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DOE/WIPP-16-3572
Revision 0

Waste Isolation Pilot Plant Annual Site Environmental Report for 2015

U.S. Department of Energy

September 2016

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2015 Annual Site Environmental Report

To our readers:

This Waste Isolation Pilot Plant (WIPP) Annual Site Environmental Report for 2015 presents summary environmental data to (1) characterize site environmental management performance; (2) summarize environmental occurrences and responses reported during the calendar year; (3) confirm compliance with environmental standards and requirements; and (4) highlight the WIPP Environmental Management System (EMS), significant environmental programs, and accomplishments, including progress toward U.S. Department of Energy (DOE) Environmental Sustainability Goals.

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

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ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

AIB	Accident Investigation Board
Am	americium
ANOVA	analysis of variance
AO	Administrative Order
ASER	Annual Site Environmental Report
BLM	U.S. Department of the Interior, Bureau of Land Management
Bq	becquerel(s)
Bq/g	becquerels per gram
Bq/L	becquerels per liter
Bq/m^3	becquerels per cubic meter
Bq/sample	becquerels per composite air filter sample
Btu	British thermal units
CAP	Corrective Action Plan
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
DMP	Detection Monitoring Program
DOE	U.S. Department of Energy
DP	discharge permit
dpm	disintegrations per minute
EDE	effective dose equivalent
EMS	Environmental Management System
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ft	foot or feet
ft^2/d	square feet per day
ft^3	cubic feet
ft^3/min	cubic feet per minute
FY	fiscal year
g/mL	gram per milliliter
GC/MS	gas chromatography / mass spectrometry
GHG	greenhouse gas
gsf	gross square feet
HEAL	Hall Environmental Analysis Laboratory

HEPA	high-efficiency particulate air (filter)
ICP	inductively coupled plasma spectroscopy
ID	identification (confidence)
in.	inch(es)
ISO	International Organization for Standardization
J	estimated concentration
K	potassium
km	kilometer(s)
km^2	square kilometers
L	liter(s)
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LEPC	Local Emergency Planning Committee
LIMS	Laboratory Information Management System
LMP	Land Management Plan
LWA	WIPP Land Withdrawal Act of 1992 (as amended)
LWB	Land Withdrawal Boundary
m	meter(s)
m^2	square meters
m^2/d	square meters per day
m^3	cubic meters
m^3/min	cubic meters per minute
MAPEP	Mixed Analyte Performance Evaluation Program
MDC	minimum detectable concentration
MDL	method detection limit
MEI	maximally exposed individual
mg/L	milligrams per liter
mi	mile(s)
mi^2	square miles
mL	milliliters
mm	millimeters
MOC	management and operating contractor
mrem	millirem
MRL	method reporting limit
MS/MSD	matrix spike / matrix spike duplicate
mSv	millisievert(s)
NEPA	*National Environmental Policy Act*
NESHAP	National Emission Standards for Hazardous Air Pollutants
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department

NRIP	National Institute of Standards and Technology Radiochemistry Intercomparison Program
NWP	Nuclear Waste Partnership LLC
PCB	polychlorinated biphenyl
Permit	WIPP Hazardous Waste Facility Permit
pH	measure of the acidity or alkalinity of a solution
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
SERC	State Emergency Response Commission
SNL	Sandia National Laboratories
SOO	samples of opportunity
SOP	standard operating procedure
SOW	statement of work
SPDV	site preliminary design validation
Sr	strontium
SSW	shallow subsurface water
Sv	sievert
SVOC	semivolatile organic compound
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

SYMBOLS

˚C	degrees Celsius
˚F	degrees Fahrenheit
>	greater than
<	less than
≤	less than or equal to
μg	microgram
μg/L	microgram per liter
μm	micrometer or micron
μmhos	micromhos
%	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 2015 (ASER) is to provide the information required by U.S. Department of Energy (DOE) Order 231.1B, *Environment, Safety, and Health Reporting*.

The DOE Carlsbad Field Office (CBFO) and the management and operating contractor (MOC) maintain and preserve the environmental resources at the WIPP facility. DOE Order 231.1B; DOE Order 436.1, *Departmental Sustainability*; and DOE Order 458.1, *Radiation Protection of the Public and the Environment*, require that the affected environment at and near DOE facilities be monitored to ensure the safety and health of the public and workers, and preservation 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 generated by the production of nuclear weapons and other activities related to the national defense of the United States.

WIPP DISPOSAL FOR 2015

In 2015, no TRU waste was disposed of at the WIPP facility, due to recovery from two repository events in February 2014. From the first receipt of waste in March 1999 through the end of 2015, 90,983 cubic meters (m^3) of TRU waste has been disposed of at the WIPP facility.

WIPP Environmental Management System

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

Monitoring for Environmental Impacts

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

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

During CY 2015, there was a single detection of $^{239/240}$Pu in the first quarter low-volume air filter composite sample from location WFF. The concentration was below the 99 percent confidence interval. There were no detections of any transuranics in water, sediment, 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. WIPP environmental personnel also conduct surveillance in the region surrounding the site to protect WIPP facilities and land from inadvertent use.

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

Environmental Radiological Monitoring Programs

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

Environmental Non-radiological Monitoring Programs

- Hydrogen and methane monitoring (underground)
- Land management
- Liquid effluent
- Meteorology
- Seismic activity

- Volatile organic compound (VOC) monitoring

Groundwater Protection Monitoring Programs

- Groundwater levels
- Groundwater quality
- Fluid density surveys
- Shallow subsurface water (SSW) levels
- SSW quality

In 2015, 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 2015:

New Mexico Submittals

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

U.S. Environmental Protection Agency (EPA) Submittals

- Delaware Basin Monitoring Annual Report
- 2015 Annual Polychlorinated Biphenyls Report

- WIPP Subsidence Monument Leveling Survey
- 2014/2015 Annual Change Report
- *Superfund Amendments and Reauthorization Act of 1986*
  - Emergency and Hazardous Chemical Inventory Report
  - Toxic Chemical Release Inventory Report

CBFO Submittals

- Quarterly Change Report

Other 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.

The DOE maintains an in-depth, integrated evaluation program that consists of audits, assessments, surveillances, and inspections. In CY 2015, 72 evaluations were conducted that monitored for compliance with environmental requirements and compliance with the procedures that implement compliance programs. This program, coupled with the WIPP project corrective action programs, helps to identify potential issues and ensures corrective/preventive actions are tracked formally through completion.

One of the highest priorities for the WIPP project during 2015 was to follow legal processes and address the issues identified by Administrative Compliance Order HWB-14-21. By the end of 2015, the settlement agreement was near completion. In addition, continued compliance with the AOs issued in 2014 was maintained.

Excluding issues associated with the February 2014 events and the Compliance Order, and one notice of violation for drinking water which is discussed in Section 2.7, the data provided in the required submittals and the evaluation program results confirm the WIPP project maintained compliance with environmental requirements during 2015.

Sustainable Practices

The WIPP EMS objectives and targets support achievement of DOE sustainability goals. As would be expected, the disruption in routine mission operations has had an impact on the progress of sustainable practices for the WIPP project. However, the project continued to contribute to these goals in 2015 with particular focus on integrating sustainability into the improvements being made to enable resumption of operations. Highlights include the following:

- A hybrid roof bolter was procured and placed in operation, reducing fossil fuel consumption, increasing safety, and accelerating accessibility of the underground.

- The Training Building was remodeled using sustainable products including low VOC paint, carpet, and furniture as well as energy efficient computers and displays.
- Continued emphasis on procurement of sustainable products including:
  - Requirements for purchasing equipment that is Energy Star or Federal Energy Management Program designated, and purchasing industrial equipment in the upper 25 percent energy efficiency for the type of equipment.
  - As applicable, BioPreferred and bio-based provisions included in 95 percent of applicable contracts.
  - Electronic Product Environmental Assessment tool electronic products purchased annually at 95 percent.
  - 83 percent of the WIPP fleet consists of alternative-fuel or hybrid vehicles.
  - 70 percent of office products purchased in 2015 contained recycled products compared to 65 percent in 2014, as reported voluntarily by major vendors.
- The facility diverted 95 percent of construction and demolition (C&D) debris from landfills through reuse and recycling.
- Temporary (less than three years) modular office space has incorporated green requirements to the extent practicable.
- Scope 1 and 2 greenhouse gas (GHG) emissions were 46 percent below the fiscal year (FY) 2008 baseline, and Scope 3 GHG emissions were 38 percent below the FY 2008 baseline.
- WIPP site building energy intensity (British thermal units per gross square foot) was reduced 33 percent compared to the FY 2003 baseline. Portions of both of these reductions were due to mission disruption. The percent reduction is expected to decrease for FY 2016 and beyond as operations resume.
- Fleet petroleum consumption was 18 percent below the FY 2005 baseline, but there was an increase from 2014 due to increased monitoring, emergency management activities and personnel traveling to the site.

Environmental Management System Implementation

In May 2015, the WIPP EMS was recertified to the International Organization for Standardization (ISO) Standard 14001:2004, *Environmental Management Systems—Requirements with Guidance for Use*. The recertification demonstrates that the WIPP Project continues to meet the President's Council on Environmental Quality and DOE's requirements for full implementation of the EMS. Recertification of the WIPP EMS was achieved through the successful completion of an in-depth audit by the ISO-accredited registrar, Advanced Waste Management Systems, Inc.

Also during this period, significant improvements in operational controls and programs that implement the EMS were accomplished. These included improvements in ventilation systems, radiological controls, and completion of the state-of-the-art emergency operations center at the Skeen-Whitlock Building. At the end of the year, 85 percent of MOC corrective actions identified from the 2014 events were completed.

Significant accomplishments of the EMS for 2015 were as follows:

- Environmental monitoring data continued to demonstrate that there has been no adverse impact to human health or the environment from WIPP facility operations.
- Environmental objectives were reviewed mid-year during a management review and objectives were updated to include:
  - Improving operational controls for safe, environmentally sound emplacement of TRU waste through recovery projects.
  - Enabling long-term, energy-efficient WIPP operations through integration with recovery projects.
  - Improving waste diversion rate to 50 percent by 2020.
  - Improving lifecycle management of electronics (including energy use in data centers).
  - Incorporating sustainability into baseline and revitalization projects.
- Eighty-five percent of environmental targets were achieved.

SUMMARY OF RELEASES AND RADIOLOGICAL DOSES TO THE PUBLIC

Doses to the Public and the Environment

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

Dose Limits

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

Background Radiation

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

Dose from Air Emissions

WIPP personnel have identified air emissions as the major pathway of concern for radionuclide transport during the receipt and emplacement of waste at the WIPP facility. To determine the radiation dose received by members of the public from WIPP facility operations, WIPP personnel use the EPA emission monitoring and test procedure (40 CFR §61.93, “Emission Monitoring and Test Procedure”), which requires the use of the EPA-approved CAP88-PC ([CAP88-PC, 2013] computer code for calculating both dose and risk from radionuclide emissions) to calculate the EDE to members of the public, CAP88-PC dose calculations are based on the assumption that exposed people remain at home during the entire year and all vegetables, milk, and meat consumed are home-produced. Thus, this dose calculation is a maximum dose that encompasses dose from inhalation, plume immersion, deposition, and ingestion of air-emitted radionuclides. The dose (8.8E-06 mrem to the maximally exposed off-site individual) resulting from that event was approximately 9.0E-5 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 WIPP facility operations and have an extremely low chance of being contaminated as a result of WIPP facility operations.

Game animals sampled and analyzed during 2015 included two quail composite samples, two deer samples, two rabbit samples, and three fish composite samples. In addition, there was a duplicate quail composite sample and a duplicate deer sample. The only radionuclide detected in any of the animal samples was naturally occurring potassium-40 (^{40}K), which was detected in all the samples. By extrapolation, no dose from WIPP-related radionuclides has been received by any individual from this pathway (i.e., the ingestion of meat from game animals) during 2015.

Based on the results of the WIPP facility environmental sampling program and the effluent monitoring program, concentrations of radionuclides in air emissions did not exceed environmental dose standards set by 40 CFR Part 191, Subpart A, "Environmental Standards for Management and Storage," for radiological dose to a member of the public from all WIPP operations. For air emissions specifically, the standards of 40 CFR Part 61, Subpart H, "National Emission Standards for Hazardous Air Pollutants," were also met. The results indicate that the hypothetical maximally exposed individual (MEI) who resides year-round at the point of highest concentration calculated at the fence line, about 650 meters (m) (2,140 feet (ft)) west-northwest from the exhaust point, would have received a dose of approximately 2.4E-06 mSv per year (4.1E-04 mrem per year) for the whole body and 1.4E-04 mSv per year (1.4E-02 mrem per year) to the critical organ. These values are in compliance with the Subpart A standards specified in 40 CFR §191.03(b). For NESHAP (40 CFR §61.92) standards, the EDE potentially received by the MEI residing 8.9 kilometers (km) (5.5 miles (mi)) west-northwest of the WIPP facility was calculated to be less than 8.8E-08 mSv per year (8.8E-06 mrem per year) for the whole body. This value is in compliance with the 40 CFR §61.92 standards.

Chapter 4 of this report presents figures and tables that provide the EDE values from CY 2003 through 2015. 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 2015. 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 in 2015.

CHAPTER 1 – INTRODUCTION

The purpose of this report is to provide information required DOE Order 231.1B, *Environment, Safety, and Health Reporting*. Specifically, the ASER presents summary environmental data to:

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

This document gives a brief overview of the WIPP facility environmental monitoring processes and reports calendar year (CY) 2015 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 waste on March 26, 1999.

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

TRU waste is disposed of 655 meters (m) (2,150 feet [ft]) below the surface in excavated disposal rooms in the Salado Formation (Salado), which is a thick sequence of Permian evaporite salt beds. At the conclusion of the WIPP disposal phase, seals will be placed in the shafts. One of the main attributes of salt at the depth of the WIPP repository, as a rock formation in which to isolate radioactive waste, is the ability of the salt to creep, that is, to deform continuously over time. Excavations into which the waste-filled drums 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 may be found 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 heals its own fractures because it behaves plastically under lithostatic pressure. This means salt formations at depth will slowly and progressively move in to fill mined areas and will seal radioactive waste within the formation, safely away from the biosphere.

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

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

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

1.3 Site Description

Located in Eddy County in the Chihuahuan Desert of southeastern New Mexico (Figure 1.1), the WIPP site encompasses 41.4 square kilometers (km^2) 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 kilometers (km) (26 miles [mi]) east of Carlsbad, New Mexico, in a region known as Los Medaños.

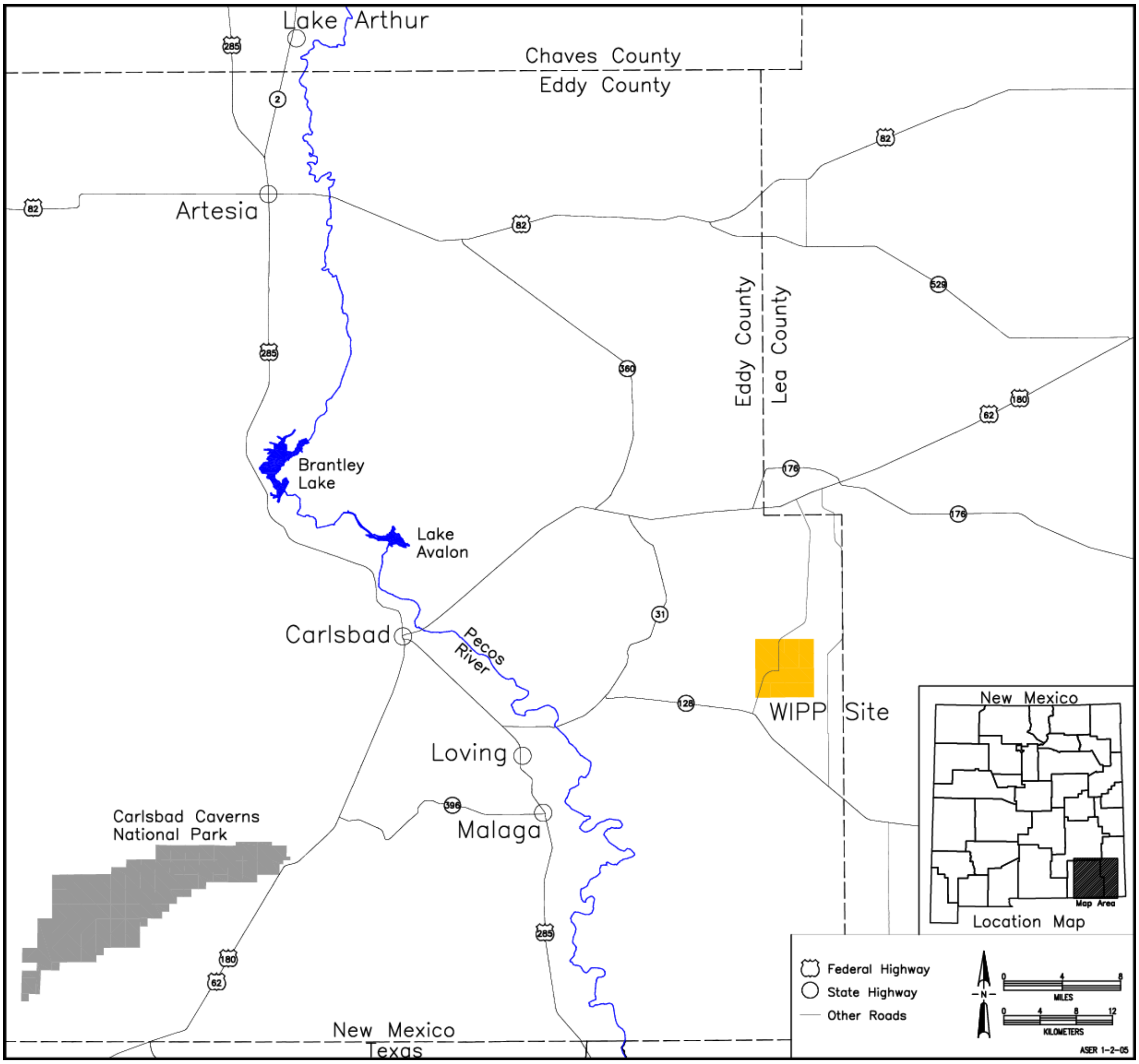


Figure 1.1 – WIPP Site Location

The WIPP LWA was signed into law on October 30, 1992, transferring the administration of federal land from the U.S. Department of the Interior to the DOE. With the exception of facilities within the boundaries of the posted 1.17 km^2 (0.45 mi^2) exclusive use area, the surface land uses remain largely unchanged from pre-1992 and are managed in accordance with accepted practices for multiple land use.

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

1.3.1 WIPP Property Areas

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

Property Protection Area

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

Exclusive Use Area

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

Off-Limits Area

Prohibitions against unauthorized entry and introduction of weapons and/or dangerous materials are posted along the perimeter of the off-limits area, which encompasses 5.88 km^2 (2.27 mi^2) (1,454 acres). Grazing and public 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 prevent unauthorized activities or use.

WIPP Land Withdrawal Area

The WIPP site boundary delineates the perimeter of the 41.4 km^2 (16 mi^2) (10,240 acres) WIPP land withdrawal area. This tract includes the property protection area, the exclusive use area, and the off-limits area, as well as outlying areas within the WIPP site boundary.

Special Management Areas

Certain properties used in the execution of the WIPP project (e.g., reclamation sites, well pads, roads) are, or may be, identified as special management areas in accordance with the WIPP Land Management Plan (LMP) (DOE/WIPP–93–004), which is described further in Chapter 5. A special management area designation is made when resources and/or other circumstances meet the criteria for protection and management under special management designations. Unique resources of value that are in danger of being lost or damaged, areas where ongoing construction is occurring, fragile plant and/or animal communities, sites of archaeological significance, locations containing safety hazards, or sectors that could receive an unanticipated elevated security status would be suitable for designation as special management areas. No areas were designated as special management areas in 2015.

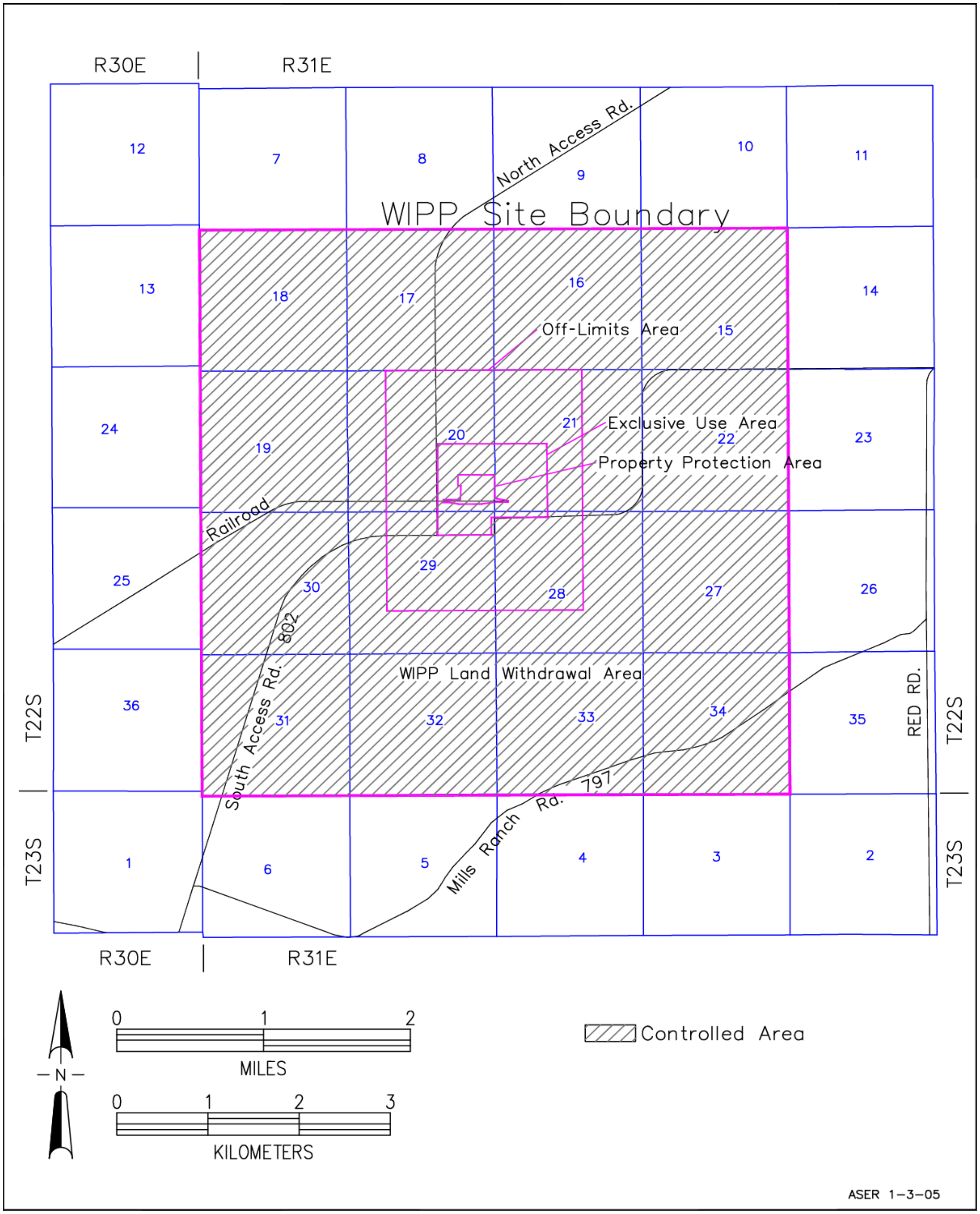


Figure 1.2 – WIPP Property Areas

1.3.2 Population

There are 19 permanent residents living within 16 km (10 mi) of the WIPP site (DOE/WIPP–93–004). This 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.

1.4 WIPP Environmental Stewardship

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

1.4.1 Environmental Monitoring Plan

The *Waste Isolation Pilot Plant Environmental Monitoring Plan* (DOE/WIPP–99–2194) outlines the program for monitoring the environment at and around the WIPP site, including the major environmental monitoring and surveillance activities at the WIPP facility. The plan discusses the WIPP project quality assurance/quality control (QA/QC) program as it relates to environmental monitoring. The purpose of the plan is to specify how the effects of WIPP facility operations on the local ecosystem are to be determined. Effluent and environmental monitoring data are necessary to demonstrate compliance with applicable environmental protection regulations. A description of sampling performed in 2015 and the respective sampling frequency provided in Table 1.1.

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

Table 1.1 – Environmental Monitoring Sampling

Program	Type of Sample	Number of Sampling Locations[a]	Sampling Frequency
Radiological	Airborne effluent[b]	2	Periodic/confirmatory
	Airborne particulate[b]	7	Weekly
	Sewage treatment system (discharge permit [DP]-831)[c]	3	Semiannual
	H-19 evaporation pond (DP–831)[c]	1	Semiannual
	Liquid effluent	1 (Waste Handling Building [(WHB] sump)	If needed
	Biotic		
	Quail Rabbit Cattle/Deer Javelina Fish Vegetation	WIPP vicinity WIPP vicinity WIPP vicinity WIPP vicinity 3 6	Annual As available As available As available Annual Annual
	Soil	6	Annual
	Surface water	Maximum of 14	Annual
	Sediment	Maximum of 12	Annual
	Groundwater (Detection Monitoring Program [DMP])	6	Annual
Non-radiological	Meteorology	1	Continuous
	VOCs		
	VOCs—repository VOCs—disposal room	2 # of active panel disposal rooms	Semiweekly Biweekly
	Hydrogen and methane	18 per filled open panel	Monthly
	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
		4 sewage lagoons	Semiannual

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) Post February 2014 event sampling for effluent and ambient air was increased in frequency, and, for ambient air, sample locations added to enhance coverage. The basic program, however, retained the core routine sampling locations. One airborne effluent station airflow was re-directed, resulting in only two effluent air sampling points for CY 2015.

(c) Includes a non-radiological program component.

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. 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 Environmental Management System (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 contained 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-14-3526).

A list of active WIPP environmental permits appears in Appendix B.

2.1 Comprehensive Environmental Response, Compensation, and Liability Act

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

2.1.1 Superfund Amendments and Reauthorization Act of 1986

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

The list of chemicals provides external emergency responders with information they may need when responding to a hazardous chemical emergency at WIPP. The list of hazardous chemicals is a one-time notification unless new hazardous chemicals in excess of 10,000 pounds, or new information on existing chemicals, are provided.

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

The Tier II Form, due on March 1 of each year, provides information to emergency responders and to the public about hazardous chemicals above threshold planning quantities that a facility has on site at any time during the year. The Tier II Form is submitted annually to the SERC and the LEPC, and to each fire department with which the CBFO maintains a memorandum of understanding. The WIPP 2015 Tier II Form was submitted to the SERC, the LEPC, and fire departments prior to March 1, 2015, as required. Title 40 CFR Part 372, "Toxic Chemical Release Reporting: Community Right to Know," identifies requirements for facilities to submit a toxic chemical release report to the U.S. Environmental Protection Agency (EPA) and the resident state if toxic chemicals are disposed 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, 2015, reporting deadline. Table 2.1 presents the 2015 *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—40 CFR Parts**	**Description of Reporting**	**Status**
355	Planning Notification	Further notification not required
302	Extremely Hazardous Substance Release Notification	Not required
355	Material Safety Data Sheet / Chemical Inventory (Tier II Form)	Yes
372	Toxic Release Inventory Report	Yes

2.1.2 Accidental Releases of Reportable Quantities of Hazardous Substances

There were no releases of hazardous substances exceeding the reportable quantity limits during 2015.

2.2 Resource Conservation and Recovery Act

The *Resource Conservation and Recovery Act* (42 U.S.C. §§6901, et seq.) (RCRA) was enacted in 1976. Initial implementing regulations were promulgated in May 1980. This body of regulations ensures that hazardous waste is managed and disposed of in a way that protects human health and the environment. The *Hazardous and Solid Waste Amendments of 1984* (Public Law 98–616, Stat. 3221) prohibit land disposal of hazardous waste unless treatment standards are met or specific exemptions apply. The amendments also emphasize waste minimization. Section 9(a) of the WIPP LWA exempts TRU mixed waste designated by the Secretary of Energy for disposal at the

WIPP facility from treatment standards. Such waste is not subject to the land disposal prohibitions of the *Solid Waste Disposal Act* (42 U.S.C. §§6901–6992, et seq.).

The New Mexico Environment Department (NMED) is authorized by the EPA to implement the hazardous waste program in New Mexico pursuant to the *New Mexico Hazardous Waste Act* (NMSA §§74–4–1, et seq., 1978). The technical standards for hazardous waste treatment, storage, and disposal facilities (TSDFs) 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.

2.2.1 Hazardous Waste Facility Permit

The WIPP Hazardous Waste Facility Permit (Permit) authorizes the DOE and the management and operating contractor (MOC) (collectively known as the Permittees) to manage, store, and dispose of contact-handled and remote-handled TRU mixed waste at the WIPP facility. Two storage units (the Parking Area Unit and the Waste Handling Building (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 5, 2014, the WIPP facility experienced an underground fire that stopped normal operations including waste shipments to the WIPP facility. On February 14, 2014, a radiological event occurred from receipt of waste mixed with an incompatible sorbent. This receipt and disposal of non-conforming waste was self-reported by the Permittees to the regulator. A small release of radiological material from the underground resulted. Due to radiological safety concerns, some permitted activities could not be performed. The NMED issued three administrative orders (AOs) providing some regulatory relief and directing certain actions from the Permittees. For example, the extensions for storage of waste in the WHB Unit were issued as disposal operations were halted.

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

In an effort to resolve the Compliance Order without further administrative or judicial actions, the Permittees and NMED engaged in settlement negotiations. The General Principles of Agreement, dated April 30, 2015, was issued and final details of the settlement agreement are currently in development.

In 2015 the Permittees were in the process of recovering the facility and resuming Permit related activities.

2.2.2 Modification Requests

In 2015, the Permittees submitted permit modification notifications and permit modification requests to NMED, as described in Table 2.2.

Table 2.2 – Permit Modification Notifications and Requests Submitted in 2015

Class	Description	Date Submitted
1	Clarify the date when laboratory procedures are provided to NMED Add new emergency response equipment	February 13, 2015
1	Update Co-Permittee project manager and the List of Active Environmental Permits	June 11, 2015
1	Change in the DOE, CBFO Manager	June 29, 2015
1	Update Figure C-1 Revise a procedure number in Table E-1 Editorial change in Permit, Part 4 Editorial change in Attachment C3	August 17, 2015
1	Update Resource Conservation and Recovery Act emergency coordinator list	August 27, 2015
1	Revise Attachment A4, Figure A4-2 to add the new east gate Revise Attachment A4, Section A4-2 to describe the purpose of the new east gate	September 15, 2015
1	Clarifications to inspections of liquid-fueled vehicles in Attachment E Addition of automatic on-board fire suppression systems to emergency equipment in Attachment D and Attachment E Enhancement of inspection frequency of mine pager phones in Attachment E Update emergency response training in Attachment F1 Update chronology in Attachment A Update Figures in Attachment D Update facsimile number in Permit Part 1	September 30, 2015
1	Change in the DOE, CBFO Manager	October 8, 2015
1	Remove obsolete references to 40 CFR §264.56(i) and related text from Part 1, Section 1.7.13.4., Section 1.13 and Attachment D, RCRA Contingency Plan	December 30, 2015
1*	Revise closure schedule dates in Attachment G, Section G-1 d (1) and Table G-1	December 30, 2015
2	Revise VOC monitoring procedures	September 8, 2015

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

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 20.5.5 NMAC, "Petroleum Storage Tanks."

The NMED conducted an inspection of the UST system on February 3, 2015. The inspector found no inconsistencies and the USTs were found to comply with NMED petroleum storage tanks standards.

2.2.4 Hazardous Waste Generator Compliance

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

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

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

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

2.2.5 Program Deliverables and Schedule

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

- Permit Part 2, Section 2.14, Recordkeeping and Reporting, requires the submittal of the biennial hazardous waste report, as required by 20.4.1.500 NMAC (incorporating 40 CFR § 264.75). The biennial hazardous waste report is due by March 1 of even-numbered years. This report was not due in 2015.
- 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 2015, representing results for July 1, 2014, through June 30, 2015.

- 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 2015, representing results for July 1, 2014, through December 31, 2014, and in October 2015, representing results for January 1, 2015, through June 30, 2015.
- Permit Part 5, Section 5.10.2.1 requires a report of the analytical results for annual DMP well samples and duplicates, as well as results of the statistical analysis of the samples showing whether statistically significant evidence of contamination is present. The report for sampling Round 37 was submitted to the NMED in November 2015. Sampling results are summarized in Appendices E and F of this Annual Site Environmental Report (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 2015 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 2015 as required.

2.3 National Environmental Policy Act

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

National Environmental Policy Act regulations and requirements are detailed in 40 CFR Parts 1500–1508, “Council on Environmental Quality.” The DOE codified its requirements for implementing NEPA regulations in 10 CFR Part 1021, “National Environmental Policy Act Implementing Procedures.” Following completion of each environmental impact statement and its associated record of decision, 10 CFR §1021.331 requires the DOE to prepare a mitigation action plan that addresses mitigation commitments expressed in the record of decision. The CBFO tracks the performance of mitigation commitments in the WIPP project annual mitigation report. This report was issued June 27, 2015.

Day-to-day operational compliance with the NEPA at the WIPP facility is achieved through implementation of a NEPA compliance plan and procedure. Twenty-three proposed projects were reviewed and approved by the CBFO NEPA Compliance Officer through the NEPA screening and approval process in 2015. Seventeen of these projects were maintenance or upgrades to WIPP facility structures and equipment to prepare for start-up of the WIPP facility. Six of the projects required Land Use Requirement evaluation since they took place outside the WIPP Site Boundary. The approvals were in addition to routine activities determined to be bounded by existing NEPA documentation and that do not require additional evaluation by the CBFO NEPA Compliance Officer. The CBFO NEPA Compliance Officer routinely participates in the development of NEPA documents for other DOE offices and other federal agencies for proposed actions that may have environmental impacts on the WIPP project.

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 2015 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 ton per year emission limit for any individual hazardous air pollutant, the 25 ton per year limit for any combination of hazardous air pollutant emissions, or the 10 ton 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 2015, VOC emissions from containers of TRU and TRU mixed waste remained less than 10 tons per year for individual VOCs monitored under the Permit.

2.5 Clean Water Act

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

The WIPP facility does not discharge wastewater or storm water runoff into waters of the United States and is not subject to regulation under the National Pollutant Discharge Elimination System program. Wastewaters generated at the WIPP facility are either disposed of off-site or managed in on-site, lined evaporation ponds. Storm water runoff is also collected in lined detention 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 discharge permit (DP) designed to prevent impacts to groundwater.

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

In accordance with DP requirements, monthly inspections are conducted of each of the storm water ponds, salt storage ponds, facultative lagoons, and salt storage cells to ensure they are maintained in good condition. When deficiencies are observed, such as liner tears or significant erosion, appropriate repairs are conducted. The sewage lagoons and H–19 Evaporation Pond are inspected weekly for signs of erosion or damage to the liners even though the permit only requires monthly inspections. The distance between normal water levels and the top (known as "freeboard") of the sewage lagoons, the H–19 Evaporation Pond, storm water ponds and salt storage ponds are monitored regularly. The DP renewal added the requirement of inspecting the leak detection sumps in Salt Storage Ponds 2 and 3. The procedure for pond inspections was modified to include this new requirement. Note that the impoundment nomenclature has changed, as given by footnote to Table 5.7.

The DP requires the sewage lagoons and H–19 Evaporation Pond to be sampled semiannually and analyzed for nitrate, total Kjeldahl nitrogen (TKN), total dissolved solids (TDS), sulfate, and chloride. The storm water ponds and salt storage ponds must be sampled annually for TDS, sulfates, and chlorides. The results of this monitoring are reported in Section 5.7, Liquid Effluent Monitoring. In addition, the permit requires annual shallow subsurface water (SSW) water level contour mapping and semiannual groundwater sampling for sulfate, chloride, and TDS. The SSW monitoring results are discussed in Chapter 6.

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 in 2015.

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.

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.

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 the WIPP land withdrawal area in 2015.

2.9 Toxic Substances Control Act

The *Toxic Substances Control Act* (15 U.S.C. §§2601, et seq.) was enacted to provide information about chemicals and to control the production of new chemicals that might present an unreasonable risk of injury to health or the environment. The act authorizes the EPA to require testing of old and new chemical substances and to regulate the manufacturing, processing, import, use, and disposal of chemicals.

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

The required PCB annual report, containing information on PCB waste received and disposed of at the WIPP facility during 2014, was submitted to EPA Region VI prior to the required submission date in 2015.

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).

All applications of restricted-use pesticides at the WIPP facility are conducted by commercial pesticide contractors who are required to meet federal and state standards. General-use pesticides are stored according to label instructions. Used, empty cans are managed and disposed of in accordance with federal and state regulations.

2.11 Endangered Species Act

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

During 2015, 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 2015, no activities involving migratory birds took place within the WIPP land withdrawal area.

2.13 Federal Land Policy and Management Act

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

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

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

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

2.14 Atomic Energy Act

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

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

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

The LWA requires the EPA to conduct recertification of continued compliance every five years after the initial receipt of TRU waste for disposal until the end of the decommissioning phase. The latest Compliance Recertification Application for the WIPP project was submitted to the EPA in March 2014. EPA issued four completeness question letters, dated December 17, 2014, January 27, 2015, June 5, 2015 and July 30, 2015 with a total of 81 questions. As of December 31, 2015, CBFO had submitted seven formal response letters on January 28, 2015, March 18, 2015, April 8, 2015, May 29, 2015, July 15, 2015, September 25, 2015 and December 8, 2015 with a total of 74 responses.

2.15 DOE Orders

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

2.15.1 DOE Order 151.1C, Comprehensive Emergency Management System

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 Program, the Emergency Response Program, the Emergency Response training program, the Emergency Readiness Program, the Emergency Response Records Management Program, and the RCRA Contingency Plan.

The corrective actions and related tasks resulting from the Accident Investigation Board (AIB) investigations of the February 2014 events were prepared to ensure full compliance with DOE Order 151.1C and are outlined in the DOE Corrective Action Plans (CAPs) and Nuclear Waste Partnership, LLC (NWP) CAPs as listed below.

- U.S. Department of Energy, Carlsbad Field Office, Corrective Action Plan Addressing the Accident Investigation Report of: the Underground Salt Haul Truck Fire at the Waste Isolation Pilot Plant, February 5, 2014, and the Radiological Release Event at the Waste Isolation Pilot Plant, on February 14, 2014, Revision 0, February 6, 2015
- Nuclear Waste Partnership LLC, Corrective Action Plan, Underground Salt Haul Truck Fire Event, February 11, 2015
- Nuclear Waste Partnership LLC, Corrective Action Plan, Phase 1 Radiological Release Event, February 11, 2015
- US. Department of Energy, Carlsbad Field Office, Corrective Action Plan Addressing the Accident Investigation Report of: the Underground Salt haul Truck Fire at the Waste Isolation Pilot Plant, February 5, 2014, the Radiological Release Event at the Waste Isolation Pilot Plant, on February 14, 2014, Revision 1, July 2015
- U.S. Department of Energy, Corrective Action Plan for Environmental Management Headquarters Phase 1: Radiological Release Event at the Waste Isolation Pilot Plant on February 14, 2014, March 2015.
- Nuclear Waste Partnership LLC, CAP Addendum, Radiological Release Event (Phase II), July 16, 2015

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 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 QA programs.

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

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

2.15.5 DOE Order 436.1, Departmental Sustainability

This order requires DOE sites to comply with the sustainability requirements contained in EOs 13423 and 13514 related to governmental sustainability. Project managers must also develop, and commit to implement, an annual site sustainability plan that identifies their respective contributions toward meeting DOE sustainability goals. The WIPP project EMS must be used for implementing the project sustainability plan. Project EMSs must maintain conformance to International Organization for Standardization (ISO) 14001:2004. The WIPP project sustainability plan for fiscal year (FY) 2015 was issued on December 2, 2015. This sixth annual update addresses the WIPP project contribution toward meeting the DOE sustainability goals including the performance status for FY 2015 and planned actions for FY 2016. The project sustainability plan becomes a basis for establishing annual project environmental objectives and targets related to sustainability. WIPP project participants work toward achieving the sustainability goals through the EMS. The WIPP EMS was certified to the ISO 14001:2004 standard in May 2009 and recertified on May 28, 2012 and May 28, 2015.

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

This order establishes DOE requirements and responsibilities for implementing the NEPA of 1969, 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.

On February 25, 2015, the CBFO NEPA Compliance Officer issued a categorical exclusion to remove and replace high-efficiency particulate air (HEPA) filters from air filtration systems at the WIPP facility for disposal as mixed low-level waste at an off-site commercial treatment and disposal facility authorized to manage that waste.

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

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

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

In addition, effective September 1, 2015, the WIPP Laboratories fully implemented a Laboratory Information Management System (LIMS). Samples (air, soil, sediment, groundwater and surface water, vegetation, and biota) are logged into the LIMS system manually from the chain of custody upon arrival. Calculations for alpha spectroscopy are completed through automated data transfers from the instrumentation to calculation templates rather than hand-entering the data. The calculated data are then uploaded to the LIMS system for data package compilation and secure storage. Continuous improvements are being made to the LIMS system to eliminate hand entries where possible. One example is updating of the software for the gamma and beta counting instrumentation to allow for automation of data transfers similar to the alpha system. In addition, software for the analytical balance is being incorporated to eliminate hand entries of tracer additions prior to destructive analyses.

2.16 Executive Orders

Executive orders 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 13423, Strengthening Federal Environmental, Energy, and Transportation Management

On January 24, 2007, EO 13423 was signed and it was codified into law by the *2009 Omnibus Appropriations Act*, which was signed on February 17, 2009. This order was superseded by EO 13693, *Planning for Federal Sustainability in the Next Decade*, which was issued in the Federal Register on March 25, 2015 with the U.S. DOE Deputy Assistant Secretary of Site Restoration communicating by memorandum dated September 10, 2015 that DOE Sites are required to comply with this EO. Therefore, the sustainability requirements and implementation at the WIPP Project are addressed in Section 2.16.3 and Chapter 3.

2.16.2 Executive Order 13514, Federal Leadership in Environmental, Energy, and Economic Performance

This EO was signed on October 5, 2009. It expanded energy reduction and environmental performance requirements for federal agencies identified in EO 13423. This order established an integrated strategy toward sustainability in the federal government and made reduction of greenhouse gas (GHG) emissions a priority for federal agencies. Similar to EO 13423, this order was replaced by EO 13693 and the WIPP Project implementation of the requirements are addressed in Section 2.16.3 and Chapter 3.

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

This EO was signed on March 19, 2015, and issued in the Federal Register on March 25, 2015. This new EO supersedes EO 13514 and 13423 as noted in the previous sections. The order adds new and/or increases existing sustainability goal levels. The goals set for sustainability improvements by federal agencies are in the following areas.

	Goal Area
GHGs	Scope 1 and 2 GHG
	Scope 3 GHG
Buildings	Energy Intensity
	Renewable Electricity

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

Accomplishments towards goals established in EOs are discussed in Chapter 3.

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

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

This EO was signed on November 1, 2013 and on June 9, 2014, the U.S. DOE Deputy Assistant Secretary for Site Restoration notified the Office of Environmental Management that sites are required to comply with the EO. The EO directs federal agencies to modernize federal programs to support climate resilient investments, plan for climate change related risks to federal facilities, operations and programs.

The WIPP Project, as part of its Site Sustainability Plan goals, prepared a Climate Change Vulnerability Screening and was incorporated into the FY 2015 and FY 2016 Site Sustainability Plans. The screening results were incorporated into the EMS end-of-year management review.

CHAPTER 3 – ENVIRONMENTAL MANAGEMENT SYSTEM

The CBFO and the MOC consider protection of workers, the public, and the environment to be the highest priority during mission activities at the WIPP facility. This commitment is made public in the WIPP Environmental Policy. Protection of the environment is ensured through implementation of the WIPP EMS. Effectiveness of the EMS is demonstrated by the negligible effect of WIPP facility operations on the environment, reduced environmental risk from safe disposal of TRU and TRU mixed waste from generator sites at the WIPP facility, project compliance, and progress in sustainability.

In 2015, the ISO 14001 accredited registrar, Advanced Waste Management Systems, confirmed that the EMS continues to meet requirements upon completion of the triennial certification audit. The certificate of registration number 00206 was issued on May 28, 2015, demonstrating conformance to the ISO Standard 14001:2004, *Environmental Management Systems—Requirements with Guidance for Use.* The certification demonstrates that the WIPP EMS continues to meet the President's Council on Environmental Quality and DOE requirements for full implementation of an EMS.

This reporting period continued to present unique challenges to the EMS and environmental performance, as well as providing opportunities for continuous improvement. Challenges and opportunities for improvement stemmed from the February 2014 salt haul truck fire and the release of americium and plutonium into the underground and the ambient atmosphere within the facility boundary. Further discussion of the EMS challenges with respect to the two events should be framed by noting that extensive on-site and off-site environmental monitoring continued to show no significant impact on the environment or human health from the operation of the WIPP facility. Significant challenges in terms of the EMS continue to be those noted in the 2014 ASER and are discussed in the remaining paragraphs in this introductory section.

The first challenge was the focus on recovery of the underground and on actions necessary for restarting operations (i.e., acceptance of TRU waste for emplacement). The continued inability to emplace waste halted the project's ability to achieve the most significant and positive impact of the WIPP mission: reduction in environmental risks achieved by eliminating storage of TRU wastes at generator sites.

The second challenge was to effectively resolve the NMED issued Compliance Order HWB-14-21(CO) issued on December 6, 2014, for alleged violations of the WIPP Permit related to the February 2014 events. In keeping with the project's commitment to full compliance with legal requirements, one of the highest priorities during 2015 was to resolve the allegations identified in the order. By the end of 2015, the settlement agreement of the order was near completion.

Making progress toward the DOE sustainability goals continued to present a challenge as resources focused on recovery and restart of site operations and infrastructure changes are energy efficient in order to establish the platform for future performance.

Significant improvements in operational controls and programs that implement the EMS were implemented in 2015. At the end of the year, 85 percent of the MOC corrective actions had been completed and submitted for closure confirmation by the CBFO. These included project design and implementation for upgrades to the ventilation system, radiation controls, completion of the state-of-the-art emergency operations center at the Skeen-Whitlock Building and restructure of the emergency management program, and upgrades to the training program and facilities. In addition, several Permit modifications were submitted to ensure the Permit and physical and operational changes are aligned.

3.1 EMS 2015 Highlights

Many of the highlights in this section reflect continuing efforts to implement improvements in site infrastructure and programs that are part of the EMS. Completion of these efforts supports resumption of TRU waste emplacement.

Environmental Aspects No further revisions were necessary in FY 2015 after the revisions reported in the 2014 ASER. During 2015, controls continued to be reviewed and strengthened as necessary for the following significant environmental aspects.

- Disposal of TRU waste (including characterization, confirmation, onsite handling, transfer and emplacement)
- Ventilation capability
- Managing site-derived waste
- Stormwater collection system

Legal and Other Requirements

During 2015, the CBFO and NWP continued to comply with the three AOs issued by the NMED to address the WIPP Permit requirements that could not be met due to inaccessibility of areas in the underground where inspections and monitoring are necessary. The first two AOs provided requirements for monitoring and reporting to the NMED on the status of recovery from the two events. The third AO required the *WIPP Nitrate Salt Bearing Waste Container Isolation Plan* to address nitrate salt-bearing waste disposed at the WIPP facility.

Throughout 2015, the Permittees diligently worked with the NMED to resolve the Compliance Order of December 2014 as a precursor for restart of operations.

Executive Order 13693, *Planning for Federal Sustainability in the Next Decade*, was signed on March 19, 2015. This new order superseded the prior two Presidential sustainability orders (EO 13423 and EO 13514) and established both new and/or increases in sustainability goal levels for federal agencies.

Objectives, Targets, and Program(s)

The WIPP significant aspects and Site Sustainability Plan provide the basis for establishing WIPP environmental objectives and targets.

The 2015 environmental objectives were reviewed in the mid-year management review and an additional objective (number 5 below) was added based on the project's transition into restart preparations. FY 2015 objectives follow:

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

FY 2015 performance resulted in completion of 85 percent of environmental targets. These targets support progress toward the objectives. The remaining 15 percent that was not completed was a result of priorities for the restart requiring changes to the schedules for accomplishing the targets.

Competence, Awareness,

The investigation of the fire and radiological release events identified several training program inadequacies. In addition, an independent Safety Management Program evaluation of the training program

and Training identified required improvements. Actions to improve the WIPP Training Program were implemented in FY 2015."

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

For 2015 Earth Day, a poster display was used to highlight the recycling program and processes, the streams recycled, and the people who make the program work. The program was highlighted in order to increase awareness and reinforce the commitment to divert waste from landfills.

Operational Control Improvements to operational controls, both physical and programmatic, for significant environmental aspects noted above continued through 2015. During the year, design and construction work on interim and supplemental ventilation systems proceeded, as well as design on the permanent ventilation system. In addition, continuous air monitors were added and the initial closure of Panel 6 and the closure of Panel 7, Room 7 was completed. Improvements to programmatic operational controls were also implemented including those for waste characterization, packaging and confirmation, radiation protection, emergency management, maintenance and work control, performance assurance, and training programs.

Emergency Preparedness and Response Significant upgrades to the Emergency Management Program were completed in 2015. These improvements addressed deficiencies identified in internal and external evaluations after the fire event and radiological release event of 2014. Improvements include revisions to the program and procedure documents, as well as development of several additional procedures and performance of extensive exercises and drills on the new procedures. Emergency management staff was increased and additional training requirements for staff were established and carried out. The drill/exercise program was strengthened, with 127 drills/exercises being conducted. Areas tested included dealing with contaminated patients, underground evacuations, addressing surface and underground fires, response to continuous air monitor alarms, and Central Monitoring Room operations.

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

Evaluation of Compliance During FY 2015, CBFO and the MOC performed 72 evaluations that included checks for compliance with requirements from regulatory agencies and DOE in areas that are part of the EMS. No regulatory noncompliance issues were identified from these evaluations. Of the 72, there were 33 evaluations that focused on environmental compliance requirements related to the WIPP Discharge Permit; environmental monitoring; groundwater protection; and TRU waste characterization, packaging, and confirmation.

Nonconformity, Corrective Action, and Preventive Action The CBFO uses the Issue Collection and Evaluation system, initially implemented in November, 2014, as the CBFO management tool for documenting and tracking identified issues through management evaluation, approval, resolution of actions, and ultimately, closure. The Issue Collection and Evaluation system implements applicable portions of DOE Order 226.1B, Admin Chg 2, *Implementation of Department of Energy Oversight Policy*; DOE Order 422.1, *Conduct of Operations*; DOE/CBFO-94-1012, *Quality Assurance Program Document*; and DOE/WIPP-04-3299, *CBFO Contractor Oversight Plan*.

The NWP Issues Management and Corrective Action Request programs continued to be robust. These are the two fundamental programs for implementing this element of the EMS. Improvements made to the NWP processes in 2014 continued, in 2015, to focus attention on significant issues that could affect WIPP Project compliance and protection of human health and the environment, while ensuring that corrective actions are implemented and reducing the paperwork burden for issues of lesser importance in 2015.

Internal Audit Internal audits of the WIPP EMS were completed for both the NWP and CBFO portions of the system. From the CBFO audit there were no findings and three areas for improvement. The improvement areas highlighted the need to revise the EMS description document. The NWP audit was conducted as part of the NWP QA internal audit program. One finding was identified, which noted that vendors coming onsite do not receive communication of the WIPP Environmental Policy during the vendor safety briefing as described in the EMS description document. This finding is being addressed through the formal corrective action program. In addition, two issues dealing with documentation were corrected during the assessment and an improvement opportunity was identified. The Emergency Management organization had also self-identified the same improvement opportunity and began the improvements via the Issues Management System. This opportunity was to address inconsistencies in implementation of new Emergency Management procedures.

Management Review CBFO and MOC senior managers performed the end of year (covering FY 2014) detailed review of the EMS and a mid-year (FY 2015) update. Both reviews resulted in adjustments to objectives and/or targets. Targets set for this or prior periods that were not completed were reconsidered for continuation, elimination, or tabled for future reconsideration. FY 2016 objectives and targets were established in the mid-year review. Objectives and targets continued to be aimed at improving operational controls and making progress in the sustainability area during the recovery period and as the project transitions to restart and baseline operations.

3.2 Significant Environmental Programs

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

Delaware Basin Drilling Surveillance

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

Environmental Monitoring

The Environmental Monitoring Program includes radiological and non-radiological monitoring, land management monitoring, and surveillance of oil and gas operations near the WIPP boundary. Radiological constituents are monitored in airborne effluent and particulates, sewage treatment and water disposal evaporation ponds, biotics, soils, surface water, sediment, and groundwater. Non-radiological monitoring includes meteorology, VOCs, groundwater, hydrogen, methane, nearby hydrocarbon drilling activity, and SSW.

Low volume air particulate monitoring (ambient air) continued to be supplemented. In 2015, 24 sampling stations were operated, which was inclusive of the seven pre-2014 stations.

Environmental Compliance Audit

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

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.

Land Management

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

Environmental Compliance Review and NEPA Implementation

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

Sustainability

This program promotes integration of energy and water efficiency; reduction in GHG emissions; sustainable buildings purchasing, waste minimization, recycling, reuse, and electronics management into the WIPP project.

Sustainable Procurement

This program provides a systematic structure for promoting and procuring sustainable products when they meet cost, availability, and performance needs. These include bio-based, recycled content, energy and water-efficient products, and products with fewer hazards or lower toxicity.

Waste Stream Profile Review and Approval

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

Waste Confirmation

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

Waste Management

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

3.3 Environmental Performance Measurement

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

3.3.1 Environmental Impacts

There were no significant adverse impacts on the environment from WIPP facility operations in 2015, as determined from extensive environmental monitoring for both radiological and non-radiological monitoring results. Detailed analyses and summaries of environmental monitoring results are included in Chapters 4, 5, and 6.

3.3.2 EMS Effectiveness

The CBFO and MOC managers jointly determine if the WIPP EMS continues to be suitable and effective for carrying out the WIPP mission in a manner consistent with environmental policy commitments. This is accomplished through the EMS management reviews. The determination for this reporting period was that the EMS is suitable and effective.

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

Policy Commitment	WIPP Performance
Comply with Environmental Requirements	The many regulatory compliance points for the project were met, with the exception of a limited number of underground inspections and VOC monitoring. In accordance with the NMED AOs that recognized and allowed for NOT completing Permit required underground inspections and VOC monitoring while the areas are not accessible, monthly reports were submitted to the NMED to summarize the status of inspections and alternative VOC monitoring. Also demonstrating the project's compliance commitment and as mentioned earlier, priority was given to working with the NMED to beneficially resolve the Compliance Order of December 2014. Overall, the DOE compliance posture with regard to the WIPP project was good throughout the year even as there continued to be challenges from limited access to areas of the underground and the primary project focus being to complete the recovery plan and prepare for restart and resumption of baseline operations.
Set objectives, targets, and measures to continually improve performance.	Eighty-five percent of FY 2015 targets were met even as significant resources were focused on support for recovery and restart. The ability of the EMS to be responsive to changing circumstances was demonstrated as objectives and targets were adjusted to reflect the changing project focus.
Seek to achieve sustainable operations through safe, responsible and cost effective methods.	Progress in this area is closely linked to the focus on restart of the WIPP mission. Restart, or returning to operation of the waste repository, will ultimately provide the WIPP's project's most significant environmental benefit to the DOE complex, that of reducing environmental risks at TRU waste generator and storage sites. The main arena for achieving more sustainable operations was through integrating energy efficiency into the purchase of new and additional equipment for operations and for site infrastructure improvements. Highlights include the following: • A hybrid rock bolter was procured and placed in operation. This rock bolter provides a reduction in fuel usage and helps protect workers while accelerating recovery of the underground. • The target to replace Training Building lighting with LED, occupant-controlled lights was added during the mid-year

2015 management review. The new lighting is scheduled for installation in 2016 and will reduce building energy use while enhancing worker comfort and satisfaction.

- The roof replacement project was initiated and identified needed upgrades/replacements for all site building roofs. Cool roof specifications were imbedded into project design and procurement.
- The Training Building remodel included use of sustainable products, including low-VOC paint, carpet, and furniture, and energy-efficient computers and displays.

Further discussion is found in Section 3.3.3.

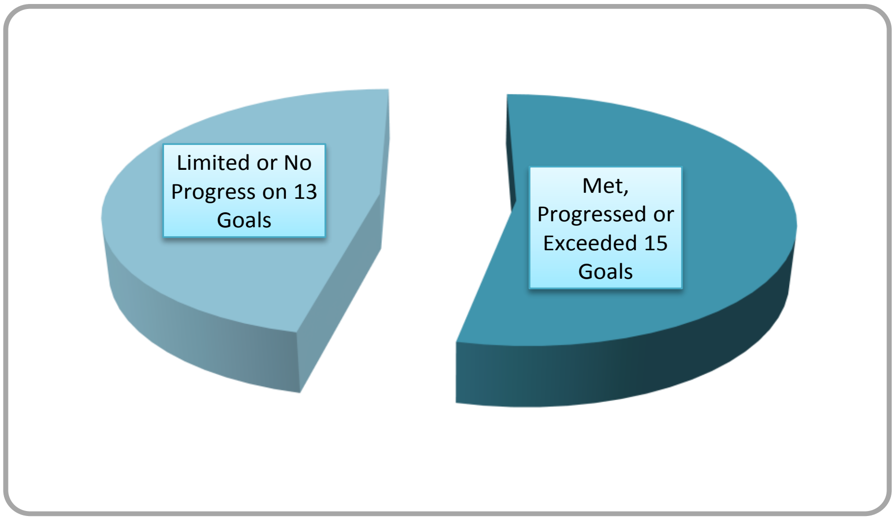
Be an environmentally responsible neighbor.	For this period, performance toward meeting this commitment was gauged based on the level of transparency practiced throughout the year with stakeholders including regulators and local communities. Mechanisms for transparency included the following:

- Teleconferences with regulators were held monthly or more frequently, as needed.
- Town hall meetings were conducted monthly to inform the community of status of WIPP recovery and restart and to communicate directly with WIPP management. Access was also provided via LiveStream video maintained on the WIPP Recovery Website (Figure 3.1).
- Sampling results continued to be made available to the public as soon as possible after data were received and validated.
- The WIPP Recovery Website continued to evolve and is the “one-stop” website for recovery information.
- The WIPP Community Relations Plan on the WIPP homepage provided a link between the public and Permit activities.

3.3.3 Sustainability Progress (Continuous Improvement)

Continuous improvement in environmental performance is demonstrated by the project’s contribution toward the DOE sustainability goals established under EOs 13514 and 13423 as superseded by EO 13693. As mentioned previously, EO 13693 expanded some goals from the superseded EOs and added some new goals, as addressed in the WIPP Site Sustainability Plan. Figure 3.2 shows WIPP Project performance status compared to the goals and illustrates the challenges ahead for making contributions to many of the DOE agency-wide goals. Limited or no progress has been made on new goals or goals with limited cost effectiveness. Specific performance is summarized in the remainder of this section.

Figure 3.1 – WIPP Recovery Website



Limited or No Progress

1. Guiding Principles for High Performance Sustainability Buildings to be met in 15% of existing buildings > 5,000 gross square feet (gsf)
2. Net Zero Buildings: existing buildings > 5000 gsf by FY 2025 (NEW)
3. Clean Energy: 10% of total electric energy from renewable and alternative energy FY 2016 – 2017; 25% by FY 2025 (NEW)
4. Renewable Energy: 10% of electric energy from renewable sources in FY 2016 – 2017, 30% by FY 2025
5. Potable Water Intensity: 16% reduction in FY 2015 with 36% by FY 2025
6. Zero Emission Vehicles: 50% of passenger vehicle acquisitions are zero emission or plug-in hybrid electric vehicles by FY 2025 (NEW)
7. Non-Hazardous Solid Waste Diversion: 50% by FY 2015
8. Performance Contracting: Use of third-party contracts for sustainability projects
9. Climate Change: policies incentivize planning and addressing impacts of climate change (NEW)
10. Climate Change: emergency response procedures and protocols account for projected changes (e.g., extreme weather events (NEW)
11. Climate Change: workforce protocols and policies reflect projected human health and safety impacts (NEW)
12. Climate Change: management demonstrates commitment to adaptation efforts through communications and policies (NEW)
13. Climate Change: adaptation and resilience policies and programs reflect best available science (NEW)

Met, Made Progress, or Exceeded

1. GHG: 19% Scope 1 and 2 reduction in FY 2015[(a)]; 50% by FY 2025
2. GHG: 6% Scope 3 GHG reduction in FY 2015[(a)]; 25% by FY 2025
3. Energy Intensity: 25% energy intensity (British thermal units per gross square foot) reduction in goal-subject buildings
4. Energy and Water Evaluation: Energy Independence and Security Act (PL 110-140) Section 432 evaluations required every four years on goal subject buildings
5. Meters: individual buildings metered for electricity and water where cost effective and appropriate
6. Data Center Efficiency: power utilization effectiveness rating of less than 1.5
7. Petroleum consumption reduction of 20%
8. GHG: fleet-wide per mile reduction of 30% by FY 2025 (0% in FY 2015; 4% in 2017)
9. Alternative fuel vehicles: 75% of light-duty vehicle acquisitions must be alternative fuel vehicles
10. Sustainable procurement promoted to the maximum extent practicable: BioPreferred and bio-based provisions included in 95% of applicable contracts
11. Waste Diversion: divert at least 50% of construction and demolition (C&D) material and debris by FY 2020
12. Electronic Product Environmental Assessment Tool electronic products purchased annually at 95%
13. Power Management enabled on 100% of eligible PCs, laptops, and monitors
14. Automatic Duplexing: 100% of eligible computers and imaging equipment have automatic duplexing enabled
15. Electronics Recycling: 100% of used electronics are reused or recycled using sound disposition options annually

Note: (a) Much of the exceedance of these DOE goal levels is due to limited process operations (hoist, ventilation system) during FY 2015.

Figure 3.2 – WIPP Project Contribution to DOE Sustainability Goals

Reduce Greenhouse Gas Emissions

The WIPP project GHG profile (Figure 3.3) demonstrates that the largest contributors to the project's footprint are electricity use for processes and buildings (Scope 2) and business travel and employee commute to the WIPP site (Scope 3).

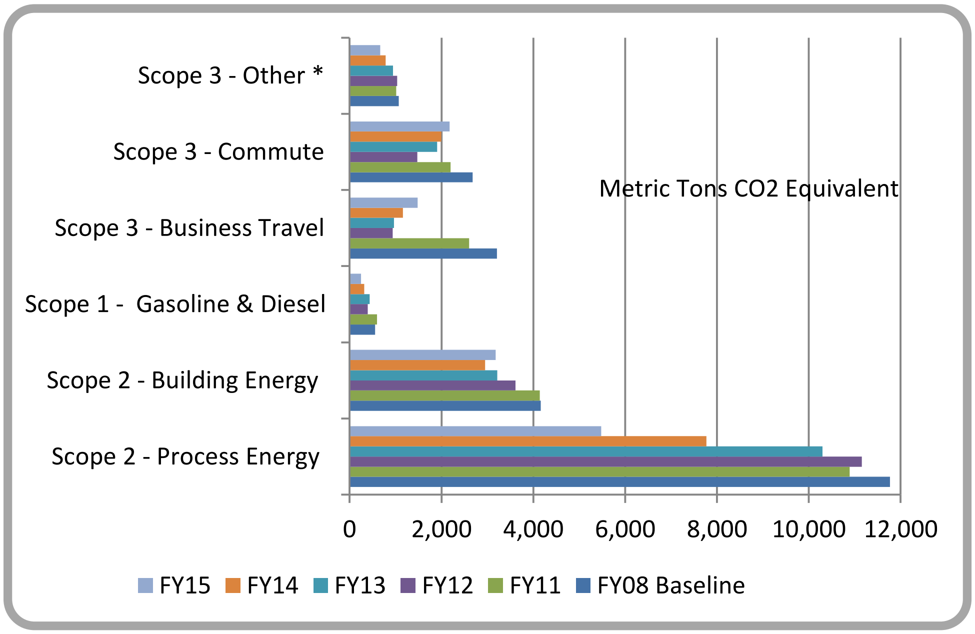


Figure 3.3 – WIPP Project Greenhouse Profile

Given the profile, the priority for GHG reduction at the WIPP project is electricity use. Overall progress in reducing Scope 1 and Scope 2 GHG emissions is illustrated in Figure 3.4.

The reductions in Scope 1 and 2 GHG emissions in FY 2014 and FY 2015 are a result of reduced operations at the WIPP facility, especially those involving process equipment. This level of reduction is not anticipated in future years. Energy and fuel use will likely increase as additional ventilation systems are constructed and come online, as a large number of diesel-fueled equipment has been replaced, and as additional new industrial equipment is put into operation. As equipment is upgraded or replaced, the CBFO and MOC maintain the focus on energy and fuel efficiency.

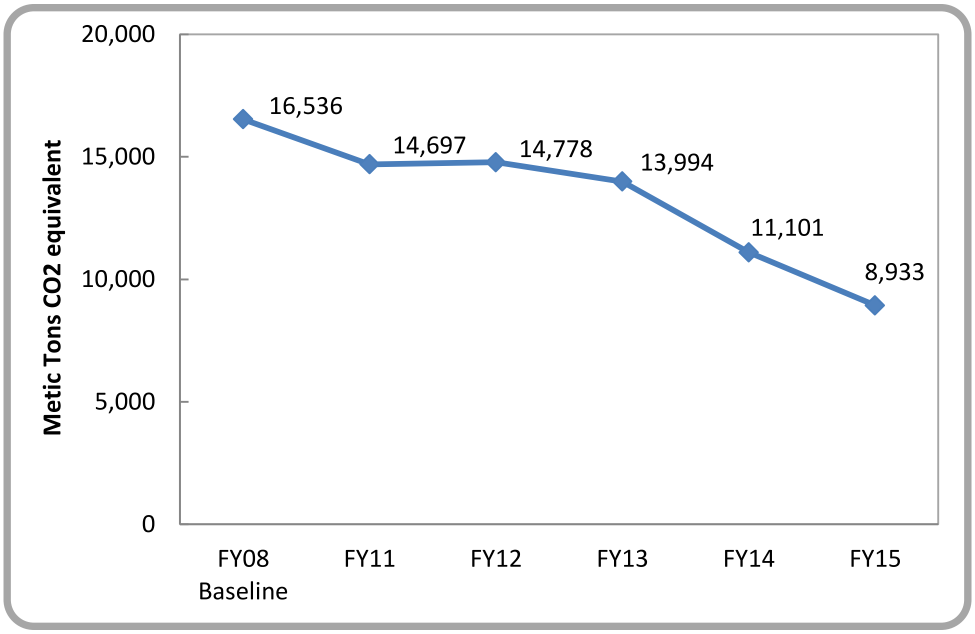


Figure 3.4 – Scope 1 and 2 Greenhouse Emission Performance

Updates in areas key to GHG emissions in FY 2015 follow:

Energy Efficiency	Specifications for energy-using equipment included the requirement for Energy Star or Federal Energy Management Program designated equipment or, in the absence of these types of equipment, that the equipment be in the upper 25 percent efficiency for its type.
Site Wide Roof Project	A project to fully analyze the condition of all roofs at the WIPP site was commissioned and completed. Results identified three sets of priorities for roof replacements or repairs. The highest priority set of roofs (approximately 12 roofs) will be repaired or replaced in FY 2016 through the DOE Roof Asset Management Program. Energy efficiency requirements were incorporated into the project specifications. Cool roof technology (increased roof insulation and reflective surface) has been applied on 13 existing buildings.
Fleet/Fuel Improvements	Eighty-three percent of the WIPP fleet consists of alternative-fuel or hybrid vehicles. Petroleum use was 18 percent below the FY 2005 baseline. Although still well below the FY 2005 baseline, the project used more fuel compared to FY 2014. This was a result of increased air monitoring in more distant areas, increased emergency management activities, and increased personnel traveling to the

	site for supplemental staffing and oversight activities.
Renewable Energy	The WIPP project was not able to install the rooftop photovoltaic equipment as planned. Due to the focus on the mission restart, resources could not be allocated to accomplish this project in FY 2015 and cannot be applied in FY 2016. The goal was carried forward as a FY 2017 environmental target.

Scope 3 GHG emissions continue to reflect significant improvements from baseline levels, as the graph in Figure 3.5 demonstrates. The overall Scope 3 reduction in FY 2015 was 38 percent, a significant improvement from baseline levels.

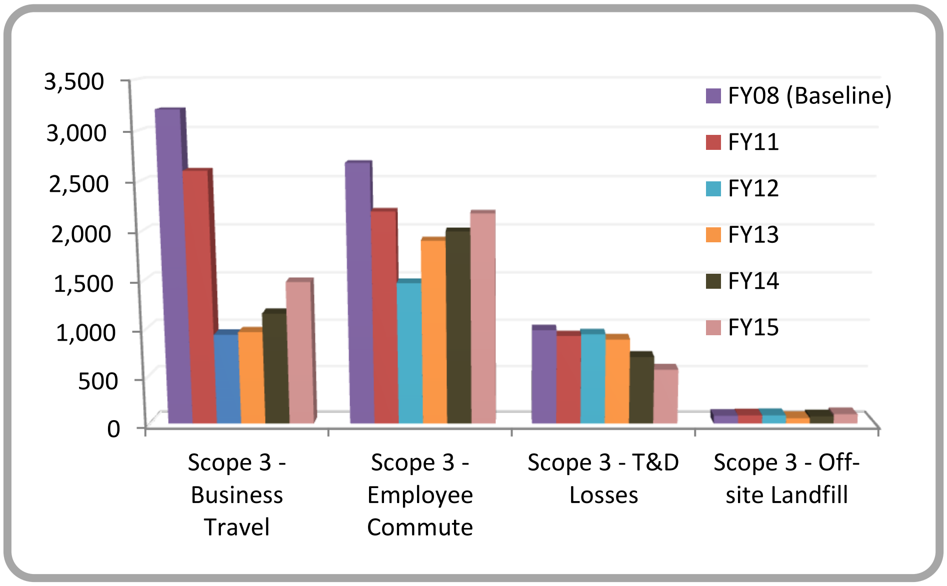


Figure 3.5 – Scope 3 Major GHG Contributor Trends

Personnel continued to use options such as teleconferencing or webcasting for meetings when practicable. Business travel and employee commute show an upward trend from FY 2013 through FY 2015. These increases were a function of the increased need for travel and additional employees and contractors commuting to the site. Once restart of the mission has occurred, emissions are anticipated to remain at a level below the baseline.

Water Efficiency and Management

WIPP facility water use is illustrated in Figure 3.6. Water use at the WIPP facility is for domestic use and fire suppression and response systems. The graphs show slight increases over the previous year in both total volume of water used (graph on left) and water used per employee per day (graph on right) in FY 2015. This was a function of additional people necessary for restart activities and return to baseline operation, as well as leaks discovered in the aging piping infrastructure.

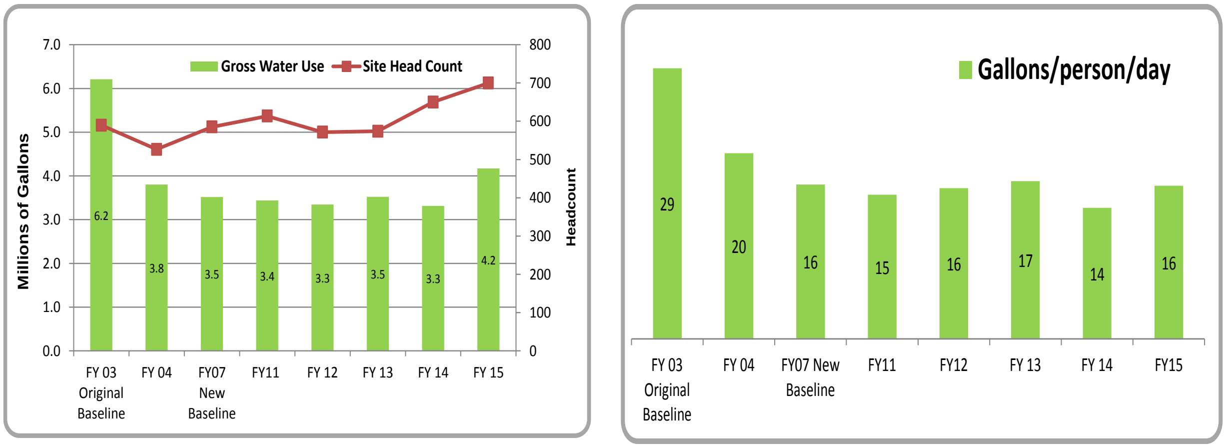


Figure 3.6 – WIPP Site Annual Potable Water Use

The WIPP project has dedicated resources to water distribution system maintenance and repair for the past eight years. This continued in FY 2015 as the site discovered and repaired four leaks in the fire water piping. Due to the age and condition of the fire suppression system piping, a project to redesign the fire water system was initiated. Initial planning was performed during the year, with the redesign scheduled to be finished in FY 2016 and installation of the new system in FY 2017, resulting in fewer and less significant leaks.

Average water use per employee per day is also monitored as it provides a reference point for gauging efficiency compared to other industrial facilities. As shown in the graph on the right in Figure 3.6, water use at WIPP is low, averaging 16 gallons per person per day in FY 2015. Average water use at comparable industrial facilities is 25 gallons per person per day, almost 35 percent higher than WIPP facility water use in FY 2015.

Waste Diversion

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

The DOE departmental target to divert 50 percent of nonhazardous solid waste and C&D debris by FY 2015 has been adopted as a WIPP facility environmental objective. Achieving a 50 percent diversion rate for nonhazardous solid waste is particularly challenging for the WIPP facility given its remote location and limited local recycling infrastructure. The nonhazardous and C&D materials diverted are listed on the left in Figure 3.7, with the percentages recycled shown in the graph on the right.

Nonhazardous and C&D Wastes Recycled
Alkaline Batteries
Aluminum Cans
Cardboard
Fencing
Paper
Plastic
Toner Cartridges
Wood Waste
Metals

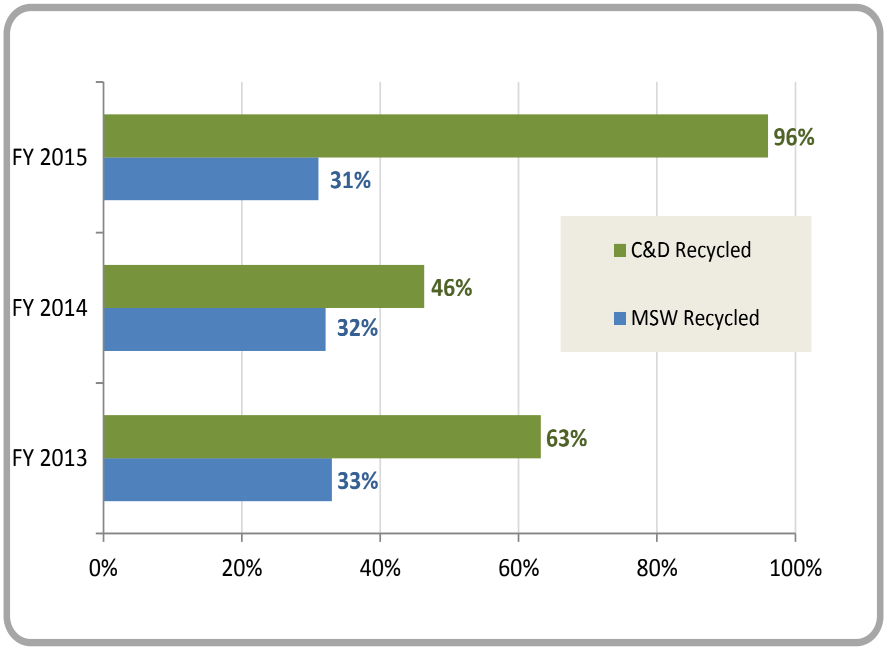


Figure 3.7 – WIPP Project Recycling and Waste Diversion

During the year, there was a focused effort to transfer records from across the site and town locations to the WIPP Records Center. This project resulted in the donation of 50 file cabinets to local schools for reuse. Of these, 30 were fire-rated storage cabinets. In addition, the project continued to donate other used office furniture, supplies, and equipment to schools or other agencies for reuse. In total, these types of transfers resulted in the diversion of 13 metric tons from the local landfills.

Sustainable Acquisition

For the office supply vendors that have agreed to voluntarily report data, 70 percent of office products purchased in FY 2015 contained recycled content, compared to 65 percent in FY 2014. The WIPP project continued to use 30 percent recycled content paper and, when products meet cost, availability, and performance requirements, sustainable janitorial products.

Procedures are in place to ensure sustainable acquisition criteria are specified in applicable procurements and sustainable materials are used when they meet cost, availability, and performance criteria. Procurement procedures also ensure that ozone-depleting substances are not purchased. There continues to be no Class 1 ozone-depleting substances on site.

Training for procurement card holders, purchase requisitioners, project personnel, and procurement personnel on sustainable purchasing continued in FY 2015.

Electronics Stewardship and Data Centers

WIPP project participants continued to use sustainable life-cycle management of electronics as demonstrated in Figure 3.8.

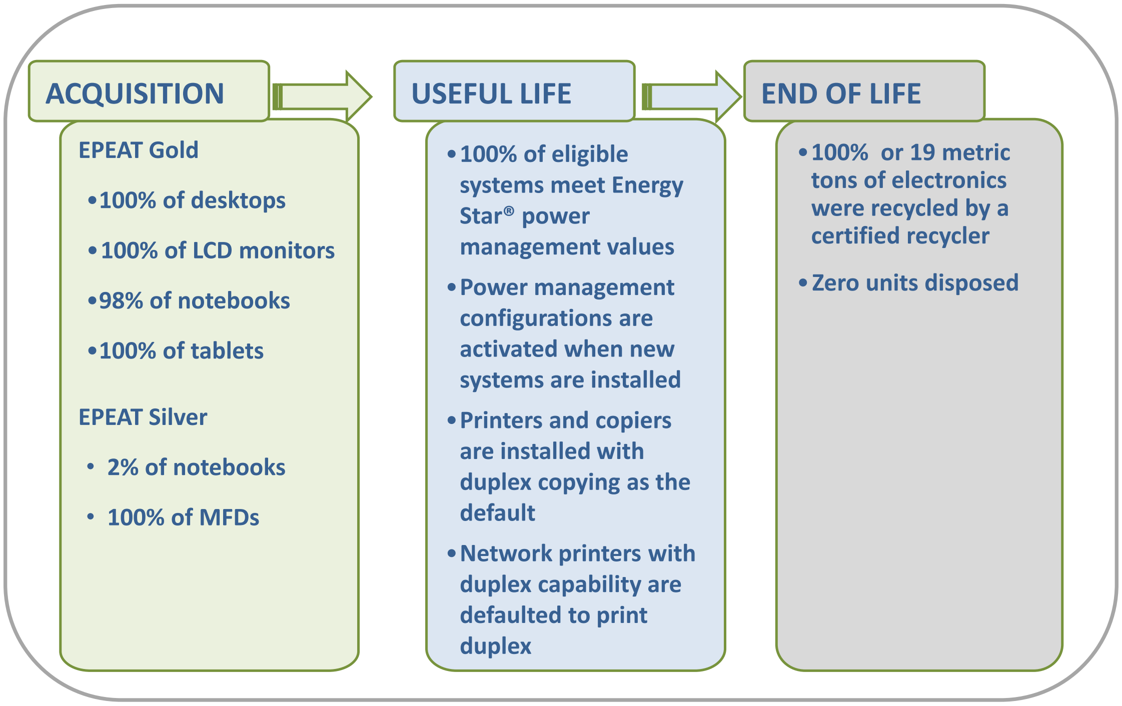


Figure 3.8 – Life-Cycle Management of Electronics at the WIPP Project

3.4 EMS Awards

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

CHAPTER 4 – ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM INFORMATION

DOE Order 458.1 states that the DOE must conduct radiological 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 *WIPP Environmental Monitoring Plan*. The radiological effluent monitoring portion of this plan meets the requirements contained in DOE/HDBK-1216-2015, *Environmental Radiological Effluent Monitoring and Environmental Surveillance*.

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

The environmental dose standards for the WIPP facility can be found in 40 CFR Part 191, Subpart A, which specifies that the combined annual dose equivalent to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation from such management and storage shall not exceed 25 millirem (mrem) to the whole body and 75 mrem to any critical organ. In a 1995 memorandum of understanding between the EPA and the DOE, the DOE agreed that the WIPP facility would comply with 40 CFR Part 61, “National Emission Standards for Hazardous Air Pollutants” (NESHAP), Subpart H, “National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities.” The NESHAP standard (40 CFR §61.92) states that the emissions of radionuclides to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent (EDE) of 10 mrem.

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

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

Table 4.1 lists the target radionuclides included in the Environmental Monitoring Program along with their radiation type, method of detection, and reason for monitoring. The WIPP airborne effluent monitoring program also monitors for these same radionuclides with the exception of ^{235}U, ^{40}K, and ^{60}Co.

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 that described in “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 in 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 $\geq$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 0.9 without consideration of the sample activity relative to the TPU and MDC. However, the identification criteria were revised starting in 2014 as described above.

Sample results are also normalized with the instrument background and/or the method blank. If either of those measurements has greater activity ranges than the actual sample, it is possible to get negative values on one end of the reported range of activities. Additional information on the equations used is provided in Appendix D.

WIPP Laboratories performed the analyses for the 10 target radionuclides in environmental radiological samples. Highly sensitive radiochemical analysis and detection techniques were used that resulted in very low detection limits. This allowed detection of radionuclides at concentration levels far below those of environmental and human health concerns. The MDCs attained by WIPP Laboratories were below the recommended MDCs specified in 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, and 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.

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

Effluent Monitoring Program

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

For each sampling event, chain-of-custody forms are initiated to track and maintain an accurate written record of filter sample handling and treatment from the time of sample collection through laboratory procedures to disposal. During 2015, 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 by the release event on February 14, 2014. A large number of additional samples collected in 2014 included air particulate filters, surface water, soil, and vegetation. Most of these samples were only analyzed for the radionuclides associated with the release event including ^{238}Pu, $^{239/240}$Pu, and ^{241}Am, although a few samples were analyzed for the 10 target radionuclides. Sampling during 2015 was in large part returned to the pre-event schedule, with no detections of radioactivity attributed to WIPP operations.

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

4.1 Effluent Monitoring

4.1.1 Sample Collection

Stations B, and C use skid-mounted fixed air samplers at each effluent air monitoring station. The volume of air sampled at each location varied depending on the sampling location and configuration. Each system is designed to provide a representative sample using a 3.0-micrometer pore size, 47-millimeter (mm) diameter acrylic copolymer membrane filter.

Daily (24-hour) filter samples were collected from the underground exhaust air after HEPA filtration. Each week at Station B approximately 583.0 cubic meters (m^3) (20,589 cubic feet [ft^3]) of air were filtered through the acrylic copolymer membrane filters. Based on the specified sampling periods, these air volumes were within plus or minus (±) 10 percent of the volume derived using the flow rate set point of 0.058 cubic meters per minute (m^3/min) (2.05 cubic feet per minute [ft^3/min]) for Station B. Since the radiological release event on February 14, 2014, Station B has been the primary emissions sample point of record, but the flow rates and sampler characteristics were not materially changed from before the event. The primary emission samples are collected daily at Station B, and an average of 82.1 m^3 (2,933 ft^3) of air were filtered through each air filter at the average annual sample flow rate of 2.04 ft^3/min.

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 2015 was 10,451.7 m^3 (369,097 ft^3). Even though there were brief periods where sampling associated with Station C was interrupted during CY 2015, total air volume sampled was well within the specified recovery limits. Associated WHB fixed air sampler results were assessed for those gaps as necessary to ascertain that no releases occurred during the sample interruptions. The calculated air volume for Station C was within ±10 percent of the average volume derived using the flow rate required for isokinetic sampling conditions. The sampling flow rate for Station C automatically tracks proportionately to the exhaust air flow in the WHB in order to maintain isokinetic sampling conditions.

The Station C effluent air sampling system was designed in accordance with ANSI Standard N13.1 1969. The 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 2015. Station B samples were collected once per day, and assembled into monthly composite samples. The weekly filter samples for Station C were composited each quarter. Filter sample composites were radiochemically analyzed for ^{241}Am, ^{238}Pu, $^{239/240}$Pu, ^{90}Sr, $^{233/234}$U, ^{238}U, and ^{137}Cs.

4.1.2 Sample Preparation

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

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

Approximately 25 milliliters (mL) (0.845 fluid ounce) of concentrated nitric acid and 1 gram (0.0353 ounce) of boric acid (to remove residual hydrofluoric acid) and carriers (strontium nitrate and barium nitrate) were added, and the samples were heated and evaporated to dryness. The sample residues were dissolved in 8 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 were measured in the air filters 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

From 16 total composite samples taken in 2015, 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 2015 are shown in Tables 4.2 and 4.3. The CAP88-PC radioactivity input criterion was to compare the 2 σ TPU with the activity value. The higher result of the two was selected for the nuclide data input for the CAP88–PC dataset report, ensuring a conservative bias to the dataset. The MDC, calculated before the analysis is performed, is an indicator of the expected analytical sensitivity for that test.

