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Waste Isolation Pilot Plant Annual Site Environmental Report for 2019

Revision 0

U.S. Department of Energy

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Waste Isolation Pilot Plant Annual Site Environmental Report for 2019

U.S. Department of Energy

September 2020

Prepared by:	/signature on file/ Anderson Ward, Ph.D. Site Regulatory Specialist Carlsbad Field Office	09/08/2020 Date
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2019 Annual Site Environmental Report

To our readers:

This Waste Isolation Pilot Plant (WIPP) Annual Site Environmental Report for 2019 presents summary environmental data to (1) characterize environmental management performance at the WIPP site; (2) summarize environmental occurrences and responses reported during the calendar year; (3) summarize 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 DOE'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	09/23/2020	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
AWMS	Advanced Waste Management Systems
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
CAR	Corrective Action Report
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
EMSD	Emergency Management and Security Department
EMSSC	Environmental Management System Steering Committee
EO	executive order
EPA	U.S. Environmental Protection Agency
EPEAT	Electronic Product Environmental Assessment Tool
EUA	Exclusive Use Area
FD	Fire Department
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
gal/ft^2	gallons per foot squared
GC/MS	gas chromatography / mass spectrometry
GHG	greenhouse gas
HEAL	Hall Environmental Analysis Laboratory
HEPA	high-efficiency particulate air (filter)
HWDU	Hazardous Waste Disposal Unit
ICE	Issue Collection and Evaluation
ICP	inductively coupled plasma
ID	identification (confidence)
in.	inch(es)
ISMS	Integrated Safety Management System
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	WIPP Land Management Plan
LWA	*Waste Isolation Pilot Plant Land Withdrawal Act* (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	milliliter(s)
mm	millimeter(s)
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
NATTS	National Air Toxics Trends Station
NCR	Non-Compliance Report
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
NPDES	National Pollutant Discharge Elimination System
NRIP	National Institute of Standards and Technology Radiochemistry Intercomparison Program
NWP	Nuclear Waste Partnership LLC
ODS	ozone depleting substance
P2	Pollution Prevention
PAS	portable air sampler
PCB	polychlorinated biphenyl
Permit	WIPP Hazardous Waste Facility Permit
pH	measure of the acidity or alkalinity of a solution
PIC	Potential Impact Category
PMR	Permit Modification Request
PPA	Property Protection Area
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
SARA	Superfunds Amendment and Reauthorization Act
SD	Security Department
SEIS-II	Supplemental Environmental Impact Statement II
SERC	State Emergency Response Commission
SHS	Salt Handling Shaft

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
SSP	Site Sustainability Plan
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

EXECUTIVE SUMMARY

PURPOSE

The purpose of the Waste Isolation Pilot Plant (WIPP) Annual Site Environmental Report for 2019 (ASER) is to provide the information required by U.S. Department of Energy (DOE) Order 231.1B Administrative Chg. 1, *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, Administrative Chg. 3, *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], with a half-life greater than 20 years) generated by the production of nuclear weapons and other activities related to the national defense of the United States.

WIPP DISPOSAL FOR 2019

In calendar year (CY) 2019, 1,682.65 cubic meters (m^3) of TRU waste (referred to as the Land Withdrawal Act [LWA] TRU waste volume) was disposed of at the WIPP facility. This waste occupies a physical volume of 2,278.78 m^3 within the disposal facility (referred to as the TRU mixed waste volume). From the first receipt of waste in March 1999, through the end of 2019, 97,331.01 m^3 of TRU mixed waste consisting of 68,920.64 m^3 of LWA TRU waste volume 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* (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.

Waste Isolation Pilot Plant 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 CY 2019, there was one detection of $^{239/240}Pu$ (plutonium) in the sediment sample from location TUT tank (TUT). The concentration was lower than the baseline concentration of 1.90E-03 becquerels per gram (Bq/g) (DOE/WIPP-98-2285). There were no detections of transuranics in the quarterly air filter composite samples, groundwater, surface water, soil, 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. Waste Isolation Pilot Plant environmental personnel also conduct surveillances in the region surrounding the site to protect WIPP facilities and land from inadvertent use.

The monitoring and surveillance programs used by the DOE at 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

- 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 2019, 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 2019:

New Mexico Submittals:

- WIPP Hazardous Waste Facility Permit (Permit)
  - Semiannual VOC, Data Summary Reports
  - Mine Ventilation Rate Monitoring Report
  - Waste Minimization Statement
  - Annual WIPP Culebra Groundwater Report
  - Semiannual Groundwater Surface Elevation Report
  - Geotechnical Analysis Report
  - Report of Implementation of the WIPP Facility RCRA Contingency Plan
  - Emergency and Hazardous Chemical Inventory Report
  - Toxic Chemical Release Inventory Report
- Discharge Permit (DP-831)
  - Semiannual Discharge Monitoring Reports

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

- Delaware Basin Monitoring Annual Report

- 2019 Annual Polychlorinated Biphenyls Report
- WIPP Subsidence Monument Leveling Survey
- 2018/2019 Annual Change Report
- Superfund Amendments and Reauthorization Act of 1986
  - Emergency and Hazardous Chemical Inventory Report
  - Toxic Chemical Release Inventory Report

CBFO Submittal:

- 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

WIPP EMS objectives are communicated as strategic level environmental objectives as denoted by the WIPP environmental management policy. The policy supports DOE sustainability goals while denoting the WIPP business standard and operational expectation. Program progress during 2019 was focused on integrating sustainability into everyday business activities.

Highlights include the following:

- The Environmental Management System Steering Committee (EMSSC) continues to function at a high level and ensures the leadership and commitment required to maintain compliance with the International Organization for Standardization (ISO) 14001:2015 standard, while providing senior management a direct path to implement and manage ISO 14001:2015 certification maintenance.
- In 2019, the DOE continued to place a priority on sustainable procurement language inclusion into applicable work packages, contracts, and purchase orders. This emphasis is designed to ensure the facility operates in a sustainable manner, ultimately increasing overall mission resiliency, and to support DOE sustainability goals. This effort mandates the use and application of sustainable products that meet the General Services Administration product labeling and certification requirements including:

– Recycled content

– BioBased/BioPreferred

– SNAP (Significant New Alternatives Policy)

– SaferChoice

– WaterSense

- Energy Star
- FEMP (Federal Energy Management Program)
- EPEAT (Electronic Product Environmental Assessment Tool)
- Policy improvements include applying standards to products containing greenhouse gases (GHGs), ozone depleting substances (ODSs) and VOCs

The DOE generated a total of 206 metric tons (MT) of municipal solid and recyclable waste. The DOE successfully diverted 71 percent or 146 MT of product from the local landfill.

Environmental Management System Implementation

Overall accomplishments of the EMS for 2019 were as follows:

- Based on environmental monitoring data, DOE demonstrated that there has been no adverse impact to human health or the environment from WIPP facility operations.
- Within the WIPP EMS program, during 2019, the DOE designated 12 environmental targets that were initiated, tracked, and reported on (for full details see Section 3.1).
- Successfully completed 2 third-party external EMS audits with zero non-conformities/findings noted.

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 (mrem/yr).

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 per year (mSv/yr) (67.0 mrem/yr). 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

Waste Isolation Pilot Plant facility 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 Clean Air Assessment Package 1988 (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 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. Calculations made using the CAP88-PC code indicate that the EDE to an individual member of the public resulting from normal operations conducted at this facility is estimated to be: 1.36E-06 mrem/yr to the maximally exposed off-site resident individual at 5.5 miles (8.85 kilometers [km]) west-northwest. In addition, during CY 2019, the EDE potentially received by the non-WIPP worker at the Safety Significant Confinement Ventilation System construction office trailer maximally exposed individual (MEI) assumed to be located 300 meters (0.2 mi) east-southeast of the WIPP facility is calculated to be 3.48E-05 mrem/yr for the whole body. These values are in compliance with the 10 mrem/yr emission standard stated in 40 CFR §61.92 and is approximately 1.36E-05 and 3.48E-04 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.

More game animals were collected in 2019 than in recent years. Game animals sampled and analyzed during 2019 included quail composite samples (three to four specimens per sample) from WEE and WNN, two fish samples from BRA and CBD, one rabbit samples of opportunity (SOO) and one deer SOO (location codes can be found in Appendix C). The quail composite sample from WNN was collected in duplicate. Naturally occurring potassium-40 (^{40}K) was detected in all the samples and uranium-233/234 ($^{233/234}U$) was detected in the fish sample from CBD. By extrapolation, no dose from WIPP-related radionuclides was received by any individual from this pathway (i.e., the ingestion of meat from game animals) during 2019.

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 WIPP facility 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 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 4.88E-07 mSv/yr (4.88E-05 mrem/yr) for the whole body and 6.18E-06 mSv/yr (6.18E-04 mrem/yr) to critical organs. 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 1.36E-08 mSv/yr(1.36E-06 mrem/yr) for the whole body. In addition, during CY 2019, the EDE potentially received by the non-WIPP worker at the Safety Significant Confinement Ventilation System construction office trailer MEI assumed to be located 300 meters (0.2 mi) east-southeast of the WIPP facility is calculated to be 3.48E-05 mrem/yr for the whole body. These values are 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 2019. 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 2019. 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 2019.

CHAPTER 1 – INTRODUCTION

The purpose of this report is to provide information required by U.S. Department of Energy (DOE) Order 231.1B Administrative Chg. 1, *Environment, Safety, and Health Reporting*. Specifically, this ASER presents summary environmental data to:

- Characterize site environmental management performance.
- Summarize environmental occurrences and responses reported during the 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 WIPP EMS.

This document gives a brief overview of the WIPP facility environmental monitoring processes and provides the CY 2019 environmental monitoring and surveillance 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 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 LWA (Public Law 102–579, as amended by Public Law 104-201) 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) in order to be eligible for disposal in the WIPP repository.

TRU waste is disposed of 655 m (2,150 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 into 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 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 10,240 acres (41.4 square kilometers [km^2] or

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 km (26 miles mi) east of Carlsbad, New Mexico, in an area known as Los Medaños.

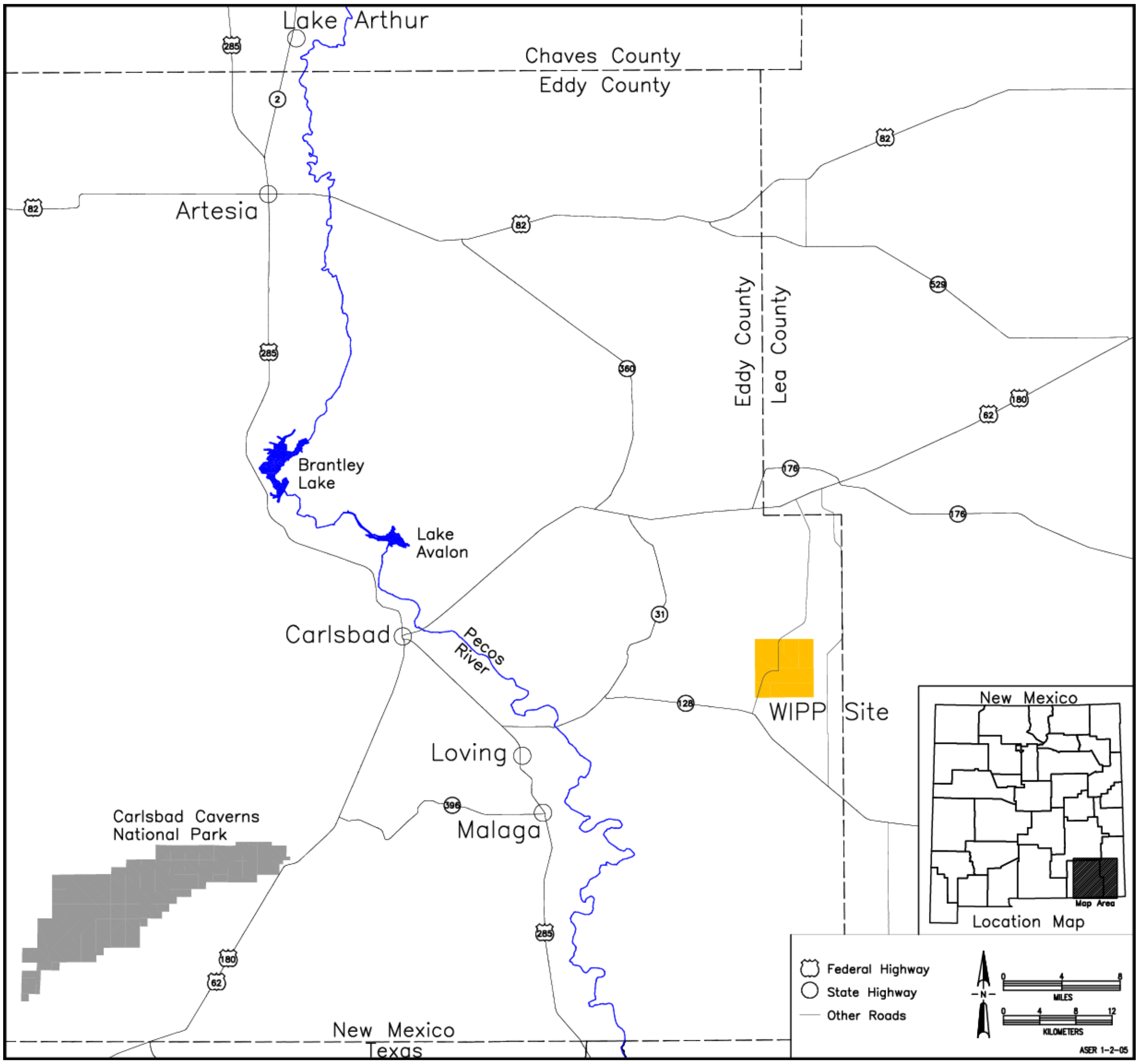

Figure 1.1 – WIPP Site Location

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) and the New Mexico State Land Office. 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 area is home to diverse populations of animals and plants.

1.3.1 WIPP Property Areas

The LWA established a withdrawal area reserved for WIPP facility. The withdrawal area is generally described as sections 15 through 22 and 27 through 34, all inclusive, of Township 22 south, Range 31 east, New Mexico Principal Meridian. Four property areas are defined within the WIPP site boundary (Figure 1.2).

Property Protection Area

The interior core and active part of the facility, established as the Property Protection Area (PPA) in the Hazardous Waste Facility Permit (Permit), encompasses approximately 34 acres (0.14 km^2 or 0.05 mi^2) without the New Filter Building and approximately 44 acres (0.18 km^2 or 0.07 mi^2) with the New Filter Building and is surrounded by a chain-link security fence and marked with signs and controlled in accordance with Permit requirements.

Exclusive Use Area

The Exclusive Use Area (EUA) comprises approximately 293 acres (1.18 km^2 or 0.46 mi^2). 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 detect unauthorized activities or uses. Additional areas related to the H-19 Evaporation Pond, New Filter Building, and shaft construction areas have also been identified as restricted access areas outside the EUA and are fenced and posted to prevent unauthorized entry.

Off-Limits Area

Unauthorized entry and introduction of weapons or dangerous materials is prohibited (as provided in 10 CFR §§860.3 and 860.4) in the Off-Limits Area. Pertinent prohibitions and penalties (10 CFR §860.5) are posted as directed in 10 CFR §860.6 along the perimeter of the Off-Limits area, which encompasses 1,453.9 acres (5.88 km^2 or 2.27 mi^2). Livestock grazing and limited public thoroughfare 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 detect unauthorized activities or use.

WIPP Land Withdrawal Area

The 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. An amendment to this law was subsequently enacted on September 23, 1996. The WIPP site boundary delineates the perimeter of the WIPP Land Withdrawal Area. This tract includes the PPA, the EUA, and the Off-Limits Area, as well as outlying areas that are open to public recreation within the WIPP site boundary. Livestock grazing and public access for recreational use will continue unless these activities present a threat to the security, safety, or environmental quality of the WIPP site. Additional details for the four property areas and access restrictions may be found in the LMP.

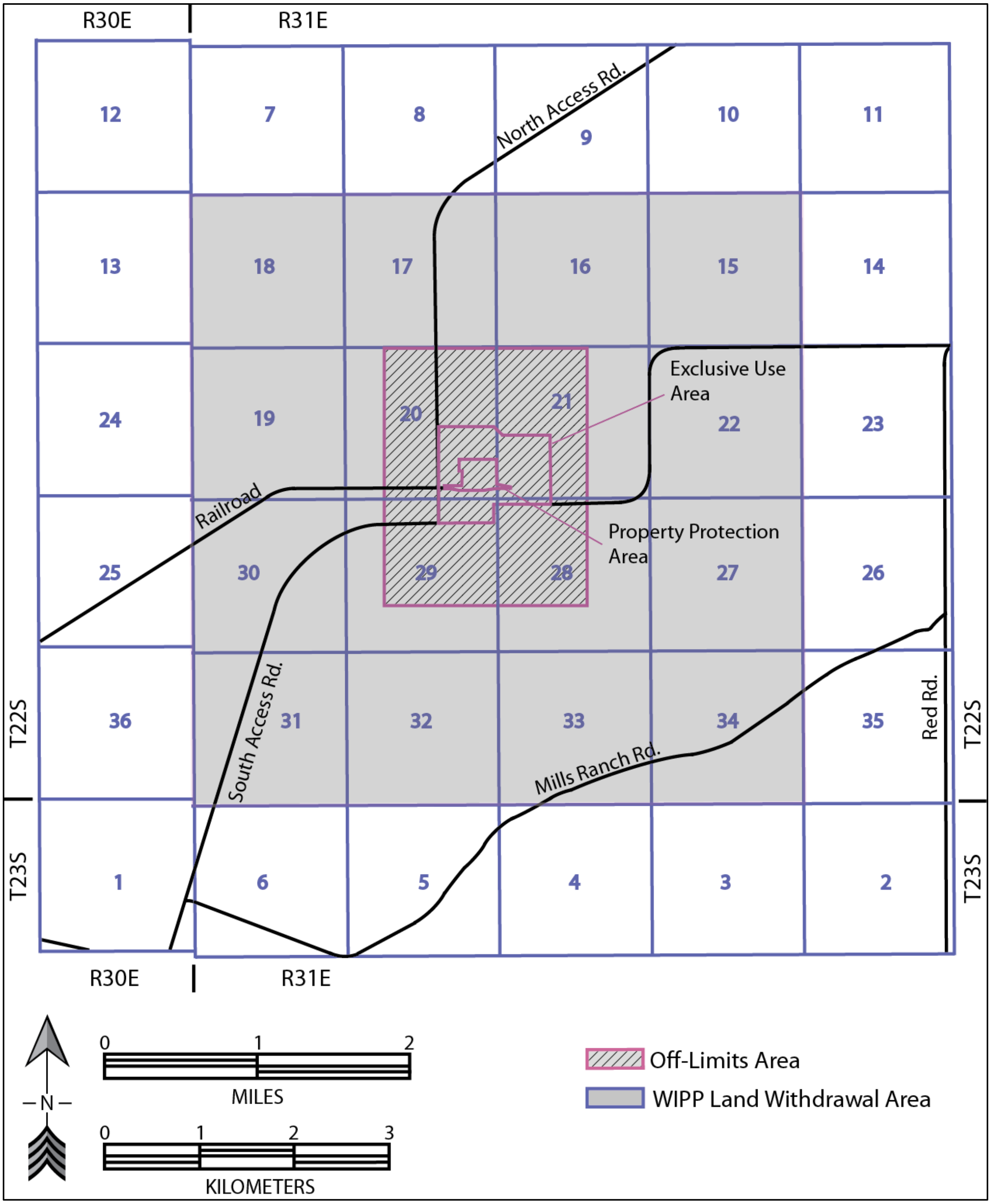

Figure 1.2 – WIPP Property Areas

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 LMP, 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 2019.

1.3.2 Population

There are 21 permanent residents living within 16 km (10 mi) of the WIPP site during CY 2019. 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 in 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 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 2019 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	17	Weekly
	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 2 6	Annual As available As available As available Annual Annual
	Soil	6	Annual
	Surface water, H-19, sewage treatment Facultative Lagoons, and Storm Water Ponds 1 and 2 (as needed)[(b)]	Maximum of 17	Annual
	Sediment	Maximum of 12	Annual
	Groundwater (Detection Monitoring Program [DMP])	6	Annual
Non-radiological	VOCs—repository VOCs—disposal room	2 # of active panel disposal rooms	Semiweekly Biweekly
	Groundwater (DMP)	6	Annual
	Shallow groundwater (DP-831)	12	Semiannual
	Surface water (DP–831)	6 storm water infiltration control ponds	Annual and after major storm events
	Shallow groundwater (DP-831)	4 sewage lagoons	Semiannual
	Meteorology	1	Continuous
	Volatile organic compounds (VOCs)		

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 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-18-3526).

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. 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 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 for emergency response. The 2019 Tier II Form for the WIPP facility was submitted to the SERC, the LEPC, and fire departments prior to March 1, 2019, as required by 40 CFR Part 370 and in compliance with Section 312 of the Emergency Planning and Community Right-to-Know Act. This report included the revised physical and health hazard classifications associated with the WIPP facility on-site chemical inventory (See Table 2-1).

Title 40 CFR Part 372, "Toxic Chemical Release Reporting: Community Right to Know," requires facilities to submit a toxic chemical release report to the 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, 2019, reporting deadline. Table 2.1 presents the 2019 *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 accidental releases of hazardous substances exceeding the reportable quantity limits during 2019.

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 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 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 the disposal of contact-handled and remote-handled TRU mixed waste.

On February 26, 2019, the NMED conducted an inspection of the WIPP facility. This inspection resulted in one violation, which was corrected during the inspection, and no violations of the WIPP Permit. The violation pertained to failure to maintain sufficient aisle space at a hazardous waste storage area in accordance with 40 CFR 262.255. The NMED inspectors observed materials in storage behind and to the right of the pallets of hazardous waste lead-acid batteries stored in a central accumulation area at the magnesium oxide shed. The pallets of batteries were configured in such a way that it would have been overly difficult to reach the rear pallets in case of a spill or an emergency. The aisle space on each side, against the wall on the left and abutting materials at the rear and on the right, was less than 2 feet.

In its Notice of Violation letter (dated March 27, 2019), NMED identified the violation was adequately addressed during the inspection, therefore, no further action was required. NMED did not assess a civil penalty for the violation.

In December 2019, the Permittees provided the Permit-required information relative to the closure of the Underground Hazardous Waste Disposal Units (HWDUs), known as Panels 3, 4, 5, and 6. These panels were closed on August 22, 2019, in accordance with Permit Attachment G and Permit Attachment G1. The closures for these panels were installed in the W170, W-30, E-140, and E-300 drifts between S-2750 and S-2520 (i.e., between Panels 9 and 10). The required survey plats and certifications were submitted to the NMED and provided to the Eddy County Clerk for recording in the land records of Eddy County, NM.

2.2.2 Modification Requests

In 2019, 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 was provided in the Information Repository.

Table 2.2 – Permit Modification Notifications and Requests Submitted in 2019

Class	Description	Date Submitted
1	Report Final LWA TRU Waste Volumes for filled Panels 1 through 6 in Permit Part 4, Table 4.1.1	March 21, 2019
	Clarify Recordkeeping Requirements in Attachment N, Section N-5h Editorial Corrections to Attachment O Revise Figures to Reflect Building Removals and Editorial Change Revise Attachment D, Figure D-3 Clarify Acreage for the Property Protection Area Revise List of Resource Conservation and Recovery Act Emergency Coordinators	July 24, 2019
	Update Department of Energy, Carlsbad Field Office Manager and the List of Active Environmental Permits	August 1, 2019
	Update Co-Permittee Project Manager	September 16, 2019
	Update Panel Closure Information	December 12, 2019
	Update Department of Energy, Carlsbad Field Office Acting Manager	December 13, 2019
2	Removal of Deteriorating/Non-Essential Water Level Monitoring Program Wells	October 25, 2019
3	Excavation of a New Shaft and Associated Connecting Drifts	August 15, 2019

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 WIPP facility has two petroleum underground storage tanks; one containing diesel and the other containing unleaded gasoline. Facility Operations personnel are Class A, B, and C Operator trained and certified to perform necessary functions according to their classification. Weekly and monthly inspections are performed for leak detection and proper operation of the storage tank systems.

The NMED conducted a biennial inspection of the UST system on October 30, 2019.

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 facility as a result of the cleanup from the February 2014 radiological release.

Hazardous wastes are managed in satellite accumulation areas; a Central Accumulation Area (less-than-90-days) on the surface, and a Central Accumulation Area (less-than-90-days) 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, Administrative Chg. 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 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 WIPP 2019 Biennial Hazardous Waste Report was submitted to the NMED on February 21, 2020.
- 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 2019, representing results for July 1, 2018, through June 30, 2019.

- Permit Part 4, Section 4.6, Maintenance and Monitoring Requirements, requires semiannual 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 semiannual reports in April 2019, representing results for July 1, 2018, through December 31, 2018, and in October 2019, representing results for January 1, 2019, through June 30, 2019. On September 7, 2018, the NMED approved a Class 3 Permit Modification Request (PMR) that removed the requirement to perform hydrogen and methane monitoring and ongoing disposal room VOC monitoring along with the associated reporting requirements. The effective date of this Class 3 PMR was October 8, 2018. As a result, the Permittees addressed the requirements for hydrogen and methane monitoring and ongoing disposal VOC monitoring data in the April 2019 semiannual report only.
- 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. Carlsbad Environmental Monitoring and Research Center participated in two quarterly PTs in 2019 as described in Section 7.2.4 of this ASER. 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 Detection Monitoring Program (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 41 was submitted to the NMED in November 2019. Sampling results are summarized in Appendices E and F of this ASER.
- Permit Part 5, Section 5.10.2.2, requires semiannual 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). Semiannual reports were submitted to the NMED in May and November 2019, 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 2019, as required.
- Permit Part 6, Section 6.7, requires the Permittees to certify in writing to the Secretary within 60 calendar days of completion of closure of each Underground HWDU, and within 60 calendar days of completion of final closure, that the Underground HWDUs and/or facility have been closed. The Permittees sought a 60-day extension for submittal of this certification. The certification for Panels 3, 4, 5, and 6 was submitted to the NMED on December 19, 2019.
- Permit Part 6, Section 6.8, requires submission of a survey plat detailing the location and dimensions of each HWDU with respect to permanently surveyed benchmarks. The Permittees sought a 60-day extension for submittal of this survey plat. The survey plat for Panels 3, 4, 5, and 6 was submitted to the NMED on December 19, 2019, and to Eddy County on December 16, 2019.

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 generated on July 10, 2019.

Day-to-day operational compliance with the NEPA at the WIPP facility is achieved through implementation of a NEPA compliance plan and procedure. Twenty-Two proposed projects were submitted through the NEPA screening and approval process in 2019. Three of these projects were maintenance or upgrades to WIPP facility structures and equipment to prepare for restarting the WIPP facility. Nineteen of the projects required Land Use Requirement evaluation since they took place outside the WIPP site boundary; these projects also required CBFO NEPA Compliance Officer approval. In addition to the 22 projects that required NEPA approvals, were numerous 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 impact 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. By the end of CY 2019, the DOE had not yet issued a final determination.

In March 2019, the DOE prepared a Categorical Exclusion Determination for a small-scale batch plant located adjacent to the WIPP Land Withdrawal Area in accordance with 10 CFR 1021.410(b). The batch plant was erected to supply engineered concrete mix for the construction of the New Filter Building in support of the New Permanent Supplemental Ventilation System (SVS) at the WIPP.

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 2019 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 2019, VOC emissions from containers of TRU and TRU mixed waste remained less than 10 tons per year for individual VOCs and less than 25 tons per year for any combination of VOCs monitored under the Permit.

Five diesel generators were scheduled to be installed at the Safety Significant Class Ventilation System (SSCVS) project to provide power to the project construction until permanent electrical power can be installed. Because of the size and number of these generators, total emissions of criteria pollutants exceeded 10 tons per year. An air permit application was submitted to the NMED – Air Quality Bureau (AQB) for these five generators. The AQB granted the air permit, New Source Review Permit Number 0310-M3, for these generators in June 2019.

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. The SSCVS and the new shaft projects required new storm water ponds and a salt cell. A permit modification to add these ponds and cell to the DP-831 was submitted to the NMED – Ground Water Quality Bureau along with the permit renewal application on December 3, 2018. During CY 2019, the permit renewal/modification was still under review by the Ground Water Quality Bureau.

In accordance with DP requirements, monthly inspections are conducted of each of the storm water ponds, salt storage ponds, facultative lagoons, H-19 Evaporation Pond, 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. As a matter of facility operation and not DP requirements, the sewage lagoons and H-19 Evaporation Pond are inspected weekly for signs of erosion or damage to the liners. 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 semiannually. The sewage lagoons are analyzed for nitrate, total Kjeldahl nitrogen (TKN), total dissolved solids (TDS), sulfate, and chloride while H-19 Evaporation Pond is analyzed for only 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 SSW level contour mapping and semiannual groundwater sampling for sulfate, chloride, and TDS. The SSW monitoring results are discussed in Chapter 6.

The DP requires the sludge in the facultative lagoon system and the Salt Storage Ponds to be measured once during the permit 5-year period. Sludge measurements were obtained for these lagoons and ponds. The lagoons were found to have sludge less than one-third the volume of the pond. Salt Storage Ponds 1 and 3 were found to have sludge less than one third the volume of the pond, but Salt Storage Pond 2 had sludge greater than one third the volume of the pond. A contract for cleaning salt from Salt Storage Pond 2 is out for bid and will be issued the second half of 2020 for work to begin in early Fall.

The DP requires semiannual 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 semiannual reports were submitted; one in July 2019 for reporting period of January 1, 2019, through June 30, 2019, and the other in January 2020, for reporting period of July 1, 2019, through December 31, 2019.

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. 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.

The WIPP Water System must be sampled for disinfection by-products annually within the distribution system. In September 2019, two sample points were sampled according to 40 CFR 141.132 "Monitoring Requirements" for disinfection by-products. Results in both samples were below regulatory limits for both disinfection by-products.

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. No archaeological investigations were required within for WIPP-related activities in 2019.

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 5-year period on April 30, 2008, and again renewed the authority for a 5-year period on May 21, 2013. On March 19, 2018, the EPA issued a Reauthorization Approval for the Storage and Disposal of Non-Liquid Polychlorinated Biphenyls Contaminated with Transuranic Waste and PCB/TRU Waste Mixed with Hazardous Waste for the WIPP facility. The re-authorization was effective on March 19, 2018, and is in effect for five years. At least six months prior to the expiration date, a re-authorization approval request will be submitted.

The required PCB annual report, containing information on PCB waste received and disposed of at the WIPP facility during 2018, was submitted to EPA Region VI in accordance with 40 CFR §761 prior to the July 15, 2019, due date.

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). On March 8, 2019, the President signed into law the Pesticide Registration Improvement Act of 2018 (PRIA 4), which authorized PRIA for 5 years through fiscal year (FY) 2023 and which updated the fee collection provisions of the Federal Insecticide, Fungicide, and Rodenticide Act.

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.

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 2019, 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 2019, 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 of 1976* (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, numerous right-of-way reservations and land-use permits have been granted to the DOE. A list of active right-of-way permits is included in Appendix B1 of Permit Attachment B. Each facility (e.g., road, well pads, 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. Facility personnel have conducted confirmatory effluent monitoring since receipt of waste began in March 1999.

The LWA requires the EPA to conduct recertification of DOE documentation of continued compliance with the standards in 40 CFR Part 191, Subpart B, "Environmental Standards for Disposal," and Subpart C, "Environmental Standards for Ground-Water Protection" every five years after the initial receipt of TRU waste for disposal until the end of the decommissioning phase. The current Compliance Recertification Application for the WIPP Project was submitted to the EPA in March 2019. The EPA is currently reviewing the 2019 WIPP Compliance Recertification Application for completeness.

2.15 DOE Orders

Department of Energy 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

Department of Energy 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 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* (DOE/WIPP-17-3573), 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, *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, Administrative Chg. 1, Radioactive Waste Management

The objective of this order is to ensure that DOE radioactive waste, including TRU waste that is disposed of at the WIPP facility, is 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 the *Transuranic Waste Acceptance Criteria for the Waste Isolation Pilot Plant* (DOE/WIPP-02-3122), and procedures governing the management and disposal of TRU radioactive waste generated off-site.

Occasionally, low-level and mixed low-level waste are generated during operations at the WIPP facility. According to the LWA, low-level waste 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 contain steps that, if followed, will ensure that site-generated low-level and mixed low-level waste is disposed of off-site in accordance with DOE Order 435.1, Administrative Chg. 1, and DOE Manual 435.1-1, Administrative Change 2.

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,* which was revoked by EO 13834, *Efficient Federal Operations.* Project managers must develop, and commit to implement, an annual Site Sustainability Plan (SSP) that identifies their respective contributions toward meeting DOE sustainability goals. The WIPP EMS must be used for implementing the project sustainability plan. The WIPP EMS must maintain conformance to ISO 14001:2015. The WIPP Project sustainability plan for fiscal year (FY) 2019 was prepared in December 2018. This eighth annual update addresses the WIPP Project contribution toward meeting the DOE sustainability goals including the performance status for FY 2018 and planned actions for FY 2019. The project sustainability plan is the basis for establishing annual project environmental objectives and targets related to sustainability. Waste Isolation Pilot Plant Project participants work toward achieving the sustainability goals through the WIPP 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 WIPP EMS was certified to the ISO14001:2015 standard in May 28, 2018.

2.15.6 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.

2.15.7 DOE Policy 451.1, National Environmental Policy Act Compliance Program

This Policy 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.

There was one categorical exclusion determination for 2019. This categorical exclusion determination was for use of small-scale batch plant machinery located adjacent to the WIPP Land Withdrawal Area to supply engineered concrete mix. The concrete mix is for the proposed construction of the New Filter Building in support of the SSCVS.

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 13834, Efficient Federal Operations

This EO was signed on May 17, 2018, and issued in the Federal Register on May 22, 2018. The order added new and/or increased sustainability goal levels. The goals for implementing this new order are as follows:

- Achieve and maintain annual reductions in building energy use and implement energy efficiency measures that reduce costs;
- Meet statutory requirements relating to the consumption of renewable energy and electricity;
- Reduce potable and non-potable water consumption, and comply with stormwater management requirements;
- Utilize performance contracting to achieve energy, water, building modernization, and infrastructure goals;
- Ensure that new construction and major renovations conform to applicable building energy efficiency requirements and sustainable design principles; consider building efficiency when renewing or entering into leases; implement space utilization and optimization practices; and annually assess and report on building conformance to sustainability metrics;
- Implement waste prevention and recycling measures and comply with Federal requirements with regard to solid, hazardous, and toxic waste management and disposal;
- Acquire, use, and dispose of products and services, including electronics, in accordance with statutory mandates for purchasing preference, Federal Acquisition Regulation requirements, and other applicable Federal procurement policies; and
- Track and, as required by Section 7(b) of this order, report on energy management activities, performance improvements, cost reductions,

greenhouse gas emissions, energy and water savings, and other appropriate performance measures.

Accomplishments towards goals established in EO 13834 are discussed in Chapter 3.

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 evident by its continued participation and certification to the ISO 14001 environmental management standard. Performance at the WIPP facility regarding program implementation of the ISO 14001 program is made public online through the WIPP Homepage in accordance with the expectations defined by the President's Council on Environmental Quality and DOE Order 436.1.

The WIPP EMS is implemented as a function of the Integrated Safety Management System (ISMS). This allows WIPP EMS program elements to be presented as a business strategy constructed as best management practices. The best management practices approach ensures the creation, implementation and maintenance of internal plans, policies, and procedures in a manner that protects the worker, the public, and the environment in a manner that documents standard conformance and regulatory compliance.

The defined scope of the WIPP EMS applies to environmental aspects of the WIPP Project under the influence and control of the CBFO and Nuclear Waste Partnership LLC (NWP). On May 4, 2018, Advanced Waste Management Systems (AWMS) confirmed the WIPP EMS program to be suitable, adequate, and effective as documented by audit ER3t. Completion of audit ER3t confirmed the facility successfully transitioned from the ISO 14001:2004 standard to the ISO 14001:2015 standard. The audit denoted no corrective actions, no findings, and no nonconformities of the system as implemented. The WIPP registration certification, dated May 28, 2018 [registration certification # E 00206], remains in effect until May 28, 2021. AWMS has been contracted to conduct five surveillance audits from 2018 to 2021; completion of this contracted activity shall confirm the effectiveness of the WIPP EMS while ensuring continuous improvement of the WIPP EMS program. This process will be managed, monitored and evaluated by the EMSSC as a means to document leadership commitment.

The WIPP EMS challenges and opportunities are summarized in the following paragraphs.

The WIPP EMS program was completely re-designed in 2018 to meet requirements of the ISO 14001:2015 standard update. The facility successfully transitioned from the ISO 14001:2004 standard to the ISO 14001:2015 satisfying DOE expectations prior to the October 2018 declaration deadline. With the support of the EMSSC, the program maintains an Environmental Policy Statement, WIPP EMS Document, Pollution Prevention Program Plan, Sustainable Procurement Plan, and an Electronic Management Policy Statement. Initial challenges during the implementation of the new WIPP EMS program were limited to program integration.

Operational TRU waste emplacement was a significant priority during 2019. The facility confirmation process denoted 292 shipments received in 2019, yielding a total emplaced volume of TRU Mixed Waste and Land Withdrawal Act TRU waste volume totaling 97,331 and 68,921 cubic meters respectively up to the end of 2019. Emplacement of TRU waste remains the most significant (positive) environmental aspect of the WIPP Project.

As in 2017 and 2018, 2019 progress toward the DOE sustainability goals were limited.

3.1 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 re-written, signed, and issued by CBFO and NWP management March 17, 2018. The new environmental policy statement documents the WIPP strategic level environmental objectives in accordance with ISO 14001:2015 standards and expectations. The policy was successfully communicated to CBFO and WIPP staff in April 2018, and requires a mandatory online training course (ENV 100/EMS Awareness Training) to be completed every 24 months. The action was supported by the distribution of a new WIPP EMS program awareness badge card to employees and subcontractors. The Environmental Policy Statement publicly communicates DOE's commitment to protect the environment and remains on a two-year revision cycle.
Environmental Aspects	During 2019, controls continued to be reviewed and strengthened as necessary for the following environmental aspects. • Disposal of TRU waste (including characterization, confirmation, onsite handling, transfer, and emplacement) • Ventilation capability
Legal and Other Requirements	In 2019 there were no legal or other requirements, levied upon the CBFO or NWP relative to WIPP Project functional activities or mission.

Objectives, Targets, and Program(s)	Significant impacts and aspects are documented in the WIPP EMS program which drives the creation of the WIPP Project strategic level environmental objectives. This is documented and made public by the Environmental Policy Statement. The SSP contributes to the establishment of the environmental targets that support DOE sustainable operation goals. A summary of the WIPP facility performance principles regarding the FY 2019 environmental targets is as follows: • **Protect the environment,** prevent pollution, protect land, air and water quality, minimize harm to endangered species, habitats, ecological sensitive areas and cultural resources, and act to correct incidents or conditions that endanger the environment. • **Comply with environmental requirements** applicable to the operation of the WIPP facility through the implementation of programs, plans, practices, and procedures. • **Seek to operate sustainably through safe, responsible, and cost-effective methods** by striving to diminish consumption of natural resources (energy, water, materials), to use sustainable products, to minimize waste generation, and to recycle or reuse materials, when practicable. • Be an **environmentally responsible neighbor** by working with stakeholders to address mutual environmental concerns related to WIPP operations and by seeking out public input and respond to stakeholder views when making decisions. • Enhance **environmental performance** by setting and working to achieve objectives and targets that are focused within these principles. Within the WIPP EMS program, the DOE denoted 12 environmental targets that were reported on in 2019, including the following: • Annual drill and/or exercise specific to emergency response to an environmental release (radiological) • Install Video Tele Conference into Skeen-Whitlock Building, Cascades, and site conference rooms • Implement – Virtual Desktop Infrastructure at WIPP site – Thin Client deployment • Replace legacy hardware

	• Install light-emitting diode (LED) lighting in the SWB Data Center • Restore the building load monitoring system (i.e., hard wired and wireless meters) to 25 percent of operability status allowing for a restoration of load monitoring • Ensure implementation of procedure 04-VU4605 that defines limiting the possibility of negative impacts of the environment by changing 80 percent of the filter bank prior to reaching 3.5 inches water gauge • Establish communication and recording for applicable WIPP site process and building meters • Submit design to install LED lighting in the WIPP employee parking lot • Verify that applicable WIPP specifications issued for use incorporate sustainability requirements • 98 percent of the infrastructure projects will utilize FEMP rated equipment • New heating, ventilation, and air conditioning appliances under configuration will use FEMP rated equipment Targets tracked and reported in support of the WIPP Environmental Policy Statement in part or in their entirety
Competence, Awareness, and Training	A WIPP EMS awareness training module, ENV 100, was designed and implemented as an online course to allow tracking via the WIPP Technical Training Learning Management System. The WIPP EMS awareness training course was issued March 28, 2018, and designed to be mandatory for WIPP personnel, NWP subcontractors, and embedded subcontractors, and is required to be retaken every 24 months. As in past years, every WIPP employee completes an in-depth initial General Employee Training and annual refresher as well as one-time Conduct of Operations Training which is fundamental to implementing the Operational Control Elements as a function of the ISMS supporting the WIPP EMS program.
Operational Control	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 and Security Department (SD) became separate entities under Operations during 2019. The effectiveness of the WIPP EM Program is continuously assessed through drills, exercises, and internal and external management assessments, and offsite interfaces. In FY19 one annual full-scale exercise was conducted that included local, state, and federal agencies and organizations as exercise participants. Additionally, 29 drills and exercises were conducted that provided training opportunities specific to underground evacuations, Central Monitoring Room operations, emergency response, and the 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 EM personnel and SD protective force coordinate with both Eddy and Lea County Sheriff Offices and emergency management offices in preparation for drills and exercises. The purpose of these drills/exercises is to develop coordination allowing these agencies to work together more smoothly and to address specific issues and enhance communications. In addition, the Emergency Management Section developed and supported the Carlsbad Medical Center medical drill. 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. The EM Section is updating applicable plans and procedures in conjunction with their Memoranda of Understanding with local, regional, state, and federal agencies. The WIPP Fire Department (FD) and Radiological Control Department are now a branch of the WIPP Environmental, Safety & Health Department. The FD Firefighters have been certified to Firefighter I/II levels. In addition, the FD conducts numerous drills throughout the year. The FD also responds to actual events (vehicle accidents) within a 15-mile radius of the site. The WIPP Fire Department has also implemented a state-certified Emergency Medical Service Basic and Advance Life Support response capability.

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, groundwater, and biota.
Evaluation of Compliance	During FY 2019, CBFO and the MOC performed ten 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 conducted management self-assessments and management field observation 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 apply two programs related to corrective actions and preventative action: • The Issue Collection and Evaluation (ICE) system is the CBFO management tool for documenting and tracking identified issues through management evaluation, approval, resolution of actions, and closure. The ICE 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/CBFO-04-3299, *CBFO Contractor Oversight Pla*n. CBFO issued 62 ICE forms and closed 118 in 2019 (CBFO rejected 33). • The Corrective Action Report (CAR) program identifies conditions adverse to quality and applies corrective actions for timely resolution to prevent recurrence. The CAR program implements applicable portions of DOE O 414.1D and DOE/CBFO-94-1012. CBFO issued 42 CARs and closed 26 in 2019. The NWP Issues Management and Corrective Action Request programs continued to be robust. • The NWP WIPP Form process identifies issues and conditions adverse to quality, and applies corrective actions for timely resolution to prevent recurrence. The WIPP Form process implements applicable portions of DOE O

	422.1, DOE O 414.1D, DOE O 226.1B, and WP 13-1, NWP *Quality Assurance Program Description*. There were 1,162 WIPP Forms issued, and 1,173 closed during this reporting period. • The NWP Non-Compliance Report (NCR) process identifies and controls nonconformities, which implements applicable portions of DOE O 414.1D. There were 20 NCRs issued and 15 closed in 2019. These are the fundamental programs for implementing this element of the WIPP 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	The NWP QA organization completed two internal assessments specific to the WIPP EMS in 2019. On February 27, 2019, NWP QA evaluated the WIPP Environmental Monitoring program in its entirety. The applicable audit report denoted one finding, no corrective actions, and no observations which was closed on July 10, 2019. NWP QA evaluated the EMS Steering Committee and Goals Status on October 31, 2019. The applicable surveillance report denoted one finding, no corrective actions, and no observations.
Management Review	A management review function of the EMSSC was conducted in May and November of 2019. These WIPP EMS semi-annual assessments were conducted by a 3rd party accreditor. During these reviews there were no non-conformances noted. The WIPP EMS program as implemented remains suitable, adequate, and effective according to the standard. The next assessment is scheduled for May 2020.

3.2 Significant Environmental Programs

Fundamental to the WIPP 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 areas that includes the WIPP site. The surveillances build on the data used to develop modeling assumptions for performance assessment used for the Compliance Recertification.

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 land withdrawal boundary. Radiological constituents that are sampled to 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, nearby hydrocarbon drilling activity, and SSW.

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 WIPP LMP provides the basis for the DOE management and oversight of WIPP lands under their jurisdiction as well as 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 is implemented to ensure that the DOE meets the requirements of the NEPA prior to making decisions to implement work at or on behalf of the WIPP facility. In addition, the program is implemented to ensure the DOE considers and addresses other environmental compliance requirements and sustainability prior to implementing work.

3.2.7 Sustainability

SUSTAINABLE WIPP

This program promotes acquisition and use of 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 WIPP 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 that allows the DOE to ensure 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 *Transuranic Waste Acceptance Criteria for the Waste Isolation Pilot Plant* (DOE/WIPP-02-3122).

3.2.10 Waste Confirmation

Under this program, the DOE confirms waste containers 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 includes the framework through which the DOE ensures that site-generated hazardous, universal, New Mexico 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 so that facility personnel can ensure that the WIPP mission is carried out in accordance with its environmental policy. This includes monitoring for (1) impacts to environment, (2) WIPP 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 2019, 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 WIPP EMS Effectiveness

The WIPP EMS program is managed and facilitated on behalf of DOE by NWP. Effectiveness of the WIPP EMS is ultimately determined by how well the WIPP EMS program is integrated into daily operations, with its effectiveness confirmed through a series of internal audits and management self-assessments in conjunction with multiple independent third-party audits which are subsequently evaluated by the EMSSC.

The EMSSC provides WIPP EMS program updates to NWP senior management via the management review process. The report includes details specific to the program's current state, changes, needs and expectations, program aspects, risks and opportunities, current objective support, target progress, program performance, monitoring and measurement, fulfillment of compliance obligations, audit results, adequacy of resource funding, communications, continual improvement, proposed changes (if applicable), followed by denoting the challenges, changes and accomplishments denoted by the WIPP EMS program specific to the sustainability and pollution prevention programs.

3.3.3 Sustainability Progress (Continuous Improvement)

The WIPP EMS annual FedCenter submittal is a web-based report used to denote WIPP EMS performance directly to DOE headquarters, Department of Environmental Management. The 2019 WIPP EMS annual FedCenter submittal stated the CBFO/MOC achieved 91.7 percent, reporting effective in 11 of the 12 goal areas.

The WIPP Site Sustainability Plan (SSP) details the DOE environmental performance specific to supporting federal sustainability goals. Refer to the 2019 SSP for details regarding energy, water, waste, and fleet management, clean and renewable energy projects, green buildings projects, sustainable acquisition and procurement, measures, funding and training, travel and commute, fugitives and refrigerants, electronic stewardship, and organizational resilience.

For FY 2019, the DOE had 19 overarching sustainability category goals. Goals included energy intensity, Energy Independence and Security Act 3432 compliance, renewable electricity, potable water intensity, clean energy, non-potable water consumption, sustainable buildings, fleet petroleum, fleet alternative fuel, fleet greenhouse gas emissions/mile, municipal solid waste, construction & demolition, electronic acquisition, electronics recycling, power management, duplex printing, sustainable acquisition, scope 1&2 greenhouse gas emissions, and scope 3 greenhouse gas emissions.

Sustainability categories for FY 2019 that were achieved: reduced fleet petroleum, diversion of municipal solid waste, EPEAT labeled electronic acquisition, electronic recycling disposal through certified recyclers, electronic power management features, and active use duplex printing features. Based on the WIPP location, mission, energy environment, as well as operational changes necessary from the February 2014 fire and radiological release events, the DOE contribution in some sustainability categories are not anticipated to meet DOE agency wide goals in future years. These areas are GHG emissions, energy, and potable water intensity reductions, use of renewable and clean energy, High Performance and Sustainable Buildings and continuing reduction in petroleum fuel use (use of alternative may become viable as the technology improves), fuels and zero emission, and/or plug-in hybrid use, and/or plug-in electric vehicles.

3.3.4 Reduce Greenhouse Gas Emissions

The DOE continues to support infrastructure upgrades specific to documenting GHG emissions performance. Current efforts are focused on repairing current metering capabilities and the promotion of onsite renewable energy initiatives. However, given the facility's geographic location, current funding capacity, primary mission in conjunction with the area's current energy environment, it is unlikely the facility will maintain its current progress specific to decreasing site generated GHG emissions.

With the facility's extended life expectancy, proposed scope change, and increased footprint induced by the construction of the facility's new SSCVS, it is evident these activities will require an expanded infrastructure which will lead to increased energy use. It is important to note, these changes will require a new sustainability reporting baseline once the projects are brought online.

3.3.5 Water Efficiency and Management

The WIPP facility overall water intensity numbers gallons per foot squared (gal/ft^2) are reflected in figure 3.1. The figure depicts water intensity that has been relatively level through FY 2014, increasing dramatically in FY 2015 and FY 2016, this was induced by recognized water leaks, water line repair/test efforts, and increased personnel associated with the recovery effort. Beginning in late 2015, water intensity had returned to the expected norm. Fiscal year 2018 shows an increase due to increased personnel associated with restart and initiation of normal operations. Water use in FY 2019 decreased again, to 3.7 million gallons. The decrease is attributed to the continuing repair of yard piping leaks and release of recovery subcontractors.

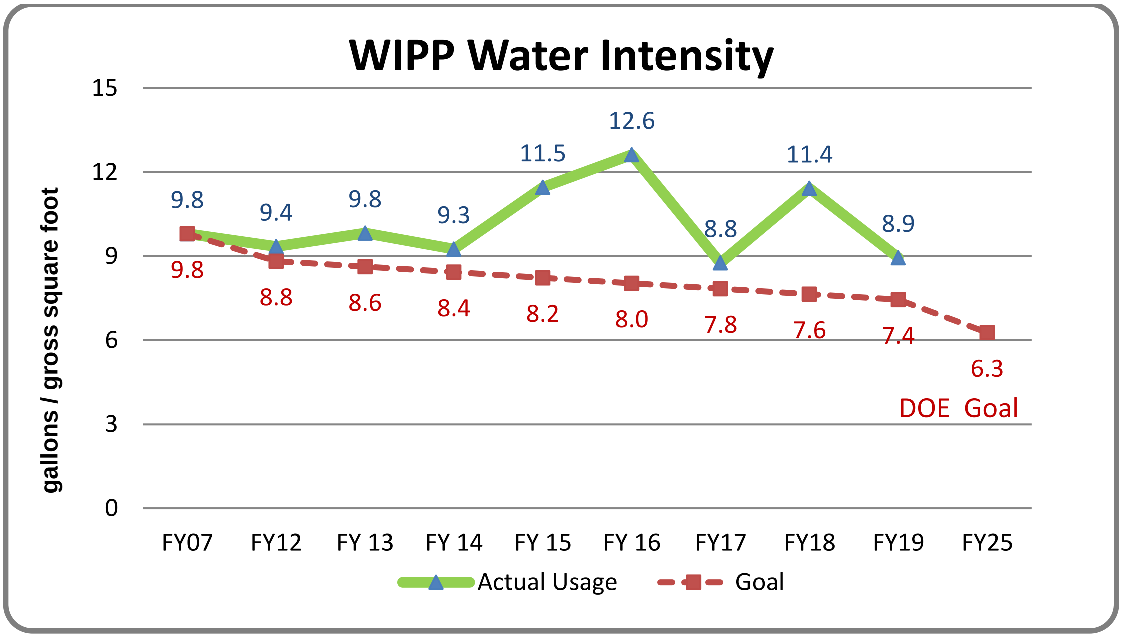

Figure 3.1 – WIPP Water Intensity

The DOE strategy to reduce water use for FY 2019 and beyond 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.
- Use clean storm water for construction applications.

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 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.

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 (P2) program is in place 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, construction and demolition (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). Site generated e-waste (computer, printers, copiers, and miscellaneous electronics) are either donated for reuse or sent for recycling. The DOE requires language to be embedded in subcontracts that they will adhere to P2 program standards, which include recycling, to the best extent possible.

During FY 2019 the DOE generated a total of 206 Metric Tons (MT) of municipal solid waste/recycling and C&D recyclable waste at the WIPP site. The DOE successfully diverted 71% or 146 MT of that product from the local landfill, which included 15 MT of mixed electronics that were donated to UNICOR. The WIPP recycling and waste diversion numbers continue to highlight the prescribed standards. The P2 policy continues to positively influence recycling and waste diversion for the project.

3.3.6.1 Plans and Projected Performance

The DOE will continue to work towards maintaining the recycling/diversion goal expectation of 50 percent. However, given the limited regional infrastructure for recycling, maintaining the 50 percent diversion rate will continue to be a challenge during 2020, and beyond.

For FY 2020, actions that will be taken to improve waste diversion rates include:

- Continued replacement of site recycling center bins and associated receptacles with new visually dynamic, ergonomic, consistent collection recycle centers. Significant design focus will be placed on enhancing form, function, and placement. These adaptations will make recycling centers convenient, easy to locate, and substantially enhance visual appeal. During FY 2019, recycling centers were placed at the Cascades, WIPP Labs, and the Skeen Whitlock Building. This action denotes the goal at 100% complete but DOE will continue to monitor for new placement areas and maintenance of the recycling bins.
- Begin recycling wood pallets through a newly acquired pallet vender.

- 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.

3.3.7 Sustainable Acquisition

The DOE requires the inclusion of sustainability contract language and inclusive clauses in site generated service and construction contracts. This requirement communicates the expectation specific to the purchase and use of sustainable products, goods, and services.

The implementation to expand the EMS with emphasis on sustainability in procurement standards was started during FY17 and continues. The increased emphasis is on procurement of recycled content, EnergyStar, 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 project expanded inclusion of preferred sustainability contract language is to be written into Scopes of Work, Purchase Orders, Service Contracts, and Construction Projects from initial design to procurement. This process enables the DOE to ensure the majority of purchases contain requirements to implement sustainable procurement standards.

3.3.7.1 Plans and Projected Performance

The EMS will continue to focus on increasing the use of sustainable products to meet projected 2020 goals. Actions to help achieve this are:

- Continued awareness efforts based on procedure training to ensure sustainability clauses are placed in contracts and sustainable products are purchased.
- Development of continued training on policy and technical procedures for individuals authorized to procure and use credit cards of requirements, contract language, and tools available for researching sustainable product options.
- Maintain an updated Sustainability website that provides standard language that may be used for statements of work for acquisitions types applicable to the WIPP Project.

3.3.8 Electronics Stewardship and Data Centers

The DOE applies sustainable lifecycle management by requiring applicable products, goods, and services document meeting management expectation as required, in part by the facilities Electronic Management Policy. In October 2018, the DOE adopted and issued an update to the electronic management policy relative to ensuring sustainable operations that strengthen the overall sustainability and resilience of the facility. The policy update requires products denoted as having EPEAT requirements shall be EPEAT Gold rated. The policy update expands expectation by revoking exception to the application of site prescribed default power management settings and the default duplex print management settings. The policy update notes the paper used to produce site generated printed material shall be printed on 100 percent recycled content copy paper.

Electronics Management continues to ensure disposition of surplus electronics are conducted in a manner that meet federal expectation. The CBFO/MOC documents 100 percent of the electronics processed are completed either through donations, transfer for reuse, or by a certified electronic product recycler.

In FY 2019, the DOE recycled 22 pallets of surplus electronics, an estimated value of $233,810 (new) through UNICOR.

3.3.8.1 Plans and Projected Performance

The DOE electronic management policy for the WIPP Project was updated in 2018, the policy notes that electronics managed under the policy will be held to a higher procurement standard that includes expanded accountability and documentation expectations.

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CHAPTER 4 – ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM INFORMATION

DOE Order 458.1, Administrative Chg. 3 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 dose 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 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 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 included airborne particulates, soil, surface water, groundwater, sediments, and biota (vegetation and animals). These samples are analyzed for 12 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 12 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 for characterizing radioactive particulate effluent: 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.

Stations B and C are categorized as Potential Impact Category (PIC) 3 sources, requiring periodic confirmatory sampling and off-line analysis to confirm air emissions to be at or less than a 0.01 potential fraction of the allowable dose limit, in accordance with American National Standards Institute Health Physics Society (ANSI/HPS) N13.1-1999.

During this reporting period, the DOE operated the SVS. The SVS consists of an auxiliary fan installed in the S-90 drift in the underground repository to provide additional ventilation air to the underground. Use of the SVS minimizes dust particulate loading on the underground ventilation system HEPA filtration units since the air flow directed to the construction (active mining) areas comes from the additional clean surface air. A portion of the salt dust laden air is exhausted up the Salt Handling Shaft (SHS). Ventilation air through the disposal area will continue to be routed through HEPA filtration (i.e., Station B). The SHS exhaust point is classified as a PIC 4, requiring an annual administrative review of facility uses to confirm absence of radioactive materials in forms and quantities not conforming to prescribed specifications and limits, confirming air emissions to be at or less than a 0.0001 potential fraction of the allowable dose limit, source in accordance with ANSI/HPS N13.1-1999.

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 2019, 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 12 target radionuclides. 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. Monitoring at the SHS is conducted using a portable air sampler (PAS). 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 m^3 (19,756 cubic feet [ft^3]) of air were filtered through the acrylic copolymer membrane filters. There were brief periods when sampling associated with Station B was interrupted during CY 2019, 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 2014, Station B has been the primary emissions sample point of record, but the flow rates and sampler characteristics were not materially changed from prior to that time. The amount of air filtered through Station B acrylic copolymer membrane filters during 2019 was 29,169.7 m^3 (1,030,118 ft^3). The primary emission samples are collected daily at Station B, and an average of 79.9 m^3 (2,822 ft^3) of air were filtered through each air filter at the average annual sample flow rate of 2.00 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 2019 was 5,604.2 m^3 (197,910 ft^3). Even though there were brief periods where sampling associated with Station C was interrupted during CY 2019 total air volume sampled was 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 ft^3/min to 114,000 ft^3/min by the addition of two more HEPA filter trains parallel to the existing two HEPA filter trains in continuous use since the February 2014 radiological event. During 2019, the ventilation system associated with Station B operated normally at a nominal flow rate of 114,000 ft^3/min 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 2019. 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.

Salt Handling Shaft PAS filters were collected three times per week. Each filter was screened for gross alpha and beta activity. Since this sampling location is classified as a PIC 4 source, samples are not required to be sent for radiochemical analysis.

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 2019. From 16 total composite samples taken in 2019, 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.

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 2019 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, 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.

For the SHS PAS, an administrative review was performed of the SVS, including trending of underground ventilation air sample radioactivity levels, to confirm absence of radioactive materials in forms and quantities not conforming to prescribed specifications and limits during this reporting period. Screening values from routine SHS air samples were at levels consistent with background levels, and at least an order of magnitude below an action level that would trigger further radiochemical analysis to confirm potential contaminant detection at or near the PIC 4 constraining values.

Table 4.2 – Station B CY 2019 Sample Results

Mo.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
Jan	^{241}Am	8.51E-03	2.30E-03	1.14E-03
Feb	^{241}Am	4.63E-03	1.86E-03	1.27E-03
Mar	^{241}Am	6.59E-03	2.12E-03	1.19E-03
Apr	^{241}Am	6.62E-03	1.90E-03	1.15E-03
May	^{241}Am	7.47E-03	1.93E-03	1.14E-03
Jun	^{241}Am	1.66E-02	3.02E-03	1.14E-03
Jul	^{241}Am	1.16E-02	2.53E-03	1.14E-03
Aug	^{241}Am	1.28E-02	2.70E-03	1.15E-03
Sep	^{241}Am	1.14E-02	2.60E-03	1.20E-03
Oct	^{241}Am	4.37E-03	1.63E-03	1.16E-03
Nov	^{241}Am	3.96E-03	1.62E-03	1.21E-03
Dec	^{241}Am	9.10E-03	2.41E-03	1.30E-04

Mo.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
Jan	^{238}Pu	-1.71E-04	3.44E-04	1.10E-03
Feb	^{238}Pu	-1.15E-04	2.36E-04	1.01E-03
Mar	^{238}Pu	3.09E-05	3.67E-04	1.09E-03
Apr	^{238}Pu	-1.69E-04	2.65E-04	1.04E-03
May	^{238}Pu	-1.87E-04	3.17E-04	1.09E-03
Jun	^{238}Pu	-5.85E-05	4.81E-04	1.17E-03
Jul	^{238}Pu	-1.44E-04	3.25E-04	9.84E-04
Aug	^{238}Pu	-8.29E-05	1.68E-04	9.73E-04
Sep	^{238}Pu	7.36E-05	4.59E-04	9.69E-04
Oct	^{238}Pu	-9.21E-05	2.76E-04	7.22E-04
Nov	^{238}Pu	3.17E-06	3.74E-04	7.77E-04
Dec	^{238}Pu	-8.95E-05	1.88E-04	7.70E-04

Mo.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
Jan	$^{239/240}$Pu	4.66E-04	6.73E-04	9.58E-04
Feb	$^{239/240}$Pu	8.33E-04	7.77E-04	9.29E-04
Mar	$^{239/240}$Pu	4.44E-04	6.59E-04	9.73E-04
Apr	$^{239/240}$Pu	5.29E-04	6.18E-04	1.07E-03
May	$^{239/240}$Pu	1.22E-03	8.33E-04	9.40E-04
Jun	$^{239/240}$Pu	2.35E-03	1.27E-03	1.03E-03
Jul	$^{239/240}$Pu	8.88E-04	8.55E-04	9.51E-04
Aug	$^{239/240}$Pu	2.50E-03	1.30E-03	1.01E-03
Sep	$^{239/240}$Pu	6.96E-04	8.58E-04	9.36E-04
Oct	$^{239/240}$Pu	4.59E-04	5.92E-04	8.77E-04
Nov	$^{239/240}$Pu	5.55E-04	6.48E-04	9.07E-04
Dec	$^{239/240}$Pu	1.05E-03	7.70E-04	8.62E-04

Mo.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
Jan	^{90}Sr	-1.01E-02	2.48E-02	2.22E-02
Feb	^{90}Sr	-1.50E-02	2.53E-02	2.23E-02
Mar	^{90}Sr	-1.43E-02	2.55E-02	2.22E-02
Apr	^{90}Sr	-1.84E-02	2.15E-02	2.46E-02
May	^{90}Sr	-1.34E-02	2.64E-02	2.27E-02
Jun	^{90}Sr	2.21E-03	2.56E-02	2.30E-02
Jul	^{90}Sr	1.06E-02	2.78E-02	2.30E-02
Aug	^{90}Sr	-7.07E-03	2.41E-02	2.71E-02
Sep	^{90}Sr	-9.92E-03	2.08E-02	2.65E-02
Oct	^{90}Sr	1.21E-03	2.16E-02	2.49E-02
Nov	^{90}Sr	-1.86E-02	2.11E-02	2.50E-02
Dec	^{90}Sr	4.88E-03	2.03E-02	2.52E-02

Mo.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
Jan	$^{233/234}U$	1.66E-04	7.07E-04	2.13E-03
Feb	$^{233/234}U$	-2.88E-05	5.77E-04	2.14E-03
Mar	$^{233/234}U$	-1.82E-04	4.88E-04	2.09E-03
Apr	$^{233/234}U$	9.44E-04	7.96E-04	2.17E-03
May	$^{233/234}U$	1.72E-04	8.21E-04	2.12E-03
Jun	$^{233/234}U$	-2.08E-04	1.02E-03	2.21E-03
Jul	$^{233/234}U$	-1.32E-04	1.07E-03	2.25E-03
Aug	$^{233/234}U$	9.25E-04	1.46E-03	2.18E-03
Sep	$^{233/234}U$	1.65E-03	1.53E-03	2.10E-03
Oct	$^{233/234}U$	1.31E-03	1.08E-03	2.10E-03
Nov	$^{233/234}U$	4.85E-04	7.84E-04	2.08E-03
Dec	$^{233/234}U$	-8.88E-04	9.14E-04	2.06E-03

Mo.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
Jan	^{238}U	-1.72E-04	3.35E-04	1.32E-03
Feb	^{238}U	-4.63E-05	4.48E-04	1.35E-03
Mar	^{238}U	1.11E-04	6.11E-04	1.34E-03
Apr	^{238}U	-1.13E-04	7.88E-04	1.37E-03
May	^{238}U	-1.95E-04	8.62E-04	1.36E-03
Jun	^{238}U	-3.70E-04	8.81E-04	1.41E-03
Jul	^{238}U	1.91E-04	1.07E-03	1.45E-03
Aug	^{238}U	-3.51E-04	1.08E-03	1.50E-03
Sep	^{238}U	6.73E-05	1.17E-03	1.46E-03
Oct	^{238}U	3.70E-05	8.25E-04	1.41E-03
Nov	^{238}U	4.88E-04	9.36E-04	1.38E-03
Dec	^{238}U	1.10E-04	8.29E-04	1.37E-03

Mo.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
Jan	^{137}Cs	-6.11E-02	1.36E-01	2.23E-01
Feb	^{137}Cs	-7.33E-03	1.12E-01	1.98E-01
Mar	^{137}Cs	1.07E-01	1.43E-01	2.43E-01
Apr	^{137}Cs	-1.05E-02	1.25E-01	2.20E-01
May	^{137}Cs	1.02E-01	1.57E-01	2.65E-01
Jun	^{137}Cs	6.07E-02	1.66E-01	2.96E-01
Jul	^{137}Cs	6.85E-02	1.59E-01	2.84E-01
Aug	^{137}Cs	-9.62E-02	1.35E-01	2.33E-01
Sep	^{137}Cs	-6.48E-02	1.50E-01	2.46E-01
Oct	^{137}Cs	4.03E-03	1.61E-01	2.83E-01
Nov	^{137}Cs	5.66E-02	1.48E-01	2.48E-01
Dec	^{137}Cs	-1.24E-01	1.25E-01	2.15E-01

(a) Total propagated uncertainty.

(b) Minimum detectable concentration.

Table 4.3 – Station C CY 2019 Sample Results

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{241}Am	-1.47E-04	8.81E-04	1.30E-03
2nd	^{241}Am	-4.74E-04	7.10E-04	1.18E-03
3rd	^{241}Am	-2.78E-04	6.96E-04	1.18E-03
4th	^{241}Am	-3.00E-04	5.70E-04	1.22E-03

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{238}Pu	1.90E-05	3.53E-04	1.04E-03
2nd	^{238}Pu	-1.28E-04	2.99E-04	9.84E-04
3rd	^{238}Pu	9.66E-05	4.63E-04	1.02E-03
4th	^{238}Pu	-1.41E-04	2.82E-04	8.03E-04

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	$^{239/240}$Pu	-1.72E-04	3.92E-04	9.88E-04
2nd	$^{239/240}$Pu	-4.18E-05	4.40E-04	8.95E-04
3rd	$^{239/240}$Pu	3.08E-05	6.40E-04	9.58E-04
4th	$^{239/240}$Pu	1.18E-04	4.44E-04	8.29E-04

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{90}Sr	1.56E-03	2.61E-02	2.24E-02
2nd	^{90}Sr	-1.29E-02	2.77E-02	2.29E-02
3rd	^{90}Sr	2.05E-03	2.29E-02	2.68E-02
4th	^{90}Sr	-2.64E-02	2.02E-02	2.52E-02

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	$^{233/234}$U	-4.63E-05	5.77E-04	2.13E-03
2nd	$^{233/234}$U	-3.10E-04	1.00E-03	2.26E-03
3rd	$^{233/234}$U	2.52E-04	1.24E-03	2.13E-03
4th	$^{233/234}$U	2.11E-04	1.13E-03	2.02E-03

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{238}U	4.85E-04	6.92E-04	1.34E-03
2nd	^{238}U	-3.37E-04	9.07E-04	1.47E-03
3rd	^{238}U	-7.10E-05	1.15E-03	1.48E-03
4th	^{238}U	1.94E-05	7.77E-04	1.32E-03

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{137}Cs	-8.47E-02	1.08E-01	1.87E-01
2nd	^{137}Cs	-7.55E-02	1.22E-01	2.70E-01
3rd	^{137}Cs	-3.96E-03	1.20E-01	2.13E-01
4th	^{137}Cs	1.48E-03	1.60E-01	2.84E-01

(a) Total propagated uncertainty.
(b) Minimum detectable concentration.

Evaluation of the 2019 filter sample results using the latest EPA-approved CAP88-PC code in effect during CY 2019, 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/yr limit, as specified in 40 CFR §61.92, and the 0.1 mrem/yr 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 16 to 80 km (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.

The Event Evaluation air sample filters collected in 2019 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. Thirteen weekly samples were composited for each quarter but for part of first and fourth quarter filters, EE-MET samples were substituted for WEE samples due to unavailability/operational issues with WEE station.

The laboratory was instructed to composite the WEE and EE-MET as separate samples. Therefore, the results for WEE as well as MET were added in Tables G.1 and G.2 (Appendix G). Airborne particulate sampling was thus performed at 17 locations using 24 samplers for second and third quarter. For first and fourth quarter, sampling was performed at 16 locations using 22 samplers. Sampling was not performed at WEE location due to unavailability/operational issues with the station. 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*.

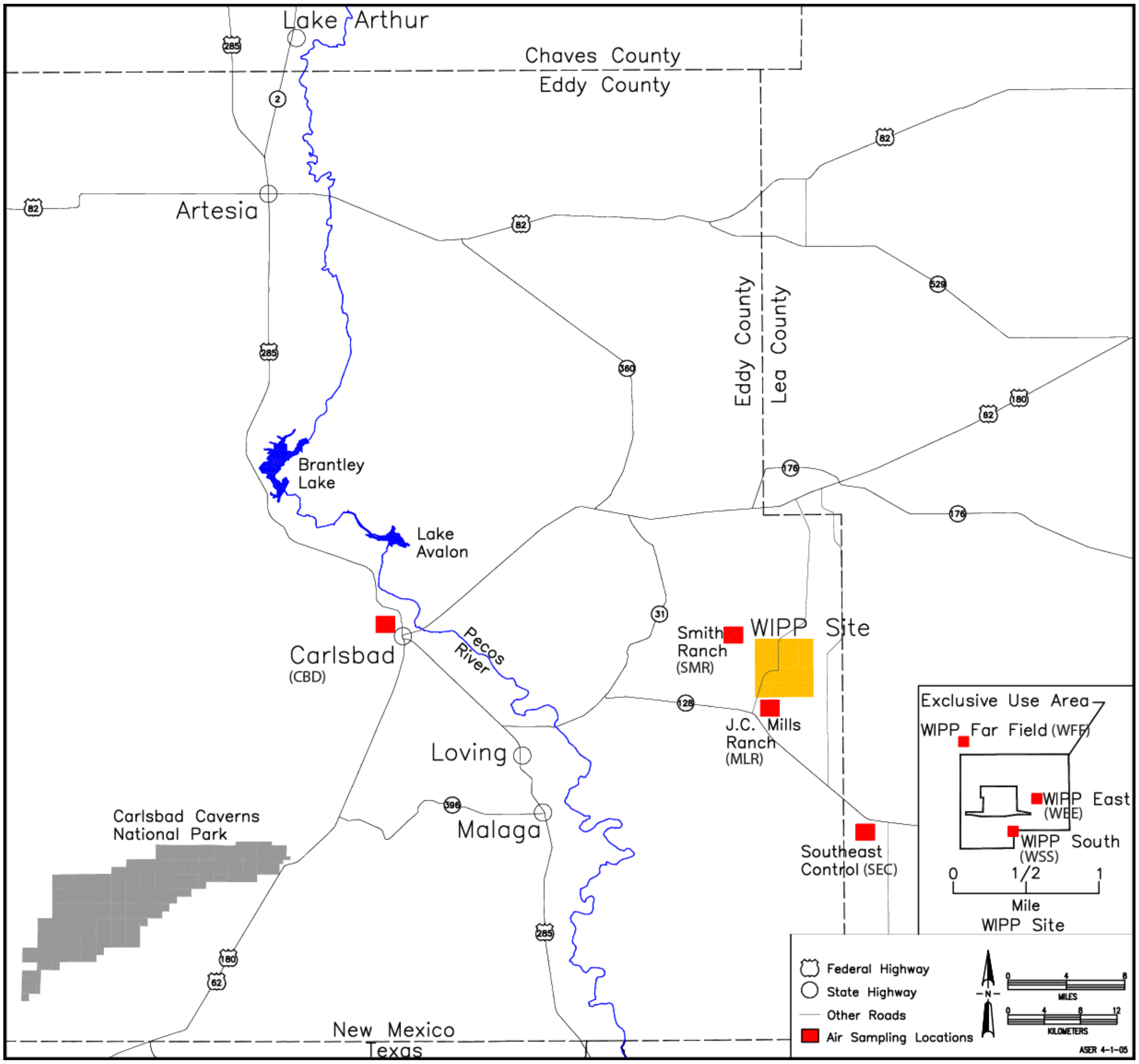

Figure 4.1 – Air Sampling Locations on and near the WIPP Site

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 2019 included the quarterly air filter composite samples, typically reported in the ASER. MET Event Evaluation samples, were analyzed and reported for part of the first and fourth quarters as a substitute for WEE site due to unavailability/operational issues.

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 Becquerel 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 Becquerel 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 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. Results (excluding gamma nuclides) for fourth quarter composite samples were qualified with "UJ" (Nuclide not detected above the reported MDC and 2 sigma counting uncertainty, and a quality deficiency affects the data, making the reported data more uncertain). The quality deficiency was a result of incorrect QC filter matrix used by the laboratory. 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 all locations in 2019. The most frequent radionuclide detections in air filter composite samples were some of the uranium isotopes; however, no uranium isotopes were detected in any of the samples in 2019. Uranium-233/234 and ^{238}U were detected above the MDC in fourth quarter field blank filter.

Detection of the uranium isotopes generally depended on the amount of dust collected on the filters. More dust is collected during dry and windy years. It has been wetter in recent years thus, no uranium isotopes were detected. Plutonium-239/240 has occasionally been detected in the air filter composite samples, but there was only one detection in 2015 and no detections since.

Since there were no detections of any radionuclides in the 2019 air filter composite samples, no ANOVA comparisons were performed between years or between locations.

