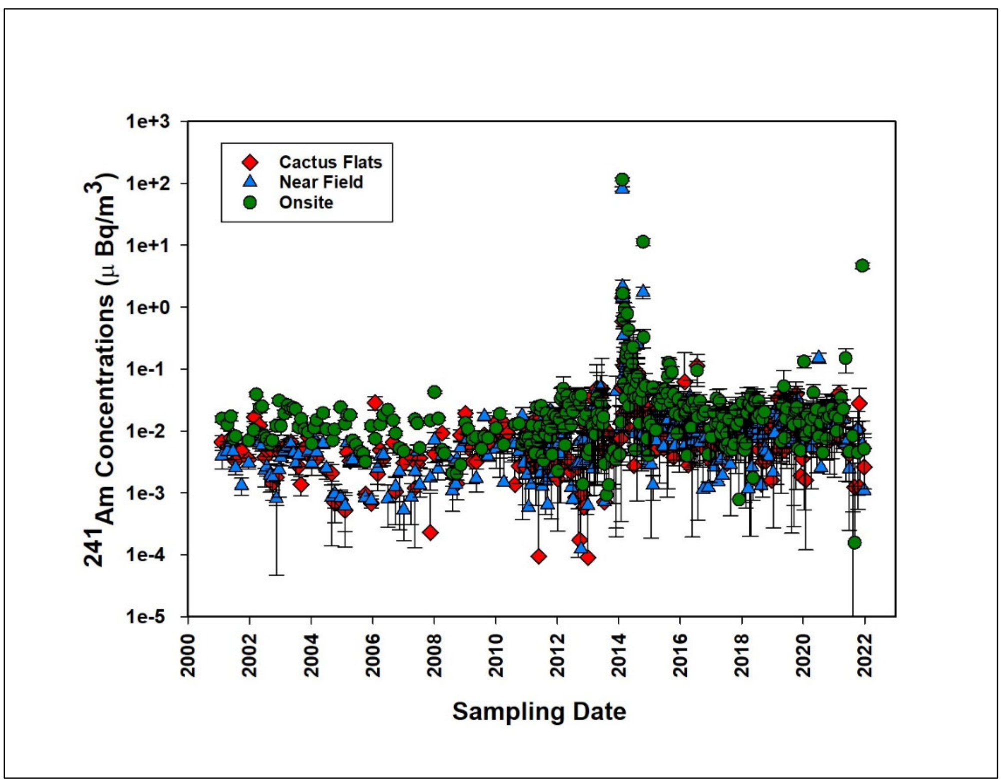


Figure 3.3. Historical ^{241}Am Concentrations at the Cactus Flats, Near Field, and Onsite Stations

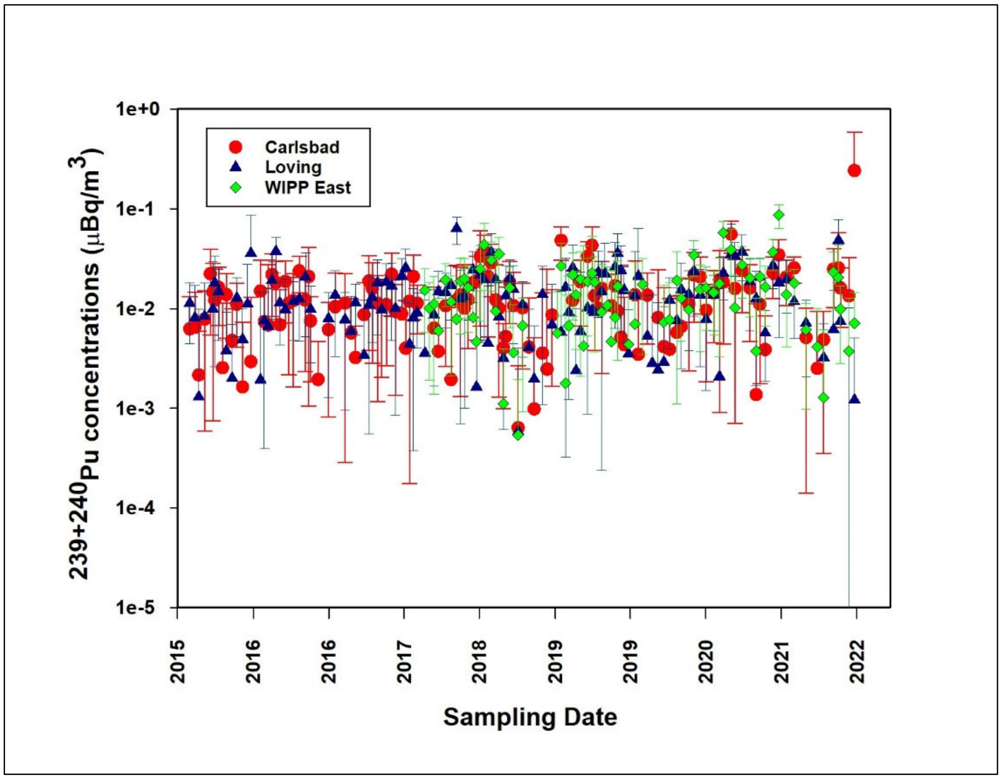


Figure 3.4. Historical $^{239+240}$Pu Concentrations at the Carlsbad, Loving, and WIPP East Stations

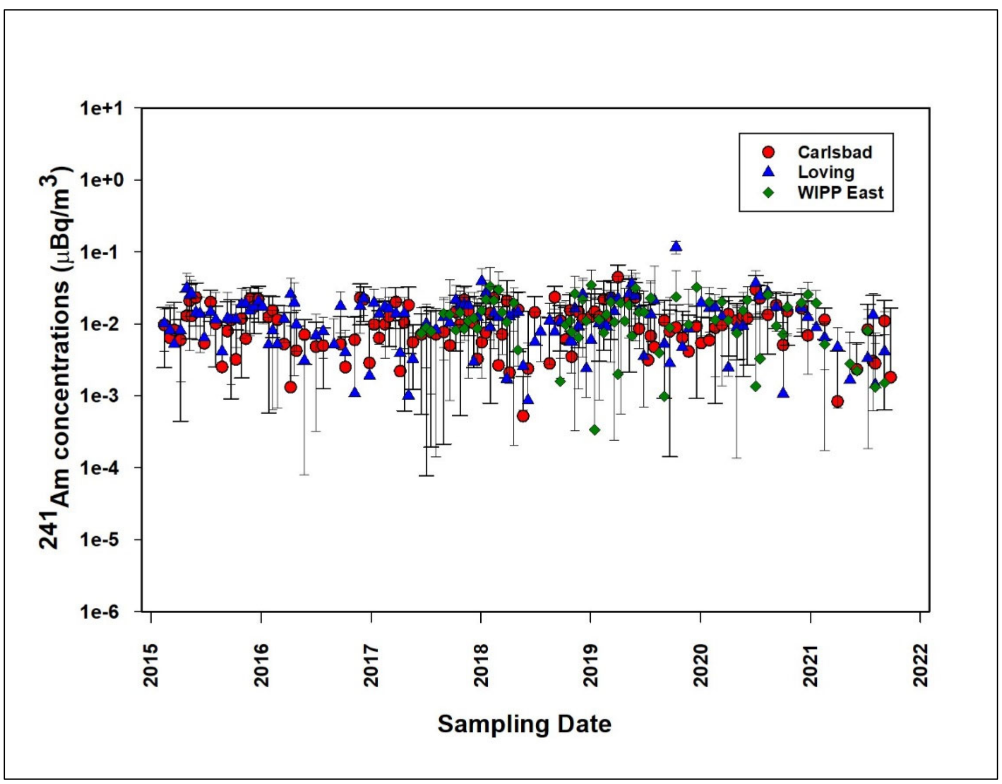
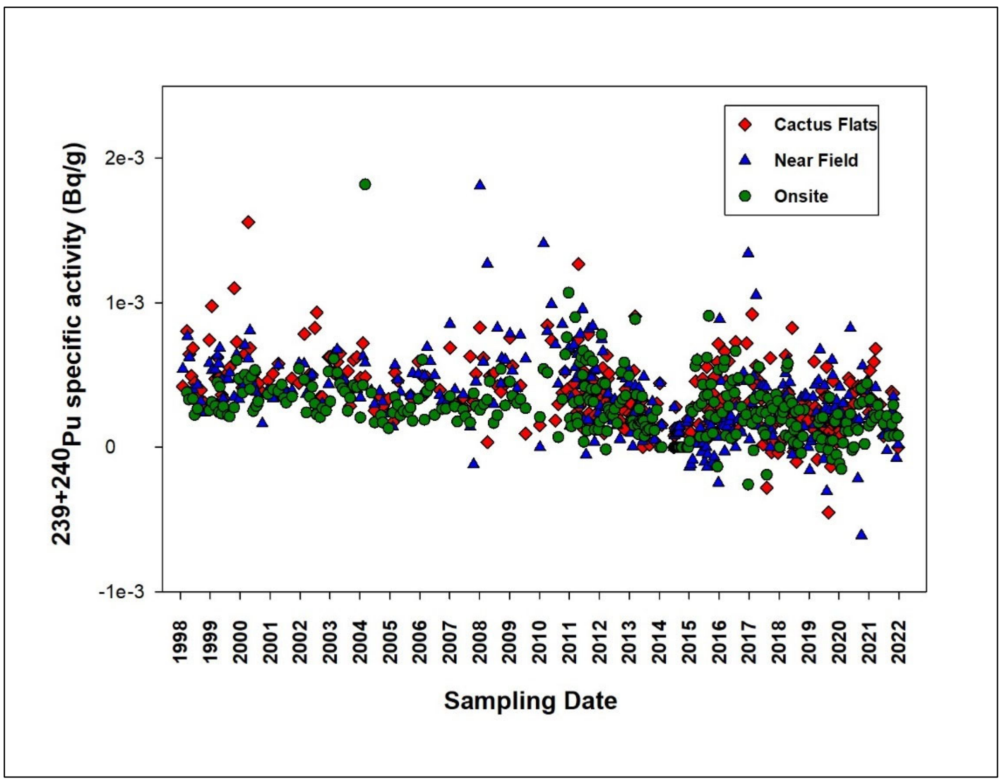


Figure 3.5. Historical ^{241}Am Concentrations at the Carlsbad, Loving, and WIPP East Stations

The $^{239+240}Pu$ specific activity (activity per unit mass aerosol collected) was in the range of 0.08-0.33 mBq/g at the Onsite station, -0.08-0.42 mBq/g at the Near Field station, 0.00-0.68 mBq/g at the Cactus Flats station, -0.07-0.68 mBq/g at the Loving Station, 0.06-0.55 at the Carlsbad station, and 0.03-1.23 mBq/g at the WIPP's East station. The ^{241}Am was in the range of -0.13-66.62 mBq/g at the Onsite station, -0.26-0.34 mBq/g at the Near Field station, -0.14-0.50 mBq/g at the Cactus Flats station, -0.07-0.32 mBq/g at the Loving Station, -0.10-0.36 at the Carlsbad station, and -0.06-0.39 mBq/g at the WIPP's East station. The aerosol mass loadings recorded in these sampling stations were in the range from 0.58-4.73 g at the Onsite, 0.61-3.26 g at the Near Field, 0.61-3.34 g at the Cactus Flats, 0.78-5.63 g at the Loving Station, 0.64-3.25 g at the Carlsbad station, and 0.64-3.44 g at the WIPP's East station. The mass loadings at all stations tend to track one another remarkably well as shown in Figure 3.6 for the Onsite, Near Field, and Cactus Flats monitoring stations and Figure 3.7 for the Carlsbad, Loving, and WIPP east monitoring. The specific activity of $^{239+240}Pu$, ^{241}Am, and ^{238}Pu in ambient air filters during 2021 are listed in Appendix B Tables B.13 to B.15 (Onsite Station), Tables B.16 to B.18 (Near Field Station), Tables B.19 to B.21 (Cactus Flats Station), Tables B.22 (Loving station), Tables B.23 (Carlsbad Station) and Tables B.24 (WIPP's East Tower).



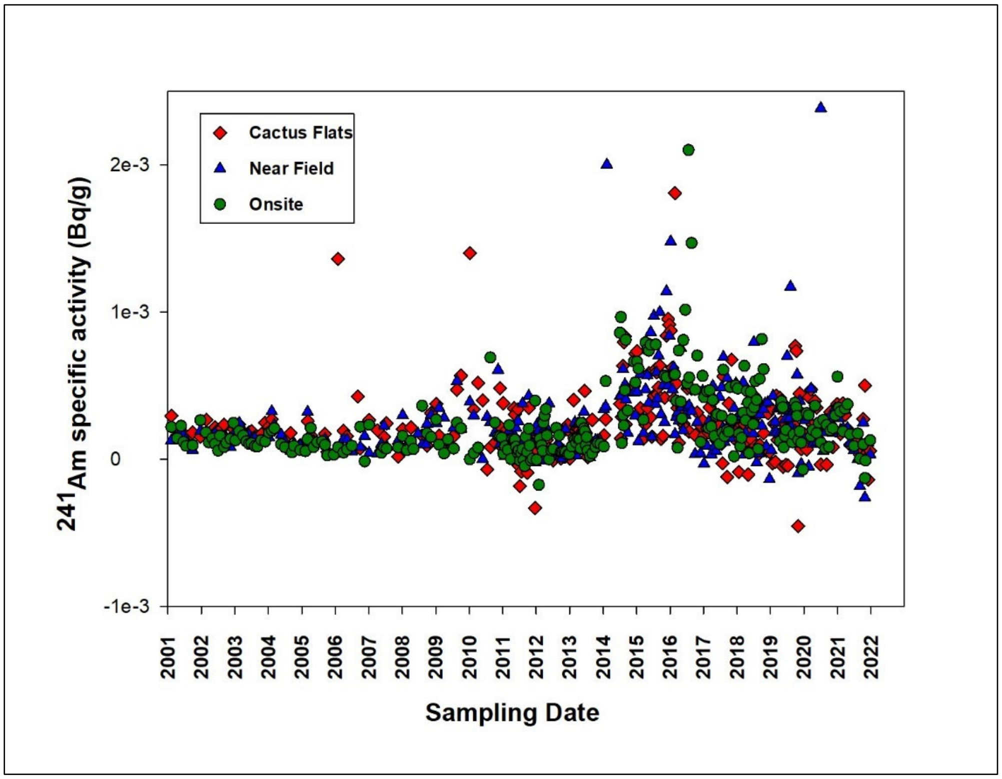
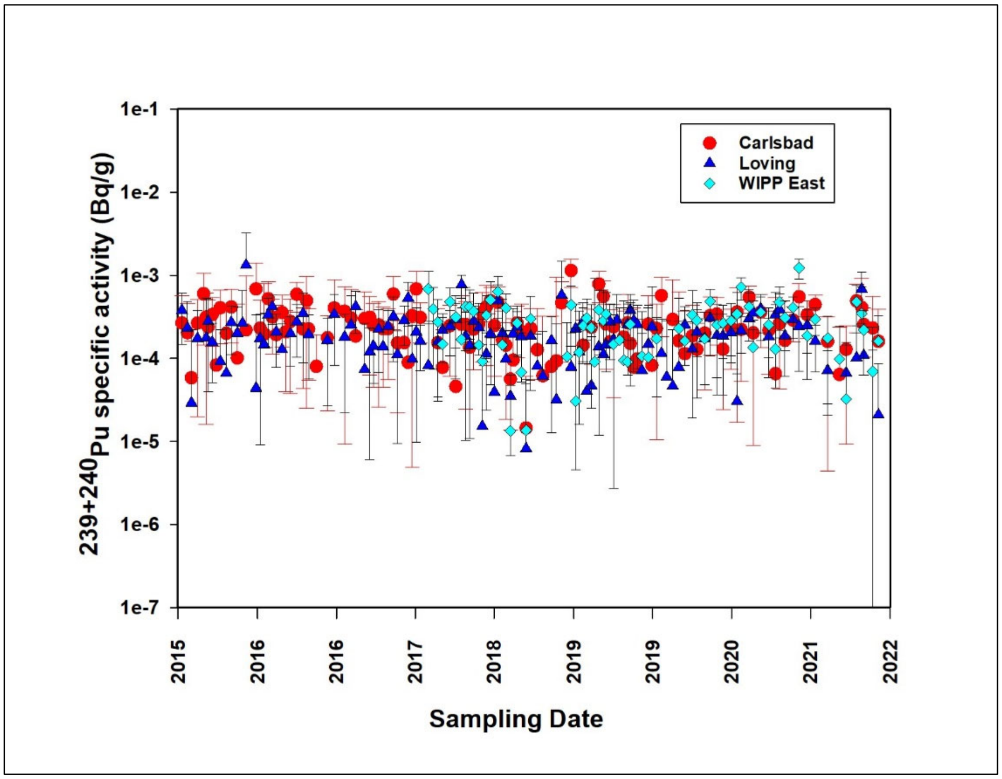


Figure 3.6. Historical $^{239+240}Pu$ (top) and ^{241}Am (bottom) Specific Activities at the Cactus Flats, Near Field, and Onsite Stations



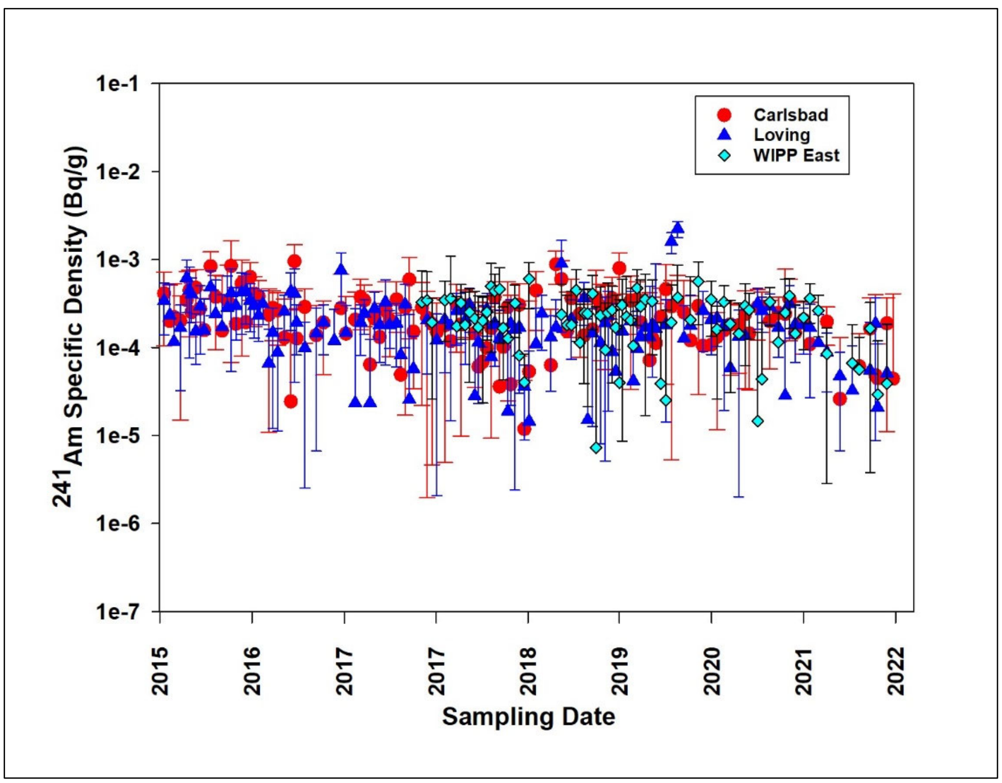
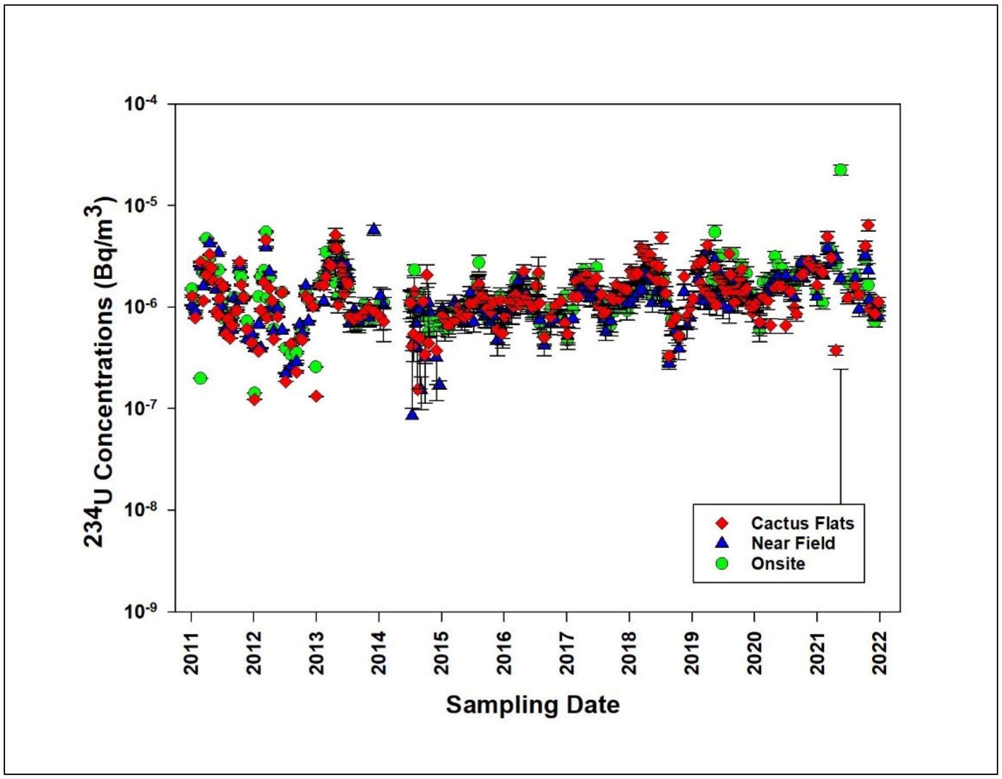


Figure 3.7. Historical $^{239+240}$Pu (top) and ^{241}Am (bottom) Specific Activities at the Carlsbad, Loving, and WIPP East Stations

3.4.2 Uranium Concentrations in Ambient Air

Uranium isotopes were detected in all the samples and at all sampling locations in 2021. Uranium occurs naturally in all rocks and soil with typical background levels ranging from approximately 2 to 4 mg/kg (Ahrens 1965, Wedepohl 1968). Thus, the detection of U in ambient air is normal. Natural sources of U in ambient air include re-suspended soil, volcanic eruptions (ATSDR 1999; Kuroda et al. 1984), and airborne particulates from coal and fuel combustion. The concentrations of uranium isotopes measured in ambient air samples are shown in Figure 3.8 for the Onsite, Near Field, and Cactus Flats stations and Figure 3.9 for the Loving, Carlsbad, and WIPP East Tower.



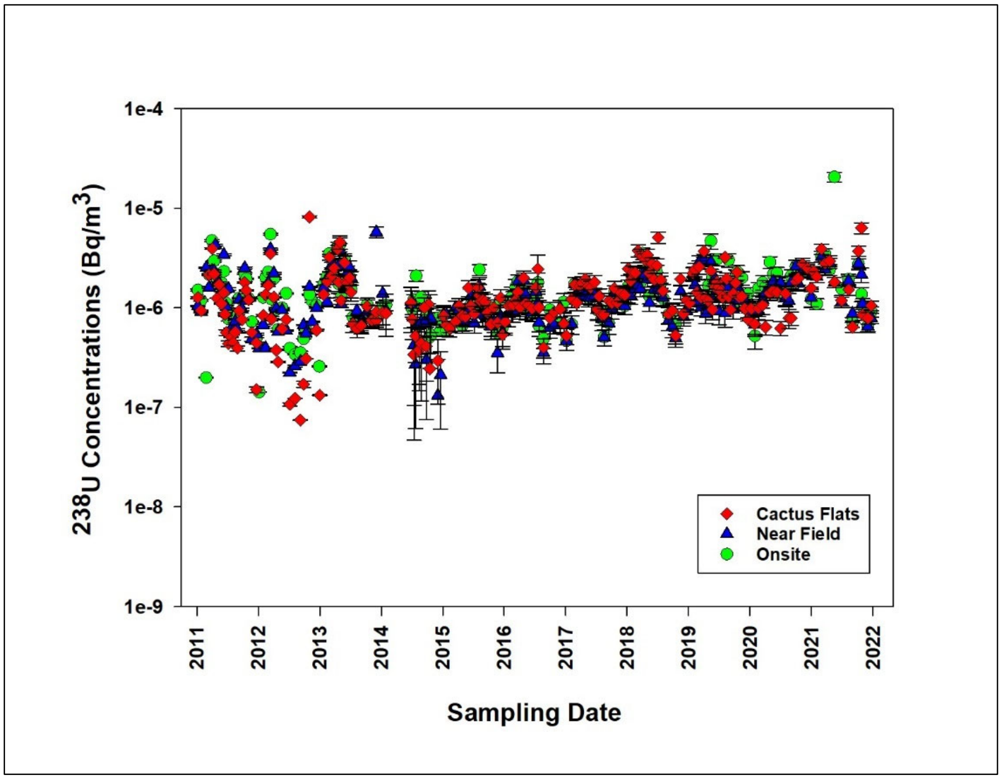
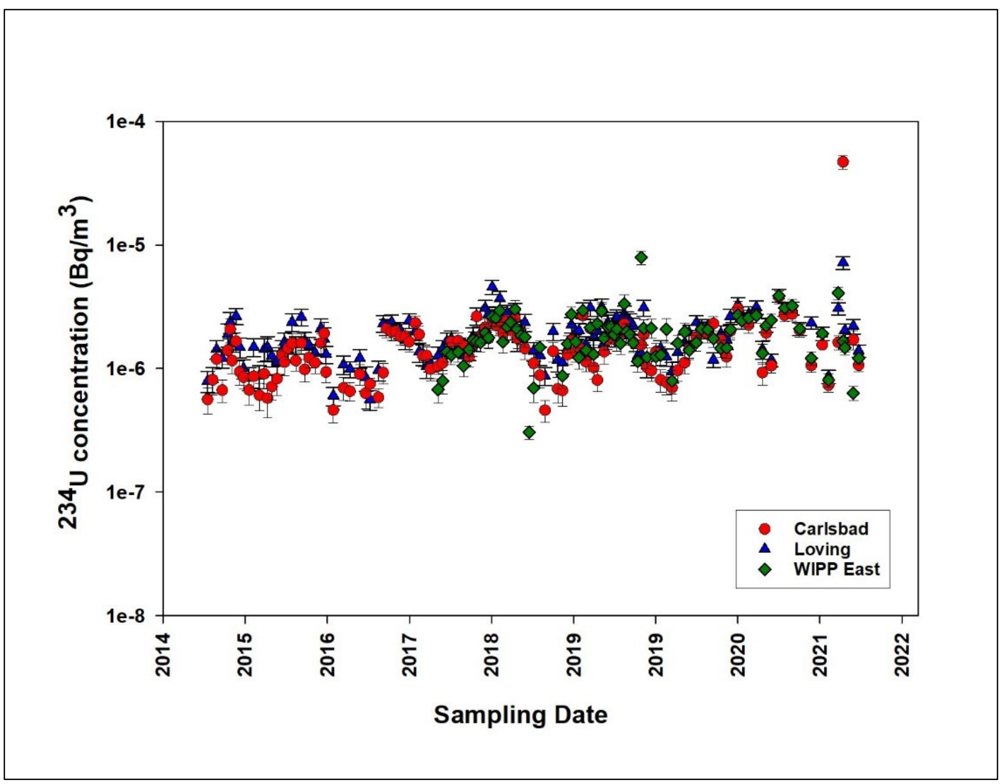


Figure 3.8. ^{234}U (top) and ^{238}U (bottom) Concentrations at the Cactus Flats, Near Field, and Onsite Stations



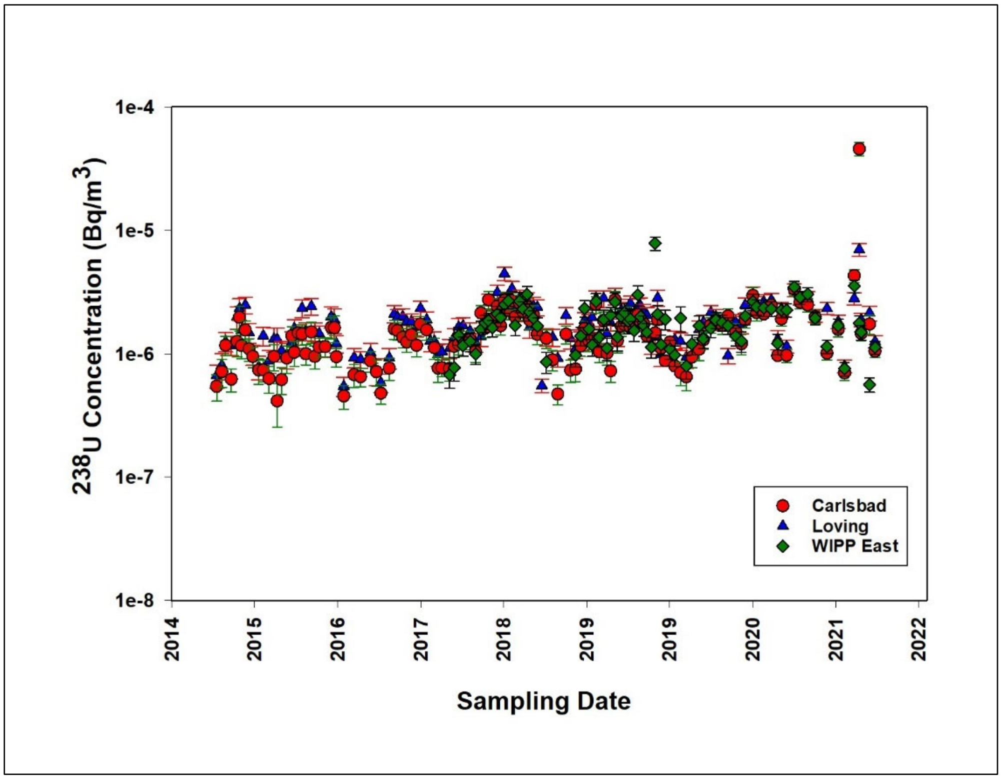


Figure 3.9. ^{234}U and ^{238}U Concentrations at the Carlsbad, Loving, and WIPP East Stations

The concentrations of ^{238}U measured were in the range of 6.63×10^{-7} to 2.06×10^{-5} Bq/m^3 at the Onsite station, 6.52×10^{-7} to 3.27×10^{-6} Bq/m^3 at the Near Field station, 6.41×10^{-7} to 6.35×10^{-6} Bq/m^3 at the Cactus Flats station, 7.94×10^{-7} to 6.98×10^{-6} Bq/m^3 at the Loving station, 6.98×10^{-7} to 4.56×10^{-5} Bq/m^3 at the Carlsbad station, and 5.62×10^{-7} to 3.54×10^{-6} Bq/m^3 at the WIPP's East Tower. The corresponding concentrations of ^{234}U were in the range of 7.25×10^{-7} to 2.25×10^{-5} Bq/m^3 at the Onsite station, 8.22×10^{-7} to 3.83×10^{-6} Bq/m^3 at the Near Field station, 9.47×10^{-9} to 6.40×10^{-6} Bq/m^3 at the Cactus Flats station, 8.63×10^{-7} to 7.18×10^{-6} Bq/m^3 at the Loving station, 7.33×10^{-7} to 4.70×10^{-5} Bq/m^3 at the Carlsbad station, and 6.32×10^{-7} to 4.07×10^{-6} Bq/m^3 at the WIPP's East Tower. There was no significant difference in the concentrations of U isotopes among locations. The individual concentrations of uranium isotopes in ambient air samples are summarized in Appendix B, Tables B.25 through B.30. Uranium ratios are used to determine the type of uranium present in the environment. Natural uranium has a ^{235}U/^{238}U ratio of 0.00725 and ^{234}U/^{238}U ratio of 1.0. The average annual ^{234}U/^{238}U ratios at the sites are consistent with naturally occurring U. The specific activities of U isotopes measured in the ambient air at all the monitoring locations are listed in Appendix B, Tables B.31 through B.36.

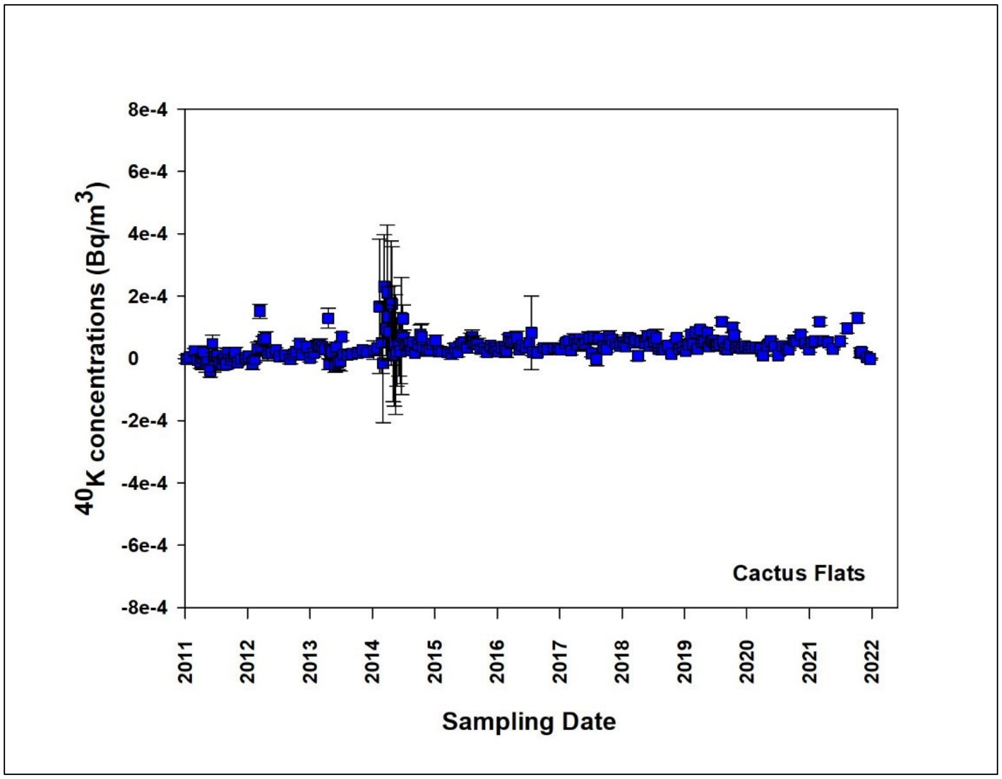
3.4.3 Gamma Radionuclide Concentrations in Ambient Air

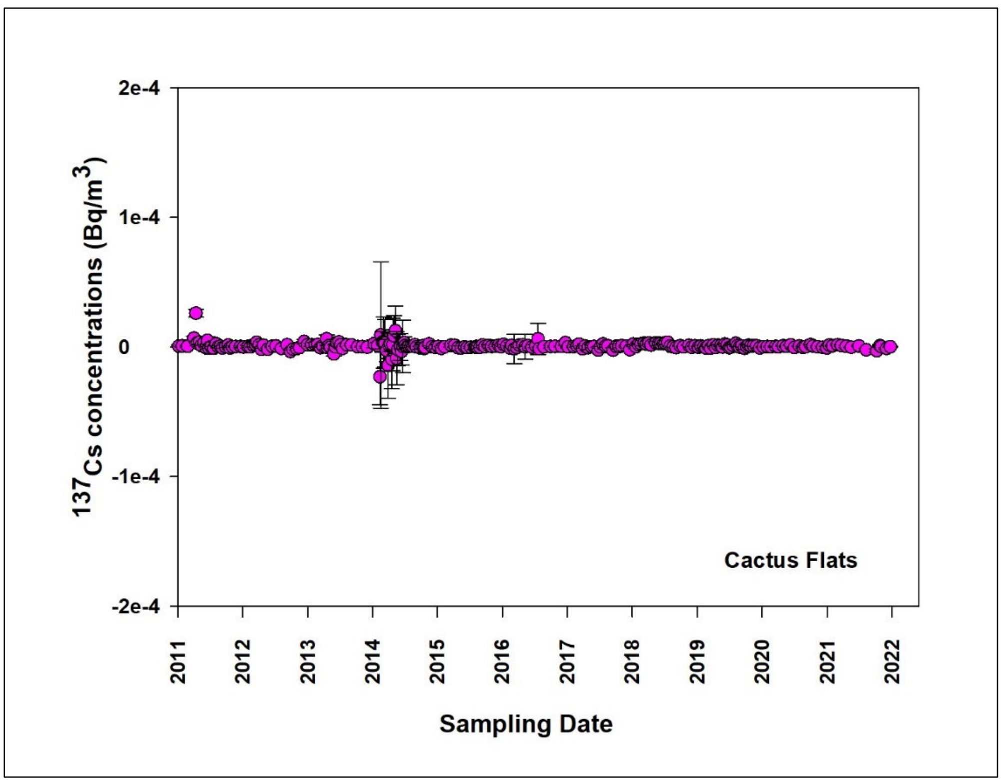
The gamma-emitting radionuclides ^{137}Cs and ^{40}K were detected in most ambient air samples at all monitoring stations, while ^{60}Co was only detected once in an ambient air filter at the Onsite station. The ^{40}K is ubiquitous in the earth's crust and thus would be expected to show up in environmental air samples. On the other hand, ^{137}Cs is a fallout radionuclide and is expected to be detected from time to time in air samples depending on the dust loading on the filters.

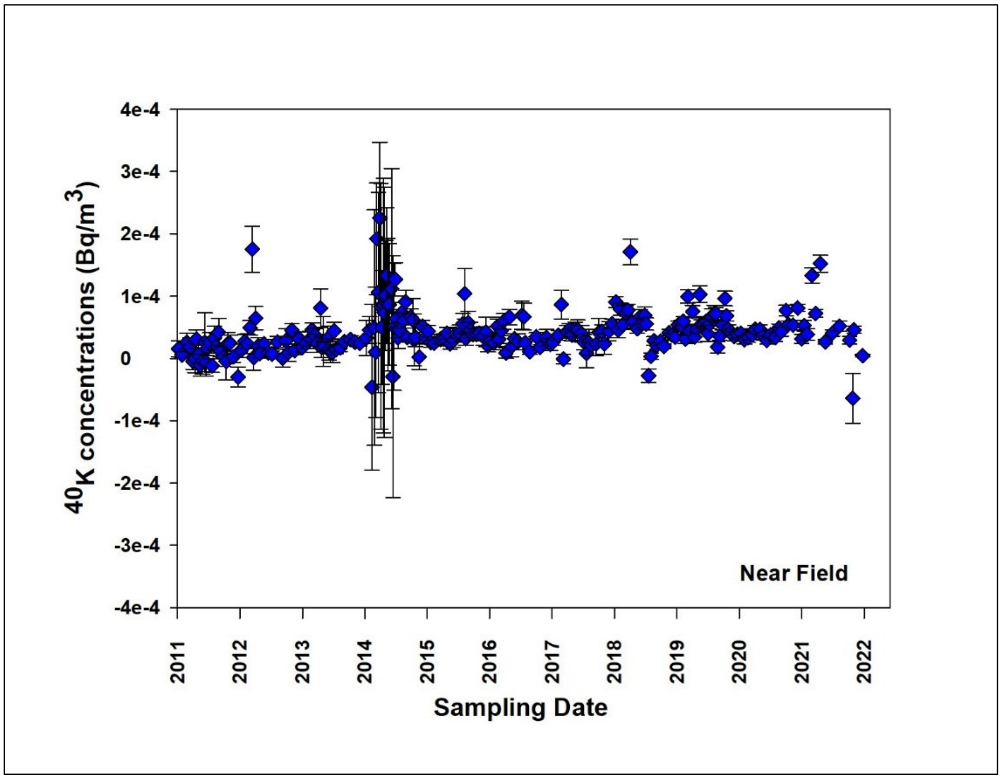
The ^{40}K concentrations measured were in the range of -1.25×10^{-4} to 1.46×10^{-4} Bq/m^3 at the Onsite station, -6.41×10^{-5} to 1.52×10^{-4} Bq/m^3 at the Near Field station, -2.57×10^{-6} to 1.30×10^{-4} Bq/m^3 at the Cactus Flats station, -3.89×10^{-5} to 1.73×10^{-4} Bq/m^3 at the Loving station, 8.44×10^{-6} to 1.58×10^{-4} Bq/m^3 at the Carlsbad station and -3.32×10^{-5} to 1.72×10^{-4} Bq/m^3 at the WIPP's East station. The detection of ^{137}Cs was less frequent than ^{40}K.

The number of ^{137}Cs detections was two at the Near Field station, three at the Carlsbad station, and one each at the Onsite, Cactus Flats, Loving, and WIPP's East stations. The concentrations measured were in the range of -1.66×10^{-6} to 2.48×10^{-6} Bq/m^3 at the Onsite station, -1.62×10^{-6} to 2.48×10^{-6} Bq/m^3 at the Near Field station, -2.83×10^{-6} to 1.71×10^{-6} Bq/m^3 at the Cactus Flats station, -1.66×10^{-6} to 1.50×10^{-6} Bq/m^3 at the Loving station, -1.56×10^{-6} to 5.08×10^{-6} Bq/m^3 at the Carlsbad station, and -2.88×10^{-6} to 4.71×10^{-6} Bq/m^3 at the WIPP's East Tower.

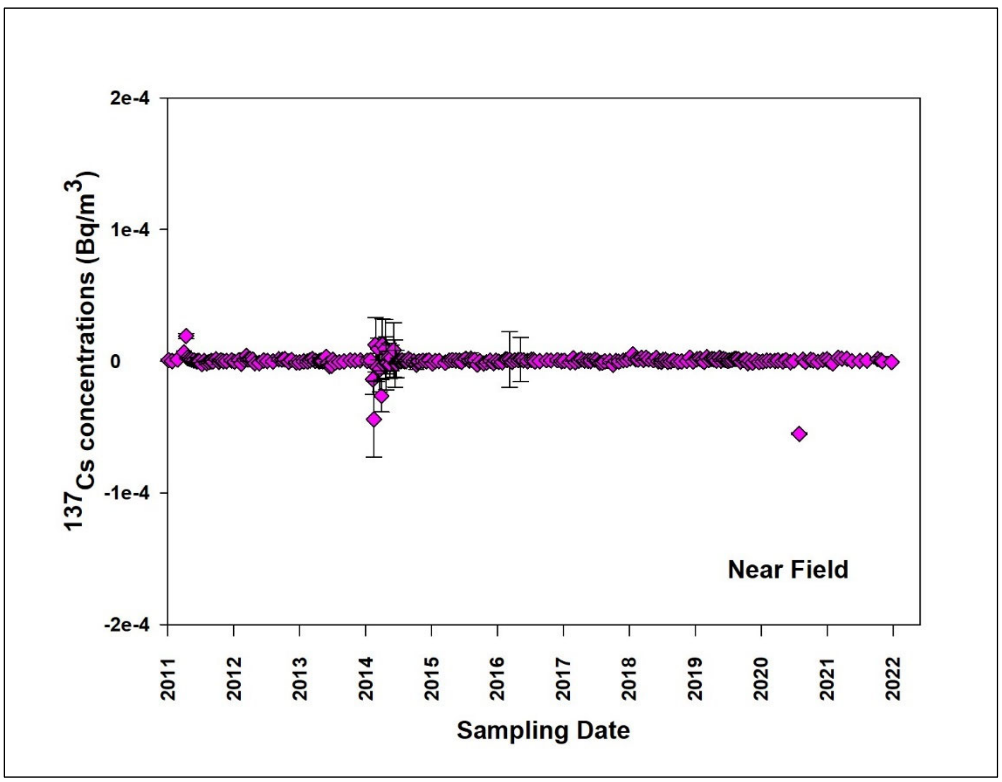
The concentrations of gamma-emitting radionuclides ^{137}Cs and ^{40}K in ambient air samples are shown in Figure 3.10 and Figure 3.11. The individual concentrations measured are shown in Appendix B, Tables B.37 through B.42. There was no significant difference in the concentrations of ^{137}Cs and ^{40}K among locations. Additionally, the analysis of historical operational data shows an occasional detection of ^{137}Cs and ^{40}K in ambient air filters at all locations. The concentrations measured in 2020 were consistent with those measured in previous years.


8e-4
6e-4
4e-4
2e-4
0
-2e-4
-4e-4
-6e-4
-8e-4
40K concentrations (Bq/m3)
Cactus Flats
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Sampling Date

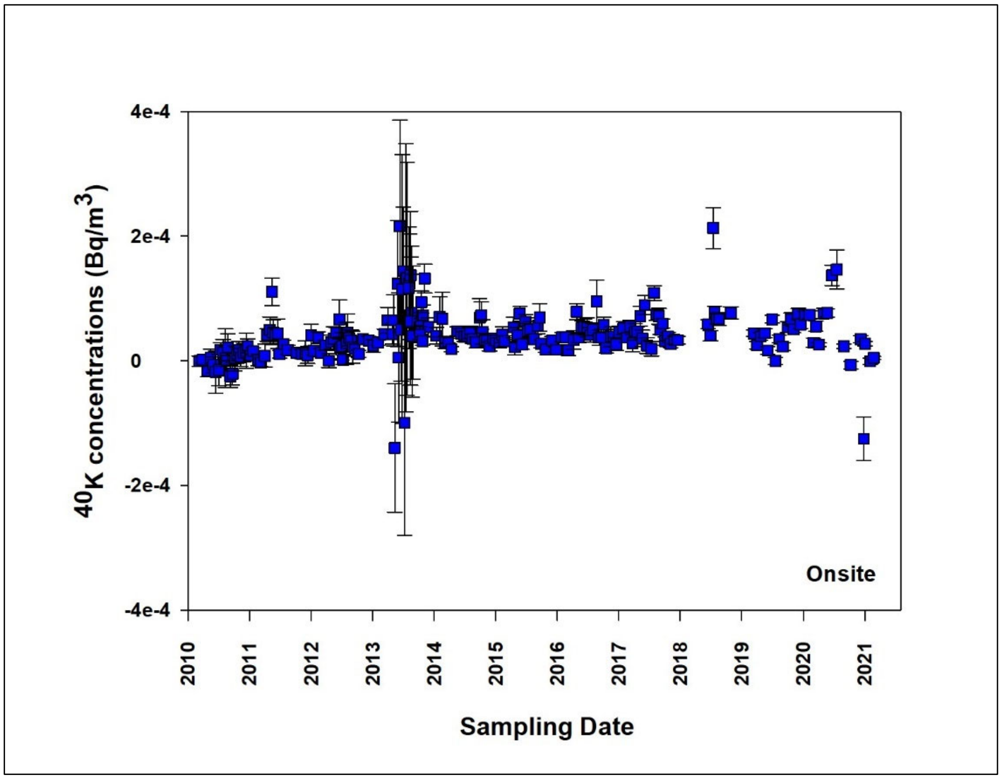

2e-4
1e-4
0
-1e-4
-2e-4
137Cs concentrations (Bq/m3)
Cactus Flats
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Sampling Date



4e-4
3e-4
2e-4
1e-4
0
-1e-4
-2e-4
-3e-4
-4e-4
^{40}K concentrations (Bq/m^3)
Near Field
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Sampling Date



2e-4
1e-4
0
-1e-4
-2e-4
^{137}Cs concentrations (Bq/m^3)
Near Field
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Sampling Date



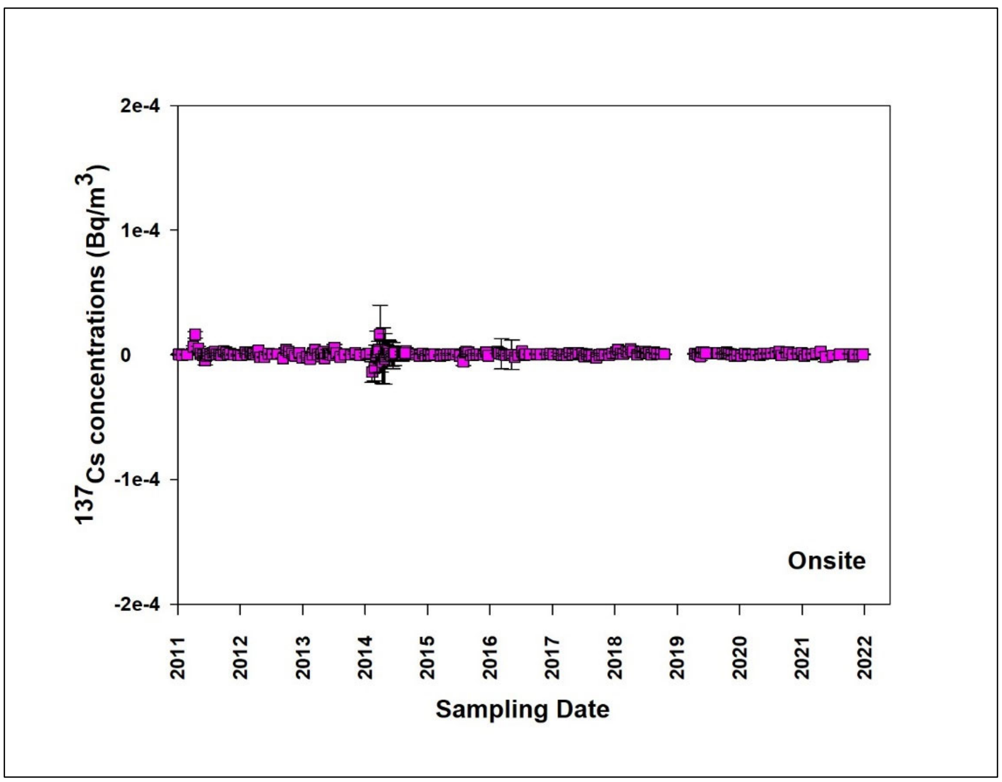
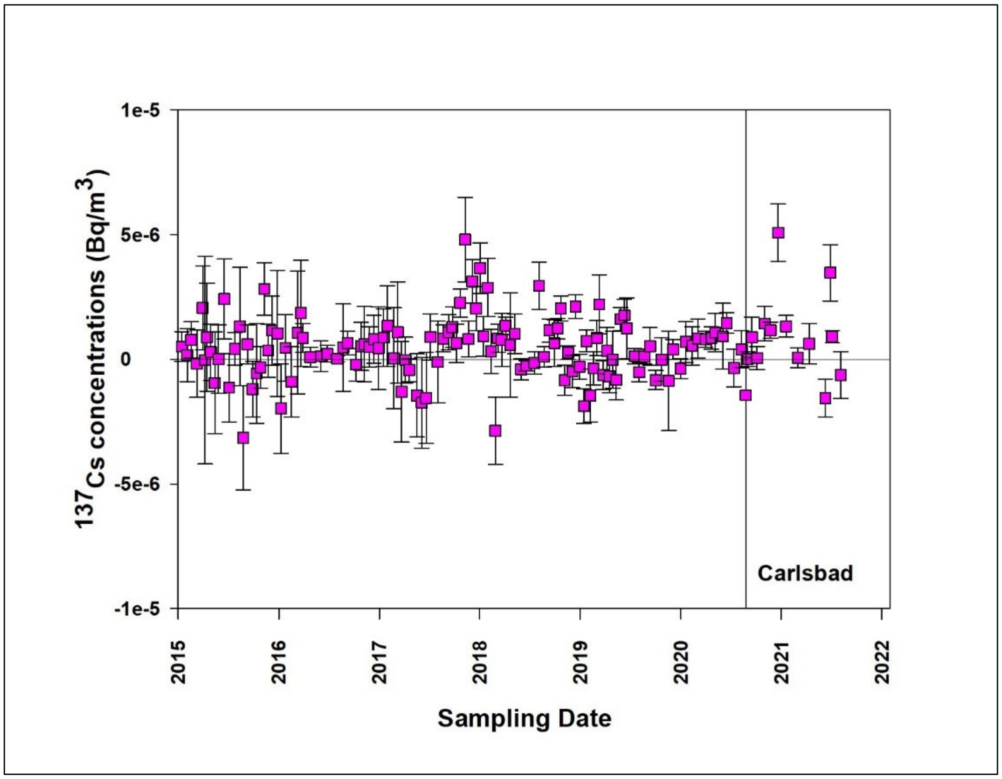
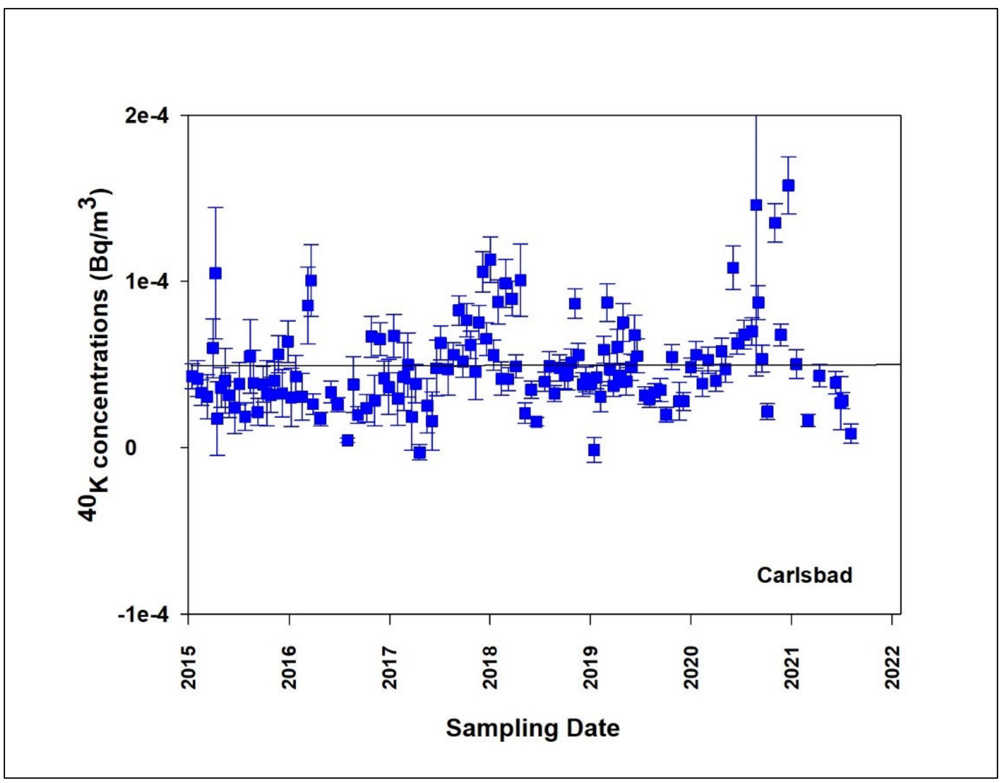
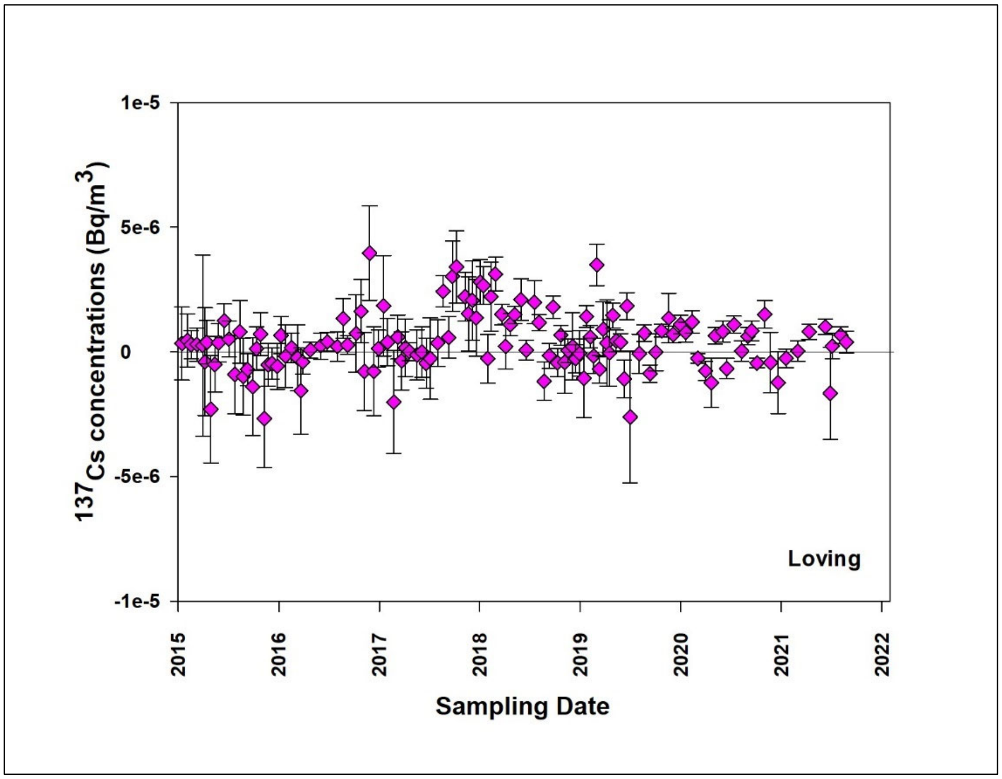


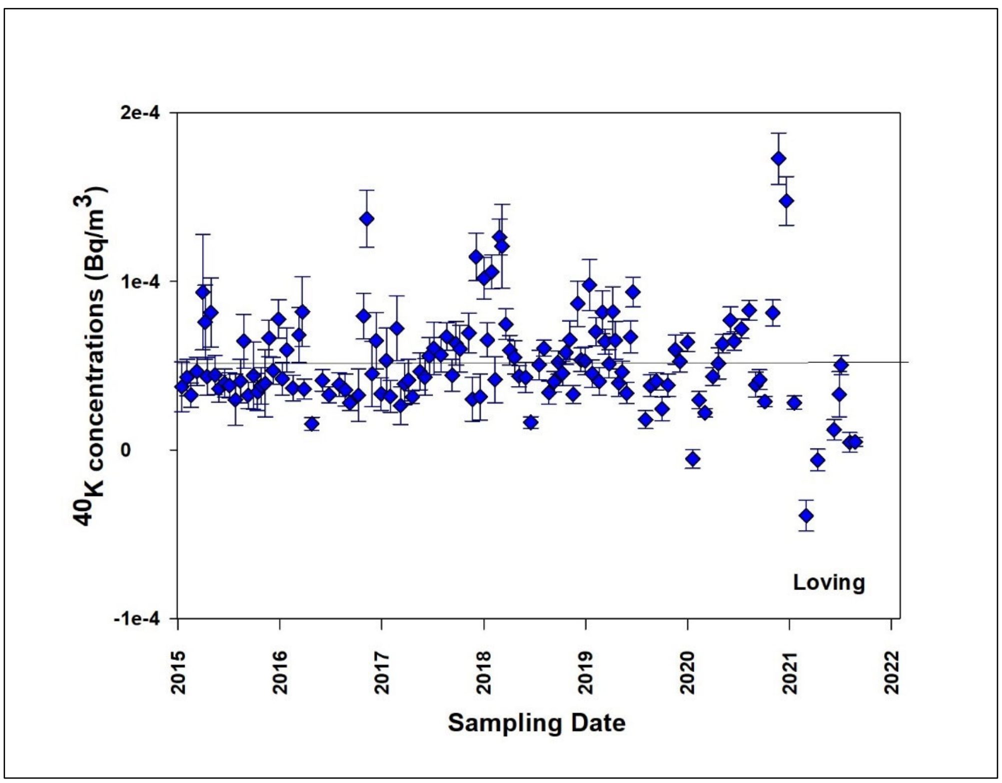
Figure 3.10. Concentrations of ^{137}Cs and ^{40}K at the Cactus Flats (a and b), Near Field (c and d), and Onsite (e and f) Stations


1e-5
5e-6
0
-5e-6
-1e-5
137Cs concentrations (Bq/m3)
Carlsbad
2015
2016
2017
2018
2019
2020
2021
2022
Sampling Date

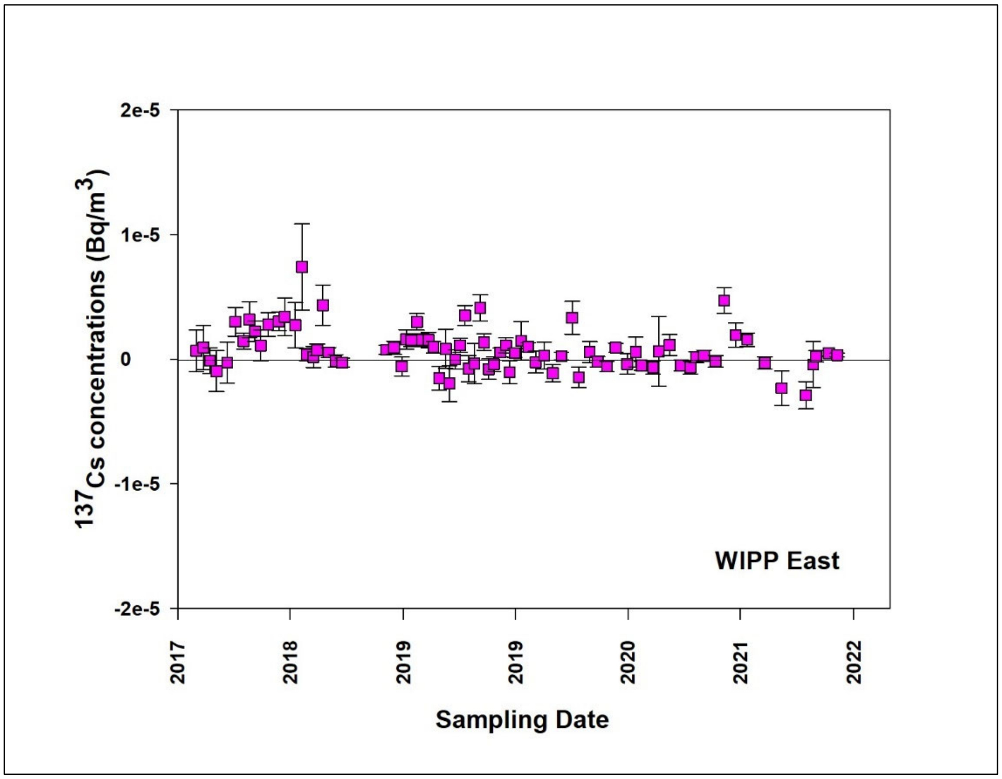

2e-4
1e-4
0
-1e-4
40K concentrations (Bq/m3)
Carlsbad
2015
2016
2017
2018
2019
2020
2021
2022
Sampling Date



1e-5
5e-6
0
-5e-6
-1e-5
^{137}Cs concentrations (Bq/m^3)
Loving
2015
2016
2017
2018
2019
2020
2021
2022
Sampling Date



2e-4
1e-4
0
-1e-4
^{40}K concentrations (Bq/m^3)
Loving
2015
2016
2017
2018
2019
2020
2021
2022
Sampling Date



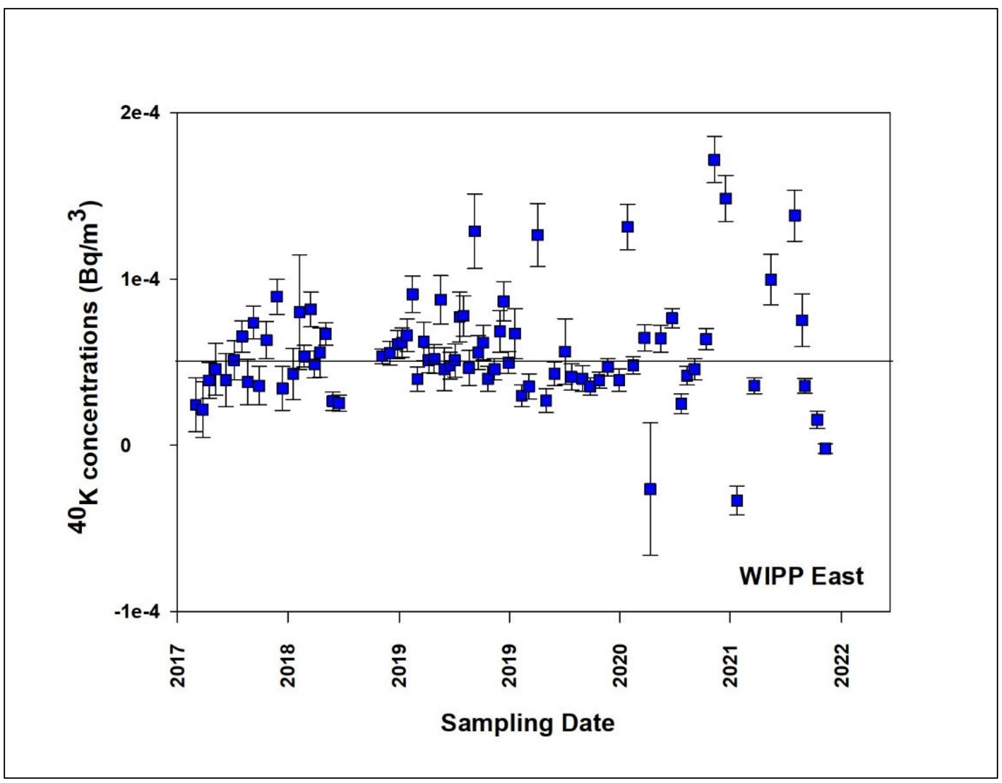


Figure 3.11. Concentrations of ^{137}Cs and ^{40}K Concentrations at the Carlsbad (a and b), Loving (c and d), and WIPP East (e and f) Stations

3.4.4 Strontium Concentrations in Ambient Air

The beta-emitting radionuclide ^{90}Sr was not detected in most of the ambient air samples and at all monitoring stations in 2021. Specifically, the ^{90}Sr radionuclide was detected in the following instances only. In two samples at the Cactus Flats station and one sample each at the Onsite and Near Field stations. The ^{90}Sr concentration at the Onsite station sample was 2.76×10^{-4} Bq/m^3 and the corresponding specific activity (activity per unit mass aerosol collected) was 5.77 Bq/g. The ^{90}Sr concentration of the sample at the Near Field station was 1.54×10^{-4} Bq/m^3 having the corresponding specific activity of 3.28 Bq/g. Finally, the ^{90}Sr concentrations in the two samples at the Cactus Flats station were 1.22×10^{-4} and 1.37×10^{-4} Bq/m^3, respectively. The corresponding ^{90}Sr specific activities were 3.07 and 3.45 Bq/g, respectively.

3.5 Conclusion

The results of the airborne particulate monitoring program for the year 2021 are summarized in this chapter. During this monitoring period, the concentrations of $^{239+240}$Pu and ^{241}Am slightly exceeded the minimum detectable concentration (MDC) and were detected in all the monitoring stations. The concentrations of $^{239+240}$Pu ranged from 0.08 to 0.33 mBq/g at the Onsite station, -0.02 to 0.42 mBq/g at the Near Field station, 0.00 to 0.68 mBq/g at the Cactus Flats station, -0.07 to 0.68 mBq/g at the Loving Station, 0.06 to 0.55 mBq/g at the Carlsbad station, and 0.03 to 1.23 mBq/g at the WIPP's East station.

Similarly, the corresponding concentrations of ^{241}Am ranged from -0.13 to 66.62 mBq/g at the Onsite station, -0.26 to 0.34 mBq/g at the Near Field station, -0.14 to 0.50 mBq/g at the Cactus Flats station, -0.07 to 0.32 mBq/g at the Loving Station, -0.10 to 0.36 mBq/g at the Carlsbad station, and -0.06 to 0.39 mBq/g at the WIPP's east station. The aerosol mass loadings recorded at these sampling stations ranged from 0.58 to 4.73 g at the Onsite, 0.61 to 3.26 g at the Near Field, 0.61 to 3.34 g at the Cactus Flats, 0.78 to 5.63 g at the Loving Station, 0.64 to 3.25 g at the Carlsbad station, and 0.64 to 3.44 g at the WIPP's East station. These levels are consistent with the measurements obtained in previous years.

As expected, uranium isotopes were detected at all the sampling locations. The highest concentration of uranium was observed at the Loving location, with levels of 3.28×10^{-6} Bq/m^3 for ^{238}U and 3.90×10^{-6} Bq/m^3 for ^{234}U. In a few ambient air samples from all monitoring stations, gamma-emitting radionuclides such as ^{137}Cs, ^{60}Co, and ^{40}K were also detected. It is important to note that ^{40}K is naturally present in the Earth's crust, so its presence in environmental air samples is expected. On the other hand^{137}Cs is a fallout radionuclide and its detection in air samples depends on the amount of dust on the filters.

Based on historical ambient air data from WIPP, it is evident that, except for the 2014 release event, the presence and levels of Pu and Am in the environment surrounding the WIPP area are primarily a result of soil particle resuspension, which is contaminated due to weapons fallout. There is no evidence indicating an increase in radionuclide activity concentrations in the region that can be attributed to releases from the WIPP. Finally, the ^{90}Sr radionuclide was only detected once at the Onsite and Near Field stations and twice at the Cactus Flats stations.

CHAPTER 4 - SOIL MONITORING

Soil is a weathered material composed of disintegrated rock and organic material that sustains growing plants. Soil can contain pollutants released directly to the ground, to the air, or through liquid effluents. The U.S. Department of Energy's (DOE) guidance for environmental monitoring states that the soil is sampled to determine the long-term build-up of radionuclides in the terrestrial environment and estimate environmental radionuclide inventories (U.S. DOE 1991).

Soil monitoring is of interest to the CEMRC environmental monitoring program because air borne releases of contaminants from within the repository could eventually be deposited into surface soils. The pollutants can be a source for continuing contaminant exposure and uptake via direct contact, food chain pathways, and re-suspension. Additionally, a soil monitoring program also offers the most direct means of determining the concentrations (activities), distribution, and long-term trends of radionuclides and chemicals present around nuclear facilities. The source of transuranic radionuclides in the soil surrounding the WIPP are mostly from global fallout as a result of nuclear weapons testing, a release at the Gnome site located near the WIPP facility, and the regional fallout from the above-ground nuclear weapons testing at the Nevada Test Site (NTS) or Nevada National Security Site (NNSS) as it is known today. Each of these sources has characteristic radionuclide signatures or abundances that can, in principle, be used to identify their presence in the soils and to estimate their concentrations.

CEMRC has been conducting surface soil monitoring near the WIPP site since 1998. The purpose was to independently establish baseline data of various anthropogenic radionuclides present in the WIPP soil before operations began. These data are compared with the disposal phase data to assess any increase in radioactivity that might have resulted from WIPP operations. The current scope of work requires soil samples to be collected annually at the two locations on the previously established grid (Near Field and Cactus Flats). Individual samples are then analyzed to determine radionuclides of concern. Details of the sample collection and analyses are described in the following sections.

4.1 Sample Collection

Soil samples were collected from the Cactus Flats site, specifically the C and D grids around the WIPP site. Soil samples at the depth of 0-2 cm were collected at random short distances and orientations from both locations. The sampling location of soil is shown in Figure 4.1. Individual sampling sites were selected on the basis of relatively flat topography, minimum surface erosion, and minimum surface disturbance by human or livestock activity. Approximately 4 L of soil were collected from within a 50×50 cm area for radionuclide analyses. As shown in Figure 4.1, soil samples were excavated using a trowel and placed in plastic bags for transport and storage. Sampling equipment was cleaned between samples. Samples were sieved through a 2 mm mesh screen to remove rocks, roots, and other large material. The soil samples were then oven dried to 105 ˚C and ground using a shatter box grinder to a fine analytical powder.

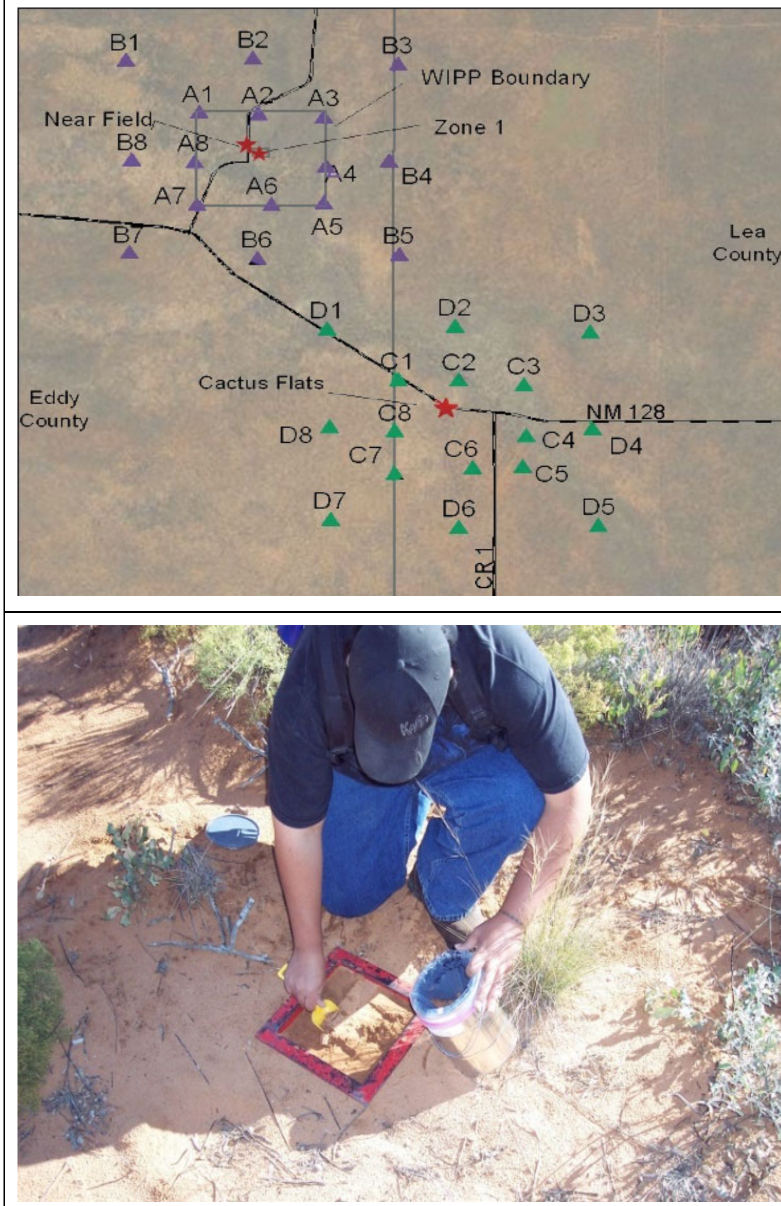


Figure 4.1. Soil Sampling Locations (top) and Collection (bottom)

4.2 Sample Preparation and Analysis

Soil samples were dried at 110 °C and blended before sampling. The samples for gamma radiation analysis were sealed in a 300 mL paint can and stored for at least 21 days to allow radon progeny to reach equilibrium with parent radionuclides before counting. Dried and sieved soil samples were counted for 48 h in a high purity germanium detector, HpGe (Mirion Technologies). The counting containers held approximately 500 g of soil.

For actinide analyses, 4-5 g of sample were heated in a muffle furnace at 500 °C for at least 6 hours to combust organic material. Each sample was then spiked with a radioactive tracer and digested in a Teflon beaker with hydrochloric, nitric, and hydrofluoric acids. Sea sand was used as a matrix for Laboratory Control Standard (LCS) and reagent blank. To remove hydrofluoric acid, the sample residues were heated with perchloric acid and boric acids. Finally, the residues were dissolved in nitric acid for processing the individual radionuclide concentrations.

4.3 Radiochemical Analysis

The actinides were then separated as a group by co-precipitation on ferric hydroxide, $Fe(OH)_3$. Plutonium was separated from americium and uranium using an anion exchange column, while uranium was separated from americium on a TRU chromatography column. After separation, plutonium and uranium fractions were purified on a second anion exchange column and the americium subsequently purified from lanthanides on TEVA. Finally, Pu, Am, and U were micro co-precipitated on stainless steel planchettes for alpha spectrometry (Mirion Technologies) and counted for five days per CEMRC's standard counting protocol. Portions of digested solutions containing strontium were co-precipitated with barium as a carbonate, then dissolved in nitric acid and barium precipitated out as chromate. The supernatants obtained were mixed with ammonium hydroxide (NH_4OH) and saturated ammonium carbonate $(NH_4)_2CO_3$ to precipitate strontium as strontium carbonate ($SrCO_3$), and the beta-radiation-emitting radioactive isotope ^{90}Sr was then counted by liquid scintillation counting. Details are described in procedure WL-1011.

4.4 Results and Discussion

The activities of the actinides and gamma radionuclides in the soil samples are reported as activity concentrations in Bq/kg. The activity concentration is calculated as the activity of radionuclides reported in Becquerel (Bq) divided by the mass of the soil in kilograms (kg).

4.4.1 Actinide Concentrations in WIPP Soil

The individual concentrations of ^{241}Am, $^{239+240}$Pu, and ^{238}Pu in the soil samples collected from the Cactus Flats are presented in Figure 4.2, Figure 4.3, and Figure 4.4. The $^{239+240}$Pu concentrations ranged from 0.033 to 0.29 Bq/kg, with a mean value of 0.16 Bq/kg, while that for ^{241}Am ranged from 0.013 to 0.20 Bq/kg, with a mean value of 0.083 Bq/kg.

The ^{238}Pu was not detected in any of the soil samples except one site with 0.22 Bq/kg. The concentrations of these nuclides are comparable to our historical data recorded for these areas prior to the arrival of TRU wastes in the WIPP and are typical of "background soil concentrations." Historical plots of $^{239+240}$Pu, ^{238}Pu, and ^{241}Am concentrations in soil in the vicinity of the WIPP site are shown in Figure 4.2, Figure 4.3, and Figure 4.4.

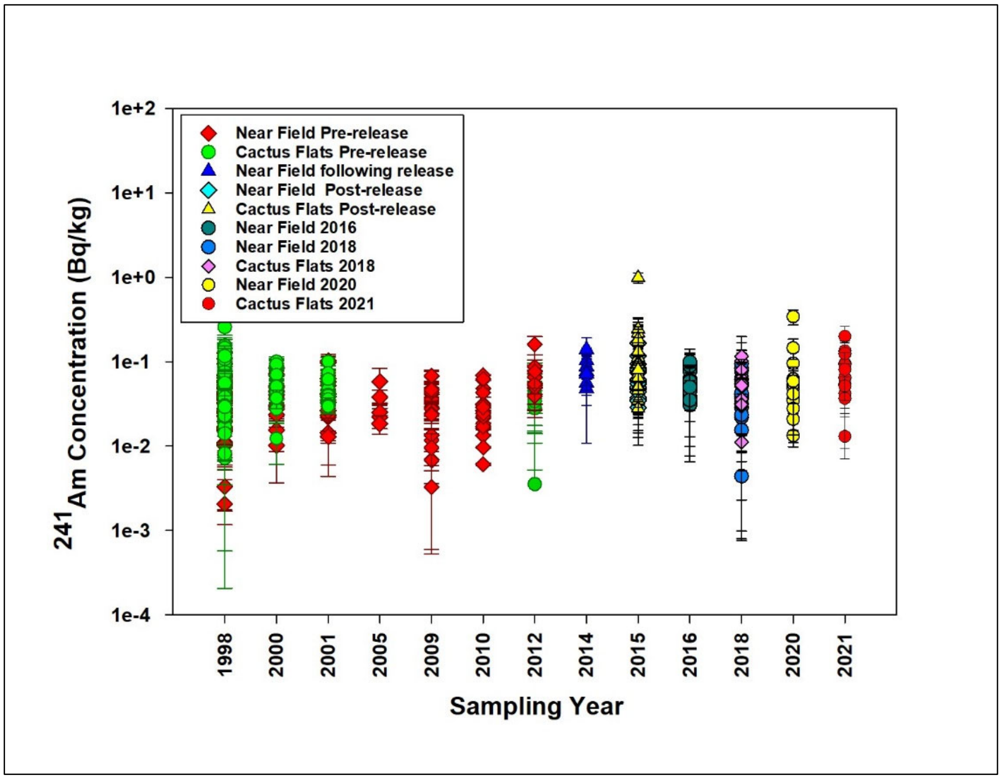


Figure 4.2. Historical Concentrations of ^{241}Am in WIPP Soil

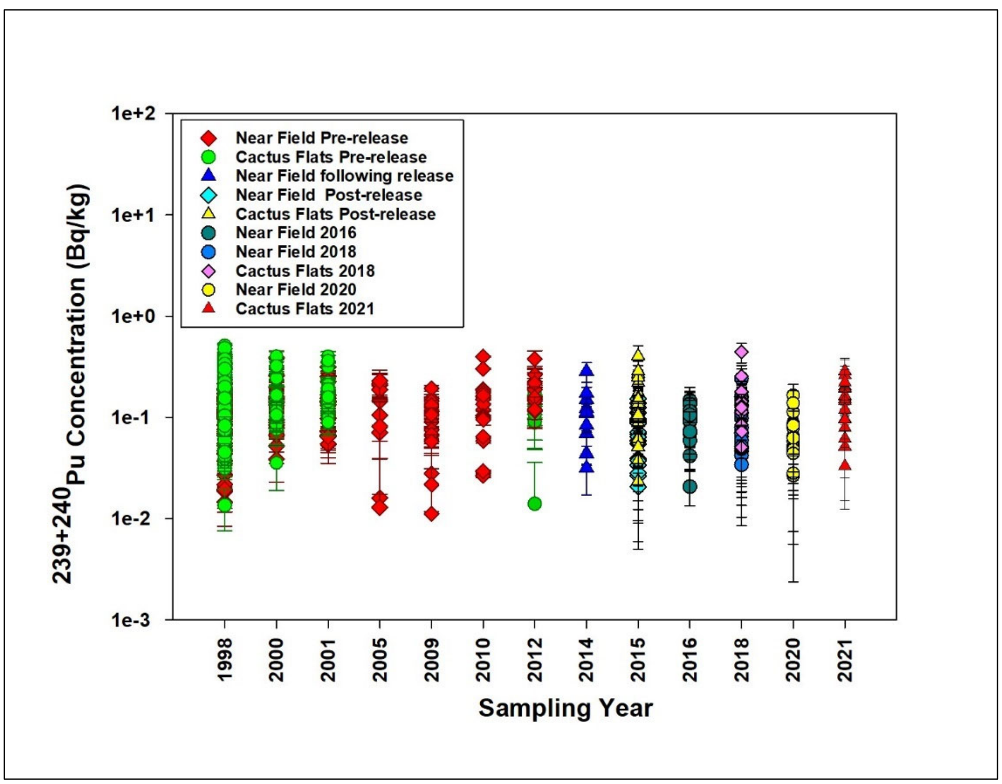


Figure 4.3. Historical Concentrations of $^{239+240}$Pu in WIPP Soil

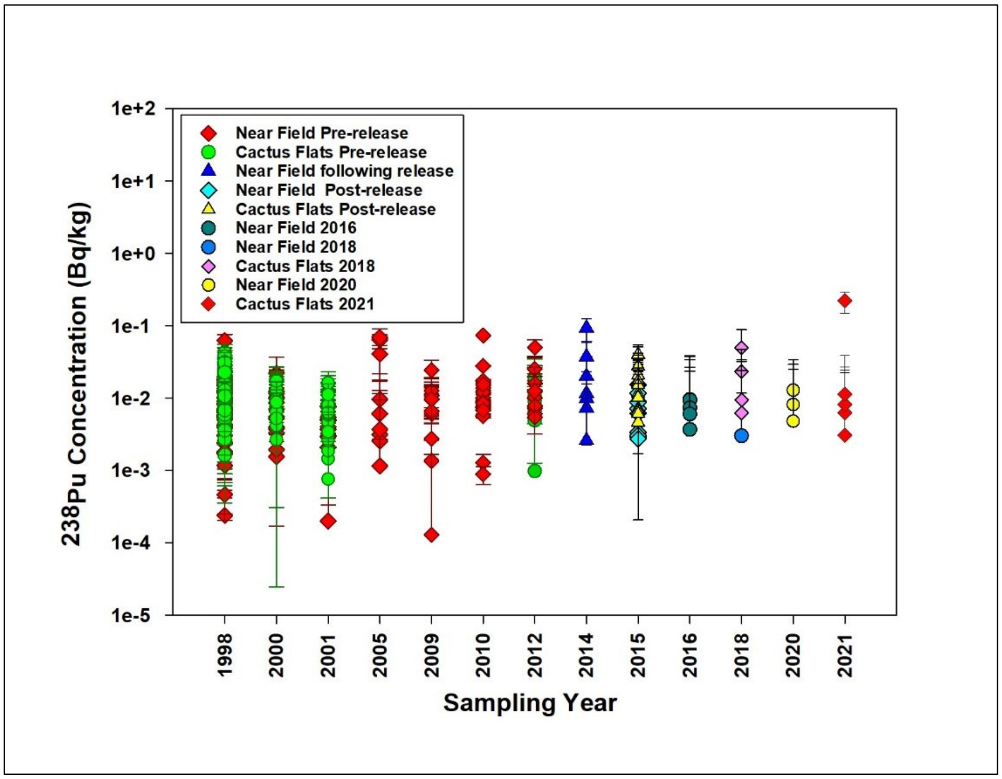
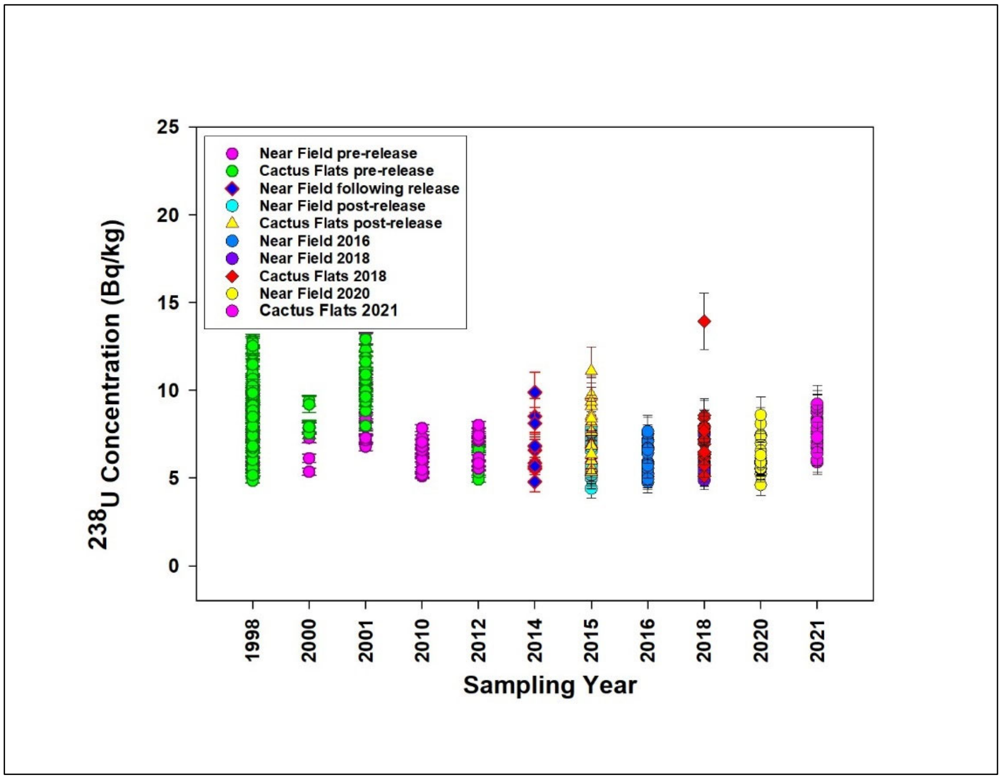


Figure 4.4. Historical Concentrations of ^{238}Pu in WIPP Soil

4.4.2 Uranium Concentrations in WIPP Soil

The naturally occurring isotopes of U were detected in all soil samples. The uranium concentrations data for individual soil samples are shown in Figure 4.5. The ^{234}U concentrations in the Cactus Flats ranged from 5.54-9.08 Bq/kg, with a mean value of 7.41 Bq/kg, while that for ^{238}U ranged from 5.91-9.21 Bq/kg, with a mean value of 7.65 Bq/kg. These values are consistent with the values measured previously from the Cactus Flats. Figure 4.5 shows the historical concentrations of ^{234}U and ^{238}U in WIPP soil since 1998. The uranium concentration in soil varies widely but typically contains about 74 Bq/kg (3 ppm). The calculated $^{234}U/^{238}U$ activity ratio in the vicinity of WIPP soil varied between 0.93 to 1.01 with an average value of 0.97±0.03 for the Cactus Flats soils. Figure 4.6 shows the variation in the $^{234}U/^{238}U$ ratio in the soil samples collected from the Near Field and Cactus Flats grids during 2015-2021. The $^{234}U/^{238}U$ activity ratio obtained indicated that these two uranium isotopes are in the state of secular radioactive equilibrium.



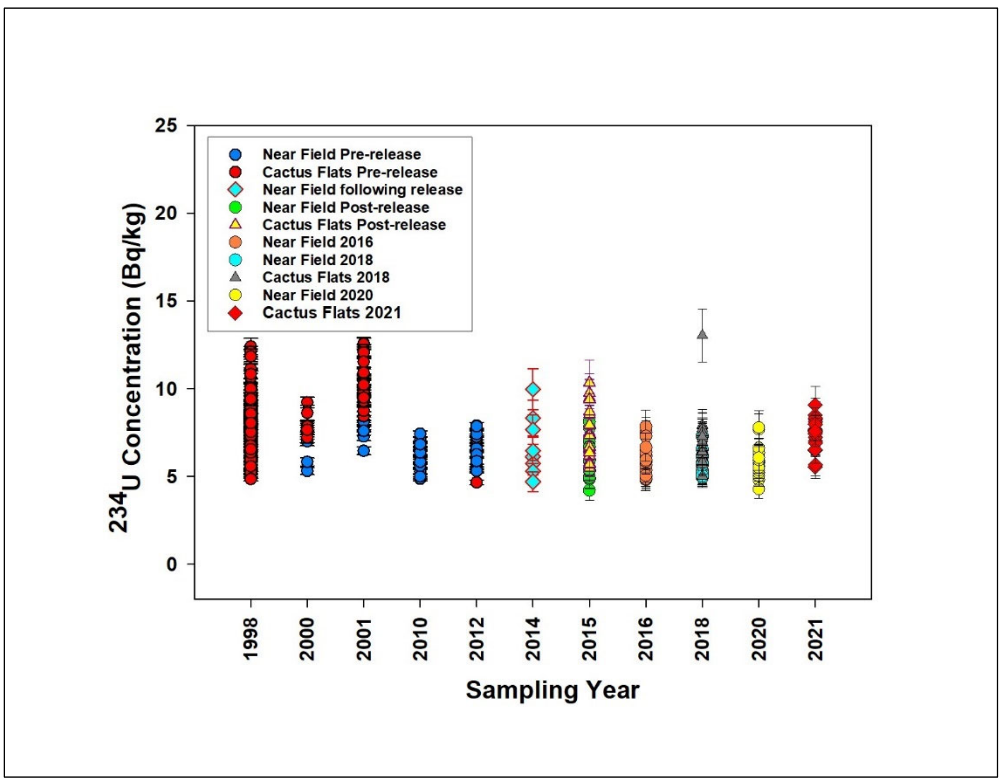
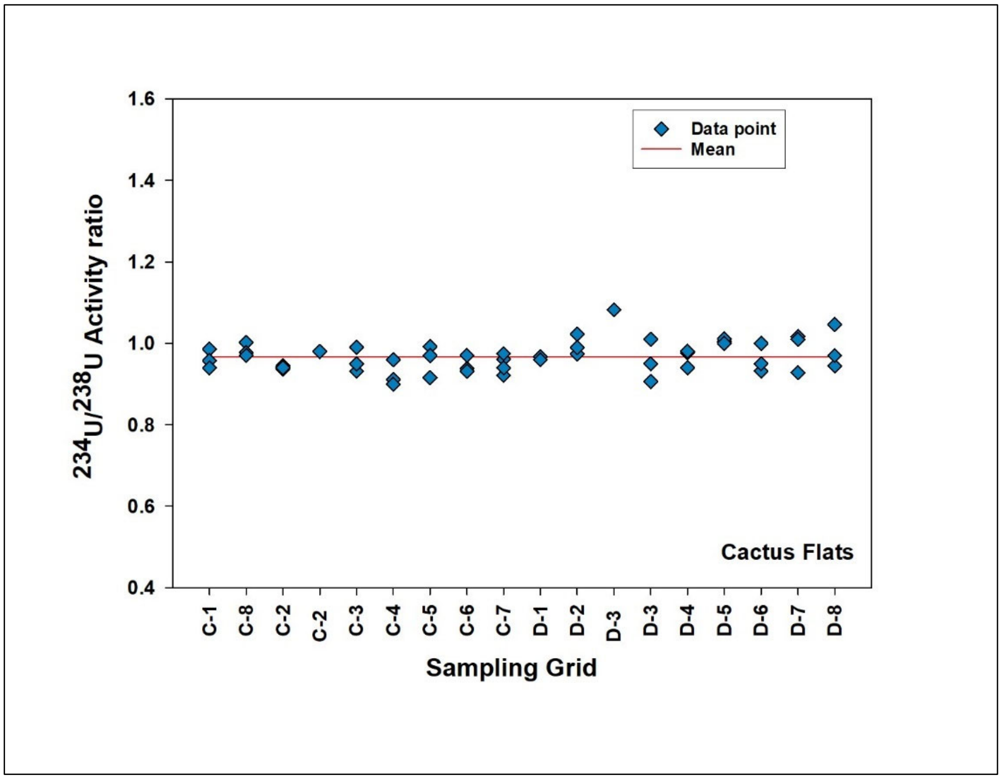


Figure 4.5. Historical Concentrations of ^{238}U and ^{234}U in WIPP Soil



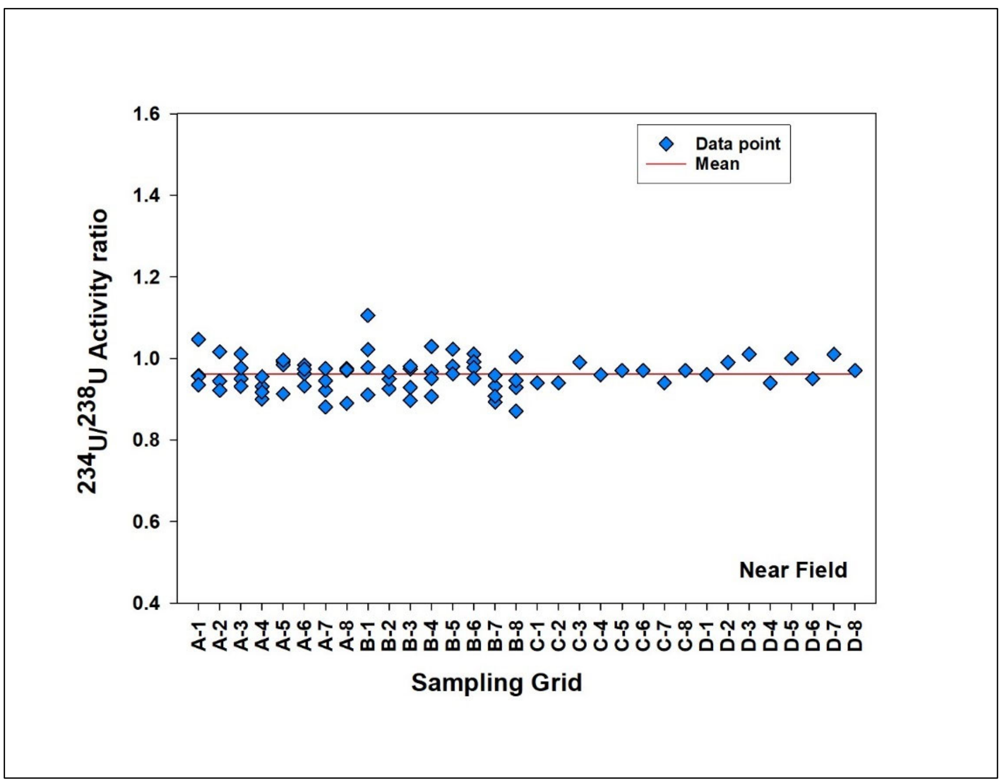
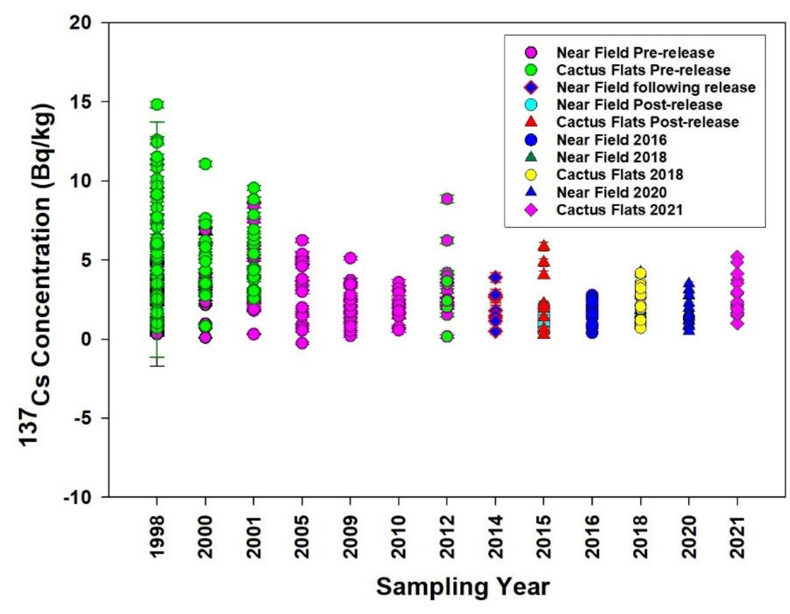


Figure 4.6. The $^{234}U/^{238}U$ Activity ratio in WIPP Soil during 2015- 2018

4.4.3 Gamma Radionuclide Concentrations in WIPP Soil

The concentrations of gamma radionuclides in the WIPP soil are presented in Table C.3 (Appendix C). The ^{137}Cs and ^{40}K were detected in all soil samples. The concentration of ^{137}Cs in the Cactus Flats soil ranged from 0.99 to 5.21 Bq/kg, with a mean value of 2.75 Bq/kg. Variability among the ^{137}Cs concentrations was not very significant. Although ^{137}Cs is a fission product, it is ubiquitous in soils because of global fallout from atmospheric weapons testing (Beck and Bennett, 2002 and UNSCEAR, 2000). The ^{40}K concentrations in the Cactus Flats soil ranged from 127-273 Bq/kg, with a mean value of 215 Bq/kg. Like, ^{137}Cs, ^{40}K is a naturally occurring gamma-emitting radionuclide and is ubiquitous in soils. There was no significant difference between concentrations of ^{137}Cs and ^{40}K among sampling locations, and the values fell within the range of concentrations previously observed in WIPP soils.

The ^{60}Co radionuclide was not detected at any sampling locations. Historical plots of ^{40}K and ^{137}Cs concentrations in WIPP soil are shown in Figure 4.7. The concentrations have remained relatively constant over the past 10+ years and generally indicate worldwide fallout. Some degree of variability is always associated with collecting and analyzing environmental samples; therefore, variations in sample concentrations from year to year are expected.



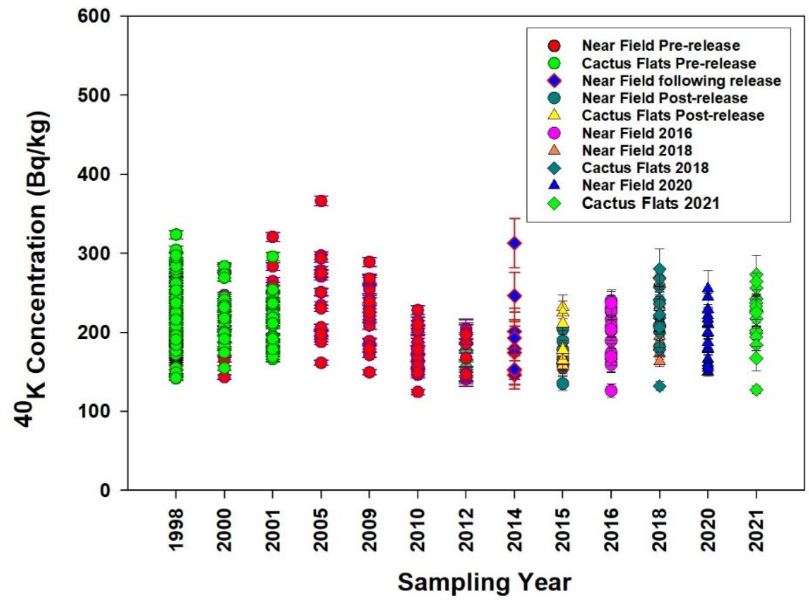


Figure 4.7. Historical Concentrations of ^{137}Cs and ^{40}K in WIPP Soil

4.4.4 Strontium Concentrations in WIPP Soil

The beta radiation emitting ^{90}Sr radionuclide was not detected in most Cactus Flats soil samples in 2021. In the four samples were ^{90}Sr concentrations were detected, the concentrations were 801, 482, 445, and 397 Bq/kg, respectively.

4.5 Conclusion

This chapter summarizes the results of the soil-monitoring program for the calendar year 2021. The $^{239+240}$Pu and ^{241}Am concentrations in the Cactus Flats ranged from 0.033 to 0.29 Bq/kg and 0.013 to 0.20 Bq/kg, respectively. Isotopes of uranium were also detected in all soil samples with ^{234}U/^{238}U ratio close to unity (1.0) at both these locations, indicating these two uranium isotopes are in secular equilibrium.

Gamma emitting radionuclides ^{137}Cs and ^{40}K were detected in all soil samples. The radionuclide concentrations in the Cactus Flats location ranged from 0.99 to 5.21 Bq/kg for ^{137}Cs and 127-273 Bq/kg for ^{40}K. The ^{90}Sr radionuclide was detected in four samples from Cactus Flats at concentrations varying between 397 and 801 Bq/kg. Furthermore, there is no apparent difference between the concentrations of the radionuclides in soil collected before and after WIPP started receiving TRU waste. The monitoring results indicate no evidence of an increase in soil radionuclide concentrations that can be attributed to the recent radiation release event at the WIPP or the normal operations of the WIPP.

CHAPTER 5 - SURFACE WATER MONITORING

The term "surface water" refers to water found in watercourses, lakes, or wetlands, including water that has naturally precipitated or risen to the surface from underground sources (groundwater). Examples of surface water include rivers, lakes, streams, ponds, wetlands, and oceans. The retention of radionuclide fallout by catchment soils, as well as sediments in rivers and lakes, plays a significant role in determining the subsequent transport of radioactive substances in aquatic systems. In the case of rivers and small lakes, radioactive contamination primarily arises from the erosion of surface soil layers within the watershed, which then run off into the water bodies. Additionally, deposition of radioactive materials can also occur on water surfaces. The fraction of a radionuclide that adsorbs to suspended particles, which can vary considerably in surface waters, strongly influences both its transport and bioaccumulation.

Routine collection and analysis of surface water samples have been carried out in the vicinity of the WIPP site since the inception of WIPP's environmental monitoring program to assess any potential impacts of WIPP operations on the aquatic environment. The current monitoring efforts require annual collection of surface water samples from three regional reservoirs located along the Pecos River, situated at a considerable distance from the WIPP site. These reservoirs include Brantley Lake, approximately 55 km (34 miles) north-northwest of the WIPP site; Red Bluff Lake on the Pecos River, with the upstream end located approximately 48 km (30 miles) southwest of the WIPP site; and Lake Carlsbad, situated in the center of Carlsbad, approximately 40 km (25 miles) northwest of the WIPP site. The Pecos River is the primary surface water body in the vicinity of the WIPP site and is used for various recreational activities, such as fishing, boating, water skiing, and swimming. In addition to these large bodies of water, samples are also collected from three small tanks that are used by livestock. These tanks might vary from year to year. Radiological analyses are conducted to quantify gamma-emitting radionuclides and actinides of concern. Further details regarding sample collection and analyses are described in subsequent sections. This chapter presents the results of radiological analyses conducted on surface water samples collected in 2021.

5.1 Sample Collection

Surface water samples were collected from the three public water reservoirs in the area, Lake Carlsbad, Brantley Lake, and Red Bluff Lake as shown in Figure 5.1. At each sampling location, one sample was collected from the surface (~ 0.5 to 1 m depth) and a second sample from approximately 0.5 to 1 m above the sediment bed. In addition, water samples were collected from three tanks that are used as sources of water for livestock, namely Hill, Noya, and Lost Tanks. Surface water from each sampling location was collected in 5-gallon plastic water bottle jugs. Water from each sampling location was used to rinse containers at least three times prior to taking the sample. Approximately 8 L of surface water was collected from each location as shown in Figure 5.2.

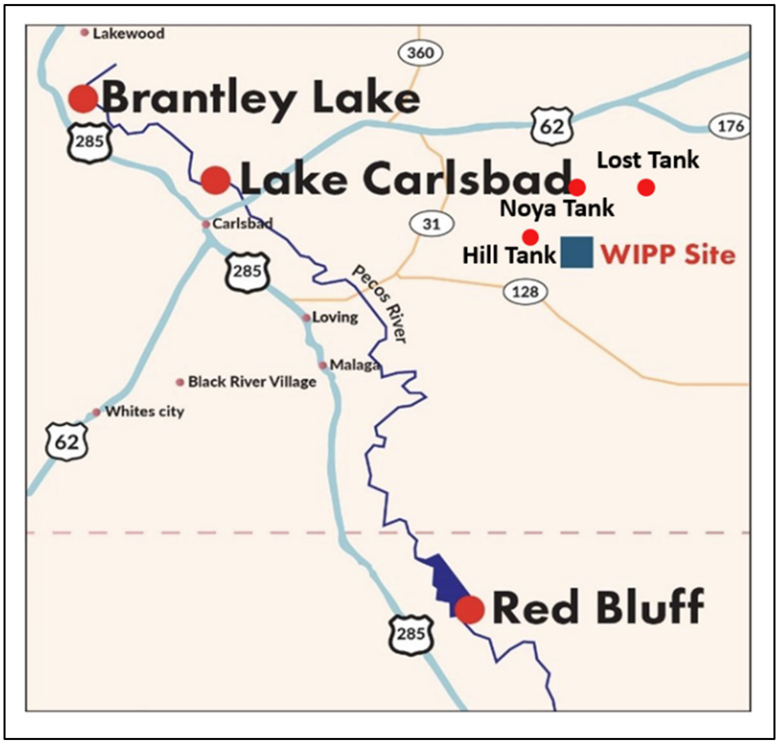


Figure 5.1. Surface Water Sampling Locations in the Vicinity of the WIPP Site

Figure 5.2. Surface Water Sample Collection from the Brantley Lake by CEMRC Personnel

5.2 Sample Preparation and Analysis

In the laboratory, surface water samples collected for radiological analyses were acidified with nitric acid (HNO_3) to a pH < 2 and the sample containers were shaken to distribute suspended material evenly. One 2 L portion was used for gamma spectroscopy and another 1 L portion was used for sequential analysis of the uranium/transuranic isotopes.

5.3 Determination of Individual Radionuclides

The first aliquot was transferred to 2 L Marinelli beakers for the measurement of the gamma-emitting radionuclides potassium (^{40}K), cobalt (^{60}Co), and cesium (^{137}Cs) by gamma spectroscopy using a high purity germanium (HPGe) detector. Before collecting the measurements, the gamma system was calibrated for energy and efficiency to enable both qualitative and quantitative analysis of the water samples. The energy and efficiency calibrations were carried out using a mixed standards material from Eckert & Ziegler Analytics Inc (Atlanta, GA) in the energy range between 60 to 2000 keV for a 2 L Marinelli geometry. The counting time for each sample was 48 hours.

The second, 1 L aliquot, was used for actinide analyses. Tracers consisting of uranium, americium, and plutonium (^{232}U, ^{243}Am, and ^{242}Pu) were added to the samples and the samples were digested using concentrated nitric acid and 30% hydrogen peroxide (H_2O_2) on a hot plate until sample volume was reduced to 100-150 mL. The actinides are separated as a group by co-precipitation on ferric hydroxide, $Fe(OH)_3$. The oxidation state of plutonium was adjusted by adding 1 mL of 1.0M ammonium iodide (NH_4I) with a 10 min wait step, followed by 2 mL of 2 M sodium nitrite ($NaNO_2$). Plutonium isotopes were then separated and purified using a two-column anion exchange resin (Dowex 1-× 8, 100-200 mesh), while TRU chromatography columns were used for the separation of Am and U. The samples were then micro-co-precipitated using an Nd-carrier and counted on the alpha spectrometer for 5-days.

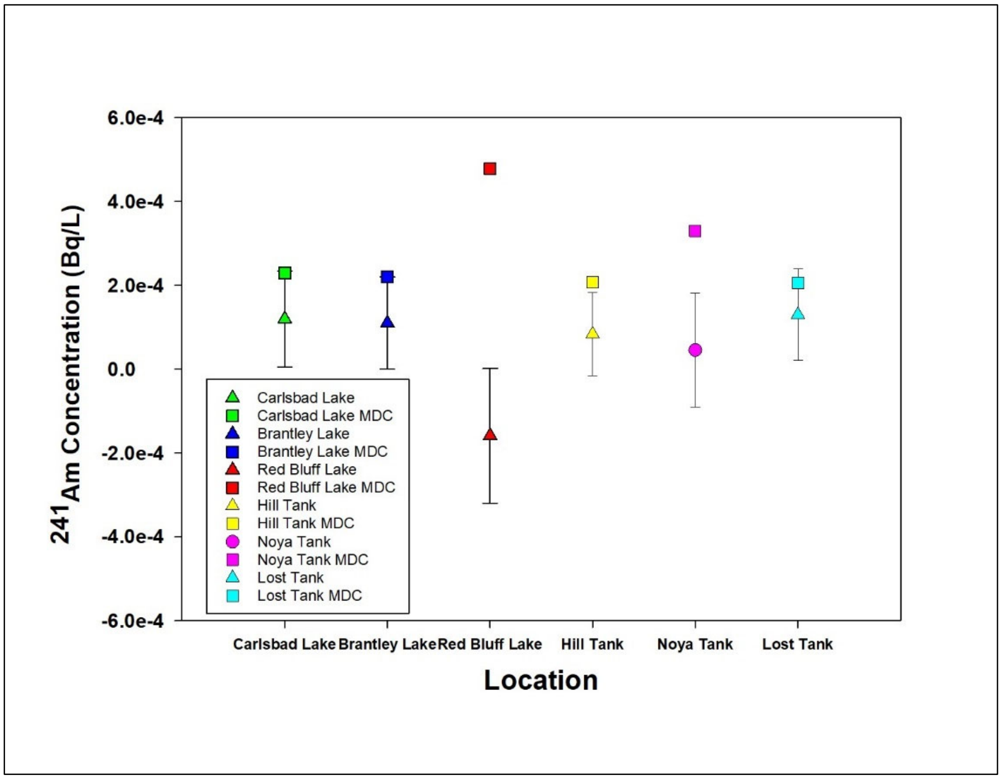
Portions of digested solutions containing strontium were co-precipitated with barium as a carbonate, then dissolved in nitric acid and barium precipitated out as chromate. The supernatants obtained were mixed with ammonium hydroxide (NH_4OH) and saturated ammonium carbonate $(NH_4)_2CO_3$ to precipitate strontium as strontium carbonate ($SrCO_3$), and the beta-radiation-emitting radioactive isotope ^{90}Sr was then counted by liquid scintillation counting. Details are described in procedure WL-1011.