Table 4.2 – Station B CY 2015 Sample Results

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
Jan	^{241}Am	4.03E-02	5.92E-03	1.30E-03
Feb	^{241}Am	1.46E+00	3.66E-01	7.40E-01
Mar	^{241}Am	4.22E-01	2.48E-02	1.85E-03
Apr	^{241}Am	9.21E-02	1.21E-02	2.90E-03
May	^{241}Am	2.22E-01	1.64E-02	1.67E-03
Jun	^{241}Am	9.81E-02	8.77E-03	1.51E-03
Jul	^{241}Am	8.58E-01	5.40E-02	4.51E-03
Aug	^{241}Am	2.86E-01	2.27E-02	1.56E-03
Sep	^{241}Am	2.24E-01	1.55E-02	1.39E-03
Oct	^{241}Am	1.59E-01	1.76E-02	2.87E-03
Nov	^{241}Am	1.12E-01	8.92E-03	1.25E-03
Dec	^{241}Am	3.85E-02	6.03E-03	2.11E-03

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
Jan	^{238}Pu	1.25E-03	1.58E-03	2.41E-03
Feb	^{238}Pu	4.48E-03	1.93E-03	1.44E-03
Mar	^{238}Pu	2.09E-03	1.30E-03	1.15E-03
Apr	^{238}Pu	9.95E-04	1.03E-03	1.32E-03
May	^{238}Pu	1.45E-03	1.24E-03	1.17E-03
Jun	^{238}Pu	9.18E-04	8.88E-04	1.25E-03
Jul	^{238}Pu	5.25E-03	3.11E-03	2.67E-03
Aug	^{238}Pu	1.61E-03	1.69E-03	2.09E-03
Sep	^{238}Pu	-2.35E-05	9.36E-04	2.05E-03
Oct	^{238}Pu	3.15E-04	9.55E-04	1.74E-03
Nov	^{238}Pu	1.19E-03	1.12E-03	1.41E-03
Dec	^{238}Pu	3.81E-04	7.73E-04	1.20E-03

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
Jan	$^{239/240}$Pu	4.44E-03	2.02E-03	1.17E-03
Feb	$^{239/240}$Pu	1.30E-01	1.28E-02	1.38E-03
Mar	$^{239/240}$Pu	6.11E-02	6.77E-03	1.00E-03
Apr	$^{239/240}$Pu	1.13E-02	3.19E-03	1.75E-03
May	$^{239/240}$Pu	2.84E-02	4.96E-03	1.15E-03
Jun	$^{239/240}$Pu	1.03E-02	2.66E-03	1.05E-03
Jul	$^{239/240}$Pu	1.08E-01	1.36E-02	2.80E-03

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
Jan	^{90}Sr	-5.44E-03	2.86E-02	1.52E-02
Feb	^{90}Sr	-1.89E-02	2.71E-02	1.51E-02
Mar	^{90}Sr	1.02E-02	3.96E-02	1.50E-02
Apr	^{90}Sr	1.00E-02	3.70E-02	1.50E-02
May	^{90}Sr	-5.92E-03	2.06E-02	1.32E-02
Jun	^{90}Sr	-8.36E-03	1.78E-02	1.28E-02
Jul	^{90}Sr	-5.92E-03	1.97E-02	1.30E-02

Aug	$^{239/240}$**Pu**	3.77E-02	7.03E-03	1.93E-03
Sep	$^{239/240}$**Pu**	1.98E-02	4.33E-03	1.75E-03
Oct	$^{239/240}$**Pu**	7.51E-03	2.95E-03	1.64E-03
Nov	$^{239/240}$**Pu**	1.51E-02	3.47E-03	1.30E-03
Dec	$^{239/240}$**Pu**	5.55E-03	2.09E-03	1.13E-03

Aug	^{90}**Sr**	1.45E-02	2.72E-02	1.38E-02
Sep	^{90}**Sr**	2.87E-03	1.98E-02	1.31E-02
Oct	^{90}**Sr**	-1.87E-03	2.50E-02	1.40E-02
Nov	^{90}**Sr**	-6.96E-03	2.30E-02	1.52E-02
Dec	^{90}**Sr**	-7.36E-03	2.28E-02	1.52E-02

Qtr.	**Nuclide**	**Activity (Bq/Sample)**	**2σTPU[a]**	**MDC[b]**
Jan	$^{233/234}$**U**	1.59E-03	1.24E-03	1.51E-03
Feb	$^{233/234}$**U**	1.10E-04	5.29E-04	1.54E-03
Mar	$^{233/234}$**U**	8.81E-04	8.84E-04	1.46E-03
Apr	$^{233/234}$**U**	6.33E-04	7.25E-04	1.45E-03
May	$^{233/234}$**U**	1.33E-03	1.11E-03	1.65E-03
Jun	$^{233/234}$**U**	4.81E-04	7.10E-04	1.90E-03
Jul	$^{233/234}$**U**	2.94E-03	5.66E-03	6.29E-03
Aug	$^{233/234}$**U**	1.58E-03	1.46E-03	2.18E-03
Sep	$^{233/234}$**U**	5.66E-04	1.13E-03	2.46E-03
Oct	$^{233/234}$**U**	8.81E-04	9.25E-04	1.87E-03
Nov	$^{233/234}$**U**	7.40E-04	9.21E-04	2.37E-03
Dec	$^{233/234}$**U**	5.88E-04	7.10E-04	2.21E-03

Qtr.	**Nuclide**	**Activity (Bq/Sample)**	**2σTPU[a]**	**MDC[b]**
Jan	^{238}**U**	4.22E-04	8.33E-04	1.28E-03
Feb	^{238}**U**	2.75E-04	7.18E-04	1.16E-03
Mar	^{238}**U**	4.18E-04	7.33E-04	1.03E-03
Apr	^{238}**U**	5.88E-04	7.44E-04	1.10E-03
May	^{238}**U**	8.99E-04	9.47E-04	1.42E-03
Jun	^{238}**U**	5.29E-04	6.85E-04	1.52E-03
Jul	^{238}**U**	1.55E-03	3.56E-03	5.18E-03
Aug	^{238}**U**	-5.96E-05	2.55E-04	1.81E-03
Sep	^{238}**U**	6.73E-04	1.06E-03	2.05E-03
Oct	^{238}**U**	-1.14E-04	3.16E-04	1.77E-03
Nov	^{238}**U**	3.25E-04	6.73E-04	2.02E-03
Dec	^{238}**U**	4.96E-04	7.55E-04	1.98E-03

Qtr.	**Nuclide**	**Activity (Bq/Sample)**	**2σTPU[a]**	**MDC[b]**
Jan	^{137}**Cs**	1.46E+00	3.66E-01	7.40E-01
Feb	^{137}**Cs**	-1.33E-01	3.57E-01	3.81E-01
Mar	^{137}**Cs**	-2.15E-01	3.77E-01	3.96E-01
Apr	^{137}**Cs**	-1.08E-01	3.53E-01	3.81E-01
May	^{137}**Cs**	1.56E-01	3.00E-01	3.63E-01
Jun	^{137}**Cs**	1.22E-01	4.26E-01	5.00E-01
Jul	^{137}**Cs**	-9.99E-02	4.66E-01	5.00E-01
Aug	^{137}**Cs**	-2.41E-01	4.00E-01	4.63E-01
Sep	^{137}**Cs**	-2.69E-04	4.14E-01	4.81E-01
Oct	^{137}**Cs**	-2.34E-02	4.14E-01	4.92E-01
Nov	^{137}**Cs**	6.51E-02	3.77E-01	4.11E-01
Dec	^{137}**Cs**	-1.39E-01	3.18E-01	3.69E-01

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

Table 4.3 – Station C CY 2015 Sample Results

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{241}Am	9.10E-04	8.44E-04	1.22E-03
2nd	^{241}Am	6.22E-04	1.00E-03	1.97E-03
3rd	^{241}Am	1.36E-04	6.55E-04	1.85E-03
4th	^{241}Am	3.57E-04	5.99E-04	1.24E-03

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{238} Pu	-1.11E-04	6.88E-04	1.67E-03
2nd	^{238} Pu	-2.01E-04	4.29E-04	1.34E-03
3rd	^{238} Pu	1.85E-04	3.63E-04	8.51E-04
4th	^{238} Pu	-2.16E-04	4.03E-04	1.36E-03

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	$^{239/240}$Pu	5.55E-05	5.77E-04	1.09E-03
2nd	$^{239/240}$Pu	1.60E-04	5.44E-04	1.22E-03
3rd	$^{239/240}$Pu	1.85E-04	6.25E-04	1.12E-03
4th	$^{239/240}$Pu	1.13E-04	4.55E-04	1.09E-03

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{90}Sr	-9.92E-03	2.37E-02	1.76E-02
2nd	^{90}Sr	4.92E-03	1.64E-02	1.27E-02
3rd	^{90}Sr	1.35E-03	2.78E-02	1.37E-02
4th	^{90}Sr	6.33E-03	2.37E-02	1.52E-02

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	$^{233/234}$U	1.95E-03	1.35E-03	1.52E-03
2nd	$^{233/234}$U	4.26E-04	5.96E-04	1.32E-03
3rd	$^{233/234}$U	1.43E-03	1.08E-03	1.53E-03
4th	$^{233/234}$U	4.03E-04	5.59E-04	2.18E-03

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{238}U	3.37E-04	6.22E-04	1.23E-03
2nd	^{238}U	6.03E-04	7.51E-04	1.11E-03
3rd	^{238}U	5.07E-04	7.51E-04	1.54E-03
4th	^{238}U	7.22E-04	8.29E-04	1.93E-03

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{137}Cs	-6.70E-01	5.77E-01	5.70E-01
2nd	^{137}Cs	9.25E-02	3.21E-01	3.74E-01
3rd	^{137}Cs	3.59E-01	5.07E-01	5.55E-01
4th	^{137}Cs	2.97E-01	3.37E-01	3.92E-01

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

Evaluation of the 2015 filter sample results using the latest EPA-approved CAP88-PC code in effect during CY 2015, CAP88-PC Version 4.0.1.17 indicated that there were no detectable releases from the WIPP facility that resulted in a dose that exceeded 25 mrem to the whole body and 75 mrem to any critical organ in accordance with the provisions of 40 CFR §191.03(b). In addition, there were no detectable airborne releases from the WIPP facility that resulted in a dose that exceeded the 10 mrem per year limit, as specified in 40 CFR §61.92, and the 0.1 mrem per year limit for periodic confirmatory sampling required by 40 CFR §61.93(b)(4)(i).

4.2 Airborne Particulates

4.2.1 Sample Collection

Weekly airborne particulate samples were collected from seven locations on or near the WIPP site (Figure 4.1) using low-volume air samplers. Locations were selected based on the prevailing wind direction. A second sampler was co-located with each of the primary samplers following the release event in 2014. These samplers were termed event evaluation samplers, and the air sample filters collected in 2015 were generally archived and were available for analysis in the case of a suspected or actual release event for screening, while primary samplers continued to integrate the sample at each location according to the normal schedule. One set of event evaluation samples (MLR, third quarter), was analyzed and the data used for precision determination when the data from the duplicate sample set was contaminated in the laboratory.

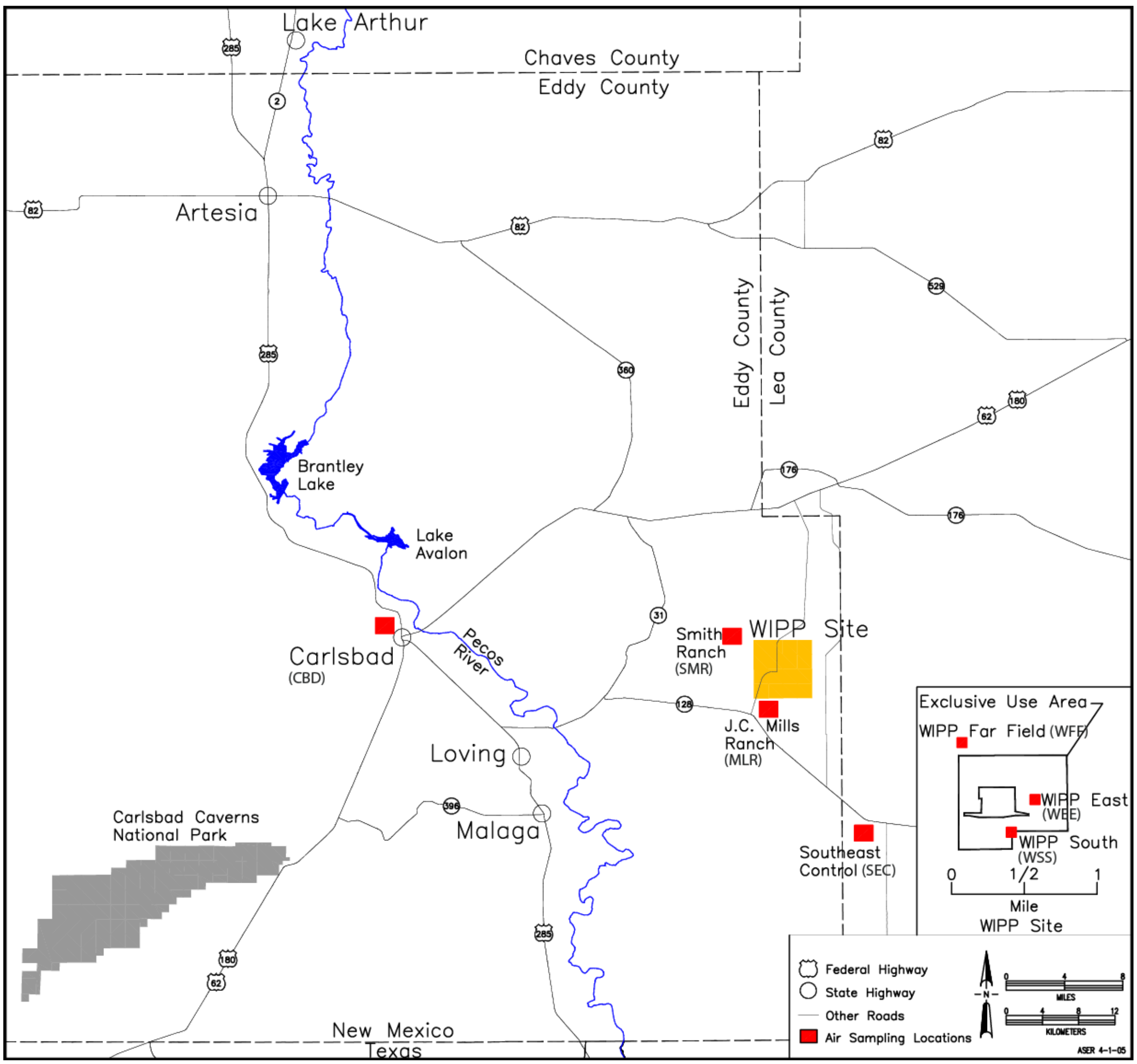


Figure 4.1 – Air Sampling Locations On and Near the WIPP Site

Two additional sets of low-volume air samplers were installed following the release event. The first set of samplers 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 fill in gaps not covered by the primary samplers.

The second set of low-volume event evaluation samplers was installed at or near six previously used preoperational monitoring locations. The locations ranged from 10 to 50 mi from the WIPP site. Data from these locations could then be compared with the pre-operational baseline data.

Airborne particulate sampling was thus performed at 17 locations using 24 samplers. The 17 sampling locations are illustrated in Figure 1 of DOE/WIPP-15-3547.

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 ^{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 and transuranic isotopes) 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 are separated into the quarterly air filter composite samples, typically reported in the ASER, and the event evaluation samples consisting of weekly air particulate samples analyzed individually as well as in monthly composite samples.

Most of the data generated following the radiation release were initially reported as disintegrations per minute (dmp) at the request of the WIPP Response Team following the event. The data are reported in units of becquerels per composite air filter sample (Bq/sample) for the quarterly composite samples so that they are consistent with previous ASERs. However, the data for the limited number of Event Evaluation samples reported below are reported in dpm/sample.

Quarterly Composite Samples

Appendix G, Table G.1 contains the results for the standard quarterly air filter composite samples. Blank filter composite samples were prepared and analyzed, and results were reported separately for each quarter. A “Q” (qualifier) column is included in the data tables in Appendix G to show whether the radionuclide was detected (i.e., whether the activity of the radionuclide is greater than the 2 σ TPU and MDC). The ID confidence was also provided for gamma analyses. If the ID confidence is greater than or equal to 0.90 and the activity of the sample is greater than 2 σ TPU and MDC, the gamma radionuclide (^{40}K, ^{60}Co, ^{137}Cs) is detected.

Table G.1 shows that there was only one detection of any of the target radionuclides in the four quarterly composite samples (i.e., the detection of $^{239/240}$Pu in the first quarter air filter composite sample from location WFF). The activity of the sample was 2.52E-03 Bq/sample corresponding to 3.41E-07 becquerels per cubic meter (Bq/m^3). The detection was confirmed in the laboratory by analyzing a separate portion of the filter composite digestate. The plutonium isotope has been occasionally detected in past years, although the most frequent detections were low concentrations of some of the uranium isotopes. Detection of the uranium isotopes generally depended on the amount of dust collected on the filters. More dust is collected during dry, windy years, and 2015 was wetter than recent years with no uranium isotopes detected. The detection of $^{239/240}$Pu does not appear to be related to the release event because no ^{241}Am was detected in the sample.

The average concentrations of the quarterly composite samples are reported for those locations where duplicate samples were collected using low-volume air samplers. As noted above, the event evaluation samples were composited to prepare the duplicate sample for location MLR during the third quarter. A "Q" (qualifier) column is included in the data in Table G.1 to show whether the radionuclide was detected in the sample. Table G.2 in Appendix G shows the Bq/sample converted to Bq/m^3 by dividing the sample activity in Bq by the total quarterly air volumes sampled.

Since there was only one detection of any radionuclides in the 2015 air filter composite samples, no ANOVA comparisons were performed between years or between locations.

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 minimum and maximum reported concentrations for each radionuclide are based on the sample activity, and the associated 2 σ TPU and MDC were inherited with that specific radionuclide activity.

Table 4.4 – 2015 Average, Minimum, and Maximum Concentrations in Air Filter Composite Samples

Radionuclide		[RN] [(a)]	2 σ TPU [(b)]	MDC [(c)]	Location	Quarter
$^{233/234}U$	Mean [(d)]	2.58E-03	4.44E-03	1.08E-02	NA [(e)]	NA [(e)]
	Minimum [(f)]	-7.57E-04	4.17E-03	1.11E-02	WSS	1
	Maximum [(f)]	6.45E-03	4.77E-03	1.06E-02	CBD	4
^{235}U	Mean	-5.75E-06	1.13E-03	1.69E-03	NA	NA
	Minimum	-6.57E-04	1.36E-03	1.73E-03	WSS	1
	Maximum	1.19E-03	1.25E-03	1.56E-03	SMR	2
^{238}U	Mean	2.91E-03	4.30E-03	1.00E-02	NA	NA
	Minimum	-1.91E-03	4.48E-03	1.03E-02	SEC	1
	Maximum	7.52E-03	4.18E-03	1.01E-02	CBD	2
^{238}Pu	Mean	-1.74E-04	6.32E-04	1.21E-03	NA	NA
	Minimum	-5.11E-04	1.02E-03	1.34E-03	WEE	4
	Maximum	6.20E-04	1.64E-03	2.14E-03	WFF	1
$^{239/240}Pu$	Mean	1.23E-04	7.45E-04	1.20E-03	NA	NA
	Minimum	-3.69E-04	7.33E-04	1.15E-03	CBD	1
	Maximum	2.52E-03	2.29E-03	9.56E-04	WFF	1
^{241}Am	Mean	-2.38E-06	1.29E-03	1.75E-03	NA	NA
	Minimum	-8.20E-04	1.56E-03	1.76E-03	SMR	1
	Maximum	8.61E-04	1.73E-03	2.02E-03	SEC	2
^{40}K	Mean	4.47E+00	7.81E+00	9.48E+00	NA	NA
	Minimum	-3.69E+00	8.34E+00	9.04E+00	WFF	3
	Maximum	1.32E+01	7.00E+00	9.05E+00	WSS	4

Radionuclide		[RN] (a)	2 σ TPU (b)	MDC (c)	Location	Quarter
^{60}Co	Mean	-6.05E-02	8.31E-01	9.32E-01	NA	NA
	Minimum	-1.88E+00	1.34E+00	1.07E+00	SEC	2
	Maximum	9.70E-01	6.79E-01	8.73E-01	SEC	3
^{137}Cs	Mean	-2.11E-02	8.69E-01	9.72E-01	NA	NA
	Minimum	-9.09E-01	1.01E+00	1.07E+00	CBD	4
	Maximum	9.99E-01	7.80E-01	1.00E+00	WFF	2
^{90}Sr	Mean	3.05E-03	2.28E-02	1.41E-02	NA	NA
	Minimum	-1.66E-02	2.29E-02	1.40E-02	WSS	4
	Maximum	1.75E-02	2.46E-02	1.80E-02	WSS	1

Notes:

Units are Bq/sample.

NA Not applicable.

(a) Radionuclide concentration. Values taken from 7 locations and 4 quarterly composite samples as shown in Table G.1. Some quarterly composite samples contained less than 13 weekly samples due to the February, 2014 release event.

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

(c) Minimum detectable concentration.

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

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

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

The measured activity of the $^{239/240}$Pu was less than the 99 percent baseline confidence interval concentration of 8.00E-06 Bq/m^3.

The precision 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 2015, field duplicate samples were taken from location WEE during the first quarter, location WSS during the second quarter, location MLR during the third quarter, and location SEC during the fourth quarter. The backup event evaluation samples were used to prepare the duplicate air filter composite sample for MLR during the third quarter. Table 4.5 presents the precision data for all the field duplicate air filter composite samples. The precision, as relative error ratio (RER), is reported for all the radionuclides in the air filter composite samples whether the radionuclide was detected in the samples or not.

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, April 2009) suggested that 85 percent of field duplicates should yield RERs less than 1.96. This objective was readily met for the air particulate samples discussed above with no RERs >1.96. Field duplicate RERs less than 2 indicate good precision for the combined sampling and laboratory analysis procedures.

Table 4.5 – Precision as Relative Error Ratio for 2015 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	WEE	$^{233/234}U$	4.43E-03	2.45E-03	2.74E-03	2.31E-03	0.502
1	WEE	^{235}U	-4.46E-04	7.94E-04	-4.91E-04	6.25E-04	0.044
1	WEE	^{238}U	-2.65E-04	2.39E-03	-2.46E-04	2.32E-03	0.005
1	WEE	^{238}Pu	5.34E-04	4.36E-04	-2.31E-04	3.39E-04	1.384
1	WEE	$^{239/240}Pu$	6.01E-04	6.12E-04	-1.93E-04	4.38E-04	1.055
1	WEE	^{241}Am	2.98E-04	6.67E-04	3.18E-04	1.15E-03	0.015
1	WEE	^{40}K	1.38E+01	4.31E+00	5.23E+00	3.95E+00	1.471
1	WEE	^{60}Co	7.36E-01	4.90E-01	-2.75E-01	4.60E-01	1.503
1	WEE	^{137}Cs	-1.02E+00	1.24E+00	-4.63E-03	4.16E-01	0.774
1	WEE	^{90}Sr	5.45E-03	7.57E-03	6.85E-03	1.22E-02	0.098
Qtr	Location	Isotope	Sample 1		Sample 2		RER[c]
			[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]	
2	WSS	$^{233/234}U$	-3.91E-04	2.21E-03	3.71E-03	2.37E-03	1.266
2	WSS	^{235}U	-1.02E-04	4.07E-04	-1.17E-05	3.40E-04	0.170
2	WSS	^{238}U	3.02E-03	1.88E-03	7.23E-03	2.12E-03	1.484
2	WSS	^{238}Pu	-2.78E-04	1.89E-04	-3.51E-04	2.49E-04	0.236
2	WSS	$^{239/240}Pu$	-1.75E-05	2.75E-04	3.37E-04	3.78E-04	0.758
2	WSS	^{241}Am	3.35E-04	5.17E-04	-2.05E-05	4.11E-04	0.539
2	WSS	^{40}K	7.02E+00	3.24E+00	1.45E+01	4.71E+00	1.308
2	WSS	^{60}Co	-6.22E-01	3.68E-01	-1.50E-01	5.98E-01	0.673
2	WSS	^{137}Cs	-5.37E-01	3.38E-01	5.33E-01	6.61E-01	1.441
2	WSS	^{90}Sr	1.81E-02	1.38E-02	1.09E-02	1.29E-02	0.381
Qtr	Location	Isotope	Sample 1		Sample 2[d]		RER[c]
			[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]	
3	MLR	$^{233/234}U$	2.80E-03	2.25E-03	4.14E-03	2.24E-03	0.421
3	MLR	^{235}U	-2.99E-04	4.72E-04	-7.50E-04	4.82E-04	0.669
3	MLR	^{238}U	1.14E-03	2.10E-03	1.42E-03	1.99E-03	0.098
3	MLR	^{238}Pu	-4.51E-05	3.46E-04	-3.87E-04	4.13E-04	0.635
3	MLR	$^{239/240}Pu$	1.95E-04	3.94E-04	-1.45E-05	5.02E-04	0.329
3	MLR	^{241}Am	-1.64E-04	6.22E-04	-8.09E-04	5.67E-04	0.766
3	MLR	^{40}K	1.76E+00	5.12E+00	6.20E-01	3.09E+00	0.191
3	MLR	^{60}Co	-7.08E-01	5.01E-01	2.72E-01	2.89E-01	1.694
3	MLR	^{137}Cs	-5.89E-01	4.68E-01	2.48E-01	3.03E-01	1.501
3	MLR	^{90}Sr	-5.13E-03	9.98E-03	1.51E-02	1.06E-02	1.390

Qtr	Location	Isotope	Sample 1		Sample 2		RER[c]
			[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]	
4	SEC	$^{233/234}U$	3.14E-03	2.13E-03	2.38E-03	2.13E-03	0.251
4	SEC	^{235}U	1.34E-04	6.15E-04	-4.53E-04	4.61E-04	0.764
4	SEC	^{238}U	4.42E-03	2.18E-03	2.20E-03	2.11E-03	0.730
4	SEC	^{238}Pu	-3.28E-04	3.40E-04	-2.67E-04	3.09E-04	0.134
4	SEC	$^{239/240}Pu$	9.72E-05	2.21E-04	-4.28E-05	2.82E-04	0.391
4	SEC	^{241}Am	-4.34E-04	4.87E-04	-4.81E-04	5.24E-04	0.065
4	SEC	^{40}K	5.30E+00	4.67E+00	5.21E+00	3.98E+00	0.015
4	SEC	^{60}Co	1.71E-01	4.83E-01	2.55E-01	3.61E-01	0.139
4	SEC	^{137}Cs	6.87E-01	5.93E-01	1.92E-01	3.73E-01	0.707
4	SEC	^{90}Sr	-3.13E-03	1.10E-02	-8.45E-03	1.16E-02	0.333

Notes:

Units are in Bq/Sample. See Appendix C for sampling location codes.

(a) Radionuclide activity.

(b) Total propagated uncertainty.

(c) Relative error ratio.

(d) The backup EE samples were used to prepare the method reporting limit (MRL) duplicate AFC sample.

The laboratory generates and analyzes lab duplicate samples from a single field sample for matrices other than air particulate 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 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 not provided in the ASER, but greater than 99 percent of the laboratory RERs from analysis of WIPP environmental samples during 2015 were less than 2.

Event Evaluation Samples

The extra sets of Event Evaluation samples were archived to be available for screening analysis in the case of a suspected or actual release event and as backup samples for the six regular sampling locations. As discussed above, these backup samples were needed for the third quarter duplicate MLR air filter composite sample because the laboratory inadvertently contaminated the original duplicate MLR air filter composite sample with the spiked reagent laboratory control sample (RLCS) during sample preparation.

The Event Evaluation samples collected on February 24, 2015, and March 10, 2015, were analyzed for ^{238}Pu, $^{239/240}$Pu, and ^{241}Am. The results are shown in Table 4.6 and are reported in dpm/sample consistent with previous Event Evaluation samples. There were no detections in any of the samples. A set of Event Evaluation samples was collected on August 5, 2015, following a HEPA filter change. These samples were analyzed for the standard list of all 10 radionuclides. The data for these analyses are shown in Table 4.7. The data are also reported in dpm/sample with no detections in any of the samples.

Some of the data in the two tables were qualified due to issues with the analyses. Some of the ^{238}Pu and $^{239/240}$Pu data in Table 4.6 were qualified "UJ" because the recovery of the ^{242}Pu tracer in the RLCS quality control (QC) sample was slightly higher than the 110 percent recovery objective upper limit. If the recovery is slightly high in a QC sample, all the samples in the batch are qualified accordingly. There was no activity in the samples and no adverse impact on the quality or usability of the data.

Some of the other ^{238}Pu and $^{239/240}$Pu data in Table 4.7 were also qualified "UJ" and the data for two samples were qualified "R" (i.e., unusable). The batch of samples, which included all the Event Evaluation samples except the SMR duplicates, was analyzed on August 12, 2015, which was about the same time a sample was submitted by WIPP Radiological Control that had been collected immediately after the February 14, 2014, event. The WIPP Radiological Control sample contained significant Am and Pu and as a result, two samples and the reagent blank were contaminated with the plutonium isotopes. Plutonium was not detected in the other samples, but since the reagent blank was contaminated they were all qualified as "UJ." In addition, three samples and the reagent blank sample for ^{241}Am contained some activity due to the same contamination. As a result, none of the alpha spectrometry data for ^{241}Am were reported. The ^{241}Am data, except for the SMR duplicates which were analyzed in a separate batch, were reported from the gamma analyses of the samples. Thus there is an associated ID confidence for the ^{241}Am results. However, ^{241}Am was not detected in any of the samples. The SMR duplicates were analyzed in a separate batch by alpha spectrometry, and the ^{241}Am data do not have an associated ID confidence. The ^{90}Sr data were also qualified "UJ" because the QC reagent blank showed high beta activity even though the samples were unaffected.

Table 4.6 – 2015 Radionuclide Concentrations in Event Evaluation Air Particulate Filter Samples

Sampling Date	Location	238Pu				239/240Pu				241Am			
		[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)]
2/24/2015	CBD	8.91E-05	1.40E-02	2.84E-02	UJ[(e)]	-6.48E-03	1.49E-02	2.43E-02	UJ[(e)]	-4.38E-03	1.53E-02	4.78E-02	U
	ART	-7.25E-03	1.16E-02	2.91E-02	UJ	1.85E-03	1.65E-02	2.48E-02	UJ	-6.40E-04	2.11E-02	4.95E-02	U
	ANG	-1.39E-03	1.12E-02	3.03E-02	UJ	2.87E-04	1.35E-02	2.59E-02	UJ	2.02E-02	2.90E-02	5.25E-02	U
	PMR	-5.09E-03	8.32E-03	2.98E-02	UJ	2.56E-04	1.34E-02	2.55E-02	UJ	-7.20E-04	2.06E-02	4.72E-02	U
	HBS	-3.76E-03	5.42E-03	2.76E-02	UJ	3.19E-04	1.27E-02	2.57E-02	UJ	-1.10E-02	2.17E-02	4.44E-02	U
	EUN	-4.43E-03	7.03E-03	2.88E-02	UJ	-4.39E-03	1.25E-02	2.85E-02	UJ	1.13E-02	2.49E-02	4.35E-02	U
	SEC	-5.09E-03	8.37E-03	2.83E-02	UJ	-2.71E-03	1.04E-02	2.42E-02	UJ	-2.10E-03	1.97E-02	4.52E-02	U
	LVG	-5.70E-03	1.43E-02	3.33E-02	U	8.77E-04	1.23E-02	2.55E-02	U	3.95E-03	3.18E-02	4.75E-02	U
	SMR	-3.58E-03	1.20E-02	3.44E-02	U	-2.41E-03	9.29E-03	2.45E-02	U	-1.20E-02	2.40E-02	4.64E-02	U
	WFF	-6.54E-03	1.51E-02	3.24E-02	U	1.67E-02	2.04E-02	2.84E-02	U	2.84E-02	4.07E-02	5.31E-02	U
	WFF Dup	-2.66E-03	1.08E-02	2.96E-02	U	-3.98E-03	1.14E-02	2.64E-02	U	-2.46E-02	4.03E-02	7.14E-02	U
	MET	-2.07E-03	1.57E-02	3.51E-02	U	-6.78E-03	1.45E-02	3.54E-02	U	-5.53E-03	3.81E-02	6.04E-02	U
	WEE	3.81E-03	1.61E-02	2.93E-02	U	3.02E-05	1.34E-02	2.92E-02	U	-4.71E-03	3.86E-02	5.16E-02	U
	WSS	-5.29E-03	1.39E-02	3.24E-02	U	-8.88E-04	1.31E-02	2.31E-02	U	-1.00E-02	3.62E-02	5.36E-02	U
	WSS Dup	-1.23E-02	2.02E-02	3.84E-02	U	-1.26E-03	2.72E-02	4.64E-02	U	1.09E-03	2.30E-02	4.53E-02	U
	MLR	-1.13E-02	2.55E-02	5.37E-02	U	1.29E-03	1.60E-02	3.19E-02	U	-6.41E-03	2.45E-02	5.54E-02	U
	SLT	7.74E-03	2.28E-02	3.24E-02	U	-4.71E-03	1.18E-02	2.87E-02	U	-2.27E-03	2.31E-02	4.38E-02	U
	SLT Dup	-1.57E-02	2.40E-02	5.36E-02	U	4.90E-03	1.69E-02	3.10E-02	U	-1.13E-02	1.91E-02	4.97E-02	U
	STB	3.19E-03	1.98E-02	2.94E-02	U	-2.72E-03	9.33E-03	2.53E-02	U	3.10E-03	2.34E-02	4.93E-02	U
	GSB	-9.48E-04	1.02E-02	2.88E-02	U	-2.69E-03	1.44E-02	3.05E-02	U	-5.73E-03	2.10E-02	4.56E-02	U
3/10/2015	CBD	-8.53E-03	1.50E-02	3.41E-02	U	-1.52E-03	1.21E-02	2.78E-02	U	-1.65E-02	2.47E-02	5.17E-02	U
	ART	-8.70E-03	1.52E-02	3.30E-02	U	-4.66E-03	8.11E-03	2.76E-02	U	-1.39E-02	2.20E-02	4.56E-02	U
	ANG	-7.51E-03	1.38E-02	3.10E-02	U	1.96E-03	1.54E-02	2.99E-02	U	-1.39E-02	2.23E-02	4.47E-02	U
	PMR	-6.90E-03	1.31E-02	3.08E-02	U	-4.89E-03	8.58E-03	2.85E-02	U	-1.50E-02	2.70E-02	4.72E-02	U

Sampling Date	Location	238Pu				239/240Pu				241Am			
		[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)]
	HBS	-4.70E-03	1.75E-02	3.29E-02	U	4.82E-03	1.32E-02	2.74E-02	U	-1.39E-02	2.91E-02	5.25E-02	U
	EUN	-7.70E-03	1.41E-02	3.18E-02	U	-4.56E-03	7.92E-03	2.65E-02	U	-6.56E-03	2.62E-02	4.82E-02	U
	SEC	-6.23E-03	1.23E-02	3.13E-02	U	-3.55E-03	5.51E-03	2.60E-02	U	-1.39E-02	2.23E-02	4.47E-02	U
	LVG	-6.67E-03	1.72E-02	3.68E-02	U	3.31E-03	1.25E-02	2.69E-02	U	-1.92E-03	2.22E-02	4.46E-02	U
	SMR	-4.05E-03	1.48E-02	3.14E-02	U	-2.09E-03	1.06E-02	2.92E-02	U	-4.28E-03	2.38E-02	4.78E-02	U
	WFF	-5.54E-03	1.63E-02	3.70E-02	U	2.13E-03	1.53E-02	3.03E-02	U	1.73E-03	2.68E-02	4.71E-02	U
	WFF Dup	-7.18E-03	2.52E-02	4.31E-02	U	-9.17E-03	1.20E-02	3.25E-02	U	-6.89E-03	2.26E-02	4.87E-02	U
	MET	2.52E-03	1.87E-02	3.10E-02	U	-7.35E-03	9.62E-03	2.74E-02	U	4.06E-03	2.52E-02	4.58E-02	U
	WEE	-2.47E-03	1.85E-02	3.69E-02	U	-6.62E-03	8.50E-03	2.97E-02	U	-3.91E-03	2.49E-02	4.66E-02	U
	WSS	3.05E-03	1.98E-02	3.39E-02	U	-6.83E-03	8.89E-03	3.46E-02	U	-7.44E-03	2.26E-02	5.00E-02	U
	WSS Dup	-5.79E-03	1.68E-02	3.46E-02	U	-4.55E-03	1.26E-02	2.69E-02	U	-4.79E-03	3.22E-02	5.27E-02	U
	MLR	-4.68E-03	1.57E-02	3.18E-02	U	-2.39E-03	9.53E-03	2.59E-02	U	1.80E-03	3.81E-02	6.95E-02	U
	SLT	-1.38E-02	2.31E-02	3.32E-02	U	-3.10E-03	1.06E-02	2.52E-02	U	-1.07E-02	2.49E-02	4.59E-02	U
	SLT Dup	-9.43E-04	2.26E-02	3.27E-02	U	3.30E-03	1.72E-02	3.26E-02	U	-6.11E-03	3.66E-02	6.52E-02	U
	STB	5.49E-04	2.13E-02	3.45E-02	U	-2.90E-03	1.03E-02	2.63E-02	U	2.95E-03	2.67E-02	4.49E-02	U
	GSB	-9.37E-03	1.99E-02	3.26E-02	U	-3.46E-03	1.70E-02	3.44E-02	U	-1.47E-02	3.18E-02	5.85E-02	U

Notes:

Units are dpm/sample.

(a) Radionuclide activity. 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.

(e) UJ: ^{238}Pu and $^{239/240}$Pu not detected above the reported 2 σ TPU and MDC, but a quality deficiency affected the data making the data more uncertain, i.e., the ^{242}Pu tracer recovery was slightly higher than the 110% objective in the associated RLCS QC sample.

Table 4.7 – 2015 Radionuclide Concentrations in Event Evaluation Air Particulate Filter Samples Collected August 5, 2015

	$^{233/234}U$				^{235}U				^{238}U			
Location	[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	-4.69E-03	5.02E-02	1.30E-01	U	-8.35E-03	1.85E-02	3.24E-02	U	-4.13E-02	4.27E-02	5.74E-02	U
MET	-2.86E-02	4.67E-02	1.32E-01	U	-9.22E-03	1.96E-02	4.47E-02	U	1.61E-03	4.89E-02	5.18E-02	U
WEE	6.64E-03	5.48E-02	1.33E-01	U	-5.46E-03	1.36E-02	2.90E-02	U	3.45E-03	4.96E-02	5.13E-02	U
WEE Dup	2.20E-03	5.06E-02	1.30E-01	U	-5.46E-03	1.36E-02	2.68E-02	U	-2.06E-03	4.67E-02	4.92E-02	U
WSS	8.48E-04	5.38E-02	1.33E-01	U	-8.12E-03	1.83E-02	3.93E-02	U	6.80E-03	5.21E-02	5.88E-02	U
MLR	-6.46E-03	5.16E-02	1.32E-01	U	-3.22E-03	2.49E-02	3.77E-02	U	7.10E-03	5.02E-02	5.18E-02	U
SLT	8.02E-03	5.27E-02	1.30E-01	U	-4.06E-04	2.06E-02	3.07E-02	U	-2.46E-02	4.01E-02	4.84E-02	U
STB	-1.49E-02	5.00E-02	1.32E-01	U	-6.98E-04	2.29E-02	3.74E-02	U	-2.44E-02	4.27E-02	5.22E-02	U
GSB	-1.31E-03	5.14E-02	1.31E-01	U	-7.13E-03	1.66E-02	3.25E-02	U	1.68E-03	4.74E-02	4.98E-02	U
SMR	-3.06E-02	6.23E-02	1.61E-01	U	-5.34E-03	1.83E-02	4.68E-02	U	-5.02E-03	5.24E-02	6.04E-02	U
SMR Dup	2.57E-03	6.64E-02	1.60E-01	U	-3.89E-03	1.60E-02	3.12E-02	U	-1.44E-02	5.07E-02	5.97E-02	U
	^{238}Pu				$^{239/240}PU$				^{90}Sr			
Location	[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	Q[(d)]	[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	Q[(d)]	[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	Q[(d)]
WFF	-7.87E-03	2.02E-02	3.99E-02	U [(f)]	1.68E-03	2.09E-02	4.00E-02	UJ[(f)]	5.07E-01	1.02E+00	5.30E+00	UJ[(h)]
MET	1.52E-02	3.05E-02	4.08E-02	R[(g)]	3.43E-01	8.19E-02	3.13E-02	R[(g)]	-1.19E-01	9.30E-01	5.30E+00	UJ
WEE	-9.38E-03	2.19E-02	4.62E-02	UJ	-1.07E-02	1.67E-02	3.86E-02	UJ	3.92E-01	9.85E-01	5.30E+00	UJ
WEE Dup	3.37E-03	2.48E-02	4.20E-02	UJ	-8.47E-03	1.32E-02	3.55E-02	UJ	-1.17E+00	1.01E+00	5.30E+00	UJ
WSS	5.21E-03	2.31E-02	4.07E-02	R	5.63E-02	3.98E-02	3.50E-02	R	-1.57E-01	9.45E-01	5.30E+00	UJ
MLR	-6.90E-04	1.75E-02	3.12E-02	UJ	1.68E-02	2.48E-02	3.35E-02	UJ	-8.21E-01	9.65E-01	5.30E+00	UJ
SLT	-7.50E-03	1.98E-02	4.16E-02	UJ	1.54E-02	2.72E-02	2.85E-02	UJ	-1.08E-01	9.33E-01	5.30E+00	UJ
STB	-6.90E-03	1.90E-02	4.69E-02	UJ	-1.27E-02	1.93E-02	7.61E-02	UJ	-5.26E-02	9.06E-01	5.30E+00	UJ
GSB	-5.35E-03	1.71E-02	3.39E-02	UJ	-8.23E-03	1.30E-02	3.12E-02	UJ	2.32E-01	1.01E+00	5.31E+00	UJ
SMR	-1.01E-02	1.91E-02	3.60E-02	U	-1.86E-03	1.73E-02	3.65E-02	U	4.43E-02	4.58E-01	8.28E-01	U
SMR Dup	-9.10E-03	2.58E-02	4.51E-02	U	5.13E-03	1.81E-02	3.14E-02	U	1.08E-01	4.91E-01	8.30E-01	U

Location	^{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)]
WFF	6.45E+01	4.75E+01	5.77E+01	0.000	U	5.02E+00	4.49E+00	5.43E+00	0.000	U
MET	9.49E+01	5.81E+01	7.86E+01	0.000	U	2.56E+00	5.13E+00	6.54E+00	0.000	U
WEE	8.51E+01	4.23E+01	5.44E+01	0.000	U	-5.12E-01	4.12E+00	4.60E+00	0.000	U
WEE Dup	4.30E+01	7.20E+01	8.81E+01	0.000	U	3.54E+00	6.94E+00	8.37E+00	0.000	U
WSS	9.07E+01	4.65E+01	5.83E+01	0.000	U	1.58E+00	4.44E+00	5.17E+00	0.000	U
MLR	1.17E+02	5.84E+01	8.11E+01	0.000	U	-3.26E-01	5.76E+00	6.86E+00	0.000	U
SLT	5.45E+01	7.17E+01	8.83E+01	0.000	U	1.72E+00	6.41E+00	7.68E+00	0.000	U
STB	1.03E+02	4.72E+01	5.97E+01	0.000	U	4.75E+00	4.16E+00	5.15E+00	0.000	U
GSB	9.83E+01	5.76E+01	7.86E+01	0.000	U	-1.53E-01	5.89E+00	7.04E+00	0.000	U
SMR	1.05E+02	4.75E+01	6.00E+01	0.000	U	1.22E+00	4.32E+00	5.02E+00	0.000	U
SMR Dup	5.61E+01	4.54E+01	5.54E+01	0.000	U	-1.49E+00	4.37E+00	4.76E+00	0.000	U
Location	^{241}Am					^{137}Cs				
	[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)]
WFF	-3.03E+01	1.03E+01	8.82E+00	0.000	U	2.94E-02	4.43E+00	4.91E+00	0.000	U
MET	-1.58E-01	2.75E+00	3.13E+00	0.000	U	1.59E-01	4.61E+00	5.47E+00	0.000	U
WEE	-5.63E+01	1.30E+01	8.90E+00	0.000	U	-1.45E+00	4.33E+00	4.65E+00	0.000	U
WEE Dup	-4.54E-01	7.21E+00	7.75E+00	0.000	U	-3.32E-01	6.39E+00	7.07E+00	0.000	U
WSS	-3.74E+01	1.09E+01	8.63E+00	0.000	U	1.95E+00	4.27E+00	4.82E+00	0.000	U
MLR	4.05E-01	2.65E+00	3.06E+00	0.000	U	4.48E-01	4.76E+00	5.62E+00	0.000	U
SLT	-2.09E+00	7.19E+00	7.62E+00	0.000	U	-1.21E+00	6.32E+00	6.90E+00	0.000	U
STB	-2.96E+01	1.02E+01	8.82E+00	0.000	U	2.18E+00	4.33E+00	4.90E+00	0.000	U
GSB	8.29E-01	2.58E+00	3.00E+00	0.000	U	-1.17E-01	5.08E+00	5.95E+00	0.000	U
SMR	-1.39E-02	5.13E-02	8.89E-02	NA	U	-2.89E+00	4.31E+00	4.61E+00	0.000	U
SMR Dup	2.46E-02	4.49E-02	5.71E-02	NA	U	3.35E+00	4.10E+00	4.69E+00	0.000	U

Notes:

Units are dpm/sample.

(a) Radionuclide activity. 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.

(e) Identification confidence for gamma radionuclides. Value >0.90 implies detection if the sample activity is greater than 2 σ TPU and the MDC. NA implies the ^{241}Am was analyzed by alpha spectrometry and not by gamma.

(f) UJ: ^{238}Pu and $^{239/240}$Pu not detected above the reported 2 σ TPU and MDC, but a quality deficiency affected the data making the data more uncertain, i.e., the ^{242}Pu tracer recovery was slightly higher than the 110% objective in the associated RLCS QC sample.

(g) The Pu data from the two samples was rejected due to known cross contamination in the samples.

(h) ^{90}Sr not detected above the reported 2 σ TPU and the MDC, but a quality deficiency affected the data making the data more uncertain, i.e., the reagent blank contained high beta activity.

4.3 Groundwater

4.3.1 Sample Collection

Groundwater samples were collected once in 2015 (Round 37) from six different detection monitoring wells on the WIPP site, as shown in Figure 6.3. The wells were completed in the Culebra Dolomite Member (Culebra), which is a water-bearing member of the Rustler Formation. 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 a solution) conductivity, and temperature, were measured in an on-site mobile laboratory, in a continuous flow-cell sampling system. Specific gravity was also measured using a classical hydrometer technique. Field parameters were measured until individual values for each parameter were within 5 percent 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 undisturbed 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 carriers (strontium nitrate and barium 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 microprecipitating 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 2015, as shown by the data in Table 4.8. The sample collection dates are also shown in the table. The concentrations reported in Table 4.8 are from the primary samples collected from each WQSP well.

Table 4.8 – 2015 Radionuclide Concentrations in Primary Groundwater from Detection Monitoring Program Wells at the WIPP Site

Location	Round	Sample 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)]	[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	Q[(d)]
			$^{233/234}U$				^{235}U				^{238}U				^{90}Sr			
WQSP-1	37	3/11/15	1.24E+00	2.34E-01	1.05E-03	+	2.10E-02	5.49E-03	8.29E-04	+	2.14E-01	4.17E-02	9.95E-04	+	-1.32E-02	2.75E-02	2.67E-02	U
WQSP-2	37	3/24/15	1.15E+00	2.28E-01	1.05E-03	+	2.02E-03	1.44E-03	9.24E-04	+	4.09E-02	8.63E-03	1.25E-03	+	-1.85E-03	2.39E-02	2.56E-02	U
WQSP-3	37	4/8/15	2.63E-01	4.42E-02	1.50E-03	+	2.83E-03	1.38E-03	6.85E-04	+	8.56E-02	1.51E-02	1.19E-03	+	-1.06E-02	2.35E-02	2.39E-02	U
WQSP-4	37	4/21/15	4.96E-01	7.67E-02	1.43E-03	+	5.48E-03	2.38E-03	8.91E-04	+	9.08E-02	1.44E-02	8.37E-04	+	-7.97E-03	1.86E-02	2.34E-02	U
WQSP-5	37	5/12/15	3.98E-01	6.82E-02	1.55E-03	+	2.26E-03	1.60E-03	1.20E-03	+	5.12E-02	1.06E-02	1.32E-03	+	4.93E-03	2.89E-02	1.74E-02	U
WQSP-6	37	5/27/15	4.79E-01	7.51E-02	1.35E-03	+	3.78E-03	1.97E-03	1.06E-03	+	6.82E-02	1.25E-02	1.12E-03	+	-1.49E-02	1.69E-02	1.79E-02	U
			^{238}Pu				$^{239/240}Pu$				^{241}Am							
WQSP-1	37	3/11/15	6.30E-05	2.67E-04	7.35E-04	U	3.78E-05	2.87E-04	6.67E-04	U	3.04E-04	5.66E-04	1.30E-03	U				
WQSP-2	37	3/24/15	1.68E-04	3.64E-04	8.38E-04	U	5.16E-05	2.84E-04	7.09E-04	U	1.20E-04	3.21E-04	1.01E-03	U				
WQSP-3	37	4/8/15	2.28E-04	4.48E-04	9.27E-04	U	1.14E-04	5.48E-04	1.20E-03	U	6.12E-04	1.02E-03	1.44E-03	U				
WQSP-4	37	4/21/15	1.57E-04	7.80E-04	1.32E-03	U	6.80E-05	4.38E-04	1.04E-03	U	1.07E-03	1.32E-03	1.77E-03	U				
WQSP-5	37	5/12/15	-4.74E-04	6.01E-04	1.61E-03	U	-1.83E-04	3.74E-04	1.20E-03	U	2.15E-04	8.03E-04	1.54E-03	U				
WQSP-6	37	5/27/15	0.00E+00	7.92E-04	1.56E-03	U	-2.02E-04	3.96E-04	1.44E-03	U	-1.39E-04	1.15E-03	2.65E-03	U				

Location	Round	Sample Date	[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)]	[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	ID Conf.[(e)]	Q[(d)]
			^{40}K					^{60}Co					^{137}Cs				
WQSP-1	37	3/11/15	2.61E+01	9.97E+00	1.02E+01	1.000	+	3.58E-01	1.25E+00	1.63E+00	0.00	U	1.85E-02	1.10E+00	1.33E+00	0.00	U
WQSP-2	37	3/24/15	1.18E+01	4.12E+00	4.88E+00	0.999	+	-3.36E-02	3.63E-01	4.15E-01	0.00	U	9.61E-02	3.52E-01	4.08E-01	0.00	U
WQSP-3	37	4/8/15	4.33E+01	1.41E+01	1.48E+01	0.998	+	4.41E-01	1.30E+00	1.68E+00	0.00	U	-8.42E-02	1.06E+00	1.27E+00	0.00	U
WQSP-4	37	4/21/15	3.48E+01	1.51E+01	2.43E+01	0.000	U	8.45E-01	1.34E+00	1.84E+00	0.00	U	2.86E-01	8.69E-01	1.13E+00	0.00	U
WQSP-5	37	5/12/15	5.89E+00	2.57E+00	3.26E+00	0.993	+	-7.08E-02	3.29E-01	3.65E-01	0.00	U	-4.64E-02	3.37E-01	3.72E-01	0.00	U
WQSP-6	37	5/27/15	7.95E+00	3.43E+00	4.55E+00	0.997	+	-6.89E-02	3.27E+00	3.66E-01	0.00	U	1.11E-01	3.32E-01	3.89E-01	0.00	U

Notes:

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

(a) Radionuclide activity of the primary sample.

(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.

The 2015 uranium groundwater concentrations in the detection monitoring wells were compared with the concentrations from the same locations in 2014 using ANOVA. The ANOVA calculations were performed using the Round 37 average uranium sample concentrations from 2015 and the average uranium concentrations from Round 36 in 2014.

The concentrations of the uranium isotopes measured in 2015 did not vary significantly from the concentrations measured in the same wells in 2014, as demonstrated by the combined ANOVA results of the wells, with all the *p* values well above the significance level of 0.05 (ANOVA $^{233/234}U$, $p = 0.95$; ANOVA ^{235}U, $p = 0.714$; and ANOVA ^{238}U, $p = 0.94$).

The average concentrations of the uranium isotopes measured in the groundwater samples in 2015 were also compared to the 2014 concentrations by location. There was significant variation by location between the wells sampled in 2015 and 2014, as demonstrated by the ANOVA results (ANOVA $^{233/234}U$, p = 1.87E-05; ANOVA ^{235}U, p = 1.35E-03; and ANOVA ^{238}U, p = 2.08E-05). The large differences in uranium isotope concentrations at the different locations are likely due to the differences in the abundance of these naturally occurring isotopes in the sedimentary rocks deposited in the area and the associated variable dissolution of the uranium isotopes into the groundwater.Concentrations of uranium isotopes in the primary groundwater samples were also compared with the 99 percent confidence interval range of the baseline concentrations measured between 1985 and 1989 (baseline values: $^{233/234}U$ = 1.30E+00 Bq/L, ^{235}U = 3.10E–02 Bq/L, and ^{238}U = 3.20E–01 Bq/L). The highest Round 37 concentration of $^{233/234}U$ of 1.31E+00 Bq/L in the duplicate sample at WQSP-1 was slightly higher than the 99 percent confidence interval range of the baseline concentration of 1.30E+00 Bq/L. The highest concentration of ^{235}U of 2.10E-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 2.27E-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 concentrations were well within the 99 percent confidence interval ranges of the baseline concentrations (DOE/WIPP–98–2285).

The groundwater samples were also analyzed using TRU alpha spectroscopy, for the following radionuclides: ^{238}Pu, $^{239/240}Pu$, and ^{241}Am (Table 4.8). These isotopes, which are related to WIPP waste disposal operations, were not detected in the groundwater samples, so no ANOVA comparisons between years or among locations could be performed.

Table 4.8 also shows the concentration of the gamma radionuclides and ^{90}Sr. The ID confidences for the gamma analyses have been included. The potassium isotope ^{40}K was detected in the primary samples of all six wells in 2015 except for the primary sample of WQSP-4 where the activity was greater than 2 σ TPU and MDC, but the ID confidence was 0.000. However, ^{40}K was detected in the duplicate groundwater WQSP-4 sample, and this concentration was used in the ANOVA calculation. In addition, ^{40}K

was detected in the primary samples of WQSP-5 and WQSP-6, but not in the duplicate samples. The primary samples concentrations were used for the ANOVA calculations. The 2014 analysis results for ^{40}K showed that it was detected in all the samples except the duplicate sample from WQSP-2. The 2014 detected concentration of ^{40}K in the primary sample was used for the ANOVA calculations resulting in detected values for six common locations.

The 2015 average concentrations of ^{40}K in the primary and duplicate groundwater samples did not vary significantly from the 2014 concentrations (ANOVA ^{40}K, p = 0.971). However, ^{40}K concentrations did vary significantly by location from well to well (ANOVA ^{40}K, p = 1.87E-04). Some differences in ^{40}K concentrations at the various wells (locations) would be expected due to differences in the abundance of this naturally occurring isotope in the sedimentary minerals deposited at various locations in the area and the associated variable dissolution of the isotope by the groundwater.

The measured concentrations of ^{40}K in the primary groundwater samples in 2015 were all within the 99 percent confidence interval range of the baseline concentrations (baseline concentration: 6.30E+01 Bq/L). The highest concentration measured in 2015 was 4.33E+01 Bq/L (the concentration in the WQSP-3 primary sample in 2014 was 4.35E+01 Bq/L and in 2013 was 4.32E+01 Bq/L).

The isotopes ^{137}Cs and ^{60}Co were not detected in any of the 2015 groundwater samples, and no ANOVA comparisons were performed.

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

A duplicate sample from each well was analyzed during each sampling episode. The duplicate sample activities and corresponding 1 σ TPUs for each radionuclide are given in Table 4.9, which shows the precision of the analysis of the primary and duplicate samples, as discussed in detail below. Precision data for radionuclides in groundwater (primary and duplicate samples) as well as in duplicate surface water, sediment, soil, and biota samples, are reported for all radionuclides whether or not they were detected. An associated qualifier column indicates whether the radionuclide was detected.

Table 4.9 – Precision Results for 2015 Field Duplicate Groundwater Sample Analyses from Round 37

Location	Radionuclide	Primary Sample (Bq/L)		Duplicate Sample (Bq/L)		RER[c]	Q[d]
		[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]		
WQSP-1	$^{233/234}U$	1.24E+00	1.19E-01	1.31E+00	1.22E-01	0.411	+
	^{235}U	2.10E-02	2.80E-03	1.48E-02	2.13E-03	1.762	+
	^{238}U	2.14E-01	2.13E-02	2.27E-01	2.18E-02	0.427	+
	^{238}Pu	6.30E-05	1.36E-04	2.35E-04	1.81E-04	0.760	U
	$^{239/240}Pu$	3.78E-05	1.46E-04	-4.15E-05	7.19E-05	0.487	U

Location	Radionuclide	Primary Sample (Bq/L)		Duplicate Sample (Bq/L)		RER[c]	Q[d]
		[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]		
	^{241}Am	3.04E-04	2.89E-04	-1.12E-04	1.42E-04	1.292	U
	^{40}K	2.61E+01	5.09E+00	1.73E+01	2.09E+00	1.599	+
	^{60}Co	3.58E-01	6.38E-01	-9.85E-02	1.77E-01	0.689	U
	^{137}Cs	1.85E-02	5.61E-01	1.87E-03	1.54E-01	0.029	U
	^{90}Sr	-1.32E-02	1.40E-02	1.32E-02	1.23E-02	1.417	U
WQSP-2	$^{233/234}$U	1.15E+00	1.17E-01	1.21E+00	1.15E-01	0.366	+
	^{235}U	1.27E-02	1.98E-03	1.73E-02	2.40E-03	1.478	+
	^{238}U	1.75E-01	1.84E-02	1.86E-01	1.83E-02	0.424	+
	^{238}Pu	1.68E-04	1.86E-04	-7.07E-05	8.63E-05	1.164	U
	$^{239/240}$Pu	5.16E-05	1.45E-04	1.62E-04	1.65E-04	0.503	U
	^{241}Am	1.20E-04	1.64E-04	1.77E-04	2.47E-04	0.192	U
	^{40}K	1.18E+01	2.10E+00	1.32E+01	1.98E+00	0.485	+
	^{60}Co	-3.36E-02	1.85E-01	-2.51E-01	1.80E-01	0.842	U
	^{137}Cs	9.61E-02	1.80E-01	1.99E-01	1.66E-01	0.420	U
	^{90}Sr	-1.85E-03	1.22E-02	-4.40E-03	9.53E-03	0.165	U
WQSP-3	$^{233/234}$U	2.63E-01	2.26E-02	2.15E-01	1.99E-02	1.594	+
	^{235}U	2.02E-03	7.34E-04	1.35E-03	6.14E-04	0.700	+
	^{238}U	4.09E-02	4.41E-03	3.32E-02	3.95E-03	1.301	+
	^{238}Pu	2.28E-04	2.28E-04	-2.25E-04	2.25E-04	1.414	U
	$^{239/240}$Pu	1.14E-04	2.80E-04	-1.56E-04	1.87E-04	0.802	U
	^{241}Am	6.12E-04	5.22E-04	3.83E-04	4.51E-04	0.332	U
	^{40}K	4.33E+01	7.19E+00	3.95E+01	3.62E+00	0.472	+
	^{60}Co	4.41E-01	6.63E-01	-1.04E+00	1.87E-01	2.150	U
	^{137}Cs	-8.42E-02	5.41E-01	-2.03E-01	1.85E-01	0.208	U
	^{90}Sr	-1.06E-02	1.20E-02	-2.56E-03	1.02E-02	0.510	U
WQSP-4	$^{233/234}$U	4.96E-01	3.91E-02	5.57E-01	4.53E-02	1.019	+
	^{235}U	5.48E-03	1.22E-03	5.56E-03	1.29E-03	0.045	+
	^{238}U	8.56E-02	7.69E-03	9.91E-02	9.00E-03	1.140	+
	^{238}Pu	1.57E-04	3.98E-04	1.89E-04	1.89E-04	0.073	U
	$^{239/240}$Pu	6.80E-05	2.23E-04	6.30E-05	2.44E-04	0.015	U
	^{241}Am	1.07E-03	6.72E-04	7.39E-04	4.97E-04	0.396	U
	^{40}K	3.48E+01	7.70E+00	2.45E+01	5.97E+00	1.057	+
	^{60}Co	8.45E-01	6.84E-01	-4.73E-01	6.73E-01	1.374	U
	^{137}Cs	2.86E-01	4.43E-01	4.65E-01	5.09E-01	0.265	U

Location	Radionuclide	Primary Sample (Bq/L)		Duplicate Sample (Bq/L)		RER[c]	Q[d]
		[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]		
	^{90}Sr	-7.97E-03	9.50E-03	-9.15E-03	1.05E-02	0.009	U
WQSP-5	$^{233/234}$U	3.98E-01	3.48E-02	3.56E-01	3.15E-02	0.895	+
	^{235}U	2.26E-03	8.15E-04	2.15E-03	8.13E-04	0.096	+
	^{238}U	5.12E-02	5.43E-03	4.73E-02	5.16E-03	0.521	+
	^{238}Pu	-4.74E-04	3.07E-04	-3.40E-04	2.56E-04	0.335	U
	$^{239/240}$Pu	-1.83E-04	1.91E-04	-7.39E-05	2.97E-04	0.309	U
	^{241}Am	2.15E-04	4.09E-04	9.86E-04	6.42E-04	1.013	U
	^{40}K	5.89E+00	1.31E+00	4.24E+00	2.73E+00	0.545	+
	^{60}Co	-7.08E-02	1.68E-01	-2.74E-01	2.62E-01	0.653	U
	^{137}Cs	-4.64E-02	1.72E-01	-9.84E-02	2.57E-01	0.168	U
	^{90}Sr	4.93E-03	1.48E-02	1.20E-02	1.30E-02	0.359	U
WQSP-6	$^{233/234}$U	4.79E-01	3.83E-02	5.60E-01	4.69E-02	0.356	+
	^{235}U	3.78E-03	1.00E-03	3.17E-03	9.38E-04	0.445	+
	^{238}U	6.82E-02	6.40E-03	7.06E-02	6.89E-03	0.255	+
	^{238}Pu	0.00E+00	4.04E-04	-6.08E-05	3.22E-04	0.118	U
	$^{239/240}$Pu	-2.02E-04	2.02E-04	6.38E-04	4.76E-04	1.624	U
	^{241}Am	-1.39E-04	5.89E-04	6.59E-04	5.77E-04	0.968	U
	^{40}K	7.95E+00	1.75E+00	1.81E+01	7.14E+00	1.381	+
	^{60}Co	-6.89E-02	1.67E+00	2.50E-01	5.10E-01	0.183	U
	^{137}Cs	1.11E-01	1.69E-01	1.86E-01	5.56E-01	0.129	U
	^{90}Sr	-1.49E-02	8.60E-03	-3.87E-03	8.53E-03	0.911	U

Notes:

See Figure 6.3 for sampling locations.

(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 primary sample but not the duplicate sample.

The Round 37 RERs in Table 4.9 show that the RERs were less than 2, except for ^{60}Co in the WQSP-3 duplicate samples where the RER was 2.150. The RER precision data indicate 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 surface water results are divided into the routine regional and local surface water sampling data and discussion as regularly reported in the ASER and one set of surface water samples of opportunity (SOOs) that were collected on January 14, 2015, and January 31, 2015. The SOO samples were analyzed for the Event Evaluation radionuclides of interest, including ^{238}Pu, $^{239/240}$Pu, and ^{241}Am by alpha spectroscopy. These samples were specifically obtained to evaluate the impact of the radiological release on the surface water on the WIPP Site around buildings following a rainfall.

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

Routine surface water and sediment sampling is normally performed in late summer of every year. At times, the cattle tanks (earthen ponds) are dry and only sediment samples can be obtained. Most of the regularly sampled surface water samples from the locations in Figure 4.2 were collected April through June 2015 except for the samples from the Upper Pecos River and the sewage lagoon SOO, which were sampled in October.

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.

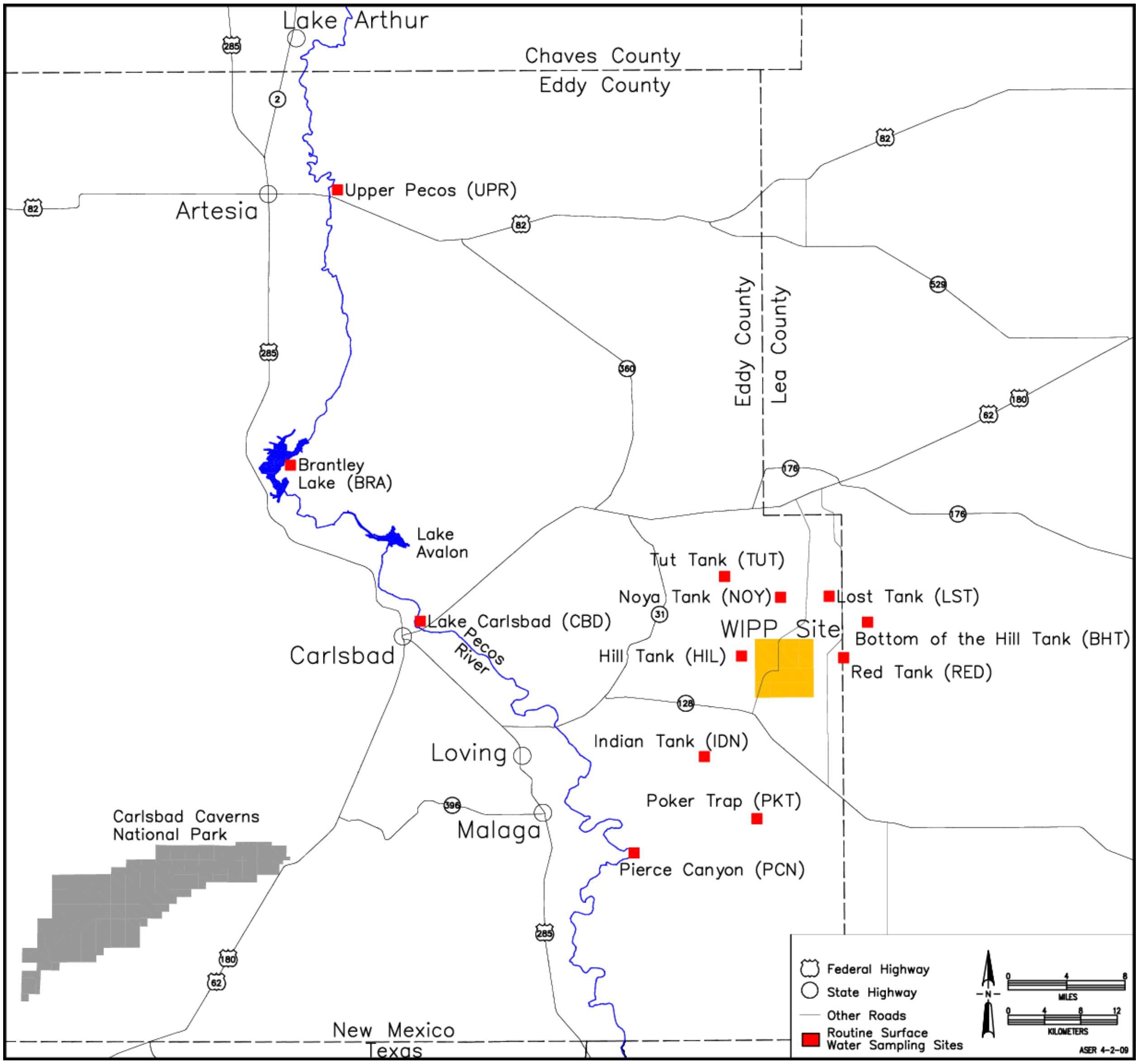


Figure 4.2 – Routine Surface Water Sampling Locations

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 carriers (strontium nitrate and barium 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 microprecipitating 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

This section is separated into the routine surface water samples typically reported in the ASER and the Event Evaluation samples consisting of the SOO that were collected following rain events on the WIPP site. The routine surface water sample analysis results are discussed immediately below and the analysis results for the surface water SOO are discussed in a separate section below.

Routine Surface Water Samples

The analysis results for the uranium isotopes in the routine surface water samples are shown in Table 4.10. Uranium isotopes were detected in most of the surface water samples, which included 14 separate samples, three sets of duplicate samples (including the blind COY sample), and a distilled water field blank (COW), which was submitted to the laboratory as a blind QC sample. The uranium isotope analyses resulted in detection of $^{233/234}U$ in all the surface water samples (not including the COW field blank), detection of ^{235}U in FWT, CBD, BRA, PCN and UPR and its duplicate, and detection of ^{238}U in all the samples except IDN and the COW field blank.

The concentrations of the uranium isotopes were compared between 2015 and 2014 and also between sampling locations using ANOVA for those locations where the uranium isotopes were detected both years. The average concentrations were used for detections at NOY, HIL, and UPR in 2015 and HIL and CBD in 2014. In 2015 and 2014, $^{233/234}U$ was detected in 14 common locations, ^{235}U was detected in only four common locations, and ^{238}U was detected in 14 common locations.

There was no significant variation in the concentrations of the uranium isotopes in the surface water between 2015 and 2014 (ANOVA $^{233/234}U$, $p = 0.469$; ANOVA ^{235}U, $p = 0.107$, and ANOVA ^{238}U, $p = 0.500$). The ^{235}U p value showed more variability than the other two uranium isotopes at only two times the 0.05 significance level, but the value was based on only four common detections for the two years and they were all in the Pecos River and associated bodies of water.

Table 4.10 – 2015 Uranium Isotope Concentrations in Standard Surface Water Samples Taken Near the WIPP Site

Location	Sampling Date	$^{233/234}U$				^{235}U				^{238}U			
		[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	Q[(d)]	[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	Q[(d)]	[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	Q[(d)]
RED	4/30/2015	2.23E-02	6.18E-03	1.64E-03	+	1.91E-04	6.80E-04	1.38E-03	U	1.38E-02	4.43E-03	1.31E-03	+
NOY	5/28/2015	6.55E-03	2.38E-03	1.38E-03	+	2.11E-04	4.62E-04	9.74E-04	U	3.43E-03	1.66E-03	1.01E-03	+
COY[(e)]	5/28/2015	8.04E-03	2.66E-03	1.37E-03	+	-3.24E-05	1.68E-04	1.02E-03	U	3.23E-03	1.61E-03	1.12E-03	+
HIL	4/27/2015	1.18E-02	3.59E-03	1.43E-03	+	5.05E-04	7.05E-04	9.72E-04	U	9.38E-03	3.14E-03	1.32E-03	+
HIL Dup	4/27/2015	1.23E-02	3.68E-03	1.42E-03	+	7.49E-04	1.10E-03	1.50E-03	U	8.20E-03	2.86E-03	1.11E-03	+
TUT	5/28/2015	7.75E-03	2.60E-03	1.33E-03	+	-8.17E-05	2.68E-04	1.10E-03	U	6.94E-03	2.45E-03	1.08E-03	+
PKT	5/5/2015	3.11E-03	1.55E-03	1.32E-03	+	1.87E-04	4.59E-04	9.88E-04	U	8.58E-04	7.94E-04	9.55E-04	+
FWT	6/15/2015	5.04E-02	9.57E-03	1.29E-03	+	1.61E-03	1.21E-03	9.72E-04	+	2.02E-02	4.86E-03	1.02E-03	+
COW[(f)]	5/29/2015	9.92E-04	9.32E-04	1.38E-03	U	-1.88E-05	1.28E-04	9.79E-04	U	4.71E-04	6.64E-04	1.08E-03	U
IDN	4/30/2015	1.67E-02	4.36E-03	1.39E-03	+	4.76E-04	6.63E-04	9.32E-04	U	9.15E-03	2.95E-03	1.07E-03	U
PCN	6/11/2015	1.79E-01	2.87E-02	1.28E-03	+	3.32E-03	1.88E-03	1.35E-03	+	8.50E-02	1.48E-02	1.03E-03	+
CBD	6/11/2015	1.24E-01	2.04E-02	1.27E-03	+	1.34E-03	1.14E-03	1.11E-03	+	5.53E-02	1.02E-02	1.06E-03	+
BRA	6/11/2015	3.07E-02	6.61E-03	1.42E-03	+	1.41E-04	5.45E-04	1.18E-03	+	1.70E-02	4.35E-03	1.04E-03	+
UPR	10/26/2015	7.30E-02	1.35E-02	1.56E-03	+	1.59E-03	1.33E-03	1.36E-03	+	4.83E-02	9.58E-03	1.42E-03	+
UPR Dup	10/26/2015	7.33E-02	1.38E-02	1.59E-03	+	1.90E-03	1.44E-03	1.37E-03	+	4.66E-02	9.45E-03	1.43E-03	+
LST	5/5/2015	4.70E-03	2.10E-03	1.49E-03	+	6.63E-04	8.96E-04	1.17E-03	U	3.14E-03	1.67E-03	1.08E-03	+
BHT	5/5/2015	4.95E-03	2.20E-03	1.39E-03	+	-1.52E-04	3.96E-04	1.45E-03	U	2.54E-03	1.54E-03	1.17E-03	+
SOO[(g)]	10/15/2015	1.94E-02	5.82E-03	1.84E-03	+	5.73E-04	9.48E-04	1.45E-03	U	4.97E-03	2.52E-03	1.92E-03	+

Notes:

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

(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) COY = semi-blind field duplicate (NOY).

(f) COW = semi-blind field blank.

(g) SOO = surface water composite consisting of Settling Lagoon 1 and 2, Effluent Lagoon A, B, and C, Polishing Lagoons 1 and 2, and H-19.

Except for the very limited number of common locations for ^{235}U where the ANOVA ^{235}U, $p = 0.249$, there was significant variation in the concentration of the uranium isotopes by location compared to 2014 with ANOVA $^{233/234}U$, p = 9.04E-05 and ANOVA ^{238}U, p = 6.79E-06. This significant variation for $^{233/234}U$ and ^{238}U concentrations by location is consistent with the data comparing the 2015 and 2014 uranium isotope concentrations and appears to be due to more than an order of magnitude difference in concentrations at some of the locations.

The 2015 uranium isotope surface water concentrations were also compared with the 99 percent confidence interval range of the baseline concentrations measured between 1985 and 1989 (DOE/WIPP–92–037). The concentrations detected for $^{233/234}U$, ^{235}U, and ^{238}U in the Pecos River and associated bodies of water, which include locations PCN, CBD, BRA, and UPR, were compared with the 99 percent confidence interval ranges of the measured baseline concentrations (baseline levels: $^{233/234}U$ = 3.30E–01 Bq/L, ^{235}U = 1.40E–02 Bq/L, and ^{238}U = 1.10E–01 Bq/L). The highest concentrations detected were 1.79E-01 Bq/L of $^{233/234}U$ at PCN, 3.32E-03 Bq/L of ^{235}U at PCN, and 8.50E-02 Bq/L of ^{238}U at PCN. Thus, none of the measured 2015 concentrations were higher than the 99 percent confidence interval concentrations from the baseline. The uranium isotope concentrations were also the highest at PCN in 2014, although each concentration was slightly higher in 2014 than in 2015.

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 $^{233/234}U$ = 1.07E-01 Bq/L, ^{235}U = 5.59E-03 Bq/L, and ^{238}U = 1.02E-01 Bq/L. The highest concentrations measured in 2015 include 5.04E-02 Bq/L $^{233/234}U$ at FWT; detection of ^{235}U in only FWT at 1.61E-03 Bq/L; and 2.02E-02 Bq/L ^{238}U at FWT. Thus, none of the measured 2015 concentrations were higher than the 99 percent confidence interval concentrations from the baseline. The FWT water source is not at the WIPP site; rather it is the groundwater pumped to the WIPP site from a distant location and stored in large tanks for use as domestic water on the WIPP site.

The SOO surface water sample is a separate type of sample prepared by compositing portions of water from several sewage lagoon locations as well as Pond H-19. The sample was formerly designated SWL. In 2012, the highest concentrations of all the uranium isotopes were detected in this sewage lagoon composite sample. There are no baseline concentrations for the uranium isotopes in the sewage lagoon composite sample. The SWL uranium isotope concentrations were much lower in 2013 to 2015; however, ^{235}U was not detected in the sample during this period. The surface water samples were also analyzed for ^{238}Pu, $^{239/240}Pu$, and ^{241}Am, as shown in Table 4.11. None of these radionuclides were detected in the surface water samples in 2015. Thus, no ANOVA comparisons between years and among locations could be performed.

Table 4.11 – 2015 Plutonium Isotope and Americium Concentrations in Standard Surface Water Samples Taken Near the WIPP Site

Location	Sampling Date	^{238}Pu				$^{239/240}$Pu				^{241}Am			
		[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	Q[(d)]	[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	Q[(d)]	[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	Q[(d)]
RED	4/30/2015	-6.55E-05	2.22E-04	1.11E-03	UJ[(e)]	7.19E-04	8.01E-04	1.03E-03	UJ[(e)]	7.57E-04	8.53E-04	1.33E-03	U
NOY	5/28/2015	-1.63E-04	3.19E-04	1.27E-03	UJ	-1.25E-04	2.79E-04	1.08E-03	UJ	4.38E-04	6.07E-04	1.28E-03	U
Coy[(f)]	5/28/2015	-4.80E-04	5.43E-04	1.65E-03	UJ	7.99E-05	5.86E-04	1.22E-03	UJ	1.19E-03	1.10E-03	1.49E-03	U
HIL	4/27/2015	1.82E-04	6.69E-04	1.24E-03	U	3.03E-04	5.97E-04	1.07E-03	U	6.75E-04	1.04E-03	1.80E-03	U
HIL Dup	4/27/2015	-6.87E-05	7.06E-04	1.93E-03	U	1.12E-04	8.76E-04	2.07E-03	U	2.67E-04	7.13E-04	1.82E-03	U
TUT	5/28/2015	1.88E-04	5.44E-04	1.10E-03	UJ	5.28E-04	7.04E-04	1.00E-03	UJ	9.42E-04	8.68E-04	1.38E-03	U
PKT	5/5/2015	-2.97E-05	5.97E-04	1.56E-03	UJ	2.82E-04	6.62E-04	1.24E-03	U	9.74E-04	1.04E-03	1.45E-03	U
FWT	6/15/2015	-8.53E-05	2.37E-04	1.18E-03	UJ	1.28E-04	3.74E-04	9.07E-04	UJ	5.33E-04	1.18E-03	1.90E-03	U
COW [(g)]	5/29/2015	-3.04E-04	4.45E-04	1.43E-03	UJ	1.44E-03	1.03E-03	1.05E-03	UJ	1.09E-03	1.11E-03	1.67E-03	U
IDN	4/30/2015	1.78E-04	3.50E-04	9.37E-04	U	8.91E-05	4.28E-04	9.84E-04	U	4.97E-04	1.02E-03	1.71E-03	U
PCN	6/11/2015	0.00E+00	9.35E-04	1.54E-03	UJ	-5.62E-05	5.04E-04	1.21E-03	UJ	1.79E-04	5.91E-04	1.59E-03	U
CBD	6/11/2015	3.52E-04	6.89E-04	1.39E-03	UJ	-1.32E-04	2.98E-04	1.12E-03	UJ	6.59E-04	8.38E-04	1.56E-03	U
BRA	6/11/2015	0.00E+00	5.19E-04	1.25E-03	UJ	6.24E-04	7.92E-04	1.26E-03	UJ	6.82E-04	8.15E-04	1.61E-03	U
UPR	10/26/2015	1.30E-04	4.06E-04	1.14E-03	U	-1.30E-04	3.02E-04	1.09E-03	U	1.59E-04	4.44E-04	1.34E-03	U
UPR dup	10/26/2015	-8.39E-05	2.51E-04	1.10E-03	U	2.24E-04	6.48E-04	9.89E-04	U	4.43E-04	6.14E-04	1.33E-03	U
LST	5/5/2015	-1.89E-04	3.86E-04	1.35E-03	UJ	3.31E-04	6.20E-04	1.18E-03	UJ	3.94E-04	6.74E-04	1.39E-03	U
BHT	5/5/2015	-1.30E-04	3.12E-04	1.11E-03	UJ	4.55E-04	7.32E-04	1.02E-03	UJ	3.23E-04	7.45E-04	1.49E-03	U
SOO[(h)]	10/15/2015	-2.85E-04	5.78E-04	1.89E-03	U	-2.09E-04	4.95E-04	1.63E-03	U	1.14E-03	1.45E-03	2.03E-03	U

Notes:

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

(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) UJ: ^{238}Pu and $^{239/240}$Pu not detected above the reported 2 σ TPU and MDC, but a quality deficiency affected the data making the data more uncertain, i.e., the ^{242}Pu tracer recovery was slightly higher than the 110% recovery objective in the associated RLCS QC sample.

(f) COY = semi-blind field duplicate (NOY).

(g) COW = semi-blind field blank.

(h) SOO = surface water composite consisting of Settling Lagoon 1 and 2, Effluent Lagoon A, B, and C, Polishing Lagoons 1 and 2, and H-19.

The analysis data for the gamma isotopes and ^{90}Sr are presented in Table 4.12. 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 TPU and MDC are required for detection. As shown in Table 4.12, ^{40}K was the only gamma radionuclide detected, and it was only detected in the SOO in 2015. The ID confidence was 0.999 in the SOO (SWL) sample. SOO (SWL) was the only location where ^{40}K was detected in 2015 and 2014; therefore, there were not enough data to perform ANOVA comparisons.

Comparison of the detected ^{40}K concentrations with the 99 percent confidence interval range of the baseline concentration data (7.60E+01 Bq/L) shows that the single 2015 detection ^{40}K concentration of 7.36E+01 Bq/L was just slightly lower than the 99 percent confidence interval range of the baseline concentration (DOE/WIPP–92–037). It is expected that ^{40}K would be detected in a sample primarily consisting of sewage since sewage contains significant potassium from human excretions, and ^{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 NOY, HIL and UPR. The RERs were calculated for all the target radionuclides in the primary and duplicate samples. The RERs for the analysis results are presented in Table 4.13.

The RERs for the radionuclides analyzed in the samples including the detected $^{233/234}$U, ^{235}U, and ^{238}U were less than 2. The analysis results data demonstrate good reproducibility for the combined sampling and radioanalytical procedures.

Surface Water Samples of Opportunity

The data for the surface water SOOs are shown in Table 4.14. The units have been converted to Bq/L so that the units are consistent with the other samples. The data in the table show that none of the three radionuclides were detected in any of the samples. The data for the plutonium isotopes in the second batch of samples were qualified UJ due to a recovery of 111 percent for the ^{242}Pu tracer in the RLCS. There was no activity in the samples and no adverse impact on the quality or usability of the data.

Table 4.12 – 2015 Gamma Radionuclides ^{90}Sr Concentrations in Standard Surface Water Samples Taken Near the WIPP Site

Location	Sampling Date	^{40}K					^{60}Co				
		[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	ID Conf.[(d)]	Q[(e)]	[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	ID Conf.[(d)]	Q[(e)]
RED	4/30/2015	2.85E+00	3.29E+00	4.34E+00	0.000	U	1.13E-01	2.87E-01	3.63E-01	0.000	U
NOY	5/28/2015	4.08E+00	3.31E+00	4.57E+00	0.000	U	-5.27E-02	3.12E-01	3.54E-01	0.000	U
COY[(f)]	5/28/2015	8.86E+00	1.13E+01	1.62E+01	0.000	U	5.11E-01	1.01E+00	1.41E+00	0.000	U
HIL	4/27/2015	4.50E+00	3.45E+00	4.75E+00	0.000	U	8.33E-02	3.34E-01	4.07E-01	0.000	U
HIL Dup	4/27/2015	2.14E+00	6.56E+00	8.44E+00	0.000	U	-9.12E-02	6.83E-01	7.82E-01	0.000	U
TUT	5/28/2015	4.67E+00	3.33E+00	4.69E+00	0.000	U	3.45E-02	3.10E-01	3.68E-01	0.000	U
PKT	5/5/2015	1.07E+01	1.23E+01	1.77E+01	0.000	U	1.98E-01	1.29E+00	1.61E+00	0.000	U
FWT	6/15/2015	3.21E+00	6.24E+00	8.44E+00	0.000	U	3.56E-01	5.35E-01	7.70E-01	0.000	U
COW[(g)]	5/28/2015	2.04E-01	3.47E+00	4.06E+00	0.000	U	3.42E-01	2.75E-01	3.96E-01	0.000	U
IDN	4/30/2015	3.52E+00	5.16E+00	7.51E+00	0.000	U	-1.37E-01	6.67E-01	7.40E-01	0.000	U
PCN	6/11/2015	2.29E+00	3.63E+00	4.60E+00	0.000	U	-1.51E-01	3.42E-01	3.60E-01	0.000	U
CBD	6/11/2015	1.01E+00	3.53E+00	4.24E+00	0.000	U	5.23E-02	3.51E-01	4.17E-01	0.000	U
BRA	6/11/2015	1.88E+00	3.06E+00	3.98E+00	0.000	U	1.45E-02	3.17E-01	3.72E-01	0.000	U
UPR	10/26/2015	6.72E+00	3.27E+00	4.93E+00	0.000	U	1.82E-01	3.42E-01	4.34E-01	0.000	U
UPR Dup	10/26/2015	3.24E+00	3.34E+00	4.46E+00	0.000	U	4.36E-02	3.14E-01	3.71E-01	0.000	U
LST	5/5/2015	1.68E+00	3.56E+00	4.44E+00	0.000	U	-5.39E-02	3.30E-01	3.68E-01	0.000	U
BHT	5/5/2015	4.19E+00	2.91E+00	4.25E+00	0.000	U	1.03E-01	3.06E-01	3.82E-01	0.000	U
SOO[(h)]	10/15/2015	7.36E+01	1.43E+01	8.09E+00	0.999	+	-2.23E-01	8.93E-01	9.64E-01	0.000	U

Location	Sampling Date	^{137}Cs					^{90}Sr			
		[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	ID Conf.[(d)]	Q[(e)]	[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	Q[(e)]
RED	4/30/2015	-6.75E-02	3.15E-01	3.45E-01	0.000	U	-2.88E-03	1.50E-02	1.70E-02	U
NOY	5/28/2015	1.23E-02	3.45E-01	3.92E-01	0.000	U	6.41E-03	1.51E-02	1.70E-02	U
COY[(f)]	5/28/2015	-6.27E-01	1.15E+00	1.25E+00	0.000	U	5.33E-03	1.48E-02	1.70E-02	U
HIL	4/27/2015	-3.62E-01	3.81E-01	3.66E-01	0.000	U	-1.17E-02	1.79E-02	1.71E-02	U
HIL Dup	4/27/2015	-2.44E-01	5.37E-01	5.50E-01	0.000	U	5.79E-03	1.78E-02	1.71E-02	U
TUT	5/28/2015	-3.76E-02	3.21E-01	3.56E-01	0.000	U	3.69E-03	1.68E-02	1.72E-02	U
PKT	5/5/2015	8.53E-02	9.93E-01	1.23E+00	0.000	U	-4.68E-03	1.50E-02	1.70E-02	U
FWT	6/15/2015	-1.98E-01	6.54E-01	7.05E-01	0.000	U	1.33E-02	1.68E-02	1.38E-02	U
COW[(g)]	5/29/2015	3.52E-02	2.62E-01	3.20E-01	0.000	U	8.45E-03	1.51E-02	1.71E-02	U
IDN	4/30/2015	3.28E-01	5.35E-01	6.86E-01	0.000	U	-2.24E-03	1.76E-02	1.71E-02	U
PCN	6/11/2015	1.54E-01	2.71E-01	3.48E-01	0.000	U	6.99E-03	1.72E-02	1.38E-02	U
CBD	6/11/2015	7.93E-02	3.08E-01	3.62E-01	0.000	U	-2.67E-04	1.69E-02	1.38E-02	U
BRA	6/11/2015	9.81E-02	2.71E-01	3.39E-01	0.000	U	1.20E-02	2.29E-02	1.44E-02	U
UPR	10/26/2015	4.63E-01	2.93E-01	3.94E-01	0.000	U	-1.94E-03	1.89E-02	1.26E-02	U
UPR Dup	10/26/2015	3.43E-01	3.45E-01	4.24E-01	0.000	U	-1.41E-02	2.13E-02	1.29E-02	U
LST	5/5/2015	6.56E-02	2.54E-01	3.15E-01	0.000	U	-1.73E-03	1.54E-02	1.70E-02	U
BHT	5/5/2015	1.27E-01	2.85E-01	3.41E-01	0.000	U	4.26E-03	1.52E-02	1.70E-02	U
SOO[(h)]	10/15/2015	3.04E-01	7.74E-01	8.89E-01	0.000	U	-9.99E-04	1.83E-02	1.25E-02	U

Notes:

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

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Identification confidence for gamma radionuclides. Value >0.90 implies detection.

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

(f) COY = semi-blind field duplicate (NOY).

(g) COW = semi-blind field blank.

(h) SOO = surface water composite consisting of Settling Lagoon 1 and 2, Effluent Lagoon A, B, and C, Polishing Lagoons 1 and 2, and H-19.

Table 4.13 – 2015 Precision Results for Duplicate Surface Water Samples

Location	Radionuclide	Primary Sample		Duplicate Sample			
		[RN][(a)]	1 σ TPU[(b)]	[RN][(a)]	1 σ TPU[(b)]	RER[(c)]	Q[(d)]
NOY and COY (NOY Dup)	$^{233/234}U$	6.55E-03	1.21E-03	8.04E-03	1.36E-03	0.819	+
	^{235}U	2.11E-04	2.36E-04	-3.24E-05	8.58E-05	-0.969	U
	^{238}U	3.43E-03	8.45E-04	3.23E-03	8.20E-04	0.170	+
	^{238}Pu	-1.63E-04	1.63E-04	-4.80E-04	2.77E-04	0.9863	UJ
	$^{239/240}Pu$	-1.25E-04	1.42E-04	7.99E-05	2.99E-04	-0.619	UJ
	^{241}Am	4.38E-04	3.10E-04	1.19E-03	5.63E-04	-1.170	U
	^{40}K	4.08E+00	1.69E+00	8.86E+00	5.77E+00	-0.795	U
	^{60}Co	-5.27E-02	1.59E-01	5.11E-01	5.15E-01	-1.046	U
	^{137}Cs	1.23E-02	1.76E-01	-6.27E-01	5.87E-01	-1.043	U
	^{90}Sr	6.41E-03	7.70E-03	5.33E-03	7.54E-03	-0.100	U
HIL and HIL Dup	$^{233/234}U$	1.18E-02	1.83E-03	1.23E-02	1.88E-03	0.191	+
	^{235}U	5.05E-04	3.60E-04	7.49E-04	5.61E-04	0.366	U
	^{238}U	9.38E-03	1.60E-03	8.20E-03	1.46E-03	0.545	+
	^{238}Pu	1.82E-04	3.41E-04	-6.87E-05	3.60E-04	0.506	U
	$^{239/240}Pu$	3.03E-04	3.04E-04	1.12E-04	4.47E-04	0.353	U
	^{241}Am	6.75E-04	5.33E-04	2.67E-04	3.64E-04	0.632	U
	^{40}K	4.50E+00	1.76E+00	2.14E+00	1.70E+00	0.929	U
	^{60}Co	8.33E-02	1.70E-01	-9.12E-02	3.48E-01	0.451	U
	^{137}Cs	-3.62E-01	1.94E-01	-2.44E-01	2.74E-01	0.351	U
	^{90}Sr	-1.17E-02	9.14E-03	5.79E-03	9.07E-03	1.358	U
UPR and UPR Dup	$^{233/234}U$	7.30E-02	6.88E-03	7.33E-02	7.02E-03	0.031	+
	^{235}U	1.59E-03	6.81E-04	1.90E-03	7.36E-04	0.309	+
	^{238}U	4.83E-02	4.89E-03	4.66E-02	4.82E-03	0.248	+
	^{238}Pu	1.30E-04	2.07E-04	-8.39E-05	1.28E-04	0.879	U
	$^{239/240}Pu$	-1.30E-04	1.54E-04	2.24E-04	3.31E-04	0.970	U
	^{241}Am	1.59E-04	2.27E-04	4.43E-04	3.13E-04	0.735	U
	^{40}K	6.72E+00	1.67E+00	3.24E+00	1.70E+00	1.460	U
	^{60}Co	1.82E-01	1.74E-01	4.36E-02	1.60E-01	0.585	U
	^{137}Cs	4.63E-01	1.49E-01	3.43E-01	1.76E-01	0.520	U
	^{90}Sr	-1.94E-03	9.46E-03	-1.41E-02	1.09E-02	0.843	U

Notes:

See Chapter 6 for sampling location codes. Units are in Bq/L.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Relative error ratio.

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

Table 4.14 – Radionuclide Concentrations in Surface Water Samples of Opportunity

Sample Location	Sample 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]
		^{238}Pu				$^{239/240}$Pu				^{241}Am			
Building 455	1/14/15	5.91E-05	3.25E-04	7.41E-04	U	-9.32E-05	2.18E-04	7.50E-04	U	6.17E-04	1.24E-03	2.24E-03	U
Building 455 Dup	1/14/15	-2.20E-04	3.27E-04	9.58E-04	U	-7.58E-05	1.92E-04	7.82E-04	U	-1.02E-04	7.00E-04	1.63E-03	U
Building 453	1/14/15	6.04E-05	2.66E-04	6.41E-04	U	7.00E-05	2.58E-04	6.15E-04	U	-7.91E-05	1.38E-03	1.98E-03	U
Building 459	1/14/15	-8.13E-05	4.41E-04	9.78E-04	U	-5.14E-05	1.66E-04	7.17E-04	U	-1.02E-04	3.34E-04	1.84E-03	U
Field Blank	1/14/15	-9.30E-05	2.23E-04	7.63E-04	U	-1.30E-04	2.64E-04	8.95E-04	U	6.42E-04	1.26E-03	2.52E-03	U
Building 451	1/31/15	-2.13E-04	2.89E-04	4.99E-04	UJ[e]	5.88E-05	2.39E-04	4.65E-04	UJ[e]	5.74E-04	6.01E-04	8.55E-04	U
Building 451 Dup	1/31/15	4.07E-05	7.50E-04	5.55E-04	UJ	-6.62E-06	3.45E-04	5.22E-04	UJ	1.30E-04	4.34E-04	1.16E-03	U
Building 481	1/31/15	-3.66E-04	5.24E-04	5.43E-04	UJ	-8.49E-05	1.97E-04	5.10E-04	UJ	1.10E-04	6.98E-04	1.62E-03	U
Building 246	1/31/15	-8.55E-05	1.90E-04	7.33E-04	UJ	-5.91E-05	3.41E-04	4.84E-04	UJ	1.82E-04	1.60E-03	1.81E-03	U
Building 971	1/31/15	5.51E-05	2.65E-04	5.20E-04	UJ	3.12E-05	2.83E-04	4.87E-04	UJ	5.80E-04	7.62E-04	1.23E-03	U
Field Blank	1/31/15	-5.73E-05	1.59E-04	5.32E-04	UJ	8.76E-05	2.49E-04	4.99E-04	UJ	6.72E-04	6.59E-04	9.60E-04	U

Notes:

See Chapter 6 for sampling location codes. Units are in Bq/L.