Although there were no detections in 2019, 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 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 – 2019 Average, Minimum, and Maximum Activities in Quarterly Air Filter Composite Samples

Radionuclide		[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	Location	Quarter	Qualifier[(d)]
$^{233/234}$U	Mean [(e)]	3.84E-03	4.73E-03	9.42E-03	NA [(f)]	NA [(f)]	NA [(f)]
	Minimum [(g)]	-8.69E-03	4.29E-03	8.90E-03	MET	4	UJ
	Maximum [(g)]	9.04E-03	5.88E-03	1.04E-02	CBD	1	U
^{235}U	Mean	1.50E-04	1.06E-03	1.63E-03	NA [(f)]	NA [(f)]	NA [(f)]

	Minimum	-4.97E-04	8.85E-04	1.42E-03	SEC	4	UJ
	Maximum	1.15E-03	1.45E-03	1.52E-03	SMR	4	UJ
^{238}U	Mean	2.59E-03	4.84E-03	9.72E-03	NA (f)	NA (f)	NA (f)
	Minimum	-1.26E-02	6.60E-03	1.09E-02	WEE	4	UJ
	Maximum	7.31E-03	4.34E-03	9.44E-03	WEE	3	U
^{238}Pu	Mean	-8.76E-05	3.86E-04	8.31E-04	NA (f)	NA (f)	NA (f)
	Minimum	-3.56E-04	4.66E-04	7.09E-04	SMR	4	UJ
	Maximum	6.40E-04	8.13E-04	9.51E-04	MLR	4	UJ
$^{239/240}Pu$	Mean	-4.71E-05	4.73E-04	1.01E-03	NA (f)	NA (f)	NA (f)
	Minimum	-2.92E-04	4.83E-04	9.12E-04	SMR	2	U
	Maximum	3.76E-04	6.57E-04	1.05E-03	SEC	4	UJ
^{241}Am	Mean	2.99E-05	6.60E-04	1.10E-03	NA (f)	NA (f)	NA (f)
	Minimum	-4.70E-04	5.71E-04	1.08E-03	MLR	3	U
	Maximum	8.29E-04	9.05E-04	1.08E-03	MLR	1	U
^{40}K	Mean	3.42E+00	2.82E+00	5.54E+00	NA (f)	NA (f)	NA (f)
	Minimum	-9.41E-01	2.82E+00	5.06E+00	SMR	4	U
	Maximum	7.22E+00	3.78E+00	7.71E+00	WSS	2	U
^{60}Co	Mean	1.97E-02	2.82E-01	5.13E-01	NA (f)	NA (f)	NA (f)
	Minimum	-2.11E-01	2.79E-01	4.39E-01	WFF	2	U
	Maximum	3.47E-01	3.33E-01	6.75E-01	WSS	3	U
^{137}Cs	Mean	1.02E-02	2.83E-01	4.98E-01	NA (f)	NA (f)	NA (f)
	Minimum	-3.90E-01	4.10E-01	6.57E-01	CBD	3	U
	Maximum	3.64E-01	3.15E-01	6.11E-01	WSS	3	U
^{90}Sr	Mean	-9.95E-03	2.07E-02	3.03E-02	NA (f)	NA (f)	NA (f)
	Minimum	-2.57E-02	2.50E-02	3.01E-02	WSS	2	U
	Maximum	9.64E-03	1.84E-02	3.19E-02	CBD	3	U

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. MET location data used to substitute for WEE data (MET data used from 01/08/2019 to 01/22/2019 and 10/08/2019 to 10/29/2019). 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. UJ equals nuclide not detected above the reported MDC and 2 sigma counting uncertainty, and a quality deficiency affects the data, making the reported data more uncertain.

(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 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 2019, field duplicate samples were taken from location SEC during the first quarter, location CBD during the second quarter, location SMR during the third quarter, and location WFF 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 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 2019 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	SEC	$^{233/234}U$	5.71E-03	3.24E-03	3.34E-03	2.57E-03	-0.573
1	SEC	^{235}U	3.35E-04	7.15E-04	1.85E-04	5.60E-04	-0.165
1	SEC	^{238}U	1.42E-03	3.16E-03	4.68E-04	2.68E-03	-0.230
1	SEC	^{238}Pu	-1.76E-04	1.69E-04	-1.85E-04	1.75E-04	0.037
1	SEC	$^{239/240}Pu$	4.92E-04	3.32E-04	1.09E-04	2.32E-04	0.946
1	SEC	^{241}Am	-1.60E-04	6.82E-04	3.74E-04	3.85E-04	-0.620
1	SEC	^{40}K	2.91E+00	1.20E+00	2.14E+00	1.27E+00	-0.441
1	SEC	^{60}Co	-3.15E-02	1.21E-01	-1.42E-01	1.34E-01	0.612
1	SEC	^{137}Cs	1.53E-02	1.19E-01	2.91E-01	1.46E-01	1.46
1	SEC	^{90}Sr	-2.78E-02	1.00E-02	-1.79E-02	1.03E-02	-0.690
Qtr	Location	Isotope	Sample 1		Sample 2		RER[c]
			[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]	
2	CBD	$^{233/234}U$	6.51E-03	2.13E-03	1.04E-02	2.38E-03	-1.22
2	CBD	^{235}U	-5.18E-04	4.43E-04	1.24E-04	5.30E-04	-0.929
2	CBD	^{238}U	2.73E-03	2.08E-03	9.11E-03	2.40E-03	-2.00
2	CBD	^{238}Pu	1.08E-04	2.54E-04	-1.23E-04	1.36E-04	-0.802
2	CBD	$^{239/240}Pu$	-1.15E-04	2.58E-04	1.58E-04	3.20E-04	-0.664
2	CBD	^{241}Am	2.20E-04	2.70E-04	7.98E-05	2.48E-04	-0.382
2	CBD	^{40}K	3.39E+00	1.23E+00	2.57E+00	1.18E+00	0.481

2	CBD	^{60}Co	-6.28E-02	1.39E-01	6.62E-02	1.18E-01	-0.708
2	CBD	^{137}Cs	-4.35E-02	1.33E-01	6.32E-03	1.15E-01	-0.283
2	CBD	^{90}Sr	-2.78E-03	1.28E-02	-7.88E-03	1.28E-02	0.282
Qtr	Location	Isotope	Sample 1		Sample 2[d]		RER[c]
			[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]	
3	SMR	$^{233/234}$U	3.28E-03	1.81E-03	7.45E-03	2.03E-03	1.53
3	SMR	^{235}U	-8.01E-05	3.98E-04	5.25E-04	5.26E-04	0.917
3	SMR	^{238}U	5.76E-03	1.89E-03	7.34E-03	1.98E-03	0.577
3	SMR	^{238}Pu	-2.25E-05	2.14E-04	-1.49E-04	1.80E-04	-0.452
3	SMR	$^{239/240}$Pu	-1.19E-04	2.37E-04	-1.48E-06	2.61E-04	0.333
3	SMR	^{241}Am	-1.19E-04	3.40E-04	2.74E-05	3.67E-04	0.293
3	SMR	^{40}K	5.12E+00	1.88E+00	2.57E+00	1.74E+00	-0.995
3	SMR	^{60}Co	-1.60E-01	2.00E-01	1.21E-01	1.79E-01	1.05
3	SMR	^{137}Cs	-2.89E-02	2.03E-01	-2.37E-02	1.60E-01	0.02
3	SMR	^{90}Sr	1.95E-02	1.04E-02	-7.16E-03	9.62E-03	-1.88
Qtr	Location	Isotope	Sample 1		Sample 2		RER[c]
			[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]	
4	WFF	$^{233/234}$U	2.12E-03	2.40E-03	2.97E-03	1.23E-03	0.315
4	WFF	^{235}U	-2.30E-04	5.01E-04	3.61E-04	5.92E-04	0.762
4	WFF	^{238}U	2.51E-03	2.43E-03	2.74E-03	2.53E-03	-0.066
4	WFF	^{238}Pu	-1.17E-04	2.42E-04	1.76E-04	2.84E-04	0.784
4	WFF	$^{239/240}$Pu	-8.96E-05	2.26E-04	-1.04E-04	2.42E-04	0.044
4	WFF	^{241}Am	-1.40E-04	3.14E-04	4.76E-05	4.08E-04	-0.365
4	WFF	^{40}K	3.04E+00	1.69E+00	2.01E+00	1.34E+00	0.478
4	WFF	^{60}Co	-1.29E-02	1.81E-01	7.42E-02	1.49E-01	0.372
4	WFF	^{137}Cs	-1.58E-01	1.72E-01	6.16E-02	1.48E-01	0.968
4	WFF	^{90}Sr	-3.60E-03	9.85E-03	-8.79E-04	9.64E-03	-0.197

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 ^{137}Cs in the first quarter SMR duplicates. 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 2019 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 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 2019 (Round 41) 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 are 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, using 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 2019, 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 Water Quality Sampling Program (WQSP) well. The data from the duplicate groundwater samples are presented in Table 4.7, where the precision of the groundwater sample analyses is reported.

Table 4.6 – 2019 Round 41 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	41	3/12/2019	1.16E+00	1.85E-01	1.29E-03	+	1.66E-02	4.13E-03	8.49E-04	+	1.90E-01	3.16E-02	1.15E-03	+
WQSP-2	41	3/26/2019	1.14E+00	1.86E-01	1.27E-03	+	1.52E-02	4.00E-03	8.79E-04	+	1.79E-01	3.06E-02	1.15E-03	+
WQSP-3	41	4/9/2019	1.18E-01	2.00E-02	1.26E-03	+	1.57E-03	1.01E-03	7.34E-04	+	1.96E-02	4.38E-03	1.08E-03	+
WQSP-4	41	5/29/2019	5.63E-01	9.64E-02	1.28E-03	+	1.52E-02	4.05E-03	7.96E-04	+	9.62E-02	1.77E-02	1.05E-03	+
WQSP-5	41	5/14/2019	5.00E-01	7.77E-02	1.22E-03	+	4.24E-03	1.73E-03	9.11E-04	+	6.72E-02	1.17E-02	1.02E-03	+
WQSP-6	41	4/17/2019	4.03E-01	6.61E-02	1.26E-03	+	3.93E-03	1.73E-03	8.72E-04	+	5.36E-02	1.01E-02	1.13E-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	41	3/12/2019	2.74E-04	5.20E-04	8.45E-04	U	8.55E-05	4.10E-04	8.58E-04	U	4.60E-04	5.12E-04	7.20E-04	U
WQSP-2	41	3/26/2019	3.57E-05	5.68E-04	1.29E-03	U	3.28E-04	6.59E-04	1.11E-03	U	7.80E-05	2.65E-04	6.72E-04	U
WQSP-3	41	4/9/2019	2.53E-04	3.91E-04	6.07E-04	U	3.89E-05	3.49E-04	6.89E-04	U	4.00E-05	3.36E-04	7.74E-04	U
WQSP-4	41	5/29/2019	4.24E-05	2.90E-04	6.74E-04	U	-5.01E-05	1.49E-04	6.92E-04	U	4.31E-05	2.94E-04	7.84E-04	U
WQSP-5	41	5/14/2019	-7.35E-05	1.86E-04	6.47E-04	U	6.12E-05	2.94E-04	6.97E-04	U	1.63E-04	3.68E-04	8.43E-04	U
WQSP-6	41	4/17/2019	-3.84E-05	1.46E-04	7.14E-04	U	2.35E-04	4.34E-04	7.38E-04	U	-7.15E-05	1.98E-04	8.51E-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	41	3/12/2019	1.67E+01	7.59E+00	1.72E+01	0.00	U	-1.96E-01	5.57E-01	8.93E-01	0.00	U
WQSP-2	41	3/26/2019	1.49E+01	3.34E+00	3.85E+00	0.999	+	-9.33E-02	1.60E-01	2.81E-01	0.00	U
WQSP-3	41	4/9/2019	4.79E+01	5.99E+00	5.13E+00	0.997	+	-1.50E-01	1.61E-01	2.69E-01	0.00	U
WQSP-4	41	5/29/2019	2.21E+01	3.71E+00	3.62E+00	1.00	+	4.76E-02	1.15E-01	2.31E-01	0.00	U
WQSP-5	41	5/14/2019	8.12E+00	2.72E+00	3.71E+00	0.986	+	-3.07E-02	1.40E-01	2.07E-01	0.00	U
WQSP-6	41	4/17/2019	5.32E+00	1.75E+00	3.99E+00	0.00	U	4.63E-02	9.82E-02	2.10E-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	40	3/12/2019	-6.09E-01	4.63E-01	6.79E-01	0.00	U	1.13E-02	2.49E-02	1.51E-02	U
WQSP-2	40	3/26/2019	-6.38E-02	1.31E-01	2.30E-01	0.00	U	1.46E-02	2.95E-02	1.56E-02	U
WQSP-3	40	4/9/2019	-1.49E-02	1.65E-01	2.92E-01	0.00	U	-5.66E-03	1.82E-02	1.16E-02	U
WQSP-4	40	5/29/2019	1.03E-01	1.10E-01	2.22E-01	0.00	U	-1.12E-02	2.39E-02	1.34E-02	U
WQSP-5	40	5/14/2019	-3.54E-02	1.26E-01	2.14E-01	0.00	U	-1.27E-02	2.01E-02	1.31E-02	U
WQSP-6	40	4/17/2019	-3.69E-02	1.32E-01	2.25E-01	0.00	U	1.19E-02	2.49E-02	1.22E-02	U

Notes:

Units are becquerels per liter (Bq/L). See Chapter 6 for sampling locations.

(a) Radionuclide concentration

(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 – 2019 Round 41 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	$^{233/234}U$	1.16E+00	9.43E-02	1.26E+00	1.18E-01	0.691	+
	^{235}U	1.66E-02	2.11E-03	1.62E-02	2.29E-03	-0.118	+
	^{238}U	1.90E-01	1.61E-02	2.08E-01	2.01E-02	-0.678	+
	^{238}Pu	2.74E-04	2.65E-04	-6.93E-05	1.20E-04	-1.179	U
	$^{239/240}Pu$	8.55E-05	2.09E-04	-6.93E-05	3.17E-04	-0.407	U
	^{241}Am	4.60E-04	2.61E-04	3.96E-04	2.29E-04	0.182	U
	^{40}K	1.67E+01	3.87E+00	1.54E+01	1.82E+00	0.304	U/+[(e)]
	^{60}Co	-1.96E-01	2.84E-01	8.13E-02	6.38E-02	0.952	U
	^{137}Cs	-6.09E-01	2.36E-01	-4.43E-02	5.31E-02	-2.332	U
	^{90}Sr	1.13E-02	1.27E-02	1.83E-02	1.37E-02	0.376	U
WQSP-2	$^{233/234}U$	1.14E+00	9.49E-02	1.15E+00	9.00E-02	0.045	+
	^{235}U	1.52E-02	2.04E-03	1.12E-02	1.62E-03	1.517	+
	^{238}U	1.79E-01	1.56E-02	1.75E-01	1.44E-02	-0.198	+
	^{238}Pu	3.57E-05	2.90E-04	-5.98E-05	1.09E-04	0.308	U
	$^{239/240}Pu$	3.28E-04	3.36E-04	-2.66E-05	7.28E-05	1.031	U
	^{241}Am	7.80E-05	1.35E-04	1.07E-04	1.26E-04	0.154	U
	^{40}K	1.49E+01	1.70E+00	1.55E+01	1.70E+00	-0.249	+
	^{60}Co	-9.33E-02	8.16E-02	1.33E-01	5.92E-02	2.244	U
	^{137}Cs	-6.38E-02	6.68E-02	-7.59E-02	6.02E-02	0.135	U
	^{90}Sr	1.46E-02	1.50E-02	2.12E-02	1.55E-02	-0.308	U
WQSP-3	$^{233/234}U$	1.28E-01	1.48E-02	1.18E-01	1.02E-02	-0.556	+
	^{235}U	1.28E-03	5.55E-04	1.57E-03	5.17E-04	-0.382	+
	^{238}U	1.68E-02	2.53E-03	1.96E-02	2.23E-03	0.830	+
	^{238}Pu	1.10E-04	1.98E-04	2.53E-04	1.99E-04	-0.509	U
	$^{239/240}Pu$	4.21E-04	3.20E-04	3.89E-05	1.78E-04	-1.043	U
	^{241}Am	5.32E-04	3.08E-04	4.00E-05	1.71E-04	-1.397	U
	^{40}K	5.27E+01	3.20E+00	4.79E+01	3.06E+00	1.084	+
	^{60}Co	-1.46E-01	7.45E-02	-1.50E-01	8.21E-02	0.036	U
	^{137}Cs	1.16E-01	6.92E-02	-1.49E-02	8.41E-02	1.202	U
	^{90}Sr	8.06E-03	9.38E-03	-5.66E-03	9.28E-03	-1.040	U
WQSP-4	$^{233/234}U$	5.63E-01	4.92E-02	4.76E-01	3.45E-02	1.448	+
	^{235}U	1.52E-02	2.07E-03	6.10E-03	1.03E-03	3.936	+

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]		
	^{238}U	9.62E-02	9.03E-03	7.91E-02	6.36E-03	1.548	+
	^{238}Pu	4.24E-05	1.48E-04	3.76E-05	1.46E-04	0.023	U
	$^{239/240}$Pu	-5.01E-05	7.61E-05	6.01E-05	1.36E-04	0.707	U
	^{241}Am	4.31E-05	1.50E-04	3.40E-04	2.55E-04	-1.004	U
	^{40}K	2.21E+01	1.89E+00	2.15E+01	1.94E+00	0.222	+
	^{60}Co	4.76E-02	5.89E-02	-4.61E-02	7.40E-02	0.991	U
	^{137}Cs	1.03E-01	5.59E-02	-2.46E-02	7.02E-02	1.422	U
	^{90}Sr	-1.12E-02	1.22E-02	-4.71E-03	1.24E-02	0.052	U
WQSP-5	$^{233/234}$U	5.00E-01	3.96E-02	4.86E-01	3.77E-02	-0.256	+
	^{235}U	4.24E-03	8.82E-04	4.57E-03	9.07E-04	0.261	+
	^{238}U	6.72E-02	5.97E-03	7.03E-02	6.09E-03	0.364	+
	^{238}Pu	-7.35E-05	9.48E-05	1.59E-04	1.95E-04	1.072	U
	$^{239/240}$Pu	6.12E-05	1.50E-04	-4.26E-05	7.13E-05	0.625	U
	^{241}Am	1.63E-04	1.88E-04	4.58E-04	2.44E-04	0.958	U
	^{40}K	8.12E+00	1.39E+00	9.43E+00	1.49E+00	0.643	+
	^{60}Co	-3.07E-02	7.16E-02	6.77E-02	5.41E-02	-1.096	U
	^{137}Cs	-3.54E-02	6.42E-02	-9.27E-02	5.87E-02	0.659	U
	^{90}Sr	-1.27E-02	1.02E-02	8.34E-03	1.01E-02	1.466	U
WQSP-6	$^{233/234}$U	4.03E-01	3.37E-02	3.83E-01	3.52E-02	0.414	+
	^{235}U	3.93E-03	8.80E-04	3.71E-03	8.76E-04	-0.171	+
	^{238}U	5.36E-02	5.14E-03	5.15E-02	5.37E-03	0.277	+
	^{238}Pu	-3.84E-05	7.43E-05	-5.65E-05	1.08E-04	0.138	U
	$^{239/240}$Pu	2.35E-04	2.21E-04	-2.45E-04	2.25E-04	1.519	U
	^{241}Am	-7.15E-05	1.01E-04	-1.26E-05	3.98E-05	0.542	U
	^{40}K	5.32E+00	8.93E-01	5.98E+00	2.99E+00	0.212	U
	^{60}Co	4.63E-02	5.01E-02	3.46E-01	2.08E-01	1.400	U
	^{137}Cs	-3.69E-02	6.73E-02	6.32E-02	2.22E-01	-0.431	U
	^{90}Sr	1.19E-02	1.27E-02	-1.04E-02	1.24E-02	1.249	U

Notes:

(a) Radionuclide concentration

(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 duplicate sample but not the primary sample.

The 2019 uranium groundwater concentrations in the detection monitoring wells were compared with the concentrations from the same locations in 2018 using ANOVA. The ANOVA calculations were performed using the Round 41 average uranium sample concentrations from 2019 and the average uranium concentrations from Round 40 in 2018.

The concentrations of the uranium isotopes measured in 2019 did not vary significantly from the concentrations measured in the same wells in 2018, as demonstrated by the combined ANOVA results of the wells, with the p values well above the significance level of 0.05 (ANOVA $^{233/234}U$, p = 0.947; ANOVA ^{235}U, p = 0.634; and ANOVA ^{238}U, p = 0.952). 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.

The average concentrations of the uranium isotopes measured in the groundwater samples in 2019 were also compared to the 2018 concentrations by location. There was significant variation by location between the wells sampled in 2019 and 2018, as demonstrated by the ANOVA results (ANOVA $^{233/234}U$, p = 6.88E-07; ANOVA ^{235}U, p = 4.43E-04; and ANOVA ^{238}U, p = 5.03E-07). In the case of uranium isotope ANOVA calculations by location, the uranium isotopes p values are much less than 0.05. The large differences in uranium isotope concentrations at the different locations are likely due to the depositional variation 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 41 concentration of $^{233/234}U$ of 1.26E+00 Bq/L in the duplicate sample at WQSP-1 was slightly lower than the 99 percent confidence interval range of the baseline concentration of 1.30E+00 Bq/L. The highest concentration of ^{235}U of 1.66E-02 Bq/L in the primary 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 2.08E-01 Bq/L in the duplicate 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 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 in four (WQSP-2, WQSP-3, WQSP-4, and WQSP-5) of the six wells in 2019. However, ^{40}K was not detected in the primary groundwater samples of WQSP-1 and it wasn't detected in WQSP-6 for both the primary and duplicate samples. The average concentrations of the primary and duplicate samples were used for WQSP-2 through WQSP-5. Duplicate groundwater sample results are discussed further below.

The ANOVA calculations showed that the 2019 concentrations of ^{40}K did not vary significantly from the 2018 concentrations (ANOVA ^{40}K, $p = 0.860$). However, the ^{40}K concentrations did vary significantly by location from well to well (ANOVA ^{40}K, $p =$ 1.59E-05). Some differences in ^{40}K concentrations at the various wells (locations) are likely due to the depositional variation in the abundance of these naturally occurring isotopes in the sedimentary rocks deposited 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 2019 were within the 99 percent confidence interval range of the baseline concentrations (baseline concentration: 6.30E+01 Bq/L). The highest concentration measured in 2019 was 5.27E+01 Bq/L in the primary sample from WQSP-3 (the concentration in the WQSP-3 duplicate sample was 4.79E+01 Bq/L). In 2018, 2017, and 2016 the concentration in the WQSP-3 primary sample were very similar at 5.72E+01 Bq/L, 4.41 E+01 Bq/L, and 3.98E+01 Bq/L, respectively.

The isotopes ^{137}Cs and ^{60}Co were not detected in any of the 2019 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 Round 41 RERs in Table 4.7 show that the RERs were less than 2, except for ^{137}Cs in the WQSP-1 (2.33), ^{60}Co in WQSP-2 (2.24) and ^{235}U in WQSP-4 (3.94). Both ^{137}Cs and ^{60}Co were not detected in primary and duplicate samples. However, ^{235}U in WQSP-4 was detected in both primary and duplicate samples but the primary sample activity (1.52E-02 Bq/L) was significantly higher than the duplicate sample (6.10E-03 Bq/L) resulting in high RER. Overall, 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. For 2019, Lost Tank location was dry so only sediment sample was collected. Most of the regularly sampled surface water samples from the locations in Figure 4.2 were collected mid-May through end of June 2019.

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.

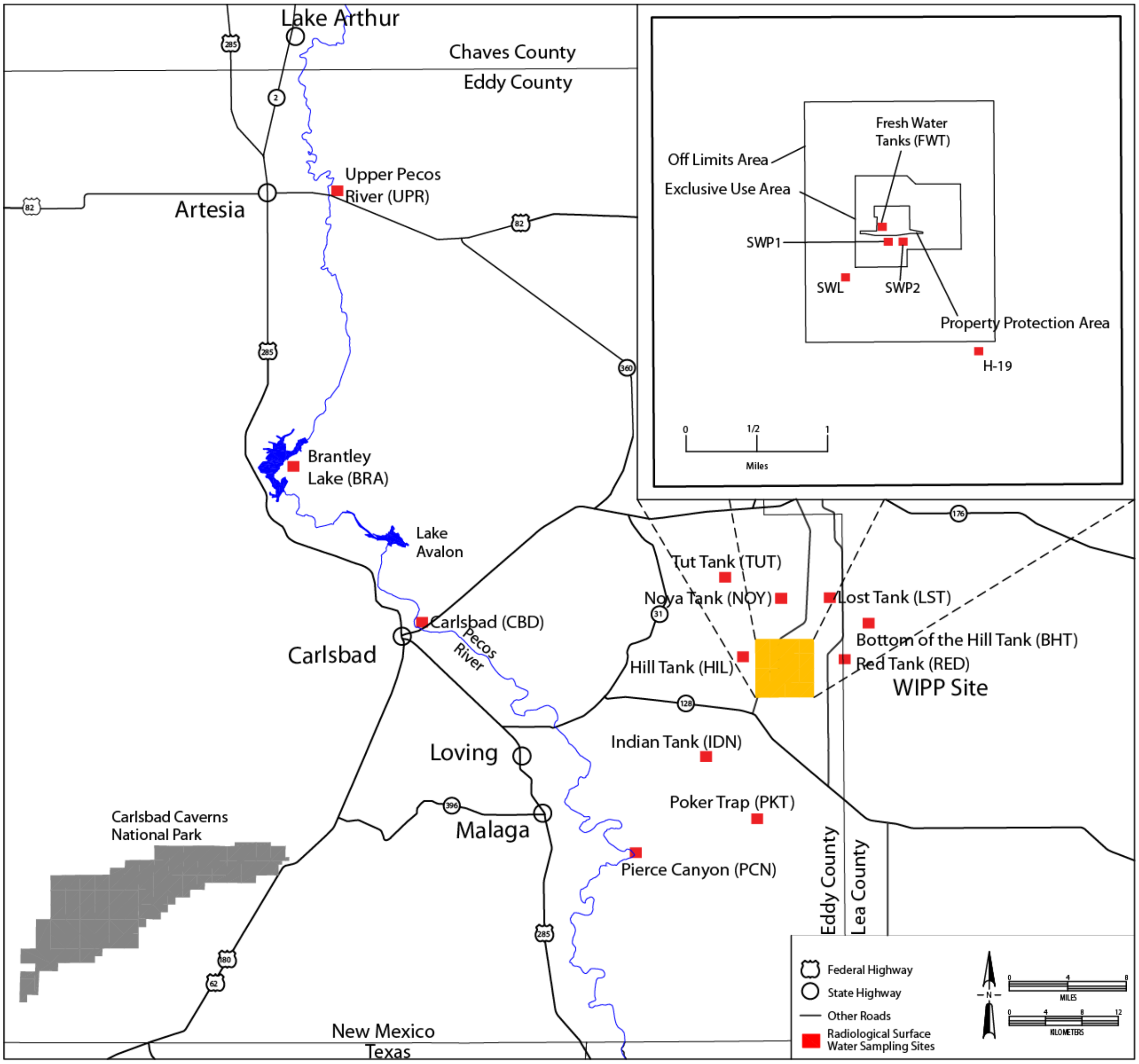

Figure 4.2 – Routine Surface Water Sampling Locations

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 2019 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 14 separate samples, two sets of duplicate samples (PCN and RED [COY]), and a deionized water field blank (COW), which was submitted to the laboratory as a blind quality control (QC) sample. At the location LST (Lost Tank) surface water was not available during the sampling period

The uranium isotope analyses from locations HIL, PKT, IDN, PCN, PCN dup, and CBD were flagged with “NJ” qualifier (Nuclide present at an estimated quantity). This is due to contaminated DI water supply caused by defective filters in the main DI water system of CEMRC building. The uranium isotope analyses resulted in detection of $^{233/234}U$ in the other surface water samples RED, COY, NOY, TUT, FWT, SWL, BRA, UPR, BHT, H-19 and the COW field blank, detection of ^{235}U in RED, COY, NOY, FWT, BRA, UPR, and H-19 and detection of ^{238}U in RED, COY, NOY, TUT, FWT, SWL, BRA, UPR, BHT, and H-19. The concentrations of the uranium isotopes were compared between 2019 and 2018 and also between sampling locations using ANOVA for those locations where the uranium isotopes were detected both years. The average concentrations were used for TUT and RED in 2018, PCN and RED in 2019. In 2018 and 2019, $^{233/234}U$ was detected in nine common locations (excluding the “NJ” qualifier samples), ^{235}U was detected in six common locations, and ^{238}U was detected in nine common locations.

There was no significant variation in the $^{233/234}U$ concentrations in the surface water between 2018 and 2019 (ANOVA $^{233/234}U$, $p = 0.879$). The ANOVA ^{235}U, $p = 0.925$. However, this calculation was only based on six common locations including weak detection at FWT. The other detections were in the Pecos River and associated bodies of water.

The ^{238}U concentrations did not show any significant variation between 2018 and 2019 ANOVA ^{238}U, $p = 0.934$.

Table 4.8 – 2019 Uranium Isotope Concentrations in Surface Water Samples Taken Near the WIPP Site

		$^{233/234}U$				^{235}U				^{238}U			
Location	**Sampling Date**	**[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	6/6/2019	7.55E-02	1.52E-02	9.91E-04	+	3.95E-03	1.73E-03	8.15E-04	+	5.91E-02	1.22E-02	1.05E-03	+
COY(g)	6/6/2019	4.71E-02	9.25E-03	9.60E-04	+	1.14E-03	8.36E-04	7.41E-04	+	3.79E-02	7.66E-03	9.39E-04	+
NOY	6/6/2019	7.45E-03	2.28E-03	9.85E-04	+	8.39E-04	7.36E-04	7.22E-04	+	7.64E-03	2.32E-03	9.93E-04	+
HIL	5/15/2019	6.30E-03	2.09E-03	1.68E-02	NJ	1.48E-04	3.45E-04	1.13E-03	NJ	7.24E-03	2.27E-03	1.58E-02	NJ
TUT	6/13/2019	1.07E-02	2.98E-03	9.98E-04	+	3.26E-04	4.90E-04	7.57E-04	U	1.07E-02	2.99E-03	1.01E-03	+
PKT	5/16/2019	3.29E-02	6.68E-03	1.68E-02	NJ	1.07E-03	8.72E-04	1.18E-03	NJ	3.03E-02	6.24E-03	1.58E-02	NJ
FWT	6/27/2019	8.63E-02	1.54E-02	9.77E-04	+	1.58E-03	1.04E-03	7.57E-04	+	2.99E-02	6.19E-03	1.01E-03	+
COW (e)	6/27/2019	1.48E-03	8.73E-04	9.29E-04	+	8.62E-05	3.39E-04	7.66E-04	U	9.20E-04	6.72E-04	9.44E-04	U
IDN	5/16/2019	1.93E-02	4.50E-03	1.68E-02	NJ	1.28E-03	9.59E-04	1.15E-03	NJ	1.52E-02	3.77E-03	1.58E-02	NJ
PCN	5/30/2019	2.41E-01	4.34E-02	1.68E-02	NJ	7.67E-03	2.65E-03	1.20E-03	NJ	1.14E-01	2.13E-02	1.59E-02	NJ
PCN dup	5/30/2019	2.12E-01	3.28E-02	1.68E-02	NJ	5.15E-03	1.92E-03	1.10E-03	NJ	9.95E-02	1.62E-02	1.58E-02	NJ
CBD	5/30/2019	1.02E-01	1.61E-02	1.68E-02	NJ	2.49E-03	1.25E-03	1.07E-03	NJ	4.73E-02	8.21E-03	1.58E-02	NJ
SWL	6/27/2019	5.18E-03	1.77E-03	9.69E-04	+	1.33E-04	3.21E-04	7.39E-04	U	1.69E-03	9.56E-04	9.61E-04	+
BRA	5/30/2019	9.08E-02	1.44E-02	9.74E-04	+	1.67E-03	1.00E-03	7.34E-04	+	4.98E-02	8.50E-03	9.27E-04	+
UPR	5/30/2019	7.64E-02	1.42E-02	1.05E-03	+	2.35E-03	1.30E-03	7.54E-04	+	5.17E-02	1.01E-02	9.85E-04	+
LST	No water	No water	No water	No water	No water	No water	No water	No water	No water	No water	No water	No water	No water
BHT	6/6/2019	5.95E-03	1.92E-03	1.03E-03	+	-3.43E-05	1.43E-04	7.43E-04	U	2.56E-03	1.19E-03	1.01E-03	+
H-19 Evap	6/27/2019	1.08E-01	1.76E-02	9.95E-04	+	2.10E-03	1.19E-03	8.10E-04	+	3.22E-02	6.19E-03	9.79E-04	+

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. NJ equals nuclide present at an estimated quantity.

(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.

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

There were some variations in the concentrations of the uranium isotopes by location. ANOVA $^{233/234}U$, *p* = 0.076 and ANOVA ^{238}U, *p* = 0.019. The ^{235}U *p* value was above the significance level with ^{235}U, p = 0.285. The ^{235}U p value was for six common locations, four of which are in the Pecos River and associated bodies of water, the other, FWT, is the groundwater from a remote location for general use at the WIPP site and H-19 evaporation pond. The 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 an order of magnitude difference in concentrations at some of the locations. The uranium isotope analyses from locations HIL, PKT, IDN, PCN, PCN dup, and CBD were flagged with "NJ" qualifier (Nuclide present at an estimated quantity) and not included in the ANOVA calculations due to potentially elevated concentrations. This is due to contaminated DI water supply caused by defective filters in the main DI water system of CEMRC building.

The 2019 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 excluding PCN, PCN Dup, and CBD (because they were NJ flagged) were 9.08E-02 Bq/L of $^{233/234}U$ in the BRA sample; 2.35E-03 Bq/L of ^{235}U at UPR; and 5.17E-02 Bq/L ^{238}U in the UPR sample. Thus, none of the uranium concentrations were higher than the baseline concentrations.

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 2019 include 8.63E-02 Bq/L $^{233/234}U$ at FWT, 3.95E-03 Bq/L ^{235}U at RED, and 5.91E-02 Bq/L ^{238}U at RED. Thus, none of the measured 2019 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 at the WIPP facility.

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. The measured uranium isotope concentrations were lower with $^{233/234}U$ at 5.18E-03 Bq/L in SWL and 8.63E-02 Bq/L in FWT; ^{235}U at 1.33E-04 Bq/L in SWL and 1.58E-03 Bq/L in FWT; and ^{238}U at 1.69E-03 Bq/L in SWL and 2.99E-02 Bq/L in FWT. The H-19 Evaporation Pond water was formerly composited with the SWL but was analyzed as a separate sample since 2016. The $^{233/234}U$ concentration was 1.08E-01 Bq/L, the ^{238}U concentration was 3.22E-02 Bq/L and ^{235}U was 2.10E-03 Bq/L 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 2018 or 2019. 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 PKT, SWL and H-19 Evaporation Pond. ^{40}K was detected in SWL and H-19 Evaporation Pond in 2018 and 2019.

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 facility, 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 = 0.451) and location (ANOVA ^{40}K, p = 0.262).

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 PKT concentration of 1.39E+01 Bq/L and SWL concentration of 4.61E+00 Bq/L were lower than the 99 percent confidence interval range of the baseline concentration (DOE/WIPP-92-037). The H-19 Evaporation Pond concentration of 2.19E+02 Bq/L was higher than the 99 percent confidence interval range. 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 PCN and RED. The RERs were calculated for 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 uranium isotopes in the RED dup sample), were less than 2. The analysis results demonstrate good reproducibility for the combined sampling and radioanalytical procedure.

Table 4.9 – 2019 Plutonium Isotope and Americium Concentrations in Surface Water Samples Taken Near the WIPP Site

Location	Sampling Date	^{238}Pu [RN][a]	^{238}Pu 2 σ TPU[b]	^{238}Pu MDC[c]	^{238}Pu Q[d]	$^{239/240}$Pu [RN][a]	$^{239/240}$Pu 2 σ TPU[b]	$^{239/240}$Pu MDC[c]	$^{239/240}$Pu Q[d]	^{241}Am [RN][a]	^{241}Am 2 σ TPU[b]	^{241}Am MDC[c]	^{241}Am Q[d]
RED	6/6/2019	5.55E-05	3.14E-04	7.25E-04	U	-6.38E-05	1.77E-04	7.75E-04	U	7.31E-04	8.41E-04	8.95E-04	U
COY [g]	6/6/2019	9.07E-05	2.58E-04	6.42E-04	U	1.46E-04	3.85E-04	8.41E-04	U	-2.88E-04	4.56E-04	7.52E-04	U
NOY	6/6/2019	4.27E-05	3.24E-04	7.94E-04	U	3.23E-04	4.66E-04	8.03E-04	U	1.64E-04	6.81E-04	9.22E-04	U
HIL	5/15/2019	-6.79E-05	1.72E-04	6.59E-04	U	-6.76E-05	1.71E-04	6.47E-04	U	2.77E-04	4.06E-04	1.20E-03	U
TUT	6/13/2019	-6.95E-05	1.76E-04	6.85E-04	U	-6.54E-05	1.70E-04	7.00E-04	U	9.74E-05	2.72E-04	1.19E-03	U
PKT	5/16/2019	-3.01E-05	1.21E-04	6.39E-04	U	5.54E-04	5.93E-04	6.89E-04	U	9.77E-04	7.15E-04	1.20E-03	U
FWT	6/27/2019	-6.57E-05	1.66E-04	6.56E-04	U	1.69E-04	3.36E-04	6.41E-04	U	2.00E-04	3.59E-04	1.20E-03	U
COW [e]	6/27/2019	-8.09E-05	1.94E-04	6.77E-04	U	1.69E-04	3.82E-04	7.39E-04	U	1.58E-04	4.05E-04	1.25E-03	U
IDN	5/16/2019	-7.77E-05	1.87E-04	6.57E-04	U	4.65E-05	2.88E-04	7.16E-04	U	8.68E-04	6.86E-04	1.21E-03	U
PCN	5/30/2019	4.26E-05	2.64E-04	6.42E-04	U	-4.85E-05	1.41E-04	6.28E-04	U	4.57E-04	5.30E-04	1.24E-03	U
PCN dup	5/30/2019	-2.53E-05	1.02E-04	5.67E-04	U	2.40E-04	4.08E-04	7.40E-04	U	6.24E-04	6.03E-04	1.22E-03	U
CBD	5/30/2019	-9.79E-05	2.06E-04	7.76E-04	U	-6.75E-05	1.71E-04	6.85E-04	U	6.17E-05	2.96E-04	1.20E-03	U
SWL[f]	6/27/2019	5.44E-05	3.37E-04	7.64E-04	U	-8.13E-05	2.06E-04	7.47E-04	U	6.24E-04	6.20E-04	1.27E-03	U
BRA	5/30/2019	-6.87E-05	1.84E-04	7.28E-04	U	-5.98E-05	1.72E-04	7.64E-04	U	3.79E-04	8.47E-04	7.84E-04	U
UPR	5/30/2019	-7.63E-05	2.11E-04	8.69E-04	U	4.05E-04	5.44E-04	7.96E-04	U	3.01E-04	8.52E-04	1.19E-03	U
LST	No water	No water	No water	No water	No water	No water	No water	No water	No water	No water	No water	No water	No water
BHT	6/6/2019	-2.39E-05	1.10E-04	6.77E-04	U	9.50E-05	2.89E-04	7.15E-04	U	-2.78E-04	4.45E-04	7.98E-04	U
H-19 Evap	6/27/2019	8.85E-05	3.42E-04	7.78E-04	U	5.20E-04	6.09E-04	7.81E-04	U	1.11E-03	8.44E-04	1.26E-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 (RED).

Table 4.10 – 2019 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	6/6/2019	4.37E+00	1.63E+00	3.69E+00	0.000	U	-1.14E-02	1.25E-01	2.43E-01	0.000	U
COY [(h)]	6/6/2019	3.64E+00	1.52E+00	3.43E+00	0.000	U	7.50E-02	1.18E-01	2.42E-01	0.000	U
NOY	6/6/2019	3.10E+00	1.58E+00	3.45E+00	0.000	U	8.93E-02	1.15E-01	2.50E-01	0.000	U
HIL	5/15/2019	5.15E+00	1.82E+00	4.08E+00	0.000	U	5.44E-02	1.02E-01	1.87E-01	0.000	U
TUT	6/13/2019	5.50E+00	1.68E+00	3.93E+00	0.000	U	-2.81E-02	1.20E-01	2.24E-01	0.000	U
PKT	5/16/2019	1.39E+01	3.38E+00	3.96E+00	0.996	+	4.13E-02	1.32E-01	2.64E-01	0.000	U
FWT	6/27/2019	2.66E+00	1.48E+00	3.23E+00	0.000	U	1.33E-01	1.32E-01	2.46E-01	0.000	U
COW [(f)]	6/27/2019	6.29E+00	4.56E+00	9.54E+00	0.000	U	-5.92E-02	3.02E-01	5.43E-01	0.000	U
IDN	5/16/2019	3.29E+00	1.58E+00	3.47E+00	0.000	U	8.86E-02	1.67E-01	2.63E-01	0.000	U
PCN	5/30/2019	3.17E+00	1.61E+00	3.53E+00	0.000	U	-6.50E-02	1.38E-01	2.50E-01	0.000	U
PCN dup	5/30/2019	1.49E+00	1.39E+00	2.91E+00	0.000	U	1.20E-01	1.23E-01	2.42E-01	0.000	U
CBD	5/30/2019	3.66E-01	1.42E+00	2.64E+00	0.000	U	-1.15E-01	1.53E-01	1.93E-01	0.000	U
SWL[(f)]	6/27/2019	4.61E+00	2.27E+00	3.36E+00	0.998	+	3.03E-02	9.84E-02	2.03E-01	0.00	U
BRA	5/30/2019	3.69E+00	1.61E+00	3.56E+00	0.000	U	4.94E-02	1.42E-01	2.62E-01	0.000	U
UPR	5/30/2019	1.96E+00	1.49E+00	3.13E+00	0.000	U	1.89E-02	1.49E-01	2.36E-01	0.000	U
LST	No water	No water	No water	No water	No water	No water	No water	No water	No water	No water	No water
BHT	6/6/2019	9.24E-03	1.59E+00	2.79E+00	0.000	U	7.16E-02	1.17E-01	2.30E-01	0.000	U
H-19 Evap	6/27/2019	2.19E+02	1.65E+01	4.56E+00	0.998	+	8.31E-03	1.98E-01	3.53E-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	6/6/2019	-5.82E-02	1.45E-01	2.40E-01	0.000	U	3.53E-03	2.74E-02	1.70E-02	U
COY [(g)]	6/6/2019	-1.41E-02	1.02E-01	1.87E-01	0.000	U	4.66E-03	2.94E-02	1.72E-02	U
NOY	6/6/2019	8.22E-02	1.09E-01	2.21E-01	0.000	U	-1.15E-02	3.09E-02	1.70E-02	U
HIL	5/15/2019	7.64E-03	1.03E-01	1.96E-01	0.000	U	-5.95E-03	2.65E-02	1.58E-02	U
TUT	6/13/2019	9.04E-02	1.08E-01	2.20E-01	0.000	U	-4.38E-03	2.90E-02	1.69E-02	U
PKT	5/16/2019	1.35E-01	1.49E-01	2.82E-01	0.000	U	1.62E-02	2.37E-02	1.58E-02	U
FWT	6/27/2019	-3.20E-02	1.32E-01	2.27E-01	0.000	U	-4.04E-03	2.50E-02	1.64E-02	U
COW [(f)]	6/27/2019	1.73E-01	2.73E-01	5.56E-01	0.000	U	-1.41E-02	2.27E-02	1.64E-02	U
IDN	5/16/2019	4.09E-02	1.42E-01	2.48E-01	0.000	U	-6.87E-04	2.51E-02	1.58E-02	U
PCN	5/30/2019	-2.02E-01	1.52E-01	2.07E-01	0.000	U	5.81E-03	1.98E-02	1.52E-02	U
PCN dup	5/30/2019	-2.15E-02	9.91E-02	1.84E-01	0.00	U	2.15E-03	1.97E-02	1.52E-02	U
CBD	5/30/2019	-4.27E-02	1.25E-01	2.11E-01	0.000	U	1.15E-02	2.18E-02	1.53E-02	U
SWL[(h)]	6/27/2019	2.34E-03	1.04E-01	1.94E-01	0.000	U	-8.28E-03	2.53E-02	1.66E-02	U
BRA	5/30/2019	-9.74E-02	1.42E-01	2.13E-01	0.000	U	2.62E-02	2.63E-02	1.66E-02	U
UPR	5/30/2019	-8.48E-02	1.41E-01	2.32E-01	0.000	U	1.56E-02	3.05E-02	1.71E-02	U
LST	No water	No water	No water	No water	No water	No water	No water	No water	No water	No water
BHT	6/6/2019	-2.85E-02	1.24E-01	2.11E-01	0.000	U	7.52E-04	2.60E-02	1.66E-02	U
H-19 Evap	6/27/2019	-7.09E-02	1.67E-01	2.74E-01	0.000	U	-4.39E-03	2.02E-02	1.60E-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) COY = semi-blind field duplicate (RED).

(h) 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 – 2019 Precision Results for Duplicate Surface Water Samples

Radionuclide	PCN		PCN Dup		RER[c]	Q[d]
	[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]		
$^{233/234}U$	2.41E-01	2.21E-02	2.12E-01	1.67E-02	1.03	NJ
^{235}U	7.67E-03	1.35E-03	5.15E-03	9.81E-04	1.51	NJ
^{238}U	1.14E-01	1.09E-02	9.95E-02	8.26E-03	1.05	NJ
^{238}Pu	4.26E-05	1.35E-04	-2.53E-05	5.22E-05	0.47	U
$^{239/240}Pu$	-4.85E-05	7.17E-05	2.40E-04	2.08E-04	-1.31	U
^{241}Am	4.57E-04	2.71E-04	6.24E-04	3.07E-04	-0.41	U
^{40}K	3.17E+00	8.21E-01	1.49E+00	7.09E-01	1.55	U
^{60}Co	-6.50E-02	7.04E-02	1.20E-01	6.28E-02	-1.96	U
^{137}Cs	-2.02E-01	7.76E+00	-2.15E-02	5.06E-02	-0.02	U
^{90}Sr	5.81E-03	1.01E-02	2.15E-03	1.00E-02	0.26	U
Radionuclide	RED		RED Dup		RER[c]	Q[d]
	[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]		
$^{233/234}U$	7.55E-02	7.76E-03	4.71E-02	4.72E-03	3.13	+
^{235}U	3.95E-03	8.84E-04	1.14E-03	4.26E-04	2.86	+
^{238}U	5.91E-02	6.20E-03	3.79E-02	3.91E-03	2.89	+
^{238}Pu	5.55E-05	1.60E-04	9.07E-05	1.32E-04	-0.17	U
$^{239/240}Pu$	-6.38E-05	9.02E-05	1.46E-04	1.97E-04	-0.97	U
^{241}Am	7.31E-04	4.29E-04	-2.88E-04	2.33E-04	2.09	U
^{40}K	4.37E+00	8.30E-01	3.64E+00	7.78E-01	0.64	U
^{60}Co	-1.14E-02	6.40E-02	7.50E-02	6.00E-02	-0.98	U
^{137}Cs	-5.82E-02	7.42E-02	-1.41E-02	5.22E-02	-0.49	U
^{90}Sr	3.53E-03	1.40E-02	4.66E-03	1.50E-02	-0.05	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 (NOY and PCN) for 14 samples total. See Figure 4.3 for sediment sample locations and Appendix C for location codes. The sites included the same sites as for 2019 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.

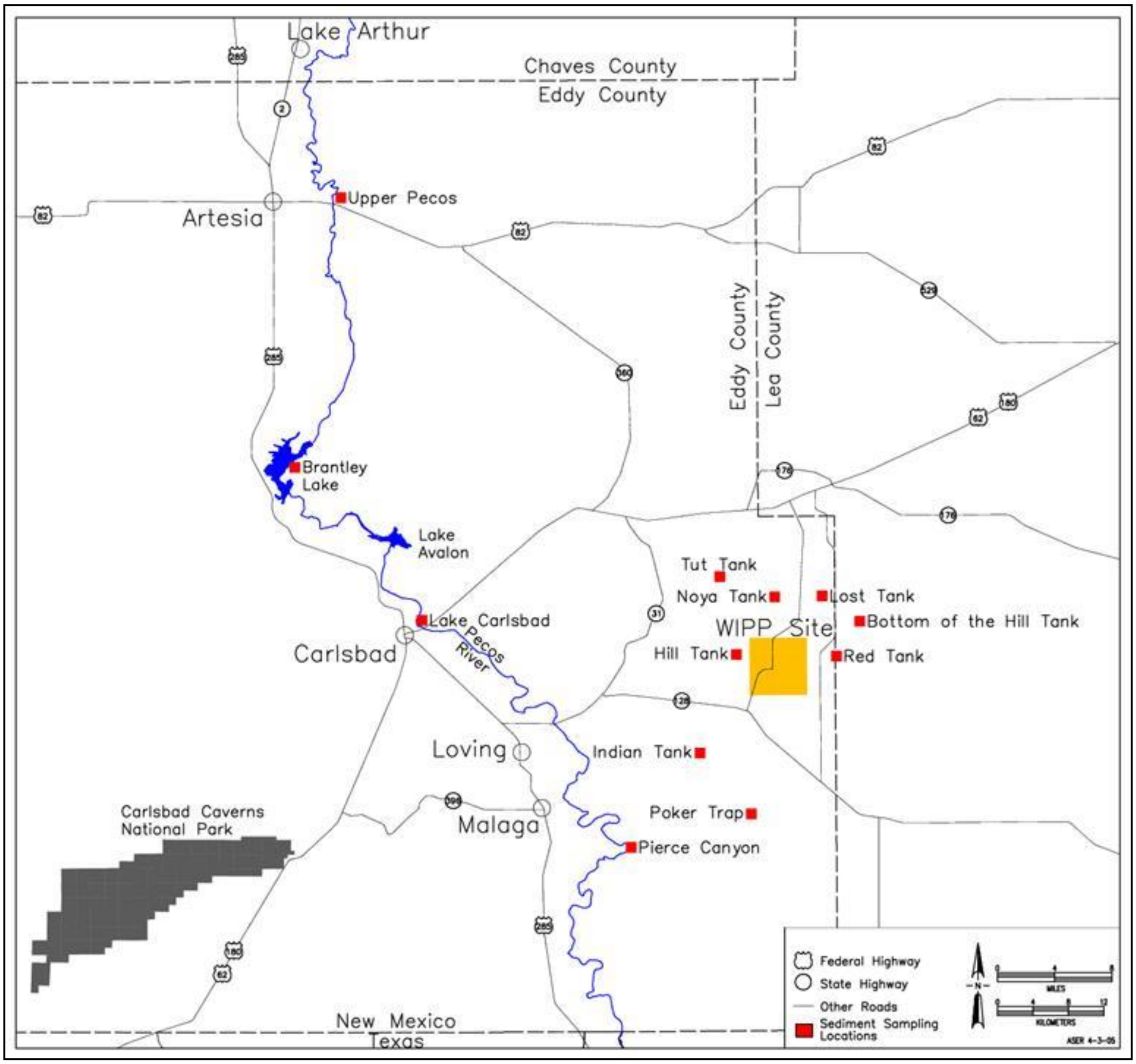

Figure 4.3 – Sediment Sampling Locations

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 2019.

ANOVA was used to compare the uranium isotope concentrations between 2018 and 2019 and between sampling locations. The average concentrations were used for the TUT and UPR duplicates in 2018 and the NOY and PCN duplicates in 2019. There were 12 common locations for uranium isotopes in 2018 and 2019. The ANOVA calculations showed slight differences in the distribution of the $^{233/234}U$ and ^{238}U isotopes between 2018 and 2019 with p values close to 0.05 ($^{233/234}U$, p = 0.0983, ^{238}U, p = 0.0620). The difference between years appears to be due to 2019 concentrations being generally higher than the 2018 concentrations. The reason for the higher concentrations is not known but may be related to the amount of precipitation between two years. On the other hand, ^{235}U showed no significant difference between 2018 and 2019 with p = 0.579.

The ANOVA calculations showed that the concentrations of the three uranium isotopes varied less by sediment location in 2019 (ANOVA $^{233/234}U$, p = 0.856; ANOVA ^{235}U, p = 0.504; and ANOVA ^{238}U, p = 0.884). The p values were higher, meaning less variability in the concentrations for the three uranium isotopes by location in 2019 compared to 2018.

Table 4.12 – 2019 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	5/20/2019	1.23E-02	1.92E-03	6.93E-04	+	3.48E-04	2.21E-04	3.40E-04	+	1.16E-02	1.83E-03	6.93E-04	+
NOY	5/15/2019	8.65E-03	1.55E-03	6.94E-04	+	5.21E-04	2.77E-04	3.40E-04	+	9.41E-03	1.66E-03	6.95E-04	+
NOY Dup	5/15/2019	1.03E-02	1.94E-03	7.00E-04	+	5.62E-04	3.06E-04	3.55E-04	+	1.18E-02	2.18E-03	7.05E-04	+
HIL	5/15/2019	1.92E-02	3.93E-03	2.03E-03	+	9.20E-04	4.37E-04	3.75E-04	+	2.00E-02	4.07E-03	7.18E-04	+
TUT	6/13/2019	1.93E-02	3.22E-03	7.03E-04	+	1.14E-03	4.38E-04	3.49E-04	+	2.00E-02	3.32E-03	7.01E-04	+
PKT	5/16/2019	1.76E-02	2.80E-03	6.96E-04	+	6.78E-04	3.26E-04	3.47E-04	+	1.48E-02	2.41E-03	6.99E-04	+
IDN	5/16/2019	2.33E-02	4.26E-03	7.16E-04	+	8.69E-04	4.16E-04	3.71E-04	+	2.61E-02	4.72E-03	7.18E-04	+
PCN	5/30/2019	1.49E-02	2.26E-03	6.93E-04	+	5.91E-04	2.82E-04	3.33E-04	+	1.46E-02	2.21E-03	6.90E-04	+
PCN Dup	5/30/2019	1.73E-02	3.70E-03	7.28E-04	+	7.60E-04	4.07E-04	3.81E-04	+	1.54E-02	3.33E-03	7.30E-04	+
CBD	5/30/2019	2.25E-02	3.64E-03	7.04E-04	+	9.22E-04	3.88E-04	3.46E-04	+	2.15E-02	3.49E-03	7.02E-04	+
BRA	5/30/2019	2.02E-02	3.06E-03	6.96E-04	+	4.65E-04	2.63E-04	3.48E-04	+	1.57E-02	2.45E-03	6.95E-04	+
UPR	5/30/2019	1.96E-02	2.93E-03	6.95E-04	+	8.03E-04	3.42E-04	3.38E-04	+	1.97E-02	2.95E-03	6.94E-04	+
LST	5/20/2019	1.35E-02	2.57E-03	7.11E-04	+	4.98E-04	2.93E-04	3.64E-04	+	1.52E-02	2.84E-03	7.15E-04	+
BHT	5/20/2019	1.79E-02	3.22E-03	7.06E-04	+	9.59E-04	4.21E-04	3.65E-04	+	1.91E-02	3.42E-03	7.10E-04	+

Notes: See Appendix C for sampling location codes. Units are in becquerels per gram (Bq/g), dry weight.

NOY and PCN 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.

The highest uranium isotope concentrations detected included 2.33E-02 Bq/g for $^{233/234}$U in the IDN sample; 1.14E-03 Bq/g for ^{235}U in the TUT sample; and 2.61E-02 Bq/g for ^{238}U in the IDN sample. The baseline concentrations included 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 the three uranium isotopes fell within the 99 percent confidence interval ranges of the baseline. 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

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 2019 from location TUT with concentration of 5.28E-04 Bq/g. The locations from previous years (PKT, CBD and BHT in 2018) did not have any detection for $^{239/240}$Pu this year. The detected concentration at TUT was lower than the baseline concentration of 1.90E-03 Bq/g covering all locations. There were not enough detections to perform ANOVA calculations.

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, TUT, PKT, IDN, LST, and BHT. The number of ^{137}Cs detections were consistent between 2018 and 2019, but has been variable in previous years with five locations in 2017, three locations in 2016, seven locations in 2015, and ten locations in 2014. Cobalt-60 and ^{90}Sr were not detected in any of the 2019 sediment samples. The highest concentration of Cs-137 in tank-like structures was from TUT with 5.87E-03 Bq/g.

The ANOVA calculations for ^{40}K used the averages for the NOY and PCN concentrations in 2019 and the averages for the TUT and UPR concentrations in 2018 with 12 common locations. The calculations showed that the sediment concentrations of ^{40}K did not vary significantly between 2018 and 2019 (ANOVA ^{40}K, $p = 0.474$). However, as is typical, the concentrations did vary significantly by location (ANOVA ^{40}K, $p = 4.93E-03$).

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 TUT for 2018 and the average for NOY for 2019. There were four common locations for the Pecos River and associated bodies of water using the average of UPR in 2018 and PCN in 2019. The variation by year for tanks and tank-like structures was ANOVA ^{40}K, $p = 0.229$, showing good correlation in the concentrations between years. There was also good correlation in the concentrations between locations (ANOVA ^{40}K, $p = 0.134$).

Table 4.13 – 2019 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	5/20/2019	7.73E-06	7.48E-05	3.01E-04	U	1.00E-04	1.21E-04	3.29E-04	U	2.04E-04	1.55E-04	4.22E-04	U
NOY	5/15/2019	-1.93E-05	4.41E-05	3.42E-04	U	1.17E-04	1.21E-04	3.17E-04	U	3.33E-04	2.07E-04	4.52E-04	U
NOY Dup	5/15/2019	4.45E-05	8.13E-05	3.43E-04	U	3.17E-05	8.87E-05	3.28E-04	U	1.52E-04	1.56E-04	4.32E-04	U
HIL	5/15/2019	3.60E-05	9.51E-05	3.55E-04	U	2.76E-04	1.85E-04	3.25E-04	U	1.84E-04	1.68E-04	4.29E-04	U
TUT	6/13/2019	4.50E-05	9.30E-05	3.61E-04	U	5.28E-04	2.51E-04	3.75E-04	+	1.68E-04	1.56E-04	4.42E-04	U
PKT	5/16/2019	2.11E-05	7.16E-05	3.56E-04	U	3.26E-04	2.11E-04	3.28E-04	U	2.40E-04	1.82E-04	4.26E-04	U
IDN	5/16/2019	1.10E-04	1.33E-04	3.58E-04	U	2.99E-04	2.02E-04	3.45E-04	U	1.40E-04	1.43E-04	4.30E-04	U
PCN	5/30/2019	6.34E-06	7.08E-05	2.96E-04	U	9.48E-05	1.13E-04	3.22E-04	U	7.82E-05	1.03E-04	4.22E-04	U
PCN Dup	5/30/2019	-9.09E-06	3.09E-05	2.89E-04	U	9.06E-06	6.87E-05	3.18E-04	U	3.96E-05	9.81E-05	4.31E-04	U
CBD	5/30/2019	6.40E-06	7.15E-05	2.92E-04	U	4.47E-05	8.25E-05	3.20E-04	U	8.82E-06	8.54E-05	4.43E-04	U
BRA	5/30/2019	1.11E-05	6.86E-05	2.93E-04	U	6.71E-05	1.02E-04	3.26E-04	U	1.50E-05	7.19E-05	4.26E-04	U
UPR	5/30/2019	1.06E-05	6.55E-05	2.87E-04	U	3.69E-05	8.32E-05	3.18E-04	U	5.58E-05	9.38E-05	4.60E-04	U
LST	5/20/2019	1.31E-04	1.46E-04	3.56E-04	U	2.35E-04	1.75E-04	3.28E-04	U	2.16E-04	1.67E-04	4.20E-04	U
BHT	5/20/2019	2.07E-04	1.65E-04	3.56E-04	U	2.01E-04	1.66E-04	3.79E-04	U	3.16E-04	1.95E-04	4.15E-04	U

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

NOY and PCN 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.

Table 4.14 – 2019 Gamma Radionuclides and ^{90}Sr Concentrations in Sediment Samples Taken Near the WIPP Site

		^{40}K					^{60}Co				
Location	Date	[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	5/20/2019	3.30E-01	3.13E-02	2.17E-02	0.999	+	3.12E-04	6.61E-04	1.32E-03	0.000	U
NOY	5/15/2019	4.20E-01	5.95E-02	2.88E-02	0.993	+	-7.63E-05	5.91E-04	1.11E-03	0.000	U
NOY Dup	5/15/2019	4.87E-01	3.61E-02	1.86E-02	1.000	+	-2.25E-04	4.94E-04	8.95E-04	0.000	U
HIL	5/15/2019	9.12E-01	1.21E-01	2.61E-02	0.995	+	1.86E-04	9.37E-04	1.81E-03	0.000	U
TUT	6/13/2019	7.03E-01	6.32E-02	2.95E-02	0.997	+	-2.43E-04	9.79E-04	1.77E-03	0.000	U
PKT	5/16/2019	5.82E-01	4.42E-02	2.40E-02	1.000	+	1.11E-04	7.36E-04	1.43E-03	0.000	U
IDN	5/16/2019	7.77E-01	1.07E-01	2.58E-02	0.991	+	-2.56E-04	1.08E-03	1.95E-03	0.000	U
PCN	5/30/2019	3.85E-01	3.10E-02	1.85E-02	1.000	+	2.41E-05	5.73E-04	1.10E-03	0.000	U
PCN Dup	5/30/2019	4.34E-01	5.99E-02	1.50E-02	0.992	+	2.19E-05	6.78E-04	1.29E-03	0.000	U
CBD	5/30/2019	2.33E-01	2.34E-02	1.86E-02	1.000	+	9.17E-04	6.84E-04	1.12E-03	0.000	U
BRA	5/30/2019	4.05E-01	3.27E-02	1.80E-02	0.997	+	5.48E-04	8.10E-04	1.50E-03	0.000	U
UPR	5/30/2019	4.48E-01	4.15E-02	2.14E-02	1.000	+	2.02E-04	7.04E-04	1.39E-03	0.000	U
LST	5/20/2019	5.13E-01	4.00E-02	2.00E-02	1.000	+	-4.99E-04	7.40E-04	1.22E-03	0.000	U
BHT	5/20/2019	6.05E-01	5.68E-02	2.80E-02	0.960	+	-1.51E-04	1.12E-03	2.08E-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	5/20/2019	1.11E-03	7.61E-04	1.54E-03	0.000	U	-4.07E-03	6.35E-03	1.51E-02	U
NOY	5/15/2019	7.91E-04	5.61E-04	1.13E-03	0.000	U	1.46E-03	5.64E-03	1.48E-02	U
NOY Dup	5/15/2019	4.75E-04	6.07E-04	1.17E-03	0.000	U	8.03E-03	6.00E-03	1.48E-02	U
HIL	5/15/2019	3.97E-03	1.66E-03	2.53E-03	0.994	+	5.03E-03	5.82E-03	1.48E-02	U
TUT	6/13/2019	5.87E-03	1.61E-03	2.23E-03	0.997	+	-1.17E-03	6.52E-03	1.51E-02	U
PKT	5/16/2019	3.59E-03	1.37E-03	2.03E-03	1.000	+	4.61E-03	5.94E-03	1.48E-02	U
IDN	5/16/2019	5.30E-03	1.64E-03	2.20E-03	0.998	+	3.01E-03	5.78E-03	1.48E-02	U
PCN	5/30/2019	9.78E-04	6.25E-04	1.25E-03	0.000	U	-3.46E-03	6.24E-03	1.51E-02	U
PCN Dup	5/30/2019	9.79E-04	6.31E-04	1.27E-03	0.000	U	-5.68E-04	6.22E-03	1.51E-02	U
CBD	5/30/2019	-3.07E-04	6.24E-04	1.03E-03	0.000	U	-4.15E-03	6.00E-03	1.50E-02	U
BRA	5/30/2019	7.96E-05	6.87E-04	1.20E-03	0.000	U	-4.09E-03	6.02E-03	1.50E-02	U
UPR	5/30/2019	5.92E-04	6.22E-04	1.22E-03	0.000	U	-5.32E-03	6.16E-03	1.50E-02	U
LST	5/20/2019	2.43E-03	1.21E-03	1.89E-03	1.000	+	3.20E-03	5.63E-03	1.48E-02	U
BHT	5/20/2019	4.01E-03	1.46E-03	2.14E-03	0.994	+	2.66E-03	5.62E-03	1.48E-02	U

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

NOY and PCN 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 ^{40}K ANOVA calculations for the Pecos River and associated bodies of water by year for 2018 and 2019 showed no significant variation by year, ANOVA ^{40}K, $p = 0.555$ for 2019 compared to $p = 0.779$ for 2017 and 2018. There was a slight variation in the Pecos River and associated bodies of water with ANOVA ^{40}K, $p = 0.074$ compared to $p = 0.358$ in 2018. 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 2019 ^{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. The 2019 ^{40}K concentrations were lower than the associated baseline concentrations.

The ANOVA calculations for ^{137}Cs were based on six common locations (HIL, TUT, PKT, IDN, LST, and BHT) and showed that the sediment concentrations did not vary significantly between years (ANOVA ^{137}Cs, $p = 0.168$). The ANOVA calculation by location yielded ANOVA, ^{137}Cs, $p = 0.607$ 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 2019, 2018, 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. 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 NOY and PCN. Precision calculations as RER were performed for the target radionuclides, as shown in Table 4.15. The qualifier column shows which radionuclides were detected in the samples.

The RER values were less than 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 – 2019 Precision Results for Duplicate Sediment Samples

Radionuclide	NOY		NOY Duplicate		RER(c)	Q(d)
	[RN](a)	1 σ TPU(b)	[RN](a)	1 σ TPU(b)		
$^{233/234}U$	8.65E-03	7.93E-04	1.03E-02	9.89E-04	1.30	+
^{235}U	5.21E-04	1.41E-04	5.62E-04	1.56E-04	0.19	+
^{238}U	9.41E-03	8.48E-04	1.18E-02	1.11E-03	1.71	+
^{238}Pu	-1.93E-05	2.25E-05	4.45E-05	4.15E-05	-1.35	U
$^{239/240}Pu$	1.17E-04	6.15E-05	3.17E-05	4.52E-05	1.12	U
^{241}Am	3.33E-04	1.06E-04	1.52E-04	7.95E-05	1.37	U
^{40}K	4.20E-01	3.04E-02	4.87E-01	1.84E-02	1.89	+
^{60}Co	-7.63E-05	3.02E-04	-2.25E-04	2.52E-04	-0.38	U
^{137}Cs	7.91E-04	2.86E-04	4.75E-04	3.10E-04	0.75	U
^{90}Sr	1.46E-03	2.88E-03	8.03E-03	3.06E-03	-1.56	U
Radionuclide	PCN		PCN Duplicate		RER(c)	Q(d)
	[RN](a)	1 σ TPU(b)	[RN](a)	1 σ TPU(b)		
$^{233/234}U$	1.49E-02	1.15E-03	1.73E-02	1.89E-03	1.08	+
^{235}U	5.91E-04	1.44E-04	7.60E-04	2.08E-04	-0.67	+
^{238}U	1.46E-02	1.13E-03	1.54E-02	1.70E-03	0.39	+
^{238}Pu	6.34E-06	3.61E-05	-9.09E-06	1.57E-05	0.39	U
$^{239/240}Pu$	9.48E-05	5.75E-05	9.06E-06	3.51E-05	-1.27	U
^{241}Am	7.82E-05	5.26E-05	3.96E-05	5.00E-05	0.53	U
^{40}K	3.85E-01	1.58E-02	4.34E-01	3.05E-02	1.43	+
^{60}Co	2.41E-05	2.92E-04	2.19E-05	3.46E-04	-0.005	U
^{137}Cs	9.78E-04	3.19E-04	9.79E-04	3.22E-04	0.002	U
^{90}Sr	-3.46E-03	3.18E-03	-5.68E-04	3.17E-03	0.64	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.

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.

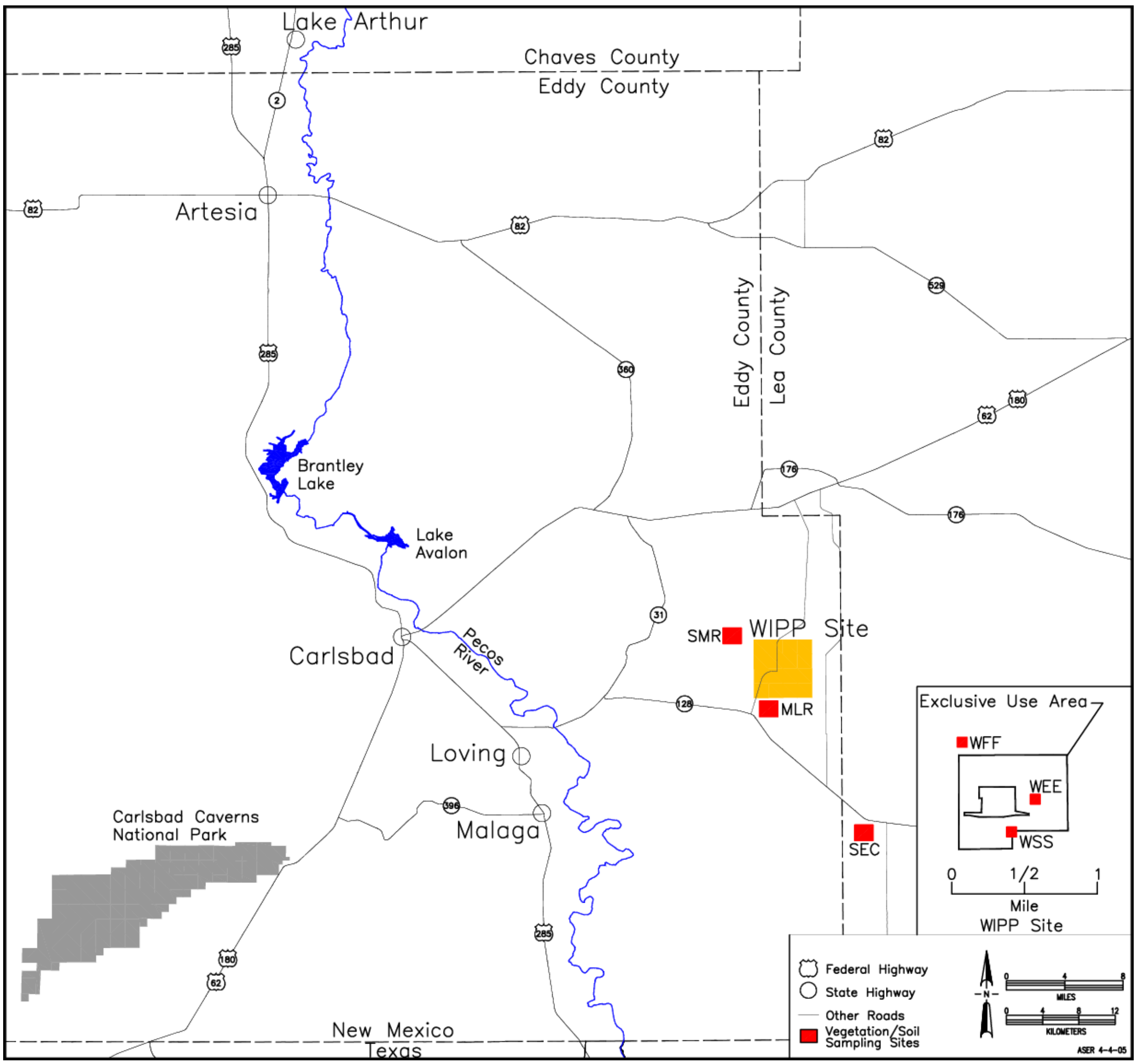

Figure 4.4 – Routine Soil and Vegetation Sampling Locations

Soil sample locations are divided into three geographic groups.

- The WIPP site group covers the smallest area with locations within 1 km (0.62 miles) 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 on March 18, 2019, WEE, WEE dup, WSS, and MLR on March 27, 2019, SEC on March 28, 2019, and SMR on April 17, 2019.

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 2019 soil samples including a set of duplicate samples collected at WEE. As shown in the table, $^{233/234}$U and ^{238}U were detected in all soil samples, while ^{235}U was detected in the three depths from WEE, shallow depth from MLR, deep sample from SEC, and the three depths from SMR. In comparing the 2018 and 2019 uranium data, the average of the primary and duplicate samples was used for SMR in 2018, and WEE in 2019.

Table 4.16 – 2019 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	3/18/2019	5.93E-03	1.36E-03	9.90E-04	+	3.62E-04	3.27E-04	4.72E-04	U	6.66E-03	1.47E-03	7.52E-04	+
WFF	2-5	3/18/2019	7.09E-03	1.59E-03	9.93E-04	+	1.79E-04	2.46E-04	4.48E-04	U	5.14E-03	1.27E-03	7.63E-04	+
WFF	5-10	3/18/2019	4.62E-03	1.13E-03	9.84E-04	+	4.87E-05	1.38E-04	4.07E-04	U	5.05E-03	1.20E-03	7.55E-04	+
WEE	0-2	3/27/2019	7.39E-03	1.59E-03	9.89E-04	+	4.46E-04	3.55E-04	4.18E-04	+	8.37E-03	1.73E-03	7.60E-04	+
WEE	2-5	3/27/2019	7.93E-03	1.72E-03	9.95E-04	+	4.26E-04	3.46E-04	4.10E-04	+	6.90E-03	1.56E-03	7.81E-04	+
WEE	5-10	3/27/2019	8.46E-03	1.74E-03	9.99E-04	+	5.33E-04	3.76E-04	3.98E-04	+	7.36E-03	1.57E-03	7.59E-04	+
WEE Dup	0-2	3/27/2019	6.83E-03	1.45E-03	9.82E-04	+	9.79E-05	1.92E-04	4.16E-04	U	5.88E-03	1.31E-03	7.52E-04	+
WEE Dup	2-5	3/27/2019	7.40E-03	1.62E-03	9.92E-04	+	1.72E-04	2.48E-04	4.42E-04	U	6.71E-03	1.51E-03	7.63E-04	+
WEE Dup	5-10	3/27/2019	7.12E-03	1.64E-03	1.01E-03	+	1.19E-04	2.15E-04	4.47E-04	U	7.51E-03	1.70E-03	7.72E-04	+
WSS	0-2	3/27/2019	5.48E-03	1.32E-03	9.91E-04	+	1.82E-04	2.26E-04	4.27E-04	U	5.14E-03	1.32E-03	8.81E-04	+
WSS	2-5	3/27/2019	5.61E-03	1.47E-03	1.01E-03	+	3.82E-04	3.56E-04	4.52E-04	U	6.73E-03	1.66E-03	7.83E-04	+
WSS	5-10	3/27/2019	4.89E-03	1.20E-03	9.75E-04	+	2.46E-04	2.67E-04	4.17E-04	U	6.00E-03	1.38E-03	7.73E-04	+
MLR	0-2	3/27/2019	1.16E-02	2.44E-03	9.97E-04	+	7.90E-04	5.07E-04	4.53E-04	+	1.03E-02	2.23E-03	7.75E-04	+
MLR	2-5	3/27/2019	1.06E-02	2.11E-03	9.85E-04	+	2.63E-04	2.77E-04	4.28E-04	U	1.23E-02	2.35E-03	7.61E-04	+
MLR	5-10	3/27/2019	1.16E-02	2.40E-03	9.88E-04	+	2.44E-04	3.08E-04	4.77E-04	U	1.12E-02	2.33E-03	7.66E-04	+
SEC	0-2	3/28/2019	7.17E-03	1.63E-03	1.00E-03	+	4.02E-04	3.27E-04	4.38E-04	U	7.09E-03	1.69E-03	1.02E-03	+
SEC	2-5	3/28/2019	7.23E-03	1.68E-03	1.01E-03	+	3.02E-04	3.13E-04	4.47E-04	U	7.54E-03	1.72E-03	7.74E-04	+
SEC	5-10	3/28/2019	8.73E-03	2.05E-03	1.02E-03	+	5.84E-04	4.49E-04	4.58E-03	+	9.29E-03	2.14E-03	8.23E-04	+
SMR	0-2	4/17/2019	1.72E-02	2.98E-03	9.29E-04	+	7.34E-04	4.45E-04	3.99E-04	+	1.78E-02	3.07E-03	8.33E-04	+
SMR	2-5	4/17/2019	1.88E-02	3.53E-03	9.46E-04	+	9.64E-04	5.65E-04	4.64E-04	+	1.90E-02	3.56E-03	8.58E-04	+
SMR	5-10	4/17/2019	1.40E-02	2.54E-03	9.22E-04	+	8.58E-04	5.00E-04	4.44E-04	+	1.41E-02	2.56E-03	8.38E-04	+

Notes:
See Appendix C for sampling location codes. Units are in Bq/g, dry weight.
(a) Radionuclide concentration
(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 2018 and 2019 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 2018 and 2019. The ANOVA calculations for concentrations of $^{233/234}U$ and ^{238}U showed some variation between 2018 and 2019 (ANOVA $^{233/234}U$, $p = 0.0974$ and ANOVA ^{238}U, $p = 0.113$). The difference between years appears to be due to generally higher uranium isotope concentrations in 2019 than 2018. The ^{235}U does not normally track very closely with the other two uranium isotopes and yielded a *p* value above the significance level (ANOVA ^{235}U, $p = 0.215$).