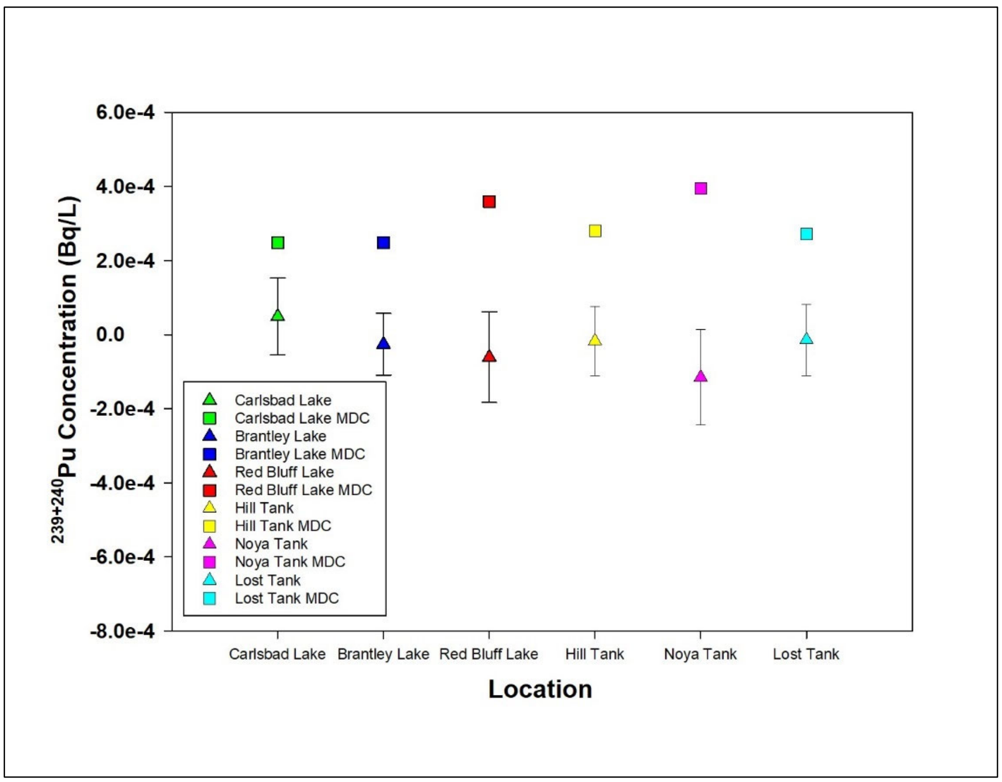
5.4 Results and Discussion

The activities of the actinides and gamma radionuclides were reported as activity concentration in Bq/L. Activity concentration is calculated as the activity of radionuclides detected in Becquerel (Bq) divided by volume of the surface water in liters (L).

5.4.1 Actinide Concentrations in Surface Water

The concentrations of ^{241}Am, ^{238}Pu, and $^{239+240}Pu$ in regional surface water samples in 2020 are listed in Appendix D, Table D.1. The alpha-emitting radionuclides, ^{238}Pu, $^{239+240}Pu$, and ^{241}Am were not detected in any of the surface water samples in 2021, which is consistent with the results of the previous years. These radionuclides have not been detected in any of the surface water samples above the MDC since monitoring commenced in 1998. The individual concentrations of ^{241}Am, ^{238}Pu, and $^{239+240}Pu$ measured in the three reservoirs are shown in Figure 5.3. The absence of a detection of WIPP radionuclides in surface water samples indicates no measurable impact of WIPP-related activities to the regional reservoirs or other sources of water.


241Am Concentration (Bq/L)
6.0e-4
4.0e-4
2.0e-4
0.0
-2.0e-4
-4.0e-4
-6.0e-4
Carlsbad Lake
Carlsbad Lake MDC
Brantley Lake
Brantley Lake MDC
Red Bluff Lake
Red Bluff Lake MDC
Hill Tank
Hill Tank MDC
Noya Tank
Noya Tank MDC
Lost Tank
Lost Tank MDC
Carlsbad Lake Brantley Lake Red Bluff Lake Hill Tank Noya Tank Lost Tank
Location


239+240Pu Concentration (Bq/L)
6.0e-4
4.0e-4
2.0e-4
0.0
-2.0e-4
-4.0e-4
-6.0e-4
-8.0e-4
Carlsbad Lake
Carlsbad Lake MDC
Brantley Lake
Brantley Lake MDC
Red Bluff Lake
Red Bluff Lake MDC
Hill Tank
Hill Tank MDC
Noya Tank
Noya Tank MDC
Lost Tank
Lost Tank MDC
Carlsbad Lake Brantley Lake Red Bluff Lake Hill Tank Noya Tank Lost Tank
Location

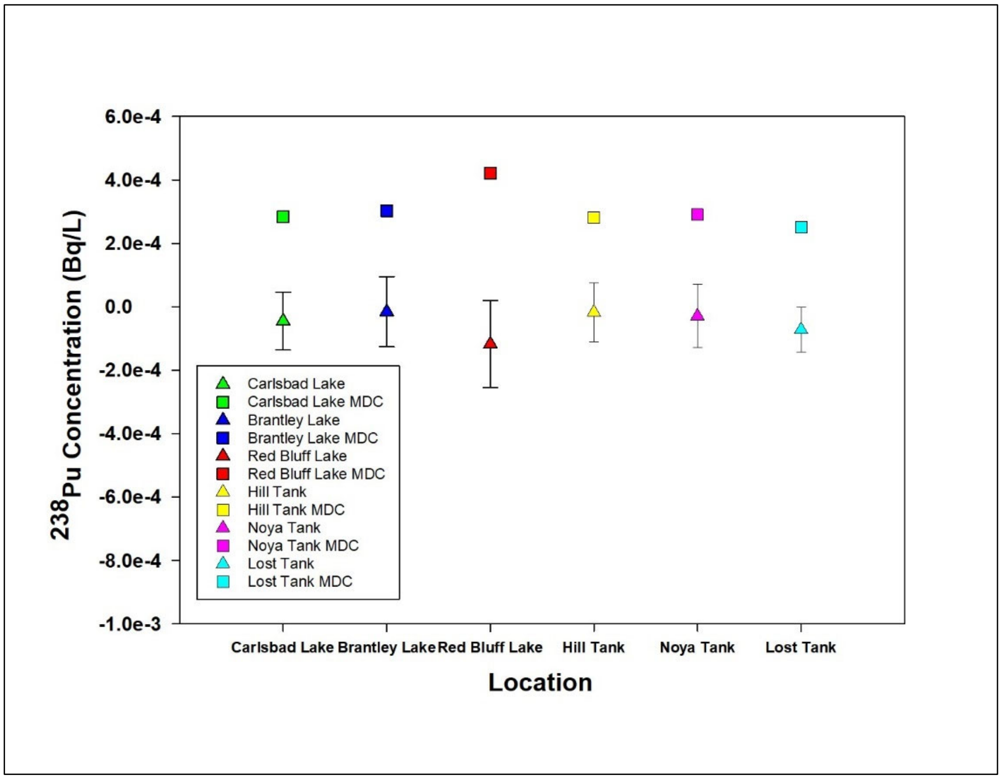


Figure 5.3. ^{241}Am (top), $^{239+240}$Pu (middle), and ^{238}Pu (bottom) Concentrations in Surface Water Samples in Three Regional Reservoirs and Three Regional Tanks in 2021

5.4.2 Uranium Concentrations in Surface Water

Isotopes of naturally occurring uranium were detected in all the surface water samples in 2021. Uranium concentrations measured in the three regional reservoirs and the three tanks near the WIPP site were in the range of 1.34-137 mBq/L for ^{238}U, 0.05-5.96 mBq/L for ^{235}U, and 1.75-281 mBq/L for ^{234}U . The individual concentrations of these radionuclides measured in the three reservoirs and three tanks in 2021 are listed in Appendix D, Table D.2. The concentration ranges for these isotopes, showed no significant difference between baseline and monitoring phases (CEMRC Report, 1998). The concentrations of the uranium isotopes were also compared between 2015 and 2017 and between sampling locations. There was no significant variation in the concentrations of the uranium isotopes in the surface water between 2015, 2017 and 2021. These observations further support our conclusion that there is no evidence of increases in radiological contaminants in the region that could be attributed to releases from WIPP. No significant difference between the baseline and monitoring phase concentrations was observed.

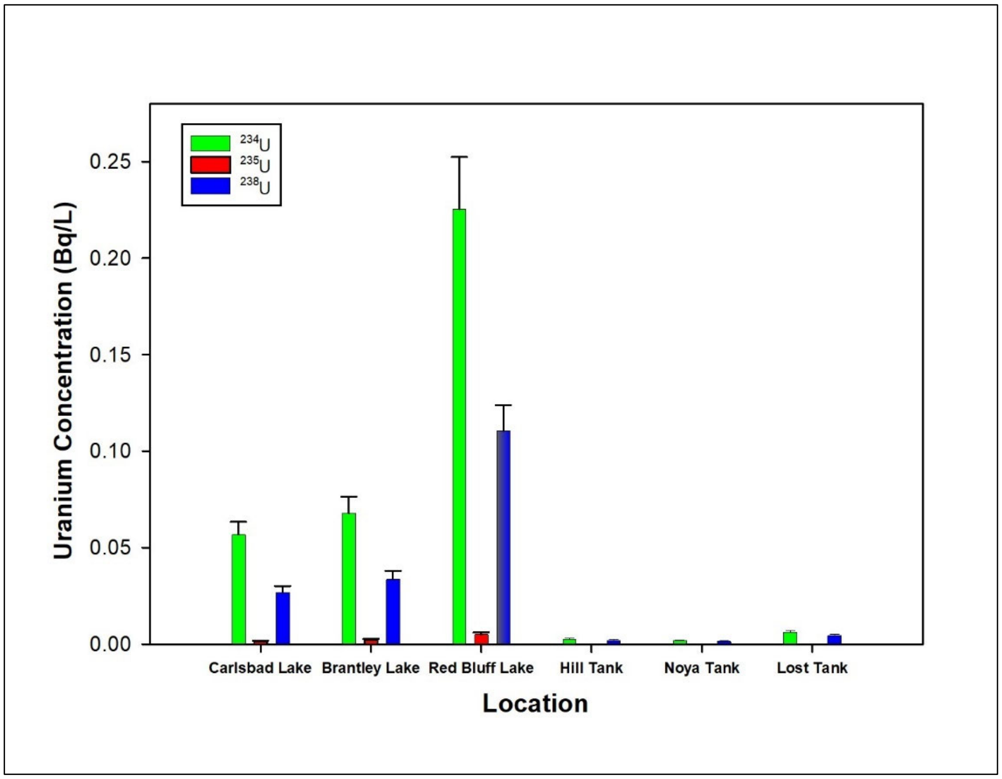


Figure 5.4. Uranium Concentrations in Surface Water Samples in Three Regional Reservoirs and Three Tanks in 2021

The $^{234}U/^{238}U$ isotopic ratios were very similar among these three Lakes. The reservoirs appeared to be slightly enriched in ^{234}U compared to ^{238}U, with the activity ratios ranging from 2.01 (Brantley Lake) to 2.11 (Carlsbad Lake), while the isotopic ratios were lower in the three tanks, ranging from 1.30 in the Hill and Noya Tanks to 1.42 in the Lost Tank (Figure 5.5). In natural bodies of water these isotopes do not occur in equilibrium and, with a few exceptions, waters typically contain more ^{234}U than ^{238}U (Cothern et al. 1983; Skwarzec et al. 2002). Higher activity of ^{234}U in water is the result of the ^{234}U atom displacement from the crystal lattice. The recoil atom, ^{234}U, is liable to be oxidized to the hexavalent stage and can be leached into the water phase more easily than its parent nuclide ^{238}U. The oxidation of U(IV) to U(VI) is an important step in leaching, because compounds containing U(VI) have a higher solubility due to the formation of strong complexes between uranyl and carbonate ions (UNSCEAR, 1977). All U(IV) compounds of uranium are practically insoluble.

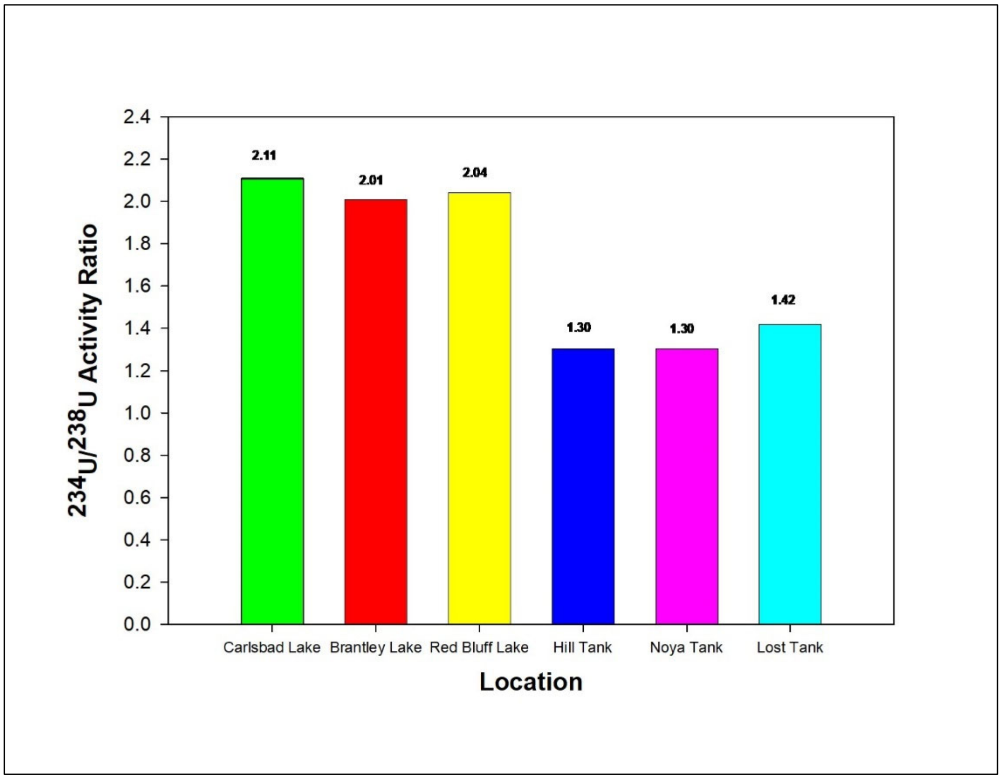


Figure 5.5. The $^{234}U/^{238}U$ Activity Ratio in Surface Water Samples of Three Reservoirs and Three Tanks in the Vicinity of the WIPP Site

5.4.3 Gamma Radionuclide Concentrations in Surface Water

The gamma emitting radionuclides^{137}Cs and ^{60}Co were not detected in any of the surface water samples, while the naturally occurring gamma-emitting radionuclide, ^{40}K was detected in Red Bluff and Lake Carlsbad surface water in the concentration of 0.91 Bq/L and 0.66-1.24 Bq/L, respectively, as shown in Appendix D, Table D.3. The isotope ^{40}K was also detected in 1998, 2000, 2012, 2017, 2019, and 2020 (CEMRC Annual Report, 1998, 2000, 2012, 2017, 2019, and 2020) in surface water samples collected from Red Bluff Lake. The concentrations detected were in the range of 0.81-1.25 Bq/L in 1998; 1.22-1.25 Bq/L in 2000, 2.47-2.72 Bq/L in 2012, 2.11 Bq/L in 2017, 1.00 Bq/L in 2019, and 0.55-0.91 Bq/L in 2020. This naturally occurring gamma-emitting radionuclide is ubiquitous in nature; therefore, an occasional detection of ^{40}K in surface water is not unusual. There was no significant difference between concentrations of ^{40}K among sampling locations and the values fell within the range of concentrations observed previously in this location. Because these isotopes were not regularly detected, no comparisons between years or among locations were performed.

5.4.4 Strontium Concentrations in Surface Water

The beta-radiation-emitting radionuclide ^{90}Sr was not detected in any of the surface water samples collected in 2021.

5.5 Conclusion

This chapter summarizes the results of the surface water monitoring program for the calendar year 2021. It is important to note that after more than twenty years of monitoring, isotopes of plutonium (^{238}Pu and $^{239+240}$Pu) and ^{241}Am, have never been detected above MDC in any of the public water reservoirs in the area surrounding the WIPP. However, the isotopes of uranium ^{234}U, ^{238}U, and ^{235}U were detected in all surface water samples. The concentrations of uranium measured were in the range of 1.34-137 mBq/L for ^{238}U, 0.05-5.96 mBq/L for ^{235}U, and 1.75-281 mBq/L for ^{234}U. The levels detected were well below the EPA recommended level of 746 mBq/L for drinking water and are within the range expected in waters from this region. The ^{234}U/ ^{238}U activity ratio indicates its presence in surface water is most likely from natural sources. In addition, the ^{90}Sr radionuclide was not detected in any of the surface water samples in 2021. Present results, as well as the results of previous analyses of surface water, were consistent for each source across sampling periods. The 2021 monitoring results continue to show no evidence of any release from the WIPP contributing to radionuclide concentrations in the environment.

CHAPTER 6 - DRINKING WATER MONITORING

Drinking water must be safe enough to be consumed by humans or to be used with a low risk of immediate or long-term impact on human health. For this reason, the quality of drinking water available in the area surrounding the WIPP site is routinely checked to assure the public that health and environmental standards are met and to identify any changes in water quality that might negatively impact public health or the environment. Aquifers in the region surrounding the WIPP site include Dewey Lake, the Culebra-Magenta, the Ogallala, the Dockum, the Pecos River alluvium, and the Capitan Reef (Mercer, 1983). The main Carlsbad water supply is the Sheep Draw well field, whose primary source is the Capitan Reef aquifer. The Ogallala aquifer feeds the Hobbs and WIPP (Double Eagle PRV4 formerly Double Eagle) public water supply systems. The Pecos River provides the Loving, Malaga, and Otis public water supply wells.

In 1974, the United States Congress passed the Safe Drinking Water Act. This law requires the U.S. Environmental Protection Agency (EPA) to determine safe levels of contaminants in U.S. drinking water. This safe level is called the maximum contaminant level (MCL). MCLs in drinking water have been established for a variety of radionuclides. The MCL has been set at 0.185 Bq/L (5pCi/L) for radium, while the uranium MCL has been set at 30 µg/L. The MCL for gross alpha radiation is 0.55 Bq/L (15pCi/L) (not including radon and uranium), and the maximum level for gross beta radiation is 1.85 Bq/L (50 pCi/L). It is important to note that the focus of this report is to monitor the impact of WIPP operations on the regional drinking water supplies and should not be used in assessing regulatory compliance.

CEMRC has been sampling drinking water for radiochemical analyses since 1997 and performing non-radiological analyses on drinking water since 1998. Summaries of methods, data, and results from previous samplings were reported in earlier CEMRC reports and can be found on the CEMRC website (http.//www.cemrc.org) under the annual reports tab. The scope of work requires drinking water samples to be collected annually from the six municipal water supply systems in the vicinity of the WIPP, including the City of Carlsbad (Sheep Draw and Double Eagle PRV4), Hobbs, Loving, Malaga, and Otis. These samples are subject to non-radiological and radiological analyses. Radiological analyses are used to quantify gamma-emitting radionuclides and actinides of concern. Details of the sample collection and analyses are described in the following sections. In this chapter, radiological analysis results are reported for the drinking water samples collected in 2021.

6.1 Sample Collection

Drinking water samples were collected from the drinking water supplies used by communities in the WIPP region. The sources included the community water supplies of Carlsbad (Sheep Draw and Double Eagle PRV4), Loving, Otis, Hobbs, and Malaga. These locations are shown in Figure 6.1.

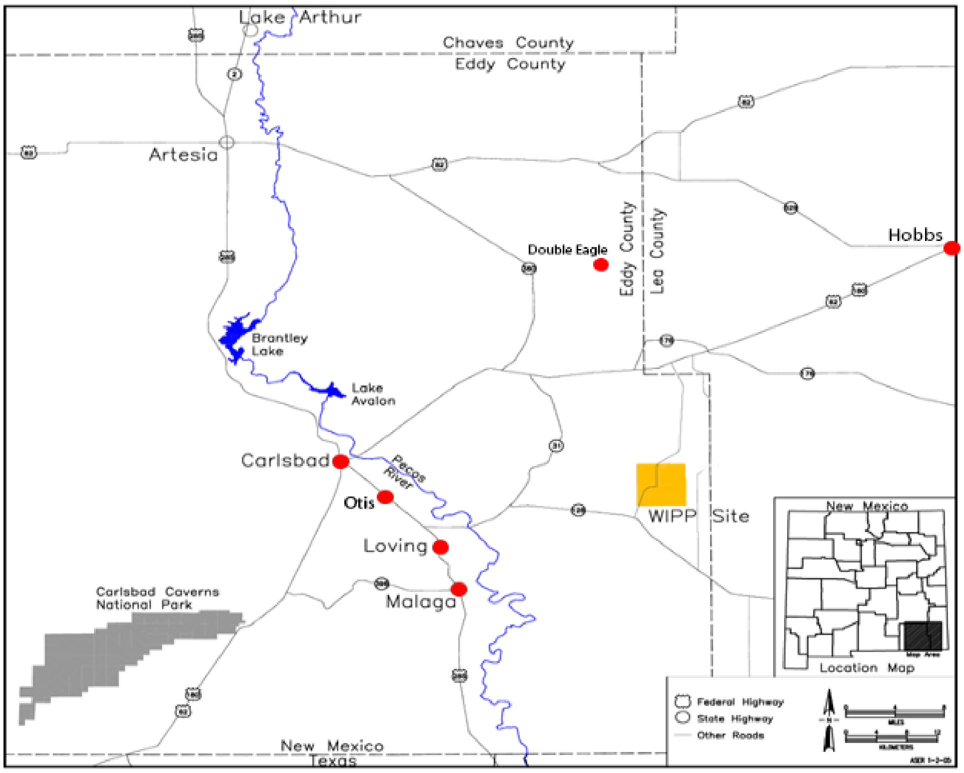


Figure 6.1. Drinking Water Sampling Locations

Drinking water from each sampling location was collected in a 5-gallon plastic water bottle. Water from each sampling location was also used to rinse containers at least three times prior to taking the sample. Approximately 8 liters of water were collected from each location. Immediately after collection, the samples were acidified to pH ≤ 2 with concentrated nitric acid to avoid losses through microbial activity and adsorption onto the vessel walls.

6.2 Sample Preparation and Analysis

Drinking water sample containers were shaken, and sample aliquots were measured into glass beakers - one 2 L portion for gamma analyses and another 1 L for alpha analyses. The first aliquot was transferred to 2 L Marinelli beakers to measure the gamma-emitting radionuclides by gamma spectroscopy. The second 1 L aliquot was used for the alpha analysis of uranium (U) and transuranic radionuclides by digesting the water samples with concentrated nitric and appropriate tracers on a hot plate. The samples were heated to dryness then wet-ashed using concentrated nitric acid and 30% hydrogen peroxide. Finally, the samples were heated to dryness, redissolved in 1 M HCl, and processed to separate the various isotopes.

6.3 Determination of Individual Radionuclides

A 2 L portion of the acidified water sample in Marinelli beakers was used directly for the gamma spectroscopy to measure the gamma-emitting radionuclides ^{40}K, ^{60}Co, and ^{137}Cs using a high purity germanium (HPGe) detector (Mirion Technologies Inc.) for 48 hours. The other 1 L portion of water was prepared by co-precipitating the target radionuclides and corresponding tracers with an iron carrier, performing ion exchange and chromatographic separations of the individual radionuclides, followed by micro-precipitating the separated radionuclides onto planchets for counting. The uranium isotopes and transuranics were counted using alpha spectroscopy for five days. Portions of digested solutions containing strontium were co-precipitated with barium as a carbonate, then dissolved in nitric acid and barium precipitated out as chromate. The supernatants obtained were mixed with ammonium hydroxide (NH_4OH) and saturated ammonium carbonate $(NH_4)_2CO_3$ to precipitate strontium as strontium carbonate ($SrCO_3$), and the beta-radiation-emitting radioactive isotope ^{90}Sr was then counted by liquid scintillation counting. Details are described in procedure WL-1011.

6.4 Results and Discussion

The actinide and gamma radionuclide activities are reported as activity concentrations in Bq/L. Activity concentrations are calculated as the activity of radionuclides reported in Becquerel (Bq) divided by the volume of the drinking water in liters (L).

6.4.1 Actinide Concentrations in Drinking Water

The concentrations of ^{238}Pu, $^{239+240}Pu$, ^{241}Am, ^{234}U, ^{235}U, and ^{238}U in regional drinking water samples in 2020 are listed in Appendix E, Table E.1. The alpha-emitting radionuclides ^{238}Pu, $^{239+240}Pu$, and ^{241}Am were not detected in any of the drinking water samples in 2021, which is consistent with results from previous years. These radionuclides have not been detected in any of the drinking water samples above the MDC since monitoring commenced in 1997. The federal and state action level for gross alpha emitters, which includes isotopes of Pu and U, is 0.56 Bq/L. This level is over 10,000 times the MDCs used at CEMRC. The historical concentrations of $^{239+240}Pu$, ^{238}Pu, and ^{241}Am measured in the drinking water from the six municipal water supply systems in the vicinity of the WIPP site are shown in Figure 6.2 through Figure 6.7.

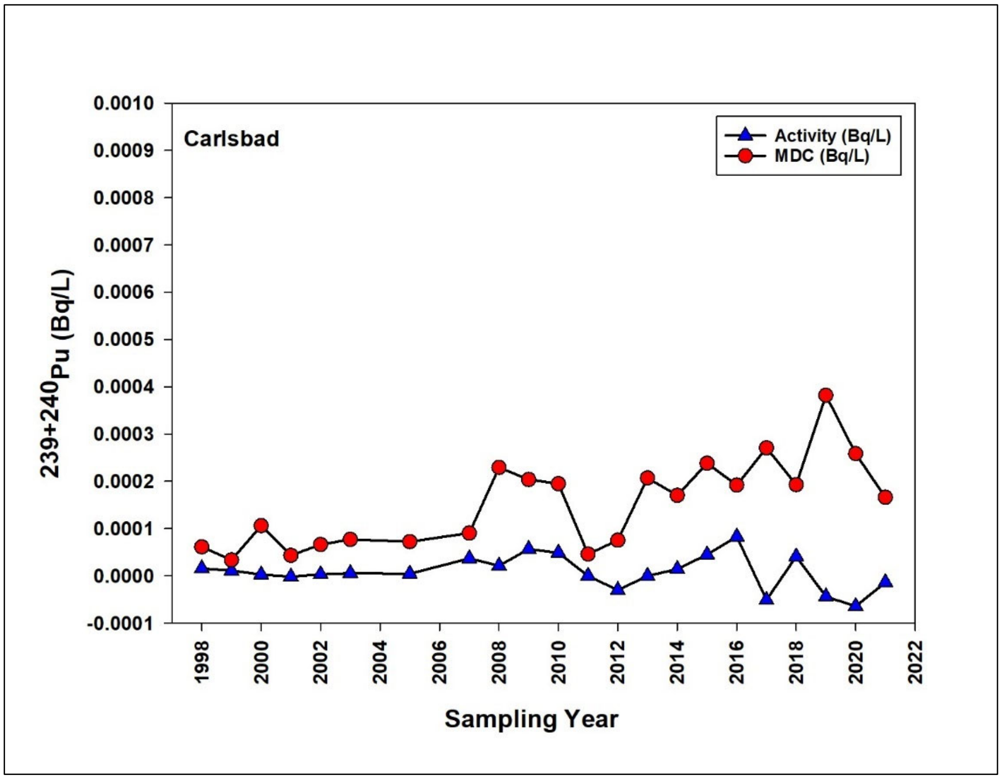
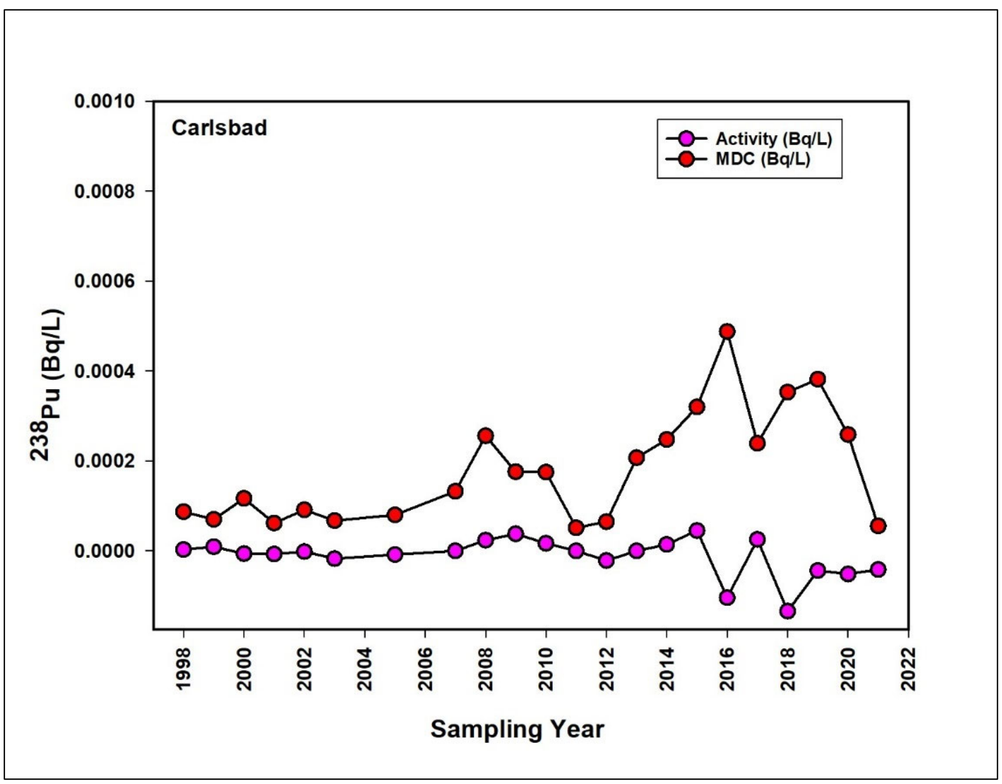


Figure 6.2. $^{239+240}Pu$ Concentrations in Carlsbad Drinking Water



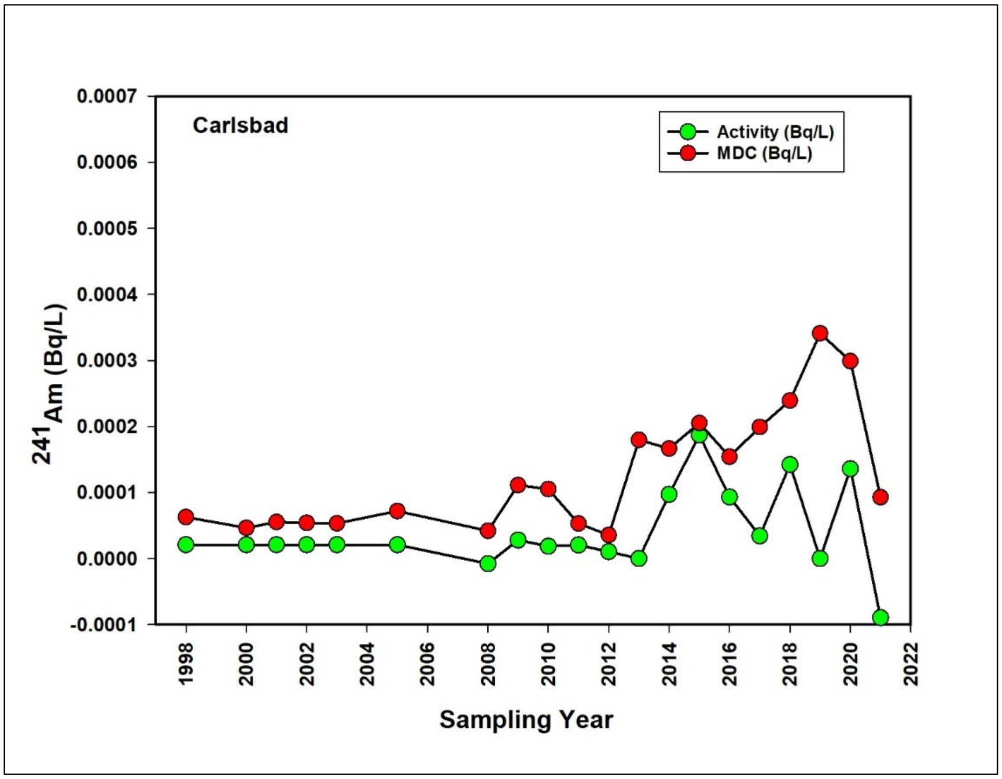
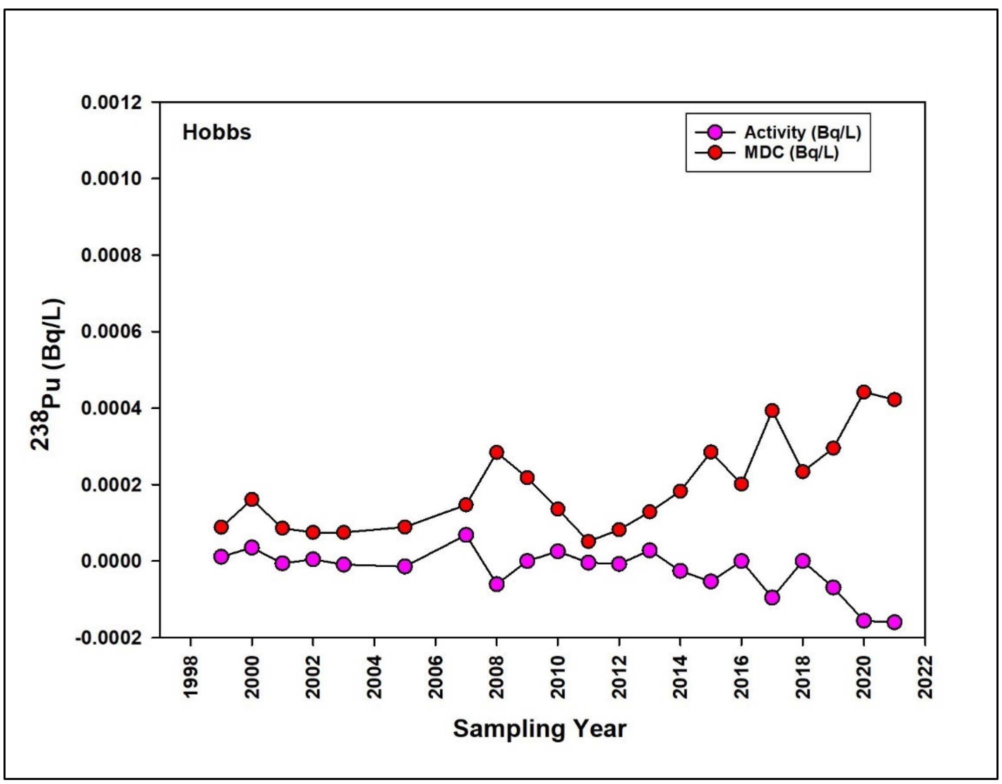


Figure 6.3. ^{238}Pu and ^{241}Am Concentrations in Carlsbad Drinking Water



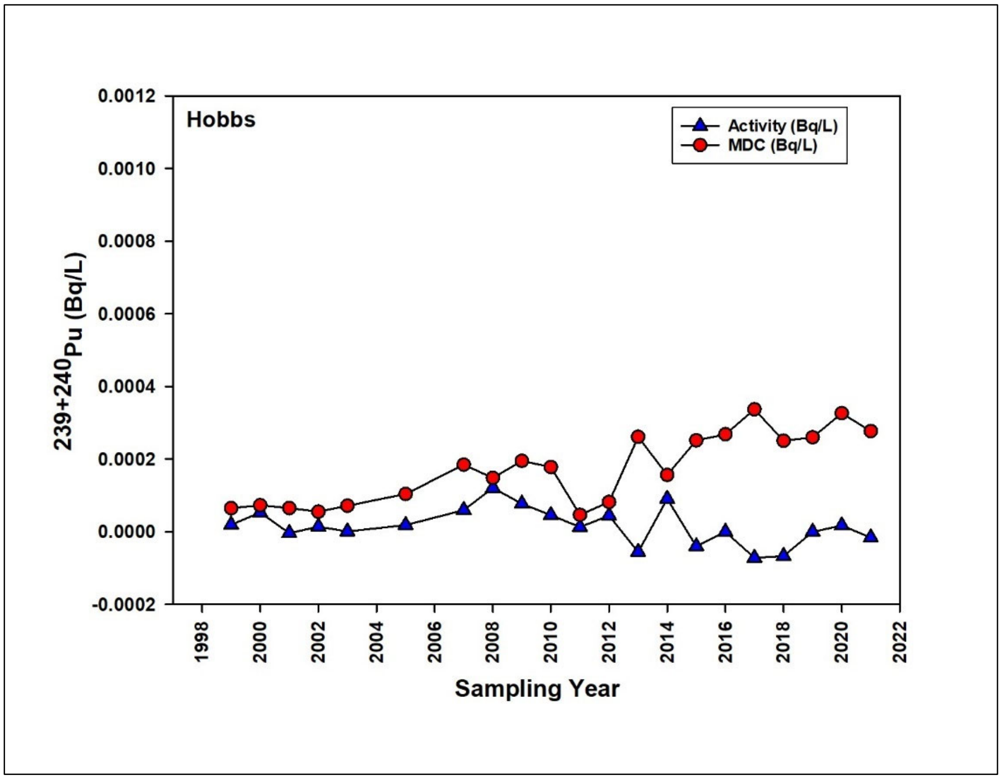
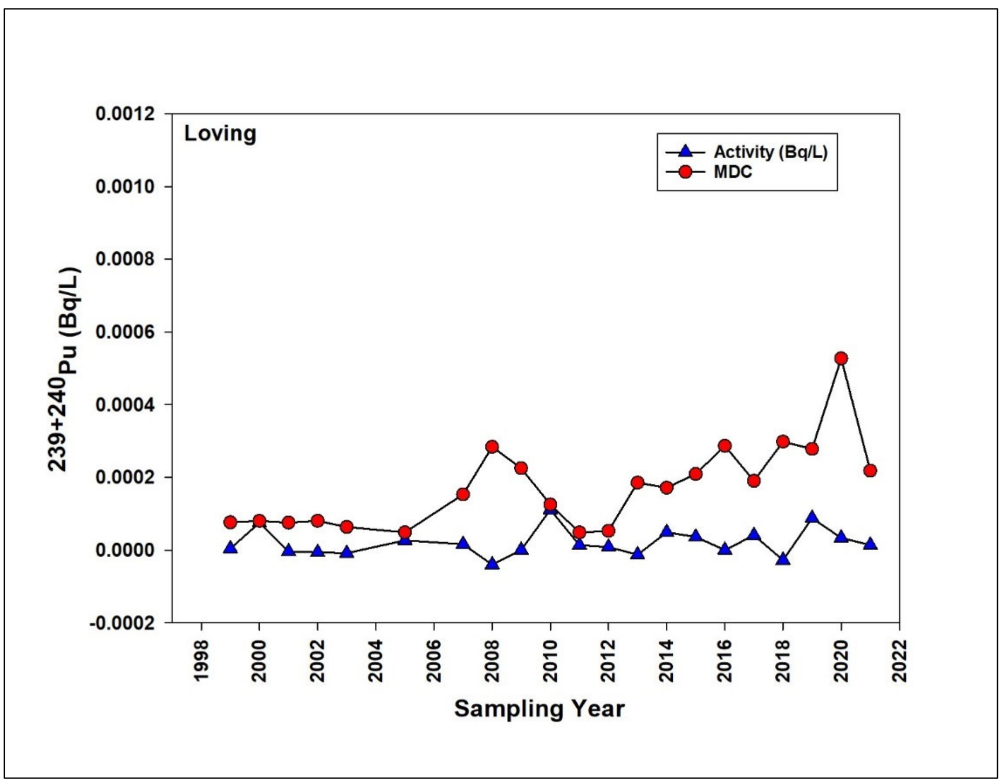


Figure 6.4. ^{238}Pu and $^{239+240}$Pu Concentrations in Hobbs Drinking Water



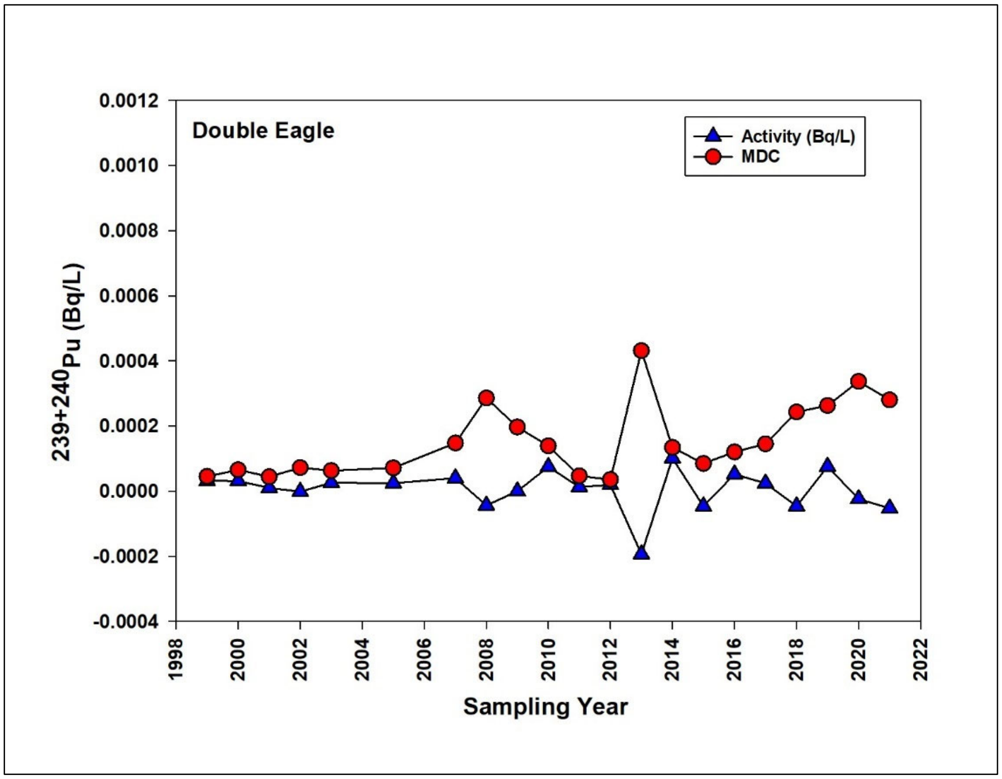
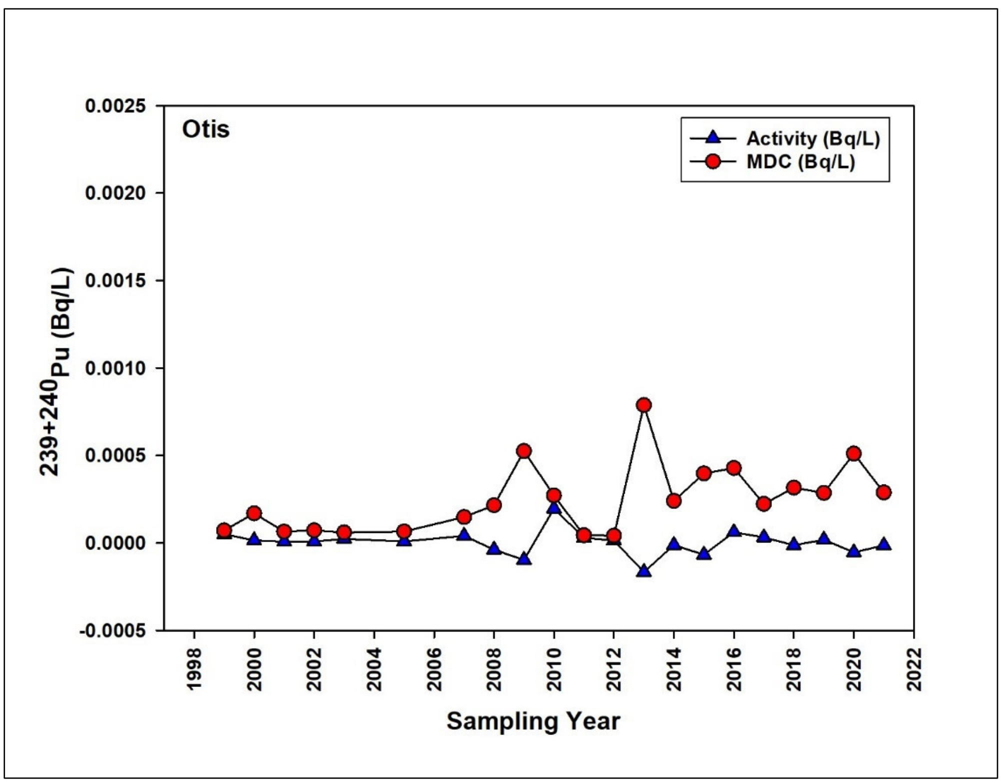


Figure 6.5. $^{239+240}$Pu Concentrations in Loving and Double Eagle Drinking Water



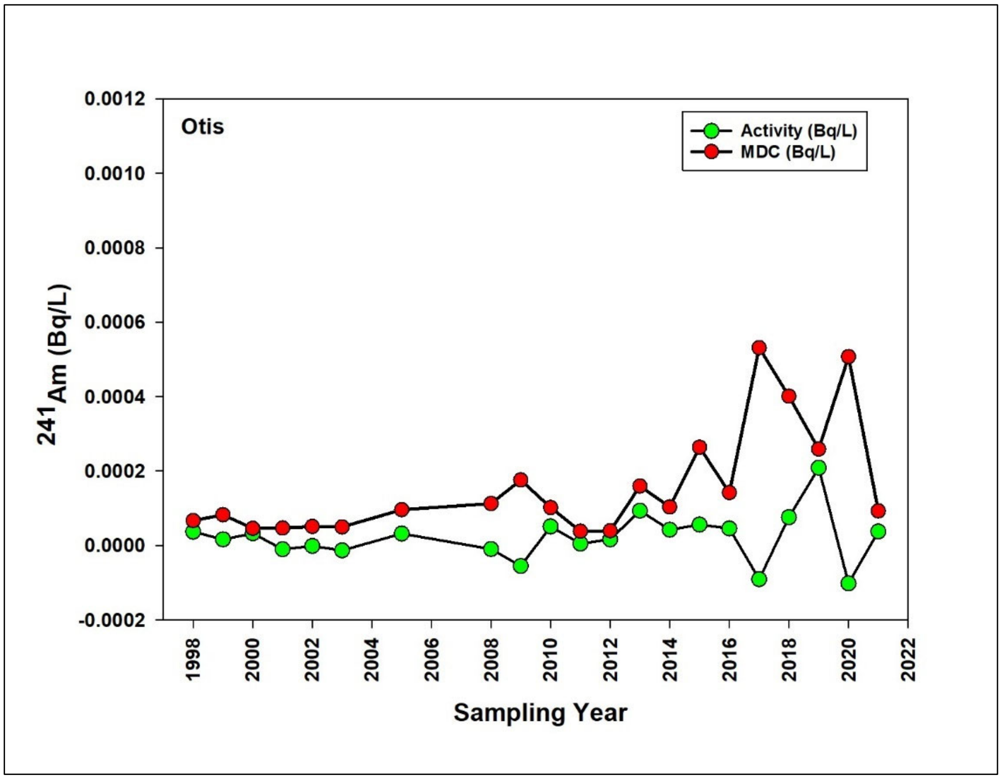
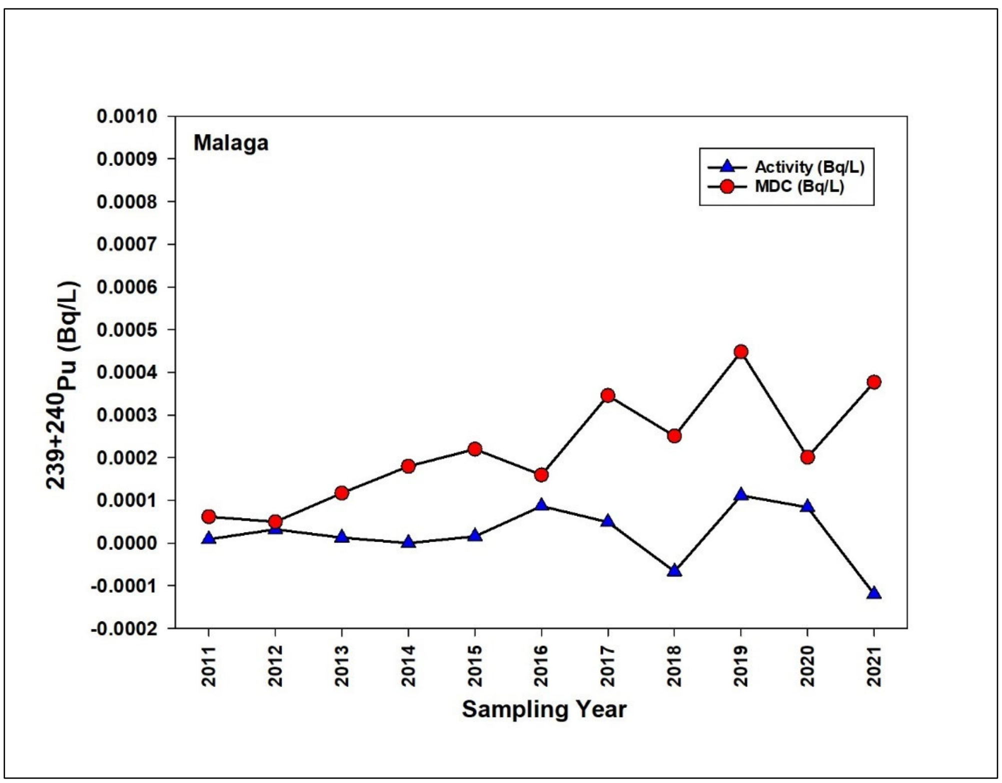


Figure 6.6. $^{239+240}Pu$ and ^{241}Am Concentrations in Otis Drinking Water



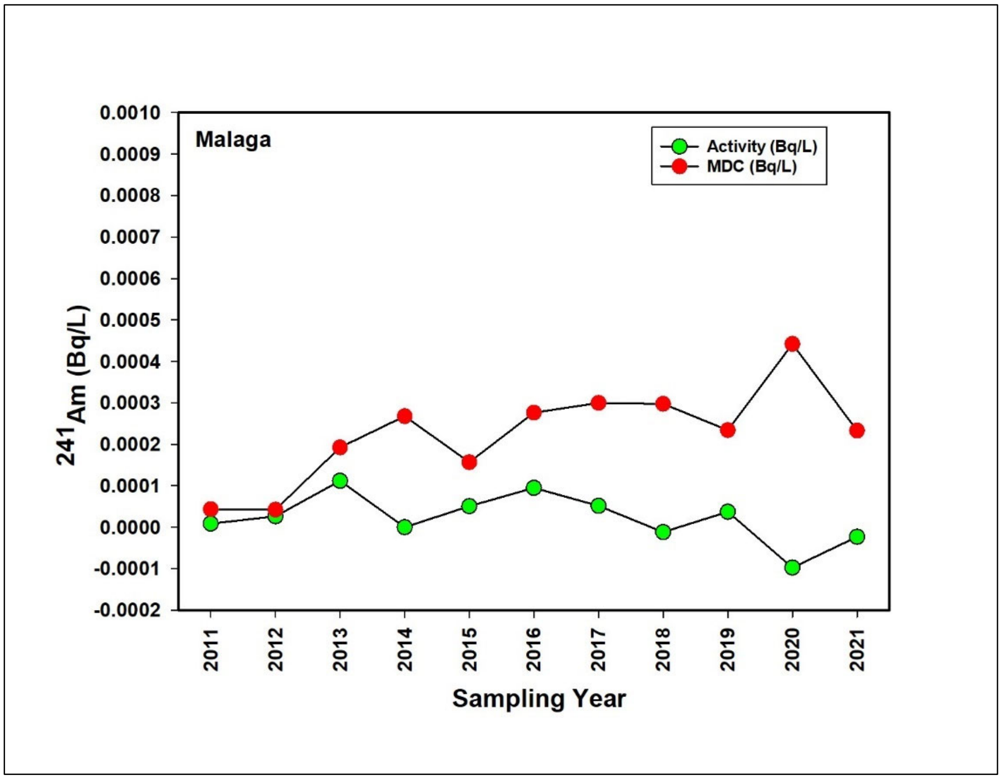


Figure 6.7. $^{239+240}$Pu and ^{241}Am Concentrations in Malaga Drinking Water

6.4.2 Uranium Concentrations in Drinking Water

Isotopes of naturally occurring uranium were detected in all the drinking water samples in 2021. Uranium concentrations measured in the communities' drinking water near the WIPP site were in the range of 10.0-65.8 mBq/L for ^{238}U, 1.14-3.99 mBq/L for ^{235}U, and 27-173 mBq/L for ^{234}U as shown in Appendix E, Table E.2. These uranium activity concentrations are well below the EPA recommended level of 746 mBq/L and are within the range expected in waters from this region. According to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 2008), the ^{238}U concentration in drinking water is about 0.5-149 mBq/L in the U.S. Cothern and Lappenbusch (1983), conducted an extensive investigation of radioactivity in drinking water in the U.S. Of the 59,812 community drinking water supplies tested in the U.S., a projected 25 to 650 exceeded a U concentration of 746 mBq/L, 100 to 2,000 exceeded 370 Bq/L, and 2,500 to 5,000 exceeded 185 mBq/L. The levels detected in the communities' drinking water sources near the WIPP site were also within the U.S.'s expected range. The concentrations of ^{234}U, ^{235}U, and ^{238}U in these drinking water locations measured in 2021 are shown in Figure 6.8. The historical activity concentrations of ^{234}U, ^{235}U, and ^{238}U measured at each site in the regional drinking water are summarized in Appendix E, Tables E.3 through E.8.

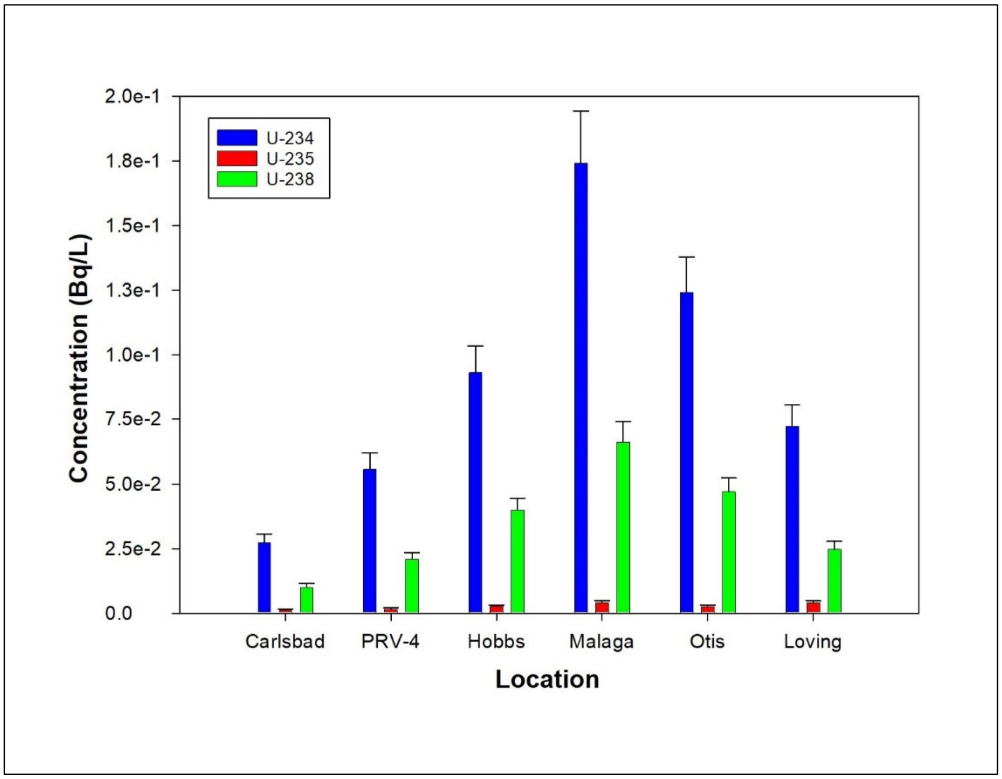


Figure 6.8. The ^{234}U, ^{235}U, and ^{238}U Concentrations (Bq/L) in Regional Drinking Water

The low activity concentration of ^{235}U in the water samples is consistent with the lower activity concentration of ^{235}U in the natural environment as compared to the activity concentrations of ^{234}U and ^{238}U. The highest activity concentrations were found in Malaga and Otis drinking waters.

Uranium in the environment occurs naturally as three radioactive isotopes. ^{238}U (99.27%), ^{235}U (0.72%), and ^{234}U (0.005%). These isotopes of uranium are also found in the earth's crust, in rocks and minerals such as granite, metamorphic rocks, lignite, monazite sand, in phosphate deposits, and in uranium minerals such as uraninite, carnotite, and pitchblende. It is also present as a trace element in coal, peat, asphalt, and some phosphate fertilizers at a level of about 100 µg/g or 2.5 Bq/g (Hess et al, 1985). All these sources can come in contact with water which may be used for drinking purposes. Thus, it is expected that some drinking and surface water sources will contain uranium.

The natural level of uranium in water can also be enhanced due to human activity. For example, the increased concentration of natural radionuclides in water can be caused by the intensive use of phosphate fertilizers in agriculture. The average phosphate fertilizers contain about 100 µg/g (or 24.8 Bq/g), of naturally occurring uranium (Cothern and Lappenbusch, 1983), which can leach from the soil to nearby rivers and lakes (Fleischer, 1980; UNSCEAR, 1982).

The $^{234}U/^{238}U$ activity ratio measured in regional drinking water from 1998 through 2021 is shown in Figure 6.9. Also shown in Figure 6.9 is the $^{234}U/^{238}U$ activity ratio measured in regional drinking water for 2021 for comparison. The $^{234}U/^{238}U$ activity ratio in these drinking water sources varies between 1.99 and 3.21 historically, which means that the two isotopes are not in radioactive equilibrium. It has been reported that the activity of uranium in natural water from ^{234}U is higher than that of ^{238}U, as shown in Figure 6.8. The $^{234}U/^{238}U$ activity ratio usually ranges between 1.0 and 3.0 (Cherdynstev et al. 1971; Gilkeson et al. 1982). In radiochemical equilibrium, natural activity ratios are typically unity (1.0) for $^{234}U/^{238}U$ and 0.045 for $^{235}U/^{238}U$ (Pimple et al, 1992). However, many studies looking at ^{238}U and ^{234}U in natural bodies of water indicate that these isotopes do not occur in equilibrium and that, with a few exceptions, waters typically contain more ^{234}U than ^{238}U (Cothern et al. 1983; Skwarzec et al. 2002). Higher activity of ^{234}U in water is the result of the ^{234}U atom displacement from the crystal lattice. The recoil atom, ^{234}U, is liable to be oxidized to the hexavalent stage and can be leached into the water phase more easily than its parent nuclide ^{238}U. The oxidation of U(IV) to U(VI) is an important step in leaching because of the higher solubility of U(VI) compounds. All U(IV) compounds of uranium are practically insoluble. The variations in $^{234}U/^{238}U$ activity ratio measured in regional drinking water since 1998 are shown in Figure 6.10.

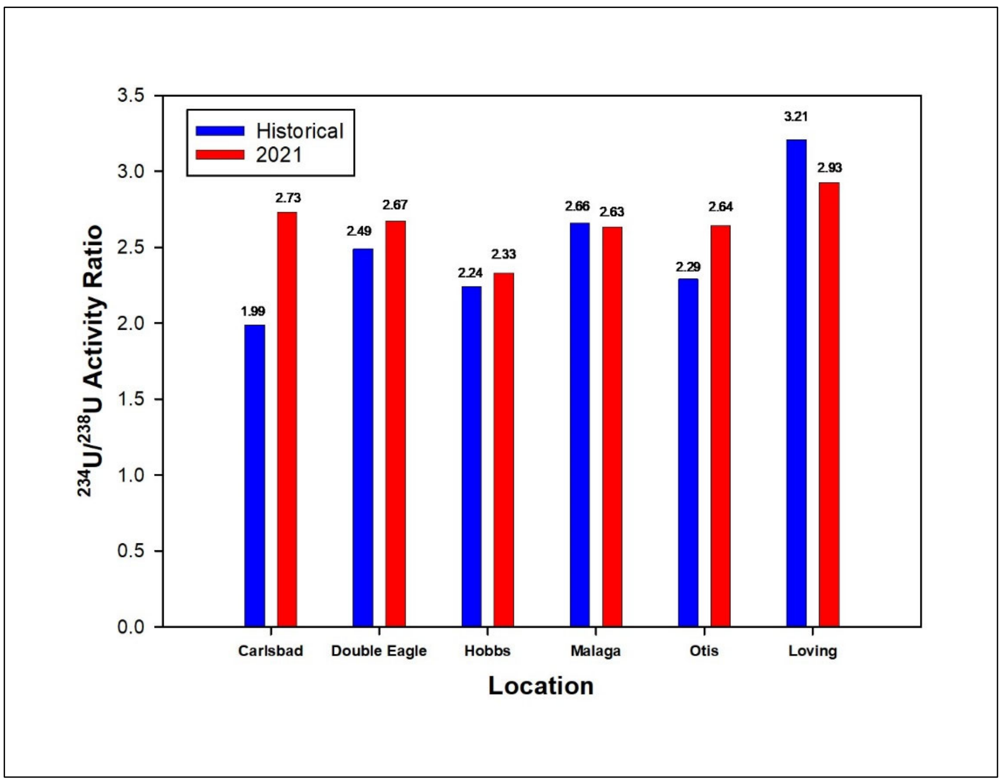


Figure 6.9. $^{234}U/^{238}U$ Activity Ratio in Regional Drinking Water from 1998-2021

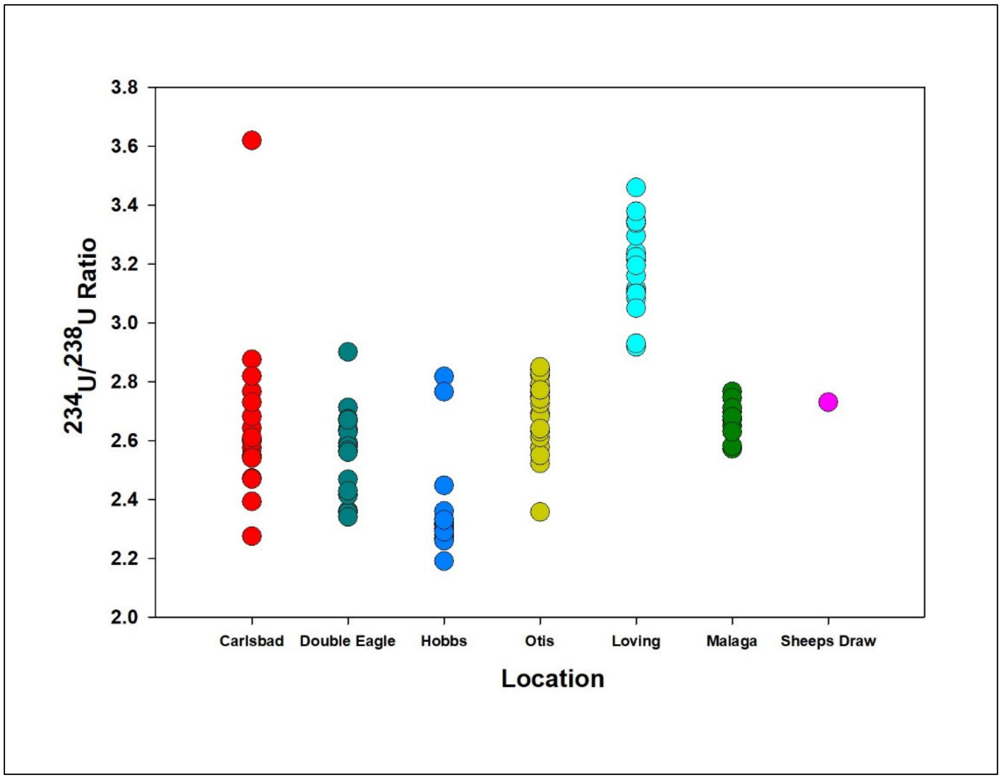


Figure 6.10. Variation in $^{234}U/^{238}U$ Activity Ratio in Regional Drinking Water from 1998-2021

6.4.3 Gamma Radionuclide Concentrations in Drinking Water

The gamma emitting radionuclides ^{40}K, ^{137}Cs, and ^{60}Co were not detected in any of the drinking water samples in 2021. However, the naturally occurring gamma-emitting radionuclide, ^{40}K was detected in Hobbs drinking water sample at a level of 1.35 Bq/L in 2014. ^{40}K was also detected in Carlsbad, Malaga, and Otis drinking waters at a level of 1.10-1.19 Bq/L in 2013. This naturally occurring gamma-emitting radionuclide is ubiquitous in nature; therefore, an occasional detection of ^{40}K in drinking water is not unusual. There was no significant difference between concentrations of ^{40}K among sampling locations; the values also fell within the range of concentrations observed previously in these drinking water locations. The other two gamma radionuclides (^{137}Cs and ^{60}Co) were not detected in any of the drinking water samples as shown in Appendix E, Table E.9. Since these isotopes were not detected, no comparisons between years or among locations were performed.

6.4.4 Strontium Concentrations in Drinking Water

The ^{90}Sr radionuclide was not detected in any of the drinking water sources of municipalities surrounding the WIPP site.

6.5 Conclusion

This chapter summarizes the results of the drinking water monitoring program for the calendar year 2021. It is important to note that after more than twenty years of monitoring, isotopes of plutonium (^{238}Pu and $^{239+240}Pu$) and ^{241}Am, have never been detected above MDC in any of the sampling locations in and around the WIPP. However, the isotopes of uranium ^{234}U, ^{238}U, and ^{235}U were detected in all drinking water samples. The concentrations of uranium measured were in the range of 10.0-65.8 mBq/L for ^{238}U, 1.14-3.99 mBq/L for ^{235}U, and 27-173 mBq/L for ^{234}U. The levels detected were well below the EPA recommended level of 746 mBq/L and are within the range expected in waters from this region. The ^{234}U/ ^{238}U activity ratio indicates its presence in drinking water is most likely from natural sources. Present results, as well as the results of previous analyses of drinking water, were consistent for each source across sampling periods. In addition, the ^{90}Sr radionuclide was not detected in any drinking water source of the region. There is no evidence of increases in radiological contaminants in the region that could be attributed to a recent release event at the WIPP or WIPP-related activities.

CHAPTER 7 - SEDIMENT MONITORING

7.1 Introduction

Sediments are finely divided solid materials that have settled out of a liquid stream or from standing water. The sediments accumulate soluble radionuclides by sorption on suspended sediment and insoluble radionuclides by settling. CEMRC has been monitoring sediment samples from the three public reservoirs in the vicinity of WIPP, Brantley Lake, Lake Carlsbad, and Red Bluff Lake, since 1998. Many sediment samples contained the fission-product ^{137}Cs; a few contained fission products ^{90}Sr and ^{134}Cs; activation-products ^{60}Co, ^{58}Co, ^{54}Mn, and ^{65}Zn; and the transuranic isotopes $^{239+240}$Pu and ^{241}Am. These radionuclides in sediments are mainly attributed to discharges at the monitored facilities. Some ^{137}Cs, ^{90}Sr, and ^{239}Pu are fallout from atmospheric nuclear tests, which peaked in 1962-1963 and, to a minor extent, from nuclear accidents such as Chernobyl and Fukushima. Naturally occurring radionuclides uranium, thorium, and ^{40}K were also detected. Many of the measured values were low, near the limits of detection. Assuming measured activities were high enough, the accumulation of radioactive materials in sediment could lead to human exposure through the ingestion of aquatic species, sediment re-suspension into drinking water supplies, or as an external radiation source (U.S. Department of Energy 1991).

To evaluate current conditions, CEMRC sampled sediment in the vicinity of the WIPP site in November 2021. The scope of work requires sediment samples to be collected annually from the same three public water reservoirs situated along the Pecos River. These locations include Brantley Lake, approximately 55 km (34 miles) north-northwest of the WIPP site, Red Bluff Lake on the Pecos River, the upstream end of which is the nearest standing water body approximately 48 km (30 miles) southwest of the WIPP site, and Lake Carlsbad in the center of Carlsbad about 40 km (25 miles) northwest from the WIPP site. Radiological analyses were performed to evaluate current radionuclide trends, especially Pu and Am, in the vicinity of the WIPP site. Details of the sample collection and analyses are described in the following sections. In this chapter, radiological analyses results are reported for the surface sediment samples collected in 2020.

7.1.1 Sample Collection

Sediment samples were collected at randomly selected locations within the deep basins of each reservoir. Deep basins were chosen for sampling to minimize the disturbance and particle mixing effects of current and wave action that occur at shallower depths. Also, many of the analytes of interest tend to concentrate on the fine sediments that settle in the deep reservoir basins; thus, measurements from these areas would typically represent the highest levels that might be expected for a given reservoir.

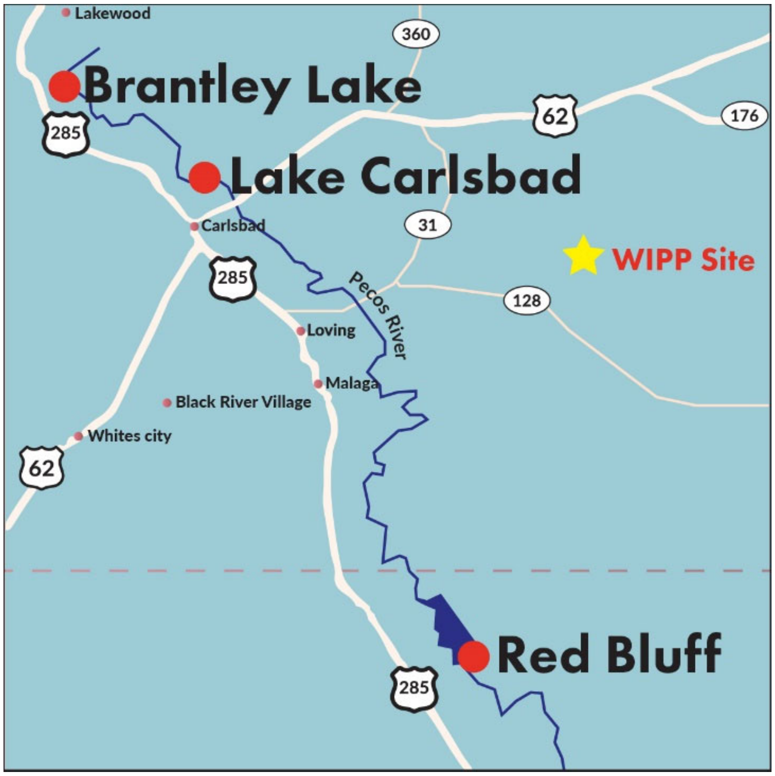


Figure 7.1. Sediment Sampling Locations

Sediment samples were collected at depths of 5-10 cm, using a grab sampler or Eckman dredge, to obtain approximately 5 L of sediment at each sampling site, as shown in Figure 7.2. Excess water was decanted from the sediment upon collection. The wet sediment was sealed in a pre-cleaned plastic bucket in the field and transported to the CEMRC laboratory for preparation before radiological analyses.

Figure 7.2. Sediment Sample Collection by CEMRC Personnel

7.2 Sample Preparation and Analysis

Sediment samples were dried at 105 °C for at least 12 hours and blended before sampling in the laboratory. The samples for gamma analysis were sealed in a 300 mL paint can and stored for at least 21 days to allow radon progeny to reach equilibrium with parent radionuclides before counting. Dried and sieved soil samples were counted for 48 h in a high purity germanium detector, HpGe (Mirion Technologies). The counting containers held approximately 500 g of sediments.

Samples for actinide analyses were dried at 105 ˚C and ground using a shatter box grinder to a fine analytical powder. For radiochemical analyses, 4-5 g of sample were heated in a muffle furnace at 500 ˚C for at least six hours to combust organic material. Each sample was then spiked with a radioactive tracer and digested in a Teflon beaker with hydrochloric, nitric, and hydrofluoric acids. Sea sand was used as a matrix for Laboratory Control Standard (LCS) and reagent blank. To remove hydrofluoric acid, the sample residues were heated with perchloric acid and boric acids. Finally, the residues were dissolved in nitric acid for processing the individual radionuclide concentrations.

7.2.1 Radiochemical Analysis

The actinides were then separated as a group by co-precipitation on ferric hydroxide, $Fe(OH)_3$. Plutonium was separated from americium and uranium using an anion exchange column, while uranium was separated from americium on a TRU chromatography column. After separation, plutonium and uranium fractions were purified on the second anion exchange column, and the americium was subsequently purified from lanthanides on TEVA. Finally, Pu, Am, and U were micro co-precipitated on stainless steel planchettes for alpha spectrometry (Mirion Technologies) and counted for five days as per CEMRC's standard counting protocol. Portions of digested solutions containing strontium were co-precipitated with barium as a carbonate, then dissolved in nitric acid and barium precipitated out as chromate. The supernatants obtained were mixed with ammonium hydroxide (NH_4OH) and saturated ammonium carbonate $(NH_4)_2CO_3$ to precipitate strontium as strontium carbonate ($SrCO_3$), and the beta-radiation-emitting radioactive isotope ^{90}Sr is then counted by liquid scintillation counting. Details are described in procedure WL-1011.

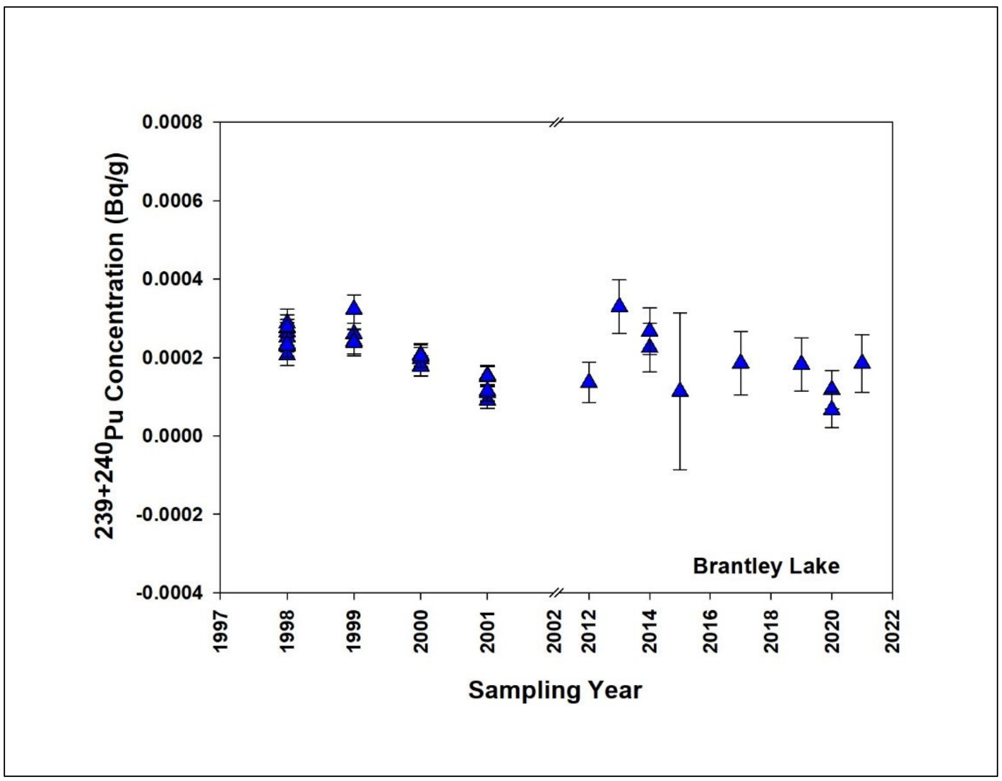
7.3 Results and Discussion

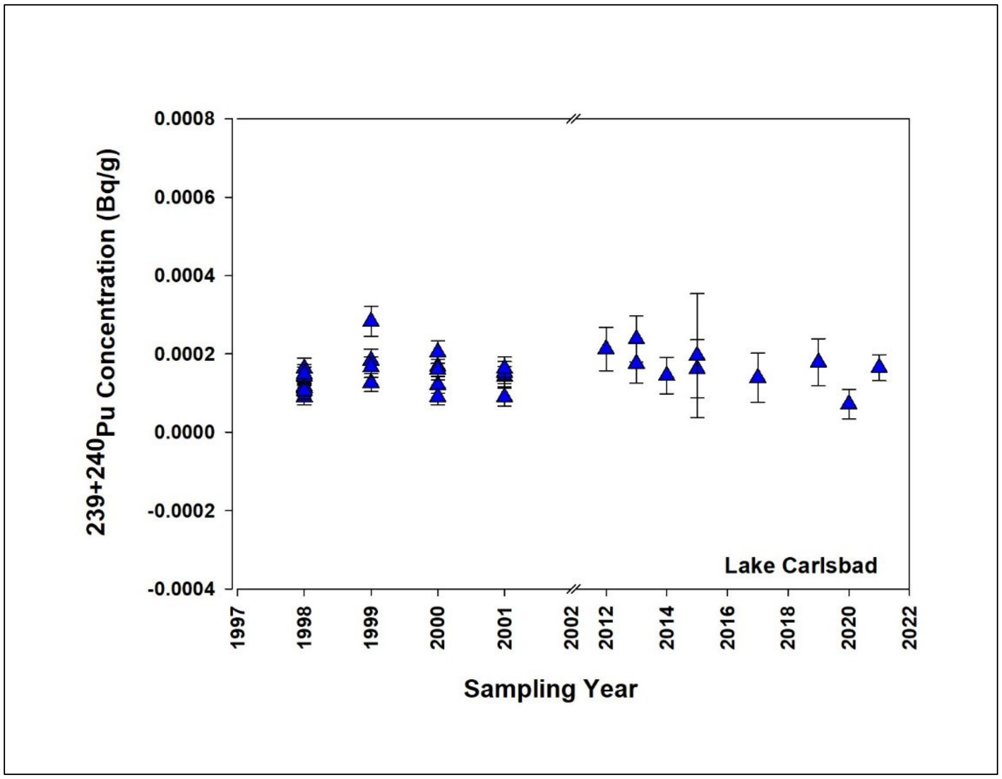
The activities of the actinides and gamma radionuclides in the sediment samples are reported as activity concentrations in Bq/g. The activity concentration is calculated as the activity of radionuclides reported in Becquerel (Bq) divided by the mass of the sediment in grams (g).

7.3.1 Actinide Concentrations in Sediments

The individual concentrations of ^{241}Am, $^{239+240}$Pu, and ^{238}Pu in the sediment samples collected from three regional reservoirs are summarized in Table F.1 (Appendix F). $^{239+240}$Pu concentrations slightly greater than MDC were detected in all sediment samples, while ^{241}Am was detected in two sediment samples, and ^{238}Pu was not detected in any of the sediment samples collected in 2021. The baseline concentrations of $^{239+240}Pu$ ranged from 0.07 to 0.41 mBq/g with the mean values of 0.13±0.03 mBq/g for Lake Carlsbad, 0.26±0.02 mBq/g for the Brantley Lake, and 0.36±0.07 mBq/g for the Red Bluff Lake (CEMRC, 1998). The activity concentrations of $^{239+240}Pu$ in Lake Carlsbad, Brantley Lake, and Red Bluff Lake varied between 0.16 and 0.22 mBq/g. Therefore, the concentrations of $^{239+240}Pu$ measured in the sediment samples in 2021 were within the range of the 1998 baseline phase data.

In the case of soil, levels of radionuclides in the sediment samples from the aforementioned three reservoirs in 2021 showed no detectable increases above those typical of previously measured natural variation. The $^{239+240}Pu$ activities are highest in the sediment collected from Red Bluff Lake (0.22 mBq/g). The $^{239+240}Pu$ activities are lowest in Lake Carlsbad (0.16 mBq/g). The activity concentrations of ^{241}Am in Lake Carlsbad, Brantley Lake, and Red Bluff Lake varied between 0.05 and 0.15 mBq/g. The comparison of activity concentrations of $^{239+240}Pu$ and ^{238}Pu determined that the baseline and monitoring phase activities reflect no increase in radionuclide concentrations for 2021, as shown in Figure 7.3.





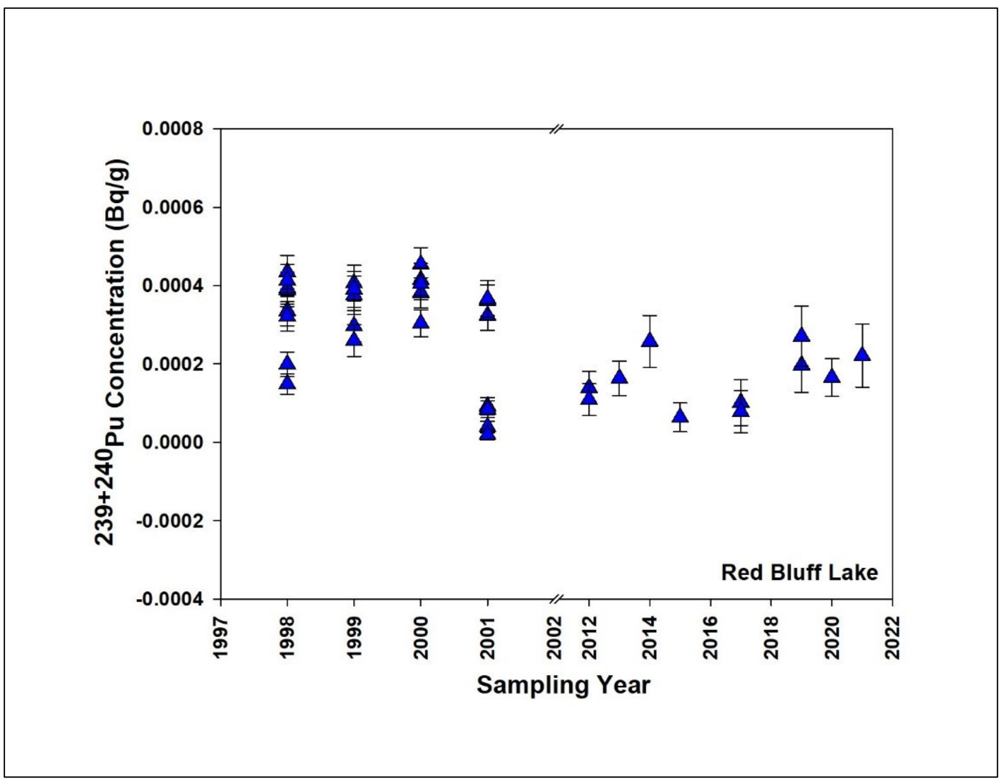
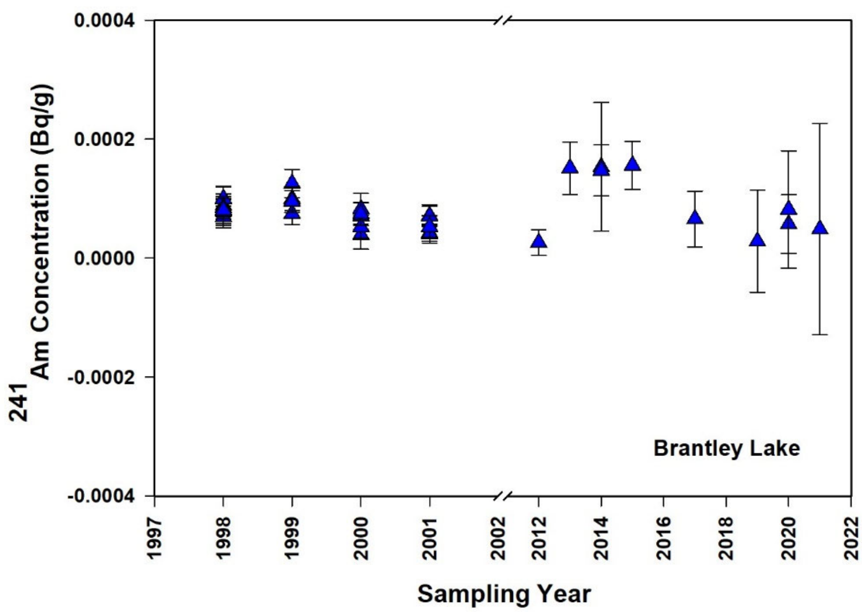
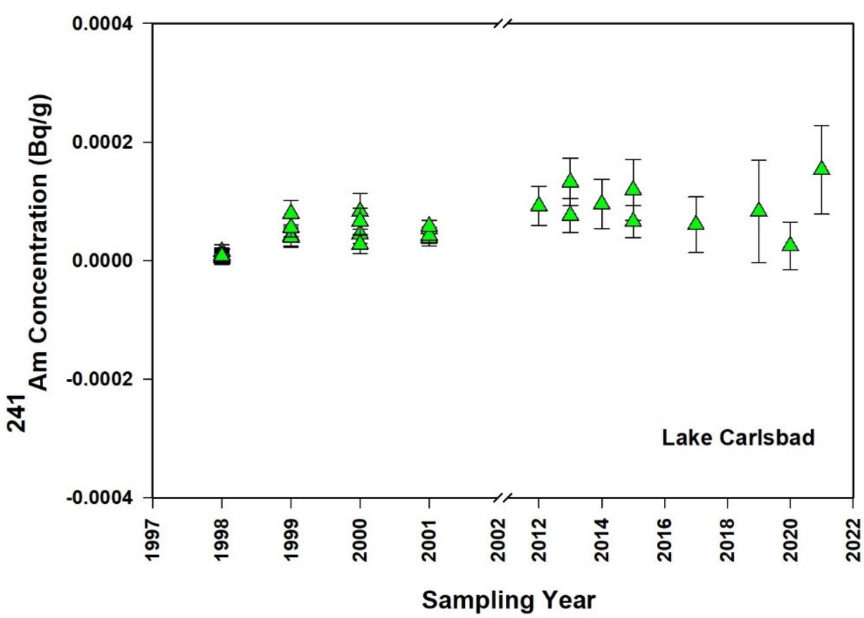


Figure 7.3. Historical Concentrations of $^{239+240}Pu$ in Regional Reservoir Sediments


0.0004
0.0002
0.0000
-0.0002
-0.0004
241Am Concentration (Bq/g)
Brantley Lake
1997
1998
1999
2000
2001
2002
2012
2014
2016
2018
2020
2022
Sampling Year


0.0004
0.0002
0.0000
-0.0002
-0.0004
241Am Concentration (Bq/g)
Lake Carlsbad
1997
1998
1999
2000
2001
2002
2012
2014
2016
2018
2020
2022
Sampling Year

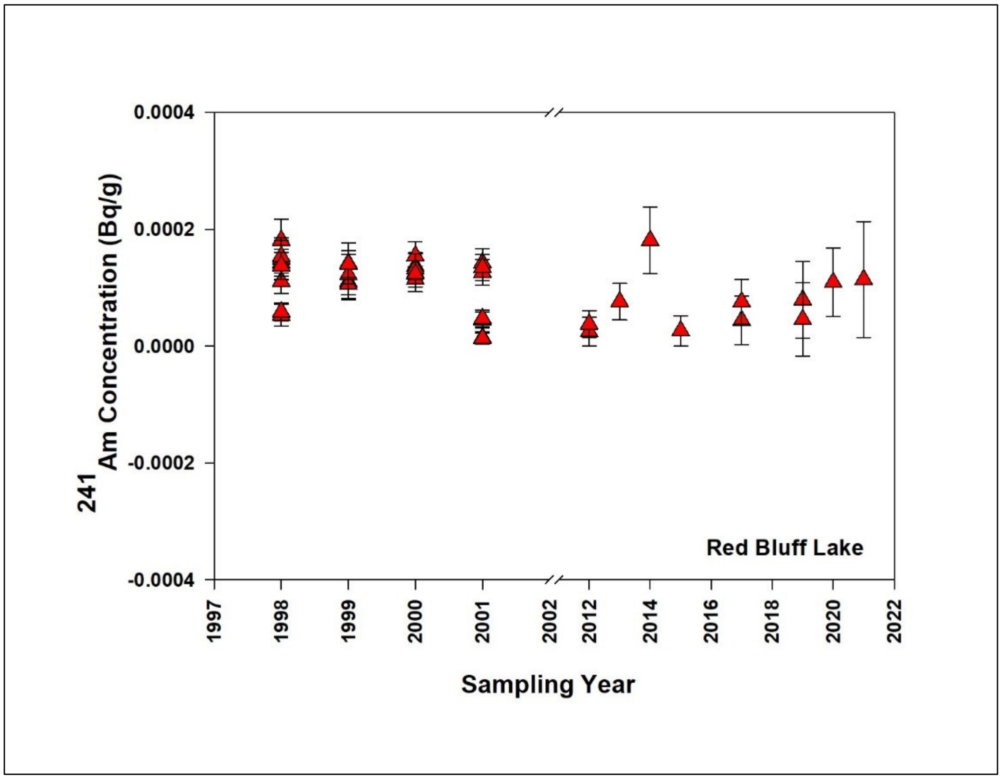


Figure 7.4. Historical Concentrations of ^{241}Am in Regional Reservoir Sediments

7.3.2 Uranium Concentrations in Sediments

Uranium isotopes (^{234}U, ^{235}U, and ^{238}U) were detected in all the sediment samples collected in 2021. The concentrations of uranium isotopes measured in the sediment samples are presented in Table F.2 (Appendix F). The concentrations range of uranium isotopes measured in the sediment samples collected from all three reservoirs in 2021 are shown in Figure 7.5. The concentrations of ^{238}U were lowest in Lake Carlsbad and highest in Red Bluff Lake, while that of ^{234}U were lowest in Carlsbad Lake and highest in Brantley Lake.

Although the sediment concentrations of uranium isotopes were variable between reservoirs, the isotopic ratios were very similar between Carlsbad Lake and Red Bluff Lake. The Lakes appeared to be slightly enriched in ^{234}U compared to ^{238}U, with the activity ratios ranging from 1.29 to 1.75 as shown in Figure 7.6.

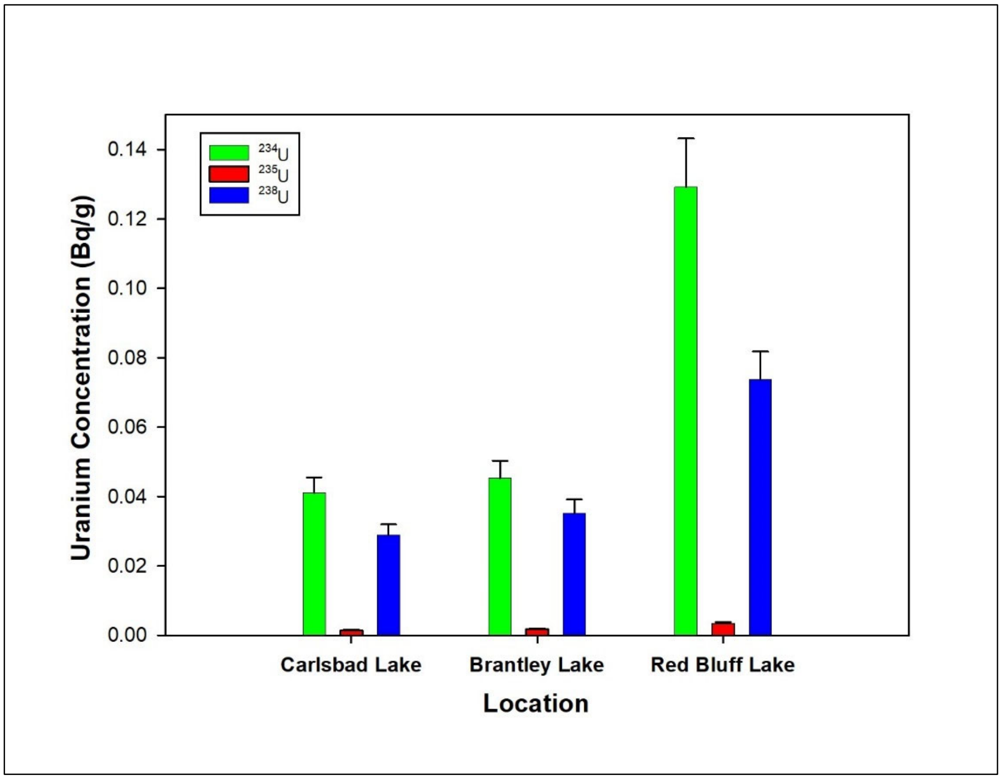


Figure 7.5. ^{234}U and ^{238}U Concentrations in Sediment Samples in Three Regional Reservoirs in 2021

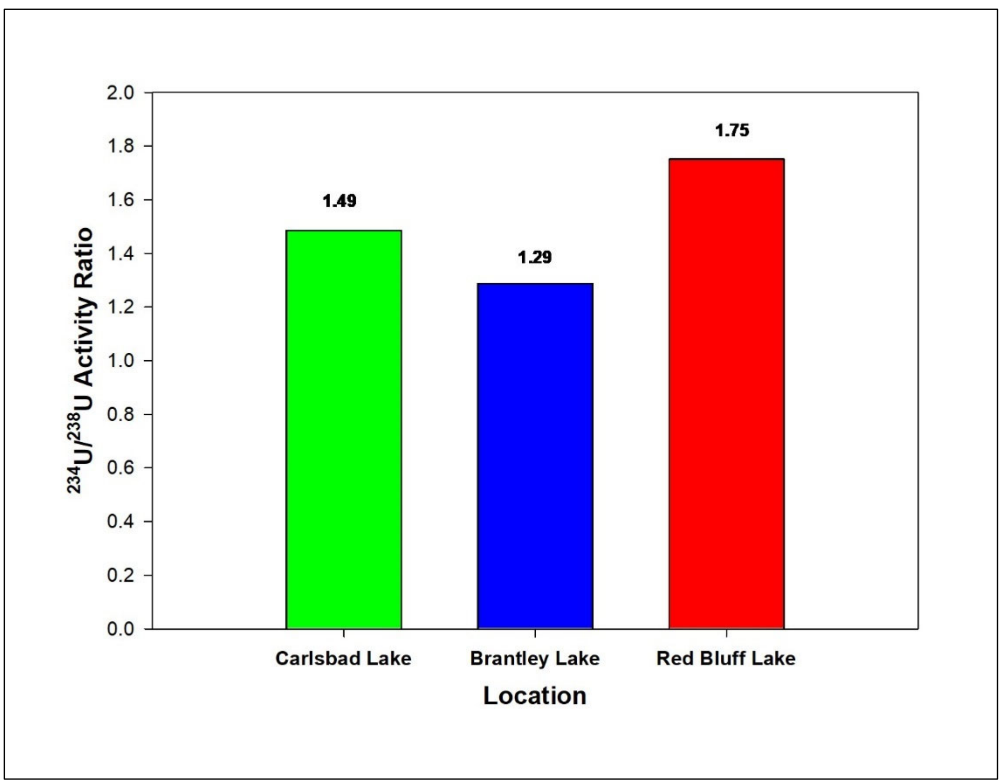
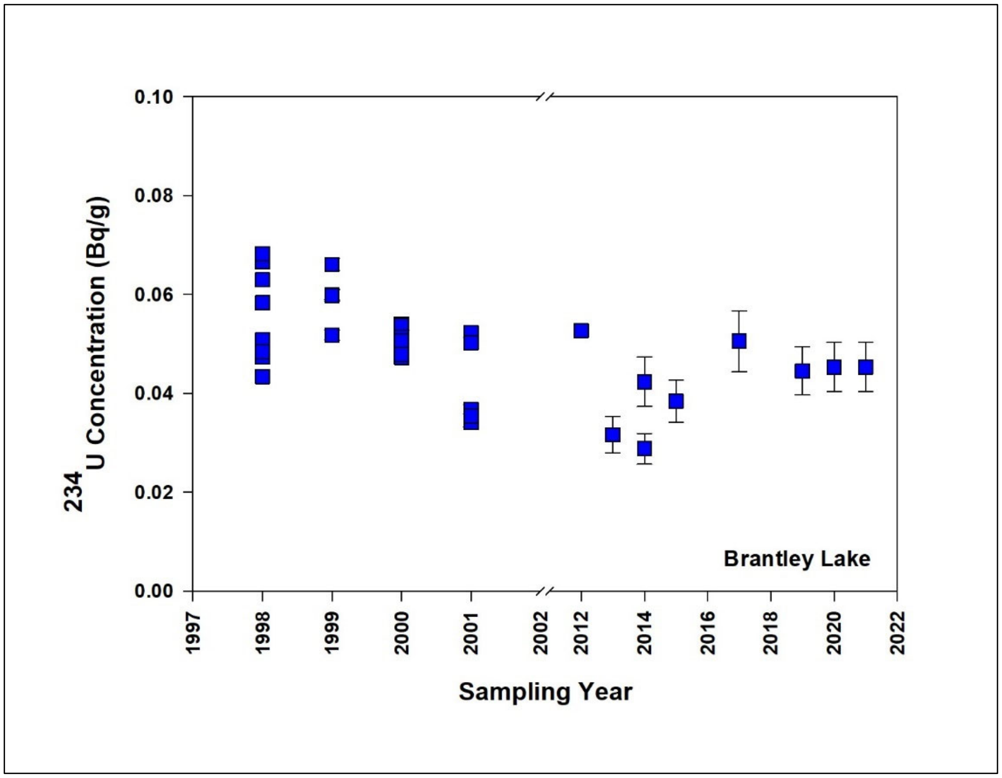
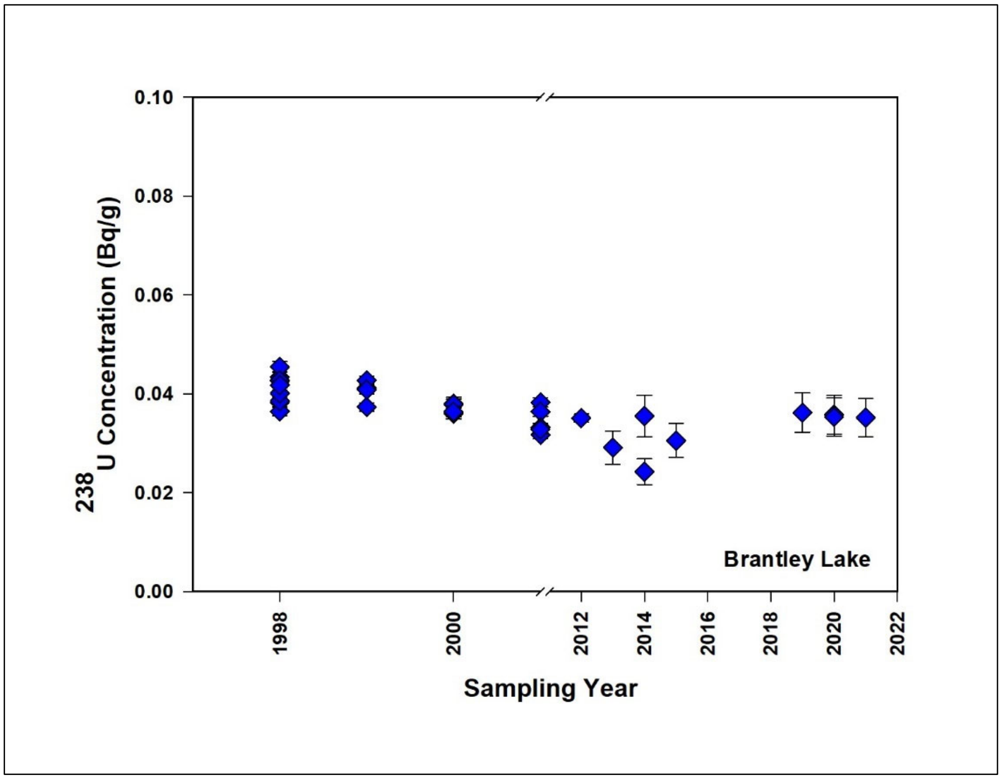
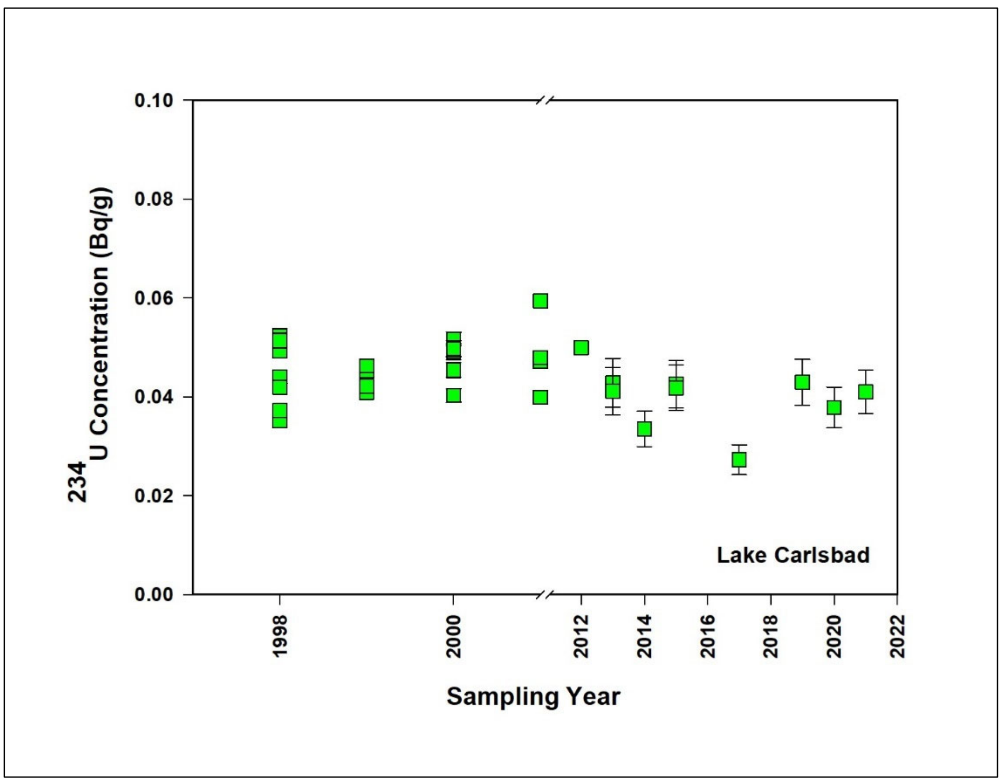


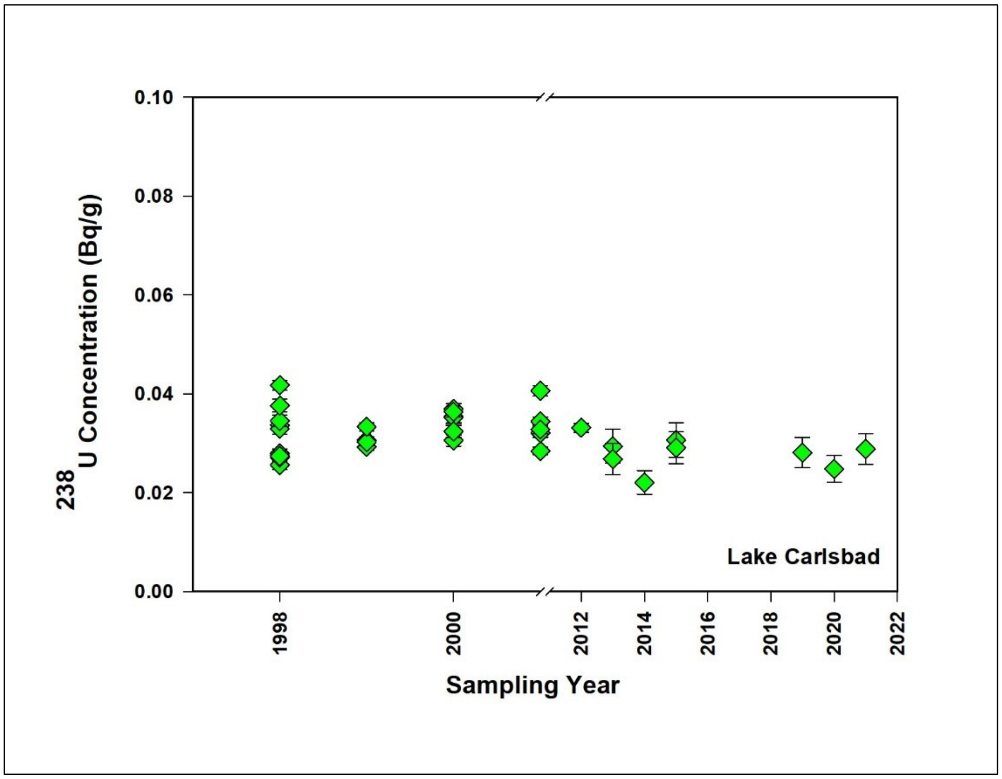
Figure 7.6. The $^{234}U/^{238}U$ Activity Ratio in Sediment Samples in Three Regional Reservoirs in 2021

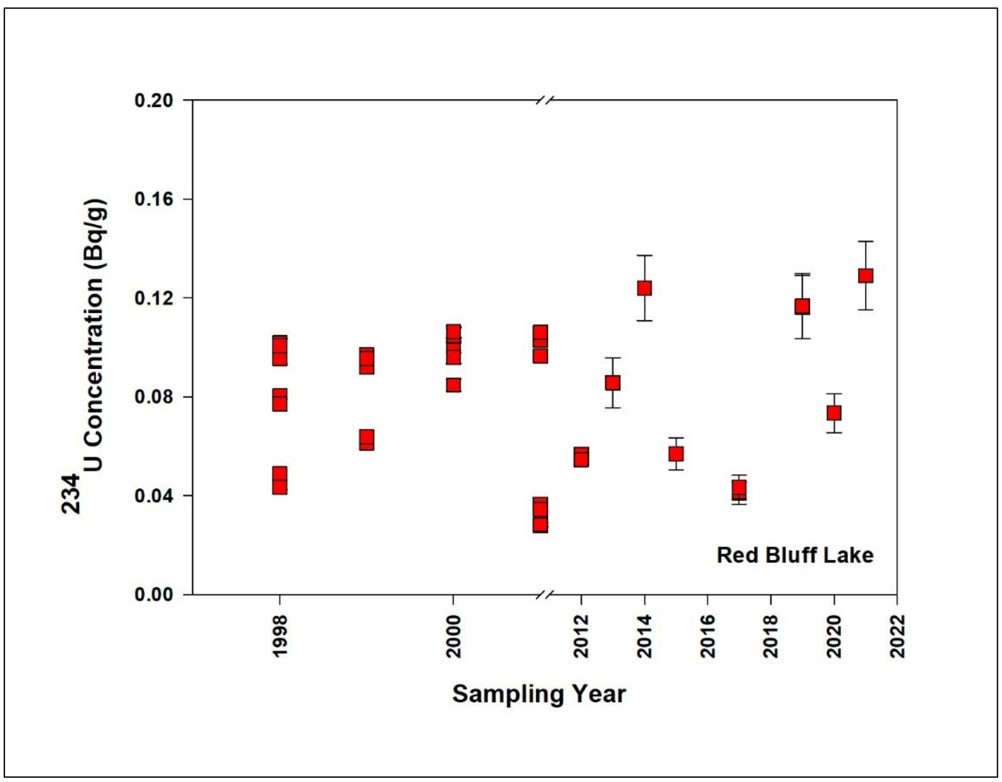
The historical concentrations of uranium isotopes measured in the sediment samples collected from the three reservoirs are shown in Figure 7.7. The activity concentration ranges for these isotopes showed no significant difference between baseline and monitoring phases, considering the 95% confidence intervals of the radio-analytical uncertainty.