(a) Radionuclide activity.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

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

(e) UJ: ^{238}Pu and $^{239/240}$Pu not detected above the reported 2 σ TPU and MDC, but a quality deficiency affected the data making the data more uncertain, i.e., the ^{242}Pu tracer recovery was slightly higher than the 110% recovery objective in the associated RLCS QC sample.

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 two sites (NOY and UPR) for 14 samples total. See Figure 4.3 for sediment sample locations and Appendix C for location codes. The sites included all the same sites as for 2015 surface water, except for locations FWT and SOO. 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. No sediment SOO samples were collected.

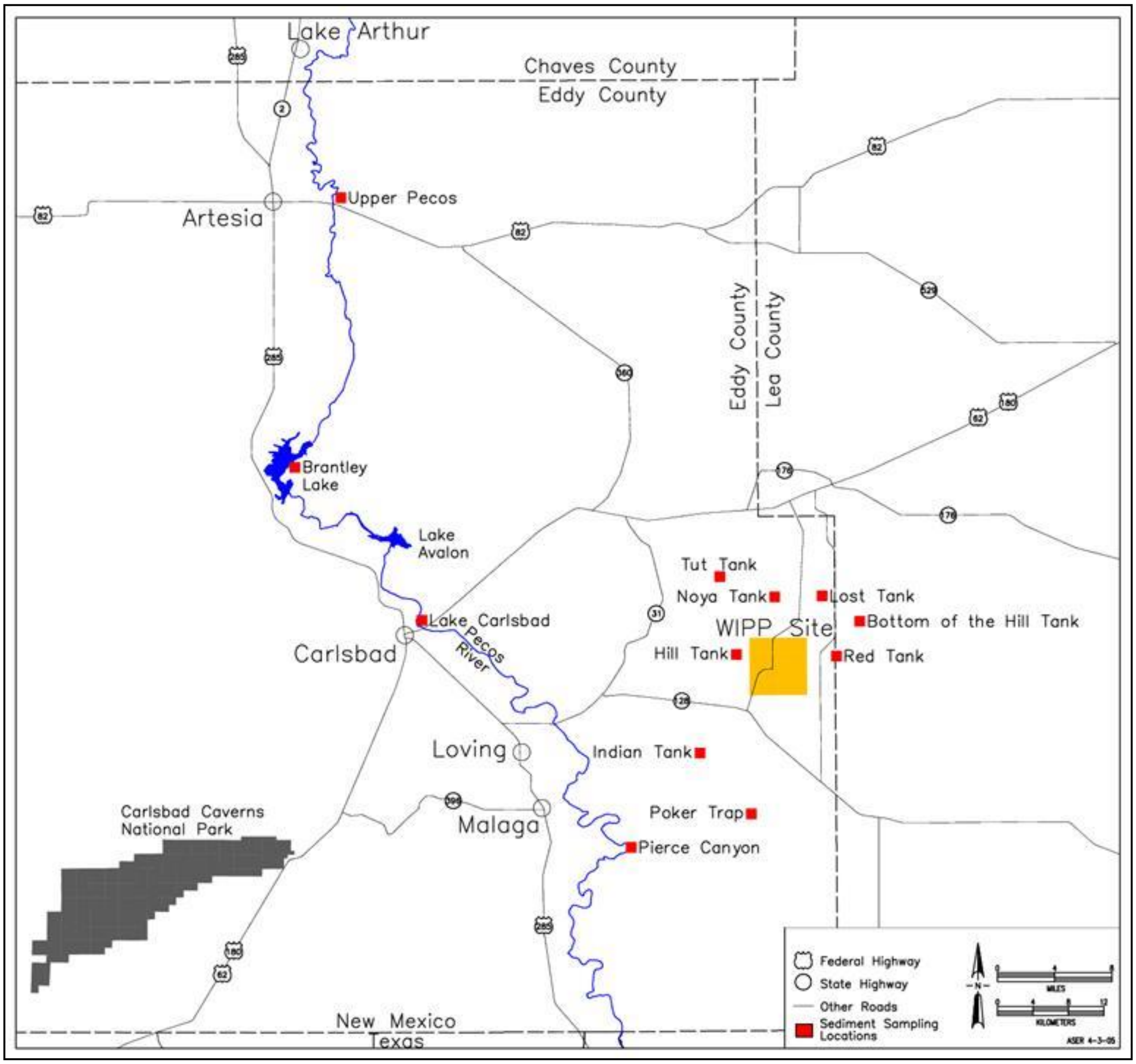


Figure 4.3 – Sediment Sampling Sites

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 carriers (strontium nitrate and barium 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 4.15 presents the results of the uranium isotope analyses in the sediment samples. U-233/234 and ^{238}U were detected in all the sediment samples. U-235 was detected in seven of the sediment samples including the NOY duplicate (but not the primary sample), HIL, PKT, BRA, the UPR duplicates, LST, and BHT.

Using ANOVA, the concentrations of the uranium isotopes were compared between 2015 and 2014 and between sampling locations. Average concentrations were used for NOY and UPR in 2015 and HIL and CBD in 2014 except for ^{235}U, which was only detected in the duplicate NOY sample. There were 12 common locations for $^{233/234}U$ and ^{238}U (all samples) in 2015 and 2014 and seven common locations for ^{235}U.The ANOVA calculations by year showed relatively weak p values for $^{233/234}U$ and ^{238}U just above the 0.05 significance value at 0.181 and 0.114, respectively. The *p* value for ^{235}U was higher at 0.503 but was based on fewer sample locations. The uranium isotope concentrations were higher in 2014 than 2015 except for TUT, BRA, UPR, and LST (4 out of 12 locations) resulting in the lower *p* values in 2015 compared to recent years. The 2015 concentrations may have been lowered due to dilution in the sediments from increased rainfall.

The ANOVA calculations showed that the concentrations of the three uranium isotopes did not vary significantly between sediment locations (ANOVA $^{233/234}U$, $p = 0.633$; ANOVA ^{235}U, $p = 0.510$; and ANOVA ^{238}U, $p = 0.602$). Thus the individual uranium isotope concentrations were not significantly different from each other at the various locations.

After several dry years, 2014 and 2015 were wetter than previous years, which likely affected the distribution of the uranium isotopes in the sediments.

Table 4.15 – 2015 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	6/12/2015	1.81E-02	3.69E-03	9.90E-04	+	3.82E-04	3.23E-04	5.21E-04	U	1.63E-02	3.37E-03	6.14E-04	+
NOY	5/28/2015	1.33E-02	2.85E-03	9.40E-04	+	2.70E-04	2.69E-04	4.96E-04	U	1.41E-02	2.99E-03	6.39E-04	+
NOY Dup	5/28/2015	1.20E-02	2.50E-03	9.30E-04	+	1.07E-03	5.68E-04	5.41E-04	+	1.53E-02	3.05E-03	6.09E-04	+
HIL	6/15/2015	1.32E-02	2.51E-03	9.72E-04	+	7.23E-04	4.29E-04	5.14E-04	+	1.53E-02	2.82E-03	5.79E-04	+
TUT	5/28/2015	1.99E-02	3.96E-03	9.89E-04	+	4.76E-04	3.62E-04	4.98E-04	U	1.98E-02	3.95E-03	6.21E-04	+
PKT	6/12/2015	2.49E-02	5.59E-03	1.03E-03	+	1.02E-03	6.05E-04	5.70E-04	+	2.24E-02	5.09E-03	6.25E-04	+
IDN	6/8/2015	1.98E-02	4.70E-03	1.04E-03	+	5.14E-04	4.29E-04	6.09E-04	U	1.96E-02	4.65E-03	6.24E-04	+
PCN	6/11/2015	1.60E-02	3.33E-03	1.01E-03	+	2.40E-04	2.92E-04	5.64E-04	U	1.34E-02	2.87E-03	6.00E-04	+
CBD	6/11/2015	1.54E-02	2.99E-03	9.82E-04	+	4.41E-04	3.34E-04	5.07E-04	U	1.48E-02	2.90E-03	5.82E-04	+
BRA	6/11/2015	2.82E-02	6.23E-03	1.06E-03	+	1.16E-03	6.53E-04	5.91E-04	+	2.74E-02	6.05E-03	6.62E-04	+
UPR	6/11/2015	2.28E-02	4.17E-03	9.83E-04	+	5.39E-04	3.77E-04	5.18E-04	+	2.21E-02	4.06E-03	5.88E-04	+
UPR Dup	6/11/2015	1.76E-02	3.38E-03	9.85E-04	+	6.82E-04	4.29E-04	5.19E-04	+	1.60E-02	3.12E-03	5.95E-04	+
LST	5/28/2015	1.36E-02	3.10E-03	9.46E-04	+	7.27E-04	4.71E-04	5.11E-04	+	1.36E-02	3.11E-03	6.21E-04	+
BHT	5/28/2015	2.37E-02	4.58E-03	9.37E-04	+	7.48E-04	4.77E-04	5.72E-04	+	2.24E-02	4.35E-03	6.16E-04	+

Notes:

See Appendix C for sampling location codes. Units are in becquerels per gram (Bq/g), dry weight. NOY and UPR used for field duplicates.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

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

The concentrations of all three uranium isotopes fell within the 99 percent confidence interval ranges of the baseline data ($^{233/234}$U: 1.10E–01 Bq/g; ^{235}U: 3.20E–03 Bq/g; ^{238}U: 5.00E–02 Bq/g).

Sediment samples were also analyzed for ^{238}Pu, $^{239/240}$Pu, and ^{241}Am, by alpha spectroscopy; the results are shown in Table 4.16. There were no detections of any of the three radionuclides in 2015, and no ANOVA calculations could be performed.

The sediment analysis results for the gamma radionuclides and ^{90}Sr are shown in Table 4.17. The gamma radionuclide ^{40}K was detected in all the sediment samples and ^{137}Cs was detected in RED, the NOY duplicate, HIL, TUT, PKT, IDN, and BHT. Cesium-137 was detected in seven locations in 2015 and 10 locations in 2014. Cobalt-60 and ^{90}Sr were not detected in any of the sediment samples.

All of the ^{40}K concentrations in the tanks and tank-like structures were less than the 99 percent confidence interval range of the baseline concentration of 1.20E+00 Bq/g.

The sediment locations associated with the Pecos River and associated bodies of water (PCN, CBD, BRA, and UPR) have a ^{40}K baseline concentration of 4.00E–01 Bq/g. One of the 2015 concentrations exceeded the 99 percent confidence interval range of the baseline concentration (BRA at 7.63E-01 Bq/g). Potassium is ubiquitous throughout the earth's crust, with variable concentrations in rocks, soil, and water, and therefore would be expected to be present at variable concentrations in the sediment samples.

The ANOVA calculations showed that the sediment concentrations of ^{40}K did not vary significantly between years (ANOVA ^{40}K, $p = 0.305$), but it did vary significantly by location (ANOVA ^{40}K, $p = 0.00743$). These p values were similar to the p values calculated between the 2014 and 2013 concentrations.

The ^{40}K ANOVA calculations were also performed differentiating the tank and tank-like structures and the Pecos River and associated bodies of water. The variation by year for tanks and tank-like structures was ANOVA ^{40}K, $p = 0.0299$, showing significant difference in the concentrations between years with all the 2014 concentrations higher than the 2015 concentrations. However, there was no significant variation in the concentrations between locations (ANOVA ^{40}K, $p = 0.340$).

The ^{40}K ANOVA calculations for the Pecos River and associated bodies of water showed a high correlation of the concentrations by year, ANOVA ^{40}K, p = 0.970. The variation by location also showed no significant variation, ANOVA ^{40}K, p = 0.211.

The ANOVA calculations showed that the sediment concentrations of ^{137}Cs did not vary significantly between years (ANOVA ^{137}Cs, $p = 0.945$). The ANOVA calculation by location yielded ANOVA, ^{137}Cs, $p = 0.0554$, very near the significance level of 0.05 indicating some, but not significant, variation in the concentrations by location. There were no detections of ^{137}Cs in the Pecos River and associated bodies of water in 2015, therefore the ANOVA calculations apply only to the tanks and tank-like structures.

Table 4.16 – 2015 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	6/12/2015	4.09E-05	1.99E-04	1.01E-03	UJ[(e)]	1.43E-04	1.93E-04	6.30E-04	UJ[(e)]	3.86E-04	2.99E-04	6.81E-04	U
NOY	5/28/2015	-1.81E-05	6.15E-05	6.08E-04	U	1.45E-04	1.95E-04	5.10E-04	U	1.46E-04	1.90E-04	8.01E-04	U
NOY Dup	5/28/2015	-1.91E-05	1.50E-04	6.39E-04	U	1.53E-05	1.27E-04	4.93E-04	U	3.86E-04	3.27E-04	8.33E-04	U
HIL	6/15/2015	-9.13E-06	4.00E-05	9.95E-04	UJ	5.47E-05	1.50E-04	6.07E-04	UJ	1.86E-04	2.05E-04	6.50E-04	U
TUT	5/28/2015	7.15E-05	2.43E-04	7.36E-04	U	1.59E-04	2.72E-04	6.16E-04	U	2.36E-04	2.39E-04	8.13E-04	U
PKT	6/12/2015	-6.16E-05	1.06E-04	1.01E-03	UJ	2.21E-04	2.51E-04	6.56E-04	UJ	3.07E-04	2.81E-04	6.85E-04	U
IDN	6/8/2015	1.34E-04	3.88E-04	1.08E-03	UJ	3.00E-04	2.97E-04	6.62E-04	UJ	5.21E-04	3.65E-04	6.89E-04	U
PCN	6/11/2015	-2.88E-05	6.91E-05	9.86E-04	UJ	5.75E-05	1.38E-04	6.00E-04	UJ	1.55E-04	2.18E-04	6.68E-04	U
CBD	6/11/2015	-7.24E-05	2.03E-04	9.97E-04	UJ	1.59E-04	1.77E-04	6.01E-04	UJ	7.31E-05	2.26E-04	7.14E-04	U
BRA	6/11/2015	2.77E-04	2.97E-04	1.05E-03	UJ	-8.24E-05	1.42E-04	7.28E-04	UJ	9.50E-05	2.22E-04	7.21E-04	U
UPR	6/11/2015	-4.48E-05	8.78E-05	9.87E-04	UJ	2.24E-05	1.07E-04	6.07E-04	UJ	2.37E-04	2.31E-04	6.49E-04	U
UPR Dup	6/11/2015	-6.99E-05	1.13E-04	1.01E-03	UJ	1.44E-04	2.06E-04	6.40E-04	UJ	1.90E-04	2.01E-04	6.51E-04	U
LST	5/28/2015	3.26E-05	2.47E-04	7.48E-04	U	3.25E-05	2.47E-04	6.56E-04	U	2.01E-04	2.55E-04	8.25E-04	U
BHT	5/28/2015	-5.03E-05	1.03E-04	6.29E-04	U	5.23E-04	3.44E-04	5.23E-04	U	1.50E-05	1.27E-04	8.17E-04	U

Notes:

See Appendix C for sampling location codes. Units are in Bq/g, dry weight. NOY and UPR used for field duplicates.

(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) UJ: ^{238}Pu and $^{239/240}$Pu not detected above the reported 2 σ TPU and MDC, but a quality deficiency affected the data making the data more uncertain, i.e., the ^{242}Pu tracer recovery was slightly higher than the 110% recovery objective in the associated RLCS QC sample.

Table 4.17 – 2015 Gamma Radionuclides and ^{90}Sr Concentrations in Sediment Samples Taken Near the WIPP Site

Location	Date	^{40}K					^{60}Co				
		[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	ID Conf.[(d)]	Q[(e)]	[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	ID Conf.[(d)]	Q[(e)]
RED	6/12/2015	5.47E-01	8.17E-02	1.29E-02	1.000	+	2.67E-04	1.21E-03	1.42E-03	0.000	U
NOY	5/28/2015	7.03E-01	1.03E-01	1.09E-02	0.993	+	1.50E-04	1.11E-03	1.27E-03	0.000	U
NOY Dup	5/28/2015	7.31E-01	1.09E-01	1.54E-02	0.997	+	7.00E-04	1.52E-03	1.91E-03	0.000	U
HIL	6/15/2015	8.56E-01	1.27E-01	1.21E-02	1.000	+	3.74E-05	1.67E-03	2.02E-03	0.000	U
TUT	5/28/2015	8.11E-01	1.23E-01	2.06E-02	0.998	+	6.63E-04	2.04E-03	2.53E-03	0.000	U
PKT	6/12/2015	8.34E-01	1.22E-01	1.47E-02	1.000	+	2.94E-04	1.51E-03	1.74E-03	0.000	U
IDN	6/8/2015	6.35E-01	9.39E-02	1.25E-02	1.000	+	6.11E-04	1.23E-03	1.47E-03	0.000	U
PCN	6/11/2015	2.62E-01	4.19E-02	8.49E-02	1.000	+	-1.80E-04	1.02E-03	1.18E-03	0.000	U
CBD	6/11/2015	2.70E-01	4.10E-02	7.75E-03	1.000	+	-2.43E-04	7.93E-04	8.55E-04	0.000	U
BRA	6/11/2015	7.63E-01	1.12E-01	1.71E-02	0.992	+	-6.38E-04	1.57E-03	1.69E-03	0.000	U
UPR	6/11/2015	3.21E-01	4.81E-02	7.73E-03	1.000	+	3.65E-04	8.62E-04	1.02E-03	0.000	U
UPR Dup	6/11/2015	3.71E-01	5.81E-02	1.21E-02	1.000	+	3.73E-04	1.23E-03	1.54E-03	0.000	U
LST	5/28/2015	5.61E-01	8.86E-02	2.06E-02	0.994	+	4.69E-04	1.90E-03	2.29E-03	0.000	U
BHT	5/28/2015	8.10E-01	1.20E-01	1.61E-02	0.993	+	6.66E-05	1.70E-03	1.96E-03	0.000	U

Location	Date	^{137}Cs [RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	ID Conf.[(d)]	Q[(e)]	^{90}Sr [RN][(a)]	2 σ TPU[b]	MDC[(c)]	Q[(e)]
RED	6/12/2015	4.57E-03	1.23E-03	1.37E-03	1.000	+	8.72E-04	6.95E-03	1.39E-02	U
NOY	5/28/2015	1.42E-03	1.25E-03	1.46E-03	0.000	U	-8.39E-04	6.46E-03	1.65E-02	U
NOY Dup	5/28/2015	2.08E-03	9.85E-04	1.37E-03	1.000	+	-3.50E-04	5.90E-03	1.65E-02	U
HIL	6/15/2015	2.60E-03	1.24E-03	1.75E-03	1.000	+	2.08E-03	7.16E-03	1.40E-02	U
TUT	5/28/2015	5.84E-03	1.80E-03	2.15E-03	1.000	+	2.06E-03	5.29E-03	1.65E-02	U
PKT	6/12/2015	7.38E-03	1.67E-03	1.64E-03	0.999	+	4.78E-04	7.21E-03	1.40E-02	U
IDN	6/8/2015	3.12E-03	1.13E-03	1.48E-03	1.000	+	-1.12E-03	7.68E-03	1.40E-02	U
PCN	6/11/2015	3.44E-04	9.72E-04	1.19E-03	0.000	U	-8.15E-04	6.98E-03	1.39E-02	U
CBD	6/11/2015	7.10E-04	8.15E-04	9.56E-04	0.000	U	1.15E-03	7.21E-03	1.39E-02	U
BRA	6/11/2015	-3.36E-04	1.48E-03	1.71E-03	0.000	U	2.08E-03	7.08E-03	1.39E-02	U
UPR	6/11/2015	6.22E-04	9.75E-04	1.11E-03	0.000	U	1.61E-03	7.07E-03	1.39E-02	U
UPR Dup	6/11/2015	1.42E-04	1.25E-03	1.50E-03	0.000	U	-1.67E-04	7.30E-03	1.39E-02	U
LST	5/28/2015	3.47E-03	2.08E-03	2.60E-03	0.000	U	2.74E-03	5.39E-03	1.64E-02	U
BHT	5/28/2015	8.60E-03	1.18E-03	1.70E-03	0.998	+	-9.47E-04	5.64E-03	1.65E-02	U

Notes:

See Appendix C for sampling location codes. Units are in Bq/g, dry weight. NOY and UPR used for field duplicates.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Identification confidence for gamma radionuclides. Value >0.90 implies detection.

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

All 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 4.17), 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 UPR. Precision calculations as RER were performed for all the target radionuclides, as shown in Table 4.18. The qualifier column shows which radionuclides were detected in the samples.

Two RERs in Table 4.18 are greater than 2:

- The RER for ^{235}U in NOY and the NOY duplicate where the ^{235}U was more than a factor of two different in the two samples and detected in the primary sample but was not detected in the duplicate sample, and ^{238}U in UPR and the UPR duplicate where the relatively high concentrations of ^{238}U cause the RER calculation to be more sensitive to differences in the sample concentrations.

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

Table 4.18 – 2015 Precision Results for Duplicate Sediment Samples

Location	Radionuclide	Primary Sample		Duplicate Sample		RER[c]	Q[d]
		[RN][a]	2 σ TPU[b]	[RN][a]	2 σ TPU[b]		
NOY and NOY Dup	$^{233/234}$U	1.33E-02	1.45E-03	1.20E-02	1.28E-03	0.672	+
	^{235}U	2.70E-04	1.37E-04	1.07E-03	2.90E-04	2.494	U/+[e]
	^{238}U	1.41E-02	1.52E-03	1.53E-02	1.56E-03	0.551	+
	^{238}Pu	-1.81E-05	3.14E-05	-1.91E-05	7.67E-05	0.012	U
	$^{239/240}$Pu	1.45E-04	9.92E-05	1.53E-05	6.46E-05	1.096	U
	^{241}Am	1.46E-04	9.69E-05	3.86E-04	1.67E-04	1.243	U
	^{40}K	7.03E-01	5.26E-02	7.31E-01	5.56E-02	0.366	+

Location	Radionuclide	Primary Sample		Duplicate Sample		RER[c]	Q[d]
		[RN][a]	2 σ TPU[b]	[RN][a]	2 σ TPU[b]		
	^{60}Co	1.50E-04	5.66E-04	7.00E-04	7.76E-04	0.573	U
	^{137}Cs	1.42E-03	6.38E-04	2.08E-03	5.03E-04	0.812	U/+[f]
	^{90}Sr	-8.39E-04	3.29E-03	-3.50E-04	3.01E-03	0.110	U
UPR and UPR Dup	$^{233/234}$U	2.28E-02	2.13E-03	1.76E-02	1.72E-03	1.899	+
	^{235}U	5.39E-04	1.92E-04	6.82E-04	2.19E-04	0.491	+
	^{238}U	2.21E-02	2.07E-03	1.60E-02	1.59E-03	2.337	+
	^{238}Pu	-4.48E-05	4.48E-05	-6.99E-05	5.75E-05	0.344	UJ[g]
	$^{239/240}$Pu	2.24E-05	5.48E-05	1.44E-04	1.05E-04	1.027	UJ[g]
	^{241}Am	2.37E-04	1.18E-04	1.90E-04	1.02E-04	0.301	U
	^{40}K	3.21E-01	2.45E-02	3.71E-01	2.96E-02	1.301	+
	^{60}Co	3.65E-04	4.40E-04	3.73E-04	6.28E-04	0.010	U
	^{137}Cs	6.22E-04	4.97E-04	1.42E-04	6.38E-04	0.594	+
	^{90}Sr	1.61E-03	3.61E-03	-1.67E-04	3.73E-03	0.342	U

Notes:

See Chapter 6 for sampling location codes. Units are in Bq/g, dry weight. NOY and UPR used for field duplicates.

(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) ^{235}U detected in the duplicate sample but not the primary sample.

(f) ^{137}Cs detected in the duplicate sample but not the primary sample.

(g) UJ: ^{238}Pu and $^{239/240}$Pu not detected above the reported 2 σ TPU and MDC, but a quality deficiency affected the data making the data more uncertain, i.e., the ^{242}Pu tracer recovery was slightly higher than the 110% recovery objective.

4.6 Soil Samples

4.6.1 Sample Collection

Regular soil samples were collected from the 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.

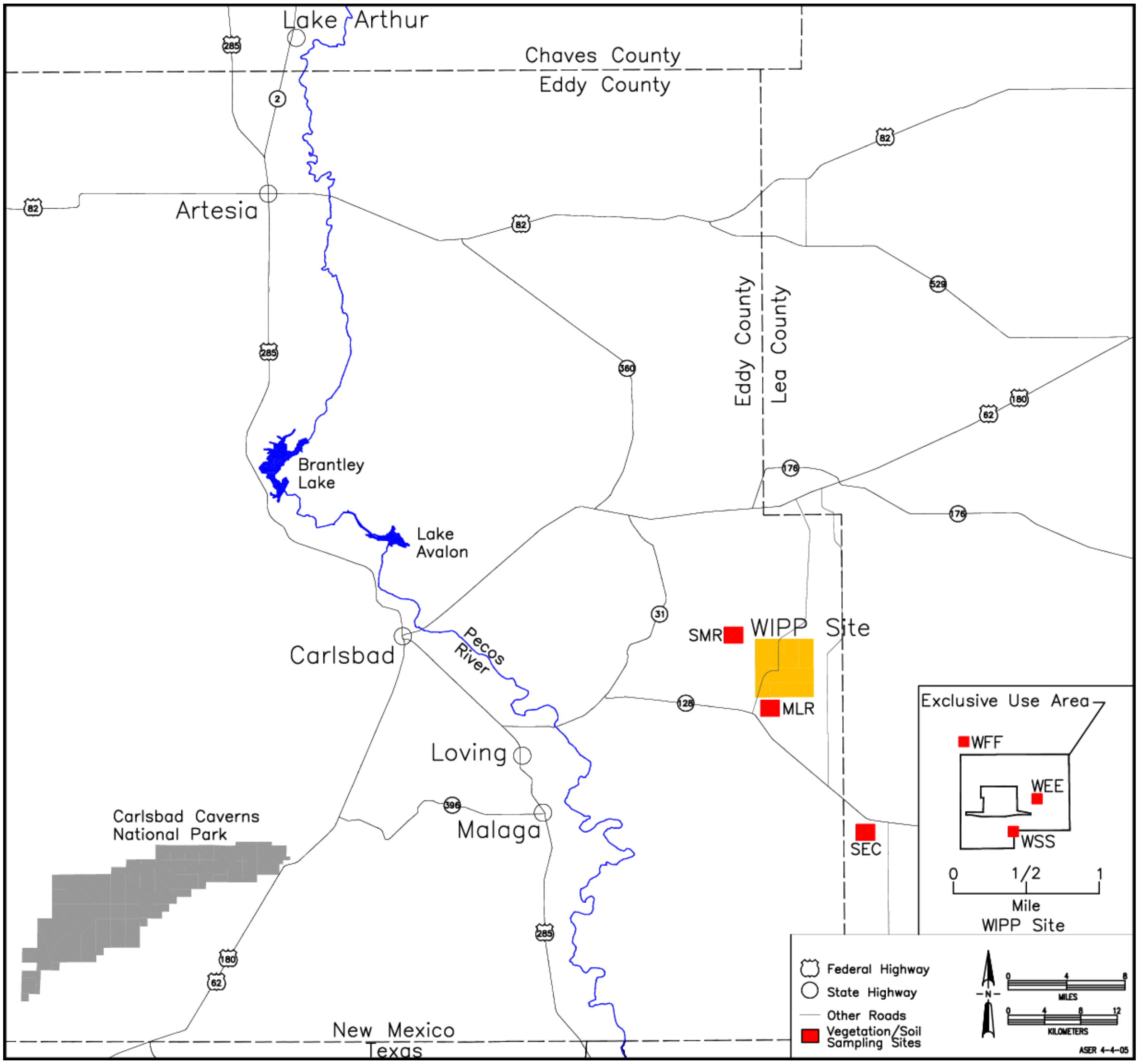


Figure 4.4 – Routine Soil and Vegetation Sampling Areas

Soil sample locations are divided into three geographic groups.

- The WIPP site group covers the smallest area with locations within 1 km of the WHB and exhaust shaft and includes WFF, WEE, and WSS.
- The 5-mile ring includes MLR and SMR.
- The outer sites group, including SEC, represents a variety of habitats, soil types and land uses and ranges from Artesia and Loving on the west to Hobbs and Jal on the east and includes the Gnome site, a potash mine, and an oil and gas production area covering a total area of 10,000 km^2.

Soil samples were collected at location WFF on February 12, 2015, at WEE and WSS (duplicates) on February 16, 2015, and at MLR, SEC, and SMR on March 9, 2015.

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 carriers (strontium nitrate and barium 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 4.19 presents the uranium isotope analysis data for the 2015 soil samples including a set of duplicate samples collected at WSS. As shown in the table, $^{233/234}$U and ^{238}U were detected in all soil samples, and ^{235}U was detected in 12 out of 21 soil samples. When detected, the ^{235}U concentration was relatively low compared to $^{233/234}$U and ^{238}U concentrations. U-235 was detected in the duplicate WSS sample from the 2 - 5 cm depth but not in the primary sample.

In comparing the 2015 and 2014 uranium data, the average of the primary and duplicate samples was used for WSS in 2015, and the WFF and SEC in 2014. All locations and all depths were common for $^{233/234}$U and ^{238}U in 2015 and 2014. 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 (WSS, 2–5 cm in 2015; WFF, 2–5 cm in 2014, SEC, 0–2 cm in 2014, and SEC, 5–10 cm in 2014). The detected concentrations were used for the ANOVA calculations.

Using ANOVA, the concentrations of the uranium isotopes were compared between 2015 and 2014 and between sampling locations using all three sample depths in the calculation. Average concentrations were used for WSS in 2015 and WFF and SEC in 2014. There were 18 common locations for $^{233/234}$U and ^{238}U, and 12 of 18 possible common locations for ^{235}U between 2015 and 2014.

Table 4.19 – 2015 Uranium Concentrations in Soil Samples Taken Near the WIPP Site

Location	Depth (cm)	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]
			$^{233/234}U$				^{235}U				^{238}U			
WFF	0 - 2	2/12/2015	5.07E-03	1.08E-03	6.85E-04	+	2.36E-04	1.99E-04	2.75E-04	U	5.12E-03	1.09E-03	6.12E-04	+
WFF	2 - 5	2/12/2015	5.80E-03	1.36E-03	6.98E-04	+	4.64E-04	2.98E-04	3.29E-04	+	5.35E-03	1.27E-03	6.24E-04	+
WFF	5 - 10	2/12/2015	5.60E-03	1.25E-03	6.89E-04	+	3.31E-04	2.39E-04	2.82E-04	+	6.29E-03	1.37E-03	6.17E-04	+
WEE	0 - 2	2/16/2015	5.62E-03	1.24E-03	6.29E-04	+	3.08E-04	2.40E-04	2.81E-04	+	6.04E-03	1.31E-03	6.14E-04	+
WEE	2 - 5	2/16/2015	7.31E-03	1.55E-03	6.31E-04	+	1.67E-04	1.99E-04	3.03E-04	U	6.91E-03	1.48E-03	6.24E-04	+
WEE	5 - 10	2/16/2015	7.91E-03	1.88E-03	6.45E-04	+	3.32E-04	2.82E-04	3.10E-04	+	7.88E-03	1.87E-03	6.33E-04	+
WSS	0 - 2	2/16/2015	7.87E-03	1.80E-03	6.38E-04	+	3.32E-04	2.72E-04	3.35E-04	U	7.13E-03	1.65E-03	6.25E-04	+
WSS	2 - 5	2/16/2015	6.22E-03	1.40E-03	6.40E-04	+	9.73E-05	1.62E-04	3.11E-04	U	6.96E-03	1.53E-03	6.29E-04	+
WSS	5 - 10	2/16/2015	7.30E-03	1.66E-03	7.07E-04	+	1.67E-04	2.66E-04	3.59E-04	U	7.76E-03	1.74E-03	6.51E-04	+
WSS Dup	0 - 2	2/16/2015	7.12E-03	1.72E-03	6.50E-04	+	1.04E-04	1.80E-04	3.12E-04	U	6.44E-03	1.59E-03	6.35E-04	+
WSS Dup	2 - 5	2/16/2015	7.00E-03	1.70E-03	6.48E-04	+	4.74E-04	3.27E-04	3.23E-04	+	6.86E-03	1.67E-03	6.40E-04	+
WSS Dup	5 - 10	2/16/2015	6.20E-03	1.64E-03	7.01E-04	+	2.12E-04	2.48E-04	3.42E-04	U	7.36E-03	1.88E-03	6.52E-04	+
MLR	0 - 2	3/9/2015	1.21E-02	2.38E-03	6.85E-04	+	5.36E-04	3.16E-04	3.33E-04	+	1.17E-02	2.31E-03	6.69E-04	+
MLR	2 - 5	3/9/2015	1.22E-02	2.78E-03	6.90E-04	+	2.43E-04	2.40E-04	3.55E-04	U	1.27E-02	2.88E-03	6.85E-04	+
MLR	5 - 10	3/9/2015	1.20E-02	2.36E-03	9.14E-04	+	6.06E-04	3.25E-04	3.59E-04	+	1.23E-02	2.42E-03	6.40E-04	+
SEC	0 - 2	3/9/2015	1.04E-02	2.92E-03	7.05E-04	+	6.43E-04	4.17E-04	3.65E-04	+	1.01E-02	2.85E-03	7.04E-04	+
SEC	2 - 5	3/9/2015	9.05E-03	2.29E-03	6.91E-04	+	7.53E-04	4.21E-04	3.46E-04	+	1.10E-02	2.70E-03	6.79E-04	+
SEC	5 - 10	3/9/2015	1.10E-02	2.63E-03	6.91E-04	+	5.97E-04	3.70E-04	3.49E-04	+	1.15E-02	2.73E-03	6.80E-04	+
SMR	0 - 2	3/9/2015	1.56E-02	3.13E-03	6.68E-04	+	8.71E-04	4.09E-04	3.34E-04	+	1.71E-02	3.38E-03	6.56E-04	+
SMR	2 - 5	3/9/2015	1.67E-02	3.77E-03	6.87E-04	+	7.79E-04	4.19E-04	3.40E-04	+	1.66E-02	3.74E-03	6.75E-04	+
SMR	5 - 10	3/9/2015	1.52E-02	3.01E-03	6.64E-04	+	8.49E-04	3.94E-04	3.11E-04	+	1.66E-02	3.26E-03	6.64E-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.

The ANOVA calculations showed that the concentrations of $^{233/234}U$, ^{235}U, and ^{238}U did not vary significantly between 2014 and 2013 (ANOVA $^{233/234}U$, $p = 0.639$; ANOVA ^{235}U, $p = 0.134$; and ANOVA ^{238}U, $p = 0.665$).

As in 2013 and 2014, the 2015 ANOVA calculations showed significant variation by location (ANOVA $^{233/234}U$, p = 1.22E-09; ANOVA ^{235}U, p = 0.0135; and ANOVA ^{238}U, p = 9.074E-11).

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 five-mile ring sites include SMR and MLR; and the outer sites include SEC.

The highest concentrations of $^{233/234}U$ measured in 2015 was 1.67E-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 of 8.71E-04 Bq/g at the 0 – 2 cm depth at location SMR was lower than the 99 percent confidence interval concentration of 1.70E–03 Bq/g for SMR and MLR. The highest ^{238}U concentration of 1.71E-02 Bq/g in the 0 - 2 cm depth sample from SMR was higher than the 99 percent confidence interval range of the baseline concentration for ^{238}U of 1.30E–02 Bq/g for SMR and MLR (DOE/WIPP–92–037). The concentration of 1.66E-02 Bq/g at both the 2 - 5 cm depth and 5 – 10 cm depths at SMR were also higher than the 99 percent confidence interval range of the baseline concentration.

None of the 2015 uranium isotope concentrations were higher than the 99 percent confidence interval concentrations for three WIPP Site locations (8.60E-03 Bq/g for $^{233/234}U$; 9.50E-04 Bq/g for ^{235}U; and 1.10E-02 Bq/g for ^{238}U.). Likewise, none of the measured uranium isotope concentrations were higher than the 99 percent confidence interval concentration for the SEC outer site (3.70E-02 Bq/g for $^{233/234}U$; 3.70E-03 Bq/g for ^{235}U; and 3.20E-02 Bq/g for ^{238}U.)

Table 4.20 presents the analysis data for ^{238}Pu, $^{239/240}Pu$, and ^{241}Am. The ^{241}Am data for one batch of samples (WSS and WSS duplicates) was qualified "UJ" due to a slightly high recovery for the ^{243}Am tracer in the RLCS QC sample analyzed with the batch. There were no detections of any of the three radionuclides in 2015 although $^{239/240}Pu$ had been detected in the sample at the 0–2 cm depth from MLR in both 2013 and 2014. Thus No ANOVA calculations could be performed.

Table 4.21 presents the 2015 soil sample analysis data for the gamma radionuclides and ^{90}Sr. The sample data in Table 4.21 show that ^{40}K and ^{137}Cs were detected in all the samples except for the 0–2 cm depth of SEC where neither radionuclide was detected. Neither ^{60}Co nor ^{90}Sr were detected in any of the samples.

Table 4.20 – 2015 Plutonium Isotope and Americium Concentrations in Soil Samples Taken Near the WIPP Site

Location	Depth (cm)	Sampling Date	^{238}Pu				$^{239/240}$Pu				^{241}Am			
			[RN][(a)]	2 ×TPU[(b)]	MDC[(c)]	Q[(d)]	[RN][(a)]	2 × TPU[(b)]	MDC[(c)]	Q[(d)]	[RN][(a)]	2 × TPU[(b)]	MDC[(c)]	Q[(d)]
WFF	0 - 2	2/12/2015	-5.53E-06	8.67E-05	3.05E-04	U	4.90E-05	9.02E-05	2.69E-04	U	2.63E-05	1.15E-04	8.08E-04	U
WFF	2 - 5	2/12/2015	1.49E-05	1.28E-04	3.10E-04	U	7.48E-05	1.32E-04	3.21E-04	U	-4.29E-05	6.77E-05	8.13E-04	U
WFF	5 - 10	2/12/2015	-3.55E-05	1.45E-04	3.22E-04	U	8.33E-05	1.19E-04	2.78E-04	U	6.67E-06	1.14E-04	8.23E-04	U
WEE	0 - 2	2/16/2015	-7.13E-05	1.82E-04	3.62E-04	U	3.53E-05	1.10E-04	2.75E-04	U	-3.28E-05	1.25E-04	8.03E-04	U
WEE	2 - 5	2/16/2015	1.47E-05	1.15E-04	2.80E-04	U	1.32E-05	1.30E-04	3.02E-04	U	9.01E-05	1.81E-04	8.16E-04	U
WEE	5 - 10	2/16/2015	-4.61E-06	9.32E-05	2.71E-04	U	1.31E-04	1.45E-04	2.63E-04	U	6.08E-05	1.56E-04	8.10E-04	U
WSS	0 - 2	2/16/2015	-3.12E-05	8.12E-05	2.87E-04	U	-3.12E-05	3.92E-05	2.74E-04	U	-4.28E-06	1.32E-04	8.02E-04	UJ[(e)]
WSS	2 - 5	2/16/2015	-7.20E-05	1.58E-04	2.93E-04	U	4.24E-05	1.04E-04	2.68E-04	U	3.25E-06	1.32E-04	8.03E-04	UJ
WSS	5 - 10	2/16/2015	-4.95E-05	1.04E-04	2.96E-04	U	7.59E-05	1.18E-04	2.72E-04	U	-1.73E-06	1.38E-04	8.11E-04	UJ
WSS Dup	0 - 2	2/16/2015	3.37E-05	1.48E-04	2.76E-04	U	7.89E-05	1.45E-04	2.93E-04	U	5.67E-05	1.64E-04	8.11E-04	UJ
WSS Dup	2 - 5	2/16/2015	-5.19E-05	1.42E-04	3.01E-04	U	6.42E-05	1.20E-04	2.76E-04	U	5.18E-05	1.48E-04	7.99E-04	UJ
WSS Dup	5 - 10	2/16/2015	2.98E-05	1.47E-04	2.94E-04	U	4.62E-05	1.13E-04	2.80E-04	U	3.00E-06	1.24E-04	7.97E-04	UJ
MLR	0 - 2	3/9/2015	7.02E-05	1.23E-04	4.10E-04	U	2.13E-04	1.71E-04	4.46E-04	U	1.01E-05	7.78E-05	5.79E-04	U
MLR	2 - 5	3/9/2015	-2.83E-06	8.81E-05	4.21E-04	U	2.20E-04	1.82E-04	4.48E-04	U	1.79E-04	1.53E-04	5.72E-04	U
MLR	5 - 10	3/9/2015	-1.04E-04	1.13E-04	4.65E-04	U	5.05E-05	1.31E-04	4.55E-04	U	8.20E-05	1.04E-04	5.73E-04	U
SEC	0 - 2	3/9/2015	-3.32E-05	6.51E-05	4.10E-04	U	7.19E-05	1.27E-04	4.50E-04	U	6.70E-05	1.10E-04	5.74E-04	U
SEC	2 - 5	3/9/2015	1.19E-04	1.75E-04	4.48E-04	U	2.23E-04	1.87E-04	4.57E-04	U	1.65E-04	1.47E-04	5.76E-04	U
SEC	5 - 10	3/9/2015	5.30E-06	8.44E-05	4.07E-04	U	3.97E-05	1.03E-04	4.54E-04	U	8.03E-05	1.01E-04	5.73E-04	U
SMR	0 - 2	3/9/2015	-4.54E-05	1.11E-04	4.25E-04	U	2.14E-04	1.77E-04	4.42E-04	U	7.30E-05	1.27E-04	5.87E-04	U
SMR	2 - 5	3/9/2015	2.25E-06	1.05E-04	3.96E-04	U	3.10E-04	2.01E-04	4.44E-04	U	1.66E-04	1.64E-04	5.83E-04	U
SMR	5 - 10	3/9/2015	-6.20E-05	8.60E-05	4.13E-04	U	5.93E-05	1.23E-04	4.57E-04	U	1.73E-04	1.64E-04	5.75E-04	U

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.

(e) Nuclide not detected above the reported 2 sigma TPU and MDC, but a quality deficiency affected the data, i.e., the ^{241}Am tracer recovery was slightly higher than the 100% recovery objective in the associated RLCS QC sample.

Table 4.21 – 2015 Gamma Radionuclide and ^{90}Sr Concentrations in Soil Samples Taken Near the WIPP Site

Location	Depth (cm)	Sampling Date	[RN][(a)]	2 × TPU[(b)]	MDC[(c)]	ID Conf.	Q[(d)]	[RN][(a)]	2 × TPU[(b)]	MDC[(c)]	ID Conf.	Q[(d)]
			^{40}K					^{60}Co				
WFF	0 - 2	2/12/2015	2.08E-01	3.05E-02	8.04E-03	0.999	+	5.00E-04	6.88E-04	8.64E-04	0.00	U
WFF	2 - 5	2/12/2015	2.09E-01	3.20E-02	9.02E-03	0.999	+	5.26E-04	9.15E-04	1.19E-03	0.00	U
WFF	5 - 10	2/12/2015	2.25E-01	3.51E-02	9.92E-03	0.998	+	5.90E-04	9.86E-04	1.32E-03	0.00	U
WEE	0 - 2	2/16/2015	2.44E-01	3.73E-02	7.28E-03	0.999	+	5.81E-04	6.19E-04	7.98E-04	0.00	U
WEE	2 - 5	2/16/2015	2.53E-01	4.06E-02	9.46E-03	0.999	+	-2.78E-04	1.00E-03	1.14E-03	0.00	U
WEE	5 - 10	2/16/2015	2.34E-01	3.32E-02	6.41E-03	0.995	+	3.98E-04	6.07E-04	7.57E-04	0.00	U
WSS	0 - 2	2/16/2015	2.51E-01	3.78E-03	9.53E-03	1.000	+	3.43E-04	9.65E-04	1.23E-03	0.00	U
WSS	2 - 5	2/16/2015	2.48E-01	3.77E-02	1.05E-02	0.998	+	1.16E-04	1.03E-03	1.27E-03	0.00	U
WSS	5 - 10	2/16/2015	2.51E-01	3.59E-02	8.57E-03	1.000	+	-1.98E-05	7.10E-04	8.11E-04	0.00	U
WSS Dup	0 - 2	2/16/2015	2.53E-01	4.05E-02	1.48E-02	1.000	+	6.78E-04	1.08E-03	1.44E-03	0.00	U
WSS Dup	2 - 5	2/16/2015	2.59E-01	3.72E-02	9.17E-03	0.999	+	1.99E-05	7.89E-04	9.02E-04	0.00	U
WSS Dup	5 - 10	2/16/2015	2.66E-01	4.00E-02	9.02E-03	0.999	+	1.10E-04	9.79E-04	1.22E-03	0.00	U
MLR	0 - 2	3/9/2015	4.05E-01	5.63E-02	8.88E-03	1.000	+	4.63E-04	9.37E-04	1.12E-03	0.00	U
MLR	2 - 5	3/9/2015	4.37E-01	6.04E-02	8.01E-03	0.993	+	-6.34E-04	9.96E-04	1.03E-03	0.00	U
MLR	5 - 10	3/9/2015	3.93E-01	5.46E-02	8.24E-03	1.000	+	3.28E-04	8.21E-04	9.89E-04	0.00	U
SEC	0 - 2	3/9/2015	-5.49E-03	9.75E-03	4.22E-02	0.000	U	3.24E-05	1.24E-03	1.46E-03	0.00	U
SEC	2 - 5	3/9/2015	2.79E-01	4.26E-02	9.15E-03	0.999	+	-5.62E-04	8.75E-04	8.89E-04	0.00	U
SEC	5 - 10	3/9/2015	2.79E-01	4.43E-02	9.42E-03	1.000	+	-2.60E-04	1.13E-03	1.31E-03	0.00	U
SMR	0 - 2	3/9/2015	8.21E-01	1.11E-01	1.07E-02	0.993	+	4.74E-05	1.14E-03	1.30E-03	0.00	U
SMR	2 - 5	3/9/2015	7.91E-01	1.08E-01	1.31E-02	0.999	+	-7.48E-04	1.32E-03	1.38E-03	0.00	U
SMR	5 - 10	3/9/2015	8.28E-01	1.19E-01	2.37E-02	0.990	+	-2.46E-03	2.75E-03	2.66E-03	0.00	U

Location	Depth (cm)	Sampling Date	[RN][a]	2 × TPU[b]	MDC[c]	ID Conf.	Q[d]	[RN][a]	2 × TPU[b]	MDC[c]	Q[d]
			^{137}Cs					^{90}Sr			
WFF	0 - 2	2/12/2015	1.52E-03	5.55E-04	7.23E-04	1.000	+	-1.25E-03	6.50E-03	2.37E-02	U
WFF	2 - 5	2/12/2015	1.55E-03	6.29E-04	8.42E-04	0.997	+	-8.05E-04	6.30E-03	2.38E-02	U
WFF	5 - 10	2/12/2015	1.79E-03	7.41E-04	9.93E-04	0.997	+	-3.26E-04	6.73E-03	2.38E-02	U
WEE	0 - 2	2/16/2015	1.97E-03	5.78E-04	6.47E-04	1.000	+	-7.43E-03	7.74E-03	2.32E-02	U
WEE	2 - 5	2/16/2015	1.88E-03	6.69E-04	8.07E-04	0.997	+	-3.57E-03	7.66E-03	2.32E-02	U
WEE	5 - 10	2/16/2015	1.44E-03	4.73E-04	5.94E-04	0.999	+	-1.50E-03	7.93E-03	2.32E-02	U
WSS	0 - 2	2/16/2015	1.39E-03	6.66E-04	9.39E-04	0.998	+	-1.54E-04	7.56E-03	2.32E-02	U
WSS	2 - 5	2/16/2015	2.13E-03	7.38E-03	9.29E-03	0.999	+	-2.55E-05	7.67E-03	2.32E-02	U
WSS	5 - 10	2/16/2015	1.12E-03	4.74E-04	6.47E-04	0.999	+	5.01E-03	7.80E-03	2.32E-02	U
WSS Dup	0 - 2	2/16/2015	1.97E-03	9.37E-04	1.31E-03	0.998	+	-2.42E-03	7.74E-03	2.32E-02	U
WSS Dup	2 - 5	2/16/2015	1.94E-03	6.17E-04	7.65E-04	1.000	+	-5.18E-03	7.86E-03	2.32E-02	U
WSS Dup	5 - 10	2/16/2015	1.06E-03	6.79E-04	1.02E-03	0.993	+	6.06E-04	7.75E-03	2.32E-02	U
MLR	0 - 2	3/9/2015	6.83E-03	1.25E-03	1.03E-03	1.000	+	-4.36E-03	6.90E-03	2.38E-02	U
MLR	2 - 5	3/9/2015	6.75E-03	1.26E-03	1.09E-03	0.998	+	-6.08E-03	7.58E-03	2.39E-02	U
MLR	5 - 10	3/9/2015	1.03E-03	5.48E-04	7.96E-04	0.999	+	-2.53E-03	6.75E-03	2.38E-02	U
SEC	0 - 2	3/9/2015	-1.27E-03	9.95E-04	1.99E-03	0.000	U	-3.66E-03	6.66E-03	2.38E-02	U
SEC	2 - 5	3/9/2015	4.86E-03	1.08E-03	1.04E-03	1.000	+	5.79E-05	6.62E-03	2.38E-02	U
SEC	5 - 10	3/9/2015	2.04E-03	7.55E-04	9.48E-04	1.000	+	1.41E-03	6.32E-03	2.38E-02	U
SMR	0 - 2	3/9/2015	5.39E-03	1.12E-03	1.10E-03	0.999	+	-1.37E-03	6.85E-03	2.38E-02	U
SMR	2 - 5	3/9/2015	9.01E-03	1.68E-03	1.48E-03	1.000	+	-3.55E-03	6.86E-03	2.38E-02	U
SMR	5 - 10	3/9/2015	8.90E-03	2.35E-03	2.70E-03	0.999	+	-5.01E-03	7.02E-03	2.38E-02	U

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.

There were 17 common locations where ^{40}K was detected between 2015 and 2014 for ANOVA comparisons. The average concentrations were used for the duplicate samples at WSS in 2015 and WFF and SEC in 2014.

There was no significant variation in the ^{40}K concentrations between 2015 and 2014 (ANOVA ^{40}K, p = 0.973). There was significant variation in the concentrations between locations, including the various soil depths (ANOVA ^{40}K, p = 5.69E-16). This variation appears to be due to the fact that 12 of the 17 concentrations were higher in 2015 than 2014. All 18 of the 2014 concentrations were higher than the 2013 concentrations.

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. It is not known why the concentrations would gradually be shifting higher.

The highest ^{40}K concentration of 8.28E-01 Bq/g in 2015 occurred at the 5–10 cm depth at location SMR as it did in 2014. All three depths of samples from MLR and all three depths of samples from SMR yielded concentrations higher than the 99 percent confidence interval range of baseline concentrations of 3.40E–01 Bq/g (DOE/WIPP–92–037). Like the uranium isotopes, ^{40}K has a 99 percent confidence interval range of baseline concentration that varies by location from the WIPP site with values of 2.80E-01 Bq/g for WFF, WEE, and WSS; 3.40E-01 Bq/g for SMR and MLR; and 7.80E-01 Bq/g for SEC. As with the uranium isotopes, the baseline concentrations are higher at greater distances from the WIPP site.

Statistical analyses for ^{137}Cs were performed for 15 common locations. The average concentrations were used for the duplicate samples at WSS in 2015 and WFF and SEC in 2014. The three samples in which ^{137}Cs was not detected were the 5–10 cm depth sample from MLR in 2014, the 5–10 cm depth sample from SMR in 2014, and the 0–2 cm depth sample from SEC in 2015.

The ANOVA calculations showed no significant difference between the concentrations in 2015 and 2014 (ANOVA ^{137}Cs, p = 0.722). However, there was a significant difference in the concentrations between the sampling locations (ANOVA ^{137}Cs, p = 0.0228.

The ^{137}Cs 99 percent confidence interval range of baseline concentrations was determined according to distance from the WIPP site. The values are both 2.40E-02 Bq/g both for the locations near the WIPP site (WFF, WEE, WSS) and within the five-mile ring sites (SMR, MLR), and 4.00E-02 Bq/g for outer site (SEC). As shown in Table 4.21, none of the 2015 ^{137}Cs concentrations were higher than 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 4.21), there were insufficient data to permit any kind of variance analysis between years or among sampling locations.

The duplicate samples from WSS were selected to perform precision calculations for all the target radionuclides. The calculated RERs for the WSS samples at all three depths are presented in Table 4.22. The qualifier column shows whether the radionuclide was detected in the samples.

The 30 RER calculations for soil samples in Table 4.22 show that all RERs were less than 2 except for ^{235}U at the 2 – 5 cm depth where the radionuclide was not detected in the primary sample but was detected in the duplicate sample. The data in Table 4.22 show good precision for the combined field sampling and laboratory analysis procedures and met the objective of >85 percent of the samples with RERs <1.96.

Table 4.22 – Precision Analysis Results for 2015 for Duplicate Sediment Samples

Location	Depth cm	Radionuclide	Primary Sample		Duplicate Sample			
			[RN][(a)]	1 σ TPU[(b)]	[RN][(a)]	1 σ TPU[(b)]	RER[(c)]	Q[(d)]
WSS	0-2	$^{233/234}$U	7.87E-03	9.16E-04	7.12E-03	8.80E-04	0.590	+
WSS	2-5	$^{233/234}$U	6.22E-03	7.15E-04	7.00E-03	8.68E-04	0.694	+
WSS	5-10	$^{233/234}$U	7.30E-03	8.49E-04	6.20E-03	8.39E-04	-0.922	+
WSS	0-2	^{235}U	3.32E-04	1.39E-04	1.04E-04	9.17E-05	-1.369	U
WSS	2-5	^{235}U	9.73E-05	8.26E-05	4.74E-04	1.67E-04	2.022	U/+[(e)]
WSS	5-10	^{235}U	1.67E-04	1.36E-04	2.12E-04	1.26E-04	0.243	U
WSS	0-2	^{238}U	7.13E-03	8.44E-04	6.44E-03	8.11E-04	0.589	+
WSS	2-5	^{238}U	6.96E-03	7.80E-04	6.86E-03	8.54E-04	0.086	+
WSS	5-10	^{238}U	7.76E-03	8.87E-04	7.36E-03	9.61E-04	-0.306	+
WSS	0-2	^{238}Pu	-3.12E-05	4.15E-05	3.37E-05	7.55E-05	0.753	U
WSS	2-5	^{238}Pu	-7.20E-05	8.05E-05	-5.19E-05	7.23E-05	-0.186	U
WSS	5-10	^{238}Pu	-4.95E-05	5.30E-05	2.98E-05	7.51E-05	-0.863	U
WSS	0-2	$^{239/240}$Pu	-3.12E-05	2.00E-05	7.89E-05	7.42E-05	-1.433	U
WSS	2-5	$^{239/240}$Pu	4.24E-05	5.30E-05	6.42E-05	6.15E-05	-0.269	U
WSS	5-10	$^{239/240}$Pu	7.59E-05	6.03E-05	4.62E-05	5.77E-05	-0.356	U
WSS	0-2	^{241}Am	-4.28E-06	6.76E-05	5.67E-05	8.36E-05	-0.567	U
WSS	2-5	^{241}Am	3.25E-06	6.72E-05	5.18E-05	7.53E-05	-0.481	U
WSS	5-10	^{241}Am	-1.73E-06	7.06E-05	3.00E-06	6.31E-05	0.050	U
WSS	0-2	^{40}K	2.51E-01	1.93E-03	2.53E-01	2.07E-02	0.096	+
WSS	2-5	^{40}K	2.48E-01	1.92E-02	2.59E-01	1.90E-02	0.407	+
WSS	5-10	^{40}K	2.51E-01	1.83E-02	2.66E-01	2.04E-02	-0.547	+
WSS	0-2	^{60}Co	3.43E-04	4.92E-04	6.78E-04	5.51E-04	-0.454	U
WSS	2-5	^{60}Co	1.16E-04	5.26E-04	1.99E-05	4.03E-04	-0.145	U

Location	Depth cm	Radionuclide	Primary Sample		Duplicate Sample			
			[RN][(a)]	1 σ TPU[(b)]	[RN][(a)]	1 σ TPU[(b)]	RER[(c)]	Q[(d)]
WSS	5-10	^{60}Co	-1.98E-05	3.62E-04	1.10E-04	4.99E-04	0.211	U
WSS	0-2	^{137}Cs	1.39E-03	3.40E-04	1.97E-03	4.78E-04	0.989	+
WSS	2-5	^{137}Cs	2.13E-03	3.77E-03	1.94E-03	3.15E-04	-0.050	+
WSS	5-10	^{137}Cs	1.12E-03	2.42E-04	1.06E-03	3.46E-04	-0.142	+
WSS	0-2	^{90}Sr	-1.54E-04	3.86E-03	-2.42E-03	3.95E-03	-0.410	U
WSS	2-5	^{90}Sr	-2.55E-05	3.91E-03	-5.18E-03	4.01E-03	0.920	U
WSS	5-10	^{90}Sr	5.01E-03	3.98E-03	6.06E-04	3.96E-03	-0.784	U

Notes:

See Chapter 6 for sampling location codes. Units are in Bq/g, dry weight.

(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) ^{235}U detected in the duplicate sample but not the primary sample.

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. All Biota samples were analyzed for the 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 carriers (strontium nitrate and barium 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 carriers (strontium nitrate and barium 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

Vegetation Samples

Table 4.23 presents the analysis results for the uranium, plutonium, and americium target radionuclides in the vegetation samples from six locations. Duplicate samples were taken at WEE during the vegetation sampling in June and July, 2015.

Table 4.23 shows that there was one detection of $^{233/234}$U in the primary WEE vegetation sample, and detections of ^{238}U in the WEE duplicate samples and in the SMR sample. No plutonium isotopes or americium were detected in any of the vegetation samples. The ^{238}Pu and $^{239/240}$Pu data were all qualified “UJ” due to a slightly high recovery for the ^{242}Pu tracer in the RLCS QC sample. The slightly high recovery did not adversely affect the quality or usability of the data.

The one measured detection of $^{233/234}$U shown in Table 4.23 was higher than the mean baseline concentration from all locations of 6.00E-05 Bq/g. The ^{238}U detections in the WEE duplicate samples were higher than the mean baseline concentration from all locations of 6.90E-04 Bq/g. The detection of ^{238}U in the SMR sample was slightly lower than the baseline mean concentration. However, the data are not directly comparable because the average baseline concentrations are reported on an ash basis according to the source document (DOE/WIPP–92–037). The measured dry weight concentration should be even higher if reported on an ash basis where the weight would be smaller.

Table 4.23 – 2015 Uranium, Plutonium and Americium Radionuclide Concentrations in Vegetation Samples Taken Near the WIPP Site

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]
		$^{233/234}U$				^{235}U				^{238}U			
WFF	6/22/2015	2.98E-04	1.90E-04	9.11E-04	U	-8.00E-06	3.14E-05	4.21E-04	U	2.84E-04	1.91E-04	5.11E-04	U
WEE	6/22/2015	1.04E-03	4.00E-04	9.13E-04	+	1.65E-04	1.49E-04	4.20E-04	U	1.69E-03	5.47E-04	5.11E-04	+
WEE Dup	6/22/2015	7.55E-04	2.98E-04	9.06E-04	U	-1.43E-05	3.98E-05	4.12E-04	U	7.34E-04	2.91E-04	5.00E-04	+
WSS	7/27/2015	2.80E-04	1.59E-04	7.73E-04	U	2.53E-05	4.98E-05	4.08E-04	U	2.04E-04	1.42E-04	5.17E-04	U
MLR	7/27/2015	4.24E-04	2.17E-04	7.83E-04	U	4.89E-05	8.99E-05	4.23E-04	U	2.06E-04	1.49E-04	5.26E-04	U
SEC	7/29/2015	2.59E-04	1.59E-04	7.77E-04	U	-1.82E-06	1.38E-05	4.14E-04	U	1.90E-04	1.36E-04	5.19E-04	U
SMR	7/30/2015	4.65E-04	1.99E-04	7.70E-04	U	1.03E-05	5.31E-05	4.04E-04	U	5.48E-04	2.24E-04	5.21E-04	+
		^{238}Pu				$^{239/240}Pu$				^{241}Am			
WFF	6/22/2015	6.48E-05	8.20E-05	5.26E-04	UJ[e]	-5.70E-06	5.75E-05	4.16E-04	UJ[e]	3.13E-05	7.14E-05	5.91E-04	U
WEE	6/22/2015	-1.70E-05	3.33E-05	5.21E-04	UJ	8.80E-05	8.68E-05	4.02E-04	UJ	-1.44E-06	8.59E-05	6.06E-04	U
WEE Dup	6/22/2015	1.98E-05	6.73E-05	5.25E-04	UJ	9.90E-06	4.75E-05	4.09E-04	UJ	3.77E-05	6.09E-05	5.97E-04	U
WSS	7/27/2015	9.91E-05	1.45E-04	5.51E-04	UJ	4.13E-05	1.07E-04	5.02E-04	UJ	5.17E-06	6.80E-05	1.03E-03	U
MLR	7/27/2015	-3.07E-05	1.05E-04	5.03E-04	UJ	2.39E-05	6.33E-05	4.56E-04	UJ	-1.90E-05	1.21E-04	1.02E-03	U
SEC	7/29/2015	4.92E-05	1.04E-04	5.01E-04	UJ	-7.02E-06	2.18E-05	4.48E-04	UJ	8.53E-05	1.15E-04	1.03E-03	U
SMR	7/30/2015	9.02E-06	4.33E-05	4.89E-04	UJ	-4.51E-06	1.77E-05	4.50E-04	UJ	0.00E+00	1.48E-04	1.05E-03	U

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.

(e) UJ: ^{238}Pu and $^{239/240}Pu$ not detected above the reported 2 σ TPU and MDC, but a quality deficiency affected the data making the data more uncertain, i.e., the ^{242}Pu tracer recovery was slightly higher than the 110% recovery objective in the associated RLCS QC sample.

A comparison of the vegetation data from 2015 and 2014 shows that for $^{233/234}U$, the only common location was WEE, and thus, there were not enough data to perform ANOVA calculations. There were two common locations for the detection of ^{238}U including WEE and SMR. Duplicate samples were also collected at WEE in 2014, but ^{238}U was only detected in one of the duplicates, and that concentration was used for the ANOVA calculation. The ANOVA calculation is able to be performed with just two common locations. The very limited data showed no significant variation in the concentration of the ^{238}U between 2015 and 2014 (ANOVA ^{238}U, p = 0.328). There was no significant variation in the ^{238}U vegetation concentrations between locations (ANOVA ^{238}U, p = 0.343).

Table 4.24 presents the analysis results for the gamma radionuclides and ^{90}Sr during the regular vegetation sampling in July and August, 2015.

Table 4.24 – 2015 Gamma and ^{90}Sr Radionuclide Concentrations in Vegetation Samples Taken Near the WIPP Site

Location	Sampling 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)]
		^{40}K					^{60}Co				
WFF	6/22/2015	7.09E-01	1.38E-01	5.88E-02	1.000	+	-4.81E-03	9.18E-03	9.83E-03	0.000	U
WEE	6/22/2015	6.71E-01	1.13E-01	5.16E-02	0.999	+	1.88E-03	4.41E-03	5.54E-03	0.000	U
WEE Dup	6/22/2015	7.27E-01	1.48E-01	8.30E-02	0.997	+	-2.53E-03	9.10E-03	9.92E-03	0.000	U
WSS	7/27/2015	5.06E-01	8.63E-02	3.94E-02	0.999	+	1.18E-03	3.67E-03	4.53E-03	0.000	U
MLR	7/27/2015	5.07E-01	8.58E-02	4.14E-02	1.000	+	2.77E-03	2.81E-03	3.95E-03	0.000	U
SEC	7/29/2015	4.95E-01	9.08E-02	5.64E-02	1.000	+	3.86E-03	3.46E-03	4.97E-03	0.000	U
SMR	7/30/2015	5.85E-01	1.22E-01	7.31E-02	0.999	+	1.61E-03	6.84E-03	8.92E-03	0.000	U
Location	**Sampling Date**	**[RN][(a)]**	**2 σ TPU[(b)]**	**MDC[(c)]**	**ID Conf[(d)]**	**Q[(e)]**	**[RN][(a)]**	**2 σ TPU[(b)]**	**MDC[(c)]**	**Q[(e)]**	
		^{137}Cs					^{90}Sr				
WFF	6/22/2015	2.58E-05	6.48E-03	7.83E-03	0.000	U	1.37E-03	2.64E-03	1.37E-02	U	
WEE	6/22/2015	1.17E-03	3.95E-03	4.91E-03	0.000	U	2.55E-03	2.72E-03	1.37E-02	U	
WEE Dup	6/22/2015	3.28E-03	7.01E-03	8.68E-03	0.000	U	2.43E-03	2.69E-03	1.37E-02	U	
WSS	7/27/2015	-3.32E-04	4.05E-03	4.49E-03	0.000	U	9.51E-04	1.82E-03	1.24E-02	U	
MLR	7/27/2015	-6.86E-04	3.04E-03	3.52E-03	0.000	U	-6.19E-04	1.81E-03	1.24E-02	U	
SEC	7/29/2015	-2.46E-03	4.26E-03	4.67E-03	0.000	U	5.36E-04	1.84E-03	1.24E-02	U	
SMR	7/30/2015	1.79E-03	5.33E-03	6.83E-03	0.000	U	-9.78E-04	1.78E-03	1.24E-02	U	

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

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

Table 4.24 shows that ^{40}K was detected in all six of the vegetation samples in 2015 including both of the WEE duplicates. All the measured concentrations of ^{40}K (dry weight basis) were less than the average baseline concentration of 3.20E+00 Bq/g (ash weight basis).

There were four common locations between 2015 and 2014 for ANOVA calculations. The average activity was used for the WEE duplicate vegetation samples since ^{40}K was detected in both samples. The ANOVA calculations showed no significant statistical difference in ^{40}K vegetation concentrations between 2015 and 2014 (ANOVA ^{40}K, p = 0.508). There also was no significant variation in the concentrations of ^{40}K between locations, (ANOVA ^{40}K, p = 0.298). The natural variability of the concentration of this naturally occurring radionuclide in the soil would be expected to yield some variation in the vegetation concentrations between locations.

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 4.25 shows the precision analysis results for all the target radionuclides in the duplicate samples from location WEE. The only detections were for $^{233/234}$U in one of the WEE duplicates, ^{238}U, and ^{40}K. The Pu data were qualified "UJ" because of the slightly high ^{242}Pu tracer recovery in the associated RLCS. The RERs for ^{235}U and ^{238}U were greater than 2 (2.285, 3.027, respectively). The RER for $^{233/234}$U was significantly lower at 1.120. The variable precision of the vegetation analyses is likely due to the need to collect multiple separate plants to yield enough mass for the primary and duplicate vegetation samples. The uranium uptake could be different in the various plants due to the nature of the plants or the distribution of uranium isotopes in the root zone.

4.7.4.2 Fauna (Animals)

The fauna analysis results for radionuclides are presented in Table 4.26 for the uranium isotopes, plutonium isotopes, and americium and in Table 4.27 for the gamma radionuclides and ^{90}Sr. The fauna samples that were analyzed included two quail composite samples plus a duplicate composite sample; two deer samples plus a duplicate sample taken from one of the deer; two rabbit samples; and three composite fish samples plus a duplicate fish composite sample. The first quail composite sample consisted of four individual birds, and the duplicate quail composite samples each consisted of four separate birds. Likewise, the fish composite samples consisted of several individual fish including the duplicate fish sample from PEC. The 2015 BRA fish sample was collected below the dam in the Pecos River because the lake location was inaccessible due to high water and muddy conditions following heavy rains.

Table 4.25 – 2015 Precision Analysis Results for Duplicate Vegetation Samples

Location	Isotope	Sample		Duplicate		RER[c]	Q[d]
		[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]		
WEE and Dup	$^{233/234}U$	1.04E-03	2.04E-04	7.55E-04	1.52E-04	1.120	+/U[e]
	^{235}U	1.65E-04	7.58E-05	-1.43E-05	2.03E-05	2.285	U
	^{238}U	1.69E-03	2.79E-04	7.34E-04	1.48E-04	3.027	+
	^{238}Pu	-1.70E-05	1.70E-05	1.98E-05	3.43E-05	0.961	UJ[f]
	$^{239/240}Pu$	8.80E-05	4.43E-05	9.90E-06	2.42E-05	1.547	UJ[f]
	^{241}Am	-1.44E-06	4.38E-05	3.77E-05	3.11E-05	0.729	U
	^{40}K	6.71E-01	5.77E-02	7.27E-01	7.55E-02	0.589	+
	^{60}Co	1.88E-03	2.25E-03	-2.53E-03	4.64E-03	0.855	U
	^{137}Cs	1.17E-03	2.02E-03	3.28E-03	3.58E-03	0.513	U
	^{90}Sr	2.55E-03	1.39E-03	2.43E-03	1.37E-03	0.061	U

Notes:

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

(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) Detected in the primary sample but not the duplicate sample.

(f) UJ: ^{238}Pu and $^{239/240}Pu$ not detected above the reported 2 σ TPU and MDC, but a quality deficiency affected the data making the data more uncertain, i.e., the ^{242}Pu tracer recovery was slightly higher than the 110% recovery objective in the associated RLCS QC sample.

Table 4.26 – 2015 Uranium, Plutonium, and Americium Radionuclide Concentrations in Fauna Samples Taken Near the WIPP Site

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)]
		$^{233/234}U$				^{235}U				^{238}U			
Rabbit (SOO)[(e)]	1/20/2015	3.26E-05	7.70E-06	6.08E-04	U	4.56E-07	1.02E-06	1.93E-04	U	2.99E-05	7.23E-06	4.36E-04	U
Quail (WEE)	1/29/2015	1.10E-04	2.35E-05	6.09E-04	U	5.67E-06	3.39E-06	1.93E-04	U	8.84E-05	1.95E-05	4.36E-04	U
Deer (SOO)	1/29/2015	5.01E-06	3.25E-06	5.87E-04	U	3.89E-07	1.32E-06	1.68E-04	U	2.63E-06	2.38E-06	4.15E-04	U
Deer (Dup)	1/29/2015	2.82E-06	2.27E-06	5.87E-04	U	-2.26E-07	6.70E-07	1.67E-04	U	7.29E-07	1.23E-06	4.14E-04	U
Quail (WNN)[(f)]	2/6/2015	1.66E-04	3.18E-05	5.40E-04	U	7.03E-06	3.59E-06	1.83E-04	U	1.38E-04	2.69E-05	5.49E-04	U
Quail (Dup)	2/6/2015	1.50E-04	3.14E-05	5.40E-04	U	8.28E-06	4.26E-06	1.83E-04	U	1.47E-04	3.07E-05	5.49E-04	U
Rabbit (SOO)	3/17/2015	5.05E-05	1.27E-05	8.78E-04	U	0.00E+00	1.91E-06	2.33E-04	U	2.73E-05	8.58E-06	5.55E-04	U
Deer (SOO)	4/15/2015	3.61E-06	3.44E-06	8.03E-04	U	7.43E-07	1.47E-06	2.68E-04	U	2.80E-06	2.79E-06	3.95E-04	U
Fish (CBD)	10/31/2015	1.35E-04	2.47E-05	7.29E-04	U	2.52E-06	2.50E-06	3.61E-04	U	7.09E-05	1.53E-05	4.43E-04	U
Fish (BRA)	10/17/2015	2.18E-04	4.24E-05	8.55E-04	U	5.29E-06	4.01E-06	3.58E-04	U	1.23E-04	2.64E-05	6.34E-04	U
Fish (PEC)	10/16/2015	1.68E-04	3.68E-05	9.91E-04	U	3.86E-06	3.91E-06	3.48E-04	U	1.01E-04	2.43E-05	8.23E-04	U
Fish (PEC) Dup	10/16/2015	1.69E-04	3.25E-05	9.91E-04	U	1.42E-06	2.24E-06	3.47E-04	U	6.70E-05	1.66E-05	8.23E-04	U
		^{238}Pu				$^{239/240}Pu$				^{241}Am			
Rabbit (SOO)[(e)]	1/20/2015	-9.18E-08	3.37E-07	2.25E-04	U	1.10E-06	1.35E-06	2.69E-04	U	1.54E-05	5.75E-06	8.34E-04	U
Quail (WEE)	1/29/2015	9.48E-07	1.60E-06	2.25E-04	U	3.26E-06	2.38E-06	2.69E-04	U	5.63E-06	4.62E-06	8.35E-04	U
Deer (SOO)[(e)]	1/29/2015	-7.02E-07	1.67E-06	2.21E-04	U	-2.40E-07	6.44E-07	1.85E-04	U	1.42E-06	2.48E-06	5.43E-04	U
Deer (Dup)	1/29/2015	-2.83E-07	6.30E-07	2.21E-04	U	-5.57E-07	8.87E-07	1.84E-04	U	-7.88E-07	1.18E-06	5.43E-04	U
Quail (WNN)[(f)]	2/6/2015	-3.74E-08	1.06E-06	2.26E-04	U	3.74E-06	2.54E-06	1.87E-04	U	7.24E-07	1.77E-06	7.41E-04	U
Quail (Dup)	2/6/2015	3.92E-08	1.17E-06	2.26E-04	U	2.70E-06	2.35E-06	1.87E-04	U	1.26E-06	2.09E-06	7.41E-04	U
Rabbit (SOO)	3/17/2015	1.11E-06	3.77E-06	3.84E-04	U	8.88E-07	2.13E-06	3.37E-04	U	1.45E-06	6.64E-06	5.48E-04	U
Deer (SOO)	4/15/2015	-3.77E-07	7.39E-07	3.54E-04	UJ[(g)]	4.39E-07	1.24E-06	3.53E-04	UJ[(g)]	1.66E-06	2.35E-06	6.65E-04	U
Fish (CBD)	10/31/2015	2.09E-07	2.22E-06	3.59E-04	U	-2.44E-07	7.45E-07	4.18E-04	U	1.63E-07	1.24E-06	9.34E-04	U
Fish (BRA)	10/17/2015	-9.84E-07	3.05E-06	4.40E-04	U	3.52E-06	4.23E-06	3.06E-04	U	4.95E-06	4.51E-06	6.12E-04	U
Fish (PEC) [(h)]	10/16/2015	-7.94E-07	1.60E-06	4.63E-04	U	1.24E-06	2.63E-06	4.09E-04	U	1.35E-06	3.74E-06	7.69E-04	U
Fish (PEC) Dup	10/16/2015	-5.56E-07	1.32E-06	4.62E-04	U	2.09E-06	3.71E-06	4.09E-04	U	5.61E-07	2.06E-06	7.69E-04	U

Notes:

See Appendix C for sampling location codes. Units are in Bq/g, wet 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.

(e) SOO = sample of opportunity.

(f) WNN = WIPP North.

(g) UJ: ^{238}Pu and $^{239/240}$Pu not detected above the reported 2 σ TPU and MDC, but a quality deficiency affected the data making the data more uncertain, i.e., the ^{242}Pu tracer recovery was slightly higher than the 110% recovery objective in the associated RLCS QC sample.

(h) The 2015 PEC fish was taken below the dam instead of in the lake because the lake was inaccessible due to high water.

Table 4.27 – 2015 Gamma and ^{90}Sr Radionuclide Concentrations in Fauna Samples Taken Near the WIPP Site

		^{40}K					^{60}Co				
Location	**Sampling 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)]**
Rabbit (SOO)[(f)]	1/20/2015	1.14E-01	1.91E-02	1.56E-02	0.997	+	2.38E-04	1.50E-03	1.72E-03	0.000	U
Quail (WEE)	1/29/2015	1.29E-01	2.15E-02	1.76E-02	1.000	+	8.33E-04	1.75E-03	2.07E-03	0.000	U
Deer (SOO)	1/29/2015	1.57E-01	2.69E-02	2.24E-03	1.000	+	1.93E-05	1.88E-03	2.14E-03	0.000	U
Deer (Dup)	1/29/2015	1.55E-01	2.56E-02	1.98E-02	0.992	+	-1.44E-03	2.06E-03	2.15E-03	0.000	U
Quail (WNN)[(g)]	2/6/2015	1.26E-01	3.75E-02	3.66E-02	0.997	+	6.89E-04	3.40E-03	4.28E-03	0.000	U
Quail (Dup)	2/6/2015	1.37E-01	2.56E-02	1.92E-02	1.000	+	1.20E-03	1.85E-03	2.22E-03	0.000	U
Rabbit (SOO)	3/17/2015	9.38E-02	2.05E-02	1.87E-02	0.983	+	1.28E-03	1.86E-03	2.26E-03	0.000	U
Deer (SOO)	4/15/2015	1.28E-01	2.20E-02	1.32E-02	0.997	+	1.06E-03	1.26E-03	1.56E-03	0.000	U
Fish (CBD)	8/21/2015	9.87E-02	2.09E-02	1.76E-02	1.000	+	-2.41E-03	2.35E-03	2.31E-03	0.000	U
Fish (BRA)	9/18/2015	1.10E-01	2.44E-01	2.33E-02	1.000	+	-8.28E-04	2.30E-03	2.50E-03	0.000	U
Fish (PEC)	10/16/2015	8.99E-02	2.47E-02	2.73E-02	0.999	+	7.86E-04	2.61E-03	3.01E-03	0.000	U
Fish (PEC) Dup	10/16/2015	8.58E-02	3.13E-02	3.60E-02	0.999	+	-2.35E-03	4.84E-03	4.95E-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)]
Rabbit (SOO)[(f)]	1/20/2015	8.88E-05	1.58E-03	1.75E-03	0.000	U	3.27E-04	1.03E-04	1.99E-02	U
Quail (WEE)	1/29/2015	-6.57E-04	1.76E-03	2.00E-03	0.000	U	1.71E-04	1.33E-04	1.99E-02	U
Deer (SOO)	1/29/2015	-2.14E-03	2.47E-03	2.54E-03	0.000	U	4.59E-07	1.11E-04	2.35E-02	U
Deer (Dup)	1/29/2015	1.49E-03	1.98E-03	2.28E-03	0.000	U	6.50E-06	9.62E-05	2.35E-02	U
Quail (WNN)[(g)]	2/6/2015	1.21E-03	4.23E-03	5.14E-03	0.000	U	6.11E-05	1.02E-04	2.28E-02	U
Quail (Dup)	2/6/2015	-3.72E-05	1.78E-03	2.08E-03	0.000	U	1.74E-05	1.09E-04	2.28E-02	U
Rabbit (SOO)	3/17/2015	2.44E-05	1.75E-03	2.06E-03	0.000	U	3.84E-04	1.25E-04	2.23E-02	U
Deer (SOO)	4/15/2015	2.94E-04	1.38E-03	1.55E-03	0.000	U	-1.52E-06	3.46E-05	1.60E-02	U
Fish (CBD)	8/21/2015	6.89E-04	2.25E-03	2.51E-03	0.000	U	-3.10E-05	6.61E-05	1.18E-02	U
Fish (BRA)	9/18/2015	-9.70E-06	2.37E-03	2.63E-03	0.000	U	1.89E-05	7.88E-05	1.11E-02	U
Fish (PEC)[(h)]	10/16/2015	1.02E-03	2.79E-03	3.11E-03	0.000	U	1.15E-05	7.07E-05	1.14E-02	U
Fish (PEC) Dup	10/16/2015	-5.96E-03	7.74E-01	8.59E-01	0.000	U	-2.68E-07	1.83E-02	1.25E-02	U

Notes:

See Appendix C for sampling location codes. Units are in Bq/g wet weight.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

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

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

(f) SOO = sample of opportunity

(g) WNN = WIPP North

(h) The 2015 PEC fish was taken below the dam instead of in the lake because the lake was inaccessible due to high water.

The only radionuclide detected in any of the animal samples was ^{40}K, which was detected in all the samples. The data for the plutonium isotopes for one of the deer samples showed the "UJ" qualifier indicating that the radionuclide activity was less than the TPU and the MDC. This is a quality deficiency affected by plutonium data, making the data more uncertain. The quality deficiency was a slightly high tracer recovery from the reagent blank QC sample analyzed with the batch. The slightly high tracer recovery in the QC sample had no adverse impact on the quality or usability of the data.

Statistical ANOVA comparisons could not be performed due to the mobile nature of the fauna samples. The detected ^{40}K concentrations were within the average baseline analysis results, including 4.1E–01Bq/g for quail (dry), 3.9E-01 Bq/g for rabbit (dry), and 6.1E–01Bq/g for fish (dry) (DOE/WIPP–92–037). An average baseline concentration was not available for deer. The reported data are not directly comparable to the average baseline concentrations because the average baseline concentrations are reported on a dry weight basis, and WIPP Labs reports the fauna data on a wet weight basis.

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. Within this limitation, the data suggest that no animal uptake of radionuclides from the WIPP facility has occurred.

Precision data were calculated for the duplicate deer sample taken from a single deer and for the duplicate PEC fish samples which consisted of four separate fish in each composite sample. The data for the duplicate fauna sample analyses are shown in Table 4.28. The precision of all the target radionuclides was calculated although only ^{40}K was detected in any of the samples.

The RERs were less than 2 except for ^{137}Cs in the duplicate deer samples and ^{238}U in the duplicate fish samples. Thus 90 percent of the precision measurements were less than the 1.96 field duplicate objective (DOE 2009). The data demonstrate generally good precision for the combined sampling and analysis procedures although precision measurements on separate fish may be of limited usefulness.

Table 4.28 – 2015 Precision Analysis Results for Duplicate Fauna (Deer and Fish) Samples

Type	Isotope	Sample		Duplicate		RER[c]	Q[d]
		[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]		
Deer and	$^{233/234}U$	5.01E-06	1.66E-06	2.82E-06	1.16E-06	1.081	U
Dup	^{235}U	3.89E-07	6.74E-07	-2.26E-07	3.42E-07	0.814	U
(SOO)	^{238}U	2.63E-06	1.22E-06	7.29E-07	6.27E-07	1.386	U
	^{238}Pu	-7.02E-07	8.50E-07	-2.83E-07	3.21E-07	0.461	U
	$^{239/240}Pu$	-2.40E-07	3.29E-07	-5.57E-07	4.53E-07	0.566	U
	^{241}Am	1.42E-06	1.27E-06	-7.88E-07	6.02E-07	1.571	U
	^{40}K	1.57E-01	1.37E-02	1.55E-01	1.31E-02	0.106	+
	^{60}Co	1.93E-05	9.57E-04	-1.44E-03	1.05E-03	1.027	U
	^{137}Cs	-2.14E-03	1.26E-03	1.49E-03	1.01E-03	2.248	U
	^{90}Sr	4.59E-07	5.67E-05	6.50E-06	4.91E-05	0.081	U
Fish and	$^{233/234}U$	1.68E-04	1.88E-05	1.69E-04	1.71E-05	0.039	U
Dup	^{235}U	3.86E-06	2.00E-06	1.42E-06	1.14E-06	1.060	U
(PEC)	^{238}U	1.01E-04	1.24E-05	6.70E-05	8.45E-06	2.266	U
	^{238}Pu	-7.94E-07	8.18E-07	-5.56E-07	6.72E-07	0.225	U
	$^{239/240}Pu$	1.24E-06	1.34E-06	2.09E-06	1.89E-06	0.367	U
	^{241}Am	1.35E-06	1.91E-06	5.61E-07	1.05E-06	0.362	U
	^{40}K	8.99E-02	1.26E-02	8.58E-02	1.60E-02	0.201	+
	^{60}Co	7.86E-04	1.33E-03	-2.35E-03	2.47E-03	1.118	U
	^{137}Cs	1.02E-03	1.43E-03	-5.96E-03	3.31E-03	1.936	U
	^{90}Sr	1.15E-05	3.61E-05	-2.68E-07	3.68E-05	0.228	U

Notes:
Units are in Bq/g, wet weight.
(a) Radionuclide concentration.
(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 generally uses CAP88–PC, which is a set of computer programs, datasets, and associated utility programs for estimating dose and risk from radionuclide air emissions. CAP88–PC uses a Gaussian Plume dispersion model, which calculates deposition rates, concentrations in food, and intake rates for people. CAP88–PC estimates dose and risk to individuals and populations from multiple pathways. Dose and risk are calculated for ingestion, inhalation, ground-level air immersion, and ground-surface irradiation exposure pathways.

The *Safe Drinking Water Act* (40 CFR §141.66, "Maximum Contaminant Levels for Radionuclides") states that average annual concentrations for beta- and gamma-emitting human-made radionuclides in drinking water shall not result in an annual dose equivalent greater than 0.04 millisievert (mSv) (4 mrem). It is important to note that these dose equivalent limits are set for radionuclides released to the environment from DOE operations. They do not include, but rather are limits 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 naturally occurring radionuclides is approximately 3 mSv (300 mrem).

4.8.3 Dose from Air Emissions

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

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

Source term input for CAP88–PC was determined by radiochemical analyses of particulate samples taken from fixed air sampling filters at Stations A, 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 activity 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 home during the entire year and all vegetables, milk, and meat consumed are home-produced. Thus, this dose calculation is a maximum potential dose, which encompasses dose from inhalation, submersion, 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 2014. 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 Compliance*

Certification Application for the Waste Isolation Pilot Plant (DOE/CAO–96–2184). Water from the Culebra is naturally not potable due to high levels of TDS.

4.8.4.2 Potential Dose from Wild Game Ingestion

Game animals sampled during 2015 were deer, rabbit, fish, and quail. The only radionuclides detected in any of the animal samples were ^{40}K, which was detected in all the samples. Therefore, no dose from WIPP facility-related radionuclides could have been received by any individual from this pathway during 2015.

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 2015 is summarized in Table 4.29 for the standards in both 40 CFR §61.92 and 40 CFR §191.03(b).

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 2015, the dose to this receptor was estimated to be 4.12E-06 mSv (4.12E-04 mrem) per year for the whole body and 1.38E-04 mSv (1.38E-02 mrem) per year to the critical organ. These values are in compliance with the requirements specified in 40 CFR §191.03(b).

For the NESHAP standard (40 CFR §61.92), the EDE potentially received by the MEI in 2015 assumed to be residing 8.9 km (5.5 mi) west-northwest of the WIPP facility is calculated to be 8.81E-08 mSv (8.81E-06 mrem) per year for the whole body. This value is in compliance with 40 CFR §61.92 requirements. Note that this distance has changed to 8,850 m from the nominal 7,500 m used in earlier dose estimates due to updates in local mapping, and single, more clearly defined designation emission point at the Station B exhaust.

As required by DOE Order 458.1, the collective dose to the public within 80 km (50 mi) of the WIPP facility has been evaluated and is 1.1E-09 person-sieverts (Sv) per year (person-Sv/year) (1.1E-07 person-rem/year) in 2015.

Table 4.29 – WIPP Radiological Dose and Releases[(a)] During 2015

^{238}Pu	$^{239/240}Pu$	^{241}Am	^{90}Sr	$^{233/234}U$	^{238}U	^{137}Cs
2.121E-08 Ci	3.538E-07 Ci	3.198E-06 Ci	4.120E-07 Ci	2.156E-08 Ci	1.435E-08 Ci	7.679E-06 Ci
7.849E+02 Bq	1.309E+04 Bq	1.183E+05 Bq	1.524E+04 Bq	7.977E+02 Bq	5.311E+02 Bq	2.841E+05 Bq

WIPP Radiological Dose Reporting Table for 2015							
Pathway	EDE to the MEI at 8,850 m WNW (mrem/year)	EDE to the MEI at 8,850 m WNW (mSv/year)	Percent of EPA 10 mrem/year limit to member of the public	Estimated population dose within 50 mi (person-rem/year)	Estimated population dose within 50 mi (person-Sv/year)	Population within 50 miles[b]	Estimated natural radiation population dose[c] (person-rem)
Air	8.81E-06	8.81E-08	8.81E-05	1.98E-05	1.98E-07	92,599	27,780
Water	N/A[(d)]	N/A	N/A	N/A	N/A	N/A	N/A
Other Pathways	N/A	N/A	N/A	N/A	N/A	N/A	N/A

WIPP Radiological Dose Reporting Table for 2015						
Pathway	Dose equivalent to the whole body of the receptor who resides year-round at WIPP fence line 650 m WNW (mrem/year)	Dose equivalent to the whole body of the receptor who resides year-round at WIPP fence line 650 m WNW (mSv/year)	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 (mrem/year)	Dose equivalent to the critical organ of the receptor who resides year-round at WIPP fence line 650 m WNW (mSv/year)	Percent of EPA 75-mrem/year critical organ limit
Air	4.12E-04	4.12E-06	1.6E-03	1.38E-02	1.38E-04	1.8E-02
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 A, 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.

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* (1991), and the International Atomic Energy Agency 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 2015 using the maximum radionuclide concentrations listed in Table 4.30, and the sum of fractions was less than 1.0 for all media. The element ^{40}K is not included in Table 4.30 because it is a natural component of the earth's crust and is not part of WIPP-related radionuclides.