The 2019 ANOVA calculations showed no significant variation for $^{233/234}U$ and ^{238}U by location (ANOVA $^{233/234}U$, $p = 0.1$ and ANOVA ^{238}U, $p = 0.188$). The *p* value for ^{235}U, which was based on many fewer common locations, also showed no significant variation between locations with ANOVA ^{235}U, $p = 0.255$.

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 2019 was 1.88E-02 Bq/g at the 2 – 5 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 9.64E-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 1.90E-02 Bq/g in the 2 – 5 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 highest uranium isotope concentrations and locations in 2019 were different than in 2018. Location MLR was the highest uranium isotope concentration in 2018.

None of the 2019 uranium isotope concentrations were higher than the 99 percent confidence interval concentrations for three WIPP site locations within 1 km of the WHB and Exhaust Shaft (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 no detections for any of the isotopes so ANOVA calculations were not performed.

Table 4.18 presents the 2019 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 of the samples and

^{137}Cs was detected at shallow and intermediate depths from WEE, the three depths from WEE dup, the shallow and intermediate samples from MLR, and the three depths from WSS and SEC. Colbalt-60 and ^{90}Sr were not detected in any of the samples.

There was no significant variation in the ^{40}K concentrations between 2018 and 2019 (ANOVA ^{40}K, $p = 0.149$). The p value for ^{40}K was higher in 2018 (0.177). There was also no significant variation in the concentrations between locations, including the various soil depths (ANOVA ^{40}K, $p = 0.253$). 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 site. 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 and SMR 5-mile ring sample concentrations at the three depths were above the baseline concentration of 3.40E-01 Bq/g, with the highest concentration of 9.02E-01 Bq/g at shallow depth from SMR. None of the ^{40}K concentrations were above the baseline for WIPP site locations (WFF, WEE, and WSS) and for the Outer Ring Site (SEC).

Statistical analyses for ^{137}Cs were performed for 8 common locations. The average concentrations were used for the duplicate samples at SMR in 2018 and WEE in 2019.

The ANOVA calculations showed no significant variation by year for 2019. The p value comparing the concentrations by year showed no significant difference between the concentrations (ANOVA ^{137}Cs, $p = 0.900$) compared to $p = 0.308$ in 2018. The p value comparing concentrations by location showed some variations with p value of 9.85E-05. In 2017 and 2018, there were no significant differences between concentrations by location (ANOVA ^{137}Cs, $p = 0.0776$ in 2017 and $p = 0.247$ in 2018).

Table 4.17 – 2019 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	3/18/2019	-3.76E-05	8.70E-05	3.45E-04	U	1.28E-04	1.93E-04	4.60E-04	U	3.99E-05	1.35E-04	5.88E-04	U
WFF	2-5	3/18/2019	-3.58E-05	9.25E-05	3.68E-04	U	1.54E-05	1.61E-04	5.10E-04	U	1.64E-04	2.28E-04	6.06E-04	U
WFF	5-10	3/18/2019	5.91E-05	1.16E-04	3.19E-04	U	1.57E-04	2.11E-04	5.01E-04	U	3.13E-04	2.63E-04	5.61E-04	U
WEE	0-2	3/27/2019	5.63E-05	1.10E-04	3.11E-04	U	1.50E-04	2.01E-04	4.70E-04	U	1.51E-04	2.02E-04	5.77E-04	U
WEE	2-5	3/27/2019	-2.04E-05	6.61E-05	3.33E-04	U	2.96E-05	1.32E-04	4.79E-04	U	1.56E-04	2.03E-04	5.73E-04	U
WEE	5-10	3/27/2019	9.70E-05	1.74E-04	3.67E-04	U	1.57E-04	2.07E-04	4.85E-04	U	1.45E-04	2.34E-04	5.90E-04	U
WEE Dup	0-2	3/27/2019	2.65E-05	1.27E-04	3.37E-04	U	2.82E-04	2.68E-04	4.74E-04	U	8.22E-05	1.70E-04	5.83E-04	U
WEE Dup	2-5	3/27/2019	-3.09E-05	8.56E-05	3.62E-04	U	1.01E-03	5.08E-04	4.92E-04	U	1.01E-04	1.69E-04	5.77E-04	U
WEE Dup	5-10	3/27/2019	8.47E-05	1.56E-04	3.41E-04	U	1.79E-04	2.16E-04	4.62E-04	U	1.66E-04	1.97E-04	5.67E-04	U
WSS	0-2	3/27/2019	-7.46E-05	1.27E-04	4.74E-04	U	1.73E-04	2.42E-04	5.51E-04	U	2.58E-04	2.66E-04	5.85E-04	U
WSS	2-5	3/27/2019	-1.04E-05	1.80E-04	5.61E-04	U	8.07E-05	2.00E-04	5.95E-04	U	7.79E-05	1.81E-04	5.91E-04	U
WSS	5-10	3/27/2019	-1.45E-05	5.68E-05	3.70E-04	U	3.68E-04	3.13E-04	5.33E-04	U	1.48E-04	2.37E-04	5.92E-04	U
MLR	0-2	3/27/2019	-7.67E-05	1.28E-04	5.74E-04	U	1.11E-04	2.18E-04	5.42E-04	U	8.97E-05	1.91E-04	5.86E-04	U
MLR	2-5	3/27/2019	-7.45E-05	1.37E-04	5.69E-04	U	1.40E-04	2.52E-04	6.46E-04	U	3.82E-05	1.38E-04	5.75E-04	U
MLR	5-10	3/27/2019	6.25E-05	1.97E-04	5.33E-04	U	1.26E-04	2.24E-04	5.48E-04	U	3.21E-05	1.24E-04	5.65E-04	U
SEC	0-2	3/28/2019	-5.83E-05	1.11E-04	4.83E-04	U	3.63E-06	1.48E-04	5.33E-04	U	1.99E-04	2.58E-04	5.87E-04	U
SEC	2-5	3/28/2019	-3.94E-06	1.67E-04	4.84E-04	U	1.37E-04	2.21E-04	5.49E-04	U	3.13E-05	1.58E-04	5.90E-04	U
SEC	5-10	3/28/2019	-1.46E-05	5.73E-05	3.64E-04	U	1.82E-05	1.48E-04	5.04E-04	U	6.81E-05	1.34E-04	5.80E-04	U
SMR	0-2	4/17/2019	-1.86E-05	6.31E-05	3.51E-04	U	3.15E-05	1.30E-04	4.57E-04	U	5.30E-05	1.04E-04	5.69E-04	U
SMR	2-5	4/17/2019	-1.11E-05	4.88E-05	3.34E-04	U	-1.11E-05	4.87E-05	4.45E-04	U	8.08E-05	2.19E-04	6.62E-04	U
SMR	5-10	4/17/2019	-1.84E-05	6.24E-05	3.30E-04	U	3.11E-05	1.29E-04	4.52E-04	U	5.42E-05	1.22E-04	5.67E-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 – 2019 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	3/18/2019	1.55E-01	2.52E-02	1.88E-02	0.999	+	-2.01E-04	6.61E-04	1.18E-03	0.000	U
WFF	2 - 5	3/18/2019	1.99E-01	2.56E-02	2.04E-02	1.000	+	3.96E-04	6.18E-04	1.24E-03	0.000	U
WFF	5 - 10	3/18/2019	2.15E-01	3.58E-02	2.13E-02	1.000	+	2.22E-04	6.50E-04	1.32E-03	0.000	U
WEE	0 - 2	3/27/2019	2.15E-01	2.19E-02	1.54E-02	0.999	+	1.35E-05	6.28E-04	9.20E-04	0.000	U
WEE	2 - 5	3/27/2019	2.04E-01	2.30E-02	1.46E-02	0.996	+	-2.69E-04	5.08E-04	9.19E-04	0.000	U
WEE	5 - 10	3/27/2019	2.30E-01	2.37E-02	1.77E-02	0.997	+	-3.26E-04	5.47E-04	9.60E-04	0.000	U
WEE Dup	0 - 2	3/27/2019	2.14E-01	3.04E-02	1.81E-02	0.998	+	5.01E-04	8.27E-04	1.69E-03	0.000	U
WEE Dup	2 - 5	3/27/2019	1.99E-01	2.25E-02	1.57E-02	1.000	+	-3.50E-04	5.16E-04	8.47E-04	0.000	U
WEE Dup	5 - 10	3/27/2019	2.10E-01	3.28E-02	1.72E-02	1.000	+	-2.10E-04	5.53E-04	9.90E-04	0.000	U
WSS	0 - 2	3/27/2019	2.04E-01	2.96E-02	2.00E-02	0.999	+	3.43E-05	7.80E-04	1.46E-03	0.000	U
WSS	2 - 5	3/27/2019	2.05E-01	3.22E-02	1.72E-02	1.000	+	1.66E-04	5.08E-04	1.03E-03	0.000	U
WSS	5 - 10	3/27/2019	1.92E-01	2.26E-02	1.98E-02	0.996	+	-4.37E-04	5.95E-04	9.21E-04	0.000	U
MLR	0 - 2	3/27/2019	3.53E-01	3.56E-02	2.07E-02	1.000	+	-3.09E-04	7.41E-04	1.32E-03	0.000	U
MLR	2 - 5	3/27/2019	3.49E-01	3.00E-02	1.81E-02	0.995	+	6.73E-04	6.63E-04	1.08E-03	0.985	U
MLR	5 - 10	3/27/2019	3.76E-01	3.76E-02	2.34E-02	1.000	+	2.91E-05	6.79E-04	1.31E-03	0.000	U
SEC	0 - 2	3/28/2019	1.83E-01	2.83E-02	1.30E-02	1.000	+	-2.07E-04	4.35E-04	7.92E-04	0.000	U
SEC	2 - 5	3/28/2019	2.03E-01	2.11E-02	1.48E-02	0.998	+	1.95E-04	5.41E-04	1.03E-03	0.000	U
SEC	5 - 10	3/28/2019	1.93E-01	2.41E-02	1.76E-02	0.993	+	2.19E-04	6.16E-04	1.25E-03	0.000	U
SMR	0 - 2	4/17/2019	9.02E-01	6.00E-02	2.33E-02	1.000	+	2.75E-07	8.48E-04	1.52E-03	0.000	U
SMR	2 - 5	4/17/2019	8.29E-01	5.76E-02	2.33E-02	0.999	+	-4.91E-05	8.51E-04	1.53E-03	0.000	U
SMR	5 - 10	4/17/2019	6.62E-01	5.58E-02	1.86E-02	0.989	+	4.71E-04	8.15E-04	1.62E-03	0.000	U

Location	Depth (cm)	Sampling Date	^{137}Cs [RN][(a)]	^{137}Cs 2 × TPU[(b)]	^{137}Cs MDC[(c)]	^{137}Cs ID Conf.	^{137}Cs Q[(d)]	^{90}Sr [RN][(a)]	^{90}Sr 2 × TPU[(b)]	^{90}Sr MDC[(c)]	^{90}Sr Q[(d)]
WFF	0 - 2	3/18/2019	9.49E-04	8.39E-04	1.36E-03	0.990	U	6.52E-03	1.12E-02	1.30E-02	U
WFF	2 - 5	3/18/2019	5.67E-04	7.78E-04	1.44E-03	0.000	U	-5.40E-03	1.07E-02	1.30E-02	U
WFF	5 - 10	3/18/2019	7.90E-04	7.91E-04	1.30E-03	1.000	U	-1.98E-03	1.14E-02	1.30E-02	U
WEE	0 - 2	3/27/2019	2.28E-03	9.48E-04	1.44E-03	1.000	+	4.87E-03	1.12E-02	1.30E-02	U
WEE	2 - 5	3/27/2019	2.66E-03	9.25E-04	1.36E-03	0.996	+	-4.15E-03	1.11E-02	1.31E-02	U
WEE	5 - 10	3/27/2019	1.33E-03	9.43E-04	1.52E-03	1.000	U	3.40E-03	1.14E-02	1.31E-02	U
WEE Dup	0 - 2	3/27/2019	1.98E-03	1.16E-03	1.81E-03	0.997	+	3.09E-03	1.10E-02	1.30E-02	U
WEE Dup	2 - 5	3/27/2019	2.01E-03	8.95E-04	1.35E-03	1.000	+	-1.56E-03	1.23E-02	1.32E-02	U
WEE Dup	5 - 10	3/27/2019	1.76E-03	8.18E-04	1.22E-03	0.999	+	6.58E-03	1.13E-02	1.30E-02	U
WSS	0 - 2	3/27/2019	2.45E-03	1.21E-03	1.86E-03	0.998	+	-3.78E-03	9.87E-03	1.33E-02	U
WSS	2 - 5	3/27/2019	2.16E-03	8.54E-04	1.24E-03	0.998	+	4.70E-03	9.64E-03	1.33E-02	U
WSS	5 - 10	3/27/2019	2.48E-03	9.35E-04	1.37E-03	0.999	+	-4.93E-03	9.50E-03	1.33E-02	U
MLR	0 - 2	3/27/2019	6.44E-03	1.49E-03	2.06E-03	1.000	+	-2.22E-03	9.09E-03	1.33E-02	U
MLR	2 - 5	3/27/2019	4.75E-03	1.25E-03	1.67E-03	0.997	+	-9.07E-05	9.84E-03	1.33E-02	U
MLR	5 - 10	3/27/2019	1.10E-03	8.81E-04	1.65E-03	0.000	U	-2.42E-03	9.23E-03	1.33E-02	U
SEC	0 - 2	3/28/2019	1.46E-03	8.47E-04	1.33E-03	0.996	+	-9.20E-04	9.79E-03	1.33E-02	U
SEC	2 - 5	3/28/2019	1.44E-03	7.79E-04	1.21E-03	1.000	+	5.47E-03	1.02E-02	1.33E-02	U
SEC	5 - 10	3/28/2019	2.43E-03	9.39E-04	1.37E-03	0.997	+	1.91E-03	9.69E-03	1.33E-02	U
SMR	0 - 2	4/17/2019	2.53E-04	8.56E-04	1.51E-03	0.000	U	-1.09E-02	9.89E-03	1.32E-02	U
SMR	2 - 5	4/17/2019	9.86E-04	9.07E-04	1.69E-03	0.000	U	-4.65E-03	9.82E-03	1.32E-02	U
SMR	5 - 10	4/17/2019	9.85E-04	7.05E-04	1.41E-03	0.000	U	-5.74E-04	1.01E-02	1.32E-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 5-mile ring sites (SMR, MLR), and 4.00E-02 Bq/g for outer site (SEC). As shown in Table 4.18, none of the 2019 ^{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.

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 WEE were selected to perform precision calculations for the target radionuclides. The calculated RERs for the WEE samples at the 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 2.249 for ^{238}U in the shallow depth soil sample and 3.661 for $^{239/240}Pu$ in the intermediate depth soil sample. The $^{239/240}Pu$ was not detected, but the ^{238}U 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 – 2019 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]		
WEE	0-2	$^{233/234}U$	7.39E-03	8.11E-04	6.83E-03	7.40E-04	-0.510	+
WEE	2-5	$^{233/234}U$	7.93E-03	8.78E-04	7.40E-03	8.27E-04	-0.440	+
WEE	5-10	$^{233/234}U$	8.46E-03	8.88E-04	7.12E-03	8.37E-04	-1.098	+
WEE	0-2	^{235}U	4.46E-04	1.81E-04	9.79E-05	9.80E-05	-1.690	+/U
WEE	2-5	^{235}U	4.26E-04	1.77E-04	1.72E-04	1.27E-04	-1.169	+/U
WEE	5-10	^{235}U	5.33E-04	1.92E-04	1.19E-04	1.10E-04	1.873	+/U
WEE	0-2	^{235}U	8.37E-03	8.83E-04	5.88E-03	6.68E-04	-2.249	+
WEE	2-5	^{235}U	6.90E-03	7.96E-04	6.71E-03	7.70E-04	-0.172	+
WEE	5-10	^{235}U	7.36E-03	8.01E-04	7.51E-03	8.67E-04	0.127	+
WEE	0-2	^{238}Pu	5.63E-05	5.61E-05	2.65E-05	6.48E-05	-0.348	U
WEE	2-5	^{238}Pu	-2.04E-05	3.37E-05	-3.09E-05	4.37E-05	0.190	U

Location	Depth cm	Radionuclide	Primary Sample		Duplicate Sample		RER[c]	Q[d]
			[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]		
WEE	5-10	^{238}Pu	9.70E-05	8.88E-05	8.47E-05	7.96E-05	0.103	U
WEE	0-2	$^{239/240}$Pu	1.50E-04	1.03E-04	2.82E-04	1.37E-04	-0.772	U
WEE	2-5	$^{239/240}$Pu	2.96E-05	6.73E-05	1.01E-03	2.59E-04	-3.661	U
WEE	5-10	$^{239/240}$Pu	1.57E-04	1.06E-04	1.79E-04	1.10E-04	-0.144	U
WEE	0-2	^{241}Am	1.51E-04	1.03E-04	8.22E-05	8.67E-05	-0.511	U
WEE	2-5	^{241}Am	1.56E-04	1.04E-04	1.01E-04	8.62E-05	0.408	U
WEE	5-10	^{241}Am	1.45E-04	1.19E-04	1.66E-04	1.01E-04	0.135	U
WEE	0-2	^{40}K	2.15E-01	1.12E-02	2.14E-01	1.55E-02	-0.052	+
WEE	2-5	^{40}K	2.04E-01	1.17E-02	1.99E-01	1.15E-02	-0.305	+
WEE	5-10	^{40}K	2.30E-01	1.21E-02	2.10E-01	1.67E-02	-0.969	+
WEE	0-2	^{60}Co	1.35E-05	3.20E-04	5.01E-04	4.22E-04	0.920	U
WEE	2-5	^{60}Co	-2.69E-04	2.59E-04	-3.50E-04	2.63E-04	-0.219	U
WEE	5-10	^{60}Co	-3.26E-04	2.79E-04	-2.10E-04	2.82E-04	-0.292	U
WEE	0-2	^{137}Cs	2.28E-03	4.84E-04	1.98E-03	5.92E-04	-0.392	+
WEE	2-5	^{137}Cs	2.66E-03	4.72E-04	2.01E-03	4.57E-04	0.990	+
WEE	5-10	^{137}Cs	1.33E-03	4.81E-04	1.76E-03	4.17E-04	-0.675	+/U
WEE	0-2	^{90}Sr	4.87E-03	5.71E-03	3.09E-03	5.61E-03	-0.222	U
WEE	2-5	^{90}Sr	-4.15E-03	5.66E-03	-1.56E-03	6.28E-03	0.306	U
WEE	5-10	^{90}Sr	3.40E-03	5.82E-03	6.58E-03	5.77E-03	0.388	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 SOO resulting from roadkill. 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 WFF during the vegetation sampling period in August 2019.

Table 4.20 shows that $^{233/234}U$ and ^{238}U were detected in MLR sample, but no other detections of uranium isotopes, plutonium isotopes, or americium in any of the vegetation samples.

ANOVA calculations could not be performed due to not enough detections in previous years.

Table 4.20 – 2019 Uranium Isotope, Plutonium isotope, and Americium Concentrations in Vegetation Samples Taken at or Near the WIPP Site

Location	Sampling Date	$^{233/234}U$ [RN][(a)]	$^{233/234}U$ 2 σ TPU[(b)]	$^{233/234}U$ MDC[(c)]	$^{233/234}U$ Q[(d)]	^{235}U [RN][(a)]	^{235}U 2 σ TPU[(b)]	^{235}U MDC[(c)]	^{235}U Q[(d)]	^{238}U [RN][(a)]	^{238}U 2 σ TPU[(b)]	^{238}U MDC[(c)]	^{238}U Q[(d)]
WFF	8/15/2019	4.04E-04	1.70E-04	6.42E-04	U	6.76E-05	7.44E-05	2.88E-04	U	2.72E-04	1.36E-04	6.29E-04	U
WFF DUP	8/15/2019	2.14E-04	1.29E-04	6.48E-04	U	7.65E-05	8.66E-05	2.97E-04	U	2.44E-04	1.40E-04	6.36E-04	U
WEE	8/21/2019	4.66E-04	2.11E-04	6.53E-04	U	2.03E-05	4.66E-05	2.99E-04	U	3.95E-04	1.90E-04	6.39E-04	U
WSS	8/21/2019	5.70E-04	2.34E-04	6.51E-04	U	9.99E-05	1.04E-04	3.02E-04	U	5.31E-04	2.24E-04	6.39E-04	U
MLR	8/15/2019	7.29E-04	2.57E-04	6.45E-04	+	7.10E-05	8.22E-05	2.95E-04	U	8.40E-04	2.81E-04	6.33E-04	+
SEC	8/15/2019	6.30E-04	2.23E-04	6.42E-04	U	4.45E-05	6.78E-05	2.92E-04	U	3.78E-04	1.63E-04	6.30E-04	U
SMR	8/21/2019	4.23E-04	2.07E-04	6.56E-04	U	2.25E-05	5.16E-05	2.63E-05	U	4.98E-04	2.30E-04	6.45E-04	U

Location	Sampling Date	^{238}Pu [RN][(a)]	^{238}Pu 2 σ TPU[(b)]	^{238}Pu MDC[(c)]	^{238}Pu Q[(d)]	$^{239/240}Pu$ [RN][(a)]	$^{239/240}Pu$ 2 σ TPU[(b)]	$^{239/240}Pu$ MDC[(c)]	$^{239/240}Pu$ Q[(d)]	^{241}Am [RN][(a)]	^{241}Am 2 σ TPU[(b)]	^{241}Am MDC[(c)]	^{241}Am Q[(d)]
WFF	8/15/2019	-2.36E-06	9.82E-06	2.99E-04	U	2.36E-06	2.77E-05	3.21E-04	U	6.85E-05	6.36E-05	8.76E-04	U
WFF DUP	8/15/2019	4.01E-07	3.31E-05	3.07E-04	U	1.68E-05	3.79E-05	3.24E-04	U	7.96E-05	8.17E-05	8.86E-04	U
WEE	8/21/2019	4.02E-06	3.05E-05	3.05E-04	U	-6.02E-06	1.67E-05	3.24E-04	U	5.31E-05	6.75E-05	8.81E-04	U
WSS	8/21/2019	-6.75E-06	1.81E-05	3.06E-04	U	-8.83E-06	2.07E-05	3.26E-04	U	2.51E-05	4.55E-05	8.79E-04	U
MLR	8/15/2019	4.95E-06	3.07E-05	3.06E-04	U	4.33E-05	5.13E-05	3.25E-04	U	-4.99E-06	1.57E-05	8.72E-04	U
SEC	8/15/2019	4.84E-06	3.00E-05	3.04E-04	U	1.69E-05	3.82E-05	3.25E-04	U	3.32E-05	4.59E-05	8.72E-04	U
SMR	8/21/2019	2.73E-05	4.39E-05	3.05E-04	U	6.22E-06	2.77E-05	3.23E-04	U	3.17E-05	5.82E-05	8.90E-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 2019.

Table 4.21 – 2019 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	8/15/2019	3.78E-01	5.29E-02	4.64E-02	0.999	+	8.43E-04	1.88E-03	3.58E-03	0.000	U
WFF DUP	8/15/2019	4.36E-01	5.35E-02	4.36E-02	1.000	+	4.77E-04	1.47E-03	2.95E-03	0.000	U
WEE	8/21/2019	5.57E-01	9.47E-02	6.60E-02	0.990	+	-2.36E-03	1.85E-03	2.58E-03	0.000	U
WSS	8/21/2019	4.57E-01	5.89E-02	5.22E-02	0.999	+	-1.20E-03	1.70E-03	2.74E-03	0.000	U
MLR	8/15/2019	7.01E-01	7.33E-02	4.38E-02	0.996	+	2.35E-04	1.49E-03	2.83E-03	0.000	U
SEC	8/15/2019	6.81E-01	7.24E-02	5.47E-02	0.999	+	2.30E-04	1.70E-03	3.30E-03	0.000	U
SMR	8/21/2019	7.61E-01	8.38E-02	5.58E-02	0.997	+	-5.47E-04	1.81E-03	3.22E-03	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]
WFF	8/15/2019	5.24E-04	1.74E-03	3.16E-03	0.000	U	2.08E-03	2.37E-03	1.38E-02	U
WFF DUP	8/15/2019	-2.27E-04	1.39E-03	2.52E-03	0.000	U	1.53E-03	2.37E-03	1.38E-02	U
WEE	8/21/2019	3.36E-04	1.47E-03	2.80E-03	0.000	U	1.96E-03	2.61E-03	1.38E-02	U
WSS	8/21/2019	-1.69E-04	1.75E-03	2.93E-03	0.000	U	1.00E-03	2.39E-03	1.38E-02	U
MLR	8/15/2019	-5.46E-04	1.55E-03	2.63E-03	0.000	U	9.49E-04	2.24E-03	1.38E-02	U
SEC	8/15/2019	7.77E-04	1.59E-03	3.11E-03	0.000	U	6.32E-04	2.39E-03	1.38E-02	U
SMR	8/21/2019	1.54E-04	1.81E-03	3.22E-03	0.000	U	1.69E-03	2.39E-03	1.38E-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.

Table 4.21 shows that ^{40}K was detected in all six of the vegetation samples including the WFF duplicates. 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.

There were six common locations between 2018 and 2019 for ANOVA calculations. The average activity was used for the WSS duplicate samples in 2018 and WFF duplicate samples in 2019. The ANOVA calculations showed no significant statistical difference in ^{40}K vegetation concentrations between 2019 and 2018 (ANOVA ^{40}K, p =

0.382). There was some variation in the concentrations of ^{40}K between locations, (ANOVA ^{40}K, p = 0.057) due to vegetation concentrations at five out of six locations being higher in 2018 compared to 2019. 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 2019.

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 the target radionuclides in the duplicate samples from location WSS. The only detections were for ^{40}K.

Table 4.22 – 2019 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)		
WFF and Dup	$^{233/234}U$	4.04E-04	8.69E-05	2.14E-04	6.59E-05	1.742	U
	^{235}U	6.76E-05	3.79E-05	7.65E-05	4.42E-05	-0.153	U
	^{238}U	2.72E-04	6.92E-05	2.44E-04	7.13E-05	-0.282	U
	^{238}Pu	-2.36E-06	5.01E-06	4.01E-07	1.69E-05	0.157	U
	$^{239/240}Pu$	2.36E-06	1.41E-05	1.68E-05	1.93E-05	-0.604	U
	^{241}Am	6.85E-05	3.24E-05	7.96E-05	4.17E-05	-0.210	U
	^{40}K	3.78E-01	2.70E-02	4.36E-01	2.73E-02	-1.511	+
	^{60}Co	8.43E-04	9.57E-04	4.77E-04	7.51E-04	0.301	U
	^{137}Cs	5.24E-04	8.90E-04	-2.27E-04	7.07E-04	0.661	U
	^{90}Sr	2.08E-03	1.21E-03	1.53E-03	1.21E-03	-0.321	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 WFF were selected to perform precision calculations for the target radionuclides. The calculated RERs for the WFF 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 were less than 1.96.

4.7.4.2 Fauna (Animals)

The number of fauna samples collected and analyzed in 2019 was less than in recent years. There was one SOO collected, a deer roadkill 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 WNN, a single quail composite sample consisting of three specimens from WIPP, three composite fish samples consisting of three catfish from PEC, three catfish from BRA, and two catfish from CBD, and deer 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.

Uranium-238 was detected in composite quail sample from WIPP location. Uranium results for the deer and three fish composite samples were qualified with NJ qualifier (Nuclide present at an estimated quantity) due to contaminated DI water supply. The only other radionuclide detected in any of the animal samples was ^{40}K, and it was detected in all the samples.

ANOVA comparisons were performed on a very limited amount of ^{40}K data. ANOVA calculations were performed for ^{40}K using the 2018 and 2019 data, and included two quail samples, two composite fish samples, and one deer SOO sample. Average concentrations were used for the duplicate quail samples in 2018 and 2019. Data were reported on a dry weight basis.

There were not enough data to perform ANOVA calculations for quail samples only. However, there were two locations for fish samples that were the same for 2018 and 2019. Potassium-40 ANOVA was performed for fish samples from two common locations (BRA and CBD). The results show no significant difference between 2018 and 2019 concentrations (ANOVA ^{40}K, $p = 0.623$) and no significant difference in the concentrations by location (ANOVA ^{40}K, $p = 0.518$).

The ANOVA calculation was also performed combining the data for the three common biota samples consisting of fish, quail, and deer for 2018 and 2019. The resulting comparison by year for all species showed (ANOVA ^{40}K, $p = 0.709$), while the comparison by location for all species yielded (ANOVA ^{40}K, $p = 0.0952$). Thus, the ^{40}K concentrations for the combined biota did not vary significantly by year or by location.

The 2019 ^{40}K concentrations for quail were within the baseline concentration of 4.10E-01 Bq/g. The highest concentration of ^{40}K in fish was 7.22E-01 Bq/g in the PEC sample compared to the mean baseline concentration of 6.10E-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.

Table 4.23 – 2019 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	WIP	2/20/2019	7.33E-04	1.64E-04	8.75E-04	U	6.32E-05	2.58E-05	2.47E-04	U	6.83E-04	1.54E-04	6.55E-04	+
Quail	WNN	01/21/2019	3.25E-04	6.17E-05	8.74E-04	U	1.97E-05	1.09E-05	2.63E-04	U	2.78E-04	5.44E-05	7.15E-04	U
Quail Dup	WNN dup	01/21/2019	2.77E-04	5.70E-05	8.74E-04	U	4.05E-06	4.95E-06	2.63E-04	U	2.78E-04	5.72E-05	7.15E-04	U
Deer	SOO	05/14/2019	2.04E-04	7.04E-05	6.51E-03	NJ	4.64E-06	7.61E-06	3.42E-04	NJ	1.82E-04	6.41E-05	5.06E-03	NJ
Fish	PEC	07/18/2019	1.61E-03	2.84E-04	4.93E-03	NJ	5.11E-05	2.29E-05	6.26E-04	NJ	1.00E-03	1.84E-04	5.08E-04	NJ
Fish	BRA	09/26/2019	1.72E-03	4.30E-04	1.04E-02	NJ	7.28E-05	4.13E-05	4.12E-04	NJ	1.35E-03	3.43E-04	9.16E-03	NJ
Fish	CBD	08/01/2019	2.33E-03	6.08E-04	1.04E-02	NJ	9.99E-05	4.85E-05	4.10E-04	NJ	1.54E-03	4.10E-04	9.16E-03	NJ
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	WIP	2/20/2019	1.02E-06	4.88E-06	1.72E-04	U	1.10E-05	1.02E-05	2.10E-04	U	1.05E-06	3.95E-06	3.63E-04	U
Quail	WNN	01/21/2019	8.87E-07	2.52E-06	1.63E-04	U	8.55E-06	6.65E-06	2.59E-04	U	3.71E-06	4.85E-06	3.18E-04	U
Quail Dup	WNN dup	01/21/2019	1.87E-06	3.37E-06	1.63E-04	U	3.86E-06	4.71E-06	2.58E-04	U	1.65E-06	3.31E-06	3.18E-04	U
Deer	SOO	05/14/2019	-3.89E-07	1.26E-06	1.27E-04	U	7.38E-07	2.36E-06	2.22E-04	U	3.08E-06	4.87E-06	8.64E-04	U
Fish	PEC	07/18/2019	-9.90E-07	4.34E-06	2.80E-04	U	6.57E-07	1.32E-05	3.00E-04	U	1.19E-05	1.36E-05	8.70E-04	U
Fish	BRA	09/26/2019	-1.49E-06	4.01E-06	2.76E-04	U	4.74E-06	8.40E-06	2.97E-04	U	1.06E-05	1.35E-05	8.70E-04	U
Fish	CBD	08/01/2019	-7.02E-06	1.81E-05	3.03E-04	UJ	-7.63E-06	1.89E-05	3.24E-04	UJ	1.54E-05	1.65E-05	8.72E-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. NJ equals nuclide present at an estimated quantity. UJ equals Nuclide not detected above the reported MDC and 2 σ counting uncertainty and a quality deficiency affects the data making the reported data more uncertain.

(e) SOO = sample of opportunity.

Table 4.24 – 2019 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	WIP	02/20/2019	2.80E-01	5.34E-02	6.63E-02	1.000	+	-1.04E-03	2.22E-03	3.93E-03	0.000	U
Quail	WNN	01/21/2019	2.19E-01	1.10E-01	1.62E-01	1.000	+	2.49E-03	6.90E-03	1.13E-02	0.000	U
Quail Dup	WNN dup	01/21/2019	2.61E-01	5.43E-02	5.66E-02	1.000	+	6.62E-04	2.05E-03	3.85E-03	0.000	U
Deer	SOO	05/14/2019	6.50E-01	8.53E-02	8.87E-02	0.997	+	-2.36E-03	3.62E-03	6.21E-03	0.000	U
Fish	PEC	07/18/2019	7.22E-01	1.16E-01	1.22E-01	0.988	+	-2.65E-03	4.36E-03	7.52E-03	0.000	U
Fish	BRA	09/26/2019	4.15E-01	1.47E-01	2.21E-01	0.994	+	-1.57E-03	6.59E-03	1.21E-02	0.000	U
Fish	CBD	08/01/2019	6.09E-01	1.32E-01	1.71E-01	0.993	+	4.91E-03	7.07E-03	1.29E-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	WIP	02/20/2019	-1.79E-05	2.29E-03	4.15E-03	0.000	U	-3.51E-05	2.63E-04	1.32E-02	U	
Quail	WNN	01/21/2019	1.88E-03	7.05E-03	1.25E-02	0.000	U	6.63E-04	2.60E-04	1.54E-02	U	
Quail Dup	WNN dup	01/21/2019	2.18E-04	2.04E-03	3.69E-03	0.000	U	5.85E-04	2.35E-04	1.54E-02	U	
Deer	SOO	05/14/2019	-4.43E-04	3.16E-03	5.71E-03	0.000	U	-8.56E-05	2.71E-04	1.32E-02	U	
Fish	PEC	07/18/2019	-2.71E-03	4.36E-03	7.65E-03	0.000	U	5.38E-04	3.34E-04	1.29E-02	U	
Fish	BRA	09/26/2019	-4.63E-03	6.79E-03	1.19E-02	0.000	U	5.21E-04	4.96E-04	1.31E-02	U	
Fish	CBD	08/01/2019	3.89E-03	6.87E-03	1.20E-02	0.000	U	4.63E-04	4.61E-04	1.31E-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

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

The data in Table 4.25 show that most of the RERs for the various radionuclides were less than 1.96 (U.S. Department of Energy, 2009). Uranium-235 RER was 2.57 but uranium isotopes were not detected in the samples. The data demonstrate good precision for the combined biota sampling and analysis procedures.

Table 4.25 – 2019 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 (WNN)	$^{233/234}U$	3.25E-04	3.15E-05	2.77E-04	2.91E-05	1.12	U
	^{235}U	1.97E-05	5.55E-06	4.05E-06	2.53E-06	2.57	U
	^{238}U	2.78E-04	2.78E-05	2.78E-04	2.92E-05	0.000	U
	^{238}Pu	8.87E-07	1.28E-06	1.87E-06	1.72E-06	0.458	U
	$^{239/240}Pu$	8.55E-06	3.39E-06	3.86E-06	2.40E-06	1.13	U
	^{241}Am	3.71E-06	2.47E-06	1.65E-06	1.69E-06	0.688	U
	^{40}K	2.19E-01	5.62E-02	2.61E-01	2.77E-02	0.670	+
	^{60}Co	2.49E-03	3.52E-03	6.62E-04	1.05E-03	0.498	U
	^{137}Cs	1.88E-03	3.60E-03	2.18E-04	1.04E-03	0.444	U
	^{90}Sr	6.63E-04	1.33E-04	5.85E-04	1.20E-04	0.435	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. The CAP88-PC software uses a Gaussian Plume dispersion model, which calculates deposition rates, concentrations in food, and intake rates for people. The CAP88-PC software 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 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 vegetables, milk, and meat consumed are locally-produced. Thus, this dose calculation is a maximum potential dose resulting from WIPP facility operations, which includes doses 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 2019. 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 in the vicinity of the WIPP facility is naturally not potable due to high levels of TDS.

4.8.4.2 Potential Dose from Wild Game Ingestion

Game animals sampled during 2019 were fish, deer, 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 2019.

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 2019 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 2019

^{238}Pu	$^{239/240}Pu$	^{241}Am	^{90}Sr	$^{233/234}U$	^{238}U	^{137}Cs
1.069E-08 Ci	2.673E-08 Ci	1.725E-07 Ci	7.745E-07 Ci	3.179E-08 Ci	2.737E-08 Ci	4.426E-06 Ci
3.955E+02 Bq	9.888E+02 Bq	6.383E+03 Bq	2.866E+04 Bq	1.176E+03 Bq	1.013E+03 Bq	1.637E+05 Bq

WIPP Radiological Dose Reporting Table for 2019(e)							
Pathway	EDE to the Office MEI at 300 m ESE		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)]
	(mrem/year)	(mSv/year)		(person-rem/year)	(person-Sv/year)		(person-rem\year)
Air	3.48E-05	3.48E-07	3.48E-04	3.72E-06	3.72E-08	92,605	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 2019							
Pathway	EDE to the Resident 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)]
	(mrem/year)	(mSv/year)		(person-rem/year)	(person-Sv/year)		(person-rem\year)
Air	1.36E-06	1.36E-08	1.36E-05	3.72E-06	3.72E-08	92,605	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 2019						
Pathway	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
	(mrem/year)	(mSv/year)		(mrem/year)	(mSv/year)	
Air	4.88E-05	4.88E-07	1.95E-04	6.18E-04	6.18E-06	8.24E-04
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.

(e) This MEI is new for 2019 as a result of the Safety Significant Confinement Ventilation System Construction.

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 2019, the dose to this hypothetical receptor was estimated to be 4.88E-07 mSv/yr (4.88E-05 mrem/yr) for the whole body and 6.18E-06 mSv/yr (6.18E-04 mrem/yr) to the critical organs. 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 resident MEI in 2019 assumed to be residing 8.9 km (5.5 mi) west-northwest of the WIPP facility is calculated to be 1.36E-08 mSv/yr (1.36E-06 mrem/yr) for the whole body. This value is in compliance with 40 CFR §61.92 requirements.

For the NESHAP standard (40 CFR §61.92), the EDE potentially received by the non-WIPP worker at the Safety Significant Confinement Ventilation System construction office trailer MEI in 2019 assumed to be located 300 meters (0.2 mi) east-southeast of the WIPP facility is calculated to be 3.48E-07 mSv/yr (3.48E-05 mrem/yr) for the whole body. This value is in compliance with 40 CFR §61.92 requirements.

As required by DOE Order 458.1, Administrative Chg. 3, the collective dose to the public within 80 km (50 mi) of the WIPP facility has been evaluated and is 3.72E-08 person-Sv/yr (3.72E-06 person-rem/yr) in 2019.

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 2019 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 – 2019 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)	$^{233/234}U$	2.33E-02	IDN	2.00E+02	1.17E-04
	^{235}U	1.14E-03	TUT	1.00E+02	1.14E-05
	^{238}U	2.61E-02	IDN	9.00E+01	2.90E-04
	^{238}Pu	ND[(c)]		2.00E+02	NA[(d)]
	$^{239/240}Pu$	5.28E-04	TUT	2.00E+02	2.64E-06
	^{241}Am	ND[(c)]		2.00E+02	NA[(d)]
	^{60}Co	ND[(c)]		5.00E+01	NA[(d)]
	^{137}Cs	5.87E-03	TUT	1.00E+02	5.87E-05
	^{90}Sr	ND[(c)]		2.00E+01	NA[(d)]
Surface Water[(b)] (Bq/L)	$^{233/234}U$	9.08E-02	BRA	7.00E+00	1.30E-02
	^{235}U	3.95E-03	RED	8.00E+00	4.94E-04
	^{238}U	5.91E-02	RED	8.00E+00	7.39E-03

Medium	Radionuclide	Maximum Detected Concentration	Location	BCG[(a)]	Concentration/BCG
	^{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					2.13E-02
Terrestrial System Evaluation					
Soil (Bq/g)	$^{233/234}U$	1.88E-02	SMR (2-5 cm)	2.00E+02	9.40E-05
	^{235}U	9.64E-04	SMR (2-5 cm)	1.00E+02	9.64E-06
	^{238}U	1.90E-02	SMRR (2-5 cm)	6.00E+01	3.17E-04
	^{238}Pu	ND[(c)]		2.00E+02	NA[(d)]
	$^{239/240}Pu$	ND[(c)]		2.00E+02	NA[(d)]
	^{241}Am	ND[(c)]		1.00E+02	NA[(d)]
	^{60}Co	ND[(c)]		3.00E+01	NA[(d)]
	^{137}Cs	6.44E-03	MLR (0-2 cm)	8.00E-01	8.05E-03
	^{90}Sr	ND[(c)]		8.00E-01	NA[(d)]
Terrestrial System Evaluation					
Surface Water (Bq/L)	$^{233/234}U$	9.08E-02	BRA	7.00E+00	1.30E-02
	^{235}U	3.95E-03	RED	8.00E+00	4.94E-04
	^{238}U	5.91E-02	RED	8.00E+00	7.39E-03
	^{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					2.93E-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 2019.

4.9 Radiological Program Conclusions

4.9.1 Effluent Monitoring

For 2019, the calculated EDE to the receptor (hypothetical MEI) who resides year-round at the Exclusive Use Area fence line is 4.88E-07 mSv/yr (4.88E-05 mrem/yr) for the whole body and 6.18E-06 mSv/yr (6.18E-04 mrem/yr) for the critical organs. 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 2019. Figure 4.6, and Table 4.29 show the dose to the critical organs for the hypothetical MEI for CY 2002 to CY 2019. 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 2019, 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. Calculated dose estimates were well within the limit of 10 mrem EDE to the off-site resident MEI.

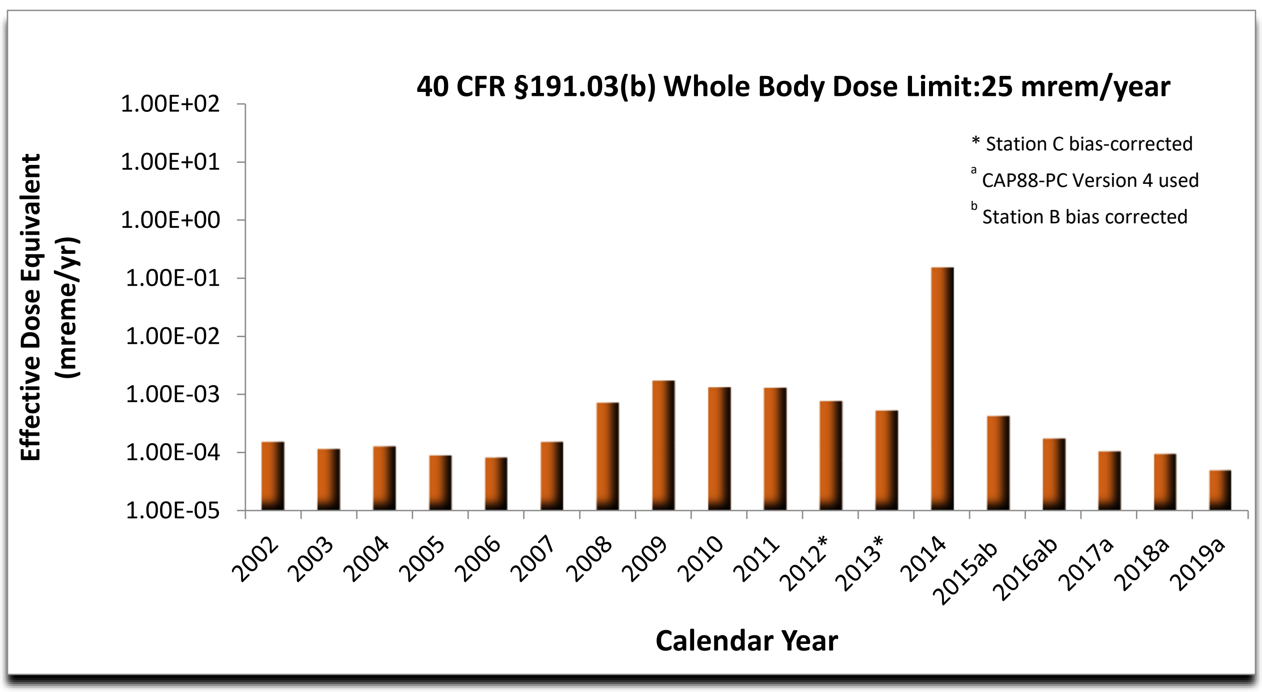

Figure 4.5 – Dose to the Whole Body for the Hypothetical Maximally Exposed Individual at the WIPP Fence Line

Table 4.28 – Comparison of Dose to the Whole Body to EPA Standard of 25 mrem/yr 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%
2018[a]	9.31E-05	0.00037%
2019[a]	4.88E-05	0.00020%
40 CFR §191.03(b) Whole Body Limit	**25**	

*Station C bias-corrected.
[a] CAP88-PC Version 4 used.
[b] Station B bias-corrected.

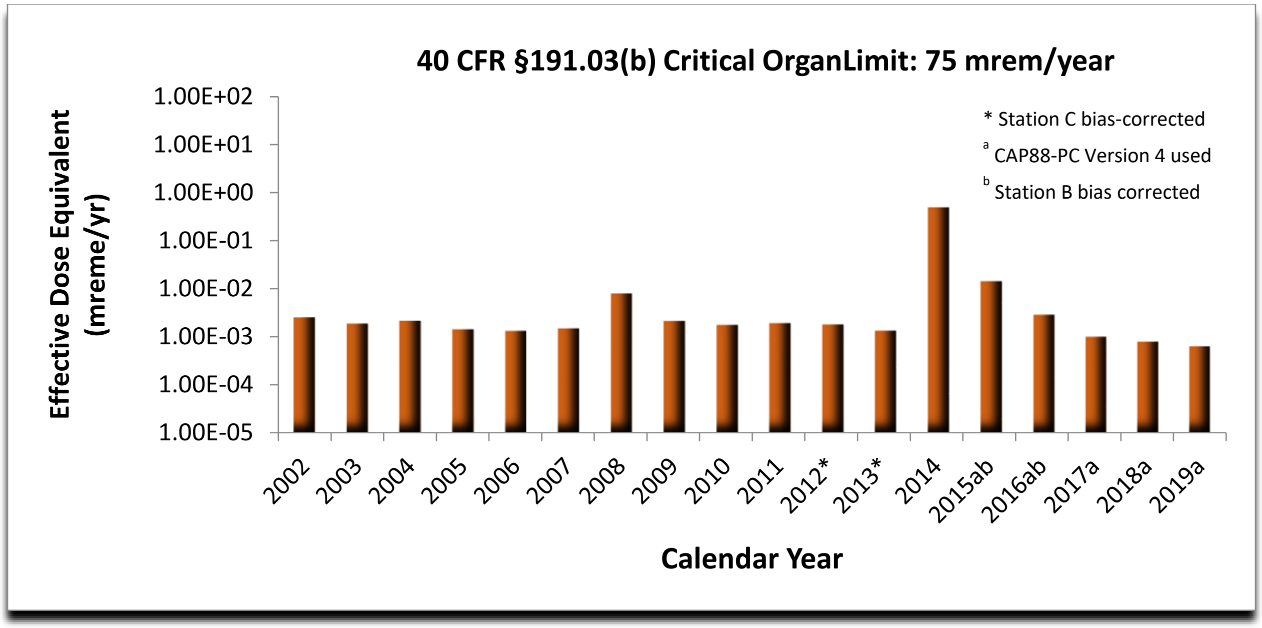

Figure 4.6 – Dose to the Critical Organ for Hypothetical Maximally Exposed Individual at the WIPP Fence Line

Table 4.29 – Comparison of Dose to the Critical Organ to EPA Standard of 75 mrem/yr 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%
2018[a]	7.82E-04	0.0010%
2019[a]	6.18E-04	0.0008%
40 CFR §191.03(b) Critical Organ Limit	75	

*Station C bias-corrected.
[a] CAP88-PC Version 4 used.

Year	Annual Dose (mrem/yr)	Percentage of EPA Standard

[b] Station B bias-corrected.

In 2019, a new MEI was added. The calculated annual EDE to the non-WIPP worker at the SSCVS construction office trailer resulting from normal operations conducted at this facility is 3.48E-07 mSv (3.48E-05 mrem) to the maximally-exposed non-resident off site individual member of the public, 0.2 mile (300 meters) east-southeast, at the nearest occupied point of the SSCVS construction site. For the WIPP Effluent Monitoring Program, Figure 4.7, and Table 4.30 show the EDE to the MEI for CY 2019. These EDE values are more than four orders of magnitude below the EPA NESHAP standard of 10 mrem per year, as specified in 40 CFR §61.92.

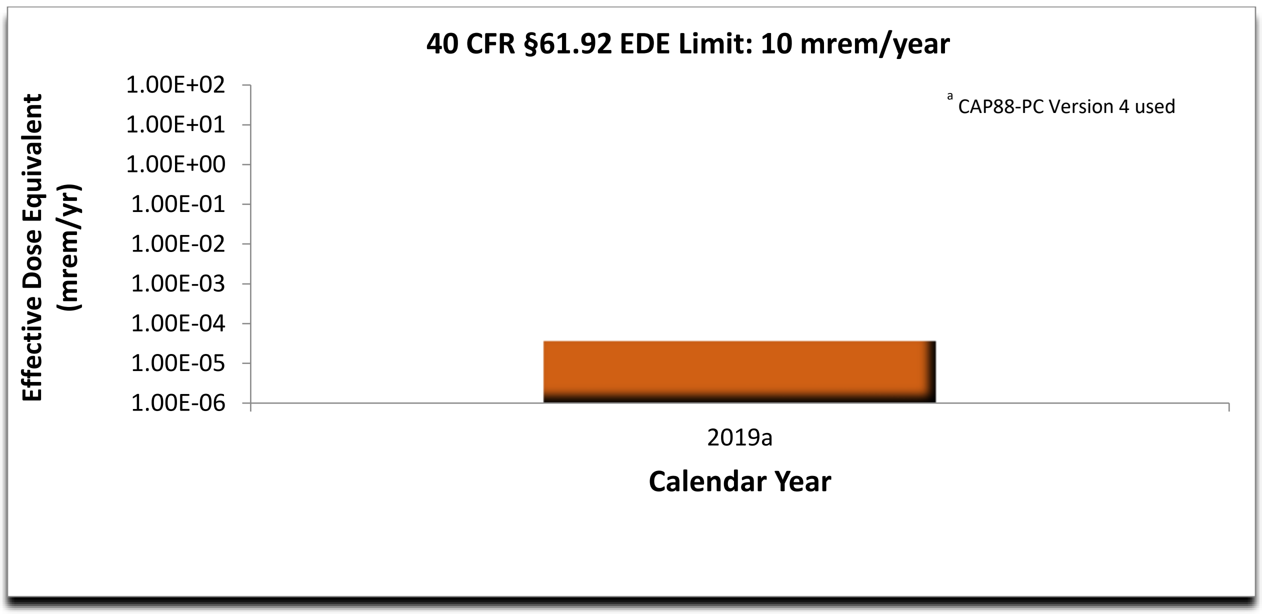

Figure 4.7 – WIPP Effective Dose Equivalent to the Off-Site Maximally Exposed Individual (i.e., a construction office trailer at the nearest occupied point of the SSCVS

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
2019[a]	3.48E-05	0.000348%
40 CFR §191.03(b) Critical Organ Limit	75	

[a] CAP88-PC Version 4 used.

For 2019, the calculated annual EDE to the off-site resident MEI from normal operations conducted at the WIPP facility is 1.36E-08 mSv (1.36E-06 mrem). For the WIPP Effluent Monitoring Program, Figure 4.8 and Table 4.31 show the EDE to the MEI for CY 2002 to CY 2019. 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.

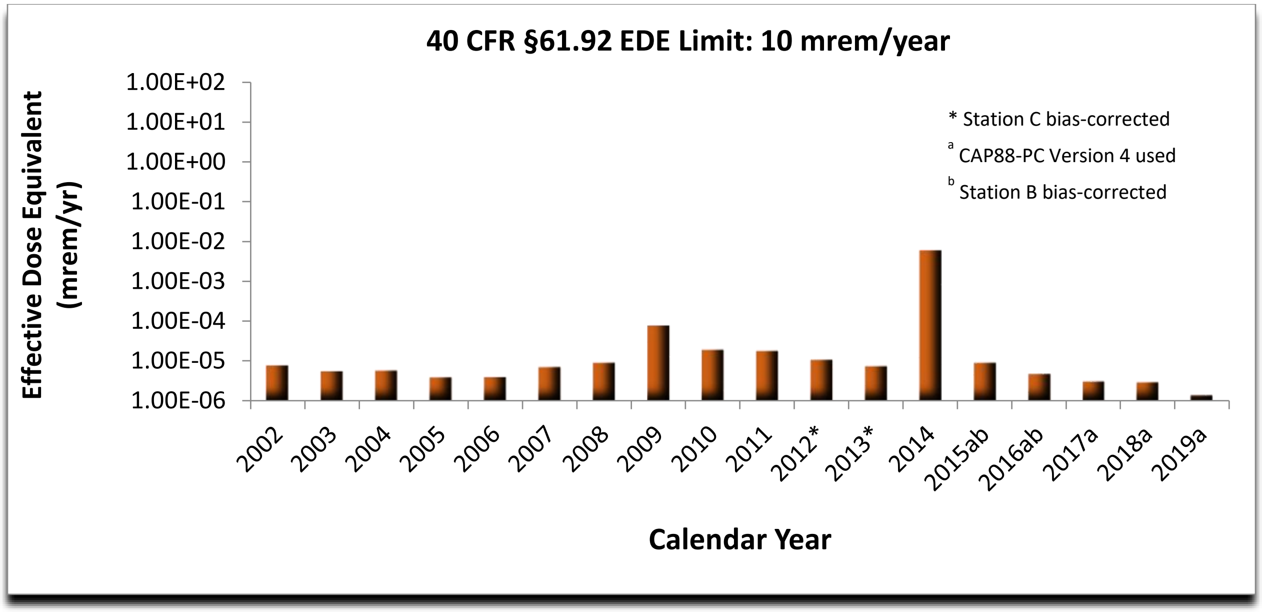

Figure 4.8 – WIPP Effective Dose Equivalent to the Off-Site Maximally Exposed Individual (i.e., individual resident member of the public)

Table 4.31 – 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%
2018[a]	2.86E-06	0.000029%
2019	1.36E-06	0.000014%
NESHAP Limit	10	

*Station C bias-corrected.
[a] CAP88-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:

- 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 H-19 pond (H-19). However, H-19 pond samples are not included in the surface water baseline. The H-19 concentration was 2.19E+02 Bq/L. ^{238}U concentration from RED (5.91E-02 Bq/L) was higher than the baseline concentration of 3.2E-02 Bq/L.
- Soil: The ^{238}U concentrations at the 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 the three depths and the sample concentrations were 1.78E-02 Bq/g, 1.90E-02 Bq/g, and 1.41E-02 Bq/g for the shallow, intermediate, and deep depths, respectively.

  The ^{40}K concentrations at the three depths at location SMR and 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 fish sample was 7.22E-01 Bq/g, which was higher than the mean baseline concentration of 6.10E-01 Bq/g.

No other groundwater, surface water, sediment, 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, 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 on 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 the 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, available to the public through the WIPP Home Page at https://www.wipp.energy.gov/library/seis/DOE-WIPP-93-004_Reprint_G_Final.pdf, 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. The 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 (Figure 1.2) 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 2019, 19 land use requests were reviewed and approved.

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. An updated list of threatened and endangered species for Eddy and Lea Counties, New Mexico was compiled from multiple sources in June 2019 and included in the LMP. This list includes federal and state listed threatened and endangered species, and species under federal review.

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.” Wildlife management objectives are detailed in the LMP.

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, noxious weeds, non-compliances)

During 2019, WIPP surveillance teams conducted monthly surveillances and field inspections.

In 2019, oil and gas industry traffic remained at a high level near the WIPP LWA and rights-of-way. Consequently, land management measures were utilized to ensure objectives were met for minimal environmental impact to WIPP properties. These measures included monitoring for illegal dumping and off-road travel. High risk areas were identified, and signs and barricades were maintained in several areas to control access. Oil and gas traffic unfortunately results in a large volume of tires and debris removed from the North and South Access Roads which requires proper disposal.

In 2019, monitoring for noxious weeds was continued on WIPP lands. A probable mode of dispersal for noxious weeds is oil and gas traffic within the WIPP LWA. Areas where noxious weeds were discovered on WIPP lands were treated and will be monitored and managed to ensure control is maintained. Noxious weed management objectives are detailed in the LMP.

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. Four new oil and gas wells were spudded during 2019 within 1.6 km (1 mi) of the WIPP LWA boundary. New wells and updates in status of existing wells are tracked by the Delaware Basin Drilling Surveillance Program.

5.3 Meteorological Monitoring

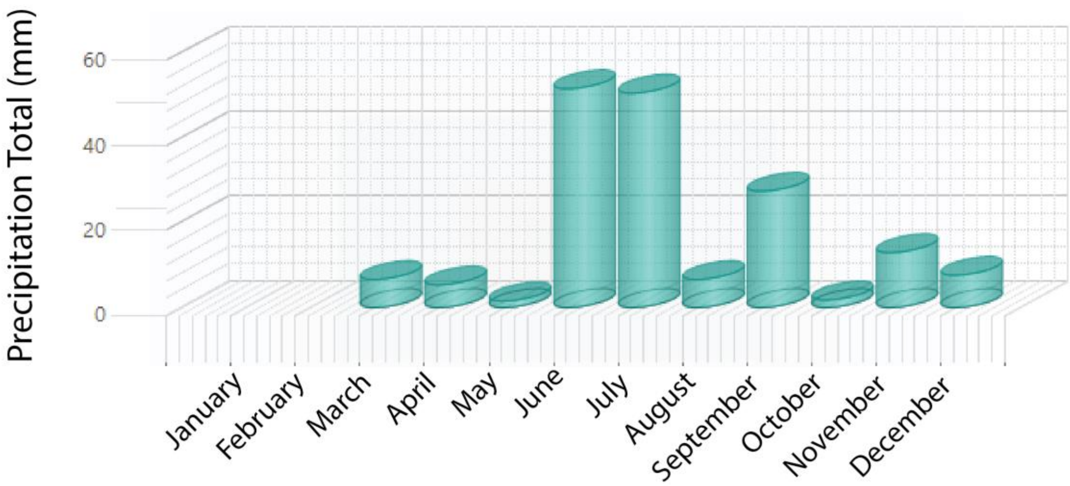
The WIPP facility meteorological station is located 600 m (1,969 ft) northeast of the WHB. The main function of the station is to provide data for atmospheric dispersion modeling. Every 15 minutes, the station records wind speed, wind direction, and temperature at elevations of 2, 10, and 50 m (6.6, 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

In September of 2018, the meteorological tower power and communication cables were severed during construction trenching for the new filter building. Due to this occurrence, for CY 2018, precipitation was populated from the meteorological tower from January to September and from a field log recording manual rain gauges from October – December; and temperature and wind data were only available from January - September. The meteorological tower power and communications have been restored for CY 2019 through the use of a generator until permanent cables can be connected.

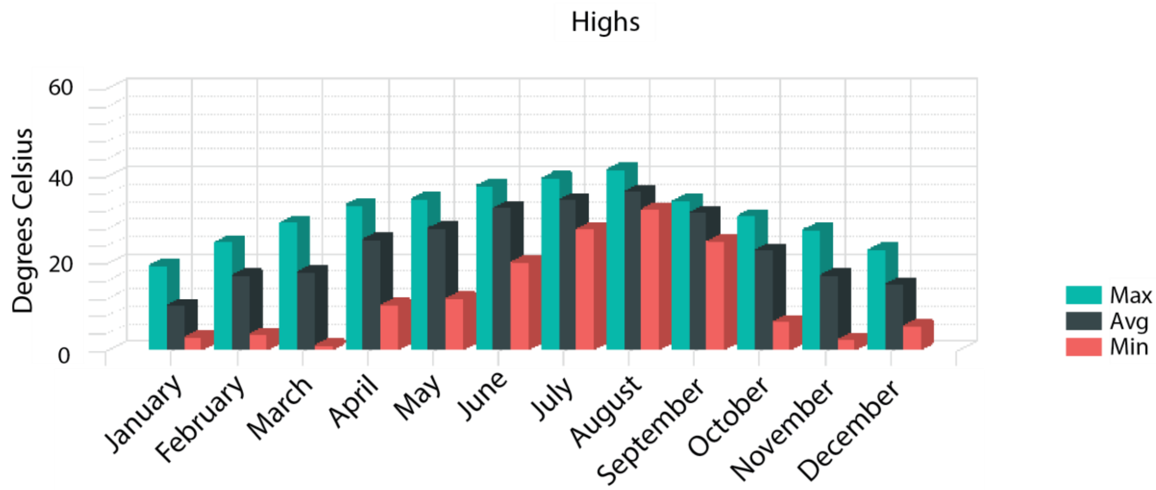
Precipitation recorded from the meteorological tower from January - December 2019 was 223.01 mm (8.78 in.) compared to 539.75 mm (21.25 in.) for 2018. The average yearly rainfall recorded at the meteorological tower since 1970 is 362.20 mm (14.26 in.). Figure 5.1 displays the monthly precipitation at the WIPP site for 2019.

The maximum recorded temperature (10-m level) at the WIPP site in 2019 was 41.26°C (106.27°F) in August, whereas the lowest temperature recorded was -7.45°C (18.59°F) in March. Monthly temperatures are illustrated in Figures 5.2, 5.3, and 5.4. The average temperature at the WIPP site in 2019 was 17.91°C (64.24°F), which is 1.46°C cooler than the 2018 average of 19.37°C (66.87°F). The average monthly temperatures for the WIPP area ranged from 29.94°C (85.89°F) during August to 5.66°C (42.19°F) in January (Figure 5.3).



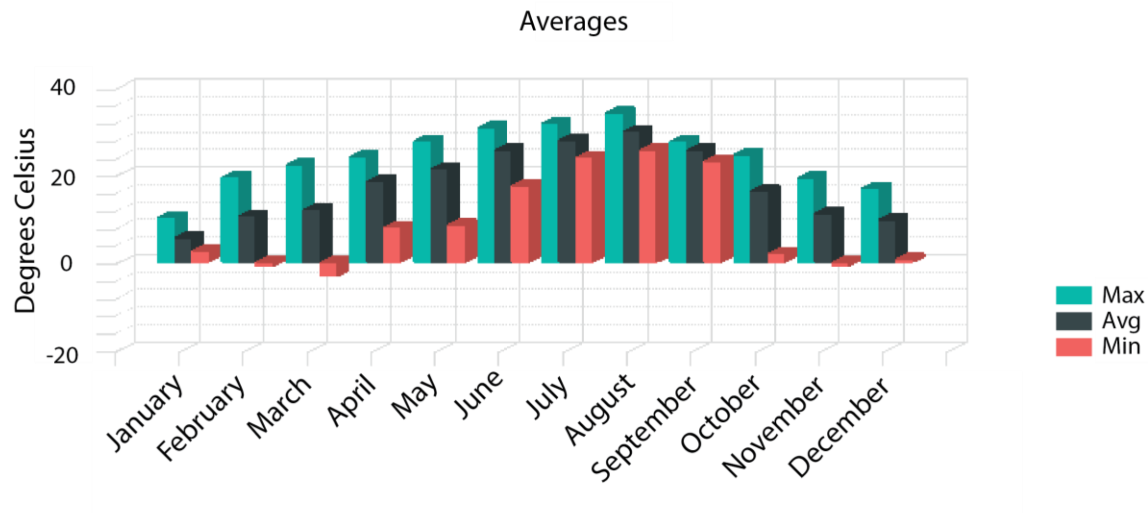
Month	Total (mm)
January	0
February	0
March	6.604
April	5.334
May	1.524
June	51.562
July	50.544
August	6.604
September	27.436
October	1.778
November	12.954
December	7.62

Figure 5.1 – WIPP Site Precipitation Report for 2019



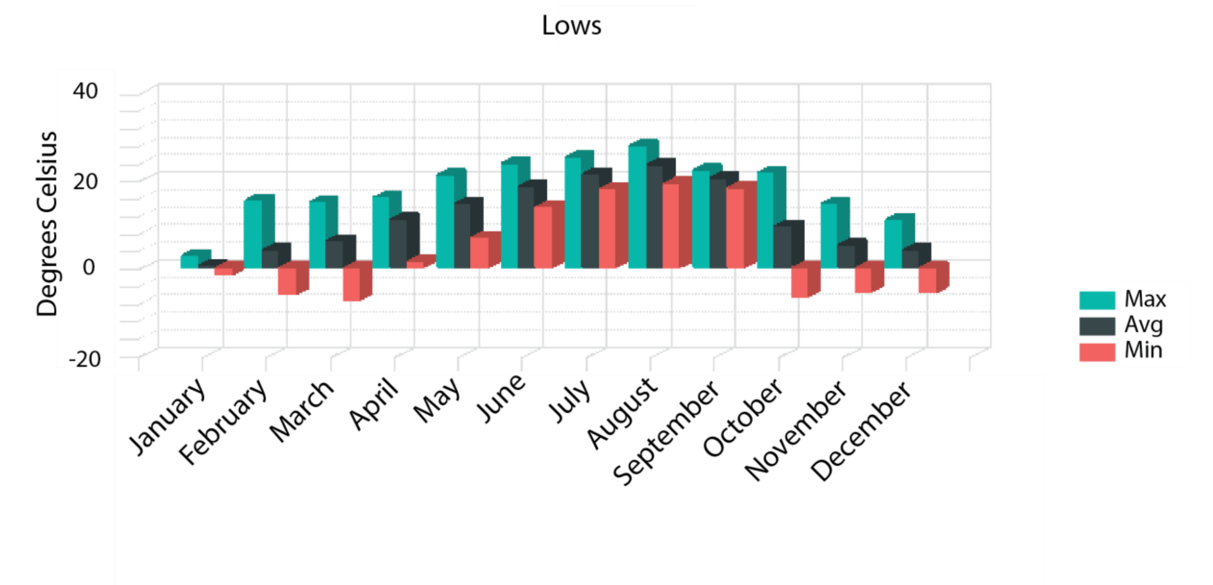
Month	Maximum High	Average High	Minimum High
January	19.30	10.17	2.74
February	24.60	16.94	3.45
March	29.10	17.80	0.91
April	33.06	25.21	10.19
May	34.51	27.80	11.67
June	37.57	32.41	20.04
July	39.27	34.38	27.58
August	41.26	36.23	32.11
September	34.08	31.40	24.81
October	30.60	22.75	6.41
November	27.43	17.09	2.27
December	22.91	15.00	5.33

Figure 5.2 – WIPP Site High Temperatures (ºC) for 2019



Month	Maximum Average	Average Average	Minimum Average
January	10.32	5.66	2.64
February	19.46	10.69	-1.02
March	22.29	12.01	-3.24
April	24.22	18.57	8.04
May	27.75	21.36	8.55
June	30.87	25.75	17.49
July	31.81	27.97	23.99
August	34.26	29.94	25.68
September	27.67	25.71	23.11
October	24.61	16.40	1.98
November	19.37	11.16	-0.94
December	16.97	9.72	0.69

Figure 5.3 – WIPP Site Average Temperatures (ºC) for 2019

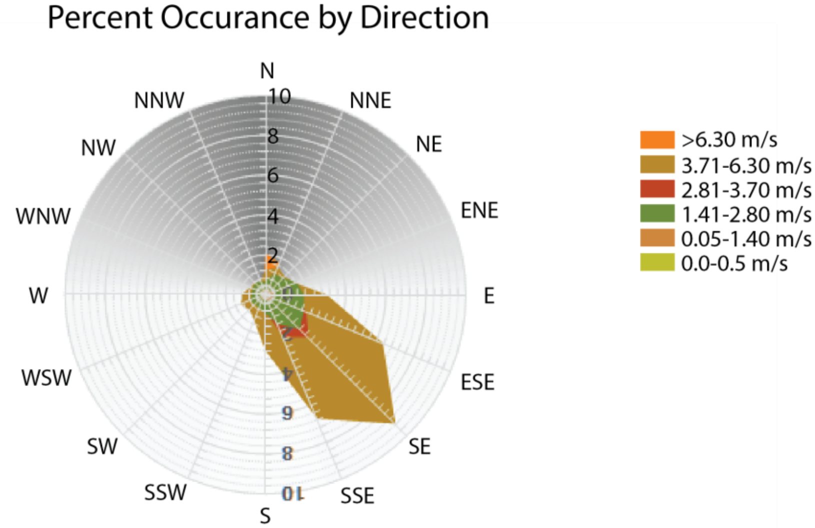


Month	Maximum Low	Average Low	Minimum Low
January	2.74	0.53	-1.71
February	15.49	4.00	-6.19
March	15.02	6.13	-7.45
April	16.10	11.10	1.45
May	21.19	14.72	6.96
June	23.83	18.56	13.87
July	25.22	21.40	18.04
August	27.91	23.49	19.27
September	22.29	20.55	18.31
October	21.74	9.53	-6.64
November	14.66	5.16	-5.53
December	10.95	4.10	-5.79

Figure 5.4 – WIPP Site Low Temperatures (ºC) for 2019

5.3.2 Wind Direction and Wind Speed

Winds in the WIPP area are predominantly from the southeast. In 2019, winds of 3.71 to 6.30 meters per second (8.30 to 14.09 miles per hour) were the most prevalent, occurring approximately 41.08 percent of the time (measured at the 10-m level). There were no tornadoes at the WIPP site in 2019. Figure 5.5 displays the annual wind data at the WIPP site for 2019.



Wind Speeds in meters per second

Wind Direction	0.0 - 0.50	0.50 - 1.40	1.41 - 2.80	2.81 - 3.70	3.71 - 6.30	>6.30	Total Percent Occurrence by Direction
E	0.02	0.29	0.95	0.85	2.81	1.28	**6.20**
ENE	0.02	0.22	0.77	0.59	1.44	1.10	**4.15**
NE	0.01	0.24	0.71	0.67	1.11	1.00	**3.75**
NNE	0.02	0.23	0.83	0.77	1.32	0.70	**3.87**
N	0.02	0.20	0.68	0.65	1.20	0.33	**3.07**
NNW	0.01	0.15	0.69	0.52	0.85	0.16	**2.38**
NW	0.02	0.19	0.78	0.62	0.81	0.17	**2.59**
WNW	0.02	0.26	0.71	0.53	0.66	0.31	**2.49**
W	0.01	0.24	0.67	0.53	1.21	2.07	**4.74**
WSW	0.01	0.22	1.13	0.71	1.53	1.74	**5.34**
SW	0.01	0.28	1.19	0.85	1.32	0.78	**4.42**
SSW	0.01	0.37	1.66	0.98	1.54	0.53	**5.08**
S	0.02	0.41	1.92	1.52	3.04	0.57	**7.48**
SSE	0.02	0.40	2.07	2.20	6.33	2.37	**13.38**
SE	0.02	0.40	2.45	3.03	9.16	3.63	**18.69**
ESE	0.02	0.31	1.62	2.30	6.75	1.37	**12.36**
	0.23%	*4.41%*	*18.83%*	*17.33%*	*41.08%*	*18.11%*	*100.00%*

Note: Group 1

Figure 5.5 – WIPP Site Wind Speed (at 10-Meter Level) Report for 2019

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 members of the public living outside the WIPP site boundary and 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 a background sampling station, VOC-D, located at groundwater pad WQSP-4. 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, 210 samples were collected from Stations VOC-C and VOC-D along with 28 field duplicate samples. Repository VOC monitoring results indicate that risk to members of the public living outside the WIPP site boundary and the non-waste surface workers continues to be below action levels. Repository VOC monitoring data were reported in the *Semi-annual VOC, and Monitoring Data Summary Reports*. Summary results for the period January 1, 2019, through December 31, 2019, 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	527	10/29/2019
Chlorobenzene	0	N/A
Chloroform	0	N/A
1,1-Dichloroethylene	0	N/A
1,2-Dichloroethane	0	N/A
Methylene Chloride	105	10/23/2019
1,1,2,2-Tetrachloroethane	0	N/A
Toluene	410	10/16/2019
1,1,1-Trichloroethane	152	10/29/2019
Trichloroethylene	191	10/29/2019

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	1.52E-07 (7/9/2019)	8.29E-03 (7/9/2019)
Maximum Result	7.55E-07 (10/29/2019)	1.20E-01 (10/29/2019)

Average and maximum results include samples for the current reporting period.

Cancer risk action level is 1E-05 for non-waste surface workers and 10^{-6} for members of the public living outside the WIPP site boundary.

Hazard index action level is 1.

With regard to the Disposal Room VOC monitoring system, for this reporting period, 167 samples were collected from disposal rooms along with 12 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	256.67	P7R6E	4,813	9,145	9,625	0
Chlorobenzene	0.04 J	P7R6E	6,500	12,350	13,000	0
Chloroform	6.23 J	P7R6E	4,965	9,433	9,930	0
1,1-Dichloroethylene	ND	N/A	2,745	5,215	5,490	0
1,2-Dichloroethane	ND	N/A	1,200	2,280	2,400	0
Methylene Chloride	0.35 J	P7R6E	50,000	95,000	100,000	0
1,1,2,2-Tetrachloroethane	0.09 J	P7R6E	1,480	2,812	2,960	0
Toluene	0.17 J	P7R6E	5,500	10,450	11,000	0
1,1,1-Trichloroethane	88.22	P7R6E	16,850	32,015	33,700	0
Trichloroethylene	63.84	P7R6E	24,000	45,600	48,000	0

N/A = Not applicable

ND = Non-Detect

ppmv = parts per million by volume

J = Estimated value

The VOC sampling reported in this section is based on 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 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 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 5.7). 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. Due to a significant expansion of the Texas seismic monitoring network (TexNet) in west Texas, this network is also used to provide data for event location and analysis.

