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Waste Isolation Pilot Plant Annual Site Environmental Report for 2017

Revision 0

U.S. Department of Energy

September 2018

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Waste Isolation Pilot Plant Annual Site Environmental Report for 2017

U.S. Department of Energy

September 2018

Prepared by: ***/signature on file/*** Date: **09/13/2018**
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2017 Annual Site Environmental Report

To our readers:

This Waste Isolation Pilot Plant (WIPP) Annual Site Environmental Report for 2017 presents summary environmental data to (1) characterize site environmental management performance; (2) summarize environmental occurrences and responses reported during the calendar year; (3) confirm compliance with environmental standards and requirements; and (4) highlight the WIPP Environmental Management System (EMS), significant environmental programs, and accomplishments, including progress toward U.S. Department of Energy (DOE) Environmental Sustainability Goals.

It is important that the information we provide is easily understood, of interest, and communicates WIPP's efforts to protect human health and minimize our impact on the environment. We would like to know from you whether we are successful in achieving these goals. Your comments are appreciated and will help us to improve our communications.

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CHANGE HISTORY SUMMARY

Revision Number	Date Issued	Description of Changes
0	09/13/18	• Initial issue.

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ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

Am	americium
ANOVA	analysis of variance
ANSI	American National Standards Institute
AO	administrative order
ASER	Annual Site Environmental Report
BLM	U.S. Department of the Interior, Bureau of Land Management
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
CBFO	Carlsbad Field Office
C&D	construction and demolition
CEMRC	Carlsbad Environmental Monitoring and Research Center
CFR	Code of Federal Regulations
cm	centimeter
Co	cobalt
Cs	cesium
CY	calendar year
DBFM	dibromofluoromethane
DMP	Detection Monitoring Program
DOE	U.S. Department of Energy
DP	discharge permit
EDE	effective dose equivalent
EMS	Environmental Management System
EO	executive order
EPA	U.S. Environmental Protection Agency
EPEAT	Electronic Product Environmental Assessment Tool
FEMP	Federal Energy Management Program
ft	foot or feet
ft^2/d	square feet per day
ft^3	cubic feet
ft^3/min	cubic feet per minute
FY	fiscal year
g/mL	gram per milliliter
GC/MS	gas chromatography / mass spectrometry
GHG	greenhouse gas
HEAL	Hall Environmental Analysis Laboratory

HEPA	high-efficiency particulate air (filter)
ICP	inductively coupled plasma
ID	identification (confidence)
in.	inch(es)
ISO	International Organization for Standardization
J	estimated concentration
K	potassium
km	kilometer(s)
km^2	square kilometers
L	liter(s)
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LED	light-emitting diode
LEPC	Local Emergency Planning Committee
LMP	Land Management Plan
LWA	WIPP Land Withdrawal Act of 1992 (as amended)
LWB	Land Withdrawal Boundary
m	meter(s)
m^2	square meters
m^2/d	square meters per day
m^3	cubic meters
m^3/min	cubic meters per minute
MAPEP	Mixed Analyte Performance Evaluation Program
MDC	minimum detectable concentration
MDL	method detection limit
MEI	maximally exposed individual
mg/L	milligrams per liter
mi	mile(s)
mi^2	square miles
mL	milliliters
mm	millimeters
MOC	management and operating contractor
mrem	millirem
MRL	method reporting limit
MS/MSD	matrix spike / matrix spike duplicate
mSv	millisievert(s)
MT	metric tons
NA	not applicable
NEPA	*National Environmental Policy Act*
NESHAP	National Emission Standards for Hazardous Air Pollutants
NIST	National Institute of Standards and Technology

NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NRIP	National Institute of Standards and Technology Radiochemistry Intercomparison Program
NWP	Nuclear Waste Partnership LLC
PCB	polychlorinated biphenyl
Permit	WIPP Hazardous Waste Facility Permit
pH	measure of the acidity or alkalinity of a solution
PT	proficiency testing
Pu	plutonium
QA	quality assurance
QA/QC	quality assurance / quality control
QC	quality control
RCRA	*Resource Conservation and Recovery Act*
rem	roentgen equivalent man
RER	relative error ratio
RLCS	reagent laboratory control sample
RPD	relative percent difference
SA	Supplement Analysis
SEIS-II	Supplemental Environmental Impact Statement II
SERC	State Emergency Response Commission
SNAP	Significant New Alternatives Policy
SNL	Sandia National Laboratories
SOO	samples of opportunity
SOP	standard operating procedure
SOW	statement of work
SPDV	Site and Preliminary Design Validation
Sr	strontium
SSCVS	Safety Significant Confinement Ventilation System
SSW	shallow subsurface water
Sv	sievert
SVOC	semivolatile organic compound
SVS	Supplemental Ventilation System
TDS	total dissolved solids
TKN	total Kjeldahl nitrogen
TOC	total organic carbon
TPU	total propagated uncertainty
TRU	transuranic
TSS	total suspended solids
U	uranium
U.S.	United States
U.S.C.	United States Code

UST	underground storage tank
UTLV	upper tolerance limit value
VOC	volatile organic compound
WHB	Waste Handling Building
WIPP	Waste Isolation Pilot Plant
WQSP	Water Quality Sampling Program

SYMBOLS

˚C	degrees Celsius
˚F	degrees Fahrenheit
>	greater than
<	less than
≤	less than or equal to
µg	microgram
µg/L	microgram per liter
%	percent
±	plus or minus
[RN]	radionuclide concentration
σ	sigma

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EXECUTIVE SUMMARY

PURPOSE

The purpose of the Waste Isolation Pilot Plant (WIPP) Annual Site Environmental Report for 2017 (ASER) is to provide the information required by U.S. Department of Energy (DOE) Order 231.1B, *Environment, Safety, and Health Reporting*.

The DOE Carlsbad Field Office (CBFO) and the management and operating contractor (MOC) maintain and protect the environmental resources at the WIPP facility. DOE Order 231.1B; DOE Order 436.1, *Departmental Sustainability*; and DOE Order 458.1, *Radiation Protection of the Public and the Environment*, require that the affected environment at and near DOE facilities be monitored to ensure the safety and health of the public and workers, and protection of the environment.

This report was prepared in accordance with DOE Order 231.1B, which requires DOE facilities to submit an ASER to the DOE Headquarters Chief Health, Safety, and Security Officer.

WIPP MISSION

The WIPP Project mission is to safely dispose of transuranic (TRU) waste (radionuclides with an atomic number greater than 92, uranium) generated by the production of nuclear weapons and other activities related to the national defense of the United States.

WIPP DISPOSAL FOR 2017

In 2017, 1,178 cubic meters (m^3) of TRU waste was disposed of at the WIPP facility. From the first receipt of waste in March 1999 through the end of 2017, 92,162 (m^3) of TRU waste has been disposed of at the WIPP facility.

WIPP Environmental Management System

The WIPP Environmental Management System (EMS) is one of the mechanisms through which the WIPP Project facilitates the protection of human health and the environment; assists in maintaining compliance with applicable environmental laws and regulations; and fosters the implementation of sustainable practices for enhancing environmental management performance. The EMS is described in the *Waste Isolation Pilot Plant Environmental Management System Description* (DOE/WIPP-05-3318). Measuring and monitoring are key activities to ensure the project meets the objectives of the EMS.

Monitoring for Environmental Impacts

The DOE collects data needed to detect and quantify potential impacts that WIPP facility operations may have on the surrounding environment. The *Waste Isolation Pilot Plant Environmental Monitoring Plan* (DOE/WIPP-99-2194) outlines major environmental monitoring and surveillance activities at the WIPP facility and discusses the WIPP facility quality assurance / quality control (QA/QC) program as it relates to environmental monitoring.

WIPP facility employees conduct both effluent monitoring (i.e., point-source monitoring at release points such as the exhaust shaft) to detect radionuclides and quantify doses, and traditional pathway and receptor monitoring in the broader environment. The WIPP facility 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 air, groundwater, surface water, soils, sediments, vegetation, and game animals. The goal of this monitoring is to determine if the local ecosystem has been, or is being, adversely impacted by WIPP facility operations and, if so, to evaluate the geographic extent and the effects on the environment.

During calendar year (CY) 2017, there were detections of $^{239/240}$Pu (plutonium) in the 0 to 2 centimeter (cm) and 2 to 5 cm depths in soil samples from the Smith Ranch (SMR) location and in the duplicate sediment sample (but not the primary sample) from the Poker Trap location. The concentrations were below the 99 percent confidence interval. There were no detections of transuranics in the quarterly air filter composite samples, groundwater, surface water, or biota samples.

The *Waste Isolation Pilot Plant Land Management Plan* (LMP) (DOE/WIPP-93-004) identifies resource values, promotes multiple-use management, and identifies long-term goals for the management of WIPP project lands. The LMP includes a land reclamation program that addresses both the short-term and long-term effects of WIPP facility operations and includes monitoring for environmental impacts. WIPP environmental personnel also conduct surveillance in the region surrounding the site to protect WIPP facilities and land from inadvertent use.

The monitoring and surveillance programs used by the WIPP facility to determine if the local ecosystem has been impacted are listed below:

Environmental Radiological Monitoring Programs

- Effluent air emissions
- Ambient airborne particulates
- Groundwater
- Surface water
- Sediments
- Soil
- Biota

Environmental Non-radiological Monitoring Programs

- Hydrogen and methane monitoring (underground, inactive)
- Land management
- Liquid effluent
- Meteorology
- Seismic activity
- Volatile organic compound (VOC) monitoring

Groundwater Protection Monitoring Programs

- Groundwater levels
- Groundwater quality
- Shallow subsurface water (SSW) levels
- SSW quality

In 2017, results of these programs, including observations and analytical data, demonstrated that (1) compliance with applicable environmental requirements was maintained, and (2) the operations at the WIPP facility have not had a negative impact on human health or the environment.

Environmental Compliance

The owner and operator(s) of the WIPP facility are required to comply with applicable federal and state laws, DOE orders and active New Mexico Environment Department (NMED) Administrative Orders (AOs). In order to accomplish and document this compliance, the following documents were among those completed and submitted in 2017:

New Mexico Submittals:

- WIPP Hazardous Waste Facility Permit (Permit)
  - Semi-annual VOC, Hydrogen, and Methane Data Summary Reports
  - Mine Ventilation Rate Monitoring Report
  - Waste Minimization Statement
  - Annual WIPP Culebra Groundwater Report
  - Semi-annual Groundwater Surface Elevation Report
  - Geotechnical Analysis Report
  - Quarterly reports required under NMED AOs dated February 27, 2014, May 12, 2014, and May 20, 2014
  - Report of Implementation of the WIPP Facility RCRA Contingency Plan and first and second supplements to the plan
  - Emergency and Hazardous Chemical Inventory Report
  - Toxic Chemical Release Inventory Report
- Discharge Permit (DP–831)
  - Semi-annual Discharge Monitoring Reports

U.S. Environmental Protection Agency (EPA) Submittals:

- Delaware Basin Monitoring Annual Report
- 2017 Annual Polychlorinated Biphenyls Report
- WIPP Subsidence Monument Leveling Survey
- 2016/2017 Annual Change Report
- *Superfund Amendments and Reauthorization Act of 1986*
  - Emergency and Hazardous Chemical Inventory Report
  - Toxic Chemical Release Inventory Report

CBFO Submittals

- Quarterly Change Report

Other relevant correspondence, regulatory submittals, monitoring reports, and the results of the EPA Annual Inspection and other inspections are described in Chapters 2 and 3 of this report.

Sustainable Practices

The WIPP EMS objectives and targets support achievement of DOE sustainability goals. Progress was focused on integrating sustainability into business activities.

Highlights include the following:

- The DOE/CBFO achieved a 32 percent decrease in greenhouse gas (GHG)/mile emissions and fleet petroleum use for fiscal year (FY) 2017 compared to the baseline years (FY 2010).
- The cool roof replacement project reported another thirteen roofs completed during FY 2017, bringing project total to 33.
- Continued emphasis on procurement of sustainable products including:
  - Purchasing equipment that is Energy Star or Federal Energy Management Program rated.
  - BioBased/BioPreferred contract language was placed in 100 percent of applicable contracts.
  - One hundred percent of electronics procured were Energy Star rated.
  - DOE/CBFO has received exemption from the alternative fuel requirement until such time as alternative fuel sources and infrastructure are available in the area.

- The site generated a total of 201 metric tons (MT) of municipal solid and recyclable waste. The site successfully diverted 56 percent or 113 MT of waste from the local landfill.

Environmental Management System Implementation

In 2017, the WIPP EMS continued to maintain certification to the International Organization for Standardization (ISO) Standard 14001:2004. The certification is maintained by demonstrating that the EMS continues to meet standard requirements as confirmed through semi-annual audits of the sites ISO-accredited registrar, Advanced Waste Management Systems, Inc.

Overall accomplishments of the EMS for 2017 were as follows:

- Environmental monitoring data continued to demonstrate that there has been no adverse impact to human health or the environment from WIPP facility operations.
- Ninety-seven percent of environmental targets were achieved.

SUMMARY OF RELEASES AND RADIOLOGICAL DOSES TO THE PUBLIC

Doses to the Public and the Environment

The radiation dose to members of the public from WIPP facility operations was calculated from WIPP facility effluent monitoring results and demonstrated compliance with applicable federal regulations.

Dose Limits

The environmental dose standard for the WIPP facility is established in Title 40 *Code of Federal Regulations* (CFR) Part 191, Subpart A, “Environmental Standards for Management and Storage.” This standard requires that the combined annual dose equivalent from all sources to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation from such management and storage shall not exceed 25 millirem (mrem) (“rem” is roentgen equivalent man) to the whole body and 75 mrem to any critical organ. In addition, in a 1995 memorandum of understanding between the EPA and the DOE, the DOE agreed the WIPP facility would comply with 40 CFR Part 61, Subpart H, “National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities,” hereafter referred to as the National Emission Standards for Hazardous Air Pollutants (NESHAP). The NESHAP standard for radionuclides requires that the emissions of radionuclides to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent (EDE) of 10 mrem per year.

Background Radiation

Site-specific background gamma measurements on the surface, taken by Sandia National Laboratories (SNL), showed an average dose rate of 7.65 microrem per hour (Minnema and Brewer, 1983), which would equate to the background gamma radiation dose of 0.67 millisieverts (mSv) per year (67.0 mrem per year). A comprehensive radiological baseline study before WIPP facility disposal operations began was also documented in *Statistical Summary of the Radiological Baseline for the Waste Isolation Pilot Plant* (DOE/WIPP-92-037), which provides the basis for environmental background comparison after WIPP facility disposal operations commenced.

Dose from Air Emissions

WIPP personnel have identified air emissions as the major pathway of concern for radionuclide transport during facility operations, which includes the receipt and disposal of waste at the WIPP facility. To determine the radiation dose received by members of the public from WIPP facility operations, WIPP personnel use the EPA emission monitoring and test procedure (40 CFR §61.93, “Emission Monitoring and Test Procedure”), which requires the use of the EPA-approved CAP88-PC ([CAP88-PC, 2013] computer code for calculating both dose and risk from radionuclide emissions) to calculate the EDE to members of the public, CAP88-PC dose calculations are based on the assumption that exposed people remain at home during the entire year and all vegetables, milk, and meat consumed are home-produced. Thus, this dose calculation is a maximum dose that encompasses dose from inhalation, plume immersion, deposition, and ingestion of air-emitted radionuclides. The dose (3.02E-06 mrem to the maximally exposed off-site individual) was approximately 3.02E-05 percent of the 10 mrem standard and did not measurably affect the public or the environment.

Total Dose from WIPP Facility Operations

The potential dose to an individual from the ingestion of WIPP facility managed radionuclides transported in water is estimated at zero. This is because drinking water for communities near the WIPP site comes from groundwater sources that are a great distance away from the WIPP facility operations. Drinking water has an extremely low chance of being contaminated as a result of WIPP facility operations.

Fewer game animals were collected in 2017 than in recent years. Game animals sampled and analyzed during 2017 included quail composite samples (three to four specimens per sample) from WEE and WNN, one fish sample from BRA and one rabbit SOO (location codes can be found in Appendix C). The quail composite sample from WEE was collected in duplicate. The only radionuclide detected in any of the animal samples was naturally occurring potassium-40 (^{40}K), which was detected in all the samples. By extrapolation, no dose from WIPP-related radionuclides has been received by any individual from this pathway (i.e., the ingestion of meat from game animals) during 2017.

Based on the results of the WIPP facility environmental sampling program and the Effluent Monitoring Program, concentrations of radionuclides in air emissions did not

exceed environmental dose standards set by 40 CFR Part 191, Subpart A, "Environmental Standards for Management and Storage," for radiological dose to a member of the public from all WIPP operations. For air emissions specifically, the standards of 40 CFR Part 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities," were also met. The results indicate that the hypothetical maximally exposed individual (MEI) who resides year-round at the point of highest concentration calculated at the WIPP facility fence line, about 650 meters (m) (2,140 feet [ft]) west-northwest from the exhaust point, would have received a dose of approximately 1.04E-06 mSv per year (1.04E-04 mrem per year) for the whole body and 9. 87E-06 mSv per year (9.87E-04 mrem per year) to the critical organ. These values are in compliance with the Subpart A standards specified in 40 CFR §191.03(b). For NESHAP (40 CFR §61.92) standards, the estimated EDE potentially received by the off-site resident MEI residing 8.9 kilometers (km) (5.5 miles [mi]) west-northwest of the WIPP facility was calculated to be 3.02E-08 mSv per year (3.02E-06 mrem per year) for the whole body. This value is in compliance with the 40 CFR §61.92 standards.

Chapter 4 of this report presents figures and tables that provide the EDE values from CY 2003 through 2017. These EDE values are below the EPA standards specified in 40 CFR Part 191, Subpart A, and limits in 40 CFR Part 61, Subpart H.

Dose to Nonhuman Biota

Dose limits that cause no deleterious effects on populations of aquatic and terrestrial organisms have been suggested by the National Council on Radiation Protection and Measurements and the International Atomic Energy Agency. These absorbed dose limits are listed below.

- Aquatic animals 10 milligrays per day (1 radiation absorbed dose per day)
- Terrestrial plants 10 milligrays per day (1 radiation absorbed dose per day)
- Terrestrial animals 1 milligrays per day (0.1 radiation absorbed dose per day)

The DOE requires discussion of radiation doses to nonhuman biota in the ASER using the DOE Technical Standard, DOE–STD–1153–2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*. This standard requires an initial screening phase using conservative assumptions. This guidance was used to screen radionuclide concentrations observed around the WIPP site during 2017. The screening results indicate radiation in the environment surrounding the WIPP site does not have a deleterious effect on populations of nonhuman biota.

Release of Property Containing Residual Radioactive Material

There was no release of radiologically contaminated materials or property from the WIPP facility in 2017.

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CHAPTER 1 – INTRODUCTION

The purpose of this report is to provide information required by U.S. Department of Energy (DOE) Order 231.1B, *Environment, Safety, and Health Reporting*. Specifically, this Annual Site Environmental Report (ASER) presents summary environmental data to:

- Characterize site environmental management performance.
- Summarize environmental occurrences and responses reported during the calendar year (CY).
- Confirm compliance with environmental standards and requirements.
- Highlight significant environmental accomplishments, including progress toward the DOE Environmental Sustainability Goals made through implementation of the Waste Isolation Pilot Plant (WIPP) Environmental Management System (EMS).

This document gives a brief overview of the WIPP facility environmental monitoring processes and reports CY 2017 results.

The WIPP facility is authorized by the DOE *National Security and Military Applications of Nuclear Energy Authorization Act of 1980* (Public Law 96–164). After more than 20 years of scientific study and public input, the WIPP facility received its first shipment of transuranic (TRU) waste on March 26, 1999.

Located in southeastern New Mexico, the WIPP facility is the nation's first underground repository permitted to dispose of TRU radioactive and mixed waste generated through defense activities and programs. TRU waste is defined in the WIPP *Land Withdrawal Act of 1992* (LWA) (Public Law 102–579) as radioactive waste containing more than 100 nanocuries (3,700 becquerels [Bq]) of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years except for: (a) high-level waste; (b) waste that the Secretary has determined, with the concurrence of the Administrator, does not need the degree of isolation required by the disposal regulations; and (c) waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with Title 10 of the Code of Federal Regulations (CFR) Part 61. Most TRU waste is contaminated industrial debris, such as rags and tools, sludges from solidified liquids, glass, metal, and other materials. The waste must meet the criteria in *Transuranic Waste Acceptance Criteria for the Waste Isolation Pilot Plant* (DOE/WIPP-02-3122).

TRU waste is disposed of 655 meters (m) (2,150 feet [ft]) below the surface in excavated disposal rooms in the Salado Formation (Salado), which is a thick sequence of Permian evaporite salt beds. At the conclusion of the WIPP disposal phase, seals will be placed in the shafts. One of the main attributes of salt at the depth of the WIPP repository, as a rock formation in which to isolate radioactive waste, is the ability of the

salt to creep, that is, to deform continuously over time until emplaced waste is encapsulated. Excavations into which the containers of waste are placed will close eventually, and the surrounding salt will flow around the drums and seal them within the Salado. A detailed description of the WIPP geology and hydrology is in Chapter 6.

1.1 WIPP Mission

The WIPP mission is to provide for the safe, environmentally sound disposal of defense-generated TRU waste left from research, development, and production of nuclear weapons.

1.2 WIPP History

Government officials and scientists initiated the WIPP site selection process in the 1950s. At that time, the National Academy of Sciences undertook an evaluation of stable geological formations that could be used to contain radioactive wastes for thousands of years. In 1957, after this evaluation, salt deposits were recommended as a promising medium for the disposal of radioactive waste.

Salt deposits were selected as the host for the disposal of nuclear waste for several reasons. Most deposits of salt are found in geologically stable areas with very little earthquake activity, ensuring the stability of a waste repository. Salt deposits also demonstrate the absence of circulating groundwater that could move waste to the surface. If water had been present in the past or was currently present, it would have dissolved the salt beds. In addition, salt is relatively easy to mine. Finally, rock salt at the depth of the WIPP repository heals its own fractures because it behaves plastically under lithostatic pressure. This means salt formations at depth will slowly and progressively move in to fill mined areas and will seal radioactive waste within the formation, safely away from the biosphere.

After a search for an appropriate site for the disposal of radioactive waste throughout the 1960s, the salt deposits in southeastern New Mexico were tested in the early 1970s. Salt and other evaporite formations at the WIPP site were deposited in thick beds during the evaporation of the Permian Sea. These geologic formations consist mainly of sodium chloride in the form of solid rock. The salt formation that serves as the host rock for the WIPP repository is approximately 610 m (2,000 ft) thick, begins 259 m (850 ft) below the earth’s surface, and constitutes a stable geologic environment.

In 1979, Congress authorized the construction of the WIPP facility, and the DOE constructed the facility during the 1980s. In late 1993, the DOE created the Carlsbad Area Office, subsequently redesignated as the Carlsbad Field Office (CBFO), to lead the TRU waste disposal effort. The CBFO coordinates the National TRU Program throughout the DOE complex.

On March 26, 1999, the WIPP facility received its first TRU waste shipment, which came from the Los Alamos National Laboratory in northern New Mexico.

1.3 Site Description

Located in Eddy County in the Chihuahuan Desert of southeastern New Mexico (Figure 1.1), the WIPP site encompasses 41.4 square kilometers (km^2) (16 square miles [mi^2]). This part of New Mexico is relatively flat and is sparsely inhabited, with little surface water. The site is 42 kilometers (km) (26 miles [mi]) east of Carlsbad, New Mexico, in a region known as Los Medaños.

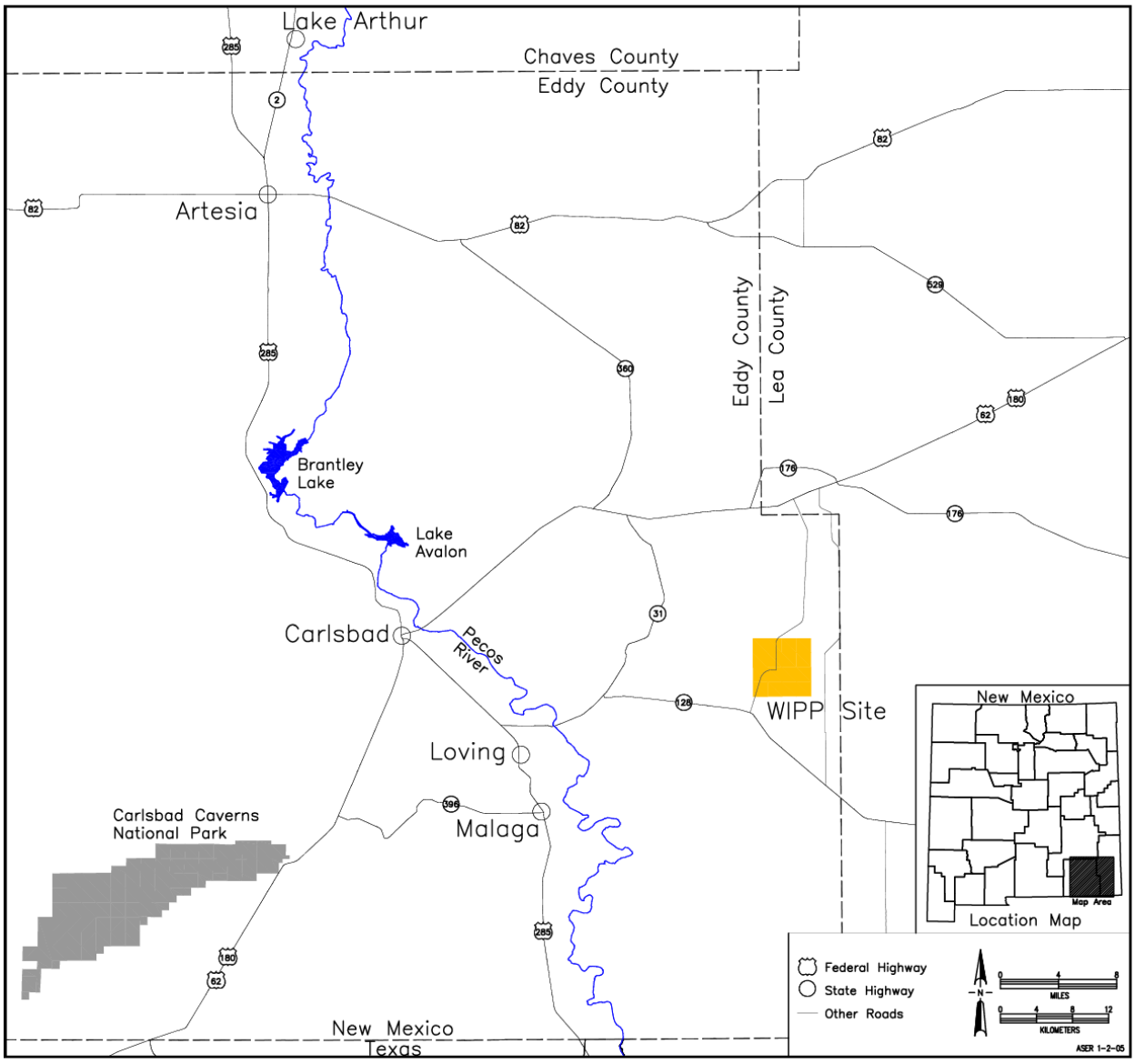

Figure 1.1 – WIPP Site Location

The majority of the lands in the immediate vicinity of the WIPP site are managed by the U.S. Department of the Interior Bureau of Land Management (BLM). Land uses in the surrounding area include livestock grazing, potash mining, oil and gas exploration and production, and recreational activities such as hunting, camping, hiking, and bird watching. The region is home to diverse populations of animals and plants.

1.3.1 WIPP Property Areas

Four property areas are defined within the WIPP site boundary (Figure 1.2).

Property Protection Area

The interior core of the facility encompasses 0.14 km^2 (0.05 mi^2) (35 acres) surrounded by a chain-link fence. Security is provided for this area 24 hours a day.

Exclusive Use Area

The exclusive use area comprises 1.17 km^2 (0.45 mi^2) (290 acres). It is surrounded by a barbed-wire fence and is restricted exclusively for the use of the DOE and its contractors and subcontractors in support of the project. This area is marked by DOE warning signs (e.g., “No Trespassing”) and is patrolled by WIPP facility security personnel to prevent unauthorized activities or uses.

Off-Limits Area

Prohibitions against unauthorized entry and introduction of weapons and/or dangerous materials are posted along the perimeter of the off-limits area, which encompasses 5.88 km^2 (2.27 mi^2) (1,454 acres). Grazing and public access will continue in this area unless these activities present a threat to the security, safety, or environmental quality of the WIPP site. This area is patrolled by WIPP facility security personnel to prevent unauthorized activities or use.

WIPP Land Withdrawal Area

The WIPP LWA was signed into law on October 30, 1992, transferring the administration of federal land from the U.S. Department of the Interior to the DOE. The WIPP site boundary delineates the perimeter of the 41.4 km^2 (16 mi^2) (10,240 acres) WIPP land withdrawal area. This tract includes the property protection area, the exclusive use area, and the off-limits area, as well as outlying areas within the WIPP site boundary.

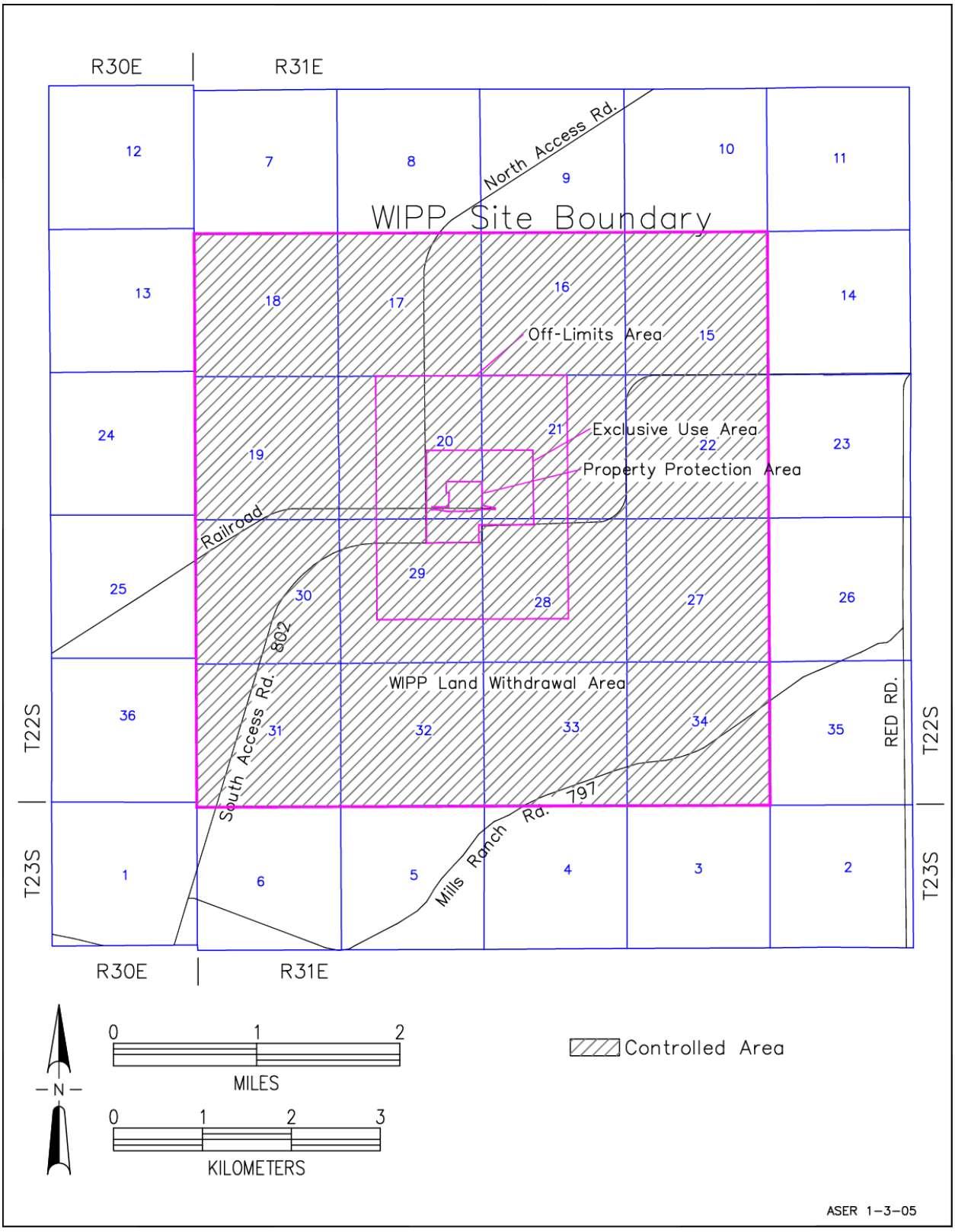

Figure 1.2 – WIPP Property Areas

Special Management Areas

Certain properties used in the execution of the WIPP project (e.g., reclamation sites, well pads, roads) are, or may be, identified as special management areas in accordance with the WIPP Land Management Plan (LMP) (DOE/WIPP-93-004), which is described further in Chapter 5. A special management area designation is made when resources and/or other circumstances meet the criteria for protection and management under special management designations. Unique resources of value that are in danger of being lost or damaged, areas where ongoing construction is occurring, fragile plant and/or animal communities, sites of archaeological significance, locations containing safety hazards, or sectors that could receive an unanticipated elevated security status would be suitable for designation as special management areas. No areas were designated as special management areas in 2017.

1.3.2 Population

There are 19 permanent residents living within 16 km (10 mi) of the WIPP site (DOE/WIPP-93-004). This permanent population is associated with ranching.

The majority of the local population within 80.5 km (50 mi) of the WIPP site is concentrated in and around the communities of Carlsbad, Hobbs, Eunice, Loving, Jal, Lovington, and Artesia, New Mexico. According to 2010 census data, the estimated population within this radius is 88,952. The nearest community is the village of Loving (estimated population 1,413), 29 km (18 mi) west-southwest of the WIPP site. The nearest major populated area is Carlsbad, 42 km (26 mi) west of the WIPP site. The 2010 census reported the population of Carlsbad as 26,138. Since 2010 two periods of rapid growth have occurred due to oil field activity which should be reflected on the 2020 census.

1.4 WIPP Environmental Stewardship

The DOE policy is to conduct its operations in compliance with applicable environmental laws and regulations, and to safeguard the integrity of the southeastern New Mexico environment. The DOE conducts effluent monitoring, environmental surveillance, land management, and assessments to verify that these objectives are met. Environmental monitoring includes collecting and analyzing environmental samples from various media and evaluating whether WIPP facility operations have caused any adverse environmental impacts.

1.4.1 Environmental Monitoring Plan

The *Waste Isolation Pilot Plant Environmental Monitoring Plan* (DOE/WIPP-99-2194) outlines the program for monitoring the environment at and around the WIPP site, including the major environmental monitoring and surveillance activities at the WIPP facility. The plan discusses the WIPP project quality assurance / quality control (QA/QC) program as it relates to environmental monitoring. The purpose of the plan is to specify

how the effects of WIPP facility operations on the local ecosystem are determined. Effluent and environmental monitoring data are necessary to demonstrate compliance with applicable environmental protection regulations. A description of sampling performed in 2017 and the respective sampling frequency is provided in Table 1.1.

Table 1.1 – Environmental Monitoring Sampling

Program	Type of Sample	Number of Sampling Locations[(a)]	Sampling Frequency
Radiological	Airborne effluent	2	Periodic/confirmatory
	Airborne particulate	7	Weekly
	Sewage treatment system (discharge permit [DP]-831)[(b)]	3	Semi-annual
	H-19 evaporation pond (DP–831)[(b)]	1	Semi-annual
	Liquid effluent	1 (Waste Handling Building [(WHB] sump)	If needed
	Biotic		
	Quail Rabbit Cattle/Deer Javelina Fish Vegetation	WIPP vicinity WIPP vicinity WIPP vicinity WIPP vicinity 3 6	Annual As available As available As available Annual Annual
	Soil	6	Annual
	Surface water	Maximum of 14	Annual
	Sediment	Maximum of 12	Annual
	Groundwater (Detection Monitoring Program [DMP])	6	Annual
Non-radiological	Meteorology	1	Continuous
	VOCs		
	VOCs—repository VOCs—disposal room	2 # of active panel disposal rooms	Semiweekly Biweekly
	Groundwater (DMP)	6	Annual
	Shallow groundwater (DP-831)	12	Semi-annual
	Surface water (DP–831)	6 storm water infiltration control ponds	Annual and after major storm events
		4 sewage lagoons	Semi-annual

Notes:

(a) The number of certain types of samples taken can be driven by site conditions. For example, during dry periods, there may be no surface water or sediment to sample at certain locations. Likewise, the number of samples for biota will vary. For example, the number of rabbits available as samples of opportunity will vary, as will fishing conditions that are affected by weather and algae levels in the water.

(b) Includes a non-radiological program component.

The plan describes the monitoring of naturally occurring and specific anthropogenic (human-made) radionuclides. The geographic scope of radiological sampling is based on projections of potential release pathways from the waste disposed at the WIPP facility. The plan also describes monitoring of volatile organic compounds (VOCs), groundwater chemistry, other non-radiological environmental parameters, and collection of meteorological data.

1.4.2 WIPP Facility Environmental Monitoring Program and Surveillance Activities

Employees of the WIPP facility monitor air, surface water, groundwater, sediments, soils, and biota (e.g., vegetation, selected mammals, quail, and fish). Environmental monitoring activities are performed in accordance with procedures that govern how samples are to be taken, preserved, and transferred. Procedures direct the verification and validation of environmental sampling data.

The atmospheric pathway, which can lead to the inhalation of radionuclides, has been determined to be the most likely release pathway to the public from the WIPP facility before final facility closure. Therefore, airborne particulate sampling for alpha-emitting radionuclides is emphasized. Air sampling results are used to trend environmental radiological levels and determine if there has been a deviation from established baseline concentrations. The geographic scope of radiological sampling is based on projections of potential release pathways and nearby populations for the types of radionuclides in TRU wastes that are managed at the WIPP facility and includes nearby communities and ranches.

Non-radiological environmental monitoring activities at the WIPP site consist of sampling and analyses designed to detect and quantify impacts of operational activities and verify compliance with applicable requirements.

1.5 Environmental Performance

DOE Order 436.1, *Departmental Sustainability*, describes the DOE commitment to environmental protection and pledges to implement sound stewardship practices that are protective of the air, water, land, and other natural and cultural resources. The provisions of DOE Order 436.1 are implemented via WIPP Project environmental policy and the WIPP EMS.

Implementation of the *Waste Isolation Pilot Plant Environmental Monitoring Plan* (DOE/WIPP-99-2194) fulfills the environmental monitoring requirements of DOE Order 436.1. Detailed information on WIPP Project environmental programs is included in the remaining chapters.

CHAPTER 2 – COMPLIANCE SUMMARY

The DOE is required to comply with the applicable regulations promulgated pursuant to federal and state statutes, DOE orders, and executive orders (EOs) with regard to the WIPP facility. Compliance with regulatory requirements is incorporated into facility plans and implementing procedures. Methods for maintaining compliance with environmental requirements include the use of engineered controls and written procedures, routine training of facility personnel, ongoing self-assessments, and personal accountability. The following sections list the environmental statutes and regulations applicable to the operation of the WIPP facility and describe significant accomplishments and ongoing compliance activities. A detailed breakdown of WIPP facility compliance with environmental laws is available in the *Waste Isolation Pilot Plant Biennial Environmental Compliance Report* (DOE/WIPP-16-3526).

A list of active WIPP environmental permits is included in Appendix B.

2.1 Comprehensive Environmental Response, Compensation, and Liability Act

The *Comprehensive Environmental Response, Compensation, and Liability Act* (42 U.S.C. [United States Code] §§9601, et seq.), or Superfund, establishes a comprehensive federal strategy for responding to, and establishing liability for, releases of hazardous substances from a facility to the environment. Any spills of hazardous substances that exceed a reportable quantity must be reported to the National Response Center under the provisions of *Comprehensive Environmental Response, Compensation, and Liability Act* and 40 CFR Part 302, “Designation, Reportable Quantities, and Notification.” Hazardous substance cleanup procedures are specified in 40 CFR Part 300, “National Oil and Hazardous Substances Pollution Contingency Plan.”

2.1.1 Superfund Amendments and Reauthorization Act of 1986

The DOE is required by the *Superfund Amendments and Reauthorization Act of 1986 Title III* (SARA) (42 U.S.C. §11001, also known as the *Emergency Planning and Community Right-to-Know Act*), which is implemented by 40 CFR Parts 355, 370, 372, and 373, to submit (1) a list of hazardous chemicals present at the facility in excess of 10,000 pounds for which Material Safety Data Sheets are required; (2) an Emergency and Hazardous Chemical Inventory Form (Tier II Form) that identifies the inventory of hazardous chemicals present during the preceding year; and (3) notification to the State Emergency Response Commission (SERC) and the Local Emergency Planning Committee (LEPC) of any accidental releases of hazardous chemicals in excess of reportable quantities.

The list of chemicals provides external emergency responders with information they may need when responding to a hazardous chemical emergency at the WIPP facility. The list of hazardous chemicals is a one-time notification unless new hazardous

chemicals in excess of 10,000 pounds, or new information on existing chemicals, are provided.

The SERC and the LEPC are notified when a new hazardous chemical is received on site in excess of 10,000 pounds at any one time. The hazardous chemical is reported to the SERC and the LEPC within 30 days of receipt.

The Tier II Form, due on March 1 of each year, provides information to emergency responders and to the public about hazardous chemicals above threshold planning quantities that a facility has on site at any time during the year. The Tier II Form is submitted annually to the SERC and the LEPC, and to each fire department with which the CBFO maintains a memorandum of understanding. The WIPP 2017 Tier II Form was submitted to the SERC, the LEPC, and fire departments prior to March 1, 2017, as required. Title 40 CFR Part 372, "Toxic Chemical Release Reporting: Community Right to Know," requires facilities to submit a toxic chemical release report to the U.S. Environmental Protection Agency (EPA) and the resident state identifying the toxic chemicals that were disposed of or released at the facility in excess of established threshold amounts. The Toxic Release Inventory Report was submitted to the EPA and to the SERC prior to the July 1, 2017, reporting deadline. Table 2.1 presents the 2017 *Emergency Planning and Community Right-to-Know Act* reporting status. A response of "yes" indicates that the report was required and submitted.

Table 2.1 – Status of Emergency Planning and Community Right-to-Know Act Reporting

***Emergency Planning and Community Right-to-Know Act* Regulations**	**Description of Reporting**	**Status**
40 CFR Part 355	Planning Notification	Further notification not required
40 CFR Part 302	Extremely Hazardous Substance Release Notification	Not required
40 CFR Part 370	Material Safety Data Sheet / Chemical Inventory (Tier II Form)	Yes
40 CFR Part 372	Toxic Release Inventory Report	Yes

2.1.2 Accidental Releases of Reportable Quantities of Hazardous Substances

There were no releases of hazardous substances exceeding the reportable quantity limits during 2017.

2.2 Resource Conservation and Recovery Act

The *Resource Conservation and Recovery Act* (42 U.S.C. §§6901, et seq.) (RCRA) was enacted in 1976. Initial implementing regulations were promulgated in May 1980. This body of regulations ensures that hazardous waste is managed and disposed of in a way that protects human health and the environment. The *Hazardous and Solid Waste Amendments of 1984* (Public Law 98–616, Stat. 3221) prohibit land disposal of

hazardous waste unless treatment standards are met or specific exemptions apply. The amendments also emphasize waste minimization. Section 9(a) of the WIPP LWA exempts TRU mixed waste designated by the Secretary of Energy for disposal at the WIPP facility from treatment standards. Such waste is not subject to the land disposal prohibitions of the *Solid Waste Disposal Act* (42 U.S.C. §§6901–6992, et seq.).

The New Mexico Environment Department (NMED) is authorized by the EPA to implement the hazardous waste program in New Mexico pursuant to the *New Mexico Hazardous Waste Act* (NMSA §§74–4–1, et seq., 1978). The technical standards for hazardous waste treatment, storage, and disposal facilities in New Mexico are outlined in 20.4.1.500 New Mexico Administrative Code (NMAC), which adopts, by reference, 40 CFR Part 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities." The hazardous waste management permitting program is administered through 20.4.1.900 NMAC, which adopts 40 CFR Part 270, "EPA Administered Permit Programs: The Hazardous Waste Permit Program."

2.2.1 Hazardous Waste Facility Permit

The WIPP Hazardous Waste Facility Permit (Permit) authorizes the DOE and the management and operating contractor (MOC) (collectively known as the Permittees) to manage, store, and dispose of contact-handled and remote-handled TRU mixed waste at the WIPP facility. Two storage units (the Parking Area Unit and the WHB Unit) are permitted for storage of TRU mixed waste. Eight underground hazardous waste disposal units or panels are currently permitted for construction and use. In addition, an underground derived waste storage area was permitted under an administrative order (AO) issued by NMED on May 12, 2014; the purpose of this storage area was to facilitate recovery efforts following the 2014 events described below. This area was subsequently closed and the NMED was notified in a letter dated August 2, 2017.

On February 5, 2014, the WIPP facility experienced an underground fire that stopped normal operations including waste shipments to the WIPP facility. On February 14, 2014, a radiological event occurred from receipt of TRU waste mixed with an incompatible sorbent. This receipt and disposal of non-conforming TRU waste was self-reported by the Permittees to the regulator. Due to radiological safety concerns, some permitted activities could not be performed. The NMED issued three AOs, dated February 27, May 12, and May 20, 2014, providing some regulatory relief and directing certain actions from the Permittees. For example, extensions for storage of waste in the WHB Unit were issued as disposal operations were halted. On December 16, 2016, the NMED closed the first of the three AOs. The second and third AOs will remain in effect until the NMED has taken final action on the Panel Closure Class 3 Permit Modification that will address the final closure of waste disposal panels. As required by the AOs and directed by the NMED in their February, 2016 letter, the Permittees have submitted quarterly reports to the NMED.

On December 6, 2014, the NMED issued an Administrative Compliance Order against the Permittees. The NMED alleged that Permittees did not implement the *RCRA Contingency Plan* in a timely manner for both events, received non-conforming waste, failed to provide timely oral and written notification, failed to maintain and operate the facility, failed to conduct adequate training, and failed to verify the completeness and accuracy of the Waste Stream Profile Form.

In an effort to resolve the Administrative Compliance Order without further administrative or judicial actions, the Permittees and NMED engaged in settlement negotiations. The NMED issued the General Principles of Agreement on April 30, 2015, followed by the Settlement Agreement and Stipulated Final Order (Settlement Agreement) on January 22, 2016. The Settlement Agreement resolved alleged violations described in the Administrative Compliance Order. The Permittees provided a response to the Settlement Agreement on March 18, 2016, providing the Evidence of Completion to corrective actions contained in Attachment A of the Settlement Agreement as required by Paragraph 31 of the Settlement Agreement. In accordance with Paragraph 53 of the Settlement Agreement, work plans were included as attachments to the response with proposed alternate completion dates for some corrective actions. During this ASER reporting period, the following activities associated with these work plans were completed:

- Class 1 Permit Modification Notification to add Live Fire Extinguisher Refresher Training into the Permit; development and submittal of course material for SAF-502FR, Fire Extinguisher Live Fire Training Refresher, dated October 6, 2017. This training was submitted to the NMED on October 23, 2017

- Class 1 Permit Modification Notification to add the Supplemental Ventilation System (SVS) to the Permit, dated June 14, 2017

- Certificate of Completion for the Settlement Agreement regarding supplemental environmental project, dated September 27, 2017, in response to Paragraph 33

The Permittees submitted an additional request for an extension of storage time for the waste currently in storage in the WHB until June 30, 2018. This extension was granted by the NMED on June 23, 2017.

The Permittees withdrew a request for a temporary authorization, which had previously been submitted on November 20, 2016 and on February 13, 2017 for the Class 3 Permit Modification Request, “Modifications to the WIPP Panel Closure Plan.” The Permittees determined that the temporary authorization was no longer needed in order to proceed with isolating the far south end of the underground repository (Panels 3 through 6).

2.2.2 Modification Requests

In 2017, the Permittees submitted permit modification notifications and permit modification requests to NMED, as described in Table 2.2.

In accordance with Permit Part 1, Section 1.14, Information Repository, Permit modification notifications and requests associated with the Permit, along with associated responses from the regulator, were posted to the Information Repository on the Permittees' webpage within 10 calendar days. Additionally, other information required by the Permit and the AOs was provided in the Information Repository.

Table 2.2 – Permit Modification Notifications and Requests Submitted in 2017

Class	Description	Date Submitted
1	Clarify Maximum Storage Capacity of the CH Bay Storage Area in Permit Part 3, Table 3.1.1, and Attachment A1	April 27, 2017 (subsequently withdrawn on May 12, 2017)
1	Update the Co-Permittee Project Manager and the List of Active Environmental Permits	June 12, 2017
1	Update Attachment E, Table E-1 Update Figure D-4 in Attachment D Editorial Change to Emergency Equipment List in Table D-2 Update Description of Roving Watch Qualification Card in Attachment F2 Editorial Change in Attachment C4 Update Information Repository Contents in Permit Part 1.14.2 Update Chronology in Attachment A Update Figure N-2 in Attachment N Update the Underground Ventilation System Description in Attachment A2	June 14, 2017
1	Editorial Correction in Attachment A4, Section A4-3 Update to Attachment E, Table E-1 Add Live Fire Extinguisher Refresher Training to Attachment F2	October 6, 2017
1*	Changes to Groundwater Sampling Procedures	October 23, 2017
2	Training Program Revisions Changes Due to Construction and Operation of a New Filter Building	November 29, 2017
Request for Determination of Class	Excavation of a New Shaft and Associated Connecting Drifts	December 22, 2017

2.2.3 Underground Storage Tanks

Title 40 CFR Part 280, "Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)," addresses USTs containing petroleum products or hazardous chemicals. Requirements for UST management pertain to the design, construction, installation, and operation of USTs, as well as notification and corrective action requirements in the event of a release and actions required for out-of-service USTs. The NMED has been authorized by the EPA to regulate USTs and implements the EPA program through 20.5 NMAC, "Petroleum Storage Tanks."

The NMED conducted a biennial inspection of the UST system March 27, 2017, which resulted in no findings.

2.2.4 Hazardous Waste Generator Compliance

Non-radioactive hazardous waste is currently generated through routine facility operations. Mixed low-level radioactive waste (i.e., low-level radioactive wastes that are known or suspected to contain hazardous constituents) is generated at the WIPP site as a result of the cleanup from the February 2014 radiological release.

Hazardous wastes are managed in satellite accumulation areas; a less-than-90-day accumulation area on the surface, and a less-than-90-day accumulation area underground. Mixed low-level radioactive waste is segregated from non-radioactive hazardous wastes and is managed as mixed hazardous waste.

Hazardous waste generated at the WIPP facility (whether non-radioactive or low-level radioactive) is accumulated, characterized, packaged, labeled, and manifested to off-site Treatment, Storage, or Disposal Facilities in accordance with the requirements codified in 20.4.1.300 NMAC, which adopts, by reference, 40 CFR Part 262, “Standards Applicable to Generators of Hazardous Waste.” In addition, mixed low-level radioactive waste is managed to comply with DOE Order 435.1, “Radioactive Waste Management.” Mixed low-level radioactive wastes are shipped off site to Treatment, Storage, or Disposal Facilities that are permitted and licensed to treat and dispose of these types of wastes.

TRU mixed waste generated as the result of recovery operations is characterized as derived waste in accordance with the Permit and is managed as contact-handled TRU mixed waste at the WIPP facility.

2.2.5 Program Deliverables and Schedule

The Permittees are in compliance with the Permit conditions related to reporting as noted below.

- Permit Part 2, Section 2.14, Recordkeeping and Reporting, requires the submittal of the biennial hazardous waste report, as required by 20.4.1.500 NMAC (incorporating 40 CFR § 264.75). The biennial hazardous waste report was not due in 2017.
- Permit Part 4, Section 4.6, Maintenance and Monitoring Requirements, requires annual reports evaluating the geomechanical monitoring program and the mine ventilation rate monitoring program. The Permittees continued to comply with these requirements by preparing and submitting annual reports in October 2017, representing results for July 1, 2016, through June 30, 2017.
- Permit Part 4, Section 4.6, Maintenance and Monitoring Requirements, requires semi-annual reports describing the results (data and analysis) of confirmatory

VOC, hydrogen, and methane monitoring. The Permittees continued to comply with this requirement by preparing and submitting semi-annual reports in April 2017, representing results for July 1, 2016, through December 31, 2016, and in October 2017, representing results for January 1, 2017, through June 30, 2017.

- Permit Part 4, Section 4.6, Maintenance and Monitoring Requirements, requires the Permittees to implement a Laboratory Performance Evaluation Program in accordance with Permit Attachment N. Accordingly, the Permittees notified the NMED that they intended to require the contract laboratory Carlsbad Environmental Monitoring and Research Center (CEMRC) to participate in a proficiency testing (PT) program. Subsequently, the Permittees have required CEMRC to participate in a low concentration PT program provided by a laboratory contracted directly with the EPA. This PT program is part of the National Air Toxics Trends Station Program, which monitors low concentration VOCs in ambient air across the United States. For determining proficiency, the laboratory's PT results are compared to the standard concentrations from the audit sample reported by the PT provider. For each round of testing the introduced standard is varied by components and concentrations. CEMERC participated in two quarterly PTs in 2017 as described in Section 7.2.4. Results of the PT were reported as required in the semi-annual reports.
- Permit Part 5, Section 5.10.2.1 requires a report of the analytical results for annual DMP well samples and duplicates, as well as results of the statistical analysis of the samples showing whether statistically significant evidence of contamination is present. The report for sampling Round 39 was submitted to the NMED in November 2017. Sampling results are summarized in Appendices E and F of this ASER.
- Permit Part 5, Section 5.10.2.2 requires semi-annual submittal of groundwater surface elevation results calculated from field measurements and freshwater head elevations calculated as specified in Permit Attachment L, Section L-4c(1). Semi-annual reports were submitted to the NMED in May and November 2017 as required.
- Permit Part 5, Section 5.10.2.3 requires that groundwater flow data be included in the Annual Culebra Groundwater Report by November 30. The groundwater flow data were submitted in November 2017 as required.

2.3 National Environmental Policy Act

The *National Environmental Policy Act* (NEPA) (42 U.S.C. §§4321, et seq.) requires the federal government to use all practical means to consider potential environmental and cultural impacts of proposed projects as part of the decision-making process. The NEPA also requires that the public be allowed to review and comment on proposed projects that have the potential to significantly affect the quality of the environment.

National Environmental Policy Act regulations and requirements are detailed in 40 CFR Parts 1500–1508, "Council on Environmental Quality." The DOE codified its

requirements for implementing NEPA regulations in 10 CFR Part 1021, “National Environmental Policy Act Implementing Procedures.” Following completion of each environmental impact statement and its associated Record of Decision, 10 CFR §1021.331 requires the DOE to prepare a mitigation action plan that addresses mitigation commitments expressed in the Record of Decision. The CBFO tracks the performance of mitigation commitments in the WIPP project annual mitigation report. This report was issued July 10, 2017.

Day-to-day operational compliance with the NEPA at the WIPP facility is achieved through implementation of a NEPA compliance plan and procedure. Eighteen proposed projects were reviewed and approved by the CBFO NEPA Compliance Officer through the NEPA screening and approval process in 2017. Five of these projects were maintenance or upgrades to WIPP facility structures and equipment to prepare for restarting the WIPP facility. Thirteen of the projects required Land Use Requirement evaluation since they took place outside the WIPP Site Boundary. The approvals were in addition to routine activities determined to be bounded by existing NEPA documentation and that do not require additional evaluation by the CBFO NEPA Compliance Officer. The CBFO NEPA Compliance Officer routinely participates in the development of NEPA documents for other DOE offices and other federal agencies for proposed actions that may have environmental impacts on the WIPP Project.

In December 2017, DOE prepared an Environmental Assessment (DOE/EA-2604) in accordance with 10 CFR §1021.330(d) and 10 CFR §1021.314, to assess the impacts to human health and the environment from the construction and operation of an Above Ground Storage Capability. Based on the analysis in the EA, the Proposed Action does not impact environmental concerns or human health. The DOE has not yet issued a final determination.

In November 2017, DOE prepared a Supplement Analysis (SA) for the New Permanent Ventilation System (DOE/EIS-0026-SA-11). This SA evaluated the potential environmental impacts associated with the proposed construction and operation of the PVS, which includes both the new filter building complex (Safety Significant Confinement Ventilation System) and a new ventilation shaft and access drifts. Based on the analysis presented in this SA, the DOE’s Proposed Action does not represent substantial changes to the 1997 Supplemental Environmental Impact Statement II (SEIS-II) and to portions of the 1980 FEIS not considered in the 1997 SEIS-II that are relevant to environmental concerns. There are no new circumstances or information relevant to environmental concerns that bear on the Proposed Action or its potential environmental impacts that would warrant additional NEPA analysis. The DOE has therefore determined that no further NEPA documentation is required for the New Permanent Ventilation System.

2.4 Clean Air Act

The *Clean Air Act* (42 U.S.C. §§7401, et seq.) provides for the preservation, protection, and enhancement of air quality. Both the state of New Mexico and the EPA have authority for regulating compliance with portions of the *Clean Air Act*. Radiological effluent monitoring in compliance with EPA standards is discussed in Chapter 4.

Based on an initial 1993 air emissions inventory, the WIPP facility is not required to operate under *Clean Air Act* permits. In 1993, the DOE obtained a New Mexico Air Quality Control (NMSA 1978 §74–2) Regulation 702 Operating Permit (recodified in 2001 as 20.2.72 NMAC, "Construction Permits") for two backup diesel generators at the WIPP facility. No activities or modifications to the operating conditions of the diesel generators occurred in 2017 requiring reporting under the conditions of the Operating Permit.

The *Clean Air Act* established National Ambient Air Quality Standards for six criteria pollutants: sulfur oxides, particulate matter, carbon monoxide, ozone, nitrogen dioxide, and lead. The initial 1993 WIPP air emissions inventory was developed as a baseline document to calculate maximum potential hourly and annual emissions of both hazardous and criteria pollutants. Based on the current air emissions inventory, WIPP facility operations do not exceed the 10 tons per year emission limit for any individual hazardous air pollutant, the 25 tons per year limit for any combination of hazardous air pollutant emissions, or the 10 tons per year emission limit for criteria pollutants except for total suspended particulate matter and particulate matter less than 10 microns in diameter. Particulate matter is produced from fugitive sources related to the management of salt tailings extracted from the underground. Consultation with the NMED Air Quality Bureau resulted in a March 2006 determination that a permit is not required for fugitive emissions of particulate matter that result from salt management at the WIPP facility. Proposed facility modifications are reviewed to determine if they will create new air emission sources and require permit applications.

For 2017, VOC emissions from containers of TRU and TRU mixed waste remained less than 10 tons per year for individual VOCs monitored under the Permit.

2.5 Clean Water Act

The *Clean Water Act* (33 U.S.C. §§1251, et seq.) establishes provisions for the issuance of permits for discharges into waters of the United States. The regulation defining the scope of the permitting process is contained in 40 CFR §122.1(b), "Scope of the NPDES [National Pollutant Discharge Elimination System] Permit Requirement," which states that "The National Pollutant Discharge Elimination System program requires permits for the discharge of 'pollutants' from any 'point source' into 'waters' of the United States."

The WIPP facility does not discharge wastewater or storm water runoff into waters of the United States and is not subject to regulation under the National Pollutant Discharge

Elimination System program. Wastewaters generated at the WIPP facility are either disposed of off-site or managed in on-site, lined evaporation ponds. Storm water runoff is also collected in lined retention ponds. The management of wastewater and storm water runoff is regulated under the *New Mexico Water Quality Act* (NMSA 1978, §§74–6–1, et seq.), as discussed in Section 2.6.

2.6 New Mexico Water Quality Act

The *New Mexico Water Quality Act* created the New Mexico Water Quality Control Commission, tasked with the development of regulations to protect New Mexico ground and surface water. New Mexico water quality regulations for ground and surface water protection are contained in 20.6.2 NMAC, “Ground and Surface Water Protection.” The WIPP facility does not discharge to surface water, but does have a DP designed to prevent impacts to groundwater.

The DOE was issued DP–831 from the NMED Groundwater Quality Bureau for the operation of the WIPP sewage treatment facility in January 1992. The DP was renewed and modified to include the H–19 Evaporation Pond in July 1997. The H–19 Evaporation Pond is used for the treatment of wastewater generated during groundwater monitoring activities, water removed from sumps in the underground, and condensation from duct work in the mine ventilation system. The DP was modified in December 2003 to incorporate infiltration controls for salt-contact storm water runoff and in December 2006 to provide a more detailed closure plan. The DP was renewed on September 9, 2008. The DP was again modified on April 5, 2010, to include an additional evaporation pond to contain storm water running off the salt pile. An application for the 5-year renewal of the DP was submitted to the NMED Groundwater Quality Bureau on May 9, 2013. The new DP was received on August 1, 2014.

In accordance with DP requirements, monthly inspections are conducted of each of the storm water ponds, salt storage ponds, facultative lagoons, and salt storage cells to ensure they are maintained in good condition. When deficiencies are observed, such as liner tears or significant erosion, appropriate repairs are conducted. The sewage lagoons and H–19 Evaporation Pond are inspected weekly for signs of erosion or damage to the liners even though the permit only requires monthly inspections. The distance between normal water levels and the top (known as “freeboard”) of the sewage lagoons, the H–19 Evaporation Pond, storm water ponds and salt storage ponds are monitored regularly. The DP renewal added the requirement of inspecting the leak detection sumps in Salt Storage Ponds 2 and 3. The procedure for pond inspections was modified to include this new requirement.

The DP requires the sewage lagoons and H–19 Evaporation Pond to be sampled semi-annually and analyzed for nitrate, total Kjeldahl nitrogen (TKN), total dissolved solids (TDS), sulfate, and chloride. The storm water ponds and salt storage ponds must be sampled annually for TDS, sulfates, and chlorides. The results of this monitoring are reported in Section 5.7, Liquid Effluent Monitoring. In addition, the permit requires annual shallow subsurface water (SSW) level contour mapping and semi-annual

groundwater sampling for sulfate, chloride, and TDS. The SSW monitoring results are discussed in Chapter 6.

The DP requires semi-annual reports to be submitted to the NMED by the first of February and August. The reports included inspection results, water analyses, and sewage and storm water discharge volumes. Both semi-annual reports were submitted in 2017.

2.7 Safe Drinking Water Act

The *Safe Drinking Water Act* (42 U.S.C. §§300f, et seq.) provides the regulatory strategy for protecting public water supply systems and underground sources of drinking water. New Mexico's drinking water regulations are contained in 20.7.10 NMAC, "Drinking Water," which adopts, by reference, 40 CFR Part 141, "National Primary Drinking Water Regulations," and 40 CFR Part 143, "National Secondary Drinking Water Regulations." Water is supplied to the WIPP facility by the City of Carlsbad. However, the WIPP facility is classified as a non-transient, non-community water system subject to New Mexico drinking water regulations.

In March 2016, the WIPP Water System Distribution System Sampling Plan was revised to comply with the new requirements of the Revised Total Coliform Rule (RTCR). Bacterial samples are collected, and residual chlorine levels are tested monthly. Chlorine levels are reported to the NMED monthly. Bacteriological analytical results have been below the *Safe Drinking Water Act* regulatory limits. Disinfectant by-products testing per 40 CFR §141.132, "Monitoring Requirements," is conducted annually by facility personnel. Results of disinfectant by-products sampling are below regulatory limits.

Every three years, the WIPP Water System must be sampled for lead and copper in the distribution system. In September 2017, ten sample points were sampled according to 40 CFR 141.86 "Monitoring Requirements for Lead and Copper in Tap Water." Results in all ten samples were below regulatory limits for both lead and copper.

2.8 National Historic Preservation Act

The *National Historic Preservation Act* (16 U.S.C. §§470, et seq.) was enacted to protect the nation's cultural resources and establish the National Register of Historic Places. Two archaeological investigations were required within the WIPP land withdrawal area in 2017. No archeological sites were found in these investigations.

2.9 Toxic Substances Control Act

The *Toxic Substances Control Act* (15 U.S.C. §§2601, et seq.) was enacted to provide information about chemicals and to control the production of new chemicals that might present an unreasonable risk of injury to health or the environment. The act authorizes

the EPA to require testing of old and new chemical substances and to regulate the manufacturing, processing, import, use, and disposal of chemicals.

Polychlorinated biphenyls (PCBs) are regulated by the *Toxic Substances Control Act*. The PCB storage and disposal regulations are listed in the applicable subparts of 40 CFR Part 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions." On May 15, 2003, EPA Region VI approved the disposal of waste containing PCBs at the WIPP facility. The WIPP facility began receiving PCB-contaminated waste on February 5, 2005. The EPA renewed the disposal authority for a five-year period on April 30, 2008, and again renewed the authority for a five-year period on May 21, 2013.

The required PCB annual report, containing information on PCB waste received and disposed of at the WIPP facility during 2016, was submitted to EPA Region VI in accordance with 40 CFR §761 prior to the July 15, 2017 due date.

On May 27, 2016 a request was sent to the EPA for a storage extension for PCB waste stored in the WHB beyond limits established in the EPA Conditions of Approval. The request was approved June 21, 2016, and the extension was granted until June 30, 2017. The waste stored in the WHB under this extension was placed in the disposal panels prior to June 30, 2017.

2.10 Federal Insecticide, Fungicide, and Rodenticide Act

The *Federal Insecticide, Fungicide, and Rodenticide Act* (7 U.S.C. §§136, et seq.) authorizes the EPA to regulate the registration, certification, use, storage, disposal, transportation, and recall of pesticides (40 CFR Parts 150–189).

Applications of restricted-use pesticides at the WIPP facility are conducted by commercial pesticide contractors who are required to meet federal and state standards. Bureau of Land Management personnel spray herbicides for mesquite and other plant species control on the sixteen sections of the WIPP Land Withdrawal Area, as well as around evaporation ponds, Salt Storage Cell 1, and Site and Preliminary Design Validation (SPDV) salt tailings pile. General-use pesticides are stored according to label instructions. Used, empty cans are managed and disposed of in accordance with federal and state regulations.

2.11 Endangered Species Act

The *Endangered Species Act of 1973* (16 U.S.C. §§1531, et seq.) was enacted to prevent the extinction of certain species of animals and plants. This act provides strong measures to help alleviate the loss of species and their habitats, and places restrictions on activities that may affect endangered and threatened animals and plants to help ensure their continued survival. With limited exceptions, the act prohibits activities that could impact protected species, unless a permit is granted from the U.S. Fish and Wildlife Service. A biological assessment and formal consultation, followed by the

issuance of a biological opinion by the U.S. Fish and Wildlife Service, may be required for any species that is determined to be in potential jeopardy.

During 2017, no species of plants or animals that are protected by the *Endangered Species Act* were identified within the WIPP land withdrawal area.

2.12 Migratory Bird Treaty Act

The *Migratory Bird Treaty Act* (16 U.S.C. §§703, et seq.) is intended to protect birds that have common migratory flyways between the United States, Canada, Mexico, Japan, and Russia. The act makes it unlawful "at any time, by any means or in any manner, to pursue, hunt, take, capture, kill, or attempt to take, capture, or kill… any migratory bird, any part, nest, or eggs of any such bird" unless specifically authorized by the Secretary of the Interior by direction or through regulations permitting and governing actions (50 CFR Part 20, "Migratory Bird Hunting"). In 2017, no activities involving migratory birds took place within the WIPP land withdrawal area.

2.13 Federal Land Policy and Management Act

The objective of the *Federal Land Policy and Management Act* (43 U.S.C. §§1701, et seq.) is to ensure that

> *…public lands be managed in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archeological values; that, where appropriate, will preserve and protect certain public lands in their natural condition; that will provide food and habitat for fish and wildlife and domestic animals; and that will provide for outdoor recreation and human occupancy and use.*

Title II under the act, *Land Use Planning; Land Acquisition and Disposition*, directs the Secretary of the Interior to prepare and maintain an inventory of public lands and to develop and maintain, with public involvement, land use plans regardless of whether subject public lands have been classified as withdrawn, set aside, or otherwise designated for one or more uses. The DOE developed, and operates in accordance with, the WIPP LMP, which is described in further detail in Section 5.2.

Under Title V, *Rights-of-Way*, the Secretary of the Interior is authorized to grant, issue, or renew rights-of-way over, upon, under, or through public lands. To date, several right-of-way reservations and land-use permits have been granted to the DOE. Examples of right-of-way permits include those obtained for an access road, a caliche borrow pit, and a sampling station. Each facility (e.g., road, pipeline, and railroad) is maintained and operated in accordance with the stipulations provided in the respective right-of-way reservation. Areas that are the subject of a right-of-way reservation are reclaimed and revegetated consistent with the terms of the right-of-way when they are no longer needed.

2.14 Atomic Energy Act

The *Atomic Energy Act of 1954*, as amended (42 U.S.C. §§2011, et seq.), initiated a national program with responsibility for the development and production of nuclear weapons and a civilian program for the development and the regulation of civilian uses of nuclear materials and facilities in the United States. Amendments to the act split these functions between the DOE, which is responsible for the development and production of nuclear weapons, promotion of nuclear power, and other energy-related work, and the U.S. Nuclear Regulatory Commission, which regulates the use of nuclear energy for domestic civilian purposes.

The statutory authority for the EPA to establish and generate applicable environmental radiation protection standards for management and disposal of spent nuclear fuel, high-level, and TRU radioactive waste is found in the *Atomic Energy Act of 1954*, Reorganization Plan Number 3 of 1970, and in the *Nuclear Waste Policy Act of 1982* (42 U.S.C. §10101, et seq.). The EPA final rule, 40 CFR Part 191, was promulgated on December 20, 1993 (effective January 19, 1994), and consists of three subparts: Subpart A, “Environmental Standards for Management and Storage,” Subpart B, “Environmental Standards for Disposal,” and Subpart C, “Environmental Standards for Ground-Water Protection.”

The results of both environmental and effluent monitoring and dose calculations have indicated that there have been no regulatory releases of radionuclides from the WIPP facility that may adversely impact the public. Results of the monitoring program demonstrate compliance with the dose limits specified in 40 CFR Part 191, Subpart A and 40 CFR §61.92 which are discussed in further detail in Chapter 4. WIPP personnel have conducted confirmatory effluent monitoring since receipt of waste began in March 1999.

The LWA requires the EPA to conduct recertification of continued compliance every five years after the initial receipt of TRU waste for disposal until the end of the decommissioning phase. The latest Compliance Recertification Application for the WIPP project was submitted to the EPA in March 2014. After several formal completeness questions and response letters between the EPA and CBFO. The EPA subsequently provided DOE with a January 13, 2017 letter declaring CRA-2014 complete. The EPA published the completeness determination in, Federal Register/Vol. 82, No. 46/Friday, March 10, 2017/Proposed Rules, page 13282. On July 13, 2017, EPA officially recertified the DOE WIPP facility, confirming that it continues to comply with the EPAs radioactive waste disposal regulations at 40 CFR Part 191, Subparts B and C, as well as with WIPP Compliance Certification Criteria at 40 CFR Part 194. This recertification decision was published in the Federal Register/Vol. 82, No. 137/Wednesday, July 19, 2017/Notices, page 33106.

2.15 DOE Orders

DOE orders are used to direct and guide project participants in the performance of their work and establish the standards of operations at the WIPP project. The DOE orders documented in this report require that emission, effluent, and environmental monitoring programs be conducted to ensure that the WIPP mission can be accomplished while protecting the public, the worker, and the environment. The list of DOE orders identified for the WIPP facility is reviewed and updated annually.

2.15.1 DOE Order 151.1D, Comprehensive Emergency Management System

DOE Order 151.1D was approved August 11, 2016, superseding DOE Order 151.1C. This order has currently not been implemented at the WIPP facility. It became a management and operating contract requirement in September of 2017. An implementation schedule and plan have been developed to have DOE Order 151.1D fully implemented by September 15, 2020. This order establishes requirements for emergency planning hazards assessment, categorization, classification, preparedness, response, notification, coordination control, public protection, and readiness assurance activities. The applicable requirements of this order are implemented through the WIPP Emergency Management Plan (WP 12-9), which addresses Emergency Response, Training, Emergency Readiness, and Emergency Records. The WIPP Emergency Management Plan also outlines Emergency Management responsibilities from the Permit including Attachment D, the RCRA Contingency Plan.

2.15.2 DOE Order 231.1B, Administrative Chg. 1, Environment, Safety, and Health Reporting

This order ensures the DOE receives timely and accurate information about events that could adversely affect the health, safety, and security of the public or workers, the environment, the operations of DOE facilities, or the credibility of the DOE. The order specifies the timely collection, reporting, analysis, and dissemination of data pertaining to environment, safety, and health that are required by law or regulation, or that are essential for evaluating DOE operations and identifying opportunities for improvement needed for planning purposes within the DOE. The order specifies the reports that must be filed, the persons or organizations responsible for filing the reports, the recipients of the reports, the format in which the reports must be prepared, and the schedule for filing the reports. This order is implemented in part at the WIPP facility through ASERs, environmental protection program reports, occupational injury and illness reports, the radiation safety manual, the dosimetry program, the fire protection program, and WIPP facility procedures.

2.15.3 DOE Order 414.1D Administrative Chg. 1, Quality Assurance

This order provides the criteria for establishing, implementing, and maintaining programs, plans, and actions to ensure quality in DOE programs. This order is implemented at the WIPP facility through the CBFO *Quality Assurance Program*

Document (DOE/CBFO-94-1012), which establishes quality assurance (QA) program requirements for quality-affecting programs, projects, and activities sponsored by the CBFO. Chapter 7 of this ASER provides additional details on the WIPP Project QA programs.

2.15.4 DOE Order 435.1, Chg. 1, Radioactive Waste Management

The objective of this order is to ensure that DOE radioactive waste (i.e., High-Level, TRU and Low-Level waste), including TRU waste that is disposed of at the WIPP facility, is characterized at generator/storage sites so that waste may be managed in a manner that is protective of workers, public safety, and the environment. In the event that a conflict exists between any requirements of this order and the WIPP LWA regarding their application to the WIPP facility, the requirements of the LWA prevail. The DOE implements the requirements of this order through generator/storage site procedures that address the requirements in the *Transuranic Waste Acceptance Criteria for the Waste Isolation Pilot Plant* (DOE/WIPP-02-3122). Only waste that is compliant with the WIPP Waste Acceptance Criteria is allowed to be shipped to the WIPP facility.

Occasionally, the WIPP facility generates low-level and mixed low-level waste which, according to the LWA, cannot be disposed of at the WIPP facility. Procedures governing the characterization, management, and disposal of radioactive waste generated on site are *Low-Level and Mixed Low-Level Waste Management Plan* (WP 02-RC.05), and *Low-Level and Mixed Low-Level Waste Characterization for Off-Site Release for Disposal* (WP 02-RC3110). These procedures ensure that site-generated low-level and mixed low-level waste are disposed of off-site in accordance with DOE Order 435.1, Change 1, and DOE Manual 435.1-1A, Administrative Change.

2.15.5 DOE Order 436.1, Departmental Sustainability

This order requires DOE sites to comply with the sustainability requirements contained in EOs 13423 and 13514. These EOs were superseded by EO 13693, *Planning for Federal Sustainability in the next Decade.* Project managers must also develop, and commit to implement, an annual site sustainability plan that identifies their respective contributions toward meeting DOE sustainability goals. The WIPP EMS must be used for implementing the project sustainability plan. The project EMS must maintain conformance to International Organization for Standardization (ISO) 14001:2004. The WIPP project sustainability plan for fiscal year (FY) 2017 was prepared in December 2016. This sixth annual update addresses the WIPP project contribution toward meeting the DOE sustainability goals including the performance status for FY 2016 and planned actions for FY 2017. The project sustainability plan becomes a basis for establishing annual project environmental objectives and targets related to sustainability. WIPP Project participants work toward achieving the sustainability goals through the EMS. The WIPP EMS was certified to the ISO 14001:2004 standard in May 2009 and recertified on May 28, 2012, and May 28, 2015. The next certification audit for the EMS is scheduled for May, 2018.

2.15.6 DOE Order 451.1B, Administrative Chg. 3, National Environmental Policy Act Compliance Program

This order establishes DOE requirements and responsibilities for implementing NEPA, the Council on Environmental Quality regulations implementing the procedural provisions of NEPA (40 CFR Parts 1500–1508), and the DOE NEPA implementing procedures (10 CFR Part 1021). This order is implemented by the DOE for the WIPP facility through the DOE site-specified NEPA procedure, compliance plans, and a screening procedure. These tools are used to evaluate environmental impacts associated with proposed activities and to determine if additional analyses are required.

This Order was canceled on December 21, 2017 and superseded by DOE Policy 451.1 which took over effect on December 21, 2017.

A Categrorial Exclusion determination was completed in April of 2017 for the installation of a Supplemental Ventilation System to support underground activities at the WIPP facility.

2.15.7 DOE Order 458.1, Administrative Chg. 3, Radiation Protection of the Public and the Environment

This order establishes standards and requirements for DOE and contractor operations with respect to protecting members of the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of DOE pursuant to the *Atomic Energy Act of 1954*, as amended. Activities and analyses describing compliance with the applicable requirements of the order are contained in the *Waste Isolation Pilot Plant Documented Safety Analysis* (DOE/WIPP-07-3372). Monitoring activities to document compliance with the order are described in the WIPP facility as-low-as-reasonably-achievable program manual, the Records Management Program, and the radiation safety manual.

Since the February 14, 2014, radiological release event, the WIPP underground facility is being operated in filtration mode, which effectively removes respirable particulate from the effluent air stream.

2.16 Executive Orders

EOs are used by the President to direct federal agencies and officials in their execution of policies. Compliance is accomplished through the WIPP EMS as described in Chapter 3. Confirmation of compliance is accomplished through the WIPP assessment processes.

2.16.1 Executive Order 13693, Planning for Federal Sustainability in the Next Decade

This EO was signed on March 19, 2015, and issued in the Federal Register on March 25, 2015. This new EO supersedes EOs 13514 and 13423 as noted in the

previous sections. The order adds new and/or increases existing sustainability goal levels. The goals set for sustainability improvements by federal agencies are in Table 2.3 below.

Table 2.3 – Goal Areas for Federal Sustainability

	Goal Area
Greenhouse Gases (GHGs)	Scope 1 and 2 GHG
	Scope 3 GHG
Buildings	Energy Intensity
	Renewable Electricity
	Total Renewable Energy
	Water Intensity
	High Performance Sustainable Buildings (HPSB) Guiding Principles
	Net Zero buildings
	Leases
	Infrastructure Planning
Fleet	Fleet GHG
	Zero Emission Passenger Cars
	Petroleum
	Alternative Fuels
	Alternative Fuel Vehicles
	Optimization of Fleet Size
Electronics	Data Center Power Utilization Efficiency
	Computer and Monitors Power Management Utilization
	Electronics Recycling
Other	Performance Contracting
	Climate Change
	Sustainable Procurement
	Supply Chain GHG
	Waste Diversion

Accomplishments towards goals established in EO 13693 are discussed in Chapter 3.

In addition, the order continues the requirements to use of the EMS as the framework for managing and continually improving in these sustainable goal areas. Requirements are implemented and integrated into WIPP operations through facility, energy and fleet and vehicle management, affirmative procurement, and pollution prevention programs.

2.16.2 Executive Order 13653, Preparing the United States for the Impacts of Climate Change

This EO was signed on November 1, 2013, and on June 9, 2014, the U.S. DOE Deputy Assistant Secretary for Site Restoration notified the Office of Environmental Management that sites are required to comply with the EO. The EO directs federal agencies to modernize federal programs to support climate resilient investments and plan for climate change related risks to federal facilities, operations, and programs. EO 13653 was revoked by EO 13783, Promoting Energy Independence and Economic Growth, on March 28, 2017. EO 13783 established actions, with deadlines, for executive departments and heads of agencies. There were no further compliance obligations applicable to the WIPP site from this order during 2017.

The WIPP Project, as part of its Site Sustainability Plan goals, prepared a Climate Change Vulnerability Screening and was incorporated into the FY 2015 and FY 2016 Site Sustainability Plans. The screening results were incorporated into the EMS end-of-year management review. No further work towards compliance with this EO was conducted in this reporting period.

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CHAPTER 3 – ENVIRONMENTAL MANAGEMENT SYSTEM

The CBFO and the MOC consider protection of workers, the public, and the environment to be the highest priority at the WIPP facility. This commitment is made public by the WIPP Environmental Policy Statement. Implementation of the EMS ensures protection of the environment as it is embedded into site implemented policy and procedure. Effectiveness and continuous improvement of the EMS is monitored and evaluated by the Environmental Management System Steering Committee (EMSSC).

In 2017, Advanced Waste Management Systems (AWMS), confirmed the EMS as implemented is adequate and effective in demonstrating conformance with the ISO 14001 standard. AWMS completed a surveillance on October 12, 2017, the surveillance report confirmed no findings and zero nonconformities of the system. AWMS originally issued ISO 14001:2004 certification on May 28, 2015 [registration 00206]. This certification remains in effect until its expiration on May 28, 2018. The defined scope of the EMS applies to environmental aspects of the WIPP project under the influence and control of the CBFO and Nuclear Waste Partnership LLC (NWP). Continued certification to the ISO14001 standard occurs through five surveillances over three years. This process demonstrates the facility meets the expectations defined by the President's Council on Environmental Quality and DOE Order 436.1.

The EMS challenges and opportunities are summarized in following paragraphs.

Challenges were limited to site operational priorities which directed focus and effort to support increasing TRU waste shipment rates to the WIPP facility. At the beginning of 2017, the authorizations were in place to begin emplacing TRU waste, which is the most significant (and positive) environmental aspect of the WIPP project. In April, shipments resumed.

As WIPP personnel focused on restart operations, progress toward the DOE sustainability goals was limited. As in 2016, progress in support of these goals focused on establishing improvements in energy and water efficiencies.

Improvements and progress in site operational controls and programs implementing the EMS were completed as environmental targets in FY 2017. Of particular significance was the placement of the SVS, placement of the De-Dusters in the underground and the withdrawal from the south-end of the mine.

3.1 2017 Environmental Management System Highlights

This section highlights improvements that support TRU waste emplacement and operation of the facility at pre-event rates for the long term.

Environmental Policy

The WIPP Environmental Policy statement was updated and signed by the new CBFO and NWP managers. In April 2016, it was sent to all CBFO and WIPP staff as well as supporting contractors. The updated statement clearly communicates the commitment of managers to protect the environment. The Environmental Policy Statement is on a two year cycle and will be updated in 2018.

Environmental Aspects

No changes to WIPP's significant aspects were needed in FY 2017. During 2017, controls continued to be reviewed and strengthened as necessary for the following significant environmental aspects.

- Disposal of TRU waste (including characterization, confirmation, onsite handling, transfer, and emplacement)
- Ventilation capability

Legal and Other Requirements

During 2017, the CBFO and NWP continued to comply with three AOs issued by the NMED to address Permit requirements that could not be met due to inaccessibility of areas in the underground where inspections and monitoring are necessary. The first two AOs provided requirements for monitoring and reporting to the NMED on the status of recovery from the two events. The third AO required the *WIPP Nitrate Salt Bearing Waste Container Isolation Plan* to address nitrate salt-bearing waste disposed at the WIPP facility. On December 16, 2016 the NMED closed the AO#1 that was issued on February 27, 2014 following an inspection of the facility on December 6, through December 9, 2016. The other two AOs were still in effect throughout CY 2017.

Objectives, Targets, and Program(s)

The WIPP significant aspects and Site Sustainability Plan provide the basis for establishing WIPP environmental objectives and targets. A summary of FY 2017 performance and targets can be found in Table 3.1

The 2017 environmental objectives follow:

1. Improve operational controls for safe, environmentally sound emplacement of TRU waste through recovery projects.
2. Enable long-term, energy-efficient WIPP operations through integration of energy efficiency with recovery projects.
3. Improve waste diversion rate to 50 percent by 2020.
4. Improve life cycle management of electronics (including energy use in data centers).
5. Incorporate sustainability into baseline and revitalization projects.

FY 2017, 97 percent of environmental targets were completed. The targets support progress toward the objectives. The remaining three percent denoted by the approved targets were not completed as a result of restart priorities requiring changes to purchases of mine equipment that met EPA Tier 4 standards.

The most significant targets were related to improving operational controls specific to mine ventilation. These targets included design of the SSCVS, placement of the SVS in the underground, and placement of the De-Dusters in the underground, which were all listed as 100 percent complete as of September 31, 2017. These major improvements enable the WIPP operations to resume and increase disposal of TRU waste. Disposal of TRU waste is one of the most significant environmental aspects of the WIPP project; these denoted improvements add additional layers of protection for both the employee and the environment.

Competence, Awareness, and Training

A training module was developed in 2016, but it was carried over into 2017 as awareness training for those who conduct Permit inspections. This training addressed a gap in understanding and performance of compliance inspections required by the Permit requirements. The gap was identified in a management assessment of inspection compliance requirements.

As in past years, every WIPP employee completed in-depth initial or refresher Conduct of Operations Training, which is fundamental to implementing the Operational Control Element of the WIPP EMS. Employees also completed EMS training through initial or annual refresher General Employee Training.

A new EMS awareness training module is in development and expected to be implemented in May 2018.

Operational Control

Improvements to operational controls, both physical and programmatic, for significant environmental aspects were made in FY 2017. Work on the ventilation system progressed as noted previously. Improvements to programmatic operational controls included those in the areas of waste characterization, packaging and confirmation, radiation protection, emergency management, maintenance and work control, performance assurance, and permit required inspections.

Emergency Preparedness and Response

The WIPP Emergency Management Program level of readiness continues to improve as this program evolves. The effectiveness of the WIPP Emergency Management Program is continuously assessed through drills, exercises, and internal and external management assessments, and offsite interfaces. Two exercises were conducted which included local, state, and federal agencies and organizations as exercise participants. Additionally, 71 drills were conducted that provided training opportunities for underground evacuations, Central Monitoring Room operations, emergency response, and practice of surface protective actions. The planning for drills and exercises is based on the data from the Emergency Planning Hazards Survey, which identifies the chemical and radiological hazards at the WIPP facility and their quantities, along with the Emergency Planning Hazard Assessment, which identifies the Emergency Planning Zones, Emergency Action Levels, and the Protective Action Criteria associated with proposed emergency events.

The WIPP Fire Department Firefighters were certified to Firefighter I/II levels. In addition, numerous Emergency Response Team members have been trained to NFPA 1081, *Industrial Firefighter Standard*, at Texas A&M Engineering Extension Service. WIPP Fire Department also implemented a state-certified Emergency Medical Service Basic

and Advance Life Support response capability.

WIPP Emergency Management & Security department personnel including protective force, fire department and emergency management personnel participated in Eddy County LEPC Meetings and the Lea County Disaster/Emergency Preparedness Committee Meetings. The purpose of these meetings is to discuss regional emergency management initiatives and issues as well as strengthen collaboration and partnerships. Lea and Eddy County emergency management staff also participated in the annual exercise at the WIPP facility, serving as emergency management liaisons from the counties to the WIPP Emergency Operations Center. As is the practice to support community emerging management effort, the WIPP emergency management collaborated on fifteen different emergency planning and coordination activities with several external emergency management organizations including local, state, and federal agencies.

Monitoring and Measurement

The WIPP Environmental Monitoring Program continued to be robust, with sampling conducted across the full range of media that could be affected by operation of the WIPP facility. Sampling included air, soil, surface water and sediment, and biota.

Evaluation of Compliance

During FY 2017, CBFO and the MOC performed seven direct audits that included checks for compliance with environmental requirements related to the aspects of environmental monitoring parameters. During the course of the year, environmental staff continued to conduct management self-assessments and perform walk-around reviews, for various environmental implications such as waste storage configuration and proper waste labeling practices. In addition, a team of environmental staff consistently review documentation of Hazardous Waste Facility Permit inspection requirements. If corrections are noted with the inspection reviews, attempts are made to perform corrective practices during the inspection time frame to both - correct an inspection form and coach those performing inspections on the core value element for continuous improvement.

Nonconformity, Corrective Action, and Preventive Action

The CBFO continued to use the Issue Collection and Evaluation system as the CBFO management tool for documenting and tracking identified issues through management evaluation, approval, resolution of actions, and closure. The Issue Collection and Evaluation system implements applicable portions of DOE Order 226.1B, *Implementation of Department of Energy Oversight Policy*; DOE Order 422.1, *Conduct of Operations*; DOE/CBFO-94-1012, *Quality Assurance Program Document*; and DOE/WIPP-04-3299, *CBFO Contractor Oversight Plan*.

The NWP Issues Management and Corrective Action Request programs continued to be robust. These are the two fundamental programs for implementing this element of the EMS. Improvements identified for correction and continuous improvement elements focus attention on issues that could affect WIPP Project compliance and protection of human health and the environment.

Internal Audit

There were no internal audits of the system performed during FY 2017.

Management Review

CBFO and MOC senior managers performed the annual detailed review of the EMS on August 15, 2017. The result of the management review was the determination that the EMS is suitable, adequate, and effective, to meet environmental policy commitments.

3.2 Significant Environmental Programs

Fundamental to the EMS are programs through which environmental protection is integrated with operations. These programs, with supporting procedures, translate the environmental policy's higher order commitments into practical actions for individual employees to take to protect the environment as they work.

3.2.1 Delaware Basin Drilling Surveillance

Surveillance of drilling activities within the Delaware Basin places specific emphasis on the nine-township area that includes the WIPP site. The surveillances build on the data used to develop modeling assumptions for performance assessment for the EPA Compliance Certification.

3.2.2 Environmental Monitoring

The Environmental Monitoring Program includes radiological and non-radiological monitoring, land management monitoring, and surveillance of oil and gas operations near the WIPP boundary. Radiological constituents that are sampled ensure environmental standards are met include: airborne effluent and particulates, sewage treatment and water disposal evaporation ponds, biotics, soils, surface water, sediment,

and groundwater. Non-radiological sampling/monitoring includes meteorology, VOCs, groundwater, hydrogen, methane, nearby hydrocarbon drilling activity, and SSW.

Low volume air particulate monitoring (ambient air) continued to be supplemented. In 2017, 24 sampling stations were operated, which was inclusive of the 7 pre-2014 stations.

3.2.3 Environmental Compliance Audit

Audits and reviews of compliance are conducted via MOC environmental compliance assessments and CBFO and MOC QA assessments.

3.2.4 Groundwater Protection

Groundwater, which may potentially be affected by DOE operations, is monitored to detect and document the effects of operations on groundwater quality and quantity, and to show compliance with applicable federal and state laws and regulations.

3.2.5 Land Management

The land management program provides for management and oversight of WIPP lands under the jurisdiction of the DOE and lands used for WIPP activities outside of the WIPP boundary. It provides protocols that are used for the management and oversight of wildlife practices, cultural resources, grazing, recreation, energy and mineral resources, lands/realty, reclamation, security, industrial safety, emergency management, maintenance, and work control on these lands.

3.2.6 Environmental Compliance Review and NEPA Implementation

This program ensures that requirements of the NEPA are met prior to making decisions to implement work at or on behalf of the WIPP facility. In addition, it ensures that other environmental compliance requirements and sustainability are considered and addressed prior to implementing work.

3.2.7 Sustainability

This program promotes acquisition and use of Federal Energy Management Program (FEMP) and Energy Star rated appliances, Electronic Procurement Electronics Assessment Tool (EPEAT) gold rated electronics, WaterSense rated plumbing fixtures, Significant New Alternatives Policy (SNAP) and SaferChoice labeled chemicals, BioBased/BioPreferred lubricants and Smart way logistic providers. These actions support the EMS regarding utility efficiency; reduction of GHG emissions; sustainable building design, waste minimization, recycling, and electronics management into the WIPP project.

3.2.8 Sustainable Procurement

This program plan provides a systematic structure for promoting and procuring sustainable products as previously described.

3.2.9 Waste Stream Profile Review and Approval

This is a critical program for ensuring that compliance requirements are met for wastes being disposed at the WIPP facility. Profiles for each waste stream are reviewed to verify that the characterization information provided by the waste generator is complete and accurate, and that waste streams comply with the Permit and the Waste Acceptance Criteria.

3.2.10 Waste Confirmation

Under this program, waste containers are confirmed to have no ignitable, corrosive, or reactive waste using radiography and/or visual examination of a statistically representative subpopulation of the waste in each shipment. This program is required by the Permit.

3.2.11 Waste Management

This program ensures that site-generated hazardous, universal, special, low-level, and mixed low-level radioactive wastes are properly handled, accumulated, and transported to approved disposal facilities in accordance with legal and internal requirements. It also includes provisions for proper management of site-derived TRU and TRU mixed waste.

3.3 Environmental Performance Measurement

Extensive monitoring and measurement is conducted to ensure that the WIPP mission is carried out in accordance with its environmental policy. This includes monitoring for (1) impacts to environment, (2) EMS effectiveness, and (3) sustainability progress. Each of these is discussed in the following sections.

3.3.1 Environmental Impacts

There were no significant adverse impacts on the environment from WIPP facility operations in 2017, as determined from extensive environmental monitoring for both radiological and non-radiological monitoring results. Detailed analyses and summaries of environmental monitoring results are included in Chapters 4, 5, and 6.

3.3.2 EMS Effectiveness

The CBFO and MOC managers jointly determine if the WIPP EMS continues to be suitable and effective for carrying out the WIPP mission in a manner consistent with environmental policy commitments. This is accomplished through the function of the

EMSSC and communicated via the management review process. The determination for this reporting period was that the EMS is suitable and effective.

Effectiveness of the EMS is ultimately determined by how well environmental policy commitments are implemented in day-to-day operations. Key factors considered in determining the effectiveness of the EMS are summarized below.

Policy Commitment	WIPP Performance
Communicate Policy to Project Workers	The environmental policy was reissued by the current CBFO and NWP manager affirming their commitment to the policy. In addition, WIPP Project internal venues were used throughout the year to communicate environmental topics to employees such as changes in recycling program and used battery management. Other areas that provided opportunity for communicating environmental policy were identified for action in FY 2017. These included adding an environmental policy/safety section to the WIPP Fundamentals Handbook and developing an EMS awareness training module, expected to be implemented in FY 2018.
Comply with Environmental Requirements	The many regulatory compliance points for the project were met with exceptions in three areas with those compliance points being addressed promptly with the regulatory agency. The three compliance areas were in the performance of a limited number of underground inspections (underground openings and explosion isolation walls) and monitoring for VOC, hydrogen, and methane in filled panels. These were addressed in the NMED AOs that recognized and allowed for not completing Permit required underground inspections and filled panel VOC, hydrogen and methane monitoring while the areas are not accessible. Quarterly reports were submitted to the NMED to summarize the status of inspections and monitoring. In CY 2017 there was not an inspection of the WIPP facility conducted by the NMED.
Be an environmentally responsible neighbor.	For this reporting period, performance toward meeting this commitment was gauged based on the impacts of the project to the environment and transparency with stakeholders (i.e., regulators and local communities.) There continued to be no environmental impact from WIPP operations on the environment. Improvements to operational controls continued to enable protection of the environment in the future with the ventilation systems work being a significant part of this work. Transparency with stakeholders continued to be strong as demonstrated by the following:

- Quarterly Town hall meetings were held with Livestream video access to keep community members apprised of the restart efforts.
- Teleconferences with regulators are held as needed.
- Sampling results for emissions from the underground after filtration are available upon request.
- The WIPP Recovery Website continued to evolve and is the "one-stop" website for recovery and restart information.
- The WIPP Community Relations Plan on the WIPP homepage provides a link between the public and Permit activities.

Seek to achieve sustainable operations

Progress in this area is closely linked to the focus on restart of the WIPP mission. Restart of waste receipt and emplacement will provide the WIPP project's most significant environmental benefit to the DOE complex, that of reducing environmental risks at TRU waste generator and storage sites. The primary arena for making the WIPP project more sustainable post restart is in setting the stage for a more energy efficient operation. In FY 2017, as in FY 2016, this was accomplished with the purchase of energy efficient equipment for operations and for site infrastructure improvements.

Highlights include the following:

- The roof replacement project started in FY 2016 continued with the project completing an additional 13 cool roofs during FY 2017, to date the project has completed 33. Projects expect another set of installations being completed during FY 2018 this action would have 100 percent of the applicable roofs on site designated as cool roofs.
- The FY 2016 target to replace lighting in the Training Building with light-emitting diode (LED) resumed in FY 2017. The project installed 25 fixtures in the engineering building. During FY 2018, this target will be continued as an end-of-life fixture replacement standard. The new lighting will reduce building energy use while enhancing worker comfort and satisfaction.

Continually improve performance

A key mechanism for continual improvement is through environmental objectives and targets. A summary of FY 2017 performance toward FY 2017 targets is depicted in Table 3.1 below.

Table 3.1 – Fiscal Year 2017 Continuous Improvement Targets

FY17 Targets		**Continuation from FY16**	**Objectives Supported**							***Overall***
Status Report										***Completion Rate: 97%*** **As of Sept 30, 2017**
			Operational Controls	Energy efficiency	50% waste diversion rate	Electronics Life-Cycle	Incorporate Sustainability	**Accountable Manager**	**Program for Implementing Target**	**% Complete**
1	Progress as scheduled - design of Safety Significant Confinement Ventilation System (SSCVS).	Yes	X		X		X	Projects	Project Schedule	100%
2	Engineering performance specification update: Update site referenced engineering performance specs [ex: Drywall Spec, Paint Spec, Lubricant Spec, etc.] to include specification integration designed to meet sustainability requirements.	Yes	X				X	Engineering, Procurement, Projects, Property, SEC	Departmental Plan	100%
3	Complete repair, replacement and installation of cool roofs - Phase II: 33 roofs.	Yes		X	X		X	Construction	Project Schedule	100%
4	Placement of Supplemental Ventilation System (SVS) as scheduled.	Yes	X				X	Projects	Project Schedule	100%
5	Relamp Building 486 (Engineering) with LED lighting. Project seeks to install another 25 fixtures during FY17.	Yes		X			X	Engineering / Construction	Continued installation at fixture end of life	100%
6	Thin Client deployment project: Project seeks to install another 50 units during FY17.	Yes		X		X		Information Technology	Continued installation at fixture end of life	94%
7	De-Duster placement in the U/G as scheduled.	No	X				X	Engineering	Project Schedule	100%
8	U/G equipment upgrades with new electric, hybrid or EPA Tier 4 equipment as scheduled – action designed to decrease site hydrocarbon emissions.	No	X	X			X	Engineering	Project Schedule	54%
9	Withdraw from south end of U/G as scheduled (Panel 9).	No	X					Operations	Project Schedule	95%
10	Reduce Rad Con PPE generated during U/G operations. (Decrease volume purchased by 35%).	No	X		X		X	Rad Con	Departmental Plan	100%

3.3.3 Sustainability Progress (Continuous Improvement)

The EMS annual FedCenter submittal is a web-based report used to denote EMS performance directly to DOE headquarters and the Department of Environmental Management. As denoted, the FY 2017 EMS annual FedCenter submittal, DOE/CBFO met the sustainability goals achieving "Green" status, reporting effective in 8 of the 10 captured and reported categories.

The WIPP Site Sustainability Plan provides the overall strategy and report regarding DOE/CBFO progress in meeting the DOE sustainability goals. For FY 2017, DOE/CBFO met the DOE goals in 10 of the 18 overarching sustainability categories. Goals met include Scope 1 & 2 GHG emissions, Scope 3 GHG emissions, fleet GHG emissions/mile, fleet petroleum use, municipal solid waste diversion, electronics recycling, use of power management on electronic equipment, use of automatic duplex printing and incorporating sustainability clauses in applicable contracts.

Sustainability categories for FY 2017 that were not achieved are energy intensity of goal subject buildings, use of renewable electricity and clean energy, buildings meeting HPSB principles, use of alternative fuels in fleet vehicles and acquisition of EPEAT rated electronics equipment. In addition, DOE/WIPP cannot show a reduction in use of water for industrial and landscape purposes as these uses are not metered separately and the only uses are for fire suppression with negligible use for the small amount of xeriscape landscaping at the site. Construction and Demolition (C&D) waste diversion is not applicable for 2017 as no waste was generated from C&D activities.

3.3.4 Reduce Greenhouse Gas Emissions

The DOE/CBFO has made progress in meeting its energy management goals both prior to, and since the establishment of the current goal baselines. Areas where the DOE/CBFO has met or exceeded energy management goals are energy use metering, energy efficiency measures, data center efficiency, and onsite renewable energy. However, given the unique nature of the WIPP facility location, mission, and energy environment, it is forecasted that the DOE/CBFO contribution in some goal areas will not meet new DOE agency wide goals for efficient energy usage such as building energy intensity.

Additionally, the DOE/CBFO will significantly increase energy and water use as the 2014 event recovery is complete and the WIPP facility continues toward full operation and as capital projects commence. Due to the unique nature of the WIPP mission several energy intensive facilities are required to be commissioned such as a new SSCVS. The WIPP mission expected life cycle has been extended and additional scope is also under review, both of these factors constitute major WIPP Project changes that will require expanded infrastructure and increased energy use. These changes will require a new sustainability reporting baseline when they are finalized.

The strategies and plans outlined in this document will be utilized by the DOE/CBFO to support the Department's sustainability goals to the greatest extent possible while fulfilling the mission and maintaining economically viable stewardship.

Efficient use of energy resources has been important to the DOE/CBFO since startup of the facility. Through efficiency upgrades, scheduling, and management of resources, the DOE/CBFO has controlled energy use throughout the mining and waste receipt/disposal process as demonstrated in Figure 3.1.

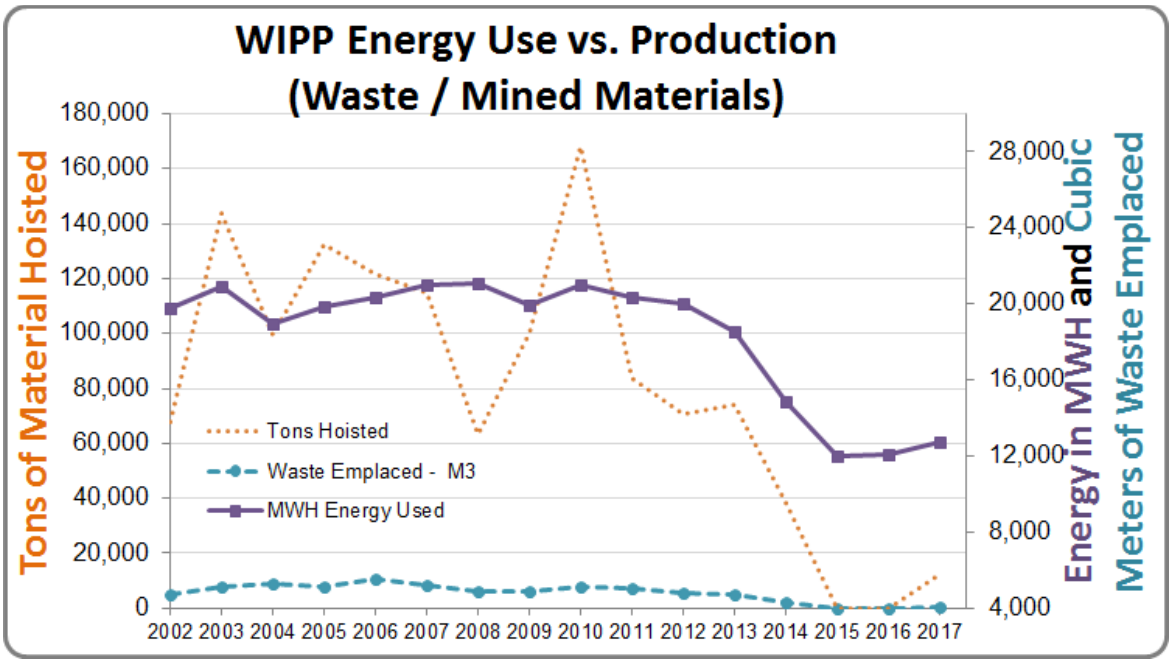

Figure 3.1 – WIPP Facility Energy Use vs. Production

This performance is particularly significant since 70-75 percent of energy consumed for the project is for process loads with the largest energy use on-site attributable to providing underground ventilation required for protection of the worker while mining salt and emplacing TRU waste. The WIPP surface structures accommodate personnel, equipment, operational facilities and support services required for the receipt and emplacement of TRU waste for permanent disposal in the underground. The WIPP underground structures occupy approximately 100 acres for permanent emplacement of waste and are located approximately 2,150 feet below the surface. DOE/CBFO has played a key role in meeting objectives established in the National TRU Waste Management Plan, receiving shipments of TRU waste for disposal from March 1999 until February, 2014 which resumed in FY 2017. This included mining support and outfitting the underground for experimental projects including Enriched Xenon Observatory, the Salt Disposal Investigation, and Salt Defense Disposal Investigation and recovery of the mine after February 2014.