0.10
0.08
0.06
0.04
0.02
0.00
^{238}U Concentration (Bq/g)
Brantley Lake
1998
2000
2012
2014
2016
2018
2020
2022
Sampling Year


0.10
0.08
0.06
0.04
0.02
0.00
^{234}U Concentration (Bq/g)
Lake Carlsbad
1998
2000
2012
2014
2016
2018
2020
2022
Sampling Year


0.10
0.08
0.06
0.04
0.02
0.00
238U Concentration (Bq/g)
Lake Carlsbad
1998
2000
2012
2014
2016
2018
2020
2022
Sampling Year


0.20
0.16
0.12
0.08
0.04
0.00
234U Concentration (Bq/g)
Red Bluff Lake
1998
2000
2012
2014
2016
2018
2020
2022
Sampling Year

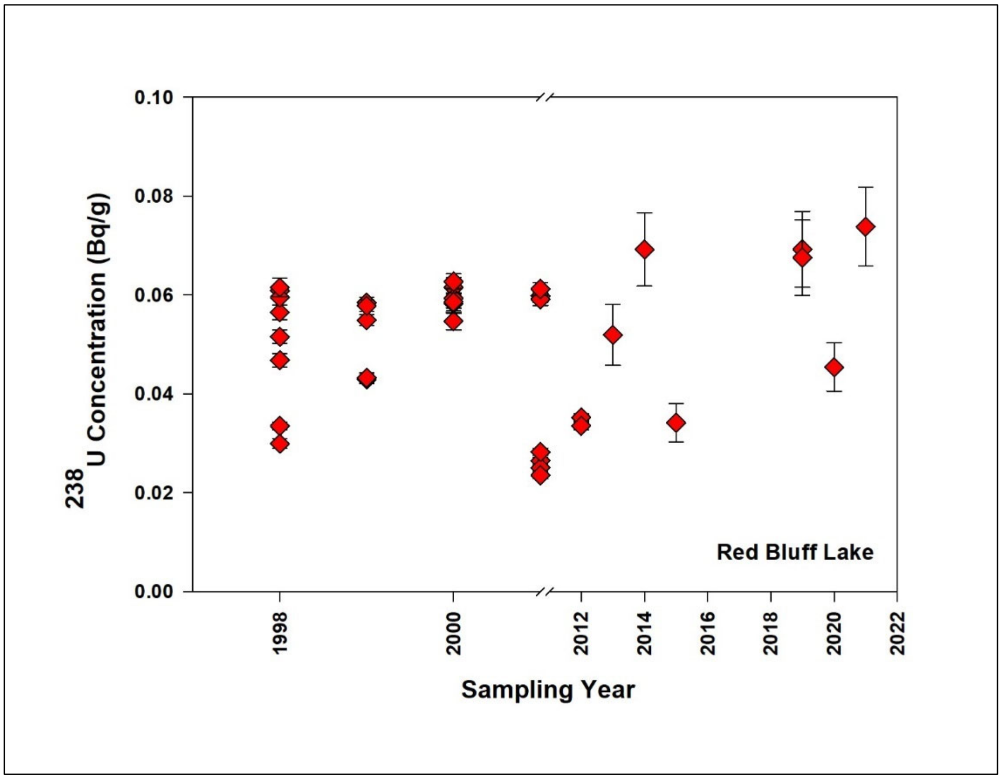
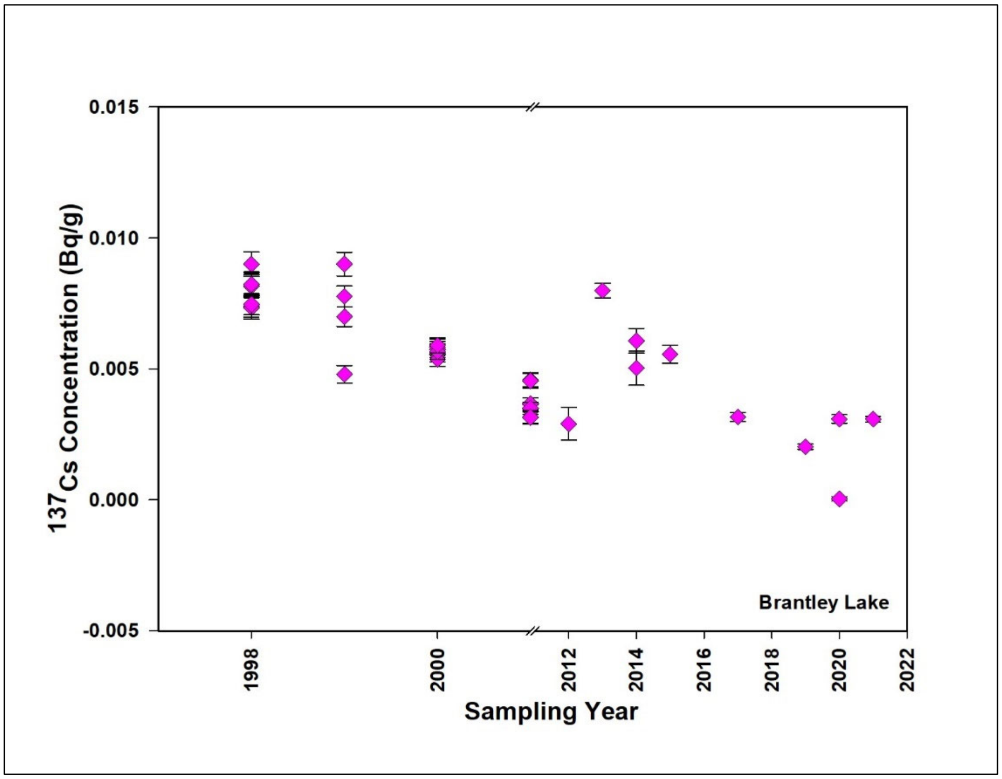


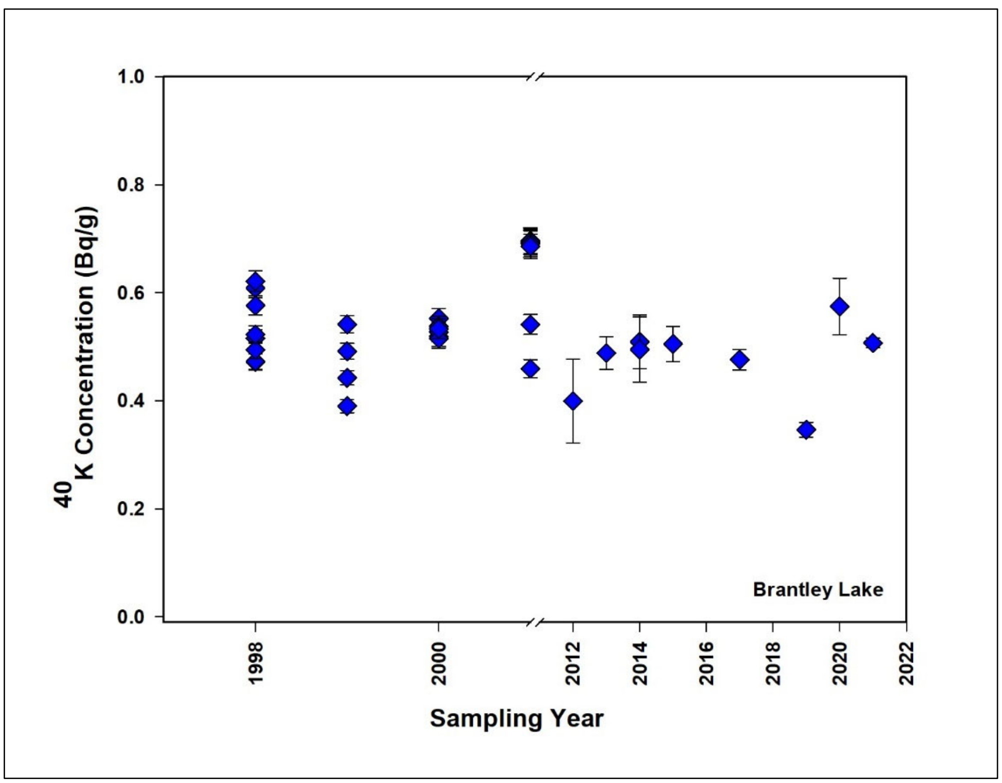
Figure 7.7. Historical Concentration of Uranium in Sediment Samples in Three Regional Reservoirs

7.3.3 Gamma Radionuclide Concentrations in Sediments

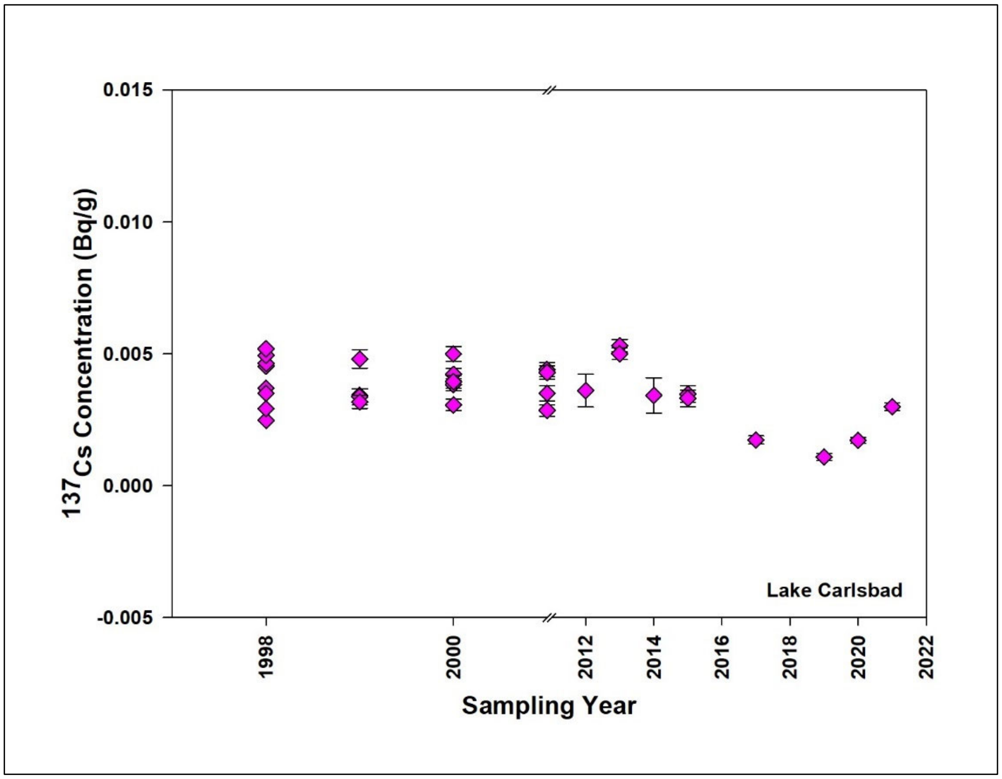
The concentrations of gamma radionuclides in sediment samples are presented in Table F.3 (Appendix F). ^{137}Cs and ^{40}K were detected in all sediment samples. Variability among the ^{137}Cs concentrations was not very significant. The maximum activity concentrations for ^{137}Cs (3.67 mBq/g) were measured in Red Bluff sediment. The ^{137}Cs is a fission product and is consistently found in sediment and soil because of global fallout from atmospheric nuclear weapons testing (Beck and Bennett, 2002; UNSCEAR, 2000). The ^{40}K was also detected in every sediment sample. This naturally occurring gamma-emitting radionuclide is ubiquitous in sediments. There was no significant difference between concentrations of ^{40}K among sampling locations and the values fell within the range of concentrations observed previously in sediment samples in three regional reservoirs around the WIPP site. As shown in Table F.3 (Appendix F), ^{60}Co was not detected at any sampling location. Activity concentrations of ^{137}Cs and ^{40}K compared to that of the baseline and monitoring phase activities reflect no increase in radionuclide concentrations for 2021. Historical plots of ^{40}K and ^{137}Cs concentrations in sediment samples collected from three public reservoirs are shown in Figure 7.8. The concentrations have remained relatively constant over the past 10+ years and generally are indicative of worldwide fallout. Some degree of variability is always associated with collecting and analyzing environmental samples; therefore, variations in sample concentrations from year to year are expected.

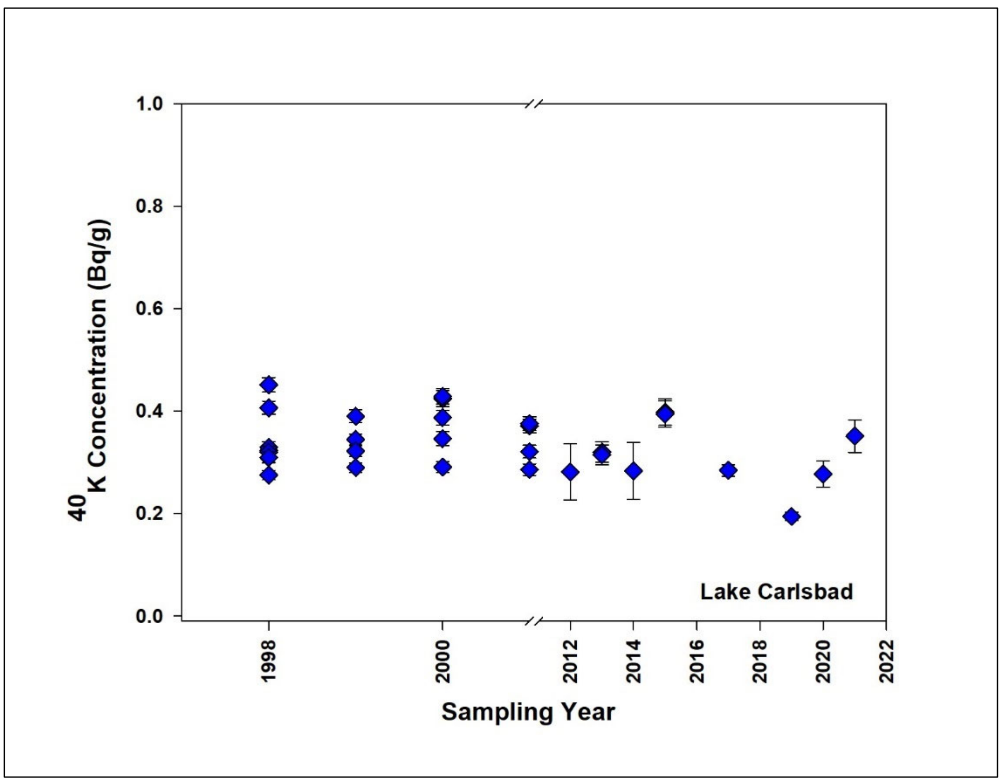


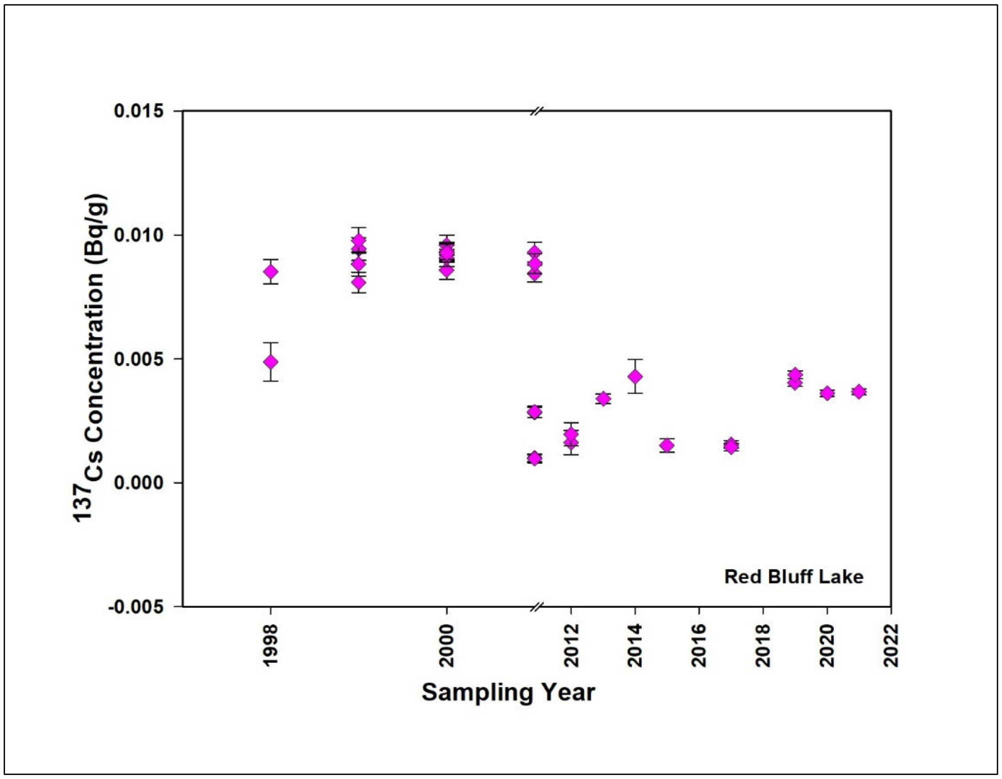
0.015
0.010
0.005
0.000
-0.005
^{137}Cs Concentration (Bq/g)
Brantley Lake
1998
2000
2012
2014
2016
2018
2020
2022
Sampling Year



1.0
0.8
0.6
0.4
0.2
0.0
^{40}K Concentration (Bq/g)
Brantley Lake
1998
2000
2012
2014
2016
2018
2020
2022
Sampling Year


0.015
0.010
0.005
0.000
-0.005
137Cs Concentration (Bq/g)
Lake Carlsbad
1998
2000
2012
2014
2016
2018
2020
2022
Sampling Year


1.0
0.8
0.6
0.4
0.2
0.0
40K Concentration (Bq/g)
Lake Carlsbad
1998
2000
2012
2014
2016
2018
2020
2022
Sampling Year



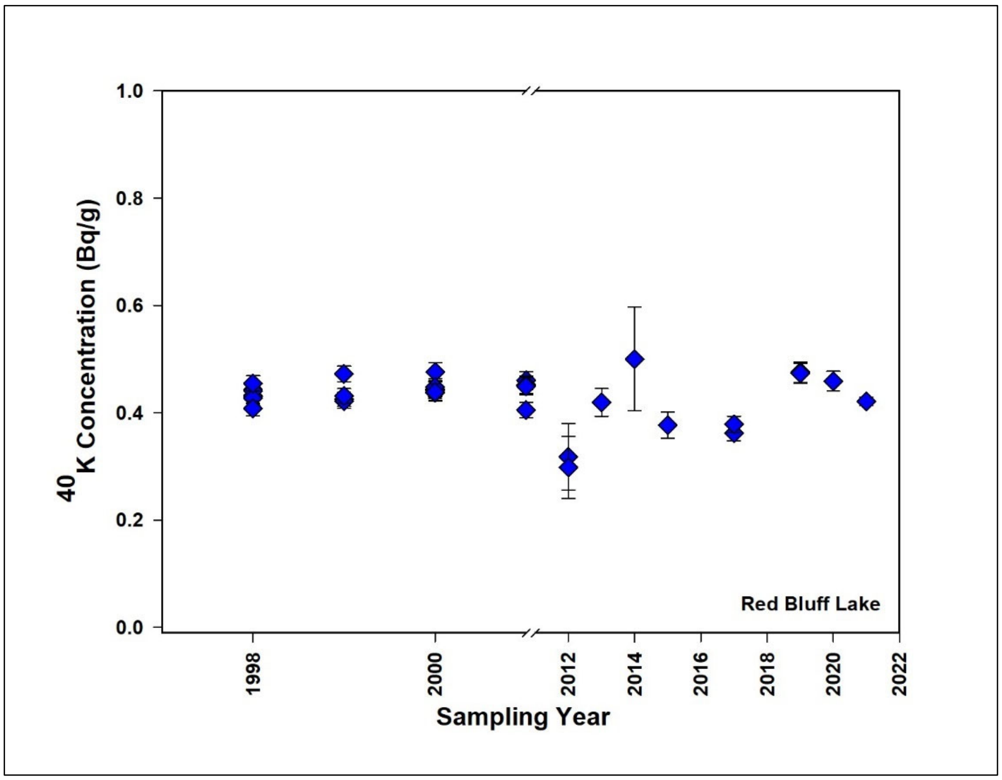


Figure 7.8. Historical Concentration of ^{137}Cs and ^{40}K in Sediment Samples in Three Regional Reservoirs

7.3.4 Strontium Concentrations in Sediments

The beta-radiation-emitting radionuclide ^{90}Sr was not detected in any sediment samples of the region's bodies of water.

7.4 Conclusion

This chapter summarizes the results of the sediment-monitoring program for the calendar year 2021. The $^{239+240}$Pu was detected in all the sediment samples, whereas ^{241}Am and ^{238}Pu were not detected in any of the sediment samples in 2021. The concentration of $^{239+240}$Pu varied in the range of 0.16 to 0.22 mBq/g. Isotopes of uranium were also detected in all the sediment samples. Although the sediment concentrations of uranium isotopes were variable between reservoirs, the isotopic ratios were very similar between Lake Carlsbad and Red Bluff Lake. The Lakes appeared to be slightly enriched in ^{234}U compared to ^{238}U, with the activity ratios ranging from 1.29 to 1.75. Finally, ^{90}Sr was not detected in any of the sediment samples. Present results, as well as the results of previous analyses of sediment samples in the area were consistent for each source across sampling periods. There is no apparent difference between the concentration of the radionuclides collected before and after WIPP started receiving TRU waste. The monitoring results indicate that there is no evidence of increase in sediment radionuclide concentrations that can be attributed to the normal operations of the WIPP.

CHAPTER 8 - VEGETATION MONITORING

8.1 Introduction

Vegetation sampling is a quantitative and adaptable method for sampling specific vegetation types in the field, which can be used for monitoring as a site-specific application. The bioavailable radionuclides from surrounding environments can be accumulated and transported in plants.

To evaluate current conditions, CEMRC sampled vegetation in the vicinity of the WIPP site in 2021. The scope of work requires vegetation samples to be collected annually. Radiological analyses were performed to evaluate current radionuclide trends, especially Pu and Am, in the vicinity of the WIPP site. Details of the sample collection and analyses are described in the following sections.

8.1.1 Sample Collection

Vegetation samples were collected from 5 sites (site 107: Near Field; site 108: Cactus Flats; site 111: Loving; site 112: Carlsbad, CEMRC; site 113: East Tower) which correspond to the aerosol sampling towers. Aerosol sampling tower 106 (Onsite) was not used, because the surrounding area at the WIPP site is entirely paved. Vegetation samples were collected at random short distances and orientations from each tower location. A vegetation sampling location is shown in Figure 8.1. Individual sampling sites were selected on the basis of relatively flat topography, minimum surface erosion, and minimum surface disturbance by human or livestock activity. Samples were obtained using vegetation pruning clippers and plants were cut at least 1 inch above the soil surface. Vegetation preferred by livestock is of particular interest; however, any leafy vegetation is acceptable. Approximately 300-500 g of vegetation were collected. Samples were transferred to the radiochemistry group upon returning to CEMRC.

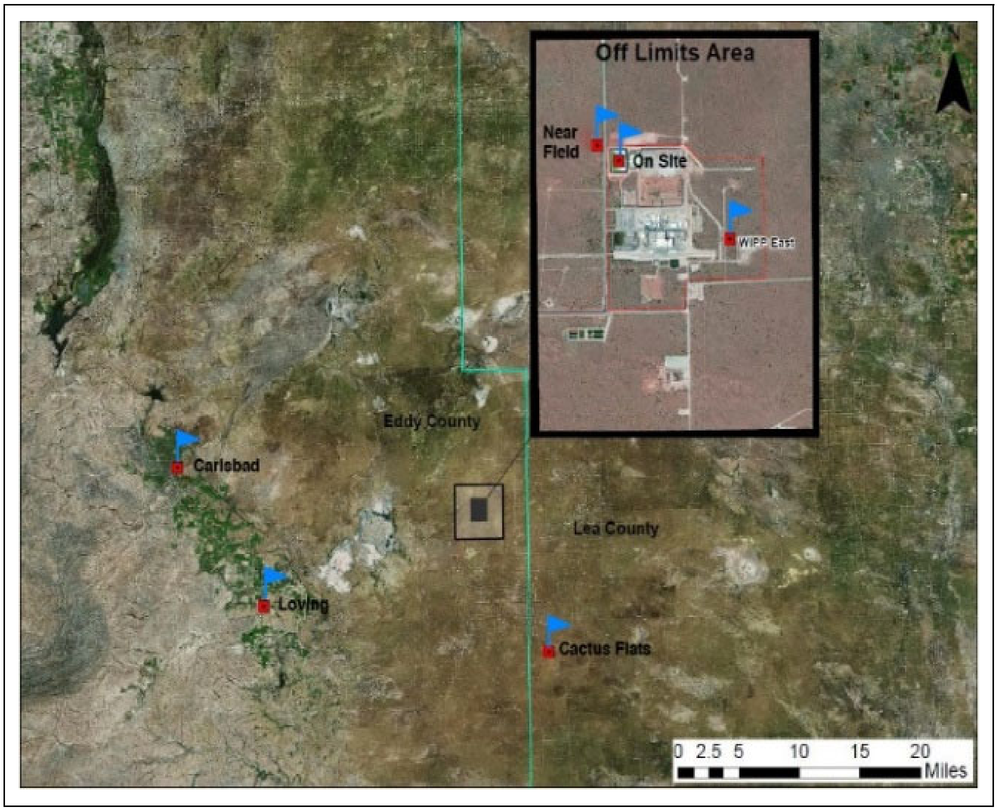


Figure 8.1. Vegetation Sampling Locations

8.1.2 Sample Preparation and Analysis

Vegetation samples were allowed to dry and were ground in ball mill jars overnight until enough fine analytical powders were obtained. Then, the vegetation sample (5 g) was digested in a Teflon beaker with nitric acid. The completely digested solution was counted for 48 h in a high purity germanium detector, HpGe (Mirion Technologies).

For actinide analyses, 4-5 g of each sample was spiked with a radioactive tracer and digested in a Teflon beaker with nitric acid. The actinides were then separated as a group by co-precipitation on $Fe(OH)_3$. Plutonium was separated from americium and uranium using an anion exchange column, while uranium was separated from americium on a TRU chromatography column. After separation, plutonium and uranium fractions were purified on the second anion exchange column, and the americium was subsequently purified from lanthanides on TEVA. Finally, Pu, Am, and U were micro co-precipitated on stainless steel planchettes for alpha spectrometry (Mirion Technologies) and counted for five days as per CEMRC's standard counting protocol.

Portions of digested solutions containing strontium were co-precipitated with barium as a carbonate, then dissolved in nitric acid and barium precipitated out as chromate. The supernatants obtained were mixed with ammonium hydroxide (NH_4OH) and saturated ammonium carbonate $(NH_4)_2CO_3$ to precipitate strontium as strontium carbonate ($SrCO_3$), and the beta-radiation-emitting radioactive isotope ^{90}Sr was then counted by liquid scintillation counting. Details are described in procedure WL-1011.

8.2 Results and Discussion

The activities of the actinides and gamma radionuclides in the vegetation samples are reported as activity concentrations in Bq/g. The activity concentration is calculated as the activity of radionuclides reported in Becquerel (Bq) divided by the mass of the vegetation in grams (g).

8.2.1 Actinide Concentrations in Vegetation Samples

^{241}Am, $^{239+240}Pu$, and ^{238}Pu concentrations were smaller than MDC in all vegetation samples. However, uranium isotopes (^{234}U, ^{235}U, and ^{238}U) were detected in some vegetation samples collected in 2021. The concentrations of uranium isotopes measured in the vegetation samples are presented in Table G.2 (Appendix G). The activity concentrations of ^{234}U in vegetation samples collected from Near Field, Cactus Flats, Loving, Carlsbad, and WIPP East Tower varied between 5.08×10^{-5} and 2.20×10^{-4} Bq/g. The concentrations of ^{234}U in vegetation samples were lowest in the samples collected from Carlsbad and highest in those collected from WIPP East Tower. ^{235}U was only detected in vegetation samples collected from Cactus Flats and Carlsbad, with concentrations of 3.67×10^{-5} and 2.66×10^{-5} Bq/g, respectively. The activity concentrations of ^{238}U in vegetation samples collected from Near Field, Cactus Flats, Carlsbad, and WIPP East Tower varied between 9.12×10^{-5} and 1.56×10^{-4} Bq/g. The concentrations of ^{238}U in vegetation samples collected in Carlsbad were the lowest, while the highest ^{238}U was measured in the samples collected from Cactus Flats.

8.2.2 Gamma Radionuclide Concentrations in Vegetation Samples

^{137}Cs and ^{60}Co were not detected in any vegetation samples. ^{40}K was detected in vegetation samples collected from Near Field, Loving, Carlsbad, and WIPP East Tower. The ^{40}K concentration in vegetation samples varied between 105 and 412 Bq/kg. The concentrations of ^{40}K in vegetation samples collected from Carlsbad were the lowest, while the highest ^{40}K were measured in those collected from the WIPP East Tower.

8.2.3 Strontium Concentrations in Vegetation Samples

^{90}Sr was not detected in the vegetation samples collected from Cactus Flats, Near Field, Loving, and WIPP East Tower. Only in Carlsbad was ^{90}Sr detected with concentration of 9.63×10^{-2} Bq/g. Note, however, that ^{90}Sr was not detected in the duplicate sample collected from Carlsbad.

8.3 Conclusion

This chapter summarizes the results of the vegetation-monitoring program for the calendar year 2021. The ^{241}Am, $^{239+240}Pu$, ^{238}Pu, ^{137}Cs, or ^{60}Co were not detected in any of the vegetation samples. ^{234}U, ^{235}U, ^{238}U, ^{40}K, and ^{90}Sr were detected in some vegetation samples. The concentration of U isotopes varied in the range of 3.67×10^{-5} to 2.22×10^{-5} Bq/g. ^{40}K

concentration varied between 0.11 and 0.41 Bq/g. ^{90}Sr concentration was detected in only one sample from the Carlsbad area but not the duplicate sample from the same area.

CHAPTER 9 - IN-VIVO MONITORING

The *in vivo* (or direct) radio-bioassay is a measurement of the human body to determine the amount of radioactive material in the body. CEMRC's Internal Dosimetry (ID) Laboratory has been performing *in-vivo* radio-bioassay measurements for radiological and radiation control workers. Additionally, CEMRC's ID Laboratory provides free radio-bioassay service to the public residing within a 100-mile radius of the WIPP site through a program called "Lie Down and Be Counted" (LDBC) since 1997. The LDBC program is the most public aspect of CEMRC and is open to adult residents and children aged 13 and older living within a 100-mile radius of the WIPP site. The purpose of the LDBC program was to establish a baseline of "normal" or "background" radiation present in adults living in the region of the WIPP prior to the emplacement of radioactive waste in the WIPP. Further, once disposal operations began at the WIPP, the LDBC program allows for the continued monitoring of public citizens to determine if WIPP-related disposal activities have any observable impact on area residents' health. Concerned citizens are encouraged to have the *In vivo* radio-bioassay to see what radiation might exist in their lungs and whole body. The data collected prior to the operation of the WIPP TRU waste management serves as a baseline for comparisons with periodic follow-up measurements that are slated to continue through the operational phase of the WIPP.

The LDBC program uses a state-of-the-art lung and whole-body counting system that can measure the body's burden of radioactive elements at extremely low levels. The CEMRC ID laboratory has unique capabilities to detect internal deposited radionuclides in the body. The procedure is non-intrusive; participants are asked to follow a small number of steps before lying down on a test bed inside of a counting room for 30 minutes, allowing for measurements to be taken. Participants will then go over their results with a CEMRC scientist. Each participant contributes to scientific research conducted by the center. Since 1997, whole-body counting has been performed at CEMRC.

The current scope of work requires CEMRC's ID laboratory to perform whole-body measurements for the Department of Energy-Carlsbad Field Office (DOE-CBFO), DOE contractors, radiological and radiation workers, and the public residing within a 100-mile radius of the WIPP site. In the event of an incident or accidental release, *in vivo* measurements will be performed for DOE clients and contractor staff within the first two days after the event. In the event of a scheduling conflict, the DOE and contractor staff's *in vivo* measurements will receive priority over non-DOE clients and members of the public. The results of in vivo measurements for members of the public will be reported in an aggregated form and all necessary precautions will be taken to ensure confidentiality and to avoid the release of individualized data. Unexpected positive results from any *in vivo* measurement will trigger an automatic recount. Details of the *in vivo* counting facility, bioassay methodologies, and demographic characteristics counting method are described in the following sections. This chapter provides an overview of the ongoing public radio-bioassay measurements through December 31, 2021.

9.1 *In vivo* Counting Facility

The *in-vivo* counting facility consists of a large, shielded counting chamber made from pre-1945 cast iron to limit the background radiation and an instrument control workstation in the adjacent room. Radio-bioassay operations are performed from the instrument control workstation. The operations room is also equipped with a video display terminal and intercom that are used to monitor subjects during the measurement. The counting chamber as shown in Figure 8.1 is equipped with high purity *germanium detector* arrays designed specifically for *lung* and *whole-body counting, an* oxygen monitor, a video camera, emergency backup lights, and a voice-activated intercom for the subjects to communicate with the operator at any time during the counting process. The counting facility is also equipped with a music system to help participants relax during counting. Four lung detectors are located on top of the bed and are positioned close to the counting subject's chest and four whole-body detectors are also located under the bed. The whole-body detectors face the torso and upper leg parts of the body. CEMRC's ID laboratory has met the requirements and recommendations of the DOE Implementation Guide for Internal Dosimetry Programs (10 CRF 835) and the American National Standards Institute Performance Criteria for Radio-bioassay (ANSI/HPS N13.30) (1996, 2011) and continues to meet the most current criteria for radio-bioassay measurements.

Figure 9.1. The Whole-Body Counting Facility at CEMRC

9.2 Minimum Detectable Activity

The minimum detectable activity or MDA is an *a priori* value used to evaluate the laboratory's ability to detect a radionuclide in a person. The MDA is defined as the amount of a radionuclide that, if present, would be detected 95% of the time under the routine operation of a facility. The MDA is used to measure the efficacy of a facility and should not be used to decide if a specific radio-bioassay has or has not detected activity within a person (ANSI/HPS N13.30, 1996). To determine whether activity has been detected in a particular person, the parameter L_C (decision Level) is used. The L_C represents the 95th percentile of a null distribution resulting from the differences of repeated, pair-wise background measurements. An individual result is assumed to be statistically greater than background if it is greater than the L_C. It is important to note that the use of this criterion will result in a statistically inherent 5% false positive error rate (5% of all measurements will be determined to be positive when there is no true activity in the person). Details of MDA and L_C calculations can be found elsewhere (CEMRC, 1998; ANSI/HPS N13.30, 1996; Webb and Kirchner, 2000).

The details of energy and efficiency calibration of the lung and whole-body counting detectors are discussed in greater detail in a previous CEMRC Report (CEMRC, 2017). The lung detector efficiency varies with the person's chest wall thickness (CWT). Average MDA (nCi) with one standard deviation and percent variation for lung and whole-body detector systems are provided in Appendix H, Tables H.1 and H.2, respectively. One complicating factor in the measurement of low-energy photon emissions from the lung is the absorption of photons in the tissue overlying the lung – adipose (fat), muscle, cartilage, and bone. The thickness of these tissues and, consequently, the attenuation can vary significantly from one individual to the next. This is particularly important for the detection of the 17 keV plutonium X-rays. At this energy, 6 mm of muscle can attenuate half of the transmitted X-rays. In the early days of lung counting, height/weight relationships had been used to estimate the CWT, but these were crude and could easily lead to errors of a factor of 2 or more (CDC, 2006, page 27). For routine *in vivo* radio-bioassay measurements where no lung activity is expected, CEMRC ID uses an empirically derived prediction algorithm to estimate chest wall thickness, using easily measurable physical parameters, namely height and weight of the subject (RB-TBM-016, 2020). This prediction algorithm is based on a composite of the works by Fry et al (1980), Garg (1977), and Dean (1973) and also chosen by CDC (CDC, 2006, page 30). In cases where a precise measurement of chest wall thickness is critical (e.g., when an intake of an insoluble radionuclide is probable or suspected) CEMRC has an established ultrasonic procedure that could be used in-lieu of the prediction algorithm. Ultrasonic measurements of the chest yield both thickness and composition. The arrangement for ultrasonic measurement is the responsibility of the participant.

A routine radio-bioassay program should be able to detect intakes within a year that will deliver a Committed Effective Dose of 100 mrem. If this performance objective cannot be met, then a performance shortfall is said to exist. The current version of CEMRC's Lung and Whole-body Counting technical manual (RB-TBM-016, 2020) provides a detailed comparison of lung and whole-body detector system's MDAs with an annual limit of intakes.

9.3 Volunteer Participation in the LDBC Program (1997 to 2021)

Between July 21, 1997, and March 26, 1999 (a period referred to as the "pre-operational" phase), CEMRC ID laboratory had counted 366 public volunteers. This group of 366 measurements constituted the pre-operational baseline to which subsequent results are compared. The WIPP became operational on March 27, 1999. Counts performed after the WIPP became operational are referred to as the "operational" phase monitoring. Between March 27, 1999, and December 31, 2021, CEMRC ID laboratory had counted 1205 public volunteers. These measurements include baseline count (individuals counted for the first time), routine count (counting of previously measured participants, counts performed on individuals at least after two years following the baseline count), and recounts (repeat counts to confirm a positive result). The total number of public volunteers who have participated in the LDBC program between July 21, 1997, and December 31, 2021, are shown in Figure 9.2.

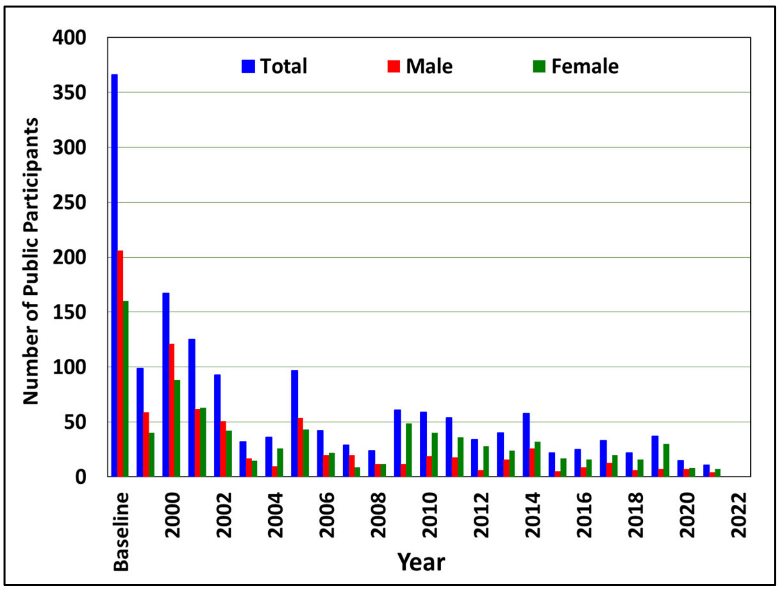


Figure 9.2. Number of LDBC Public Participants from 1997-2021

In addition to the LDBC public counts, the CEMRC ID laboratory also provides *in vivo* radio-bioassay service to Waste Control Specialists (Andrews, TX), Los Alamos National Laboratory, Carlsbad Office, WIPP laboratories (located at CEMRC) and Nuclear Waste Partnership personnel. The total number of radio-bioassay measurements performed through December 2021 is 5709, which includes baseline (in this context baseline means the first time counted at CEMRC), routine, recounts, exit, potential intake, and any other special counts on radiological workers.

9.4 Demographic Characteristics

Public volunteers participating in the LDBC project are asked to complete a questionnaire to gather a demographic profile of the participants, such as age, gender, ethnicity, occupation, foreign travel, wild game consumption, smoking habits, and any nuclear medicine procedures. Appendix H, Table H.3 compares the LDBC demographic characteristics between the baseline and operational phase date. An increase of voluntary participation by Hispanics from 13.4% to 23.6% can be seen during the period between 1999 and 2021. According to the U.S. census, the percentage of the Hispanic population nationwide for this same time period increased from 12.5% to 18.9% and from 42.1% to 50.1% in the State of New Mexico. In addition, it is important to note that if the presence of a radionuclide is dependent on a subclass of interest (i.e., gender, ethnicity, etc.), valid population estimates can still be made by correcting for the proportion of under- or over-sampling for the particular subclass. Variations observed for the remainder of the demographic characteristics are also listed in Appendix H, Table H.3.

9.5 Results and Discussion

9.5.1 LDBC Results Greater Than the Decision Limits (L_C)

The LDBC results greater than the decision limits (LC) for the baseline and operational measurements for the period 1997-2021 are listed in Appendix H, Table H.4. Results listed in Appendix H; Table H.4 are for the participants counted only once. For the baseline measurements (N = 366), the percentage of results greater than L_C were consistent with a 5% random false-positive error rate, at the 95% confidence level (1% to 9%), for all radionuclides except ^{232}Th via the decay of ^{212}Pb, ^{235}U/^{226}Ra, ^{60}Co, ^{137}Cs, ^{40}K, ^{54}Mn, and ^{232}Th via the decay of ^{228}Ac. As discussed in the 1998 report, five of these radionuclides [^{232}Th via ^{212}Pb, ^{60}Co, ^{40}K, ^{54}Mn (^{228}Ac interference), and ^{232}Th (via ^{228}Ac)] are part of the shield-room background and positive detection is expected at low frequency. The ^{40}K is a naturally occurring isotope of an essential biological element, so detection in all individuals is expected. ^{137}Cs and ^{235}U/^{226}Ra are not components of the shielded room background and were observed at frequencies greater than the 95% confidence interval for the false-positive error rate, discussed in more detail below.

For the operational measurement (N = 1214), the percentage of results greater than L_C were consistent with the baseline at a 95% confidence level (margin of error), except for ^{60}Co and ^{232}Th (via ^{228}Ac). For these radionuclides, the percentage of results greater than L_C decreased relative to the baseline. This would be expected for ^{60}Co, given that it has a relatively short half-life (5.2 years) and the content of ^{60}Co within the shield has decreased via decay by approximately 80% since the baseline phase of monitoring. The differences in ^{232}Th (via ^{228}Ac) results between the baseline and operational monitoring phase were also observed in 2001 and 2002 and are likely due to the replacement of aluminum (tends to contain Th and U) in some of the detector cryostat components with those manufactured from low radiation background steel.

The percentage of results greater than L_C for ^{235}U/^{226}Ra (11% for the baseline) is significantly higher than the distribution-free confidence interval for a 5% random false-positive error rate. These data are not nearly as compelling as those for ^{137}Cs, but the large sample size of the current cohort tends to support the observed pattern. ^{235}U and ^{226}Ra cannot be identified separately by individual gamma energies by the current operating system. The activity result is reported together for ^{235}U and ^{226}Ra using the 186 keV gamma ray. Currently, MDA activities of ^{235}U and ^{226}Ra are calculated using their respective abundances for the 186 keV gamma ray. During the 2019-2020 upgrade testing of the facility, the feasibility of identification of ^{235} U by 185.72 keV gamma ray (57% abundance) and ^{226}Ra by 186.21 keV gamma ray (3.64% abundance) was considered; implementation is pending until the system is upgraded to APEX In vivo operating system possibly by the end of 2022. If software resolution of the 185.7 keV and 186.2 keV gamma peaks which are only 0.5 keV apart becomes possible then the 95% confidence level of determining ^{235}U and ^{226}Ra will be re-evaluated.

The ^{40}K results have been positive for all participants counted both before and after WIPP became operational. For the in-vivo radio bioassays performed during the period from 7/2/1/1997 to 12/31/2021, for the public participants, the ^{40}K body burden is in the range from 550 to 5559 Bq per person. For the period 7/2/1/1997 to 12/31/2021, the overall mean ^{40}K value ± standard error (SE) is 2384 (± 20) Bq per person, 3011 (± 25) Bq per person for males, 1841 (± 15) Bq per person for females. The ^{40}K content in the body of an adult person with body weight 70 kg ranges from 4,000 to 5,000 Bq (ICRP Publication 23, 1975). Figure 9.3 shows the number of LDBC participants with ^{40}K values > L_C. Such results are expected since ^{40}K is an essential biological element contained primarily in muscle. The amount of potassium in the body is proportionate to the muscle mass, which depends on sex, age, and physical activity level. Muscle mass also depends on human ethnicity, height, and body weight (Silva 2010, He et al., 2003). The ^{40}K average value per person for males was significantly greater than that of females because in general, males tend to have larger body sizes and greater muscle content than females. These results are consistent with findings previously reported in the CEMRC reports and elsewhere (Webb and Kirchner, 2000). The mean ^{40}K value (± SE) for males tends to be significantly greater than that of females. This is expected since, in general, males tend to have larger body sizes and greater muscle content than females. Figure 9.4 shows the ^{40}K activities in the LDBC participants through December 2021.

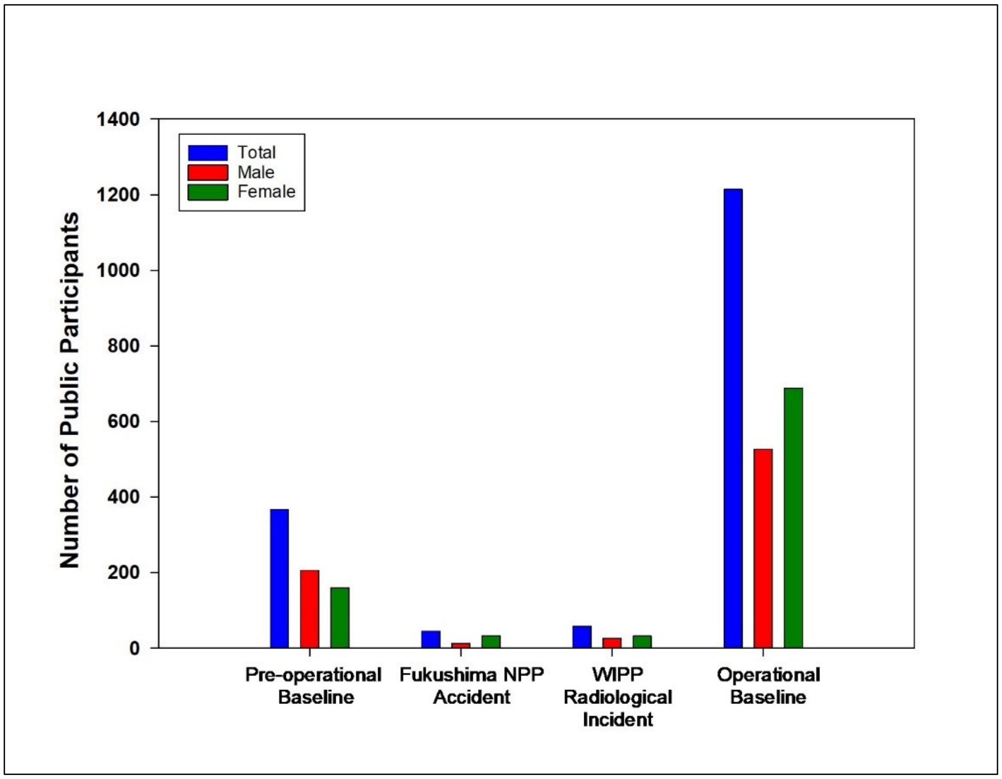


Figure 9.3. Number of Participants with ^{40}K Results Greater Than L_c during 1997-2021

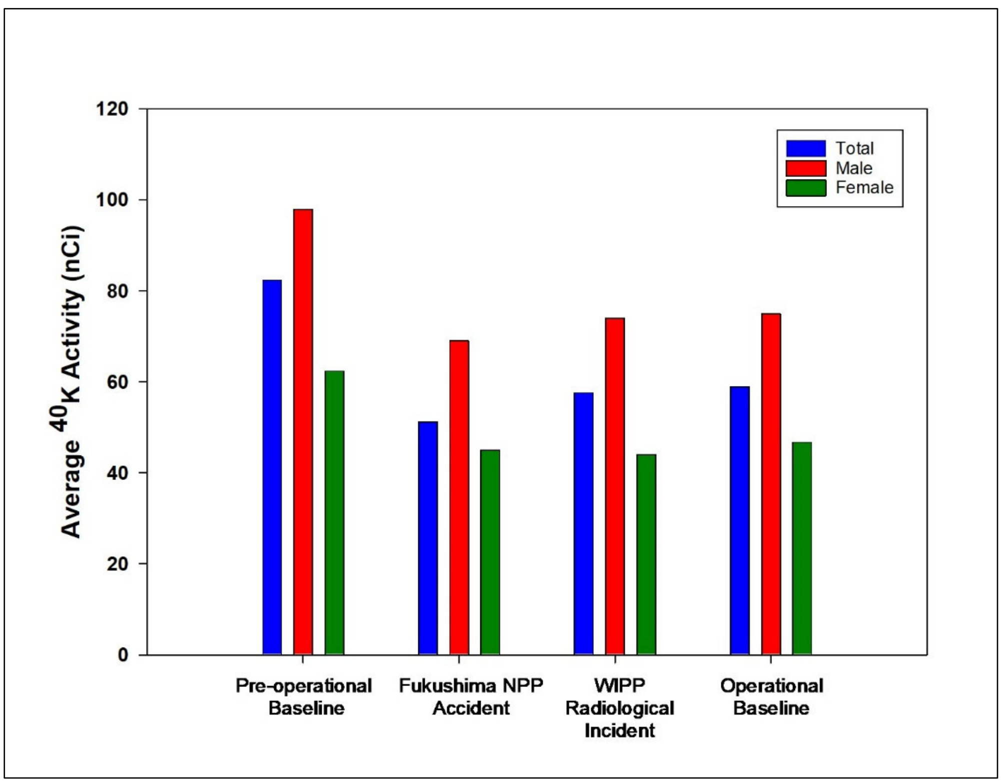


Figure 9.4. Average ^{40}K Activity (nCi) Among LDBC Participants During 1997-2021

Detectable ^{137}Cs is present in about 28% (95% confidence level) for baseline, and 16.6% operational monitoring counts of citizens living in the Carlsbad area as shown in Figure 9.5 and Table H.4. These results are consistent with findings previously reported in the CEMRC reports and elsewhere (Webb and Kirchner, 2000). Detectable ^{137}Cs body burdens ranged from 5 to 128 Bq per person with an overall mean (± SE) of 10 (± 1) Bq per person. The mean ^{137}Cs body burden for males (± SE), was 11 (± 1) Bq per person, which was significantly greater than that of females, which was 10 (± 1) Bq per person (Figure 9.6). As previously reported (CERMC Reports; Webb and Kirchner, 2000) the presence of ^{137}Cs was independent of ethnicity, age, radiation work history, consumption of wild game, nuclear medical treatments, and European travel. However, the occurrence of detectable ^{137}Cs was associated with gender where males had a higher prevalence (65%) of ^{137}Cs relative to females (35%).

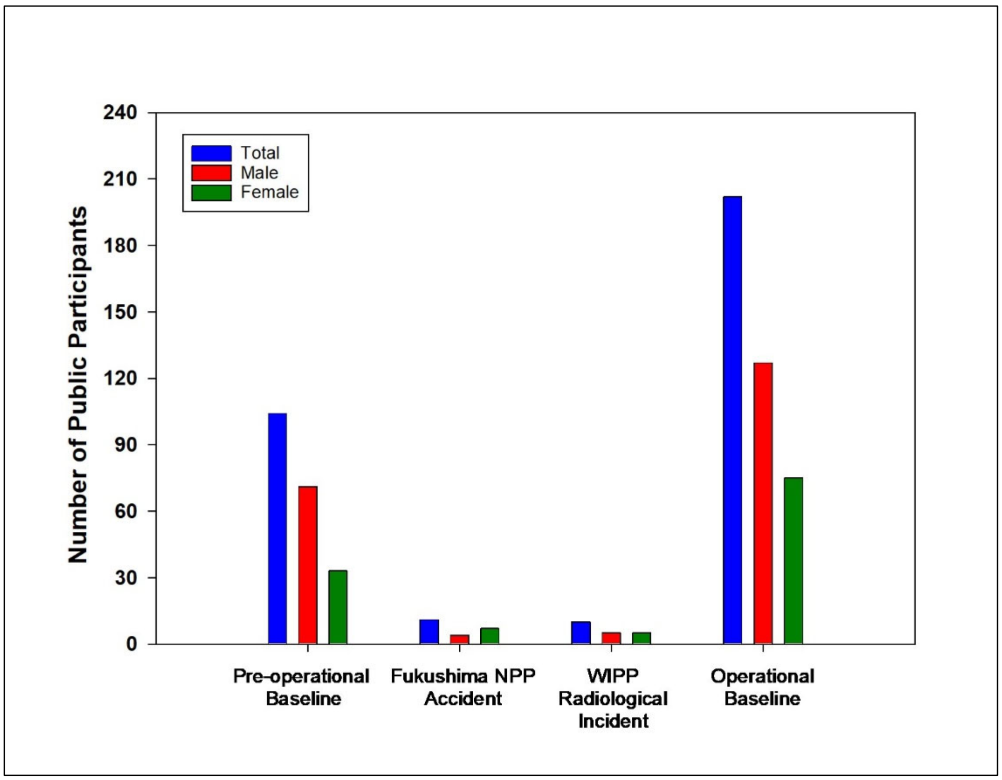


Figure 9.5. Number of Participants with ^{137}Cs Results Greater Than L_c during 1997-2021

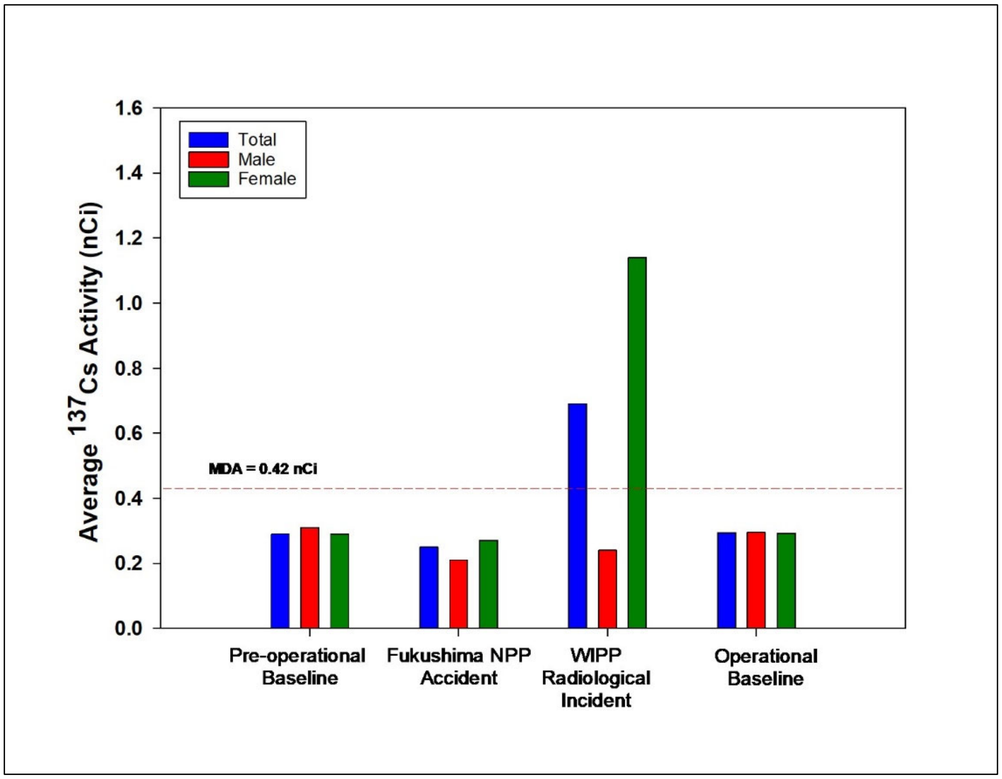


Figure 9.6. Average ^{137}Cs Activity (nCi) Among LDBC Participants During 1997-2021

Furthermore, the presence of ^{137}Cs was associated with smoking. Smokers had a higher prevalence of detectable ^{137}Cs (29.7%) as compared to non-smokers (24.1%) (CEMRC Report, 2005/2006). The association with gender is likely related to the tendency for a larger muscle mass in males than in females, as supported by the ^{40}K results. The association of ^{137}Cs with smoking could be related to the presence of fallout ^{137}Cs in tobacco, a decreased pulmonary clearing capability in smokers, or other as yet unidentified factors.

Plutonium and americium isotopes, the main component of the WIPP's waste, were also monitored among the public. Lung counting is the primary method for determining intakes of Pu isotopes and ^{241}Am. The lung burdens of plutonium isotopes and ^{241}Am in public participants were measured using the 17 keV X-ray line for plutonium isotopes and the 59.5 keV gamma line for ^{241}Am. Efficiency, and therefore the sensitivity level, varies for every count due to the effects of chest wall thickness (CWT) on the attenuation of the 17 keV x-rays and the 59.5 keV gamma ray. A typical low energy gamma spectrum of the lung counter, of public count and background are shown in Figure 9.7. CWT is estimated by weight to height ratios for routine counting. However, the use of ultrasound for CWT measurement is recommended for special or positive counts. For lung counts, increases in chest wall thickness can increase the individual's MDA. In its more than 20 years of *in vivo* monitoring, CEMRC has never detected Pu isotopes or ^{241}Am in any public volunteers.

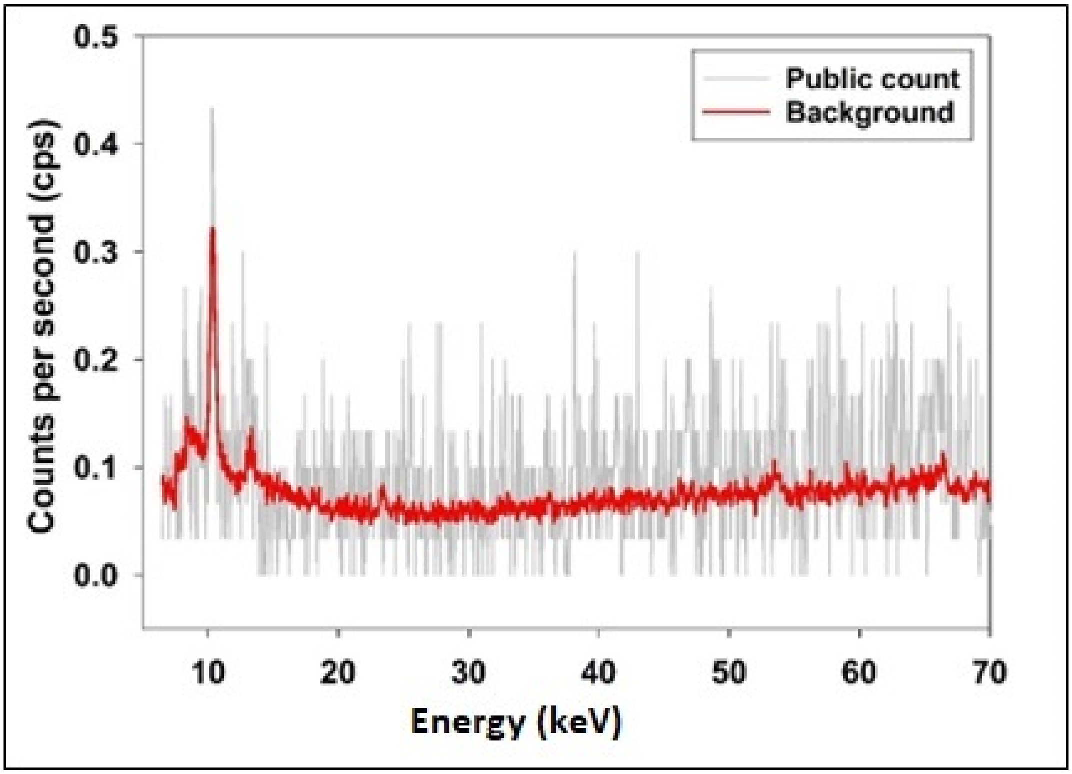


Figure 9.7. Typical 17 keV (Pu isotopes) and ^{241}Am (59.5 keV) Low Lung Gamma Spectra of Public Volunteer

For most radio-bioassay results, a two-step process is used to decide whether the analyte is present. In the first step, a statistical decision level (L_C) is used to determine if the counts in an energy region of a sample spectrum are significantly greater than in the same region in a background spectrum. This process is discussed in CEMRC Report 1998. The second step of the process involves a review of the spectrum by a technical expert to confirm the first step's conclusion. For example, the application of a decision level (L_C) to a low lung count spectrum may lead to the conclusion that no ^{241}Am is present. In contrast, a ^{241}Am photopeak may be visible to the technical person. In such cases, the technical expert may decide to overrule the initial decision and declare that ^{241}Am is present. At CEMRC, the *in vivo* bioassay program attempts to perform measurements with 95% confidence level and therefore there will be a false positive rate of 5%, meaning 5% of all measurements will be determined to be positive when there is no actual activity in the person. These results, particularly the absence of detectable plutonium and americium levels, suggest that there has been no impact from the WIPP's operations.

9.6 Conclusion

CEMRC's ID has been satisfactorily conducting the LDBC program since its inception in 1997. Comparisons of radiological activities measured between the pre-operational and operational groups revealed no significant differences, thereby indicating that waste disposal activities at the WIPP showed no measurable radiological impact on local residents' health. Furthermore, the absence of detectable levels of plutonium and americium suggests that there has been no impact from WIPP operations.

Resident participation from communities other than Carlsbad, NM, has not been significant, partly because of the time and distance involved. Resident participation from Carlsbad has also been declining steadily since 2006. The main reason for this decline has been overwhelming public trust and support for the WIPP project. Local acceptance of the WIPP is due partly to its robust safety record and comprehensive environmental monitoring program. Despite its recent shortcomings, there is not a great degree of concern among the local and surrounding communities about their health and safety because of WIPP's operation. Even though there was not a substantial increase in the number of citizens who take advantage of the LDBC program, the mere availability of such a service and their direct participation in CEMRC's whole-body counting program provides transparency which is key to maintaining public trust and confidence.

However, in recent years, there has been increased awareness and interest among students participating in the Early College Initiative in Carlsbad. Additionally, the ID group is also continuing to enhance the visibility of the LDBC program, by participating in the community events such as job fair, science nights during summer camps for young adults; by interacting individually with persons living in different areas.

CHAPTER 10 - NON-RADIOLOGICAL MONITORING

Non-radiological monitoring is a vital part of the WIPP-EM program because the activities in WIPP may generate both radioactive and hazardous (non-radioactive) materials. The focus of the Environmental Chemistry (EC) group is to monitor the hazard potential on the environment in, and around, the WIPP site by analyzing various sample types including airborne effluent, air particulate, drinking water, and surface water. The current scope of work requires non-radiological studies for a variety of metals, inorganic anion constituents, and inorganic cation constituents, as well as characterizing some common indicator parameters of local water sources. Current methods utilized by the EC group for non-radiochemical analyses performed on each sample type are provided in Appendix I, Table I.1. In 2021, CEMRC's non-radiological monitoring program included effluent monitoring at the FAS Stations A and B, airborne particulate monitoring surrounding the WIPP site, and annual sampling of local drinking water and surface water sources.

CEMRC has been sampling and analyzing WIPP exhaust air for non-radiological constituents since December 1998. Before the 2014 event, only Station A was used for exhaust air compliance monitoring purposes. After the 2014 event, non-radiological analyses of WIPP exhaust air were halted because all the filters collected were analyzed for radiological constituents to support the evaluation of the event. CEMRC resumed non-radiochemical analyses of exhaust air in 2015 for both Station A and Station B filters.

CEMRC has also been sampling and analyzing ambient air (i.e., aerosol samples) surrounding the WIPP site since 1999. However, in 2005, the sampling process changed. The CEMRC resumed reporting results for ambient air in 2020.

In addition to air monitoring, CEMRC has also been sampling and analyzing non-radiological constituents in drinking water from six community supplies and three regional surface water reservoirs since 1997. Three additional surface water locations were added to the list in 2021. In this chapter, non-radiological analysis results for WIPP exhaust air, drinking water and surface water are provided for the year 2021.

10.1 Non-Radiological Monitoring of Airborne Effluent

10.1.1 Sample Collection

Particulates in the exhaust air are collected on 47 mm diameter membrane filters (Versapor™ membrane filter, PALL Corporation, Port Washington, NY, USA) with the use of a cylindrical shrouded probe, commonly referred to as a Fixed Air Sampler (FAS). Typically, two sets of filters are collected from both Station A and Station B: a primary set and a secondary (backup) set. Before the 2014 accidental release event, the primary set of filters was used for the analyses of both radiological and non-radiological constituents, while the backup set of filters was archived. After the 2014 event, the primary set of filters was used for radiochemical analyses, while the backup set was used for non-radiological analyses. Occasionally, both the primary and backup filter sets are needed for immediate radiochemical analyses. In such instances, non-radiological analyses are not performed on this sample type.

10.1.2 Sample Preparation and Analysis

In 2020, additional analyses were requested on the FAS filters. In order to meet the new requirements, each FAS filter was cut in half, with one half digested for metal analysis and the other used for selected anion and cation analysis. Current methods utilized by CEMRC for non-radiochemical analyses are summarized in Appendix I, Table I.1.

The backup filters for non-radiological metal analyses are digested in a strong acid mixture with the use of a CEM MARS Xpress™ or CEM MARS 6™ microwave unit (Charlotte, NC, USA). Individual FAS filters are placed in separate Teflon vessels and digested at 195 ˚C within an acid matrix consisting of nitric acid, hydrochloric acid, and hydrofluoric acids. A blank filter and Certified Reference Material (CRM) filter are also digested simultaneously with these FAS filters using the same method for quality control (QC) purposes. Acids used for digestions are either purchased as “trace metal” grade as noted by the manufacturer or purified in-house with a Milestone Inc. (Shelton, CT, USA) sub-boiling quartz distillation apparatus. After digestion, individual FAS filter solutions are combined into a weekly (Station A) or monthly composite (Station B), and the composite is analyzed, together with the blank filter and CRM filter, for selected metals by Perkin Elmer Inductively Coupled Plasma-Mass Spectrometers (ICP-MS). Metal concentrations of FAS filters from Station A and Station B are reported as the mass of metal divided by the volume of air (ng/m^3).

For anion and cation analyses, a water extraction using 40 mL ultrapure water is performed and the extraction solutions are combined into a weekly (Station A) or monthly composite (Station B). The composite solution is filtered prior to analysis by Ion Chromatography (IC) for selected inorganic anions and cations. Blanks and spiked blanks are also extracted in the same manner for quality control purposes. Anion and Cation concentrations of FAS filters from Station A and Station B are reported as the mass of metal divided by the volume of air (ng/m^3).

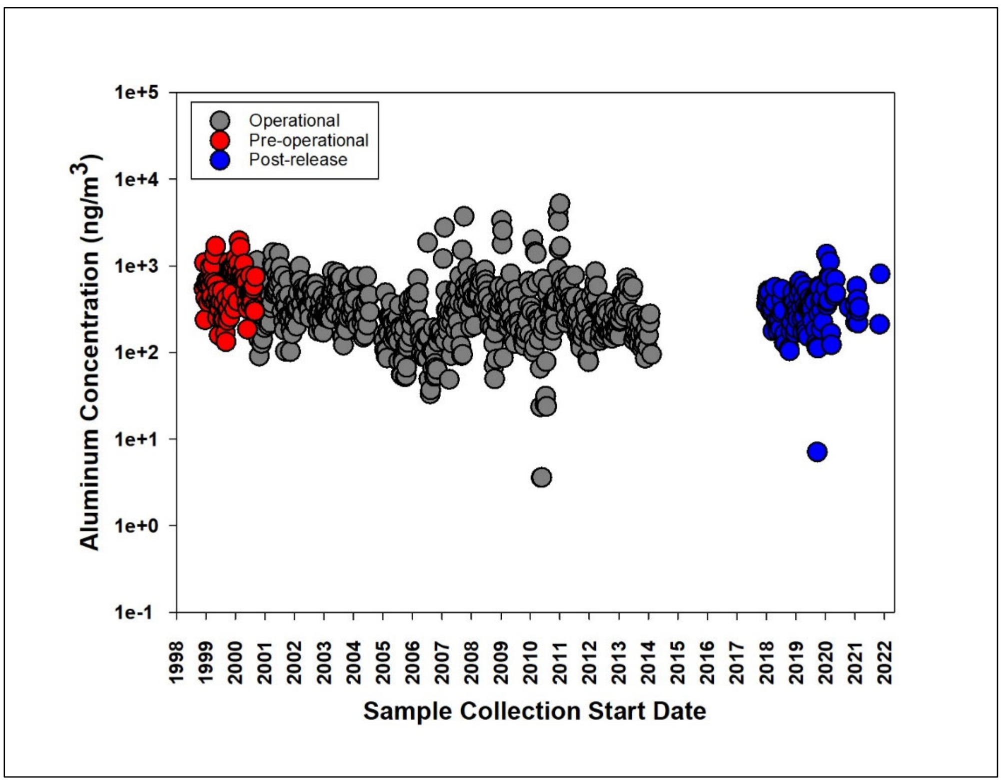
10.1.3 Anion and Cation Concentrations Measured at Station A and Station B

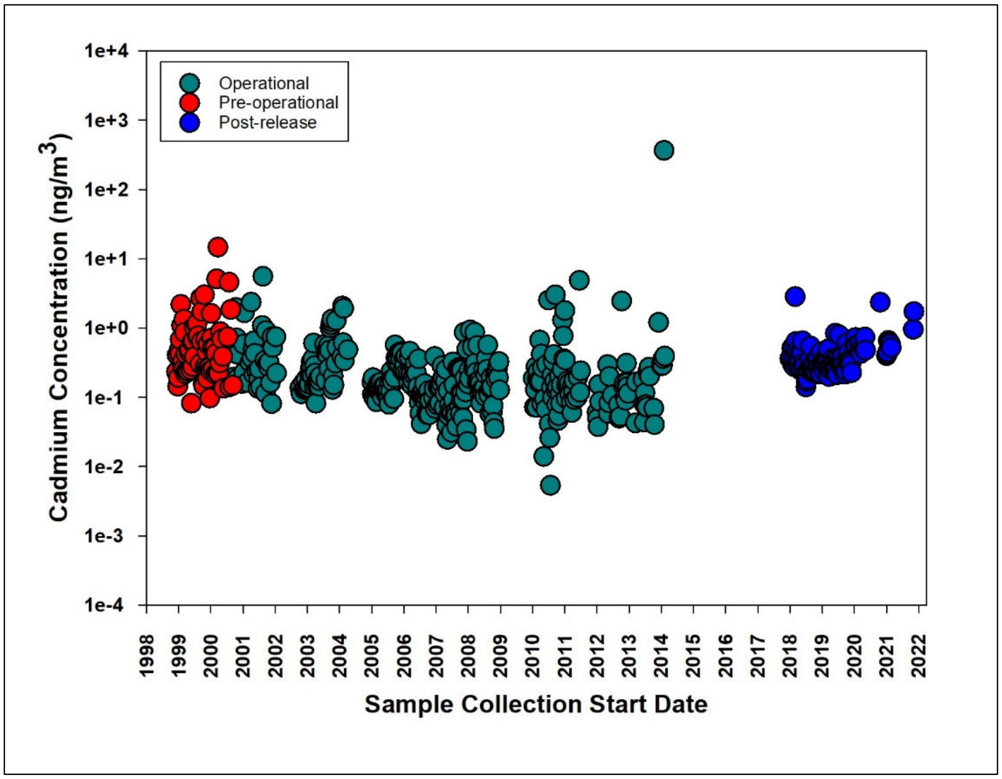
Inorganic anion and cation analysis for Station A and Station B filters began in 2020. Selected anions include chloride, nitrate, phosphate and sulfate and selected cations include ammonium, calcium, potassium, and magnesium. Detailed concentrations for anions and cations are reported in Appendix I for Station A (Table I.3 and I.4) and Station B (Table I.6 and I.7), respectively. Chloride, sulfate, calcium, potassium, magnesium and sodium are all regularly detected above the MDC in Station A filters. Only chloride, sodium and calcium are detected regularly above the MDC in Station B filters.

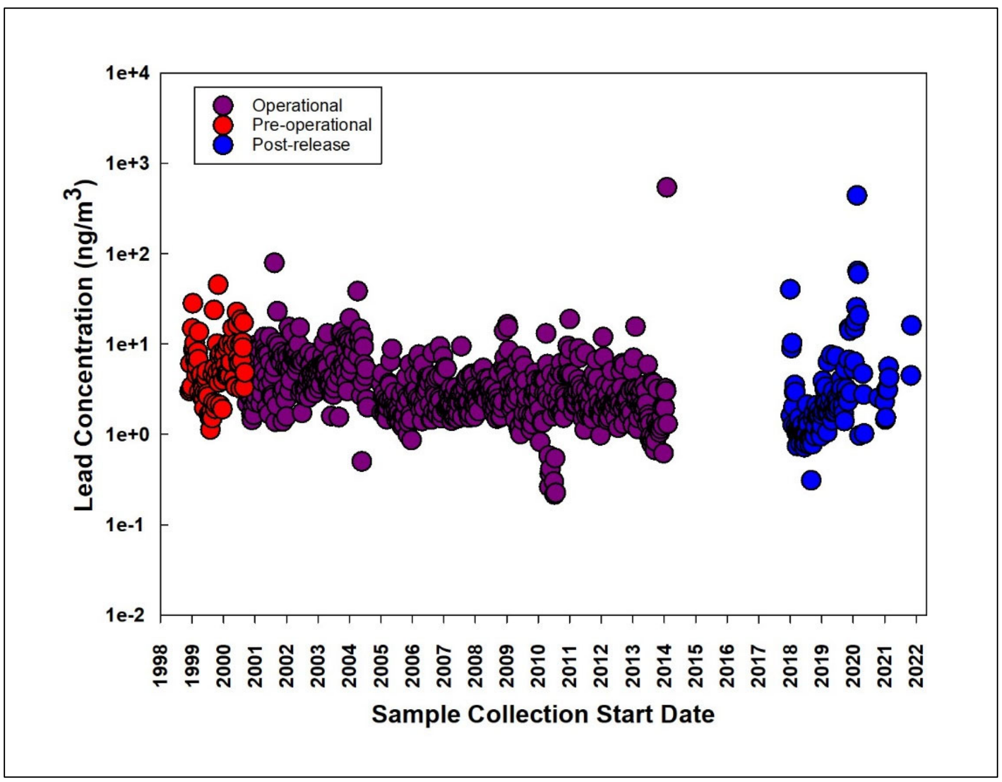
10.1.4 Metal Concentrations at Station A

Historical time-series plots for selected trace metals are shown in Figure 10.1 from 1998 through December 2021. It should be noted that there was a problem with one of the sampling skids for Station A in 2021 and over 6 months of backup filters were not provided for non-radiochemical analyses this year. Concentrations for selected trace metals on Station A filters collected in 2021 are reported in Appendix I, Table I.2. Aluminum (Al), cadmium (Cd), magnesium (Mg), and lead (Pb) are regularly detected above the MDC at Station A. The concentrations of these trace metals are in the range of 0.40-1.73 ng/m^3 for Cd, 1.46-16.1 ng/m^3 for Pb, 212-807 ng/m^3 for Al, and 570-9794 ng/m^3 for Mg. Thorium (Th), silicon (Si) and uranium (U) are only occasionally measured for the 2021 sampling period. Values for Si, Th, and U are reported in Appendix I, Table I.2. While variability between weekly composite results is common, long–term monitoring data show that there are no differences between the baseline, operational, and post-release data.

Aluminum concentrations are of particular interest because of the relationship observed between Al concentrations in ambient air and the $^{239+240}$Pu and ^{241}Am activities (Arimoto et al., 2002 and 2005). Windblown dust is the main source for Al and many other elements (e.g., Fe, Mn, Sc and the rare earth elements), as well as represents a source for U and some other naturally occurring radionuclides (Arimoto et al., 2005; Kirchner et.al., 2002). Special attention was also paid to magnesium as it is the primary component in the MgO backfill material that is the only engineered barrier at WIPP.




Operational
Pre-operational
Post-release
Cadmium Concentration (ng/m3)
1e+4
1e+3
1e+2
1e+1
1e+0
1e-1
1e-2
1e-3
1e-4
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Sample Collection Start Date


Operational
Pre-operational
Post-release
Lead Concentration (ng/m3)
1e+4
1e+3
1e+2
1e+1
1e+0
1e-1
1e-2
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Sample Collection Start Date

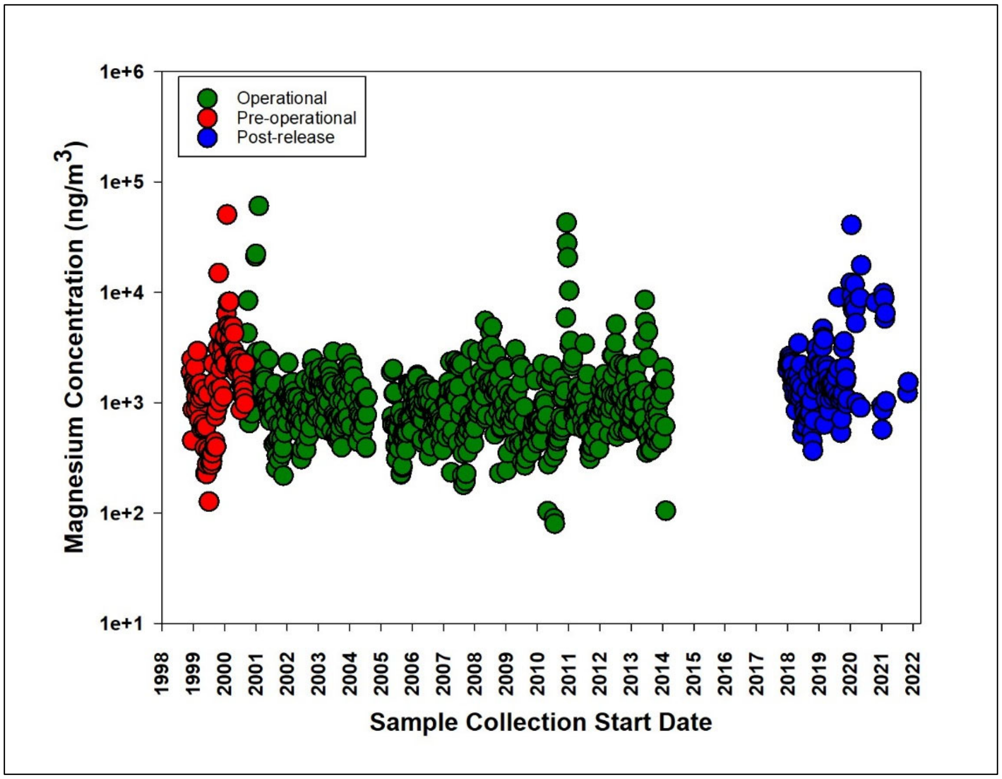
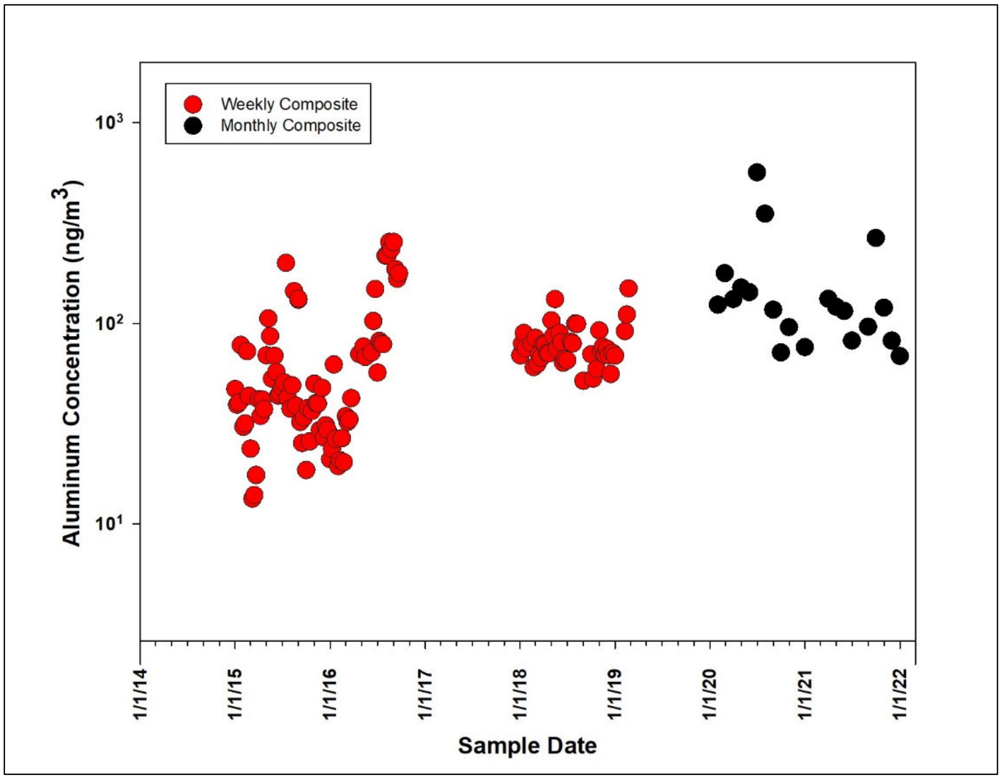
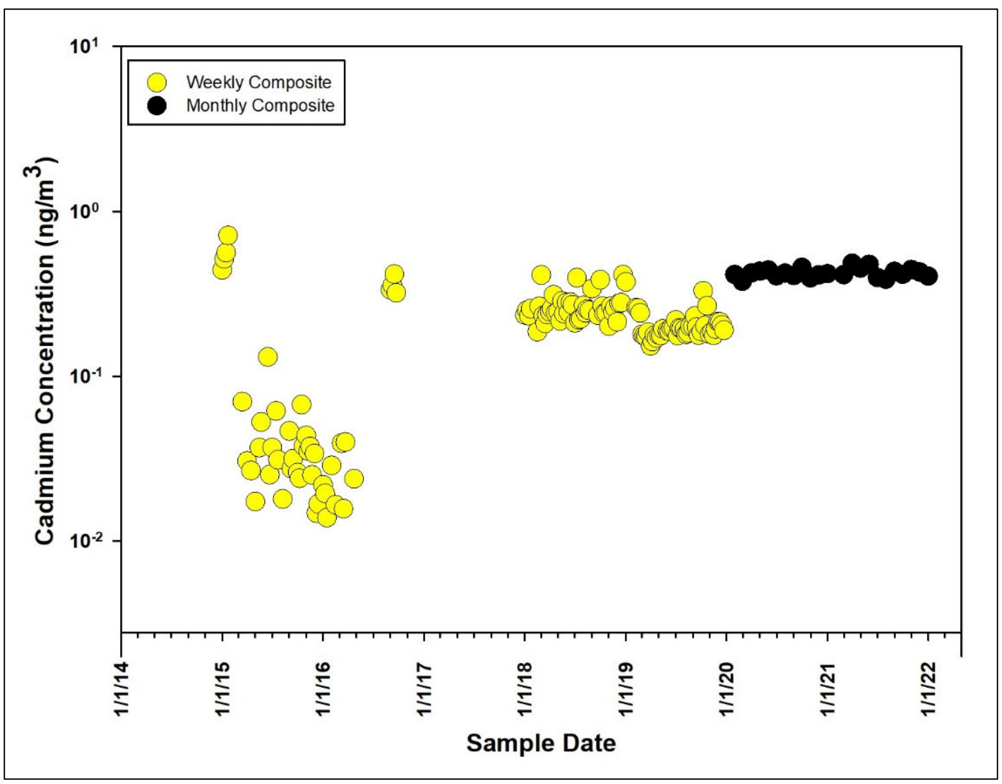


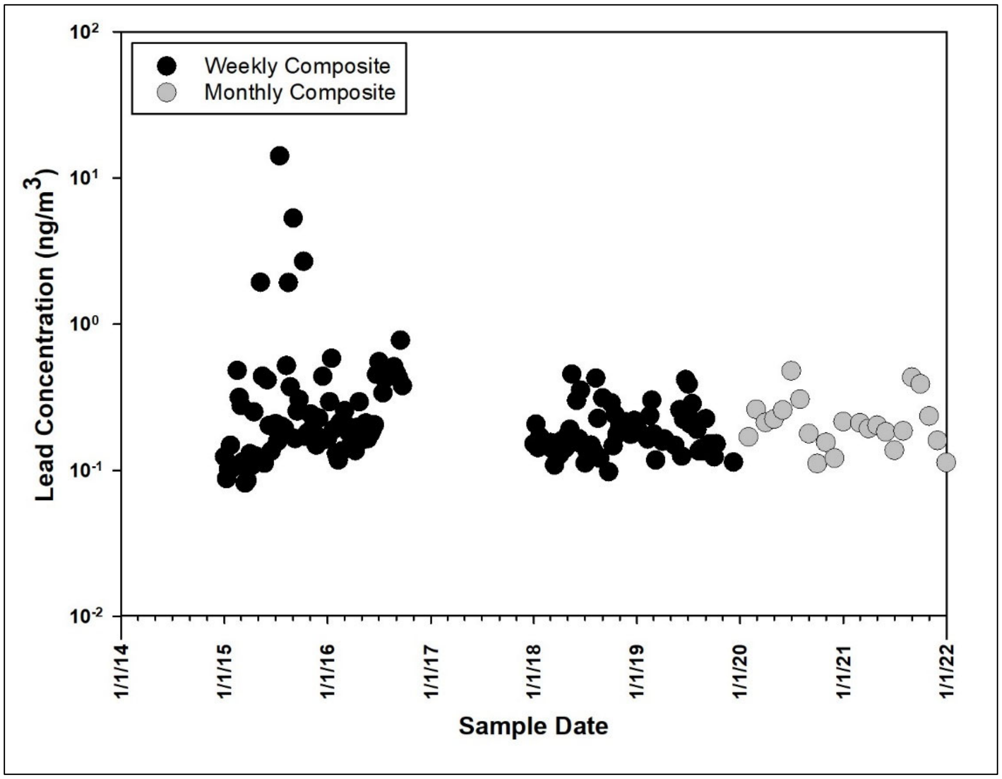
Figure 10.1. Historical Concentrations of Selected Metals at Station A

10.1.5 Metal Concentrations at Station B

Non-radiochemical analyses for Station B exhaust filters began in 2015. Historical time-series plots for Station B filters are shown in Figure 10.2. Concentrations for weekly composites of Al, Mg, Cd, and Pb are detected regularly above the MDC at Station B since 2015. In 2020, CEMRC switched from reporting the analysis results for weekly composites of Station B samples to monthly composites. Results of selected metals for 2021 monthly composites are reported in Appendix I, Table I.5. It is noteworthy that the concentrations of most elements detected at Station B are much lower than at Station A, which is expected, given that station B collects effluent air after HEPA filtration.


Weekly Composite
Monthly Composite
Aluminum Concentration (ng/m3)
10³
10²
10¹
1/1/14
1/1/15
1/1/16
1/1/17
1/1/18
1/1/19
1/1/20
1/1/21
1/1/22
Sample Date


Weekly Composite
Monthly Composite
Cadmium Concentration (ng/m3)
10¹
10⁰
10⁻¹
10⁻²
1/1/14
1/1/15
1/1/16
1/1/17
1/1/18
1/1/19
1/1/20
1/1/21
1/1/22
Sample Date



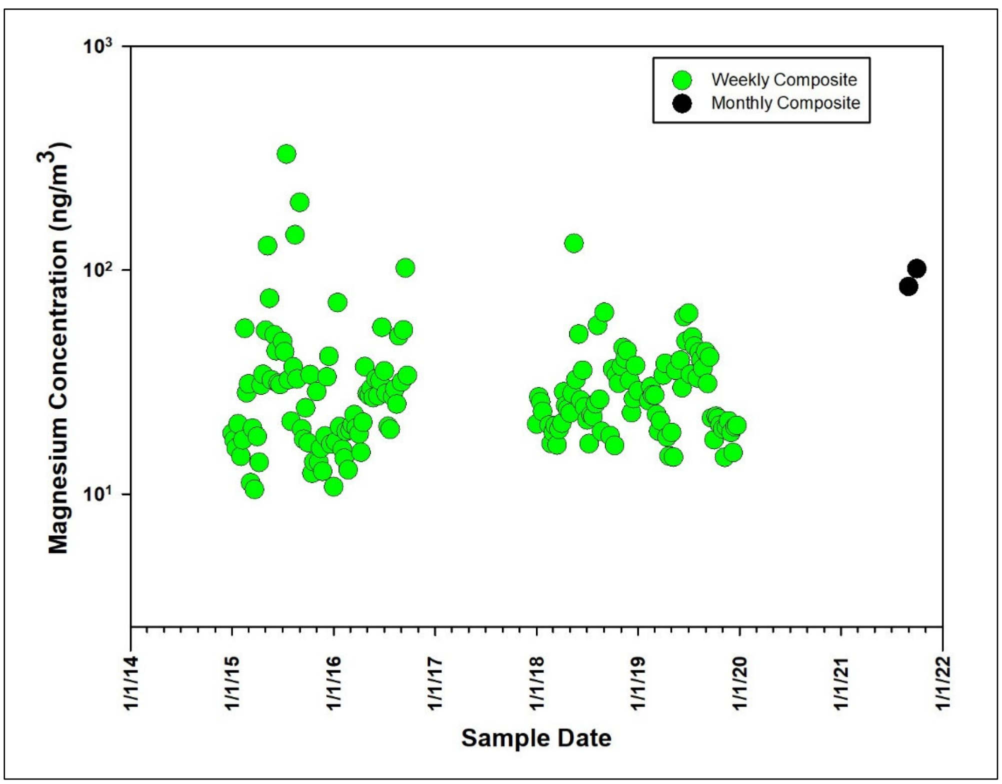


Figure 10.2. Historical Concentrations of Selected Metals at Station B

10.2 Non-Radiological Monitoring of Airborne Particulates

10.2.1 Sample Collection

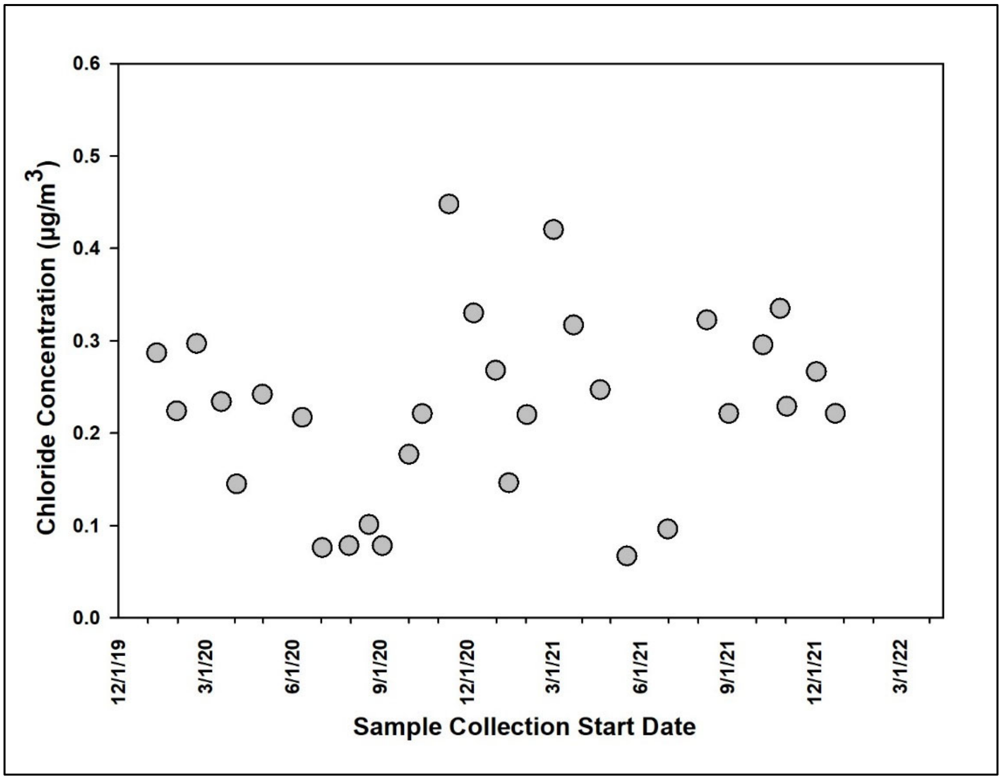
Airborne particulates in the air surrounding the WIPP site are collected on cellulose-based, Whatman 41 filters (GE Healthcare Life Sciences) in a similar way to the glass fiber filters collected above ground for radiochemical analyses. The Whatman 41 filters are only used for non-radiochemical analyses at the following two locations: Near Field and Cactus Flats.

10.2.2 Sample Preparation and Analysis

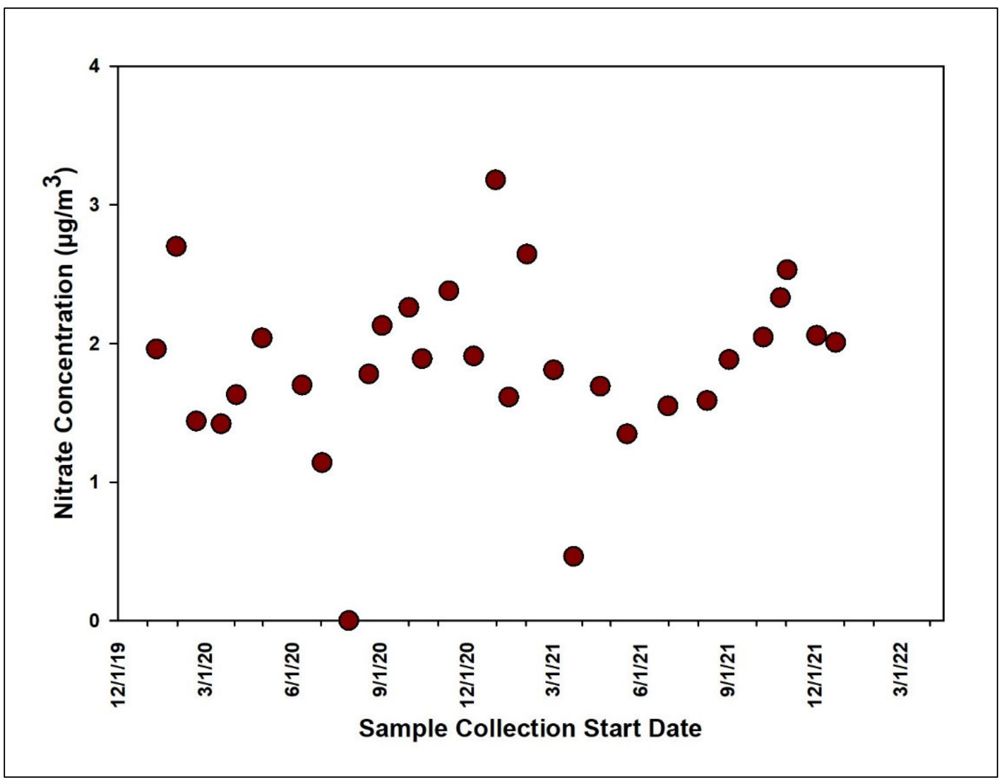
A water extraction using 40 mL ultrapure water is performed at room temperature on a ¼-sheet of each Whatman 41 filter sample. The extracted solution is filtered prior to analysis by Ion Chromatography (IC) for inorganic anions and cations. Blanks and spiked blanks are also extracted in the same manner for quality control purposes. All samples are filtered prior to analysis by Ion Chromatography (IC). Current methods utilized by CEMRC for non-radiochemical analyses performed on each sample type are summarized in Appendix I, Table I.1.

10.2.3 Anion and Cation Concentrations Measured at Near Field

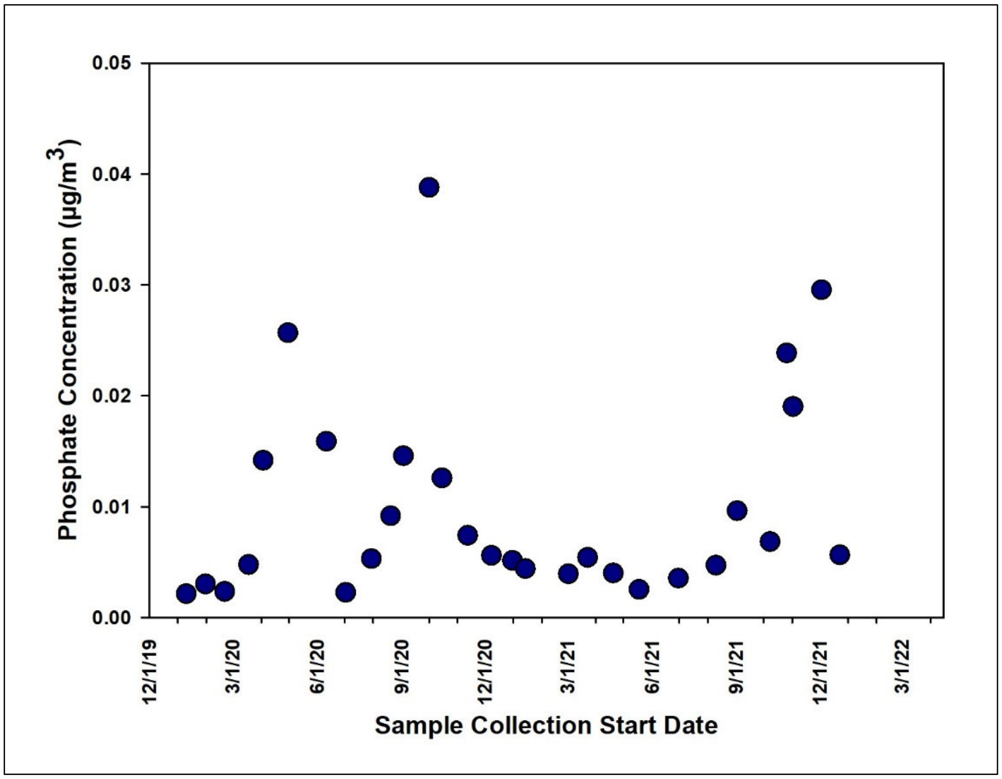
Historical time-series plots for selected inorganic anions and cations are shown in Figure 10.3 from January 2020 through December 2021 for samples collected at Near Field. Chloride, nitrate, phosphate, sulfate, ammonium, calcium, potassium, magnesium and sodium are all regularly detected above the MDC at the Near Field location. Detailed concentrations of selected anions and cations for 2021 Near Field samples are reported in Appendix I, Table I.8 and I.9, respectively.