The mean operational efficiency of the WIPP seismic monitoring stations during 2019 was approximately 94 percent. From January 1, through December 31, 2019, locations for 4,841 seismic events were recorded within 300 km (186 mi) of the WIPP site. Recorded data included origin times, epicenter coordinates, and magnitudes. The strongest recorded event (magnitude 2.98) occurred on September 30, 2019; this event was approximately 277 km (172 mi) east of the site. The closest earthquake to the site was approximately 8 km (5 mi) northeast and had a magnitude of 1.23.

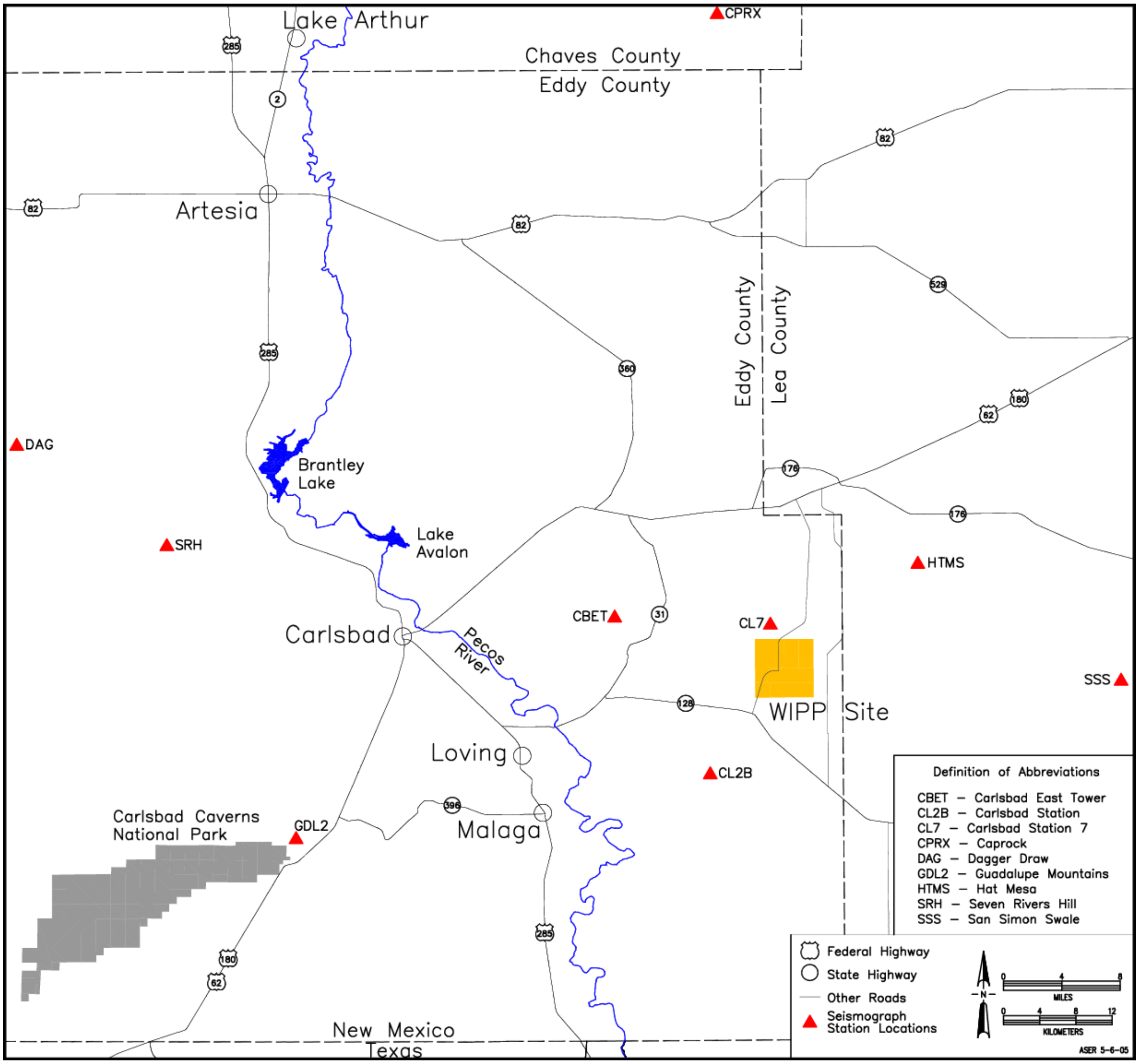


Figure 5.6 – Seismograph Station Locations in the Vicinity of the WIPP Site

5.6 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 5 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. A renewal of the DP is pending before the NMED.

Table 5.2 – Sewage Lagoon and H-19 Analytical Results for Spring 2019

Analyte	Settling Lagoon 2[(a)]	Evaporation Pond B	Evaporation Pond C	H–19 Evaporation Pond
Nitrate (mg/L)	ND	N/A	N/A	N/A
TKN (mg/L)	150	N/A	N/A	N/A
TDS (mg/L)	590	N/A	N/A	N/A
Sulfate (mg/L)	57	N/A	N/A	N/A
Chloride (mg/L)	126	N/A	N/A	N/A

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 2019

Location	Nitrate (mg/L)	TKN (mg/L)	TDS (mg/L)	Sulfate (mg/L)	Chloride (mg/L)
Settling Lagoon 2	ND	170	760	46.3	124
Effluent Lagoon B	N/A	N/A	571,000	32,900	187,000
Effluent Lagoon C	N/A	N/A	500,000	118,000	324,000
Evaporation Pond H-19	N/A	N/A	121,000	3,110	58,000
Salt Storage Pond 1	N/A	N/A	243,000	2,000	138,000
Salt Storage Pond 2	N/A	N/A	331,000	7,580	182,000
Salt Storage Pond 3	N/A	N/A	395,000	40,900	199,000
Storm Water Pond 1	N/A	N/A	858	46.3	301
Storm Water Pond 2	N/A	N/A	391	8.5	125
Storm Water Pond 3	N/A	N/A	844	94.7	278

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

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.

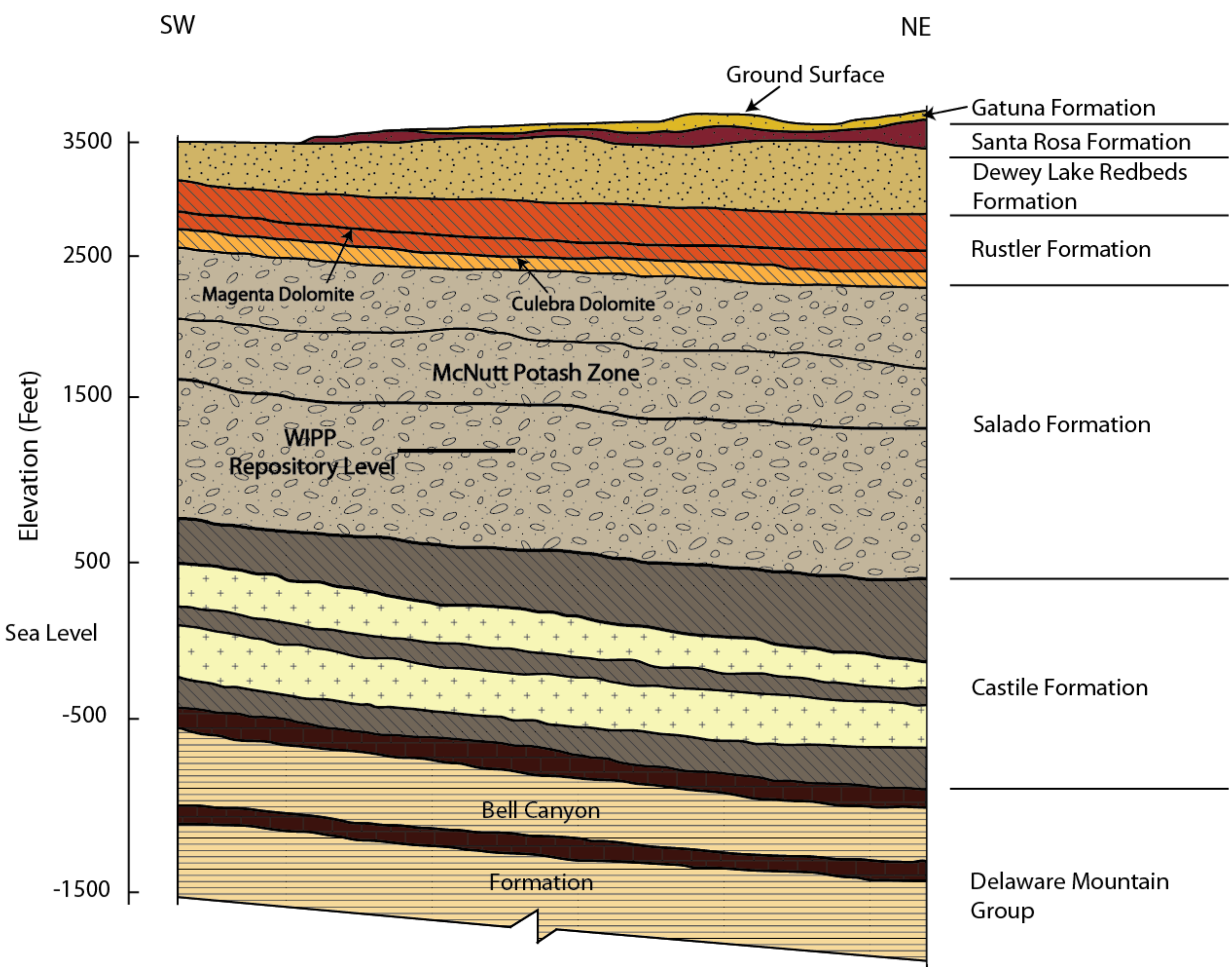


Figure 6.1 – WIPP Stratigraphy

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 of the 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) (1.08E-22 to 3.23E-15 square feet [ft^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 (2.15E-19 to 9.67E-18 ft^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 WIPP 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 7.6 m (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 m^2 per day (m^2/d) to approximately 112 m^2/d (1.29E-07 ft^2 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.

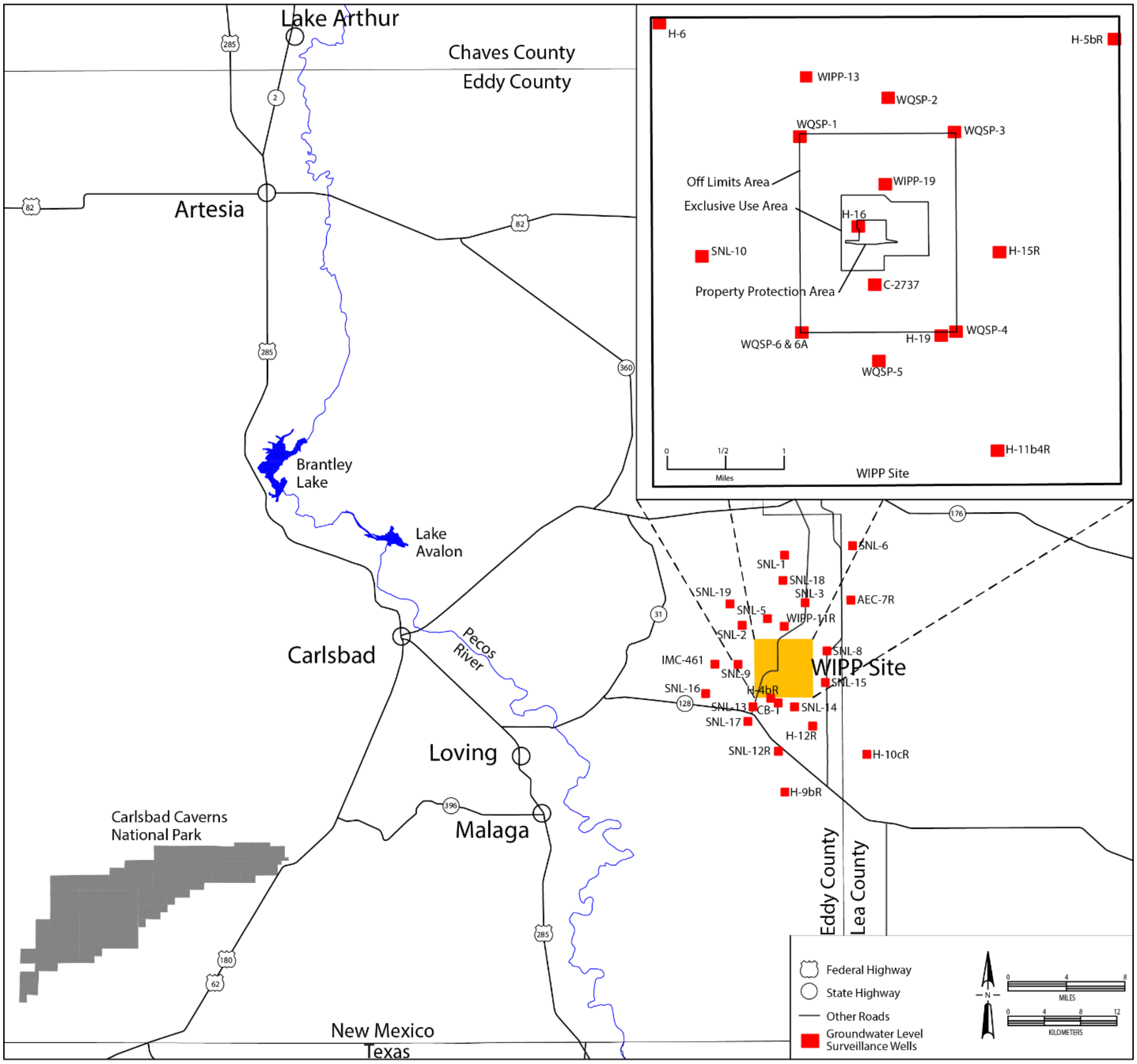


Figure 6.2 – Groundwater Level Surveillance Well Pads (Inset Represents the Groundwater Surveillance Wells in the WIPP Land Withdrawal Area)

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 5-year compliance recertification applications.

Baseline water chemistry data in the 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 2019 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 2019 included hydraulic testing and non-Permit groundwater quality sampling (Section 6.4). Table 6.1 presents a summary of WIPP groundwater monitoring activities in 2019.

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 2019.

Radiological data for 2019 from the DMP are summarized in Chapter 4. The remaining data from the DMP are contained in this chapter.

Table 6.1 – Summary of 2019 DOE WIPP Groundwater Monitoring Program

Number of Active Wells at CY End	84
Number of Analyses	268[(a)]
Number of Water Level Measurements	802
Total Number of Analyte Measurements	1,300[(b)]

Notes:

(a) Includes primary, duplicate, and blank samples taken from six wells in 2019.

(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, and 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 41 for 2019). 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 268 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.

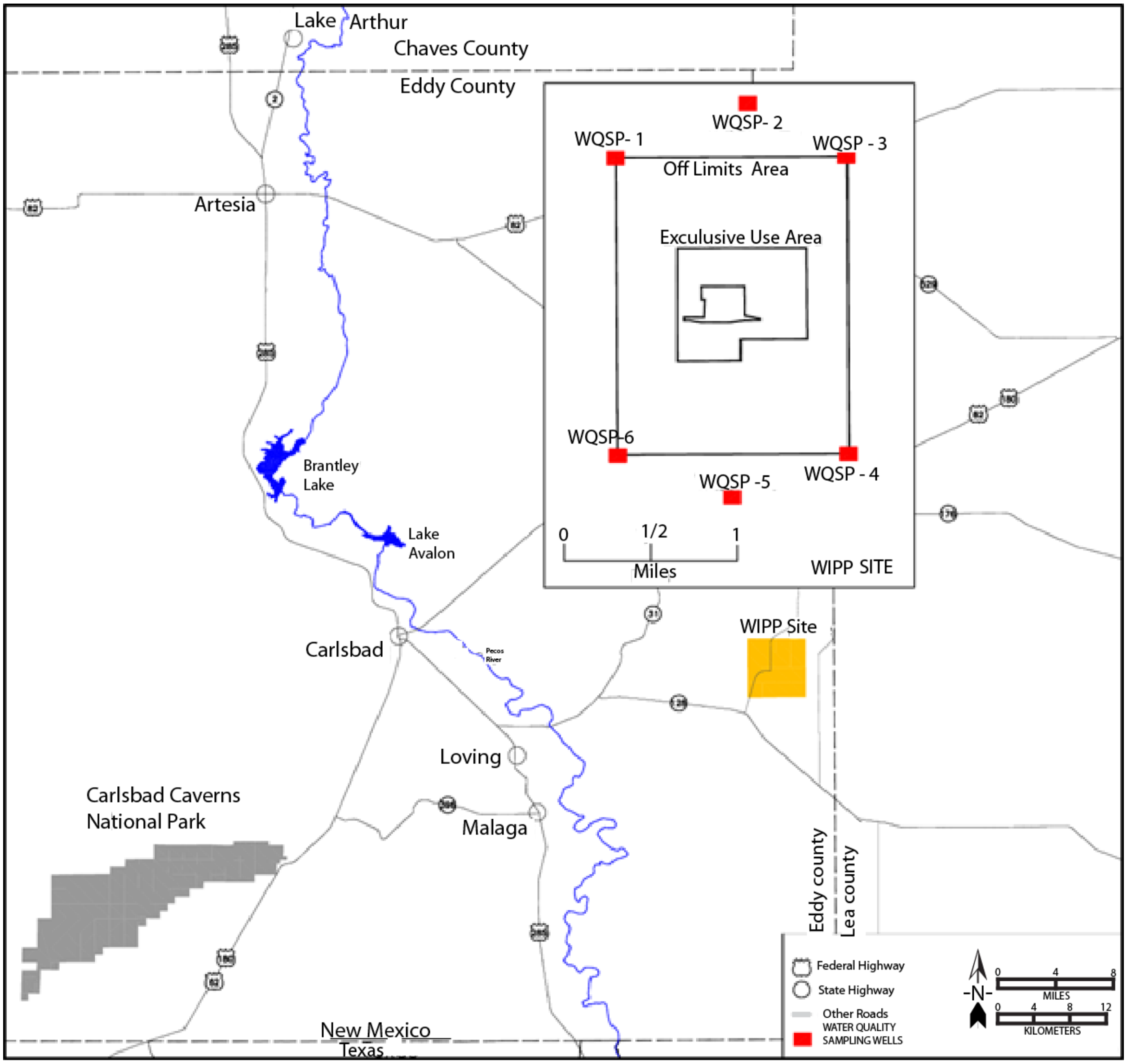


Figure 6.3 – Detection Monitoring Program Wells

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 2019 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):	**General Chemistry:**	**Trace Metals:**
Isobutanol	Density (measured as specific gravity)	Antimony (Sb)
Carbon tetrachloride	pH	Arsenic (As)
Chlorobenzene	Specific conductance	Barium (Ba)
Chloroform	TOC (total organic carbon)	Beryllium (Be)
1,1-Dichloroethane	TDS	Cadmium (Cd)
1,2-Dichloroethane	TSS (total suspended solids)	Chromium (Cr)
1,1-Dichloroethylene		Lead (Pb)
Trans-1,2-Dichloroethylene	**Major Cations:**	Mercury (Hg)
Methyl ethyl ketone	Calcium (Ca^{++})	Nickel (Ni)
Methylene chloride	Magnesium (Mg^{++})	Selenium (Se)
1,1,2,2-Tetrachloroethane	Potassium (K^{+})	Silver (Ag)
Tetrachloroethylene		Thallium (Tl)
1,1,1-Trichloroethane	**Major Anions:**	Vanadium (V)
1,1,2-Trichloroethane	Chloride (Cl^{-})	
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		

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 2019, TDS concentrations in the Culebra (as measured in detection monitoring wells) varied from a low of 15,600 mg/L (WQSP-6 Dup) to a high of 226,000 mg/L (WQSP-3 Primary). 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 2019, the TDS concentrations (see Table 6.5 later in this chapter) in water from well WQSP-6A, obtained from the Dewey Lake, averaged 3,340 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 2019 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 2019 (Round 41) 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) (Table F.1, Appendix F) for the contract laboratory. These values were recomputed after the baseline sampling was completed in 2000 and were applied to sampling Round 41 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 41, including those of the major cations, were all below the concentrations from the baseline studies with the following exceptions:

- WQSP-2: The TSS concentration of 43 mg/L in the duplicate sample was equal to the 95th percentile of 43 mg/L.

- WQSP-3: The TSS concentrations of 162 mg/L in the primary groundwater sample and 203 mg/L in the duplicate sample were higher than the 95th percentile concentration of 107 mg/L.
- WQSP-4: The TSS concentration of 49 mg/L in the primary groundwater sample while the duplicate sample was 73 mg/L, which was higher than the 95th percentile concentration of 57 mg/L.
- WQSP-5: The TSS concentrations of 12 mg/L in the primary groundwater sample and 9 mg/L in the duplicate sample were higher than the 95th percentile concentration of <10 mg/L.
- WQSP-6: The Specific Conductance of 29,000 µmhos/cm in the primary and duplicate groundwater sample were higher than the 95th percentile concentration of 27,600 µmhos/cm.

The Round 41 VOC concentrations reported for man-made organic compounds were less than the Permit background values and less than the MRL in groundwater samples. Water quality data for Round 41 can be found in the *Annual Culebra Groundwater* Report (U.S. Department of Energy, November 2019).

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 2019, 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 2019 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 24 naturally changing wells. The subset of wells analyzed were those that had a sufficient period of record to analyze through CY 2019 (Appendix F, Table F.3). Additional filtering of the water level data could not be performed to remove wells affected by unnatural fluctuations for 2019 due to the vast majority of wells being impacted by a halt in 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 2019 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 higher than average precipitation over the last 5 years. The highest amount of rainfall was 796.29 mm (31.35 in) in 2016, while the lowest was 223.01 mm (8.78 in) in 2019. Water level fell in 19 of the 24 naturally occurring water level changes, which averaged -560.83 mm (-1.84 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 2019, none of the WQSP wells experienced water level increases greater than 2 feet. Hydrographs for the Culebra groundwater wells are included in the *Annual Culebra Groundwater Report* (U.S. Department of Energy, November 2019).

For the Culebra wells in the vicinity of the WIPP site, equivalent freshwater heads for August 2019 were used to calibrate a groundwater flow model, which was used by 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 2019 Potentiometric Surface Calibration, Culebra Hydraulic Unit

Well I.D.	Date Measured	Adjusted Freshwater Head (feet, amsl)	Specific Gravity	Notes
C-2737 (PIP)	08/12/19	3008.22	1.024	
ERDA-9	08/12/19	3024.10	1.075	

H-02b2	08/07/19	3036.86	1.013	
H-04bR	08/06/19	2998.39	1.018	
H-05b	08/06/19	3079.67	1.102	
H-06bR	08/06/19	3064.23	1.035	
H-07b1	08/05/19	2994.70	1.011	
H-09bR	08/05/19	2984.32	1.005	
H-10cR	08/06/19	3013.85	1.081	
H-11b4R	08/07/19	2997.57	1.078	
H-12R	08/06/19	3002.85	1.110	
H-15R	08/12/19	3007.46	1.121	
H-16	08/12/19	3039.56	1.033	
H-17	08/07/19	2997.03	1.132	
H-19b0	08/07/19	3001.93	1.067	
I-461	08/05/19	3037.46	1.002	
SNL-01	08/05/19	3077.24	1.031	
SNL-02	08/05/19	3064.09	1.008	
SNL-03	08/06/19	3074.48	1.028	
SNL-05	08/05/19	3066.49	1.007	
SNL-06	08/06/19	3419.32	1.248	Excluded from mapping, long term recovery
SNL-08	08/06/19	3059.64	1.106	
SNL-09	08/07/19	3048.63	1.017	
SNL-10	08/06/19	3048.68	1.011	
SNL-12	08/05/19	2995.73	1.015	
SNL-13	08/06/19	2999.47	1.022	
SNL-14	08/07/19	2995.42	1.047	
SNL-15	08/06/19	3090.87	1.227	Excluded from mapping, long term recovery
SNL-16	08/05/19	3008.66	1.016	
SNL-17	08/05/19	3001.57	1.009	
SNL-18	08/05/19	3069.15	1.013	
SNL-19	08/05/19	3064.60	1.006	
WIPP-11	08/06/19	3076.40	1.039	
WIPP-13	08/07/19	3071.27	1.034	
WIPP-19	08/12/19	3059.31	1.059	
WQSP-1	08/07/19	3070.36	1.049	
WQSP-2	08/05/19	3076.81	1.047	
WQSP-3	08/05/19	3065.78	1.146	
WQSP-4	08/07/19	3003.21	1.077	
WQSP-5	08/07/19	3000.42	1.030	

WQSP-6	08/07/19	3012.77	1.016	

Modeled freshwater head contours for August 2019 for the model domain are shown in Figure 6.4 (Hayes, 2020). 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 August 2019 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 August 2019 were computed using 2018 densities.

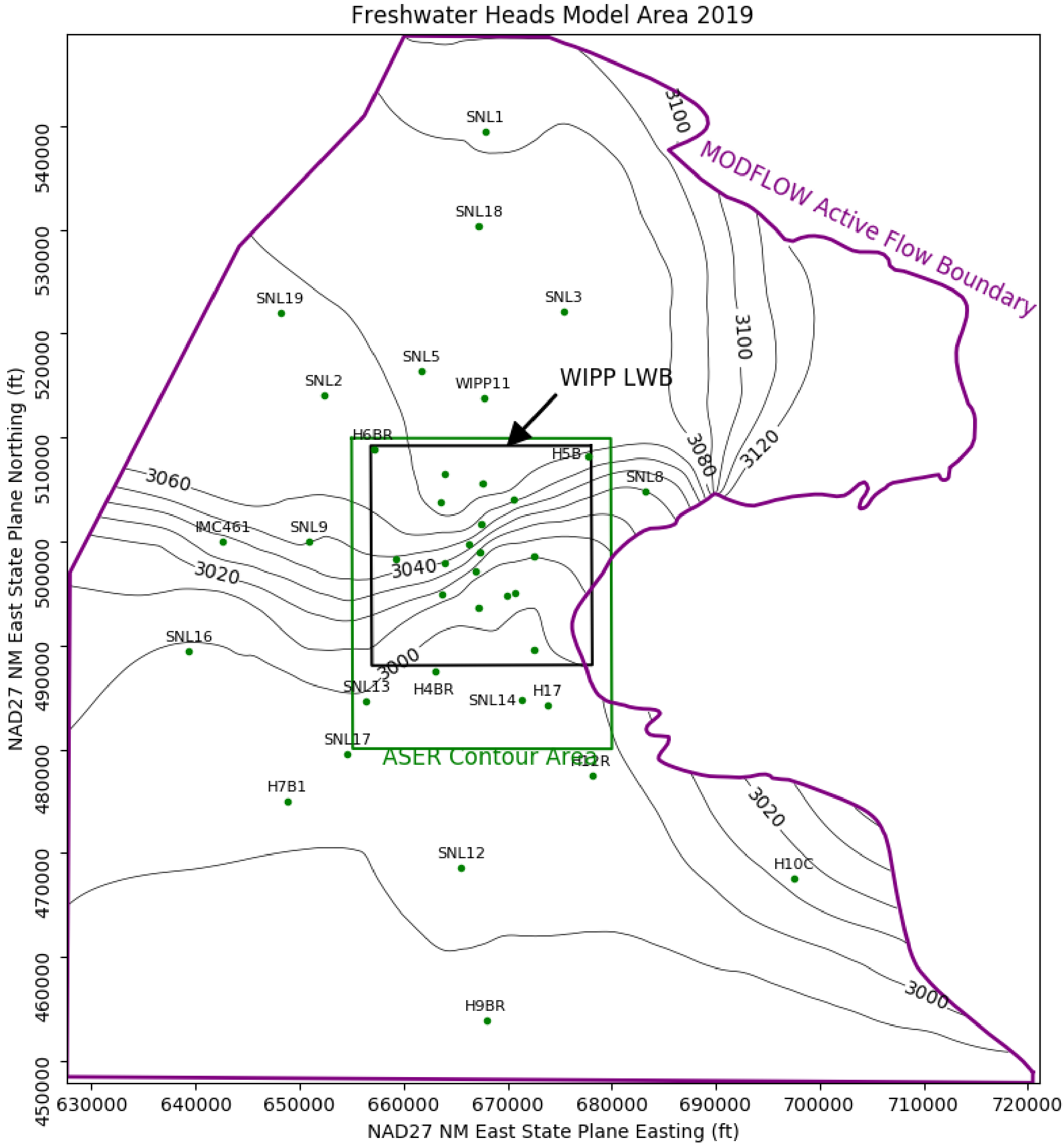


Figure 6.4 – Model-Generated August 2019 Freshwater Head Contours in the Model Domain (Contour in Feet Above Mean Sea Level)

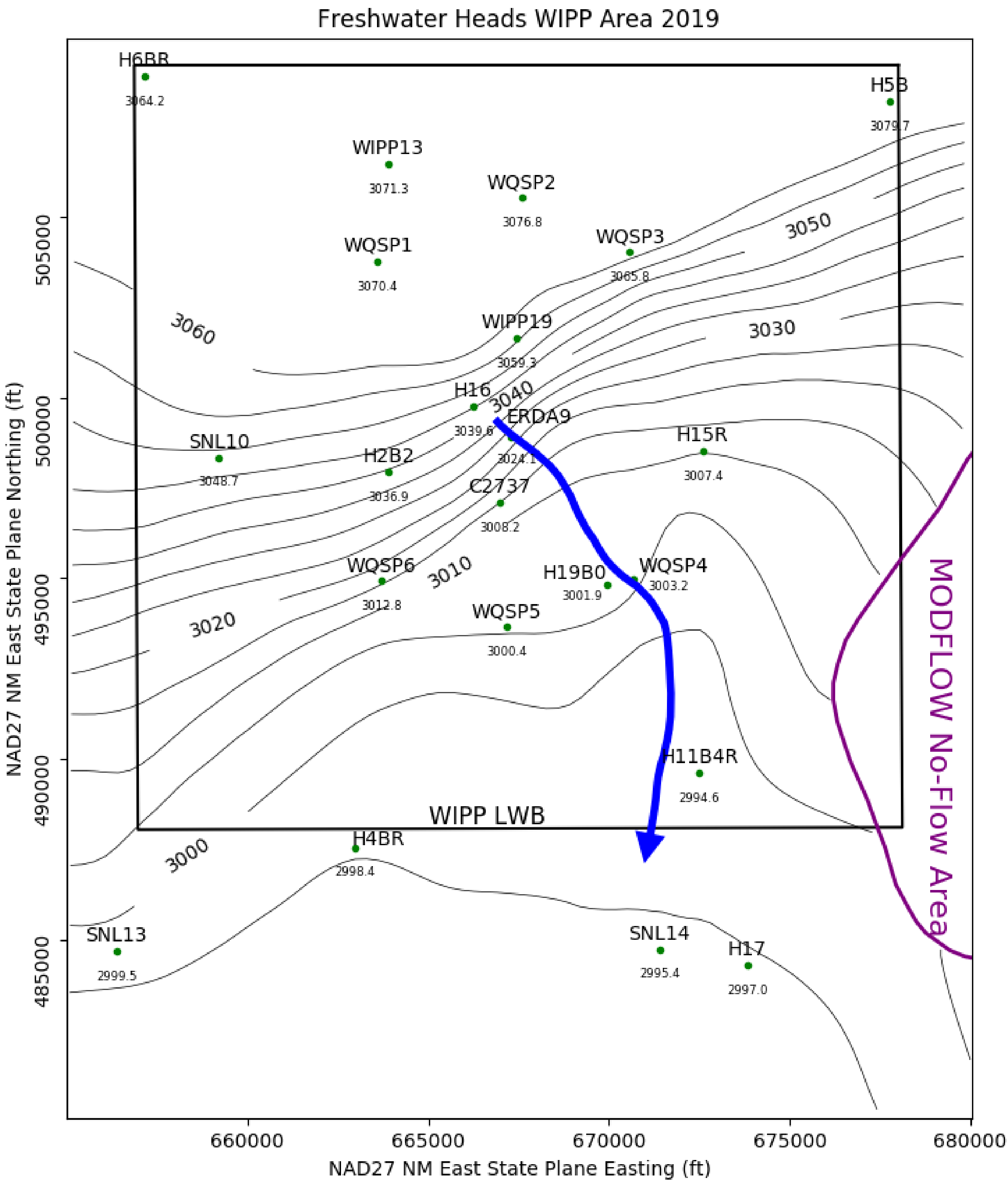


Figure 6.5 – Model-Generated August 2019 Freshwater Head Contours (5-ft Contour Interval) in the WIPP Vicinity with Water Particle Track (Dark Blue) from Waste-Handling Shaft to WIPP Land Withdrawal Boundary (Contour in Feet Above Mean Sea Level)

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, 2020). The difference between observed and modeled freshwater head within the LWB can be as large as 7.0 ft, particularly in the vicinity of WQSP-5.

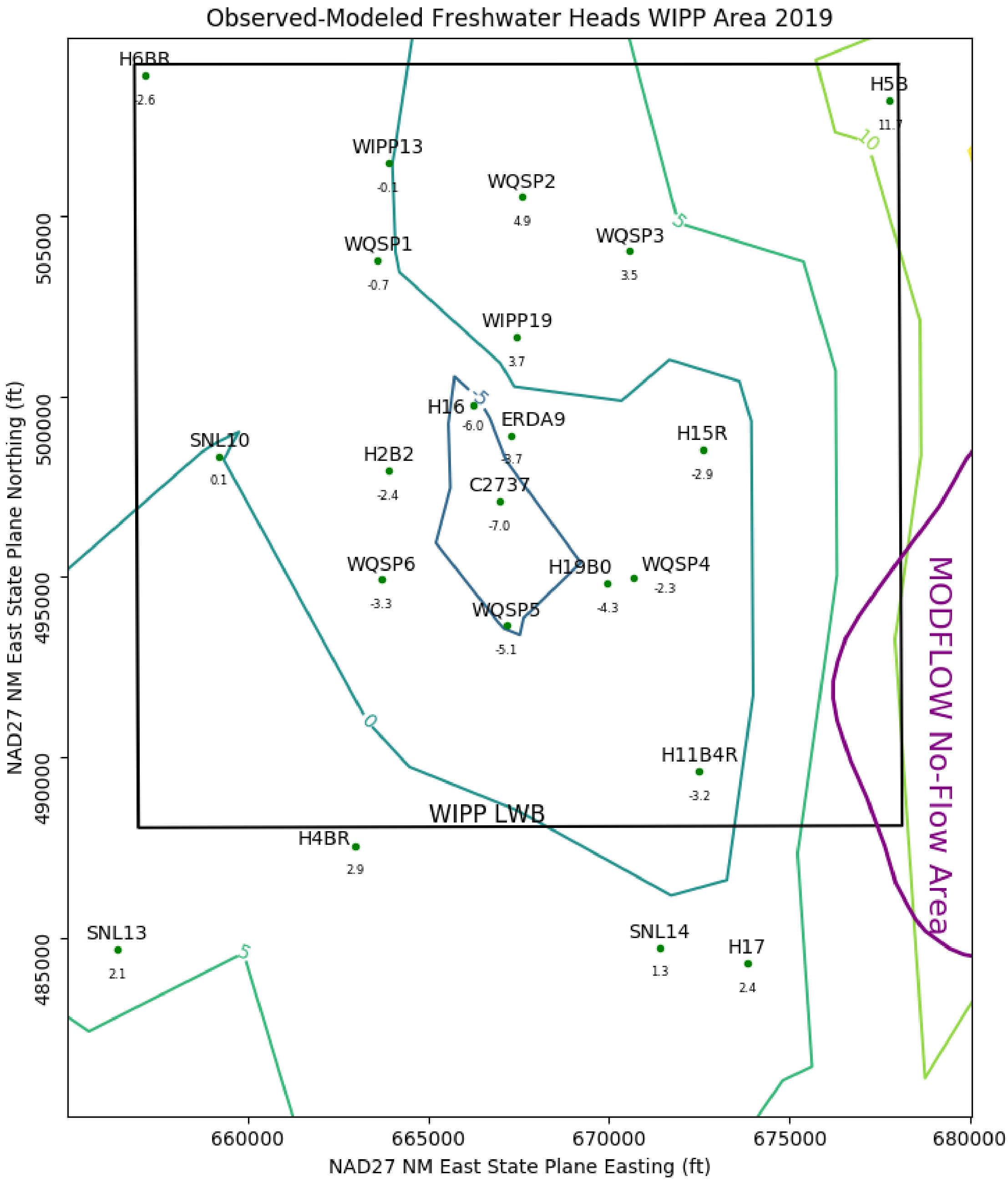


Figure 6.6 – Triangulated Contours (in 5-ft intervals) for Measured Minus Modeled Freshwater Head

The scatter plot in Figure 6.7 shows measured and modeled freshwater heads at the observation locations used in the PEST 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.

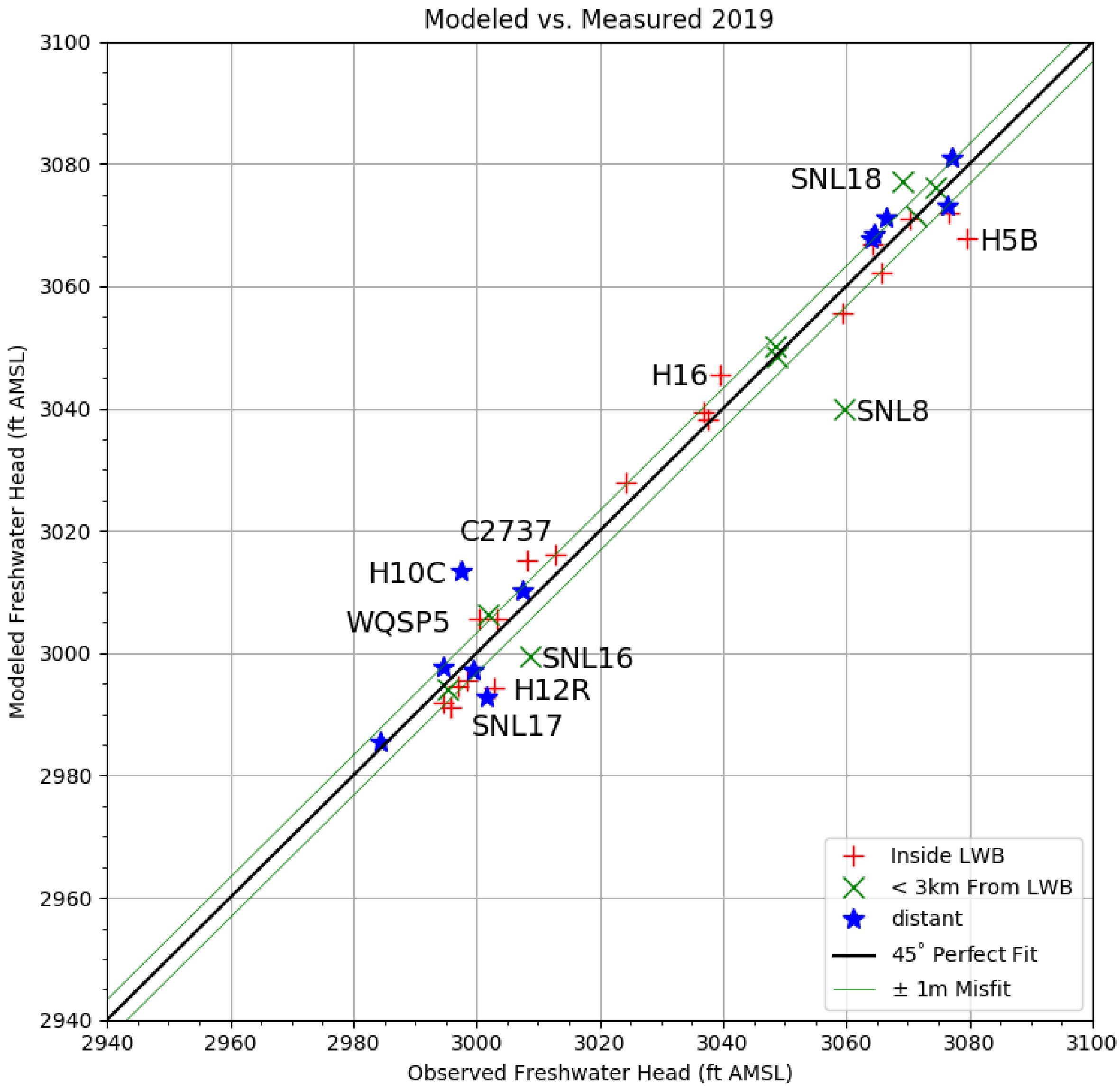


Figure 6.7 – Measured Versus Modeled Scatter Plot for Parameter Estimation Tool-Calibrated MODFLOW 2000 Generated Heads and August 2019 Freshwater Heads

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 [2.56 miles (mi)]). Assuming a thickness of 4 m (13.12 ft) for the transmissive portion of the Culebra and a constant porosity of 16 percent, the travel time to the WIPP LWB is 5,589 years (output from DTRKMF is adjusted from a 7.75-m (25.43 ft) Culebra thickness), for an average velocity of 0.73 m/yr (2.4 ft/yr). 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 2019, 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. After an H-03b2 video log in 2017, it was discovered that the open-hole completed section had collapsed. It was decided that this well would not produce reliable data and the transducer was removed. For the DMP wells, field hydrometer measurements are always used. For comparison, 2017 and 2018 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 2019

	2017 Fluid Density Survey Result	2017 Conversion to Specific Gravity at 70°F	2018 Fluid Density Survey Result	2018 Conversion to Specific Gravity at 70°F	2019 Fluid Density Survey Result	2019 Conversion to Specific Gravity at 70°F	
Well	Density (g/ cm^3)	Density (g/cm^3)	Density (g/cm^3)	Density (g/cm^3)	Density (g/cm^3)	Density (g/cm^3)	Notes for 2017–2019 Fluid Density Survey
AEC-7R	1.066	1.068	1.075	1.077	1.063	1.065	
C-2737	1.027	1.029	1.022	1.024	1.022	1.024	
ERDA-9	1.071	1.073	1.073	1.075	1.071	1.073	
H-2b2	1.011	1.013	1.011	1.013	1.013	1.015	
H-3b2	1.051	1.053	NA	NA	NA	NA	Open-hole completion collapse, data not reliable
H-4bR	1.018	1.020	1.016	1.018	1.018	1.020	

Well	2017 Fluid Density Survey Result	2017 Conversion to Specific Gravity at 70°F	2018 Fluid Density Survey Result	2018 Conversion to Specific Gravity at 70°F	2019 Fluid Density Survey Result	2019 Conversion to Specific Gravity at 70°F	Notes for 2017–2019 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-5b	1.096	1.098	1.100	1.102	1.103	1.105	H-5b was plugged in Sept 2019
H-6bR	1.037	1.039	1.033	1.035	1.037	1.039	
H-7b1	1.005	1.007	1.009	1.011	1.011	1.013	
H-9bR	1.002	1.004	1.003	1.005	1.003	1.005	
H-10cR	1.076	1.078	1.079	1.081	1.085	1.087	
H-11b4R	1.076	1.078	1.076	1.078	1.076	1.078	
H-12R	1.102	1.104	1.108	1.110	1.102	1.104	
H-15R	1.116	1.118	1.119	1.121	1.123	1.125	
H-16	1.031	1.033	1.031	1.033	1.030	1.032	
H-17	1.131	1.133	1.130	1.132	1.129	1.131	
H-19b0	1.064	1.066	1.065	1.067	1.064	1.066	
I-461	1.000	1.002	1.000	1.002	0.998	1.000	
SNL-1	1.029	1.031	1.029	1.031	1.031	1.033	
SNL-2	1.006	1.008	1.006	1.008	1.008	1.010	
SNL-3	1.025	1.027	1.026	1.028	1.027	1.029	
SNL-5	1.010	1.012	1.005	1.007	1.005	1.007	
SNL-6	1.245	1.247	1.246	1.248	1.243	1.245	
SNL-8	1.099	1.101	1.104	1.106	1.089	1.091	
SNL-9	1.015	1.017	1.015	1.017	1.016	1.018	
SNL-10	1.008	1.010	1.009	1.011	1.009	1.011	
SNL-12	1.011	1.013	1.013	1.015	1.008	1.010	
SNL-13	1.022	1.024	1.020	1.022	1.022	1.024	
SNL-14	1.044	1.046	1.045	1.047	1.045	1.047	
SNL-15	1.223	1.225	1.225	1.227	1.229	1.231	
SNL-16	1.012	1.014	1.014	1.016	1.015	1.017	
SNL-17	1.004	1.006	1.007	1.009	10.012	1.014	
SNL-18	1.008	1.010	1.011	1.013	1.009	1.011	
SNL-19	1.005	1.007	1.004	1.006	1.004	1.006	
WIPP-11	1.034	1.036	1.037	1.039	1.034	1.036	WIPP-11 was plugged in Sept. 2019
WIPP-13	1.034	1.036	1.032	1.034	1.033	1.035	
WIPP-19	1.053	1.055	1.057	1.059	1.059	1.061	
WQSP-1	1.047	1.049	1.047	1.049	1.039	1.041	SNL Trolls installed February 2019
WQSP-2	1.046	1.048	1.046	1.048	1.031	1.033	SNL Trolls installed February 2019
WQSP-3	1.144	1.146	1.146	1.148	1.139	1.141	SNL Trolls installed February 2019

Well	2017 Fluid Density Survey Result	2017 Conversion to Specific Gravity at 70°F	2018 Fluid Density Survey Result	2018 Conversion to Specific Gravity at 70°F	2019 Fluid Density Survey Result	2019 Conversion to Specific Gravity at 70°F	Notes for 2017–2019 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)	
WQSP-4	1.075	1.077	1.075	1.077	1.075	1.078	Average sampling Round 41, field hydrometer
WQSP-5	1.028	1.030	1.029	1.031	1.027	1.029	Average sampling Round 41, field hydrometer
WQSP-6	1.015	1.017	1.014	1.016	1.014	1.016	Average sampling Round 41, field hydrometer

Notes:
NA – No available measurement.

6.3 Drilling Activities

During 2019, H-5b and H-5c were plugged on 09/06/2019 and 09/05/2019 respectively. Replacement well H-5bR was completed on 09/12/2019 to ensure the Culebra is still being monitored at the H-5 location. WIPP-11 was plugged on 09/04/2019 and replaced by WIPP-11R, which was completed on 09/21/2019. Drilling and plugging methods used were in accordance with the New Mexico Office of the State Engineer regulations.

6.4 Hydraulic Testing and Other Water Quality Sampling

No hydraulic testing was completed in 2019.

6.5 Well Maintenance and Development

Well maintenance activities included work at H-9bR to clean algae in August 2019.

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 2.79 liters per minute (1 gallon per minute) in monitoring wells and piezometers, and the water contains varying concentrations of TDS (874 mg/L to 274,000 mg/L) and chloride (146 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 0.8 km (0.5 mi) south of the WIPP facility property protection area fence.

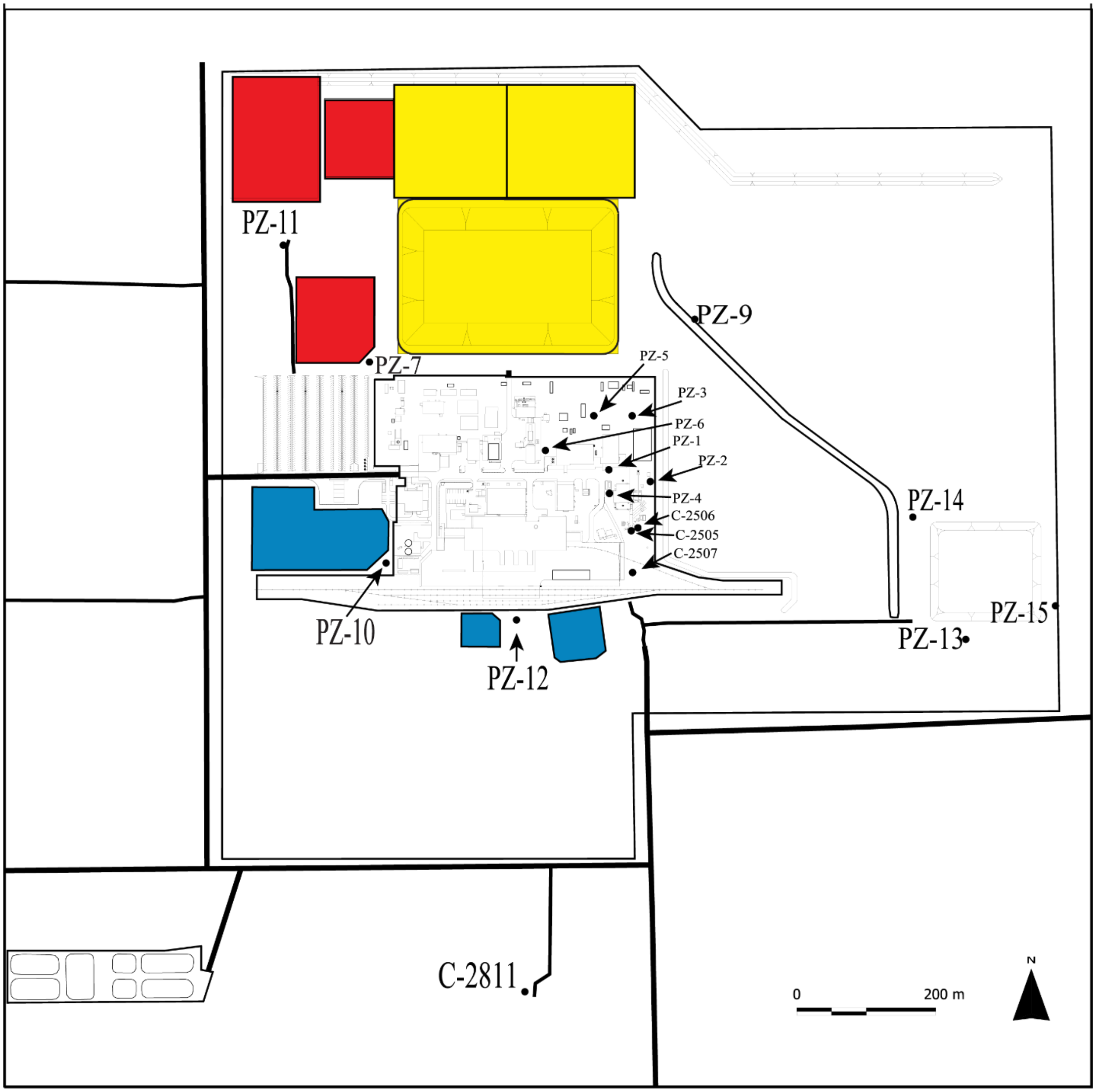


Figure 6.8 – Location of Shallow Subsurface Water Wells (Piezometers PZ-1through PZ-7, PZ-9 through PZ-15, C-2811, C-2505, C-2506, and C-2507)

In order to investigate the SSW, 15 piezometers (PZ-1 to PZ-7 and PZ-9 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 2019 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 semiannual basis. These wells were sampled in April/May and October 2019, and the parameters shown in Table 6.5 were analyzed.

Table 6.5 – 2019 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	05/02/2019	NA	2,160	37,100	63,600	NA
PZ-1	10/16/2019	NA	1,940	29,000	54,500	NA
PZ-5	05/02/2019	NA	617	7,170	14,500	NA
PZ-5	10/17/2019	NA	540	6,700	12,800	NA
PZ-6	05/02/2019	NA	1,160	19,100	32,100	NA
PZ-6	10/17/2019	NA	1,000	16,000	28,100	NA
PZ-7	04/29/2019	NA	2,650	54,600	100,000	NA
PZ-7	10/14/2019	NA	2,520	60,000	105,000	NA
PZ-9	05/02/2019	NA	5,830	126,000	204,000	NA
PZ-9	10/17/2019	NA	4,800	100,000	175,000	NA
PZ-10	04/29/2019	NA	179	146	874	NA
PZ-10	10/14/2019	NA	205	163	921	NA
PZ-11	04/29/2019	NA	744	15,900	26,300	NA
PZ-11	10/16/2019	NA	1,620	27,200	48,800	NA
PZ-12	04/29/2019	NA	521	2,310	5,340	NA
PZ-12	10/14/2019	NA	522	2,680	5,880	NA
PZ-13	4/30/2019	NA	2,850	156,000	265,000	NA
PZ-13	10/16/2019	NA	2,780	156,000	243,000	NA
C-2811	04/29/2019	NA	348	1,020	2,680	NA
C-2811	10/14/2019	NA	325	930	2,210	NA
C-2507	05/02/2019	NA	748	4,210	8,770	NA
C-2507	10/17/2019	NA	670	3,900	8,560	NA
WQSP-6A	04/30/2019	4.14	1,940	309	3,230	<1.0
WQSP-6A	10/16/2019	4.97	1,800	366	3,450	<1.0

NA: Not analyzed, parameter not required per permit conditions.

H: Hold times for preparation or analysis exceeded

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 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 2019 data is presented in Figure 6.9. The contours were generated using *SURFER*, Version 16; 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.

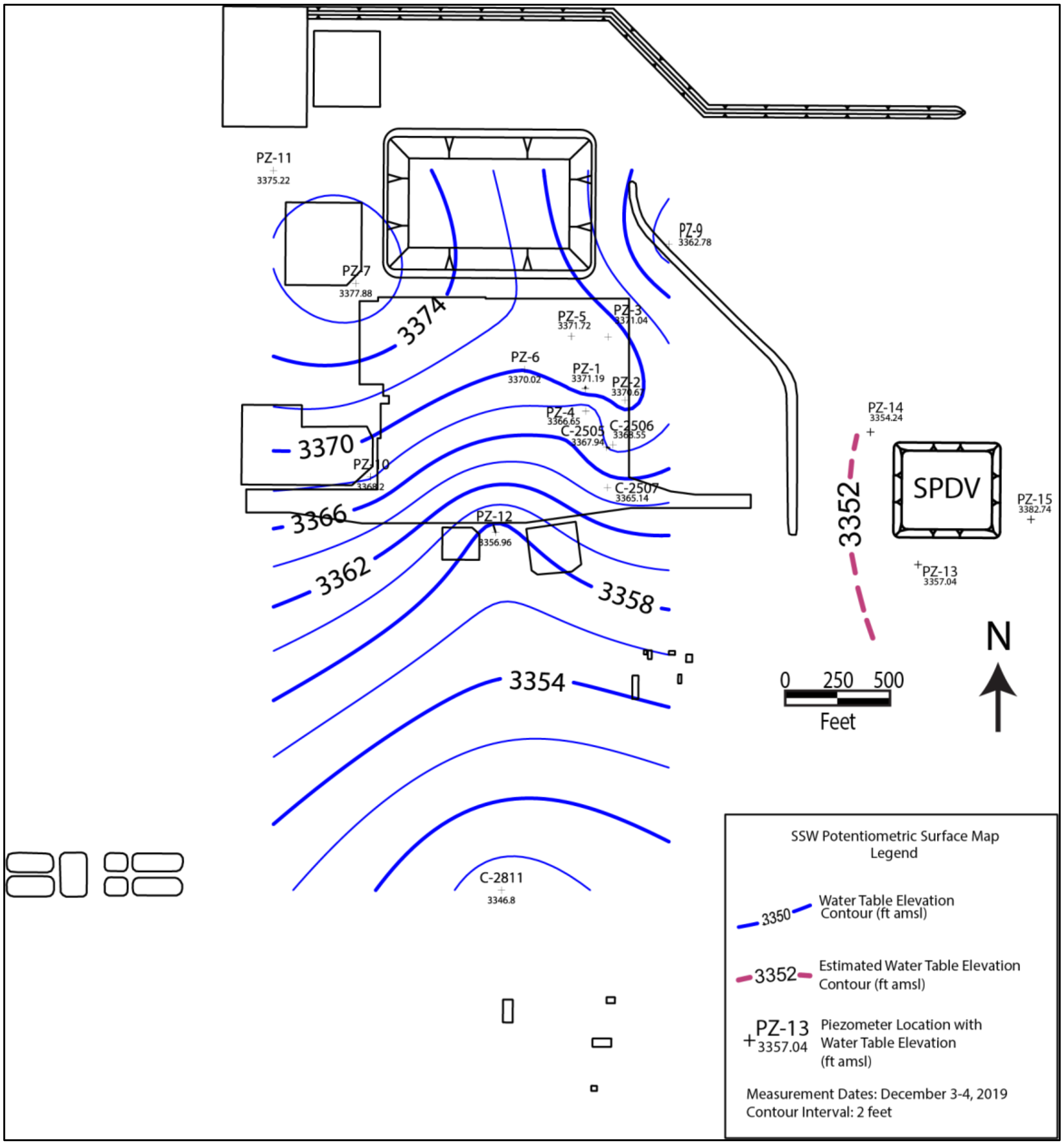


Figure 6.9 – December 2019 Shallow Subsurface Water Potentiometric Surface

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 4.8 km (3 mi) south-southwest of the WIPP surface facilities and about 2.8 km (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 2019, 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 Project 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 DOE 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 DOE 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 (using 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.
- DOE/CBFO and the MOC also performs routine assessments of the WIPP Laboratories.

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 2019 there were no detections of ^{241}Am. WIPP Laboratories is located in CEMRC building.

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 2019. 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

$1\,\sigma\,TPU$ = 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 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 the target radionuclides are considered, not just those results where the analyte was detected.

The data in Table 7.1 show that in eleven cases the field duplicate in 2019 RERs were greater than or equal to 1.96, six of which were non-detects and five cases where the radionuclide was detected. There were 6 cases where the RERs were greater than or equal to 1.96 in 2018. The total number of RER measurements was 190. Thus, 94.2 percent of the field duplicate precision results were less than 1.96, which readily met the precision objective. The radionuclides included in the eleven cases were one $^{233/234}$U, three ^{235}U, three ^{238}U, one $^{239/240}$Pu, one ^{241}Am one ^{60}Co, and one ^{137}Cs. The largest RER was for ^{235}U (3.94), where it was detected in duplicate sample at a lot lower concentration than in the primary sample.

Table 7.1 – 2019 Summary of Field Duplicate Precision Analysis Results with RERs Greater than 1.96

Matrix	Duplicate Samples	Radionuclide	RER	Detected?
Air filter composites (2)	CBD	^{238}U	2.01	No
Groundwater	WQSP-1	^{137}Cs	2.33	No
Groundwater	WQSP-2	^{60}Co	2.24	No
Groundwater	WQSP-4	^{235}U	3.94	Yes
Surface water	RED	^{234}U	3.13	Yes
Surface water	RED	^{235}U	2.86	Yes
Surface water	RED	^{238}U	2.89	Yes
Surface water	RED	^{241}Am	2.09	No
Soil	WEE	^{238}U	2.25	Yes
Soil	WEE	$^{239/240}Pu$	3.66	No
Biota	Quail	^{235}U	2.57	No

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 94.2 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 RLCSs 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 RLCSs. 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 are used to 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 shows the two sets of 2019 MAPEP soil, water, air filter, and vegetation performance evaluation samples (MAPEP Series 40 and 41). The data in Table 7.2 show that the WIPP Laboratories results for the MAPEP Series 40 samples were acceptable. However, series 41 had 3 warnings (U-234 and U-238 for water and Sr-90 for filter) and 1 unacceptable (Sr-90 for vegetation). Although the bias for Sr-90 in vegetation was -65.4, it shouldn't affect the Sr-90 data since Sr-90 was not detected in any vegetation samples and Sr-90 was acceptable in previous series of MAPEP for vegetation.

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.

Table 7.2 – Mixed Analyte Performance Evaluation Program Review for WIPP Laboratories, Reported in 2019 (Series 40 and 41)

	MATRIX: Soil (Bq/kg) MAPEP–17-MaS40				MATRIX: Water (Bq/L) MAPEP–17–MaW40			
Analyte	Reported [RN][(a)]	MAPEP[(b)] [RN][(a)]	E[(c)]	% Bias	Reported [RN][(a)]	MAPEP[(b)] [RN][(a)]	E[(c)]	% Bias
^{241}Am	49.3	49.9	A	-1.2	0.553	0.582	A	-5.0
^{60}Co	945	855	A	10.5	6.88	6.7	A	2.7
^{137}Cs	1330	1164	A	14.3	-0.0383	NR	A	(d)
^{238}Pu	68.5	71.0	A	-3.5	0.446	0.451	A	-1.1
$^{239/240}$Pu	58.9	59.8	A	-1.5	0.00865	0.0045	A	(e)
^{90}Sr	-1.86	NR	A	(d)	6.24	6.35	A	-1.7
$^{233/234}$U	54.3	56	A	-3.0	0.844	0.80	A	5.5
^{238}U	187	205	A	-8.8	0.827	0.81	A	2.1
^{40}K	589	585	A	0.7	-0.0672	NR	A	(d)
	MATRIX: Air Filter (Bq/filter) MAPEP–17–RdF40				**MATRIX: Vegetation (Bq/Sample) MAPEP–17–RdV40**			
[RN]	**Reported Value**	**MAPEP Value**	**E[(c)]**	**% Bias**	**Reported Value**	**MAPEP Value**	**E[(c)]**	**% Bias**
^{241}Am	0.0304	0.0294	A	3.4	0.000685	NR	A	(d)
^{60}Co	0.338	0.340	A	-0.6	0.0268	NR	A	(d)
^{137}Cs	0.304	0.290	A	4.8	2.37	2.30	A	3.0
^{238}Pu	0.0533	0.0526	A	1.3	0.0391	0.0339	A	15.3
$^{239/240}$Pu	0.0372	0.0379	A	-1.8	0.0494	0.0460	A	7.4
^{90}Sr	0.625	0.662	A	-5.6	-0.0228	NR	A	(d)
$^{233/234}$U	0.116	0.106	A	9.4	0.204	0.217	A	-6.0
^{238}U	0.117	0.110	A	6.4	0.202	0.225	A	-10.2
^{40}K	NR	NR	NA	NA	NR	NR	NA	NA
	MATRIX: Soil (Bq/kg) MAPEP–17-MaS41				**MATRIX: Water (Bq/L) MAPEP–17–MaW41**			
Analyte	**Reported [RN][(a)]**	**MAPEP[(b)] [RN][(a)]**	**E[(c)]**	**% Bias**	**Reported [RN][(a)]**	**MAPEP[(b)] [RN][(a)]**	**E[(c)]**	**% Bias**
^{241}Am	79.8	74.7	A	6.8	0.484	0.522	A	-7.3
^{60}Co	814	760	A	7.1	8.11	8.8	A	-7.8
^{137}Cs	873	789	A	10.6	17.4	18.4	A	-5.4
^{238}Pu	50.1	52.1	A	-3.8	0.0123	0.0063	A	(e)
$^{239/240}$Pu	59.3	61.4	A	-3.4	0.743	0.727	A	2.2
^{90}Sr	511	572	A	-10.7	11.3	10.6	A	6.6
$^{233/234}$U	110	116	A	-5.2	0.811	1.07	W	-24.2
^{238}U	111	117	A	-5.1	0.797	1.05	W	-24.1
^{40}K	573	555	A	3.2	0.759	NR	A	(d)

[RN]	MATRIX: Air Filter (Bq/filter) MAPEP–17–RdF41				MATRIX: Vegetation (Bq/Sample) MAPEP–17–RdV41			
	Reported Value	MAPEP Value	E(c)	% Bias	Reported Value	MAPEP Value	E(c)	% Bias
^{241}Am	0.000385	NR	A	(d)	0.0863	0.090	A	-4.1
^{60}Co	0.766	0.815	A	-6.0	5.41	5.30	A	2.1
^{137}Cs	1.55	1.58	A	-1.9	3.39	3.28	A	3.4
^{238}Pu	0.0715	0.0761	A	-6.0	0.0830	0.081	A	2.5
$^{239/240}Pu$	0.0452	0.0468	A	-3.4	0.000462	NR	A	(d)
^{90}Sr	0.383	0.498	W	-23.1	0.346	1.00	N	-65.4
$^{233/234}U$	0.0954	0.093	A	2.6	0.0637	0.0647	A	-1.5
^{238}U	0.100	0.096	A	4.2	0.0675	0.0670	A	0.7
^{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
(e) Sensitivity Evaluation
NA = Not applicable
NR = Not reported

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 2019.

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 2019.

7.2.1 Completeness

Completeness is defined in WP 12-VC.01, *Volatile Organic Compound Monitoring Plan*, and WP 12-VC.02, *Quality Assurance Project Plan for Volatile Organic Compound 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 2019, 377 VOC compliance samples and 38 field duplicate samples were submitted to CEMRC for analysis; the submitted samples produced valid data. Two field duplicate samples were voided in the field due to canister pressure issues. Because of this, for surface VOC monitoring, the program analytical completion percentage was 99.1 percent. The analytical completeness percentage for disposal room VOC monitoring was 100 percent. The overall analytical completeness percentage was 99.5 percent.

7.2.2 Precision

Precision is demonstrated in the VOC Monitoring Program 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. 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

An LCS and an LCSD were generated and evaluated for data submitted in 2019. The LCS/LCSD data generated during 2019 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 2019, 37 of 38 field duplicates met the acceptance criterion. One disposal room field duplicate (collected on 2/13/2019) did not meet the less than or equal to 35 RPD criterion. The previous and subsequent field duplicates met the performance criterion.

7.2.3 Accuracy

The VOC monitoring program is used to evaluate 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.

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.

$$\text{Relative Response Factor} = \frac{\text{(Analyte Response)(Internal Standard Concentration)}}{\text{(Internal Standard Response)(Analyte Concentration)}}$$

$$\text{Relative Standard Deviation} = \left[\frac{\text{Standard Deviation of Relative Response Factor}}{\text{Average Relative Response Factor of Analyte} \times 100}\right]$$

During 2019, 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 2019, 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 2019, 100 percent of internal standards met the ±40 percent criterion.

Sensitivity

To meet sensitivity requirements, method detection limit (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 2019 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 2019, ion abundance criteria were within tolerance.

7.2.4 Comparability

CEMRC participated in the National Air Toxics Trends Station (NATTS) proficiency test for VOC analysis in the first quarter of 2019.

For the NATTS first quarter 2019 PT, 1,1,2,2-tetrachloroethane, 1,2-dichloroethane, carbon tetrachloride, chloroform, methylene chloride, and trichloroethylene each met the acceptance criterion of ± 30 percent of the nominal spike value established in the WIPP Laboratory Proficiency Testing Program (Table 7.3). No corrective actions were needed as a result of this PT. Waste Isolation Pilot Plant target compounds present in the first quarter 2019 PT sample were identified and met the performance criteria.

Table 7.3 – CEMRC Proficiency Testing Results

Target Compounds	The CEMRC Reported Value (ppbv)	NATTS Spike Value (ppbv)	Relative Percent Difference
1,1,2,2-Tetrachloroethane	0.177	0.195	9.1
1,2-Dichloroethane	0.461	0.462	0.2
Carbon Tetrachloride	0.216	0.202	6.7
Chloroform	0.496	0.520	4.7
Methylene Chloride	0.334	0.342	2.5
Trichloroethylene	0.444	0.455	2.3

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

Hall Environmental Analysis Laboratory performed the chemical analyses for the Round 41 groundwater sampling in 2019. Hall Environmental Analysis Laboratory 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 2019 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

Hall Environmental Analysis Laboratory 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. Laboratory control 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. Laboratory control sample duplicates were prepared 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. An 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 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 7.4 shows those cases where the precision objective (RPD≤20) was not met for the duplicate groundwater samples, LCSs/LCSDs, MS/MSD samples, and duplicate analysis of single groundwater samples when applicable. The data in Table 7.3 show that all but four of the samples where the precision objective was not met were for MS/MSD QC samples rather than groundwater samples. The four examples 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.

Table 7.4 contains 28 entries for SVOCs, four entries for TSS, and three entries for trace metals (cadmium, silver and lead). The SVOC and trace metals entries are for matrix spike samples, and the TSS entries are for duplicate samples. Thus the imprecision of any of the QC sample analyses was almost entirely due to variability in recovering SVOCs spiked into the groundwater matrix, while the other analysis methods used for the groundwater samples yielded precise results with just a couple of exceptions. 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 7.4 contains four entries 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 content of the groundwater samples and the results depend on how long the samples are allowed to stand following shaking and before filtering.

The poor precision for the metals cadmium, silver and lead was for the MS/MSD samples associated with the concentrated brine WQSP-3 groundwater samples. These metals have shown poorer recoveries from spiked WQSP-3 groundwater in previous years as well.

It should be noted that LCSs/LCSDs 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 7.4 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 41, the number of duplicate groundwater samples and QA samples that did not meet the precision objective was very low.

Table 7.4 – Individual Cases Where the Round 41 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	Parameter or Constituent	Constituent type	Primary	Duplicate	RPD
WQSP-1	2,4-Dinitrophenol	SVOC	11.2 µg/L (MS)	8.24 µg/L (MSD)	30.6
WQSP-1	2-Methylphenol	SVOC	43.2 µg/L (MS)	23.2 µg/L (MSD)	60.3
WQSP-1	3+4-Methylphenol	SVOC	30.8 µg/L (MS)	15.8 µg/L (MSD)	64.5
WQSP-1	Pentachlorophenol	SVOC	9.58 µg/L (MS)	ND (MSD)	200
WQSP-2	1,2-Dichlorobenzene	SVOC	32.5 µg/L (MS)	14.6 µg/L (MSD)	76.2
WQSP-2	1,4-Dichlorobenzene	SVOC	30.6 µg/L (MS)	14.3 µg/L (MSD)	72.2
WQSP-2	2,4-Dinitrophenol	SVOC	12.9 µg/L (MS)	6.72 µg/L (MSD)	63.1
WQSP-2	2,4-Dinitrotoluene	SVOC	79.7 µg/L (MS)	39.3 µg/L (MSD)	67.9
WQSP-2	Hexachlorobenzene	SVOC	76.9 µg/L (MS)	39.2 µg/L (MSD)	65.1
WQSP-2	Hexachloroethane	SVOC	26.3 µg/L (MS)	12.4 µg/L (MSD)	71.8
WQSP-2	2-Methylphenol	SVOC	22.3 µg/L (MS)	7.96 µg/L (MSD)	94.8
WQSP-2	3+4-Methylphenol	SVOC	18.9 µg/L (MS)	ND (MSD)	200
WQSP-2	Nitrobenzene	SVOC	74.3 µg/L (MS)	33.0 µg/L (MSD)	77.0
WQSP-2	Pentachlorophenol	SVOC	12.4 µg/L (MS)	ND (MSD)	200
WQSP-2	Pyridine	SVOC	44.5 µg/L (MS)	23.8 µg/L (MSD)	60.6
WQSP-3	TSS	General Chemistry parameter	162 mg/L (Primary)	203 mg/L (Duplicate)	22.5
WQSP-3	1,2-Dichlorobenzene	SVOC	21.0 µg/L (MS)	37.5 µg/L (MSD)	56.2
WQSP-3	1,4-Dichlorobenzene	SVOC	18.8 µg/L (MS)	33.9 µg/L (MSD)	57.2
WQSP-3	2,4-Dinitrotoluene	SVOC	42.6 µg/L (MS)	55.2 µg/L (MSD)	25.9
WQSP-3	Hexachlorobenzene	SVOC	43.9 µg/L (MS)	61.0 µg/L (MSD)	32.6
WQSP-3	Hexachloroethane	SVOC	20.4 µg/L (MS)	36.4 µg/L (MSD)	56.3
WQSP-3	2-Methylphenol	SVOC	18.9 µg/L (MS)	27.0 µg/L (MSD)	35.2
WQSP-3	3+4-Methylphenol	SVOC	10.6 µg/L (MS)	16.9 µg/L (MSD)	45.8
WQSP-3	Nitrobenzene	SVOC	38.2 µg/L (MS)	58.6 µg/L (MSD)	42.1
WQSP-3	Pyridne	SVOC	ND (MS)	5.76 µg/L (MSD)	200
WQSP-3	Cadmium	Metals	0.105 mg/L (MS)	0.225 mg/L (MSD)	73.0
WQSP-3	Silver	Metals	0.072 mg/L (MS)	0.11 mg/L (MSD)	38.0
WQSP-3	Lead	Metals	0.022 mg/L (MS)	0.13 mg/L (MSD)	143
WQSP-4	TSS	General Chemistry parameter	49.0 mg/L (Primary)	73.0 mg/L (Duplicate)	39.3
WQSP-4	2,4-Dinitrophenol	SVOC	20.7 µg/L (MS)	12.9 µg/L (MSD)	46.7
WQSP-4	Pentachlorophenol	SVOC	18.1 µg/L (MS)	9.76 µg/L (MSD)	59.7

DMW	Parameter or Constituent	Constituent type	Primary	Duplicate	RPD
WQSP-5	TSS	General Chemistry parameter	12.0 mg/L (Primary)	9.00 mg/L (Duplicate)	28.6
WQSP-6	TSS	General Chemistry parameter	5.00 mg/L (Primary)	4.00 mg/L (Duplicate)	22.2
WQSP-6	2,4-Dinitrophenol	SVOC	12.8 µg/L (MS)	8.40 µg/L (MSD)	41.4
WQSP-6	Pentachlorophenol	SVOC	56.1 µg/L (MS)	22.6 µg/L (MSD)	84.9

[a] Only samples with concentrations above the MRL are reported. (J-flagged estimated concentrations not reported).

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 LCSs and MS samples.
- 90-110 percent recovery for chloride and sulfate in LCSs (MS samples not analyzed due to the high native concentrations in groundwater).
- 80-120 percent recovery for mercury and recoverable metals in LCSs.
- 75-125 percent recovery for mercury and recoverable metals in MS samples.
- 90-110 or 80-120 percent recovery for general chemistry parameters in LCSs.
- 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 7.5 summarizes the QC samples for which the accuracy QA objective, as measured by percent recovery, was not met during the Round 41 sampling and analysis in 2019. 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 7.5 since MS/MSD recovery data are not applicable per EPA guidance for samples with high native concentrations of a given analyte.