Table 4.30 – 2015 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) Near the WIPP Site

Medium	Radionuclide	Maximum Detected Concentration	Location	BCG[a]	Concentration/BCG
Aquatic System Evaluation					
Sediment (Bq/g)	$^{233/234}$U	2.82E-02	BRA	2.00E+02	1.41E-04
	^{235}U	1.16E-03	BRA	1.00E+02	1.16E-05
	^{238}U	2.74E-02	BRA	9.00E+01	3.04E-04
	^{238}Pu	ND[c]	NA	2.00E+02	NA[d]
	$^{239/240}$Pu	ND[c]	NA	2.00E+02	NA[d]
	^{241}Am	ND[c]	NA	2.00E+02	NA[d]
	^{60}Co	ND[c]	NA	5.00E+01	NA[d]
	^{137}Cs	8.60E-03	BHT	1.00E+02	8.60E-05
	^{90}Sr	ND[c]	NA	2.00E+01	NA[d]
Surface Water[b] (Bq/L)	$^{233/234}$U	1.79E-01	PCN	7.00E+00	2.56E-02
	^{235}U	3.32E-03	PCN	8.00E+00	4.15E-04
	^{238}U	8.50E-02	PCN	8.00E+00	1.06E-02
	^{238}Pu	ND[c]	NA	7.00E+00	NA[d]
	$^{239/240}$Pu	ND[c]	NA	7.00E+00	NA[d]
	^{241}Am	ND[c]	NA	2.00E+01	NA[d]
	^{60}Co	ND[c]	NA	1.00E+02	NA[d]
	^{137}Cs	ND[c]	NA	2.00E+00	NA[d]
	^{90}Sr	ND[c]	NA	1.00E+01	NA[d]

Medium	Radionuclide	Maximum Detected Concentration	Location	BCG[(a)]	Concentration/BCG
Sum of Fractions					3.72E-02
Terrestrial System Evaluation					
Soil (Bq/g)	$^{233/234}U$	1.67E-02	SMR (2-5 cm)	2.00E+02	8.35E-05
	^{235}U	8.71E-04	SMR (0-2 cm)	1.00E+02	8.71E-06
	^{238}U	1.71E-02	SMR (0-2 cm)	6.00E+01	2.85E-04
	^{238}Pu	ND[(c)]	NA	2.00E+02	NA[(d)]
	$^{239/240}Pu$	ND[(c)]	NA	2.00E+02	NA[(d)]
	^{241}Am	ND[(c)]	NA	1.00E+02	NA[(d)]
	^{60}Co	ND[(c)]	NA	3.00E+01	NA[(d)]
	^{137}Cs	9.01E-03	SMR (2-5 cm)	8.00E-01	1.13E-02
	^{90}Sr	ND[(c)]	NA	8.00E-01	NA[(d)]
Surface Water (Bq/L)	$^{233/234}U$	1.79E-01	PCN	7.00E+00	2.56E-02
	^{235}U	3.32E-03	PCN	8.00E+00	4.15E-04
	^{238}U	8.50E-02	PCN	8.00E+00	1.06E-02
	^{238}Pu	ND[(c)]	NA	7.00E+00	NA[(d)]
	$^{239/240}Pu$	ND[(c)]	NA	7.00E+00	NA[(d)]
	^{241}Am	ND[(c)]	NA	2.00E+01	NA[(d)]
	^{60}Co	ND[(c)]	NA	1.00E+02	NA[(d)]
	^{137}Cs	ND[(c)]	NA	2.00E+04	NA[(d)]
	^{90}Sr	ND[(c)]	NA	2.00E+04	NA[(d)]
Sum of Fractions					4.83E-02

Notes:

Maximum detected concentrations were compared with biota concentration guide (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).

NA Not applicable.

(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 2015.

4.9 Radiological Program Conclusions

4.9.1 Effluent Monitoring

For 2015, the calculated EDE to the receptor (hypothetical MEI) who resides year-round at the Exclusive Use Area fence line is 4.12E-06 mSv (4.12E-04 mrem) per year for the whole body and 1.38E-04 mSv (1.38E-02 mrem) per year for the critical organ. For the WIPP effluent monitoring program, Figure 4.5 and Table 4.30 show the dose to the whole body for the hypothetical MEI for CY 2003 to CY 2015. Figure 4.6 and Table 4.31 show the dose to the critical organ for the hypothetical MEI for CY 2003 to CY 2015. 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 2015, the dose was estimated to be considerably less than for the previous year, as would be expected given the February 2014 radiological release event and subsequent return to normal conditions. All calculated dose estimates were well within the limit of 10 mrem EDE to the MEI.

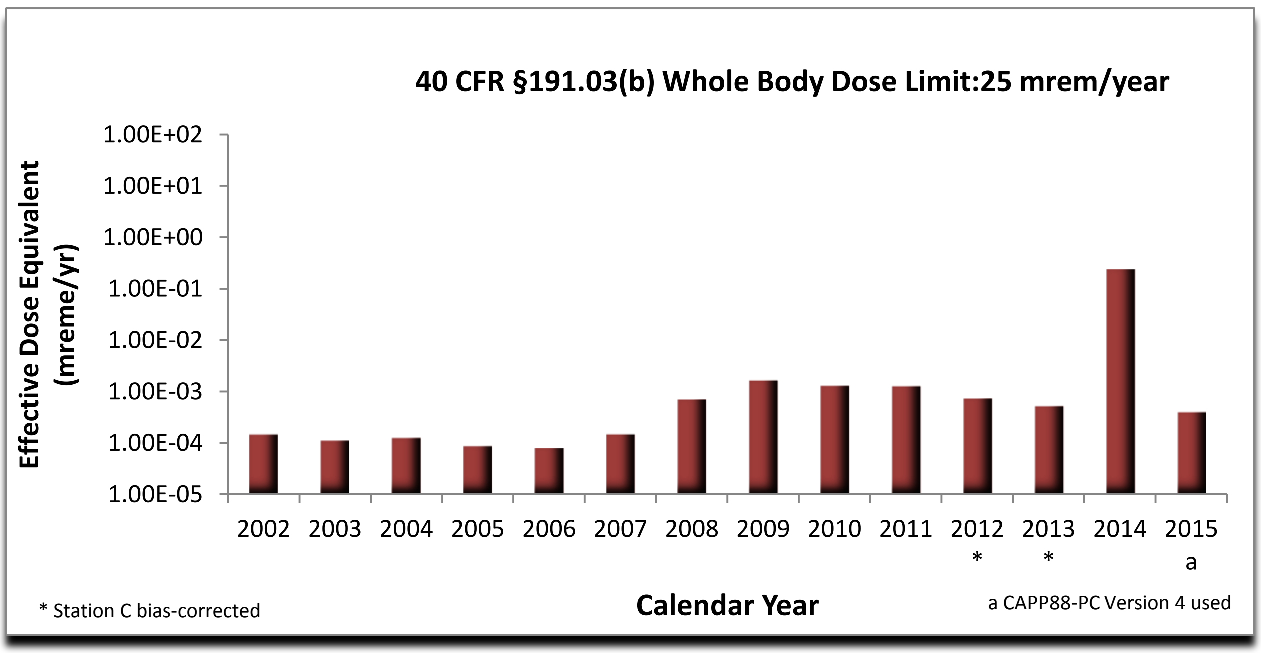


Figure 4.5 – Dose to the Whole Body for the Hypothetical Maximally Exposed Individual at the WIPP Fence Line

Table 4.31 – Comparison of Dose to the Whole Body to EPA Standard of 25 mrem/year per 40 CFR §191.03(b)

Year	Annual Dose (mrem/yr)	Percentage of EPA Standard
2002	1.51E-04	0.00060%
2003	1.15E-04	0.00046%

Year	Annual Dose (mrem/yr)	Percentage of EPA Standard
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	0.00224%
2014	2.38E-01	0.96000%
2015[a]	4.12E-04	0.00165%
40 CFR §191.03(b) Whole Body Limit	**25**	

*Station C bias-corrected.

[a] CAPP88-PC Version 4 used.

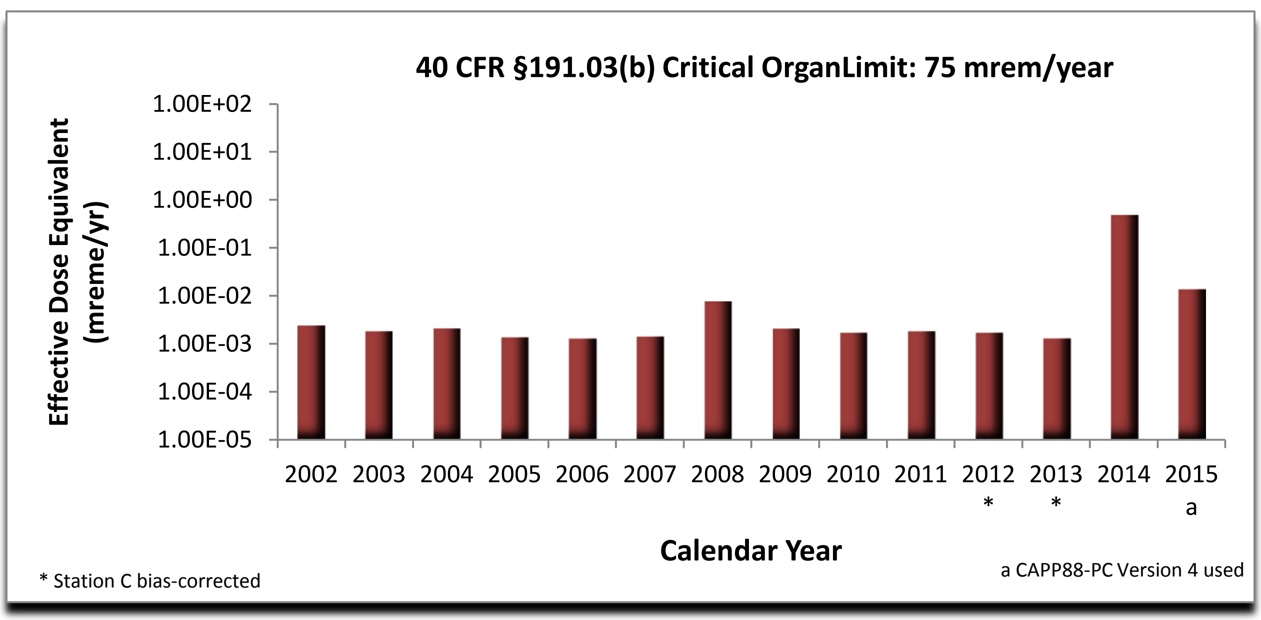


Figure 4.6 – Dose to the Critical Organ for Hypothetical Maximally Exposed Individual at the WIPP Fence Line

Table 4.32 – Comparison of Dose to the Critical Organ to EPA Standard of 75 mrem/year per 40 CFR §191.03(b)

Year	Annual Dose (mrem/yr)	Percentage of EPA Standard
2001	1.56E-03	0.0021%
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]	1.38E-02	0.0184%
40 CFR §191.03(b) Critical Organ Limit	**75**	

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

For 2015, the calculated EDE to the MEI from normal operations conducted at the WIPP facility is 8.81E-08 mSv (8.81E-06 mrem). For the WIPP effluent monitoring program, Figure 4.7 and Table 4.32 show the EDE to the MEI for CY 2003 to CY 2015. These EDE values are more than five orders of magnitude below the EPA NESHAP standard of 10 mrem per year, as specified in 40 CFR §61.92.

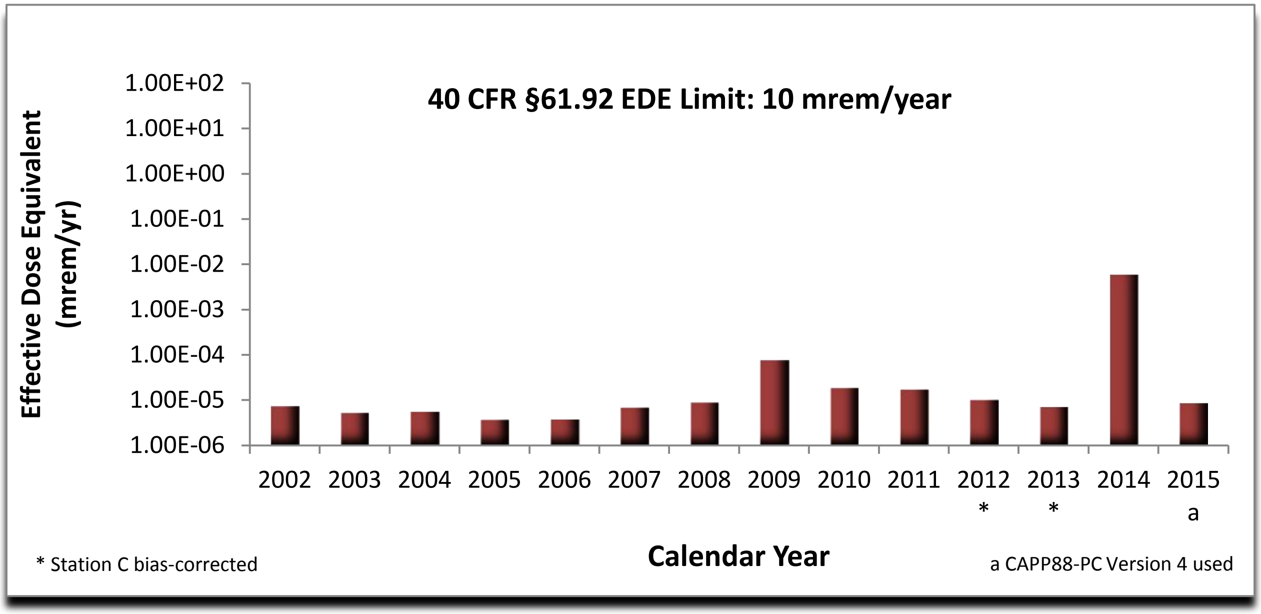


Figure 4.7 – WIPP Effective Dose Equivalent to the Off-Site Maximally Exposed Individual

Table 4.33 – 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[a]	8.81E-06	0.000112%
NESHAP Limit	**10**	

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

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 detected radionuclide concentrations to their respective baseline values.

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

- The sediment BRA concentration (Pecos River Valley and associated bodies of water) of ^{40}K at 7.63E-01 Bq/g was higher than the baseline concentration of 5.00E-01 Bq/g.
- The soil SMR ^{238}U concentrations at 0–2 cm 1.71E-02 Bq/g were higher than the baseline concentration of 1.30E-02 Bq/g.
- The soil SMR ^{40}K concentration at 5 – 10 cm of 8.28E-01 Bq/g was higher than the baseline concentration of 3.40E-01 Bq/g.
- The WEE vegetation sample concentration of $^{233/234}U$ at 1.04E-02 Bq/g was higher than the baseline concentration of 6.00E-05 Bq/g.
- The WEE duplicate vegetation sample concentration of ^{238}U at 1.69E-02 Bq/g was higher than the baseline concentration of 6.90E-04 Bq/g.

A few other soil and vegetation samples contained concentrations of uranium isotopes and ^{40}K that were slightly higher than the baseline concentrations but were not the highest concentrations. These were not included in Appendix H and are not listed above. The higher concentrations are most likely due to natural spatial variability, and they are so far below the regulatory limit as to be non-impactive.

CHAPTER 5 – ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INFORMATION

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

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

5.2 Land Management Plan

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

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

5.2.1 Land Use Requests

Parties who wish to conduct activities that may impact lands under the jurisdiction of the DOE but outside the property protection area are required by the LMP to prepare a land use request. A land use request consists of a narrative description of the project, a completed environmental review, and a map depicting the location of the proposed activity. This documentation is used to determine if applicable regulatory requirements have been met prior to the approval of a proposed project. A land use request is submitted to the Land Use Coordinator by organizations wishing to complete 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 2015, five land use requests were submitted to and approved by the Land Use Coordinator.

5.2.2 Wildlife Population Monitoring

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

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

5.2.3 Reclamation of Disturbed Lands

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

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

5.2.4 Oil and Gas Surveillance

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

- Survey staking
- Surface geophysical exploration

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

During 2015, WIPP surveillance teams conducted monthly surveillances and field inspections.

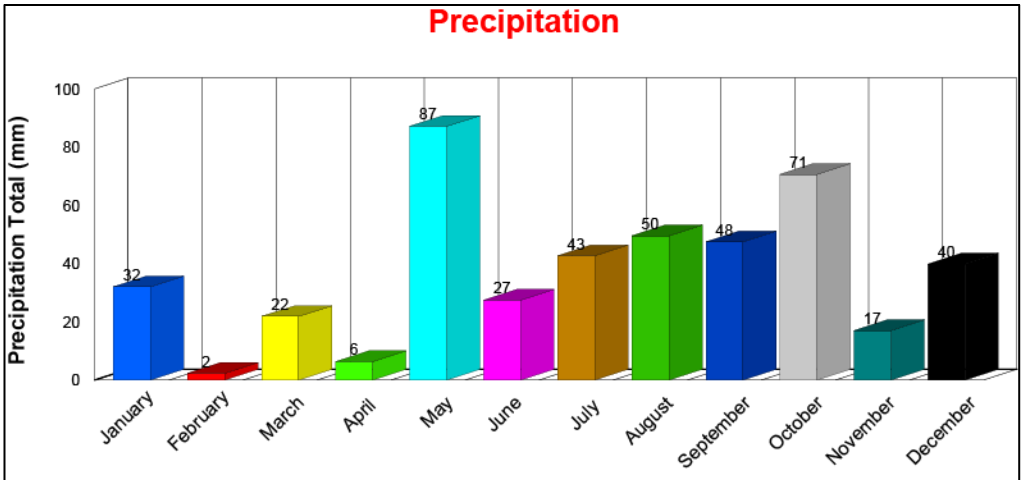
Proposed new well locations staked within 1.6 km (1 mi) of the WIPP site boundary are field-verified. This ensures that the proposed location is of sufficient distance from the WIPP site boundary to protect the WIPP withdrawal from potential surface and subsurface trespass. Eight wells were completed in 2015 within 1.6 km (1 mi) of the WIPP site boundary. If a well is within 100 m (330 ft) of the WIPP site boundary, the driller is required to submit daily deviation surveys to the WIPP Land Use Coordinator to assess the horizontal drift of the well bore during drilling. None of these wells deviated inside of the WIPP site boundary.

5.3 Meteorological Monitoring

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

5.3.1 Weather Data

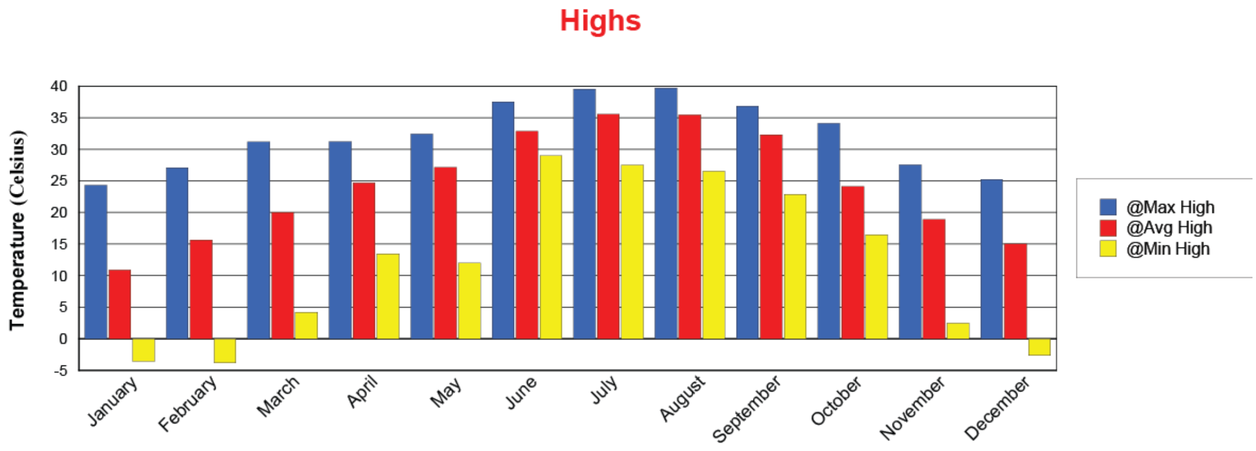
Precipitation at the WIPP site for 2015 was 486.41 mm (19.15 in.) compared to 548.64 mm (21.6 in.) for 2014. The average yearly rainfall recorded at the meteorological tower since 1970 is 336.804 mm (13.26 in). Figure 5.1 displays the monthly precipitation at the WIPP site for 2015.



Month	Total (mm)
January	32.00
February	2.29
March	21.84
April	6.35
May	87.12
June	27.43
July	42.67
August	49.53
September	47.50
October	70.62
November	17.02
December	39.88

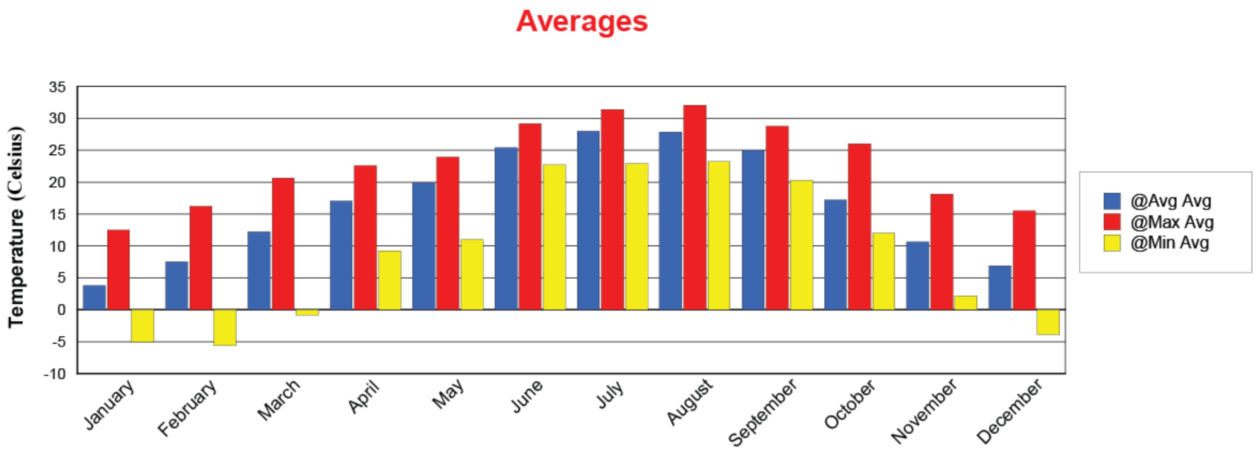
Figure 5.1 – WIPP Site Precipitation Report for 2015

The maximum recorded surface temperature (2-m level) at the WIPP site in 2015 was 39.70°C (103.46°F) in August, whereas the lowest surface temperature recorded was −10.17°C (13.69°F) in December. Monthly temperatures are illustrated in Figures 5.2, 5.3, and 5.4. The mean temperature at the WIPP site in 2015 was 16.80°C (62.24°F), which is 0.26 °C cooler than the 2014 average of 17.06 °C (62.71 °F). The average monthly temperatures for the WIPP area ranged from 28.03°C (82.454°F) during July to 3.82°C (38.88°F) in January (Figure 5.3).



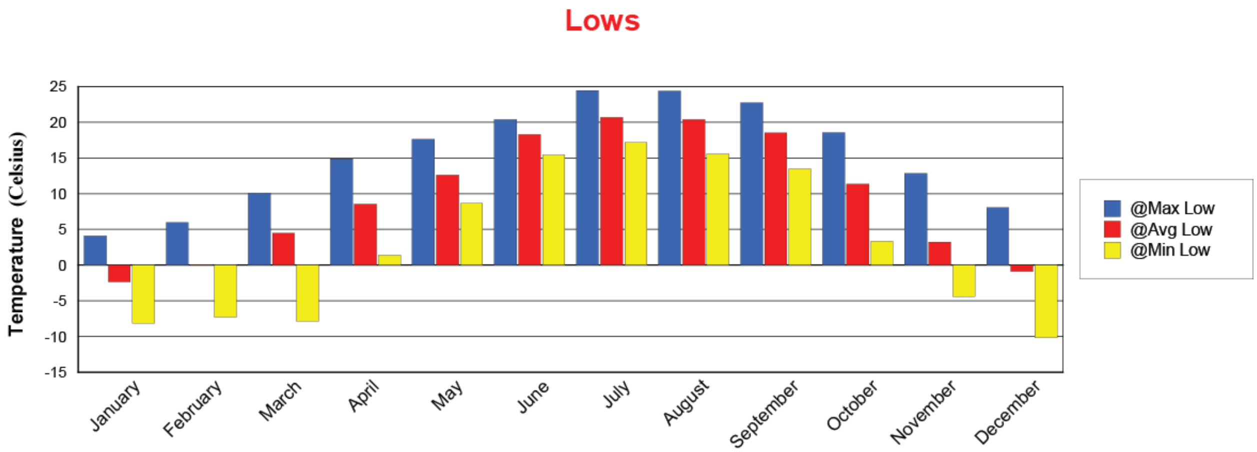
Month	Maximum High	Average High	Minimum High
January	24.27	10.85	-3.57
February	27.06	15.61	-3.82
March	31.17	19.99	4.21
April	31.20	24.65	13.47
May	32.41	27.10	11.98
June	37.51	32.84	28.97
July	39.53	35.54	27.49
August	39.70	35.47	26.53
September	36.84	32.30	22.85
October	34.06	24.06	16.48
November	27.54	18.89	2.49
December	25.26	15.00	-2.70

Figure 5.2 – WIPP Site High Temperatures (^oC) for 2015



Month	Maximum Average	Average Average	Minimum Average
January	12.45	3.82	-5.08
February	16.18	7.51	-5.59
March	20.67	12.20	-0.82
April	22.62	17.04	9.25
May	23.94	19.92	11.01
June	29.18	25.41	22.74
July	31.38	28.03	22.94
August	32.03	27.90	23.22
September	28.77	25.02	20.30
October	26.03	17.18	12.00
November	18.16	10.64	2.12
December	15.48	6.87	-3.88

Figure 5.3 – WIPP Site Average Temperatures (°C) for 2015

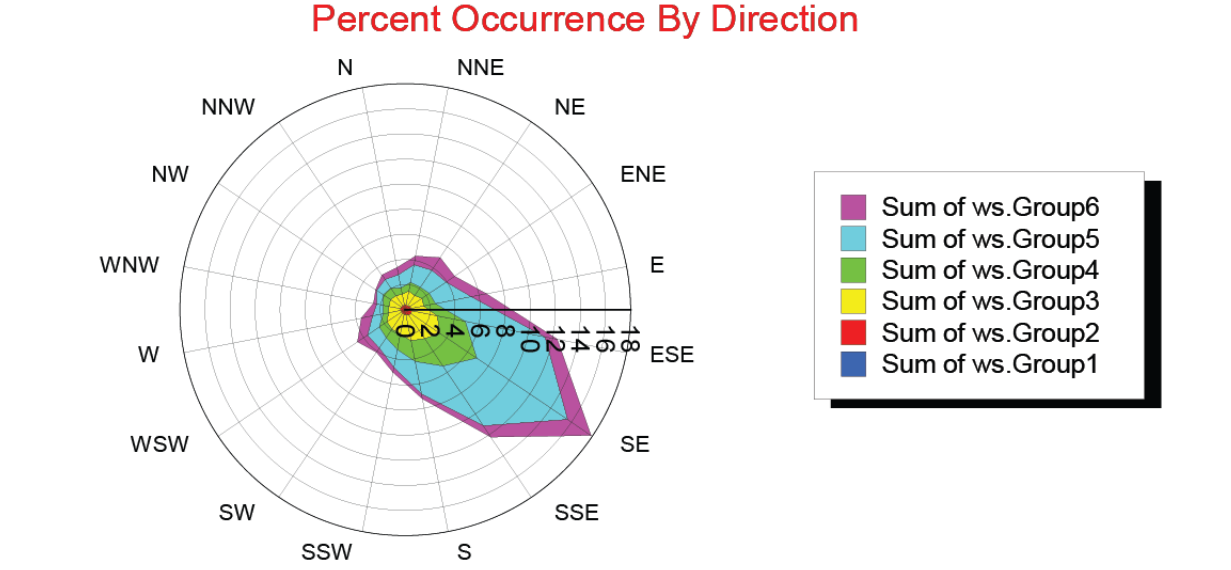


Month	Maximum Low	Average Low	Minimum Low
January	4.07	-2.36	-8.16
February	5.96	0.04	-7.27
March	10.10	4.45	-7.87
April	14.88	8.53	1.41
May	17.58	12.59	8.64
June	20.37	18.26	15.40
July	24.43	20.68	17.14
August	24.36	20.37	15.54
September	22.68	18.50	13.42
October	18.55	11.33	3.32
November	12.80	3.23	-4.41
December	8.02	-0.88	-10.17

Figure 5.4 – WIPP Site Low Temperatures (°C) for 2015

5.3.2 Wind Direction and Wind Speed

Winds in the WIPP area are predominantly from the southeast. In 2015, winds of 3.71 to 6.30 meters per second (8.30 to 14.09 miles per hour) were the most prevalent, occurring approximately 39 percent of the time (measured at the 10-m level). There were no tornadoes at the WIPP site in 2015. Figure 5.5 displays the annual wind data at WIPP for 2015.



Wind Direction	0.0 - 0.50	0.51 - 1.40	1.41 - 2.80	2.81 - 3.70	3.71 - 6.30	>6.30	Total Percent Occurrence by Direction
	Wind Speeds in meters per second						
E	0.02	0.44	1.06	0.98	2.91	1.20	6.60
ENE	0.02	0.46	1.13	0.71	1.63	0.80	4.76
NE	0.04	0.30	1.03	0.81	1.62	1.20	5.00
NNE	0.02	0.41	1.09	0.70	1.45	0.68	4.34
N	0.01	0.35	0.91	0.51	1.07	0.58	3.42
NNW	0.02	0.35	0.97	0.72	0.84	0.41	3.32
NW	0.00	0.35	1.09	0.69	0.60	0.10	2.84
WNW	0.03	0.41	0.91	0.46	0.53	0.25	2.58
W	0.02	0.36	0.99	0.45	0.85	0.91	3.57
WSW	0.01	0.34	1.43	0.73	1.15	0.94	4.59
SW	0.02	0.37	1.50	0.81	0.99	0.40	4.10
SSW	0.01	0.40	1.60	1.24	1.46	0.37	5.09
S	0.02	0.39	2.11	1.68	2.67	0.36	7.23
SSE	0.03	0.52	2.25	2.64	5.75	1.08	12.26
SE	0.02	0.55	2.81	3.52	8.77	2.25	17.92
ESE	0.03	0.50	2.08	2.28	6.49	0.99	12.37
	0.32%	6.50%	22.95%	18.93%	38.78%	12.53%	100.00%

Figure 5.5 – WIPP Site Wind Speed (at 10-Meter Level) Report for 2015

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.

After the underground truck fire of February 5, 2014, no VOC samples were taken in the underground due to safety concerns. Sampling of VOCs in ambient underground air has been eliminated from the Permit. Surface VOC sampling is being conducted in lieu of underground sampling for repository emissions.

The NMED approved modifications to the WIPP Permit Part 4 with an effective date of February 10, 2016, for implementing the changes in the Permit. Reporting of the results for samples collected during this reporting period are based on the Permit in effect at that time. Permittees implemented the Permit changes beginning February 1, 2016, and these include the following:

- The addition of trichloroethene (TCE) to the VOC target analyte list.
- Establishment of selective ion monitoring and scan MRLs.
- Changing compliance sampling locations for repository VOC monitoring from Stations VOC-A and VOC-B in the underground to new Stations VOC-C and VOC-D on the surface. Surface sampling has been underway since February 2014 with VOC-C actively sampled as "Building 489 Air Intake," and VOC-D actively sampled as "WQSP-4."
- Use of subatmospheric sampling methodologies for repository and disposal room VOC monitoring. This eliminated the use of pressurized sampling systems.
- Changing sampling durations for VOC monitoring.
- Use of risk-based calculations for determining compliance with the non-waste surface worker environmental performance standard for air emissions. This eliminated individual concentrations of concern.
- Removal of the measurement and reporting of the minimum running annual average mine ventilation exhaust rate.

WIPP VOC monitoring, as required by Permit Part 4 and Attachment N prior to February 1, 2016, has not been conducted since early February 2014 due to the occurrence of two separate events in the underground facility, a fire on February 5 and a breach of a waste container that resulted in the release of radioactive material on February 14. Underground VOC monitoring has not been possible since then due to the ongoing re-entry and recovery operations and the risk of exposure to sampling personnel from radiological contamination. The last underground repository VOC Monitoring Program samples collected were on February 4, 2014. This chapter describes requirements for underground VOC monitoring as well as additional sampling activities that have been performed on the surface since the two February 2014 events.

The nine target VOCs selected for monitoring were determined to represent approximately 99 percent of the risk due to air emissions. Starting with samples collected on or after May 12, 2014, trichloroethylene was added as a target analyte in compliance with the NMED AO dated May 12, 2014.

Repository VOC monitoring was implemented in November 1999 and disposal room VOC monitoring was implemented in November 2006. The requirements for disposal room VOC monitoring include the addition of sampling locations within active underground hazardous waste disposal units. As seen in Figure 5.6, two sampling locations are required for each filled disposal room, one at the exhaust side of the room and one at the inlet side of the room. In addition, each room actively receiving waste is required to be sampled at the exhaust side of the room. In April 2008, new Permit conditions (for Panels 3 through 8) were implemented for ongoing disposal room VOC monitoring in filled panels (panels in which waste emplacement is complete). This included continued monthly VOC monitoring in Room 1 of a filled panel unless an explosion-isolation wall is installed.

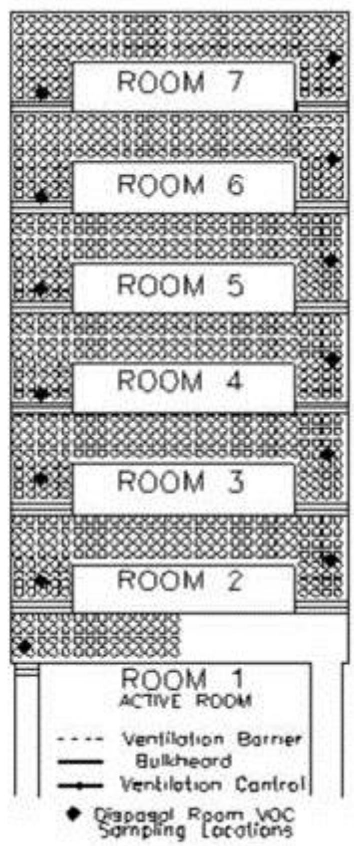


Figure 5.6 – Disposal Room Volatile Organic Compound Monitoring

For 2015, repository VOC monitoring was required to be performed twice per week at two ambient air monitoring stations: Station VOC-A, sample inlet located downstream from hazardous waste disposal unit Panel 1 in the E-300 drift; and Station VOC-B, sample inlet located upstream from the active panel(s). As waste is emplaced in new panels, Station VOC-B will be relocated to ensure that it samples underground air before it passes the waste panels. As stated previously, this underground monitoring has not been performed since the two events in February 2014.

Target compounds found at Station VOC-B are considered to be non-waste-emplacement-related. The VOCs collected at this location are entering the mine through the air intake shaft and may include VOCs from facility operations upstream of the waste panels. As prescribed by the Permit, target VOC concentrations are normalized and differences calculated between the two stations represent VOC contributions from the waste panels (i.e., underground hazardous waste disposal unit emissions). The normalized emission concentrations for a sample event and the running annual averages of emission concentrations must be less than the concentrations of concern listed in the Permit.

The basis for the VOC sampling reported in this section is the guidance included in Compendium Method TO–15, *Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed by Gas Chromatography/Mass Spectrometry (GC/MS)* (EPA, 1999). The samples were analyzed using gas chromatography/mass spectrometry (GC/MS) under an established QA/QC program. Laboratory analytical procedures were developed based on the concepts contained in both TO–15 and *Contract Laboratory Program Volatile Organics Analysis of Ambient Air in Canisters* (EPA, 1994).

5.5 Hydrogen and Methane Monitoring

Monitoring for hydrogen and methane in “filled” panels until final panel closure, unless an explosion-isolation wall is installed, was implemented in April 2008 (for Panels 3 through 8). Hydrogen and methane sampling locations include two locations in each room (exhaust and inlet) and four additional locations installed near the back (roof) of the bulkheads located in the panel access drifts. Monitoring is performed monthly at locations with working sample lines. Hydrogen and methane monitoring was not conducted between January 1, 2015, and December 31, 2015, due to inaccessibility of the sampling locations.

Hydrogen and methane samples are analyzed using gas chromatography with thermal conductivity detection under an established QA/QC program. Specialized laboratory analytical procedures were developed based on standard laboratory techniques and approved through established QA processes.

5.6 Additional Surface VOC Monitoring

After the February 2014 fire event, VOC sampling activities began at surface locations with the first post-event sample collected on February 12, 2014. These samples were intended to allow for determination of compliance with environmental performance standards associated with the Repository VOC sampling program. During the collection of surface samples, multiple sample locations were tested. Surface VOC sampling continued throughout 2015.

Sampling is performed using a commercially available portable passive air sampling kit. Each sample is set to collect as a 24-hour time-integrated sample consistent with EPA Compendium Method TO-15. Surface VOC monitoring data were reported in the Semi-annual VOC, Hydrogen, and Methane Data Summary Reports. Summary results for the period January 1, 2015, through December 31, 2015, are included in Table 5.1.

In 2015, eight samples were rejected by the Permittees due to suspected equipment contamination. Two samples were collected with the same canister that exhibited signs of losing passivity. The sample canister was removed from service. Six samples were collected using canisters previously used in disposal room VOC monitoring. Typical concentrations associated with disposal room samples are several orders of magnitude higher than typical concentrations associated with surface sampling. The results for the eight samples that were rejected were in the parts per million volume range and clearly were outside of the range of surface sample results. Canisters that were previously used in collecting disposal room samples have been controlled and excluded from use in surface VOC monitoring.

Table 5.1 – Summary of Surface VOC Monitoring Results for Reporting Period January 1, 2015 through December 31, 2015

Target Compound	Max. Value (pptv)	Sampling Date
Carbon Tetrachloride	1,544.7	6/17/2015
Chlorobenzene	14.9 J	6/30/2015
Chloroform	129.3 J	6/17/2015
1,1-Dichloroethylene	U	N/A
1,2-Dichloroethane	68.8 J	4/1/2015
Methylene Chloride	134.8 J	12/3/2015
1,1,2,2-Tetrachloroethane	37.3 J	9/3/2015
Toluene	1,137.5	4/1/2015
1,1,1-Trichloroethane	306.2	6/17/2015
Trichloroethylene	4,238.7	3/25/2015

J Estimated value – the target analyte was detected at a concentration below the MRL but above the MLD. The sample quantitation limit must be adjusted for dilution.

N/A Not applicable

pptv Parts per trillion volume

U Indicates target analyte was analyzed for, but not detected above MDL. The sample limit must be adjusted for dilution.

5.7 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 also exchanged with the University of Texas at El Paso and Texas Tech University in Lubbock, both of which operate monitoring stations in west Texas.

The mean operational efficiency of the WIPP seismic monitoring stations during 2015 was approximately 43 percent. The reduction in network availability is primarily due to seismic and communication equipment downtime. During this reporting period the seismic sensors, long haul communication equipment, and data acquisition system were upgraded. The transition to the new system occurred in December 2015. From January 1 through December 31, 2015, locations for 64 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 3.2) occurred on November 10, 2015, and was approximately 136 km (84 mi) southeast of the site. The closest earthquake to the site was approximately 82 km (51 mi) west and had a magnitude of 1.1.

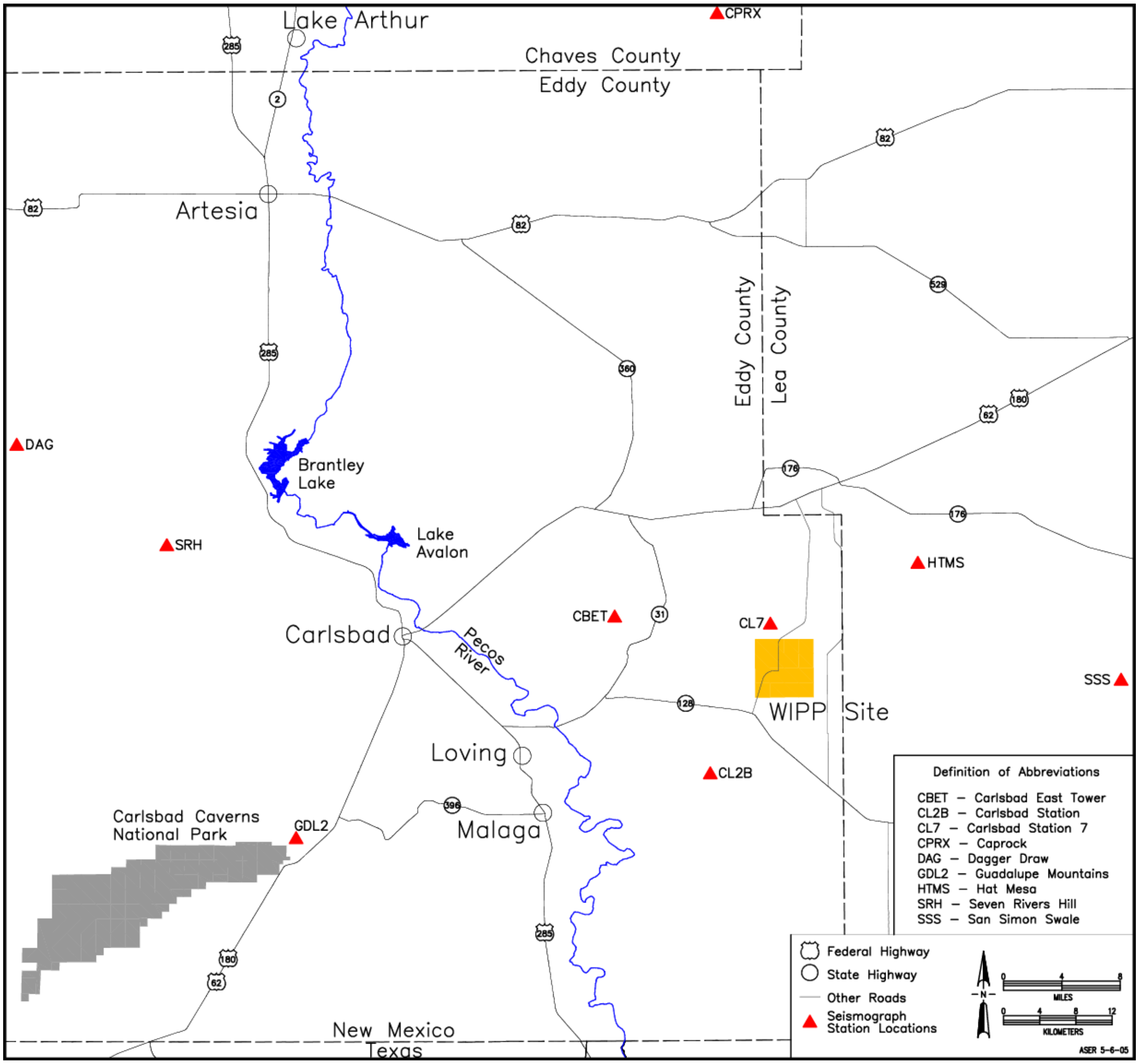


Figure 5.7 – Seismograph Station Locations in the Vicinity of the WIPP Site

5.8 Liquid Effluent Monitoring

The NMED Ground and Surface Water Protection regulations set forth in 20.6.2 NMAC regulate discharges that could impact surface water or groundwater. DOE compliance with these regulations is discussed in Chapter 2. The DP was renewed on July 29, 2014. A renewal is necessary every five years. No modification occurred during this renewal process. The names of the ponds were changed to reflect a more orderly nomenclature. However, the water sample collection processes remained the same as the last DP modification. Analytical data from the discharge monitoring reports are summarized in Table 5.2 and Table 5.3.

Table 5.2 – Sewage Lagoon and H–19 Analytical Results for Spring 2015

Analyte	Influent Pond 2A[(a)]	Evaporation Pond B	Evaporation Pond C	H–19 Evaporation Pond
Nitrate (mg/L)	ND	N/A	N/A	N/A
TKN (mg/L)	112	N/A	N/A	N/A
TDS (mg/L)	589 [(a)]	NS	NS	NS
Sulfate (mg/L)	49.0 [(a)]	NS	NS	NS
Chloride (mg/L)	94.8 [(a)]	NS	NS	NS

Notes:

mg/L Milligrams per liter.

N/A Not applicable.

ND Non-detect.

NS Not sampled.

TKN Total Kjeldahl nitrogen.

(a) Average of duplicate samples.

Table 5.3 – Sewage Lagoon, H-19, and Infiltration Control Pond Analytical Results for Fall 2015

Location	Nitrate (mg/L)	TKN (mg/L)	TDS (mg/L)	Sulfate (mg/L)	Chloride (mg/L)
Influent Pond 2A (Settling Lagoon 2)	ND	48.2	670[(a)]	53.6[(a)]	104[(a)]
Evaporation Pond B (Effluent Lagoon B)	N/A	N/A	50,600	883	33,500
Evaporation Pond C (Effluent Lagoon C)	N/A	N/A	272	4.0 J	121
H-19 Evaporation Pond	N/A	N/A	64,500[(a)]	49.5[(a)]	33,200[(a)]
Salt Pile Evaporation Pond (Salt Storage Pond 1)	N/A	N/A	6,330[(a)]	49.3[(a)]	3,770[(a)]
Salt Storage Extension Evaporation Basin I (Salt Storage Pond 2)	N/A	N/A	271,000	12,900	170,000
Salt Storage Extension Evaporation Basin II (Salt Storage Pond 3)	N/A	N/A	122,000	6,360	81,200
Pond 1 (Storm Water Pond 1)	N/A	N/A	421[(a)]	19.5[(a)]	186[(a)]
Pond 2 (Storm Water Pond 2)	N/A	N/A	480	13.6	230
Pond A (Storm Water Pond 3)	N/A	N/A	172	7.67	71.6

Notes:

J Estimated concentration between MDL and reporting limit.

N/A Not applicable.

ND Non-detect.

TKN Total Kjeldahl nitrogen (as N).

(a) Average of duplicate samples.

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

Current groundwater monitoring activities for the WIPP facility are outlined in the *WIPP Groundwater Monitoring Program Plan* (WP 02–1). In addition, the WIPP facility 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; Beauheim, 1987; Beauheim and Ruskauff, 1998.

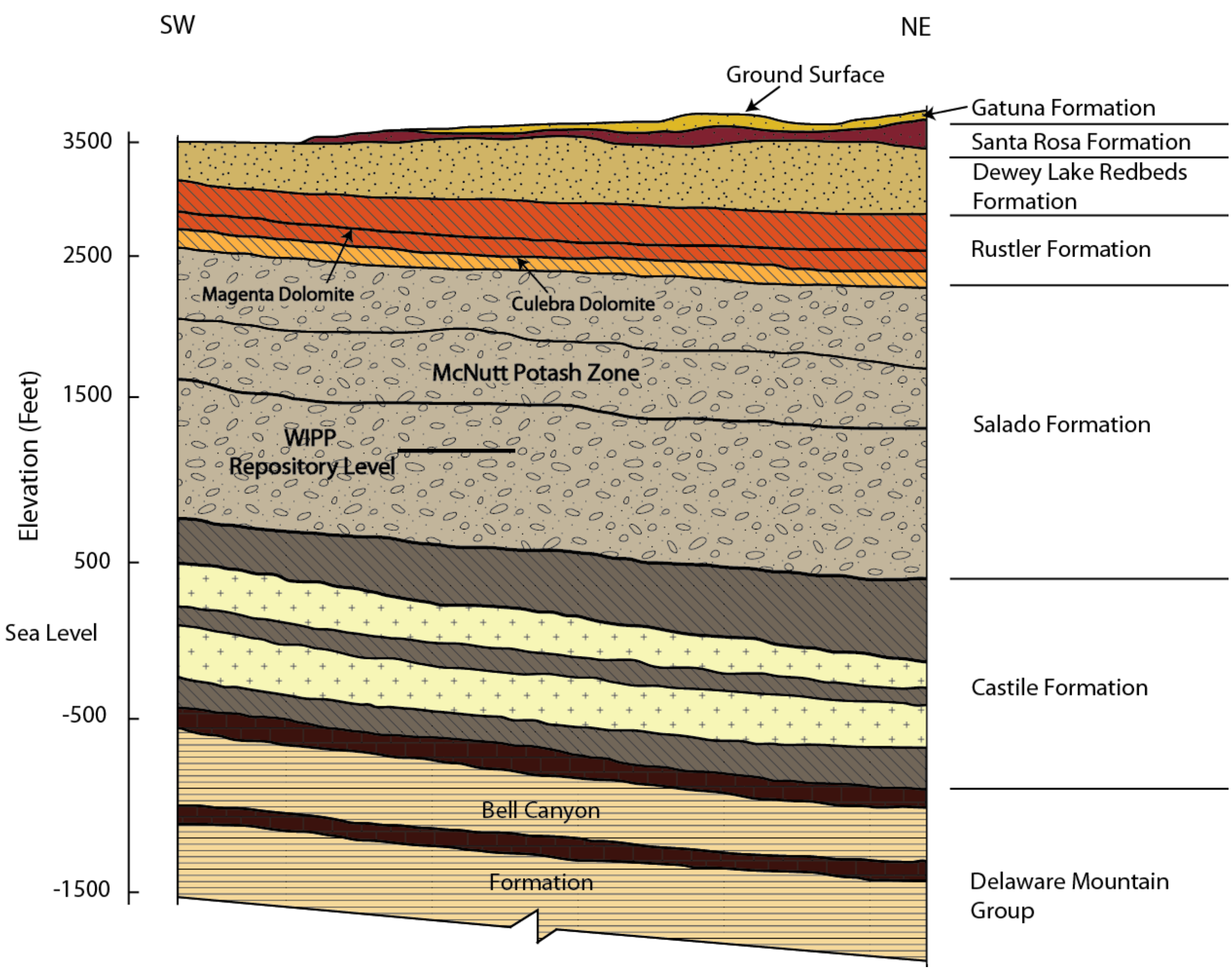


Figure 6.1 – WIPP Stratigraphy

6.1.1 Surface Hydrology

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

6.1.2 Subsurface Hydrology

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

6.1.2.1 Hydrology of the Castile Formation

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

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

6.1.2.2 Hydrology of the Salado Formation

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

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

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

6.1.2.3 Hydrology of the Rustler-Salado Contact

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

6.1.2.5 Hydrology of the Magenta Member

The Magenta is situated above the Culebra and, although it is not the water-bearing zone of interest for monitoring of a facility release, it is of interest in understanding water-level changes that occur in the Culebra. The Magenta has been tested in 18 cased and open holes at and around the WIPP site. Magenta transmissivities within the WIPP site range from 2.0E–04 to 3.5E–02 m^2/d (2.1E–03 to 3.8E–01 ft^2/d) (Beauheim et al., 1991; Beauheim and Ruskauff, 1998; Bowman and Roberts, 2009).

6.1.2.6 Hydrology of the Dewey Lake Redbeds Formation

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

WIPP monitoring well WQSP–6A (Figure 6.2) intersects natural water in the Dewey Lake. At this location, the saturated horizon is within the middle portion of the formation. The saturated zone at well WQSP–6A is both vertically and laterally distinct from the water at 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 Site and Preliminary Design Validation (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.

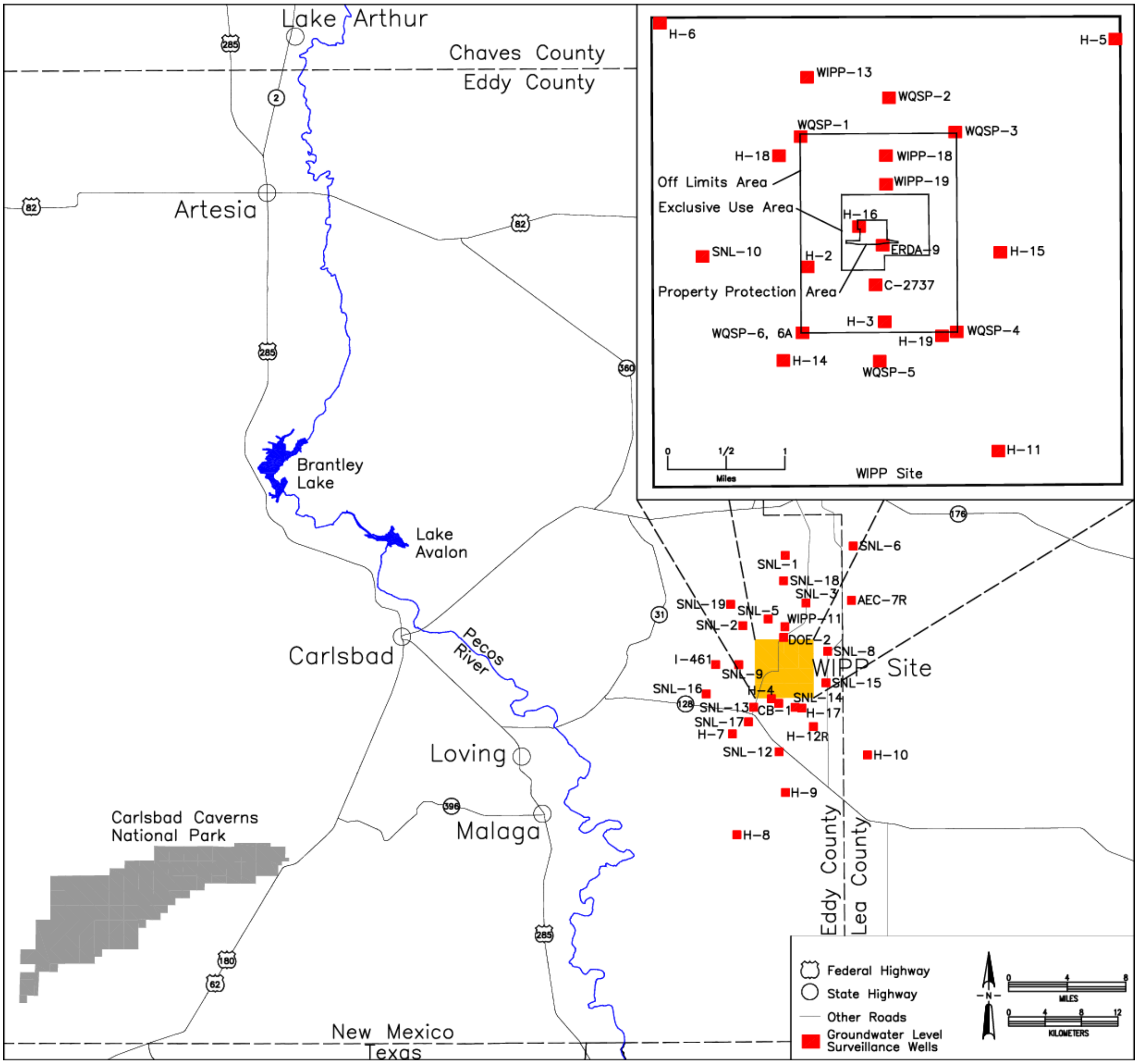


Figure 6.2 – Groundwater Level Surveillance Wells (Inset Represents the Groundwater Surveillance Wells in the WIPP Land Withdrawal Area)

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 the *Compliance Certification Application for the Waste Isolation Pilot Plant* (DOE/CAO–96–2184) and five-year recertification applications.

Baseline water chemistry data 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 2015 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 2015 included hydraulic testing and non-Permit groundwater quality sampling (Section 6.4). Table 6.1 presents a summary of WIPP groundwater monitoring activities in 2015.

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 2015.

Radiological data for 2015 from the DMP are summarized in Chapter 4. The remaining data from the DMP are contained in this chapter.

Table 6.1 – Summary of 2015 DOE WIPP Groundwater Monitoring Program

Number of Active Wells	84
Number of Physical Samples Collected	264[(a)]
Number of Water Level Measurements	777
Total Number of Analyte Measurements	1,362[(b)]

Notes:

(a) Includes primary, duplicate, and blank samples taken from six wells in 2015.

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

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

6.2.3 Groundwater Quality Sampling

The Permit requires groundwater quality sampling once a year, from March through May (Round 37 for 2015). 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 264 samples analyzed 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.

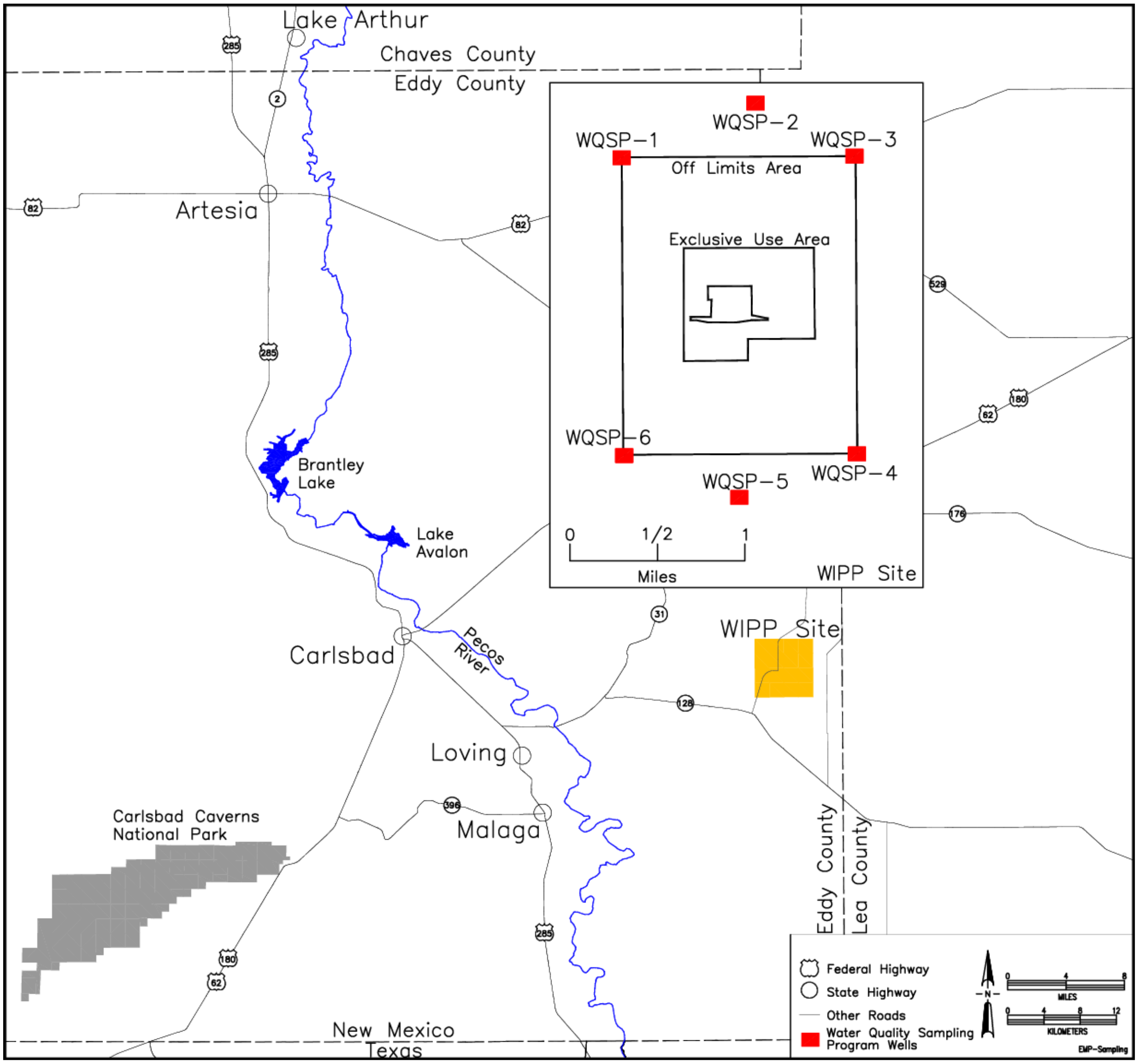


Figure 6.3 – Detection Monitoring Program Wells

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 2015 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-, & 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 2015, TDS concentrations in the Culebra (as measured in detection monitoring wells) varied from a low of 16,100 mg/L (WQSP–6) to a high of 222,000 mg/L (WQSP–3). The groundwater of the Culebra is considered to be Class III water (nonpotable) 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 2015, the TDS concentrations (see Table 6.6 later in this chapter) in water from well WQSP–6A, obtained from the Dewey Lake, averaged 3,405 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 2015 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 2015 (Round 37) 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 nondetectable concentrations of organic compounds, the limits for organic compounds were considered nonparametric and based on the contract-required MRL for the contract laboratory. These values were recomputed after the baseline sampling was completed in 2000 and were applied to sampling Round 37 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 37, including those of the major cations, were all below the concentrations from the baseline studies with the following exceptions:

- WQSP–1: The concentrations of total suspended solids (TSS) in the primary and duplicate groundwater samples were 50 mg/L and 44 mg/L, respectively, which are higher than the 95th percentile concentration of 33.3 mg/L.

- WQSP-2: The TSS concentrations of 56 mg/L in the primary groundwater sample and 47 mg/L in the duplicate sample were higher than the 95th percentile concentration of 43 mg/L.
- WQSP–3: The TSS concentrations of 151 mg/L in the primary groundwater sample and 149 mg/L in the duplicate sample were higher than the 95th percentile concentration of 107 mg/L.
- WQSP–5: The TSS concentrations in the primary and duplicate groundwater samples were 13 mg/L and 24 mg/L respectively, which are higher than the 95th percentile concentration of <10 mg/L.

The Round 37 VOC concentrations reported for man-made organic compounds were less than the Permit background values and less than the MRL in all groundwater samples. Water quality data for Round 37 can be found in the *Annual Culebra Groundwater* Report (U.S. Department of Energy, November 2015).

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 2015, water levels in 50 Culebra wells were measured (including the Culebra zone of a dual completion well and the well that was plugged and replaced) 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. Nineteen wells in the SSW zone of the Santa Rosa/Dewey Lake contact were measured and 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 2015 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 49 wells completed or isolated in the Culebra, which showed only 16 naturally changing wells. The subset of wells analyzed were those that had a sufficient period of record to analyze through CY 2015 (Appendix F, Table F.3). Additional filtering of the water level data could not be performed to remove wells affected by unnatural fluctuations for 2015 due to the vast majority of wells being impacted by pumping at Mills Ranch. If the pumping-impacted well data were removed, there would not have been enough data points for mapping. Excluded from trend analysis were SNL–6 and SNL–15, which were both in long-term water level recovery. Because they were only measured quarterly, the redundant H–19 wells were also excluded.

The dominant trend through 2015 on naturally occurring changes was a general decreasing freshwater equivalent level in the Culebra monitoring wells at the WIPP site. This decrease can be attributed to the wells returning to stabilization after the rain event that occurred in September 2014 resulting in 291.59 mm (11.48 in) for the month. Water level fell in 12 of the 16 naturally occurring water level changes, which averaged 1.05 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 2015, WQSP-4, 5 and 6 all experienced water level decreases greater than two feet due to the pumping associated with Mills Ranch. The Mills Ranch pumping is associated with selling water for oil field activities. Hydrographs for all Culebra groundwater wells are included in the *Annual Culebra Groundwater Report* (U.S. Department of Energy, November 2015).

For the Culebra wells in the vicinity of the WIPP site, equivalent freshwater heads for January 2015 were used to calibrate a groundwater flow model, which was used by Sandia National Laboratories (SNL) to compute a potentiometric surface using SNL procedure SP 9–9. This month was judged to have the most number of Culebra water levels available, few wells affected by pumping events, and all wells in quasi-steady state, with few individual wells contrary to the general water-level trend. Table 6.3 shows the water-level data set. Wells SNL–6 and SNL–15 were not included in the mapping because the elevations do not represent static conditions. These wells are located in the low transmissivity zone of the Culebra and after drilling and testing, are still in recovery to reach equilibrium. Adjusted freshwater heads are typically accurate to ±1.5 ft, given the density measurement error. Density measurement error is less than 0.019 specific gravity units (WP 02–1).

Table 6.3 – Water Level Elevations for the 2015 Potentiometric Surface Calibration, Culebra Hydraulic Unit

Well ID	Date of Measurement	Adjusted Freshwater Head (ft, amsl)	Density (g/cm^3)[(a)]	Notes
C-2737[(b)]	01/13/15	417.10	1.024	
ERDA-9	01/07/15	421.56	1.072	
H-02b2	01/13/15	349.87	1.012	
H-03b2[(b)]	01/07/15	425.45	1.027	
H-04bR[(b)]	01/07/15	389.88	1.027	
H-05b	01/06/15	466.40	1.089	

Table 6.3 – Water Level Elevations for the 2015 Potentiometric Surface Calibration, Culebra Hydraulic Unit

Well ID	Date of Measurement	Adjusted Freshwater Head (ft, amsl)	Density (g/cm³)[(a)]	Notes
H-06bR	01/03/15	291.61	1.038	
H-07b1	01/05/15	166.29	1.009	
H-09bR[(b)]	01/06/15	445.54	1.004	
H-10c	01/06/15	713.45	1.096	
H-11b4R[(b)]	01/07/15	475.79	1.077	
H-12R	01/07/15	543.00	1.042	
H-15R[(b)]	01/13/15	387.60	1.118	
H-16	01/07/15	462.69	1.035	
H-17[(b)]	01/07/15	464.39	1.134	
H-19b0[(b)]	01/05/15	239.58	1.067	
IMC-461	01/05/15	439.84	1.000	
SNL-01	01/05/15	253.41	1.030	
SNL-02	01/13/15	422.44	1.010	
SNL-03	01/05/15	310.06	1.027	
SNL-05	01/06/15	536.51	1.008	
SNL-06	01/06/15	540.06	1.246	Excluded from mapping
SNL-08	01/05/15	312.56	1.095	
SNL-09	01/06/15	331.13	1.018	
SNL-10	01/06/15	387.29	1.010	
SNL-12[(b)]	01/06/15	316.07	1.007	
SNL-13	01/07/15	426.76	1.022	
SNL-14[(b)]	01/07/15	522.75	1.046	
SNL-15	01/05/15	119.30	1.230	Excluded from mapping.
SNL-16	01/05/15	247.58	1.012	
SNL-17[(b)]	01/05/15	303.39	1.007	
SNL-18	01/07/15	543.00	1.009	
SNL-19	01/05/15	152.02	1.006	
WIPP-11	01/09/15	366.52	1.038	
WIPP-13	01/09/15	344.36	1.037	
WIPP-19	01/07/15	398.31	1.053	
WQSP-1	01/09/15	362.50	1.050	
WQSP-2	01/07/15	401.15	1.047	

Table 6.3 – Water Level Elevations for the 2015 Potentiometric Surface Calibration, Culebra Hydraulic Unit

Well ID	Date of Measurement	Adjusted Freshwater Head (ft, amsl)	Density (g/cm^3)[(a)]	Notes
WQSP-3	01/07/15	468.53	1.146	
WQSP-4	01/15/15	481.50	1.076	
WQSP-5	01/07/15	415.94	1.027	
WQSP-6	01/07/15	373.46	1.107	

Notes:

amsl Above mean sea level.

ID Identification.

(a) 2013 conversion to specific gravity at 70˚F.

(b) Significantly influenced by Mills Ranch Pumping.

Modeled freshwater head contours for January 2015 for the model domain are shown in Figure 6.4. 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 January 2015 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 January 2015 were computed using 2014 densities.

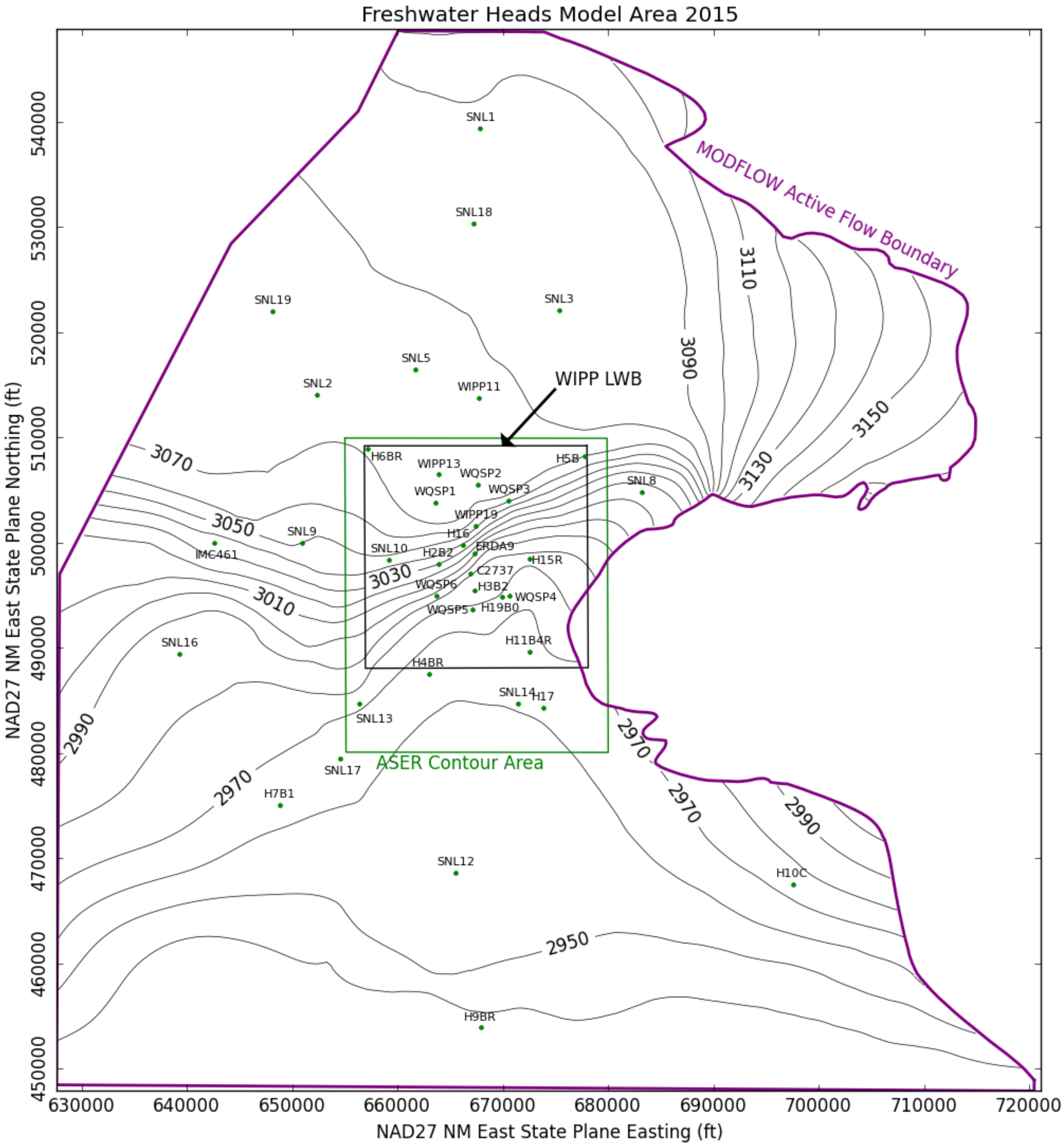


Figure 6.4 – Model-Generated February 2015 Freshwater Head Contours in the Model Domain (Contour in Feet Above Mean Sea Level)

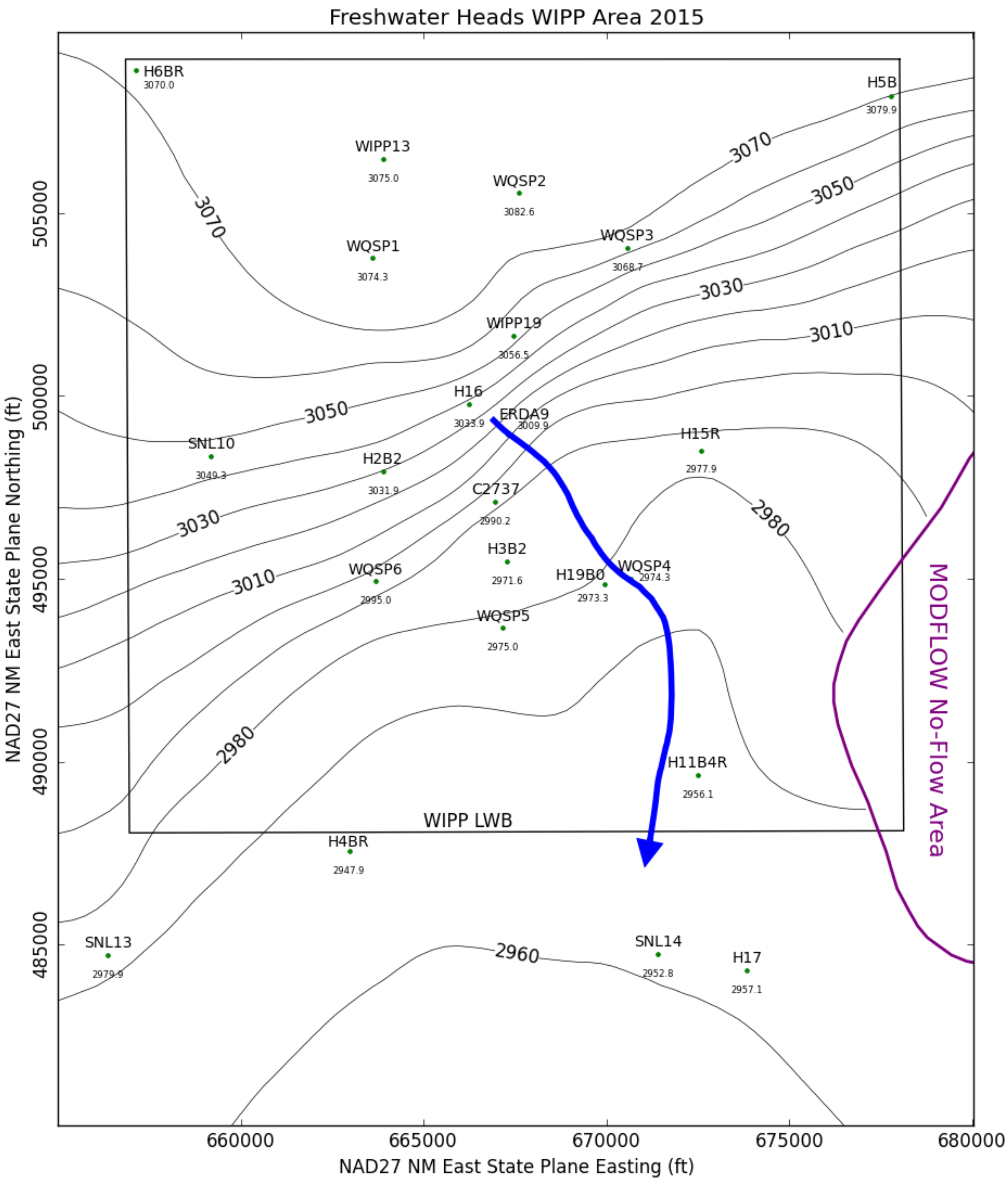


Figure 6.5 – Model-Generated February 2015 Freshwater Head Contours (5-ft Contour Interval) in the WIPP Vicinity with Water Particle Track (Dark Blue) from Waste-Handling Shaft to WIPP Land Withdrawal Boundary (Contour in Feet Above Mean Sea Level)

Figure 6.6 shows the difference between the modeled and observed freshwater heads is mainly in part due to pumping at the Mills Ranch (Thomas, 2016). The difference between observed freshwater head within the LWA boundary can be as large as 15 ft, particularly in the vicinity of H-4bR.

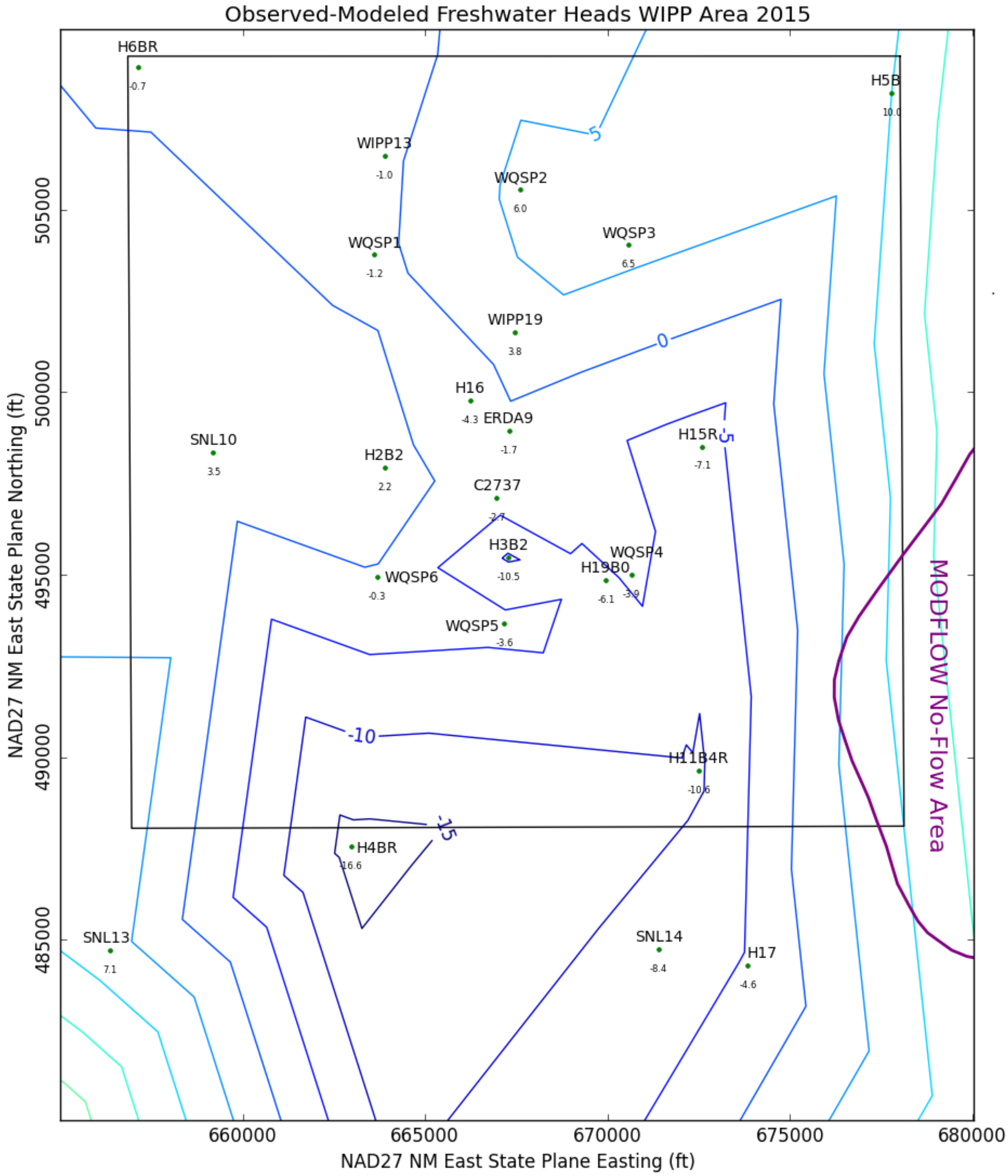


Figure 6.6 – Triangulated Contours (in 5-ft intervals) for Measured Minus Modeled Freshwater Head

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 Land Withdrawal Boundary (LWB) are represented by red crosses, wells outside but within 3 km of the LWB are represented with green '×'s, and other wells within the MODFLOW model domain but distant from the WIPP site are indicated with blue stars. AEC-7 was given a low weight (0.01) to prevent its large residual from dominating the optimization. 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.

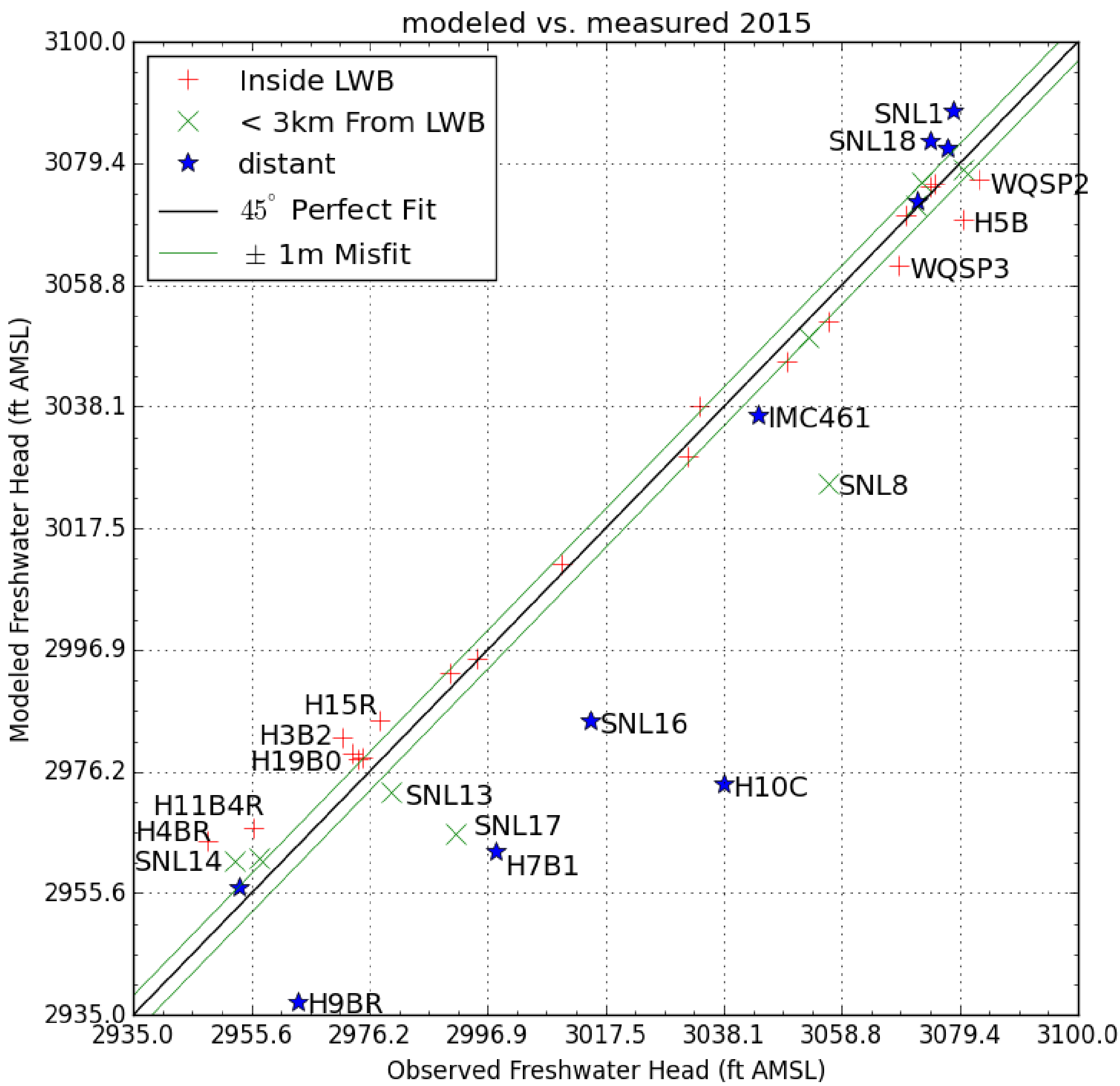


Figure 6.7 – Measured Versus Modeled Scatter Plot for Parameter Estimation Tool-Calibrated MODFLOW 2000 Generated Heads and February 2015 Freshwater Heads

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 4.092 km). Assuming a thickness of 4 m for the transmissive portion of the Culebra and a constant porosity of 16 percent, the travel time to the WIPP LWB is 3,647 years (output from DTRKMF is adjusted from a 7.75-m Culebra thickness), for an average velocity of 1.1 meter per year. This estimated flow velocity is higher than in previous years due to the steeper gradient caused by Mills Ranch pumping. Since the flow model has the ensemble hydraulic conductivity and anisotropy fields as inputs, the freshwater head contours and particle tracks take into account the variability of known aquifer conditions across the site.

6.2.6 Fluid Density Surveys

At the WIPP site, variable TDS concentrations result in variability in groundwater density (WP 02–1). WIPP personnel measure the density of well-bore fluids in water-level monitoring wells to adjust water levels to their equivalent freshwater head values. This allows more accurate determination of relative heads between wells. In 2015, densities were derived from 37 wells containing pressure transducers installed by SNL (Table 6.4), six wells from hydrometers as part of the DMP sampling program, and six from the redundant H–19 wells. This approach employed several calibrated pressure-measuring transducers dedicated to given wells during the year. For the DMP wells, field hydrometer measurements are always used. For comparison, 2013 and 2014 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 2015

	2013 Fluid Density Survey Result	2013 Conversion to Specific Gravity at 70°F	2014 Fluid Density Survey Result	2014 Conversion to Specific Gravity at 70°F	2015 Fluid Density Survey Result	2015 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 2013–2015 Fluid Density Survey
AEC-7	1.066	1.068	NA	NA	NA	NA	AEC-7 was plugged in 2013.
AEC-7R	NA	NA	1.071	1.073	1.056	1.058	AEC-7R was drilled in 2013.
C-2737	1.021	1.023	1.022	1.025	1.023	1.025	
ERDA-9	1.069	1.071	1.070	1.072	1.071	1.073	
H-02b2	1.011	1.013	1.010	1.012	1.009	1.011	

Well	2013 Fluid Density Survey Result	2013 Conversion to Specific Gravity at 70°F	2014 Fluid Density Survey Result	2014 Conversion to Specific Gravity at 70°F	2015 Fluid Density Survey Result	2015 Conversion to Specific Gravity at 70°F	Notes for 2013–2015 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-03b2	1.030	1.032	1.025	1.027	1.017	1.019	
H-04bR	1.015	1.017	1.025	1.027	1.027	1.029	
H-05b	1.090	1.092	1.087	1.089	1.083	1.085	
H-06bR	1.037	1.039	1.036	1.038	1.036	1.038	
H-07b1	1.005	1.007	1.007	1.009	1.007	1.009	
H-9bR	0.999	1.001	1.004	1.006	1.002	1.004	* Rounded up to 1.000 for 2012.
H-10c	1.093	1.095	1.096	1.098	1.095	1.097	Plugged in October 2015.
H-11b4R	1.074	1.076	1.077	1.079	1.076	1.078	
H-12	1.106	1.108	NA	NA	NA	NA	Plugged in 2014.
H-12R	NA	NA	1.040	1.042	1.106	1.108	Drilled in 2014 and developed. 2014 density is not representative of formation water.
H-15R	1.116	1.118	1.118	1.120	1.117	1.119	
H-16	1.034	1.036	1.035	1.037	1.032	1.034	
H-17	1.131	1.133	1.134	1.136	1.131	1.133	
H-19b0	1.064	1.066	1.067	1.069	1.064	1.066	
H-19b2	1.066	1.068	1.070	1.072	1.070	1.072	
H-19b3	1.064	1.066	1.073	1.075	1.070	1.072	
H-19b4	1.064	1.066	1.069	1.071	1.070	1.073	
H-19b5	1.067	1.069	1.072	1.074	1.072	1.074	
H-19b6	1.068	1.070	1.073	1.075	1.074	1.076	
H-19b7	1.068	1.070	1.073	1.075	1.073	1.075	
I-461	1.000*	1.000*	1.000*	1.000*	1.002	1.004	* Rounded up to 1.000 for 2012–2014.
SNL-01	1.028	1.030	1.030	1.032	1.028	1.030	
SNL-02	1.007	1.009	1.010	1.012	1.006	1.008	
SNL-03	1.026	1.028	1.027	1.029	1.026	1.028	
SNL-05	1.007	1.009	1.008	1.010	1.007	1.009	
SNL-06	1.241	1.243	1.246	1.248	1.244	1.246	
SNL-08	1.093	1.095	1.095	1.097	1.093	1.095	
SNL-09	1.016	1.018	1.018	1.020	1.016	1.018	
SNL-10	1.008	1.010	1.010	1.012	1.008	1.010	
SNL-12	1.004	1.006	1.007	1.009	1.005	1.007	
SNL-13	1.015	1.017	1.022	1.024	1.023	1.025	
SNL-14	1.044	1.046	1.046	1.048	1.042	1.044	

Well	2013 Fluid Density Survey Result	2013 Conversion to Specific Gravity at 70°F	2014 Fluid Density Survey Result	2014 Conversion to Specific Gravity at 70°F	2015 Fluid Density Survey Result	2015 Conversion to Specific Gravity at 70°F	Notes for 2013–2015 Fluid Density Survey
	Density (g/cm^3)	Density (g/cm^3)	Density (g/ cm^3)	Density (g/cm^3)	Density (g/cm^3)	Density (g/cm^3)	
SNL-15	1.227	1.229	1.230	1.232	1.229	1.231	
SNL-16	1.006	1.008	1.012	1.014	1.012	1.014	
SNL-17	1.003	1.005	1.007	1.009	1.007	1.009	
SNL-18	1.007	1.009	1.009	1.011	1.007	1.009	
SNL-19	1.005	1.007	1.006	1.008	1.003	1.005	
WIPP-11	1.036	1.038	1.038	1.040	1.036	1.038	
WIPP-13	1.038	1.040	1.037	1.039	1.034	1.036	
WIPP-19	1.050	1.052	1.053	1.055	1.048	1.050	
WQSP-1	1.047	1.049	1.048	1.050	1.047	1.049	Average of Round 37 field hydrometer measurements.
WQSP-2	1.045	1.047	1.045	1.047	1.045	1.047	Average of Round 37 field hydrometer measurements.
WQSP-3	1.146	1.148	1.144	1.146	1.143	1.146	Average of Round 37 field hydrometer measurements.
WQSP-4	1.074	1.076	1.074	1.076	1.074	1.076	Average of Round 37 field hydrometer measurements.
WQSP-5	1.025	1.027	1.025	1.027	1.027	1.029	Average of Round 37 field hydrometer measurements.
WQSP-6	1.013	1.015	1.015	1.017	1.017	1.019	Average of Round 37 field hydrometer measurements.