Funding for energy conservation measures were previously allocated from the annual baseline operating budget along with mission essential requirements to concentrate on

Recovery activities through FY 2016 and into FY 2017. In March of 2017, after an approximate 3-year recovery from a fire and release events, the DOE/CBFO once again started operations to support its mission.

The DOE/CBFO will continue to scrutinize the energy market for improvements in economic viability of renewable energy projects on WIPP lands. Meanwhile, Xcel Energy, the WIPP Project sole energy provider continues making progress in GHG reductions. In CY 2017, the Xcel southwest energy mix consists of 39 percent coal, 38 percent natural gas, 22 percent wind, and 1 percent solar or a total of 23 percent carbon free energy generation. Several large-scale wind and solar projects are proposed for implementation in CY 2018 by Xcel, which will offset further expansion of their carbon foot print. This information is not part of the WIPP EMS SSP status and goals. However, the benefit is still realized through reduced emissions and lower GHG production.

Phase 1 of a photovoltaic solar array on WIPP Building 953 was halted with the events in February 2014. Design for Phase 1 resumed in FY 2016 resulting in procurement of the array equipment; however, installation is currently in the FY 2018 or beyond.

3.3.5 Water Efficiency and Management

The WIPP facility water use status is illustrated by the figure 3.2. An audit conducted in early FY 2003 (November 2002) provided 100 percent completion of water assessment and initial baseline for the site and as a result significant improvements were achieved in FY 2004, continuing through FY 2014. Water use increases in FY 2015 and FY 2016 resulted from activities associated with recovery and infrastructure repairs. In FY 2017 water use has dropped to the pre-event level seen in FY 2013, as indicated by Figure 3.2.

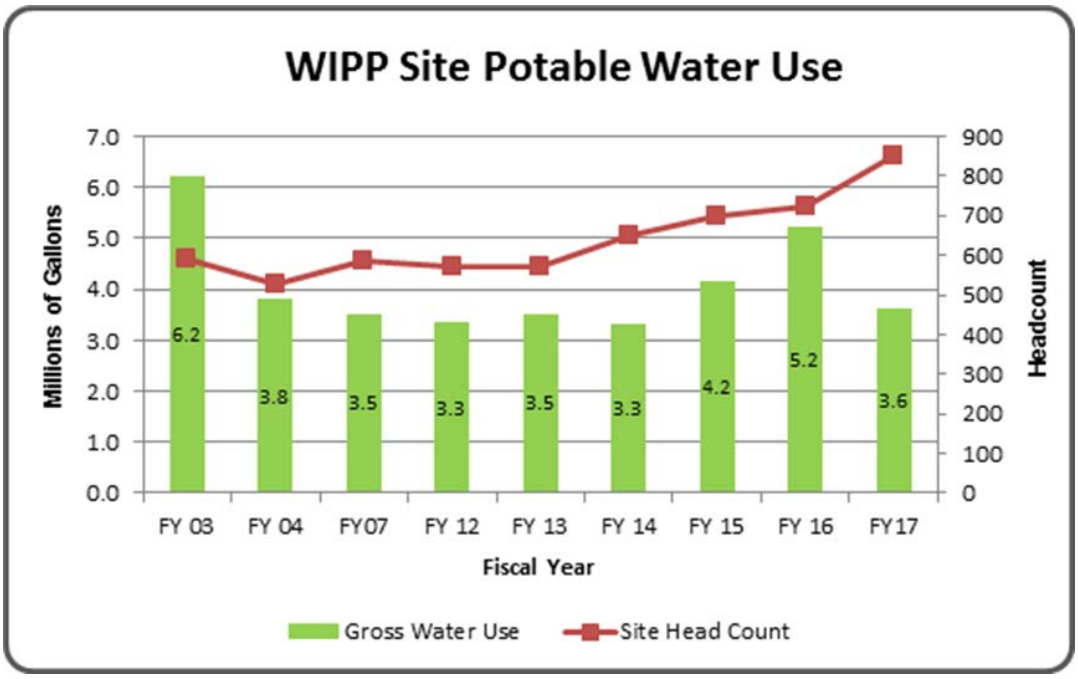

Figure 3.2 – WIPP Site Potable Water Use

For approximately eight years, the DOE/CBFO has implemented a project for water distribution system maintenance resulting in the identification and repair of water leaks from the site fire suppression underground distribution loop. In addition, the DOE/CBFO continues ongoing efforts to conserve water through maintaining and repairing leaking toilets, urinals and faucets, installing low-flow showerheads, and providing employee information and education.

The WIPP facility water intensity shows a relatively flat usage trend until FY 2014. The increase in FY 2015 and FY 2016 is attributed to water leaks, water line repair/test efforts, and increased personnel with the recovery effort. FY 2017 water use has nearly returned to FY 2013 and FY 2014 levels as the WIPP facility has returned to an operational status and some of the fire loop leaks have been either fixed or bypassed. Note that FY 2017 has a moderately higher water usage than FY 2013 and FY 2014 but there is also a higher head count at the site for FY 2017. The National Renewable Energy Laboratory Audit of FY 2013 provides recommendations for potential water reductions. However, there is no payback associated due to the current water use agreement with the City of Carlsbad.

WIPP overall water intensity numbers are reflected in Figure 3.3.

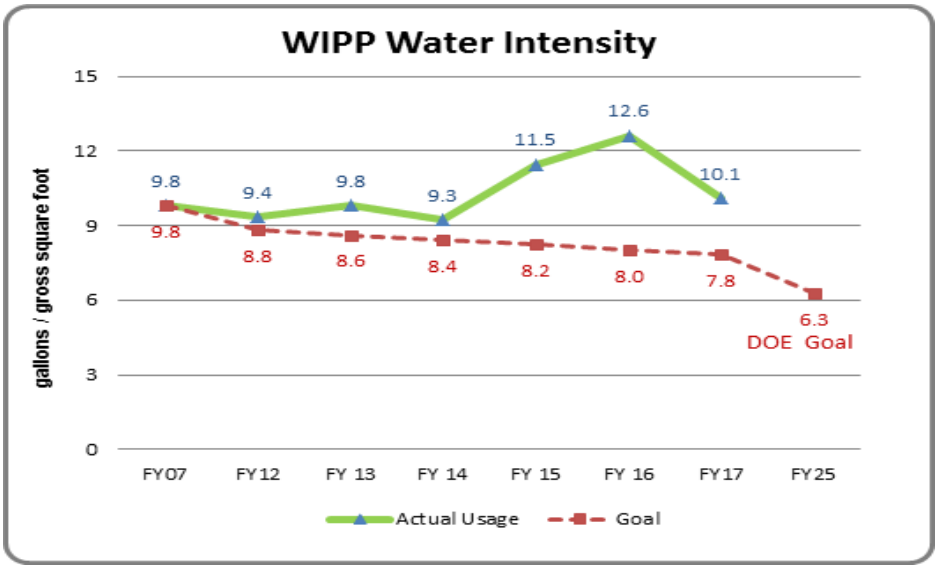

Figure 3.3 – WIPP Water Intensity

Water use is attributed to two primary functions, fire water system flow tests and domestic needs. The larger water consumer of the two is domestic use. Because of this profile, the WIPP facility metric is the total water used compared to employee count and "water use per person per day," as depicted in Figure 3.4, which is the measure and the means to communicate the DOE/CBFO progress in water use efficiency and management.

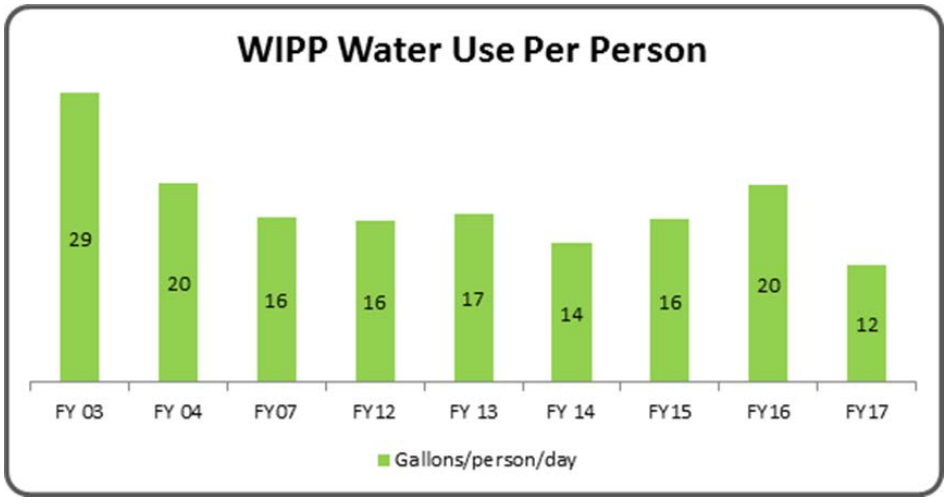

Figure 3.4 – WIPP Water Use Per Person

Overall water usage for the site is low for an industrial operation. Water use for FY 2017 averaged 12 gallons per person per day which is substantially down from the FY 2016 20 gallons per person per day. Potable water use includes water used for ice

machines, fire system flow tests, toilets and showers. Average water use at a factory or other industrial facility is 25 gallons per person per day which means that the WIPP facility water use for FY 2017 is approximately 48 percent less than a standard industrial facility.

Plans and Projected Performance

The DOE/CBFO does not anticipate contributions to this DOE goal as water reductions were accomplished prior to this baseline and there is no economic driver to reduce water consumption because the site receives up to 6.6 million gallons of water per year at no cost based upon an agreement with the City of Carlsbad. Also, a De-Duster process to be utilized in the New Exhaust Filter Building is anticipated to double site water usage. Site strategy to reduce water use for FY 2017 forward includes the following:

- Complete an external (independent) condition assessment for water supply infrastructure to determine water infrastructure improvement opportunities.
- Install conservation measures when practicable including low-flow urinals, toilets, and faucets and more efficient showerheads.
- Continue water distribution system repairs to mitigate water loss from the existing systems.
- Pursue water conservation options when working with third parties for onsite solar generation projects. For example, there is potential to use brackish, non-potable water from sources at the WIPP in renewable energy generation.

Water Management:

Industrial, Landscape and Agricultural Water Reduction Performance Status

The goal is for a 30 percent consumption reduction of industrial, landscape and agricultural water by FY 2025 from a FY 2010 baseline.

Performance Status

Industrial uses of water at the WIPP facility are limited to nuisance dust control in mining activities, and fire water protection system testing. The DOE/CBFO uses negligible water for landscaping purposes and no water for agricultural use. Water used at the site is not metered at a level sufficient to identify industrial vs. personal use. However, because the types of water use are known, total industrial use of water is minimal. Contributions to this goal include:

- Continued implementation of the long-term maintenance project on the piping associated with the fire protection system. This project assures the mission can continue to be implemented and water resources conserved.

- Xeriscaping for the minimal landscaping at the site.

Plans and Projected Performance, Projected actions that will contribute to this goal are:

- Continue use of xeriscaping.
- Analysis of water system to determine opportunities for conservation.
- Pursuit of metering pending funding and economic viability.

3.3.6 Waste Diversion

An active Pollution Prevention Program has been in place since the 1990s with recycling as a key component of the program. As a result, the WIPP Project has historically recycled the waste streams that can be recycled within its regional infrastructure. These include a narrow scope of municipal solid waste, C&D, hazardous, universal and New Mexico special waste streams. Non-hazardous site generated waste recycled by the P2 program include alkaline batteries, aluminum, cardboard, glass, ink and toner cartridges, paper, plastics, wood pallets, and C&D waste which includes asphalt, concrete, wood, and scrap metal. Other wastes recycled or recovered include antifreeze, circuit boards, motor oil, universal batteries (cadmium, lead, lithium, silver-oxide, zinc) and universal lighting (fluorescent, LED, incandescent). All site generated e-waste (computer, printers, copiers and miscellaneous electronics are either donated for reuse or sent for recycling. DOE/CBFO requires language to be embedded in subcontractor contracts that they will adhere to P2 program standards which include recycling, to the best extent possible.

The site generated a total of 201 Metric Tons (MT) of municipal solid and recyclable waste. The DOE/CBFO successfully diverted 56 percent or 113 MT of waste from the local landfill. The DOE/CBFO recycling and waste diversion numbers continue to highlight the prescribed standards and policy continues to positively influence recycling and waste diversion numbers for the project.

The P2 program coordinator introduced the single stream recycling method during FY 2017. Program efforts were uniformly accepted; the program adaptation allowed for the collection of additional types of plastic and mixed paper products, representing a 20 percent increase in the type of materials collected on site.

Plans and Projected Performance

WIPP will continue to work towards maintaining the DOE goal expectation of 50 percent. However, given the limited regional infrastructure for recycling, achieving and maintaining the 50 percent diversion rate remains a challenge.

For FY 2018, actions that will be taken to improve waste diversion rates will be:

- Continue the replacement of site recycling center bins and associated receptacles with new visually dynamic, ergonomic, and consistent collection recycle centers. Significant design focus will be placed on enhancing form, function and placement. These adaptations will make recycling centers more convenient, easier to locate and substantially enhance visual appeal. As of FY 2017 year end, the DOE/CBFO successfully replaced approximately 54 percent of the currently deployed recycling centers.

- Perform regional search for wood waste and wood pallet diversion options.

- Re-address how site P2 program initiatives are communicated and presented to site staff, so that outreach efforts assure focus on inspiring participation, ultimately increasing the waste diversion and recycling rate.

Waste diversion is a key component of the WIPP Project pollution prevention and sustainability programs. The WIPP Project recycles nonhazardous, C&D, hazardous, universal, and New Mexico special wastes that can be recycled. Excluding the nonhazardous solid waste stream, recycled materials included used motor oil, antifreeze, universal batteries, fluorescent tubes, and electronics (e.g., ballasts, computers, circuit boards).

The DOE departmental target to divert 50 percent of nonhazardous solid waste and C&D debris has been adopted as a WIPP Project environmental objective. Achieving a 50 percent diversion rate for nonhazardous solid waste and C&D debris is particularly challenging for the WIPP Project given its remote location and limited local recycling infrastructure. This was reinforced in the later part of 2016 as the recycling vendor used by the WIPP Project ceased to operate, thus eliminating the only local option for recycling paper, plastics, aluminum, and glass. In addition, the City of Carlsbad ceased having the capability to recycle wood waste. Even with these challenges, the DOE/CBFO was able to recycle 71 percent of C&D debris solely through recycling of scrap metal.

3.3.7 Sustainable Acquisition

The DOE/CBFO achieved a 100 percent rate toward this goal in FY 2017 with all 54 of the qualifying new construction contract awards containing the applicable sustainability acquisition clauses for materials. The DOE/CBFO requires the inclusion of sustainability clauses in service and construction contracts to require the purchase and use of recycled and bio-based content products by subcontractors when they meet Cost, Availability, and Performance requirements. The DOE/CBFO will continue to be diligent in incorporating sustainable acquisition into contracts.

Efforts to expand the emphasis on sustainability in procurement standards were implemented during FY 2017. The increased emphasis was on procurement of

recycled content, Energy Star, FEMP, EPEAT, SNAP, and SaferChoice labeling, WaterSense, BioBased/BioPreferred content, while utilizing SmartWay logistic providers. SNAP and SaferChoice are the standards that mandate LOW - ZERO VOC products and ZERO tolerance for products containing ozone depleting substances.

In addition, the DOE/CBFO expanded inclusion of preferred sustainability contract language to be placed into Scopes of Work, Purchase Orders, Service Contracts and Construction Projects. This process ensures the majority of purchases and implemented design modifications apply the best management practices approach strategy as defined by the General Services Administration sustainable procurement standards.

Plans and Projected Performance

For FY 2018 projections, DOE/CBFO will continue to focus on increasing the use of sustainable products to meet this goal. Actions to help achieve this are:

- Continued awareness efforts to ensure sustainability clauses are placed in contracts and sustainable products are purchased.
- Development of a specific training module to further familiarize requisitioners and credit card holders of requirements, contract language and tools available for researching sustainable product options.
- Maintain updated Sustainability website providing requisitioners with standard language for statements of work for acquisition types applicable the WIPP Project.

3.3.8 Electronics Stewardship and Data Centers

DOE/CBFO practices sustainable lifecycle management beginning with the implemented WIPP Electronics Policy which states electronics shall conform to the preferred EPEAT standard and at minimum have an Energy Star rating. The DOE/CBFO continues to implement power management, default duplex printing while ensuring disposition of equipment is completed 100 percent either through donations, transfer for reuse, or certified recycler.

FY 2017 performance included the procurement of 94 central processing units (1 EPEAT Silver, 22 EPEAT GOLD and 72 Energy Star compliant); 37 Monitors (37 Energy Star compliant); 26 Note Books (1 EPEAT Gold, 25 Energy Star compliant); 18 units of Energy Star compliant imaging equipment (printers and multifunction devices); 1 Television (Energy Star compliant) and 5 Servers (5 Energy Star compliant).

Relative to sustainable operations of electronics, new computers, monitors, and networked copiers/multi-function devices are installed with power management activated. Copiers/MFD's are set to default double side print. Altering power management and/or double-sided printing requires a justification be on file that is approved by sustainability and/or property personnel. There are approximately eight

percent of computers that have exemptions from power management based on the need for workers to be able to remotely access their computer. Only two MFD's are exempt from printing duplex based on specific privacy and work process requirements.

In FY 2017 the site recycled 6,900 pounds of surplus electronics through the contracted electronics recycling vender.

Plans and Projected Performance

The DOE/CBFO will implement improvements in the electronic procurement process in order to ensure that electronics meet the preferred EPEAT Gold Standard as described by the site electronic management policy.

3.4 EMS Awards

The WIPP Project did not receive any environmental or EMS awards during this reporting period.

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CHAPTER 4 – ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM INFORMATION

DOE Order 458.1 states that the DOE must conduct radiological monitoring activities to ensure that:

- exposure to members of the public is maintained within the dose limits established in the order;
- the radiological clearance of DOE real and personal property is controlled;
- potential radiation exposures to members of the public are as low as is reasonably achievable;
- DOE sites have the capabilities, consistent with the types of radiological activities conducted, to monitor routine and non-routine radiological releases and to assess the radiation dose to members of the public; and
- protection of the environment from the effects of radiation and radioactive material is provided.

Radionuclides present in the environment, whether naturally occurring or human-made, may result in radiation doses to humans. Therefore, environmental monitoring around nuclear facilities is imperative to characterize radiological baseline conditions, identify any releases, and determine the effects of releases should they occur.

Personnel at the WIPP facility sample air, groundwater, surface water, soils, sediments, and biota to monitor the radiological environment around the facility. This monitoring is carried out in accordance with the *Waste Isolation Pilot Plant Environmental Monitoring Plan* (DOE/WIPP-99-2194). The radiological effluent monitoring portion of this plan meets the requirements contained in DOE/HDBK-1216-2015, *Environmental Radiological Effluent Monitoring and Environmental Surveillance*.

For the WIPP facility, the DOE is required to comply with environmental radiation protection standards in 40 CFR §191.03, Subpart A, which applies to management and storage of radioactive waste. The standards in 40 CFR §191.03(b) state that management and storage of TRU waste at DOE facilities shall be conducted in a manner that provides reasonable assurance that the annual radiation to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation from such management and storage shall not exceed specified limits. Based on analysis of WIPP facility operations, the DOE has identified air emissions as the only plausible pathway for radionuclide transport to the environment outside the facility during receipt and emplacement of TRU waste. Waste operations, including the underground TRU waste disposal areas and the WHB, are monitored through the WIPP airborne Effluent Monitoring Program.

The environmental dose standards for the WIPP facility can be found in 40 CFR Part 191, Subpart A, which specifies that the combined annual dose equivalent to any

member of the public in the general environment resulting from discharges of radioactive material and direct radiation from such management and storage shall not exceed 25 millirem (mrem) to the whole body and 75 mrem to any critical organ. In a 1995 memorandum of understanding between the EPA and the DOE, the DOE agreed that the WIPP facility would comply with 40 CFR Part 61, “National Emission Standards for Hazardous Air Pollutants” (NESHAP), Subpart H, “National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities.” The NESHAP standard (40 CFR §61.92) states that the emissions of radionuclides to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent (EDE) of 10 mrem.

The *Statistical Summary of the Radiological Baseline for the Waste Isolation Pilot Plant* (DOE/WIPP-92-037) summarizes the radiological baseline data obtained at and near the WIPP site during the period 1985 through 1989, prior to the time that the WIPP became operational. Radioisotope concentrations in environmental media sampled under the current ongoing monitoring program are compared with this baseline to gain information regarding annual fluctuations. Appendix H presents data that compare the highest concentrations of radionuclides detected in the current year to the baseline data.

The media sampled as part of the Environmental Monitoring Program include airborne particulates, soil, surface water, groundwater, sediments, and biota (vegetation and animals). These samples are analyzed for 10 radionuclides, including natural uranium ($^{233/234}$U, ^{235}U, and ^{238}U); potassium (^{40}K); TRU actinides expected to be present in the waste (plutonium [^{238}Pu, $^{239/240}$Pu], and americium [^{241}Am]); major fission products (cesium [^{137}Cs] and strontium [^{90}Sr]); and reactor structural materials (cobalt [^{60}Co]). Environmental levels of these radionuclides could provide corroborating information on which to base conclusions regarding releases from WIPP facility operations.

Table 4.1 lists the target radionuclides included in the Environmental Monitoring Program along with their radiation type, method of detection, and reason for monitoring. The WIPP airborne Effluent Monitoring Program also monitors for these same radionuclides with the exception of ^{235}U, ^{40}K, and ^{60}Co because they are not part of the source term from contact-handled and remote-handled TRU radionuclides with the highest potential to deliver a dose to an off-site receptor.

Radionuclides are considered detected in an environmental sample if the measured concentration or activity is greater than the total propagated uncertainty (TPU) at the 2 sigma (σ) TPU level, and greater than the minimum detectable concentration (MDC). This methodology was patterned after “Hanford Decision Level for Alpha Spectrometry Bioassay Analyses Based on the Sample-Specific Total Propagated Uncertainty” (MacLellan, 1999). The MDC is determined by the analytical laboratory based on the natural background radiation, the analytical technique, and inherent characteristics of the analytical equipment. The MDC represents the minimum concentration of a radionuclide detectable in a given environmental sample using the given equipment and

techniques with a specific statistical confidence (usually 95 percent). The TPU is an estimate of the uncertainty in the measurement due to all sources, including counting error, measurement error, chemical recovery error, detector efficiency, randomness of radioactive decay, and any other sources of uncertainty.

Table 4.1 – Radioactive Nuclides Monitored at the WIPP Site

Radionuclide	Radiation	Detection Method	Reason for Monitoring
$^{233/234}U$	Alpha	Alpha spectroscopy	Naturally occurring
^{235}U	Alpha	Alpha spectroscopy	Naturally occurring
^{238}U	Alpha	Alpha spectroscopy	Naturally occurring
^{40}K	Gamma	Gamma spectroscopy	Ubiquitous in nature
^{238}Pu	Alpha	Alpha spectroscopy	Component of waste
$^{239/240}Pu$	Alpha	Alpha spectroscopy	Component of waste
^{241}Am	Alpha	Alpha spectroscopy	Component of waste
^{137}Cs	Gamma	Gamma spectroscopy	Fission product/potential component of waste
^{60}Co	Gamma	Gamma spectrometry	Activation product of reactor structural materials
^{90}Sr	Beta	Gas proportional counting	Fission product/potential component of waste

Note: The radionuclides ^{243}Am, ^{242}Pu, and ^{232}U are used as tracers by the WIPP Laboratories.

Measurements of radioactivity in environmental samples are actually probabilities due to the random nature of the disintegration process. The radioisotope in the sample is decaying as it is being measured, so no finite value can be assigned. Instead, the ranges of possible activities are reported by incorporating the TPUs of the method.

For radionuclides in environmental samples determined by gamma spectroscopy (^{137}Cs, ^{60}Co, and ^{40}K), an additional factor considered in the determination of detectability is the identification confidence (ID confidence) with which the peak or peaks associated with the particular radionuclide can be identified by the gamma spectroscopy software. If the activity of the radionuclide is greater than 2 σ TPU and MDC and the ID confidence is greater than or equal to 0.90, the radionuclide is detected. If the sample activity is greater than the 2 σ TPU and the MDC, but the ID confidence is less than 0.90, the radionuclide is not detected. If the sample activity is less than the 2 σ TPU and/or the MDC, even if the ID confidence is greater than or equal to 0.90, the radionuclide is not detected. It follows that if the sample activity is less than the 2 σ TPU and/or the MDC and the ID confidence is less than 0.90, the radionuclide is not detected. Note that in previous ASERs the lab reported a few gamma detections based solely on an ID confidence greater than or equal to 0.90 without consideration of the sample activity relative to the TPU and MDC. However, the identification criteria were revised starting in 2014 as described above.

Sample results are also normalized with the instrument background and/or the method blank. If either of those measurements has greater activity ranges than the actual

sample, it is possible to get negative values on one end of the reported range of activities. Additional information on the equations used is provided in Appendix D.

WIPP Laboratories performed the analyses for the 10 target radionuclides in environmental radiological samples. Highly sensitive radiochemical analysis and detection techniques were used that resulted in very low detection limits. This allowed detection of radionuclides at concentration levels far below those of environmental and human health concerns. The MDCs attained by WIPP Laboratories were below the recommended MDCs specified in American National Standards Institute (ANSI) N13.30, *Performance Criteria for Radiobioassay*.

Comparisons of radionuclide concentrations in environmental samples were made between years and between locations using the analysis of variance (ANOVA) statistical procedure for those data sets containing a sufficient number of detects to make such comparisons statistically meaningful. When this or other statistical tests were used, the *p* value was reported. The *p* value is the probability under the null hypothesis of observing a value as unlikely as or more unlikely than the value of the test statistic. The *p* value is the significance level for ANOVA calculations. A value of $p > 0.05$ indicates no significant difference in the values from a data set, and a value of $p < 0.05$ indicates a significant difference in the values from a data set. In many cases, scientists have accepted a value of $p < 0.05$ as indicative of a difference between samples.

Interpretation of *p* values requires some judgment on the part of the reader. A *p* value of 0.927 would show less difference among a set of values than a *p* value of 0.076 although both values indicate no significant difference in the values in a data set, and a *p* value of 5.92E-06 would indicate a greater significant difference than a *p* value of 0.0345 for a data set. Individual readers may choose to defend a higher or lower value for *p* as the cutoff value. However, for this report, a *p* value of 0.05 was used with some observation of how much the *p* values differ from 0.05.

The air monitoring for radionuclides is divided between two programs: the WIPP facility Effluent Monitoring Program and the Environmental Monitoring Program. Descriptions of these two programs are provided in the following sections.

Effluent Monitoring Program

There are two airborne effluent monitoring stations in use at the WIPP facility: Stations B and C. Each station employs one or more fixed air samplers, collecting particulates from the effluent air stream using an acrylic copolymer membrane filter. Fixed air samplers at Station B, collect samples from the underground exhaust air after high-efficiency particulate air (HEPA) filtration. At Station C, samples are collected from the exhaust air from the WHB after HEPA filtration.

For each sampling event, chain-of-custody forms are initiated to track and maintain an accurate written record of filter sample handling and treatment from the time of sample collection through laboratory procedures to disposal. During 2017, filter samples from

the two effluent air monitoring stations were analyzed for ^{238}Pu, $^{239/240}$Pu, ^{241}Am, ^{90}Sr, ^{137}Cs, $^{233/234}$U, and ^{238}U.

Environmental Radiological Monitoring Program

The purpose of the Environmental Radiological Monitoring Program is to measure radionuclides in the ambient environmental media. These data allow for a comparison of sample data to results from previous years and baseline data, to determine what impact, if any, the WIPP facility is having on the surrounding environment. Radiological monitoring at the WIPP site includes sampling and analysis of air, groundwater, surface water, sediment, soil, and biota. For each sampling event, chain-of-custody forms were initiated to track and maintain an accurate written record of sample handling and treatment from the time of sample collection through delivery to the laboratory. Internal chain-of-custody forms are used by the laboratory to track and maintain custody while samples are at the laboratory. The radionuclides analyzed were ^{238}Pu, $^{239/240}$Pu, ^{241}Am, $^{233/234}$U, ^{235}U, ^{238}U, ^{137}Cs, ^{60}Co, ^{40}K, and ^{90}Sr. Plutonium and americium isotopes were analyzed because they are the most significant alpha-emitting radionuclides among the constituents of TRU wastes received at the WIPP facility. Uranium isotopes were analyzed because they are prominent alpha-emitting radionuclides in the natural environment.

Strontium-90, ^{60}Co, and ^{137}Cs were analyzed to demonstrate the ability to quantify these beta and gamma-emitting radionuclides should they appear in the TRU waste stream. Potassium-40, a natural gamma-emitting radionuclide that is ubiquitous in the earth's crust, was also monitored.

The environmental sampling program was impacted in 2014, and slightly in 2015, by the release event on February 14, 2014, with the collection of additional air particulate filter samples termed Event Evaluation samples. During 2015 these samples were only analyzed for the radionuclides associated with the release event including ^{238}Pu, $^{239/240}$Pu, and ^{241}Am, although a few samples were analyzed for the 10 target radionuclides. During 2016, and again in 2017, Event Evaluation samples continued to be collected including co-located samples at each primary location plus additional samples at the same locations designated in 2014 following the release event. However, these samples were archived and not included in the samples submitted to the laboratory.

The radionuclide analysis results for the traditional ASER samples are provided in this section of the ASER and in the appendices.

4.1 Effluent Monitoring

4.1.1 Sample Collection

Stations B and C use skid-mounted fixed air samplers at each effluent air monitoring station. The volume of air sampled at each location varied depending on the sampling

location and configuration. Each system is designed to provide a representative sample using a 3.0-micrometer pore size, 47-millimeter (mm) diameter acrylic copolymer membrane filter.

Daily (24-hour) filter samples were collected from the underground exhaust air after HEPA filtration. Each week at Station B approximately 559.4 cubic meters (m^3) (19,756 cubic feet [ft^3]) of air were filtered through the acrylic copolymer membrane filters. There were brief periods where sampling associated with Station B was interrupted during CY 2017, including planned outage periods when there was no underground ventilation flow; however, total air volume sampled was well within the specified recovery limits. Based on the specified sampling periods, these air volumes were within plus or minus (±) 10 percent of the volume derived using the flow rate set point of 0.058 cubic meters per minute (m^3/min) (2.05 cubic feet per minute [ft^3/min]) for Station B. Since the radiological release event on February 14, 2014, Station B has been the primary emissions sample point of record, but the flow rates and sampler characteristics were not materially changed from before the event. The amount of air filtered through Station B acrylic copolymer membrane filters during 2017 was 29,090.5 m^3 (1,027,321 ft^3). The primary emission samples are collected daily at Station B, and an average of 79.7 m^3 (2,815 ft^3) of air were filtered through each air filter at the average annual sample flow rate of 2.02 ft^3/min. The average annual sample flow rate is calculated by averaging the sample flow rates (start flow rate and end flow rate) documented for each filter over the entire year.

Weekly filter samples were collected at Station C, which samples the air from the WHB after HEPA filtration. The amount of air filtered through the Station C acrylic copolymer membrane filters during 2017 was 7,517.4 m^3 (265,473 ft^3). Even though there were brief periods where sampling associated with Station C was interrupted during CY 2017, total air volume sampled was well within the specified recovery limits. Associated WHB fixed air sampler results were assessed for those gaps as necessary to ascertain that no releases occurred during the sample interruptions. The calculated air volume for Station C was within ±10 percent of the average volume derived using the flow rate required for isokinetic sampling conditions. The sampling flow rate for Station C automatically tracks proportionately to the exhaust air flow in the WHB in order to maintain isokinetic sampling conditions.

The ventilation flow capacity of the Station B exhaust duct was increased in the fall of 2016 from 60,000 cubic feet per minute to 114,000 cubic feet per minute by the addition of two more HEPA filter trains parallel to the existing two HEPA filter trains in continuous use since the February 2014 radiological event. During 2017, the ventilation system associated with Station B operated normally at nominal flow rate of 114,000 cubic feet per minute rate.

The Station C effluent air sampling system was designed in accordance with ANSI Standard N13.1 1969. A CY 2011 update of the flow control system replaced obsolete instruments with their current models. The isokinetic sampling configuration did not

change, thus maintaining compliance with the 1969 standard. This was necessary since ANSI/HPS N13.12–1999 does not address isokinetic sampling.

Station B has been the sample point of record for emissions from the underground repository during 2017. Station B samples were collected once per day and assembled into monthly composite samples. The weekly filter samples for Station C were composited each quarter. Filter sample composites were radiochemically analyzed for ^{241}Am, ^{238}Pu, $^{239/240}$Pu, ^{90}Sr, $^{233/234}$U, ^{238}U, and ^{137}Cs.

4.1.2 Sample Preparation

The samples collected daily and weekly were grouped into monthly and quarterly filter sample composites, respectively. The composites were transferred to borosilicate beakers, spiked with appropriate tracers (^{232}U, ^{243}Am, and ^{242}Pu), and heated in a muffle furnace at 250 degrees Celsius (°C) (482 degrees Fahrenheit [°F]) for two hours, followed by two hours of heating at 375°C (707°F) and six hours of heating at 525°C (977°F).

The filters were ashed and cooled, and then transferred into polytetrafluoroethylene beakers by rinsing with concentrated nitric acid and heated with concentrated hydrofluoric acid until completely dissolved. Hydrofluoric acid was removed by evaporation to dryness.

Approximately 25 milliliters (mL) (0.845 fluid ounce) of concentrated nitric acid and 1 gram (0.0353 ounce) of boric acid (to remove residual hydrofluoric acid) and a carrier (strontium nitrate) were added, and the samples were heated and evaporated to dryness. The sample residues were dissolved in eight molar nitric acid for gamma spectroscopy and measurement of ^{90}Sr and the alpha-emitting radionuclides.

4.1.3 Determination of Individual Radionuclides

Gamma-emitting radionuclides in the air filters were measured by gamma spectroscopy. Strontium-90 and alpha-emitting radionuclides were measured by sequential separation and counting. Strontium-90 was counted on a gas proportional counter. The actinides were co-precipitated, separated on an anion exchange column, and analyzed by alpha spectroscopy.

4.1.4 Results and Discussion

Station B and C operated within specifications and no modifications to sample data were necessary for CY 2017. From 16 total composite samples taken in 2017, 112 analyses were performed, as shown in Tables 4.2 and 4.3. The analytes of interest were ^{241}Am, ^{238}Pu, $^{239/240}$Pu, ^{90}Sr, $^{233/234}$U, ^{238}U, and ^{137}Cs.

Table 4.2 – Station B CY 2017 Sample Results

Mo.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
Jan	^{241}Am	1.81E-02	3.89E-03	1.24E-03
Feb	^{241}Am	8.95E-03	2.70E-03	1.04E-03
Mar	^{241}Am	1.38E-02	2.97E-03	8.44E-04
Apr	^{241}Am	8.77E-03	2.31E-03	1.00E-03
May	^{241}Am	4.14E-02	4.51E-03	7.14E-04
Jun	^{241}Am	8.07E-03	2.10E-03	1.11E-03
Jul	^{241}Am	7.10E-03	1.76E-03	6.81E-04
Aug	^{241}Am	1.54E-02	2.70E-03	5.74E-04
Sep	^{241}Am	1.17E-02	2.38E-03	6.51E-04
Oct	^{241}Am	5.62E-03	1.80E-03	8.51E-04
Nov	^{241}Am	1.66E-02	2.96E-03	5.88E-04
Dec	^{241}Am	2.08E-02	3.37E-03	7.10E-04

Mo.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
Jan	^{238} Pu	8.62E-05	2.62E-04	5.70E-04
Feb	^{238} Pu	1.00E-04	2.76E-04	7.14E-04
Mar	^{238} Pu	6.62E-05	3.17E-04	7.59E-04
Apr	^{238} Pu	6.59E-05	2.76E-04	5.40E-04
May	^{238} Pu	4.63E-04	5.74E-04	7.73E-04
Jun	^{238} Pu	3.60E-04	4.48E-04	5.99E-04
Jul	^{238} Pu	3.92E-04	4.55E-04	5.44E-04
Aug	^{238} Pu	1.83E-04	3.41E-04	5.55E-04
Sep	^{238} Pu	-2.90E-05	9.47E-05	4.11E-04
Oct	^{238} Pu	-2.50E-05	1.03E-04	4.96E-04
Nov	^{238} Pu	-5.18E-05	1.47E-04	5.40E-04
Dec	^{238} Pu	5.81E-05	2.67E-04	6.29E-04

Mo.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
Jan	$^{239/240}$Pu	2.83E-03	1.14E-03	5.88E-04
Feb	$^{239/240}$Pu	1.17E-03	8.21E-04	7.03E-04
Mar	$^{239/240}$Pu	8.77E-04	7.03E-04	6.99E-04
Apr	$^{239/240}$Pu	1.86E-03	9.18E-04	5.14E-04
May	$^{239/240}$Pu	5.03E-03	1.53E-03	6.07E-04
Jun	$^{239/240}$Pu	2.17E-03	1.03E-03	5.22E-04
Jul	$^{239/240}$Pu	1.60E-03	8.47E-04	5.74E-04
Aug	$^{239/240}$Pu	1.17E-03	7.51E-04	6.85E-04
Sep	$^{239/240}$Pu	1.00E-03	5.85E-04	5.44E-04
Oct	$^{239/240}$Pu	5.03E-04	5.00E-04	6.70E-04
Nov	$^{239/240}$Pu	1.82E-03	8.88E-04	6.03E-04
Dec	$^{239/240}$Pu	3.09E-03	1.17E-03	6.25E-04

Mo.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
Jan	^{90}Sr	-3.04E-03	1.97E-02	1.29E-02
Feb	^{90}Sr	-8.10E-02	3.37E-02	3.33E-02
Mar	^{90}Sr	-1.44E-02	1.85E-02	1.27E-02
Apr	^{90}Sr	2.26E-02	2.50E-02	2.14E-02
May	^{90}Sr	4.63E-03	2.19E-02	2.11E-02
Jun	^{90}Sr	1.73E-02	2.87E-02	2.17E-02
Jul	^{90}Sr	2.02E-04	2.43E-02	2.14E-02
Aug	^{90}Sr	-2.01E-02	2.84E-02	2.09E-02
Sep	^{90}Sr	1.48E-03	2.05E-02	1.59E-02
Oct	^{90}Sr	3.44E-03	2.54E-02	1.65E-02
Nov	^{90}Sr	-1.17E-02	2.41E-02	1.62E-02
Dec	^{90}Sr	2.68E-03	2.58E-02	1.85E-02

Qtr.	Nuclide	Activity[c] (Bq/Sample)	2σTPU[a]	MDC[b]
Jan	$^{233/234}$U	1.05E-03	7.47E-04	9.55E-04
Feb	$^{233/234}$U	7.92E-04	6.22E-04	9.25E-04
Mar	$^{233/234}$U	8.73E-04	6.29E-04	9.07E-04
Apr	$^{233/234}$U	6.92E-04	6.11E-04	1.18E-03
May	$^{233/234}$U	3.60E-04	5.03E-04	1.25E-03
Jun	$^{233/234}$U	1.11E-03	7.62E-04	1.15E-03
Jul	$^{233/234}$U	1.41E-03	1.13E-03	1.48E-03
Aug	$^{233/234}$U	3.39E-03	2.78E-03	2.31E-03
Sep	$^{233/234}$U	7.62E-04	8.95E-04	1.63E-03
Oct	$^{233/234}$U	1.05E-03	7.18E-04	1.41E-03
Nov	$^{233/234}$U	4.92E-04	4.88E-04	1.38E-03
Dec	$^{233/234}$U	8.25E-04	6.55E-04	1.43E-03

Qtr.	Nuclide	Activity[c] (Bq/Sample)	2σTPU[a]	MDC[b]
Jan	^{238}U	4.55E-04	4.96E-04	9.99E-04
Feb	^{238}U	6.59E-04	5.77E-04	9.66E-04
Mar	^{238}U	2.82E-04	4.03E-04	9.92E-04
Apr	^{238}U	3.47E-04	4.26E-04	7.92E-04
May	^{238}U	2.34E-04	4.11E-04	9.40E-04
Jun	^{238}U	3.43E-04	4.44E-04	8.10E-04
Jul	^{238}U	1.06E-03	9.58E-04	1.38E-03
Aug	^{238}U	1.40E-03	1.72E-03	2.20E-03
Sep	^{238}U	-1.06E-04	2.94E-04	1.43E-03
Oct	^{238}U	6.62E-04	5.92E-04	1.20E-03
Nov	^{238}U	4.81E-04	4.92E-04	1.18E-03
Dec	^{238}U	9.58E-04	6.92E-04	1.18E-03

Qtr.	Nuclide	Activity[c] (Bq/Sample)	2σTPU[a]	MDC[b]
Jan	^{137}Cs	3.42E-01	3.81E-01	4.48E-01
Feb	^{137}Cs	2.36E-01	4.26E-01	4.70E-01
Mar	^{137}Cs	4.59E-01	3.92E-01	4.55E-01
Apr	^{137}Cs	5.99E-02	3.92E-01	4.29E-01
May	^{137}Cs	1.39E-01	5.33E-01	6.29E-01
Jun	^{137}Cs	-1.32E-01	3.62E-01	4.11E-01
Jul	^{137}Cs	-6.22E-02	3.77E-01	4.33E-01
Aug	^{137}Cs	1.10E-01	4.51E-01	4.96E-01
Sep	^{137}Cs	-4.33E-02	3.06E-01	3.51E-01
Oct	^{137}Cs	3.56E-02	3.54E-01	4.11E-01
Nov	^{137}Cs	2.90E-02	3.55E-01	4.11E-01
Dec	^{137}Cs	-7.70E-03	2.76E-01	3.20E-01

(a) Total propagated uncertainty.
(b) Minimum detectable concentration.
(c) For negative values refer to DOE-HDBK-1216-2015v2

Table 4.3 – Station C CY 2017 Sample Results

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{241}Am	8.21E-04	7.96E-04	9.29E-04
2nd	^{241}Am	-2.47E-05	1.23E-04	7.51E-04
3rd	^{241}Am	-1.27E-04	2.75E-04	9.88E-04
4th	^{241}Am	-6.36E-05	1.69E-04	6.70E-04

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{238} Pu	-7.07E-05	1.75E-04	6.25E-04
2nd	^{238} Pu	1.84E-04	3.89E-04	6.62E-04
3rd	^{238} Pu	-5.92E-05	1.92E-04	7.29E-04
4th	^{238} Pu	2.56E-05	3.08E-04	8.40E-04

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	$^{239/240}$Pu	4.92E-04	5.25E-04	6.33E-04
2nd	$^{239/240}$Pu	8.81E-05	2.78E-04	6.40E-04
3rd	$^{239/240}$Pu	6.77E-05	3.96E-04	8.25E-04
4th	$^{239/240}$Pu	-5.11E-05	1.52E-04	6.36E-04

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{90}Sr	-5.44E-03	2.63E-02	1.35E-02
2nd	^{90}Sr	-5.33E-03	1.78E-02	1.61E-02
3rd	^{90}Sr	-9.29E-03	2.42E-02	2.17E-02
4th	^{90}Sr	1.36E-02	2.33E-02	1.61E-02

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	$^{233/234}$U	1.05E-03	7.40E-04	9.51E-04
2nd	$^{233/234}$U	7.33E-04	7.25E-04	1.30E-03
3rd	$^{233/234}$U	3.00E-03	1.72E-03	1.62E-03
4th	$^{233/234}$U	9.51E-04	6.62E-04	1.39E-03

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{238}U	6.77E-04	6.03E-04	9.84E-04
2nd	^{238}U	6.07E-04	6.33E-04	8.99E-04
3rd	^{238}U	1.33E-03	1.12E-03	1.42E-03
4th	^{238}U	4.18E-04	4.37E-04	1.15E-03

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{137}Cs	9.92E-02	4.33E-01	4.74E-01
2nd	^{137}Cs	1.99E-01	5.07E-01	5.96E-01
3rd	^{137}Cs	-7.18E-02	3.34E-01	3.81E-01
4th	^{137}Cs	-4.18E-02	4.18E-01	4.55E-01

(a) Total propagated uncertainty.
(b) Minimum detectable concentration.
(c) For negative values see DOE-HDBK-1216-2015v2

Radionuclides are considered detected in an effluent air sample if the measured activity is greater than the 2 σ TPU (two times the standard deviation considering the total of all propagated uncertainties). Radioanalytical results of air filter samples representing WIPP facility air emissions in CY 2017 are shown in Tables 4.2 and 4.3. The CAP88-PC radioactivity input criterion was to compare the 2 σ TPU with the activity value. The higher result of the two was selected for the nuclide data input for the CAP88–PC dataset report, ensuring a conservative bias to the dataset. The MDC, calculated before the analysis is performed, is an indicator of the expected analytical sensitivity for that test.

Evaluation of the 2017 filter sample results using the latest EPA-approved CAP88-PC code in effect during CY 2017, CAP88-PC Version 4.0.1.17 indicated that there were no detectable releases from the WIPP facility that resulted in a dose that exceeded 25 mrem to the whole body and 75 mrem to any critical organ in accordance with the provisions of 40 CFR §191.03(b). In addition, there were no detectable airborne releases from the WIPP facility that resulted in a dose that exceeded the 10 mrem per year limit, as specified in 40 CFR §61.92, and the 0.1 mrem per year limit for periodic confirmatory sampling required by 40 CFR §61.93(b)(4)(i).

4.2 Airborne Particulates

4.2.1 Sample Collection

Weekly airborne particulate samples were collected from seven locations on or near the WIPP site (Figure 4.1) using low-volume air samplers. Locations were selected based on the prevailing wind direction. A second set of low-volume samplers was co-located with each of the primary samplers following the radiation release event in 2014. The samples collected from these samplers are termed Event Evaluation samples. Event Evaluation samples would only be analyzed if there were detections in any samples from the seven primary sampling locations or in the case of a lost sample from the primary set of air samplers.

Two additional sets of Event Evaluation samplers were also installed. The first set was comprised of an inner ring of four on-site samplers that sampled the ambient air both inside and outside the property protection area. The locations were within several hundred meters of the property protection area fence and were selected to supplement the coverage provided by the primary samplers. The second set of low-volume Event Evaluation samplers was installed at or near six distant locations ranging from 10 to 50 mi from the WIPP site. If these samples were analyzed due to a detection at one of the primary sampling locations, the data from these locations could then be compared with the pre-operational baseline data.

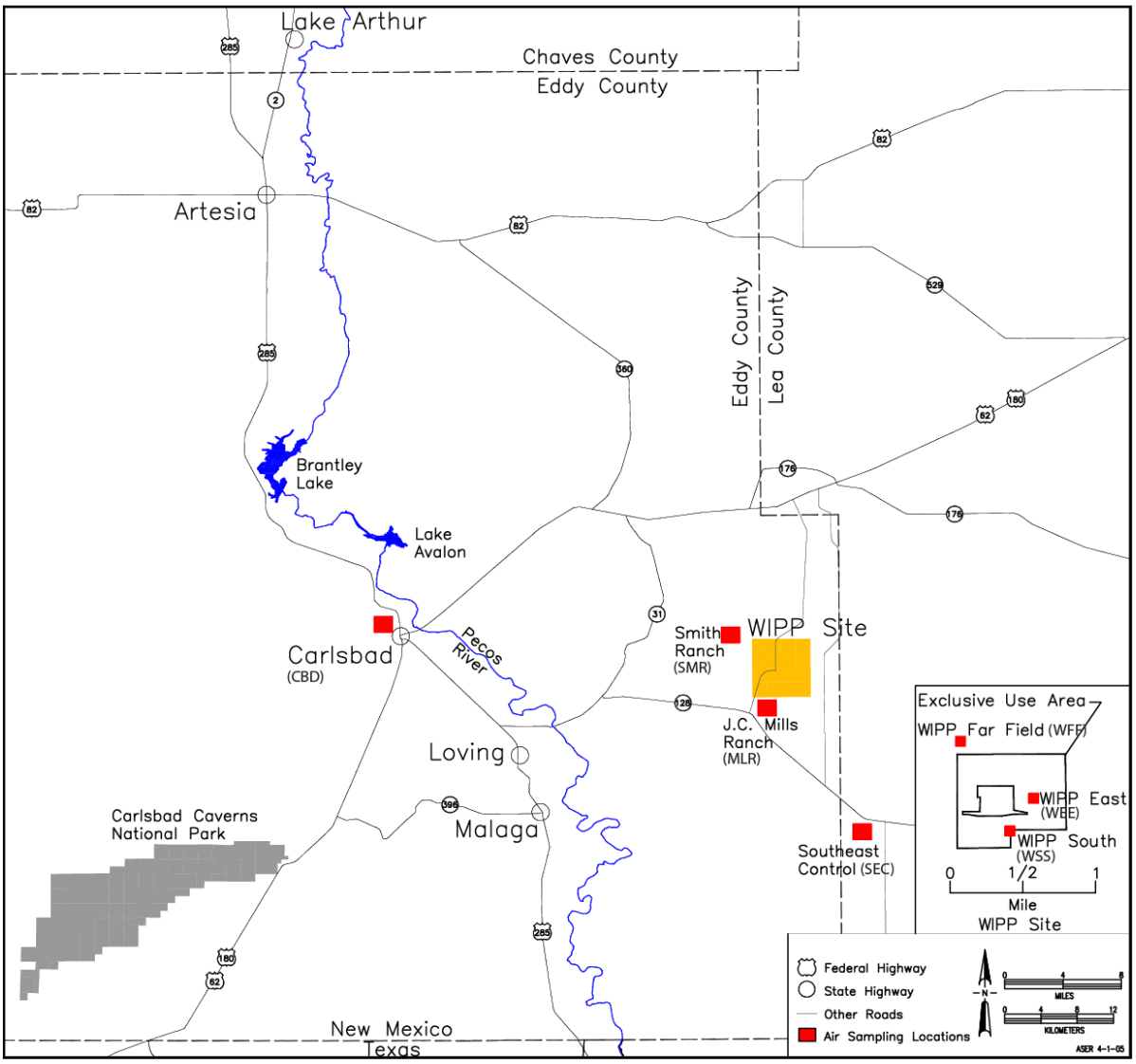

Figure 4.1 – Air Sampling Locations on and Near the WIPP Site

The Event Evaluation air sample filters collected in 2017 were archived and were available for analysis in the case of a suspected or actual release event, while primary samplers continued to integrate the sample at each location according to the normal schedule. No archived Event Evaluation samples had to be analyzed in 2017.

Airborne particulate sampling was thus performed at 17 locations using 24 samplers. The 17 sampling locations are illustrated in Figure 1 of DOE/WIPP-15-3547, *WIPP Environmental Radiological Field Sampling Analytical Summary February 2014 to February 2015*.

Location codes are shown in Appendix C. Each week at each sampling location, approximately 600 m^3 (21,187 ft^3) of air was sampled through a 4.7-centimeter (cm)

(1.85-inch [in.]) diameter glass microfiber filter using a continuous low-volume air sampler.

4.2.2 Sample Preparation

Weekly air filter particulate samples were analyzed for gross alpha and beta using a gas flow proportional counter and then composited for each quarter. The composite samples were transferred into a borosilicate beaker and spiked with tracers including ^{232}U, ^{243}Am, ^{242}Pu, and Sodium (^{22}Na) (a tracer for the gamma isotopes). A stable strontium carrier was added to determine the recovery of ^{90}Sr. The samples were heated in a muffle furnace at 250°C (482°F) for two hours, followed by heating for two hours at 375°C (707°F), and heating for six hours at 525°C (977°F).

The filters were wet-ashed and cooled, and then transferred into polytetrafluoroethylene beakers by rinsing with concentrated nitric acid. The mixture was then heated with concentrated hydrofluoric acid until completely dissolved. Most of the hydrofluoric acid was removed by evaporation to dryness.

Approximately 25 mL of concentrated nitric acid and 1 gram of boric acid were added to buffer the remaining hydrogen fluoride. The boric acid step was followed by digestion in aqua regia (one part nitric acid, three parts hydrochloric acid) to neutralize and reduce boric acid.

4.2.3 Determination of Individual Radionuclides

The acid digestates of the filter composite samples were split into two fractions using Class A pipettes and volumetric flasks. One-half of each sample was brought to 500 mL in a Marinelli beaker for gamma analysis of ^{40}K, ^{60}Co, and ^{137}Cs. The other fraction was transferred to a glass beaker and taken to dryness. The residue was dissolved in 6M nitric acid (where M = molarity), and then 2M aluminum nitrate solution was added. The oxidation states of the target radionuclides (uranium/transuranic radioisotopes) were adjusted with various reagents, and the radiochemical separations were performed using stacked resin cartridges and elution with various reagent solutions.

The alpha emitters were microprecipitated with neodymium trifluoride and mounted onto 0.1-micron porosity commercial radionuclide chromatographic separation resin filters on planchets for analysis by alpha spectroscopy for the uranium/transuranic isotopes. The strontium was eluted from the strontium resin with nitric acid solutions and precipitated as strontium carbonate to determine the recovery gravimetrically. The ^{90}Sr was then analyzed by gas proportional counting.

4.2.4 Results and Discussion

The data and discussion for 2017 only include the quarterly air filter composite samples, typically reported in the ASER. None of the archived Event Evaluation samples, which served as backup samples, were analyzed and reported.

Most of the data generated following the radiation release were initially reported as disintegrations per minute at the request of the WIPP Response Team following the event. The quarterly composite sample data are reported in units of becquerels per composite air filter sample (Bq/sample) by the laboratory. The Bq/sample data was also divided by the total volume of air sampled to yield becquerels per cubic meter (Bq/m^3). Both sets of data are provided in Appendix G.

Appendix G, Table G.1 contains the results for the standard quarterly air filter composite samples. Blank filter composite samples were prepared and analyzed, and results were reported separately for each quarter. The average concentrations of the quarterly composite samples are reported for those locations where the regular quality control duplicate samples were collected using low-volume air samplers. A "Q" (qualifier) column is included in the data tables in Table G.1 of Appendix G to show whether the radionuclide was detected (i.e., whether the activity of the radionuclide is greater than the 2 σ TPU and MDC). The ID confidence was also provided for gamma analyses. If the ID confidence is greater than or equal to 0.90 and the activity of the sample is greater than 2 σ TPU and MDC, the gamma radionuclide (^{40}K, ^{60}Co, ^{137}Cs) is detected. Table G.2 in Appendix G shows the Bq/sample from Table G.1 converted to Bq/m^3 by dividing the sample activity in Bq by the total quarterly air volumes sampled.

Table G.1 shows no detections of any of the target radionuclides in the four quarterly composite samples from each of the seven locations in 2017. The most frequent radionuclide detections in previous air filter composite samples were some of the uranium isotopes; however, no uranium isotopes were detected in any of the samples in 2017. Detection of the uranium isotopes generally depended on the amount of dust collected on the filters. More dust is collected during dry, windy years, and 2017, like 2016 and 2015, was wetter than recent years with no uranium isotopes detected. Pu-239/240 has occasionally been detected in the air filter composite samples, but there was only one detection in 2015 and no detections in 2016 and 2017.

Since there were no detections of any radionuclides in the 2017 air filter composite samples, no ANOVA comparisons were performed between years or between locations.

Although there were no detections in 2017, Table 4.4 shows the combined mean, minimum, and maximum measured activities in the air filter composite samples in units of Bq/sample along with the location and sampling quarter for the minimum and maximum activities. The row of mean values is the average of all the sample activities, 2 σ TPUs, and MDCs (seven sample locations times four quarters), while the minimum and maximum reported activities for each radionuclide are selected from all the sample activities, and the associated 2 σ TPU and MDC were inherited with that specific radionuclide concentration. Since there were no detections, the data in Table 4.4 are of limited value, but are reported annually to provide an indication of the measured activities.

Table 4.4 – 2017 Round 39 Precision Results for Field Duplicate Groundwater Sample Analyses

Radionuclide		[RN][a]	2 σ TPU[b]	MDC[c]	Location	Quarter	Qualifier[d]
$^{233/234}U$	Mean [e]	3.22E-03	5.28E-03	1.06E-02	NA [f]	NA [f]	NA [f]
	Minimum [g]	-2.12E-03	1.28E-02	1.17E-02	SEC	3	U
	Maximum [g]	8.72E-03	3.93E-03	1.02E-02	CBD	4	U
^{235}U	Mean	1.74E-04	3.23E-03	1.94E-03	NA	NA	NA
	Minimum	-2.31E-03	1.51E-02	4.46E-03	SEC	3	U
	Maximum	1.40E-03	1.68E-02	5.27E-03	MLR	3	U
^{238}U	Mean	4.03E-03	4.30E-03	1.00E-02	NA	NA	NA
	Minimum	-5.72E-04	5.47E-03	1.23E-02	MLR	3	U
	Maximum	8.49E-03	4.51E-03	9.64E-03	CBD	2	U
^{238}Pu	Mean	-2.31E-05	3.69E-04	8.16E-04	NA	NA	NA
	Minimum	-2.02E-04	3.07E-04	8.00E-04	WEE	2	U
	Maximum	2.98E-04	6.93E-04	1.02E-03	SEC	4	U
$^{239/240}Pu$	Mean	9.14E-05	4.35E-04	9.57E-04	NA	NA	NA
	Minimum	-1.54E-04	4.75E-04	9.28E-04	WSS	1	U
	Maximum	5.15E-04	5.67E-04	9.42E-04	SMR	4	U
^{241}Am	Mean	2.72E-05	5.56E-04	1.11E-03	NA	NA	NA
	Minimum	-3.15E-04	4.76E-04	1.02E-03	WFF	1	U
	Maximum	3.95E-04	7.96E-04	1.10E-03	SMR	1	U
^{40}K	Mean	4.76E+00	8.19E+00	9.73E+00	NA	NA	NA
	Minimum	-8.46E-01	8.11E+00	9.13E+00	SEC	4	U
	Maximum	1.24E+01	9.13E+00	1.24E+01	CBD	1	U
^{60}Co	Mean	2.52E-01	8.39E-01	9.86E-01	NA	NA	NA
	Minimum	-4.99E-01	8.41E-01	8.76E-01	SMR	4	U
	Maximum	8.35E-01	7.30E-01	9.18E-01	WFF	1	U
^{137}Cs	Mean	-2.62E-01	8.31E-01	9.16E-01	NA	NA	NA
	Minimum	-2.75E+00	8.56E-01	9.20E-01	WEE	1	U
	Maximum	8.46E-01	1.12E+00	1.40E+00	MLR	1	U
^{90}Sr	Mean	4.86E-04	2.34E-02	3.05E-02	NA	NA	NA
	Minimum	-1.71E-02	2.80E-02	3.11E-02	SEC	4	U
	Maximum	1.40E-02	2.13E-02	3.05E-02	CBD	3	U

Radionuclide	[RN][a]	2 σ TPU[b]	MDC[c]	Location	Quarter	Qualifier[d]

Notes:

NA = Not applicable.

(a) Radionuclide concentration. Values taken from 7 locations and 4 quarterly composite samples as shown in Appendix G, Table G.1. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty at the 2 σ level.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

(e) Arithmetic average for concentration, 2 σ TPU, and MDC.

(f) Not Applicable. The mean is based on averaging the activities of the quarterly composite samples from all the 7 sampling locations.

(g) Minimum and maximum reported concentrations for each radionuclide are based on the [RN], while the associated 2 σ TPU and MDC were inherited with that specific [RN].

The precision, as a measure of quality, of the combined sampling and analysis steps for the air filter composite samples was determined by collecting field duplicate samples at one location each quarter. During 2017, field duplicate samples were taken from location WSS during the first quarter, location MLR during the second quarter, location SEC during the third quarter, and location CBD during the fourth quarter. Table 4.5 presents the precision data for all the field duplicate air filter composite samples. The precision, as relative error ratio (RER), is reported for all the radionuclides in the air filter composite samples whether the radionuclide was detected in the samples or not.

Table 4.5 –Precision as Relative Error Ratio of 2017 Duplicate Air Filter Composite Samples

Qtr	Location	Isotope	Sample 1		Sample 2		RER[c]
			[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]	
1	WSS	$^{233/234}$U	3.85E-03	1.90E-03	4.07E-03	1.92E-03	0.081
1	WSS	^{235}U	6.34E-04	5.15E-04	8.52E-04	5.17E-04	0.299
1	WSS	^{238}U	3.68E-03	1.56E-03	5.45E-03	1.67E-03	0.775
1	WSS	^{238}Pu	1.65E-04	2.27E-04	-1.44E-04	2.06E-04	1.008
1	WSS	$^{239/240}$Pu	-1.29E-04	2.30E-04	-1.78E-04	2.54E-04	0.143
1	WSS	^{241}Am	-1.13E-04	3.23E-04	-3.32E-04	2.53E-04	0.534
1	WSS	^{40}K	6.71E+00	3.75E+00	1.17E+01	4.19E+00	0.887
1	WSS	^{60}Co	3.32E-01	3.69E-01	9.44E-02	4.28E-01	0.420
1	WSS	^{137}Cs	-1.21E-01	4.43E-01	3.27E-01	3.81E-01	0.767
1	WSS	^{90}Sr	-4.69E-03	1.16E-02	-6.99E-03	1.07E-02	0.146

Qtr	Location	Isotope	Sample 1		Sample 2		RER[(c)]
			[RN][(a)]	1 σ TPU[(b)]	[RN][(a)]	1 σ TPU[(b)]	
2	MLR	$^{233/234}U$	3.88E-03	2.18E-03	3.80E-03	2.19E-03	0.026
2	MLR	^{235}U	7.31E-04	5.04E-04	-1.33E-04	3.08E-04	1.463
2	MLR	^{238}U	6.34E-03	2.03E-03	5.21E-03	1.98E-03	0.398
2	MLR	^{238}Pu	-2.04E-04	1.58E-04	-1.34E-04	8.65E-05	0.389
2	MLR	$^{239/240}Pu$	2.99E-04	2.44E-04	-1.38E-04	1.55E-04	1.512
2	MLR	^{241}Am	-1.27E-04	1.72E-04	1.36E-04	2.48E-04	0.871
2	MLR	^{40}K	7.73E+00	4.05E+00	5.44E+00	5.49E+00	0.336
2	MLR	^{60}Co	4.35E-01	3.67E-01	-5.73E-01	6.39E-01	1.368
2	MLR	^{137}Cs	-5.67E-03	3.90E-01	-7.64E-01	6.80E-01	0.967
2	MLR	^{90}Sr	9.24E-03	1.25E-02	-8.66E-03	1.17E-02	1.045
Qtr	Location	Isotope	Sample 1		Sample 2[(d)]		RER[(c)]
			[RN][(a)]	1 σ TPU[(b)]	[RN][(a)]	1 σ TPU[(b)]	
3	SEC	$^{233/234}U$	-2.39E-03	6.37E-03	-1.85E-03	6.70E-03	0.058
3	SEC	^{235}U	-3.25E-03	7.49E-03	-1.36E-03	7.85E-03	0.174
3	SEC	^{238}U	-1.47E-04	2.79E-03	7.27E-04	2.61E-03	0.229
3	SEC	^{238}Pu	-1.03E-04	1.26E-04	-7.42E-06	1.96E-04	0.410
3	SEC	$^{239/240}Pu$	2.13E-04	2.77E-04	2.72E-04	2.86E-04	0.148
3	SEC	^{241}Am	2.49E-04	3.25E-04	2.12E-05	3.11E-04	0.506
3	SEC	^{40}K	-3.63E-01	4.85E+00	2.49E+00	3.78E+00	0.464
3	SEC	^{60}Co	3.64E-01	5.17E-01	-3.40E-01	4.08E-01	1.069
3	SEC	^{137}Cs	-2.93E-01	5.39E-01	2.91E-01	3.35E-01	0.920
3	SEC	^{90}Sr	3.42E-03	1.04E-02	7.66E-03	1.10E-02	0.280
Qtr	Location	Isotope	Sample 1		Sample 2		RER[(c)]
			[RN][(a)]	1 σ TPU[(b)]	[RN][(a)]	1 σ TPU[(b)]	
4	CBD	$^{233/234}U$	8.49E-03	2.01E-03	8.94E-03	1.99E-03	0.159
4	CBD	^{235}U	2.37E-04	3.67E-04	1.93E-04	3.57E-04	0.086
4	CBD	^{238}U	5.69E-03	2.06E-03	5.94E-03	2.03E-03	0.086
4	CBD	^{238}Pu	-1.46E-04	1.71E-04	1.02E-05	2.79E-04	0.477
4	CBD	$^{239/240}Pu$	2.01E-04	2.53E-04	-5.06E-05	9.79E-05	0.927
4	CBD	^{241}Am	-7.76E-06	4.54E-04	-1.48E-04	3.95E-04	0.233
4	CBD	^{40}K	1.38E+01	5.67E+00	-3.11E+00	5.27E+00	2.184
4	CBD	^{60}Co	-8.65E-01	7.09E-01	4.34E-01	4.57E-01	1.540
4	CBD	^{137}Cs	-2.18E-01	6.04E-01	8.17E-03	4.79E-01	0.293
4	CBD	^{90}Sr	2.19E-02	1.61E-02	-1.29E-03	1.39E-02	1.090

Notes: See Appendix C for sampling location codes. Units are Bq/sample.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty.

(c) Relative error ratio.

There is no firmly established QA objective for the precision of field duplicates, since the composition of field samples could be slightly different. One source (*Rocky Flats Annual Report of Site Surveillance and Maintenance Activities—CY 2008*, Doc. No. S05247, U.S. Department of Energy, 2009) suggested that 85 percent of field duplicate samples should yield RERs less than 1.96. This objective was readily met for the air particulate samples discussed above with only one RER greater than 1.96. The RER was for ^{40}K in the fourth quarter CBD duplicates where the activity for the duplicate sample was negative. Field duplicate RERs less than 2 indicate good precision for the combined sampling and laboratory analysis procedures.

The laboratory generates and analyzes lab duplicate samples from a single field sample for matrices other than air filter composite samples where enough of the sample is available for an additional sample analysis. In the case of laboratory duplicates for the WIPP environmental analysis program, the QA objective for laboratory duplicate precision is a RER of less than 2. The laboratory-generated precision data are calculated for all the radionuclides in a sample whether the radionuclides were detected or not, based on the activities compared to the 1 σ TPUs and MDCs measured in the samples. The laboratory duplicate sample RERs are provided in the laboratory data packages, although they are not provided in the ASER. Greater than 99 percent of laboratory RERs from analysis of WIPP environmental samples during 2017 were less than 2.

Field duplicate RERs are calculated during data verification and validation from the data in the laboratory data packages and are provided for all the sample matrices in this chapter of the ASER. Individual cases where the RER did not meet the objective of less than 1.96 are discussed in Chapter 7, Quality Assurance.

4.3 Groundwater

4.3.1 Sample Collection

Groundwater samples were collected once in 2017 (Round 39) from each of six different detection monitoring wells on the WIPP site, as shown in Figure 6.3 in Section 6.2.3. The wells were completed in the Culebra Dolomite Member (Culebra), which is a water-bearing member of the Rustler Formation (Rustler). The groundwater from the detection monitoring wells was collected from depths ranging from 180 to 270 m (591 to 886 ft) from the six wells (WQSP-1 to WQSP-6). Each well was purged and the field parameters, including pH (measure of the acidity or alkalinity of an aqueous sample) conductivity, and temperature, were measured in an on-site mobile laboratory, in a

continuous flow-cell sampling system. Specific gravity was also measured using a classical hydrometer technique. Field parameters were measured until individual values for each parameter were within five percent of each other for three consecutive measurements, or until no more than three well bore volumes had been purged, whichever occurred first. At this point, the detection monitoring well was considered stable (i.e., the sampled water was representative of the groundwater found in the formation) and was analyzed for hazardous constituents (volatile and semivolatile organics and metals), general chemistry parameters, and radionuclides.

Approximately 23 liters (L) of groundwater were collected from a continuous sample stream during each of the six sampling episodes. Each chemical or radiological profile required a primary sample and a duplicate sample collected for analysis. Approximately 8 L of water from each well was sent to the laboratory for measurement of the target radionuclides. The remaining sample portions (15 L each) were used for the non-radiological analyses or were placed in storage as backup samples. The radionuclide samples were filtered during collection and acidified to pH less than or equal to 2 with concentrated nitric acid.

4.3.2 Sample Preparation

The acidified groundwater sample containers were shaken to distribute any suspended material evenly, and sample aliquots were measured into glass beakers. The first 0.5-L portion was used directly for gamma spectroscopy analysis, and the second 0.5-L portion was used for uranium, TRU target isotopes and ^{90}Sr. Tracers (^{232}U, ^{243}Am, and ^{242}Pu) and a carrier (strontium nitrate) were added to the second portion, and the samples were digested using concentrated nitric acid and hydrofluoric acid. The samples were then heated to dryness and wet-ashed using concentrated nitric acid and hydrogen peroxide. Finally, the samples were heated to dryness, taken up in nitric acid solution, and processed to separate the various isotopes.

4.3.3 Determination of Individual Radionuclides

The first portion of the water sample was used directly for the measurement of the gamma-emitting radionuclides ^{40}K, ^{60}Co, and ^{137}Cs by gamma spectroscopy. The second 0.5-L portion of the water sample was used for the sequential separation of the uranium isotopes, the transuranics, and ^{90}Sr. The digested samples described in Section 4.3.2 were prepared for counting by co-precipitating the target isotopes and corresponding tracers with an iron carrier, performing ion exchange and chromatographic separations of the individual radionuclides as described in Section 4.2.3, and micro-precipitating the separated radionuclides onto planchets for counting the uranium/transuranic isotopes by alpha spectroscopy and ^{90}Sr by gas proportional counting.

4.3.4 Results and Discussion

Isotopes of naturally occurring uranium ($^{233/234}$U, ^{235}U, and ^{238}U) were detected in all the groundwater well samples in 2017, as shown by the data in Table 4.6. The sample collection dates are also shown in the table. The concentrations reported in Table 4.6 are from the primary samples collected from each WQSP well. The data from the duplicate groundwater samples is presented in Table 4.7, where the precision of the groundwater sample analyses is reported.

The 2017 uranium groundwater concentrations in the detection monitoring wells were compared with the concentrations from the same locations in 2016 using ANOVA. The ANOVA calculations were performed using the Round 39 average uranium sample concentrations from 2017 and the average uranium concentrations from Round 38 in 2016.

The concentrations of the uranium isotopes measured in 2017 did not vary significantly from the concentrations measured in the same wells in 2016, as demonstrated by the combined ANOVA results of the wells, with all the *p* values well above the significance level of 0.05 (ANOVA $^{233/234}$U, $p = 0.966$; ANOVA ^{235}U, $p = 0.199$; and ANOVA ^{238}U, $p = 0.995$). The *p* value for ^{235}U was lower than for the other two uranium isotopes, but still above the 0.05 significance level. The lower *p* value is likely due to the much lower concentrations of ^{235}U.

Table 4.6 – 2017 Round 39 Radionuclide Concentrations in Primary Groundwater from Detection Monitoring Program Wells at the WIPP Site

Location	Round	Sample Date	$^{233/234}$U				^{235}U				^{238}U			
			[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
WQSP-1	39	3/7/17	1.24E+00	1.87E-01	9.84E-04	+	1.17E-02	3.12E-03	7.11E-04	+	2.12E-01	3.31E-02	8.53E-04	+
WQSP-2	39	3/21/17	1.15E+00	1.61E-01	9.52E-04	+	1.50E-02	3.61E-03	7.16E-04	+	1.75E-01	2.59E-02	9.28E-04	+
WQSP-3	39	4/18/17	1.82E-01	4.22E-02	3.59E-03	+	1.06E-02	6.66E-03	3.48E-03	+	3.09E-02	1.15E-02	3.85E-03	+
WQSP-4	39	4/26/17	5.52E-01	9.49E-02	2.76E-03	+	6.89E-03	4.73E-03	3.03E-03	+	1.20E-01	2.56E-02	3.09E-03	+
WQSP-5	39	5/9/17	4.81E-01	7.34E-02	8.35E-04	+	7.38E-03	2.11E-03	6.27E-04	+	6.02E-02	1.01E-02	9.73E-04	+
WQSP-6	39	5/16/17	3.44E-01	5.38E-02	8.56E-04	+	4.79E-03	1.62E-03	6.26E-04	+	4.48E-02	7.92E-03	1.12E-03	+
Location	Round	Sample Date	^{238}Pu				$^{239/240}$Pu				^{241}Am			
			[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
WQSP-1	39	3/7/17	1.15E-04	2.26E-04	5.24E-04	U	-1.65E-05	8.55E-05	5.88E-04	U	8.08E-05	2.36E-04	5.83E-04	U
WQSP-2	39	3/21/17	1.11E-04	2.18E-04	5.03E-04	U	6.36E-05	2.61E-04	6.60E-04	U	-3.46E-05	1.22E-04	7.04E-04	U
WQSP-3	39	4/18/17	3.17E-04	1.52E-03	3.20E-03	U	-1.90E-04	6.80E-04	2.76E-03	U	6.47E-04	1.27E-03	2.03E-03	U
WQSP-4	39	4/26/17	1.04E-03	2.43E-03	4.04E-03	U	-2.40E-04	7.44E-04	2.90E-03	U	5.71E-04	1.33E-03	2.49E-03	U
WQSP-5	39	5/9/17	7.19E-05	2.44E-04	5.52E-04	U	1.44E-04	3.45E-04	5.97E-04	U	-7.06E-05	1.83E-04	9.02E-04	U
WQSP-6	39	5/16/17	2.18E-04	4.13E-04	7.05E-04	U	1.06E-04	2.08E-04	5.24E-04	U	-1.36E-04	2.58E-04	9.19E-04	U

Location	Round	Sample Date	^{40}K					^{60}Co				
			[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf.[e]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf.[e]	Q[d]
WQSP-1	39	3/7/17	2.88E+01	1.42E+01	2.25E+01	0.00	U	-4.19E-01	1.38E+00	1.56E+00	0.00	U
WQSP-2	39	3/21/17	1.54E+01	4.16E+00	4.26E+00	1.00	+	-7.92E-02	3.34E-01	3.78E-01	0.00	U
WQSP-3	39	4/18/17	4.41E+01	7.83E+00	4.64E+00	0.998	+	-1.06E-01	4.19E-01	4.63E-01	0.00	U
WQSP-4	39	4/26/17	2.69E+01	5.55E+00	4.19E+00	0.998	+	6.34E-01	3.31E-01	4.88E-01	0.00	U
WQSP-5	39	5/9/17	1.23E+01	3.52E+00	3.57E+00	1.00	+	6.81E-02	3.38E-01	4.07E-01	0.00	U
WQSP-6	39	5/16/17	2.47E+00	1.38E+00	1.89E+00	0.999	+	9.00E-04	1.77E-01	2.06E-01	0.00	U

Location	Round	Sample Date	^{137}Cs					^{90}Sr			
			[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf.[e]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
WQSP-1	39	3/7/17	2.56E-01	1.16E+00	1.44E+00	0.00	U	-1.59E-03	2.16E-02	1.39E-02	U
WQSP-2	39	3/21/17	-2.14E-02	3.48E-01	4.03E-01	0.00	U	-7.07E-03	2.17E-02	1.38E-02	U
WQSP-3	39	4/18/17	1.57E-01	3.25E-01	4.07E-01	0.00	U	4.06E-03	1.91E-02	1.21E-02	U
WQSP-4	39	4/26/17	3.54E-01	3.41E-01	4.42E-01	0.00	U	1.14E-02	1.78E-02	1.20E-02	U
WQSP-5	39	5/9/17	2.60E-01	3.41E-01	4.16E-01	0.00	U	-1.54E-03	1.80E-02	1.22E-02	U
WQSP-6	39	5/16/17	-4.25E-02	1.60E-01	1.84E-01	0.00	U	5.44E-03	2.74E-02	1.33E-02	U

Notes: Units are becquerels per liter (Bq/L). See Appendix C for sampling location codes.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated Uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

(e) Identification Confidence for Gamma Radionuclides. Value >0.90 implies detection if the sample activity is greater than 2 σ TPU and MDC.

Table 4.7 – 2017 Round 39 Precision Results for Field Duplicate Groundwater Sample Analyses

Location	Radionuclide	Primary Sample (Bq/L)		Duplicate Sample (Bq/L)		RER[c]	Q[d]
		[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]		
WQSP-1	$^{233/234}$U	1.24E+00	9.56E-02	1.26E+00	9.79E-02	0.146	+
	^{235}U	1.17E-02	1.59E-03	1.68E-02	2.06E-03	1.960	+
	^{238}U	2.12E-01	1.69E-02	2.09E-01	1.69E-02	0.126	+
	^{238}Pu	1.15E-04	1.15E-04	2.02E-04	1.60E-04	0.442	U
	$^{239/240}$Pu	-1.65E-05	4.36E-05	1.93E-04	1.63E-04	1.242	U
	^{241}Am	8.08E-05	1.20E-04	-3.73E-05	6.46E-05	0.867	U
	^{40}K	2.88E+01	7.24E+00	1.33E+01	4.18E+00	1.854	U/+ [e]
	^{60}Co	-4.19E-01	7.04E-01	3.40E-01	4.21E-01	0.925	U
	^{137}Cs	2.56E-01	5.92E-01	-3.06E-01	4.32E-01	0.767	U
	^{90}Sr	-1.59E-03	1.10E-02	8.65E-03	1.08E-02	0.664	U
WQSP-2	$^{233/234}$U	1.15E+00	8.23E-02	1.37E+00	1.12E-01	1.583	+
	^{235}U	1.50E-02	1.84E-03	1.33E-02	1.84E-03	0.653	+
	^{238}U	1.75E-01	1.32E-03	2.04E-01	1.74E-02	1.328	+
	^{238}Pu	1.11E-04	1.11E-04	8.44E-06	1.52E-04	0.545	U
	$^{239/240}$Pu	6.36E-05	1.33E-04	3.38E-05	1.43E-04	0.153	U
	^{241}Am	-3.46E-05	6.24E-05	-1.65E-05	4.20E-05	0.241	U
	^{40}K	1.54E+01	2.12E+00	1.27E+01	1.95E+00	0.937	+
	^{60}Co	-7.92E-02	1.70E-01	5.77E-02	1.64E-01	0.580	U
	^{137}Cs	-2.14E-02	1.78E-01	-1.00E-01	1.70E-01	0.319	U
	^{90}Sr	-7.07E-03	1.11E-02	-2.86E-02	1.51E-02	1.149	U
WQSP-3	$^{233/234}$U	1.82E-01	2.15E-02	2.15E-01	2.74E-02	0.948	+
	^{235}U	1.06E-02	3.40E-03	2.80E-03	2.01E-03	1.975	+
	^{238}U	3.09E-02	5.85E-03	4.14E-02	7.58E-03	1.097	+
	^{238}Pu	3.17E-04	7.76E-04	-2.77E-04	4.08E-04	0.678	U
	$^{239/240}$Pu	-1.90E-04	3.47E-04	4.15E-04	6.86E-04	0.787	U
	^{241}Am	6.47E-04	6.47E-04	6.72E-04	1.26E-03	0.018	U
	^{40}K	4.41E+01	3.99E+00	3.93E+01	7.19E+00	0.584	+
	^{60}Co	-1.06E-01	2.14E-01	-1.01E+00	8.42E-01	1.041	U
	^{137}Cs	1.57E-01	1.66E-01	8.91E-02	5.97E-01	0.110	U
	^{90}Sr	4.06E-03	9.74E-03	1.01E-02	9.37E-03	0.447	U

Location	Radionuclide	Primary Sample (Bq/L)		Duplicate Sample (Bq/L)		RER[c]	Q[d]
		[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]		
WQSP-4	$^{233/234}U$	5.52E-01	4.84E-02	4.65E-01	3.87E-02	1.404	+
	^{235}U	6.89E-03	2.41E-03	1.14E-02	3.13E-03	1.142	+
	^{238}U	1.20E-01	1.31E-02	8.16E-02	9.39E-03	2.382	+
	^{238}Pu	1.04E-03	1.24E-03	-6.72E-04	6.31E-04	1.230	U
	$^{239/240}Pu$	-2.40E-04	3.79E-04	7.91E-04	9.68E-04	0.992	U
	^{241}Am	5.71E-04	6.77E-04	-2.00E-04	3.87E-04	0.989	U
	^{40}K	2.69E+01	2.83E+00	2.46E+01	2.65E+00	0.593	+
	^{60}Co	6.34E-01	1.69E-01	1.21E-01	1.65E-01	2.172	U
	^{137}Cs	3.54E-01	1.74E-01	6.40E-02	1.94E-01	1.113	U
	^{90}Sr	1.14E-02	9.09E-03	1.71E-02	9.07E-03	0.046	U
WQSP-5	$^{233/234}U$	4.81E-01	3.74E-02	5.33E-01	4.75E-02	0.860	+
	^{235}U	7.38E-03	1.08E-03	9.34E-03	1.37E-03	1.124	+
	^{238}U	6.02E-02	5.17E-03	7.32E-02	7.00E-03	1.494	+
	^{238}Pu	7.19E-05	1.24E-04	1.47E-04	1.80E-04	0.344	U
	$^{239/240}Pu$	1.44E-04	1.76E-04	7.34E-05	2.01E-04	0.264	U
	^{241}Am	-7.06E-05	9.34E-05	0.00E+00	1.93E-04	0.329	U
	^{40}K	1.23E+01	1.80E+00	1.41E+01	4.30E+00	0.386	+
	^{60}Co	6.81E-02	1.72E-01	-4.64E-01	4.98E-01	1.010	U
	^{137}Cs	2.60E-01	1.74E-01	2.20E-01	4.63E-01	0.081	U
	^{90}Sr	-1.54E-03	9.18E-03	8.68E-03	1.41E-02	0.607	U
WQSP-6	$^{233/234}U$	3.44E-01	2.74E-02	3.37E-01	2.70E-02	0.182	+
	^{235}U	4.79E-03	8.27E-04	8.35E-03	1.20E-03	2.443	+
	^{238}U	4.48E-02	4.04E-03	4.22E-02	3.86E-03	0.465	+
	^{238}Pu	2.18E-04	2.11E-04	8.01E-05	1.39E-04	0.546	U
	$^{239/240}Pu$	1.06E-04	1.06E-04	4.00E-05	1.55E-04	0.351	U
	^{241}Am	-1.36E-04	1.32E-04	4.28E-05	1.54E-04	0.882	U
	^{40}K	2.47E+00	7.04E-01	3.45E+00	1.20E+00	0.704	+
	^{60}Co	9.00E-04	9.03E-02	8.90E-02	1.56E-01	0.489	U
	^{137}Cs	-4.25E-02	8.16E-02	-1.23E-01	1.76E-01	0.415	U
	^{90}Sr	5.44E-03	1.40E-02	-5.62E-03	1.17E-02	0.606	U

Location	Radionuclide	Primary Sample (Bq/L)		Duplicate Sample (Bq/L)		RER[c]	Q[d]
		[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]		

Notes: See Figure 6.3 for Sampling Locations.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty.

(c) Relative error ratio.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

(e) ^{40}K detected in the primary sample but not the duplicate sample.

The average concentrations of the uranium isotopes measured in the groundwater samples in 2017 were also compared to the 2016 concentrations by location. There was significant variation by location between the wells sampled in 2017 and 2016, as demonstrated by the ANOVA results (ANOVA $^{233/234}$U, p = 3. 97E-08; ANOVA ^{235}U, p = 3.21E-02; and ANOVA ^{238}U, p = 4.90E-08). In the case of uranium isotope ANOVA calculations by location, the $^{233/234}$U and ^{238}U p values are much less than 0.05, while the ^{235}U p value is less than 0.05 but much closer to 0.05 than the other two values. The large differences in uranium isotope concentrations at the different locations are likely due to the differences in the abundance of these naturally occurring isotopes in the sedimentary rocks deposited in the area and the associated variable dissolution of the uranium isotopes into the groundwater.

Concentrations of uranium isotopes in the primary groundwater samples were also compared with the 99 percent confidence interval range of the baseline concentrations measured between 1985 and 1989 (baseline values: $^{233/234}$U = 1.30E+00 Bq/L, ^{235}U = 3.10E–02 Bq/L, and ^{238}U = 3.20E–01 Bq/L). The highest Round 39 concentration of $^{233/234}$U of 1.37E+00 Bq/L in the duplicate sample at WQSP-2 was slightly higher than the 99 percent confidence interval range of the baseline concentration of 1.30E+00 Bq/L. The highest concentration of ^{235}U of 1.68E-02 Bq/L in the duplicate sample at WQSP-1 was lower than the 99 percent confidence interval range of the baseline concentration of 3.10E-02 Bq/L. The highest concentration of ^{238}U of 2.12E-01 Bq/L in the primary sample at WQSP-1 was also lower than the 99 percent confidence interval range of the baseline concentration of 3.20E-01 Bq/L. The other individual and average $^{233/234}$U, ^{235}U, and ^{238}U groundwater concentrations were well within the 99 percent confidence interval ranges of the baseline concentrations (DOE/WIPP-98-2285).

The groundwater samples were also analyzed using TRU alpha spectroscopy, for the following radionuclides: ^{238}Pu, $^{239/240}$Pu, and ^{241}Am (Table 4.6). These isotopes, which are related to WIPP waste disposal operations, were not detected in any of the groundwater samples, so no ANOVA comparisons between years or among locations could be performed.

Table 4.6 also shows the concentration of the gamma radionuclides and ^{90}Sr. The ID confidences have been included for the gamma analyses. The potassium isotope ^{40}K

was detected in the primary samples of all six wells in 2017 except for WQSP-1. The sample activity was greater than the 2 sigma TPU and MDC, but the ID confidence was 0.00. However, ^{40}K was detected in the duplicate groundwater sample of WQSP-1, and the duplicate concentration was used in the ANOVA calculations. The average concentrations of the primary and duplicate samples were used for WQSP-2 through WQSP-6. Duplicate groundwater sample results are discussed further in the paragraphs below.

The ANOVA calculations showed that the 2017 concentrations of ^{40}K did not vary significantly from the 2016 concentrations (ANOVA ^{40}K, p = 0.994). However, the ^{40}K concentrations did vary significantly by location from well to well (ANOVA ^{40}K, p = 6.16E-06). Some differences in ^{40}K concentrations at the various wells (locations) would be expected due to differences in the abundance of this naturally occurring isotope in the sedimentary minerals deposited at various locations in the area and the associated variable dissolution of the isotope by the groundwater.

The measured concentrations of ^{40}K in the groundwater samples in 2017 were all within the 99 percent confidence interval range of the baseline concentrations (baseline concentration: 6.30E+01 Bq/L). The highest concentration measured in 2017 was 4.41E+01 Bq/L in the primary sample from WQSP-3 (the concentration in the WQSP-3 primary sample in 2016, 2015, and 2014 were very similar at 3.98 Bq/L, 4.33E+01 Bq/L, and 4.35E+01 Bq/L, respectively).

The isotopes ^{137}Cs and ^{60}Co were not detected in any of the 2017 groundwater samples, and no ANOVA comparisons were performed.

The beta emitter, ^{90}Sr, was also not detected in any of the groundwater samples, thus no ANOVA comparisons between years or among locations could be performed.

The precision of the groundwater analysis results was determined from the activities and corresponding 1 σ TPUs of the primary and duplicate groundwater sample analysis results as shown in Table 4.7. The Qualifier column shows whether the radionuclide was detected in the groundwater samples. The detections were the same for the primary and duplicate samples except that ^{40}K was not detected in the primary sample from WQSP-1. The undetected activity of 2.88E+01 Bq/L was significantly higher than the detected activity of 1.33E+01 Bq/L, and the resulting RER was close to 1.96 at 1.85.

The Round 39 RERs in Table 4.7 show that the RERs were less than 2, except for ^{238}U in the WQSP-4 duplicate samples (2.38); ^{60}Co in the WQSP-4 duplicate samples (2.17); and ^{235}U in the WQSP-6 duplicate samples (2.44). The two uranium isotopes were detected in the samples. The RER precision data in Table 4.7 demonstrate good reproducibility for the combined sampling and analysis procedures for the primary and duplicate groundwater samples.

4.4 Surface Water

4.4.1 Sample Collection

The *Waste Isolation Pilot Plant Environmental Monitoring Plan* (DOE/WIPP-99-2194) includes routine regional and local surface water and sediment sampling that extends as far north as Artesia, NM, on the upper Pecos River, to as far south as Pierce Canyon on the lower Pecos River. Figure 4.2 (see Appendix C for sampling location codes) shows the locations where samples are collected annually and reported in the ASER. If a particular surface water collection location was dry, only a sediment sample was collected. Sediment sample analysis results are discussed in Section 4.5.

Routine surface water and sediment sampling is normally performed in late summer of every year. At times, the cattle tanks (earthen ponds) are dry and only sediment samples can be obtained. Most of the regularly sampled surface water samples from the locations in Figure 4.2 were collected late June through late August 2017.

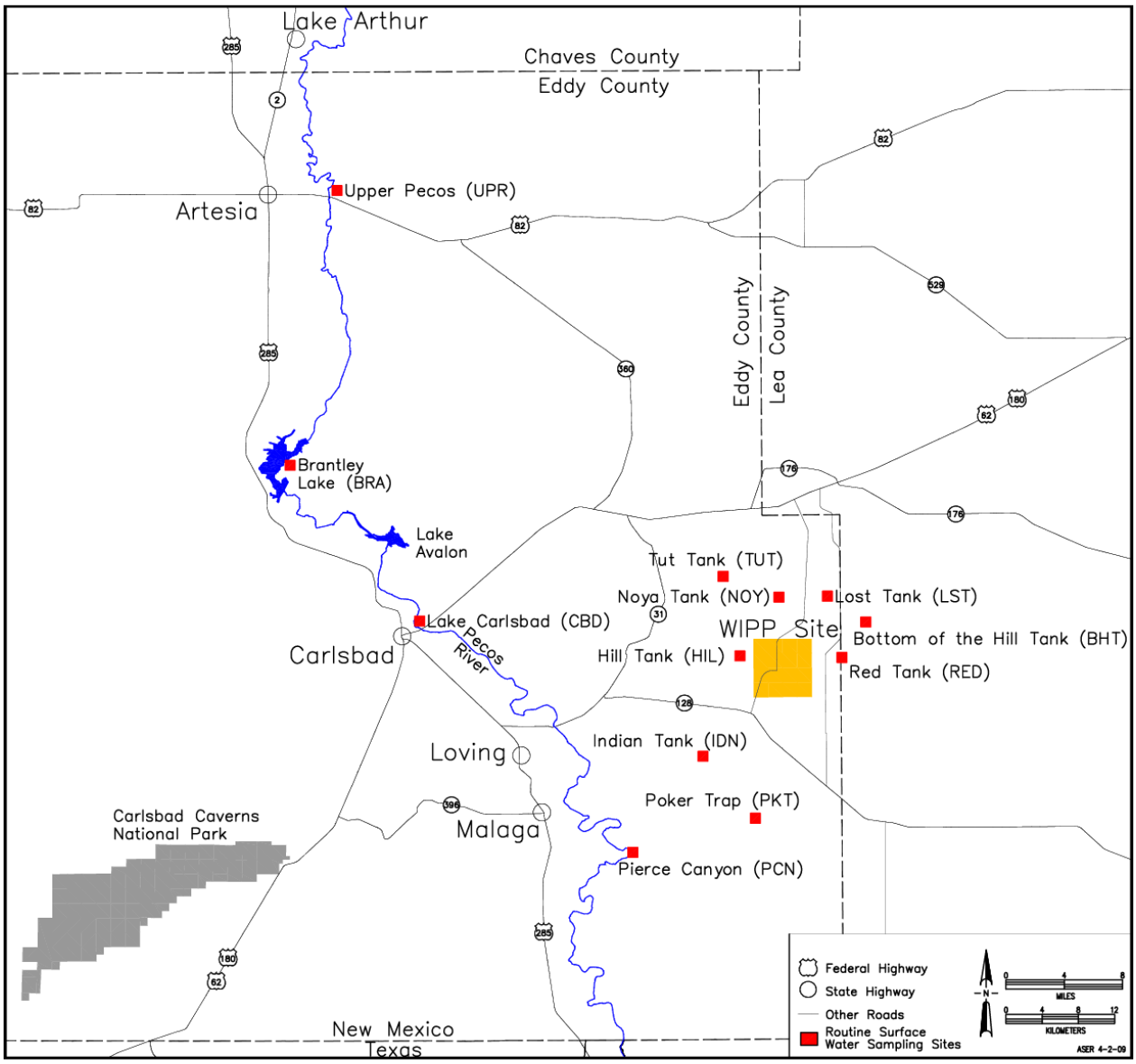

Figure 4.2 – Routine Surface Water Sampling Locations

Water from each sampling location was used to rinse 3.78-L (1-gallon) polyethylene containers at least three times prior to taking the sample. Approximately 1 gallon of water was collected from each location. Immediately after collection, the samples were acidified to pH ≤ 2 with concentrated nitric acid. Later, the samples were transferred to the WIPP Laboratories for analysis. Chain of custody was maintained throughout the process.

4.4.2 Sample Preparation

Surface water sample containers were shaken to distribute suspended material evenly, and sample aliquots were measured into glass beakers. One 0.5-L portion was used for

gamma spectroscopy, and another 0.5-L portion was used for sequential analysis of the uranium/transuranic isotopes and ^{90}Sr. Tracers (^{232}U, ^{243}Am, and ^{242}Pu) and a carrier (strontium nitrate) were added to the second sample portion, and the samples were then digested using concentrated nitric acid and hydrofluoric acid. The samples were heated to dryness and wet-ashed using concentrated nitric acid and hydrogen peroxide. Finally, the samples were heated to dryness, taken up in nitric acid solution, and processed to separate the various isotopes.

4.4.3 Determination of Individual Radionuclides

A 0.5-L portion of the acidified water sample was used directly for the gamma spectroscopy measurement of the gamma-emitting radionuclides ^{40}K, ^{60}Co, and ^{137}Cs. The other 0.5-L portion of the water was prepared by co-precipitating the target isotopes and corresponding tracers with an iron carrier, performing ion exchange and chromatographic separations of the individual radionuclides as described in Section 4.2.3, and micro-precipitating the separated radionuclides onto planchets for counting. The uranium isotopes and transuranics were counted using alpha spectroscopy, and ^{90}Sr was beta counted using a gas proportional detector.

4.4.4 Results and Discussion

The 2017 analysis results for the uranium isotopes in the routine surface water samples are shown in Table 4.8. Uranium isotopes were detected in most of the surface water samples, which included 15 separate samples, two sets of duplicate samples, and a deionized water field blank (COW), which was submitted to the laboratory as a blind quality control (QC) sample. The uranium isotope analyses resulted in detection of $^{233/234}$U in all the surface water samples except BHT and the COW field blank, detection of ^{235}U in FWT, PCN, CBD, SWL, BRA, and UPR and its duplicate and detection of ^{238}U in all the samples except BHT and the COW deionized water field blank.

The concentrations of the uranium isotopes were compared between 2017 and 2016 and also between sampling locations using ANOVA for those locations where the uranium isotopes were detected both years. The average concentrations were used for HIL and PCN in 2016 and IDN and UPR in 2017. In 2016 and 2017, $^{233/234}$U was detected in 14 common locations, ^{235}U was detected in five common locations, and ^{238}U was detected in 14 common locations.

There was no significant variation in the $^{233/234}$U concentrations in the surface water between 2016 and 2017 (ANOVA $^{233/234}$U, $p = 0.689$). The ^{235}U p showed a much stronger p value in 2017 than recent years ANOVA ^{235}U, $p = 0.744$. However, this calculation was only based on five common locations including weak detections at FWT, and SWL. The other detections were all in the Pecos River and associated bodies of water.

The ^{238}U concentrations did not show any significant variation between 2016 and 2017 ANOVA ^{238}U, $p = 0.586$.

Table 4.8 – 2017 Uranium Isotope Concentrations in Surface Water Samples Taken Near the WIPP Site

Location	Sampling Date	$^{233/234}U$				^{235}U				^{238}U			
		[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
RED	4/20/2017	6.07E-03	1.92E-03	9.16E-04	+	5.93E-04	6.15E-04	6.91E-04	U	4.68E-03	1.64E-03	1.03E-03	+
NOY	4/20/2017	1.92E-03	1.01E-03	9.56E-04	+	-2.74E-05	1.26E-04	7.03E-04	U	1.20E-03	7.78E-04	1.02E-03	+
HIL	4/10/2017	7.61E-03	2.42E-03	9.95E-04	+	6.67E-04	6.94E-04	7.57E-04	U	5.19E-03	1.91E-03	1.12E-03	+
TUT	6/21/2017	1.02E-02	3.57E-03	1.56E-03	+	1.67E-04	6.52E-04	1.16E-03	U	9.21E-03	3.29E-03	1.11E-03	+
PKT	8/2/2017	1.12E-02	3.18E-03	1.32E-03	+	-5.94E-05	2.02E-04	9.98E-04	U	6.86E-03	2.30E-03	1.12E-03	+
FWT	6/26/2017	4.29E-02	1.01E-02	1.28E-03	+	8.58E-04	7.89E-04	8.26E-04	+	1.73E-02	4.65E-03	1.18E-03	+
COW [e]	6/26/2017	4.49E-04	6.65E-04	1.40E-03	U	-6.16E-05	2.10E-04	9.33E-04	U	9.12E-04	8.49E-04	1.16E-03	U
IDN	6/8/2017	2.52E-03	1.31E-03	1.38E-03	+	2.18E-04	5.26E-04	8.52E-04	U	2.01E-03	1.15E-03	1.10E-03	+
IDN Dup	6/8/2017	1.92E-03	1.22E-03	1.42E-03	+	4.22E-05	4.96E-04	1.03E-03	U	1.91E-03	1.28E-03	1.44E-03	+
PCN	4/13/2017	2.00E-01	3.03E-02	9.01E-04	+	4.91E-03	1.81E-03	6.84E-04	+	9.62E-02	1.53E-02	1.02E-03	+
CBD	4/13/2017	9.96E-02	1.47E-02	8.83E-04	+	2.44E-03	1.18E-03	7.04E-04	+	4.46E-02	7.29E-03	1.00E-03	+
SWL [f]	5/24/2017	2.34E-02	8.15E-03	1.51E-03	+	1.26E-03	1.19E-03	1.24E-03	+	1.12E-02	4.42E-03	1.33E-03	+
BRA	4/13/2017	1.32E-01	2.04E-02	9.21E-04	+	5.23E-03	1.88E-03	6.87E-04	+	6.67E-02	1.10E-02	1.03E-03	+
UPR	4/13/2017	1.50E-01	2.30E-02	8.98E-04	+	4.47E-03	1.68E-03	6.48E-04	+	6.73E-02	1.11E-02	1.03E-03	+
UPR Dup	4/13/2017	1.62E-01	2.64E-02	9.75E-04	+	4.46E-03	1.81E-03	7.70E-04	+	7.44E-02	1.30E-02	1.05E-03	+
LST	4/20/2017	3.57E-03	1.37E-03	9.37E-04	+	9.13E-05	3.29E-04	7.10E-04	U	1.78E-03	9.59E-04	1.02E-03	+
BHT	4/20/2017	9.65E-04	7.51E-04	9.79E-04	U	1.19E-04	3.48E-04	7.49E-04	U	5.61E-04	6.02E-04	1.10E-03	U
H-19 Evap	5/24/2017	6.51E-02	5.29E-02	3.37E-03	+	4.51E-03	5.31E-03	3.79E-03	U	2.12E-02	1.82E-02	2.71E-03	+

Notes: See Appendix C for sampling location codes. Units are Bq/L.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected; U equals undetected.

(e) COW = semi-blind deionized field blank.

(f) SWL = surface water composite consisting of Settling Lagoons 1 and 2, Evaporation Lagoons A, B, and C, and Polishing Lagoons 1 and 2.

There was significant variation in the concentrations of the uranium isotopes by location. ANOVA $^{233/234}$U, p = 1.04E-06 and ANOVA ^{238}U, p = 9.66E-07. The p value for ^{235}U was slightly above the significance level ANOVA ^{235U}, p = 0.0518. The ^{235}U p value was for only five common locations, four of which are in the Pecos River and associated bodies of water, and the other, FWT, is the groundwater from a remote location for general use at the WIPP site. The significant variation for $^{233/234}$U and ^{238}U concentrations by location is consistent with the data in previous years comparing the uranium isotope concentrations by location. This appears to be due to more than an order of magnitude difference in concentrations at some of the locations with the highest concentrations of $^{233/234}$U and ^{238}U at PCN and the other locations with the highest concentrations also in the Pecos River and associated bodies of water.

The 2017 uranium isotope surface water concentrations were also compared with the 99 percent confidence interval range of the baseline concentrations measured between 1985 and 1989 (DOE/WIPP-92-037). The concentrations detected for $^{233/234}$U, ^{235}U, and ^{238}U in the Pecos River and associated bodies of water, which include locations PCN, CBD, BRA, and UPR, were compared with the 99 percent confidence interval ranges of the measured baseline concentrations (baseline levels: $^{233/234}$U = 3.30E–01 Bq/L, ^{235}U = 1.40E–02 Bq/L, and ^{238}U = 1.10E–01 Bq/L). The highest concentrations detected were 2.00E-01 Bq/L of $^{233/234}$U in the PCN sample; 5.23E-03 Bq/L of ^{235}U at BRA; and 9.62E-02 Bq/L ^{238}U in the PCN sample. Thus, none of the uranium isotope concentrations were higher than the baseline concentrations. Location PCN has consistently had the highest concentrations of uranium isotope concentrations during the past few years.

The 99 percent confidence interval ranges of the baseline concentrations for the tank and tank-like structures (RED, NOY, HIL, TUT, FWT, PKT, IDN, BHT, and LST) are $^{233/234}$U = 1.00E-01 Bq/L, ^{235}U = 5.20E-03 Bq/L, and ^{238}U = 3.20E-02 Bq/L. The highest concentrations measured in 2017 include 4.29E-02 Bq/L $^{233/234}$U at FWT, 8.54E-04 Bq/L ^{235}U at FWT, and 1.73E-02 Bq/L ^{238}U at FWT. FWT is the groundwater that is pumped into tanks at the WIPP site and thus is different than the other tanks and tank-like structures on the WIPP site. Thus, none of the measured 2017 concentrations were higher than the 99 percent confidence interval concentrations from the baseline. The FWT water source is not at the WIPP site; rather it is the groundwater pumped to the WIPP site from a distant location and stored in large tanks for use as domestic water on the WIPP site.

One other type of surface water sample reported in Table 4.8 was sewage sludge (SWL) which was a composite sample consisting of Settling Lagoons 1 and 2, Evaporation Lagoons A, B, and C, and Polishing Lagoons 1 and 2. The original source of the water to the lagoons was FWT, thus the measured uranium isotope concentrations were similar with $^{233/234}$U at 2.34E-02 Bq/L in SWL and 4.29E-02 Bq/L in FWT; ^{235}U at 1.26E-03 Bq/L in SWL and 8.58E-04 Bq/L in FWT; and ^{238}U at 1.12E-02 Bq/L in SWL and 1.73E-02 Bq/L in FWT. The H-19 Evaporation Pond water was formerly composited with the SWL but was analyzed as a separate sample in 2016 and 2017. The $^{233/234}$U concentration was 6.51E-02 Bq/L and the ^{238}U concentration was

2.12E-02 Bq/L with no ^{235}U detected in the sample. The radionuclide baseline concentration database for the WIPP facility does not contain any values for sewage.

The surface water samples were also analyzed for ^{238}Pu, $^{239/240}Pu$, and ^{241}Am, as shown in Table 4.9. None of these radionuclides were detected in the surface water samples in 2016 or 2017. Thus, no ANOVA comparisons between years and among locations could be performed.

The analysis data for the gamma isotopes and ^{90}Sr are presented in Table 4.10. A column has been added for the gamma isotopes to show the ID confidence. An ID confidence greater than or equal to 0.90 and sample activity greater than the 2 σ TPU and MDC are required for detection. As shown in Table 4.10, ^{40}K was the only gamma radionuclide detected, and it was only detected in the SWL and H-19 Evaporation Pond in 2016 and 2017.