Table 7.5 – Individual Cases Where the Round 41 Quality Assurance Objective Was Not Met Per EPA Guidance

DMW	Constituent or Parameter	Constituent type	Sample	% Rec.	Sample	% Rec.
WQSP-1	1,1,2,2-Tetrachloroethane	VOC	MS	131*	MSD	131*
WQSP-1	Isobutyl alcohol	VOC	MS	157*	MSD	156*
WQSP-1	Pyridine	SVOC	LCS	19.6*	LCSD	19.7*
WQSP-1	2,4-Dinitrophenol	SVOC	MS	11.2*	MSD	8.24*
WQSP-1	2-Methylphenol	SVOC	MS	43.2	MSD	23.2*
WQSP-1	3+4-Methylphenol	SVOC	MS	30.8	MSD	15.8*
WQSP-1	Pentachlorophenol	SVOC	MS	9.58*	MSD	ND
WQSP-1	Lead	Metals	MS	73.9	MSD	74.7
WQSP-1	Nickel	Metals	MS	74.0	MSD	76.0
WQSP-1	Silver	Metals	MS	139	MSD	143
WQSP-2	2-Butanone	VOC	MS	162*	MSD	167*
WQSP-2	1,1,2,2-Tetrachloroethane	VOC	MS	131*	MSD	123
WQSP-2	1,2-Dichlorobenzene	SVOC	MS	32.5**	MSD	14.6**
WQSP-2	1,4-Dichlorobenzene	SVOC	MS	30.6**	MSD	14.3**
WQSP-2	2,4-Dinitrophenol	SVOC	MS	12.9**	MSD	6.72**
WQSP-2	Hexachloroethane	SVOC	MS	26.3**	MSD	12.4**
WQSP-2	2-Methylphenol	SVOC	MS	22.3**	MSD	7.96**
WQSP-2	3+4-Methylphenol	SVOC	MS	18.9**	MSD	0.00**

DMW	Constituent or Parameter	Constituent type	Sample	% Rec.	Sample	% Rec.
WQSP-2	Nitrobenzene	SVOC	MS	74.3	MSD	33.0**
WQSP-2	Pentachlorophenol	SVOC	MS	12.4**	MSD	0.00**
WQSP-2	Pyridine	SVOC	MS	44.5	MSD	23.8**
WQSP-3	2-butanone	VOC	MS	279	MSD	322**
WQSP-3	Isobutyl alcohol	VOC	MS	349**	MSD	350**
WQSP-3	1,4-Dichlorobenzene	SVOC	LCS	38.7*	LCSD	38.4*
WQSP-3	Hexachloroethane	SVOC	LCS	31.3*	LCSD	32.0*
WQSP-3	Pyridine	SVOC	LCS	20.6*	LCSD	20.6*
WQSP-3	1,2,-Dichlorobenzene	SVOC	MS	21.0**	MSD	37.5**
WQSP-3	1,4-Dichlorobenzene	SVOC	MS	18.8**	MSD	33.9**
WQSP-3	2,4-Dinitrophenol	SVOC	MS	ND**	MSD	ND**
WQSP-3	Hexachloroethane	SVOC	MS	20.4**	MSD	36.4**
WQSP-3	2-Methylphenol	SVOC	MS	18.9**	MSD	27.0**
WQSP-3	3+4-Methylphenol	SVOC	MS	10.6**	MSD	16.9**
WQSP-3	Nitrobenzene	SVOC	MS	38.2**	MSD	58.6
WQSP-3	Pentachlorophenol	SVOC	MS	ND**	MSD	ND**
WQSP-3	Pyridine	SVOC	MS	ND**	MSD	5.74**
WQSP-3	Mercury	Metals	MS	57.2**	MSD	55.0**
WQSP-3	Cadmium	Metals	MS	21.0**	MSD	45.1**
WQSP-3	Silver	Metals	MS	43.7**	MSD	77.3
WQSP-3	Lead	Metals	MS	4.44**	MSD	26.5**
WQSP-4	Isobutyl alcohol	VOC	LCS	141**	LCSD	132**
WQSP-4	2-Butanone	VOC	MS	152*	MSD	139*
WQSP-4	1,1,2,2-Tetrachloroethane	VOC	MS	140*	MSD	124
WQSP-4	Isobutyl alcohol	VOC	MS	227*	MSD	232*
WQSP-4	Pyridine	SVOC	LCS	16.4*	LCSD	15.5*
WQSP-4	2,4-Dinitrophenol	SVOC	MS	20.7*	MSD	12.9*
WQSP-4	3+4-Methylphenol	SVOC	MS	33.6**	MSD	33.1**
WQSP-4	Pentachlorophenol	SVOC	MS	18.1*	MSD	9.76*
WQSP-5	2-Butanone	VOC	MS	133*	MSD	134*
WQSP-5	Isobutyl alcohol	VOC	MS	143*	MSD	120*
WQSP-5	2,4-Dinitrophenol	SVOC	MS	18.3*	MSD	20.5*
WQSP-6	Isobutyl alcohol	VOC	LCS	138*	LCSD	136*
WQSP-6	Isobutyl alcohol	VOC	MS	129	MSD	139*
WQSP-6	Pyridine	SVOC	LCS	19.7*	LCSD	20.6*
WQSP-6	2,4-Dinitrophenol	SVOC	MS	12.8*	MSD	8.40*
WQSP-6	Pentachlorophenol	SVOC	MS	56.1	MSD	22.6*

DMW	Constituent or Parameter	Constituent type	Sample	% Rec.	Sample	% Rec.

Note: Most of the percent recoveries for SVOCs in the table met the lab's wider historical control chart range.

*The quality assurance objective for accuracy as percent recovery was met.

** Calculated percent recovery met the lab's wider historical control chart range.

***did not meet the lab's historical control chart range.

na – not analyzed

Table 7.5 shows that the accuracy objective as measured by percent recovery in QC samples was not met for some VOC, SVOC, and metals spiked samples. Two LCS/LCSD pairs yielded slightly high recoveries for isobutyl alcohol, four LCS/LCSD pairs yielded low recoveries for pyridine, one LCS/LCSD pair yielded low recoveries for 1,4-Dichlorobenzene and one LCS/LCSD pair yielded low recoveries for hexachloroethane. Low recoveries from the SVOC LCS/LCSD pairs suggest that the method was not in control for those particular compounds.

The other entries in Table 7.5 are for VOCs, SVOCs, and metals that did not meet the accuracy objective when the target compounds were spiked into groundwater samples. There are 12 entries for VOC compounds, but the recoveries were high instead of low. One of the compounds, 2-butanone, was detected in some field blank samples, but was not detected in groundwater samples. Thus the high MS/MSD recoveries did not adversely affect the usability of the groundwater data.

Table 7.5 contains 28 rows with low recoveries for SVOC compounds in MS and MSD samples, but in six of the rows the recovery objective was met for one of the samples but not the other sample from the MS/MSD pair. The low recoveries of SVOC compounds from spiked groundwater is generally due to the high brine groundwater matrix since the recoveries are within the acceptable range in the associated LCSs/LCSDs except for four cases of pyridine and one case for hexachloroethane and 1,4-dichlorobenzene discussed above. Pentachlorophenol and 2,4-dinitrophenol were the most affected SVOC compounds with as low as zero percent recoveries in the high TDS WQSP-2 and WQSP-3 samples. The fact that there is variability between recoveries from the MS compared to the MSD demonstrates some variability in either the sample preparation process or the condition of the GC/MS column during analysis. No SVOCs were detected in any of the Round 41 groundwater samples, and no SVOCs have been detected in previous rounds.

Table 7.5 contains seven MS/MSD rows for metals including one MS/MSD pair for mercury, one MS/MSD pair for cadmium, one MS/MSD pair for nickel, two MS/MSD pair for lead and two MS/MSD pair for silver that did not meet the recovery objective. Lead (73.9% MS and 74.7% MSD) and nickel (74.0% MS) were low in WQSP-1 and silver recoveries were high in (139% MS and 143% MSD). In WQSP-3, the recoveries were low. Lead, silver, and cadmium recoveries were particularly variable with 4.44% in MS and 26.5% in MSD for lead; 43.7% in MS and 77.3% in MSD for silver; 21.0% in MS and 45.1% MSD for cadmium. These metals have also showed low recoveries in previous rounds. The lower recoveries are likely due to filtration losses during the sample preparation process of these high TDS samples. None of the three metals were detected in 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.

Environmental Protection Agency 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 7.6 shows the recoveries of the VOC surrogates from the groundwater and QC samples. As shown in the table, there were seven slightly high recoveries for bromofluoromethane and two high recoveries for 1,2-dichloroethane-d4. The high recoveries were within the lab's historical control chart range of 70%-130%. There were nine slightly low recoveries for bromofluoromethane. The low recoveries were within the lab's historical control chart range of 70%-130%. The good recoveries demonstrate good accuracy for any VOC compounds present in the groundwater samples.

Table 7.6 – Percent Recovery of VOC Surrogates from Round 41 Groundwater and QC Samples as a Measure of Accuracy

DMW	Sample	d4-dce 80-120	4-BFM 86-115	DBFM 86-118	d8-tol 88-110
WQSP-1	Primary	99.0	100	97.0	102
WQSP-1	Duplicate	102	102	100	104
WQSP-1	Field Blank	102	96.8	100	105
WQSP-1	Trip Blank	96.6	96.2	98.8	104
WQSP-1	MB	95.6	102	97.9	104
WQSP-1	LCS	92.2	105	93.2	99.5
WQSP-1	LCSD	100	94.5	96.0	100
WQSP-1	MS	106	98.1	101	98.6
WQSP-1	MSD	103	101	97.4	107
WQSP-2	Primary	111	92.7	124*	98.9
WQSP-2	Duplicate	110	94.4	115	98.0
WQSP-2	Field Blank	105	93.6	119*	98.5
WQSP-2	Trip Blank	109	95.3	119*	100
WQSP-2	MB	99.6	90.7	112	99.1
WQSP-2	LCS	109	94.0	119*	98.7

DMW	Sample	d4-dce 80-120	4-BFM 86-115	DBFM 86-118	d8-tol 88-110
WQSP-2	LCSD	104	94.5	112	103
WQSP-2	MS	110	99.7	118	103
WQSP-2	MSD	113	96.5	120*	101
WQSP-3	Primary	116	95.7	118	98.1
WQSP-3	Duplicate	116	104	118	98.6
WQSP-3	Field Blank	109	98.1	116	96.9
WQSP-3	Trip Blank	109	97.4	111	98.1
WQSP-3	MB	111	97.8	113	98.4
WQSP-3	LCS	111	98.4	109	102
WQSP-3	LCSD	110	100	110	99.0
WQSP-3	MS	122*	95.5	119*	97.9
WQSP-3	MSD	121*	92.2	119*	98.4
WQSP-4	Primary	88.7	93.7	76.1	98.2
WQSP-4	Duplicate	92.6	106	77.7	102
WQSP-4	Field Blank	83.5	95.7	73.3	96.5
WQSP-4	Trip Blank	88.3	96.9	76.1	95.3
WQSP-4	MB	88.8	95.6	77.1	99.1
WQSP-4	LCS	92.2	98.3	78.9	103
WQSP-4	LCSD	87.4	93.9	73.1	106
WQSP-4	MS	88.9	102	74.7	99.9
WQSP-4	MSD	101	91.4	85.8	97.0
WQSP-5	Primary	104	97.8	91.3	97.8
WQSP-5	Duplicate	107	103	90.9	100
WQSP-5	Field Blank	102	99.6	92.0	98.4
WQSP-5	Trip Blank	105	93.0	92.6	97.7
WQSP-5	MB	100	94.1	87.7	98.2
WQSP-5	LCS	103	97.9	88.7	96.7
WQSP-5	LCSD	103	103	88.3	99.5
WQSP-5	MS	108	99.7	90.4	97.4
WQSP-5	MSD	106	103	91.2	93.0
WQSP-6	Primary	107	105	105	101
WQSP-6	Duplicate	104	103	102	103
WQSP-6	Field Blank	106	97.1	106	99.2
WQSP-6	Trip Blank	104	102	103	99.3
WQSP-6	MB	102	96.6	104	99.8
WQSP-6	LCS	104	95.7	102	98.2

DMW	Sample	d4-dce 80-120	4-BFM 86-115	DBFM 86-118	d8-tol 88-110
WQSP-6	LCSD	101	102	102	97.1
WQSP-6	MS	104	100	105	104
WQSP-6	MSD	109	107	103	95.3

* Indicates results outside of accuracy range.

Table 7.7 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 7.7 – Percent Recovery of SVOC Surrogates from Round 41 Groundwater and QC Samples as a Measure of Accuracy

DMW	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	0.460*	44.8	0.520*	48.1	51.8	1.76*
WQSP-1	Duplicate	0.390*	40.8*	0.640*	47.6	45.1	2.43*
WQSP-1	MB	71.9	50.6	42.0	58.3	56.7	34.2
WQSP-1	LCS	85.8	78.4	60.2	76.7	83.1	51.4
WQSP-1	LCSD	83.2	78.5	60.9	82.4	79.7	51.0
WQSP-1	MS	11.5**	87.2	12.3*	82.7	77.2	15.6
WQSP-1	MSD	4.74*	87.9	5.42*	87.4	75.3	7.40*
WQSP-2	Primary	0.72*	32.4**	0.56*	56.9	46.1	2.02*
WQSP-2	Duplicate	0.46*	49.0	0.56*	69.5	71.6	1.76*
WQSP-2	MB	80.2	55.0	57.0	72.8	77.7	42.5
WQSP-2	LCS	103	92.9	87.3	110	114	68.0
WQSP-2	LCSD	NA	NA	NA	NA	NA	NA
WQSP-2	MS	13.8**	53.6	15.0*	75.9	69.3	15.2
WQSP-2	MSD	1.92*	26.7*	0.94*	40.9	32.8	2.60*
WQSP-3	Primary	0.34*	42.6	0*	67.1	61.0	1.32*
WQSP-3	Duplicate	0.82*	35.9	0.85*	66.9	59.5	3.78*
WQSP-3	MB	95.6	69.9	54.6	98.6	80.8	44.6
WQSP-3	LCS	65.6	63.3	44.3	68.1	65.5	36.8
WQSP-3	LCSD	68.2	61.1	46.2	69.0	65.0	37.2

DMW	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-3	MS	0.52*	41.0	1.02*	45.2	37.4	3.56*
WQSP-3	MSD	0.56*	55.6	1.20*	58.6	55.8	4.72*
WQSP-4	Primary	0.69*	67.9	0.80*	72.8	79.1	3.72*
WQSP-4	Duplicate	1.09*	71.4	1.07*	85.9	83.9	5.65*
WQSP-4	MB	87.7	79.2	69.8	85.6	90.8	52.0
WQSP-4	LCS	119**	97.6	77.5	112	105	61.0
WQSP-4	LCSD	116**	96.7	75.4	110	102	58.5
WQSP-4	MS	25.3	101	10.9*	120	95.9	15.1
WQSP-4	MSD	13.0**	92.9	12.3*	109	92.8	15.7
WQSP-5	Primary	44.9	73.4	55.3	85.9	85.0	52.2
WQSP-5	Duplicate	75.0	75.4	69.8	78.5	87.1	58.2
WQSP-5	MB	90.4	71.3	79.8	89.1	92.3	71.7
WQSP-5	LCS	111	109**	90.8	120	116**	84.6**
WQSP-5	LCSD	110	106	88.0	116	112	78.9
WQSP-5	MS	85.9	101	69.0	99.7	95.5	59.1
WQSP-5	MSD	74.8	98.3	67.2	96.2	94.0	56.0
WQSP-6	Primary	82.0	82.7	68.6	86.4	96.2	53.0
WQSP-6	Duplicate	59.4	51.4	47.0	63.1	63.0	35.8
WQSP-6	MB	77.8	52.8	50.2	65.9	64.6	38.4
WQSP-6	LCS	86.4	81.1	66.6	87.2	88.6	51.2
WQSP-6	LCSD	81.8	88.2	68.0	87.6	90.7	52.6
WQSP-6	MS	76.4	78.8	59.6	78.5	77.8	47.3
WQSP-6	MSD	79.7	75.6	55.0	79.2	80.6	44.3

*Calculated percent recovery did not meet EPA objective.
***did not meet the lab historical control chart range.
na – not analyzed

The data show 246 surrogate recovery entries for which there were 39 low recoveries that did not meet the EPA QAO. The low recoveries were for acidic surrogates, and for the high-TDS WQSP-2 and WQSP-3 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 was not analyzed for WQSP-2 in 246 recovery entries instead of 252 entries. A LCSD is normally not required for client samples per Hall's SVOC SOP, and the lab inadvertently did not analyze a LCSD with this batch of WIPP groundwater samples. However, a MS and MSD were analyzed for 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 QA 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 µg/L (microgram per liter).

Hall Environmental Analysis Laboratory and its subcontract laboratories are certified by several states and by the National Environmental Laboratory Accreditation Program through Oregon for HEAL and Anatek. Hall Environmental Analysis Laboratory 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 7.8 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 their performance evaluation samples.

Hall Environmental Analysis Laboratory analyzed Phenova water pollution proficiency testing samples in 2019. The Phenova water pollution proficiency evaluation samples included chloride, nitrate, sulfate, trace metals, mercury, pH, TOC, VOCs, and SVOCs. The performance evaluation samples covered the WIPP target analytes except isobutyl alcohol (a VOC) and specific gravity (a general chemistry parameter). The inductively coupled plasma (ICP)/MS metals analyzed by Anatek were also from Phenova Certified Reference Materials.

Table 7.8 – Performance Evaluation Sample Analysis Results for WIPP Groundwater Analytes, 2019

Target Analytes	Acceptable Results	Not Acceptable Results
HEAL: VOCs by GC/MS Method 8260 (carbon tetrachloride, chlorobenzene, chloroform, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethene, trans-1,2-dichloroethen, 2-butanone, methylene chloride, 1,1,2,2-tetrachloroethane, tetrachloroethene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, toluene, trichloroethene, trichlorofluoromethane, vinyl chloride, xylenes (PT-VOA-WP for the VOCs)	36	0

HEAL: SVOCs by GC/MS Method 8270 (1,2-dichlorobenzene, 1,4-dichlorobenzene, 2,4-dinitrophenol, 2,4-dinitrotoluene, hexachlorobenzene, hexachloroethane, 2-methylphenol, 3+4-methylphenol, nitrobenzene, pentachlorophenol, pyridine (PT-BN-WP for the SVOCs)	22	0
HEAL: Trace and Dissolved Metals by ICP Method 6010B (barium, beryllium, cadmium, chromium, lead, nickel, silver, vanadium, calcium, magnesium, potassium, sodium) (Phenova PT-TM1-WP for trace metals)	24	0
HEAL: Mercury by Graphite Furnace Atomic Absorption Spectroscopy Method 7470 (PT-HG-WP for mercury)	2	0
Anatek: Metals by ICP/MS Method 6020 (antimony, arsenic, selenium, thallium) (Phenova PT-TM1-WP for trace metals)	8	0
HEAL: General Chemistry Parameters (chloride, sulfate, nitrate, total organic carbon, alkalinity, specific conductance, pH, total dissolved solids, total suspended solids, total Kjeldahl nitrogen)	20	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 7.8 show that the HEAL and the Anatek measurements of WIPP analytes in the performance evaluation samples were 100 percent correct, confirming 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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APPENDIX B – ENVIRONMENTAL PERMITS

Table B.1 – Major Active Environmental Permits for the Waste Isolation Pilot Plant as of December 31, 2019

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	07/29/14	07/29/19	Active, Timely Renewal
New Mexico Environment Department Air Quality Bureau	Operating Permit for Two Backup Diesel Generators	310-M-2	12/07/93	None	Active
New Mexico Environmental Department Air Quality Bureau	Construction Permit for Five Diesel Generators	0310-M3	07/12/19	None	Active
New Mexico Environment Department Petroleum Storage Tank Bureau	Storage Tank Registration Certificate	Registration Number 1248 Facility Number 31539	07/01/19	06/30/20	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	03/19/18	03/19/23	Active
U.S. Fish and Wildlife Service	Special Purpose – Relocate	MB155189-0	05/01/17	03/31/20	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	SWP1	Storm Water Pond 1 (DP-831)
HIL	Hill Tank	SWP2	Storm Water Pond 2 (DP-831)
H2P	H-2 Well Pad	SWP3	Storm Water Pond 3 (DP-831)
H-19	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 MDC and greater than the 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 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 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 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*).

$$\text{RER} = \frac{(MeanActivity)pri - (MeanActivity)dup}{\sqrt{(1\sigma TPU)^2 pri + (1\sigma TPU)^2 dup}}$$

Where:

$(Mean\ Activity)^{pri}$ = mean activity of the primary sample

$(Mean\ Activity)^{dup}$ = mean activity of the duplicate sample

$1\sigma TPU$ = 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

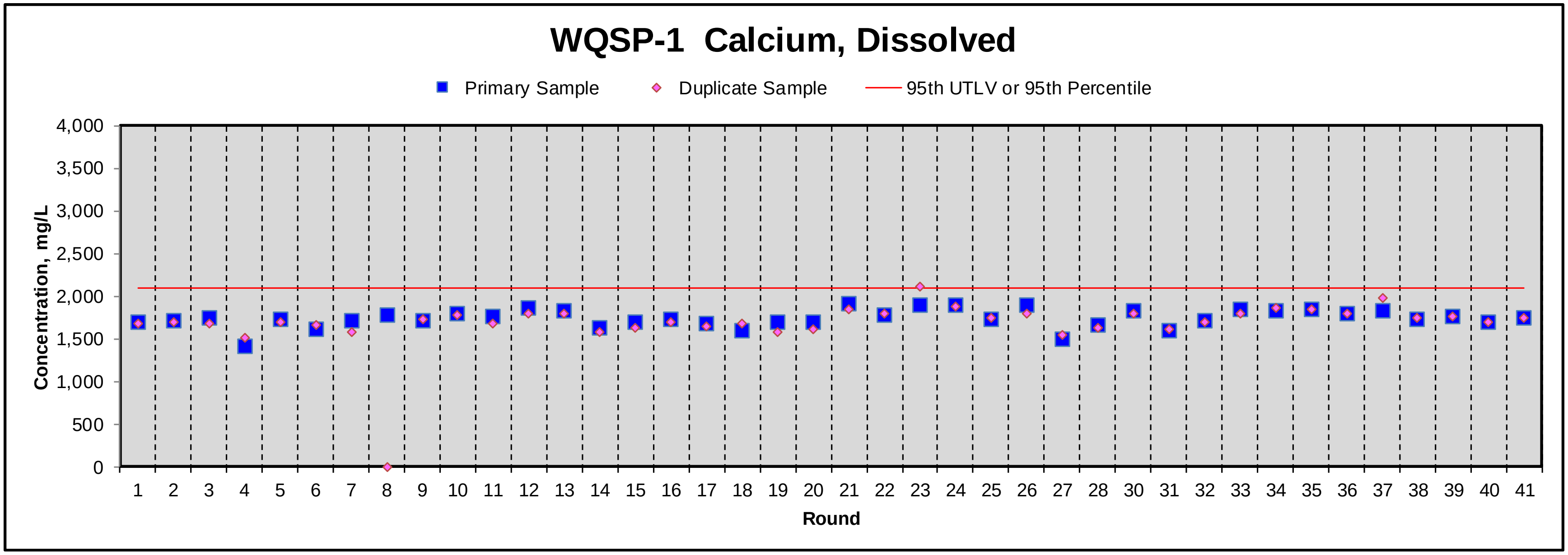
A_m = measured sample activity

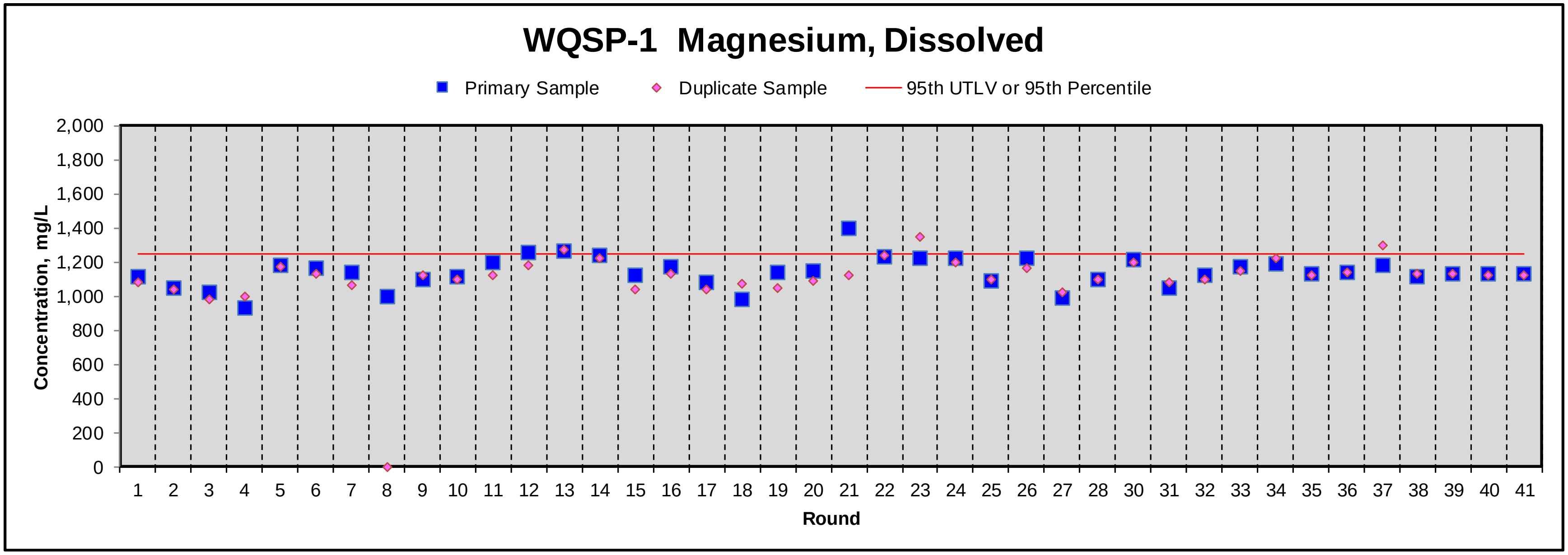
A_k = known sample activity

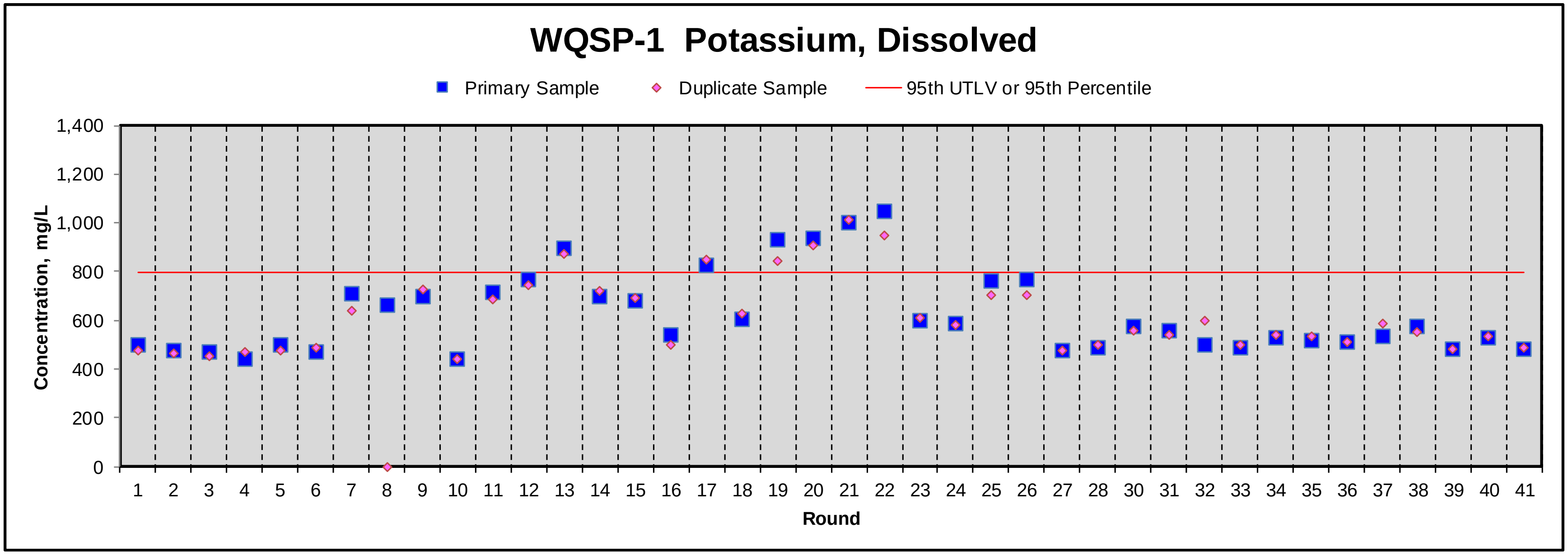
APPENDIX E – TIME TREND PLOTS FOR MAIN PARAMETERS IN GROUNDWATER

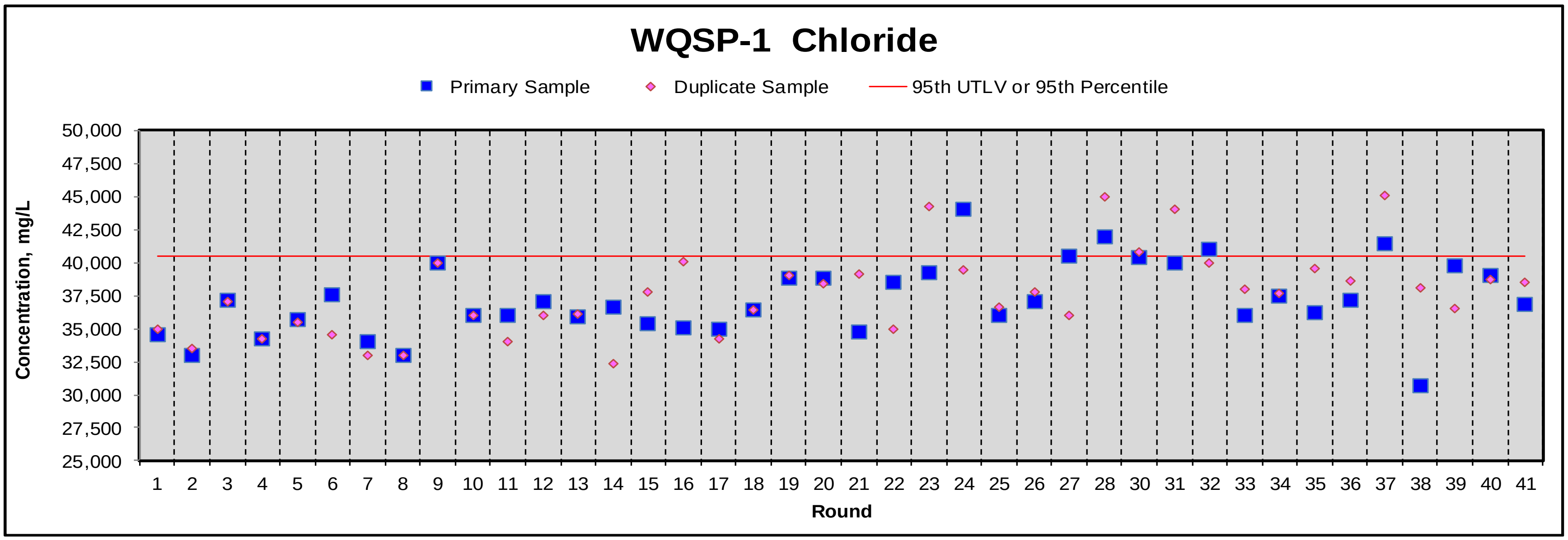
The first 10 sampling rounds were conducted from 1995 through 2000 (prior to receiving mixed waste at the WIPP) and were used to establish the original baseline for groundwater chemistry at each sampling location. The baseline sample sets are used to determine whether statistically significant changes 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, and total dissolved solids. These plots show the concentrations in the primary sample and the duplicate sample for all sampling rounds.

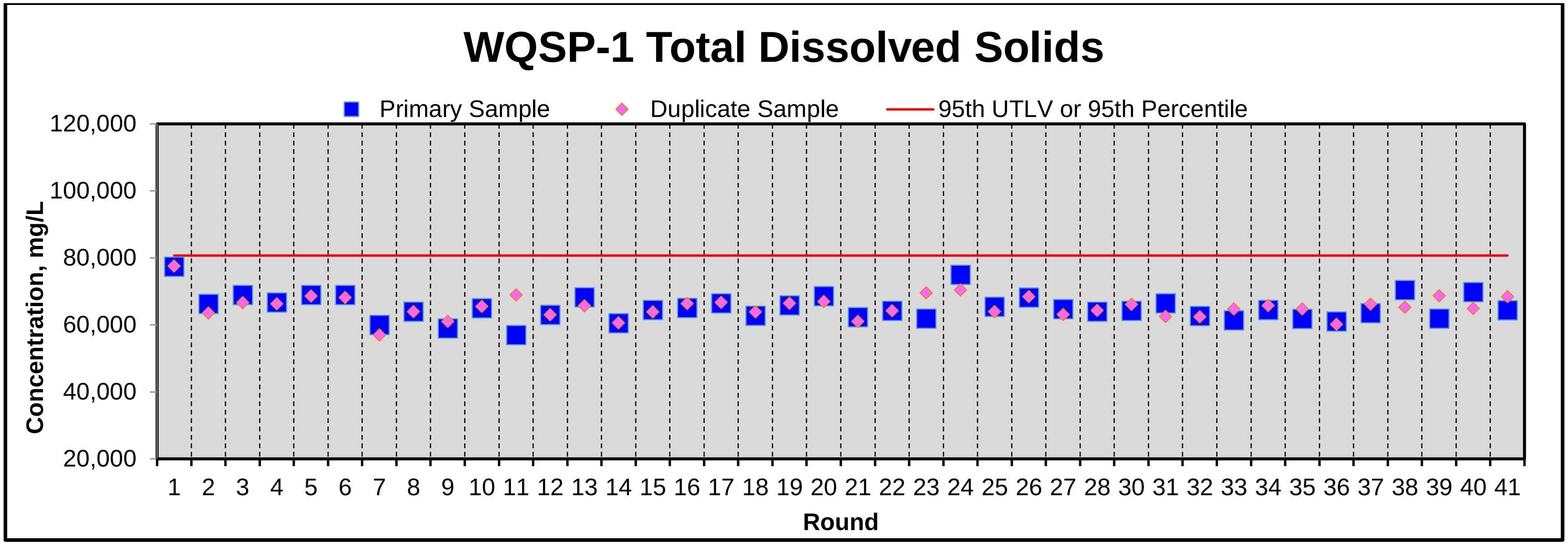
The 2019 laboratory analytical results were verified and validated in accordance with WIPP procedures and U.S. Environmental Protection Agency technical guidance. Sampling Round 41 samples were taken March through May 2019. See Appendix F for the concentrations of the target analytes in the Detection Monitoring Program wells.

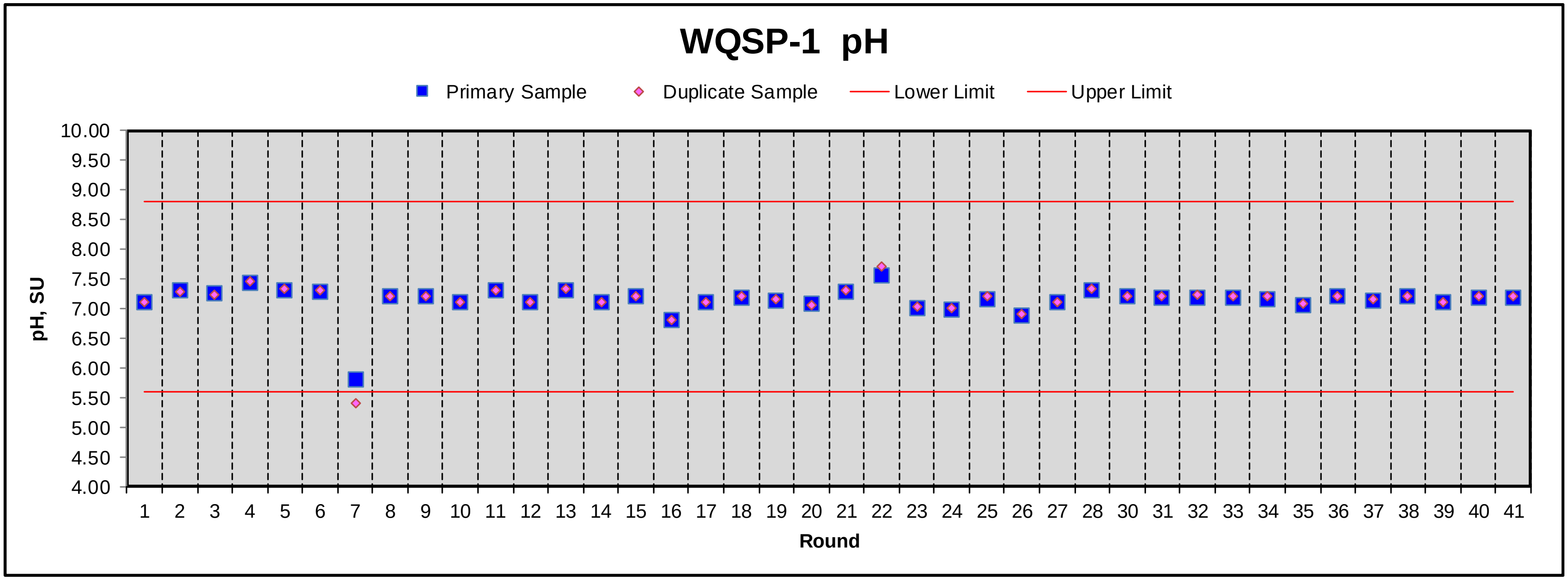

WQSP-1 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 30 31 32 33 34 35 36 37 38 39 40 41
Round

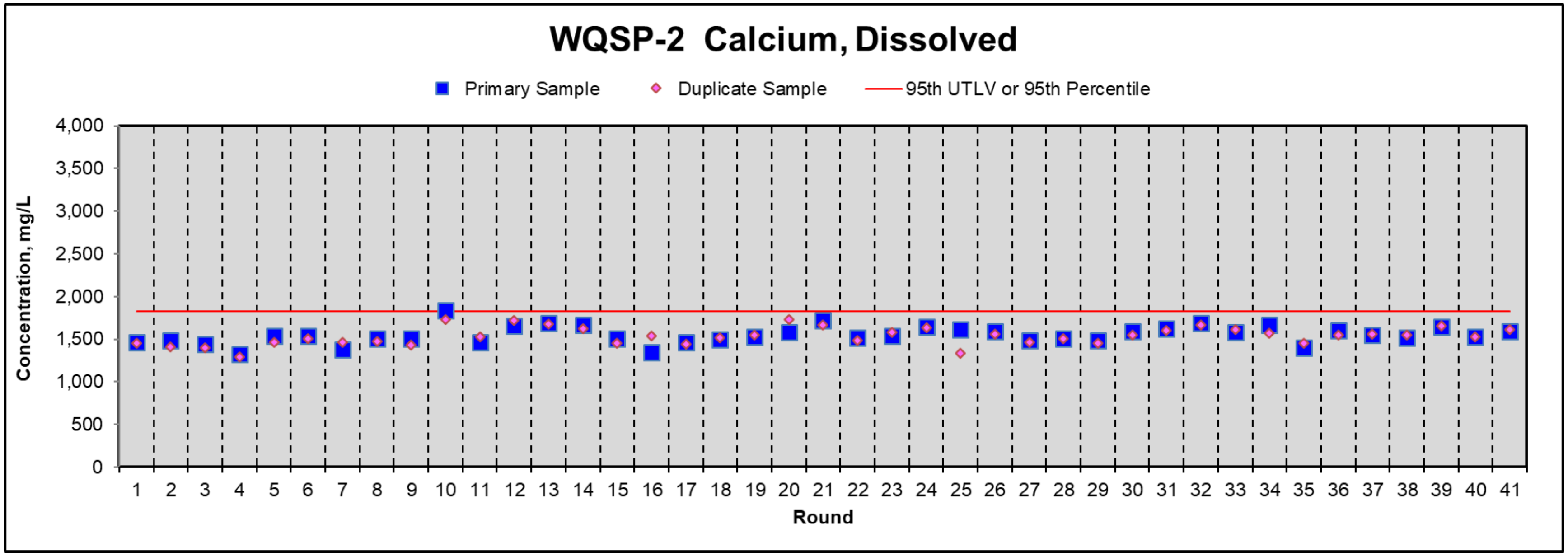

WQSP-1 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 30 31 32 33 34 35 36 37 38 39 40 41
Round

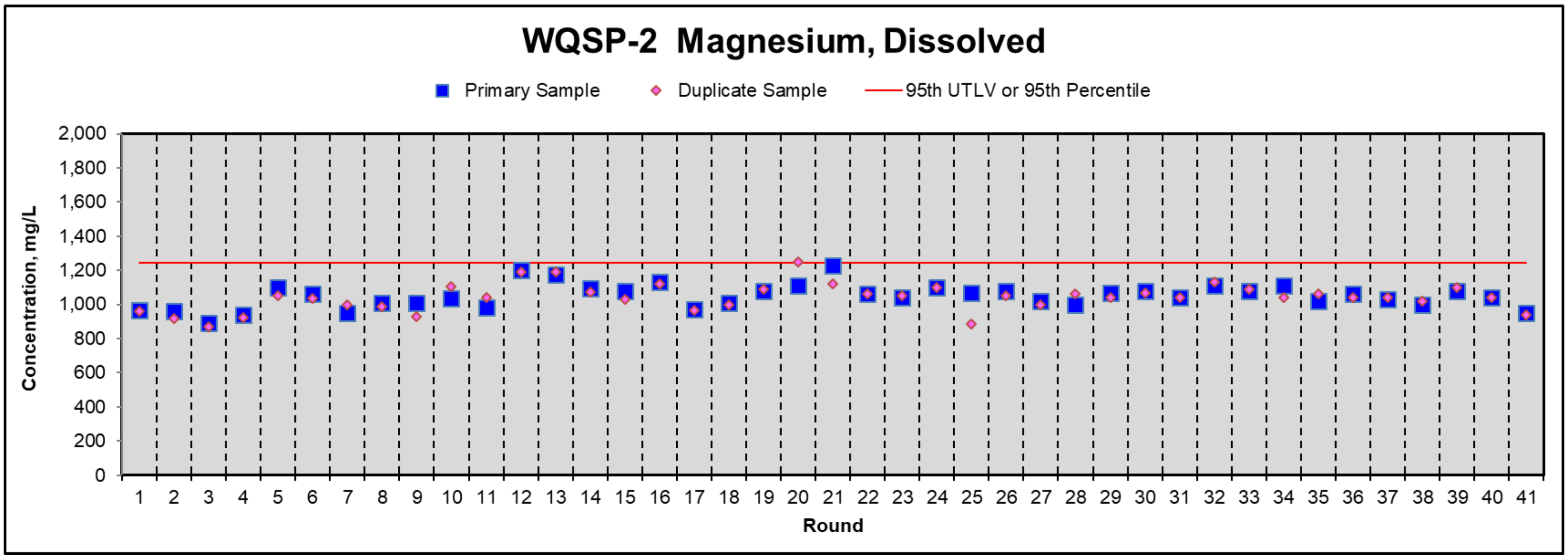

WQSP-1 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
1,400
1,200
1,000
800
600
400
200
0
Concentration, mg/L
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 30 31 32 33 34 35 36 37 38 39 40 41
Round

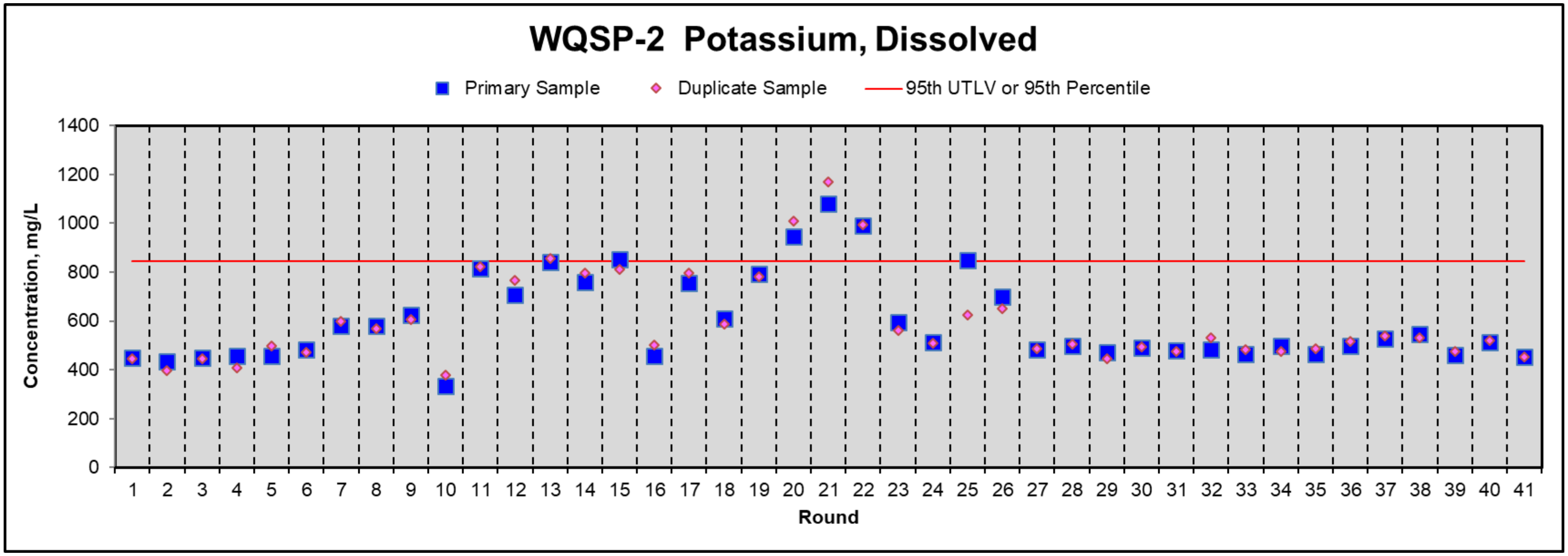

WQSP-1 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
50,000
47,500
45,000
42,500
40,000
37,500
35,000
32,500
30,000
27,500
25,000
Concentration, mg/L
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 30 31 32 33 34 35 36 37 38 39 40 41
Round

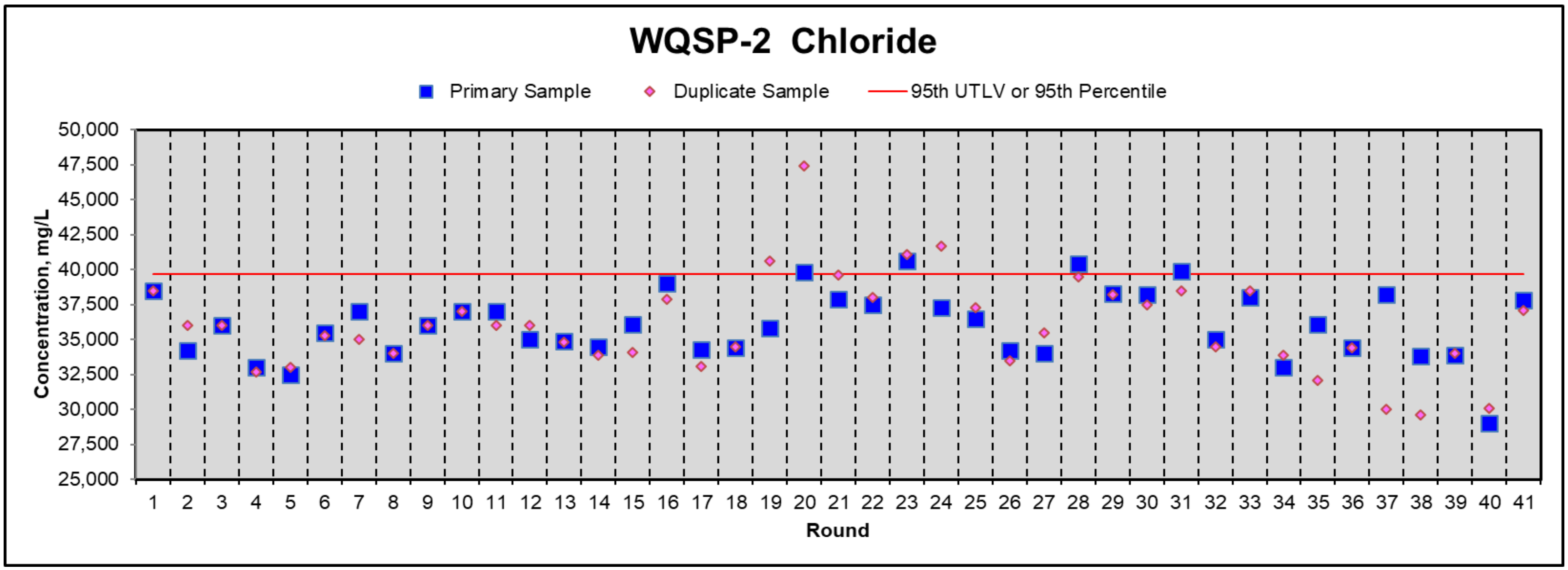

WQSP-1 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
120,000
100,000
80,000
60,000
40,000
20,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 30 31 32 33 34 35 36 37 38 39 40 41
Round

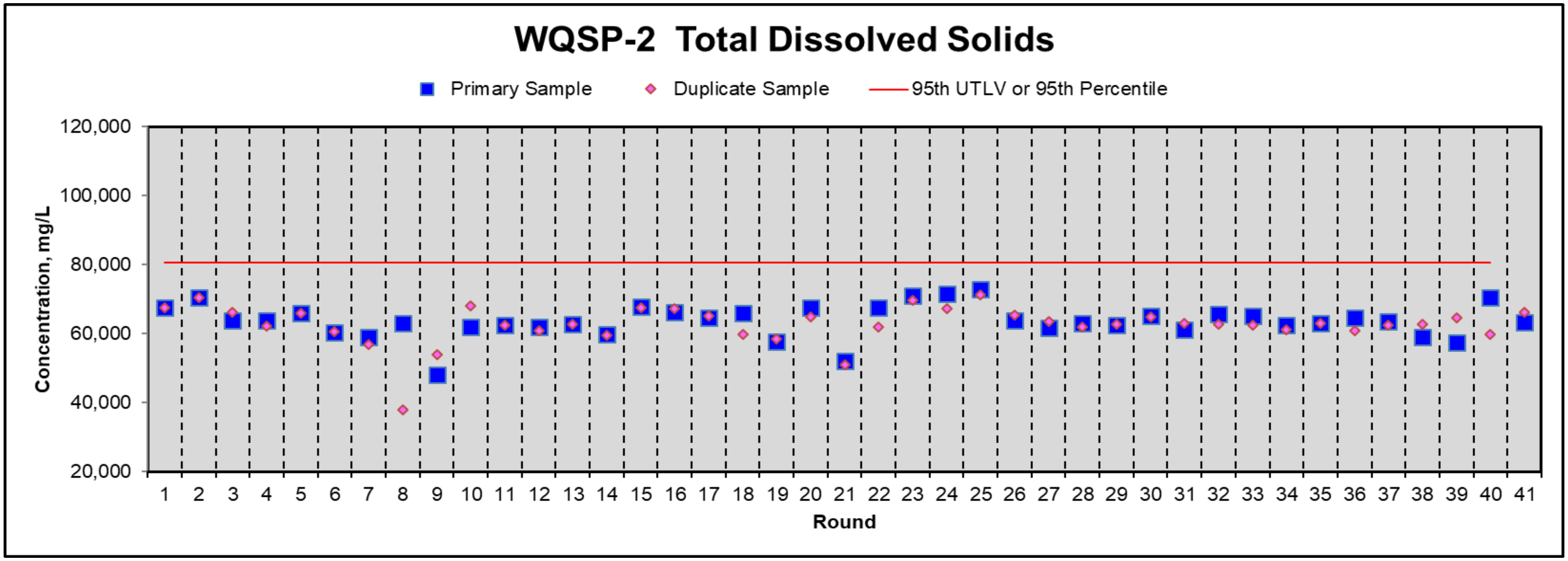

WQSP-1 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
10.00
9.50
9.00
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 30 31 32 33 34 35 36 37 38 39 40 41
Round

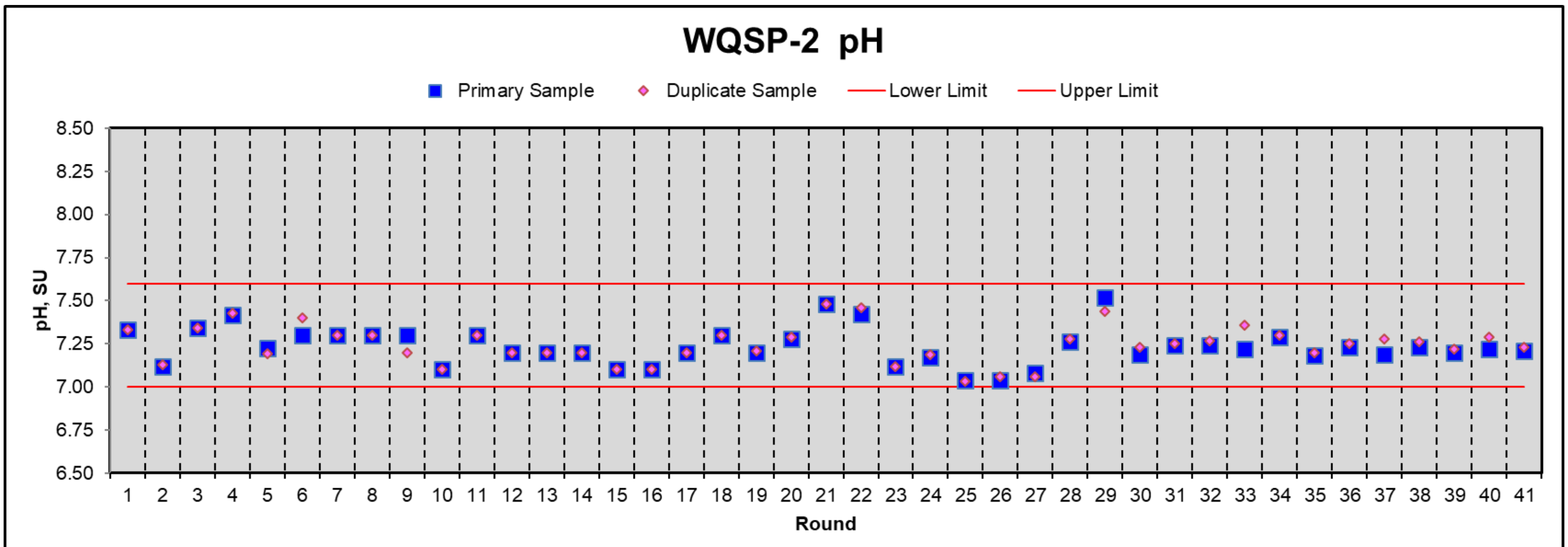

WQSP-2 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

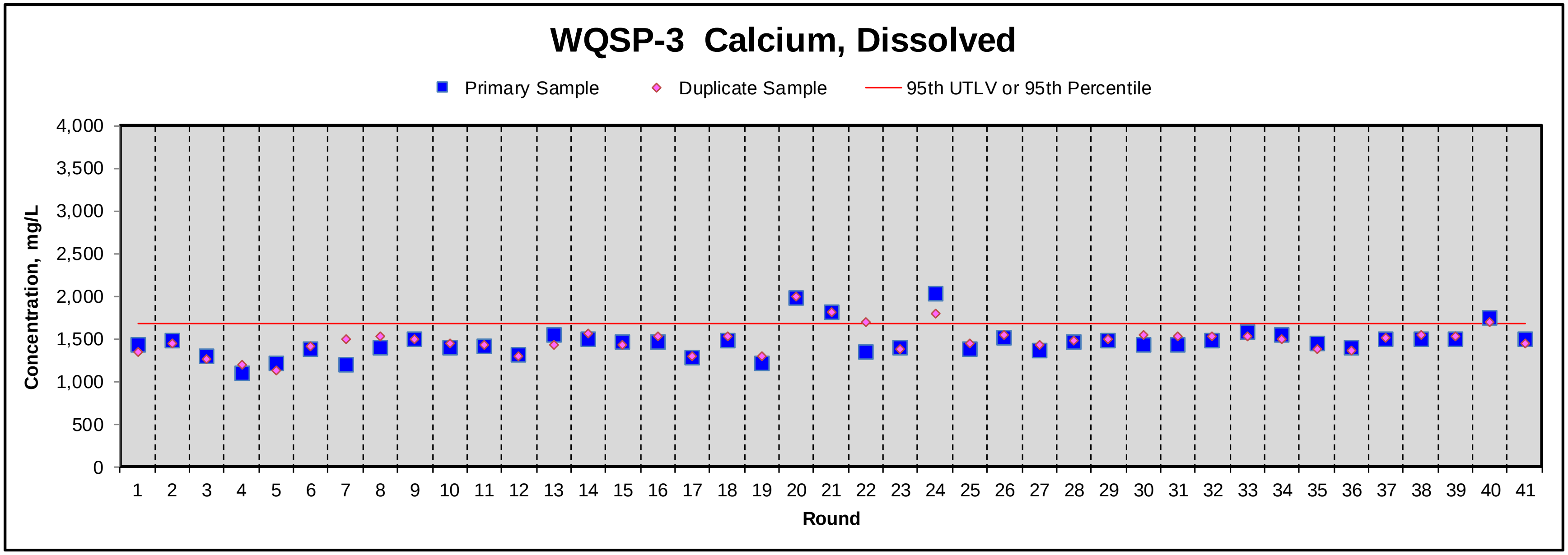

WQSP-2 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

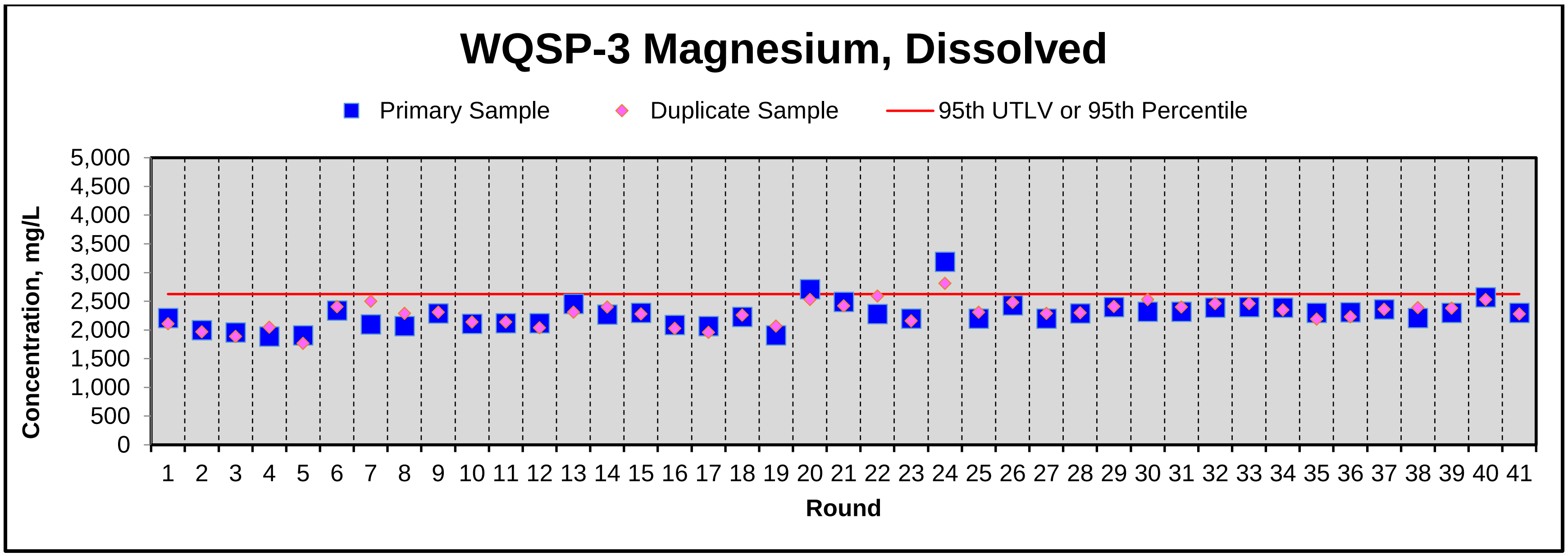

WQSP-2 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
0
200
400
600
800
1000
1200
1400
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

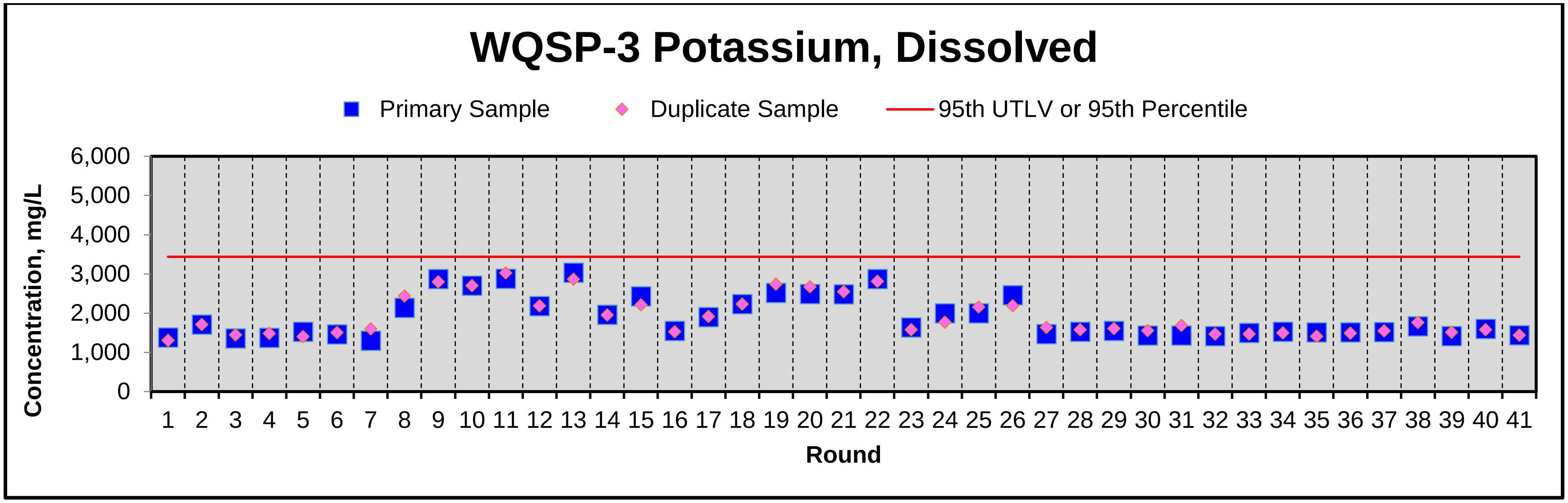

WQSP-2 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
25,000
27,500
30,000
32,500
35,000
37,500
40,000
42,500
45,000
47,500
50,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

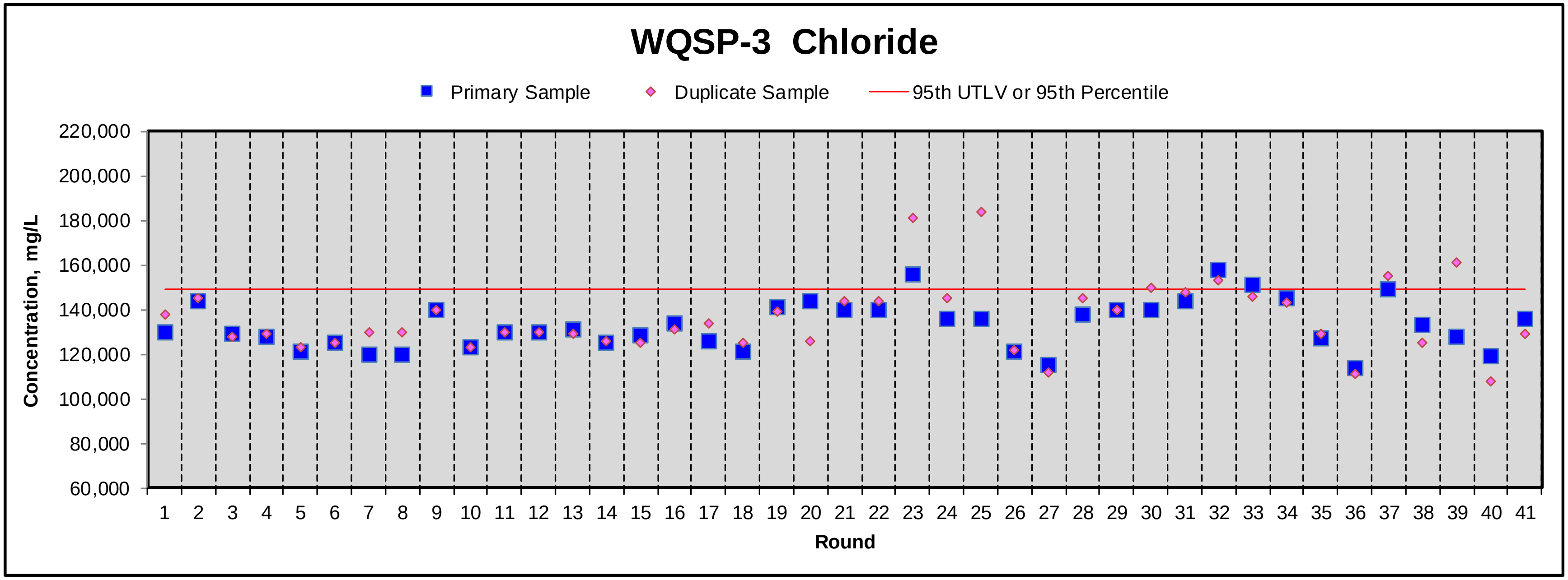

WQSP-2 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
120,000
100,000
80,000
60,000
40,000
20,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

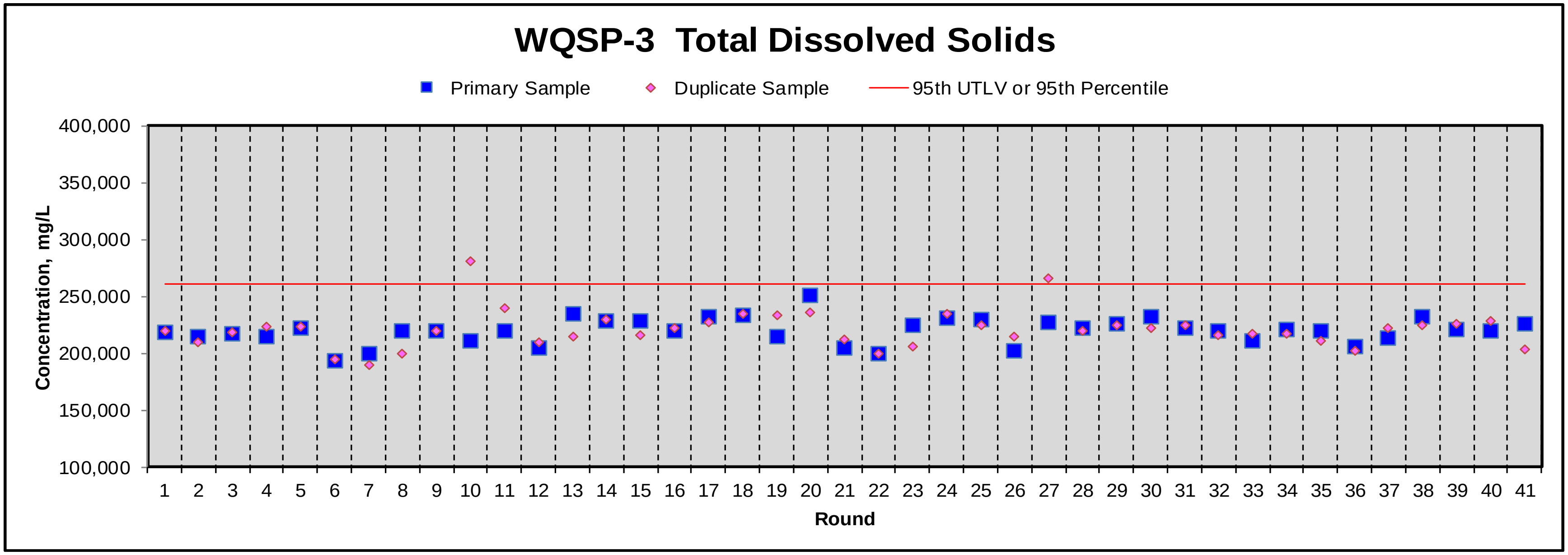

WQSP-2 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
8.50
8.25
8.00
7.75
7.50
7.25
7.00
6.75
6.50
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

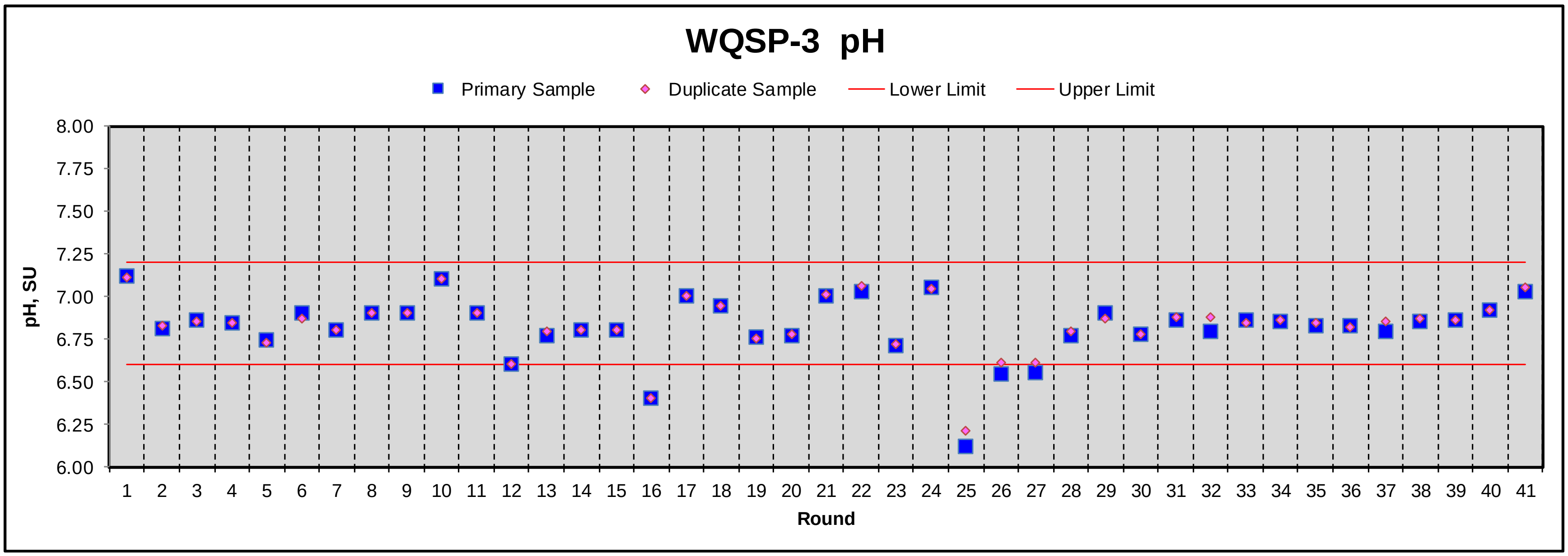

WQSP-3 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

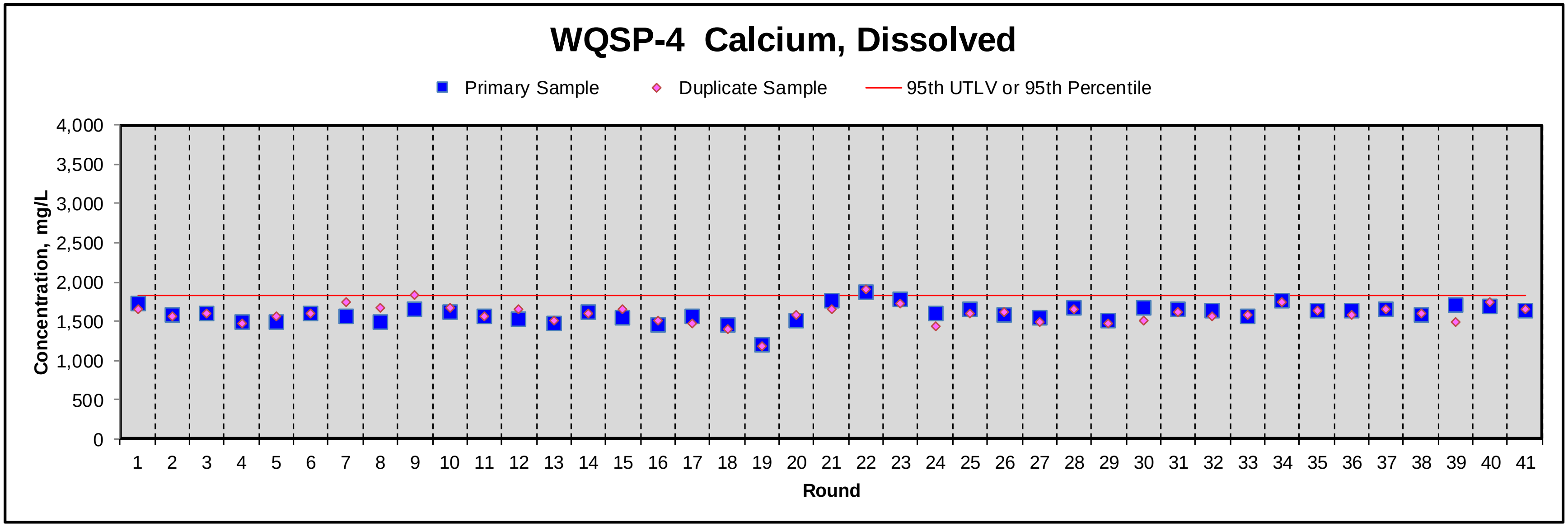

WQSP-3 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

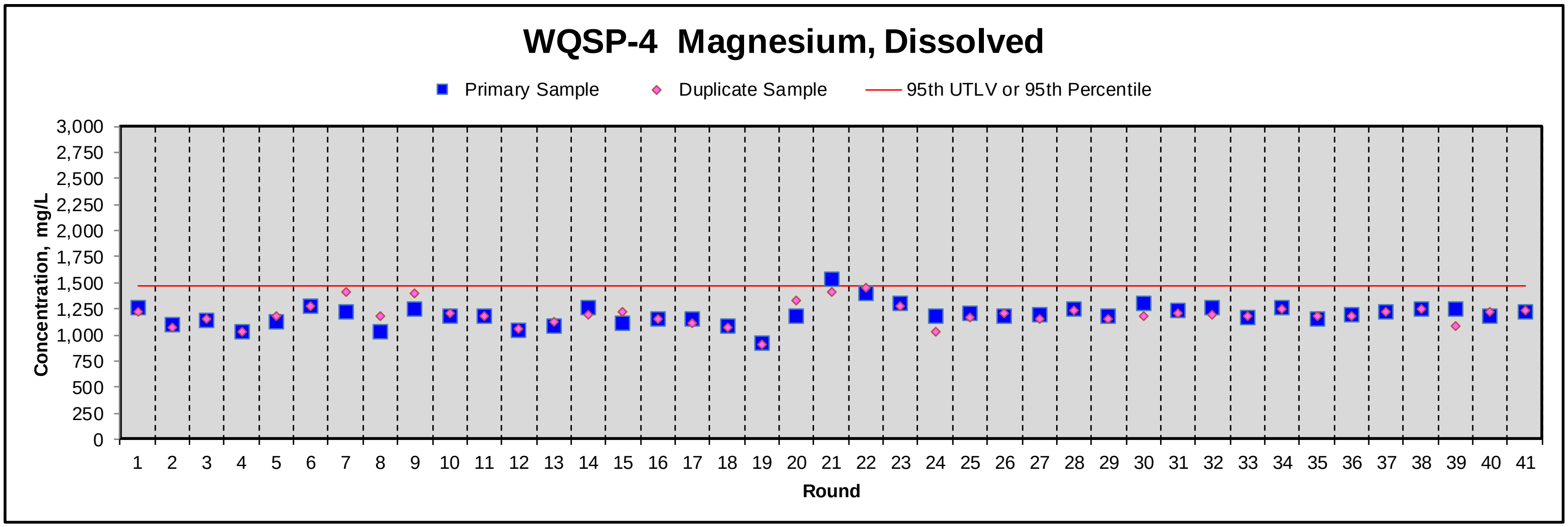

WQSP-3 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
6,000
5,000
4,000
3,000
2,000
1,000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