Notes:

NA No available measurement.

6.3 Drilling Activities

Well H-10c was plugged and abandoned due to its deteriorating condition and replaced by H-10cR in September 2015. The total depth of the drill hole was 428.24 m (1405 ft) below ground surface with the screened interval in the Culebra at 413.67–420.62 m (1357.2–1380 ft) below ground surface.

6.4 Hydraulic Testing and Other Water Quality Sampling

In addition to the chemical testing in the six DMP wells as required by the Permit, WIPP personnel conducted basic water chemistry tests in two other wells as listed in Table 6.5.

Table 6.5 – 2015 Well Testing Activities

Well Location	Dates	Activity
AEC-7R, Culebra	March 2015	SNL 80 hr pump test
H-12R, Culebra	April 2015	SNL 80 hr pump test

6.5 Well Maintenance

Well maintenance was conducted at IMC-461 in July and August of 2015. The maintenance in July included treating the well with a de-scaler followed by brushing and clearing the well of mineral obstructions.

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 6.8). Water yields are generally less than 1 gallon per minute in monitoring wells and piezometers, and the water contains varying concentrations of TDS (910 mg/L to 274,000 mg/L) and chloride (167 mg/L to 197,000 mg/L). To the south, yields are greater and TDS and chloride concentrations lower. The origin of the high TDS and chlorides in this water is believed to be primarily from anthropogenic sources, with some contribution from natural sources. The SSW occurs not only under the WIPP site surface facilities but also to the south, as indicated by shallow water in drill hole C-2811, about one-half mile south of the WIPP property protection fence.

In order to investigate the SSW, 15 piezometers (PZ–1 to PZ–15) and four wells (C-2505, C–2506, C–2507, and C–2811) were drilled as part of a monitoring program to measure spatial and temporal changes in SSW levels and water quality. Monitoring activities during 2015 included SSW level surveillance at these 19 locations.

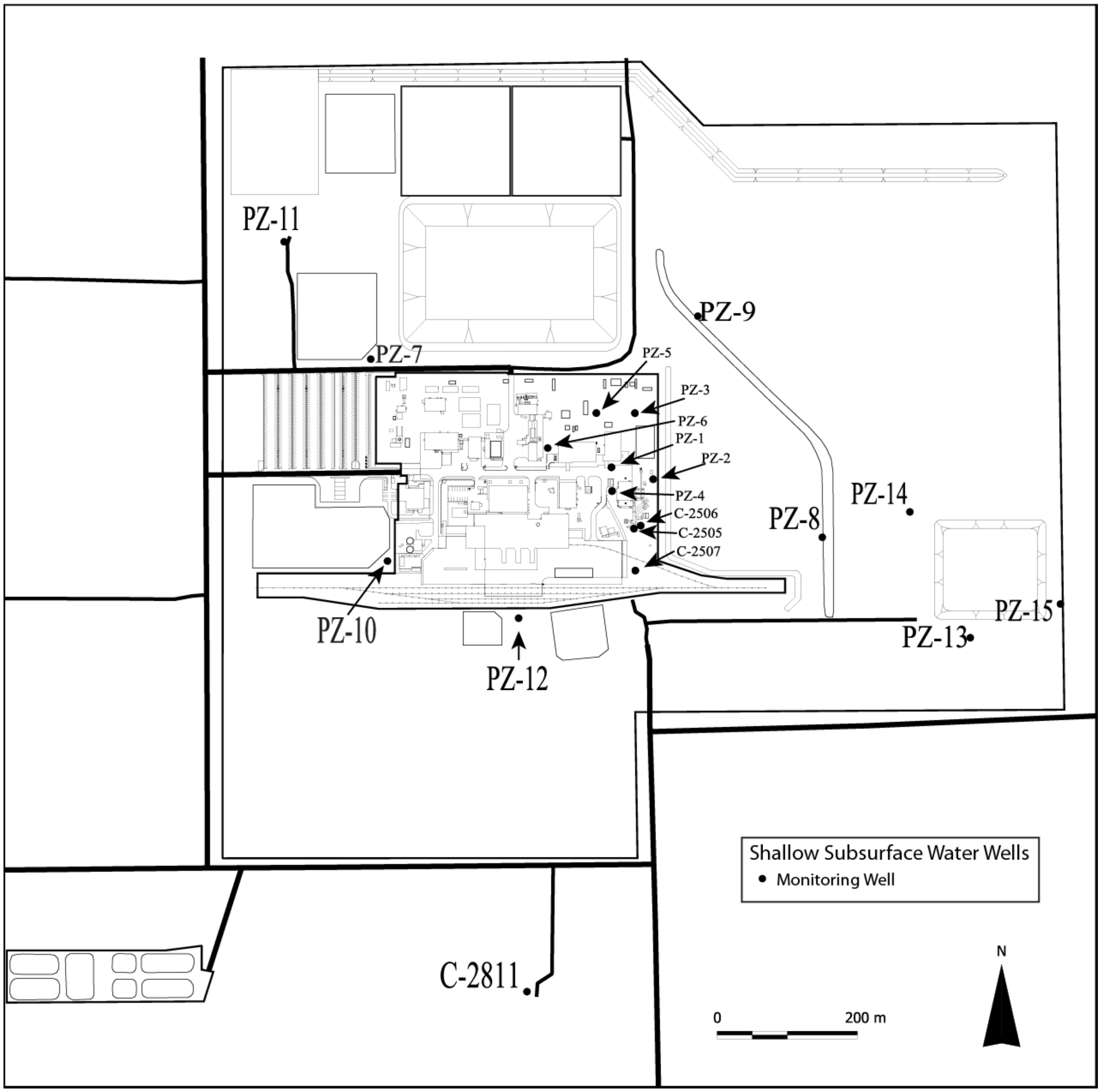


Figure 6.8 – Location of Shallow Subsurface Water Wells (Piezometers PZ–1 through PZ–15, C-2811, C–2505, C–2506, and C–2507)

In 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 (J. C. 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 May and November 2015, and the parameters shown in Table 6.6 were analyzed.

Table 6.6 – 2015 DP-831 Shallow Subsurface Water Quality Sampling Results

Monitoring Site	Sample Date	Nitrate (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	TDS (mg/L)	TKN (mg/L)
PZ-1	5/13/2015	NA	1,830	40,800	73,400	NA
PZ-1	11/10/2015	NA	1,740	37,100	75,800	NA
PZ-5	5/13/2015	NA	1,100	7,380	14,800	NA
PZ-5	11/10/2015	NA	917	7,470	15,200	NA
PZ-6	5/13/2015	NA	2,180	49,200	77,000	NA
PZ-6	11/10/2015	NA	1,900	37,500	69,200	NA
PZ-7	5/12/2015	NA	3,240	68,200	118,000	NA
PZ-7	11/9/2015	NA	2,960	44,900	114,000	NA
PZ-9	5/13/2015	NA	7,090	112,000	175,000	NA
PZ-9	11/10/2015	NA	4,390	84,300	176,000	NA
PZ-10	5/12/2015	NA	435	370	1,620	NA
PZ-10	11/9/2015	NA	339	255	1,310	NA
PZ-11	5/12/2015	NA	2,590	57,000	105,000	NA
PZ-11	11/9/2015	NA	2,770	59,900	96,400	NA
PZ-12	5/12/2015	NA	665	4,470	8,720	NA
PZ-12	11/9/2015	NA	627	3,450	8,280	NA
PZ-13	5/13/2015	NA	3,550	197,000	267,000	NA
PZ-13	11/10/2015	NA	2,980	118,000	233,000	NA
C-2811	5/12/2015	NA	586	1,430	3,460	NA
C-2811	11/9/2015	NA	451	1260	3,300	NA
C-2507	5/13/2015	NA	683	3,430	7,590	NA
C-2507	11/10/2015	NA	605	2,800	6,850	NA
WQSP-6A	5/14/2015	5.11	1,940	294	3,520	<1.0
WQSP-6A	11/11/2015	5.45	1,840	296	3,290	<1.0

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

6.6.2 Shallow Subsurface Water Level Surveillance

A water budget analysis in 2003 (Daniel B. Stephens & Associates, Inc., 2003) indicated that seepage from five primary sources (salt pile and four surface water detention basins) provided sufficient recharge to account for the observed SSW saturated lens, and that the lens was expected to spread.

The potential extent for long-term SSW migration was examined by expanding the saturated flow model domain to include the 16-mi^2 WIPP LWA. 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 2015 data is presented in Figure 6.9. The contours were generated using *SURFER*, Version 11, 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.

6.7 Public Drinking Water Protection

The water wells nearest the WIPP site that use the natural shallow groundwater for domestic use are the Barn Well and Ranch Well located on the J. C. Mills Ranch. These wells are located approximately 3 mi south-southwest of the WIPP surface facilities and about 1.75 mi south of WQSP–6A (Figure 6.2). These wells are used for livestock and industrial purposes. Total dissolved solids in the Barn Well have ranged from 630 to 720 mg/L, and TDS concentrations in the Ranch Well have ranged from 2,800 to 3,300 mg/L (DOE/CAO–96–2184).

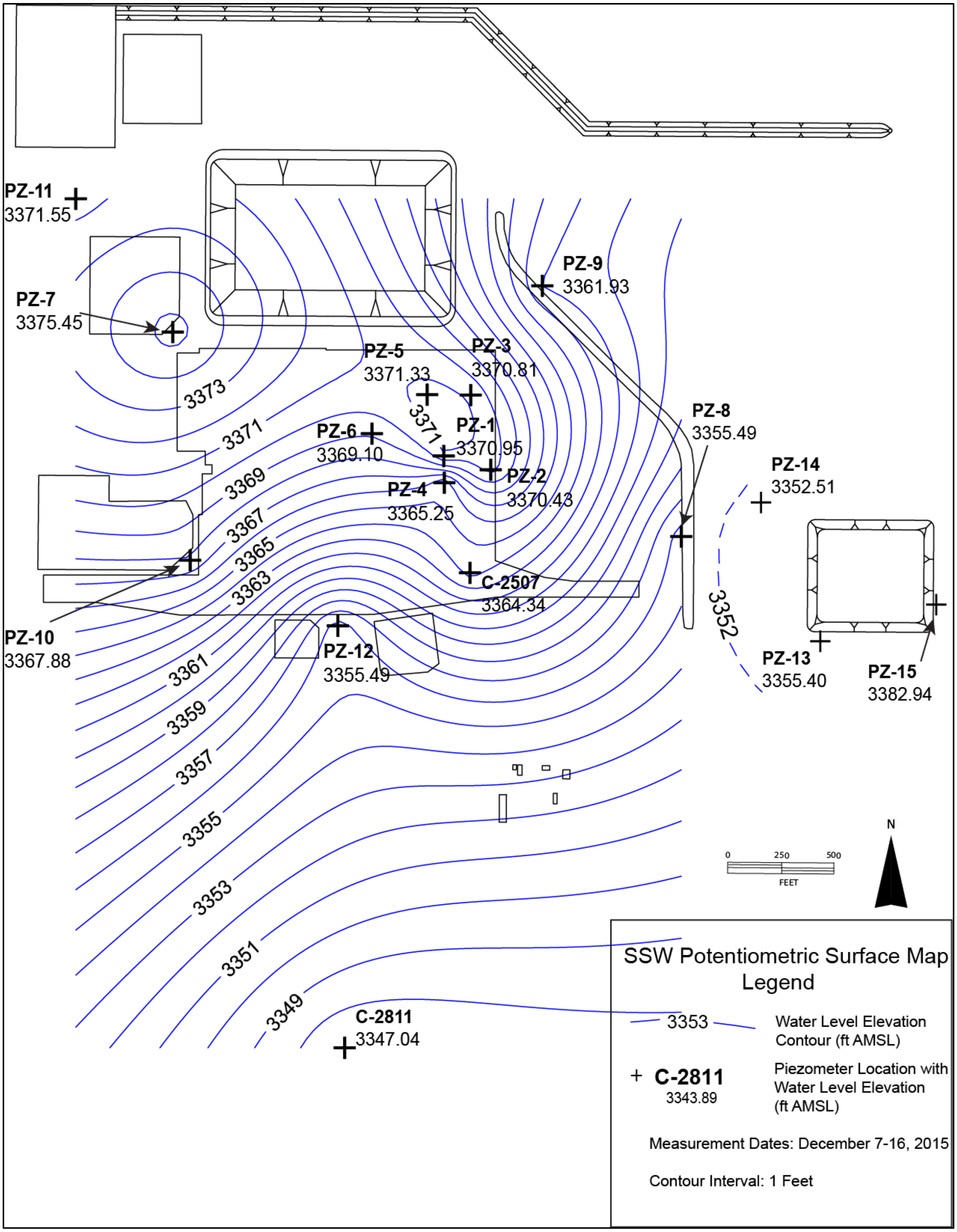


Figure 6.9 – Shallow Subsurface Water Potentiometric Surface

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. Samples are collected and analyzed in sample delivery groups along with the requisite QC samples using standardized and proven 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 2015, WIPP Laboratories performed the radiological analyses of environmental samples from the WIPP site. The Organic Chemistry Laboratory at the Carlsbad Environmental Monitoring and Research Center (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 analyses. In addition, HEAL subcontracted groundwater analyses to Anatek Laboratories 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 NELAC Institute. All reports from Anatek Laboratories are received by HEAL and reviewed before they are submitted to WIPP and included in WIPP reports.

All the laboratories, except CEMRC, demonstrated the quality of their analytical data through participation in reputable, inter-laboratory comparison programs such as the National Institute of Standards and Technology Radiochemistry Intercomparison Program (NRIP), Mixed Analyte Performance Evaluation Program (MAPEP), and National Environmental Laboratory Accreditation Conference (NELAC) proficiency testing studies. Laboratories used by WIPP are also required to 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 Organic Chemistry Laboratory at CEMRC was not required to participate in inter-comparison programs during 2015.

The WIPP sampling program and the subcontracted analytical laboratories operate in accordance with QA plans and QA project plans that incorporate QA requirements from the MOC *Quality Assurance Program Description*. These plans address the following elements:

- Management and organization
- Quality system and description
- Personnel qualification and training

- Procurement of products and services, including supplier-related nonconformances
- Documents and records
- Computer hardware and software
- Planning
- Management of work processes (SOPs)
- Assessment and response
- Quality improvement, including the reporting of non-administrative nonconformances.

To ensure that the quality of systems, processes, and deliverables is maintained or improved, three layers of assessments and audits are performed:

- DOE/CBFO performs assessments and audits of the MOC QA program.
- MOC performs internal assessments and audits of its own QA program.
- MOC performs assessments and audits of subcontractor QA programs as applied to MOC contract work.

The QA objectives for the sampling and analysis program are completeness, precision, accuracy, comparability, and representativeness. Each laboratory processes QA/QC data independently according to laboratory SOPs and statements of work (SOWs). Sections 7.1, 7.2, and 7.3 discuss the QC results for the WIPP Laboratories, CEMRC, and HEAL/Anatek, 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. The reported concentrations at various locations in 2015 were generally representative of the baseline concentrations with no residual concentrations of $^{239/240}$Pu and ^{241}Am which were released during the February 2014 radiation release event.

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

Samples and measurements for all environmental media (air particulate composites, groundwater, surface water, soil, sediment, plant, and animal) were 100 percent complete for 2015.

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 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 matrix type. (Field duplicates would not necessarily apply to all sample types, such as small animals.) The precision of laboratory duplicates was reported by WIPP Laboratories and reviewed by the data validator, and the precision of field duplicates was calculated and reviewed by the data validator.

The measure of precision for radionuclide sample analyses is the RER, which is expressed as:

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

Where:

RER = relative error ratio

(Activity)pri = activity of the primary sample

(Activity)dup = activity of the duplicate sample

1 σ TPU = total propagated uncertainty at the 1 σ level

In order to generate analysis precision data, the laboratory performed duplicate analyses 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 duplicate analyses of separate aliquots of the same sample evaluated the precision of sub-sampling in the laboratory, the heterogeneity of the media sampled, 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 this ASER. The verification and validation review showed that every laboratory duplicate RER met the WIPP QA objective of less than two for the sample batches analyzed in 2015, demonstrating good precision for the analysis procedures.

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 sometimes had to be 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. Duplicate field samples were taken from a single deer specimen and analyzed as a measure of combined sampling and analysis precision. However, the collection and analysis of separate biota samples as field duplicates could result in poorer precision due to actual differences in the levels of radionuclides in the 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, April 2009). This source suggests that 85 percent of field duplicates should yield RERs less than 1.96. Thus, 15 percent of the precision values would be allowed to be greater than 1.96. Table 7.1 summarizes the field duplicate samples with precision RERs greater than 1.96 from the data in Tables 4.6, 4.10, 4.14, 4.19, 4.23, 4.26, and 4.29 (see Appendix C for location codes). Duplicate analysis results for all the target radionuclides are considered, not just those results where the analyte was detected.

Table 7.1 – Summary of Field Duplicate Precision Analysis Results with RERs >1.96

Matrix	Duplicate Sample	Radionuclide	RER	Detected?
Air Filter Composite	None	NA	NA	NA
Groundwater	WQSP-1	^{235}U	2.497	Yes
Groundwater	WQSP-3	^{235}U	3.298	Yes
Sediment	NOY Dup	^{235}U	2.494	No/Yes[(a)]
Sediment	UPR	^{238}U	2.337	Yes
Soil	WSS (2 – 5 cm)	^{235}U	2.022	No/Yes[(a)]
Vegetation Biota	WEE	^{235}U	2.285	No
Vegetation Biota	WEE	^{238}U	3.027	Yes
Deer Biota	SOO	^{137}Cs	2.248	No
Fish Biota	PEC	^{238}U	2.266	No

(a) Detected in the duplicate sample but not the primary sample.

The data in Table 7.1 show that there were nine cases where the field duplicate RERs were >1.96. The total number of RER measurements was 210. Thus, 95.7 percent of the field duplicate precision results were <1.96, which readily met the precision objective. Five of the nine measurements were for ^{235}U, which was present in some but not all samples. In the case of one sediment and one soil sample, the ^{235}U was detected in the duplicate sample but not the primary sample. Three of the nine cases (two vegetation, one fish) involved the sampling of separate specimens where the composition could be different in the samples.

In summary, the precision of the combined sampling and analysis procedures was good based on nearly all the RERs meeting the precision objective of less than 1.96 for field duplicate samples.

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 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 are spiked with tracers, samples for ^{90}Sr analysis are spiked with a carrier, and air filter samples for gamma analysis are spiked with a ^{22}Na tracer. The percent recovery of the tracers and carriers are reported as a measure of accuracy, and the analysis results are 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 National Institute of Standards and Technology-traceable radiochemistry standards for instrument calibration. The reagent method blanks were used to confirm that the accuracy of the radiological sample analysis was not adversely affected by the presence of any of the target radionuclides as background contaminants that may have been introduced during sample preparation and analysis. The filter matrix blank sample was an unused clean particulate filter that was not used for sampling but was analyzed to correct for any particulate filter background. The RLCSs were analyzed to check that the analytical method was in control by measuring the percent recoveries of the target radionuclides spiked into clean water. Duplicate RLCS samples were prepared and analyzed for some of the radiochemical batches, when laboratory duplicate samples were not available, e.g., air filter composite samples.

The radiochemical SOW requires the measured accuracy to meet control criteria or guidelines established in the industry-standard methods used for sample analysis. However, the SOW does not require the analysis of matrix spike / matrix spike duplicate MS/MSD samples as a measure of accuracy and precision.

National Institute of Standards and Technology-traceable standards were spiked into clean water or a clean solid matrix to prepare RLCS samples. Analysis of RLCSs containing the radionuclides of interest was performed on a minimum 10 percent basis (1 per batch of 10 or fewer samples). The QA objective for the analysis results was for the measured concentration to be within ±20 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 all 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, the DOE Laboratory Accreditation Program, and the NRIP inter-laboratory comparison program (through National Institute of Standards and Technology), as discussed in more detail in Section 7.1.4. Under these programs, WIPP Laboratories analyzed blind performance evaluation samples, and the analysis results were compared with the official results measured by the DOE Laboratory Accreditation Program, MAPEP, and NRIP 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

The DOE Laboratory Accreditation Program and NRIP primarily include the analyses of bioassay samples (urine and feces). Bioassay samples are not analyzed as part of the WIPP environmental program, and NRIP and DOE Laboratory Accreditation Program performance evaluation bioassay analysis results are not specifically discussed in this report. The NRIP bioassay samples are part of an emergency preparedness exercise where the accuracy has a relatively wide acceptance range, but a fast turnaround time for reporting the results is very important.

WIPP Laboratories analyzed eight MAPEP environmental samples consisting of two each of soil, water, air filter, and vegetation samples. The analysis results are presented in Section 7.1.4. 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 samples.

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, MAPEP, and NRIP involve preparing QC samples containing various alpha-, beta-, and gamma-emitting radionuclides in synthetic urine, synthetic feces, air filter, water, soil, and vegetation media, and distributing the samples to the participating laboratories.

The programs are inter-laboratory comparisons in that the analysis results generated by the laboratory participants are compared with the analysis results experimentally measured by the administering agencies. The programs assess each laboratory's analysis results as acceptable (passing) or not acceptable (failing), based on the accuracy of the analyses. A warning may be issued for a result near the borderline of acceptability.

Table 7.2 presents the analysis results for the first set of MAPEP soil, water, air filter, and vegetation performance evaluation samples (Series 32) analyzed in 2015. The acceptable range for the MAPEP samples is a bias less than or equal to ±20 percent; the acceptable range with a warning is a bias greater than ±20 percent but less than ±30 percent, and the not acceptable (N) results are those with a bias greater than ±30 percent.

The WIPP Laboratories analysis results for the soil, water, air filter, and vegetation samples showed that the results were acceptable for the target radionuclides, which 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.

Table 7.2 – Mixed Analyte Performance Evaluation Program Review for WIPP Laboratories, 2015, First Set (Series 32)

Analyte	MATRIX: Soil (Bq/kg) MAPEP–15–MaS32				MATRIX: Water (Bq/L) MAPEP–15–MaW32			
	Reported [RN][(a)]	MAPEP[(b)] [RN][(a)]	E[(c)]	% Bias	Reported [RN][(a)]	MAPEP[(b)] [RN][(a)]	E[(c)]	% Bias
^{241}Am	95.7	97	A	-1.3	0.586	0.654	A	-10.4
^{60}Co	773	817	A	-5.4	0.158	(d)	A	NA
^{137}Cs	0.603	(d)	A	NA	18.1	19.1	A	-5.2
^{238}Pu	83.3	83.9	A	-0.7	0.00650	0.0089	A	(e)
$^{239/240}$Pu	69.4	70.8	A	-2.0	0.791	0.832	A	-4.9
^{90}Sr	593	653	A	-9.2	9.27	9.48	A	-2.2
$^{233/234}$U	53.0	52.5	A	1.0	0.143	0.148	A	-3.4
^{238}U	191	201	A	-5.0	0.942	0.97	A	-2.9
^{40}K	621	622	A	-0.2	3.42	(d)	A	NA
Analyte	**MATRIX: Air Filter (Bq/Filter) MAPEP–15–RdF32**				**MATRIX: Vegetation (Bq/Sample) MAPEP–15–RdV32**			
	Reported [RN][(a)]	**MAPEP[(b)] [RN][(a)]**	**E[(c)]**	**% Bias**	**Reported [RN][(a)]**	**MAPEP[(b)] [RN][(a)]**	**E[(c)]**	**% Bias**
^{241}Am	0.0630	0.0681	A	-7.5	0.101	0.108	A	-6.5
^{60}Co	0.0346	(d)	A	NA	4.78	5.55	A	-13.9
^{137}Cs	-0.0189	(d)	A	NA	7.52	9.18	A	-18.1
^{238}Pu	0.000543	(d)	A	NA	0.0842	0.085	A	-0.9
$^{239/240}$Pu	0.0841	0.0847	A	-0.7	0.0908	0.094	A	-3.4
^{90}Sr	-0.00168	(d)	A	NA	1.08	1.08	A	0.0
$^{233/234}$U	0.0142	0.0155	A	-8.4	0.0231	0.0218	A	6.0
^{238}U	0.0889	0.099	A	-10.2	0.115	0.128	A	-10.2
^{40}K	NR	NR	NA	NA	NR	NR	NA	NA

Notes:
Bq/kg Becquerels per kilogram.
NA Not applicable.
NR Not reported by MAPEP.
(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.

The lab also reported gross alpha/beta results for air filter sample MAPEP–13–GrF32 (not shown). Gross alpha/beta results are not reported in the ASER, but the weekly low-volume air particulate filter samples are analyzed by gross alpha/beta before they are combined on a quarterly basis and analyzed as the quarterly air filter composite samples reported in the ASER. The gross alpha acceptable range is ±70 percent, and the gross beta acceptance range is ±50 percent. The WIPP Laboratories analysis results showed a -37.9 percent bias for gross alpha and a -11.3 percent bias for gross beta. Thus, the results were within the acceptable range.

Table 7.3 presents the results for the second set of MAPEP soil, water, air filter, and vegetation performance evaluation samples (MAPEP–14, Series 33) analyzed in 2015. The data in Table 7.3 show that the WIPP Laboratories results for the MAPEP Series 33 samples were acceptable for the target radionuclides in the soil, air filters, water, and vegetation samples with just one "Warning" for ^{40}K in soil where the WIPP Laboratories result was just 0.9 percent bias higher (20.9) that the upper acceptance limit for bias (20).

Table 7.3 – Mixed Analyte Performance Evaluation Program Review for WIPP Laboratories, 2015 Second Set (Series 33)

	MATRIX: Soil (Bq/g) MAPEP–14-MaS33				MATRIX: Water (Bq/L) MAPEP–14–MaW33			
Analyte	**Reported [RN][a]**	**MAPEP[b] [RN][a]**	**E[c]**	**% Bias**	**Reported [RN][a]**	**MAPEP[b] [RN][a]**	**E[c]**	**% Bias**
^{241}Am	48.4	49.5	A	-2.2	1.01	1.055	A	-4.3
^{60}Co	1.76	1.30	A	(e)	15.9	17.1	A	-7.0
^{137}Cs	966	809	A	19.4	0.139	(d)	A	NA
^{238}Pu	97.5	97.5	A	0.0	0.648	0.681	A	-4.8
$^{239/240}$Pu	82.6	80.4	A	2.7	0.884	0.900	A	-1.8
^{90}Sr	359	425	A	-15.5	4.49	4.80	A	-6.5
$^{233/234}$U	57.6	56	N	2.9	1.19	1.14	A	4.4
^{238}U	219	220	A	-0.5	1.16	1.18	A	-1.7
^{40}K	724	599	W	20.9	198	214	A	-7.5
	MATRIX: Air Filter (Bq/filter) MAPEP–14–RdF33				**MATRIX: Vegetation (Bq/Sample) MAPEP–14–RdV33**			
[RN]	**Reported Value**	**MAPEP Value**	**E[c]**	**% Bias**	**Reported Value**	**MAPEP Value**	**E[c]**	**% Bias**
^{241}Am	0.135	0.147	A	-8.2	0.110	0.108	A	1.9
^{60}Co	1.68	1.71	A	-1.8	5.21	4.56	A	14.3
^{137}Cs	2.03	1.96	A	3.6	-0.0917	(d)	A	NA
^{238}Pu	0.102	0.104	A	-1.9	0.000855	0.0007	A	(e)
$^{239/240}$Pu	0.00268	0.0025	A	(e)	0.0824	0.077	A	7.0
^{90}Sr	1.95	2.18	A	-10.6	1.31	1.30	A	0.8
$^{233/234}$U	0.148	0.143	A	3.5	0.165	0.162	A	1.9
^{238}U	0.139	0.148	A	-6.1	0.178	0.168	A	6.0
^{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 collect environmental data that can be used to determine that the health and safety of the population surrounding the WIPP facility is being protected. According to the SOW, analytical representativeness is ensured through the use of technically sound and accepted approaches for environmental investigations, including industry-standard procedures for sample collection and monitoring for potential sample cross-contamination through the analysis of field blank samples and laboratory method blank samples. These conditions were satisfied during the sample collection and analysis practices of the WIPP Environmental Monitoring Program.

The environmental media samples (air, groundwater, surface water, soil, sediment, and biota) were collected from areas representative of potential pathways for intake of radionuclides. The samples were collected using generally accepted methodologies for environmental sampling, ensuring that they would be representative of the media sampled. Both sample collection blanks (field blanks) and laboratory method blanks were used, as appropriate, to check for cross-contamination and to ensure sample integrity.

7.2 Carlsbad Environmental Monitoring and Research Center

The Organic Chemistry Laboratory at CEMRC performed the analyses of VOC samples collected at the WIPP facility during 2015.

7.2.1 Completeness

Completeness is defined in WP 12–VC.01, *Volatile Organic Compound Monitoring Program*, and WP 12–VC.04, *Quality Assurance Project Plan for Hydrogen and Methane Monitoring*, as being “the percentage of the ratio of the number of valid sample results received that meet other quality objectives versus the total number of samples required to be collected.” The QA objective for completeness for each monitoring program is 95 percent.

For 2015, 245 VOC samples (including field duplicates and additional surface samples) were submitted to CEMRC for analysis; 245 of these produced valid data. For surface

VOC monitoring, the program analytical completion percentage was 100 percent. Although eight samples were ultimately rejected due to suspected sampling equipment contamination issues, the produced analytical data were valid.

7.2.2 Precision

Precision is demonstrated in both the VOC monitoring and hydrogen and methane monitoring programs by evaluating results from both laboratory duplicate analysis and field duplicate samples. The laboratory duplicate samples consist of a laboratory control sample (LCS) and a laboratory control sample duplicate (LCSD) and laboratory sample duplicates (duplicate runs of monitoring program samples). The field duplicate is a duplicate sample that is collected in parallel with the original sample. Duplicate samples are evaluated using the relative percent difference (RPD), as defined in WP 12–VC.01 and WP 12–VC.04. The RPD is calculated using the following equation.

$$RPD = \frac{|(A-B)|}{(A+B)\,/\,2} \times 100$$

Where:

RPD = relative percent difference

A = original sample result

B = duplicate sample result

A LCS and a LCSD were generated and evaluated for data submitted in 2015. The LCS/LCSD data generated during 2015 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 2015, 19 of 19 field duplicates met the acceptance criterion.

7.2.3 Accuracy

The VOC monitoring program evaluates both quantitative and qualitative accuracy and recovery of internal standards. Qualitative evaluation consists of the evaluation of standard ion abundance for the instrument tune, which is a mass calibration check with bromofluorobenzene performed prior to analyses of calibration curves and samples.

The hydrogen and methane monitoring program evaluates quantitative accuracy. The quantitative evaluation includes performance verification for instrument calibrations and LCS recoveries.

7.2.3.1 Quantitative Accuracy

Instrument Calibrations

Instrument calibrations are required to have a relative standard deviation percentage of less than or equal to 30 percent for each analyte of the calibration. For VOCs, this is calculated by first calculating the relative response factor as indicated below.

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

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

For hydrogen and methane, the calculations are similar except the method does not require internal standards and thus not factored into the equations.

During 2015, 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 2015, 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 2015, 100 percent of internal standards met the ±40 percent criterion.

Sensitivity

To meet sensitivity requirements, MDL for each of the nine target compounds must be evaluated before sampling begins. The initial and annual MDL evaluation is performed in accordance with Appendix B of 40 CFR Part 136, “Guidelines Establishing Test Procedures for the Analysis of Pollutants,” and with Chapter 1, *Quality Control,* of EPA

SW–846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (1996). The CEMRC met the MDL requirements for 2015 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 2015, ion abundance criteria were within tolerance.

7.2.4 Comparability

There is no Permit requirement for comparability in the VOC monitoring program and the hydrogen and methane monitoring program. However, comparability is maintained through the use of consistent, approved SOPs for sample collection and analyses.

7.2.5 Representativeness

Representativeness is ensured by use of programmatic plans and procedures implementing EPA guidance designed to collect and analyze samples in a consistent manner.

7.3 Hall Environmental Analysis Laboratory

HEAL performed the chemical analyses for the Round 37 groundwater sampling in 2015. HEAL followed laboratory SOPs based on standard analytical methods from EPA and from *Standard Methods for the Examination of Water and Wastewater* (Eaton et al., 2005). The trace metals analysis for antimony, arsenic, selenium, and thallium by inductively coupled plasma emission spectroscopy/mass spectrometry was subcontracted to Anatek Laboratories in order to achieve the requisite detection limits.

7.3.1 Completeness

Six WQSP wells were sampled once in 2015 during the period March through May for the WIPP groundwater DMP. The completeness objective was met as analytical results were received for the samples submitted (100 percent completeness).

7.3.2 Precision

HEAL and Anatek provided precision data for the analyses of LCS/LCSD pairs, MS/MSD pairs, and analysis of single primary groundwater samples in duplicate for selected analytes where MS/MSD samples are not applicable. LCS samples were prepared by spiking the target constituent (VOCs, SVOCs, and trace metals) and general chemistry parameter target analytes into clean water and preparing and analyzing the samples. Duplicate LCS samples (LCSDs) were analyzed for analytical methods where LCSDs are specified to be analyzed in the laboratory SOPs. These methods included GC/MS analyses, inductively coupled plasma emission spectroscopy analyses, and inductively coupled plasma emission spectroscopy/mass spectrometry analyses, and some of the general chemistry parameters. A LCSD is a separately prepared LCS sample. MS/MSD samples were generated by spiking the target constituents and selected general chemistry indicator parameter analytes into separate portions of the primary groundwater samples. The LCS/LCSD and MS/MSD samples generally contained all the target constituents and general chemistry parameters for precision measurement. The samples were analyzed, and the percent recoveries of the VOCs, SVOCs, and metals and general chemistry indicator parameters were determined and reported.

LCS/LCSD and MS/MSD analyses are not applicable for some analyses such as pH, specific gravity, TSS, and specific conductance. Precision data were generated for these types of analyses by analyzing a field sample in duplicate and calculating the associated RPD. The QA objective for the precision of the LCS/LCSR, MS/MSD, and duplicate sample concentrations is less than or equal to 20 RPD for 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.

The duplicate groundwater precision measurements were calculated for the detectable concentrations of the major cations including calcium, magnesium, potassium, and sodium; some detected trace metals including barium, beryllium, and vanadium; and general chemistry parameters detected in the groundwater samples including chloride, TOC, specific gravity, TDS, TSS, pH, specific conductance, and alkalinity. The precision would not be expected to be as good for constituents and general chemistry parameters with low concentrations between the MDL and MRL.

Table 7.4 shows those cases where the precision objective (RPD$\leq$20) was not met for the duplicate groundwater samples, LCS/LCSD, MS/MSD samples, and duplicate analysis of single samples when applicable.

The data in Table 7.4 show that nearly all of the samples where the precision objective was not met were for QC samples rather than groundwater samples, and most of the QC samples were LCS/LCSD and MS/MSD samples for the analysis of acidic or basic SVOCs by GC/MS (17 out of 24 cases). No SVOCs were detected in any of the groundwater samples. One isobutyl alcohol LCS/LCSD analyzed with the WQSP-5 samples slightly missed the precision objective. The compound has not been detected in any of the groundwater samples.

Poor precision should not be an issue in the LCS/LCSD samples where analyte-free water is spiked with the target analytes, i.e., no matrix effects due to high salt content. However, the extraction efficiency for acidic and basic SVOCs can vary from sample to sample due to such issues as deactivation of the glassware used for the sample preparation and also absorption sites in the capillary columns used for the GC/MS analyses.

There were three entries for metals in the MS/MSD samples analyzed with WQSP-4 (cadmium, silver, lead) plus a repeat analysis for Pb in a MS/MSD pair (MSD-2). The reason for this lack of precision in one set of QC samples is not known, but appears to be an isolated incident.

Table 7.4 – Individual Cases Where the Groundwater Sampling Round 36 Relative Percent Differences were >20 for the Primary and Duplicate Groundwater Samples, Matrix Spike/Matrix Spike Duplicate Pairs, and Laboratory Duplicate Quality Assurance/Quality Control Samples

DMW	Parameter or Constituent	Primary[(a)]	Duplicate[(a)]	RPD
WQSP-1	2,4-dinitrophenol	35.7 ug/L (LCS)	81.3 ug/L (LCSD)	77.9
WQSP-1	Pentachlorophenol	47.4 ug/L (LCS)	103 ug/L (LCSD)	74.2
WQSP-1	Pyridine	71.9 ug/L (LCS)	33.1 ug/L (LCSD)	73.9
WQSP-1	Pentachlorophenol	3.36 ug/L (MS)	4.78 ug/L (MSD)	34.9
WQSP-2	Chloride	38,200 mg/L	30,000 mg/L	24
WQSP-2	2,4-dinitrophenol	24.4 ug/L (LCS)	81.4 ug/L (LCSD)	108
WQSP-2	Pyridine	63.9 ug/L (LCS)	33.8 ug/L (LCSD)	61.6
WQSP-2	2,4-dinitrophenol	27.4 ug/L (MS)	4.88 ug/L (MSD)	139
WQSP-2	Pentachlorophenol	61.0 ug/L (MS)	0.0 ug/L (MSD)	200
WQSP-3	2,4-dinitrophenol	30.2 ug/L (LCS)	37.1 ug/L (LCSD)	20.4
WQSP-3	2,4-dinitrophenol	19.0 ug/L (MS)	26.6 ug/L (MSD)	33.4
WQSP-3	Pentachlorophenol	27.5 ug/L (MS)	49.1 ug/L (MSD)	56.3
WQSP-4	Cadmium	0.192 mg/L (MS)	0.300 mg/L (MSD)	44.1
WQSP-4	Lead	0.186 mg/L (MS)	0.268 mg/L (MSD)	36.4
WQSP-4	Silver	0.0456 mg/L (MS)	0.0668 mg/L (MSD)	37.8
WQSP-4	Lead	0.242 mg/L (MS-2)	0.194 mg/L (MSD-2)	21.9
WQSP-5	Total suspended solids	13 mg/L	24 mg/L	59.5
WQSP-5	Isobutyl alcohol	36.9 ug/L (LCS)	45.6 ug/L (LCSD)	21.1
WQSP-6	1,2-dichlorobenzene	50.8 ug/L (LCS)	68.4 ug/L (LCSD)	29.7
WQSP-6	Hexachloroethane	40.6 ug/L (LCS)	54.6 ug/L (LCSD)	29.5
WQSP-6	2-methylphenol	77.5 ug/L (LCS)	95.2 ug/L (LCSD)	20.4
WQSP-6	Pyridine	31.9 ug/L (LCS)	44.0 ug/L (LCSD)	31.9
WQSP-6	2,4-dinitrophenol	11.6 ug/L (MS)	15.3 ug/L (MSD)	27.8
WQSP-6	3-, & 4-methylphenol	93.3 ug/L (MS)	75.4 ug/L (MSD)	21.2

Notes:

DMW Detection monitoring well.

MS Matrix spike.

MSD Matrix spike duplicate.

RPD Relative percent difference.

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

The only cases where the precision objective was not met for groundwater sample duplicates was for chloride in the duplicate groundwater samples from WQSP-2 and the TSS in the duplicate groundwater samples from WQSP-5. Chloride analyses normally yield quite precise results, and the reason for this variation is not known. Unlike the WIPP Laboratories radiochemical analysis lab, a commercial lab does not repeat QC analyses until QC objectives are met. Total suspended solids analyses can be more problematic with respect to achieving good precision because the TSS weights depend on factors such as the size of the particles and how long the samples are allowed to settle prior to filtering.

Considering the hundreds of groundwater sample data points and QA/QC sample data points that were generated during Round 37, the number of duplicate groundwater samples and QA samples that did not meet the precision QA objective was very low, at less than three percent.

7.3.3 Accuracy

The accuracy of the analyses was checked by analyzing initial calibration verification standards, continuing calibration verification standards, method blanks, LCS and LCSD samples, and MS/MSD samples as specified in the standard methods and in the corresponding lab SOPs. The daily calibration standards were used to confirm that the response in the daily standard closely matched the corresponding response during the initial calibration. The method blanks were used to confirm that the accuracy of the groundwater sample analyses was not adversely affected by the presence of any of the target analytes as background contaminants that may have been introduced during sample preparation and analysis. The LCS and LCSD samples, where applicable, were analyzed to check that the analytical method was in control by measuring the percent recoveries of the target analytes spiked into clean water. MS/MSD samples were prepared and analyzed to check the effect of the groundwater sample matrix on the accuracy of the analytical measurements as percent recovery.

The objective for the percent recoveries varies with the type of analysis:

- 70–130 percent recovery for VOCs in LCS samples and MS samples.
- 90–110 percent recovery for chloride and sulfate in LCS samples.
- 80–120 percent recovery for mercury and recoverable metals in LCS samples.
- 75–125 percent recovery for mercury and recoverable metals in MS samples.
- 90–110 or 80–120 percent recovery for general chemistry parameters in LCS samples.
- 80–120 percent recovery or 75–125 percent recovery for general chemistry parameters in MS samples.
- SVOC recovery objectives vary widely according to the lab’s historical control chart range. The general EPA guidance for SVOC recoveries is 40–140 percent for base/neutral SVOCs and 30–130 percent for acidic SVOCs with wider ranges for surrogate recovery compounds, e.g., 10 to 94 percent for phenol-d5 and 20 to 123 percent for 2,4,6-tribromophenol.

The HEAL historical control chart recovery range for some of the acidic compounds is similar to the EPA ranges for the two acidic surrogate recovery compounds. The lab’s historical control chart range varies widely by compound and ranged from 6.98 to 106 percent for 2,4-dinitrophenol and 15.2 to 89.7 percent for pyridine to 56.4 to 106 percent for hexachlorobenzene.

The accuracy QA objectives for the general chemistry indicator parameters are generally tighter than for the 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 no detection 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 37 sampling and analysis in 2015. 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 matrix spike 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 contains eight rows where a SVOC compound did not meet the %R objective in LCS/LCSD samples and eight rows where a SVOC compound did not meet the %R objective in MS/MSD samples. Several rows contained percent recovery values marked with an asterisk (*) indicating an acceptable recovery, but the other recovery in the row was low. No recoveries of SVOC compounds were high. The low LCS/LCSD recoveries involved acidic or basic compounds and were likely due to extraction efficiency or to the gas chromatographic column adsorbing a portion of the compound. The low MS/MSD recoveries likely resulted from matrix extraction effects from the brine combined with losses due to chromatographic absorption. None of the affected SVOC compounds were detected in any of the groundwater samples.

Table 7.5 contains several listings for VOC compounds, but all the recoveries are high rather than low, and none of the compounds were detected in the groundwater samples. High MS and MSD recoveries for the polar VOC compounds listed are usually associated with more efficient purging of the compounds from samples with dissolved salts, i.e., the groundwater matrix, compared to the purging efficiency of the same polar compounds from the aqueous calibration standards.

Table 7.5 – Individual Cases Where the Round 37 Accuracy Objectives Were Not Met in QC Samples Per EPA Guidance

DMW	Constituent or Parameter	Sample	% Rec.	Sample	%R
WQSP-1	2-butanone	LCS	137	LCSD	130*
WQSP-1	2-butanone	MS	133	MSD	137
WQSP-1	1,1,2,2-tetrachloroethane	MS	159	MSD	166
WQSP-1	Isobutyl alcohol	MS	214	MSD	209
WQSP-1	2,4-dinitrophenol	MS	6.44	MSD	7.78
WQSP-1	Pentachlorophenol	MS	3.36	MSD	4.78
WQSP-1	Cadmium	MS	51.1	MSD	52.6

DMW	Constituent or Parameter	Sample	% Rec.	Sample	%R
WQSP-1	Lead	MS	48.6	MSD	48.7
WQSP-1	Silver	MS	59.9	MSD	66.8
WQSP-2	2-butanone	LCS	146	LCSD	146
WQSP-2	2-butanone	MS	150	MSD	166
WQSP-2	1,1,2,2-tetrachloroethane	MS	135	MSD	128
WQSP-2	Isobutyl alcohol	MS	134	MSD	140
WQSP-2	2,4-Dinitrophenol	LCS	24.4	LCSD	81.4*
WQSP-2	Pyridine	LCS	63.9*	LCSD	33.8
WQSP-2	2,4-dinitrophenol	MS	27.4	MSD	4.88
WQSP-2	Pentachlorophenol	MS	61.0*	MSD	0.0
WQSP-3	2-butanone	LCS	151	LCSD	169
WQSP-3	2-butanone	MS	289	MSD	282
WQSP-3	1,1,2,2-tetrachloroethane	MS	177	MSD	177
WQSP-3	Isobutyl alcohol	MS	348	MSD	403
WQSP-3	2,4-dinitrophenol	MS	19.0	MSD	26.6
WQSP-3	Pentachlorophenol	MS	27.5	MSD	49.1*
WQSP-4	2-butanone	MS	154	MSD	149
WQSP-4	1,1,2,2-tetrachloroethane	MS	143	MSD	138
WQSP-4	Isobutyl alcohol	MS	280	MSD	249
WQSP-4	Pyridine	LCS	35.0	LCSD	26.2
WQSP-4	Pyridine	MS	45.9*	MSD	30.7
WQSP-4	Cadmium	MS	38.4	MSD	60.1
WQSP-4	Lead	MS	37.2	MSD	53.7
WQSP-4	Silver	MS	45.6	MSD	66.8
WQSP-4	Cadmium	MS-2	47.1	MSD-2	39.6
WQSP-4	Lead	MS-2	48.4	MSD-2	38.8
WQSP-4	Silver	MS-2	58.0	MSD-2	52.2
WQSP-5	2-butanone	MS	125*	MSD	131
WQSP-5	Isobutyl alcohol	MS	183	MSD	169
WQSP-5	Silver	MS	132	MSD	135
WQSP-6	Isobutyl alcohol	LCS	171	LCSD	166
WQSP-6	2-butanone	MS	131	MSD	121*
WQSP-6	Pyridine	LCS	31.9	LCSD	44.0*
WQSP-6	2,4-dinitrophenol	MS	11.6	MSD	15.3

Notes:

Most of the recoveries in the table met the HEAL Laboratory's historical control chart range for recovery.

* Indicates acceptable recovery, but the other recovery in the row was low.

Cadmium, lead, and silver showed some low recoveries from MS/MSD samples associated with the WQSP-1 and WQSP-4 groundwater. The WQSP-5 groundwater showed slightly high recoveries for silver. The reason for the low recoveries is not known since the metals usually meet the percent recovery objective from spiked groundwater. The laboratory reanalyzed the WQSP-4 MS/MSD analyses, but the three metals again yielded low recoveries. The low recoveries were apparently not due to the high-brine matrix because the WQSP-3 groundwater contains the highest salt concentration, and the metals recoveries the WQSP-3 MS/MSD were not adversely affected. The reason for the slightly high recoveries of silver from WQSP-5 groundwater is not known. The three metals were not detected in any of the groundwater samples.

Table 7.5 does not contain any entries for general chemistry indicator parameters. All the accuracy objectives were met for the general chemistry parameters in the QC samples.

Table 7.6 shows the recoveries of the SVOC surrogates from the Round 37 groundwater and QC samples. Every calibration standard, groundwater sample, and QC sample analyzed by GC/MS served as a surrogate spike sample in that the organic 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.

The SVOC surrogates include 2,4,6-tribromophenol (2,4,6-TBP); 2-fluorobiphenyl (2-FBP); 2-fluorophenol (2-FOH); d14-terphenyl (d14-Ter); d5-nitrobenzene (d5-NB); and d5-phenol. The surrogates generally display wide percent recovery ranges due to variable extraction efficiencies and gas chromatographic properties. Three of the surrogates (2,4,6-TBP, 2-FlOH, and d5-phenol) are acidic and can chromatograph poorly if the gas chromatographic column has developed any active sites where portions of the compounds can be lost during analysis. These acidic compounds are also susceptible to absorption onto glassware during sample preparation. The EPA surrogate objective covers a wide range of percent recoveries as follows:

- 2,4,6-tribromophenol: 10 to 123 percent
- 2-fluorobiphenyl: 43 to 116 percent
- 2-fluorophenol: 21 to 100 percent
- d14-p-terphenyl: 33 to 141 percent
- d5-nitrobenzene: 35 to 144 percent
- d5-phenol: 10 to 94 percent

The surrogate recovery data show that just six of 216 surrogate recoveries did not meet the EPA recovery objective. The six low recoveries were for acidic surrogates that tend to display lower recoveries than the other surrogates due to extraction and column absorption difficulties.

Table 7.6 – Percent Recovery of SVOC Surrogates from Round 37 Groundwater and QC Samples as a Measure of Accuracy

DMW	Sample	2,4,6-TBP	2-FBP	2-FlOH	d14-Ter	d5-NB	d5-Phenol
WQSP-1	Primary	25.1	72.1	19.8*	81.4	79.9	31.1
WQSP-1	Duplicate	31.6	66.0	24.6	78.6	71.9	31.6
WQSP-1	MB	95.3	75.8	75.0	93.5	77.4	64.5
WQSP-1	LCS	59.5	92.1	31.0	110	88.1	43.9
WQSP-1	LCSD	104	83.3	72.3	110	85.6	74.1
WQSP-1	MS	12.6	84.9	5.76*	98.6	82.8	17.0

DMW	Sample	2,4,6-TBP	2-FBP	2-FlOH	d14-Ter	d5-NB	d5-Phenol
WQSP-1	MSD	9.20*	65.2	6.60*	83.4	72.9	16.9
WQSP-2	Primary	2.09*	64.7	3.05*	61.6	68.5	11.8
WQSP-2	Duplicate	10.9	62.2	22.4	61.2	74.1	38.4
WQSP-2	MB	91.5	66.2	52.4	73.7	68.2	40.2
WQSP-2	LCS	93.7	96.4	62.2	70.4	76.7	47.6
WQSP-2	LCSD	101	79.4	57.5	74.2	76.1	44.9
WQSP-2	MS	78.0	67.8	58.2	64.2	66.4	51.9
WQSP-2	MSD	33.4	73.5	45.5	68.1	66.7	45.8
WQSP-3	Primary	30.3	64.2	28.6	62.9	76.7	42.6
WQSP-3	Duplicate	44.4	67.3	30.9	79.4	75.1	32.4
WQSP-3	MB	87.1	59.7	63.6	72.9	68.8	66.4
WQSP-3	LCS	48.5	50.6	33.2	61.9	55.7	27.1
WQSP-3	LCSD	82.5	69.2	82.5	70.5	74.8	40.8
WQSP-3	MS	59.5	77.5	59.5	71.3	72.8	48.0
WQSP-3	MSD	73.3	70.0	73.3	69.8	65.5	48.0
WQSP-4	Primary	98.0	82.4	75.3	84.5	76.5	75.0
WQSP-4	Duplicate	97.7	87.5	83.4	90.4	80.3	77.0
WQSP-4	MB	80.6	71.2	64.8	87.3	76.0	59.1
WQSP-4	LCS	107	96.8	79.8	123	91.8	74.6
WQSP-4	LCSD	86.0	78.0	72.1	109	82.4	65.9
WQSP-4	MS	115	90.7	86.6	127	90.1	76.4
WQSP-4	MSD	107	93.9	77.3	115	86.8	77.6
WQSP-5	Primary	56.2	85.4	42.7	65.4	98.6	39.2
WQSP-5	Duplicate	33.1	82.8	25.3	53.4	85.9	27.5
WQSP-5	MB	82.4	79.1	67.5	61.3	80.3	47.8
WQSP-5	LCS	78.0	81.5	66.6	92.8	84.7	47.5
WQSP-5	LCSD	84.2	82.1	53.9	90.2	78.8	44.4
WQSP-5	MS	61.9	88.3	44.5	103	80.4	41.3
WQSP-5	MSD	55.0	85.6	36.9	97.4	85.3	35.2
WQSP-6	Primary	80.3	81.8	61.1	63.2	78.7	49.5
WQSP-6	Duplicate	51.7	52.5	43.0	48.0	55.7	34.4
WQSP-6	MB	91.1	77.3	60.6	82.4	73.7	50.4
WQSP-6	LCS	82.1	72.3	59.8	95.2	76.1	49.6
WQSP-6	LCSD	89.8	87.4	73.1	100	85.3	57.1
WQSP-6	MS	88.2	94.1	74.0	97.8	94.2	62.6
WQSP-6	MSD	87.7	87.6	62.7	95.4	81.9	50.2

*Calculated %R did not meet EPA objective.

Overall, the quality of the accuracy QC data was excellent, with nearly all the spiked LCS/LCSD data, the MS/MSD data, and the surrogate recoveries meeting the accuracy objectives.

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 SOPs for sample collection and analyses. The normal reporting unit for metals and general chemistry parameters is mg/L, and the normal reporting unit for organics is micrograms per liter (µg/L).

HEAL and its subcontract laboratories are certified by several states and by the National Environmental Laboratory Accreditation Program through Oregon for HEAL and Anatek. HEAL is certified in Oregon, Utah, Texas, New Mexico, and Arizona. The labs participate in inter-laboratory evaluation programs, including on-site National Environmental Laboratory Accreditation Conference QA audits. The labs also regularly analyze performance evaluation samples provided by a National Environmental Laboratory Accreditation Conference–accredited proficiency standard vendor. The HEAL vendor was Phenova Certified Reference Materials, and the Anatek vendor was Sigma-Aldrich.

The details of the HEAL performance evaluation sample results are discussed in this section and presented in Table 7.7. Likewise, Anatek successfully analyzed for the four target inductively coupled plasma emission spectroscopy/mass spectrometry metals in its performance evaluation samples, as shown in the table.

Table 7.7 – Performance Evaluation Sample Analysis Results for WIPP Groundwater Analyses, 2015

Target Analytes	Acceptable Results	Not Acceptable Results
VOCs by GC/MS Method 8260 (carbon tetrachloride, chlorobenzene, chloroform, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethene, trans-1,2-dichloroethene, 2-butanone, methylene chloride, 1,1,2,2-tetrachloroethane, tetrachloroethene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, toluene, trichloroethene, trichlorofluoromethane, vinyl chloride, xylenes	36	0
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	24	0
Trace and Dissolved Metals by inductively coupled plasma spectroscopy Method 6010 (barium, beryllium, cadmium, chromium, lead, nickel, silver, vanadium, calcium, magnesium, potassium, sodium)	32	0
Mercury by Graphite Furnace Atomic Absorption Spectroscopy Method 7470	2	0
Metals by ICP/MS Method 6020 (antimony, arsenic, selenium, thallium)	4	0
General Chemistry Parameters (chloride, sulfate, nitrate, TOC, alkalinity, specific conductance, pH, TDS, TSS, total Kjeldahl nitrogen)	20	0

HEAL analyzed four sets of performance evaluation samples in 2015, including two Phenova water pollution proficiency testing samples and two Phenova water supply proficiency testing samples. The Phenova water supply performance evaluation samples included chloride, nitrate, sulfate, trace metals, mercury, pH, TOC, regulated VOCs, and unregulated VOCs. The Phenova water supply testing performance evaluation samples included chloride, sulfate, TDS, TSS, nitrate, TKN, alkalinity, trace metals, mercury, specific conductance, pH, VOCs, and SVOCs (acids and base-neutrals). The performance evaluation samples covered all the WIPP target analytes except isobutyl alcohol (a VOC) and specific gravity (a general chemistry parameter).

Each of the WIPP target analytes were included in two of the sample sets analyzed by HEAL. The ICP/MS metals analyzed by Anatek were contained in one of the performance evaluation samples. Some of the analytes such as sulfate, nitrate, sodium, and total Kjeldahl are not reported as groundwater analytes but are reported for other WIPP samples and to measure the difference between the total cations and total anions, termed charge balance error, which is a measure of the accuracy of the analyses. The performance evaluation sample sets also included a large number of analytes that are not WIPP analytes.

The results shown in Table 7.7 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 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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42 U.S.C. §§6901-6992, et seq. *Solid Waste Disposal Act*. United States Code. U.S. Government Printing Office, Washington, D.C.

42 U.S.C. §§7401, et seq. *Clean Air Act*. United States Code. U.S. Government Printing Office, Washington, D.C.

42 U.S.C. §§9601, et seq. *Comprehensive Environmental Response, Compensation, and Liability Act (including the Superfund Amendments and Reauthorization Act of 1986)*. United States Code. U.S. Government Printing Office, Washington, D.C.

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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, 2015

Granting Agency	Type of Permit	Permit Number	Granted/ Submitted	Expiration	Current Permit Status
New Mexico Environment Department	Hazardous Waste Facility Permit	NM4890139088–TSDF	12/30/10	12/30/20	Active
New Mexico Environment Department Groundwater Quality Bureau	Discharge Permit	DP–831	7/29/14	7/29/19	Active
New Mexico Environment Department Air Quality Bureau	Operating Permit for Two Backup Diesel Generators	310–M–2	12/07/93	None	Active
New Mexico Environment Department Petroleum Storage Tank Bureau	Storage Tank Registration Certificate	Registration Number 2121 Facility Number 31539	7/1/14	6/30/16	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	5/21/2013	4/30/2018	Active
U.S. Fish and Wildlife Service	Special Purpose – Relocate	MB155189–0	2/20/14	03/31/16	Active
New Mexico Department of Game and Fish	Biotic Collection Permit	Authorization # 3293	01/26/14	12/31/16	Active

N/A = Not applicable

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APPENDIX C – LOCATION CODES

Table C.1 – Location Codes

ANG	Angel Ranch	PL1	Polishing Lagoon 1(DP-831)
ART	Artesia	PL2	Polishing Lagoon 2 (DP-831)
BHT	Bottom of the Hill Tank	RED	Red Tank
BLK	Blank	SEC	Southeast Control
BRA	Brantley Lake	SL1	Settling Lagoon 1 (DP-831)
CBD	Carlsbad	SL2	Settling Lagoon 2 (DP-831)
COW	Coyote Well (deionized water blank)	SLT	Salt Hoist
COY	Coyote (surface water duplicate)	SMR	Smith Ranch
ELA	Evaporation Lagoon A (DP-831)	SOO	Sample of Opportunity*
ELB	Evaporation Lagoon B (DP-831)	SSP1	Salt Storage Pond 1(DP-831)
ELC	Evaporation Lagoon C (DP-831)	SSP2	Salt Storage Pond 2 (DP-831)
EUN	Eunice	SSP3	Salt Storage Pond 3 (DP-831)
FWT	Fresh Water Tank	STB	Southeast of Training Building
GSB	Guard and Security Building	SWL	Sewage Lagoon
HBS	Hobbs	SWP 1	Storm Water Pond 1 (DP-831)
HIL	Hill Tank	SWP 2	Storm Water Pond 2 (DP-831)
H2P	H-2 Well Pad	SWP 3	Storm Water Pond 3 (DP-831)
H19	Evaporation Pond H-19 (DP-831)	TUT	Tut Tank
IDN	Indian Tank	UPR	Upper Pecos River
LST	Lost Tank	WA1	WIPP Air Blank 1
LVG	Loving	WA2	WIPP Air Blank 2
LWE	Land Withdrawal East	WA3	WIPP Air Blank 3
MET	Meteorology Tower Building	WA4	WIPP Air Blank 4
MLR	Mills Ranch	WA5	WIPP Air Blank 5
MS5	Mosaic Shaft 5	WEE	WIPP East
NOY	Noya Tank	WFF	WIPP Far Field
PCN	Pierce Canyon	WIP	WIPP 16 Sections
PEC	Pecos River	WNN	WIPP North
PKT	Poker Trap	WSS	WIPP South
PMR	Potash Mines Road		

* A sample of opportunity is taken at a location that may present itself aside from any other named location.

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APPENDIX D – RADIOCHEMICAL EQUATIONS

DETECTION

All 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 activity or concentration [RN] is greater than the minimum detectable concentration (MDC) and greater than the total propagated uncertainty (TPU) at the 2 σ level. The gamma radionuclides are considered detected in environmental samples when the above criteria are met and the gamma spectroscopy software used to identify the peak generates an associated ID confidence of 90 percent or greater (ID confidence ≥0.90). If the ID confidence is <0.90, the radionuclide is not considered detected even if the sample activity is greater than the 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 5 percent probability of nondetection while accepting a 5 percent probability of erroneously deciding that a positive quantity of a radionuclide is present in an appropriate blank sample. This method assures that any claimed MDC has at least a 95 percent chance of being detected. It is possible to achieve a very low level of detection by analyzing a large sample size and counting for a very long time.

The Waste Isolation Pilot Plant (WIPP) Laboratories use the following equation for calculating the MDCs for each radionuclide in various sample matrices:

$$MDC = \frac{4.66\sqrt{S}}{K\,T} + \frac{3.00}{K\,T}$$

Where:

S = net method blank counts. When the method blank counts = 0, the average of the last 30 blanks analyzed are substituted

K = a correction factor that includes items such as unit conversions, sample volume/weight, decay correction, detector efficiency, chemical recovery, abundance correction, etc.

T = counting time where the background and sample counting time are identical

For further evaluation of the MDC, refer to 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 σ level (2 σ TPU). For further discussion of TPU, refer to ANSI N13.30.

RELATIVE ERROR RATIO

The relative error ratio (RER) is a method, similar to a t-test, with which to compare duplicate 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
1σTPU	=	total propagated uncertainty at the 1 σ level

PERCENT BIAS

The percent bias is a measure of the accuracy of radiochemical separation methods and counting instruments, that is, a measure of how reliable the results of analyses are when compared to the actual values.

$$\%\ BIAS = \frac{(A_m - A_k)}{A_k} \times 100$$

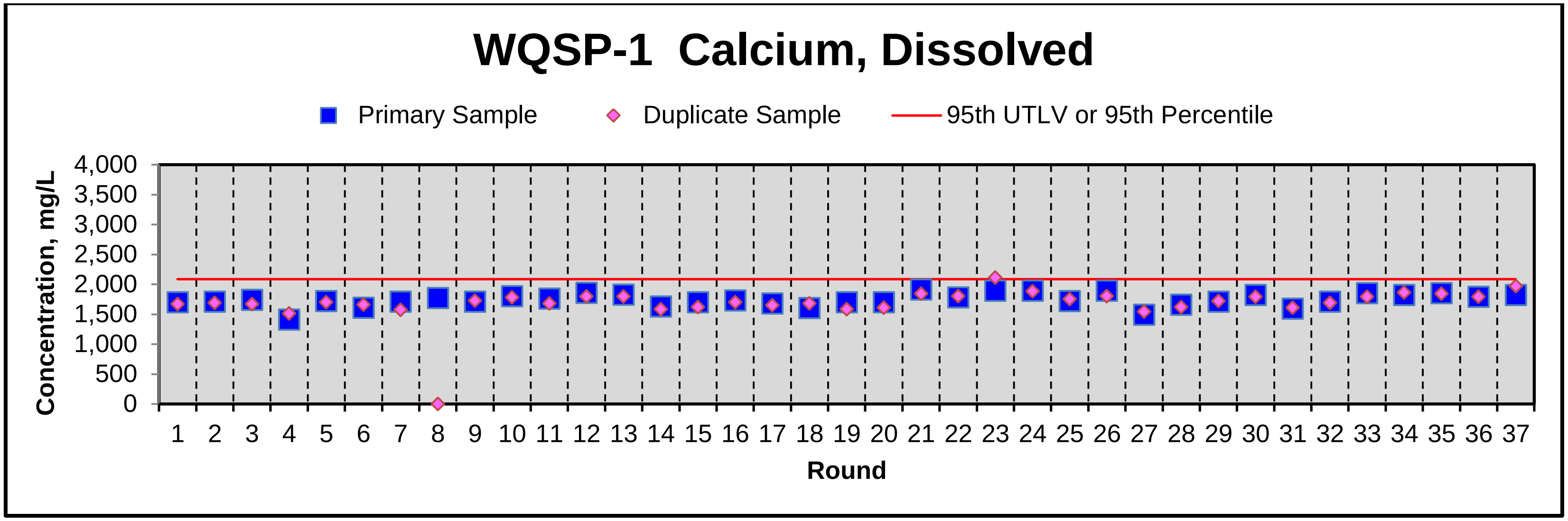
Where:

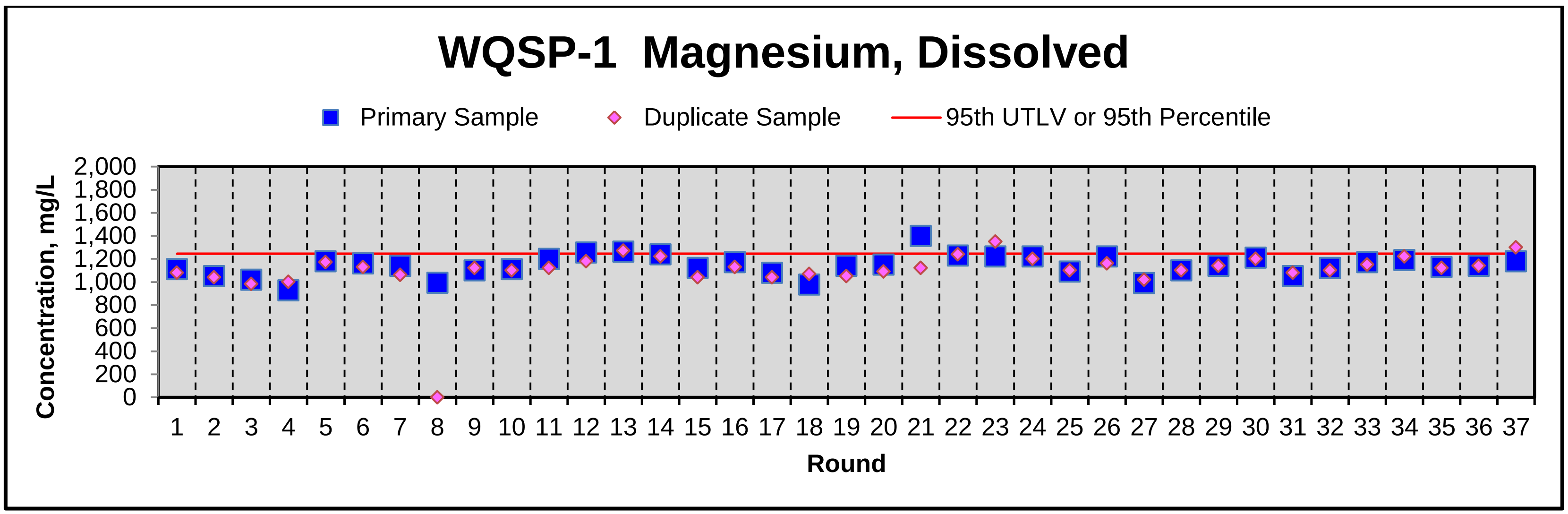
% BIAS	=	percent bias
Am	=	measured sample activity
Ak	=	known sample activity

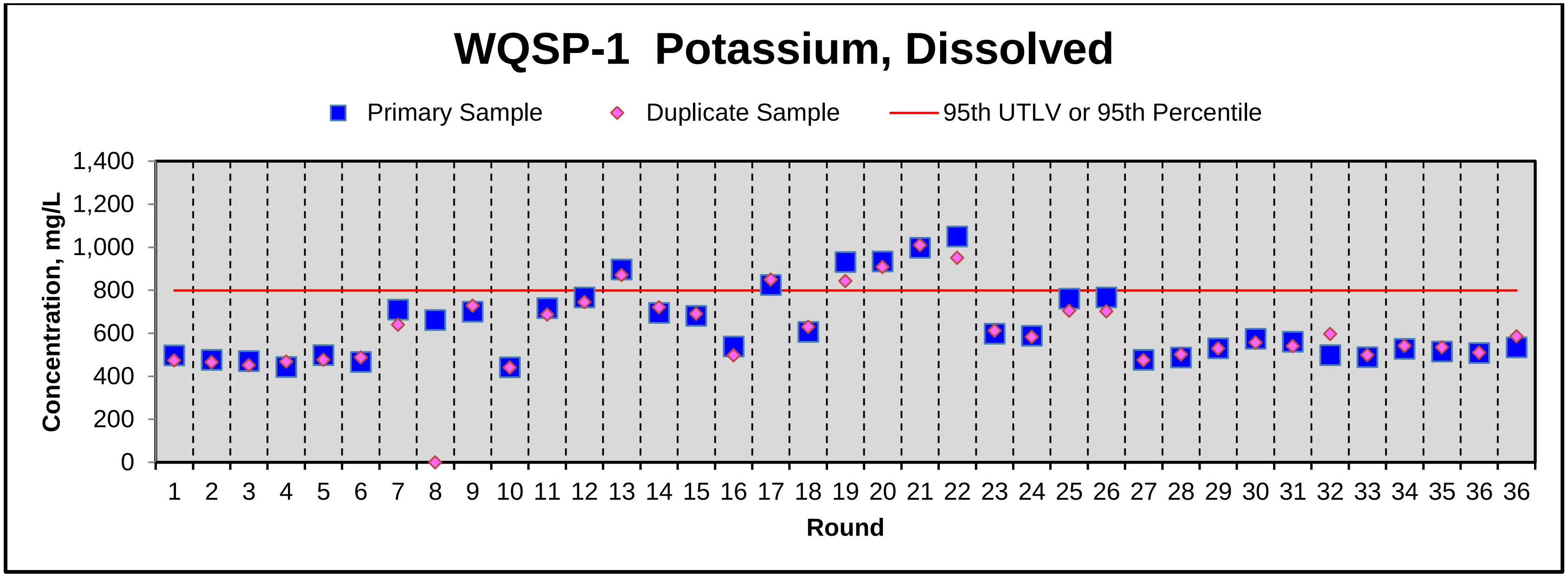
APPENDIX E – TIME TREND PLOTS FOR MAIN PARAMETERS IN GROUNDWATER

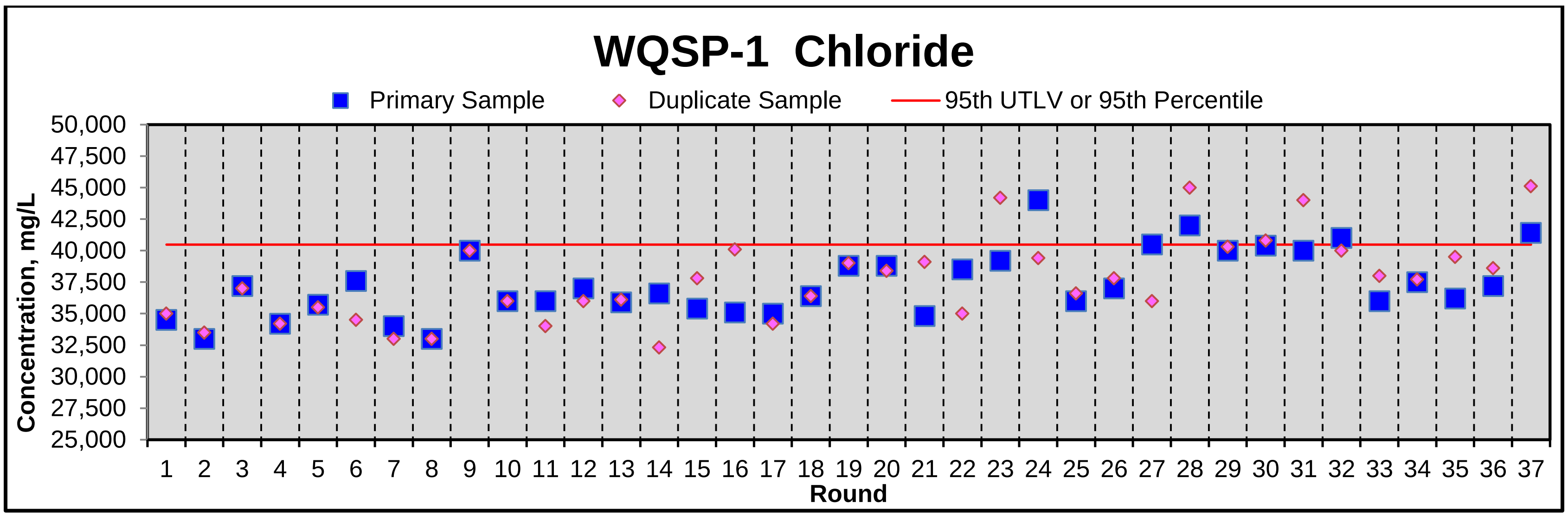
The first 10 sampling rounds were conducted from 1995 through 2000 (prior to receiving mixed waste at the Waste Isolation Pilot Plant [WIPP]) and were used to establish the original baseline for groundwater chemistry at each sampling location. The baseline sample sets are used to determine whether statistically significant changes have occurred at any well. Time trend plots are provided below for the following general chemistry indicator parameters: dissolved calcium, chloride, dissolved magnesium, pH, dissolved potassium, sulfate, and TDS. These plots show the concentrations in the primary sample and the duplicate sample for all sampling rounds.

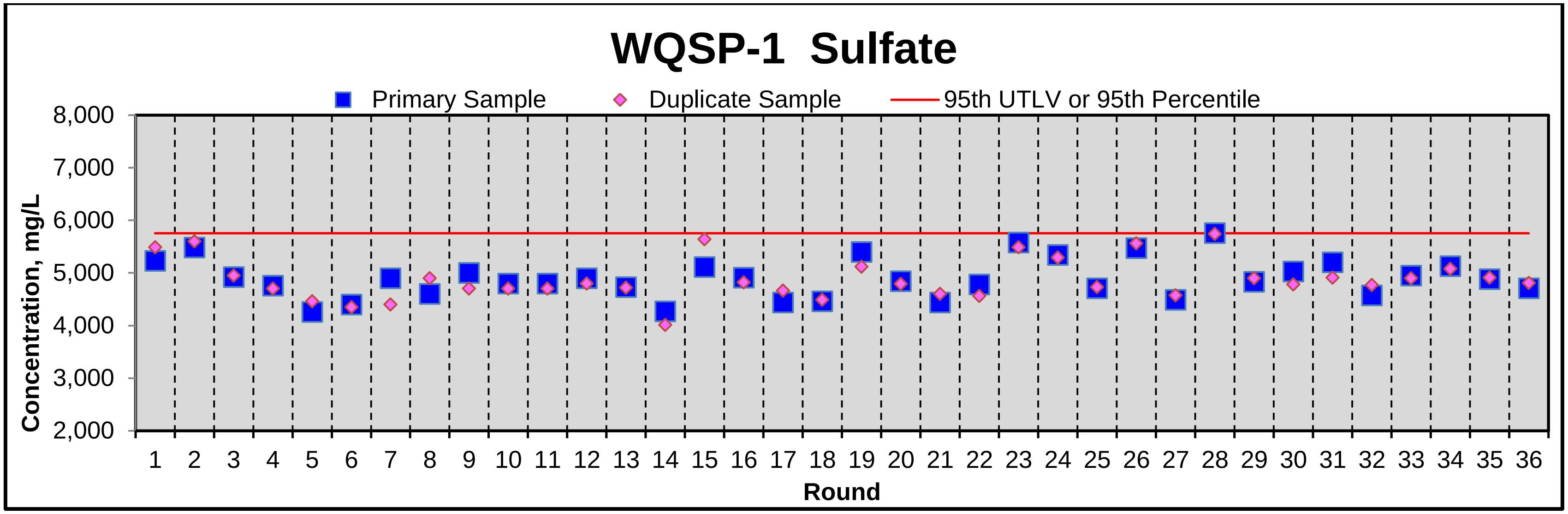
The 2015 laboratory analytical results were verified and validated in accordance with WIPP procedures and U.S. Environmental Protection Agency technical guidance. Sampling Round 37 samples were taken March through May 2015. See Appendix F for the concentrations of the target analytes in the detection monitoring wells.

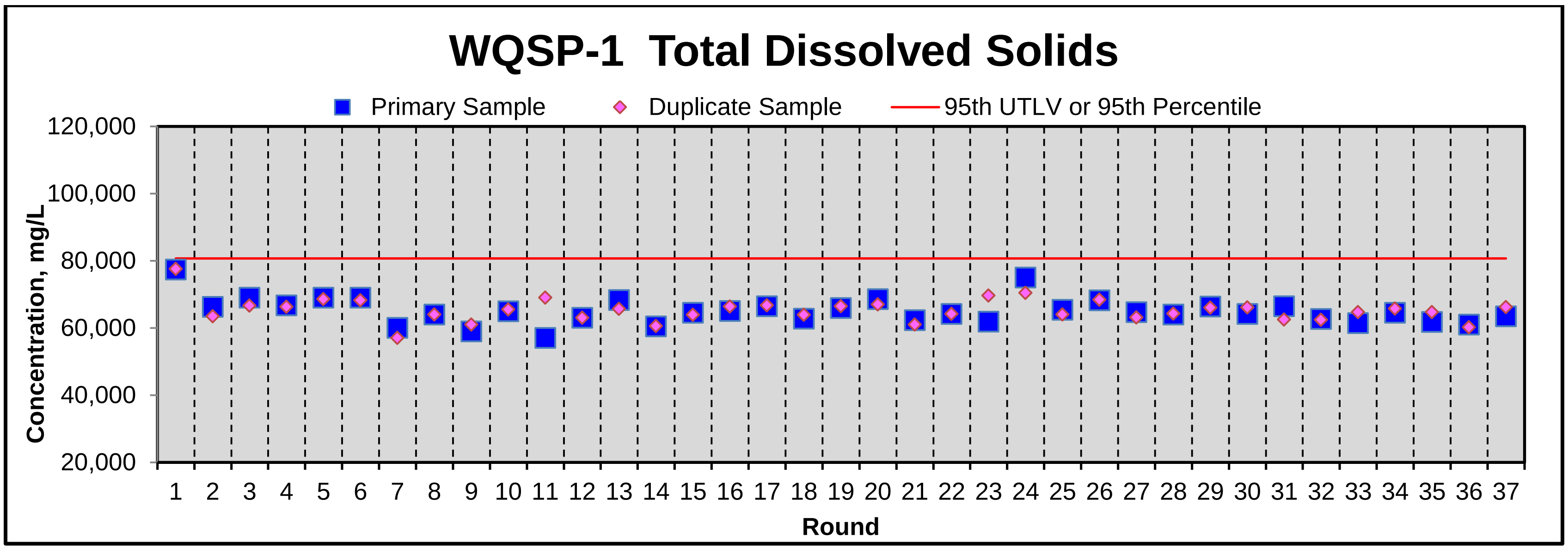

WQSP-1 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round


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 29 30 31 32 33 34 35 36 37
Round


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


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


WQSP-1 Sulfate
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
8,000
7,000
6,000
5,000
4,000
3,000
2,000
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
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
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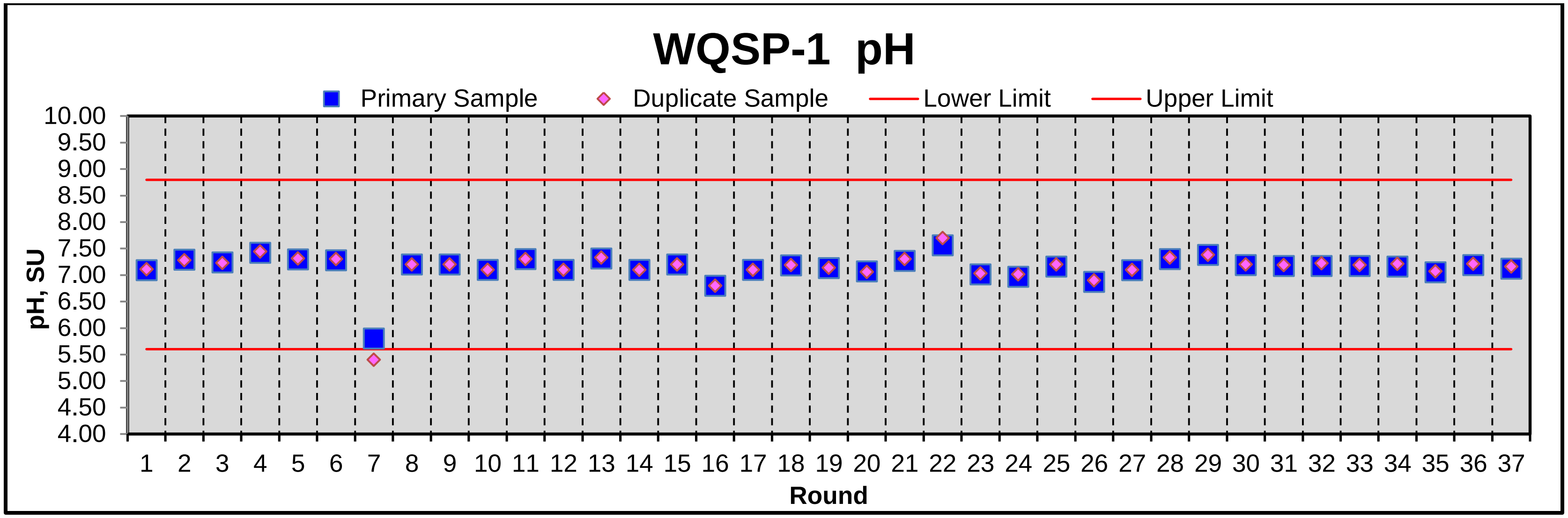
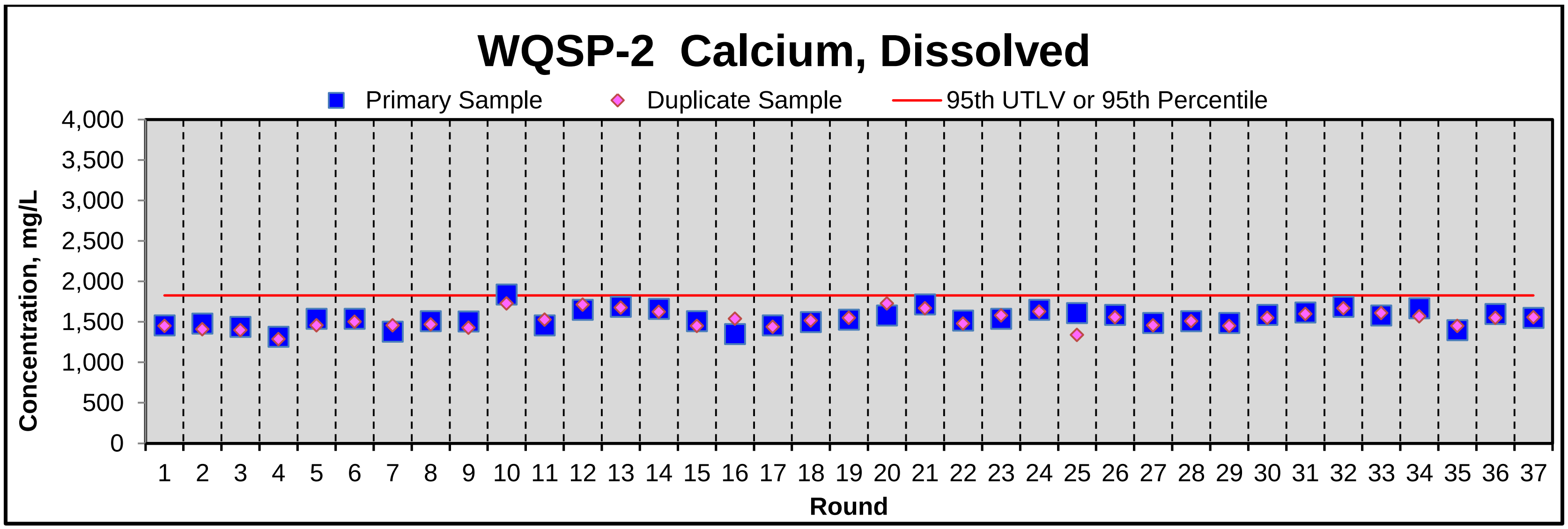
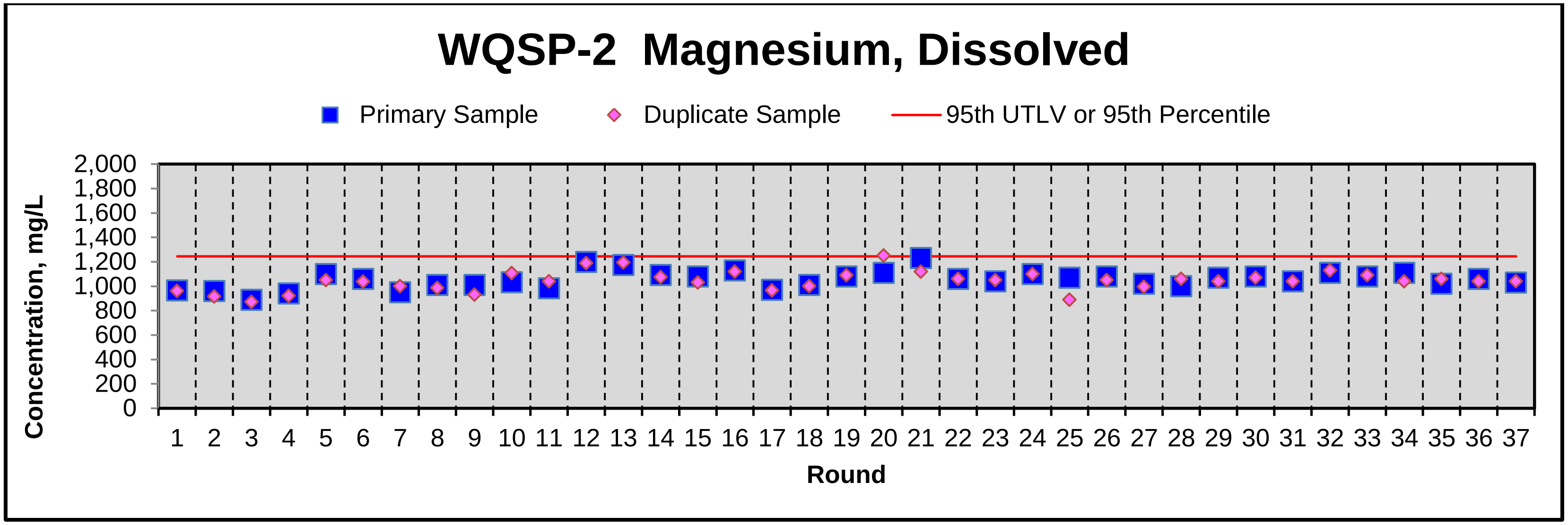
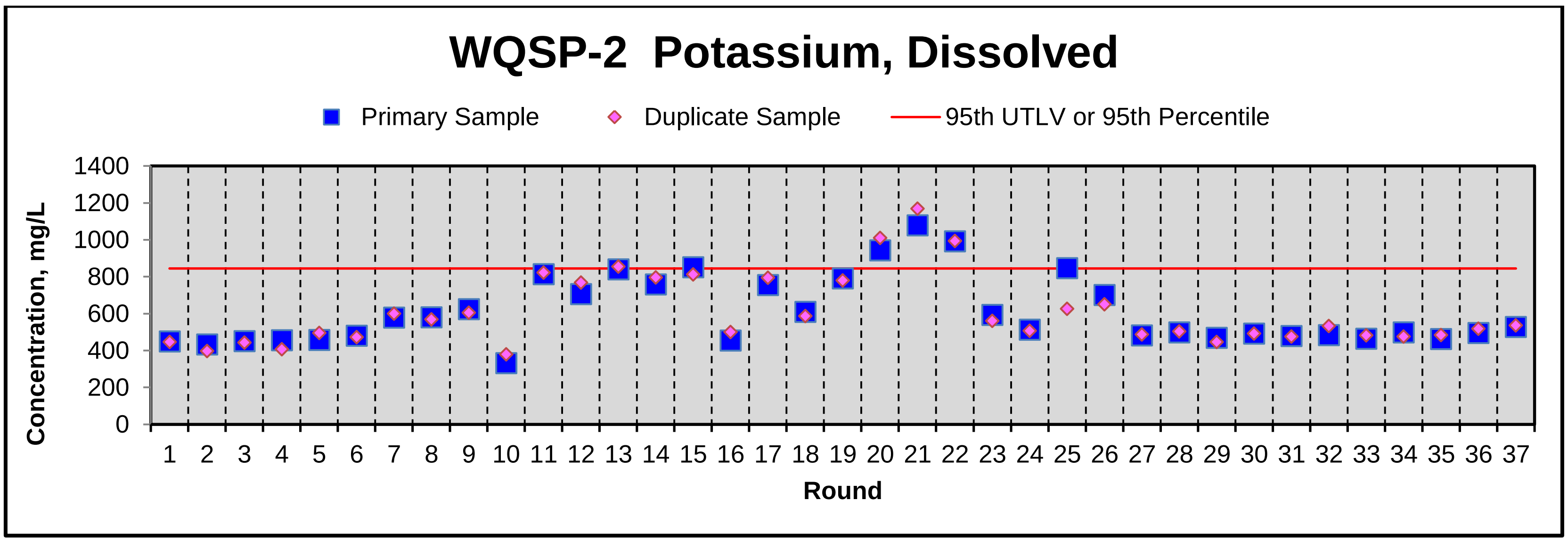
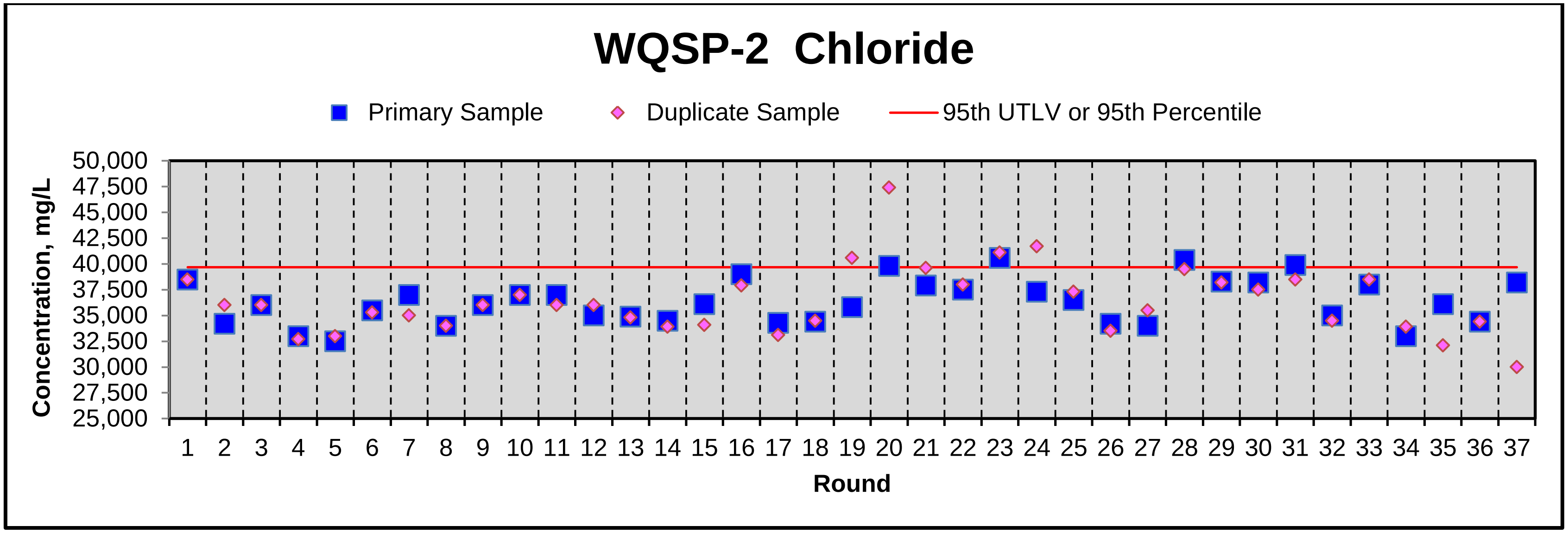
Round