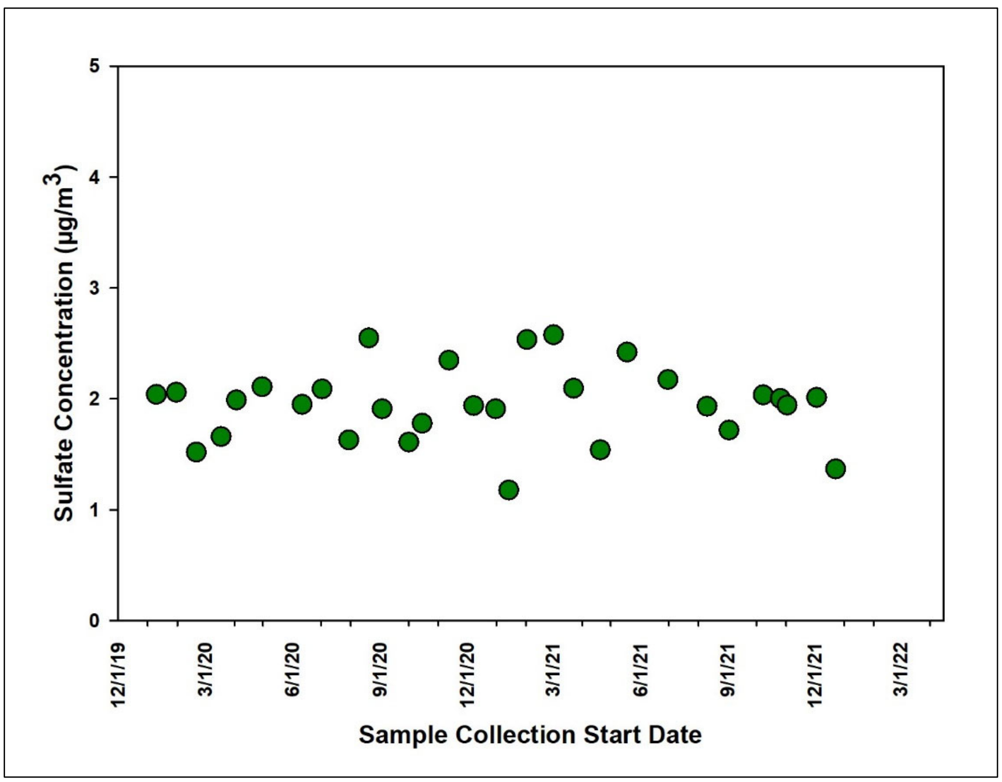


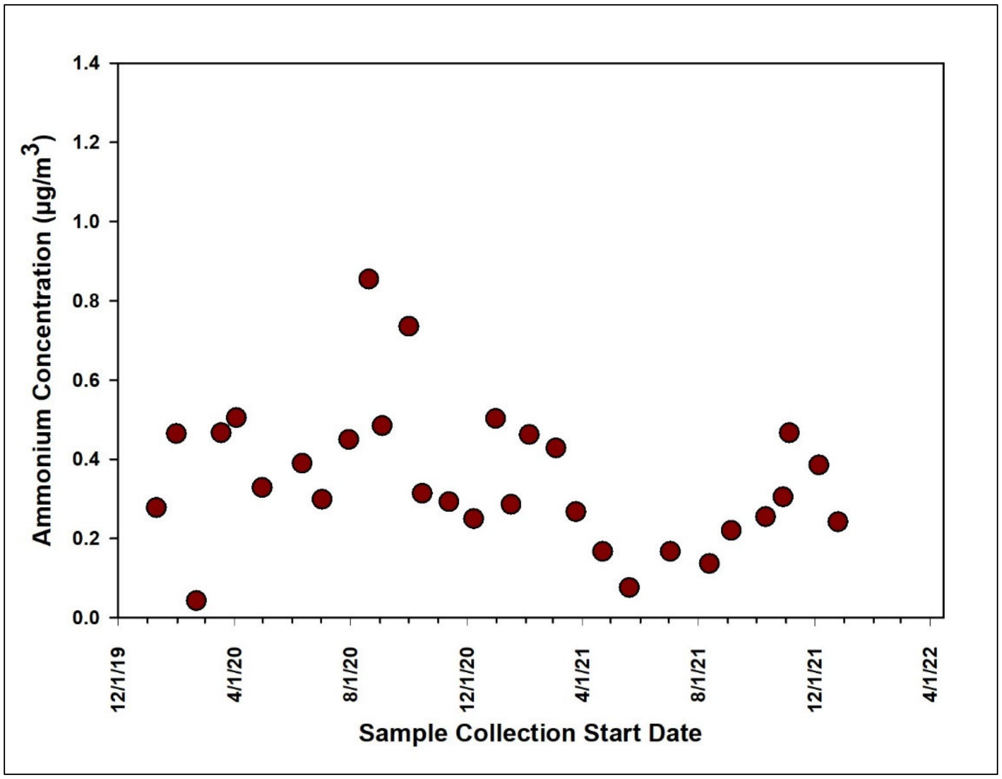
Chloride Concentration (µg/m3)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
12/1/19
3/1/20
6/1/20
9/1/20
12/1/20
3/1/21
6/1/21
9/1/21
12/1/21
3/1/22
Sample Collection Start Date



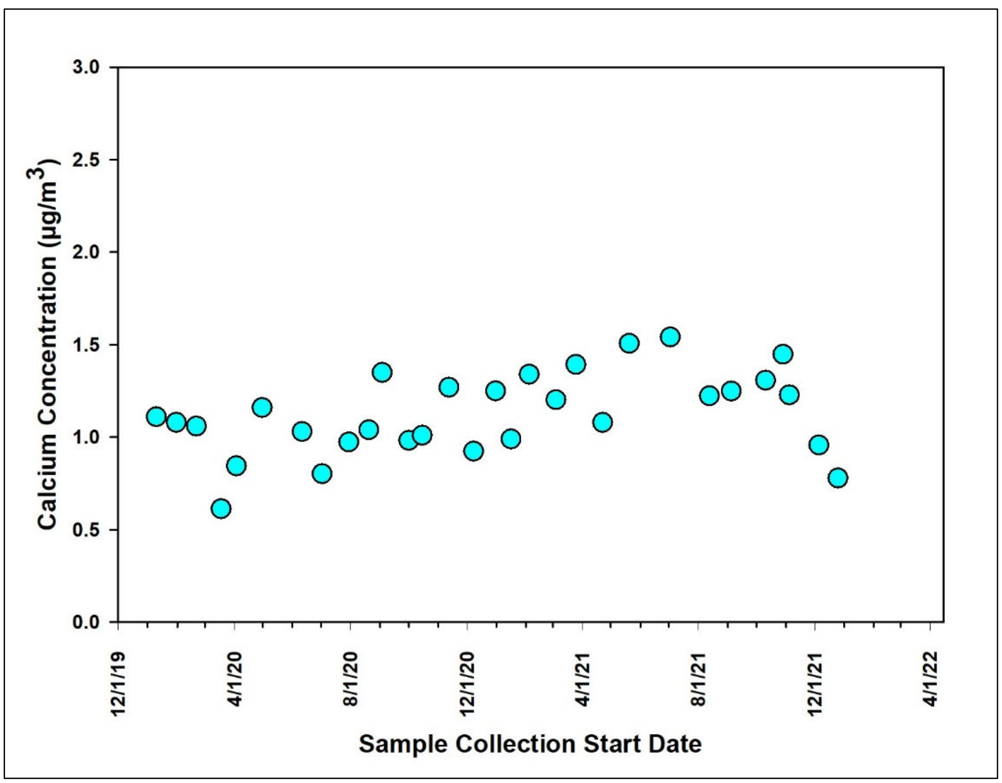
Nitrate Concentration (µg/m3)
0
1
2
3
4
12/1/19
3/1/20
6/1/20
9/1/20
12/1/20
3/1/21
6/1/21
9/1/21
12/1/21
3/1/22
Sample Collection Start Date


Phosphate Concentration (µg/m3)
0.05
0.04
0.03
0.02
0.01
0.00
12/1/19
3/1/20
6/1/20
9/1/20
12/1/20
3/1/21
6/1/21
9/1/21
12/1/21
3/1/22
Sample Collection Start Date

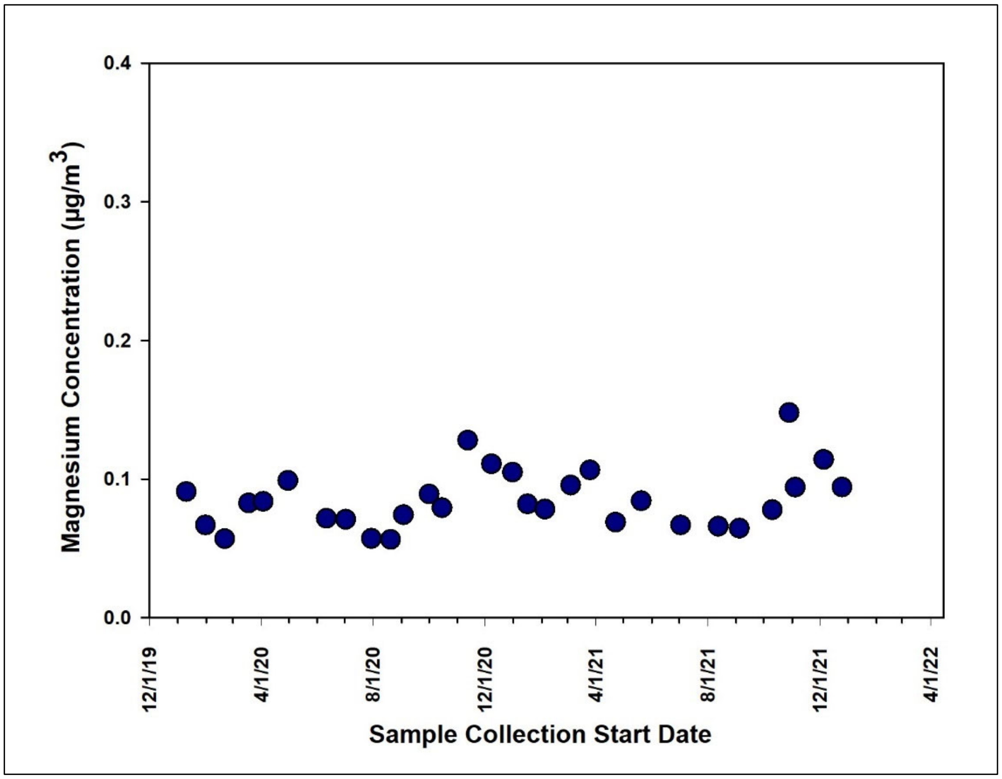

Sulfate Concentration (µg/m3)
5
4
3
2
1
0
12/1/19
3/1/20
6/1/20
9/1/20
12/1/20
3/1/21
6/1/21
9/1/21
12/1/21
3/1/22
Sample Collection Start Date

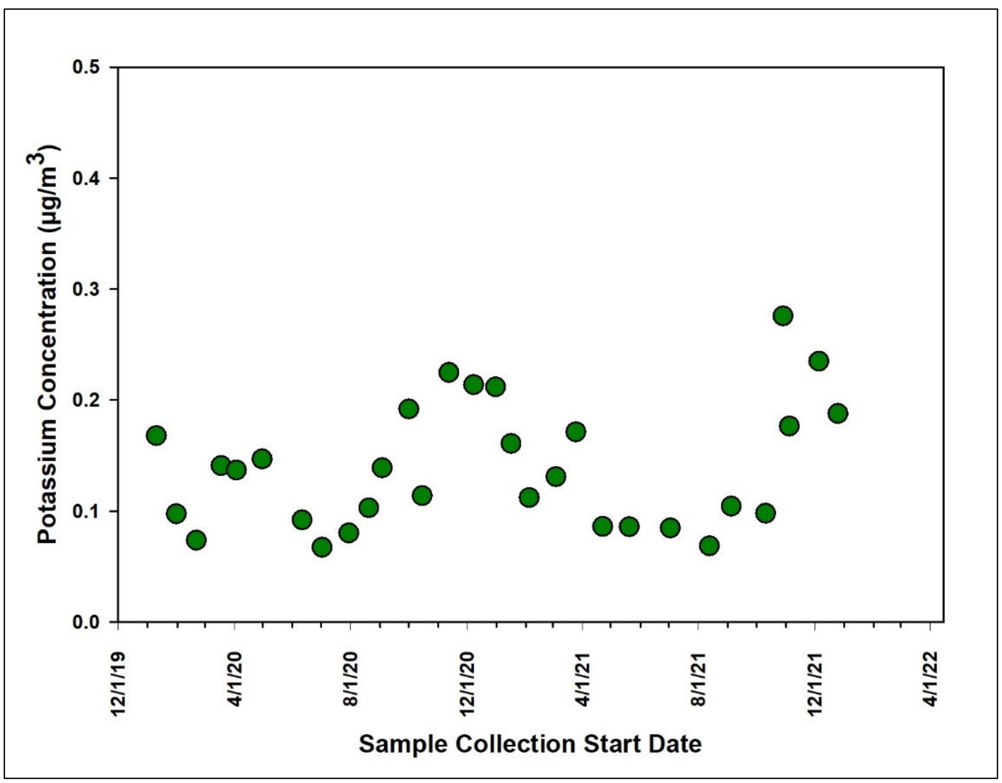


Ammonium Concentration (µg/m3)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
12/1/19
4/1/20
8/1/20
12/1/20
4/1/21
8/1/21
12/1/21
4/1/22
Sample Collection Start Date



Calcium Concentration (µg/m3)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
12/1/19
4/1/20
8/1/20
12/1/20
4/1/21
8/1/21
12/1/21
4/1/22
Sample Collection Start Date


Magnesium Concentration (µg/m3)
0.4
0.3
0.2
0.1
0.0
12/1/19
4/1/20
8/1/20
12/1/20
4/1/21
8/1/21
12/1/21
4/1/22
Sample Collection Start Date


Potassium Concentration (µg/m3)
0.5
0.4
0.3
0.2
0.1
0.0
12/1/19
4/1/20
8/1/20
12/1/20
4/1/21
8/1/21
12/1/21
4/1/22
Sample Collection Start Date

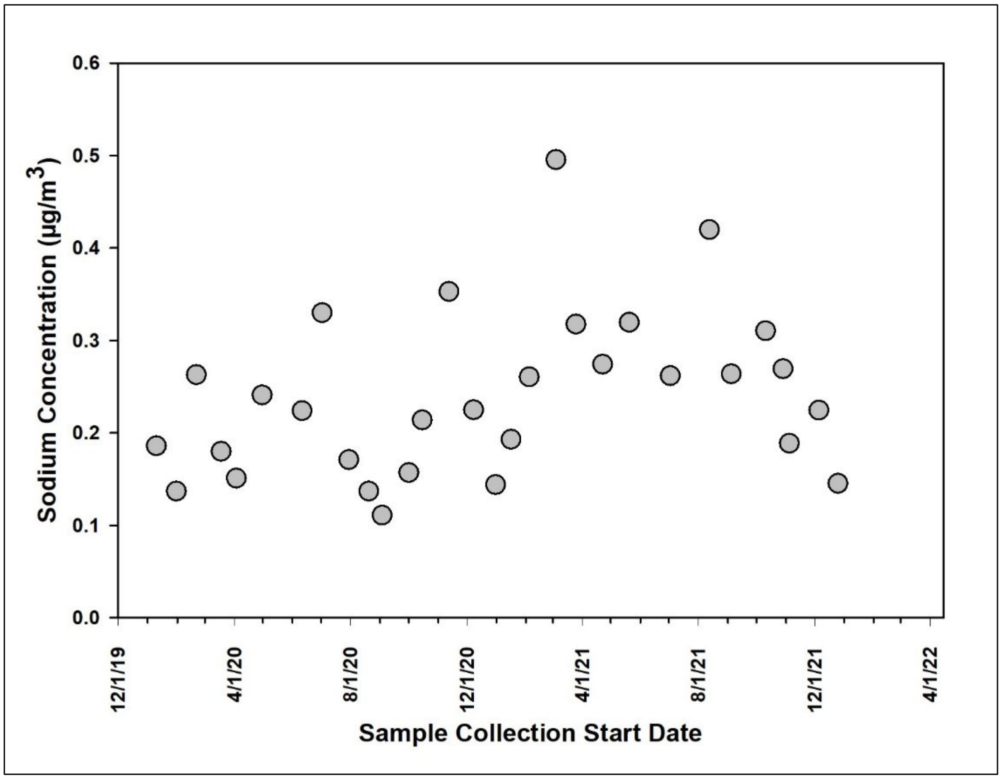
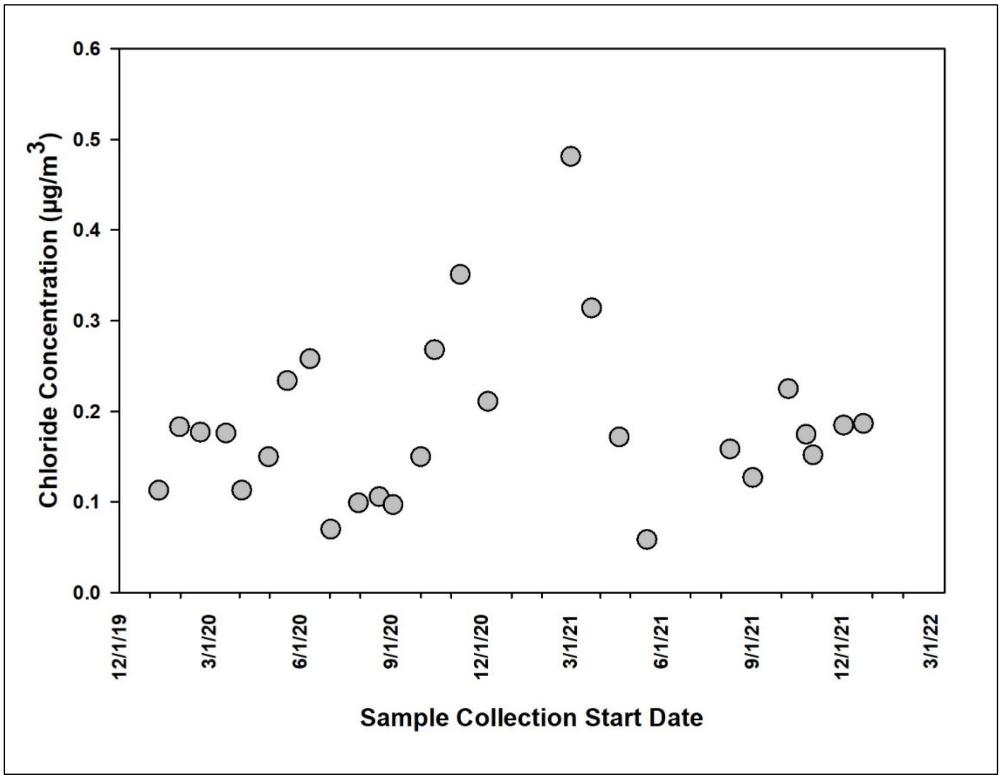
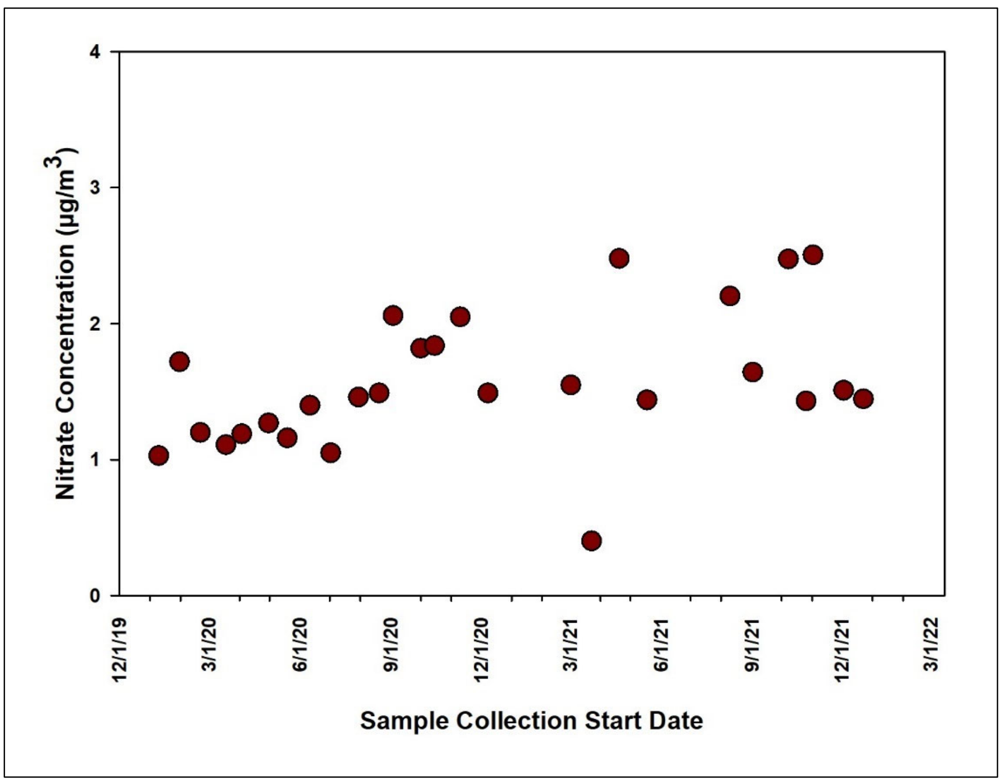


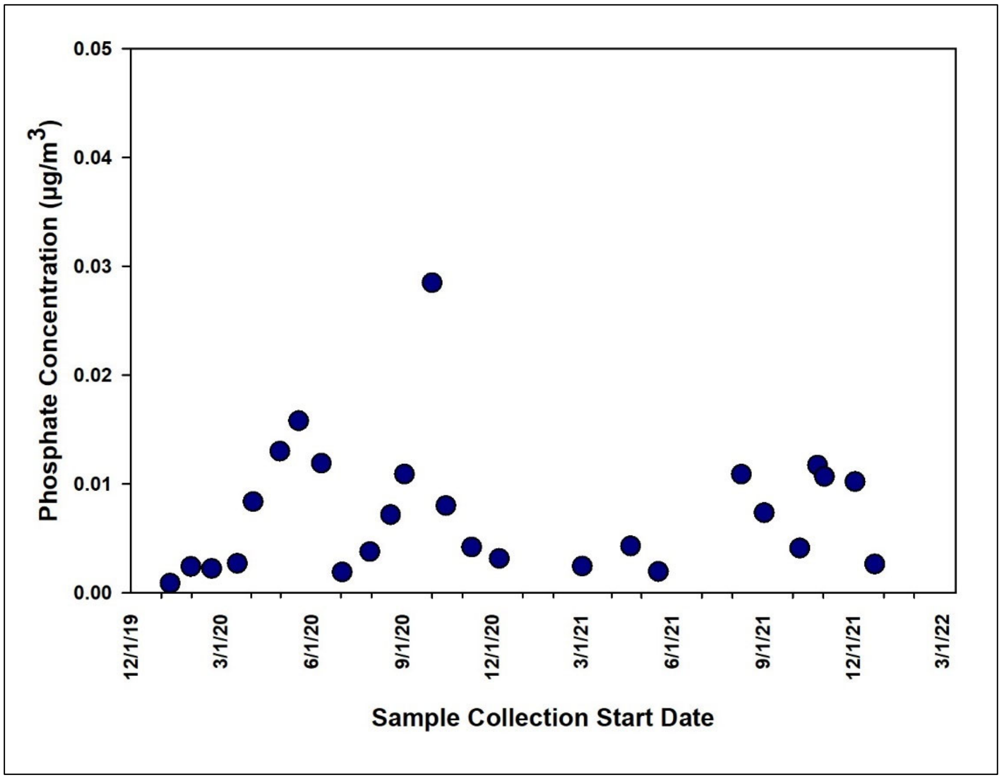
Figure 10.3. Historical Concentrations of Selected Anions and Cations at Near Field

10.2.4 Anion and Cation Concentrations Measured at Cactus Flats

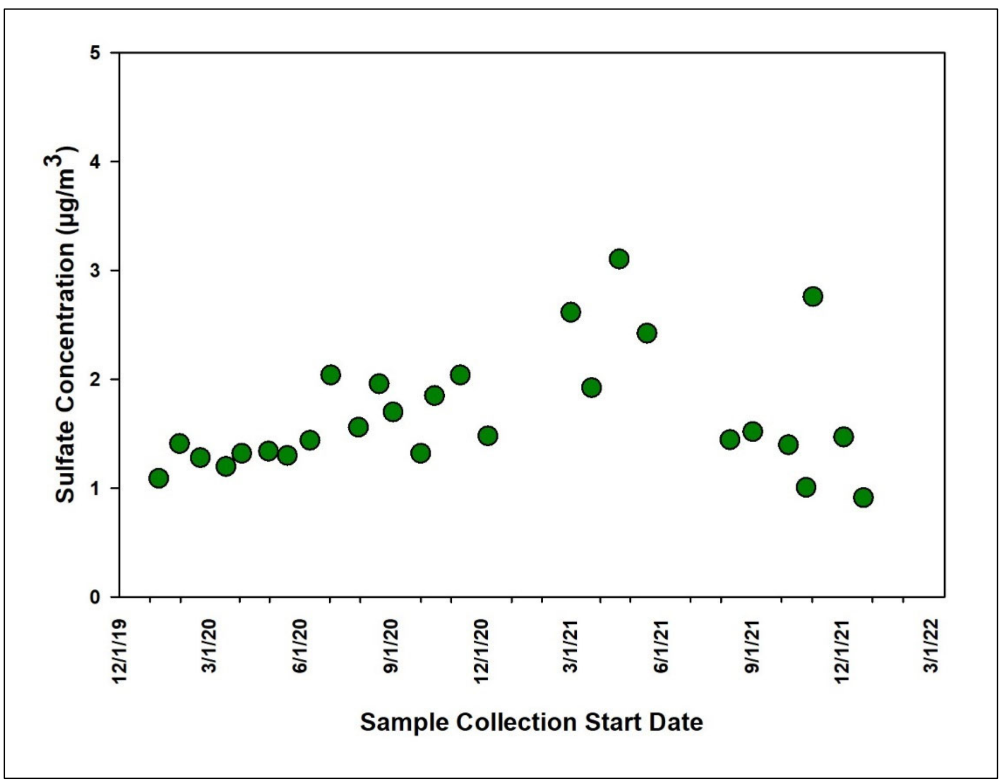
Historical time-series plots for selected inorganic anions and cations are shown in Figure 10.4 from January 2020 through December 2021 for samples collected at Cactus Flats. Chloride, nitrate, phosphate, sulfate, ammonium, calcium, potassium, magnesium, and sodium are all regularly detected above the MDC at the Cactus Flats location and are similar to concentrations measured at the Near Field site. Detailed concentrations of selected anions and cations for 2021 Cactus Flats samples are reported in Appendix I, Table I.10 and I.11.


Chloride Concentration (µg/m3)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
12/1/19
3/1/20
6/1/20
9/1/20
12/1/20
3/1/21
6/1/21
9/1/21
12/1/21
3/1/22
Sample Collection Start Date

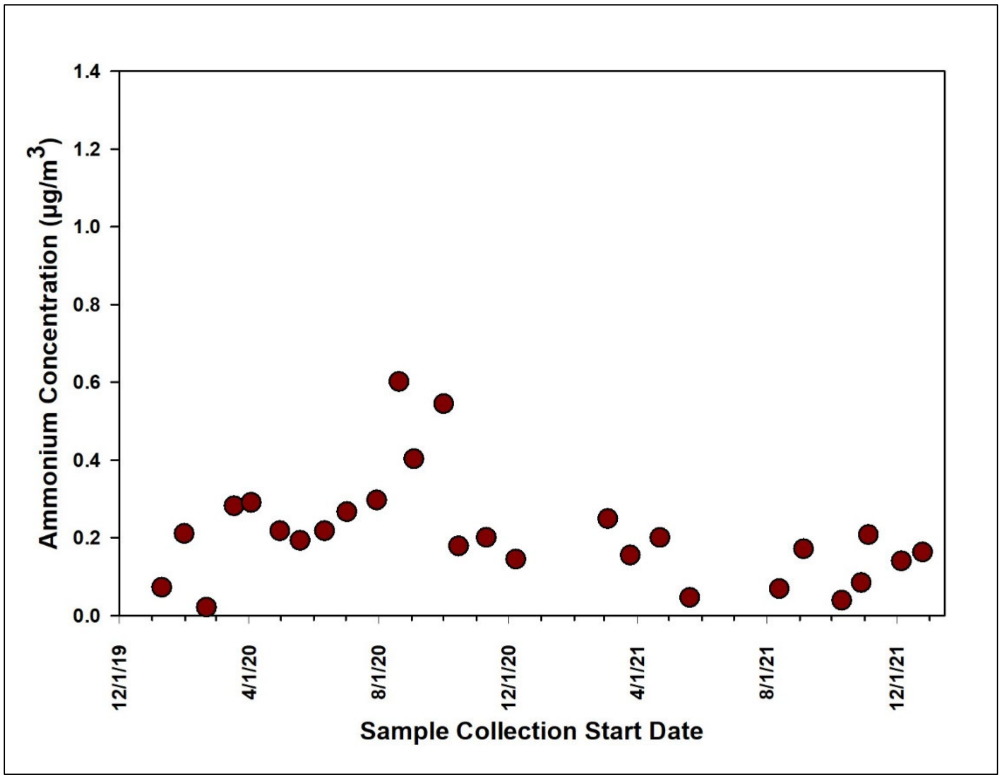

Nitrate Concentration (µg/m3)
4
3
2
1
0
12/1/19
3/1/20
6/1/20
9/1/20
12/1/20
3/1/21
6/1/21
9/1/21
12/1/21
3/1/22
Sample Collection Start Date

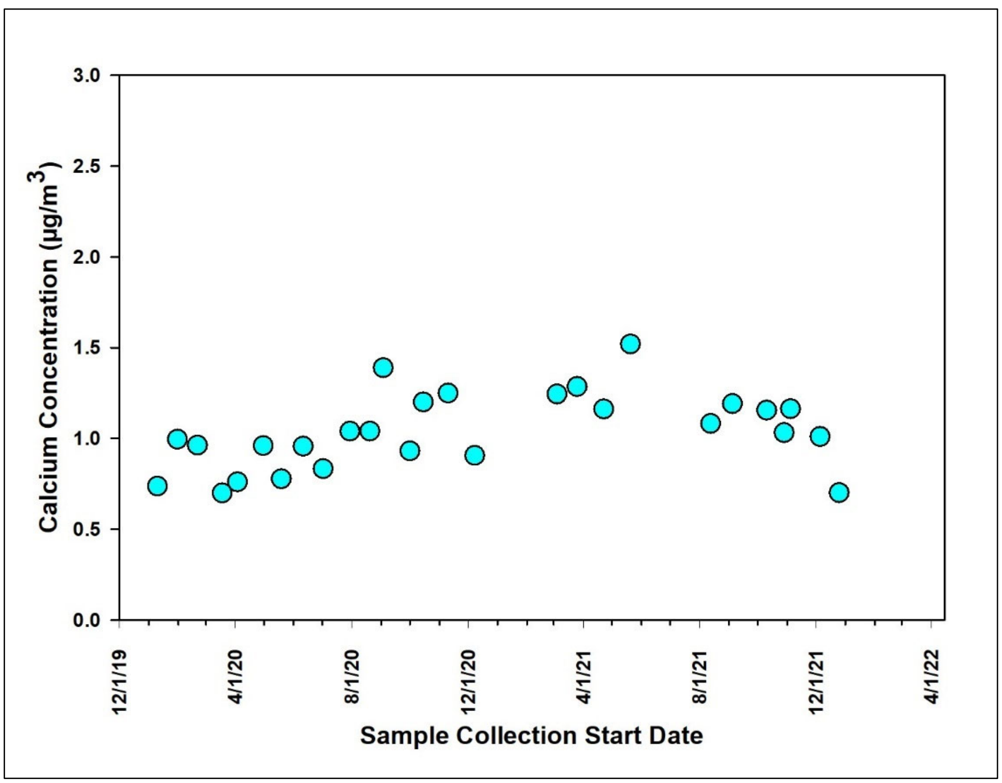


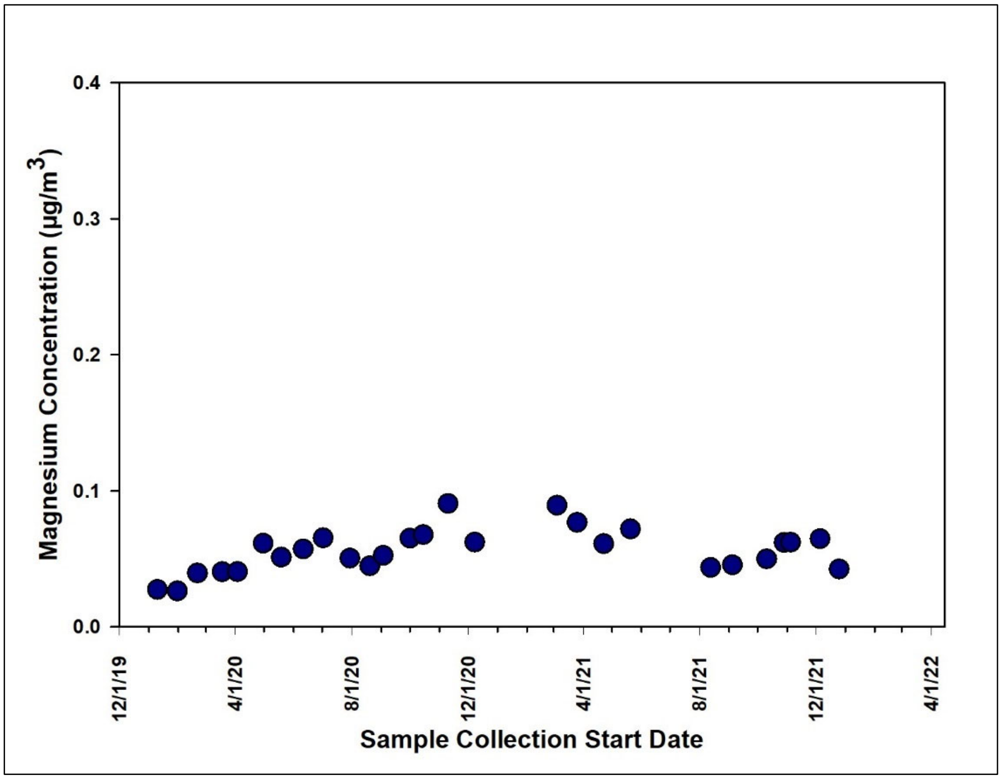
Phosphate Concentration (µg/m3)
0.05
0.04
0.03
0.02
0.01
0.00
12/1/19
3/1/20
6/1/20
9/1/20
12/1/20
3/1/21
6/1/21
9/1/21
12/1/21
3/1/22
Sample Collection Start Date

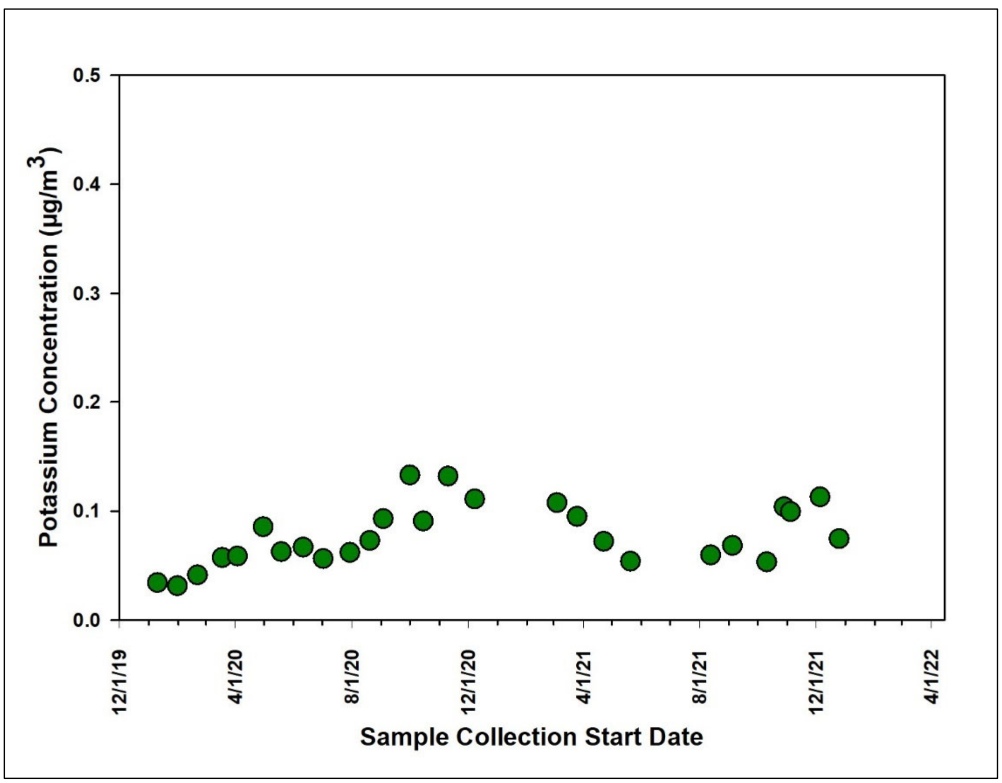


Sulfate Concentration (µg/m3)
5
4
3
2
1
0
12/1/19
3/1/20
6/1/20
9/1/20
12/1/20
3/1/21
6/1/21
9/1/21
12/1/21
3/1/22
Sample Collection Start Date


Ammonium Concentration (µg/m3)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
12/1/19
4/1/20
8/1/20
12/1/20
4/1/21
8/1/21
12/1/21
Sample Collection Start Date


Calcium Concentration (µg/m3)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
12/1/19
4/1/20
8/1/20
12/1/20
4/1/21
8/1/21
12/1/21
4/1/22
Sample Collection Start Date


Magnesium Concentration (µg/m3)
0.4
0.3
0.2
0.1
0.0
12/1/19
4/1/20
8/1/20
12/1/20
4/1/21
8/1/21
12/1/21
4/1/22
Sample Collection Start Date


Potassium Concentration (µg/m3)
0.5
0.4
0.3
0.2
0.1
0.0
12/1/19
4/1/20
8/1/20
12/1/20
4/1/21
8/1/21
12/1/21
4/1/22
Sample Collection Start Date

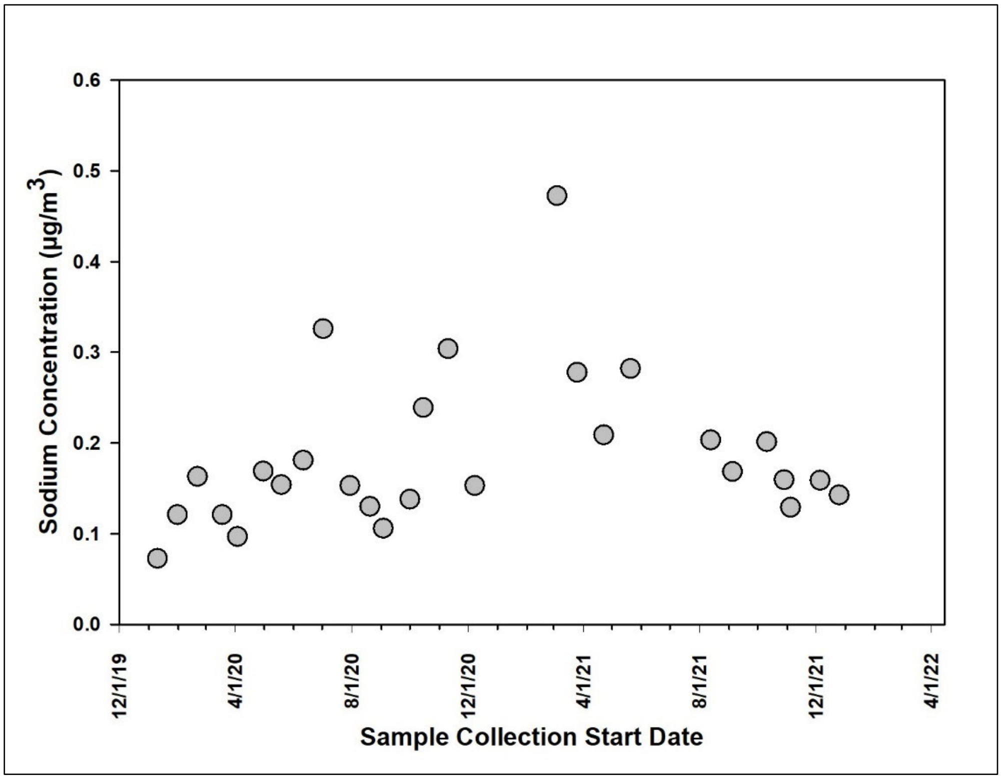


Figure 10.4. Historical Concentrations of Selected Anions and Cations at Cactus Flats

10.3 Non-Radiological Monitoring of Drinking Water

10.3.1 Sample Collection

In 2021, drinking water samples for non-radiological analyses were collected from six community water supplies of Carlsbad, Loving, Otis, Hobbs, Malaga, and Double Eagle. Details regarding the sampling locations and procedure for drinking water sample collection are described in Chapter 6.

10.3.2 Sample Preparation and Analysis

Once the water samples are received by the CEMRC facility, three aliquots are removed immediately for non-radiochemical analyses: (1) 1 L for inorganic analysis, (2) 500 mL for mercury analysis, and (3) 1 L for metal analysis. Each 1 L aliquot removed for inorganic analysis is split in two parts. The first 1 L sub-sample is immediately refrigerated and analyzed for inorganic anions within 48 hours of collection. No preservative is added to this sample. The other part of the 1 L inorganic sub-sample is preserved with a dilute nitric acid solution for inorganic anion and cation analysis. Due to the high salinity of these drinking water samples, both types of inorganic analyses (anions and cations) require further dilution using ultrapure water prior to analysis. For metal analysis, each aliquot is preserved with nitric acid during collection. Because of the high salinity, drinking water samples are also diluted using the same nitric acid prior to analysis.

For mercury analysis, each sample is collected in a 500 mL glass container and preserved with bromo-monochloride immediately upon arrival at CEMRC. Sample dilution is not performed for mercury analysis of water samples because mercury is rarely detected above background values. It should be noted that mercury analysis is performed separately from other metals in drinking water samples because of the specific requirements for sample preservation.

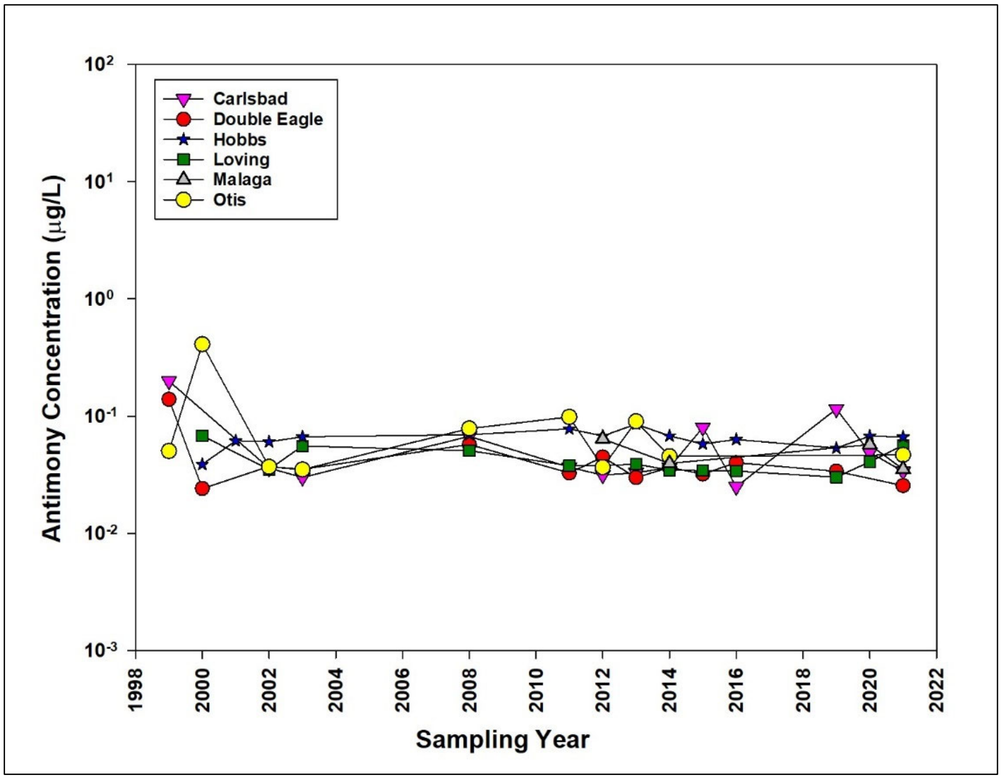
Metal analyses are performed using an ICP-MS, while inorganic cation and anion analyses are performed using an IC. Current methods utilized by CEMRC for non-radiochemical analyses performed on each sample type and their detection limits are summarized in Appendix I, Table I.1.

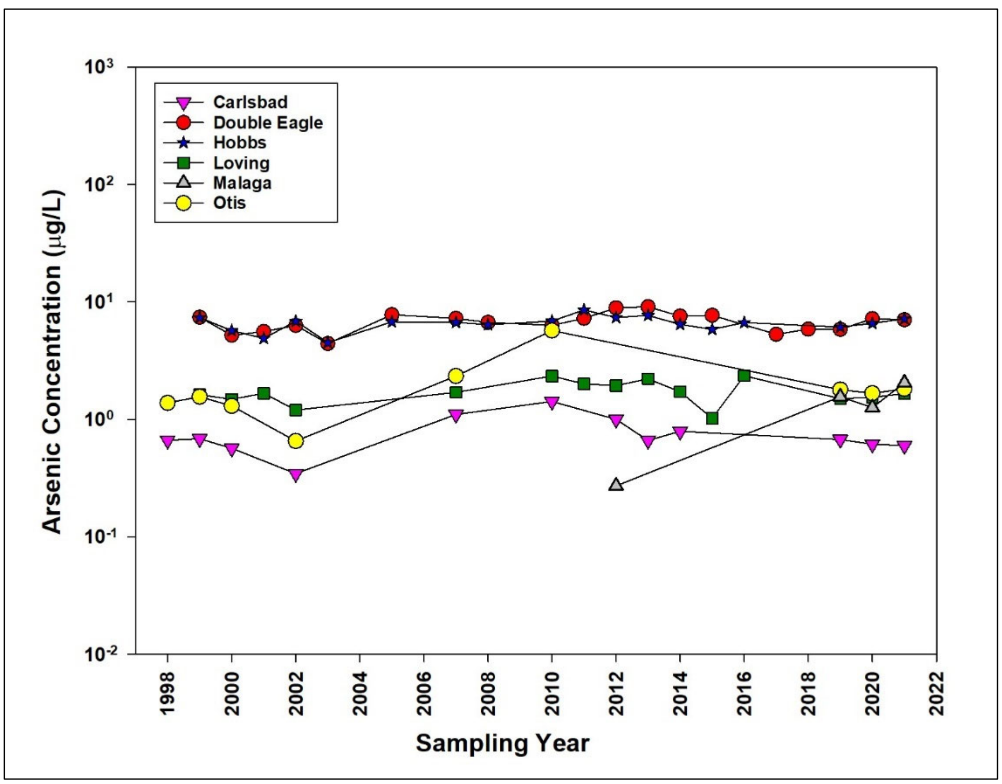
The 2021 trace metal and inorganic anion and cation concentrations measured in drinking water samples are reported in µg/L, which is calculated as the element mass in micrograms (µg) divided by volume of the drinking water in liters (L).

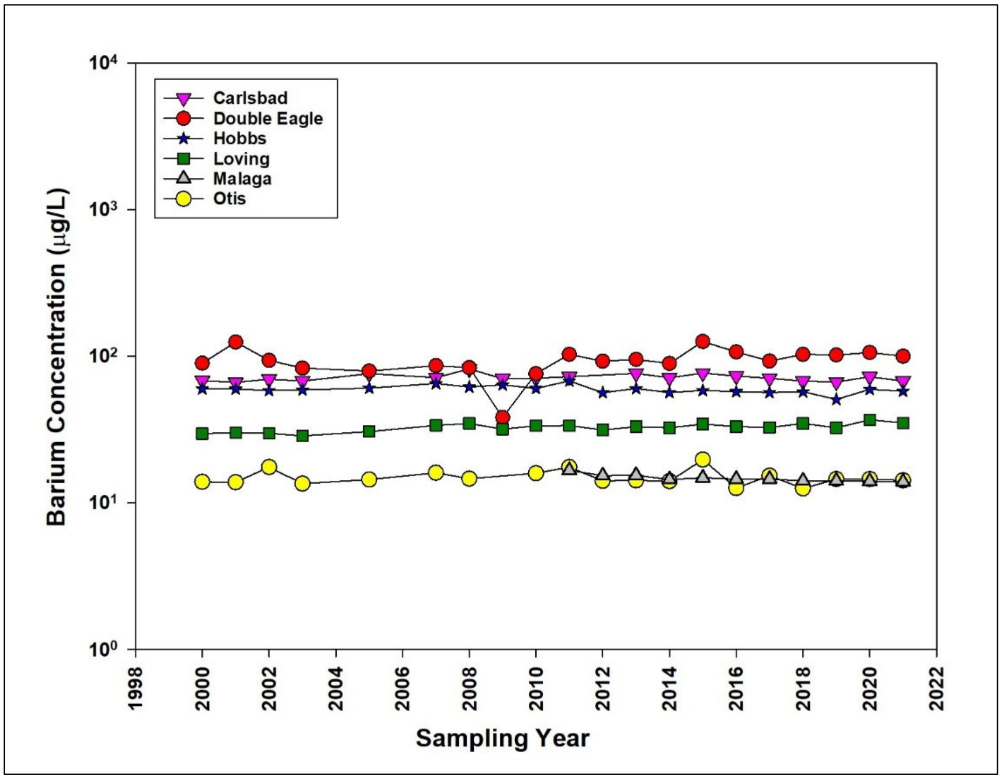
10.3.3 Metal Concentrations in Drinking Water

The following elemental constituents are commonly above the MDC in the drinking water samples collected from the areas surrounding the WIPP site: arsenic (As), barium (Ba), chromium (Cr), copper (Cu), lead (Pb), and antimony (Sb). Figure 10.5 illustrates the historical concentrations of these selected metals from six regional drinking water locations. Analytical results for 2021 drinking water samples are reported in Appendix I, Table I.12 through I.17.

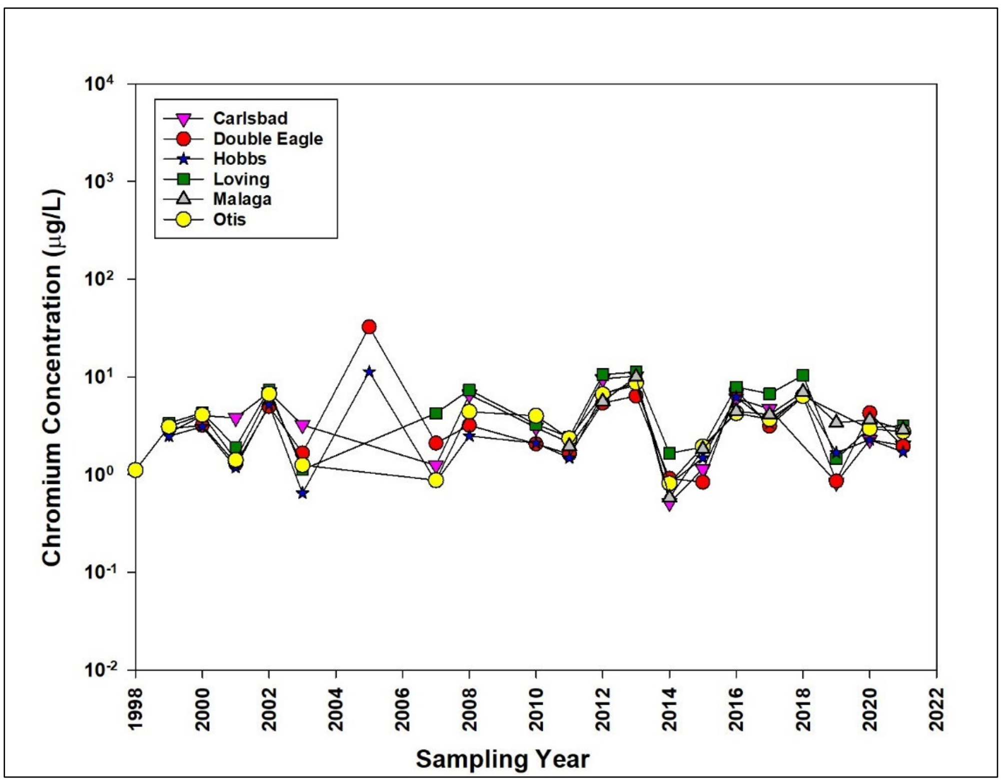
Minerals are a natural part of all water sources. The amount of inorganic materials in drinking water is controlled primarily by local geology and topography, but it can also be influenced by urban storm water runoff, industrial or domestic wastewater discharge, oil and gas production, mining, and/or farming, etc. (NRC, 1980). In 2021, Pb was detected in drinking water samples at the level of 0.30-1.70µg/L, which is lower than the EPA action level of 15 µg/L set for Pb. Mercury was not detected in any drinking water sources, while arsenic was detected in the range of 0.60 – 7.20 µg/L, which is also below the EPA action level of 10 µg/L set for arsenic (US-EPA, 2018).


Carlsbad
Double Eagle
Hobbs
Loving
Malaga
Otis
Antimony Concentration (µg/L)
Sampling Year
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022

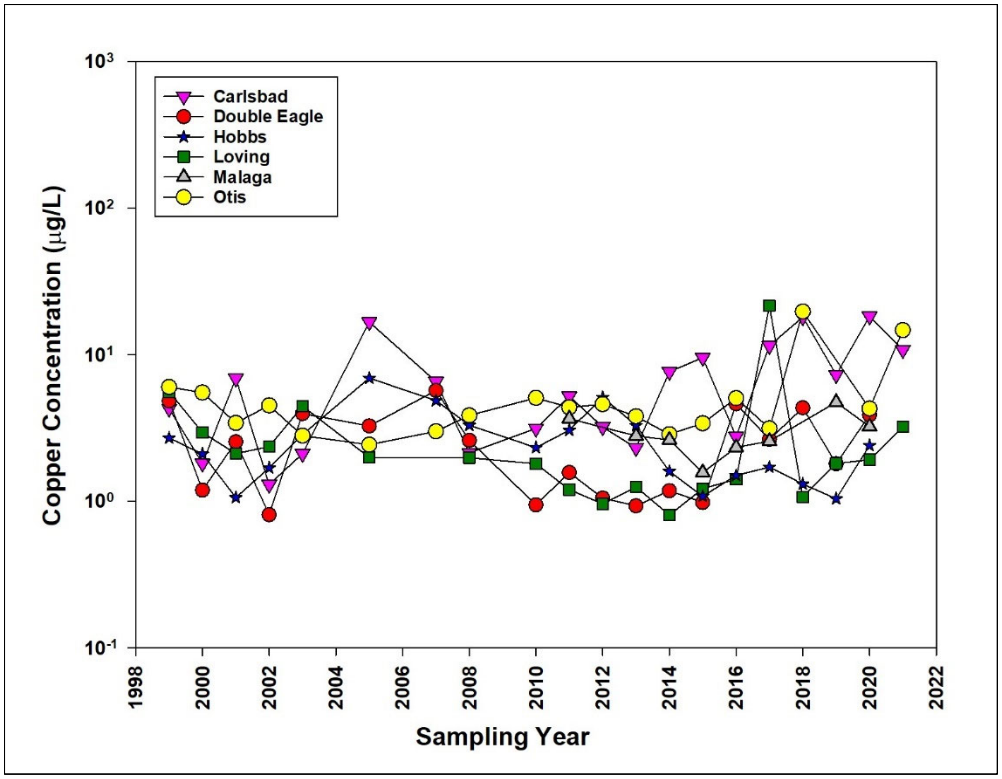

Carlsbad
Double Eagle
Hobbs
Loving
Malaga
Otis
Arsenic Concentration (µg/L)
Sampling Year
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022



Carlsbad
Double Eagle
Hobbs
Loving
Malaga
Otis
Barium Concentration (μg/L)
Sampling Year



Carlsbad
Double Eagle
Hobbs
Loving
Malaga
Otis
Chromium Concentration (μg/L)
Sampling Year



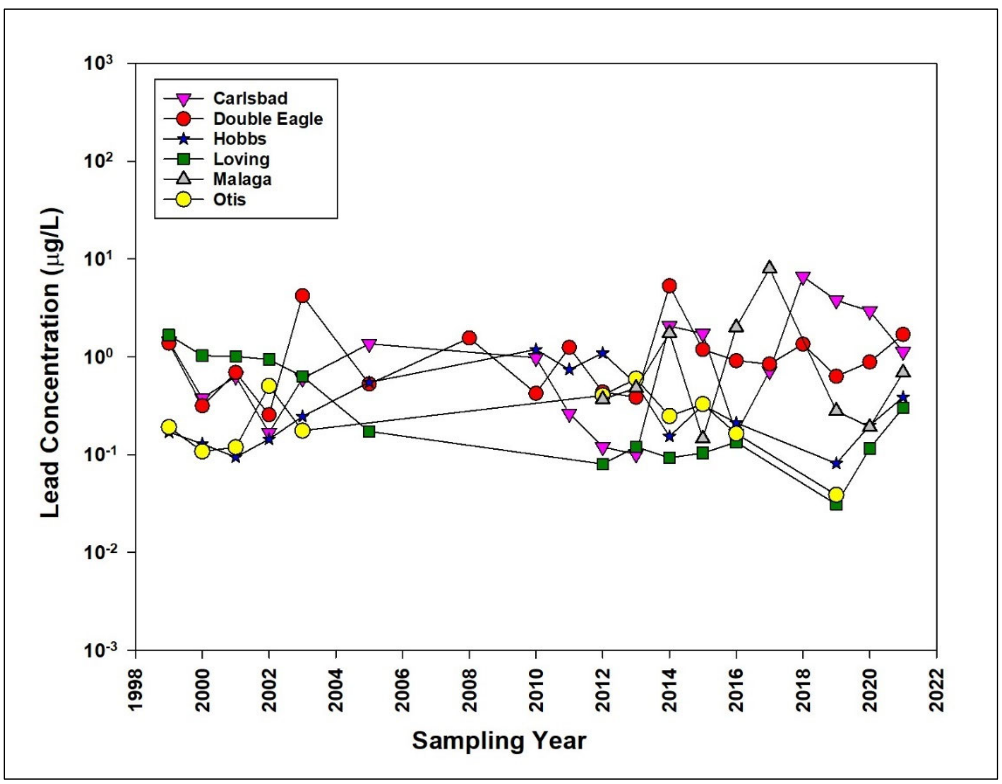
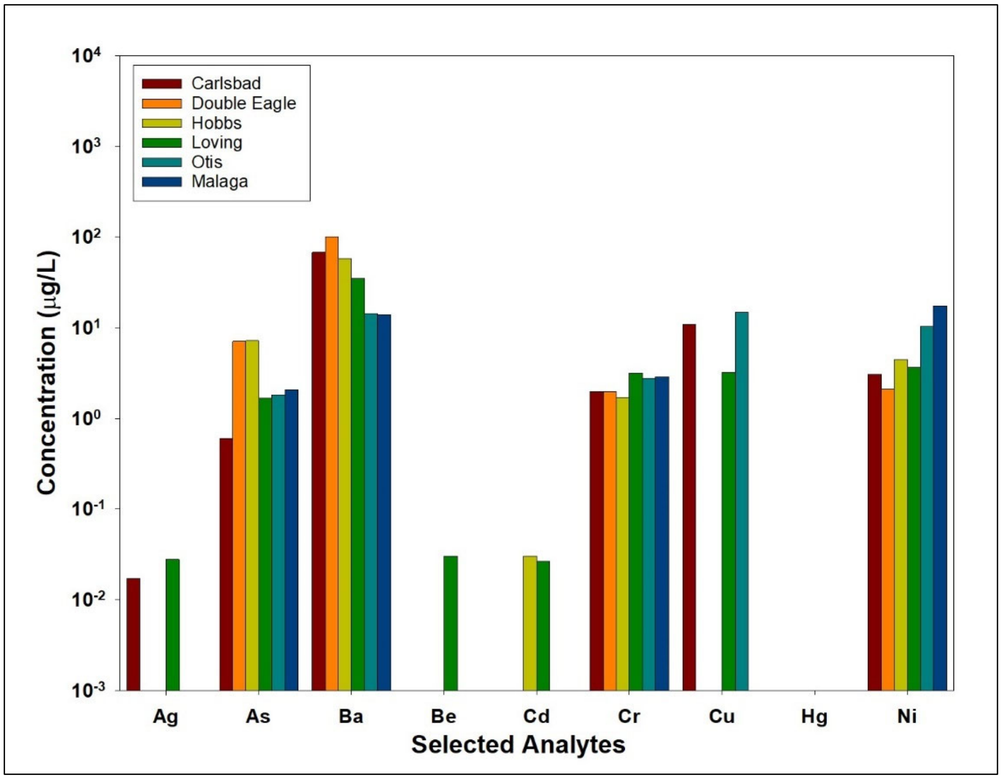


Figure 10.5. Historical Concentrations of Selected Metals in Drinking Water

Ranges for other common metal concentrations of drinking water samples collected in 2021 are presented in Appendix I, Tables I.12 through I.17). The maximum concentrations measured for these metals are as follows: 100 µg/L for Ba, 3.17 µg/L for Cr, and 14.7 µg/L for Cu. Present results as well as the results of previous analyses of drinking water are consistent for each source across sampling periods and are also below levels specified under SDWA (Safe Drinking Water Act) (US-EPA, 2018). Furthermore, the 2021 CEMRC results for drinking water from the Carlsbad (Sheep Draw) and WIPP (Double Eagle) locations generally agree with the measurements for the same elements monitored by the City of Carlsbad every year (CCR-2021).



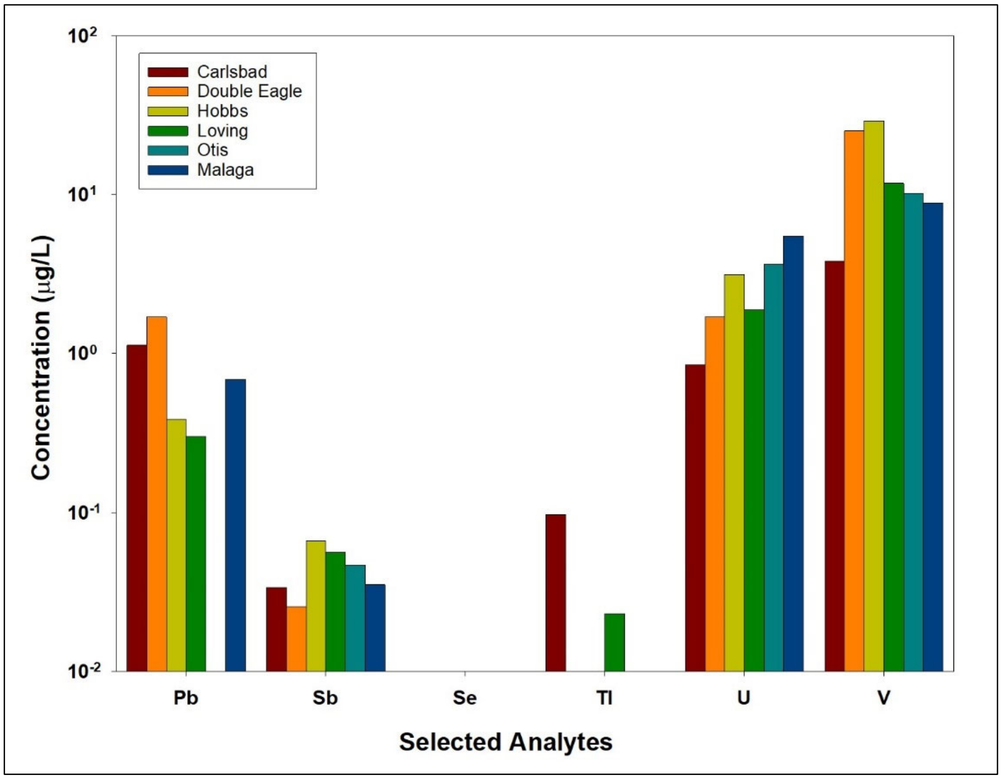


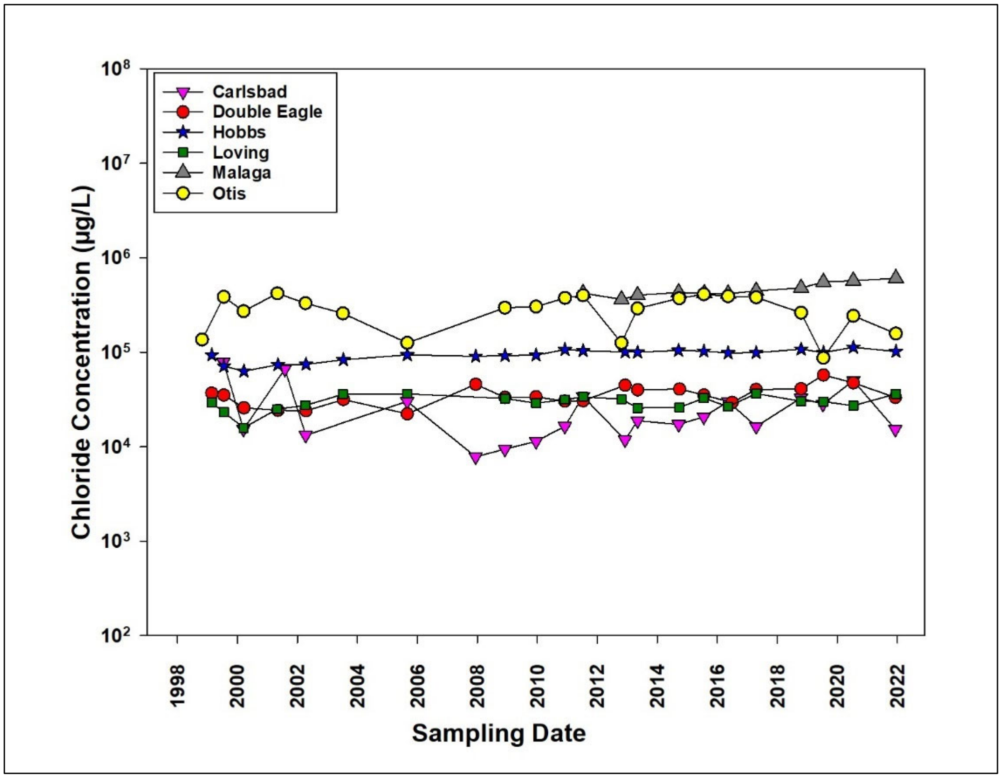
Figure 10.6. Location Comparison of Selected Metals in 2021 Drinking Water

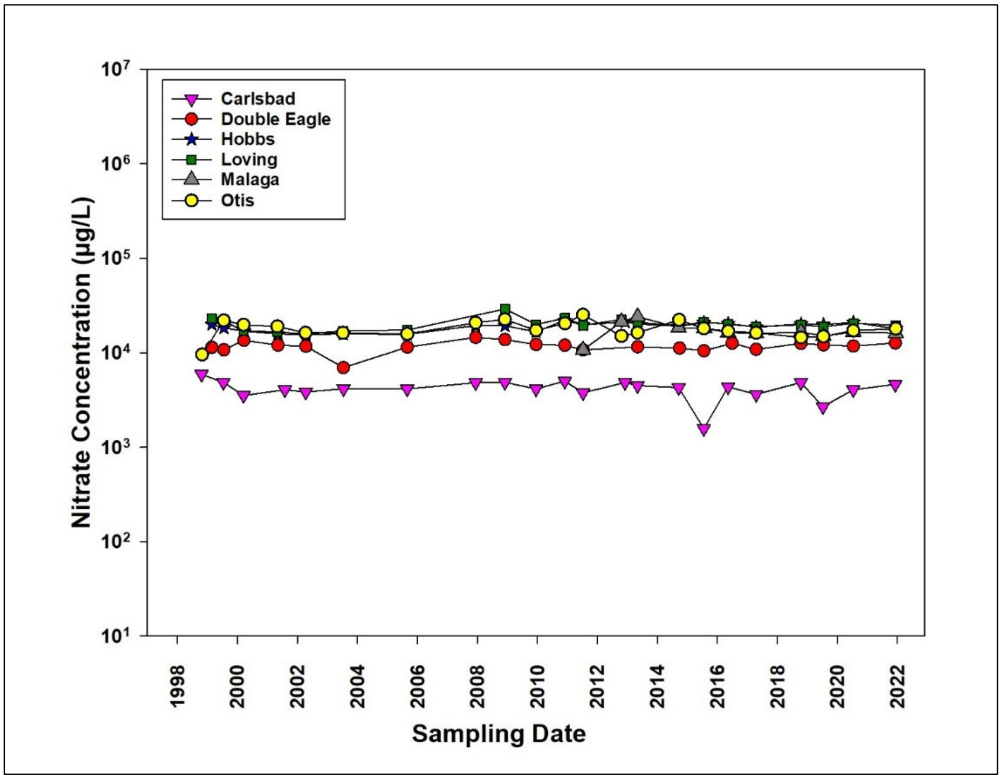
10.3.4 Concentrations of Inorganic Anions in Drinking Water

Of the seven inorganic anions that are monitored, only chloride, fluoride, nitrate, and sulfate are detected regularly above the MDC for inorganic anions. Chloride is always below the EPA secondary limit of 250 mg/L (US-EPA, 2018) for Carlsbad, Double Eagle, Hobbs, and Loving since 1998. However, chloride is frequently detected above the EPA secondary limit (US-EPA-2018) for Malaga drinking water. In fact, all analyses thus far from the Malaga site are above the EPA secondary limit; chloride is measured at the highest level of 608 mg/L in 2021 since the sampling began. Since no pre-operational baseline data is available from the Malaga site for comparison, these high concentrations cannot be directly attributed to the WIPP operations. It should be noted that secondary EPA regulations are also not enforceable.

In 2021, all reported fluoride concentrations are below the EPA limit of 4 mg/L (US-EPA, 2018). All reported nitrate concentrations are also below the EPA limit (44.2 mg/L for the nitrate ion) (US-EPA, 2018). Loving, Otis, Malaga, and Hobbs water typically have higher nitrate concentrations than Double Eagle and Carlsbad. According to the EPA, common sources of nitrogen in the form of nitrites and nitrates are fertilizer runoff, leaching from septic tanks and sewage, and from erosion of natural deposits.

Sulfate is detected below the EPA secondary limit for the Carlsbad, Double Eagle, Hobbs, and Loving locations, but is routinely detected above the EPA secondary limit of 250 mg/L (US-EPA, 2018) in Malaga and Otis water. It is noteworthy that CEMRC has been detecting high levels of sulfate in Otis water since monitoring began in 1998. Therefore, the high sulfate concentrations in Otis water cannot be a result of the WIPP-related activities. It should be noted that secondary EPA regulations are not enforceable. Furthermore, the EPA does not list any potential health effects from long-term exposure to sulfate. Figure 9.6 shows the historical variations of common anions in regional drinking water samples.





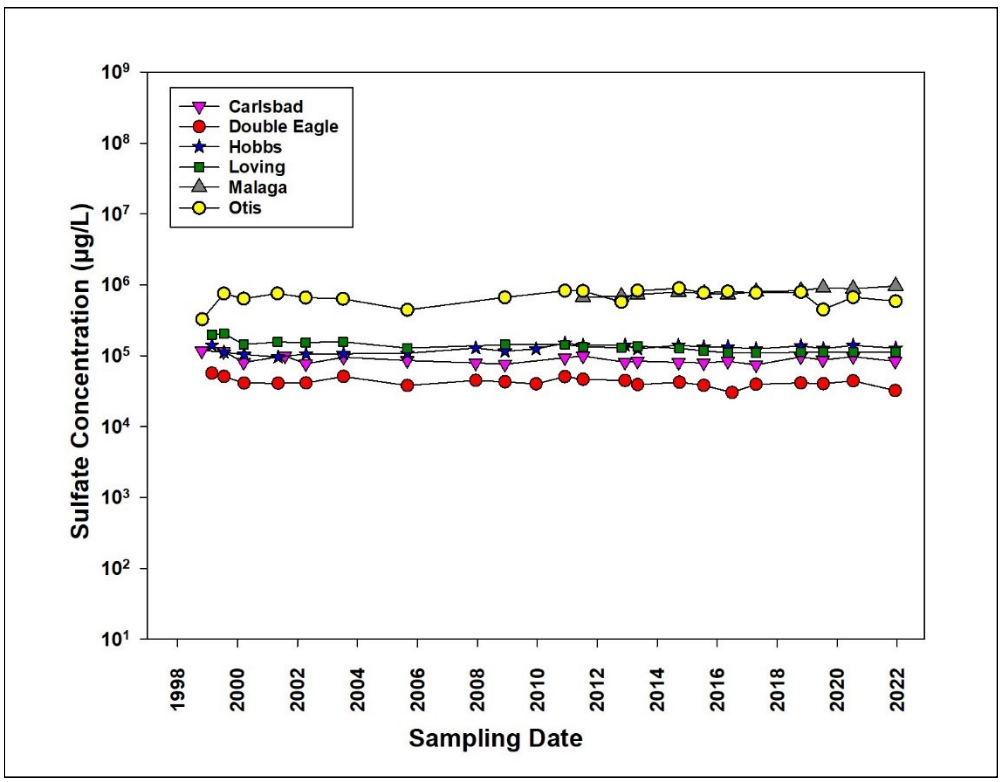
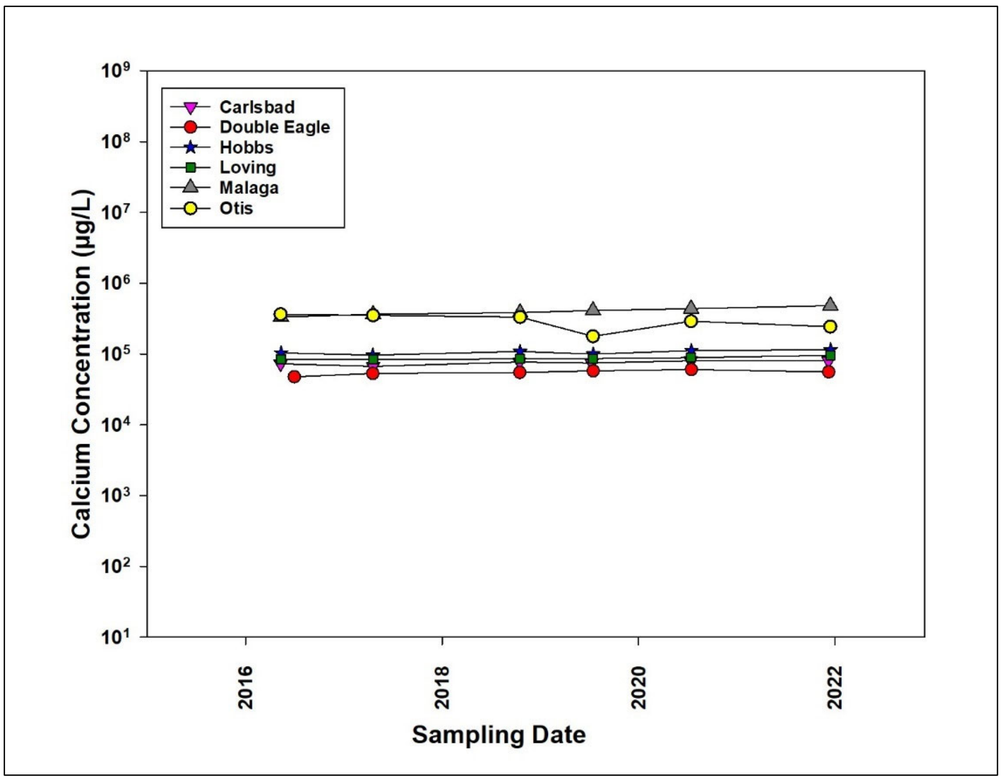
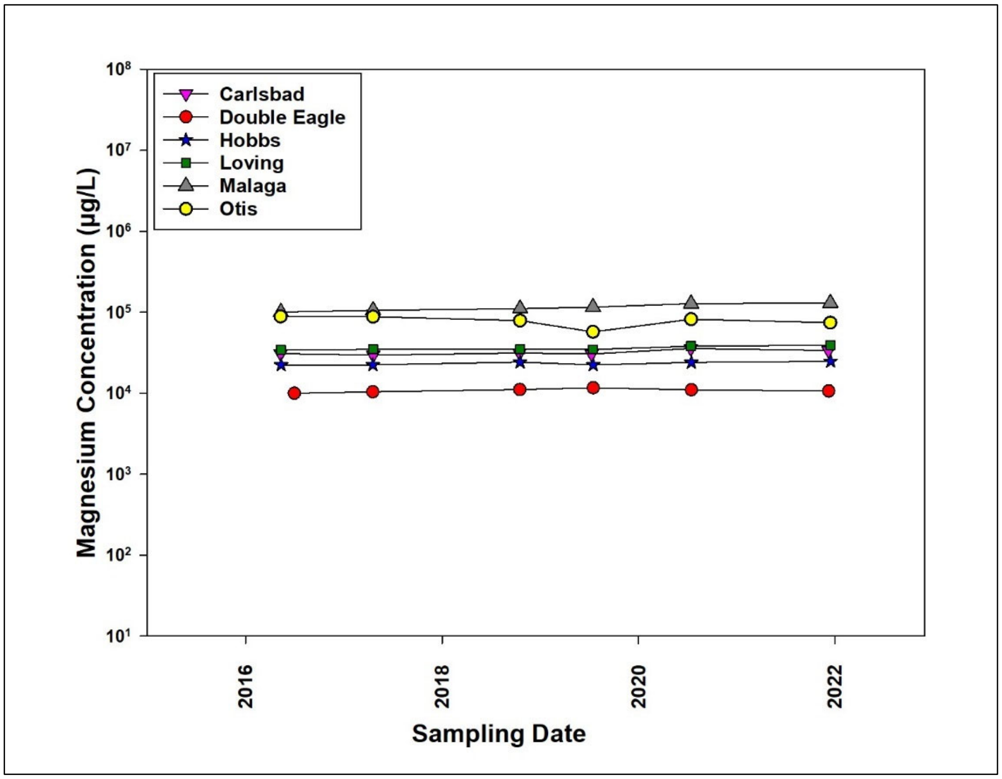


Figure 10.7. Historical Concentrations of Selected Anions in Drinking Water

10.3.5 Concentrations of Inorganic Cations in Drinking Water

Only concentrations for calcium (Ca), magnesium (Mg), and sodium (Na) are consistently measured above the MDC since cation analysis began in 2016. As illustrated in Figure 9.7, the past 5 years show very consistent measurements in all drinking water sampling locations. Potassium is only occasionally detected above the MDC for all sampling locations. In 2021, potassium was detected above the MDC at the Double Eagle location (1.95 mg/L), Loving location (3.02 mg/L), and Hobbs (3.15 mg/L). Lithium was only measured above the MDC in Double Eagle PRV4 in 2016 and in 2019. Thus far, ammonium is the only inorganic cation which has never been detected above the MDC at any of the drinking water sampling locations surrounding the WIPP site. Currently, none of the six inorganic cations are monitored by EPA and measured concentrations of these cations are consistent for the 2016–2021-time frame.





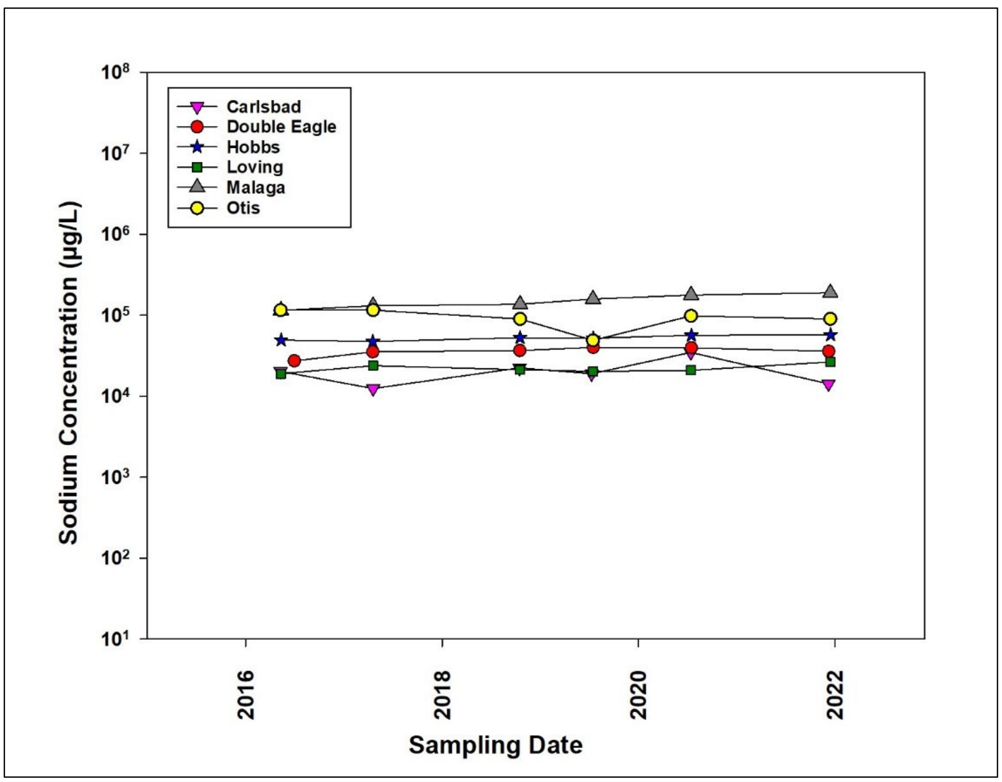


Figure 10.8. Historical Concentrations of Select Cations in Drinking Water

10.3.6 Additional Analyses Performed on Drinking Water

To characterize the drinking water more comprehensively, several new types of non-radiological analyses are performed this year, including specific gravity, pH, conductance, total organic carbon, total dissolved solids, and total suspended solids. Results of these analyses are provided in Appendix I, Tables I.18 - I.22.

10.4 Non-Radiological Monitoring of Surface Water

10.4.1 Sample Collection

In 2021, surface water samples for non-radiological analyses were collected from three regional surface water reservoirs situated on the Pecos River. These locations include Lake Carlsbad, Brantley Lake, and Red Bluff Lake. This year, CEMRC also sampled three locations with potential for livestock uptake in coordination with the WIPP personnel. These samples were identified as "Hill Tank", "Noya Tank", and "Lost Tank" and were collected following the WIPP methods.

10.4.2 Sample Preparation and Analysis

Once the surface water samples are received by the CEMRC facility, samples are divided into the same aliquots as drinking water: (1) 1L for inorganic constituent analysis, (2) 500 mL for mercury analysis and (3) 1 L for elemental analyses. Surface water samples are preserved and analyzed in the same manner as drinking water samples except that all surface water samples are filtered prior to analysis because of the high particulate content.

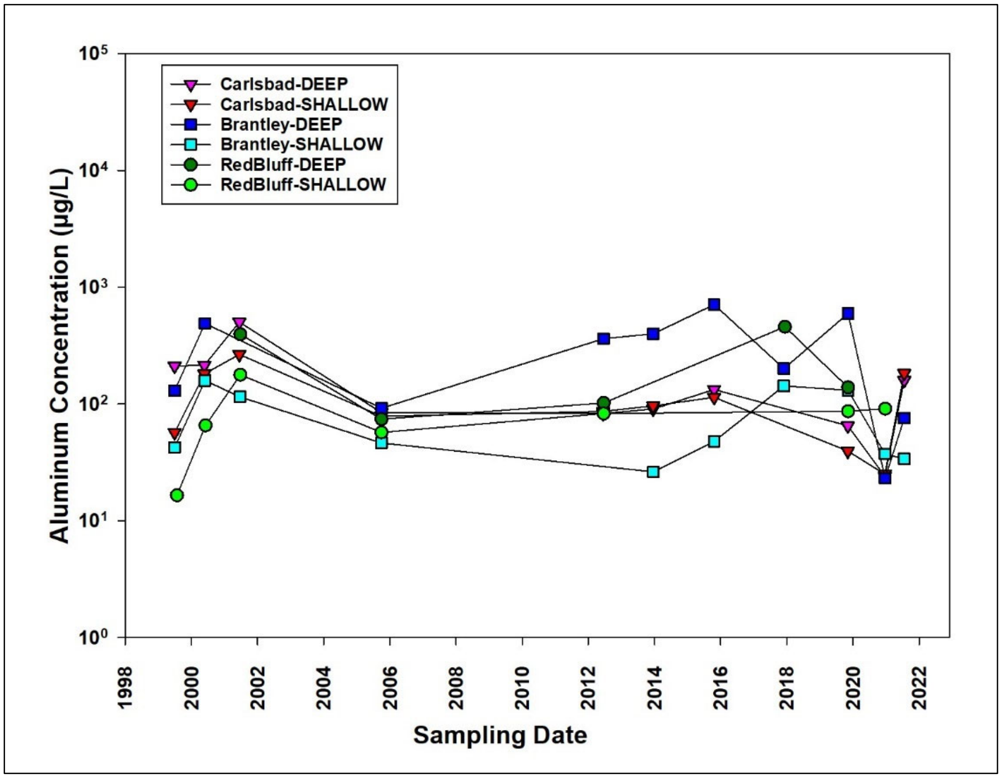
The 2021 trace metal and inorganic anion/cation concentrations measured in surface water samples are reported in µg/L. The concentration is calculated as the element mass in micrograms (µg) divided by volume of the surface water in liters (L).

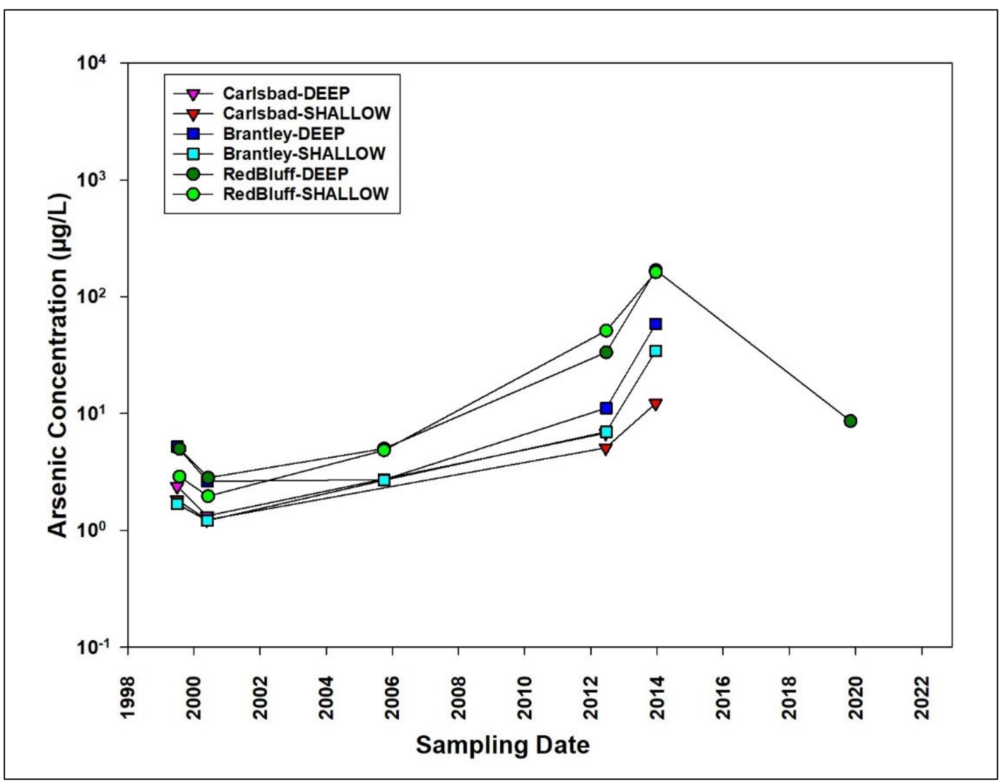
10.4.3 Metal Concentrations in Surface Water

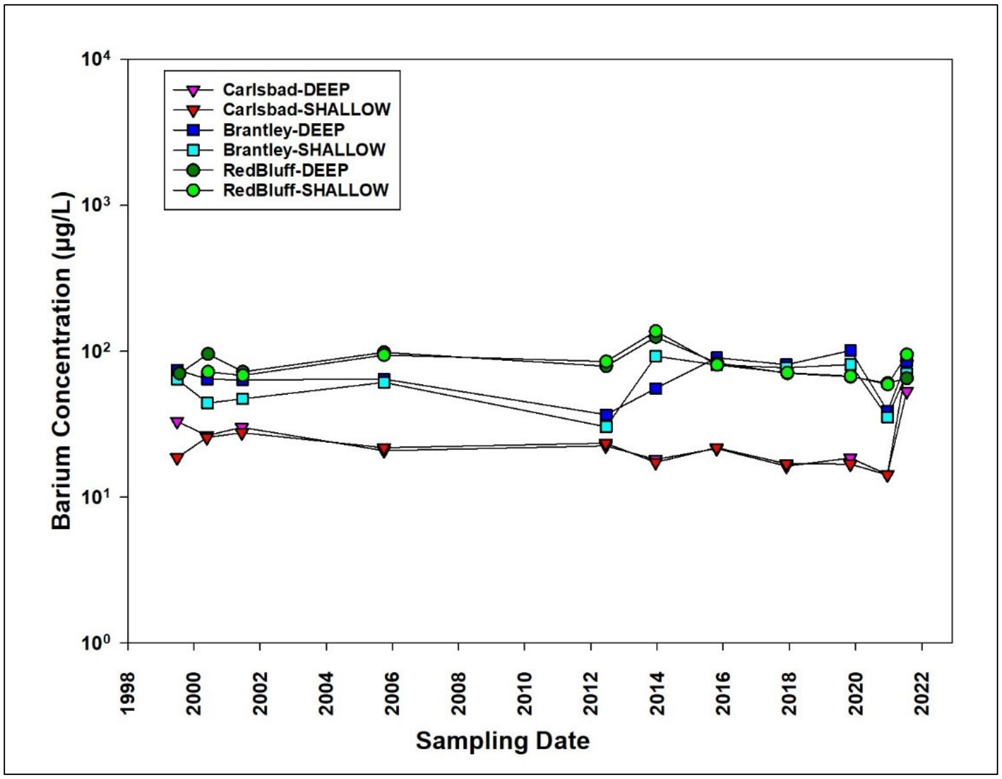
Aluminum (Al), barium (Ba), iron (Fe), and nickel (Ni) are metals commonly found above the MDC in the surface water samples collected from the areas surrounding the WIPP site. The amount of non-radiochemical materials in surface water is determined primarily by local geology and topography, but it can be influenced by urban storm water runoff, industrial or domestic wastewater discharges, oil and gas production, mining, and/or farming, etc. Figure 9.8 illustrates the historical concentrations of these selected metals at the three regional surface water locations from both deep and shallow collection areas. In 2021, lead (Pb) and arsenic (As) concentrations in surface water were all below the MDC at the Lake Carlsbad, Brantley Lake and Red Bluff locations. However, Pb and As were above the MDC at the three "tank" locations in the range of 1.5 – 8.9µg/L and 4.3 – 7.8 µg/L, respectively. The recommended EPA concentration of 150 µg/L in surface water is the limit in which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.

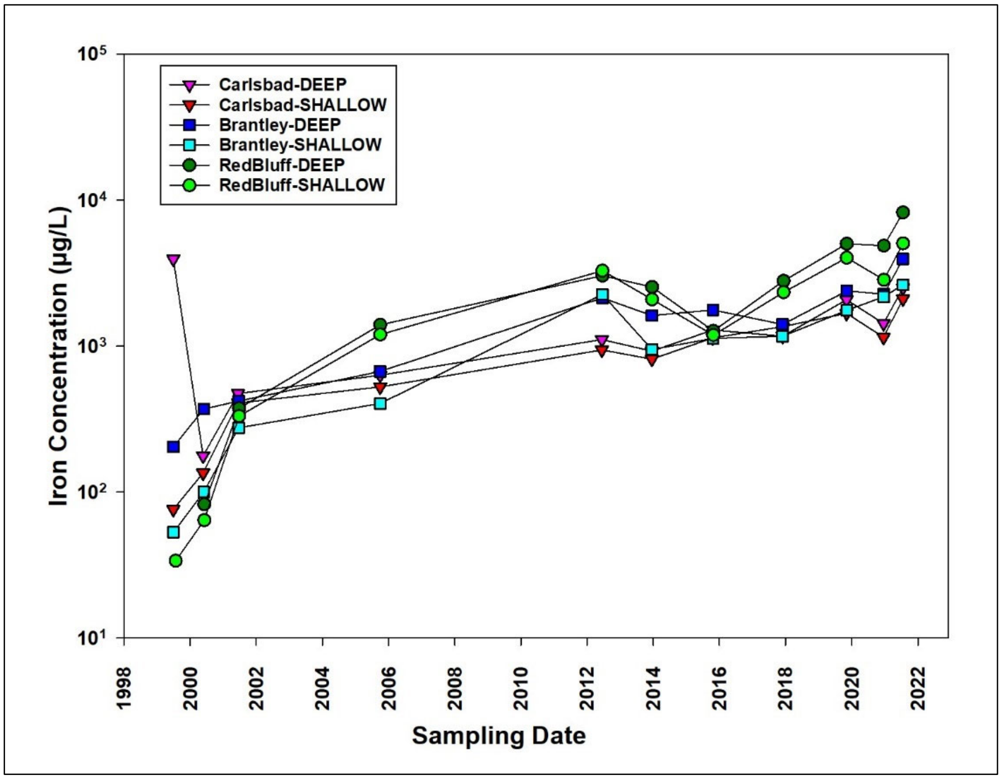
Mercury was not detected in any surface water sources in 2021. However, mercury (Hg) was detected in Lake Carlsbad at the level of 0.028 µg/L and in Brantley Lake at the level of 0.18µg/L in 2001. Mercury was also detected at the level of 0.42 µg/L in Brantley Lake and

0.21 µg/L in Red Bluff Lake in 2012. Another detection of mercury was occurred in 2017 in Lake Carlsbad at the level of 0.03 µg/L. All concentrations were well below the EPA recommended limit of 0.77µg/L in surface water.

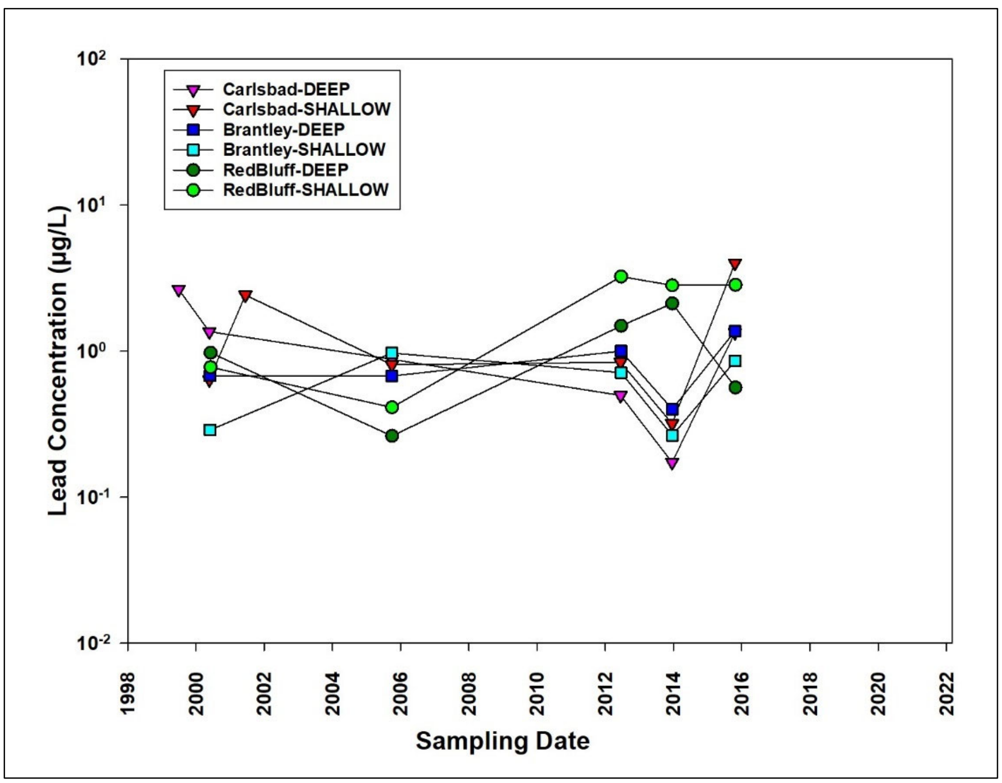





Carlsbad-DEEP
Carlsbad-SHALLOW
Brantley-DEEP
Brantley-SHALLOW
RedBluff-DEEP
RedBluff-SHALLOW
Barium Concentration (µg/L)
10^4
10^3
10^2
10^1
10^0
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
Sampling Date



Carlsbad-DEEP
Carlsbad-SHALLOW
Brantley-DEEP
Brantley-SHALLOW
RedBluff-DEEP
RedBluff-SHALLOW
Iron Concentration (µg/L)
Sampling Date



Carlsbad-DEEP
Carlsbad-SHALLOW
Brantley-DEEP
Brantley-SHALLOW
RedBluff-DEEP
RedBluff-SHALLOW
Lead Concentration (µg/L)
Sampling Date

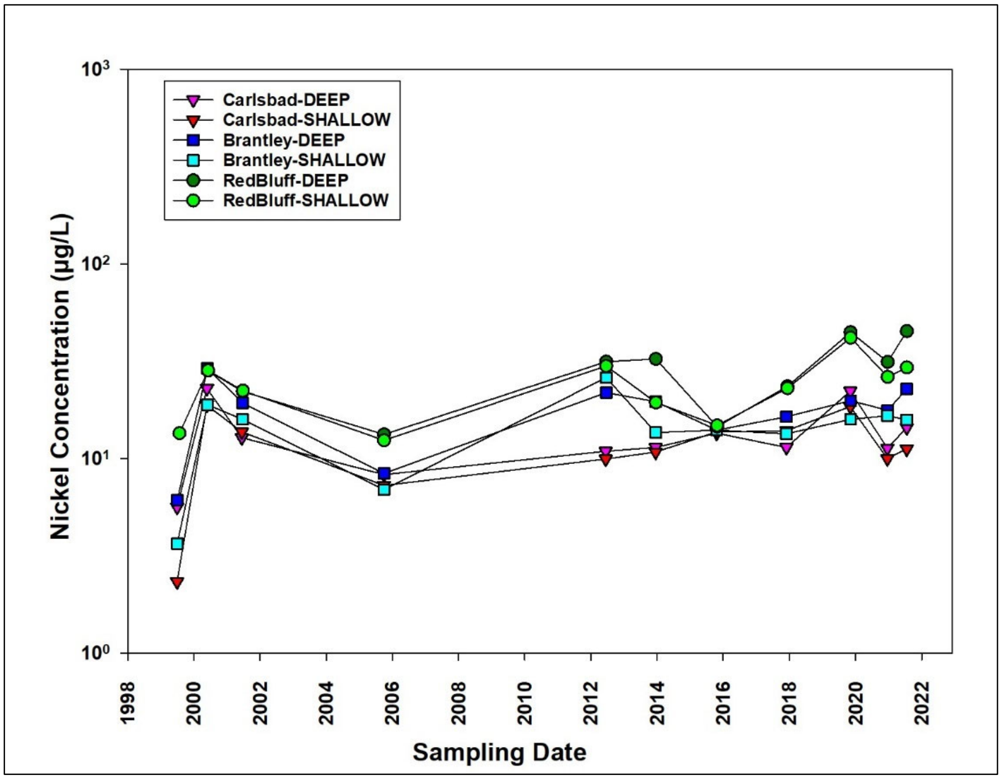
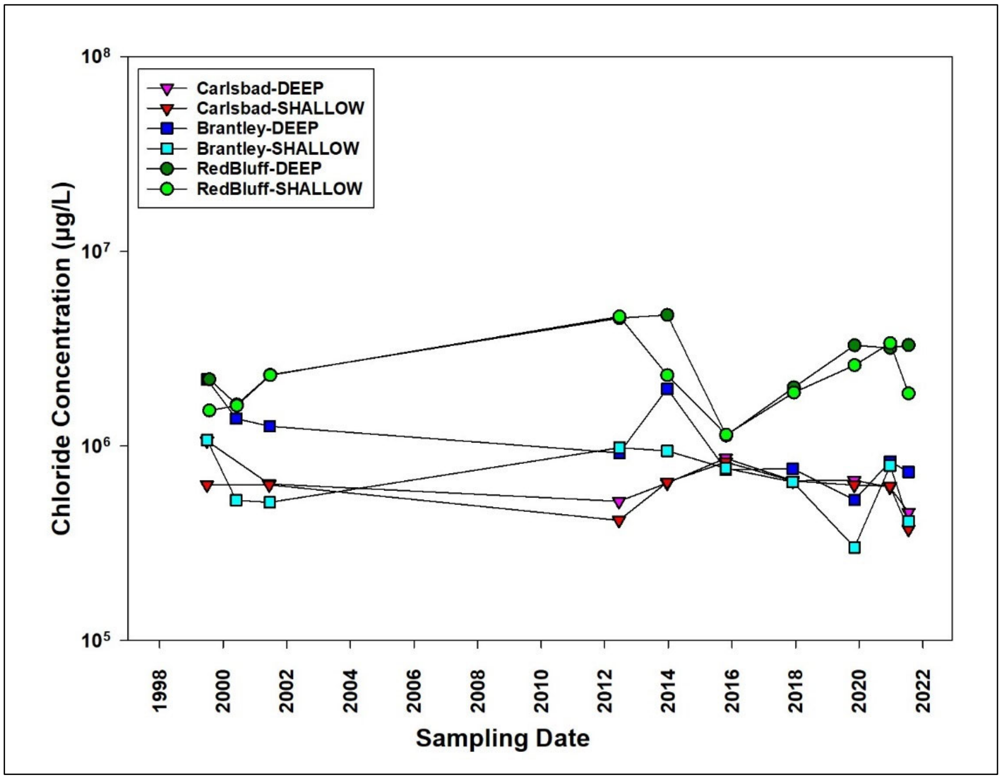


Figure 10.9. Historical Concentrations of Select Metals in Surface Water

The maximum concentrations measured for some of these metals are as follows: 7.8 µg/L for As, 203 µg/L for Ba, and 9870 µg/L for Al. Present results as well as the results of previous analyses of surface water were consistent for each source across sampling periods.

10.4.4 Concentrations of Inorganic Anions in Surface Water

Inorganic anion concentrations measured in regional surface water samples are listed in Appendix I, Table I.23. Of the seven inorganic anions that are monitored, chloride, fluoride, nitrate, and sulfate have been detected regularly above the MDC. The only inorganic anion monitored by the EPA, is chloride. The chloride levels in all three regional reservoirs are often above the EPA recommendation of 860 mg/L (EPA, 1988). In 2021, only Red Bluff was detected above the limit with a range of 3,190 mg/L (deep level) to 3,370 mg/L (shallow level). Figure 10.9 shows the historical variations of common anions in regional surface water samples. Results for the three locations with potential for livestock uptake, “Hill Tank”, “Noya Tank”, and “Lost Tank” are provided in Appendix I, Table I.23.



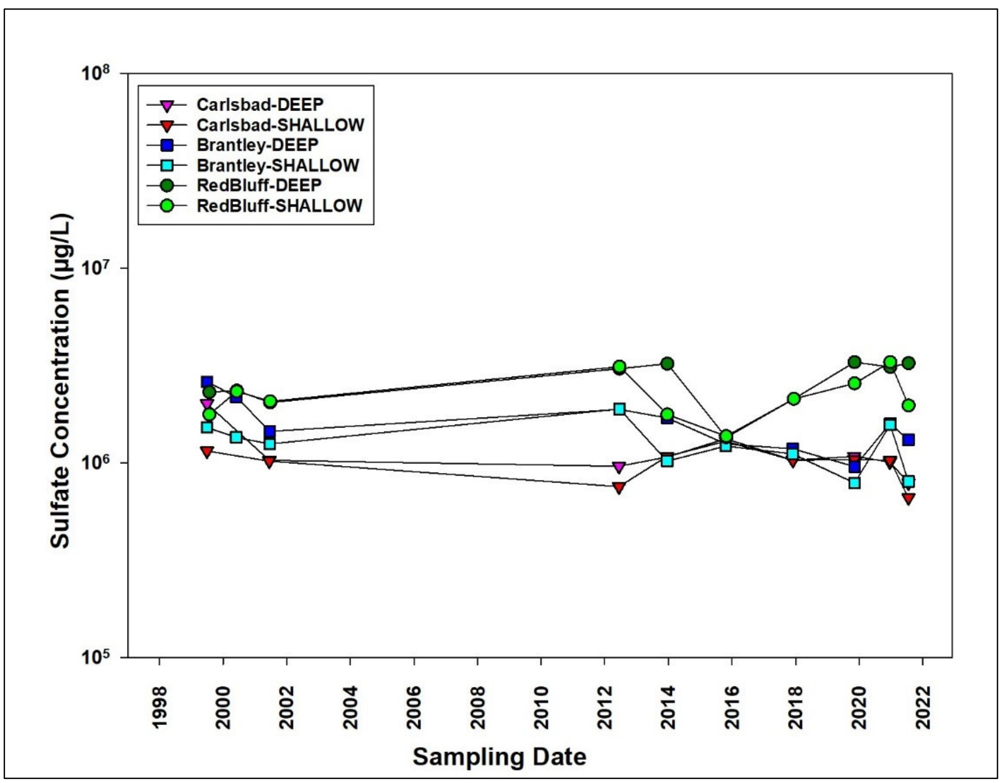
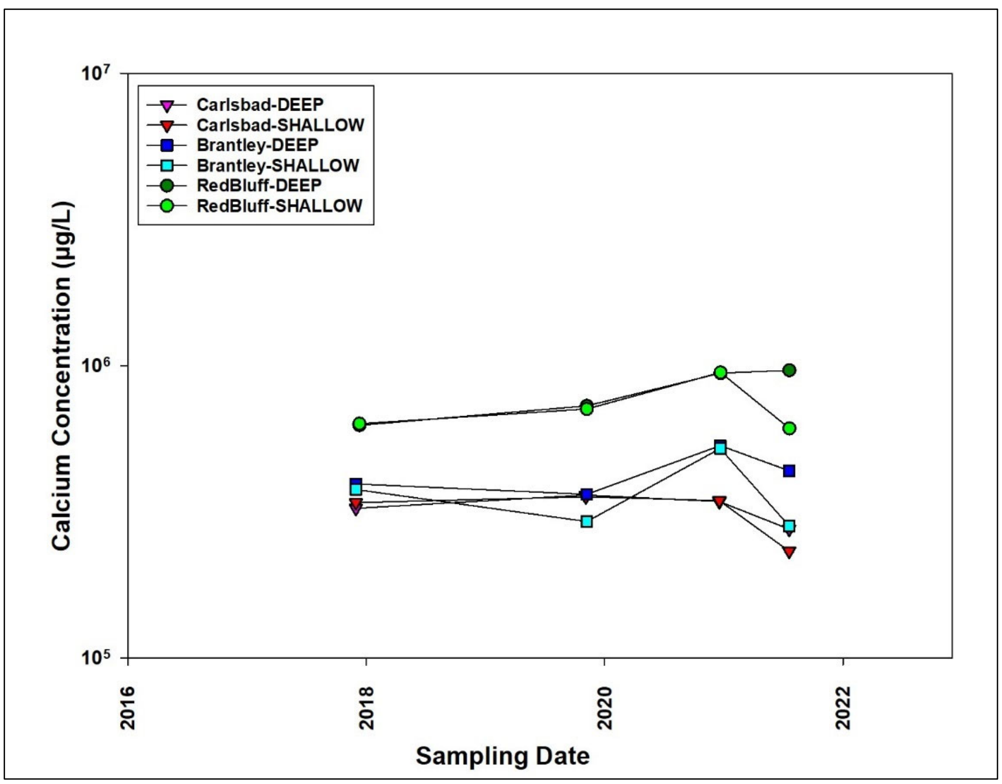
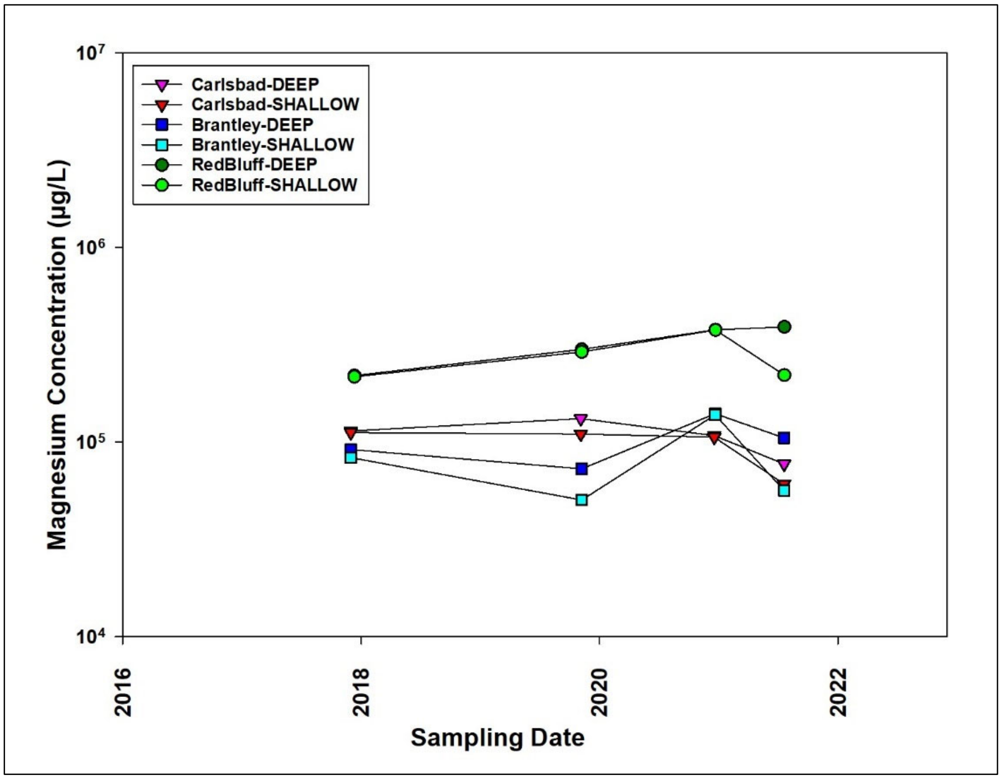


Figure 10.10. Historical Concentrations of Selected Anions in Surface Water

10.4.5 Concentrations of Inorganic Cations in Surface Water

The 2021 concentrations of inorganic cations measured in three surface water reservoirs are provided in Appendix I, Table I.24. The corresponding concentration ranges of these cations measured previously are also listed for comparison. Only concentrations for calcium (Ca), magnesium (Mg), and sodium (Na) have consistently been detected since cation analysis began in 2017. Figure 10.10 shows that all three of these cations have shown consistent measurements in all surface water sampling locations prior to 2021. Potassium is only occasionally detected. However, in 2021, potassium was detected in virtually all locations. Lake Carlsbad at 3.14 mg/L (shallow level only), in Brantley Lake at 3.74 mg/L and 3.40 mg/L (shallow and deep, respectively) and Red Bluff at 16.1 mg/L and 62.9 mg/L (shallow and deep, respectively). The highest concentration of potassium was detected in the “Hill tank” sample at 15.7 mg/L. Thus far, ammonium is the only inorganic cation, which has never been detected above the MDC in any of the regional surface water reservoirs surrounding the WIPP site. However, it was detected above the MDC in all 3 of the new “tank” samples, ranging between 0.35 – 0.66 mg/L. Currently, none of the six inorganic cations are monitored by the EPA. It is important to note that inorganic cation analyses in surface water began in 2017. Results for the three locations with potential for livestock uptake, “Hill Tank”, “Noya Tank”, and “Lost Tank” are provided in Appendix I, Table I.24.





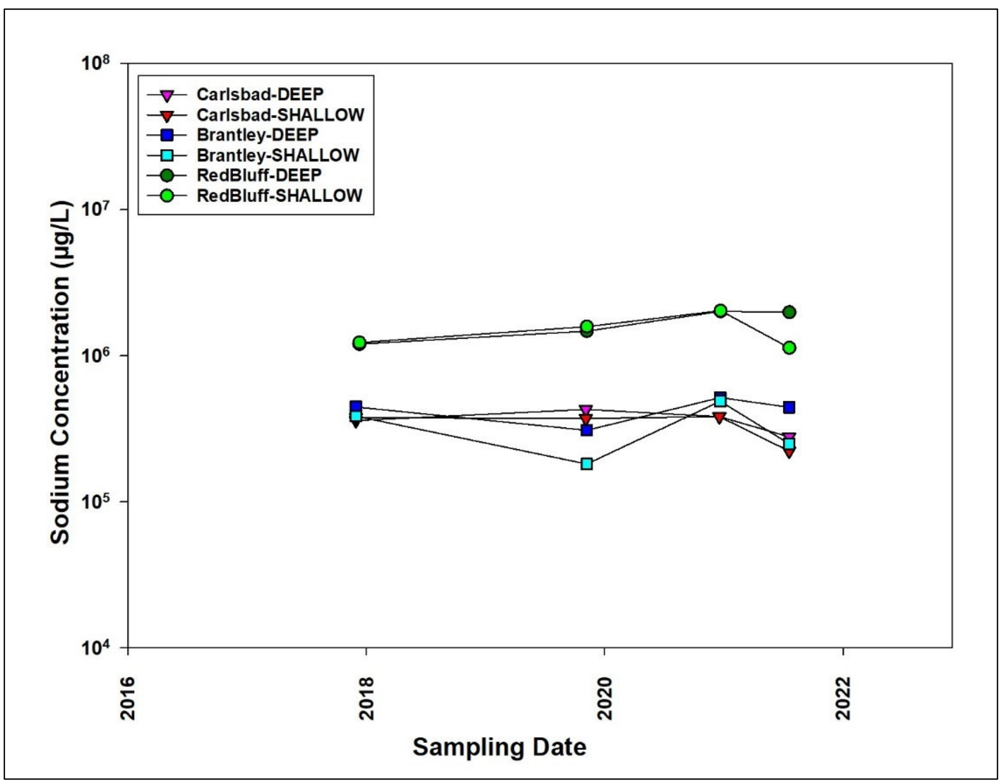


Figure 10.11. Historical Concentrations of Selected Cations in Surface Water

10.4.6 Additional Analyses Performed on Surface Water

Several new types of non-radiological characterization have been added to surface water analyses this year: specific gravity, pH, conductance, total organic carbon, total dissolved solids, and total suspended solids. Results of these analyses are summarized in Appendix I, Tables I.25 - I.28 for all locations sampled.

10.5 Conclusion

This chapter presents the monitoring results of a variety of environmental media including effluent air, airborne particulates, drinking water and surface water for the calendar year 2021. For this monitoring period, the concentrations of Al, Cd, and Pb are detected above the MDC at both the monitoring stations (A and B), and within the range of previously measured results at these sampling locations.

This is the second time that anion and cation concentrations are reported for airborne particulates collected around the WIPP site. Some variation over the two years (2019-2021) of data presented is observed.

In drinking water, barium (Ba), chromium (Cr), copper (Cu), and lead (Pb) are detected above the MDC. They are comparable with the previous values measured at these sampling locations and are all below the EPA action levels. No noticeable changes in the 2021 elemental or inorganic levels are observed which could be attributed to activities at the WIPP site.

Aluminum (Al), barium (Ba), iron (Fe), and nickel (Ni) are some metals commonly measured above the MDC in regional surface water samples collected from the areas surrounding the WIPP site. Their concentrations are within the range of previously measured results at these sampling locations. No noticeable changes in the 2021 elemental or inorganic levels are observed which could be attributed to activities at the WIPP site.

CHAPTER 11 - VOLATILE ORGANIC COMPOUND MONITORING

The WIPP Hazardous Waste Facility Permit (HWFP), Attachment N, mandates the monitoring of volatile organic compound (VOC) emissions from mixed waste, which may be entrained in the exhaust air from the WIPP underground hazardous waste disposal units (HWDUs). The purpose of the VOC monitoring is to verify that regulated VOCs emitted by the waste are within the concentration limits specified by the HWFP. The program is designed to determine VOC concentrations attributed to open and closed panels. Currently, ten target VOCs selected for monitoring were determined to represent approximately 99% of the risk due to air emissions. These target compounds are 1,1-dichloroethylene, methylene chloride, chloroform, 1,1,1-trichloroethane, carbon tetrachloride, 1,2-dichloroethane, toluene, chlorobenzene, 1,1,2,2-tetrachloroethane, and trichloroethylene. In 2014, trichloroethylene was added to the analyte list in compliance with the NMED Administrative Order. These ten compounds and their method reporting limits for different types of samples are summarized in Appendix J, Table J.1. Compounds consistently detected in ambient air samples in the underground may be added to the list of compounds of interest.

Repository VOC monitoring was implemented in November 1999 and disposal room VOC monitoring was implemented in November 2006. CEMRC first began analyzing samples for the Confirmatory VOCs Monitoring Plan in April 2004. Originally, the samples were collected from only two stations in the WIPP underground for each filled disposal room, referred to as Repository VOC monitoring. Since 2006, each room actively receiving waste is also sampled at the exhaust side of the room, referred to as disposal room VOC monitoring. The requirements for disposal room VOC monitoring include the addition of sampling locations within active underground hazardous waste disposal units. Disposal room sampling terminates upon initiation of panel closure activities.

Before the 2014 fire and radiation release events, repository VOC sampling for target compounds was performed biweekly at two ambient air monitoring stations, VOC-A, located downstream from HWDU panel 1 in Drift E300, and VOC-B, located upstream from the active panel. As waste is placed in new panels, VOC-B will be relocated to ensure that it samples underground air before it passes the waste panels. Target compounds found in VOC-B represent background concentrations found in the underground. The VOC concentrations measured at this location are VOCs entering the mine through the air intake shaft and VOCs contributed by facility operations upstream of the waste panels. Differences measured between the two stations represent any VOC contributions from the waste panels. After the February 2014 fire event, the waste panels sampling locations for repository VOC monitoring have been changed from Stations VOC-A and VOC-B in the underground to new Stations VOC-C and VOC-D on the surface. Surface VOC sampling has been underway since February 2014.

Disposal room VOC sampling activity was suspended following the 2014 salt truck fire and radiation release event in the WIPP underground. The disposal room VOC monitoring for

Panel 7 (current active waste disposal panel) was activated on December 19, 2016. Details of the sample collection and analyses are described in the following sections.

11.1 Sample Collection

The surface VOC samples were collected twice weekly from two air-sampling locations. These stations are located at the following locations: (1) Station VOC-C, located at the west side of Building 489, and (2) Station VOC-D, at the groundwater pad WQSP-4 for measuring background VOCs. Disposal room VOC samples were collected biweekly from Panel 7, the current active disposal panel. Sample location data are identified by the source panel number, room number, and intake (I) or exhaust (E) function. For example, Panel 7 Room 6 exhaust location is coded P7R6E. Samples were collected by NWP LLC, personnel using a commercially available portable passive air canister and delivered for analysis to CEMRC in weekly batches. For the 2021 monitoring period, a total of 229 surface VOC samples and 235 disposal room VOC samples were collected.

11.2 Sample Preparation and Analysis

Regular VOC samples were analyzed using an Agilent 6890/5975 gas chromatography-mass spectrometry (GC-MS) system interface with an Entech 7100 pre-concentrator, while low-level VOC analyses were primarily analyzed using an Agilent 7820/5977 GCMS interface with Entech 7200/7016D pre-concentrator/auto-sampler system. Analytical procedures employed for the analyses were based on the concepts contained in Compendium Method TO-15 *Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially–Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS)"* (1999).

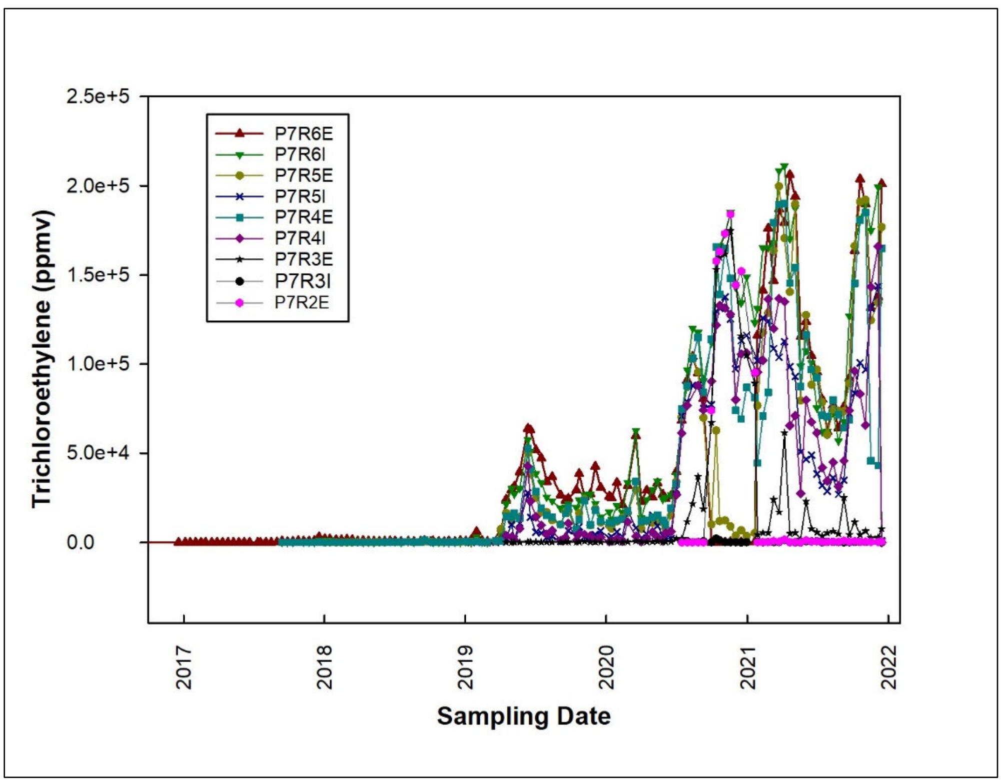
For analysis, a known volume of air sampled from the canister was directed to a pre-concentrator. The pre-concentrator captures VOCs and removes most of the water vapor and bulk gases such as oxygen, nitrogen, and carbon dioxide from the sample prior to introducing the target VOCs to the GC-MS. The VOC screening results were used to determine pre-analysis dilutions required for analysis using Entech 4600 Dynamic Diluter. Canisters were cleaned after sample analysis using the Entech 3100 Canister Cleaning system. All cleaned canisters were analyzed to assure the desired level of cleanliness has been achieved.