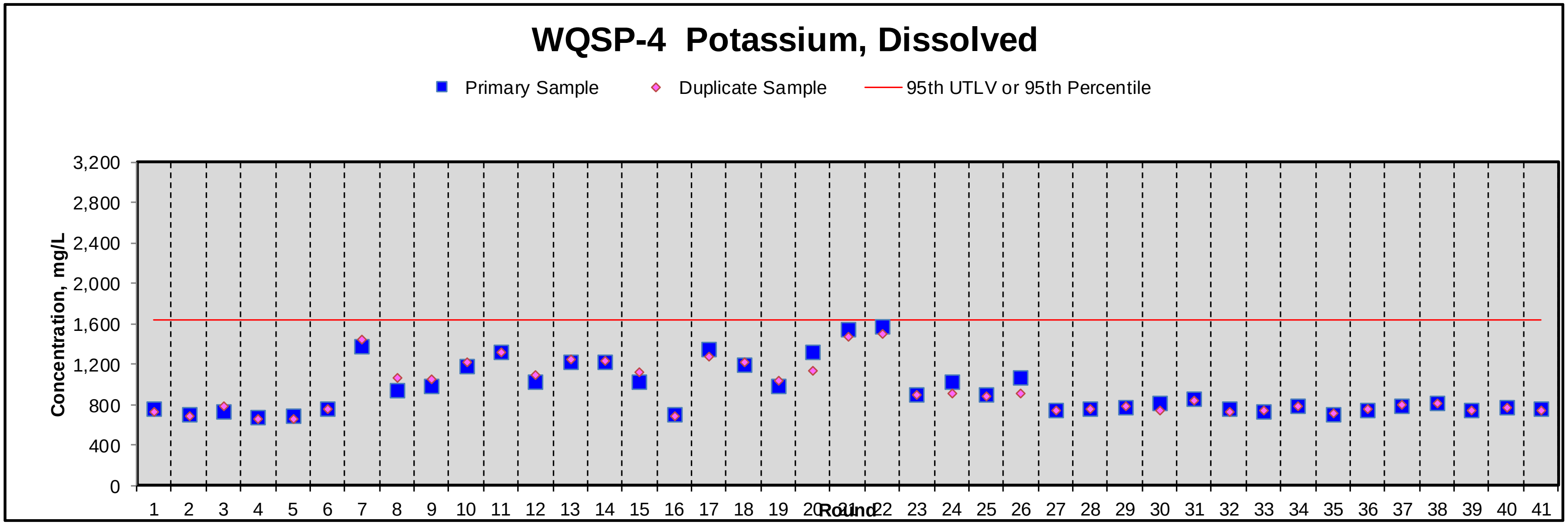

WQSP-3 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
220,000
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

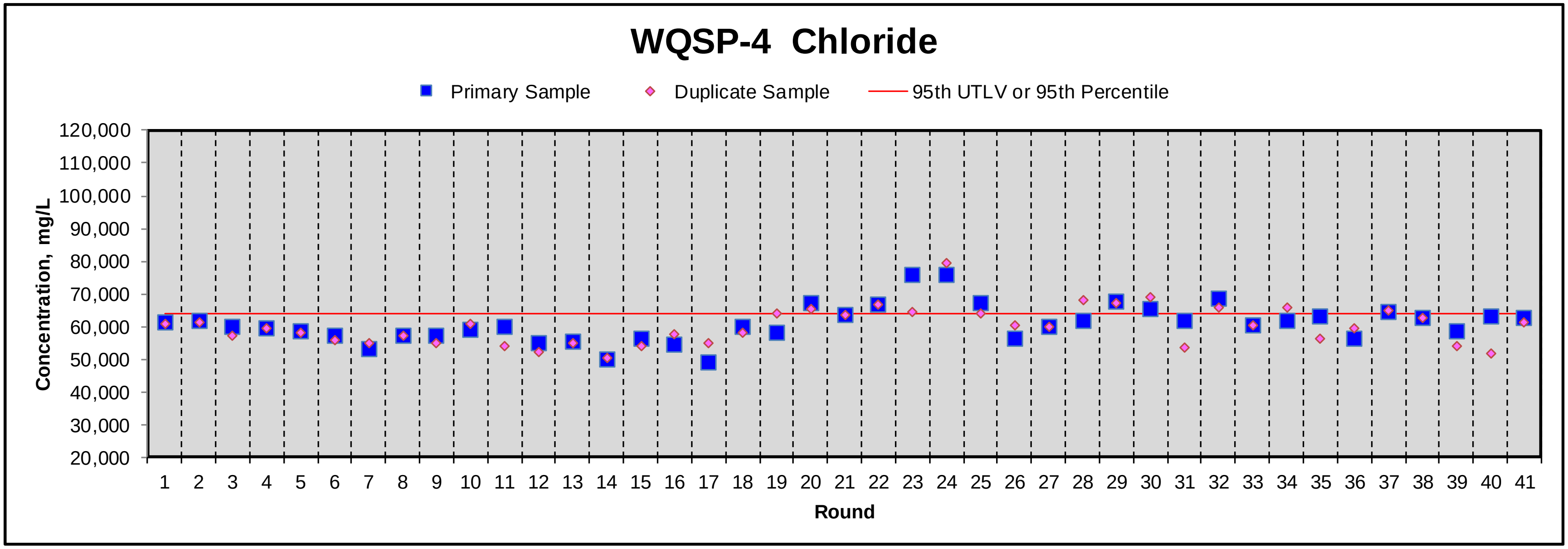

WQSP-3 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
400,000
350,000
300,000
250,000
200,000
150,000
100,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

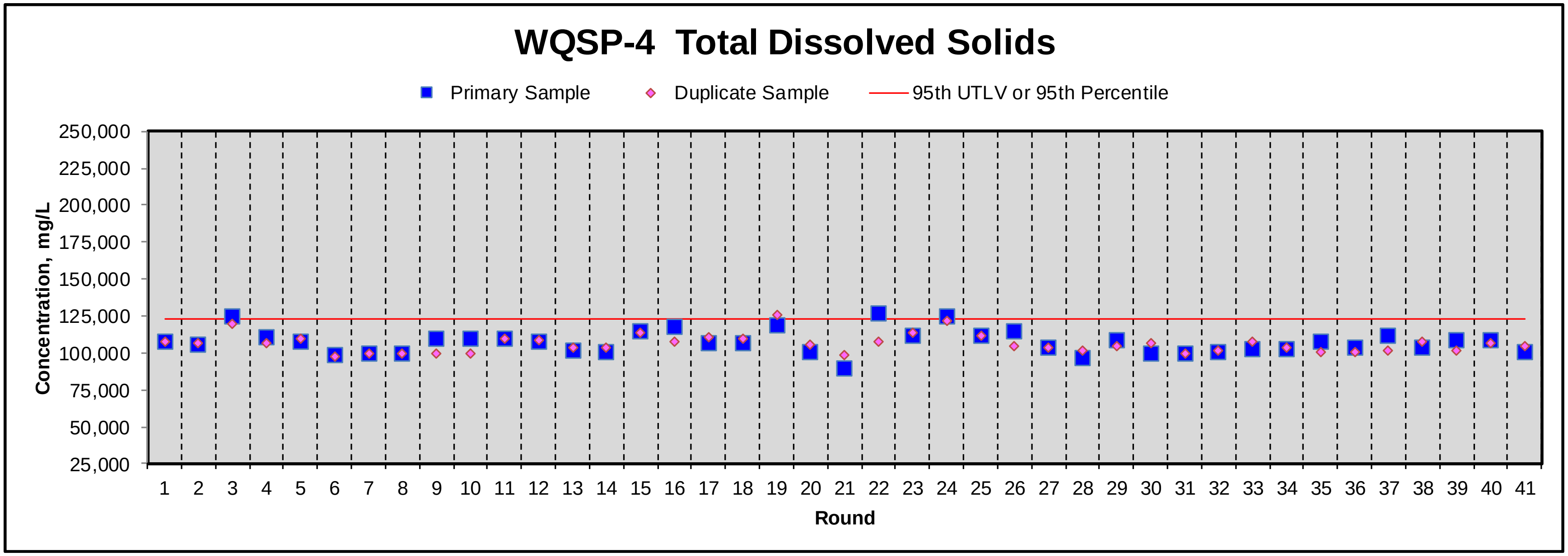

WQSP-3 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
8.00
7.75
7.50
7.25
7.00
6.75
6.50
6.25
6.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

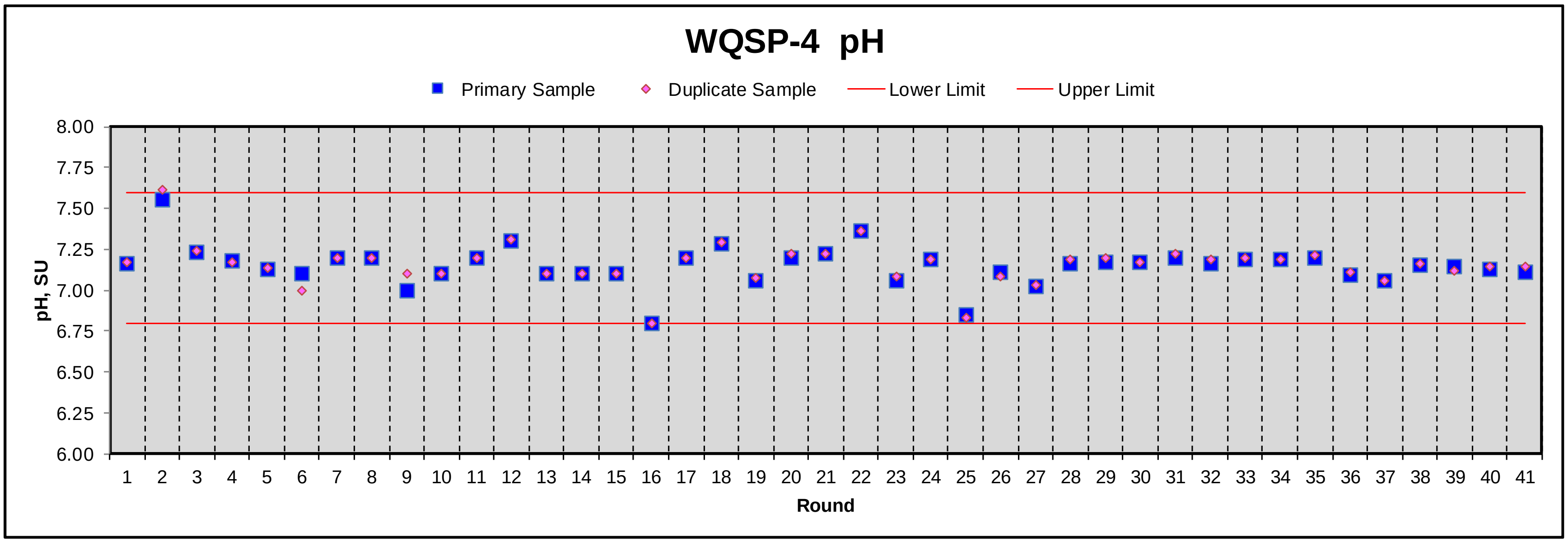

WQSP-4 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

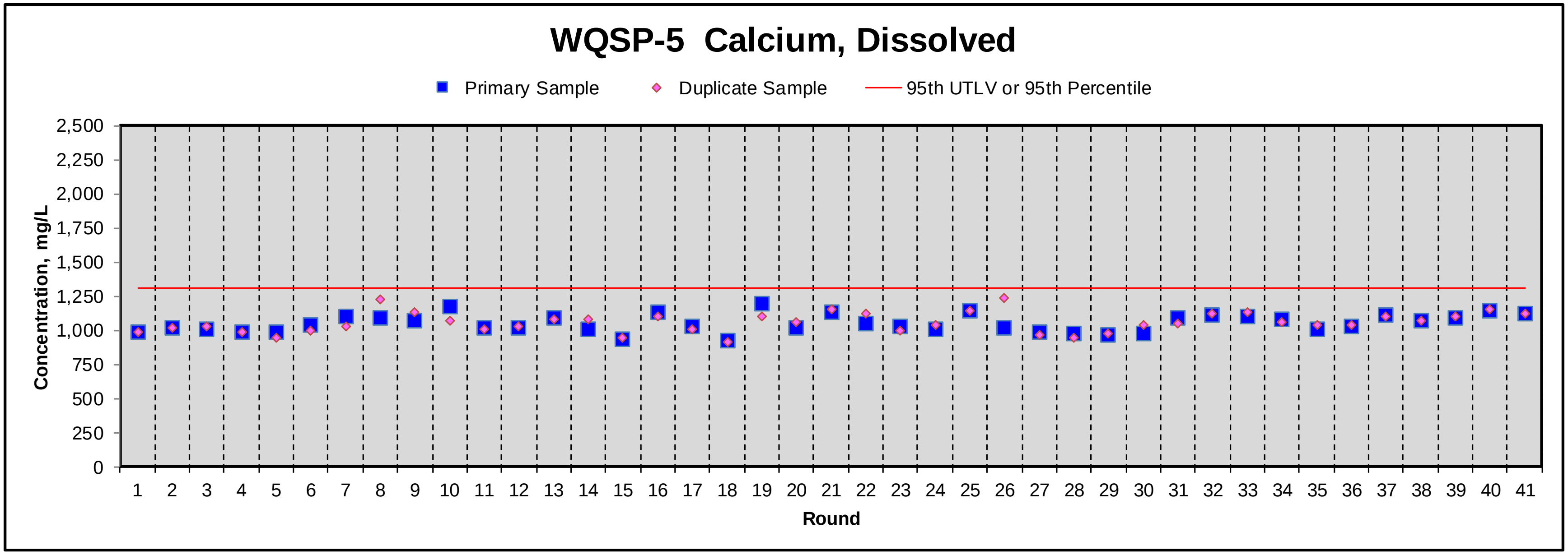

WQSP-4 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
3,000
2,750
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

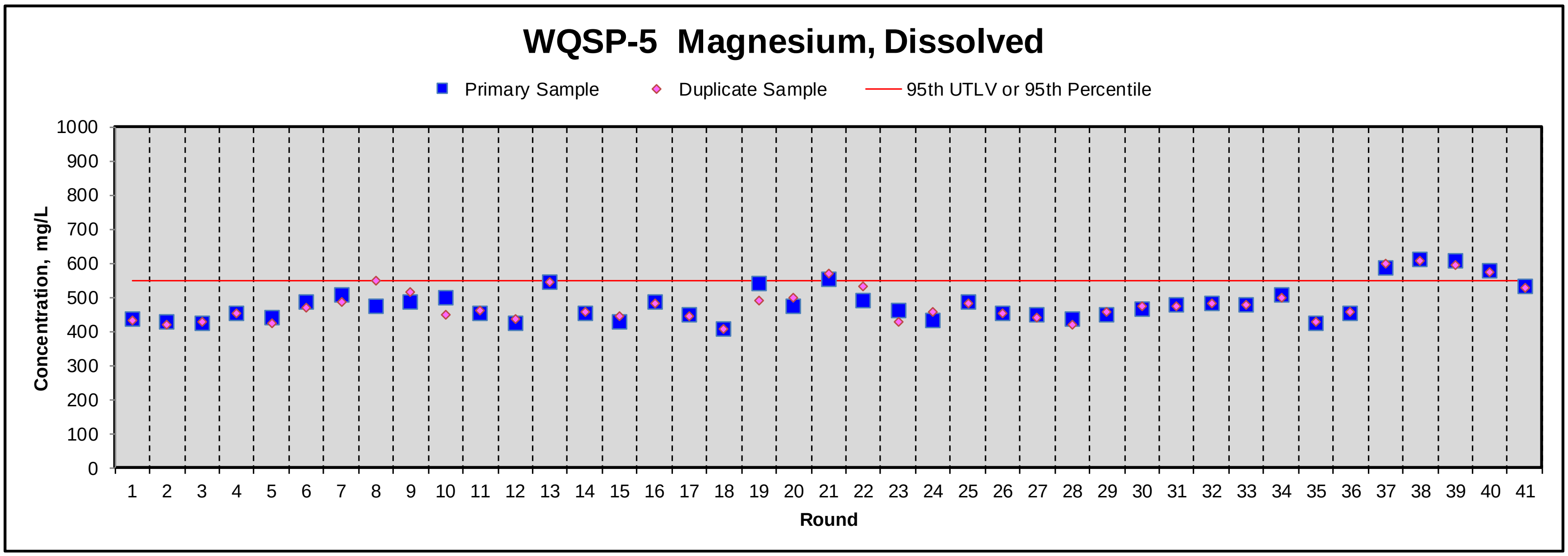

WQSP-4 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
3,200
2,800
2,400
2,000
1,600
1,200
800
400
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

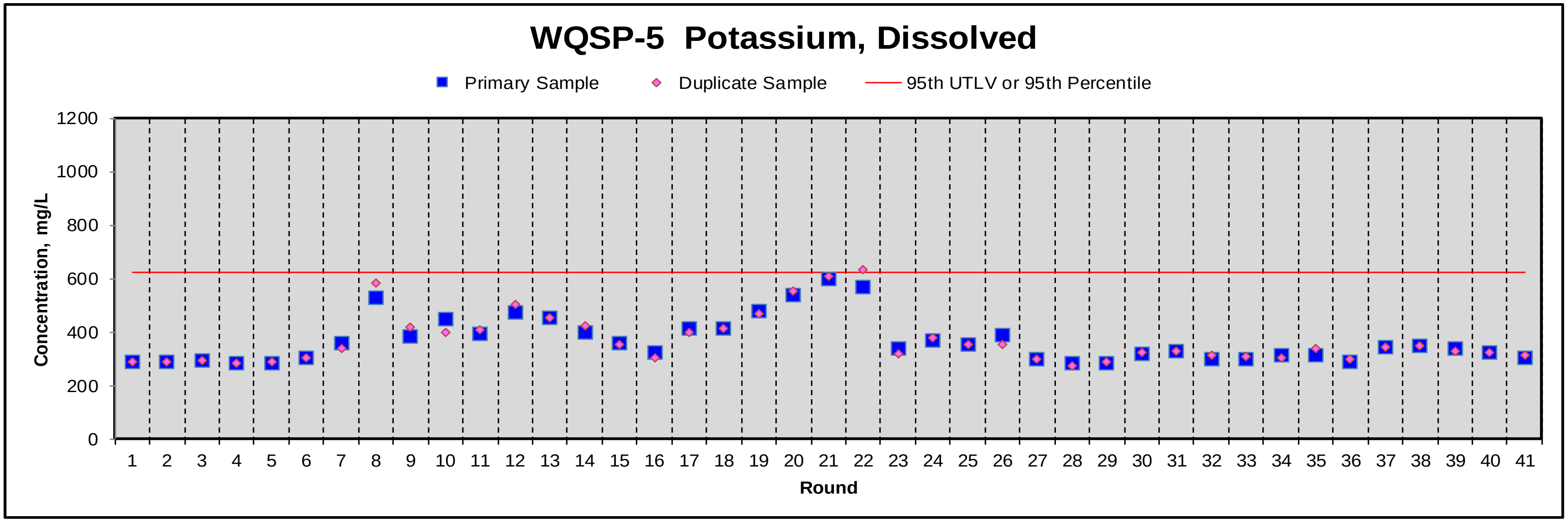

WQSP-4 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

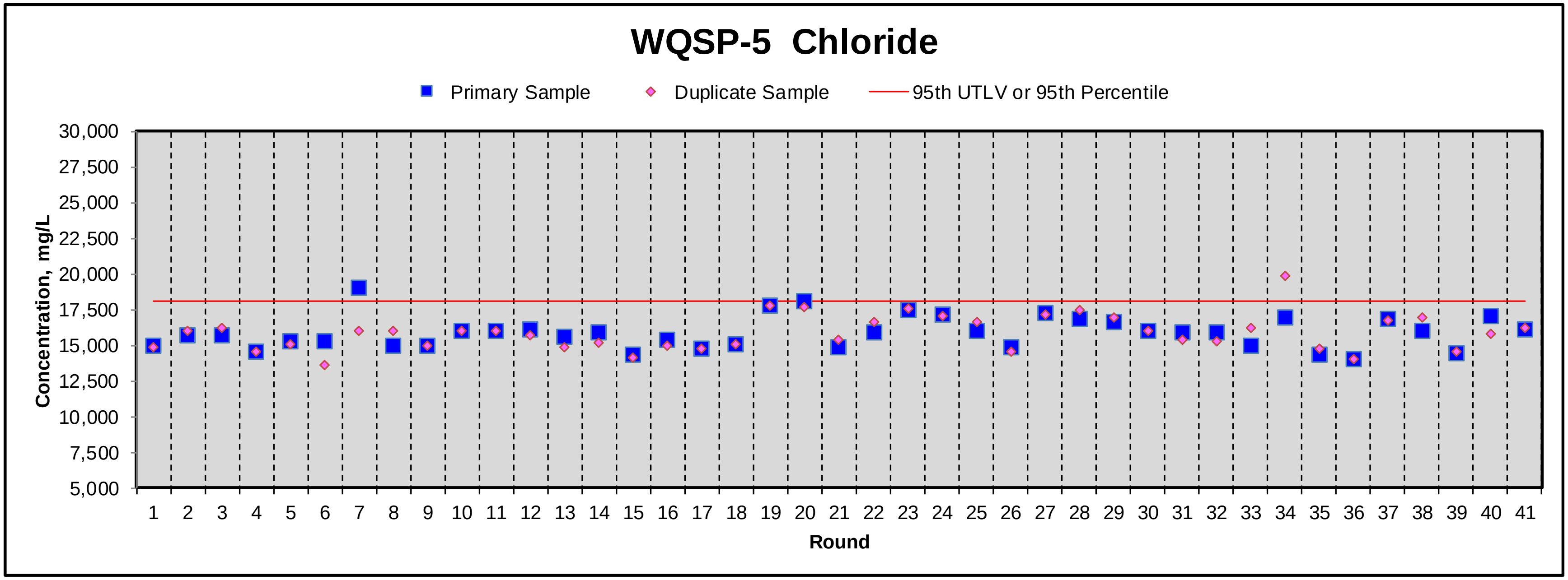

WQSP-4 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
250,000
225,000
200,000
175,000
150,000
125,000
100,000
75,000
50,000
25,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

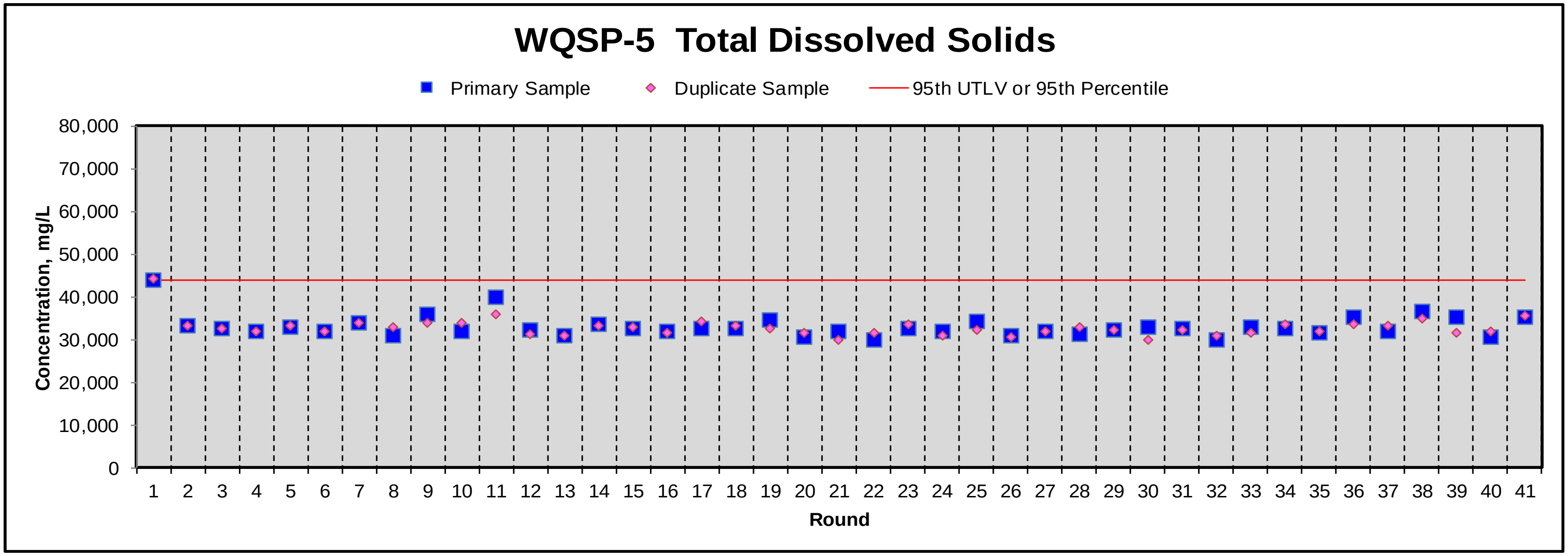

WQSP-4 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
8.00
7.75
7.50
7.25
7.00
6.75
6.50
6.25
6.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

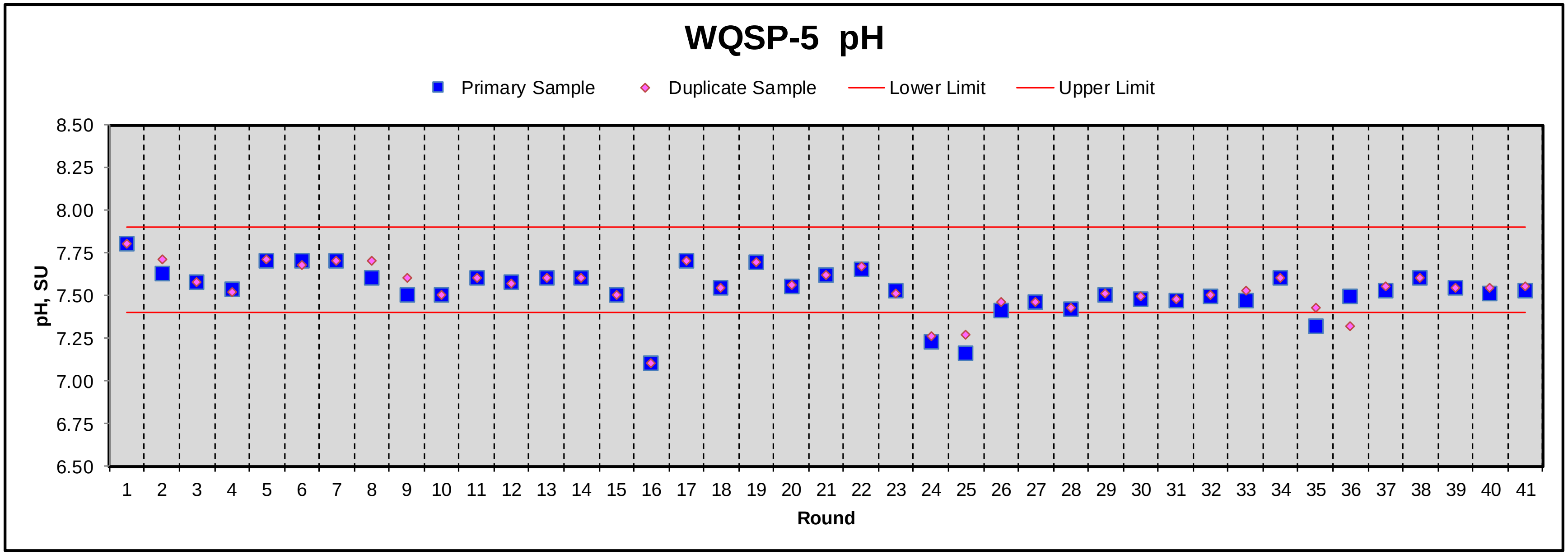

WQSP-5 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
0
250
500
750
1,000
1,250
1,500
1,750
2,000
2,250
2,500
Round
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41

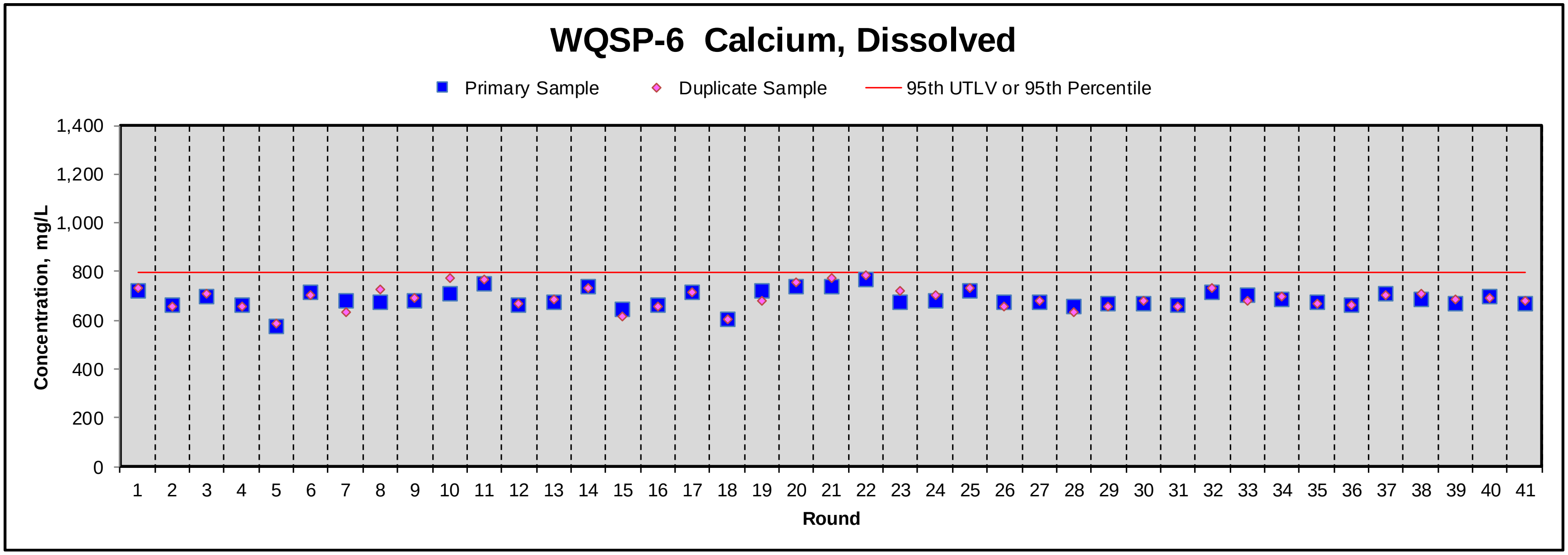

WQSP-5 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
0
100
200
300
400
500
600
700
800
900
1000
Round
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41

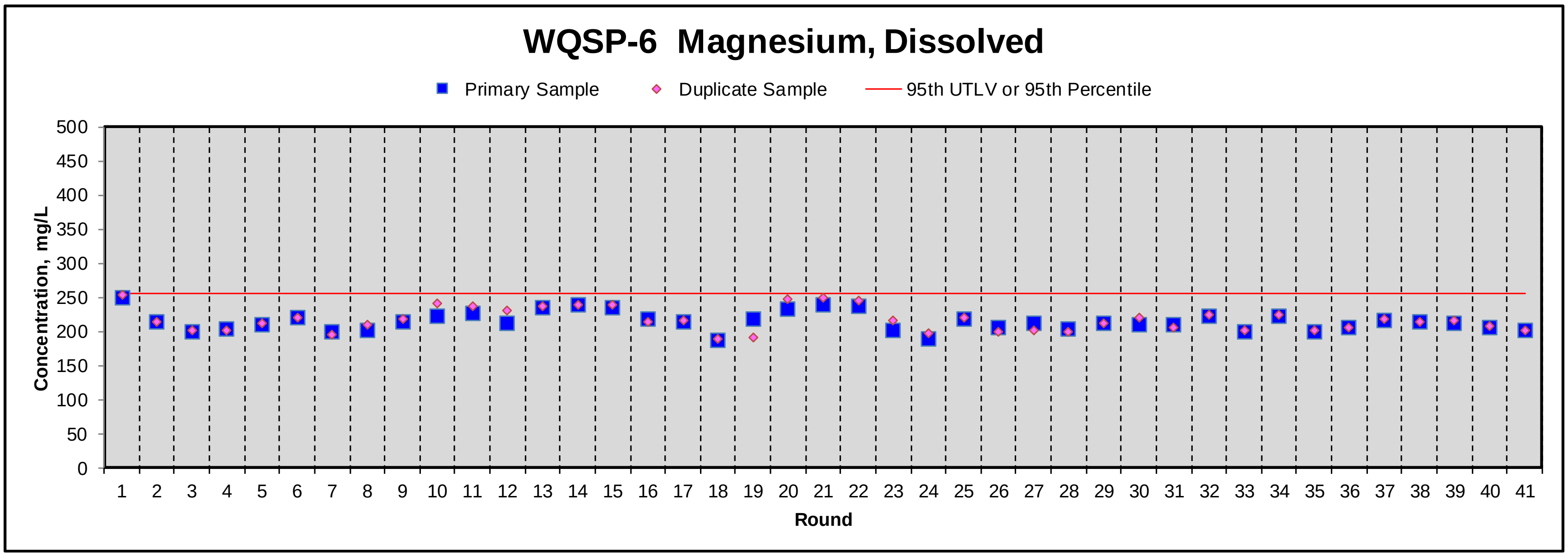

WQSP-5 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
0
200
400
600
800
1000
1200
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

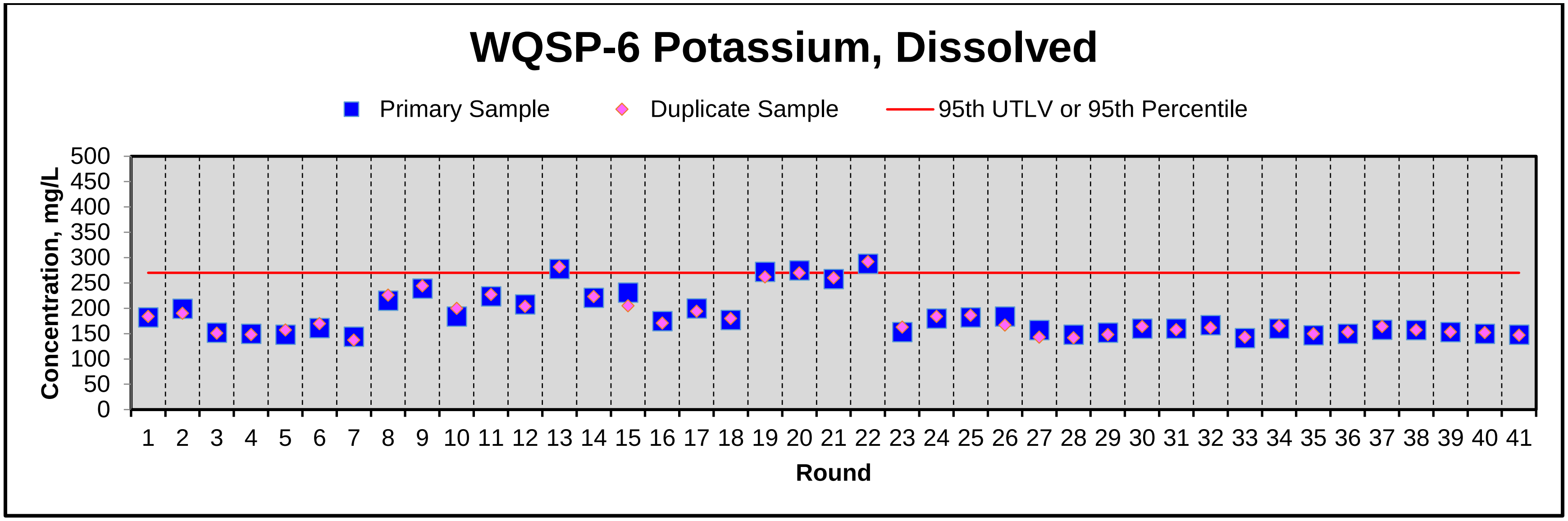

WQSP-5 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
5,000
7,500
10,000
12,500
15,000
17,500
20,000
22,500
25,000
27,500
30,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

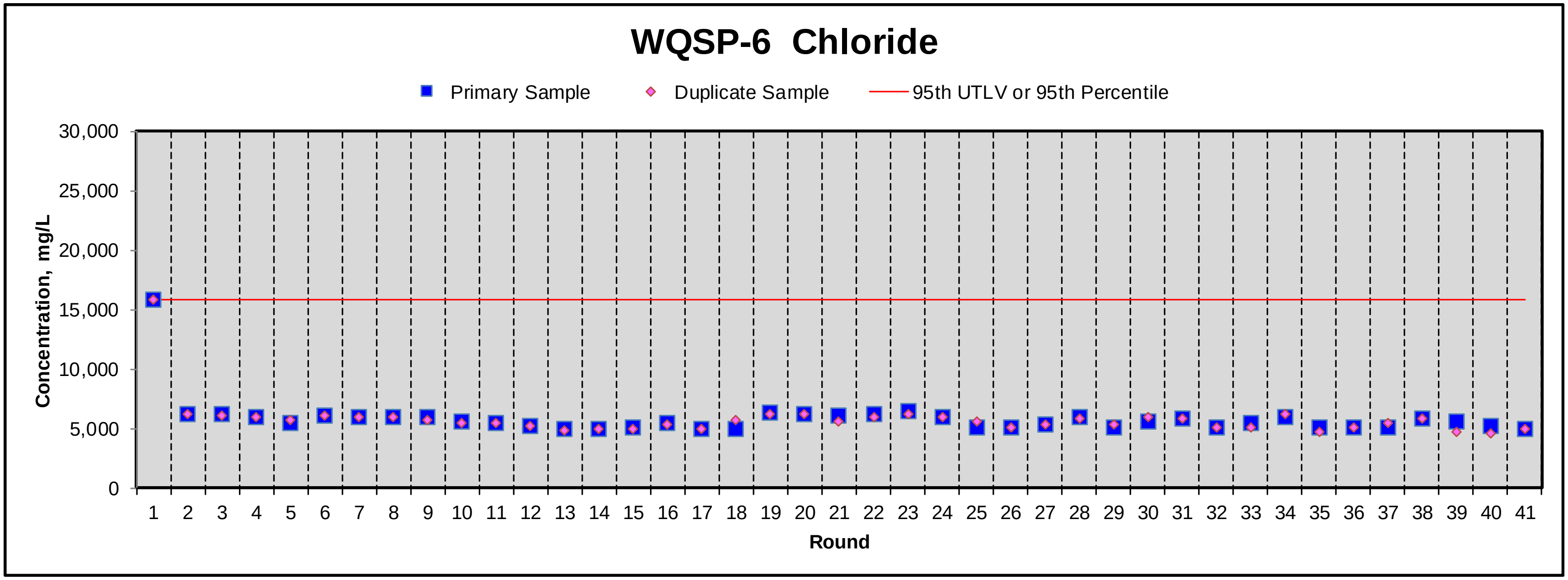

WQSP-5 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

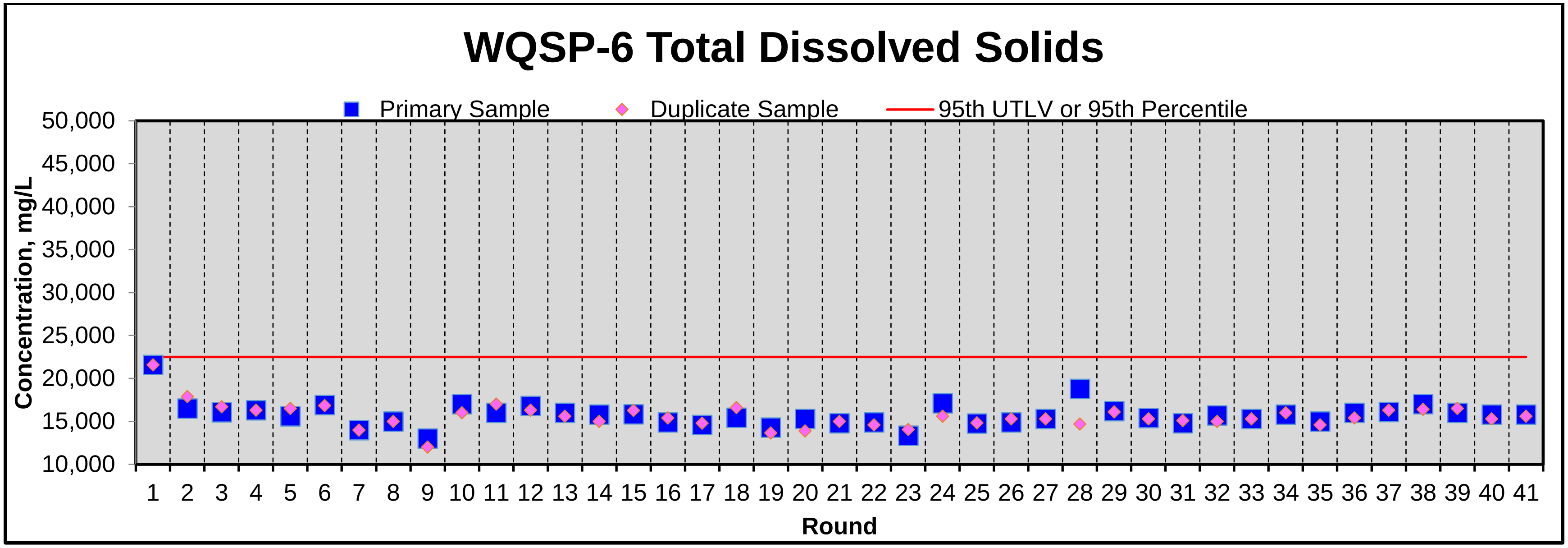

WQSP-5 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
8.50
8.25
8.00
7.75
7.50
7.25
7.00
6.75
6.50
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round

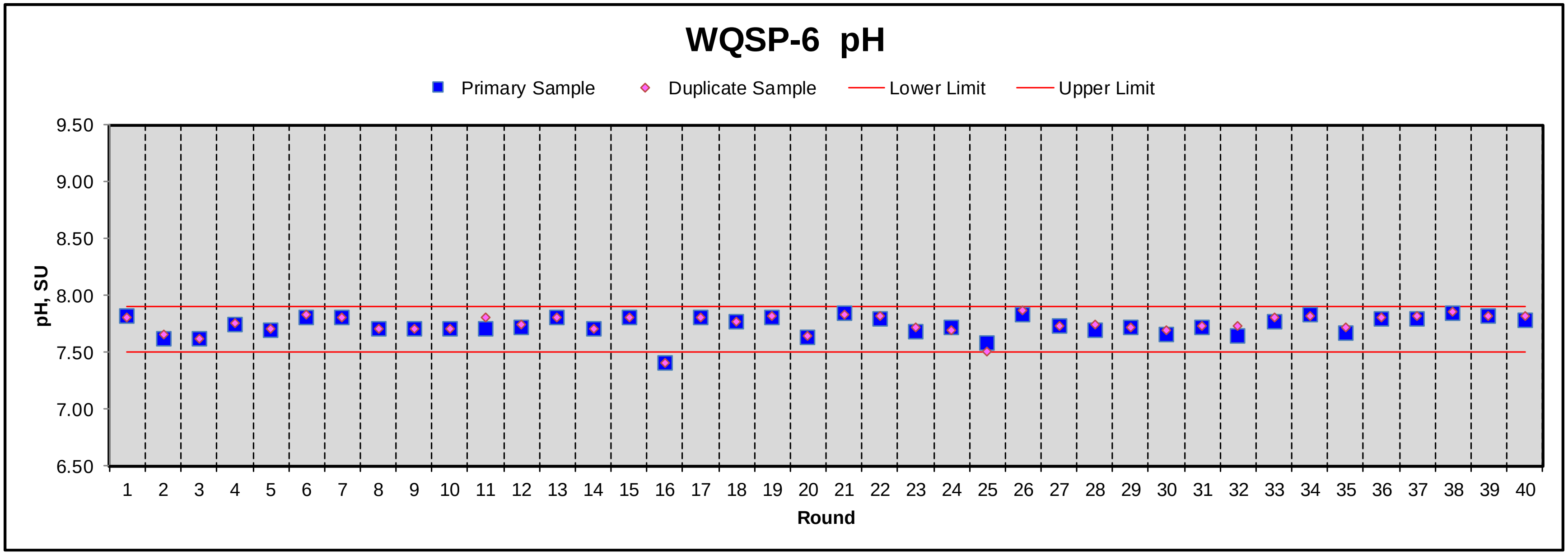

WQSP-6 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
0
200
400
600
800
1,000
1,200
1,400
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Round


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 40 41
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 40 41
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 40 41
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 40 41
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 40
Round

APPENDIX F – GROUNDWATER DATA TABLES

Table F.1 – Volatile Organic Compound and Semivolatile Organic Compound Results for Detection Monitoring Wells in 2019 (Round 41) 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 Culebra (Round 41)

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]	1.048	1.046	Normal	1.07	N/A
pH (standard units)	7.18	7.19	Lognormal	5.6 to 8.8	N/A
Spec. Conductance (μmhos/cm)	124,000	127,000	Lognormal	175,000	N/A
Total Dissolved Solids (mg/L)	64,400	68,400	Lognormal	80,700	N/A
Total Organic Carbon (mg/L)	0.28 J	0.22 J	Nonparametric	<5.0	N/A
Total Suspended Solids (mg/L)	ND	ND	Nonparametric	33.3	N/A
WQSP-1 Trace Metals					
Antimony (mg/L)	ND (0.0010)	ND (0.0010)	Nonparametric	0.33	0.33
Arsenic (mg/L)	ND (0.0010)	ND (0.001)	Nonparametric	<0.1	0.10
Barium (mg/L)	0.03 (0.02)	0.03 (0.02)	Nonparametric	<1.0	1.00
Beryllium (mg/L)	0.0012 J	0.0013 J	Nonparametric	<0.02	0.02
Cadmium (mg/L)	ND (0.0010)	ND (0.0010)	Nonparametric	<0.2	0.20
Chromium (mg/L)	ND (0.0011)	ND (0.0011)	Nonparametric	<0.5	0.50
Lead (mg/L)	ND (0.005)	ND (0.005)	Nonparametric	0.105	0.11
Mercury (mg/L)	ND (0.00019)	ND (0.00019)	Nonparametric	<0.002	0.002
Nickel (mg/L)	ND (0.003)	ND (0.003)	Nonparametric	0.490	0.50
Selenium (mg/L)	ND (0.0010)	ND (0.0010)	Nonparametric	0.150	0.15
Silver (mg/L)	0.023 (0.0018)	0.023 (0.0018)	Nonparametric	<0.5	0.50
Thallium (mg/L)	ND (0.0010)	ND (0.0010)	Nonparametric	0.98	1.00
Vanadium (mg/L)	0.009 J	0.01 J	Nonparametric	<0.1	0.10
WQSP-1 Major Cations, Dissolved					
Calcium (mg/L)	1,740	1,740	Normal	2,087	N/A
Magnesium (mg/L)	1,130	1,120	Normal	1,247	N/A
Potassium (mg/L)	481	488	Lognormal	799	N/A
WQSP-1 Major Anions					
Chloride (mg/L)	36,800	38,500	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]	1.043	1.041	Lognormal	1.06	N/A
pH (standard units)	7.21	7.23	Normal	7.0 to 7.6	N/A
Spec. Conductance (μmhos/cm)	120,000	120,000	Lognormal	124,000	N/A
Total Dissolved Solids (mg/L)	63,300	66,100	Normal	80,500	N/A
Total Organic Carbon (mg/L)	0.21 J	0.23 J	Nonparametric	7.97	N/A
Total Suspended Solids (mg/L)	41.0	**43.0**	Nonparametric	**43.0**	N/A
WQSP-2 Trace Metals					
Antimony (mg/L)	ND (0.0030)	ND (0.0030)	Nonparametric	<0.5	0.50
Arsenic (mg/L)	ND (0.0030)	ND (0.0030)	Nonparametric	0.062	0.06
Barium (mg/L)	0.025 J (0.20)	0.025 J (0.20)	Nonparametric	<1.0	1.00
Beryllium (mg/L)	0.0017 J	0.0015 J	Nonparametric	<1.0	1.00
Cadmium (mg/L)	ND (0.0028)	ND (0.0028)	Nonparametric	<0.5	0.50
Chromium (mg/L)	ND (0.004)	ND (0.004)	Nonparametric	<0.5	0.50
Lead (mg/L)	ND (0.017)	ND (0.017)	Nonparametric	0.163	0.17
Mercury (mg/L)	ND (0.00004)	ND (0.00004)	Nonparametric	<0.002	0.002
Nickel (mg/L)	ND (0.014)	ND (0.014)	Nonparametric	0.37	0.50
Selenium (mg/L)	ND (0.0030)	ND (0.0030)	Nonparametric	0.150	0.15
Silver (mg/L)	0.023 J	0.021 J	Nonparametric	<0.5	0.50
Thallium (mg/L)	ND (0.0030)	ND (0.0030)	Nonparametric	0.980	1.00
Vanadium (mg/L)	0.031 J	0.029 J	Nonparametric	<0.1	0.10
WQSP-2 Major Cations, Dissolved					
Calcium (mg/L)	1,590	1,610	Lognormal	1,827	N/A
Magnesium (mg/L)	950	941	Normal	1,244	N/A
Potassium (mg/L)	454	452	Lognormal	845	N/A
WQSP-2 Major Anions					
Chloride (mg/L)	37,800	37,100	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]	1.141	1.143	Normal	1.17	N/A
pH (standard units)	7.03	7.05	Lognormal	6.6 to 7.2	N/A
Spec. Conductance (μmhos/cm)	380,000	380,000	Normal	517,000	N/A
Total Dissolved Solids (mg/L)	226,000	203,000	Lognormal	261,000	N/A
Total Organic Carbon (mg/L)	2.82	2.57	Nonparametric	<5.0	N/A
Total Suspended Solids (mg/L)	**162**	**203**	Nonparametric	**107**	N/A
WQSP-3 Trace Metals					
Antimony (mg/L)	ND (0.005)	ND (0.005)	Nonparametric	<1.0	1.00
Arsenic (mg/L)	ND (0.005)	ND (0.005)	Nonparametric	<1.0	0.21
Barium (mg/L)	0.052 J	0.048 J	Nonparametric	<1.0	1.00
Beryllium (mg/L)	0.00142 J	ND (0.0013)	Nonparametric	<0.1	0.10
Cadmium (mg/L)	ND (0.0099)	ND (0.0099)	Nonparametric	<0.5	0.50
Chromium (mg/L)	ND (0.0054)	ND (0.0054)	Nonparametric	<2.0	2.00
Lead (mg/L)	ND (0.050)	ND (0.050)	Nonparametric	0.8	0.80
Mercury (mg/L)	ND (0.00019)	ND (0.00019)	Nonparametric	<0.002	0.002
Nickel (mg/L)	0.016 J	ND (0.014)	Nonparametric	<5.0	5.00
Selenium (mg/L)	ND (0.005)	ND (0.005)	Nonparametric	<2.0	2.00
Silver (mg/L)	0.028 J	0.025 J	Nonparametric	0.31	0.31
Thallium (mg/L)	ND (0.005)	ND (0.005)	Nonparametric	5.8	5.80
Vanadium (mg/L)	0.014 J	0.011 J	Nonparametric	<5.0	5.00
WQSP-3 Major Cations, Dissolved					
Calcium (mg/L)	1,490	1,440	Normal	1,680	N/A
Magnesium (mg/L)	2,300	2,280	Lognormal	2,625	N/A
Potassium (mg/L)	1,440	1,440	Lognormal	3,438	N/A
WQSP-3 Major Anions					
Chloride (mg/L)	136,000	129,000	Lognormal	149,100	N/A

[a,b] 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]	1.070	1.067	Lognormal	1.09	N/A
pH (standard units)	7.11	7.14	Lognormal	6.8 to 7.6	N/A
Spec. Conductance (μmhos/cm)	192,000	194,000	Lognormal	319,800	N/A
Total Dissolved Solids (mg/L)	101,000	105,000	Normal	123,500	N/A
Total Organic Carbon (mg/L)	ND	0.79 J	Nonparametric	<5.0	N/A
Total Suspended Solids (mg/L)	49.0	**73.0**	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)	0.025 J	0.025 J	Nonparametric	1.00	1.00
Beryllium (mg/L)	0.0024 J	0.0028 J	Nonparametric	0.25	0.25
Cadmium (mg/L)	ND (0.0028)	ND (0.0028)	Nonparametric	<0.5	0.50
Chromium (mg/L)	ND (0.0043)	ND (0.0043)	Nonparametric	<2.0	2.00
Lead (mg/L)	ND (0.017)	ND (0.017)	Nonparametric	0.525	0.53
Mercury (mg/L)	ND (3.75E-05)	ND (3.75E-05)	Nonparametric	<0.002	0.002
Nickel (mg/L)	ND (0.014)	0.03 J	Nonparametric	<5.0	5.00
Selenium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	2.009	2.00
Silver (mg/L)	0.025 J	0.025 J	Nonparametric	0.519	0.52
Thallium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	1.00	1.00
Vanadium (mg/L)	ND (0.004)	ND (0.004)	Nonparametric	<5.0	5.00
WQSP-4 Major Cations, Dissolved					
Calcium (mg/L)	1,630	1,650	Lognormal	1,834	N/A
Magnesium (mg/L)	1,230	1,240	Lognormal	1,472	N/A
Potassium (mg/L)	752	750	Lognormal	1,648	N/A
WQSP-4 Major Anions					
Chloride (mg/L)	62,600	61,300	Normal	63,960	N/A

[a,b] 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	1.025	Normal	1.04	N/A
pH (standard units)	7.53	7.55	Normal	7.4 to 7.9	N/A
Spec. Conductance (μmhos/cm)	63,000	63,000	Lognormal	67,700	N/A
Total Dissolved Solids (mg/L)	35,100	35,500	Nonparametric	43,950	N/A
Total Organic Carbon (mg/L)	0.27 J	0.25 J	Nonparametric	<5.0	N/A
Total Suspended Solids (mg/L)	**12.0**	9.00	Nonparametric	**<10**	N/A
WQSP-5 Total Trace Metals					
Antimony (mg/L)	ND (0.004)	ND (0.004)	Nonparametric	0.073	0.07
Arsenic (mg/L)	ND (0.004)	ND (0.004)	Nonparametric	<0.5	0.50
Barium (mg/L)	0.013 J	0.015 J	Nonparametric	<1.0	1.00
Beryllium (mg/L)	0.0034 J	0.0038 J	Nonparametric	<0.02	0.02
Cadmium (mg/L)	ND (0.0050)	ND (0.0050)	Nonparametric	<0.05	0.05
Chromium (mg/L)	ND (0.0054)	ND (0.0054)	Nonparametric	<0.5	0.50
Lead (mg/L)	0.036	ND (0.017)	Nonparametric	<0.05	0.05
Mercury (mg/L)	0.0000395	ND (3.75E-05)	Nonparametric	<0.002	0.002
Nickel (mg/L)	ND (0.014)	ND (0.014)	Nonparametric	<0.1	0.10
Selenium (mg/L)	ND (0.004)	ND (0.004)	Nonparametric	<0.1	0.10
Silver (mg/L)	0.014 J	0.013 J	Nonparametric	<0.5	0.50
Thallium (mg/L)	ND (0.004)	ND (0.004)	Nonparametric	0.209	0.21
Vanadium (mg/L)	0.027 J	0.027 J	Nonparametric	2.70	2.70
WQSP-5 Major Cations, Dissolved					
Calcium (mg/L)	1,120	1,120	Lognormal	1,303	N/A
Magnesium (mg/L)	530	526	Nonparametric	547	N/A
Potassium (mg/L)	305	315	Lognormal	622	N/A
WQSP-5 Major Anions					
Chloride (mg/L)	16,100	16,200	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]	1.010	1.011	Normal	1.02	N/A
pH (standard units)	7.81	7.83	Normal	7.5 to 7.9	N/A
Spec. Conductance (μmhos/cm)	**29,000**	**29,000**	Lognormal	**27,660**	N/A
Total Dissolved Solids (mg/L)	15,800	15,600	Lognormal	22,500	N/A
Total Organic Carbon (mg/L)	0.38 J	0.37 J	Nonparametric	10.14	N/A
Total Suspended Solids (mg/L)	5.00	4.00	Nonparametric	14.8	N/A
WQSP-6 Trace Metals					
Antimony (mg/L)	ND (0.005)	ND (0.005)	Nonparametric	0.140	0.14
Arsenic (mg/L)	ND (0.005)	ND (0.005)	Nonparametric	<0.5	0.50
Barium (mg/L)	0.015 J	0.015 J	Nonparametric	<1.0	1.00
Beryllium (mg/L)	ND (0.0013)	ND (0.0013)	Nonparametric	<0.02	0.02
Cadmium (mg/L)	ND (0.0028)	ND (0.0028)	Nonparametric	<0.05	0.05
Chromium (mg/L)	ND (0.0043)	ND (0.0043)	Nonparametric	<0.5	0.50
Lead (mg/L)	ND (0.017)	ND (0.017)	Nonparametric	0.150	0.15
Mercury (mg/L)	0.000127 J	0.0000546 J	Nonparametric	<0.002	0.002
Nickel (mg/L)	ND (0.014)	ND (0.014)	Nonparametric	<0.5	0.50
Selenium (mg/L)	ND (0.005)	ND (0.005)	Nonparametric	0.10	0.10
Silver (mg/L)	0.013 J	0.016 J	Nonparametric	<0.5	0.50
Thallium (mg/L)	ND (0.005)	ND (0.005)	Nonparametric	0.560	0.56
Vanadium (mg/L)	ND (0.004)	ND (0.004)	Nonparametric	0.070	0.10
WQSP-6 Major Cations, Dissolved					
Calcium (mg/L)	668	677	Normal	796	N/A
Magnesium (mg/L)	202	201	Lognormal	255	N/A
Potassium (mg/L)	148	147	Lognormal	270	N/A
WQSP-6 Major Anions					
Chloride (mg/L)	4,900	4,960	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 percent non-detects.

[b] Specific gravity is compared to density (gram per milliliter) as presented in *Waste Isolation Pilot Plant RCRA Background Groundwater Quality Baseline Report, Addendum* 1 (DOE, 2000).

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 percent).

Table F.3 – WIPP Well Inventory for 2019

Sorted by Active Wells at Year-End				Sorted by Formation for Wells Measured at Least Once in 2019			
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/D		2	DOE-2	B/C	
3	C-2506	SR/D		3	AEC-7R	CUL	
4	C-2507	SR/D		4	ERDA-9	CUL	
5	C-2737	MAG / CUL		5	H-2b2	CUL	
6	C-2811	SR/D		6	H-3b2	CUL	Bottom of well collapsed in 2018
7	CB-1 (PIP)	B/C		7	H-4bR	CUL	
8	DOE-2	B/C		8	H-5b	CUL	Plugged Sept 2019
9	ERDA-9	CUL		9	H-5bR	CUL	Drilled in Sept 2019
10	H-2b1	MAG		10	H-6bR	CUL	
11	H-2b2	CUL		11	H-7b1	CUL	
12	H-3b1	MAG		12	H-9bR	CUL	
13	H-3b2	CUL		13	H-10cR	CUL	
14	H-3D	SR/D	dry; not measured in 2019	14	H-11b4R	CUL	
15	H-4bR	CUL		15	H-12R	CUL	
16	H-4c	MAG		16	H-17	CUL	
17	H-5bR	CUL	Drilled in Sept 2019	17	H-19b0	CUL	
18	H-6bR	CUL		18	H-19b2	CUL	
19	H-6c	MAG		19	H-19b3	CUL	Redundant to H19b0
20	H-7b1	CUL		20	H-19b4	CUL	Redundant to H19b0
21	H-8a	MAG		21	H-19b5	CUL	Redundant to H19b0
22	H-9c	MAG		22	H-19b6	CUL	Redundant to H19b0
23	H-9bR	CUL		23	H-19b7	CUL	Redundant to H19b0
24	H-10a	MAG		24	I-461	CUL	Redundant to H19b0
25	H-10cR	CUL		25	SNL-1	CUL	
26	H-11b2	MAG		26	SNL-2	CUL	
27	H-11b4R	CUL		27	SNL-3	CUL	
28	H-12R	CUL		28	SNL-5	CUL	

Sorted by Active Wells at Year-End				Sorted by Formation for Wells Measured at Least Once in 2019			
Count	**Well Number**	**Zone**	**Comments**	**Count**	**Well Number**	**Zone**	**Reason Not Assessed for Long-Term Water Level Trend in Culebra**
29	H-14	MAG		29	SNL-6	CUL	Long term recovery
30	H-15R	CUL		30	SNL-8	CUL	
31	H-15	MAG		31	SNL-9	CUL	
32	H-16	CUL		32	H-15R	CUL	
33	H-17	CUL		33	SNL-10	CUL	
34	H-18	MAG		34	H-16	CUL	
35	H-19b0	CUL		35	SNL-12	CUL	
36	H-19b2	CUL		36	SNL-13	CUL	
37	H-19b3	CUL		37	SNL-14	CUL	
38	H-19b4	CUL		38	SNL-15	CUL	Long term recovery
39	H-19b5	CUL		39	SNL-16	CUL	
40	H-19b6	CUL		40	SNL-17	CUL	
41	H-19b7	CUL		41	SNL-18	CUL	
42	I-461	CUL		42	SNL-19	CUL	
43	SNL-1	CUL		43	WIPP-11	CUL	Plugged Sept 2019
44	SNL-2	CUL		44	WIPP-11R	CUL	Drilled in Sept 2019
45	SNL-3	CUL		45	WIPP-13	CUL	
46	SNL-5	CUL		46	WIPP-19	CUL	
47	SNL-6	CUL		47	WQSP-1	CUL	
48	SNL-8	CUL		48	WQSP-2	CUL	
49	SNL-9	CUL		49	WQSP-3	CUL	
50	SNL-10	CUL		50	WQSP-4	CUL	
51	SNL-12	CUL		51	WQSP-5	CUL	
52	SNL-13	CUL		52	WQSP-6	CUL	
53	SNL-14	CUL		53	WQSP-6A	DL	
54	SNL-15	CUL		54	H-2b1	MAG	
55	SNL-16	CUL		55	H-3b1	MAG	
56	SNL-17	CUL		56	H-4c	MAG	
57	SNL-18	CUL		57	H-5c	MAG	
58	SNL-19	CUL		58	H-6c	MAG	
59	PZ-1	SR/D		59	H-8a	MAG	
60	PZ-2	SR/D		60	H-9c	MAG	
61	PZ-3	SR/D		61	H-10a	MAG	

Sorted by Active Wells at Year-End				Sorted by Formation for Wells Measured at Least Once in 2019			
Count	Well Number	Zone	Comments	Count	Well Number	Zone	Reason Not Assessed for Long-Term Water Level Trend in Culebra
62	PZ-4	SR/D		62	H-11b2	MAG	
63	PZ-5	SR/D		63	H-14	MAG	
64	PZ-6	SR/D		64	H-18	MAG	
65	PZ-7	SR/D		65	WIPP-18	MAG	
66	PZ-9	SR/D		66	H-15	MAG	
67	PZ-10	SR/D		67	C-2737	MAG / CUL	
68	PZ-11	SR/D		68	C-2505	SR/D	
69	PZ-12	SR/D		69	C-2506	SR/D	
70	PZ-13	SR/D		70	C-2507	SR/D	
71	PZ-14	SR/D		71	C-2811	SR/D	
72	PZ-15	SR/D		72	PZ-1	SR/D	
73	WIPP-11R	CUL	Drilled in Sept. 2019	73	PZ-2	SR/D	
74	WIPP-13	CUL		74	PZ-3	SR/D	
75	WIPP-18	MAG		75	PZ-4	SR/D	
76	WIPP-19	CUL		76	PZ-5	SR/D	
77	WQSP-1	CUL		77	PZ-6	SR/D	
78	WQSP-2	CUL		78	PZ-7	SR/D	
79	WQSP-3	CUL		79	PZ-9	SR/D	
80	WQSP-4	CUL		80	PZ-10	SR/D	
81	WQSP-5	CUL		81	PZ-11	SR/D	
82	WQSP-6	CUL		82	PZ-12	SR/D	
83	WQSP-6A	DL		83	PZ-13	SR/D	
				84	PZ-14	SR/D	
				85	PZ-15	Gatuna	

Table F.4 – 2019 Water Levels

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
AEC-7R	CUL	01/07/19	614.67	3043.68	3063.63
AEC-7R	CUL	02/04/19	614.68	3043.67	3063.62
AEC-7R	CUL	03/05/19	614.99	3043.36	3063.29
AEC-7R	CUL	04/01/19	614.86	3043.49	3063.42
AEC-7R	CUL	05/07/19	614.61	3043.74	3063.69
AEC-7R	CUL	06/03/19	614.75	3043.60	3063.55
AEC-7R	CUL	07/10/19	614.88	3043.47	3063.40
AEC-7R	CUL	08/06/19	614.80	3043.55	3063.49
AEC-7R	CUL	09/16/19	614.81	3043.54	3063.48
AEC-7R	CUL	10/08/19	614.81	3043.54	3063.48
AEC-7R	CUL	11/05/19	615.04	3043.31	3063.23
AEC-7R	CUL	12/03/19	614.84	3043.51	3063.45
C-2737 (PIP)	CUL	01/09/19	400.48	3000.28	3007.25
C-2737 (PIP)	CUL	02/18/19	399.94	3000.82	3007.81
C-2737 (PIP)	CUL	03/05/19	400.12	3000.64	3007.62
C-2737 (PIP)	CUL	04/02/19	399.65	3001.11	3008.10
C-2737 (PIP)	CUL	05/08/19	399.35	3001.41	3008.41
C-2737 (PIP)	CUL	06/06/19	399.45	3001.31	3008.31
C-2737 (PIP)	CUL	07/10/19	399.21	3001.55	3008.55
C-2737 (PIP)	CUL	08/12/19	399.54	3001.22	3008.22
C-2737 (PIP)	CUL	09/23/19	398.53	3002.23	3009.25
C-2737 (PIP)	CUL	10/08/19	398.79	3001.97	3008.98
C-2737 (PIP)	CUL	11/06/19	398.35	3002.41	3009.44
C-2737 (PIP)	CUL	12/03/19	399.46	3001.30	3008.30
ERDA-9	CUL	01/09/19	410.34	2999.83	3022.84
ERDA-9	CUL	02/06/19	409.90	3000.27	3023.32
ERDA-9	CUL	03/07/19	410.01	3000.16	3023.20
ERDA-9	CUL	04/02/19	409.85	3000.32	3023.37
ERDA-9	CUL	05/07/19	409.52	3000.65	3023.72
ERDA-9	CUL	06/05/19	409.55	3000.62	3023.69
ERDA-9	CUL	07/11/19	409.35	3000.82	3023.91
ERDA-9	CUL	08/12/19	409.17	3001.00	3024.10
ERDA-9	CUL	09/24/19	408.85	3001.32	3024.44
ERDA-9	CUL	10/08/19	408.81	3001.36	3024.49
ERDA-9	CUL	11/06/19	409.01	3001.16	3024.27
ERDA-9	CUL	12/03/19	409.34	3000.83	3023.92
H-2b2	CUL	01/09/19	346.17	3032.19	3035.95
H-2b2	CUL	02/18/19	345.57	3032.79	3036.56
H-2b2	CUL	03/07/19	345.46	3032.90	3036.67

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-2b2	CUL	04/03/19	345.35	3033.01	3036.78
H-2b2	CUL	05/08/19	345.18	3033.18	3036.95
H-2b2	CUL	06/04/19	345.35	3033.01	3036.78
H-2b2	CUL	07/10/19	345.34	3033.02	3036.79
H-2b2	CUL	08/07/19	345.27	3033.09	3036.86
H-2b2	CUL	09/23/19	345.28	3033.08	3036.85
H-2b2	CUL	10/08/19	345.20	3033.16	3036.93
H-2b2	CUL	11/06/19	345.31	3033.05	3036.82
H-2b2	CUL	12/03/19	345.24	3033.12	3036.89
H-4bR	CUL	01/09/19	341.71	2992.93	2995.92
H-4bR	CUL	02/05/19	341.44	2993.20	2996.20
H-4bR	CUL	03/05/19	341.63	2993.01	2996.00
H-4bR	CUL	04/03/19	340.83	2993.81	2996.82
H-4bR	CUL	05/08/19	340.13	2994.51	2997.53
H-4bR	CUL	06/05/19	339.75	2994.89	2997.92
H-4bR	CUL	07/11/19	339.69	2994.95	2997.98
H-4bR	CUL	08/06/19	339.28	2995.36	2998.39
H-4bR	CUL	09/19/19	338.72	2995.92	2998.96
H-4bR	CUL	10/08/19	338.59	2996.05	2999.10
H-4bR	CUL	11/05/19	344.02	2990.62	2993.57
H-4bR	CUL	12/03/19	341.05	2993.59	2996.59
H-5b	CUL	01/07/19	470.92	3035.86	3080.67
H-5b	CUL	02/05/19	470.87	3035.91	3080.73
H-5b	CUL	03/06/19	471.20	3035.58	3080.37
H-5b	CUL	04/01/19	471.32	3035.46	3080.23
H-5b	CUL	05/07/19	471.24	3035.54	3080.32
H-5b	CUL	06/04/19	471.47	3035.31	3080.07
H-5b	CUL	07/11/19	471.70	3035.08	3079.82
H-5b	CUL	08/06/19	471.83	3034.95	3079.67
H-5b	CUL	Well Plugged September 2019			
H-5bR	CUL	10/08/19	452.71	3054.07	3100.74
H-5bR	CUL	11/05/19	474.53	3032.25	3076.70
H-5bR	CUL	12/04/19	474.29	3032.49	3076.96
H-6bR	CUL	01/08/19	294.87	3054.35	3065.64
H-6bR	CUL	02/05/19	294.82	3054.40	3065.69
H-6bR	CUL	03/06/19	295.21	3054.01	3065.28
H-6bR	CUL	04/03/19	295.20	3054.02	3065.29
H-6bR	CUL	05/08/19	295.41	3053.81	3065.08
H-6bR	CUL	06/04/19	295.84	3053.38	3064.63
H-6bR	CUL	07/09/19	295.98	3053.24	3064.49

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-6bR	CUL	08/06/19	296.23	3052.99	3064.23
H-6bR	CUL	09/19/19	296.51	3052.71	3063.94
H-6bR	CUL	10/07/19	297.23	3051.99	3063.19
H-6bR	CUL	11/04/19	296.88	3052.34	3063.56
H-6bR	CUL	12/02/19	297.21	3052.01	3063.21
H-7b1	CUL	01/08/19	170.88	2992.84	2993.93
H-7b1	CUL	02/04/19	170.40	2993.32	2994.41
H-7b1	CUL	03/04/19	170.44	2993.28	2994.37
H-7b1	CUL	04/02/19	170.21	2993.51	2994.61
H-7b1	CUL	05/06/19	170.28	2993.44	2994.54
H-7b1	CUL	06/03/19	170.71	2993.01	2994.10
H-7b1	CUL	07/09/19	170.46	2993.26	2994.35
H-7b1	CUL	08/05/19	170.12	2993.60	2994.70
H-7b1	CUL	09/11/19	170.29	2993.43	2994.53
H-7b1	CUL	10/07/19	170.46	2993.26	2994.35
H-7b1	CUL	11/04/19	170.53	2993.19	2994.28
H-7b1	CUL	12/02/19	170.45	2993.27	2994.36
H-9bR	CUL	01/08/19	435.81	2972.53	2973.68
H-9bR	CUL	02/04/19	433.36	2974.98	2976.14
H-9bR	CUL	03/04/19	431.00	2977.34	2978.51
H-9bR	CUL	04/03/19	428.52	2979.82	2981.00
H-9bR	CUL	05/06/19	426.87	2981.47	2982.66
H-9bR	CUL	06/03/19	426.17	2982.17	2983.36
H-9bR	CUL	07/10/19	425.59	2982.75	2983.95
H-9bR	CUL	08/05/19	425.22	2983.12	2984.32
H-9bR	CUL	09/11/19	423.73	2984.61	2985.82
H-9bR	CUL	10/08/19	423.12	2985.22	2986.43
H-9bR	CUL	11/04/19	425.38	2982.96	2984.16
H-9bR	CUL	12/02/19	423.50	2984.84	2986.05
H-10cR	CUL	01/08/19	730.11	2959.96	3012.10
H-10cR	CUL	02/04/19	730.35	2959.72	3011.84
H-10cR	CUL	03/04/19	730.15	2959.92	3012.05
H-10cR	CUL	04/01/19	729.83	2960.24	3012.40
H-10cR	CUL	05/06/19	729.19	2960.88	3013.09
H-10cR	CUL	06/03/19	729.04	2961.03	3013.25
H-10cR	CUL	07/10/19	728.67	2961.40	3013.65
H-10cR	CUL	08/06/19	728.49	2961.58	3013.85
H-10cR	CUL	09/19/19	728.46	2961.61	3013.88
H-10cR	CUL	10/08/19	728.53	2961.54	3013.80
H-10cR	CUL	11/05/19	728.42	2961.65	3013.92

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-10cR	CUL	12/02/19	728.17	2961.90	3014.19
H-11b4R	CUL	01/07/19	439.98	2971.89	2994.97
H-11b4R	CUL	02/05/19	440.66	2971.21	2994.23
H-11b4R	CUL	03/05/19	440.20	2971.67	2994.73
H-11b4R	CUL	04/01/19	439.63	2972.24	2995.35
H-11b4R	CUL	05/07/19	438.78	2973.09	2996.26
H-11b4R	CUL	06/04/19	438.31	2973.56	2996.77
H-11b4R	CUL	07/11/19	438.17	2973.70	2996.92
H-11b4R	CUL	08/07/19	437.57	2974.30	2997.57
H-11b4R	CUL	09/19/19	436.75	2975.12	2998.45
H-11b4R	CUL	10/08/19	436.66	2975.21	2998.55
H-11b4R	CUL	11/06/19	443.21	2968.66	2991.49
H-11b4R	CUL	12/02/19	439.72	2972.15	2995.25
H-12R	CUL	01/07/19	470.57	2958.31	2998.95
H-12R	CUL	02/04/19	466.00	2962.88	3004.02
H-12R	CUL	03/07/19	466.92	2961.96	3003.00
H-12R	CUL	04/01/19	463.59	2965.29	3006.69
H-12R	CUL	05/06/19	465.37	2963.51	3004.72
H-12R	CUL	06/03/19	466.04	2962.84	3003.97
H-12R	CUL	07/10/19	466.90	2961.98	3003.02
H-12R	CUL	08/06/19	467.05	2961.83	3002.85
H-12R	CUL	09/19/19	466.25	2962.63	3003.74
H-12R	CUL	10/08/19	466.12	2962.76	3003.88
H-12R	CUL	11/05/19	467.13	2961.75	3002.76
H-12R	CUL	12/02/19	467.51	2961.37	3002.34
H-15R	CUL	01/09/19	519.12	2962.90	3005.69
H-15R	CUL	02/12/19	518.67	2963.35	3006.19
H-15R	CUL	03/07/19	519.02	2963.00	3005.80
H-15R	CUL	04/03/19	518.81	2963.21	3006.03
H-15R	CUL	05/08/19	518.51	2963.51	3006.37
H-15R	CUL	06/06/19	518.08	2963.94	3006.85
H-15R	CUL	07/10/19	517.89	2964.13	3007.06
H-15R	CUL	08/12/19	517.54	2964.48	3007.46
H-15R	CUL	09/23/19	517.03	2964.99	3008.03
H-15R	CUL	10/08/19	516.84	2965.18	3008.24
H-15R	CUL	11/06/19	518.71	2963.31	3006.15
H-15R	CUL	12/03/19	518.68	2963.34	3006.18
H-16	CUL	01/09/19	382.35	3027.71	3038.67
H-16	CUL	02/18/19	381.87	3028.19	3039.16
H-16	CUL	03/07/19	381.91	3028.15	3039.12