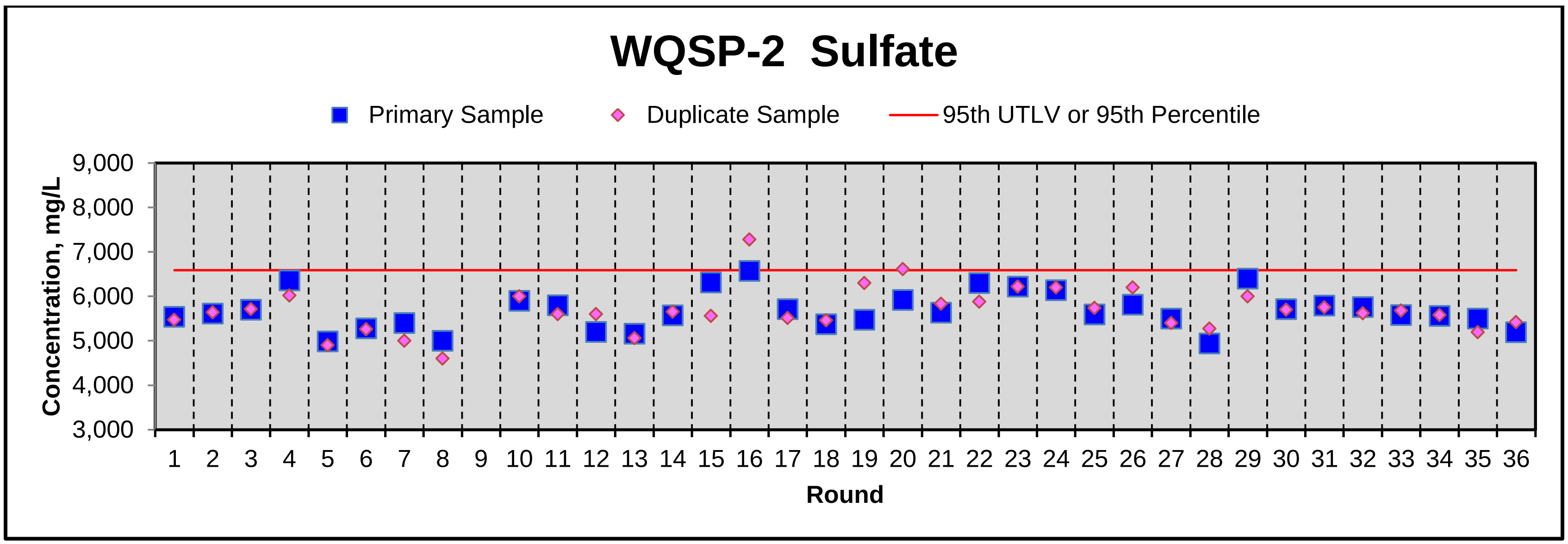

WQSP-1 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
10.00
9.50
9.00
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

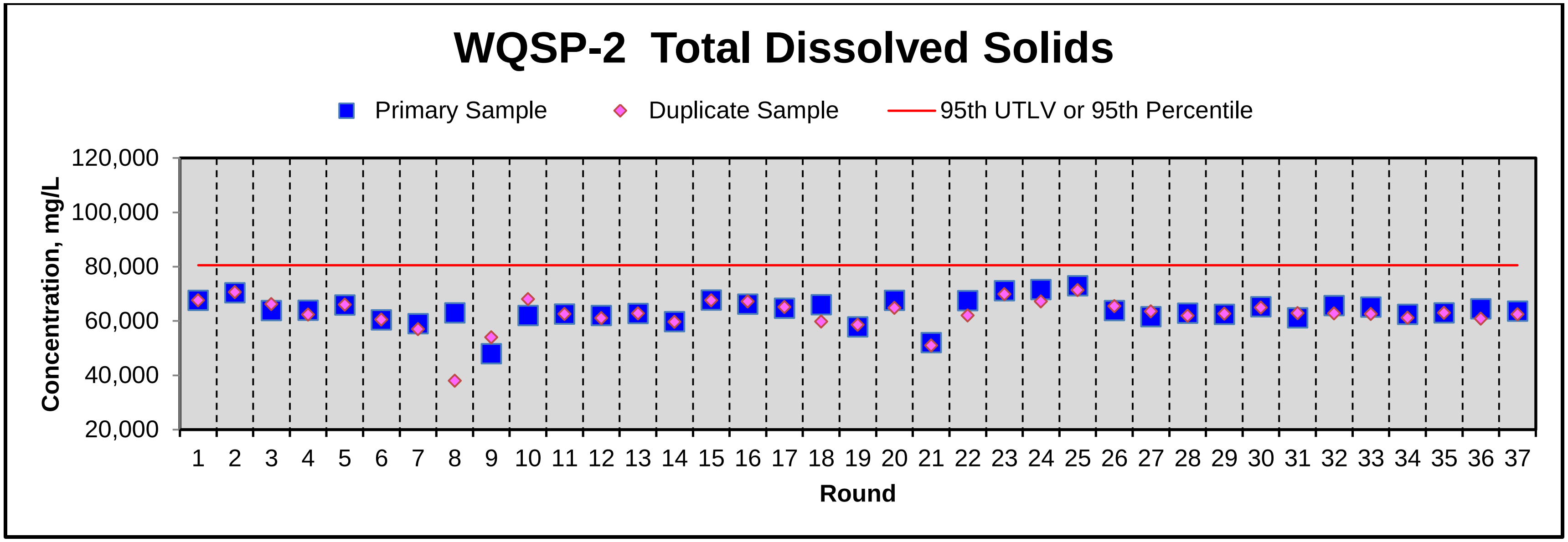

WQSP-2 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

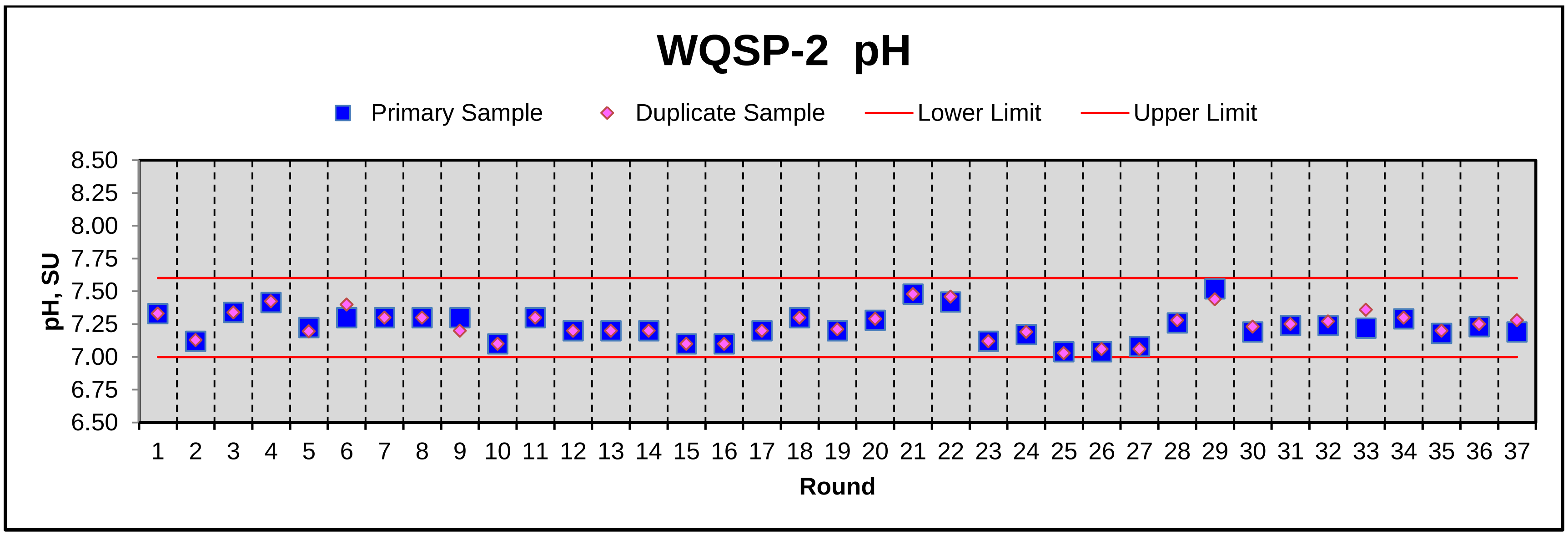

WQSP-2 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

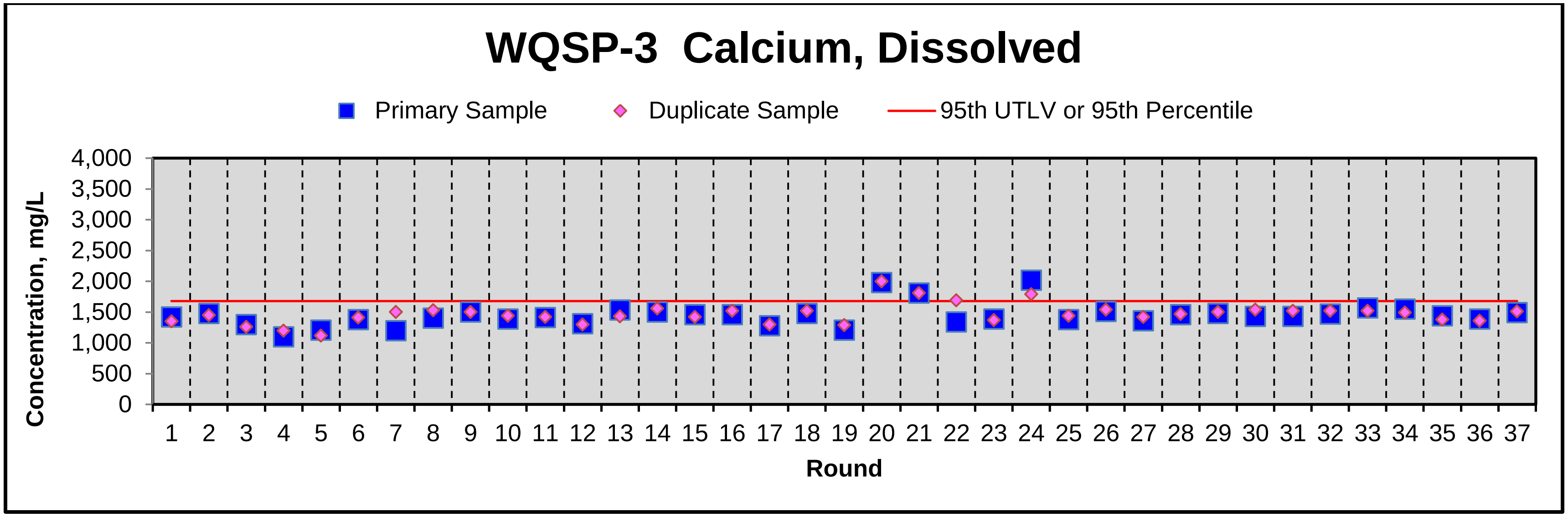

WQSP-2 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
1400
1200
1000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

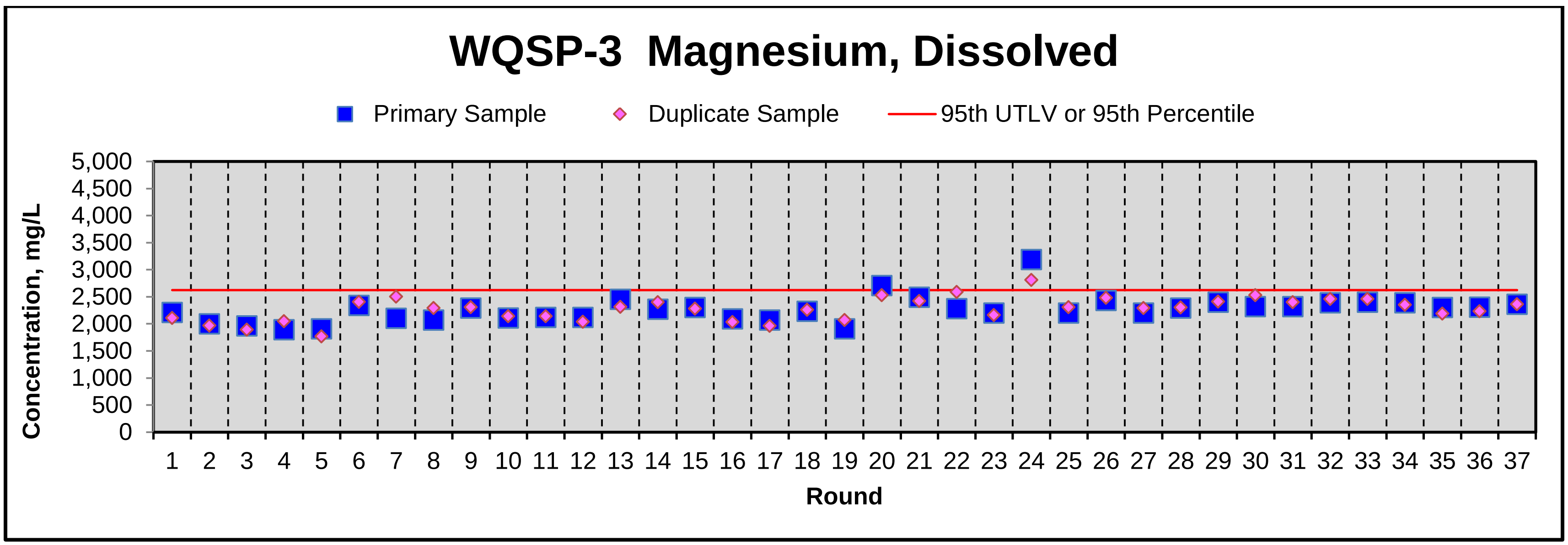

WQSP-2 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
50,000
47,500
45,000
42,500
40,000
37,500
35,000
32,500
30,000
27,500
25,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

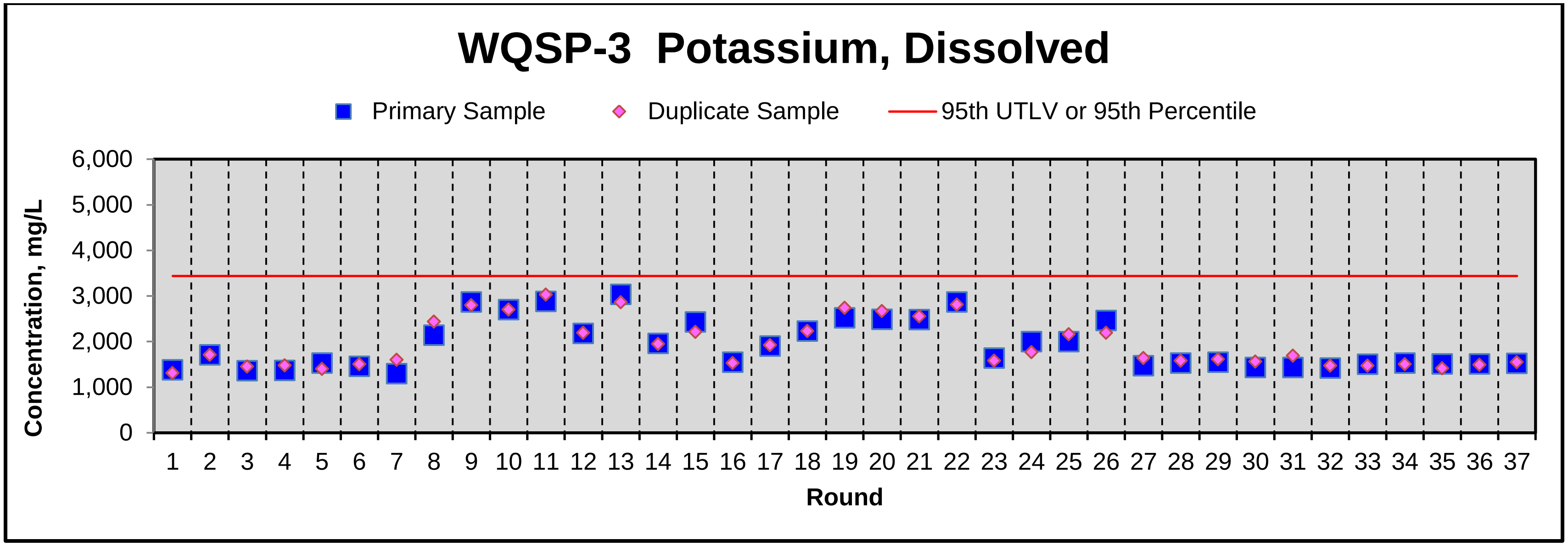

WQSP-2 Sulfate
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
9,000
8,000
7,000
6,000
5,000
4,000
3,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

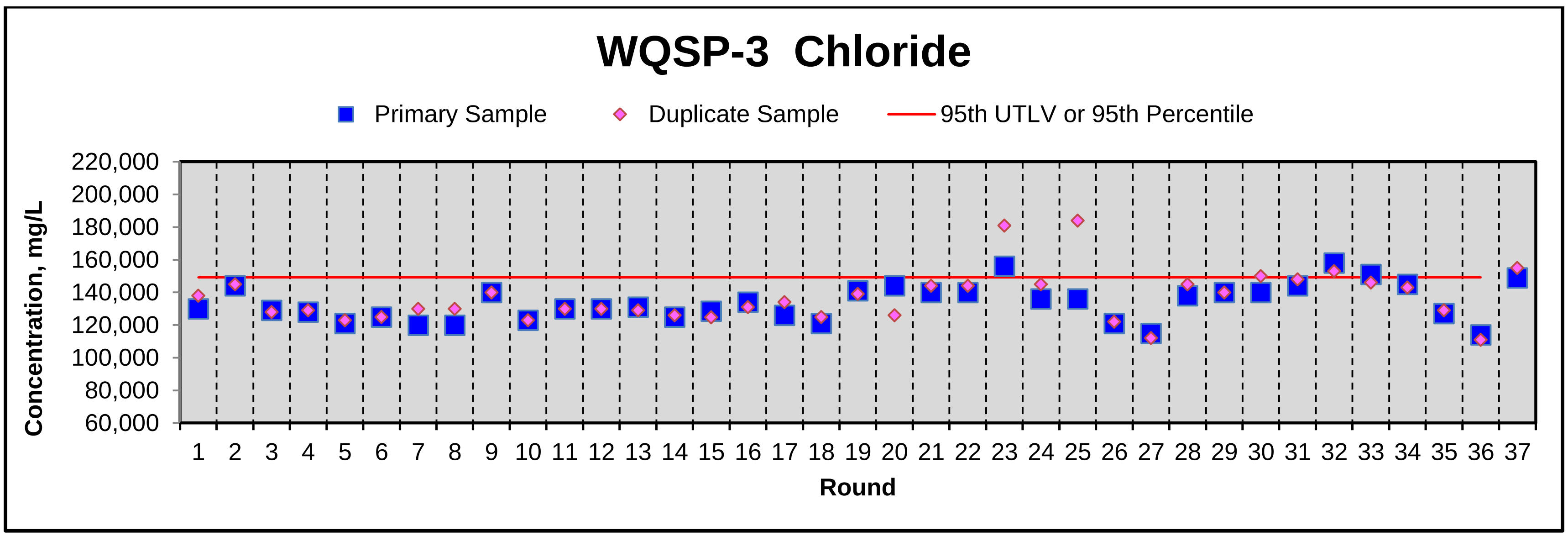

WQSP-2 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
120,000
100,000
80,000
60,000
40,000
20,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

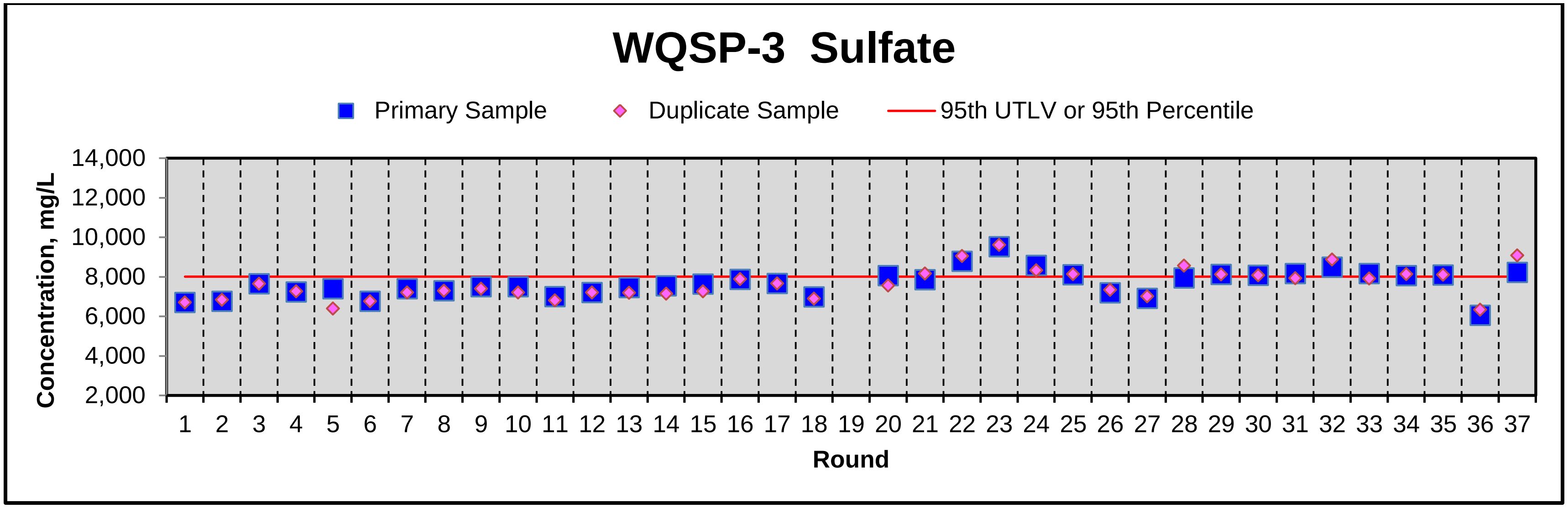

WQSP-2 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
8.50
8.25
8.00
7.75
7.50
7.25
7.00
6.75
6.50
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

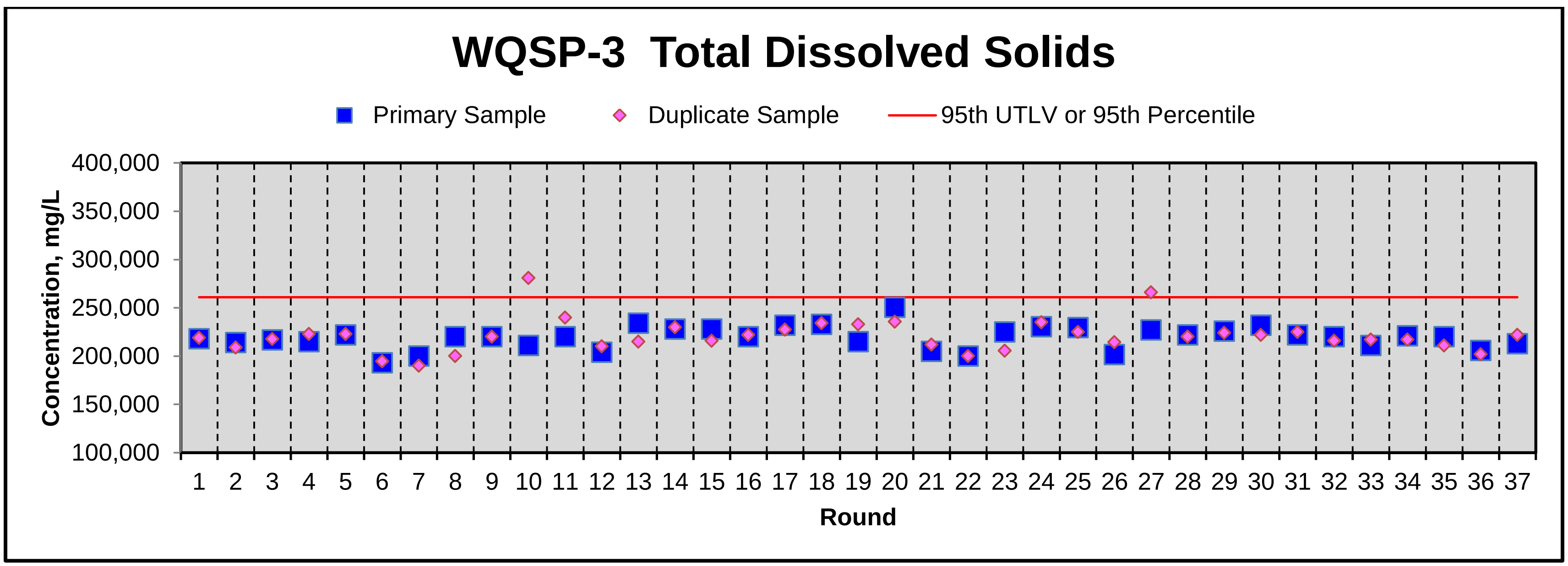

WQSP-3 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

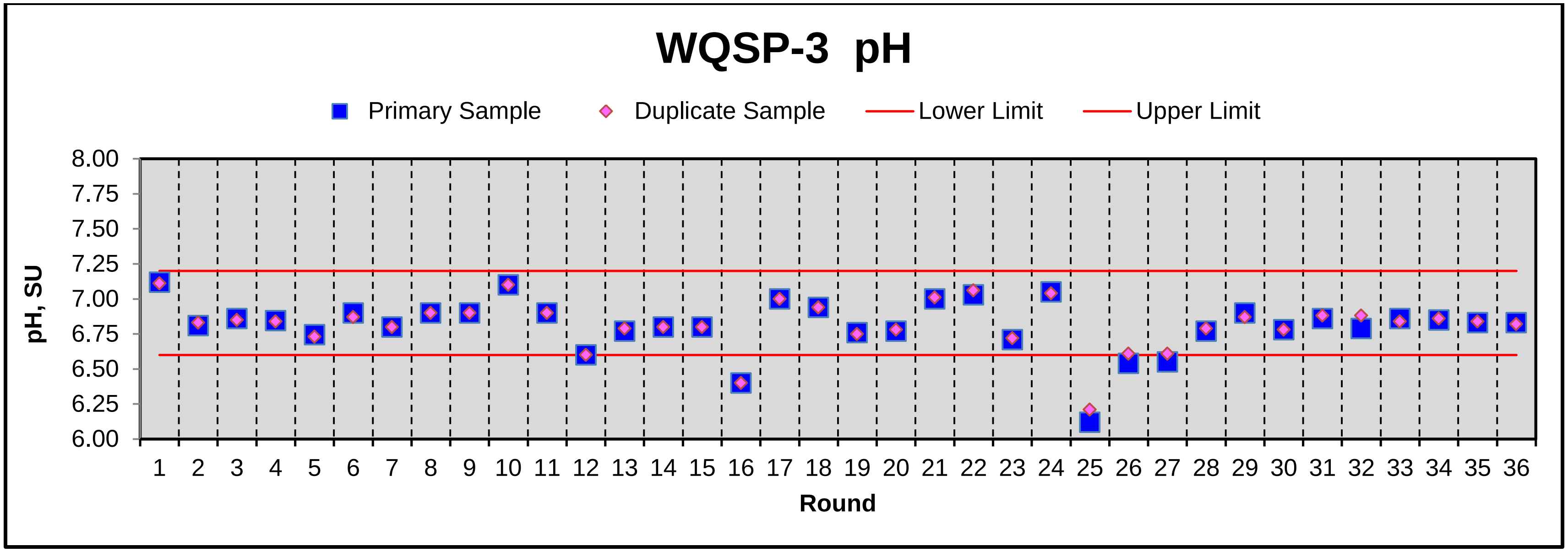

WQSP-3 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

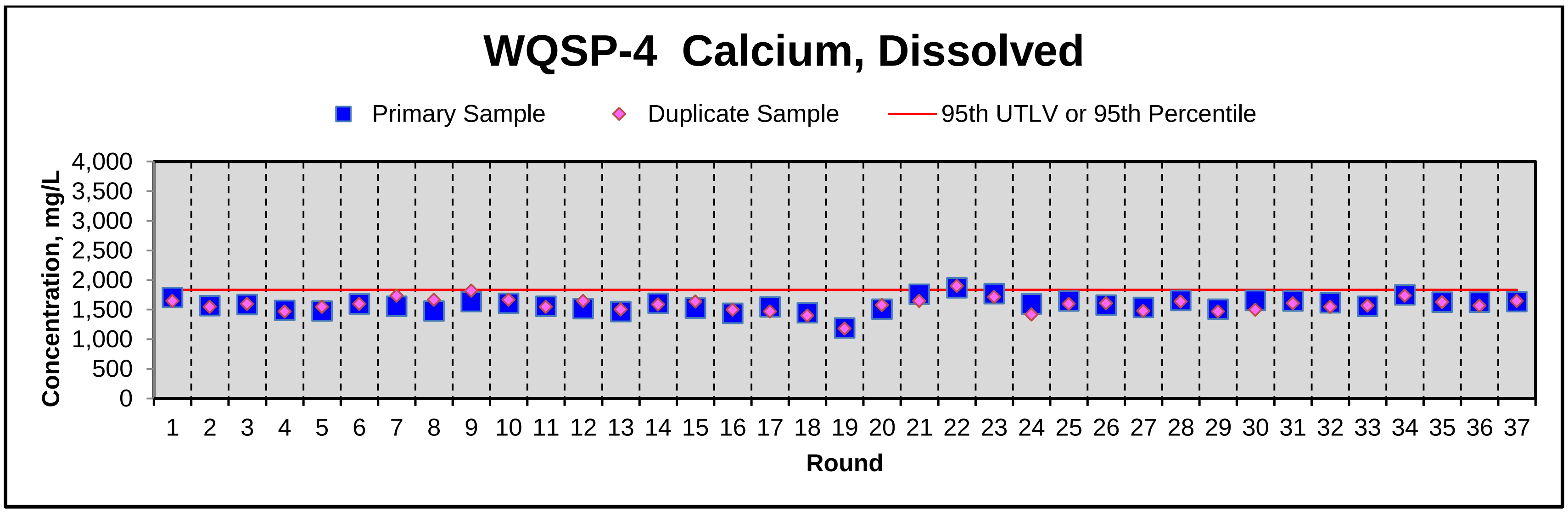

WQSP-3 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
6,000
5,000
4,000
3,000
2,000
1,000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

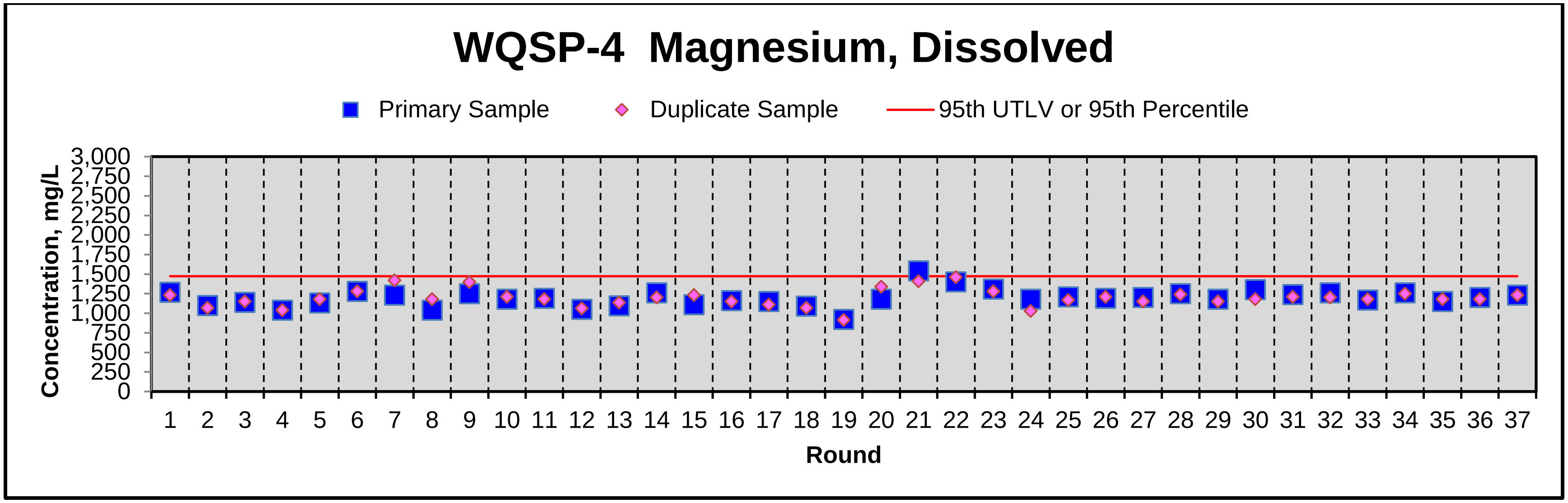

WQSP-3 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
220,000
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

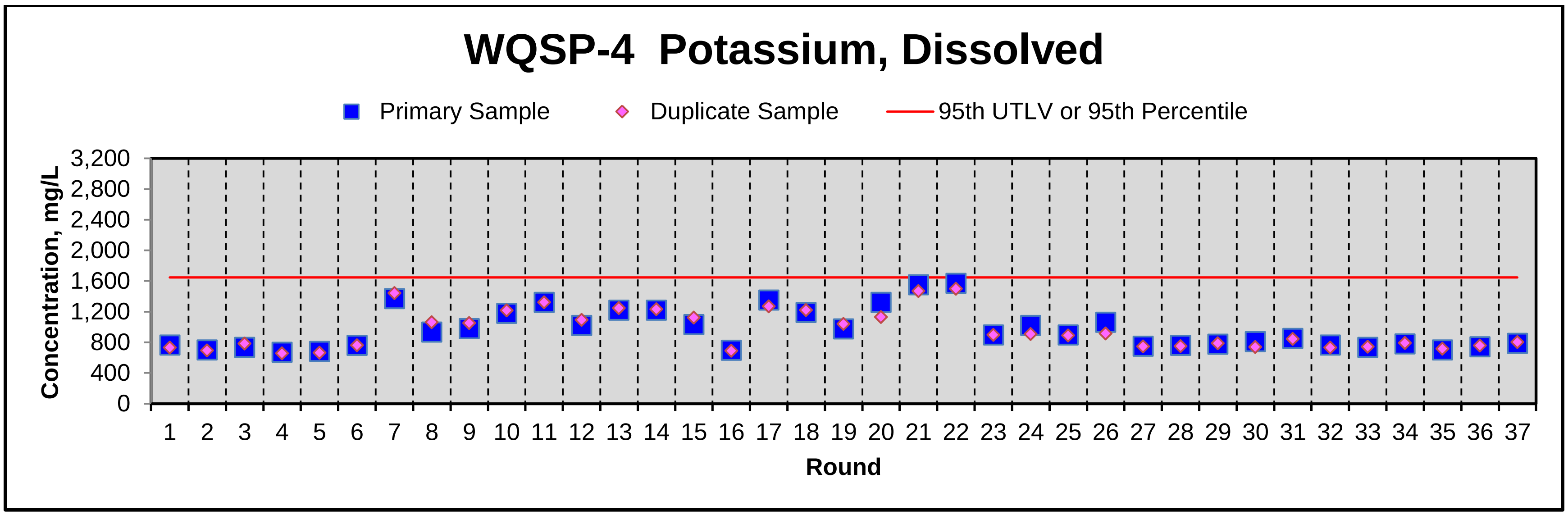

WQSP-3 Sulfate
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
14,000
12,000
10,000
8,000
6,000
4,000
2,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

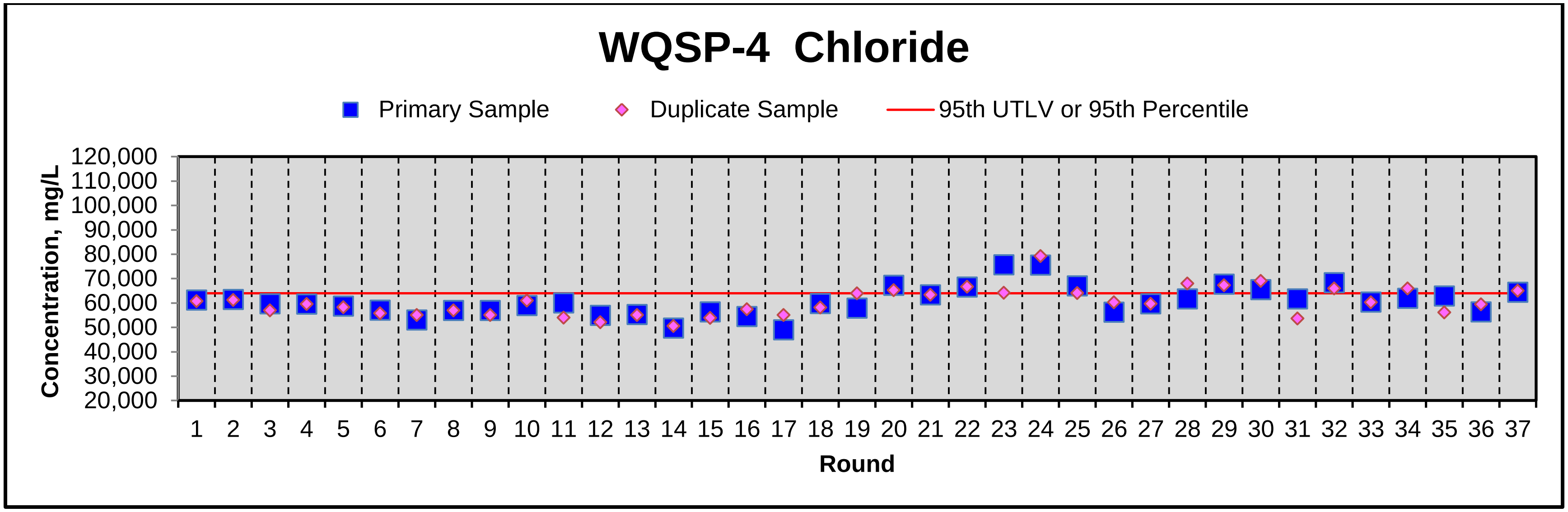

WQSP-3 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
400,000
350,000
300,000
250,000
200,000
150,000
100,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

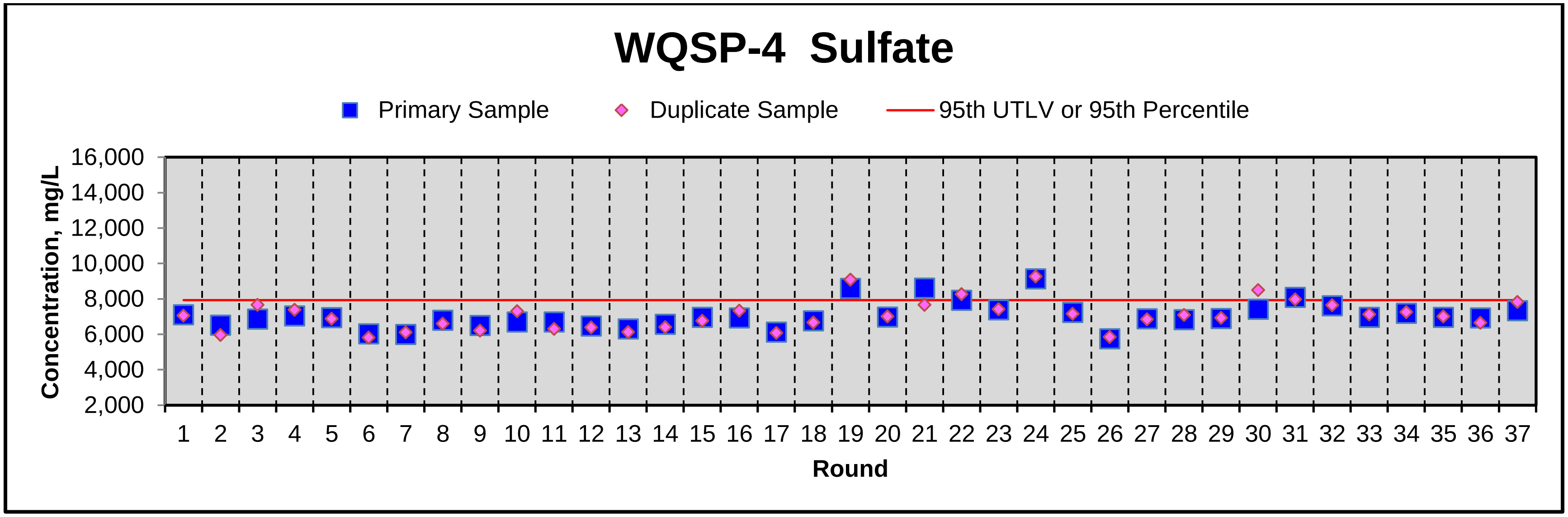

WQSP-3 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
8.00
7.75
7.50
7.25
7.00
6.75
6.50
6.25
6.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

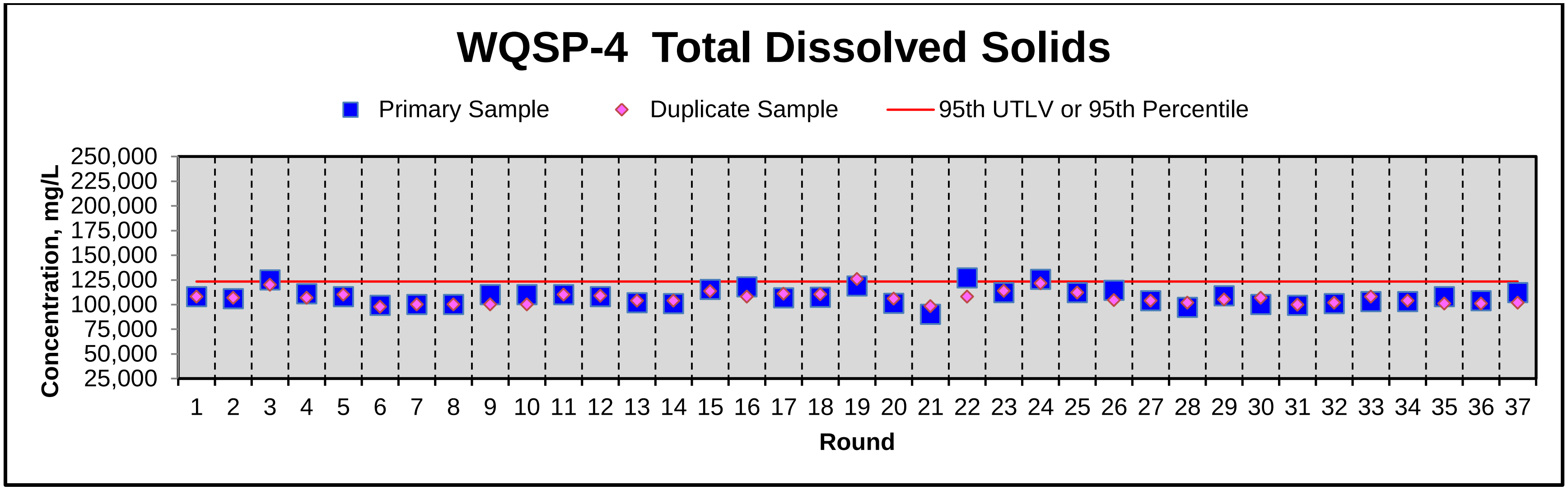

WQSP-4 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

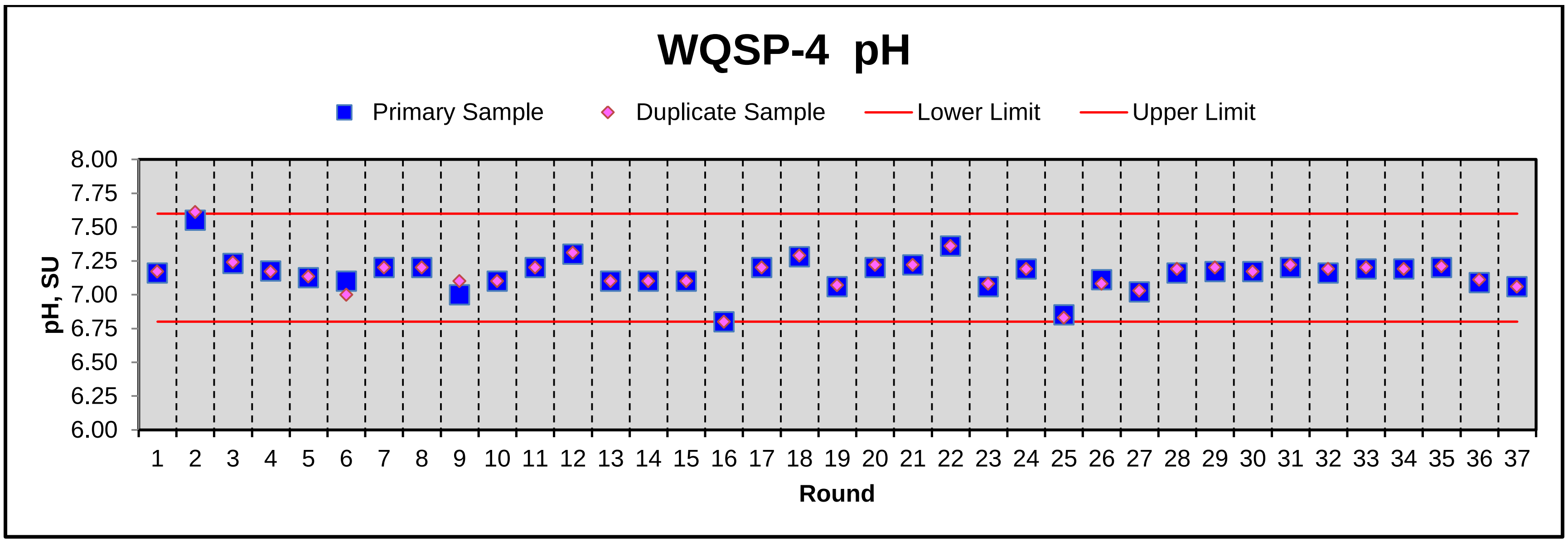

WQSP-4 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
3,000
2,750
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

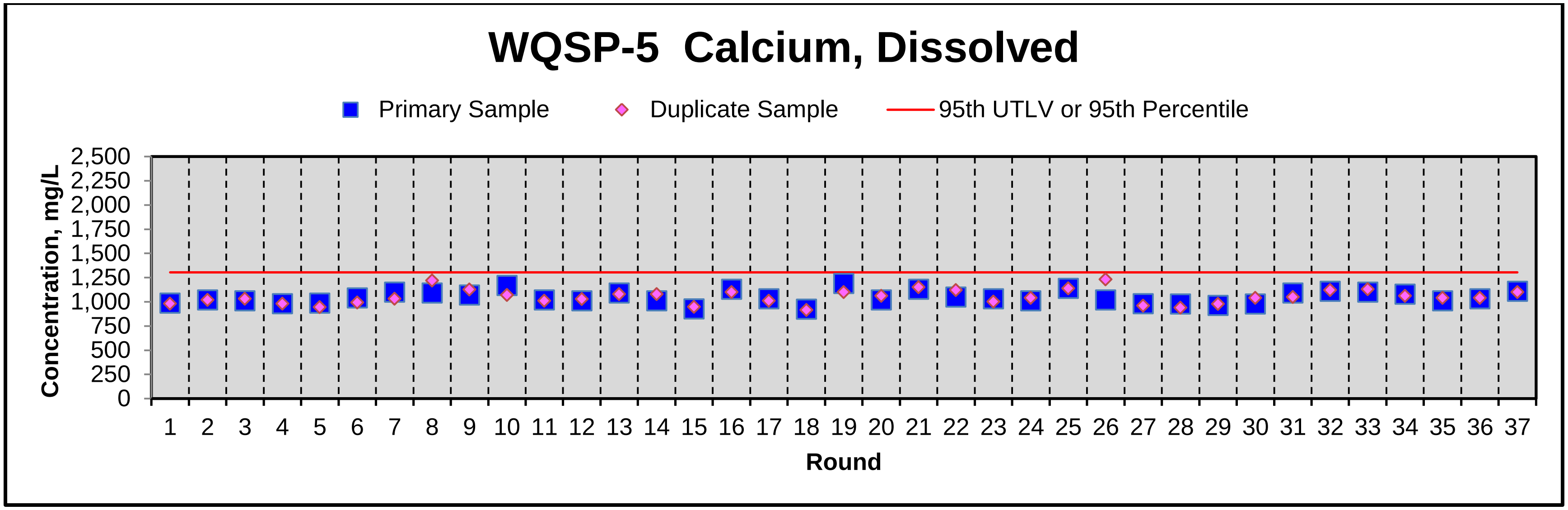

WQSP-4 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
3,200
2,800
2,400
2,000
1,600
1,200
800
400
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

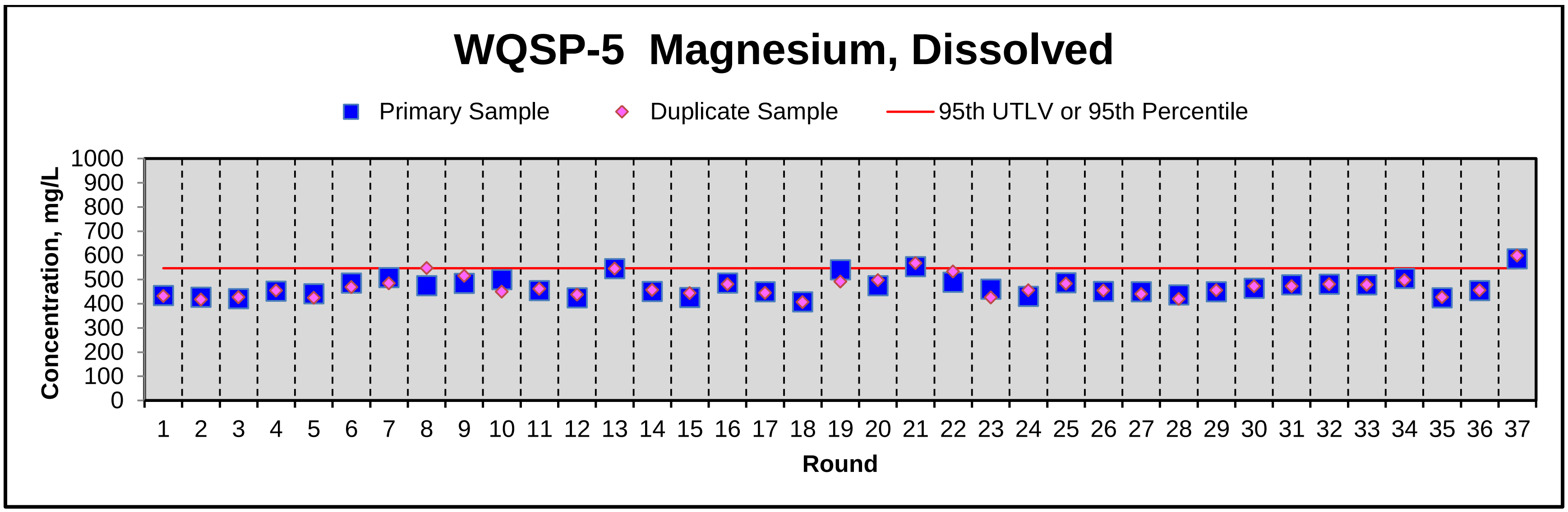

WQSP-4 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

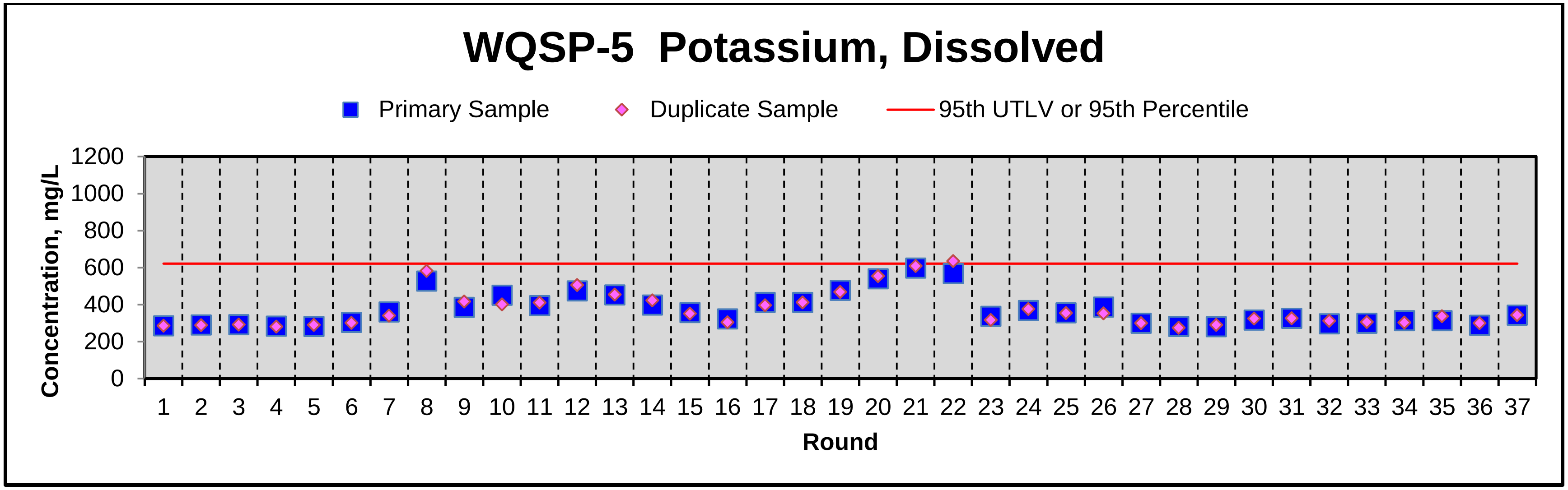

WQSP-4 Sulfate
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

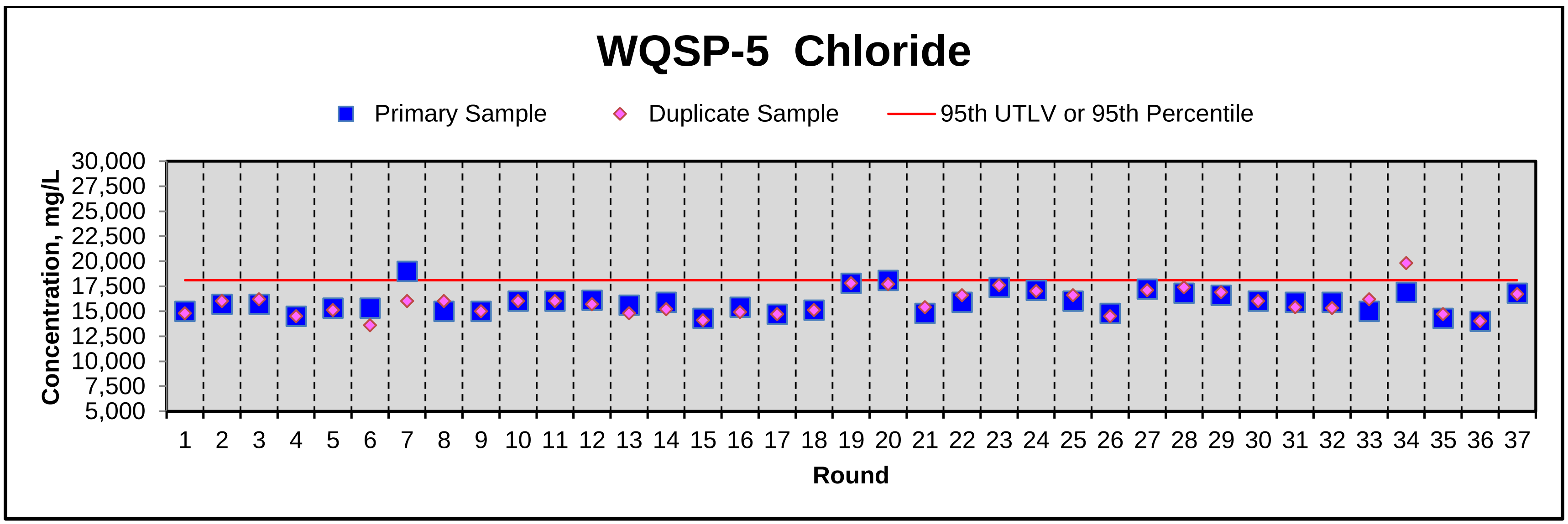

WQSP-4 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
250,000
225,000
200,000
175,000
150,000
125,000
100,000
75,000
50,000
25,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

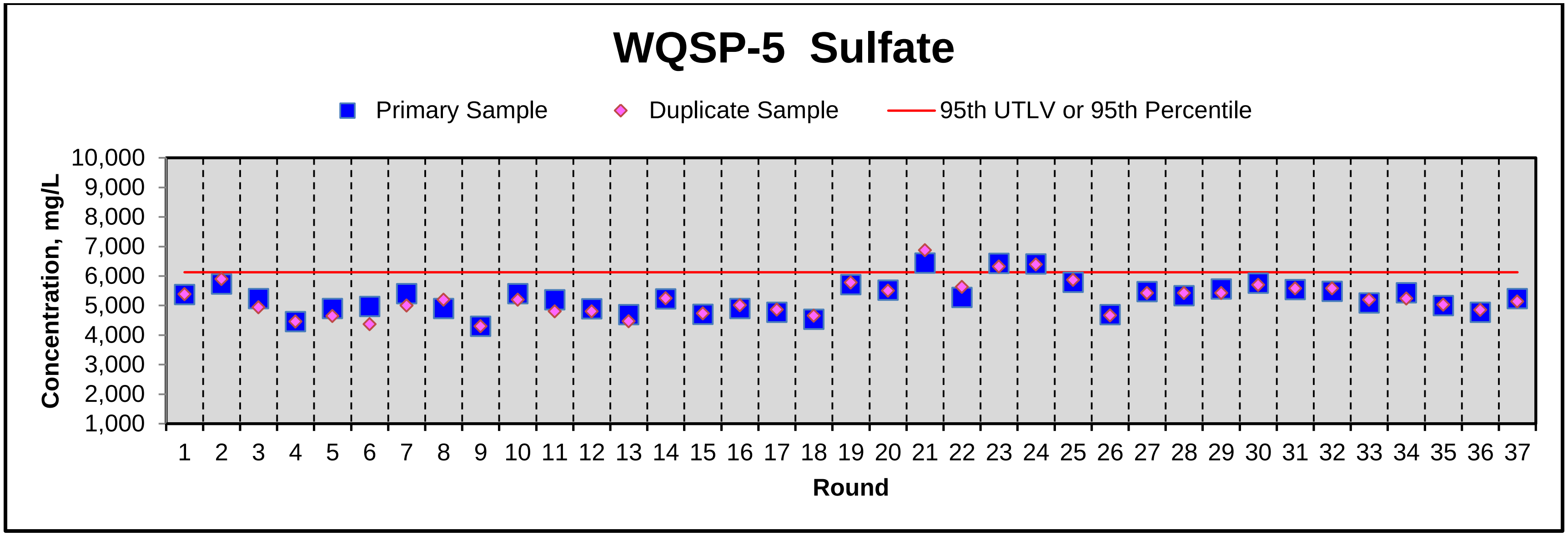

WQSP-4 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
8.00
7.75
7.50
7.25
7.00
6.75
6.50
6.25
6.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

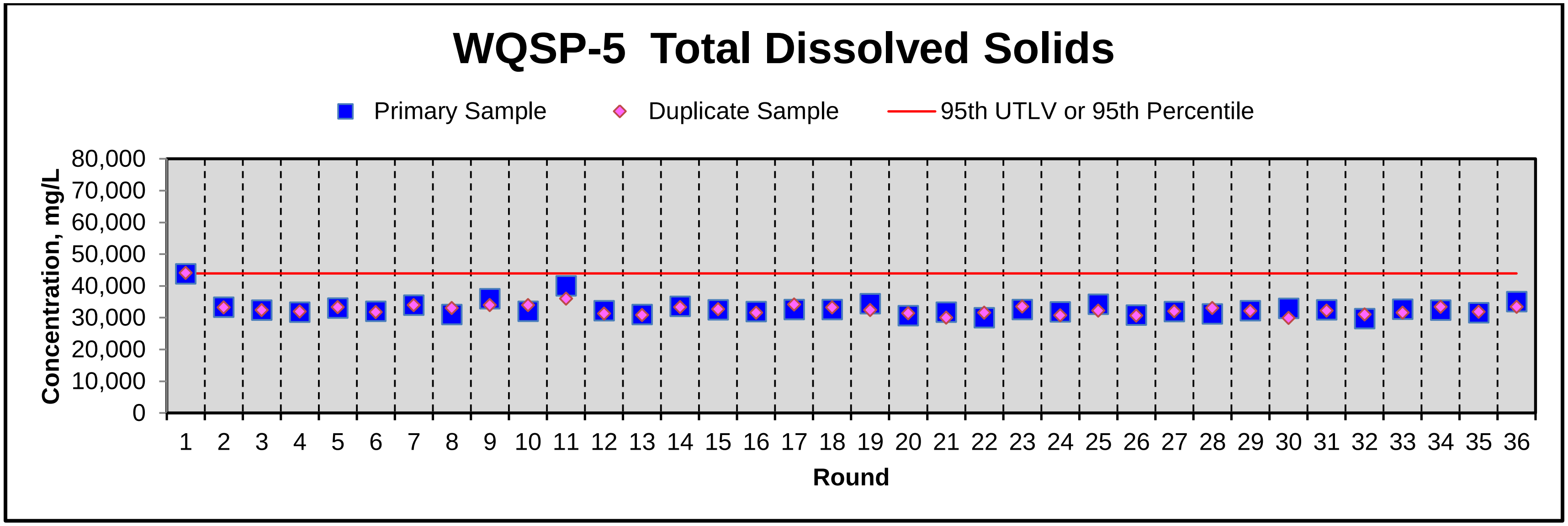

WQSP-5 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

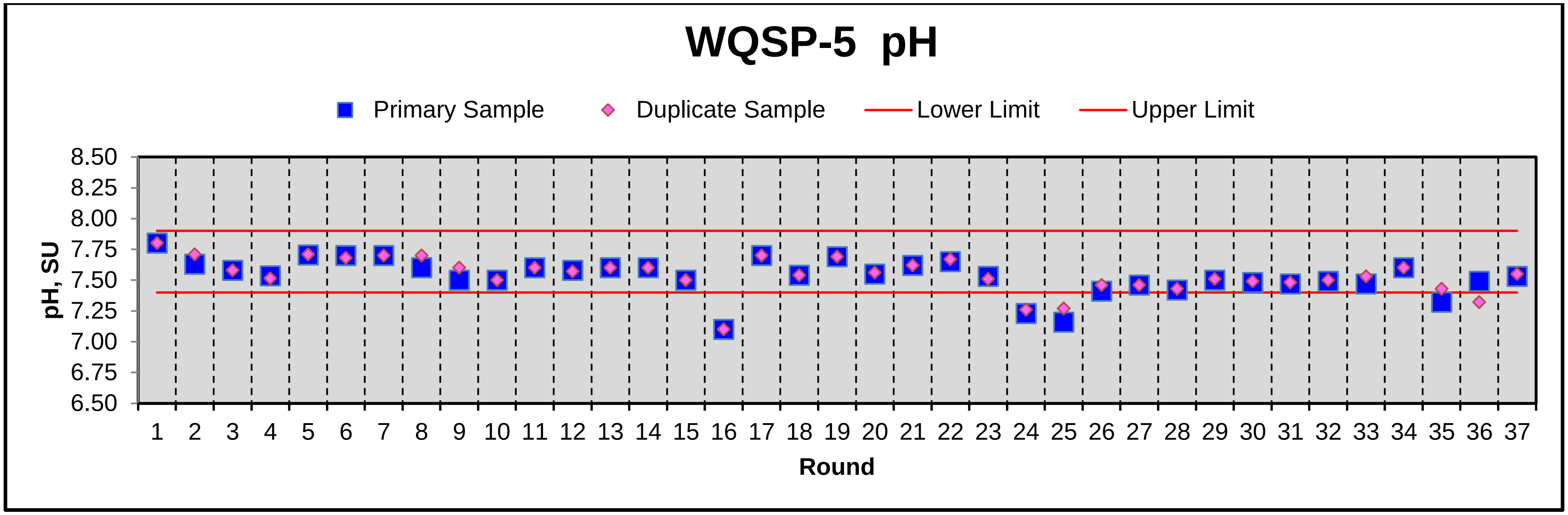

WQSP-5 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
1000
900
800
700
600
500
400
300
200
100
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

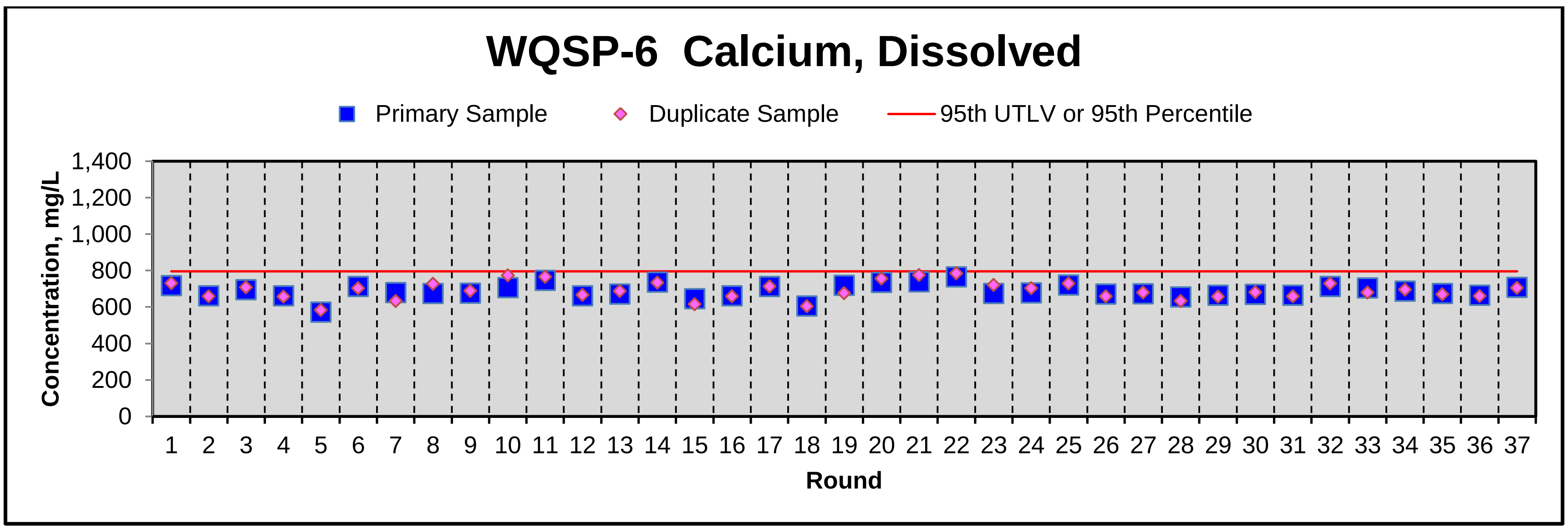

WQSP-5 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
0
200
400
600
800
1000
1200
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

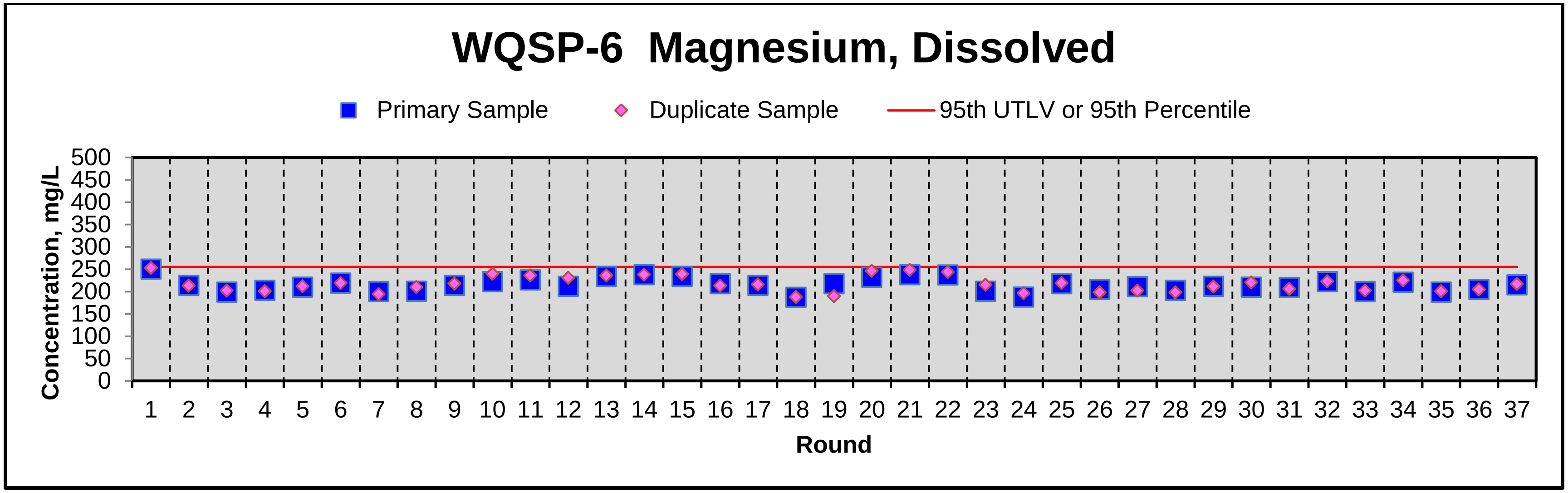

WQSP-5 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
5,000
7,500
10,000
12,500
15,000
17,500
20,000
22,500
25,000
27,500
30,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

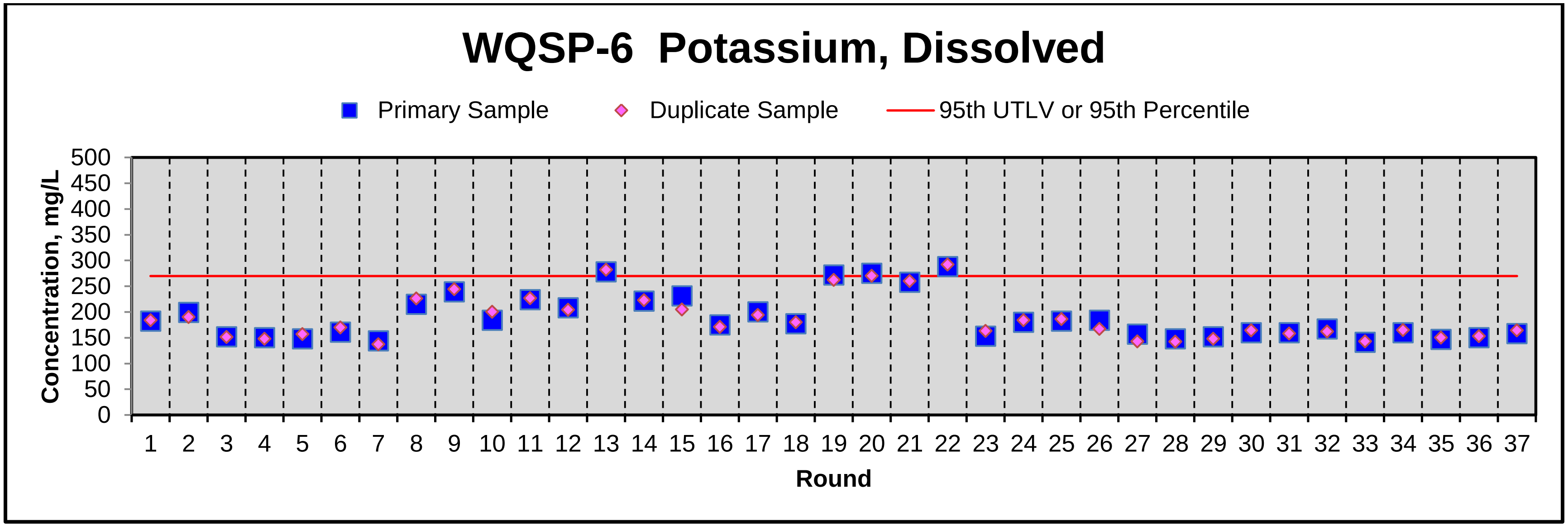

WQSP-5 Sulfate
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

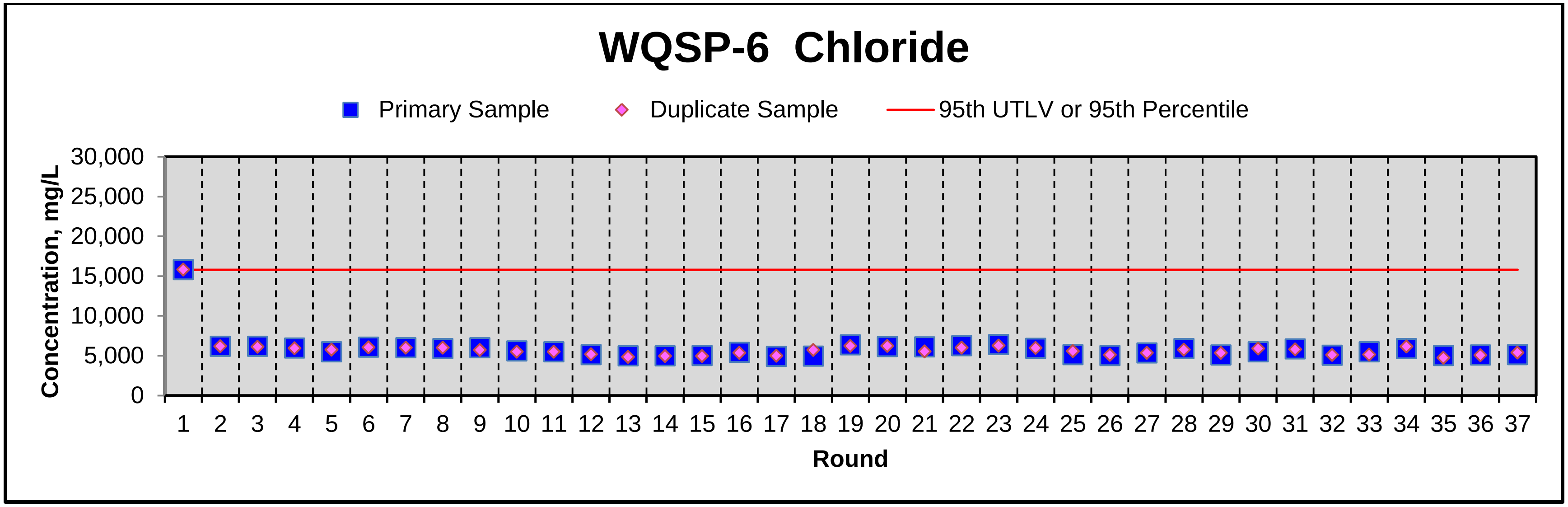

WQSP-5 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

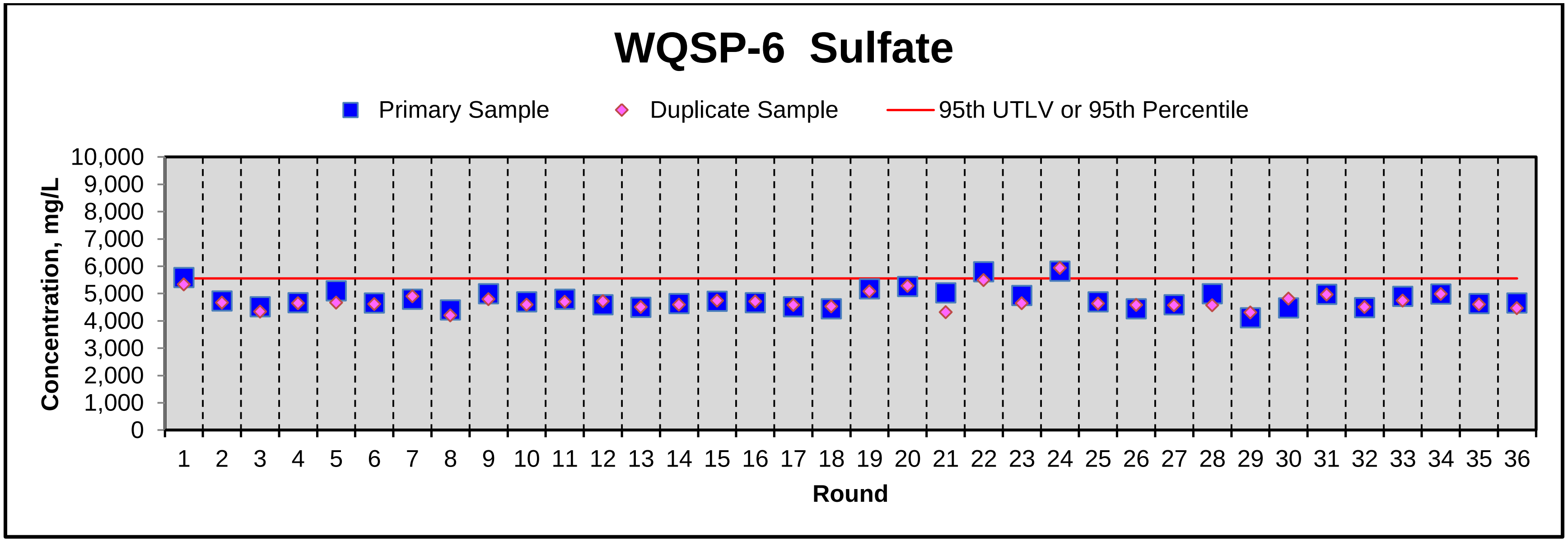

WQSP-5 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
8.50
8.25
8.00
7.75
7.50
7.25
7.00
6.75
6.50
pH, SU
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

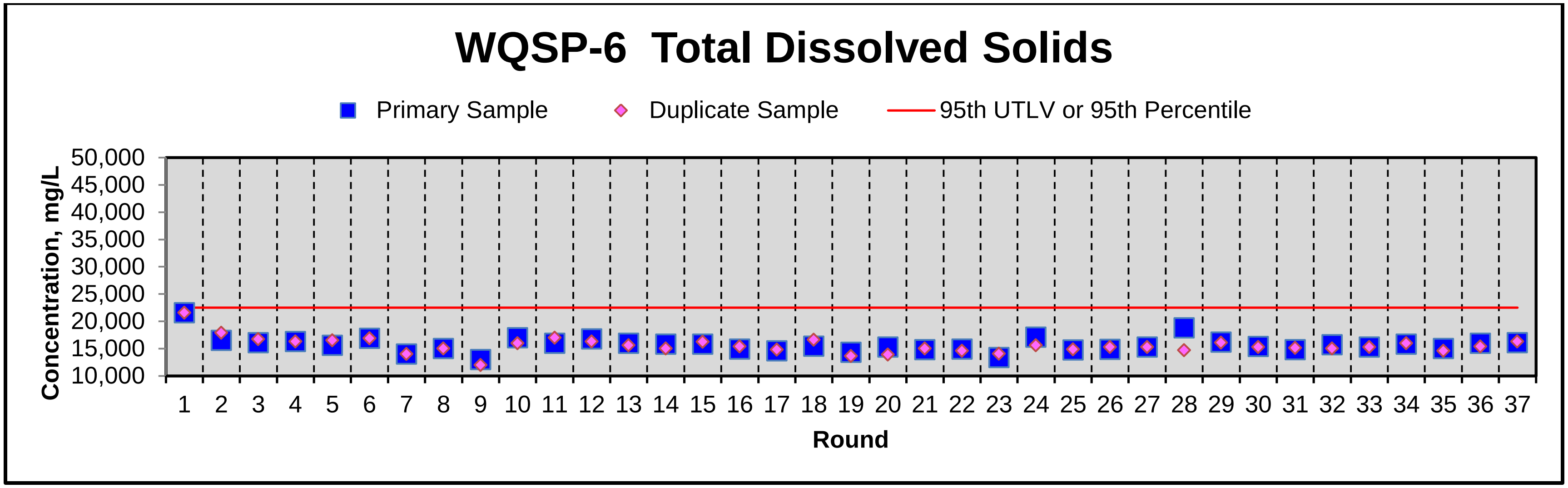

WQSP-6 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
1,400
1,200
1,000
800
600
400
200
0
Concentration, mg/L
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round

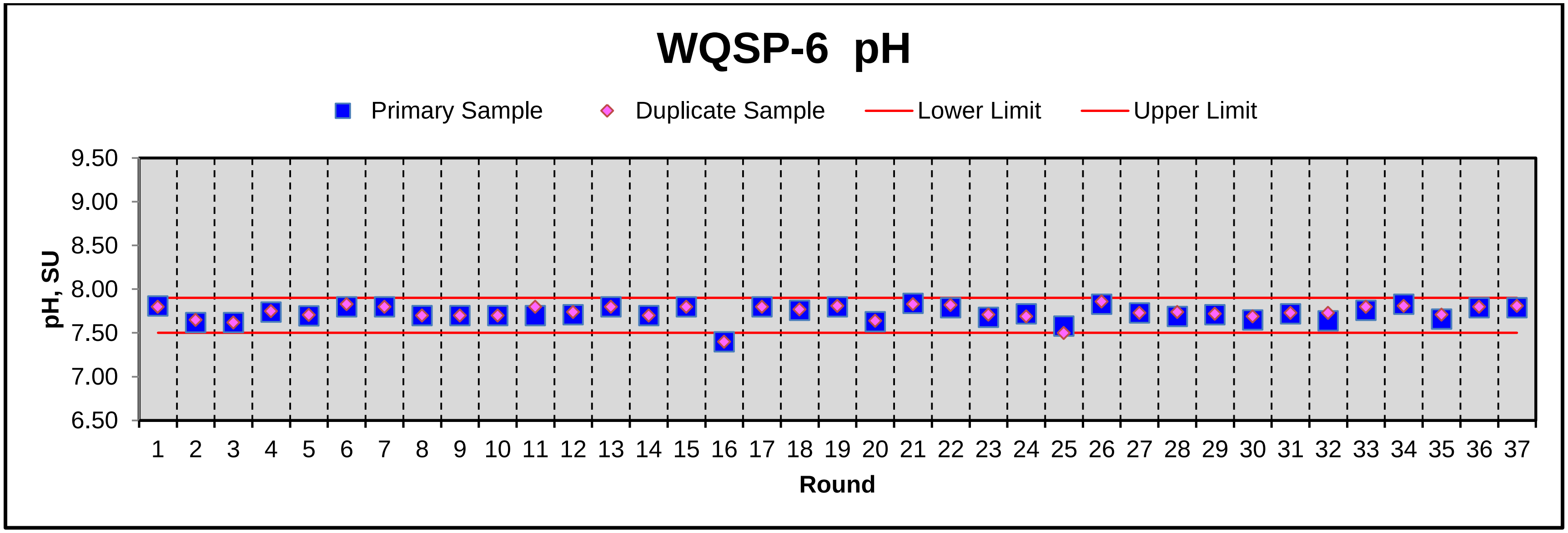

WQSP-6 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
0
50
100
150
200
250
300
350
400
450
500
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Round


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
Round


WQSP-6 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
30,000
25,000
20,000
15,000
10,000
5,000
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
Round


WQSP-6 Sulfate
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
10,000
9,000
8,000
7,000
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
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
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
Round

APPENDIX F – GROUNDWATER DATA TABLES

Table F.1 – Volatile Organic Compound and Semivolatile Organic Compound Results for Detection Monitoring Wells in 2015 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-1 Culebra

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]	1.031	1.032	Normal	1.07	N/A
pH (standard units)	7.12	7.16	Lognormal	5.6 to 8.8	N/A
Spec. Conductance (μmhos/cm)	121,000	121,000	Lognormal	175,000	N/A
Total Dissolved Solids mg/L)	63,500	66,200	Lognormal	80,700	N/A
Total Organic Carbon (mg/L)	0.71 J	0.78 J	Nonparametric	<5.0	N/A
Total Suspended Solids (mg/L)	**50**	**44**	Nonparametric	**33.3**	N/A
WQSP-1 Trace Metals					
Antimony (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.33	0.33
Arsenic (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	<0.1	0.10
Barium (mg/L)	0.032 J	0.031 J	Nonparametric	<1.0	1.00
Beryllium (mg/L)	0.0033 J	ND (0.0030)	Nonparametric	<0.02	0.02
Cadmium (mg/L)	ND (0.0026)	ND (0.0026)	Nonparametric	<0.2	0.20
Chromium (mg/L)	ND (0.0075)	ND (0.0075)	Nonparametric	<0.5	0.50
Lead (mg/L)	ND (0.023)	ND (0.023)	Nonparametric	0.105	0.11
Mercury (mg/L)	ND (0.00029)	ND (0.00029)	Nonparametric	<0.002	0.002
Nickel (mg/L)	ND (0.024)	ND (0.024)	Nonparametric	0.490	0.50
Selenium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.150	0.15
Silver (mg/L)	ND (0.0050)	ND (0.0050)	Nonparametric	<0.5	0.50
Thallium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.98	1.00
Vanadium (mg/L)	0.036 J	0.028 J	Nonparametric	<0.1	0.10
WQSP-1 Major Cations, Dissolved					
Calcium (mg/L)	1,820	1,970	Normal	2,087	N/A
Magnesium (mg/L)	1,180	**1,300**	Normal	**1,247**	N/A
Potassium (mg/L)	534	586	Lognormal	799	N/A
WQSP-1 Major Anions					
Chloride (mg/L)	**41,400**	**45,100**	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]	1.047	1.043	Lognormal	1.06	N/A
pH (standard units)	7.19	7.28	Normal	7.0 to 7.6	N/A
Spec. Conductance (μmhos/cm)	113,000	117,000	Lognormal	124,000	N/A
Total Dissolved Solids mg/L)	63,600	62,400	Normal	80,500	N/A
Total Organic Carbon (mg/L)	0.21 J	0.25 J	Nonparametric	7.97	N/A
Total Suspended Solids (mg/L)	**56**	**47**	Nonparametric	**43.0**	N/A
WQSP-2 Trace Metals					
Antimony (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	<0.5	0.50
Arsenic (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.062	0.06
Barium (mg/L)	0.027 J	0.029 J	Nonparametric	<1.0	1.00
Beryllium (mg/L)	0.0040 J	0.0035 J	Nonparametric	<1.0	1.00
Cadmium (mg/L)	ND (0.0026)	ND (0.0026)	Nonparametric	<0.5	0.50
Chromium (mg/L)	ND (0.0075)	ND (0.0075)	Nonparametric	<0.5	0.50
Lead (mg/L)	ND (0.023)	ND (0.023)	Nonparametric	0.163	0.17
Mercury (mg/L)	ND (0.00029)	ND (0.00029)	Nonparametric	<0.002	0.002
Nickel (mg/L)	ND (0.024)	ND (0.024)	Nonparametric	0.37	0.50
Selenium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.150	0.15
Silver (mg/L)	ND (0.0050)	ND (0.0050)	Nonparametric	<0.5	0.50
Thallium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.980	1.00
Vanadium (mg/L)	0.037 J	0.034 J	Nonparametric	<0.1	0.10
WQSP-2 Major Cations, Dissolved					
Calcium (mg/L)	1,550	1,560	Lognormal	1,827	N/A
Magnesium (mg/L)	1,030	1,040	Normal	1,244	N/A
Potassium (mg/L)	528	537	Lognormal	845	N/A
WQSP-2 Major Anions					
Chloride (mg/L)	38,200	30,000	Normal	39,670	N/A

a, b Refer to footnotes at end of table.