An ANOVA calculation was performed for ^{40}K using only the two locations with detections, SWL and H-19. The calculation is of limited value since the source of water for the two locations is quite different. The SWL water originates from FWT, the groundwater used for domestic use at the WIPP site, and the H-19 Evaporation Pond water originates from a variety of sources including brine water in the underground where condensate water dissolved various concentrations of underground salt consisting of sodium chloride and potassium chloride, and the brine water was disposed of in the H-19 Evaporation Pond. The ANOVA calculations showed no significant variation by year (ANOVA ^{40}K, $p = 0.462$) or by location (ANOVA ^{40}K, $p = 0.447$).

Comparison of the detected ^{40}K concentrations with the 99 percent confidence interval range of the baseline concentration data (7.60E+01 Bq/L for tanks and Pecos River and associated bodies of water) shows that the SWL concentration of 1.91E+02 Bq/L and the H-19 Evaporation Pond concentration of 7.04E+02 Bq/L were higher than the 99 percent confidence interval range of the baseline concentration (DOE/WIPP-92-037). However, these sample matrices are completely different than the tank and Pecos River samples. It is expected that ^{40}K would be detected in a sample consisting of sewage since sewage contains significant potassium from human excretions and that underground brine containing KCl would also contain significant ^{40}K since ^{40}K makes up 0.012 percent of all naturally occurring potassium.

The reproducibility of the sampling and analysis procedures was assessed by collecting and analyzing duplicate field samples from locations IDN and UPR. The RERs were calculated for all the target radionuclides in the primary and duplicate samples. The RERs for the analysis results are presented in Table 4.11.

The RERs of the detected radionuclides, i.e., the uranium isotopes (except for ^{235}U in the IDN samples), were less than 2. None of the RERs for the undetected radionuclides were higher than 2. The analysis results demonstrate good reproducibility for the combined sampling and radioanalytical procedure.

Table 4.9 – 2017 Plutonium Isotope and Americium Concentrations in Surface Water Samples Taken Near the WIPP Site

Location	Sampling Date	^{238}Pu				$^{239/240}$Pu				^{241}Am			
		[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
RED	4/20/2017	5.61E-05	2.70E-04	6.56E-04	U	7.21E-05	2.56E-04	6.19E-04	U	2.27E-04	3.71E-04	7.11E-04	U
NOY	4/20/2017	1.55E-05	2.90E-04	8.37E-04	U	1.55E-04	3.41E-04	6.09E-04	U	3.20E-04	4.52E-04	7.51E-04	U
HIL	4/10/2017	-6.14E-05	1.61E-04	5.46E-04	U	-4.90E-05	1.44E-04	6.65E-04	U	-7.44E-05	2.06E-04	8.90E-04	U
TUT	6/21/2017	-2.24E-05	9.82E-05	4.89E-04	U	-5.21E-05	1.50E-04	6.01E-04	U	4.57E-05	3.02E-04	7.53E-04	U
PKT	8/2/2017	-6.24E-05	1.61E-04	6.07E-04	U	-9.05E-05	1.93E-04	6.65E-04	U	7.50E-05	2.72E-04	7.33E-04	U
FWT	6/26/2017	3.16E-05	3.10E-04	7.30E-04	U	-3.78E-05	1.32E-04	6.49E-04	U	7.87E-05	3.18E-04	8.02E-04	U
COW [e]	6/26/2017	-4.64E-05	1.40E-04	5.70E-04	U	-5.78E-05	1.56E-04	6.17E-04	U	-2.51E-05	1.07E-04	7.16E-04	U
IDN	6/8/2017	2.92E-05	2.86E-04	6.95E-04	U	8.14E-05	2.43E-04	5.82E-04	U	-4.94E-05	1.49E-04	7.09E-04	U
IDN Dup	6/8/2017	2.11E-05	3.55E-04	6.82E-04	U	9.81E-05	2.93E-04	6.64E-04	U	8.90E-05	2.43E-04	6.78E-04	U
PCN	4/13/2017	1.43E-04	3.59E-04	6.41E-04	U	9.53E-05	2.33E-04	5.89E-04	U	3.11E-04	4.39E-04	7.37E-04	U
CBD	4/13/2017	9.09E-05	2.50E-04	5.38E-04	U	-5.78E-05	1.60E-04	7.26E-04	U	-5.26E-05	1.58E-04	7.45E-04	U
SWL [f]	5/24/2017	-1.08E-04	2.30E-04	8.09E-04	U	-5.38E-05	1.62E-04	7.66E-04	U	-5.65E-05	1.71E-04	7.95E-04	U
BRA	4/13/2017	1.56E-04	3.67E-04	5.98E-04	U	3.04E-04	4.14E-04	6.29E-04	U	1.45E-04	3.98E-04	7.93E-04	U
UPR	4/13/2017	1.77E-04	3.24E-04	5.65E-04	U	6.15E-05	2.52E-04	6.05E-04	U	-6.07E-05	1.69E-04	7.14E-04	U
UPR Dup	4/13/2017	-1.01E-04	2.05E-04	7.29E-04	U	7.74E-05	2.41E-04	5.99E-04	U	-2.87E-05	1.22E-04	7.33E-04	U
LST	4/20/2017	4.35E-05	2.90E-04	6.36E-04	U	-7.24E-05	1.79E-04	6.36E-04	U	-4.04E-05	1.33E-04	6.76E-04	U
BHT	4/20/2017	2.92E-04	4.28E-04	6.10E-04	U	2.08E-04	3.40E-04	6.19E-04	U	2.31E-04	3.78E-04	7.39E-04	U
H-19 Evap	5/24/2017	5.17E-04	1.20E-03	1.97E-03	U	1.05E-03	1.32E-03	1.59E-03	U	5.44E-05	4.84E-04	1.08E-03	U

Notes: See Appendix C for sampling location codes. Units are Bq/L.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected; U equals undetected.

(e) COW = semi-blind deionized water field blank.

(f) SWL = surface water composite consisting of Settling Lagoons 1 and 2, Evaporation Lagoons A, B, and C, and Polishing Lagoons 1 and 2.

(g) COY = semi-blind field duplicate (PCN).

Table 4.10 – 2017 Gamma Radionuclides and ^{90}Sr Concentrations in Standard Surface Water Samples Taken Near the WIPP Site

Location	Sampling Date	^{40}K					^{60}Co				
		[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf.[d]	Q[e]	[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf.[d]	Q[e]
RED	4/20/2017	3.45E+00	3.21E+00	4.43E+00	0.000	U	1.97E-01	3.15E-01	4.10E-01	0.000	U
NOY	4/20/2017	1.81E+00	6.90E+00	8.82E+00	0.000	U	-5.89E-02	6.85E-01	8.05E-01	0.000	U
HIL	4/10/2017	4.45E+00	3.24E+00	4.61E+00	0.000	U	-5.69E-03	3.54E-01	4.12E-01	0.000	U
TUT	6/21/2017	7.39E+00	3.02E+00	4.88E+00	0.000	U	5.75E-02	3.19E-01	3.83E-01	0.000	U
PKT	8/2/2017	3.25E+00	3.19E+00	4.30E+00	0.000	U	2.31E-01	3.01E-01	4.06E-01	0.000	U
FWT	6/26/2017	2.87E+00	3.51E+00	4.62E+00	0.000	U	-1.34E-01	3.48E-01	3.67E-01	0.000	U
COW [e]	6/26/2017	1.05E+01	1.00E+01	1.36E+01	0.000	U	-3.44E-01	9.65E-01	1.07E+00	0.000	U
IDN	6/8/2017	2.25E+01	1.03E+01	1.85E+01	0.000	U	2.52E-01	1.36E+00	1.68E+00	0.000	U
IDN Dup	6/8/2017	3.24E+00	3.25E+00	4.40E+00	0.000	U	-1.05E-01	3.17E-01	3.42E-01	0.000	U
PCN	4/13/2017	4.29E+00	3.42E+00	4.74E+00	0.000	U	2.59E-02	3.45E-01	4.06E-01	0.000	U
CBD	4/13/2017	2.67E+00	3.13E+00	4.15E+00	0.000	U	-2.61E-02	3.23E-01	3.69E-01	0.000	U
SWL [f]	5/24/2017	1.91E+02	2.69E+01	4.78E+00	1.000	+	-5.04E-01	5.23E-01	4.92E-01	0.000	U
BRA	4/13/2017	1.44E+01	8.79E+00	1.32E+01	0.000	U	5.60E-01	7.86E-01	1.08E+00	0.000	U
UPR	4/13/2017	5.27E+00	6.76E+00	9.43E+00	0.000	U	-1.98E-02	6.44E-01	7.59E-01	0.000	U
UPR Dup	4/13/2017	-5.06E+00	1.74E+01	1.91E+01	0.000	U	-5.38E-01	1.46E+00	1.54E+00	0.000	U
LST	4/20/2017	1.70E-01	9.64E+00	1.43E+01	0.000	U	-1.18E-01	9.69E-01	1.13E+00	0.000	U
BHT	4/20/2017	4.61E-01	3.24E+00	3.83E+00	0.000	U	-6.03E-02	3.43E-01	3.87E-01	0.000	U
H-19 Evap	5/24/2017	7.04E+02	9.38E+01	5.31E+00	0.998	+	-1.85E-01	6.72E-01	7.34E-01	0.000	U

Location	Sampling Date	^{137}Cs					^{90}Sr			
		[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf.[d]	Q[e]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[e]
RED	4/20/2017	3.51E-01	3.22E-01	4.09E-01	0.000	U	5.93E-03	2.06E-02	1.21E-02	U
NOY	4/20/2017	2.47E-01	5.38E-01	7.08E-01	0.000	U	4.52E-03	1.42E-02	1.21E-02	U
HIL	4/10/2017	2.55E-01	2.72E-01	3.61E-01	0.000	U	-4.99E-03	1.98E-02	1.21E-02	U
TUT	6/21/2017	2.05E-01	2.84E-01	3.69E-01	0.000	U	2.57E-05	2.19E-02	1.93E-02	U
PKT	8/2/2017	7.26E-02	3.24E-01	3.78E-01	0.000	U	1.01E-02	2.30E-02	1.94E-02	U
FWT	6/26/2017	-3.05E-03	3.14E-01	3.57E-01	0.000	U	6.91E-03	2.14E-02	1.91E-02	U
COW (f)	6/26/2017	2.06E-02	8.33E-01	1.01E+00	0.000	U	-5.85E-04	2.19E-02	1.92E-02	U
IDN	6/8/2017	2.37E-01	9.90E-01	1.25E+00	0.000	U	3.15E-03	2.16E-02	1.92E-02	U
IDN Dup	6/8/2017	1.30E-01	3.26E-01	3.85E-01	0.000	U	4.93E-03	2.26E-02	1.92E-02	U
PCN	4/13/2017	-6.36E-02	3.33E-01	3.66E-01	0.000	U	-9.65E-04	1.88E-02	1.18E-02	U
CBD	4/13/2017	-1.07E-01	3.41E-01	3.68E-01	0.000	U	1.17E-02	2.02E-02	1.20E-02	U
SWL (g)	5/24/2017	-1.06E-01	4.05E-01	4.36E-01	0.000	U	7.23E-03	2.88E-02	1.98E-02	U
BRA	4/13/2017	8.13E-01	7.84E-01	1.06E+00	0.000	U	2.88E-04	2.01E-02	1.21E-02	U
UPR	4/13/2017	6.65E-02	5.36E-01	6.47E-01	0.000	U	-6.35E-03	2.10E-02	1.22E-02	U
UPR Dup	4/13/2017	-3.15E-03	1.07E+00	1.30E+00	0.000	U	1.72E-03	2.01E-02	1.19E-02	U
LST	4/20/2017	-3.51E-03	7.78E-01	9.40E-01	0.000	U	-1.13E-02	2.08E-02	1.21E-02	U
BHT	4/20/2017	7.51E-02	3.11E-01	3.62E-01	0.000	U	1.31E-03	2.05E-02	1.21E-02	U
H-19 Evap	5/24/2017	2.17E-01	5.28E-01	6.03E-01	0.000	U	3.48E-03	2.37E-02	1.93E-02	U

Notes: See Appendix C for sampling location codes. Units are Bq/L.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Identification confidence for gamma radionuclides. Value >0.90 implies detection if sample activity is greater than 2 sigma TPU and MDC.

(e) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected; U equals undetected.

(f) COW = semi-blind deionized water field blank.

(g) SWL = surface water composite consisting of Settling Lagoons 1 and 2, Evaporation Lagoons A, B, and C, and Polishing Lagoons 1 and 2

Table 4.11 – 2017 Precision Results for Duplicate Surface Water Samples

Radionuclide	IDN		IDN Dup		RER[c]	Q[d]
	[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]		
$^{233/234}$U	2.52E-03	6.70E-04	1.92E-03	6.20E-04	0.657	+
^{235}U	2.18E-04	2.68E-04	4.22E-05	2.53E-04	0.477	U
^{238}U	2.01E-03	5.86E-04	1.91E-03	6.55E-04	0.114	+
^{238}Pu	2.92E-05	1.46E-04	2.11E-05	1.81E-04	0.035	U
$^{239/240}$Pu	8.14E-05	1.24E-04	9.81E-05	1.50E-04	0.086	U
^{241}Am	-4.94E-05	7.61E-05	8.90E-05	1.24E-04	0.951	U
^{40}K	2.25E+01	5.26E+00	3.24E+00	1.66E+00	3.492	U
^{60}Co	2.52E-01	6.94E-01	-1.05E-01	1.62E-01	0.501	U
^{137}Cs	2.37E-01	5.05E-01	1.30E-01	1.66E-01	0.201	U
^{90}Sr	3.15E-03	1.10E-02	4.93E-03	1.15E-02	0.112	U
Radionuclide	**UPR**		**UPR Dup**		**RER[c]**	**Q[d]**
	[RN][a]	**1 σ TPU[b]**	**[RN][a]**	**1 σ TPU[b]**		
233/234U	1.50E-01	1.17E-02	1.62E-01	1.35E-02	0.672	+
235U	4.47E-03	8.59E-04	4.46E-03	9.25E-04	0.008	+
238U	6.73E-02	5.65E-03	7.44E-02	6.62E-03	0.816	+
238Pu	1.77E-04	1.65E-04	-1.01E-04	1.05E-04	1.421	U
239/240Pu	6.15E-05	1.29E-04	7.74E-05	1.23E-04	0.089	U
241Am	-6.07E-05	8.62E-05	-2.87E-05	6.20E-05	0.301	U
40K	5.27E+00	3.45E+00	-5.06E+00	8.88E+00	1.084	U
60Co	-1.98E-02	3.29E-01	-5.38E-01	7.45E-01	0.636	U
137Cs	6.65E-02	2.73E-01	-3.15E-03	5.46E-01	0.114	U
90Sr	-6.35E-03	1.07E-02	1.72E-03	1.02E-02	0.546	U

Notes:

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty at the 1 sigma level.

(c) Relative error ratio.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected; U equals undetected.

4.5 Sediments

4.5.1 Sample Collection

Sediment samples were collected from 12 locations around the WIPP site (Figure 4.3); duplicate samples were collected from 2 sites (PKT and UPR) for 14 samples total. See Figure 4.3 for sediment sample locations and Appendix C for location codes. The sites included all the same sites as for 2017 surface water, except for locations FWT, SWL,

and H-19 Evaporation Pond. The samples were collected in 1-L plastic containers from the top 15 cm (6 in.) of sediment of the water bodies and transferred to WIPP Laboratories for determination of individual radionuclides.

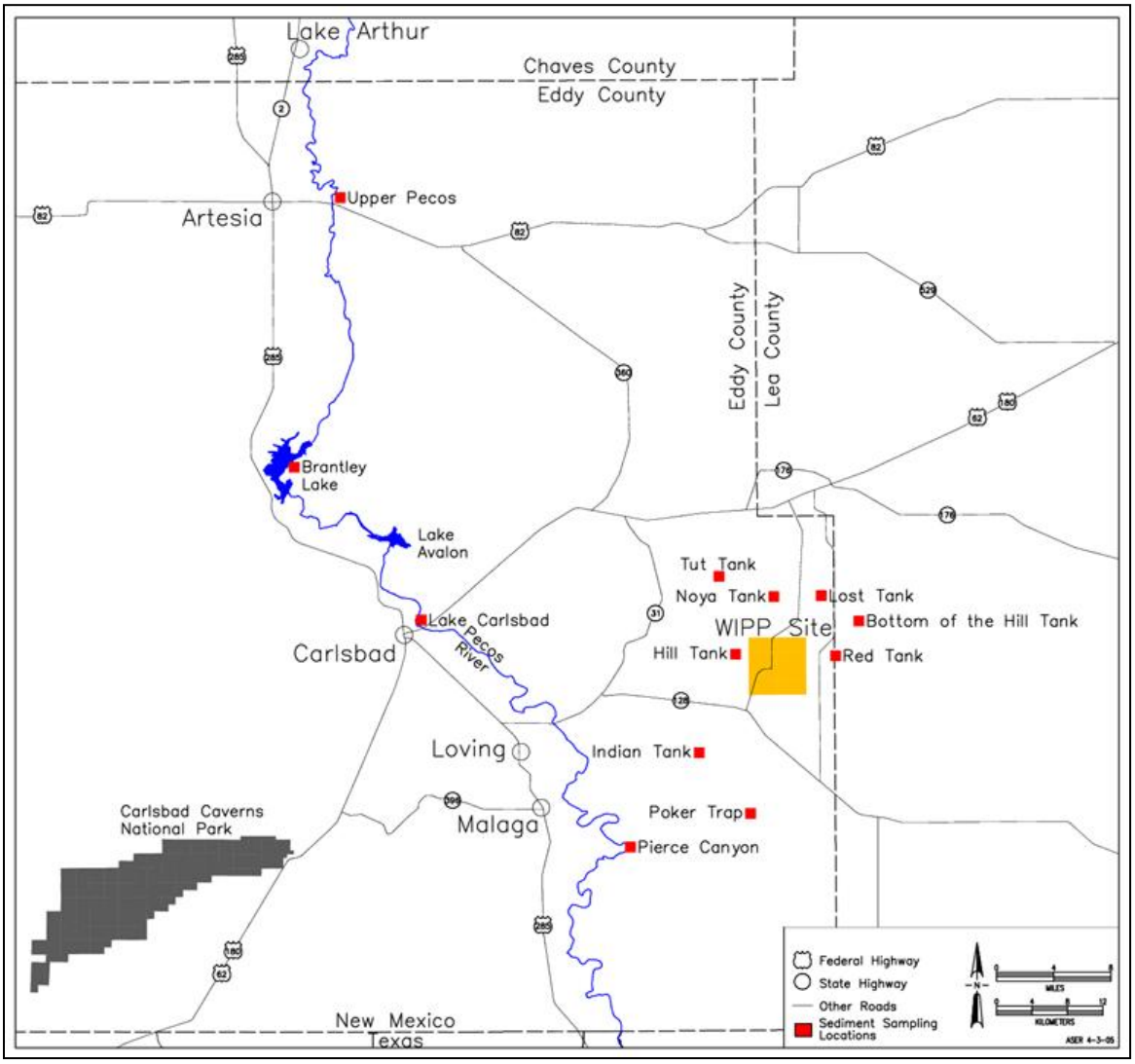

Figure 4.3 – Sediment Sampling Locations

4.5.2 Sample Preparation

Sediment samples were dried at 110°C (230°F) for several hours and homogenized by grinding into smaller particle sizes. Tracers (^{232}U, ^{243}Am, and ^{242}Pu) and a carrier (strontium nitrate) were added to a 2-gram aliquot of each of the dried and homogenized sediment samples, which were subsequently dissolved by heating with a mixture of nitric, hydrochloric, and hydrofluoric acids. The sample residues were heated with nitric and boric acids to remove hydrofluoric acid. Finally, the residues were dissolved in hydrochloric acid in preparation for separation of the radionuclides.

4.5.3 Determination of Individual Radionuclides

The hydrochloric acid digestates of the sediment samples were split into two fractions. One fraction was analyzed by gamma spectroscopy for ^{40}K, ^{60}Co, and ^{137}Cs. The other fraction was analyzed sequentially for the uranium/transuranic radioisotopes and ^{90}Sr by employing a series of chemical, physical, and ion exchange separations as described in Section 4.2.3, followed by mounting the sample residues on planchets for counting. The uranium/transuranic isotopes were measured by alpha spectroscopy and the ^{90}Sr by gas proportional counting.

4.5.4 Results and Discussion

Table 4.12 presents the results of the uranium isotope analyses in the sediment samples. The isotopes $^{233/234}$U, ^{235}U, and ^{238}U were detected in all the sediment samples in 2017.

ANOVA was used to compare the uranium isotope concentrations between 2016 and 2017 and between sampling locations. The average concentrations were used for the HIL and PCN duplicates in 2016 and the PKT and UPR duplicates in 2017 except for ^{235}U, which was only detected in the duplicate PCN sample in 2016.

There were 12 common locations for $^{233/234}$U and ^{238}U (all samples) in 2016 and 2017 and 11 common locations for ^{235}U (all locations except BRA). The ANOVA calculations showed no significant difference in the distribution of the isotopes between 2016 and 2017 with ANOVA $^{233/234}$U, p = 0.839, ANOVA ^{235}U, p = 0.169, and ANOVA ^{238}U, p = 0.591. Some of the uranium isotope concentrations were higher in 2016 and some were higher in 2017.

The ANOVA calculations showed that the concentrations of the three uranium isotopes varied more by sediment location except for ^{235}U (ANOVA $^{233/234}$U, p = 0.0869; ANOVA ^{235}U, p = 0.712; and ANOVA ^{238}U, p = 0.0185). The $^{233/234}$U p value was only slightly higher than the significance value and the ^{238}U p value was significantly less than the p value. The ^{235}U p values often do not track with the $^{233/234}$U and ^{238}U values. The p values were much lower for $^{233/234}$U and ^{238}U by location in 2016/2017 compared to 2015/2016, while the p value for ^{235}U was higher. The reason for the higher variability by location is not known for certain but may be related to the relatively high precipitation in recent years, especially in 2017.

The highest uranium isotope concentrations detected included 2.76E-02 Bq/g for $^{233/234}$U in the PKT duplicate sample; 1.72E-03 Bq/g for ^{235}U in the IDN sample; and 2.63E-02 Bq/g for ^{238}U in the PKT duplicate sample. The baseline concentrations include 1.10E-01 Bq/g for $^{233/234}$U, 3.20E-03 Bq/g for ^{235}U, and 5.00E–02 Bq/g for ^{238}U. The concentrations of all three uranium isotopes fell within the 99 percent confidence interval ranges of the baseline.

Sediment samples were also analyzed for ^{238}Pu, $^{239/240}$Pu, and ^{241}Am, by alpha spectroscopy; the results are shown in Table 4.13. There was one detection of $^{239/240}$Pu

in 2017, the duplicate sample from PKT (but not the primary sample). Pu-239/249 was also detected in the PKT sediment sample in 2016 at a very similar concentration (6.04E-04 Bq/g in 2017 and 5.83E-04 Bq/g in 2017). Both concentrations were lower than the baseline concentration of 1.90E-03 Bq/g covering all locations. There were not enough detections to perform ANOVA calculations.

Table 4.12 – 2017 Uranium Isotope Concentrations in Sediment Samples Taken Near the WIPP Site

Location	Sampling Date	$^{233/234}U$				^{235}U				^{238}U			
		[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
RED	4/20/2017	1.82E-02	3.27E-03	6.63E-04	+	7.95E-04	3.38E-04	3.37E-04	+	1.78E-02	3.19E-03	7.22E-04	+
NOY	4/20/2017	1.16E-02	2.13E-03	6.61E-04	+	4.91E-04	2.53E-04	3.17E-04	+	1.25E-02	2.28E-03	7.36E-04	+
HIL	4/10/2017	2.09E-02	4.29E-03	7.04E-04	+	8.95E-04	4.45E-04	3.71E-04	+	2.10E-02	4.31E-03	7.66E-04	+
TUT	6/21/2017	1.92E-02	3.55E-03	9.17E-04	+	4.61E-04	3.02E-04	4.19E-04	+	2.11E-02	3.87E-03	6.96E-04	+
PKT	8/2/2017	1.84E-02	3.05E-03	9.01E-04	+	6.40E-04	3.21E-04	3.87E-04	+	2.00E-02	3.28E-03	6.80E-04	+
PKT Dup	8/2/2017	2.76E-02	4.85E-03	9.11E-04	+	9.76E-04	4.24E-04	3.96E-04	+	2.63E-02	4.62E-03	6.87E-04	+
IDN	6/8/2017	2.42E-02	4.06E-03	9.01E-04	+	1.72E-03	5.63E-04	3.87E-04	+	2.42E-02	4.06E-03	6.81E-04	+
PCN	4/13/2017	1.63E-02	2.62E-03	6.72E-04	+	6.88E-04	3.16E-04	3.22E-04	+	1.50E-02	2.44E-03	7.36E-04	+
CBD	4/13/2017	9.59E-03	1.77E-03	6.85E-04	+	5.48E-04	3.02E-04	3.61E-04	+	9.41E-03	1.74E-03	7.45E-04	+
BRA	4/13/2017	2.05E-02	3.08E-03	6.68E-04	+	9.61E-04	3.71E-04	3.21E-04	+	1.59E-02	2.46E-03	7.31E-04	+
UPR	4/13/2017	2.19E-02	3.72E-03	6.83E-04	+	9.06E-04	3.97E-04	3.46E-04	+	1.90E-02	3.27E-03	7.47E-04	+
UPR Dup	4/13/2017	2.20E-02	4.15E-03	6.67E-04	+	8.43E-04	3.62E-04	3.27E-04	+	2.23E-02	4.20E-03	7.32E-04	+
LST	4/20/2017	1.53E-02	2.66E-03	6.68E-04	+	6.37E-04	2.95E-04	3.09E-04	+	1.52E-02	2.65E-03	7.20E-04	+
BHT	4/20/2017	1.96E-02	3.39E-03	6.58E-04	+	1.05E-03	3.78E-04	3.08E-04	+	1.83E-02	3.19E-03	7.19E-04	+

Notes: See Appendix C for sampling location codes. Units are in Bq/g, dry weight.

PKT and UPR used for field duplicates.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected; U equals undetected.

Table 4.13 – 2017 Plutonium Isotope and Americium Concentrations in Sediment Samples Taken Near the WIPP Site

Location	Sampling Date	^{238}Pu				$^{239/240}$Pu				^{241}Am			
		[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
RED	4/20/2017	2.05E-05	6.18E-05	2.53E-04	U	7.46E-05	1.00E-04	3.46E-04	U	4.61E-05	7.74E-05	3.96E-04	U
NOY	4/20/2017	1.67E-05	6.45E-05	2.54E-04	U	1.26E-04	1.27E-04	3.46E-04	U	2.42E-05	6.36E-05	4.05E-04	U
HIL	4/10/2017	-9.40E-06	3.69E-05	2.91E-04	U	2.82E-04	2.15E-04	3.56E-04	U	7.73E-05	1.12E-04	4.29E-04	U
TUT	6/21/2017	1.70E-05	6.85E-05	2.45E-04	U	1.31E-04	1.35E-04	3.09E-04	U	-2.26E-05	6.84E-05	4.20E-04	U
PKT	8/2/2017	5.07E-05	8.98E-05	2.44E-04	U	1.69E-04	1.49E-04	3.12E-04	U	9.28E-05	1.29E-04	3.35E-04	U
PKT Dup	8/2/2017	1.19E-04	1.35E-04	2.58E-04	U	5.83E-04	2.76E-04	3.17E-04	+	1.25E-04	1.48E-04	3.47E-04	U
IDN	6/8/2017	-7.84E-06	3.35E-05	2.61E-04	U	2.44E-04	1.98E-04	3.29E-04	U	1.23E-04	1.30E-04	3.37E-04	U
PCN	4/13/2017	1.80E-05	6.61E-05	2.68E-04	U	7.36E-05	1.04E-04	3.33E-04	U	1.85E-05	6.79E-05	4.26E-04	U
CBD	4/13/2017	5.29E-05	7.69E-05	2.56E-04	U	4.60E-05	8.13E-05	3.24E-04	U	5.63E-05	9.01E-05	4.29E-04	U
BRA	4/13/2017	2.20E-05	5.79E-05	2.58E-04	U	1.84E-04	1.42E-04	3.22E-04	U	1.39E-04	1.29E-04	4.24E-04	U
UPR	4/13/2017	7.17E-05	9.22E-05	2.56E-04	U	2.93E-05	8.65E-05	3.24E-04	U	1.11E-04	1.29E-04	4.33E-04	U
UPR Dup	4/13/2017	-2.15E-05	5.13E-05	2.74E-04	U	4.27E-05	1.02E-04	3.63E-04	U	3.45E-05	6.76E-05	4.16E-04	U
LST	4/20/2017	2.31E-05	6.19E-05	2.57E-04	U	1.08E-04	1.17E-04	3.48E-04	U	1.93E-04	1.57E-04	4.11E-04	U
BHT	4/20/2017	3.80E-05	9.72E-05	2.88E-04	U	2.00E-04	1.59E-04	3.51E-04	U	1.56E-04	1.62E-04	4.24E-04	U

Notes: See Appendix C for sampling location codes. Units are in Bq/g, dry weight.

PKT and UPR used as field duplicates.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected; U equals undetected.

The sediment analysis results for the gamma radionuclides and ^{90}Sr are shown in Table 4.14. The gamma radionuclide ^{40}K was detected in all the sediment samples, while ^{137}Cs was only detected in HIL, PKT (and PKT duplicate), IDN, LSD, and BHT. The number of ^{137}Cs detections has generally been decreasing in recent years with three locations in 2016, seven locations in 2015 and 10 locations in 2014. ^{60}Co and ^{90}Sr were not detected in any of the sediment samples.

The ANOVA calculations for ^{40}K used the averages for the PKT and UPR concentrations in 2017 and the averages for the HIL and PCN concentrations in 2016 with 12 common locations. The calculations showed that the sediment concentrations of ^{40}K did not vary significantly between 2016 and 2017 (ANOVA ^{40}K, p = 0.602). However, as is typical, the concentrations did vary significantly by location (ANOVA ^{40}K, p = 3.35E-03).

ANOVA calculations were also performed differentiating the tank and tank-like structures and the Pecos River and associated bodies of water. There were eight common locations for tanks and tank-like structures using the average from HIL for 2016 and the average for PKT for 2017. There were four common locations for the Pecos River and associated bodies of water using the average of PCN in 2016 and UPR in 2017. The variation by year for tanks and tank-like structures was ANOVA ^{40}K, p = 0.633, showing good correlation in the concentrations between years. However, there was significant variation in the concentrations between locations (ANOVA ^{40}K, p = 2.40E-02). The concentrations at TUT, HIL, and PKT are higher than the others.

The ^{40}K ANOVA calculations for the Pecos River and associated bodies of water by year for 2016 and 2017 showed an unexpectedly high variation by year, ANOVA ^{40}K, p = 2.11E-04 compared to p = 0.708 for 2015 and 2016. The reason for this high variability appears to be a higher concentration at PCN and lower concentration at BRA in 2017 compared to 2016. However, the variation by location showed no significant variation in the Pecos River and associated bodies of water, ANOVA ^{40}K, p = 0.972 compared to p = 1.65E-02 for 2015 and 2016 since the 2017 concentrations were within a factor of about two of each other. Potassium is ubiquitous throughout the earth's crust, with variable concentrations in rocks, soil, and water, and therefore it would be expected to be present at variable concentrations in the various types of sediment samples.

The 2017 ^{40}K concentrations in sediment were compared to the 99 percent confidence interval range of the baseline concentrations including 1.20E+00 Bq/g for the tanks and tank-like structures and 5.00E-01 Bq/g for the Pecos River and associated bodies of water. All the 2017 ^{40}K concentrations were lower than the associated baseline concentrations.

Table 4.14 – 2017 Gamma Radionuclides and ^{90}Sr Concentrations in Sediment Samples Taken Near the WIPP Site

Location	Date	^{40}K					^{60}Co				
		[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf.[d]	Q[e]	[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf.[d]	Q[e]
RED	4/20/2017	3.51E-01	5.62E-02	2.17E-02	0.997	+	2.14E-04	2.01E-03	2.38E-03	0.000	U
NOY	4/20/2017	5.12E-01	7.49E-02	1.94E-02	1.000	+	-6.35E-04	1.65E-03	1.83E-03	0.000	U
HIL	4/10/2017	9.26E-01	1.31E-01	2.54E-02	0.994	+	1.39E-03	2.22E-03	2.78E-03	0.000	U
TUT	6/21/2017	6.55E-01	1.00E-01	2.03E-02	1.000	+	1.12E-04	1.92E-03	2.23E-03	0.000	U
PKT	8/2/2017	7.66E-01	1.17E-01	2.39E-02	0.999	+	4.12E-04	2.18E-03	2.55E-03	0.000	U
PKT Dup	8/2/2017	7.86E-01	1.33E-01	4.07E-02	0.995	+	1.54E-03	3.68E-03	4.67E-03	0.000	U
IDN	6/8/2017	5.55E-01	9.33E-02	2.85E-02	1.000	+	-1.32E-03	3.13E-03	3.30E-03	0.000	U
PCN	4/13/2017	4.05E-01	6.59E-02	2.32E-02	0.996	+	-6.92E-05	2.49E-03	2.90E-03	0.000	U
CBD	4/13/2017	2.00E-01	3.30E-02	1.49E-02	0.998	+	-7.23E-04	1.44E-03	1.51E-03	0.000	U
BRA	4/13/2017	2.37E-01	5.15E-02	3.47E-02	1.000	+	-9.84E-04	3.16E-03	3.45E-03	0.000	U
UPR	4/13/2017	3.60E-01	5.38E-02	1.55E-02	0.991	+	2.00E-04	1.59E-03	1.84E-03	0.000	U
UPR Dup	4/13/2017	4.29E-01	6.93E-02	2.56E-02	0.998	+	2.43E-03	2.37E-03	3.23E-03	0.000	U
LST	4/20/2017	4.65E-01	6.96E-02	2.12E-02	0.999	+	-1.12E-04	1.97E-03	2.26E-03	0.000	U
BHT	4/20/2017	6.09E-01	9.16E-02	2.73E-02	0.984	+	-5.88E-05	2.61E-03	2.97E-03	0.000	U

Location	Date	^{137}Cs					^{90}Sr			
		[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf.[d]	Q[e]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[e]
RED	4/20/2017	1.63E-03	2.11E-03	2.54E-03	0.000	U	2.46E-03	6.92E-03	1.12E-02	U
NOY	4/20/2017	9.37E-04	1.39E-03	1.74E-03	0.000	U	2.72E-03	6.83E-03	1.12E-02	U
HIL	4/10/2017	4.08E-03	1.55E-03	2.05E-03	0.997	+	-1.21E-03	4.54E-03	1.14E-02	U
TUT	6/21/2017	9.91E-04	1.89E-03	2.20E-03	0.000	U	-3.12E-03	4.52E-03	1.51E-02	U
PKT	8/2/2017	8.89E-03	2.06E-03	1.91E-03	1.000	+	-8.93E-04	4.40E-03	1.51E-02	U
PKT Dup	8/2/2017	8.64E-03	3.49E-03	4.58E-03	1.000	+	-4.46E-03	4.45E-03	1.51E-02	U
IDN	6/8/2017	5.78E-03	2.17E-03	2.74E-03	0.998	+	9.97E-04	4.64E-03	1.51E-02	U
PCN	4/13/2017	2.56E-03	1.95E-03	2.61E-03	0.000	U	-2.89E-03	4.18E-03	1.13E-02	U
CBD	4/13/2017	1.18E-04	1.42E-03	1.60E-03	0.000	U	-2.35E-03	3.92E-03	1.13E-02	U
BRA	4/13/2017	2.15E-03	2.69E-03	3.60E-03	0.000	U	-2.26E-03	3.97E-03	1.13E-02	U
UPR	4/13/2017	-4.18E-04	1.49E-03	1.70E-03	0.000	U	-1.16E-03	4.14E-03	1.13E-02	U
UPR Dup	4/13/2017	7.79E-04	2.21E-03	2.71E-03	0.000	U	6.29E-04	7.20E-03	1.12E-02	U
LST	4/20/2017	1.83E-03	1.00E-03	1.45E-03	1.000	+	5.19E-03	6.80E-03	1.12E-02	U
BHT	4/20/2017	7.07E-03	2.10E-03	2.49E-03	0.999	+	3.38E-03	7.06E-03	1.12E-02	U

Notes: See Appendix C for sampling location codes. Units are in Bq/g, dry weight.

PKT and UPR used for field duplicates.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) ID Conf. = Identification confidence for gamma radionuclides. Value >0.90 implies detection if the sample activity is greater than 2 σ TPU and MDC.

(e) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected; U equals undetected.

The ANOVA calculations for ^{137}Cs were based on only three common locations (HIL, PKT, and BHT) and showed that the sediment concentrations did not vary significantly between years (ANOVA ^{137}Cs, p = 0.999). The ANOVA calculation by location yielded ANOVA, ^{137}Cs, p = 0.152 indicating no significant variation in the concentrations by location of this limited sample set. There were no detections of ^{137}Cs in the Pecos River and associated bodies of water in 2016 and 2017; therefore, the ANOVA calculations apply only to the tanks and tank-like structures.

The ^{137}Cs concentrations in the tanks and tank-like structures were less than the 99 percent confidence interval range of the baseline concentration of 3.50E–02 Bq/g. The 99 percent confidence interval range of the baseline concentration for ^{137}Cs in the Pecos River and associated bodies of water is 5.00E-03 Bq/g, but there were no detections to compare to this value.

Cesium-137 is a fission product and is consistently found in sediment because of global fallout from atmospheric nuclear weapons testing (Beck and Bennett, 2002; UNSCEAR, 2000). Thus, it is not present in sediments in the same manner as ^{40}K, which is abundant in rocks and soils. The concentrations of ^{137}Cs would be expected to gradually decrease with a half-life of about 30 years and no significant additions to the environment. The number of ^{137}Cs detections has been decreasing each year as discussed above.

Because ^{90}Sr and ^{60}Co were not detected in any of the sediment samples (Table 4.14), no ANOVA comparisons among sampling locations or between years could be calculated.

Duplicate analyses were performed for the target radionuclides in sediment samples from sampling locations PKT and UPR. Precision calculations as RER were performed for all the target radionuclides, as shown in Table 4.15. The qualifier column shows which radionuclides were detected in the samples.

As noted above $^{239/240}$Pu was detected in the PKT duplicate sample but not the primary sample resulting in the only RER value greater than 1.96 (2.201). The same situation applied to the HIL duplicate samples in 2016 when $^{239/240}$Pu was detected in the primary sample but not the duplicate sample. The $^{239/240}$Pu could be associated with particulate matter and it could be possible for the distribution to be different in different samples from the same location.

Ninety five percent of the RER values were <1.96, which is better than the field duplicate precision objective of 85 percent of the values less than 1.96 and demonstrates good precision for the combined sediment sampling and analysis procedures.

Table 4.15 – 2017 Precision Results for Duplicate Sediment Samples

Radionuclide	PKT		PKT Duplicate		RER[c]	Q[d]
	[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]		
$^{233/234}U$	1.84E-02	1.55E-03	2.76E-02	2.47E-03	3.155	+
^{235}U	6.40E-04	1.64E-04	9.76E-04	2.16E-04	1.239	+
^{238}U	2.00E-02	1.67E-03	2.63E-02	2.36E-03	2.179	+
^{238}Pu	5.07E-05	4.58E-05	1.19E-04	6.87E-05	0.827	U
$^{239/240}Pu$	1.69E-04	7.60E-05	5.83E-04	1.41E-04	2.585	U/+ [e]
^{241}Am	9.28E-05	6.58E-05	1.25E-04	7.56E-05	0.321	U
^{40}K	7.66E-01	5.97E-02	7.86E-01	6.79E-02	0.221	+
^{60}Co	4.12E-04	1.11E-03	1.54E-03	1.88E-03	0.517	U
^{137}Cs	8.89E-03	1.05E-03	8.64E-03	1.78E-03	0.121	+
^{90}Sr	-8.93E-04	2.25E-03	-4.46E-03	2.27E-03	1.116	U
Radionuclide	**UPR**		**UPR Duplicate**		**RER[c]**	**Q[d]**
	[RN][a]	**1 σ TPU[b]**	**[RN][a]**	**1 σ TPU[b]**		
$^{233/234}U$	2.19E-02	1.90E-03	2.20E-02	2.12E-03	0.035	+
^{235}U	9.06E-04	2.03E-04	8.43E-04	1.85E-04	0.229	+
^{238}U	1.90E-02	1.67E-03	2.23E-02	2.14E-03	1.216	+
^{238}Pu	7.17E-05	4.70E-05	-2.15E-05	2.62E-05	1.732	U
$^{239/240}Pu$	2.93E-05	4.42E-05	4.27E-05	5.21E-05	0.196	U
^{241}Am	1.11E-04	6.58E-05	3.45E-05	3.45E-05	1.030	U
^{40}K	3.60E-01	2.74E-02	4.29E-01	3.54E-02	1.541	+
^{60}Co	2.00E-04	8.11E-04	2.43E-03	1.21E-03	1.531	U
^{137}Cs	-4.18E-04	7.60E-04	7.79E-04	1.13E-03	0.879	U
^{90}Sr	-1.16E-03	2.11E-03	6.29E-04	3.68E-03	0.422	U

Notes: See Appendix C for sampling location codes. Units are Bq/g, dry weight.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty at the one sigma level.

(c) RER = relative error ratio.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected; U equals undetected.

(e) +/U. $^{239/240}$ Pu detected in the duplicate PKT sample but not the primary sample.

4.6 Soil Samples

4.6.1 Sample Collection

Regular soil samples were collected from the same six locations where the low-volume air samplers are stationed around the WIPP site: WFF, WEE, WSS, MLR, SEC, and SMR (Figure 4.4). Samples were collected from each location in three incremental profiles: surface (shallow) soil (0–2 cm [0–0.8 in.]), intermediate soil (2–5 cm [0.8–2 in.]), and deep soil (5–10 cm [2–4 in.]). Measurements of radionuclides in depth profiles may provide information about their vertical movements in the soil systems.

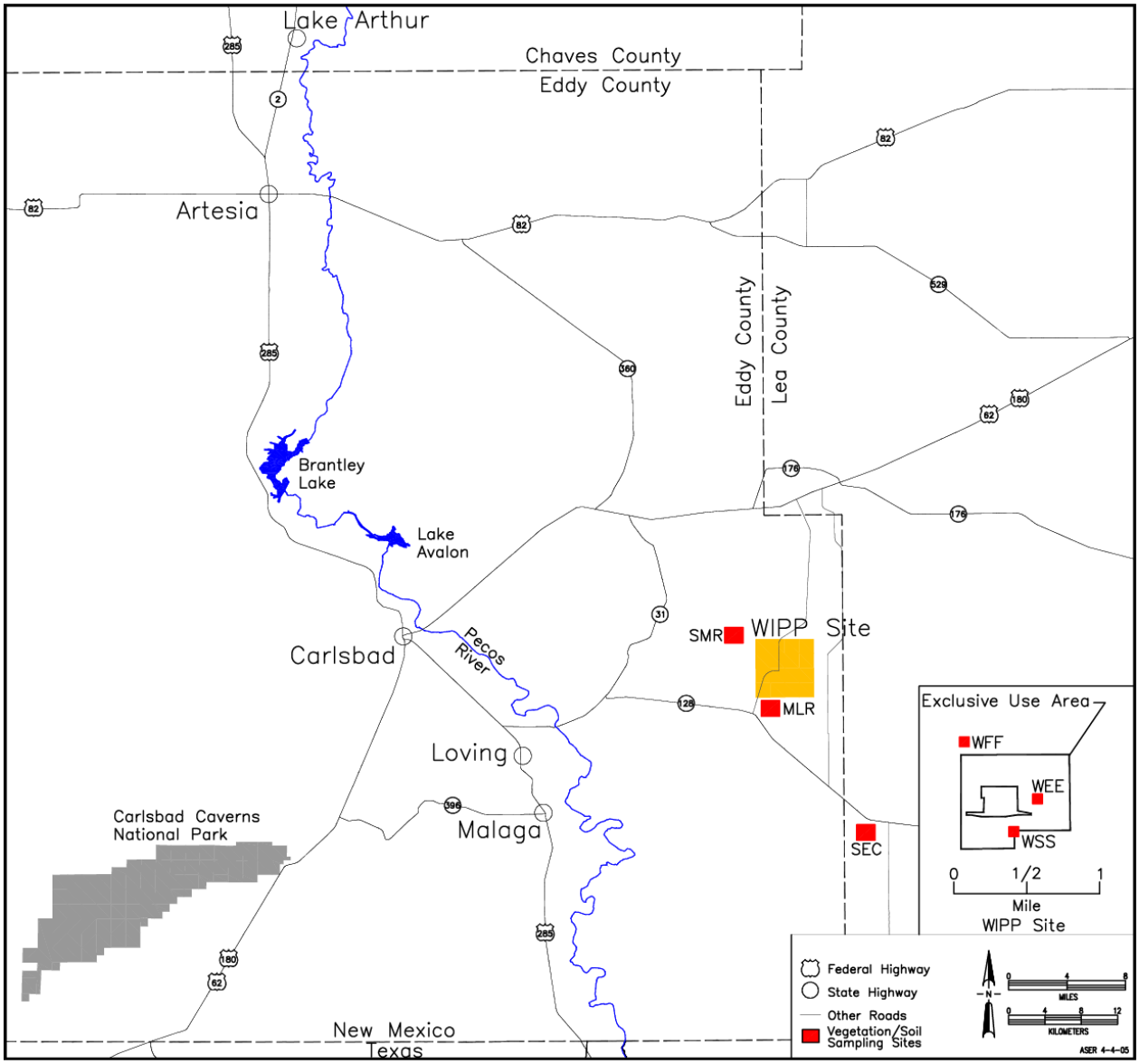

Figure 4.4 – Routine Soil and Vegetation Sampling Locations

Soil sample locations are divided into three geographic groups.

- The WIPP site group covers the smallest area with locations within 1 km of the WHB and Exhaust Shaft and includes WFF, WEE, and WSS.
- The 5-mile ring includes MLR and SMR.
- The outer sites group only includes sampling location SEC.

Soil samples were collected at location WFF and WEE on February 27, 2017, at WSS on March 2, 2017, at MLR on March 13, 2017, and at SEC (duplicates) and SMR on March 16, 2017.

4.6.2 Sample Preparation

Soil samples were dried at 110°C (230°F) for several hours and homogenized by grinding to small particles. Tracers (^{232}U, ^{243}Am, and ^{242}Pu) and a carrier (strontium nitrate) were added to a 2-gram aliquot of each of the dried and homogenized soil samples, which were subsequently dissolved by heating with a mixture of nitric, hydrochloric, and hydrofluoric acids. The sample residues were heated with nitric and boric acids to remove hydrofluoric acid. Finally, the residues were dissolved in nitric acid for processing the individual radionuclide concentrations.

4.6.3 Determination of Individual Radionuclides

The nitric acid digestates of the soil samples were split into two fractions. One fraction was analyzed by gamma spectroscopy for ^{40}K, ^{60}Co, and ^{137}Cs. The other fraction was analyzed sequentially for the uranium/transuranic radioisotopes and ^{90}Sr by employing a series of chemical, physical, and ion exchange separations as described in Section 4.2.3, then mounting the sample residues on a planchet for counting. The uranium/transuranic isotopes were measured by alpha spectroscopy and the ^{90}Sr by gas proportional counting.

4.6.4 Results and Discussion

Table 4.16 presents the uranium isotope analysis data for the 2017 soil samples including a set of duplicate samples collected at SEC. As shown in the table, $^{233/234}$U and ^{238}U were detected in all soil samples, while ^{235}U was detected in the shallow and deep samples from WFF; all three depths from WEE; the shallow and deep sample from WSS; the intermediate and deep sample from MLR; the shallow and deep samples in both the primary and duplicate samples from SEC; and all three depths at SMR.

In comparing the 2016 and 2017 uranium data, the average of the primary and duplicate samples was used for MLR in 2016 and SEC in 2017.

Table 4.16 – 2017 Uranium Isotope Concentrations in Soil Samples Taken at or Near the WIPP Site

Location	Depth (cm)	Date	$^{233/234}U$				^{235}U				^{238}U			
			[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
WFF	0 - 2	2/27/2017	5.15E-03	1.11E-03	7.19E-04	+	5.58E-04	2.97E-04	3.04E-04	+	5.94E-03	1.24E-03	6.09E-04	+
WFF	2 - 5	2/27/2017	5.90E-03	1.08E-03	7.11E-04	+	2.58E-04	1.89E-04	2.96E-04	U	5.75E-03	1.06E-03	5.99E-04	+
WFF	5 - 10	2/27/2017	6.89E-03	1.30E-03	7.17E-04	+	3.89E-04	2.46E-04	3.07E-04	+	7.01E-03	1.31E-03	6.05E-04	+
WEE	0 - 2	2/27/2017	7.69E-03	1.44E-03	7.18E-04	+	3.22E-04	2.23E-04	3.06E-04	+	7.22E-03	1.36E-03	6.05E-04	+
WEE	2 - 5	2/27/2017	6.61E-03	1.20E-03	7.10E-04	+	3.02E-04	2.06E-04	2.97E-04	+	6.00E-03	1.12E-03	5.99E-04	+
WEE	5 - 10	2/27/2017	6.76E-03	1.33E-03	7.20E-04	+	4.71E-04	2.73E-04	3.08E-04	+	7.05E-03	1.37E-03	6.07E-04	+
WSS	0 - 2	3/2/2017	6.79E-03	1.32E-03	7.14E-04	+	4.23E-04	2.54E-04	3.05E-04	+	7.40E-03	1.41E-03	6.02E-04	+
WSS	2 - 5	3/2/2017	6.59E-03	1.26E-03	7.15E-04	+	2.04E-04	1.78E-04	3.04E-04	U	7.30E-03	1.36E-03	6.11E-04	+
WSS	5 - 10	3/2/2017	6.38E-03	1.26E-03	7.20E-04	+	5.27E-04	2.95E-04	3.19E-04	+	6.33E-03	1.25E-03	6.07E-04	+
MLR	0 - 2	3/13/2017	1.10E-02	1.89E-03	6.55E-04	+	2.94E-04	2.13E-04	3.04E-04	U	1.15E-02	1.96E-03	6.32E-04	+
MLR	2 - 5	3/13/2017	1.26E-02	2.33E-03	6.66E-04	+	3.51E-04	2.38E-04	3.05E-04	+	1.15E-02	2.16E-03	6.44E-04	+
MLR	5 - 10	3/13/2017	1.18E-02	2.01E-03	6.56E-04	+	6.28E-04	3.08E-04	2.98E-04	+	1.13E-02	1.93E-03	6.33E-04	+
SEC	0 - 2	3/16/2017	9.03E-03	1.60E-03	6.60E-04	+	3.55E-04	2.35E-04	3.03E-04	+	7.75E-03	1.42E-03	6.36E-04	+
SEC	2 - 5	3/16/2017	7.69E-03	1.38E-03	6.58E-04	+	1.94E-04	1.78E-04	3.06E-04	U	7.09E-03	1.29E-03	6.36E-04	+
SEC	5 - 10	3/16/2017	8.60E-03	1.55E-03	6.60E-04	+	3.91E-04	2.44E-04	3.01E-04	+	8.57E-03	1.55E-03	6.34E-04	+
SEC Dup	0 - 2	3/16/2017	9.41E-03	2.74E-03	6.99E-04	+	5.62E-04	3.94E-04	3.75E-04	+	8.20E-03	2.43E-03	7.02E-04	+
SEC Dup	2 - 5	3/16/2017	8.62E-03	1.66E-03	6.77E-04	+	2.83E-04	2.20E-04	3.19E-04	U	9.02E-03	1.72E-03	6.38E-04	+
SEC Dup	5 - 10	3/16/2017	8.60E-03	1.49E-03	6.65E-04	+	3.88E-04	2.37E-04	2.94E-04	+	8.62E-03	1.49E-03	6.30E-04	+
SMR	0 - 2	3/16/2017	1.83E-02	3.50E-03	6.88E-04	+	5.27E-04	3.21E-04	3.28E-04	+	1.88E-02	3.59E-03	6.53E-04	+
SMR	2 - 5	3/16/2017	1.72E-02	4.62E-03	7.04E-04	+	6.98E-04	4.58E-04	4.01E-04	+	1.80E-02	4.82E-03	7.07E-04	+
SMR	5 - 10	3/16/2017	1.76E-02	3.83E-03	7.02E-04	+	6.82E-04	3.92E-04	3.45E-04	+	1.84E-02	3.99E-03	6.72E-04	+

Notes: See Appendix C for sampling location codes. Units are in Bq/g, dry weight.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

Using ANOVA, the concentrations of the uranium isotopes were compared between 2016 and 2017 and between sampling locations using all three sample depths in the calculation. There were 18 common locations for $^{233/234}$U and ^{238}U. However, for ^{235}U, there were variable detections both years and cases where the radionuclide was detected in one of the duplicates but not the other. The detected concentrations were used for the ANOVA calculations resulting in only 4 of 18 possible common locations for ^{235}U between 2016 and 2017. The ANOVA calculations showed that the concentrations of $^{233/234}$U and ^{238}U did not vary significantly between 2016 and 2017 (ANOVA $^{233/234}$U, p = 0.907 and ANOVA ^{238}U, p = 0.990). The ^{235}U does not normally track very closely with the other two uranium isotopes and yielded a p value just above the significance level (ANOVA ^{235}U, p = 0.0770).

The 2017 ANOVA calculations showed significant variation for $^{233/234}$U and ^{238}U by location (ANOVA $^{233/234}$U, p = 3.72E-03 and ANOVA ^{238}U, p = 4.87E-14). The p value for ^{235}U, which was based on many fewer common locations, showed no significant variation between locations with ANOVA ^{235}U, p = 0.581 and again did not track with the other uranium isotopes.

There are three soil baseline concentrations for the three uranium isotopes based on location. The WIPP site group of baseline concentrations is for locations WFF, WEE, and WSS; the 5-mile ring sites include SMR and MLR; and the outer sites include SEC.

The highest concentrations of $^{233/234}$U measured in 2017 was 1.83E-02 Bq/g at the 0 - 2 cm depth from location SMR. This concentration fell within the 99 percent confidence interval baseline concentration of 2.20E−02 Bq/g for SMR and MLR.

The highest ^{235}U concentration was 6.98E-04 Bq/g at the 2 - 5 cm depth at location SMR. The concentration was lower than the 99 percent confidence interval concentration of 1.70E–03 Bq/g for SMR and MLR.

The highest ^{238}U concentration was 1.88E-02 Bq/g in the 0 - 2 cm depth sample from SMR. The concentration was higher than the 99 percent confidence interval range of the baseline concentration of 1.30E–02 Bq/g for SMR and MLR (DOE/WIPP-92-037). The concentrations of 1.80E-02 Bq/g at the 2 – 5 cm depth and 1.84E-02 Bq/g at the 5 – 10 cm depth at SMR were also higher than the 99 percent confidence interval range of the baseline concentration. The highest uranium isotope concentrations and locations in 2017 were the same as in 2016.

None of the 2017 uranium isotope concentrations were higher than the 99 percent confidence interval concentrations for three WIPP site locations (8.60E-03 Bq/g for $^{233/234}$U; 9.50E-04 Bq/g for ^{235}U; and 1.10E-02 Bq/g for ^{238}U.). Likewise, none of the measured uranium isotope concentrations were higher than the 99 percent confidence interval concentration for the SEC outer site (3.70E-02 Bq/g for $^{233/234}$U; 3.70E-03 Bq/g for ^{235}U; and 3.20E-02 Bq/g for ^{238}U.)

Table 4.17 presents the analysis data for ^{238}Pu, $^{239/240}$Pu, and ^{241}Am. There were two detections of $^{239/240}$Pu, which were at the shallow and intermediate depths at SMR. There was one detection of $^{239/240}$Pu in 2016 at the intermediate depth from SMR. There were not enough data points to perform ANOVA calculations. The detected concentrations of $^{239/240}$Pu were lower than the baseline concentration of 1.90E-03 Bq/g. This observation for $^{239/240}$Pu applies to all soil depths at all locations.

Table 4.18 presents the 2017 soil sample analysis data for the gamma radionuclides and ^{90}Sr. The data in Table 4.18 show that ^{40}K was detected in all the samples and ^{137}Cs was at the shallow and deep samples from WEE, the shallow and intermediate samples from WSS and MLR, and samples from all three depths from SEC (duplicates) and SMR. ^{137}Cs was detected in all the samples at all depths in 2016. ^{60}Co and ^{90}Sr were not detected in any of the samples.

There was no significant variation in the ^{40}K concentrations between 2016 and 2017 (ANOVA ^{40}K, p = 0.294). The p value for ^{40}K was higher in 2016 (0.859). All measured ^{40}K concentrations were lower in 2017 compared to 2016. There was significant variation in the concentrations between locations, including the various soil depths (ANOVA ^{40}K, p = 9.38E-08). This appears to be due to the concentrations at SMR being significantly higher than at the other locations.

Potassium-40 is a naturally occurring gamma-emitting radionuclide that is ubiquitous in soils with various concentrations, depending on weathering of various rock and mineral sources.

The baseline concentrations for ^{40}K vary by location in the same manner as the uranium isotopes are higher for locations more distant from the WIPP. The measured concentrations were compared to the baseline concentrations which include WIPP Site locations (WFF, WEE, and WSS) with a baseline concentration of 2.80E-01 Bq/g; the 5-mile ring locations (SMR and MLR) with a baseline concentration of 3.40E-01 Bq/g; and the Outer Ring Site (SEC) with a baseline concentration of 7.80E-01 Bq/g (DOE/WIPP–92–037). The MLR 5-mile ring shallow sample concentration of 3.42 E-01 Bq/g and the MLR intermediate sample concentration of 3.66E-01 Bq/g were higher than the baseline concentration of 3.40 Bq/g. The MLR deep sample concentration of 3.36 Bq/g was just below the baseline concentration. The SMR 5-mile ring shallow concentration of 7.50 E-01 Bq/g, the SMR intermediate sample concentration of 6.32E-01 Bq/g, and the SMR deep sample concentration of 6.25E-01 Bq/g were all higher than the baseline concentration of 3.40E-01 Bq/g. None of the 40K conenctrations were above the baseline for WIPP site locations WFF, WEE, and WSS.Statistical analyses for ^{137}Cs were performed for 12 common locations. The average concentrations were used for the duplicate samples at MLR in 2016 and SEC in 2017.

The ANOVA calculations showed significantly different p values by year and by location for 2017 compared to 2016. The p value comparing the concentrations by year showed no significant difference between the concentrations (ANOVA ^{137}Cs, p = 0.177) compared to p = 0.578 in 2016. The p value comparing concentrations by location also

showed no significant difference between concentrations by location (ANOVA ^{137}Cs, p = 0.149) compared to p = 5.21E-07 in 2016. The differences in the p values may be due to fewer concentrations to compare between years and generally lower concentrations.

Table 4.17 – 2017 Plutonium Isotope and Americium Concentrations in Soil Samples Taken at or Near the WIPP Site

Location	Depth (cm)	Sampling Date	^{238}Pu				$^{239/240}$Pu				^{241}Am			
			[RN][a]	2 ×TPU[b]	MDC[c]	Q[d]	[RN][a]	2 × TPU[b]	MDC[c]	Q[d]	[RN][a]	2 × TPU[b]	MDC[c]	Q[d]
WFF	0 - 2	2/27/2017	-9.63E-06	3.27E-05	2.91E-04	U	4.33E-05	8.95E-05	2.97E-04	U	1.02E-05	7.77E-05	3.57E-04	U
WFF	2 - 5	2/27/2017	-1.75E-05	4.49E-05	2.95E-04	U	1.07E-04	1.23E-04	3.05E-04	U	2.59E-05	9.73E-05	3.37E-04	U
WFF	5 - 10	2/27/2017	1.26E-05	6.03E-05	2.79E-04	U	2.53E-04	1.70E-04	2.94E-04	U	7.27E-05	9.97E-05	3.23E-04	U
WEE	0 - 2	2/27/2017	2.88E-05	9.78E-05	3.11E-04	U	7.68E-05	1.03E-04	2.97E-04	U	9.84E-05	1.21E-04	3.30E-04	U
WEE	2 - 5	2/27/2017	1.42E-05	6.80E-05	2.97E-04	U	1.30E-04	1.29E-04	2.95E-04	U	5.19E-05	8.16E-05	3.26E-04	U
WEE	5 - 10	2/27/2017	-1.37E-05	3.80E-05	2.83E-04	U	1.73E-04	1.49E-04	2.93E-04	U	6.30E-05	1.06E-04	3.29E-04	U
WSS	0 - 2	3/2/2017	3.87E-05	8.61E-05	2.93E-04	U	9.11E-05	1.16E-04	2.92E-04	U	-3.47E-06	1.92E-05	3.21E-04	U
WSS	2 - 5	3/2/2017	7.43E-05	1.09E-04	2.94E-04	U	1.19E-04	1.43E-04	3.17E-04	U	4.34E-05	8.97E-05	3.34E-04	U
WSS	5 - 10	3/2/2017	4.51E-06	7.01E-05	2.90E-04	U	1.73E-04	1.41E-04	2.90E-04	U	2.56E-05	6.51E-05	3.29E-04	U
MLR	0 - 2	3/13/2017	7.01E-05	9.41E-05	2.80E-04	U	2.63E-04	1.63E-04	3.14E-04	U	1.06E-04	1.26E-04	3.20E-04	U
MLR	2 - 5	3/13/2017	3.01E-05	5.90E-05	2.82E-04	U	1.96E-04	1.62E-04	3.29E-04	U	1.94E-05	6.58E-05	3.09E-04	U
MLR	5 - 10	3/13/2017	-8.25E-06	3.03E-05	2.84E-04	U	7.42E-05	1.05E-04	3.20E-04	U	4.18E-05	9.06E-05	3.14E-04	U
SEC	0 - 2	3/16/2017	-8.29E-06	3.04E-05	2.94E-04	U	1.91E-04	1.55E-04	3.23E-04	U	-6.15E-06	8.37E-05	3.37E-04	U
SEC	2 - 5	3/16/2017	5.14E-05	7.52E-05	2.74E-04	U	1.77E-04	1.42E-04	3.13E-04	U	1.06E-04	1.13E-04	3.05E-04	U
SEC	5 - 10	3/16/2017	-5.80E-06	2.45E-05	2.77E-04	U	1.02E-04	1.09E-04	3.13E-04	U	2.35E-05	6.54E-05	3.16E-04	U
SEC Dup	0 - 2	3/16/2017	8.18E-05	9.72E-05	2.74E-04	U	8.34E-05	9.64E-05	3.11E-04	U	2.11E-04	1.72E-04	3.72E-04	U
SEC Dup	2 - 5	3/16/2017	5.19E-06	8.05E-05	3.01E-04	U	1.39E-04	1.39E-04	3.23E-04	U	7.72E-05	1.04E-04	3.29E-04	U
SEC Dup	5 - 10	3/16/2017	-1.91E-05	4.47E-05	2.86E-04	U	6.95E-05	9.93E-05	3.14E-04	U	4.47E-05	9.94E-05	3.38E-04	U
SMR	0 - 2	3/16/2017	2.15E-05	5.77E-05	2.68E-04	U	4.03E-04	2.04E-04	3.32E-04	+	1.45E-05	8.59E-05	3.49E-04	U
SMR	2 - 5	3/16/2017	4.79E-05	9.61E-05	2.83E-04	U	5.16E-04	2.56E-04	3.55E-04	+	1.57E-04	2.45E-04	5.14E-04	U
SMR	5 - 10	3/16/2017	9.61E-05	1.29E-04	3.05E-04	U	2.40E-04	1.91E-04	3.47E-04	U	1.87E-04	1.92E-04	3.79E-04	U

Notes: See Appendix C for sampling location codes. Units are in Bq/g, dry weight.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

Table 4.18 – 2017 Gamma Radionuclide and ^{90}Sr Concentrations in Soil Samples Taken at or Near the WIPP Site

Location	Depth (cm)	Sampling Date	^{40}K					^{60}Co				
			[RN][a]	2 × TPU[b]	MDC[c]	ID Conf.	Q[d]	[RN][a]	2 × TPU[b]	MDC[c]	ID Conf.	Q[d]
WFF	0 - 2	2/27/2017	1.63E-01	2.80E-02	1.41E-02	1.00	+	5.31E-04	9.09E-04	1.20E-03	0.00	U
WFF	2 - 5	2/27/2017	1.60E-01	3.40E-02	2.43E-02	1.00	+	-9.71E-06	6.71E-04	7.73E-04	0.00	U
WFF	5 - 10	2/27/2017	1.95E-01	3.29E-02	1.59E-02	0.997	+	6.76E-04	6.74E-04	8.71E-04	0.00	U
WEE	0 - 2	2/27/2017	2.32E-01	3.77E-02	1.63E-02	1.00	+	3.60E-04	6.79E-04	8.67E-04	0.00	U
WEE	2 - 5	2/27/2017	2.04E-01	3.96E-02	1.87E-02	0.999	+	-2.41E-04	1.62E-03	1.84E-03	0.00	U
WEE	5 - 10	2/27/2017	2.25E-01	3.69E-02	1.56E-02	0.999	+	-1.34E-04	7.01E-04	7.98E-04	0.00	U
WSS	0 - 2	3/2/2017	1.76E-01	3.45E-02	1.93E-02	1.00	+	-3.60E-04	1.05E-03	1.16E-03	0.00	U
WSS	2 - 5	3/2/2017	2.17E-01	3.66E-02	1.81E-02	1.00	+	5.44E-05	7.14E-04	8.16E-04	0.00	U
WSS	5 - 10	3/2/2017	1.98E-01	4.26E-02	2.78E-02	1.00	+	2.29E-04	7.15E-04	8.55E-04	0.00	U
MLR	0 - 2	3/13/2017	3.42E-01	5.24E-02	1.87E-02	1.00	+	-2.88E-04	8.78E-04	9.76E-04	0.00	U
MLR	2 - 5	3/13/2017	3.66E-01	5.91E-02	1.70E-02	1.00	+	7.85E-04	1.21E-03	1.55E-03	0.00	U
MLR	5 - 10	3/13/2017	3.36E-01	5.61E-02	2.07E-02	0.999	+	4.82E-04	8.99E-04	1.08E-03	0.00	U
SEC	0 - 2	3/16/2017	2.07E-01	4.33E-02	2.22E-02	1.00	+	-2.16E-04	6.69E-04	7.25E-04	0.00	U
SEC	2 - 5	3/16/2017	2.03E-01	4.16E-02	2.60E-02	1.00	+	2.56E-04	8.38E-04	9.95E-04	0.00	U
SEC	5 - 10	3/16/2017	2.20E-01	3.84E-02	1.60E-02	1.00	+	-4.43E-04	7.72E-04	8.05E-04	0.00	U
SEC Dup	0 - 2	3/16/2017	2.46E-01	3.93E-02	1.59E-02	1.00	+	2.46E-04	8.68E-04	1.03E-03	0.00	U
SEC Dup	2 - 5	3/16/2017	2.13E-01	3.46E-02	1.54E-02	0.999	+	2.05E-04	8.87E-04	1.06E-03	0.00	U
SEC Dup	5 - 10	3/16/2017	2.26E-01	3.72E-02	1.65E-02	1.00	+	-2.01E-04	1.34E-03	1.54E-03	0.00	U
SMR	0 - 2	3/16/2017	7.50E-01	1.08E-01	2.43E-02	1.00	+	6.58E-05	1.24E-03	1.45E-03	0.00	U
SMR	2 - 5	3/16/2017	6.32E-01	9.79E-02	2.88E-02	1.00	+	9.50E-04	1.22E-03	1.50E-03	0.00	U
SMR	5 - 10	3/16/2017	6.25E-01	9.04E-02	2.08E-02	0.999	+	1.94E-03	1.09E-03	1.50E-03	0.00	U

Location	Depth (cm)	Sampling Date	^{137}Cs					^{90}Sr			
			[RN][a]	2 × TPU[b]	MDC[c]	ID Conf.	Q[d]	[RN][a]	2 × TPU[b]	MDC[c]	Q[d]
WFF	0 - 2	2/27/2017	2.38E-04	1.20E-03	1.45E-03	0.00	U	-3.75E-03	5.36E-03	1.30E-02	U
WFF	2 - 5	2/27/2017	1.61E-03	1.79E-03	2.34E-03	0.00	U	-1.15E-03	5.23E-03	1.30E-02	U
WFF	5 - 10	2/27/2017	1.58E-03	1.44E-03	1.86E-03	0.00	U	-6.03E-03	5.28E-03	1.30E-02	U
WEE	0 - 2	2/27/2017	2.23E-03	8.95E-04	1.18E-03	1.00	+	-2.20E-03	4.99E-03	1.30E-02	U
WEE	2 - 5	2/27/2017	9.02E-04	2.12E-03	2.65E-03	0.00	U	-2.09E-03	5.08E-03	1.30E-02	U
WEE	5 - 10	2/27/2017	1.86E-03	9.98E-04	1.44E-03	1.00	+	8.83E-04	4.97E-03	1.30E-02	U
WSS	0 - 2	3/2/2017	2.18E-03	1.07E-03	1.45E-03	0.991	+	-2.87E-03	5.78E-03	1.31E-02	U
WSS	2 - 5	3/2/2017	1.82E-03	9.54E-04	1.37E-03	0.998	+	-2.07E-03	5.49E-03	1.30E-02	U
WSS	5 - 10	3/2/2017	1.41E-03	1.11E-03	1.65E-03	0.999	U	-7.53E-04	5.24E-03	1.30E-02	U
MLR	0 - 2	3/13/2017	5.60E-03	1.50E-03	1.72E-03	1.00	+	-2.30E-03	4.84E-03	1.11E-02	U
MLR	2 - 5	3/13/2017	2.10E-03	9.70E-04	1.29E-03	0.998	+	-3.47E-03	4.57E-03	1.10E-02	U
MLR	5 - 10	3/13/2017	1.13E-03	8.32E-04	1.24E-03	0.993	U	-4.26E-05	4.66E-03	1.10E-02	U
SEC	0 - 2	3/16/2017	2.82E-03	1.36E-03	1.76E-03	0.997	+	-4.05E-03	4.69E-03	1.11E-02	U
SEC	2 - 5	3/16/2017	3.41E-03	1.17E-03	1.28E-03	0.998	+	-3.84E-03	4.62E-03	1.10E-02	U
SEC	5 - 10	3/16/2017	1.55E-03	7.03E-04	9.04E-04	0.999	+	-4.53E-03	4.60E-03	1.10E-02	U
SEC Dup	0 - 2	3/16/2017	3.14E-03	1.08E-03	1.38E-03	1.00	+	2.98E-03	5.68E-03	1.09E-02	U
SEC Dup	2 - 5	3/16/2017	1.70E-03	9.55E-04	1.40E-03	0.999	+	9.22E-04	4.60E-03	1.07E-02	U
SEC Dup	5 - 10	3/16/2017	1.47E-03	7.30E-04	1.01E-03	1.00	+	1.21E-03	4.67E-03	1.07E-02	U
SMR	0 - 2	3/16/2017	7.14E-03	1.97E-03	2.27E-03	1.00	+	-9.80E-04	5.04E-03	1.07E-02	U
SMR	2 - 5	3/16/2017	5.94E-03	1.96E-03	2.39E-03	1.00	+	2.64E-03	6.19E-03	1.10E-02	U
SMR	5 - 10	3/16/2017	3.96E-03	1.55E-03	2.09E-03	0.997	+	-7.11E-04	5.46E-03	1.08E-02	U

Notes: See Appendix C for sampling location codes. Units are in Bq/g, dry weight.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

The ^{137}Cs 99 percent confidence interval range of baseline concentrations was determined according to distance from the WIPP site. The values are 2.40E-02 Bq/g both for the locations near the WIPP site (WFF, WEE, WSS) and within the five-mile ring sites (SMR, MLR), and 4.00E-02 Bq/g for outer site (SEC). As shown in Table 4.18, none of the 2017 ^{137}Cs concentrations were higher than the 99 percent confidence interval range of the baseline concentrations. Cesium-137 is a fission product and is ubiquitous in soils because of global fallout from atmospheric nuclear weapons testing (Beck and Bennett, 2002; UNSCEAR, 2000). The concentrations of the radionuclide would be expected to gradually decrease with a half-life of about 30 years and no significant additions to the environment. This expected trend became more apparent in 2017, with most concentrations decreasing.

Since ^{90}Sr and ^{60}Co were not detected at any sampling locations (Table 4.18), there were insufficient data to permit any kind of variance analysis between years or among sampling locations.

The duplicate samples from SEC were selected to perform precision calculations for all the target radionuclides. The calculated RERs for the SEC samples at all three depths are presented in Table 4.19. The qualifier column shows whether the radionuclide was detected in the samples.

The 30 RER calculations for soil samples in Table 4.20 show that two RERs were greater than 1.96 including 2.222 for ^{241}Am in the shallow depth soil sample and 2.220 for ^{137}Cs in the intermediate depth soil sample. The ^{241}Am was not detected, but the ^{137}Cs was detected in the samples.

The data in Table 4.19 show good precision for the combined field sampling and laboratory analysis procedures for soil and met the objective of greater than 85 percent of the samples with RERs <1.96.

Table 4.19 - 2017 Precision Analysis Results for Duplicate Soil Samples

Location	Depth cm	Radionuclide	Primary Sample		Duplicate Sample		RER[c]	Q[d]
			[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]		
SEC	0-2	$^{233/234}$U	9.03E-03	8.19E-04	9.41E-03	1.40E-03	0.234	+
SEC	2-5	$^{233/234}$U	7.69E-03	7.02E-04	8.62E-03	8.45E-04	0.847	+
SEC	5-10	$^{233/234}$U	8.60E-03	7.92E-04	8.60E-03	7.59E-04	0.000	+
SEC	0-2	^{235}U	3.55E-04	1.20E-04	5.62E-04	2.01E-04	0.884	+
SEC	2-5	^{235}U	1.94E-04	9.10E-05	2.83E-04	1.12E-04	0.617	U [e]
SEC	5-10	^{235}U	3.91E-04	1.25E-04	3.88E-04	1.21E-04	0.017	+
SEC	0-2	^{238}U	7.75E-03	7.25E-04	8.20E-03	1.24E-03	0.313	+
SEC	2-5	^{238}U	7.09E-03	6.58E-04	9.02E-03	8.76E-04	1.762	+
SEC	5-10	^{238}U	8.57E-03	7.89E-04	8.62E-03	7.60E-04	0.046	+

Location	Depth cm	Radionuclide	Primary Sample		Duplicate Sample		RER[(c)]	Q[(d)]
			[RN][(a)]	1 σ TPU[(b)]	[RN][(a)]	1 σ TPU[(b)]		
SEC	0-2	^{238}Pu	-8.29E-06	1.55E-05	8.18E-05	4.96E-05	1.734	U
SEC	2-5	^{238}Pu	5.14E-05	3.84E-05	5.19E-06	4.11E-05	0.822	U
SEC	5-10	^{238}Pu	-5.80E-06	1.25E-05	-1.91E-05	2.28E-05	0.512	U
SEC	0-2	$^{239/240}$Pu	1.91E-04	7.91E-05	8.34E-05	4.92E-05	1.155	U
SEC	2-5	$^{239/240}$Pu	1.77E-04	7.23E-05	1.39E-04	7.08E-05	0.376	U
SEC	5-10	$^{239/240}$Pu	1.02E-04	5.55E-05	6.95E-05	5.06E-05	0.433	U
SEC	0-2	^{241}Am	-6.15E-06	4.27E-05	2.11E-04	8.79E-05	2.222	U
SEC	2-5	^{241}Am	1.06E-04	5.75E-05	7.72E-05	5.29E-05	0.369	U
SEC	5-10	^{241}Am	2.35E-05	3.34E-05	4.47E-05	5.07E-05	0.349	U
SEC	0-2	^{40}K	2.07E-01	2.21E-02	2.46E-01	2.01E-02	1.306	+
SEC	2-5	^{40}K	2.03E-01	2.12E-02	2.13E-01	1.77E-02	0.362	+
SEC	5-10	^{40}K	2.20E-01	1.96E-02	2.26E-01	1.90E-02	0.220	+
SEC	0-2	^{60}Co	-5.72E-04	1.24E-03	4.44E-04	6.94E-04	0.715	U
SEC	2-5	^{60}Co	-1.49E-03	1.03E-03	1.17E-04	6.02E-04	1.347	U
SEC	5-10	^{60}Co	5.24E-04	6.12E-04	-1.01E-04	6.63E-04	0.693	U
SEC	0-2	^{137}Cs	2.82E-03	6.94E-04	3.14E-03	5.51E-04	0.361	+
SEC	2-5	^{137}Cs	3.41E-03	5.97E-04	1.70E-03	4.87E-04	2.220	+
SEC	5-10	^{137}Cs	1.55E-03	3.59E-04	1.47E-03	3.72E-04	0.155	+
SEC	0-2	^{90}Sr	-4.05E-03	2.39E-03	2.98E-03	2.90E-03	1.871	U
SEC	2-5	^{90}Sr	-3.84E-03	2.36E-03	9.22E-04	2.35E-03	1.430	U
SEC	5-10	^{90}Sr	-4.53E-03	2.35E-03	1.21E-03	2.38E-03	1.716	U

Notes: See Appendix C for sampling location codes. Units are in Bq/g, dry weight.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty.

(c) Relative error ratio.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

(e) ^{235}U detected in either 2-5 cm samples.

4.7 Biota

4.7.1 Sample Collection

Rangeland vegetation samples were collected from the same six locations as the soil samples (Figure 4.4). Fauna (animal) samples were also collected when available. Most fauna samples were samples of opportunity (SOO) resulting from road kill. All biota samples were analyzed for the ten target radionuclides.

4.7.2 Sample Preparation

4.7.2.1 Vegetation

The vegetation samples were chopped into 2.5- to 5-cm (1- to 2- in.) pieces, mixed together well, and air dried at room temperature. Weighed aliquots were spiked with tracers (^{232}U, ^{243}Am, and ^{242}Pu) and a carrier (strontium nitrate) and heated in a muffle furnace to burn off organic matter.

The samples were digested with concentrated nitric acid, hydrochloric acid, hydrofluoric acid, and hydrogen peroxide. The samples were dried and heated in a muffle furnace. The remaining residue was repetitively wet-ashed with concentrated acids until only a white or pale-yellow residue remained. The residue was dissolved in nitric acid for processing the individual radionuclides.

4.7.2.2 Fauna (Animals)

The animal tissue samples were spiked with tracers (^{232}U, ^{243}Am, and ^{242}Pu) and a carrier (strontium nitrate) and dried in a muffle furnace. The samples were then digested with concentrated acids and hydrogen peroxide in the same manner as the vegetation samples, and the residue was then dissolved in nitric acid for processing the individual radionuclides.

4.7.3 Determination of Individual Radionuclides

The nitric acid digestates of the biota samples were split into two fractions. One fraction was analyzed by gamma spectroscopy for ^{40}K, ^{60}Co, and ^{137}Cs. The other fraction was analyzed sequentially for the uranium/transuranic radionuclides and ^{90}Sr by employing a series of chemical, physical, and ion exchange separations as described in Section 4.2.3, then mounting the sample residues on a planchet for counting. The uranium/transuranics were counted by alpha spectroscopy and the ^{90}Sr by gas proportional counting.

4.7.4 Results and Discussion

4.7.4.1 Vegetation Samples

Table 4.20 presents the analysis results for the uranium, plutonium, and americium target radionuclides in the vegetation samples from the six locations. Duplicate samples were taken at MLR during the vegetation sampling period in July 2017 with one sample (SMR) collected in October 2017.

Table 4.20 shows that there were no detections of uranium isotopes, plutonium isotopes or americium in any of the vegetation samples.

Since there were no detections in 2017, no ANOVA calculations could be performed.

Table 4.20 – 2017 Uranium Isotope, Plutonium isotope, and Americium Concentrations in Vegetation Samples Taken at or Near the WIPP Site

Location	Sampling Date	$^{233/234}$U				^{235}U				^{238}U			
		[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
WFF	7/20/2017	2.65E-04	1.19E-04	8.41E-04	U	-6.45E-06	1.93E-05	3.24E-04	U	1.40E-04	8.67E-05	6.05E-04	U
WEE	7/20/2017	2.35E-04	1.10E-04	8.38E-04	U	2.59E-05	4.06E-05	3.21E-04	U	3.92E-04	1.47E-04	6.02E-04	U
WSS	7/26/2017	2.72E-04	1.44E-04	8.47E-04	U	-3.77E-06	1.61E-05	3.31E-04	U	2.55E-04	1.39E-04	6.11E-04	U
MLR	7/31/2017	6.49E-04	1.92E-04	8.38E-04	U	2.72E-05	4.00E-05	3.20E-04	U	3.84E-04	1.41E-04	6.03E-04	U
MLR Dup	7/31/2017	5.37E-04	2.00E-04	8.48E-04	U	1.14E-05	4.15E-05	3.33E-04	U	5.37E-04	1.99E-04	6.12E-04	U
SEC	7/31/2017	3.70E-04	1.65E-04	8.50E-04	U	-4.43E-06	1.81E-05	3.35E-04	U	2.45E-04	1.31E-04	6.14E-04	U
SMR	10/9/2017	7.35E-04	3.46E-04	9.96E-04	U	2.53E-05	6.48E-05	3.84E-04	U	6.78E-04	3.28E-04	8.09E-04	U
Location	Sampling Date	^{238}Pu				$^{239/240}$Pu				^{241}Am			
		[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
WFF	7/20/2017	3.26E-06	3.09E-05	1.74E-04	U	-5.93E-06	1.65E-05	2.52E-04	U	1.64E-05	3.38E-05	2.75E-04	U
WEE	7/20/2017	8.83E-06	3.00E-05	1.75E-04	U	7.35E-06	3.12E-05	2.55E-04	U	-2.65E-06	1.12E-05	2.77E-04	U
WSS	7/26/2017	-3.75E-06	1.27E-05	1.70E-04	U	6.06E-05	5.67E-05	2.51E-04	U	2.91E-05	4.26E-05	2.75E-04	U
MLR	7/31/2017	-5.10E-06	1.73E-05	1.82E-04	U	2.55E-05	4.58E-05	2.63E-04	U	2.58E-05	4.06E-05	2.82E-04	U
MLR Dup	7/31/2017	3.08E-05	3.90E-05	1.69E-04	U	6.77E-06	2.56E-05	2.49E-04	U	6.44E-06	3.54E-05	2.84E-04	U
SEC	7/31/2017	-6.18E-06	1.82E-05	1.78E-04	U	-6.95E-06	1.93E-05	2.57E-04	U	5.42E-06	4.11E-05	2.93E-04	U
SMR	10/9/2017	1.48E-05	4.28E-05	1.53E-04	U	5.84E-05	5.92E-05	2.49E-04	U	4.47E-05	6.40E-05	3.71E-04	U

Notes: See Appendix C for sampling location codes. Units are in Bq/g, dry weight.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

Table 4.21 presents the analysis results for the gamma radionuclides and ^{90}Sr during the regular vegetation sampling in 2017.

Table 4.21 shows that ^{40}K was detected in all six of the vegetation samples including the MLR duplicates. All the measured concentrations of ^{40}K (dry weight basis) were less than the average baseline concentration of 3.20E+00 Bq/g (ash weight basis). Since the results were reported on a different weight basis, they are not directly comparable.

Table 4.21 – 2017 Gamma and ^{90}Sr Radionuclide Concentrations in Vegetation Samples Taken at or Near the WIPP Site

Location	Sampling Date	^{40}K					^{60}Co				
		[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf[d]	Q[e]	[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf[d]	Q[e]
WFF	7/20/2017	5.31E-01	1.07E-01	7.74E-02	1.00	+	1.73E-03	6.22E-03	7.67E-03	0.00	U
WEE	7/20/2017	6.72E-01	1.23E-01	5.38E-02	1.00	+	2.91E-03	5.87E-03	7.66E-03	0.00	U
WSS	7/26/2017	4.78E-01	9.15E-02	5.87E-02	0.997	+	-3.89E-03	5.69E-03	5.68E-03	0.00	U
MLR	7/31/2017	4.51E-01	8.34E-02	5.02E-02	0.997	+	1.59E-03	3.83E-03	4.86E-03	0.00	U
MLR Dup	7/31/2017	4.15E-01	8.15E-02	5.78E-02	1.00	+	-2.44E-03	4.61E-03	4.91E-03	0.00	U
SEC	7/31/2017	5.13E-01	1.25E-01	1.04E-01	0.998	+	9.68E-04	7.65E-03	9.50E-03	0.00	U
SMR	10/9/2017	6.78E-01	1.33E-01	8.32E-02	1.00	+	3.65E-03	6.38E-03	8.47E-03	0.00	U

Location	Sampling Date	^{137}Cs					^{90}Sr			
		[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf[d]	Q[e]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[e]
WFF	7/20/2017	-3.09E-04	5.89E-03	7.01E-03	0.00	U	2.53E-03	1.93E-03	1.52E-02	U
WEE	7/20/2017	7.68E-04	4.55E-03	5.64E-03	0.00	U	1.82E-03	1.90E-03	1.52E-02	U
WSS	7/26/2017	2.87E-03	4.67E-03	5.67E-03	0.00	U	1.88E-03	1.93E-03	1.52E-02	U
MLR	7/31/2017	-3.96E-05	4.32E-03	4.88E-03	0.00	U	-1.64E-04	1.89E-03	1.52E-02	U
MLR Dup	7/31/2017	-1.04E-03	3.98E-03	4.58E-03	0.00	U	-1.50E-04	1.87E-03	1.52E-02	U
SEC	7/31/2017	-5.23E-03	6.78E-03	6.94E-03	0.00	U	1.05E-03	1.99E-03	1.52E-02	U
SMR	10/9/2017	1.59E-03	5.30E-03	6.55E-03	0.00	U	-1.62E-03	2.63E-03	2.00E-02	U

Notes: See Appendix C for sampling location codes. Units are in Bq/g, dry weight.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) ID Conf. = Identification confidence for gamma radionuclide analysis.

(e) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

There were six common locations between 2016 and 2017 for ANOVA calculations. The average activity was used for the WSS duplicates in 2016 and the MLR duplicate

samples in 2017. The ANOVA calculations showed no significant statistical difference in ^{40}K vegetation concentrations between 2016 and 2017 (ANOVA ^{40}K, p = 0.615). There also was no significant variation in the concentrations of ^{40}K between locations, (ANOVA ^{40}K, p = 0.380). Some vegetation concentrations were higher in 2016 and some were higher in 2017. However, the concentrations were quite similar at all the locations. The natural variability of the concentration of ^{40}K in the soil would be expected to yield some variation in the uptake of ^{40}K into plants, but the differences in vegetation concentrations were minimal in the plants collected in 2017.

Since there were no detections of ^{238}Pu, $^{239/240}$Pu, ^{241}Am, ^{60}Co, ^{137}Cs, and ^{90}Sr in any of the vegetation samples, no ANOVA statistical comparisons between years or locations could be performed.

Table 4.22 shows the precision analysis results for all the target radionuclides in the duplicate samples from location WEE. The only detections were for ^{40}K.

Table 4.22 – 2017 Precision Analysis Results for Duplicate Vegetation Samples

Location	Isotope	Sample		Duplicate		RER[c]	Q[d]
		[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]		
WEE and Dup	$^{233/234}$U	6.49E-04	9.79E-05	5.37E-04	1.02E-04	0.792	U
	^{235}U	2.72E-05	2.04E-05	1.14E-05	2.12E-05	0.537	U
	^{238}U	3.84E-04	7.20E-05	5.37E-04	1.01E-04	1.234	U
	^{238}Pu	-5.10E-06	8.84E-06	3.08E-05	1.99E-05	1.649	U
	$^{239/240}$Pu	2.55E-05	2.34E-05	6.77E-06	1.30E-05	0.700	U
	^{241}Am	2.58E-05	2.07E-05	6.44E-06	1.81E-05	0.704	U
	^{40}K	4.51E-01	4.26E-02	4.15E-01	4.16E-02	0.605	+
	^{60}Co	1.59E-03	1.95E-03	-2.44E-03	2.35E-03	1.320	U
	^{137}Cs	-3.96E-05	2.20E-03	-1.04E-03	2.03E-03	0.334	U
	^{90}Sr	-1.64E-04	9.63E-04	-1.50E-04	9.53E-04	0.010	U

Notes: See Appendix C for sampling location codes. Units are in Bq/g, dry weight.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty.

(c) Relative error ratio.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

The duplicate vegetation samples from WEE were selected to perform precision calculations for all the target radionuclides. The calculated RERs for the WEE vegetation samples show that all 10 RERs were less than 1.96 and met the precision objective of greater than 85 percent of environmental radiochemical RERs <1.96.

4.7.4.2 Fauna (Animals)

The number of fauna samples collected and analyzed in 2017 was much fewer than in recent years. There was only one sample of opportunity (SOO) collected, which was a rabbit. Only one small catfish was caught at the second fishing location (CBD) so there was not enough fish to make a composite sample. The fauna samples analyzed included a primary quail sample consisting of four specimens and a duplicate quail composite sample consisting of three specimens from WEE, a single quail composite sample consisting of three specimens from WNN, a composite fish sample consisting of three channel catfish from BRA, and the rabbit SOO.

The fauna analysis results for radionuclides are presented in Table 4.23 for the uranium isotopes, plutonium isotopes, and americium and in Table 4.24 for the gamma radionuclides and ^{90}Sr.

The only radionuclide detected in any of the animal samples was ^{40}K, and it was detected in all samples.

ANOVA comparisons were performed on a very limited amount of ^{40}K data. ANOVA calculations were performed for ^{40}K using the 2016 and 2017 data and included two quail samples, one rabbit sample, and one fish sample. Average concentrations were used for the duplicate quail samples in 2016 and 2017. All data were reported on a dry weight basis.

Some ANOVA calculations were performed based on a very limited amount of data. The quail results were based on an average concentration for duplicate quail samples for 2016 and 2017, a 2016 quail concentration from WFF and a 2017 quail concentration from WNN. The results show a significant difference between the 2016 and 2017 concentrations (ANOVA ^{40}K, p = 3.77E-03) due to higher concentrations in 2017 compared to 2016, but no significant difference in the concentrations by location (ANOVA ^{40}K, p = 0.955).

The ANOVA calculation was also performed combining the data for the three common biota samples consisting of fish, quail, and rabbits for 2016 and 2017. The resulting comparison by year for all species showed (ANOVA ^{40}K, p = 0.109), while the comparison by location for all species yielded (ANOVA ^{40}K, p = 0.379). Thus, the ^{40}K concentrations for the combined biota did not vary significantly by year or by location although the p value comparing the years was weak compared to the comparison by location. The 2017 ^{40}K concentrations were all higher than the corresponding 2016 concentrations.

The detected ^{40}K concentration was higher than the baseline for the rabbit SOO concentration of 4.52E-01 Bq/g compared to the baseline concentration of 3.90E-01 Bq/g. The 2017 ^{40}K concentrations for quail and fish were within the baseline concentration for quail of 4.10E-01 Bq/g and for fish (6.1E-01 Bq/g). These results can only be used as a gross indication of uptake by the animals, since there were too few

samples to provide a detailed statistical analysis. However, within this limitation, the data suggest that there has been no animal uptake of radionuclides from the WIPP facility.

Precision data were calculated for the duplicate quail samples. The data for the duplicate fauna sample analyses are shown in Table 4.25. The precision of all the target radionuclides was calculated although only ^{40}K was detected in the samples.

The data in Table 4.25 show that the RERs for the various radionuclides were all less than the objective of 85 percent of the RERs less than 1.96 (U.S. Department of Energy, 2009). The data demonstrate good precision for the challenging combined biota sampling and analysis procedures.

Table 4.23 – 2017 Uranium, Plutonium, and Americium Radionuclide Concentrations in Fauna Samples

Type	Location	Sampling Date	$^{233/234}$U				^{235}U				^{238}U			
			[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
Quail	WEE	2/14/2017	4.63E-04	7.85E-05	6.49E-04	U	2.60E-05	1.10E-05	2.25E-04	U	4.60E-04	7.80E-05	5.01E-04	U
Quail Dup	WEE	2/14/2017	4.71E-04	9.07E-05	6.50E-04	U	1.69E-05	1.05E-05	2.26E-04	U	4.46E-04	8.64E-05	5.02E-04	U
Quail	WNN	2/21/2017	3.34E-04	6.49E-05	6.50E-04	U	1.75E-05	1.06E-05	2.26E-04	U	3.27E-04	6.37E-05	5.02E-04	U
Fish	BRA	9/29/2017	9.00E-04	1.58E-04	9.36E-04	U	2.28E-05	1.42E-05	3.13E-04	U	6.43E-04	1.18E-04	6.86E-04	U
Rabbit	SOO[e]	10/30/2017	6.31E-05	2.21E-05	9.47E-04	U	5.67E-06	7.05E-06	3.04E-04	U	6.10E-05	2.17E-05	7.56E-04	U
Type	Location	Sampling Date	^{238}Pu				$^{239/240}$Pu				^{241}Am			
			[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
Quail	WEE	2/14/2017	-3.30E-07	1.29E-06	2.12E-04	U	3.95E-06	4.48E-06	2.31E-04	U	5.71E-06	4.57E-06	2.48E-04	U
Quail Dup	WEE	2/14/2017	-5.76E-07	1.66E-06	2.12E-04	U	8.06E-06	6.71E-06	2.31E-04	U	4.63E-06	5.11E-06	2.49E-04	U
Quail	WNN	2/21/2017	-2.79E-07	1.14E-06	2.12E-04	U	8.00E-06	6.44E-06	2.31E-04	U	3.16E-06	3.86E-06	2.49E-04	U
Fish	BRA	9/29/2017	-9.41E-07	2.48E-06	1.28E-04	U	1.22E-06	3.75E-06	2.17E-04	U	-6.46E-07	1.97E-06	3.45E-04	U
Rabbit	SOO[e]	10/30/2017	-3.32E-07	1.38E-06	1.28E-04	U	1.49E-06	2.93E-06	2.26E-04	U	7.11E-07	3.22E-06	2.91E-04	U

Notes: See Appendix C for sampling location codes. Units are in Bq/g, dry weight.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

(e) SOO = sample of opportunity.

Table 4.24 – 2017 Gamma Radionuclides and ^{90}Sr Radionuclide Concentrations in Fauna Samples

Type	Location	Sampling Date	^{40}K					^{60}Co				
			[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf[d]	Q[e]	[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf[d]	Q[e]
Quail	WEE	2/14/2017	2.94E-01	6.17E-02	5.37E-02	0.999	+	-3.57E-04	5.04E-03	5.84E-03	0.000	U
Quail Dup	WEE	2/14/2017	2.81E-01	6.76E-02	6.37E-02	0.999	+	1.27E-03	5.81E-03	7.15E-03	0.000	U
Quail	WNN	2/21/2017	2.83E-01	6.48E-02	5.12E-02	0.998	+	4.47E-03	6.24E-03	7.74E-03	0.000	U
Fish	BRA	9/29/2017	4.79E-01	1.03E-01	9.54E-02	0.999	+	-2.41E-03	9.45E-03	1.04E-02	0.000	U
Rabbit	SOO[f]	10/30/2017	4.52E-01	1.24E-01	1.17E-01	0.999	+	7.79E-03	1.26E-02	1.61E-02	0.000	U

Type	Location	Sampling Date	^{137}Cs					^{90}Sr			
			[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf[d]	Q[e]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[e]
Quail	WEE	2/14/2017	-1.31E-03	5.49E-03	6.30E-03	0.000	U	5.03E-04	2.23E-04	1.18E-02	U
Quail Dup	WEE	2/14/2017	-3.19E-03	6.75E-03	7.81E-03	0.000	U	6.50E-04	3.01E-04	1.18E-02	U
Quail	WNN	2/21/2017	-4.63E-03	7.96E-03	8.81E-03	0.000	U	5.64E-04	2.11E-04	1.18E-02	U
Fish	BRA	9/29/2017	-4.77E-05	9.82E-03	1.09E-02	0.000	U	1.81E-05	4.15E-04	1.97E-02	U
Rabbit	SOO[f]	10/30/2017	1.76E-02	1.33E-02	1.73E-02	0.000	U	3.94E-03	4.97E-04	1.95E-02	U

Notes: See Appendix C for sampling location codes. Units are in Bq/g, dry weight.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Identification Confidence.

(e) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected

(f) Sample of Opportunity

Table 4.25 – 2017 Precision Analysis Results for Duplicate Quail Samples

Type	Isotope	Sample		Duplicate		RER[(c)]	Q[(d)]
		[RN][(a)]	1 σ TPU[(b)]	[RN][(a)]	1 σ TPU[(b)]		
Quail and Dup (WEE)	$^{233/234}$U	4.63E-04	4.00E-05	4.71E-04	4.63E-05	0.131	U
	^{235}U	2.60E-05	5.62E-06	1.69E-05	5.37E-06	1.171	U
	^{238}U	4.60E-04	3.98E-05	4.46E-04	4.41E-05	0.236	U
	^{238}Pu	-3.30E-07	6.60E-07	-5.76E-07	8.48E-07	0.229	U
	$^{239/240}$Pu	3.95E-06	2.28E-06	8.06E-06	3.43E-06	0.998	U
	^{241}Am	5.71E-06	2.33E-06	4.63E-06	2.60E-06	0.309	U
	^{40}K	2.94E-01	3.15E-02	2.81E-01	3.45E-02	0.278	+
	^{60}Co	-3.57E-04	2.57E-03	1.27E-03	2.97E-03	0.414	U
	^{137}Cs	-1.31E-03	2.80E-03	-3.19E-03	3.44E-03	0.424	U
	^{90}Sr	5.03E-04	1.14E-04	6.50E-04	1.53E-04	0.770	U

Notes: Units are in Bq/g, dry weight.

(a) Radionuclide concentration. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

(b) Total propagated uncertainty.

(c) Relative error ratio.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

4.8 Potential Dose from WIPP Operations

4.8.1 Dose Limits

Compliance with the environmental radiation dose standards is determined by comparing annual radiation doses to the dose standards, discussed in the introduction to this chapter.

Compliance with the environmental radiation dose standards is determined by monitoring, extracting, and calculating the EDE. The EDE is the weighted sum of the doses to the individual organs of the body. The dose to each organ is weighted according to the risk that dose represents. These organ doses are then added together, and the total is the EDE. Calculating the EDE to members of the public requires the use of CAP88–PC or other EPA-approved computer models and procedures. The WIPP Effluent Monitoring Program uses the latest approved version of CAP88–PC, which is a set of computer programs, datasets, and associated utility programs for estimating dose and risk from radionuclide air emissions. CAP88–PC uses a Gaussian Plume dispersion model, which calculates deposition rates, concentrations in food, and intake rates for people. CAP88–PC estimates dose and risk to individuals and populations from multiple pathways. Dose and risk are calculated for ingestion, inhalation, ground-level air immersion, and ground-surface irradiation exposure pathways.

The *Safe Drinking Water Act* (40 CFR §141.66, "Maximum Contaminant Levels for Radionuclides") states that average annual concentrations for beta- and gamma-emitting human-made radionuclides in drinking water shall not result in an annual dose equivalent greater than 0.04 millisievert (mSv) (4 mrem). It is important to note that these dose equivalent limits are set for radionuclides released to the environment from DOE operations. These limits do not include, but rather are exposures in addition to, doses from natural background radiation or from medical procedures.

4.8.2 Background Radiation

There are several sources of natural radiation: cosmic and cosmogenic radiation (from outer space and the earth's atmosphere), terrestrial radiation (from the earth's crust), and internal radiation (naturally occurring radiation in our bodies, such as ^{40}K). The most common sources of terrestrial radiation are uranium and thorium, and their decay products. Another source of terrestrial radiation is ^{40}K. Radon gas, a decay product of uranium, is a widely known naturally occurring terrestrial radionuclide. In addition to natural radioactivity, small amounts of radioactivity are present in the environment from aboveground nuclear weapons tests and the 1986 Chernobyl nuclear accident. Together, these sources of radiation are called background radiation.

Naturally occurring radiation in the environment can deliver both internal and external doses. Internal dose is received as a result of the intake of radionuclides through ingestion (consuming food or drink containing radionuclides) and inhalation (breathing radioactive particulates). External dose can occur from immersion in contaminated air or deposition of contaminants on surfaces. The average annual dose received by a member of the public from natural background radiation is approximately 3 mSv (300 mrem).

4.8.3 Dose from Air Emissions

The standard 40 CFR Part 191, Subpart A, limits radiation doses to members of the public and the general environment from all sources (i.e., air, soil, water). The DOE has identified air emissions as the major pathway of concern for the WIPP facility during operations.

Compliance with Subpart A (40 CFR §191.03[b]) and the NESHAP standard (40 CFR §61.92) is determined by comparing annual radiation doses to the maximally exposed individual (MEI) to the regulatory standards. As recommended by the EPA, the DOE uses computer modeling to calculate radiation doses for compliance with the Subpart A and NESHAP standards. Compliance procedures for DOE facilities (40 CFR §61.93[a]) require the use of CAP88–PC or AIRDOS–PC computer programs, or equivalent, to calculate dose to members of the public.

Source term input for CAP88–PC was determined by radiochemical analyses of particulate samples taken from fixed air sampling filters at Stations B and C. Air filter samples were analyzed for ^{241}Am, $^{239/240}$Pu, ^{238}Pu, ^{90}Sr, $^{233/234}$U, ^{238}U, and ^{137}Cs

because these radionuclides constitute over 98 percent of the dose potential from contact-handled and remote-handled TRU waste. A conservative dataset using the higher value of either the measured radionuclide concentration or 2 σ TPU was used as input to the CAP88–PC computer program to calculate the EDEs to members of the public. See Section 4.1.4 for more information on the results and discussion of the effluent monitoring data.

CAP88–PC dose calculations are based on the assumption that exposed persons remain at the same point of exposure during the entire year and all vegetables, milk, and meat consumed are locally-produced. Thus, this dose calculation is a maximum potential dose, which encompasses dose from inhalation, immersion, deposition, and ingestion of radionuclides emitted via the air pathway from the WIPP facility.

4.8.4 Total Potential Dose from WIPP Operations

Specific environmental radiation standards in 40 CFR Part 191, Subpart A state that the combined annual dose equivalent to any member of the public in the general environment resulting from the discharges of radioactive material and direct radiation from management and storage shall not exceed 0.25 mSv (25 mrem) to the whole body and 0.75 mSv (75 mrem) to any critical organ. The following sections discuss the potential dose equivalent through other pathways and the total potential dose equivalent a member of the public may have received from the WIPP facility during 2017. Section 4.8.4.3 discusses the potential dose equivalent received from radionuclides released to the air from the WIPP facility.

4.8.4.1 Potential Dose from Water Ingestion Pathway

The potential dose to individuals from the ingestion of WIPP facility-related radionuclides transported in water is determined to be zero for several reasons. Drinking water for communities near the WIPP facility comes from groundwater sources that are too remote to be affected by WIPP facility contaminants, based on current radionuclide transport scenarios summarized in *Title 40 CFR Part 191 Subparts B&C Compliance Certification Application for the Waste Isolation Pilot Plant* (DOE/CAO-96-2184). Water from the Culebra is naturally not potable due to high levels of TDS.

4.8.4.2 Potential Dose from Wild Game Ingestion

Game animals sampled during 2017 were rabbit, fish, and quail. The only radionuclides detected in any of the animal samples were ^{40}K, which was detected in all the samples. Therefore, no dose from WIPP facility-related radionuclides could have been received by any individual from this pathway during 2017.

4.8.4.3 Total Potential Dose from All Pathways

The only credible pathway from the WIPP facility to humans is through air emissions; therefore, this is the only pathway for which a dose is calculated. The total radiological

dose and atmospheric release at the WIPP facility in 2017 is summarized in Table 4.26 for the standards in both 40 CFR §61.92 and 40 CFR §191.03(b).