11.3 Results and Discussion

The concentrations of VOCs are reported here either in parts per billion by volume (ppbv) or parts per million by volume (ppmv). Table J.1 lists the maximum MRLs for the ten target compounds for undiluted samples. Due to the samples being diluted in the laboratory, the laboratory MRL for diluted samples is a factor of the lowest calibration level and the dilution factor. For disposal room VOC samples, the laboratory MRL varies for each sample based on the dilution factor (which is calculated based on the estimated concentration for the sample). In comparison, all surface VOC samples have a dilution factor of 2, so for example, the laboratory MRL for SIM mode analysis is 0.1 ppbv (where the lowest calibration level is 0.05 ppbv).

11.3.1 Disposal Room VOC Monitoring Results

Samples were collected from nine rooms in Panel 7 (P7R6E, P7R6I, P7R5E, P7R5I, P7R4E, P7R4I, P7R3E, P7R3I, and P7R2E) in 2021. Maximum sample results for the disposal room VOCs are summarized in Appendix J, Table J.2. Three target VOC compounds, carbon tetrachloride; 1,1,1-trichloethane; and trichloroethylene were detected above the laboratory MRL in all nine locations. The variations of carbon tetrachloride, trichloroethylene, and 1,1,1-trichloroethane in the disposal room VOC samples over the period of 2016-2021 are shown in Figure 10.1. The maximum concentrations were 643.94 ppmv for carbon tetrachloride, 230.16 ppmv for 1,1,1-trichloroethane, and 211.09 ppmv for trichloroethylene. Chloroform was also detected above the laboratory MRL almost regularly and the maximum concentration was 24.14 ppmv. Concentrations of other target VOC compounds, such as methylene chloride, 1,1,2,2-tetrachloroethane, and toluene were detected at concentrations less than the method reporting limit, while concentrations of chlorobenzene, 1,2-dichloroethane and 1,1-dichloroethylene were either below the method detection limit or not detected. The levels detected were continuously below the 50% action level as listed in Appendix J, Table J.3.



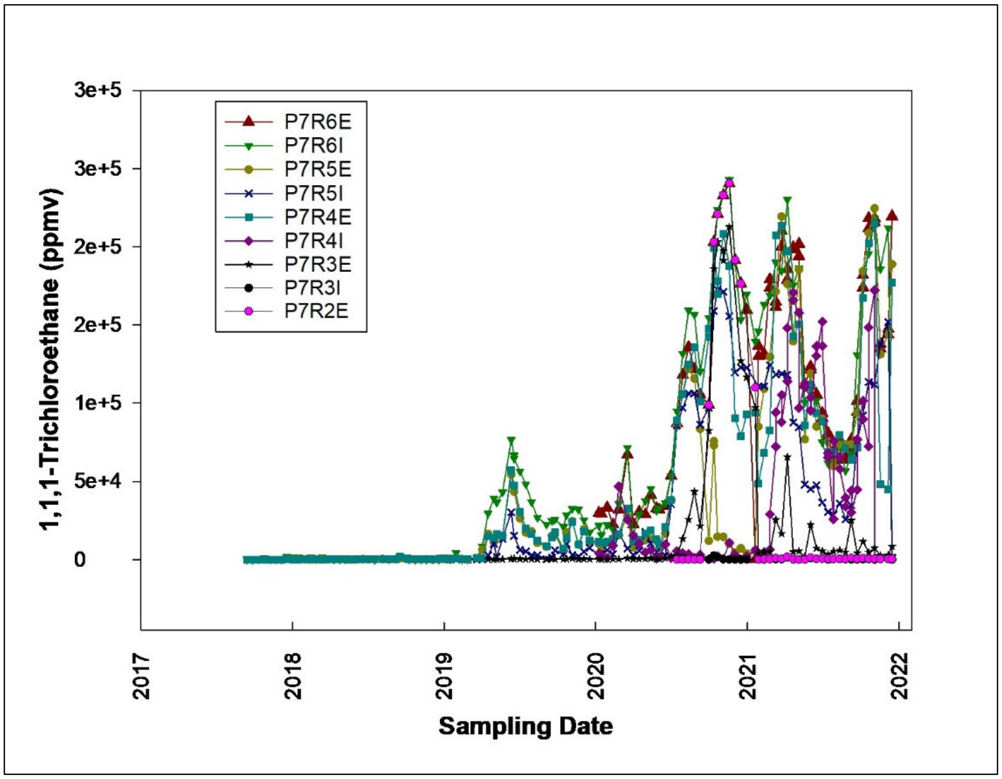
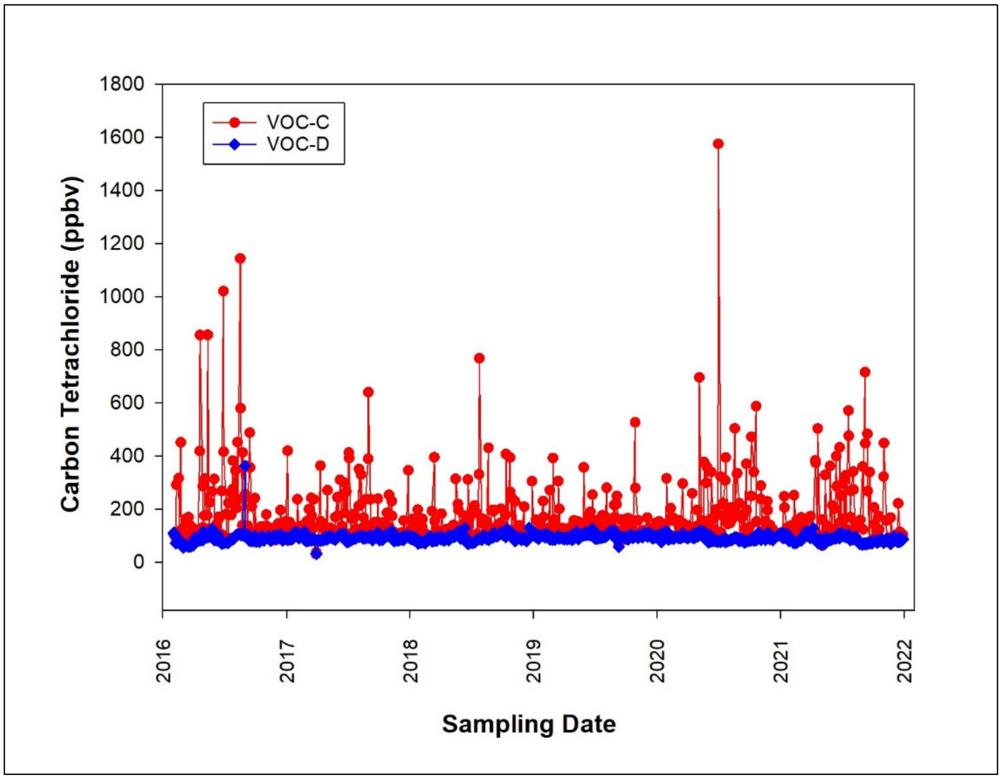
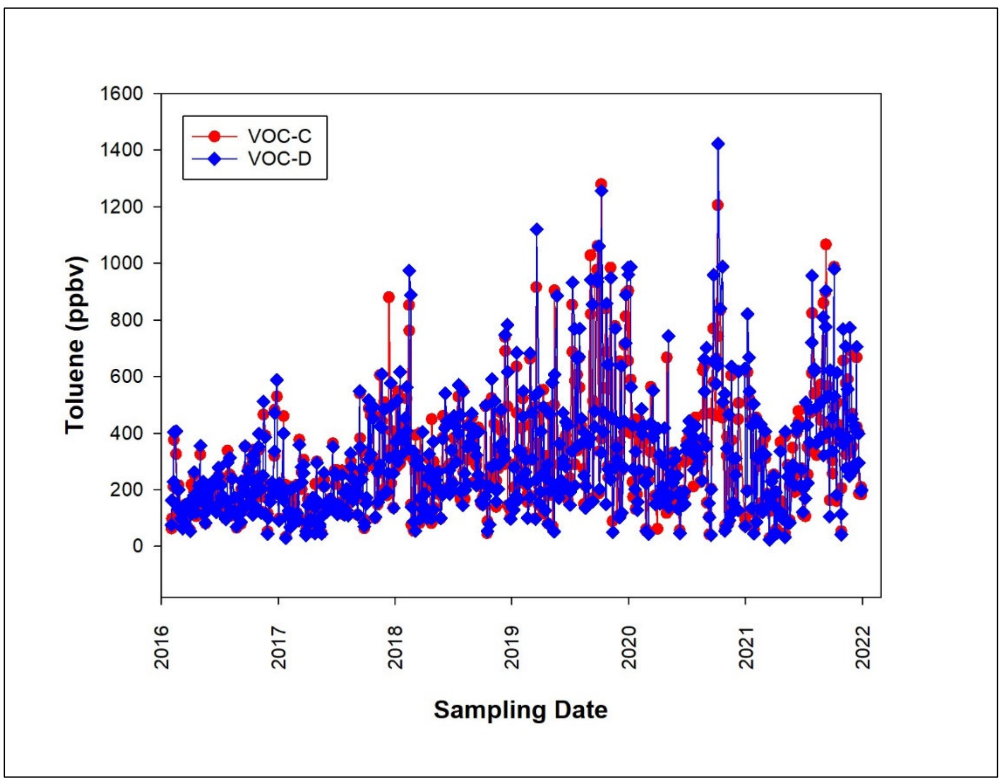


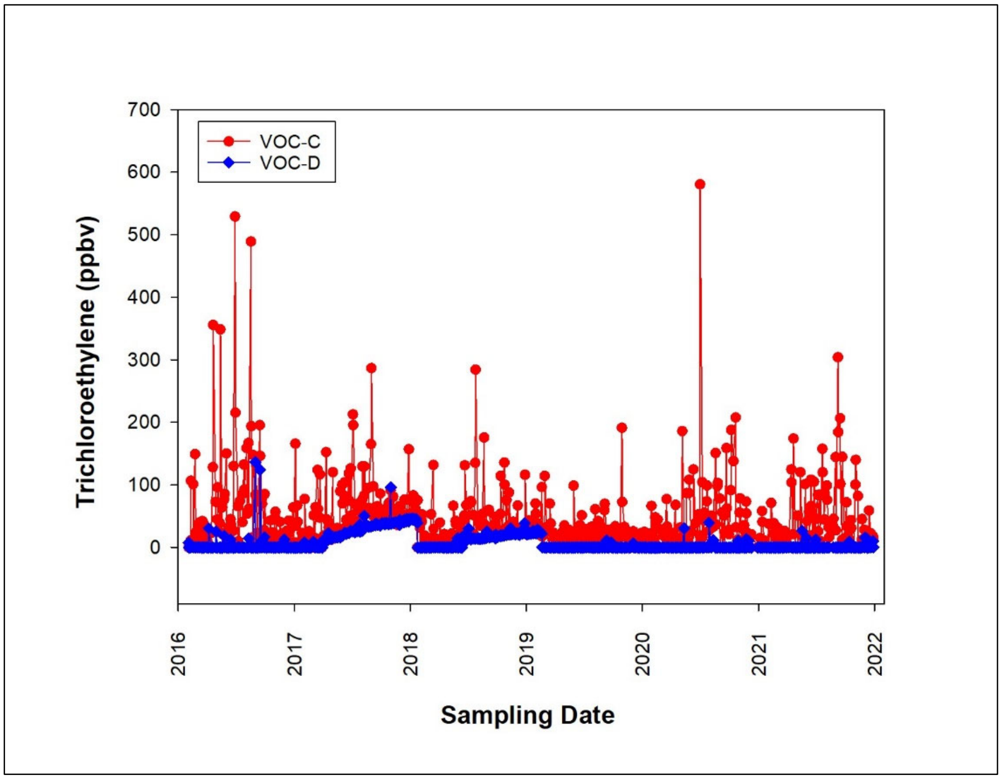
Figure 11.1. Concentrations of some Target VOC Compounds in Disposal Room VOC Samples

11.3.2 Surface VOC Monitoring Results

The concentration ranges of the target VOC compounds at sampling stations VOC-C and VOC-D are listed in Appendix J, Table J.4. Carbon tetrachloride and toluene were mostly detected above the laboratory MRL (0.1 ppbv) with very few instances below it at VOC-C sampling location. Trichloroethylene, 1,1,1-trichloroethane, and methylene chloride were detected above the MRL occasionally with values mostly below the MRL at VOC-C location. All other compounds were below the laboratory MRL or were not detected at VOC-C location. Comparatively at VOC-D sampling station, toluene was the only compound detected mostly above the MRL regularly, whereas carbon tetrachloride concentration was typically around the MRL. Typically, concentrations of toluene and methylene chloride are mostly similar at VOC-C and VOC-D locations. All other compounds at VOC-D location were either non-detect or below the MRL. The concentrations of carbon tetrachloride, trichloroethylene, toluene, and methylene chloride for VOC-C and VOC-D sampling stations for the period of 2016-2021 are shown in Figure 11.2.


VOC-C
VOC-D
Carbon Tetrachloride (ppbv)
1800
1600
1400
1200
1000
800
600
400
200
0
2016
2017
2018
2019
2020
2021
2022
Sampling Date


VOC-C
VOC-D
Toluene (ppbv)
1600
1400
1200
1000
800
600
400
200
0
2016
2017
2018
2019
2020
2021
2022
Sampling Date



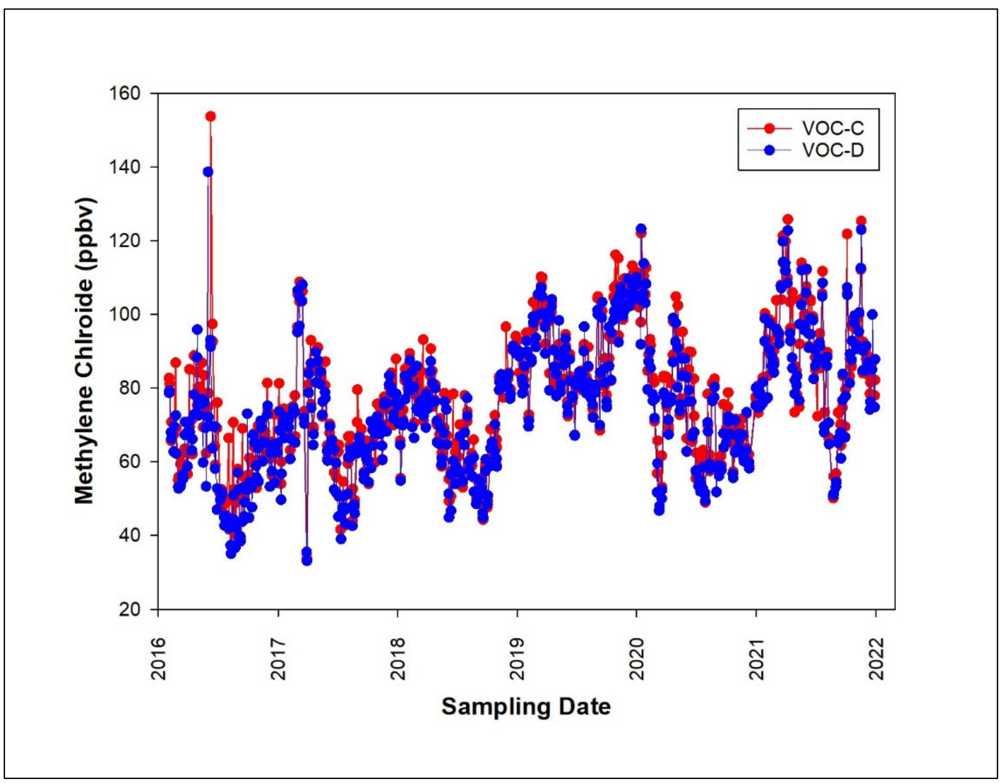


Figure 11.2. Concentrations of Some Target VOC Compounds in Surface VOC Samples

The maximum concentrations of target compounds detected above the MRL at VOC-C were 0.72 ppbv for carbon tetrachloride, 0.30 ppbv for trichloroethylene, 0.27 ppbv for 1,1,1-trichloroethane, 0.13 ppbv for methylene chloride, and 3.90 for toluene. The maximum detected value for compounds detected above MRL at VOC-D were as follows: carbon tetrachloride was 0.13 ppbv, methylene chloride was 0.12 ppbv, and toluene was 0.98 ppb.

CEMRC does not assess the health risks to the public and workers from the release of VOCs from the Repository and/or VOC in the Repository air. However, the risks evaluation studies conducted by the NWP, LLC indicate that risk to the non-waste surface workers continues to be below action levels. Studies also reported that cancer risk and hazard Index from the release of VOC were an order of magnitude below an action level (ASER Report-2021, DOE/WIPP-21-3631 and DOE/WIPP-22-3636).

11.4 Conclusion

This chapter summarizes the results of the VOC monitoring program for the calendar year 2021. For disposal room VOC monitoring, 235, and for surface VOC monitoring, 229 samples were collected during 2021. Carbon tetrachloride and toluene were most regularly detected above the MRL at VOC-C sampling location. Three of the ten target compounds were regularly detected above the MRL for disposal room samples. The levels measured in 2021 were below the 50% action level as specified in Module IV of the HWFP. The VOC monitoring results indicate that risk to the non-waste surface workers continues to be below action levels. There is no evidence of increases in VOCs in the region that could be attributed to releases from WIPP.

The more detailed results of the 2021 VOC monitoring program are reported in the Semi-Annual Volatile Organic Compound Data Summary Report (DOE/WIPP-21-3631 and DOE/WIPP-22-3636)

CHAPTER 12 - LOW BACKGROUND RADIATION EXPERIMENTS

12.1 Introduction

In recent years, we have shown that both unicellular prokaryotes (e.g., Castillo et al. 2018) and multicellular animals (Van Voorhies et al. 2020) develop a biologically and statistically significant response to the deprivation of normal levels of radiation. In 2021, we have published a study demonstrating that mammalian tissue culture cells also can detect vanishingly low levels of radiation, and we have demonstrated that cell viability decreases in the presence of below background radiation levels (Castillo et al. 2021b).

In past work, we have varied the quantity of radiation (e.g., 100 nGy/h for radiation sufficient treatments and 1-15 nGy/h for radiation-deprived treatments) and documented that all organisms tested to date respond to these quantitative differences in radiation field. We have now initiated a series of experiments in which we ask the following question. Are model biological organisms capable of differentially responding to different qualities of radiation, given the same or similar dose rates. In this sub-project, it should be noted that we are only varying sources of gamma radiation. Described here are some methodological information and results from our RNA transcriptome analyses from this Volcanic Radiation source experiment. Additionally, G.B. Smith completed his role as lead editor of the Frontiers Research Topic *The Biogeochemistry, Biophysics, Radiobiology and Technical Challenges of Deep Subsurface Research.* A short summary of this international project is included below.

12.2 Experimental Design

12.2.1 Radiation Quality and Use of Volcanic Radiation Sources

As discussed in previous reports, approximately 60 kg of two volcanic materials (Tufo and Pozzolana) were obtained from the area around Rome Italy and sent to NMSU. We loaded varying masses of natural radiation sources (potash (98% KCl from Intrepid Potash), Pozzolana and Tufo) to try to get near equal dose rates from these three materials. See Table 11.1 for the masses used to load the new irradiators and the resultant radiation dose rates measured with an ion chamber. Please note that replicate measurements continue to be taken from these irradiators and radiation levels will be updated for eventual publication*.

	KCl Irradiator	Pozzolana Irradiator	Tufo Irradiator
Mass of all 6 panels (g)	14016.5	13000.0	10759.2
Dose NMSU (nGy/hr.)	229.9	210.6	355.2
Background Dose NMSU (nGy/hr.)	113.6	113.6	113.6
Calculated Dose (nGy/hr.)	116.3	97.1	241.6

Figure 12.1. Irradiator characteristics.

Our colleagues in Italy's Istituto Superiore di Sanita (ISS) analyzed an equal mixture of volcanic tufo and pozzolana using a High Purity Germanium (HPGe) detector and this revealed the spectra of throrium and uranium daughter products as expected (Figure 11.1A). For comparison, a HPGe spectrum of KCl is shown in Figure 11.1B). Our hypothesis has been that the more complex, broader spectral volcanic sources will evoke a more significant biological response compared to when cells are exposed to the single energy-level K-40.

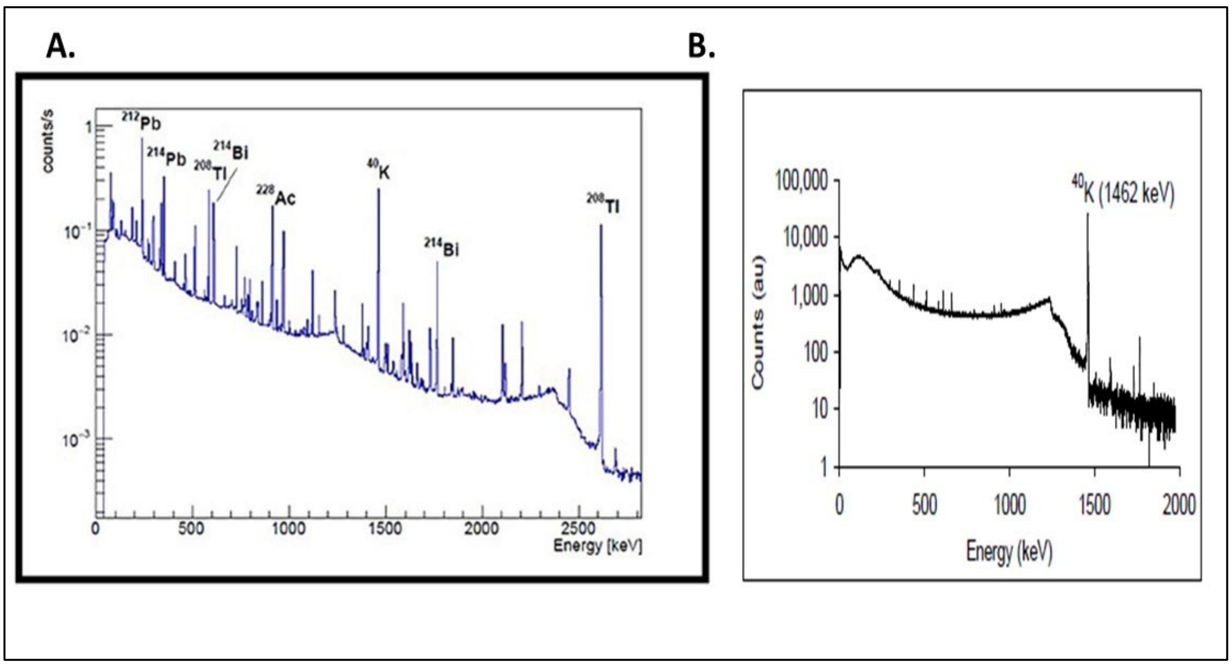


Figure 12.2. High-purity germanium detector scans of equal parts Tufo and Pozzolana (A, Esposito, unpublished) and KCl (B, Espinoza et al. 2009)

We incubated *E. coli* (K-12) underground at WIPP in the 4 incubators: in the vault ("minus" treatment), and in three incubators in the LBRE connex in irradiators containing KCl or Tufo or Pozzolana. As discussed in previous reports (2020) and publications (Van Voorhies et al. 2020), after incubation in these four conditions, we extracted RNA underground and had transcriptome sequencing carried out by Novogene as described below for the bacterium *D. radiodurans*.

12.2.2 Mammalian Culture Cells and Bacterial Incubations

For the mammalian tissue culture work at WIPP (Castillo et al. 2021b), hamster cells (*Cricetulus griseus*) of the lung fibroblast cell line (ATCC CCL-93) were cultured in Dulbecco's modified Eagle's medium (DMEM) supplemented with 10% fetal bovine serum and 2.5 µg/mL amphotericin B solution (an antifungal agent). Triplicate independent cultures were started from frozen samples kept in liquid nitrogen at the New Mexico State University Department of Biology and transported to the surface laboratory at WIPP. These cultures were maintained separate for the duration of the experiment, hence treated as biological replicates.

The cells were passaged on days 2, 5, 7, 9, 12, 16, 19, 21, and 23 after resuspension with 0.25% trypsin following standard procedures and keeping the transfer volume constant. Cell viability was determined by removing cell samples in duplicate to measure viability using the vital stain, Trypan blue, using the exclusion assay using the BioRad TC20 automatic cell counter (Hercules, CA, USA). Samples were extracted for RNA and sent for gene expression analysis by RNA-Seq (details in Castillo et al. 2021b)

For the bacterial work at WIPP, *Deinococcus radiodurans* ATCC 35073 (also known as the "Sark" strain), was grown as described in previous reports and as described by Castillo et al. 2015). After an initial 24-hour pre-incubation period underground at WIPP, the cells were transferred and incubated for an additional 48 hours with time points taken to determine cell growth and RNA yield. Cells were incubated underground, one set incubated in the steel vault (at 0.9 nGy/hr) and the other set in an incubator supplemented with 12 kg of KCl (at 72 nGy/h) to approximate natural background levels of radiation. Transcriptome analysis was carried out by the procedures reported by Castillo et al. 2018, except that *de novo* assembly was used since a reference gene for the Sark strain was not available (Castillo et al. 2021a).

12.3 Results and Discussion

12.3.1 Radiation Quality and Use of Volcanic Sources

We did not observe any significant differences in *E. coli* growth rate when cells were grown in the absence of normal levels of radiation in the vault and compared to growth in radiation-supplemented irradiators. Interestingly, the transcriptome analysis revealed an un-expected finding: the KCl source evoked about a 10-fold higher genetic response compared to either of the two volcanic sources, Tufo or Pozzolana (Figure 11.2). Ninety-four genes were differentially regulated in the radiation-deficient cells grown shielded in the vault compared to the cells grown in the KCl irradiator, whereas there were only 9 and 3 respective genes regulated in the Pozzolana and Tufo irradiators compared to the shielded cells. According to our hypothesis, we expected the multiple sources in the volcanic materials (which come from uranium and thorium daughter products according to Nuccetelli and Bolzan, 2001), to evoke a stronger response in cells compared to the single-gamma K-40 in KCl. We are preparing two manuscripts for publication on these results, and more analyses will be brought to bear. However, it is clear that, at least in *E. coli* exposed to different sources of gamma, cells are more sensitive to radiation quality than quantity. For example, cells were exposed to more than twice the dose rate in the Tufo irradiator than in the KCl irradiator, but there were 30-times more genes that responded to the KCl treatment compared to the Tufo treatment Figure 11.2).

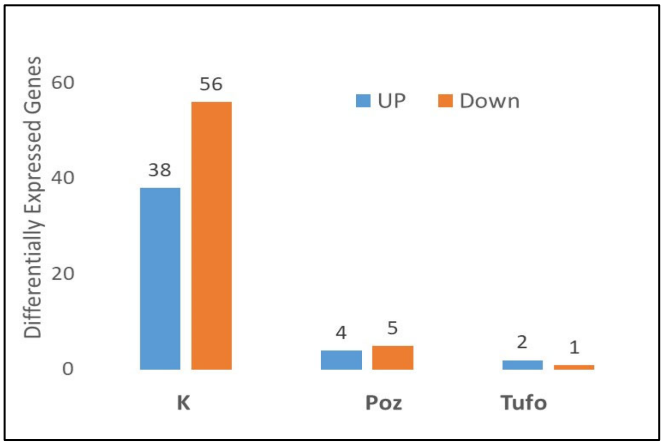


Figure 12.3. Data represent the number of differentially expressed genes (Up- or Down-regulated) comparing the cells shielded in the vault to cells exposed to 3 radiation sources: KCl, Pozzolana and Tufo.

12.3.2 Mammalian Cell Study

We have been working with mammalian tissues cells for many years. Smith learned how to grow Chinese hamster (*Cricetulus griseus*) V79 cells while on a sabbatical leave at the Gran Sasso laboratory in Assegai Italy. In October 2021, we published our first paper on mammalian tissue cells grown underground at WIPP (Castillo et al. 2021b). At WIPP we grew the V-79 cells for 23 days using three different dose rates: 0.91 nGy/h (below background underground in the steel vault at WIPP), 72 nGy/h (underground in the LBRE lab supplemented with KCl to mimic natural background) and at 35 nGy/hr at the WIPP surface.

As we have observed with other biological models, there was a toll on the mammalian cells that were grown in the absence of normal levels of background radiation. In 7 of the 9 timepoints, cell viability was decreased in the cells deprived of normal radiation (in the belowground vault) compared to cells grown in the presence of normal radiation in the WIPP surface lab Figure 11.3).

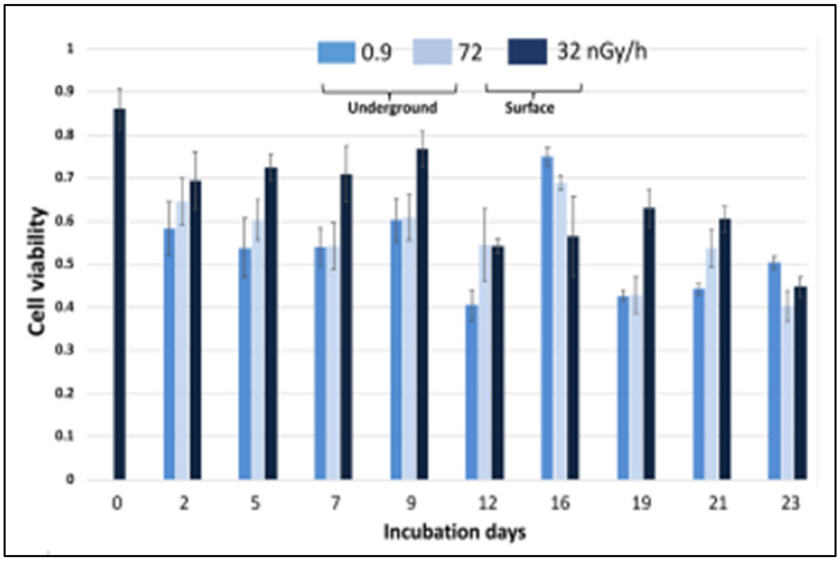


Figure 12.4. Cell viability of mammalian tissue culture cells (V79) shielded in the WIPP underground in a steel vault (0.9 nGy/hr), in the underground in an irradiator supplemented with KCl (72 nGy/hr) and at the WIPP surface (32 nGy/hr). Cells were grown at 5% CO_2 at 37℃ for 23 days.

After gene expression analysis (transcriptome by RNA-Seq), we have documented various Gene Ontology (GO) groups of genes that were significantly upregulated in cells grown in the absence of normal levels of radiation. Genes important in cell proliferation, regulation of signaling and homeostasis were all upregulated, indicating that lack of normal levels of radiation is a significant perturbation to the cells (Figure 11.4). Consistent with our results in bacteria, depriving mammalian cells of normal levels of radiation also leads to a significant reaction at both the physiological and genetic levels.

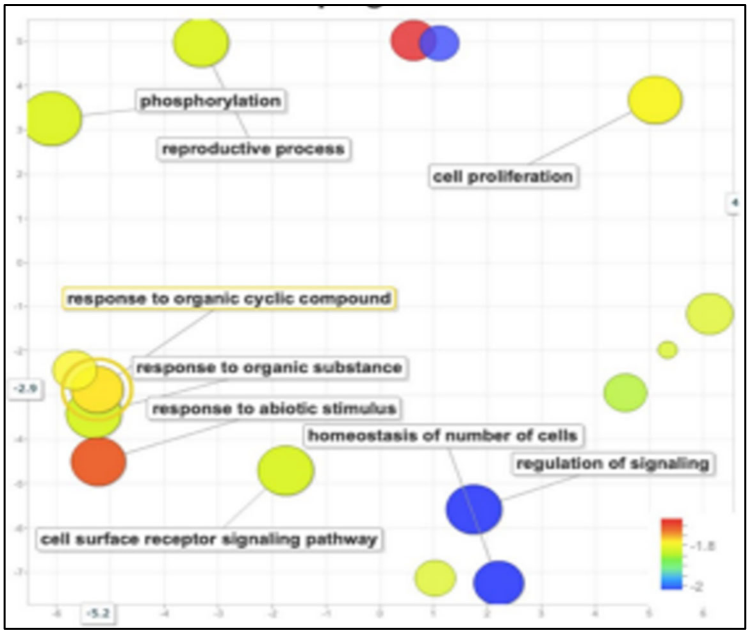


Figure 12.5. Transcriptome response of cells grown shielded underground compared to cells grown in the presence of normal background levels at the WIPP surface. The circle colors of the Gene Ontology (GO) terms range in statistical significance from blue (p=0.01) to red (p=0.05).

12.3.3 Bacterial Study.

As we have observed in previous studies (Castillo et al. 2018), *D. radiodurans* is growth inhibited when deprived of natural levels of radiation (see Figure 1 in Castillo et al. 2021a). This is in contrast to *Shewanella oneidensis* which is not growth inhibited when incubated in the steel vault underground at WIPP (Castillo et al. 2018). In general, there is a more effective gene expression response in *S. oneidensis* to the absence of radiation which we have proposed is the reason why it is able to grow as well as the radiation-sufficient conditions. We have proposed that the reason why *D. radiodurans* becomes growth inhibited in the radiation deprived conditions is that it is not able to maintain homeostatic control (Castillo et al. 2018). Shown below is a comparison of the gene expression responses to below background radiation in both these bacteria (Figure 11.5 from Castillo et al. 2021a).

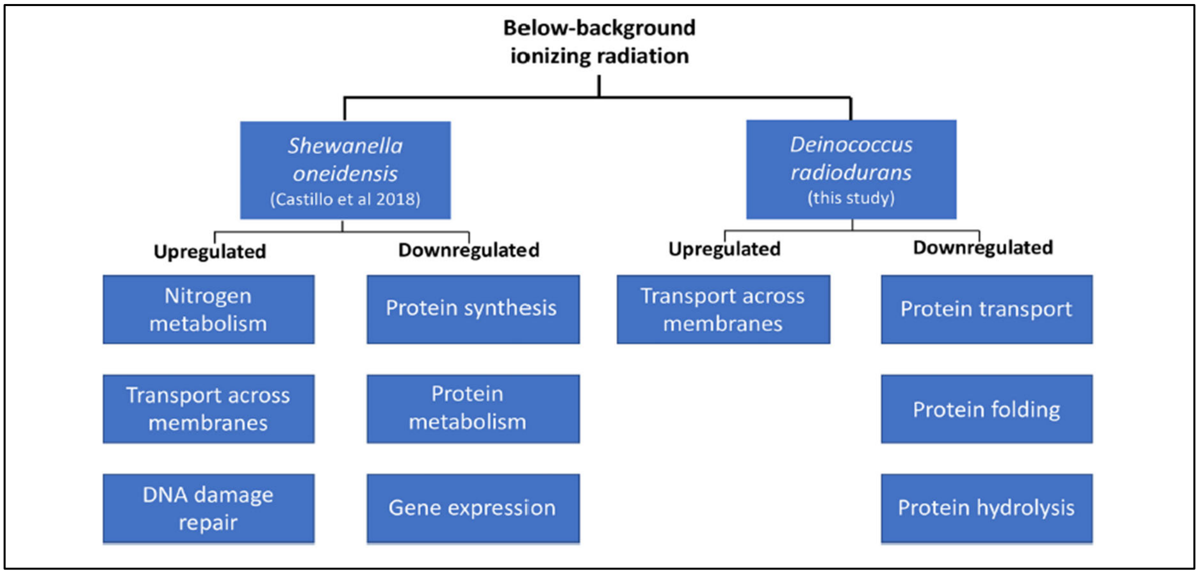


Figure 12.6. The biological processes that are expressed in the two model bacteria used at WIPP in response to growth in the absence of normal background levels of radiation (Castillo et al. 2021a).

12.3.4 Presentations and Press.

-- In May, 2021, the Frontiers of Earth Science Research Topic, *The Biogeochemistry, Biophysics, Radiobiology and Technical Challenges of Deep Subsurface Research* was completed. With the publication of our peer-reviewed editorial, Tabochinni, Pena-Geray and I completed our editorial work in getting 15 manuscripts published in our Frontiers Deep Subsurface Science research collection (Smith et al. 2021). As of June 2021, there were more than 25,000 views of the Research Topic and, as a result, WIPP and the LBRE project have received significant international attention (https://www.frontiersin.org/research-topics/12041/the-biogeochemistry-biophysics-radiobiology-and-technical-challenges-of-deep-subsurface-research).

The research topic brought together the top scientists who are carrying out research in the deep terrestrial subsurface. The 15 manuscripts were multi-disciplinary with the papers being published in one research collection totaling 139 pages. Additionally, the articles were published individually in one of the following Frontiers journals: *Earth Science, Public Health, Physics, Astronomy and Space Science* and *Microbiology*.

-- G.B. Smith was invited to give an overview of the Radiation Biology work at WIPP at the Radiation Research Society conference on October 4, 2021. The talk was titled, *Physiological and Molecular-level Responses to the Deprivation of Natural Radiation in the Deep Subsurface.* https://na.eventscloud.com/website/23992/rrsspeakers/

-- April 2021 Rio Grande American Society for Microbiology. This presentation summarized a comparative study of techniques for differential expression analysis on transcriptome responses to below background radiation and natural background radiation.

https://ttuhscep.edu/the-scope/community/rio-grande-branch-asm-annual-meeting-april-8-9-2021.aspx

-- Our research group was interviewed by a reporter from Carlsbad's *Current Argus* and an article was published July 16, 2021. https://www.currentargus.com/story/news/local/2021/07/16/nmsu-scientists-study-low-radiation-impacts-waste-isolation-pilot-plant/7976887002/

12.3.5 Provisional Patent.

Title of Invention: Auger energy, a soft electron therapy for mitochondrial disorders in children and aging adults. Maurizio Tomasi and Geoffrey B. Smith. U.S. Provisional Application No. 63/243,453. Submitted October 7, 2021

The invention is an enriched source of natural potassium that is used therapeutically to treat mitochondrial diseases in children (e.g., Leigh syndrome) and aging adults (e.g., acquired cardiomyopathy and Parkinson's Disease). The Auger electrons that are emitted from naturally occurring K-40 are at the energy level that we propose is biologically accessible to normal electron transport reactions carried out in human mitochondria. There are no current treatments for child mitochondrial myopathy (https://www.childneurologyfoundation.org/disorder/mitochondrial-myopathies/). Collaborative discussions are underway at the Urenco plant in Eunice, NM, and with Los Alamos National Laboratory.

12.4 Summary and Future Work

Results to date have further expanded our understanding of the biological response to low-level radiation. Not only are organisms able to distinguish between very low quantities of radiation (e.g., 75 nGy/h and 1 nGy/h), but, given two sources of radiation at the same dose rate around 100 nGy/h, *E. coli* differentially responds to these sources, evidently because the quality of the gamma sources is different. Two manuscripts are planned for publication based on these results using these different volcanic sources of radiation, one a transcriptome software analysis paper (currently in review at Biomedical Central-Genomics) and the second on the biological response to radiation quantity vs radiation quality. We are planning to carry out a follow-up experiment this summer at WIPP, an experiment in which we more closely examine the role the ^{40}K plays in the biological response to different sources of radiation.

Recent work with different biological models (e.g., mammalian cells, Castillo et al. 2021b and bacteria, Castillo et al. 2021b) confirm previous work demonstrating that depriving cells of natural levels of background radiation exerts some sort of toll on the cells. We plan on continuing to expand the organisms that we document this response from, with the upcoming year devoted at least in part to getting a new model organism (the *Aedes aegytpi* mosquito) growing in the underground. Pilot studies in 2021 revealed several technical problems in raising male mosquitos at WIPP that we hope to ameliorate this year (Liam Goodale, MS thesis in progress). Lastly, we plan to provide an initial report next year on our efforts to identify ancient DNA and other biomarkers from WIPP halite inclusions (Beowulf Owen, MS thesis in progress).

CHAPTER 13 - QUALITY ASSURANCE

13.1 General Analytical Quality Assurance

Quality assurance and quality control practices encompass all aspects of CEMRC's WIPP Environmental Monitoring Programs (WIPP-EM). The development and implementation of an independent health and environmental monitoring program has been CEMRC's primary activity. The multilayered components of the CEMRC Quality Assurance (QA) Program ensure that all analytical data reported in this report are reliable and of high quality and that, all environmental monitoring data meet quality assurance and quality control objectives.

CEMRC is subject to the policies, procedures, and guidelines adopted by NMSU, as well as state and federal laws and regulations that govern the operation of the University and radiological facilities. The management of CEMRC is committed to conducting a well-defined quality assurance program, incorporating good professional practices, and focusing on the quality of its testing and calibration in research and service to sponsors. CEMRC's technical programmatic areas in 2021 included: Environmental Chemistry, Organic Chemistry, Radiochemistry, Field Programs, and Internal Dosimetry. Since its inception, CEMRC's WIPP-EM program has been conducted as a scientific investigation, meaning that it operates without any compliance, regulatory, or oversight responsibilities. As such, there are no specific requirements for reporting data other than following good scientific practices.

13.2 Quality Assurance/Quality Control for Field Sampling

Samples for CEMRC's WIPP-EM Programs are collected by personnel trained following approved procedures. Established sampling locations are accurately identified and documented to ensure continuity of data. Field duplicate samples are used to assess sampling and measurement precision. Logbooks are maintained by technical staff in field operations to record locations and other specifics of the sample collection, and data on instrument identifications, performance, calibration, and maintenance. Data generated from field sampling equipment are error checked by using routine cross-checks, control charts, and graphical summaries. Most data collected in written form are also entered in electronic files and electronic copies are crossed checked against the original data forms. All electronic files are backed up daily.

Calibration and maintenance of equipment and analytical instruments are carried out on predetermined schedules coinciding with the manufacturer's specifications or modified to special project needs. Calibrations are either carried out by equipment vendors or by CEMRC personnel using certified calibration standards.

13.3 Quality Assurance/Quality Control for Radiochemistry

Quality control in the analytical laboratories is maintained through tracking and verification of analytical instrument performance, through the use of American Chemical Society (ACS) certified reagents, through the use of National Institute of Standards and Technology (NIST) traceable radionuclide solutions, and through verification testing of radionuclide concentrations for tracers not purchased directly from NIST or Eckert & Ziegler Analytics Inc. When making laboratory solutions, volumes and lot numbers of stock chemicals are recorded. Prior to weighing radionuclide tracers and samples, the balance being used is checked using NIST traceable weights.

Control checks are performed on all nuclear counting instrumentation each day or prior to counting a new sample. The type of instrument and methods used for performance checks were as follows: for the Protean 9604 gas-flow α/β proportional counter used for the FAS program, efficiency control charting is performed using ^{239}Pu and ^{90}Sr check sources along with ensuring that α/β cross-talk was within limits. Sixty-minute background counts are recorded daily. Two blanks per week for the WIPP Effluent air sampling program are counted for 20 hours and are used as a background history for calculating results.

Routine background determinations are made on the HPGe detector systems by counting blank samples; the data are used to blank correct the sample concentrations.

For the alpha spectrometer, efficiency, resolution, and centroid control charting are performed using Eckert and Ziegler Analytics check sources regularly. Before each sample count, pulser checks are performed to ensure acceptable detector resolution and centroid. Blanks counted for five days are used as a background history for calculating results. Analytical data are verified and validated as required by project-specific quality objectives before being used to support decision-making.

CEMRC also participates in the two national performance evaluation programs, NIST Radiochemistry Inter-Comparison Program (NIST-RIP) and the DOE-Mixed-Analyte Performance Evaluation Program (MAPEP) for soil, air filter, and water analysis. The proficiency tests help ensure the accuracy of analytical results reported to DOE and other stakeholders while also providing an efficient means for laboratories to demonstrate analytical proficiency. Under these programs, CEMRC analyzed blind check samples, and the analysis results are compared with the official results measured by the MAPEP and NRIP laboratories. CEMRC radio-analytical program analyzes MAPEP- air filter, water, soil, gross alpha/beta on air filters & water and unknown sample matrix and NIST-NRIP - glass fiber filters, soil, and acidified water samples. Isotopes of interest in these performance evolution programs are $^{233/234}$U, ^{238}U, ^{238}Pu, $^{239+240}$Pu, and ^{241}Am, ^{244}Cm, and gamma emitters. The analyses are carried out using CEMRC’s actinide separation procedures and were treated as a regular sample set to test regular performance. CEMRC’s results are consistently close to the known value. MAPEP and NIST-NRIP results are presented in this annual report. Based on the number of A (Acceptable) ratings earned by CEMRC for the analysis of performance evaluation samples, the laboratory provided accurate and reliable radionuclide analysis data for WIPP environmental samples. In addition, for each sample set, reagent blank and tracer spikes are also carried through the entire separation and counting process for recovery determination and quality control. The NIST and MAPEP performance evaluation results are listed in Appendix K, Tables K.1 through K.5. In 2021, CEMRC did not receive NIST-RIP samples and thus, no analyses report has been reported.

13.4 Quality Assurance/Quality Control for Organic Chemistry

To ensure that all procedures, processes, and deliverables are maintained and followed, two layers of assessments and audits are performed every year. A VOCs Confirmatory Monitoring Audit conducted by NWP, as part of their routine yearly program audits in compliance with contract requirements, was performed in January 2021. Additionally, CEMRC internal QA audit was conducted on the organic chemistry group in August 2018. Both audits passed and were conducted in compliance with CEMRC's QAP.

CEMRC's organic chemistry laboratory also participated in the National Air Toxics Trends Station (NATTS) proficiency test for VOC analysis thrice in 2021. For all three NATTS first tests, 1,1,2,2-tetrachloroethane, 1,2-dichloroethane, carbon tetrachloride, chloroform, and trichloroethylene each met the acceptance criterion of ± 30 percent of the nominal spike value. Methylene chloride failed the acceptance criteria in the first and third test, while it passed in the second test when compared to the nominal spike value. In the first test, recovery of methylene chloride for referee laboratories was also high, and in the third test, methylene chloride passed the acceptance criteria when compared to the referee laboratories, so no corrective action was taken. Methylene chloride has a history of higher recoveries which may be based on canister, instrument, or spiking issues.

13.5 Quality Assurance/Quality Control for Environmental Chemistry

The analytical methods employed for inorganic analyses in the environmental chemistry program at CEMRC are based, when applicable, on various standard procedures (EPA/600/4-79-020, 1983; EPA/SW-846, 1997; American Public Health Association, 1981). For some matrix/analyte combinations, appropriate external standard procedures don't exist. For those cases, specialized procedures were developed to meet the need of the WIPP-EM.

Inorganic analyses were performed using Perkin Elmer Inductively Coupled Plasma Mass Spectrometry (ICP-MS), while inorganic cations and anions were measured using Ion Chromatography (IC). For ICP-MS, triplicate readings were performed on each sample, with the average result reported. Instrument performance checks shown in Appendix K, Table K.6 were run daily; the instrument was calibrated before every sample analysis. The calibration range depends on the type of sample being analyzed.

The Ion Chromatography (IC) instrument was calibrated for inorganic cation concentrations ranging from 0.25 to 10 ppm and inorganic anion concentrations ranging from 2 to 100 ppm. Currently CEMRC procedures for IC analysis only require calibrating the IC instrument once a month, but calibration checks were performed during every sample analysis as routine quality assurance.

For both ICP-MS and IC analyses, a variety of quality control samples (including blanks, spiked blanks, duplicates, and spiked samples) were prepared and run alongside every set of WIPP-EM samples during analysis. Certified reference materials were also analyzed with every sample batch. Once a year, CEMRC participated in several blind proficiency test (PT) studies coordinated by the Environmental Resource Associates (ERA). All of the reported results were within the acceptable ranges as set forth by ERA for inorganic metals, anions, and cations. The results of the blind tests are shown in Appendix K, Tables K.7 through I.9.

13.6 Quality Assurance/Quality Control for Internal Dosimetry

The *in vivo* bioassay program at CEMRC participates in the Department of Energy's *In- Vivo* Laboratory Accreditation Program (DOELAP) via Nuclear Waste Partnership LLC of WIPP and is currently accredited as a service laboratory to perform the following direct bioassays.

Direct radiobioassay DOELAP categories are.

- Transuranic elements via L x-rays of ^{238}Pu
- ^{241}Am in lung
- ^{234}Th in lung
- ^{235}U in lung
- Fission and activation products in the lung include ^{54}Mn, ^{57}Co, ^{58}Co, and ^{60}Co
- Fission and activation products in the total body include ^{134}Cs and ^{137}Cs

Under DOELAP, the *in vivo* bioassay program is subject to the performance and quality assurance requirements specified in the Department of Energy Laboratory Accreditation Program for Radiobioassay (DOE-STD-1112-98) and Performance Criteria for Radiobioassay (ANSI-N13.30). A DOELAP testing cycle was completed in 2018 that included counting phantoms representative of each of the categories listed above.

To evaluate system performance, quality control data were routinely performed throughout the year in order to verify that the lung and whole-body counting system was operating as it was at the time the system was calibrated. Quality control parameters that track both overall system performance and individual detector performance were measured. Quality control parameters tracked to evaluate individual detector performance, included.

- Net peak area, peak centroid and peak resolution (FWHM) across the energy range of the spectrum
- Detector background

Quality control parameters tracked to assess overall system performance included.

- Mean weighted activity of a standard source
- Summed detector background,

Efficiency calibration verification using NIST-traceable standards and phantoms.

In addition, CEMRC's Internal Dosimetry program has participated in the DOE Radiological and Environmental Sciences Laboratory (*RESL*) quarterly blind testing of Bottle Manikin Absorber (BOMAB) phantom for ^{54}Mn, ^{60}Co, and $^{134,\ 137}$Cs and Torso for ^{238}Pu, ^{241}Am, $^{235,\ 238}$U, $^{57,\ 60}$Co, ^{54}Mn activities deposited in the body. These bottle phantom/torso were counted on the whole-body counting system and the measured activities were reported back to RESL to compare against the known activities. CEMRC has consistently passed all performance criteria for the tests.

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APPENDIX A - RADIONUCLIDE CONCENTRATIONS AND SPECIFIC ACTIVITIES AT STATIONS A AND B

Actinide concentrations and specific activities at Stations A and B

Uranium concentrations and specific activities at Stations A and B

Gamma radionuclide concentrations and specific activities at Stations A and B

Strontium concentrations and specific activities at Stations A and B

Table A.1. Activity concentrations of ^{241}Am (Bq/m^3) at Station A

Sample Date	^{241}Am Activity	Unc. (2σ)	MDC	Status
January 2021				
1st week	1.98E-05	4.96E-06	1.40E-06	Detected
2nd week	9.97E-06	3.38E-06	2.09E-06	Detected
3rd week	1.79E-05	6.17E-06	4.30E-06	Detected
4th week	1.74E-05	3.91E-06	1.39E-06	Detected
February 2021				
1st week	1.87E-05	5.04E-06	2.06E-06	Detected
2nd week	1.68E-05	4.68E-06	2.11E-06	Detected
3rd week	3.97E-05	7.67E-06	1.74E-06	Detected
4th week	4.12E-05	7.88E-06	1.61E-06	Detected
March 2021				
1st week	1.95E-05	5.46E-06	2.64E-06	Detected
2nd week	4.33E-05	8.13E-06	2.20E-06	Detected
3rd week	6.32E-05	1.08E-05	2.94E-06	Detected
4th week	3.23E-05	6.07E-06	1.28E-06	Detected
April 2021				
1st week	1.45E-04	2.08E-05	1.91E-06	Detected
2nd week	3.95E-06	2.06E-06	2.28E-06	Detected
3rd week	1.54E-05	4.18E-06	2.31E-06	Detected
4th week	8.64E-06	2.61E-06	1.68E-06	Detected
May 2021				
1st week	4.11E-06	2.19E-06	2.00E-06	Detected
2nd week	5.86E-06	2.36E-06	1.51E-06	Detected
3rd week	6.36E-06	2.44E-06	1.23E-06	Not Detected
4th week	1.04E-05	3.54E-06	2.36E-06	Detected
June 2021				
1st week	1.57E-06	1.59E-06	2.78E-06	Detected
2nd week	6.29E-06	2.52E-06	2.41E-06	Detected
3rd week	4.71E-06	2.17E-06	2.02E-06	Detected
4th week	1.72E-05	4.09E-06	2.12E-06	Detected

Table A.1. Activity concentrations of ^{241}Am (Bq/m^3) at Station A (continued)

Sample Date	^{241}Am Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
July 2021				
1st week	1.08E-05	3.54E-06	2.47E-06	Detected
2nd week	3.52E-06	1.99E-06	2.39E-06	Detected
3rd week	1.03E-05	3.36E-06	1.79E-06	Detected
4th week	3.19E-05	5.88E-06	1.17E-06	Detected
August 2021				
1st week	5.58E-06	2.38E-06	2.22E-06	Detected
2nd week	5.84E-06	2.78E-06	2.87E-06	Detected
3rd week	2.91E-06	1.74E-06	1.99E-06	Detected
4th week	8.59E-06	2.60E-06	1.24E-06	Detected
September 2021				
1st week	1.71E-05	4.34E-06	1.72E-06	Detected
2nd week	1.00E-05	3.20E-06	1.99E-06	Detected
3rd week	3.93E-06	2.12E-06	2.77E-06	Detected
4th week	8.50E-06	2.72E-06	1.35E-06	Detected
October 2021				
1st week	7.29E-06	3.23E-06	2.37E-06	Detected
2nd week	1.73E-05	5.28E-06	2.76E-06	Detected
3rd week	2.17E-04	3.33E-05	1.82E-06	Detected
4th week	1.07E-05	2.86E-06	1.28E-06	Detected
November 2021				
1st week	1.26E-05	3.58E-06	1.54E-06	Detected
2nd week	9.51E-06	3.10E-06	2.05E-06	Detected
3rd week	1.25E-05	3.65E-06	2.08E-06	Detected
4th week	1.49E-05	3.68E-06	1.39E-06	Detected
December 2021				
1st week	1.42E-05	3.92E-06	1.87E-06	Detected
2nd week	1.95E-05	4.74E-06	1.82E-06	Detected
3rd week	9.53E-06	3.03E-06	1.52E-06	Detected
4th week	4.99E-06	1.84E-06	1.55E-06	Detected

Table A.2. Activity concentrations of $^{239+240}Pu$ (Bq/m^3) at Station A

Sample Date	$^{239+240}Pu$ Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
January 2021				
1st week	3.05E-06	2.31E-06	3.10E-06	Detected
2nd week	5.35E-07	8.68E-07	1.77E-06	Detected
3rd week	2.65E-06	2.76E-06	5.09E-06	Detected
4th week	2.49E-06	1.29E-06	1.14E-06	Detected
February 2021				
1st week	2.05E-06	1.68E-06	1.85E-06	Detected
2nd week	3.37E-06	1.87E-06	2.00E-06	Detected
3rd week	5.22E-06	2.26E-06	1.31E-06	Detected
4th week	3.68E-06	1.86E-06	1.83E-06	Detected
March 2021				
1st week	2.23E-06	1.68E-06	2.26E-06	Detected
2nd week	6.70E-06	2.67E-06	1.80E-06	Not detected
3rd week	7.22E-06	2.59E-06	1.20E-06	Not detected
4th week	3.43E-06	1.47E-06	9.35E-07	Detected
April 2021				
1st week	1.91E-05	4.64E-06	1.05E-06	Not detected
2nd week	2.08E-07	6.18E-07	1.62E-06	Detected
3rd week	1.39E-06	1.19E-06	1.70E-06	Not detected
4th week	1.09E-06	9.89E-07	1.55E-06	Detected
May 2021				
1st week	3.16E-07	7.17E-07	1.73E-06	Detected
2nd week	1.09E-06	1.05E-06	1.52E-06	Detected
3rd week	7.99E-07	1.11E-06	2.30E-06	Not detected
4th week	2.14E-06	1.52E-06	1.47E-06	Detected
June 2021				
1st week	9.48E-08	7.22E-07	2.17E-06	Detected
2nd week	1.42E-06	1.29E-06	2.02E-06	Detected
3rd week	7.20E-07	8.64E-07	1.41E-06	Detected
4th week	1.36E-06	1.08E-05	1.45E-06	Not Detected

Table A.2. Activity concentrations $^{239+240}Pu$ (Bq/m^3) at Station A (continued)

Sample Date	$^{239+240}Pu$ Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
July 2021				
1st week	3.70E-06	1.96E-06	1.95E-06	Detected
2nd week	6.41E-07	1.11E-06	2.45E-06	Not detected
3rd week	2.57E-07	1.10E-06	2.97E-06	Detected
4th week	4.71E-06	1.81E-06	9.14E-07	Detected
August 2021				
1st week	8.26E-07	1.06E-06	2.00E-06	Detected
2nd week	2.60E-07	6.39E-07	1.58E-06	Detected
3rd week	1.04E-06	1.44E-06	3.00E-06	Detected
4th week	6.50E-07	7.35E-07	1.07E-06	Detected
September 2021				
1st week	4.62E-06	2.19E-06	1.17E-06	Detected
2nd week	1.39E-06	1.31E-06	2.15E-06	Detected
3rd week	5.22E-07	8.48E-07	1.73E-06	Not detected
4th week	7.80E-07	8.18E-07	1.35E-06	Not detected
October 2021				
1st week	2.71E-06	1.64E-06	1.15E-06	Not detected
2nd week	1.38E-06	1.18E-06	1.83E-06	Detected
3rd week	4.85E-05	9.22E-06	1.59E-06	Detected
4th week	3.73E-06	1.91E-06	2.03E-06	Detected
November 2021				
1st week	4.07E-07	8.56E-07	2.02E-06	Detected
2nd week	2.19E-06	1.59E-06	2.13E-06	Detected
3rd week	8.04E-07	1.11E-06	2.32E-06	Not detected
4th week	4.47E-06	1.78E-06	1.11E-06	Detected
December 2021				
1st week	3.32E-06	1.86E-06	2.16E-06	Not detected
2nd week	4.98E-07	7.40E-07	1.39E-06	Not detected
3rd week	1.53E-06	1.31E-06	1.87E-06	Not detected
4th week	6.86E-07	7.13E-07	1.04E-06	Detected

Table A.3. Activity concentrations of ^{238}Pu (Bq/m^3) at Station A

Sample Date	^{238}Pu Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
January 2021				
1st week	1.72E-05	5.52E-06	3.10E-06	Detected
2nd week	1.36E-05	4.08E-06	2.41E-06	Detected
3rd week	1.71E-05	6.32E-06	5.80E-06	Detected
4th week	1.93E-05	4.12E-06	9.75E-07	Detected
February 2021				
1st week	1.72E-05	5.17E-06	2.07E-06	Detected
2nd week	1.20E-05	3.59E-06	1.81E-06	Detected
3rd week	1.61E-05	4.26E-06	1.31E-06	Detected
4th week	1.51E-05	3.94E-06	1.65E-06	Detected
March 2021				
1st week	1.11E-05	3.70E-06	2.02E-06	Detected
2nd week	2.18E-05	5.25E-06	1.54E-06	Not detected
3rd week	1.53E-05	3.99E-06	1.20E-06	Not detected
4th week	1.76E-05	3.82E-06	1.23E-06	Detected
April 2021				
1st week	2.92E-05	6.13E-06	2.16E-06	Detected
2nd week	1.87E-05	4.62E-06	2.46E-06	Detected
3rd week	2.38E-05	5.34E-06	2.53E-06	Detected
4th week	2.62E-05	5.32E-06	1.55E-06	Detected
May 2021				
1st week	2.88E-05	5.95E-06	1.73E-06	Detected
2nd week	3.82E-05	7.37E-06	2.08E-06	Detected
3rd week	1.49E-05	4.01E-06	2.62E-06	Detected
4th week	2.59E-05	6.02E-06	1.65E-06	Detected
June 2021				
1st week	4.76E-05	8.89E-06	1.96E-06	Detected
2nd week	4.57E-05	8.56E-06	2.27E-06	Detected
3rd week	4.99E-05	9.00E-06	2.25E-06	Detected
4th week	6.18E-05	1.02E-05	1.85E-06	Detected

Table A.3. Activity concentrations of ^{238}Pu (Bq/m^3) at Station A (continued)

Sample Date	^{238}Pu Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
July 2021				
1st week	4.98E-05	9.11E-06	1.95E-06	Detected
2nd week	6.09E-05	1.12E-05	2.74E-06	Detected
3rd week	6.50E-05	1.17E-05	3.38E-06	Detected
4th week	6.40E-05	1.01E-05	1.03E-06	Detected
August 2021				
1st week	5.86E-05	1.05E-05	2.00E-06	Detected
2nd week	6.29E-05	1.08E-05	2.15E-06	Detected
3rd week	7.54E-05	1.33E-05	3.42E-06	Detected
4th week	7.00E-05	1.16E-05	1.20E-06	Detected
September 2021				
1st week	7.18E-05	1.28E-05	1.83E-06	Detected
2nd week	7.85E-05	1.36E-05	2.59E-06	Detected
3rd week	7.15E-05	1.28E-05	2.36E-06	Detected
4th week	5.64E-05	9.65E-06	1.27E-06	Detected
October 2021				
1st week	7.01E-05	1.25E-05	1.79E-06	Detected
2nd week	4.61E-05	8.49E-06	2.21E-06	Detected
3rd week	5.83E-05	1.06E-05	2.17E-06	Detected
4th week	3.16E-05	6.77E-06	1.73E-06	Detected
November 2021				
1st week	3.47E-05	7.05E-06	1.48E-06	Detected
2nd week	3.48E-05	7.47E-06	2.39E-06	Detected
3rd week	2.69E-05	5.90E-06	2.64E-06	Detected
4th week	2.73E-05	5.45E-06	1.52E-06	Detected
December 2021				
1st week	2.54E-05	5.74E-06	1.84E-06	Detected
2nd week	2.53E-05	5.72E-06	1.91E-06	Detected
3rd week	2.25E-05	5.46E-06	2.07E-06	Detected
4th week	2.42E-05	5.11E-06	1.75E-06	Detected

Table A.4. Specific activities of ^{241}Am (Bq/g) at Station A

Sample Date	^{241}Am Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
January 2021				
1st week	3.27E-01	8.21E-02	2.32E-02	Detected
2nd week	1.71E-01	5.80E-02	3.59E-02	Detected
3rd week	1.99E-01	6.85E-02	4.78E-02	Detected
4th week	1.21E-01	2.72E-02	9.68E-03	Detected
February 2021				
1st week	1.04E-01	2.81E-02	1.14E-02	Detected
2nd week	1.31E-01	3.65E-02	1.65E-02	Detected
3rd week	2.27E-01	4.38E-02	9.94E-03	Detected
4th week	3.33E-01	6.37E-02	1.30E-02	Detected
March 2021				
1st week	1.28E-01	3.60E-02	1.74E-02	Detected
2nd week	6.04E-01	1.13E-01	3.07E-02	Detected
3rd week	2.06E-01	3.51E-02	9.60E-03	Detected
4th week	1.10E-01	2.07E-02	4.37E-03	Detected
April 2021				
1st week	4.38E-01	6.28E-02	5.78E-03	Detected
2nd week	1.83E-02	9.54E-03	1.05E-02	Detected
3rd week	7.19E-02	1.95E-02	1.08E-02	Detected
4th week	4.23E-02	1.28E-02	8.21E-03	Detected
May 2021				
1st week	2.34E-02	1.25E-02	1.14E-02	Detected
2nd week	2.68E-02	1.08E-02	6.90E-03	Detected
3rd week	3.25E-02	1.25E-02	6.30E-03	Not Detected
4th week	7.44E-02	2.52E-02	1.68E-02	Detected
June 2021				
1st week	1.07E-02	1.08E-02	1.89E-02	Detected
2nd week	4.74E-02	1.90E-02	1.82E-02	Detected
3rd week	2.70E-02	1.25E-02	1.16E-02	Detected
4th week	1.17E-01	2.77E-02	1.44E-02	Detected

Table A.4. Specific activities of ^{241}Am (Bq/g) at Station A (continued)

Sample Date	^{241}Am Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
July 2021				
1st week	8.51E-02	2.78E-02	1.94E-02	Detected
2nd week	1.87E-02	1.06E-02	1.27E-02	Detected
3rd week	4.24E-02	1.39E-02	7.36E-03	Detected
4th week	1.55E-01	2.85E-02	5.67E-03	Detected
August 2021				
1st week	5.43E-02	2.31E-02	2.16E-02	Detected
2nd week	7.23E-02	3.43E-02	3.55E-02	Detected
3rd week	3.27E-02	1.96E-02	2.24E-02	Detected
4th week	7.77E-02	2.35E-02	1.12E-02	Detected
September 2021				
1st week	4.16E-01	1.06E-01	4.19E-02	Detected
2nd week	2.64E-01	8.42E-02	5.24E-02	Detected
3rd week	1.02E-01	5.53E-02	7.21E-02	Detected
4th week	3.24E-02	1.04E-02	5.16E-03	Detected
October 2021				
1st week	8.07E-02	3.57E-02	2.62E-02	Detected
2nd week	2.14E-01	6.52E-02	3.41E-02	Detected
3rd week	1.18E+00	1.81E-01	9.90E-03	Detected
4th week	9.72E-02	2.60E-02	1.17E-02	Detected
November 2021				
1st week	1.94E-01	5.49E-02	2.36E-02	Detected
2nd week	5.23E-02	1.70E-02	1.13E-02	Detected
3rd week	9.63E-02	2.81E-02	1.60E-02	Detected
4th week	2.48E-01	6.10E-02	2.31E-02	Detected
December 2021				
1st week	1.95E-01	5.39E-02	2.57E-02	Detected
2nd week	1.57E-01	3.80E-02	1.46E-02	Detected
3rd week	1.41E-01	4.49E-02	2.25E-02	Detected
4th week	8.74E-02	3.22E-02	2.72E-02	Detected

Table A.5. Specific activities of $^{239+240}Pu$ (Bq/g) at Station A

Sample Date	$^{239+240}Pu$ Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
January 2021				
1st week	5.04E-02	3.82E-02	5.12E-02	Detected
2nd week	9.19E-03	1.49E-02	3.03E-02	Detected
3rd week	2.94E-02	3.07E-02	5.66E-02	Detected
4th week	1.73E-02	8.96E-03	7.96E-03	Detected
February 2021				
1st week	1.14E-02	9.34E-03	1.03E-02	Detected
2nd week	2.62E-02	1.45E-02	1.56E-02	Detected
3rd week	2.98E-02	1.29E-02	7.50E-03	Detected
4th week	2.97E-02	1.50E-02	1.48E-02	Detected
March 2021				
1st week	1.46E-02	1.11E-02	1.49E-02	Detected
2nd week	9.34E-02	3.72E-02	2.51E-02	Not detected
3rd week	2.36E-02	8.44E-03	3.93E-03	Not detected
4th week	1.17E-02	4.99E-03	3.18E-03	Detected
April 2021				
1st week	5.76E-02	1.40E-02	3.17E-03	Not detected
2nd week	9.62E-04	2.86E-03	7.51E-03	Detected
3rd week	6.49E-03	5.54E-03	7.92E-03	Not detected
4th week	5.32E-03	4.84E-03	7.61E-03	Detected
May 2021				
1st week	1.80E-03	4.07E-03	9.81E-03	Detected
2nd week	4.98E-03	4.79E-03	6.96E-03	Detected
3rd week	4.09E-03	5.65E-03	1.18E-02	Not detected
4th week	1.52E-02	1.08E-02	1.05E-02	Detected
June 2021				
1st week	6.44E-04	4.90E-03	1.47E-02	Detected
2nd week	1.07E-02	9.72E-03	1.53E-02	Detected
3rd week	4.14E-03	4.96E-03	8.10E-03	Detected
4th week	9.25E-03	7.30E-02	9.83E-03	Not detected

Table A.5. Specific activities of $^{239+240}Pu$ (Bq/g) at Station A (continued)

Sample Date	$^{239+240}Pu$ Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
July 2021				
1st week	2.90E-02	1.54E-02	1.53E-02	Detected
2nd week	3.41E-03	5.91E-03	1.30E-02	Not detected
3rd week	1.06E-03	4.55E-03	1.22E-02	Detected
4th week	2.29E-02	8.81E-03	4.43E-03	Detected
August 2021				
1st week	8.04E-03	1.03E-02	1.95E-02	Detected
2nd week	3.22E-03	7.90E-03	1.95E-02	Detected
3rd week	1.17E-02	1.62E-02	3.38E-02	Detected
4th week	5.88E-03	6.64E-03	9.69E-03	Detected
September 2021				
1st week	1.13E-01	5.34E-02	2.84E-02	Detected
2nd week	3.67E-02	3.46E-02	5.66E-02	Detected
3rd week	1.36E-02	2.21E-02	4.51E-02	Not detected
4th week	2.97E-03	3.12E-03	5.13E-03	Not detected
October 2021				
1st week	3.00E-02	1.81E-02	1.27E-02	Not detected
2nd week	1.70E-02	1.46E-02	2.25E-02	Detected
3rd week	2.64E-01	5.01E-02	8.65E-03	Detected
4th week	3.38E-02	1.74E-02	1.85E-02	Detected
November 2021				
1st week	6.25E-03	1.31E-02	3.10E-02	Detected
2nd week	1.20E-02	8.76E-03	1.17E-02	Detected
3rd week	6.18E-03	8.55E-03	1.78E-02	Not detected
4th week	7.41E-02	2.96E-02	1.84E-02	Detected
December 2021				
1st week	4.57E-02	2.56E-02	2.97E-02	Not detected
2nd week	4.00E-03	5.94E-03	1.12E-02	Not detected
3rd week	2.28E-02	1.95E-02	2.78E-02	Not detected
4th week	1.20E-02	1.25E-02	1.82E-02	Detected

Table A.6. Specific activities of ^{238}Pu (Bq/g) at Station A

Sample Date	^{238}Pu Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
January 2021				
1st week	2.85E-01	9.13E-02	5.12E-02	Detected
2nd week	2.34E-01	7.01E-02	4.14E-02	Detected
3rd week	1.90E-01	7.03E-02	6.45E-02	Detected
4th week	1.34E-01	2.87E-02	6.79E-03	Detected
February 2021				
1st week	9.60E-02	2.88E-02	1.15E-02	Detected
2nd week	9.33E-02	2.80E-02	1.41E-02	Detected
3rd week	9.18E-02	2.44E-02	7.50E-03	Detected
4th week	1.22E-01	3.19E-02	1.34E-02	Detected
March 2021				
1st week	7.32E-02	2.43E-02	1.33E-02	Detected
2nd week	3.04E-01	7.31E-02	2.14E-02	Not Detected
3rd week	5.00E-02	1.30E-02	3.93E-03	Not detected
4th week	6.00E-02	1.30E-02	4.17E-03	Detected
April 2021				
1st week	8.81E-02	1.85E-02	6.52E-03	Detected
2nd week	8.64E-02	2.14E-02	1.14E-02	Detected
3rd week	1.11E-01	2.49E-02	1.18E-02	Detected
4th week	1.28E-01	2.61E-02	7.61E-03	Detected
May 2021				
1st week	1.64E-01	3.38E-02	9.81E-03	Detected
2nd week	1.74E-01	3.37E-02	9.49E-03	Detected
3rd week	7.64E-02	2.05E-02	1.34E-02	Detected
4th week	1.85E-01	4.29E-02	1.18E-02	Detected
June 2021				
1st week	3.23E-01	6.04E-02	1.33E-02	Detected
2nd week	3.45E-01	6.46E-02	1.71E-02	Detected
3rd week	2.87E-01	5.17E-02	1.29E-02	Detected
4th week	4.19E-01	6.89E-02	1.26E-02	Detected

Table A.6. Specific activities of ^{238}Pu (Bq/g) at Station A (continued)

Sample Date	^{238}Pu Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
July 2021				
1st week	3.91E-01	7.15E-02	1.53E-02	Detected
2nd week	3.23E-01	5.97E-02	1.46E-02	Detected
3rd week	2.68E-01	4.82E-02	1.39E-02	Detected
4th week	3.11E-01	4.92E-02	4.98E-03	Detected
August 2021				
1st week	5.70E-01	1.02E-01	1.95E-02	Detected
2nd week	7.79E-01	1.34E-01	2.66E-02	Detected
3rd week	8.49E-01	1.49E-01	3.85E-02	Detected
4th week	6.33E-01	1.05E-01	1.09E-02	Detected
September 2021				
1st week	1.75E+00	3.12E-01	4.45E-02	Detected
2nd week	2.07E+00	3.57E-01	6.84E-02	Detected
3rd week	1.86E+00	3.34E-01	6.16E-02	Detected
4th week	2.15E-01	3.68E-02	4.83E-03	Detected
October 2021				
1st week	7.76E-01	1.38E-01	1.99E-02	Detected
2nd week	5.69E-01	1.05E-01	2.72E-02	Detected
3rd week	3.17E-01	5.77E-02	1.18E-02	Detected
4th week	2.87E-01	6.15E-02	1.57E-02	Detected
November 2021				
1st week	5.33E-01	1.08E-01	2.27E-02	Detected
2nd week	1.92E-01	4.11E-02	1.31E-02	Detected
3rd week	2.07E-01	4.53E-02	2.03E-02	Detected
4th week	4.52E-01	9.04E-02	2.52E-02	Detected
December 2021				
1st week	3.49E-01	7.89E-02	2.53E-02	Detected
2nd week	2.03E-01	4.59E-02	1.53E-02	Detected
3rd week	3.33E-01	8.10E-02	3.06E-02	Detected
4th week	4.25E-01	8.96E-02	3.07E-02	Detected

Table A.7. Monthly activity concentrations of U isotopes at Station A

Radionuclide	Sample Date	Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{234}U	January	1.57E-07	5.88E-07	1.63E-06	Not detected
	February	1.81E-07	4.72E-07	1.18E-06	Not detected
	March	1.19E-06	8.34E-07	1.11E-06	Detected
	April	9.12E-07	7.66E-07	1.20E-06	Not detected
	May	1.13E-06	8.49E-07	1.00E-06	Detected
	June	6.92E-08	1.32E-07	3.00E-07	Not detected
	July	2.95E-08	7.83E-08	1.96E-07	Not detected
	August	3.50E-08	4.50E-08	8.50E-08	Not detected
	September	3.54E-07	5.92E-07	1.30E-06	Not detected
	October	9.90E-07	7.55E-07	1.09E-06	Not detected
	November	4.52E-07	5.96E-07	1.21E-06	Not detected
	December	1.03E-06	6.95E-07	6.36E-07	Detected
^{235}U	January	1.94E-07	3.50E-07	7.18E-07	Not detected
	February	1.28E-07	3.26E-07	7.96E-07	Not detected
	March	2.30E-07	4.15E-07	8.51E-07	Not detected
	April	3.75E-07	5.09E-07	8.56E-07	Not detected
	May	-2.04E-07	3.80E-07	1.41E-06	Not detected
	June	-6.15E-08	3.20E-07	9.12E-07	Not detected
	July	1.18E-07	4.43E-07	1.23E-06	Not detected
	August	-5.85E-08	3.04E-07	8.67E-07	Not detected
	September	7.49E-07	7.09E-07	7.79E-07	Not detected
	October	1.90E-07	3.96E-07	9.03E-07	Not detected
	November	1.06E-07	3.98E-07	1.10E-06	Not detected
	December	-5.29E-08	2.75E-07	7.85E-07	Not detected

Table A.7. Monthly activity concentrations of U isotopes at Station A (continued)

Radionuclide	Sample Date	Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{238}U	January	-2.54E-07	2.43E-07	1.07E-06	Not detected
	February	2.06E-07	5.46E-07	1.36E-06	Not detected
	March	1.30E-06	9.01E-07	1.30E-06	Not detected
	April	2.56E-07	6.06E-07	1.47E-06	Not detected
	May	4.94E-07	6.34E-07	1.20E-06	Not detected
	June	9.92E-08	3.72E-07	1.03E-06	Not detected
	July	2.39E-07	5.66E-07	1.38E-06	Not detected
	August	1.65E-07	5.02E-07	1.29E-06	Not detected
	September	-1.51E-07	2.81E-07	1.04E-06	Not detected
	October	1.36E-06	8.49E-07	1.00E-06	Detected
	November	1.50E-07	4.57E-07	1.17E-06	Not detected
	December	5.55E-07	5.35E-07	7.76E-07	Not detected

Table A.8. Specific activities of U isotopes at Station A

Radionuclide	Sample Date	Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{234}U	January	1.66E-03	6.22E-03	1.72E-02	Not detected
	February	1.20E-03	3.12E-03	7.82E-03	Not detected
	March	5.43E-03	3.82E-03	5.08E-03	Detected
	April	3.81E-03	3.20E-03	5.02E-03	Not detected
	May	6.14E-03	4.62E-03	5.45E-03	Detected
	June	3.47E-04	6.61E-04	1.51E-03	Not detected
	July	1.43E-04	3.80E-04	9.50E-04	Not detected
	August	1.71E-04	2.19E-04	4.15E-04	Not detected
	September	3.34E-03	5.58E-03	1.22E-02	Not detected
	October	8.55E-03	6.52E-03	9.42E-03	Not detected
	November	4.27E-03	5.62E-03	1.14E-02	Not detected
	December	1.32E-02	8.89E-03	8.14E-03	Detected
^{235}U	January	2.05E-03	3.70E-03	7.59E-03	Not detected
	February	8.43E-04	2.15E-03	5.26E-03	Not detected
	March	1.05E-03	1.90E-03	3.90E-03	Not detected
	April	1.57E-03	2.13E-03	3.58E-03	Not detected
	May	-1.11E-03	2.06E-03	7.66E-03	Not detected
	June	-4.09E-04	2.13E-03	6.06E-03	Not detected
	July	6.15E-04	2.30E-03	6.37E-03	Not detected
	August	-6.00E-04	3.12E-03	8.90E-03	Not detected
	September	7.06E-03	6.67E-03	7.33E-03	Not detected
	October	1.64E-03	3.42E-03	7.80E-03	Not detected
	November	1.00E-03	3.75E-03	1.04E-02	Not detected
	December	-6.77E-04	3.52E-03	1.00E-02	Not detected

Table A.8. Specific activities of U isotopes at Station A (continued)

Radionuclide	Sample Date	Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{238}U	-2.69E-03	2.57E-03	1.13E-02	Not detected	-2.69E-03
	1.36E-03	3.61E-03	9.02E-03	Not detected	1.36E-03
	5.94E-03	4.13E-03	5.96E-03	Not detected	5.94E-03
	1.07E-03	2.54E-03	6.15E-03	Not detected	1.07E-03
	2.69E-03	3.45E-03	6.52E-03	Not detected	2.69E-03
	6.60E-04	2.47E-03	6.84E-03	Not detected	6.60E-04
	1.24E-03	2.94E-03	7.15E-03	Not detected	1.24E-03
	1.70E-03	5.15E-03	1.32E-02	Not detected	1.70E-03
	-1.42E-03	2.65E-03	9.84E-03	Not detected	-1.42E-03
	1.17E-02	7.34E-03	8.66E-03	Detected	1.17E-02
	1.42E-03	4.31E-03	1.11E-02	Not detected	1.42E-03
	7.10E-03	6.85E-03	9.92E-03	Not detected	7.10E-03

Table A.9. Activity concentrations of ^{137}Cs (Bq/m^3) at Station A

Sample Date	^{137}Cs Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
January 2021				
1st week	1.27E-04	4.57E-05	1.47E-04	Not detected
2nd week	4.30E-05	8.71E-05	2.92E-04	Not detected
3rd week	5.36E-05	3.28E-05	1.08E-04	Not detected
4th week	-2.85E-05	6.25E-05	2.12E-04	Not detected
February 2021				
1st week	-6.23E-05	4.22E-05	1.45E-04	Not detected
2nd week	4.35E-05	3.68E-05	1.22E-04	Not detected
3rd week	-9.17E-05	3.67E-05	1.29E-04	Not detected
4th week	-4.82E-05	4.10E-05	1.41E-04	Not detected
March 2021				
1st week	1.16E-05	7.82E-05	2.66E-04	Not detected
2nd week	8.67E-05	4.42E-05	1.44E-04	Not detected
3rd week	6.89E-05	9.54E-05	3.20E-04	Not detected
4th week	1.55E-04	9.64E-05	3.17E-04	Not detected
April 2021				
1st week	-3.49E-04	1.21E-04	4.27E-04	Not detected
2nd week	3.05E-04	1.26E-04	4.10E-04	Not detected
3rd week	8.36E-05	8.69E-05	2.91E-04	Not detected
4th week	-2.38E-04	9.25E-05	3.25E-04	Not detected
May 2021				
1st week	-1.62E-04	1.41E-04	4.82E-04	Not detected
2nd week	-2.83E-04	1.32E-04	4.59E-04	Not detected
3rd week	1.11E-04	1.04E-04	3.46E-04	Not detected
4th week	4.33E-04	1.42E-04	4.56E-04	Not detected
June 2021				
1st week	1.54E-04	1.18E-04	3.91E-04	Not detected
2nd week	5.95E-05	1.08E-04	3.65E-04	Not detected
3rd week	-4.28E-04	1.21E-04	4.30E-04	Not detected
4th week	1.51E-04	9.95E-05	3.28E-04	Not detected

Table A.9. Activity concentrations of ^{137}Cs (Bq/m^3) at Station A (continued)

Sample Date	^{137}Cs Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
July 2021				
1st week	4.10E-05	9.59E-05	3.24E-04	Not detected
2nd week	-3.36E-04	8.38E-05	3.02E-04	Not detected
3rd week	7.86E-05	1.34E-04	4.49E-04	Not detected
4th week	6.36E-05	6.68E-05	2.23E-04	Not detected
August 2021				
1st week	-1.35E-04	1.02E-04	3.50E-04	Not detected
2nd week	8.06E-04	1.67E-03	5.63E-03	Not detected
3rd week	-2.06E-03	1.16E-03	4.19E-03	Not detected
4th week	3.06E-04	5.85E-04	1.97E-03	Not detected
September 2021				
1st week	-1.49E-04	9.07E-05	3.13E-04	Not detected
2nd week	-1.11E-04	9.49E-05	3.32E-04	Not detected
3rd week	8.95E-05	1.44E-04	4.80E-04	Not detected
4th week	-1.07E-05	9.09E-05	3.05E-04	Not detected
October 2021				
1st week	-1.78E-05	4.66E-05	1.61E-04	Not detected
2nd week	-1.18E-05	5.65E-05	1.91E-04	Not detected
3rd week	-9.24E-05	4.09E-05	1.43E-04	Not detected
4th week	1.52E-05	2.31E-05	7.76E-05	Not detected
November 2021				
1st week	5.75E-05	3.52E-05	1.16E-04	Not detected
2nd week	3.84E-05	3.27E-05	1.09E-04	Not detected
3rd week	3.52E-07	2.81E-05	9.64E-05	Not detected
4th week	-1.92E-05	2.97E-05	1.02E-04	Not detected
December 2021				
1st week	-1.92E-05	2.99E-05	1.04E-04	Not detected
2nd week	-2.33E-06	3.00E-05	1.03E-04	Not detected
3rd week	-1.88E-05	2.91E-05	1.01E-04	Not detected
4th week	-6.47E-05	2.86E-05	1.00E-04	Not detected

Table A.10. Activity concentrations of ^{40}K (Bq/m^3) at Station A

Sample Date	^{40}K Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
January 2021				
1st week	4.92E-04	5.97E-04	2.00E-03	Not detected
2nd week	8.05E-04	7.66E-04	2.56E-03	Not detected
3rd week	2.03E-04	5.53E-04	1.87E-03	Not detected
4th week	7.91E-04	5.22E-04	1.72E-03	Not detected
February 2021				
1st week	3.37E-04	5.15E-04	1.73E-03	Not detected
2nd week	-3.41E-04	5.40E-04	1.86E-03	Not detected
3rd week	-1.55E-04	4.60E-04	1.58E-03	Not detected
4th week	-4.01E-04	4.59E-04	1.60E-03	Not detected
March 2021				
1st week	1.12E-03	8.99E-04	2.98E-03	Not detected
2nd week	4.12E-04	5.84E-04	1.96E-03	Not detected
3rd week	-4.21E-04	1.21E-03	4.18E-03	Not detected
4th week	-1.50E-03	9.93E-04	3.49E-03	Not detected
April 2021				
1st week	1.28E-03	1.23E-03	4.09E-03	Not detected
2nd week	6.23E-04	1.66E-03	5.61E-03	Not detected
3rd week	4.35E-04	1.15E-03	3.91E-03	Not detected
4th week	1.31E-04	9.71E-04	3.30E-03	Not detected
May 2021				
1st week	-2.82E-04	1.16E-03	3.99E-03	Not detected
2nd week	-7.32E-04	1.24E-03	4.28E-03	Not detected
3rd week	4.70E-04	1.43E-03	4.83E-03	Not detected
4th week	2.61E-03	1.42E-03	4.65E-03	Not detected
June 2021				
1st week	-9.93E-04	1.97E-03	6.76E-03	Not detected
2nd week	3.73E-04	1.14E-03	3.89E-03	Not detected
3rd week	-6.35E-04	1.16E-03	4.02E-03	Not detected
4th week	-2.02E-03	1.13E-03	4.00E-03	Not detected

Table A.10. Activity concentrations ^{40}K (Bq/m^3) at Station A (continued)

Sample Date	^{40}K Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
July 2021				
1st week	2.59E-03	1.20E-03	3.89E-03	Not detected
2nd week	1.95E-04	9.27E-04	3.14E-03	Not detected
3rd week	-1.40E-03	1.53E-03	5.30E-03	Not detected
4th week	3.07E-05	7.99E-04	2.74E-03	Not detected
August 2021				
1st week	1.88E-04	8.38E-04	2.85E-03	Not detected
2nd week	8.06E-04	1.67E-03	5.63E-03	Not detected
3rd week	-2.06E-03	1.16E-03	4.19E-03	Not detected
4th week	3.06E-04	5.85E-04	1.97E-03	Not detected
September 2021				
1st week	-3.13E-04	8.78E-04	3.01E-03	Not detected
2nd week	-5.55E-03	1.45E-03	5.33E-03	Not detected
3rd week	-2.09E-03	1.12E-03	4.05E-03	Not detected
4th week	1.72E-04	6.33E-04	2.15E-03	Not detected
October 2021				
1st week	-1.11E-03	8.01E-04	2.80E-03	Not detected
2nd week	5.05E-04	4.80E-04	1.60E-03	Not detected
3rd week	4.56E-04	4.71E-04	1.57E-03	Not detected
4th week	-4.55E-04	3.77E-04	1.32E-03	Not detected
November 2021				
1st week	-9.52E-04	5.53E-04	1.95E-03	Not detected
2nd week	-1.41E-03	5.86E-04	2.08E-03	Not detected
3rd week	-1.69E-03	6.42E-04	2.27E-03	Not detected
4th week	-1.33E-03	3.98E-04	1.45E-03	Not detected
December 2021				
1st week	-1.35E-03	5.15E-04	1.85E-03	Not detected
2nd week	-1.64E-03	5.20E-04	1.89E-03	Not detected
3rd week	-2.04E-03	5.35E-04	1.96E-03	Not detected
4th week	1.24E-04	3.02E-04	1.02E-03	Not detected

Table A.11. Activity concentrations of ^{60}Co (Bq/m^3) at Station A

Sample Date	^{60}Co Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
January 2021				
1st week	-4.08E-05	3.73E-05	1.33E-04	Not detected
2nd week	2.31E-05	5.35E-05	1.84E-04	Not detected
3rd week	-1.28E-05	3.49E-05	1.22E-04	Not detected
4th week	2.99E-05	3.54E-05	1.20E-04	Not detected
February 2021				
1st week	4.02E-05	3.07E-05	1.02E-04	Not detected
2nd week	4.98E-05	3.42E-05	1.13E-04	Not detected
3rd week	1.15E-05	3.24E-05	1.11E-04	Not detected
4th week	1.57E-05	3.02E-05	1.03E-04	Not detected
March 2021				
1st week	2.72E-05	6.64E-05	2.28E-04	Not detected
2nd week	6.24E-05	3.55E-05	1.16E-04	Not detected
3rd week	9.41E-05	8.70E-05	2.92E-04	Not detected
4th week	1.14E-04	6.22E-05	2.03E-04	Not detected
April 2021				
1st week	7.72E-05	1.02E-04	3.44E-04	Not detected
2nd week	1.37E-04	9.89E-05	3.28E-04	Not detected
3rd week	1.71E-05	1.71E-05	7.81E-05	Not detected
4th week	-1.81E-05	7.04E-05	2.45E-04	Not detected
May 2021				
1st week	1.88E-04	8.89E-05	2.88E-04	Not detected
2nd week	1.34E-04	9.90E-05	3.28E-04	Not detected
3rd week	2.17E-05	9.39E-05	3.22E-04	Not detected
4th week	-1.62E-05	9.78E-05	3.42E-04	Not detected
June 2021				
1st week	8.20E-05	1.11E-04	3.77E-04	Not detected
2nd week	1.33E-04	8.77E-05	2.89E-04	Not detected
3rd week	3.03E-05	7.97E-05	2.73E-04	Not detected
4th week	1.60E-04	7.71E-05	2.50E-04	Not detected

Table A.11. Activity concentrations of ^{60}Co (Bq/m³) at Station A (continued)

Sample Date	^{60}Co Activity Bq/m³	Unc. (2σ) Bq/m³	MDC Bq/m³	Status
July 2021				
1st week	7.91E-05	8.11E-05	2.73E-04	Not detected
2nd week	1.16E-04	6.37E-05	2.08E-04	Not detected
3rd week	-7.15E-05	9.23E-05	3.27E-04	Not detected
4th week	6.72E-05	6.04E-05	2.02E-04	Not detected
August 2021				
1st week	5.89E-06	5.73E-05	1.97E-04	Not detected
2nd week	-3.57E-06	1.06E-04	3.66E-04	Not detected
3rd week	-2.02E-04	8.74E-05	3.26E-04	Not detected
4th week	6.89E-05	3.91E-05	1.28E-04	Not detected
September 2021				
1st week	1.20E-04	6.46E-05	2.11E-04	Not detected
2nd week	-3.79E-05	9.28E-05	3.25E-04	Not detected
3rd week	-1.47E-04	8.71E-05	3.17E-04	Not detected
4th week	1.56E-04	5.70E-05	1.82E-04	Not detected
October 2021				
1st week	3.96E-05	5.04E-05	1.70E-04	Not detected
2nd week	2.38E-05	3.65E-05	1.24E-04	Not detected
3rd week	1.55E-06	2.98E-05	1.03E-04	Not detected
4th week	-5.95E-06	2.11E-05	7.43E-05	Not detected
November 2021				
1st week	4.56E-05	3.38E-05	1.12E-04	Not detected
2nd week	-2.04E-05	3.27E-05	1.16E-04	Not detected
3rd week	3.21E-05	3.90E-05	1.31E-04	Not detected
4th week	-1.15E-05	2.68E-05	9.40E-05	Not detected
December 2021				
1st week	-4.54E-07	2.92E-05	1.02E-04	Not detected
2nd week	-1.23E-05	3.04E-05	1.07E-04	Not detected
3rd week	-1.90E-05	3.09E-05	1.10E-04	Not detected
4th week	-1.10E-05	2.13E-05	7.48E-05	Not detected

Table A.12. Specific activities of ^{137}Cs (Bq/g) at Station A

Sample Date	^{137}Cs Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
January 2021				
1st week	2.10E+00	7.56E-01	2.44E+00	Not detected
2nd week	7.39E-01	1.50E+00	5.01E+00	Not detected
3rd week	5.96E-01	3.64E-01	1.20E+00	Not detected
4th week	-1.98E-01	4.35E-01	1.48E+00	Not detected
February 2021				
1st week	-3.47E-01	2.35E-01	8.09E-01	Not detected
2nd week	3.39E-01	2.87E-01	9.51E-01	Not detected
3rd week	-5.24E-01	2.09E-01	7.37E-01	Not detected
4th week	-3.90E-01	3.32E-01	1.14E+00	Not detected
March 2021				
1st week	7.66E-02	5.15E-01	1.75E+00	Not detected
2nd week	1.21E+00	6.16E-01	2.01E+00	Not detected
3rd week	2.25E-01	3.11E-01	1.05E+00	Not detected
4th week	5.28E-01	3.28E-01	1.08E+00	Not detected
April 2021				
1st week	-1.05E+00	3.66E-01	1.29E+00	Not detected
2nd week	1.41E+00	5.85E-01	1.90E+00	Not detected
3rd week	3.90E-01	4.06E-01	1.36E+00	Not detected
4th week	-1.16E+00	4.53E-01	1.59E+00	Not detected
May 2021				
1st week	-9.23E-01	8.02E-01	2.74E+00	Not detected
2nd week	-1.29E+00	6.03E-01	2.10E+00	Not detected
3rd week	5.68E-01	5.33E-01	1.77E+00	Not detected
4th week	3.08E+00	1.01E+00	3.25E+00	Not detected
June 2021				
1st week	1.04E+00	8.01E-01	2.65E+00	Not detected
2nd week	4.49E-01	8.19E-01	2.75E+00	Not detected
3rd week	-2.46E+00	6.96E-01	2.47E+00	Not detected
4th week	1.02E+00	6.75E-01	2.22E+00	Not detected

Table A.12. Specific activities of ^{137}Cs (Bq/g) at Station A (continued)

Sample Date	^{137}Cs Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
July 2021				
1st week	3.21E-01	7.52E-01	2.54E+00	Not detected
2nd week	-1.79E+00	4.45E-01	1.60E+00	Not detected
3rd week	3.24E-01	5.53E-01	1.85E+00	Not detected
4th week	3.09E-01	3.24E-01	1.08E+00	Not detected
August 2021				
1st week	-1.32E+00	9.93E-01	3.40E+00	Not detected
2nd week	9.97E+00	2.07E+01	6.97E+01	Not detected
3rd week	-2.32E+01	1.31E+01	4.71E+01	Not detected
4th week	2.77E+00	5.29E+00	1.78E+01	Not detected
September 2021				
1st week	-3.64E+00	2.21E+00	7.63E+00	Not detected
2nd week	-2.92E+00	2.50E+00	8.74E+00	Not detected
3rd week	2.33E+00	3.75E+00	1.25E+01	Not detected
4th week	-4.08E-02	3.46E-01	1.16E+00	Not Detected
October 2021				
1st week	-1.98E-01	5.16E-01	1.79E+00	Not detected
2nd week	-1.45E-01	6.98E-01	2.36E+00	Not detected
3rd week	-5.02E-01	2.22E-01	7.79E-01	Not detected
4th week	1.38E-01	2.10E-01	7.05E-01	Not detected
November 2021				
1st week	8.83E-01	5.40E-01	1.78E+00	Not detected
2nd week	2.11E-01	1.80E-01	5.98E-01	Not detected
3rd week	2.71E-03	2.16E-01	7.41E-01	Not detected
4th week	-3.18E-01	4.92E-01	1.69E+00	Not detected
December 2021				
1st week	-2.65E-01	4.11E-01	1.43E+00	Not detected
2nd week	-1.87E-02	2.41E-01	8.27E-01	Not detected
3rd week	-2.79E-01	4.31E-01	1.50E+00	Not detected
4th week	-1.13E+00	5.02E-01	1.76E+00	Not detected

Table A.13. Specific activities of ^{40}K (Bq/g) at Station A

Sample Date	^{40}K Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
January 2021				
1st week	8.14E+00	9.87E+00	3.30E+01	Not detected
2nd week	1.38E+01	1.32E+01	4.39E+01	Not detected
3rd week	2.26E+00	6.14E+00	2.08E+01	Not detected
4th week	5.51E+00	3.63E+00	1.20E+01	Not detected
February 2021				
1st week	1.88E+00	2.87E+00	9.63E+00	Not detected
2nd week	-2.66E+00	4.20E+00	1.45E+01	Not detected
3rd week	-8.83E-01	2.63E+00	9.04E+00	Not detected
4th week	-3.24E+00	3.71E+00	1.29E+01	Not detected
March 2021				
1st week	7.37E+00	5.92E+00	1.96E+01	Not detected
2nd week	5.74E+00	8.15E+00	2.73E+01	Not detected
3rd week	-1.37E+00	3.94E+00	1.36E+01	Not detected
4th week	-5.12E+00	3.38E+00	1.19E+01	Not detected
April 2021				
1st week	0.00E+00	0.00E+00	0.00E+00	Not detected
2nd week	0.00E+00	0.00E+00	0.00E+00	Not detected
3rd week	0.00E+00	0.00E+00	0.00E+00	Not detected
4th week	0.00E+00	0.00E+00	0.00E+00	Not detected
May 2021				
1st week	0.00E+00	0.00E+00	0.00E+00	Not detected
2nd week	0.00E+00	0.00E+00	0.00E+00	Not detected
3rd week	0.00E+00	0.00E+00	0.00E+00	Not detected
4th week	0.00E+00	0.00E+00	0.00E+00	Not detected
June 2021				
1st week	0.00E+00	0.00E+00	0.00E+00	Not detected
2nd week	0.00E+00	0.00E+00	0.00E+00	Not detected
3rd week	-3.65E+00	6.68E+00	2.31E+01	Not detected
4th week	-1.37E+01	7.69E+00	2.71E+01	Not detected

Table A.13. Specific activities of ^{40}K (Bq/g) at Station A (continued)

Sample Date	^{40}K Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
July 2021				
1st week	2.03E+01	9.42E+00	3.05E+01	Not detected
2nd week	1.03E+00	4.92E+00	1.67E+01	Not detected
3rd week	-5.76E+00	6.30E+00	2.18E+01	Not detected
4th week	1.49E-01	3.88E+00	1.33E+01	Not detected
August 2021				
1st week	1.83E+00	8.16E+00	2.77E+01	Not detected
2nd week	9.97E+00	2.07E+01	6.97E+01	Not detected
3rd week	-2.32E+01	1.31E+01	4.71E+01	Not detected
4th week	2.77E+00	5.29E+00	1.78E+01	Not detected
September 2021				
1st week	-7.61E+00	2.14E+01	7.34E+01	Not detected
2nd week	-1.46E+02	3.83E+01	1.40E+02	Not detected
3rd week	-5.46E+01	2.92E+01	1.05E+02	Not detected
4th week	6.55E-01	2.41E+00	8.18E+00	Not detected
October 2021				
1st week	-1.23E+01	8.87E+00	3.10E+01	Not detected
2nd week	6.23E+00	5.92E+00	1.98E+01	Not detected
3rd week	2.48E+00	2.56E+00	8.55E+00	Not detected
4th week	-4.13E+00	3.43E+00	1.20E+01	Not detected
November 2021				
1st week	-1.46E+01	8.49E+00	2.99E+01	Not detected
2nd week	-7.73E+00	3.22E+00	1.14E+01	Not detected
3rd week	-1.30E+01	4.93E+00	1.75E+01	Not detected
4th week	-2.20E+01	6.60E+00	2.41E+01	Not detected
December 2021				
1st week	-1.86E+01	7.08E+00	2.55E+01	Not detected
2nd week	-1.32E+01	4.18E+00	1.52E+01	Not detected
3rd week	-3.02E+01	7.94E+00	2.91E+01	Not detected
4th week	2.18E+00	5.29E+00	1.79E+01	Not detected

Table A.14. Specific activities of ^{60}Co (Bq/g) at Station A

Sample Date	^{60}Co Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
January 2021				
1st week	-6.75E-01	6.17E-01	2.19E+00	Not detected
2nd week	3.97E-01	9.18E-01	3.15E+00	Not detected
3rd week	-1.42E-01	3.88E-01	1.35E+00	Not detected
4th week	2.08E-01	2.47E-01	8.34E-01	Not detected
February 2021				
1st week	2.24E-01	1.71E-01	5.67E-01	Not detected
2nd week	3.88E-01	2.66E-01	8.80E-01	Not detected
3rd week	6.58E-02	1.85E-01	6.31E-01	Not detected
4th week	1.27E-01	2.44E-01	8.31E-01	Not detected
March 2021				
1st week	1.79E-01	4.37E-01	1.50E+00	Not detected
2nd week	8.70E-01	4.95E-01	1.62E+00	Not detected
3rd week	3.07E-01	2.84E-01	9.52E-01	Not detected
4th week	3.86E-01	2.12E-01	6.91E-01	Not detected
April 2021				
1st week	2.33E-01	3.09E-01	1.04E+00	Not detected
2nd week	6.34E-01	4.57E-01	1.52E+00	Not detected
3rd week	8.01E-02	8.01E-02	3.64E-01	Not detected
4th week	-8.89E-02	3.45E-01	1.20E+00	Not detected
May 2021				
1st week	1.07E+00	5.05E-01	1.64E+00	Not detected
2nd week	6.14E-01	4.52E-01	1.50E+00	Not detected
3rd week	1.11E-01	4.80E-01	1.65E+00	Not detected
4th week	-1.15E-01	6.97E-01	2.44E+00	Not detected
June 2021				
1st week	5.56E-01	7.57E-01	2.56E+00	Not detected
2nd week	1.01E+00	6.62E-01	2.18E+00	Not detected
3rd week	1.74E-01	4.58E-01	1.57E+00	Not detected
4th week	1.08E+00	5.23E-01	1.69E+00	Not detected

Table A.14. Specific activities of ^{60}Co (Bq/g) at Station A (continued)

Sample Date	^{60}Co Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
July 2021				
1^{st} week	6.21E-01	6.37E-01	2.14E+00	Not detected
2^{nd} week	6.16E-01	3.38E-01	1.11E+00	Not detected
3^{rd} week	-2.95E-01	3.80E-01	1.35E+00	Not detected
4^{th} week	3.26E-01	2.93E-01	9.81E-01	Not detected
August 2021				
1^{st} week	5.73E-02	5.57E-01	1.92E+00	Not detected
2^{nd} week	-4.42E-02	1.31E+00	4.53E+00	Not detected
3^{rd} week	-2.28E+00	9.84E-01	3.67E+00	Not detected
4^{th} week	6.23E-01	3.53E-01	1.15E+00	Not detected
September 2021				
1^{st} week	2.92E+00	1.57E+00	5.13E+00	Not detected
2^{nd} week	-9.99E-01	2.45E+00	8.55E+00	Not detected
3^{rd} week	-3.84E+00	2.27E+00	8.27E+00	Not detected
4^{th} week	5.94E-01	2.17E-01	6.95E-01	Not detected
October 2021				
1^{st} week	4.38E-01	5.58E-01	1.88E+00	Not detected
2^{nd} week	2.93E-01	4.51E-01	1.53E+00	Not detected
3^{rd} week	8.40E-03	1.62E-01	5.60E-01	Not detected
4^{th} week	-5.40E-02	1.92E-01	6.75E-01	Not detected
November 2021				
1^{st} week	7.00E-01	5.19E-01	1.72E+00	Not detected
2^{nd} week	-1.12E-01	1.80E-01	6.37E-01	Not detected
3^{rd} week	2.47E-01	3.00E-01	1.01E+00	Not detected
4^{th} week	-1.91E-01	4.44E-01	1.56E+00	Not detected
December 2021				
1^{st} week	-6.24E-03	4.01E-01	1.40E+00	Not detected
2^{nd} week	-9.89E-02	2.44E-01	8.63E-01	Not detected
3^{rd} week	-2.82E-01	4.59E-01	1.63E+00	Not detected
4^{th} week	-1.92E-01	3.73E-01	1.31E+00	Not detected

Table A.15. Activity concentrations of ^{241}Am (Bq/m^3) at Station B

Radionuclide	Sample Date	^{241}Am Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{241}Am	January	2.60E-06	8.63E-07	4.93E-07	Detected
	February	1.29E-06	6.43E-07	6.96E-07	Detected
	March	1.99E-06	7.00E-07	4.51E-07	Detected
	April	1.06E-06	4.93E-07	4.77E-07	Detected
	May	5.73E-07	4.04E-07	6.38E-07	Not Detected
	June	2.04E-06	6.93E-07	3.88E-07	Detected
	July	2.31E-06	7.23E-07	4.06E-07	Detected
	August	3.27E-06	8.80E-07	3.38E-07	Detected
	September	2.79E-06	8.25E-07	4.15E-07	Detected
	October	2.36E-06	8.09E-07	5.09E-07	Detected
	November	4.61E-07	3.12E-07	3.39E-07	Detected
	December	6.61E-07	5.94E-07	8.07E-07	Not Detected

Table A.16. Activity concentrations of $^{239+240}Pu$ (Bq/m^3) at Station B

Radionuclides	Sample Date	$^{239+240}Pu$ Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
$^{239+240}Pu$	January	1.96E-07	2.25E-07	3.82E-07	Not Detected
	February	4.09E-07	3.28E-07	4.13E-07	Not Detected
	March	3.18E-07	2.68E-07	3.31E-07	Not Detected
	April	1.28E-07	1.89E-07	3.80E-07	Not Detected
	May	1.52E-07	1.82E-07	2.97E-07	Not Detected
	June	5.14E-07	3.65E-07	4.68E-07	Detected
	July	2.29E-07	2.30E-07	3.58E-07	Not Detected
	August	3.58E-07	3.26E-07	5.12E-07	Not Detected
	September	-9.15E-09	1.43E-07	4.69E-07	Not Detected
	October	2.95E-08	1.48E-07	4.29E-07	Not Detected
	November	1.62E-07	2.08E-07	3.68E-07	Not Detected
	December	0.00E+00	1.74E-07	5.27E-07	Not Detected

Table A.17. Activity concentrations of ^{238}Pu (Bq/m^3) at Station B

Radionuclide	Sample Date	^{238}Pu Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{238}Pu	January	-3.92E-08	1.06E-07	3.56E-07	Not Detected
	February	-1.02E-07	1.42E-07	6.38E-07	Not Detected
	March	-6.96E-08	1.21E-07	5.27E-07	Not Detected
	April	2.75E-08	1.71E-07	4.86E-07	Not Detected
	May	-4.46E-08	9.78E-08	3.48E-07	Not Detected
	June	-5.35E-08	1.17E-07	4.18E-07	Not Detected
	July	1.10E-07	1.62E-07	3.05E-07	Not Detected
	August	1.57E-07	2.32E-07	4.64E-07	Not Detected
	September	-6.40E-08	1.04E-07	3.99E-07	Not Detected
	October	-6.87E-08	1.11E-07	4.29E-07	Not Detected
	November	-1.01E-07	1.21E-07	5.02E-07	Not Detected
	December	-1.46E-07	1.26E-07	6.01E-07	Not Detected

Table A.18. Specific activities of ^{241}Am (Bq/g) at Station B

Radionuclide	Sample Date	^{241}Am Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{241}Am	January	1.30E+00	4.33E-01	2.47E-01	Detected
	February	4.52E-01	2.26E-01	2.45E-01	Detected
	March	2.22E+00	7.82E-01	5.04E-01	Detected
	April	6.61E-02	3.07E-02	2.98E-02	Detected
	May	4.04E-02	2.86E-02	4.50E-02	Not Detected
	June	1.63E-01	5.55E-02	3.11E-02	Detected
	July	4.02E-01	1.26E-01	7.09E-02	Detected
	August	4.25E-01	1.14E-01	4.40E-02	Detected
	September	9.87E-01	2.92E-01	1.47E-01	Detected
	October	2.30E+00	7.91E-01	4.97E-01	Detected
	November	1.40E-01	9.50E-02	1.03E-01	Detected
	December	3.30E-01	2.97E-01	4.03E-01	Not Detected

Table A.19. Specific activities of $^{239+240}Pu$ (Bq/g) at Station B

Radionuclides	Sample Date	$^{239+240}Pu$ Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
$^{239+240}Pu$	January	9.82E-02	1.13E-01	1.92E-01	Not Detected
	February	1.44E-01	1.15E-01	1.45E-01	Not Detected
	March	3.56E-01	3.00E-01	3.70E-01	Not Detected
	April	8.02E-03	1.18E-02	2.37E-02	Not Detected
	May	1.07E-02	1.28E-02	2.09E-02	Not Detected
	June	4.12E-02	2.93E-02	3.75E-02	Detected
	July	4.00E-02	4.01E-02	6.24E-02	Not Detected
	August	4.66E-02	4.25E-02	6.67E-02	Not Detected
	September	-3.24E-03	5.07E-02	1.66E-01	Not Detected
	October	2.88E-02	1.45E-01	4.19E-01	Not Detected
	November	4.94E-02	6.33E-02	1.12E-01	Not Detected
	December	0.00E+00	8.67E-02	2.63E-01	Not Detected

Table A.20. Specific activities of ^{238}Pu (Bq/g) at Station B

Radionuclide	Sample Date	^{238}Pu Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{238}Pu	January	-1.96E-02	5.29E-02	1.78E-01	Not Detected
	February	-3.60E-02	5.01E-02	2.24E-01	Not Detected
	March	-7.78E-02	1.36E-01	5.89E-01	Not Detected
	April	1.72E-03	1.07E-02	3.03E-02	Not Detected
	May	-3.15E-03	6.90E-03	2.46E-02	Not Detected
	June	-4.29E-03	9.41E-03	3.35E-02	Not Detected
	July	1.92E-02	2.83E-02	5.32E-02	Not Detected
	August	2.04E-02	3.01E-02	6.04E-02	Not Detected
	September	-2.27E-02	3.68E-02	1.42E-01	Not Detected
	October	-6.71E-02	1.09E-01	4.19E-01	Not Detected
	November	-3.09E-02	3.67E-02	1.53E-01	Not Detected
	December	-7.31E-02	6.27E-02	3.00E-01	Not Detected