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-16	CUL	04/03/19	381.78	3028.28	3039.26
H-16	CUL	05/07/19	381.58	3028.48	3039.46
H-16	CUL	06/06/19	381.52	3028.54	3039.53
H-16	CUL	07/10/19	381.61	3028.45	3039.43
H-16	CUL	08/12/19	381.49	3028.57	3039.56
H-16	CUL	09/23/19	381.47	3028.59	3039.58
H-16	CUL	10/09/19	381.47	3028.59	3039.58
H-16	CUL	11/06/19	381.75	3028.31	3039.29
H-16	CUL	12/04/19	381.88	3028.18	3039.15
H-17	CUL	01/07/19	428.64	2956.60	2995.12
H-17	CUL	02/05/19	428.83	2956.41	2994.90
H-17	CUL	03/05/19	429.11	2956.13	2994.59
H-17	CUL	04/01/19	428.74	2956.50	2995.00
H-17	CUL	05/07/19	428.07	2957.17	2995.76
H-17	CUL	06/04/19	427.51	2957.73	2996.40
H-17	CUL	07/11/19	427.31	2957.93	2996.62
H-17	CUL	08/07/19	426.95	2958.29	2997.03
H-17	CUL	09/19/19	426.05	2959.19	2998.05
H-17	CUL	10/08/19	425.85	2959.39	2998.28
H-17	CUL	11/06/19	431.28	2953.96	2992.13
H-17	CUL	12/03/19	429.15	2956.09	2994.54
H-19b0	CUL	01/07/19	438.98	2979.35	3000.45
H-19b0	CUL	02/18/19	439.02	2979.31	3000.41
H-19b0	CUL	03/05/19	439.27	2979.06	3000.14
H-19b0	CUL	04/03/19	438.75	2979.58	3000.70
H-19b0	CUL	05/07/19	438.37	2979.96	3001.10
H-19b0	CUL	06/05/19	438.48	2979.85	3000.99
H-19b0	CUL	07/11/19	438.06	2980.27	3001.43
H-19b0	CUL	08/07/19	437.59	2980.74	3001.93
H-19b0	CUL	09/23/19	436.98	2981.35	3002.59
H-19b0	CUL	10/08/19	436.62	2981.71	3002.97
H-19b0	CUL	11/06/19	438.62	2979.71	3000.84
H-19b0	CUL	12/03/19	438.54	2979.79	3000.92
H-19b2	CUL	03/05/19	440.72	2978.21	2999.34
H-19b2	CUL	06/05/19	439.92	2979.01	3000.19
H-19b2	CUL	09/23/19	438.39	2980.54	3001.82
H-19b2	CUL	12/03/19	440.04	2978.89	3000.06
H-19b3	CUL	03/05/19	440.87	2978.15	2999.17
H-19b3	CUL	06/05/19	440.07	2978.95	3000.02
H-19b3	CUL	09/23/19	438.63	2980.39	3001.56

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-19b3	CUL	12/03/19	440.17	2978.85	2999.92
H-19b4	CUL	03/05/19	439.70	2979.28	3000.38
H-19b4	CUL	06/05/19	439.38	2979.60	3000.72
H-19b4	CUL	09/23/19	437.90	2981.08	3002.30
H-19b4	CUL	12/03/19	439.43	2979.55	3000.67
H-19b5	CUL	03/05/19	440.12	2978.46	2999.50
H-19b5	CUL	06/05/19	439.38	2979.20	3000.29
H-19b5	CUL	09/23/19	437.83	2980.75	3001.95
H-19b5	CUL	12/03/19	439.38	2979.20	3000.29
H-19b6	CUL	03/05/19	440.86	2978.16	2999.18
H-19b6	CUL	06/05/19	440.06	2978.96	3000.04
H-19b6	CUL	09/23/19	438.56	2980.46	3001.64
H-19b6	CUL	12/03/19	440.11	2978.91	2999.98
H-19b7	CUL	03/05/19	440.62	2978.32	2999.35
H-19b7	CUL	06/05/19	439.90	2979.04	3000.12
H-19b7	CUL	09/23/19	438.38	2980.56	3001.74
H-19b7	CUL	12/03/19	439.92	2979.02	3000.10
I-461	CUL	01/08/19	244.86	3039.02	3039.28
I-461	CUL	02/04/19	245.10	3038.78	3039.04
I-461	CUL	03/06/19	245.50	3038.38	3038.65
I-461	CUL	04/02/19	245.46	3038.42	3038.68
I-461	CUL	05/06/19	245.72	3038.16	3038.42
I-461	CUL	06/03/19	246.55	3037.33	3037.59
I-461	CUL	07/09/19	246.28	3037.60	3037.86
I-461	CUL	08/05/19	246.68	3037.20	3037.46
I-461	CUL	09/11/19	247.44	3036.44	3036.70
I-461	CUL	10/07/19	247.24	3036.64	3036.90
I-461	CUL	11/04/19	247.03	3036.85	3037.11
I-461	CUL	12/02/19	247.31	3036.57	3036.83
SNL-1	CUL	01/07/19	440.08	3072.76	3078.12
SNL-1	CUL	02/04/19	439.95	3072.89	3078.25
SNL-1	CUL	03/06/19	440.27	3072.57	3077.92
SNL-1	CUL	04/02/19	440.26	3072.58	3077.93
SNL-1	CUL	05/06/19	440.22	3072.62	3077.97
SNL-1	CUL	06/03/19	440.47	3072.37	3077.71
SNL-1	CUL	07/09/19	440.74	3072.10	3077.44
SNL-1	CUL	08/05/19	440.93	3071.91	3077.24
SNL-1	CUL	09/11/19	441.21	3071.63	3076.95
SNL-1	CUL	10/07/19	441.74	3071.10	3076.40
SNL-1	CUL	11/04/19	441.34	3071.50	3076.82

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-1	CUL	12/02/19	441.78	3071.06	3076.36
SNL-2	CUL	01/07/19	258.57	3064.49	3066.19
SNL-2	CUL	02/04/19	258.80	3064.26	3065.96
SNL-2	CUL	03/06/19	259.33	3063.73	3065.42
SNL-2	CUL	04/02/19	259.40	3063.66	3065.35
SNL-2	CUL	05/06/19	259.77	3063.29	3064.98
SNL-2	CUL	06/03/19	260.11	3062.95	3064.64
SNL-2	CUL	07/09/19	260.43	3062.63	3064.31
SNL-2	CUL	08/05/19	260.65	3062.41	3064.09
SNL-2	CUL	09/11/19	261.06	3062.00	3063.68
SNL-2	CUL	10/07/19	261.49	3061.57	3063.24
SNL-2	CUL	11/04/19	262.02	3061.04	3062.71
SNL-2	CUL	12/02/19	262.48	3060.58	3062.25
SNL-3	CUL	01/07/19	424.35	3066.00	3075.58
SNL-3	CUL	02/05/19	424.23	3066.12	3075.70
SNL-3	CUL	03/06/19	424.51	3065.84	3075.42
SNL-3	CUL	04/02/19	424.52	3065.83	3075.41
SNL-3	CUL	05/07/19	424.75	3065.60	3075.17
SNL-3	CUL	06/04/19	424.97	3065.38	3074.94
SNL-3	CUL	07/09/19	425.40	3064.95	3074.50
SNL-3	CUL	08/06/19	425.42	3064.93	3074.48
SNL-3	CUL	09/11/19	425.54	3064.81	3074.36
SNL-3	CUL	10/08/19	426.42	3063.93	3073.45
SNL-3	CUL	11/06/19	425.91	3064.44	3073.98
SNL-3	CUL	12/03/19	425.91	3064.44	3073.98
SNL-5	CUL	01/07/19	314.06	3065.92	3068.26
SNL-5	CUL	02/04/19	313.84	3066.14	3068.49
SNL-5	CUL	03/05/19	314.20	3065.78	3068.12
SNL-5	CUL	04/02/19	314.52	3065.46	3067.80
SNL-5	CUL	05/06/19	314.75	3065.23	3067.57
SNL-5	CUL	06/03/19	315.08	3064.90	3067.24
SNL-5	CUL	07/09/19	315.54	3064.44	3066.77
SNL-5	CUL	08/05/19	315.82	3064.16	3066.49
SNL-5	CUL	09/11/19	315.85	3064.13	3066.46
SNL-5	CUL	10/07/19	316.92	3063.06	3065.38
SNL-5	CUL	11/04/19	315.10	3064.88	3067.22
SNL-5	CUL	12/02/19	316.31	3063.67	3066.00
SNL-6	CUL	01/07/19	455.91	3190.20	3409.01
SNL-6	CUL	02/04/19	455.54	3190.57	3409.47
SNL-6	CUL	03/05/19	453.66	3192.45	3411.82

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-6	CUL	04/01/19	452.55	3193.56	3413.20
SNL-6	CUL	05/07/19	451.06	3195.05	3415.06
SNL-6	CUL	06/03/19	450.19	3195.92	3416.15
SNL-6	CUL	07/11/19	448.76	3197.35	3417.93
SNL-6	CUL	08/06/19	447.65	3198.46	3419.32
SNL-6	CUL	09/16/19	446.90	3199.21	3420.25
SNL-6	CUL	10/08/19	445.33	3200.78	3422.21
SNL-6	CUL	11/05/19	444.38	3201.73	3423.40
SNL-6	CUL	12/03/19	443.41	3202.70	3424.61
SNL-8	CUL	01/07/19	540.71	3015.02	3060.50
SNL-8	CUL	02/05/19	540.74	3014.99	3060.46
SNL-8	CUL	03/05/19	541.18	3014.55	3059.98
SNL-8	CUL	04/01/19	541.21	3014.52	3059.94
SNL-8	CUL	05/07/19	541.08	3014.65	3060.09
SNL-8	CUL	06/03/19	541.26	3014.47	3059.89
SNL-8	CUL	07/11/19	541.45	3014.28	3059.68
SNL-8	CUL	08/06/19	541.48	3014.25	3059.64
SNL-8	CUL	09/19/19	541.58	3014.15	3059.53
SNL-8	CUL	10/08/19	541.40	3014.33	3059.73
SNL-8	CUL	11/05/19	541.46	3014.27	3059.67
SNL-8	CUL	12/03/19	541.59	3014.14	3059.52
SNL-9	CUL	01/08/19	314.25	3046.71	3051.01
SNL-9	CUL	02/05/19	315.40	3045.56	3049.84
SNL-9	CUL	03/06/19	315.71	3045.25	3049.52
SNL-9	CUL	04/03/19	315.70	3045.26	3049.53
SNL-9	CUL	05/08/19	315.79	3045.17	3049.44
SNL-9	CUL	06/04/19	316.20	3044.76	3049.03
SNL-9	CUL	07/09/19	316.28	3044.68	3048.94
SNL-9	CUL	08/07/19	316.59	3044.37	3048.63
SNL-9	CUL	09/19/19	316.89	3044.07	3048.32
SNL-9	CUL	10/07/19	316.22	3044.74	3049.01
SNL-9	CUL	11/04/19	317.28	3043.68	3047.93
SNL-9	CUL	12/02/19	317.60	3043.36	3047.60
SNL-10	CUL	01/08/19	331.09	3046.50	3049.61
SNL-10	CUL	02/05/19	331.06	3046.53	3049.64
SNL-10	CUL	03/05/19	331.61	3045.98	3049.08
SNL-10	CUL	04/02/19	331.44	3046.15	3049.25
SNL-10	CUL	05/08/19	331.48	3046.11	3049.21
SNL-10	CUL	06/04/19	331.68	3045.91	3049.01
SNL-10	CUL	07/09/19	331.84	3045.75	3048.85

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-10	CUL	08/06/19	332.01	3045.58	3048.68
SNL-10	CUL	09/19/19	332.29	3045.30	3048.39
SNL-10	CUL	10/07/19	332.60	3044.99	3048.08
SNL-10	CUL	11/05/19	332.63	3044.96	3048.05
SNL-10	CUL	12/03/19	332.85	3044.74	3047.83
SNL-12	CUL	01/08/19	351.37	2988.09	2991.38
SNL-12	CUL	02/04/19	351.03	2988.43	2991.73
SNL-12	CUL	03/04/19	350.65	2988.81	2992.11
SNL-12	CUL	04/03/19	349.49	2989.97	2993.29
SNL-12	CUL	05/06/19	348.35	2991.11	2994.45
SNL-12	CUL	06/03/19	347.87	2991.59	2994.93
SNL-12	CUL	07/10/19	347.58	2991.88	2995.23
SNL-12	CUL	08/05/19	347.09	2992.37	2995.73
SNL-12	CUL	09/11/19	346.60	2992.86	2996.22
SNL-12	CUL	10/08/19	346.16	2993.30	2996.67
SNL-12	CUL	11/04/19	353.59	2985.87	2989.13
SNL-12	CUL	12/02/19	348.72	2990.74	2994.07
SNL-13	CUL	01/08/19	297.57	2996.54	2998.82
SNL-13	CUL	02/05/19	297.38	2996.73	2999.01
SNL-13	CUL	03/07/19	297.29	2996.82	2999.10
SNL-13	CUL	04/02/19	297.46	2996.65	2998.93
SNL-13	CUL	05/08/19	297.12	2996.99	2999.28
SNL-13	CUL	06/04/19	297.16	2996.95	2999.23
SNL-13	CUL	07/09/19	297.08	2997.03	2999.32
SNL-13	CUL	08/06/19	296.93	2997.18	2999.47
SNL-13	CUL	09/11/19	296.69	2997.42	2999.72
SNL-13	CUL	10/07/19	296.78	2997.33	2999.62
SNL-13	CUL	11/05/19	296.50	2997.61	2999.91
SNL-13	CUL	12/03/19	296.60	2997.51	2999.81
SNL-14	CUL	01/07/19	389.49	2978.92	2992.08
SNL-14	CUL	02/05/19	389.46	2978.95	2992.11
SNL-14	CUL	03/05/19	389.54	2978.87	2992.03
SNL-14	CUL	04/01/19	388.66	2979.75	2992.95
SNL-14	CUL	05/07/19	387.61	2980.80	2994.05
SNL-14	CUL	06/04/19	387.05	2981.36	2994.64
SNL-14	CUL	07/11/19	386.90	2981.51	2994.79
SNL-14	CUL	08/07/19	386.30	2982.11	2995.42
SNL-14	CUL	09/19/19	385.60	2982.81	2996.15
SNL-14	CUL	10/08/19	385.42	2982.99	2996.34
SNL-14	CUL	11/06/19	392.65	2975.76	2988.77

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-14	CUL	12/03/19	388.19	2980.22	2993.44
SNL-15	CUL	01/07/19	491.69	2988.24	3086.11
SNL-15	CUL	02/05/19	490.81	2989.12	3087.19
SNL-15	CUL	03/05/19	490.42	2989.51	3087.67
SNL-15	CUL	04/01/19	489.91	2990.02	3088.29
SNL-15	CUL	05/07/19	489.23	2990.70	3089.13
SNL-15	CUL	06/03/19	488.79	2991.14	3089.67
SNL-15	CUL	07/10/19	488.21	2991.72	3090.38
SNL-15	CUL	08/06/19	487.81	2992.12	3090.87
SNL-15	CUL	09/19/19	487.78	2992.15	3090.91
SNL-15	CUL	10/08/19	487.14	2992.79	3091.69
SNL-15	CUL	11/05/19	486.39	2993.54	3092.61
SNL-15	CUL	12/02/19	486.01	2993.92	3093.08
SNL-16	CUL	01/08/19	124.68	3008.32	3009.63
SNL-16	CUL	02/04/19	124.65	3008.35	3009.66
SNL-16	CUL	03/04/19	124.98	3008.02	3009.32
SNL-16	CUL	04/02/19	124.81	3008.19	3009.49
SNL-16	CUL	05/06/19	125.07	3007.93	3009.23
SNL-16	CUL	06/03/19	125.59	3007.41	3008.70
SNL-16	CUL	07/09/19	125.32	3007.68	3008.98
SNL-16	CUL	08/05/19	125.63	3007.37	3008.66
SNL-16	CUL	09/11/19	126.20	3006.80	3008.08
SNL-16	CUL	10/07/19	126.24	3006.76	3008.04
SNL-16	CUL	11/04/19	126.07	3006.93	3008.21
SNL-16	CUL	12/02/19	126.38	3006.62	3007.90
SNL-17	CUL	01/08/19	238.11	2999.95	3000.95
SNL-17	CUL	02/05/19	237.92	3000.14	3001.14
SNL-17	CUL	03/04/19	238.07	2999.99	3000.99
SNL-17	CUL	04/02/19	237.79	3000.27	3001.28
SNL-17	CUL	05/06/19	237.70	3000.36	3001.37
SNL-17	CUL	06/03/19	237.78	3000.28	3000.95
SNL-17	CUL	07/09/19	237.63	3000.43	3001.44
SNL-17	CUL	08/05/19	237.50	3000.56	3001.57
SNL-17	CUL	09/11/19	237.43	3000.63	3001.64
SNL-17	CUL	10/07/19	237.51	3000.55	3001.56
SNL-17	CUL	11/04/19	238.76	2999.30	3000.30
SNL-17	CUL	12/04/19	238.12	2999.94	3000.94
SNL-18	CUL	01/07/19	307.83	3067.61	3070.77
SNL-18	CUL	02/04/19	307.68	3067.76	3070.93
SNL-18	CUL	03/06/19	307.95	3067.49	3070.65

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-18	CUL	04/02/19	308.33	3067.11	3070.27
SNL-18	CUL	05/06/19	308.48	3066.96	3070.12
SNL-18	CUL	06/03/19	308.70	3066.74	3069.89
SNL-18	CUL	07/17/19	309.23	3066.21	3069.36
SNL-18	CUL	08/05/19	309.43	3066.01	3069.15
SNL-18	CUL	09/11/19	309.49	3065.95	3069.09
SNL-18	CUL	10/07/19	309.83	3065.61	3068.75
SNL-18	CUL	11/04/19	308.09	3067.35	3070.51
SNL-18	CUL	12/02/19	309.76	3065.68	3068.82
SNL-19	CUL	01/07/19	156.96	3065.69	3066.88
SNL-19	CUL	02/04/19	157.19	3065.46	3066.65
SNL-19	CUL	03/06/19	157.82	3064.83	3066.01
SNL-19	CUL	04/02/19	157.92	3064.73	3065.91
SNL-19	CUL	05/06/19	158.23	3064.42	3065.60
SNL-19	CUL	06/03/19	158.58	3064.07	3065.25
SNL-19	CUL	07/09/19	158.88	3063.77	3064.95
SNL-19	CUL	08/05/19	159.22	3063.43	3064.60
SNL-19	CUL	09/11/19	159.55	3063.10	3064.27
SNL-19	CUL	10/07/19	159.84	3062.81	3063.98
SNL-19	CUL	11/04/19	160.35	3062.30	3063.47
SNL-19	CUL	12/02/19	160.86	3061.79	3062.96
WIPP-11	CUL	01/07/19	369.00	3058.78	3077.84
WIPP-11	CUL	02/05/19	368.95	3058.83	3077.89
WIPP-11	CUL	03/06/19	369.28	3058.50	3077.55
WIPP-11	CUL	04/02/19	369.33	3058.45	3077.50
WIPP-11	CUL	05/07/19	369.57	3058.21	3077.25
WIPP-11	CUL	06/04/19	369.84	3057.94	3076.97
WIPP-11	CUL	07/09/19	370.07	3057.71	3076.73
WIPP-11	CUL	08/06/19	370.39	3057.39	3076.40
WIPP-11	CUL	Well Plugged in September 2019			
WIPP-11R	CUL	10/07/19	222.27	3205.51	3230.29
WIPP-11R	CUL	11/06/19	224.04	3203.74	3228.46
WIPP-11R	CUL	12/04/19	369.42	3058.36	3077.41
WIPP-13	CUL	01/08/19	345.84	3059.83	3072.39
WIPP-13	CUL	02/05/19	345.65	3060.02	3072.59
WIPP-13	CUL	03/06/19	345.90	3059.77	3072.33
WIPP-13	CUL	04/03/19	346.12	3059.55	3072.10
WIPP-13	CUL	05/08/19	346.35	3059.32	3071.87
WIPP-13	CUL	06/04/19	346.61	3059.06	3071.60
WIPP-13	CUL	07/10/19	346.93	3058.74	3071.27

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
WIPP-13	CUL	08/07/19	346.93	3058.74	3071.27
WIPP-13	CUL	09/16/19	347.21	3058.46	3070.98
WIPP-13	CUL	10/07/19	348.31	3057.36	3069.84
WIPP-13	CUL	11/06/19	347.49	3058.18	3070.69
WIPP-13	CUL	12/04/19	347.67	3058.00	3070.50
WIPP-19	CUL	01/09/19	396.65	3037.67	3059.65
WIPP-19	CUL	02/06/19	396.20	3038.12	3060.13
WIPP-19	CUL	03/07/19	396.43	3037.89	3059.89
WIPP-19	CUL	04/03/19	396.48	3037.84	3059.83
WIPP-19	CUL	05/08/19	396.56	3037.76	3059.75
WIPP-19	CUL	06/04/19	396.75	3037.57	3059.55
WIPP-19	CUL	07/10/19	397.09	3037.23	3059.19
WIPP-19	CUL	08/12/19	396.97	3037.35	3059.31
WIPP-19	CUL	09/16/19	397.05	3037.27	3059.23
WIPP-19	CUL	10/09/19	397.43	3036.89	3058.83
WIPP-19	CUL	11/06/19	397.49	3036.83	3058.76
WIPP-19	CUL	12/04/19	397.49	3036.83	3058.76
WQSP-1	CUL	01/08/19	364.76	3054.49	3071.59
WQSP-1	CUL	02/12/19	364.84	3054.41	3071.50
WQSP-1	CUL	03/06/19	364.83	3054.42	3071.51
WQSP-1	CUL	04/03/19	364.95	3054.30	3071.39
WQSP-1	CUL	05/08/19	365.22	3054.03	3071.10
WQSP-1	CUL	06/04/19	365.47	3053.78	3070.84
WQSP-1	CUL	07/11/19	365.83	3053.42	3070.46
WQSP-1	CUL	08/07/19	365.93	3053.32	3070.36
WQSP-1	CUL	09/23/19	368.44	3050.81	3067.73
WQSP-1	CUL	10/09/19	366.91	3052.34	3069.33
WQSP-1	CUL	11/06/19	366.24	3053.01	3070.03
WQSP-1	CUL	12/03/19	366.43	3052.82	3069.83
WQSP-2	CUL	01/09/19	405.58	3058.29	3078.01
WQSP-2	CUL	02/12/19	405.49	3058.38	3078.10
WQSP-2	CUL	03/06/19	405.52	3058.35	3078.07
WQSP-2	CUL	04/01/19	405.97	3057.90	3077.60
WQSP-2	CUL	05/07/19	405.96	3057.91	3077.61
WQSP-2	CUL	06/04/19	406.23	3057.64	3077.33
WQSP-2	CUL	07/10/19	406.73	3057.14	3076.80
WQSP-2	CUL	08/05/19	406.72	3057.15	3076.81
WQSP-2	CUL	09/16/19	406.88	3056.99	3076.64
WQSP-2	CUL	10/09/19	407.73	3056.14	3075.75
WQSP-2	CUL	11/06/19	407.06	3056.81	3076.46

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
WQSP-2	CUL	12/04/19	407.45	3056.42	3076.05
WQSP-3	CUL	01/09/19	469.41	3010.73	3067.73
WQSP-3	CUL	02/12/19	469.26	3010.88	3067.90
WQSP-3	CUL	03/06/19	469.21	3010.93	3067.96
WQSP-3	CUL	04/01/19	469.25	3010.89	3067.92
WQSP-3	CUL	05/07/19	469.62	3010.52	3067.49
WQSP-3	CUL	06/04/19	469.76	3010.38	3067.33
WQSP-3	CUL	07/10/19	470.78	3009.36	3066.16
WQSP-3	CUL	08/05/19	471.11	3009.03	3065.78
WQSP-3	CUL	09/16/19	470.84	3009.30	3066.09
WQSP-3	CUL	10/09/19	471.12	3009.02	3065.77
WQSP-3	CUL	11/06/19	471.17	3008.97	3065.72
WQSP-3	CUL	12/04/19	471.02	3009.12	3065.89
WQSP-4	CUL	01/07/19	456.23	2976.86	3001.86
WQSP-4	CUL	02/18/19	456.30	2976.79	3001.78
WQSP-4	CUL	03/05/19	456.51	2976.58	3001.56
WQSP-4	CUL	04/03/19	456.06	2977.03	3002.04
WQSP-4	CUL	05/07/19	455.62	2977.47	3002.52
WQSP-4	CUL	06/05/19	455.67	2977.42	3002.46
WQSP-4	CUL	07/11/19	455.29	2977.80	3002.87
WQSP-4	CUL	08/07/19	454.98	2978.11	3003.21
WQSP-4	CUL	09/19/19	454.06	2979.03	3004.20
WQSP-4	CUL	10/08/19	453.81	2979.28	3004.47
WQSP-4	CUL	11/06/19	455.90	2977.19	3002.21
WQSP-4	CUL	12/03/19	455.79	2977.30	3002.33
WQSP-5	CUL	01/09/19	393.69	2990.69	2998.64
WQSP-5	CUL	02/18/19	393.21	2991.17	2999.13
WQSP-5	CUL	03/05/19	393.42	2990.96	2998.92
WQSP-5	CUL	04/03/19	392.95	2991.43	2999.40
WQSP-5	CUL	05/07/19	392.69	2991.69	2999.67
WQSP-5	CUL	06/05/19	392.74	2991.64	2999.62
WQSP-5	CUL	07/11/19	392.42	2991.96	2999.95
WQSP-5	CUL	08/07/19	391.96	2992.42	3000.42
WQSP-5	CUL	09/19/19	391.22	2993.16	3001.18
WQSP-5	CUL	10/08/19	390.95	2993.43	3001.46
WQSP-5	CUL	11/06/19	391.54	2992.84	3000.85
WQSP-5	CUL	12/03/19	392.02	2992.36	3000.36
WQSP-6	CUL	01/09/19	357.28	3007.44	3011.28
WQSP-6	CUL	02/18/19	356.66	3008.06	3011.91
WQSP-6	CUL	03/05/19	356.82	3007.90	3011.74

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
WQSP-6	CUL	04/03/19	356.35	3008.37	3012.22
WQSP-6	CUL	05/07/19	356.56	3008.16	3012.01
WQSP-6	CUL	06/05/19	356.21	3008.51	3011.88
WQSP-6	CUL	07/11/19	356.10	3008.62	3012.48
WQSP-6	CUL	08/07/19	355.81	3008.91	3012.77
WQSP-6	CUL	09/19/19	355.43	3009.29	3012.67
WQSP-6	CUL	10/08/19	355.27	3009.45	3013.32
WQSP-6	CUL	11/05/19	355.20	3009.52	3013.39
WQSP-6	CUL	12/03/19	355.14	3009.58	3012.97
H-3b2	CUL	01/09/19	402.28	2987.63	(b)
H-3b2	CUL	02/18/19	401.91	2988.00	(b)
H-3b2	CUL	03/05/19	402.10	2987.81	(b)
H-3b2	CUL	04/03/19	401.61	2988.30	(b)
H-3b2	CUL	05/07/19	401.28	2988.63	(b)
H-3b2	CUL	06/06/19	401.42	2988.49	(b)
H-3b2	CUL	07/10/19	401.03	2988.88	(b)
H-3b2	CUL	08/07/19	400.58	2989.33	(b)
H-3b2	CUL	09/23/19	399.98	2989.93	(b)
H-3b2	CUL	10/08/19	399.70	2990.21	(b)
H-3b2	CUL	11/06/19	400.68	2989.23	(b)
H-3b2	CUL	12/03/19	400.40	2989.51	(b)
C-2737 (ANNULUS)	MAG	01/09/19	244.84	3155.92	(a)
C-2737 (ANNULUS)	MAG	02/18/19	244.50	3156.26	(a)
C-2737 (ANNULUS)	MAG	03/05/19	244.75	3156.01	(a)
C-2737 (ANNULUS)	MAG	04/02/19	244.61	3156.15	(a)
C-2737 (ANNULUS)	MAG	05/08/19	244.53	3156.23	(a)
C-2737 (ANNULUS)	MAG	06/06/19	244.54	3156.22	(a)
C-2737 (ANNULUS)	MAG	07/10/19	244.56	3156.20	(a)
C-2737 (ANNULUS)	MAG	08/12/19	244.62	3156.14	(a)
C-2737 (ANNULUS)	MAG	09/23/19	244.66	3156.10	(a)
C-2737 (ANNULUS)	MAG	10/08/19	244.82	3155.94	(a)
C-2737 (ANNULUS)	MAG	11/06/19	244.75	3156.01	(a)
C-2737 (ANNULUS)	MAG	12/03/19	244.78	3155.98	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-2b1	MAG	01/09/19	229.38	3149.11	(a)
H-2b1	MAG	02/18/19	229.12	3149.37	(a)
H-2b1	MAG	03/07/19	229.06	3149.43	(a)
H-2b1	MAG	04/03/19	228.97	3149.52	(a)
H-2b1	MAG	05/08/19	228.87	3149.62	(a)
H-2b1	MAG	06/04/19	228.75	3149.74	(a)
H-2b1	MAG	07/10/19	228.66	3149.83	(a)
H-2b1	MAG	08/07/19	228.62	3149.87	(a)
H-2b1	MAG	09/23/19	228.25	3150.24	(a)
H-2b1	MAG	10/08/19	228.49	3150.00	(a)
H-2b1	MAG	11/06/19	228.43	3150.06	(a)
H-2b1	MAG	12/03/19	228.36	3150.13	(a)
H-3b1	MAG	01/09/19	232.55	3158.17	(a)
H-3b1	MAG	02/18/19	232.30	3158.42	(a)
H-3b1	MAG	03/05/19	232.50	3158.22	(a)
H-3b1	MAG	04/03/19	232.57	3158.15	(a)
H-3b1	MAG	05/07/19	232.26	3158.46	(a)
H-3b1	MAG	06/06/19	232.41	3158.31	(a)
H-3b1	MAG	07/10/19	232.52	3158.20	(a)
H-3b1	MAG	08/07/19	232.55	3158.17	(a)
H-3b1	MAG	09/23/19	232.61	3158.11	(a)
H-3b1	MAG	10/08/19	232.68	3158.04	(a)
H-3b1	MAG	11/06/19	232.77	3157.95	(a)
H-3b1	MAG	12/03/19	232.83	3157.89	(a)
H-4c	MAG	01/09/19	185.41	3148.87	(a)
H-4c	MAG	02/05/19	185.34	3148.94	(a)
H-4c	MAG	03/05/19	185.38	3148.90	(a)
H-4c	MAG	04/03/19	185.34	3148.94	(a)
H-4c	MAG	05/08/19	185.24	3149.04	(a)
H-4c	MAG	06/05/19	185.38	3148.90	(a)
H-4c	MAG	07/11/19	185.68	3148.60	(a)
H-4c	MAG	08/06/19	185.70	3148.58	(a)
H-4c	MAG	09/19/19	185.79	3148.49	(a)
H-4c	MAG	10/08/19	186.49	3147.79	(a)
H-4c	MAG	11/05/19	185.91	3148.37	(a)
H-4c	MAG	12/03/19	186.01	3148.27	(a)
H-6c	MAG	01/08/19	277.30	3071.39	(a)
H-6c	MAG	02/05/19	277.61	3071.08	(a)
H-6c	MAG	03/06/19	277.69	3071.00	(a)
H-6c	MAG	04/03/19	277.49	3071.20	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-6c	MAG	05/08/19	277.55	3071.14	(a)
H-6c	MAG	06/04/19	277.70	3070.99	(a)
H-6c	MAG	07/09/19	277.83	3070.86	(a)
H-6c	MAG	08/06/19	277.91	3070.78	(a)
H-6c	MAG	09/19/19	278.19	3070.50	(a)
H-6c	MAG	10/07/19	278.27	3070.42	(a)
H-6c	MAG	11/04/19	278.10	3070.59	(a)
H-6c	MAG	12/02/19	278.34	3070.35	(a)
H-8a	MAG	01/08/19	404.99	3028.29	(a)
H-8a	MAG	02/04/19	405.12	3028.16	(a)
H-8a	MAG	03/04/19	405.19	3028.09	(a)
H-8a	MAG	04/03/19	405.23	3028.05	(a)
H-8a	MAG	05/06/19	405.10	3028.18	(a)
H-8a	MAG	06/03/19	405.13	3028.15	(a)
H-8a	MAG	07/10/19	404.77	3028.51	(a)
H-8a	MAG	08/05/19	405.25	3028.03	(a)
H-8a	MAG	09/11/19	405.36	3027.92	(a)
H-8a	MAG	10/08/19	405.37	3027.91	(a)
H-8a	MAG	11/04/19	405.42	3027.86	(a)
H-8a	MAG	12/02/19	405.45	3027.83	(a)
H-9c	MAG	01/08/19	270.28	3136.77	(a)
H-9c	MAG	02/04/19	270.27	3136.78	(a)
H-9c	MAG	03/04/19	270.51	3136.54	(a)
H-9c	MAG	04/03/19	270.53	3136.52	(a)
H-9c	MAG	05/06/19	269.82	3137.23	(a)
H-9c	MAG	06/03/19	269.58	3137.47	(a)
H-9c	MAG	07/10/19	269.08	3137.97	(a)
H-9c	MAG	08/05/19	268.63	3138.42	(a)
H-9c	MAG	09/11/19	268.55	3138.50	(a)
H-9c	MAG	10/08/19	268.14	3138.91	(a)
H-9c	MAG	11/04/19	267.50	3139.55	(a)
H-9c	MAG	12/02/19	266.43	3140.62	(a)
H-10a	MAG	01/08/19	577.43	3111.02	(a)
H-10a	MAG	02/04/19	577.90	3110.55	(a)
H-10a	MAG	03/04/19	578.12	3110.33	(a)
H-10a	MAG	04/01/19	578.14	3110.31	(a)
H-10a	MAG	05/06/19	578.00	3110.45	(a)
H-10a	MAG	06/03/19	578.12	3110.33	(a)
H-10a	MAG	07/10/19	578.18	3110.27	(a)
H-10a	MAG	08/06/19	578.13	3110.32	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-10a	MAG	09/19/19	578.35	3110.10	(a)
H-10a	MAG	10/08/19	578.49	3109.96	(a)
H-10a	MAG	11/05/19	578.56	3109.89	(a)
H-10a	MAG	12/02/19	578.51	3109.94	(a)
H-11b2	MAG	01/07/19	263.72	3148.14	(a)
H-11b2	MAG	02/05/19	263.50	3148.36	(a)
H-11b2	MAG	03/05/19	263.72	3148.14	(a)
H-11b2	MAG	04/01/19	263.21	3148.65	(a)
H-11b2	MAG	05/07/19	263.49	3148.37	(a)
H-11b2	MAG	06/04/19	263.65	3148.21	(a)
H-11b2	MAG	07/11/19	264.27	3147.59	(a)
H-11b2	MAG	08/07/19	264.23	3147.63	(a)
H-11b2	MAG	09/19/19	264.19	3147.67	(a)
H-11b2	MAG	10/08/19	264.25	3147.61	(a)
H-11b2	MAG	11/06/19	263.82	3148.04	(a)
H-11b2	MAG	12/02/19	264.48	3147.38	(a)
H-14	MAG	01/09/19	204.89	3142.19	(a)
H-14	MAG	02/12/19	204.83	3142.25	(a)
H-14	MAG	03/07/19	204.80	3142.28	(a)
H-14	MAG	04/02/19	204.76	3142.32	(a)
H-14	MAG	05/08/19	204.76	3142.32	(a)
H-14	MAG	06/04/19	204.70	3142.38	(a)
H-14	MAG	07/10/19	204.83	3142.25	(a)
H-14	MAG	08/07/19	204.69	3142.39	(a)
H-14	MAG	09/19/19	204.32	3142.76	(a)
H-14	MAG	10/07/19	204.73	3142.35	(a)
H-14	MAG	11/05/19	204.70	3142.38	(a)
H-14	MAG	12/03/19	204.71	3142.37	(a)
H-15	MAG	01/09/19	315.64	3168.14	(a)
H-15	MAG	02/12/19	315.58	3168.20	(a)
H-15	MAG	03/07/19	315.60	3168.18	(a)
H-15	MAG	04/03/19	315.76	3168.02	(a)
H-15	MAG	05/08/19	315.84	3167.94	(a)
H-15	MAG	06/06/19	316.21	3167.57	(a)
H-15	MAG	07/10/19	316.62	3167.16	(a)
H-15	MAG	08/12/19	316.81	3166.97	(a)
H-15	MAG	09/23/19	316.92	3166.86	(a)
H-15	MAG	10/08/19	316.90	3166.88	(a)
H-15	MAG	11/06/19	317.23	3166.55	(a)
H-15	MAG	12/03/19	317.37	3166.41	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-18	MAG	01/08/19	252.54	3161.67	(a)
H-18	MAG	02/12/19	252.39	3161.82	(a)
H-18	MAG	03/06/19	252.41	3161.80	(a)
H-18	MAG	04/03/19	252.22	3161.99	(a)
H-18	MAG	05/08/19	252.12	3162.09	(a)
H-18	MAG	06/04/19	252.22	3161.99	(a)
H-18	MAG	07/10/19	252.32	3161.89	(a)
H-18	MAG	08/07/19	252.22	3161.99	(a)
H-18	MAG	09/23/19	252.27	3161.94	(a)
H-18	MAG	10/09/19	252.20	3162.01	(a)
H-18	MAG	11/06/19	252.25	3161.96	(a)
H-18	MAG	12/03/19	252.25	3161.96	(a)
WIPP-18	MAG	01/09/19	292.20	3165.37	(a)
WIPP-18	MAG	02/05/19	292.02	3165.55	(a)
WIPP-18	MAG	03/07/19	292.23	3165.34	(a)
WIPP-18	MAG	04/03/19	292.27	3165.30	(a)
WIPP-18	MAG	05/08/19	292.33	3165.24	(a)
WIPP-18	MAG	06/04/19	292.39	3165.18	(a)
WIPP-18	MAG	07/10/19	292.54	3165.03	(a)
WIPP-18	MAG	08/12/19	292.62	3164.95	(a)
WIPP-18	MAG	09/16/19	292.81	3164.76	(a)
WIPP-18	MAG	10/09/19	292.80	3164.77	(a)
WIPP-18	MAG	11/06/19	292.52	3165.05	(a)
WIPP-18	MAG	12/04/19	293.04	3164.53	(a)
WQSP-6a	DL	01/09/19	168.54	3195.26	(a)
WQSP-6a	DL	02/18/19	168.24	3195.56	(a)
WQSP-6a	DL	03/05/19	168.43	3195.37	(a)
WQSP-6a	DL	04/03/19	168.03	3195.77	(a)
WQSP-6a	DL	05/07/19	168.14	3195.66	(a)
WQSP-6a	DL	06/05/19	168.26	3195.54	(a)
WQSP-6a	DL	07/11/19	168.40	3195.40	(a)
WQSP-6a	DL	08/07/19	168.17	3195.63	(a)
WQSP-6a	DL	09/19/19	168.19	3195.61	(a)
WQSP-6a	DL	10/08/19	168.19	3195.61	(a)
WQSP-6a	DL	11/05/19	168.32	3195.48	(a)
WQSP-6a	DL	12/03/19	168.26	3195.54	(a)
CB-1	B/C	01/07/19	285.42	3043.70	(a)
CB-1	B/C	02/05/19	284.95	3044.17	(a)
CB-1	B/C	03/05/19	284.60	3044.52	(a)
CB-1	B/C	04/01/19	284.25	3044.87	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
CB-1	B/C	05/07/19	283.73	3045.39	(a)
CB-1	B/C	06/04/19	283.40	3045.72	(a)
CB-1	B/C	07/11/19	283.12	3046.00	(a)
CB-1	B/C	08/07/19	282.85	3046.27	(a)
CB-1	B/C	09/19/19	282.49	3046.63	(a)
CB-1	B/C	10/08/19	282.19	3046.93	(a)
CB-1	B/C	11/06/19	281.89	3047.23	(a)
CB-1	B/C	12/02/19	281.58	3047.54	(a)
DOE-2	B/C	01/08/19	349.46	3069.72	(a)
DOE-2	B/C	02/05/19	349.38	3069.80	(a)
DOE-2	B/C	03/06/19	349.46	3069.72	(a)
DOE-2	B/C	04/02/19	349.35	3069.83	(a)
DOE-2	B/C	05/08/19	349.27	3069.91	(a)
DOE-2	B/C	06/04/19	349.26	3069.92	(a)
DOE-2	B/C	07/10/19	349.23	3069.95	(a)
DOE-2	B/C	08/06/19	349.23	3069.95	(a)
DOE-2	B/C	09/16/19	349.23	3069.95	(a)
DOE-2	B/C	10/09/19	349.14	3070.04	(a)
DOE-2	B/C	11/06/19	349.23	3069.95	(a)
DOE-2	B/C	12/04/19	349.08	3070.10	(a)
C-2505	SR/DL	03/07/19	44.40	3368.53	(a)
C-2505	SR/DL	06/05/19	44.53	3368.40	(a)
C-2505	SR/DL	09/23/19	44.97	3367.96	(a)
C-2505	SR/DL	12/04/19	44.99	3367.94	(a)
C-2506	SR/DL	03/07/19	43.73	3369.11	(a)
C-2506	SR/DL	06/05/19	43.83	3369.01	(a)
C-2506	SR/DL	09/23/19	44.22	3368.62	(a)
C-2506	SR/DL	12/04/19	44.29	3368.55	(a)
C-2507	SR/DL	03/07/19	44.15	3365.76	(a)
C-2507	SR/DL	06/05/19	44.27	3365.64	(a)
C-2507	SR/DL	09/23/19	44.63	3365.28	(a)
C-2507	SR/DL	12/04/19	44.76	3365.15	(a)
C-2811	SR/DL	03/05/19	51.31	3347.53	(a)
C-2811	SR/DL	06/06/19	51.17	3347.67	(a)
C-2811	SR/DL	09/23/19	51.85	3346.99	(a)
C-2811	SR/DL	12/03/19	52.03	3346.81	(a)
PZ-1	SR/DL	03/07/19	41.56	3371.72	(a)
PZ-1	SR/DL	06/05/19	41.68	3371.60	(a)
PZ-1	SR/DL	09/23/19	42.01	3371.27	(a)
PZ-1	SR/DL	12/04/19	42.09	3371.19	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
PZ-2	SR/DL	03/07/19	42.24	3371.12	(a)
PZ-2	SR/DL	06/05/19	42.37	3370.99	(a)
PZ-2	SR/DL	09/23/19	42.69	3370.67	(a)
PZ-2	SR/DL	12/04/19	42.69	3370.67	(a)
PZ-3	SR/DL	03/07/19	44.49	3371.63	(a)
PZ-3	SR/DL	06/05/19	44.60	3371.52	(a)
PZ-3	SR/DL	09/23/19	44.95	3371.17	(a)
PZ-3	SR/DL	12/03/19	45.08	3371.04	(a)
PZ-4	SR/DL	03/07/19	44.48	3367.53	(a)
PZ-4	SR/DL	06/05/19	44.72	3367.29	(a)
PZ-4	SR/DL	09/23/19	45.21	3366.80	(a)
PZ-4	SR/DL	12/04/19	45.36	3366.65	(a)
PZ-5	SR/DL	03/07/19	42.83	3372.41	(a)
PZ-5	SR/DL	06/05/19	42.99	3372.25	(a)
PZ-5	SR/DL	09/23/19	43.38	3371.86	(a)
PZ-5	SR/DL	12/04/19	43.52	3371.72	(a)
PZ-6	SR/DL	03/07/19	42.41	3370.92	(a)
PZ-6	SR/DL	06/05/19	42.73	3370.60	(a)
PZ-6	SR/DL	09/23/19	43.20	3370.13	(a)
PZ-6	SR/DL	12/04/19	43.31	3370.02	(a)
PZ-7	SR/DL	03/07/19	35.16	3378.68	(a)
PZ-7	SR/DL	06/04/19	35.39	3378.45	(a)
PZ-7	SR/DL	09/16/19	35.69	3378.15	(a)
PZ-7	SR/DL	12/03/19	35.96	3377.88	(a)
PZ-9	SR/DL	03/07/19	58.22	3362.87	(a)
PZ-9	SR/DL	06/04/19	58.12	3362.97	(a)
PZ-9	SR/DL	09/16/19	58.20	3362.89	(a)
PZ-9	SR/DL	12/04/19	58.31	3362.78	(a)
PZ-10	SR/DL	03/07/19	36.01	3369.72	(a)
PZ-10	SR/DL	06/05/19	36.69	3369.04	(a)
PZ-10	SR/DL	09/23/19	37.38	3368.35	(a)
PZ-10	SR/DL	12/03/19	37.53	3368.20	(a)
PZ-11	SR/DL	03/07/19	41.36	3377.42	(a)
PZ-11	SR/DL	06/04/19	41.80	3376.98	(a)
PZ-11	SR/DL	09/16/19	41.78	3377.00	(a)
PZ-11	SR/DL	12/04/19	43.56	3375.22	(a)
PZ-12	SR/DL	03/07/19	50.89	3358.03	(a)
PZ-12	SR/DL	06/05/19	51.19	3357.73	(a)
PZ-12	SR/DL	09/23/19	51.82	3357.10	(a)
PZ-12	SR/DL	12/03/19	51.96	3356.96	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
PZ-13	SR/DL	03/06/19	64.85	3357.39	(a)
PZ-13	SR/DL	06/05/19	64.97	3357.27	(a)
PZ-13	SR/DL	09/16/19	65.03	3357.21	(a)
PZ-13	SR/DL	12/04/19	65.20	3357.04	(a)
PZ-14	SR/DL	03/06/19	66.11	3354.47	(a)
PZ-14	SR/DL	06/05/19	66.25	3354.33	(a)
PZ-14	SR/DL	09/16/19	66.27	3354.31	(a)
PZ-14	SR/DL	12/04/19	66.34	3354.24	(a)
PZ-15	GAT	03/06/19	47.21	3383.65	(a)
PZ-15	GAT	06/05/19	47.65	3383.21	(a)
PZ-15	GAT	09/16/19	48.18	3382.68	(a)
PZ-15	GAT	12/04/19	48.12	3382.74	(a)

Notes:

amsl Above mean sea level

ft Feet or foot

NA Not Available

(a) Not Applicable

(b) No fluid density measurements were collected due to well open-hole completion collapse. No freshwater head available.

APPENDIX G – AIR SAMPLING DATA: CONCENTRATIONS OF RADIONUCLIDES IN AIR FILTER COMPOSITES

Table G.1 – 2019 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	5.09E-03	5.40E-03	1.05E-02	U	5.30E-04	1.26E-03	1.93E-03	U	5.16E-03	5.95E-03	1.05E-02	U
	2	5.33E-03	4.16E-03	9.24E-03	U	-4.89E-04	8.63E-04	1.41E-03	U	3.68E-03	4.21E-03	9.63E-03	U
	3	-5.50E-05	4.62E-03	8.49E-03	U	7.31E-04	9.50E-04	1.43E-03	U	2.41E-03	4.28E-03	8.73E-03	U
	4 (Avg)	2.55E-03	4.82E-03	8.93E-03	UJ	6.55E-05	1.07E-03	1.43E-03	UJ	2.63E-03	4.87E-03	9.22E-03	UJ
WEE	1	1.79E-03	5.73E-03	1.08E-02	U	-4.90E-04	8.52E-04	2.47E-03	U	-5.98E-04	6.17E-03	1.08E-02	U
MET[(f)]	1	-4.51E-03	5.55E-03	1.09E-02	U	9.74E-05	1.12E-03	2.33E-03	U	-7.62E-03	6.60E-03	1.09E-02	U
WEE	2	5.31E-03	4.19E-03	9.26E-03	U	-1.73E-04	9.70E-04	1.44E-03	U	3.67E-03	4.24E-03	9.65E-03	U
	3	5.79E-03	4.23E-03	8.87E-03	U	-1.13E-05	9.24E-04	1.62E-03	U	7.31E-03	4.34E-03	9.44E-03	U
MET[(f)]	4	-8.69E-03	4.29E-03	8.90E-03	UJ	-2.50E-04	9.76E-04	1.39E-03	UJ	-9.61E-03	4.33E-03	9.19E-03	UJ
WEE	4	-2.87E-03	4.40E-03	8.90E-03	UJ	5.33E-05	1.04E-03	1.38E-03	UJ	-1.26E-02	4.80E-03	9.29E-03	UJ
WSS	1	5.56E-03	6.04E-03	1.06E-02	U	6.67E-04	1.44E-03	2.15E-03	U	5.37E-03	6.58E-03	1.06E-02	U
	2	4.84E-03	4.05E-03	9.23E-03	U	8.52E-05	1.01E-03	1.39E-03	U	2.69E-03	4.06E-03	9.62E-03	U
	3	6.43E-03	3.78E-03	8.77E-03	U	3.00E-04	9.35E-04	1.42E-03	U	5.41E-03	3.59E-03	9.33E-03	U
	4	7.38E-03	5.50E-03	8.98E-03	UJ	-1.26E-04	1.07E-03	1.50E-03	UJ	2.72E-03	5.11E-03	9.27E-03	UJ
MLR	1	2.19E-03	6.30E-03	1.09E-02	U	1.44E-04	1.12E-03	2.30E-03	U	-1.98E-03	6.56E-03	1.09E-02	U
	2	3.98E-03	3.94E-03	9.22E-03	U	-2.32E-04	9.27E-04	1.40E-03	U	2.89E-03	4.05E-03	9.61E-03	U
	3	4.74E-03	3.64E-03	8.77E-03	U	-2.75E-04	7.26E-04	1.42E-03	U	5.30E-03	3.60E-03	9.34E-03	U
	4	5.12E-03	5.29E-03	8.98E-03	UJ	2.54E-04	1.18E-03	1.51E-03	UJ	7.25E-03	5.56E-03	9.28E-03	UJ
SEC	1 (Avg)	4.53E-03	5.70E-03	1.06E-02	U	2.60E-04	1.25E-03	2.28E-03	U	9.44E-04	5.73E-03	1.06E-02	U
	2	1.28E-03	3.75E-03	9.22E-03	U	1.64E-04	1.04E-03	1.38E-03	U	3.56E-03	4.08E-03	9.61E-03	U
	3	4.68E-03	3.86E-03	8.82E-03	U	1.01E-03	1.20E-03	1.48E-03	U	6.24E-03	3.94E-03	9.39E-03	U
	4	3.25E-03	4.80E-03	8.92E-03	UJ	-4.97E-04	8.85E-04	1.42E-03	UJ	-4.24E-04	4.62E-03	9.22E-03	UJ

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			
CBD	1	9.04E-03	5.88E-03	1.04E-02	U	7.39E-04	1.30E-03	1.85E-03	U	5.37E-03	5.73E-03	1.04E-02	U
	2 (Avg)	8.46E-03	4.42E-03	9.24E-03	U	-1.97E-04	9.55E-04	1.43E-03	U	5.92E-03	4.39E-03	9.63E-03	U
	3	5.06E-03	3.58E-03	8.75E-03	U	4.46E-04	9.38E-04	1.39E-03	U	6.77E-03	3.65E-03	9.32E-03	U
	4	4.29E-03	4.97E-03	8.94E-03	UJ	1.05E-05	1.05E-03	1.43E-03	UJ	3.19E-03	4.94E-03	9.24E-03	UJ
SMR	1	5.27E-03	5.39E-03	1.05E-02	U	7.95E-04	1.40E-03	1.93E-03	U	4.85E-03	5.85E-03	1.05E-02	U
	2	7.51E-03	4.27E-03	9.23E-03	U	-4.85E-04	8.47E-04	1.42E-03	U	3.91E-03	4.15E-03	9.62E-03	U
	3 (Avg)	5.37E-03	3.77E-03	8.79E-03	U	2.22E-04	9.05E-04	1.44E-03	U	6.55E-03	3.79E-03	9.35E-03	U
	4	6.36E-03	5.44E-03	8.98E-03	UJ	1.15E-03	1.45E-03	1.52E-03	UJ	6.62E-03	5.52E-03	9.27E-03	UJ
Mean		3.84E-03	4.73E-03	9.42E-03	NA	1.50E-04	1.06E-03	1.63E-03	NA	2.59E-03	4.84E-03	9.72E-03	NA
Minimum[(e)]		-8.69E-03	4.29E-03	8.90E-03	MET (4)	-4.97E-04	8.85E-04	1.42E-03	SEC (4)	-1.26E-02	6.60E-03	1.09E-02	WEE (4)
Maximum[(e)]		9.04E-03	5.88E-03	1.04E-02	CBD (1)	1.15E-03	1.45E-03	1.52E-03	SMR (4)	7.31E-03	4.34E-03	9.44E-03	WEE (3)
WAB (Filter Blank)	1	-1.51E-03	3.81E-03	1.02E-02	U	-1.43E-06	8.45E-04	1.58E-03	U	7.43E-04	4.45E-03	1.02E-02	U
	2	5.80E-05	3.68E-03	9.22E-03	U	3.10E-04	1.08E-03	1.39E-03	U	-7.72E-05	3.86E-03	9.61E-03	U
	3	2.34E-03	3.59E-03	8.82E-03	U	4.60E-04	1.03E-03	1.48E-03	U	2.22E-03	3.47E-03	9.38E-03	U
	4	1.29E-02	3.36E-03	8.94E-03	NJ	7.83E-04	7.51E-04	1.44E-03	UJ	1.31E-02	3.39E-03	9.24E-03	UJ

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)]
		^{238}Pu				$^{239/240}PU$				^{241}Am			
WFF	1	-4.41E-05	4.25E-04	8.43E-04	U	4.78E-06	3.64E-04	1.02E-03	U	1.26E-04	7.14E-04	1.09E-03	U
	2	-1.27E-04	2.75E-04	7.53E-04	U	-1.64E-04	4.98E-04	9.21E-04	U	3.06E-04	6.59E-04	1.21E-03	U
	3	-1.52E-04	3.57E-04	8.18E-04	U	-2.42E-04	4.02E-04	9.79E-04	U	-2.86E-04	5.68E-04	1.09E-03	U
	4 (Avg)	2.95E-05	5.16E-04	8.03E-04	UJ	-9.68E-05	4.58E-04	9.77E-04	UJ	-4.62E-05	7.07E-04	1.18E-03	UJ
WEE	1	-4.85E-05	4.12E-04	8.13E-04	U	-1.04E-04	2.00E-04	9.86E-04	U	9.44E-05	7.21E-04	1.10E-03	U
MET[(f)]	1	-1.55E-04	2.98E-04	7.86E-04	U	-1.44E-04	2.80E-04	9.99E-04	U	-3.81E-04	4.68E-04	1.08E-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]
		^{238}Pu				$^{239/240}PU$				^{241}Am			
WEE	2	-1.15E-04	2.47E-04	7.78E-04	U	-1.52E-04	5.04E-04	1.02E-03	U	7.84E-05	4.94E-04	1.09E-03	U
	3	-1.18E-04	3.11E-04	7.58E-04	U	-2.03E-05	5.29E-04	9.70E-04	U	-1.91E-04	6.83E-04	1.15E-03	U
MET[f]	4	-1.85E-04	3.53E-04	1.07E-03	UJ	-3.98E-05	5.55E-04	1.22E-03	UJ	1.17E-05	7.85E-04	1.06E-03	UJ
WEE	4	-2.77E-04	4.66E-04	8.86E-04	UJ	-1.10E-04	4.76E-04	1.03E-03	UJ	3.11E-04	8.20E-04	1.06E-03	UJ
WSS	1	-2.12E-04	3.79E-04	8.08E-04	U	-1.30E-04	2.55E-04	9.55E-04	U	-4.01E-04	4.89E-04	1.08E-03	U
	2	-9.64E-05	2.02E-04	8.29E-04	U	-7.06E-05	6.11E-04	1.07E-03	U	2.90E-04	5.86E-04	1.12E-03	U
	3	-1.19E-05	4.69E-04	8.86E-04	U	2.52E-05	5.96E-04	1.12E-03	U	-1.23E-04	6.10E-04	1.08E-03	U
	4	5.66E-05	4.99E-04	8.30E-04	UJ	6.47E-05	4.88E-04	9.88E-04	UJ	-3.67E-04	6.68E-04	1.29E-03	UJ
MLR	1	-7.60E-05	4.61E-04	8.41E-04	U	2.46E-04	5.48E-04	1.03E-03	U	8.29E-04	9.05E-04	1.08E-03	U
	2	-1.36E-04	2.92E-04	7.89E-04	U	-1.52E-04	4.90E-04	9.27E-04	U	2.93E-04	5.97E-04	1.12E-03	U
	3	-9.53E-05	2.76E-04	7.07E-04	U	6.13E-05	5.66E-04	9.97E-04	U	-4.70E-04	5.71E-04	1.08E-03	U
	4	6.40E-04	8.13E-04	9.51E-04	UJ	-2.16E-04	3.91E-04	1.02E-03	UJ	-7.62E-05	7.36E-04	1.10E-03	UJ
SEC	1 (Avg)	-1.81E-04	3.37E-04	8.74E-04	U	3.01E-04	5.53E-04	1.06E-03	U	6.50E-06	7.44E-04	1.11E-03	U
	2	-4.24E-05	3.99E-04	7.60E-04	U	-1.70E-04	5.26E-04	9.51E-04	U	7.96E-04	7.45E-04	1.08E-03	U
	3	-1.42E-04	3.44E-04	8.43E-04	U	-1.41E-04	5.08E-04	1.04E-03	U	2.07E-04	7.82E-04	1.11E-03	U
	4	-6.13E-05	4.16E-04	8.20E-04	UJ	3.76E-04	6.57E-04	1.05E-03	UJ	-2.73E-05	6.91E-04	1.08E-03	UJ
CBD	1	6.78E-05	4.86E-04	7.76E-04	U	-1.45E-04	2.82E-04	9.56E-04	U	3.59E-04	7.71E-04	1.07E-03	U
	2 (Avg)	-7.50E-06	3.83E-04	8.18E-04	U	2.15E-05	5.66E-04	9.72E-04	U	1.50E-04	5.07E-04	1.10E-03	U
	3	-2.11E-04	4.29E-04	1.10E-03	U	2.13E-05	5.89E-04	1.10E-03	U	-2.01E-04	6.55E-04	1.13E-03	U
	4	-2.33E-04	4.14E-04	8.53E-04	UJ	-8.49E-05	4.50E-04	1.00E-03	UJ	2.05E-04	7.74E-04	1.06E-03	UJ
SMR	1	-1.82E-04	3.40E-04	9.01E-04	U	3.39E-07	3.98E-04	1.04E-03	U	-2.50E-04	5.21E-04	1.05E-03	U
	2	-7.18E-05	1.23E-04	7.01E-04	U	-2.92E-04	4.83E-04	9.12E-04	U	4.12E-05	4.83E-04	1.04E-03	U
	3 (Avg)	-8.58E-05	3.87E-04	8.38E-04	U	-6.02E-05	4.88E-04	9.84E-04	U	-4.58E-05	6.94E-04	1.15E-03	U
	4	-3.56E-04	4.66E-04	7.09E-04	UJ	-2.41E-07	4.90E-04	9.32E-04	UJ	-3.42E-04	6.45E-04	1.11E-03	UJ
Mean		-8.76E-05	3.86E-04	8.31E-04	NA	-4.71E-05	4.73E-04	1.01E-03	NA	2.99E-05	6.60E-04	1.10E-03	NA
Minimum[e]		-3.56E-04	4.66E-04	7.09E-04	SMR (4)	-2.92E-04	4.83E-04	9.12E-04	SMR (2)	-4.70E-04	5.71E-04	1.08E-03	MLR (3)
Maximum[e]		6.40E-04	8.13E-04	9.51E-04	MLR (4)	3.76E-04	6.57E-04	1.05E-03	SEC (4)	8.29E-04	9.05E-04	1.08E-03	MLR (1)
	1	-1.75E-04	3.28E-04	8.06E-04	U	-1.16E-04	2.27E-04	1.01E-03	U	-4.62E-04	5.50E-04	1.04E-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)]
		^{238}Pu				$^{239/240}$PU				^{241}Am			
WAB (Filter Blank)	2	-1.23E-04	2.64E-04	7.76E-04	U	-4.92E-05	5.63E-04	9.48E-04	U	-1.50E-04	3.29E-04	1.14E-03	U
	3	-9.82E-06	3.91E-04	7.91E-04	U	-1.01E-04	4.34E-04	9.25E-04	U	-2.05E-04	6.39E-04	1.10E-03	U
	4	1.34E-04	2.64E-04	9.15E-04	UJ	1.34E-04	2.63E-04	1.05E-03	UJ	2.41E-04	5.98E-04	1.35E-03	UJ

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	3.92E+00	2.40E+00	4.90E+00	U	-3.12E-02	2.51E-01	4.54E-01	U	8.48E-02	2.43E-01	4.47E-01	U
	2	2.29E+00	2.51E+00	4.88E+00	U	-2.11E-01	2.79E-01	4.39E-01	U	7.39E-02	2.95E-01	5.06E-01	U
	3	1.65E+00	3.75E+00	6.90E+00	U	1.47E-02	3.28E-01	6.15E-01	U	-2.08E-01	3.06E-01	5.31E-01	U
	4 (Avg)	2.53E+00	2.97E+00	5.83E+00	U	3.07E-02	3.24E-01	5.92E-01	U	-4.82E-02	3.14E-01	5.45E-01	U
WEE	1	2.28E+00	2.48E+00	4.83E+00	U	-1.45E-01	3.01E-01	4.82E-01	U	3.59E-01	2.95E-01	5.31E-01	U
MET[(f)]	1	4.10E+00	2.36E+00	4.82E+00	U	7.02E-02	2.25E-01	4.31E-01	U	-1.88E-02	2.21E-01	3.94E-01	U
WEE	2	2.85E+00	2.26E+00	4.52E+00	U	1.52E-01	2.36E-01	4.58E-01	U	-1.39E-01	2.14E-01	3.75E-01	U
	3	5.72E+00	3.39E+00	6.92E+00	U	-5.22E-02	3.12E-01	5.77E-01	U	-7.96E-02	3.05E-01	5.42E-01	U
MET[(f)]	4	2.17E+00	2.49E+00	4.80E+00	U	-1.87E-01	2.50E-01	4.22E-01	U	1.69E-01	2.35E-01	4.39E-01	U
WEE	4	2.66E+00	2.39E+00	4.73E+00	U	2.68E-03	2.37E-01	4.41E-01	U	-9.04E-02	3.03E-01	5.04E-01	U
WSS	1	4.10E+00	2.51E+00	5.04E+00	U	1.48E-01	2.44E-01	4.53E-01	U	9.27E-02	2.19E-01	4.06E-01	U
	2	7.22E+00	3.78E+00	7.71E+00	U	7.49E-02	3.39E-01	6.38E-01	U	2.43E-02	3.23E-01	5.85E-01	U
	3	3.97E+00	4.60E+00	7.68E+00	U	3.47E-01	3.33E-01	6.75E-01	U	3.64E-01	3.15E-01	6.11E-01	U
	4	4.47E+00	2.49E+00	5.14E+00	U	1.95E-01	2.56E-01	4.97E-01	U	-1.79E-01	3.14E-01	5.14E-01	U
MLR	1	3.95E+00	2.67E+00	5.35E+00	U	-1.16E-01	2.34E-01	4.19E-01	U	1.72E-02	2.92E-01	4.89E-01	U
	2	2.86E+00	2.40E+00	4.76E+00	U	-8.64E-02	2.50E-01	4.33E-01	U	-2.52E-01	2.17E-01	3.67E-01	U
	3	4.77E+00	3.47E+00	6.93E+00	U	-1.61E-01	3.21E-01	5.69E-01	U	-2.81E-01	3.03E-01	5.18E-01	U
	4	5.16E+00	2.66E+00	5.40E+00	U	-7.74E-02	2.48E-01	4.49E-01	U	2.08E-01	2.49E-01	4.67E-01	U
SEC	1 (Avg)	2.53E+00	2.42E+00	4.77E+00	U	-8.68E-02	2.50E-01	4.36E-01	U	1.53E-01	2.60E-01	4.66E-01	U
	2	1.40E+00	2.14E+00	4.17E+00	U	1.92E-01	2.24E-01	4.38E-01	U	-2.37E-02	2.21E-01	3.95E-01	U
	3	3.32E+00	3.19E+00	6.41E+00	U	7.73E-03	3.82E-01	6.26E-01	U	5.75E-02	4.02E-01	6.90E-01	U
	4	1.82E+00	2.79E+00	5.27E+00	U	4.13E-02	2.72E-01	4.87E-01	U	3.47E-02	3.16E-01	5.29E-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]
		^{40}K				^{60}Co				^{137}Cs			
CBD	1	3.94E+00	2.37E+00	4.81E+00	U	-1.05E-02	2.37E-01	4.24E-01	U	5.47E-02	2.27E-01	4.19E-01	U
	2 (Avg)	2.98E+00	2.36E+00	4.71E+00	U	1.70E-03	2.52E-01	4.52E-01	U	-1.86E-02	2.44E-01	4.23E-01	U
	3	2.64E+00	3.88E+00	7.31E+00	U	9.46E-02	4.00E-01	7.06E-01	U	-3.90E-01	4.10E-01	6.57E-01	U
	4	4.50E+00	2.49E+00	5.10E+00	U	2.09E-01	2.55E-01	5.01E-01	U	4.32E-02	3.10E-01	5.26E-01	U
SMR	1	3.94E+00	2.55E+00	5.16E+00	U	2.21E-01	2.46E-01	4.89E-01	U	1.44E-01	2.39E-01	4.46E-01	U
	2	5.94E+00	2.57E+00	5.36E+00	U	1.26E-01	2.60E-01	4.93E-01	U	3.81E-02	2.25E-01	4.11E-01	U
	3 (Avg)	3.85E+00	3.55E+00	6.96E+00	U	-1.41E-01	3.72E-01	6.38E-01	U	-2.63E-02	3.58E-01	6.22E-01	U
	4	-9.41E-01	2.82E+00	5.06E+00	U	-3.36E-02	3.51E-01	6.44E-01	U	1.43E-01	3.19E-01	5.98E-01	U
Mean		3.42E+00	2.82E+00	5.54E+00	NA	1.97E-02	2.82E-01	5.13E-01	NA	1.02E-02	2.83E-01	4.98E-01	NA
Minimum[e]		-9.41E-01	2.82E+00	5.06E+00	SMR (4)	-2.11E-01	2.79E-01	4.39E-01	WFF (2)	-3.90E-01	4.10E-01	6.57E-01	CBD (3)
Maximum[e]		7.22E+00	3.78E+00	7.71E+00	WSS (2)	3.47E-01	3.33E-01	6.75E-01	WSS (3)	3.64E-01	3.15E-01	6.11E-01	WSS (3)
WAB (Filter Blank)	1	3.93E+00	3.82E+00	6.31E+00	U	7.41E-02	2.40E-01	4.57E-01	U	-2.00E-01	3.01E-01	4.86E-01	U
	2	3.70E+00	2.57E+00	5.16E+00	U	8.76E-02	2.68E-01	4.81E-01	U	6.56E-02	2.84E-01	4.89E-01	U
	3	4.91E+00	3.20E+00	6.51E+00	U	-1.20E-01	3.09E-01	5.43E-01	U	-1.07E-01	2.94E-01	5.23E-01	U
	4	5.00E+00	2.60E+00	5.36E+00	U	-1.46E-01	2.73E-01	4.82E-01	U	-1.44E-01	2.70E-01	4.72E-01	U

		^{90}Sr			
Location	**Quarter**	**[RN][a]**	**2 σ TPU[b]**	**MDC[c]**	**Q[d]**
WFF	1	-9.36E-03	2.11E-02	2.73E-02	U
	2	-2.14E-02	2.44E-02	3.01E-02	U
	3	-2.25E-03	1.80E-02	3.19E-02	U
	4 (Avg)	-8.56E-03	1.87E-02	3.19E-02	UJ
WEE	1	-1.52E-02	2.10E-02	2.73E-02	U
MET[f]	1	-2.46E-02	2.11E-02	2.74E-02	U
WEE	2	-2.43E-03	2.48E-02	3.01E-02	U
	3	6.59E-03	1.85E-02	3.20E-02	U
MET[f]	4	-1.36E-02	1.88E-02	3.19E-02	UJ
WEE	4	-2.03E-02	1.88E-02	3.19E-02	UJ

WSS	1	-1.88E-02	2.04E-02	2.74E-02	U
	2	-2.57E-02	2.50E-02	3.01E-02	U
	3	-8.62E-03	1.84E-02	3.19E-02	U
	4	-2.34E-03	1.96E-02	3.19E-02	UJ
		^{90}Sr			
Location	**Quarter**	**[RN][a]**	**2 σ TPU[b]**	**MDC[c]**	**Q[d]**
MLR	1	-1.47E-02	2.06E-02	2.73E-02	U
	2	-1.10E-02	2.48E-02	3.02E-02	U
	3	6.97E-03	1.86E-02	3.19E-02	U
	4	-7.71E-03	1.94E-02	3.20E-02	UJ
SEC	1 (Avg)	-2.29E-02	1.99E-02	2.74E-02	U
	2	-1.43E-03	2.55E-02	3.01E-02	U
	3	-4.50E-03	1.84E-02	3.20E-02	U
	4	-1.21E-02	1.79E-02	3.18E-02	UJ
CBD	1	-2.27E-02	2.09E-02	2.73E-02	U
	2 (Avg)	-5.33E-03	2.51E-02	3.02E-02	U
	3	9.64E-03	1.84E-02	3.19E-02	U
	4	-8.94E-03	1.79E-02	3.19E-02	UJ
SMR	1	-1.98E-02	2.13E-02	2.74E-02	U
	2	-2.33E-03	2.40E-02	3.01E-02	U
	3 (Avg)	6.17E-03	1.97E-02	3.21E-02	U
	4	-2.13E-02	1.89E-02	3.19E-02	UJ
Mean		-9.95E-03	2.07E-02	3.03E-02	NA
Minimum[e]		-2.57E-02	2.50E-02	3.01E-02	WSS (2)
Maximum[e]		9.64E-03	1.84E-02	3.19E-02	CBD (3)
WAB (Filter Blank)	1	-1.84E-02	2.04E-02	2.73E-02	U
	2	-1.93E-02	2.49E-02	3.00E-02	U
	3	-1.08E-02	1.78E-02	3.18E-02	U

	4	1.13E-02	1.42E-02	3.22E-02	UJ

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.

(b) Total Propagated Uncertainty

(c) Minimum Detectable Concentration

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected. UJ equals nuclide not detected above the reported MDC and 2 sigma counting uncertainty and a quality deficiency affects the data making the reported data more uncertain. NJ equals nuclide present at an estimated quantity.

(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.

(f) MET location data used to substitute for WEE data (MET data used from 01/08/2019 to 01/22/2019 and 10/08/2019 to 10/29/2019).