Table 4.26 – WIPP Radiological Dose and Releases[(a)] During 2017

^{238}Pu	$^{239/240}$Pu	^{241}Am	^{90}Sr	$^{233/234}$U	^{238}U	^{137}Cs
8.285E-09 Ci	3.975E-08 Ci	2.805E-07 Ci	6.971E-07 Ci	3.509E-08 Ci	2.040E-08 Ci	1.162E-05 Ci
3.066E+02 Bq	1.471E+03 Bq	1.038E+04 Bq	2.579E+04 Bq	1.298E+03 Bq	7.548E+02 Bq	4.301E+05 Bq

WIPP Radiological Dose Reporting Table for 2017							
	EDE to the MEI at 8,850 m WNW		Percent of EPA 10 mrem/year limit to member of the public	Estimated population dose within 50 mi		Population within 50 miles[(b)]	Estimated natural radiation population dose[(c)]
Pathway	(mrem/year)	(mSv/year)		(person-rem/year)	(person-Sv/year)		(person-rem\year)
Air	3.02E-06	3.02E-08	3.02E-05	9.93E-06	9.93E-08	92,599	27,780
Water	N/A[(d)]	N/A	N/A	N/A	N/A	N/A	N/A
Other Pathways	N/A	N/A	N/A	N/A	N/A	N/A	N/A

WIPP Radiological Dose Reporting Table for 2017						
	Dose equivalent to the whole body of the receptor who resides year-round at WIPP fence line 650 m WNW		Percent of EPA 25 mrem/year whole body limit	Dose equivalent to the critical organ of the receptor who resides year-round at WIPP fence line 650 m WNW		Percent of EPA 75-mrem/year critical organ limit
Pathway	(mrem/year)	(mSv/year)		(mrem/year)	(mSv/year)	
Air	1.04E-04	1.04E-06	4.2E-04	9.87E-04	9.87E-06	1.3E-03
Water	N/A	N/A	N/A	N/A	N/A	N/A
Other Pathways	N/A	N/A	N/A	N/A	N/A	N/A

Notes:

(a) Total releases from combination of Stations B and C. Values are calculated from detected activities plus 2 σ TPU or the central value, whichever is greater, and multiplied by the ratio of sample flow to stack flow volumes.

(b) Source: United States Census Bureau (2010 Census Data).

(c) Estimated natural radiation population dose = (population within 50 mi) × (300 mrem/year).

(d) Not applicable at the WIPP facility.

In compliance with 40 CFR Part 191, Subpart A, the receptor selected is assumed to reside year-round at the exclusive use area fence line in the west-northwest sector. For 2017, the dose to this receptor was estimated to be 1.04E-06 mSv (1.04E-04 mrem) per year for the whole body and 9.87E-06 mSv (9.87E-04 mrem) per year to the critical

organ. These values are in compliance with the requirements specified in 40 CFR §191.03(b).

For the NESHAP standard (40 CFR §61.92), the EDE potentially received by the off-site MEI in 2017 assumed to be residing 8.9 km (5.5 mi) west-northwest of the WIPP facility is calculated to be 3.02E-08 mSv (3.02E-06 mrem) per year for the whole body. This value is in compliance with 40 CFR §61.92 requirements.

As required by DOE Order 458.1, the collective dose to the public within 80 km (50 mi) of the WIPP facility has been evaluated and is 9.93E-08 person-sieverts (Sv) per year (person-Sv/year) (9.93E-06 person-rem/year) in 2017.

4.8.5 Dose to Nonhuman Biota

Dose limits for populations of aquatic and terrestrial organisms are discussed in National Council on Radiation Protection and Measurements Report No. 109, *Effects of Ionizing Radiation on Aquatic Organisms* (NCRP 1991), and the International Atomic Energy Agency (1992) Technical Report Series No. 332, *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards*. Those dose limits are:

- Aquatic animals—10 milligrays per day (1 radiation absorbed dose per day)
- Terrestrial plants—10 milligrays per day (1 radiation absorbed dose per day)
- Terrestrial animals—1 milligrays per day (0.1 radiation absorbed dose per day)

The DOE has considered establishing these dose standards for aquatic and terrestrial biota in proposed rule 10 CFR Part 834, “Radiation Protection of the Public and the Environment,” but has delayed finalizing this rule until guidance for demonstrating compliance is developed. *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE–STD–1153–2002) was developed to meet this need.

The DOE requires reporting of radiation doses to nonhuman biota in the ASER using DOE–STD–1153–2002, which requires an initial general screening using conservative assumptions. In the initial screen, biota concentration guides are derived using conservative assumptions for a variety of generic organisms. Maximum concentrations of radionuclides detected in soil, sediment, and water during environmental monitoring are divided by the biota concentration guides, and the results are summed for each organism. If the sum of these fractions is less than 1.0, the site is deemed to have passed the screen, and no further action is required. This screening evaluation is intended to provide a very conservative evaluation of the site in relation to the recommended limits. This guidance was used to screen radionuclide concentrations observed around WIPP during 2017 using the maximum radionuclide concentrations listed in Table 4.27, and the sum of fractions was less than 1.0 for all media. The element ^{40}K is not included in Table 4.27 because it is a natural component of the earth’s crust and is not part of WIPP-related radionuclides.

Table 4.27 – 2017 General Screening Results for Potential Radiation Dose to Nonhuman Biota from Radionuclide Concentrations in Surface Water (Bq/L), Sediment (Bq/g), and Soil (Bq/g)

Medium	Radionuclide	Maximum Detected Concentration	Location	BCG[a]	Concentration/BCG
Aquatic System Evaluation					
Sediment (Bq/g)	$^{233/234}$U	2.76E-02	PKT	2.00E+02	1.38E-04
	^{235}U	1.72E-03	IDN	1.00E+02	1.72E-05
	^{238}U	2.63E-02	PKT	9.00E+01	2.92E-04
	^{238}Pu	ND[c]		2.00E+02	NA[d]
	$^{239/240}$Pu	5.83E-04	PKT	2.00E+02	2.92E-06
	^{241}Am	ND[c]		2.00E+02	NA[d]
	^{60}Co	ND[c]		5.00E+01	NA[d]
	^{137}Cs	8.89E-03	PKT	1.00E+02	8.89E-05
	^{90}Sr	ND[c]		2.00E+01	NA[d]
Surface Water[b] (Bq/L)	$^{233/234}$U	2.00E-01	PCN	7.00E+00	2.86E-02
	^{235}U	5.23E-03	BRA	8.00E+00	6.54E-04
	^{238}U	9.62E-02	PCN	8.00E+00	1.20E-02
	^{238}Pu	ND[c]		7.00E+00	NA[d]
	$^{239/240}$Pu	ND[c]		7.00E+00	NA[d]
	^{241}Am	ND[c]		2.00E+01	NA[d]
	^{60}Co	ND[c]		1.00E+02	NA[d]
	^{137}Cs	ND[c]		2.00E+00	NA[d]
	^{90}Sr	ND[c]		1.00E+01	NA[d]
Sum of Fractions					4.18E-02
Terrestrial System Evaluation					
Soil (Bq/g)	$^{233/234}$U	1.83E-02	SMR (0-2 cm)	2.00E+02	9.15E-05
	^{235}U	6.98E-04	SMR (2-5 cm)	1.00E+02	6.98E-06
	^{238}U	1.88E-02	SMR (0-2 cm)	6.00E+01	3.13E-04
	^{238}Pu	ND[c]		2.00E+02	NA[d]
	$^{239/240}$Pu	5.16E-04	SMR (2-5 cm)	2.00E+02	2.58E-06
	^{241}Am	ND[c]		1.00E+02	NA[d]
	^{60}Co	ND[c]		3.00E+01	NA[d]
	^{137}Cs	7.14E-03	SMR (0-2 cm)	8.00E-01	8.93E-03
	^{90}Sr	ND[c]		8.00E-01	NA[d]

Medium	Radionuclide	Maximum Detected Concentration	Location	BCG[a]	Concentration/BCG
Terrestrial System Evaluation					
Surface Water (Bq/L)	$^{233/234}$U	2.00E-01	PCN	7.00E+00	2.86E-02
	^{235}U	5.23E-03	BRA	8.00E+00	6.54E-04
	^{238}U	9.62E-02	PCN	8.00E+00	1.20E-02
	^{238}Pu	ND[c]		7.00E+00	NA[d]
	$^{239/240}$Pu	ND[c]		7.00E+00	NA[d]
	^{241}Am	ND[c]		2.00E+01	NA[d]
	^{60}Co	ND[c]		1.00E+02	NA[d]
	^{137}Cs	ND[c]		2.00E+04	NA[d]
	^{90}Sr	ND[c]		2.00E+04	NA[d]
Sum of Fractions					5.06E-02

Notes:

Maximum detected concentrations were compared with BCG values to assess potential dose to biota. As long as the sum of the ratios between detected maximum concentrations and the associated BCG is below 1.0, no adverse effects on plant or animal populations are expected (DOE-STD-1153-2002).

(a) The radionuclide concentration in the medium that would produce a radiation dose in the organism equal to the dose limit under the conservative assumptions in the model.

(b) Sediment and surface water sample were assumed to be co-located.

(c) Not detected in any of the sampling locations for a given sample matrix.

(d) Not available for calculation.

4.8.6 Release of Property Containing Residual Radioactive Material

No radiologically contaminated materials or property were released from the WIPP facility in 2017.

4.9 Radiological Program Conclusions

4.9.1 Effluent Monitoring

For 2017, the calculated EDE to the receptor (hypothetical MEI) who resides year-round at the Exclusive Use Area fence line is 1.04E-06 mSv (1.04E-04 mrem) per year for the whole body and 9.87E-06 mSv (9.87E-04 mrem) per year for the critical organ. For the WIPP Effluent Monitoring Program, Figure 4.5 and Table 4.28 show the dose to the whole body for the hypothetical MEI for CY 2002 to CY 2017. Figure 4.6 and Table 4.29 show the dose to the critical organ for the hypothetical MEI for CY 2002 to CY 2017. These dose equivalent values are below 25 mrem to the whole body and 75 mrem to any critical organ, in accordance with the provisions of 40 CFR §191.03(b).

In CY 2017, the dose was estimated to be trending downward from the previous year, as would be expected given the period of time after the February 2014 radiological release event and subsequent return to normal operating conditions. All calculated dose estimates were well within the limit of 10 mrem EDE to the off-site resident MEI.

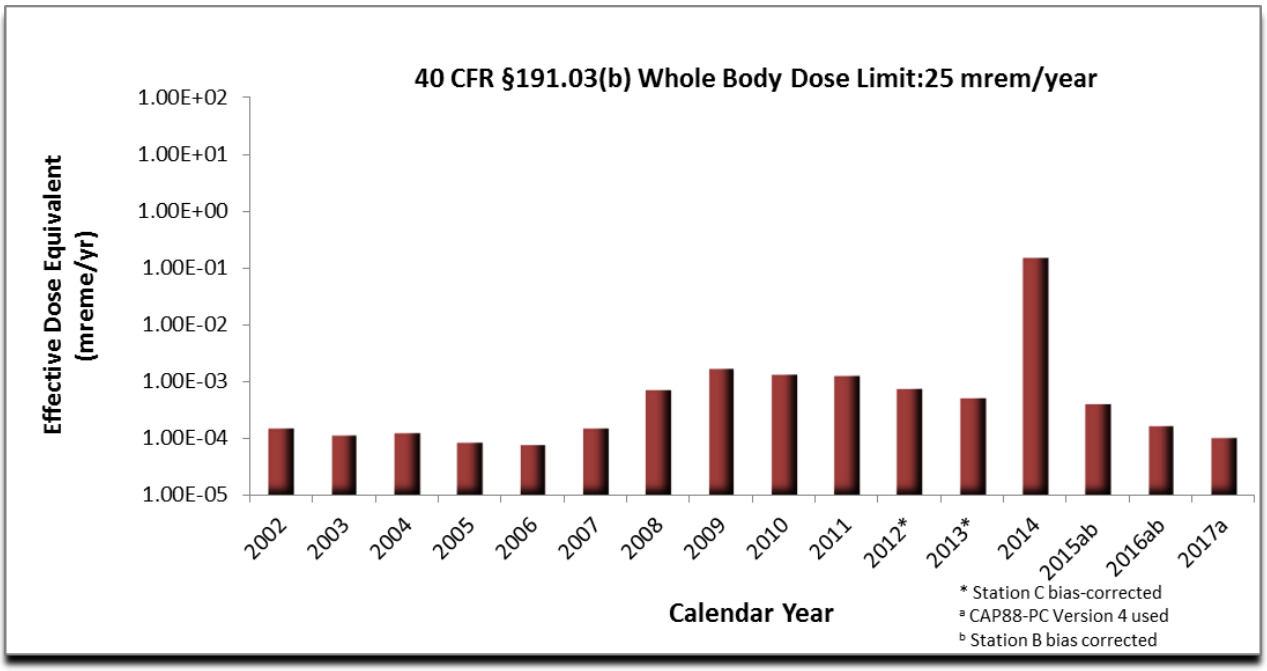

Figure 4.5 – Dose to the Whole Body for the Hypothetical Maximally Exposed Individual at the WIPP Fence Line

Table 4.28 – Comparison of Dose to the Whole Body to EPA Standard of 25 mrem/year per 40 CFR §191.03(b)

Year	Annual Dose (mrem/yr)	Percentage of EPA Standard
2002	1.51E-04	0.00060%
2003	1.15E-04	0.00046%
2004	1.27E-04	0.00051%
2005	8.86E-05	0.00035%
2006	8.16E-05	0.00033%
2007	1.52E-04	0.00061%
2008	7.14E-04	0.00286%
2009	1.71E-03	0.00684%
2010	1.31E-03	0.00524%
2011	1.29E-03	0.00516%
2012 *	7.55E-04	0.00302%
2013 *	5.25E-04	0.00210%
2014[a]	1.49E-01	0.59600%
2015[a,b]	4.23E-04	0.00169%
2016[a]	1.71E-04	0.00068%
2017[a]	1.04E-04	0.00042%
40 CFR §191.03(b) Whole Body Limit	**25**	

*Station C bias-corrected.
[a] CAPP88-PC Version 4 used.
[b] Station B bias-corrected.

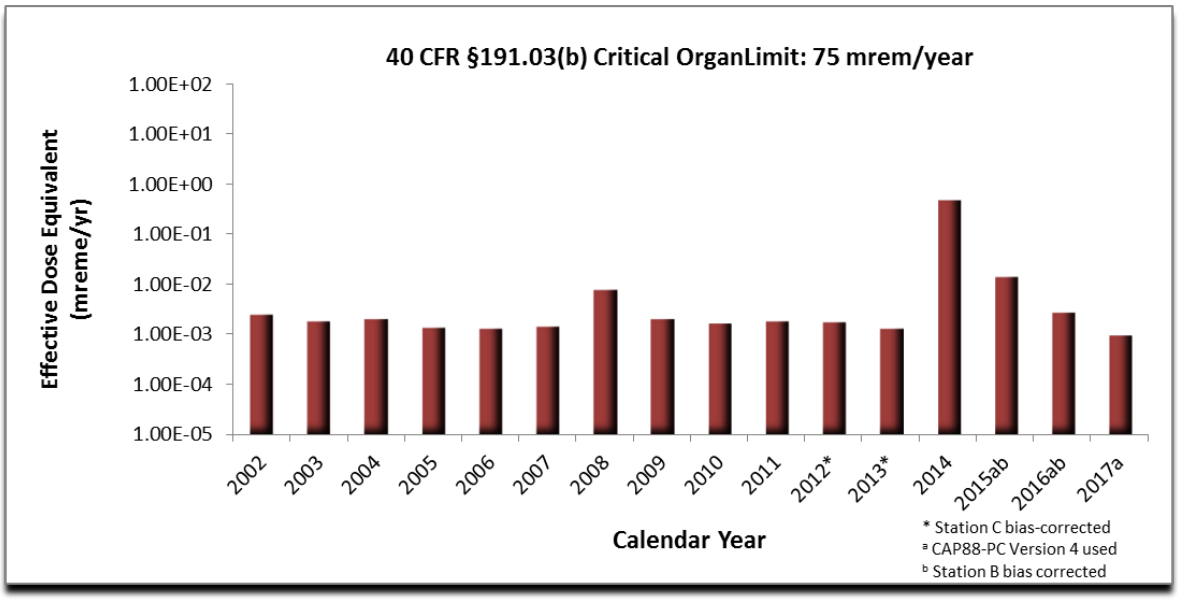

Figure 4.6 – Dose to the Critical Organ for Hypothetical Maximally Exposed Individual at the WIPP Fence Line

Table 4.29 – Comparison of Dose to the Critical Organ to EPA Standard of 75 mrem/year per 40 CFR §191.03(b)

Year	Annual Dose (mrem/yr)	Percentage of EPA Standard
2002	2.46E-03	0.0033%
2003	1.85E-03	0.0025%
2004	2.11E-03	0.0028%
2005	1.41E-03	0.0019%
2006	1.30E-03	0.0017%
2007	1.46E-03	0.0019%
2008	7.81E-03	0.0104%
2009	2.10E-03	0.0028%
2010	1.73E-03	0.0023%
2011	1.86E-03	0.0025%
2012 *	1.75E-03	0.0023%
2013 *	1.31E-03	0.0017%
2014	4.80E-01	0.6400%
2015[a,b]	1.41E-02	0.0188%
2016[a]	2.79E-03	0.0037%
2017[a]	9.87E-04	0.0013%
40 CFR §191.03(b) Critical Organ Limit	**75**	

*Station C bias-corrected.
[a] CAPP88-PC Version 4 used.
[b] Station B bias-corrected.

For 2017, the calculated EDE to the off-site resident MEI from normal operations conducted at the WIPP facility is 3.02E-08 mSv (3.02E-06 mrem). For the WIPP Effluent Monitoring Program, Figure 4.7 and Table 4.30 show the EDE to the MEI for CY 2002 to CY 2017. These EDE values are more than five orders of magnitude below the EPA NESHAP standard of 10 mrem per year, as specified in 40 CFR §61.92.

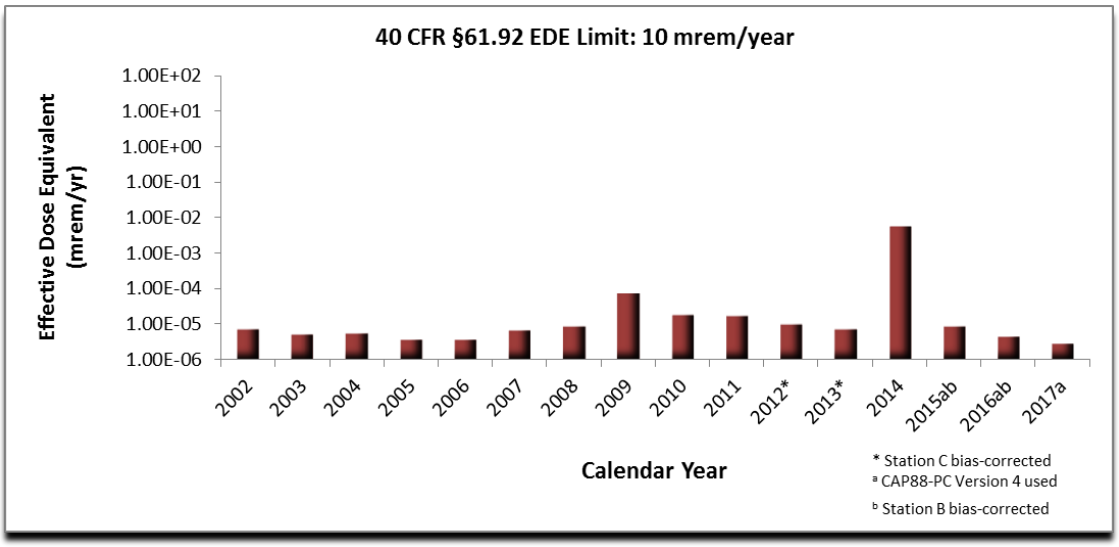

Figure 4.7 – WIPP Effective Dose Equivalent to the Off-Site Maximally Exposed Individual

Table 4.30 – Comparison of EDEs to EPA Standard of 10 mrem/year per 40 CFR §61.92

Year	Annual Dose (mrem/yr)	Percentage of EPA Standard
2002	7.61E-06	0.000076%
2003	5.43E-06	0.000054%
2004	5.69E-06	0.000057%
2005	3.85E-06	0.000039%
2006	3.93E-06	0.000039%
2007	7.01E-06	0.000070%
2008	9.05E-06	0.000091%
2009	7.80E-05	0.000780%
2010	1.91E-05	0.000191%
2011	1.75E-05	0.000175%
2012 *	1.06E-05	0.000110%
2013 *	7.39E-06	0.000081%
2014	5.86E-03	0.058600%
2015[ab]	8.98E-06	0.000090%
2016[a]	4.72E-06	0.000047%
2017[a]	3.02E-06	0.000030%
NESHAP Limit	**10**	

*Station C bias-corrected.
[a] CAPP88-PC Version 4 used.
[b] Station B bias-corrected.

4.9.2 Environmental Monitoring

Radionuclide concentrations observed in environmental monitoring samples were extremely small and comparable to radiological baseline levels. Appendix H contains graphs comparing the highest detected radionuclide concentrations compared to their respective baseline values.

Environmental samples that contained the highest concentrations of radionuclides that were higher (or equal) to the baseline concentrations included the following:

- Groundwater: The duplicate groundwater sample from WQSP-2 had the highest concentration for $^{233/234}$U at 1.37E+00 Bq/L, which was slightly higher than the 99 percent confidence interval range of the groundwater baseline concentration of 1.30E+00 Bq/L
- Surface water: The ^{40}K baseline concentration of 7.60E+01 Bq/L for tanks and tank-like structures and the Pecos River and associated bodies of water was exceeded by the ^{40}K concentrations in the the sewage sludge composite sample (SWL) and the H-19 pond (H-19). However, these types of samples are not included in the surface water baseline. The SWL concentration was 1.91E+02 Bq/L and the H-19 concentration was 7.04E+02 Bq/L.
- Sediments: The highest ^{40}K concentration in the Pecos River and associated bodies of water was 4.29E-01 Bq/g from the UPR duplicate. The concentration was slightly lower than the 99 percent confidence interval range of the baseline concentration of 5.00E-01 Bq/g for the Pecos River and associated bodies of water.
- Soil: The ^{238}U concentrations at all three depths at location SMR were higher than the 99 percent confidence interval range of the baseline concentration for locations within the 5-mile ring. The baseline concentration is 1.30E-02 Bq/g for all three depths and the sample concentrations were 1.88E-02 Bq/g, 1.80E-02 Bq/g, and 1.84E-02 Bq/g for the shallow, intermediate, and deep depths, respectively.

  The ^{40}K concentrations at all three depths at location SMR and the shallow and intermediate concentrations at location MLR were higher than the 99 percent baseline confidence interval range of the baseline concentration of 3.40E-01 Bq/g for locations within the 5-mile ring.
- Fauna: The highest concentration of ^{40}K in the single rabbit sample was 4.52E-01 Bq/g, which was higher than the mean baseline concentration of 3.90E-01 Bq/g.

No other soil, vegetation, or fauna samples yielded concentrations higher than the baseline concentration. The concentrations higher than the baseline listed above are most likely due to natural spatial variability, and they are so far below the regulatory limit as to be non-impactive.

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CHAPTER 5 – ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INFORMATION

Non-radiological programs at the WIPP facility include land management, meteorological monitoring, VOC monitoring, hydrogen and methane monitoring, seismic monitoring, certain aspects of liquid effluent, as well as surface water and groundwater monitoring. The monitoring is performed to comply with the Permit requirements and provisions of the WIPP authorization documents. Radiological and non-radiological groundwater monitoring are discussed in Chapters 4 and 6, respectively.

5.1 Principal Functions of Non-Radiological Sampling

The principal functions of the non-radiological environmental surveillance program are to:

- Assess the impacts of the WIPP facility operations of the human health.
- Assess the impacts of WIPP facility operations on the surrounding ecosystem.
- Monitor ecological conditions in the Los Medaños region.
- Provide data that have not or will not be acquired by other programs but are important to WIPP mission.
- Comply with applicable commitments (e.g., DOE/BLM Memorandum of Understanding and interagency agreements).

5.2 Land Management Plan

The DOE developed the LMP as required by the WIPP LWA to identify resource values, promote multiple-use management, and identify long-term goals for the management of WIPP lands. The LMP was developed in consultation with the BLM and the State of New Mexico.

The LMP sets forth cooperative arrangements and protocols for addressing WIPP-related land management actions. This LMP is reviewed biennially to assess the adequacy and effectiveness of the document, or as may be necessary to address emerging issues affecting WIPP lands. Affected agencies, groups, and/or individuals may be involved in the review process.

5.2.1 Land Use Requests

Parties who wish to conduct activities that may impact lands under the jurisdiction of the DOE but outside the property protection area are required by the LMP to prepare a land use request. A land use request consists of a narrative description of the project, a completed environmental review, and a map depicting the location of the proposed activity. This documentation is used to determine if applicable regulatory requirements have been met prior to the approval of a proposed project. A land use request is

submitted to the Land Use Coordinator by organizations wishing to perform construction on rights-of-way, pipeline easements, or similar actions within the WIPP LWA, or on lands used in the operation of the WIPP facility, under the jurisdiction of the DOE. In 2017, 15 land use requests were submitted to and approved by the Land Use Coordinator.

5.2.2 Wildlife Population Monitoring

In 1995, the U.S. Fish and Wildlife Service provided an updated list of threatened and endangered species for Eddy and Lea Counties in New Mexico. Included were 18 species that may be present on DOE lands. A comprehensive evaluation in support of the SEIS-II (*Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement*, DOE/EIS-0026-S-2) was conducted in 1996 to determine the presence or absence of threatened or endangered species in the vicinity of the WIPP site and the effect of WIPP facility operations on these species. Results indicated that activities associated with the operation of the WIPP facility have no negative impact on wildlife species.

Employees of the WIPP facility continue to consider resident species when planning activities that may impact their habitat, in accordance with the DOE/BLM Memorandum of Understanding, the Joint Powers Agreement with the State of New Mexico (Appendices C and G of the LMP, respectively), and 50 CFR Part 17, “Endangered and Threatened Wildlife and Plants.”

5.2.3 Reclamation of Disturbed Lands

Reclamation serves to mitigate the effects of WIPP-related activities on affected plant and animal communities. The objective of the reclamation program is to restore lands used in the operation of the WIPP facility that are no longer needed for those activities. Reclamation is intended to reduce soil erosion, increase the rate of plant colonization and succession, and provide habitat for wildlife in disturbed areas.

The DOE follows a reclamation program and a long-range reclamation plan in accordance with the LMP and specified right-of-way permit conditions. As locations are identified for reclamation, WIPP personnel reclaim these areas by using the best acceptable reclamation practices. Seed mixes used reflect those species indigenous to the area, with priority given to those plant species that are conducive to soil stabilization, wildlife, and livestock needs.

5.2.4 Oil and Gas Surveillance

Oil and gas activities within 1.6 km (1 mi) of the WIPP site boundary are routinely monitored in accordance with the LMP to identify new activities associated with oil and gas exploration and production, including the following:

- Survey staking
- Surface geophysical exploration

- Drilling
- Pipeline construction
- Work-overs
- Changes in well status
- Anomalous occurrences (e.g., leaks, spills, accidents)

During 2017, WIPP surveillance teams conducted monthly surveillances and field inspections.

Proposed new well locations staked within 1.6 km (1 mi) of the WIPP site boundary are field-verified. This ensures that the proposed location is of sufficient distance from the WIPP site boundary to protect the WIPP withdrawal from potential surface and subsurface trespass. No new Oil and Gas wells were completed during 2017 within the 1.6 km (1 mi) of the WIPP LWA boundary.

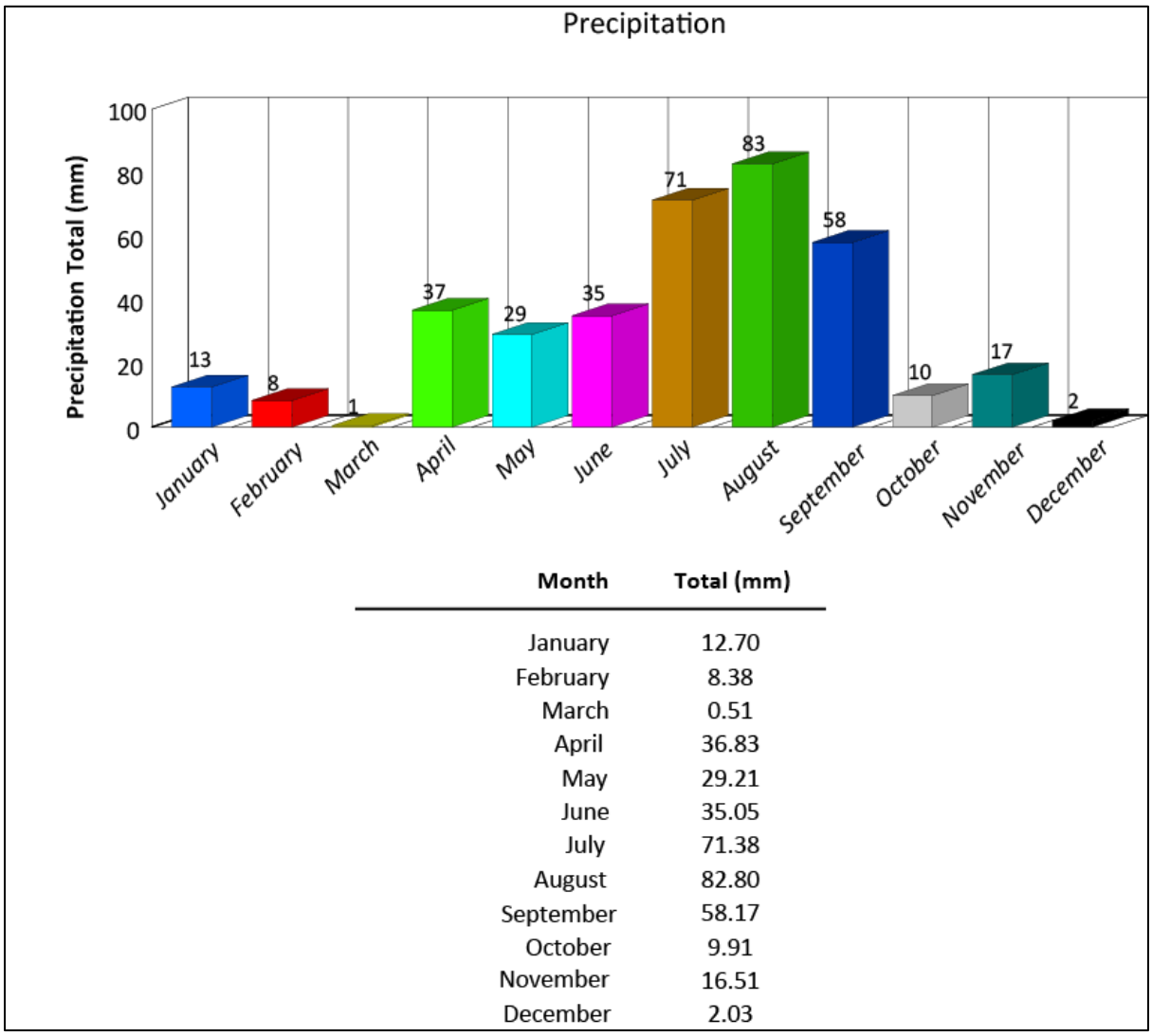
5.3 Meteorological Monitoring

The WIPP facility meteorological station is located 600 m (1,969 ft) northeast of the WHB. The main function of the station is to provide data for atmospheric dispersion modeling. Every 15 minutes, the station records wind speed, wind direction, and temperature at elevations of 2, 10, and 50 m (6.6, 33, and 164 ft). The station also records ground-level measurements of barometric pressure, relative humidity, precipitation, and solar radiation.

5.3.1 Weather Data

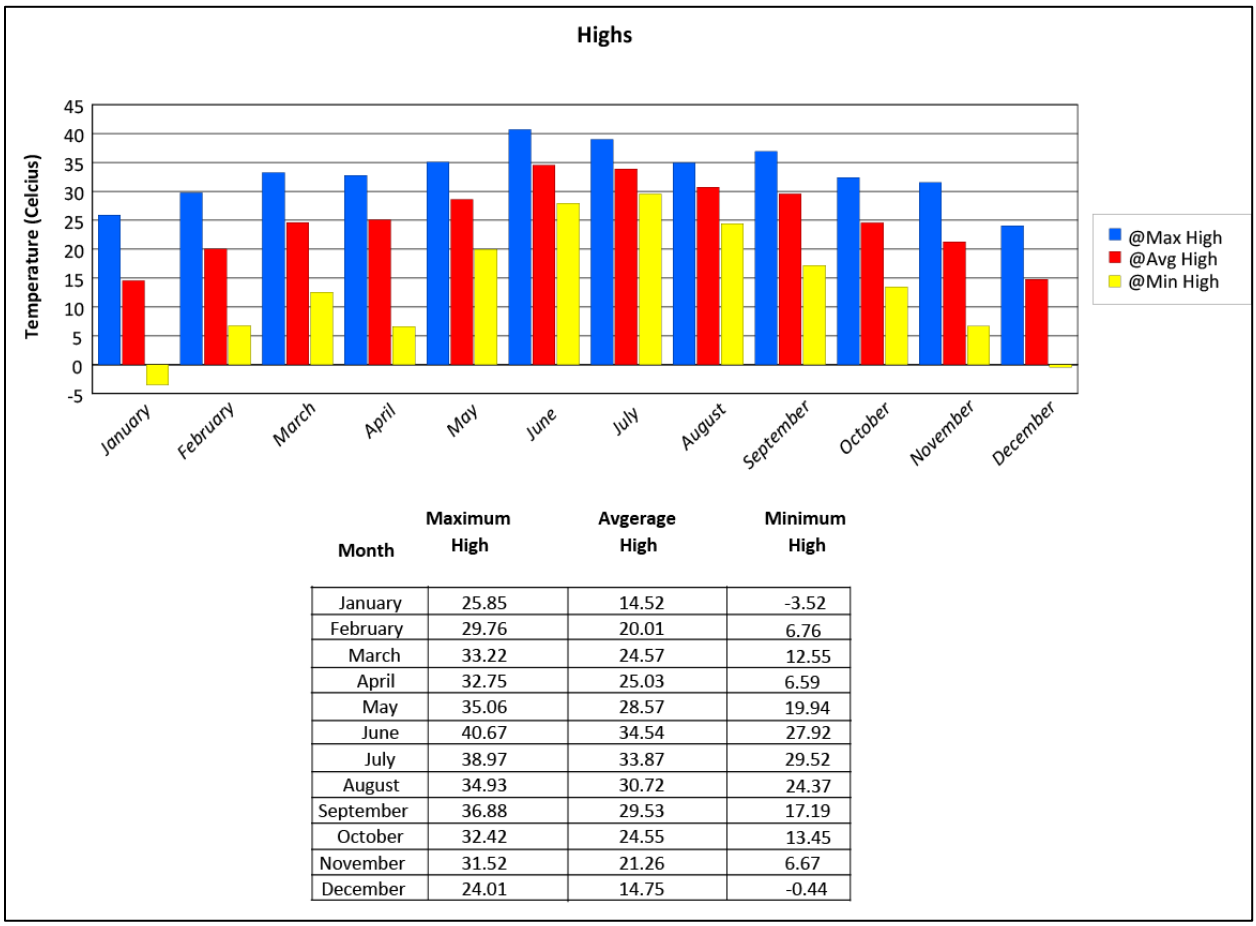
Precipitation at the WIPP site for 2017 was 363.48 mm (14.31 in.) compared to 801.39 mm (31.55 in.) for 2016. The average yearly rainfall recorded at the meteorological tower since 1970 is 354.58 mm (13.96 in.). Figure 5.1 displays the monthly precipitation at the WIPP site for 2017.

The maximum recorded temperature (10-m level) at the WIPP site in 2017 was 40.67°C (105.21°F) in May, whereas the lowest temperature recorded was -10.74°C (12.67°F) in December. Monthly temperatures are illustrated in Figures 5.2, 5.3, and 5.4. The average temperature at the WIPP site in 2017 was 18.57°C (65.43°F), which is 0.39°C warmer than the 2016 average of 18.18°C (64.72°F). The average monthly temperatures for the WIPP area ranged from 27.51°C (81.52°F) during July to 7.69°C (45.84°F) in December (Figure 5.3).



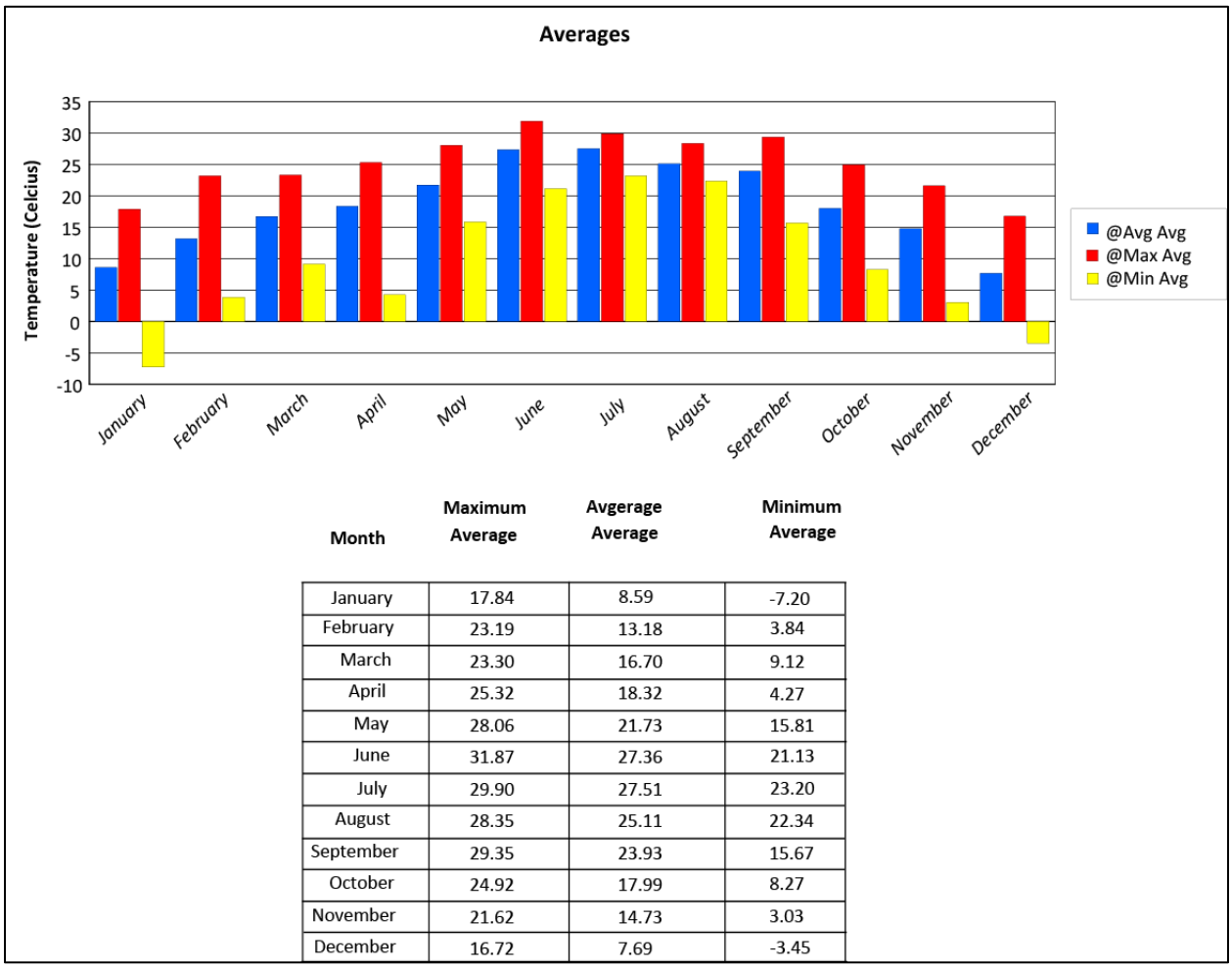
Month	Total (mm)
January	12.70
February	8.38
March	0.51
April	36.83
May	29.21
June	35.05
July	71.38
August	82.80
September	58.17
October	9.91
November	16.51
December	2.03

Figure 5.1 – WIPP Site Precipitation Report for 2017



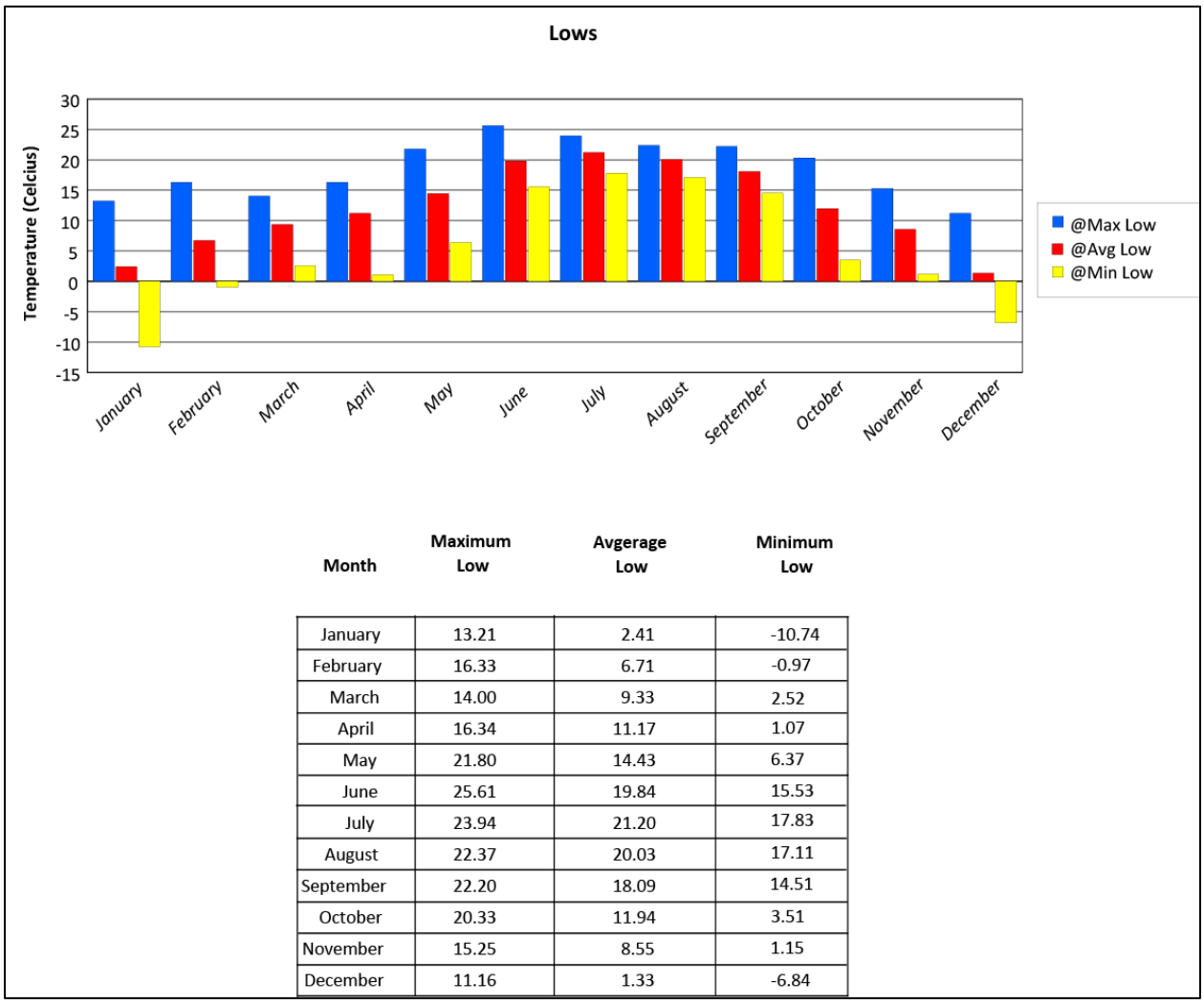
Month	Maximum High	Avgerage High	Minimum High
January	25.85	14.52	-3.52
February	29.76	20.01	6.76
March	33.22	24.57	12.55
April	32.75	25.03	6.59
May	35.06	28.57	19.94
June	40.67	34.54	27.92
July	38.97	33.87	29.52
August	34.93	30.72	24.37
September	36.88	29.53	17.19
October	32.42	24.55	13.45
November	31.52	21.26	6.67
December	24.01	14.75	-0.44

Figure 5.2 – WIPP Site High Temperatures (ºC) for 2017



Month	Maximum Average	Avgerage Average	Minimum Average
January	17.84	8.59	-7.20
February	23.19	13.18	3.84
March	23.30	16.70	9.12
April	25.32	18.32	4.27
May	28.06	21.73	15.81
June	31.87	27.36	21.13
July	29.90	27.51	23.20
August	28.35	25.11	22.34
September	29.35	23.93	15.67
October	24.92	17.99	8.27
November	21.62	14.73	3.03
December	16.72	7.69	-3.45

Figure 5.3 – WIPP Site Average Temperatures (ºC) for 2017

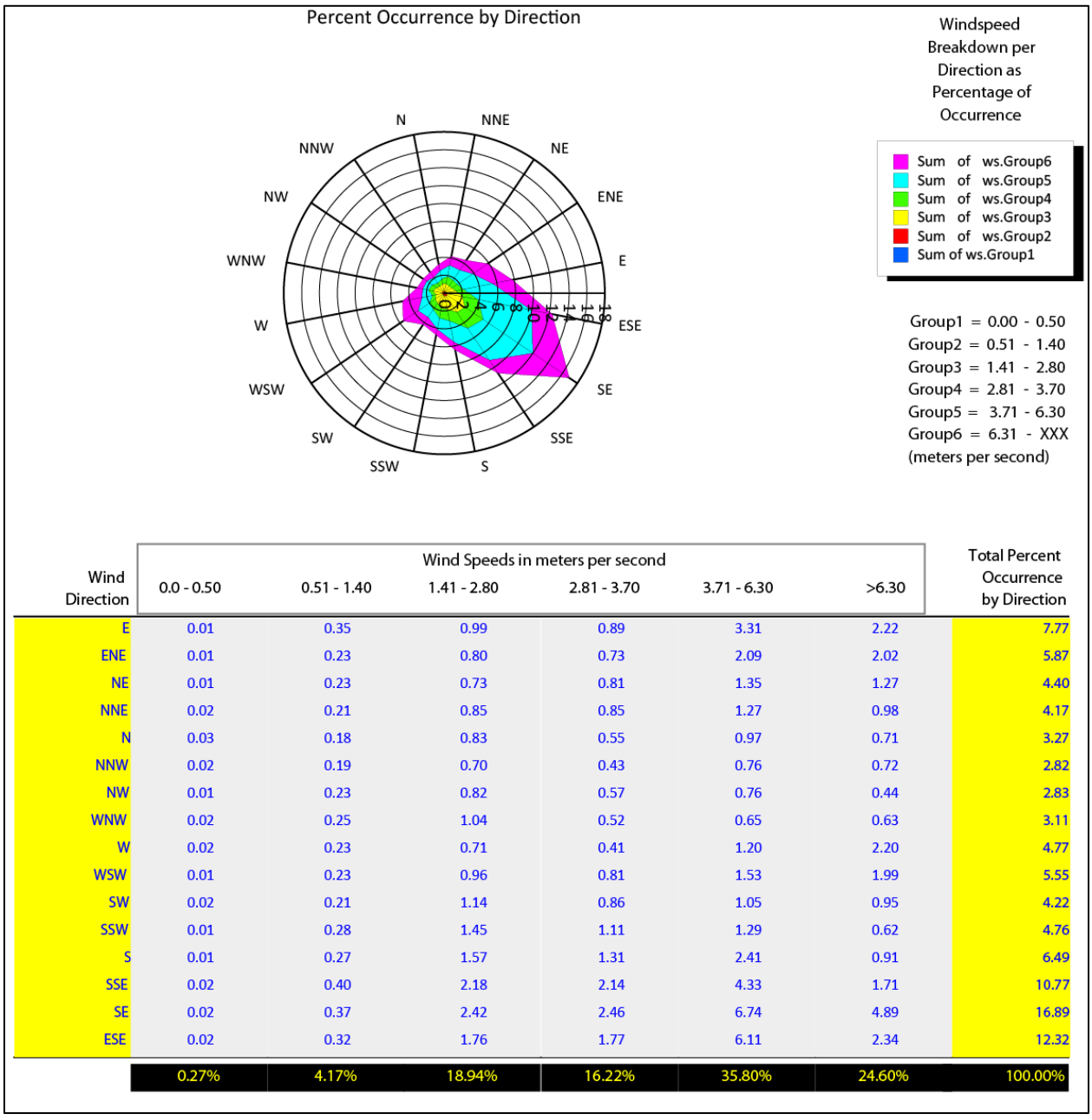


Month	Maximum Low	Avgerage Low	Minimum Low
January	13.21	2.41	-10.74
February	16.33	6.71	-0.97
March	14.00	9.33	2.52
April	16.34	11.17	1.07
May	21.80	14.43	6.37
June	25.61	19.84	15.53
July	23.94	21.20	17.83
August	22.37	20.03	17.11
September	22.20	18.09	14.51
October	20.33	11.94	3.51
November	15.25	8.55	1.15
December	11.16	1.33	-6.84

Figure 5.4 – WIPP Site Low Temperatures (ºC) for 2017

5.3.2 Wind Direction and Wind Speed

Winds in the WIPP area are predominantly from the southeast. In 2017, winds of 3.71 to 6.30 meters per second (8.30 to 14.09 miles per hour) were the most prevalent, occurring approximately 35.8 percent of the time (measured at the 10-m level). There were no tornadoes at the WIPP site in 2017. Figure 5.5 displays the annual wind data at the WIPP site for 2017.



Wind Direction	Wind Speeds in meters per second 0.0 - 0.50	0.51 - 1.40	1.41 - 2.80	2.81 - 3.70	3.71 - 6.30	>6.30	Total Percent Occurrence by Direction
E	0.01	0.35	0.99	0.89	3.31	2.22	7.77
ENE	0.01	0.23	0.80	0.73	2.09	2.02	5.87
NE	0.01	0.23	0.73	0.81	1.35	1.27	4.40
NNE	0.02	0.21	0.85	0.85	1.27	0.98	4.17
N	0.03	0.18	0.83	0.55	0.97	0.71	3.27
NNW	0.02	0.19	0.70	0.43	0.76	0.72	2.82
NW	0.01	0.23	0.82	0.57	0.76	0.44	2.83
WNW	0.02	0.25	1.04	0.52	0.65	0.63	3.11
W	0.02	0.23	0.71	0.41	1.20	2.20	4.77
WSW	0.01	0.23	0.96	0.81	1.53	1.99	5.55
SW	0.02	0.21	1.14	0.86	1.05	0.95	4.22
SSW	0.01	0.28	1.45	1.11	1.29	0.62	4.76
S	0.01	0.27	1.57	1.31	2.41	0.91	6.49
SSE	0.02	0.40	2.18	2.14	4.33	1.71	10.77
SE	0.02	0.37	2.42	2.46	6.74	4.89	16.89
ESE	0.02	0.32	1.76	1.77	6.11	2.34	12.32
	0.27%	4.17%	18.94%	16.22%	35.80%	24.60%	100.00%

Figure 5.5 – WIPP Site Wind Speed (at 10-Meter Level) Report for 2017

5.4 Volatile Organic Compound Monitoring

The purpose of the VOC monitoring program is to demonstrate compliance with the limits specified in the WIPP Permit Part 4, in order to document continued protection of human health and the environment.

The Repository VOC Monitoring Program is designed to monitor the VOC concentrations, to which the non-waste surface workers are exposed, that are attributable to TRU mixed waste emplaced in the underground. The repository VOC sampling locations are Station VOC-C, located at the west side of Building 489, and Station VOC-D, at groundwater pad WQSP-4 for measuring background VOCs. Sampling frequency for repository VOC monitoring is twice per week for the two air-sampling locations in accordance with Permit Attachment N, Section N-3d.

For this reporting period, 208 samples were collected from Stations VOC-C and VOC-D along with 26 field duplicate samples. Repository VOC monitoring results indicate that risk to the non-waste surface workers continues to be below action levels. Repository VOC monitoring data were reported in the Semi-annual VOC, Hydrogen, and Methane Data Summary Reports. Summary results for the period January 1, 2017, through December 31, 2017, are included in Table 5.1a and 5.1b.

Table 5.1a – Target Analyte Maximum Emission Value

Target Compound	Max. Value (pptv)	Sample Date
Carbon Tetrachloride	640	8/31/2017
Chlorobenzene	N/A	N/A
Chloroform	N/A	N/A
1,1-Dichloroethylene	N/A	N/A
1,2-Dichloroethane	N/A	N/A
Methylene Chloride	104	3/7/2017
1,1,2,2-Tetrachloroethane	N/A	N/A
Toluene	303	12/13/2017
1,1,1-Trichloroethane	191	8/31/2017
Trichloroethylene	287	8/31/2017

pptv – parts per trillion by volume

Table 5.1b – Annual Average and Maximum Result for Cancer Risk and Hazard Index

Calculation	Cancer Risk	Hazard Index
Annual Average	1.66E-07	1.54E-02
Maximum Result	9.55E-07 (8/31/2017)	1.78E-01 (8/31/2017)

Average and maximum results include samples for the current reporting period.
Cancer risk action level is 1E-05.
Hazard index action level is 1.

In accordance with NMED Administrative Order, ongoing disposal room VOC monitoring was not conducted during this reporting period. Monitoring was discontinued in early February 2014 due to the occurrence of two separate events in the WIPP underground facility that interrupted normal waste emplacement operations. The last Ongoing Disposal Room VOC Monitoring Program sample was collected on February 3, 2014. This sampling program remains inactive because entry into the sampling locations is prohibited due to radiological and ground conditions.

Due to the radiological event in February 2014, the Panel 7 disposal room VOC monitoring system was inactive until December 19, 2016. In preparation for resumption of waste emplacement, the Panel 7 disposal room VOC monitoring system was reactivated and used to collect a preliminary sample (prior to resumption of waste emplacement) on December 19, 2016, from the Room 6E sample location. On January 4, 2017, waste emplacement was resumed in Room 6 of Panel 7. Routine bi-weekly samples have been collected since December 19, 2016 and continue to be collected.

For this reporting period, 42 samples were collected from disposal rooms along with 10 field duplicate samples. Sample results are summarized in Table 5.1c. Sample location data are identified by the source panel number, room number, and intake (I) or exhaust (E) function. For example, the Panel 7 Room 6 exhaust location is coded P7R6E.

Table 5.1c – Disposal Room VOC Monitoring Results

Target Compound	Maximum Detected Value (ppmv)	Location of Maximum Detected Value	50% Action Level (ppmv)	95% Action Level (ppmv)	Room-based Limits (ppmv)	Total Exceedances
Carbon Tetrachloride	10.3	P7R6E	4,813	9,145	9,625	0
Chlorobenzene	0.01	P7R6E	6,500	12,350	13,000	0
Chloroform	0.37	P7R6E	4,965	9,433	9,930	0
1,1-Dichloroethylene	N/A	N/A	2,745	5,215	5,490	0
1,2-Dichloroethane	N/A	N/A	1,200	2,280	2,400	0
Methylene Chloride	0.03	P7R6E	50,000	95,000	100,000	0
1,1,2,2-Tetrachloroethane	0.01	P7R6E	1,480	2,812	2,960	0

Toluene	0.01	P7R6E	5,500	10,450	11,000	0
1,1,1-Trichloroethane	4.35	P7R6E	16,850	32,015	33,700	0
Trichloroethylene	3.08	P7R6E	24,000	45,600	48,000	0

N/A = Not applicable

ppmv = parts per million by volume

The basis for the VOC sampling reported in this section is the guidance included in EPA 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)* (EPA, 1999). The samples were analyzed using gas chromatography/mass spectrometry (GC/MS) under an established QA/QC program. Laboratory analytical procedures were developed based on the concepts contained in both TO–15 and *Draft Contract Laboratory Program Volatile Organics Analysis of Ambient Air in Canisters* (EPA, 1994).

5.5 Hydrogen and Methane Monitoring

In accordance with NMED Administrative Order, hydrogen and methane monitoring was not conducted during this reporting period. Monitoring was discontinued in early February 2014 due to the occurrence of two separate events in the WIPP underground facility that interrupted normal waste emplacement operations. The last Hydrogen and Methane Monitoring Program sample was collected on February 3, 2014. This sampling program remains inactive because entry into the sampling locations is prohibited due to radiological and ground conditions.

5.6 Seismic Activity

Currently, seismicity within 300 km (186 mi) of the WIPP site is being monitored by the New Mexico Institute of Mining and Technology using data from a nine-station network approximately centered on the site (Figure 5.6). Station signals are transmitted to the New Mexico Institute of Mining and Technology Seismological Observatory in Socorro, New Mexico. When appropriate, readings from the WIPP network stations are combined with readings from an additional New Mexico Institute of Mining and Technology network in the central Rio Grande Rift. Occasionally, data are exchanged with the University of Texas at El Paso and Texas Tech University in Lubbock, both of which operate monitoring stations in west Texas.

The mean operational efficiency of the WIPP seismic monitoring stations during 2017 was approximately 95 percent. In the past year since the network upgrade, many dozens of events were detected that were not recorded by any other seismic network in the state or adjacent states. From January 1 through September 30, 2017, locations for 528 seismic events were recorded within 300 km (186 mi) of the WIPP site. Events for the period from October 1 through December 31, 2017 have not been analyzed. Data for these events will be reported in the 2018 ASER. Recorded data included origin times, epicenter coordinates, and magnitudes. The strongest recorded events

(magnitude 3.3) occurred on October 22 and December 15, 2017; these events were approximately 180 kms (110 mi) south of the site. The closest earthquake to the site was approximately 8 km (5 mi) north-northeast and had a magnitude of 1.7.

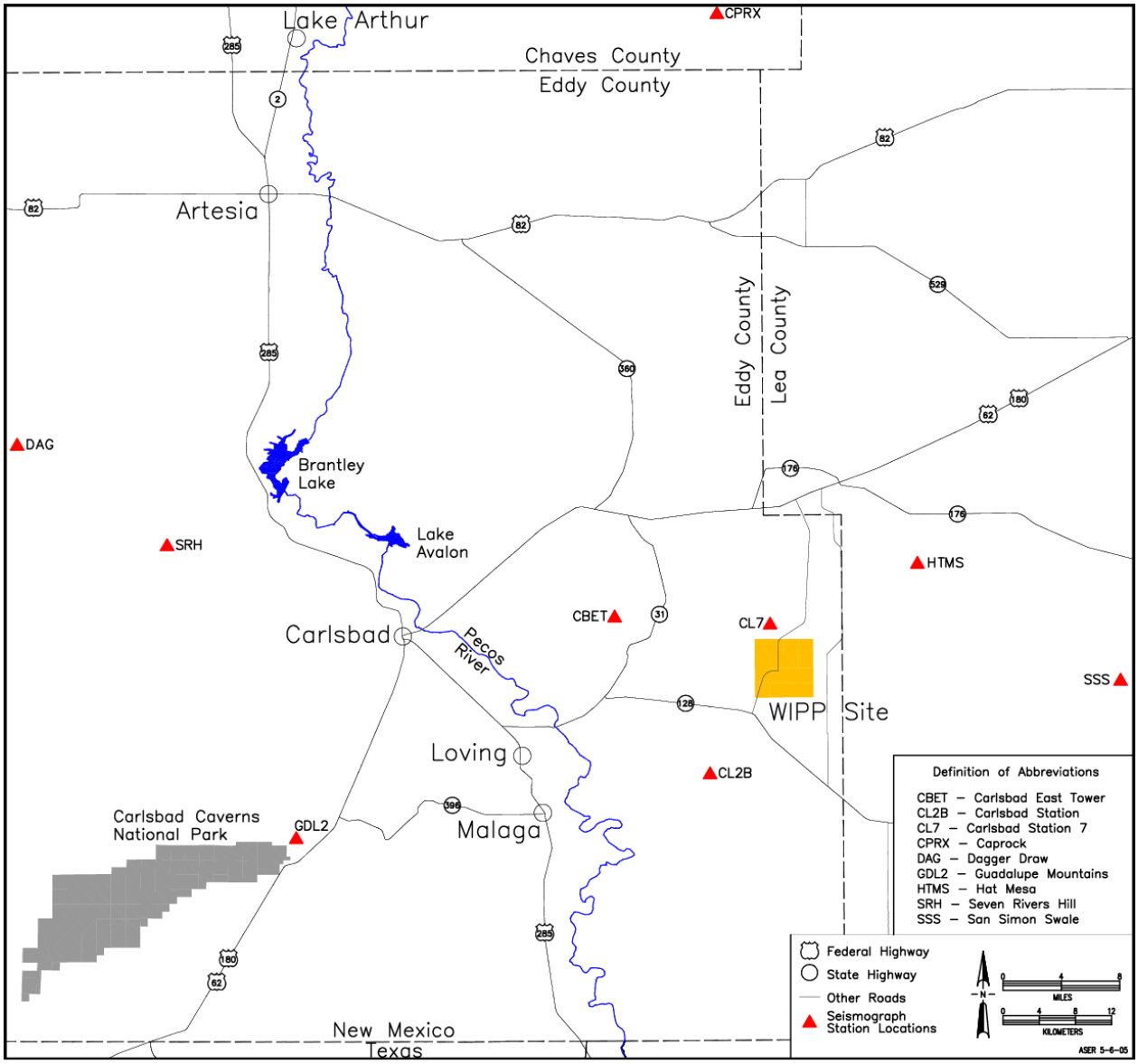


Figure 5.6 – Seismograph Station Locations in the Vicinity of the WIPP Site

5.7 Liquid Effluent Monitoring

The NMED Ground and Surface Water Protection regulations set forth in 20.6.2 NMAC regulate discharges that could impact surface water or groundwater. DOE compliance with these regulations is discussed in Chapter 2. The DP was renewed on July 29, 2014. A renewal is necessary every five years. No modification occurred during this renewal process. The names of the ponds were changed to reflect a more orderly

nomenclature. However, the water sample collection processes remained the same as the last DP modification. Analytical data from the discharge monitoring reports are summarized in Table 5.2 and Table 5.3.

Table 5.2 – Sewage Lagoon and H–19 Analytical Results for Spring 2017

Analyte	Influent Pond 2A[(a)]	Evaporation Pond B	Evaporation Pond C	H–19 Evaporation Pond
Nitrate (mg/L)	ND	N/A	N/A	N/A
TKN (mg/L)	120	N/A	N/A	N/A
TDS (mg/L)	370	360,000	336,000	475,000
Sulfate (mg/L)	46	90,000	64,500	330
Chloride (mg/L)	100	130,000	180,000	340,000

Notes:
mg/L Milligrams per liter.
N/A Not applicable (analysis not required by DP-831).
ND Non-detect.
TKN Total Kjeldahl nitrogen.
(a) Average of duplicate samples.

Table 5.3 – Sewage Lagoon, H-19, and Infiltration Control Pond Analytical Results for Fall 2017

Location	Nitrate (mg/L)	TKN (mg/L)	TDS (mg/L)	Sulfate (mg/L)	Chloride (mg/L)
Settling Lagoon 2	ND	130	545[(a)]	52[(a)]	110[(a)]
Effluent Lagoon B	N/A	N/A	427,000	130,000	270,000
Effluent Lagoon C	N/A	N/A	407,000	92,000	250,000
Evaporation Pond H-19	N/A	N/A	451,000	670	510,000
Salt Storage Pond 1	N/A	N/A	287,000	2,780	146,000
Salt Storage Pond 2	N/A	N/A	322,000	9,530	154,000
Salt Storage Pond 3	N/A	N/A	360,000	22,800	191,000
Storm Water Pond 1	N/A	N/A	407	13.7	174
Storm Water Pond 2	N/A	N/A	160.5	3.425	50.6
Storm Water Pond 3	N/A	N/A	299	13.1	96.8

Notes:
N/A Not applicable (analysis not required by DP-831).
ND Non-detect.
TKN Total Kjeldahl nitrogen (as N).
(a) Average of duplicate samples.

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CHAPTER 6 – SITE HYDROLOGY, GROUNDWATER MONITORING, AND PUBLIC DRINKING WATER PROTECTION

Current groundwater monitoring activities in the vicinity of the WIPP facility are outlined in the *WIPP Groundwater Monitoring Program Plan* (WP 02–1). In addition, the MOC has detailed procedures for performing specific activities, such as pumping system installations, field monitoring analyses and documentation, and QA records management. Groundwater monitoring activities are also included in the *Waste Isolation Pilot Plant Environmental Monitoring Plan* (DOE/WIPP-99-2194).

6.1 Site Hydrology

The hydrology at and surrounding the WIPP site has been studied extensively over the past 40 years. A summary of the hydrology in this area is contained in the following sections. Figure 6.1 shows a generalized schematic of the stratigraphy at the site. Details for hydrology and stratigraphy can be found in Mercer, 1983; Beauheim, 1986, 1987; and Beauheim and Ruskauff, 1998.

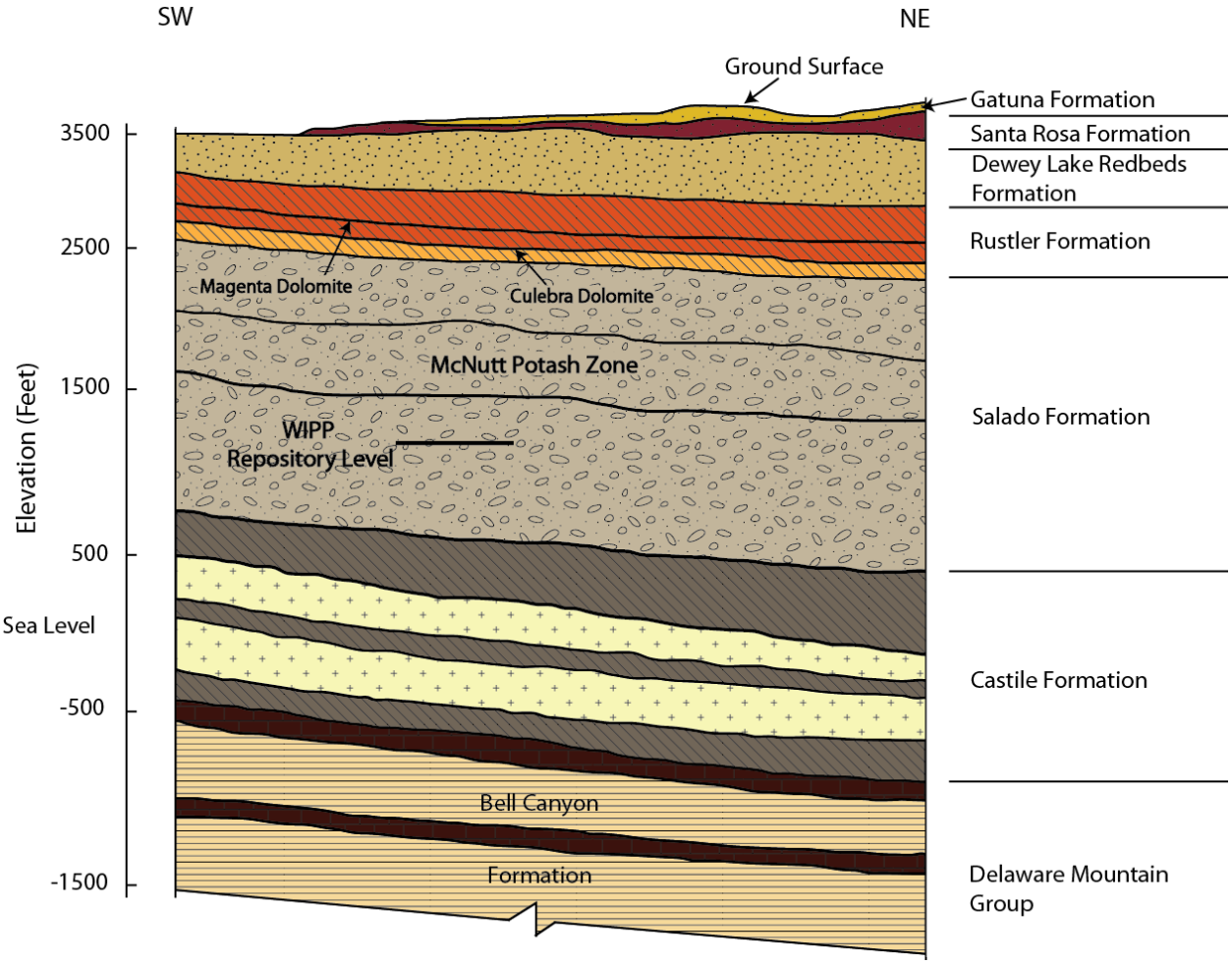


Figure 6.1 – WIPP Stratigraphy

6.1.1 Surface Hydrology

Surface water is absent from the WIPP site. The nearest significant surface water body, Laguna Grande de la Sal, is 13 km (8 mi) west-southwest of the center of the WIPP site in Nash Draw, where shallow brine ponds occur. Small, manmade livestock watering holes (tanks) occur several kilometers from the WIPP site, but are not hydrologically connected to the formations overlying the WIPP repository.

6.1.2 Subsurface Hydrology

Several water-bearing zones have been identified and extensively studied at and near the WIPP site. Limited amounts of potable water are found in the middle Dewey Lake Redbeds Formation (Dewey Lake) and the overlying Triassic Dockum group in the southern part of the WIPP LWA area. Two water-bearing units, the Culebra and the Magenta Dolomite (Magenta), occur in the Rustler and produce brackish to saline water at and in the vicinity of the WIPP site. Another very low transmissivity, saline water-bearing zone occurs at the Rustler and Salado contact.

6.1.2.1 Hydrology of the Castile Formation

The Castile Formation (Castile) is composed of a sequence of three thick anhydrite beds separated by two thick halite beds. This formation acts as an aquitard, separating the Salado from the underlying water-bearing sandstones of the Bell Canyon Formation (Bell Canyon). In the halite zones, the occurrence of circulating groundwater is restricted because halite at these depths does not readily maintain secondary porosity, open fractures, or solution channels.

No regional groundwater flow system has been found in the Castile in the vicinity of the WIPP site. The only significant water present in the formation occurs in isolated brine reservoirs in fractured anhydrite. Wells have encountered pressurized brine reservoirs in the upper anhydrite unit of the Castile in the vicinity of the WIPP site. Two such encounters were made by boreholes drilled for the WIPP project: ERDA 6, northeast of the WIPP site, encountered a pressurized brine reservoir in 1975; and borehole WIPP–12, 1 mi north of the center of the WIPP site, encountered a brine reservoir in 1981. Both encounters were hydrologically and chemically tested in 1981 and determined to be unconnected (Popielak et al., 1983).

6.1.2.2 Hydrology of the Salado Formation

The massive halite beds within the Salado host the WIPP repository horizon. The Salado represents a regional aquiclude due to the hydraulic properties of the bedded halite that forms most of the formation. In the halites, the presence of circulating groundwater is restricted because halites do not readily maintain primary porosity, solution channels, or open fractures.

The results of permeability testing, both within the facility and from the surface, provide interpreted Darcy permeabilities that range from less than 1E-23 to 3E-16 square meters (m^2), with the more pure (less argillaceous) halites having the lower permeability. Anhydrite interbeds typically have permeabilities ranging from 2E-20 to 9E-18 m^2 (Beauheim and Roberts, 2002). The only significant variation to these extremely low permeabilities occurs in the immediate vicinity of the underground workings (Stormont et al., 1991). This increase is believed to be a result of near-field fracturing due to the excavation.

Small quantities of brine have been observed to collect in boreholes drilled into Marker Bed 139 a few feet below the floor of the WIPP underground repository rooms and have been observed to seep out of the excavated walls. The long-term performance assessment for the WIPP disposal system assumes that small quantities of brine will be present in the WIPP repository.

6.1.2.3 Hydrology of the Rustler-Salado Contact

In Nash Draw and areas immediately west of the site, the Rustler-Salado contact exists as a dissolution residue capable of transmitting water. Eastward from Nash Draw toward the WlPP site, the amount of dissolution decreases and the transmissivity of this interval decreases (Mercer, 1983). Small quantities of brine were found in the test holes in this zone at the WIPP site (Mercer and Orr, 1977).

6.1.2.4 Hydrology of the Culebra Member

The Culebra is the most transmissive hydrologic unit in the WIPP site area and is considered the most significant potential hydrologic pathway for a radiologic release to the accessible environment.

Tests show that the Culebra is a fractured, heterogeneous system approximately 25 ft thick, with varying local anisotropic characteristics (Mercer and Orr, 1977; Mercer, 1983; Beauheim, 1986, 1987; Beauheim and Ruskauff, 1998). Calculated transmissivities for the Culebra within the WIPP site boundary have a wide range, with values between 1.2E–08 square meters per day (m^2/d) to approximately 112 m^2/d (1.29E–07 square feet per day [ft^2/d] to 1.20E+03 ft^2/d). The majority of the values are less than 9.3E–02 m^2/d (1 ft^2/d) (DOE/WIPP-09-3424, *Compliance Recertification Application*, Appendix HYDRO, 2009). Transmissivities generally decrease from west to east across the site area, with a relatively high transmissivity zone trending southeast from the center of the WIPP site to the site boundary. The regional flow direction of groundwater in the Culebra is generally south.

6.1.2.5 Hydrology of the Magenta Member

The Magenta is situated above the Culebra and, although it is not the water-bearing zone of interest for monitoring of a facility release, it is of interest in understanding water-level changes that occur in the Culebra. The Magenta has been tested in 18 cased and open holes at and around the WIPP site. Magenta transmissivities within the

WIPP site range from 2.0E–04 to 3.5E–02 m^2/d (2.1E–03 to 3.8E–01 ft^2/d) (Beauheim et al., 1991; Beauheim and Ruskauff, 1998; Bowman and Roberts, 2009).

6.1.2.6 Hydrology of the Dewey Lake Redbeds Formation

The Dewey Lake at the WIPP site is approximately 152 m (500 ft) thick and consists of alternating thin beds of siltstone and fine-grained sandstone. The upper Dewey Lake consists of a thick, generally unsaturated section. The middle Dewey Lake is the interval immediately above a cementation change, from carbonate (above) to sulfate (below), where saturated conditions and a natural water table have been identified in limited areas. An anthropogenic saturated zone has been observed in the overlying Santa Rosa Formation (Santa Rosa) and in the upper part of the Dewey Lake since 1995. This is described in Section 6.6. The lower Dewey Lake is below the sulfate cementation change, with much lower permeabilities.

WIPP monitoring well WQSP–6A (Figure 6.2) intersects natural water in the Dewey Lake. At this location, the saturated horizon is within the middle portion of the formation. The saturated zone at well WQSP–6A is both vertically and laterally distinct from the water at well C–2811 (see Section 6.6 for a full discussion of SSW). Well C–2811 is located approximately 1.61 km (1 mi) to the northeast of WQSP–6A on the C–2737 well pad (Figure 6.2). Approximately 1.61 km (1 mi) south of the WIPP site, domestic and stock supply wells produce water from the middle Dewey Lake.

6.1.2.7 Hydrology of the Santa Rosa and Gatuña Formations

Within the WIPP site boundary, the Santa Rosa is relatively thin to absent. At the air Intake Shaft, 0.6 m (2 ft) of rock is classified as the Santa Rosa. The Santa Rosa is a maximum of 78 m (256 ft) thick in exploratory potash holes drilled for the WIPP project, east of the site boundary. The Santa Rosa is thicker to the east. The geologic data from site characterization studies have been incorporated with data from drilling to investigate SSW for the purpose of mapping Santa Rosa structure and thickness in the vicinity of the WIPP surface structures. These results are consistent with the broader regional distribution of the Santa Rosa (*WIPP Compliance Recertification Application*, DOE/WIPP-04-3231).

Water in the Santa Rosa has been found in the center part of the WIPP site since 1995. Because no water was found in this zone during the mapping of the shafts in 1980s, the water is deemed to be caused by human activity (Daniel B. Stephens & Associates, Inc., 2003). To assess the quantity and quality of this water, piezometers PZ–1 to PZ-12 were installed in the area between the WIPP shafts. Also, wells C–2505, C–2506, and C–2507 were drilled and tested in 1996 and 1997 (*Exhaust Shaft Hydraulic Assessment Data Report*, DOE/WIPP-97-2219). These wells are shown in Figure 6.8 later in this chapter. During October 2007, three additional piezometers (PZ–13, PZ–14, and PZ–15) were installed around the SPDV tailings pile to evaluate the nature and extent of SSW around this area.

The Gatuña Formation (Gatuña) unconformably overlies the Santa Rosa at the WIPP site, ranging in thickness from approximately 6 to 9 m (20 to 30 ft). The Gatuña consists of silt, sand, and clay, with deposits formed in localized depressions during the Pleistocene period.

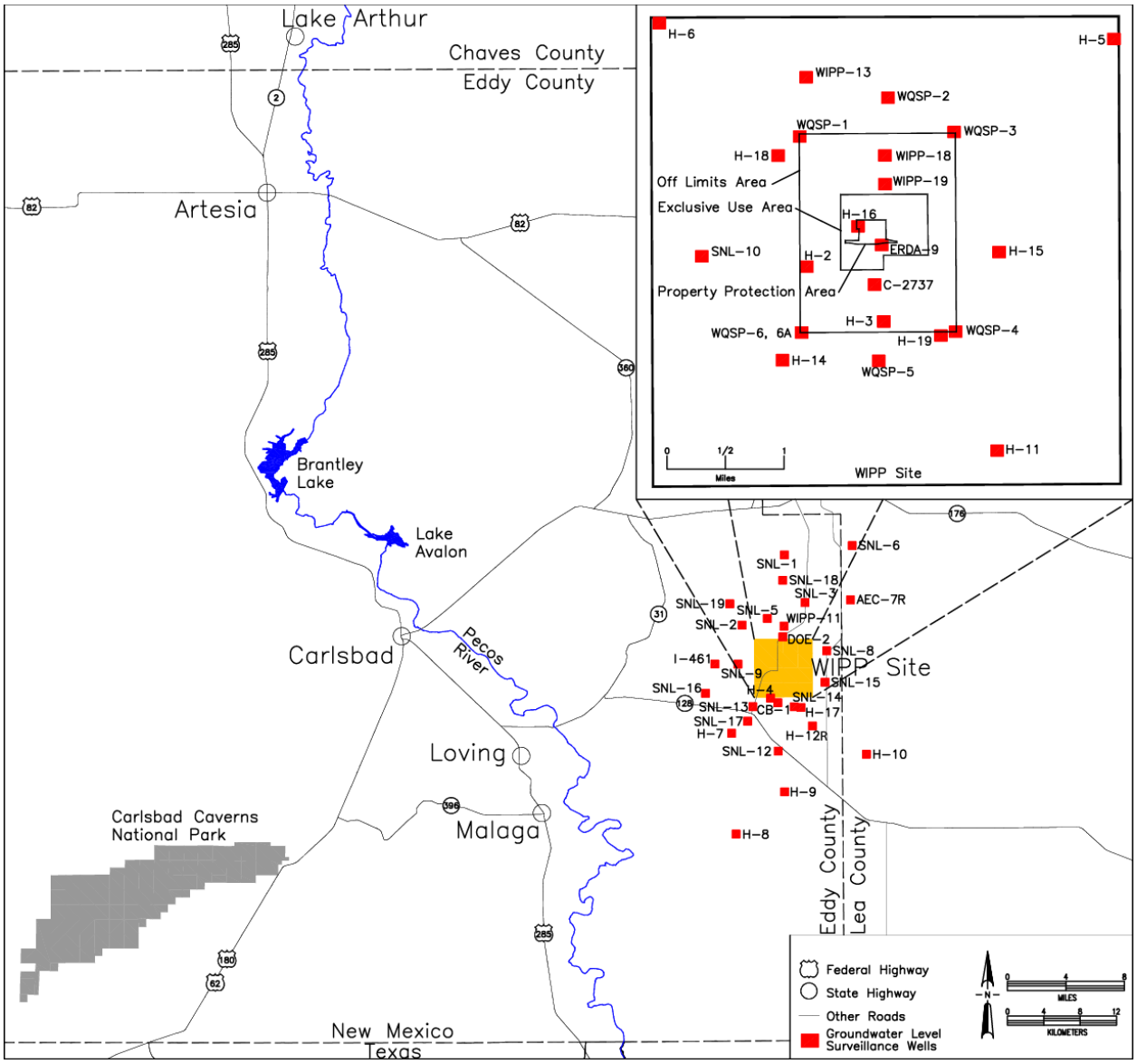


Figure 6.2 – Groundwater Level Surveillance Well Pads (Inset Represents the Groundwater Surveillance Wells in the WIPP Land Withdrawal Area)

The Gatuña is water bearing in some areas, with saturation occurring in discontinuous perched zones. However, because of its erratic distribution, the Gatuña has no known continuous saturation zone. Drilling at the WIPP site, including 30 exploration borings drilled between 1978 and 1979, did not identify saturated zones in the Gatuña (Daniel B. Stephens & Associates, Inc., 2003).

6.2 Groundwater Monitoring

6.2.1 Program Objectives

The objectives of the groundwater monitoring program are to:

- Monitor the physical and chemical characteristics of groundwater.
- Maintain surveillance of groundwater levels surrounding the WIPP facility throughout the operational lifetime of the facility.
- Document and identify effects, if any, of WIPP operations on groundwater parameters throughout the operational lifetime (including closure) and post-closure of the facility.

Data obtained through the WIPP groundwater monitoring program support two major regulatory programs: (1) the *Resource Conservation and Recovery Act* DMP supporting the Permit in compliance with 20.4.1.500 NMAC (incorporating 40 CFR Part 264, Subpart F, "Releases From Solid Waste Management Units," and 40 CFR Part 264, Subpart X, "Miscellaneous Units"), and (2) performance assessment supporting *Title 40 CFR Part 191 Subparts B&C Compliance Certification Application for the Waste Isolation Pilot Plant* (DOE/CAO-96-2184) and five-year recertification applications.

Baseline water chemistry data in the Water Quality Sampling Program (WQSP) wells were collected from 1995 through 1997 and reported in the *Waste Isolation Pilot Plant RCRA Background Groundwater Quality Baseline Report* (DOE/WIPP-98-2285). The baseline data were expanded in 2000 to include ten rounds of sampling instead of five. The data were published in Addendum 1, *Waste Isolation Pilot Plant RCRA Background Groundwater Quality Baseline Update Report* (IT Corporation, 2000). These baseline data are compared to water quality data collected annually.

6.2.2 Summary of 2017 Activities

Routine Culebra groundwater monitoring activities include groundwater quality sampling, groundwater level monitoring, and the fluid density survey, as described in this section. These programs are required by the Permit. Activities supported during 2017 included hydraulic testing and non-Permit groundwater quality sampling (Section 6.4). Table 6.1 presents a summary of WIPP groundwater monitoring activities in 2017.

Wells are classified as environmental surveillance wells. The WIPP facility does not have wells required for remediation, waste management, or other requirements. Appendix F, Table F.3, lists active groundwater monitoring wells used by the DOE for the WIPP facility at the end of 2017.

Radiological data for 2017 from the DMP are summarized in Chapter 4. The remaining data from the DMP are contained in this chapter.

Table 6.1 – Summary of 2017 DOE WIPP Groundwater Monitoring Program

Number of Active Wells	84
Number of Analyses	267[(a)]
Number of Water Level Measurements	797
Total Number of Analyte Measurements	1,368[(b)]

Notes:

(a) Includes primary, duplicate, and blank samples taken from six wells in 2017.

(b) Includes primary, duplicate, and QA (blanks) sample analyses.

Regular monthly groundwater level data were gathered from 58 wells across the WIPP region (Figure 6.2), one of which is equipped with a production-injection packer to allow groundwater level surveillance of more than one hydrologic zone in the same well. The six redundant wells on the H–19 pad, the 19 shallow water wells, and H–03D, which was dry (for Santa Rosa/Dewey Lake contact listed in Appendix F, Table F.3), were measured quarterly. Table F.4 shows the water level data. Water level data were not taken where access was unavailable, or in certain wells when testing equipment was present.

6.2.3 Groundwater Quality Sampling

The Permit requires groundwater quality sampling once a year, from March through May (Round 39 for 2017). Sampling for groundwater quality was performed at six well sites (Figure 6.3). Field analyses for pH, specific gravity, specific conductance, and temperature were performed during the sampling to determine when the well had stabilized for final sampling.

Primary and duplicate samples for groundwater quality were taken from each of the six wells completed in the Culebra (WQSP–1 through WQSP–6), for a total of 267 analyses completed per sampling round.

Wells WQSP–1, WQSP–2, and WQSP–3 are upgradient of the WIPP shafts within the Land Withdrawal Boundary (LWB). The locations of the wells were selected to be representative of the groundwater moving downgradient onto the WIPP site. Wells WQSP–4, WQSP–5, and WQSP–6 are downgradient of the WIPP shafts within the LWB. WQSP–4 was also specifically located to monitor a zone of higher transmissivity.

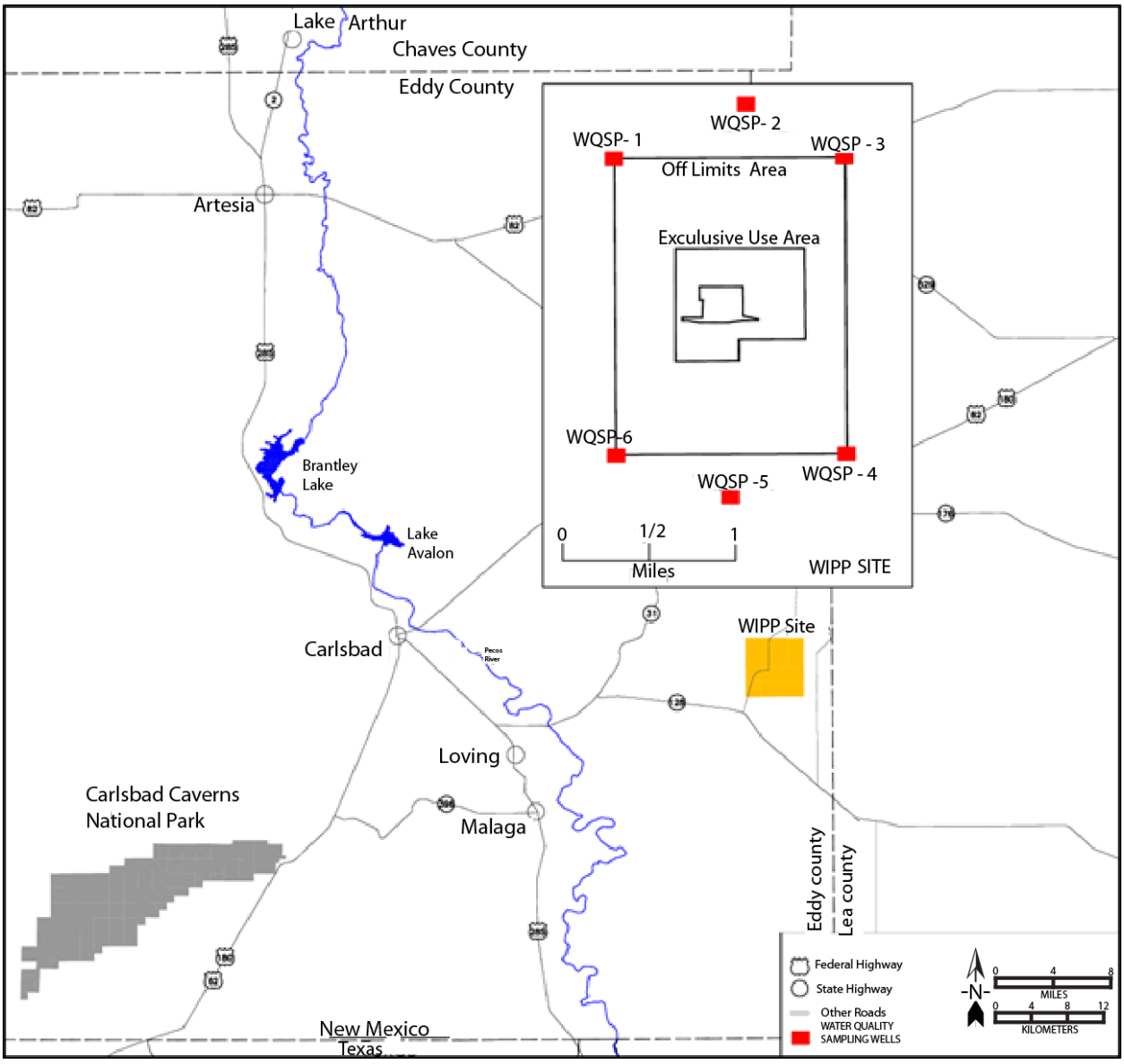


Figure 6.3 – Detection Monitoring Program Wells

The difference between the depth of the WIPP repository and the depth of the detection monitoring wells completed in the Culebra varies from 387 m to 587 m (1,270 ft to 1,926 ft). The DOE does not anticipate finding WIPP-related contamination in the groundwater because a release from the repository to the Culebra is highly unlikely. In order for contaminated liquid to move from the repository to the Culebra, three conditions would have to be met. First, sufficient brine would have to accumulate in the waste disposal areas to leach contaminants from the disposed waste. Second, sufficient pressure would have to build up in the disposal area to overcome the hydrostatic head between the repository and the Culebra. Third, a pathway would have to exist and

remain open for contaminated brine to flow from the repository to the Culebra. Since the times required for the brine accumulation and repository pressurization are on the order of thousands of years, and current plans call for the sealing of the shafts and boreholes that could potentially become such pathways upon closure of the facility, WIPP-related contamination of the groundwater is highly unlikely.

Table 6.2 lists the analytical parameters and hazardous constituents included in the 2017 groundwater sampling program.

Table 6.2 – Permit-Required Indicator Parameters and Hazardous Constituents List

Hazardous Constituents: Volatile and Semivolatile Organic Compounds	Indicator Parameters: General Chemistry and Major Cations/Anions	Hazardous Constituents Total Trace Metals
Volatile organic compounds (VOCs): Isobutanol Carbon tetrachloride Chlorobenzene Chloroform 1,1-Dichloroethane 1,2-Dichloroethane 1,1-Dichloroethylene Trans-1,2-Dichloroethylene Methyl ethyl ketone Methylene chloride 1,1,2,2-Tetrachloroethane Tetrachloroethylene 1,1,1-Trichloroethane 1,1,2-Trichloroethane Toluene Trichloroethylene Trichlorofluoromethane Vinyl chloride Xylenes **Semivolatile organic compounds (SVOCs):** 1,2-Dichlorobenzene 1,4-Dichlorobenzene 2,4-Dinitrophenol 2,4-Dinitrotoluene Hexachlorobenzene Hexachloroethane Cresols (2-, 3-, and 4-Methylphenols) Nitrobenzene Pentachlorophenol Pyridine	**General Chemistry:** Density (measured as specific gravity) pH Specific conductance TOC (total organic carbon) TDS TSS (total suspended solids) **Major Cations:** Calcium (Ca^{++}) Magnesium (Mg^{++}) Potassium (K^{+}) **Major Anions:** Chloride (Cl^{-})	**Trace Metals:** Antimony (Sb) Arsenic (As) Barium (Ba) Beryllium (Be) Cadmium (Cd) Chromium (Cr) Lead (Pb) Mercury (Hg) Nickel (Ni) Selenium (Se) Silver (Ag) Thallium (Tl) Vanadium (V)

Notes:
pH Hydrogen ion potential (measure of alkalinity or acidity).
Alkalinity, sodium, and sulfate are parameters for additional analysis.

6.2.4 Evaluation of Culebra Groundwater Quality

The quality of the Culebra groundwater sampled at the WIPP site is naturally poor and not suitable for human consumption or for agricultural purposes because the TDS concentrations are generally above 10,000 mg/L. In 2017, TDS concentrations in the Culebra (as measured in detection monitoring wells) varied from a low of 16,000 mg/L (WQSP–6) to a high of 221,000 mg/L (WQSP–3). The groundwater of the Culebra is considered to be Class III water (non-potable) by EPA guidelines.

For comparison, water quality measurements performed in the Dewey Lake indicate the water is considerably better quality than in the Culebra. In 2017, the TDS concentrations (see Table 6.5 later in this chapter) in water from well WQSP–6A, obtained from the Dewey Lake, averaged 3,385 mg/L. This water is suitable for livestock consumption and is classified as Class II water by EPA guidelines. Saturation of the Dewey Lake in the area of the WIPP facility is discontinuous. In addition to this naturally occurring groundwater, anthropogenic SSW has been encountered in the upper Dewey Lake at the Santa Rosa contact (see Section 6.6).

Because of the highly variable TDS concentrations within the Culebra, baseline groundwater quality was defined for each individual well. The 2017 analytical results showing the concentrations of detectable constituents are displayed as time trend plots compared to the baseline concentrations (Appendix E). The analytical results for each parameter or constituent for the sampling in 2017 (Round 39) are summarized in Appendix F, Tables F.1 through F.2. The tables in Appendix F display either the 95th upper tolerance limit value (UTLV) or the 95th percentile value (as calculated for the background sampling rounds) for each parameter, depending on the type of distribution exhibited by the particular parameter or constituent. Both values represent the concentrations below which 95 percent of the concentrations in a population are expected to occur. The UTLVs were calculated for data that exhibited a normal or a lognormal distribution. The 95th percentile was applied to data that were considered nonparametric (i.e., having neither a normal nor a lognormal distribution with 16–95 percent non-detects). Due to the large number of non-detectable concentrations of organic compounds, the limits for organic compounds were considered nonparametric and based on the contract-required method reporting limit (MRL) for the contract laboratory. These values were recomputed after the baseline sampling was completed in 2000 and were applied to sampling Round 39 to evaluate potential contamination of the local groundwater. None of the constituents of interest (organics and trace metals) exceeded the baseline concentrations.

The indicator parameter concentrations in Round 39, including those of the major cations, were all below the concentrations from the baseline studies with the following exceptions:

- WQSP–1: The concentrations of TSS in the primary and duplicate groundwater samples were 61 mg/L and 67 mg/L, respectively, which are higher than the 95th percentile concentration of 33.3 mg/L.
- WQSP–2: The specific conductance for the primary sample was 124,000 µmhos/cm, while the duplicate sample was 125,000 µmhos/cm, which is higher than the 95th percentile of 124,000 µmhos/cm.
- WQSP–3: The TSS concentrations of 116 mg/L in the primary groundwater sample and 124 mg/L in the duplicate sample were higher than the 95th percentile concentration of 107 mg/L. The chloride concentration in the duplicate sample was higher than the 95th percentile concentration of 149,100 mg/L with a concentration of 161,000 mg/L.
- WQSP–4: The TSS concentrations of 82 mg/L in the primary groundwater sample and 95 mg/L in the duplicate sample were higher than the 95th percentile concentration of 57 mg/L. Alkalinity reached a concentration of 48.0 mg/L in the primary sample, which was higher than the 95th percentile of 47.1.
- WQSP–5: The TSS concentrations in the primary and duplicate groundwater samples were 20 mg/L and 19 mg/L respectively, which are higher than the 95th percentile concentration of <10 mg/L. Magnesium concentrations in the primary and duplicate groundwater samples were also higher than the 95th percentile concentration of 547 mg/L with concentrations of 608 mg/L and 592 mg/L respectively. Sodium was also higher than the 95th percentile of 11,190 mg/L for the primary sample having a concentration of 11,200 mg/L.
- WQSP–6: The Specific Conductance concentrations in primary and duplicate groundwater samples were 29,600 µmhos/cm and 34,600 µmhos/cm respectively, which are higher than the 95th percentile concentration of 27,660 µmhos/cm.

The Round 39 VOC concentrations reported for man-made organic compounds were less than the Permit background values and less than the MRL in all groundwater samples. Water quality data for Round 39 can be found in the *Annual Culebra Groundwater* Report (U.S. Department of Energy, November 2017).

6.2.5 Groundwater Level Surveillance

Wells were used to perform surveillance of the groundwater surface elevation of five water-bearing zones in the vicinity of the WIPP facility:

- SSW (Santa Rosa/Dewey Lake contact)
- Dewey Lake
- Magenta
- Culebra
- Bell Canyon

During 2017, water levels in 49 Culebra wells were measured (including the Culebra zone of a dual completion well) and 13 wells in the Magenta (including the Magenta zone of a dual completion well). One Dewey Lake well and two Bell Canyon wells were measured. Eighteen wells in the SSW zone of the Santa Rosa/Dewey Lake contact were measured as well as one in the Gatuña. Groundwater level measurements were taken monthly in at least one accessible well bore at each well site for each available formation (Figure 6.2). Water levels in redundant well bores (well bores located on well pads with multiple wells completed in the same formation) were measured on a quarterly basis (Appendix F, Table F.4). Water levels at SSW wells and piezometers were also measured on a quarterly basis.

A breakdown of the groundwater zones intercepted by each well measured at least once in 2017 is given in Appendix F, Table F.3. Note that one existing well (Culebra/Magenta C–2737) is completed at multiple depths by using a production-injection packer.

Water elevation trend analysis was performed for 43 Culebra wells, which showed only 17 naturally changing wells and one with no change. The subset of wells analyzed were those that had a sufficient period of record to analyze through CY 2017 (Appendix F, Table F.3). Additional filtering of the water level data could not be performed to remove wells affected by unnatural fluctuations for 2017 due to the vast majority of wells being impacted by pumping at Mills Ranch. If the pumping-impacted well data were removed, there would not have been enough data points for mapping. Excluded from trend analysis were SNL–6 and SNL–15, which were both in long-term water level recovery. Because they were only measured quarterly, the redundant H–19 wells were also excluded.

The dominant trend through 2017 on naturally occurring changes was a general decreasing equivalent freshwater head in the Culebra monitoring wells at the WIPP site. This decrease can be attributed to the wells returning to stabilization after the rain events that occurred in August and September 2016 resulting in 259.34 mm (10.21 in) and 316.75 mm (12.47 in). Water level fell in 12 of the 17 naturally occurring water level changes, which averaged -1.02 ft.

The Permit requires that the NMED be notified if a cumulative groundwater surface elevation change of more than 2 ft is detected in wells WQSP–1 to WQSP–6 over the course of one year that is not attributable to site tests or natural stabilization of the site hydrologic system. In 2017, WQSP-4 and 5 experienced water level increases greater than 2 feet due to water level recovery from a decrease in pumping rate associated with Mills Ranch, while WQSP-6 was just under 2 feet at 1.95 ft of rise. Hydrographs for the Culebra groundwater wells are included in the *Annual Culebra Groundwater Report* (U.S. Department of Energy, November 2017). The differences in water levels were communicated to the NMED through semi-annual Culebra Surface Elevation Reports.

For the Culebra wells in the vicinity of the WIPP site, equivalent freshwater heads for September 2017 were used to calibrate a groundwater flow model, which was used by

Sandia National Laboratories (SNL) to compute a potentiometric surface using SNL procedure SP 9–9. This month was judged to have the most number of Culebra water levels available, few wells affected by pumping events, and all wells in quasi-steady state, with few individual wells contrary to the general water-level trend. Table 6.3 shows the water-level data set. Wells SNL–6 and SNL–15 were not included in the mapping because the elevations do not represent static conditions. These wells are located in the low transmissivity zone of the Culebra and after drilling and testing, are still in recovery to reach equilibrium. Adjusted freshwater heads are typically accurate to ±1.5 ft, given the density measurement error. Density measurement error is less than 0.019 specific gravity units (WP 02–1).

Table 6.3 – Water Level Elevations for the 2017 Potentiometric Surface Calibration, Culebra Hydraulic Unit

Well ID	Measurement Date	Adjusted Freshwater Head (m amsl)	Density (g/cm^3)[(a)]	Notes
AEC-7R	**09/14/17**	**927.73**	**1.060**	Excluded from mapping
C-2737[(b)]	**09/18/17**	**909.08**	**1.023**	
ERDA-9[(b)]	**09/18/17**	**910.61**	**1.073**	
H-02b2[(b)]	**09/18/17**	**922.18**	**1.011**	
H-03b2[(b)]	**09/18/17**	**904.32**	**1.013**	
H-04bR[(b)]	**09/18/17**	**904.83**	**1.023**	
H-05b	**09/14/17**	**925.74**	**1.082**	
H-06bR	**09/15/17**	**931.51**	**1.038**	
H-07b1	**09/15/17**	**913.07**	**1.008**	
H-09bR	**09/14/17**	**905.31**	**1.004**	
H-10cR	**09/14/17**	**901.49**	**1.105**	Excluded from mapping
H-11b4R[(b)]	**09/14/17**	**899.75**	**1.078**	
H-12R	**09/14/17**	**896.86**	**1.110**	
H-15R[(b)]	**09/18/17**	**897.43**	**1.119**	
H-16[(b)]	**09/19/17**	**921.03**	**1.035**	
H-17[(b)]	**09/14/17**	**895.12**	**1.133**	
H-19b0[(b)]	**09/18/17**	**901.83**	**1.066**	
IMC-461	**09/13/17**	**926.39**	**1.002**	
SNL-01	**09/13/17**	**937.06**	**1.031**	
SNL-02	**09/13/17**	**934.92**	**1.009**	
SNL-03	**09/15/17**	**935.04**	**1.028**	
SNL-05	**09/13/17**	**935.33**	**1.010**	

Well ID	Measurement Date	Adjusted Freshwater Head (m amsl)	Density (g/cm^3)[(a)]	Notes
SNL-06	**09/14/17**	**965.76**	**1.247**	Excluded from mapping
SNL-08	**09/14/17**	**919.15**	**1.096**	
SNL-09	**09/15/17**	**928.60**	**1.018**	
SNL-10	**09/15/17**	**928.14**	**1.010**	
SNL-12[(b)]	**09/14/17**	**904.53**	**1.006**	
SNL-13[(b)]	**09/15/17**	**907.66**	**1.025**	
SNL-14[(b)]	**09/14/17**	**901.75**	**1.045**	
SNL-15	**09/14/17**	**908.18**	**1.232**	Excluded from mapping
SNL-16	**09/13/17**	**917.13**	**1.015**	
SNL-17	**09/15/17**	**912.46**	**1.008**	
SNL-18	**09/13/17**	**935.85**	**1.010**	
SNL-19	**09/13/17**	**935.12**	**1.006**	
WIPP-11	**09/15/17**	**932.86**	**1.038**	
WIPP-13	**09/15/17**	**933.10**	**1.035**	
WIPP-19	**09/15/17**	**927.12**	**1.052**	
WQSP-1	**09/18/17**	**931.51**	**1.049**	
WQSP-2	**09/15/17**	**932.81**	**1.048**	
WQSP-3	**09/15/17**	**917.58**	**1.144**	
WQSP-4[(b)]	**09/18/17**	**901.08**	**1.076**	
WQSP-5[(b)]	**09/18/17**	**904.99**	**1.028**	
WQSP-6[(b)]	**09/18/17**	**911.15**	**1.016**	

Notes:

Amsl = above mean sea level.

g/cm^3 = grams per centimeter cubed

ID = Identification.

(a) 2017 conversion to specific gravity at 70˚F.

(b) Significantly influenced by Mills Ranch Pumping.

Modeled freshwater head contours for September 2017 for the model domain are shown in Figure 6.4 (Hayes, 2018). These contours were generated using the results of the Culebra MODFLOW 2K (Harbaugh et al., 2000) run using ensemble average distributed aquifer parameters from the SNL Culebra flow model, which was calibrated as part of the performance assessment baseline calculation for the 2009 *Compliance Recertification Application Performance Assessment Baseline Calculation* (Clayton et al., 2009). Because that model was calibrated to both a snapshot of assumed steady-state water levels (May 2007) and to transient multi-well responses observed during

large-scale pumping tests throughout the domain, the boundary conditions were adjusted to improve the match between the model and the observed September 2017 Culebra freshwater heads presented in this report (see Section 6.2.6). The portion of the flow domain of interest to the site is extracted as shown in Figure 6.5. The freshwater head values for September 2017 were computed using 2016 densities.