Table A.21. Activity concentrations of U isotopes at Station B

Radionuclide	Sample Date	Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{234}U	January	-3.51E-07	4.12E-07	1.88E-06	Not Detected
	February	-2.28E-07	6.67E-07	2.72E-06	Not Detected
	March	4.23E-07	5.82E-07	1.10E-06	Not Detected
	April	2.61E-08	4.93E-07	1.47E-06	Not Detected
	May	4.04E-07	5.20E-07	9.21E-07	Not Detected
	June	3.91E-07	5.69E-07	1.17E-06	Not Detected
	July	3.72E-07	6.41E-07	1.43E-06	Not Detected
	August	4.60E-08	4.32E-07	1.26E-06	Not Detected
	September	-2.76E-08	3.07E-07	1.15E-06	Not Detected
	October	-2.03E-07	3.78E-07	1.40E-06	Not Detected
	November	-5.13E-07	7.44E-07	2.94E-06	Not Detected
	December	4.21E-07	8.39E-07	1.96E-06	Not Detected
^{235}U	January	-2.09E-07	6.11E-07	2.49E-06	Not Detected
	February	2.11E-07	7.34E-07	2.09E-06	Not Detected
	March	-1.40E-07	3.76E-07	1.27E-06	Not Detected
	April	5.80E-07	6.57E-07	9.56E-07	Not Detected
	May	4.38E-07	5.48E-07	7.81E-07	Not Detected
	June	-1.21E-07	3.26E-07	1.10E-06	Not Detected
	July	1.23E-07	4.59E-07	1.27E-06	Not Detected
	August	-8.52E-08	3.26E-07	1.30E-06	Not Detected
	September	-2.04E-07	3.81E-07	1.41E-06	Not Detected
	October	0.00E+00	5.91E-07	1.54E-06	Not Detected
	November	-2.37E-07	8.39E-07	2.63E-06	Not Detected
	December	2.40E-07	5.88E-07	1.45E-06	Not Detected

Table A.21. Activity concentrations of U isotopes at Station B (continued)

Radionuclide	Sample Date	Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{238}U	January	-2.22E-07	5.21E-07	1.91E-06	Not Detected
	February	-3.39E-14	6.23E-07	2.21E-06	Not Detected
	March	1.68E-07	5.16E-07	1.34E-06	Not Detected
	April	-6.24E-07	3.75E-07	1.81E-06	Not Detected
	May	-7.57E-08	2.89E-07	1.15E-06	Not Detected
	June	2.44E-08	4.60E-07	1.37E-06	Not Detected
	July	7.42E-08	4.62E-07	1.31E-06	Not Detected
	August	-2.29E-07	2.73E-07	1.14E-06	Not Detected
	September	6.34E-07	6.96E-07	1.72E-07	Not Detected
	October	2.70E-07	6.12E-07	1.47E-06	Not Detected
	November	-6.39E-08	9.98E-07	3.28E-06	Not Detected
	December	-1.29E-07	7.18E-07	2.24E-06	Not Detected

Table A.22. Specific activities of U isotopes at Station B

Radionuclide	Sample Date	Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{234}U	January	-1.76E-01	2.06E-01	9.44E-01	Not Detected
	February	-8.02E-02	2.35E-01	9.57E-01	Not Detected
	March	4.73E-01	6.50E-01	1.23E+00	Not Detected
	April	1.63E-03	3.08E-02	9.17E-02	Not Detected
	May	2.86E-02	3.67E-02	6.50E-02	Not Detected
	June	3.13E-02	4.56E-02	9.36E-02	Not Detected
	July	6.49E-02	1.12E-01	2.50E-01	Not Detected
	August	5.98E-03	5.62E-02	1.64E-01	Not Detected
	September	-9.78E-03	1.09E-01	4.06E-01	Not Detected
	October	-1.99E-01	3.70E-01	1.37E+00	Not Detected
	November	-1.56E-01	2.26E-01	8.94E-01	Not Detected
	December	2.10E-01	4.19E-01	9.79E-01	Not Detected

Table A.22. Specific activities of U isotopes at Station B (continued)

Radionuclide	Sample Date	Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{235}U	January	-1.05E-01	3.06E-01	1.25E+00	Not Detected
	February	7.41E-02	2.58E-01	7.35E-01	Not Detected
	March	-1.56E-01	4.20E-01	1.42E+00	Not Detected
	April	3.62E-02	4.10E-02	5.97E-02	Not Detected
	May	3.09E-02	3.87E-02	5.51E-02	Not Detected
	June	-9.68E-03	2.61E-02	8.78E-02	Not Detected
	July	2.14E-02	8.01E-02	2.22E-01	Not Detected
	August	-1.11E-02	4.24E-02	1.69E-01	Not Detected
	September	-7.24E-02	1.35E-01	5.01E-01	Not Detected
	October	0.00E+00	5.77E-01	1.50E+00	Not Detected
	November	-7.23E-02	2.55E-01	8.02E-01	Not Detected
	December	1.20E-01	2.94E-01	7.25E-01	Not Detected
^{238}U	January	-1.11E-01	2.61E-01	9.60E-01	Not Detected
	February	-1.19E-08	2.19E-01	7.78E-01	Not Detected
	March	1.88E-01	5.77E-01	1.50E+00	Not Detected
	April	-3.90E-02	2.34E-02	1.13E-01	Not Detected
	May	-5.34E-03	2.04E-02	8.15E-02	Not Detected
	June	1.95E-03	3.68E-02	1.10E-01	Not Detected
	July	1.29E-02	8.06E-02	2.29E-01	Not Detected
	August	-2.98E-02	3.55E-02	1.48E-01	Not Detected
	September	2.25E-01	2.47E-01	6.08E-02	Not Detected
	October	2.64E-01	5.98E-01	1.44E+00	Not Detected
	November	-1.95E-02	3.04E-01	9.98E-01	Not Detected
	December	-6.44E-02	3.59E-01	1.12E+00	Not Detected

Table A.23. Activity concentrations of ^{137}Cs (Bq/m^3) at Station B

Radionuclide	Sample Date	Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{137}Cs	January	-2.20E-05	2.0E-05	6.88E-05	Not detected
	February	2.55E-05	1.66E-05	5.48E-05	Not detected
	March	1.08E-05	7.43E-06	2.45E-05	Not detected
	April	6.83E-05	2.64E-05	8.50E-05	Not detected
	May	2.65E-05	2.61E-05	8.70E-05	Not detected
	June	-6.43E-05	2.11E-05	7.44E-05	Not detected
	July	3.59E-05	2.20E-05	7.22E-05	Not detected
	August	-2.31E-06	1.98E-05	6.78E-05	Not detected
	September	-3.81E-05	2.48E-05	8.49E-05	Not detected
	October	1.06E-05	7.93E-06	2.63E-05	Not detected
	November	-3.67E-06	6.63E-06	2.30E-05	Not detected
	December	-2.88E-05	9.31E-06	3.30E-05	Not detected

Table A.24. Activity concentrations of ^{40}K (Bq/m^3) at Station B

Radionuclide	Sample Date	Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{40}K	January	-2.43E-04	3.33E-04	1.15E-03	Not detected
	February	-1.15E-04	1.74E-04	6.08E-04	Not detected
	March	-1.09E-04	1.29E-04	4.46E-04	Not detected
	April	-2.45E-04	3.48E-04	1.20E-03	Not detected
	May	-5.80E-04	2.51E-04	9.14E-04	Not detected
	June	-2.16E-04	1.89E-04	6.61E-04	Not detected
	July	-3.48E-04	3.21E-04	1.12E-03	Not detected
	August	-1.87E-04	2.54E-04	8.91E-04	Not detected
	September	-1.80E-04	1.90E-04	6.61E-04	Not detected
	October	-1.51E-04	1.26E-04	4.39E-04	Not detected
	November	2.37E-05	1.42E-04	4.81E-04	Not detected
	December	2.82E-05	1.05E-04	3.56E-04	Not detected

Table A.25. Activity concentrations of ^{60}Co (Bq/m^3) at Station B

Radionuclide	Sample Date	Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{60}Co	January	-1.34E-05	2.07E-05	7.32E-05	Not detected
	February	-5.06E-07	1.23E-05	4.30E-05	Not detected
	March	3.67E-06	7.86E-06	2.68E-05	Not detected
	April	7.88E-07	2.15E-05	7.45E-05	Not detected
	May	1.31E-05	1.77E-05	6.02E-05	Not detected
	June	1.23E-05	1.35E-05	4.53E-05	Not detected
	July	-1.16E-06	2.10E-05	7.28E-05	Not detected
	August	3.06E-05	2.12E-05	7.00E-05	Not detected
	September	-9.13E-06	1.28E-05	4.53E-05	Not detected
	October	6.76E-06	7.13E-06	2.40E-05	Not detected
	November	4.46E-06	8.47E-06	2.88E-05	Not detected
	December	1.65E-05	6.39E-06	2.03E-05	Not detected

Table A.26. Monthly specific activities of ^{137}Cs (Bq/g) in Station B (post-HEPA) filters in 2021

Radionuclide	Sample Date	Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{137}Cs	January	-1.10E+01	9.92E+00	3.45E+01	Not detected
	February	8.96E+00	5.85E+00	1.93E+01	Not detected
	March	1.21E+01	8.30E+00	2.74E+01	Not detected
	April	4.27E+00	1.65E+00	5.30E+00	Not detected
	May	1.87E+00	1.85E+00	6.14E+00	Not detected
	June	-5.16E+00	1.69E+00	5.96E+00	Not detected
	July	6.26E+00	3.83E+00	1.26E+01	Not detected
	August	-3.01E-01	2.57E+00	8.82E+00	Not detected
	September	-1.35E+01	8.78E+00	3.01E+01	Not detected
	October	1.04E+01	7.75E+00	2.57E+01	Not detected
	November	-1.12E+00	2.02E+00	7.01E+00	Not detected
	December	-1.44E+01	4.65E+00	1.65E+01	Not detected

Table A.27. Specific activities of ^{40}K (Bq/g) at Station B

Radionuclide	Sample Date	Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{40}K	January	-1.22E+02	1.67E+02	5.77E+02	Not detected
	February	-4.04E+01	6.11E+01	2.14E+02	Not detected
	March	-1.21E+02	1.44E+02	4.99E+02	Not detected
	April	-1.53E+01	2.17E+01	7.50E+01	Not detected
	May	-4.09E+01	1.77E+01	6.45E+01	Not detected
	June	-1.73E+01	1.51E+01	5.30E+01	Not detected
	July	-6.08E+01	5.60E+01	1.95E+02	Not detected
	August	-2.44E+01	3.30E+01	1.16E+02	Not detected
	September	-6.38E+01	6.71E+01	2.34E+02	Not detected
	October	-1.47E+02	1.23E+02	4.29E+02	Not detected
	November	7.23E+00	4.33E+01	1.46E+02	Not detected
	December	1.41E+01	5.24E+01	1.78E+02	Not detected

Table A.28. Specific activities of ^{60}Co (Bq/g) at Station B

Radionuclide	Sample Date	Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{60}Co	January	-6.71E+00	1.04E+01	3.67E+01	Not detected
	February	-1.78E-01	4.33E+00	1.51E+01	Not detected
	March	4.10E+00	8.79E+00	2.99E+01	Not detected
	April	4.92E-02	1.34E+00	4.65E+00	Not detected
	May	9.27E-01	1.25E+00	4.25E+00	Not detected
	June	9.84E-01	1.08E+00	3.63E+00	Not detected
	July	-2.03E-01	3.67E+00	1.27E+01	Not detected
	August	3.99E+00	2.75E+00	9.10E+00	Not detected
	September	-3.24E+00	4.54E+00	1.61E+01	Not detected
	October	6.60E+00	6.97E+00	2.35E+01	Not detected
	November	1.36E+00	2.58E+00	8.76E+00	Not detected
	December	8.22E+00	3.19E+00	1.01E+01	Not detected

Table A.29. Activity concentrations of ^{90}Sr (Bq/m^3) at Station A

Sample Date	^{90}Sr Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
January 2021				
1st week	8.14E-03	8.15E-04	1.19E-02	Not detected
2nd week	7.23E-03	7.42E-04	1.18E-02	Not detected
3rd week	9.16E-03	8.79E-04	1.15E-02	Not detected
4th week	6.74E-03	6.38E-04	7.75E-03	Not detected
February 2021				
1st week	1.17E-02	1.08E-03	1.19E-02	Not detected
2nd week	8.96E-03	8.75E-04	1.12E-02	Not detected
3rd week	1.17E-02	1.01E-03	1.16E-02	Detected
4th week	1.43E-02	1.16E-03	1.17E-02	Detected
March 2021				
1st week	1.66E-02	1.43E-03	1.44E-02	Detected
2nd week	1.05E-02	9.28E-04	1.17E-02	Not detected
3rd week	8.40E-03	8.26E-04	1.19E-02	Not detected
4th week	7.86E-03	6.70E-04	8.23E-03	Not detected
April 2021				
1st week	8.90E-03	8.40E-04	1.18E-02	Not detected
2nd week	9.56E-03	8.95E-04	1.20E-02	Not detected
3rd week	9.05E-03	8.44E-04	1.17E-02	Not detected
4th week	7.02E-03	6.71E-04	9.35E-03	Not detected
May 2021				
1st week	9.33E-03	8.74E-04	1.17E-02	Not detected
2nd week	1.17E-02	1.02E-03	1.22E-02	Not detected
3rd week	8.51E-03	8.01E-04	1.17E-02	Not detected
4th week	1.19E-02	1.06E-03	1.37E-02	Not detected
June 2021				
1st week	9.80E-03	9.92E-04	1.48E-02	Not detected
2nd week	8.40E-03	8.26E-04	1.23E-02	Not detected
3rd week	8.82E-03	8.32E-04	1.21E-02	Not detected
4th week	6.71E-03	6.56E-04	9.51E-03	Not detected

Table A.29. Activity concentrations of ^{90}Sr (Bq/m^3) at Station A (continued)

Sample Date	^{90}Sr Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
July 2021				
1st week	6.20E-03	6.64E-04	1.22E-02	Not detected
2nd week	8.28E-03	8.26E-04	1.25E-02	Not detected
3rd week	7.32E-03	7.47E-04	1.23E-02	Not detected
4th week	6.38E-03	6.01E-04	8.51E-03	Not detected
August 2021				
1st week	8.34E-03	8.07E-04	1.22E-02	Not detected
2nd week	7.60E-03	7.84E-04	1.28E-02	Not detected
3rd week	-	-	-	-
4th week	5.64E-03	5.52E-04	8.39E-03	Not detected
September 2021				
1st week	8.57E-03	8.15E-04	1.20E-02	Not detected
2nd week	7.81E-03	7.72E-04	1.20E-02	Not detected
3rd week	8.31E-03	8.18E-04	1.20E-02	Not detected
4th week	6.05E-03	5.99E-04	9.31E-03	Not detected
October 2021				
1st week	1.07E-02	9.40E-04	1.20E-02	Not detected
2nd week	6.46E-03	7.06E-04	1.20E-02	Not detected
3rd week	6.18E-03	6.78E-04	1.20E-02	Not detected
4th week	-	-	-	-
November 2021				
1st week	6.44E-03	6.91E-04	1.14E-02	Not detected
2nd week	6.98E-03	7.24E-04	1.14E-02	Not detected
3rd week	8.86E-03	8.36E-04	1.14E-02	Not detected
4th week	6.26E-03	6.17E-04	8.87E-03	Not detected
December 2021				
1st week	1.02E-02	9.01E-04	1.14E-02	Not detected
2nd week	8.59E-03	8.26E-04	1.14E-02	Not detected
3rd week	8.31E-03	7.98E-04	1.14E-02	Not detected
4th week	7.15E-03	6.40E-04	8.00E-03	Not detected

Table A.30. Specific activities of ^{90}Sr (Bq/g) at Station A

Sample Date	^{90}Sr Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
January 2021				
1st week	1.35E+02	1.35E+01	1.97E+02	Not detected
2nd week	1.24E+02	1.27E+01	2.03E+02	Not detected
3rd week	1.02E+02	9.78E+00	1.27E+02	Not detected
4th week	4.69E+01	4.44E+00	5.39E+01	Not detected
February 2021				
1st week	6.54E+01	6.00E+00	6.62E+01	Not detected
2nd week	6.98E+01	6.82E+00	8.73E+01	Not detected
3rd week	6.68E+01	5.80E+00	6.61E+01	Detected
4th week	1.15E+02	9.39E+00	9.42E+01	Detected
March 2021				
1st week	1.09E+02	9.44E+00	9.50E+01	Detected
2nd week	1.46E+02	1.29E+01	1.63E+02	Not detected
3rd week	2.74E+01	2.70E+00	3.89E+01	Not detected
4th week	2.67E+01	2.28E+00	2.80E+01	Not detected
April 2021				
1st week	2.69E+01	2.54E+00	3.58E+01	Not detected
2nd week	4.42E+01	4.14E+00	5.55E+01	Not detected
3rd week	4.22E+01	3.94E+00	5.46E+01	Not detected
4th week	3.44E+01	3.29E+00	4.58E+01	Not detected
May 2021				
1st week	5.30E+01	4.97E+00	6.66E+01	Not detected
2nd week	5.34E+01	4.68E+00	5.59E+01	Not detected
3rd week	4.35E+01	4.10E+00	5.98E+01	Not detected
4th week	8.47E+01	7.58E+00	9.79E+01	Not detected
June 2021				
1st week	6.65E+01	6.73E+00	1.01E+02	Not detected
2nd week	6.34E+01	6.23E+00	9.27E+01	Not detected
3rd week	5.06E+01	4.78E+00	6.96E+01	Not detected
4th week	4.55E+01	4.45E+00	6.45E+01	Not detected

Table A.30. Specific activities of ^{90}Sr (Bq/g) at Station A (continued)

Sample Date	^{90}Sr Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
July 2021				
1st week	4.86E+01	5.21E+00	9.58E+01	Not detected
2nd week	4.40E+01	4.39E+00	6.64E+01	Not detected
3rd week	3.02E+01	3.08E+00	5.06E+01	Not detected
4th week	3.10E+01	2.92E+00	4.13E+01	Not detected
August 2021				
1st week	8.12E+01	7.86E+00	1.19E+02	Not detected
2nd week	9.41E+01	9.70E+00	1.58E+02	Not detected
3rd week	-	-	-	-
4th week	5.09E+01	4.99E+00	7.58E+01	Not detected
September 2021				
1st week	2.09E+02	1.98E+01	2.91E+02	Not detected
2nd week	2.06E+02	2.03E+01	3.17E+02	Not detected
3rd week	2.17E+02	2.13E+01	3.12E+02	Not detected
4th week	2.30E+01	2.28E+00	3.55E+01	Not detected
October 2021				
1st week	1.19E+02	1.04E+01	1.33E+02	Not detected
2nd week	7.97E+01	8.71E+00	1.48E+02	Not detected
3rd week	3.36E+01	3.69E+00	6.53E+01	Not detected
4th week	-	-	-	-
November 2021				
1st week	9.89E+01	1.06E+01	1.75E+02	Not detected
2nd week	3.84E+01	3.98E+00	6.28E+01	Not detected
3rd week	6.81E+01	6.43E+00	8.78E+01	Not detected
4th week	1.04E+02	1.02E+01	1.47E+02	Not detected
December 2021				
1st week	1.40E+02	1.24E+01	1.57E+02	Not detected
2nd week	6.90E+01	6.63E+00	9.17E+01	Not detected
3rd week	1.23E+02	1.18E+01	1.69E+02	Not detected
4th week	1.25E+02	1.12E+01	1.40E+02	Not detected

Table A.31. Activity concentrations of ^{90}Sr (Bq/m^3) at Station B

Radionuclide	Sample Date	^{90}Sr Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{90}Sr	January	2.34E-03	2.08E-04	2.62E-03	Not detected
	February	1.88E-03	1.85E-04	2.86E-03	Not detected
	March	2.25E-03	2.08E-04	2.83E-03	Not detected
	April	1.95E-03	1.86E-04	2.85E-03	Not detected
	May	1.99E-03	1.89E-04	2.74E-03	Not detected
	June	2.13E-03	1.99E-04	2.84E-03	Not detected
	July	2.00E-03	1.87E-04	2.74E-03	Not detected
	August	2.10E-03	1.92E-04	2.80E-03	Not detected
	September	1.75E-03	1.77E-04	2.83E-03	Not detected
	October	2.06E-03	1.91E-04	2.75E-03	Not detected
	November	2.13E-03	2.00E-04	2.84E-03	Not detected
	December	3.15E-03	2.51E-04	3.16E-03	Not detected

Table A.32. Specific activities of ^{90}Sr (Bq/g) at Station B

Radionuclide	Sample Date	^{90}Sr Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{90}Sr	January	1.17E+03	1.04E+02	1.31E+03	Not detected
	February	6.61E+02	6.51E+01	1.00E+03	Not detected
	March	2.52E+03	2.32E+02	3.17E+03	Not detected
	April	1.22E+02	1.16E+01	1.78E+02	Not detected
	May	1.41E+02	1.33E+01	1.93E+02	Not detected
	June	1.71E+02	1.60E+01	2.27E+02	Not detected
	July	3.48E+02	3.27E+01	4.79E+02	Not detected
	August	2.73E+02	2.50E+01	3.64E+02	Not detected
	September	6.20E+02	6.28E+01	1.00E+03	Not detected
	October	2.02E+03	1.86E+02	2.69E+03	Not detected
	November	6.48E+02	6.08E+01	8.64E+02	Not detected
	December	1.57E+03	1.25E+02	1.58E+03	Not detected

APPENDIX B - AIRBORNE PARTICULATE MONITORING

Actinide concentrations and specific activities at six monitoring stations around WIPP

Uranium concentrations and specific activities at six monitoring stations around WIPP

Gamma radionuclide concentrations and specific activities at six monitoring stations around WIPP

Strontium concentrations and specific activities at six monitoring stations around WIPP

Table B.1. Activity concentrations of $^{239+240}Pu$ at Onsite Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
$^{239+240}Pu$	Jan. 14 – Feb. 2	1.67E-08	1.43E-08	2.95E-08	Not detected
	Feb. 2 – Mar. 2	5.43E-09	4.29E-09	7.89E-09	Not detected
	Mar. 2 – Mar. 23	1.86E-08	9.68E-09	1.31E-08	Detected
	Mar. 23 – Apr. 20	2.05E-08	1.49E-08	2.94E-08	Not detected
	Apr. 20 – May 18	1.76E-08	9.46E-09	1.39E-08	Detected
	May 18 – Jun. 30	1.97E-07	7.48E+00	1.05E-07	Detected
	Jun. 30 – Aug. 10	8.58E-09	5.08E-09	6.85E-09	Detected
	Aug. 10 – Sep. 2	1.03E-08	7.34E-09	1.26E-08	Not detected
	Sep. 2 – Oct. 8	3.81E-09	3.92E-09	7.98E-09	Not detected
	Oct. 8 – Oct. 26	7.18E-09	8.49E-09	1.79E-08	Not detected
	Oct. 26 - Nov. 2	1.56E-08	1.95E-08	4.12E-08	Not detected
	Nov. 2 – Dec. 3	4.34E-09	1.04E-08	2.52E-08	Not detected
	Dec. 3 - Dec. 23	1.43E-08	1.35E-08	2.69E-08	Not detected
	Dec. 23 - Feb. 2	3.27E-09	3.08E-09	5.76E-09	Not detected

Table B.2. Activity concentrations of ^{241}Am at Onsite Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{241}Am	Jan. 14 – Feb. 2	1.75E-08	1.12E-08	1.96E-08	Not detected
	Feb. 2 – Mar. 2	9.89E-09	5.34E-09	8.64E-09	Detected
	Mar. 2 – Mar. 23	1.58E-08	9.42E-09	1.52E-08	Detected
	Mar. 23 – Apr. 20	3.41E-08	1.24E-08	7.38E-09	Detected
	Apr. 20 – May 18	2.26E-08	9.19E-09	6.16E-09	Detected
	May 18 – Jun. 30	1.50E-07	6.32E-08	8.88E-08	Detected
	Jun. 30 – Aug. 10	4.63E-09	4.38E-09	8.97E-09	Not detected
	Aug. 10 – Sep. 2	8.28E-09	7.80E-09	1.62E-08	Not detected
	Sep. 2 – Oct. 8	1.56E-10	1.13E-09	2.94E-09	Not detected
	Oct. 8 – Oct. 26	4.47E-09	9.65E-09	2.28E-08	Not detected
	Oct. 26 - Nov. 2	-6.91E-09	1.55E-08	4.40E-08	Not detected
	Nov. 2 – Dec. 3	-5.23E-10	4.31E-09	1.17E-08	Not detected
	Dec. 3 - Dec. 23	4.68E-06	4.85E-07	2.26E-08	Not detected
	Dec. 23 - Feb. 2	5.10E-09	3.96E-09	7.39E-09	Not detected

Table B.3. Activity concentrations of ^{238}Pu at Onsite Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{238}Pu	Jan. 14 – Feb. 2	0.00E+00	2.96E-09	9.72E-09	Not detected
	Feb. 2 – Mar. 2	4.53E-10	3.00E-09	7.89E-09	Not detected
	Mar. 2 – Mar. 23	-4.64E-09	5.59E-09	1.87E-08	Not detected
	Mar. 23 – Apr. 20	-2.16E-09	7.47E-09	2.17E-08	Not detected
	Apr. 20 – May 18	1.76E-09	4.31E-09	1.06E-08	Not detected
	May 18 – Jun. 30	3.14E-08	3.49E-08	7.11E+00	Not detected
	Jun. 30 – Aug. 10	1.14E-09	3.24E-09	8.05E-09	Not detected
	Aug. 10 – Sep. 2	2.38E-09	6.55E-09	1.60E-08	Not detected
	Sep. 2 – Oct. 8	-1.70E-09	2.95E-09	9.04E-09	Not detected
	Oct. 8 – Oct. 26	0.00E+00	6.49E-09	1.79E-08	Not detected
	Oct. 26 - Nov. 2	-2.08E-08	1.57E-08	5.54E-08	Not detected
	Nov. 2 – Dec. 3	-2.89E-09	8.19E-09	2.52E-08	Not detected
	Dec. 3 - Dec. 23	-4.28E-09	1.03E-08	3.04E-08	Not detected
	Dec. 23 - Feb. 2	-4.09E-10	2.16E-09	6.48E-09	Not detected

Table B.4. Activity concentrations of $^{239+240}Pu$ at Near Field Station

Radionuclides	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
$^{239+240}Pu$	Jan. 14 – Feb. 2	8.21E-09	9.13E-09	1.86E-08	Not detected
	Feb. 2 – Mar. 2	1.39E-08	9.39E-09	1.61E-08	Not detected
	Mar. 2 – Mar. 23	2.50E-08	1.31E-08	2.04E-08	Detected
	Mar. 23 – Apr. 20	2.50E-08	1.28E-08	1.80E-08	Detected
	Apr. 20 – May 18	1.95E-08	1.42E-08	2.81E-08	Not detected
	May 18 – Jun. 30	1.11E-08	6.80E-09	1.19E-08	Not detected
	Jun. 30 – Aug. 10	3.21E-09	3.32E-09	6.43E-09	Not detected
	Aug. 10 – Sep. 2	-9.75E-10	8.05E-09	2.19E-08	Not detected
	Sep. 2 – Oct. 8	5.94E-09	5.13E-09	7.86E-09	Not detected
	Oct. 8 – Oct. 26	1.05E-08	8.82E-09	1.66E-08	Not detected
	Oct. 26 - Nov. 2	1.98E-08	2.20E-08	4.48E-08	Not detected
	Nov. 2 – Dec. 3	4.65E-09	1.10E-08	2.62E-08	Not detected
	Dec. 3 - Dec. 23	-4.09E-09	1.29E-08	3.84E-08	Not detected
	Dec. 23 - Feb. 2	6.88E-10	4.42E-10	6.36E-10	Detected

Table B.5. Activity concentrations of ^{241}Am at Near Field Station

Radionuclides	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{241}Am	Jan. 14 – Feb. 2	1.22E-08	1.24E-08	2.60E-08	Not detected
	Feb. 2 – Mar. 2	9.12E-09	1.00E-08	2.14E-08	Not detected
	Mar. 2 – Mar. 23	1.72E-08	1.09E-08	1.93E-08	Not detected
	Mar. 23 – Apr. 20	2.02E-08	1.09E-08	1.60E-08	Detected
	Apr. 20 – May 18	1.52E-08	8.77E-09	1.34E-08	Detected
	May 18 – Jun. 30	6.33E-09	4.80E-09	9.30E-09	Not detected
	Jun. 30 – Aug. 10	2.43E-09	3.78E-09	8.62E-09	Not detected
	Aug. 10 – Sep. 2	1.27E-15	5.67E-09	1.50E-08	Not detected
	Sep. 2 – Oct. 8	-8.83E-09	1.00E-08	2.90E-08	Not detected
	Oct. 8 – Oct. 26	1.07E-08	9.75E-09	1.95E-08	Not detected
	Oct. 26 - Nov. 2	-1.47E-08	1.47E-08	4.67E-08	Not detected
	Nov. 2 – Dec. 3	0.00E+00	3.51E-09	9.42E-09	Not detected
	Dec. 3 - Dec. 23	6.02E-09	8.53E-09	1.89E-08	Not detected
	Dec. 23 - Feb. 2	1.09E-09	4.10E-09	1.03E-08	Not detected

Table B.6. Activity concentrations of ^{238}Pu at Near Field Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m3	MDC Bq/m^3	Status
^{238}Pu	Jan. 14 – Feb. 2	-3.52E-09	8.46E-09	2.50E-08	Not detected
	Feb. 2 – Mar. 2	-4.63E-09	6.16E-09	1.97E-08	Not detected
	Mar. 2 – Mar. 23	-5.43E-09	7.23E-09	2.31E-08	Not detected
	Mar. 23 – Apr. 20	-2.27E-09	9.65E-09	2.67E-08	Not detected
	Apr. 20 – May 18	-1.03E-09	7.41E-09	2.07E-08	Not detected
	May 18 – Jun. 30	-3.34E-09	4.47E-09	1.37E-08	Not detected
	Jun. 30 – Aug. 10	-4.56E-09	3.46E-09	1.17E-08	Not detected
	Aug. 10 – Sep. 2	-8.76E-09	8.05E-09	2.58E-08	Not detected
	Sep. 2 – Oct. 8	0.00E+00	2.40E-09	6.24E-09	Not detected
	Oct. 8 – Oct. 26	-1.91E-09	7.16E-09	2.04E-08	Not detected
	Oct. 26 - Nov. 2	-8.48E-09	2.19E-08	6.34E-08	Not detected
	Nov. 2 – Dec. 3	-1.40E-08	9.78E-09	3.06E-08	Not detected
	Dec. 3 - Dec. 23	-1.63E-08	1.93E-08	5.76E-08	Not detected
	Dec. 23 - Feb. 2	-1.06E-10	3.35E-10	9.89E-10	Not detected

Table B.7. Activity concentrations of $^{239+240}Pu$ at Cactus Flats Station

Radionuclides	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
$^{239+240}Pu$	Jan. 14 – Feb. 2	2.66E-08	1.25E-08	1.56E-08	Detected
	Feb. 2 – Mar. 2	1.67E-08	8.50E-09	8.62E-09	Detected
	Mar. 2 – Mar. 23	6.29E-08	2.20E-08	2.79E-08	Detected
	Mar. 23 – Apr. 20	4.44E-08	1.60E-08	1.94E-08	Detected
	Apr. 20 – May 18	2.21E-08	1.10E-08	1.53E-08	Detected
	May 18 – Jun. 30	1.75E-08	6.35E-09	6.92E-09	Detected
	Jun. 30 – Aug. 10	2.80E-09	4.63E-09	1.06E-08	Not detected
	Aug. 10 – Sep. 2	5.09E-09	7.34E-09	1.61E-08	Not detected
	Sep. 2 – Oct. 8	5.83E-09	1.76E-09	3.95E-09	Detected
	Oct. 8 – Oct. 26	1.49E-08	1.15E-08	2.16E-08	Not detected
	Oct. 26 - Nov. 2	2.09E-08	2.61E-08	5.52E-08	Not detected
	Nov. 2 – Dec. 3	4.28E-09	4.53E-09	8.57E-09	Not detected
	Dec. 3 - Dec. 23	1.32E-08	1.53E-08	3.11E-08	Not detected
	Dec. 23 - Feb. 2	4.72E-16	5.42E-09	1.40E-08	Not detected

Table B.8. Activity concentrations of ^{241}Am at Cactus Flats Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{241}Am	Jan. 14 – Feb. 2	1.58E-08	1.60E-08	3.45E-08	Not detected
	Feb. 2 – Mar. 2	8.40E-09	9.54E-09	2.06E-08	Not detected
	Mar. 2 – Mar. 23	4.02E-08	1.51E-08	9.25E-09	Detected
	Mar. 23 – Apr. 20	1.94E-08	1.29E-08	2.30E-08	Not detected
	Apr. 20 – May 18	1.53E-08	1.02E-08	1.84E-08	Not detected
	May 18 – Jun. 30	5.84E-09	5.91E-09	1.28E-08	Not detected
	Jun. 30 – Aug. 10	4.20E-09	2.70E-09	2.82E-09	Detected
	Aug. 10 – Sep. 2	4.85E-09	5.74E-09	1.21E-08	Not detected
	Sep. 2 – Oct. 8	1.23E-09	1.76E-09	3.95E-09	Not detected
	Oct. 8 – Oct. 26	1.05E-08	9.94E-09	2.05E-08	Not detected
	Oct. 26 - Nov. 2	2.79E-08	2.09E-08	3.97E-08	Not detected
	Nov. 2 – Dec. 3	1.22E-09	3.89E-09	9.54E-09	Not detected
	Dec. 3 - Dec. 23	-8.97E-09	8.46E-09	2.60E-08	Not detected
	Dec. 23 - Feb. 2	2.62E-09	5.24E-09	1.23E-08	Not detected

Table B.9. Activity concentrations of ^{238}Pu in the filter samples collected from Cactus Flats Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{238}Pu	Jan. 14 – Feb. 2	-3.33E-09	7.37E-09	2.23E-08	Not detected
	Feb. 2 – Mar. 2	5.57E-09	4.95E-09	6.83E-09	Not detected
	Mar. 2 – Mar. 23	-2.62E-09	8.29E-09	2.47E-08	Not detected
	Mar. 23 – Apr. 20	0.00E+00	6.52E-09	1.80E-08	Not detected
	Apr. 20 – May 18	-4.81E-09	7.47E-09	2.26E-08	Not detected
	May 18 – Jun. 30	-8.74E-10	3.71E-09	1.03E-08	Not detected
	Jun. 30 – Aug. 10	-5.58E-09	4.24E-09	1.43E-08	Not detected
	Aug. 10 – Sep. 2	-8.12E-09	7.06E-09	2.39E-08	Not detected
	Sep. 2 – Oct. 8	5.83E-09	3.57E-09	4.98E-09	Detected
	Oct. 8 – Oct. 26	-1.24E-09	5.56E-09	1.75E-08	Not detected
	Oct. 26 - Nov. 2	6.96E-09	1.97E-08	4.90E-08	Not detected
	Nov. 2 – Dec. 3	-7.13E-10	3.19E-09	1.01E-08	Not detected
	Dec. 3 - Dec. 23	-1.10E-08	1.17E-08	4.15E-08	Not detected
	Dec. 23 - Feb. 2	9.90E-10	3.13E-09	7.85E-09	Not detected

Table B.10. Activity concentrations of ^{241}Am, $^{239+240}Pu$, and ^{238}Pu in the filter samples collected from Loving Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{241}Am	Jan. 14 – Feb. 2	1.69E-08	1.01E-08	1.64E-08	Detected
	Feb. 2 – Mar. 2	5.61E-09	3.55E-09	4.35E-09	Detected
	Mar. 2 – Mar. 23	1.67E-08	9.00E-09	1.32E-08	Detected
	Mar. 23 – Apr. 20	1.25E-08	1.05E-08	2.10E-08	Not detected
	Apr. 20 – May 18	8.88E-09	9.77E-09	2.09E-08	Not detected
	May 18 – Jun. 30	6.44E-09	4.16E-09	7.01E-09	Not detected
	Jun. 30 – Aug. 10	4.73E-09	4.06E-09	7.52E-09	Not detected
	Aug. 10 – Sep. 2	1.67E-09	3.69E-09	8.81E-09	Not detected
	Sep. 2 – Oct. 8	-8.00E-10	3.76E-09	1.02E-08	Not detected
	Oct. 8 – Oct. 26	3.34E-09	8.52E-09	2.05E-08	Not detected
	Oct.26 – Nov. 2	1.33E-08	1.27E-08	2.28E-08	Not detected
	Nov. 2 – Dec. 3	1.43E-09	6.07E-09	1.52E-08	Not detected
	Dec. 3 - Dec. 23	4.13E-09	1.05E-08	2.53E-08	Not detected
	Dec. 23 - Feb. 2	-4.19E-09	5.99E-09	1.73E-08	Not detected
$^{239+240}Pu$	Jan. 14 – Feb. 2	2.07E-08	1.12E-08	1.77E-08	Detected
	Feb. 2 – Mar. 2	5.70E-09	3.85E-09	5.70E-09	Not detected
	Mar. 2 – Mar. 23	2.70E-08	1.11E-08	1.12E-08	Detected
	Mar. 23 – Apr. 20	1.82E-08	1.31E-08	2.43E-08	Not detected
	Apr. 20 – May 18	1.96E-08	1.06E-08	1.68E-08	Detected
	May 18 – Jun. 30	1.17E-08	6.74E-09	1.20E-08	Not detected
	Jun. 30 – Aug. 10	7.13E-09	5.08E-09	8.37E-09	Not detected
	Aug. 10 – Sep. 2	-3.37E-09	8.26E-09	2.30E-08	Not detected
	Sep. 2 – Oct. 8	3.23E-09	3.78E-09	8.12E-09	Not detected
	Oct. 8 – Oct. 26	6.15E-09	8.89E-09	1.95E-08	Not detected
	Oct.26 – Nov. 2	4.85E-08	3.00E-08	4.56E-08	Detected
	Nov. 2 – Dec. 3	7.45E-09	8.82E-09	1.85E-08	Not detected
	Dec. 3 - Dec. 23	6.04E-16	1.01E-08	2.70E-08	Not detected
	Dec. 23 - Feb. 2	1.21E-09	3.83E-09	9.61E-09	Not detected

Table B.10. Activity concentrations of ^{241}Am, $^{239+240}Pu$, and ^{238}Pu in the filter samples collected from Loving Station (continued)

Radionuclides	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{238}Pu	Jan. 14 – Feb. 2	-5.65E-09	5.99E-09	2.01E-08	Not detected
	Feb. 2 – Mar. 2	0.00E+00	2.69E-09	7.53E-09	Not detected
	Mar. 2 – Mar. 23	5.59E-09	5.92E-09	1.12E-08	Not detected
	Mar. 23 – Apr. 20	-2.27E-09	7.22E-09	2.15E-08	Not detected
	Apr. 20 – May 18	-8.92E-10	5.35E-09	1.55E-08	Not detected
	May 18 – Jun. 30	-2.45E+01	2.95E-09	9.84E-09	Not detected
	Jun. 30 – Aug. 10	5.93E-10	3.92E-09	1.03E-08	Not detected
	Aug. 10 – Sep. 2	-3.37E-09	4.78E-09	1.58E-08	Not detected
	Sep. 2 – Oct. 8	-4.03E-10	2.91E-09	8.12E-09	Not detected
	Oct. 8 – Oct. 26	-4.92E-09	8.54E-09	2.62E-08	Not detected
	Oct.26 – Nov. 2	-1.94E-08	1.72E-08	6.08E-08	Not detected
	Nov. 2 – Dec. 3	-2.13E-09	6.03E-09	1.85E-08	Not detected
	Dec. 3 - Dec. 23	1.27E-09	1.10E-08	2.84E-08	Not detected
	Dec. 23 - Feb. 2	-3.03E-09	3.65E-09	1.22E-08	Not detected

Table B.11. Activity concentrations of ^{241}Am, $^{239+240}Pu$, and ^{238}Pu in the filter samples collected from Carlsbad Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{241}Am	Jan. 14 – Feb. 2	1.49E-08	9.87E-09	1.76E-08	Not detected
	Feb. 2 – Mar. 2	3.47E-09	4.44E-09	9.74E-09	Not detected
	Mar. 2 – Mar. 23	1.64E-08	9.72E-09	1.65E-08	Not detected
	Mar. 23 – Apr. 20	6.85E-09	1.37E-08	3.21E-08	Not detected
	Apr. 20 – May 18	0.00E+00	1.09E-08	2.77E-08	Not detected
	May 18 – Jun. 30	1.13E-08	5.25E-09	7.84E-09	Detected
	Jun. 30 – Aug. 10	8.30E-10	3.32E-09	8.33E-09	Not detected
	Aug. 10 – Sep. 2	-4.00E-09	4.23E-09	1.42E-08	Not detected
	Sep. 2 – Oct. 8	2.32E-09	3.10E-09	6.73E-09	Not detected
	Oct. 8 – Oct. 26	8.31E-09	1.03E-08	2.26E-08	Not detected
	Oct.26 – Nov. 2	3.02E-09	2.18E-08	5.68E-08	Not detected
	Nov. 2 – Dec. 3	2.81E-09	4.07E-09	8.92E-09	Not detected
	Dec. 3 - Dec. 23	1.09E-08	1.03E-08	1.92E-08	Not detected
	Dec. 23 - Feb. 2	1.80E-09	1.49E-08	3.84E-08	Not detected
$^{239+240}Pu$	Jan. 14 – Feb. 2	1.10E-08	9.22E-09	1.74E-08	Not detected
	Feb. 2 – Mar. 2	3.88E-09	4.57E-09	9.75E-09	Not detected
	Mar. 2 – Mar. 23	2.29E-08	1.02E-08	1.24E-08	Detected
	Mar. 23 – Apr. 20	3.45E-08	1.49E-08	1.74E-08	Detected
	Apr. 20 – May 18	2.07E-08	9.95E-09	1.27E-08	Detected
	May 18 – Jun. 30	2.55E-08	7.49E-09	6.09E-09	Detected
	Jun. 30 – Aug. 10	5.12E-09	4.98E-09	9.92E-09	Not detected
	Aug. 10 – Sep. 2	2.51E-09	6.91E-09	1.68E-08	Not detected
	Sep. 2 – Oct. 8	4.87E-09	4.52E-09	8.62E-09	Not detected
	Oct. 8 – Oct. 26	2.49E-08	1.47E-08	1.99E-08	Detected
	Oct.26 – Nov. 2	2.55E-08	3.19E-08	6.86E-08	Not detected
	Nov. 2 – Dec. 3	1.61E-08	9.60E-09	1.56E-08	Detected
	Dec. 3 - Dec. 23	1.34E-08	1.91E-08	4.21E-08	Not detected
	Dec. 23 - Feb. 2	2.43E-07	3.47E-07	7.78E-07	Not detected

Table B.11. Activity concentrations of ^{241}Am, $^{239+240}Pu$, and ^{238}Pu in the filter samples collected from Carlsbad Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{238}Pu	Jan. 14 – Feb. 2	-2.00E-09	5.65E-09	1.74E-08	Not detected
	Feb. 2 – Mar. 2	-1.46E-09	3.22E-09	9.75E-09	Not detected
	Mar. 2 – Mar. 23	-1.76E-09	4.98E-09	1.53E-08	Not detected
	Mar. 23 – Apr. 20	2.46E-09	9.85E-09	2.48E-08	Not detected
	Apr. 20 – May 18	-1.80E-09	6.24E-09	1.81E-08	Not detected
	May 18 – Jun. 30	0.00E+00	3.46E-09	9.21E-09	Not detected
	Jun. 30 – Aug. 10	2.28E-09	2.80E-09	5.30E-09	Not detected
	Aug. 10 – Sep. 2	8.33E-10	4.44E-09	1.18E-08	Not detected
	Sep. 2 – Oct. 8	-4.34E-09	3.78E-09	1.28E-08	Not detected
	Oct. 8 – Oct. 26	0.00E+00	1.15E-08	3.12E-08	Not detected
	Oct.26 – Nov. 2	-1.46E-08	2.53E-08	7.76E-08	Not detected
	Nov. 2 – Dec. 3	-3.57E-09	6.20E-09	1.90E-08	Not detected
	Dec. 3 - Dec. 23	-4.48E-09	1.68E-08	4.77E-08	Not detected
	Dec. 23 - Feb. 2	-1.87E-09	7.47E-09	2.09E-08	Not detected

Table B.12. Activity concentrations of ^{241}Am, $^{239+240}$Pu, and ^{238}Pu in the filter samples collected from East Tower Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{241}Am	Jan. 14 – Feb. 2	1.70E-08	9.78E-09	1.41E-08	Detected
	Feb. 2 – Mar. 2	7.72E-09	8.62E-09	1.83E-08	Not detected
	Mar. 2 – Mar. 23	1.95E-08	1.10E-08	1.91E-08	Detected
	Mar. 23 – Apr. 20	2.55E-08	1.21E-08	1.71E-08	Detected
	Apr. 20 – May 18	1.94E-08	9.65E-09	1.41E-08	Detected
	May 18 – Jun. 30	5.17E-09	5.00E-09	1.05E-08	Not detected
	Jun. 30 – Aug. 10	-8.12E-10	3.45E-09	9.53E-09	Not detected
	Aug. 10 – Sep. 2	2.79E-09	4.84E-09	1.11E-08	Not detected
	Sep. 2 – Oct. 8	2.22E-09	2.97E-09	6.44E-09	Not detected
	Oct. 8 – Oct. 26	7.99E-09	7.81E-09	1.63E-08	Not detected
	Oct.26 – Nov. 2	0.00E+00	1.16E-08	3.25E-08	Not detected
	Nov. 2 – Dec. 3	1.31E-09	4.01E-09	9.82E-09	Not detected
	Dec. 3 - Dec. 23	1.50E-09	5.61E-09	1.41E-08	Not detected
	Dec. 23 - Feb. 2	-2.48E-09	6.33E-09	1.75E-08	Not detected
$^{239+240}$Pu	Jan. 14 – Feb. 2	2.08E-08	1.13E-08	1.73E-08	Detected
	Feb. 2 – Mar. 2	1.65E-08	9.88E-09	1.54E-08	Detected
	Mar. 2 – Mar. 23	3.69E-08	1.28E-08	1.24E-08	Detected
	Mar. 23 – Apr. 20	8.71E-08	2.35E-08	2.16E-08	Detected
	Apr. 20 – May 18	1.38E-08	9.69E-09	1.73E-08	Not detected
	May 18 – Jun. 30	1.80E-08	6.61E-09	8.09E-09	Detected
	Jun. 30 – Aug. 10	6.14E-09	5.16E-09	9.75E-09	Not detected
	Aug. 10 – Sep. 2	4.12E-09	5.97E-09	1.31E-08	Not detected
	Sep. 2 – Oct. 8	1.27E-09	4.87E-09	1.20E-08	Not detected
	Oct. 8 – Oct. 26	2.33E-08	1.34E-08	1.93E-08	Detected
	Oct.26 – Nov. 2	2.05E-08	2.28E-08	4.64E-08	Not detected
	Nov. 2 – Dec. 3	9.86E-09	7.03E-09	1.20E-08	Not detected
	Dec. 3 - Dec. 23	3.74E-09	9.00E-09	2.17E-08	Not detected
	Dec. 23 - Feb. 2	7.15E-09	7.34E-09	1.52E-08	Not detected

Table B.12. Activity concentrations of ^{241}Am, $^{239+240}Pu$, and ^{238}Pu in the filter samples collected from East Tower Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{238}Pu	Jan. 14 – Feb. 2	-4.96E-09	6.61E-09	2.12E-08	Not detected
	Feb. 2 – Mar. 2	-6.80E-09	7.05E-09	2.28E-08	Not detected
	Mar. 2 – Mar. 23	-1.76E-09	4.97E-09	1.53E-08	Not detected
	Mar. 23 – Apr. 20	-4.58E-09	7.95E-09	2.44E-08	Not detected
	Apr. 20 – May 18	-5.53E-09	5.86E-09	1.96E-08	Not detected
	May 18 – Jun. 30	-2.15E-09	2.86E-09	9.16E-09	Not detected
	Jun. 30 – Aug. 10	-1.12E-09	2.25E-09	7.91E-09	Not detected
	Aug. 10 – Sep. 2	-1.65E-09	6.18E-09	1.76E-08	Not detected
	Sep. 2 – Oct. 8	-5.93E-09	4.52E-09	1.39E-08	Not detected
	Oct. 8 – Oct. 26	2.74E-09	1.03E-08	2.58E-08	Not detected
	Oct.26 – Nov. 2	1.17E-08	2.34E-08	5.50E-08	Not detected
	Nov. 2 – Dec. 3	-3.79E-09	5.89E-09	1.78E-08	Not detected
	Dec. 3 - Dec. 23	-1.25E-09	1.14E-08	3.06E-08	Not detected
	Dec. 23 - Feb. 2	-2.15E-09	5.55E-09	1.61E-08	Not detected

Table B.13. Specific activities of ^{241}Am in the filter samples collected from Onsite Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{241}Am	Jan. 14 – Feb. 2	3.48E-04	2.22E-04	3.89E-04	Not detected
	Feb. 2 – Mar. 2	3.22E-04	1.74E-04	2.82E-04	Detected
	Mar. 2 – Mar. 23	1.88E-04	1.12E-04	1.82E-04	Detected
	Mar. 23 – Apr. 20	3.41E-04	1.24E-04	7.38E-05	Detected
	Apr. 20 – May 18	3.72E-04	1.51E-04	1.01E-04	Detected
	May 18 – Jun. 30	1.67E-04	7.05E-05	9.90E-05	Detected
	Jun. 30 – Aug. 10	8.87E-05	8.40E-05	1.72E-04	Not detected
	Aug. 10 – Sep. 2	1.73E-04	1.63E-04	3.40E-04	Not detected
	Sep. 2 – Oct. 8	3.18E-06	2.30E-05	5.99E-05	Not detected
	Oct. 8 – Oct. 26	9.96E-05	2.15E-04	5.08E-04	Not detected
	Oct.26 – Nov. 2	-1.30E-04	2.90E-04	8.25E-04	Not detected
	Nov. 2 – Dec. 3	-9.75E-06	8.04E-05	2.19E-04	Not detected
	Dec. 3 - Dec. 23	6.66E-02	6.91E-03	3.22E-04	Not detected
	Dec. 23 - Feb. 2	1.27E-04	9.86E-05	1.84E-04	Not detected

Table B.14. Specific activities of $^{239+240}Pu$ in the filter samples collected from Onsite Station

Radionuclides	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
$^{239+240}Pu$	Jan. 14 – Feb. 2	3.32E-04	2.84E-04	5.84E-04	Not detected
	Feb. 2 – Mar. 2	1.77E-04	1.40E-04	2.57E-04	Not detected
	Mar. 2 – Mar. 23	2.22E-04	1.16E-04	1.56E-04	Detected
	Mar. 23 – Apr. 20	2.05E-04	1.49E-04	2.94E-04	Not detected
	Apr. 20 – May 18	2.90E-04	1.56E-04	2.29E-04	Detected
	May 18 – Jun. 30	2.20E-04	8.34E+03	1.18E-04	Detected
	Jun. 30 – Aug. 10	1.65E-04	9.75E-05	1.31E-04	Detected
	Aug. 10 – Sep. 2	2.16E-04	1.54E-04	2.63E-04	Not detected
	Sep. 2 – Oct. 8	7.76E-05	7.98E-05	1.62E-04	Not detected
	Oct. 8 – Oct. 26	1.60E-04	1.89E-04	3.98E-04	Not detected
	Oct.26 – Nov. 2	2.92E-04	3.66E-04	7.73E-04	Not detected
	Nov. 2 – Dec. 3	8.09E-05	1.95E-04	4.69E-04	Not detected
	Dec. 3 - Dec. 23	2.03E-04	1.92E-04	3.83E-04	Not detected
	Dec. 23 - Feb. 2	8.14E-05	7.66E-05	1.43E-04	Not detected

Table B.15. Specific activities of ^{238}Pu in the filter samples collected from Onsite Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{238}Pu	Jan. 14 – Feb. 2	0.00E+00	5.86E-05	1.93E-04	Not detected
	Feb. 2 – Mar. 2	1.48E-05	9.79E-05	2.57E-04	Not detected
	Mar. 2 – Mar. 23	-5.54E-05	6.68E-05	2.23E-04	Not detected
	Mar. 23 – Apr. 20	-2.16E-05	7.47E-05	2.17E-04	Not detected
	Apr. 20 – May 18	2.90E-05	7.10E-05	1.74E-04	Not detected
	May 18 – Jun. 30	3.50E-05	3.89E-05	7.93E+03	Not detected
	Jun. 30 – Aug. 10	2.19E-05	6.22E-05	1.54E-04	Not detected
	Aug. 10 – Sep. 2	4.98E-05	1.37E-04	3.34E-04	Not detected
	Sep. 2 – Oct. 8	-3.47E-05	6.01E-05	1.84E-04	Not detected
	Oct. 8 – Oct. 26	0.00E+00	1.44E-04	3.98E-04	Not detected
	Oct.26 – Nov. 2	-3.90E-04	2.95E-04	1.04E-03	Not detected
	Nov. 2 – Dec. 3	-5.39E-05	1.53E-04	4.69E-04	Not detected
	Dec. 3 - Dec. 23	-6.10E-05	1.47E-04	4.33E-04	Not detected
	Dec. 23 - Feb. 2	-1.02E-05	5.38E-05	1.61E-04	Not detected

Table B.16. Specific activities of ^{241}Am in the filter samples collected from Near Field Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{241}Am	Jan. 14 – Feb. 2	2.78E-04	2.83E-04	5.94E-04	Not detected
	Feb. 2 – Mar. 2	1.98E-04	2.18E-04	4.65E-04	Not detected
	Mar. 2 – Mar. 23	2.08E-04	1.31E-04	2.33E-04	Not detected
	Mar. 23 – Apr. 20	3.35E-04	1.81E-04	2.66E-04	Detected
	Apr. 20 – May 18	2.10E-04	1.21E-04	1.85E-04	Detected
	May 18 – Jun. 30	1.10E-04	8.33E-05	1.62E-04	Not detected
	Jun. 30 – Aug. 10	6.14E-05	9.56E-05	2.18E-04	Not detected
	Aug. 10 – Sep. 2	2.99E-11	1.33E-04	3.52E-04	Not detected
	Sep. 2 – Oct. 8	-1.85E-04	2.10E-04	6.06E-04	Not detected
	Oct. 8 – Oct. 26	2.49E-04	2.28E-04	4.55E-04	Not detected
	Oct.26 – Nov. 2	-2.61E-04	2.62E-04	8.32E-04	Not detected
	Nov. 2 – Dec. 3	0.00E+00	7.47E-05	2.01E-04	Not detected
	Dec. 3 - Dec. 23	1.11E-04	1.57E-04	3.48E-04	Not detected
	Dec. 23 - Feb. 2	3.13E-05	1.17E-04	2.94E-04	Not detected

Table B.17. Specific activities of $^{239+240}Pu$ at Near Field Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
$^{239+240}Pu$	Jan. 14 – Feb. 2	1.87E-04	2.08E-04	4.25E-04	Not detected
	Feb. 2 – Mar. 2	3.01E-04	2.04E-04	3.50E-04	Not detected
	Mar. 2 – Mar. 23	3.02E-04	1.59E-04	2.47E-04	Detected
	Mar. 23 – Apr. 20	4.16E-04	2.12E-04	3.00E-04	Detected
	Apr. 20 – May 18	2.70E-04	1.97E-04	3.88E-04	Not detected
	May 18 – Jun. 30	1.94E-04	1.18E-04	2.06E-04	Not detected
	Jun. 30 – Aug. 10	8.11E-05	8.40E-05	1.63E-04	Not detected
	Aug. 10 – Sep. 2	-2.29E-05	1.89E-04	5.15E-04	Not detected
	Sep. 2 – Oct. 8	1.24E-04	1.07E-04	1.64E-04	Not detected
	Oct. 8 – Oct. 26	2.45E-04	2.06E-04	3.89E-04	Not detected
	Oct.26 – Nov. 2	3.52E-04	3.91E-04	7.98E-04	Not detected
	Nov. 2 – Dec. 3	9.91E-05	2.35E-04	5.59E-04	Not detected
	Dec. 3 - Dec. 23	-7.53E-05	2.38E-04	7.09E-04	Not detected
	Dec. 23 - Feb. 2	1.97E-05	1.26E-05	1.82E-05	Detected

Table B.18. Specific activities of ^{238}Pu at Near Field Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{238}Pu	Jan. 14 – Feb. 2	-8.03E-05	1.93E-04	5.71E-04	Not detected
	Feb. 2 – Mar. 2	-1.00E-04	1.34E-04	4.28E-04	Not detected
	Mar. 2 – Mar. 23	-6.57E-05	8.74E-05	2.80E-04	Not detected
	Mar. 23 – Apr. 20	-3.78E-05	1.61E-04	4.45E-04	Not detected
	Apr. 20 – May 18	-1.42E-05	1.02E-04	2.85E-04	Not detected
	May 18 – Jun. 30	-5.81E-05	7.77E-05	2.37E-04	Not detected
	Jun. 30 – Aug. 10	-1.15E-04	8.76E-05	2.95E-04	Not detected
	Aug. 10 – Sep. 2	-2.06E-04	1.89E-04	6.06E-04	Not detected
	Sep. 2 – Oct. 8	0.00E+00	5.01E-05	1.31E-04	Not detected
	Oct. 8 – Oct. 26	-4.46E-05	1.67E-04	4.75E-04	Not detected
	Oct.26 – Nov. 2	-1.51E-04	3.90E-04	1.13E-03	Not detected
	Nov. 2 – Dec. 3	-2.97E-04	2.08E-04	6.51E-04	Not detected
	Dec. 3 - Dec. 23	-3.01E-04	3.55E-04	1.06E-03	Not detected
	Dec. 23 - Feb. 2	-3.02E-06	9.57E-06	2.83E-05	Not detected

Table B.19. Specific activities of ^{241}Am at Cactus Flats Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{241}Am	Jan. 14 – Feb. 2	3.14E-04	3.18E-04	6.88E-04	Not detected
	Feb. 2 – Mar. 2	1.71E-04	1.94E-04	4.19E-04	Not detected
	Mar. 2 – Mar. 23	3.79E-04	1.42E-04	8.71E-05	Detected
	Mar. 23 – Apr. 20	2.99E-04	1.99E-04	3.54E-04	Not detected
	Apr. 20 – May 18	2.04E-04	1.36E-04	2.46E-04	Not detected
	May 18 – Jun. 30	9.90E-05	1.00E-04	2.17E-04	Not detected
	Jun. 30 – Aug. 10	1.14E-04	7.30E-05	7.64E-05	Detected
	Aug. 10 – Sep. 2	1.24E-04	1.47E-04	3.09E-04	Not detected
	Sep. 2 – Oct. 8	3.11E-05	4.45E-05	9.96E-05	Not detected
	Oct. 8 – Oct. 26	2.71E-04	2.57E-04	5.32E-04	Not detected
	Oct.26 – Nov. 2	5.00E-04	3.75E-04	7.11E-04	Not detected
	Nov. 2 – Dec. 3	3.07E-05	9.81E-05	2.40E-04	Not detected
	Dec. 3 - Dec. 23	-1.39E-04	0.00E+00	0.00E+00	Not detected
	Dec. 23 - Feb. 2	5.65E-05	1.14E-04	2.68E-04	Not detected

Table B.20. Specific activities of $^{239+240}Pu$ at Cactus Flats Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
$^{239+240}Pu$	Jan. 14 – Feb. 2	5.31E-04	2.49E-04	3.12E-04	Detected
	Feb. 2 – Mar. 2	3.40E-04	1.73E-04	1.75E-04	Detected
	Mar. 2 – Mar. 23	5.92E-04	2.08E-04	2.63E-04	Detected
	Mar. 23 – Apr. 20	6.83E-04	2.47E-04	2.99E-04	Detected
	Apr. 20 – May 18	2.95E-04	1.47E-04	2.04E-04	Detected
	May 18 – Jun. 30	2.96E-04	1.08E-04	1.17E-04	Detected
	Jun. 30 – Aug. 10	7.58E-05	1.25E-04	2.86E-04	Not detected
	Aug. 10 – Sep. 2	1.30E-04	1.88E-04	4.12E-04	Not detected
	Sep. 2 – Oct. 8	1.47E-04	4.45E-05	9.96E-05	Detected
	Oct. 8 – Oct. 26	3.86E-04	2.97E-04	5.61E-04	Not detected
	Oct.26 – Nov. 2	3.74E-04	4.68E-04	9.89E-04	Not detected
	Nov. 2 – Dec. 3	1.08E-04	1.14E-04	2.16E-04	Not detected
	Dec. 3 - Dec. 23	2.06E-04	2.39E-04	4.84E-04	Not detected
	Dec. 23 - Feb. 2	1.02E-11	1.17E-04	3.01E-04	Not detected

Table B.21. Specific activities of ^{238}Pu at Cactus Flats Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{238}Pu	Jan. 14 – Feb. 2	-6.64E-05	1.47E-04	4.45E-04	Not detected
	Feb. 2 – Mar. 2	1.13E-04	1.01E-04	1.39E-04	Not detected
	Mar. 2 – Mar. 23	-2.47E-05	7.81E-05	2.32E-04	Not detected
	Mar. 23 – Apr. 20	0.00E+00	1.00E-04	2.76E-04	Not detected
	Apr. 20 – May 18	-6.42E-05	9.98E-05	3.02E-04	Not detected
	May 18 – Jun. 30	-1.48E-05	6.29E-05	1.74E-04	Not detected
	Jun. 30 – Aug. 10	-1.51E-04	1.15E-04	3.87E-04	Not detected
	Aug. 10 – Sep. 2	-2.08E-04	1.81E-04	6.13E-04	Not detected
	Sep. 2 – Oct. 8	1.47E-04	8.99E-05	1.26E-04	Detected
	Oct. 8 – Oct. 26	-3.22E-05	1.44E-04	4.54E-04	Not detected
	Oct.26 – Nov. 2	1.25E-04	3.53E-04	8.79E-04	Not detected
	Nov. 2 – Dec. 3	-1.80E-05	8.03E-05	2.53E-04	Not detected
	Dec. 3 - Dec. 23	-1.71E-04	1.82E-04	6.45E-04	Not detected
	Dec. 23 - Feb. 2	2.14E-05	6.76E-05	1.70E-04	Not detected

Table B.22. Specific activities of ^{241}Am, $^{239+240}Pu$, and ^{238}Pu in the filter samples collected from Loving Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{241}Am	Jan. 14 – Feb. 2	1.69E-08	1.01E-08	1.64E-08	Detected
	Feb. 2 – Mar. 2	5.61E-09	3.55E-09	4.35E-09	Detected
	Mar. 2 – Mar. 23	1.67E-08	9.00E-09	1.32E-08	Detected
	Mar. 23 – Apr. 20	1.25E-08	1.05E-08	2.10E-08	Not detected
	Apr. 20 – May 18	8.88E-09	9.77E-09	2.09E-08	Not detected
	May 18 – Jun. 30	6.44E-09	4.16E-09	7.01E-09	Not detected
	Jun. 30 – Aug. 10	4.73E-09	4.06E-09	7.52E-09	Not detected
	Aug. 10 – Sep. 2	3.26E-05	7.22E-05	1.72E-04	Not detected
	Sep. 2 – Oct. 8	-1.65E-05	7.75E-05	2.11E-04	Not detected
	Oct. 8 – Oct. 26	5.52E-05	1.41E-04	3.38E-04	Not detected
	Oct.26 – Nov. 2	1.87E-04	1.78E-04	3.21E-04	Not detected
	Nov. 2 – Dec. 3	2.09E-05	8.88E-05	2.23E-04	Not detected
	Dec. 3 - Dec. 23	5.12E-05	1.31E-04	3.14E-04	Not detected
	Dec. 23 - Feb. 2	-7.23E-05	1.04E-04	3.00E-04	Not detected
$^{239+240}Pu$	Jan. 14 – Feb. 2	3.87E-04	2.10E-04	3.31E-04	Detected
	Feb. 2 – Mar. 2	1.86E-04	1.26E-04	1.87E-04	Not detected
	Mar. 2 – Mar. 23	2.96E-04	1.22E-04	1.23E-04	Detected
	Mar. 23 – Apr. 20	2.46E-04	1.76E-04	3.27E-04	Not detected
	Apr. 20 – May 18	2.50E-04	1.35E-04	2.14E-04	Detected
	May 18 – Jun. 30	1.61E-04	9.24E-05	1.64E-04	Not detected
	Jun. 30 – Aug. 10	7.17E-05	5.11E-05	8.41E-05	Not detected
	Aug. 10 – Sep. 2	-6.59E-05	1.62E-04	4.51E-04	Not detected
	Sep. 2 – Oct. 8	6.67E-05	7.80E-05	1.68E-04	Not detected
	Oct. 8 – Oct. 26	1.02E-04	1.47E-04	3.23E-04	Not detected
	Oct.26 – Nov. 2	6.82E-04	4.23E-04	6.41E-04	Detected
	Nov. 2 – Dec. 3	1.09E-04	1.29E-04	2.71E-04	Not detected
	Dec. 3 - Dec. 23	7.48E-12	1.25E-04	3.34E-04	Not detected
	Dec. 23 - Feb. 2	2.09E-05	6.62E-05	1.66E-04	Not detected

Table B.22. Specific activities of ^{241}Am, $^{239+240}Pu$, and ^{238}Pu in the filter samples collected from Loving Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{238}Pu	Jan. 14 – Feb. 2	-1.06E-04	1.12E-04	3.75E-04	Not detected
	Feb. 2 – Mar. 2	0.00E+00	8.79E-05	2.47E-04	Not detected
	Mar. 2 – Mar. 23	6.13E-05	6.49E-05	1.23E-04	Not detected
	Mar. 23 – Apr. 20	-3.06E-05	9.72E-05	2.89E-04	Not detected
	Apr. 20 – May 18	-1.14E-05	6.83E-05	1.98E-04	Not detected
	May 18 – Jun. 30	-3.35E-05	4.04E-05	1.35E-04	Not detected
	Jun. 30 – Aug. 10	5.96E-06	3.94E-05	1.04E-04	Not detected
	Aug. 10 – Sep. 2	-6.59E-05	9.36E-05	3.10E-04	Not detected
	Sep. 2 – Oct. 8	-8.31E-06	6.01E-05	1.68E-04	Not detected
	Oct. 8 – Oct. 26	-8.13E-05	1.41E-04	4.33E-04	Not detected
	Oct.26 – Nov. 2	-2.73E-04	2.42E-04	8.56E-04	Not detected
	Nov. 2 – Dec. 3	-3.12E-05	8.82E-05	2.71E-04	Not detected
	Dec. 3 - Dec. 23	1.57E-05	1.37E-04	3.52E-04	Not detected
	Dec. 23 - Feb. 2	-5.23E-05	6.30E-05	2.10E-04	Not detected

Table B.23. Specific activities of ^{241}Am, $^{239+240}$Pu, and ^{238}Pu in the filter samples collected from Carlsbad Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{241}Am	Jan. 14 – Feb. 2	3.57E-04	2.37E-04	4.22E-04	Not detected
	Feb. 2 – Mar. 2	1.47E-04	1.89E-04	4.14E-04	Not detected
	Mar. 2 – Mar. 23	2.07E-04	1.23E-04	2.08E-04	Not detected
	Mar. 23 – Apr. 20	1.10E-04	2.20E-04	5.14E-04	Not detected
	Apr. 20 – May 18	0.00E+00	1.78E-04	4.50E-04	Not detected
	May 18 – Jun. 30	1.97E-04	9.16E-05	1.37E-04	Detected
	Jun. 30 – Aug. 10	2.60E-05	1.04E-04	2.61E-04	Not detected
	Aug. 10 – Sep. 2	-1.02E-04	1.08E-04	3.61E-04	Not detected
	Sep. 2 – Oct. 8	6.11E-05	8.17E-05	1.77E-04	Not detected
	Oct. 8 – Oct. 26	1.64E-04	2.04E-04	4.48E-04	Not detected
	Oct.26 – Nov. 2	4.86E-05	3.51E-04	9.15E-04	Not detected
	Nov. 2 – Dec. 3	4.48E-05	6.48E-05	1.42E-04	Not detected
	Dec. 3 - Dec. 23	1.88E-04	1.77E-04	3.32E-04	Not detected
	Dec. 23 - Feb. 2	4.43E-05	3.65E-04	9.44E-04	Not detected
$^{239+240}$Pu	Jan. 14 – Feb. 2	2.63E-04	2.21E-04	4.17E-04	Not detected
	Feb. 2 – Mar. 2	1.65E-04	1.94E-04	4.14E-04	Not detected
	Mar. 2 – Mar. 23	2.88E-04	1.29E-04	1.56E-04	Detected
	Mar. 23 – Apr. 20	5.52E-04	2.38E-04	2.78E-04	Detected
	Apr. 20 – May 18	3.36E-04	1.61E-04	2.06E-04	Detected
	May 18 – Jun. 30	4.45E-04	1.31E-04	1.06E-04	Detected
	Jun. 30 – Aug. 10	1.60E-04	1.56E-04	3.11E-04	Not detected
	Aug. 10 – Sep. 2	6.40E-05	1.76E-04	4.28E-04	Not detected
	Sep. 2 – Oct. 8	1.28E-04	1.19E-04	2.27E-04	Not detected
	Oct. 8 – Oct. 26	4.93E-04	2.91E-04	3.94E-04	Detected
	Oct.26 – Nov. 2	4.11E-04	5.13E-04	1.10E-03	Not detected
	Nov. 2 – Dec. 3	2.56E-04	1.53E-04	2.48E-04	Detected
	Dec. 3 - Dec. 23	2.32E-04	3.29E-04	7.28E-04	Not detected
	Dec. 23 - Feb. 2	1.61E-04	2.30E-04	5.15E-04	Not detected

Table B.23. Specific activity of ^{241}Am, $^{239+240}Pu$, and ^{238}Pu in the filter samples collected from Carlsbad Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{238}Pu	Jan. 14 – Feb. 2	-4.79E-05	1.36E-04	4.17E-04	Not detected
	Feb. 2 – Mar. 2	-6.18E-05	1.37E-04	4.14E-04	Not detected
	Mar. 2 – Mar. 23	-2.22E-05	6.28E-05	1.93E-04	Not detected
	Mar. 23 – Apr. 20	3.94E-05	1.58E-04	3.96E-04	Not detected
	Apr. 20 – May 18	-2.92E-05	1.01E-04	2.94E-04	Not detected
	May 18 – Jun. 30	0.00E+00	6.03E-05	1.61E-04	Not detected
	Jun. 30 – Aug. 10	7.15E-05	8.78E-05	1.66E-04	Not detected
	Aug. 10 – Sep. 2	2.12E-05	1.13E-04	3.00E-04	Not detected
	Sep. 2 – Oct. 8	-1.14E-04	9.95E-05	3.37E-04	Not detected
	Oct. 8 – Oct. 26	0.00E+00	2.28E-04	6.18E-04	Not detected
	Oct.26 – Nov. 2	-2.35E-04	4.08E-04	1.25E-03	Not detected
	Nov. 2 – Dec. 3	-5.69E-05	9.88E-05	3.03E-04	Not detected
	Dec. 3 - Dec. 23	-7.74E-05	2.90E-04	8.24E-04	Not detected
	Dec. 23 - Feb. 2	-4.59E-05	1.84E-04	5.15E-04	Not detected

Table B.24. Specific activities of ^{241}Am, $^{239+240}Pu$, and ^{238}Pu in the filter samples collected from East Tower Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{241}Am	Jan. 14 – Feb. 2	3.89E-04	2.24E-04	3.23E-04	Detected
	Feb. 2 – Mar. 2	1.44E-04	1.61E-04	3.42E-04	Not detected
	Mar. 2 – Mar. 23	2.18E-04	1.23E-04	2.13E-04	Detected
	Mar. 23 – Apr. 20	3.60E-04	1.71E-04	2.41E-04	Detected
	Apr. 20 – May 18	2.63E-04	1.31E-04	1.91E-04	Detected
	May 18 – Jun. 30	8.51E-05	8.23E-05	1.73E-04	Not detected
	Jun. 30 – Aug. 10	-2.32E-05	9.86E-05	2.73E-04	Not detected
	Aug. 10 – Sep. 2	6.67E-05	1.16E-04	2.65E-04	Not detected
	Sep. 2 – Oct. 8	5.62E-05	7.51E-05	1.63E-04	Not detected
	Oct. 8 – Oct. 26	1.64E-04	1.61E-04	3.36E-04	Not detected
	Oct.26 – Nov. 2	0.00E+00	1.97E-04	5.53E-04	Not detected
	Nov. 2 – Dec. 3	2.93E-05	8.96E-05	2.19E-04	Not detected
	Dec. 3 - Dec. 23	3.88E-05	1.45E-04	3.65E-04	Not detected
	Dec. 23 - Feb. 2	-5.58E-05	1.42E-04	3.93E-04	Not detected
$^{239+240}Pu$	Jan. 14 – Feb. 2	4.77E-04	2.58E-04	3.96E-04	Detected
	Feb. 2 – Mar. 2	3.09E-04	1.85E-04	2.88E-04	Detected
	Mar. 2 – Mar. 23	4.11E-04	1.43E-04	1.38E-04	Detected
	Mar. 23 – Apr. 20	1.23E-03	3.32E-04	3.04E-04	Detected
	Apr. 20 – May 18	1.87E-04	1.31E-04	2.35E-04	Not detected
	May 18 – Jun. 30	2.97E-04	1.09E-04	1.33E-04	Detected
	Jun. 30 – Aug. 10	1.76E-04	1.47E-04	2.79E-04	Not detected
	Aug. 10 – Sep. 2	9.87E-05	1.43E-04	3.13E-04	Not detected
	Sep. 2 – Oct. 8	3.23E-05	1.23E-04	3.03E-04	Not detected
	Oct. 8 – Oct. 26	4.79E-04	2.75E-04	3.97E-04	Detected
	Oct.26 – Nov. 2	3.48E-04	3.87E-04	7.89E-04	Not detected
	Nov. 2 – Dec. 3	2.20E-04	1.57E-04	2.69E-04	Not detected
	Dec. 3 - Dec. 23	6.97E-05	1.68E-04	4.05E-04	Not detected
	Dec. 23 - Feb. 2	1.61E-04	1.65E-04	3.43E-04	Not detected

Table B.24. Specific activities of ^{241}Am, $^{239+240}$Pu, and ^{238}Pu in the filter samples collected from East Tower Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{238}Pu	Jan. 14 – Feb. 2	-1.14E-04	1.51E-04	4.85E-04	Not detected
	Feb. 2 – Mar. 2	-1.27E-04	1.32E-04	4.27E-04	Not detected
	Mar. 2 – Mar. 23	-1.96E-05	5.53E-05	1.70E-04	Not detected
	Mar. 23 – Apr. 20	-6.46E-05	1.12E-04	3.44E-04	Not detected
	Apr. 20 – May 18	-7.48E-05	7.93E-05	2.66E-04	Not detected
	May 18 – Jun. 30	-3.54E-05	4.71E-05	1.51E-04	Not detected
	Jun. 30 – Aug. 10	-3.20E-05	6.42E-05	2.26E-04	Not detected
	Aug. 10 – Sep. 2	-3.94E-05	1.48E-04	4.21E-04	Not detected
	Sep. 2 – Oct. 8	-1.50E-04	1.14E-04	3.53E-04	Not detected
	Oct. 8 – Oct. 26	5.63E-05	2.11E-04	5.30E-04	Not detected
	Oct.26 – Nov. 2	1.99E-04	3.99E-04	9.36E-04	Not detected
	Nov. 2 – Dec. 3	-8.47E-05	1.32E-04	3.98E-04	Not detected
	Dec. 3 - Dec. 23	-2.32E-05	2.13E-04	5.70E-04	Not detected
	Dec. 23 - Feb. 2	-4.83E-05	1.25E-04	3.61E-04	Not detected

Table B.25. Activity concentrations of U isotopes (^{234}U, ^{235}U, and ^{238}U) at Onsite Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{234}U	Jan. 14 – Feb. 2	2.46E-06	3.12E-07	3.54E-08	Detected
	Feb. 2 – Mar. 2	1.10E-06	1.38E-07	2.29E-08	Detected
	Mar. 2 – Mar. 23	3.77E-06	4.60E-07	4.12E-08	Detected
	Mar. 23 – Apr. 20	3.54E-06	4.45E-07	5.24E-08	Detected
	Apr. 20 – May 18	2.59E-06	3.26E-07	3.12E-08	Detected
	May 18 – Jun. 30	2.25E-05	2.56E-06	1.11E+01	Not detected
	Jun. 30 – Aug. 10	1.74E-06	2.59E-07	4.10E-08	Detected
	Aug. 10 – Sep. 2	2.10E-06	2.58E-07	2.66E-08	Detected
	Sep. 2 – Oct. 8	1.38E-06	1.50E-07	7.41E-09	Detected
	Oct. 8 – Oct. 26	2.95E-06	3.55E-07	4.52E-08	Detected
	Oct.26 – Nov. 2	1.64E-06	2.53E-07	7.45E-07	Detected
	Nov. 2 – Dec. 3	1.18E-06	1.46E-07	2.69E-08	Detected
	Dec. 3 - Dec. 23	7.25E-07	9.18E-08	1.68E-08	Detected
	Dec. 23 - Feb. 2	9.37E-07	1.10E-07	1.34E-08	Detected
^{235}U	Jan. 14 – Feb. 2	1.12E-07	3.82E-08	4.37E-08	Detected
	Feb. 2 – Mar. 2	4.11E-08	1.53E-08	1.88E-08	Detected
	Mar. 2 – Mar. 23	1.40E-07	4.01E-08	2.72E-08	Detected
	Mar. 23 – Apr. 20	2.10E-07	5.29E-08	3.45E-08	Detected
	Apr. 20 – May 18	1.04E-07	3.49E-08	3.51E-08	Detected
	May 18 – Jun. 30	1.44E-06	2.58E-07	5.37E-08	Detected
	Jun. 30 – Aug. 10	7.52E-08	3.09E-08	3.02E-08	Detected
	Aug. 10 – Sep. 2	1.10E-07	3.11E-08	2.10E-08	Detected
	Sep. 2 – Oct. 8	6.99E-08	1.32E-08	3.98E-09	Detected
	Oct. 8 – Oct. 26	1.58E-07	4.01E-08	2.71E-08	Detected
	Oct.26 – Nov. 2	2.37E-07	8.82E-08	1.09E-07	Detected
	Nov. 2 – Dec. 3	1.20E-07	2.87E-08	1.24E-08	Detected
	Dec. 3 - Dec. 23	8.28E-08	2.15E-08	1.33E-08	Detected
	Dec. 23 - Feb. 2	6.34E-08	1.55E-08	8.86E-09	Detected

Table B.25. Activity concentrations of U isotopes (^{234}U, ^{235}U, and ^{238}U) at Onsite Station (continued)

Radionuclides	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{238}U	Jan. 14 – Feb. 2	2.23E-06	2.86E-07	3.77E-08	Detected
	Feb. 2 – Mar. 2	1.09E-06	1.38E-07	2.06E-08	Detected
	Mar. 2 – Mar. 23	3.28E-06	4.05E-07	4.10E-08	Detected
	Mar. 23 – Apr. 20	3.47E-06	4.37E-07	6.48E-08	Detected
	Apr. 20 – May 18	2.42E-06	3.07E-07	4.01E-08	Detected
	May 18 – Jun. 30	2.06E-05	2.36E-06	1.18E-07	Detected
	Jun. 30 – Aug. 10	1.56E-06	2.36E-07	5.33E-08	Detected
	Aug. 10 – Sep. 2	1.94E-06	2.41E-07	3.73E-08	Detected
	Sep. 2 – Oct. 8	7.17E-07	8.07E-08	8.82E-09	Detected
	Oct. 8 – Oct. 26	2.76E-06	3.35E-07	5.53E-08	Detected
	Oct.26 – Nov. 2	1.37E-06	2.23E-07	9.40E-08	Detected
	Nov. 2 – Dec. 3	1.04E-06	1.30E-07	2.03E-08	Detected
	Dec. 3 - Dec. 23	6.63E-07	8.54E-08	2.35E-08	Detected
	Dec. 23 - Feb. 2	9.13E-07	1.08E-07	1.63E-08	Detected

Table B.26. Activity concentrations of U isotopes (^{234}U, ^{235}U, and ^{238}U) at Near Field Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{234}U	Jan. 14 – Feb. 2	2.28E-06	3.02E-07	4.85E-08	Detected
	Feb. 2 – Mar. 2	2.15E-06	2.71E-07	2.26E-08	Detected
	Mar. 2 – Mar. 23	3.83E-06	4.74E-07	5.61E-08	Detected
	Mar. 23 – Apr. 20	2.74E-06	3.39E-07	4.45E-08	Detected
	Apr. 20 – May 18	3.09E-06	3.69E-07	3.86E-08	Detected
	May 18 – Jun. 30	1.91E-06	2.18E-07	1.14E-08	Detected
	Jun. 30 – Aug. 10	1.22E-06	1.50E-07	1.85E-08	Detected
	Aug. 10 – Sep. 2	1.94E-06	2.37E-07	2.73E-08	Detected
	Sep. 2 – Oct. 8	9.49E-07	1.42E-07	5.36E-08	Detected
	Oct. 8 – Oct. 26	3.25E-06	3.79E-07	3.46E-08	Detected
	Oct.26 – Nov. 2	2.29E-06	3.85E-07	2.19E-07	Detected
	Nov. 2 – Dec. 3	1.18E-06	1.47E-07	2.52E-08	Detected
	Dec. 3 - Dec. 23	8.47E-07	1.11E-07	2.80E-08	Detected
	Dec. 23 - Feb. 2	8.22E-07	9.76E-08	1.32E-08	Detected
^{235}U	Jan. 14 – Feb. 2	1.21E-07	4.37E-08	4.47E-08	Detected
	Feb. 2 – Mar. 2	1.13E-07	3.52E-08	3.72E-08	Detected
	Mar. 2 – Mar. 23	1.35E-07	4.31E-08	4.62E-08	Detected
	Mar. 23 – Apr. 20	1.28E-07	3.86E-08	4.04E-08	Detected
	Apr. 20 – May 18	1.10E-07	3.11E-08	2.09E-08	Detected
	May 18 – Jun. 30	9.76E-08	1.95E-08	9.29E-09	Detected
	Jun. 30 – Aug. 10	5.93E-08	1.66E-08	8.65E-09	Detected
	Aug. 10 – Sep. 2	1.04E-07	2.85E-08	1.47E-08	Detected
	Sep. 2 – Oct. 8	8.91E-08	3.35E-08	2.51E-08	Detected
	Oct. 8 – Oct. 26	1.54E-07	3.72E-08	2.36E-08	Detected
	Oct.26 – Nov. 2	7.77E-07	1.98E-07	1.15E-07	Detected
	Nov. 2 – Dec. 3	7.93E-08	2.32E-08	1.86E-08	Detected
	Dec. 3 - Dec. 23	2.06E-07	4.26E-08	1.50E-08	Detected
	Dec. 23 - Feb. 2	7.17E-08	1.59E-08	6.17E-09	Detected

Table B.26. Activity concentrations of U isotopes (^{234}U, ^{235}U, and ^{238}U) at Near Field Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/m3	Unc. (2σ) Bq/m3	MDC Bq/m3	Status
^{238}U	Jan. 14 – Feb. 2	2.22E-06	2.95E-07	5.48E-08	Detected
	Feb. 2 – Mar. 2	2.05E-06	2.59E-07	3.00E-08	Detected
	Mar. 2 – Mar. 23	3.27E-06	4.08E-07	5.05E-08	Detected
	Mar. 23 – Apr. 20	2.44E-06	3.06E-07	4.90E-08	Detected
	Apr. 20 – May 18	2.81E-06	3.38E-07	4.92E-08	Detected
	May 18 – Jun. 30	1.80E-06	2.06E-07	1.30E-08	Detected
	Jun. 30 – Aug. 10	1.14E-06	1.41E-07	1.42E-08	Detected
	Aug. 10 – Sep. 2	1.86E-06	2.29E-07	3.26E-08	Detected
	Sep. 2 – Oct. 8	8.74E-07	1.32E-07	4.10E-08	Detected
	Oct. 8 – Oct. 26	2.78E-06	3.29E-07	3.57E-08	Detected
	Oct.26 – Nov. 2	2.15E-06	3.66E-07	1.97E-07	Detected
	Nov. 2 – Dec. 3	1.10E-06	1.38E-07	2.27E-08	Detected
	Dec. 3 - Dec. 23	6.52E-07	9.08E-08	3.33E-08	Detected
	Dec. 23 - Feb. 2	7.85E-07	9.35E-08	1.01E-08	Detected

Table B.27. Activity concentrations of U isotopes (^{234}U, ^{235}U, and ^{238}U) at Cactus Flats Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{234}U	Jan. 14 – Feb. 2	2.39E-06	3.06E-07	5.51E-08	Detected
	Feb. 2 – Mar. 2	2.20E-06	2.70E-07	2.49E-08	Detected
	Mar. 2 – Mar. 23	4.92E-06	5.88E-07	2.99E-08	Detected
	Mar. 23 – Apr. 20	3.06E-06	3.62E-07	1.89E-08	Detected
	Apr. 20 – May 18	3.74E-07	3.85E-08	2.49E-08	Detected
	May 18 – Jun. 30	9.47E-09	2.36E-07	2.00E-08	Not detected
	Jun. 30 – Aug. 10	1.23E-06	1.49E-07	1.63E-08	Detected
	Aug. 10 – Sep. 2	1.61E-06	1.99E-07	2.79E-08	Detected
	Sep. 2 – Oct. 8	1.32E-06	1.43E-07	8.38E-09	Detected
	Oct. 8 – Oct. 26	3.99E-06	4.63E-07	4.10E-08	Detected
	Oct.26 – Nov. 2	6.40E-06	7.92E-07	1.32E-07	Detected
	Nov. 2 – Dec. 3	9.57E-07	1.19E-07	2.86E-08	Detected
	Dec. 3 - Dec. 23	8.58E-07	1.09E-07	2.39E-08	Detected
	Dec. 23 - Feb. 2	1.12E-06	1.26E-07	9.40E-09	Detected
^{235}U	Jan. 14 – Feb. 2	1.06E-07	3.72E-08	3.63E-08	Detected
	Feb. 2 – Mar. 2	8.13E-08	2.71E-08	2.49E-08	Detected
	Mar. 2 – Mar. 23	1.46E-07	4.61E-08	4.92E-08	Detected
	Mar. 23 – Apr. 20	1.17E-07	3.13E-08	1.99E-08	Detected
	Apr. 20 – May 18	1.76E-07	4.22E-08	1.80E-08	Detected
	May 18 – Jun. 30	8.62E-08	2.00E-08	1.32E-08	Detected
	Jun. 30 – Aug. 10	7.03E-08	1.79E-08	1.21E-08	Detected
	Aug. 10 – Sep. 2	8.40E-08	2.54E-08	1.84E-08	Detected
	Sep. 2 – Oct. 8	8.34E-08	1.52E-08	5.53E-09	Detected
	Oct. 8 – Oct. 26	2.87E-07	5.70E-08	3.23E-08	Detected
	Oct.26 – Nov. 2	3.91E-07	1.15E-07	9.35E-08	Detected
	Nov. 2 – Dec. 3	6.49E-08	2.01E-08	2.21E-08	Detected
	Dec. 3 - Dec. 23	1.73E-07	3.56E-08	1.58E-08	Detected
	Dec. 23 - Feb. 2	7.76E-08	1.63E-08	7.40E-09	Detected

Table B.27. Activity concentrations of U isotopes (^{234}U, ^{235}U, and ^{238}U) at Cactus Flats Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{238}U	Jan. 14 – Feb. 2	2.31E-06	2.97E-07	6.82E-08	Detected
	Feb. 2 – Mar. 2	2.05E-06	2.53E-07	3.04E-08	Detected
	Mar. 2 – Mar. 23	3.91E-06	4.74E-07	3.97E-08	Detected
	Mar. 23 – Apr. 20	2.80E-06	3.34E-07	2.52E-08	Detected
	Apr. 20 – May 18	2.95E-06	3.59E-07	3.33E-08	Detected
	May 18 – Jun. 30	1.81E-06	2.14E-07	2.34E-08	Detected
	Jun. 30 – Aug. 10	1.19E-06	1.45E-07	1.47E-08	Detected
	Aug. 10 – Sep. 2	1.53E-06	1.90E-07	3.38E-08	Detected
	Sep. 2 – Oct. 8	6.41E-07	7.30E-08	1.02E-08	Detected
	Oct. 8 – Oct. 26	3.72E-06	4.35E-07	5.61E-08	Detected
	Oct.26 – Nov. 2	6.35E-06	7.86E-07	1.31E-07	Detected
	Nov. 2 – Dec. 3	8.56E-07	1.08E-07	2.43E-08	Detected
	Dec. 3 - Dec. 23	7.90E-07	1.02E-07	2.89E-08	Detected
	Dec. 23 - Feb. 2	1.05E-06	1.21E-07	1.31E-08	Detected

Table B.28. Activity concentrations of U isotopes (^{234}U, ^{235}U, and ^{238}U) in the filter samples collected from Loving Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{234}U	Jan. 14 – Feb. 2	2.26E-06	2.89E-07	5.02E-08	Detected
	Feb. 2 – Mar. 2	1.17E-06	1.40E-07	1.68E-08	Detected
	Mar. 2 – Mar. 23	3.90E-06	4.71E-07	2.90E-08	Detected
	Mar. 23 – Apr. 20	3.01E-06	3.57E-07	2.28E-08	Detected
	Apr. 20 – May 18	3.08E-06	3.74E-07	3.51E-08	Detected
	May 18 – Jun. 30	2.10E-06	2.43E-07	1.00E-08	Detected
	Jun. 30 – Aug. 10	2.34E-06	2.61E-07	1.27E-08	Detected
	Aug. 10 – Sep. 2	1.91E-06	2.42E-07	3.71E-08	Detected
	Sep. 2 – Oct. 8	8.63E-07	1.04E-07	1.45E-08	Detected
	Oct. 8 – Oct. 26	3.07E-06	3.55E-07	2.49E-08	Detected
	Oct.26 – Nov. 2	7.18E-06	8.75E-07	1.22E-07	Detected
	Nov. 2 – Dec. 3	2.04E-06	2.55E-07	5.28E-08	Detected
	Dec. 3 - Dec. 23	2.20E-06	3.00E-07	6.64E-08	Detected
	Dec. 23 - Feb. 2	1.39E-06	1.55E-07	1.15E-08	Detected
^{235}U	Jan. 14 – Feb. 2	1.03E-07	3.72E-08	4.56E-08	Detected
	Feb. 2 – Mar. 2	5.40E-08	1.51E-08	1.36E-08	Detected
	Mar. 2 – Mar. 23	1.31E-07	3.75E-08	2.90E-08	Detected
	Mar. 23 – Apr. 20	1.02E-07	2.91E-08	2.28E-08	Detected
	Apr. 20 – May 18	1.14E-07	3.41E-08	3.06E-08	Detected
	May 18 – Jun. 30	9.34E-08	2.05E-08	1.36E-08	Detected
	Jun. 30 – Aug. 10	9.85E-08	1.89E-08	1.08E-08	Detected
	Aug. 10 – Sep. 2	1.17E-07	3.33E-08	2.25E-08	Detected
	Sep. 2 – Oct. 8	6.13E-08	1.56E-08	7.40E-09	Detected
	Oct. 8 – Oct. 26	2.53E-07	4.81E-08	1.83E-08	Detected
	Oct.26 – Nov. 2	5.65E-07	1.38E-07	7.71E-08	Detected
	Nov. 2 – Dec. 3	2.67E-07	5.80E-08	3.16E-08	Detected
	Dec. 3 - Dec. 23	2.92E-07	7.40E-08	3.39E-08	Detected
	Dec. 23 - Feb. 2	5.99E-08	1.42E-08	6.18E-09	Detected

Table B.28. Activity concentrations of U isotopes (^{234}U, ^{235}U, and ^{238}U) in the filter samples collected from Loving Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/m³	Unc. (2σ) Bq/m³	MDC Bq/m³	Status
^{238}U	Jan. 14 – Feb. 2	2.31E-06	2.95E-07	5.53E-08	Detected
	Feb. 2 – Mar. 2	1.15E-06	1.38E-07	1.55E-08	Detected
	Mar. 2 – Mar. 23	3.28E-06	4.01E-07	3.53E-08	Detected
	Mar. 23 – Apr. 20	2.83E-06	3.36E-07	2.78E-08	Detected
	Apr. 20 – May 18	2.82E-06	3.45E-07	4.25E-08	Detected
	May 18 – Jun. 30	2.04E-06	2.36E-07	1.48E-08	Detected
	Jun. 30 – Aug. 10	2.33E-06	2.60E-07	1.23E-08	Detected
	Aug. 10 – Sep. 2	1.82E-06	2.31E-07	4.73E-08	Detected
	Sep. 2 – Oct. 8	7.94E-07	9.65E-08	1.37E-08	Detected
	Oct. 8 – Oct. 26	2.80E-06	3.23E-07	3.25E-08	Detected
	Oct.26 – Nov. 2	6.98E-06	8.53E-07	1.59E-07	Detected
	Nov. 2 – Dec. 3	1.88E-06	2.37E-07	6.44E-08	Detected
	Dec. 3 - Dec. 23	2.14E-06	2.92E-07	6.28E-08	Detected
	Dec. 23 - Feb. 2	1.26E-06	1.41E-07	1.37E-08	Detected

Table B.29. Activity concentrations of U isotopes (^{234}U, ^{235}U, and ^{238}U) in the filter samples collected from Carlsbad Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{234}U	Jan. 14 – Feb. 2	1.94E-06	2.43E-07	2.67E-08	Detected
	Feb. 2 – Mar. 2	1.06E-06	1.32E-07	1.86E-08	Detected
	Mar. 2 – Mar. 23	3.80E-06	4.57E-07	4.19E-08	Detected
	Mar. 23 – Apr. 20	2.70E-06	3.21E-07	3.00E-08	Detected
	Apr. 20 – May 18	2.76E-06	3.42E-07	4.75E-08	Detected
	May 18 – Jun. 30	2.04E-06	2.38E-07	1.46E-08	Detected
	Jun. 30 – Aug. 10	1.06E-06	1.27E-07	7.24E-09	Detected
	Aug. 10 – Sep. 2	1.55E-06	2.01E-08	2.42E-08	Detected
	Sep. 2 – Oct. 8	7.33E-07	9.22E-08	1.70E-08	Detected
	Oct. 8 – Oct. 26	1.63E-06	2.05E-07	3.77E-08	Detected
	Oct.26 – Nov. 2	4.70E-05	5.80E-06	9.73E-07	Detected
	Nov. 2 – Dec. 3	1.56E-06	2.01E-07	4.17E-08	Detected
	Dec. 3 - Dec. 23	1.71E-06	3.00E-07	1.42E-07	Detected
	Dec. 23 - Feb. 2	1.06E-06	1.23E-07	1.34E-08	Detected
^{235}U	Jan. 14 – Feb. 2	9.08E-08	2.96E-08	2.67E-08	Detected
	Feb. 2 – Mar. 2	2.99E-08	1.28E-08	1.76E-08	Detected
	Mar. 2 – Mar. 23	1.31E-07	3.74E-08	3.41E-08	Detected
	Mar. 23 – Apr. 20	1.17E-07	3.12E-08	2.49E-08	Detected
	Apr. 20 – May 18	1.06E-07	3.51E-08	3.91E-08	Detected
	May 18 – Jun. 30	7.56E-08	1.81E-08	1.13E-08	Detected
	Jun. 30 – Aug. 10	5.23E-08	1.41E-08	8.97E-09	Detected
	Aug. 10 – Sep. 2	6.57E-08	2.68E-08	3.53E-08	Detected
	Sep. 2 – Oct. 8	5.35E-08	1.56E-08	1.26E-08	Detected
	Oct. 8 – Oct. 26	2.79E-07	6.25E-08	2.44E-08	Detected
	Oct.26 – Nov. 2	2.54E-06	8.19E-07	8.52E-07	Detected
	Nov. 2 – Dec. 3	2.96E-07	6.03E-08	2.96E-08	Detected
	Dec. 3 - Dec. 23	1.79E-07	8.28E-08	1.01E-07	Detected
	Dec. 23 - Feb. 2	7.73E-08	1.70E-08	6.53E-09	Detected

Table B.29. Activity concentrations of U isotopes (^{234}U, ^{235}U, and ^{238}U) in the filter samples collected from Carlsbad Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{238}U	Jan. 14 – Feb. 2	1.91E-06	2.40E-07	3.25E-08	Detected
	Feb. 2 – Mar. 2	9.70E-07	1.22E-07	1.77E-08	Detected
	Mar. 2 – Mar. 23	3.33E-06	4.03E-07	3.88E-08	Detected
	Mar. 23 – Apr. 20	2.61E-06	3.11E-07	2.55E-08	Detected
	Apr. 20 – May 18	2.48E-06	3.10E-07	4.28E-08	Detected
	May 18 – Jun. 30	1.99E-06	2.32E-07	1.53E-08	Detected
	Jun. 30 – Aug. 10	1.01E-06	1.22E-07	9.53E-09	Detected
	Aug. 10 – Sep. 2	1.57E-06	2.02E-07	3.05E-08	Detected
	Sep. 2 – Oct. 8	6.98E-07	8.82E-08	1.53E-08	Detected
	Oct. 8 – Oct. 26	4.29E-06	5.02E-07	1.97E-08	Detected
	Oct.26 – Nov. 2	4.56E-05	5.66E-06	1.24E-06	Detected
	Nov. 2 – Dec. 3	1.46E-06	1.90E-07	5.91E-08	Detected
	Dec. 3 - Dec. 23	1.74E-06	3.09E-07	2.02E-07	Detected
	Dec. 23 - Feb. 2	1.05E-06	1.21E-07	1.86E-08	Detected

Table B.30. Activity concentrations of U isotopes (^{234}U, ^{235}U, and ^{238}U) in the filter samples collected from East Tower Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{234}U	Jan. 14 – Feb. 2	2.22E-06	2.82E-07	4.35E-08	Detected
	Feb. 2 – Mar. 2	2.47E-06	3.10E-07	3.65E-08	Detected
	Mar. 2 – Mar. 23	3.90E-06	4.59E-07	3.53E-08	Detected
	Mar. 23 – Apr. 20	3.09E-06	3.65E-07	2.24E-08	Detected
	Apr. 20 – May 18	3.21E-06	4.02E-07	2.69E-08	Detected
	May 18 – Jun. 30	2.09E-06	2.36E-07	9.46E-09	Detected
	Jun. 30 – Aug. 10	1.21E-06	1.48E-07	1.95E-08	Detected
	Aug. 10 – Sep. 2	1.92E-06	2.38E-07	3.14E-08	Detected
	Sep. 2 – Oct. 8	8.10E-07	9.97E-08	2.12E-08	Detected
	Oct. 8 – Oct. 26	4.07E-06	4.88E-07	5.51E-08	Detected
	Oct.26 – Nov. 2	1.66E-06	2.50E-07	5.36E-08	Detected
	Nov. 2 – Dec. 3	1.47E-06	1.94E-07	4.88E-08	Detected
	Dec. 3 - Dec. 23	6.32E-07	8.24E-08	2.20E-08	Detected
	Dec. 23 - Feb. 2	1.22E-06	1.44E-07	1.10E-08	Detected
^{235}U	Jan. 14 – Feb. 2	1.04E-07	3.52E-08	3.62E-08	Detected
	Feb. 2 – Mar. 2	1.00E-07	3.28E-08	2.98E-08	Detected
	Mar. 2 – Mar. 23	1.63E-07	4.05E-08	3.34E-08	Detected
	Mar. 23 – Apr. 20	1.98E-07	4.26E-08	2.51E-08	Detected
	Apr. 20 – May 18	1.41E-07	4.31E-08	4.43E-08	Detected
	May 18 – Jun. 30	1.26E-07	2.25E-08	8.75E-09	Detected
	Jun. 30 – Aug. 10	5.61E-08	1.58E-08	1.06E-08	Detected
	Aug. 10 – Sep. 2	6.40E-08	2.32E-08	2.08E-08	Detected
	Sep. 2 – Oct. 8	3.98E-08	1.36E-08	1.63E-08	Detected
	Oct. 8 – Oct. 26	1.89E-07	5.32E-08	4.83E-08	Detected
	Oct.26 – Nov. 2	2.70E-07	8.39E-08	5.11E-08	Detected
	Nov. 2 – Dec. 3	5.03E-07	8.81E-08	2.73E-08	Detected
	Dec. 3 - Dec. 23	7.15E-08	1.99E-08	1.07E-08	Detected
	Dec. 23 - Feb. 2	8.15E-08	1.98E-08	1.61E-08	Detected

Table B.30. Activity concentrations of U isotopes (^{234}U, ^{235}U, and ^{238}U) in the filter samples collected from East Tower Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{238}U	Jan. 14 – Feb. 2	2.24E-06	2.84E-07	3.70E-08	Detected
	Feb. 2 – Mar. 2	2.26E-06	2.86E-07	5.22E-08	Detected
	Mar. 2 – Mar. 23	3.46E-06	4.10E-07	3.37E-08	Detected
	Mar. 23 – Apr. 20	2.85E-06	3.38E-07	2.87E-08	Detected
	Apr. 20 – May 18	3.03E-06	3.81E-07	3.57E-08	Detected
	May 18 – Jun. 30	1.94E-06	2.20E-07	1.07E-08	Detected
	Jun. 30 – Aug. 10	1.14E-06	1.40E-07	1.59E-08	Detected
	Aug. 10 – Sep. 2	1.69E-06	2.12E-07	2.63E-08	Detected
	Sep. 2 – Oct. 8	7.53E-07	9.33E-08	1.79E-08	Detected
	Oct. 8 – Oct. 26	3.54E-06	4.30E-07	7.02E-08	Detected
	Oct.26 – Nov. 2	1.76E-06	2.60E-07	4.13E-08	Detected
	Nov. 2 – Dec. 3	1.49E-06	1.96E-07	5.02E-08	Detected
	Dec. 3 - Dec. 23	5.62E-07	7.53E-08	3.06E-08	Detected
	Dec. 23 - Feb. 2	1.12E-06	1.34E-07	1.39E-08	Detected

Table B.31. Specific activities of U isotopes (^{234}U, ^{235}U, and ^{238}U) at Onsite Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{234}U	Jan. 14 – Feb. 2	4.87E-02	6.17E-03	7.03E-04	Detected
	Feb. 2 – Mar. 2	3.57E-02	4.50E-03	7.46E-04	Detected
	Mar. 2 – Mar. 23	4.49E-02	5.49E-03	4.91E-04	Detected
	Mar. 23 – Apr. 20	3.54E-02	4.45E-03	5.24E-04	Detected
	Apr. 20 – May 18	4.26E-02	5.38E-03	5.14E-04	Detected
	May 18 – Jun. 30	2.50E-02	2.86E-03	1.24E-04	Detected
	Jun. 30 – Aug. 10	3.33E-02	4.96E-03	7.86E-04	Detected
	Aug. 10 – Sep. 2	4.39E-02	5.41E-03	5.57E-04	Detected
	Sep. 2 – Oct. 8	2.82E-02	3.05E-03	1.51E-04	Detected
	Oct. 8 – Oct. 26	6.57E-02	7.91E-03	1.01E-03	Detected
	Oct.26 – Nov. 2	3.08E-02	4.74E-03	1.40E-02	Detected
	Nov. 2 – Dec. 3	2.19E-02	2.72E-03	5.02E-04	Detected
	Dec. 3 - Dec. 23	1.03E-02	1.31E-03	2.40E-04	Detected
	Dec. 23 - Feb. 2	2.33E-02	2.74E-03	3.34E-04	Detected
^{235}U	Jan. 14 – Feb. 2	2.21E-03	7.57E-04	8.67E-04	Detected
	Feb. 2 – Mar. 2	1.34E-03	4.99E-04	6.14E-04	Detected
	Mar. 2 – Mar. 23	1.68E-03	4.79E-04	3.25E-04	Detected
	Mar. 23 – Apr. 20	2.10E-03	5.29E-04	3.45E-04	Detected
	Apr. 20 – May 18	1.71E-03	5.75E-04	5.78E-04	Detected
	May 18 – Jun. 30	1.60E-03	2.88E-04	5.99E-05	Detected
	Jun. 30 – Aug. 10	1.44E-03	5.93E-04	5.78E-04	Detected
	Aug. 10 – Sep. 2	2.31E-03	6.52E-04	4.39E-04	Detected
	Sep. 2 – Oct. 8	1.42E-03	2.68E-04	8.11E-05	Detected
	Oct. 8 – Oct. 26	3.51E-03	8.93E-04	6.04E-04	Detected
	Oct.26 – Nov. 2	4.45E-03	1.65E-03	2.04E-03	Detected
	Nov. 2 – Dec. 3	2.24E-03	5.35E-04	2.31E-04	Detected
	Dec. 3 - Dec. 23	1.18E-03	3.06E-04	1.89E-04	Detected
	Dec. 23 - Feb. 2	1.58E-03	3.86E-04	2.20E-04	Detected

Table B.31. Specific activities of U isotopes (^{234}U, ^{235}U, and ^{238}U) at Onsite Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{238}U	Jan. 14 – Feb. 2	4.43E-02	5.66E-03	7.48E-04	Detected
	Mar. 2 – Mar. 23	3.92E-02	4.83E-03	4.89E-04	Detected
	Mar. 23 – Apr. 20	3.47E-02	4.37E-03	6.48E-04	Detected
	Apr. 20 – May 18	3.98E-02	5.06E-03	6.60E-04	Detected
	May 18 – Jun. 30	2.30E-02	2.63E-03	1.32E-04	Detected
	Jun. 30 – Aug. 10	2.99E-02	4.52E-03	1.02E-03	Detected
	Aug. 10 – Sep. 2	4.05E-02	5.04E-03	7.80E-04	Detected
	Sep. 2 – Oct. 8	1.46E-02	1.64E-03	1.80E-04	Detected
	Oct. 8 – Oct. 26	6.15E-02	7.45E-03	1.23E-03	Detected
	Oct.26 – Nov. 2	2.58E-02	4.17E-03	1.76E-03	Detected
	Nov. 2 – Dec. 3	1.93E-02	2.42E-03	3.79E-04	Detected
	Dec. 3 - Dec. 23	9.45E-03	1.22E-03	3.35E-04	Detected
	Dec. 23 - Feb. 2	2.27E-02	2.68E-03	4.05E-04	Detected

Table B.32. Specific activities of U isotopes (^{234}U, ^{235}U, and ^{238}U) in the filter samples collected from Near Field Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{234}U	Jan. 14 – Feb. 2	5.21E-02	6.91E-03	1.11E-03	Detected
	Feb. 2 – Mar. 2	4.67E-02	5.87E-03	4.90E-04	Detected
	Mar. 2 – Mar. 23	4.64E-02	5.73E-03	6.79E-04	Detected
	Mar. 23 – Apr. 20	4.55E-02	5.64E-03	7.40E-04	Detected
	Apr. 20 – May 18	4.26E-02	5.10E-03	5.33E-04	Detected
	May 18 – Jun. 30	3.32E-02	3.79E-03	1.98E-04	Detected
	Jun. 30 – Aug. 10	3.09E-02	3.81E-03	4.68E-04	Detected
	Aug. 10 – Sep. 2	4.55E-02	5.56E-03	6.42E-04	Detected
	Sep. 2 – Oct. 8	1.99E-02	2.96E-03	1.12E-03	Detected
	Oct. 8 – Oct. 26	7.58E-02	8.86E-03	8.08E-04	Detected
	Oct.26 – Nov. 2	4.08E-02	6.86E-03	3.90E-03	Detected
	Nov. 2 – Dec. 3	2.52E-02	3.14E-03	5.37E-04	Detected
	Dec. 3 - Dec. 23	1.56E-02	2.05E-03	5.16E-04	Detected
	Dec. 23 - Feb. 2	2.35E-02	2.79E-03	3.77E-04	Detected
^{235}U	Jan. 14 – Feb. 2	2.76E-03	9.98E-04	1.02E-03	Detected
	Feb. 2 – Mar. 2	2.44E-03	7.64E-04	8.07E-04	Detected
	Mar. 2 – Mar. 23	1.63E-03	5.21E-04	5.59E-04	Detected
	Mar. 23 – Apr. 20	2.14E-03	6.41E-04	6.72E-04	Detected
	Apr. 20 – May 18	1.52E-03	4.29E-04	2.89E-04	Detected
	May 18 – Jun. 30	1.70E-03	3.39E-04	1.62E-04	Detected
	Jun. 30 – Aug. 10	1.50E-03	4.19E-04	2.19E-04	Detected
	Aug. 10 – Sep. 2	2.44E-03	6.71E-04	3.45E-04	Detected
	Sep. 2 – Oct. 8	1.86E-03	7.00E-04	5.24E-04	Detected
	Oct. 8 – Oct. 26	3.60E-03	8.68E-04	5.51E-04	Detected
	Oct.26 – Nov. 2	1.38E-02	3.53E-03	2.05E-03	Detected
	Nov. 2 – Dec. 3	1.69E-03	4.93E-04	3.97E-04	Detected
	Dec. 3 - Dec. 23	3.79E-03	7.86E-04	2.77E-04	Detected
	Dec. 23 - Feb. 2	2.05E-03	4.55E-04	1.76E-04	Detected