WQSP-3					
Parameter (units)	**Primary**	**Duplicate**	**Distribution Type[a]**	**95th UTLV Or 95th Percentile[a]**	**Permit Table 5.6**
WQSP-3 General Chemistry					
Specific Gravity (unitless)[b]	1.146	1.144	Normal	1.17	N/A
pH (standard units)	6.79	6.85	Lognormal	6.6 to 7.2	N/A
Spec. Conductance (μmhos/cm)	387,000	395,000	Normal	517,000	N/A
Total Dissolved Solids mg/L)	213,000	222,000	Lognormal	261,000	N/A
Total Organic Carbon (mg/L)	0.18 J	ND (0.16)	Nonparametric	<5.0	N/A
Total Suspended Solids (mg/L)	**151**	**149**	Nonparametric	**107**	N/A
WQSP-3 Trace Metals					
Antimony (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	<1.0	1.00
Arsenic (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	<1.0	0.21
Barium (mg/L)	0.039 J	0.036 J	Nonparametric	<1.0	1.00
Beryllium (mg/L)	ND (0.015)	ND (0.015)	Nonparametric	<0.1	0.10
Cadmium (mg/L)	ND (0.013)	ND (0.013)	Nonparametric	<0.5	0.50
Chromium (mg/L)	ND (0.037)	ND (0.037)	Nonparametric	<2.0	2.00
Lead (mg/L)	ND (0.011)	ND (0.011)	Nonparametric	0.8	0.80
Mercury (mg/L)	ND (0.00029)	ND (0.00029)	Nonparametric	<0.002	0.002
Nickel (mg/L)	ND (0.12)	ND (0.12)	Nonparametric	<5.0	5.00
Selenium (mg/L)	0.011	0.012	Nonparametric	<2.0	2.00
Silver (mg/L)	ND (0.025)	ND (0.025)	Nonparametric	0.31	0.31
Thallium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	5.8	5.80
Vanadium (mg/L)	0.088 J	ND (0.025)	Nonparametric	<5.0	5.00
WQSP-3 Major Cations, Dissolved					
Calcium (mg/L)	1,490	1,510	Normal	1,680	N/A
Magnesium (mg/L)	2,360	2,360	Lognormal	2,625	N/A
Potassium (mg/L)	1,520	1,550	Lognormal	3,438	N/A
WQSP-3 Major Anions					
Chloride (mg/L)	149,000	**155,000**	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	1.072	Lognormal	1.09	N/A
pH (standard units)	7.06	7.06	Lognormal	6.8 to 7.6	N/A
Spec. Conductance (μmhos/cm)	176,000	176,000	Lognormal	319,800	N/A
Total Dissolved Solids mg/L)	112,000	102,000	Normal	123,500	N/A
Total Organic Carbon (mg/L)	0.42 J	0.40 J	Nonparametric	<5.0	N/A
Total Suspended Solids (mg/L)	52	52	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)	0.030 J	0.034 J	Nonparametric	1.00	1.00
Beryllium (mg/L)	ND (0.0030)	ND (0.0030)	Nonparametric	0.25	0.25
Cadmium (mg/L)	ND (0.0026)	ND (0.0026)	Nonparametric	<0.5	0.50
Chromium (mg/L)	ND (0.0075)	ND (0.0075)	Nonparametric	<2.0	2.00
Lead (mg/L)	ND (0.023)	ND (0.023)	Nonparametric	0.525	0.53
Mercury (mg/L)	ND (0.00029)	ND (0.00029)	Nonparametric	<0.002	0.002
Nickel (mg/L)	0.046 J	0.050 J	Nonparametric	<5.0	5.00
Selenium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	2.009	2.00
Silver (mg/L)	ND (0.0050)	ND (0.0050)	Nonparametric	0.519	0.52
Thallium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	1.00	1.00
Vanadium (mg/L)	0.027 J	0.027 J	Nonparametric	<5.0	5.00
WQSP-4 Major Cations, Dissolved					
Calcium (mg/L)	1,640	1,650	Lognormal	1,834	N/A
Magnesium (mg/L)	1,230	1,230	Lognormal	1,472	N/A
Potassium (mg/L)	788	803	Lognormal	1,648	N/A
WQSP-4 Major Anions					
Chloride (mg/L)	**64,400**	**65,000**	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]	1.019	1.018	Normal	1.04	N/A
pH (standard units)	7.53	7.55	Normal	7.4 to 7.9	N/A
Spec. Conductance (μmhos/cm)	65,000	66,000	Lognormal	67,700	N/A
Total Dissolved Solids mg/L)	32,000	33,100	Nonparametric	43,950	N/A
Total Organic Carbon (mg/L)	0.33 J	0.35 J	Nonparametric	<5.0	N/A
Total Suspended Solids (mg/L)	**13**	**24**	Nonparametric	**<10**	N/A
WQSP-5 Total Trace Metals					
Antimony (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.073	0.07
Arsenic (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	<0.5	0.50
Barium (mg/L)	0.023 J	0.023 J	Nonparametric	<1.0	1.00
Beryllium (mg/L)	0.0040 J	0.0035 J	Nonparametric	<0.02	0.02
Cadmium (mg/L)	ND (0.0026)	ND (0.0026)	Nonparametric	<0.05	0.05
Chromium (mg/L)	ND (0.0075)	ND (0.0075)	Nonparametric	<0.5	0.50
Lead (mg/L)	ND(0.023)	ND (0.023)	Nonparametric	<0.05	0.05
Mercury (mg/L)	ND (0.00029)	ND (0.00029)	Nonparametric	<0.002	0.002
Nickel (mg/L)	ND (0.024)	ND (0.024)	Nonparametric	<0.1	0.10
Selenium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	<0.1	0.10
Silver (mg/L)	ND (0.0050)	ND (0.0050)	Nonparametric	<0.5	0.50
Thallium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.209	0.21
Vanadium (mg/L)	0.031 J	0.029 J	Nonparametric	2.70	2.70
WQSP-5 Major Cations, Dissolved					
Calcium (mg/L)	1,110	1,100	Lognormal	1,303	N/A
Magnesium (mg/L)	**586**	**599**	Nonparametric	**547**	N/A
Potassium (mg/L)	343	343	Lognormal	622	N/A
WQSP-5 Major Anions					
Chloride (mg/L)	16,800	16,700	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]	1.007	1.006	Normal	1.02	N/A
pH (standard units)	7.79	7.81	Normal	7.5 to 7.9	N/A
Spec. Conductance (μmhos/cm)	**30,100**	**30,200**	Lognormal	**27,660**	N/A
Total Dissolved Solids mg/L)	16,100	16,300	Lognormal	22,500	N/A
Total Organic Carbon (mg/L)	0.52 J	0.53 J	Nonparametric	10.14	N/A
Total Suspended Solids (mg/L)	ND	ND	Nonparametric	14.8	N/A
WQSP-6 Trace Metals					
Antimony (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.140	0.14
Arsenic (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	<0.5	0.50
Barium (mg/L)	0.011 J	0.011 J	Nonparametric	<1.0	1.00
Beryllium (mg/L)	0.00071 J	0.00075 J	Nonparametric	<0.02	0.02
Cadmium (mg/L)	ND (0.00052)	ND (0.00052)	Nonparametric	<0.05	0.05
Chromium (mg/L)	ND (0.0015)	ND (0.0015)	Nonparametric	<0.5	0.50
Lead (mg/L)	ND (0.0046)	ND (0.0046)	Nonparametric	0.150	0.15
Mercury (mg/L)	ND (0.000059)	ND (0.000059)	Nonparametric	<0.002	0.002
Nickel (mg/L)	ND (0.0049)	ND (0.0049)	Nonparametric	<0.5	0.50
Selenium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.10	0.10
Silver (mg/L)	ND (0.0010)	ND (0.0010)	Nonparametric	<0.5	0.50
Thallium (mg/L)	ND (0.010)	ND (0.010)	Nonparametric	0.560	0.56
Vanadium (mg/L)	0.0056 J	0.0058 J	Nonparametric	0.070	0.10
WQSP-6 Major Cations, Dissolved					
Calcium (mg/L)	709	706	Normal	796	N/A
Magnesium (mg/L)	215	217	Lognormal	255	N/A
Potassium (mg/L)	158	164	Lognormal	270	N/A
WQSP-6 Major Anions					
Chloride (mg/L)	5,120	5,400	Nonparametric	15,800	N/A

Notes:

Values (concentrations) in bold exceed or are outside of the baseline range for the 95th UTLV, 95th percentile, or Hazardous Waste Facility Permit background value. In these cases, the UTLV, 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 (g/mL) 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 2015

Sorted by Active Wells at Year-End				Sorted by Formation for Wells Measured at Least Once in 2015			
Count	Well Number	Zone	Comments	Count	Well Number	Zone	Reason Not Assessed for Long-Term Water Level Trend in Culebra
1	AEC-7R	CUL		1	CB-1(PIP)	B/C	
2	C-2505	SR/DL		2	DOE-2	B/C	
3	C-2506	SR/DL		3	AEC-7R	CUL	
4	C-2507	SR/DL		4	ERDA-9	CUL	
5	C-2737	MAG/CUL		5	H-02b2	CUL	
6	C-2811	SR/DL		6	H-03b2	CUL	
7	CB-1(PIP)	B/C		7	H-04bR	CUL	
8	DOE-2	B/C		8	H-05b	CUL	
9	ERDA-9	CUL		9	H-06bR	CUL	
10	H-02b1	MAG		10	H-07b1	CUL	
11	H-02b2	CUL		11	H-09bR	CUL	
12	H-03b1	MAG		12	H-10cR	CUL	Completed October 2015
13	H-03b2	CUL		13	H-10c	CUL	Plugged in October 2015
14	H-03D	SR/DL	Dry; not measured in 2013	14	H-12R	CUL	Completed in September 2014
15	H-04bR	CUL		16	H-17	CUL	
16	H-04c	MAG		17	H-19b0	CUL	
17	H-05b	CUL		18	H-19b2	CUL	Redundant to H19b0
18	H-06bR	CUL		19	H-19b3	CUL	Redundant to H19b0
19	H-06c	MAG		20	H-19b4	CUL	Redundant to H19b0
20	H-07b1	CUL		21	H-19b5	CUL	Redundant to H19b0
21	H-08a	MAG		22	H-19b6	CUL	Redundant to H19b0
22	H-09c	MAG		23	H-19b7	CUL	Redundant to H19b0
23	H-09bR	CUL		24	I-461	CUL	
24	H-10a	MAG		25	SNL-01	CUL	
25	H-10cR	CUL		26	SNL-02	CUL	
26	H-11b2	MAG		27	SNL-03	CUL	
27	H-11b4R	CUL		28	SNL-05	CUL	
28	H-12R	CUL		29	SNL-6	CUL	Depressed from projected equilibrium
29	H-14	MAG		30	SNL-08	CUL	
30	H-15R	CUL		31	SNL-09	CUL	

Sorted by Active Wells at Year-End				Sorted by Formation for Wells Measured at Least Once in 2015			
Count	Well Number	Zone	Comments	Count	Well Number	Zone	Reason Not Assessed for Long-Term Water Level Trend in Culebra
31	H-15	MAG		32	H-15R	CUL	
32	H-16	CUL		33	SNL-10	CUL	
33	H-17	CUL		34	H-16	CUL	Seasonal changes
34	H-18	MAG		35	SNL-12	CUL	
35	H-19b0	CUL		36	SNL-13	CUL	Rise from oil field activities
36	H-19b2	CUL		37	SNL-14	CUL	
37	H-19b3	CUL		38	SNL-15	CUL	Depressed from projected equilibrium
38	H-19b4	CUL		39	SNL-16	CUL	
39	H-19b5	CUL		40	SNL-17	CUL	
40	H-19b6	CUL		41	SNL-18	CUL	
41	H-19b7	CUL		42	SNL-19	CUL	
42	I-461	CUL		43	WIPP-11	CUL	
43	SNL-01	CUL		44	WIPP-13	CUL	
44	SNL-02	CUL		45	WIPP-19	CUL	
45	SNL-03	CUL		46	WQSP-1	CUL	
46	SNL-05	CUL		47	WQSP-2	CUL	
47	SNL-06	CUL		48	WQSP-3	CUL	
48	SNL-08	CUL		49	WQSP-4	CUL	
49	SNL-09	CUL		50	WQSP-5	CUL	
50	SNL-10	CUL		51	WQSP-6	CUL	
51	SNL-12	CUL		52	WQSP-6A	DL	
52	SNL-13	CUL		53	H-02b1	MAG	
53	SNL-14	CUL		54	H-03b1	MAG	
54	SNL-15	CUL		55	H-04c	MAG	
55	SNL-16	CUL		56	H-06c	MAG	
56	SNL-17	CUL		57	H-08a	MAG	
57	SNL-18	CUL		58	H-10a	MAG	
58	SNL-19	CUL		59	H-11b2	MAG	
59	PZ-01	SR/DL		60	H-14	MAG	
60	PZ-02	SR/DL		61	H-18	MAG	
61	PZ-03	SR/DL		62	WIPP-18	MAG	
62	PZ-04	SR/DL		63	H-15	MAG	

Sorted by Active Wells at Year-End				Sorted by Formation for Wells Measured at Least Once in 2015			
Count	Well Number	Zone	Comments	Count	Well Number	Zone	Reason Not Assessed for Long-Term Water Level Trend in Culebra
63	PZ-05	SR/DL		64	H-09c	MAG	
64	PZ-06	SR/DL		65	C-2737	MAG/CUL	
65	PZ-07	SR/DL		66	C-2505	SR/DL	
66	PZ-08	SR/DL		67	C-2506	SR/DL	
67	PZ-09	SR/DL		68	C-2507	SR/DL	
68	PZ-10	SR/DL		69	C-2811	SR/DL	
69	PZ-11	SR/DL		70	PZ-01	SR/DL	
70	PZ-12	SR/DL		71	PZ-02	SR/DL	
71	PZ-13	SR/DL		72	PZ-03	SR/DL	
72	PZ-14	SR/DL		73	PZ-04	SR/DL	
73	PZ-15	SR/DL		74	PZ-05	SR/DL	
74	WIPP-11	CUL		75	PZ-06	SR/DL	
75	WIPP-13	CUL		76	PZ-07	SR/DL	
76	WIPP-18	MAG		77	PZ-08	SR/DL	
77	WIPP-19	CUL		78	PZ-09	SR/DL	
78	WQSP-1	CUL		79	PZ-10	SR/DL	
79	WQSP-2	CUL		80	PZ-11	SR/DL	
80	WQSP-3	CUL		81	PZ-12	SR/DL	
81	WQSP-4	CUL		82	PZ-13	SR/DL	
82	WQSP-5	CUL		83	PZ-14	SR/DL	
83	WQSP-6	CUL		84	PZ-15	SR/DL	
84	WQSP-6A	DL		85	H-03D	SR/DL	Dry; not measured since 2013

Table F.4 – Water Levels

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
AEC-7R	CUL	January	SNL Test		
AEC-7R	CUL	February	SNL Test		
AEC-7R	CUL	March	SNL Test		
AEC-7R	CUL	April	SNL Test		
AEC-7R	CUL	May	SNL Test		
AEC-7R	CUL	June	SNL Test		
AEC-7R	CUL	July	SNL Test		
AEC-7R	CUL	August	SNL Test		
AEC-7R	CUL	09/01/15	615.62	3044.36	3062.84
AEC-7R	CUL	10/13/15	615.31	3044.67	3063.17
AEC-7R	CUL	11/04/15	615.08	3044.90	3063.42
AEC-7R	CUL	12/07/15	615.27	3044.71	3063.21
C-2737 (PIP)	CUL	01/13/15	417.10	2983.66	2990.24
C-2737 (PIP)	CUL	02/05/15	417.46	2983.30	2989.87
C-2737 (PIP)	CUL	03/06/15	418.07	2982.69	2989.24
C-2737 (PIP)	CUL	04/06/15	418.14	2982.62	2989.17
C-2737 (PIP)	CUL	05/06/15	418.35	2982.41	2988.96
C-2737 (PIP)	CUL	06/03/15	419.05	2981.71	2988.24
C-2737 (PIP)	CUL	07/08/15	420.34	2980.42	2986.92
C-2737 (PIP)	CUL	08/06/15	421.00	2979.76	2986.24
C-2737 (PIP)	CUL	09/09/15	421.82	2978.94	2985.40
C-2737 (PIP)	CUL	10/14/15	422.65	2978.11	2984.55
C-2737 (PIP)	CUL	11/13/15	423.15	2977.61	2984.04
C-2737 (PIP)	CUL	12/10/15	423.49	2977.27	2983.69
ERDA-9	CUL	01/07/15	421.56	2988.61	3009.89
ERDA-9	CUL	02/05/15	421.76	2988.41	3009.68
ERDA-9	CUL	03/05/15	422.23	2987.94	3009.18
ERDA-9	CUL	04/06/15	422.34	2987.83	3009.06
ERDA-9	CUL	05/06/15	422.62	2987.55	3008.76
ERDA-9	CUL	06/03/15	423.06	2987.11	3008.29
ERDA-9	CUL	07/08/15	423.77	2986.40	3007.52
ERDA-9	CUL	08/06/15	424.50	2985.67	3006.74
ERDA-9	CUL	09/03/15	424.99	2985.18	3006.22
ERDA-9	CUL	10/13/15	425.79	2984.38	3005.36

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
ERDA-9	CUL	11/04/15	425.97	2984.20	3005.17
ERDA-9	CUL	12/10/15	426.64	2983.53	3004.45
H-02b2	CUL	01/13/15	349.87	3028.49	3031.92
H-02b2	CUL	02/05/15	350.06	3028.30	3031.73
H-02b2	CUL	03/06/15	350.44	3027.92	3031.34
H-02b2	CUL	04/01/15	350.35	3028.01	3031.43
H-02b2	CUL	05/06/15	350.74	3027.62	3031.04
H-02b2	CUL	06/04/15	351.21	3027.15	3030.56
H-02b2	CUL	07/08/15	351.74	3026.62	3030.03
H-02b2	CUL	08/06/15	352.17	3026.19	3029.59
H-02b2	CUL	09/09/15	352.71	3025.65	3029.04
H-02b2	CUL	10/14/15	353.17	3025.19	3028.58
H-02b2	CUL	11/13/15	353.59	3024.77	3028.15
H-02b2	CUL	12/09/15	353.71	3024.65	3028.03
H-03b2	CUL	01/07/15	425.45	2964.46	2971.54
H-03b2	CUL	02/05/15	425.65	2964.26	2971.34
H-03b2	CUL	03/06/15	426.27	2963.64	2970.70
H-03b2	CUL	04/06/15	425.89	2964.02	2971.09
H-03b2	CUL	05/06/15	426.40	2963.51	2970.57
H-03b2	CUL	06/03/15	427.46	2962.45	2969.48
H-03b2	CUL	07/08/15	429.21	2960.70	2967.68
H-03b2	CUL	08/06/15	429.55	2960.36	2967.33
H-03b2	CUL	09/03/15	430.34	2959.57	2966.52
H-03b2	CUL	10/13/15	431.44	2958.47	2965.39
H-03b2	CUL	11/13/15	432.02	2957.89	2964.79
H-03b2	CUL	12/10/15	432.23	2957.68	2964.58
H-04bR	CUL	01/07/15	389.88	2944.76	2947.95
H-04bR	CUL	02/04/15	410.45	2924.19	2926.82
H-04bR	CUL	03/04/15	397.52	2937.12	2940.10
H-04bR	CUL	04/06/15	401.27	2933.37	2936.25
H-04bR	CUL	05/05/15	412.25	2922.39	2924.97
H-04bR	CUL	06/03/15	418.15	2916.49	2918.91
H-04bR	CUL	07/07/15	400.51	2934.13	2937.03
H-04bR	CUL	08/05/15	414.73	2919.91	2922.43
H-04bR	CUL	09/02/15	417.86	2916.78	2919.21
H-04bR	CUL	10/14/15	412.52	2922.12	2924.69

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-04bR	CUL	11/13/15	416.44	2918.20	2920.67
H-04bR	CUL	12/09/15	388.76	2945.88	2949.10
H-05b	CUL	01/06/15	466.40	3040.38	3079.89
H-05b	CUL	02/02/15	466.46	3040.32	3079.82
H-05b	CUL	03/02/15	466.58	3040.20	3079.69
H-05b	CUL	04/01/15	466.48	3040.30	3079.80
H-05b	CUL	05/05/15	466.58	3040.20	3079.69
H-05b	CUL	06/02/15	466.81	3039.97	3079.44
H-05b	CUL	07/07/15	466.94	3039.84	3079.30
H-05b	CUL	08/05/15	467.02	3039.76	3079.21
H-05b	CUL	09/01/15	467.30	3039.48	3078.91
H-05b	CUL	10/13/15	467.40	3039.38	3078.80
H-05b	CUL	11/04/15	467.30	3039.48	3078.91
H-05b	CUL	12/07/15	467.61	3039.17	3078.57
H-06bR	CUL	01/03/15	291.61	3057.61	3069.99
H-06bR	CUL	02/04/15	291.49	3057.73	3070.11
H-06bR	CUL	03/04/15	291.61	3057.61	3069.99
H-06bR	CUL	04/02/15	291.77	3057.45	3069.82
H-06bR	CUL	05/05/15	291.92	3057.30	3069.67
H-06bR	CUL	06/03/15	292.08	3057.14	3069.50
H-06bR	CUL	07/06/15	292.26	3056.96	3069.31
H-06bR	CUL	08/04/15	292.50	3056.72	3069.06
H-06bR	CUL	09/02/15	292.81	3056.41	3068.74
H-06bR	CUL	10/14/15	292.71	3056.51	3068.85
H-06bR	CUL	11/13/15	292.36	3056.86	3069.21
H-06bR	CUL	12/08/15	292.08	3057.14	3069.50
H-07b1	CUL	01/05/15	166.29	2997.43	2998.36
H-07b1	CUL	02/02/15	166.14	2997.58	2998.51
H-07b1	CUL	03/03/15	165.62	2998.10	2999.04
H-07b1	CUL	04/01/15	168.38	2995.34	2996.25
H-07b1	CUL	05/04/15	168.70	2995.02	2995.93
H-07b1	CUL	06/01/15	167.98	2995.74	2996.66
H-07b1	CUL	07/06/15	166.64	2997.08	2998.01
H-07b1	CUL	08/04/15	168.88	2994.84	2995.75
H-07b1	CUL	09/01/15	169.25	2994.47	2995.38
H-07b1	CUL	10/06/15	169.87	2993.85	2994.75

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-07b1	CUL	11/12/15	170.14	2993.58	2994.48
H-07b1	CUL	12/08/15	167.54	2996.18	2997.10
H-09bR	CUL	01/06/15	445.54	2962.80	2963.68
H-09bR	CUL	02/02/15	445.19	2963.15	2964.03
H-09bR	CUL	03/03/15	443.71	2964.63	2965.51
H-09bR	CUL	04/01/15	443.00	2965.34	2966.23
H-09bR	CUL	05/04/15	445.70	2962.64	2963.52
H-09bR	CUL	06/03/15	447.83	2960.51	2961.38
H-09bR	CUL	07/07/15	445.96	2962.38	2963.26
H-09bR	CUL	08/04/15	445.60	2962.74	2963.62
H-09bR	CUL	09/02/15	447.83	2960.51	2961.38
H-09bR	CUL	10/06/15	447.50	2960.84	2961.71
H-09bR	CUL	11/12/15	448.21	2960.13	2961.00
H-09bR	CUL	12/09/15	447.16	2961.18	2962.05
H-10c	CUL	01/06/15	713.45	2974.95	3038.18
H-10c	CUL	02/02/15	715.30	2973.10	3036.15
H-10c	CUL	03/02/15	716.52	2971.88	3034.82
H-10c	CUL	04/01/15	716.79	2971.61	3034.52
H-10c	CUL	05/05/15	717.45	2970.95	3033.80
H-10c	CUL	06/02/15	717.91	2970.49	3033.29
H-10c	CUL	07/07/15	718.30	2970.10	3032.86
H-10c	CUL	08/04/15	718.50	2969.90	3032.65
H-10c	CUL	09/01/15	718.80	2969.60	3032.32
H-10c	CUL	10/06/15	714.21	2974.19	3037.35
H-10cR	CUL	11/05/15	729.53	2962.27	3023.66
H-10cR	CUL	12/09/15	727.05	2964.75	3026.38
H-11b4R	CUL	01/07/15	475.79	2936.08	2956.10
H-11b4R	CUL	02/04/15	475.21	2936.66	2956.73
H-11b4R	CUL	03/03/15	474.78	2937.09	2957.19
H-11b4R	CUL	04/02/15	472.32	2939.55	2959.84
H-11b4R	CUL	05/05/15	475.96	2935.91	2955.92
H-11b4R	CUL	06/02/15	479.45	2932.42	2952.16
H-11b4R	CUL	07/07/15	477.72	2934.15	2954.03
H-11b4R	CUL	08/05/15	478.92	2932.95	2952.73
H-11b4R	CUL	09/02/15	481.12	2930.75	2950.36
H-11b4R	CUL	10/13/15	480.30	2931.57	2951.25

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-11b4R	CUL	11/12/15	481.56	2930.31	2949.89
H-11b4R	CUL	12/09/15	480.11	2931.76	2951.45
H-12	CUL	SNL Testing			
H-12	CUL	SNL Testing			
H-12	CUL	SNL Testing			
H-12	CUL	SNL Testing			
H-12	CUL	SNL Testing			
H-12	CUL	SNL Testing			
H-12	CUL	SNL Testing			
H-12	CUL	SNL Testing			
H-12R	CUL	09/01/15	540.60	2889.96	2902.33
H-12R	CUL	10/13/15	494.44	2936.12	2950.43
H-12R	CUL	11/12/15	494.61	2935.95	2950.25
H-12R	CUL	12/08/15	495.08	2935.48	2949.76
H-15R	CUL	01/07/15	543.00	2939.02	2977.93
H-15R	CUL	02/05/15	542.73	2939.29	2978.23
H-15R	CUL	03/05/15	543.37	2938.65	2977.51
H-15R	CUL	04/06/15	542.64	2939.38	2978.33
H-15R	CUL	05/06/15	542.97	2939.05	2977.96
H-15R	CUL	06/03/15	544.53	2937.49	2976.22
H-15R	CUL	07/08/15	546.26	2935.76	2974.28
H-15R	CUL	08/06/15	546.09	2935.93	2974.47
H-15R	CUL	09/03/15	546.97	2935.05	2973.49
H-15R	CUL	10/14/15	547.80	2934.22	2972.56
H-15R	CUL	11/13/15	548.20	2933.82	2972.11
H-15R	CUL	12/16/15	548.48	2933.54	2971.80
H-16	CUL	01/13/15	387.60	3022.46	3033.90
H-16	CUL	02/06/15	387.60	3022.46	3033.90
H-16	CUL	03/06/15	388.05	3022.01	3033.43
H-16	CUL	04/06/15	387.84	3022.22	3033.65
H-16	CUL	05/07/15	387.96	3022.10	3033.53
H-16	CUL	06/04/15	388.19	3021.87	3033.29
H-16	CUL	07/08/15	388.85	3021.21	3032.61
H-16	CUL	08/06/15	388.74	3021.32	3032.72
H-16	CUL	09/09/15	388.14	3021.92	3033.34
H-16	CUL	10/15/15	389.79	3020.27	3031.63

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-16	CUL	11/13/15	390.19	3019.87	3031.22
H-16	CUL	12/10/15	390.28	3019.78	3031.13
H-17	CUL	01/07/15	462.69	2922.55	2957.09
H-17	CUL	02/04/15	461.55	2923.69	2958.38
H-17	CUL	03/03/15	461.99	2923.25	2957.88
H-17	CUL	04/02/15	460.03	2925.21	2960.10
H-17	CUL	05/05/15	461.70	2923.54	2958.21
H-17	CUL	06/02/15	464.35	2920.89	2955.21
H-17	CUL	07/07/15	465.66	2919.58	2953.72
H-17	CUL	08/05/15	465.03	2920.21	2954.43
H-17	CUL	09/02/15	466.69	2918.55	2952.55
H-17	CUL	10/13/15	466.66	2918.58	2952.59
H-17	CUL	11/12/15	467.29	2917.95	2951.87
H-17	CUL	12/07/15	468.00	2917.24	2951.07
H-19b0	CUL	01/07/15	464.39	2953.94	2973.34
H-19b0	CUL	02/05/15	464.22	2954.11	2973.52
H-19b0	CUL	03/04/15	464.58	2953.75	2973.14
H-19b0	CUL	04/16/15	464.09	2954.24	2973.66
H-19b0	CUL	05/05/15	464.81	2953.52	2972.89
H-19b0	CUL	06/02/15	466.31	2952.02	2971.29
H-19b0	CUL	07/08/15	467.94	2950.39	2969.55
H-19b0	CUL	08/05/15	467.97	2950.36	2969.52
H-19b0	CUL	09/03/15	468.97	2949.36	2968.45
H-19b0	CUL	10/13/15	469.88	2948.45	2967.48
H-19b0	CUL	11/12/15	470.34	2947.99	2966.99
H-19b0	CUL	12/16/15	470.53	2947.80	2966.79
H-19b2	CUL	03/04/15	466.00	2952.93	2972.65
H-19b2	CUL	06/02/15	467.34	2951.59	2971.80
H-19b2	CUL	09/03/15	470.40	2948.53	2968.52
H-19b2	CUL	12/16/15	471.95	2946.98	2966.87
H-19b3	CUL	03/04/15	466.15	2952.87	2971.91
H-19b3	CUL	06/02/15	467.92	2951.10	2970.02
H-19b3	CUL	09/03/15	470.56	2948.46	2969.20
H-19b3	CUL	12/16/15	472.12	2946.90	2967.52
H-19b4	CUL	03/04/15	465.38	2953.60	2972.69
H-19b4	CUL	06/02/15	467.21	2951.77	2971.60

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-19b4	CUL	09/03/15	469.80	2949.18	2968.83
H-19b4	CUL	12/16/15	471.39	2947.59	2967.13
H-19b5	CUL	03/04/15	465.42	2953.16	2973.08
H-19b5	CUL	06/02/15	467.09	2951.49	2972.16
H-19b5	CUL	09/03/15	469.82	2948.76	2969.23
H-19b5	CUL	12/16/15	471.39	2947.19	2967.55
H-19b6	CUL	03/04/15	466.03	2952.99	2973.19
H-19b6	CUL	06/02/15	467.92	2951.10	2972.03
H-19b6	CUL	09/03/15	470.55	2948.47	2969.21
H-19b6	CUL	12/16/15	472.14	2946.88	2967.50
H-19b7	CUL	SNL Testing			
H-19b7	CUL	SNL Testing			
H-19b7	CUL	SNL Testing			
H-19b7	CUL	SNL Testing			
I-461	CUL	01/05/15	239.58	3044.03	3044.03
I-461	CUL	2/40/15	239.83	3043.78	3043.78
I-461	CUL	03/03/15	240.20	3043.41	3043.41
I-461	CUL	04/02/15	240.72	3042.89	3042.89
I-461	CUL	05/04/15	241.30	3042.31	3042.31
I-461	CUL	06/01/15	241.40	3042.21	3042.21
I-461	CUL	07/06/15	241.66	3041.95	3041.95
I-461	CUL	SNL Cleaning			
I-461	CUL	09/01/15	243.52	3041.97	3041.97
I-461	CUL	10/06/15	243.58	3041.91	3041.91
I-461	CUL	11/12/15	242.41	3043.08	3043.08
I-461	CUL	12/08/15	242.33	3043.16	3043.16
SNL-01	CUL	01/05/15	439.84	3073.00	3078.19
SNL-01	CUL	02/03/15	439.72	3073.12	3078.31
SNL-01	CUL	03/02/15	439.32	3073.52	3078.73
SNL-01	CUL	04/02/15	439.01	3073.83	3079.04
SNL-01	CUL	05/04/15	439.15	3073.69	3078.90
SNL-01	CUL	06/01/15	439.25	3073.59	3078.80
SNL-01	CUL	07/06/15	439.12	3073.72	3078.93
SNL-01	CUL	08/05/15	439.30	3073.54	3078.75
SNL-01	CUL	09/01/15	439.39	3073.45	3078.65
SNL-01	CUL	10/05/15	439.52	3073.32	3078.52

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-01	CUL	11/04/15	439.00	3073.84	3079.06
SNL-01	CUL	12/08/15	439.79	3073.05	3078.24
SNL-02	CUL	01/05/15	253.41	3069.65	3071.82
SNL-02	CUL	02/04/15	253.82	3069.24	3071.41
SNL-02	CUL	03/03/15	254.02	3069.04	3071.21
SNL-02	CUL	04/02/15	254.43	3068.63	3070.79
SNL-02	CUL	05/04/15	254.58	3068.48	3070.64
SNL-02	CUL	06/01/15	254.62	3068.44	3070.60
SNL-02	CUL	07/06/15	254.97	3068.09	3070.25
SNL-02	CUL	08/05/15	255.55	3067.51	3069.66
SNL-02	CUL	09/01/15	255.45	3067.61	3069.76
SNL-02	CUL	10/06/15	255.29	3067.77	3069.92
SNL-02	CUL	11/11/15	253.99	3069.07	3071.24
SNL-02	CUL	12/08/15	254.03	3069.03	3071.20
SNL-03	CUL	01/13/15	422.44	3067.91	3077.20
SNL-03	CUL	02/03/15	422.19	3068.16	3077.46
SNL-03	CUL	03/02/15	422.18	3068.17	3077.47
SNL-03	CUL	04/02/15	422.08	3068.27	3077.57
SNL-03	CUL	05/05/15	422.10	3068.25	3077.55
SNL-03	CUL	06/01/15	422.37	3067.98	3077.27
SNL-03	CUL	07/06/15	422.37	3067.98	3077.27
SNL-03	CUL	08/05/15	422.59	3067.76	3077.05
SNL-03	CUL	09/02/15	422.81	3067.54	3076.82
SNL-03	CUL	10/13/15	422.98	3067.37	3076.65
SNL-03	CUL	11/04/15	422.60	3067.75	3077.04
SNL-03	CUL	12/08/15	422.55	3067.80	3077.09
SNL-05	CUL	01/05/15	310.06	3069.92	3072.63
SNL-05	CUL	02/40/15	309.60	3070.38	3073.10
SNL-05	CUL	03/03/15	309.56	3070.42	3073.14
SNL-05	CUL	04/02/15	309.93	3070.05	3072.76
SNL-05	CUL	05/04/15	310.10	3069.88	3072.59
SNL-05	CUL	06/01/15	310.35	3069.63	3072.34
SNL-05	CUL	07/06/15	310.67	3069.31	3072.02
SNL-05	CUL	08/05/15	311.04	3068.94	3071.64
SNL-05	CUL	09/01/15	311.38	3068.60	3071.30
SNL-05	CUL	10/06/15	311.71	3068.27	3070.97

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-05	CUL	11/12/15	311.41	3068.57	3071.27
SNL-05	CUL	12/08/15	311.30	3068.68	3071.38
SNL-06	CUL	01/06/15	536.51	3109.60	3306.82
SNL-06	CUL	02/02/15	536.93	3109.18	3306.29
SNL-06	CUL	03/02/15	534.76	3111.35	3309.00
SNL-06	CUL	04/01/15	532.37	3113.74	3311.98
SNL-06	CUL	05/05/15	529.88	3116.23	3315.08
SNL-06	CUL	06/02/15	527.73	3118.38	3317.76
SNL-06	CUL	07/06/15	525.27	3121.84	3322.07
SNL-06	CUL	08/05/15	523.11	3124.00	3324.76
SNL-06	CUL	09/01/15	521.21	3124.90	3325.88
SNL-06	CUL	10/13/15	518.34	3127.77	3329.46
SNL-06	CUL	11/04/15	516.74	3129.37	3331.45
SNL-06	CUL	01/06/15	540.06	3015.67	3056.49
SNL-08	CUL	02/02/15	540.20	3015.53	3056.34
SNL-08	CUL	03/03/15	539.85	3015.88	3056.72
SNL-08	CUL	04/01/15	539.67	3016.06	3056.92
SNL-08	CUL	05/05/15	539.45	3016.28	3057.16
SNL-08	CUL	06/02/15	539.36	3016.37	3057.26
SNL-08	CUL	07/07/15	539.28	3016.45	3057.34
SNL-08	CUL	08/05/15	539.18	3016.55	3057.45
SNL-08	CUL	09/01/15	539.18	3016.55	3057.45
SNL-08	CUL	10/13/15	539.34	3016.39	3057.28
SNL-08	CUL	11/12/15	539.38	3016.35	3057.23
SNL-08	CUL	12/07/15	539.48	3016.25	3057.12
SNL-09	CUL	01/05/15	312.56	3048.40	3052.98
SNL-09	CUL	02/04/15	312.52	3048.44	3053.02
SNL-09	CUL	03/04/15	312.70	3048.26	3052.84
SNL-09	CUL	04/02/15	312.82	3048.14	3052.72
SNL-09	CUL	05/05/15	313.28	3047.68	3052.25
SNL-09	CUL	06/01/15	313.72	3047.24	3051.80
SNL-09	CUL	07/06/15	313.75	3047.21	3051.77
SNL-09	CUL	08/04/15	313.97	3046.99	3051.55
SNL-09	CUL	09/02/15	314.41	3046.55	3051.10
SNL-09	CUL	10/14/15	314.30	3046.66	3051.21
SNL-09	CUL	11/11/15	313.75	3047.21	3051.77

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-09	CUL	12/08/15	313.61	3047.35	3051.91
SNL-10	CUL	01/06/15	331.13	3046.46	3049.28
SNL-10	CUL	02/04/15	330.98	3046.61	3049.44
SNL-10	CUL	03/04/15	331.31	3046.28	3049.10
SNL-10	CUL	04/01/15	331.01	3046.58	3049.40
SNL-10	CUL	05/06/15	331.49	3046.10	3048.92
SNL-10	CUL	06/01/15	331.99	3045.60	3048.42
SNL-10	CUL	07/07/15	332.50	3045.09	3047.90
SNL-10	CUL	08/05/15	332.58	3045.01	3047.82
SNL-10	CUL	09/02/15	332.88	3044.71	3047.52
SNL-10	CUL	10/13/15	333.15	3044.44	3047.24
SNL-10	CUL	11/05/15	332.97	3044.62	3047.43
SNL-10	CUL	12/08/15	332.99	3044.60	3047.41
SNL-12	CUL	01/06/15	387.29	2952.17	2953.45
SNL-12	CUL	02/02/15	394.71	2944.75	2945.98
SNL-12	CUL	03/03/15	388.32	2951.14	2952.42
SNL-12	CUL	04/01/15	386.34	2953.12	2954.41
SNL-12	CUL	05/04/15	396.22	2943.24	2944.46
SNL-12	CUL	06/03/15	400.95	2938.51	2939.70
SNL-12	CUL	07/07/15	391.91	2947.55	2948.80
SNL-12	CUL	08/04/15	398.24	2941.22	2942.43
SNL-12	CUL	09/02/15	401.26	2938.20	2939.39
SNL-12	CUL	10/06/15	397.88	2941.58	2942.79
SNL-12	CUL	11/12/15	400.98	2938.48	2939.67
SNL-12	CUL	12/09/15	388.67	2950.79	2952.07
SNL-13	CUL	01/06/15	316.07	2978.04	2979.91
SNL-13	CUL	02/04/15	317.02	2977.09	2978.94
SNL-13	CUL	03/04/15	317.41	2976.70	2978.54
SNL-13	CUL	04/01/15	317.52	2976.59	2978.43
SNL-13	CUL	05/06/15	317.73	2976.38	2978.21
SNL-13	CUL	06/01/15	318.79	2975.32	2977.13
SNL-13	CUL	07/07/15	320.12	2973.99	2975.77
SNL-13	CUL	08/05/15	320.45	2973.66	2975.43
SNL-13	CUL	09/02/15	321.14	2972.97	2974.73
SNL-13	CUL	10/13/15	322.24	2971.87	2973.60
SNL-13	CUL	11/13/15	322.82	2971.29	2973.01

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-13	CUL	12/08/15	323.25	2970.86	2972.57
SNL-14	CUL	01/07/15	426.76	2941.65	2952.82
SNL-14	CUL	02/04/15	429.11	2939.30	2950.36
SNL-14	CUL	03/03/15	426.19	2942.22	2953.41
SNL-14	CUL	04/02/15	423.47	2944.94	2956.26
SNL-14	CUL	05/05/15	430.28	2938.13	2949.13
SNL-14	CUL	06/02/15	434.36	2934.05	2944.87
SNL-14	CUL	07/07/15	428.55	2939.86	2950.94
SNL-14	CUL	08/05/15	432.60	2935.81	2946.71
SNL-14	CUL	09/02/15	435.34	2933.07	2943.84
SNL-14	CUL	10/13/15	433.35	2935.06	2945.92
SNL-14	CUL	11/12/15	435.34	2933.07	2943.84
SNL-14	CUL	12/07/15	431.29	2937.12	2948.08
SNL-15	CUL	01/07/15	522.75	2957.18	3049.20
SNL-15	CUL	02/02/15	522.75	2957.18	3049.20
SNL-15	CUL	03/03/15	521.72	2958.21	3050.47
SNL-15	CUL	04/01/15	520.32	2959.61	3052.19
SNL-15	CUL	05/05/15	519.51	2960.42	3053.18
SNL-15	CUL	06/02/15	518.71	2961.22	3054.17
SNL-15	CUL	07/07/15	517.85	2962.08	3055.23
SNL-15	CUL	08/05/15	517.09	2962.84	3056.16
SNL-15	CUL	09/01/15	516.41	2963.52	3057.00
SNL-15	CUL	10/13/15	515.43	2964.50	3058.20
SNL-15	CUL	11/12/15	514.66	2965.27	3059.15
SNL-15	CUL	12/08/15	514.02	2965.91	3059.94
SNL-16	CUL	01/05/15	119.30	3013.70	3014.74
SNL-16	CUL	02/02/15	119.68	3013.32	3014.36
SNL-16	CUL	03/03/15	119.86	3013.14	3014.18
SNL-16	CUL	SNL Testing			
SNL-16	CUL	SNL Testing			
SNL-16	CUL	SNL Testing			
SNL-16	CUL	SNL Testing			
SNL-16	CUL	SNL Testing			
SNL-16	CUL	09/02/15	122.90	3010.10	3011.10
SNL-16	CUL	10/06/15	123.08	3009.92	3010.92
SNL-16	CUL	11/12/15	122.41	3010.59	3011.60

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-16	CUL	12/08/15	122.22	3010.78	3011.79
SNL-17	CUL	01/05/15	247.58	2990.48	2991.19
SNL-17	CUL	02/02/15	252.31	2985.75	2986.43
SNL-17	CUL	03/03/15	249.53	2988.53	2989.23
SNL-17	CUL	04/01/15	249.97	2988.09	2988.79
SNL-17	CUL	05/04/15	254.03	2984.03	2984.70
SNL-17	CUL	06/01/15	255.59	2982.47	2983.13
SNL-17	CUL	07/06/15	252.40	2985.66	2986.34
SNL-17	CUL	08/04/15	255.39	2982.67	2983.33
SNL-17	CUL	09/02/15	256.38	2981.68	2982.33
SNL-17	CUL	10/06/15	255.54	2982.52	2983.18
SNL-17	CUL	11/12/15	256.78	2981.28	2981.93
SNL-17	CUL	12/09/15	250.16	2987.90	2988.60
SNL-18	CUL	01/05/15	303.39	3072.05	3074.28
SNL-18	CUL	02/04/15	303.13	3072.31	3074.54
SNL-18	CUL	03/02/15	303.26	3072.18	3074.41
SNL-18	CUL	04/02/15	303.37	3072.07	3074.30
SNL-18	CUL	05/04/15	303.47	3071.97	3074.20
SNL-18	CUL	06/01/15	303.71	3071.73	3073.96
SNL-18	CUL	07/06/15	304.16	3071.28	3073.50
SNL-18	CUL	08/05/15	304.55	3070.89	3073.11
SNL-18	CUL	09/01/15	304.89	3070.55	3072.77
SNL-18	CUL	10/05/15	305.23	3070.21	3072.42
SNL-18	CUL	11/04/15	304.70	3070.74	3072.96
SNL-18	CUL	12/08/15	304.85	3070.59	3072.81
SNL-19	CUL	01/05/15	152.02	3070.63	3071.85
SNL-19	CUL	02/04/15	152.41	3070.24	3071.46
SNL-19	CUL	03/03/15	152.66	3069.99	3071.20
SNL-19	CUL	04/02/15	153.12	3069.53	3070.74
SNL-19	CUL	05/04/15	153.25	3069.40	3070.61
SNL-19	CUL	06/01/15	153.31	3069.34	3070.55
SNL-19	CUL	07/06/15	153.68	3068.97	3070.18
SNL-19	CUL	08/05/15	154.20	3068.45	3069.66
SNL-19	CUL	09/02/15	154.13	3068.52	3069.73
SNL-19	CUL	10/06/15	154.00	3068.65	3069.86
SNL-19	CUL	11/11/15	152.79	3069.86	3071.07

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-19	CUL	12/08/15	152.89	3069.76	3070.97
WIPP-11	CUL	01/09/15	366.52	3061.26	3079.93
WIPP-11	CUL	02/02/15	366.30	3061.48	3080.16
WIPP-11	CUL	03/02/15	366.28	3061.50	3080.18
WIPP-11	CUL	04/02/15	366.18	3061.60	3080.28
WIPP-11	CUL	05/06/15	366.32	3061.46	3080.14
WIPP-11	CUL	06/04/15	366.49	3061.29	3079.96
WIPP-11	CUL	07/06/15	366.68	3061.10	3079.76
WIPP-11	CUL	08/04/15	366.95	3060.83	3079.48
WIPP-11	CUL	09/02/15	367.14	3060.64	3079.28
WIPP-11	CUL	10/06/15	367.43	3060.35	3078.98
WIPP-11	CUL	11/04/15	367.04	3060.74	3079.39
WIPP-11	CUL	12/08/15	366.92	3060.86	3079.51
WIPP-13	CUL	01/09/15	344.36	3061.31	3075.04
WIPP-13	CUL	02/05/15	344.14	3061.53	3075.27
WIPP-13	CUL	03/04/15	343.84	3061.83	3075.58
WIPP-13	CUL	04/02/15	343.97	3061.70	3075.44
WIPP-13	CUL	05/06/15	343.93	3061.74	3075.48
WIPP-13	CUL	06/04/15	344.15	3061.52	3075.26
WIPP-13	CUL	07/08/15	344.24	3061.43	3075.16
WIPP-13	CUL	08/05/15	344.50	3061.17	3074.89
WIPP-13	CUL	09/03/15	344.59	3061.08	3074.80
WIPP-13	CUL	10/14/15	344.81	3060.86	3074.57
WIPP-13	CUL	11/13/15	344.65	3061.02	3074.74
WIPP-13	CUL	12/09/15	344.32	3061.35	3075.08
WIPP-19	CUL	01/07/15	398.31	3036.80	3056.51
WIPP-19	CUL	02/05/15	398.12	3036.99	3056.71
WIPP-19	CUL	03/06/15	398.15	3036.96	3056.67
WIPP-19	CUL	04/06/15	398.06	3037.05	3056.77
WIPP-19	CUL	05/06/15	398.24	3036.87	3056.58
WIPP-19	CUL	06/03/15	398.44	3036.67	3056.37
WIPP-19	CUL	07/08/15	398.88	3036.23	3055.91
WIPP-19	CUL	08/06/15	399.08	3036.03	3055.69
WIPP-19	CUL	09/03/15	399.29	3035.82	3055.47
WIPP-19	CUL	10/14/15	399.62	3035.49	3055.13
WIPP-19	CUL	11/13/15	399.80	3035.31	3054.94

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
WIPP-19	CUL	12/09/15	399.72	3035.39	3055.02
WQSP-1	CUL	01/09/15	362.50	3056.75	3074.31
WQSP-1	CUL	02/04/15	362.03	3057.22	3074.80
WQSP-1	CUL	03/04/15	362.09	3057.16	3074.74
WQSP-1	CUL	04/02/15	362.51	3056.74	3074.30
WQSP-1	CUL	05/06/15	362.34	3056.91	3074.48
WQSP-1	CUL	06/03/15	362.48	3056.77	3074.33
WQSP-1	CUL	07/08/15	362.67	3056.58	3074.13
WQSP-1	CUL	08/06/15	362.94	3056.31	3073.85
WQSP-1	CUL	09/03/15	363.05	3056.20	3073.73
WQSP-1	CUL	10/14/15	363.21	3056.04	3073.56
WQSP-1	CUL	11/13/15	363.15	3056.10	3073.63
WQSP-1	CUL	12/09/15	362.77	3056.48	3074.02
WQSP-2	CUL	01/07/15	401.15	3062.72	3082.64
WQSP-2	CUL	02/05/15	402.42	3061.45	3081.31
WQSP-2	CUL	03/03/15	402.07	3061.80	3081.68
WQSP-2	CUL	04/06/15	402.47	3061.40	3081.26
WQSP-2	CUL	05/06/15	402.52	3061.35	3081.21
WQSP-2	CUL	06/03/15	402.65	3061.22	3081.07
WQSP-2	CUL	07/08/15	402.85	3061.02	3080.86
WQSP-2	CUL	08/06/15	403.14	3060.73	3080.56
WQSP-2	CUL	09/03/15	403.31	3060.56	3080.38
WQSP-2	CUL	10/14/15	403.43	3060.44	3080.26
WQSP-2	CUL	11/04/15	403.27	3060.60	3080.42
WQSP-2	CUL	12/09/15	403.06	3060.81	3080.64
WQSP-3	CUL	01/07/15	468.53	3011.61	3068.74
WQSP-3	CUL	02/05/15	468.19	3011.95	3069.13
WQSP-3	CUL	03/06/15	468.25	3011.89	3069.06
WQSP-3	CUL	04/06/15	467.99	3012.15	3069.36
WQSP-3	CUL	05/06/15	469.02	3011.12	3068.18
WQSP-3	CUL	06/04/15	468.81	3011.33	3068.42
WQSP-3	CUL	07/08/15	468.90	3011.24	3068.32
WQSP-3	CUL	08/06/15	469.00	3011.14	3068.20
WQSP-3	CUL	09/03/15	468.13	3012.01	3069.20
WQSP-3	CUL	10/14/15	468.31	3011.83	3068.99
WQSP-3	CUL	11/13/15	469.40	3010.74	3067.74

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
WQSP-3	CUL	12/09/15	469.23	3010.91	3067.94
WQSP-4	CUL	01/15/15	481.50	2951.59	2974.34
WQSP-4	CUL	02/05/15	481.58	2951.51	2974.26
WQSP-4	CUL	03/04/15	482.21	2950.88	2973.58
WQSP-4	CUL	04/06/15	481.43	2951.66	2974.42
WQSP-4	CUL	05/05/15	482.13	2950.96	2973.67
WQSP-4	CUL	06/03/15	483.61	2949.48	2972.07
WQSP-4	CUL	07/08/15	485.21	2947.88	2970.35
WQSP-4	CUL	08/05/15	485.23	2947.86	2970.33
WQSP-4	CUL	09/03/15	486.26	2946.83	2969.22
WQSP-4	CUL	10/13/15	487.15	2945.94	2968.26
WQSP-4	CUL	11/13/15	487.73	2945.36	2967.64
WQSP-4	CUL	12/16/15	487.78	2945.31	2967.59
WQSP-5	CUL	01/07/15	415.94	2968.44	2974.99
WQSP-5	CUL	02/05/15	416.36	2968.02	2974.56
WQSP-5	CUL	03/05/15	416.98	2967.40	2973.93
WQSP-5	CUL	04/06/15	416.84	2967.54	2974.07
WQSP-5	CUL	05/05/15	417.21	2967.17	2973.69
WQSP-5	CUL	06/02/15	418.62	2965.76	2972.24
WQSP-5	CUL	07/08/15	419.66	2964.72	2971.17
WQSP-5	CUL	08/06/15	420.47	2963.91	2970.34
WQSP-5	CUL	09/02/15	421.20	2963.18	2969.59
WQSP-5	CUL	10/14/15	422.43	2961.95	2968.33
WQSP-5	CUL	11/13/15	423.03	2961.35	2967.71
WQSP-5	CUL	12/10/15	423.32	2961.06	2967.41
WQSP-6	CUL	01/07/15	373.46	2991.26	2995.06
WQSP-6	CUL	02/04/15	373.67	2991.05	2994.85
WQSP-6	CUL	03/05/15	374.59	2990.13	2993.91
WQSP-6	CUL	04/06/15	374.76	2989.96	2993.74
WQSP-6	CUL	05/05/15	374.73	2989.99	2993.77
WQSP-6	CUL	06/03/15	376.01	2988.71	2992.47
WQSP-6	CUL	07/08/15	377.15	2987.57	2991.31
WQSP-6	CUL	08/06/15	377.81	2986.91	2990.64
WQSP-6	CUL	09/02/15	378.39	2986.33	2990.05
WQSP-6	CUL	10/14/15	379.50	2985.22	2988.92
WQSP-6	CUL	11/13/15	380.12	2984.60	2988.29

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
WQSP-6	CUL	12/10/15	384.51	2980.21	2983.82
C-2737 (ANNULUS)	MAG	01/13/15	254.74	3146.02	(a)
C-2737 (ANNULUS)	MAG	02/05/15	254.59	3146.17	(a)
C-2737 (ANNULUS)	MAG	03/06/15	254.63	3146.13	(a)
C-2737 (ANNULUS)	MAG	04/06/15	254.39	3146.37	(a)
C-2737 (ANNULUS)	MAG	05/06/15	254.30	3146.46	(a)
C-2737 (ANNULUS)	MAG	06/03/15	254.56	3146.20	(a)
C-2737 (ANNULUS)	MAG	07/08/15	254.21	3146.55	(a)
C-2737 (ANNULUS)	MAG	08/06/15	254.03	3146.73	(a)
C-2737 (ANNULUS)	MAG	09/09/15	253.74	3147.02	(a)
C-2737 (ANNULUS)	MAG	10/14/15	253.33	3147.43	(a)
C-2737 (ANNULUS)	MAG	11/13/15	253.01	3147.75	(a)
C-2737 (ANNULUS)	MAG	12/10/15	252.41	3148.35	(a)
H-02b1	MAG	01/13/15	234.05	3144.44	(a)
H-02b1	MAG	02/05/15	233.95	3144.54	(a)
H-02b1	MAG	03/06/15	233.85	3144.64	(a)
H-02b1	MAG	04/01/15	233.79	3144.70	(a)
H-02b1	MAG	05/06/15	233.70	3144.79	(a)
H-02b1	MAG	06/04/15	233.65	3144.84	(a)
H-02b1	MAG	07/08/15	233.68	3144.81	(a)
H-02b1	MAG	08/06/15	233.67	3144.82	(a)
H-02b1	MAG	09/09/15	233.70	3144.79	(a)
H-02b1	MAG	10/14/15	233.70	3144.79	(a)
H-02b1	MAG	11/13/15	233.50	3144.99	(a)
H-02b1	MAG	12/09/15	233.61	3144.88	(a)
H-03b1	MAG	01/07/15	242.28	3148.44	(a)
H-03b1	MAG	02/05/15	242.04	3148.68	(a)
H-03b1	MAG	03/06/15	242.00	3148.72	(a)
H-03b1	MAG	04/06/15	241.88	3148.84	(a)
H-03b1	MAG	05/06/15	241.71	3149.01	(a)
H-03b1	MAG	06/03/15	241.71	3149.01	(a)
H-03b1	MAG	07/08/15	241.65	3149.07	(a)
H-03b1	MAG	08/06/15	241.49	3149.23	(a)
H-03b1	MAG	09/03/15	241.29	3149.43	(a)
H-03b1	MAG	10/13/15	240.79	3149.93	(a)
H-03b1	MAG	11/13/15	240.40	3150.32	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-03b1	MAG	12/10/15	239.86	3150.86	(a)
H-04c	MAG	01/07/15	185.35	3148.93	(a)
H-04c	MAG	02/04/15	185.12	3149.16	(a)
H-04c	MAG	03/04/15	185.08	3149.20	(a)
H-04c	MAG	04/06/15	185.05	3149.23	(a)
H-04c	MAG	05/05/15	185.10	3149.18	(a)
H-04c	MAG	06/03/15	184.98	3149.30	(a)
H-04c	MAG	07/07/15	185.12	3149.16	(a)
H-04c	MAG	08/05/15	185.20	3149.08	(a)
H-04c	MAG	09/02/15	185.32	3148.96	(a)
H-04c	MAG	10/14/15	185.29	3148.99	(a)
H-04c	MAG	11/13/15	185.33	3148.95	(a)
H-04c	MAG	12/09/15	185.29	3148.99	(a)
H-06c	MAG	01/13/15	276.98	3071.71	(a)
H-06c	MAG	02/04/15	276.63	3072.06	(a)
H-06c	MAG	03/04/15	276.49	3072.20	(a)
H-06c	MAG	04/02/15	276.45	3072.24	(a)
H-06c	MAG	05/05/15	276.49	3072.20	(a)
H-06c	MAG	06/03/15	276.57	3072.12	(a)
H-06c	MAG	07/06/15	276.64	3072.05	(a)
H-06c	MAG	08/04/15	276.70	3071.99	(a)
H-06c	MAG	09/02/15	276.73	3071.96	(a)
H-06c	MAG	10/14/15	276.61	3072.08	(a)
H-06c	MAG	11/18/15	276.73	3071.96	(a)
H-06c	MAG	12/08/15	276.59	3072.10	(a)
H-08a	MAG	01/06/15	404.00	3029.28	(a)
H-08a	MAG	02/02/15	404.00	3029.28	(a)
H-08a	MAG	03/03/15	403.90	3029.38	(a)
H-08a	MAG	04/01/15	403.85	3029.43	(a)
H-08a	MAG	05/04/15	403.83	3029.45	(a)
H-08a	MAG	06/04/15	403.79	3029.49	(a)
H-08a	MAG	07/07/15	403.87	3029.41	(a)
H-08a	MAG	08/04/15	403.88	3029.40	(a)
H-08a	MAG	09/02/15	403.79	3029.49	(a)
H-08a	MAG	10/06/15	403.88	3029.40	(a)
H-08a	MAG	11/12/15	403.79	3029.49	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-08a	MAG	12/09/15	403.79	3029.49	(a)
H-09c	MAG	01/06/15	271.53	3135.52	(a)
H-09c	MAG	02/02/15	271.45	3135.60	(a)
H-09c	MAG	03/03/15	271.24	3135.81	(a)
H-09c	MAG	04/01/15	271.22	3135.83	(a)
H-09c	MAG	05/04/15	271.25	3135.80	(a)
H-09c	MAG	06/03/15	271.20	3135.85	(a)
H-09c	MAG	07/07/15	271.53	3135.52	(a)
H-09c	MAG	08/04/15	271.52	3135.53	(a)
H-09c	MAG	09/01/15	271.65	3135.40	(a)
H-09c	MAG	10/06/15	271.60	3135.45	(a)
H-09c	MAG	11/12/15	271.51	3135.54	(a)
H-09c	MAG	12/09/15	271.38	3135.67	(a)
H-10a	MAG	01/06/15	575.08	3113.37	(a)
H-10a	MAG	02/02/15	575.24	3113.21	(a)
H-10a	MAG	03/02/15	574.83	3113.62	(a)
H-10a	MAG	04/01/15	575.56	3112.89	(a)
H-10a	MAG	05/05/15	575.62	3112.83	(a)
H-10a	MAG	06/02/15	575.72	3112.73	(a)
H-10a	MAG	07/70/15	575.87	3112.58	(a)
H-10a	MAG	08/04/15	575.95	3112.50	(a)
H-10a	MAG	09/02/15	575.97	3112.48	(a)
H-10a	MAG	10/06/15	568.38	3120.07	(a)
H-10a	MAG	11/05/15	571.83	3116.62	(a)
H-10a	MAG	12/09/15	574.63	3113.82	(a)
H-11b2	MAG	01/07/15	270.92	3140.94	(a)
H-11b2	MAG	02/04/15	270.53	3141.33	(a)
H-11b2	MAG	03/03/15	270.73	3141.13	(a)
H-11b2	MAG	04/02/15	270.78	3141.08	(a)
H-11b2	MAG	05/05/15	270.66	3141.20	(a)
H-11b2	MAG	06/02/15	270.56	3141.30	(a)
H-11b2	MAG	07/07/15	270.56	3141.30	(a)
H-11b2	MAG	08/05/15	270.50	3141.36	(a)
H-11b2	MAG	09/02/15	270.30	3141.56	(a)
H-11b2	MAG	10/13/15	269.80	3142.06	(a)
H-11b2	MAG	11/12/15	269.50	3142.36	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-11b2	MAG	12/09/15	269.14	3142.72	(a)
H-14	MAG	01/05/15	206.00	3141.08	(a)
H-14	MAG	02/04/15	205.96	3141.12	(a)
H-14	MAG	03/04/15	205.93	3141.15	(a)
H-14	MAG	04/01/15	205.75	3141.33	(a)
H-14	MAG	05/05/15	205.72	3141.36	(a)
H-14	MAG	06/04/15	205.68	3141.40	(a)
H-14	MAG	07/08/15	205.71	3141.37	(a)
H-14	MAG	08/06/15	205.66	3141.42	(a)
H-14	MAG	09/02/15	205.61	3141.47	(a)
H-14	MAG	10/14/15	205.61	3141.47	(a)
H-14	MAG	11/13/15	205.61	3141.47	(a)
H-14	MAG	12/09/15	205.63	3141.45	(a)
H-15	MAG	01/07/15	270.92	3212.86	(a)
H-15	MAG	02/05/15	329.54	3154.24	(a)
H-15	MAG	03/05/15	325.99	3157.79	(a)
H-15 [(b)]	MAG	04/06/15	321.79	3161.99	(a)
H-15	MAG	05/06/15	318.02	3165.76	(a)
H-15	MAG	06/03/15	314.95	3168.83	(a)
H-15	MAG	07/08/15	312.30	3171.48	(a)
H-15	MAG	08/06/15	310.53	3173.25	(a)
H-15	MAG	09/03/15	309.63	3174.15	(a)
H-15	MAG	10/14/15	309.04	3174.74	(a)
H-15	MAG	11/13/15	308.75	3175.03	(a)
H-15	MAG	12/16/15	388.40	3095.38	(a)
H-18	MAG	01/09/15	255.56	3158.65	(a)
H-18	MAG	02/04/15	255.18	3159.03	(a)
H-18	MAG	03/04/15	255.13	3159.08	(a)
H-18	MAG	04/02/15	255.07	3159.14	(a)
H-18	MAG	05/05/15	255.05	3159.16	(a)
H-18	MAG	06/03/15	255.05	3159.16	(a)
H-18	MAG	07/08/15	255.56	3158.65	(a)
H-18	MAG	08/05/15	255.10	3159.11	(a)
H-18	MAG	09/03/15	255.07	3159.14	(a)
H-18	MAG	10/14/15	254.97	3159.24	(a)
H-18	MAG	11/13/15	255.02	3159.19	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-18	MAG	12/09/15	254.69	3159.52	(a)
WIPP-18	MAG	01/07/15	305.23	3152.34	(a)
WIPP-18	MAG	02/05/15	305.03	3152.54	(a)
WIPP-18	MAG	03/06/15	305.05	3152.52	(a)
WIPP-18	MAG	04/06/15	304.91	3152.66	(a)
WIPP-18	MAG	05/06/15	304.74	3152.83	(a)
WIPP-18	MAG	06/03/15	304.69	3152.88	(a)
WIPP-18	MAG	07/08/15	304.13	3153.44	(a)
WIPP-18	MAG	08/05/15	304.19	3153.38	(a)
WIPP-18	MAG	09/03/15	303.70	3153.87	(a)
WIPP-18	MAG	10/14/15	302.95	3154.62	(a)
WIPP-18	MAG	11/13/15	302.21	3155.36	(a)
WIPP-18	MAG	12/09/15	301.65	3155.92	(a)
WQSP-6a	DL	01/07/15	168.25	3195.55	(a)
WQSP-6a	DL	02/04/15	167.60	3196.20	(a)
WQSP-6a	DL	03/05/15	168.14	3195.66	(a)
WQSP-6a	DL	04/06/15	167.69	3196.11	(a)
WQSP-6a	DL	05/05/15	167.71	3196.09	(a)
WQSP-6a	DL	06/03/15	167.73	3196.07	(a)
WQSP-6a	DL	07/08/15	167.88	3195.92	(a)
WQSP-6a	DL	08/06/15	167.86	3195.94	(a)
WQSP-6a	DL	09/02/15	167.92	3195.88	(a)
WQSP-6a	DL	10/14/15	167.94	3195.86	(a)
WQSP-6a	DL	11/11/15	167.77	3196.03	(a)
WQSP-6a	DL	12/10/15	167.60	3196.20	(a)
CB-1	B/C	01/07/15	298.49	3030.63	(a)
CB-1	B/C	02/04/15	294.47	3034.65	(a)
CB-1	B/C	03/03/15	297.64	3031.48	(a)
CB-1	B/C	04/02/15	297.49	3031.63	(a)
CB-1	B/C	05/05/15	297.16	3031.96	(a)
CB-1	B/C	06/02/15	297.14	3031.98	(a)
CB-1	B/C	07/07/15	296.79	3032.33	(a)
CB-1	B/C	08/05/15	296.62	3032.50	(a)
CB-1	B/C	09/02/15	296.25	3032.87	(a)
CB-1	B/C	10/13/15	295.79	3033.33	(a)
CB-1	B/C	11/12/15	295.48	3033.64	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
CB-1	B/C	12/07/15	295.02	3034.10	(a)
DOE-2	B/C	01/13/15	350.38	3068.80	(a)
DOE-2	B/C	02/05/15	350.38	3068.80	(a)
DOE-2	B/C	03/04/15	350.08	3069.10	(a)
DOE-2	B/C	04/02/15	350.05	3069.13	(a)
DOE-2	B/C	05/06/15	350.00	3069.18	(a)
DOE-2	B/C	06/04/15	349.94	3069.24	(a)
DOE-2	B/C	07/08/15	350.11	3069.07	(a)
DOE-2	B/C	08/04/15	350.00	3069.18	(a)
DOE-2	B/C	09/03/15	350.00	3069.18	(a)
DOE-2	B/C	10/14/15	350.00	3069.18	(a)
DOE-2	B/C	11/04/15	349.91	3069.27	(a)
DOE-2	B/C	12/09/15	350.02	3069.16	(a)
C-2505	SR/DL	03/06/15	46.30	3366.63	(a)
C-2505	SR/DL	NA	NA	NA	(a)
C-2505	SR/DL	09/09/15	46.29	3366.64	(a)
C-2505	SR/DL	NA	NA	NA	(a)
C-2506	SR/DL	03/06/15	45.56	3367.28	(a)
C-2506	SR/DL	NA	NA	NA	(a)
C-2506	SR/DL	09/09/15	45.51	3367.33	(a)
C-2506	SR/DL	NA	NA	NA	(a)
C-2507	SR/DL	03/06/15	46.16	3363.75	(a)
C-2507	SR/DL	06/04/15	46.00	3363.91	(a)
C-2507	SR/DL	09/09/15	46.06	3363.85	(a)
C-2507	SR/DL	12/09/15	45.57	3364.34	(a)
C-2811	SR/DL	03/06/15	53.16	3345.68	(a)
C-2811	SR/DL	06/03/15	52.21	3346.63	(a)
C-2811	SR/DL	09/09/15	52.49	3346.35	(a)
C-2811	SR/DL	12/10/15	51.80	3347.04	(a)
PZ-01	SR/DL	03/06/15	42.67	3370.61	(a)
PZ-01	SR/DL	06/04/15	42.99	3370.29	(a)
PZ-01	SR/DL	09/09/15	42.95	3370.33	(a)
PZ-01	SR/DL	12/10/15	42.33	3370.95	(a)
PZ-02	SR/DL	03/06/15	44.15	3369.21	(a)
PZ-02	SR/DL	06/04/15	43.54	3369.82	(a)
PZ-02	SR/DL	09/09/15	43.61	3369.75	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
PZ-02	SR/DL	12/10/15	42.93	3370.43	(a)
PZ-03	SR/DL	03/06/15	46.27	3369.85	(a)
PZ-03	SR/DL	06/04/15	45.76	3370.36	(a)
PZ-03	SR/DL	09/09/15	45.78	3370.34	(a)
PZ-03	SR/DL	12/10/15	45.31	3370.81	(a)
PZ-04	SR/DL	NA	NA	NA	(a)
PZ-04	SR/DL	06/04/15	47.58	3364.43	(a)
PZ-04	SR/DL	09/09/15	47.54	3364.47	(a)
PZ-05	SR/DL	12/10/15	46.76	3365.25	(a)
PZ-05	SR/DL	03/06/15	44.72	3370.52	(a)
PZ-05	SR/DL	06/04/15	44.41	3370.83	(a)
PZ-05	SR/DL	09/09/15	44.45	3370.79	(a)
PZ-06	SR/DL	12/10/15	43.91	3371.33	(a)
PZ-06	SR/DL	03/06/15	45.18	3368.15	(a)
PZ-06	SR/DL	06/04/15	44.97	3368.36	(a)
PZ-06	SR/DL	09/09/15	44.84	3368.49	(a)
PZ-07	SR/DL	03/05/15	39.68	3374.16	(a)
PZ-07	SR/DL	06/05/15	38.99	3374.85	(a)
PZ-07	SR/DL	09/03/15	38.85	3374.99	(a)
PZ-07	SR/DL	12/09/15	38.39	3375.45	(a)
PZ-08	SR/DL	03/05/15	68.80	3349.39	(a)
PZ-08	SR/DL	06/04/15	68.81	3349.38	(a)
PZ-08	SR/DL	09/03/15	66.53	3351.66	(a)
PZ-08	SR/DL	12/09/15	62.70	3355.49	(a)
PZ-09	SR/DL	03/05/15	59.64	3361.45	(a)
PZ-09	SR/DL	06/03/15	59.14	3361.95	(a)
PZ-09	SR/DL	09/03/15	59.15	3361.94	(a)
PZ-09	SR/DL	12/09/15	59.16	3361.93	(a)
PZ-10	SR/DL	03/06/15	39.61	3366.12	(a)
PZ-10	SR/DL	06/03/15	39.45	3366.28	(a)
PZ-10	SR/DL	09/03/15	38.96	3366.77	(a)
PZ-10	SR/DL	12/10/15	37.85	3367.88	(a)
PZ-11	SR/DL	03/06/15	47.68	3371.10	(a)
PZ-11	SR/DL	06/03/15	47.22	3371.56	(a)
PZ-11	SR/DL	09/03/15	47.44	3371.34	(a)
PZ-11	SR/DL	12/10/15	47.23	3371.55	(a)

Well	Zone	Date	Adjusted Depth Top of Casing (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
PZ-12	SR/DL	03/06/15	55.09	3353.83	(a)
PZ-12	SR/DL	06/04/15	54.51	3354.41	(a)
PZ-12	SR/DL	09/03/15	54.22	3354.70	(a)
PZ-12	SR/DL	12/10/15	53.43	3355.49	(a)
PZ-13	SR/DL	03/05/15	67.13	3355.11	(a)
PZ-13	SR/DL	06/04/15	67.53	3354.71	(a)
PZ-13	SR/DL	09/03/15	67.33	3354.91	(a)
PZ-13	SR/DL	12/10/15	66.84	3355.40	(a)
PZ-14	SR/DL	03/05/15	68.38	3352.20	(a)
PZ-14	SR/DL	06/04/15	68.26	3352.32	(a)
PZ-14	SR/DL	09/03/15	68.24	3352.34	(a)
PZ-14	SR/DL	12/10/15	68.07	3352.51	(a)
PZ-15	SR/DL	03/05/15	48.16	3382.70	(a)
PZ-15	SR/DL	06/04/15	48.49	3382.37	(a)
PZ-15	SR/DL	09/03/15	48.74	3382.12	(a)
PZ-15	SR/DL	12/10/15	47.92	3382.94	(a)

Notes:

amsl Above mean sea level.

ft Feet or foot.

NA Not Available.

(a) Not Applicable.

(b) Top of casing changed; now measured from top of casing with straight edge.

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

Table G.1 – 2015 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	2.98E-03	4.58E-03	1.11E-02	U	-4.62E-04	1.25E-03	1.65E-03	U	-4.66E-04	4.65E-03	1.03E-02	U
	2	1.54E-03	4.53E-03	1.10E-02	U	-9.73E-05	8.10E-04	1.68E-03	U	5.39E-03	4.00E-03	1.01E-02	U
	3	3.07E-03	4.46E-03	1.07E-02	U	-1.76E-05	1.01E-03	1.59E-03	U	2.80E-03	4.29E-03	9.83E-03	U
	4	1.64E-03	4.02E-03	1.05E-02	U	-4.09E-04	8.36E-04	1.52E-03	U	1.05E-03	3.97E-03	9.73E-03	U
WEE	1 (Avg)	3.59E-03	4.67E-03	1.11E-02	U	-4.69E-04	1.39E-03	1.81E-03	U	-2.55E-04	4.62E-03	1.03E-02	U
	2	9.24E-04	4.48E-03	1.10E-02	U	2.56E-04	8.48E-04	1.59E-03	U	3.80E-03	3.85E-03	1.01E-02	U
	3	4.76E-03	4.65E-03	1.07E-02	U	-7.17E-05	1.05E-03	1.65E-03	U	3.14E-03	4.35E-03	9.85E-03	U
	4	4.39E-03	4.43E-03	1.06E-02	U	1.96E-04	1.26E-03	1.72E-03	U	1.68E-03	4.14E-03	9.77E-03	U
WSS	1	-7.57E-04	4.17E-03	1.11E-02	U	-6.57E-04	1.36E-03	1.73E-03	U	6.52E-04	4.65E-03	1.03E-02	U
	2 (Avg)	1.66E-03	4.48E-03	1.10E-02	U	-5.68E-05	7.32E-04	1.60E-03	U	5.13E-03	3.92E-03	1.01E-02	U
	3	2.46E-03	4.34E-03	1.07E-02	U	6.33E-04	1.29E-03	1.58E-03	U	5.01E-03	4.46E-03	9.82E-03	U
	4	-1.67E-04	4.02E-03	1.06E-02	U	-4.96E-04	9.57E-04	1.78E-03	U	4.59E-03	4.45E-03	9.77E-03	U
MLR	1	3.22E-03	4.56E-03	1.10E-02	U	2.98E-04	1.52E-03	1.63E-03	U	2.42E-03	4.85E-03	1.03E-02	U
	2	8.95E-04	4.42E-03	1.10E-02	U	1.41E-04	9.30E-04	1.80E-03	U	4.46E-03	3.86E-03	1.01E-02	U
	3 (Avg)	3.47E-03	4.40E-03	1.07E-02	U	-5.25E-04	9.35E-04	1.64E-03	U	1.28E-03	4.01E-03	9.85E-03	U
	4	3.71E-03	4.39E-03	1.06E-02	U	7.28E-04	1.41E-03	1.73E-03	U	3.34E-03	4.33E-03	9.77E-03	U
SEC	1	1.93E-03	4.40E-03	1.10E-02	U	-3.13E-04	1.39E-03	1.73E-03	U	-1.91E-03	4.48E-03	1.03E-02	U
	2	4.56E-03	4.97E-03	1.11E-02	U	-4.07E-05	8.07E-04	1.75E-03	U	7.01E-03	4.37E-03	1.02E-02	U
	3	5.28E-03	4.83E-03	1.08E-02	U	-2.93E-04	9.64E-04	1.80E-03	U	3.93E-03	4.53E-03	9.87E-03	U
	4 (Avg)	2.76E-03	4.18E-03	1.06E-02	U	-1.59E-04	1.05E-03	1.83E-03	U	3.31E-03	4.21E-03	9.75E-03	U

Location	Quarter	[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	Q[(d)]	[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	Q[(d)]	[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	Q[(d)]
CBD	1	1.61E-03	4.30E-03	1.10E-02	U	2.25E-04	1.47E-03	1.59E-03	U	-3.35E-04	4.49E-03	1.03E-02	U
	2	2.38E-03	4.52E-03	1.10E-02	U	-5.08E-05	7.20E-04	1.60E-03	U	7.52E-03	4.18E-03	1.01E-02	U
	3	2.30E-03	4.34E-03	1.07E-02	U	9.36E-05	1.19E-03	1.70E-03	U	4.71E-03	4.44E-03	9.82E-03	U
	4	6.45E-03	4.77E-03	1.06E-02	U	-5.23E-04	1.01E-03	1.80E-03	U	4.12E-03	4.51E-03	9.82E-03	U
SMR	1	7.98E-04	4.28E-03	1.10E-02	U	1.13E-04	1.61E-03	2.00E-03	U	-9.62E-04	4.50E-03	1.03E-02	U
	2	3.43E-04	4.36E-03	1.10E-02	U	1.19E-03	1.25E-03	1.56E-03	U	3.95E-03	3.77E-03	1.01E-02	U
	3	5.42E-03	4.72E-03	1.07E-02	U	7.05E-04	1.33E-03	1.62E-03	U	4.93E-03	4.53E-03	9.85E-03	U
	4	1.10E-03	3.98E-03	1.06E-02	U	-9.37E-05	1.12E-03	1.77E-03	U	1.23E-03	3.99E-03	9.73E-03	U
Mean		2.58E-03	4.44E-03	1.08E-02	NA	-5.75E-06	1.13E-03	1.69E-03	NA	2.91E-03	4.30E-03	1.00E-02	NA
Minimum(e)		-7.57E-04	4.17E-03	1.11E-02	WSS (1)	-6.57E-04	1.36E-03	1.73E-03	WSS (1)	-1.91E-03	4.48E-03	1.03E-02	SEC (1)
Maximum(e)		6.45E-03	4.77E-03	1.06E-02	CBD (4)	1.19E-03	1.25E-03	1.56E-03	SMR (2)	7.52E-03	4.18E-03	1.01E-02	CBD (2)
WAB	1	8.90E-03	2.99E-03	1.11E-02	U	9.98E-04	9.89E-04	1.60E-03	U	1.02E-02	3.21E-03	1.03E-02	U
(Filter	2	9.55E-03	3.07E-03	1.10E-02	U	2.46E-04	4.83E-04	1.58E-03	U	5.95E-03	2.38E-03	1.01E-02	U
Blank)	3	8.80E-03	2.99E-03	1.08E-02	U	4.64E-04	7.35E-04	1.63E-03	U	8.27E-03	2.90E-03	9.88E-03	U
	4	9.07E-03	2.73E-03	1.05E-02	U	6.26E-04	7.13E-04	1.50E-03	U	9.00E-03	2.72E-03	9.70E-03	U
		^{238}Pu				$^{239/240}$PU				^{241}Am			
WFF	1	6.20E-04	1.64E-03	2.14E-03	U	2.52E-03	2.01E-03	1.70E-03	+	-2.46E-04	1.96E-03	2.25E-03	U
	2	-1.01E-04	5.54E-04	1.07E-03	U	-2.73E-04	4.59E-04	1.27E-03	U	4.23E-04	1.67E-03	1.57E-03	U
	3	-1.20E-04	5.02E-04	8.70E-04	U	-2.68E-04	5.96E-04	9.76E-04	U	2.91E-04	1.33E-03	1.51E-03	U
	4	-1.60E-04	4.58E-04	1.02E-03	U	2.57E-04	6.84E-04	1.19E-03	U	-3.92E-04	9.20E-04	1.94E-03	U
WEE	1 (Avg)	1.52E-04	7.60E-04	1.21E-03	U	2.04E-04	1.03E-03	1.19E-03	U	3.08E-04	1.78E-03	1.94E-03	U
	2	-2.39E-04	2.90E-04	1.02E-03	U	9.69E-05	7.46E-04	1.31E-03	U	4.78E-04	9.82E-04	1.40E-03	U
	3	-3.30E-04	1.16E-03	1.47E-03	U	-1.85E-04	4.74E-04	1.07E-03	U	5.01E-05	1.17E-03	1.27E-03	U
	4	-5.11E-04	1.02E-03	1.34E-03	U	-1.05E-04	3.44E-04	1.24E-03	U	1.03E-05	8.51E-04	1.35E-03	U
WSS	1	-3.69E-04	4.30E-04	1.08E-03	U	-1.40E-04	9.80E-04	1.39E-03	U	-5.69E-04	1.17E-03	1.40E-03	U
	2 (Avg)	-3.14E-04	4.29E-04	1.21E-03	U	1.60E-04	6.40E-04	1.20E-03	U	1.57E-04	9.10E-04	1.47E-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)]
	3	-2.06E-04	6.17E-04	1.15E-03	U	1.77E-05	5.89E-04	1.11E-03	U	3.10E-04	1.41E-03	1.63E-03	U
	4	-3.40E-04	6.78E-04	1.23E-03	U	-1.39E-04	4.07E-04	1.13E-03	U	-1.81E-04	1.06E-03	1.93E-03	U
MLR	1	-4.61E-04	5.81E-04	1.46E-03	U	2.76E-05	9.20E-04	1.14E-03	U	-2.28E-04	1.90E-03	2.03E-03	U
	2	-2.33E-04	2.77E-04	1.39E-03	U	-5.95E-06	5.11E-04	1.24E-03	U	2.67E-05	8.03E-04	1.63E-03	U
	3 (Avg)	-2.16E-04	7.44E-04	1.36E-03	U	9.03E-05	8.78E-04	1.27E-03	U	-4.87E-04	1.17E-03	2.22E-03	U
	4	-1.01E-04	6.45E-04	9.79E-04	U	-2.01E-05	5.37E-04	1.36E-03	U	2.94E-04	1.27E-03	2.31E-03	U
SEC	1	-4.38E-04	5.32E-04	1.30E-03	U	-2.14E-04	8.63E-04	1.28E-03	U	-2.94E-04	1.22E-03	1.42E-03	U
	2	-3.64E-04	5.05E-04	1.25E-03	U	7.90E-04	9.36E-04	1.15E-03	U	8.61E-04	1.73E-03	2.02E-03	U
	3	1.78E-04	7.29E-04	1.03E-03	U	-3.01E-05	5.95E-04	1.08E-03	U	-2.63E-04	1.13E-03	1.31E-03	U
	4 (Avg)	-9.34E-05	6.17E-04	1.14E-03	U	3.80E-04	7.65E-04	1.11E-03	U	2.99E-04	1.43E-03	1.66E-03	U
CBD	1	4.37E-05	6.44E-04	1.08E-03	U	-3.69E-04	7.33E-04	1.15E-03	U	2.02E-04	1.54E-03	1.86E-03	U
	2	-3.17E-04	4.36E-04	1.33E-03	U	-3.50E-04	5.61E-04	1.20E-03	U	8.49E-05	1.09E-03	1.70E-03	U
	3	2.07E-04	1.16E-03	1.25E-03	U	-3.13E-05	6.20E-04	1.08E-03	U	2.36E-05	1.42E-03	1.73E-03	U
	4	-1.62E-04	4.60E-04	9.78E-04	U	3.77E-04	7.74E-04	1.21E-03	U	-2.65E-04	8.28E-04	2.29E-03	U
SMR	1	-4.51E-04	5.50E-04	1.22E-03	U	4.20E-04	1.05E-03	1.18E-03	U	-8.20E-04	1.56E-03	1.76E-03	U
	2	-3.20E-04	4.42E-04	1.41E-03	U	2.16E-04	8.62E-04	1.25E-03	U	-5.54E-04	1.31E-03	2.10E-03	U
	3	-5.30E-05	3.86E-04	8.22E-04	U	1.50E-04	9.12E-04	1.07E-03	U	6.36E-04	1.38E-03	1.34E-03	U
	4	-1.61E-04	4.58E-04	9.55E-04	U	-1.25E-04	3.81E-04	1.12E-03	U	-2.23E-04	1.10E-03	1.99E-03	U
Mean		-1.74E-04	6.32E-04	1.21E-03	NA	1.23E-04	7.45E-04	1.20E-03	NA	-2.38E-06	1.29E-03	1.75E-03	NA
Minimum[(e)]		-5.11E-04	1.02E-03	1.34E-03	WEE (4)	-3.69E-04	7.33E-04	1.15E-03	CBD (1)	-8.20E-04	1.56E-03	1.76E-03	SMR (1)
Maximum[(e)]		6.20E-04	1.64E-03	2.14E-03	WFF (1)	2.52E-03	2.29E-03	9.56E-04	WFF (1)	8.61E-04	1.73E-03	2.02E-03	SEC (2)
WAB	1	-2.41E-04	4.17E-04	1.54E-03	U	2.75E-04	7.79E-04	1.70E-03	U	6.49E-04	1.05E-03	1.52E-03	U
(Filter	2	-1.77E-04	3.47E-04	1.14E-03	U	-1.18E-04	2.83E-04	1.09E-03	U	1.02E-04	4.90E-04	1.45E-03	U
Blank)	3	-5.30E-05	5.81E-04	1.28E-03	U	1.35E-04	4.41E-04	1.17E-03	U	6.37E-04	9.47E-04	1.53E-03	U
		1.01E-04	4.27E-04	1.06E-03	U	-2.01E-05	1.18E-04	1.08E-03	U	1.22E-04	7.96E-04	1.66E-03	U

Location	Quarter	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
		^{40}K				^{60}Co				^{137}Cs			
WFF	1	6.57E+00	8.66E+00	1.08E+01	U	3.02E-01	9.71E-01	1.15E+00	U	-3.85E-01	9.46E-01	1.07E+00	U
	2	1.88E+00	8.76E+00	1.05E+01	U	-3.41E-01	7.99E-01	8.95E-01	U	9.99E-01	7.80E-01	1.00E+00	U
	3	-3.69E+00	8.34E+00	9.04E+00	U	1.38E-01	8.26E-01	1.03E+00	U	1.79E-01	8.66E-01	1.04E+00	U
	4	4.98E+00	7.46E+00	8.95E+00	U	4.33E-01	6.55E-01	8.15E-01	U	3.50E-01	7.38E-01	8.82E-01	U
WEE	1 (Avg)	6.92E+00	4.24E+00	6.32E+00	U	2.31E-01	9.31E-01	1.13E+00	U	-5.11E-01	1.03E+00	1.11E+00	U
	2	-1.45E+00	7.06E+00	7.84E+00	U	2.58E-02	6.74E-01	7.78E-01	U	-1.12E-01	7.48E-01	8.20E-01	U
	3	-3.52E+00	7.27E+00	7.69E+00	U	3.02E-01	6.69E-01	7.97E-01	U	-8.27E-01	8.27E-01	8.10E-01	U
	4	8.96E+00	7.29E+00	9.07E+00	U	-1.20E-01	8.06E-01	8.99E-01	U	1.70E-01	8.74E-01	9.73E-01	U
WSS	1	-8.36E-01	6.76E+00	7.59E+00	U	2.21E-01	6.81E-01	8.07E-01	U	-2.24E-01	7.52E-01	8.11E-01	U
	2 (Avg)	1.08E+01	7.80E+00	1.07E+01	U	-3.86E-01	9.47E-01	1.00E+00	U	-2.22E-03	9.79E-01	1.08E+00	U
	3	1.59E+00	1.14E+01	1.29E+01	U	-4.17E-02	1.03E+00	1.16E+00	U	-7.22E-02	1.29E+00	1.39E+00	U
	4	1.32E+01	7.00E+00	9.05E+00	U	-2.01E-01	7.59E-01	8.33E-01	U	1.26E-01	8.09E-01	9.02E-01	U
MLR	1	6.01E+00	6.34E+00	8.03E+00	U	3.44E-01	6.67E-01	8.08E-01	U	3.80E-01	6.52E-01	7.96E-01	U
	2	2.59E+00	7.25E+00	8.43E+00	U	5.09E-01	6.88E-01	8.51E-01	U	-7.90E-02	7.43E-01	8.17E-01	U
	3 (Avg)	1.19E+00	8.03E+00	9.53E+00	U	-2.18E-01	7.75E-01	8.61E-01	U	-1.71E-01	7.56E-01	8.40E-01	U
	4	8.78E+00	7.62E+00	9.69E+00	U	1.68E-01	7.72E-01	9.32E-01	U	1.15E-02	6.98E-01	8.46E-01	U
SEC	1	-2.24E+00	7.23E+00	7.71E+00	U	5.64E-02	6.53E-01	7.59E-01	U	3.77E-01	7.25E-01	8.29E-01	U
	2	5.95E+00	9.40E+00	1.17E+01	U	-1.88E+00	1.34E+00	1.07E+00	U	-2.42E-02	1.27E+00	1.38E+00	U
	3	1.20E+00	7.66E+00	8.80E+00	U	9.70E-01	6.79E-01	8.73E-01	U	2.56E-01	6.59E-01	7.91E-01	U
	4 (Avg)	3.58E+00	8.53E+00	1.03E+01	U	-4.53E-01	1.01E+00	9.70E-01	U	1.16E-01	9.64E-01	1.09E+00	U
CBD	1	5.47E+00	8.40E+00	1.09E+01	U	-7.40E-01	9.64E-01	9.95E-01	U	-3.45E-01	8.84E-01	9.99E-01	U
	2	8.01E+00	6.50E+00	8.35E+00	U	1.88E-01	7.01E-01	8.25E-01	U	1.93E-01	7.29E-01	8.21E-01	U
	3	7.76E+00	1.15E+01	1.38E+01	U	3.03E-02	1.08E+00	1.23E+00	U	-6.36E-01	1.44E+00	1.46E+00	U
	4	1.08E+01	9.76E+00	1.28E+01	U	-2.18E-01	1.06E+00	1.18E+00	U	-9.09E-01	1.01E+00	1.07E+00	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]
SMR	1	5.36E+00	3.84E+00	5.76E+00	U	-5.13E-01	7.57E-01	7.78E-01	U	5.54E-01	7.09E-01	8.26E-01	U
	2	-5.88E-01	9.21E+00	1.07E+01	U	-4.16E-01	9.09E-01	1.02E+00	U	-3.29E-01	8.50E-01	9.64E-01	U
	3	9.29E+00	7.31E+00	9.15E+00	U	-1.43E-01	7.54E-01	8.40E-01	U	5.32E-02	8.19E-01	9.11E-01	U
	4	6.68E+00	7.99E+00	9.55E+00	U	5.42E-02	7.17E-01	8.26E-01	U	2.75E-01	7.82E-01	8.83E-01	U
Mean		4.47E+00	7.81E+00	9.48E+00	NA	-6.05E-02	8.31E-01	9.32E-01	NA	-2.11E-02	8.69E-01	9.72E-01	NA
Minimum[e]		-3.69E+00	8.34E+00	9.04E+00	WFF (3)	-1.88E+00	1.34E+00	1.07E+00	SEC (2)	-9.09E-01	1.01E+00	1.07E+00	CBD (4)
Maximum[e]		1.32E+01	7.00E+00	9.05E+00	WSS (4)	9.70E-01	6.79E-01	8.73E-01	SEC (3)	9.99E-01	7.80E-01	1.00E+00	WFF (2)
WAB	1	4.16E+00	6.10E+00	7.56E+00	U	7.35E-01	7.03E-01	8.80E-01	U	5.17E-02	6.37E-01	7.56E-01	U
(Filter	2	8.79E+00	6.61E+00	8.45E+00	U	3.04E-02	7.18E-01	8.22E-01	U	7.32E-03	7.12E-01	7.92E-01	U
Blank)	3	7.12E+00	6.89E+00	8.64E+00	U	-1.25E-01	7.34E-01	8.18E-01	U	1.72E-01	6.73E-01	8.04E-01	U
	4	3.21E+00	7.27E+00	8.84E+00	U	5.38E-01	7.18E-01	9.13E-01	U	5.80E-01	6.38E-01	8.05E-01	U

Location	Quarter	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
		^{90}Sr			
WFF	1	1.52E-02	2.44E-02	1.81E-02	U
	2	-6.64E-03	2.58E-02	1.33E-02	U
	3	-2.80E-03	1.96E-02	1.13E-02	U
	4	-4.21E-03	2.32E-02	1.40E-02	U
WEE	1 (Avg)	6.15E-03	1.94E-02	1.76E-02	U
	2	2.05E-03	2.62E-02	1.34E-02	U
	3	1.03E-03	1.94E-02	1.13E-02	U
	4	8.37E-03	2.17E-02	1.39E-02	U
WSS	1	1.75E-02	2.46E-02	1.80E-02	U
	2 (Avg)	1.45E-02	2.61E-02	1.34E-02	U
	3	-2.16E-03	2.07E-02	1.13E-02	U
	4	-1.66E-02	2.29E-02	1.40E-02	U
MLR	1	-3.63E-03	2.48E-02	1.80E-02	U
	2	7.07E-04	2.55E-02	1.34E-02	U

Location	Quarter	[RN][(a)]	2 σ TPU[(b)]	MDC[(c)]	Q[(d)]
	3 (Avg)	4.99E-03	2.03E-02	1.21E-02	U
	4	-5.24E-03	2.19E-02	1.40E-02	U
SEC	1	1.25E-02	2.43E-02	1.80E-02	U
	2	1.21E-02	2.42E-02	1.32E-02	U
	3	-2.27E-03	2.00E-02	1.13E-02	U
	4 (Avg)	4.89E-03	2.21E-02	1.22E-02	U
CBD	1	3.47E-03	2.56E-02	1.81E-02	U
	2	1.20E-02	2.51E-02	1.34E-02	U
	3	-5.05E-03	2.09E-02	1.15E-02	U
	4	2.42E-04	2.17E-02	1.40E-02	U
SMR	1	7.82E-03	2.41E-02	1.80E-02	U
	2	5.62E-03	2.40E-02	1.32E-02	U
	3	2.13E-03	1.90E-02	1.12E-02	U
	4	2.58E-03	2.16E-02	1.39E-02	U
Mean		3.05E-03	2.28E-02	1.41E-02	NA
Minimum[(e)]		-1.66E-02	2.29E-02	1.40E-02	WSS (4)
Maximum[(e)]		1.75E-02	2.46E-02	1.80E-02	WSS (1)
WAB	1	4.78E-03	1.71E-02	1.81E-02	U
(Filter	2	5.72E-04	1.79E-02	1.32E-02	U
Blank)	3	2.80E-03	6.94E-03	1.06E-02	U
	4	-6.34E-03	1.61E-02	1.39E-02	U

Notes:

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

(a) Radionuclide activity. The average is used for duplicate samples. Only radionuclides with activities greater than 2 σ TPU and the MDC are considered detections.