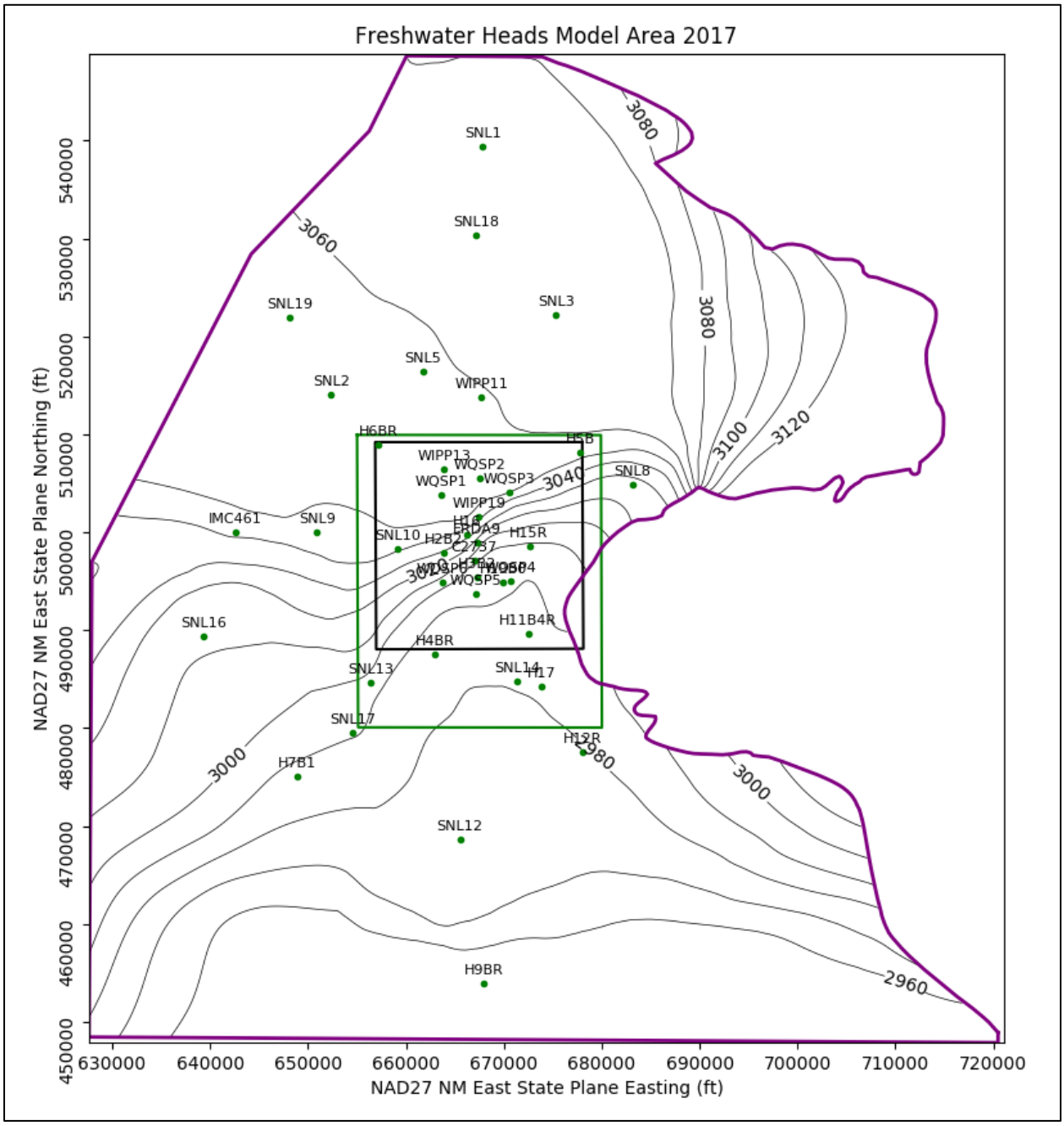


Figure 6.4 – Model-Generated September 2017 Freshwater Head Contours in the Model Domain (Contour in Feet Above Mean Sea Level)

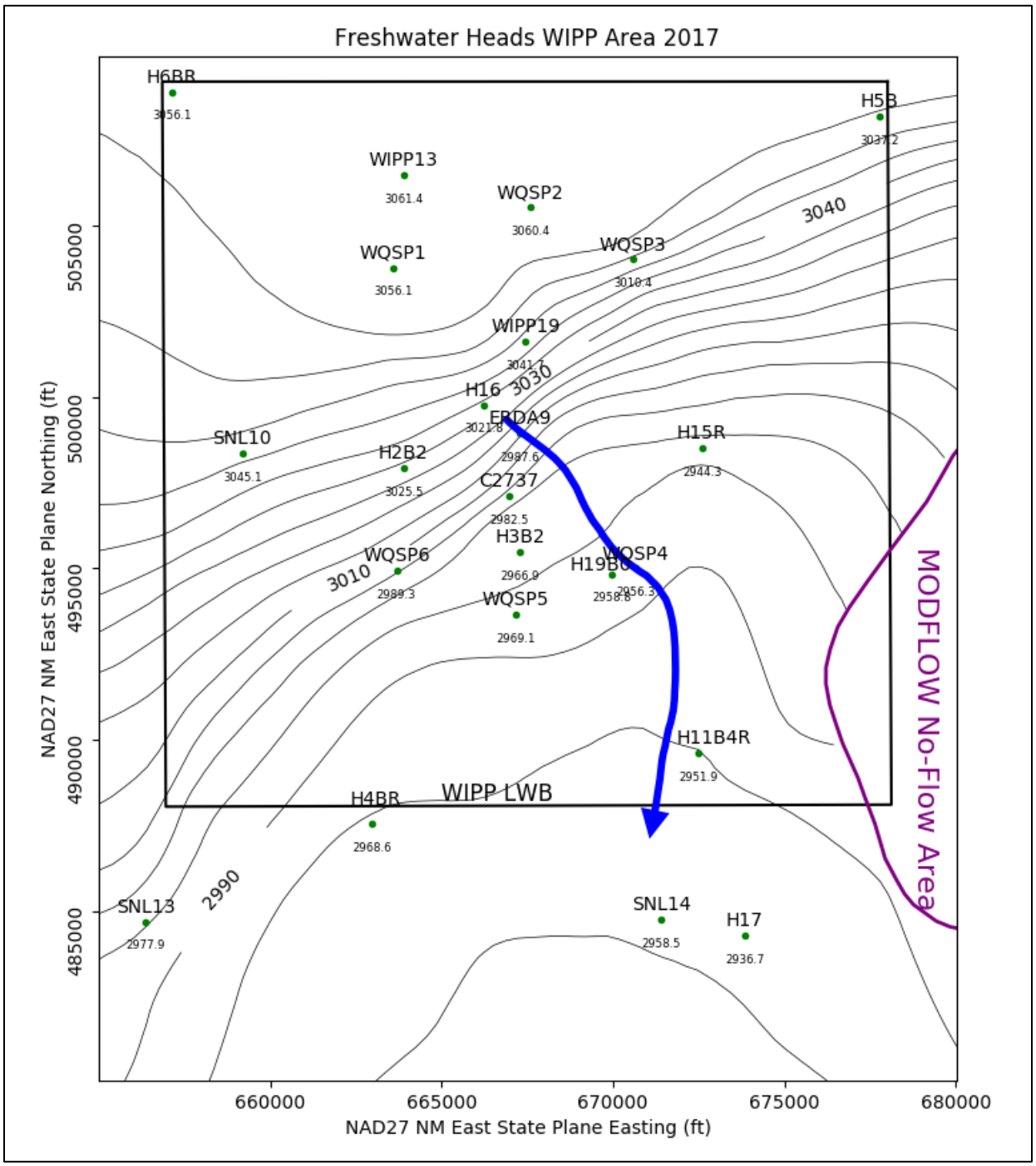
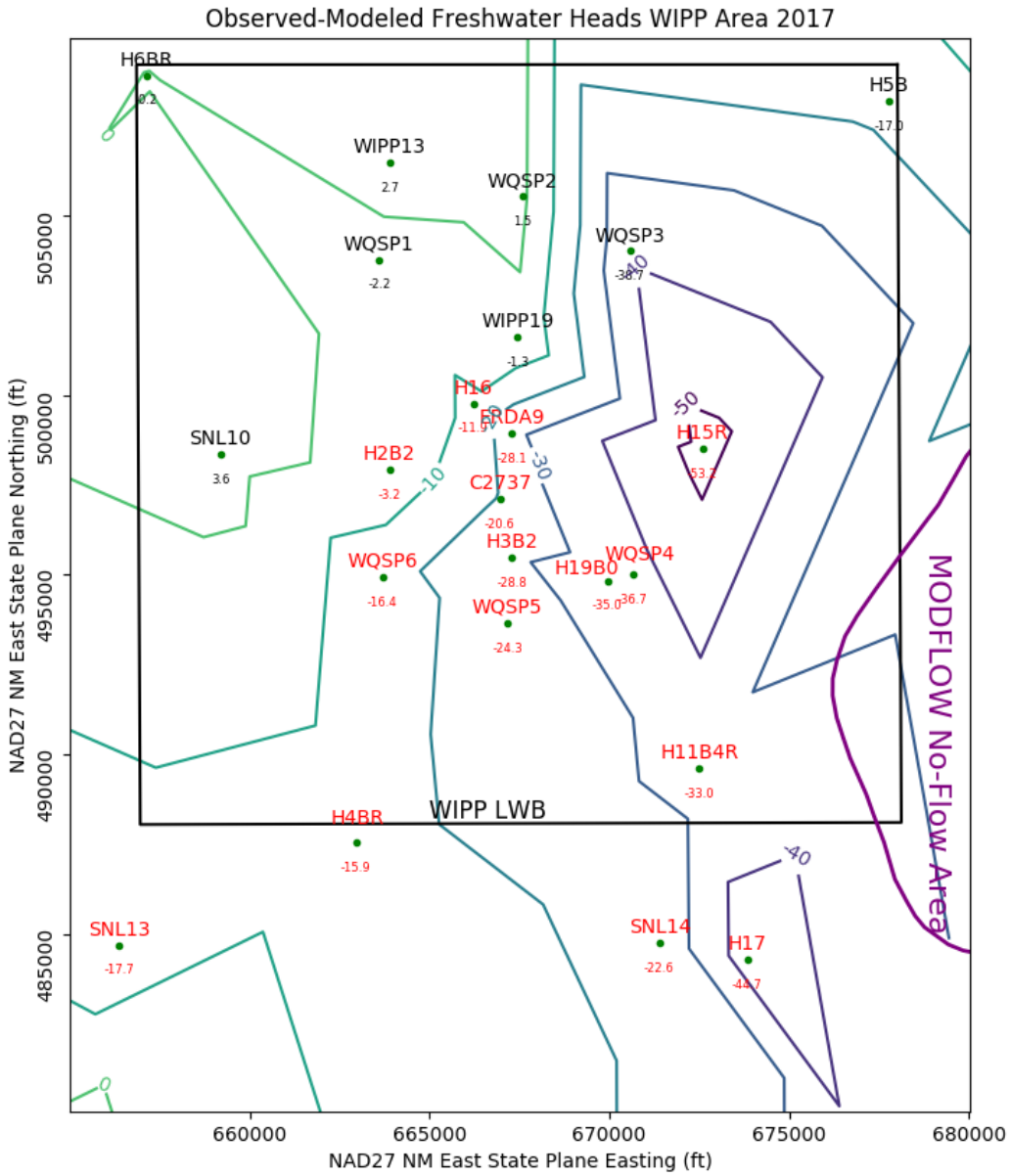


Figure 6.5 – Model-Generated September 2017 Freshwater Head Contours (5-ft Contour Interval) in the WIPP Vicinity with Water Particle Track (Dark Blue) from Waste-Handling Shaft to WIPP Land Withdrawal Boundary (Contour in Feet Above Mean Sea Level)

Figure 6.6 shows the difference between the modeled and observed freshwater heads is mainly in part due to pumping at the Mills Ranch (Hayes, 2018). The difference

between observed and modeled freshwater head within the LWB can be as large as 53.2 ft, particularly in the vicinity of H-4bR.



Note: Red labels indicate wells designated as significantly impacted by Mills pumping, which were assigned a smaller weight (0.05) in the calibration process.

Figure 6.6 – Triangulated Contours (in 8-ft intervals) for Measured Minus Modeled Freshwater Head

The scatter plot in Figure 6.7 shows measured and modeled freshwater heads at the observation locations used in the parameter estimation (PEST) software calibration. The observations are divided into three groups, based on proximity to the WIPP site. Wells

within the LWB are represented by red crosses, wells outside but within 3 km of the LWB are represented with green ‘x’s, and other wells within the MODFLOW model domain but distant from the WIPP site are indicated with blue stars. Additional observations representing the average heads north of the LWB and south of the LWB were used to help prevent over-smoothing of the estimated results across the LWB.

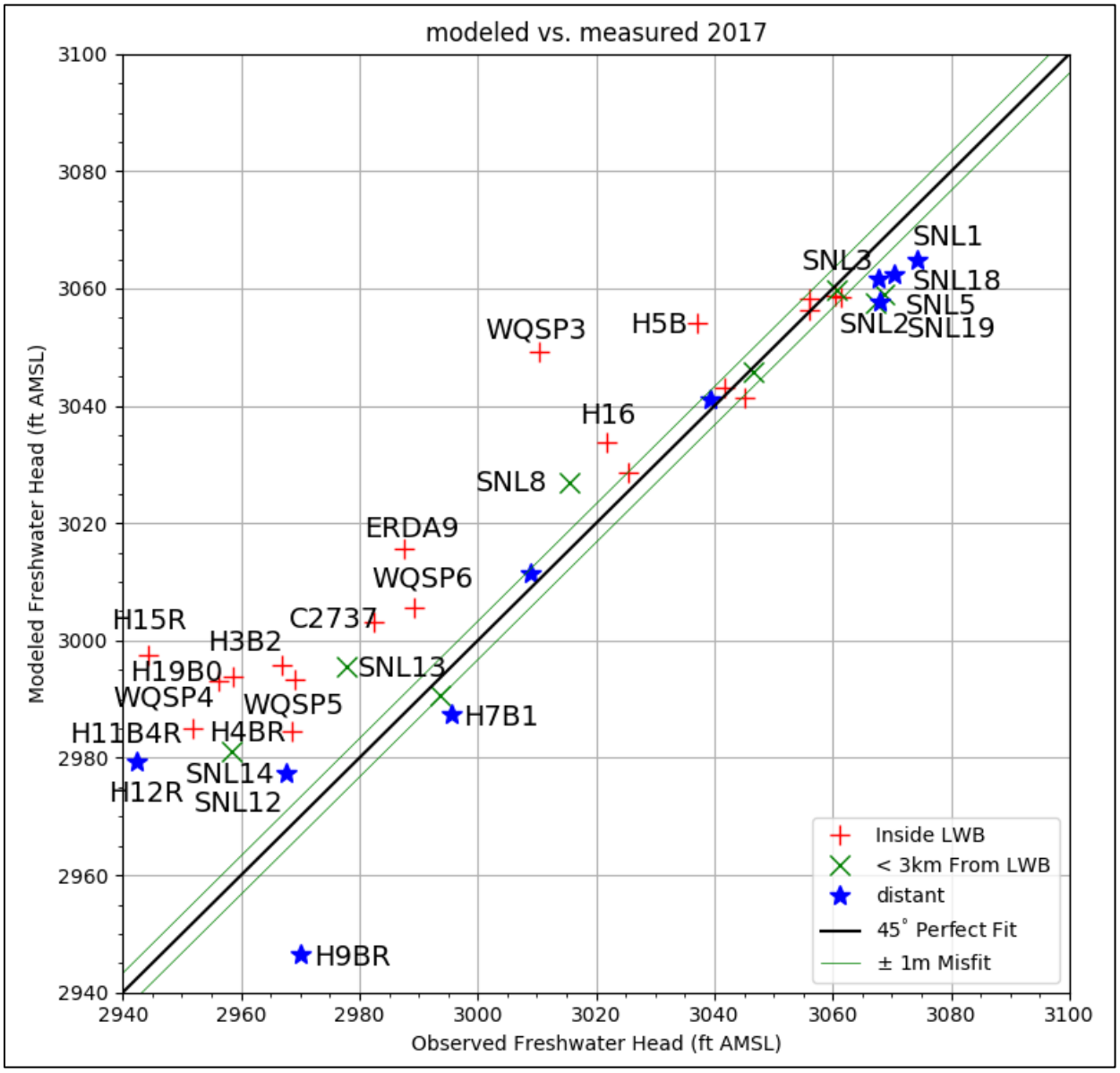


Figure 6.7 – Measured Versus Modeled Scatter Plot for PEST-Calibrated MODFLOW 2000 Generated Heads and September 2017 Freshwater Heads

The base transmissivity fields and the 100 calibrated model realizations derived from them for the performance assessment baseline calculation embody the hydrologic and geologic understanding of the Culebra behavior in the vicinity of the WIPP site

(Kuhlman, 2012). Using the ensemble average of these 100 realizations, therefore, captures the mean flow behavior of the system and allows straightforward contouring of results from a single-flow model.

The illustrated particle in Figure 6.5 (heavy blue line) shows the DTRKMF predicted path a water particle would take through the Culebra from the coordinates corresponding to the WIPP Waste Handling Shaft to the LWB (a computed path length of 4.121 km). Assuming a thickness of 4 m for the transmissive portion of the Culebra and a constant porosity of 16 percent, the travel time to the WIPP LWB is 5,248 years (output from DTRKMF is adjusted from a 7.75-m Culebra thickness), for an average velocity of 0.78 meter per year. This estimated flow velocity is higher than in previous years due to the steeper gradient caused by Mills Ranch pumping. Since the flow model has the ensemble hydraulic conductivity and anisotropy fields as inputs, the freshwater head contours and particle tracks take into account the variability of known aquifer conditions across the site.

6.2.6 Fluid Density Surveys

At the WIPP site, variable TDS concentrations result in variability in groundwater density (WP 02–1). WIPP personnel measure the density of well-bore fluids in water-level monitoring wells to adjust water levels to their equivalent freshwater head values. This allows more accurate determination of relative heads between wells. In 2017, densities were derived from 37 wells containing pressure transducers installed by SNL (Table 6.4) and six wells from hydrometers as part of the DMP. Pressure density is no longer sampled in redundant H-19 wells as this requirement was removed from the Permit in 2017. This approach employed several calibrated pressure-measuring transducers dedicated to given wells during the year. For the DMP wells, field hydrometer measurements are always used. For comparison, 2015 and 2016 density data are shown. Year-to-year density differences are within the error as described in WP 02-1.

Table 6.4 – Fluid Density Survey for 2017

Well	2015 Fluid Density Survey Result Density (g/cm^3)	2015 Conversion to Specific Gravity at 70°F Density (g/cm^3)	2016 Fluid Density Survey Result Density (g/cm^3)	2016 Conversion to Specific Gravity at 70°F Density (g/cm^3)	2017 Fluid Density Survey Result Density (g/cm^3)	2017 Conversion to Specific Gravity at 70°F Density (g/cm^3)	Notes for 2015–2017 Fluid Density Survey
AEC-7R	1.056	1.058	1.058	1.060	1.066	1.068	
C-2737	1.023	1.025	1.021	1.023	1.027	1.029	
ERDA-9	1.071	1.073	1.071	1.073	1.071	1.073	
H-02b2	1.009	1.011	1.009	1.011	1.011	1.013	
H-03b2	1.017	1.019	1.011	1.013	1.051	1.053	
H-04bR	1.027	1.029	1.021	1.023	1.018	1.020	
H-05b	1.083	1.085	1.080	1.082	1.096	1.098	
H-06bR	1.036	1.038	1.036	1.038	1.037	1.039	

Well	2015 Fluid Density Survey Result	2015 Conversion to Specific Gravity at 70°F	2016 Fluid Density Survey Result	2016 Conversion to Specific Gravity at 70°F	2017 Fluid Density Survey Result	2017 Conversion to Specific Gravity at 70°F	Notes for 2015–2017 Fluid Density Survey
	Density (g/cm^3)	Density (g/cm^3)	Density (g/cm^3)	Density (g/cm^3)	Density (g/cm^3)	Density (g/cm^3)	
H-07b1	1.007	1.009	1.006	1.008	1.005	1.007	
H-09bR	1.002	1.004	1.002	1.004	1.002	1.004	
H-10c	1.095	1.097	NA	NA	NA	NA	Plugged October 2015
H-10cR	NA	NA	1.103	1.105	1.076	1.078	Drilled October 2015
H-11b4R	1.076	1.078	1.076	1.078	1.076	1.078	
H-12R	1.106	1.108	1.108	1.110	1.102	1.104	Drilled in October 2014
H-15R	1.117	1.119	1.117	1.119	1.116	1.118	
H-16	1.032	1.034	1.033	1.035	1.031	1.033	
H-17	1.131	1.133	1.131	1.133	1.131	1.133	
H-19b0	1.064	1.066	1.064	1.066	1.064	1.066	
H-19b2	1.070	1.072	1.073	1.075	NA	NA	Redundant H-19 wells no longer required
H-19b3	1.070	1.072	1.073	1.075	NA	NA	Redundant H-19 wells no longer required
H-19b4	1.070	1.073	1.070	1.072	NA	NA	Redundant H-19 wells no longer required
H-19b5	1.072	1.074	1.073	1.075	NA	NA	Redundant H-19 wells no longer required
H-19b6	1.074	1.076	1.075	1.077	NA	NA	Redundant H-19 wells no longer required
H-19b7	1.073	1.075	1.072	1.074	NA	NA	Redundant H-19 wells no longer required
I-461	1.002	1.004	1.000	1.002	1.000	1.002	
SNL-01	1.028	1.030	1.029	1.031	1.029	1.031	
SNL-02	1.006	1.008	1.007	1.009	1.006	1.008	
SNL-03	1.026	1.028	1.026	1.028	1.025	1.027	
SNL-05	1.007	1.009	1.008	1.010	1.010	1.012	
SNL-06	1.244	1.246	1.245	1.247	1.245	1.247	
SNL-08	1.093	1.095	1.094	1.096	1.099	1.101	
SNL-09	1.016	1.018	1.016	1.018	1.015	1.017	
SNL-10	1.008	1.010	1.008	1.010	1.008	1.010	
SNL-12	1.005	1.007	1.004	1.006	1.011	1.013	
SNL-13	1.023	1.025	1.023	1.025	1.022	1.024	
SNL-14	1.042	1.044	1.043	1.045	1.044	1.046	
SNL-15	1.229	1.231	1.230	1.232	1.223	1.225	
SNL-16	1.012	1.014	1.013	1.015	1.012	1.014	
SNL-17	1.007	1.009	1.006	1.008	1.004	1.006	
SNL-18	1.007	1.009	1.008	1.010	1.008	1.010	

Well	2015 Fluid Density Survey Result	2015 Conversion to Specific Gravity at 70°F	2016 Fluid Density Survey Result	2016 Conversion to Specific Gravity at 70°F	2017 Fluid Density Survey Result	2017 Conversion to Specific Gravity at 70°F	Notes for 2015–2017 Fluid Density Survey
	Density (g/cm^3)	Density (g/cm^3)	Density (g/cm^3)	Density (g/cm^3)	Density (g/cm^3)	Density (g/cm^3)	
SNL-19	1.003	1.005	1.004	1.006	1.005	1.007	
WIPP-11	1.036	1.038	1.036	1.038	1.034	1.036	
WIPP-13	1.034	1.036	1.033	1.035	1.034	1.036	
WIPP-19	1.048	1.050	1.050	1.052	1.053	1.055	
WQSP-1	1.047	1.059	1.047	1.049	1.047	1.049	Average sampling Round 39, field hydrometer
WQSP-2	1.045	1.047	1.046	1.048	1.046	1.048	Average sampling Round 39, field hydrometer
WQSP-3	1.143	1.146	1.142	1.144	1.144	1.146	Average sampling Round 39, field hydrometer
WQSP-4	1.074	1.076	1.074	1.076	1.075	1.077	Average sampling Round 39, field hydrometer
WQSP-5	1.027	1.029	1.026	1.028	1.028	1.030	Average sampling Round 39, field hydrometer
WQSP-6	1.017	1.019	1.014	1.016	1.015	1.017	Average sampling Round 39, field hydrometer

Notes:
NA No available measurement.

6.3 Drilling Activities

No drilling activities occurred during 2017.

6.4 Hydraulic Testing and Other Water Quality Sampling

Sandia National Labs performed a 72-hour pump test on H-10cR from July 24th to July 27th.

6.5 Well Maintenance and Development

Well maintenance activities include pump and power cable replacement in WQSP-3 due to smoke being produced during a test run. The surface casing was repaired on WIPP-19 after it was snapped due to cattle. Well development purges were conducted on H-10cR on January 10, 19, and 25, February 1, and 16, March 28th and May 3rd of 2017.

6.6 Shallow Subsurface Water Monitoring Program

Shallow subsurface water occurs beneath the WIPP site at a depth of 12–21 m (39–69 ft) below ground level at the contact between the Santa Rosa and the Dewey Lake (Figure 6.1). Water yields are generally less than 1 gallon per minute in monitoring wells and piezometers, and the water contains varying concentrations of TDS (910 mg/L to

274,000 mg/L) and chloride (167 mg/L to 197,000 mg/L). The range in concentrations is due to infiltrating waters coming into contact with unlined ponds and salt piles prior to 2008. To the south, yields are greater and TDS and chloride concentrations lower. The origin of the high TDS and chlorides in this water is believed to be primarily from anthropogenic sources, with some contribution from natural sources. The SSW occurs not only under the WIPP site surface facilities but also to the south, as indicated by shallow water in drill hole C-2811, about one-half mile south of the WIPP facility property protection fence.

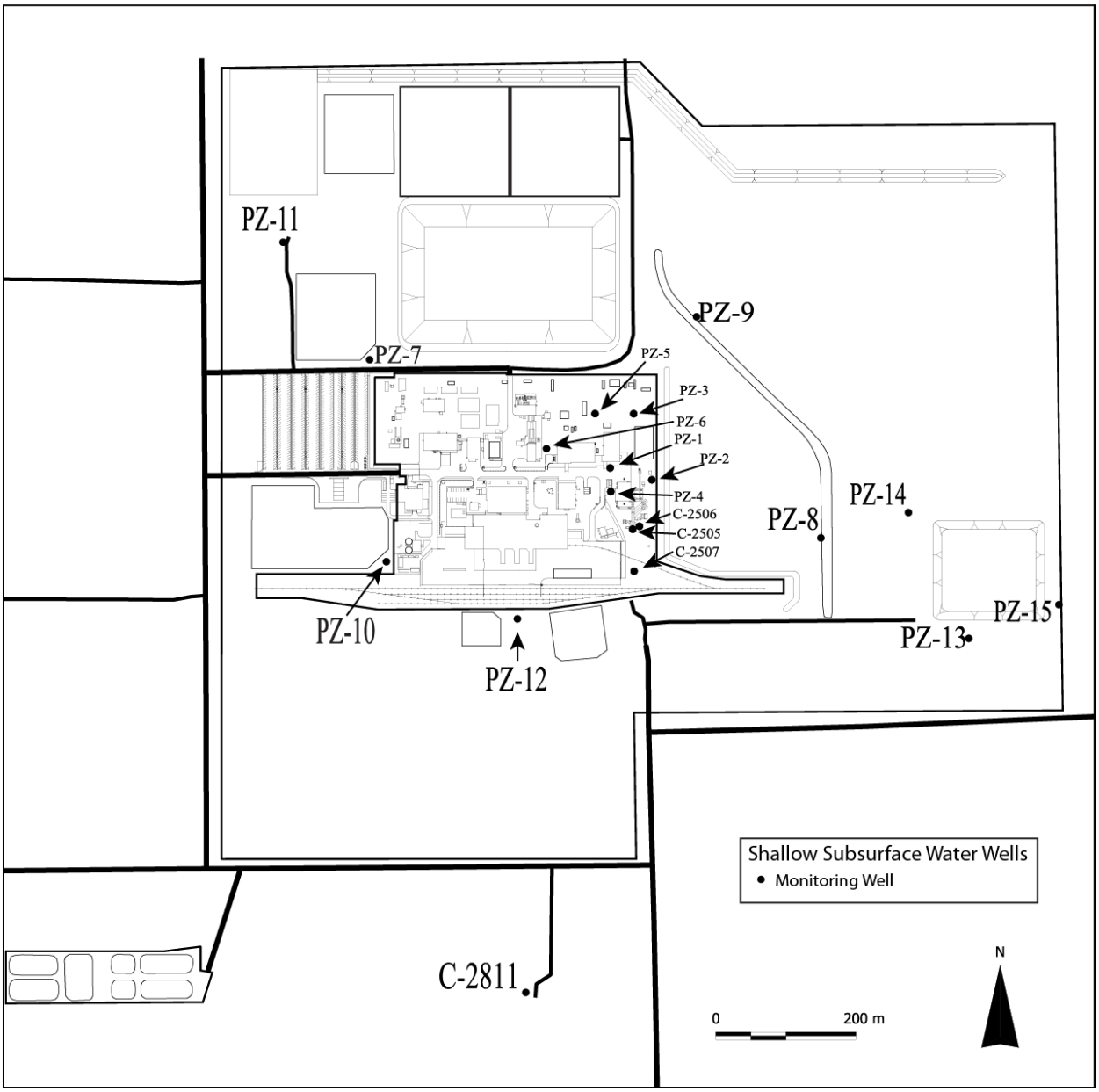


Figure 6.8 – Location of Shallow Subsurface Water Wells (Piezometers PZ–1 through PZ–15, C-2811, C–2505, C–2506, and C–2507)

In order to investigate the SSW, 15 piezometers (PZ–1 to PZ–15) and four wells (C-2505, C–2506, C–2507, and C–2811) were drilled as part of a monitoring program to measure spatial and temporal changes in SSW levels and water quality. Monitoring activities during 2017 included SSW level surveillance at these 19 locations (Figure 6.8).

In addition, drilling in 2007 around the SPDV salt pile tailings revealed shallow water in three piezometers (PZ–13, PZ–14, and PZ–15, shown in Figure 6.8). Natural shallow groundwater occurs in the middle part of the Dewey Lake at the southern portion of the WIPP site (WQSP–6A; see Figure 6.2) and to the south of the WIPP site (Mills Ranch). To date, based on water chemistry, there is no indication that the anthropogenic SSW has affected the naturally occurring groundwater in the Dewey Lake.

6.6.1 Shallow Subsurface Water Quality Sampling

The DP-831, as modified, requires 11 SSW wells (C–2507, C–2811, PZ–1, PZ–5, PZ–6, PZ–7, PZ–9, PZ–10, PZ–11, PZ–12 and PZ–13) and WQSP-6A to be sampled on a semi-annual basis. These wells were sampled in May and October 2017, and the parameters shown in Table 6.5 were analyzed.

Table 6.5 – 2017 DP-831 Shallow Subsurface Water Quality Sampling Results

Monitoring Site	Sample Date	Nitrate (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	TDS (mg/L)	TKN (mg/L)
PZ-1	5/31/2017	NA	1,890	37,600	71,200	NA
PZ-1	10/10/2017	NA	1,900	36,100	63,900	NA
PZ-5	5/31/2017	NA	737	4,470	10,300	NA
PZ-5	10/10/2017	NA	638	4,790	11,300	NA
PZ-6	5/31/2017	NA	1,230	21,000	39,300	NA
PZ-6	10/10/2017	NA	1,260	20,800	37,500	NA
PZ-7	5/30/2017	NA	2,890	59,800	111,000	NA
PZ-7	10/9/2017	NA	2,170	36,800	80,100	NA
PZ-9	5/30/2017	NA	5,200	113,000	169,000	NA
PZ-9	10/10/2017	NA	4,580	91,900	172,000	NA
PZ-10	5/30/2017	NA	203	173	998	NA
PZ-10	10/9/2017	NA	161	135	414	NA
PZ-11	5/30/2017	NA	911	18,000	40,000	NA
PZ-11	10/9/2017	NA	1,710	49,800	61,900	NA
PZ-12	5/30/2017	NA	509	2,470	6,100	NA
PZ-12	10/9/2017	NA	521	2,840	6,740	NA
PZ-13	5/31/2017	NA	2,730	150,000	251,000	NA
PZ-13	10/10/2017	NA	2,650	134,000	251,000	NA

Monitoring Site	Sample Date	Nitrate (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	TDS (mg/L)	TKN (mg/L)
C-2811	5/30/2017	NA	479	1,020	3,100	NA
C-2811	10/9/2017	NA	375	1,110	2,640	NA
C-2507	5/31/2017	NA	683	3,490	8,020	NA
C-2507	10/10/2017	NA	627	2,890	7,270	NA
WQSP-6A	6/1/2017	5.27	1,870	322	3,380	<1.0
WQSP-6A	10/11/2017	4.87	1,880	342	3,390	<1.0

NA = Not analyzed, parameter not required per permit conditions.

6.6.2 Shallow Subsurface Water Level Surveillance

A water budget analysis in 2003 (Daniel B. Stephens & Associates, Inc., 2003) indicated that seepage from five primary sources (the salt pile and four surface water detention basins) provided sufficient recharge to account for the observed SSW saturated lens, and that the lens was expected to spread.

The potential extent for long-term SSW migration was examined by expanding the saturated flow model domain to include the 16-mi^2 WIPP LWA area. The long-term migration model simulations indicated the engineered seepage controls now in place will substantially reduce the extent of migration.

Nineteen wells were used for surveillance of the SSW-bearing horizon in the Santa Rosa and the upper portion of the Dewey Lake. Water levels were measured quarterly at the piezometers and wells shown in Figure 6.8.

The potentiometric surface for the SSW using December 2017 data is presented in Figure 6.9. The contours were generated using *SURFER*, Version 13; a surface mapping software by Golden Software. Sixteen data points were used in the contour development, whereas the contours around the SPDV salt pile were estimated by hand.

Groundwater elevation measurements in the SSW indicate that flow is to the east and south away from a potentiometric high located near PZ–7 adjacent to the Salt Pile Evaporation Pond (Figure 6.9). At this time, it appears that the water identified in PZ–13 and PZ–14 is separate and distinct from the SSW in the other wells at the WIPP facilities area (DOE/WIPP-08-3375, *Basic Data Report for Piezometers PZ–13, PZ–14, PZ–15 and SSW)*. PZ–13 and PZ–14 were completed at the contact of the Santa Rosa and Dewey Lake. PZ–15 was completed at a shallower level in the Gatuña, where it appears rainwater has accumulated from a localized recharge source. Geochemically, the piezometer wells around the SPDV salt pile are distinct from the SSW wells located in the WIPP facilities area. Because of the recharge influence from a localized depression near PZ–15, this is geochemically distinct from the areas around the SPDV salt pile and the WIPP facilities.

In 2004, storm water evaporation ponds were lined with high-density polyethylene in accordance with DP–831 requirements. Since the installation of the liners, there has been a decrease in SSW elevations, which indicates that the liners have reduced the rate of infiltration.

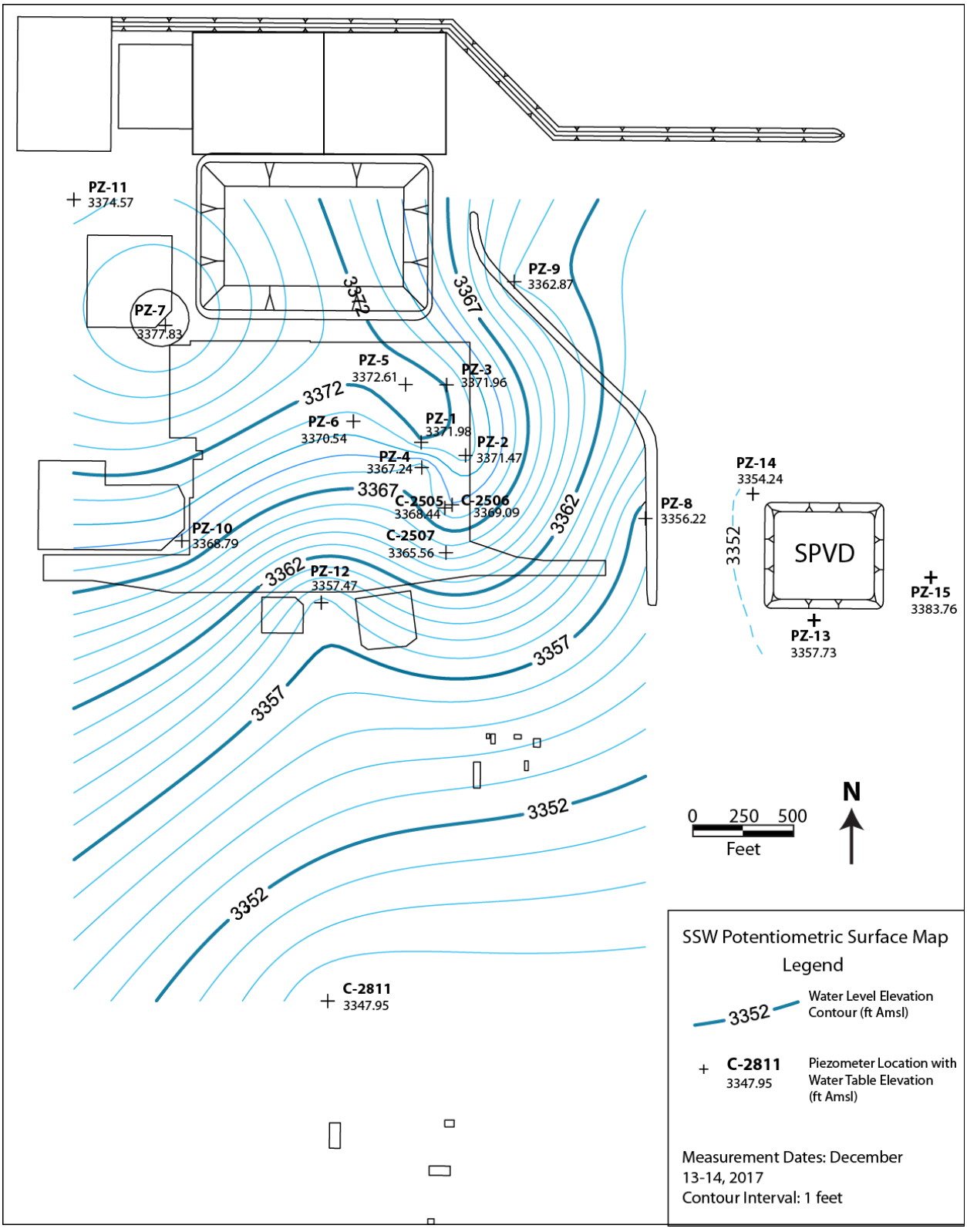


Figure 6.9 – December 2017 Shallow Subsurface Water Potentiometric Surface

6.7 Public Drinking Water Protection

The water wells nearest the WIPP site that use the natural Dewey Lake groundwater for domestic use are the wells located on the Mills Ranch. These wells are located approximately 3 mi south-southwest of the WIPP surface facilities and about 1.75 mi south of WQSP–6A (Figure 6.2). These wells are used for livestock and industrial purposes. Total dissolved solids in the Barn Well have ranged from 630 to 720 mg/L, and TDS concentrations in the Ranch Well have ranged from 2,800 to 3,300 mg/L (DOE/CAO-96-2184).

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CHAPTER 7 – QUALITY ASSURANCE

The fundamental objective of the environmental QA program is to facilitate the acquisition of accurate and precise analytical data that are technically and legally defensible. Quality data are generated through a series of activities that plan, implement, review, assess, and correct as necessary. Field samples are collected and analyzed in sample delivery groups along with the requisite QC samples using industry-standard analytical methods. The sample analysis results and associated QC data are reviewed, verified, validated, and incorporated into succinct and informative reports, which present the data and describe how well the lab met its QA objectives.

During 2017, WIPP Laboratories performed the radiological analyses of environmental samples from the WIPP site. The Organic Chemistry Laboratory at the CEMRC in Carlsbad, New Mexico, performed the non-radiological VOC analyses, and Hall Environmental Analysis Laboratory (HEAL) in Albuquerque, New Mexico, performed the non-radiological groundwater sample analyses. In addition, HEAL subcontracted groundwater analyses to Anatek Laboratories in Moscow, Idaho, to perform some of the trace metal analyses. The subcontracted laboratories have documented QA programs, including an established QA plan, and laboratory-specific standard operating procedures (SOPs) based on published standard analytical methods. Anatek Laboratories is a subcontract laboratory used to measure trace concentrations of metals by EPA Method 6020 (inductively coupled plasma emission spectroscopy/mass spectrometry) and is accredited by The National Environmental Laboratory Accreditation Conference Institute. Reports from Anatek Laboratories are received by HEAL and reviewed before they are submitted and included in WIPP groundwater reports.

The laboratories demonstrated the quality of their analytical data through participation in reputable, inter-laboratory comparison programs such as the National Institute of Standards and Technology (NIST) Radiochemistry Intercomparison Program (NRIP), Mixed Analyte Performance Evaluation Program (MAPEP), National Environmental Laboratory Accreditation Conference, and National Air Toxics Trends Station PT studies. Laboratories used by WIPP must meet the applicable requirements of the CBFO *Quality Assurance Program Document* (DOE/CBFO-94-1012), as flowed down through the NWP *Quality Assurance Program Description* (WP 13–1).

The WIPP sampling program and the subcontracted analytical laboratories operate in accordance with general QA plans and specific QA project plans that incorporate QA requirements from the NWP *Quality Assurance Program Description*. These plans address the following elements:

- Management and organization
- Quality system and description
- Personnel qualification and training

- Procurement of products and services, including supplier-related nonconformances
- Documents and records
- Computer hardware and software
- Planning
- Management of work processes (SOPs)
- Assessment and response
- Quality improvement, including the reporting of non-administrative nonconformances.

To ensure that the quality of systems, processes, and deliverables is maintained or improved, three layers of assessments and audits are performed:

- DOE/CBFO performs assessments and audits of the MOC QA program.
- The MOC performs internal assessments and audits of its own QA program.
- The MOC performs assessments and audits of subcontractor QA programs as applied to MOC contract work.

The QA objectives for the sampling and analysis program are completeness, precision, accuracy, comparability, and representativeness. Each laboratory processes QA/QC data independently according to laboratory SOPs and statements of work (SOWs). Sections 7.1, 7.2, and 7.3 discuss the QC results for the WIPP Laboratories, CEMRC and HEAL/Anatek respectively, in terms of how well they met the QA objectives.

7.1 WIPP Laboratories

Samples for analysis of radionuclides were collected using approved WIPP procedures. The procedures are based on generally accepted methodologies for environmental sampling, ensuring that the samples were representative of the media sampled. The samples were analyzed for natural radioactivity, fallout radioactivity from nuclear weapons tests, and radionuclides contained in the TRU waste disposed at the WIPP facility. During 2017 there were no detections of ^{241}Am and $^{239/240}$Pu. Environmental soil and sediment samples occasionally show detections of $^{239/240}$Pu with concentrations generally below the baseline concentrations.

7.1.1 Completeness

The SOW for analyses performed by WIPP Laboratories states that “analytical completeness, as measured by the amount of valid data collected versus the amount of data expected or needed, shall be greater than 90 percent for the MOC sampling programs.” For radiological sampling and analysis programs, this contract requirement translates into the following quantitative definition of completeness.

Completeness is expressed as the number of samples analyzed with valid results as a percentage of the total number of samples submitted for analysis, or

$$\%C = \frac{V}{n} \times 100$$

Where:

%C = percent completeness

V = number of samples with valid results

n = number of samples submitted for analysis

Valid data were generated from all the samples analyzed in 2017. Thus, 100 percent of the expected samples and measurements for the sampled environmental media (air particulate composites, groundwater, surface water, soil, sediment, plants, and animals) were reported.

7.1.2 Precision

The SOW states that analytical precision (as evaluated through replicate measurements) will meet control criteria or guidelines established in the industry-standard radiochemical methods used for sample analysis. To ensure overall quality of analysis of environmental samples, precision was evaluated for sample collection and sample analysis procedures combined, as well as the sample analysis procedures alone. At least one pair of field duplicates was collected and analyzed for each sample matrix type when possible. (Field duplicates would not necessarily apply to all sample matrix types, such as small animals.) The precision of laboratory-generated duplicates was reported by WIPP Laboratories and reviewed by the data validator, and the precision of field duplicates was calculated and reported by the data validator from the analysis results of the individual samples.

The measure of precision for radionuclide sample analyses is the RER, which is expressed as:

$$RER = \frac{(Activity)pri - (Activity)dup}{\sqrt{(1\,\sigma\,TPU)^2 pri\; +\; (1\,\sigma\,TPU)^2 dup}}$$

Where:

RER = relative error ratio

(Activity)pri = activity of the primary sample

(Activity)dup = activity of the duplicate sample

1 σ TPU = total propagated uncertainty at the 1 σ level

In order to assess precision of laboratory procedures, duplicate analyses are performed on separate portions of the same homogenized sample (laboratory duplicate). At least

one sample was taken from each batch for each type of sample matrix to analyze as a laboratory duplicate except for air filter composite samples, where only one sample is available. However, a field duplicate air filter composite sample was taken from a different location each quarter. The results of duplicate analyses from aliquots of the same sample were used to evaluate the precision of sub-sampling in the laboratory, the heterogeneity of the sample media, and the precision of the analytical method. These laboratory duplicate precision data, as RERs, are reviewed and evaluated during verification and validation of the data, but are not included in the ASERs. The verification and validation review showed that every laboratory duplicate RER met the WIPP QA objective of less than two for the sample batches analyzed in 2017, demonstrating good precision for the analysis procedures. The precision objective is a requirement of the laboratory, and in some cases, batches of samples were recounted or reprocessed to achieve the laboratory duplicate precision objective before the data were reported.

The RERs for field duplicate samples were calculated by the data reviewer as an indicator of the overall precision, reflecting the combination of both sample collection and laboratory analysis. Duplicate samples were collected at the same time, same place, and under similar conditions as the primary samples. In the case of vegetation samples, separate plants were collected to generate a duplicate sample. In the case of fauna (animals), field duplicates required the collection of multiple separate animals, i.e., quail and fish, to prepare composite field duplicate samples. The collection and analysis of separate vegetation and fauna samples as field duplicates could result in poorer precision due to actual differences in the levels of radionuclides in the individual samples.

The WIPP Environmental Monitoring Program has not defined a QA objective for the precision of the analysis results for field duplicate samples. Nonetheless, precision for field duplicate measurements is tracked. For the purposes of this report, precision data were evaluated using the guidance for a similar monitoring project as cited in the reference document *Rocky Flats Annual Report of Site Surveillance and Maintenance Activities-CY 2008* (Doc. No. S05247, U.S. Department of Energy, 2009). This source suggests that 85 percent of field duplicates should yield RERs less than 1.96. The value of 1.96 is based on the 95 percent confidence interval, but 15 percent of the precision values would be allowed to be greater than 1.96. However, the WIPP field duplicate analyses yielded few RER values greater than 1.96 whether the radionuclide was detected or not. Table 7.1 summarizes the field duplicate samples with precision RERs greater than 1.96 from the data in Tables 4.5, 4.7, 4.11, 4.15, 4.19, 4.22, and 4.25 containing RERs (see Appendix C for location codes). Duplicate analysis results for all the target radionuclides are considered, not just those results where the analyte was detected.

Table 7.1 – 2017 Summary of Field Duplicate Precision Analysis Results with RERs Greater than 1.96

Matrix	Duplicate Samples	Radionuclide	RER	Detected?
Quarterly Air filter composites	4th qtr, CBD	^{40}K	2.184	No
Groundwater	WQSP-1	^{235}U	1.960	Yes
Groundwater	WQSP-3	^{235}U	1.975	Yes
Groundwater	WQSP-4	^{238}U	2.382	Yes
Groundwater	WQSP-4	^{60}Co	2.172	No
Groundwater	WQSP-6	^{235}U	2.443	Yes
Surface water	IDN	^{40}K	3.492	No
Sediment	PKT	$^{233/234}$U	3.155	Yes
Sediment	PKT	^{238}U	2.179	Yes
Sediment	PKT	$^{239/240}$Pu	2.585	No/Yes (a)
Soil	SEC (0 - 2 cm)	^{241}Am	2.222	No
Soil	SEC (2 - 5 cm)	^{137}Cs	2.220	Yes

(a) Detected in the duplicate sample but not the primary sample.

The data in Table 7.1 show that in 12 cases the field duplicate RERs were greater than or equal to 1.96, 4 of which were non-detects and one case where the radionuclide was detected in the duplicate sample but not the primary sample. There were 10 cases where the RERs were greater than or equal to 1.96 in 2016. The total number of RER measurements was 210. Thus, 94.3 percent of the field duplicate precision results were less than 1.96, which readily met the precision objective. The radionuclides included in the 12 were one $^{233/234}$U, three ^{235}U, two ^{238}U, one $^{239/240}$Pu, one ^{241}Am, two ^{40}K, one ^{60}Co, and one ^{137}Cs. Pu-239/240 was detected in the duplicate PKT sediment sample but not in the primary sample. The radionuclide could exist as particulate and be present in one sample but not the other. The largest RER was for ^{40}K (3.492) where it was not detected in either of the IDN surface water duplicate samples.

In summary, the precision of the combined sampling and analysis procedures meets the precision objective of less than 1.96 for field duplicate samples for 94.3 percent of the RERs.

7.1.3 Accuracy

The accuracy of the radiochemical analyses was checked by analyzing initial and continuing calibration standards, reagent method blanks, matrix filter blanks in the case of air filter composite samples, some aqueous field blanks, and reagent laboratory control samples (RLCSs), which are spiked method blanks as specified in the published industry-standard analytical methods and in the corresponding lab SOPs. Samples for alpha spectrometry analysis were spiked with tracers, samples for ^{90}Sr analysis were spiked with a carrier, and air filter samples and fauna samples gamma analysis were

spiked with a ^{22}Na tracer. The percent recovery of the tracers and carriers were reported as a measure of accuracy, and the analysis results were corrected for the percent recoveries to improve the accuracy of the analyses. The tracer recoveries need to meet certain recovery objectives for the sample data to be acceptable, i.e., tracer recovery of 30–110 percent and carrier recovery of 40–110 percent. If the recoveries are outside this range, the samples are reprocessed until the recovery objective is met.

The daily calibration standards were used to confirm that the response in the daily standard closely matched the corresponding response during the initial calibration. Instrument accuracy was ensured by using NIST-traceable radiochemistry standards for instrument calibration. The reagent method blanks were used to confirm that the accuracy of the radiological sample analysis was not adversely affected by the presence of any of the target radionuclides as background contaminants that may have been introduced during sample preparation and analysis. The filter matrix blank sample was an unused clean particulate filter that was not used for sampling but was analyzed to correct for any particulate filter background. The RLCSs were analyzed to check that the analytical method was in control by measuring the percent recoveries of the target radionuclides spiked into clean water. Duplicate RLCS samples were prepared and analyzed for some of the radiochemical batches, when laboratory duplicate samples were not available, e.g., air filter composite samples.

The radiochemical SOW requires the measured accuracy to meet control criteria or guidelines established in the industry-standard methods used for sample analysis. However, the SOW does not require the analysis of matrix spike / matrix spike duplicate (MS/MSD) samples as a measure of accuracy and precision.

NIST-traceable standards were spiked into clean water or a clean solid matrix to prepare RLCS samples. Analysis of RLCSs containing the radionuclides of interest was performed on a minimum 10 percent basis (1 per batch of 10 or fewer samples). The QA objective for the analysis results was for the measured concentration to be within 80 to 120 percent of the known expected concentration. If this criterion was not met, the entire sample batch was re-analyzed. RLCS results for each radionuclide were tracked on a running basis using control charts. The data validator recalculated the control chart points to ensure the data points matched those reported by the laboratory. The review showed that the radiological RLCS results fell within the established recovery range, indicating good accuracy.

Accuracy was also ensured through the participation of WIPP Laboratories in the DOE MAPEP and the DOE Laboratory Accreditation Program, as discussed in more detail in Section 7.1.4. Under these programs, WIPP Laboratories analyzed blind environmental performance evaluation samples, and the results were compared with the official results measured by the DOE Laboratory Accreditation Program, MAPEP laboratories.

Performance was established by percent bias, calculated as:

$$\%Bias = \frac{(A_m - A_k)}{A_k} \times 100$$

Where:

% Bias = percent bias

A_m = measured sample activity

A_k = known sample activity

7.1.4 Comparability

The mission of WIPP Laboratories is to produce high-quality and defensible analytical data in support of the WIPP operations. The SOW requires WIPP Laboratories to ensure consistency through the use of standard analytical methods coupled with specific procedures that govern the handling of samples and the reporting of analytical results.

A key element in the WIPP Laboratories QA program is analysis of performance evaluation samples distributed as part of inter-laboratory comparison programs by reputable agencies. The DOE Laboratory Accreditation Program and MAPEP involve preparing QC samples containing various alpha-, beta-, and gamma-emitting radionuclides in synthetic urine, synthetic feces, air filter, water, soil, and vegetation media, and distributing the samples to the participating laboratories.

The programs are inter-laboratory comparisons in that the analysis results generated by the laboratory participants are compared with the analysis results experimentally measured by the administering agencies. The programs assess each laboratory's analysis results as acceptable (passing) or not acceptable (failing), based on the accuracy of the analyses. A warning may be issued for a result near the borderline of acceptability. The DOE Laboratory Accreditation Program primarily includes the analyses of bioassay samples (urine and feces). Bioassay samples are not analyzed as part of the WIPP environmental program, and DOE Laboratory Accreditation Program performance evaluation bioassay analysis results are not specifically discussed in this report.

WIPP Laboratories analyzed eight MAPEP environmental samples consisting of two each of soil, water, air filter, and vegetation samples. The target radionuclides included the WIPP target radionuclides $^{233/234}$U, ^{238}U, ^{238}Pu, $^{239/240}$Pu, ^{241}Am, ^{40}K, ^{60}Co, ^{137}Cs, and ^{90}Sr. Results for the other WIPP radionuclide, ^{235}U, were not requested by MAPEP. The acceptable range for the MAPEP samples is a bias less than or equal to ±20 percent, i.e., within 80 to 120 percent of the MAPEP value. The acceptable range with a warning is a bias greater than ±20 percent but less than ±30 percent, i.e., within 70 to 80 percent or 120 to 130 percent of the MAPEP value. The not acceptable (N) results are those

with a bias greater than ±30 percent, i.e., less than 70 percent or greater than 130 percent of the MAPEP value.

Table 7.2 presents the results for the first set of 2017 MAPEP soil, water, air filter, and vegetation performance evaluation samples (MAPEP–17, Series 36). The data in Table 7.2 show that the WIPP Laboratories results for the MAPEP Series 36 samples were all acceptable.

Table 7.2 – Mixed Analyte Performance Evaluation Program Review for WIPP Laboratories, Reported in 2017, First Set (Series 36)

Analyte	MATRIX: Soil (Bq/kg) MAPEP–17-MaS36				MATRIX: Water (Bq/L) MAPEP–17–MaW36			
	Reported [RN][a]	MAPEP[b] [RN][a]	E[c]	% Bias	Reported [RN][a]	MAPEP[b] [RN][a]	E[c]	% Bias
^{241}Am	57.3	67.0	A	-14.5	0.840	0.846	A	-0.7
^{60}Co	880	891	A	-1.2	11.4	12.3	A	-7.3
^{137}Cs	636	611	A	4.1	10.6	11.1	A	-4.5
^{238}Pu	0.435	0.41	A	6.1	0.644	0.703	A	-8.4
$^{239/240}$Pu	52.2	59.8	A	-12.7	0.871	0.934	A	-6.7
^{90}Sr	606	624	A	-2.9	10.6	10.1	A	5.0
$^{233/234}$U	47.8	48.1	A	-0.6	1.15	1.16	A	-0.9
^{238}U	49.5	48.8	A	1.4	1.21	1.20	A	0.8
^{40}K	596	607	A	-1.8	237	254	A	-6.7
	MATRIX: Air Filter (Bq/filter) MAPEP–17–RdF36				MATRIX: Vegetation (Bq/Sample) MAPEP–17–RdV36			
[RN]	Reported Value	MAPEP Value	E[c]	% Bias	Reported Value	MAPEP Value	E[c]	% Bias
^{241}Am	0.0359	0.0376	A	-4.5	0.000354	NR	A	(d)
^{60}Co	0.792	0.78	A	1.5	9.41	8.75	A	7.5
^{137}Cs	0.666	0.685	A	-2.8	4.87	4.60	A	5.9
^{238}Pu	0.0601	0.0598	A	0.5	0.0616	0.0598	A	3.0
$^{239/240}$Pu	0.0477	0.0460	A	3.7	0.0897	0.089	A	0.8
^{90}Sr	0.655	0.651	A	0.6	1.52	1.75	A	-13.1
$^{233/234}$U	0.102	0.104	A	-1.9	0.185	0.179	A	3.3
^{238}U	0.107	0.107	A	0.0	0.187	0.186	A	0.5
^{40}K	NR	NR	NA	NA	NR	NR	NA	NA

Notes:

(a) Activity.

(b) MAPEP = Mixed Analyte Performance Evaluation Program.

(c) E = evaluation rating (A = acceptable, W = acceptable with warning, N = not acceptable).

(d) False positive test.

NA = Not applicable.

NR = Not reported.

The results of the Second Set of 2017 MAPEP samples are not yet available and will be reported in the next ASER.

Based on the number of acceptable (A) ratings earned by WIPP Laboratories for the analysis of performance evaluation samples, the laboratory provided accurate and reliable radionuclide analysis data for the WIPP Environmental Program samples.

7.1.5 Representativeness

Representativeness is the extent to which measurements actually represent the true environmental condition or population at the time a sample was collected. The primary objective of the Environmental Monitoring Program is to generate environmental data that can be used to determine that the health and safety of the population surrounding the WIPP facility is being protected. Analytical representativeness is ensured through the use of technically sound and accepted approaches for environmental investigations, including industry-standard analytical methods and WIPP procedures for sample collection and monitoring for potential sample cross-contamination through the analysis of field blank samples and laboratory method/reagent blank samples. These conditions were satisfied during the sample collection and analysis practices of the WIPP Environmental Monitoring Program in 2017.

7.2 Carlsbad Environmental Monitoring and Research Center

The Organic Chemistry Laboratory at CEMRC performed the analyses of air VOC samples collected at the WIPP facility during 2017. Hydrogen and methane samples were not collected in 2017.

7.2.1 Completeness

Completeness is defined in WP 12–VC.01, *Volatile Organic Compound Monitoring Plan*, and WP 12–VC.04, *Quality Assurance Project Plan for Hydrogen and Methane Monitoring*, as being “the percentage of the ratio of the number of valid sample results received that meet other quality objectives versus the total number of samples required to be collected.” The QA objective for completeness for each monitoring program is 95 percent.

For 2017, 250 VOC compliance samples and 36 field duplicate samples were submitted to CEMRC for analysis; all submitted samples produced valid data. For surface VOC monitoring, the program analytical completion percentage was 100 percent.

7.2.2 Precision

Precision is demonstrated in both the VOC monitoring and Hydrogen and Methane Monitoring Programs by evaluating results from both laboratory duplicate analysis and field duplicate samples. The laboratory duplicate samples consist of a laboratory control sample (LCS) and a laboratory control sample duplicate (LCSD) and laboratory sample duplicates (duplicate runs of monitoring program samples). The field duplicate is a

duplicate sample that is collected in parallel with the original sample and is intended to show consistency in the sample collection method. Duplicate samples are evaluated using the relative percent difference (RPD), as defined in WP 12–VC.01 and WP 12–VC.04. The RPD is calculated using the following equation.

$$RPD = \frac{|(A - B)|}{(A + B) / 2} \times 100$$

Where:

RPD = relative percent difference

A = original sample result

B = duplicate sample result

A LCS and a LCSD were generated and evaluated for data submitted in 2017. The LCS/LCSD data generated during 2017 yielded RPDs less than or equal to 25.

Laboratory duplicate samples yielded RPDs less than or equal to 25.

Field duplicate samples were also collected and compared for precision. The acceptable range for the RPD between measured concentrations is less than or equal to ±35. For each target VOC value reported over the MRL in 2016, 36 of 36 field duplicates met the acceptance criterion.

7.2.3 Accuracy

The VOC monitoring program evaluates both quantitative and qualitative accuracy and recovery of internal standards. Qualitative evaluation consists of the evaluation of standard ion abundance for the instrument tune, which is a mass calibration check with bromofluorobenzene performed prior to analyses of calibration curves and samples.

The Hydrogen and Methane Monitoring Program evaluates quantitative accuracy. The quantitative evaluation includes performance verification for instrument calibrations and LCS recoveries.

7.2.3.1 Quantitative Accuracy

Instrument Calibrations

Instrument calibrations are required to have a relative standard deviation percentage of less than or equal to 30 percent for each analyte of the calibration. For VOCs, this is calculated by first calculating the relative response factor as indicated below.

$$\text{Relative Response Factor} = \frac{(\text{Analyte Response})(\text{Internal Standard Concentration})}{(\text{Internal Standard Response})(\text{Analyte Concentration})}$$

$$\text{Relative Standard Deviation} = \left[\frac{\text{Standard Deviation of Relative Response Factor}}{\text{Average Relative Response Factor of Analyte} \times 100}\right]$$

For hydrogen and methane, the calculations are similar except the method does not require internal standards and thus not factored into the equations.

During 2017, 100 percent of instrument calibrations met criteria of less than or equal to 30 percent.

Laboratory Control Sample Recoveries

Laboratory control sample recoveries are required to have an acceptance criterion of ±40 percent (60 to 140 percent recoveries). Laboratory control sample recoveries are calculated as:

$$PercentRecovery = \frac{X}{T} \times 100$$

Where

X = experimentally determined value of the analyte recovered from the standard

T = true reference value of the analyte being measured

During 2017, 100 percent of the LCS recoveries met the ±40 percent criterion.

Internal Standard Area

For VOC analyses, internal standard areas are compared to a calibrated standard area to evaluate accuracy. The acceptance criterion is ±40 percent.

During 2017, 100 percent of internal standards met the ±40 percent criterion.

Sensitivity

To meet sensitivity requirements, MDL for each of the nine target compounds must be evaluated before sampling begins. The initial and annual MDL evaluation is performed in accordance with Appendix B of 40 CFR Part 136, “Guidelines Establishing Test

Procedures for the Analysis of Pollutants," and with Chapter 1, *Quality Control,* of EPA SW–846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (1996). The CEMRC met the MDL requirements for 2017 data.

7.2.3.2 Qualitative Accuracy

For VOC analyses, the standard ion abundance criterion for bromofluorobenzene is used to evaluate the performance of the analytical system in the ID of target analytes as well as unknown constituents (qualitative accuracy). This ensures that the instrumentation is functioning properly during the analysis of air samples.

During 2017, ion abundance criteria were within tolerance.

7.2.4 Comparability

CEMRC participated in the National Air Toxics Trends Station proficiency test for VOC analysis in the first and third quarters of 2017.

For the National Air Toxics Trends Station first quarter 2017 PT, carbon tetrachloride, 1,2-dichloroethane, and trichloroethylene each met the acceptance criterion of within 30 percent of the nominal spike value established in the WIPP Laboratory Proficiency Testing Plan. Chloroform, methylene chloride, and 1,1,2,2-tetrachloroethane did not meet the acceptance criterion. Each of the three compounds not meeting the acceptance criterion were reported by CEMRC higher than the nominal concentration. Due to the widespread results outside of acceptance criteria, submitted by other participating laboratories, the results of the first quarter 2017 PT were indeterminate for laboratory proficiency.

For the third quarter 2017 PT, the results show that CEMRC passed the National Air Toxics Trends Station criteria as well as the criteria listed in the WIPP Laboratory Proficiency Testing Plan. Nominal value comparison of ≤30 percent is the acceptance criteria detailed in the WIPP Laboratory Proficiency Testing Plan. All WIPP target compounds present in the PT sample were identified and met the performance criteria.

7.2.5 Representativeness

Representativeness is ensured by use of programmatic plans and procedures implementing EPA guidance designed to collect and analyze samples in a consistent manner.

7.3 Hall Environmental Analysis Laboratory

HEAL performed the chemical analyses for the Round 39 groundwater sampling in 2017. HEAL followed laboratory SOPs based on standard analytical methods from EPA and from *Standard Methods for the Examination of Water and Wastewater* (Eaton et al., 2005). The trace metal analyses for antimony, arsenic, selenium, and thallium by inductively coupled plasma emission spectroscopy/mass spectrometry were

subcontracted to Anatek Laboratories in order to achieve the requisite method reporting limits.

7.3.1 Completeness

Six WQSP wells were sampled once in 2017 during the period March through May for the WIPP groundwater DMP. The completeness objective was met as analytical results were received for all the samples submitted (100 percent completeness).

7.3.2 Precision

HEAL and Anatek provided precision data for the analyses of LCS/LCSD pairs, MS/MSD pairs, and single primary groundwater samples analyzed as laboratory duplicates for selected analytes where MS/MSD samples are not applicable. LCS samples were prepared by spiking the target constituent (VOCs, SVOCs, and trace metals) and general chemistry parameter target analytes into clean water and preparing and analyzing the samples. Duplicate LCS samples (LCSDs) were analyzed for analytical methods where LCSDs are specified to be analyzed in the laboratory SOPs. These methods included GC/MS analyses for VOCs and SVOCs, inductively coupled plasma emission spectroscopy analyses for metals, and inductively coupled plasma emission spectroscopy/mass spectrometry analyses for arsenic, antimony, selenium, thallium and some of the general chemistry parameters. A LCSD is a separately prepared LCS sample. The MS/MSD samples were generated by spiking the target constituents and selected general chemistry indicator parameter analytes into separate portions of the primary groundwater samples. The LCS/LCSD and MS/MSD samples generally contained all the target constituents and general chemistry parameters for precision measurement. The samples were analyzed and the precision of the duplicate VOC, SVOC, metals, and general chemistry parameter analyses as RPD was determined and reported.

The LCS/LCSD and MS/MSD samples are not applicable for some analyses such as pH, specific gravity, TSS, and specific conductance. Precision data for these types of analyses were generated by analyzing a field sample in duplicate and calculating the associated RPD. The QA objective for the precision of the LCS/LCSD, MS/MSD, and duplicate sample concentrations is less than or equal to 20 RPD for hazardous constituents and general chemistry parameters. In addition, the data validator calculated the precision of the analysis results for each detected analyte in the primary and duplicate groundwater samples. Since the primary and duplicate groundwater samples are separate samples, there are no particular precision requirements for the analysis results. However, the duplicate samples are taken consecutively from continuously flowing water, and the composition of the samples is generally expected to be as consistent as separating a single groundwater sample into two fractions, and the resulting RPDs should accordingly be less than 20.

The duplicate groundwater precision measurements were calculated for the detectable concentrations of the major cations including calcium, magnesium, potassium, and

sodium; the detected trace metals generally including barium, beryllium, and vanadium; and general chemistry parameters including chloride, TOC, specific gravity, TDS, TSS, pH, specific conductance, and alkalinity. Precision is typically more variable for constituents and general chemistry parameters with low concentrations between the MDL and MRL, i.e., results that are J-flagged as estimated, and the less-than-20 RPD criteria does not apply to these low concentrations.

Table 7.3 shows those cases where the precision objective (RPD≤20) was not met for the duplicate groundwater samples, LCS/LCSD samples, MS/MSD samples, and duplicate analysis of single groundwater samples when applicable. The data in Table 7.3 show that all but one of the samples where the precision objective was not met were for MS/MSD QC samples rather than groundwater samples. All but three of the MS/MSD samples were for the analysis of acidic or basic SVOCs by GC/MS. The affected compounds include 2,4-dinitrophenol, pentachlorophenol, pyridine, 1,2-dichlorobenzene, 1,4-dichlorobenzene, hexachloroethane, 2-methylphenol, 3+4-methylphenol, nitrobenzene, and hexachlorobenzene. The other MS/MSD analytes that did not meet the precision objective were the VOC compound isobutyl alcohol, and the two metals cadmium and lead. The single example of a primary and duplicate groundwater analyte not meeting the precision objective was the general chemistry parameter TSS. All LCS/LCSD pairs met the precision objective.

The SVOC analyses are more prone to poorer precision than VOC analyses due to variations in extraction efficiency between samples. No SVOCs were detected in the groundwater samples so no groundwater data were affected.

Table 7.3 contains one entry for TSS in groundwater samples. The quality assurance objective for precision is sometimes not met for analytes, such as TSS, where the analytical methods are challenged by the high-brine groundwater samples. Analyses for TSS can be affected by the high salt content of the groundwater samples and the results depend on how long the samples are allowed to stand following shaking and before filtering. However, the 2017 TSS analyses were more precise than in recent years. The poor precision for the metals cadmium and lead was for the MS/MSD samples associated with the concentrated brine WQSP-3 groundwater samples. These two metals plus silver have shown poorer recoveries from spiked WQSP-3 groundwater in previous years as well.

Table 7.3 – Individual Cases Where the Round 39 Groundwater RPDs were Greater than 20 for the Primary and Duplicate Groundwater Samples, LCS/LCSD Pairs, MS/MSD Pairs, and Laboratory Duplicate QC Samples[(a)]

DMW[(b)]	Parameter or Constituent	Primary	Duplicate	RPD[(c)]
WQSP-1	Isobutyl alcohol	35.7 µg/L (MS)	25.2 µg/L (MSD)	34.5
WQSP-1	2,4-dinitrophenol	32.8 µg/L (MS)	21.1 µg/L (MSD)	43.4
WQSP-1	2,4-dinitrotoluene	87.9 µg/L (MS)	109 µg/L (MSD)	21.3
WQSP-1	Hexachlorobenzene	78.6 µg/L (MS)	98.5 µg/L (MSD)	22.4

DMW[(b)]	Parameter or Constituent	Primary	Duplicate	RPD[(c)]
WQSP-1	Pentachlorophenol	68.0 µg/L (MS)	85.2 µg/L (MSD)	22.3
WQSP-2	1,2-Dichlorobenzene	30.7 µg/L (MS)	20.1 µg/L (MSD)	41.6
WQSP-2	1,4-Dichlorobenzene	31.5 µg/L (MS)	20.1 µg/L (MSD)	44.0
WQSP-2	2,4-Dinitrotoluene	43.8 µg/L (MS)	33.3 µg/L (MSD)	27.2
WQSP-2	Hexachlorobenzene	44.3 µg/L (MS)	34.3 µg/L (MSD)	25.5
WQSP-2	Hexachloroethane	29.9 µg/L (MS)	18.5 µg/L (MSD)	47.0
WQSP-2	2-Methylphenol	39.1 µg/L (MS)	30.6 µg/L (MSD)	24.4
WQSP-2	3+4-Methylphenol	35.8 µg/L (MS)	27.3 µg/L (MSD)	27.0
WQSP-2	Pyridine	27.9 µg/L (MS)	18.8 µg/L (MSD)	39.0
WQSP-3	1,2-Dichlorobenzene	20.4 µg/L (MS)	41.1 µg/L (MSD)	67.5
WQSP-3	1,4-Dichlorobenzene	19.3 µg/L (MS)	42.9 µg/L (MSD)	76.1
WQSP-3	2,4-Dinitrophenol	0.0 µg/L (MS)	3.28 µg/L (MS)	200
WQSP-3	2,4-Dinitrotoluene	50.6 µg/L (MS)	82.4 µg/L (MSD)	47.9
WQSP-3	Hexachlorobenzene	44.0 µg/L (MS)	75.5 µg/L (MSD)	52.6
WQSP-3	Hexachloroethane	18.0 µg/L (MS)	38.5 µg/L (MSD)	72.6
WQSP-3	Nitrobenzene	33.1 µg/L (MS)	68.8 µg/L (MSD)	70.0
WQSP-3	Pyridine	8.42 µg/L (MS)	14.7 µg/L (MSD)	54.1
WQSP-3	PCP ND in MS/MSD (LCS/LCSD OK)	0.0 µg/L	0.0 µg/L	0.0
WQSP-3	Cadmium	0.0314 mg/L (MS)	0.0420 mg/L (MSD)	28.7
WQSP-3	Lead	0.0303 mg/L(MS)	0.0374 mg/L (MSD)	21.5
WQSP-4	TSS	82 mg/L	108 mg/L	27.4
WQSP-5	2,4-Dinitrophenol	7.72 µg/L (MS)	3.58 µg/L (MSD)	73.3
WQSP-5	2-Methylphenol	61.6 (MS)	75.5 µg/L (MSD)	20.3
WQSP-5	Nitrobenzene	57.3 (MS)	71.0 µg/L (MSD)	21.3
WQSP-5	Pentachlorophenol	33.2 µg/L (MS)	9.6 µg/L (MSD)	111

Note:

(a) Only samples with concentrations above the MRL are reported. (J-flagged estimated concentrations not reported.)
(b) Detection Monitoring Well
(c) Relative Percent Difference

It should be noted that LCS/LCSD samples use analyte-free water spiked with the target analytes for the expressed purpose of ensuring high precision during sample analysis, i.e., there are no matrix effects due to the high TDS content. Most or all the examples of the poorer precision in Table 7.3 were due to the high-brine groundwater sample matrix.

Considering the hundreds of groundwater sample data points and QA/QC sample data points that were generated during Round 39, the number of duplicate groundwater

samples and QA samples that did not meet the precision objective was very low, at less than two percent.

7.3.3 Accuracy

The accuracy of the analyses was checked by analyzing initial calibration verification standards, continuing calibration verification standards, method blanks, LCS and LCSD samples, and MS/MSD samples as specified in the standard methods and in the corresponding lab SOPs. The daily calibration standards were used to confirm that the response in the daily standard closely matched the corresponding response during the initial calibration. The method blanks were used to confirm that the accuracy of the groundwater sample analyses was not adversely affected by the presence of any of the target analytes as background contaminants that may have been introduced during sample preparation and analysis. The LCS and LCSD samples, where applicable, were analyzed to check that the analytical method was in control by measuring the percent recoveries of the target analytes spiked into clean water. MS/MSD samples were prepared and analyzed to check the effect of the groundwater sample matrix on the accuracy of the analytical measurements as percent recovery.

The objective for the percent recoveries varies with the type of analysis:

- 70–130 percent recovery for VOCs in LCS samples and MS samples.
- 90–110 percent recovery for chloride and sulfate in LCS samples (MS samples not analyzed due to the high native concentrations in groundwater).
- 80–120 percent recovery for mercury and recoverable metals in LCS samples.
- 75–125 percent recovery for mercury and recoverable metals in MS samples.
- 90–110 or 80–120 percent recovery for general chemistry parameters in LCS samples.
- 80–120 percent recovery or 75–125 percent recovery for general chemistry parameters in MS samples.
- SVOC recovery objectives vary widely according to the lab's historical control chart range. The general EPA guidance for SVOC recoveries is 40–140 percent for base/neutral SVOCs and 30–130 percent for acidic SVOCs with wider ranges for surrogate recovery compounds, e.g., 10 to 94 percent for phenol-d5 and 20 to 123 percent for 2,4,6-tribromophenol.

The HEAL historical control chart recovery range for some of the acidic compounds is similar to the EPA ranges for the two acidic surrogate recovery compounds. The lab's historical control chart range varies widely by compound and ranged from 6.98 to 106 percent for 2,4-dinitrophenol and 15.2 to 89.7 percent for pyridine to 56.4 to 106 percent for hexachlorobenzene.

The accuracy QA objectives for the general chemistry indicator parameters are generally tighter than for the hazardous constituent organics and metals, with recoveries of 80–120 percent, and with any detected analytes in the method blanks at concentrations less than the MRL or preferably not detected at all.

Table 7.4 summarizes the QC samples for which the accuracy QA objective, as measured by percent recovery, was not met during the Round 39 sampling and analysis in 2017. Some of the VOC recoveries are higher than the objective rather than lower. None of the target analytes were detected in method blank samples as contaminants at concentrations above the MRL; thus, accuracy was not adversely affected by contamination. The recoveries of analytes that contained native sample concentrations greater than four times the MS concentration, such as the major cations, chloride, and sulfate, are not included in Table 7.4 since MS/MSD recovery data are not applicable per EPA guidance for samples with high native concentrations of a given analyte.

Table 7.4 – Individual Cases Where the Round 39 Quality Assurance Objective Were Not Met Per EPA Guidance

DMW[(a)]	Constituent or Parameter	Sample	% Rec.	Sample	% Rec.
WQSP-1	2-butanone	MS	146	MSD	166
WQSP-1	Isobutyl alcohol	MS	178	MSD	126*
WQSP-1	2,4-dinitrophenol	MS	32.8*	MSD	21.1
WQSP-2	2-butanone	LCS	132	LCSD	136
WQSP-2	2-butanone	MS	159	MSD	165
WQSP-2	2,4-dinitrophenol	MS	20.5	MSD	20.2
WQSP-2	Pentachlorophenol	MS	27.0	MSD	31.0*
WQSP-3	2-butanone	MS	221	MSD	228
WQSP-3	1,1,2,2-tetrachloroethane	MS	174	MSD	168
WQSP-3	Isobutyl alcohol	MS	189	MSD	183
WQSP-3	1,2-Dichlorobenzene	MS	20.4	MSD	41.1*
WQSP-3	1,4-Dichlorobenzene	MS	19.3	MSD	42.9*
WQSP-3	2,4-Dinitrophenol	MS	0.0	MSD	3.3
WQSP-3	Hexachloroethane	MS	18.0	MSD	38.5
WQSP-3	3+4-Methylphenol	MS	30.8*	MSD	25.9
WQSP-3	Nitrobenzene	MS	33.1	MSD	68.8*
WQSP-3	Pentachlorophenol	MS	0.0	MSD	0.0
WQSP-3	Pyridine	MS	8.4	MSD	14.7
WQSP-3	Cadmium	MS	62.9	MSD	84.0*
WQSP-3	Lead	MS	60.3	MSD	74.9*
WQSP-4	2-butanone	MS	154	MSD	155
WQSP-4	1,1,2,2-tetrachloroethane	MS	143	MSD	139

DMW[(a)]	Constituent or Parameter	Sample	% Rec.	Sample	% Rec.
WQSP-4	Isobutyl alcohol	MS	149	MSD	145
WQSP-4	2,4-Dinitrophenol	LCS	8.6	LCSD	8.5
WQSP-4	Pentachlorophenol	LCS	10.9	LCSD	11.2
WQSP-4	2,4-Dinitrophenol	MS	3.3	MSD	3.3
WQSP-4	Pentachlorophenol	MS	3.5	MSD	3.5
WQSP-4	Cadmium	MS	40.5	MSD	47.2
WQSP-4	Lead	MS	38.0	MSD	39.2
WQSP-4	Silver	MS	59.6	MSD	65.1
WQSP-5	Hexachloroethane	LCS	33.2	LCSD	34.9
WQSP-5	Pyridine	LCS	30.7	LCSD	32.0
WQSP-5	1,2-Dichlorobenzene	MS	38.9	MSD	45.2*
WQSP-5	1,4-Dichlorobenzene	MS	38.8	MSD	47.4*
WQSP-5	2,4-Dinitrophenol	MS	7.7	MSD	3.6
WQSP-5	Hexachloroethane	MS	34.4	MSD	36.5
WQSP-5	Pentachlorophenol	MS	33.2*	MSD	9.6
WQSP-5	Pyridine	MS	44.3*	MSD	37.2
WQSP-6	2,4-dinitrophenol	MS	23.6	MSD	89.7*
WQSP-6	Pyridine	MS	77.9*	MSD	23.2

Note: Most of the percent recoveries for SVOCs in the table met the wider lab's historical control chart range.

(a) Detection Monitoring Well

*The QAO for accuracy as percent recovery was met.

Table 7.4 contains one row where the VOC 2-butanone yielded a slightly high recovery in the LCS sample, indicating a high bias for the calibration curve since the salting-out effect would not apply to the compound spiked into distilled water. Table 7.4 contains nine rows which yielded high MS and/or MSD recoveries for three different VOCs including four rows for 2-butanone, three rows for isobutyl alcohol, and two rows for 1,1,2,2-tetrachloroethane. The salting-out effect would enhance the recoveries of the two polar compounds 2-butanone and isobutyl alcohol compared to their recoveries from spiked distilled water. It is likely that 1,1,2,2-tetrachloroethane forms through degradation of other chlorinated VOCs in the spiked high-brine groundwater samples to yield the higher recoveries. The only one of the three compounds detected in any of the Round 39 groundwater samples was 2-butanone at concentrations lower than the MRL. The compound was detected in the primary and duplicate groundwater samples at 2.0 ug/L and in the WQSP-4 groundwater, at 1.9 ug/L in the primary sample, and 2.1 ug/L in the duplicate sample. These concentrations are probably overestimated due to higher purging efficiency from the groundwater compared to the distilled water calibration standards.

Table 7.4 contains 25 rows where the MS and/or MSD yielded low recoveries for a SVOC compound including seven entries for 2,4-dinitrophenol, five entries for pentachlorophenol, two entries for 1,2-dichlorobenzene and 1,4-dichlorobenzene, four entries for pyridine, three entries for hexachlorobenzene, and one entry each for 3-+4-methylphenol and nitrobenzene. These low recoveries, which were most prevalent in WQSP-3 groundwater, are due to matrix effects from the high salt concentrations since the recoveries from the LCS/LDSD samples met the recovery objective. The WQSP-6 MS and MSD showed one low and one good recovery for both 2,4-dinitrophenol and pyridine. The two low recoveries would not be due to a matrix effect but some other unknown effect which affected an acidic compound (2,4-dinitrophenol) in one sample and a basic compound (pyridine) in the other sample. The acidic compounds 2,4-dinitrophenol and pentachlorophenol generally yield lower recoveries than the other target SVOCs from groundwater, likely due to poor extraction efficiency combined with some gas chromatography sorption losses. Neither compound has been detected in any DMP groundwater samples. In fact, no target SVOC compounds have been detected in the groundwater from any of the sampling rounds.

Table 7.4 contains five rows for metals, including cadmium, lead, and silver, two from WQSP-3 and three from WQSP-4. The recovery objective was met for cadmium and lead in the WQSP-3 MSD but not the MS. The reason for these particular low recoveries is not known although it likely involved a lab error associated with the filtration step during the sample preparation of the high-TDS groundwater. None of the three metals were detected any of the groundwater samples.

Every groundwater sample and associated QC sample analyzed for VOCs and SVOCs by gas chromatography/mass spectrometry also served as a QC surrogate spike sample in that the surrogate recovery compounds were spiked into the samples prior to analysis and their recoveries were reported as a measure of the accuracy of the analyses.

EPA guidance recommends that VOC surrogate recoveries from water should be in the range of 80 to 120 percent for d4-dichloroethane (d4-dce), 86 to 118 percent for dibromofluoromethane (DBFM), 86 to 115 percent for 4-bromofluorobenzene (4-BFM); and 88 to 110 percent for d8-toluene (d8-tol). The corresponding EPA guidance for recovery of SVOC surrogates from water includes 10 to 123 percent for 2,4,6-tribromophenol (2,4,6-TBP); 43 to 116 percent for 2-fluorobiphenyl (2-FBP); 21 to 100 percent for 2-fluorophenol (2-FlOH); 33 to 141 percent for d14-p-terphenyl (d14-ter); 35 to 144 percent for d5-nitrobenzene (d5-NB); and 10 to 94 percent for d5-phenol.

Table 7.5 shows the recoveries of the VOC surrogates from the groundwater and QC samples. As shown in the table, the VOC surrogate recoveries met the QA objective for accuracy with only three recoveries of d4-1,2-dichloroethane slightly above the 120-percent recovery objective. There were no low recoveries. The good recoveries demonstrate good accuracy for any VOC compounds present in the groundwater samples.

Table 7.5 – Percent Recovery of VOC Surrogates from Round 39 Groundwater and QC Samples as a Measure of Accuracy

DMW[(a)]	Sample	d4-dce 80–120	4-BFM 86–115	DBFM 86–118	d8-tol 88–110
WQSP-1	Primary	120	89.6	119*	104
WQSP-1	Duplicate	115	88.0	115	103
WQSP-1	Field Blank	114	87.8	116	101
WQSP-1	Trip Blank	113	86.9	117	103
WQSP-1	MB	115	88.7	110	103
WQSP-1	LCS	115	95.2	104	103
WQSP-1	LCSD	117	96.9	103	105
WQSP-1	MS	126*	96.4	112	103
WQSP-1	MSD	127*	96.5	112	101
WQSP-2	Primary	119	94.9	113	102
WQSP-2	Duplicate	117	92.8	111	103
WQSP-2	Field Blank	113	94.1	115	99.9
WQSP-2	Trip Blank	110	89.3	114	100
WQSP-2	MB	111	91.8	113	102
WQSP-2	LCS	119	97.6	108	101
WQSP-2	LCSD	116	95.2	106	101
WQSP-2	MS	124*	90.2	107	102
WQSP-2	MSD	120	94.9	107	100
WQSP-3	Primary	101	107	100	104
WQSP-3	Duplicate	102	103	101	103
WQSP-3	Field Blank	95.5	99.2	95.8	101
WQSP-3	Trip Blank	97.6	97.8	96.0	101
WQSP-3	MB	94.8	102	97.4	102
WQSP-3	LCS	104	104	97.7	100
WQSP-3	LCSD	101	100	103	100
WQSP-3	MS	110	104	101	99.3
WQSP-3	MSD	112	104	101	98.5
WQSP-4	Primary	105	103	103	102
WQSP-4	Duplicate	103	101	100	101
WQSP-4	Field Blank	99.7	99.8	102	101
WQSP-4	Trip Blank	100	102	102	104
WQSP-4	MB	101	102	103	101
WQSP-4	LCS	105	105	105	99.3
WQSP-4	LCSD	105	104	105	96.7

DMW[(a)]	Sample	d4-dce 80–120	4-BFM 86–115	DBFM 86–118	d8-tol 88–110
WQSP-4	MS	109	104	105	101
WQSP-4	MSD	112	103	102	99.4
WQSP-5	Primary	97.0	97.9	101	101
WQSP-5	Duplicate	95.1	96.8	100	98.8
WQSP-5	Field Blank	98.2	100	98.5	100
WQSP-5	Trip Blank	95.8	97.6	99.4	98.1
WQSP-5	95.3	97.4	97.0	97.4	95.3
WQSP-5	104	102	105	97.2	104
WQSP-5	103	104	103	97.8	103
WQSP-5	110	95.9	105	96.8	110
WQSP-5	110	100	105	96.1	110
WQSP-6	Primary	94.4	95.7	95.9	98.8
WQSP-6	Duplicate	94.2	101	98.5	95.0
WQSP-6	Field Blank	90.3	97.2	99.1	95.6
WQSP-6	Trip Blank	94.7	98.5	97.9	95.7
WQSP-6	MB	91.1	99.1	97.3	99.2
WQSP-6	LCS	97.6	102	101	94.4
WQSP-6	LCSD	101	102	103	92.1
WQSP-6	MS	103	98.7	101	93.4
WQSP-6	MSD	105	102	101	96.7

(a) Detection Monitoring Well

*Calculated percent recovery did not meet EPA objective

Table 7.6 presents the recoveries of the SVOC surrogates from the spiked groundwater and associated QC samples. The header shows the recovery objective for each surrogate. The surrogates, which are spiked into samples prior to sample preparation and analysis, generally display wide percent recovery ranges due to variable extraction efficiencies and gas chromatographic column properties. Three of the surrogates (2,4,6-TBP, 2-FlOH, and d5-phenol) are acidic and can exhibit poorer extraction efficiencies than non-polar compounds using a non-polar extraction solvent, i.e., methylene chloride. The compounds are also susceptible to adsorption onto glassware during sample preparation and can chromatograph poorly if the gas chromatographic column has developed any active sites due to age and use.

Table 7.6 – Percent Recovery of SVOC Surrogates from Round 39 Groundwater and QC Samples as a Measure of Accuracy

DMW[(a)]	Sample	2,4,6-TBP 10–123	2-FBP 43–116	2-FlOH 21–100	d14-Ter 33–141	d5-NB 35–144	d5-Phenol 10–94
WQSP-1	Primary	67.0	76.5	41.8	24.1*	70.1	45.3

DMW[(a)]	Sample	2,4,6-TBP 10–123	2-FBP 43–116	2-FlOH 21–100	d14-Ter 33–141	d5-NB 35–144	d5-Phenol 10–94
WQSP-1	Duplicate	61.7	74.1	36.2	24.8*	71.4	38.8
WQSP-1	MB	101	116	106	88.7	95.0	102
WQSP-1	LCS	75.8	64.3	50.7	104	51.8	54.6
WQSP-1	LCSD	77.1	59.8	48.8	87.2	52.7	52.6
WQSP-1	MS	72.5	81.2	35.7	89.4	71.7	38.3
WQSP-1	MSD	98.9	86.2	35.1	118	68.6	37.7
WQSP-2	Primary	53.3	45.1	24.1	55.6	44.5	26.9
WQSP-2	Duplicate	49.3	70.6	35.3	65.4	65.5	37.6
WQSP-2	MB	82.2	73.7	54.1	69.0	74.1	41.5
WQSP-2	LCS	92.8	88.5	79.3	101	94.2	66.1
WQSP-2	LCSD	na	na	na	na	na	na
WQSP-2	MS	64.2	71.0	49.3	88.9	69.7	52.8
WQSP-2	MSD	54.2	57.5	32.7	71.3	59.6	34.2
WQSP-3	Primary	1.74*	17.2*	3.0*	26.1*	16.5*	9.7*
WQSP-3	Duplicate	1.0*	43.9	0.15*	60.1	45.6	3.4*
WQSP-3	MB	77.3	74.8	55.2	68.3	77.0	41.9
WQSP-3	LCS	74.6	53.3	45.3	81.7	61.3	38.1
WQSP-3	LCSD	73.7	54.0	46.2	82.4	60.1	39.8
WQSP-3	MS	5.1*	41.4	8.9*	51.3	33.1*	21.9*
WQSP-3	MSD	2.7*	69.8	0.38*	82.3	70.3	7.2*
WQSP-4	Primary	12.4*	60.3	19.1*	56.4	58.2	34.7
WQSP-4	Duplicate	23.4*	53.5	37.3	56.4	62.8	41.4
WQSP-4	MB	69.4	68.2	47.1	65.2	67.4	34.1
WQSP-4	LCS	14.3*	65.3	11.6*	78.7	75.8	17.6*
WQSP-4	LCSD	14.3*	64.7	11.3*	80.4	74.7	17.7*
WQSP-4	MS	10.6*	61.8	19.0*	72.8	67.0	22.9*
WQSP-4	MSD	8.9*	73.5	20.0*	95.4	81.0	27.0*
WQSP-5	Primary	58.7	57.6	43.8	57.1	57.0	33.1
WQSP-5	Duplicate	25.2*	26.4*	16.9*	28.2*	30.0*	15.1*
WQSP-5	MB	68.8	64.0	50.8	59.4	71.8	37.8
WQSP-5	LCS	77.0	66.7	49.7	81.5	69.0	44.9
WQSP-5	LCSD	75.7	67.5	53.2	83.7	64.9	46.7
WQSP-5	MS	58.0	57.4	39.9	66.6	56.7	36.5
WQSP-5	MSD	56.9	67.6	43.0	79.8	71.1	39.5
WQSP-6	Primary	66.6	61.0	45.0	62.2	63.5	34.5

DMW[(a)]	Sample	2,4,6-TBP 10–123	2-FBP 43–116	2-FlOH 21–100	d14-Ter 33–141	d5-NB 35–144	d5-Phenol 10–94
WQSP-6	Duplicate	62.3	62.1	40.6	54.6	59.4	31.8
WQSP-6	MB	76.5	73.1	54.3	65.7	80.2	39.6
WQSP-6	LCS	71.6	64.4	51.1	76.7	68.2	45.3
WQSP-6	LCSD	69.2	67.2	51.5	75.8	68.1	44.2
WQSP-6	MS	95.6	89.9	74.1	106	96.4	62.0
WQSP-6	MSD	95.7	89.3	71.0	101	88.6	60.0

*Calculated percent recovery did not meet EPA objective.
(a) Detection Monitoring Well

The data show 246 surrogate recovery entries for which there were 39 low recoveries that did not meet the EPA recovery objective. However, many of the 39 low recoveries met HEAL's historical control chart recovery range. Thirty of the 39 low recoveries were for acidic surrogates, and 29 of the 39 low recoveries were for the high-TDS WQSP-3 and WQSP-4 groundwater samples. The low surrogate recoveries generally correlated with the low MS/MSD recoveries for some of the target analytes, especially the acidic analytes such as 2,4-dinitrophenol and pentachlorophenol.

A LCSD sample was not analyzed for WQSP-2 resulting in 246 recovery entries instead of 252 entries. A LCSD is normally not required for HEAL's other clients, and they inadvertently did not analyze a LCSD with this batch of WIPP groundwater samples. However, a MS and MSD were analyzed for accuracy and precision determination.

Although the laboratory experienced difficulties with some of the SVOC matrix spike samples, the accuracy of the QC data was quite good with nearly all LCS/LCSD and most MS/MSD recoveries meeting the recovery objective for accuracy.

7.3.4 Comparability

The Permit requires that groundwater analytical results be comparable by reporting data in consistent units and collecting and analyzing samples using consistent methodology. These comparability requirements were met through the use of consistent, approved procedures for sample collection and SOPs for sample analyses. The normal reporting unit for metals and general chemistry parameters is mg/L, and the normal reporting unit for organics is micrograms per liter (µg/L).

HEAL and its subcontract laboratories are certified by several states and by the National Environmental Laboratory Accreditation Program through Oregon for HEAL and Anatek. HEAL is certified in Oregon, Utah, Texas, New Mexico, and Arizona. The labs participate in inter-laboratory evaluation programs, including on-site National Environmental Laboratory Accreditation Conference QA audits. The labs also regularly analyze performance evaluation samples provided by a National Environmental Laboratory Accreditation Conference–accredited proficiency standard vendor. The

HEAL vendor was Phenova Certified Reference Materials, and the Anatek vendor was Sigma-Aldrich.

The details of the HEAL performance evaluation sample results are discussed in this section and presented in Table 7.7 along with HEAL's subcontract laboratory, Anatek, which analyzed for the four target inductively coupled plasma emission spectroscopy/mass spectrometry metals (As, Sb, Se, and Tl) in its two separate performance evaluation sample sets from Sigma-Aldrich analyzed in 2017.

HEAL analyzed two sets of performance evaluation samples in 2017, including two Phenova water pollution PT samples. The Phenova water pollution proficiency evaluation samples included anions, trace metals, mercury, general chemistry indicator parameters, VOCs, and SVOCs. The performance evaluation samples covered the WIPP target analytes except for isobutyl alcohol (a VOC) and specific gravity (a general chemistry parameter). HEAL did not report trans-1,2-dichloroethene in one of the two VOC performance evaluation samples.

The inductively coupled plasma spectroscopy / mass spectrometry metals analyzed by Anatek were contained in each of the two sets of performance evaluation samples. Anatek provided one high result for selenium. The reported result was 24.1 ug/L. The assigned value was 17.0 ug/L with an acceptable range from 13.6 to 20.4 ug/L. None of the four target metals analyzed by inductively coupled plasma (ICP)/MS were detected in any of the Round 39 groundwater samples.

Table 7.7 – Performance Evaluation Sample Analysis Results for WIPP Groundwater Analytes, 2017

Target Analytes	Acceptable Results	Not Acceptable Results
HEAL: VOCs by GC/MS Method 8260B (carbon tetrachloride, chlorobenzene, chloroform, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethene, trans-1,2-dichloroethene, 2-butanone, methylene chloride, 1,1,2,2-tetrachloroethane, tetrachloroethene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, toluene, trichloroethene, trichlorofluoromethane, vinyl chloride, xylenes	35	1 (missed reporting trans-1,2-dichloroethene in one sample)
HEAL: Base/Neutral SVOCs by GC/MS Method 8270C (1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dinitrotoluene, hexachlorobenzene, hexachloroethane, nitrobenzene, pyridine	14	0
HEAL: Acid SVOCs by GC/MS Method 8270C (2,4-dinitrophenol, 2-methylphenol, 3+4-methylphenol, pentachlorophenol	8	0
HEAL: Trace and Dissolved Metals by inductively coupled plasma spectroscopy Method 6010B (barium, beryllium, cadmium, chromium, lead, nickel, silver, vanadium, calcium, magnesium, potassium, sodium)	24	0
HEAL: Mercury by Graphite Furnace Atomic Absorption Spectroscopy Method 7470A	2	0
Anatek: Metals by ICP/MS Method 6020B (antimony, arsenic, selenium, thallium)	7	1 (high Se in one sample)

HEAL: General Chemistry Parameters (chloride, sulfate, nitrate, TOC, alkalinity, specific conductance, pH, TDS, TSS)	18	0

ICP/MS = inductively coupled plasma spectroscopy / mass spectrometry

Some of the analytes such as sulfate, nitrate, and sodium are not reported as groundwater analytes but the concentration data from these anions is reported by HEAL and used to calculate the difference in concentrations between the total cation milliequivalents and total anion milliequivalents. This difference, termed charge balance error, provides a measure of the accuracy of the cation and anion analyses. The performance evaluation sample sets of both laboratories also included a large number of analytes that are not WIPP analytes.

The results shown in Table 7.7 show that HEAL and the Anatek provided acceptable results for all but one of the WIPP analytes. Neither of these analytes were detected in WIPP samples in 2017. The performance evaluation data confirm that both laboratories were able to provide accurate and reliable environmental analysis results for the WIPP groundwater samples.

7.3.5 Representativeness

The groundwater DMP is designed so that representative groundwater samples are collected from specific monitoring well locations. Prior to collecting the final samples from each well, serial samples were collected and analyzed in an on-site mobile laboratory to help determine whether the water being pumped from the monitoring wells was stable and representative of the natural groundwater at each well. The parameters analyzed in the mobile laboratory included temperature, pH, specific gravity, and specific conductance. The final samples for analysis of VOCs, SVOCs, metals, and general chemistry parameters were collected only when it had been determined from the serial sampling analysis results that the water being pumped was representative of the natural groundwater at each location.

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APPENDIX A – REFERENCES

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WP 02-RC3110, *Low-Level and Mixed Low Level Waste Characterization for Off-Site Release for Disposal*, Nuclear Waste Partnership LLC. Waste Isolation Pilot Plant, Carlsbad, NM.

WP 12-VC.01, *Volatile Organic Compound Monitoring Plan*. Nuclear Waste Partnership LLC. Waste Isolation Pilot Plant, Carlsbad, NM.

WP 12-VC.04, *Quality Assurance Project Plan for Hydrogen and Methane Monitoring*. Nuclear Waste Partnership LLC. Waste Isolation Pilot Plant, Carlsbad, NM.

WP 13-1, *Quality Assurance Program Description*. Nuclear Waste Partnership LLC. Waste Isolation Pilot Plant, Carlsbad, NM.

APPENDIX B – ENVIRONMENTAL PERMITS

Table B.1 – Major Active Environmental Permits for the Waste Isolation Pilot Plant as of December 31, 2017

Granting Agency	Type of Permit	Permit Number	Granted/ Submitted	Expiration	Current Permit Status
New Mexico Environment Department	Hazardous Waste Facility Permit	NM4890139088–TSDF	12/30/10	12/30/20	Active
New Mexico Environment Department Groundwater Quality Bureau	Discharge Permit	DP–831	7/29/14	7/29/19	Active
New Mexico Environment Department Air Quality Bureau	Operating Permit for Two Backup Diesel Generators	310–M–2	12/07/93	None	Active
New Mexico Environment Department Petroleum Storage Tank Bureau	Storage Tank Registration Certificate	Registration Number 1317 Facility Number 31539	07/01/17	06/30/18	Active
U.S. Environmental Protection Agency Region 6	Conditions of Approval for Disposal of PCB/TRU and PCB/TRU Mixed Waste at the US Department of Energy (DOE) Waste Isolation Pilot Plant (WIPP) Carlsbad, New Mexico	N/A	3/19/18	3/19/23	Active
U.S. Fish and Wildlife Service	Special Purpose – Relocate	MB155189–0	05/01/14	04/30/17	Active
New Mexico Department of Game and Fish	Biotic Collection Permit	Authorization # 3293	02/02/17	12/31/19	Active

N/A = Not applicable

APPENDIX C – LOCATION CODES

Table C.1 – Location Codes			
ANG	Angel Ranch	PL1	Polishing Lagoon 1(DP-831)
ART	Artesia	PL2	Polishing Lagoon 2 (DP-831)
BHT	Bottom of the Hill Tank	RED	Red Tank
BLK	Blank	SEC	Southeast Control
BRA	Brantley Lake	SL1	Settling Lagoon 1 (DP-831)
CBD	Carlsbad	SL2	Settling Lagoon 2 (DP-831)
COW	Coyote Well (deionized water blank)	SLT	Salt Hoist
COY	Coyote (surface water duplicate)	SMR	Smith Ranch
ELA	Evaporation Lagoon A (DP-831)	SOO	Sample of Opportunity*
ELB	Evaporation Lagoon B (DP-831)	SSP1	Salt Storage Pond 1(DP-831)
ELC	Evaporation Lagoon C (DP-831)	SSP2	Salt Storage Pond 2 (DP-831)
EUN	Eunice	SSP3	Salt Storage Pond 3 (DP-831)
FWT	Fresh Water Tank	STB	Southeast of Training Building
GSB	Guard and Security Building	SWL	Sewage Lagoon
HBS	Hobbs	SWP 1	Storm Water Pond 1 (DP-831)
HIL	Hill Tank	SWP 2	Storm Water Pond 2 (DP-831)
H2P	H-2 Well Pad	SWP 3	Storm Water Pond 3 (DP-831)
H19	Evaporation Pond H-19 (DP-831)	TUT	Tut Tank
IDN	Indian Tank	UPR	Upper Pecos River
LST	Lost Tank	WA1	WIPP Air Blank 1
LVG	Loving	WA2	WIPP Air Blank 2
LWE	Land Withdrawal East	WA3	WIPP Air Blank 3
MET	Meteorology Tower Building	WA4	WIPP Air Blank 4
MLR	Mills Ranch	WA5	WIPP Air Blank 5
MS5	Mosaic Shaft 5	WEE	WIPP East
NOY	Noya Tank	WFF	WIPP Far Field
PCN	Pierce Canyon	WIP	WIPP 16 Sections
PEC	Pecos River	WNN	WIPP North
PKT	Poker Trap	WSS	WIPP South
PMR	Potash Mines Road		

* A sample of opportunity is taken at a location that may present itself aside from any other named location.

APPENDIX D – RADIOCHEMICAL EQUATIONS

DETECTION

Radionuclides with the exception of the gamma spectroscopy targets (^{137}Cs, ^{60}Co, and ^{40}K) are considered to be detected in environmental samples if the radionuclide concentration or concentration [RN] is greater than the minimum detectable concentration (MDC) and greater than the total propagated uncertainty (TPU) at the 2 σ level. The gamma radionuclides are considered detected in environmental samples when the above criteria are met and the gamma spectroscopy software used to identify the peak generates an associated identification confidence (ID confidence) of 90 percent or greater (ID confidence ≥0.90). If the ID confidence is less than 0.90, the radionuclide is not considered detected even if the sample activity is greater than the 2 σ TPU and the MDC.

MINIMUM DETECTABLE CONCENTRATION

The MDC is the smallest amount (activity or mass) of a radionuclide in an environmental sample that will be detected with a five percent probability of non-detection while accepting a five percent probability of erroneously deciding that a positive quantity of a radionuclide is present in an appropriate blank sample. This method ensures that any claimed MDC has at least a 95 percent chance of being detected. It is possible to achieve a very low level of detection by analyzing a large sample size and counting for a very long time.

The Waste Isolation Pilot Plant (WIPP) Laboratories use the following equation for calculating the MDCs for each radionuclide in various sample matrices:

$$MDC = \frac{4.66\sqrt{S}}{K\,T} + \frac{3.00}{K\,T}$$

Where:

- S = net method blank counts. When the method blank counts = 0, the average of the last 30 blanks analyzed are substituted
- K = a correction factor that includes items such as unit conversions, sample volume/weight, decay correction, detector efficiency, chemical recovery, abundance correction, etc.
- T = counting time where the background and sample counting time are identical

For further evaluation of the MDC, refer to American National Standards Institute (ANSI) N13.30, *Performance Criteria for Radiobioassay*.

TOTAL PROPAGATED UNCERTAINTY

The TPU is an estimate of the uncertainty in the measurement due to all sources, including counting error, measurement error, chemical recovery error, detector efficiency, randomness of radioactive decay, and any other sources of uncertainty.

The TPU for each data point must be reported at the 2 sigma level (2 σ TPU). For further discussion of TPU, refer to ANSI N13.30.