Table B.32. Specific activities of U isotopes (^{234}U, ^{235}U, and ^{238}U) in the filter samples collected from Near Field Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{238}U	Jan. 14 – Feb. 2	5.07E-02	6.74E-03	1.25E-03	Detected
	Mar. 2 – Mar. 23	3.95E-02	4.94E-03	6.11E-04	Detected
	Mar. 23 – Apr. 20	4.06E-02	5.09E-03	8.15E-04	Detected
	Apr. 20 – May 18	3.88E-02	4.67E-03	6.79E-04	Detected
	May 18 – Jun. 30	3.12E-02	3.57E-03	2.26E-04	Detected
	Jun. 30 – Aug. 10	2.89E-02	3.57E-03	3.58E-04	Detected
	Aug. 10 – Sep. 2	4.38E-02	5.38E-03	7.65E-04	Detected
	Sep. 2 – Oct. 8	1.83E-02	2.76E-03	8.58E-04	Detected
	Oct. 8 – Oct. 26	6.50E-02	7.67E-03	8.34E-04	Detected
	Oct.26 – Nov. 2	3.83E-02	6.51E-03	3.51E-03	Detected
	Nov. 2 – Dec. 3	2.33E-02	2.93E-03	4.84E-04	Detected
	Dec. 3 - Dec. 23	1.20E-02	1.67E-03	6.14E-04	Detected
	Dec. 23 - Feb. 2	2.24E-02	2.67E-03	2.88E-04	Detected

Table B.33. Specific activities of U isotopes (^{234}U, ^{235}U, and ^{238}U) in the filter samples collected from Cactus Flats Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{234}U	Jan. 14 – Feb. 2	4.77E-02	6.10E-03	1.10E-03	Detected
	Feb. 2 – Mar. 2	4.47E-02	5.49E-03	5.07E-04	Detected
	Mar. 2 – Mar. 23	4.64E-02	5.54E-03	2.81E-04	Detected
	Mar. 23 – Apr. 20	4.70E-02	5.58E-03	2.92E-04	Detected
	Apr. 20 – May 18	4.99E-03	5.14E-04	3.32E-04	Detected
	May 18 – Jun. 30	1.61E-04	4.00E-03	3.40E-04	Not detected
	Jun. 30 – Aug. 10	3.32E-02	4.04E-03	4.41E-04	Detected
	Aug. 10 – Sep. 2	4.12E-02	5.10E-03	7.14E-04	Detected
	Sep. 2 – Oct. 8	3.34E-02	3.62E-03	2.11E-04	Detected
	Oct. 8 – Oct. 26	1.03E-01	1.20E-02	1.06E-03	Detected
	Oct.26 – Nov. 2	1.15E-01	1.42E-02	2.36E-03	Detected
	Nov. 2 – Dec. 3	2.41E-02	3.01E-03	7.21E-04	Detected
	Dec. 3 - Dec. 23	1.33E-02	1.69E-03	3.71E-04	Detected
	Dec. 23 - Feb. 2	2.43E-02	2.73E-03	2.03E-04	Detected
^{235}U	Jan. 14 – Feb. 2	2.10E-03	7.43E-04	7.24E-04	Detected
	Feb. 2 – Mar. 2	1.65E-03	5.50E-04	5.06E-04	Detected
	Mar. 2 – Mar. 23	1.38E-03	4.34E-04	4.63E-04	Detected
	Mar. 23 – Apr. 20	1.79E-03	4.81E-04	3.06E-04	Detected
	Apr. 20 – May 18	2.35E-03	5.64E-04	2.40E-04	Detected
	May 18 – Jun. 30	1.46E-03	3.39E-04	2.23E-04	Detected
	Jun. 30 – Aug. 10	1.90E-03	4.83E-04	3.27E-04	Detected
	Aug. 10 – Sep. 2	2.15E-03	6.49E-04	4.72E-04	Detected
	Sep. 2 – Oct. 8	2.10E-03	3.83E-04	1.40E-04	Detected
	Oct. 8 – Oct. 26	7.44E-03	1.48E-03	8.36E-04	Detected
	Oct.26 – Nov. 2	7.01E-03	2.06E-03	1.67E-03	Detected
	Nov. 2 – Dec. 3	1.63E-03	5.05E-04	5.57E-04	Detected
	Dec. 3 - Dec. 23	2.70E-03	5.54E-04	2.45E-04	Detected
	Dec. 23 - Feb. 2	1.68E-03	3.52E-04	1.60E-04	Detected

Table B.33. Specific activities of U isotopes (^{234}U, ^{235}U, and ^{238}U) in the filter samples collected from Cactus Flats Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{238}U	Jan. 14 – Feb. 2	4.61E-02	5.93E-03	1.36E-03	Detected
	Feb. 2 – Mar. 2	4.16E-02	5.15E-03	6.18E-04	Detected
	Mar. 2 – Mar. 23	3.68E-02	4.46E-03	3.74E-04	Detected
	Mar. 23 – Apr. 20	4.31E-02	5.14E-03	3.88E-04	Detected
	Apr. 20 – May 18	3.94E-02	4.79E-03	4.44E-04	Detected
	May 18 – Jun. 30	3.08E-02	3.63E-03	3.96E-04	Detected
	Jun. 30 – Aug. 10	3.22E-02	3.92E-03	3.98E-04	Detected
	Aug. 10 – Sep. 2	3.91E-02	4.86E-03	8.66E-04	Detected
	Sep. 2 – Oct. 8	1.62E-02	1.84E-03	2.56E-04	Detected
	Oct. 8 – Oct. 26	9.65E-02	1.13E-02	1.45E-03	Detected
	Oct.26 – Nov. 2	1.14E-01	1.41E-02	2.35E-03	Detected
	Nov. 2 – Dec. 3	2.16E-02	2.72E-03	6.11E-04	Detected
	Dec. 3 - Dec. 23	1.23E-02	1.58E-03	4.50E-04	Detected
	Dec. 23 - Feb. 2	2.27E-02	2.61E-03	2.84E-04	Detected

Table B.34. Specific activities of U isotopes (^{234}U, ^{235}U, and ^{238}U) in the filter samples collected from Loving Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{234}U	Jan. 14 – Feb. 2	4.22E-02	5.41E-03	9.39E-04	Detected
	Feb. 2 – Mar. 2	3.83E-02	4.60E-03	5.49E-04	Detected
	Mar. 2 – Mar. 23	4.28E-02	5.17E-03	3.18E-04	Detected
	Mar. 23 – Apr. 20	4.05E-02	4.80E-03	3.07E-04	Detected
	Apr. 20 – May 18	3.93E-02	4.77E-03	4.48E-04	Detected
	May 18 – Jun. 30	2.88E-02	3.33E-03	1.37E-04	Detected
	Jun. 30 – Aug. 10	2.35E-02	2.63E-03	1.28E-04	Detected
	Aug. 10 – Sep. 2	3.75E-02	4.73E-03	7.27E-04	Detected
	Sep. 2 – Oct. 8	1.78E-02	2.15E-03	2.99E-04	Detected
	Oct. 8 – Oct. 26	5.07E-02	5.87E-03	4.11E-04	Detected
	Oct.26 – Nov. 2	1.01E-01	1.23E-02	1.72E-03	Detected
	Nov. 2 – Dec. 3	2.99E-02	3.73E-03	7.72E-04	Detected
	Dec. 3 - Dec. 23	2.73E-02	3.71E-03	8.22E-04	Detected
	Dec. 23 - Feb. 2	2.40E-02	2.68E-03	1.99E-04	Detected
^{235}U	Jan. 14 – Feb. 2	1.93E-03	6.95E-04	8.53E-04	Detected
	Feb. 2 – Mar. 2	1.77E-03	4.96E-04	4.46E-04	Detected
	Mar. 2 – Mar. 23	1.44E-03	4.11E-04	3.18E-04	Detected
	Mar. 23 – Apr. 20	1.37E-03	3.92E-04	3.07E-04	Detected
	Apr. 20 – May 18	1.45E-03	4.35E-04	3.91E-04	Detected
	May 18 – Jun. 30	1.28E-03	2.82E-04	1.86E-04	Detected
	Jun. 30 – Aug. 10	9.91E-04	1.90E-04	1.09E-04	Detected
	Aug. 10 – Sep. 2	2.29E-03	6.52E-04	4.40E-04	Detected
	Sep. 2 – Oct. 8	1.27E-03	3.22E-04	1.53E-04	Detected
	Oct. 8 – Oct. 26	4.19E-03	7.96E-04	3.03E-04	Detected
	Oct.26 – Nov. 2	7.95E-03	1.94E-03	1.08E-03	Detected
	Nov. 2 – Dec. 3	3.91E-03	8.49E-04	4.63E-04	Detected
	Dec. 3 - Dec. 23	3.61E-03	9.17E-04	4.20E-04	Detected
	Dec. 23 - Feb. 2	1.04E-03	2.46E-04	1.07E-04	Detected

Table B.34. Specific activities of U isotopes (^{234}U, ^{235}U, and ^{238}U) in the filter samples collected from Loving Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{238}U	Jan. 14 – Feb. 2	4.32E-02	5.53E-03	1.03E-03	Detected
	Feb. 2 – Mar. 2	3.75E-02	4.51E-03	5.07E-04	Detected
	Mar. 2 – Mar. 23	3.60E-02	4.39E-03	3.88E-04	Detected
	Mar. 23 – Apr. 20	3.81E-02	4.53E-03	3.74E-04	Detected
	Apr. 20 – May 18	3.60E-02	4.40E-03	5.43E-04	Detected
	May 18 – Jun. 30	2.79E-02	3.24E-03	2.02E-04	Detected
	Jun. 30 – Aug. 10	2.34E-02	2.62E-03	1.24E-04	Detected
	Aug. 10 – Sep. 2	3.57E-02	4.52E-03	9.26E-04	Detected
	Sep. 2 – Oct. 8	1.64E-02	1.99E-03	2.83E-04	Detected
	Oct. 8 – Oct. 26	4.63E-02	5.33E-03	5.38E-04	Detected
	Oct.26 – Nov. 2	9.83E-02	1.20E-02	2.23E-03	Detected
	Nov. 2 – Dec. 3	2.75E-02	3.47E-03	9.43E-04	Detected
	Dec. 3 - Dec. 23	2.65E-02	3.62E-03	7.77E-04	Detected
	Dec. 23 - Feb. 2	2.17E-02	2.44E-03	2.37E-04	Detected

Table B.35. Specific activities of U isotopes (^{234}U, ^{235}U, and ^{238}U) in the filter samples collected from Carlsbad Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{234}U	Jan. 14 – Feb. 2	4.65E-02	5.82E-03	6.41E-04	Detected
	Feb. 2 – Mar. 2	4.48E-02	5.59E-03	7.88E-04	Detected
	Mar. 2 – Mar. 23	4.79E-02	5.76E-03	5.29E-04	Detected
	Mar. 23 – Apr. 20	4.33E-02	5.14E-03	4.80E-04	Detected
	Apr. 20 – May 18	4.47E-02	5.55E-03	7.70E-04	Detected
	May 18 – Jun. 30	3.55E-02	4.14E-03	2.55E-04	Detected
	Jun. 30 – Aug. 10	3.32E-02	3.99E-03	2.27E-04	Detected
	Aug. 10 – Sep. 2	3.95E-02	5.10E-04	6.15E-04	Detected
	Sep. 2 – Oct. 8	1.93E-02	2.43E-03	4.48E-04	Detected
	Oct. 8 – Oct. 26	3.22E-02	4.05E-03	7.47E-04	Detected
	Oct.26 – Nov. 2	7.57E-01	9.35E-02	1.57E-02	Detected
	Nov. 2 – Dec. 3	2.49E-02	3.20E-03	6.63E-04	Detected
	Dec. 3 - Dec. 23	2.95E-02	5.18E-03	2.46E-03	Detected
	Dec. 23 - Feb. 2	2.62E-02	3.02E-03	3.29E-04	Detected
^{235}U	Jan. 14 – Feb. 2	2.18E-03	7.10E-04	6.40E-04	Detected
	Feb. 2 – Mar. 2	1.27E-03	5.45E-04	7.46E-04	Detected
	Mar. 2 – Mar. 23	1.65E-03	4.72E-04	4.30E-04	Detected
	Mar. 23 – Apr. 20	1.87E-03	5.00E-04	4.00E-04	Detected
	Apr. 20 – May 18	1.72E-03	5.70E-04	6.35E-04	Detected
	May 18 – Jun. 30	1.32E-03	3.16E-04	1.98E-04	Detected
	Jun. 30 – Aug. 10	1.64E-03	4.40E-04	2.81E-04	Detected
	Aug. 10 – Sep. 2	1.67E-03	6.81E-04	8.98E-04	Detected
	Sep. 2 – Oct. 8	1.41E-03	4.12E-04	3.32E-04	Detected
	Oct. 8 – Oct. 26	5.52E-03	1.24E-03	4.84E-04	Detected
	Oct.26 – Nov. 2	4.10E-02	1.32E-02	1.37E-02	Detected
	Nov. 2 – Dec. 3	4.71E-03	9.60E-04	4.71E-04	Detected
	Dec. 3 - Dec. 23	3.09E-03	1.43E-03	1.74E-03	Detected
	Dec. 23 - Feb. 2	1.90E-03	4.17E-04	1.60E-04	Detected

Table B.35. Specific activities of U isotopes (^{234}U, ^{235}U, and ^{238}U) in the filter samples collected from Carlsbad Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{238}U	Jan. 14 – Feb. 2	4.59E-02	5.75E-03	7.81E-04	Detected
	Feb. 2 – Mar. 2	4.12E-02	5.18E-03	7.52E-04	Detected
	Mar. 2 – Mar. 23	4.19E-02	5.08E-03	4.89E-04	Detected
	Mar. 23 – Apr. 20	4.18E-02	4.98E-03	4.09E-04	Detected
	Apr. 20 – May 18	4.03E-02	5.04E-03	6.94E-04	Detected
	May 18 – Jun. 30	3.46E-02	4.04E-03	2.66E-04	Detected
	Jun. 30 – Aug. 10	3.16E-02	3.82E-03	2.99E-04	Detected
	Aug. 10 – Sep. 2	3.99E-02	5.14E-03	7.76E-04	Detected
	Sep. 2 – Oct. 8	1.84E-02	2.32E-03	4.04E-04	Detected
	Oct. 8 – Oct. 26	8.50E-02	9.94E-03	3.90E-04	Detected
	Oct.26 – Nov. 2	7.35E-01	9.11E-02	2.00E-02	Detected
	Nov. 2 – Dec. 3	2.33E-02	3.03E-03	9.41E-04	Detected
	Dec. 3 - Dec. 23	3.00E-02	5.33E-03	3.48E-03	Detected
	Dec. 23 - Feb. 2	2.58E-02	2.98E-03	4.58E-04	Detected

Table B.36. Specific activities of U isotopes (^{234}U, ^{235}U, and ^{238}U) in the filter samples collected from East Tower Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{234}U	Jan. 14 – Feb. 2	5.08E-02	6.45E-03	9.95E-04	Detected
	Feb. 2 – Mar. 2	4.61E-02	5.79E-03	6.82E-04	Detected
	Mar. 2 – Mar. 23	4.34E-02	5.12E-03	3.93E-04	Detected
	Mar. 23 – Apr. 20	4.36E-02	5.15E-03	3.15E-04	Detected
	Apr. 20 – May 18	4.35E-02	5.45E-03	3.64E-04	Detected
	May 18 – Jun. 30	3.44E-02	3.88E-03	1.56E-04	Detected
	Jun. 30 – Aug. 10	3.46E-02	4.23E-03	5.57E-04	Detected
	Aug. 10 – Sep. 2	4.60E-02	5.70E-03	7.52E-04	Detected
	Sep. 2 – Oct. 8	2.05E-02	2.53E-03	5.36E-04	Detected
	Oct. 8 – Oct. 26	8.37E-02	1.00E-02	1.13E-03	Detected
	Oct.26 – Nov. 2	2.83E-02	4.25E-03	9.12E-04	Detected
	Nov. 2 – Dec. 3	3.29E-02	4.34E-03	1.09E-03	Detected
	Dec. 3 - Dec. 23	1.18E-02	1.54E-03	4.10E-04	Detected
^{235}U	Jan. 14 – Feb. 2	2.38E-03	8.06E-04	8.28E-04	Detected
	Feb. 2 – Mar. 2	1.87E-03	6.13E-04	5.56E-04	Detected
	Mar. 2 – Mar. 23	1.82E-03	4.51E-04	3.72E-04	Detected
	Mar. 23 – Apr. 20	2.79E-03	6.01E-04	3.55E-04	Detected
	Apr. 20 – May 18	1.91E-03	5.84E-04	6.00E-04	Detected
	May 18 – Jun. 30	2.07E-03	3.71E-04	1.44E-04	Detected
	Jun. 30 – Aug. 10	1.61E-03	4.52E-04	3.02E-04	Detected
	Aug. 10 – Sep. 2	1.53E-03	5.56E-04	4.97E-04	Detected
	Sep. 2 – Oct. 8	1.01E-03	3.45E-04	4.14E-04	Detected
	Oct. 8 – Oct. 26	3.88E-03	1.09E-03	9.93E-04	Detected
	Oct.26 – Nov. 2	4.59E-03	1.43E-03	8.70E-04	Detected
	Nov. 2 – Dec. 3	1.12E-02	1.97E-03	6.10E-04	Detected
	Dec. 3 - Dec. 23	1.33E-03	3.71E-04	2.00E-04	Detected
	Dec. 23 - Feb. 2	1.83E-03	4.46E-04	3.63E-04	Detected

Table B.36. Specific activities of U isotopes (^{234}U, ^{235}U, and ^{238}U) in the filter samples collected from East Tower Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{238}U	Jan. 14 – Feb. 2	5.14E-02	6.51E-03	8.47E-04	Detected
	Feb. 2 – Mar. 2	4.22E-02	5.34E-03	9.76E-04	Detected
	Mar. 2 – Mar. 23	3.85E-02	4.57E-03	3.75E-04	Detected
	Mar. 23 – Apr. 20	4.02E-02	4.76E-03	4.05E-04	Detected
	Apr. 20 – May 18	4.10E-02	5.16E-03	4.84E-04	Detected
	May 18 – Jun. 30	3.20E-02	3.62E-03	1.76E-04	Detected
	Jun. 30 – Aug. 10	3.26E-02	4.00E-03	4.55E-04	Detected
	Aug. 10 – Sep. 2	4.04E-02	5.07E-03	6.29E-04	Detected
	Sep. 2 – Oct. 8	1.91E-02	2.36E-03	4.54E-04	Detected
	Oct. 8 – Oct. 26	7.29E-02	8.84E-03	1.44E-03	Detected
	Oct.26 – Nov. 2	2.99E-02	4.42E-03	7.02E-04	Detected
	Nov. 2 – Dec. 3	3.33E-02	4.38E-03	1.12E-03	Detected
	Dec. 3 - Dec. 23	1.05E-02	1.40E-03	5.70E-04	Detected
	Dec. 23 - Feb. 2	2.53E-02	3.02E-03	3.13E-04	Detected

Table B.37. Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Onsite Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{137}**Cs**	Jan. 14 – Feb. 2	-9.63E-07	6.89E-07	2.35E-06	Not detected
	Feb. 2 – Mar. 2	5.92E-07	1.86E-07	5.99E-07	Not detected
	Mar. 2 – Mar. 23	5.00E-07	5.29E-07	1.75E-06	Not detected
	Mar. 23 – Apr. 20	1.11E-06	2.78E-07	8.85E-07	Detected
	Apr. 20 – May 18	2.48E-06	8.96E-07	2.90E-06	Not detected
	May 18 – Jun. 30	-1.66E-06	3.95E-06	1.33E-05	Not detected
	Jun. 30 – Aug. 10	-4.91E-07	4.07E-07	1.38E-06	Not detected
	Aug. 10 – Sep. 2	3.11E-07	3.07E-07	1.02E-06	Not detected
	Sep. 2 – Oct. 8	6.48E-08	1.26E-07	4.22E-07	Not detected
	Oct. 8 – Oct. 26	7.08E-07	3.34E-07	1.09E-06	Not detected
	Oct. 26 - Nov. 2	-1.42E-06	1.94E-06	6.60E-06	Not detected
	Nov. 2 – Dec. 3	4.36E-07	2.24E-07	7.34E-07	Not detected
	Dec. 3 - Dec. 23	1.85E-07	2.23E-07	7.41E-07	Not detected
	Dec. 23 - Feb. 2	3.20E-07	1.27E-07	4.13E-07	Not detected
^{60}**Co**	Jan. 14 – Feb. 2	2.54E-07	5.09E-07	1.72E-06	Not detected
	Feb. 2 – Mar. 2	2.13E-07	1.70E-07	5.64E-07	Not detected
	Mar. 2 – Mar. 23	1.60E-07	4.27E-07	1.43E-06	Not detected
	Mar. 23 – Apr. 20	1.47E-06	3.40E-07	1.07E-06	Detected
	Apr. 20 – May 18	4.57E-07	6.66E-07	2.24E-06	Not detected
	May 18 – Jun. 30	5.30E-06	2.94E-06	9.62E-06	Not detected
	Jun. 30 – Aug. 10	4.24E-07	2.60E-07	8.54E-07	Not detected
	Aug. 10 – Sep. 2	-2.16E-07	2.42E-07	8.40E-07	Not detected
	Sep. 2 – Oct. 8	8.05E-08	1.18E-07	3.95E-07	Not detected
	Oct. 8 – Oct. 26	2.51E-07	2.17E-07	7.18E-07	Not detected
	Oct. 26 - Nov. 2	6.24E-07	1.76E-06	5.97E-06	Not detected
	Nov. 2 – Dec. 3	2.59E-07	2.54E-07	8.42E-07	Not detected
	Dec. 3 - Dec. 23	1.56E-07	3.03E-07	1.02E-06	Not detected
	Dec. 23 - Feb. 2	2.47E-07	1.20E-07	3.90E-07	Not detected

Table B.37. Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Onsite Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{40}K	Jan. 14 – Feb. 2	5.55E-05	7.97E-06	2.31E-05	Detected
	Feb. 2 – Mar. 2	2.57E-05	2.75E-06	8.01E-06	Detected
	Mar. 2 – Mar. 23	7.60E-05	7.97E-06	2.42E-05	Detected
	Mar. 23 – Apr. 20	7.66E-05	7.00E-06	2.06E-05	Detected
	Apr. 20 – May 18	1.37E-04	1.65E-05	5.01E-05	Detected
	May 18 – Jun. 30	1.46E-04	3.14E-05	9.44E-05	Detected
	Jun. 30 – Aug. 10	2.31E-05	3.57E-06	1.04E-05	Detected
	Aug. 10 – Sep. 2	-6.50E-06	6.18E-06	2.09E-05	Not detected
	Sep. 2 – Oct. 8	-2.77E-06	3.16E-06	1.07E-05	Not detected
	Oct. 8 – Oct. 26	3.47E-05	5.81E-06	1.81E-05	Detected
	Oct. 26 - Nov. 2	-1.25E-04	3.49E-05	1.22E-04	Not detected
	Nov. 2 – Dec. 3	2.75E-05	3.70E-06	1.14E-05	Detected
	Dec. 3 - Dec. 23	-9.14E-07	4.73E-06	1.59E-05	Not detected
	Dec. 23 - Feb. 2	4.51E-06	2.60E-06	8.53E-06	Not detected

Table B.38. Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Near Field Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{137}Cs	Jan. 14 – Feb. 2	5.26E-05	8.80E-06	2.59E-05	Detected
	Feb. 2 – Mar. 2	3.89E-05	9.12E-06	2.86E-05	Detected
	Mar. 2 – Mar. 23	1.33E-04	1.21E-05	3.20E-05	Detected
	Mar. 23 – Apr. 20	7.23E-05	5.93E-06	1.65E-05	Detected
	Apr. 20 – May 18	1.52E-04	1.36E-05	3.86E-05	Detected
	May 18 – Jun. 30	2.67E-05	3.67E-06	1.05E-05	Detected
	Jun. 30 – Aug. 10	4.08E-05	4.94E-06	1.50E-05	Detected
	Aug. 10 – Sep. 2	5.19E-05	7.84E-06	2.30E-05	Detected
	Sep. 2 – Oct. 8	3.66E-05	8.27E-06	2.57E-05	Detected
	Oct. 8 – Oct. 26	2.92E-05	6.19E-06	1.88E-05	Detected
	Oct. 26 - Nov. 2	7.66E-07	2.75E-06	9.17E-06	Not detected
	Nov. 2 – Dec. 3	-9.31E-08	4.86E-07	1.64E-06	Not detected
	Dec. 3 - Dec. 23	7.50E-07	8.66E-07	2.87E-06	Not detected
	Dec. 23 - Feb. 2	-5.72E-07	3.29E-07	1.13E-06	Not detected
^{60}Co	Jan. 14 – Feb. 2	-8.43E-07	6.07E-07	2.16E-06	Not detected
	Feb. 2 – Mar. 2	-7.79E-07	5.96E-07	2.08E-06	Not detected
	Mar. 2 – Mar. 23	1.63E-06	6.70E-07	2.17E-06	Not detected
	Mar. 23 – Apr. 20	5.40E-09	2.40E-07	8.20E-07	Not detected
	Apr. 20 – May 18	-5.70E-07	6.15E-07	2.14E-06	Not detected
	May 18 – Jun. 30	5.34E-07	2.49E-07	8.08E-07	Not detected
	Jun. 30 – Aug. 10	-9.72E-09	2.40E-07	8.15E-07	Not detected
	Aug. 10 – Sep. 2	4.06E-07	5.47E-07	1.85E-06	Not detected
	Sep. 2 – Oct. 8	4.72E-07	5.69E-07	1.92E-06	Not detected
	Oct. 8 – Oct. 26	2.35E-08	5.27E-07	1.81E-06	Not detected
	Oct. 26 - Nov. 2	1.20E-06	1.86E-06	6.25E-06	Not detected
	Nov. 2 – Dec. 3	-1.15E-07	3.97E-07	1.37E-06	Not detected
	Dec. 3 - Dec. 23	9.31E-07	6.70E-07	2.22E-06	Not detected
	Dec. 23 - Feb. 2	4.08E-07	2.88E-07	9.52E-07	Not detected

Table B.38. Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Near Field Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{40}K	Jan. 14 – Feb. 2	5.26E-05	8.80E-06	2.59E-05	Detected
	Feb. 2 – Mar. 2	3.89E-05	9.12E-06	2.86E-05	Detected
	Mar. 2 – Mar. 23	1.33E-04	1.21E-05	3.20E-05	Detected
	Mar. 23 – Apr. 20	7.23E-05	5.93E-06	1.65E-05	Detected
	Apr. 20 – May 18	1.52E-04	1.36E-05	3.86E-05	Detected
	May 18 – Jun. 30	2.67E-05	3.67E-06	1.05E-05	Detected
	Jun. 30 – Aug. 10	4.08E-05	4.94E-06	1.50E-05	Detected
	Aug. 10 – Sep. 2	5.19E-05	7.84E-06	2.30E-05	Detected
	Sep. 2 – Oct. 8	3.66E-05	8.27E-06	2.57E-05	Detected
	Oct. 8 – Oct. 26	2.92E-05	6.19E-06	1.88E-05	Detected
	Oct. 26 - Nov. 2	-6.41E-05	4.03E-05	1.37E-04	Not detected
	Nov. 2 – Dec. 3	4.61E-05	5.43E-06	1.53E-05	Detected
	Dec. 3 - Dec. 23	8.56E-06	6.09E-06	2.01E-05	Not detected
	Dec. 23 - Feb. 2	4.46E-06	2.35E-06	7.67E-06	Not detected

Table B.39. Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Cactus Flats Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{137}Cs	Jan. 14 – Feb. 2	1.54E-06	4.36E-07	1.40E-06	Detected
	Feb. 2 – Mar. 2	9.99E-07	3.74E-07	1.22E-06	Not detected
	Mar. 2 – Mar. 23	1.71E-06	6.22E-07	2.03E-06	Not detected
	Mar. 23 – Apr. 20	1.10E-06	7.78E-07	2.56E-06	Not detected
	Apr. 20 – May 18	6.22E-07	8.75E-07	2.91E-06	Not detected
	May 18 – Jun. 30	-1.69E-07	3.64E-07	1.23E-06	Not detected
	Jun. 30 – Aug. 10	7.81E-07	4.53E-07	1.49E-06	Not detected
	Aug. 10 – Sep. 2	-2.13E-06	1.08E-06	3.67E-06	Not detected
	Sep. 2 – Oct. 8	-1.31E-06	7.42E-07	2.49E-06	Not detected
	Oct. 8 – Oct. 26	-2.83E-06	1.15E-06	3.91E-06	Not detected
	Oct.26 – Nov. 2	9.74E-07	8.14E-07	2.69E-06	Not detected
	Nov. 2 – Dec. 3	4.04E-07	1.74E-07	5.67E-07	Not detected
	Dec. 3 - Dec. 23	-1.11E-06	6.58E-07	2.26E-06	Not detected
	Dec. 23 - Feb. 2	2.29E-07	1.64E-07	5.41E-07	Not detected
^{60}Co	Jan. 14 – Feb. 2	1.37E-07	3.05E-07	1.03E-06	Not detected
	Feb. 2 – Mar. 2	-2.46E-08	3.17E-07	1.07E-06	Not detected
	Mar. 2 – Mar. 23	4.84E-07	4.18E-07	1.39E-06	Not detected
	Mar. 23 – Apr. 20	4.78E-07	5.16E-07	1.73E-06	Not detected
	Apr. 20 – May 18	8.00E-07	4.93E-07	1.62E-06	Not detected
	May 18 – Jun. 30	-1.86E-08	2.54E-07	8.74E-07	Not detected
	Jun. 30 – Aug. 10	3.65E-07	3.42E-07	1.14E-06	Not detected
	Aug. 10 – Sep. 2	1.92E-07	7.24E-07	2.45E-06	Not detected
	Sep. 2 – Oct. 8	6.48E-07	4.78E-07	1.58E-06	Not detected
	Oct. 8 – Oct. 26	1.06E-06	9.51E-07	3.16E-06	Not detected
	Oct.26 – Nov. 2	9.63E-07	6.84E-07	2.26E-06	Not detected
	Nov. 2 – Dec. 3	1.71E-07	1.76E-07	5.88E-07	Not detected
	Dec. 3 - Dec. 23	6.81E-07	6.06E-07	2.02E-06	Not detected
	Dec. 23 - Feb. 2	2.36E-07	1.56E-07	5.13E-07	Not detected

Table B.39. Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Cactus Flats Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/m3	Unc. (2σ) Bq/m3	MDC Bq/m3	Status
^{40}K	Jan. 14 – Feb. 2	5.13E-05	7.41E-06	2.28E-05	Detected
	Feb. 2 – Mar. 2	5.60E-05	7.16E-06	2.21E-05	Detected
	Mar. 2 – Mar. 23	1.18E-04	1.16E-05	3.52E-05	Detected
	Mar. 23 – Apr. 20	5.65E-05	7.84E-06	2.27E-05	Detected
	Apr. 20 – May 18	5.14E-05	7.64E-06	2.22E-05	Detected
	May 18 – Jun. 30	3.10E-05	3.97E-06	1.13E-05	Detected
	Jun. 30 – Aug. 10	5.58E-05	8.42E-06	2.62E-05	Detected
	Aug. 10 – Sep. 2	9.71E-05	1.58E-05	4.94E-05	Detected
	Sep. 2 – Oct. 8	4.22E-05	8.03E-06	2.52E-05	Detected
	Oct. 8 – Oct. 26	1.30E-04	1.52E-05	4.59E-05	Detected
	Oct.26 – Nov. 2	1.84E-05	1.54E-05	5.09E-05	Not detected
	Nov. 2 – Dec. 3	2.01E-05	3.41E-06	1.07E-05	Detected
	Dec. 3 - Dec. 23	3.95E-06	4.79E-06	1.61E-05	Not detected
	Dec. 23 - Feb. 2	-2.57E-06	2.66E-06	9.00E-06	Not detected

Table B.40. Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Loving Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{137}Cs	Jan. 14 – Feb. 2	8.42E-07	4.02E-07	1.32E-06	Not detected
	Feb. 2 – Mar. 2	-4.48E-07	1.91E-07	6.49E-07	Not detected
	Mar. 2 – Mar. 23	1.50E-06	5.54E-07	1.81E-06	Not detected
	Mar. 23 – Apr. 20	-4.30E-07	1.21E-06	4.06E-06	Not detected
	Apr. 20 – May 18	-1.23E-06	1.24E-06	4.18E-06	Not detected
	May 18 – Jun. 30	-2.58E-07	3.72E-07	1.26E-06	Not detected
	Jun. 30 – Aug. 10	3.39E-08	4.01E-07	1.35E-06	Not detected
	Aug. 10 – Sep. 2	8.05E-07	3.02E-07	9.78E-07	Not detected
	Sep. 2 – Oct. 8	-1.65E-06	5.61E-07	1.92E-06	Not detected
	Oct. 8 – Oct. 26	1.00E-06	3.08E-07	9.90E-07	Detected
	Oct.26 – Nov. 2	-1.66E-06	1.85E-06	6.28E-06	Not detected
	Nov. 2 – Dec. 3	2.34E-07	5.11E-07	1.71E-06	Not detected
	Dec. 3 - Dec. 23	6.75E-07	3.25E-07	1.06E-06	Not detected
	Dec. 23 - Feb. 2	3.88E-07	4.30E-07	1.43E-06	Not detected
^{60}Co	Jan. 14 – Feb. 2	2.34E-07	2.81E-07	9.41E-07	Not detected
	Feb. 2 – Mar. 2	1.98E-07	1.30E-07	4.30E-07	Not detected
	Mar. 2 – Mar. 23	2.74E-07	3.08E-07	1.03E-06	Not detected
	Mar. 23 – Apr. 20	8.51E-08	6.19E-07	2.10E-06	Not detected
	Apr. 20 – May 18	1.27E-06	6.46E-07	2.11E-06	Not detected
	May 18 – Jun. 30	1.54E-07	2.57E-07	8.68E-07	Not detected
	Jun. 30 – Aug. 10	-4.00E-08	2.90E-07	9.97E-07	Not detected
	Aug. 10 – Sep. 2	-1.38E-08	2.29E-07	7.84E-07	Not detected
	Sep. 2 – Oct. 8	2.49E-07	3.60E-07	1.21E-06	Not detected
	Oct. 8 – Oct. 26	2.67E-07	3.56E-07	1.19E-06	Not detected
	Oct.26 – Nov. 2	8.19E-07	1.60E-06	5.44E-06	Not detected
	Nov. 2 – Dec. 3	3.04E-07	4.12E-07	1.39E-06	Not detected
	Dec. 3 - Dec. 23	3.89E-07	3.07E-07	1.02E-06	Not detected
	Dec. 23 - Feb. 2	1.94E-07	2.95E-07	9.98E-07	Not detected

Table B.40. Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Loving Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{40}K	Jan. 14 – Feb. 2	4.17E-05	5.83E-06	1.78E-05	Detected
	Feb. 2 – Mar. 2	2.87E-05	3.10E-06	9.31E-06	Detected
	Mar. 2 – Mar. 23	8.12E-05	7.76E-06	2.34E-05	Detected
	Mar. 23 – Apr. 20	1.73E-04	1.52E-05	4.45E-05	Detected
	Apr. 20 – May 18	1.48E-04	1.45E-05	4.29E-05	Detected
	May 18 – Jun. 30	2.81E-05	3.91E-06	1.13E-05	Detected
	Jun. 30 – Aug. 10	-3.89E-05	9.16E-06	3.16E-05	Not detected
	Aug. 10 – Sep. 2	-5.93E-06	6.43E-06	2.16E-05	Not detected
	Sep. 2 – Oct. 8	6.67E-05	8.07E-06	2.45E-05	Detected
	Oct. 8 – Oct. 26	1.20E-05	6.05E-06	1.98E-05	Not detected
	Oct.26 – Nov. 2	3.31E-05	1.34E-05	4.31E-05	Not detected
	Nov. 2 – Dec. 3	5.03E-05	5.66E-06	1.57E-05	Detected
	Dec. 3 - Dec. 23	4.42E-06	5.88E-06	1.95E-05	Not detected
	Dec. 23 - Feb. 2	4.75E-06	2.55E-06	8.32E-06	Not detected

Table B.41. Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Carlsbad Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{137}Cs	Jan. 14 – Feb. 2	8.88E-07	8.09E-07	2.68E-06	Not detected
	Feb. 2 – Mar. 2	5.39E-08	4.60E-07	1.53E-06	Not detected
	Mar. 2 – Mar. 23	1.44E-06	6.92E-07	2.26E-06	Not detected
	Mar. 23 – Apr. 20	1.16E-06	3.31E-07	1.06E-06	Detected
	Apr. 20 – May 18	5.08E-06	1.15E-06	3.67E-06	Detected
	May 18 – Jun. 30	1.32E-06	4.36E-07	1.41E-06	Not detected
	Jun. 30 – Aug. 10	6.77E-08	4.01E-07	1.34E-06	Not detected
	Aug. 10 – Sep. 2	6.25E-07	8.19E-07	2.72E-06	Not detected
	Sep. 2 – Oct. 8	2.17E-07	1.55E-07	5.10E-07	Not detected
	Oct. 8 – Oct. 26	-1.56E-06	7.68E-07	2.64E-06	Not detected
	Oct.26 – Nov. 2	3.47E-06	1.13E-06	3.66E-06	Not detected
	Nov. 2 – Dec. 3	9.06E-07	2.37E-07	7.58E-07	Detected
	Dec. 3 - Dec. 23	-6.30E-07	9.33E-07	3.15E-06	Not detected
	Dec. 23 - Feb. 2	-1.44E-06	1.65E-05	5.53E-05	Not detected
^{60}Co	Jan. 14 – Feb. 2	2.60E-07	4.99E-07	1.69E-06	Not detected
	Feb. 2 – Mar. 2	-3.27E-07	3.18E-07	1.10E-06	Not detected
	Mar. 2 – Mar. 23	9.21E-07	7.56E-07	2.50E-06	Not detected
	Mar. 23 – Apr. 20	4.39E-07	2.53E-07	8.32E-07	Not detected
	Apr. 20 – May 18	-2.98E-07	6.94E-07	2.38E-06	Not detected
	May 18 – Jun. 30	4.27E-08	3.75E-07	1.27E-06	Not detected
	Jun. 30 – Aug. 10	5.81E-07	2.69E-07	8.72E-07	Not detected
	Aug. 10 – Sep. 2	1.12E-06	5.58E-07	1.81E-06	Not detected
	Sep. 2 – Oct. 8	2.52E-07	1.54E-07	5.07E-07	Not detected
	Oct. 8 – Oct. 26	-2.95E-07	5.95E-07	2.08E-06	Not detected
	Oct.26 – Nov. 2	3.43E-07	7.22E-07	2.45E-06	Not detected
	Nov. 2 – Dec. 3	2.71E-07	2.22E-07	7.37E-07	Not detected
	Dec. 3 - Dec. 23	8.00E-07	6.88E-07	2.29E-06	Not detected
	Dec. 23 - Feb. 2	1.17E-05	1.24E-05	4.16E-05	Not detected

Table B.41. Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Carlsbad Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{40}K	Jan. 14 – Feb. 2	5.35E-05	8.02E-06	2.35E-05	Detected
	Feb. 2 – Mar. 2	2.17E-05	4.75E-06	1.48E-05	Detected
	Mar. 2 – Mar. 23	1.35E-04	1.17E-05	3.04E-05	Detected
	Mar. 23 – Apr. 20	6.79E-05	6.49E-06	1.91E-05	Detected
	Apr. 20 – May 18	1.58E-04	1.73E-05	5.20E-05	Detected
	May 18 – Jun. 30	5.03E-05	8.58E-06	2.70E-05	Detected
	Jun. 30 – Aug. 10	1.64E-05	3.70E-06	1.14E-05	Detected
	Aug. 10 – Sep. 2	4.34E-05	6.71E-06	1.94E-05	Detected
	Sep. 2 – Oct. 8	1.24E-05	3.05E-06	9.80E-06	Detected
	Oct. 8 – Oct. 26	3.92E-05	6.85E-06	2.01E-05	Detected
	Oct.26 – Nov. 2	2.67E-05	1.60E-05	5.27E-05	Not detected
	Nov. 2 – Dec. 3	2.82E-05	4.80E-06	1.51E-05	Detected
	Dec. 3 - Dec. 23	8.44E-06	5.81E-06	1.92E-05	Not detected
	Dec. 23 - Feb. 2	1.46E-04	1.03E-04	3.40E-04	Not detected

Table B.42. Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from East Tower Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{137}Cs	Jan. 14 – Feb. 2	1.66E-07	4.47E-07	1.49E-06	Not detected
	Feb. 2 – Mar. 2	2.91E-07	4.42E-07	1.47E-06	Not detected
	Mar. 2 – Mar. 23	-1.60E-07	4.80E-07	1.60E-06	Not detected
	Mar. 23 – Apr. 20	4.71E-06	1.04E-06	3.29E-06	Detected
	Apr. 20 – May 18	1.95E-06	9.77E-07	3.20E-06	Not detected
	May 18 – Jun. 30	1.58E-06	5.31E-07	1.72E-06	Not detected
	Jun. 30 – Aug. 10	-2.82E-07	4.81E-07	1.61E-06	Not detected
	Aug. 10 – Sep. 2	-2.32E-06	1.38E-06	4.63E-06	Not detected
	Sep. 2 – Oct. 8	-5.53E-07	4.13E-07	1.40E-06	Not detected
	Oct. 8 – Oct. 26	-2.88E-06	1.10E-06	3.76E-06	Not detected
	Oct.26 – Nov. 2	-4.16E-07	1.84E-06	6.20E-06	Not detected
	Nov. 2 – Dec. 3	2.39E-07	4.55E-07	1.52E-06	Not detected
	Dec. 3 - Dec. 23	4.89E-07	2.33E-07	7.61E-07	Not detected
	Dec. 23 - Feb. 2	3.40E-07	1.48E-07	4.81E-07	Not detected
^{60}Co	Jan. 14 – Feb. 2	3.45E-07	2.83E-07	9.38E-07	Not detected
	Feb. 2 – Mar. 2	6.58E-07	3.06E-07	9.99E-07	Not detected
	Mar. 2 – Mar. 23	9.47E-08	2.64E-07	8.86E-07	Not detected
	Mar. 23 – Apr. 20	-3.56E-07	6.08E-07	2.10E-06	Not detected
	Apr. 20 – May 18	5.03E-08	6.05E-07	2.06E-06	Not detected
	May 18 – Jun. 30	-4.15E-07	3.00E-07	1.06E-06	Not detected
	Jun. 30 – Aug. 10	1.93E-07	2.67E-07	8.94E-07	Not detected
	Aug. 10 – Sep. 2	4.31E-07	6.67E-07	2.25E-06	Not detected
	Sep. 2 – Oct. 8	7.52E-08	2.70E-07	9.25E-07	Not detected
	Oct. 8 – Oct. 26	1.14E-06	6.15E-07	2.01E-06	Not detected
	Oct.26 – Nov. 2	1.16E-06	1.24E-06	4.15E-06	Not detected
	Nov. 2 – Dec. 3	7.67E-07	3.72E-07	1.21E-06	Not detected
	Dec. 3 - Dec. 23	4.89E-07	2.78E-07	9.11E-07	Not detected
	Dec. 23 - Feb. 2	2.96E-08	1.41E-07	4.79E-07	Not detected

Table B.42. Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from East Tower Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{40}K	Jan. 14 – Feb. 2	4.20E-05	5.52E-06	1.68E-05	Detected
	Feb. 2 – Mar. 2	4.58E-05	6.23E-06	1.92E-05	Detected
	Mar. 2 – Mar. 23	6.39E-05	6.28E-06	1.85E-05	Detected
	Mar. 23 – Apr. 20	1.72E-04	1.40E-05	3.89E-05	Detected
	Apr. 20 – May 18	1.48E-04	1.38E-05	3.95E-05	Detected
	May 18 – Jun. 30	-3.32E-05	8.61E-06	2.97E-05	Not detected
	Jun. 30 – Aug. 10	3.59E-05	4.85E-06	1.49E-05	Detected
	Aug. 10 – Sep. 2	9.96E-05	1.53E-05	4.73E-05	Detected
	Sep. 2 – Oct. 8	2.28E-05	3.74E-06	1.11E-05	Detected
	Oct. 8 – Oct. 26	1.38E-04	1.54E-05	4.61E-05	Detected
	Oct.26 – Nov. 2	7.52E-05	1.58E-05	4.76E-05	Detected
	Nov. 2 – Dec. 3	3.58E-05	4.51E-06	1.27E-05	Detected
	Dec. 3 - Dec. 23	1.53E-05	5.24E-06	1.70E-05	Not detected
	Dec. 23 - Feb. 2	-2.01E-06	2.93E-06	9.89E-06	Not detected

Table B.43. Specific activities of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Onsite Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{137}Cs	Jan. 14 – Feb. 2	-1.91E-02	1.36E-02	4.67E-02	Not detected
	Feb. 2 – Mar. 2	1.93E-02	6.05E-03	1.95E-02	Not detected
	Mar. 2 – Mar. 23	5.97E-03	6.31E-03	2.09E-02	Not detected
	Mar. 23 – Apr. 20	1.11E-02	2.78E-03	8.85E-03	Detected
	Apr. 20 – May 18	4.09E-02	1.48E-02	4.78E-02	Not detected
	May 18 – Jun. 30	-1.85E-03	4.41E-03	1.49E-02	Not detected
	Jun. 30 – Aug. 10	-9.42E-03	7.81E-03	2.65E-02	Not detected
	Aug. 10 – Sep. 2	6.50E-03	6.42E-03	2.13E-02	Not detected
	Sep. 2 – Oct. 8	1.32E-03	2.57E-03	8.59E-03	Not detected
	Oct. 8 – Oct. 26	1.58E-02	7.44E-03	2.43E-02	Not detected
	Oct.26 – Nov. 2	-2.67E-02	3.64E-02	1.24E-01	Not detected
	Nov. 2 – Dec. 3	8.13E-03	4.17E-03	1.37E-02	Not detected
	Dec. 3 - Dec. 23	2.64E-03	3.17E-03	1.06E-02	Not detected
	Dec. 23 - Feb. 2	7.97E-03	3.16E-03	1.03E-02	Not detected
^{60}Co	Jan. 14 – Feb. 2	5.04E-03	1.01E-02	3.42E-02	Not detected
	Feb. 2 – Mar. 2	6.94E-03	5.55E-03	1.84E-02	Not detected
	Mar. 2 – Mar. 23	1.91E-03	5.10E-03	1.70E-02	Not detected
	Mar. 23 – Apr. 20	1.47E-02	3.40E-03	1.07E-02	Detected
	Apr. 20 – May 18	7.52E-03	1.10E-02	3.68E-02	Not detected
	May 18 – Jun. 30	5.91E-03	3.28E-03	1.07E-02	Not detected
	Jun. 30 – Aug. 10	8.13E-03	4.98E-03	1.64E-02	Not detected
	Aug. 10 – Sep. 2	-4.52E-03	5.06E-03	1.76E-02	Not detected
	Sep. 2 – Oct. 8	1.64E-03	2.39E-03	8.05E-03	Not detected
	Oct. 8 – Oct. 26	5.59E-03	4.82E-03	1.60E-02	Not detected
	Oct.26 – Nov. 2	1.17E-02	3.30E-02	1.12E-01	Not detected
	Nov. 2 – Dec. 3	4.82E-03	4.73E-03	1.57E-02	Not detected
	Dec. 3 - Dec. 23	2.22E-03	4.31E-03	1.45E-02	Not detected
	Dec. 23 - Feb. 2	6.16E-03	2.99E-03	9.72E-03	Not detected

Table B.43. Specific activities of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Onsite Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{40}K	Jan. 14 – Feb. 2	1.10E+00	1.58E-01	4.59E-01	Detected
	Feb. 2 – Mar. 2	8.39E-01	8.97E-02	2.61E-01	Detected
	Mar. 2 – Mar. 23	9.07E-01	9.51E-02	2.89E-01	Detected
	Mar. 23 – Apr. 20	7.66E-01	7.00E-02	2.06E-01	Detected
	Apr. 20 – May 18	2.26E+00	2.71E-01	8.25E-01	Detected
	May 18 – Jun. 30	1.63E-01	3.50E-02	1.05E-01	Detected
	Jun. 30 – Aug. 10	4.44E-01	6.84E-02	1.99E-01	Detected
	Aug. 10 – Sep. 2	-1.36E-01	1.29E-01	4.38E-01	Not Detected
	Sep. 2 – Oct. 8	-5.64E-02	6.43E-02	2.17E-01	Not detected
	Oct. 8 – Oct. 26	7.74E-01	1.29E-01	4.04E-01	Detected
	Oct.26 – Nov. 2	-2.35E+00	6.54E-01	2.28E+00	Not detected
	Nov. 2 – Dec. 3	5.13E-01	6.90E-02	2.12E-01	Detected
	Dec. 3 - Dec. 23	-1.30E-02	6.74E-02	2.26E-01	Not detected
	Dec. 23 - Feb. 2	1.12E-01	6.46E-02	2.12E-01	Not detected

Table B.44. Specific activities of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Near Field Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{137}Cs	Jan. 14 – Feb. 2	-3.71E-04	2.23E-02	7.48E-02	Not detected
	Feb. 2 – Mar. 2	-3.52E-02	1.70E-02	5.81E-02	Not detected
	Mar. 2 – Mar. 23	3.00E-02	8.10E-03	2.59E-02	Detected
	Mar. 23 – Apr. 20	3.21E-02	7.29E-03	2.33E-02	Detected
	Apr. 20 – May 18	2.84E-02	1.25E-02	4.07E-02	Not detected
	May 18 – Jun. 30	3.04E-03	7.99E-03	2.66E-02	Not detected
	Jun. 30 – Aug. 10	5.39E-03	1.17E-02	3.89E-02	Not detected
	Aug. 10 – Sep. 2	1.47E-02	1.70E-02	5.67E-02	Not detected
	Sep. 2 – Oct. 8	-1.22E-02	1.53E-02	5.20E-02	Not detected
	Oct. 8 – Oct. 26	4.13E-02	2.24E-02	7.34E-02	Not detected
	Oct.26 – Nov. 2	1.36E-02	4.89E-02	1.63E-01	Not detected
	Nov. 2 – Dec. 3	-1.98E-03	1.04E-02	3.48E-02	Not detected
	Dec. 3 - Dec. 23	1.38E-02	1.60E-02	5.30E-02	Not detected
	Dec. 23 - Feb. 2	-1.64E-02	9.40E-03	3.23E-02	Not detected
^{60}Co	Jan. 14 – Feb. 2	-1.93E-02	1.39E-02	4.93E-02	Not detected
	Feb. 2 – Mar. 2	-1.69E-02	1.29E-02	4.51E-02	Not detected
	Mar. 2 – Mar. 23	1.97E-02	8.10E-03	2.63E-02	Not detected
	Mar. 23 – Apr. 20	8.98E-05	3.99E-03	1.36E-02	Not detected
	Apr. 20 – May 18	-7.87E-03	8.50E-03	2.96E-02	Not detected
	May 18 – Jun. 30	9.28E-03	4.33E-03	1.40E-02	Not detected
	Jun. 30 – Aug. 10	-2.46E-04	6.08E-03	2.06E-02	Not detected
	Aug. 10 – Sep. 2	9.54E-03	1.29E-02	4.34E-02	Not detected
	Sep. 2 – Oct. 8	9.87E-03	1.19E-02	4.02E-02	Not detected
	Oct. 8 – Oct. 26	5.49E-04	1.23E-02	4.23E-02	Not detected
	Oct.26 – Nov. 2	2.14E-02	3.31E-02	1.11E-01	Not detected
	Nov. 2 – Dec. 3	-2.46E-03	8.45E-03	2.92E-02	Not detected
	Dec. 3 - Dec. 23	1.72E-02	1.23E-02	4.09E-02	Not detected
	Dec. 23 - Feb. 2	1.16E-02	8.22E-03	2.72E-02	Not detected

Table B.44. Specific activities of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Near Field Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{40}K	Jan. 14 – Feb. 2	1.20E+00	2.01E-01	5.92E-01	Detected
	Feb. 2 – Mar. 2	8.43E-01	1.98E-01	6.19E-01	Detected
	Mar. 2 – Mar. 23	1.61E+00	1.46E-01	3.87E-01	Detected
	Mar. 23 – Apr. 20	1.20E+00	9.85E-02	2.75E-01	Detected
	Apr. 20 – May 18	2.10E+00	1.88E-01	5.33E-01	Detected
	May 18 – Jun. 30	4.64E-01	6.38E-02	1.82E-01	Detected
	Jun. 30 – Aug. 10	1.03E+00	1.25E-01	3.80E-01	Detected
	Aug. 10 – Sep. 2	1.22E+00	1.84E-01	5.41E-01	Detected
	Sep. 2 – Oct. 8	7.66E-01	1.73E-01	5.37E-01	Detected
	Oct. 8 – Oct. 26	6.82E-01	1.45E-01	4.38E-01	Detected
	Oct.26 – Nov. 2	-1.14E+00	7.17E-01	2.44E+00	Not detected
	Nov. 2 – Dec. 3	9.81E-01	1.16E-01	3.26E-01	Detected
	Dec. 3 - Dec. 23	1.58E-01	1.12E-01	3.71E-01	Not detected
	Dec. 23 - Feb. 2	1.28E-01	6.72E-02	2.19E-01	Not detected

Table B.45. Specific activities of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Cactus Flats Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{137}Cs	Jan. 14 – Feb. 2	3.07E-02	8.69E-03	2.80E-02	Detected
	Feb. 2 – Mar. 2	2.03E-02	7.61E-03	2.48E-02	Not detected
	Mar. 2 – Mar. 23	1.61E-02	5.86E-03	1.91E-02	Not detected
	Mar. 23 – Apr. 20	1.69E-02	1.20E-02	3.95E-02	Not detected
	Apr. 20 – May 18	8.31E-03	1.17E-02	3.88E-02	Not detected
	May 18 – Jun. 30	-2.86E-03	6.17E-03	2.08E-02	Not detected
	Jun. 30 – Aug. 10	2.11E-02	1.23E-02	4.03E-02	Not detected
	Aug. 10 – Sep. 2	-5.44E-02	2.78E-02	9.40E-02	Not detected
	Sep. 2 – Oct. 8	-3.30E-02	1.87E-02	6.28E-02	Not detected
	Oct. 8 – Oct. 26	-7.34E-02	2.99E-02	1.01E-01	Not detected
	Oct.26 – Nov. 2	1.75E-02	1.46E-02	4.83E-02	Not detected
	Nov. 2 – Dec. 3	1.02E-02	4.38E-03	1.43E-02	Not detected
	Dec. 3 - Dec. 23	-1.72E-02	1.02E-02	3.52E-02	Not detected
	Dec. 23 - Feb. 2	4.94E-03	3.54E-03	1.17E-02	Not detected
^{60}Co	Jan. 14 – Feb. 2	2.74E-03	6.08E-03	2.05E-02	Not detected
	Feb. 2 – Mar. 2	-5.00E-04	6.44E-03	2.18E-02	Not detected
	Mar. 2 – Mar. 23	4.56E-03	3.94E-03	1.31E-02	Not detected
	Mar. 23 – Apr. 20	7.36E-03	7.94E-03	2.66E-02	Not detected
	Apr. 20 – May 18	1.07E-02	6.58E-03	2.16E-02	Not detected
	May 18 – Jun. 30	-3.15E-04	4.31E-03	1.48E-02	Not detected
	Jun. 30 – Aug. 10	9.89E-03	9.25E-03	3.08E-02	Not detected
	Aug. 10 – Sep. 2	4.92E-03	1.85E-02	6.27E-02	Not detected
	Sep. 2 – Oct. 8	1.63E-02	1.21E-02	3.99E-02	Not detected
	Oct. 8 – Oct. 26	2.74E-02	2.46E-02	8.18E-02	Not detected
	Oct.26 – Nov. 2	1.72E-02	1.22E-02	4.05E-02	Not detected
	Nov. 2 – Dec. 3	4.30E-03	4.44E-03	1.48E-02	Not detected
	Dec. 3 - Dec. 23	1.06E-02	9.43E-03	3.15E-02	Not detected
	Dec. 23 - Feb. 2	5.09E-03	3.36E-03	1.11E-02	Not detected

Table B.45. Specific activities of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Cactus Flats Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{40}K	Jan. 14 – Feb. 2	1.02E+00	1.48E-01	4.56E-01	Detected
	Feb. 2 – Mar. 2	1.14E+00	1.46E-01	4.50E-01	Detected
	Mar. 2 – Mar. 23	1.11E+00	1.09E-01	3.32E-01	Detected
	Mar. 23 – Apr. 20	8.69E-01	1.21E-01	3.49E-01	Detected
	Apr. 20 – May 18	6.87E-01	1.02E-01	2.96E-01	Detected
	May 18 – Jun. 30	5.26E-01	6.72E-02	1.91E-01	Detected
	Jun. 30 – Aug. 10	1.51E+00	2.28E-01	7.08E-01	Detected
	Aug. 10 – Sep. 2	2.49E+00	4.05E-01	1.27E+00	Detected
	Sep. 2 – Oct. 8	1.06E+00	2.03E-01	6.37E-01	Detected
	Oct. 8 – Oct. 26	3.36E+00	3.94E-01	1.19E+00	Detected
	Oct.26 – Nov. 2	3.29E-01	2.76E-01	9.11E-01	Not detected
	Nov. 2 – Dec. 3	5.06E-01	8.58E-02	2.68E-01	Detected
	Dec. 3 - Dec. 23	6.14E-02	7.45E-02	2.51E-01	Not detected
	Dec. 23 - Feb. 2	-5.54E-02	5.74E-02	1.94E-01	Not detected

Table B.46. Specific activities of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Loving Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{137}Cs	Jan. 14 – Feb. 2	1.57E-02	7.53E-03	2.46E-02	Not Detected
	Feb. 2 – Mar. 2	-1.47E-02	6.25E-03	2.12E-02	Not detected
	Mar. 2 – Mar. 23	1.64E-02	6.08E-03	1.98E-02	Not detected
	Mar. 23 – Apr. 20	-5.79E-03	1.64E-02	5.47E-02	Not detected
	Apr. 20 – May 18	-1.57E-02	1.59E-02	5.33E-02	Not detected
	May 18 – Jun. 30	-3.53E-03	5.09E-03	1.72E-02	Not detected
	Jun. 30 – Aug. 10	3.41E-04	4.03E-03	1.35E-02	Not detected
	Aug. 10 – Sep. 2	1.58E-02	5.92E-03	1.91E-02	Not detected
	Sep. 2 – Oct. 8	-3.40E-02	1.16E-02	3.97E-02	Not detected
	Oct. 8 – Oct. 26	1.66E-02	5.09E-03	1.64E-02	Detected
	Oct.26 – Nov. 2	-2.34E-02	2.60E-02	8.84E-02	Not detected
	Nov. 2 – Dec. 3	3.43E-03	7.48E-03	2.50E-02	Not detected
	Dec. 3 - Dec. 23	8.35E-03	4.02E-03	1.32E-02	Not detected
	Dec. 23 - Feb. 2	6.71E-03	7.43E-03	2.46E-02	Not detected
	Nov. 2 – Dec. 3	0.00E+00	0.00E+00	0.00E+00	Not detected
^{60}Co	Jan. 14 – Feb. 2	4.37E-03	5.26E-03	1.76E-02	Not detected
	Feb. 2 – Mar. 2	6.50E-03	4.27E-03	1.41E-02	Not detected
	Mar. 2 – Mar. 23	3.00E-03	3.38E-03	1.12E-02	Not detected
	Mar. 23 – Apr. 20	1.15E-03	8.33E-03	2.83E-02	Not detected
	Apr. 20 – May 18	1.62E-02	8.25E-03	2.69E-02	Not detected
	May 18 – Jun. 30	2.11E-03	3.52E-03	1.19E-02	Not detected
	Jun. 30 – Aug. 10	-4.02E-04	2.92E-03	1.00E-02	Not detected
	Aug. 10 – Sep. 2	-2.70E-04	4.49E-03	1.53E-02	Not detected
	Sep. 2 – Oct. 8	5.14E-03	7.43E-03	2.50E-02	Not detected
	Oct. 8 – Oct. 26	4.42E-03	5.88E-03	1.96E-02	Not detected
	Oct.26 – Nov. 2	1.15E-02	2.26E-02	7.66E-02	Not detected
	Nov. 2 – Dec. 3	4.45E-03	6.02E-03	2.03E-02	Not detected
	Dec. 3 - Dec. 23	4.81E-03	3.80E-03	1.26E-02	Not detected
	Dec. 23 - Feb. 2	3.36E-03	5.11E-03	1.72E-02	Not detected

Table B.46. Specific activities of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Loving Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{40}K	Jan. 14 – Feb. 2	7.81E-01	1.09E-01	3.32E-01	Detected
	Feb. 2 – Mar. 2	9.40E-01	1.02E-01	3.05E-01	Detected
	Mar. 2 – Mar. 23	8.91E-01	8.51E-02	2.57E-01	Detected
	Mar. 23 – Apr. 20	2.33E+00	2.05E-01	5.99E-01	Detected
	Apr. 20 – May 18	1.88E+00	1.85E-01	5.47E-01	Detected
	May 18 – Jun. 30	3.84E-01	5.36E-02	1.55E-01	Detected
	Jun. 30 – Aug. 10	-3.92E-01	9.21E-02	3.17E-01	Not detected
	Aug. 10 – Sep. 2	-1.16E-01	1.26E-01	4.24E-01	Not detected
	Sep. 2 – Oct. 8	1.38E+00	1.66E-01	5.06E-01	Detected
	Oct. 8 – Oct. 26	1.98E-01	1.00E-01	3.28E-01	Not detected
	Oct.26 – Nov. 2	4.65E-01	1.89E-01	6.06E-01	Not detected
	Nov. 2 – Dec. 3	7.36E-01	8.29E-02	2.29E-01	Detected
	Dec. 3 - Dec. 23	5.48E-02	7.28E-02	2.42E-01	Not detected
	Dec. 23 - Feb. 2	8.22E-02	4.41E-02	1.44E-01	Not detected

Table B.47. Specific activities of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Carlsbad Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{137}Cs	Jan. 14 – Feb. 2	2.13E-02	1.94E-02	6.43E-02	Not detected
	Feb. 2 – Mar. 2	2.29E-03	1.96E-02	6.52E-02	Not detected
	Mar. 2 – Mar. 23	1.81E-02	8.73E-03	2.85E-02	Not detected
	Mar. 23 – Apr. 20	1.86E-02	5.29E-03	1.70E-02	Detected
	Apr. 20 – May 18	8.24E-02	1.86E-02	5.95E-02	detected
	May 18 – Jun. 30	2.31E-02	7.61E-03	2.46E-02	Not detected
	Jun. 30 – Aug. 10	2.12E-03	1.26E-02	4.20E-02	Not detected
	Aug. 10 – Sep. 2	1.59E-02	2.08E-02	6.93E-02	Not detected
	Sep. 2 – Oct. 8	5.72E-03	4.09E-03	1.34E-02	Not detected
	Oct. 8 – Oct. 26	-3.09E-02	1.52E-02	5.23E-02	Not detected
	Oct.26 – Nov. 2	5.60E-02	1.82E-02	5.89E-02	Not detected
	Nov. 2 – Dec. 3	1.44E-02	3.78E-03	1.21E-02	Detected
	Dec. 3 - Dec. 23	-1.09E-02	1.61E-02	5.45E-02	Not detected
	Dec. 23 - Feb. 2	-9.53E-04	1.09E-02	3.66E-02	Not detected
	Nov. 2 – Dec. 3	0.00E+00	0.00E+00	0.00E+00	Not detected
^{60}Co	Jan. 14 – Feb. 2	6.23E-03	1.20E-02	4.06E-02	Not detected
	Feb. 2 – Mar. 2	-1.39E-02	1.35E-02	4.67E-02	Not detected
	Mar. 2 – Mar. 23	1.16E-02	9.53E-03	3.15E-02	Not detected
	Mar. 23 – Apr. 20	7.03E-03	4.06E-03	1.33E-02	Not detected
	Apr. 20 – May 18	-4.84E-03	1.13E-02	3.86E-02	Not detected
	May 18 – Jun. 30	7.45E-04	6.54E-03	2.22E-02	Not detected
	Jun. 30 – Aug. 10	1.82E-02	8.43E-03	2.73E-02	Not detected
	Aug. 10 – Sep. 2	2.85E-02	1.42E-02	4.62E-02	Not detected
	Sep. 2 – Oct. 8	6.65E-03	4.06E-03	1.33E-02	Not detected
	Oct. 8 – Oct. 26	-5.84E-03	1.18E-02	4.11E-02	Not detected
	Oct.26 – Nov. 2	5.52E-03	1.16E-02	3.95E-02	Not detected
	Nov. 2 – Dec. 3	4.32E-03	3.53E-03	1.17E-02	Not detected
	Dec. 3 - Dec. 23	1.38E-02	1.19E-02	3.96E-02	Not detected
	Dec. 23 - Feb. 2	7.78E-03	8.23E-03	2.76E-02	Not detected

Table B.47. Specific activities of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from Carlsbad Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{40}K	Jan. 14 – Feb. 2	1.28E+00	1.92E-01	5.65E-01	Detected
	Feb. 2 – Mar. 2	9.20E-01	2.02E-01	6.30E-01	Detected
	Mar. 2 – Mar. 23	1.70E+00	1.47E-01	3.83E-01	Detected
	Mar. 23 – Apr. 20	1.09E+00	1.04E-01	3.06E-01	Detected
	Apr. 20 – May 18	2.56E+00	2.80E-01	8.44E-01	Detected
	May 18 – Jun. 30	8.76E-01	1.50E-01	4.70E-01	Detected
	Jun. 30 – Aug. 10	5.13E-01	1.16E-01	3.58E-01	Detected
	Aug. 10 – Sep. 2	1.11E+00	1.71E-01	4.93E-01	Detected
	Sep. 2 – Oct. 8	3.27E-01	8.05E-02	2.58E-01	Detected
	Oct. 8 – Oct. 26	7.75E-01	1.36E-01	3.98E-01	Detected
	Oct.26 – Nov. 2	4.31E-01	2.58E-01	8.49E-01	Not Detected
	Nov. 2 – Dec. 3	4.50E-01	7.65E-02	2.40E-01	Detected
	Dec. 3 - Dec. 23	1.46E-01	1.00E-01	3.32E-01	Not detected
	Dec. 23 - Feb. 2	9.66E-02	6.81E-02	2.25E-01	Not detected

Table B.48. Specific activities of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from East Tower Station

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{137}Cs	Jan. 14 – Feb. 2	3.81E-03	1.02E-02	3.40E-02	Not detected
	Feb. 2 – Mar. 2	5.45E-03	8.27E-03	2.74E-02	Not detected
	Mar. 2 – Mar. 23	-1.79E-03	5.35E-03	1.78E-02	Not detected
	Mar. 23 – Apr. 20	6.64E-02	1.46E-02	4.64E-02	Detected
	Apr. 20 – May 18	2.64E-02	1.32E-02	4.33E-02	Not detected
	May 18 – Jun. 30	2.60E-02	8.74E-03	2.83E-02	Not detected
	Jun. 30 – Aug. 10	-8.07E-03	1.38E-02	4.60E-02	Not detected
	Aug. 10 – Sep. 2	-5.55E-02	3.30E-02	1.11E-01	Not detected
	Sep. 2 – Oct. 8	-1.40E-02	1.05E-02	3.56E-02	Not detected
	Oct. 8 – Oct. 26	-5.93E-02	2.26E-02	7.73E-02	Not detected
	Oct.26 – Nov. 2	-7.08E-03	3.14E-02	1.06E-01	Not detected
	Nov. 2 – Dec. 3	5.34E-03	1.02E-02	3.38E-02	Not detected
	Dec. 3 - Dec. 23	9.12E-03	4.34E-03	1.42E-02	Not detected
	Dec. 23 - Feb. 2	7.64E-03	3.33E-03	1.08E-02	Not detected
^{60}Co	Jan. 14 – Feb. 2	7.90E-03	6.48E-03	2.15E-02	Not detected
	Feb. 2 – Mar. 2	1.23E-02	5.72E-03	1.87E-02	Not detected
	Mar. 2 – Mar. 23	1.06E-03	2.94E-03	9.88E-03	Not detected
	Mar. 23 – Apr. 20	-5.02E-03	8.57E-03	2.97E-02	Not detected
	Apr. 20 – May 18	6.80E-04	8.19E-03	2.79E-02	Not detected
	May 18 – Jun. 30	-6.83E-03	4.94E-03	1.75E-02	Not detected
	Jun. 30 – Aug. 10	5.53E-03	7.65E-03	2.56E-02	Not detected
	Aug. 10 – Sep. 2	1.03E-02	1.60E-02	5.38E-02	Not detected
	Sep. 2 – Oct. 8	1.91E-03	6.84E-03	2.34E-02	Not detected
	Oct. 8 – Oct. 26	2.35E-02	1.26E-02	4.14E-02	Not detected
	Oct.26 – Nov. 2	1.98E-02	2.11E-02	7.06E-02	Not detected
	Nov. 2 – Dec. 3	1.71E-02	8.32E-03	2.70E-02	Not detected
	Dec. 3 - Dec. 23	9.12E-03	5.18E-03	1.70E-02	Not detected
	Dec. 23 - Feb. 2	6.67E-04	3.17E-03	1.08E-02	Not detected

Table B.48. Specific activities of gamma emitting isotopes (^{137}Cs, ^{60}Co, and ^{40}K) in the filter samples collected from East Tower Station (continued)

Radionuclide	Sample Date 2021	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{40}K	Jan. 14 – Feb. 2	9.63E-01	1.26E-01	3.85E-01	Detected
	Feb. 2 – Mar. 2	8.56E-01	1.16E-01	3.59E-01	Detected
	Mar. 2 – Mar. 23	7.12E-01	6.99E-02	2.07E-01	Detected
	Mar. 23 – Apr. 20	2.42E+00	1.97E-01	5.48E-01	Detected
	Apr. 20 – May 18	2.01E+00	1.87E-01	5.35E-01	Detected
	May 18 – Jun. 30	-5.46E-01	1.42E-01	4.89E-01	Not detected
	Jun. 30 – Aug. 10	1.03E+00	1.39E-01	4.27E-01	Detected
	Aug. 10 – Sep. 2	2.38E+00	3.66E-01	1.13E+00	Detected
	Sep. 2 – Oct. 8	5.77E-01	9.48E-02	2.81E-01	Detected
	Oct. 8 – Oct. 26	2.84E+00	3.16E-01	9.49E-01	Detected
	Oct.26 – Nov. 2	1.28E+00	2.69E-01	8.10E-01	Detected
	Nov. 2 – Dec. 3	7.99E-01	1.01E-01	2.83E-01	Detected
	Dec. 3 - Dec. 23	2.86E-01	9.76E-02	3.16E-01	Not detected
	Dec. 23 - Feb. 2	-4.53E-02	6.60E-02	2.23E-01	Not detected

Table B.49. Activity concentrations of ^{90}Sr (Bq/m^3) at Onsite Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{90}Sr	Jan. 14 – Feb. 2	1.70E-04	1.65E-05	2.42E-04	Not detected
	Feb. 2 – Mar. 2	7.83E-05	7.76E-06	1.27E-04	Not detected
	Mar. 2 – Mar. 23	1.98E-04	1.80E-05	2.50E-04	Not detected
	Mar. 23 – Apr. 20	2.32E-04	1.95E-05	2.35E-04	Not detected
	Apr. 20 – May 18	1.95E-04	1.74E-05	2.39E-04	Not detected
	May 18 – Jun. 30	8.71E-04	8.43E-05	1.28E-03	Not detected
	Jun. 30 – Aug. 10	9.19E-05	8.59E-06	1.19E-04	Not detected
	Aug. 10 – Sep. 2	2.76E-04	2.09E-05	2.39E-04	Detected
	Sep. 2 – Oct. 8	7.56E-05	7.61E-06	1.19E-04	Not detected
	Oct. 8 – Oct. 26	1.89E-04	1.68E-05	2.26E-04	Not detected
	Nov. 2 – Dec. 3	9.76E-05	9.53E-06	1.37E-04	Not detected
	Dec. 3 – Dec. 23	1.52E-04	1.42E-05	1.84E-04	Not detected
	Dec. 23 – Feb. 2	3.35E-04	3.02E-05	3.66E-04	Not detected

Table B.50. Specific activities of ^{90}Sr (Bq/g) at Onsite Station

Radionuclide	Sample Date 2021	^{90}Sr Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{90}Sr	Jan. 14 – Feb. 2	3.37E+00	3.27E-01	4.81E+00	Not detected
	Feb. 2 – Mar. 2	2.55E+00	2.53E-01	4.13E+00	Not detected
	Mar. 2 – Mar. 23	2.36E+00	2.15E-01	2.98E+00	Not detected
	Mar. 23 – Apr. 20	2.32E+00	1.95E-01	2.35E+00	Not detected
	Apr. 20 – May 18	3.20E+00	2.86E-01	3.93E+00	Not detected
	May 18 – Jun. 30	9.72E-01	9.40E-02	1.43E+00	Not detected
	Jun. 30 – Aug. 10	1.76E+00	1.65E-01	2.29E+00	Not detected
	Aug. 10 – Sep. 2	5.77E+00	4.37E-01	5.00E+00	Detected
	Sep. 2 – Oct. 8	1.54E+00	1.55E-01	2.43E+00	Not detected
	Oct. 8 – Oct. 26	4.21E+00	3.75E-01	5.03E+00	Not detected
	Nov. 2 – Dec. 3	1.82E+00	1.78E-01	2.55E+00	Not detected
	Dec. 3 – Dec. 23	2.16E+00	2.02E-01	2.62E+00	Not detected
	Dec. 23 – Feb. 2	3.18E+00	2.86E-01	3.47E+00	Not detected

Table B.51. Activity concentrations of ^{90}Sr (Bq/m^3) at Near Field Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{90}Sr	Jan. 14 – Feb. 2	2.09E-04	6.47E-07	2.98E-04	Not detected
	Feb. 2 – Mar. 2	1.46E-04	5.57E-07	2.39E-04	Not detected
	Mar. 2 – Mar. 23	2.30E-04	5.14E-07	2.54E-04	Not detected
	Mar. 23 – Apr. 20	2.16E-04	4.74E-07	2.35E-04	Not detected
	Apr. 20 – May 18	1.57E-04	5.42E-07	2.39E-04	Not detected
	May 18 – Jun. 30	7.56E-05	2.73E-08	1.19E-04	Not detected
	Jun. 30 – Aug. 10	8.65E-05	2.62E-07	1.19E-04	Not detected
	Aug. 10 – Sep. 2	2.32E-04	4.45E-07	2.39E-04	Not detected
	Sep. 2 – Oct. 8	1.66E-04	5.64E-07	2.53E-04	Not detected
	Oct. 8 – Oct. 26	1.69E-04	5.31E-07	2.41E-04	Not detected
	Nov. 2 – Dec. 3	1.54E-04	2.82E-07	1.52E-04	Detected
	Dec. 3 – Dec. 23	1.54E-04	3.64E-07	1.78E-04	Not detected
	Dec. 23 – Feb. 2	1.06E-04	2.34E-07	1.16E-04	Not detected

Table B.52. Specific activities of ^{90}Sr (Bq/g) at Near Field Station

Radionuclide	Sample Date 2021	^{90}Sr Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{90}Sr	Jan. 14 – Feb. 2	4.77E+00	1.48E-02	6.80E+00	Not detected
	Feb. 2 – Mar. 2	3.16E+00	1.21E-02	5.18E+00	Not detected
	Mar. 2 – Mar. 23	2.78E+00	6.22E-03	3.08E+00	Not detected
	Mar. 23 – Apr. 20	3.59E+00	7.89E-03	3.91E+00	Not detected
	Apr. 20 – May 18	2.16E+00	7.48E-03	3.30E+00	Not detected
	May 18 – Jun. 30	1.31E+00	4.74E-04	2.07E+00	Not detected
	Jun. 30 – Aug. 10	2.19E+00	6.62E-03	3.02E+00	Not detected
	Aug. 10 – Sep. 2	5.46E+00	1.05E-02	5.61E+00	Not detected
	Sep. 2 – Oct. 8	3.48E+00	1.18E-02	5.29E+00	Not detected
	Oct. 8 – Oct. 26	3.94E+00	1.24E-02	5.62E+00	Not detected
	Nov. 2 – Dec. 3	3.28E+00	6.00E-03	3.24E+00	Detected
	Dec. 3 – Dec. 23	2.85E+00	6.72E-03	3.27E+00	Not detected
	Dec. 23 – Feb. 2	3.02E+00	6.68E-03	3.30E+00	Not detected

Table B.53. Activity concentrations of ^{90}Sr (Bq/m^3) at Cactus Flats Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{90}Sr	Jan. 14 – Feb. 2	1.96E-04	6.28E-07	2.89E-04	Not detected
	Feb. 2 – Mar. 2	1.84E-04	4.96E-07	2.39E-04	Not detected
	Mar. 2 – Mar. 23	2.78E-04	6.90E-07	3.41E-04	Not detected
	Mar. 23 – Apr. 20	2.27E-04	4.60E-07	2.39E-04	Not detected
	Apr. 20 – May 18	1.56E-04	5.74E-07	2.46E-04	Not detected
	May 18 – Jun. 30	8.11E-05	2.65E-07	1.19E-04	Not detected
	Jun. 30 – Aug. 10	6.75E-05	2.84E-07	1.19E-04	Not detected
	Aug. 10 – Sep. 2	1.73E-04	5.15E-07	2.39E-04	Not detected
	Sep. 2 – Oct. 8	1.22E-04	2.25E-07	1.19E-04	Detected
	Oct. 8 – Oct. 26	1.44E-04	5.19E-07	2.28E-04	Not detected
	Oct.26 – Nov.2	5.42E-04	1.26E-06	6.05E-04	Not detected
	Nov. 2 – Dec. 3	1.37E-04	2.45E-07	1.32E-04	Detected
	Dec. 3 – Dec. 23	1.65E-04	4.04E-07	1.94E-04	Not detected
	Dec. 23 – Feb. 2	1.11E-04	2.54E-07	1.24E-04	Not detected

Table B.54. Specific activities of ^{90}Sr (Bq/g) at Cactus Flats Station

Radionuclide	Sample Date 2021	^{90}Sr Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{90}Sr	Jan. 14 – Feb. 2	3.91E+00	1.25E-02	5.76E+00	Not detected
	Feb. 2 – Mar. 2	3.73E+00	1.01E-02	4.85E+00	Not detected
	Mar. 2 – Mar. 23	2.62E+00	6.49E-03	3.21E+00	Not detected
	Mar. 23 – Apr. 20	3.49E+00	7.08E-03	3.67E+00	Not detected
	Apr. 20 – May 18	2.08E+00	7.65E-03	3.29E+00	Not detected
	May 18 – Jun. 30	1.37E+00	4.49E-03	2.02E+00	Not detected
	Jun. 30 – Aug. 10	1.83E+00	7.69E-03	3.23E+00	Not detected
	Aug. 10 – Sep. 2	4.43E+00	1.32E-02	6.11E+00	Not detected
	Sep. 2 – Oct. 8	3.07E+00	5.68E-03	3.01E+00	Detected
	Oct. 8 – Oct. 26	3.74E+00	1.34E-02	5.90E+00	Not detected
	Oct.26 – Nov.2	9.72E+00	2.27E-02	1.08E+01	Not detected
	Nov. 2 – Dec. 3	3.45E+00	6.16E-03	3.33E+00	Detected
	Dec. 3 – Dec. 23	2.56E+00	6.29E-03	3.02E+00	Not detected
	Dec. 23 – Feb. 2	2.39E+00	5.47E-03	2.68E+00	Not detected

Table B.55. Activity concentrations of ^{90}Sr (Bq/m^3) at Loving Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{90}Sr	Jan. 14 – Feb. 2	1.89E-04	4.88E-07	2.39E-04	Not detected
	Feb. 2 – Mar. 2	9.46E-05	2.51E-07	1.19E-04	Not detected
	Mar. 2 – Mar. 23	1.78E-04	5.15E-07	2.39E-04	Not detected
	Mar. 23 – Apr. 20	1.73E-04	5.19E-07	2.39E-04	Not detected
	Apr. 20 – May 18	1.35E-04	5.73E-07	2.39E-04	Not detected
	May 18 – Jun. 30	1.00E-04	2.39E-07	1.19E-04	Not detected
	Jun. 30 – Aug. 10	8.38E-05	2.59E-07	1.19E-04	Not detected
	Aug. 10 – Sep. 2	2.00E-04	4.78E-07	2.39E-04	Not detected
	Sep. 2 – Oct. 8	1.19E-04	2.21E-07	1.19E-04	Not detected
	Oct. 8 – Oct. 26	1.63E-04	5.30E-07	2.41E-04	Not detected
	Oct.26 – Nov.2	3.90E-04	1.42E-06	6.05E-04	Not detected
	Nov. 2 – Dec. 3	1.40E-04	3.37E-07	1.65E-04	Not detected
	Dec. 3 – Dec. 23	2.40E-04	5.24E-07	2.62E-04	Not detected
	Dec. 23 – Feb. 2	1.52E-04	3.52E-07	1.71E-04	Not detected

Table B.56. Specific activities of ^{90}Sr (Bq/g) at Loving Station

Radionuclide	Sample Date 2021	^{90}Sr Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{90}Sr	Jan. 14 – Feb. 2	3.54E+00	9.13E-03	4.47E+00	Not detected
	Feb. 2 – Mar. 2	3.10E+00	8.22E-03	3.91E+00	Not detected
	Mar. 2 – Mar. 23	1.96E+00	5.65E-03	2.62E+00	Not detected
	Mar. 23 – Apr. 20	2.33E+00	6.99E-03	3.21E+00	Not detected
	Apr. 20 – May 18	1.72E+00	7.31E-03	3.05E+00	Not detected
	May 18 – Jun. 30	1.37E+00	3.27E-03	1.64E+00	Not detected
	Jun. 30 – Aug. 10	8.42E-01	2.60E-03	1.20E+00	Not detected
	Aug. 10 – Sep. 2	3.91E+00	9.36E-03	4.67E+00	Not detected
	Sep. 2 – Oct. 8	2.45E+00	4.55E-03	2.46E+00	Not detected
	Oct. 8 – Oct. 26	2.70E+00	8.75E-03	3.98E+00	Not detected
	Oct.26 – Nov.2	5.49E+00	1.99E-02	8.52E+00	Not detected
	Nov. 2 – Dec. 3	2.05E+00	4.94E-03	2.41E+00	Not detected
	Dec. 3 – Dec. 23	2.96E+00	6.49E-03	3.24E+00	Not detected
	Dec. 23 – Feb. 2	2.63E+00	6.09E-03	2.95E+00	Not detected

Table B.57. Activity concentrations of ^{90}Sr (Bq/m^3) at Carlsbad Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{90}Sr	Jan. 14 – Feb. 2	1.78E-04	5.01E-07	2.39E-04	Not detected
	Feb. 2 – Mar. 2	9.19E-05	2.53E-07	1.19E-04	Not detected
	Mar. 2 – Mar. 23	1.84E-04	5.01E-07	2.39E-04	Not detected
	Mar. 23 – Apr. 20	2.11E-04	4.73E-07	2.39E-04	Not detected
	Apr. 20 – May 18	1.68E-04	5.28E-07	2.39E-04	Not detected
	May 18 – Jun. 30	7.83E-05	2.70E-07	1.19E-04	Not detected
	Jun. 30 – Aug. 10	8.38E-05	2.63E-07	1.19E-04	Not detected
	Aug. 10 – Sep. 2	1.89E-04	4.91E-07	2.39E-04	Not detected
	Sep. 2 – Oct. 8	8.92E-05	2.56E-07	1.19E-04	Not detected
	Oct. 8 – Oct. 26	1.68E-04	6.02E-07	2.65E-04	Not detected
	Oct.26 – Nov.2	4.45E-04	1.47E-06	6.45E-04	Not detected
	Nov. 2 – Dec. 3	1.59E-04	3.59E-07	1.77E-04	Not detected
	Dec. 3 – Dec. 23	1.74E-04	3.56E-07	1.81E-04	Not detected
	Dec. 23 – Feb. 2	1.12E-04	2.62E-07	1.26E-04	Not detected

Table B.58. Specific activities of ^{90}Sr (Bq/g) at Carlsbad Station

Radionuclide	Sample Date 2021	^{90}Sr Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{90}Sr	Jan. 14 – Feb. 2	4.28E+00	1.20E-02	5.73E+00	Not detected
	Feb. 2 – Mar. 2	3.90E+00	1.08E-02	5.07E+00	Not detected
	Mar. 2 – Mar. 23	2.32E+00	6.32E-03	3.01E+00	Not detected
	Mar. 23 – Apr. 20	3.38E+00	7.57E-03	3.82E+00	Not detected
	Apr. 20 – May 18	2.72E+00	8.56E-03	3.87E+00	Not detected
	May 18 – Jun. 30	1.37E+00	4.70E-03	2.08E+00	Not detected
	Jun. 30 – Aug. 10	2.62E+00	8.24E-03	3.74E+00	Not detected
	Aug. 10 – Sep. 2	4.81E+00	1.25E-02	6.07E+00	Not detected
	Sep. 2 – Oct. 8	2.35E+00	6.75E-03	3.14E+00	Not detected
	Oct. 8 – Oct. 26	3.32E+00	1.19E-02	5.24E+00	Not detected
	Oct.26 – Nov.2	7.17E+00	2.36E-02	1.04E+01	Not detected
	Nov. 2 – Dec. 3	2.53E+00	5.72E-03	2.82E+00	Not detected
	Dec. 3 – Dec. 23	3.01E+00	6.15E-03	3.13E+00	Not detected
	Dec. 23 – Feb. 2	2.76E+00	6.44E-03	3.10E+00	Not detected

Table B.59. Activity concentrations of ^{90}Sr (Bq/m^3) at East Tower Station

Radionuclide	Sample Date 2021	Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{90}Sr	Jan. 14 – Feb. 2	1.86E-04	5.50E-07	2.56E-04	Not detected
	Feb. 2 – Mar. 2	1.78E-04	5.08E-07	2.39E-04	Not detected
	Mar. 2 – Mar. 23	1.58E-04	5.38E-07	2.41E-04	Not detected
	Mar. 23 – Apr. 20	2.16E-04	4.73E-07	2.39E-04	Not detected
	Apr. 20 – May 18	1.62E-04	5.29E-07	2.39E-04	Not detected
	May 18 – Jun. 30	1.08E-04	2.32E-07	1.19E-04	Not detected
	Jun. 30 – Aug. 10	7.02E-05	2.80E-07	1.19E-04	Not detected
	Aug. 10 – Sep. 2	1.62E-04	5.27E-07	2.39E-04	Not detected
	Sep. 2 – Oct. 8	8.92E-05	2.48E-07	1.19E-04	Not detected
	Oct. 8 – Oct. 26	1.94E-04	4.78E-07	2.27E-04	Not detected
	Nov. 2 – Dec. 3	1.16E-04	2.96E-07	1.40E-04	Not detected
	Dec. 3 – Dec. 23	1.31E-04	3.10E-07	1.49E-04	Not detected
	Dec. 23 – Feb. 2	1.18E-04	2.55E-07	1.29E-04	Not detected

Table B.60. Specific activities of ^{90}Sr (Bq/g) at East Tower Station

Radionuclide	Sample Date 2021	^{90}Sr Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{90}Sr	Jan. 14 – Feb. 2	4.25E+00	1.26E-02	5.87E+00	Not detected
	Feb. 2 – Mar. 2	3.33E+00	9.50E-03	4.46E+00	Not detected
	Mar. 2 – Mar. 23	1.76E+00	6.00E-03	2.68E+00	Not detected
	Mar. 23 – Apr. 20	3.05E+00	6.66E-03	3.37E+00	Not detected
	Apr. 20 – May 18	2.19E+00	7.16E-03	3.23E+00	Not detected
	May 18 – Jun. 30	1.78E+00	3.82E-03	1.96E+00	Not detected
	Jun. 30 – Aug. 10	2.01E+00	8.02E-03	3.41E+00	Not detected
	Aug. 10 – Sep. 2	3.88E+00	1.26E-02	5.72E+00	Not detected
	Sep. 2 – Oct. 8	2.26E+00	6.28E-03	3.02E+00	Not detected
	Oct. 8 – Oct. 26	3.98E+00	9.83E-03	4.67E+00	Not detected
	Nov. 2 – Dec. 3	2.59E+00	6.61E-03	3.13E+00	Not detected
	Dec. 3 – Dec. 23	2.45E+00	5.79E-03	2.77E+00	Not detected
	Dec. 23 – Feb. 2	2.65E+00	5.74E-03	2.90E+00	Not detected

APPENDIX C - SOIL MONITORING

Actinide concentrations in soil samples

Uranium concentrations in soil samples

Gamma radionuclide concentrations in soil samples

Strontium concentrations in soil samples

Table C.1. Activity concentrations of ^{241}Am, $^{239+240}Pu$, and ^{238}Pu (Bq/kg) in soil samples collected from Cactus Flats in the vicinity of the WIPP site.

Radionuclide	Grid Node	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
^{241}Am	C-1	5/26/2021	2.00E-01	6.26E-02	6.33E-02	Detected
	C-2	5/26/2021	4.18E-02	3.25E-02	6.05E-02	Not detected
	C-3	5/26/2021	9.56E-02	4.45E-02	6.79E-02	Detected
	C-4	4/23/2021	1.24E-01	4.15E-02	4.49E-02	Detected
	C-5	4/23/2021	5.45E-02	3.21E-02	5.53E-02	Not detected
	C-6	4/23/2021	1.34E-01	3.99E-02	1.86E-02	Detected
	C-7	6/2/2021	6.38E-02	3.09E-02	4.22E-02	Detected
	C-8	6/2/2021	9.38E-02	3.86E-02	4.95E-02	Detected
	C-3 Dup	6/2/2021	9.56E-02	4.35E-02	6.41E-02	Detected
	D-1	4/14/2021	5.42E-02	3.21E-02	5.44E-02	Not detected
	D-2	4/14/2021	6.47E-02	3.65E-02	6.34E-02	Detected
	D-3	4/14/2021	1.30E-02	3.56E-02	8.52E-02	Not detected
	D-4	4/14/2021	9.25E-02	3.63E-02	4.47E-02	Detected
	D-5	4/14/2021	1.25E-01	4.42E-02	5.46E-02	Detected
	D-6	4/23/2021	6.53E-02	3.06E-02	3.84E-02	Detected
	D-7	6/2/2021	5.17E-02	2.75E-02	3.45E-02	Detected
	D-8	6/2/2021	3.66E-02	2.95E-02	5.66E-02	Not detected
	D-6 Dup	4/23/2021	8.10E-02	4.66E-02	8.27E-02	Not detected
$^{239+240}Pu$	C-1	5/26/2021	9.68E-02	4.91E-02	6.50E-02	Detected
	C-2	5/26/2021	5.15E-02	3.64E-02	6.40E-02	Not detected
	C-3	5/26/2021	1.94E-01	7.22E-02	8.46E-02	Detected
	C-4	4/23/2021	2.03E-01	5.92E-02	6.17E-02	Detected
	C-5	4/23/2021	1.59E-01	5.08E-02	4.93E-02	Detected
	C-6	4/23/2021	1.96E-01	6.10E-02	8.13E-02	Detected
	C-7	6/2/2021	1.51E-01	4.84E-02	3.79E-02	Detected
	C-8	6/2/2021	1.63E-01	5.53E-02	6.81E-02	Detected
	C-3 Dup	6/2/2021	2.62E-01	6.14E-02	3.27E-02	Detected
	D-1	4/14/2021	6.19E-02	4.96E-02	8.92E-02	Not detected
	D-2	4/14/2021	1.45E-01	5.91E-02	9.21E-02	Detected
	D-3	4/14/2021	7.92E-02	5.39E-02	8.97E-02	Not detected
	D-4	4/14/2021	2.87E-01	9.55E-02	1.06E-01	Detected

Table C.1. Activity concentrations of ^{241}Am, $^{239+240}Pu$, and ^{238}Pu (Bq/kg) in soil samples collected from Cactus Flats in the vicinity of the WIPP site (continued).

Radionuclide	Grid Node	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
$^{239+240}Pu$	D-5	4/14/2021	2.86E-01	8.77E-02	7.33E-02	Detected
	D-6	4/23/2021	1.19E-01	5.79E-02	8.59E-02	Detected
	D-7	6/2/2021	9.49E-02	4.45E-02	5.58E-02	Detected
	D-8	6/2/2021	3.30E-02	4.12E-02	8.86E-02	Not detected
	D-6 Dup	4/23/2021	2.22E-01	7.33E-02	6.67E-02	Detected
^{238}Pu	C-1	5/26/2021	0.00E+00	2.92E-02	8.03E-02	Not detected
	C-2	5/26/2021	-7.35E-03	1.80E-02	5.83E-02	Not detected
	C-3	5/26/2021	-1.46E-02	4.01E-02	1.14E-01	Not detected
	C-4	4/23/2021	3.07E-03	2.38E-02	6.17E-02	Not detected
	C-5	4/23/2021	-1.55E-02	2.41E-02	7.31E-02	Not detected
	C-6	4/23/2021	-3.17E-02	3.23E-02	9.47E-02	Not detected
	C-7	6/2/2021	6.31E-03	1.78E-02	4.44E-02	Not detected
	C-8	6/2/2021	-3.20E-03	2.12E-02	6.02E-02	Not detected
	C-3 Dup	6/2/2021	8.18E-03	1.44E-02	3.27E-02	Not detected
	D-1	4/14/2021	1.13E-02	2.76E-02	6.76E-02	Not detected
	D-2	4/14/2021	-1.01E-02	2.24E-02	6.78E-02	Not detected
	D-3	4/14/2021	-4.52E-02	3.95E-02	1.33E-01	Not detected
	D-4	4/14/2021	0.00E+00	3.56E-02	9.81E-02	Not detected
	D-5	4/14/2021	-5.20E-03	3.75E-02	1.05E-01	Not detected
	D-6	4/23/2021	-9.13E-03	3.42E-02	9.73E-02	Not detected
	D-7	6/2/2021	-3.95E-02	2.99E-02	1.01E-01	Not detected
	D-8	6/2/2021	-3.77E-02	3.79E-02	1.20E-01	Not detected
	D-6 Dup	4/23/2021	2.22E-01	7.33E-02	6.67E-02	Detected

Table C.2. Activity concentrations of ^{234}U, ^{235}U, and ^{238}U (Bq/kg) in soil samples collected from Cactus Flats in the vicinity of the WIPP site.

Radionuclide	Grid Node	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
^{234}U	C-1	5/26/2021	8.25E+00	9.39E-01	7.77E-02	Detected
	C-2	5/26/2021	5.54E+00	6.47E-01	4.10E-02	Detected
	C-3	5/26/2021	7.02E+00	8.02E-01	4.60E-02	Detected
	C-4	4/23/2021	7.52E+00	8.52E-01	4.72E-02	Detected
	C-5	4/23/2021	6.48E+00	7.43E-01	5.09E-02	Detected
	C-6	4/23/2021	8.11E+00	9.32E-01	7.72E-02	Detected
	C-7	6/2/2021	7.69E+00	8.73E-01	6.84E-02	Detected
	C-8	6/2/2021	8.49E+00	9.69E-01	4.05E-02	Detected
	C-3 Dup	6/2/2021	8.33E+00	9.33E-01	4.06E-02	Detected
	D-1	4/14/2021	7.23E+00	8.39E-01	5.49E-02	Detected
	D-2	4/14/2021	9.08E+00	1.05E+00	6.42E-02	Detected
	D-3	4/14/2021	6.90E+00	7.89E-01	6.79E-02	Detected
	D-4	4/14/2021	5.67E+00	6.59E-01	7.00E-02	Detected
	D-5	4/14/2021	7.62E+00	8.76E-01	4.93E-02	Detected
	D-6	4/23/2021	7.44E+00	8.58E-01	6.77E-02	Detected
	D-7	6/2/2021	6.52E+00	7.54E-01	5.39E-02	Detected
	D-8	6/2/2021	7.97E+00	9.44E-01	7.61E-02	Detected
	D-6 Dup	4/23/2021	7.58E+00	8.77E-01	8.55E-02	Detected
^{235}U	C-1	5/26/2021	3.82E-01	8.86E-02	7.05E-02	Detected
	C-2	5/26/2021	2.87E-01	7.24E-02	4.30E-02	Detected
	C-3	5/26/2021	3.19E-01	7.48E-02	4.60E-02	Detected
	C-4	4/23/2021	3.77E-01	8.22E-02	5.82E-02	Detected
	C-5	4/23/2021	3.24E-01	7.49E-02	4.69E-02	Detected
	C-6	4/23/2021	3.46E-01	8.19E-02	5.08E-02	Detected
	C-7	6/2/2021	3.64E-01	8.16E-02	6.21E-02	Detected
	C-8	6/2/2021	4.21E-01	9.04E-02	4.25E-02	Detected
	C-3 Dup	6/2/2021	4.51E-01	8.79E-02	4.05E-02	Detected
	D-1	4/14/2021	4.10E-01	9.23E-02	6.77E-02	Detected
	D-2	4/14/2021	4.82E-01	1.05E-01	5.92E-02	Detected
	D-3	4/14/2021	4.31E-01	8.86E-02	4.47E-02	Detected
	D-4	4/14/2021	2.70E-01	7.00E-02	6.37E-02	Detected

Table C.2. Activity concentrations of ^{234}U, ^{235}U, and ^{238}U (Bq/kg) in soil samples collected from Cactus Flats in the vicinity of the WIPP site (continued).

Radionuclide	Grid Node	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
^{235}U	D-5	4/14/2021	3.95E-01	8.73E-02	4.92E-02	Detected
	D-6	4/23/2021	4.11E-01	9.05E-02	5.64E-02	Detected
	D-7	6/2/2021	3.21E-01	7.96E-02	6.65E-02	Detected
	D-8	6/2/2021	3.37E-01	9.17E-02	7.01E-02	Detected
	D-6 Dup	4/23/2021	3.91E-01	9.18E-02	5.63E-02	Detected
^{238}U	C-1	5/26/2021	8.74E+00	9.92E-01	8.56E-02	Detected
	C-2	5/26/2021	5.91E+00	6.87E-01	5.45E-02	Detected
	C-3	5/26/2021	7.07E+00	8.07E-01	5.61E-02	Detected
	C-4	4/23/2021	7.84E+00	8.87E-01	5.02E-02	Detected
	C-5	4/23/2021	6.70E+00	7.67E-01	5.74E-02	Detected
	C-6	4/23/2021	8.37E+00	9.61E-01	9.55E-02	Detected
	C-7	6/2/2021	8.22E+00	9.29E-01	7.53E-02	Detected
	C-8	6/2/2021	8.78E+00	1.00E+00	5.38E-02	Detected
	C-3 Dup	6/2/2021	8.99E+00	1.00E+00	4.95E-02	Detected
	D-1	4/14/2021	7.54E+00	8.69E-01	5.84E-02	Detected
	D-2	4/14/2021	9.21E+00	1.07E+00	7.25E-02	Detected
	D-3	4/14/2021	6.85E+00	7.84E-01	8.40E-02	Detected
	D-4	4/14/2021	6.03E+00	6.98E-01	7.71E-02	Detected
	D-5	4/14/2021	7.62E+00	8.74E-01	5.99E-02	Detected
	D-6	4/23/2021	7.84E+00	9.01E-01	5.77E-02	Detected
	D-7	6/2/2021	6.44E+00	7.45E-01	5.73E-02	Detected
	D-8	6/2/2021	8.18E+00	9.67E-01	8.58E-02	Detected
	D-6 Dup	4/23/2021	7.32E+00	8.50E-01	1.06E-01	Detected

Table C.3. Activity concentrations of ^{137}Cs, ^{40}K, and ^{60}Co (Bq/kg) in soil samples collected from Cactus Flats in the vicinity of the WIPP site.

Radionuclide	Grid Node	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
^{137}Cs	C-1	5/26/2021	1.48E+00	8.17E-02	1.64E-01	Detected
	C-2	5/26/2021	9.86E-01	6.73E-02	1.93E-01	Detected
	C-3	5/26/2021	3.51E+00	1.04E-01	1.87E-01	Detected
	C-4	4/23/2021	3.73E+00	1.61E-01	1.65E-01	Detected
	C-5	4/23/2021	2.13E+00	1.01E-01	1.47E-01	Detected
	C-6	4/23/2021	5.21E+00	1.50E-01	2.65E-01	Detected
	C-7	6/2/2021	2.19E+00	9.06E-02	2.28E-01	Detected
	C-8	6/2/2021	2.86E+00	1.31E-01	1.84E-01	Detected
	C-3 Dup	6/2/2021	4.85E+00	1.44E-01	2.64E-01	Detected
	D-1	4/14/2021	1.67E+00	8.82E-02	1.67E-01	Detected
	D-2	4/14/2021	2.35E+00	1.10E-01	1.59E-01	Detected
	D-3	4/14/2021	2.01E+00	9.15E-02	2.35E-01	Detected
	D-4	4/14/2021	3.52E+00	1.52E-01	1.52E-01	Detected
	D-5	4/14/2021	4.13E+00	1.34E-01	2.76E-01	Detected
	D-6	4/23/2021	2.34E+00	8.88E-02	2.10E-01	Detected
	D-7	6/2/2021	1.60E+00	8.55E-02	1.63E-01	Detected
	D-8	6/2/2021	1.88E+00	8.85E-02	2.30E-01	Detected
	D-6 Dup	4/23/2021	2.97E+00	1.33E-01	1.65E-01	Detected
^{40}K	C-1	5/26/2021	2.42E+02	2.19E+01	1.93E+00	Detected
	C-2	5/26/2021	1.27E+02	5.04E+00	2.43E+00	Detected
	C-3	5/26/2021	1.99E+02	7.86E+00	2.21E+00	Detected
	C-4	4/23/2021	2.37E+02	2.15E+01	2.04E+00	Detected
	C-5	4/23/2021	1.84E+02	1.67E+01	1.92E+00	Detected
	C-6	4/23/2021	2.26E+02	8.81E+00	2.19E+00	Detected
	C-7	6/2/2021	2.56E+02	1.01E+01	2.17E+00	Detected
	C-8	6/2/2021	2.73E+02	2.48E+01	2.19E+00	Detected
	C-3 Dup	6/2/2021	2.64E+02	1.03E+01	2.53E+00	Detected
	D-1	4/14/2021	2.02E+02	1.83E+01	1.94E+00	Detected
	D-2	4/14/2021	1.94E+02	1.76E+01	2.03E+00	Detected
	D-3	4/14/2021	1.84E+02	7.22E+00	2.26E+00	Detected
	D-4	4/14/2021	1.67E+02	1.52E+01	1.98E+00	Detected

Table C.3. Activity concentrations of ^{137}Cs, ^{40}K, and ^{60}Co (Bq/kg) in soil samples collected from Cactus Flats in the vicinity of the WIPP site (continued).