Table G.2 – 2019 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, m³**	**Bq/sample**	**Bq/m³**	**Bq/sample**	**Bq/m³**	**Bq/sample**	**Bq/m³**	**Bq/sample**	**Bq/m³**	**Bq/sample**	**Bq/m³**	**Bq/sample**	**Bq/m³**
WFF	1	6884.44	5.09E-03	7.39E-07	5.30E-04	7.70E-08	5.16E-03	7.50E-07	-4.41E-05	-6.41E-09	4.78E-06	6.94E-10	1.26E-04	1.83E-08
	2	7283.57	5.33E-03	7.32E-07	-4.89E-04	-6.71E-08	3.68E-03	5.05E-07	-1.27E-04	-1.74E-08	-1.64E-04	-2.25E-08	3.06E-04	4.20E-08
	3	7216.11	-5.50E-05	-7.62E-09	7.31E-04	1.01E-07	2.41E-03	3.34E-07	-1.52E-04	-2.11E-08	-2.42E-04	-3.35E-08	-2.86E-04	-3.96E-08
	4 (Avg)	7330.56	2.55E-03	3.47E-07	6.55E-05	8.94E-09	2.63E-03	3.58E-07	2.95E-05	4.02E-09	-9.68E-05	-1.32E-08	-4.62E-05	-6.30E-09
WEE	1	4454.10	1.79E-03	4.02E-07	-4.90E-04	-1.10E-07	-5.98E-04	-1.34E-07	-4.85E-05	-1.09E-08	-1.04E-04	-2.33E-08	9.44E-05	2.12E-08
MET[(f)]	1	1608.90	-4.51E-03	-2.80E-06	9.74E-05	6.05E-08	-7.62E-03	-4.74E-06	-1.55E-04	-9.63E-08	-1.44E-04	-8.95E-08	-3.81E-04	-2.37E-07
WEE	2	5383.88	5.31E-03	9.86E-07	-1.73E-04	-3.21E-08	3.67E-03	6.82E-07	-1.15E-04	-2.14E-08	-1.52E-04	-2.82E-08	7.84E-05	1.46E-08
	3	4645.70	5.79E-03	1.25E-06	-1.13E-05	-2.43E-09	7.31E-03	1.57E-06	-1.18E-04	-2.54E-08	-2.03E-05	-4.37E-09	-1.91E-04	-4.11E-08
MET[(f)]	4	2248.77	-8.69E-03	-3.86E-06	-2.50E-04	-1.11E-07	-9.61E-03	-4.27E-06	-1.85E-04	-8.23E-08	-3.98E-05	-1.77E-08	1.17E-05	5.20E-09
WEE	4	5151.53	-2.87E-03	-5.57E-07	5.33E-05	1.03E-08	-1.26E-02	-2.45E-06	-2.77E-04	-5.38E-08	-1.10E-04	-2.14E-08	3.11E-04	6.04E-08
WSS	1	6945.11	5.56E-03	8.01E-07	6.67E-04	9.60E-08	5.37E-03	7.73E-07	-2.12E-04	-3.05E-08	-1.30E-04	-1.87E-08	-4.01E-04	-5.77E-08
	2	7403.07	4.84E-03	6.54E-07	8.52E-05	1.15E-08	2.69E-03	3.63E-07	-9.64E-05	-1.30E-08	-7.06E-05	-9.54E-09	2.90E-04	3.92E-08
	3	7283.56	6.43E-03	8.83E-07	3.00E-04	4.12E-08	5.41E-03	7.43E-07	-1.19E-05	-1.63E-09	2.52E-05	3.46E-09	-1.23E-04	-1.69E-08
	4	7449.54	7.38E-03	9.91E-07	-1.26E-04	-1.69E-08	2.72E-03	3.65E-07	5.66E-05	7.60E-09	6.47E-05	8.69E-09	-3.67E-04	-4.93E-08
MLR	1	7249.74	2.19E-03	3.02E-07	1.44E-04	1.99E-08	-1.98E-03	-2.73E-07	-7.60E-05	-1.05E-08	2.46E-04	3.39E-08	8.29E-04	1.14E-07
	2	7190.18	3.98E-03	5.54E-07	-2.32E-04	-3.23E-08	2.89E-03	4.02E-07	-1.36E-04	-1.89E-08	-1.52E-04	-2.11E-08	2.93E-04	4.08E-08
	3	7398.14	4.74E-03	6.41E-07	-2.75E-04	-3.72E-08	5.30E-03	7.16E-07	-9.53E-05	-1.29E-08	6.13E-05	8.29E-09	-4.70E-04	-6.35E-08
	4	6139.98	5.12E-03	8.34E-07	2.54E-04	4.14E-08	7.25E-03	1.18E-06	6.40E-04	1.04E-07	-2.16E-04	-3.52E-08	-7.62E-05	-1.24E-08
SEC	1 (Avg)	5891.09	4.53E-03	7.68E-07	2.60E-04	4.41E-08	9.44E-04	1.60E-07	-1.81E-04	-3.06E-08	3.01E-04	5.10E-08	6.50E-06	1.10E-09
	2	6169.35	1.28E-03	2.07E-07	1.64E-04	2.66E-08	3.56E-03	5.77E-07	-4.24E-05	-6.87E-09	-1.70E-04	-2.76E-08	7.96E-04	1.29E-07
	3	6176.11	4.68E-03	7.58E-07	1.01E-03	1.64E-07	6.24E-03	1.01E-06	-1.42E-04	-2.30E-08	-1.41E-04	-2.28E-08	2.07E-04	3.35E-08
	4	6218.72	3.25E-03	5.23E-07	-4.97E-04	-7.99E-08	-4.24E-04	-6.82E-08	-6.13E-05	-9.86E-09	3.76E-04	6.05E-08	-2.73E-05	-4.39E-09
CBD	1	6092.20	9.04E-03	1.48E-06	7.39E-04	1.21E-07	5.37E-03	8.81E-07	6.78E-05	1.11E-08	-1.45E-04	-2.38E-08	3.59E-04	5.89E-08
	2 (Avg)	6209.11	8.46E-03	1.36E-06	-1.97E-04	-3.17E-08	5.92E-03	9.53E-07	-7.50E-06	-1.21E-09	2.15E-05	3.46E-09	1.50E-04	2.41E-08
	3	6304.62	5.06E-03	8.03E-07	4.46E-04	7.07E-08	6.77E-03	1.07E-06	-2.11E-04	-3.35E-08	2.13E-05	3.38E-09	-2.01E-04	-3.19E-08

			$^{233/234}U$		^{235}U		^{238}U		^{238}Pu		$^{239/240}Pu$		^{241}Am	
Location	**Quarter**	**Vol, m³**	**Bq/sample**	**Bq/m³**	**Bq/sample**	**Bq/m³**	**Bq/sample**	**Bq/m³**	**Bq/sample**	**Bq/m³**	**Bq/sample**	**Bq/m³**	**Bq/sample**	**Bq/m³**
	4	6157.81	4.29E-03	6.97E-07	1.05E-05	1.71E-09	3.19E-03	5.18E-07	-2.33E-04	-3.78E-08	-8.49E-05	-1.38E-08	2.05E-04	3.33E-08
SMR	1	6122.79	5.27E-03	8.61E-07	7.95E-04	1.30E-07	4.85E-03	7.92E-07	-1.82E-04	-2.97E-08	3.39E-07	5.54E-11	-2.50E-04	-4.08E-08
	2	6167.54	7.51E-03	1.22E-06	-4.85E-04	-7.86E-08	3.91E-03	6.34E-07	-7.18E-05	-1.16E-08	-2.92E-04	-4.73E-08	4.12E-05	6.68E-09
	3 (Avg)	5238.52	5.37E-03	1.02E-06	2.22E-04	4.25E-08	6.55E-03	1.25E-06	-8.58E-05	-1.64E-08	-6.02E-05	-1.15E-08	-4.58E-05	-8.74E-09
	4	6158.15	6.36E-03	1.03E-06	1.15E-03	1.87E-07	6.62E-03	1.07E-06	-3.56E-04	-5.78E-08	-2.41E-07	-3.91E-11	-3.42E-04	-5.55E-08
Mean		6072.43	3.84E-03	4.54E-07	1.50E-04	2.19E-08	2.59E-03	1.91E-07	-8.76E-05	-1.85E-08	-4.71E-05	-1.04E-08	2.99E-05	-7.49E-10
Minimum		1608.90	-8.69E-03	-3.86E-06	-4.97E-04	-1.11E-07	-1.26E-02	-4.74E-06	-3.56E-04	-9.63E-08	-2.92E-04	-8.95E-08	-4.70E-04	-2.37E-07
Maximum		7449.54	9.04E-03	1.48E-06	1.15E-03	1.87E-07	7.31E-03	1.57E-06	6.40E-04	1.04E-07	3.76E-04	6.05E-08	8.29E-04	1.29E-07

			^{40}K		^{60}Co		^{137}Cs		^{90}Sr	
Location	**Quarter**	**Vol, m³**	**Bq/sample**	**Bq/m³**	**Bq/sample**	**Bq/m³**	**Bq/sample**	**Bq/m³**	**Bq/sample**	**Bq/m³**
WFF	1	6884.44	3.92E+00	5.69E-04	-3.12E-02	-4.53E-06	8.48E-02	1.23E-05	-9.36E-03	-1.36E-06
	2	7283.57	2.29E+00	3.14E-04	-2.11E-01	-2.90E-05	7.39E-02	1.01E-05	-2.14E-02	-2.94E-06
	3	7216.11	1.65E+00	2.29E-04	1.47E-02	2.04E-06	-2.08E-01	-2.88E-05	-2.25E-03	-3.12E-07
	4 (Avg)	7330.56	2.53E+00	3.44E-04	3.07E-02	4.18E-06	-4.82E-02	-6.58E-06	-8.56E-03	-1.17E-06
WEE	1	4454.10	2.28E+00	5.12E-04	-1.45E-01	-3.26E-05	3.59E-01	8.06E-05	-1.52E-02	-3.41E-06
MET[f]	1	1608.90	4.10E+00	2.55E-03	7.02E-02	4.36E-05	-1.88E-02	-1.17E-05	-2.46E-02	-1.53E-05
WEE	2	5383.88	2.85E+00	5.29E-04	1.52E-01	2.82E-05	-1.39E-01	-2.58E-05	-2.43E-03	-4.51E-07
	3	4645.70	5.72E+00	1.23E-03	-5.22E-02	-1.12E-05	-7.96E-02	-1.71E-05	6.59E-03	1.42E-06
MET[f]	4	2248.77	2.17E+00	9.65E-04	-1.87E-01	-8.32E-05	1.69E-01	7.52E-05	-1.36E-02	-6.05E-06
WEE	4	5151.53	2.66E+00	5.16E-04	2.68E-03	5.20E-07	-9.04E-02	-1.75E-05	-2.03E-02	-3.94E-06
WSS	1	6945.11	4.10E+00	5.90E-04	1.48E-01	2.13E-05	9.27E-02	1.33E-05	-1.88E-02	-2.71E-06
	2	7403.07	7.22E+00	9.75E-04	7.49E-02	1.01E-05	2.43E-02	3.28E-06	-2.57E-02	-3.47E-06
	3	7283.56	3.97E+00	5.45E-04	3.47E-01	4.76E-05	3.64E-01	5.00E-05	-8.62E-03	-1.18E-06
	4	7449.54	4.47E+00	6.00E-04	1.95E-01	2.62E-05	-1.79E-01	-2.40E-05	-2.34E-03	-3.14E-07
MLR	1	7249.74	3.95E+00	5.45E-04	-1.16E-01	-1.60E-05	1.72E-02	2.37E-06	-1.47E-02	-2.03E-06
	2	7190.18	2.86E+00	3.98E-04	-8.64E-02	-1.20E-05	-2.52E-01	-3.50E-05	-1.10E-02	-1.53E-06

			^{40}K		^{60}Co		^{137}Cs		^{90}Sr	
Location	**Quarter**	**Vol, m³**	**Bq/sample**	**Bq/m³**	**Bq/sample**	**Bq/m³**	**Bq/sample**	**Bq/m³**	**Bq/sample**	**Bq/m³**
	3	7398.14	4.77E+00	6.45E-04	-1.61E-01	-2.18E-05	-2.81E-01	-3.80E-05	6.97E-03	9.42E-07
	4	6139.98	5.16E+00	8.40E-04	-7.74E-02	-1.26E-05	2.08E-01	3.39E-05	-7.71E-03	-1.26E-06
SEC	1 (Avg)	5891.09	2.53E+00	4.29E-04	-8.68E-02	-1.47E-05	1.53E-01	2.60E-05	-2.29E-02	-3.88E-06
	2	6169.35	1.40E+00	2.27E-04	1.92E-01	3.11E-05	-2.37E-02	-3.84E-06	-1.43E-03	-2.32E-07
	3	6176.11	3.32E+00	5.38E-04	7.73E-03	1.25E-06	5.75E-02	9.31E-06	-4.50E-03	-7.29E-07
	4	6218.72	1.82E+00	2.93E-04	4.13E-02	6.64E-06	3.47E-02	5.58E-06	-1.21E-02	-1.95E-06
CBD	1	6092.20	3.94E+00	6.47E-04	-1.05E-02	-1.72E-06	5.47E-02	8.98E-06	-2.27E-02	-3.73E-06
	2 (Avg)	6209.11	2.98E+00	4.80E-04	1.70E-03	2.74E-07	-1.86E-02	-2.99E-06	-5.33E-03	-8.58E-07
	3	6304.62	2.64E+00	4.19E-04	9.46E-02	1.50E-05	-3.90E-01	-6.19E-05	9.64E-03	1.53E-06
	4	6157.81	4.50E+00	7.31E-04	2.09E-01	3.39E-05	4.32E-02	7.02E-06	-8.94E-03	-1.45E-06
SMR	1	6122.79	3.94E+00	6.43E-04	2.21E-01	3.61E-05	1.44E-01	2.35E-05	-1.98E-02	-3.23E-06
	2	6167.54	5.94E+00	9.63E-04	1.26E-01	2.04E-05	3.81E-02	6.18E-06	-2.33E-03	-3.78E-07
	3 (Avg)	5238.52	3.85E+00	7.34E-04	-1.41E-01	-2.68E-05	-2.63E-02	-5.02E-06	6.17E-03	1.18E-06
	4	6158.15	-9.41E-01	-1.53E-04	-3.36E-02	-5.46E-06	1.43E-01	2.32E-05	-2.13E-02	-3.46E-06
Mean		6072.43	3.42E+00	6.28E-04	1.97E-02	1.90E-06	1.02E-02	3.75E-06	-9.95E-03	-2.07E-06
Minimum		1608.90	-9.41E-01	-1.53E-04	-2.11E-01	-8.32E-05	-3.90E-01	-6.19E-05	-2.57E-02	-1.53E-05
Maximum		7449.54	7.22E+00	2.55E-03	3.47E-01	4.76E-05	3.64E-01	8.06E-05	9.64E-03	1.53E-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 2019 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 the 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 2019.
- Groundwater: The duplicate groundwater sample from WQSP-1 had the highest concentration for $^{233/234}U$ at 1.26E+00 Bq/L, which is lower 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 primary and duplicate respectively 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 5.27E+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 BRA location having the highest concentrations of $^{233/234}U$ and while UPR had the highest concentration of ^{235}U and ^{238}U. The highest concentrations were 9.08E-02 Bq/L for $^{233/234}U$; 2.35E-03 Bq/L for ^{235}U; and 5.17E-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.

  The highest concentrations of uranium isotopes in samples from tanks and tank-like structures were FWT with 8.63E-02 Bq/L for $^{233/234}U$; RED with 3.95E-03 Bq/L for ^{235}U; and RED with 5.91E-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 three other samples, the sewage sludge composite sample (SWL), PKT, 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 4.61E+00 Bq/L, which was lower than the 2018 concentration of 1.02E+02 Bq/L. The PKT concentration was 1.39e+01 Bq/L and the H-19 concentration was 2.19E+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 IDN sample of 2.33E-02 Bq/g was lower than the 99 percent confidence concentration of 1.10E-01 Bq/g; the concentration of ^{235}U in the TUT sample of 1.14E-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 IDN sample of 2.61E-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 reported on a dry weight basis.

  There were six sediment detections of ^{137}Cs, all in tanks and tank-like structures including HIL, TUT, PKT, IDN, LST, and BHT. There were no detections in the sediments associated with the Pecos River. The highest concentration of 5.87E-03 Bq/g was in the TUT 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 9.12E-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 4.48E-01 Bq/g from the UPR sample. 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 reported on a dry weight basis.

  There was one detection of $^{239/240}$Pu in sediment samples in 2019. The detected concentrations were 5.28E-04 Bq/g in the TUT sample. The concentration was lower than the 99 percent confidence interval range of the baseline concentration of 1.90E-03 Bq/g.

- Soil: There are three soil baseline concentrations for the 3 uranium isotopes, ^{40}K, and ^{137}Cs. 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 site include SEC.

WIPP site group (WFF, WEE, and WSS), the highest $^{233/234}U$ was 8.46E-03 Bq/g at the 5 to 10 cm depth of WEE; the highest ^{235}U concentration was 5.33E-04 Bq/g at 5 to 10 cm depth of WEE; and the highest ^{238}U concentration was 8.37E-03 Bq/g at 0 to 2 cm depth of WEE. The corresponding 99 percent confidence interval range of the baseline concentrations were 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. Thus, none of the concentrations were higher than the 99 percent confidence interval range of the baseline concentrations.

As for the 5-mile ring sites (SMR and MLR), highest uranium concentration of $^{233/234}U$ was 1.88E-02 Bq/g at the 2 to 5 cm depth of SMR; the highest ^{235}U concentration was 9.64E-04 Bq/g at the 2 to 5 cm depth of SMR; and the highest ^{238}U concentration was 1.90E-02 Bq/g at the 2 to 5 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, ^{238}U concentration was higher than the 99 percent confidence interval range of the baseline concentration for concentrations within the 5-mile ring.

The outer SEC site, highest uranium concentration of $^{233/234}U$ was 8.73E-03 Bq/g at the 5 to 10 cm depth of SEC; the highest ^{235}U concentration was 5.84E-04 Bq/g at the 5 to 10 cm depth of SEC; and the highest ^{238}U concentration was 9.29E-03 Bq/g at the 5 to 10 cm depth of SEC. The corresponding 99 percent confidence interval range of the baseline concentrations are 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. Hence, none of the concentrations were higher than the 99 percent confidence interval range of the baseline concentrations.

Potassium-40 was detected in all the soil samples. The highest concentration at the WIPP site group was 2.30E-01 Bq/g at the 5 to 10 cm depth of WEE, which was lower than the 99 percent confidence interval range of the baseline concentration of 2.80E-01 Bq/g.

The highest concentration of ^{40}K at the 5-mile ring sites was 9.02E-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 (8.29E-01 Bq/g) and at the 5 to 10 cm depth (6.62E-01 Bq/g) were also higher than the baseline concentration. Potassium 40 concentrations at MLR at all depths were also higher than the 99 percent baseline.

The ^{40}K highest concentration at the outer site was 2.03E-01 Bq/g at SEC, which was lower than the 99 percent confidence interval range of the baseline concentration of 7.80E-01 Bq/g.

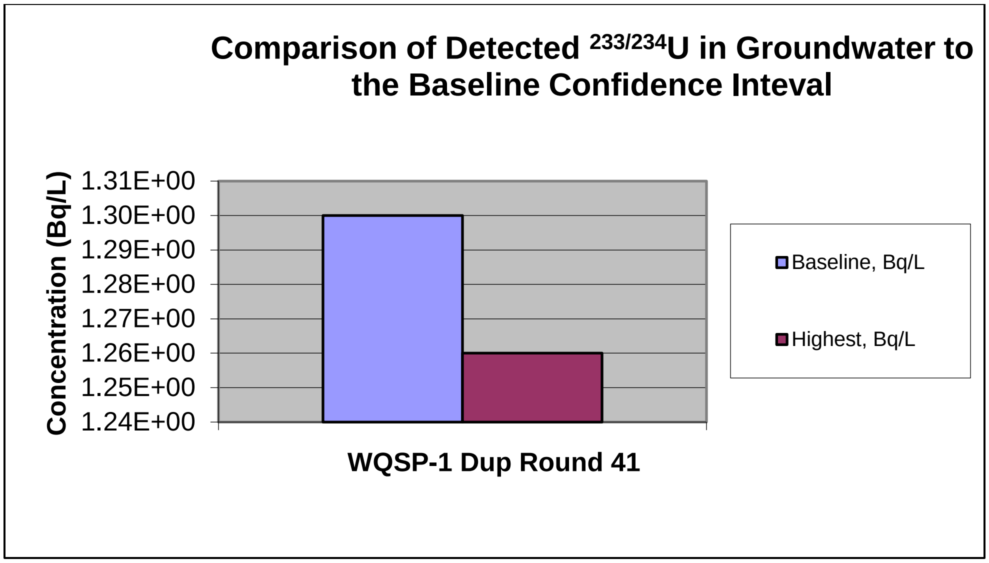
The highest ^{137}Cs concentration of 2.66E-03 at the 2 to 5 cm depth at the WEE sample was lower than the 99 percent baseline confidence interval range of the baseline concentration of 2.40E-02 Bq/g.

The highest ^{137}Cs concentration at the 5-mile radius sites was 6.44E-03 Bq/g at the 0 to 2 cm depth in the MLR sample was lower than the 99 percent baseline confidence interval range of the baseline concentration of 2.40E-02 Bq/g.

Caesium-137 was detected in all three depths at the SEC site. The highest concentration of 2.43E-03 Bq/g at the 5 to 10 cm depth, which was lower than the 99 percent baseline confidence interval range of the baseline concentration of 4.00E-02 Bq/g. All the soil sample results were reported on a dry weight basis.

- Vegetation: The only radionuclide detected in any of the vegetation samples in 2019 was ^{40}K. It was detected in all the samples including WFF, WFF (Dup), WEE, WSS, MLR, SEC, and SMR. The highest concentration, reported on a dry weight basis, was 7.61E-01 Bq/g in the SMR sample, which was lower than the mean baseline concentration of 3.20E+00 Bq/g. Uranium-234 and uranium -238 were detected in MLR sample at 7.29E-04 Bq/g and 8.40E-04 Bq/g, which are higher than the mean baseline concentration of 6.00E-05 Bq/g and 6.90E-04 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, deer, and fish. K-40 was detected in all the samples. The highest concentration of ^{40}K in fish was 7.22E-01 Bq/g in the PEC sample compared to the mean baseline concentration of 6.10E-01 Bq/g. The highest concentration of ^{40}K detected in quail was 2.80E-01 Bq/g in the sample from WIP compared to the mean baseline concentration of 4.10E-01 Bq/g. The highest concentration in the single deer sample was 6.50E-01 Bq/g; there are no baseline data to compare the concentration to in the deer sample.

A detailed discussion of environmental monitoring radionuclide sample results is presented in Chapter 4.


Comparison of Detected 233/234U in Groundwater to the Baseline Confidence Inteval
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1.27E+00
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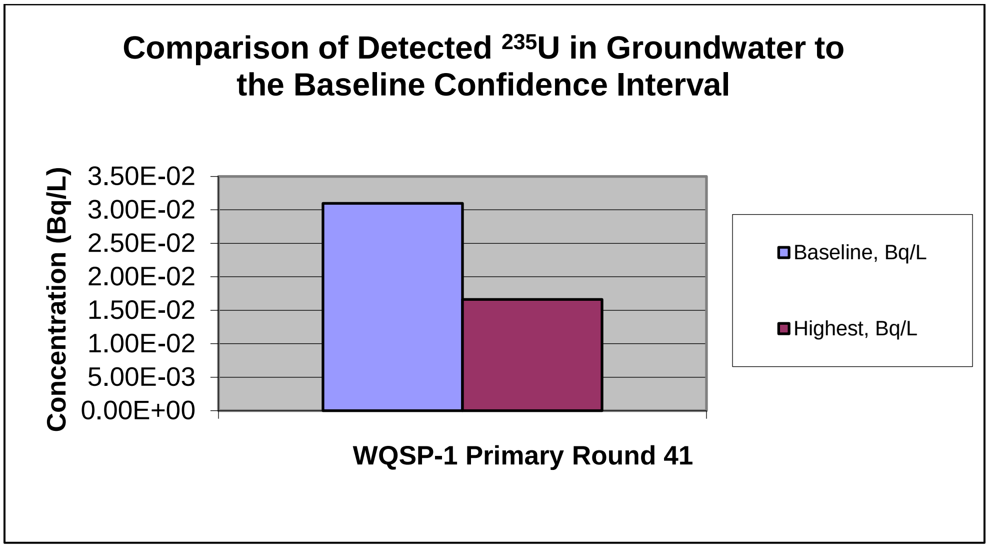
1.25E+00
1.24E+00
WQSP-1 Dup Round 41
Baseline, Bq/L
Highest, Bq/L


Comparison of Detected 235U in Groundwater to the Baseline Confidence Interval
Concentration (Bq/L)
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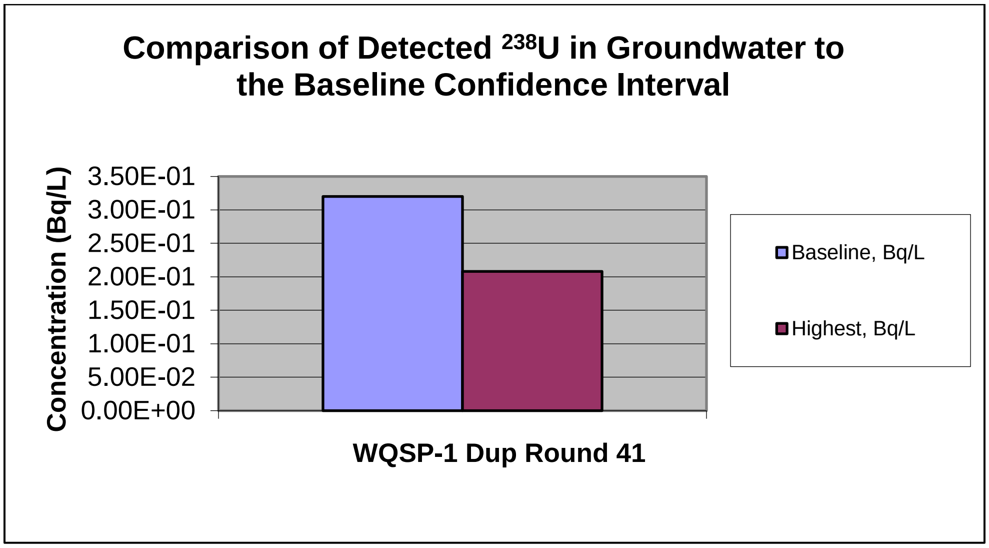
WQSP-1 Primary Round 41
Baseline, Bq/L
Highest, Bq/L


Comparison of Detected 238U in Groundwater to the Baseline Confidence Interval
Concentration (Bq/L)
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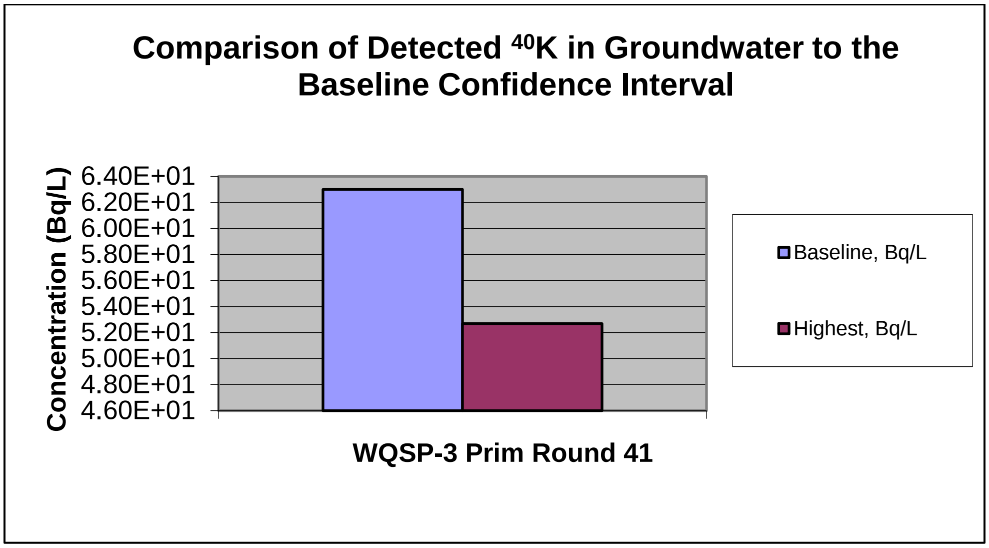
WQSP-1 Dup Round 41
Baseline, Bq/L
Highest, Bq/L


Comparison of Detected 40K in Groundwater to the Baseline Confidence Interval
Concentration (Bq/L)
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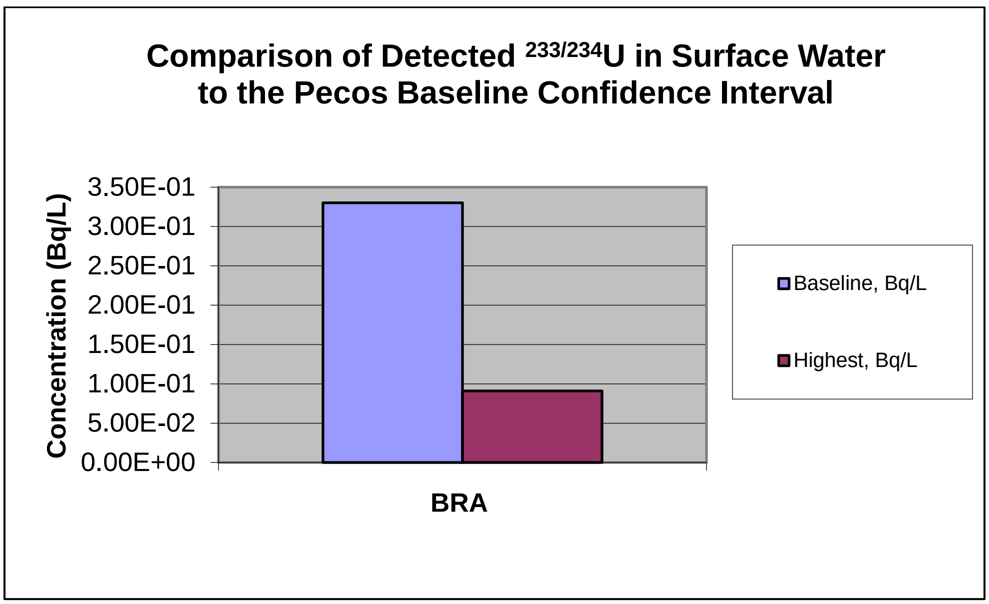
6.00E+01
5.80E+01
5.60E+01
5.40E+01
5.20E+01
5.00E+01
4.80E+01
4.60E+01
WQSP-3 Prim Round 41
Baseline, Bq/L
Highest, Bq/L


Comparison of Detected 233/234U in Surface Water to the Pecos Baseline Confidence Interval
Concentration (Bq/L)
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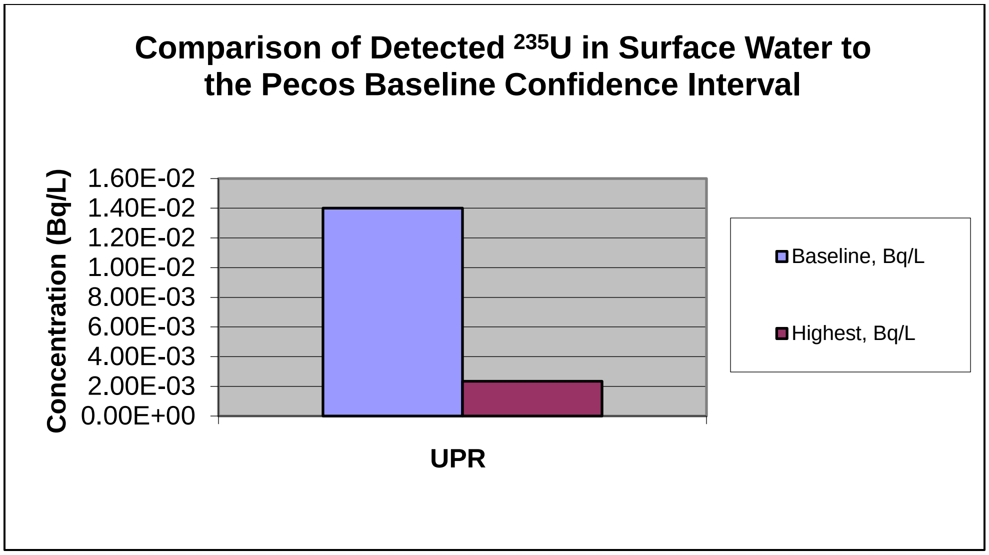
3.00E-01
2.50E-01
2.00E-01
1.50E-01
1.00E-01
5.00E-02
0.00E+00
BRA
Baseline, Bq/L
Highest, Bq/L


Comparison of Detected 235U in Surface Water to the Pecos Baseline Confidence Interval
Concentration (Bq/L)
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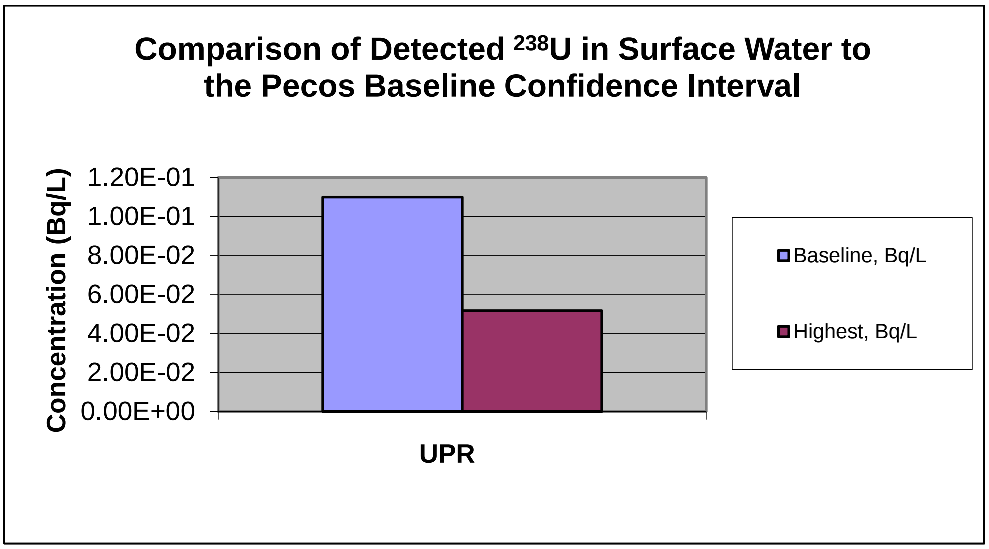
0.00E+00
UPR
Baseline, Bq/L
Highest, Bq/L


Comparison of Detected 238U in Surface Water to the Pecos Baseline Confidence Interval
Concentration (Bq/L)
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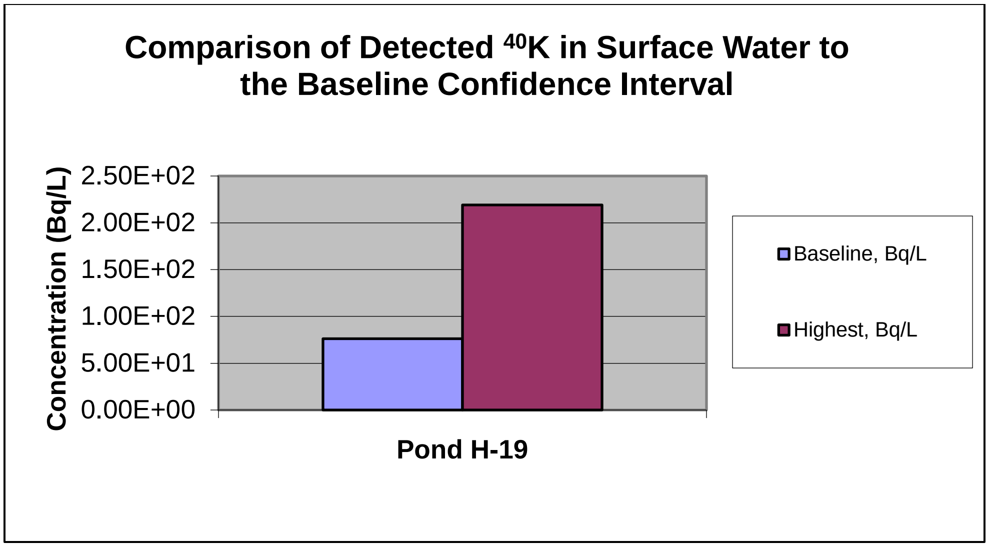
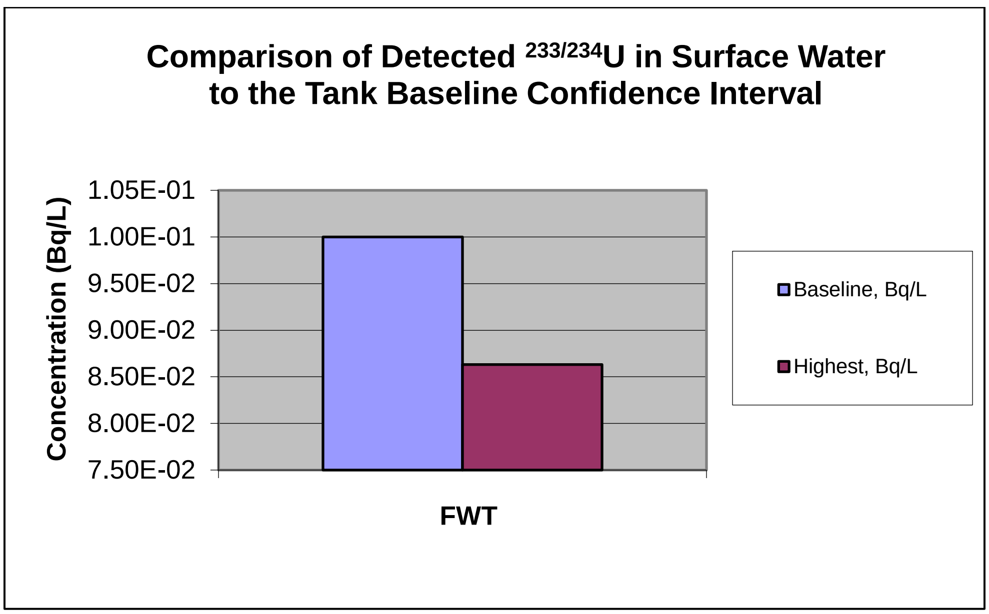
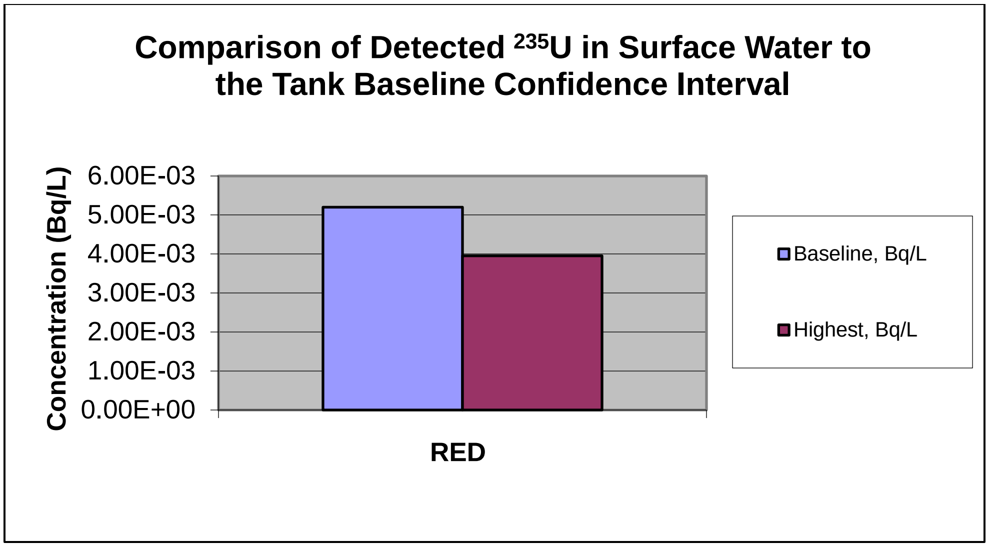
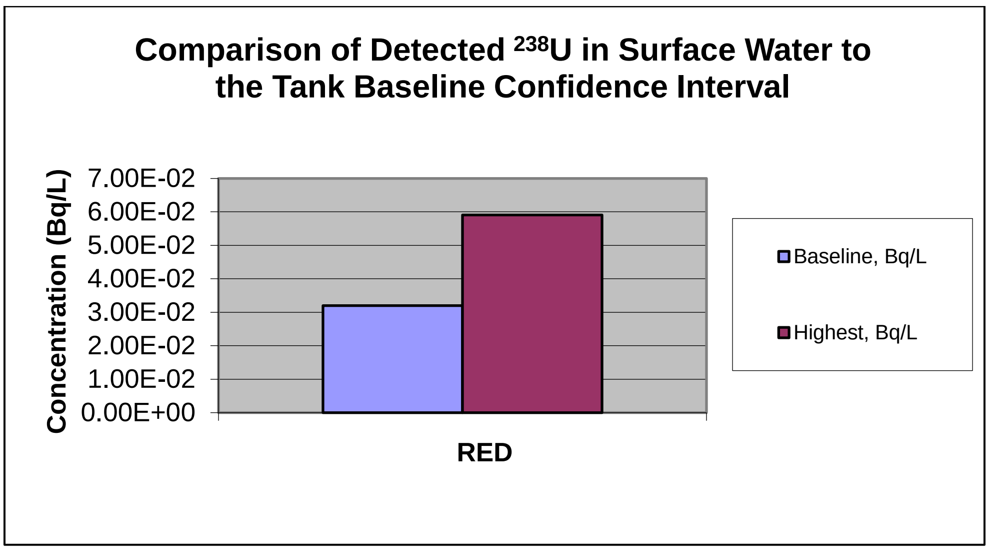
4.00E-02
2.00E-02
0.00E+00
UPR
Baseline, Bq/L
Highest, Bq/L



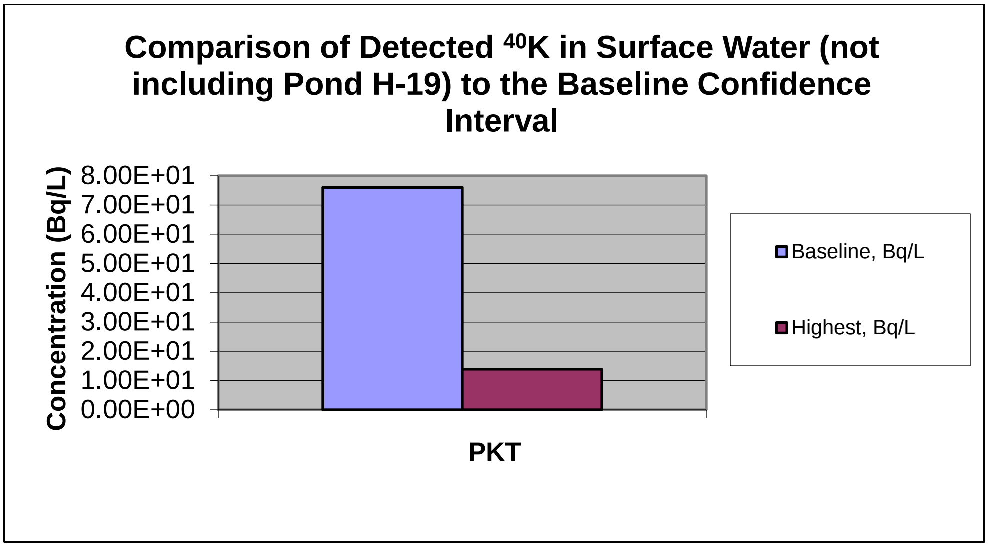
The higher concentration is due to the very high concentration of brine in the H-19 Pond, a portion of which comes from the naturally occurring ^{40}K in the brine's potassium chloride.

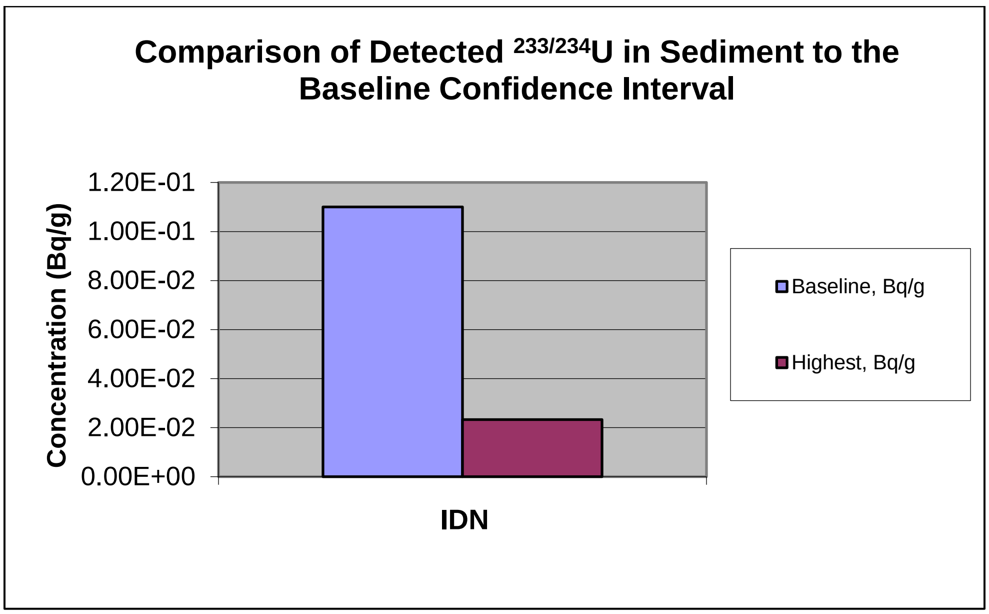


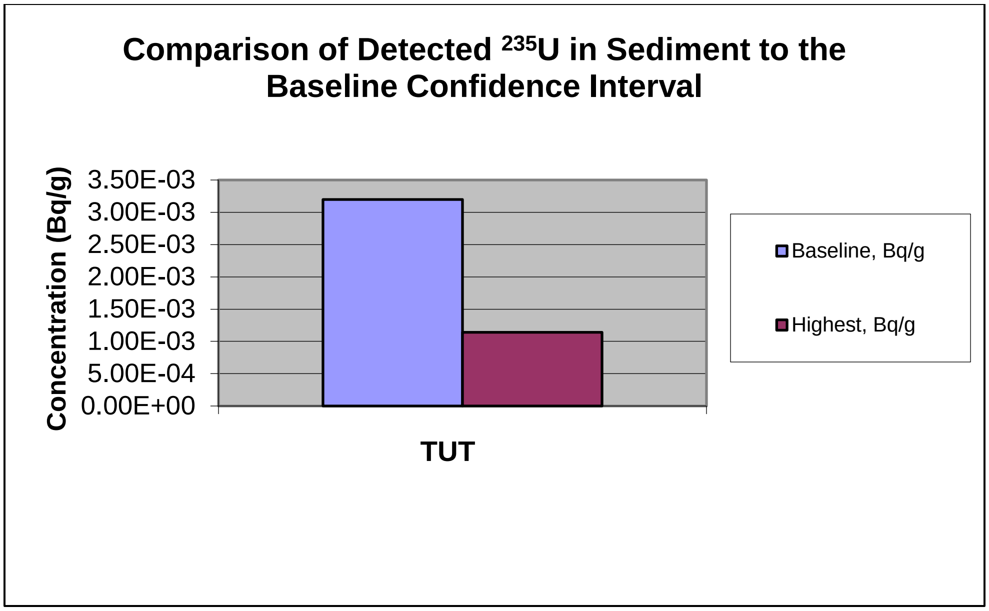


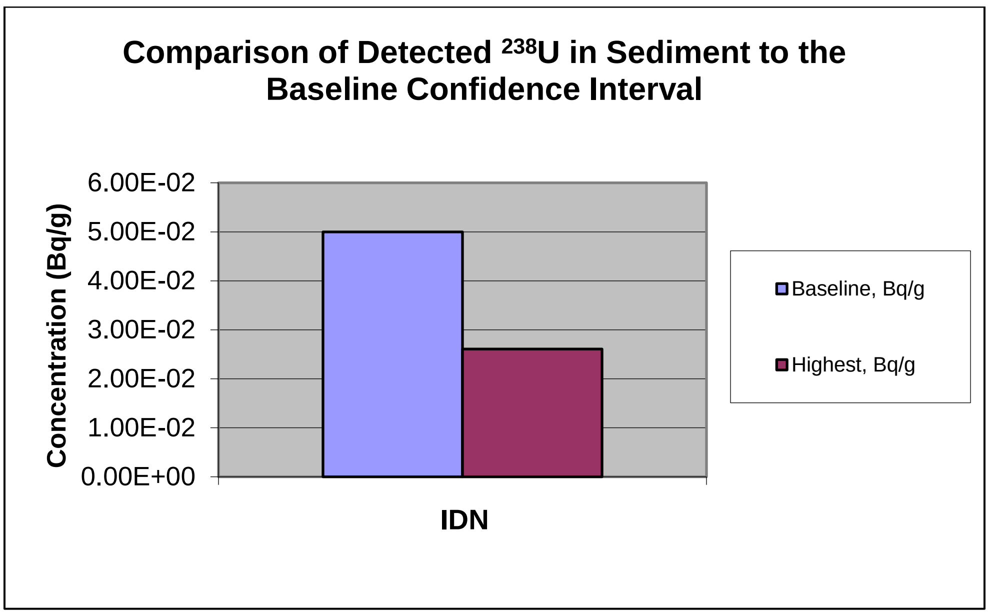


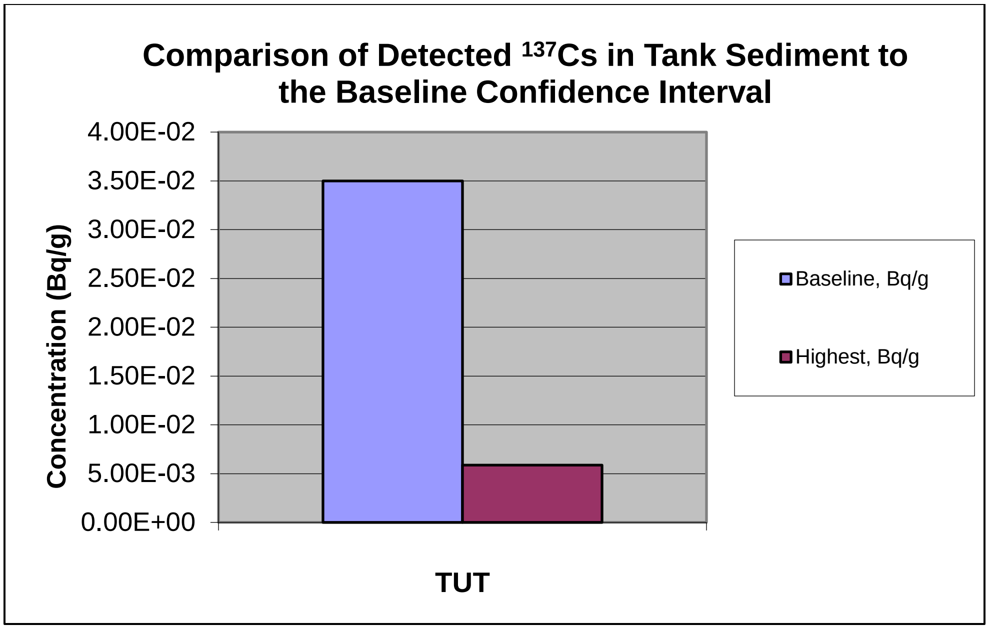
Higher concentration is unlikely to be related to WIPP operations because natural concentrations of uranium varies widely in the Earth's crust, and this variation is reflected in the amounts of uranium dissolved in surface water.

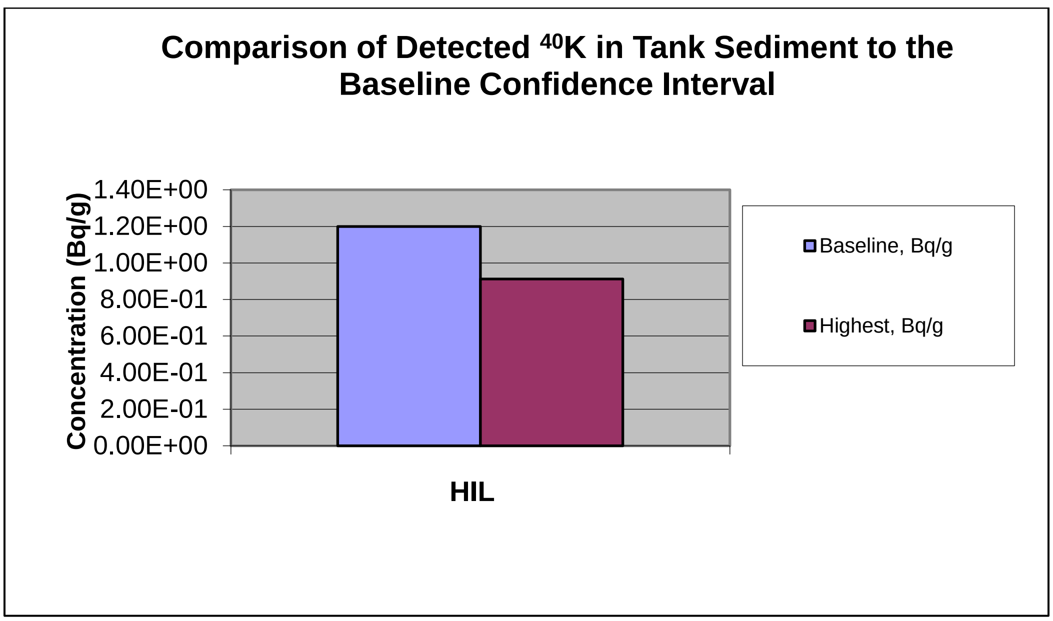

Comparison of Detected ^{40}K in Surface Water (not including Pond H-19) to the Baseline Confidence Interval
Concentration (Bq/L)
8.00E+01
7.00E+01
6.00E+01
5.00E+01
4.00E+01
3.00E+01
2.00E+01
1.00E+01
0.00E+00
PKT
Baseline, Bq/L
Highest, Bq/L

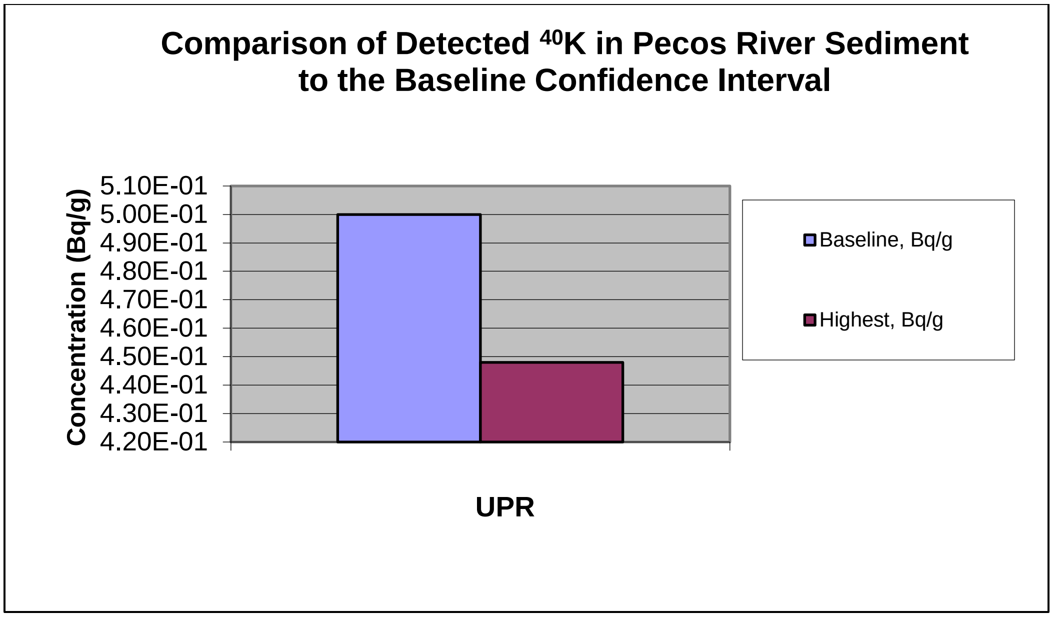

Comparison of Detected $^{233/234}U$ in Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
1.20E-01
1.00E-01
8.00E-02
6.00E-02
4.00E-02
2.00E-02
0.00E+00
IDN
Baseline, Bq/g
Highest, Bq/g

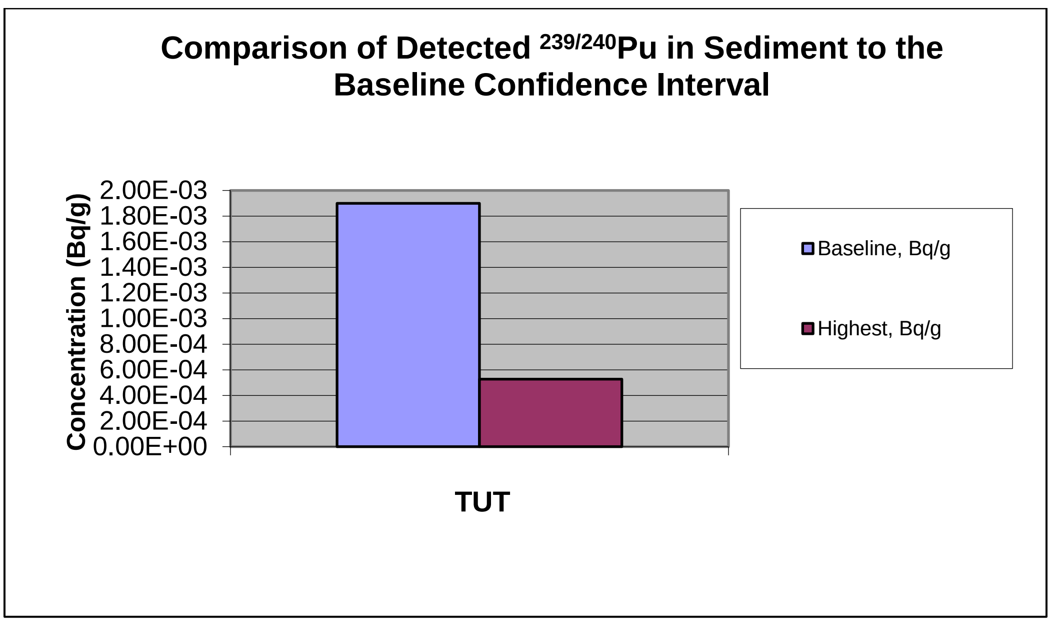

Comparison of Detected ^{235}U in Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
3.50E-03
3.00E-03
2.50E-03
2.00E-03
1.50E-03
1.00E-03
5.00E-04
0.00E+00
TUT
Baseline, Bq/g
Highest, Bq/g

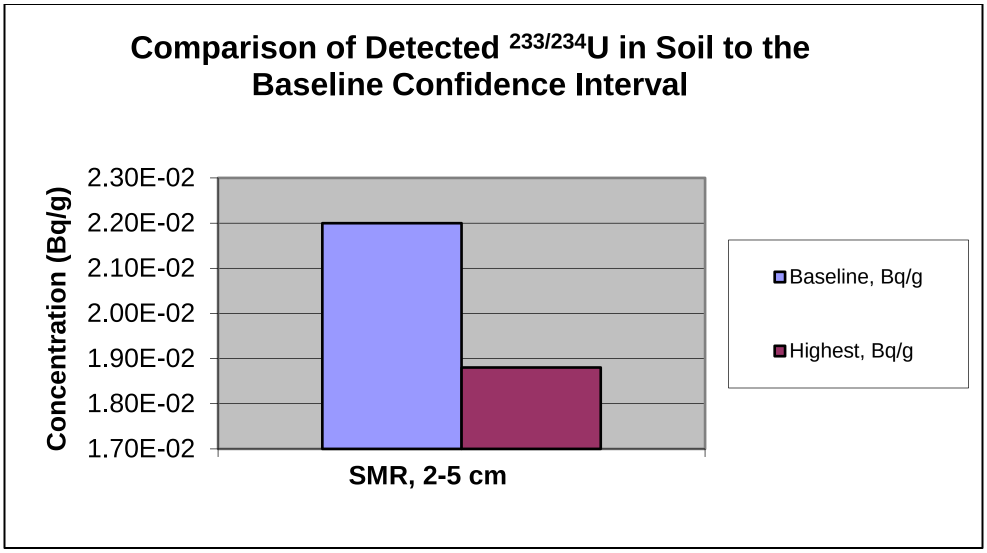

Comparison of Detected ^{238}U in Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
6.00E-02
5.00E-02
4.00E-02
3.00E-02
2.00E-02
1.00E-02
0.00E+00
IDN
Baseline, Bq/g
Highest, Bq/g

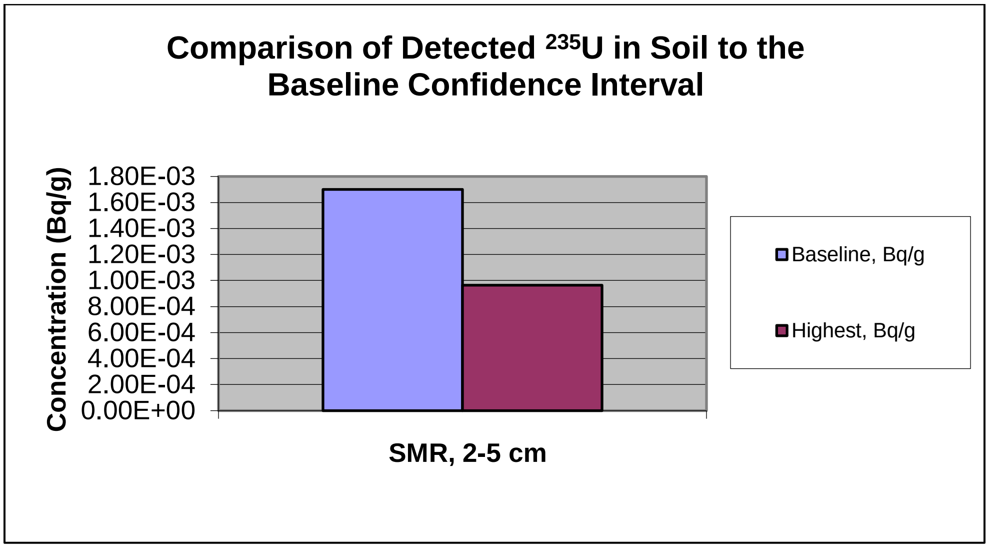

Comparison of Detected 137Cs in Tank Sediment to the Baseline Confidence Interval
4.00E-02
3.50E-02
3.00E-02
2.50E-02
2.00E-02
1.50E-02
1.00E-02
5.00E-03
0.00E+00
Concentration (Bq/g)
TUT
Baseline, Bq/g
Highest, Bq/g

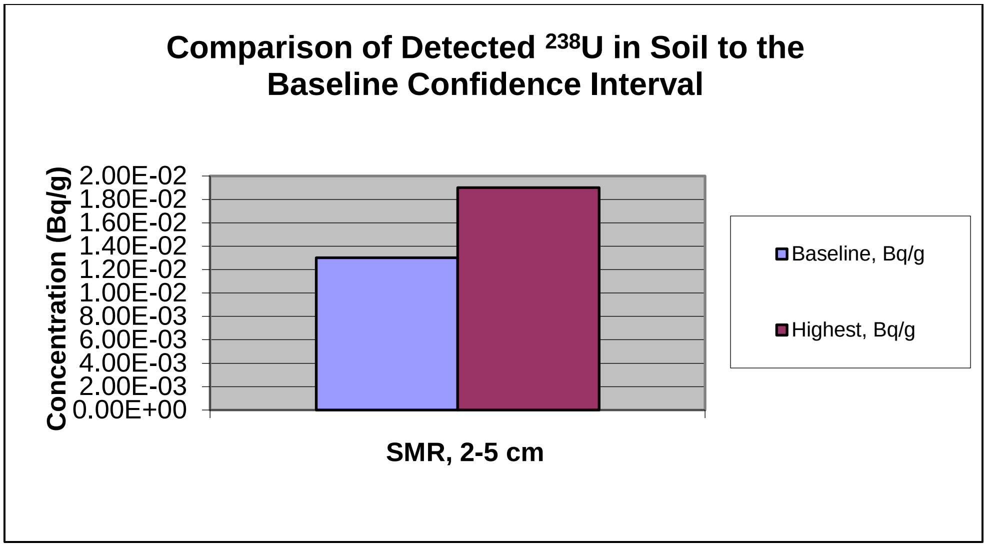

Comparison of Detected 40K in Tank Sediment to the Baseline Confidence Interval
1.40E+00
1.20E+00
1.00E+00
8.00E-01
6.00E-01
4.00E-01
2.00E-01
0.00E+00
Concentration (Bq/g)
HIL
Baseline, Bq/g
Highest, Bq/g


Comparison of Detected 40K in Pecos River Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
5.10E-01
5.00E-01
4.90E-01
4.80E-01
4.70E-01
4.60E-01
4.50E-01
4.40E-01
4.30E-01
4.20E-01
UPR
Baseline, Bq/g
Highest, Bq/g

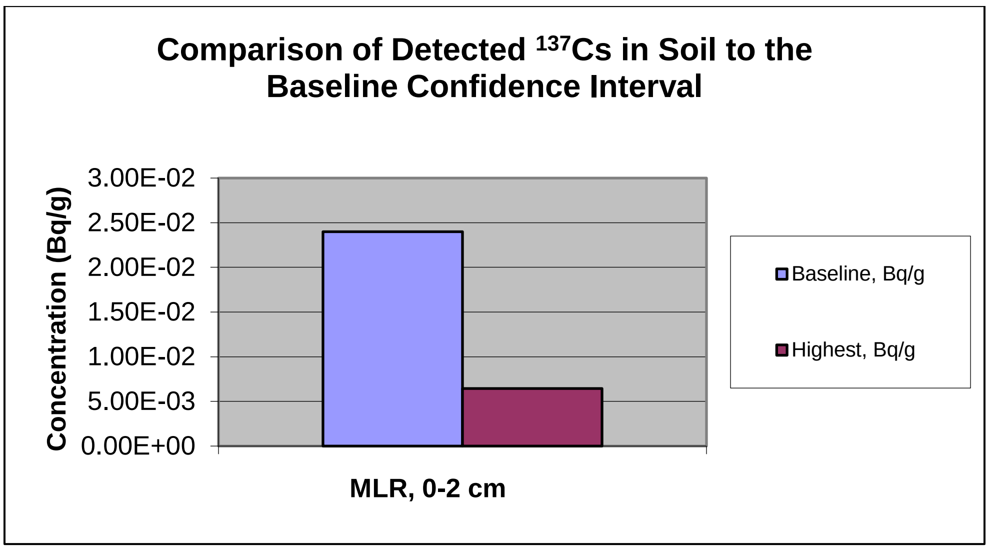

Comparison of Detected 239/240Pu in Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
2.00E-03
1.80E-03
1.60E-03
1.40E-03
1.20E-03
1.00E-03
8.00E-04
6.00E-04
4.00E-04
2.00E-04
0.00E+00
TUT
Baseline, Bq/g
Highest, Bq/g

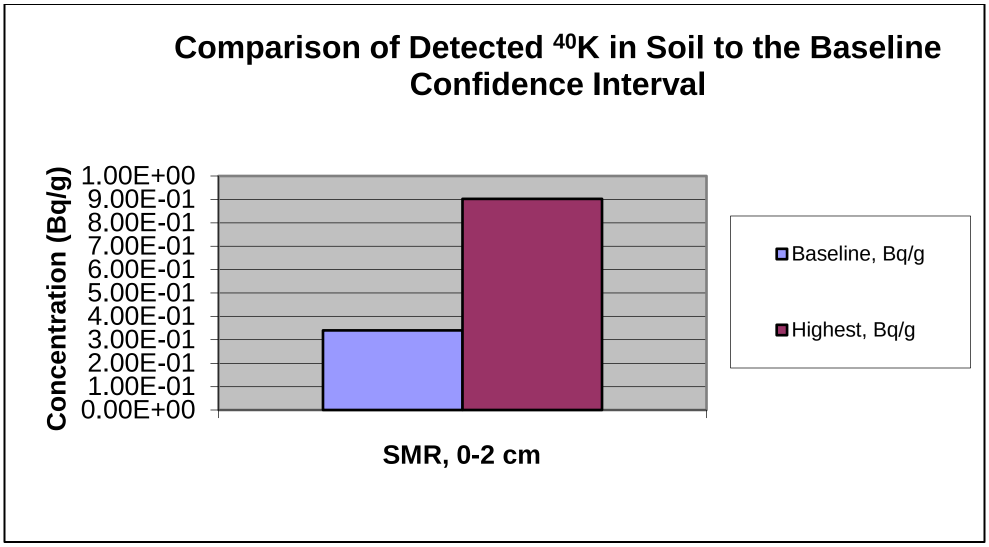

Comparison of Detected 233/234U in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
2.30E-02
2.20E-02
2.10E-02
2.00E-02
1.90E-02
1.80E-02
1.70E-02
SMR, 2-5 cm
Baseline, Bq/g
Highest, Bq/g


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

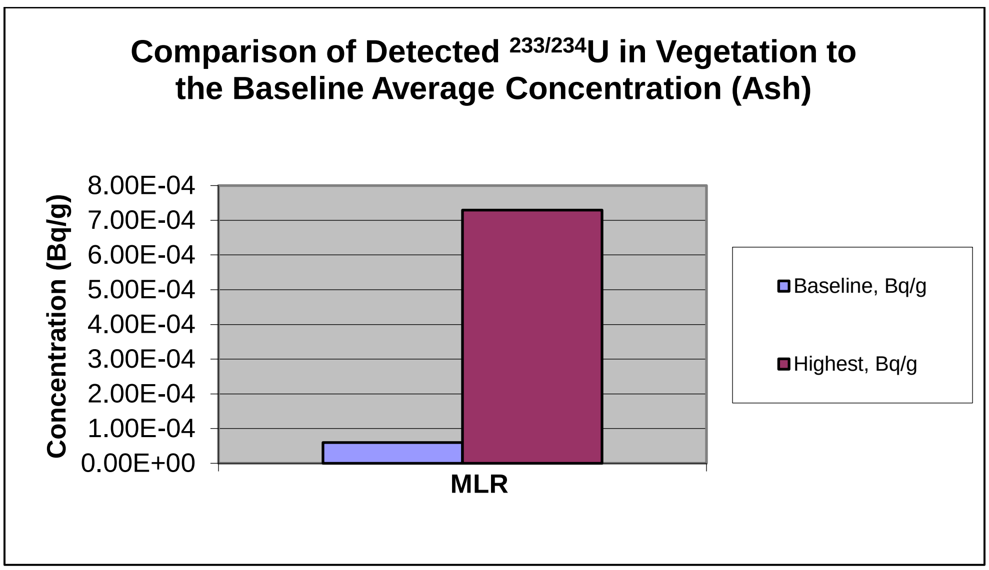


The detected uranium concentrations in soil follow a pattern of variability consistent with the distribution of natural uranium found in soils throughout the world.

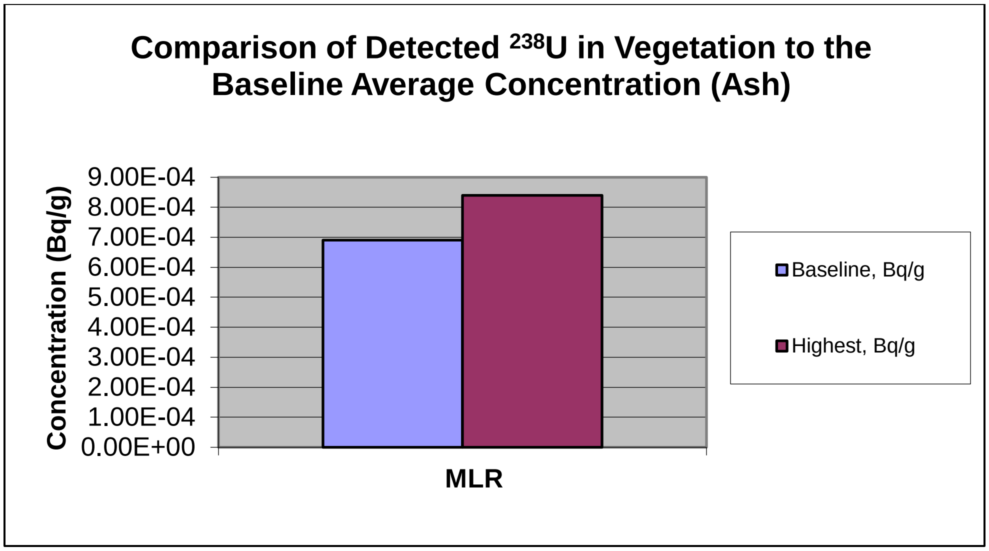




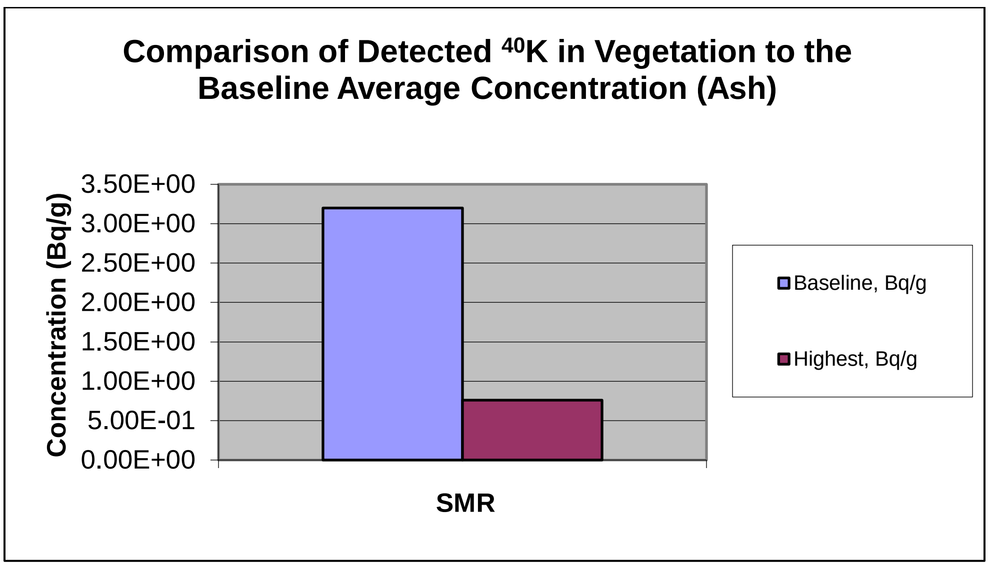
Potassium 40 is ubiquitous throughout the Earth's crust with various concentrations, depending on weathering of different rocks and mineral sources and this variation is reflected in the amounts of ^{40}K detected.

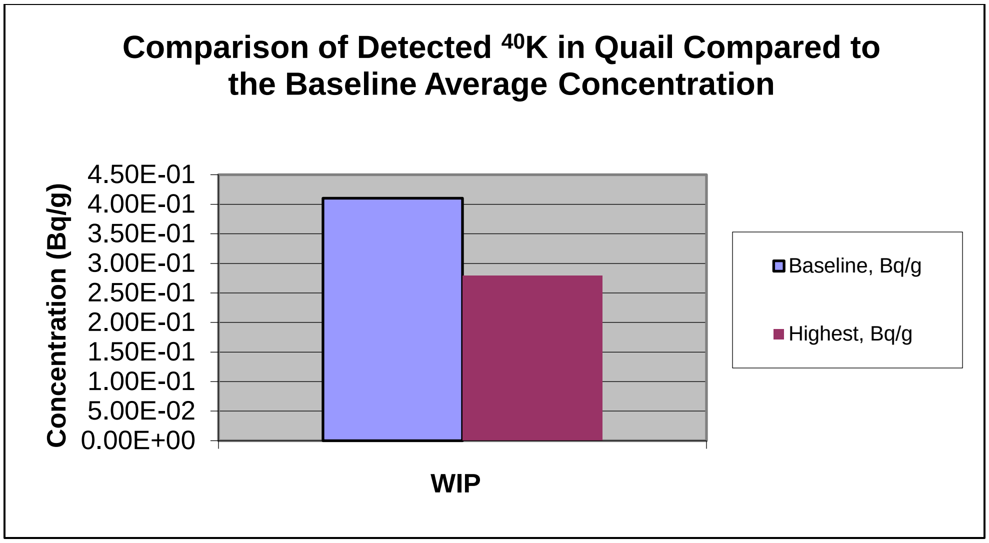


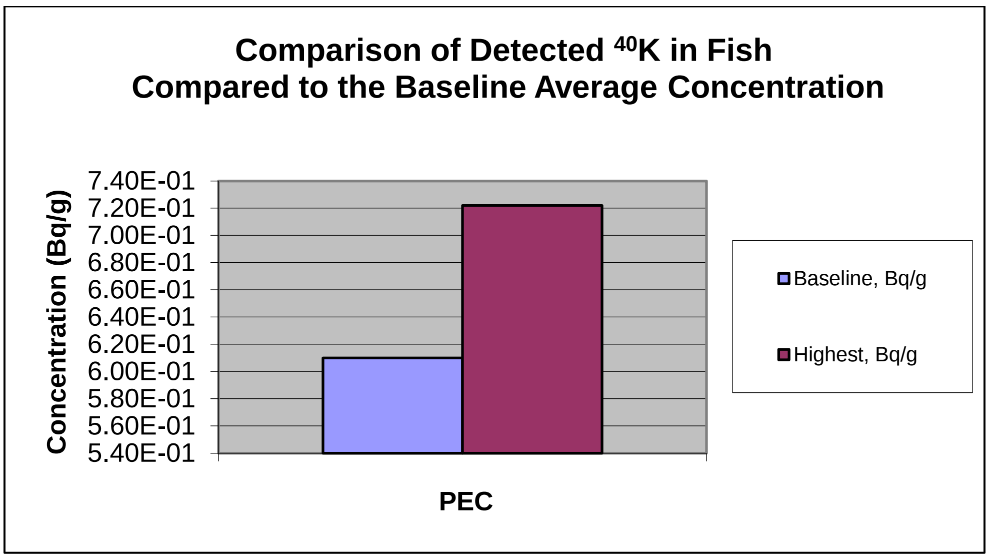
The baseline data were reported on an ashed weight basis and the vegetation data are reported on a dry weight basis. Also, the natural variability of this naturally occurring radionuclide in the soil would be expected to yield some variation in the vegetation concentrations.



The baseline data were reported on an ashed weight basis and the vegetation data are reported on a dry weight basis. Also, natural variability in uranium distribution as well as plant uptake will affect the concentration detected in vegetation samples.







Potassium-40 is the largest source of natural radioactivity in animals including humans. The higher concentration is unlikely to be related to WIPP operations because of the natural variability in ^{40}K distribution and uptake by animals.