RELATIVE ERROR RATIO

The relative error ratio (RER) is a method, similar to a t-test, with which to compare duplicate sample analysis results (see Chapters 4 and 7, and WP 02-EM3004, *Radiological Data Verification and Validation*).

$$\mathrm{RER} = \frac{(MeanActivity)^{pri} - (MeanActivity)^{dup}}{\sqrt{(1\sigma TPU)^{2pri} + (1\sigma TPU)^{2dup}}}$$

Where:

(Mean Activity)^{pri} = mean activity of the primary sample

(Mean Activity)^{dup} = mean activity of the duplicate sample

1σTPU = total propagated uncertainty at the 1 σ level

PERCENT BIAS

The percent bias is a measure of the accuracy of radiochemical separation methods and counting instruments, that is, a measure of how reliable the results of analyses are when compared to the actual values.

$$\%\ BIAS = \frac{(A_m - A_k)}{A_k} \times 100$$

Where:

% BIAS = percent bias

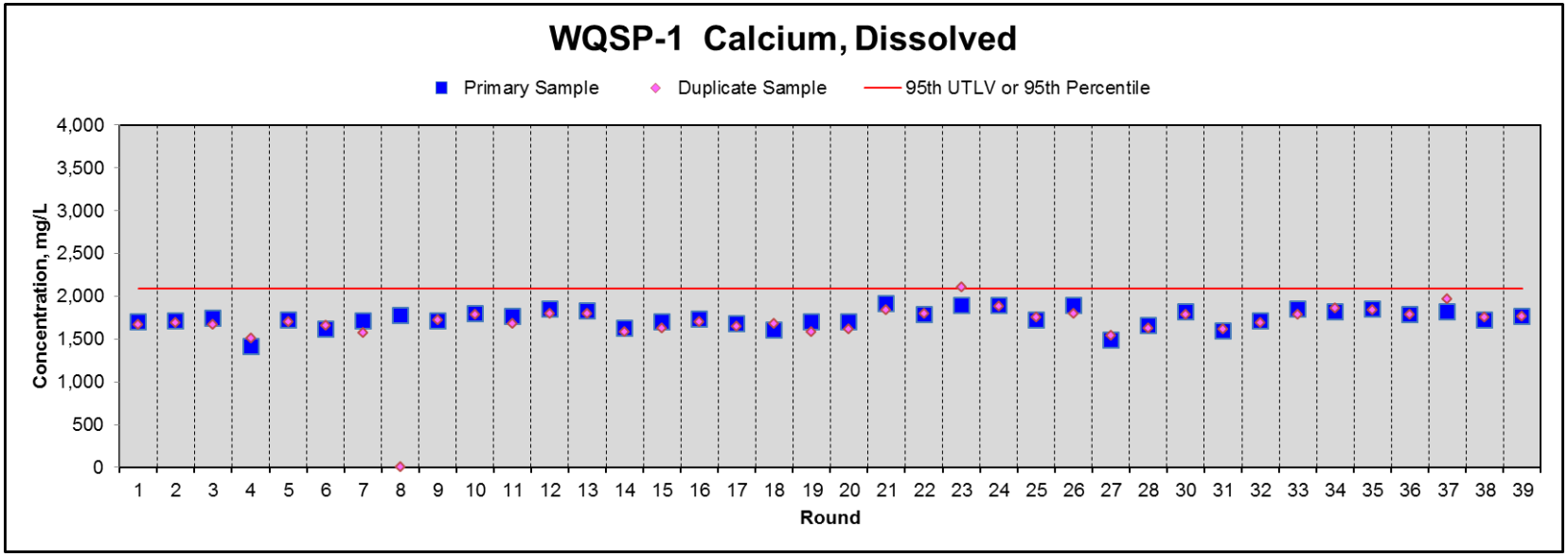
Am = measured sample activity

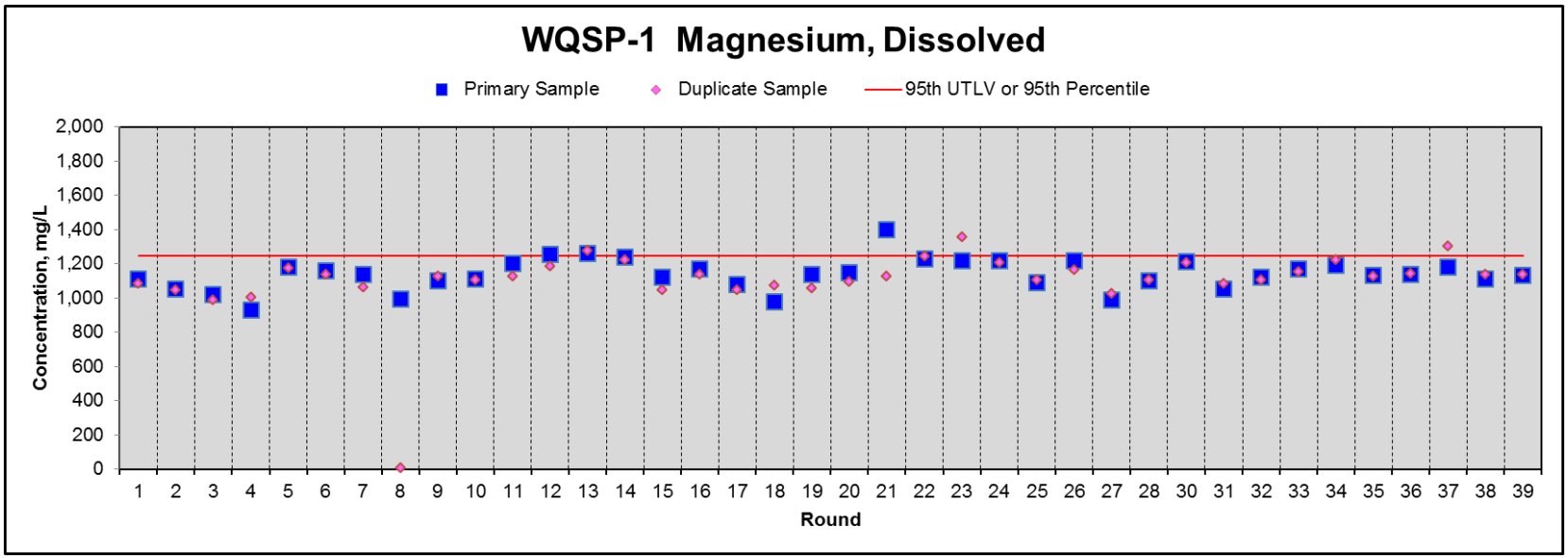
Ak = known sample activity

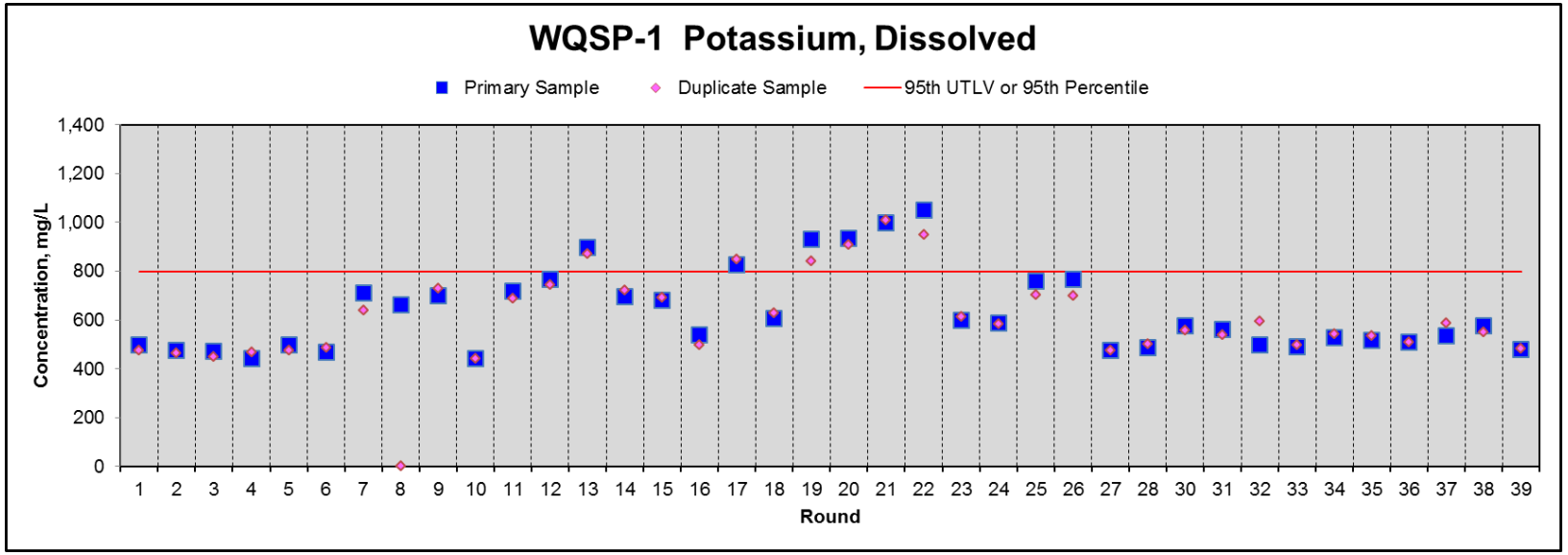
APPENDIX E – TIME TREND PLOTS FOR MAIN PARAMETERS IN GROUNDWATER

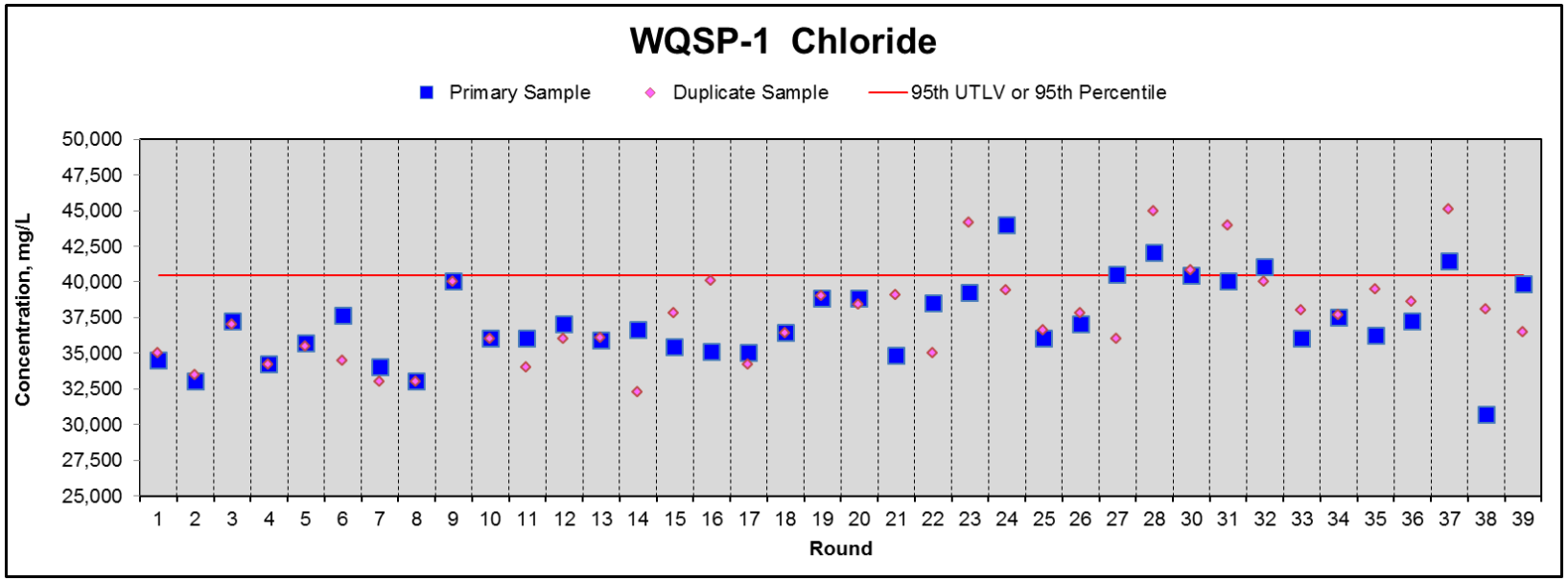
The first 10 sampling rounds were conducted from 1995 through 2000 (prior to receiving mixed waste at the Waste Isolation Pilot Plant [WIPP]) and were used to establish the original baseline for groundwater chemistry at each sampling location. The baseline sample sets are used to determine whether statistically significant changes have occurred at any well. Time trend plots are provided below for the following general chemistry indicator parameters: dissolved calcium, chloride, dissolved magnesium, pH, dissolved potassium, sulfate, and total dissolved solids. These plots show the concentrations in the primary sample and the duplicate sample for all sampling rounds.

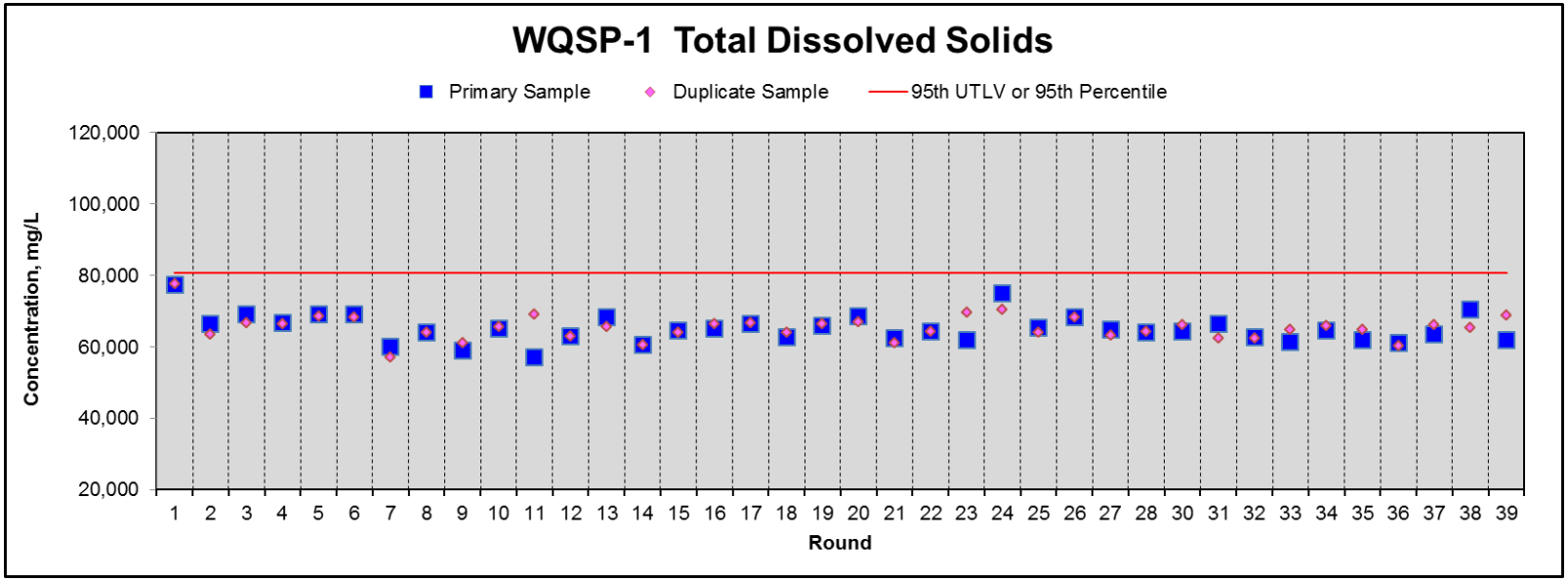
The 2017 laboratory analytical results were verified and validated in accordance with WIPP procedures and U.S. Environmental Protection Agency technical guidance. Sampling Round 39 samples were taken March through May 2017. See Appendix F for the concentrations of the target analytes in the Detection Monitoring Program wells.

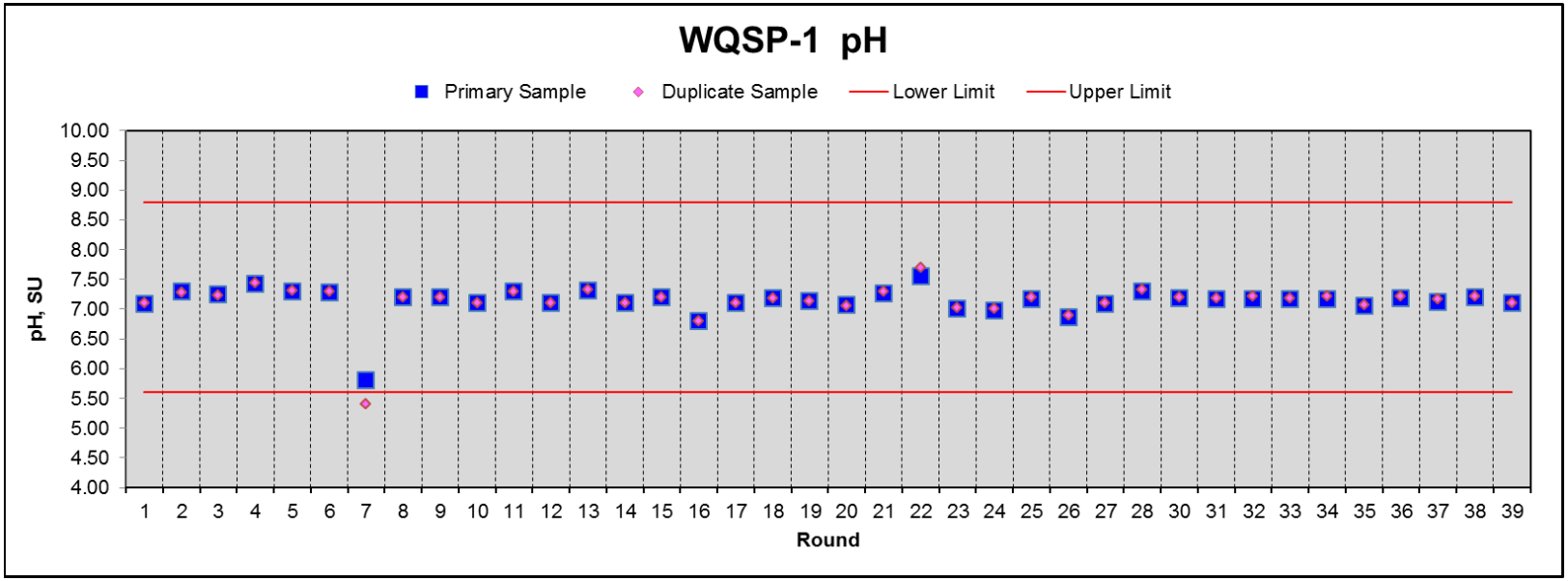

WQSP-1 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 30 31 32 33 34 35 36 37 38 39
Round

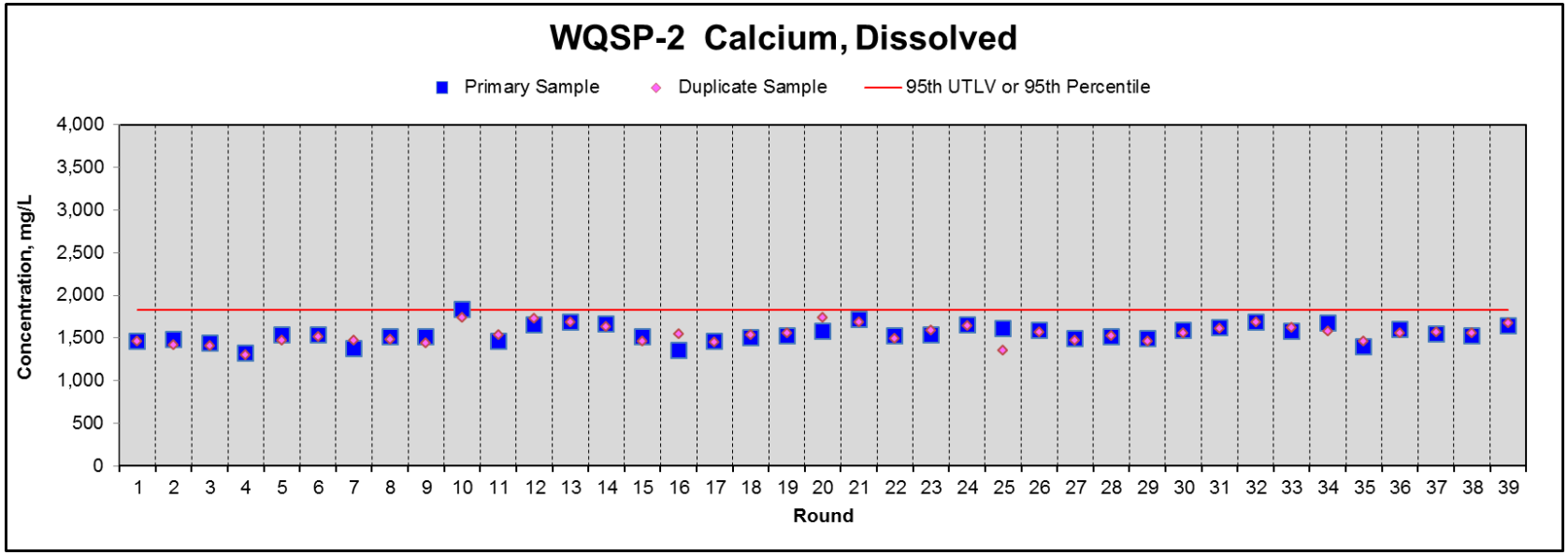

WQSP-1 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 30 31 32 33 34 35 36 37 38 39
Round

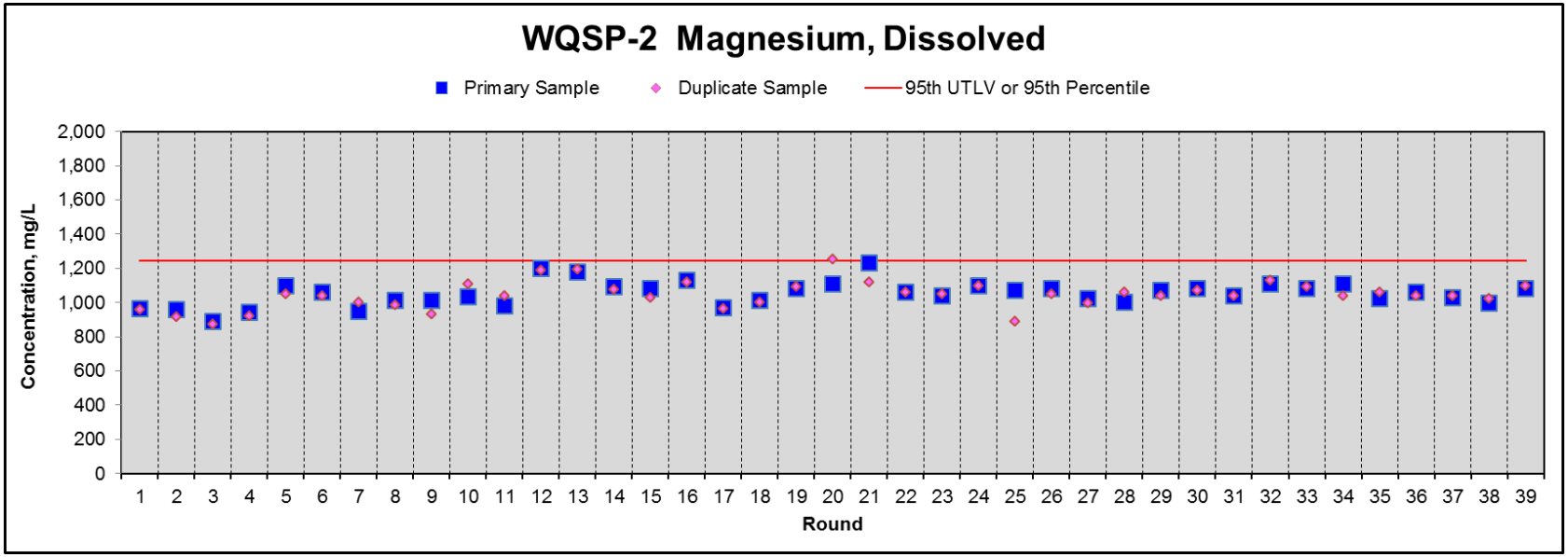

WQSP-1 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
1,400
1,200
1,000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 30 31 32 33 34 35 36 37 38 39
Round

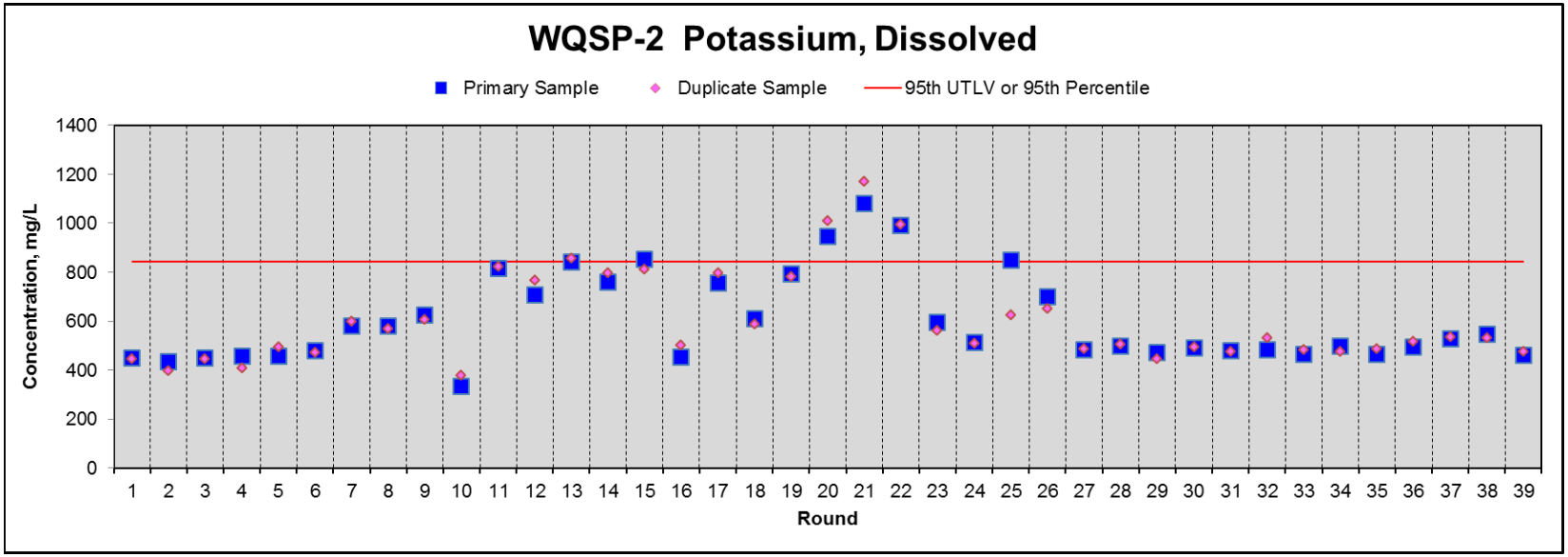

WQSP-1 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
50,000
47,500
45,000
42,500
40,000
37,500
35,000
32,500
30,000
27,500
25,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 30 31 32 33 34 35 36 37 38 39
Round

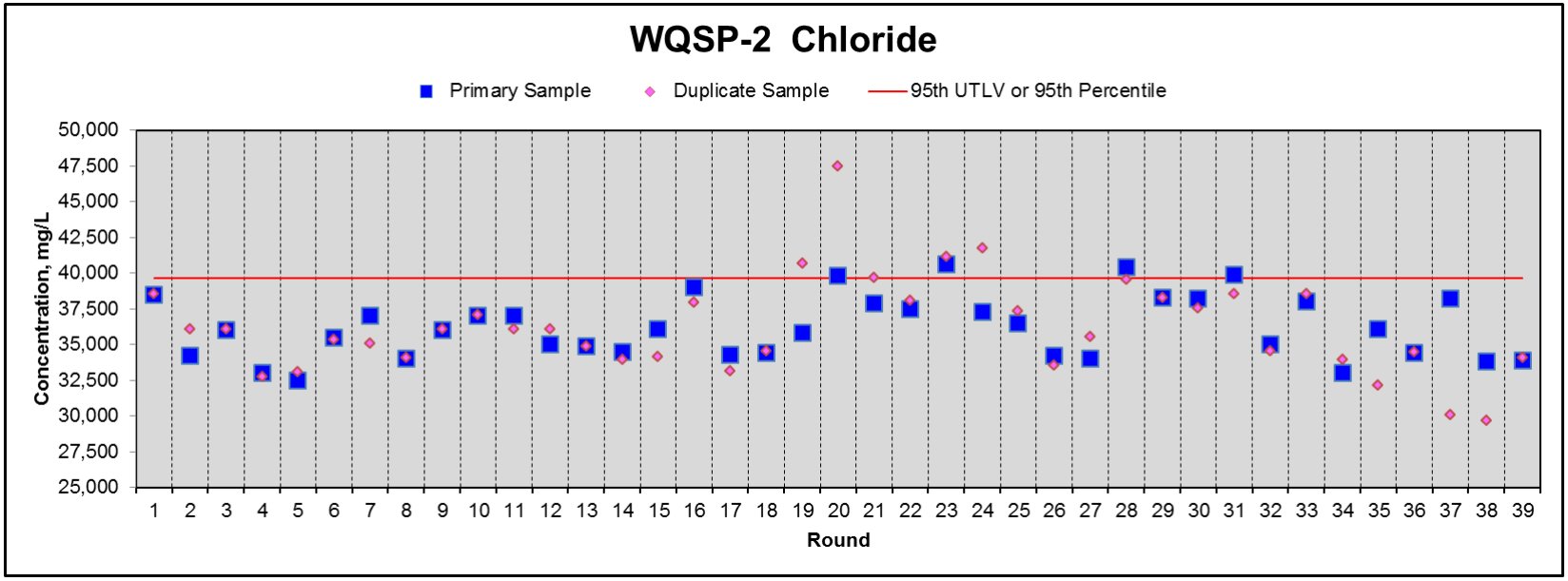

WQSP-1 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
120,000
100,000
80,000
60,000
40,000
20,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 30 31 32 33 34 35 36 37 38 39
Round

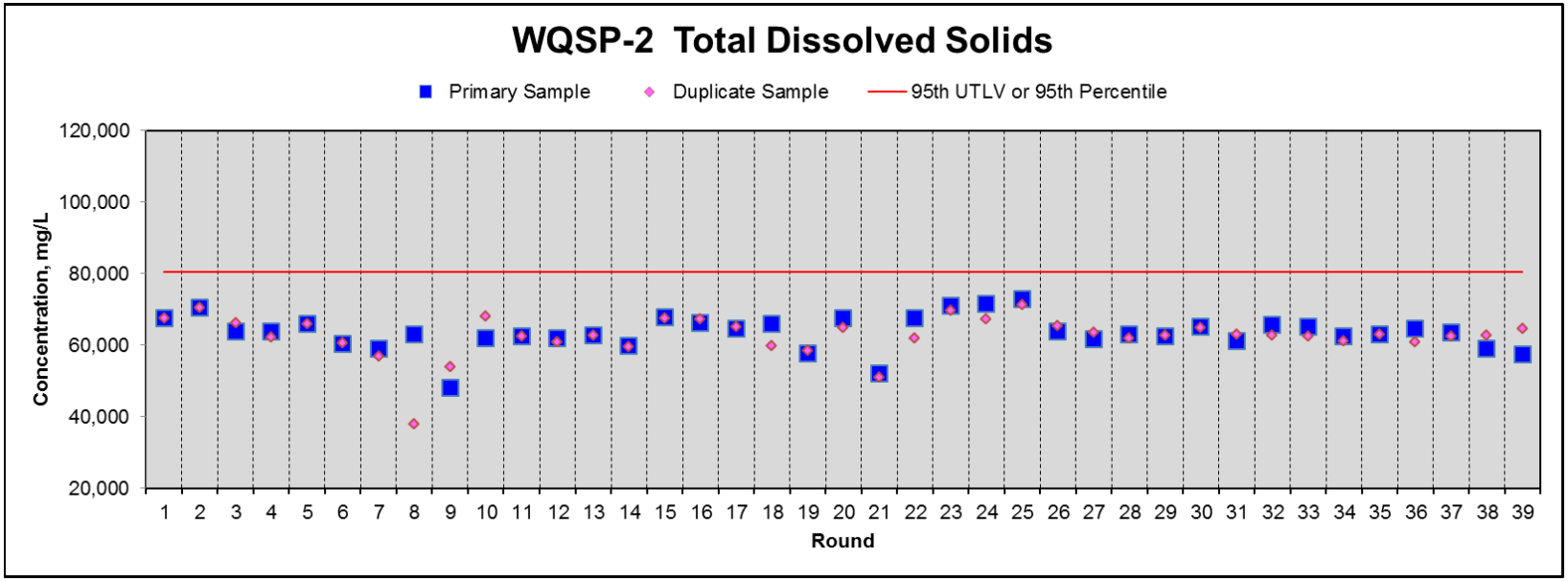

WQSP-1 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
10.00
9.50
9.00
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 30 31 32 33 34 35 36 37 38 39
Round

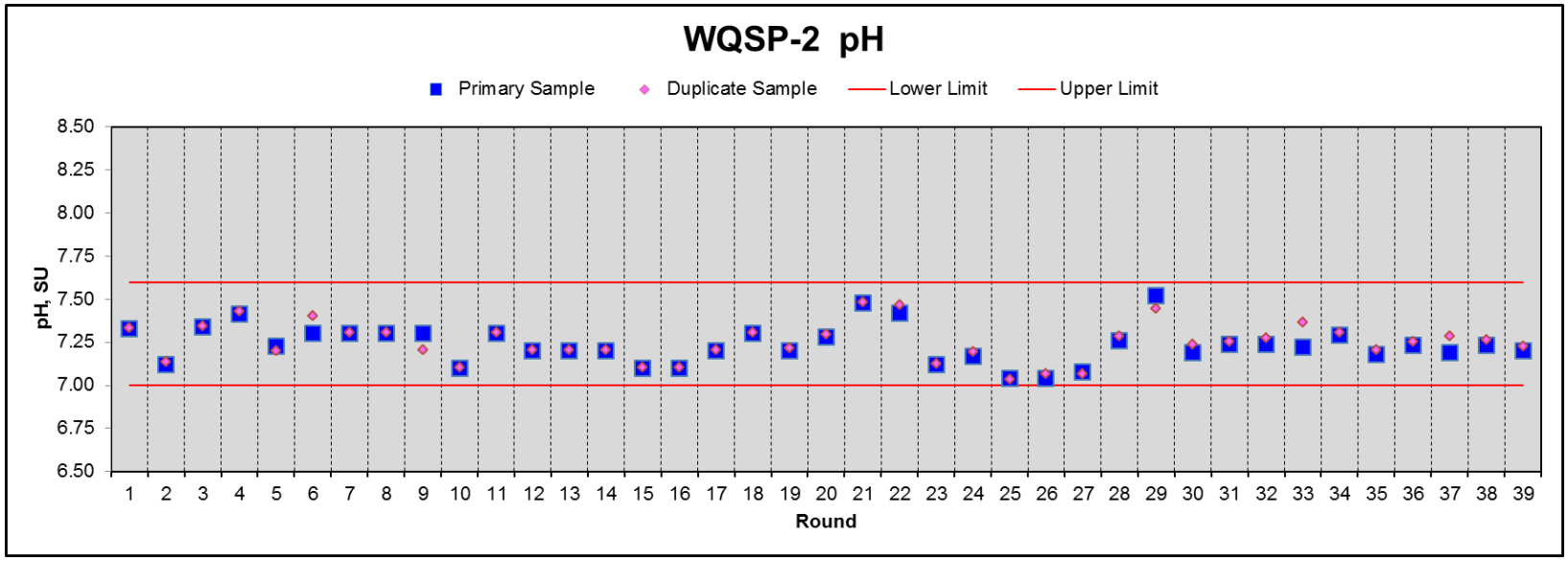

WQSP-2 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

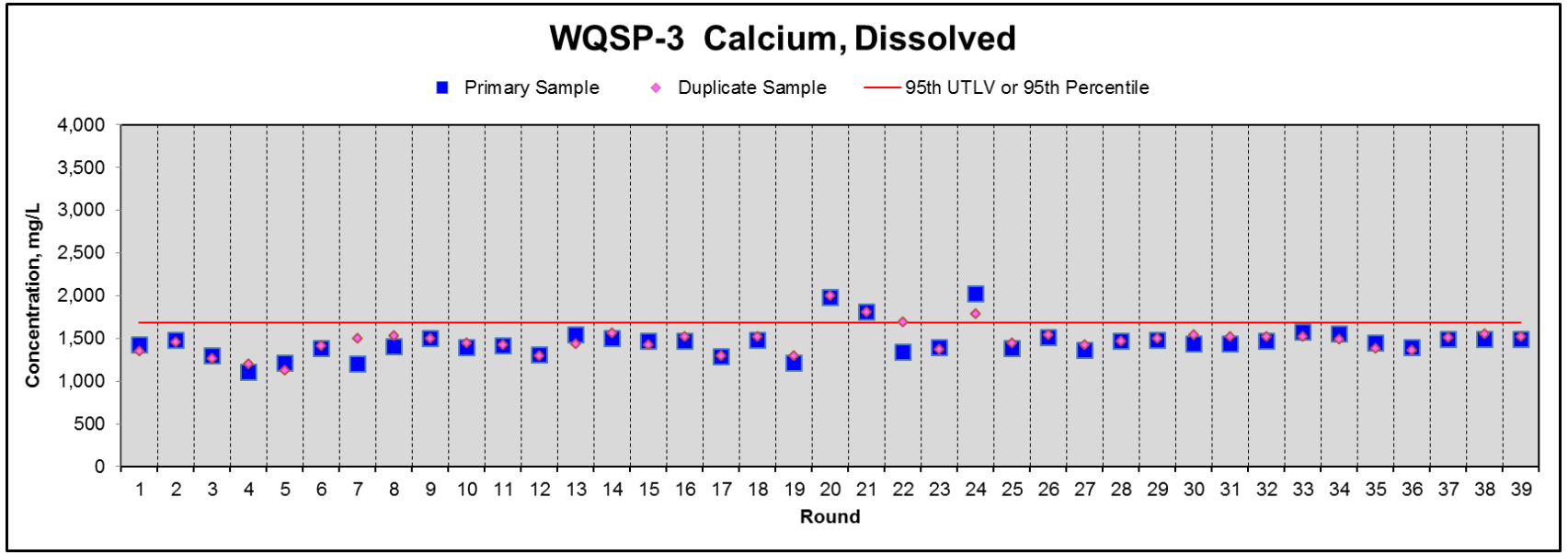

WQSP-2 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

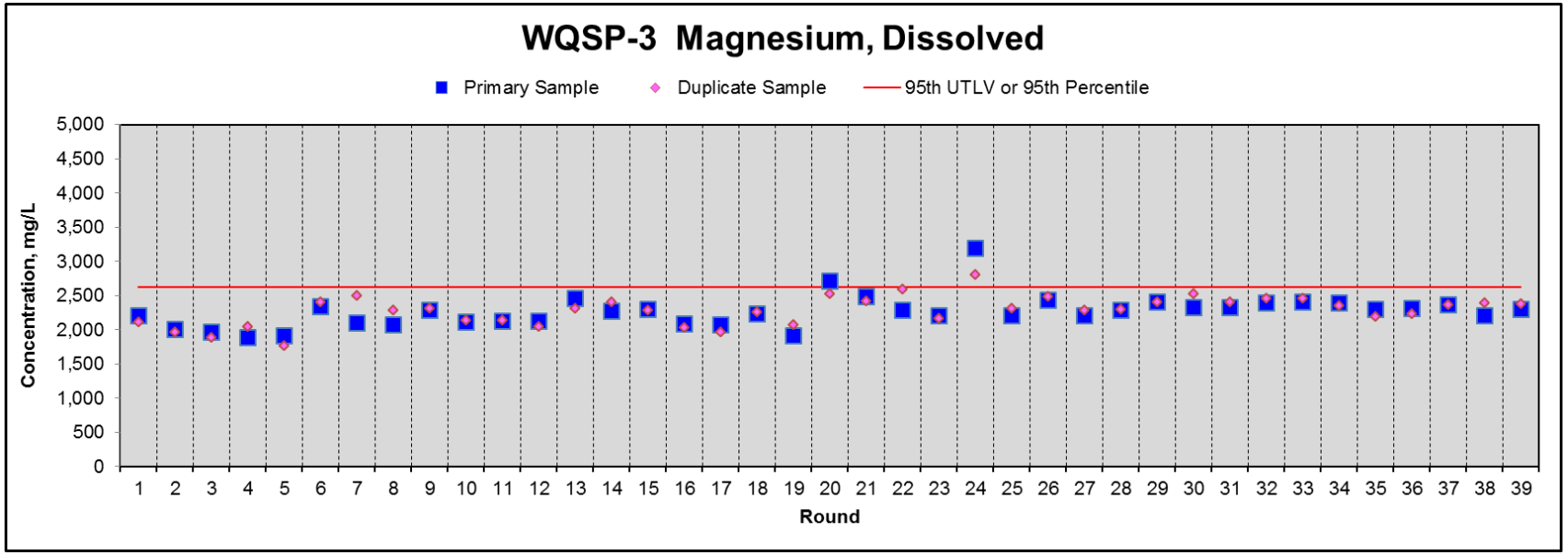

WQSP-2 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
0
200
400
600
800
1000
1200
1400
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

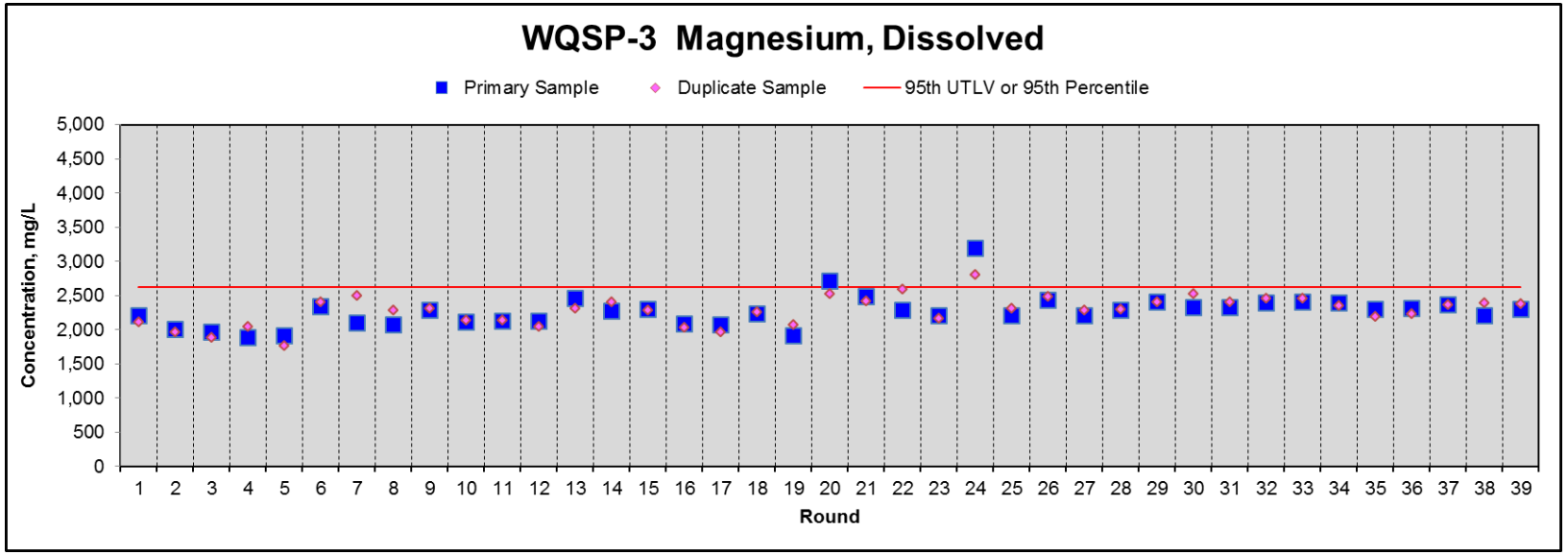

WQSP-2 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
25,000
27,500
30,000
32,500
35,000
37,500
40,000
42,500
45,000
47,500
50,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

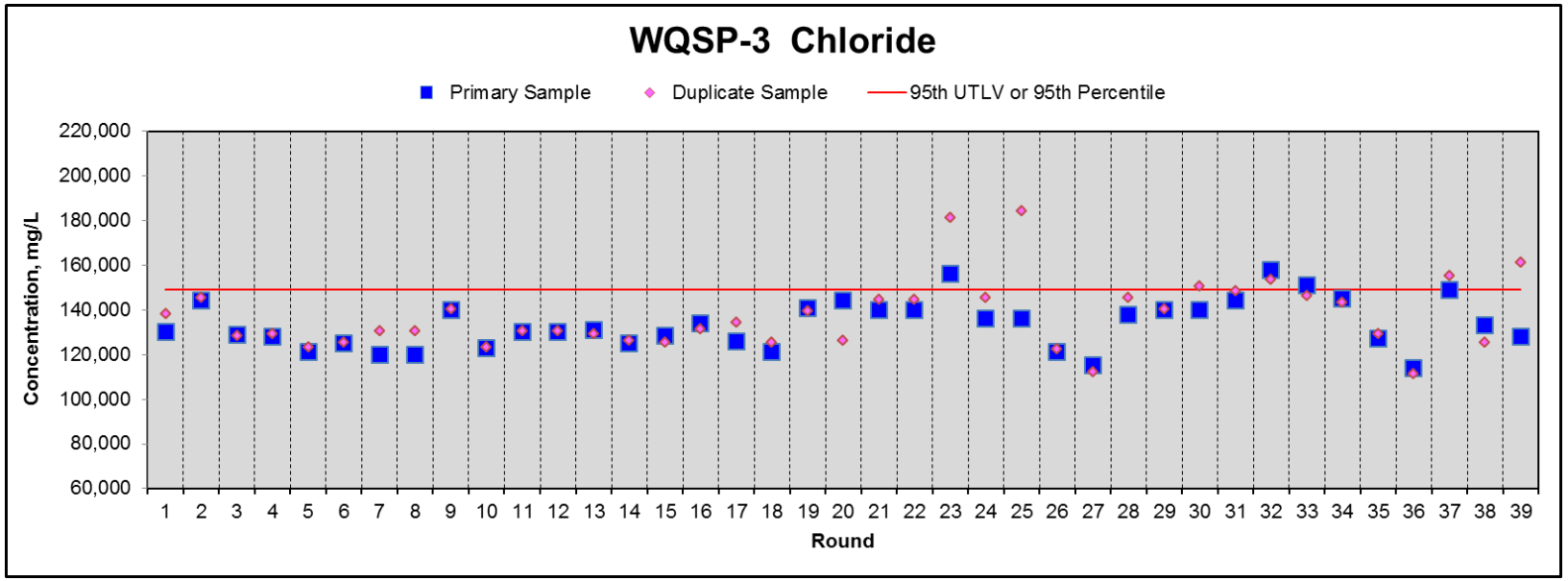

WQSP-2 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
120,000
100,000
80,000
60,000
40,000
20,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

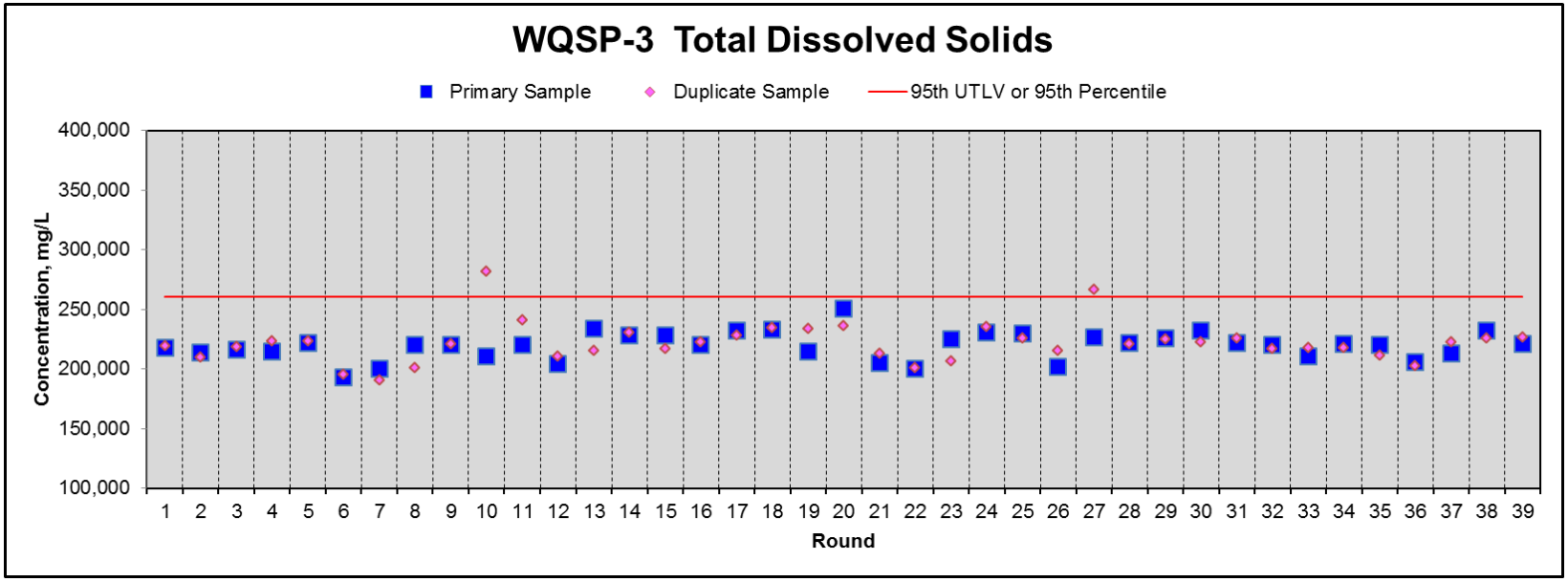

WQSP-2 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
8.50
8.25
8.00
7.75
7.50
7.25
7.00
6.75
6.50
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

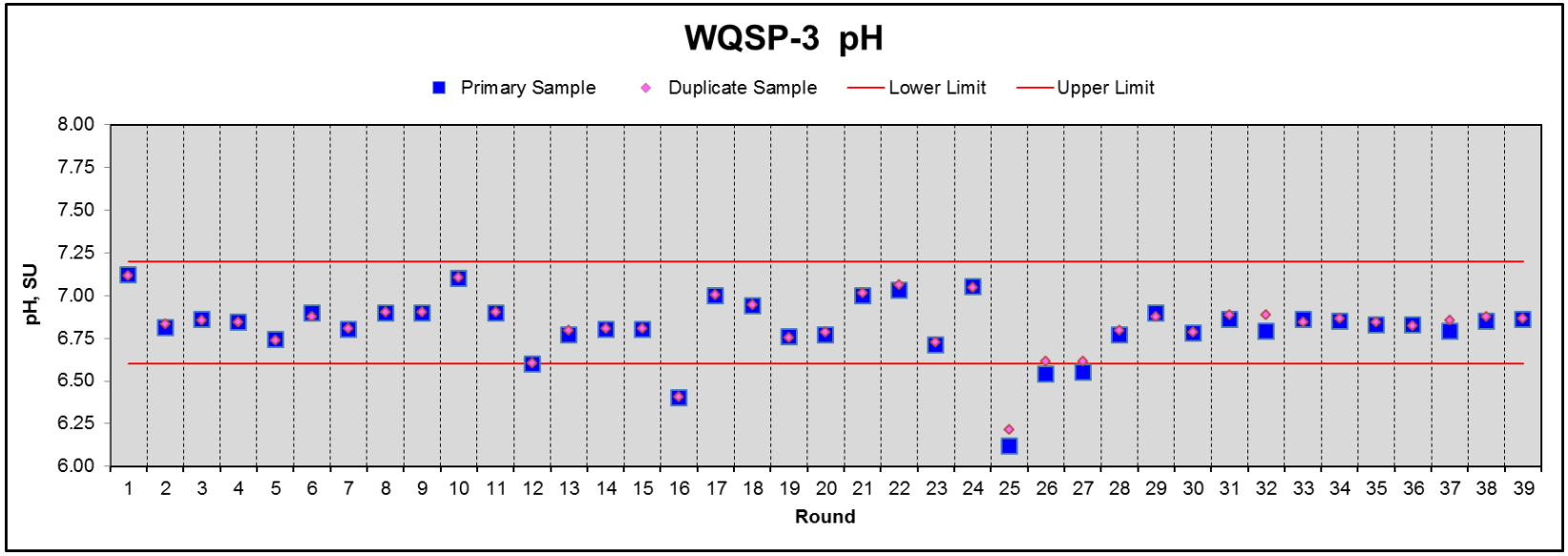

WQSP-3 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

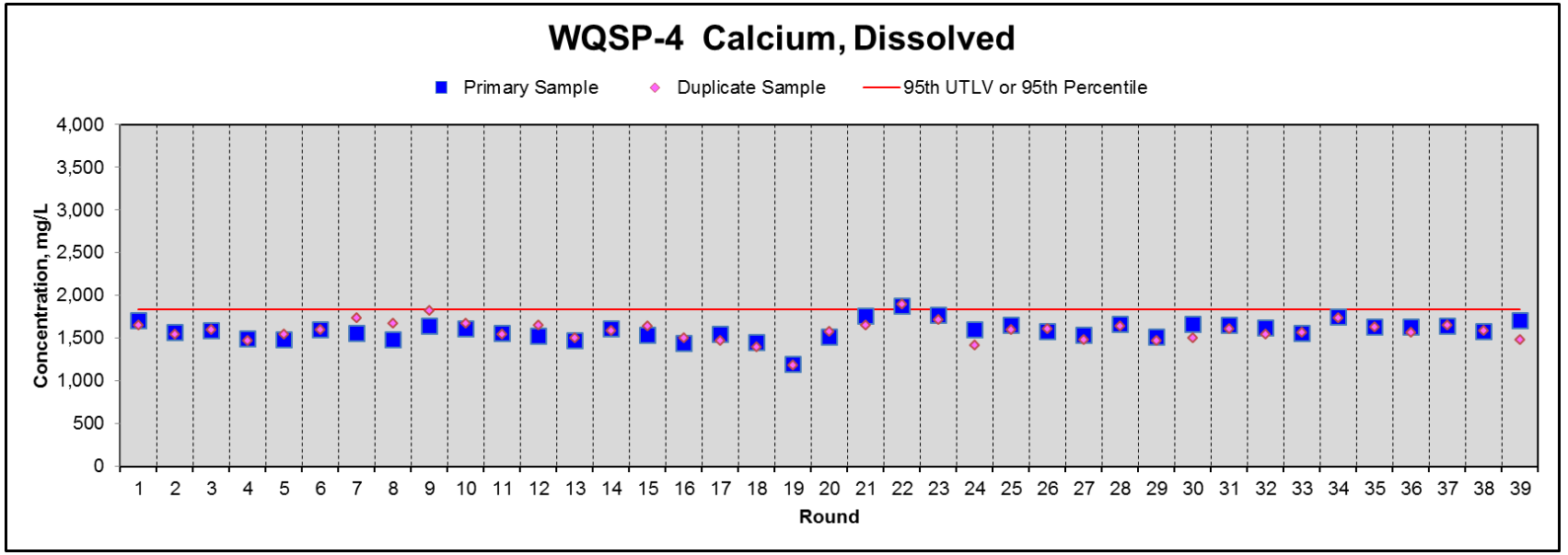

WQSP-3 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

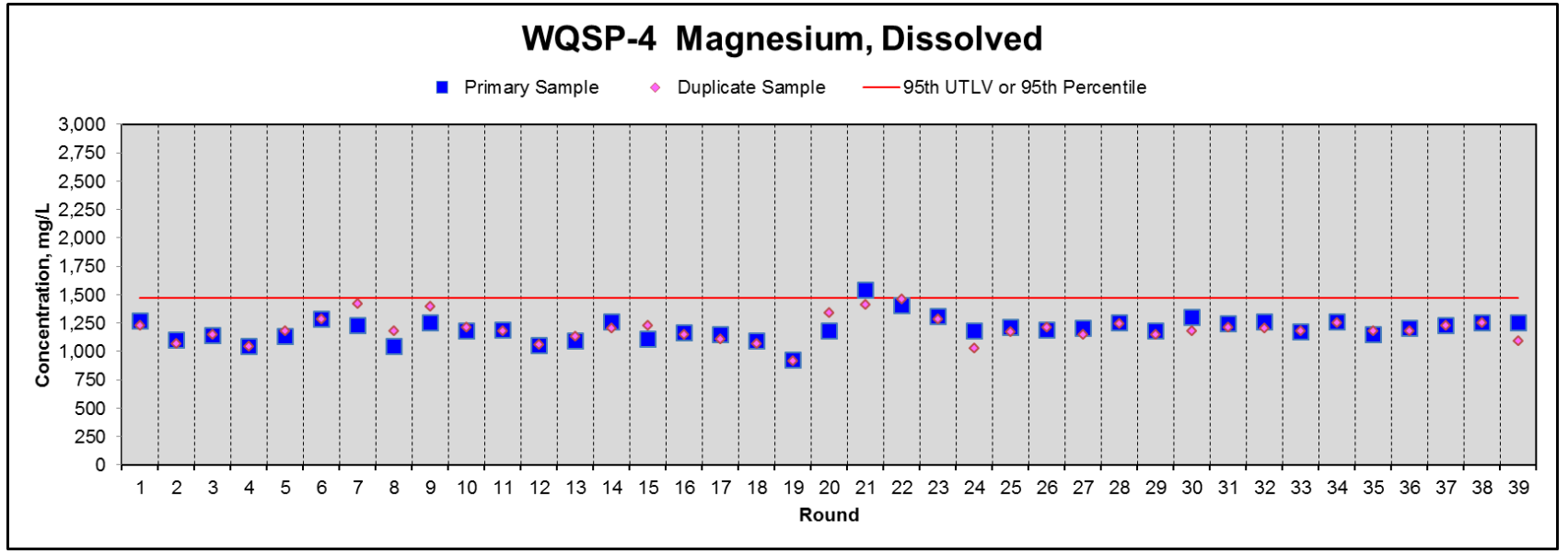

WQSP-3 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

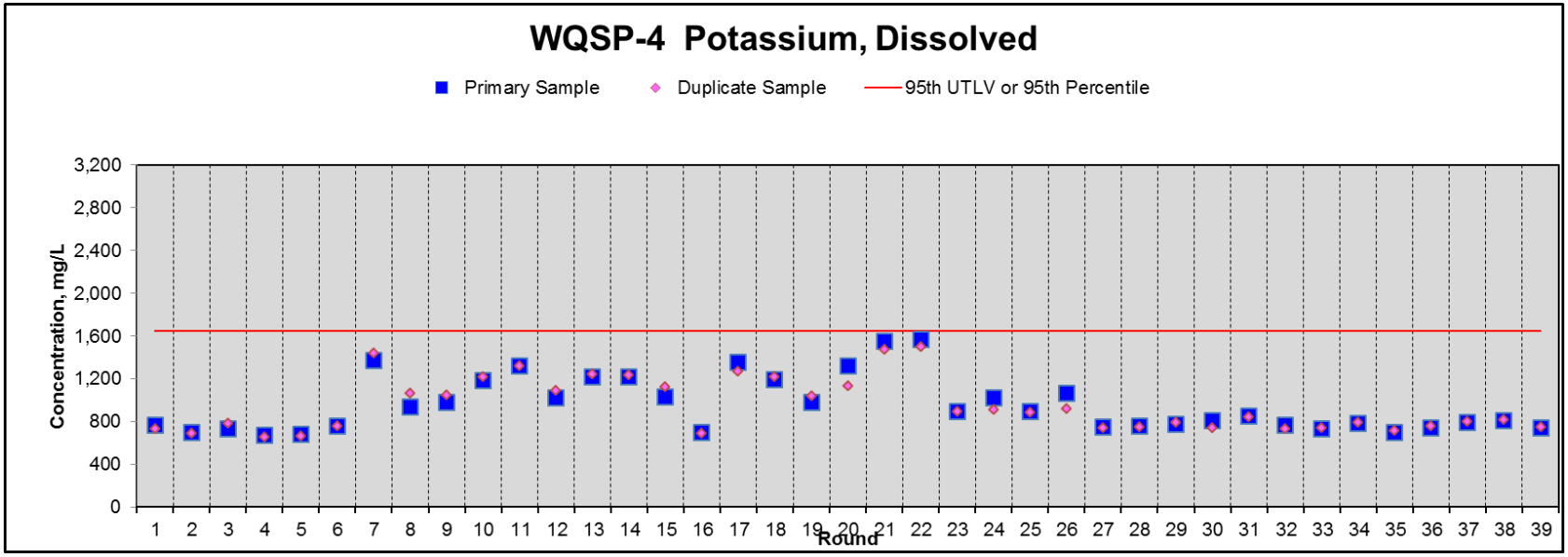

WQSP-3 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
220,000
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

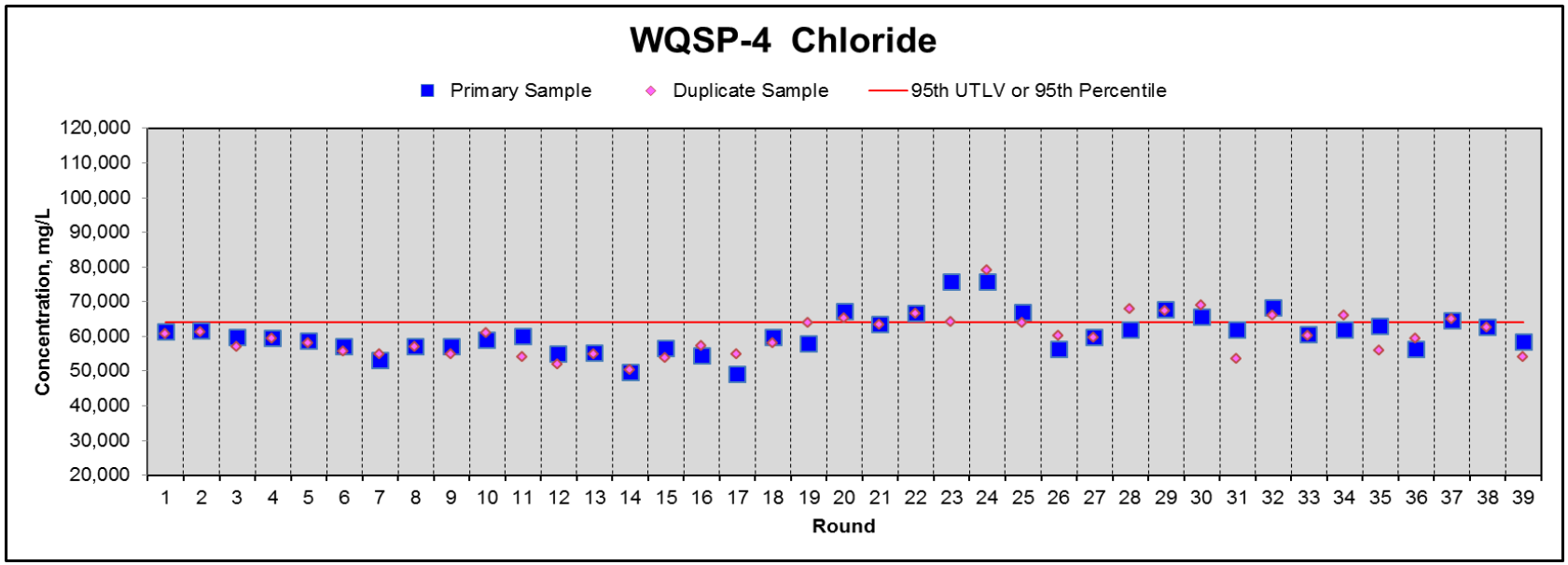

WQSP-3 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
400,000
350,000
300,000
250,000
200,000
150,000
100,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

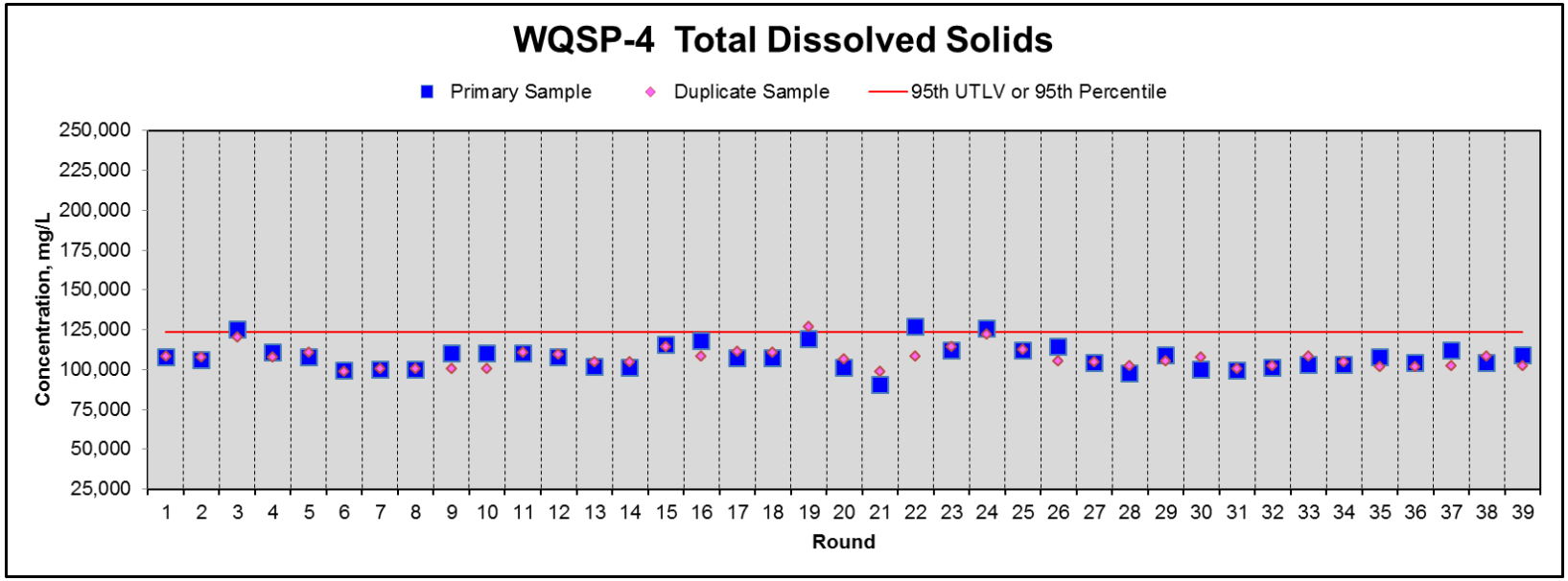

WQSP-3 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
8.00
7.75
7.50
7.25
7.00
6.75
6.50
6.25
6.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

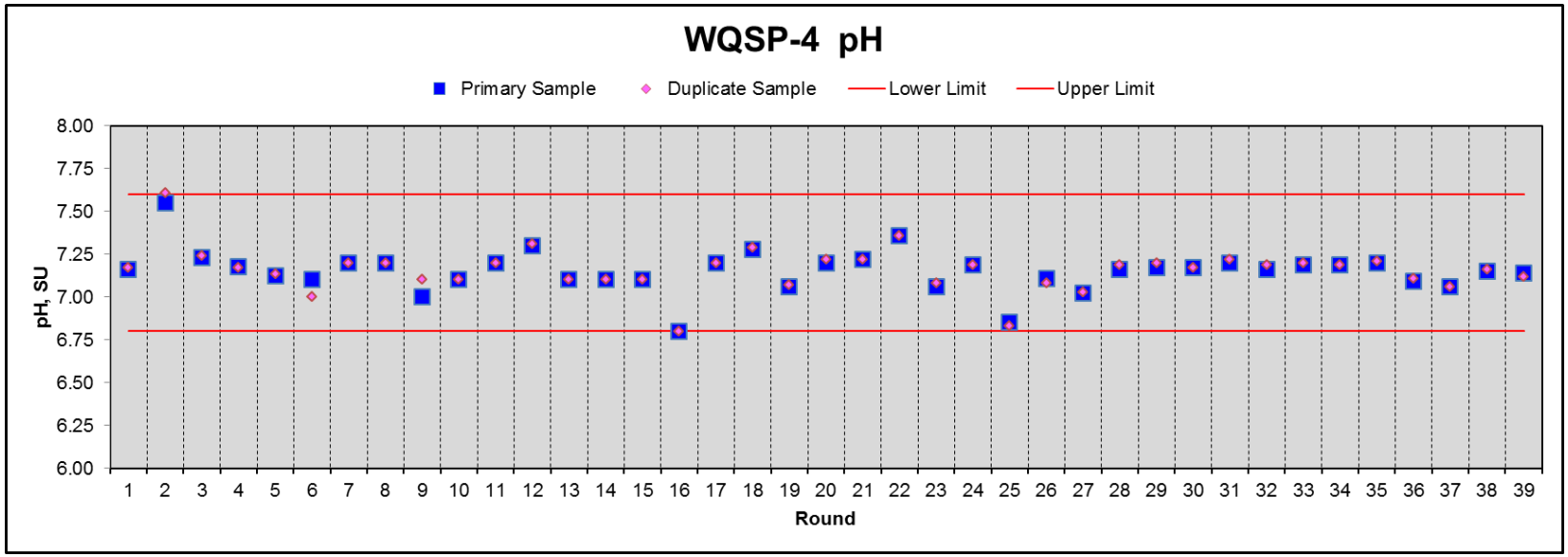

WQSP-4 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

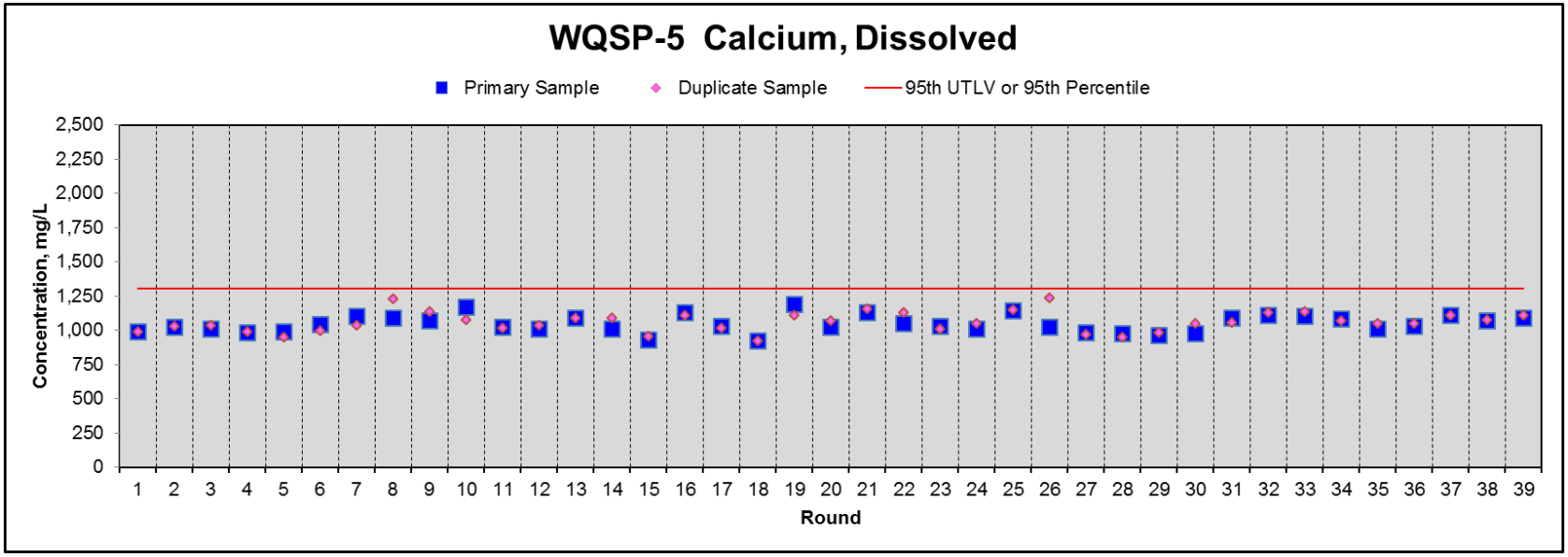

WQSP-4 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
3,000
2,750
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

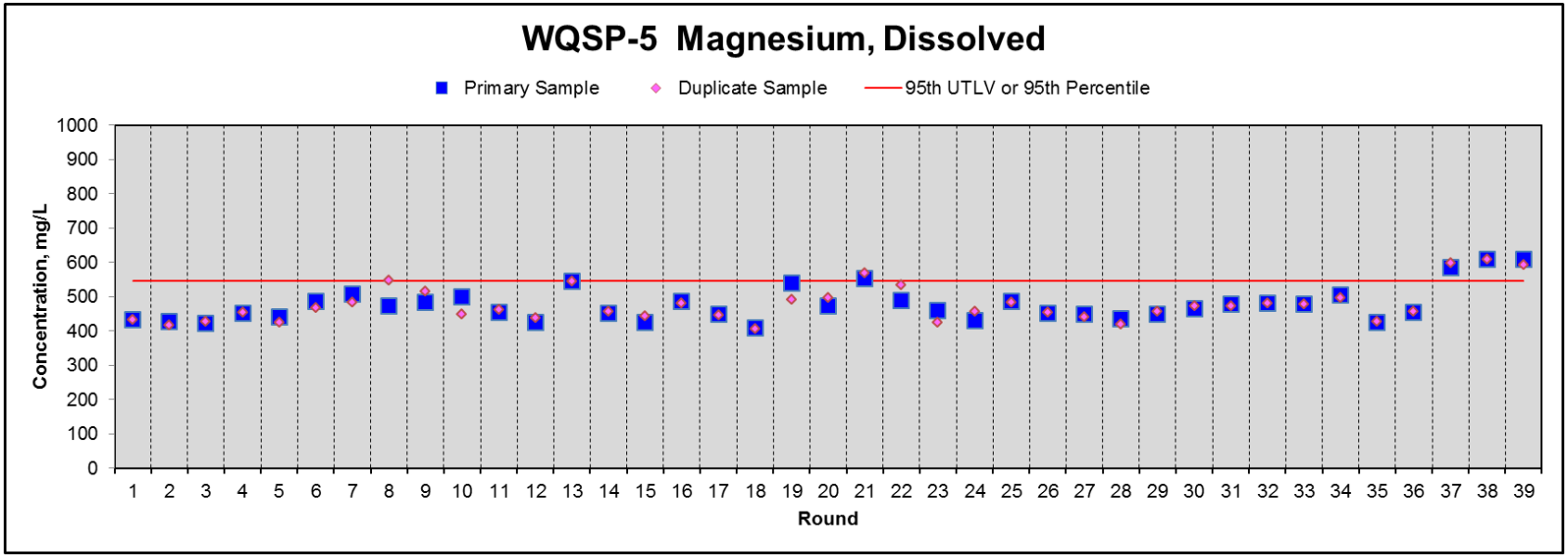

WQSP-4 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
3,200
2,800
2,400
2,000
1,600
1,200
800
400
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

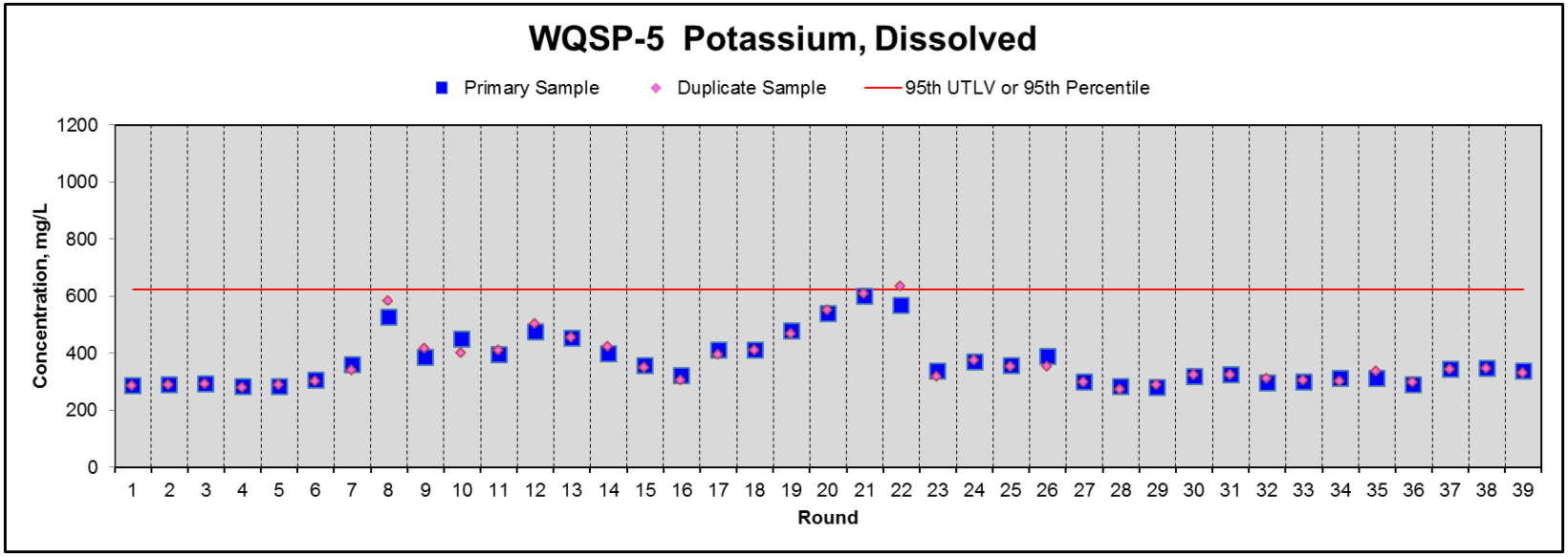

WQSP-4 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

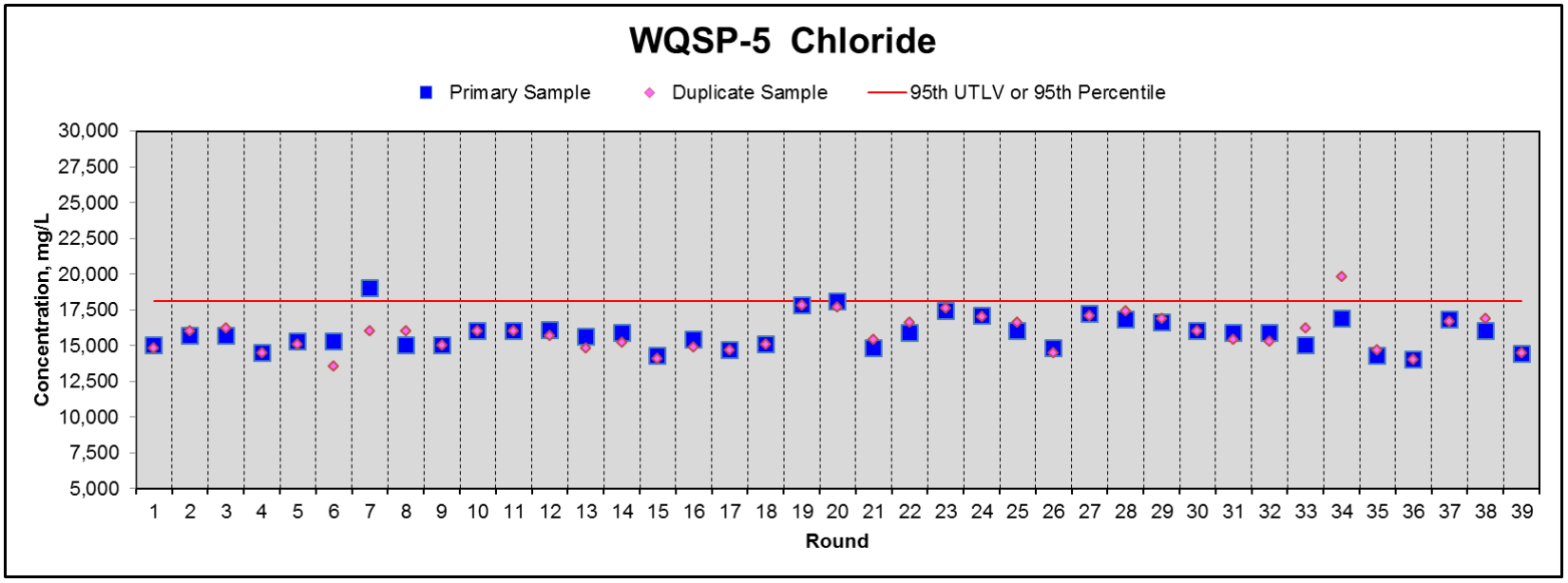

WQSP-4 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
250,000
225,000
200,000
175,000
150,000
125,000
100,000
75,000
50,000
25,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

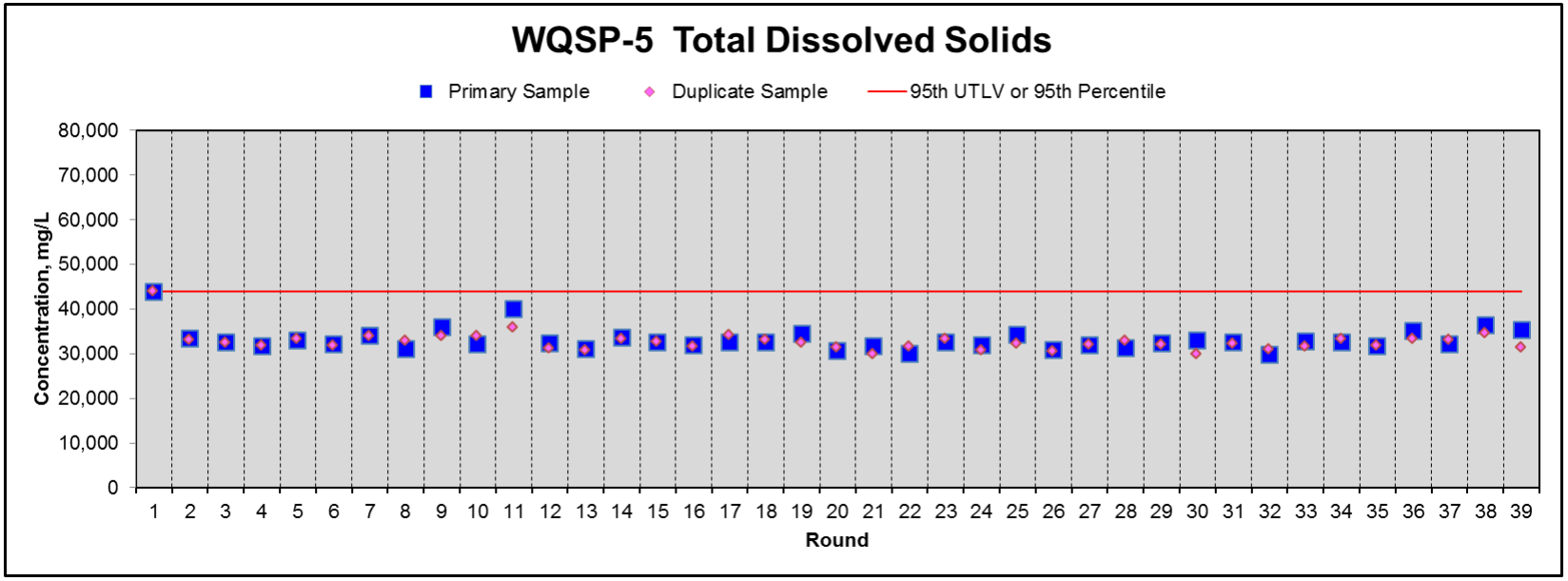

WQSP-4 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
8.00
7.75
7.50
7.25
7.00
6.75
6.50
6.25
6.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

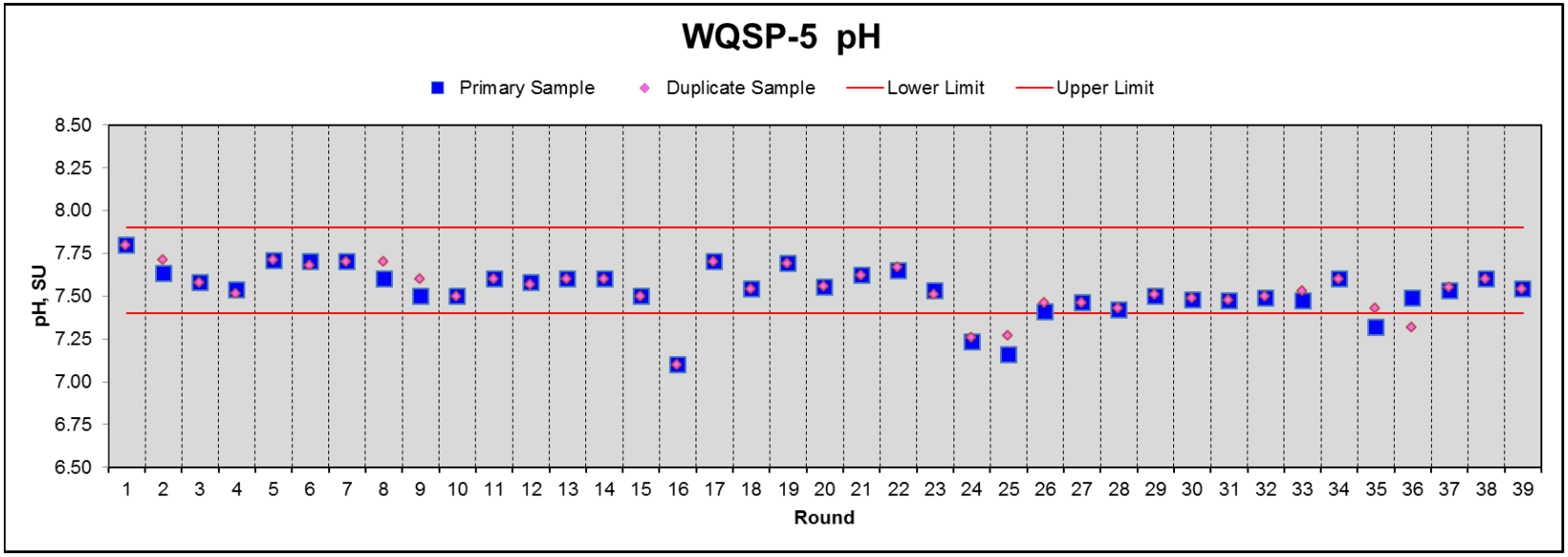

WQSP-5 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

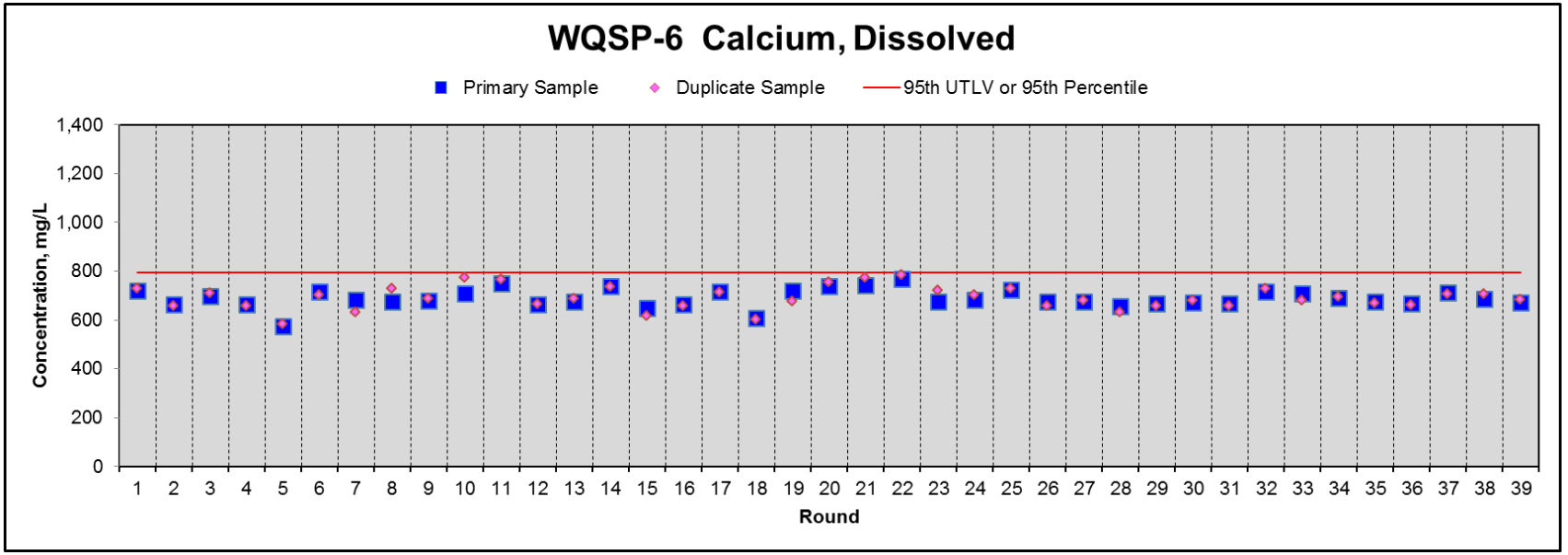

WQSP-5 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
1000
900
800
700
600
500
400
300
200
100
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

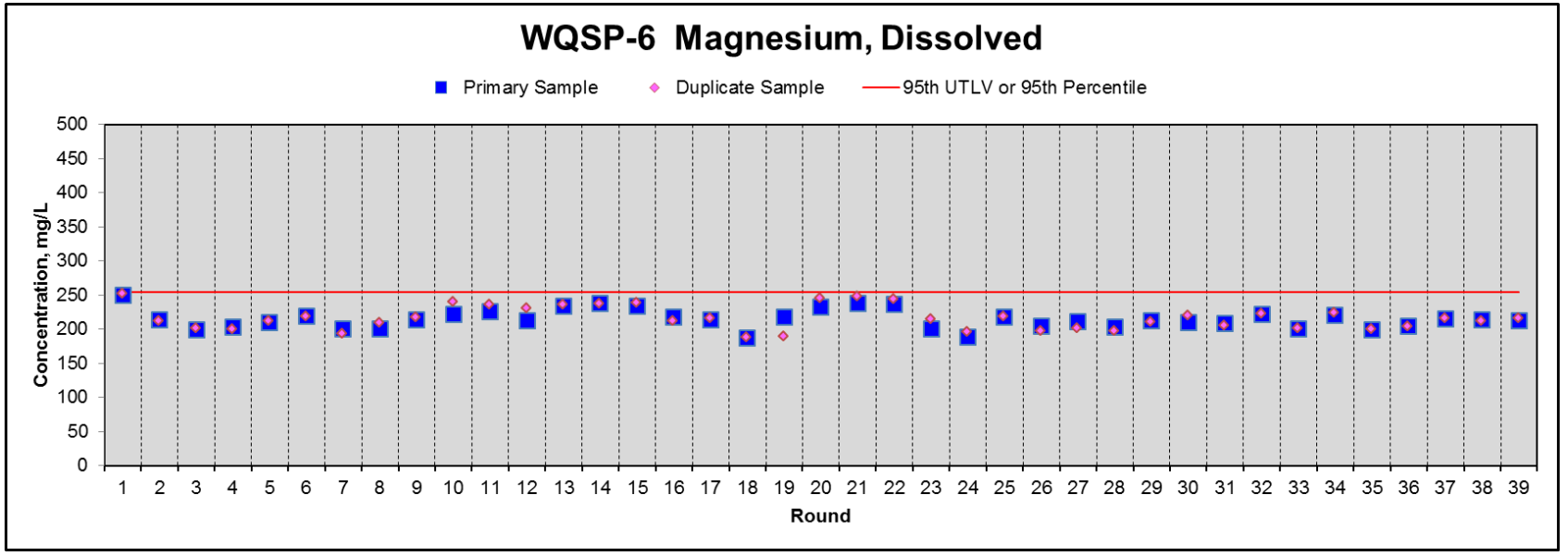

WQSP-5 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
0
200
400
600
800
1000
1200
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

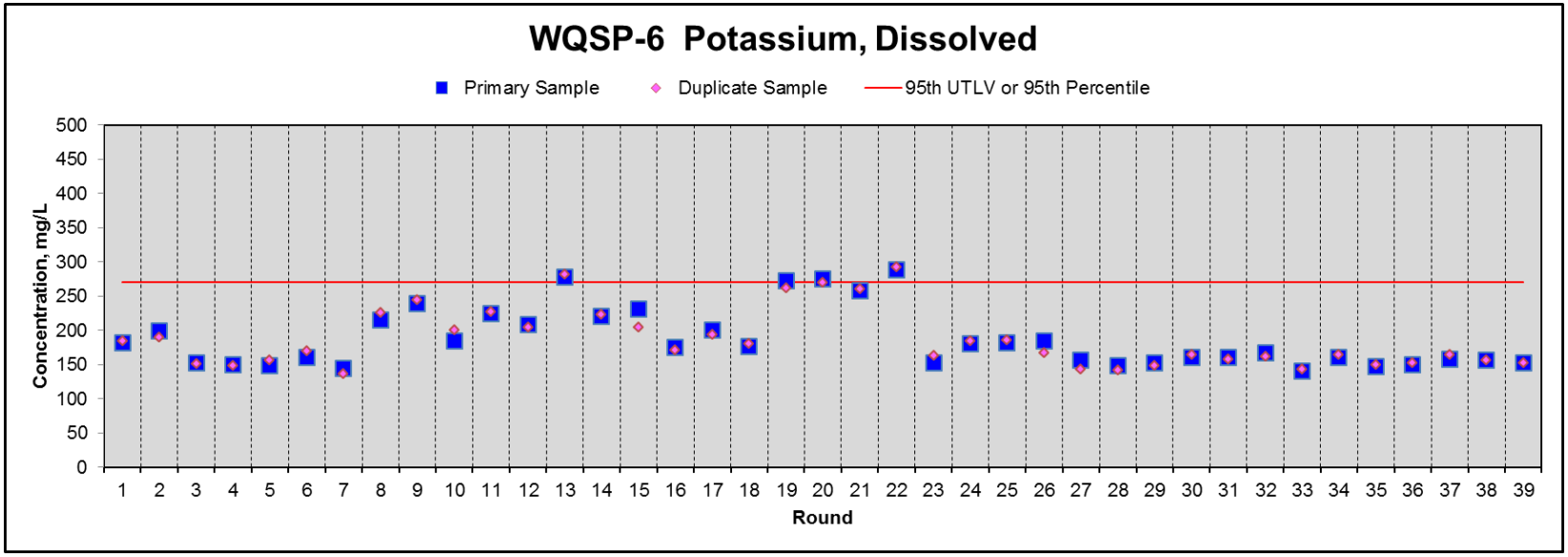

WQSP-5 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
5,000
7,500
10,000
12,500
15,000
17,500
20,000
22,500
25,000
27,500
30,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

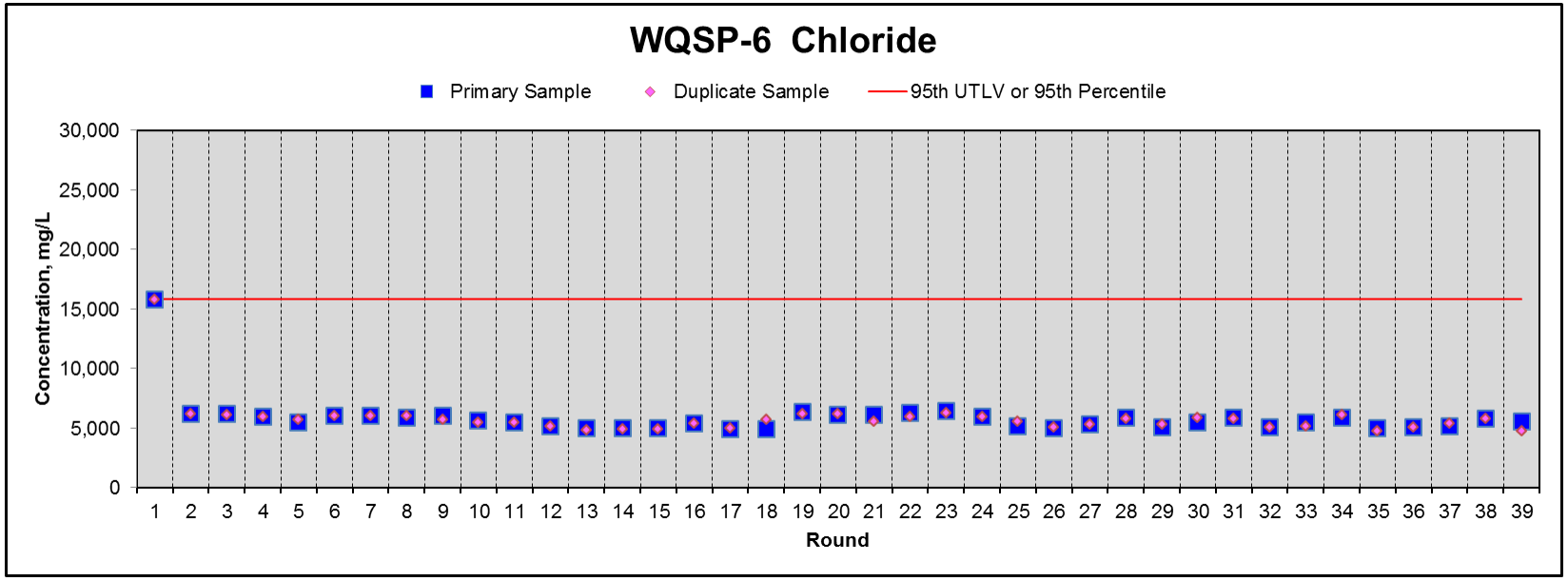

WQSP-5 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

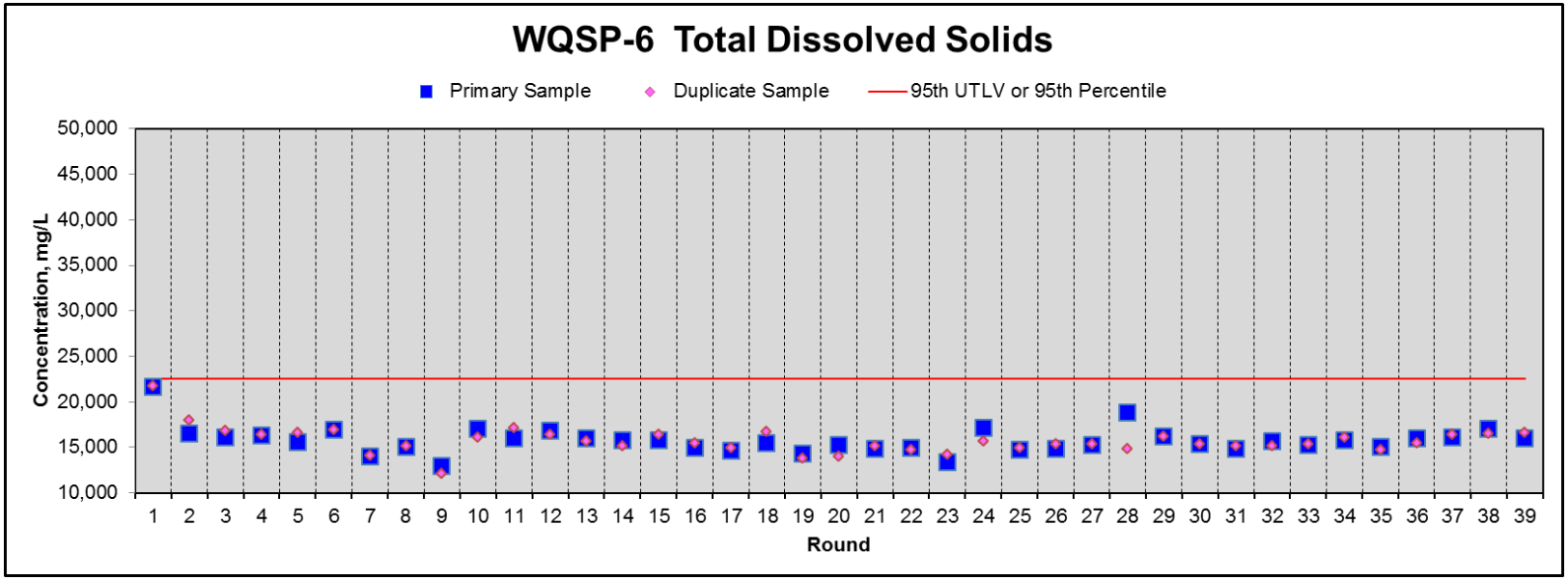

WQSP-5 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
8.50
8.25
8.00
7.75
7.50
7.25
7.00
6.75
6.50
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

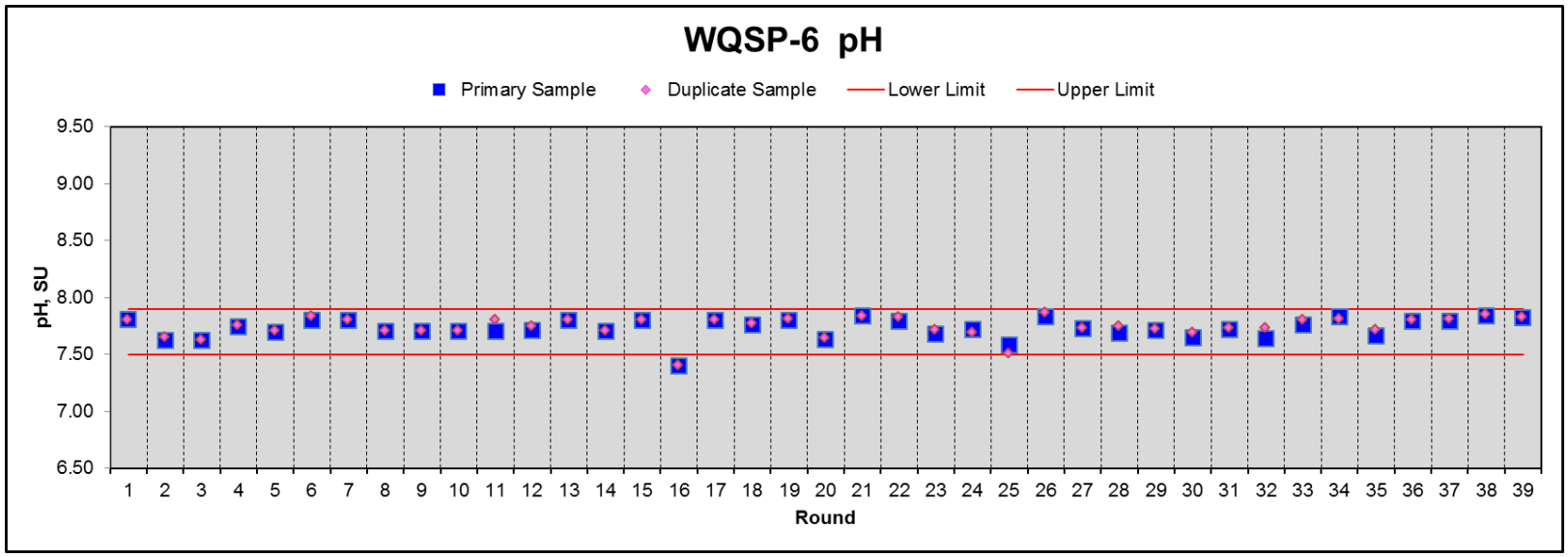

WQSP-6 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
0
200
400
600
800
1,000
1,200
1,400
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round


WQSP-6 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
0
50
100
150
200
250
300
350
400
450
500
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round


WQSP-6 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
0
50
100
150
200
250
300
350
400
450
500
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round


WQSP-6 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
0
5,000
10,000
15,000
20,000
25,000
30,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round


WQSP-6 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round


WQSP-6 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
9.50
9.00
8.50
8.00
7.50
7.00
6.50
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
Round

APPENDIX F – GROUNDWATER DATA TABLES

Table F.1 – Volatile Organic Compound and Semivolatile Organic Compound Results for Detection Monitoring Wells in 2017 were Reported Below the Method Reporting Limit for Each Parameter Shown Below

Compound [a]	MRL, µg/L	Trace Metal	MRL, mg/L
VOCs			
Isobutanol (Isobutyl Alcohol)	5.0	Antimony	0.025
Carbon tetrachloride	1.0	Arsenic	0.050
Chlorobenzene	1.0	Barium	0.020
Chloroform	1.0	Beryllium	0.010
1,1-Dichloroethane	1.0	Cadmium	0.010
1,2-Dichloroethane	1.0	Chromium	0.025
1,1-Dichloroethylene (1,1-Dichloroethene)	1.0	Lead	0.020
trans-1,2-Dichloroethylene (trans-1,2-DCE)	1.0	Mercury	0.0002
Methyl ethyl ketone (2-Butanone)	5.0	Nickel	0.025
Methylene chloride	5.0	Selenium	0.025
1,1,2,2-Tetrachloroethane	1.0	Silver	0.013
Tetrachloroethylene (Tetrachloroethene)	1.0	Thallium	0.025
1,1,1-Trichloroethane	1.0	Vanadium	0.025
1,1,2-Trichloroethane	1.0		
Toluene	1.0		
Trichloroethylene (Trichloroethene)	1.0		
Trichlorofluoromethane	1.0		
Vinyl chloride	1.0		
Xylenes (Xylenes, Total)	1.0		
SVOCs			
1,2-Dichlorobenzene	5.0		
1,4-Dichlorobenzene	5.0		
2,4-Dinitrophenol	5.0		
2,4-Dinitrotoluene	5.0		
Hexachlorobenzene	5.0		
Hexachloroethane	5.0		
2-Methylphenol [b]	5.0		
3-Methylphenol [b]	5.0		
4-Methylphenol [b]	5.0		
Nitrobenzene	5.0		
Pentachlorophenol	5.0		
Pyridine	5.0		

(a) Chemical synonyms used by the current analytical laboratory, HEAL, are noted in parentheses.
(b) 2-, 3-, and 4-methylphenol, are listed collectively as cresols in the Hazardous Waste Facility Permit.
µg/L = microgram(s) per liter
mg/L = milligrams per liter

Table F.2 – WQSP Sample Results

WQSP-1					
Parameter (units)	**Primary**	**Duplicate**	**Distribution Type**	**95th UTLV or 95th Percentile[a]**	**Permit Table 5.6**
WQSP-1 General Chemistry					
Specific Gravity (unitless)[b]	1.042	1.046	Normal	1.07	N/A
pH (standard units)	7.10	7.10	Lognormal	5.6 to 8.8	N/A
Spec. Conductance (μmhos/cm)	125,000	129,0000	Lognormal	175,000	N/A
Total Dissolved Solids mg/L)	61,900	68,700	Lognormal	80,700	N/A
Total Organic Carbon (mg/L)	0.61 J	0.62 J	Nonparametric	<5.0	N/A
Total Suspended Solids (mg/L)	**61**	**67**	Nonparametric	**33.3**	N/A
WQSP-1 Trace Metals					
Antimony (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.33	0.33
Arsenic (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	<0.1	0.10
Barium (mg/L)	0.034 J	0.039 J	Nonparametric	<1.0	1.00
Beryllium (mg/L)	0.0058 J	0.0064 J	Nonparametric	<0.02	0.02
Cadmium (mg/L)	ND (0.0020)	ND (0.0020)	Nonparametric	<0.2	0.20
Chromium (mg/L)	ND (0.011)	ND (0.011)	Nonparametric	<0.5	0.50
Lead (mg/L)	ND (0.014)	ND (0.014)	Nonparametric	0.105	0.11
Mercury (mg/L)	0.00028 J	0.000058 J	Nonparametric	<0.002	0.002
Nickel (mg/L)	ND (0.0046)	ND (0.0046)	Nonparametric	0.490	0.50
Selenium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.150	0.15
Silver (mg/L)	ND (0.0038)	ND (0.0038)	Nonparametric	<0.5	0.50
Thallium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.98	1.00
Vanadium (mg/L)	0.040 J	0.048 J	Nonparametric	<0.1	0.10
WQSP-1 Major Cations, Dissolved					
Calcium (mg/L)	1,760	1,760	Normal	2,087	N/A
Magnesium (mg/L)	1,130	1,130	Normal	1,247	N/A
Potassium (mg/L)	480	482	Lognormal	799	N/A
WQSP-1 Major Anions					
Chloride (mg/L)	39,800	36,500	Normal	40,472	N/A

[a,b] Refer to footnotes at end of table.