Radionuclide	Grid Node	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
^{40}K	D-5	4/14/2021	2.17E+02	8.51E+00	2.61E+00	Detected
	D-6	4/23/2021	2.25E+02	8.86E+00	2.07E+00	Detected
	D-7	6/2/2021	2.28E+02	2.07E+01	2.12E+00	Detected
	D-8	6/2/2021	2.33E+02	9.12E+00	2.43E+00	Detected
	D-6 Dup	4/23/2021	2.25E+02	2.04E+01	2.08E+00	Detected
^{60}Co	C-1	5/26/2021	-2.45E-02	4.12E-02	1.39E-01	Not Detected
	C-2	5/26/2021	2.29E-02	4.03E-02	1.34E-01	Not Detected
	C-3	5/26/2021	5.32E-02	4.31E-02	1.42E-01	Not Detected
	C-4	4/23/2021	7.85E-02	5.06E-02	1.66E-01	Not Detected
	C-5	4/23/2021	1.24E-02	4.27E-02	1.42E-01	Not Detected
	C-6	4/23/2021	-1.56E-02	4.78E-02	1.60E-01	Not Detected
	C-7	6/2/2021	1.43E-01	6.90E-02	2.26E-01	Not Detected
	C-8	6/2/2021	3.32E-02	3.81E-02	1.26E-01	Not Detected
	C-3 Dup	6/2/2021	2.64E-02	5.57E-02	1.85E-01	Not Detected
	D-1	4/14/2021	-1.61E-03	3.93E-02	1.32E-01	Not Detected
	D-2	4/14/2021	4.01E-03	3.55E-02	1.19E-01	Not Detected
	D-3	4/14/2021	-1.88E-02	4.25E-02	1.43E-01	Not Detected
	D-4	4/14/2021	-1.96E-02	3.56E-02	1.20E-01	Not Detected
	D-5	4/14/2021	8.18E-02	5.43E-02	1.79E-01	Not Detected
	D-6	4/23/2021	7.56E-02	5.85E-02	1.93E-01	Not Detected
	D-7	6/2/2021	1.68E-02	4.65E-02	1.55E-01	Not Detected
	D-8	6/2/2021	-2.59E-02	6.15E-02	2.06E-01	Not Detected
	D-6 Dup	4/23/2021	-4.11E-02	3.93E-02	1.33E-01	Not Detected

Table C.4. Activity concentrations of ^{90}Sr (Bq/kg) in soil samples collected from Cactus Flats in the vicinity of the WIPP site

Radionuclide	Grid Node	Sample Date 2020	^{90}Sr Activity Bq/kg	Unc.(2σ) Bq/kg	MDC Bq/kg	Status
^{90}Sr	C-1	5/26/2021	4.67E+02	4.18E+01	4.69E+02	Not detected
	C-2	5/26/2021	3.35E+02	3.28E+01	4.62E+02	Not detected
	C-3	5/26/2021	3.95E+02	3.65E+01	4.47E+02	Not detected
	C-4	4/23/2021	8.01E+02	5.55E+01	4.25E+02	Detected
	C-5	4/23/2021	3.39E+02	3.37E+01	4.31E+02	Not detected
	C-6	4/23/2021	4.01E+02	3.79E+01	4.31E+02	Not detected
	C-7	6/2/2021	4.82E+02	4.12E+01	4.12E+02	Detected
	C-8	6/2/2021	4.45E+02	3.99E+01	4.35E+02	Detected
	C-3 Dup	6/2/2021	3.61E+02	3.41E+01	4.42E+02	Not detected
	D-1	4/14/2021	2.78E+02	2.88E+01	4.49E+02	Not detected
	D-2	4/14/2021	4.00E+02	3.79E+01	4.42E+02	Not detected
	D-3	4/14/2021	3.90E+02	3.70E+01	4.31E+02	Not detected
	D-4	4/14/2021	3.87E+02	3.76E+01	4.51E+02	Not detected
	D-5	4/14/2021	3.56E+02	3.47E+01	4.62E+02	Not detected
	D-6	4/23/2021	3.75E+02	3.49E+01	4.35E+02	Not detected
	D-7	6/2/2021	3.10E+02	3.07E+01	4.20E+02	Not detected
	D-8	6/2/2021	3.59E+02	3.39E+01	4.18E+02	Not detected
	D-6 Dup	4/23/2021	3.97E+02	3.55E+01	3.97E+02	Detected

APPENDIX D - RADIONUCLIDE CONCENTRATIONS IN SURFACE WATER

Actinide concentrations in surface water

Uranium concentrations in surface water

Gamma radionuclide concentrations in surface water

Strontium concentrations in surface water

Table D.1. Actinide concentrations in surface water

Radionuclide	Location	Activity Bq/L	Unc (2σ) (Bq/L)	MDC (Bq/L)	Status
^{241}Am	Lake Carlsbad (Shallow)	8.83E-05	1.21E-04	2.68E-04	Not detected
	Lake Carlsbad (Deep)	1.02E-04	1.09E-04	2.23E-04	Not detected
	Lake Carlsbad (Shallow, Dup)	1.85E-04	1.19E-04	2.01E-04	Not detected
	Lake Carlsbad (Deep, Dup)	1.03E-04	1.10E-04	2.25E-04	Not detected
	Brantley Lake (Shallow)	1.11E-04	1.02E-04	1.96E-04	Not detected
	Brantley Lake (Deep)	1.09E-04	1.17E-04	2.44E-04	Not detected
	Red Bluff (Shallow)	-1.23E-05	1.07E-04	2.89E-04	Not detected
	Red Bluff (Deep)	-3.06E-04	2.14E-04	6.69E-04	Not detected
	Hill Tank (Shallow)	8.36E-05	9.89E-05	2.07E-04	Not detected
	Noya Tank (Shallow)	4.554E-05	1.36E-04	3.30E-04	Not detected
	Lost Tank (Shallow)	1.30E-04	1.09E-04	2.06E-04	Not detected
	Trip Blank	7.33E-05	9.80E-05	2.12E-04	Not detected
$^{239+240}Pu$	Lake Carlsbad (Shallow)	1.58E-04	1.63E-04	3.38E-04	Not detected
	Lake Carlsbad (Deep)	-6.16E-05	8.74E-05	2.89E-04	Not detected
	Lake Carlsbad (Shallow, Dup)	5.78E-05	9.16E-05	2.03E-04	Not detected
	Lake Carlsbad (Deep, Dup)	4.12E-05	7.28E-05	1.65E-04	Not detected
	Brantley Lake (Shallow)	-6.64E-05	8.00E-05	2.67E-04	Not detected
	Brantley Lake (Deep)	1.44E-05	8.67E-05	2.28E-04	Not detected
	Red Bluff (Shallow)	-1.47E-04	1.32E-04	4.15E-04	Not detected
	Red Bluff (Deep)	2.52E-05	1.13E-04	3.04E-04	Not detected
	Hill Tank (Shallow)	-1.76E-05	9.36E-05	2.80E-04	Not detected
	Noya Tank (Shallow)	-1.15E-04	1.29E-04	3.95E-04	Not detected
	Lost Tank (Shallow)	-1.44E-05	9.57E-05	2.71E-04	Not detected

	Trip Blank	0.00E+00	0.00E+00	0.00E+00	Not detected

Table D.1. Actinide Concentrations in Surface Water (continued)

Radionuclide	Location	Activity Bq/L	Unc (2σ) (Bq/L)	MDC (Bq/L)	Status
^{238}Pu	Lake Carlsbad (Shallow)	-4.75E-05	9.54E-05	2.98E-04	Not detected
	Lake Carlsbad (Deep)	-6.16E-05	1.06E-04	3.28E-04	Not detected
	Lake Carlsbad (Shallow, Dup)	-4.34E-05	9.59E-05	2.90E-04	Not detected
	Lake Carlsbad (Deep, Dup)	-2.74E-05	6.73E-05	2.17E-04	Not detected
	Brantley Lake (Shallow)	2.65E-05	1.06E-04	2.67E-04	Not detected
	Brantley Lake (Deep)	-5.78E-05	1.15E-04	3.40E-04	Not detected
	Red Bluff (Shallow)	-2.35E-04	1.52E-04	4.84E-04	Not detected
	Red Bluff (Deep)	0.00E+00	1.24E-04	3.57E-04	Not detected
	Hill Tank (Shallow)	-1.76E-05	9.36E-05	2.80E-04	Not detected
	Noya Tank (Shallow)	-2.88E-05	9.94E-05	2.90E-04	Not detected
	Lost Tank (Shallow)	-7.21E-05	7.11E-05	2.51E-04	Not detected
	Trip Blank	0.00E+00	0.00E+00	0.00E+00	Not detected

Table D.2. Uranium concentrations in surface water

Radionuclide	Location	Activity Bq/L	Unc (2σ) (Bq/L)	MDC (Bq/L)	Status
^{234}U	Lake Carlsbad (Shallow)	4.47E-02	5.19E-03	2.63E-04	Detected
	Lake Carlsbad (Deep)	6.52E-02	7.78E-03	6.49E-04	Detected
	Lake Carlsbad (Shallow, Dup)	4.69E-02	5.32E-03	3.04E-04	Detected
	Lake Carlsbad (Deep, Dup)	7.01E-02	8.23E-03	3.95E-04	Detected
	Brantley Lake (Shallow)	5.26E-02	6.34E-03	4.47E-04	Detected
	Brantley Lake (Deep)	8.31E-02	1.08E-02	1.08E-03	Detected
	Red Bluff (Shallow)	1.70E-01	1.98E-02	6.40E-04	Detected
	Red Bluff (Deep)	2.81E-01	3.41E-02	4.91E-04	Detected
	Hill Tank (Shallow)	2.54E-03	4.85E-04	2.54E-04	Detected
	Noya Tank (Shallow)	1.75E-03	3.87E-04	2.60E-04	Detected
	Lost Tank (Shallow)	6.20E-03	9.18E-04	4.01E-04	detected
	Trip Blank	1.46E-04	1.42E-04	2.82E-04	Not detected
^{235}U	Lake Carlsbad (Shallow)	1.27E-03	3.56E-04	1.90E-04	Detected
	Lake Carlsbad (Deep)	1.59E-03	5.02E-04	5.35E-04	Detected
	Lake Carlsbad (Shallow, Dup)	9.03E-04	2.80E-04	2.65E-04	Detected
	Lake Carlsbad (Deep, Dup)	1.89E-03	5.22E-04	4.87E-04	Detected
	Brantley Lake (Shallow)	2.32E-03	5.92E-04	4.12E-04	Detected
	Brantley Lake (Deep)	1.96E-03	7.19E-04	7.11E-04	Detected
	Red Bluff (Shallow)	3.96E-03	8.48E-04	5.81E-04	Detected
	Red Bluff (Deep)	5.96E-03	1.24E-03	5.15E-04	Detected
	Hill Tank (Shallow)	7.23E-05	1.14E-04	2.54E-04	Not detected
	Noya Tank (Shallow)	5.51E-05	1.21E-04	2.91E-04	Not detected
	Lost Tank (Shallow)	1.63E-04	1.31E-04	2.17E-04	Not detected
	Trip Blank	-1.99E-05	8.94E-05	2.82E-04	Not detected

Table D.2. Uranium concentrations in Surface Water (continued)

Radionuclide	Location	Activity Bq/L	Unc (2σ) (Bq/L)	MDC (Bq/L)	Status
^{238}U	Lake Carlsbad (Shallow)	2.15E-02	2.65E-03	3.52E-04	Detected
	Lake Carlsbad (Deep)	3.11E-02	3.91E-03	5.85E-04	Detected
	Lake Carlsbad (Shallow, Dup)	2.27E-02	2.69E-03	3.69E-04	Detected
	Lake Carlsbad (Deep, Dup)	3.19E-02	3.93E-03	4.20E-04	Detected
	Brantley Lake (Shallow)	2.71E-02	3.45E-03	5.05E-04	Detected
	Brantley Lake (Deep)	4.00E-02	5.56E-03	1.33E-03	Detected
	Red Bluff (Shallow)	8.40E-02	9.96E-03	7.04E-04	Detected
	Red Bluff (Deep)	1.37E-01	1.69E-02	6.52E-04	Detected
	Hill Tank (Shallow)	1.95E-03	4.16E-04	3.10E-04	Detected
	Noya Tank (Shallow)	1.34E-03	3.42E-04	3.32E-04	Detected
	Lost Tank (Shallow)	4.37E-03	7.23E-04	5.10E-04	Detected
	Trip Blank	-3.23E-05	1.21E-04	3.44E-04	Not detected

Table D.3. Gamma emitting radionuclides in surface water

Radionuclide	Location	Activity Bq/L	Unc (2-sig) (Bq/L)	MDC (Bq/L)	Status
^{137}Cs	Lake Carlsbad (Shallow)	3.54E-02	1.59E-02	5.20E-02	Not detected
	Lake Carlsbad (Deep)	-2.03E-02	1.62E-02	5.46E-02	Not detected
	Lake Carlsbad (Shallow, Dup)	3.31E-02	1.73E-02	5.69E-02	Not detected
	Lake Carlsbad (Deep, Dup)	3.88E-02	1.58E-02	5.16E-02	Not detected
	Brantley Lake (Shallow)	-1.53E-02	1.39E-02	4.71E-02	Not detected
	Brantley Lake (Deep)	-2.46E-02	1.76E-02	5.92E-02	Not detected
	Red Bluff (Shallow)	3.43E-02	1.63E-02	5.34E-02	Not detected
	Red Bluff (Deep)	-3.87E-03	1.35E-02	4.54E-02	Not detected
	Hill Tank (Shallow)	1.02E-02	1.13E-02	3.75E-02	Not detected
	Noya Tank (Shallow)	6.09E-03	3.04E-02	1.01E-01	Not detected
	Lost Tank (Shallow)	-7.36E-03	1.68E-02	5.63E-02	Not detected
	Trip Blank	-8.11E-03	1.63E-02	5.44E-02	Not detected
^{60}Co	Lake Carlsbad (Shallow)	1.07E-02	1.18E-02	3.92E-02	Not detected
	Lake Carlsbad (Deep)	4.41E-03	1.18E-02	3.96E-02	Not detected
	Lake Carlsbad (Shallow, Dup)	-1.94E-03	1.10E-02	3.73E-02	Not detected
	Lake Carlsbad (Deep, Dup)	-5.67E-03	1.12E-02	3.81E-02	Not detected
	Brantley Lake (Shallow)	2.16E-02	1.42E-02	4.66E-02	Not detected
	Brantley Lake (Deep)	8.54E-03	8.63E-03	2.87E-02	Not detected
	Red Bluff (Shallow)	8.18E-03	1.41E-02	4.71E-02	Not detected
	Red Bluff (Deep)	3.34E-02	1.67E-02	5.47E-02	Not detected
	Hill Tank (Shallow)	2.01E-02	1.05E-02	3.44E-02	Not detected
	Noya Tank (Shallow)	-7.77E-03	1.93E-02	6.56E-02	Not detected
	Lost Tank (Shallow)	-2.03E-03	1.18E-02	3.97E-02	Not detected
	Trip Blank	-4.68E-03	8.73E-03	2.99E-02	Not detected

Table D.3. Gamma emitting radionuclides in surface water (continued)

Radionuclide	Location	Activity Bq/L	Unc (2σ) (Bq/L)	MDC (Bq/L)	Status
^{40}K	Lake Carlsbad (Shallow)	1.24E+00	2.43E-01	7.71E-01	Detected
	Lake Carlsbad (Deep)	6.58E-01	1.75E-01	5.62E-01	Detected
	Lake Carlsbad (Shallow, Dup)	-2.20E-01	2.09E-01	7.06E-01	Not detected
	Lake Carlsbad (Deep, Dup)	4.04E-02	2.20E-01	7.33E-01	Not detected
	Brantley Lake (Shallow)	2.88E-01	1.76E-01	5.78E-01	Not detected
	Brantley Lake (Deep)	-1.65E-01	1.50E-01	5.09E-01	Not detected
	Red Bluff (Shallow)	4.75E-01	2.04E-01	6.64E-01	Not detected
	Red Bluff (Deep)	9.14E-01	2.39E-01	7.69E-01	Detected
	Hill Tank (Shallow)	1.09E-01	1.86E-01	6.20E-01	Not detected
	Noya Tank (Shallow)	6.79E-02	2.38E-01	8.00E-01	Not detected
	Lost Tank (Shallow)	1.99E-02	1.88E-01	6.28E-01	Not detected
	Trip Blank	-2.88E-01	1.49E-01	5.10E-01	Not detected

Table D.4. Strontium concentration in surface water

Radionuclide	Location	Activity Bq/L	Unc (2σ) (Bq/L)	MDC (Bq/L)	Status
^{90}Sr	Lake Carlsbad (Shallow)	1.18E+01	1.18E+00	1.94E+01	Not detected
	Lake Carlsbad (Deep)	1.29E+01	1.22E+00	1.70E+01	Not detected
	Lake Carlsbad (Shallow, Dup)	1.25E+01	1.24E+00	1.70E+01	Not detected
	Lake Carlsbad (Deep, Dup)	1.29E+01	1.23E+00	1.70E+01	Not detected
	Brantley Lake (Shallow)	1.03E+01	1.04E+00	1.70E+01	Not detected
	Brantley Lake (Deep)	1.14E+01	1.09E+00	1.70E+01	Not detected
	Red Bluff (Shallow)	1.25E+01	1.24E+00	1.70E+01	Not detected
	Red Bluff (Deep)	1.56E+01	1.39E+00	1.94E+01	Not detected
	Hill Tank (Shallow)	1.63E+01	1.46E+00	1.94E+01	Not detected
	Noya Tank (Shallow)	1.56E+01	1.43E+00	1.94E+01	Not detected
	Lost Tank (Shallow)	1.48E+01	1.37E+00	1.70E+01	Not detected
	Trip Blank	1.18E+01	1.18E+00	1.94E+01	Not detected

APPENDIX E - RADIONUCLIDE CONCENTRATIONS IN DRINKING WATER

Actinide concentrations in drinking water

Uranium concentrations in drinking water

Gamma radionuclide concentrations in drinking water

Strontium concentrations in drinking water

Table E.1. Actinide concentrations in drinking water

Radionuclide	Location	Activity Bq/L	Unc (2σ) (Bq/L)	MDC (Bq/L)	Status
^{241}Am	Carlsbad	-8.95E-05	9.27E-05	3.00E-04	Not detected
	Double Eagle	-2.53E-04	1.51E-04	4.88E-04	Not detected
	Double Eagle-Dup	-6.93E-05	1.04E-04	3.05E-04	Not detected
	Hobbs	0.00E+00	7.17E-05	1.97E-04	Not detected
	Malaga	-2.32E-05	8.05E-05	2.33E-04	Not detected
	Otis	3.78E-05	5.06E-05	9.30E-05	Not detected
	Loving	-4.57E-05	9.73E-05	2.80E-04	Not detected
	Trip Blank	0.00E+00	8.74E-05	2.34E-04	Not detected
$^{239+240}$Pu	Carlsbad	-1.38E-05	4.80E-05	1.66E-04	Not detected
	Double Eagle	-5.26E-05	9.12E-05	2.80E-04	Not detected
	Double Eagle -Dup	0.00E+00	0.00E+00	0.00E+00	Not detected
	Hobbs	-1.60E-05	9.59E-05	2.77E-04	Not detected
	Malaga	-1.20E-04	1.22E-04	3.77E-04	Not detected
	Otis	-1.43E-05	1.03E-04	2.88E-04	Not detected
	Loving	1.37E-05	8.26E-05	2.18E-04	Not detected
	Trip Blank	1.29E-05	6.82E-05	1.82E-04	Not detected
^{238}Pu	Carlsbad	-4.15E-05	5.55E-05	1.95E-04	Not detected
	Double Eagle	-5.26E-05	7.44E-05	2.47E-04	Not detected
	Double Eagle -Dup	-1.35E-04	1.15E-04	3.68E-04	Not detected
	Hobbs	-1.60E-04	1.28E-04	4.22E-04	Not detected
	Malaga	-2.41E-04	1.31E-04	4.39E-04	Not detected
	Otis	-5.73E-05	9.08E-05	2.88E-04	Not detected
	Loving	-6.89E-05	1.06E-04	3.23E-04	Not detected
	Trip Blank	-5.16E-05	6.33E-05	2.25E-04	Not detected

Table E.2. Uranium concentrations in drinking water

Radionuclide	Location	Activity Bq/L	Unc (2σ) (Bq/L)	MDC (Bq/L)	Status
^{234}U	Carlsbad	2.73E-02	3.31E-03	2.77E-04	Detected
	Double Eagle	5.56E-02	6.44E-03	4.56E-04	Detected
	Double Eagle -Dup	5.86E-02	6.78E-03	4.76E-04	Detected
	Hobbs	9.28E-02	1.04E-02	3.69E-04	Detected
	Malaga	1.73E-01	2.01E-02	6.41E-04	Detected
	Otis	1.24E-01	1.38E-02	4.40E-04	Detected
	Loving	7.19E-02	8.30E-03	3.45E-04	Detected
	Trip Blank	-8.83E-05	1.54E-04	4.50E-04	Not detected
^{235}U	Carlsbad	1.14E-03	3.44E-04	2.00E-04	Detected
	Double Eagle	1.57E-03	4.35E-04	4.28E-04	Detected
	Double Eagle -Dup	1.44E-03	4.00E-04	3.03E-04	Detected
	Hobbs	2.61E-03	5.37E-04	1.80E-04	Detected
	Malaga	3.99E-03	8.32E-04	4.08E-04	Detected
	Otis	2.50E-03	5.15E-04	1.73E-04	Detected
	Loving	3.94E-03	7.52E-04	3.59E-04	Detected
	Trip Blank	4.35E-05	8.73E-05	2.02E-04	Not detected
^{238}U	Carlsbad	1.00E-02	1.39E-03	2.76E-04	Detected
	Double Eagle	2.08E-02	2.59E-03	4.84E-04	Detected
	Double Eagle -Dup	2.21E-02	2.73E-03	3.02E-04	Detected
	Hobbs	3.98E-02	4.64E-03	3.33E-04	Detected
	Malaga	6.58E-02	7.90E-03	4.98E-04	Detected
	Otis	4.69E-02	5.39E-03	3.39E-04	Detected
	Loving	2.46E-02	3.03E-03	3.67E-04	Detected
	Trip Blank	-8.79E-05	1.83E-04	5.10E-04	Not detected

Table E.3. Historical concentrations of ^{234}U, ^{235}U, and ^{238}U (Bq/L) in Carlsbad drinking water

Year	^{234}U (Bq/L)	^{235}U (Bq/L)	^{238}U (Bq/L)
1998	3.34E-02	7.52E-04	1.35E-02
1999	2.94E-02	6.99E-04	1.14E-02
2000	2.81E-02	8.12E-04	1.08E-02
2001	3.15E-02	9.68E-04	1.21E-02
2002	3.02E-02	7.97E-04	1.26E-02
2003	2.90E-02	5.52E-04	1.05E-02
2005	2.75E-02	1.54E-03	1.11E-02
2007	NR	NR	NR
2008	7.73E-02	3.09E-03	3.18E-02
2009	2.48E-02	3.57E-04	9.24E-03
2010	2.99E-02	5.64E-04	1.17E-02
2011	2.83E-02	7.83E-03	1.09E-02
2012	9.20E-03	1.85E-04	3.26E-03
2013	2.47E-02	3.80E-04	9.35E-03
2014	2.85E-02	5.83E-04	1.06E-02
2015	2.09E-02	3.39E-04	7.80E-03
2016	3.34E-02	9.90E-04	1.23E-02
2017	3.02E-02	5.41E-04	8.36E-02
2018	2.80E-02	5.87E-04	1.10E-02
2019	1.00E-01	2.35E-03	4.42E-02
2020	2.79E-02	6.77E-04	1.07E-02
2021	2.73E-02	1.14E-03	1.00E-02

Table E.4. Historical concentrations of ^{234}U, ^{235}U, and ^{238}U (Bq/L) in Double Eagle

Year	^{234}U (Bq/L)	^{235}U (Bq/L)	^{238}U(Bq/L)
1998	NR	NR	NR
1999	6.19E-02	1.35E-04	2.32E-02
2000	5.40E-02	1.38E-04	2.19E-02
2001	4.10E-02	1.22E-04	1.74E-02
2002	4.16E-02	1.01E-04	1.77E-02
2003	4.25E-02	8.89E-05	1.61E-02
2005	5.83E-02	1.43E-04	2.48E-02
2007	NR	NR	NR
2008	1.86E-01	4.31E-04	7.94E-02
2009	6.97E-02	7.55E-04	2.89E-02
2010	4.89E-02	1.36E-04	2.01E-02
2011	4.80E-02	8.45E-05	1.86E-02
2012	8.75E-03	3.55E-04	3.22E-03
2013	4.69E-02	4.90E-03	1.81E-02
2014	4.94E-02	6.12E-04	1.85E-02
2015	4.55E-02	9.19E-04	1.57E-02
2016	5.14E-02	1.19E-03	1.96E-02
2017	9.65E-02	2.36E-03	4.13E-02
2018	6.56E-02	1.85E-03	2.54E-02
2019	8.22E-02	1.57E-03	3.20E-02
2020	4.96E-02	1.02E-03	1.94E-02
2021	4.56E-02	1.57E-03	2.08E-02

Table E.5. Historical concentrations of ^{234}U, ^{235}U, and ^{238}U in Hobbs drinking water

Year	^{234}U (Bq/L)	^{235}U (Bq/L)	^{238}U (Bq/L)
1998	NR	NR	NR
1999	8.81E-02	2.46E-03	3.86E-02
2000	9.06E-02	2.34E-03	3.99E-02
2001	7.52E-02	2.59E-03	3.32E-02
2002	9.40E-02	2.37E-03	4.05E-02
2003	1.30E-01	2.51E-03	4.61E-02
2005	9.82E-02	2.68E-03	4.27E-02
2007	NR	NR	NR
2008	2.87E-01	1.18E-02	1.31E-01
2009	8.94E-02	1.99E-03	3.86E-02
2010	1.04E-01	2.23E-03	4.59E-02
2011	1.04E-01	2.60E-03	4.50E-02
2012	1.61E-02	4.31E-04	5.82E-03
2013	9.25E-02	2.18E-03	3.97E-02
2014	9.82E-02	1.89E-03	4.01E-02
2015	9.67E-02	2.17E-03	4.17E-02
2016	1.05E-01	2.48E-03	4.44E-02
2017	4.82E-02	2.37E-03	5.08E-02
2018	9.82E-02	2.54E-03	4.49E-02
2019	9.96E-02	2.30E-03	4.35E-02
2020	1.07E-01	3.25E-03	4.55E-02
2021	9.28E-02	2.61E-03	3.98E-02

Table E.6. Historical concentrations of ^{234}U, ^{235}U, and ^{238}U in Otis drinking water

Year	^{234}U (Bq/L)	^{235}U (Bq/L)	^{238}U (Bq/L)
1998	1.29E-01	2.73E-03	4.67E-02
1999	1.50E-01	2.85E-03	5.30E-02
2000	1.44E-01	2.97E-03	5.16E-02
2001	1.62E-01	3.30E-03	6.01E-02
2002	1.47E-01	3.34E-03	5.34E-02
2003	1.34E-01	2.56E-03	4.81E-02
2005	1.17E-01	2.60E-03	4.36E-02
2007	NR	NR	NR
2008	3.89E-01	1.35E-02	1.53E-01
2009	1.47E-01	3.80E-03	5.35E-02
2010	1.54E-01	2.66E-03	5.41E-02
2011	1.54E-01	1.19E-02	2.39E-01
2012	3.94E-02	1.00E-03	1.39E-02
2013	1.51E-01	3.17E-03	5.45E-02
2014	1.71E-01	3.46E-03	7.24E-02
2015	1.70E-01	2.95E-03	6.61E-02
2016	2.70E-02	1.44E-03	1.13E-02
2017	1.68E-01	2.86E-03	6.59E-02
2018	1.71E-01	3.36E-03	6.54E-02
2019	1.15E-01	2.01E-03	4.02E-02
2020	1.46E-01	3.50E-03	5.56E-02
2021	1.24E-01	2.50E-03	4.69E-02

Table E.7. Historical concentrations of ^{234}U, ^{235}U, and ^{238}U in Loving drinking water

Year	^{234}U (Bq/L)	^{235}U (Bq/L)	^{238}U (Bq/L)
1998	NR	NR	NR
1999	8.15E-02	1.66E-03	2.63E-02
2000	8.38E-02	1.63E-03	2.59E-02
2001	8.05E-02	1.61E-03	2.48E-02
2002	8.82E-02	1.63E-03	2.83E-02
2003	7.91E-02	1.35E-03	2.40E-02
2005	8.13E-02	1.42E-03	2.64E-02
2007	NR	NR	NR
2008	2.56E-01	5.15E-03	7.71E-02
2009	7.42E-02	1.26E-03	2.22E-02
2010	8.00E-02	1.20E-03	2.49E-02
2011	7.50E-02	3.90E-02	2.57E-02
2012	2.53E-02	4.93E-04	7.58E-03
2013	7.17E-02	1.20E-03	2.31E-02
2014	7.57E-02	1.63E-03	2.24E-02
2015	7.42E-02	1.26E-03	2.30E-02
2016	7.05E-02	1.23E-03	2.23E-02
2017	7.48E-02	1.01E-03	2.16E-02
2018	7.31E-02	1.35E-03	2.35E-02
2019	8.18E-02	1.42E-03	2.56E-02
2020	7.43E-02	1.42E-03	2.43E-02
2021	7.19E-02	3.94E-03	2.46E-02

Table E.8. Historical concentrations of ^{234}U, ^{235}U, and ^{238}U (Bq/L) in Malaga drinking water

Year	^{234}U (Bq/L)	^{235}U (Bq/L)	^{238}U (Bq/L)
2011	1.38E-01	2.56E-03	5.34E-02
2012	1.33E-01	1.92E-03	4.83E-02
2013	1.40E-01	3.33E-03	5.46E-02
2014	1.67E-01	4.59E-03	6.19E-02
2015	1.57E-01	4.99E-03	6.07E-02
2016	1.47E-01	2.36E-03	5.43E-02
2017	1.65E-01	3.24E-03	6.24E-02
2018	1.61E-01	3.41E-03	6.01E-02
2019	1.81E-01	4.09E-03	6.67E-02
2020	1.86E-01	3.32E-03	6.93E-02
2021	1.73E-01	3.99E-03	6.58E-02

*Collection started in 2011

Table E.9. Gamma emitting radionuclides in drinking water

Radionuclide	Location	Activity Bq/L	Unc(2-sig) (Bq/L)	MDC (Bq/L)	Status
^{137}Cs	Carlsbad	9.52E-03	1.13E-02	3.74E-02	Not detected
	Double Eagle	-3.32E-02	1.64E-02	5.54E-02	Not detected
	Double Eagle - Dup	4.19E-03	1.52E-02	5.07E-02	Not detected
	Hobbs	-2.05E-02	1.57E-02	5.28E-02	Not detected
	Malaga	1.30E-02	1.10E-02	3.65E-02	Not detected
	Otis	8.81E-03	8.96E-03	2.98E-02	Not detected
	Loving	-1.91E-02	1.54E-02	5.19E-02	Not detected
	Trip Blank	-3.62E-02	1.29E-02	4.45E-02	Not detected
^{60}Co	Carlsbad	1.37E-02	8.44E-03	2.78E-02	Not detected
	Double Eagle	3.44E-03	7.09E-03	2.39E-02	Not detected
	Double Eagle - Dup	1.03E-02	9.71E-03	3.22E-02	Not detected
	Hobbs	-6.19E-03	7.80E-03	2.70E-02	Not detected
	Malaga	1.75E-02	1.00E-02	3.29E-02	Not detected
	Otis	2.17E-02	1.05E-02	3.42E-02	Not detected
	Loving	3.38E-03	9.69E-03	3.26E-02	Not detected
	Trip Blank	-1.27E-02	1.22E-02	4.17E-02	Not detected
^{40}K	Carlsbad	-4.15E-01	1.41E-01	4.88E-01	Not detected
	Double Eagle	-2.76E-01	1.56E-01	5.31E-01	Not detected
	Double Eagle -4-Dup	2.35E-02	1.63E-01	5.45E-01	Not detected
	Hobbs	-1.66E-01	1.51E-01	5.13E-01	Not detected
	Malaga	-4.21E-02	1.52E-01	5.09E-01	Not detected
	Otis	-1.11E-01	1.51E-01	5.09E-01	Not detected
	Loving	-3.23E-01	1.57E-01	5.37E-01	Not detected
	Trip Blank	-3.81E-01	1.29E-01	4.56E-01	Not detected

Table E.10. Sr concentrations in drinking water

Radionuclide	Location	Activity Bq/L	Unc(2σ) (Bq/L)	MDC (Bq/L)	Status
^{90}Sr	Sheep Draw	1.70E+01	1.59E+00	2.40E+01	Not detected
	PRV-4	1.89E+01	1.72E+00	2.43E+01	Not detected
	PRV-4-Dup	1.98E+01	1.76E+00	2.40E+01	Not detected
	Hobbs	1.33E+01	1.40E+00	2.40E+01	Not detected
	Malaga	1.89E+01	1.73E+00	2.43E+01	Not detected
	Otis	1.47E+01	1.45E+00	2.40E+01	Not detected
	Loving	2.07E+01	1.78E+00	2.43E+01	Not detected
	Trip Blank	1.93E+01	1.66E+00	2.43E+01	Not detected

APPENDIX F - RADIONUCLIDE CONCENTRATIONS IN SEDIMENT SAMPLES

Actinide concentrations in sediment samples

Uranium concentrations in sediment samples

Gamma radionuclide concentrations in sediment samples

Strontium concentrations in sediment samples

Table F.1. Activity concentrations of ^{241}Am, $^{239+240}Pu$, and ^{238}Pu (Bq/g) in sediment samples collected from the three reservoirs in the vicinity of the WIPP site

Radionuclides	Location	Sample Date	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{241}Am	Lake Carlsbad	7/20/2021	1.53E-04	5.76E-05	7.47E-05	Detected
	Lake Carlsbad-Dup	7/20/2021	9.27E-05	5.22E-05	9.41E-05	Not detected
	Brantley	7/20/2021	4.87E-05	7.77E-05	1.78E-04	Not detected
	Red Bluff	7/21/2021	1.14E-04	6.36E-05	9.91E-05	Detected
$^{239+240}Pu$	Lake Carlsbad	7/20/2021	1.65E-04	5.27E-05	3.32E-05	Detected
	Lake Carlsbad-Dup	7/20/2021	1.79E-04	5.86E-05	6.78E-05	Detected
	Brantley	7/20/2021	1.85E-04	6.74E-05	7.36E-05	Detected
	Red Bluff	7/21/2021	2.21E-04	7.23E-05	8.01E-05	Detected
^{238}Pu	Lake Carlsbad	7/20/2021	-7.15E-06	2.03E-05	6.22E-05	Not detected
	Lake Carlsbad-Dup	7/20/2021	3.38E-06	1.79E-05	4.75E-05	Not detected
	Brantley	7/20/2021	-1.39E-05	3.81E-05	1.09E-04	Not detected
	Red Bluff	7/21/2021	0.00E+00	2.69E-05	7.41E-05	Not detected

Dup = duplicate

Table F.2. Activity concentrations of ^{234}U, ^{235}U, and ^{238}U (Bq/g) in sediment samples collected from the three reservoirs in the vicinity of the WIPP site

Radionuclides	Location	Sample Date	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{234}U	Lake Carlsbad	7/20/2021	4.10E-02	4.46E-03	6.01E-05	Detected
	Lake Carlsbad-Dup	7/20/2021	4.82E-02	5.22E-03	6.10E-05	Detected
	Brantley	7/20/2021	4.53E-02	5.00E-03	9.79E-05	Detected
	Red Bluff	7/21/2021	1.29E-01	1.39E-02	9.61E-05	Detected
^{235}U	Lake Carlsbad	7/20/2021	1.45E-03	2.19E-04	7.42E-05	Detected
	Lake Carlsbad-Dup	7/20/2021	1.68E-03	2.36E-04	3.29E-05	Detected
	Brantley	7/20/2021	1.75E-03	2.62E-04	6.45E-05	Detected
	Red Bluff	7/21/2021	3.37E-03	4.37E-04	8.73E-05	Detected
^{238}U	Lake Carlsbad	7/20/2021	2.88E-02	3.15E-03	6.41E-05	Detected
	Lake Carlsbad-Dup	7/20/2021	3.26E-02	3.55E-03	7.28E-05	Detected
	Brantley	7/20/2021	3.52E-02	3.91E-03	1.22E-04	Detected
	Red Bluff	7/21/2021	7.38E-02	7.98E-03	1.06E-04	Detected

Dup = duplicate

Table F.3. Activity concentrations of ^{137}Cs, ^{40}K, and ^{60}Co (Bq/g) in sediment samples collected from the three reservoirs in the vicinity of the WIPP site

Radionuclides	Location	Sample Date	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{137}Cs	Lake Carlsbad	7/20/2021	2.99E-03	1.55E-04	2.81E-04	Detected
	Lake Carlsbad-Dup	7/20/2021	3.51E-03	1.74E-04	2.97E-04	Detected
	Brantley	7/20/2021	3.08E-03	1.12E-04	3.10E-04	Detected
	Red Bluff	7/21/2021	3.67E-03	1.19E-04	3.19E-04	Detected
^{40}K	Lake Carlsbad	7/20/2021	3.51E-01	3.18E-02	3.43E-03	Detected
	Lake Carlsbad-Dup	7/20/2021	3.72E-01	3.38E-02	3.23E-03	Detected
	Brantley	7/20/2021	5.07E-01	8.96E-03	3.14E-03	Detected
	Red Bluff	7/21/2021	4.21E-01	7.55E-03	3.49E-03	Detected
^{60}Co	Lake Carlsbad	7/20/2021	-4.68E-05	6.15E-05	2.08E-04	Not detected
	Lake Carlsbad-Dup	7/20/2021	1.91E-05	8.31E-05	2.77E-04	Not detected
	Brantley	7/20/2021	-5.28E-05	7.82E-05	2.61E-04	Not detected
	Red Bluff	7/21/2021	1.45E-05	7.18E-05	2.39E-04	Not detected

Dup = duplicate

Table F.4. Activity concentrations of ^{90}Sr (Bq/kg) in sediment samples collected from the three reservoirs in the vicinity of the WIPP site

Radionuclide	Location	Sample Date	Activity Bq/kg	Unc. (2-sig) Bq/kg	MDC Bq/kg	Status
^{90}Sr	Lake Carlsbad	7/20/2021	3.87E+02	3.65E+01	4.49E+02	Not detected
	Lake Carlsbad-Dup	7/20/2021	3.82E+02	3.53E+01	4.55E+02	Not detected
	Brantley	7/20/2021	3.68E+02	3.45E+01	4.28E+02	Not detected
	Red Bluff	7/21/2021	3.99E+02	3.82E+01	4.63E+02	Not detected

APPENDIX G - RADIONUCLIDE CONCENTRATIONS IN VEGETATION SAMPLES

Table G.1. Activity concentrations of ^{241}Am, $^{239+240}Pu$, and ^{238}Pu (Bq/g) in vegetation samples

Radionuclides	Location	Sample Date	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{241}Am	Near Field	11/11/2021	-4.74E-06	7.35E-06	2.23E-05	Not detected
	Cactus Flats	10/5/2021	0.00E+00	9.81E-06	2.64E-05	Not detected
	Loving	11/11/2021	2.36E-06	8.18E-06	2.06E-05	Not detected
	East Tower	10/20/2021	-1.53E-05	1.08E-05	3.76E-05	Not detected
	Carlsbad	10/20/2021	7.92E-06	8.40E-06	1.59E-05	Not detected
	Carlsbad-Dup	12/3/2021	-9.09E-06	1.14E-05	3.56E-05	Not detected
$^{239+240}Pu$	Near Field	11/11/2021	0.00E+00	5.18E-06	1.56E-05	Not detected
	Cactus Flats	10/5/2021	-1.28E-06	6.77E-06	2.03E-05	Not detected
	Loving	11/11/2021	3.16E-06	9.99E-06	2.51E-05	Not detected
	East Tower	10/20/2021	1.38E-06	8.30E-06	2.20E-05	Not detected
	Carlsbad	10/20/2021	-3.85E-06	8.53E-06	2.58E-05	Not detected
	Carlsbad-Dup	12/3/2021	-1.34E-05	1.56E-05	5.01E-05	Not detected
^{238}Pu	Near Field	11/11/2021	1.30E-06	9.34E-06	2.44E-05	Not detected
	Cactus Flats	10/5/2021	-6.39E-06	9.25E-06	2.87E-05	Not detected
	Loving	11/11/2021	1.58E-06	8.36E-06	2.23E-05	Not detected
	East Tower	10/20/2021	1.38E-06	7.32E-06	1.95E-05	Not detected
	Carlsbad	10/20/2021	-1.03E-05	8.97E-06	3.02E-05	Not detected
	Carlsbad-Dup	12/3/2021	-6.70E-06	1.73E-05	5.01E-05	Not detected

Dup = duplicate

Table G.2. Activity concentrations of ^{234}U, ^{235}U, and ^{238}U (Bq/g) in vegetation samples

Radionuclides	Location	Sample Date	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{234}U	Near Field	11/11/2021	8.34E-05	3.26E-05	3.13E-05	Detected
	Cactus Flats	10/5/2021	1.84E-04	4.83E-05	5.42E-05	Detected
	Loving	11/11/2021	5.31E-05	2.13E-05	2.88E-05	Detected
	East Tower	10/20/2021	2.20E-04	4.55E-05	3.60E-05	Detected
	Carlsbad	10/20/2021	1.29E-04	3.77E-05	4.40E-05	Detected
	Carlsbad-Dup	12/3/2021	5.08E-05	2.31E-05	3.62E-05	Detected
^{235}U	Near Field	11/11/2021	3.22E-05	2.43E-05	3.86E-05	Not detected
	Cactus Flats	10/5/2021	3.67E-05	2.17E-05	2.94E-05	Detected
	Loving	11/11/2021	1.59E-05	1.38E-05	2.49E-05	Not detected
	East Tower	10/20/2021	1.99E-05	1.67E-05	3.15E-05	Not detected
	Carlsbad	10/20/2021	1.11E-05	1.48E-05	3.12E-05	Not detected
	Carlsbad-Dup	12/3/2021	2.66E-05	1.64E-05	2.28E-05	Detected
^{238}U	Near Field	11/11/2021	9.86E-05	3.68E-05	4.12E-05	Detected
	Cactus Flats	10/5/2021	1.56E-04	4.27E-05	4.43E-05	Detected
	Loving	11/11/2021	2.43E-05	2.13E-05	4.48E-05	Not detected
	East Tower	10/20/2021	1.39E-04	3.70E-05	4.58E-05	Detected
	Carlsbad	10/20/2021	9.12E-05	3.22E-05	4.38E-05	Detected
	Carlsbad-Dup	12/3/2021	1.99E-05	2.16E-05	4.69E-05	Not detected

Dup = duplicate

Table G.3. Activity concentrations of ^{137}Cs, ^{40}K, and ^{60}Co (Bq/kg) in vegetation samples

Radionuclides	Location	Sample Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
^{137}Cs	Near Field	11/11/2021	1.55E+00	4.14E+00	1.38E+01	Not Detected
	Cactus Flats	10/5/2021	-2.97E+00	3.92E+00	1.33E+01	Not Detected
	Loving	11/11/2021	3.06E+00	1.17E+00	3.79E+00	Not Detected
	East Tower	10/20/2021	3.66E+00	1.66E+00	5.40E+00	Not Detected
	Carlsbad	10/20/2021	-6.75E+00	4.58E+00	1.56E+01	Not Detected
	Carlsbad-Dup	12/3/2021	2.55E-01	1.49E+00	5.00E+00	Not Detected
^{40}K	Near Field	11/11/2021	2.81E+02	4.21E+01	1.23E+02	Detected
	Cactus Flats	10/5/2021	6.96E+01	2.87E+01	9.20E+01	Not Detected
	Loving	11/11/2021	1.89E+02	3.53E+01	1.11E+02	Detected
	East Tower	10/20/2021	4.12E+02	3.69E+01	1.08E+02	Detected
	Carlsbad	10/20/2021	1.05E+02	2.98E+01	9.22E+01	Detected
	Carlsbad-Dup	12/3/2021	1.43E+02	3.23E+01	1.03E+02	Detected
^{60}Co	Near Field	11/11/2021	4.63E-01	3.15E+00	1.08E+01	Not Detected
	Cactus Flats	10/5/2021	-3.60E+02	3.38E+00	1.19E+01	Not Detected
	Loving	11/11/2021	-7.57E-01	1.71E+00	5.86E+00	Not Detected
	East Tower	10/20/2021	-2.34E-01	1.46E+00	5.00E+00	Not Detected
	Carlsbad	10/20/2021	3.37E-01	3.37E+00	1.15E+01	Not Detected
	Carlsbad-Dup	12/3/2021	1.66E+00	1.44E+00	4.78E+00	Not Detected

Dup = duplicate

Table G.4. Activity concentrations of ^{90}Sr (Bq/g) in vegetation samples

Radionuclide	Location	Sample Date	Activity Bq/g	Unc. (2-sig) Bq/g	MDC Bq/g	Status
^{90}Sr	Near Field	11/11/2021	7.84E-02	7.34E-03	9.44E-02	Not detected
	Cactus Flats	10/5/2021	4.92E-02	5.32E-03	9.26E-02	Not detected
	Loving	11/11/2021	8.54E-02	7.90E-03	9.25E-02	Not detected
	East Tower	10/20/2021	7.82E-02	7.26E-03	8.91E-02	Not detected
	Carlsbad	10/20/2021	9.63E-02	8.55E-03	9.49E-02	Detected
	Carlsbad-Dup	12/3/2021	5.69E-02	5.86E-03	9.13E-02	Not detected

APPENDIX H - IN VIVO MONITORING RESULTS

Average MDA of lung detector through December 2021

Average MDA of whole-body counting detector December 2021

Demographic characteristics of the LDBC population through December 2021

LDBC results greater than the decision limits (L_C) through December 2021

Table H.1. Average MDA (nCi) of lung detector as a function of chest wall thickness between 2006 and 2021

Radionuclide	Energy (keV)	MDA (nCi) as a function of Chest Wall Thickness (CWT in cm)													
		1.6 cm		2.22 cm		3.01 cm		3.33 cm		4.18 cm		5.10 cm		6.0 cm	
		Avg	1-Stdev	Avg	1 Stdev	Avg	1 Stdev	Avg	1 Stdev	Avg	1 Stdev	Avg	1 Stdev	Avg	1 Stdev
^{241}Am	59.5	0.18	0.01	0.23	0.01	0.30	0.01	0.34	0.01	0.46	0.01	0.65	0.03	0.90	0.05
^{144}Ce	133.5	0.48	0.01	0.56	0.01	0.71	0.01	0.78	0.01	1.01	0.02	1.33	0.04	1.74	0.07
^{252}Cf	19.2	18	1	35	1	83	3	118	5	302	18	833	65	2249	216
^{244}Cm	18.1	17	1	35	1	92	4	136	6	382	21	1173	82	3515	301
^{155}Eu	105.3	0.27	0.01	0.34	0.01	0.44	0.01	0.48	0.01	0.64	0.02	0.86	0.04	1.16	0.07
^{237}Np	86.5	0.48	0.02	0.60	0.02	0.79	0.02	0.88	0.03	1.19	0.05	1.63	0.09	2.2	0.2
^{238}Pu	17.1	18	1	42	2	121	6	186	9	586	33	2028	136	6833	534
^{239}Pu	17.1	45	2	104	5	300	14	463	23	1458	83	5045	337	17001	1330
^{240}Pu	17.1	18	1	41	2	118	6	182	9	573	32	1982	133	6679	522
^{242}Pu	17.1	21	1	49	2	142	7	219	11	691	39	2391	160	8057	630
^{226}Ra	186.1	1.72	0.07	1.96	0.05	2.40	0.07	2.61	0.08	3.3	0.1	4.2	0.2	5.3	0.3
^{232}Th via ^{212}Pb	238.6	0.152	0.004	0.179	0.004	0.221	0.004	0.240	0.004	0.30	0.01	0.39	0.01	0.49	0.02
^{232}Th	59.0	33	1	43	1	57	1	64	2	87	4	122	7	170	11
^{232}Th via ^{228}Th[a]	84.3	4.77	0.21	6	0	8	0	9	0	12	1	16	1	22	2
^{233}U	440.3	0.66	0.02	0.77	0.02	0.93	0.02	1.01	0.02	1.24	0.03	1.55	0.04	1.94	0.06
^{235}U[b]	185.7	0.106	0.004	0.121	0.003	0.149	0.004	0.162	0.005	0.20	0.01	0.26	0.01	0.32	0.02
Nat U via ^{234}Th[c]	63.3	1.58	0.07	2.03	0.05	2.68	0.07	3.01	0.08	4.1	0.2	5.7	0.3	7.9	0.5

[a] Radionuclide used to indicate natural thorium.

[b] Radionuclide used to indicate enriched uranium.

[c] Radionuclide used to indicate natural uranium or depleted uranium.

Table H.2. Average MDA (nCi) of whole-body detector (from 2002 to 2021).

Radionuclide	Energy (keV)	Average MDA (nCi)	1-stdev (nCi)
^{133}Ba	356	0.78	0.04
^{140}Ba	537	1.51	0.08
^{141}Ce	145	1.63	0.13
^{58}Co	811	0.36	0.02
^{60}Co	1333	0.36	0.01
^{51}Cr	320	4.47	0.36
^{134}Cs	604	0.35	0.03
^{137}Cs	662	0.42	0.02
^{152}Eu	344	1.60	0.11
^{154}Eu	1275	0.95	0.04
^{155}Eu	105	3.81	0.33
^{59}Fe	1099	0.67	0.03
^{131}I	365	0.48	0.03
^{133}I	530	0.42	0.03
^{192}Ir	317	0.55	0.04
^{54}Mn	835	0.45	0.01
^{103}Ru	497	0.40	0.03
^{106}Ru	622	3.31	0.14
^{125}Sb	428	1.33	0.10
^{232}Th via ^{228}Ac	911	1.23	0.07
^{88}Y	898	0.37	0.02
^{65}Zn	1116	1.10	0.04
^{95}Zr	757	0.59	0.03

Table H.3. Demographic characteristics of the LDBC population during 1997-2021.

Characteristic		Voluntary Participants		2000[a]		2021[b] Estimates	
		Baseline	Operational	NM	US	NM	US
Gender	Male	56.2% (52.2% to 61.9%)[C]	43.3% (40.6% to 46.1%)	49.2%	49.1%	49.8%	49.2%
	Female	43.8% (38.6% to 48.3%)	56.7% (53.9 to 59.4 %)	50.8%	50.9%	50.2%	50.8%
Ethnicity	Hispanic	13.4% (9.5% to 16.3%)	23.6% (21.2% to 26.0%)	42.1%	12.5%	50.1%	18.9%
	All others	86.6% (83.3% to 90.9%)	76.4% (74.0% to 78.8%)	57.9%	87.5%	49.9%	81.1%
Age 65 years or over		16.70%[d]	35.7% (33.0% to 38.4%)	11.7%	12.4%	18.5%	16.8%
Currently or previously classified as a radiation worker		4.0%[d]	9.6% (8.0% to 11.3%)	NA	NA	NA	NA
Consumption of wild game within 3 months prior to count		16.4%[d]	22.1% (19.8% to 24.5%)	NA	NA	NA	NA
Medical treatment other than X-rays using radionuclides		9%[d]	5.7% (4.4% to 7.0%)	NA	NA	NA	NA
European/Japan travel within 2 years prior to the count		4%[d]	4.7% (3.5% to 5.9%)	NA	NA	NA	NA
Current smoker		13.9%[d]	13.1% (11.2% to 15.0%)	N/A	N/A	14% - 16.4%[e]	12.5%[e]

a: 2000 Census data for U.S. and NM
https://www2.census.gov/library/publications/2001/dec/2kh00.pdf (accessed on 10/17/2022).
https://usa.ipums.org/usa/resources/voliii/pubdocs/2000/c2kprof00-nm.pdf (accessed on 10/17/2022).
b: 2021 Census data for U.S. and NM https://www.census.gov/quickfacts/fact/table/US/PST045219 (accessed on 10/17/2022). https://www.census.gov/quickfacts/fact/table/NM (retrieved on 10/17/2022).

c: Values in parentheses are margin of error (margin of error represents the 95% confidence interval of the observed percentage
d: Margin of error canNot be quoted due to small sample size.
e: % Adult smoking in NM and f: % Adult smoking in U.S.
https://www.cdc.gov/tobacco/data_statistics/fact_sheets/adult_data/cig_smoking/index.htm
(Page last reviewed: March 17, 2022, retrieved on 10/17/2022)

Table H.4. LDBC results greater than the decision limits (L_C) through December 2021.

Radionuclides	*In-Vivo* count type	Baseline counts (N = 366) % of results □ L_C[a]	Operational counts (N = 1214) % of results □□L_C[a]
^{241}Am	Lung	5.2 (4.0 to 6.4)	4.2 (3.1 to 5.3)
^{144}Ce	Lung	4.6 (3.5 to 5.7)	4.7 (3.5 to 5.9)
^{252}Cf	Lung	4.1 (3.1 to 5.1)	5.9 (4.6 to 7.3)
^{244}Cm	Lung	5.7 (4.5 to 7.0)	4.8 (3.6 to 6)
^{155}Eu	Lung	7.1 (5.8 to 8.4)	5.1 (3.9 to 6.3)
^{237}Np	Lung	3.6 (2.6 to 4.5)	3.9 (2.8 to 5)
^{210}Pb	Lung	4.4 (3.3 to 5.4)	6 (4.7 to 7.4)
Pu-Isotopes [c]	Lung	5.7 (4.5 to 7.0)	5 (3.8 to 6.3)
^{232}Th via ^{212}Pb[d]	Lung	34.2 (31.7 to 36.6)	31.7 (29.1 to 34.3)
^{232}Th	Lung	4.9 (3.8 to 6.0)	5.6 (4.3 to 6.9)
^{232}Th via ^{228}Th	Lung	4.1 (3.1 to 5.1)	4.8 (3.6 to 6)
^{233}U	Lung	5.7 (4.5 to 7.0)	9 (7.4 to 10.6)
^{235}U_^{226}Ra[e]	Lung	10.7 (9.0 to 12.3)	11 (9.2 to 12.7)
^{238}U	Lung	5.2 (4.0 to 6.4)	5.4 (4.1 to 6.6)
^{133}Ba	Whole Body	3.6 (2.6 to 4.5)	3.2 (2.2 to 4.2)
^{140}Ba	Whole Body	5.2 (4.0 to 6.4)	4 (2.9 to 5.1)
^{141}Ce	Whole Body	3.6 (2.6 to 4.5)	4.7 (3.5 to 5.9)
^{58}Co	Whole Body	4.4 (3.3 to 5.4)	3.8 (2.7 to 4.9)
[d] ^{60}Co	Whole Body	54.6 (52.0 to 57.2)	21.3 (19 to 23.6)
^{51}Cr	Whole Body	5.7 (4.5 to 7.0)	4.4 (3.3 to 5.6)
^{134}Cs	Whole Body	1.6 (1.0 to 2.3)	2.7 (1.8 to 3.6)
^{137}Cs	Whole Body	28.4 (26.1 to 30.8)	16.6 (14.5 to 18.7)
^{152}Eu	Whole Body	7.4 (6.0 to 8.7)	5.5 (4.2 to 6.8)
^{154}Eu	Whole Body	3.8 (2.8 to 4.8)	3.5 (2.5 to 4.6)
^{155}Eu	Whole Body	3.8 (2.8 to 4.8)	3.4 (2.4 to 4.4)
^{59}Fe	Whole Body	3.8 (2.8 to 4.8)	5.7 (4.4 to 7)
^{131}I	Whole Body	5.2 (4.0 to 6.4)	4.5 (3.4 to 5.7)
^{133}I	Whole Body	3.3 (2.3 to 4.2)	4.1 (3 to 5.2)
^{192}Ir	Whole Body	4.1 (3.1 to 5.1)	4.3 (3.1 to 5.4)
^{40}K	Whole Body	100.0 (100.0 to 100.0)	100 (100 to 100)
[d] ^{54}Mn	Whole Body	12.3 (10.6 to 14.0)	12.6 (10.7 to 14.5)
^{103}Ru	Whole Body	2.2 (1.4 to 3.0)	1.8 (1.1 to 2.6)

^{106}Ru	Whole Body	4.4 (3.3 to 5.4)	4.4 (3.3 to 5.6)
^{125}Sb	Whole Body	5.2 (4.0 to 6.4)	4.5 (3.4 to 5.7)
^{232}Th via ^{228}Ac	Whole Body	34.7 (32.2 to 37.2)	26.7 (24.2 to 29.2)
^{88}Y	Whole Body	7.7 (6.3 to 9.0)	6.7 (5.3 to 8.1)
^{95}Zr	Whole Body	6.6 (5.3 to 7.9)	3.8 (2.7 to 4.9)

[a] N = number of individuals. Baseline counts include only the initial counts during this baseline period.
[b] Margin of error represents the 95% confidence interval of the observed percentage.
[c] $^{238\text{-}240,\ 242}$ Pu isotopes are identified as a group, deNoted as Pu-Isotopes by the software.
[d] These radionuclides are present in the shield background, so they are expected to be detected periodically.
[e] ^{235}U and ^{226}Ra have gamma ray energies 185.72 keV and 186.21 keV respectively. Current software identifies both with the same 186 keV gamma ray energy, calculates the individual activity using the corresponding yields

APPENDIX I - NON-RADIOLOGICAL MONITORING

Detection limits of different methods

Weekly composite concentrations of selected metals (ng/m^3) at Station A
Weekly composite concentrations of selected anions (ng/m^3) at Station A
Weekly composite concentrations of selected cations (ng/m^3) at Station A

Monthly composite concentrations of selected metals (ng/m^3) at Station B
Monthly composite concentrations of selected anions (ng/m^3) at Station B
Monthly composite concentrations of selected cations (ng/m^3) at Station B

Concentrations of selected anion concentrations (ng/m^3) in ambient air at Near Field
Concentrations of selected cation concentrations (ng/m^3) in ambient air at Near Field

Concentrations of selected anion concentrations (ng/m^3) in ambient air at Cactus Flats
Concentrations of selected cation concentrations (ng/m^3) in ambient air at Cactus Flats

Summary of metal concentrations in drinking water samples during 1998 - 2021
Summaries of other analyses performed on drinking water samples in 2021

Selected anion concentrations in surface water samples during 2017 - 2021
Selected cation concentrations in surface water samples during 2017 - 2021
Summaries of other analyses performed on surface water samples in 2021

Table I.1. Summary of sample type, analytes, methods, and detection limits used for non-radioactive analyses in 2021

Sample Type	Detection method	Method/ Parameters	Analytes of Interest	Detection Limits* (µg/L)
Drinking Water	ICP-MS	Metals analysis (EPA 200.8)	Over 30 different metals	Varies by element**
Drinking Water	ICP-MS	Mercury (EPA 200.8)	Hg	0.34
Drinking Water	IC	Anions (EPA 300.0)	F^-, Cl^-, Br^-, NO_2^-, NO_3^-, PO_4^{3-}, SO_4^{2-}	2.6 – 8.9
Drinking Water	IC	Cations (ASTM Standard D6919-09)	Li^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, NH_4^+, Mg^{2+}	4.4 - 51
Surface Water	ICP-MS	Metals analysis (EPA 200.8)	Over 30 different metals	Varies by element**
Surface Water	ICP-MS	Mercury (EPA 200.8)	Hg	0.19
Surface Water	IC	Anions (EPA 300.0)	F^-, Cl^-, Br^-, NO_2^-, NO_3^-, PO_4^{3-}, SO_4^{2-}	1.3 – 19.1
Surface Water	IC	Cations (ASTM Standard D6919-09)	Li^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, NH_4^+, Mg^{2+}	2.3 - 76
Station A and B filters	ICP-MS	Metals analysis (EPA 200.8)	Al Cd Mg Pb Si Th U	335 0.41 402 741 0.30 0.065
Station A and B filters	IC	Anions (EPA 300.0)	F^-, Cl^-, Br^-, NO_2^-, NO_3^-, PO_4^{3-}, SO_4^{2-}	1.9 - 627
Station A and B filters	IC	Cations (ASTM Standard D6919-09)	Li^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, NH_4^+, Mg^{2+}	15 - 150
Whatman 41 filters	IC	Anions (EPA 300.0)	F^-, Cl^-, Br^-, NO_2^-, NO_3^-, PO_4^{3-}, SO_4^{2-}	9.3 - 1786
Whatman 41 filters	IC	Cations (ASTM Standard D6919-09)	Li^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, NH_4^+, Mg^{2+}	5.8 - 310

* Detection limits are determined/updated annually.

** Current MDC values for individual metals are included in the results section of this chapter.

Table I.2. Concentrations of selected metals (ng/m^3) in weekly composites from Station A in 2021

Sample Date	Aluminum	Cadmium	Lead	Magnesium	Silica	Thorium	Uranium
January							
1st week	354	0.40	2.31	937	861	0.057	0.032
2nd week	223	0.42	1.46	570	N/A	<MDL	0.018
3rd week	257	0.45	1.53	858	N/A	0.042	0.029
4th week	580	0.66	3.14	9794	N/A	0.090	0.056
February							
1st week	410	0.63	N/A	8839	1096	0.077	0.051
2nd week	218	0.55	3.12	5792	662	0.041	0.031
3rd week	302	0.59	5.63	6480	829	0.051	0.040
4th week	331	0.52	4.24	1025	840	0.060	0.034
March							
1st week	495	1.78	23.2	2072	<MDL	0.072	0.046
2nd week	782	1.43	4.28	1684	<MDL	0.1374	0.059
3rd week	1167	1.41	39.5	5958	<MDL	0.20	0.17
4th week	2013	2.11	7.53	4421	<MDL	0.40	0.19
September							
1st week	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2nd week	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3rd week	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4th week	536	2.32	2.52	2779	<MDL	<MDL	<MDL
October							
1st week	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2nd week	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3rd week	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4th week	327	1.15	7.44	955	<MDL	<MDL	0.0343
November							
1st week	212	0.96	4.49	1224	842	0.23	0.045
2nd week	807	1.73	16.1	1530	2269	1.07	0.15
3rd week	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4th week	N/A	N/A	N/A	N/A	N/A	N/A	N/A

NOTE: Filters were only received for January, February, March, September, October and November in 2021

Table I.3. Concentrations of selected anions (ng/m^3) in 2021 weekly composites from Station A

Sample Date	Chloride	Nitrate	Phosphate	Sulfate
January				
1st week	48728	<MDL	<MDL	10412
2nd week	39231	<MDL	<MDL	10831
3rd week	82641	<MDL	<MDL	14511
4th week	129309	<MDL	<MDL	19128
February				
1st week	160149	<MDL	<MDL	23058
2nd week	111031	251	<MDL	17504
3rd week	147164	417	<MDL	25943
4th week	103766	208	<MDL	15600
March				
1st week	110243	<MDL	<MDL	19346
2nd week	43461	<MDL	<MDL	11845
3rd week	223086	<MDL	<MDL	114578
4th week	154493	<MDL	<MDL	71142
September				
1st week	N/A	N/A	N/A	N/A
2nd week	N/A	N/A	N/A	N/A
3rd week	N/A	N/A	N/A	N/A
4th week	265034	<MDL	<MDL	12005
October				
1st week	N/A	N/A	N/A	N/A
2nd week	N/A	N/A	N/A	N/A
3rd week	N/A	N/A	N/A	N/A
4th week	134519	<MDL	<MDL	23511
November				
1st week	44755	<MDL	<MDL	11693
2nd week	38384	<MDL	<MDL	12005
3rd week	N/A	N/A	N/A	N/A
4th week	N/A	N/A	N/A	N/A
NOTE: Filters were only received for January, February, March, September, October and November in 2021				

Table I.4. Concentrations of selected cations (ng/m^3) in 2021 weekly composites from Station A

Sample Date	Sodium	Ammonium	Magnesium	Potassium	Calcium
January					
1st week	31818	<MDL	907	571	4840
2nd week	25187	358	585	451	3793
3rd week	512135	<MDL	929	707	5963
4th week	795956	<MDL	1226	1317	7187
February					
1st week	1025348	<MDL	1450	1699	8742
2nd week	705200	<MDL	955	1183	6358
3rd week	931315	<MDL	1288	1512	9002
4th week	657802	<MDL	1110	1014	6622
March					
1st week	681933	<MDL	1832	1946	7692
2nd week	28722	<MDL	1195	881	6596
3rd week	1418639	<MDL	4477	6916	45081
4th week	104151	<MDL	3533	4047	30537
September					
1st week	N/A	N/A	N/A	N/A	N/A
2nd week	N/A	N/A	N/A	N/A	N/A
3rd week	N/A	N/A	N/A	N/A	N/A
4th week	220317	<MDL	3738	5944	18553
October					
1st week	N/A	N/A	N/A	N/A	N/A
2nd week	N/A	N/A	N/A	N/A	N/A
3rd week	N/A	N/A	N/A	N/A	N/A
4th week	80918	<MDL	830	1308	4977
November					
1st week	30188	<MDL	476	597	3857
2nd week	25902	<MDL	803	667	4941
3rd week	N/A	N/A	N/A	N/A	N/A
4th week	N/A	N/A	N/A	N/A	N/A

NOTE: Filters were only received for January, February, March, September, October and November in 2021

Table I.5. Concentrations of selected metals (ng/m^3) in 2021 monthly composites from Station B

Sample Date	Aluminum	Cadmium	Lead	Magnesium	Silica	Thorium	Uranium
January	N/A	N/A	N/A	N/A	N/A	N/A	N/A
February	<MDC	0.413	0.211	<MDC	<MDC	<MDC	<MDC
March	133	0.485	0.193	<MDC	N/A	<MDC	<MDC
April	121	0.453	0.203	<MDC	N/A	<MDC	<MDC
May	115	0.477	0.183	<MDC	N/A	<MDC	<MDC
June	82.1	0.397	0.137	<MDC	214	<MDC	<MDC
July	<MDC	0.388	0.186	<MDC	222	<MDC	<MDC
August	96.3	0.433	0.433	84.5	376	<MDC	<MDC
September	266	0.416	0.390	102	451	<MDC	<MDC
October	120	0.444	0.235	<MDC	439	<MDC	<MDC
November	82.1	0.429	0.160	<MDC	287	<MDC	<MDC
December	68.8	0.405	0.113	<MDC	278	<MDC	<MDC

Table I.6. Concentrations of selected anions (ng/m^3) in 2021 monthly composites from Station B

Sample Date	Chloride ng/m^3	Nitrate ng/m^3	Phosphate ng/m^3	Sulfate ng/m^3
January	N/A	N/A	N/A	N/A
February	<MDL	<MDL	<MDL	<MDL
March	<MDL	<MDL	<MDL	<MDL
April	353	<MDL	<MDL	<MDL
May	<MDL	<MDL	<MDL	<MDL
June	403	<MDL	<MDL	<MDL
July	489	<MDL	<MDL	<MDL
August	1120	<MDL	<MDL	<MDL
September	825	<MDL	<MDL	<MDL
October	596	<MDL	<MDL	<MDL
November	523	<MDL	<MDL	<MDL
December	505	<MDL	<MDL	<MDL

Table I.7. Concentrations of selected cations (ng/m³) in 2021 monthly composites from Station B

Sample Date	Sodium	Ammonium	Magnesium	Potassium	Calcium
January	N/A	N/A	N/A	N/A	N/A
February	<MDL	<MDL	<MDL	<MDL	54
March	<MDL	<MDL	<MDL	<MDL	77
April	76	<MDL	<MDL	<MDL	71
May	58	<MDL	<MDL	<MDL	70
June	112	<MDL	<MDL	<MDL	52
July	88	<MDL	<MDL	<MDL	32
August	359	<MDL	<MDL	<MDL	155
September	151	<MDL	<MDL	<MDL	177
October	71	<MDL	<MDL	<MDL	182
November	<MDL	<MDL	<MDL	<MDL	110
December	<MDL	<MDL	<MDL	<MDL	49

Table I.8. Concentrations of anions in ambient air (µg/m³) at Near Field

Start Date	Chloride	Nitrate	Phosphate	Sulfate
1/14/2021	0.146	1.61	0.00443	1.18
2/2/2021	0.219	2.65	<MDL	2.54
3/2/2021	0.420	1.81	0.00396	2.58
3/23/2021	0.317	0.46	0.00544	2.10
4/20/2021	0.246	1.69	0.00403	1.54
5/18/2021	0.0669	1.35	0.00256	2.42
6/30/2021	0.0961	1.55	0.00357	2.17
8/10/2021	0.322	1.59	0.00474	1.93
9/2/2021	0.221	1.89	0.00965	1.72
10/8/2021	0.295	2.05	0.00687	2.04
10/26/2021	0.33	2.33	0.0239	2.00
11/2/2021	0.228	2.53	0.0190	1.94
12/3/2021	0.266	2.06	0.0296	2.01
12/23/2021	0.221	2.01	0.00567	1.37

Table I.9. Concentrations of cations in ambient air (μg/m^3) at Near Field

Sample Date	Sodium	Magnesium	Potassium	Calcium
1/14/2021	0.193	0.082	0.161	0.990
2/2/2021	0.261	0.078	0.112	1.34
3/2/2021	0.496	0.096	0.131	1.20
3/23/2021	0.318	0.107	0.171	1.39
4/20/2021	0.274	0.069	0.086	1.08
5/18/2021	0.320	0.084	0.086	1.51
6/30/2021	0.262	0.067	0.085	1.54
8/10/2021	0.420	0.0660	0.0687	1.22
9/2/2021	0.264	0.0646	0.105	1.25
10/8/2021	0.311	0.0779	0.0981	1.31
10/27/2021	0.270	0.148	0.276	1.45
11/2/2021	0.189	0.0941	0.177	1.23
12/3/2021	0.225	0.114	0.235	0.957
12/23/2021	0.145	0.0942	0.188	0.779

Table I.10. Concentrations of anions in ambient air (μg/m^3) at Cactus Flats

Start Date	Chloride	Nitrate	Phosphate	Sulfate
3/2/2021	0.481	1.55	0.00244	2.62
3/23/2021	0.314	0.403	<MDL	1.92
4/20/2021	0.172	2.48	0.00430	3.11
5/18/2021	0.0586	1.44	0.00196	2.42
8/10/2021	0.158	2.20	0.0109	1.45
9/2/2021	0.127	1.64	0.00735	1.52
10/8/2021	0.225	2.48	0.00410	1.40
10/26/2021	0.175	1.43	0.0117	1.01
11/2/2021	0.152	2.51	0.0107	2.76
12/3/2021	0.185	1.51	0.0102	1.47
12/23/2021	0.187	1.45	0.00264	0.913

Table I.11. Concentrations of cations in ambient air (μg/m^3) at Cactus Flats

Sample Date	Sodium	Magnesium	Potassium	Calcium
3/2/2021	0.473	0.089	0.108	1.25
3/23/2021	0.278	0.077	0.095	1.29
4/20/2021	0.209	0.061	0.072	1.16
5/18/2021	0.282	0.072	0.054	1.52
8/10/2021	0.203	0.0436	0.0596	1.08
9/2/2021	0.168	0.0660	0.0687	1.22
10/8/2021	0.201	0.0500	0.0533	1.16
10/26/2021	0.159	0.0620	0.104	1.03
11/2/2021	0.129	0.0622	0.0994	1.16
12/3/2021	0.159	0.0648	0.113	1.01
12/23/2021	0.143	0.0425	0.0746	0.701

Table I.12. Summary of metal concentrations (µg/L) measured in Carlsbad drinking water from 1998 – 2021

Metals	2021 Concentration	MDC	Concentration ranges from 1998-2020
Ag	0.0171	0.0136	0.0175-0.0599
Al	43.4E	3.94	1.83-41.1
As	0.598	0.120	0.297-1.42
B	N/A	N/A	28.9-44.4
Ba	67.7	0.0780	66.4-81.9
Be	<MDC	0.00580	N/A
Ca	59900	260	59000-78200
Cd	<MDC	0.00940	0.0124-0.0187
Ce	0.0283	0.00144	0.00581-0.0342
Co	0.150	0.0420	0.088-0.37
Cr	1.98	0.200	0.514-10.2
Cu	10.8	1.08	1.3-18.3
Dy	<MDC	0.00300	0.00356-0.00356
Er	<MDC	0.00116	0.00332-0.00338
Eu	0.0171	0.00186	0.0104-0.028
Fe	372	15.4	0.71-652
Ga	N/A	N/A	3.25-3.25
Gd	0.00227	0.00200	0.00196-0.0622
Hg	<MDC	0.339	0.0226-0.0314
K	1070	27.0	1020-3560
La	0.0123	0.00260	0.00581-0.0442
Li	6.73	0.0400	5.14-8.86
Mg	31100	8.00	27300-34700
Mn	0.184	0.0440	0.055-29.3
Mo	1.35	0.0178	0.893-1.37
Na	11200	39.5	8160-45500
Nd	0.0154	0.00220	0.0085-0.00935
Ni	3.07	0.00540	1.46-3.97
P	<MDC	11.2	7.25-49.5
Pb	1.13	0.0720	0.101-6.62

Table I.12. Summary of metal concentrations (μg/L) measured in Carlsbad drinking water from 1998 – 2021 (continued)

Metals	2021 Concentration	MDC	Concentration ranges from 1998-2020
Pr	0.00376	0.00128	0.00193-0.00372
Sb	0.0337	0.00500	0.025-0.199
Sc	2.55	0.0240	1.18-3.03
Se	<MDC	5.60	N/A
Si	6070	567	5350-7000
Sr	337	0.800	261-404
Th	<MDC	0.0110	0.00632-0.0176
Tl	0.0970	0.00178	0.0897-1.3
U	0.852	0.00900	0.654-1.05
V	3.82	0.148	3.07-6.57
Zn	13.5	4.60	2.13-38.7

Table I.13. Summary of metal concentrations (μg/L) measured in Double Eagle water from 1998 – 2021

Metals	2021 Concentration	MDC	Concentration ranges from 1998-2020
Ag	<MDC	0.0680	0.00362-0.178
Al	47.4	19.7	1.93-72.2
As	7.06	0.600	4.48-9.11
B	N/A	N/A	29.8-85.5
Ba	100	0.390	38.2-126
Be	<MDC	0.0290	0.0363-0.0676
Ca	46000	52.0	41500-59400
Cd	<MDC	0.0470	0.0187-0.0187
Ce	0.0301	0.00720	0.00363-0.0322
Co	<MDC	0.210	0.0573-1.12
Cr	1.95	1.00	0.838-32.5
Cu	<MDC	5.40	0.809-5.69
Dy	<MDC	0.0150	0.0615-0.0615
Er	<MDC	0.00580	0.0579-0.0579
Eu	0.0234	0.00930	0.0168-0.0932
Fe	261	77.0	0.0301-932
Ga	N/A	N/A	4.46-4.46
Gd	<MDC	0.0100	N/A
Hg	<MDC	0.339	N/A
K	2730	135	2220-29400
La	0.0156	0.0130	0.0119-0.075
Li	19.2	0.200	9.97-21.7
Mg	10300	1.60	8510-12500
Mn	0.340	0.220	0.222-15
Mo	1.66	0.0890	1.42-6.7
Na	28400	7.90	3840-41500
Nd	0.0123	0.0110	0.00235-0.0488
Ni	2.08	0.270	0.768-4.03
P	<MDC	56.0	6.38-23.5

Table I.13. Summary of metal concentrations (µg/L) measured in Double Eagle water from 1998 – 2021 (continued)

Metals	2021 Concentration	MDC	Concentration ranges from 1998-2020
Pb	1.70	0.360	0.256-5.32
Pr	<MDC	0.00640	N/A
Sb	0.0255	0.0250	0.0241-0.139
Sc	6.07	0.120	1.4-6.59
Se	<MDC	28.0	N/A
Si	15600	2840	7370-19500
Sr	583	0.160	50.6-640
Th	<MDC	0.0550	0.00207-0.0838
Tl	<MDC	0.00890	N/A
U	1.70	0.0450	1.17-2.38
V	25.3	0.740	7.71-40.6
Zn	<MDC	23.0	1.46-12.5

Table I.14. Summary of metal concentrations (µg/L) measured in Hobbs water from 1998 – 2021

Metals	2021 Concentration	MDC	Concentration ranges from 1998-2020
Ag	<MDC	0.0340	0.00386-0.104
Al	12.4	9.85	3.03-114
As	7.20	0.300	4.55-8.56
B	N/A	N/A	141-197
Ba	57.8	0.195	50.7-67.9
Be	<MDC	0.0145	0.0539-0.0539
Ca	90400	260	76300-110000
Cd	0.0304	0.0235	N/A
Ce	0.0103	0.00360	0.0051-0.0356
Co	0.226	0.105	0.0978-0.597
Cr	1.70	0.500	0.644-11.3
Cu	<MDC	2.70	1.04-6.93
Dy	<MDC	0.00750	0.00418-0.00418
Er	<MDC	0.00290	0.0096-0.0096
Eu	0.0129	0.00465	0.0112-0.0197
Fe	574	38.5	36.4-495
Ga	N/A	N/A	2.56-2.56
Gd	<MDC	0.00500	N/A
Hg	N/A	N/A	N/A
K	2850	67.5	2110-25200
La	<MDC	0.00650	0.0125-0.0501
Li	36.2	0.100	26.5-38.9
Mg	24300	0.800	19000-26700
Mn	3.75	0.110	0.379-3.76
Mo	3.35	0.0445	2.36-3.31
Na	47600	39.5	4970-58000
Nd	<MDC	0.00550	0.00301-0.0144
Ni	4.46	0.135	1.67-5.08
P	<MDC	28.0	17.4-83.1
Pb	0.387	0.180	0.0812-1.19

Table I.14. Summary of metal concentrations (μg/L) measured in Hobbs water from 1998 – 2021 (continued)

Metals	2021 Concentration (μg/L)	MDC (μg/L)	Concentration ranges from 1998-2020 (μg/L)
Pr	<MDC	0.00320	0.00157-0.00188
Sb	0.0664	0.0125	0.0388-0.0853
Sc	9.48	0.0600	3.06-10.5
Se	<MDC	14.0	N/A
Si	25500	1420	22000-28600
Sr	1230	0.800	78.9-1220
Th	<MDC	0.0275	0.00229-0.136
Tl	<MDC	0.00445	0.00945-0.0224
U	3.15	0.0225	2.9-4.3
V	29.1	0.370	30.4-39.9
Zn	<MDC	11.5	0.844-4.37

Table I.15. Summary of metal concentrations (µg/L) measured in Loving water from 1998 – 2021

Metals	2021 Concentration	MDC	Concentration ranges from 1998-2020
Ag	0.0277	0.0136	0.00255-0.217
Al	16.6	3.94	1.43-376
As	1.66	0.120	0.789-2.35
B	N/A	N/A	75.5-112
Ba	35.0	0.0780	29.6-36.8
Be	0.0304	0.00580	0.0935-0.0935
Ca	79600	104	67100-100000
Cd	0.0264	0.00940	0.0119-0.0119
Ce	0.0113	0.00144	0.000974-0.253
Co	0.193	0.0420	0.0842-0.404
Cr	3.17	0.200	1.12-11.2
Cu	3.22	1.08	0.806-21.6
Dy	<MDC	0.00300	N/A
Er	<MDC	0.00116	0.0353-0.0353
Eu	0.0291	0.00186	0.007-0.0557
Fe	451	15.4	3.6-416
Ga	N/A	N/A	1.26-1.26
Gd	<MDC	0.00200	0.00215-0.0432
Hg	<MDC	0.339	N/A
K	1950	27.0	1690-19800
La	0.0259	0.00260	0.00666-0.0519
Li	20.3	0.0400	15-22.4
Mg	35200	3.20E	30200-42100
Mn	0.270	0.0440	0.0143-1.77
Mo	1.66	0.0178	1.28-1.72
Na	21400	15.8	2330-28200
Nd	0.00567	0.00220	0.00337-0.0393
Ni	3.66	0.0540	1.41-3.87
P	<MDC	11.2	12.9-73.2
Pb	0.301	0.0720	0.0311-1.67

Table I.15. Summary of metal concentrations (µg/L) measured in Loving drinking water from 1998 – 2021 (continued)

Metals	2021 Concentration	MDC	Concentration ranges from 1998-2020
Pr	0.00161	0.00128	N/A
Sb	0.0563	0.00500	0.0301-0.184
Sc	3.71	0.0240	1.5-4.72
Se	<MDC	5.60	N/A
Si	9960	567	8910-10900
Sr	768	0.320	76-937
Th	0.0218	0.0110	0.00569-0.00738
Tl	0.0231	0.00178	0.00224-0.0432
U	1.88	0.00900	1.68-2.3
V	11.8	0.148	11.1-16.1
Zn	6.73	4.60	2.21-53.3

Table I.16. Summary of metal concentrations (μg/L) measured in Otis drinking water from 1998 – 2021

Metals	2021 Concentration	MDC	Concentration ranges from 1998-2020
Ag	<MDC	0.0680	N/A
Al	25.7	19.7	2.69-1060
As	1.82	0.600	0.653-2.34
B	N/A	N/A	146-239
Ba	14.2	0.390	12.5-19.7
Be	<MDC	0.0290	N/A
Ca	200000	520	171000-360000
Cd	<MDC	0.0470	N/A
Ce	0.0114	0.00720	N/A
Co	0.473	0.210	0.244-1.44
Cr	2.75	1.00	0.812-8.72
Cu	14.7	5.40	2.43-19.7
Dy	<MDC	0.0150	0.00339-0.117
Er	<MDC	0.00580	N/A
Eu	<MDC	0.00930	0.00342-0.111
Fe	1230	77.0	2.87-1420
Ga	N/A	N/A	0.654-0.654
Gd	<MDC	0.0100	N/A
Hg	<MDC	0.339	N/A
K	2720	135	2410-4010
La	<MDC	0.0130	0.00336-0.106
Li	41.6	0.200	30.8-67.9
Mg	71500	16.0	51600-108000
Mn	0.273	0.220	0.198-4.91
Mo	3.23	0.0890	2.25-5.03
Na	74700	79.0	48600-197000
Nd	<MDC	0.0110	0.0048-0.0905
Ni	10.3	0.270	2.62-21.1
P	<MDC	56.0	45.4-368
Pb	<MDC	0.360	0.0388-0.598

Table I.16. Summary of metal concentrations (μg/L) measured in Otis drinking water from 1998 – 2021 (continued)

Metals	2021 Concentration (μg/L)	MDC (μg/L)	Concentration ranges from 1998-2020 (μg/L)
Pr	<MDC	0.00640	N/A
Sb	0.0466	0.0250	0.0366-0.41
Sc	3.90	0.120	0.655-5.35
Se	<MDC	28.0	N/A
Si	10100	2840	9290-13900
Sr	2620	1.60	1850-4970
Th	<MDC	0.0550	0.00119-0.116
Tl	<MDC	0.00890	N/A
U	3.64	0.0450	2.87-6.1
V	10.2	0.740	7.87-12.9
Zn	<MDC	23.0	1.54-25.2

Table I.17. Summary of metal concentrations (µg/L) measured in Malaga drinking water from 1998 – 2021

Metals	2021 Concentration	MDC	Concentration ranges from 2011-2020
Ag	<MDC	0.0680	0.069-0.069
Al	22.6	19.7	2.39-11.6
As	2.05	0.600	1.26-5.44
B	N/A	N/A	N/A
Ba	13.9	0.390	14-16.6
Be	<MDC	0.0290	0.304-0.304
Ca	407000	520	241000-456000
Cd	<MDC	0.0470	N/A
Ce	0.0147	0.00720	N/A
Co	0.845	0.210	0.339-1.72
Cr	2.88	1.00	0.58-10
Cu	<MDC	5.40	1.57-4.73
Dy	<MDC	0.0150	N/A
Er	<MDC	0.00580	0.0681-0.0681
Eu	<MDC	0.00930	0.084-0.084
Fe	3320	77.0	590-2480
Ga	N/A	N/A	N/A
Gd	<MDC	0.0100	N/A
Hg	<MDC	0.339	N/A
K	4030	135	2570-4310
La	<MDC	0.0130	N/A
Li	62.3	0.200	37.2-58.7
Mg	124000	16.0	69800-128000
Mn	1.42	0.220	0.284-1.3
Mo	4.30	0.0890	3.23-3.99
Na	170000	79.0	75300-182000
Nd	<MDC	0.0110	0.0668-0.0668
Ni	17.5	0.270	5.66-19.6
P	<MDC	56.0	25.8-445
Pb	0.690	0.360	0.146-7.98

Table I.17. Summary of metal concentrations (µg/L) measured in Malaga drinking water from 2011-2021 (continued)

Metals	2021 Concentration	MDC	Concentration ranges from 2011-2020
Pr	<MDC	0.00640	N/A
Sb	0.0352	0.0250	0.0395-0.0638
Sc	4.41	0.120	1.45-3.66
Se	<MDC	28.0	16.5-16.5
Si	10800	2840	9120-12300
Sr	5450	1.60	3710-5350
Th	<MDC	0.0550	N/A
Tl	<MDC	0.00890	N/A
U	5.49	0.0450	4.38-5.61
V	8.91	0.740	8.3-12.9
Zn	78.7	23.0	15.2-167

Table I.18. Summary of conductivities measured in drinking water samples for 2021

Location	Conductivity (mS/cm)	Temperature (°C)
Sheep Draw	0.57	16.0
Loving	0.69	15.5
Otis	1.59	15.5
Malaga	3.08	15.5
Double Eagle PRV4	0.44	16.0
Hobbs	0.81	16.3

Table I.19. Summary of pH measurements conducted on drinking water samples for 2021

Location	pH @ 17.9°C
Sheep Draw	7.321
Loving	7.660
Otis	7.701
Malaga	7.403
Double Eagle PRV4	7.895
Hobbs	7.557

Table I.20. Summary of specific gravity measured in drinking water samples for 2021

Location	$SG_{T/4°C}$
Sheep Draw	0.964
Loving	0.963
Otis	0.969
Malaga	0.967
Double PRV4	0.965
Hobbs	0.965

Table I.21. Summary of total dissolved solids (TDS) and total suspended solids (TSS) measured in drinking water samples for 2021

Location	TDS mg/L	TSS* mg/L
Sheep Draw	360	N.D.
Loving	450	N.D.
Otis	1300	N.D.
Malaga	2840	N.D.
Double Eagle PRV4	180	N.D.
Hobbs	530	N.D.

*ND = non-detectable

Table I.22. Summary of total organic carbon (TOC), total inorganic carbon (TIC), and total nitrogen (TN) measured in drinking water samples for 2021

Location	TOC mg/L	TIC mg/L	TN mg/L
Carlsbad	0.432	47.16	1.104
Loving	0.236	47.41	4.466
Otis	0.559	36.83	4.225
Malaga	0.410	30.50	3.781
Double Eagle (PRV4)	0.414	32.06	2.940
Hobbs	0.857	33.20	4.415

Table I.23. Selected anion concentrations (µg/L) in surface water from 1999 – 2021

Anions	2021 Concentration	MDC
Hill Tank (2021)		
Bromide	17	3
Chloride	2610	3
Fluoride	121	1
Nitrate	<MDC	6
Nitrite	<MDC	6
Phosphate	393	19
Sulfate	23800	4
Noya Tank (2021)		
Bromide	8	3
Chloride	846	3
Fluoride	105	1
Nitrate	<MDC	6
Nitrite	<MDC	6
Phosphate	188	19
Sulfate	1850	4
Lost Tank (2021)		
Bromide	46	3
Chloride	1870	3
Fluoride	119	1
Nitrate	<MDC	6
Nitrite	<MDC	6
Phosphate	<MDC	19
Sulfate	1020	4

Table I.24. Selected cation concentrations in surface water from 2017-2021

Anions	2021 Concentration (µg/L)	MDC (µg/L)
Hill Tank (2021)		
Ammonium	384	23
Calcium	33900	235
Lithium	<MDC	2
Magnesium	4670	12
Potassium	15700	380
Sodium	1370	7
Noya Tank (2021)		
Ammonium	660	23
Calcium	40300	235
Lithium	<MDC	2
Magnesium	3460	12
Potassium	5940	76
Sodium	373	7
Lost Tank (2021)		
Ammonium	354	23
Calcium	48100	235
Lithium	<MDC	2
Magnesium	4600	12
Potassium	12300	380
Sodium	495	7

Table I.25. Summary of conductivities measured in surface water samples for 2021

Location	Conductivity mS/cm	Temperature (°C)
Lake Carlsbad (Shallow)	2.34	20.0
Lake Carlsbad (Deep)	2.73	20.0
Brantley Lake (Shallow)	2.51	20.0
Brantley Lake (Deep)	4.17	20.0
Red Bluff (Shallow)	7.88	20.0
Red Bluff (Deep)	12.15	20.0
Hill Tank	0.271	20.0
Noya Tank	0.205	20.0
Lost Tank	0.283	20.0

Table I.26. Summary of pH measurements conducted on surface water samples for 2021

Location	pH @ 22.3°C
Lake Carlsbad, shallow	7.555
Lake Carlsbad, deep	7.665
Brantley Lake, shallow	7.548
Brantley Lake, deep	7.423
Red Bluff, shallow	7.655
Red Bluff, deep	7.483
Hill tank	7.104
Noya tank	7.909
Lost tank	7.821

Table I.27. Summary of specific gravity measured in surface water samples for 2021

Location	SG $_{T/4°C}$
Lake Carlsbad, shallow	0.987
Lake Carlsbad, deep	0.987
Brantley Lake, shallow	0.986
Brantley Lake, deep	0.966
Red Bluff, shallow	0.966
Red Bluff, deep	0.972
Hill Tank	0.989
Noya Tank	0.989
Lost Tank	0.988

Table I.28. Summary of total organic carbon (TOC), total inorganic carbon (TIC), and total nitrogen (TN) measured in surface water samples for 2021

Location	TOC mg/L	TIC mg/L	TN mg/L
Lake Carlsbad (shallow)	5.55	17.36	0.886
Lake Carlsbad (deep)	3.33	25.23	1.04
Brantley Lake (shallow)	5.33	13.27	0.542
Brantley Lake (deep)	4.02	16.67	1.30
Red Bluff (shallow)	7.25	10.34	1.01
Red Bluff (deep)	8.10	14.83	1.57
Hill Tank	6.71	15.50	1.42
Noya Tank	4.44	19.16	2.27
Lost Tank	13.62	21.28	2.95

APPENDIX J - VOC COMPOUNDS AND CONCENTRATIONS OF DISPOSAL AND SURFACE RESULTS

Target Compounds for WIPP confirmatory VOC

Concentrations of concern for VOC

Disposal room VOC monitoring results for Panel 7

Surface VOC results

Table J.1. Target compounds for WIPP confirmatory VOC monitoring program and the maximum MRLs for undiluted repository and disposal room VOCs

Target Compound	MRL (ppbv) for Repository air VOC in SIM mode	MRL (ppbv) for repository air VOC in SCAN mode	MRL (ppbv) for Disposal Room VOC
1,1-Dichloroethylene	0.1	0.2	500
Carbon tetrachloride	0.1	0.2	500
Methylene chloride	0.1	0.2	500
Chloroform	0.1	0.2	500
1,1,2,2-Tetrachloroethane	0.1	0.2	500
1,1,1-Trichloroethane	0.1	0.2	500
Chlorobenzene	0.1	0.2	500
1,2-Dichloroethane	0.1	0.2	500
Toluene	0.1	0.2	500
Trichloroethylene	0.1	0.2	500

ppbv- Parts per billion by volume
MRL – Maximum Method Reporting Limit for undiluted samples.
SIM- Selected Ion Monitoring

Table J.2. Disposal room VOC monitoring maximum results for Panel 7

Target Compound	P7R6E (ppmv)	P7R6I (ppmv)	P7R5E (ppmv)	P7R5I (ppmv)
Carbon tetrachloride	614.89	643.94	624.26	433.03
Chlorobenzene	U	U	U	U
Chloroform	24.14	23.88	23.16	16.40
1,2-Dichloroethane	U	U	U	U
1,1-Dichloroethylene	U	U	U	U
Methylene chloride	2.36J	2.36J	2.27J	1.38J
1,1,2,2-Tetrachloroethane	U	U	U	U
Toluene	U	U	U	U
1,1,1-Trichloroethane	219.57	230.16	224.56	152.02
Trichloroethylene	206.10	211.09	199.72	143.75

ppmv-Parts per million by volume
U – Not-Detected (ND) or below Method Detection Limit
J – Estimated value, below laboratory Method Reporting Limit

Table J.3. Disposal room VOC monitoring maximum results for Panel 7

Target Compound	P7R4E (ppmv)	P7R4I (ppmv)	P7R3E (ppmv)	P7R3I (ppmv)	P7R2E (ppmv)
Carbon tetrachloride	594.34	489.71	179.95	3.60	4.99
Chlorobenzene	U	U	U	U	U
Chloroform	22.83	18.37	6.39	0.11	0.17
1,2-Dichloroethane	U	U	U	U	U
1,1-Dichloroethylene	U	U	U	U	U
Methylene chloride	2.10J	1.44J	0.67J	0.008J	0.02J
1,1,2,2-Tetrachloroethane	U	U	U	U	0.001J
Toluene	U	0.0005J	U	0.002J	0.001J
1,1,1-Trichloroethane	214.59	172.23	65.58	1.27	1.79
Trichloroethylene	189.92	165.93	61.53	1.25	1.67

ppmv-Parts per million by volume
U – Not-Detected (ND) or below Method Detection Limit
J – Estimated value, below laboratory Method Reporting Limit

Table J.4. Concentrations of concern for VOC, from Module IV of the HWFP (No. NM4890139088-TSDF)

Target Compound	50% Action Level (ppmv)	95% Action Level (ppmv)	Room based Limits (ppmv)
1,1-Dichloroethylene	2,745	5,215	5,490
Carbon tetrachloride	4,813	9,145	9,625
Methylene Chloride	50,000	95,000	100,000
Chloroform	4,965	9,433	9,930
1,1,2,2-Tetrachloroethane	1,480	2,812	2,960
1,1,1-Trichloroethane	16,850	32,015	33,700
Chlorobenzene	6500	12350	13000
1,2-Dichloroethane	1,200	2,280	2,400
Toluene	5,500	10,450	11,000
Trichloroethylene	24,000	45,600	48,000

Table J.5. Surface VOC results for stations VOC-C and VOC-D

Target Compounds	VOC-C (ppbv)	VOC-D (ppbv)
Carbon Tetrachloride	0.063J-0.716	0.067J-0.128
Chlorobenzene	U-0.064J	U-0.033J
Chloroform	U-0.042J	U-0.038J
1,2-Dichloroethane	U-0.055J	U-0.044J
1,1-Dichloroethylene	U	U-0.022J
Methylene chloride	0.050J-0.126	0.051J-0.123
1,1,2,2-Tetrachloroethane	U-0.061J	U-0.038J
Toluene	0.029J-3.90	0.023J-0.980
1,1,1-Trichloroethane	U-0.271	U-0.027J
Trichloroethylene	U-0.304	U-0.027J

ppbv-Parts per billion by volume
U – Not-Detected (ND) or below Method Detection Limit
J – Estimated value, below laboratory Method Reporting Limit

APPENDIX K - RADIOCHEMISTRY INTERCOMPARISON, ICP-MS PERFORMANCE, ENVIRONMENTAL CHEMISTRY PROFICIENCY

NIST radiochemistry intercomparison program test results

MAPEP radiochemistry intercomparison program test results

Daily performance tests for ICP-MS

Environmental chemistry proficiency test results for metal analyses, mercury, inorganic anions, and cations

Table K.1. Radiochemistry MAPEP 2021 inter-comparison results

MAPEP Mixed Analyte Performance Evaluation Program

Department of Energy RESL - 1955 Fremont Ave, MS4149 - Idaho Falls, ID 83415

Laboratory Results For MAPEP-21-GrF44
(CMRC01) Carlsbad Environmental Monitoring and Research Center
1400 University Dr.
Carlsbad, NM 88220

Radiological							Units: (Bq/sample)	
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Gross alpha	1.536	1.77	A		-13.2	0.53 - 3.01	0.182	A
Gross beta	0.846	0.649	A		30.4	0.325 - 0.974	0.093	A

Radiological Reference Date: February 1, 2021

Gross Alpha Flags:

A = Result acceptable, Bias <= +/- 70% with a statistically positive result at two standard deviations (Result/Uncertainty > 2, i.e., the range encompassing the result, plus or minus the total uncertainty at two standard deviations, does not include zero).

N = Result not acceptable, Bias > +/- 70% or the reported result is not statistically positive at two standard deviations (Result/Uncertainty <= 2, i.e., the range encompassing the result, plus or minus the total uncertainty at two standard deviations, includes zero).

Gross Beta Flags:

A = Result acceptable, Bias <= +/- 50% with a statistically positive result at two standard deviations (Result/Uncertainty > 2, i.e., the range encompassing the result, plus or minus the total uncertainty at two standard deviations, does not include zero).

N = Result not acceptable, Bias > +/- 50% or the reported result is not statistically positive at two standard deviations (Result/Uncertainty <= 2, i.e., the range encompassing the result, plus or minus the total uncertainty at two standard deviations, includes zero).

Uncertainty Flags:

NOT ACCEPTABLE..........................RP<2%

ACCEPTABLE..................................2%<=RP<=15%

ACCEPTABLE WITH WARNING...........15%<RP<=30%

NOT ACCEPTABLE...........................RP>30%

RP = Relative Precision

Issued 6/14/2021 Printed 6/16/2023

Table K.2. Radiochemistry MAPEP 2021 inter-comparison results for soil

MAPEP Mixed Analyte Performance Evaluation Program

Department of Energy RESL - 1955 Fremont Ave, MS4149 - Idaho Falls, ID 83415

Laboratory Results For MAPEP-21-MaS44
(CMRC01) Carlsbad Environmental Monitoring and Research Center
1400 University Dr.
Carlsbad, NM 88220

Inorganic							Units: (mg/kg)	
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Antimony	NR	78				55 - 101		
Arsenic	NR	45.8				32.1 - 59.5		
Barium	NR	223				156 - 290		
Beryllium	NR	60.6				42.4 - 78.8		
Cadmium	NR	7.05				4.94 - 9.17		
Chromium	NR	49.9				34.9 - 64.9		
Cobalt	NR	194				136 - 252		
Copper	NR	37.7				26.4 - 49.0		
Lead	NR	28.8				20.2 - 37.4		
Nickel	NR	148				104 - 192		
Selenium	NR	16.9				11.8 - 22.0		
Silver	NR	42.5				29.8 - 55.3		
Technetium-99	NR	0.00101				0.00071 - 0.00131		
Thallium	NR	11.0				7.7 - 14.3		
Uranium-235	NR	0.0469				0.0328 - 0.0610		
Uranium-238	NR	16.7				11.7 - 21.7		
Uranium-Total	NR	16.7				11.7 - 21.7		
Vanadium	NR	279				195 - 363		
Zinc	NR	370				259 - 481		

Radiological							Units: (Bq/kg)	
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Americium-241	8.60E+01	88	A		-2.3	62 - 114	6.33	A
Cesium-134	-9.16E-01		A			False Positive Test	5.61E-01	
Cesium-137	1.79E+03	1550	A		15.5	1085 - 2015	1.91	N
Cobalt-57	9.72E+02	920	A		5.7	644 - 1196	2.05	A
Cobalt-60	1.39E+03	1370	A		1.5	959 - 1781	1.64	N
Iron-55	NR	910				637 - 1183		
Manganese-54	7.09E-01		A			False Positive Test	5.79E-01	
Nickel-63	NR	689				482 - 896		
Plutonium-238	5.11E+01	49.1	A		4.1	34.4 - 63.8	4.37	A
Plutonium-239/240	2.33E-01		A			False Positive Test	8.82E-02	
Potassium-40	6.55E+02	618	A		6.0	433 - 803	1.40	A
Strontium-90	NR	272				190 - 354		
Technetium-99	NR	638				447 - 829		
Uranium-234	5.61E+01	59	A		-4.9	41 - 77	4.59	A

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Table K.2. Radiochemistry MAPEP 2021 inter-comparison results for soil (continued)

Radiological							Units: (Bq/kg)	
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Uranium-238	2.04E+02	208	A		-1.9	146 - 270	1.52	A
Zinc-65	6.81E+02	604	A		12.7	423 - 785	8.55	N

Radiological Reference Date: February 1, 2021

Results Flags:

A = Result acceptable Bias <=20%

W = Result acceptable with warning 20% < Bias < 30%

N = Result not acceptable Bias > 30%

RW = Report Warning

NR = Not Reported

Uncertainty Flags:

NOT ACCEPTABLE............................RP<2%

ACCEPTABLE..................................2%<=RP<=15%

ACCEPTABLE WITH WARNING...........15%<RP<=30%

NOT ACCEPTABLE............................RP>30%

RP = Relative Precision

Table K.3. Radiochemistry MAPEP 2021 inter-comparison results for water

MAPEP Mixed Analyte Performance Evaluation Program

Department of Energy RESL - 1955 Fremont Ave, MS4149 - Idaho Falls, ID 83415

Laboratory Results For MAPEP-21-MaW44
(CMRC01) Carlsbad Environmental Monitoring and Research Center
1400 University Dr.
Carlsbad, NM 88220

Inorganic								Units: (mg/L)
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Antimony	NR	8.63				6.04 - 11.22		
Arsenic	NR	2.06				1.44 - 2.68		
Barium	NR	7.58				5.31 - 9.85		
Beryllium	NR	3.15				2.21 - 4.10		
Cadmium	NR	0.748				0.524 - 0.972		
Chromium	NR	4.01				2.81 - 5.21		
Cobalt	NR	10.3				7.2 - 13.4		
Copper	NR	5.53				3.87 - 7.19		
Lead	NR	2.52				1.76 - 3.28		
Mercury	NR	0.106				0.074 - 0.138		
Nickel	NR	5.05				3.54 - 6.57		
Selenium	NR	0.676				0.473 - 0.879		
Technetium-99	NR	6.35E-6				4.45E-6 - 8.26E-6		
Thallium	NR	2.46				1.72 - 3.20		
Uranium-235	NR	0.000499				3.49E-4 - 6.49E-4		
Uranium-238	NR	0.069				0.048 - 0.090		
Uranium-Total	NR	0.070				0.049 - 0.091		
Vanadium	NR	17.4				12.2 - 22.6		
Zinc	NR	15.5				10.9 - 20.2		

Radiological								Units: (Bq/L)
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Americium-241	2.00E-3		A			False Positive Test	8.46E-04	
Cesium-134	9.28E+00	11.5	A		-19.3	8.1 - 15.0	4.44E-01	A
Cesium-137	8.22E+00	7.9	A		4.1	5.5 - 10.3	5.31E-01	A
Cobalt-57	1.18E+01	11.4	A		3.5	8.0 - 14.8	4.03E-01	A
Cobalt-60	5.65E-02		A			False Positive Test	1.75E-01	
Hydrogen-3	NR					False Positive Test		
Iron-55	NR	26.9				18.8 - 35.0		
Manganese-54	1.57E+01	15.5	A		1.3	10.9 - 20.2	7.80E-01	A
Nickel-63	NR	8.2				5.7 - 10.7		
Plutonium-238	5.40E-01	0.577	A		-6.4	0.404 - 0.750	3.86E-02	A
Plutonium-239/240	6.07E-01	0.649	A		-6.5	0.454 - 0.844	4.32E-02	A
Potassium-40	-2.22E+00		A			False Positive Test	3.48	
Radium-226	NR	0.632				0.442 - 0.822		
Strontium-90	NR	4.47				3.13 - 5.81		

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Table K.3. Radiochemistry MAPEP 2021 inter-comparison results for water (continued)

Radiological							Units: (Bq/L)	
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Technetium-99	NR	4.01				2.81 - 5.21		
Uranium-234	8.84E-01	0.85	A		4.0	0.60 - 1.11	6.37E-02	A
Uranium-238	8.82E-01	0.86	A		2.6	0.60 - 1.12	6.37E-02	A
Zinc-65	1.11E+01	10.5	A		5.7	7.4 - 13.7	1.14	A

Radiological Reference Date: February 1, 2021

Uncertainty Flags:

NOT ACCEPTABLE..........................RP<2%

ACCEPTABLE.................................2%<=RP<=15%

ACCEPTABLE WITH WARNING..........15%<RP<=30%

NOT ACCEPTABLE...........................RP>30%

RP = Relative Precision

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Table K.4. Radiochemistry MAPEP 2021 inter-comparison results for filter

MAPEP Mixed Analyte Performance Evaluation Program

Department of Energy RESL - 1955 Fremont Ave, MS4149 - Idaho Falls, ID 83415

Laboratory Results For MAPEP-21-RdF44

(CMRC01) Carlsbad Environmental Monitoring and Research Center
1400 University Dr.
Carlsbad, NM 88220

Inorganic							Units: (ug/sample)	
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Uranium-235	NR	0.0353				0.0247 - 0.0459		
Uranium-238	NR	5.03				3.52 - 6.54		
Uranium-Total	NR	5.07				3.55 - 6.59		

Radiological							Units: (Bq/sample)	
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Americium-241	3.84E-02	0.037	A		3.8	0.026 - 0.048	3.02E-03	A
Cesium-134	1.86E+00	2.14	A		-13.1	1.50 - 2.78	3.94E-02	A
Cesium-137	-5.96E-03		A			False Positive Test	2.81E-02	
Cobalt-57	6.97E-01	0.686	A		1.6	0.480 - 0.892	2.96E-02	A
Cobalt-60	1.16E-02		A			False Positive Test	4.85E-02	
Manganese-54	3.20E-01	0.312	A		2.6	0.218 - 0.406	1.55E-01	N
Plutonium-238	2.39E-02	0.0228	A		4.8	0.0160 - 0.0296	2.07E-03	A
Plutonium-239/240	4.53E-02	0.0453	A		0.0	0.0317 - 0.0589	3.57E-03	A
Strontium-90	NR	0.749				0.524 - 0.974		
Uranium-234	6.09E-02	0.06	A		1.5	0.04 - 0.08	5.03E-03	A
Uranium-238	6.01E-02	0.063	A		-4.6	0.044 - 0.082	4.97E-03	A
Zinc-65	4.15E-01	0.352	A		17.9	0.246 - 0.458	6.93E-02	W

Radiological Reference Date: February 1, 2021

Result Flags:

A = Result acceptable Bias <=20%

W = Result acceptable with warning 20% < Bias < 30%

N = Result not acceptable Bias > 30%

RW = Report Warning

NR = Not Reported

Uncertainty Flags:

NOT ACCEPTABLE............................RP<2%

ACCEPTABLE...................................2%<=RP<=15%

ACCEPTABLE WITH WARNING...........15%<RP<=30%

Issued 6/14/2021 Printed 6/16/2023

Table K.4. Radiochemistry MAPEP 2021 inter-comparison results for filter (continued)

Radiological								Units: (Bq/sample)
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag

NOT ACCEPTABLE............................RP>30%

Issued 6/14/2021 Printed 6/16/2023

Table K.5. Radiochemistry MAPEP 2020 inter-comparison results for unknown sample

MAPEP Mixed Analyte Performance Evaluation Program

Department of Energy RESL - 1955 Fremont Ave, MS4149 - Idaho Falls, ID 83415

Laboratory Results For MAPEP-20-XrM43
(CMRC01) Carlsbad Environmental Monitoring and Research Center
1400 University Dr.
Carlsbad, NM 88220

Radiological			Units: (Bq/sample)	
Sample ID	Nuclide	Known Activity	Experimental Activity	Bias (%)
MAPEP-20-XrM43	Am-241	0.0477 +/- 0.0012	4.60E-02 +/- 3.46E-03	-3.6
MAPEP-20-XrM43	Cs-134	0.159 +/- 0.004	1.73E-01 +/- 3.25E-02	8.8
MAPEP-20-XrM43	Cs-137	1.118 +/- 0.018	1.52E+00 +/- 7.92E-02	36.0
MAPEP-20-XrM43	Co-57	0.0144 +/- 0.0003	1.88E-02 +/- 2.57E-02	30.6
MAPEP-20-XrM43	Co-60	0.504 +/- 0.016	6.20E-01 +/- 4.32E-02	23.0
MAPEP-20-XrM43	Cm-244	0.0543 +/- 0.0007	4.68E-02 +/- 3.52E-03	-13.8
MAPEP-20-XrM43	Mn-54	0.0177 +/- 0.0004	1.56E-02 +/- 2.13E-02	-11.9
MAPEP-20-XrM43	Pu-238	0.0587 +/- 0.0012	5.66E-02 +/- 4.57E-03	-3.6
MAPEP-20-XrM43	Pu-239	0.0483 +/- 0.0012	4.73E-02 +/- 3.92E-03	-2.1
MAPEP-20-XrM43	K-40		3.47E+00 +/- 5.03E-01	
MAPEP-20-XrM43	Sr-90	0.657 +/- 0.015		
MAPEP-20-XrM43	Tc-99	0.694 +/- 0.015		
MAPEP-20-XrM43	U-234	0.00804 +/- 0.00017	8.64E-03 +/- 1.35E-03	7.5
MAPEP-20-XrM43	U-235		1.08E-03 +/- 4.92E-04	
MAPEP-20-XrM43	U-238	0.0610 +/- 0.0012	5.90E-02 +/- 5.66E-03	-3.3
MAPEP-20-XrM43	Zn-65	0.00399 +/- 0.00009	2.22E-02 +/- 2.43E-02	

Radiological Reference Date: August 1, 2020

Issued 12/11/2020 Printed 12/14/2020

Table K.6. Daily performance tests (ICP-MS, NexION)

	Acceptable Ranges	03/12/2021			07/14/21		
	Criteria for Net Intensity Mean of 5 replicate readings	Measured Intensity Mean	RSD	Performance Evaluation	Measured Mean Intensity	RSD	Performance Evaluation
Be	>3,500	7,077.3	5.8	Acceptable	6,428.1	3.3	Acceptable
In	>500,000	128,145.5	2.8	Acceptable	94,817.0	1.5	Acceptable
U	>40,000	114,122.6	4.8	Acceptable	109,776.1	2.6	Acceptable
CeO	≤3%	2.3%	N/A	Acceptable	2.5%	N/A	Acceptable
Ce++	≤3%	0.9%	N/A	Acceptable	1.5%	N/A	Acceptable
Bkgd	≤10	0.033	N/A	Acceptable	0.10	N/A	Acceptable

RSD = Relative Standard Deviation

Table K.7. Environmental chemistry proficiency test results for metal analyses

ERA
A Waters Company

WS-296 Final Evaluation Report

Adrienne Chancellor
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Carlsbad, NM 88220-3575
(575) 234-5525

EPA ID: Not Reported
ERA Customer Number: N215603
Report Issued: 04/26/21
Study Dates: 03/08/21 - 04/22/21

TNI Analyte Code	Analyte	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation	Method Description	Analysis Date	Z Score	Study Mean	Study Standard Deviation	Analyst Name
WS Metals (cat# 590, lot# S296-697)												
1000	Aluminum	µg/L	722.0	701	596 - 806	Acceptable	EPA 200.8 5.4 1994	4/20/2021	0.155	717	34.3	
1005	Antimony	µg/L	40.1	43.4	30.4 - 56.4	Acceptable	EPA 200.8 5.4 1994	4/20/2021	-1.24	42.9	2.26	
1010	Arsenic	µg/L	36.9	41.7	29.2 - 54.2	Acceptable	EPA 200.8 5.4 1994	4/20/2021	-1.10	40.0	2.81	
1015	Barium	µg/L	1527.8	1600	1360 - 1840	Acceptable	EPA 200.8 5.4 1994	4/20/2021	-0.799	1580	61.0	
1020	Beryllium	µg/L	11.6	11.4	9.69 - 13.1	Acceptable	EPA 200.8 5.4 1994	4/20/2021	0.902	11.1	0.572	
1025	Boron	µg/L		1160	986 - 1330	Not Reported				1160	62.3	
1030	Cadmium	µg/L	32.8	35.7	28.6 - 42.8	Acceptable	EPA 200.8 5.4 1994	4/20/2021	-1.15	34.9	1.85	
1040	Chromium	µg/L	76.5	84.0	71.4 - 96.6	Acceptable	EPA 200.8 5.4 1994	4/20/2021	-1.73	83.7	4.15	
1055	Copper	µg/L	1754.1	1910	1720 - 2100	Acceptable	EPA 200.8 5.4 1994	4/20/2021	-1.30	1880	95.4	
1070	Iron	µg/L	271.5	311	264 - 358	Acceptable	EPA 200.8 5.4 1994	4/20/2021	-1.97	313	20.9	
1075	Lead	µg/L	56.5	57.9	40.5 - 75.3	Acceptable	EPA 200.8 5.4 1994	4/20/2021	-0.274	57.5	3.50	
1090	Manganese	µg/L	433.7	443	377 - 509	Acceptable	EPA 200.8 5.4 1994	4/20/2021	-0.407	442	19.3	
1100	Molybdenum	µg/L	85.3	81.8	69.5 - 94.1	Acceptable	EPA 200.8 5.4 1994	4/20/2021	1.40	78.6	4.82	
1105	Nickel	µg/L	127.7	142	121 - 163	Acceptable	EPA 200.8 5.4 1994	4/20/2021	-1.68	141	7.60	
1140	Selenium	µg/L	20.6	21.9	17.5 - 26.3	Acceptable	EPA 200.8 5.4 1994	4/20/2021	-1.04	22.1	1.44	
1150	Silver	µg/L	51.7	55.3	38.7 - 71.9	Acceptable	EPA 200.8 5.4 1994	4/20/2021	-0.980	55.0	3.41	
1165	Thallium	µg/L	3.5	3.84	2.69 - 4.99	Acceptable	EPA 200.8 5.4 1994	4/20/2021	-1.03	3.72	0.217	
1185	Vanadium	µg/L	864.8	899	764 - 1030	Acceptable	EPA 200.8 5.4 1994	4/20/2021	-0.443	886	48.6	
1190	Zinc	µg/L	730.8	744	632 - 856	Acceptable	EPA 200.8 5.4 1994	4/20/2021	-0.288	739	29.4	

Table K.8. Environmental chemistry proficiency test results for mercury and inorganic anions

ERA
A Waters Company

WS-295 Final Evaluation Report

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EPA ID:	Not Reported
ERA Customer Number:	N215603
Report Issued:	03/29/21
Study Dates:	02/08/21 - 03/25/21

TNI Analyte Code	Analyte	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation	Method Description	Analysis Date	Z Score	Study Mean	Study Standard Deviation	Analyst Name
WS Inorganics (cat# 591, lot# S295-698)												
1505	Alkalinity as CaCO3	mg/L		179	161 - 197	Not Reported				178	5.62	
1575	Chloride	mg/L	34.8	36.7	31.2 - 42.2	Acceptable	EPA 300.0 2.1 1993	3/23/2021	-1.33	37.1	1.73	
1610	Conductivity at 25°C	µmhos/cm		990	891 - 1090	Not Reported				981	24.8	
1730	Fluoride	mg/L	2.8	2.90	2.61 - 3.19	Acceptable	EPA 300.0 2.1 1993	3/23/2021	-1.35	2.97	0.127	
1820	Nitrate + Nitrite as N	mg/L		7.17	6.09 - 8.25	Not Reported				7.29	0.314	
1810	Nitrate as N	mg/L	7.0	7.17	6.45 - 7.89	Acceptable	EPA 300.0 2.1 1993	3/23/2021	-0.841	7.24	0.280	
1125	Potassium	mg/L		26.0	22.1 - 29.9	Not Reported				27.0	1.71	
2000	Sulfate	mg/L	204.4	207	176 - 238	Acceptable	EPA 300.0 2.1 1993	3/23/2021	-1.11	211	6.30	
1955	Total Dissolved Solids at 180°C	mg/L		839	671 - 1010	Not Reported				803	28.8	
WS Mercury (cat# 551, lot# S295-666)												
1095	Mercury	µg/L	1.8	1.92	1.34 - 2.50	Acceptable	EPA 200.8 5.4 1994	3/22/2021	-0.556	1.93	0.234	

Table K.9. Environmental chemistry proficiency test results for hardness (cations)

ERA
A Waters Company

WS-294 Final Evaluation Report

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EPA ID:	Not Reported
ERA Customer Number:	N215603
Report Issued:	03/01/21
Study Dates:	01/11/21 - 02/25/21

TNI Analyte Code	Analyte	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation	Method Description	Analysis Date	Z Score	Study Mean	Study Standard Deviation	Analyst Name
WS Hardness (cat# 555, lot# S294-693)												
1035	Calcium	mg/L	35.0	37.1	31.5 - 42.7	Acceptable	ASTM D6919-09 2009	1/21/2021	-1.83	37.5	1.37	
1085	Magnesium	mg/L	2.9	3.13	2.66 - 3.60	Acceptable	ASTM D6919-09 2009	1/21/2021	-1.45	3.12	0.149	
1155	Sodium	mg/L	45.9	45.9	39.0 - 52.8	Acceptable	ASTM D6919-09 2009	2/21/2021	0.291	45.4	1.67	
1550	Calcium Hardness as CaCO3	mg/L	87.6	92.7	78.8 - 107	Acceptable		1/21/2021	-2.01	93.8	3.11	
1755	Total Hardness as CaCO3	mg/L	99.6	106	90.1 - 122	Acceptable		1/21/2021	-1.61	106	4.13	