(b) Total Propagated Uncertainty.

(c) Minimum detectable concentration.

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

(e) Minimum and maximum reported concentrations for each radionuclide are based on the sample's activity, [RN], while the associated 2 σ TPU and MDC are inherited with the specific [RN], i.e., they are not averages.

Table G.2 – 2015 Radionuclide Concentrations in Quarterly Air Filter Composite Samples Collected from Locations Surrounding the WIPP Site

			$^{233/234}U$		^{235}U		^{238}U		^{238}Pu		$^{239/240}Pu$		^{241}Am	
Location	Quarter	Vol, m^3	Bq/sample	Bq/m^3	Bq/sample	Bq/m^3	Bq/sample	Bq/m^3	Bq/sample	Bq/m^3	Bq/sample	Bq/m^3	Bq/sample	Bq/m^3
WFF	1	7388.110	2.98E-03	4.03E-07	-4.62E-04	-6.25E-08	-4.66E-04	-6.31E-08	6.20E-04	8.39E-08	2.52E-03	3.41E-07	-2.46E-04	-3.33E-08
	2	7373.468	1.54E-03	2.09E-07	-9.73E-05	-1.32E-08	5.39E-03	1.15E-06	-1.01E-04	-1.37E-08	-2.73E-04	-3.70E-08	4.23E-04	5.74E-08
	3	7332.172	3.07E-03	4.19E-07	-1.76E-05	-2.40E-09	2.80E-03	3.55E-07	-1.20E-04	-1.64E-08	-2.68E-04	-3.66E-08	2.91E-04	3.97E-08
	4	7197.283	1.64E-03	2.28E-07	-4.09E-04	-5.68E-08	1.05E-03	4.68E-07	-1.60E-04	-2.22E-08	2.57E-04	3.57E-08	-3.92E-04	-5.45E-08
WEE	1 (Avg)	7401.946	3.59E-03	4.85E-07	-4.69E-04	-6.34E-08	-2.55E-04	2.08E-07	1.52E-04	2.05E-08	2.04E-04	2.76E-08	3.08E-04	4.16E-08
	2	7392.259	9.24E-04	1.25E-07	2.56E-04	3.46E-08	3.80E-03	5.38E-07	-2.39E-04	-3.23E-08	9.69E-05	1.31E-08	4.78E-04	6.47E-08
	3	7388.763	4.76E-03	6.44E-07	-7.17E-05	-9.70E-09	3.14E-03	2.34E-07	-3.30E-04	-4.47E-08	-1.85E-04	-2.50E-08	5.01E-05	6.78E-09
	4	7367.567	4.39E-03	5.96E-07	1.96E-04	2.66E-08	1.68E-03	1.71E-07	-5.11E-04	-6.94E-08	-1.05E-04	-1.43E-08	1.03E-05	1.40E-09
WSS	1	7441.275	-7.57E-04	-1.02E-07	-6.57E-04	-8.83E-08	6.52E-04	2.06E-07	-3.69E-04	-4.96E-08	-1.40E-04	-1.88E-08	-5.69E-04	-7.65E-08
	2 (Avg)	7363.613	1.66E-03	2.25E-07	-5.68E-05	-7.71E-09	5.13E-03	1.08E-06	-3.14E-04	-4.26E-08	1.60E-04	2.17E-08	1.57E-04	2.13E-08
	3	7341.060	2.46E-03	3.35E-07	6.33E-04	8.62E-08	5.01E-03	5.28E-09	-2.06E-04	-2.81E-08	1.77E-05	2.41E-09	3.10E-04	4.22E-08
	4	7398.905	-1.67E-04	-2.26E-08	-4.96E-04	-6.70E-08	4.59E-03	5.05E-07	-3.40E-04	-4.60E-08	-1.39E-04	-1.88E-08	-1.81E-04	-2.45E-08
MLR	1	7390.413	3.22E-03	4.35E-07	2.98E-04	4.03E-08	2.42E-03	5.67E-07	-4.61E-04	-6.23E-08	2.76E-05	3.73E-09	-2.28E-04	-3.08E-08
	2	6863.775	8.95E-04	1.30E-07	1.41E-04	2.05E-08	4.46E-03	9.60E-07	-2.33E-04	-3.40E-08	-5.95E-06	-8.67E-10	2.67E-05	3.89E-09
	3 (Avg)	7314.269	3.47E-03	4.74E-07	-5.25E-04	-7.18E-08	1.28E-03	2.02E-07	-2.16E-04	-2.95E-08	9.03E-05	1.23E-08	-4.87E-04	-6.66E-08
	4	7397.135	3.71E-03	5.02E-07	7.28E-04	9.84E-08	3.34E-03	4.14E-07	-1.01E-04	-1.36E-08	-2.01E-05	-2.72E-09	2.94E-04	3.98E-08
SEC	1	7322.220	1.93E-03	2.63E-07	-3.13E-04	-4.27E-08	-1.91E-03	3.85E-07	-4.38E-04	-5.98E-08	-2.14E-04	-2.93E-08	-2.94E-04	-4.01E-08
	2	7366.684	4.56E-03	6.19E-07	-4.07E-05	-5.52E-09	7.01E-03	8.46E-07	-3.64E-04	-4.95E-08	7.90E-04	1.07E-07	8.61E-04	1.17E-07
	3	7311.942	5.28E-03	7.23E-07	-2.93E-04	-4.01E-08	3.93E-03	2.44E-07	1.78E-04	2.43E-08	-3.01E-05	-4.12E-09	-2.63E-04	-3.60E-08
	4 (Avg)	7384.613	2.76E-03	3.74E-07	-1.59E-04	-2.15E-08	3.31E-03	6.11E-07	-9.34E-05	-1.27E-08	3.80E-04	5.14E-08	2.99E-04	4.05E-08
CBD	1	7241.964	1.61E-03	2.22E-07	2.25E-04	3.10E-08	-3.35E-04	6.13E-07	4.37E-05	6.04E-09	-3.69E-04	-5.10E-08	2.02E-04	2.80E-08
	2	7349.051	2.38E-03	3.24E-07	-5.08E-05	-6.91E-09	7.52E-03	1.29E-06	-3.17E-04	-4.31E-08	-3.50E-04	-4.76E-08	8.49E-05	1.16E-08
	3	6919.667	2.30E-03	3.33E-07	9.36E-05	1.35E-08	4.71E-03	5.76E-07	2.07E-04	2.99E-08	-3.13E-05	-4.53E-09	2.36E-05	3.41E-09
	4	7463.732	6.45E-03	8.64E-07	-5.23E-04	-7.01E-08	4.12E-03	7.18E-07	-1.62E-04	-2.17E-08	3.77E-04	5.05E-08	-2.65E-04	-3.55E-08
SMR	1	7362.187	7.98E-04	1.08E-07	1.13E-04	1.53E-08	-9.62E-04	-3.07E-08	-4.51E-04	-6.12E-08	4.20E-04	5.71E-08	-8.20E-04	-1.11E-07

			$^{233/234}U$		^{235}U		^{238}U		^{238}Pu		$^{239/240}Pu$		^{241}Am	
Location	**Quarter**	**Vol, m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**	**Bq/sample**	**Bq/m^3**
	2	7340.757	3.43E-04	4.67E-08	1.19E-03	1.61E-07	3.95E-03	1.64E-06	-3.20E-04	-4.37E-08	2.16E-04	2.94E-08	-5.54E-04	-7.54E-08
	3	7284.001	5.42E-03	7.44E-07	7.05E-04	9.68E-08	4.93E-03	5.73E-07	-5.30E-05	-7.28E-09	1.50E-04	2.05E-08	6.36E-04	8.73E-08
	4	7208.005	1.10E-03	1.53E-07	-9.37E-05	-1.30E-08	1.23E-03	6.27E-07	-1.61E-04	-2.23E-08	-1.25E-04	-1.73E-08	-2.23E-04	-3.09E-08
Mean		7318.101	2.58E-03	3.52E-07	-5.76E-06	-6.37E-10	2.91E-03	5.39E-07	-1.74E-04	-2.36E-08	1.23E-04	1.66E-08	-2.37E-06	-3.27E-10
Minimum		6863.775	-7.57E-04	-1.02E-07	-6.57E-04	-8.83E-08	-1.91E-03	-6.31E-08	-5.11E-04	-6.94E-08	-3.69E-04	-5.10E-08	-8.20E-04	-1.11E-07
Maximum		7463.732	6.45E-03	8.64E-07	1.19E-03	1.61E-07	7.52E-03	1.64E-06	6.20E-04	8.39E-08	2.52E-03	3.41E-07	8.61E-04	1.17E-07`

Note: See Appendix C for sampling location codes.

APPENDIX H – COMPARISON OF DETECTED RADIONUCLIDES TO THE RADIOLOGICAL BASELINE

The figures in this appendix show the highest detected radionuclides from 2015 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 filter particulate, groundwater, surface water, sediment, soil, vegetation and fauna radiochemical analysis results. Note that all results with the exception of vegetation and fauna were compared to the baseline upper 99 percentile probability value. The baseline did not include probability distributions for vegetation and fauna; therefore, vegetation and fauna sample results are compared to the baseline mean values.

A few items to note from the figures include the following:

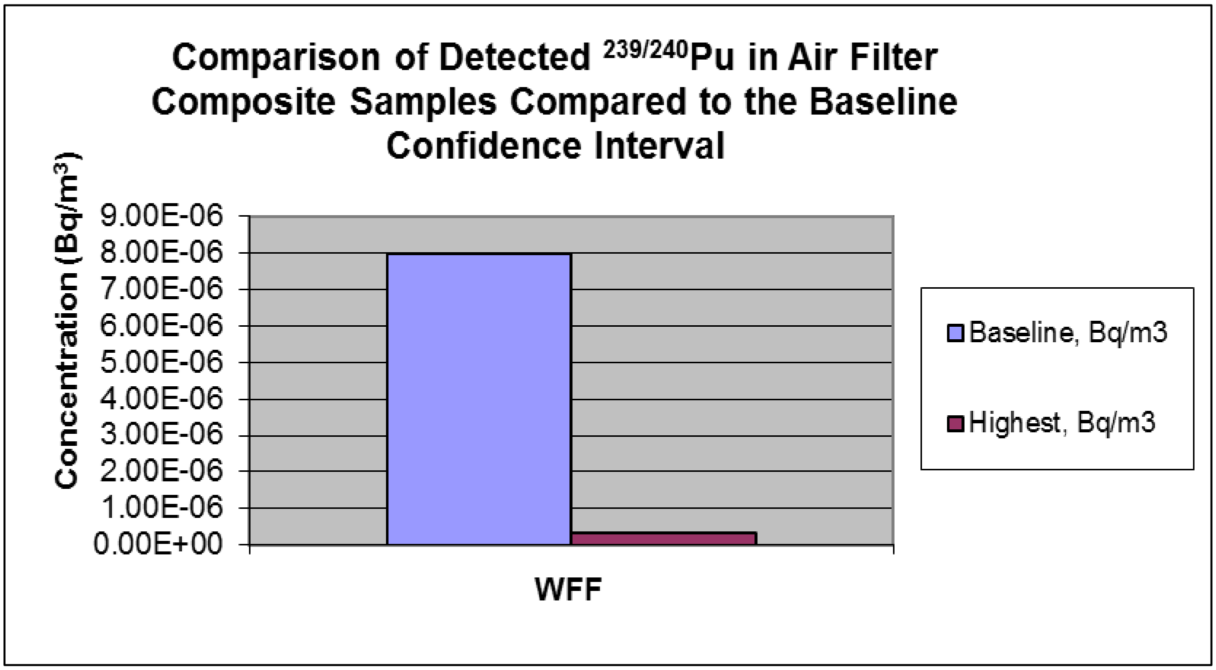
- Figures are provided for only the first quarter air filter composite sample since it was the only sample with any detections ($^{239/240}$Pu). None of the limited number of Event Evaluation samples collected in 2015 contained any detections.
- The duplicate sample of WQSP-1 had the highest concentration for $^{233/234}$U at 1.31E+00 Bq/L, just above 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 also highest at WQSP-1 but were lower than the 99 percent baseline confidence interval ranges of 3.10E-02 Bq/L and 3.20 Bq/L, respectively. The highest ^{40}K concentration was at WQSP-3 at 4.33E+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 highest concentrations of uranium isotopes in surface water samples were from locations associated with the Pecos River and were associated with Pierce Canyon (PCN). The highest concentrations were 1.79E-01 Bq/L for 233/234U (3.30E-01 Bq/L); 3.32E-03 Bq/L for 235U (1.40E-02 Bq/L); and 8.50E-02 Bq/L for 238 U (1.10E-01 Bq/L). The concentrations were lower than the 99 percent confidence interval range of the baseline concentrations shown in parentheses. The only other surface detection was for ^{40}K in the sewage sludge composite/H-19 Sample of Opportunity of 7.36E+01 Bq/L; however, there is no 99 percent confidence interval range of the baseline concentration for ^{40}K in sewage sludge.
- The highest concentrations of the uranium isotopes in sediment samples were also from the Pecos River and Associated Bodies of Water, but at location BRA instead of PCN. The 99 percent confidence interval concentrations for sediments do not distinguish between the Pecos River and Associated Bodies of Water and tanks and tank-like structures. The BRA concentration of $^{233/234}$U of 2.82E-02 Bq/g is lower than the 99 percent confidence concentration of 1.10E-01 Bq/g; the ^{235}U concentration of 1.16E-03 Bq/g is lower than the 99 percent confidence concentration of 3.20E-03 Bq/g; and the ^{238}U concentration of 2.74E-02 Bq/g is lower than the 99 percent confidence concentration of 5.00E-02 Bq/g. The results are all reported on a dry weight basis.

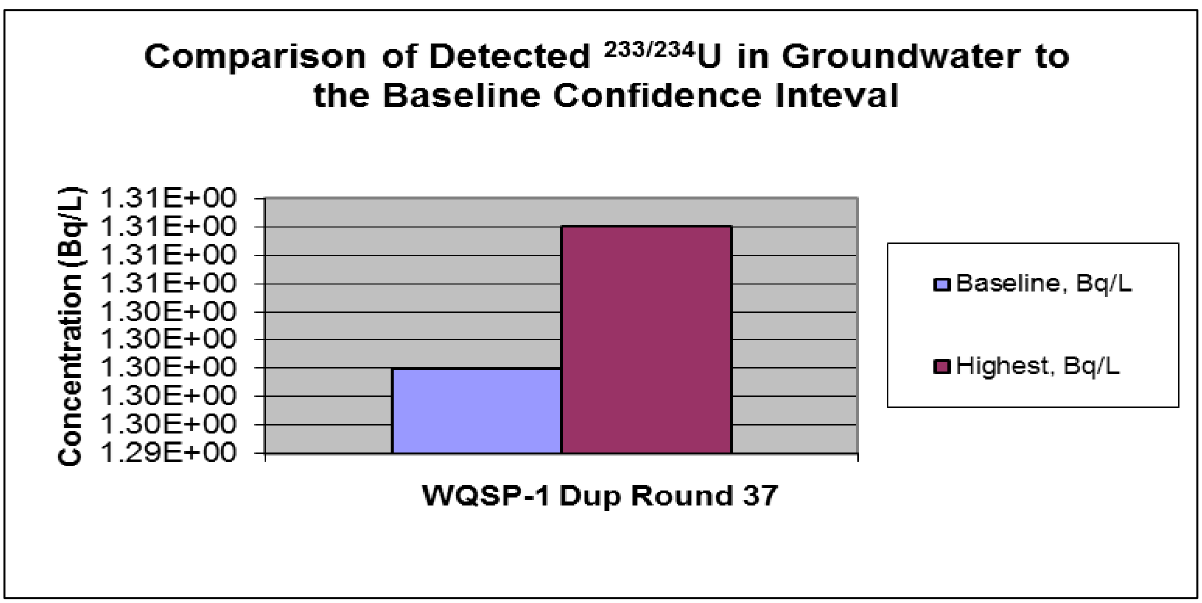
- The highest ^{40}K sediment concentration of 8.56E-01 Bq/g at HIL (tank and tank-like structure) is lower than the 99 percent confidence concentration of 1.20E+00 Bq/g, but this concentration includes the Laguna Grande de la Sal location, which likely contains higher ^{40}K concentrations than the tanks and tank-like structures. The highest ^{40}K concentration in the Pecos River and Associated Bodies of Water is 3.71E-01 Bq/g at BRA, which is lower than the 99 percent confidence concentration of 5.00E-01 Bq/g for the Pecos River and Associated Bodies of Water. The results are all reported on a dry weight basis.
- The highest ^{137}Cs sediment concentration of 8.60E-03 Bq/g at BHT is lower than the 99 percent confidence concentration of 3.50E-02 Bq/g for tanks and tank-like structures. There were no detections of $^{239/240}Pu$ in any sediment samples in 2015.
- The highest concentrations of detected radionuclides in soil samples were at location SMR, which is within the 5-mile radius of the WIPP site. There were no detections of plutonium isotopes in soil samples in 2015. The highest uranium concentrations were as follows (99 percent confidence concentrations in parenthesis): $^{233/234}U$: 1.67E-02 Bq/g at the 2-5 cm depth of SMR (2.20E-02 Bq/g); ^{235}U: 8.71E-04 Bq/g at the 0-2 cm depth at SMR (1.70E-03 Bq/g); and ^{238}U: 1.71E-02 Bq/g and the 0-2 cm depth at SMR (1.30E-02 Bq/g). Thus the ^{238}U concentration was higher than the 99 percent confidence concentration for concentrations within the 5-mile ring. The highest ^{40}K concentration of 8.28E-01 Bq/g at the 5-10 cm depth of SMR is higher than the 99 percent baseline confidence interval concentration of 3.40E-01 Bq/g for the 5-mile ring. The highest ^{137}Cs concentration of 9.01E-03 Bq/g at the 2-5 depth at SMR is lower than the 99 percent baseline confidence interval concentration of 2.40E-01 Bq/g. The results are reported on a dry weight basis.
- The single detection of $^{233/234}U$ in the WEE primary vegetation sample at 1.04E-03 Bq/g is higher than the mean baseline concentration of 6.00E-05 Bq/g. The highest ^{238}U concentration in the same sample at 1.69E-03 Bq/g is higher than the mean baseline concentration of 6.90E-04 Bq/g. The highest ^{40}K concentration of 7.27E-01 Bq/g in the duplicate vegetation sample from WEE is lower than the mean baseline concentration of 3.20E+00 Bq/g. However, since the average baseline concentrations are reported on an ashed weight basis, and WIPP Labs reports the results on a dry weight basis, the results are not directly comparable. The lab reports the data on a dry weight basis, and the average baseline data are reported on an ashed weight basis, and thus the data are not directly comparable.
- The animal biota samples contained ^{40}K, but no other radionuclides were detected. The highest ^{40}K concentration was 1.57E-01 Bq/g for a deer sample, but there is no average baseline concentration for deer with which to compare. Average baseline concentrations are available for fish, quail, and rabbit, but the results are reported on a dry basis and may not be directly comparable to the wet weight basis results reported by WIPP Laboratories. The animal biota data are reported by WIPP Laboratories on a wet weight basis, whereas the average

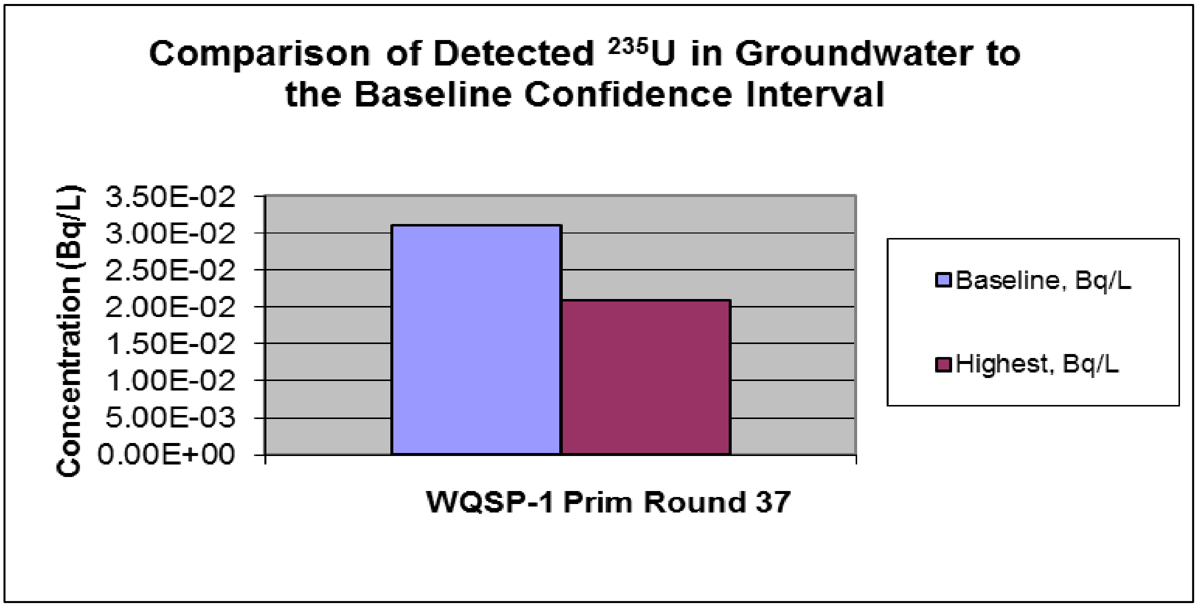
baseline concentrations are reported on a dry weight basis, and thus the data are not directly comparable.

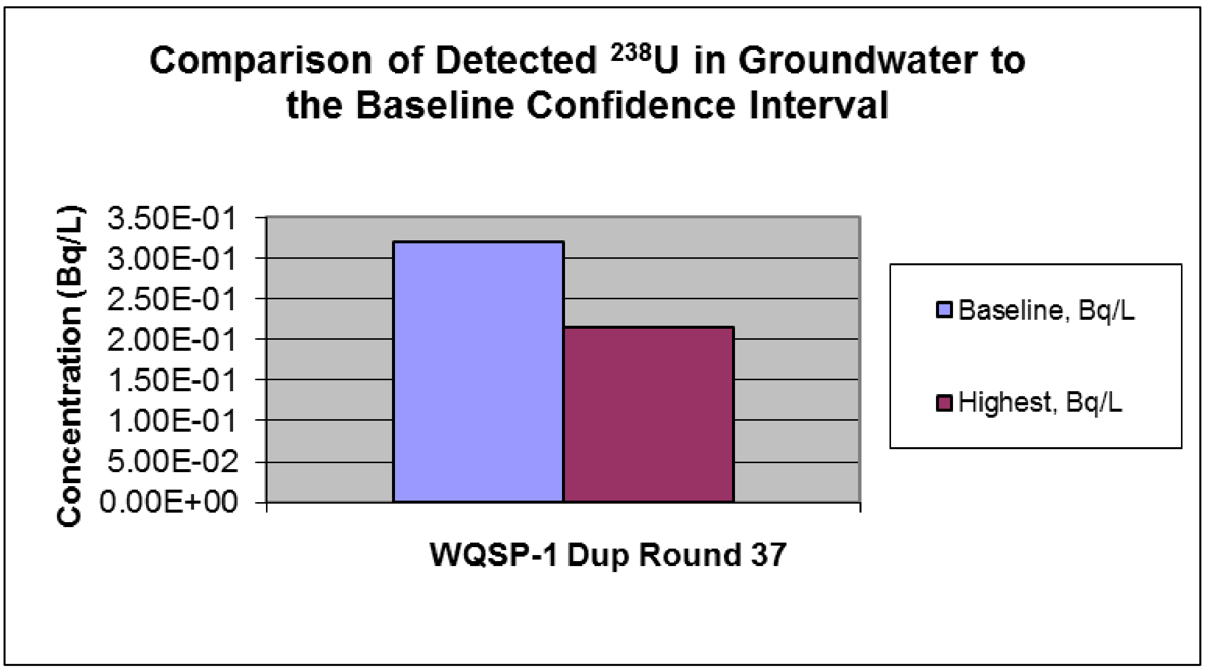
A detailed discussion of environmental monitoring radionuclide sample results is presented in Chapter 4.

Note: Graphs with no location only display the baseline as no detections were encountered for that radionuclide.






Comparison of Detected 235U in Groundwater to the Baseline Confidence Interval
Concentration (Bq/L)
3.50E-02
3.00E-02
2.50E-02
2.00E-02
1.50E-02
1.00E-02
5.00E-03
0.00E+00
WQSP-1 Prim Round 37
Baseline, Bq/L
Highest, Bq/L


Comparison of Detected 238U in Groundwater to the Baseline Confidence Interval
Concentration (Bq/L)
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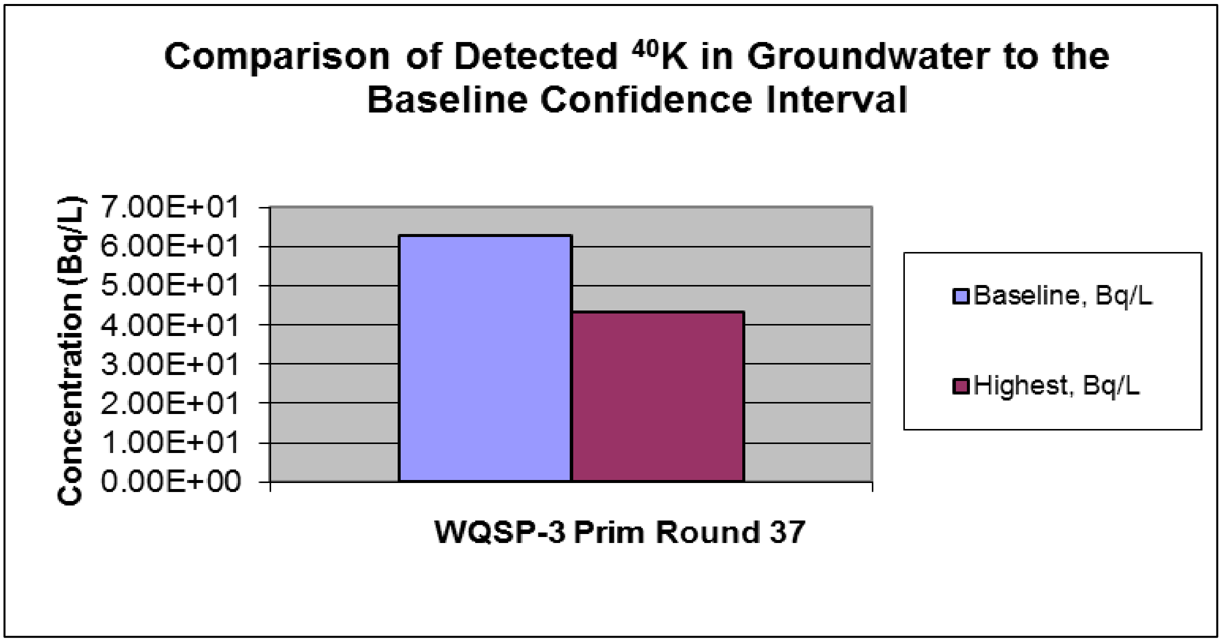
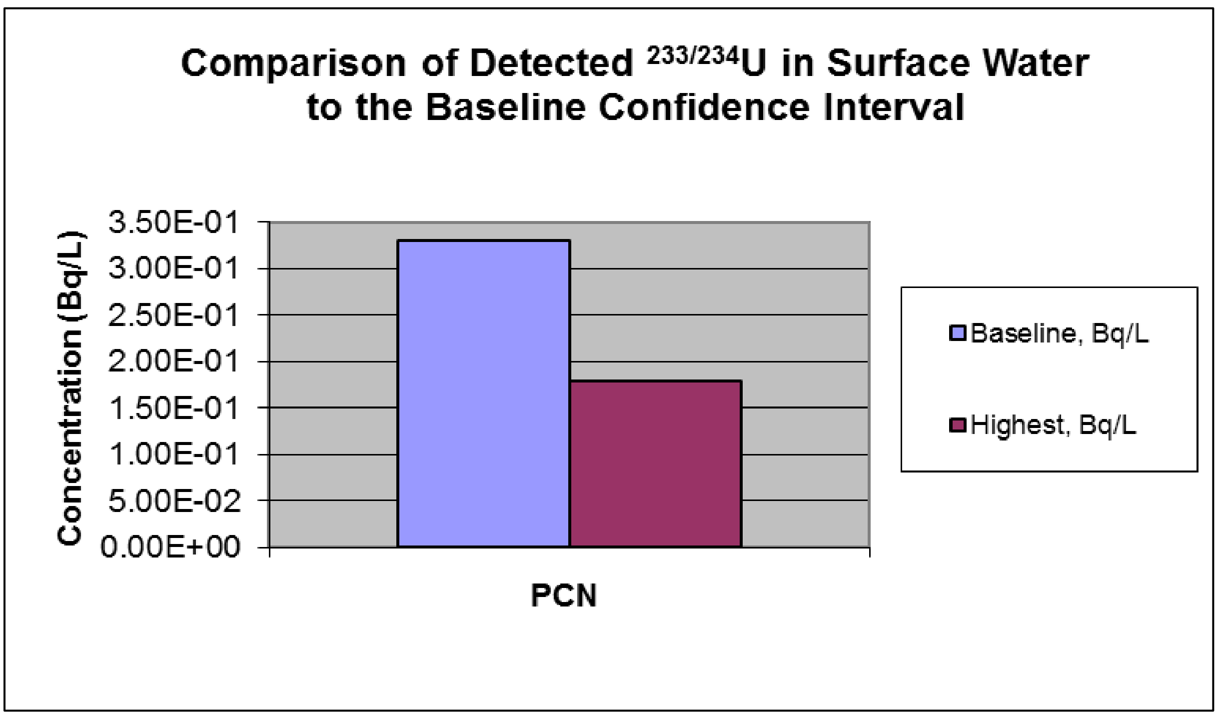
3.00E-01
2.50E-01
2.00E-01
1.50E-01
1.00E-01
5.00E-02
0.00E+00
WQSP-1 Dup Round 37
Baseline, Bq/L
Highest, Bq/L


Comparison of Detected 40K in Groundwater to the Baseline Confidence Interval
Concentration (Bq/L)
7.00E+01
6.00E+01
5.00E+01
4.00E+01
3.00E+01
2.00E+01
1.00E+01
0.00E+00
WQSP-3 Prim Round 37
Baseline, Bq/L
Highest, Bq/L


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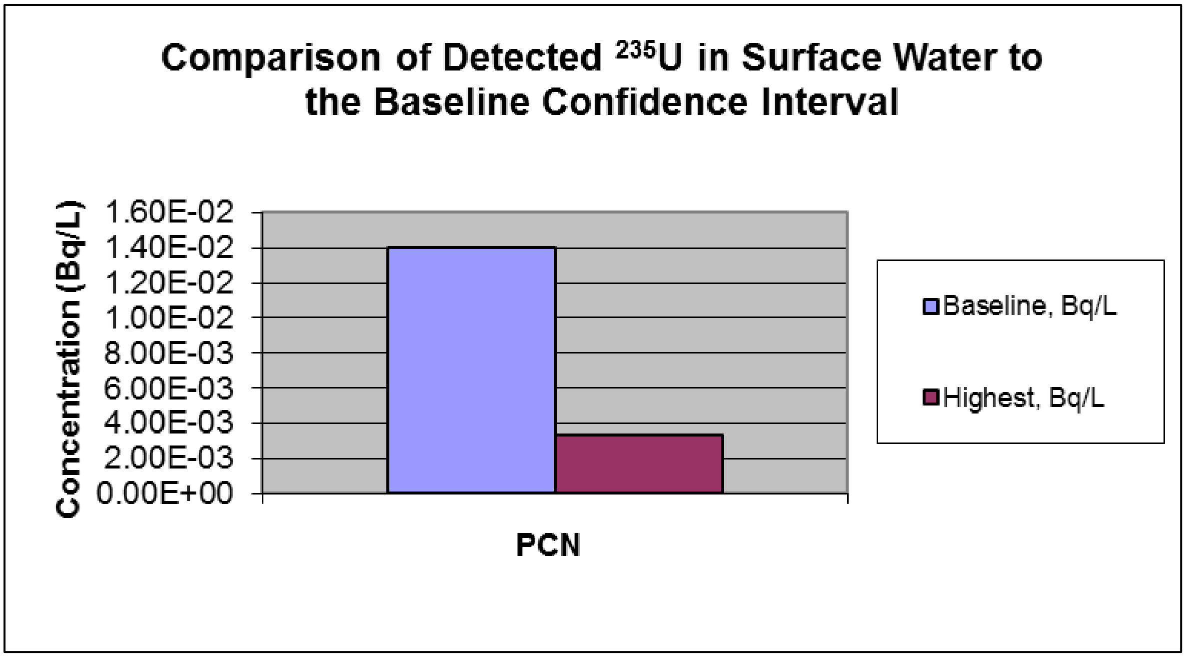
3.00E-01
2.50E-01
2.00E-01
1.50E-01
1.00E-01
5.00E-02
0.00E+00
PCN
Baseline, Bq/L
Highest, Bq/L


Comparison of Detected 235U in Surface Water to the Baseline Confidence Interval
Concentration (Bq/L)
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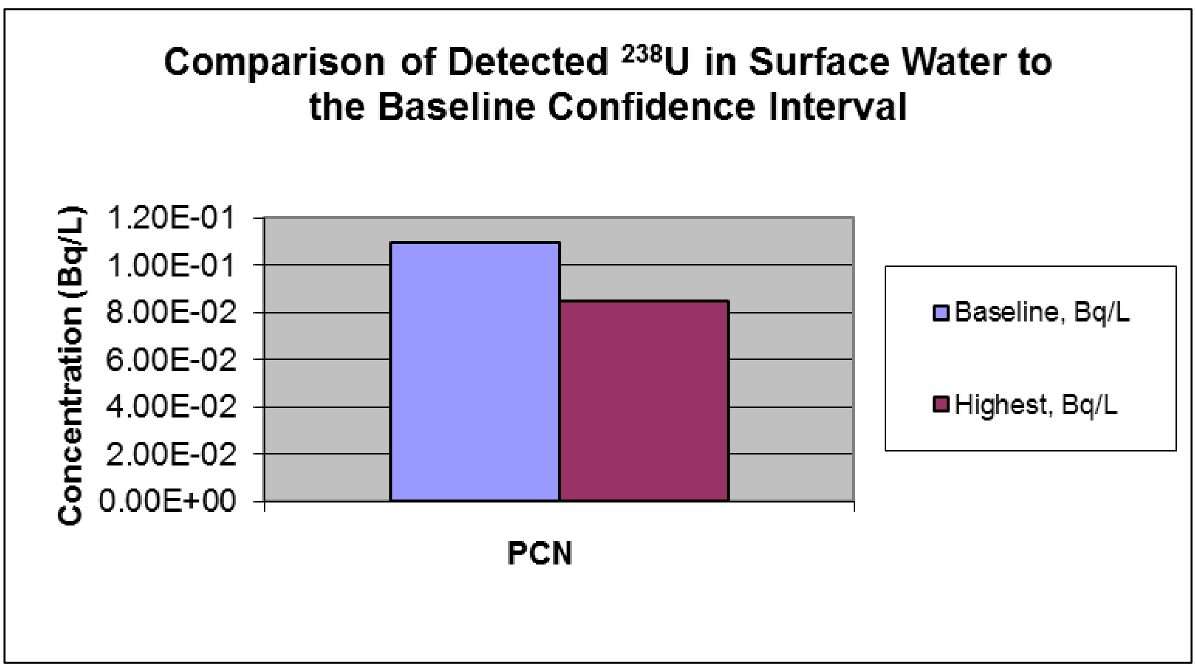
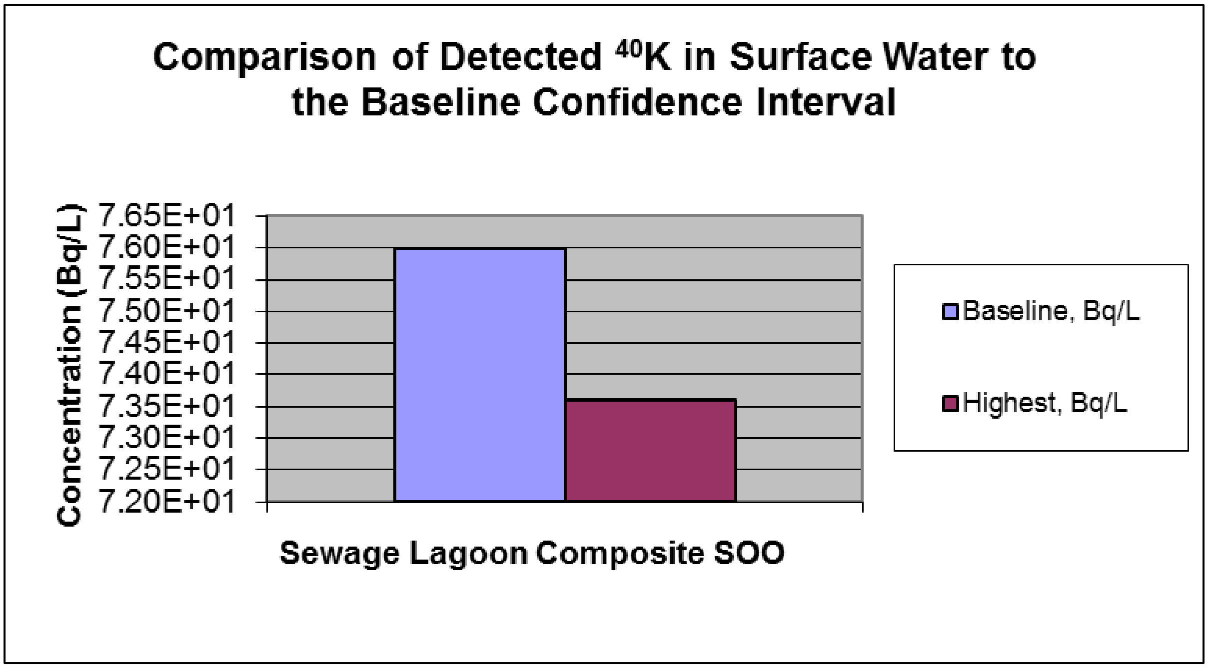
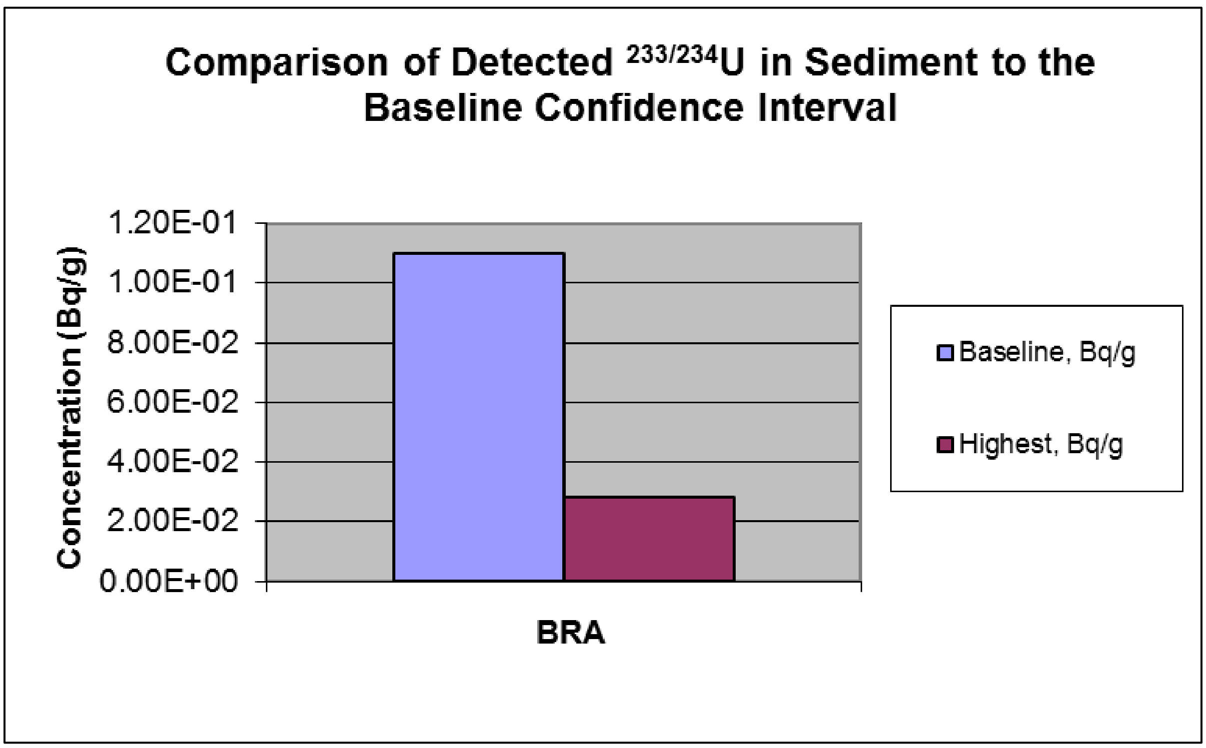
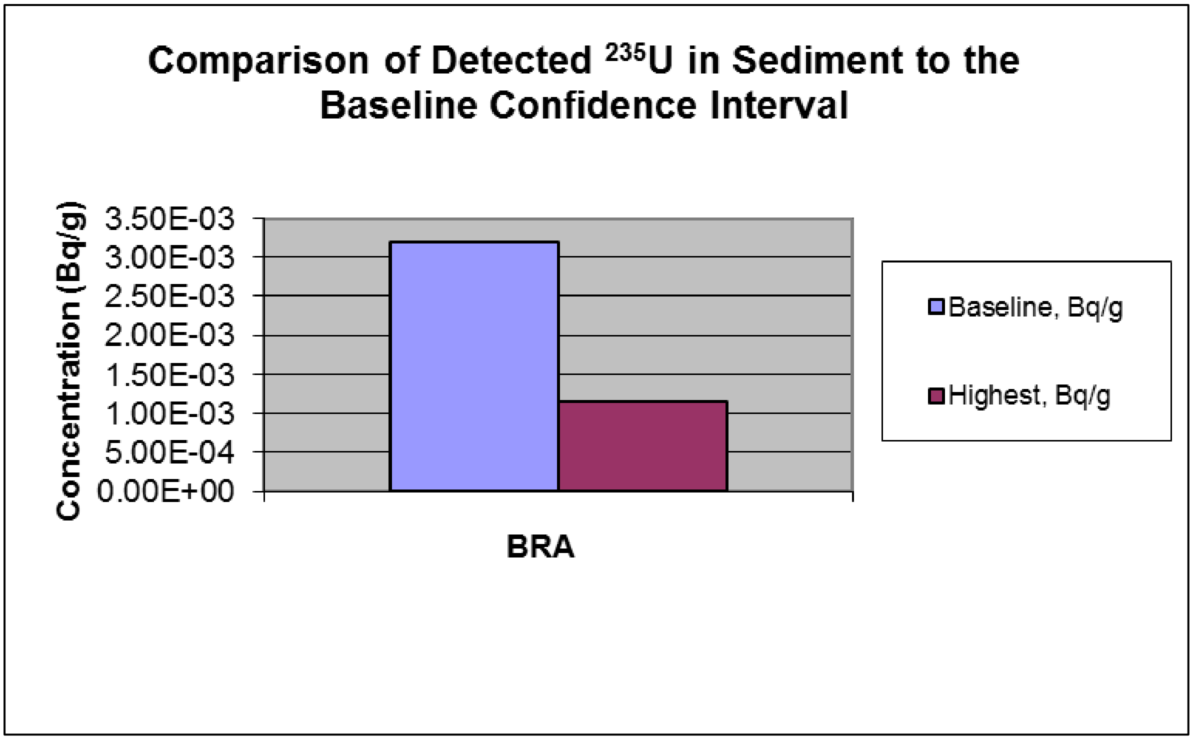
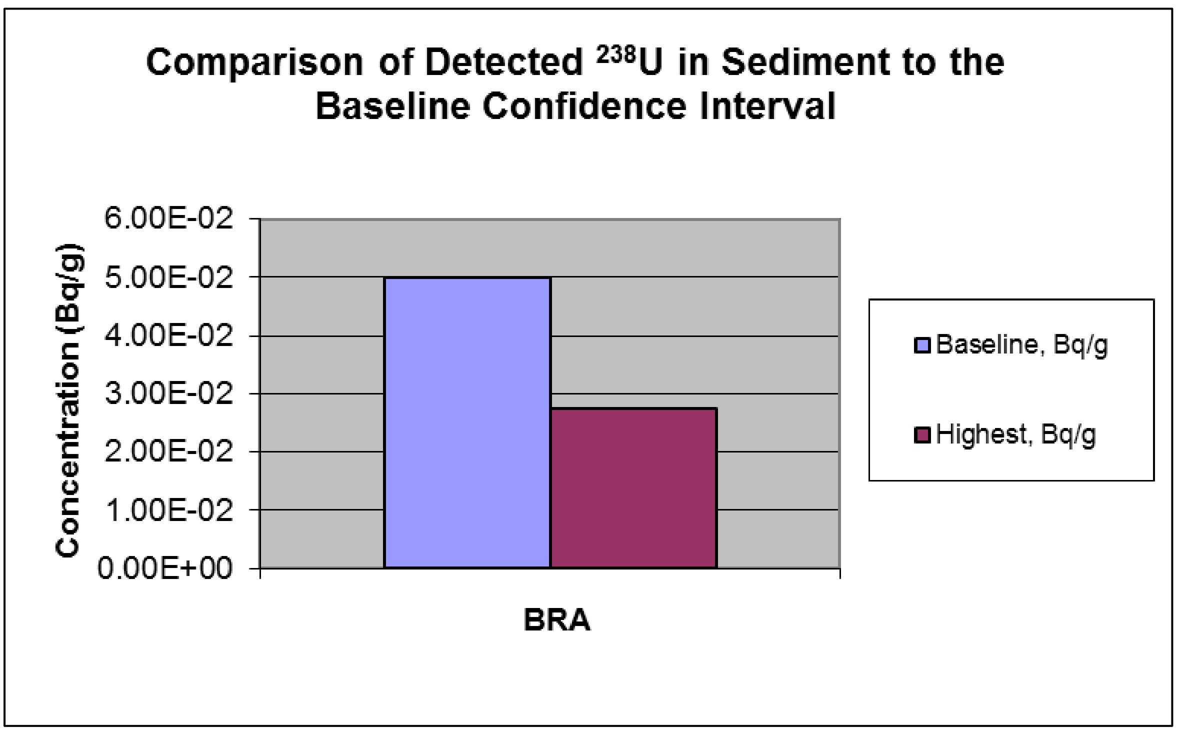
1.40E-02
1.20E-02
1.00E-02
8.00E-03
6.00E-03
4.00E-03
2.00E-03
0.00E+00
PCN
Baseline, Bq/L
Highest, Bq/L

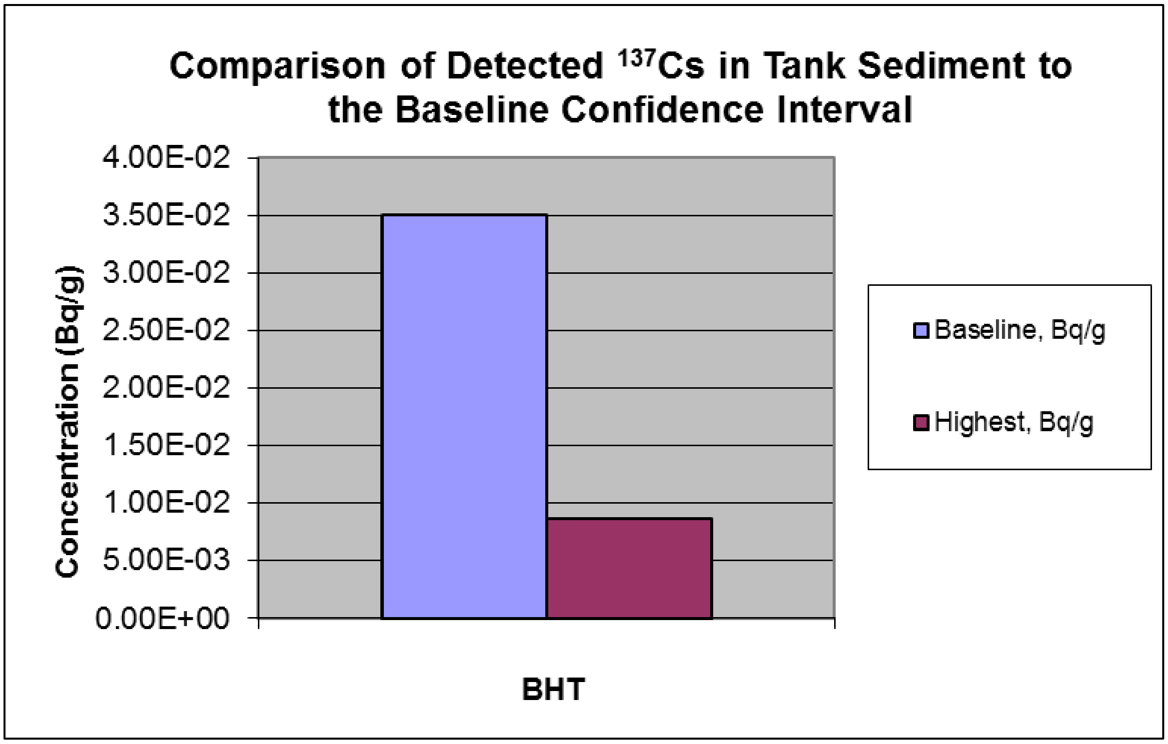

Comparison of Detected 238U in Surface Water to the Baseline Confidence Interval
Concentration (Bq/L)
1.20E-01
1.00E-01
8.00E-02
6.00E-02
4.00E-02
2.00E-02
0.00E+00
PCN
Baseline, Bq/L
Highest, Bq/L

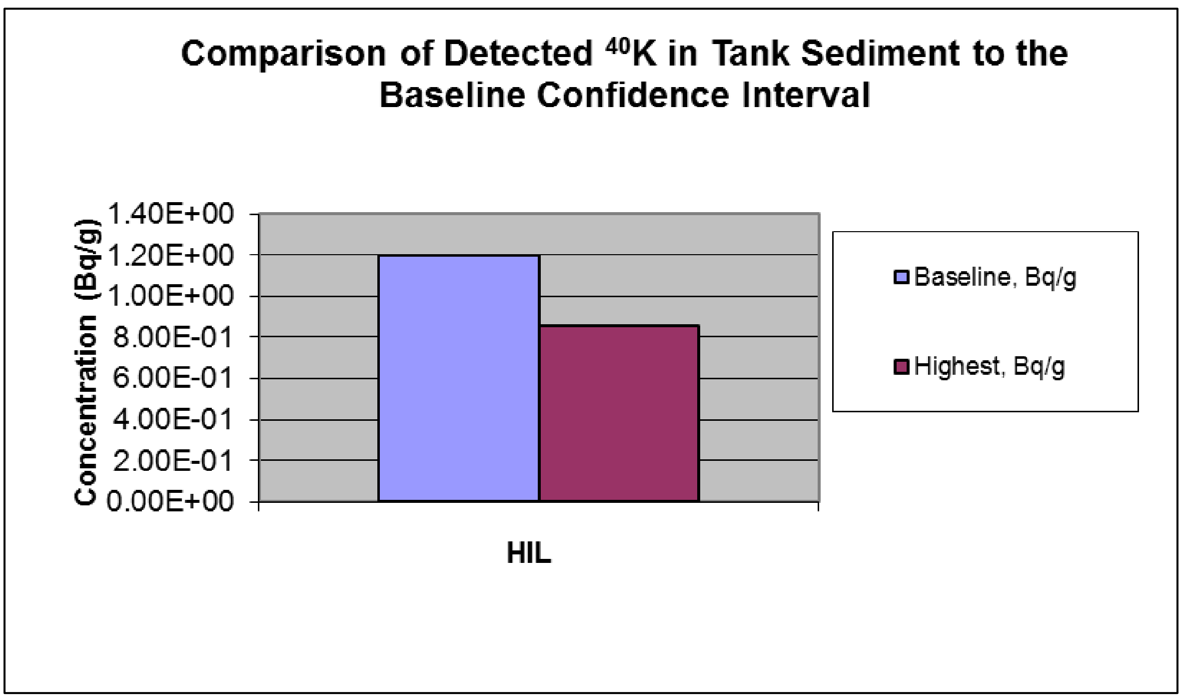

Comparison of Detected 40K in Surface Water to the Baseline Confidence Interval
Concentration (Bq/L)
7.65E+01
7.60E+01
7.55E+01
7.50E+01
7.45E+01
7.40E+01
7.35E+01
7.30E+01
7.25E+01
7.20E+01
Sewage Lagoon Composite SOO
Baseline, Bq/L
Highest, Bq/L

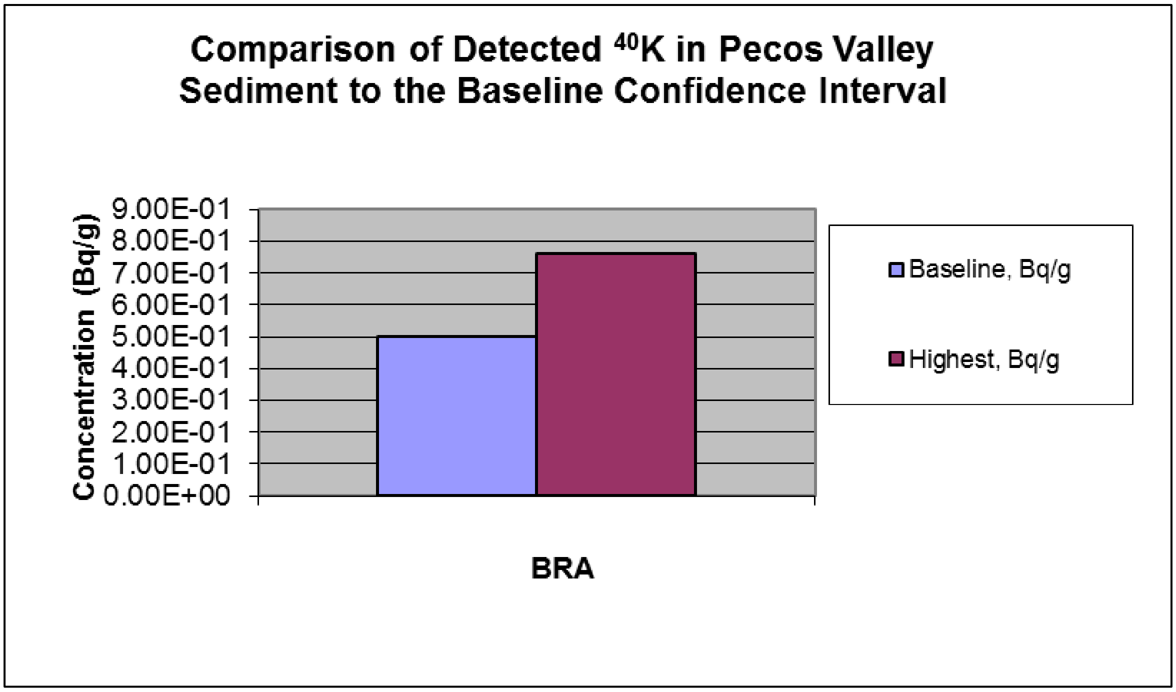

Comparison of Detected 233/234U in Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
1.20E-01
1.00E-01
8.00E-02
6.00E-02
4.00E-02
2.00E-02
0.00E+00
BRA
Baseline, Bq/g
Highest, Bq/g

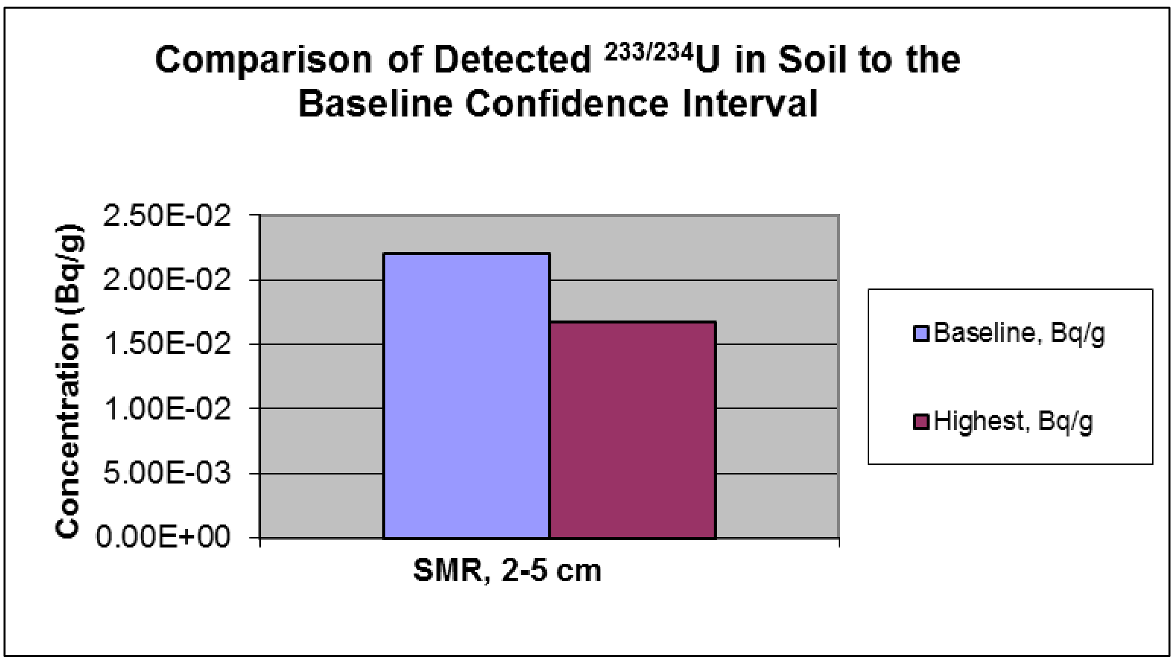

Comparison of Detected 235U in Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
3.50E-03
3.00E-03
2.50E-03
2.00E-03
1.50E-03
1.00E-03
5.00E-04
0.00E+00
BRA
Baseline, Bq/g
Highest, Bq/g

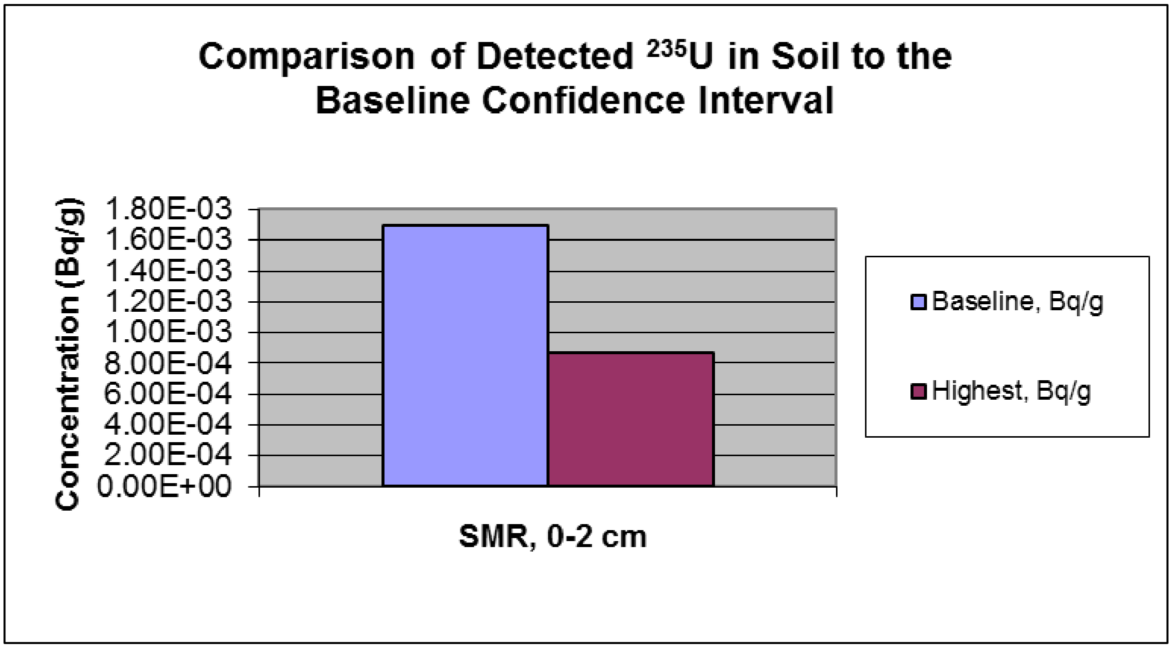

Comparison of Detected 238U in Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
6.00E-02
5.00E-02
4.00E-02
3.00E-02
2.00E-02
1.00E-02
0.00E+00
BRA
Baseline, Bq/g
Highest, Bq/g

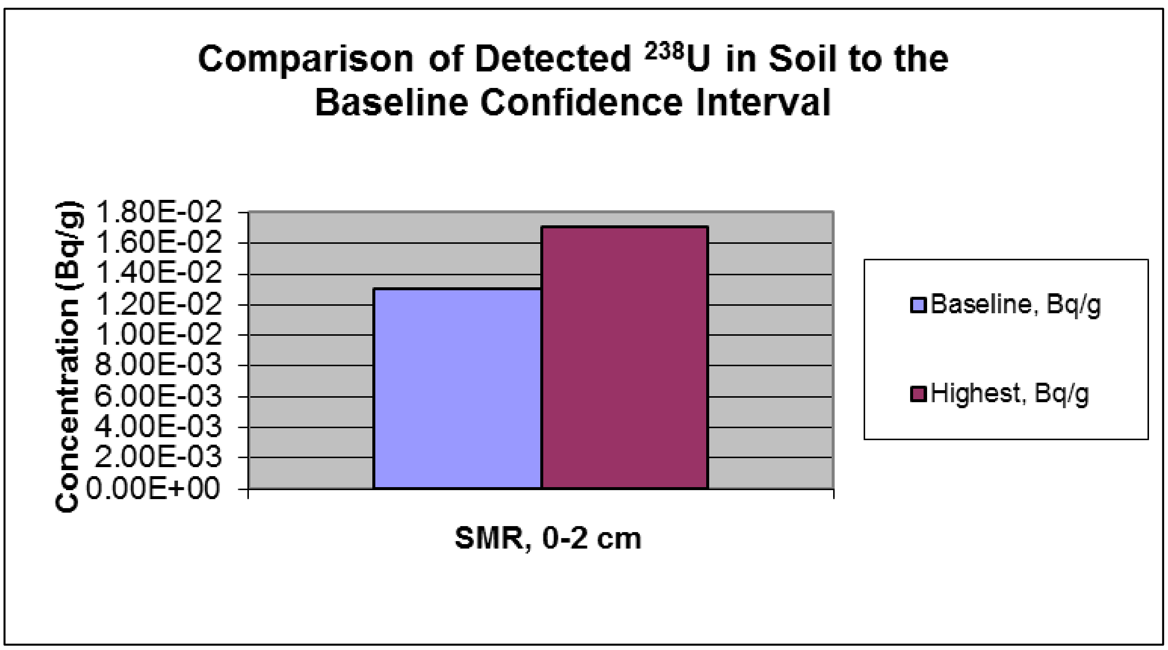

Comparison of Detected 137Cs in Tank Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
4.00E-02
3.50E-02
3.00E-02
2.50E-02
2.00E-02
1.50E-02
1.00E-02
5.00E-03
0.00E+00
BHT
Baseline, Bq/g
Highest, Bq/g

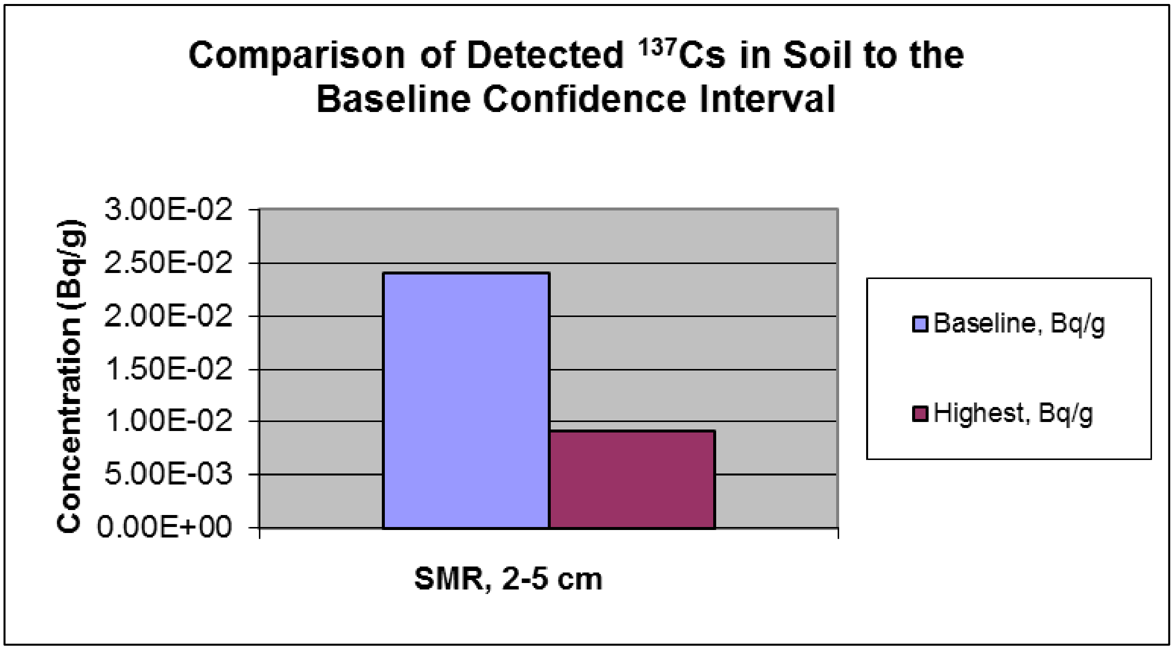

Comparison of Detected 40K in Tank Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
1.40E+00
1.20E+00
1.00E+00
8.00E-01
6.00E-01
4.00E-01
2.00E-01
0.00E+00
HIL
Baseline, Bq/g
Highest, Bq/g

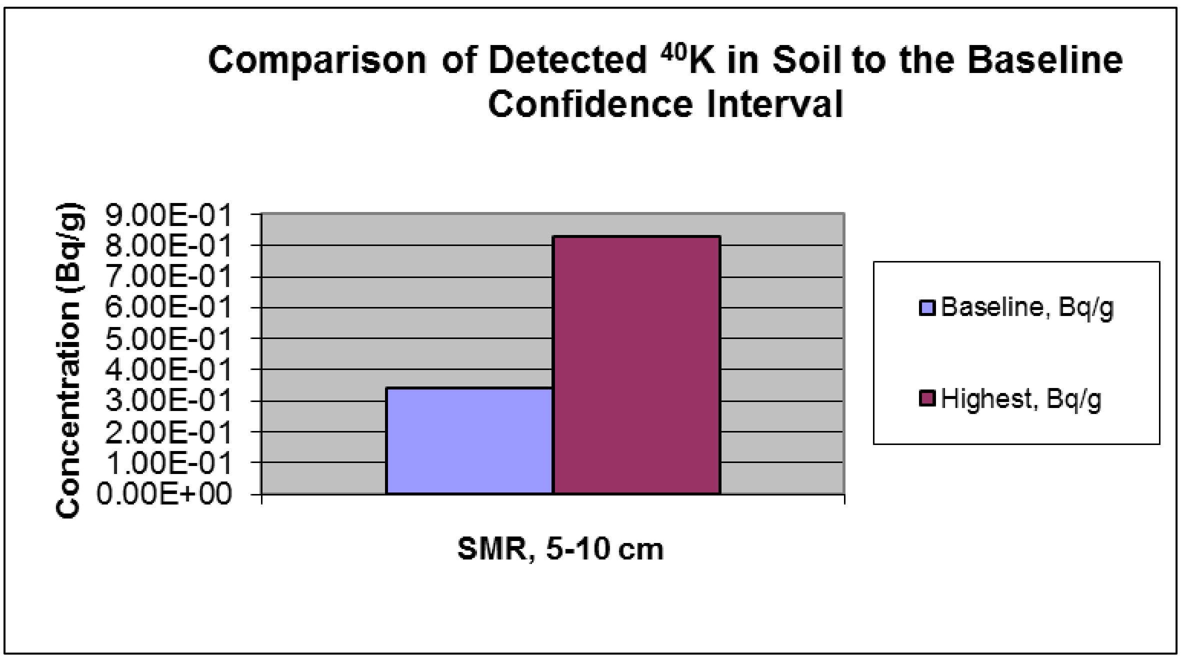

Comparison of Detected 40K in Pecos Valley Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
BRA
Baseline, Bq/g
Highest, Bq/g

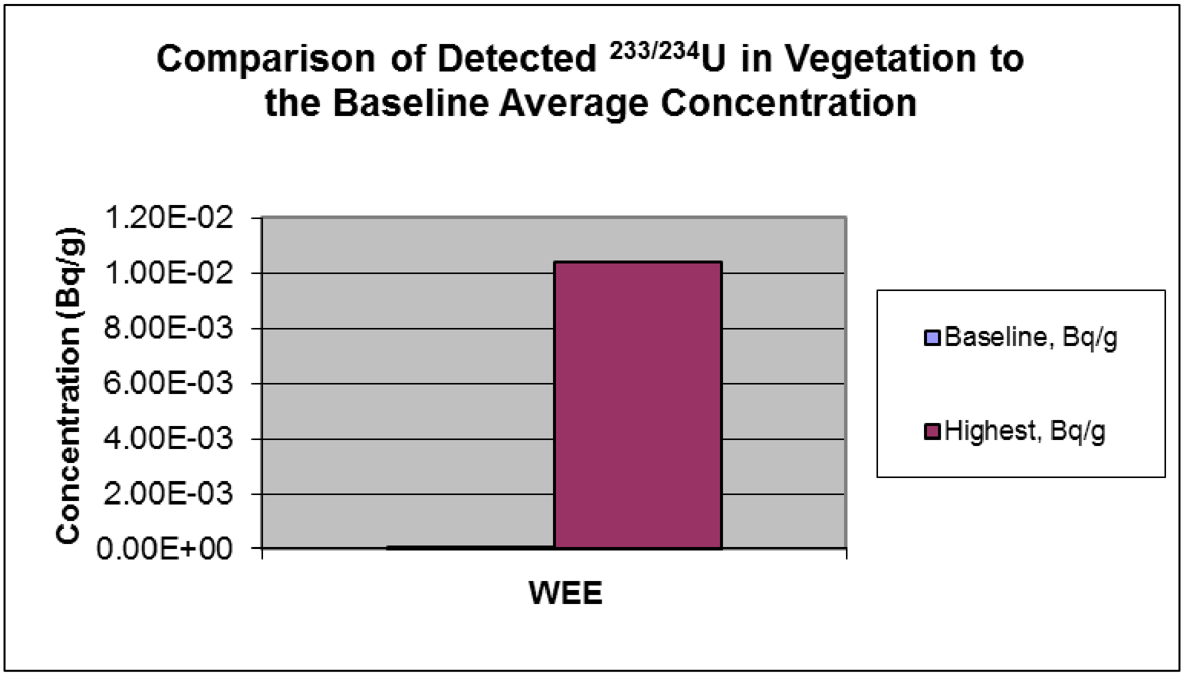

Comparison of Detected 233/234U in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
2.50E-02
2.00E-02
1.50E-02
1.00E-02
5.00E-03
0.00E+00
SMR, 2-5 cm
Baseline, Bq/g
Highest, Bq/g

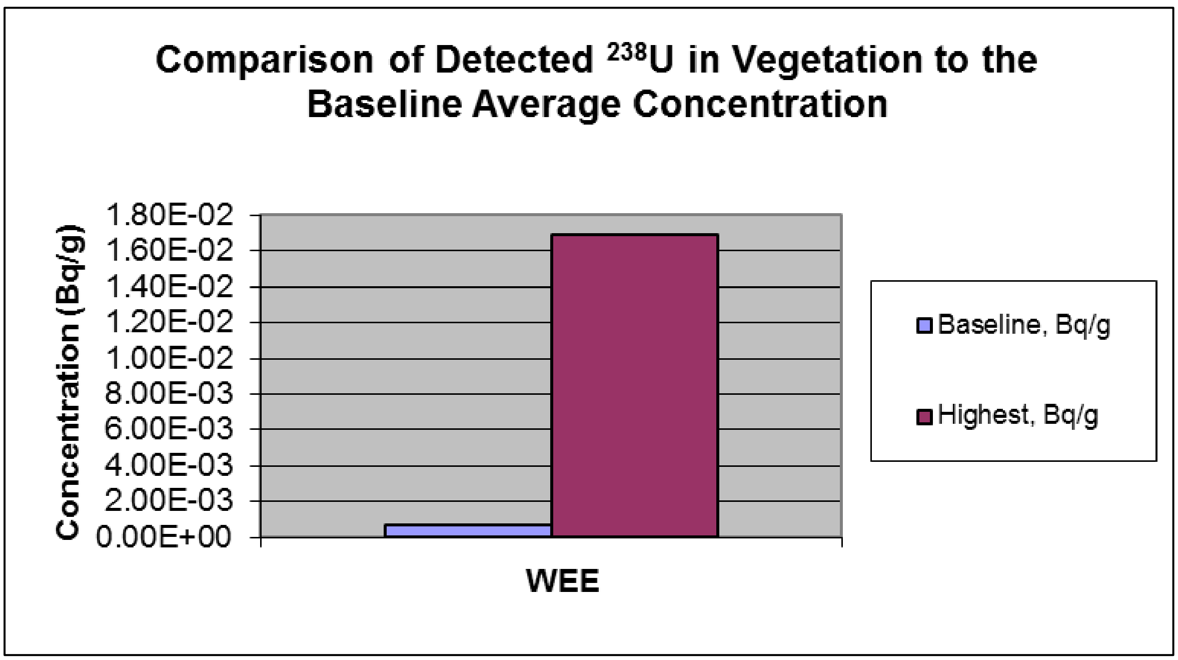

Comparison of Detected 235U in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
1.80E-03
1.60E-03
1.40E-03
1.20E-03
1.00E-03
8.00E-04
6.00E-04
4.00E-04
2.00E-04
0.00E+00
SMR, 0-2 cm
Baseline, Bq/g
Highest, Bq/g

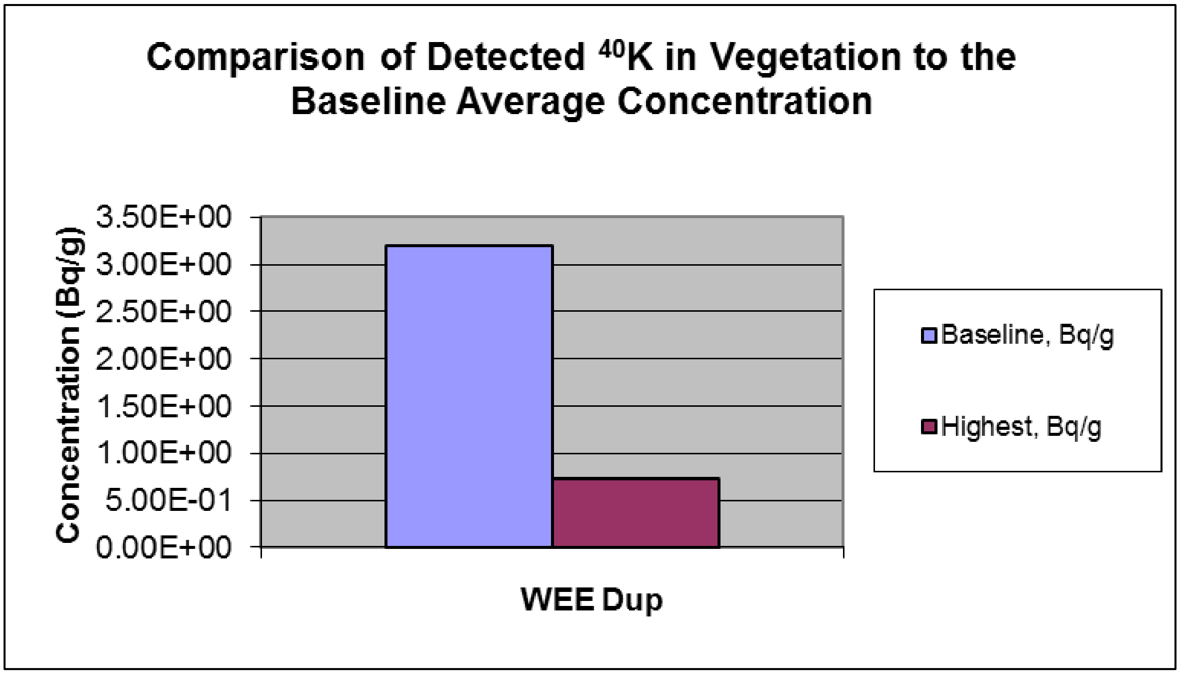

Comparison of Detected 238U in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
1.80E-02
1.60E-02
1.40E-02
1.20E-02
1.00E-02
8.00E-03
6.00E-03
4.00E-03
2.00E-03
0.00E+00
SMR, 0-2 cm
Baseline, Bq/g
Highest, Bq/g

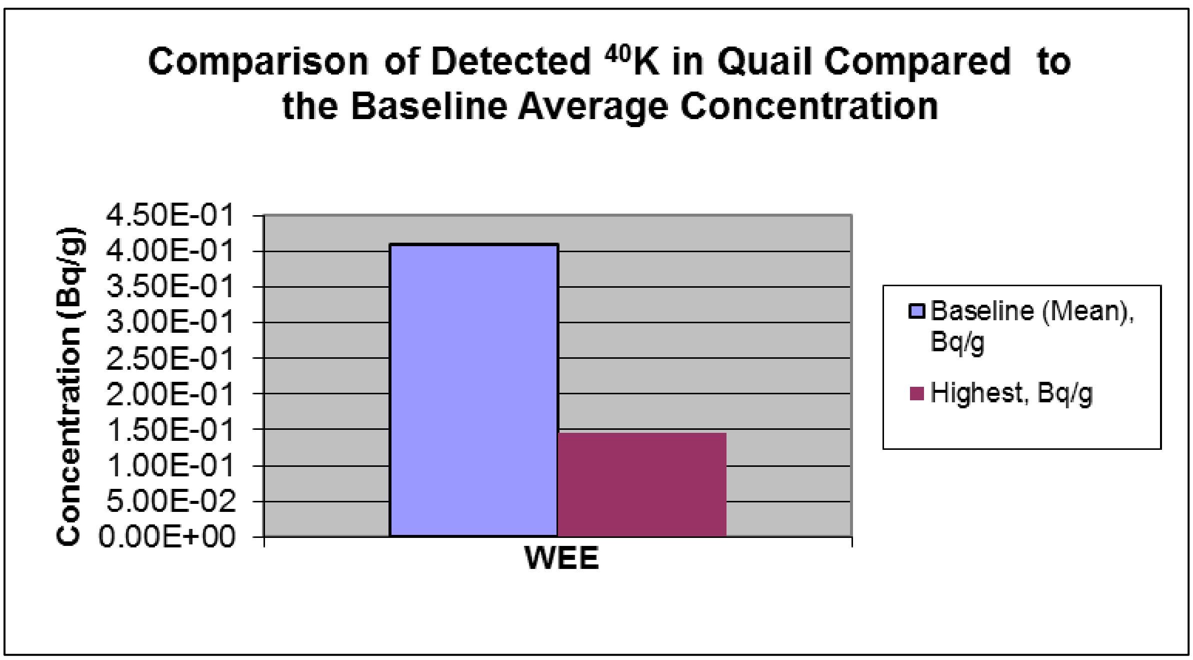

Comparison of Detected 137Cs in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
3.00E-02
2.50E-02
2.00E-02
1.50E-02
1.00E-02
5.00E-03
0.00E+00
SMR, 2-5 cm
Baseline, Bq/g
Highest, Bq/g

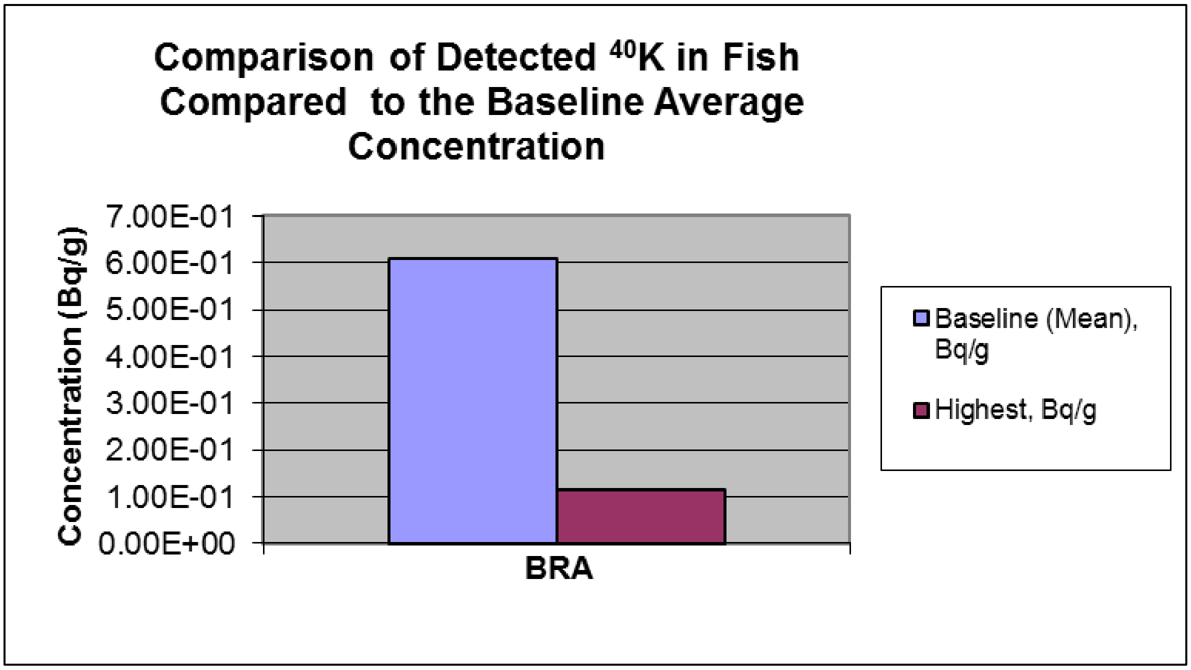

Comparison of Detected 40K in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
SMR, 5-10 cm
Baseline, Bq/g
Highest, Bq/g

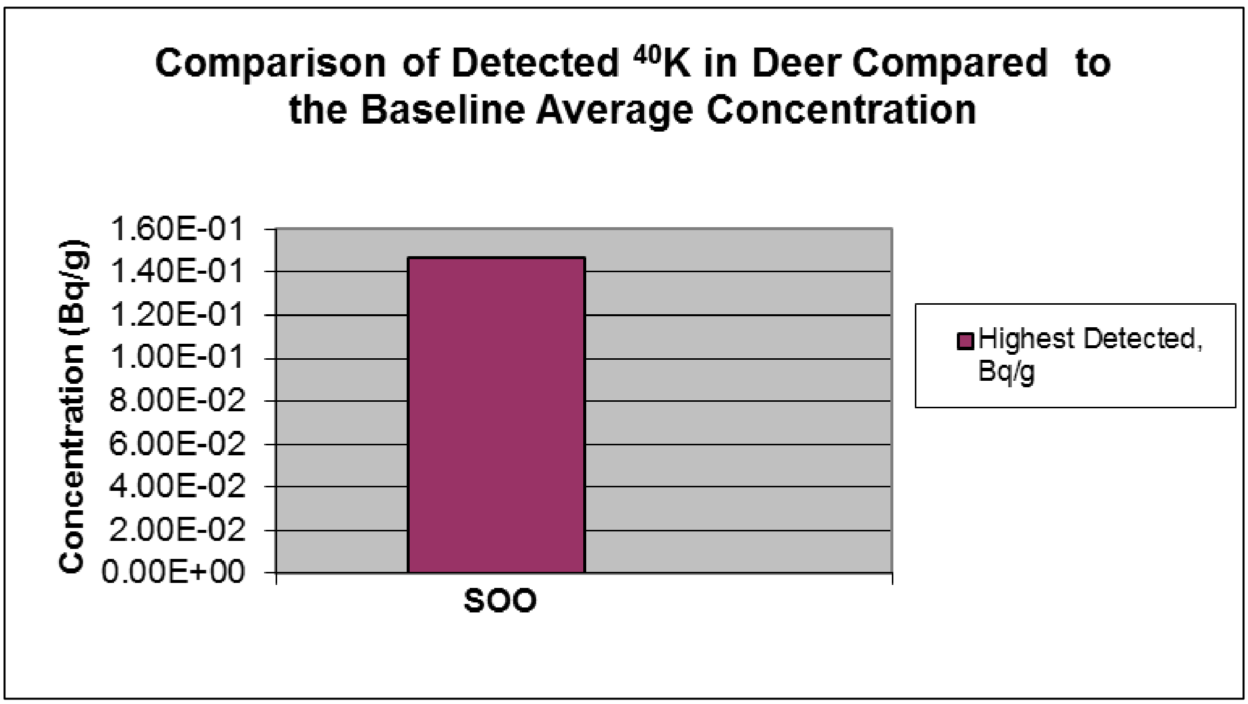

Comparison of Detected 233/234U in Vegetation to the Baseline Average Concentration
Concentration (Bq/g)
1.20E-02
1.00E-02
8.00E-03
6.00E-03
4.00E-03
2.00E-03
0.00E+00
WEE
Baseline, Bq/g
Highest, Bq/g


Comparison of Detected 238U in Vegetation to the Baseline Average Concentration
Concentration (Bq/g)
1.80E-02
1.60E-02
1.40E-02
1.20E-02
1.00E-02
8.00E-03
6.00E-03
4.00E-03
2.00E-03
0.00E+00
WEE
Baseline, Bq/g
Highest, Bq/g


Comparison of Detected 40K in Vegetation to the Baseline Average Concentration
Concentration (Bq/g)
3.50E+00
3.00E+00
2.50E+00
2.00E+00
1.50E+00
1.00E+00
5.00E-01
0.00E+00
WEE Dup
Baseline, Bq/g
Highest, Bq/g


Comparison of Detected 40K in Quail Compared to the Baseline Average Concentration
Concentration (Bq/g)
4.50E-01
4.00E-01
3.50E-01
3.00E-01
2.50E-01
2.00E-01
1.50E-01
1.00E-01
5.00E-02
0.00E+00
WEE
Baseline (Mean), Bq/g
Highest, Bq/g


Comparison of Detected 40K in Fish Compared to the Baseline Average Concentration
Concentration (Bq/g)
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
BRA
Baseline (Mean), Bq/g
Highest, Bq/g


Comparison of Detected 40K in Deer Compared to the Baseline Average Concentration
Concentration (Bq/g)
1.60E-01
1.40E-01
1.20E-01
1.00E-01
8.00E-02
6.00E-02
4.00E-02
2.00E-02
0.00E+00
SOO
Highest Detected, Bq/g

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