WQSP-2					
Parameter (units)	**Primary**	**Duplicate**	**Distribution Type[a]**	**95th UTLV or 95th Percentile[a]**	**Permit Table 5.6**
WQSP-2 General Chemistry					
Specific Gravity (unitless)[b]	1.045	1.044	Lognormal	1.06	N/A
pH (standard units)	7.20	7.22	Normal	7.0 to 7.6	N/A
Spec. Conductance (μmhos/cm)	**124,000**	**125,000**	Lognormal	**124,000**	N/A
Total Dissolved Solids mg/L)	57,300	64,600	Normal	80,500	N/A
Total Organic Carbon (mg/L)	0.28 J	0.49 J	Nonparametric	7.97	N/A
Total Suspended Solids (mg/L)	28	32	Nonparametric	43.0	N/A
WQSP-2 Trace Metals					
Antimony (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	<0.5	0.50
Arsenic (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.062	0.06
Barium (mg/L)	0.032 J	0.030 J	Nonparametric	<1.0	1.00
Beryllium (mg/L)	0.0047 J	0.0044 J	Nonparametric	<1.0	1.00
Cadmium (mg/L)	ND (0.0020)	ND (0.0020)	Nonparametric	<0.5	0.50
Chromium (mg/L)	ND (0.011)	ND (0.011)	Nonparametric	<0.5	0.50
Lead (mg/L)	ND (0.014)	ND (0.014)	Nonparametric	0.163	0.17
Mercury (mg/L)	0.00052 J	0.000087 J	Nonparametric	<0.002	0.002
Nickel (mg/L)	ND (0.0046)	ND (0.0046)	Nonparametric	0.37	0.50
Selenium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.150	0.15
Silver (mg/L)	ND (0.0038)	ND (0.0038)	Nonparametric	<0.5	0.50
Thallium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.980	1.00
Vanadium (mg/L)	0.036 J	0.034 J	Nonparametric	<0.1	0.10
WQSP-2 Major Cations, Dissolved					
Calcium (mg/L)	1,640	1,660	Lognormal	1,827	N/A
Magnesium (mg/L)	1,080	1,100	Normal	1,244	N/A
Potassium (mg/L)	460	475	Lognormal	845	N/A
WQSP-2 Major Anions					
Chloride (mg/L)	33,900	34,000	Normal	39,670	N/A

[a,b] Refer to footnotes at end of table.

WQSP-3					
Parameter (units)	**Primary**	**Duplicate**	**Distribution Type[a]**	**95th UTLV or 95th Percentile[a]**	**Permit Table 5.6**
WQSP-3 General Chemistry					
Specific Gravity (unitless)[b]	1.135	1.136	Normal	1.17	N/A
pH (standard units)	6.86	6.86	Lognormal	6.6 to 7.2	N/A
Spec. Conductance (μmhos/cm)	336,000	329,000	Normal	517,000	N/A
Total Dissolved Solids mg/L)	221,000	226,000	Lognormal	261,000	N/A
Total Organic Carbon (mg/L)	0.77 J	1.12	Nonparametric	<5.0	N/A
Total Suspended Solids (mg/L)	**116**	**124**	Nonparametric	**107**	N/A
WQSP-3 Trace Metals					
Antimony (mg/L)	ND (0.020)	ND (0.020)	Nonparametric	<1.0	1.00
Arsenic (mg/L)	ND (0.020)	ND (0.020)	Nonparametric	<1.0	0.21
Barium (mg/L)	0.058 J	0.052 J	Nonparametric	<1.0	1.00
Beryllium (mg/L)	0.0077 J	0.0089 J	Nonparametric	<0.1	0.10
Cadmium (mg/L)	ND (0.0040)	ND (0.0040)	Nonparametric	<0.5	0.50
Chromium (mg/L)	ND (0.022)	ND (0.022)	Nonparametric	<2.0	2.00
Lead (mg/L)	ND (0.028)	ND (0.028)	Nonparametric	0.8	0.80
Mercury (mg/L)	ND (0.00075)	ND (0.00075)	Nonparametric	<0.002	0.002
Nickel (mg/L)	ND (0.0093)	ND (0.0093)	Nonparametric	<5.0	5.00
Selenium (mg/L)	ND (0.020)	ND (0.020)	Nonparametric	<2.0	2.00
Silver (mg/L)	ND (0.0077)	ND (0.0077)	Nonparametric	0.31	0.31
Thallium (mg/L)	ND (0.020)	ND (0.020)	Nonparametric	5.8	5.80
Vanadium (mg/L)	0.052 J	0.062 J	Nonparametric	<5.0	5.00
WQSP-3 Major Cations, Dissolved					
Calcium (mg/L)	1,490[c]	1,520	Normal	1,680	N/A
Magnesium (mg/L)	2,300[c]	2,380	Lognormal	2,625	N/A
Potassium (mg/L)	1,420[c]	1,510	Lognormal	3,438	N/A
WQSP-3 Major Anions					
Chloride (mg/L)[c]	128,000[c]	**161,000[d]**	Lognormal	**149,100**	N/A

[a,b,c,d] Refer to footnotes at end of table.

WQSP-4					
Parameter (units)	**Primary**	**Duplicate**	**Distribution Type[a]**	**95th UTLV or 95th Percentile[a]**	**Permit Table 5.6**
WQSP-4 General Chemistry					
Specific Gravity (unitless)[b]	1.075	1.068	Lognormal	1.09	N/A
pH (standard units)	7.14	7.12	Lognormal	6.8 to 7.6	N/A
Spec. Conductance (μmhos/cm)	192,000	191,000	Lognormal	319,800	N/A
Total Dissolved Solids mg/L)	109,000	102,000	Normal	123,500	N/A
Total Organic Carbon (mg/L)	0.92 J	1.2	Nonparametric	<5.0	N/A
Total Suspended Solids (mg/L)	**82**	**95**	Nonparametric	**57.0**	N/A
WQSP-4 Trace Metals					
Antimony (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	<10.0	0.80
Arsenic (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	<0.5	0.50
Barium (mg/L)	0.035 J	0.035 J	Nonparametric	1.00	1.00
Beryllium (mg/L)	ND (0.0022)	0.0028 J	Nonparametric	0.25	0.25
Cadmium (mg/L)	ND (0.0020)	ND (0.0020)	Nonparametric	<0.5	0.50
Chromium (mg/L)	ND (0.011)	ND (0.011)	Nonparametric	<2.0	2.00
Lead (mg/L)	ND (0.014)	ND (0.014)	Nonparametric	0.525	0.53
Mercury (mg/L)	ND (0.00018)	ND (0.00018)	Nonparametric	<0.002	0.002
Nickel (mg/L)	0.0063 J	0.0080 J	Nonparametric	<5.0	5.00
Selenium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	2.009	2.00
Silver (mg/L)	ND (0.0038)	ND (0.0038)	Nonparametric	0.519	0.52
Thallium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	1.00	1.00
Vanadium (mg/L)	0.024 J	0.026 J	Nonparametric	<5.0	5.00
WQSP-4 Major Cations, Dissolved					
Calcium (mg/L)	1,700	1,480[c]	Lognormal	1,834	N/A
Magnesium (mg/L)	1,250	1,090[c]	Lognormal	1,472	N/A
Potassium (mg/L)	737	747[c]	Lognormal	1,648	N/A
WQSP-4 Major Anions					
Chloride (mg/L)	58,500	54,000[c]	Normal	63,960	N/A

[a,b,c] Refer to footnotes at end of table.

WQSP-5					
Parameter (units)	**Primary**	**Duplicate**	**Distribution Type[a]**	**95th UTLV or 95th Percentile[a]**	**Permit Table 5.6**
WQSP-5 General Chemistry					
Specific Gravity (unitless)[b]	1.022	1.023	Normal	1.04	N/A
pH (standard units)	7.54	7.54	Normal	7.4 to 7.9	N/A
Spec. Conductance (μmhos/cm)	66,000	65,900	Lognormal	67,700	N/A
Total Dissolved Solids mg/L)	35,300	31,500	Nonparametric	43,950	N/A
Total Organic Carbon (mg/L)	0.28 J	0.35 J	Nonparametric	<5.0	N/A
Total Suspended Solids (mg/L)	**20**	**19**	Nonparametric	**<10**	N/A
WQSP-5 Total Trace Metals					
Antimony (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.073	0.07
Arsenic (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	<0.5	0.50
Barium (mg/L)	0.021 J	0.019 J	Nonparametric	<1.0	1.00
Beryllium (mg/L)	0.0028 J	0.0023 J	Nonparametric	<0.02	0.02
Cadmium (mg/L)	ND (0.0020)	ND (0.0020)	Nonparametric	<0.05	0.05
Chromium (mg/L)	ND (0.011)	ND (0.011)	Nonparametric	<0.5	0.50
Lead (mg/L)	ND(0.014)	ND (0.014)	Nonparametric	<0.05	0.05
Mercury (mg/L)	ND (0.00018)	ND (0.00018)	Nonparametric	<0.002	0.002
Nickel (mg/L)	ND (0.0046)	ND (0.0046)	Nonparametric	<0.1	0.10
Selenium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	<0.1	0.10
Silver (mg/L)	ND (0.0038)	ND (0.0038)	Nonparametric	<0.5	0.50
Thallium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.209	0.21
Vanadium (mg/L)	0.019 J	0.021 J	Nonparametric	2.70	2.70
WQSP-5 Major Cations, Dissolved					
Calcium (mg/L)	1,090	1,100	Lognormal	1,303	N/A
Magnesium (mg/L)	**608**	**592**	Nonparametric	**547**	N/A
Potassium (mg/L)	338	330	Lognormal	622	N/A
WQSP-5 Major Anions					
Chloride (mg/L)	14,400	14,500	Lognormal	18,100	N/A

[a,b] Refer to footnotes at end of table.

WQSP-6					
Parameter (units)	**Primary**	**Duplicate**	**Distribution Type[a]**	**95th UTLV or 95th Percentile[a]**	**Permit Table 5.6**
WQSP-6 General Chemistry					
Specific Gravity (unitless)[b]	1.008	1.008	Normal	1.02	N/A
pH (standard units)	7.82	7.82	Normal	7.5 to 7.9	N/A
Spec. Conductance (μmhos/cm)	**29,600**	**34,600**	Lognormal	**27,660**	N/A
Total Dissolved Solids mg/L)	16,000	16,500	Lognormal	22,500	N/A
Total Organic Carbon (mg/L)	0.60 J	0.59 J	Nonparametric	10.14	N/A
Total Suspended Solids (mg/L)	10	11	Nonparametric	14.8	N/A
WQSP-6 Trace Metals					
Antimony (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.140	0.14
Arsenic (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	<0.5	0.50
Barium (mg/L)	0.012 J	0.012 J	Nonparametric	<1.0	1.00
Beryllium (mg/L)	0.00083 J	0.00078 J	Nonparametric	<0.02	0.02
Cadmium (mg/L)	ND (0.00078)	ND (0.00092)	Nonparametric	<0.05	0.05
Chromium (mg/L)	ND (0.0022)	ND (0.0022)	Nonparametric	<0.5	0.50
Lead (mg/L)	ND (0.0028)	ND (0.0028)	Nonparametric	0.150	0.15
Mercury (mg/L)	ND (0.000037)	ND (0.000037)	Nonparametric	<0.002	0.002
Nickel (mg/L)	ND (0.00093)	ND (0.00093)	Nonparametric	<0.5	0.50
Selenium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.10	0.10
Silver (mg/L)	ND (0.00077)	ND (0.00077)	Nonparametric	<0.5	0.50
Thallium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.560	0.56
Vanadium (mg/L)	0.0048 J	0.0041 J	Nonparametric	0.070	0.10
WQSP-6 Major Cations, Dissolved					
Calcium (mg/L)	669[c]	686	Normal	796	N/A
Magnesium (mg/L)	212[c]	216	Lognormal	255	N/A
Potassium (mg/L)	153[c]	153	Lognormal	270	N/A
WQSP-6 Major Anions					
Chloride (mg/L)	4,300[c]	4,720	Nonparametric	15,800	N/A

Footnotes:

Note: Values (concentrations) in bold exceed or are outside of the baseline range for the 95th UTLV, 95th percentile, or Permit background value. In these cases, the UTLVs, 95th percentile, or Permit background values are also shown in bold for ease of comparison.

(a) Baseline sample distribution type based upon Rounds 1 through 10. The 95th UTLV is used in cases where the sample distribution type is either normal or lognormal. The 95th percentile value is used in cases where the sample distribution type is nonparametric or had greater than 15% non-detects.

(b) Specific gravity is compared to density (grams per milliliter [g/mL]) as presented in *Waste Isolation Pilot Plant RCRA Background Groundwater Quality Baseline Report, Addendum* 1 (DOE, 2000).

(c) These chloride and dissolved cation concentrations were from samples re-collected in August 2017.

(d) This concentration is suspect based on the analysis results from the re-collected sample and likely due to the multiple dilutions required for chloride analysis. The lab ensured accurate dilutions for the re-collected primary sample, and a duplicate sample would be expected to yield a similar concentration.

J = Estimated concentration. The concentration is between the laboratory's MDL and the MRL.

N/A = Not applicable

ND = not detected; the analytical parameter was analyzed, but not detected in the sample. Most of the metals were analyzed by inductively coupled plasma spectroscopy (ICP). Antimony, Arsenic, Selenium, and Thallium were analyzed by ICP/mass spectrometry (ICP/MS). The MDLs are shown in parentheses.

95th UTLV = Upper tolerance limit value in mg/L (coverage and tolerance coefficient value of 95%).

Table F.3 – WIPP Well Inventory for 2017

Sorted by Active Wells at Year-End				Sorted by Formation for Wells Measured at Least Once in 2017			
Count	Well Number	Zone	Comments	Count	Well Number	Zone	Reason Not Assessed for Long-Term Water Level Trend in Culebra
1	AEC-7R	CUL		1	CB-1(PIP)	B/C	
2	C-2505	SR/DL		2	DOE-2	B/C	
3	C-2506	SR/DL		3	AEC-7R	CUL	
4	C-2507	SR/DL		4	ERDA-9	CUL	
5	C-2737	MAG/CUL		5	H-02b2	CUL	
6	C-2811	SR/DL		6	H-03b2	CUL	
7	CB-1(PIP)	B/C		7	H-04bR	CUL	
8	DOE-2	B/C		8	H-05b	CUL	
9	ERDA-9	CUL		9	H-06bR	CUL	
10	H-02b1	MAG		10	H-07b1	CUL	
11	H-02b2	CUL		11	H-09bR	CUL	
12	H-03b1	MAG		12	H-10cR	CUL	Completed October 2015
13	H-03b2	CUL		13	H-11b4R	CUL	
14	H-03D	SR/DL	Dry; not measured in 2013	14	H-12R	CUL	Completed in September 2014
15	H-04bR	CUL		15	H-17	CUL	
16	H-04c	MAG		16	H-19b0	CUL	
17	H-05b	CUL		17	H-19b2	CUL	Redundant to H19b0
18	H-06bR	CUL		18	H-19b3	CUL	Redundant to H19b0
19	H-06c	MAG		19	H-19b4	CUL	Redundant to H19b0
20	H-07b1	CUL		20	H-19b5	CUL	Redundant to H19b0
21	H-08a	MAG		21	H-19b6	CUL	Redundant to H19b0
22	H-09c	MAG		22	H-19b7	CUL	Redundant to H19b0
23	H-09bR	CUL		23	I-461	CUL	
24	H-10a	MAG		24	SNL-01	CUL	
25	H-10cR	CUL		25	SNL-02	CUL	
26	H-11b2	MAG		26	SNL-03	CUL	
27	H-11b4R	CUL		27	SNL-05	CUL	
28	H-12R	CUL		28	SNL-6	CUL	Depressed from projected equilibrium
29	H-14	MAG		29	SNL-08	CUL	

Sorted by Active Wells at Year-End				Sorted by Formation for Wells Measured at Least Once in 2017			
Count	**Well Number**	**Zone**	**Comments**	**Count**	**Well Number**	**Zone**	**Reason Not Assessed for Long-Term Water Level Trend in Culebra**
30	H-15R	CUL		30	SNL-09	CUL	
31	H-15	MAG		31	H-15R	CUL	
32	H-16	CUL		32	SNL-10	CUL	
33	H-17	CUL		33	H-16	CUL	Seasonal changes
34	H-18	MAG		34	SNL-12	CUL	
35	H-19b0	CUL		35	SNL-13	CUL	Rise from oil field activities
36	H-19b2	CUL		36	SNL-14	CUL	
37	H-19b3	CUL		37	SNL-15	CUL	Depressed from projected equilibrium
38	H-19b4	CUL		38	SNL-16	CUL	
39	H-19b5	CUL		39	SNL-17	CUL	
40	H-19b6	CUL		40	SNL-18	CUL	
41	H-19b7	CUL		41	SNL-19	CUL	
42	I-461	CUL		42	WIPP-11	CUL	
43	SNL-01	CUL		43	WIPP-13	CUL	
44	SNL-02	CUL		44	WIPP-19	CUL	
45	SNL-03	CUL		45	WQSP-1	CUL	
46	SNL-05	CUL		46	WQSP-2	CUL	
47	SNL-06	CUL		47	WQSP-3	CUL	
48	SNL-08	CUL		48	WQSP-4	CUL	
49	SNL-09	CUL		49	WQSP-5	CUL	
50	SNL-10	CUL		50	WQSP-6	CUL	
51	SNL-12	CUL		51	WQSP-6A	DL	
52	SNL-13	CUL		52	H-02b1	MAG	
53	SNL-14	CUL		53	H-03b1	MAG	
54	SNL-15	CUL		54	H-04c	MAG	
55	SNL-16	CUL		55	H-06c	MAG	
56	SNL-17	CUL		56	H-08a	MAG	
57	SNL-18	CUL		57	H-10a	MAG	
58	SNL-19	CUL		58	H-11b2	MAG	
59	PZ-01	SR/DL		59	H-14	MAG	
60	PZ-02	SR/DL		60	H-18	MAG	

Sorted by Active Wells at Year-End				Sorted by Formation for Wells Measured at Least Once in 2017			
Count	**Well Number**	**Zone**	**Comments**	**Count**	**Well Number**	**Zone**	**Reason Not Assessed for Long-Term Water Level Trend in Culebra**
61	PZ-03	SR/DL		61	WIPP-18	MAG	
62	PZ-04	SR/DL		62	H-15	MAG	
63	PZ-05	SR/DL		63	H-09c	MAG	
64	PZ-06	SR/DL		64	C-2737	MAG/CUL	
65	PZ-07	SR/DL		65	C-2505	SR/DL	
66	PZ-08	SR/DL		66	C-2506	SR/DL	
67	PZ-09	SR/DL		67	C-2507	SR/DL	
68	PZ-10	SR/DL		68	C-2811	SR/DL	
69	PZ-11	SR/DL		69	PZ-01	SR/DL	
70	PZ-12	SR/DL		70	PZ-02	SR/DL	
71	PZ-13	SR/DL		71	PZ-03	SR/DL	
72	PZ-14	SR/DL		72	PZ-04	SR/DL	
73	PZ-15	Gatuña		73	PZ-05	SR/DL	
74	WIPP-11	CUL		74	PZ-06	SR/DL	
75	WIPP-13	CUL		75	PZ-07	SR/DL	
76	WIPP-18	MAG		76	PZ-08	SR/DL	
77	WIPP-19	CUL		77	PZ-09	SR/DL	
78	WQSP-1	CUL		78	PZ-10	SR/DL	
79	WQSP-2	CUL		79	PZ-11	SR/DL	
80	WQSP-3	CUL		80	PZ-12	SR/DL	
81	WQSP-4	CUL		81	PZ-13	SR/DL	
82	WQSP-5	CUL		82	PZ-14	SR/DL	
83	WQSP-6	CUL		83	PZ-15	Gatuña	
84	WQSP-6A	DL		84	H-03D	SR/DL	Dry; not measured since 2013

Table F.4 – 2017 Water Levels

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
AEC-7R	CUL	01/05/17	614.56	3043.79	3059.34
AEC-7R	CUL	02/07/17	614.63	3043.72	3059.27
AEC-7R	CUL	03/14/17	614.79	3043.56	3059.10
AEC-7R	CUL	04/04/17	614.50	3043.85	3059.41
AEC-7R	CUL	05/24/17	614.71	3043.64	3059.18
AEC-7R	CUL	06/05/17	614.67	3043.68	3059.22
AEC-7R	CUL	07/10/17	614.75	3043.60	3059.14
AEC-7R	CUL	08/08/17	614.80	3043.55	3059.09
AEC-7R	CUL	09/14/17	614.62	3043.73	3059.28
AEC-7R	CUL	10/03/17	614.72	3043.63	3059.17
AEC-7R	CUL	11/09/17	614.82	3043.53	3059.07
AEC-7R	CUL	12/12/17	615.08	3043.27	3058.79
C-2737 (PIP)	CUL	01/11/17	416.53	2984.23	2990.54
C-2737 (PIP)	CUL	02/16/17	417.06	2983.70	2990.00
C-2737 (PIP)	CUL	03/15/17	417.83	2982.93	2989.21
C-2737 (PIP)	CUL	04/05/17	418.48	2982.28	2988.55
C-2737 (PIP)	CUL	05/26/17	418.85	2981.91	2988.17
C-2737 (PIP)	CUL	06/08/17	419.27	2981.49	2987.74
C-2737 (PIP)	CUL	07/17/17	418.62	2982.14	2988.41
C-2737 (PIP)	CUL	08/09/17	418.28	2982.48	2988.75
C-2737 (PIP)	CUL	09/18/17	418.21	2982.55	2988.83
C-2737 (PIP)	CUL	10/04/17	417.72	2983.04	2989.33
C-2737 (PIP)	CUL	11/10/17	415.13	2985.63	2991.98
C-2737 (PIP)	CUL	12/14/17	413.42	2987.34	2993.73
ERDA-9	CUL	01/11/17	421.91	2988.26	3009.81
ERDA-9	CUL	02/16/17	422.31	2987.86	3009.38
ERDA-9	CUL	03/15/17	422.59	2987.58	3009.08
ERDA-9	CUL	04/05/17	422.87	2987.30	3008.78
ERDA-9	CUL	05/25/17	423.28	2986.89	3008.34
ERDA-9	CUL	06/08/17	423.65	2986.52	3007.95
ERDA-9	CUL	07/17/17	423.37	2986.80	3008.25
ERDA-9	CUL	08/09/17	423.04	2987.13	3008.60
ERDA-9	CUL	09/18/17	422.59	2987.58	3009.08
ERDA-9	CUL	10/04/17	422.29	2987.88	3009.41

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
ERDA-9	CUL	11/10/17	421.14	2989.03	3010.64
ERDA-9	CUL	12/14/17	419.90	2990.27	3011.97
H-02b2	CUL	01/11/17	351.30	3027.06	3030.19
H-02b2	CUL	02/16/17	351.73	3026.63	3029.75
H-02b2	CUL	03/16/17	351.90	3026.46	3029.58
H-02b2	CUL	04/05/17	352.17	3026.19	3029.31
H-02b2	CUL	05/25/17	352.35	3026.01	3029.13
H-02b2	CUL	06/07/17	352.73	3025.63	3028.74
H-02b2	CUL	07/17/17	352.98	3025.38	3028.49
H-02b2	CUL	08/08/17	353.01	3025.35	3028.46
H-02b2	CUL	09/18/17	352.85	3025.51	3028.62
H-02b2	CUL	10/02/17	352.60	3025.76	3028.87
H-02b2	CUL	11/09/17	352.54	3025.82	3028.93
H-02b2	CUL	12/13/17	351.93	3026.43	3029.55
H-03b2	CUL	01/11/17	423.28	2966.63	2970.07
H-03b2	CUL	02/16/17	423.80	2966.11	2969.54
H-03b2	CUL	03/15/17	424.98	2964.93	2968.35
H-03b2	CUL	04/05/17	425.52	2964.39	2967.80
H-03b2	CUL	05/25/17	426.28	2963.63	2967.03
H-03b2	CUL	06/08/17	426.65	2963.26	2966.65
H-03b2	CUL	07/17/17	424.72	2965.19	2968.61
H-03b2	CUL	August	SNL Testing		
H-03b2	CUL	09/18/17	422.99	2966.92	2970.36
H-03b2	CUL	10/04/17	422.27	2967.64	2971.09
H-03b2	CUL	11/10/17	419.47	2970.44	2973.93
H-03b2	CUL	12/14/17	414.02	2975.89	2979.45
H-04bR	CUL	01/10/17	382.80	2951.84	2954.72
H-04bR	CUL	02/16/17	404.05	2930.59	2932.98
H-04bR	CUL	03/14/17	394.68	2939.96	2942.56
H-04bR	CUL	04/04/17	380.26	2954.38	2957.32
H-04bR	CUL	05/26/17	386.65	2947.99	2950.78
H-04bR	CUL	06/07/17	368.79	2965.85	2969.05
H-04bR	CUL	07/12/17	395.07	2939.57	2942.16
H-04bR	CUL	08/09/17	374.21	2960.43	2963.50
H-04bR	CUL	09/18/17	366.05	2968.59	2971.85

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-04bR	CUL	10/04/17	353.22	2981.42	2984.98
H-04bR	CUL	11/10/17	350.33	2984.31	2987.93
H-04bR	CUL	12/12/17	363.06	2971.58	2974.91
H-05b	CUL	01/10/17	469.00	3037.78	3073.96
H-05b	CUL	02/07/17	468.93	3037.85	3074.04
H-05b	CUL	03/14/17	469.12	3037.66	3073.84
H-05b	CUL	04/03/17	468.99	3037.79	3073.98
H-05b	CUL	05/24/17	469.25	3037.53	3073.69
H-05b	CUL	06/05/17	469.25	3037.53	3073.69
H-05b	CUL	07/10/17	469.48	3037.30	3073.45
H-05b	CUL	08/07/17	469.49	3037.29	3073.43
H-05b	CUL	09/14/17	469.59	3037.19	3073.33
H-05b	CUL	10/03/17	469.60	3037.18	3073.32
H-05b	CUL	11/09/17	469.86	3036.92	3073.03
H-05b	CUL	12/11/17	470.09	3036.69	3072.79
H-06bR	CUL	01/10/17	292.70	3056.52	3068.86
H-06bR	CUL	02/08/17	292.93	3056.29	3068.62
H-06bR	CUL	03/14/17	293.13	3056.09	3068.41
H-06bR	CUL	04/04/17	292.98	3056.24	3068.56
H-06bR	CUL	05/25/17	292.78	3056.44	3068.77
H-06bR	CUL	06/06/17	293.05	3056.17	3068.49
H-06bR	CUL	07/11/17	292.92	3056.30	3068.63
H-06bR	CUL	08/10/17	292.97	3056.25	3068.58
H-06bR	CUL	09/15/17	293.09	3056.13	3068.45
H-06bR	CUL	10/04/17	293.22	3056.00	3068.32
H-06bR	CUL	11/09/17	293.24	3055.98	3068.30
H-06bR	CUL	12/12/17	293.60	3055.62	3067.92
H-07b1	CUL	01/05/17	167.60	2996.12	2996.94
H-07b1	CUL	02/07/17	168.80	2994.92	2995.73
H-07b1	CUL	03/13/17	168.24	2995.48	2996.29
H-07b1	CUL	04/03/17	167.47	2996.25	2997.07
H-07b1	CUL	05/24/17	167.97	2995.75	2996.57
H-07b1	CUL	06/05/17	167.69	2996.03	2996.85
H-07b1	CUL	07/11/17	168.09	2995.63	2996.44
H-07b1	CUL	08/07/17	168.05	2995.67	2996.48

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-07b1	CUL	09/15/17	168.08	2995.64	2996.45
H-07b1	CUL	10/02/17	167.66	2996.06	2996.88
H-07b1	CUL	11/08/17	168.64	2995.08	2995.89
H-07b1	CUL	12/11/17	169.36	2994.36	2995.16
H-09bR	CUL	01/05/17	441.49	2966.85	2967.74
H-09bR	CUL	02/07/17	441.33	2967.01	2967.90
H-09bR	CUL	03/13/17	446.80	2961.54	2962.41
H-09bR	CUL	04/03/17	440.95	2967.39	2968.29
H-09bR	CUL	05/24/17	443.75	2964.59	2965.47
H-09bR	CUL	06/05/17	440.80	2967.54	2968.44
H-09bR	CUL	07/11/17	440.35	2967.99	2968.89
H-09bR	CUL	08/07/17	443.45	2964.89	2965.78
H-09bR	CUL	09/14/17	438.16	2970.18	2971.09
H-09bR	CUL	10/02/17	435.26	2973.08	2974.00
H-09bR	CUL	11/08/17	434.62	2973.72	2974.64
H-09bR	CUL	12/11/17	436.95	2971.39	2972.30
H-10cR	CUL	January	SNL Testing		
H-10cR	CUL	February	SNL Testing		
H-10cR	CUL	March	SNL Testing		
H-10cR	CUL	April	SNL Testing		
H-10cR	CUL	May	SNL Testing		
H-10cR	CUL	June	SNL Testing		
H-10cR	CUL	July	SNL Testing		
H-10cR	CUL	August	SNL Testing		
H-10cR	CUL	09/14/17	732.42	2957.65	3024.99
H-10cR	CUL	September	SNL Testing		
H-10cR	CUL	11/08/17	731.16	2958.91	3026.38
H-10cR	CUL	12/11/17	730.97	2959.10	3026.59
H-11b4R	CUL	01/10/17	468.90	2942.97	2963.79
H-11b4R	CUL	02/16/17	469.85	2942.02	2962.77
H-11b4R	CUL	03/14/17	475.08	2936.79	2957.13
H-11b4R	CUL	04/04/17	467.00	2944.87	2965.84
H-11b4R	CUL	05/25/17	474.42	2937.45	2957.84
H-11b4R	CUL	06/06/17	469.69	2942.18	2962.94
H-11b4R	CUL	07/11/17	464.97	2946.90	2968.03

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-11b4R	CUL	08/08/17	467.84	2944.03	2964.93
H-11b4R	CUL	09/14/17	459.95	2951.92	2973.44
H-11b4R	CUL	10/03/17	456.65	2955.22	2977.00
H-11b4R	CUL	11/09/17	452.81	2959.06	2981.14
H-11b4R	CUL	12/12/17	450.77	2961.10	2983.34
H-12R	CUL	01/05/17	487.23	2941.65	2980.45
H-12R	CUL	02/07/17	487.50	2941.38	2980.15
H-12R	CUL	03/14/17	488.55	2940.33	2978.99
H-12R	CUL	04/03/17	488.78	2940.10	2978.73
H-12R	CUL	05/24/17	489.43	2939.45	2978.01
H-12R	CUL	06/05/17	489.60	2939.28	2977.82
H-12R	CUL	07/11/17	487.78	2941.10	2979.84
H-12R	CUL	08/07/17	487.70	2941.18	2979.93
H-12R	CUL	09/14/17	486.41	2942.47	2981.36
H-12R	CUL	10/03/17	485.53	2943.35	2982.34
H-12R	CUL	11/09/17	483.44	2945.44	2984.66
H-12R	CUL	12/11/17	481.68	2947.20	2986.61
H-15R	CUL	01/11/17	539.60	2942.42	2982.06
H-15R	CUL	02/16/17	539.96	2942.06	2981.66
H-15R	CUL	03/15/17	541.55	2940.47	2979.88
H-15R	CUL	04/05/17	541.65	2940.37	2979.77
H-15R	CUL	05/26/17	542.51	2939.51	2978.80
H-15R	CUL	06/08/17	542.70	2939.32	2978.59
H-15R	CUL	07/17/17	539.86	2942.16	2981.77
H-15R	CUL	08/09/17	540.11	2941.91	2981.49
H-15R	CUL	09/18/17	537.71	2944.31	2984.18
H-15R	CUL	10/05/17	536.79	2945.23	2985.21
H-15R	CUL	11/10/17	533.82	2948.20	2988.53
H-15R	CUL	12/13/17	531.53	2950.49	2991.09
H-16	CUL	01/11/17	387.65	3022.41	3033.85
H-16	CUL	02/17/17	388.08	3021.98	3033.40
H-16	CUL	03/16/17	388.26	3021.80	3033.22
H-16	CUL	04/05/17	388.66	3021.40	3032.80
H-16	CUL	05/26/17	388.73	3021.33	3032.73
H-16	CUL	06/07/17	388.85	3021.21	3032.61

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-16	CUL	07/17/17	388.64	3021.42	3032.82
H-16	CUL	08/09/17	388.61	3021.45	3032.85
H-16	CUL	09/19/17	388.32	3021.74	3033.15
H-16	CUL	10/04/17	388.43	3021.63	3033.04
H-16	CUL	11/10/17	387.97	3022.09	3033.52
H-16	CUL	12/14/17	387.49	3022.57	3034.01
H-17	CUL	01/10/17	455.81	2929.43	2964.63
H-17	CUL	02/16/17	455.93	2929.31	2964.49
H-17	CUL	03/14/17	459.99	2925.25	2959.89
H-17	CUL	04/04/17	456.51	2928.73	2963.83
H-17	CUL	05/25/17	460.40	2924.84	2959.43
H-17	CUL	06/06/17	458.58	2926.66	2961.49
H-17	CUL	07/11/17	451.60	2933.64	2969.40
H-17	CUL	08/08/17	454.73	2930.51	2965.85
H-17	CUL	09/14/17	448.50	2936.74	2972.91
H-17	CUL	10/03/17	446.85	2938.39	2974.78
H-17	CUL	11/09/17	442.43	2942.81	2979.79
H-17	CUL	12/12/17	438.85	2946.39	2983.84
H-19b0	CUL	01/11/17	461.17	2957.16	2976.48
H-19b0	CUL	02/16/17	461.61	2956.72	2976.01
H-19b0	CUL	03/15/17	463.57	2954.76	2973.92
H-19b0	CUL	04/04/17	463.04	2955.29	2974.49
H-19b0	CUL	05/25/17	464.55	2953.78	2972.88
H-19b0	CUL	06/08/17	464.43	2953.90	2973.01
H-19b0	CUL	07/12/17	462.58	2955.75	2974.98
H-19b0	CUL	08/09/17	462.04	2956.29	2975.55
H-19b0	CUL	09/18/17	459.57	2958.76	2978.19
H-19b0	CUL	10/04/17	458.58	2959.75	2979.24
H-19b0	CUL	11/10/17	455.39	2962.94	2982.64
H-19b0	CUL	12/13/17	453.03	2965.30	2985.16
H-19b2	CUL	03/15/17	464.93	2954.00	2975.83
H-19b2	CUL	06/08/17	465.88	2953.05	2974.81
H-19b2	CUL	09/18/17	460.96	2957.97	2980.10
H-19b2	CUL	12/13/17	454.39	2964.54	2987.16
H-19b3	CUL	03/15/17	465.10	2953.92	2975.63

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-19b3	CUL	06/08/17	466.09	2952.93	2974.57
H-19b3	CUL	09/18/17	461.18	2957.84	2979.85
H-19b3	CUL	12/13/17	454.55	2964.47	2986.98
H-19b4	CUL	03/15/17	464.33	2954.65	2975.55
H-19b4	CUL	06/08/17	465.33	2953.65	2974.48
H-19b4	CUL	09/18/17	460.58	2958.40	2979.57
H-19b4	CUL	12/13/17	453.94	2965.04	2986.69
H-19b5	CUL	03/15/17	464.44	2954.14	2975.87
H-19b5	CUL	06/08/17	465.30	2953.28	2974.95
H-19b5	CUL	09/18/17	460.43	2958.15	2980.18
H-19b5	CUL	12/13/17	453.91	2964.67	2987.19
H-19b6	CUL	03/15/17	465.12	2953.90	2976.19
H-19b6	CUL	06/08/17	466.11	2952.91	2975.13
H-19b6	CUL	09/18/17	461.19	2957.83	2980.42
H-19b6	CUL	12/13/17	454.62	2964.40	2987.50
H-19b7	CUL	03/15/17	464.89	2954.05	2975.48
H-19b7	CUL	06/08/17	465.85	2953.09	2974.45
H-19b7	CUL	09/18/17	460.91	2958.03	2979.76
H-19b7	CUL	12/13/17	454.39	2964.55	2986.76
I-461	CUL	01/05/17	243.85	3040.03	3040.30
I-461	CUL	02/07/17	243.33	3040.55	3040.82
I-461	CUL	03/13/17	243.84	3040.04	3040.31
I-461	CUL	04/03/17	243.78	3040.10	3040.37
I-461	CUL	05/24/17	244.10	3039.78	3040.05
I-461	CUL	06/05/17	244.13	3039.75	3040.02
I-461	CUL	07/10/17	244.24	3039.64	3039.91
I-461	CUL	08/07/17	244.64	3039.24	3039.50
I-461	CUL	09/13/17	244.53	3039.35	3039.61
I-461	CUL	10/02/17	244.60	3039.28	3039.54
I-461	CUL	11/08/17	244.82	3039.06	3039.32
I-461	CUL	12/11/17	245.19	3038.69	3038.95
SNL-01	CUL	01/05/17	437.97	3074.87	3080.29
SNL-01	CUL	02/07/17	438.05	3074.79	3080.21
SNL-01	CUL	03/13/17	438.45	3074.39	3079.80
SNL-01	CUL	04/03/17	438.73	3074.11	3079.51

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-01	CUL	05/24/17	438.25	3074.59	3080.00
SNL-01	CUL	06/05/17	438.25	3074.59	3080.00
SNL-01	CUL	07/10/17	439.34	3073.50	3078.88
SNL-01	CUL	08/07/17	438.36	3074.48	3079.89
SNL-01	CUL	09/13/17	438.49	3074.35	3079.75
SNL-01	CUL	10/02/17	438.60	3074.24	3079.64
SNL-01	CUL	11/08/17	438.91	3073.93	3079.32
SNL-01	CUL	12/11/17	439.09	3073.75	3079.14
SNL-02	CUL	01/05/17	254.83	3068.23	3070.17
SNL-02	CUL	02/07/17	255.63	3067.43	3069.37
SNL-02	CUL	03/13/17	256.10	3066.96	3068.89
SNL-02	CUL	04/03/17	255.70	3067.36	3069.30
SNL-02	CUL	05/24/17	254.82	3068.24	3070.18
SNL-02	CUL	06/05/17	255.23	3067.83	3069.77
SNL-02	CUL	07/10/17	255.33	3067.73	3069.67
SNL-02	CUL	08/07/17	255.47	3067.59	3069.53
SNL-02	CUL	09/13/17	255.73	3067.33	3069.27
SNL-02	CUL	10/02/17	255.86	3067.20	3069.13
SNL-02	CUL	11/08/17	256.27	3066.79	3068.72
SNL-02	CUL	12/12/17	257.14	3065.92	3067.84
SNL-03	CUL	01/10/17	422.55	3067.80	3077.43
SNL-03	CUL	02/08/17	422.59	3067.76	3077.39
SNL-03	CUL	03/15/17	422.94	3067.41	3077.03
SNL-03	CUL	04/03/17	422.64	3067.71	3077.34
SNL-03	CUL	05/24/17	422.65	3067.70	3077.33
SNL-03	CUL	06/06/17	422.69	3067.66	3077.29
SNL-03	CUL	07/11/17	422.49	3067.86	3077.49
SNL-03	CUL	08/08/17	422.62	3067.73	3077.36
SNL-03	CUL	09/15/17	422.64	3067.71	3077.34
SNL-03	CUL	10/04/17	422.87	3067.48	3077.10
SNL-03	CUL	11/09/17	422.90	3067.45	3077.07
SNL-03	CUL	12/12/17	423.29	3067.06	3076.67
SNL-05	CUL	01/05/17	311.85	3068.13	3071.50
SNL-05	CUL	02/07/17	312.03	3067.95	3071.32
SNL-05	CUL	03/13/17	312.54	3067.44	3070.80

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-05	CUL	04/03/17	312.42	3067.56	3070.93
SNL-05	CUL	05/24/17	311.33	3068.65	3072.03
SNL-05	CUL	06/05/17	311.34	3068.64	3072.02
SNL-05	CUL	07/10/17	311.31	3068.67	3072.05
SNL-05	CUL	08/07/17	310.98	3069.00	3072.38
SNL-05	CUL	09/13/17	311.31	3068.67	3072.05
SNL-05	CUL	10/02/17	311.53	3068.45	3071.82
SNL-05	CUL	11/08/17	311.93	3068.05	3071.42
SNL-05	CUL	12/12/17	312.17	3067.81	3071.18
SNL-06	CUL	01/05/17	492.03	3154.08	3363.09
SNL-06	CUL	02/08/17	489.30	3156.81	3366.49
SNL-06	CUL	03/14/17	487.43	3158.68	3368.82
SNL-06	CUL	04/04/17	486.14	3159.97	3370.43
SNL-06	CUL	05/24/17	483.58	3162.53	3373.62
SNL-06	CUL	06/06/17	482.77	3163.34	3374.63
SNL-06	CUL	07/10/17	481.77	3164.34	3375.88
SNL-06	CUL	08/08/17	479.56	3166.55	3378.64
SNL-06	CUL	09/14/17	477.59	3168.52	3381.09
SNL-06	CUL	10/03/17	476.53	3169.58	3382.41
SNL-06	CUL	11/09/17	474.80	3171.31	3384.57
SNL-06	CUL	12/12/17	473.31	3172.80	3386.43
SNL-08	CUL	01/10/17	539.71	3016.02	3057.30
SNL-08	CUL	02/07/17	539.73	3016.00	3057.28
SNL-08	CUL	03/14/17	539.96	3015.77	3057.03
SNL-08	CUL	04/03/17	539.87	3015.86	3057.13
SNL-08	CUL	05/24/17	540.26	3015.47	3056.70
SNL-08	CUL	06/05/17	540.09	3015.64	3056.89
SNL-08	CUL	07/11/17	541.18	3014.55	3055.69
SNL-08	CUL	08/07/17	540.16	3015.57	3056.81
SNL-08	CUL	09/14/17	540.14	3015.59	3056.83
SNL-08	CUL	10/03/17	540.17	3015.56	3056.80
SNL-08	CUL	11/09/17	540.24	3015.49	3056.72
SNL-08	CUL	12/11/17	540.36	3015.37	3056.59
SNL-09	CUL	01/10/17	313.80	3047.16	3051.72
SNL-09	CUL	02/08/17	313.94	3047.02	3051.58

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-09	CUL	03/14/17	314.43	3046.53	3051.08
SNL-09	CUL	04/04/17	314.15	3046.81	3051.36
SNL-09	CUL	05/24/17	314.49	3046.47	3051.02
SNL-09	CUL	06/06/17	314.43	3046.53	3051.08
SNL-09	CUL	07/11/17	314.20	3046.76	3051.31
SNL-09	CUL	08/08/17	314.63	3046.33	3050.88
SNL-09	CUL	09/15/17	314.36	3046.60	3051.15
SNL-09	CUL	10/04/17	314.39	3046.57	3051.12
SNL-09	CUL	11/08/17	314.34	3046.62	3051.17
SNL-09	CUL	12/12/17	314.81	3046.15	3050.69
SNL-10	CUL	01/10/17	331.92	3045.67	3048.49
SNL-10	CUL	02/08/17	332.03	3045.56	3048.37
SNL-10	CUL	03/14/17	332.46	3045.13	3047.94
SNL-10	CUL	04/04/17	332.41	3045.18	3047.99
SNL-10	CUL	05/25/17	332.59	3045.00	3047.81
SNL-10	CUL	06/06/17	332.88	3044.71	3047.52
SNL-10	CUL	07/10/17	332.70	3044.89	3047.70
SNL-10	CUL	08/08/17	332.71	3044.88	3047.69
SNL-10	CUL	09/15/17	332.51	3045.08	3047.89
SNL-10	CUL	10/03/17	332.44	3045.15	3047.96
SNL-10	CUL	11/09/17	332.18	3045.41	3048.22
SNL-10	CUL	12/12/17	332.21	3045.38	3048.19
SNL-12	CUL	01/05/17	387.56	2951.90	2953.00
SNL-12	CUL	02/07/17	385.22	2954.24	2955.35
SNL-12	CUL	03/14/17	390.60	2948.86	2949.94
SNL-12	CUL	04/03/17	377.07	2962.39	2963.55
SNL-12	CUL	05/24/17	387.17	2952.29	2953.39
SNL-12	CUL	06/06/17	375.53	2963.93	2965.10
SNL-12	CUL	07/11/17	381.41	2958.05	2959.19
SNL-12	CUL	08/08/17	378.17	2961.29	2962.45
SNL-12	CUL	09/14/17	371.84	2967.62	2968.81
SNL-12	CUL	10/02/17	361.47	2977.99	2979.25
SNL-12	CUL	11/08/17	358.83	2980.63	2981.90
SNL-12	CUL	12/11/17	362.15	2977.31	2978.56
SNL-13	CUL	01/10/17	316.10	2978.01	2980.13

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-13	CUL	02/08/17	316.40	2977.71	2979.83
SNL-13	CUL	03/13/17	317.45	2976.66	2978.75
SNL-13	CUL	04/04/17	317.61	2976.50	2978.59
SNL-13	CUL	05/25/17	318.23	2975.88	2977.95
SNL-13	CUL	06/06/17	318.76	2975.35	2977.41
SNL-13	CUL	07/10/17	317.71	2976.40	2978.48
SNL-13	CUL	08/08/17	317.44	2976.67	2978.76
SNL-13	CUL	09/15/17	316.22	2977.89	2980.01
SNL-13	CUL	10/04/17	315.49	2978.62	2980.76
SNL-13	CUL	11/09/17	313.47	2980.64	2982.83
SNL-13	CUL	12/12/17	311.83	2982.28	2984.51
SNL-14	CUL	01/10/17	420.53	2947.88	2959.08
SNL-14	CUL	02/16/17	423.85	2944.56	2955.61
SNL-14	CUL	03/14/17	428.45	2939.96	2950.81
SNL-14	CUL	04/04/17	415.46	2952.95	2964.38
SNL-14	CUL	05/25/17	425.68	2942.73	2953.70
SNL-14	CUL	06/06/17	417.20	2951.21	2962.56
SNL-14	CUL	07/11/17	415.57	2952.84	2964.27
SNL-14	CUL	08/10/17	416.82	2951.59	2962.96
SNL-14	CUL	09/14/17	409.92	2958.49	2970.17
SNL-14	CUL	10/03/17	403.07	2965.34	2977.33
SNL-14	CUL	11/09/17	399.60	2968.81	2980.96
SNL-14	CUL	12/12/17	399.90	2968.51	2980.64
SNL-15	CUL	01/10/17	505.02	2974.91	3071.84
SNL-15	CUL	02/07/17	504.40	2975.53	3072.61
SNL-15	CUL	03/14/17	503.69	2976.24	3073.48
SNL-15	CUL	04/04/17	503.30	2976.63	3073.96
SNL-15	CUL	05/24/17	503.12	2976.81	3074.18
SNL-15	CUL	06/06/17	503.13	2976.80	3074.17
SNL-15	CUL	07/11/17	501.70	2978.23	3075.93
SNL-15	CUL	08/08/17	501.15	2978.78	3076.61
SNL-15	CUL	09/14/17	500.33	2979.60	3077.62
SNL-15	CUL	10/03/17	500.00	2979.93	3078.03
SNL-15	CUL	11/09/17	499.25	2980.68	3078.95
SNL-15	CUL	12/12/17	498.64	2981.29	3079.70

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-16	CUL	01/05/17	121.64	3011.36	3012.63
SNL-16	CUL	02/07/17	122.15	3010.85	3012.11
SNL-16	CUL	03/13/17	122.88	3010.12	3011.37
SNL-16	CUL	04/03/17	122.78	3010.22	3011.47
SNL-16	CUL	05/24/17	123.41	3009.59	3010.83
SNL-16	CUL	06/05/17	123.45	3009.55	3010.79
SNL-16	CUL	07/10/17	123.67	3009.33	3010.57
SNL-16	CUL	08/07/17	124.07	3008.93	3010.16
SNL-16	CUL	09/13/17	124.05	3008.95	3010.18
SNL-16	CUL	10/02/17	124.10	3008.90	3010.13
SNL-16	CUL	11/08/17	124.20	3008.80	3010.03
SNL-16	CUL	12/11/17	124.95	3008.05	3009.27
SNL-17	CUL	01/10/17	244.72	2993.34	2994.18
SNL-17	CUL	02/16/17	250.36	2987.70	2988.49
SNL-17	CUL	03/16/17	247.18	2990.88	2991.70
SNL-17	CUL	04/03/17	246.55	2991.51	2992.33
SNL-17	CUL	05/24/17	247.80	2990.26	2991.07
SNL-17	CUL	06/06/17	244.66	2993.40	2994.24
SNL-17	CUL	07/11/17	249.41	2988.65	2989.45
SNL-17	CUL	08/07/17	245.70	2992.36	2993.19
SNL-17	CUL	09/15/17	244.44	2993.62	2994.46
SNL-17	CUL	10/02/17	241.07	2996.99	2997.86
SNL-17	CUL	11/08/17	240.57	2997.49	2998.36
SNL-17	CUL	12/11/17	243.06	2995.00	2995.85
SNL-18	CUL	01/04/17	305.81	3069.63	3072.08
SNL-18	CUL	02/07/17	305.98	3069.46	3071.91
SNL-18	CUL	03/13/17	306.39	3069.05	3071.50
SNL-18	CUL	04/03/17	306.38	3069.06	3071.51
SNL-18	CUL	05/24/17	304.91	3070.53	3072.99
SNL-18	CUL	06/05/17	305.00	3070.44	3072.90
SNL-18	CUL	07/10/17	304.93	3070.51	3072.97
SNL-18	CUL	08/07/17	304.67	3070.77	3073.24
SNL-18	CUL	09/13/17	305.05	3070.39	3072.85
SNL-18	CUL	10/02/17	305.26	3070.18	3072.64
SNL-18	CUL	11/08/17	305.58	3069.86	3072.32

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-18	CUL	12/11/17	305.70	3069.74	3072.20
SNL-19	CUL	01/05/17	153.79	3068.86	3070.07
SNL-19	CUL	02/07/17	154.44	3068.21	3069.41
SNL-19	CUL	03/13/17	154.80	3067.85	3069.05
SNL-19	CUL	04/03/17	154.68	3067.97	3069.17
SNL-19	CUL	05/24/17	153.79	3068.86	3070.07
SNL-19	CUL	06/05/17	154.00	3068.65	3069.86
SNL-19	CUL	07/10/17	154.20	3068.45	3069.66
SNL-19	CUL	08/07/17	154.40	3068.25	3069.45
SNL-19	CUL	09/13/17	154.66	3067.99	3069.19
SNL-19	CUL	10/02/17	154.68	3067.97	3069.17
SNL-19	CUL	11/08/17	155.05	3067.60	3068.80
SNL-19	CUL	12/11/17	155.70	3066.95	3068.15
WIPP-11	CUL	01/10/17	367.25	3060.53	3079.17
WIPP-11	CUL	02/08/17	367.34	3060.44	3079.08
WIPP-11	CUL	03/15/17	367.65	3060.13	3078.75
WIPP-11	CUL	04/04/17	367.49	3060.29	3078.92
WIPP-11	CUL	05/25/17	367.11	3060.67	3079.32
WIPP-11	CUL	06/06/17	367.32	3060.46	3079.10
WIPP-11	CUL	07/11/17	367.16	3060.62	3079.26
WIPP-11	CUL	08/08/17	367.21	3060.57	3079.21
WIPP-11	CUL	09/15/17	367.23	3060.55	3079.19
WIPP-11	CUL	10/04/17	367.45	3060.33	3078.96
WIPP-11	CUL	11/09/17	367.48	3060.30	3078.93
WIPP-11	CUL	12/12/17	367.87	3059.91	3078.53
WIPP-13	CUL	01/11/17	344.46	3061.21	3074.19
WIPP-13	CUL	02/17/17	344.46	3061.21	3074.19
WIPP-13	CUL	03/16/17	344.82	3060.85	3073.82
WIPP-13	CUL	04/04/17	344.73	3060.94	3073.91
WIPP-13	CUL	05/25/17	344.43	3061.24	3074.22
WIPP-13	CUL	06/07/17	344.56	3061.11	3074.09
WIPP-13	CUL	07/17/17	344.43	3061.24	3074.22
WIPP-13	CUL	08/08/17	344.38	3061.29	3074.27
WIPP-13	CUL	09/15/17	344.32	3061.35	3074.34
WIPP-13	CUL	10/04/17	344.63	3061.04	3074.02

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
WIPP-13	CUL	11/09/17	344.63	3061.04	3074.02
WIPP-13	CUL	12/13/17	344.68	3060.99	3073.96
WIPP-19	CUL	01/11/17	398.69	3036.42	3055.73
WIPP-19	CUL	02/16/17	398.95	3036.16	3055.46
WIPP-19	CUL	03/15/17	399.18	3035.14	3054.38
WIPP-19	CUL	04/05/17	399.38	3034.94	3054.18
WIPP-19	CUL	05/26/17	398.62	3035.70	3054.97
WIPP-19	CUL	06/08/17	400.41	3033.91	3053.09
WIPP-19	CUL	07/17/17	398.81	3035.51	3054.77
WIPP-19	CUL	08/09/17	398.66	3035.66	3054.93
WIPP-19	CUL	09/15/17	392.57	3041.75	3061.34
WIPP-19	CUL	10/04/17	398.75	3035.57	3054.84
WIPP-19	CUL	11/10/17	398.54	3035.78	3055.06
WIPP-19	CUL	12/13/17	399.71	3034.61	3053.83
WQSP-1	CUL	01/11/17	362.97	3056.28	3073.46
WQSP-1	CUL	02/17/17	363.00	3056.25	3073.43
WQSP-1	CUL	03/15/17	363.47	3055.78	3072.94
WQSP-1	CUL	04/04/17	363.27	3055.98	3073.15
WQSP-1	CUL	05/25/17	363.04	3056.21	3073.39
WQSP-1	CUL	06/07/17	363.19	3056.06	3073.23
WQSP-1	CUL	07/17/17	363.07	3056.18	3073.36
WQSP-1	CUL	08/08/17	363.04	3056.21	3073.39
WQSP-1	CUL	09/18/17	363.12	3056.13	3073.31
WQSP-1	CUL	10/04/17	363.31	3055.94	3073.11
WQSP-1	CUL	11/10/17	363.30	3055.95	3073.12
WQSP-1	CUL	12/14/17	363.38	3055.87	3073.03
WQSP-2	CUL	01/11/17	403.42	3060.45	3080.69
WQSP-2	CUL	02/16/17	403.57	3060.30	3080.53
WQSP-2	CUL	03/15/17	403.87	3060.00	3080.22
WQSP-2	CUL	04/04/17	403.73	3060.14	3080.36
WQSP-2	CUL	05/26/17	403.51	3060.36	3080.59
WQSP-2	CUL	06/08/17	403.59	3060.28	3080.51
WQSP-2	CUL	07/17/17	403.52	3060.35	3080.58
WQSP-2	CUL	08/08/17	403.52	3060.35	3080.58
WQSP-2	CUL	09/15/17	403.48	3060.39	3080.63

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
WQSP-2	CUL	10/04/17	403.78	3060.09	3080.31
WQSP-2	CUL	11/10/17	403.80	3060.07	3080.29
WQSP-2	CUL	12/13/17	403.71	3060.16	3080.39
WQSP-3	CUL	01/11/17	469.04	3011.10	3067.38
WQSP-3	CUL	02/16/17	469.05	3011.09	3067.36
WQSP-3	CUL	03/15/17	469.18	3010.96	3067.22
WQSP-3	CUL	04/03/17	468.54	3011.60	3067.95
WQSP-3	CUL	05/26/17	469.60	3010.54	3066.73
WQSP-3	CUL	06/08/17	469.64	3010.50	3066.69
WQSP-3	CUL	07/10/17	469.52	3010.62	3066.83
WQSP-3	CUL	08/08/17	469.61	3010.53	3066.72
WQSP-3	CUL	09/15/17	469.70	3010.44	3066.62
WQSP-3	CUL	10/04/17	469.86	3010.28	3066.44
WQSP-3	CUL	11/10/17	469.88	3010.26	3066.41
WQSP-3	CUL	12/13/17	469.49	3010.65	3066.86
WQSP-4	CUL	01/11/17	478.43	2954.66	2977.65
WQSP-4	CUL	02/16/17	478.87	2954.22	2977.17
WQSP-4	CUL	03/15/17	480.87	2952.22	2975.02
WQSP-4	CUL	04/04/17	480.30	2952.79	2975.63
WQSP-4	CUL	05/25/17	481.93	2951.16	2973.88
WQSP-4	CUL	06/08/17	481.72	2951.37	2974.11
WQSP-4	CUL	07/12/17	479.96	2953.13	2976.00
WQSP-4	CUL	08/09/17	479.29	2953.80	2976.72
WQSP-4	CUL	09/18/17	476.78	2956.31	2979.42
WQSP-4	CUL	10/04/17	475.66	2957.43	2980.63
WQSP-4	CUL	11/10/17	472.46	2960.63	2984.07
WQSP-4	CUL	12/13/17	470.12	2962.97	2986.59
WQSP-5	CUL	01/11/17	414.43	2969.95	2976.79
WQSP-5	CUL	02/16/17	415.11	2969.27	2976.09
WQSP-5	CUL	03/15/17	416.07	2968.31	2975.10
WQSP-5	CUL	04/04/17	416.42	2967.96	2974.74
WQSP-5	CUL	05/25/17	417.41	2966.97	2973.73
WQSP-5	CUL	06/06/17	417.98	2966.40	2973.14
WQSP-5	CUL	07/12/17	418.07	2966.31	2973.05
WQSP-5	CUL	08/09/17	416.31	2968.07	2974.86

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
WQSP-5	CUL	04/04/17	416.42	2967.96	2974.74
WQSP-5	CUL	10/04/17	414.54	2969.84	2976.68
WQSP-5	CUL	11/10/17	411.90	2972.48	2979.39
WQSP-5	CUL	12/14/17	409.63	2974.75	2981.72
WQSP-6	CUL	01/11/17	373.56	2991.16	2994.74
WQSP-6	CUL	02/16/17	374.14	2990.58	2994.15
WQSP-6	CUL	03/15/17	374.61	2990.11	2993.67
WQSP-6	CUL	04/04/17	374.83	2989.89	2993.45
WQSP-6	CUL	05/25/17	376.70	2988.02	2991.55
WQSP-6	CUL	06/07/17	376.48	2988.24	2991.77
WQSP-6	CUL	07/12/17	376.42	2988.30	2991.83
WQSP-6	CUL	08/09/17	375.79	2988.93	2992.47
WQSP-6	CUL	09/18/17	375.39	2989.33	2992.88
WQSP-6	CUL	10/04/17	374.90	2989.82	2993.38
WQSP-6	CUL	11/10/17	373.38	2991.34	2994.92
WQSP-6	CUL	12/14/17	371.64	2993.08	2996.69
C-2737 (ANNULUS)	MAG	01/11/17	247.69	3153.07	(a)
C-2737 (ANNULUS)	MAG	02/16/17	247.50	3153.26	(a)
C-2737 (ANNULUS)	MAG	03/15/17	247.35	3153.41	(a)
C-2737 (ANNULUS)	MAG	04/05/17	247.13	3153.63	(a)
C-2737 (ANNULUS)	MAG	05/26/17	246.75	3154.01	(a)
C-2737 (ANNULUS)	MAG	06/08/17	246.84	3153.92	(a)
C-2737 (ANNULUS)	MAG	07/17/17	246.64	3154.12	(a)
C-2737 (ANNULUS)	MAG	08/09/17	246.55	3154.21	(a)
C-2737 (ANNULUS)	MAG	09/18/17	244.68	3156.08	(a)
C-2737 (ANNULUS)	MAG	10/04/17	246.23	3154.53	(a)
C-2737 (ANNULUS)	MAG	11/10/17	246.06	3154.70	(a)
C-2737 (ANNULUS)	MAG	12/14/17	245.83	3154.93	(a)
H-02b1	MAG	01/11/17	232.53	3145.96	(a)
H-02b1	MAG	02/16/17	232.59	3145.90	(a)
H-02b1	MAG	03/16/17	232.28	3146.21	(a)
H-02b1	MAG	04/05/17	232.16	3146.33	(a)
H-02b1	MAG	05/25/17	231.95	3146.54	(a)
H-02b1	MAG	06/07/17	231.94	3146.55	(a)
H-02b1	MAG	07/17/17	231.84	3146.65	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-02b1	MAG	08/08/17	231.82	3146.67	(a)
H-02b1	MAG	09/18/17	231.62	3146.87	(a)
H-02b1	MAG	10/02/17	231.59	3146.90	(a)
H-02b1	MAG	11/09/17	231.43	3147.06	(a)
H-02b1	MAG	12/13/17	231.32	3147.17	(a)
H-03b1	MAG	01/11/17	235.29	3155.43	(a)
H-03b1	MAG	02/16/17	235.08	3155.64	(a)
H-03b1	MAG	03/15/17	234.89	3155.83	(a)
H-03b1	MAG	09/18/17	233.89	3156.83	(a)
H-03b1	MAG	05/26/17	234.39	3156.33	(a)
H-03b1	MAG	06/08/17	234.43	3156.29	(a)
H-03b1	MAG	07/17/17	234.27	3156.45	(a)
H-03b1	MAG	08/09/17	234.14	3156.58	(a)
H-03b1	MAG	09/18/17	233.89	3156.83	(a)
H-03b1	MAG	10/04/17	233.82	3156.90	(a)
H-03b1	MAG	11/09/17	233.72	3157.00	(a)
H-03b1	MAG	12/14/17	233.56	3157.16	(a)
H-04c	MAG	01/10/17	185.33	3148.95	(a)
H-04c	MAG	02/16/17	185.43	3148.85	(a)
H-04c	MAG	03/14/17	185.38	3148.90	(a)
H-04c	MAG	04/05/17	185.20	3149.08	(a)
H-04c	MAG	05/25/17	185.39	3148.89	(a)
H-04c	MAG	06/06/17	185.42	3148.86	(a)
H-04c	MAG	07/12/17	186.51	3147.77	(a)
H-04c	MAG	08/09/17	185.51	3148.77	(a)
H-04c	MAG	09/18/17	185.62	3148.66	(a)
H-04c	MAG	10/04/17	185.59	3148.69	(a)
H-04c	MAG	11/10/17	185.63	3148.65	(a)
H-04c	MAG	12/12/17	185.79	3148.49	(a)
H-06c	MAG	01/10/17	276.73	3071.96	(a)
H-06c	MAG	02/08/17	276.70	3071.99	(a)
H-06c	MAG	03/14/17	276.84	3071.85	(a)
H-06c	MAG	04/04/17	276.63	3072.06	(a)
H-06c	MAG	05/25/17	276.70	3071.99	(a)
H-06c	MAG	06/06/17	276.94	3071.75	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-06c	MAG	07/11/17	277.04	3071.65	(a)
H-06c	MAG	08/08/17	277.20	3071.49	(a)
H-06c	MAG	09/15/17	277.11	3071.58	(a)
H-06c	MAG	10/04/17	277.23	3071.46	(a)
H-06c	MAG	11/09/17	277.29	3071.40	(a)
H-06c	MAG	12/12/17	277.43	3071.26	(a)
H-08a	MAG	01/05/17	404.14	3029.14	(a)
H-08a	MAG	02/07/17	404.16	3029.12	(a)
H-08a	MAG	03/13/17	404.18	3029.10	(a)
H-08a	MAG	04/03/17	404.16	3029.12	(a)
H-08a	MAG	05/24/17	404.26	3029.02	(a)
H-08a	MAG	06/05/17	404.27	3029.01	(a)
H-08a	MAG	07/11/17	404.43	3028.85	(a)
H-08a	MAG	08/07/17	404.42	3028.86	(a)
H-08a	MAG	09/14/17	404.47	3028.81	(a)
H-08a	MAG	10/02/17	404.49	3028.79	(a)
H-08a	MAG	11/08/17	404.52	3028.76	(a)
H-08a	MAG	12/11/17	404.64	3028.64	(a)
H-09c	MAG	01/05/17	271.75	3135.30	(a)
H-09c	MAG	02/07/17	271.81	3135.24	(a)
H-09c	MAG	03/13/17	272.03	3135.02	(a)
H-09c	MAG	04/03/17	271.82	3135.23	(a)
H-09c	MAG	05/24/17	271.93	3135.12	(a)
H-09c	MAG	06/05/17	271.80	3135.25	(a)
H-09c	MAG	07/11/17	271.68	3135.37	(a)
H-09c	MAG	08/07/17	271.53	3135.52	(a)
H-09c	MAG	09/14/17	271.51	3135.54	(a)
H-09c	MAG	10/02/17	271.46	3135.59	(a)
H-09c	MAG	11/08/17	271.81	3135.24	(a)
H-09c	MAG	12/11/17	272.08	3134.97	(a)
H-10a	MAG	01/05/17	576.21	3112.24	(a)
H-10a	MAG	02/07/17	576.06	3112.39	(a)
H-10a	MAG	03/14/17	576.05	3112.40	(a)
H-10a	MAG	04/03/17	576.00	3112.45	(a)
H-10a	MAG	05/24/17	576.15	3112.30	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-10a	MAG	06/05/17	576.22	3112.23	(a)
H-10a	MAG	07/11/17	576.15	3112.30	(a)
H-10a	MAG	08/07/17	576.32	3112.13	(a)
H-10a	MAG	09/14/17	576.26	3112.19	(a)
H-10a	MAG	10/03/17	577.37	3111.08	(a)
H-10a	MAG	11/08/17	576.28	3112.17	(a)
H-10a	MAG	12/11/17	576.38	3112.07	(a)
H-11b2	MAG	01/10/17	265.55	3146.31	(a)
H-11b2	MAG	02/16/17	265.38	3146.48	(a)
H-11b2	MAG	03/14/17	265.21	3146.65	(a)
H-11b2	MAG	04/04/17	264.97	3146.89	(a)
H-11b2	MAG	05/25/17	264.73	3147.13	(a)
H-11b2	MAG	06/06/17	264.86	3147.00	(a)
H-11b2	MAG	07/11/17	264.67	3147.19	(a)
H-11b2	MAG	08/08/17	264.63	3147.23	(a)
H-11b2	MAG	09/14/17	264.51	3147.35	(a)
H-11b2	MAG	10/03/17	264.38	3147.48	(a)
H-11b2	MAG	11/09/17	264.43	3147.43	(a)
H-11b2	MAG	12/12/17	264.42	3147.44	(a)
H-14	MAG	01/10/17	205.05	3142.03	(a)
H-14	MAG	02/08/17	205.24	3141.84	(a)
H-14	MAG	03/14/17	205.26	3141.82	(a)
H-14	MAG	04/04/17	205.28	3141.80	(a)
H-14	MAG	05/25/17	205.29	3141.79	(a)
H-14	MAG	06/06/17	205.29	3141.79	(a)
H-14	MAG	07/17/17	205.31	3141.77	(a)
H-14	MAG	08/08/17	205.32	3141.76	(a)
H-14	MAG	09/15/17	205.31	3141.77	(a)
H-14	MAG	10/03/17	205.39	3141.69	(a)
H-14	MAG	11/09/17	205.22	3141.86	(a)
H-14	MAG	12/12/17	205.35	3141.73	(a)
H-15	MAG	01/11/17	310.52	3173.26	(a)
H-15	MAG	02/16/17	310.85	3172.93	(a)
H-15	MAG	03/15/17	311.24	3172.54	(a)
H-15	MAG	04/05/17	311.47	3172.31	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-15	MAG	05/26/17	311.49	3172.29	(a)
H-15	MAG	06/08/17	311.92	3171.86	(a)
H-15	MAG	07/17/17	312.21	3171.57	(a)
H-15	MAG	08/09/17	312.41	3171.37	(a)
H-15	MAG	09/18/17	312.68	3171.10	(a)
H-15	MAG	10/05/17	312.53	3171.25	(a)
H-15	MAG	11/10/17	313.04	3170.74	(a)
H-15	MAG	12/13/17	313.20	3170.58	(a)
H-18	MAG	01/11/17	253.89	3160.32	(a)
H-18	MAG	02/17/17	253.78	3160.43	(a)
H-18	MAG	03/15/17	253.95	3160.26	(a)
H-18	MAG	04/04/17	253.04	3161.17	(a)
H-18	MAG	05/25/17	253.58	3160.63	(a)
H-18	MAG	06/07/17	253.79	3160.42	(a)
H-18	MAG	07/17/17	253.74	3160.47	(a)
H-18	MAG	08/08/17	253.70	3160.51	(a)
H-18	MAG	09/18/17	253.64	3160.57	(a)
H-18	MAG	10/04/17	253.62	3160.59	(a)
H-18	MAG	11/10/17	253.55	3160.66	(a)
H-18	MAG	12/13/17	253.38	3160.83	(a)
WIPP-18	MAG	01/11/17	294.57	3163.00	(a)
WIPP-18	MAG	02/07/17	294.24	3163.33	(a)
WIPP-18	MAG	03/15/17	293.98	3163.59	(a)
WIPP-18	MAG	04/05/17	293.73	3163.84	(a)
WIPP-18	MAG	05/26/17	293.49	3164.08	(a)
WIPP-18	MAG	06/08/17	293.45	3164.12	(a)
WIPP-18	MAG	07/17/17	293.33	3164.24	(a)
WIPP-18	MAG	08/09/17	293.15	3164.42	(a)
WIPP-18	MAG	09/15/17	292.98	3164.59	(a)
WIPP-18	MAG	10/04/17	292.92	3164.65	(a)
WIPP-18	MAG	11/10/17	292.62	3164.95	(a)
WIPP-18	MAG	12/13/17	292.80	3164.77	(a)
WQSP-6a	DL	01/11/17	167.75	3196.05	(a)
WQSP-6a	DL	02/16/17	168.03	3195.77	(a)
WQSP-6a	DL	03/15/17	168.19	3195.61	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
WQSP-6a	DL	04/04/17	167.90	3195.90	(a)
WQSP-6a	DL	05/25/17	167.95	3195.85	(a)
WQSP-6a	DL	06/07/17	168.21	3195.59	(a)
WQSP-6a	DL	07/12/17	169.17	3194.63	(a)
WQSP-6a	DL	08/09/17	168.28	3195.52	(a)
WQSP-6a	DL	09/18/17	168.21	3195.59	(a)
WQSP-6a	DL	10/04/17	168.39	3195.41	(a)
WQSP-6a	DL	11/10/17	168.21	3195.59	(a)
WQSP-6a	DL	12/14/17	168.04	3195.76	(a)
CB-1	B/C	01/10/17	293.95	3035.17	(a)
CB-1	B/C	02/16/17	293.67	3035.45	(a)
CB-1	B/C	03/14/17	293.53	3035.59	(a)
CB-1	B/C	04/04/17	293.10	3036.02	(a)
CB-1	B/C	05/25/17	292.70	3036.42	(a)
CB-1	B/C	06/06/17	292.79	3036.33	(a)
CB-1	B/C	07/11/17	292.39	3036.73	(a)
CB-1	B/C	08/08/17	292.10	3037.02	(a)
CB-1	B/C	09/14/17	291.63	3037.49	(a)
CB-1	B/C	10/03/17	291.43	3037.69	(a)
CB-1	B/C	11/09/17	291.09	3038.03	(a)
CB-1	B/C	12/12/17	290.91	3038.21	(a)
DOE-2	B/C	01/11/17	349.84	3069.34	(a)
DOE-2	B/C	02/17/17	349.82	3069.36	(a)
DOE-2	B/C	03/15/17	349.87	3069.31	(a)
DOE-2	B/C	04/04/17	349.69	3069.49	(a)
DOE-2	B/C	05/28/17	349.91	3069.27	(a)
DOE-2	B/C	06/07/17	350.08	3069.10	(a)
DOE-2	B/C	07/11/17	350.16	3069.02	(a)
DOE-2	B/C	08/08/17	350.13	3069.05	(a)
DOE-2	B/C	09/15/17	350.20	3068.98	(a)
DOE-2	B/C	10/04/17	350.14	3069.04	(a)
DOE-2	B/C	11/09/17	350.19	3068.99	(a)
DOE-2	B/C	12/13/17	350.20	3068.98	(a)
C-2505	SR/DL	03/16/17	43.99	3368.94	(a)
C-2505	SR/DL	06/07/17	44.18	3368.75	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
C-2505	SR/DL	09/18/17	44.38	3368.55	(a)
C-2505	SR/DL	12/14/17	44.49	3368.44	(a)
C-2506	SR/DL	03/16/17	43.28	3369.56	(a)
C-2506	SR/DL	06/07/17	43.43	3369.41	(a)
C-2506	SR/DL	09/18/17	43.62	3369.22	(a)
C-2506	SR/DL	12/14/17	43.75	3369.09	(a)
C-2507	SR/DL	03/16/17	43.92	3365.99	(a)
C-2507	SR/DL	06/07/17	44.04	3365.87	(a)
C-2507	SR/DL	09/18/17	44.22	3365.69	(a)
C-2507	SR/DL	12/14/17	44.35	3365.56	(a)
C-2811	SR/DL	03/15/17	49.37	3349.47	(a)
C-2811	SR/DL	06/08/17	49.75	3349.09	(a)
C-2811	SR/DL	09/18/17	50.48	3348.36	(a)
C-2811	SR/DL	12/14/17	50.89	3347.95	(a)
PZ-01	SR/DL	03/16/17	40.98	3372.30	(a)
PZ-01	SR/DL	06/07/17	41.09	3372.19	(a)
PZ-01	SR/DL	09/18/17	41.21	3372.07	(a)
PZ-01	SR/DL	12/14/17	41.30	3371.98	(a)
PZ-02	SR/DL	03/16/17	41.37	3371.99	(a)
PZ-02	SR/DL	06/07/17	41.59	3371.77	(a)
PZ-02	SR/DL	09/18/17	41.75	3371.61	(a)
PZ-02	SR/DL	12/14/17	41.89	3371.47	(a)
PZ-03	SR/DL	03/16/17	43.78	3372.34	(a)
PZ-03	SR/DL	06/07/17	43.91	3372.21	(a)
PZ-03	SR/DL	09/20/17	44.03	3372.09	(a)
PZ-03	SR/DL	12/14/17	44.16	3371.96	(a)
PZ-04	SR/DL	03/16/17	44.45	3367.56	(a)
PZ-04	SR/DL	06/07/17	44.60	3367.41	(a)
PZ-04	SR/DL	09/18/17	44.79	3367.22	(a)
PZ-04	SR/DL	12/14/17	44.77	3367.24	(a)
PZ-05	SR/DL	03/16/17	42.18	3373.06	(a)
PZ-05	SR/DL	06/07/17	42.35	3372.89	(a)
PZ-05	SR/DL	09/20/17	42.58	3372.66	(a)
PZ-05	SR/DL	12/14/17	42.63	3372.61	(a)
PZ-06	SR/DL	03/16/17	42.35	3370.98	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
PZ-06	SR/DL	06/07/17	42.56	3370.77	(a)
PZ-06	SR/DL		Area Under Construction		
PZ-06	SR/DL	12/14/17	42.79	3370.54	(a)
PZ-07	SR/DL	03/15/17	35.78	3378.06	(a)
PZ-07	SR/DL	06/06/17	35.82	3378.02	(a)
PZ-07	SR/DL	09/18/17	35.93	3377.91	(a)
PZ-07	SR/DL	12/14/17	36.01	3377.83	(a)
PZ-08	SR/DL	03/15/17	62.65	3355.54	(a)
PZ-08	SR/DL	06/06/17	62.54	3355.65	(a)
PZ-08	SR/DL	09/18/17	62.31	3355.88	(a)
PZ-08	SR/DL	12/13/17	61.97	3356.22	(a)
PZ-09	SR/DL	03/15/17	58.74	3362.35	(a)
PZ-09	SR/DL	06/06/17	58.54	3362.55	(a)
PZ-09	SR/DL	09/18/17	58.25	3362.84	(a)
PZ-09	SR/DL	12/13/17	58.22	3362.87	(a)
PZ-10	SR/DL	03/15/17	36.45	3369.28	(a)
PZ-10	SR/DL	06/06/17	36.95	3368.78	(a)
PZ-10	SR/DL	09/18/17	37.05	3368.68	(a)
PZ-10	SR/DL	12/14/17	36.94	3368.79	(a)
PZ-11	SR/DL	03/15/17	42.71	3376.07	(a)
PZ-11	SR/DL	06/06/17	43.05	3375.73	(a)
PZ-11	SR/DL	09/18/17	43.72	3375.06	(a)
PZ-11	SR/DL	12/14/17	44.21	3374.57	(a)
PZ-12	SR/DL	03/15/17	49.92	3359.00	(a)
PZ-12	SR/DL	06/06/17	51.13	3357.79	(a)
PZ-12	SR/DL	09/18/17	51.52	3357.40	(a)
PZ-12	SR/DL	12/14/17	51.45	3357.47	(a)
PZ-13	SR/DL	03/15/17	67.49	3354.75	(a)
PZ-13	SR/DL	06/08/17	65.21	3357.03	(a)
PZ-13	SR/DL	09/18/17	64.83	3357.41	(a)
PZ-13	SR/DL	12/13/17	64.51	3357.73	(a)
PZ-14	SR/DL	03/15/17	67.77	3352.81	(a)
PZ-14	SR/DL	06/08/17	66.93	3353.65	(a)
PZ-14	SR/DL	09/18/17	66.62	3353.96	(a)
PZ-14	SR/DL	12/13/17	66.34	3354.24	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
PZ-15	SR/DL	03/15/17	46.74	3384.12	(a)
PZ-15	SR/DL	06/08/17	46.93	3383.93	(a)
PZ-15	SR/DL	09/18/17	47.10	3383.76	(a)
PZ-15	SR/DL	12/13/17	47.13	3383.73	(a)

Notes:

amsl Above mean sea level.

ft Feet or foot.

NA Not Available.

(a) Not Applicable.

(b) Top of casing changed; now measured from top of casing with straight edge.

APPENDIX G – AIR SAMPLING DATA: CONCENTRATIONS OF RADIONUCLIDES IN AIR FILTER COMPOSITES

Table G.1 – 2017 Radionuclide Concentrations in Quarterly Air Filter Composite Samples Collected from Locations Surrounding the WIPP Site

Location	Quarter	[RN](a)	2 σ TPU(b)	MDC(c)	Q(d)	[RN](a)	2 σ TPU(b)	MDC(c)	Q(d)	[RN](a)	2 σ TPU(b)	MDC(c)	Q(d)
		$^{233/234}$U				^{235}U				^{238}U			
WFF	1	1.14E-03	3.38E-03	1.03E-02	U	1.09E-04	8.12E-04	1.32E-03	U	1.10E-03	2.75E-03	9.56E-03	U
	2	3.60E-03	4.19E-03	1.05E-02	U	3.87E-04	8.26E-04	1.51E-03	U	4.63E-03	3.75E-03	9.57E-03	U
	3	-1.44E-03	4.61E-03	1.07E-02	UJ	-8.71E-04	4.21E-03	1.57E-03	UJ	6.89E-05	1.33E-03	1.04E-02	UJ
	4	5.88E-03	3.75E-03	1.02E-02	U	2.17E-04	7.72E-04	1.51E-03	U	3.54E-03	3.94E-03	9.66E-03	U
WEE	1	3.51E-03	3.55E-03	1.03E-02	U	7.04E-05	8.33E-04	1.38E-03	U	3.13E-03	2.92E-03	9.56E-03	U
	2	1.12E-03	3.92E-03	1.05E-02	U	3.86E-04	7.81E-04	1.45E-03	U	6.13E-03	3.84E-03	9.56E-03	U
	3	-1.48E-03	4.73E-03	1.07E-02	UJ	-1.00E-03	4.05E-03	1.68E-03	UJ	-1.38E-05	2.02E-03	1.04E-02	UJ
	4	5.67E-03	3.64E-03	1.02E-02	U	3.82E-04	7.95E-04	1.47E-03	U	5.74E-03	4.07E-03	9.64E-03	U
WSS	1 (Avg)	3.96E-03	3.74E-03	1.04E-02	U	7.43E-04	2.42E-03	1.58E-03	U	4.57E-03	3.17E-03	9.58E-03	U
	2	4.11E-03	4.21E-03	1.05E-02	U	1.02E-03	1.06E-03	1.50E-03	U	6.31E-03	3.89E-03	9.56E-03	U
	3	-1.82E-03	4.52E-03	1.07E-02	UJ	-7.75E-04	3.77E-03	1.58E-03	UJ	-2.45E-04	1.79E-03	1.04E-02	UJ
	4	6.77E-03	3.64E-03	1.01E-02	U	4.79E-04	8.23E-04	1.43E-03	U	2.43E-03	3.65E-03	9.61E-03	U
MLR	1	4.78E-03	3.91E-03	1.04E-02	U	2.41E-04	8.98E-04	1.39E-03	U	5.17E-03	3.33E-03	9.61E-03	U
	2 (Avg)	3.84E-03	4.28E-03	1.05E-02	U	2.99E-04	7.95E-04	1.53E-03	U	5.78E-03	3.94E-03	9.59E-03	U
	3	6.30E-04	1.43E-02	1.23E-02	UJ	1.40E-03	1.68E-02	5.27E-03	UJ	-5.72E-04	5.47E-03	1.23E-02	UJ
	4	3.98E-03	3.18E-03	1.01E-02	U	2.70E-04	6.82E-04	1.36E-03	U	1.82E-03	3.43E-03	9.57E-03	U
SEC	1	1.94E-03	3.44E-03	1.03E-02	U	7.15E-04	9.41E-04	1.30E-03	U	5.03E-03	3.11E-03	9.57E-03	U
	2	5.08E-03	4.29E-03	1.05E-02	U	2.43E-04	7.31E-04	1.47E-03	U	6.08E-03	3.88E-03	9.58E-03	U
	3 (Avg)	-2.12E-03	1.28E-02	1.17E-02	UJ	-2.31E-03	1.51E-02	4.46E-03	UJ	2.90E-04	5.30E-03	1.17E-02	UJ
	4	7.62E-03	4.30E-03	1.03E-02	U	3.29E-04	8.66E-04	1.62E-03	U	7.40E-03	4.71E-03	9.74E-03	U

Location	Quarter	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
CBD	1	6.74E-03	3.99E-03	1.04E-02	U	8.14E-04	1.06E-03	1.40E-03	U	7.93E-03	3.58E-03	9.64E-03	U
	2	8.53E-03	5.03E-03	1.06E-02	U	9.25E-04	1.09E-03	1.57E-03	U	8.49E-03	4.51E-03	9.64E-03	U
	3	4.29E-04	2.07E-02	1.38E-02	UJ	3.57E-04	2.38E-02	7.50E-03	UJ	3.81E-03	2.46E-02	1.36E-02	UJ
	4 (Avg)	8.72E-03	3.93E-03	1.02E-02	U	2.15E-04	7.09E-04	1.44E-03	U	5.82E-03	4.01E-03	9.63E-03	U
SMR	1	2.44E-03	3.51E-03	1.04E-02	U	-2.15E-04	7.93E-04	1.48E-03	U	6.18E-03	3.26E-03	9.61E-03	U
	2	2.41E-03	4.19E-03	1.06E-02	U	4.24E-04	8.55E-04	1.52E-03	U	6.72E-03	4.08E-03	9.59E-03	U
	3	-1.41E-03	4.66E-03	1.07E-02	UJ	-1.80E-04	3.57E-03	1.55E-03	UJ	8.17E-06	2.13E-03	1.04E-02	UJ
	4	5.65E-03	3.46E-03	1.01E-02	U	1.65E-04	6.74E-04	1.40E-03	U	5.49E-03	3.86E-03	9.60E-03	U
Mean		3.22E-03	5.28E-03	1.06E-02	NA	1.73E-04	3.23E-03	1.94E-03	NA	4.03E-03	4.30E-03	1.00E-02	NA
Minimum[e]		-2.12E-03	1.28E-02	1.17E-02	SEC (3)	-2.31E-03	1.51E-02	4.46E-03	SEC (3)	-5.72E-04	5.47E-03	1.23E-02	MLR (3)
Maximum[e]		8.72E-03	3.93E-03	1.02E-02	CBD (4)	1.40E-03	1.68E-02	5.27E-03	MLR (3)	8.49E-03	4.51E-03	9.64E-03	CBD (2)
WAB (Filter Blank)	1	9.44E-03	2.36E-03	1.03E-02	U	5.40E-04	6.19E-04	1.32E-03	U	6.85E-03	1.89E-03	9.56E-03	U
	2	1.04E-02	2.61E-03	1.05E-02	U	2.41E-04	4.34E-04	1.41E-03	U	8.05E-03	2.21E-03	9.51E-03	U
	3	3.04E-03	1.05E-02	1.39E-02	UJ	2.96E-03	1.22E-02	8.51E-03	UJ	-3.56E-04	2.11E-03	1.40E-02	UJ
	4	7.28E-03	2.04E-03	1.01E-02	U	2.42E-04	4.11E-04	1.37E-03	U	9.30E-03	2.37E-03	9.57E-03	U
		^{238}Pu				$^{239/240}$PU				^{241}Am			
WFF	1	7.10E-06	4.31E-04	9.03E-04	U	-2.52E-05	5.22E-04	9.28E-04	U	-3.15E-04	4.76E-04	1.02E-03	U
	2	9.45E-06	3.05E-04	7.79E-04	U	2.64E-05	3.69E-04	1.04E-03	U	5.71E-06	4.41E-04	1.07E-03	U
	3	1.94E-04	3.97E-04	7.59E-04	U	-8.44E-05	3.73E-04	9.72E-04	U	2.80E-04	6.17E-04	1.09E-03	U
	4	-2.37E-05	4.01E-04	7.41E-04	U	2.11E-04	3.44E-04	9.10E-04	U	-1.01E-05	4.63E-04	1.07E-03	U
WEE	1	-3.53E-05	4.77E-04	8.51E-04	U	-2.42E-05	5.24E-04	9.30E-04	U	-2.73E-05	6.41E-04	1.12E-03	U
	2	-2.02E-04	3.07E-04	8.00E-04	U	1.75E-04	3.93E-04	9.48E-04	U	-1.27E-05	4.18E-04	1.01E-03	U
	3	-1.61E-04	3.54E-04	9.09E-04	U	4.10E-04	6.45E-04	1.02E-03	U	-2.19E-05	5.51E-04	1.13E-03	U
	4	-1.68E-04	3.63E-04	7.91E-04	U	-5.51E-05	2.03E-04	9.53E-04	U	1.54E-04	5.41E-04	1.07E-03	U
WSS	1 (Avg)	1.05E-05	4.03E-04	8.71E-04	U	-1.54E-04	4.75E-04	9.28E-04	U	-2.23E-04	5.65E-04	1.06E-03	U
	2	-3.29E-05	3.43E-04	8.22E-04	U	-1.05E-04	2.47E-04	9.78E-04	U	9.26E-05	5.52E-04	1.09E-03	U
	3	-1.02E-04	2.46E-04	7.79E-04	U	1.41E-05	4.62E-04	9.65E-04	U	3.74E-04	7.19E-04	1.13E-03	U

Location	Quarter	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
	4	-1.50E-04	3.39E-04	7.84E-04	U	1.62E-04	3.93E-04	9.30E-04	U	1.51E-05	4.02E-04	1.00E-03	U
MLR	1	-4.69E-05	2.64E-04	7.02E-04	U	2.04E-04	6.04E-04	9.18E-04	U	1.08E-04	6.34E-04	1.02E-03	U
	2 (Avg)	-1.69E-04	2.40E-04	8.82E-04	U	8.05E-05	3.91E-04	9.83E-04	U	4.50E-06	4.11E-04	1.01E-03	U
	3	6.95E-05	2.89E-04	7.51E-04	U	6.52E-05	4.30E-04	9.67E-04	U	-2.24E-05	5.49E-04	1.11E-03	U
	4	-2.82E-05	4.26E-04	7.93E-04	U	7.78E-05	3.11E-04	9.67E-04	U	-2.33E-04	4.86E-04	1.21E-03	U
SEC	1	-1.30E-04	3.85E-04	9.02E-04	U	-1.26E-04	4.52E-04	9.27E-04	U	-7.72E-06	5.98E-04	1.07E-03	U
	2	-4.75E-05	3.22E-04	7.43E-04	U	1.53E-04	3.57E-04	9.07E-04	U	1.52E-04	4.73E-04	1.02E-03	U
	3 (Avg)	-5.52E-05	2.96E-04	7.75E-04	U	2.43E-04	5.52E-04	9.97E-04	U	1.35E-04	6.24E-04	1.18E-03	U
	4	2.98E-04	6.93E-04	1.02E-03	U	3.26E-04	5.20E-04	1.03E-03	U	-3.54E-05	5.39E-04	1.23E-03	U
CBD	1	2.38E-05	4.44E-04	7.95E-04	U	2.60E-04	6.66E-04	1.01E-03	U	-1.80E-04	5.31E-04	1.02E-03	U
	2	-3.35E-05	3.23E-04	7.84E-04	U	8.75E-06	3.51E-04	9.38E-04	U	4.14E-05	4.39E-04	1.11E-03	U
	3	-6.42E-05	1.35E-04	7.49E-04	U	6.25E-05	4.31E-04	9.63E-04	U	2.06E-05	4.86E-04	1.05E-03	U
	4 (Avg)	-6.79E-05	4.41E-04	8.60E-04	U	7.52E-05	3.44E-04	9.95E-04	U	-7.79E-05	8.32E-04	1.32E-03	U
SMR	1	1.16E-04	4.94E-04	8.05E-04	U	-1.11E-04	4.31E-04	9.07E-04	U	3.95E-04	7.96E-04	1.10E-03	U
	2	3.05E-05	4.41E-04	9.68E-04	U	2.46E-04	4.55E-04	9.20E-04	U	-1.42E-04	3.57E-04	1.08E-03	U
	3	-1.04E-04	2.52E-04	7.80E-04	U	-7.15E-05	3.55E-04	9.25E-04	U	1.40E-04	6.58E-04	1.29E-03	U
	4	2.17E-04	5.10E-04	7.54E-04	U	5.15E-04	5.67E-04	9.42E-04	U	1.51E-04	7.83E-04	1.33E-03	U
Mean		-2.31E-05	3.69E-04	8.16E-04	NA	9.14E-05	4.35E-04	9.57E-04	NA	2.72E-05	5.56E-04	1.11E-03	NA
Minimum[e]		-2.02E-04	3.07E-04	8.00E-04	WEE (2)	-1.54E-04	4.75E-04	9.28E-04	WSS (1)	-3.15E-04	4.76E-04	1.02E-03	WFF (1)
Maximum[e]		2.98E-04	6.93E-04	1.02E-03	SEC (4)	5.15E-04	5.67E-04	9.42E-04	SMR (4)	3.95E-04	7.96E-04	1.10E-03	SMR (1)
WAB (Filter Blank)	1	3.53E-05	3.17E-04	8.34E-04	U	2.11E-04	3.65E-04	9.38E-04	U	2.62E-04	4.29E-04	1.07E-03	U
	2	-1.04E-04	2.23E-04	8.44E-04	U	-4.15E-05	1.41E-04	9.48E-04	U	7.95E-05	3.01E-04	1.04E-03	U
	3	-4.79E-05	1.63E-04	8.83E-04	U	2.98E-05	3.75E-04	1.07E-03	U	6.77E-05	4.19E-04	1.22E-03	U
	4	9.46E-05	2.77E-04	7.78E-04	U	-1.26E-05	7.80E-05	9.33E-04	U	9.26E-05	3.31E-04	1.09E-03	U

Location	Quarter	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
		^{40}K				^{60}Co				^{137}Cs			
WFF	1	5.21E+00	4.25E+00	6.54E+00	U	8.35E-01	7.30E-01	9.18E-01	U	-4.86E-01	7.70E-01	8.53E-01	U
	2	9.06E+00	7.68E+00	9.64E+00	U	3.37E-01	8.25E-01	9.58E-01	U	-2.22E-01	7.35E-01	8.41E-01	U
	3	4.38E+00	7.34E+00	8.75E+00	U	6.49E-01	7.02E-01	8.63E-01	U	-6.20E-01	7.07E-01	7.62E-01	U
	4	3.01E+00	7.72E+00	9.12E+00	U	5.06E-01	7.26E-01	8.91E-01	U	-4.84E-01	7.74E-01	8.55E-01	U
WEE	1	7.63E+00	7.26E+00	9.01E+00	U	-6.95E-02	7.38E-01	8.30E-01	U	-2.75E+00	8.56E-01	9.20E-01	U
	2	1.18E+01	6.93E+00	9.16E+00	U	2.26E-01	7.94E-01	9.30E-01	U	-6.30E-01	8.91E-01	9.17E-01	U
	3	1.93E+00	1.03E+01	1.21E+01	U	1.30E-01	9.47E-01	1.12E+00	U	-3.23E-01	9.44E-01	1.08E+00	U
	4	-6.45E-01	1.06E+01	1.08E+01	U	5.23E-01	9.44E-01	1.18E+00	U	-1.32E+00	9.21E-01	1.07E+00	U
WSS	1 (Avg)	9.21E+00	7.79E+00	9.67E+00	U	2.13E-01	7.81E-01	9.25E-01	U	1.03E-01	8.08E-01	9.22E-01	U
	2	3.16E+00	7.88E+00	9.07E+00	U	4.79E-01	7.24E-01	8.82E-01	U	1.09E-01	8.61E-01	9.60E-01	U
	3	7.72E+00	7.41E+00	8.91E+00	U	7.01E-01	8.55E-01	8.71E-01	U	1.03E-01	7.62E-01	8.49E-01	U
	4	9.98E+00	7.56E+00	9.87E+00	U	4.84E-01	7.23E-01	9.15E-01	U	-3.01E-01	7.73E-01	8.76E-01	U
MLR	1	8.83E-01	1.05E+01	1.25E+01	U	2.73E-01	9.66E-01	1.19E+00	U	8.46E-01	1.12E+00	1.40E+00	U
	2 (Avg)	6.59E+00	9.37E+00	1.19E+01	U	-6.90E-02	9.85E-01	1.11E+00	U	-3.85E-01	1.05E+00	1.18E+00	U
	3	8.44E+00	7.80E+00	9.63E+00	U	-2.50E-01	7.86E-01	8.81E-01	U	-3.48E-01	7.26E-01	8.17E-01	U
	4	4.54E+00	9.36E+00	1.22E+01	U	3.94E-01	9.96E-01	1.23E+00	U	2.50E-01	1.09E+00	1.33E+00	U
SEC	1	1.54E+00	7.66E+00	8.88E+00	U	-2.06E-02	7.42E-01	8.41E-01	U	-5.73E-03	7.40E-01	8.61E-01	U
	2	7.27E-01	1.01E+01	1.17E+01	U	2.68E-01	1.13E+00	1.33E+00	U	-2.61E-01	1.03E+00	1.18E+00	U
	3 (Avg)	1.06E+00	8.46E+00	4.87E+00	U	1.20E-02	9.05E-01	1.06E+00	U	-1.00E-03	8.59E-01	9.98E-01	U
	4	-8.46E-01	8.11E+00	9.13E+00	U	4.23E-01	7.22E-01	8.85E-01	U	2.24E-02	8.47E-01	9.36E-01	U
CBD	1	1.24E+01	9.13E+00	1.24E+01	U	8.00E-01	1.08E+00	1.36E+00	U	3.91E-01	1.01E+00	1.15E+00	U
	2	1.68E+00	7.57E+00	8.83E+00	U	3.78E-01	7.49E-01	9.01E-01	U	-2.70E-01	8.63E-01	9.28E-01	U
	3	2.21E+00	8.05E+00	9.31E+00	U	2.13E-01	7.32E-01	8.47E-01	U	-4.09E-01	8.20E-01	8.66E-01	U
	4 (Avg)	5.35E+00	1.07E+01	1.35E+01	U	-2.16E-01	1.14E+00	1.26E+00	U	-1.05E-01	2.94E-02	3.11E-02	U
SMR	1	4.48E+00	7.19E+00	8.58E+00	U	-9.33E-02	7.86E-01	8.82E-01	U	-2.92E-02	8.21E-01	9.06E-01	U
	2	2.46E+00	7.90E+00	9.09E+00	U	3.62E-01	7.28E-01	8.74E-01	U	9.88E-02	8.81E-01	4.50E-01	U

Location	Quarter	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
	3	7.04E+00	6.77E+00	8.25E+00	U	7.52E-02	7.11E-01	8.20E-01	U	-7.71E-01	8.00E-01	8.04E-01	U
	4	2.37E+00	7.86E+00	9.03E+00	U	-4.99E-01	8.41E-01	8.76E-01	U	4.50E-01	7.86E-01	9.03E-01	U
Mean		4.76E+00	8.19E+00	9.73E+00	NA	2.52E-01	8.39E-01	9.86E-01	NA	-2.62E-01	8.31E-01	9.16E-01	NA
Minimum[e]		-8.46E-01	8.11E+00	9.13E+00	SEC (4)	-4.99E-01	8.41E-01	8.76E-01	SMR (4)	-2.75E+00	8.56E-01	9.20E-01	WEE (1)
Maximum[e]		1.24E+01	9.13E+00	1.24E+01	CBD (1)	8.35E-01	7.30E-01	9.18E-01	WFF (1)	8.46E-01	1.12E+00	1.40E+00	MLR (1)
WAB (Filter Blank)	1	4.59E+00	8.99E+00	1.15E+01	U	8.76E-03	1.02E+00	1.19E+00	U	1.70E-01	1.13E+00	1.36E+00	U
	2	7.76E+00	9.27E+00	1.12E+01	U	-4.87E-01	9.31E-01	1.01E+00	U	-4.43E-01	8.93E-01	1.00E+00	U
	3	2.76E+00	9.57E+00	1.16E+01	U	8.34E-01	9.28E-01	1.26E+00	U	-2.25E-01	1.11E+00	1.28E+00	U
	4	6.48E+00	5.93E+00	7.54E+00	U	5.06E-01	5.46E-01	7.06E-01	U	-3.83E-02	5.67E-01	6.62E-01	U

Location	Quarter	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
		^{90}Sr			
WFF	1	-9.98E-03	2.64E-02	3.10E-02	U
	2	-3.69E-03	2.14E-02	2.98E-02	U
	3	1.22E-03	2.16E-02	3.06E-02	U
	4	4.35E-05	2.79E-02	3.09E-02	U
WEE	1	-6.01E-03	2.33E-02	3.07E-02	U
	2	1.48E-03	2.15E-02	2.98E-02	U
	3	7.14E-03	2.14E-02	3.06E-02	U
	4	1.04E-02	2.63E-02	3.07E-02	U
WSS	1 (Avg)	-5.84E-03	2.19E-02	3.05E-02	U
	2	4.46E-03	2.18E-02	2.98E-02	U
	3	9.98E-03	2.28E-02	3.07E-02	U
	4	-5.40E-03	2.37E-02	3.04E-02	U
MLR	1	-9.07E-03	2.23E-02	3.06E-02	U
	2 (Avg)	2.90E-04	2.38E-02	3.01E-02	U

Location	Quarter	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
	3	1.47E-03	2.30E-02	3.07E-02	U
	4	4.71E-03	2.44E-02	3.05E-02	U
SEC	1	-1.21E-03	2.40E-02	3.07E-02	U
	2	-2.41E-03	2.07E-02	2.97E-02	U
	3 (Avg)	5.54E-03	2.10E-02	3.05E-02	U
	4	-1.71E-02	2.80E-02	3.11E-02	U
CBD	1	8.11E-03	2.48E-02	3.08E-02	U
	2	-3.44E-03	2.23E-02	2.99E-02	U
	3	1.40E-02	2.13E-02	3.05E-02	U
	4 (Avg)	1.03E-02	2.94E-02	3.11E-02	U
SMR	1	-4.75E-03	2.31E-02	3.06E-02	U
	2	3.27E-03	2.03E-02	2.97E-02	U
	3	-1.01E-02	2.04E-02	3.05E-02	U
	4	1.02E-02	2.62E-02	3.07E-02	U
Mean		4.86E-04	2.34E-02	3.05E-02	NA
Minimum[e]		-1.71E-02	2.80E-02	3.11E-02	SEC (4)
Maximum[e]		1.40E-02	2.13E-02	3.05E-02	CBD (3)
WAB (Filter Blank)	1	1.55E-02	1.63E-02	3.06E-02	U
	2	6.27E-03	1.48E-02	2.98E-02	U
	3	9.68E-03	1.53E-02	3.07E-02	U
	4	1.11E-02	8.84E-03	2.99E-02	U

Notes:

See Appendix C for sampling location codes. Units are Bq/sample.

(a) Radionuclide activity. The average is used for duplicate samples. Only radionuclides with activities greater than 2 σ TPU and the MDC are considered detections. Negative values may occur since sample counts are compared to background counts and background counts reflect naturally occurring radionuclides and cosmic radiation that are detected by laboratory instrumentation. Samples that are not different from background may have a negative value when background radioactivity is subtracted.

Location	Quarter	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

(e) Minimum and maximum reported concentrations for each radionuclide are based on the sample's activity, [RN], while the associated 2 σ TPU and MDC are inherited with the specific [RN], i.e., they are not averages.

Table G.2 – 2017 Radionuclide Concentrations in Quarterly Air Filter Composite Samples Collected from Locations Surrounding the WIPP Site

			$^{233/234}$U		^{235}U		^{238}U		^{238}Pu		$^{239/240}$Pu		^{241}Am	
Location	**Quarter**	**Vol, m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**
WFF	1	7318.09	1.14E-03	1.56E-07	1.09E-04	1.49E-08	1.10E-03	1.50E-07	7.10E-06	9.70E-10	-2.52E-05	-3.44E-09	-3.15E-04	-4.30E-08
	2	7506.69	3.60E-03	4.80E-07	3.87E-04	5.16E-08	4.63E-03	6.17E-07	9.45E-06	1.26E-09	2.64E-05	3.52E-09	5.71E-06	7.61E-10
	3	7160.18	-1.44E-03	-2.01E-07	-8.71E-04	-1.22E-07	6.89E-05	9.62E-09	1.94E-04	2.71E-08	-8.44E-05	-1.18E-08	2.80E-04	3.91E-08
	4	4666.70	5.88E-03	1.26E-06	2.17E-04	4.65E-08	3.54E-03	7.59E-07	-2.37E-05	-5.08E-09	2.11E-04	4.52E-08	-1.01E-05	-2.16E-09
WEE	1	7331.07	3.51E-03	4.79E-07	7.04E-05	9.60E-09	3.13E-03	4.27E-07	-3.53E-05	-4.82E-09	-2.42E-05	-3.30E-09	-2.73E-05	-3.72E-09
	2	6742.08	1.12E-03	1.66E-07	3.86E-04	5.73E-08	6.13E-03	9.09E-07	-2.02E-04	-3.00E-08	1.75E-04	2.60E-08	-1.27E-05	-1.88E-09
	3	7156.18	-1.48E-03	-2.07E-07	-1.00E-03	-1.40E-07	-1.38E-05	-1.93E-09	-1.61E-04	-2.25E-08	4.10E-04	5.73E-08	-2.19E-05	-3.06E-09
	4	4712.35	5.67E-03	1.20E-06	3.82E-04	8.11E-08	5.74E-03	1.22E-06	-1.68E-04	-3.57E-08	-5.51E-05	-1.17E-08	1.54E-04	3.27E-08
WSS	1 (Avg)	7304.79	3.96E-03	5.42E-07	7.43E-04	1.02E-07	4.57E-03	6.25E-07	1.05E-05	1.44E-09	-1.54E-04	-2.10E-08	-2.23E-04	-3.05E-08
	2	7546.61	4.11E-03	5.45E-07	1.02E-03	1.35E-07	6.31E-03	8.36E-07	-3.29E-05	-4.36E-09	-1.05E-04	-1.39E-08	9.26E-05	1.23E-08
	3	7272.50	-1.82E-03	-2.50E-07	-7.75E-04	-1.07E-07	-2.45E-04	-3.37E-08	-1.02E-04	-1.40E-08	1.41E-05	1.94E-09	3.74E-04	5.14E-08
	4	4484.98	6.77E-03	1.51E-06	4.79E-04	1.07E-07	2.43E-03	5.42E-07	-1.50E-04	-3.34E-08	1.62E-04	3.61E-08	1.51E-05	3.37E-09
MLR	1	6859.96	4.78E-03	6.97E-07	2.41E-04	3.51E-08	5.17E-03	7.54E-07	-4.69E-05	-6.84E-09	2.04E-04	2.97E-08	1.08E-04	1.57E-08
	2 (Avg)	7044.05	3.84E-03	5.45E-07	2.99E-04	4.24E-08	5.78E-03	8.20E-07	-1.69E-04	-2.40E-08	8.05E-05	1.14E-08	4.50E-06	6.39E-10
	3	7183.45	6.30E-04	8.77E-08	1.40E-03	1.95E-07	-5.72E-04	-7.96E-08	6.95E-05	9.68E-09	6.52E-05	9.08E-09	-2.24E-05	-3.12E-09
	4	4558.23	3.98E-03	8.73E-07	2.70E-04	5.92E-08	1.82E-03	3.99E-07	-2.82E-05	-6.19E-09	7.78E-05	1.71E-08	-2.33E-04	-5.11E-08
SEC	1	6666.43	1.94E-03	2.91E-07	7.15E-04	1.07E-07	5.03E-03	7.55E-07	-1.30E-04	-1.95E-08	-1.26E-04	-1.89E-08	-7.72E-06	-1.16E-09
	2	6715.15	5.08E-03	7.56E-07	2.43E-04	3.62E-08	6.08E-03	9.05E-07	-4.75E-05	-7.07E-09	1.53E-04	2.28E-08	1.52E-04	2.26E-08
	3 (avg)	7319.688	-2.12E-03	-2.90E-07	-2.31E-03	-3.15E-07	2.90E-04	3.96E-08	-5.52E-05	-7.54E-09	2.43E-04	3.31E-08	1.35E-04	1.85E-08
	4	4533.21	7.62E-03	1.68E-06	3.29E-04	7.26E-08	7.40E-03	1.63E-06	2.98E-04	6.57E-08	3.26E-04	7.19E-08	-3.54E-05	-7.81E-09
CBD	1	6762.14	6.74E-03	9.97E-07	8.14E-04	1.20E-07	7.93E-03	1.17E-06	2.38E-05	3.52E-09	2.60E-04	3.84E-08	-1.80E-04	-2.66E-08
	2	6738.84	8.53E-03	1.27E-06	9.25E-04	1.37E-07	8.49E-03	1.26E-06	-3.35E-05	-4.97E-09	8.75E-06	1.30E-09	4.14E-05	6.14E-09
	3	7383.16	4.29E-04	5.81E-08	3.57E-04	4.84E-08	3.81E-03	5.16E-07	-6.42E-05	-8.70E-09	6.25E-05	8.47E-09	2.06E-05	2.79E-09
	4 (avg)	4463.039	8.72E-03	1.95E-06	2.15E-04	4.82E-08	5.82E-03	1.30E-06	-6.79E-05	-1.52E-08	7.52E-05	1.68E-08	-7.79E-05	-1.74E-08

			$^{233/234}$U		^{235}U		^{238}U		^{238}Pu		$^{239/240}$Pu		^{241}Am	
Location	**Quarter**	**Vol, m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**
SMR	1	6746.73	2.44E-03	3.62E-07	-2.15E-04	-3.19E-08	6.18E-03	9.16E-07	1.16E-04	1.72E-08	-1.11E-04	-1.65E-08	3.95E-04	5.85E-08
	2	6943.70	2.41E-03	3.47E-07	4.24E-04	6.11E-08	6.72E-03	9.68E-07	3.05E-05	4.39E-09	2.46E-04	3.54E-08	-1.42E-04	-2.05E-08
	3	6733.34	-1.41E-03	-2.09E-07	-1.80E-04	-2.67E-08	8.17E-06	1.21E-09	-1.04E-04	-1.54E-08	-7.15E-05	-1.06E-08	1.40E-04	2.08E-08
	4	4074.95	5.65E-03	1.39E-06	1.65E-04	4.05E-08	5.49E-03	1.35E-06	2.17E-04	5.33E-08	5.15E-04	1.26E-07	1.51E-04	3.71E-08
Mean		6426.01	3.22E-03	5.89E-07	1.73E-04	3.09E-08	4.03E-03	6.70E-07	-2.31E-05	-2.88E-09	9.14E-05	1.72E-08	2.72E-05	3.94E-09
Minimum		4074.95	-2.12E-03	-2.90E-07	-2.31E-03	-3.15E-07	-5.72E-04	-7.96E-08	-2.02E-04	-3.57E-08	-1.54E-04	-2.10E-08	-3.15E-04	-5.11E-08
Maximum		7546.61	8.72E-03	1.95E-06	1.40E-03	1.95E-07	8.49E-03	1.63E-06	2.98E-04	6.57E-08	5.15E-04	1.26E-07	3.95E-04	5.85E-08

			^{40}K		^{60}Co		^{137}Cs		^{90}Sr	
Location	**Quarter**	**Vol, m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**
WFF	1	7318.09	5.21E+00	7.12E-04	8.35E-01	1.14E-04	-4.86E-01	-6.64E-05	-9.98E-03	-1.36E-06
	2	7506.69	9.06E+00	1.21E-03	3.37E-01	4.49E-05	-2.22E-01	-2.96E-05	-3.69E-03	-4.92E-07
	3	7160.18	4.38E+00	6.12E-04	6.49E-01	9.06E-05	-6.20E-01	-8.66E-05	1.22E-03	1.70E-07
	4	4666.70	3.01E+00	6.45E-04	5.06E-01	1.08E-04	-4.84E-01	-1.04E-04	4.35E-05	9.32E-09
WEE	1	7331.07	7.63E+00	1.04E-03	-6.95E-02	-9.48E-06	-2.75E+00	-3.75E-04	-6.01E-03	-8.20E-07
	2	6742.08	1.18E+01	1.75E-03	2.26E-01	3.35E-05	-6.30E-01	-9.34E-05	1.48E-03	2.20E-07
	3	7156.18	1.93E+00	2.70E-04	1.30E-01	1.82E-05	-3.23E-01	-4.51E-05	7.14E-03	9.98E-07
	4	4712.35	-6.45E-01	-1.37E-04	5.23E-01	1.11E-04	-1.32E+00	-2.80E-04	1.04E-02	2.21E-06
WSS	1	7304.79	9.21E+00	1.26E-03	2.13E-01	2.92E-05	1.03E-01	1.41E-05	-5.84E-03	-7.99E-07
	2	7546.61	3.16E+00	4.19E-04	4.79E-01	6.35E-05	1.09E-01	1.44E-05	4.46E-03	5.91E-07
	3	7272.50	7.72E+00	1.06E-03	7.01E-01	9.64E-05	1.03E-01	1.42E-05	9.98E-03	1.37E-06
	4	4484.98	9.98E+00	2.23E-03	4.84E-01	1.08E-04	-3.01E-01	-6.71E-05	-5.40E-03	-1.20E-06
MLR	1	6859.96	8.83E-01	1.29E-04	2.73E-01	3.98E-05	8.46E-01	1.23E-04	-9.07E-03	-1.32E-06
	2	7044.05	6.59E+00	9.35E-04	-6.90E-02	-9.80E-06	-3.85E-01	-5.46E-05	2.90E-04	4.12E-08
	3	7183.45	8.44E+00	1.17E-03	-2.50E-01	-3.48E-05	-3.48E-01	-4.84E-05	1.47E-03	2.05E-07
	4	4558.23	4.54E+00	9.96E-04	3.94E-01	8.64E-05	2.50E-01	5.48E-05	4.71E-03	1.03E-06

			^{40}K		^{60}Co		^{137}Cs		^{90}Sr	
Location	**Quarter**	**Vol, m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**
SEC	1	6666.43	1.54E+00	2.31E-04	-2.06E-02	-3.09E-06	-5.73E-03	-8.60E-07	-1.21E-03	-1.82E-07
	2	6715.15	7.27E-01	1.08E-04	2.68E-01	3.99E-05	-2.61E-01	-3.89E-05	-2.41E-03	-3.59E-07
	3	7319.688	1.06E+00	1.45E-04	1.20E-02	1.64E-06	-1.00E-03	-1.37E-07	5.54E-03	7.57E-07
	4	4533.21	-8.46E-01	-1.87E-04	4.23E-01	9.33E-05	2.24E-02	4.94E-06	-1.71E-02	-3.77E-06
CBD	1	6762.14	1.24E+01	1.83E-03	8.00E-01	1.18E-04	3.91E-01	5.78E-05	8.11E-03	1.20E-06
	2	6738.84	1.68E+00	2.49E-04	3.78E-01	5.61E-05	-2.70E-01	-4.01E-05	-3.44E-03	-5.10E-07
	3	7383.16	2.21E+00	2.99E-04	2.13E-01	2.88E-05	-4.09E-01	-5.54E-05	1.40E-02	1.90E-06
	4	4463.039	5.35E+00	1.20E-03	-2.16E-01	-4.83E-05	-1.05E-01	-2.35E-05	1.03E-02	2.31E-06
SMR	1	6746.73	4.48E+00	6.64E-04	-9.33E-02	-1.38E-05	-2.92E-02	-4.33E-06	-4.75E-03	-7.04E-07
	2	6943.70	2.46E+00	3.54E-04	3.62E-01	5.21E-05	9.88E-02	1.42E-05	3.27E-03	4.71E-07
	3	6733.34	7.04E+00	1.05E-03	7.52E-02	1.12E-05	-7.71E-01	-1.15E-04	-1.01E-02	-1.50E-06
	4	4074.95	2.37E+00	5.82E-04	-4.99E-01	-1.22E-04	4.50E-01	1.10E-04	1.02E-02	2.50E-06
Mean		6426.01	4.76E+00	7.44E-04	2.52E-01	3.94E-05	-2.62E-01	-4.00E-05	4.86E-04	1.05E-07
Minimum		4074.95	-8.46E-01	-1.87E-04	-4.99E-01	-1.22E-04	-2.75E+00	-3.75E-04	-1.71E-02	-3.77E-06
Maximum		7546.61	1.24E+01	2.23E-03	8.35E-01	1.18E-04	8.46E-01	1.23E-04	1.40E-02	2.50E-06

Note: See Appendix C for Sample Location Codes.

APPENDIX H – COMPARISON OF DETECTED RADIONUCLIDES TO THE RADIOLOGICAL BASELINE

The figures in this appendix show the highest detected radionuclides from 2017 environmental monitoring sample analysis results compared to the 99 percent confidence interval radiological baseline values established for these isotopes (DOE/WIPP-92-037). The figures include air particulate filter, groundwater, surface water, sediment, soil, vegetation and fauna radiochemical analysis results. Note that all results with the exception of vegetation and fauna were compared to the baseline upper 99 percentile probability value. The baseline did not include probability distributions for vegetation and fauna; therefore, vegetation and fauna sample results are compared to the mean baseline concentrations.

A few items to note from the figures include the following:

- Air filter composites: There were no detections in the air filter composite samples in 2017.
- Groundwater: The duplicate groundwater sample from WQSP-2 had the highest concentration for $^{233/234}$U at 1.37E+00 Bq/L, which is slightly higher than the 99 percent confidence interval range of the groundwater baseline concentration of 1.30E+00 Bq/L. The ^{235}U and ^{238}U concentrations were highest at WQSP-1 but were lower than the 99 percent baseline confidence interval ranges of 3.10E-02 Bq/L and 3.20 Bq/L, respectively. The highest ^{40}K concentration was in the primary sample from WQSP-3 at 4.41E+01 Bq/L, but the concentration was lower than the 99 percent confidence interval concentration range of the baseline of 6.30E+01 Bq/L. The uranium isotope and ^{40}K concentrations were very similar to previous years.
- Surface water: The highest concentrations of uranium isotopes in surface water samples were from locations associated with the Pecos River with the PCN location having the highest concentrations of $^{233/234}$U and ^{238}U, while BRA had the highest concentration of ^{235}U. The highest concentrations were 2.00E-01 Bq/L for $^{233/234}$U; 5.23E-03 Bq/L for ^{235}U; and 9.62E-02 Bq/L for ^{238}U. The corresponding 99 percent confidence interval of the baseline concentrations are 3.30E-01 Bq/L for $^{233/234}$U; 1.40E-02 Bq/L for ^{235}U; and 1.10E-01 Bq/L for ^{238}U. All three concentrations were lower than the 99 percent confidence interval range of the baseline concentration.

  The highest concentrations of uranium isotopes in samples from tanks and tank-like structures were all in the FWT groundwater including 4.29E-02 Bq/L for $^{233/234}$U; 8.58E-04 Bq/L for ^{235}U; and 1.73E-02 Bq/L for ^{238}U. The concentrations were lower than the corresponding baseline concentrations of 1.00E-01 Bq/L for $^{233/234}$U, 5.20E-03 Bq/L for ^{235}U, and 3.20E-02 Bq/L for ^{238}U. There were no other detections for the target radionuclides in the surface water samples from the Pecos River and associated bodies of water or tanks and tank-like structures.

However, ^{40}K was detected in two other samples, the sewage sludge composite sample (SWL) and the H-19 pond (H-19). These types of samples are not included in the surface water baseline of 7.60E+01 Bq/L, which includes both tanks and tank-like structures and the Pecos River and associated bodies of water. The SWL concentration was 1.91E+02 Bq/L, which was lower than the 2016 concentration of 7.43E+03 Bq/L. The H-19 concentration was 7.04E+02 Bq/L. This higher concentration is due to the very high concentration of brine in the H-19 Pond, a portion of which comes from the naturally occurring ^{40}K in the brine's potassium chloride. Both concentrations were higher than the 99 percent confidence interval range of the baseline concentration for surface water.

- Sediments: The highest concentrations of the uranium isotopes in sediment samples were from tanks and tank-like structures and not from the Pecos River and associated bodies of water. The 99 percent confidence interval range of the baseline concentrations for sediments does not distinguish between the Pecos River and associated bodies of water and tanks and tank-like structures. The concentration of $^{233/234}$U in the PKT duplicate sample of 2.76E-02 Bq/g was lower than the 99 percent confidence concentration of 1.10E-01 Bq/g; the concentration of ^{235}U in the IDN sample of 1.72E-03 Bq/g was lower than the 99 percent confidence concentration of 3.20E-03 Bq/g; and the concentration of ^{238}U in the PKT duplicate sample of 2.63E-02 Bq/g was lower than the 99 percent confidence interval range of the baseline concentration of 5.00E-02 Bq/g. The results are all reported on a dry weight basis.

  There were five sediment detections of ^{137}Cs, all in tanks and tank-like structures including HIL, PKT (plus duplicate), IDN, LST, and BHT. There were no detections in the sediments associated with the Pecos River. The highest concentration of 8.89E-03 Bq/g was in the PKT primary sample. The concentration was well below the 99 percent confidence interval range of the baseline concentration of 3.50E-02 Bq/g.

  The highest ^{40}K sediment concentration in samples from tanks and tank-like structures was 9.26E-01 Bq/g in the HIL sample. The concentration was lower than the 99 percent confidence concentration of 1.20E+00 Bq/g. The highest ^{40}K concentration in the Pecos River and associated bodies of water was 4.29E-01 Bq/g from the UPR duplicate. The concentration was slightly lower than the 99 percent confidence interval range of the baseline concentration of 5.00E-01 Bq/g for the Pecos River and associated bodies of water. The results are all reported on a dry weight basis.

  There was one detection of $^{239/240}$Pu in sediment samples in 2017. The detected concentration was 5.83E-04 Bq/g in the duplicate sample from PKT. It was not detected in the PKT primary sample. The concentration was lower than the 99 percent confidence interval range of the baseline concentration of 1.90E-03 Bq/g.

- Soil: The highest soil concentrations were all detected at location SMR, which is within the 5-mile radius of the WIPP site. There were two detections of $^{239/240}$Pu with the highest concentration of 5.16E-04 Bq/g at the 2 to 5 cm depth and the

other detection with a concentration of 4.03E-04 Bq/g at the 0 to 2 cm depth. The concentrations were lower than the 99 percent confidence interval of the baseline concentration of 1.90E-03 Bq/g.

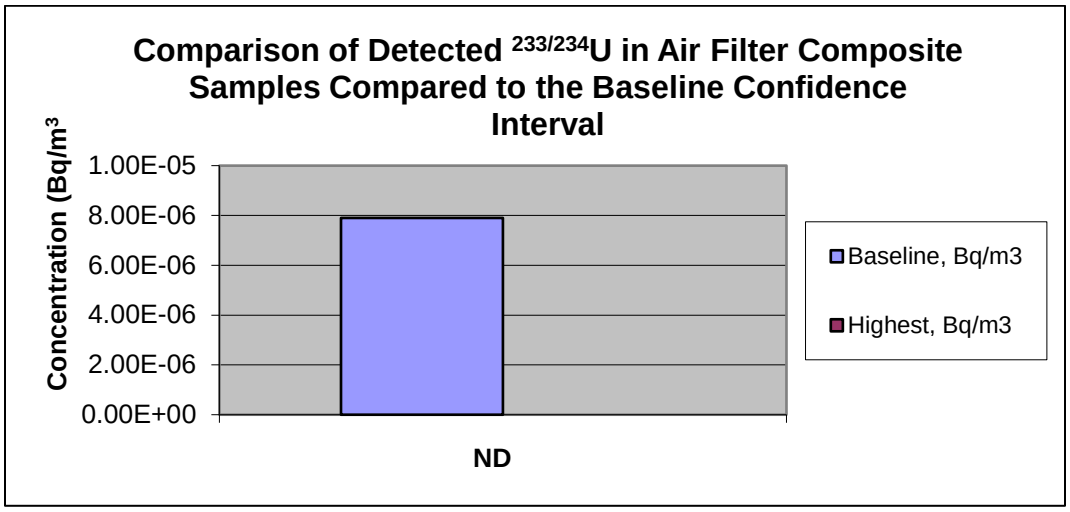
The highest uranium concentration of $^{233/234}$U was 1.83E-02 Bq/g at the 0 to depth of SMR; the highest ^{235}U concentration was 6.98E-04 Bq/g at the 2 to 5 cm depth of SMR; and the highest ^{238}U concentration was 1.88E-02 Bq/g at the 0 to 2 cm depth of SMR. The corresponding 99 percent confidence interval range of the baseline concentrations are 2.20E-02 Bq/g for $^{233/234}$U; 1.70E-03 Bq/g for ^{235}U; and 1.30E-02 Bq/g for ^{238}U. Thus, the ^{238}U concentration was higher than the 99 percent confidence interval range of the baseline concentration for concentrations within the 5-mile ring.

The highest concentration of ^{40}K was 7.50E-01 Bq/g at the 0 to 2 cm depth of SMR. The concentration was higher than the 99 percent baseline confidence interval range of the baseline concentration of 3.40E-01 Bq/g for the 5-mile ring. In addition, the concentrations at the 2 to 5 cm depth (6.32E-01 Bq/g) and at the 5 to 10 cm depth (6.25E-01 Bq/g) were higher than the baseline concentration. The 0 to 2 cm depth sample from MLR (3.42E-01 Bq/g) and the 2 to 5 cm depth sample from MLR (3.66E-01 Bq/g) also yielded concentrations higher than the baseline concentration of 3.40E-01 Bq/g. The highest ^{137}Cs concentration of 7.14E-03 Bq/g at the 0 to 2 cm depth in the SMR sample was lower than the 99 percent baseline confidence interval range of the baseline concentration of 2.40E-02 Bq/g. The soil sample results were reported on a dry weight basis.

- Vegetation: The only radionuclide detected in any of the vegetation samples was ^{40}K. It was detected in all the samples including WFF, WEE, WSS, MLR (and duplicate), SEC, and SMR. The highest concentration, reported on a dry weight basis, was 6.78E-01 Bq/g in the SMR sample, which was lower than the mean baseline concentration of 3.20E+00 Bq/g. However, the results are not directly comparable because the mean baseline data were reported on an ashed weight basis and the vegetation data are reported on a dry weight basis.
- Fauna: The fauna samples only included quail, rabbit, and fish. K-40 was detected in all the samples, but no uranium isotopes were detected in any of the samples. The highest concentration of ^{40}K in fish was 4.79E-01 Bq/g in the BRA sample compared to the mean baseline concentration of 6.10E-01 Bq/g. The highest concentration of ^{40}K detected in quail was 2.94E-01 Bq/g in the primary sample from WEE compared to the mean baseline concentration of 4.10E-01 Bq/g. The highest concentration of ^{40}K in the single rabbit sample was 4.52E-01 Bq/g, which was higher than the mean baseline concentration of 3.90E-01 Bq/g.

A detailed discussion of environmental monitoring radionuclide sample results is presented in Chapter 4.

Note: Graphs with no location only display the baseline as no detections were encountered for that radionuclide.


Comparison of Detected 233/234U in Air Filter Composite Samples Compared to the Baseline Confidence Interval
Concentration (Bq/m3
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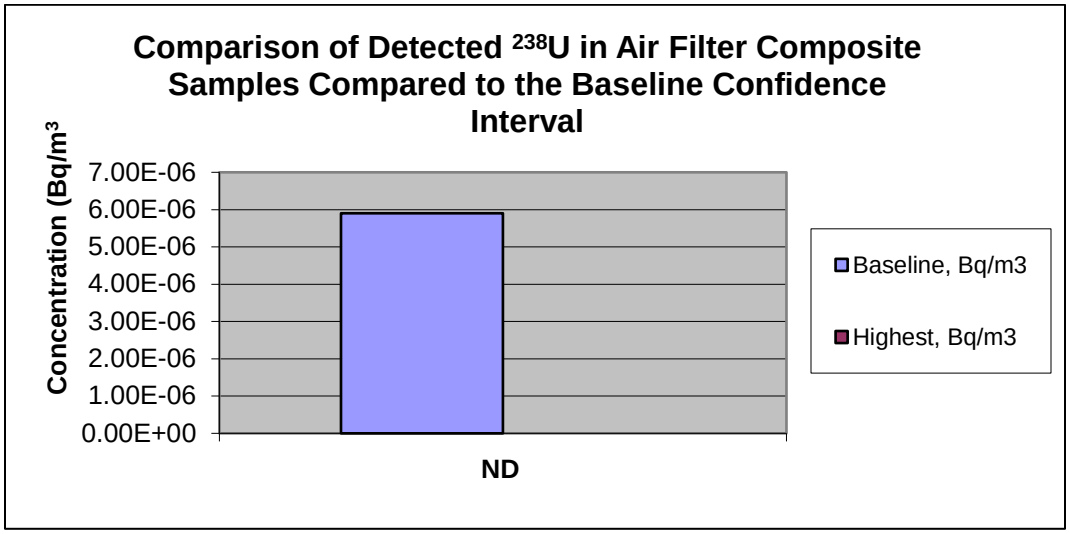
6.00E-06
4.00E-06
2.00E-06
0.00E+00
ND
Baseline, Bq/m3
Highest, Bq/m3


Comparison of Detected 238U in Air Filter Composite Samples Compared to the Baseline Confidence Interval
Concentration (Bq/m3
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5.00E-06
4.00E-06
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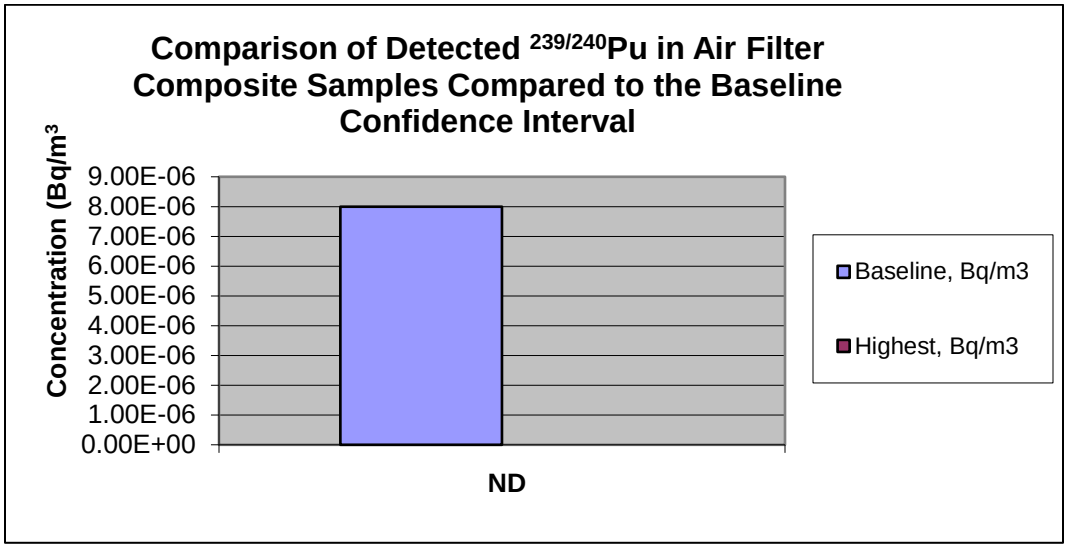
1.00E-06
0.00E+00
ND
Baseline, Bq/m3
Highest, Bq/m3


Comparison of Detected 239/240Pu in Air Filter Composite Samples Compared to the Baseline Confidence Interval
Concentration (Bq/m3
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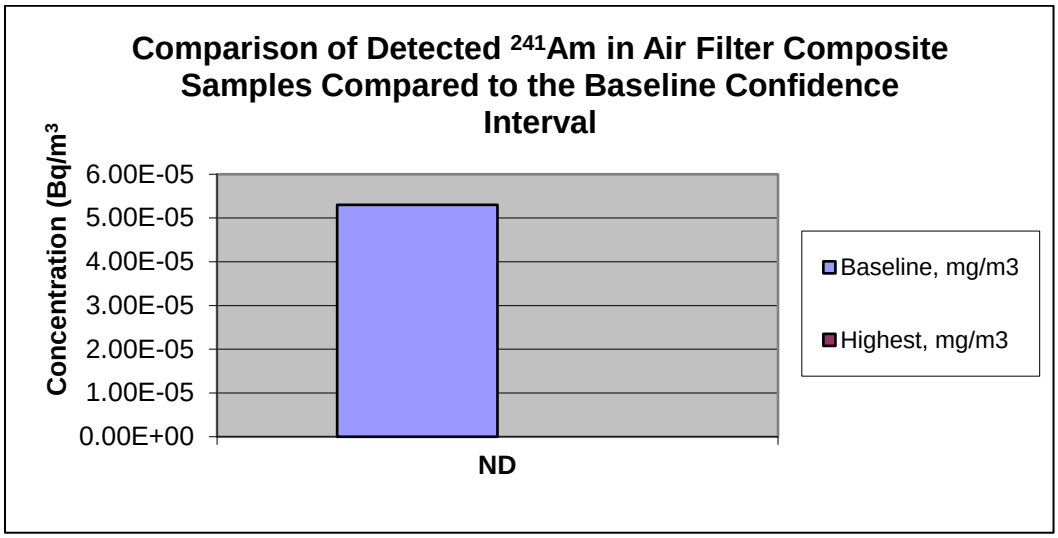
8.00E-06
7.00E-06
6.00E-06
5.00E-06
4.00E-06
3.00E-06
2.00E-06
1.00E-06
0.00E+00
ND
Baseline, Bq/m3
Highest, Bq/m3


Comparison of Detected 241Am in Air Filter Composite Samples Compared to the Baseline Confidence Interval
Concentration (Bq/m3)
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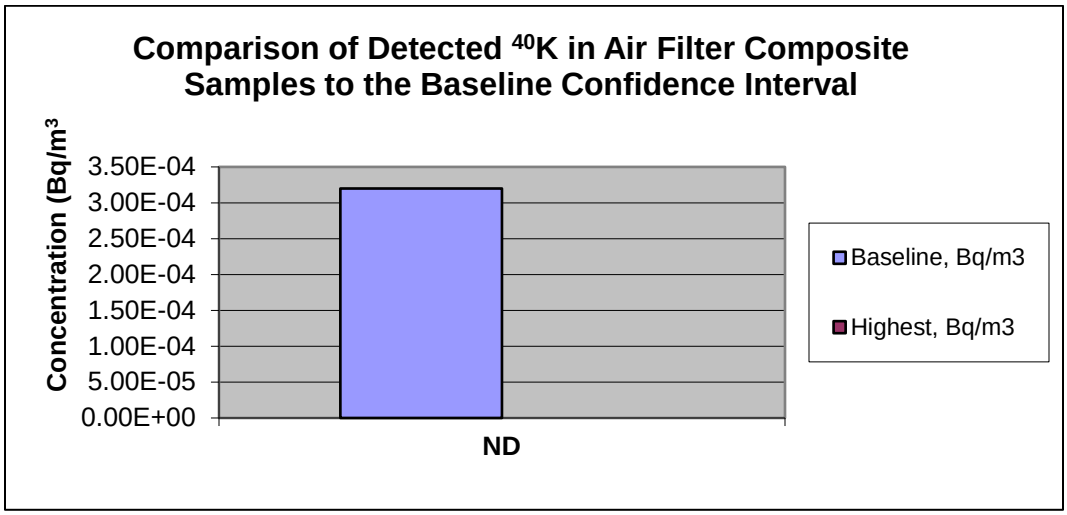
5.00E-05
4.00E-05
3.00E-05
2.00E-05
1.00E-05
0.00E+00
ND
Baseline, mg/m3
Highest, mg/m3


Comparison of Detected 40K in Air Filter Composite Samples to the Baseline Confidence Interval
Concentration (Bq/m3)
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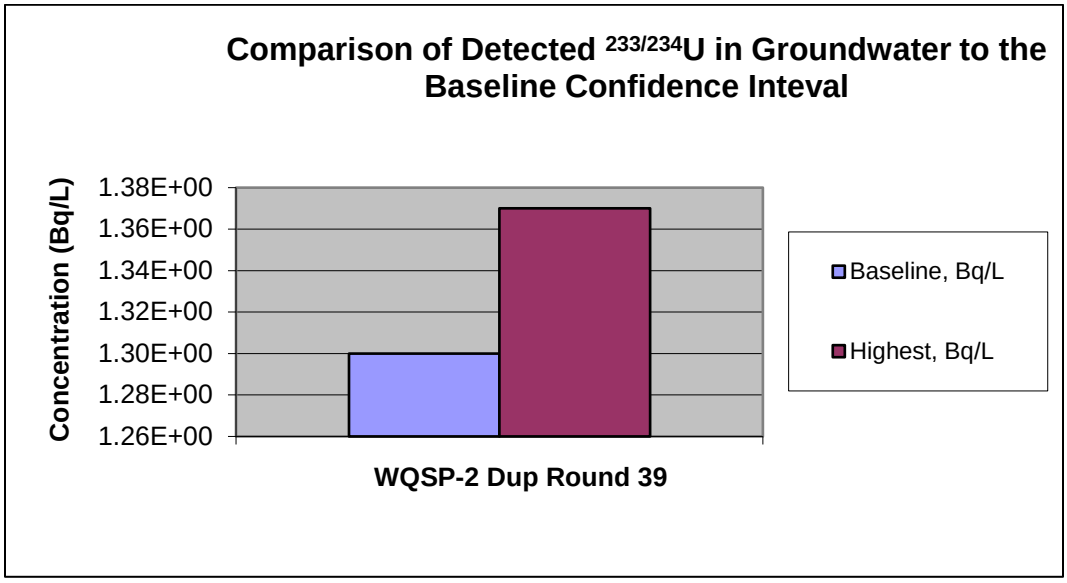
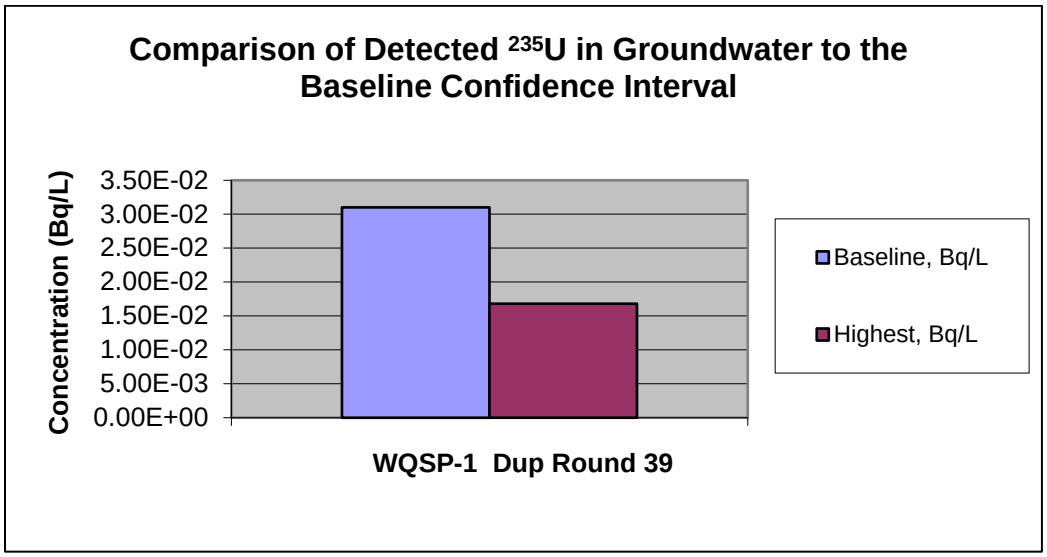
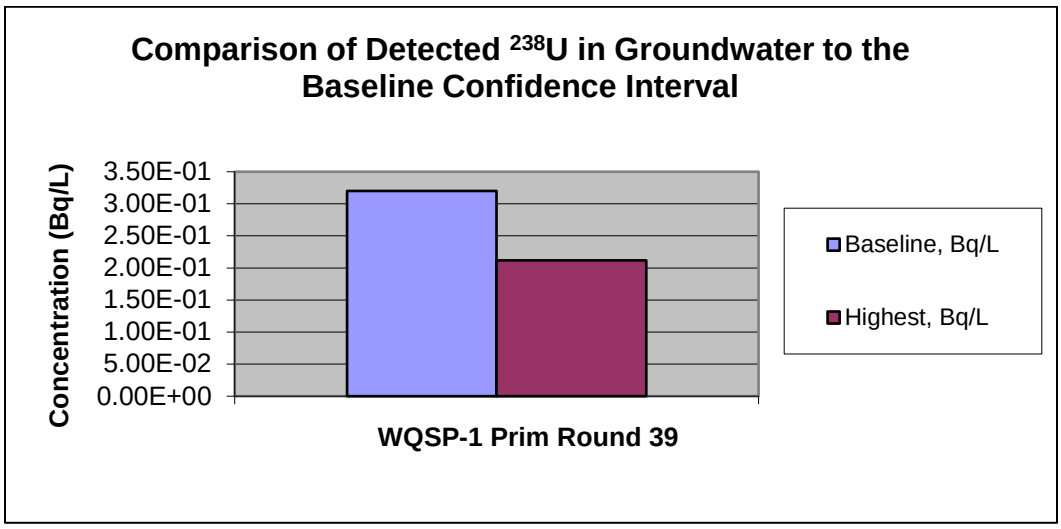
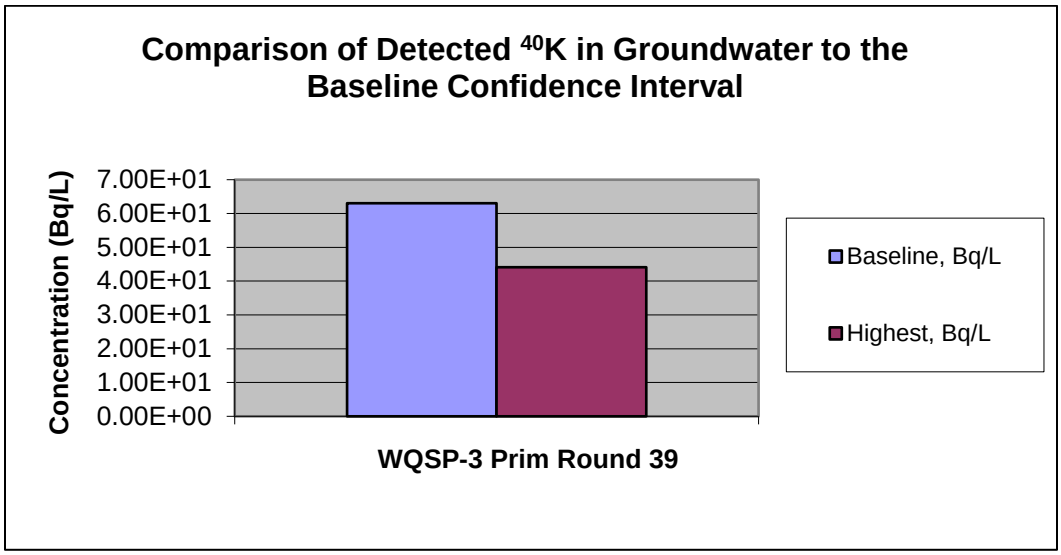
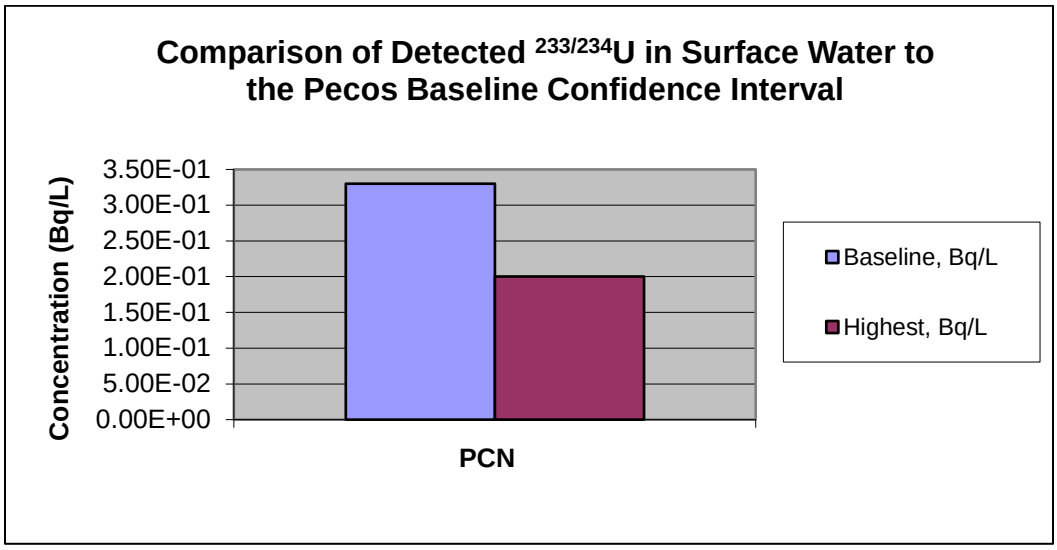
3.00E-04
2.50E-04
2.00E-04
1.50E-04
1.00E-04
5.00E-05
0.00E+00
ND
Baseline, Bq/m3
Highest, Bq/m3

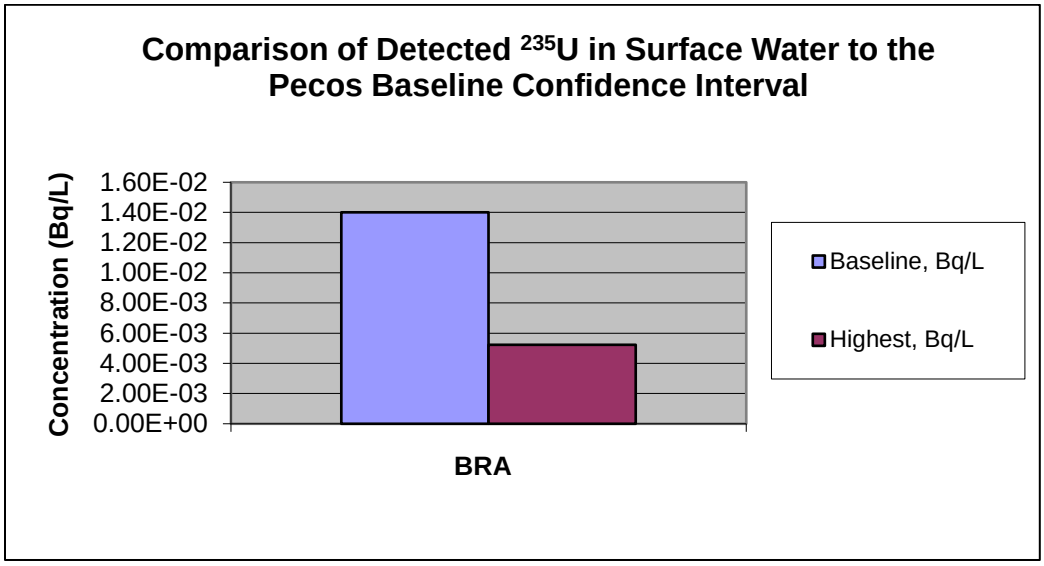

Comparison of Detected 233/234U in Groundwater to the Baseline Confidence Inteval
Concentration (Bq/L)
1.38E+00
1.36E+00
1.34E+00
1.32E+00
1.30E+00
1.28E+00
1.26E+00
WQSP-2 Dup Round 39
Baseline, Bq/L
Highest, Bq/L

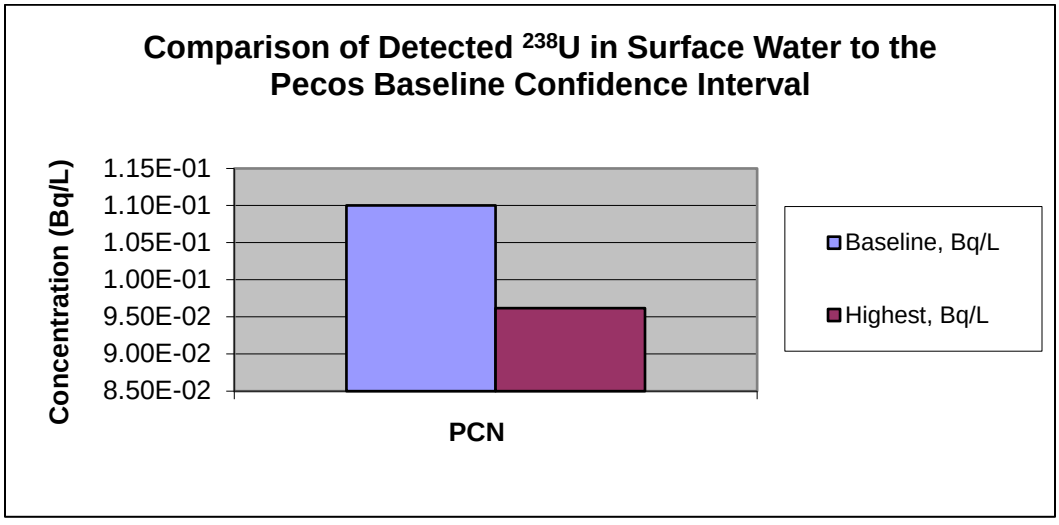

Comparison of Detected 235U in Groundwater to the Baseline Confidence Interval
Concentration (Bq/L)
3.50E-02
3.00E-02
2.50E-02
2.00E-02
1.50E-02
1.00E-02
5.00E-03
0.00E+00
Baseline, Bq/L
Highest, Bq/L
WQSP-1 Dup Round 39

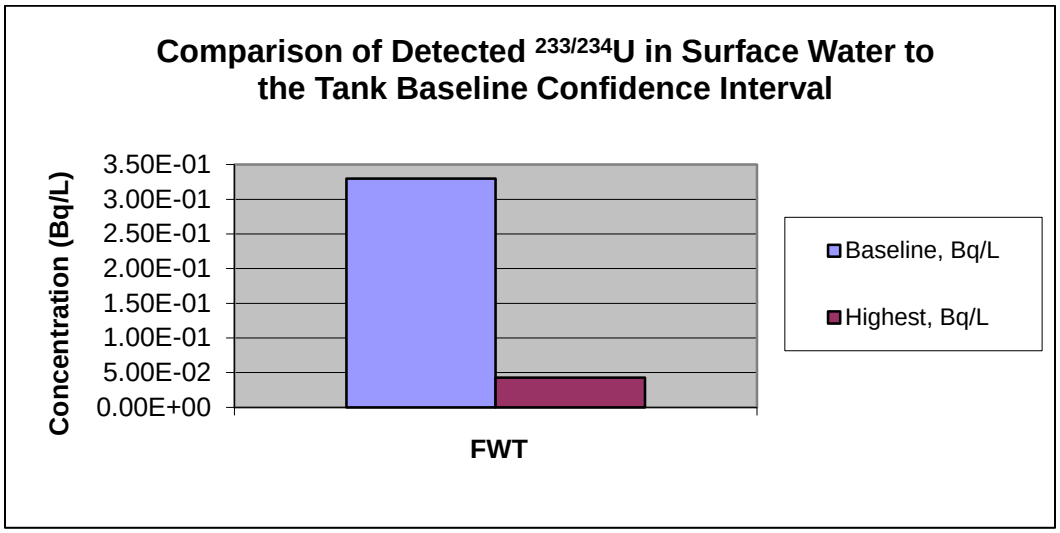

Comparison of Detected 238U in Groundwater to the Baseline Confidence Interval
Concentration (Bq/L)
3.50E-01
3.00E-01
2.50E-01
2.00E-01
1.50E-01
1.00E-01
5.00E-02
0.00E+00
Baseline, Bq/L
Highest, Bq/L
WQSP-1 Prim Round 39

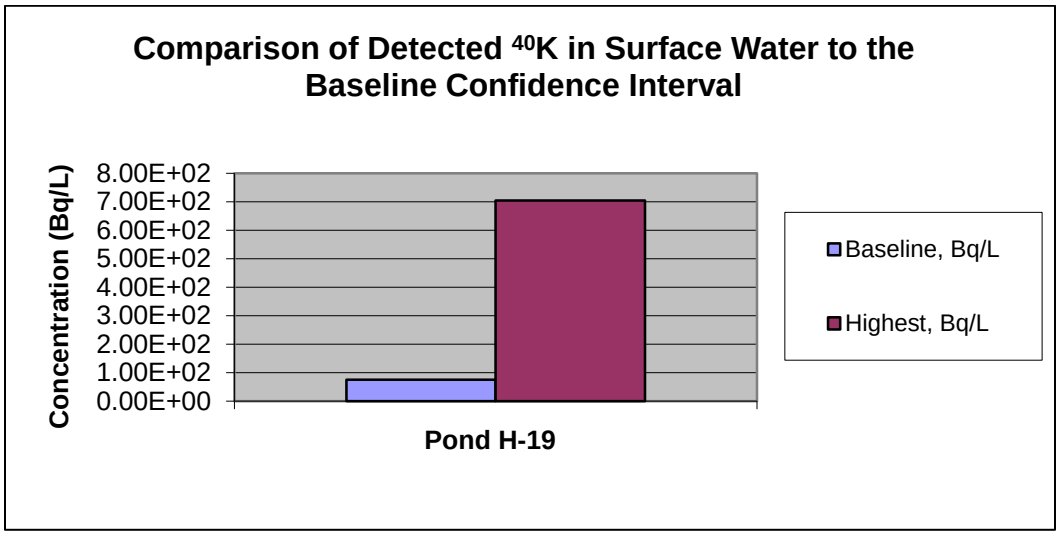

Comparison of Detected 40K in Groundwater to the Baseline Confidence Interval
Concentration (Bq/L)
7.00E+01
6.00E+01
5.00E+01
4.00E+01
3.00E+01
2.00E+01
1.00E+01
0.00E+00
Baseline, Bq/L
Highest, Bq/L
WQSP-3 Prim Round 39

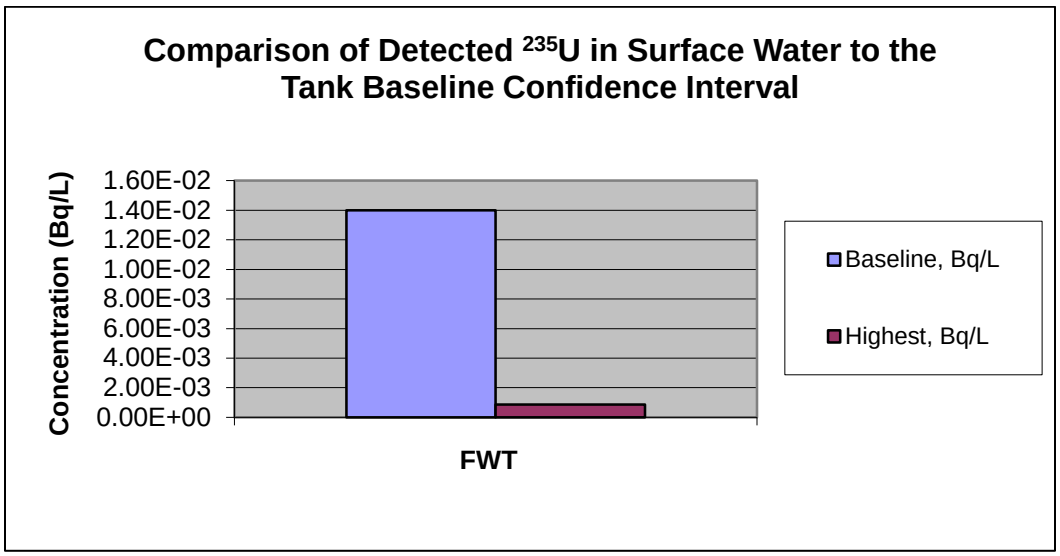

Comparison of Detected 233/234U in Surface Water to the Pecos Baseline Confidence Interval
Concentration (Bq/L)
3.50E-01
3.00E-01
2.50E-01
2.00E-01
1.50E-01
1.00E-01
5.00E-02
0.00E+00
PCN
Baseline, Bq/L
Highest, Bq/L

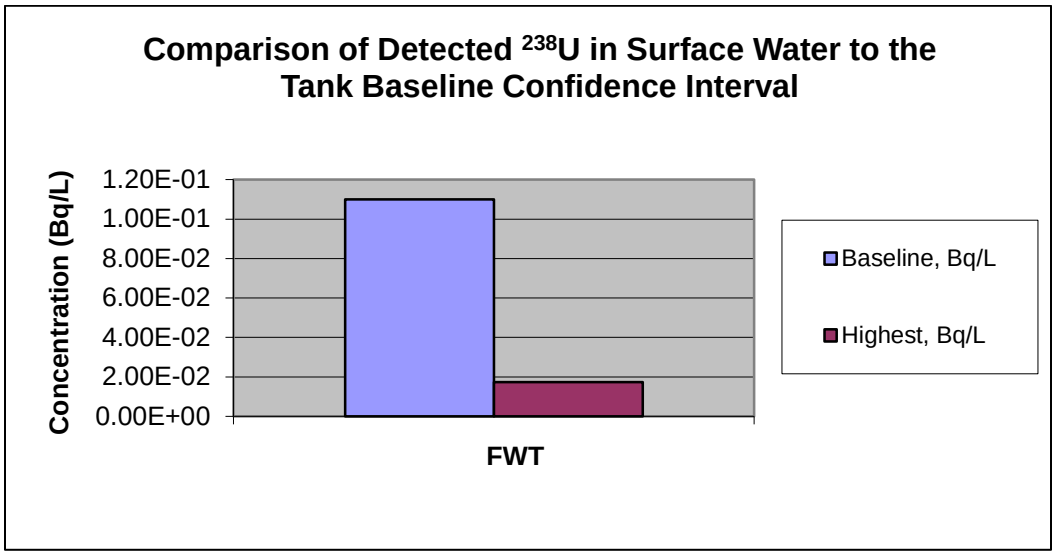

Comparison of Detected 235U in Surface Water to the Pecos Baseline Confidence Interval
Concentration (Bq/L)
1.60E-02
1.40E-02
1.20E-02
1.00E-02
8.00E-03
6.00E-03
4.00E-03
2.00E-03
0.00E+00
BRA
Baseline, Bq/L
Highest, Bq/L

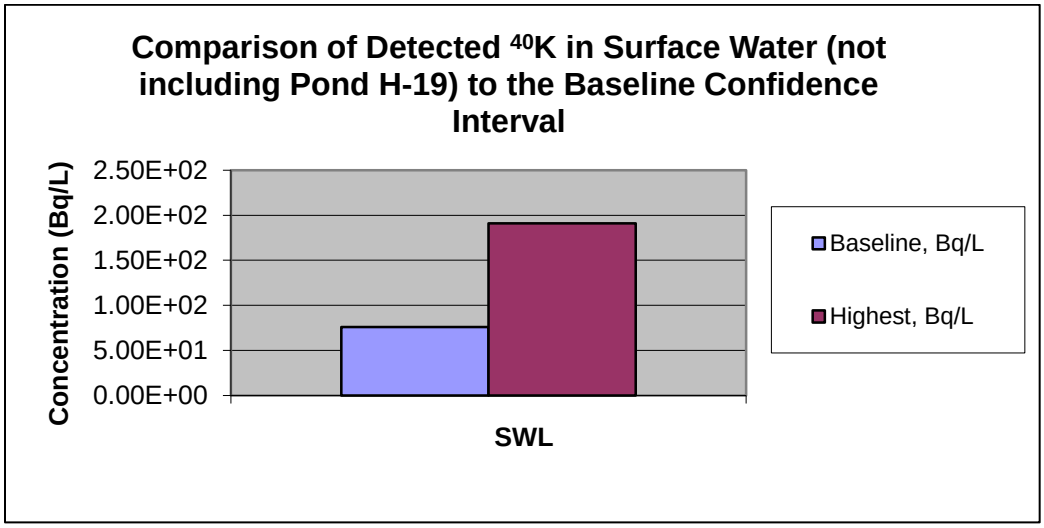

Comparison of Detected 238U in Surface Water to the Pecos Baseline Confidence Interval
Concentration (Bq/L)
1.15E-01
1.10E-01
1.05E-01
1.00E-01
9.50E-02
9.00E-02
8.50E-02
PCN
Baseline, Bq/L
Highest, Bq/L

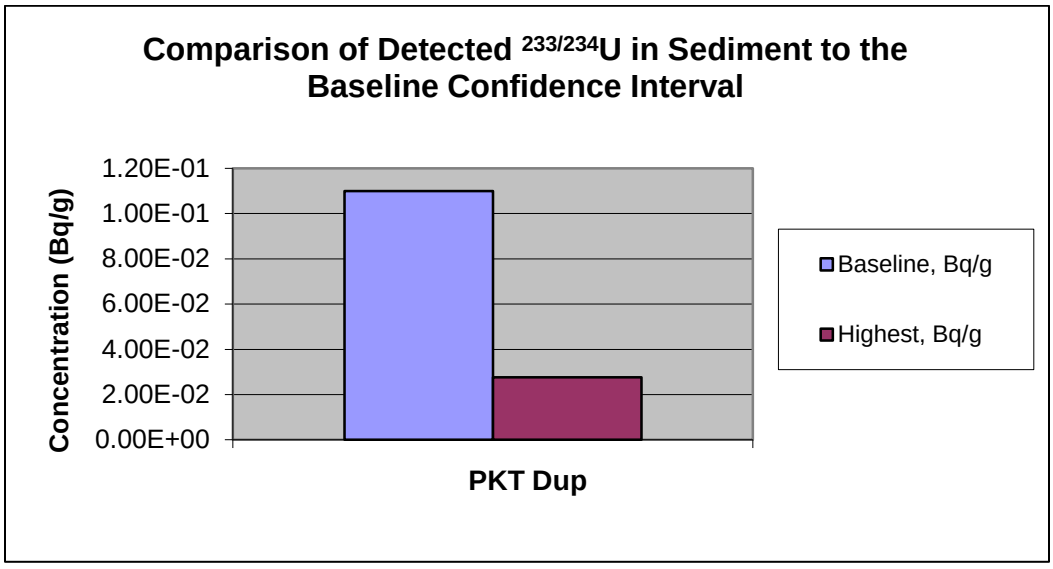

Comparison of Detected 233/234U in Surface Water to the Tank Baseline Confidence Interval
Concentration (Bq/L)
3.50E-01
3.00E-01
2.50E-01
2.00E-01
1.50E-01
1.00E-01
5.00E-02
0.00E+00
FWT
Baseline, Bq/L
Highest, Bq/L

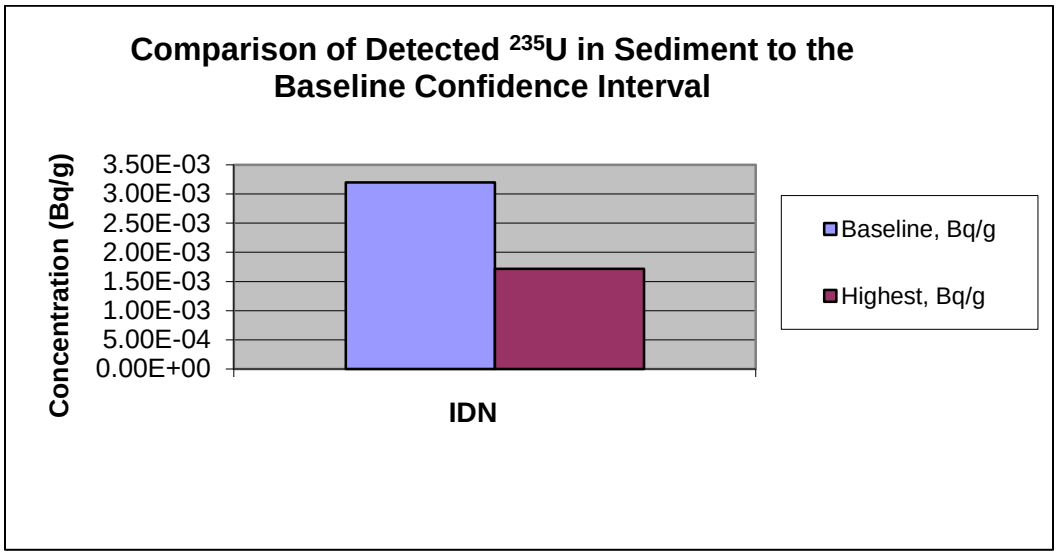

Comparison of Detected 40K in Surface Water to the Baseline Confidence Interval
Concentration (Bq/L)
8.00E+02
7.00E+02
6.00E+02
5.00E+02
4.00E+02
3.00E+02
2.00E+02
1.00E+02
0.00E+00
Pond H-19
Baseline, Bq/L
Highest, Bq/L

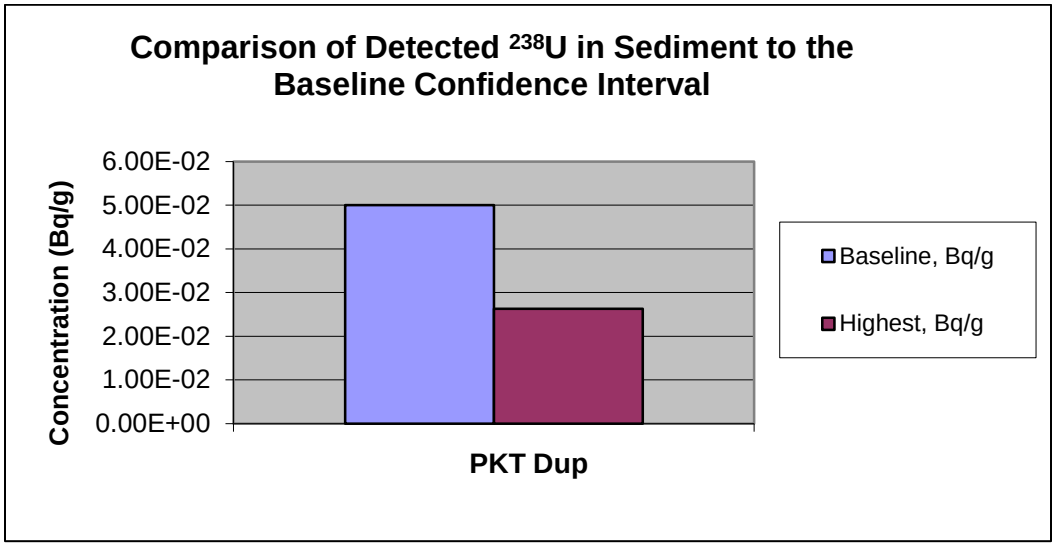

Comparison of Detected 235U in Surface Water to the Tank Baseline Confidence Interval
Concentration (Bq/L)
1.60E-02
1.40E-02
1.20E-02
1.00E-02
8.00E-03
6.00E-03
4.00E-03
2.00E-03
0.00E+00
FWT
Baseline, Bq/L
Highest, Bq/L

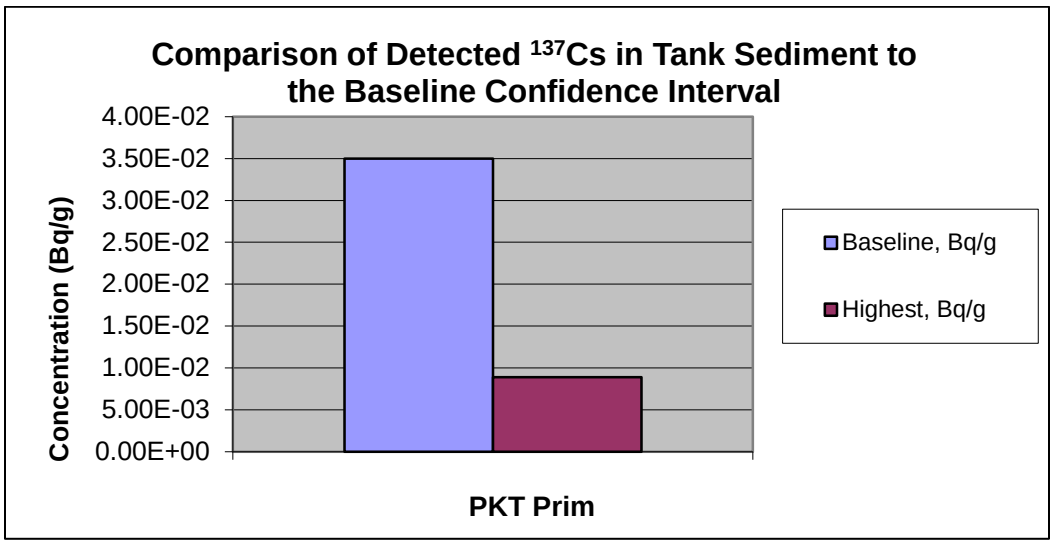

Comparison of Detected 238U in Surface Water to the Tank Baseline Confidence Interval
Concentration (Bq/L)
1.20E-01
1.00E-01
8.00E-02
6.00E-02
4.00E-02
2.00E-02
0.00E+00
FWT
Baseline, Bq/L
Highest, Bq/L

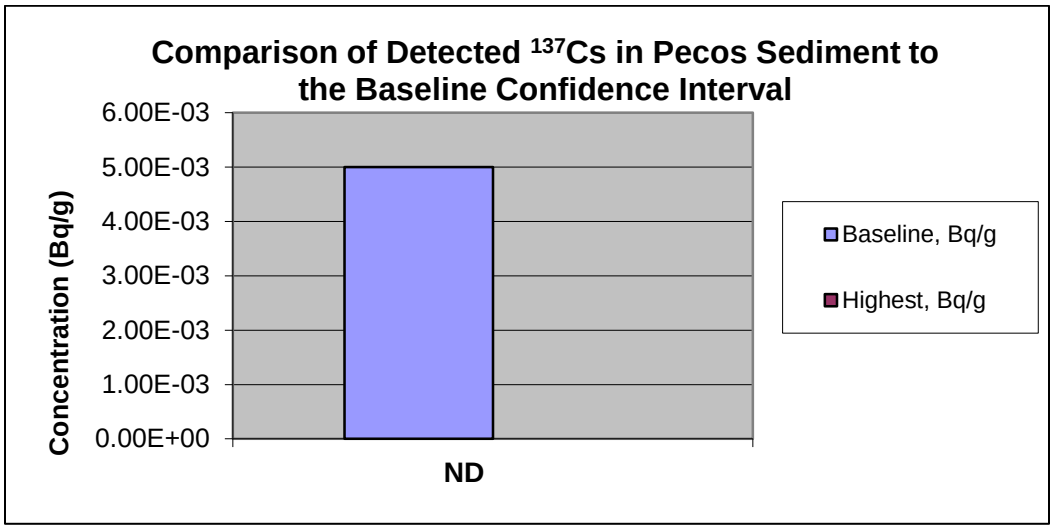

Comparison of Detected 40K in Surface Water (not including Pond H-19) to the Baseline Confidence Interval
Concentration (Bq/L)
2.50E+02
2.00E+02
1.50E+02
1.00E+02
5.00E+01
0.00E+00
SWL
Baseline, Bq/L
Highest, Bq/L

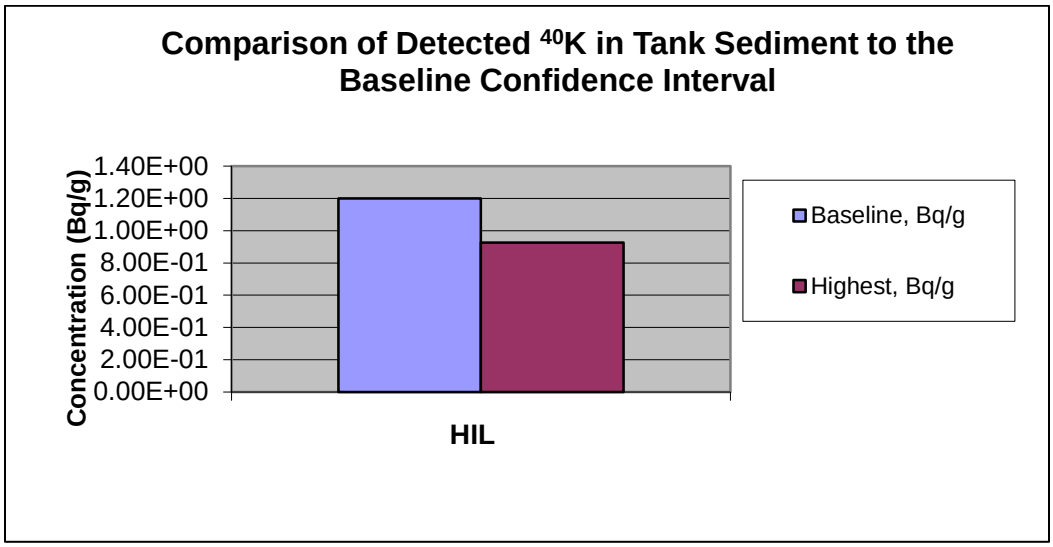

Comparison of Detected 233/234U in Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
1.20E-01
1.00E-01
8.00E-02
6.00E-02
4.00E-02
2.00E-02
0.00E+00
PKT Dup
Baseline, Bq/g
Highest, Bq/g

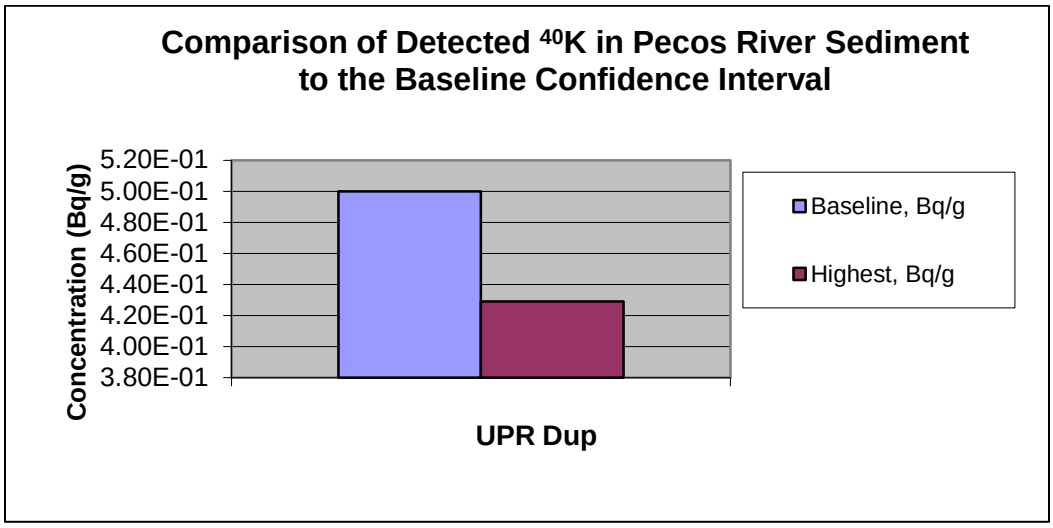

Comparison of Detected 235U in Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
3.50E-03
3.00E-03
2.50E-03
2.00E-03
1.50E-03
1.00E-03
5.00E-04
0.00E+00
IDN
Baseline, Bq/g
Highest, Bq/g

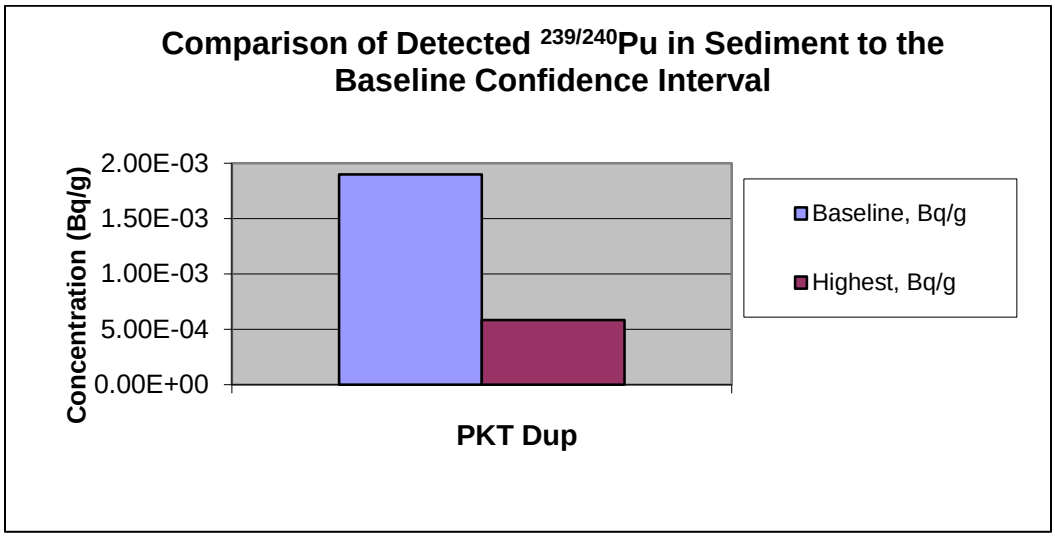

Comparison of Detected 238U in Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
6.00E-02
5.00E-02
4.00E-02
3.00E-02
2.00E-02
1.00E-02
0.00E+00
PKT Dup
Baseline, Bq/g
Highest, Bq/g

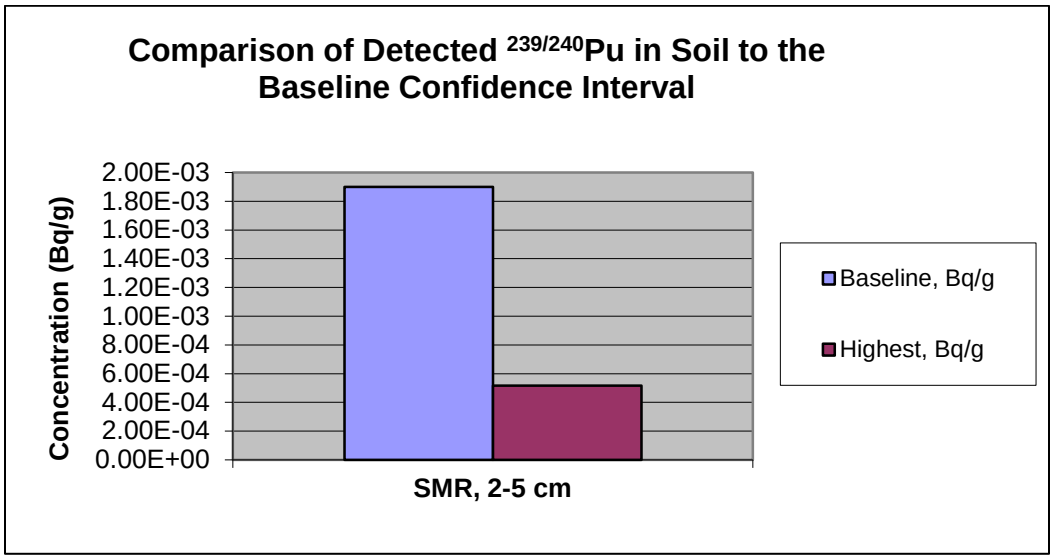

Comparison of Detected 137Cs in Tank Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
4.00E-02
3.50E-02
3.00E-02
2.50E-02
2.00E-02
1.50E-02
1.00E-02
5.00E-03
0.00E+00
PKT Prim
Baseline, Bq/g
Highest, Bq/g

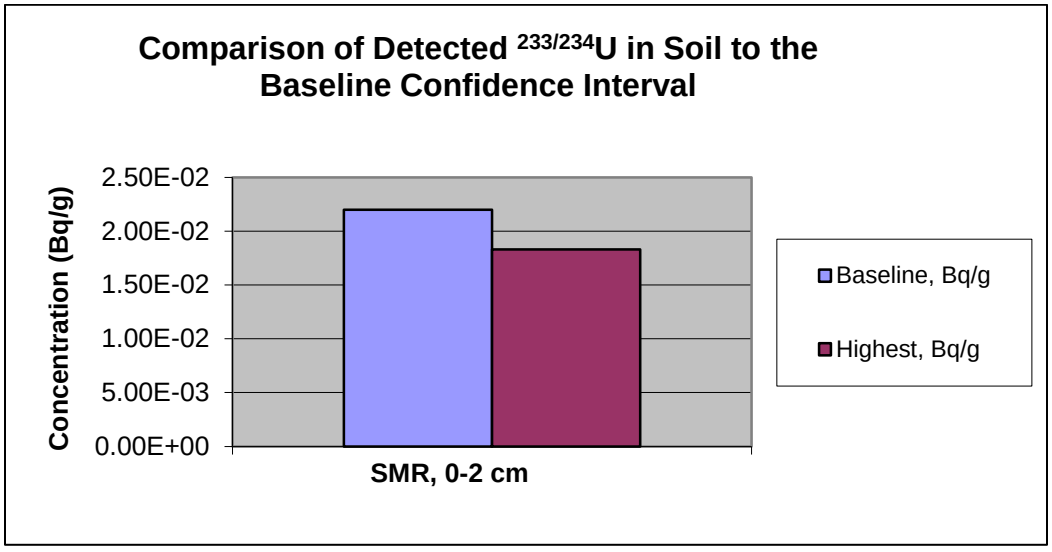

Comparison of Detected 137Cs in Pecos Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
6.00E-03
5.00E-03
4.00E-03
3.00E-03
2.00E-03
1.00E-03
0.00E+00
ND
Baseline, Bq/g
Highest, Bq/g

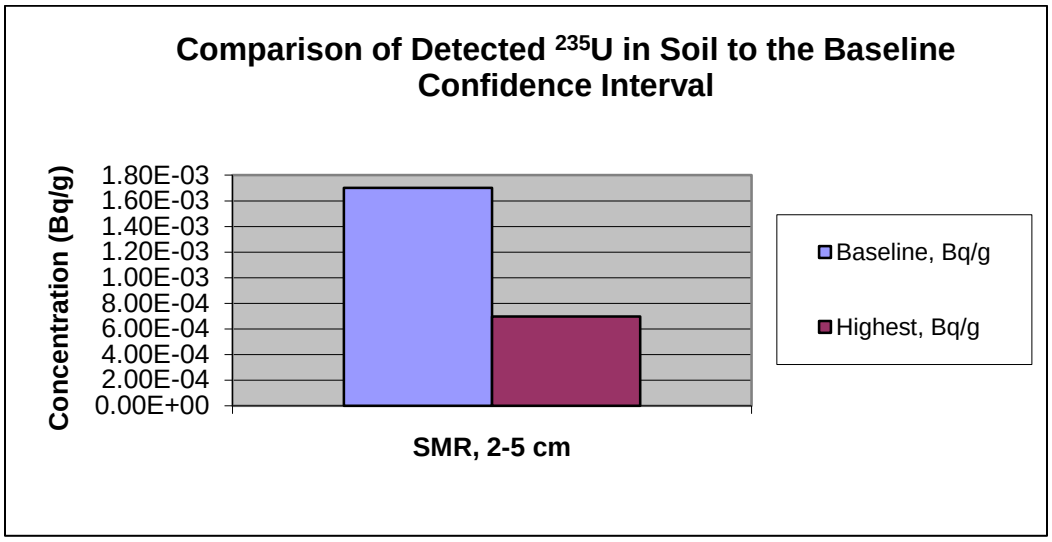

Comparison of Detected 40K in Tank Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
1.40E+00
1.20E+00
1.00E+00
8.00E-01
6.00E-01
4.00E-01
2.00E-01
0.00E+00
HIL
Baseline, Bq/g
Highest, Bq/g

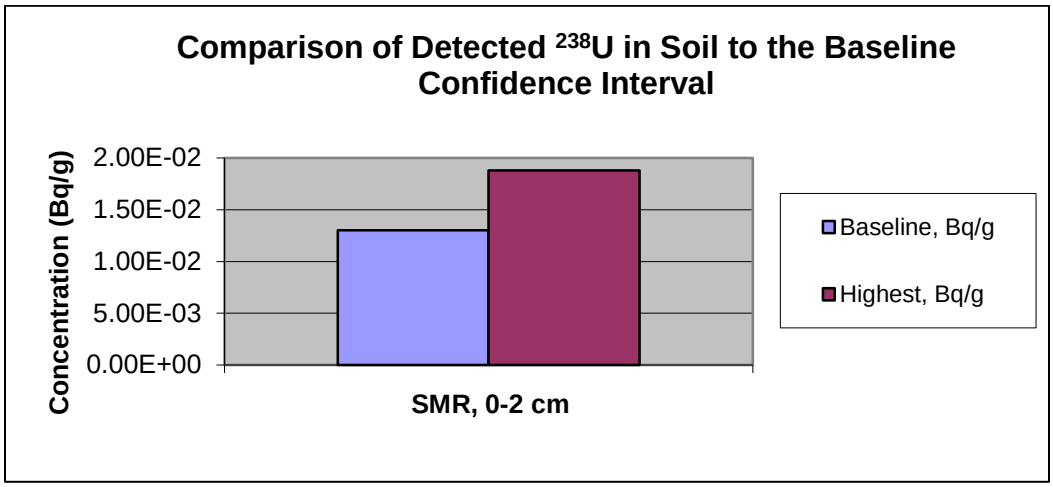

Comparison of Detected 40K in Pecos River Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
5.20E-01
5.00E-01
4.80E-01
4.60E-01
4.40E-01
4.20E-01
4.00E-01
3.80E-01
UPR Dup
Baseline, Bq/g
Highest, Bq/g

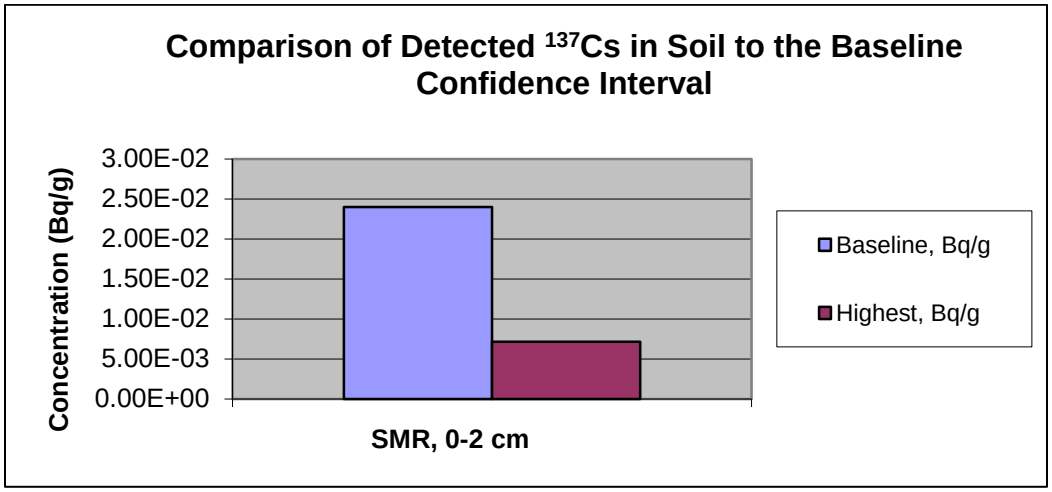

Comparison of Detected 239/240Pu in Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
2.00E-03
1.50E-03
1.00E-03
5.00E-04
0.00E+00
PKT Dup
Baseline, Bq/g
Highest, Bq/g

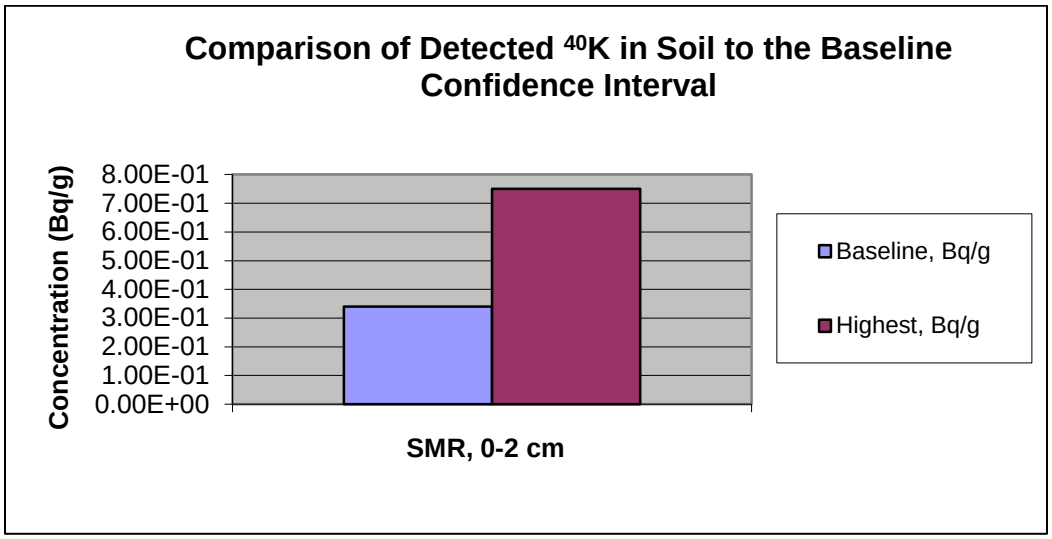

Comparison of Detected 239/240Pu in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
2.00E-03
1.80E-03
1.60E-03
1.40E-03
1.20E-03
1.00E-03
8.00E-04
6.00E-04
4.00E-04
2.00E-04
0.00E+00
SMR, 2-5 cm
Baseline, Bq/g
Highest, Bq/g

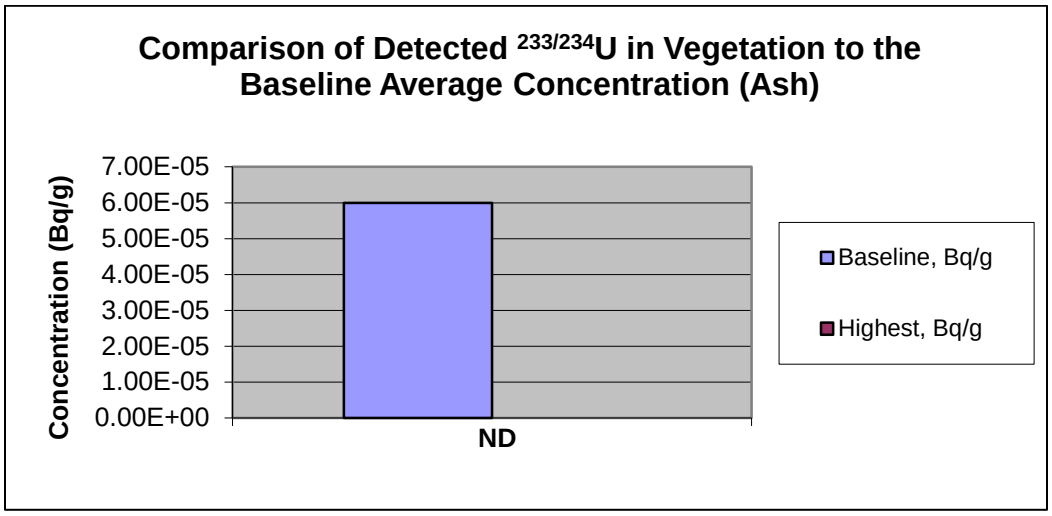

Comparison of Detected 233/234U in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
2.50E-02
2.00E-02
1.50E-02
1.00E-02
5.00E-03
0.00E+00
SMR, 0-2 cm
Baseline, Bq/g
Highest, Bq/g

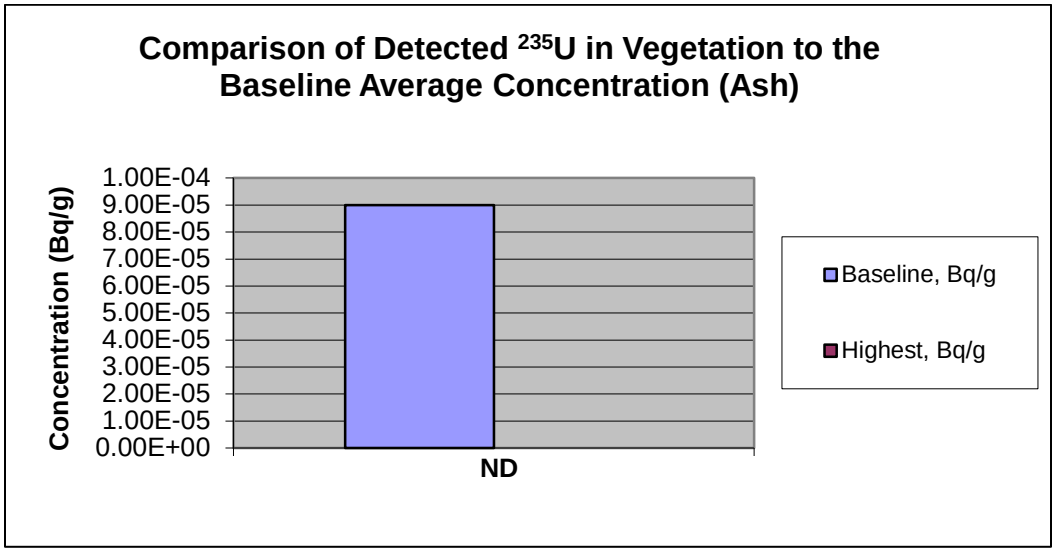

Comparison of Detected 235U in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
1.80E-03
1.60E-03
1.40E-03
1.20E-03
1.00E-03
8.00E-04
6.00E-04
4.00E-04
2.00E-04
0.00E+00
SMR, 2-5 cm
Baseline, Bq/g
Highest, Bq/g

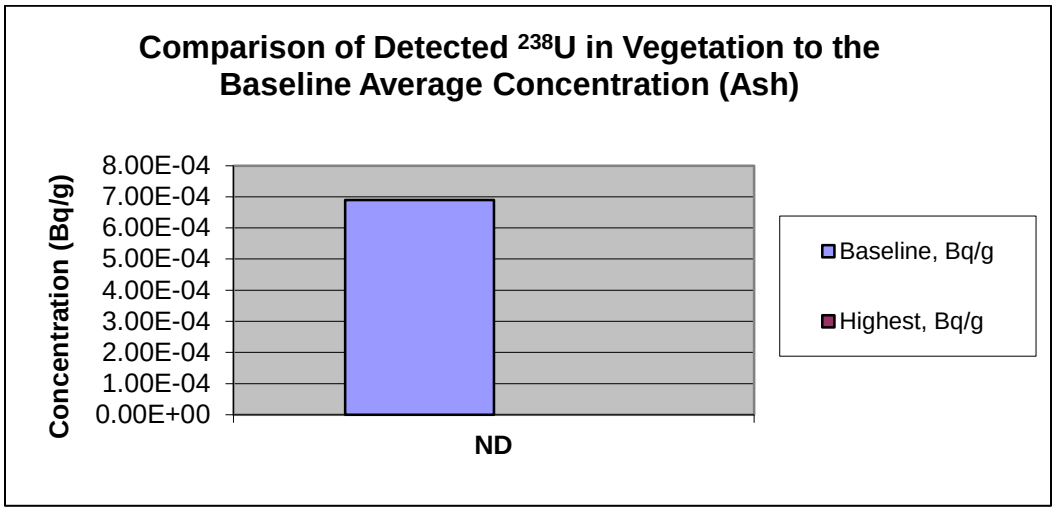

Comparison of Detected 238U in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
2.00E-02
1.50E-02
1.00E-02
5.00E-03
0.00E+00
SMR, 0-2 cm
Baseline, Bq/g
Highest, Bq/g

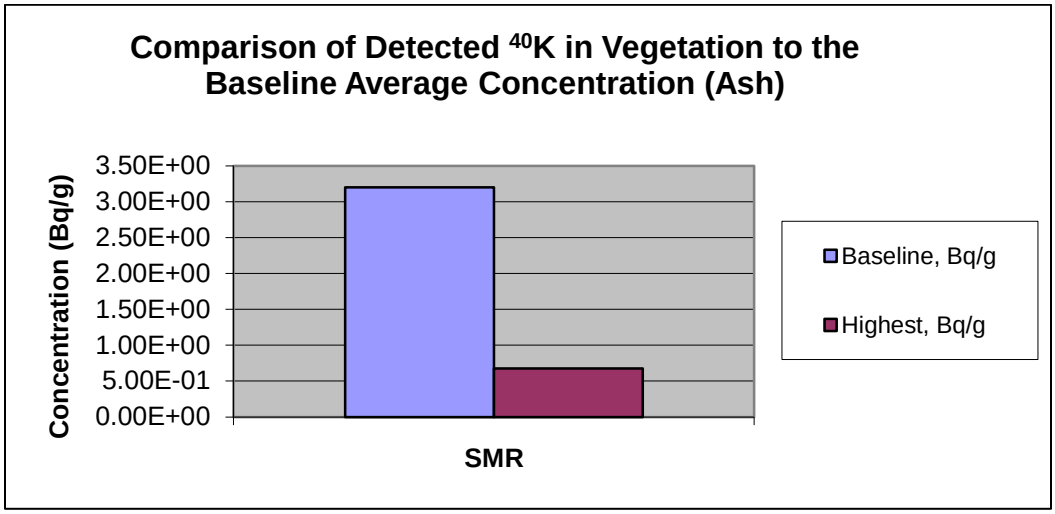

Comparison of Detected 137Cs in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
3.00E-02
2.50E-02
2.00E-02
1.50E-02
1.00E-02
5.00E-03
0.00E+00
SMR, 0-2 cm
Baseline, Bq/g
Highest, Bq/g

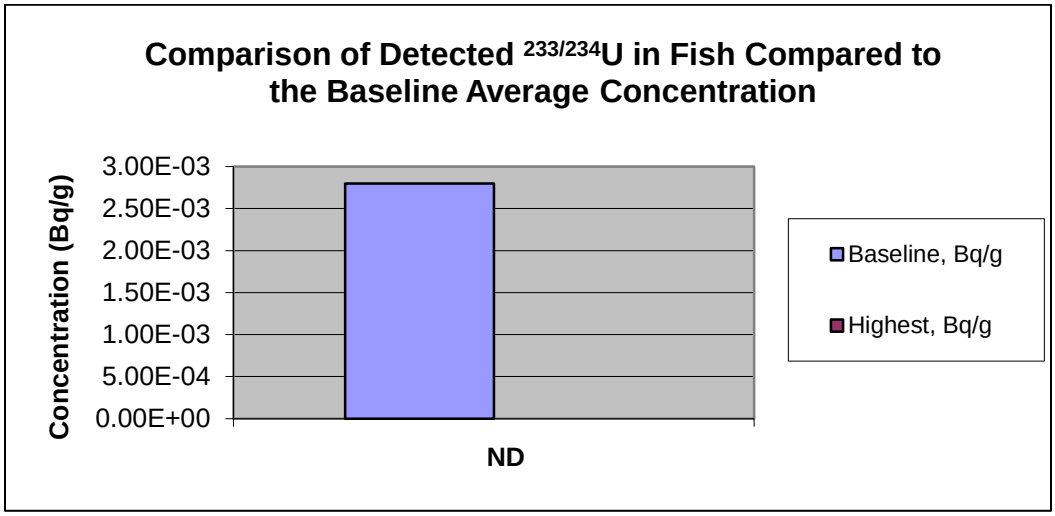

Comparison of Detected 40K in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
SMR, 0-2 cm
Baseline, Bq/g
Highest, Bq/g

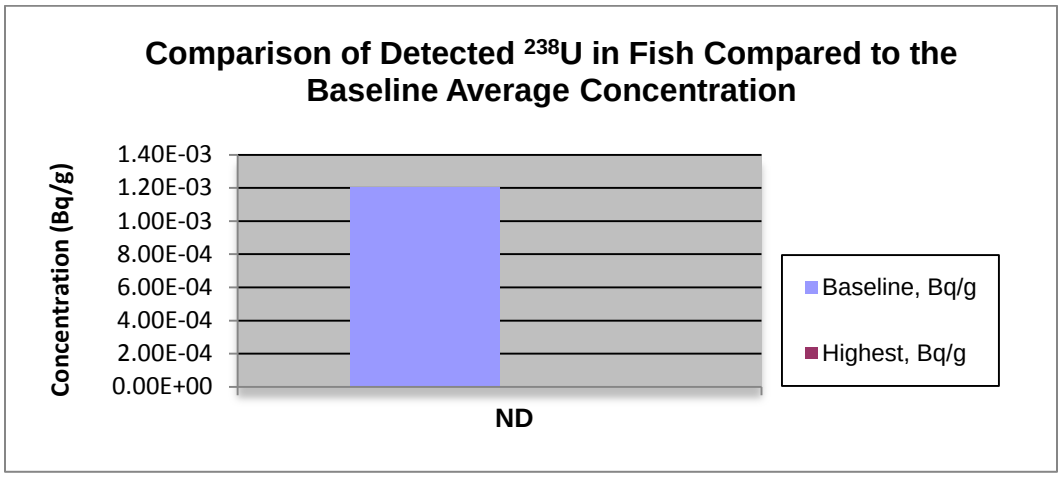

Comparison of Detected 233/234U in Vegetation to the Baseline Average Concentration (Ash)
Concentration (Bq/g)
7.00E-05
6.00E-05
5.00E-05
4.00E-05
3.00E-05
2.00E-05
1.00E-05
0.00E+00
ND
Baseline, Bq/g
Highest, Bq/g

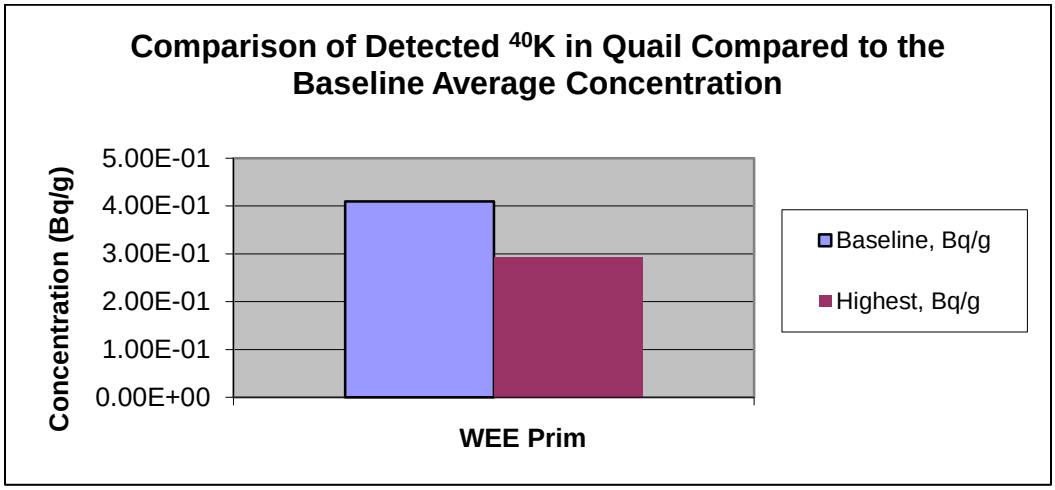

Comparison of Detected 235U in Vegetation to the Baseline Average Concentration (Ash)
Concentration (Bq/g)
1.00E-04
9.00E-05
8.00E-05
7.00E-05
6.00E-05
5.00E-05
4.00E-05
3.00E-05
2.00E-05
1.00E-05
0.00E+00
ND
Baseline, Bq/g
Highest, Bq/g

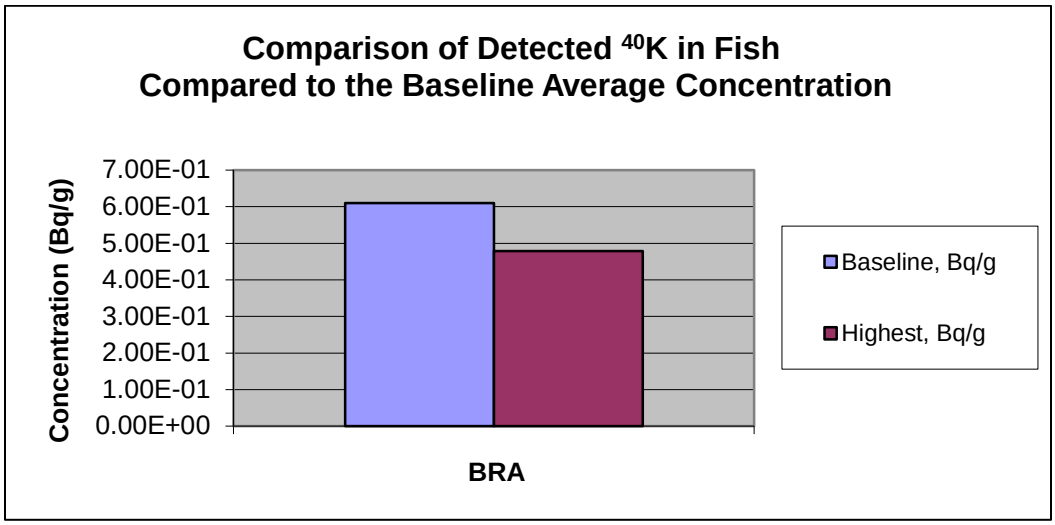

Comparison of Detected 238U in Vegetation to the Baseline Average Concentration (Ash)
Concentration (Bq/g)
8.00E-04
7.00E-04
6.00E-04
5.00E-04
4.00E-04
3.00E-04
2.00E-04
1.00E-04
0.00E+00
ND
Baseline, Bq/g
Highest, Bq/g

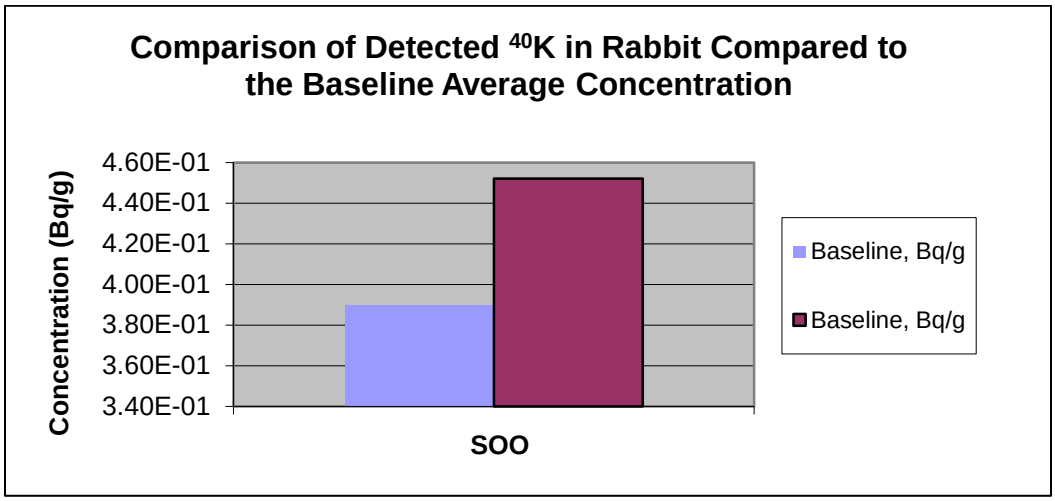

Comparison of Detected 40K in Vegetation to the Baseline Average Concentration (Ash)
Concentration (Bq/g)
3.50E+00
3.00E+00
2.50E+00
2.00E+00
1.50E+00
1.00E+00
5.00E-01
0.00E+00
SMR
Baseline, Bq/g
Highest, Bq/g


Comparison of Detected 233/234U in Fish Compared to the Baseline Average Concentration
Concentration (Bq/g)
3.00E-03
2.50E-03
2.00E-03
1.50E-03
1.00E-03
5.00E-04
0.00E+00
ND
Baseline, Bq/g
Highest, Bq/g


Comparison of Detected 238U in Fish Compared to the Baseline Average Concentration
Concentration (Bq/g)
1.40E-03
1.20E-03
1.00E-03
8.00E-04
6.00E-04
4.00E-04
2.00E-04
0.00E+00
ND
Baseline, Bq/g
Highest, Bq/g


Comparison of Detected 40K in Quail Compared to the Baseline Average Concentration
Concentration (Bq/g)
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
WEE Prim
Baseline, Bq/g
Highest, Bq/g


Comparison of Detected 40K in Fish Compared to the Baseline Average Concentration
Concentration (Bq/g)
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
BRA
Baseline, Bq/g
Highest, Bq/g


Comparison of Detected 40K in Rabbit Compared to the Baseline Average Concentration
Concentration (Bq/g)
4.60E-01
4.40E-01
4.20E-01
4.00E-01
3.80E-01
3.60E-01
3.40E-01
SOO
Baseline, Bq/g
Baseline, Bq/g